AGREEMENT AMONG

THE UNITED STATES OF AMERICA, THROUGH THE DEPARTMENT OF THE
INTERIOR, BUREAU OF RECLAMATION, THE STATE OF ARIZONA, THROUGH
THE ARIZONA DEPARTMENT OF WATER RESOURCES, THE CENTRAL
ARIZONA WATER CONSERVATION DISTRICT, AND THE COLORADO RIVER
INDIAN TRIBES TO FUND THE CREATION OF COLORADO RIVER SYSTEM
WATER THROUGH VOLUNTARY WATER CONSERVATION AND REDUCTIONS
IN USE DURING CALENDAR YEARS 2020-2022

1. **PREAMBLE.** THIS AGREEMENT ("Agreement") is entered into this 20th day of
   July, 2019, by and between the UNITED STATES OF AMERICA ("United States"),
   represented by the Secretary of the Interior ("Secretary") acting through the Regional Director of
   the Bureau of Reclamation, Lower Colorado Region ("Reclamation"), the State of Arizona, acting
   through the Arizona Department of Water Resources ("ADWR"), the Central Arizona Water
   Conservation District ("CAWCD") and the Colorado River Indian Tribes ("CRIT") each being
   referred to individually as "Party" and collectively as the "Parties".

2. **EXPLANATORY RECITALS**

2.1 WHEREAS, on December 13, 2007, the Secretary executed a Record of Decision
   that included Interim Guidelines for Lower Basin Shortages and Coordinated Operations of Lake
   Powell and Lake Mead ("2007 Guidelines");

2.2. WHEREAS, the State of Arizona, certain other parties in the Lower Basin of the
    Colorado River and the Secretary developed the Lower Basin Drought Contingency Plan
    ("LBDCP") to address and reduce the likelihood of the continued decline of the elevation of Lake
    Mead;

2.3 WHEREAS, the major terms of the LBDCP are set forth in the Lower Basin
    Drought Contingency Operations ("LBOps");

2.4 WHEREAS, Section IV.F. of the LBOps provides that the Secretary shall not
    release pursuant to Article II of the Consolidated Decree water intentionally conserved by a
    conservation program within a Lower Division State in which the Secretary participates and that
    results in reductions in consumptive use;
2.5. WHEREAS, stakeholders within Arizona, together with Arizona legislative leaders, developed a plan to implement the LBDCP in Arizona, including partially mitigating the impacts of the LBDCP on certain water users in Arizona and conserving additional water in Lake Mead to protect the elevation of the lake (Arizona Lower Basin Drought Contingency Plan Framework Agreement).

2.6 WHEREAS, the Parties desire to take steps during calendar years 2020, 2021 and 2022 towards conserving water in Lake Mead, consistent with Section IV.F of the LBOps and the Law of the River, to achieve the goals of the Arizona Lower Basin Drought Contingency Plan Framework Agreement;

2.7 WHEREAS, CRIT holds Entitlements to Colorado River water in the states of Arizona and California as specified in the Consolidated Decree of the Supreme Court of the United States in the case of Arizona v. California, et al., entered March 27, 2006, (547 U.S. 150), as it may be further modified ("Consolidated Decree");

2.8 WHEREAS, CRIT’s Colorado River water Entitlement for use in the State of Arizona is set forth in Article I.A of the Appendix to the Consolidated Decree (Federal Establishments’ Present Perfected Rights) as: (i) an annual diversion of a total of 662,402 acre-feet, or (ii) the consumptive use required for irrigation of 99,375 acres and for satisfaction of related uses, whichever of (i) or (ii) is less;

2.9 WHEREAS, CRIT and Reclamation entered into System Conservation Implementation Agreements ("SCIA") No. 16-XX-30-W0606 dated September 14, 2016, No. 18-XX-30-W0634 dated September 14, 2018 and No. 19-XX-30-W0647 dated February 25, 2019 as part of a Pilot Program established by Reclamation and four municipal entities in July 2014 to fund the creation of Colorado River system water through voluntary water conservation and reductions in use. The SCIA provided for the creation of System Conservation Water by CRIT through the fallowing of lands within the Colorado River Indian Reservation in Arizona ("CRIR"), establishing a methodology to account for reduced consumptive use as system water;

2.10 WHEREAS, the Arizona legislature passed SB 1227 which was signed into law by the Governor on January 31, 2019 creating the Arizona System Conservation Fund ("Fund") to receive contributions and provide funding for the creation of System Conservation Water as contemplated by this Agreement (A.R.S. § 45-118, added by Laws 2019, Chapter 1, Sec. 1);
2.11 WHEREAS, CRIT will forego water deliveries and fallow lands within a portion of CRIR for three years beginning January 1, 2020 and ending December 31, 2022, and make the conserved water available to the Lower Colorado River System thereby increasing storage in Lake Mead in exchange for payment from the Fund;

2.12 WHEREAS, the Parties have differences of opinion as to CAWCD’s rights and obligations with respect to the creation of System Conservation Water but have agreed to CAWCD’s inclusion as a Party as provided in Section 9 below in order to provide additional certainty in the implementation of this Agreement;

2.13 WHEREAS, the Parties desire to enter into this Agreement to provide for: (1) payment of monies from the Fund to CRIT for the fallowing of sufficient land within CRIR to create 50,000 acre-feet per year of System Conservation Water during calendar years 2020 and 2021 and an additional volume of System Conservation Water in calendar year 2022, not to exceed 150,000 acre-feet of System Conservation Water over the three years, and (2) for the monitoring and accounting for the water created by CRIT as System Conservation Water in Lake Mead by Reclamation and CRIT (the “Project”); and,

2.14 WHEREAS, the Parties understand that the cost to create 150,000 acre-feet of System Conservation Water in Lake Mead is $38,160,000. The Arizona State Legislature appropriated $30,000,000 to be deposited in the Fund and the Parties understood that an additional $8,000,000 would be contributed to the Fund by the Environmental Defense Fund (EDF) with monies contributed by certain non-governmental organizations (“NGO’s”). To the extent that the full $8,000,000 is not contributed by EDF, the Parties will seek additional funding. Interest on any monies deposited in the Fund for the purposes of funding the Project shall accrue to the benefit of this Agreement up to the total amount of funding for CRIT to create 150,000 acre-feet of System Conservation Water.

NOW, THEREFORE, in consideration of the mutual promises contained in this Agreement, the Parties agree as follows:

3. **DEFINITIONS.** For the purposes of this Agreement, the following definitions shall apply:
3.1 Accounting and Water Use Report means Reclamation’s annual Colorado River Accounting and Water Use Report; Arizona, California and Nevada, published on or about May 15th each year.

3.2 Adjusted Maximum Diversion means the maximum volume of water CRIT will divert in any given year during the Fallowing Period. This number is calculated by subtracting from the Baseline Diversion the sum of the Reduced Diversion Amounts stated for each parcel identified in Exhibit A.

3.3 Baseline Diversion is 612,725 acre-feet per year, which was calculated using the average of the four highest years 2013 through 2017 as reported in the Accounting and Water Use Report and adding back any diversion reduction created under the applicable SCIA.

3.4 BIA means the Bureau of Indian Affairs, an agency within the U.S. Department of the Interior.

3.5 CRIR means the portion of the Colorado River Indian Reservation lands located in the State of Arizona.

3.6 Colorado River System shall have the meaning ascribed to such term in the Colorado River Compact, signed on November 24, 1922, at Santa Fe, New Mexico, pursuant to an act of Congress approved August 19, 1921 (42 Stat. 171) and approved in Section 13(a) of the Boulder Canyon Project Act.

3.7 Consolidated Decree means the decree entered by the United States Supreme Court in the matter of Arizona v. California on March 27, 2006 (547 U.S. 150).

3.8 Consumptive Use Reduction Quantity means, for any given year during the Fallowing Period, the calculated quantity of reduction in CRIT consumptive use required within CRIR Project Lands as set forth in Paragraph 6.2 and Exhibit A of this Agreement.

3.9 DCP Contribution shall have the same meaning as set forth in the LBOps.

3.10 Entitlement shall have the same meaning as “allocation” as found in the Consolidated Decree.

3.11 Exhibit A consists of Exhibit A 2020, Exhibit A 2021 and Exhibit A 2022, each of which includes a list of Project Lands and the Technical Memoranda for each parcel within the
Project Lands that will be fallowed during the applicable year. Exhibit A 2020 is attached hereto and made part of this Agreement. Exhibit A 2021 and Exhibit A 2022 shall be prepared by CRIT and provided to the other Parties as described in Paragraph 6.5.

3.12 **Exhibit B** is a copy of the Project Funding Agreement between the Arizona Department of Water Resources and Environmental Defense Fund ("EDF") which is a Project specific funding agreement. Exhibit B is attached hereto and made part of this Agreement.

3.13 **Fallowing Period** means the period beginning January 1, 2020 and ending December 31, 2022.

3.14 **Fund** means the Arizona System Conservation Fund established by the Arizona State Legislature in A.R.S. § 45-118 (Laws 2019, Chapter 1, Sec. 1).

3.15 **Future Funding Exhibit** refers to funding exhibits executed by ADWR and as yet unidentified contributors to the Fund for the express purpose of funding the Project. Upon execution, such exhibits will be attached hereto as Exhibits B “X” with “X” representing a consecutive number and made part of this Agreement.

3.16 **LBOPs** means the Lower Basin Drought Contingency Operations attached as Exhibit 1 to the LBDCP Agreement and incorporated by reference therein.

3.17 **Project** means those activities described in this Agreement and Exhibit A attached herein.

3.18 **Project Lands** means the lands, designated in Exhibit A and updated annually, located within CRIR that have been irrigated in four out of the most recent five years unless fallowed pursuant to a SCIA, or this Agreement.

3.19 **Reduced Diversion Amount** means, for any given year during the Fallowing Period, the reduction in CRIT diversions that needs to be made during the year in order to achieve the Consumptive Use Reduction Quantity within Project Lands as set forth in Paragraph 6.2.

3.20 **Remaining Balance** means all monies remaining in the Fund as of July 15, 2021 that were deposited for the purpose of funding the Project and all accrued interest on those monies. The Remaining Balance shall also include a commercially reasonable estimate of interest to be accrued while those monies remain in the Fund until the Final Payment is made pursuant to Section 8.5.3.
3.21 **Shortfall** means, for any year in which CRIT fails to meet the System Conservation Water requirement, the difference in the volume of System Conservation Water created in the year and the Consumptive Use Reduction Quantity for that year.

3.22 **System Conservation Implementation Agreement** ("SCIA") means the agreements listed in Paragraph 2.9 entered into by Reclamation and CRIT to implement a Pilot System Conservation Program for the funding and creation of water for the Colorado River System through voluntary water conservation and reductions in use by CRIT.

3.23 **System Conservation Water** means water that is conserved for storage in Lake Mead to benefit the Colorado River System through a voluntary, measurable reduction of Consumptive Use of Colorado River water by CRIT.

4. **EFFECTIVE DATE**

The obligations of the Parties under this Agreement shall become effective on the date signed by all of the Parties.

5. **SYSTEM CONSERVATION WATER NOT A DCP CONTRIBUTION.**

The Parties to this Agreement agree that the System Conservation Water created under this Agreement shall not be used to satisfy any Lower Basin States’ DCP Contribution required under the LBOps.

6. **CRIT AGREEMENTS**

6.1 **Cancellation of SCIA**: Upon execution of this Agreement, CRIT shall provide written notice to the parties to the applicable SCIA that it is not exercising its right to extend any SCIA beyond December 31, 2019. CRIT shall provide a copy of such notice to the Parties to this Agreement.

6.2 **Consumptive Use Reduction Quantity**: CRIT shall fallow sufficient Project Lands each year during the Fallowing Period to produce an annual Consumptive Use Reduction Quantity as follows:

6.2.1 A Consumptive Use Reduction Quantity of no less than 50,000 acre-feet per year during calendar years 2020 and 2021.
6.2.2 A Consumptive Use Reduction Quantity during calendar year 2022 of no less than the quantity of System Conservation Water that the Fund can secure at a price of $261.60 per acre-foot, but not to exceed 150,000 acre-feet of System Conservation Water over the entire Fallowing Period.

6.3 *Project Lands:* The Project Lands shall be located in CRIR, as listed annually in Exhibit A. In order to qualify for falling, these lands must have been irrigated for at least four out of the most recent five years unless fallowed pursuant to a SCIA or this Agreement. CRIT states that absent this Agreement, the Project Lands would have been irrigated during the Fallowing Period.

6.4 *ICS Creation:* During the Fallowing Period, CRIT may designate any Consumptive Use Reduction Quantity in excess of the amounts set forth in Paragraph 6.2 as Extraordinary Conservation Intentionally Created Surplus ("EC-ICS") to the benefit of CRIT, provided that such Consumptive Use Reduction Quantity also qualifies as EC-ICS under the 2007 Guidelines and the CRIT ICS Exhibit, and provided further that the creation of EC-ICS is consistent with the LBOps, and the Framework Agreement among the United States, ADWR, and CAWCD for an Arizona ICS Program ("Arizona ICS Framework Agreement").

6.5 *Technical Memorandum:* The Technical Memorandum for the first year of the Fallowing Period is attached to this Agreement as Exhibit A 2020. On or before August 1, 2020, CRIT shall provide to the other Parties the Technical Memorandum for 2021, which shall be Exhibit A 2021. On or before August 1, 2021, CRIT shall provide to the other Parties the Technical Memorandum for 2022, which shall be Exhibit A 2022. Each Exhibit A Technical Memorandum shall identify each parcel of Project Lands to be fallowed during the year and include the historic farming practices on the parcels, the quantification methods and calculations used to determine the Consumptive Use Reduction Quantity for those parcels and the anticipated annual Reduced Diversion Amount. The Technical Memorandum shall also include a map showing the location of the parcels. Technical Memoranda for 2021 and 2022 shall be similar in form and content to Exhibit A 2020. After CRIT provides to the other Parties the Technical Memorandum for 2021 or 2022, the other Parties shall have thirty (30) days to review the Technical Memorandum and provide comments to CRIT. CRIT shall meet and confer with the Parties to address any identified issues during the following September with sufficient time to
prepare and submit the annual water order to BIA on or about October 1. If a Reclamation on-field verification pursuant to Paragraph 7.1 finds that less land has been fallowed than indicated in the annual Technical Memorandum attached as Exhibit A to this Agreement, CRIT agrees to immediately increase the acreage of fallowed lands in accordance with the applicable Technical Memorandum.

6.6 Vegetation Control: During the Fallowing Period, in order to ensure that any vegetation remaining on the Project Lands does not consumptively use Colorado River water by drawing water from the Colorado River aquifer, CRIT shall, at its expense, ensure that any such vegetation is desiccated or eradicated through application of herbicides or other means while maintaining land cover or other sufficient dust control methods or technology and controlling and eliminating, to the extent possible, growth of any weeds. CRIT agrees to provide Reclamation with information and updates, when requested, regarding the live vegetation desiccation and eradication, dust control and weed control program.

6.7 CRIT Limitation of Consumptive Use: The Parties acknowledge that the creation of System Conservation Water must be achieved through a reduction in the consumptive use of Colorado River water by the farming operations within CRIR controlled by CRIT during the Fallowing Period. Approximately 71 percent of the land irrigated within CRIR is leased to third parties for farming or is held as an assignment or allotment (designated “lessees” herein). CRIT does not control the number of acres irrigated by the lessees nor the crops that are planted on those acres. Both of these factors affect the total annual water diversions and consumptive use within CRIR. Nevertheless, in addition to the active fallowing program created by the Project, CRIT also agrees that during the Fallowing Period, it shall use best efforts to limit the consumptive use within CRIR at or below the average of the four highest consumptive use years from 2013 through 2017 as reported for CRIR in the Accounting and Water Use Report adding back any consumptive use reduction according to a SCIA that is not reported in an Accounting and Water Use Report for this period.

6.8 CRIT Costs: CRIT agrees to bear all of its costs for implementation of this Section, including the activities specified in Paragraph 6.6 and the operation and maintenance costs for the Colorado River Irrigation Project payable to the BIA for lands that are included in the Project.
6.9 **Forbearance:** In order to provide further assurances to the Parties regarding water use on CRIR, CRIT further agrees to the following during the Fallowing Period as agreed upon forbearance:

6.9.1 CRIT shall not permit irrigation water to be used on more than a total of 72,871 acres within CRIR each year during the Fallowing Period. The total acreage is based on the highest amount of acreage within CRIR with a history of irrigation within the most recent five years. The annual calculation of total acreage shall include those lands fallowed for the purposes of this Agreement and for the creation of ICS.

6.9.2 CRIT agrees not to irrigate any lands, or lease any lands, for irrigated agriculture within CRIR that have not been historically irrigated.

6.9.3 CRIT shall not use Colorado River water for irrigation or other purposes from any new infrastructure that could be used to reduce return flows from CRIR to the Colorado River.

6.9.4 For each year of the Fallowing Period, CRIT agrees to maintain total water diversions from the Colorado River at or below the Adjusted Maximum Diversion for that year. For each year of the Fallowing Period, CRIT will reduce its annual water order request to the BIA so that the order does not exceed the Adjusted Maximum Diversion. CRIT agrees to monitor its water diversions and adjust its diversions as needed to avoid exceeding the Adjusted Maximum Diversion in each year.

6.9.4.1 If, after July 1st of any year during the Fallowing Period, the daily forecast published on Reclamation’s website consistently indicates a diversion in excess of the monthly schedule contained in CRIT’s annual water order, CRIT shall take the following actions:

a. Meet with the BIA Irrigation Project Management and Reclamation to determine the reason for the excess diversion.

b. If necessary, request that the monthly schedule for the balance of the year be reduced so as to not exceed the Adjusted Maximum Diversion by the end of the year.

6.9.4.2 In the event that the actual diversion of water by CRIT as measured by USGS and reported to Reclamation at the end of the year exceeds the Adjusted Maximum
Diversion for that year, CRIT agrees to work with Reclamation to arrange to repay the Colorado River System in the amount by which the actual diversion exceeded the Adjusted Maximum Diversion as follows:

a. If the exceedance occurs in 2020 or 2021 and the Inadvertent Overrun and Payback Policy ("IOPP") is in effect for the year of the exceedance, Reclamation will, before the Accounting and Water Use Report is issued by Reclamation for that year, and in consultation with CRIT, account for the excess diversion as delivery of CRIT ICS to CRIT in the year of the exceedance, up to the amount of full balance of CRIT’s ICS. If CRIT does not have ICS available to cover the full exceedance, CRIT shall submit an IOPP payback plan to Reclamation by July 1st. The plan shall require that the amount of water diverted in excess of the Adjusted Maximum Diversion, less any amount accounted for as delivery of CRIT ICS to CRIT, be paid back in one or more of the following ways: (1) amend CRIT’s water order for the current year to reduce CRIT diversions to the Adjusted Maximum Diversion for that year, plus the amount of the previous year exceedance; or (2) undertake other mechanisms mutually acceptable to the Parties by which the excess diversion may be repaid to the Colorado River System.

b. If the exceedance occurs in 2020 or 2021 and the IOPP is not in effect for the year of exceedance, CRIT shall nevertheless pay back the Colorado River System according to one or more of the methods described in 6.9.4.2(a).

c. If the exceedance occurs in 2022, Reclamation will, before the Accounting and Water Use Report is issued by Reclamation for that year, and in consultation with CRIT, account for the excess diversion as delivery of CRIT ICS to CRIT in 2022, up to the amount of the full balance of CRIT’s ICS. If sufficient CRIT ICS is not available to cover this exceedance, ADWR may reduce its Final Payment to CRIT in accordance with the provisions in Paragraph 8.5.3, or the Parties may agree to one or more of the mechanisms described in Paragraph 6.9.4.2(a) to leave water in the Colorado River System in the year after the excess diversion.
6.9.5 CRIT agrees to furnish and install padlocks to lock the irrigation ditch turnouts on fields fallowed under the terms of this Agreement. In the event that a turnout serves multiple fields which are not all being fallowed, other practical mechanisms, including but not limited to, dirt berms in the portion of the irrigation ditch serving the fallowed field, or sealing the turnouts onto fallowed fields will be used to the extent possible to assure that no water deliveries can be made onto the fallowed fields.

6.10 Same Year System Conservation Adjustments: The Parties agree to meet during the month of October in each year of the Fallowing Period to review available Reclamation field verification, remotely-sensed imagery and other data regarding fallowing of the lands identified in Exhibit A for the current year. If the amount of System Conservation Water is likely to be less than the Consumptive Use Reduction Quantity for that year, the Parties agree that CRIT shall do one or more of the following to meet the System Conservation Water creation requirement for that year: (1) amend its ICS creation plan to decrease the current year ICS creation and increase the current year System Conservation Water creation; or (2) fallow additional lands.

6.11 Remedies For Failure to Meet System Conservation Water Requirement: If CRIT fails to meet the System Conservation Water requirement for a year during the Fallowing Period, as reflected in the Arizona Conservation Table of the Accounting and Water Use Report, the following shall apply.

6.11.1 If CRIT fails to meet the System Conservation Water requirement for 2020 or 2021, CRIT shall: (1) take delivery of CRIT ICS in the year in which the Shortfall occurs and leave the water in Lake Mead for the benefit of the Colorado River System; or (2) amend CRIT’s ICS creation plan for the year after the year in which the Shortfall occurs to decrease ICS creation in that year and increase System Conservation Water in that year; or (3) undertake other mechanisms acceptable to the Parties by which the Shortfall is made up.

6.11.2 If CRIT fails to meet the System Conservation Water requirement for 2022, ADWR shall adjust its Final Payment to CRIT pursuant to 8.5.3 unless a different remedy can be agreed to by the Parties.

6.12 CRIT ICS: CRIT will diligently work to accumulate 9,000 acre-feet of ICS in Lake Mead. Once created, CRIT agrees to maintain a balance of no less than 9,000 acre-feet of
ICS until all events of Paragraph 8.5.3 have occurred. If CRIT’s ICS account falls below 9,000 acre-feet after repaying an exceeded diversion amount under this Section or any Shortfall in creation of System Conservation Water required in Paragraph 6.10. CRIT will replenish its ICS account as soon as practicable to meet the commitments in this Paragraph.

6.12.1 If during any single fallowing year CRIT both exceeds the Adjusted Maximum Diversion with a payback to be charged against CRIT ICS according to Paragraph 6.9.4.2 and CRIT has a Shortfall that shall be charged against CRIT ICS according to Paragraph 6.11, the full amount of any Shortfall shall be charged against CRIT ICS before any payback of excess diversions.

6.13  Access to CRIR: CRIT hereby grants access to Reclamation and agrees to grant access to the other Parties upon request to perform periodic on-site inspections of the Project to verify compliance with this Agreement.

7.  RECLAMATION AGREEMENTS

7.1  Verification: Reclamation agrees to verify and document reductions in consumptive use of Colorado River water for the Project by CRIT, consistent with this Agreement and the 2007 Guidelines. Reclamation further agrees to account for reductions in consumptive use in Exhibit A 2020 and Exhibit A 2021 that is in excess of 50,000 acre-feet as CRIT extraordinary conservation ICS (“EC-ICS”) if consistent with the 2007 Guidelines, the LBOps, the CRIT ICS Exhibit and the Arizona ICS Framework Agreement.

7.2  System Conservation Water: Reclamation will use its existing water order approval process and other authorities including the LBOps Section IV.F to ensure that the System Conservation Water created under this Agreement is not released pursuant to Article II of the Consolidated Decree.

7.3  Information Sharing: Reclamation will use its existing in-person, periodic, on-field verification process, and satellite imagery in conjunction with its Remotely Sensed Data Acquisition Program to determine whether the lands associated with this Agreement are being fallowed in accordance with Exhibit A. Reclamation further agrees to provide all data related to this Agreement to the Parties by the end of September of each year of this Agreement and to participate in any meetings of the Parties.
7.4 **Reporting:** In 2020, 2021 and 2022, Reclamation shall provide written confirmation to ADWR that Reclamation has received a copy of CRIT’s annual water order reducing its annual diversion to an amount not more than the Adjusted Maximum Diversion for the applicable year.

7.5 **Accounting:** Reclamation shall account for the quantity of System Conservation Water created each year pursuant to this Agreement in the section of the Accounting and Water Use Report titled, “Transfers, Exchanges and Water Made Available by Extraordinary Conservation,” or such other section(s) as may be added. Reclamation agrees to work with the Parties to timely review and identify any exceedance of diversion over the Adjusted Maximum Diversion or Shortfall in System Conservation Water in each year and to work with the Parties to apply the remedies for such exceedance or Shortfall as selected from the options provided in Section 6 above.

8. **ADWR AGREEMENTS**

8.1 **Appropriated Funds:** During fiscal year 2019-20, the State of Arizona will deposit $30,000,000 of appropriated funds in the Fund to pay CRIT for a reduction in its consumptive use during the Fallowing Period. Interest accrued on the monies deposited in the Fund for the purpose of funding this Project shall accrue to the benefit of this Agreement up to the total amount required to pay CRIT in accordance with Paragraphs 8.4 and 8.5. This amount shall be the maximum amount of the State’s obligation to CRIT under this Agreement.

8.2 **EDF Funding:** EDF has agreed in a Project Funding Agreement with ADWR to contribute a total of $2,000,000 to the Fund before January 31, 2020 to assist in the funding of the Project during the Fallowing Period. EDF has made significant progress toward raising an additional $2,000,000 to $3,000,000 to contribute to the Fund by January 31, 2021 and has agreed to use best efforts to raise an additional amount of money to contribute to the Fund on or before July 15, 2021 in an amount equal to the difference between $8,000,000 and the total amount of monies previously contributed to the Fund by EDF. A copy of the ADWR and EDF Project Funding Agreement is attached as Exhibit B.

8.2.1 Neither ADWR nor EDF shall be liable for the other’s failure to contribute funds as required by this Agreement or the Project Funding Agreement. EDF has agreed that should it be unable to meet any of its funding commitments as set forth in Exhibit B, it shall provide
advance written notice to ADWR and CRIT by July 1, 2021 stating the reason it is not meeting its funding commitments. Upon receipt of such notice, ADWR shall immediately notify the Parties who shall meet and confer to determine what, if any, options may be available to complete the storage of the full 150,000 acre-feet of CRIT System Conservation Water in Lake Mead during the Fallowing Period. Parties to Future Funding Exhibits shall be subject to a similar notice requirement.

8.3 CRIT Payback and Shortfall: Notwithstanding any other provision in this Agreement, CRIT must meet any annual payback obligation for exceeded diversion amounts as required in Paragraph 6.9.4.2 and make up any Shortfall required by Paragraph 6.11 before being compensated for any additional System Conservation Water under this Agreement.

8.4 Payments for System Conservation Water Created in 2020 and 2021: ADWR shall pay CRIT a total of $25,080,000 from the Fund in the amounts and at the times designated below for the creation of 100,000 acre-feet of System Conservation Water in 2020 and 2021:

<table>
<thead>
<tr>
<th>Payments</th>
<th>Amounts &amp; Approximate Payment Dates</th>
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<tbody>
<tr>
<td>Year 1, Payment 1.1</td>
<td>$7,770,000 (End of 2019)</td>
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<tr>
<td>Year 1, Payment 1.2</td>
<td>$5,770,000 (Sept 2020)</td>
</tr>
<tr>
<td>Year 2, Payment 2.1</td>
<td>$5,770,000 (Feb 2021)</td>
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<tr>
<td>Year 2, Payment 2.2</td>
<td>$5,770,000 (Sept 2021)</td>
</tr>
<tr>
<td>Total Payment for 2020 and 2021 of the Fallowing Period</td>
<td>$25,080,000</td>
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</table>

8.4.1 ADWR shall pay CRIT Payment 1.1 in the amount of $7,770,000 no later than 60 days after the last of following events occurs: (1) the Effective Date of this Agreement; (2) CRIT provides ADWR with a copy of its BIA water order reflecting a reduction in its 2020 annual diversion to an amount not more than the Adjusted Maximum Diversion for 2020; and (3) at least $7,770,000 has been deposited in the Fund.

8.4.2 ADWR shall pay CRIT Payment 1.2 in the amount of $5,770,000 no later than 60 days after both of the following events occurs: (1) Reclamation provides written
confirmation to the Parties that the 2020 designated Project Lands in Exhibit A 2020 are
fallowed after performance of Reclamation’s spring/summer 2020 field verification inspection;
and (2) CRIT provides to the Parties its best available aerial imagery in conjunction with the
Reclamation’s Remote Sensing Data Acquisition Program illustrating that the designated
Project Lands in Exhibit A 2020 are being fallowed in 2020.

8.4.3 ADWR shall pay CRIT Payment 2.1 in the amount of $5,770,000 no later
than 60 days after the last of the following events occurs: (1) CRIT provides a copy of its BIA
water order reflecting a reduction in its 2021 annual diversion to an amount not more than the
Adjusted Maximum Diversion for 2021; (2) Reclamation provides written confirmation to
ADWR that the 2020 designated Project Lands in Exhibit A 2020 were fallowed after
performance of Reclamation’s December 2020 field verification inspection; and (3) any
exceedance of the Adjusted Maximum Diversion or Shortfall in System Conservation Water has
been properly addressed under Paragraphs 6.9.4 and 6.11.

8.4.4 ADWR shall pay CRIT Payment 2.2 in the amount of $5,770,000 no later
than 60 days after the last of the following events occurs: (1) Reclamation provides written
confirmation to the Parties that the 2021 designated Project Lands in Exhibit A 2021 are
fallowed after performance of Reclamation’s spring/summer 2021 field verification inspection;
(2) CRIT provides to the Parties its best available imagery in conjunction with the Reclamation’s
Remote Sensing Data Acquisition Program illustrating that the designated Project Lands in
Exhibit A 2021 are being fallowed in 2021; and (3) any exceedance of the Adjusted Maximum
Diversion or Shortfall in System Conservation Water has been properly addressed under
Paragraphs 6.9.4 and 6.11.

8.5 Payment for System Conservation Water Created in 2022: No later than July 16,
2021, ADWR shall provide CRIT with an accounting of the Remaining Balance in the Fund as
of July 15, 2021. Based upon the Remaining Balance, ADWR and CRIT shall determine the
maximum quantity of System Conservation Water that can be created by CRIT in 2022 (not to
exceed 50,000 acre-feet) that the Fund can secure at a price of $261.60 per acre-foot without
exceeding the Remaining Balance. CRIT shall prepare Exhibit A 2022 for conservation of that
quantity of water and submit it to the Parties no later than August 1, 2021. That quantity,
multiplied by the price of $261.60 per acre foot, shall be the 2022 cost for System Conservation
Water. ADWR shall pay CRIT for the 2022 cost of System Conservation Water in three installments on the dates designated below:

<table>
<thead>
<tr>
<th>Payments</th>
<th>Amounts &amp; Approximate Payment Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 3, Payment 3.1</td>
<td>1/3 of 2022 cost (Feb 2022)</td>
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<tr>
<td>Year 3, Payment 3.2</td>
<td>1/3 of 2022 cost (Sept 2022)</td>
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<tr>
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<td>1/3 of 2022 cost (May 2023), subject to adjustment as provided below</td>
</tr>
</tbody>
</table>

8.5.1 ADWR shall pay CRIT Payment 3.1 in the amount of one-third of the 2022 cost no later than 60 days after the last of the following events occurs: (1) CRIT provides the Parties with a copy of its BIA water order reflecting a reduction in its 2022 annual diversion request to an amount not more than the Adjusted Maximum Diversion for 2022; (2) Reclamation provides written confirmation to ADWR that the 2021 designated Project Lands in Exhibit A 2021 were fallowed after performance of Reclamation’s December 2021 field verification inspection; and (3) any exceedance of the Adjusted Maximum Diversion or Shortfall in System Conservation Water has been properly addressed under Paragraphs 6.9.4 and 6.11.

8.5.2 ADWR shall pay CRIT Payment 3.2 in the amount of one-third of the 2022 cost no later than 60 days after the last of the following events occurs: (1) Reclamation provides written confirmation to the Parties that the 2022 designated Project Lands in Exhibit A 2022 are fallowed after performance of Reclamation’s spring/summer 2022 field verification inspection; (2) CRIT provides to the Parties its best available imagery in conjunction with Reclamation’s *Remotely Sensed Data Acquisition Program* illustrating that the designated Project Lands in Exhibit A 2022 are being fallowed in 2022; and (3) any exceedance of the Adjusted Maximum Diversion or Shortfall in System Conservation Water has been properly addressed under Paragraphs 6.9.4 and 6.11.

8.5.3 ADWR shall pay CRIT the Final Payment in the amount of one third of the 2022 cost no later than 30 days after publication of the 2022 Accounting and Water Use Report subject to the following:
8.5.3.1 If the amount reported is less than the amount of System Conservation Water required to be created in Exhibit A 2022, the Final Payment shall be reduced by $261.60 (2022 water price) per acre-foot for each acre-foot not conserved in Lake Mead as contemplated under Exhibit A 2022, unless the Parties have agreed to a different remedy for the Shortfall pursuant to Paragraph 6.11.2.

8.5.3.2 If CRIT exceeded the Adjusted Maximum Diversion in 2022, the Final Payment shall be reduced by $122.95 (47% of the 2022 water price) per acre-foot for each acre-foot of the excess diversion, unless the Parties have agreed to a different remedy for the excess diversion pursuant to Paragraph 6.9.4.2(c).

8.5.3.3 The reductions in payment expressed in Paragraphs 8.5.3.1 and 8.5.3.2 are cumulative. If the total amount of the payment reductions exceeds the amount of the Final Payment, ADWR shall not make the Final Payment and CRIT shall pay to ADWR the difference between the total amount of the payment reductions and the amount of the Final Payment within 30 days after publication of the 2022 Accounting and Water Use Report.

9. CAWCD AGREEMENTS

9.1 CAWCD agrees not to divert or order delivery of System Conservation Water created under this Agreement provided that such creation is consistent with the technical memoranda prepared by CRIT pursuant to Paragraph 6.5.

9.2 CAWCD agrees that participation in this Agreement is for the limited purposes of agreeing not to divert or order delivery of System Conservation Water created by CRIT, participating in meetings of the Parties in order to implement this Agreement, and to receive notices from the Parties.

9.3 CAWCD specifically and further agrees that it does not have enforcement authority against any other Party to this Agreement. In the event any court of competent jurisdiction interprets this Agreement to provide CAWCD with enforcement authority, CAWCD waives any such right to enforce against ADWR, CRIT, Reclamation and any other third party contributing to the Fund, including EDF.
9.4 To the extent that any court finds that CAWCD has sovereign immunity, CAWCD waives such immunity for the limited purpose of enforcing CAWCD’s agreement not to divert or order delivery of System Conservation Water created under this Agreement.

10. **LIMITED WAIVER OF SOVEREIGN IMMUNITY.** CRIT hereby agrees to a limited waiver of its sovereign immunity from suit solely for the purpose of enforcement of this Agreement. Enforcement is limited to claims to recoup monies actually paid or to be paid under this Agreement by ADWR to CRIT where CRIT has failed to satisfy the terms and conditions for payment. In no event shall CRIT’s liability for any claim arising under this Agreement exceed the amounts paid or to be paid under this Agreement. This limited waiver of sovereign immunity does not extend to claims by any other party to this Agreement or third parties, claims brought for declaratory injunctive relief, claims brought under tort liability, or claims for indirect, special, incidental, consequential or punitive damages, or specific performance. Any claims to recoup monies actually paid under this Agreement must be brought by ADWR within one (1) year from when ADWR has knowledge of a failure to satisfy the terms and conditions of a payment made under the Agreement. This limited waiver of sovereign immunity shall terminate one (1) year after Reclamation issues its Accounting and Water Use Report for calendar year 2022 but shall continue in effect with respect to any lawsuit brought by ADWR that is timely filed before the termination date. Any judgment may only be satisfied through the unrestricted assets of CRIT.

11. **GENERAL TERMS.**

11.1 *Non-waiver.* No Party to this Agreement shall be considered to have waived any right hereunder except when such waiver of the right is given in writing. The failure of a Party to insist in any one or more instances upon strict performance of any provisions of this Agreement or to take advantage of any of its rights hereunder shall not be construed as a waiver of any such provisions or a relinquishment of any such rights for the future, but such provisions and rights shall continue and remain in full force and effect.

11.2 *Uncontrollable Forces.* No Party shall be considered to be in default in the performance of any of its obligations under this Agreement when a failure of performance shall be due to any cause beyond the control of the Party affected, including but not limited to, facilities failure, flood, earthquake, storm, lightning, fire, epidemic, war, riot, civil disturbance, labor disturbance, sabotage, and restraint by court or public authority which by exercise of due diligence
and foresight such Party could not have reasonably expected to avoid. A Party rendered unable to fulfill any of its obligations under this Agreement by reason of an Uncontrollable Force shall give prompt written notice of such act to the other Parties and shall exercise due diligence to remove such inability with all reasonable dispatch. Failure to perform under this provision shall excuse reciprocal performance until cured.

11.3 **Representations and Warranties.**

11.3.1 Each Party has all legal power and authority to enter into this Agreement and to perform its obligations hereunder on the terms set forth in this Agreement, and the execution and delivery hereof by each Party and the performance by each Party of its obligations hereunder shall not violate or constitute an event of default under the terms or provisions of any agreement, document, or instrument to which each of the Parties is a party or by which each Party is bound.

11.3.2 Each Party warrants and represents that the individual executing this Agreement on behalf of the Party has the full power and authority to bind the Party he or she represents to the terms of this Agreement.

11.3.3 This Agreement constitutes a valid and binding agreement of each Party, enforceable against each Party in accordance with its terms.

11.3.4 Each Party: (i) warrants and represents that such Party is authorized by, and has undertaken all prerequisite actions required by, applicable Federal and State laws and regulations to perform the obligations and exercise the rights contemplated herein, (ii) acknowledges that such warranty and representation is a material inducement to, and has been relied upon by, the other Parties in entering into this Agreement and performing their respective obligations hereinafter; and (iii) with respect to System Conservation Water funded by this Agreement, the Parties will cooperate to use reasonable best efforts in the support, preservation and defense thereof, including any lawsuit or administrative proceeding challenging the legality, validity or enforceability related to such System Conservation Water, and will to the extent appropriate enter into such agreements, including joint defense or common interest agreements, as are necessary therefor; provided that each Party shall bear its own costs of participation and representation in any such matter.

Page 19 of 26
11.4 *Governing Law and Venue.* Federal law controls the interpretation and enforcement of CRIT water rights in the Lower Colorado River Basin, and is the basis for all functions and responsibilities the Secretary performs as Water Master of the Lower Colorado River. This Agreement shall be interpreted, governed by, and construed under Arizona state law. Any action between the State of Arizona and CRIT to enforce the terms of this Agreement shall be in Arizona state court and CRIT shall waive its right to remove it to Federal court. This Agreement does not waive the United States’ right to object to any Arizona state court exercising jurisdiction over disputes brought under this Agreement involving the United States as a party.

11.5 *Binding Effect and Limited Assignment.* The provisions of this Agreement shall apply to and bind the successors and assigns of the Parties only upon receipt of written agreement to the terms of this Agreement, but no assignment or transfer of this Agreement or any right or interest therein shall be valid unless and until approved in writing by all Parties. This Agreement is and shall be binding upon and shall inure to the benefit of the Parties and, upon dissolution, the legal successors and assigns of their assets and liabilities.

11.6 *Amendment, Modification, and/or Supplement.* This Agreement may be amended, modified, or supplemented only by the written agreement of the Parties. No amendment, modification, or supplement shall be binding unless it is in writing and signed by all Parties.

11.7 *Drafting Considerations.* Each Party and its counsel have participated fully in the drafting, review, and revision of this Agreement, each of whom is sophisticated in the matters to which this Agreement pertains, and no one Party shall be considered to have drafted this Agreement.

11.8 *Notices.* All notices and requests required or allowed under the terms of this Agreement shall be in writing and shall be mailed first class postage paid to the following entities at the following addresses:

State of Arizona
Arizona Department of Water Resources
P.O. Box 36020
Phoenix, AZ 85067
Attn: Director
Notice shall be deemed complete three (3) business days after mailing. A Party may change its address by giving the other Parties advance notice of the change in writing.

11.9 Consultation Required. In the event that any dispute arises regarding this Agreement, the Parties agree to meet and attempt to resolve the dispute before seeking any other remedy.

11.10 Availability of Information. Subject to applicable State laws and regulations, each Party to this Agreement shall have the right during office hours to examine and make copies of the other Party’s books and records relating to matters covered by this Agreement. All information and data obtained or developed within the performance of duties mentioned in this Agreement shall be available upon request to a Party, subject to the provisions of the Arizona Public Records Law or other applicable law. However, use of said reports, data and information shall appropriately reference the source for the respective documents.
11.11 **State Obligation Contingent on Appropriation or Allotment of Funds.** The expenditure or advance of any money as provided in Section 8 herein, or the performance of any obligation for payment under this Agreement shall be contingent upon the respective appropriation or allotment of funds. Nothing in this Agreement shall bind the State of Arizona or ADWR to expenditures in excess of funds appropriated and allotted for the purposes set forth in this Agreement.

11.12 **Federal Obligation Contingent on Appropriation or Allotment of Funds.** The expenditure or advance of any money or the performance of any obligation of the United States under this Agreement shall be contingent upon appropriation or allotment of funds. No liability shall accrue to the United States in case funds are not appropriated or allotted.

11.13 **Cancellation of State Contracts.** The Parties to this Agreement are hereby notified of A.R.S. § 38-511.

11.14 **Equal Opportunity/Non-Discrimination.** The Parties to this Agreement agree to comply with all applicable federal or state laws relating to equal opportunity and non-discrimination.

11.15 **Officials Not to Benefit.** No Member of or Delegate to the Congress, or Resident Commissioner, or official of the State of Arizona, the BIA, Reclamation, or CRIT shall benefit from this Agreement other than as a water user or landowner in the same manner as other water users or landowners.

11.16 **No Third-Party Beneficiaries.** This Agreement is not intended nor shall it be construed to create any third-party beneficiary rights to enforce the terms of this Agreement on any person or entity that is not a Party.

11.17 **Counterparts.** This Agreement may be executed in counterparts, each of which shall be an original and all of which, together, shall constitute only one Agreement.

11.18 **Authority of the Secretary.** Nothing in this Agreement diminishes or abrogates the authority of the Secretary under applicable Federal law, regulation, or the Consolidated Decree, as it may be further modified.
11.19 Compliance with Law. CRIT agrees to remain in compliance with applicable Federal, State, and local environmental, cultural, and paleontological resource protection laws and regulations throughout the term of this Agreement.

IN WITNESS WHEREOF, the Parties hereto have executed this Agreement on the day and year first written above.

ARIZONA DEPARTMENT OF WATER RESOURCES

By: [Signature]
Name: Thomas Buschatzke
Title: Director
Date: 7/8/19

Approved as to form: [Signature]
Name: Ken Slowinski
Title: Chief Counsel
COLORADO RIVER INDIAN TRIBES

By: [Signature]

Name: Dennis Patch
Title: Chairman
Date: JUL 3 2019

Approved as to form: [Signature]

Name: Rebecca A. Lordbear
Title: Attorney General
THE UNITED STATES OF AMERICA

By: [Signature]
Terrance J. Fulp, Ph.D.
Regional Director
Lower Colorado Region
Bureau of Reclamation

Date: 7/24/19
CENTRAL ARIZONA WATER CONSERVATION DISTRICT

By: Lisa A. Atkins
Name: Lisa A. Atkins
Title: President
Date: July 19

Approved as to form:
Name: Mary M. Johnson
Title: General Counsel
EXHIBIT A – TECHNICAL MEMORANDUMS
TECHNICAL MEMORANDUM

Date: July 15, 2019

To: Tribal Council, Colorado River Indian Tribes (CRIT)

Cc: Rebecca Loudbear, Attorney General, CRIT
Margaret Vick, Esq., Special Counsel

From: Natural Resources Consulting Engineers, Inc.

PROPOSED LANDS FOR COMPENSATED SYSTEM CONSERVATION PROGRAM (SCP) AND EXTRAORDINARY CONSERVATION INTENTIONALLY CREATED SURPLUS (EC ICS)

G. Farm Unit: CRIT Farms CRIT II Unit

Overview

This technical memorandum provides summary information and technical analyses for proposed temporary fallowing of irrigated farm land on the Colorado River Irrigation Project (Project) and other lands outside the boundary of the Project, Colorado River Indian Reservation, State of Arizona. The proposed fallowing is recommended for consideration under the Compensated System Conservation (SC) Program and Extraordinary Conservation Intentionally Created Surplus (EC ICS) Program. Temporary agricultural land fallowing is recognized by the Programs as means for reducing consumptive use to result in conserved water stored in Lake Mead. Parcels of land will be designated for fallowing on an annual basis and described in a Creation Plan. At the time of designation each parcel will have a history of irrigation for at least three out of the most recent five years. Each parcel may be designated for fallowing for no more than five consecutive years.

Under this proposal, the Colorado River Indian Tribes (CRIT) would temporarily fallow irrigated cropland on nine different Farm Units. Summary data and information regarding the location of each Farm Unit, the crops produced, irrigated crop acreage, estimated crop evapotranspiration, effective rainfall, net crop consumptive use, and estimated total irrigation
diversion requirement averaged over the previous 5-year period for each Farm Unit is provided below. Fallowing is proposed to begin in calendar year 2019 and continue through 2022.

Project Description

CRIT proposes to forego irrigation water deliveries and reduce consumptive use of Colorado River water by temporarily fallowing irrigated cropland as described immediately below during the period 2019-2022. CRIT proposes to create Compensated System Conservation through fallowing of specific Farm Units and make the conserved water available to the Colorado River System to increase storage in Lake Mead during 2020-2022. CRIT proposes to create EC ICS through fallowing of specific Farm Units for various periods of time during 2019 and may designate part of the consumptive use not compensated as system conservation for EC ICS during 2020-2022.

Figure 1 is an overview map showing the locations of the Farm Units proposed for fallowing on the Colorado River Indian Reservation (Reservation) in the State of Arizona. The majority of these Farm Units are served by the Tribe’s Colorado River Irrigation Project (Project), which diverts Colorado River water for irrigation of about 80,000 acres of land on the Reservation. One Farm Unit is located outside of the Project service area and diverts water directly from the Colorado River by pumping.

Two of the proposed Farm Units are currently fallowed and participating in the Pilot System Conservation Program:

a. MTA 6627—October 1, 2018 to September 30, 2019
b. Quail Mesa 6808—January 1, 2019 to December 31, 2019

Estimated Conservation of Colorado River System Water

Estimated average annual consumptive use reduction due to fallowing, and the associated reductions in diversions at Headgate Rock Dam or by direct pumping for each Farm Unit are summarized in Table 1 below.

CRIT proposes to use the average annual consumptive use reduction during October-December for Unit MTA 6627 and the total average annual consumptive use reduction for Unit Rayner 9035 for EC ICS creation in 2019. CRIT proposes to use all sites listed in Table 1
Figure 1. Overview of CRIT farm units proposed for following for SC and EC ICS.

### Summary of CRIT ICS for 2019

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Ave. Cropping Pattern</th>
<th>Net Consumptive Use</th>
<th>Efficiency Factor</th>
<th>Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Overall AF/acre</td>
<td></td>
<td>Overall AF/acre</td>
</tr>
<tr>
<td>6627</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1884.0</td>
<td>60% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>1,470</td>
<td>0.301</td>
</tr>
<tr>
<td>9035</td>
<td>Rayner</td>
<td>2013-17</td>
<td>1055.7</td>
<td>43% alfalfa 33% cotton 14% Bermuda (grass hay) 8% Sudan</td>
<td>4.55</td>
<td>4,804</td>
<td>0.301</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>2,940</strong></td>
<td>6,274</td>
<td><strong>12,523</strong></td>
</tr>
</tbody>
</table>

*Oct 1 2019-Dec 31 2019 only
**Estimates in this table for 9035 are based on 2013-2017 USGS cropping data

### Summary of CRIT System Conservation and ICS for 2020 (System Conservation in excess of 50,000 AF will be considered ICS)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Ave. Cropping Pattern</th>
<th>Total Net Consumptive Use</th>
<th>Net Consumptive Use Proration</th>
<th>Diversion Reduction Proration</th>
<th>Total Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total AF/acre</td>
<td>System Conservation AFY</td>
<td>ECICS AFY</td>
<td>System Conservation AFY</td>
</tr>
<tr>
<td>6627</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1884.0</td>
<td>60% alfalfa 20% Sudan grass</td>
<td>10,157</td>
<td>9,450.7</td>
<td>700.2</td>
<td>17,664.8</td>
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<tr>
<td>6808</td>
<td>Quail Mesa</td>
<td>2014-18</td>
<td>3046.6</td>
<td>58% alfalfa 4% small grain 6% Bermuda (grass hay) 11% Sudan 21% Miscellaneous (onion, garlic, corn, potato)</td>
<td>18,130</td>
<td>16,869.7</td>
<td>1,240.6</td>
<td>31,532.2</td>
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<tr>
<td>6693</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1183.9</td>
<td>64% alfalfa 18% cotton 6% small grain 13% Bermuda (grass hay) 14% Sudan 21% Miscellaneous (onion, garlic, corn, potato)</td>
<td>5,886</td>
<td>5,478.3</td>
<td>409.2</td>
<td>10,236.1</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Vitorio</td>
<td>2014-18</td>
<td>406.8</td>
<td>60% alfalfa 5% cotton 17% small grain 12% Bermuda (grass hay) 5% Sudan</td>
<td>4,89</td>
<td>1,877</td>
<td>1,746.5</td>
<td>3,204.4</td>
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<tr>
<td>CRIT Farms</td>
<td>Frimann</td>
<td>2014-18</td>
<td>674.7</td>
<td>52% alfalfa 26% cotton 18% small grain 4% Sudan</td>
<td>4,37</td>
<td>2,951</td>
<td>2,743.4</td>
<td>5,131.7</td>
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<tr>
<td>CRIT Farms</td>
<td>CRIT II</td>
<td>2014-18</td>
<td>1283.7</td>
<td>73% alfalfa 19% cotton 6% small grain 2% Miscellaneous (onion, garlic, corn, potato)</td>
<td>6,247</td>
<td>5,812.4</td>
<td>434.3</td>
<td>10,864.4</td>
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<tr>
<td>CRIT Farms</td>
<td>MTA 700</td>
<td>2014-18</td>
<td>465.8</td>
<td>80% alfalfa 7% cotton 7% Bermuda (grass hay)</td>
<td>5,50</td>
<td>2,562</td>
<td>2,383.8</td>
<td>4,455.7</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Shawler Ranch</td>
<td>2014-18</td>
<td>435.5</td>
<td>69% alfalfa 30% cotton 2% Sudan</td>
<td>5,02</td>
<td>2,206</td>
<td>2,023.9</td>
<td>3,837.2</td>
</tr>
<tr>
<td>9035</td>
<td>Rayner</td>
<td>2013-17</td>
<td>788.0</td>
<td>52% alfalfa 32% cotton 12% Bermuda (grass hay) 4% Sudan</td>
<td>4,72</td>
<td>3,721</td>
<td>3,462</td>
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<td><strong>Total</strong></td>
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<td><strong>10,786</strong></td>
<td><strong>50,000</strong></td>
<td><strong>3,736</strong></td>
<td><strong>92,757</strong></td>
</tr>
</tbody>
</table>

*Based on Project overall average irrigation efficiency equal to 53.5%
**Based on Project CU Diversion ratio of 0.475 for 2018 using methodology designated in the LBops ICS Exhibit S for CRIT.
***Estimates in this table for 9035 are based on 2013-2017 USGS cropping data with linear move sprinkler area removed; and, for System Conservation diversion reduction, an overall average irrigation efficiency for direct pumping from River equal to 60%
to create up to 50,000 AF/year of Compensated System Conservation with any excess over 50,000 AF/year designated as EC ICS during the period 2020. The same farm units listed in Table 1 or different farm units may be designated for fallowing in 2021 and 2022.

Methodology

This section provides a brief description of the data and methods used to estimate:

- the amount of water conserved due to fallowing of irrigated cropland on each Farm Unit for each year of analysis; this is the net consumptive irrigation water use savings due the cropland fallowing; and,

- the associated irrigation water diversion required to provide that amount of water at the farm field.

Results are presented for each proposed Farm Unit in individual succeeding sub-sections of this technical memorandum.

Farm Unit Description and Location

Location data and legal description (PLSS) for each Farm Unit proposed for fallowing were obtained from CRIT Realty and/or CRIT Farms, the Tribal farming enterprise. This information generally included total gross and net acreage of the unit. Net irrigated crop acreage on each field of each Unit was determined using CRIT Water Resources Department (WRD) AGR05 field parcel polygon shapefile. The maximum net irrigated field acreage in any single year of the study period was used to determine the total volume of consumptive use savings due to fallowing.

Information on the Colorado River Irrigation Project (Project) irrigation delivery system was generally available from the US Bureau of Indian Affairs (BIA), the Federal agency that owns and operates the Project on behalf of CRIT. NRCE has prepared a detailed assessment of the Project (NRCE, 2016; NRCE, 2017).

Cropping Patterns

Crops typically produced on the Reservation include alfalfa (for hay), cotton, small grains (wheat, oats, barley), Bermuda and other grass hay, Sudan grass, and variety of minor miscellaneous crops (onions, garlic, corn, potato) (NRCE, 2016).
Crop patterns/crop mix for field parcels on the Farm Units for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD). The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. For Unit 9035, cropping pattern data were not available from the CRIT WRD. For this unit, cropping pattern data collected by the USGS for the period 2013-2017 were made available by the USBR (Jeremy Dodds, USBR, personal communication, July 12, 2019). Unit 9035 has not been farmed since May 2018, and thus 2018 is not included in the analysis. The USGS crop pattern data are 100% coverage, on the ground crop survey data collected annually on the Rayner unit for USBR during 2013-17. Cropping pattern/crop mix maps for all Farm Units for the respective years analyzed are included in the subsection for each Farm Unit. A table summarizing the cropping pattern/crop mix for each Farm Unit for each year and average for the period analyzed is included.

**Estimation of Consumptive Use**

The factors considered in estimating crop consumptive use include cropped area and cropping patterns, reference evapotranspiration, crop coefficients, and precipitation. Crop evapotranspiration (ET<sub>c</sub>) or crop consumptive use (crop CU) is defined as the evapotranspiration rate from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under given climatic conditions (Allen et al., 1998). Potential crop water use or crop evapotranspiration estimates for the period 1996 to present for the Colorado River Irrigation Project service area have been prepared (NRCE, 2016).

For the purposes of this study, ET<sub>c</sub> estimates using the single (mean) crop coefficient-reference evapotranspiration approach. Under this approach, reference crop evapotranspiration for a hypothetical green surface of actively transpiring vegetation is multiplied by a crop coefficient for a specific crop to estimate crop ET on a daily or monthly basis:

\[
ET_c = K_c \times ET_o
\]

where:

- \(ET_c\) = crop evapotranspiration (inches or mm);
The reference ET-crop coefficient method is widely used due to its simplicity, reproducibility, relatively good accuracy, and transportability among locations and climates.

For this analysis, reference ET (ET of an extensive area of short crop similar to 12-cm grass not short of water, ET₀) was computed using the ASCE Standardized Reference Evapotranspiration Equation (ASCE, 2005). The ASCE Standardized Reference ET Equation for a short (grass) reference surface is:

\[
ET₀ = \frac{0.408ΔR_n + γ \frac{900}{T + \frac{273}{u_2}} (e_s - e_a)}{Δ + γ(1 + 0.34u_2)}
\]

where:

- \(ET₀\) = standardized reference crop evapotranspiration for (grass) short crop
- \(Δ\) = slope of the saturation vapor pressure-temperature curve
- \(R_n\) = net radiation at the crop surface
- \(γ\) = psychrometric constant
- \(T\) = mean daily air temperature measured at 1.5-2 m above ground level
- \(u_2\) = mean daily wind speed measured at 2 m above ground level
- \(e_s\) = saturation vapor pressure
- \(e_a\) = mean actual vapor pressure

This equation is the same as the ASCE Penman-Monteith Equation (Jensen et al., 1990 and Jensen and Allen, 2016) but with several simplifying “standardized” methods employed to compute several of the variables and parameter used in the Equation as given in ASCE (2005).

Jensen et al. (1990) report and summarize results of a comprehensive study comparing evapotranspiration estimates from different estimating methods to measurements of
evapotranspiration made at 11 different lysimeter sites around the world representing a wide range of climatic conditions from humid to arid, and elevations from below sea level to 9100 ft MSL. Nineteen methods were compared to lysimeter measurements on a monthly basis, and thirteen methods were compared on a daily basis. The ASCE Penman-Monteith method as given in Jensen et al. (1990) was determined to provide the overall best estimates of seasonal ET and average peak monthly ET with the least error as compared to lysimeter measurements across all ranges of climate and elevation.

The ASCE Reference ET Equation (ASCE, 2005) is a physically-based approach accounting for energy available for evaporation and aerodynamic transport of moisture away from the evaporating surface. Because of this physically-based formulation, it requires detailed weather measurements including air temperature, relative humidity, incoming total solar radiation, and wind speed. Such weather measurements are available from the Arizona Meteorological Network (AZMET) operated by the University of Arizona College of Agriculture and Live Sciences and Arizona Cooperative Extension (https://cals.arizona.edu/AZMET/). Two AZMET electronic weather stations are currently in operation in the Parker Valley and both stations are located on the Colorado River Indian Reservation (https://www.usbr.gov/lc/region/g4000/wtracct.html):

Parker No. 1 (site 8), Latitude 33.964296, Longitude -114.485501, Elev. 322 ft above MSL
Parker No. 2 (site 35) Latitude 33.863015, Longitude -114.472974, Elev. 302 ft above MSL

Daily weather and ET₀ data from the AZMET Parker No. 2 Station for the respective 5-year period of analysis were used in this study (AZMET, 2013-2018).

The crop coefficient, Kᵦ, integrates the effects/differences of specific crop characteristics that affect water use of the specific crop to the water use of the reference crop. This methodology for estimated crop ET assumes the crop is growing under ideal conditions, and not stressed for water or nutrients, and thus, is considered the potential crop ET or potential consumptive use. Actual crop ET in farm fields is typically less than potential crop ET due to factors such as water stress, salinity, insect and disease pressure, etc.

Daily crop coefficient values for the primary crops comprising around 90% of the total irrigated crop acreage [alfalfa, cotton, small grains (wheat, oats, rye, barley, millet), Bermuda hay,
Sudan grass) grown on the Reservation were obtained from reports on crop coefficients prepared for the USBR LCRAS ([https://www.usbr.gov/lc/region/g4000/wtracct.html#LCRAS](https://www.usbr.gov/lc/region/g4000/wtracct.html#LCRAS)) program (Jensen, 1998 and Jensen, 2003). Several minor “miscellaneous” crops have been and currently are produced on small acreage on the Reservation. Over the period 2013-2018, these minor crops have comprised an average of only 3.52% of the total irrigated crop acreage on the Project. These include but are not limited to corn, onions, garlic, crucifers, lettuce, and other small vegetable and melon crops. Most often these crops are produced for seed (crucifers, lettuce) or dehydration (onion, garlic) or animal feed (corn silage) and not as fresh market produce. Crop coefficients for a “miscellaneous” crop category were assumed to be equal to the average of the primary crops. This process is explained in more detail in Appendix B of NRCE (2016).

In the case of alfalfa, Jensen (1998, Appendix C) recognized the published crop coefficients for alfalfa hay represent potential (maximum) alfalfa ET under conditions where harvest and removal of hay is not delayed, and crop water stress does not occur. Jensen (1998) estimated the coefficients were about 15% too high for normal farm practices when hay may not be removed right after cuttings, some water stress might occur, non-uniformity of crop conditions, etc. To adjust for these effects and provide alfalfa hay consumptive use estimates closer to actual conditions, Jensen (1998) applied a factor of 0.85 to the alfalfa hay crop coefficients.

The differences between actual ET occurring under the field conditions of the PROJECT and potential ET from crop coefficient-reference ET approach can be estimated using a remote sensing approach which allows for the determination of actual evapotranspiration from both vegetated and bare soil surfaces by solving the full surface energy balance using remotely sensed visible and thermal band data. While this type of study has not been performed on the Project service area, two such studies have been conducted on large irrigation districts in the region and the results provide some insight on the differences between actual and potential crop consumptive use that may be occurring on the Project:

- Clark et al. (2008) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different combinations of soils, on-farm irrigation method, and crop types, found on Imperial Irrigation District (IID). In this case, the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, 1998) and
LandSat satellite imagery with 30 m thermal resolution for water year 1998 was used to estimate actual ET. Potential ET was estimated using the dual crop coefficient approach presented in Allen et al. (1998). The results were presented as ratios of actual ET to potential ET. Across IID the average ratio was found to be 0.85. For graded border and graded furrow irrigation of mature alfalfa and new alfalfa on all soil types, the IID ratio of actual ET to potential ET ranged from 0.83 to 0.87.

- Elhaddad and Garcia (2014) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different crop types found on Palo Verde Irrigation District (PVID). In this case, actual ET was estimated using the ReSET Raster method (Elhaddad and Garcia, 2008) and LandSat 7 satellite imagery with 30 m thermal resolution for calendar year 2002. Potential ET was estimated using methods employed by the USBR in the Lower Colorado River Accounting System (LCRAS) (USBR, 1996-2014). The average ratio of actual ET to potential ET across PVID was found to be 0.86. For alfalfa, the ratio was found to be 0.86.

The results of these studies support the alfalfa hay crop coefficient adjustments suggested by Jensen (1998). Thus, for this analysis, alfalfa crop ET, as computed using the Jensen (1998, 2003) alfalfa crop coefficients (published coefficients multiplied by a factor of 0.85 to account for less than ideal growth conditions) was taken as an estimate of actual alfalfa crop ET. For Sudan, small grains, and grass hay, actual crop ET was estimated to be 0.85 times potential crop ET. For cotton and higher value minor miscellaneous crops (garlic, onion, potato) a factor of 1.00 was assumed.

Growing season durations of the various crops are implicit in the daily crop coefficients prepared by Jensen (1998, 2003) and were adopted for this analysis.

The net irrigation water requirement (NIR) or net consumptive irrigation water use (NetCU) represents the quantity of water required at the farm field to supply the estimated irrigation water demand of a crop during its growth period over and above the amount of natural precipitation water available for crop use. NIR or NetCU is computed as the crop ET minus the effective precipitation. Effective precipitation is that portion of total precipitation which is available for crop use. NRCE
adopted the flat monthly multiplier approach to estimate effective precipitation (Jensen, 1993) as used in USBR LCRAS reporting of crop water use. Average annual precipitation measured at the AZMET Parker No. 2 Station is 3.96 inches for the period: 2014-2018 (AZMET, 2013-2018). Using the LCRAS method, effective precipitation on the Reservation is about 0.76 inches per year, or just less than about 20 percent of average annual precipitation, for the 2014-2018 period at this location.

For each year analyzed, the weighted average NIR or NetCU was determined based on acreages of the individual crop types and the NIR or NetCU of each crop for that year. Using this result, an overall average unit area net crop consumptive irrigation water use (AF/ac) for the 5-year study period was determined. This 5-year average unit area net crop consumptive irrigation water use is listed for each Farm Unit in Table 1. The 5-year average unit area net crop consumptive irrigation water use is multiplied by the maximum (for the 5-year study period) annual acres irrigated for the Farm Unit to determine the total volume of NetCU due to fallowing and listed for each parcel in Table 1.

**Diversion Requirements**

NRCE (2017) has performed water balance analyses at the conveyance/delivery system level to estimate the magnitude of conveyance system losses (seepage, evaporation, and operational spills) experienced with the current infrastructure and operational management of the Project. Farm gate deliveries were estimated. These analyses allowed an assessment of conveyance/delivery system efficiency. As well, farm field level water balance analyses comparing net crop irrigation water requirements (NIR) to the estimated field level supplies or farmgate deliveries were performed. These comparisons allowed an assessment of on-farm losses to ditch seepage, deep percolation and tailwater runoff and estimation of on-farm efficiency. The overall assessment comparing net crop irrigation water requirements (NIR) to diversions allowed estimation of Project irrigation efficiency.

For the proposed Farm Units served by the Project, the total irrigation diversion requirement at Headgate Rock Dam corresponding to the Farm Unit net consumptive irrigation water use was estimated by dividing the farm field (NIR or NetCU) by the estimated project irrigation efficiency (product of irrigation delivery system conveyance efficiency and on-farm application efficiency).
For the purposes of these analyses, an overall Project irrigation efficiency of 53.5% was applied (NRCE, 2017).

Farm Unit 9035 is not served by the Project. This site diverts irrigation water by pumping directly from the Colorado River. Water is distributed across the farm using concrete lined ditches. Irrigation for the period of study 2013-17 was by flood (low gradient border and furrow) irrigation, although in years prior to this period linear move sprinklers were used on parts of the lease, and CRIT’s future plans include leasing parts of the unit and irrigating with the linear move sprinkler again. An average application efficiency of about 65-66% for border and furrow irrigation on the Reservation is used. For Unit 9035, the conveyance losses to seepage and operational spill are minor compared to the Project. A conservative conveyance efficiency of 90% is assigned on this unit. This results in an irrigation efficiency estimate of 60% for the unit.

**Monthly Distribution**

The annual cropping patterns found for each Farm Unit illustrate varying acreages of the primary crops from year to year and from Unit to Unit. To normalize this variability, monthly distributions of the total average annual NetCU savings and total average annual diversion reductions for each Farm Unit were determined by computing a monthly proportion of the total annual volume based on the 5-year average monthly and annual alfalfa crop evapotranspiration computed using reference crop ET$_0$ from the AZMET Parker No. 2 electronic weather station and LCRAS crop coefficients for alfalfa.

**Verification**

During the fallowing period, in order to ensure that any vegetation remaining on the fallowed lands does not consumptively use Colorado River water by drawing water from the Colorado River aquifer, CRIT shall, at its expense, control and eradicate any green vegetation growth.

Weed control will likely performed using chemical applications. Records of weed control applications, including date, chemicals used, rates of application, etc. will be prepared and maintained. CRIT agrees to provide Reclamation, Arizona Department of Water Resources, and other applicable entities, with information and updates, when requested, regarding the vegetation eradication program. Stubble from previous cropping will be kept on field surface to the extent
possible to reduce wind erosion. USBR personnel will be granted access to the Farms to perform periodic on-site inspections to verify compliance.

The means of irrigation water deliveries to each Farm Unit proposed for fallowing are described for each respective Unit. Irrigation water deliveries can be completely curtailed through control of farm gate turnouts or through control of sublateral head gates. CRIT agrees to furnish and install padlocks to lock the farm gate turnouts on fields fallowed to the extent possible to do so. In the event that a turnout serves multiple fields of which not all are being fallowed, other practical mechanisms, including but not limited to, dirt berms in the portion of the irrigation ditch serving the fallowed field, or sealing the on-farm turnouts onto fallowed fields will be used to the extent possible to assure that no water deliveries can be made onto the fallowed fields.

Verification of Conserved Water Diversion Reduction from Approved Water Order

Total estimated diversion requirements on monthly and annual time steps for the actively irrigated areas of the proposed Farm Units that will be fallowed have been estimated. CRIT’s annual water order (as determined and approved through the 43 CFR, Part 417 (Part 417) consultation between the BIA, US Bureau of Reclamation and CRIT) will be reduced by the estimated annual diversion requirements of the Farm Units for the agreed fallowing periods. Estimated monthly net consumptive use and diversion requirements of the Farm Units have also been determined. These monthly estimates allow determination of partial year water conservation and diversion reductions when fallowing periods are not a full 12-month period. Total annual CRIT Project and other Arizona diversions (with the fallowing and diversion reduction in progress) will not exceed CRIT’s Colorado River annual water right allocation for Arizona as adjusted by the diversion reductions, and thereby avoid inadvertent overruns (diversions in excess of CRIT’s adjusted entitlement—decreeed AZ water right less the estimated diversion requirements of the fallowing program).

For Unit 9035, which diverts by direct pumping of water from the Colorado River, conserved water diversion reduction can be verified through routine monitoring of the electric power meter readings and account for the Unit’s pumping facilities.
**Farm Description and Location**

The CRIT Farms CRIT II Unit is located on the Colorado River Indian Reservation within the Project service area with field parcels located within Sections 18, 19, and 30 Township 5N Range 21W (Gila and Salt River Meridian), La Paz County, Arizona. The CRIT II Unit is bounded by the Lower Main Drain on the west, Mesa Drain on the north, Mohave Road on the east and Tyson Wasteway on the south. Figure G1 is an overview map of the Unit. A maximum of 1,238.74 net field acres have been in irrigated crop production for at least the past 5 years. The acreage not in production is idle or occupied by hay and equipment storage yards, roads, canals, and drains.

The irrigated cropland on the CRIT II Unit is served primarily by Sub-lateral Lower 90 of the Project. While the CRIT II Unit is the last farm unit served by Lower 90, Project operational spill to Tyson Wash/Wasteway occurs at the end of Lower 90 and thus it cannot be turned off at the head gate or another upstream check structure. Farm gate turnouts on Sublateral Lower 90 serving the CRIT II Unit will be chained and locked.

CRIT Water Resources Dept. provided geospatial data (AGR05 shapefile and associated attribute table) of delineated irrigated field parcels across the Project. A total of up to 64 irrigated field parcels were identified within the actively irrigated area of the Unit (see Figure G1), although field parcel boundaries are noted to have changed with some consolidation or further subdivision apparent during the study period. Background aerial imagery in Figure G1 is dated 2017 and from the USDA National Agriculture Aerial Imagery Program (NAIP): (http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/). The CRIT field parcel delineations were found to show good agreement with the NAIP aerial imagery.
Figure G1. Overview Map of CRIT Farms CRIT II Unit.
Cropping Patterns

Crop patterns/crop mix for field parcels on the CRIT II Unit for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD) and are summarized in Table G1. The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. The annual cropping pattern for the CRIT II Unit is mapped in Figures G2-G6, for years 2014-2018, respectively.

Table G1. Cropping Patterns/Crop Mix of the CRIT Farms CRIT II Unit, 2014-2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated Crop Acreage</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
<th>Idle Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1238.7</td>
<td>51%</td>
<td>40%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>9%</td>
<td>9.0</td>
</tr>
<tr>
<td>2015</td>
<td>1238.7</td>
<td>66%</td>
<td>8%</td>
<td>26%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>9.0</td>
</tr>
<tr>
<td>2016</td>
<td>1238.7</td>
<td>89%</td>
<td>8%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>9.0</td>
</tr>
<tr>
<td>2017</td>
<td>1238.7</td>
<td>78%</td>
<td>20%</td>
<td>0%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>9.0</td>
</tr>
<tr>
<td>2018</td>
<td>1199.1</td>
<td>80%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>48.7</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>73%</td>
<td>19%</td>
<td>6%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td></td>
</tr>
</tbody>
</table>
Figure G2. Cropping Pattern on CRIT Farms CRIT II Unit in 2014.
Figure G3. Cropping Pattern on CRIT Farms CRIT II Unit in 2015.
Figure G4. Cropping Pattern on CRIT Farms CRIT II Unit in 2016.
Figure G5. Cropping Pattern on CRIT Farms CRIT II Unit in 2017.
Figure G6. Cropping Pattern on CRIT Farms CRIT II Unit in 2018.
Estimated Crop Evapotranspiration

Table G2 below presents estimated annual and 5-year average reference ET₀ and crop ET (inches/year) for crops grown on the Reservation during the 5-year study period using weather data from the AZMET Parker No. 2 weather station.

Table G2. Annual and 5-year Average Reference ET₀ and crop ET (inches/year) for Reservation Crops for 2014-2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET₀</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.9</td>
<td>37.7</td>
<td>24.5</td>
<td>49.6</td>
<td>44.6</td>
<td>44.9</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.2</td>
<td>39.1</td>
<td>23.0</td>
<td>49.7</td>
<td>43.8</td>
<td>44.5</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.9</td>
<td>43.2</td>
<td>24.3</td>
<td>53.7</td>
<td>46.4</td>
<td>48.0</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.5</td>
<td>40.5</td>
<td>23.6</td>
<td>50.9</td>
<td>46.2</td>
<td>46.2</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>69.7</td>
<td>40.1</td>
<td>24.5</td>
<td>50.5</td>
<td>46.2</td>
<td>46.1</td>
</tr>
<tr>
<td>Average (in)</td>
<td>70.0</td>
<td>40.1</td>
<td>24.0</td>
<td>50.9</td>
<td>45.4</td>
<td>45.9</td>
<td></td>
</tr>
<tr>
<td>Average (af/ac)</td>
<td>5.84</td>
<td>3.34</td>
<td>2.00</td>
<td>4.24</td>
<td>3.79</td>
<td>3.83</td>
<td></td>
</tr>
</tbody>
</table>

1 Reference evapotranspiration of a short crop similar to 12-cm tall grass.

Estimated Net Consumptive Irrigation Water Use and Diversion Requirement

Table G3 below presents reference ET₀, area-weighted average crop ET, effective precipitation, area-weighted average net consumptive use (NetCU), and associated diversion requirement (diversion reduction) for each year of the study period, and as an average of the 5-year period: 2014-18, based on the crop acreage and cropping pattern/mix discussed above. The estimated average annual unit area consumptive use on this Farm Unit for 2014-2018 is 5.04 AF/ac. The total estimated volume of water conserved due to the proposed fallowing of a maximum acreage of 674.7 acres on the Farm Unit is 6,246 AFY. Using an estimated average overall irrigation efficiency of 53.5%, the diversion requirement associated with this net water conservation is 11,676 AFY.
Table G3. Annual and 5-year Average Reference ET₀, Area Weighted Crop ET, Effective Precipitation, Area Weighted Net CU and Diversion Reduction for 2014-2018. CRIT Farms CRIT II Unit.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET₀</th>
<th>Weighted Average Crop ET (ETa)²</th>
<th>Effective Precip.</th>
<th>Weighted Average Net Consumptive Use</th>
<th>Net Crop Area Fallowed</th>
<th>Net Consumptive Use Demand³</th>
<th>Diversion Reduction⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td></td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(ac)</td>
<td>(AF)</td>
<td>(AF)</td>
</tr>
<tr>
<td>2014</td>
<td>75.11</td>
<td>53.85</td>
<td>0.30</td>
<td>53.64</td>
<td>1,238.7</td>
<td>5,537</td>
<td>10,350</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>54.02</td>
<td>0.93</td>
<td>53.22</td>
<td>1,238.7</td>
<td>5,493</td>
<td>10,268</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>69.97</td>
<td>1.03</td>
<td>69.01</td>
<td>1,238.7</td>
<td>7,124</td>
<td>13,316</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>64.15</td>
<td>0.82</td>
<td>63.49</td>
<td>1,238.7</td>
<td>6,554</td>
<td>12,251</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>63.92</td>
<td>0.70</td>
<td>63.28</td>
<td>1,199.1</td>
<td>6,323</td>
<td>11,819</td>
</tr>
<tr>
<td>Average</td>
<td>77.26</td>
<td>61.18</td>
<td>0.76</td>
<td>60.53</td>
<td>1,230.8</td>
<td>6,206</td>
<td>11,601</td>
</tr>
</tbody>
</table>

- **Unit area Net CU (AF/ac)**: 5.04

1 Reference evapotranspiration of a short crop similar to 12-cm tall grass.
2 Estimated actual crop ET accounting for water stress and less than ideal growth conditions.
3 Weighted average calculated using irrigated acreages.
4 Column (8) divided by overall Project efficiency
The monthly distribution of the total average annual NetCU saving and total average annual diversion reduction for CRIT Farms CRIT II Unit is presented in Table G4.


<table>
<thead>
<tr>
<th>Month</th>
<th>Average annual Alfalfa Crop ET (in) for period of analysis</th>
<th>Monthly Net Consumptive Use Demand</th>
<th>Monthly Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(inches)</td>
<td>% of total</td>
<td>(AF)</td>
</tr>
<tr>
<td>January</td>
<td>2.02</td>
<td>2.88%</td>
<td>180.1</td>
</tr>
<tr>
<td>February</td>
<td>3.57</td>
<td>5.09%</td>
<td>318.1</td>
</tr>
<tr>
<td>March</td>
<td>4.82</td>
<td>6.87%</td>
<td>429.3</td>
</tr>
<tr>
<td>April</td>
<td>6.83</td>
<td>9.74%</td>
<td>608.3</td>
</tr>
<tr>
<td>May</td>
<td>7.93</td>
<td>11.31%</td>
<td>706.7</td>
</tr>
<tr>
<td>June</td>
<td>9.09</td>
<td>12.96%</td>
<td>809.4</td>
</tr>
<tr>
<td>July</td>
<td>9.20</td>
<td>13.13%</td>
<td>820.0</td>
</tr>
<tr>
<td>August</td>
<td>8.71</td>
<td>12.42%</td>
<td>776.0</td>
</tr>
<tr>
<td>September</td>
<td>7.80</td>
<td>11.12%</td>
<td>694.7</td>
</tr>
<tr>
<td>October</td>
<td>4.40</td>
<td>6.28%</td>
<td>392.2</td>
</tr>
<tr>
<td>November</td>
<td>2.72</td>
<td>3.88%</td>
<td>242.2</td>
</tr>
<tr>
<td>December</td>
<td>3.03</td>
<td>4.32%</td>
<td>269.7</td>
</tr>
<tr>
<td>Annual</td>
<td>70.12</td>
<td>100.00%</td>
<td>6,246.5</td>
</tr>
</tbody>
</table>
References


TECHNICAL MEMORANDUM

Date: July 15, 2019

To: Tribal Council, Colorado River Indian Tribes (CRIT)

Cc: Rebecca Loudbear, Attorney General, CRIT
    Margaret Vick, Esq., Special Counsel

From: Natural Resources Consulting Engineers, Inc.

PROPOSED LANDS FOR COMPENSATED SYSTEM CONSERVATION PROGRAM (SCP) AND EXTRAORDINARY CONSERVATION INTENTIONALLY CREATED SURPLUS (EC ICS)

F. Farm Unit: CRIT Farms Frimann Unit

Overview

This technical memorandum provides summary information and technical analyses for proposed temporary fallowing of irrigated farm land on the Colorado River Irrigation Project (Project) and other lands outside the boundary of the Project, Colorado River Indian Reservation, State of Arizona. The proposed fallowing is recommended for consideration under the Compensated System Conservation (SC) Program and Extraordinary Conservation Intentionally Created Surplus (EC ICS) Program. Temporary agricultural land fallowing is recognized by the Programs as means for reducing consumptive use to result in conserved water stored in Lake Mead. Parcels of land will be designated for fallowing on an annual basis and described in a Creation Plan. At the time of designation each parcel will have a history of irrigation for at least three out of the most recent five years. Each parcel may be designated for fallowing for no more than five consecutive years.

Under this proposal, the Colorado River Indian Tribes (CRIT) would temporarily fallow irrigated cropland on nine different Farm Units. Summary data and information regarding the location of each Farm Unit, the crops produced, irrigated crop acreage, estimated crop evapotranspiration, effective rainfall, net crop consumptive use, and estimated total irrigation...
diversion requirement averaged over the previous 5-year period for each Farm Unit is provided below. Fallowing is proposed to begin in calendar year 2019 and continue through 2022.

**Project Description**

CRIT proposes to forego irrigation water deliveries and reduce consumptive use of Colorado River water by temporarily fallowing irrigated cropland as described immediately below during the period 2019-2022. CRIT proposes to create Compensated System Conservation through fallowing of specific Farm Units and make the conserved water available to the Colorado River System to increase storage in Lake Mead during 2020-2022. CRIT proposes to create EC ICS through fallowing of specific Farm Units for various periods of time during 2019 and may designate part of the consumptive use not compensated as system conservation for EC ICS during 2020-2022.

Figure 1 is an overview map showing the locations of the Farm Units proposed for fallowing on the Colorado River Indian Reservation (Reservation) in the State of Arizona. The majority of these Farm Units are served by the Tribe’s Colorado River Irrigation Project (Project), which diverts Colorado River water for irrigation of about 80,000 acres of land on the Reservation. One Farm Unit is located outside of the Project service area and diverts water directly from the Colorado River by pumping.

Two of the proposed Farm Units are currently fallowed and participating in the Pilot System Conservation Program:

- a. MTA 6627—October 1, 2018 to September 30, 2019
- b. Quail Mesa 6808—January 1, 2019 to December 31, 2019

**Estimated Conservation of Colorado River System Water**

Estimated average annual consumptive use reduction due to fallowing, and the associated reductions in diversions at Headgate Rock Dam or by direct pumping for each Farm Unit are summarized in Table 1 below.

CRIT proposes to use the average annual consumptive use reduction during October-December for Unit MTA 6627 and the total average annual consumptive use reduction for Unit Rayner 9035 for EC ICS creation in 2019. CRIT proposes to use all sites listed in Table 1
Figure 1. Overview of CRIT farm units proposed for fallowing for SC and EC ICS.

### Summary of CRIT ICS for 2019

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Cropping Pattern</th>
<th>Net Consumptive Use</th>
<th>Efficiency Factor</th>
<th>Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average AF/acre</td>
<td>Annual AFY</td>
<td></td>
<td>Annual AFY</td>
</tr>
<tr>
<td>6627</td>
<td>MTA Farms</td>
<td>2014-15</td>
<td>1884.0</td>
<td>80% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>1,470</td>
<td>0.501</td>
</tr>
<tr>
<td>9035</td>
<td>Rayner</td>
<td>2013-17</td>
<td>1055.7</td>
<td>43% alfalfa 35% cotton 14% Bermuda (grass hay) 8% Sudan</td>
<td>4.55</td>
<td>4,804</td>
<td>0.501</td>
</tr>
<tr>
<td></td>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td>2,860</td>
<td>6,274</td>
<td></td>
</tr>
</tbody>
</table>

* Oct 1 2019-Dec 31 2019 only
** estimates in this table for 9035 are based on 2013-2017 USGS cropping data

### Summary of CRIT System Conservation and ICS for 2020 (System Conservation in excess of 50,000 AF will be considered ICS)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Cropping Pattern</th>
<th>Total Net Consumptive Use</th>
<th>Net Consumptive Use Prorata</th>
<th>Diversion Reduction</th>
<th>System Conservation Prorata</th>
<th>System Conservation* AFY</th>
<th>System Conservation** AFY</th>
<th>Total Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average AF/acre</td>
<td>Annual AFY</td>
<td>System Conservation AFY</td>
<td></td>
<td>System Conservation* AFY</td>
<td></td>
<td>System Conservation** AFY</td>
<td>Total Diversion Reduction</td>
</tr>
<tr>
<td>6627</td>
<td>MTA Farms</td>
<td>2014-15</td>
<td>1884.0</td>
<td>80% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>10,157</td>
<td>3,000.7</td>
<td>17,664.8</td>
<td>1,486.7</td>
<td>10,152</td>
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<tr>
<td>6088</td>
<td>Quail Mesa</td>
<td>2014-15</td>
<td>3704.6</td>
<td>58% alfalfa 4% small grain 6% Bermuda (grass hay) 11% Sudan 21% Miscellaneous (onion, garlic, corn, potato)</td>
<td>4.89</td>
<td>8,130</td>
<td>16,869.7</td>
<td>1,260.6</td>
<td>31,532.2</td>
<td>2,633.9</td>
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<tr>
<td>6693</td>
<td>MTA Farms</td>
<td>2014-15</td>
<td>1183.9</td>
<td>64% alfalfa 1% cotton 6% small grain 13% Bermuda (grass hay) 14% Sudan 21% Miscellaneous (onion, garlic, corn, potato)</td>
<td>4.97</td>
<td>5,886</td>
<td>5,476.3</td>
<td>409.2</td>
<td>10,236.1</td>
<td>861.5</td>
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<tr>
<td>CRIT Farms Victorio</td>
<td>2014-15</td>
<td>400.6</td>
<td>60% alfalfa 5% cotton 17% small grain 12% Bermuda (grass hay) 5% Sudan</td>
<td>4.61</td>
<td>1,877</td>
<td>1,746.5</td>
<td>130.5</td>
<td>3,264.4</td>
<td>274.7</td>
<td>3,539</td>
<td></td>
</tr>
<tr>
<td>CRIT Farms Frimann</td>
<td>2014-15</td>
<td>674.7</td>
<td>52% alfalfa 26% cotton 18% small grain 4% Sudan</td>
<td>4.37</td>
<td>2,951</td>
<td>2,745.4</td>
<td>205.2</td>
<td>5,131.7</td>
<td>431.9</td>
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<tr>
<td>CRIT Farms CRIT II</td>
<td>2014-15</td>
<td>1238.7</td>
<td>73% alfalfa 19% cotton 4% small grain 2% Miscellaneous (onion, garlic, corn, potato)</td>
<td>5.04</td>
<td>6,247</td>
<td>5,812.4</td>
<td>434.3</td>
<td>10,864.4</td>
<td>914.4</td>
<td>11,779</td>
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<tr>
<td>CRIT Farms MTA 700</td>
<td>2014-15</td>
<td>465.8</td>
<td>85% alfalfa 7% cotton 7% Bermuda (grass hay)</td>
<td>5.50</td>
<td>2,562</td>
<td>2,383.8</td>
<td>178.1</td>
<td>4,435.7</td>
<td>375.0</td>
<td>4,811</td>
<td></td>
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<tr>
<td>CRIT Farms Sharler Ranch</td>
<td>2014-15</td>
<td>439.5</td>
<td>69% alfalfa 30% cotton 10% Sudan</td>
<td>5.02</td>
<td>2,206</td>
<td>2,052.9</td>
<td>153.4</td>
<td>3,837.2</td>
<td>323.0</td>
<td>4,160</td>
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<tr>
<td>9035</td>
<td>Rayner</td>
<td>2013-17</td>
<td>783.0</td>
<td>22% alfalfa 32% cotton 12% Bermuda (grass hay) 4% Sudan</td>
<td>4.72</td>
<td>3,721</td>
<td>3,462</td>
<td>239</td>
<td>5,770</td>
<td>545</td>
<td>6,315</td>
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<td>Totals</td>
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<td>10,786</td>
<td>53,738</td>
<td>50,000</td>
<td>3,736</td>
<td>92,757</td>
<td>7,806</td>
<td>100,623</td>
</tr>
</tbody>
</table>

* based on Project overall average irrigation efficiency equal to 53.5%
** based on Project CU Diversion ratio of 0.475 for 2018 using methodology designated in the LBOps ICS Exhibit S for CRIT.
*** estimates in this table for 9035 are based on 2013-2017 USGS cropping data with linear move sprinkler area removed; and, for System Conservation diversion reduction, an overall average irrigation efficiency for direct pumping from River equal to 60%
to create up to 50,000 AF/year of Compensated System Conservation with any excess over 50,000 AF/year designated as EC ICS during the period 2020. The same farm units listed in Table 1 or different farm units may be designated for fallowing in 2021 and 2022.

Methodology

This section provides a brief description of the data and methods used to estimate:

- the amount of water conserved due to fallowing of irrigated cropland on each Farm Unit for each year of analysis; this is the net consumptive irrigation water use savings due the cropland fallowing; and,
- the associated irrigation water diversion required to provide that amount of water at the farm field.

Results are presented for each proposed Farm Unit in individual succeeding sub-sections of this technical memorandum.

Farm Unit Description and Location

Location data and legal description (PLSS) for each Farm Unit proposed for fallowing were obtained from CRIT Realty and/or CRIT Farms, the Tribal farming enterprise. This information generally included total gross and net acreage of the unit. Net irrigated crop acreage on each field of each Unit was determined using CRIT Water Resources Department (WRD) AGR05 field parcel polygon shapefile. The maximum net irrigated field acreage in any single year of the study period was used to determine the total volume of consumptive use savings due to fallowing.

Information on the Colorado River Irrigation Project (Project) irrigation delivery system was generally available from the US Bureau of Indian Affairs (BIA), the Federal agency that owns and operates the Project on behalf of CRIT. NRCE has prepared a detailed assessment of the Project (NRCE, 2016; NRCE, 2017).

Cropping Patterns

Crops typically produced on the Reservation include alfalfa (for hay), cotton, small grains (wheat, oats, barley), Bermuda and other grass hay, Sudan grass, and variety of minor miscellaneous crops (onions, garlic, corn, potato) (NRCE, 2016).
Crop patterns/crop mix for field parcels on the Farm Units for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD). The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. For Unit 9035, cropping pattern data were not available from the CRIT WRD. For this unit, cropping pattern data collected by the USGS for the period 2013-2017 were made available by the USBR (Jeremy Dodds, USBR, personal communication, July 12, 2019). Unit 9035 has not been farmed since May 2018, and thus 2018 is not included in the analysis. The USGS crop pattern data are 100% coverage, on the ground crop survey data collected annually on the Rayner unit for USBR during 2013-17. Cropping pattern/crop mix maps for all Farm Units for the respective years analyzed are included in the subsection for each Farm Unit. A table summarizing the cropping pattern/crop mix for each Farm Unit for each year and average for the period analyzed is included.

**Estimation of Consumptive Use**

The factors considered in estimating crop consumptive use include cropped area and cropping patterns, reference evapotranspiration, crop coefficients, and precipitation. Crop evapotranspiration \( (E_{TC}) \) or crop consumptive use \( (\text{crop } CU) \) is defined as the evapotranspiration rate from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under given climatic conditions (Allen et al., 1998). Potential crop water use or crop evapotranspiration estimates for the period 1996 to present for the Colorado River Irrigation Project service area have been prepared (NRCE, 2016).

For the purposes of this study, \( E_{TC} \) estimates using the single (mean) crop coefficient-reference evapotranspiration approach. Under this approach, reference crop evapotranspiration for a hypothetical green surface of actively transpiring vegetation is multiplied by a crop coefficient for a specific crop to estimate crop ET on a daily or monthly basis:

\[
E_{TC} = K_c \times E_{T_0}
\]

where:

\( E_{TC} \) = crop evapotranspiration (inches or mm);
\( K_c \) = crop coefficient (dimensionless);

\( ETo \) = grass reference crop evapotranspiration (inches or mm)

The reference ET-crop coefficient method is widely used due to its simplicity, reproducibility, relatively good accuracy, and transportability among locations and climates.

For this analysis, reference ET (ET of an extensive area of short crop similar to 12-cm grass not short of water, \( ETo \)) was computed using the ASCE Standardized Reference Evapotranspiration Equation (ASCE, 2005). The ASCE Standardized Reference ET Equation for a short (grass) reference surface is:

\[
ETo = \frac{0.408 \Delta Rn + \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34 u_2)}
\]

where:

\( ETo \) = standardized reference crop evapotranspiration for (grass) short crop

\( \Delta \) = slope of the saturation vapor pressure-temperature curve

\( Rn \) = net radiation at the crop surface

\( \gamma \) = psychrometric constant

\( T \) = mean daily air temperature measured at 1.5-2 m above ground level

\( u_2 \) = mean daily wind speed measured at 2 m above ground level

\( e_s \) = saturation vapor pressure

\( e_a \) = mean actual vapor pressure

This equation is the same as the ASCE Penman-Monteith Equation (Jensen et al., 1990 and Jensen and Allen, 2016) but with several simplifying “standardized” methods employed to compute several of the variables and parameter used in the Equation as given in ASCE (2005).

Jensen et al. (1990) report and summarize results of a comprehensive study comparing evapotranspiration estimates from different estimating methods to measurements of
Evapotranspiration made at 11 different lysimeter sites around the world representing a wide range of climatic conditions from humid to arid, and elevations from below sea level to 9100 ft MSL. Nineteen methods were compared to lysimeter measurements on a monthly basis, and thirteen methods were compared on a daily basis. The ASCE Penman-Monteith method as given in Jensen et al. (1990) was determined to provide the overall best estimates of seasonal ET and average peak monthly ET with the least error as compared to lysimeter measurements across all ranges of climate and elevation.

The ASCE Reference ET Equation (ASCE, 2005) is a physically-based approach accounting for energy available for evaporation and aerodynamic transport of moisture away from the evaporating surface. Because of this physically-based formulation, it requires detailed weather measurements including air temperature, relative humidity, incoming total solar radiation, and wind speed. Such weather measurements are available from the Arizona Meteorological Network (AZMET) operated by the University of Arizona College of Agriculture and Live Sciences and Arizona Cooperative Extension (https://cals.arizona.edu/AZMET/). Two AZMET electronic weather stations are currently in operation in the Parker Valley and both stations are located on the Colorado River Indian Reservation (https://www.usbr.gov/lc/region/g4000/wtracct.html):

Parker No. 1 (site 8), Latitude 33.964296, Longitude -114.485501, Elev. 322 ft above MSL
Parker No. 2 (site 35) Latitude 33.863015, Longitude -114.472974, Elev. 302 ft above MSL

Daily weather and ET₀ data from the AZMET Parker No. 2 Station for the respective 5-year period of analysis were used in this study (AZMET, 2013-2018).

The crop coefficient, Kc, integrates the effects/differences of specific crop characteristics that affect water use of the specific crop to the water use of the reference crop. This methodology for estimated crop ET assumes the crop is growing under ideal conditions, and not stressed for water or nutrients, and thus, is considered the potential crop ET or potential consumptive use. Actual crop ET in farm fields is typically less than potential crop ET due to factors such as water stress, salinity, insect and disease pressure, etc.

Daily crop coefficient values for the primary crops comprising around 90% of the total irrigated crop acreage [alfalfa, cotton, small grains (wheat, oats, rye, barley, millet), Bermuda hay,
Sudan grass) grown on the Reservation were obtained from reports on crop coefficients prepared for the USBR LCRAS (https://www.usbr.gov/lc/region/g4000/wtracct.html#LCRAS) program (Jensen, 1998 and Jensen, 2003). Several minor “miscellaneous” crops have been and currently are produced on small acreage on the Reservation. Over the period 2013-2018, these minor crops have comprised an average of only 3.52% of the total irrigated crop acreage on the Project. These include but are not limited to corn, onions, garlic, crucifers, lettuce, and other small vegetable and melon crops. Most often these crops are produced for seed (crucifers, lettuce) or dehydration (onion, garlic) or animal feed (corn silage) and not as fresh market produce. Crop coefficients for a “miscellaneous” crop category were assumed to be equal to the average of the primary crops. This process is explained in more detail in Appendix B of NRCE (2016).

In the case of alfalfa, Jensen (1998, Appendix C) recognized the published crop coefficients for alfalfa hay represent potential (maximum) alfalfa ET under conditions where harvest and removal of hay is not delayed, and crop water stress does not occur. Jensen (1998) estimated the coefficients were about 15% too high for normal farm practices when hay may not be removed right after cuttings, some water stress might occur, non-uniformity of crop conditions, etc. To adjust for these effects and provide alfalfa hay consumptive use estimates closer to actual conditions, Jensen (1998) applied a factor of 0.85 to the alfalfa hay crop coefficients.

The differences between actual ET occurring under the field conditions of the PROJECT and potential ET from crop coefficient-reference ET approach can be estimated using a remote sensing approach which allows for the determination of actual evapotranspiration from both vegetated and bare soil surfaces by solving the full surface energy balance using remotely sensed visible and thermal band data. While this type of study has not been performed on the Project service area, two such studies have been conducted on large irrigation districts in the region and the results provide some insight on the differences between actual and potential crop consumptive use that may be occurring on the Project:

- Clark et al. (2008) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different combinations of soils, on-farm irrigation method, and crop types, found on Imperial Irrigation District (IID). In this case, the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, 1998) and
LandSat satellite imagery with 30 m thermal resolution for water year 1998 was used to estimate actual ET. Potential ET was estimated using the dual crop coefficient approach presented in Allen et al. (1998). The results were presented as ratios of actual ET to potential ET. Across IID the average ratio was found to be 0.85. For graded border and graded furrow irrigation of mature alfalfa and new alfalfa on all soil types, the IID ratio of actual ET to potential ET ranged from 0.83 to 0.87.

- Elhaddad and Garcia (2014) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different crop types found on Palo Verde Irrigation District (PVID). In this case, actual ET was estimated using the ReSET Raster method (Elhaddad and Garcia, 2008) and LandSat 7 satellite imagery with 30 m thermal resolution for calendar year 2002. Potential ET was estimated using methods employed by the USBR in the Lower Colorado River Accounting System (LCRAS) (USBR, 1996-2014). The average ratio of actual ET to potential ET across PVID was found to be 0.86. For alfalfa, the ratio was found to be 0.86.

The results of these studies support the alfalfa hay crop coefficient adjustments suggested by Jensen (1998). Thus, for this analysis, alfalfa crop ET, as computed using the Jensen (1998, 2003) alfalfa crop coefficients (published coefficients multiplied by a factor of 0.85 to account for less than ideal growth conditions) was taken as an estimate of actual alfalfa crop ET. For Sudan, small grains, and grass hay, actual crop ET was estimated to be 0.85 times potential crop ET. For cotton and higher value minor miscellaneous crops (garlic, onion, potato) a factor of 1.00 was assumed.

Growing season durations of the various crops are implicit in the daily crop coefficients prepared by Jensen (1998, 2003) and were adopted for this analysis.

The net irrigation water requirement (NIR) or net consumptive irrigation water use (NetCU) represents the quantity of water required at the farm field to supply the estimated irrigation water demand of a crop during its growth period over and above the amount of natural precipitation water available for crop use. NIR or NetCU is computed as the crop ET minus the effective precipitation. Effective precipitation is that portion of total precipitation which is available for crop use. NRCE
adopted the flat monthly multiplier approach to estimate effective precipitation (Jensen, 1993) as used in USBR LCRAS reporting of crop water use. Average annual precipitation measured at the AZMET Parker No. 2 Station is 3.96 inches for the period: 2014-2018 (AZMET, 2013-2018). Using the LCRAS method, effective precipitation on the Reservation is about 0.76 inches per year, or just less than about 20 percent of average annual precipitation, for the 2014-2018 period at this location.

For each year analyzed, the weighted average NIR or NetCU was determined based on acreages of the individual crop types and the NIR or NetCU of each crop for that year. Using this result, an overall average unit area net crop consumptive irrigation water use (AF/ac) for the 5-year study period was determined. This 5-year average unit area net crop consumptive irrigation water use is listed for each Farm Unit in Table 1. The 5-year average unit area net crop consumptive irrigation water use is multiplied by the maximum (for the 5-year study period) annual acres irrigated for the Farm Unit to determine the total volume of NetCU due to fallowing and listed for each parcel in Table 1.

**Diversion Requirements**

NRCE (2017) has performed water balance analyses at the conveyance/delivery system level to estimate the magnitude of conveyance system losses (seepage, evaporation, and operational spills) experienced with the current infrastructure and operational management of the Project. Farm gate deliveries were estimated. These analyses allowed an assessment of conveyance/delivery system efficiency. As well, farm field level water balance analyses comparing net crop irrigation water requirements (NIR) to the estimated field level supplies or farmgate deliveries were performed. These comparisons allowed an assessment of on-farm losses to ditch seepage, deep percolation and tailwater runoff and estimation of on-farm efficiency. The overall assessment comparing net crop irrigation water requirements (NIR) to diversions allowed estimation of Project irrigation efficiency.

For the proposed Farm Units served by the Project, the total irrigation diversion requirement at Headgate Rock Dam corresponding to the Farm Unit net consumptive irrigation water use was estimated by dividing the farm field (NIR or NetCU) by the estimated project irrigation efficiency (product of irrigation delivery system conveyance efficiency and on-farm application efficiency).
For the purposes of these analyses, an overall Project irrigation efficiency of 53.5% was applied (NRCE, 2017).

Farm Unit 9035 is not served by the Project. This site diverts irrigation water by pumping directly from the Colorado River. Water is distributed across the farm using concrete lined ditches. Irrigation for the period of study 2013-17 was by flood (low gradient border and furrow) irrigation, although in years prior to this period linear move sprinklers were used on parts of the lease, and CRIT’s future plans include leasing parts of the unit and irrigating with the linear move sprinkler again. An average application efficiency of about 65-66% for border and furrow irrigation on the Reservation is used. For Unit 9035, the conveyance losses to seepage and operational spill are minor compared to the Project. A conservative conveyance efficiency of 90% is assigned on this unit. This results in an irrigation efficiency estimate of 60% for the unit.

**Monthly Distribution**

The annual cropping patterns found for each Farm Unit illustrate varying acreages of the primary crops from year to year and from Unit to Unit. To normalize this variability, monthly distributions of the total average annual NetCU savings and total average annual diversion reductions for each Farm Unit were determined by computing a monthly proportion of the total annual volume based on the 5-year average monthly and annual alfalfa crop evapotranspiration computed using reference crop ET\textsubscript{o} from the AZMET Parker No. 2 electronic weather station and LCRAS crop coefficients for alfalfa.

**Verification**

During the fallowing period, in order to ensure that any vegetation remaining on the fallowed lands does not consumptively use Colorado River water by drawing water from the Colorado River aquifer, CRIT shall, at its expense, control and eradicate any green vegetation growth.

Weed control will likely performed using chemical applications. Records of weed control applications, including date, chemicals used, rates of application, etc. will be prepared and maintained. CRIT agrees to provide Reclamation, Arizona Department of Water Resources, and other applicable entities, with information and updates, when requested, regarding the vegetation eradication program. Stubble from previous cropping will be kept on field surface to the extent
possible to reduce wind erosion. USBR personnel will be granted access to the Farms to perform periodic on-site inspections to verify compliance.

The means of irrigation water deliveries to each Farm Unit proposed for fallowing are described for each respective Unit. Irrigation water deliveries can be completely curtailed through control of farm gate turnouts or through control of sublateral head gates. CRIT agrees to furnish and install padlocks to lock the farm gate turnouts on fields fallowed to the extent possible to do so. In the event that a turnout serves multiple fields of which not all are being fallowed, other practical mechanisms, including but not limited to, dirt berms in the portion of the irrigation ditch serving the fallowed field, or sealing the on-farm turnouts onto fallowed fields will be used to the extent possible to assure that no water deliveries can be made onto the fallowed fields.

Verification of Conserved Water Diversion Reduction from Approved Water Order

Total estimated diversion requirements on monthly and annual time steps for the actively irrigated areas of the proposed Farm Units that will be fallowed have been estimated. CRIT’s annual water order (as determined and approved through the 43 CFR, Part 417 (Part 417) consultation between the BIA, US Bureau of Reclamation and CRIT) will be reduced by the estimated annual diversion requirements of the Farm Units for the agreed fallowing periods. Estimated monthly net consumptive use and diversion requirements of the Farm Units have also been determined. These monthly estimates allow determination of partial year water conservation and diversion reductions when fallowing periods are not a full 12-month period. Total annual CRIT Project and other Arizona diversions (with the fallowing and diversion reduction in progress) will not exceed CRIT’s Colorado River annual water right allocation for Arizona as adjusted by the diversion reductions, and thereby avoid inadvertent overruns (diversions in excess of CRIT’s adjusted entitlement—decreed AZ water right less the estimated diversion requirements of the fallowing program).

For Unit 9035, which diverts by direct pumping of water from the Colorado River, conserved water diversion reduction can be verified through routine monitoring of the electric power meter readings and account for the Unit’s pumping facilities.
F. Farm Unit: CRIT Farms Frimann Unit

Farm Description and Location

The CRIT Farms Frimann Unit is located on the Colorado River Indian Reservation within the Project service area with field parcels located within Sections 12 and 13 Township 5N Range 22W (Gila and Salt River Meridian), La Paz County, Arizona. The Frimann Unit is bounded by Project Sub-lateral Lower 90 on the west and south, irrigated crop land on the north, the Lower Main Drain on the east. Figure F1 is an overview map of the Unit. A maximum of 674.74 net field acres have been in irrigated crop production for at least the past 5 years. The acreage not in production is idle or occupied by hay and equipment storage yards, roads, canals, and drains.

The irrigated cropland on the Frimann Unit is served primarily by Sub-lateral Lower 90 of the Project. This sublateral serves other farm fields in the area and thus cannot be turned off at the head gate. Farm gate turnouts on Sublateral Lower 90 serving the Frimann Unit will be chained and locked.

CRIT Water Resources Dept. provided geospatial data (AGR05 shapefile and associated attribute table) of delineated irrigated field parcels across the Project. A total of up to 30 irrigated field parcels were identified within the actively irrigated area of the Unit (see Figure F1), although field parcel boundaries are noted to have changed with some consolidation or further subdivision apparent during the study period. Background aerial imagery in Figure F1 is dated 2017 and from the USDA National Agriculture Aerial Imagery Program (NAIP): (http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/). The CRIT field parcel delineations were found to show good agreement with the NAIP aerial imagery.
Figure F1. Overview Map of CRIT Farms Frimann Unit.
Cropping Patterns

Crop patterns/crop mix for field parcels on the Frimann Unit for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD) and are summarized in Table F1. The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. The annual cropping pattern for the Frimann Unit is mapped in Figures F2-F6, for years 2014-2018, respectively.

Table F1. Cropping Patterns/Crop Mix of the CRIT Farms Frimann Unit, 2014-2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated Crop Acreage</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/ Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
<th>Idle Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>674.7</td>
<td>43%</td>
<td>38%</td>
<td>19%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0.0</td>
</tr>
<tr>
<td>2015</td>
<td>674.7</td>
<td>60%</td>
<td>0%</td>
<td>40%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0.0</td>
</tr>
<tr>
<td>2016</td>
<td>674.7</td>
<td>23%</td>
<td>47%</td>
<td>30%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0.0</td>
</tr>
<tr>
<td>2017</td>
<td>674.7</td>
<td>35%</td>
<td>45%</td>
<td>0%</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
<td>0.0</td>
</tr>
<tr>
<td>2018</td>
<td>674.7</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0.0</td>
</tr>
<tr>
<td>Average</td>
<td>52%</td>
<td>26%</td>
<td>18%</td>
<td>0%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Figure F2. Cropping Pattern on CRIT Farms Frimann Unit in 2014.
Figure F3. Cropping Pattern on CRIT Farms Frimann Unit in 2015.
Figure F4. Cropping Pattern on CRIT Farms Frimann Unit in 2016.
Figure F5. Cropping Pattern on CRIT Farms Frimann Unit in 2017.
Figure F6. Cropping Pattern on CRIT Farms Frimann Unit in 2018.
Estimated Crop Evapotranspiration

Table F2 below presents estimated annual and 5-year average reference $\text{E}_\text{T}_0$ and crop ET (inches/year) for crops grown on the Reservation during the 5-year study period using weather data from the AZMET Parker No. 2 weather station.

Table F2. Annual and 5-year Average Reference $\text{E}_\text{T}_0$ and crop ET (inches/year) for Reservation Crops for 2014-2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference $\text{ET}_0$</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/ Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.9</td>
<td>37.7</td>
<td>24.5</td>
<td>49.6</td>
<td>44.6</td>
<td>44.9</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.2</td>
<td>39.1</td>
<td>23.0</td>
<td>49.7</td>
<td>43.8</td>
<td>44.5</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.9</td>
<td>43.2</td>
<td>24.3</td>
<td>53.7</td>
<td>46.4</td>
<td>48.0</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.5</td>
<td>40.5</td>
<td>23.6</td>
<td>50.9</td>
<td>46.2</td>
<td>46.2</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>69.7</td>
<td>40.1</td>
<td>24.5</td>
<td>50.5</td>
<td>46.2</td>
<td>46.1</td>
</tr>
<tr>
<td>Average (in)</td>
<td>70.0</td>
<td>40.1</td>
<td>24.0</td>
<td>50.9</td>
<td>45.4</td>
<td>45.9</td>
<td></td>
</tr>
<tr>
<td>Average (af/ac)</td>
<td>5.84</td>
<td>3.34</td>
<td>2.00</td>
<td>4.24</td>
<td>3.79</td>
<td>3.83</td>
<td></td>
</tr>
</tbody>
</table>

1 Reference evapotranspiration of a short crop similar to 12-cm tall grass.

Estimated Net Consumptive Irrigation Water Use and Diversion Requirement

Table F3 below presents reference $\text{E}_\text{T}_0$, area-weighted average crop ET, effective precipitation, area-weighted average net consumptive use (NetCU), and associated diversion requirement (diversion reduction) for each year of the study period, and as an average of the 5-year period: 2014-18, based on the crop acreage and cropping pattern/mix discussed above. The estimated average annual unit area consumptive use on this Farm Unit for 2014-2018 is 4.37 AF/acre. The total estimated volume of water conserved due to the proposed fallowing of a maximum acreage of 674.7 acres on the Farm Unit is 2,951 AFY. Using an estimated average overall irrigation efficiency of 53.5%, the diversion requirement associated with this net water conservation is 5,515 AFY.
Table F3. Annual and 5-year Average Reference ET₀, Area Weighted Crop ET, Effective Precipitation, Area Weighted Net CU and Diversion Reduction for 2014-2018. CRIT Farms Frimann Unit.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET₀</th>
<th>Weighted Average Crop ET (ETa)</th>
<th>Effective Precip.</th>
<th>Weighted Average Net Consumptive Use</th>
<th>Net Crop Area Fallowed</th>
<th>Net Consumptive Use Demand</th>
<th>Diversion Reduction⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
</tr>
<tr>
<td></td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(ac)</td>
<td>(AF)</td>
<td>(AF)</td>
</tr>
<tr>
<td>2014</td>
<td>75.11</td>
<td>48.12</td>
<td>0.30</td>
<td>47.92</td>
<td>674.7</td>
<td>2,694</td>
<td>5,036</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>50.15</td>
<td>0.93</td>
<td>49.35</td>
<td>674.7</td>
<td>2,775</td>
<td>5,187</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>44.81</td>
<td>1.03</td>
<td>44.25</td>
<td>674.7</td>
<td>2,488</td>
<td>4,651</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>52.17</td>
<td>0.82</td>
<td>51.88</td>
<td>674.7</td>
<td>2,917</td>
<td>5,453</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>69.69</td>
<td>0.70</td>
<td>68.99</td>
<td>674.7</td>
<td>3,879</td>
<td>7,250</td>
</tr>
<tr>
<td>Average</td>
<td>77.26</td>
<td>52.99</td>
<td>0.76</td>
<td>52.48</td>
<td>674.7</td>
<td>2,951</td>
<td>5,515</td>
</tr>
</tbody>
</table>

| Unit area Net CU (AF/ac) | 4.37 |
| Max acreage | 674.7 | 2,951 | 5,515 |

¹ Reference evapotranspiration of a short crop similar to 12-cm tall grass.
² Estimated actual crop ET accounting for water stress and less than ideal growth conditions.
Weighted average calculated using irrigated acreages.
³ Column (5) divided by 12 and multiplied by Column (6)
⁴ Column (8) divided by overall Project efficiency
The monthly distribution of the total average annual NetCU saving and total average annual diversion reduction for CRIT Farms Frimann Unit is presented in Table F4.


<table>
<thead>
<tr>
<th>Month</th>
<th>Average annual Alfalfa Crop ET (in) for period of analysis</th>
<th>Monthly Net Consumptive Use Demand</th>
<th>Monthly Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(inches)</td>
<td>% of total</td>
<td>(AF)</td>
</tr>
<tr>
<td>January</td>
<td>2.02</td>
<td>2.88%</td>
<td>85.1</td>
</tr>
<tr>
<td>February</td>
<td>3.57</td>
<td>5.09%</td>
<td>150.3</td>
</tr>
<tr>
<td>March</td>
<td>4.82</td>
<td>6.87%</td>
<td>202.8</td>
</tr>
<tr>
<td>April</td>
<td>6.83</td>
<td>9.74%</td>
<td>287.3</td>
</tr>
<tr>
<td>May</td>
<td>7.93</td>
<td>11.31%</td>
<td>333.8</td>
</tr>
<tr>
<td>June</td>
<td>9.09</td>
<td>12.96%</td>
<td>382.4</td>
</tr>
<tr>
<td>July</td>
<td>9.20</td>
<td>13.13%</td>
<td>387.3</td>
</tr>
<tr>
<td>August</td>
<td>8.71</td>
<td>12.42%</td>
<td>366.6</td>
</tr>
<tr>
<td>September</td>
<td>7.80</td>
<td>11.12%</td>
<td>328.2</td>
</tr>
<tr>
<td>October</td>
<td>4.40</td>
<td>6.28%</td>
<td>185.2</td>
</tr>
<tr>
<td>November</td>
<td>2.72</td>
<td>3.88%</td>
<td>114.4</td>
</tr>
<tr>
<td>December</td>
<td>3.03</td>
<td>4.32%</td>
<td>127.4</td>
</tr>
<tr>
<td>Annual</td>
<td>70.12</td>
<td>100.00%</td>
<td>2,950.7</td>
</tr>
</tbody>
</table>
References


**TECHNICAL MEMORANDUM**

Date: July 15, 2019

To: Tribal Council, Colorado River Indian Tribes (CRIT)

Cc: Rebecca Loudbear, Attorney General, CRIT
    Margaret Vick, Esq., Special Counsel

From: Natural Resources Consulting Engineers, Inc.

**PROPOSED LANDS FOR COMPENSATED SYSTEM CONSERVATION PROGRAM (SCP) AND EXTRAORDINARY CONSERVATION INTENTIONALLY CREATED SURPLUS (EC ICS)**

**H. FARM UNIT: CRIT FARMS MTA 700 UNIT**

**Overview**

This technical memorandum provides summary information and technical analyses for proposed temporary fallowing of irrigated farm land on the Colorado River Irrigation Project (Project) and other lands outside the boundary of the Project, Colorado River Indian Reservation, State of Arizona. The proposed fallowing is recommended for consideration under the Compensated System Conservation (SC) Program and Extraordinary Conservation Intentionally Created Surplus (EC ICS) Program. Temporary agricultural land fallowing is recognized by the Programs as means for reducing consumptive use to result in conserved water stored in Lake Mead. Parcels of land will be designated for fallowing on an annual basis and described in a Creation Plan. At the time of designation each parcel will have a history of irrigation for at least three out of the most recent five years. Each parcel may be designated for fallowing for no more than five consecutive years.

Under this proposal, the Colorado River Indian Tribes (CRIT) would temporarily fallow irrigated cropland on nine different Farm Units. Summary data and information regarding the location of each Farm Unit, the crops produced, irrigated crop acreage, estimated crop evapotranspiration, effective rainfall, net crop consumptive use, and estimated total irrigation...
diversion requirement averaged over the previous 5-year period for each Farm Unit is provided below. Fallowing is proposed to begin in calendar year 2019 and continue through 2022.

**Project Description**

CRIT proposes to forego irrigation water deliveries and reduce consumptive use of Colorado River water by temporarily fallowing irrigated cropland as described immediately below during the period 2019-2022. CRIT proposes to create Compensated System Conservation through fallowing of specific Farm Units and make the conserved water available to the Colorado River System to increase storage in Lake Mead during 2020-2022. CRIT proposes to create EC ICS through fallowing of specific Farm Units for various periods of time during 2019 and may designate part of the consumptive use not compensated as system conservation for EC ICS during 2020-2022.

Figure 1 is an overview map showing the locations of the Farm Units proposed for fallowing on the Colorado River Indian Reservation (Reservation) in the State of Arizona. The majority of these Farm Units are served by the Tribe's Colorado River Irrigation Project (Project), which diverts Colorado River water for irrigation of about 80,000 acres of land on the Reservation. One Farm Unit is located outside of the Project service area and diverts water directly from the Colorado River by pumping.

Two of the proposed Farm Units are currently fallowed and participating in the Pilot System Conservation Program:

a. MTA 6627—October 1, 2018 to September 30, 2019
b. Quail Mesa 6808—January 1, 2019 to December 31, 2019

**Estimated Conservation of Colorado River System Water**

Estimated average annual consumptive use reduction due to fallowing, and the associated reductions in diversions at Headgate Rock Dam or by direct pumping for each Farm Unit are summarized in Table 1 below.

CRIT proposes to use the average annual consumptive use reduction during October-December for Unit MTA 6627 and the total average annual consumptive use reduction for Unit Rayner 9035 for EC ICS creation in 2019. CRIT proposes to use all sites listed in Table 1
Figure 1. Overview of CRIT farm units proposed for follow-up for SC and EC ICS.

Natural Resources Consulting Engineers, Inc.

<table>
<thead>
<tr>
<th>Summary of CRIT ICS for 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit</strong></td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Unit</strong></td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td><strong>MTA Farms</strong></td>
</tr>
<tr>
<td><strong>Rayner</strong></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
</tr>
</tbody>
</table>

*Oct 1 2019-Dec 31 2019 only
**estimates in this table for Rayner are based on 2013-2017 USGS cropping data

<table>
<thead>
<tr>
<th>Summary of CRIT System Conservation and ICS for 2020 (System Conservation in excess of 50,000 AF will be considered ICS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit</strong></td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Unit</strong></td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td><strong>MTA Farms</strong></td>
</tr>
<tr>
<td><strong>Frimus</strong></td>
</tr>
<tr>
<td><strong>MTA Farms</strong></td>
</tr>
<tr>
<td><strong>Shawler Ranch</strong></td>
</tr>
<tr>
<td><strong>Rayner</strong></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
</tr>
</tbody>
</table>

*based on Project overall average irrigation efficiency equal to 53.5%
**based on Project CU Diversion ratio of 0.475 for 2018 using methodology designated in the LBOps ICS Exhibit S for CRIT.
***estimates in this table for Rayner are based on 2013-2017 USGS cropping data with linear move sprinkler area removed; and, for System Conservation diversion reduction, an overall average irrigation efficiency for direct pumping from River equal to 60%

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to create up to 50,000 AF/year of Compensated System Conservation with any excess over 50,000 AF/year designated as EC ICS during the period 2020. The same farm units listed in Table 1 or different farm units may be designated for fallowing in 2021 and 2022.

Methodology

This section provides a brief description of the data and methods used to estimate:
- the amount of water conserved due to fallowing of irrigated cropland on each Farm Unit for each year of analysis; this is the net consumptive irrigation water use savings due the cropland fallowing; and,
- the associated irrigation water diversion required to provide that amount of water at the farm field.

Results are presented for each proposed Farm Unit in individual succeeding sub-sections of this technical memorandum.

Farm Unit Description and Location

Location data and legal description (PLSS) for each Farm Unit proposed for fallowing were obtained from CRIT Realty and/or CRIT Farms, the Tribal farming enterprise. This information generally included total gross and net acreage of the unit. Net irrigated crop acreage on each field of each Unit was determined using CRIT Water Resources Department (WRD) AGR05 field parcel polygon shapefile. The maximum net irrigated field acreage in any single year of the study period was used to determine the total volume of consumptive use savings due to fallowing.

Information on the Colorado River Irrigation Project (Project) irrigation delivery system was generally available from the US Bureau of Indian Affairs (BIA), the Federal agency that owns and operates the Project on behalf of CRIT. NRCE has prepared a detailed assessment of the Project (NRCE, 2016; NRCE, 2017).

Cropping Patterns

Crops typically produced on the Reservation include alfalfa (for hay), cotton, small grains (wheat, oats, barley), Bermuda and other grass hay, Sudan grass, and variety of minor miscellaneous crops (onions, garlic, corn, potato) (NRCE, 2016).
Crop patterns/crop mix for field parcels on the Farm Units for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD). The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. For Unit 9035, cropping pattern data were not available from the CRIT WRD. For this unit, cropping pattern data collected by the USGS for the period 2013-2017 were made available by the USBR (Jeremy Dodds, USBR, personal communication, July 12, 2019). Unit 9035 has not been farmed since May 2018, and thus 2018 is not included in the analysis. The USGS crop pattern data are 100% coverage, on the ground crop survey data collected annually on the Rayner unit for USBR during 2013-17. Cropping pattern/crop mix maps for all Farm Units for the respective years analyzed are included in the subsection for each Farm Unit. A table summarizing the cropping pattern/crop mix for each Farm Unit for each year and average for the period analyzed is included.

**Estimation of Consumptive Use**

The factors considered in estimating crop consumptive use include cropped area and cropping patterns, reference evapotranspiration, crop coefficients, and precipitation. Crop evapotranspiration (ET<sub>c</sub>) or crop consumptive use (crop CU) is defined as the evapotranspiration rate from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under given climatic conditions (Allen et al., 1998). Potential crop water use or crop evapotranspiration estimates for the period 1996 to present for the Colorado River Irrigation Project service area have been prepared (NRCE, 2016).

For the purposes of this study, ET<sub>c</sub> estimates using the single (mean) crop coefficient-reference evapotranspiration approach. Under this approach, reference crop evapotranspiration for a hypothetical green surface of actively transpiring vegetation is multiplied by a crop coefficient for a specific crop to estimate crop ET on a daily or monthly basis:

\[
ET_c = K_c \cdot ET_o
\]

where:

- \( ET_c \) = crop evapotranspiration (inches or mm);
The reference ET-crop coefficient method is widely used due to its simplicity, reproducibility, relatively good accuracy, and transportability among locations and climates.

For this analysis, reference ET (ET of an extensive area of short crop similar to 12-cm grass not short of water, ET₀) was computed using the ASCE Standardized Reference Evapotranspiration Equation (ASCE, 2005). The ASCE Standardized Reference ET Equation for a short (grass) reference surface is:

\[
ET₀ = \frac{0.408 \Delta R_n + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34 u_2)}
\]

where:

- \(ET₀\) = standardized reference crop evapotranspiration for (grass) short crop
- \(\Delta\) = slope of the saturation vapor pressure-temperature curve
- \(R_n\) = net radiation at the crop surface
- \(\gamma\) = psychrometric constant
- \(T\) = mean daily air temperature measured at 1.5-2 m above ground level
- \(u_2\) = mean daily wind speed measured at 2 m above ground level
- \(e_s\) = saturation vapor pressure
- \(e_a\) = mean actual vapor pressure

This equation is the same as the ASCE Penman-Monteith Equation (Jensen et al., 1990 and Jensen and Allen, 2016) but with several simplifying “standardized” methods employed to compute several of the variables and parameter used in the Equation as given in ASCE (2005).

Jensen et al. (1990) report and summarize results of a comprehensive study comparing evapotranspiration estimates from different estimating methods to measurements of
evapotranspiration made at 11 different lysimeter sites around the world representing a wide range of climatic conditions from humid to arid, and elevations from below sea level to 9100 ft MSL. Nineteen methods were compared to lysimeter measurements on a monthly basis, and thirteen methods were compared on a daily basis. The ASCE Penman-Monteith method as given in Jensen et al. (1990) was determined to provide the overall best estimates of seasonal ET and average peak monthly ET with the least error as compared to lysimeter measurements across all ranges of climate and elevation.

The ASCE Reference ET Equation (ASCE, 2005) is a physically-based approach accounting for energy available for evaporation and aerodynamic transport of moisture away from the evaporating surface. Because of this physically-based formulation, it requires detailed weather measurements including air temperature, relative humidity, incoming total solar radiation, and wind speed. Such weather measurements are available from the Arizona Meteorological Network (AZMET) operated by the University of Arizona College of Agriculture and Live Sciences and Arizona Cooperative Extension (https://cals.arizona.edu/AZMET/). Two AZMET electronic weather stations are currently in operation in the Parker Valley and both stations are located on the Colorado River Indian Reservation (https://www.usbr.gov/lc/region/g4000/wtracct.html):

* Parker No. 1 (site 8), Latitude 33.964296, Longitude -114.485501, Elev. 322 ft above MSL
* Parker No. 2 (site 35) Latitude 33.863015, Longitude -114.472974, Elev. 302 ft above MSL

Daily weather and ET₀ data from the AZMET Parker No. 2 Station for the respective 5-year period of analysis were used in this study (AZMET, 2013-2018).

The crop coefficient, Kc, integrates the effects/differences of specific crop characteristics that affect water use of the specific crop to the water use of the reference crop. This methodology for estimated crop ET assumes the crop is growing under ideal conditions, and not stressed for water or nutrients, and thus, is considered the potential crop ET or potential consumptive use. Actual crop ET in farm fields is typically less than potential crop ET due to factors such as water stress, salinity, insect and disease pressure, etc.

Daily crop coefficient values for the primary crops comprising around 90% of the total irrigated crop acreage [alfalfa, cotton, small grains (wheat, oats, rye, barley, millet), Bermuda hay,
Sudan grass) grown on the Reservation were obtained from reports on crop coefficients prepared for the USBR LCRAS (https://www.usbr.gov/lc/region/g4000/wtracct.html#LCRAS) program (Jensen, 1998 and Jensen, 2003). Several minor “miscellaneous” crops have been and currently are produced on small acreage on the Reservation. Over the period 2013-2018, these minor crops have comprised an average of only 3.52% of the total irrigated crop acreage on the Project. These include but are not limited to corn, onions, garlic, crucifers, lettuce, and other small vegetable and melon crops. Most often these crops are produced for seed (crucifers, lettuce) or dehydration (onion, garlic) or animal feed (corn silage) and not as fresh market produce. Crop coefficients for a “miscellaneous” crop category were assumed to be equal to the average of the primary crops. This process is explained in more detail in Appendix B of NRCE (2016).

In the case of alfalfa, Jensen (1998, Appendix C) recognized the published crop coefficients for alfalfa hay represent potential (maximum) alfalfa ET under conditions where harvest and removal of hay is not delayed, and crop water stress does not occur. Jensen (1998) estimated the coefficients were about 15% too high for normal farm practices when hay may not be removed right after cuttings, some water stress might occur, non-uniformity of crop conditions, etc. To adjust for these effects and provide alfalfa hay consumptive use estimates closer to actual conditions, Jensen (1998) applied a factor of 0.85 to the alfalfa hay crop coefficients.

The differences between actual ET occurring under the field conditions of the PROJECT and potential ET from crop coefficient-reference ET approach can be estimated using a remote sensing approach which allows for the determination of actual evapotranspiration from both vegetated and bare soil surfaces by solving the full surface energy balance using remotely sensed visible and thermal band data. While this type of study has not been performed on the Project service area, two such studies have been conducted on large irrigation districts in the region and the results provide some insight on the differences between actual and potential crop consumptive use that may be occurring on the Project:

- Clark et al. (2008) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different combinations of soils, on-farm irrigation method, and crop types, found on Imperial Irrigation District (IID). In this case, the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, 1998) and
LandSat satellite imagery with 30 m thermal resolution for water year 1998 was used to estimate actual ET. Potential ET was estimated using the dual crop coefficient approach presented in Allen et al. (1998). The results were presented as ratios of actual ET to potential ET. Across IID the average ratio was found to be 0.85. For graded border and graded furrow irrigation of mature alfalfa and new alfalfa on all soil types, the IID ratio of actual ET to potential ET ranged from 0.83 to 0.87.

- Elhaddad and Garcia (2014) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different crop types found on Palo Verde Irrigation District (PVID). In this case, actual ET was estimated using the ReSET Raster method (Elhaddad and Garcia, 2008) and LandSat 7 satellite imagery with 30 m thermal resolution for calendar year 2002. Potential ET was estimated using methods employed by the USBR in the Lower Colorado River Accounting System (LCRAS) (USBR, 1996-2014). The average ratio of actual ET to potential ET across PVID was found to be 0.86. For alfalfa, the ratio was found to be 0.86.

The results of these studies support the alfalfa hay crop coefficient adjustments suggested by Jensen (1998). Thus, for this analysis, alfalfa crop ET, as computed using the Jensen (1998, 2003) alfalfa crop coefficients (published coefficients multiplied by a factor of 0.85 to account for less than ideal growth conditions) was taken as an estimate of actual alfalfa crop ET. For Sudan, small grains, and grass hay, actual crop ET was estimated to be 0.85 times potential crop ET. For cotton and higher value minor miscellaneous crops (garlic, onion, potato) a factor of 1.00 was assumed.

Growing season durations of the various crops are implicit in the daily crop coefficients prepared by Jensen (1998, 2003) and were adopted for this analysis.

The net irrigation water requirement (NJR) or net consumptive irrigation water use (NetCU) represents the quantity of water required at the farm field to supply the estimated irrigation water demand of a crop during its growth period over and above the amount of natural precipitation water available for crop use. NIR or NetCU is computed as the crop ET minus the effective precipitation. Effective precipitation is that portion of total precipitation which is available for crop use.
adopted the flat monthly multiplier approach to estimate effective precipitation (Jensen, 1993) as used in USBR LCRAS reporting of crop water use. Average annual precipitation measured at the AZMET Parker No. 2 Station is 3.96 inches for the period: 2014-2018 (AZMET, 2013-2018). Using the LCRAS method, effective precipitation on the Reservation is about 0.76 inches per year, or just less than about 20 percent of average annual precipitation, for the 2014-2018 period at this location.

For each year analyzed, the weighted average NIR or NetCU was determined based on acreages of the individual crop types and the NIR or NetCU of each crop for that year. Using this result, an overall average unit area net crop consumptive irrigation water use (AF/ ac) for the 5-year study period was determined. This 5-year average unit area net crop consumptive irrigation water use is listed for each Farm Unit in Table 1. The 5-year average unit area net crop consumptive irrigation water use is multiplied by the maximum (for the 5-year study period) annual acres irrigated for the Farm Unit to determine the total volume of NetCU due to fallowing and listed for each parcel in Table 1.

**Diversion Requirements**

NRCE (2017) has performed water balance analyses at the conveyance/delivery system level to estimate the magnitude of conveyance system losses (seepage, evaporation, and operational spills) experienced with the current infrastructure and operational management of the Project. Farmgate deliveries were estimated. These analyses allowed an assessment of conveyance/delivery system efficiency. As well, farm field level water balance analyses comparing net crop irrigation water requirements (NIR) to the estimated field level supplies or farmgate deliveries were performed. These comparisons allowed an assessment of on-farm losses to ditch seepage, deep percolation and tailwater runoff and estimation of on-farm efficiency. The overall assessment comparing net crop irrigation water requirements (NIR) to diversions allowed estimation of Project irrigation efficiency.

For the proposed Farm Units served by the Project, the total irrigation diversion requirement at Headgate Rock Dam corresponding to the Farm Unit net consumptive irrigation water use was estimated by dividing the farm field (NIR or NetCU) by the estimated project irrigation efficiency (product of irrigation delivery system conveyance efficiency and on-farm application efficiency).
For the purposes of these analyses, an overall Project irrigation efficiency of 53.5% was applied (NRCE, 2017).

Farm Unit 9035 is not served by the Project. This site diverts irrigation water by pumping directly from the Colorado River. Water is distributed across the farm using concrete lined ditches. Irrigation for the period of study 2013-17 was by flood (low gradient border and furrow) irrigation, although in years prior to this period linear move sprinklers were used on parts of the lease, and CRIT’s future plans include leasing parts of the unit and irrigating with the linear move sprinkler again. An average application efficiency of about 65-66% for border and furrow irrigation on the Reservation is used. For Unit 9035, the conveyance losses to seepage and operational spill are minor compared to the Project. A conservative conveyance efficiency of 90% is assigned on this unit. This results in an irrigation efficiency estimate of 60% for the unit.

**Monthly Distribution**

The annual cropping patterns found for each Farm Unit illustrate varying acreages of the primary crops from year to year and from Unit to Unit. To normalize this variability, monthly distributions of the total average annual NetCU savings and total average annual diversion reductions for each Farm Unit were determined by computing a monthly proportion of the total annual volume based on the 5-year average monthly and annual alfalfa crop evapotranspiration computed using reference crop ET₀ from the AZMET Parker No. 2 electronic weather station and LCRAS crop coefficients for alfalfa.

**Verification**

During the fallowing period, in order to ensure that any vegetation remaining on the fallowed lands does not consumptively use Colorado River water by drawing water from the Colorado River aquifer, CRIT shall, at its expense, control and eradicate any green vegetation growth.

Weed control will likely performed using chemical applications. Records of weed control applications, including date, chemicals used, rates of application, etc. will be prepared and maintained. CRIT agrees to provide Reclamation, Arizona Department of Water Resources, and other applicable entities, with information and updates, when requested, regarding the vegetation eradication program. Stubble from previous cropping will be kept on field surface to the extent
possible to reduce wind erosion. USBR personnel will be granted access to the Farms to perform periodic on-site inspections to verify compliance.

The means of irrigation water deliveries to each Farm Unit proposed for fallowing are described for each respective Unit. Irrigation water deliveries can be completely curtailed through control of farm gate turnouts or through control of sublateral head gates. CRIT agrees to furnish and install padlocks to lock the farm gate turnouts on fields fallowed to the extent possible to do so. In the event that a turnout serves multiple fields of which not all are being fallowed, other practical mechanisms, including but not limited to, dirt berms in the portion of the irrigation ditch serving the fallowed field, or sealing the on-farm turnouts onto fallowed fields will be used to the extent possible to assure that no water deliveries can be made onto the fallowed fields.

Verification of Conserved Water Diversion Reduction from Approved Water Order

Total estimated diversion requirements on monthly and annual time steps for the actively irrigated areas of the proposed Farm Units that will be fallowed have been estimated. CRIT’s annual water order (as determined and approved through the 43 CFR, Part 417 (Part 417) consultation between the BIA, US Bureau of Reclamation and CRIT) will be reduced by the estimated annual diversion requirements of the Farm Units for the agreed fallowing periods. Estimated monthly net consumptive use and diversion requirements of the Farm Units have also been determined. These monthly estimates allow determination of partial year water conservation and diversion reductions when fallowing periods are not a full 12-month period. Total annual CRIT Project and other Arizona diversions (with the fallowing and diversion reduction in progress) will not exceed CRIT’s Colorado River annual water right allocation for Arizona as adjusted by the diversion reductions, and thereby avoid inadvertent overruns (diversions in excess of CRIT’s adjusted entitlement—decreed AZ water right less the estimated diversion requirements of the fallowing program).

For Unit 9035, which diverts by direct pumping of water from the Colorado River, conserved water diversion reduction can be verified through routine monitoring of the electric power meter readings and account for the Unit’s pumping facilities.
**H. Farm Unit: CRIT Farms MTA 700 Unit**

Farm Description and Location

The CRIT Farms MTA 700 Unit is located on the Colorado River Indian Reservation within the Project service area with field parcels located within Sections 25 and 26 Township 6N Range 22W (Gila and Salt River Meridian), La Paz County, Arizona. The MTA 700 Unit is bounded by the levee and the USBR Palo Verde Drain on the west, irrigated cropland on the north and south, and Project Sublateral Lower 90 on the east. Figure H1 is an overview map of the Unit. Gross area of the unit is about 484.3 acres. A maximum of 465.8 net field acres have been in irrigated crop production for at least the past 5 years. The acreage not in production is idle or occupied by hay and equipment storage yards, roads, canals, and drains.

The irrigated cropland on the MTA 700 Unit is served primarily by Sub-lateral Lower 90 of the Project. Other farm units are served by Lower 90 downstream of this Unit and thus it cannot be turned off at the head gate or another upstream check structure. Farm gate turnouts on Sublateral Lower 90 serving the MTA 700 Unit will be chained and locked.

CRIT Water Resources Dept. provided geospatial data (AGR05 shapefile and associated attribute table) of delineated irrigated field parcels across the Project. A total of up to 18 irrigated field parcels were identified within the actively irrigated area of the Unit (see Figure H1), although field parcel boundaries are noted to have changed with some consolidation or further subdivision apparent during the study period. Background aerial imagery in Figure H1 is dated 2017 and from the USDA National Agriculture Aerial Imagery Program (NAIP): (http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/). The CRIT field parcel delineations were found to show good agreement with the NAIP aerial imagery.
Figure H1. Overview Map of CRIT Farms MTA 700 Unit.
Cropping Patterns

Crop patterns/crop mix for field parcels on the MTA 700 Unit for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD) and are summarized in Table H1. The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. The annual cropping pattern for the MTA 700 Unit is mapped in Figures H2-H6, for years 2014-2018, respectively.

Table H1. Cropping Patterns/Crop Mix of the CRIT Farms MTA 700 Unit, 2014-2018

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated Crop Acreage</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
<th>Idle Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>465.8</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>4.2</td>
</tr>
<tr>
<td>2015</td>
<td>465.8</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>4.2</td>
</tr>
<tr>
<td>2016</td>
<td>465.8</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>4.2</td>
</tr>
<tr>
<td>2017</td>
<td>465.8</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>4.2</td>
</tr>
<tr>
<td>2018</td>
<td>465.8</td>
<td>33%</td>
<td>34%</td>
<td>0%</td>
<td>34%</td>
<td>0%</td>
<td>0%</td>
<td>4.2</td>
</tr>
<tr>
<td>Average</td>
<td>87%</td>
<td>7%</td>
<td>0%</td>
<td>7%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>4.2</td>
</tr>
</tbody>
</table>
Figure H2. Cropping Pattern on CRIT Farms MTA 700 Unit in 2014.
Figure H3. Cropping Pattern on CRIT Farms MTA 700 Unit in 2015.
Figure H4. Cropping Pattern on CRIT Farms MTA 700 Unit in 2016.
Figure H5. Cropping Pattern on CRIT Farms MTA 700 Unit in 2017.
Figure H6. Cropping Pattern on CRIT Farms MTA 700 Unit in 2018.
Estimated Crop Evapotranspiration

Table H2 below presents estimated annual and 5-year average reference ET₀ and crop ET (inches/year) for crops grown on the Reservation during the 5-year study period using weather data from the AZMET Parker No. 2 weather station.

Table H2. Annual and 5-year Average Reference ET₀ and crop ET (inches/year) for Reservation Crops for 2014-2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET₀</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.9</td>
<td>37.7</td>
<td>24.5</td>
<td>49.6</td>
<td>44.6</td>
<td>44.9</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.2</td>
<td>39.1</td>
<td>23.0</td>
<td>49.7</td>
<td>43.8</td>
<td>44.5</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.9</td>
<td>43.2</td>
<td>24.3</td>
<td>53.7</td>
<td>46.4</td>
<td>48.0</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.5</td>
<td>40.5</td>
<td>23.6</td>
<td>50.9</td>
<td>46.2</td>
<td>46.2</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>69.7</td>
<td>40.1</td>
<td>24.5</td>
<td>50.5</td>
<td>46.2</td>
<td>46.1</td>
</tr>
<tr>
<td>Average (in)</td>
<td></td>
<td>70.0</td>
<td>40.1</td>
<td>24.0</td>
<td>50.9</td>
<td>45.4</td>
<td>45.9</td>
</tr>
<tr>
<td>Average (af/ac)</td>
<td></td>
<td>5.84</td>
<td>3.34</td>
<td>2.00</td>
<td>4.24</td>
<td>3.79</td>
<td>3.83</td>
</tr>
</tbody>
</table>

¹ Reference evapotranspiration of a short crop similar to 12-cm tall grass.

Estimated Net Consumptive Irrigation Water Use and Diversion Requirement

Table H3 below presents reference ET₀, area-weighted average crop ET, effective precipitation, area-weighted average net consumptive use (NetCU), and associated diversion requirement (diversion reduction) for each year of the study period, and as an average of the 5-year period: 2014-18, based on the crop acreage and cropping pattern/mix discussed above. The estimated average annual unit area consumptive use on this Farm Unit for 2014-2018 is 5.50 AF/acre. The total estimated volume of water conserved due to the proposed fallowing of a maximum acreage of 465.8 acres on the Farm Unit is 2,562 AFY. Using an estimated average overall irrigation efficiency of 53.5%, the diversion requirement associated with this net water conservation is 4,789 AFY.
Table H3. Annual and 5-year Average Reference ET₀, Area Weighted Crop ET, Effective Precipitation, Area Weighted Net CU and Diversion Reduction for 2014-2018. CRIT Farms MTA 700 Unit.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET₀</th>
<th>Weighted Average Crop ET (ETa)</th>
<th>Effective Precip.</th>
<th>Weighted Average Net Consumptive Use</th>
<th>Net Crop Area Fallowed</th>
<th>Net Consumptive Use Demand</th>
<th>Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td></td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(ac)</td>
<td>(AF)</td>
<td>(AF)</td>
</tr>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.87</td>
<td>0.30</td>
<td>67.57</td>
<td>465.8</td>
<td>2,623</td>
<td>4,903</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.19</td>
<td>0.93</td>
<td>67.25</td>
<td>465.8</td>
<td>2,611</td>
<td>4,880</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.89</td>
<td>1.03</td>
<td>72.86</td>
<td>465.8</td>
<td>2,828</td>
<td>5,286</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.51</td>
<td>0.82</td>
<td>69.69</td>
<td>465.8</td>
<td>2,705</td>
<td>5,056</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>53.27</td>
<td>0.70</td>
<td>52.68</td>
<td>465.8</td>
<td>2,045</td>
<td>3,822</td>
</tr>
<tr>
<td>Average</td>
<td>77.26</td>
<td>66.75</td>
<td>0.76</td>
<td>66.01</td>
<td>465.8</td>
<td>2,562</td>
<td>4,789</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Max acreage</th>
<th>Unit area Net CU (AF/ac)</th>
<th>5.50</th>
</tr>
</thead>
</table>

1 Reference evapotranspiration of a short crop similar to 12-cm tall grass.
2 Estimated actual crop ET accounting for water stress and less than ideal growth conditions.
3 Weighted average calculated using irrigated acreages.
4 Column (8) divided by overall Project efficiency

Natural Resources Consulting Engineers, Inc. 23
The monthly distribution of the total average annual NetCU saving and total average annual diversion reduction for CRIT Farms MTA 700 Unit is presented in Table H4.


<table>
<thead>
<tr>
<th>Month</th>
<th>Average annual Alfalfa Crop ET (in) for period of analysis</th>
<th>Monthly Net Consumptive Use Demand</th>
<th>Monthly Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(inches)</td>
<td>% of total</td>
<td>(AF)</td>
</tr>
<tr>
<td>January</td>
<td>2.02</td>
<td>2.88%</td>
<td>73.9</td>
</tr>
<tr>
<td>February</td>
<td>3.57</td>
<td>5.09%</td>
<td>130.5</td>
</tr>
<tr>
<td>March</td>
<td>4.82</td>
<td>6.87%</td>
<td>176.1</td>
</tr>
<tr>
<td>April</td>
<td>6.83</td>
<td>9.74%</td>
<td>249.5</td>
</tr>
<tr>
<td>May</td>
<td>7.93</td>
<td>11.31%</td>
<td>289.9</td>
</tr>
<tr>
<td>June</td>
<td>9.09</td>
<td>12.96%</td>
<td>332.0</td>
</tr>
<tr>
<td>July</td>
<td>9.20</td>
<td>13.13%</td>
<td>336.3</td>
</tr>
<tr>
<td>August</td>
<td>8.71</td>
<td>12.42%</td>
<td>318.3</td>
</tr>
<tr>
<td>September</td>
<td>7.80</td>
<td>11.12%</td>
<td>285.0</td>
</tr>
<tr>
<td>October</td>
<td>4.40</td>
<td>6.28%</td>
<td>160.9</td>
</tr>
<tr>
<td>November</td>
<td>2.72</td>
<td>3.88%</td>
<td>99.3</td>
</tr>
<tr>
<td>December</td>
<td>3.03</td>
<td>4.32%</td>
<td>110.6</td>
</tr>
<tr>
<td>Annual</td>
<td>70.12</td>
<td>100.00%</td>
<td>2,562.3</td>
</tr>
</tbody>
</table>
References


TECHNICAL MEMORANDUM

Date: July 15, 2019

To: Tribal Council, Colorado River Indian Tribes (CRIT)

Cc: Rebecca Loudbear, Attorney General, CRIT
    Margaret Vick, Esq., Special Counsel

From: Natural Resources Consulting Engineers, Inc.

PROPOSED LANDS FOR COMPENSATED SYSTEM CONSERVATION PROGRAM (SCP) AND EXTRAORDINARY CONSERVATION INTENTIONALLY CREATED SURPLUS (EC ICS)

I. FARM UNIT: CRIT FARMS SHAWLER RANCH UNIT

Overview

This technical memorandum provides summary information and technical analyses for proposed temporary fallowing of irrigated farm land on the Colorado River Irrigation Project (Project) and other lands outside the boundary of the Project, Colorado River Indian Reservation, State of Arizona. The proposed fallowing is recommended for consideration under the Compensated System Conservation Program (SCP) and Extraordinary Conservation Intentionally Created Surplus Program (EC ICS). Temporary agricultural land fallowing is recognized by the Programs as means for reducing consumptive use to result in conserved water stored in Lake Mead. Parcels of land will be designated for fallowing on an annual basis and described in a Creation Plan. At the time of designation each parcel will have a history of irrigation for at least three out of the most recent five years. Each parcel may be designated for fallowing for no more than five consecutive years.

Under this proposal, the Colorado River Indian Tribes (CRIT) would temporarily fallow irrigated cropland on nine different Farm Units. Summary data and information regarding the location of each Farm Unit, the crops produced, irrigated crop acreage, estimated crop evapotranspiration, effective rainfall, net crop consumptive use, and estimated total irrigation...
diversion requirement averaged over the previous 5-year period for each Farm Unit is provided below. Fallowing is proposed to begin in calendar year 2019 and continue through 2022.

Project Description

CRIT proposes to forego irrigation water deliveries and reduce consumptive use of Colorado River water by temporarily fallowing irrigated cropland as described immediately below during the period 2019-2022. CRIT proposes to create Compensated System Conservation through fallowing of specific Farm Units and make the conserved water available to the Colorado River System to increase storage in Lake Mead during 2020-2022. CRIT proposes to create EC ICS through fallowing of specific Farm Units for various periods of time during 2019 and may designate part of the consumptive use not compensated as system conservation for EC ICS during 2020-2022.

Figure 1 is an overview map showing the locations of the Farm Units proposed for fallowing on the Colorado River Indian Reservation (Reservation) in the State of Arizona. The majority of these Farm Units are served by the Tribe’s Colorado River Irrigation Project (Project), which diverts Colorado River water for irrigation of about 80,000 acres of land on the Reservation. One Farm Unit is located outside of the Project service area and diverts water directly from the Colorado River by pumping.

Two of the proposed Farm Units are currently fallowed and participating in the Pilot System Conservation Program:

a. MTA 6627—October 1, 2018 to September 30, 2019
b. Quail Mesa 6808—January 1, 2019 to December 31, 2019

Estimated Conservation of Colorado River System Water

Estimated average annual consumptive use reduction due to fallowing, and the associated reductions in diversions at Headgate Rock Dam or by direct pumping for each Farm Unit are summarized in Table 1 below.

CRIT proposes to use the average annual consumptive use reduction during October-December for Unit MTA 6627 and the total average annual consumptive use reduction for Unit Rayner 9035 for EC ICS creation in 2019. CRIT proposes to use the sites listed in Table 1.
Figure 1. Overview of CRIT farm units proposed for fallowing for SC and EC ICS.

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**Summary of CRIT ICS for 2019**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Ave. Cropping Pattern</th>
<th>Net Consumptive Use</th>
<th>Efficiency Factor**</th>
<th>Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average AF/acre</td>
<td>Annual AFY</td>
<td>Annual AFY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6627*</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1084.0</td>
<td>80% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>1,470</td>
<td>0.501</td>
</tr>
<tr>
<td>9035**</td>
<td>Rayner</td>
<td>2013-17</td>
<td>1055.7</td>
<td>63% alfalfa 35% cotton 14% Bermuda (grass hay) 8% Sudan</td>
<td>4.55</td>
<td>4,804</td>
<td>0.501</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,940</td>
<td>6,274</td>
<td></td>
</tr>
</tbody>
</table>

* Oct 1 2019-Dec 31 2019 only
** estimates in this table for 9035 are based on 2013-2017 USGS cropping data

**Summary of CRIT System Conservation and ICS for 2020 (System Conservation in excess of 50,000 AF will be considered ICS)**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Ave. Cropping Pattern</th>
<th>Total Net Consumptive Use</th>
<th>Net Consumptive Use Proration</th>
<th>Diversion Reduction Proration</th>
<th>Total Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average AF/acre</td>
<td>Annual AFY</td>
<td>System Conservation AFY</td>
<td>EC ICS AFY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6627</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1084.0</td>
<td>80% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>10,157</td>
<td>9,450.7</td>
<td>706.3</td>
</tr>
<tr>
<td>6808</td>
<td>Quail Mesa</td>
<td>2014-18</td>
<td>3704.6</td>
<td>58% alfalfa 4% small grain 6% Bermuda (grass hay) 11% Sudan 21% Miscellaneous (onion, garlic, corn, potato)</td>
<td>4.89</td>
<td>18,130</td>
<td>16,869.7</td>
<td>1,260.6</td>
</tr>
<tr>
<td>6693</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1183.9</td>
<td>64% alfalfa 1% cotton 6% small grain 13% Bermuda (grass hay) 14% Sudan 21% Miscellaneous (onion, garlic, corn, potato)</td>
<td>4.97</td>
<td>5,886</td>
<td>5,476.3</td>
<td>409.2</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Victoria</td>
<td>2014-18</td>
<td>406.8</td>
<td>60% alfalfa 5% cotton 17% small grain 12% Bermuda (grass hay) 7% Sudan</td>
<td>4.61</td>
<td>1,877</td>
<td>1,746.5</td>
<td>130.5</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Friman</td>
<td>2014-18</td>
<td>674.7</td>
<td>52% alfalfa 26% cotton 15% small grain 4% Sudan</td>
<td>4.37</td>
<td>2,951</td>
<td>2,745.4</td>
<td>205.2</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>CRIT II</td>
<td>2014-18</td>
<td>1238.7</td>
<td>73% alfalfa 19% cotton 6% small grain 2% Miscellaneous (onion, garlic, corn, potato)</td>
<td>5.04</td>
<td>6,249</td>
<td>5,812.4</td>
<td>434.3</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>MTA 700</td>
<td>2014-18</td>
<td>465.8</td>
<td>86% alfalfa 7% cotton 7% Bermuda (grass hay)</td>
<td>5.50</td>
<td>2,562</td>
<td>2,383.8</td>
<td>178.1</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Shawler Ranch</td>
<td>2014-18</td>
<td>489.5</td>
<td>69% alfalfa 30% cotton 25% Sudan</td>
<td>5.02</td>
<td>2,206</td>
<td>2,052.9</td>
<td>153.4</td>
</tr>
<tr>
<td>9035***</td>
<td>Rayner</td>
<td>2013-17</td>
<td>788.0</td>
<td>52% alfalfa 32% cotton 12% Bermuda (grass hay) 4% Sudan</td>
<td>4.72</td>
<td>3,721</td>
<td>3,462</td>
<td>259</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td>10,786</td>
<td></td>
<td>10,786</td>
<td>53,734</td>
<td>50,000</td>
<td>3,734</td>
</tr>
</tbody>
</table>

* based on Project overall average irrigation efficiency equal to 52.5%
** based on Project CU Diversion ratio of 0.475 for 2018 using methodology designated in the LB Ops ICS Exhibit 8 for CRIT.
*** estimates in this table for 9035 are based on 2013-2017 USGS cropping data with linear move sprinkler area removed.
and, for System Conservation diversion reduction, an overall average irrigation efficiency for direct pumping from River equal to 60%
to create up to 50,000 AF/year of Compensated System Conservation with any excess over 50,000 AF/year designated as EC ICS during the period 2020. The same farm units listed in Table 1 or different farm units may be designated for fallowing in 2021 and 2022.

Methodology

This section provides a brief description of the data and methods used to estimate:

- the amount of water conserved due to fallowing of irrigated cropland on each Farm Unit for each year of analysis; this is the net consumptive irrigation water use savings due to the cropland fallowing; and,
- the associated irrigation water diversion required to provide that amount of water at the farm field.

Results are presented for each proposed Farm Unit in individual succeeding sub-sections of this technical memorandum.

Farm Unit Description and Location

Location data and legal description (PLSS) for each Farm Unit proposed for fallowing were obtained from CRIT Realty and/or CRIT Farms, the Tribal farming enterprise. This information generally included total gross and net acreage of the unit. Net irrigated crop acreage on each field of each Unit was determined using CRIT Water Resources Department (WRD) AGR05 field parcel polygon shapefile. The maximum net irrigated field acreage in any single year of the study period was used to determine the total volume of consumptive use savings due to fallowing.

Information on the Colorado River Irrigation Project (Project) irrigation delivery system was generally available from the US Bureau of Indian Affairs (BIA), the Federal agency that owns and operates the Project on behalf of CRIT. NRCE has prepared a detailed assessment of the Project (NRCE, 2016; NRCE, 2017).

Cropping Patterns

Crops typically produced on the Reservation include alfalfa (for hay), cotton, small grains (wheat, oats, barley), Bermuda and other grass hay, Sudan grass, and variety of minor miscellaneous crops (onions, garlic, corn, potato) (NRCE, 2016).
Crop patterns/crop mix for field parcels on the Farm Units for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD). The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. For Unit 9035, cropping pattern data were not available from the CRIT WRD. For this unit, cropping pattern data collected by the USGS for the period 2013-2017 were made available by the USBR (Jeremy Dodds, USBR, personal communication, July 12, 2019). Unit 9035 has not been farmed since May 2018, and thus 2018 is not included in the analysis. The USGS crop pattern data are 100% coverage, on the ground crop survey data collected annually on the Rayner unit for USBR during 2013-17. Cropping pattern/crop mix maps for all Farm Units for the respective years analyzed are included in the subsection for each Farm Unit. A table summarizing the cropping pattern/crop mix for each Farm Unit for each year and average for the period analyzed is included.

**Estimation of Consumptive Use**

The factors considered in estimating crop consumptive use include cropped area and cropping patterns, reference evapotranspiration, crop coefficients, and precipitation. Crop evapotranspiration (ETc) or crop consumptive use (crop CU) is defined as the evapotranspiration rate from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under given climatic conditions (Allen et al., 1998). Potential crop water use or crop evapotranspiration estimates for the period 1996 to present for the Colorado River Irrigation Project service area have been prepared (NRCE, 2016).

For the purposes of this study, ETc estimates using the single (mean) crop coefficient-reference evapotranspiration approach. Under this approach, reference crop evapotranspiration for a hypothetical green surface of actively transpiring vegetation is multiplied by a crop coefficient for a specific crop to estimate crop ET on a daily or monthly basis:

\[ \text{ET}_c = K_C \times \text{ET}_o \]

where:

\[ \text{ET}_c = \text{crop evapotranspiration (inches or mm)}; \]
The reference ET-crop coefficient method is widely used due to its simplicity, reproducibility, relatively good accuracy, and transportability among locations and climates.

For this analysis, reference ET (ET of an extensive area of short crop similar to 12-cm grass not short of water, ET₀) was computed using the ASCE Standardized Reference Evapotranspiration Equation (ASCE, 2005). The ASCE Standardized Reference ET Equation for a short (grass) reference surface is:

\[
ET₀ = \frac{0.408ΔR_n + γ \left( \frac{900}{T + 273} u_2 (e_s - e_a) \right)}{Δ + γ(1 + 0.34u_2)}
\]

where:

- \( ET₀ \) = standardized reference crop evapotranspiration for (grass) short crop
- \( Δ \) = slope of the saturation vapor pressure-temperature curve
- \( R_n \) = net radiation at the crop surface
- \( γ \) = psychrometric constant
- \( T \) = mean daily air temperature measured at 1.5-2 m above ground level
- \( u_2 \) = mean daily wind speed measured at 2 m above ground level
- \( e_s \) = saturation vapor pressure
- \( e_a \) = mean actual vapor pressure

This equation is the same as the ASCE Penman-Monteith Equation (Jensen et al., 1990 and Jensen and Allen, 2016) but with several simplifying “standardized” methods employed to compute several of the variables and parameters used in the Equation as given in ASCE (2005).

Jensen et al. (1990) report and summarize results of a comprehensive study comparing evapotranspiration estimates from different estimating methods to measurements of
evapotranspiration made at 11 different lysimeter sites around the world representing a wide range of climatic conditions from humid to arid, and elevations from below sea level to 9100 ft MSL. Nineteen methods were compared to lysimeter measurements on a monthly basis, and thirteen methods were compared on a daily basis. The ASCE Penman-Monteith method as given in Jensen et al. (1990) was determined to provide the overall best estimates of seasonal ET and average peak monthly ET with the least error as compared to lysimeter measurements across all ranges of climate and elevation.

The ASCE Reference ET Equation (ASCE, 2005) is a physically-based approach accounting for energy available for evaporation and aerodynamic transport of moisture away from the evaporating surface. Because of this physically-based formulation, it requires detailed weather measurements including air temperature, relative humidity, incoming total solar radiation, and wind speed. Such weather measurements are available from the Arizona Meteorological Network (AZMET) operated by the University of Arizona College of Agriculture and Live Sciences and Arizona Cooperative Extension (https://cals.arizona.edu/AZMET/). Two AZMET electronic weather stations are currently in operation in the Parker Valley and both stations are located on the Colorado River Indian Reservation (https://www.usbr.gov/lc/region/g4000/wtraacct.html):

- Parker No. 1 (site 8), Latitude 33.964296, Longitude -114.485501, Elev. 322 ft above MSL
- Parker No. 2 (site 35) Latitude 33.863015, Longitude -114.472974, Elev. 302 ft above MSL

Daily weather and ET₀ data from the AZMET Parker No. 2 Station for the respective 5-year period of analysis were used in this study (AZMET, 2013-2018).

The crop coefficient, Kc, integrates the effects/differences of specific crop characteristics that affect water use of the specific crop to the water use of the reference crop. This methodology for estimated crop ET assumes the crop is growing under ideal conditions, and not stressed for water or nutrients, and thus, is considered the potential crop ET or potential consumptive use. Actual crop ET in farm fields is typically less than potential crop ET due to factors such as water stress, salinity, insect and disease pressure, etc.

Daily crop coefficient values for the primary crops comprising around 90% of the total irrigated crop acreage [alfalfa, cotton, small grains (wheat, oats, rye, barley, millet), Bermuda hay,
Sudan grass) grown on the Reservation were obtained from reports on crop coefficients prepared for the USBR LCRAS (https://www.usbr.gov/1c/region/g4000/wtracct.html#LCRAS) program (Jensen, 1998 and Jensen, 2003). Several minor “miscellaneous” crops have been and currently are produced on small acreage on the Reservation. Over the period 2013-2018, these minor crops have comprised an average of only 3.52% of the total irrigated crop acreage on the Project. These include but are not limited to corn, onions, garlic, crucifers, lettuce, and other small vegetable and melon crops. Most often these crops are produced for seed (crucifers, lettuce) or dehydration (onion, garlic) or animal feed (corn silage) and not as fresh market produce. Crop coefficients for a “miscellaneous” crop category were assumed to be equal to the average of the primary crops. This process is explained in more detail in Appendix B of NRCE (2016).

In the case of alfalfa, Jensen (1998, Appendix C) recognized the published crop coefficients for alfalfa hay represent potential (maximum) alfalfa ET under conditions where harvest and removal of hay is not delayed, and crop water stress does not occur. Jensen (1998) estimated the coefficients were about 15% too high for normal farm practices when hay may not be removed right after cuttings, some water stress might occur, non-uniformity of crop conditions, etc. To adjust for these effects and provide alfalfa hay consumptive use estimates closer to actual conditions, Jensen (1998) applied a factor of 0.85 to the alfalfa hay crop coefficients.

The differences between actual ET occurring under the field conditions of the PROJECT and potential ET from crop coefficient-reference ET approach can be estimated using a remote sensing approach which allows for the determination of actual evapotranspiration from both vegetated and bare soil surfaces by solving the full surface energy balance using remotely sensed visible and thermal band data. While this type of study has not been performed on the Project service area, two such studies have been conducted on large irrigation districts in the region and the results provide some insight on the differences between actual and potential crop consumptive use that may be occurring on the Project:

- Clark et al. (2008) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different combinations of soils, on-farm irrigation method, and crop types, found on Imperial Irrigation District (IID). In this case, the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, 1998) and
LandSat satellite imagery with 30 m thermal resolution for water year 1998 was used to estimate actual ET. Potential ET was estimated using the dual crop coefficient approach presented in Allen et al. (1998). The results were presented as ratios of actual ET to potential ET. Across IID the average ratio was found to be 0.85. For graded border and graded furrow irrigation of mature alfalfa and new alfalfa on all soil types, the IID ratio of actual ET to potential ET ranged from 0.83 to 0.87.

- Elhaddad and Garcia (2014) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different crop types found on Palo Verde Irrigation District (PVID). In this case, actual ET was estimated using the ReSET Raster method (Elhaddad and Garcia, 2008) and LandSat 7 satellite imagery with 30 m thermal resolution for calendar year 2002. Potential ET was estimated using methods employed by the USBR in the Lower Colorado River Accounting System (LCRAS) (USBR, 1996-2014). The average ratio of actual ET to potential ET across PVID was found to be 0.86. For alfalfa, the ratio was found to be 0.86.

The results of these studies support the alfalfa hay crop coefficient adjustments suggested by Jensen (1998). Thus, for this analysis, alfalfa crop ET, as computed using the Jensen (1998, 2003) alfalfa crop coefficients (published coefficients multiplied by a factor of 0.85 to account for less than ideal growth conditions) was taken as an estimate of actual alfalfa crop ET. For Sudan, small grains, and grass hay, actual crop ET was estimated to be 0.85 times potential crop ET. For cotton and higher value minor miscellaneous crops (garlic, onion, potato) a factor of 1.00 was assumed.

Growing season durations of the various crops are implicit in the daily crop coefficients prepared by Jensen (1998, 2003) and were adopted for this analysis.

The net irrigation water requirement (NIR) or net consumptive irrigation water use (NetCU) represents the quantity of water required at the farm field to supply the estimated irrigation water demand of a crop during its growth period over and above the amount of natural precipitation water available for crop use. NIR or NetCU is computed as the crop ET minus the effective precipitation. Effective precipitation is that portion of total precipitation which is available for crop use. NRCE
adopted the flat monthly multiplier approach to estimate effective precipitation (Jensen, 1993) as used in USBR LCRAS reporting of crop water use. Average annual precipitation measured at the AZMET Parker No. 2 Station is 3.96 inches for the period: 2014-2018 (AZMET, 2013-2018). Using the LCRAS method, effective precipitation on the Reservation is about 0.76 inches per year, or just less than about 20 percent of average annual precipitation, for the 2014-2018 period at this location.

For each year analyzed, the weighted average NIR or NetCU was determined based on acreages of the individual crop types and the NIR or NetCU of each crop for that year. Using this result, an overall average unit area net crop consumptive irrigation water use (AF/ac) for the 5-year study period was determined. This 5-year average unit area net crop consumptive irrigation water use is listed for each Farm Unit in Table 1. The 5-year average unit area net crop consumptive irrigation water use is multiplied by the maximum (for the 5-year study period) annual acres irrigated for the Farm Unit to determine the total volume of NetCU due to fallowing and listed for each parcel in Table 1.

**Diversion Requirements**

NRCE (2017) has performed water balance analyses at the conveyance/delivery system level to estimate the magnitude of conveyance system losses (seepage, evaporation, and operational spills) experienced with the current infrastructure and operational management of the Project. Farm gate deliveries were estimated. These analyses allowed an assessment of conveyance/delivery system efficiency. As well, farm field level water balance analyses comparing net crop irrigation water requirements (NIR) to the estimated field level supplies or farmgate deliveries were performed. These comparisons allowed an assessment of on-farm losses to ditch seepage, deep percolation and tailwater runoff and estimation of on-farm efficiency. The overall assessment comparing net crop irrigation water requirements (NIR) to diversions allowed estimation of Project irrigation efficiency.

For the proposed Farm Units served by the Project, the total irrigation diversion requirement at Headgate Rock Dam corresponding to the Farm Unit net consumptive irrigation water use was estimated by dividing the farm field (NIR or NetCU) by the estimated project irrigation efficiency (product of irrigation delivery system conveyance efficiency and on-farm application efficiency).
For the purposes of these analyses, an overall Project irrigation efficiency of 53.5% was applied (NRCE, 2017).

Farm Unit 9035 is not served by the Project. This site diverts irrigation water by pumping directly from the Colorado River. Water is distributed across the farm using concrete lined ditches. Irrigation for the period of study 2013-17 was by flood (low gradient border and furrow) irrigation, although in years prior to this period linear move sprinklers were used on parts of the lease, and CRIT’s future plans include leasing parts of the unit and irrigating with the linear move sprinkler again. An average application efficiency of about 65-66% for border and furrow irrigation on the Reservation is used. For Unit 9035, the conveyance losses to seepage and operational spill are minor compared to the Project. A conservative conveyance efficiency of 90% is assigned on this unit. This results in an irrigation efficiency estimate of 60% for the unit.

**Monthly Distribution**

The annual cropping patterns found for each Farm Unit illustrate varying acreages of the primary crops from year to year and from Unit to Unit. To normalize this variability, monthly distributions of the total average annual NetCU savings and total average annual diversion reductions for each Farm Unit were determined by computing a monthly proportion of the total annual volume based on the 5-year average monthly and annual alfalfa crop evapotranspiration computed using reference crop $E_{T_0}$ from the AZMET Parker No. 2 electronic weather station and LCRAS crop coefficients for alfalfa.

**Verification**

During the fallowing period, in order to ensure that any vegetation remaining on the fallowed lands does not consumptively use Colorado River water by drawing water from the Colorado River aquifer, CRIT shall, at its expense, control and eradicate any green vegetation growth.

Weed control will likely performed using chemical applications. Records of weed control applications, including date, chemicals used, rates of application, etc. will be prepared and maintained. CRIT agrees to provide Reclamation, Arizona Department of Water Resources, and other applicable entities, with information and updates, when requested, regarding the vegetation eradication program. Stubble from previous cropping will be kept on field surface to the extent
possible to reduce wind erosion. USBR personnel will be granted access to the Farms to perform periodic on-site inspections to verify compliance.

The means of irrigation water deliveries to each Farm Unit proposed for fallowing are described for each respective Unit. Irrigation water deliveries can be completely curtailed through control of farm gate turnouts or through control of sublateral head gates. CRIT agrees to furnish and install padlocks to lock the farm gate turnouts on fields fallowed to the extent possible to do so. In the event that a turnout serves multiple fields of which not all are being fallowed, other practical mechanisms, including but not limited to, dirt berms in the portion of the irrigation ditch serving the fallowed field, or sealing the on-farm turnouts onto fallowed fields will be used to the extent possible to assure that no water deliveries can be made onto the fallowed fields.

**Verification of Conserved Water Diversion Reduction from Approved Water Order**

Total estimated diversion requirements on monthly and annual time steps for the actively irrigated areas of the proposed Farm Units that will be fallowed have been estimated. CRIT’s annual water order (as determined and approved through the 43 CFR, Part 417 (Part 417) consultation between the BIA, US Bureau of Reclamation and CRIT) will be reduced by the estimated annual diversion requirements of the Farm Units for the agreed fallowing periods. Estimated monthly net consumptive use and diversion requirements of the Farm Units have also been determined. These monthly estimates allow determination of partial year water conservation and diversion reductions when fallowing periods are not a full 12-month period. Total annual CRIT Project and other Arizona diversions (with the fallowing and diversion reduction in progress) will not exceed CRIT’s Colorado River annual water right allocation for Arizona as adjusted by the diversion reductions, and thereby avoid inadvertent overruns (diversions in excess of CRIT’s adjusted entitlement—decree AZ water right less the estimated diversion requirements of the fallowing program).

For Unit 9035, which diverts by direct pumping of water from the Colorado River, conserved water diversion reduction can be verified through routine monitoring of the electric power meter readings and account for the Unit’s pumping facilities.
I. Farm Unit: CRIT Farms Shawler Ranch Unit

Farm Description and Location

The CRIT Farms Shawler Ranch Unit is located on the Colorado River Indian Reservation within the Project service area with field parcels located within Sections 25, 27 and 34 Township 7N Range 21W (Gila and Salt River Meridian), La Paz County, Arizona. The Shawler Ranch Unit is not one contiguous block but contains three separate subunits (8 parcels in Section 25, 2 parcels in Section 27, and 3 parcels in Section 34). It is generally bounded by Navajo Road on the south, Peterson Road on the north and 14th Avenue on the west and 10th Avenue on the east. Figure 11 is an overview map of the Unit. Gross area of the unit is about 454.9 acres. A maximum of 439.5 net field acres have been in irrigated crop production for at least the past 5 years. The acreage not in production is idle or occupied by hay and equipment storage yards, roads, canals, and drains.

The irrigated cropland on the Shawler Ranch Unit is served primarily by sub-laterals 73-36 and 73-36-7 of the Project. Other farm units are served by these sub-laterals and thus they cannot be turned off at the head gate or another upstream check structure. Farm gate turnouts on the sub-laterals serving the Shawler Ranch Unit (subunits) will be chained and locked.

CRIT Water Resources Dept. provided geospatial data (AGR05 shapefile and associated attribute table) of delineated irrigated field parcels across the Project. A total of up to 13 irrigated field parcels were identified within the actively irrigated area of the Unit (see Figure 11). Background aerial imagery in Figure H1 is dated 2017 and from the USDA National Agriculture Aerial Imagery Program (NAIP): (http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/). The CRIT field parcel delineations were found to show good agreement with the NAIP aerial imagery.
Figure 11. Overview Map of CRIT Farms Shawler Ranch Unit.
Cropping Patterns

Crop patterns/crop mix for field parcels on the Shawler Ranch Unit for the years 2014-2018 inclusive were available from CRIT Farms and are summarized in Table II. The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. The annual cropping pattern for the Shawler Ranch Unit is mapped in Figures 12-16, for years 2014-2018, respectively.

Table II. Cropping Patterns/Crop Mix of the CRIT Farms Shawler Ranch Unit, 2014-2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated Crops</th>
<th>Alfalfa - Perennial</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
<th>Idle Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>439.5</td>
<td>72%</td>
<td>28%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>15.4</td>
</tr>
<tr>
<td>2015</td>
<td>439.5</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>15.4</td>
</tr>
<tr>
<td>2016</td>
<td>424.5</td>
<td>63%</td>
<td>37%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>30.4</td>
</tr>
<tr>
<td>2017</td>
<td>424.5</td>
<td>55%</td>
<td>37%</td>
<td>0%</td>
<td>0%</td>
<td>8%</td>
<td>0%</td>
<td>30.4</td>
</tr>
<tr>
<td>2018</td>
<td>424.5</td>
<td>55%</td>
<td>45%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>30.4</td>
</tr>
<tr>
<td>Average</td>
<td>69%</td>
<td>30%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>
Figure 12. Cropping Pattern on CRIT Farms Shawler Ranch Unit in 2014.
Figure 13. Cropping Pattern on CRIT Farms Shawler Ranch Unit in 2015.
Figure 14. Cropping Pattern on CRIT Farms Shawler Ranch Unit in 2016.
Figure 15. Cropping Pattern on CRIT Farms Shawler Ranch Unit in 2017.
Figure 16. Cropping Pattern on CRIT Farms Shawler Ranch Unit in 2018.
Estimated Crop Evapotranspiration

Table I2 below presents estimated annual and 5-year average reference ET₀ and crop ET (inches/year) for crops grown on the Reservation during the 5-year study period using weather data from the AZMET Parker No. 2 weather station.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET₀¹</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.9</td>
<td>37.7</td>
<td>24.5</td>
<td>49.6</td>
<td>44.6</td>
<td>44.9</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.2</td>
<td>39.1</td>
<td>23.0</td>
<td>49.7</td>
<td>43.8</td>
<td>44.5</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.9</td>
<td>43.2</td>
<td>24.3</td>
<td>53.7</td>
<td>46.4</td>
<td>48.0</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.5</td>
<td>40.5</td>
<td>23.6</td>
<td>50.9</td>
<td>46.2</td>
<td>46.2</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>69.7</td>
<td>40.1</td>
<td>24.5</td>
<td>50.5</td>
<td>46.2</td>
<td>46.1</td>
</tr>
<tr>
<td>Average (in)</td>
<td>70.0</td>
<td>40.1</td>
<td>24.0</td>
<td>50.9</td>
<td>45.4</td>
<td>45.9</td>
<td></td>
</tr>
<tr>
<td>Average (af/ac)</td>
<td>5.84</td>
<td>3.34</td>
<td>2.00</td>
<td>4.24</td>
<td>3.79</td>
<td>3.83</td>
<td></td>
</tr>
</tbody>
</table>

¹Reference evapotranspiration of a short crop similar to 12-cm tall grass.

Estimated Net Consumptive Irrigation Water Use and Diversion Requirement

Table I3 below presents reference ET₀, area-weighted average crop ET, effective precipitation, area-weighted average net consumptive use (NetCU), and associated diversion requirement (diversion reduction) for each year of the study period, and as an average of the 5-year period: 2014-18, based on the crop acreage and cropping pattern/mix discussed above. The estimated average annual unit area consumptive use on this Farm Unit for 2014-2018 is 5.02 AF/ac. The total estimated volume of water conserved due to the proposed fallowing of a maximum acreage of 439.5 acres on the Farm Unit is 2,206 AFY. Using an estimated average overall irrigation efficiency of 53.5%, the diversion requirement associated with this net water conservation is 4,124 AFY.
Table 13. Annual and 5-year Average Reference ET, Area Weighted Crop ET, Effective Precipitation, Area Weighted Net CU and Diversion Reduction for 2014-2018. CRIT Farms Shawler Ranch Unit.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET&lt;sub&gt;0&lt;/sub&gt;</th>
<th>Weighted Average Actual Crop ET (ET&lt;sub&gt;a&lt;/sub&gt;)&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Effective Precip.</th>
<th>Net Actual Consumptive Use</th>
<th>Net Crop Area Fallowed</th>
<th>Net Actual Consumptive Use Demand&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Diversion Reduction at Headgate Rock Dam (AF)&lt;sup&gt;4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
</tr>
<tr>
<td></td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(ac)</td>
<td>(AF)</td>
<td>(AF)</td>
</tr>
<tr>
<td>2014</td>
<td>75.11</td>
<td>59.42</td>
<td>0.30</td>
<td>59.18</td>
<td>439.5</td>
<td>2,168</td>
<td>4,052</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.19</td>
<td>0.93</td>
<td>67.25</td>
<td>439.5</td>
<td>2,463</td>
<td>4,604</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>62.40</td>
<td>1.03</td>
<td>61.73</td>
<td>424.5</td>
<td>2,184</td>
<td>4,082</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>57.46</td>
<td>0.82</td>
<td>57.00</td>
<td>424.5</td>
<td>2,017</td>
<td>3,769</td>
</tr>
<tr>
<td>2018</td>
<td>76.38</td>
<td>56.38</td>
<td>0.70</td>
<td>55.83</td>
<td>424.5</td>
<td>1,975</td>
<td>3,691</td>
</tr>
<tr>
<td>Average</td>
<td>77.26</td>
<td>60.77</td>
<td>0.76</td>
<td>60.20</td>
<td>430.5</td>
<td>2,161</td>
<td>4,040</td>
</tr>
</tbody>
</table>

1 Reference evapotranspiration of a short crop similar to 12-cm tall grass.
2 Estimated actual crop ET accounting for water stress and less than ideal growth conditions.
   Weighted average calculated using irrigated acreages.
3 Column (5) divided by 12 and multiplied by Column (6)
4 Column (8) divided by overall Project efficiency
The monthly distribution of the total average annual NetCU saving and total average annual diversion reduction for CRIT Farms Shawler Ranch Unit is presented in Table I4.


<table>
<thead>
<tr>
<th>Month</th>
<th>Mean annual Alfalfa Crop ET (in) for period of analysis</th>
<th>% of total</th>
<th>Monthly Net Actual Consumptive Use Demand (AF)</th>
<th>Monthly Diversion Reduction at Headgate Rock Dam (AF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>2.02</td>
<td>2.88%</td>
<td>63.6</td>
<td>118.9</td>
</tr>
<tr>
<td>February</td>
<td>3.57</td>
<td>5.09%</td>
<td>112.4</td>
<td>210.0</td>
</tr>
<tr>
<td>March</td>
<td>4.82</td>
<td>6.87%</td>
<td>151.6</td>
<td>283.4</td>
</tr>
<tr>
<td>April</td>
<td>6.83</td>
<td>9.74%</td>
<td>214.8</td>
<td>401.6</td>
</tr>
<tr>
<td>May</td>
<td>7.93</td>
<td>11.31%</td>
<td>249.6</td>
<td>466.6</td>
</tr>
<tr>
<td>June</td>
<td>9.09</td>
<td>12.96%</td>
<td>285.9</td>
<td>534.4</td>
</tr>
<tr>
<td>July</td>
<td>9.20</td>
<td>13.13%</td>
<td>289.6</td>
<td>541.3</td>
</tr>
<tr>
<td>August</td>
<td>8.71</td>
<td>12.42%</td>
<td>274.1</td>
<td>512.3</td>
</tr>
<tr>
<td>September</td>
<td>7.80</td>
<td>11.12%</td>
<td>245.4</td>
<td>458.7</td>
</tr>
<tr>
<td>October</td>
<td>4.40</td>
<td>6.28%</td>
<td>138.5</td>
<td>258.9</td>
</tr>
<tr>
<td>November</td>
<td>2.72</td>
<td>3.88%</td>
<td>85.5</td>
<td>159.9</td>
</tr>
<tr>
<td>December</td>
<td>3.03</td>
<td>4.32%</td>
<td>95.3</td>
<td>178.1</td>
</tr>
<tr>
<td>Annual</td>
<td>70.12</td>
<td>100.00%</td>
<td>2,206.4</td>
<td>4,124.0</td>
</tr>
</tbody>
</table>
References


TECHNICAL MEMORANDUM

Date: July 15, 2019

To: Tribal Council, Colorado River Indian Tribes (CRIT)

Cc: Rebecca Loudbear, Attorney General, CRIT
Margaret Vick, Esq., Special Counsel

From: Natural Resources Consulting Engineers, Inc.

PROPOSED LANDS FOR COMPENSATED SYSTEM CONSERVATION PROGRAM (SCP) AND EXTRAORDINARY CONSERVATION INTENTIONALLY CREATED SURPLUS (ECICS)

E. Farm Unit: CRIT Farms Victorio Unit

Overview

This technical memorandum provides summary information and technical analyses for proposed temporary fallowing of irrigated farm land on the Colorado River Irrigation Project (Project) and other lands outside the boundary of the Project, Colorado River Indian Reservation, State of Arizona. The proposed fallowing is recommended for consideration under the Compensated System Conservation (SC) Program and Extraordinary Conservation Intentionally Created Surplus (ECICS) Program. Temporary agricultural land fallowing is recognized by the Programs as means for reducing consumptive use to result in conserved water stored in Lake Mead. Parcels of land will be designated for fallowing on an annual basis and described in a Creation Plan. At the time of designation each parcel will have a history of irrigation for at least three out of the most recent five years. Each parcel may be designated for fallowing for no more than five consecutive years.

Under this proposal, the Colorado River Indian Tribes (CRIT) would temporarily fallow irrigated cropland on nine different Farm Units. Summary data and information regarding the location of each Farm Unit, the crops produced, irrigated crop acreage, estimated crop evapotranspiration, effective rainfall, net crop consumptive use, and estimated total irrigation...
diversion requirement averaged over the previous 5-year period for each Farm Unit is provided below. Fallowing is proposed to begin in calendar year 2019 and continue through 2022.

Project Description

CRIT proposes to forego irrigation water deliveries and reduce consumptive use of Colorado River water by temporarily fallowing irrigated cropland as described immediately below during the period 2019-2022. CRIT proposes to create Compensated System Conservation through fallowing of specific Farm Units and make the conserved water available to the Colorado River System to increase storage in Lake Mead during 2020-2022. CRIT proposes to create EC ICS through fallowing of specific Farm Units for various periods of time during 2019 and may designate part of the consumptive use not compensated as system conservation for EC ICS during 2020-2022.

Figure 1 is an overview map showing the locations of the Farm Units proposed for fallowing on the Colorado River Indian Reservation (Reservation) in the State of Arizona. The majority of these Farm Units are served by the Tribe’s Colorado River Irrigation Project (Project), which diverts Colorado River water for irrigation of about 80,000 acres of land on the Reservation. One Farm Unit is located outside of the Project service area and diverts water directly from the Colorado River by pumping.

Two of the proposed Farm Units are currently fallowed and participating in the Pilot System Conservation Program:

a. MTA 6627—October 1, 2018 to September 30, 2019
b. Quail Mesa 6808—January 1, 2019 to December 31, 2019

Estimated Conservation of Colorado River System Water

Estimated average annual consumptive use reduction due to fallowing, and the associated reductions in diversions at Headgate Rock Dam or by direct pumping for each Farm Unit are summarized in Table 1 below.

CRIT proposes to use the average annual consumptive use reduction during October-December for Unit MTA 6627 and the total average annual consumptive use reduction for Unit Rayner 9035 for EC ICS creation in 2019. CRIT proposes to use all sites listed in Table 1
Figure 1. Overview of CRIT farm units proposed for following for SC and EC ICS.

### Summary of CRIT ICS for 2019

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Ave. Cropping Pattern</th>
<th>Net Consumptive Use</th>
<th>Efficiency Factor*</th>
<th>Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average AF/acre</td>
<td>Annual AFY</td>
<td>Annual AFY</td>
</tr>
<tr>
<td>6627*</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1884.0</td>
<td>80% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>1,470</td>
<td>0.501</td>
</tr>
<tr>
<td>9035**</td>
<td>Rayner</td>
<td>2013-17</td>
<td>1055.7</td>
<td>53% alfalfa 35% cotton 14% Bermuda (grass hay) 8% Sudan</td>
<td>4.55</td>
<td>4,804</td>
<td>0.501</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,840</td>
<td>6,274</td>
<td></td>
</tr>
</tbody>
</table>

* Oct 1 2019-Dec 31 2019 only  
** estimates in this table for 9035 are based on 2013-2017 USGS cropping data

### Summary of CRIT System Conservation and ICS for 2020 (System Conservation in excess of 50,000 AF will be considered ICS).

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Ave. Cropping Pattern</th>
<th>Total Net Consumptive Use</th>
<th>Net Consumptive Use Proration</th>
<th>System Conservation AFY</th>
<th>EC ICS AFY</th>
<th>System Conservation* AFY</th>
<th>EC ICS** AFY</th>
<th>Total Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average AF/acre</td>
<td>Annual AFY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6627</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1884.0</td>
<td>80% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>10,157</td>
<td>9,459.7</td>
<td>706.2</td>
<td>17,664.8</td>
<td>1,486.7</td>
<td>19,152</td>
</tr>
<tr>
<td>6808</td>
<td>Quail Mesa</td>
<td>2014-18</td>
<td>3704.6</td>
<td>58% alfalfa 4% small grain 6% Bermuda (grass hay) 11% Sudan 21% Miscellaneous (onion, garlic, com, potato)</td>
<td>4.89</td>
<td>18,130</td>
<td>16,899.7</td>
<td>1,260.6</td>
<td>31,532.2</td>
<td>2,653.9</td>
<td>34,186</td>
</tr>
<tr>
<td>6693</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1183.9</td>
<td>64% alfalfa 1% cotton 6% small grain 13% Bermuda (grass hay) 14% Sudan 21% Miscellaneous (onion, garlic, com, potato)</td>
<td>4.97</td>
<td>5,886</td>
<td>5,476.3</td>
<td>409.2</td>
<td>10,236.1</td>
<td>861.5</td>
<td>11,098</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Victorio</td>
<td>2014-18</td>
<td>406.8</td>
<td>60% alfalfa 5% cotton 17% small grain 12% Bermuda (grass hay) 5% Sudan</td>
<td>4.61</td>
<td>1,877</td>
<td>1,748.5</td>
<td>130.5</td>
<td>3,264.4</td>
<td>274.7</td>
<td>3,539</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Frimann</td>
<td>2014-18</td>
<td>674.7</td>
<td>52% alfalfa 35% cotton 18% small grain 4% Sudan</td>
<td>4.37</td>
<td>2,951</td>
<td>2,745.4</td>
<td>205.2</td>
<td>5,131.7</td>
<td>431.9</td>
<td>5,564</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>CRIT II</td>
<td>2014-18</td>
<td>1238.7</td>
<td>73% alfalfa 19% cotton 6% small grain 2% Miscellaneous (onion, garlic, com, potato)</td>
<td>5.04</td>
<td>6,247</td>
<td>5,812.4</td>
<td>434.3</td>
<td>10,864.4</td>
<td>914.4</td>
<td>11,779</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>MTA 700</td>
<td>2014-18</td>
<td>465.8</td>
<td>85% alfalfa 7% cotton 7% Bermuda (grass hay)</td>
<td>5.50</td>
<td>2,562</td>
<td>2,343.8</td>
<td>178.1</td>
<td>4,455.7</td>
<td>372.0</td>
<td>4,831</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Shawler Ranch</td>
<td>2014-18</td>
<td>439.5</td>
<td>69% alfalfa 30% cotton 2% Sudan</td>
<td>5.02</td>
<td>2,206</td>
<td>2,052.9</td>
<td>153.4</td>
<td>3,837.2</td>
<td>323.0</td>
<td>4,160</td>
</tr>
<tr>
<td>9035**</td>
<td>Rayner</td>
<td>2013-17</td>
<td>788.0</td>
<td>52% alfalfa 32% cotton 12% Bermuda (grass hay) 4% Sudan</td>
<td>4.72</td>
<td>3,721</td>
<td>3,462</td>
<td>259</td>
<td>5,770</td>
<td>545</td>
<td>6,315</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10,786</td>
<td>33,714</td>
<td>30,000</td>
<td>3,734</td>
<td>82,757</td>
<td>7,866</td>
<td>100,623</td>
</tr>
</tbody>
</table>

* based on Project overall average irrigation efficiency equal to 53.5%  
** based on Project CU/Diversion ratio of 1.475 for 2018 using methodology designated in the LBOps ICS Exhibit S for CRIT.  
*** estimates in this table for 9035 are based on 2013-2017 USGS cropping data with linear move sprinkler area removed;  
and, for System Conservation diversion reduction, an overall average irrigation efficiency for direct pumping from River equal to 60%
to create up to 50,000 AF/year of Compensated System Conservation with any excess over 50,000 AF/year designated as EC ICS during the period 2020. The same farm units listed in Table 1 or different farm units may be designated for fallowing in 2021 and 2022.

Methodology

This section provides a brief description of the data and methods used to estimate:

- the amount of water conserved due to fallowing of irrigated cropland on each Farm Unit for each year of analysis; this is the net consumptive irrigation water use savings due the cropland fallowing; and,

- the associated irrigation water diversion required to provide that amount of water at the farm field.

Results are presented for each proposed Farm Unit in individual succeeding sub-sections of this technical memorandum.

Farmland Description and Location

Location data and legal description (PLSS) for each Farm Unit proposed for fallowing were obtained from CRIT Realty and/or CRIT Farms, the Tribal farming enterprise. This information generally included total gross and net acreage of the unit. Net irrigated crop acreage on each field of each Unit was determined using CRIT Water Resources Department (WRD) AGR05 field parcel polygon shapefile. The maximum net irrigated field acreage in any single year of the study period was used to determine the total volume of consumptive use savings due to fallowing.

Information on the Colorado River Irrigation Project (Project) irrigation delivery system was generally available from the US Bureau of Indian Affairs (BIA), the Federal agency that owns and operates the Project on behalf of CRIT. NRCE has prepared a detailed assessment of the Project (NRCE, 2016; NRCE, 2017).

Cropping Patterns

Crops typically produced on the Reservation include alfalfa (for hay), cotton, small grains (wheat, oats, barley), Bermuda and other grass hay, Sudan grass, and variety of minor miscellaneous crops (onions, garlic, corn, potato) (NRCE, 2016).
Crop patterns/crop mix for field parcels on the Farm Units for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD). The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. For Unit 9035, cropping pattern data were not available from the CRIT WRD. For this unit, cropping pattern data collected by the USGS for the period 2013-2017 were made available by the USBR (Jeremy Dodds, USBR, personal communication, July 12, 2019). Unit 9035 has not been farmed since May 2018, and thus 2018 is not included in the analysis. The USGS crop pattern data are 100% coverage, on the ground crop survey data collected annually on the Rayner unit for USBR during 2013-17. Cropping pattern/crop mix maps for all Farm Units for the respective years analyzed are included in the subsection for each Farm Unit. A table summarizing the cropping pattern/crop mix for each Farm Unit for each year and average for the period analyzed is included.

Estimation of Consumptive Use

The factors considered in estimating crop consumptive use include cropped area and cropping patterns, reference evapotranspiration, crop coefficients, and precipitation. Crop evapotranspiration (ET<sub>c</sub>) or crop consumptive use (crop CU) is defined as the evapotranspiration rate from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under given climatic conditions (Allen et al., 1998). Potential crop water use or crop evapotranspiration estimates for the period 1996 to present for the Colorado River Irrigation Project service area have been prepared (NRCE, 2016).

For the purposes of this study, ET<sub>c</sub> estimates using the single (mean) crop coefficient-reference evapotranspiration approach. Under this approach, reference crop evapotranspiration for a hypothetical green surface of actively transpiring vegetation is multiplied by a crop coefficient for a specific crop to estimate crop ET on a daily or monthly basis:

\[
ET_c = K_c \times ET_o
\]

where:

\[
ET_c \quad = \quad \text{crop evapotranspiration (inches or mm)};
\]
$K_c = \text{crop coefficient (dimensionless)}$;

$ET_o = \text{grass reference crop evapotranspiration (inches or mm)}$

The reference ET-crop coefficient method is widely used due to its simplicity, reproducibility, relatively good accuracy, and transportability among locations and climates.

For this analysis, reference ET (ET of an extensive area of short crop similar to 12-cm grass not short of water, ET$_o$) was computed using the ASCE Standardized Reference Evapotranspiration Equation (ASCE, 2005). The ASCE Standardized Reference ET Equation for a short (grass) reference surface is:

$$ET_o = \frac{0.408 \Delta R_n + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34 u_2)}$$

where:

$ET_o = \text{standardized reference crop evapotranspiration for (grass) short crop}$

$\Delta = \text{slope of the saturation vapor pressure-temperature curve}$

$R_n = \text{net radiation at the crop surface}$

$\gamma = \text{psychrometric constant}$

$T = \text{mean daily air temperature measured at 1.5-2 m above ground level}$

$u_2 = \text{mean daily wind speed measured at 2 m above ground level}$

$e_s = \text{saturation vapor pressure}$

$e_a = \text{mean actual vapor pressure}$

This equation is the same as the ASCE Penman-Monteith Equation (Jensen et al., 1990 and Jensen and Allen, 2016) but with several simplifying “standardized” methods employed to compute several of the variables and parameter used in the Equation as given in ASCE (2005).

Jensen et al. (1990) report and summarize results of a comprehensive study comparing evapotranspiration estimates from different estimating methods to measurements of
Evapotranspiration made at 11 different lysimeter sites around the world representing a wide range of climatic conditions from humid to arid, and elevations from below sea level to 9100 ft MSL. Nineteen methods were compared to lysimeter measurements on a monthly basis, and thirteen methods were compared on a daily basis. The ASCE Penman-Monteith method as given in Jensen et al. (1990) was determined to provide the overall best estimates of seasonal ET and average peak monthly ET with the least error as compared to lysimeter measurements across all ranges of climate and elevation.

The ASCE Reference ET Equation (ASCE, 2005) is a physically-based approach accounting for energy available for evaporation and aerodynamic transport of moisture away from the evaporating surface. Because of this physically-based formulation, it requires detailed weather measurements including air temperature, relative humidity, incoming total solar radiation, and wind speed. Such weather measurements are available from the Arizona Meteorological Network (AZMET) operated by the University of Arizona College of Agriculture and Live Sciences and Arizona Cooperative Extension (https://cals.arizona.edu/AZMET/). Two AZMET electronic weather stations are currently in operation in the Parker Valley and both stations are located on the Colorado River Indian Reservation (https://www.usbr.gov/lc/region/g4000/wtracct.html):

Parker No. 1 (site 8), Latitude 33.964296, Longitude -114.485501, Elev. 322 ft above MSL
Parker No. 2 (site 35) Latitude 33.863015, Longitude -114.472974, Elev. 302 ft above MSL

Daily weather and ET₀ data from the AZMET Parker No. 2 Station for the respective 5-year period of analysis were used in this study (AZMET, 2013-2018).

The crop coefficient, Kc, integrates the effects/differences of specific crop characteristics that affect water use of the specific crop to the water use of the reference crop. This methodology for estimated crop ET assumes the crop is growing under ideal conditions, and not stressed for water or nutrients, and thus, is considered the potential crop ET or potential consumptive use. Actual crop ET in farm fields is typically less than potential crop ET due to factors such as water stress, salinity, insect and disease pressure, etc.

Daily crop coefficient values for the primary crops comprising around 90% of the total irrigated crop acreage [alfalfa, cotton, small grains (wheat, oats, rye, barley, millet), Bermuda hay,
Sudan grass) grown on the Reservation were obtained from reports on crop coefficients prepared for the USBR LCRAS (https://www.usbr.gov/1c/region/g4000/wtracct.html#LCRAS) program (Jensen, 1998 and Jensen, 2003). Several minor “miscellaneous” crops have been and currently are produced on small acreage on the Reservation. Over the period 2013-2018, these minor crops have comprised an average of only 3.52% of the total irrigated crop acreage on the Project. These include but are not limited to corn, onions, garlic, crucifers, lettuce, and other small vegetable and melon crops. Most often these crops are produced for seed (crucifers, lettuce) or dehydration (onion, garlic) or animal feed (corn silage) and not as fresh market produce. Crop coefficients for a “miscellaneous” crop category were assumed to be equal to the average of the primary crops. This process is explained in more detail in Appendix B of NRCE (2016).

In the case of alfalfa, Jensen (1998, Appendix C) recognized the published crop coefficients for alfalfa hay represent potential (maximum) alfalfa ET under conditions where harvest and removal of hay is not delayed, and crop water stress does not occur. Jensen (1998) estimated the coefficients were about 15% too high for normal farm practices when hay may not be removed right after cuttings, some water stress might occur, non-uniformity of crop conditions, etc. To adjust for these effects and provide alfalfa hay consumptive use estimates closer to actual conditions, Jensen (1998) applied a factor of 0.85 to the alfalfa hay crop coefficients.

The differences between actual ET occurring under the field conditions of the PROJECT and potential ET from crop coefficient-reference ET approach can be estimated using a remote sensing approach which allows for the determination of actual evapotranspiration from both vegetated and bare soil surfaces by solving the full surface energy balance using remotely sensed visible and thermal band data. While this type of study has not been performed on the Project service area, two such studies have been conducted on large irrigation districts in the region and the results provide some insight on the differences between actual and potential crop consumptive use that may be occurring on the Project:

- Clark et al. (2008) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different combinations of soils, on-farm irrigation method, and crop types, found on Imperial Irrigation District (IID). In this case, the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, 1998) and
LandSat satellite imagery with 30 m thermal resolution for water year 1998 was used to estimate actual ET. Potential ET was estimated using the dual crop coefficient approach presented in Allen et al. (1998). The results were presented as ratios of actual ET to potential ET. Across IID the average ratio was found to be 0.85. For graded border and graded furrow irrigation of mature alfalfa and new alfalfa on all soil types, the IID ratio of actual ET to potential ET ranged from 0.83 to 0.87.

- Elhaddad and Garcia (2014) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different crop types found on Palo Verde Irrigation District (PVID). In this case, actual ET was estimated using the ReSET Raster method (Elhaddad and Garcia, 2008) and LandSat 7 satellite imagery with 30 m thermal resolution for calendar year 2002. Potential ET was estimated using methods employed by the USBR in the Lower Colorado River Accounting System (LCRAS) (USBR, 1996-2014). The average ratio of actual ET to potential ET across PVID was found to be 0.86. For alfalfa, the ratio was found to be 0.86.

The results of these studies support the alfalfa hay crop coefficient adjustments suggested by Jensen (1998). Thus, for this analysis, alfalfa crop ET, as computed using the Jensen (1998, 2003) alfalfa crop coefficients (published coefficients multiplied by a factor of 0.85 to account for less than ideal growth conditions) was taken as an estimate of actual alfalfa crop ET. For Sudan, small grains, and grass hay, actual crop ET was estimated to be 0.85 times potential crop ET. For cotton and higher value minor miscellaneous crops (garlic, onion, potato) a factor of 1.00 was assumed.

Growing season durations of the various crops are implicit in the daily crop coefficients prepared by Jensen (1998, 2003) and were adopted for this analysis.

The net irrigation water requirement (NIR) or net consumptive irrigation water use (NetCU) represents the quantity of water required at the farm field to supply the estimated irrigation water demand of a crop during its growth period over and above the amount of natural precipitation water available for crop use. NIR or NetCU is computed as the crop ET minus the effective precipitation. Effective precipitation is that portion of total precipitation which is available for crop use. NRCE
adopted the flat monthly multiplier approach to estimate effective precipitation (Jensen, 1993) as used in USBR LCRAS reporting of crop water use. Average annual precipitation measured at the AZMET Parker No. 2 Station is 3.96 inches for the period: 2014-2018 (AZMET, 2013-2018). Using the LCRAS method, effective precipitation on the Reservation is about 0.76 inches per year, or just less than about 20 percent of average annual precipitation, for the 2014-2018 period at this location.

For each year analyzed, the weighted average NIR or NetCU was determined based on acreages of the individual crop types and the NIR or NetCU of each crop for that year. Using this result, an overall average unit area net crop consumptive irrigation water use (AF/ac) for the 5-year study period was determined. This 5-year average unit area net crop consumptive irrigation water use is listed for each Farm Unit in Table 1. The 5-year average unit area net crop consumptive irrigation water use is multiplied by the maximum (for the 5-year study period) annual acres irrigated for the Farm Unit to determine the total volume of NetCU due to fallowing and listed for each parcel in Table 1.

**Diversion Requirements**

NRCE (2017) has performed water balance analyses at the conveyance/delivery system level to estimate the magnitude of conveyance system losses (seepage, evaporation, and operational spills) experienced with the current infrastructure and operational management of the Project. Farm gate deliveries were estimated. These analyses allowed an assessment of conveyance/delivery system efficiency. As well, farm field level water balance analyses comparing net crop irrigation water requirements (NIR) to the estimated field level supplies or farmgate deliveries were performed. These comparisons allowed an assessment of on-farm losses to ditch seepage, deep percolation and tailwater runoff and estimation of on-farm efficiency. The overall assessment comparing net crop irrigation water requirements (NIR) to diversions allowed estimation of Project irrigation efficiency.

For the proposed Farm Units served by the Project, the total irrigation diversion requirement at Headgate Rock Dam corresponding to the Farm Unit net consumptive irrigation water use was estimated by dividing the farm field (NIR or NetCU) by the estimated project irrigation efficiency (product of irrigation delivery system conveyance efficiency and on-farm application efficiency).
For the purposes of these analyses, an overall Project irrigation efficiency of 53.5% was applied (NRCE, 2017).

Farm Unit 9035 is not served by the Project. This site diverts irrigation water by pumping directly from the Colorado River. Water is distributed across the farm using concrete lined ditches. Irrigation for the period of study 2013-17 was by flood (low gradient border and furrow) irrigation, although in years prior to this period linear move sprinklers were used on parts of the lease, and CRIT’s future plans include leasing parts of the unit and irrigating with the linear move sprinkler again. An average application efficiency of about 65-66% for border and furrow irrigation on the Reservation is used. For Unit 9035, the conveyance losses to seepage and operational spill are minor compared to the Project. A conservative conveyance efficiency of 90% is assigned on this unit. This results in an irrigation efficiency estimate of 60% for the unit.

**Monthly Distribution**

The annual cropping patterns found for each Farm Unit illustrate varying acreages of the primary crops from year to year and from Unit to Unit. To normalize this variability, monthly distributions of the total average annual NetCU savings and total average annual diversion reductions for each Farm Unit were determined by computing a monthly proportion of the total annual volume based on the 5-year average monthly and annual alfalfa crop evapotranspiration computed using reference crop ET$_0$ from the AZMET Parker No. 2 electronic weather station and LCRAS crop coefficients for alfalfa.

**Verification**

During the fallowing period, in order to ensure that any vegetation remaining on the fallowed lands does not consumptively use Colorado River water by drawing water from the Colorado River aquifer, CRIT shall, at its expense, control and eradicate any green vegetation growth.

Weed control will likely performed using chemical applications. Records of weed control applications, including date, chemicals used, rates of application, etc. will be prepared and maintained. CRIT agrees to provide Reclamation, Arizona Department of Water Resources, and other applicable entities, with information and updates, when requested, regarding the vegetation eradication program. Stubble from previous cropping will be kept on field surface to the extent
possible to reduce wind erosion. USBR personnel will be granted access to the Farms to perform periodic on-site inspections to verify compliance.

The means of irrigation water deliveries to each Farm Unit proposed for fallowing are described for each respective Unit. Irrigation water deliveries can be completely curtailed through control of farm gate turnouts or through control of sublateral head gates. CRIT agrees to furnish and install padlocks to lock the farm gate turnouts on fields fallowed to the extent possible to do so. In the event that a turnout serves multiple fields of which not all are being fallowed, other practical mechanisms, including but not limited to, dirt berms in the portion of the irrigation ditch serving the fallowed field, or sealing the on-farm turnouts onto fallowed fields will be used to the extent possible to assure that no water deliveries can be made onto the fallowed fields.

**Verification of Conserved Water Diversion Reduction from Approved Water Order**

Total estimated diversion requirements on monthly and annual time steps for the actively irrigated areas of the proposed Farm Units that will be fallowed have been estimated. CRIT’s annual water order (as determined and approved through the 43 CFR, Part 417 (Part 417) consultation between the BIA, US Bureau of Reclamation and CRIT) will be reduced by the estimated annual diversion requirements of the Farm Units for the agreed fallowing periods. Estimated monthly net consumptive use and diversion requirements of the Farm Units have also been determined. These monthly estimates allow determination of partial year water conservation and diversion reductions when fallowing periods are not a full 12-month period. Total annual CRIT Project and other Arizona diversions (with the fallowing and diversion reduction in progress) will not exceed CRIT’s Colorado River annual water right allocation for Arizona as adjusted by the diversion reductions, and thereby avoid inadvertent overruns (diversions in excess of CRIT’s adjusted entitlement—decreed AZ water right less the estimated diversion requirements of the fallowing program).

For Unit 9035, which diverts by direct pumping of water from the Colorado River, conserved water diversion reduction can be verified through routine monitoring of the electric power meter readings and account for the Unit’s pumping facilities.
E. Farm Unit: CRIT Farms Victorio Unit

Farm Description and Location

The CRIT Farms Victorio Unit is located on the Colorado River Indian Reservation within the Project service area with field parcels located within Sections 33 and 34 Township 6N Range 21W (Gila and Salt River Meridian), La Paz County, Arizona. The Victorio Unit is bounded by 17th Avenue on the west, Farm Unit 6693 on the north, Mesa Drain on the east and idle land on the south. Figure E1 is an overview map of the Unit. A maximum of 424.7 net field acres have been in irrigated crop production for at least the past 5 years. The acreage not in production is idle or occupied by hay and equipment storage yards, roads, canals, and drains.

The irrigated cropland on the Victorio Unit is served primarily by Sub-lateral 90-56 of the Project. This sublateral serves other farm fields in the area and thus cannot be turned off at the head gate. Farm gate turnouts on Sublateral 90-56 serving the Victorio Unit will be chained and locked.

CRIT Water Resources Dept. provided geospatial data (AGR05 shapefile and associated attribute table) of delineated irrigated field parcels across the Project. A total of up to 19 irrigated field parcels were identified within the actively irrigated area of the Unit (see Figure E1), although field parcel boundaries are noted to have changed with some consolidation or further subdivision apparent during the study period. Background aerial imagery in Figure E1 is dated 2017 and from the USDA National Agriculture Aerial Imagery Program (NAIP): (http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/). The CRIT field parcel delineations were found to show good agreement with the NAIP aerial imagery.
Figure E1. Overview Map of CRIT Farms Victorio Unit.
Crop patterns/crop mix for field parcels on the Victorio Unit for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD) and are summarized in Table E1. The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. The annual cropping pattern for the Victorio Unit is mapped in Figures E2-E6, for years 2014-2018, respectively.

Table E1. Cropping Patterns/Crop Mix of the CRIT Farms Victorio Unit, 2014-2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated Crop Acreage</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
<th>Idle Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>370.7</td>
<td>95%</td>
<td>0%</td>
<td>0%</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
<td>54.0</td>
</tr>
<tr>
<td>2015</td>
<td>406.8</td>
<td>87%</td>
<td>0%</td>
<td>0%</td>
<td>13%</td>
<td>0%</td>
<td>0%</td>
<td>17.9</td>
</tr>
<tr>
<td>2016</td>
<td>406.8</td>
<td>0%</td>
<td>0%</td>
<td>87%</td>
<td>13%</td>
<td>0%</td>
<td>0%</td>
<td>17.9</td>
</tr>
<tr>
<td>2017</td>
<td>406.8</td>
<td>59%</td>
<td>0%</td>
<td>0%</td>
<td>13%</td>
<td>27%</td>
<td>0%</td>
<td>17.9</td>
</tr>
<tr>
<td>2018</td>
<td>406.8</td>
<td>59%</td>
<td>27%</td>
<td>0%</td>
<td>13%</td>
<td>0%</td>
<td>0%</td>
<td>17.9</td>
</tr>
<tr>
<td>Average</td>
<td>406.8</td>
<td>60%</td>
<td>5%</td>
<td>17%</td>
<td>12%</td>
<td>5%</td>
<td>0%</td>
<td>17.9</td>
</tr>
</tbody>
</table>
Figure E2. Cropping Pattern on CRIT Farms Victorio Unit in 2014.
Figure E3. Cropping Pattern on CRIT Farms Victorio Unit in 2015.
Figure E4. Cropping Pattern on CRIT Farms Victorio Unit in 2016.
Figure E5. Cropping Pattern on CRIT Farms Victorio Unit in 2017.
Figure E6. Cropping Pattern on CRIT Farms Victorio Unit in 2018.
Estimated Crop Evapotranspiration

Table E2 below presents estimated annual and 5-year average reference ET (inches/year) for crops grown on the Reservation during the 5-year study period using weather data from the AZMET Parker No. 2 weather station.

Table E2. Annual and 5-year Average Reference ET, and crop ET (inches/year) for Reservation Crops for 2014-2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET(^1)</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.9</td>
<td>37.7</td>
<td>24.5</td>
<td>49.6</td>
<td>44.6</td>
<td>44.9</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.2</td>
<td>39.1</td>
<td>23.0</td>
<td>49.7</td>
<td>43.8</td>
<td>44.5</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.9</td>
<td>43.2</td>
<td>24.3</td>
<td>53.7</td>
<td>46.4</td>
<td>48.0</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.5</td>
<td>40.5</td>
<td>23.6</td>
<td>50.9</td>
<td>46.2</td>
<td>46.2</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>69.7</td>
<td>40.1</td>
<td>24.5</td>
<td>50.5</td>
<td>46.2</td>
<td>46.1</td>
</tr>
<tr>
<td>Average (in)</td>
<td></td>
<td>70.0</td>
<td>40.1</td>
<td>24.0</td>
<td>50.9</td>
<td>45.4</td>
<td>45.9</td>
</tr>
<tr>
<td>Average (af/ac)</td>
<td></td>
<td>5.84</td>
<td>3.34</td>
<td>2.00</td>
<td>4.24</td>
<td>3.79</td>
<td>3.83</td>
</tr>
</tbody>
</table>

\(^1\) Reference evapotranspiration of a short crop similar to 12-cm tall grass.

Estimated Net Consumptive Irrigation Water Use and Diversion Requirement

Table E3 below presents reference ET\(_0\), area-weighted average crop ET, effective precipitation, area-weighted average net consumptive use (NetCU), and associated diversion requirement (diversion reduction) for each year of the study period, and as an average of the 5-year period: 2014-18, based on the crop acreage and cropping pattern/mix discussed above. The estimated average annual unit area consumptive use on this Farm Unit for 2014-2018 is 4.61 AF/ac. The total estimated volume of water conserved due to the proposed fallowing of a maximum acreage of 406.8 acres on the Farm Unit is 1,877 AFY. Using an estimated average overall irrigation efficiency of 53.5%, the diversion requirement associated with this net water conservation is 3,508 AFY.
Table E3. Annual and 5-year Average Reference ET₀, Area Weighted Crop ET, Effective Precipitation, Area Weighted Net CU and Diversion Reduction for 2014-2018. CRIT Farms Victorio Unit.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET₀</th>
<th>Weighted Average Actual Crop ET (ETa)</th>
<th>Effective Precip.</th>
<th>Weighted Average Net Consumptive Use</th>
<th>Net Crop Area Fallowed</th>
<th>Net Consumptive Use Demand</th>
<th>Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>66.99</td>
<td>0.30</td>
<td>66.68</td>
<td>370.7</td>
<td>2,060</td>
<td>3,850</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>65.73</td>
<td>0.93</td>
<td>64.80</td>
<td>406.8</td>
<td>2,197</td>
<td>4,106</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>28.20</td>
<td>1.03</td>
<td>27.24</td>
<td>406.8</td>
<td>923</td>
<td>1,726</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>61.25</td>
<td>0.82</td>
<td>60.66</td>
<td>406.8</td>
<td>2,056</td>
<td>3,843</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>59.06</td>
<td>0.70</td>
<td>58.45</td>
<td>406.8</td>
<td>1,981</td>
<td>3,704</td>
</tr>
<tr>
<td>Average</td>
<td>77.26</td>
<td>56.25</td>
<td>0.76</td>
<td>55.57</td>
<td>399.6</td>
<td>1,844</td>
<td>3,446</td>
</tr>
</tbody>
</table>

1 Reference evapotranspiration of a short crop similar to 12-cm tall grass.
2 Estimated actual crop ET accounting for water stress and less than ideal growth conditions.
3 Weighted average calculated using irrigated acreages.
4 Column (8) divided by overall Project efficiency
The monthly distribution of the total average annual NetCU saving and total average annual diversion reduction for CRIT Farms Victorio Unit is presented in Table E4.


<table>
<thead>
<tr>
<th>Month</th>
<th>Average annual Alfalfa Crop ET (in) for period of analysis</th>
<th>Monthly Net Consumptive Use Demand</th>
<th>Monthly Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(inches) % of total</td>
<td>(AF)</td>
<td>(AF)</td>
</tr>
<tr>
<td>January</td>
<td>2.02 2.88%</td>
<td>54.1</td>
<td>101.1</td>
</tr>
<tr>
<td>February</td>
<td>3.57 5.09%</td>
<td>95.6</td>
<td>178.6</td>
</tr>
<tr>
<td>March</td>
<td>4.82 6.87%</td>
<td>129.0</td>
<td>241.1</td>
</tr>
<tr>
<td>April</td>
<td>6.83 9.74%</td>
<td>182.8</td>
<td>341.6</td>
</tr>
<tr>
<td>May</td>
<td>7.93 11.31%</td>
<td>212.3</td>
<td>396.9</td>
</tr>
<tr>
<td>June</td>
<td>9.09 12.96%</td>
<td>243.2</td>
<td>454.6</td>
</tr>
<tr>
<td>July</td>
<td>9.20 13.13%</td>
<td>246.4</td>
<td>460.5</td>
</tr>
<tr>
<td>August</td>
<td>8.71 12.42%</td>
<td>233.2</td>
<td>435.8</td>
</tr>
<tr>
<td>September</td>
<td>7.80 11.12%</td>
<td>208.7</td>
<td>390.2</td>
</tr>
<tr>
<td>October</td>
<td>4.40 6.28%</td>
<td>117.8</td>
<td>220.2</td>
</tr>
<tr>
<td>November</td>
<td>2.72 3.88%</td>
<td>72.8</td>
<td>136.0</td>
</tr>
<tr>
<td>December</td>
<td>3.03 4.32%</td>
<td>81.0</td>
<td>151.5</td>
</tr>
<tr>
<td>Annual</td>
<td>70.12 100.00%</td>
<td>1,876.8</td>
<td>3,508.1</td>
</tr>
</tbody>
</table>
References


TECHNICAL MEMORANDUM

Date: July 15, 2019

To: Tribal Council, Colorado River Indian Tribes (CRIT)

Cc: Rebecca Loudbear, Attorney General, CRIT
    Margaret Vick, Esq., Special Counsel

From: Natural Resources Consulting Engineers, Inc.

PROPOSED LANDS FOR COMPENSATED SYSTEM CONSERVATION PROGRAM (SCP) AND EXTRAORDINARY CONSERVATION INTENTIONALLY CREATED SURPLUS (EC ICS)

A. FARM UNIT: MTA 6627

Overview

This technical memorandum provides summary information and technical analyses for proposed temporary fallowing of irrigated farm land on the Colorado River Irrigation Project (Project) and other lands outside the boundary of the Project, Colorado River Indian Reservation, State of Arizona. The proposed fallowing is recommended for consideration under the Compensated System Conservation (SC) Program and Extraordinary Conservation Intentionally Created Surplus (EC ICS) Program. Temporary agricultural land fallowing is recognized by the Programs as means for reducing consumptive use to result in conserved water stored in Lake Mead. Parcels of land will be designated for fallowing on an annual basis and described in a Creation Plan. At the time of designation each parcel will have a history of irrigation for at least three out of the most recent five years. Each parcel may be designated for fallowing for no more than five consecutive years.

Under this proposal, the Colorado River Indian Tribes (CRIT) would temporarily fallow irrigated cropland on nine different Farm Units. Summary data and information regarding the location of each Farm Unit, the crops produced, irrigated crop acreage, estimated crop evapotranspiration, effective rainfall, net crop consumptive use, and estimated total irrigation
diversion requirement averaged over the previous 5-year period for each Farm Unit is provided below. Fallowing is proposed to begin in calendar year 2019 and continue through 2022.

**Project Description**

CRIT proposes to forego irrigation water deliveries and reduce consumptive use of Colorado River water by temporarily fallowing irrigated cropland as described immediately below during the period 2019-2022. CRIT proposes to create Compensated System Conservation through fallowing of specific Farm Units and make the conserved water available to the Colorado River System to increase storage in Lake Mead during 2020-2022. CRIT proposes to create EC ICS through fallowing of specific Farm Units for various periods of time during 2019 and may designate part of the consumptive use not compensated as system conservation for EC ICS during 2020-2022.

Figure 1 is an overview map showing the locations of the Farm Units proposed for fallowing on the Colorado River Indian Reservation (Reservation) in the State of Arizona. The majority of these Farm Units are served by the Tribe’s Colorado River Irrigation Project (Project), which diverts Colorado River water for irrigation of about 80,000 acres of land on the Reservation. One Farm Unit is located outside of the Project service area and diverts water directly from the Colorado River by pumping.

Two of the proposed Farm Units are currently fallowed and participating in the Pilot System Conservation Program:

a. MTA 6627—October 1, 2018 to September 30, 2019

b. Quail Mesa 6808—January 1, 2019 to December 31, 2019

**Estimated Conservation of Colorado River System Water**

Estimated average annual consumptive use reduction due to fallowing, and the associated reductions in diversions at Headgate Rock Dam or by direct pumping for each Farm Unit are summarized in Table 1 below.

CRIT proposes to use the average annual consumptive use reduction during October-December for Unit MTA 6627 and the total average annual consumptive use reduction for Unit Rayner 9035 for EC ICS creation in 2019. CRIT proposes to use all sites listed in Table 1
Overview of CRIT Lands Proposed for System Conservation or Intentionally Created Surplus

Figure 1. Overview of CRIT farm units proposed for fallowing for SC and EC ICS.

### Summary of CRIT ICS for 2019

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Average</th>
<th>Ave. Cropping Pattern</th>
<th>Net Consumptive Use</th>
<th>Efficiency Factors</th>
<th>Diversion Reduction</th>
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<tbody>
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<td></td>
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<td>Average AF/acre</td>
<td>Annual AFY</td>
<td>Annual AFY</td>
</tr>
<tr>
<td>6627*</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1884.0</td>
<td>60% alfalfa 20% Sudan grass</td>
<td>5.39</td>
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<td>0.501</td>
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<tr>
<td>9035**</td>
<td>Rainner</td>
<td>2013-17</td>
<td>1053.7</td>
<td>43% alfalfa 35% cotton 14% Bermuda (grass hay)</td>
<td>4.55</td>
<td>4,804</td>
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<td><strong>Totals</strong></td>
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<td></td>
<td></td>
<td></td>
<td>2,940</td>
<td>6,274</td>
<td>12,523</td>
</tr>
</tbody>
</table>

* Oct 1 2019-Dec 31 2019 only
** estimates in this table for 9035 are based on 2013-2017 USGS cropping data

### Summary of CRIT System Conservation and ICS for 2020 (System Conservation in excess of 50,000 AF will be considered ICS).

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Average</th>
<th>Ave. Cropping Pattern</th>
<th>Total Net Consumptive Use</th>
<th>Net Consumptive Use Proration</th>
<th>Diversion Reduction Proration</th>
<th>Total Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Annual AFY</td>
<td>System Conservation AFY</td>
<td>System Conservation** AFY</td>
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<tr>
<td>6627</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1884.0</td>
<td>60% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>10,157</td>
<td>9,450.7</td>
<td>17,664.8</td>
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<tr>
<td>6808</td>
<td>Quail Mesa</td>
<td>2014-18</td>
<td>3704.6</td>
<td>25% alfalfa 4% small grain 6% Bermuda (grass hay)</td>
<td>11% Sudan 21% Miscellaneous (onion, garlic, com, potato)</td>
<td>4.39</td>
<td>18,130</td>
<td>16,869.7</td>
</tr>
<tr>
<td>6693</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1183.9</td>
<td>64% alfalfa 1% cotton 6% small grain 13% Bermuda (grass hay)</td>
<td>14% Sudan 21% Miscellaneous (onion, garlic, com, potato)</td>
<td>4.97</td>
<td>5,886</td>
<td>5,476.3</td>
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<tr>
<td>CRIT Farms</td>
<td>Victoria</td>
<td>2014-18</td>
<td>406.8</td>
<td>60% alfalfa 5% cotton 17% small grain 12% Bermuda (grass hay)</td>
<td>7% Sudan</td>
<td>4.61</td>
<td>1,877</td>
<td>1,746.5</td>
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<tr>
<td>CRIT Farms</td>
<td>Feismann</td>
<td>2014-18</td>
<td>674.7</td>
<td>52% alfalfa 26% cotton 18% small grain 4% Sudan</td>
<td></td>
<td>4.33</td>
<td>2,951</td>
<td>2,745.4</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>CRIT II</td>
<td>2014-18</td>
<td>1283.7</td>
<td>73% alfalfa 19% cotton 6% small grain 2% Miscellaneous (onion, garlic, com, potato)</td>
<td></td>
<td>5.04</td>
<td>6,247</td>
<td>5,812.4</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>MTA 700</td>
<td>2014-18</td>
<td>465.8</td>
<td>60% alfalfa 7% cotton 7% Bermuda (grass hay)</td>
<td></td>
<td>5.50</td>
<td>2,567</td>
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<tr>
<td>CRIT Farms</td>
<td>Shawler Ranch</td>
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<td>438.5</td>
<td>69% alfalfa 30% cotton 2% Sudan</td>
<td></td>
<td>5.02</td>
<td>2,206</td>
<td>2,052.9</td>
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<tr>
<td>9035***</td>
<td>Rainner</td>
<td>2013-17</td>
<td>788.0</td>
<td>52% alfalfa 32% cotton 12% Bermuda (grass hay)</td>
<td>4% Sudan</td>
<td>4.72</td>
<td>3,721</td>
<td>3,462</td>
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<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10,786</td>
<td>53,736</td>
<td>50,000</td>
<td>92,737</td>
</tr>
</tbody>
</table>

* based on Project overall average irrigation efficiency equal to 52.5%
** based on Project CU Diversion ratio of 0.475 for 2018 using methodology designated in the LBOps ICS Exhibit 8 for CRIT.
*** estimates in this table for 9035 are based on 2013-2017 USGS cropping data with linear move sprinkler area removed;
and, for System Conservation diversion reduction, an overall average irrigation efficiency for direct pumping from River equal to 60%
to create up to 50,000 AF/year of Compensated System Conservation with any excess over 50,000 AF/year designated as EC ICS during the period 2020. The same farm units listed in Table 1 or different farm units may be designated for fallowing in 2021 and 2022.

Methodology

This section provides a brief description of the data and methods used to estimate:

- the amount of water conserved due to fallowing of irrigated cropland on each Farm Unit for each year of analysis; this is the net consumptive irrigation water use savings due the cropland fallowing; and,
- the associated irrigation water diversion required to provide that amount of water at the farm field.

Results are presented for each proposed Farm Unit in individual succeeding sub-sections of this technical memorandum.

Farm Unit Description and Location

Location data and legal description (PLSS) for each Farm Unit proposed for fallowing were obtained from CRIT Realty and/or CRIT Farms, the Tribal farming enterprise. This information generally included total gross and net acreage of the unit. Net irrigated crop acreage on each field of each Unit was determined using CRIT Water Resources Department (WRD) AGR05 field parcel polygon shapefile. The maximum net irrigated field acreage in any single year of the study period was used to determine the total volume of consumptive use savings due to fallowing.

Information on the Colorado River Irrigation Project (Project) irrigation delivery system was generally available from the US Bureau of Indian Affairs (BIA), the Federal agency that owns and operates the Project on behalf of CRIT. NRCE has prepared a detailed assessment of the Project (NRCE, 2016; NRCE, 2017).

Cropping Patterns

Crops typically produced on the Reservation include alfalfa (for hay), cotton, small grains (wheat, oats, barley), Bermuda and other grass hay, Sudan grass, and variety of minor miscellaneous crops (onions, garlic, corn, potato) (NRCE, 2016).
Crop patterns/crop mix for field parcels on the Farm Units for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD). The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. For Unit 9035, cropping pattern data were not available from the CRIT WRD. For this unit, cropping pattern data collected by the USGS for the period 2013-2017 were made available by the USBR (Jeremy Dodds, USBR, personal communication, July 12, 2019). Unit 9035 has not been farmed since May 2018, and thus 2018 is not included in the analysis. The USGS crop pattern data are 100% coverage, on the ground crop survey data collected annually on the Rayner unit for USBR during 2013-17. Cropping pattern/crop mix maps for all Farm Units for the respective years analyzed are included in the subsection for each Farm Unit. A table summarizing the cropping pattern/crop mix for each Farm Unit for each year and average for the period analyzed is included.

*Estimation of Consumptive Use*

The factors considered in estimating crop consumptive use include cropped area and cropping patterns, reference evapotranspiration, crop coefficients, and precipitation. Crop evapotranspiration (ETc) or crop consumptive use (crop CU) is defined as the evapotranspiration rate from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under given climatic conditions (Allen et al., 1998). Potential crop water use or crop evapotranspiration estimates for the period 1996 to present for the Colorado River Irrigation Project service area have been prepared (NRCE, 2016).

For the purposes of this study, ETc estimates using the single (mean) crop coefficient-reference evapotranspiration approach. Under this approach, reference crop evapotranspiration for a hypothetical green surface of actively transpiring vegetation is multiplied by a crop coefficient for a specific crop to estimate crop ET on a daily or monthly basis:

\[
ET_c = K_c \times ET_o
\]

where:

ETc = crop evapotranspiration (inches or mm);
The reference ET-crop coefficient method is widely used due to its simplicity, reproducibility, relatively good accuracy, and transportability among locations and climates.

For this analysis, reference ET (ET of an extensive area of short crop similar to 12-cm grass not short of water, ET₀) was computed using the ASCE Standardized Reference Evapotranspiration Equation (ASCE, 2005). The ASCE Standardized Reference ET Equation for a short (grass) reference surface is:

\[
ET₀ = \frac{0.408ΔR_n + γ \frac{900}{T + 273} u_2 (e_s - e_a)}{Δ + γ (1 + 0.34u_2)}
\]

where:

- \( ET₀ \) = standardized reference crop evapotranspiration for (grass) short crop
- \( Δ \) = slope of the saturation vapor pressure-temperature curve
- \( R_n \) = net radiation at the crop surface
- \( γ \) = psychrometric constant
- \( T \) = mean daily air temperature measured at 1.5-2 m above ground level
- \( u_2 \) = mean daily wind speed measured at 2 m above ground level
- \( e_s \) = saturation vapor pressure
- \( e_a \) = mean actual vapor pressure

This equation is the same as the ASCE Penman-Monteith Equation (Jensen et al., 1990 and Jensen and Allen, 2016) but with several simplifying “standardized” methods employed to compute several of the variables and parameter used in the Equation as given in ASCE (2005).

Jensen et al. (1990) report and summarize results of a comprehensive study comparing evapotranspiration estimates from different estimating methods to measurements of
evapotranspiration made at 11 different lysimeter sites around the world representing a wide range of climatic conditions from humid to arid, and elevations from below sea level to 9100 ft MSL. Nineteen methods were compared to lysimeter measurements on a monthly basis, and thirteen methods were compared on a daily basis. The ASCE Penman-Monteith method as given in Jensen et al. (1990) was determined to provide the overall best estimates of seasonal ET and average peak monthly ET with the least error as compared to lysimeter measurements across all ranges of climate and elevation.

The ASCE Reference ET Equation (ASCE, 2005) is a physically-based approach accounting for energy available for evaporation and aerodynamic transport of moisture away from the evaporating surface. Because of this physically-based formulation, it requires detailed weather measurements including air temperature, relative humidity, incoming total solar radiation, and wind speed. Such weather measurements are available from the Arizona Meteorological Network (AZMET) operated by the University of Arizona College of Agriculture and Live Sciences and Arizona Cooperative Extension (https://cals.arizona.edu/AZMET/). Two AZMET electronic weather stations are currently in operation in the Parker Valley and both stations are located on the Colorado River Indian Reservation (https://www.usbr.gov/lc/region/g4000/wtracct.html):

Parker No. 1 (site 8), Latitude 33.964296, Longitude -114.485501, Elev. 322 ft above MSL
Parker No. 2 (site 35) Latitude 33.863015, Longitude -114.472974, Elev. 302 ft above MSL

Daily weather and ETo data from the AZMET Parker No. 2 Station for the respective 5-year period of analysis were used in this study (AZMET, 2013-2018).

The crop coefficient, Kc, integrates the effects/differences of specific crop characteristics that affect water use of the specific crop to the water use of the reference crop. This methodology for estimated crop ET assumes the crop is growing under ideal conditions, and not stressed for water or nutrients, and thus, is considered the potential crop ET or potential consumptive use. Actual crop ET in farm fields is typically less than potential crop ET due to factors such as water stress, salinity, insect and disease pressure, etc.

Daily crop coefficient values for the primary crops comprising around 90% of the total irrigated crop acreage [alfalfa, cotton, small grains (wheat, oats, rye, barley, millet), Bermuda hay,
Sudan grass) grown on the Reservation were obtained from reports on crop coefficients prepared for the USBR LCRAS (https://www.usbr.gov/lc/region/g4000/wtracct.html#LCRAS) program (Jensen, 1998 and Jensen, 2003). Several minor “miscellaneous” crops have been and currently are produced on small acreage on the Reservation. Over the period 2013-2018, these minor crops have comprised an average of only 3.52% of the total irrigated crop acreage on the Project. These include but are not limited to corn, onions, garlic, crucifers, lettuce, and other small vegetable and melon crops. Most often these crops are produced for seed (crucifers, lettuce) or dehydration (onion, garlic) or animal feed (corn silage) and not as fresh market produce. Crop coefficients for a “miscellaneous” crop category were assumed to be equal to the average of the primary crops. This process is explained in more detail in Appendix B of NRCE (2016).

In the case of alfalfa, Jensen (1998, Appendix C) recognized the published crop coefficients for alfalfa hay represent potential (maximum) alfalfa ET under conditions where harvest and removal of hay is not delayed, and crop water stress does not occur. Jensen (1998) estimated the coefficients were about 15% too high for normal farm practices when hay may not be removed right after cuttings, some water stress might occur, non-uniformity of crop conditions, etc. To adjust for these effects and provide alfalfa hay consumptive use estimates closer to actual conditions, Jensen (1998) applied a factor of 0.85 to the alfalfa hay crop coefficients.

The differences between actual ET occurring under the field conditions of the PROJECT and potential ET from crop coefficient-reference ET approach can be estimated using a remote sensing approach which allows for the determination of actual evapotranspiration from both vegetated and bare soil surfaces by solving the full surface energy balance using remotely sensed visible and thermal band data. While this type of study has not been performed on the Project service area, two such studies have been conducted on large irrigation districts in the region and the results provide some insight on the differences between actual and potential crop consumptive use that may be occurring on the Project:

- Clark et al. (2008) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different combinations of soils, on-farm irrigation method, and crop types, found on Imperial Irrigation District (IID). In this case, the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, 1998) and
LandSat satellite imagery with 30 m thermal resolution for water year 1998 was used to estimate actual ET. Potential ET was estimated using the dual crop coefficient approach presented in Allen et al. (1998). The results were presented as ratios of actual ET to potential ET. Across IID the average ratio was found to be 0.85. For graded border and graded furrow irrigation of mature alfalfa and new alfalfa on all soil types, the IID ratio of actual ET to potential ET ranged from 0.83 to 0.87.

- Elhaddad and Garcia (2014) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different crop types found on Palo Verde Irrigation District (PVID). In this case, actual ET was estimated using the ReSET Raster method (Elhaddad and Garcia, 2008) and LandSat 7 satellite imagery with 30 m thermal resolution for calendar year 2002. Potential ET was estimated using methods employed by the USBR in the Lower Colorado River Accounting System (LCRAS) (USBR, 1996-2014). The average ratio of actual ET to potential ET across PVID was found to be 0.86. For alfalfa, the ratio was found to be 0.86.

The results of these studies support the alfalfa hay crop coefficient adjustments suggested by Jensen (1998). Thus, for this analysis, alfalfa crop ET, as computed using the Jensen (1998, 2003) alfalfa crop coefficients (published coefficients multiplied by a factor of 0.85 to account for less than ideal growth conditions) was taken as an estimate of actual alfalfa crop ET. For Sudan, small grains, and grass hay, actual crop ET was estimated to be 0.85 times potential crop ET. For cotton and higher value minor miscellaneous crops (garlic, onion, potato) a factor of 1.00 was assumed.

Growing season durations of the various crops are implicit in the daily crop coefficients prepared by Jensen (1998, 2003) and were adopted for this analysis.

The net irrigation water requirement (NIR) or net consumptive irrigation water use (NetCU) represents the quantity of water required at the farm field to supply the estimated irrigation water demand of a crop during its growth period over and above the amount of natural precipitation water available for crop use. NIR or NetCU is computed as the crop ET minus the effective precipitation. Effective precipitation is that portion of total precipitation which is available for crop use. NRCE
adopted the flat monthly multiplier approach to estimate effective precipitation (Jensen, 1993) as used in USBR LCRAS reporting of crop water use. Average annual precipitation measured at the AZMET Parker No. 2 Station is 3.96 inches for the period: 2014-2018 (AZMET, 2013-2018). Using the LCRAS method, effective precipitation on the Reservation is about 0.76 inches per year, or just less than about 20 percent of average annual precipitation, for the 2014-2018 period at this location.

For each year analyzed, the weighted average NIR or NetCU was determined based on acreages of the individual crop types and the NIR or NetCU of each crop for that year. Using this result, an overall average unit area net crop consumptive irrigation water use (AF/ac) for the 5-year study period was determined. This 5-year average unit area net crop consumptive irrigation water use is listed for each Farm Unit in Table 1. The 5-year average unit area net crop consumptive irrigation water use is multiplied by the maximum (for the 5-year study period) annual acres irrigated for the Farm Unit to determine the total volume of NetCU due to fallowing and listed for each parcel in Table 1.

**Diversion Requirements**

NRCE (2017) has performed water balance analyses at the conveyance/delivery system level to estimate the magnitude of conveyance system losses (seepage, evaporation, and operational spills) experienced with the current infrastructure and operational management of the Project. Farm gate deliveries were estimated. These analyses allowed an assessment of conveyance/delivery system efficiency. As well, farm field level water balance analyses comparing net crop irrigation water requirements (NIR) to the estimated field level supplies or farmgate deliveries were performed. These comparisons allowed an assessment of on-farm losses to ditch seepage, deep percolation and tailwater runoff and estimation of on-farm efficiency. The overall assessment comparing net crop irrigation water requirements (NIR) to diversions allowed estimation of Project irrigation efficiency.

For the proposed Farm Units served by the Project, the total irrigation diversion requirement at Headgate Rock Dam corresponding to the Farm Unit net consumptive irrigation water use was estimated by dividing the farm field (NIR or NetCU) by the estimated project irrigation efficiency (product of irrigation delivery system conveyance efficiency and on-farm application efficiency).
For the purposes of these analyses, an overall Project irrigation efficiency of 53.5% was applied (NRCE, 2017).

Farm Unit 9035 is not served by the Project. This site diverts irrigation water by pumping directly from the Colorado River. Water is distributed across the farm using concrete lined ditches. Irrigation for the period of study 2013-17 was by flood (low gradient border and furrow) irrigation, although in years prior to this period linear move sprinklers were used on parts of the lease, and CRIT’s future plans include leasing parts of the unit and irrigating with the linear move sprinkler again. An average application efficiency of about 65-66% for border and furrow irrigation on the Reservation is used. For Unit 9035, the conveyance losses to seepage and operational spill are minor compared to the Project. A conservative conveyance efficiency of 90% is assigned on this unit. This results in an irrigation efficiency estimate of 60% for the unit.

Monthly Distribution

The annual cropping patterns found for each Farm Unit illustrate varying acreages of the primary crops from year to year and from Unit to Unit. To normalize this variability, monthly distributions of the total average annual NetCU savings and total average annual diversion reductions for each Farm Unit were determined by computing a monthly proportion of the total annual volume based on the 5-year average monthly and annual alfalfa crop evapotranspiration computed using reference crop ET₀ from the AZMET Parker No. 2 electronic weather station and LCRAS crop coefficients for alfalfa.

Verification

During the fallowing period, in order to ensure that any vegetation remaining on the fallowed lands does not consumptively use Colorado River water by drawing water from the Colorado River aquifer, CRIT shall, at its expense, control and eradicate any green vegetation growth.

Weed control will likely performed using chemical applications. Records of weed control applications, including date, chemicals used, rates of application, etc. will be prepared and maintained. CRIT agrees to provide Reclamation, Arizona Department of Water Resources, and other applicable entities, with information and updates, when requested, regarding the vegetation eradication program. Stubble from previous cropping will be kept on field surface to the extent
possible to reduce wind erosion. USBR personnel will be granted access to the Farms to perform periodic on-site inspections to verify compliance.

The means of irrigation water deliveries to each Farm Unit proposed for fallowing are described for each respective Unit. Irrigation water deliveries can be completely curtailed through control of farm gate turnouts or through control of sublateral head gates. CRIT agrees to furnish and install padlocks to lock the farm gate turnouts on fields fallowed to the extent possible to do so. In the event that a turnout serves multiple fields of which not all are being fallowed, other practical mechanisms, including but not limited to, dirt berms in the portion of the irrigation ditch serving the fallowed field, or sealing the on-farm turnouts onto fallowed fields will be used to the extent possible to assure that no water deliveries can be made onto the fallowed fields.

Verification of Conserved Water Diversion Reduction from Approved Water Order

Total estimated diversion requirements on monthly and annual time steps for the actively irrigated areas of the proposed Farm Units that will be fallowed have been estimated. CRIT’s annual water order (as determined and approved through the 43 CFR, Part 417 (Part 417) consultation between the BIA, US Bureau of Reclamation and CRIT) will be reduced by the estimated annual diversion requirements of the Farm Units for the agreed fallowing periods. Estimated monthly net consumptive use and diversion requirements of the Farm Units have also been determined. These monthly estimates allow determination of partial year water conservation and diversion reductions when fallowing periods are not a full 12-month period. Total annual CRIT Project and other Arizona diversions (with the fallowing and diversion reduction in progress) will not exceed CRIT’s Colorado River annual water right allocation for Arizona as adjusted by the diversion reductions, and thereby avoid inadvertent overruns (diversions in excess of CRIT’s adjusted entitlement—decreeed AZ water right less the estimated diversion requirements of the fallowing program).

For Unit 9035, which diverts by direct pumping of water from the Colorado River, conserved water diversion reduction can be verified through routine monitoring of the electric power meter readings and account for the Unit’s pumping facilities.
A. Farm Unit: MTA 6627

Farm Description and Location

Farm Unit MTA 6627 (aka MTA Farms) is located on the Colorado River Indian Reservation within the Project service area with field parcels located within Sections 3, 4, 8, 9, 10, 16, and 17 Township 6N Range 21W (Gila and Salt River Meridian), La Paz County, Arizona. Unit 6627 is bounded by Mohave Road on the west, Navajo Road on the north, and Tsosie Road on the south. Figure A1 is an overview map of the Unit. Gross land area of MTA Farms is 1,957.63 acres. Approximately a maximum of 1,884.4 net field acres have been in irrigated crop production for at least the past 5 years. The acreage not in production is occupied by buildings, hay and equipment storage yards, roads, canals, and drains.

The irrigated cropland on MTA Farms is served primarily by Sub-lateral 73-36 of the Project. This sublateral serves other farm fields in the area and thus cannot be turned off at the headgate. Farm gate turnouts on Sublateral 73-36 serving MTA Farm will be chained and locked. An area of approximately 280 acres on MTA Farm is served water from Sublateral 73-25R-37. This sublateral can be shut off at its headgate and the headgate chained and locked. An area of approximately 280 acres on MTA Farm is served water from left turnout #9 on Sublateral 90-56. This turnout can be chained and locked.

CRIT Water Resources Dept. provided geospatial data (AGR05 shapefile and associated attribute table) of delineated irrigated field parcels across the Project. A total of 66 irrigated field parcels were identified within the actively irrigated area of MTA Farms (see Figure A1). Background aerial imagery in Figure A1 is dated 2017 and from the USDA National Agriculture Aerial Imagery Program (NAIP): (http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/). The CRIT field parcel delineations were found to show good agreement with the NAIP aerial imagery.
Figure A1. Overview Map of Farm Unit MTA 6627.
Cropping Patterns

Crop patterns/crop mix for field parcels on Farm Unit 6627 for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD) and are summarized in Table A1. The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. The annual cropping pattern for Farm Unit 6627 is mapped in Figures A2-A6, for years 2014-2018, respectively.


<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated Crop Acreage</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/ Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
<th>Idle Acreage</th>
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</thead>
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<tr>
<td>2014</td>
<td>1882.9</td>
<td>98%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>0%</td>
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<tr>
<td>2015</td>
<td>1882.9</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0.0</td>
</tr>
<tr>
<td>2016</td>
<td>1845.3</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>37.7</td>
</tr>
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<td>2017</td>
<td>1884.0</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0.0</td>
</tr>
<tr>
<td>2018</td>
<td>1884.0</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>98%</td>
<td>0%</td>
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</tr>
<tr>
<td>Average</td>
<td>1884.0</td>
<td>80%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>20%</td>
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</tr>
</tbody>
</table>
Figure A2. Cropping Pattern on Farm Unit MTA 6627 in 2014.
Figure A3. Cropping Pattern on Farm Unit MTA 6627 in 2015.
Figure A4. Cropping Pattern on Farm Unit MTA 6627 in 2016.
Figure A5. Cropping Pattern on Farm Unit MTA 6627 in 2017.
Figure A6. Cropping Pattern on Farm Unit MTA 6627 in 2018.
Estimated Crop Evapotranspiration

Table A2 below presents computed annual and 5-year average reference ET₀ and crop ET (inches/year) for crops grown on the Reservation during the 5-year study period using weather data from the AZMET Parker No. 2 weather station.

Table A2. Annual and 5-year Average Reference ET₀ and crop ET (inches/year) for Reservation Crops for 2014-2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET₀</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.9</td>
<td>37.7</td>
<td>24.5</td>
<td>49.6</td>
<td>44.6</td>
<td>44.9</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.2</td>
<td>39.1</td>
<td>23.0</td>
<td>49.7</td>
<td>43.8</td>
<td>44.5</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.9</td>
<td>43.2</td>
<td>24.3</td>
<td>53.7</td>
<td>46.4</td>
<td>48.0</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.5</td>
<td>40.5</td>
<td>23.6</td>
<td>50.9</td>
<td>46.2</td>
<td>46.2</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>69.7</td>
<td>40.1</td>
<td>24.5</td>
<td>50.5</td>
<td>46.2</td>
<td>46.1</td>
</tr>
<tr>
<td>Average (in)</td>
<td></td>
<td>70.0</td>
<td>40.1</td>
<td>24.0</td>
<td>50.9</td>
<td>45.4</td>
<td>45.9</td>
</tr>
<tr>
<td>Average (af/ac)</td>
<td></td>
<td>5.84</td>
<td>3.34</td>
<td>2.00</td>
<td>4.24</td>
<td>3.79</td>
<td>3.83</td>
</tr>
</tbody>
</table>

1 Reference evapotranspiration of a short crop similar to 12-cm tall grass.

Estimated Net Consumptive Irrigation Water Use and Diversion Requirement

Table A3 below presents reference ET₀, area-weighted average crop ET, effective precipitation, area-weighted average net consumptive use (NetCU), and associated diversion requirement (diversion reduction) for each year of the study period, and as an average of the 5-year period: 2014-18, based on the crop acreage and cropping pattern/mix discussed above. The estimated average annual unit area consumptive use on this Farm Unit for 2014-2018 is 5.39 AF/ac. The total estimated volume of water conserved due to the proposed fallowing of a maximum acreage of 1884 acres on the Farm Unit is 10,157 AFY. Using an estimated average overall irrigation efficiency of 53.5%, the diversion requirement associated with this net water conservation is 18,985 AFY.
Table A3. Annual and 5-year Average Reference ET<sub>0</sub>, Area Weighted Crop ET, Effective Precipitation, Area Weighted Net CU and Diversion Reduction for 2014-2018. Farm Unit MTA 6627.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET&lt;sub&gt;0&lt;/sub&gt;,&lt;sup&gt;1&lt;/sup&gt; (in)</th>
<th>Weighted Average Actual Crop ET (ETa)&lt;sup&gt;2&lt;/sup&gt; (in)</th>
<th>Effective Precip. (in)</th>
<th>Weighted Average Net Consumptive Use (in)</th>
<th>Net Crop Area Fallowed (ac)</th>
<th>Net Consumptive Use Demand&lt;sup&gt;3&lt;/sup&gt; (AF)</th>
<th>Diversion Reduction&lt;sup&gt;4&lt;/sup&gt; (AF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.45</td>
<td>0.30</td>
<td>67.15</td>
<td>1,882.9</td>
<td>10,537</td>
<td>19,696</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.19</td>
<td>0.93</td>
<td>67.25</td>
<td>1,882.9</td>
<td>10,553</td>
<td>19,725</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.89</td>
<td>1.03</td>
<td>72.86</td>
<td>1,845.3</td>
<td>11,204</td>
<td>20,942</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.51</td>
<td>0.82</td>
<td>69.69</td>
<td>1,884.0</td>
<td>10,942</td>
<td>20,452</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>46.69</td>
<td>0.70</td>
<td>46.68</td>
<td>1,884.0</td>
<td>7,328</td>
<td>13,698</td>
</tr>
<tr>
<td>Average</td>
<td>77.26</td>
<td>65.35</td>
<td>0.76</td>
<td>64.73</td>
<td>1,875.8</td>
<td>10,113</td>
<td>18,903</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit area Net CU (AF/ac)</th>
<th>Max acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,884.0</td>
</tr>
<tr>
<td></td>
<td>10,157</td>
</tr>
<tr>
<td></td>
<td>18,985</td>
</tr>
</tbody>
</table>

<sup>1</sup> Reference evapotranspiration of a short crop similar to 12-cm tall grass.

<sup>2</sup> Estimated actual crop ET accounting for water stress and less than ideal growth conditions.

<sup>3</sup> Weighted average calculated using irrigated acreages.

<sup>4</sup> Column (8) divided by overall Project efficiency.
The monthly distribution of the total average annual NetCU saving and total average annual diversion reduction for Farm Unit MTA 6627 is presented in Table A4.


<table>
<thead>
<tr>
<th>Month</th>
<th>Average annual Alfalfa Crop ET (in) for period of analysis</th>
<th>Monthly Net Consumptive Use Demand</th>
<th>Monthly Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(inches)</td>
<td>% of total</td>
<td>(AF)</td>
</tr>
<tr>
<td>January</td>
<td>2.02</td>
<td>2.88%</td>
<td>292.8</td>
</tr>
<tr>
<td>February</td>
<td>3.57</td>
<td>5.09%</td>
<td>517.2</td>
</tr>
<tr>
<td>March</td>
<td>4.82</td>
<td>6.87%</td>
<td>698.0</td>
</tr>
<tr>
<td>April</td>
<td>6.83</td>
<td>9.74%</td>
<td>989.1</td>
</tr>
<tr>
<td>May</td>
<td>7.93</td>
<td>11.31%</td>
<td>1,149.1</td>
</tr>
<tr>
<td>June</td>
<td>9.09</td>
<td>12.96%</td>
<td>1,316.1</td>
</tr>
<tr>
<td>July</td>
<td>9.20</td>
<td>13.13%</td>
<td>1,333.3</td>
</tr>
<tr>
<td>August</td>
<td>8.71</td>
<td>12.42%</td>
<td>1,261.8</td>
</tr>
<tr>
<td>September</td>
<td>7.80</td>
<td>11.12%</td>
<td>1,129.7</td>
</tr>
<tr>
<td>October</td>
<td>4.40</td>
<td>6.28%</td>
<td>637.7</td>
</tr>
<tr>
<td>November</td>
<td>2.72</td>
<td>3.88%</td>
<td>393.8</td>
</tr>
<tr>
<td>December</td>
<td>3.03</td>
<td>4.32%</td>
<td>438.6</td>
</tr>
<tr>
<td>Annual</td>
<td>70.12</td>
<td>100.00%</td>
<td>10,157.0</td>
</tr>
</tbody>
</table>
CRIT PROPOSED LANDS FOR SCP AND EC ICS

References


TECHNICAL MEMORANDUM

Date: July 15, 2019

To: Tribal Council, Colorado River Indian Tribes (CRIT)

Cc: Rebecca Loudbear, Attorney General, CRIT
Margaret Vick, Esq., Special Counsel

From: Natural Resources Consulting Engineers, Inc.

PROPOSED LANDS FOR COMPENSATED SYSTEM CONSERVATION PROGRAM (SCP) AND EXTRAORDINARY CONSERVATION INTENTIONALLY CREATED SURPLUS (EC ICS)

D. Farm Unit: MTA 6693

Overview

This technical memorandum provides summary information and technical analyses for proposed temporary fallowing of irrigated farm land on the Colorado River Irrigation Project (Project) and other lands outside the boundary of the Project, Colorado River Indian Reservation, State of Arizona. The proposed fallowing is recommended for consideration under the Compensated System Conservation (SC) Program and Extraordinary Conservation Intentionally Created Surplus (EC ICS) Program. Temporary agricultural land fallowing is recognized by the Programs as means for reducing consumptive use to result in conserved water stored in Lake Mead. Parcels of land will be designated for fallowing on an annual basis and described in a Creation Plan. At the time of designation each parcel will have a history of irrigation for at least three out of the most recent five years. Each parcel may be designated for fallowing for no more than five consecutive years.

Under this proposal, the Colorado River Indian Tribes (CRIT) would temporarily fallow irrigated cropland on nine different Farm Units. Summary data and information regarding the location of each Farm Unit, the crops produced, irrigated crop acreage, estimated crop evapotranspiration, effective rainfall, net crop consumptive use, and estimated total irrigation...
diversion requirement averaged over the previous 5-year period for each Farm Unit is provided below. Fallowing is proposed to begin in calendar year 2019 and continue through 2022.

Project Description

CRIT proposes to forego irrigation water deliveries and reduce consumptive use of Colorado River water by temporarily fallowing irrigated cropland as described immediately below during the period 2019-2022. CRIT proposes to create Compensated System Conservation through fallowing of specific Farm Units and make the conserved water available to the Colorado River System to increase storage in Lake Mead during 2020-2022. CRIT proposes to create EC ICS through fallowing of specific Farm Units for various periods of time during 2019 and may designate part of the consumptive use not compensated as system conservation for EC ICS during 2020-2022.

Figure 1 is an overview map showing the locations of the Farm Units proposed for fallowing on the Colorado River Indian Reservation (Reservation) in the State of Arizona. The majority of these Farm Units are served by the Tribe’s Colorado River Irrigation Project (Project), which diverts Colorado River water for irrigation of about 80,000 acres of land on the Reservation. One Farm Unit is located outside of the Project service area and diverts water directly from the Colorado River by pumping.

Two of the proposed Farm Units are currently fallowed and participating in the Pilot System Conservation Program:

a. MTA 6627—October 1, 2018 to September 30, 2019
b. Quail Mesa 6808—January 1, 2019 to December 31, 2019

Estimated Conservation of Colorado River System Water

Estimated average annual consumptive use reduction due to fallowing, and the associated reductions in diversions at Headgate Rock Dam or by direct pumping for each Farm Unit are summarized in Table 1 below.

CRIT proposes to use the average annual consumptive use reduction during October-December for Unit MTA 6627 and the total average annual consumptive use reduction for Unit Rayner 9035 for EC ICS creation in 2019. CRIT proposes to use all sites listed in Table 1
Figure 1. Overview of CRIT farm units proposed for follow-up for SC and EC ICS.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Ave. Cropping Pattern</th>
<th>Net Consumptive Use</th>
<th>Efficiency Factor*</th>
<th>Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average AF/ac</td>
<td>Annual AFY</td>
<td>Annual AFY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6627*</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1840</td>
<td>80% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>5,390</td>
<td>1,470</td>
</tr>
<tr>
<td>9035**</td>
<td>Rayner</td>
<td>2013-17</td>
<td>1055.7</td>
<td>43% alfalfa 35% cotton 14% Bermuda (grass hay) 8% Sudan</td>
<td>4.55</td>
<td>4,804</td>
<td>1,501</td>
</tr>
<tr>
<td>**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,940</td>
<td>6,274</td>
<td>12,523</td>
</tr>
</tbody>
</table>

* Oct 1 2019-Dec 31 2019 only
** estimates in this table for 9035 are based on 2013-2017 USGS cropping data
*** estimates in this table for 9035 are based on 2013-2017 USGS cropping data with linear move sprinkler area removed;

Total Net Diversion Reduction

<table>
<thead>
<tr>
<th>Total Net Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>100/623</td>
</tr>
</tbody>
</table>
to create up to 50,000 AF/year of Compensated System Conservation with any excess over 50,000 AF/year designated as EC ICS during the period 2020. The same farm units listed in Table 1 or different farm units may be designated for fallowing in 2021 and 2022.

Methodology

This section provides a brief description of the data and methods used to estimate:

- the amount of water conserved due to fallowing of irrigated cropland on each Farm Unit for each year of analysis; this is the net consumptive irrigation water use savings due the cropland fallowing; and,
- the associated irrigation water diversion required to provide that amount of water at the farm field.

Results are presented for each proposed Farm Unit in individual succeeding sub-sections of this technical memorandum.

Farm Unit Description and Location

Location data and legal description (PLSS) for each Farm Unit proposed for fallowing were obtained from CRIT Realty and/or CRIT Farms, the Tribal farming enterprise. This information generally included total gross and net acreage of the unit. Net irrigated crop acreage on each field of each Unit was determined using CRIT Water Resources Department (WRD) AGR05 field parcel polygon shapefile. The maximum net irrigated field acreage in any single year of the study period was used to determine the total volume of consumptive use savings due to fallowing.

Information on the Colorado River Irrigation Project (Project) irrigation delivery system was generally available from the US Bureau of Indian Affairs (BIA), the Federal agency that owns and operates the Project on behalf of CRIT. NRCE has prepared a detailed assessment of the Project (NRCE, 2016; NRCE, 2017).

Cropping Patterns

Crops typically produced on the Reservation include alfalfa (for hay), cotton, small grains (wheat, oats, barley), Bermuda and other grass hay, Sudan grass, and variety of minor miscellaneous crops (onions, garlic, corn, potato) (NRCE, 2016).
Crop patterns/crop mix for field parcels on the Farm Units for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD). The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. For Unit 9035, cropping pattern data were not available from the CRIT WRD. For this unit, cropping pattern data collected by the USGS for the period 2013-2017 were made available by the USBR (Jeremy Dodds, USBR, personal communication, July 12, 2019). Unit 9035 has not been farmed since May 2018, and thus 2018 is not included in the analysis. The USGS crop pattern data are 100% coverage, on the ground crop survey data collected annually on the Rayner unit for USBR during 2013-17. Cropping pattern/crop mix maps for all Farm Units for the respective years analyzed are included in the subsection for each Farm Unit. A table summarizing the cropping pattern/crop mix for each Farm Unit for each year and average for the period analyzed is included.

**Estimation of Consumptive Use**

The factors considered in estimating crop consumptive use include cropped area and cropping patterns, reference evapotranspiration, crop coefficients, and precipitation. Crop evapotranspiration (ETc) or crop consumptive use (crop CU) is defined as the evapotranspiration rate from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under given climatic conditions (Allen et al., 1998). Potential crop water use or crop evapotranspiration estimates for the period 1996 to present for the Colorado River Irrigation Project service area have been prepared (NRCE, 2016).

For the purposes of this study, ETc estimates using the single (mean) crop coefficient-reference evapotranspiration approach. Under this approach, reference crop evapotranspiration for a hypothetical green surface of actively transpiring vegetation is multiplied by a crop coefficient for a specific crop to estimate crop ET on a daily or monthly basis:

\[ \text{ET}_c = K_c \times \text{ET}_o \]

where:

\( \text{ET}_c \) = crop evapotranspiration (inches or mm);
The reference ET-crop coefficient method is widely used due to its simplicity, reproducibility, relatively good accuracy, and transportability among locations and climates.

For this analysis, reference ET (ET of an extensive area of short crop similar to 12-cm grass not short of water, ET₀) was computed using the ASCE Standardized Reference Evapotranspiration Equation (ASCE, 2005). The ASCE Standardized Reference ET Equation for a short (grass) reference surface is:

\[
ET_c = \frac{0.408\Delta R_n + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34 u_2)}
\]

where:

- \(ET_c\) = standardized reference crop evapotranspiration for (grass) short crop
- \(\Delta\) = slope of the saturation vapor pressure-temperature curve
- \(R_n\) = net radiation at the crop surface
- \(\gamma\) = psychrometric constant
- \(T\) = mean daily air temperature measured at 1.5-2 m above ground level
- \(u_2\) = mean daily wind speed measured at 2 m above ground level
- \(e_s\) = saturation vapor pressure
- \(e_a\) = mean actual vapor pressure

This equation is the same as the ASCE Penman-Monteith Equation (Jensen et al., 1990 and Jensen and Allen, 2016) but with several simplifying “standardized” methods employed to compute several of the variables and parameter used in the Equation as given in ASCE (2005).

Jensen et al. (1990) report and summarize results of a comprehensive study comparing evapotranspiration estimates from different estimating methods to measurements of
evapotranspiration made at 11 different lysimeter sites around the world representing a wide range of climatic conditions from humid to arid, and elevations from below sea level to 9100 ft MSL. Nineteen methods were compared to lysimeter measurements on a monthly basis, and thirteen methods were compared on a daily basis. The ASCE Penman-Monteith method as given in Jensen et al. (1990) was determined to provide the overall best estimates of seasonal ET and average peak monthly ET with the least error as compared to lysimeter measurements across all ranges of climate and elevation.

The ASCE Reference ET Equation (ASCE, 2005) is a physically-based approach accounting for energy available for evaporation and aerodynamic transport of moisture away from the evaporating surface. Because of this physically-based formulation, it requires detailed weather measurements including air temperature, relative humidity, incoming total solar radiation, and wind speed. Such weather measurements are available from the Arizona Meteorological Network (AZMET) operated by the University of Arizona College of Agriculture and Life Sciences and Arizona Cooperative Extension (https://cals.arizona.edu/AZMET/). Two AZMET electronic weather stations are currently in operation in the Parker Valley and both stations are located on the Colorado River Indian Reservation (https://www.usbr.gov/1c/region/g4000/wtracct.html):

Parker No. 1 (site 8), Latitude 33.964296, Longitude -114.485501, Elev. 322 ft above MSL
Parker No. 2 (site 35) Latitude 33.863015, Longitude -114.472974, Elev. 302 ft above MSL

Daily weather and ET₀ data from the AZMET Parker No. 2 Station for the respective 5-year period of analysis were used in this study (AZMET, 2013-2018).

The crop coefficient, Kᵦ, integrates the effects/differences of specific crop characteristics that affect water use of the specific crop to the water use of the reference crop. This methodology for estimated crop ET assumes the crop is growing under ideal conditions, and not stressed for water or nutrients, and thus, is considered the potential crop ET or potential consumptive use. Actual crop ET in farm fields is typically less than potential crop ET due to factors such as water stress, salinity, insect and disease pressure, etc.

Daily crop coefficient values for the primary crops comprising around 90% of the total irrigated crop acreage [alfalfa, cotton, small grains (wheat, oats, rye, barley, millet), Bermuda hay,
Sudan grass) grown on the Reservation were obtained from reports on crop coefficients prepared for the USBR LCRAS (https://www.usbr.gov/lc/region/g4000/wtracct.html#LCRAS) program (Jensen, 1998 and Jensen, 2003). Several minor “miscellaneous” crops have been and currently are produced on small acreage on the Reservation. Over the period 2013-2018, these minor crops have comprised an average of only 3.52% of the total irrigated crop acreage on the Project. These include but are not limited to corn, onions, garlic, crucifers, lettuce, and other small vegetable and melon crops. Most often these crops are produced for seed (crucifers, lettuce) or dehydration (onion, garlic) or animal feed (corn silage) and not as fresh market produce. Crop coefficients for a “miscellaneous” crop category were assumed to be equal to the average of the primary crops. This process is explained in more detail in Appendix B of NRCE (2016).

In the case of alfalfa, Jensen (1998, Appendix C) recognized the published crop coefficients for alfalfa hay represent potential (maximum) alfalfa ET under conditions where harvest and removal of hay is not delayed, and crop water stress does not occur. Jensen (1998) estimated the coefficients were about 15% too high for normal farm practices when hay may not be removed right after cuttings, some water stress might occur, non-uniformity of crop conditions, etc. To adjust for these effects and provide alfalfa hay consumptive use estimates closer to actual conditions, Jensen (1998) applied a factor of 0.85 to the alfalfa hay crop coefficients.

The differences between actual ET occurring under the field conditions of the PROJECT and potential ET from crop coefficient-reference ET approach can be estimated using a remote sensing approach which allows for the determination of actual evapotranspiration from both vegetated and bare soil surfaces by solving the full surface energy balance using remotely sensed visible and thermal band data. While this type of study has not been performed on the Project service area, two such studies have been conducted on large irrigation districts in the region and the results provide some insight on the differences between actual and potential crop consumptive use that may be occurring on the Project:

- Clark et al. (2008) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different combinations of soils, on-farm irrigation method, and crop types, found on Imperial Irrigation District (IID). In this case, the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, 1998) and
LandSat satellite imagery with 30 m thermal resolution for water year 1998 was used to estimate actual ET. Potential ET was estimated using the dual crop coefficient approach presented in Allen et al. (1998). The results were presented as ratios of actual ET to potential ET. Across IID the average ratio was found to be 0.85. For graded border and graded furrow irrigation of mature alfalfa and new alfalfa on all soil types, the IID ratio of actual ET to potential ET ranged from 0.83 to 0.87.

- Elhaddad and Garcia (2014) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different crop types found on Palo Verde Irrigation District (PVID). In this case, actual ET was estimated using the ReSET Raster method (Elhaddad and Garcia, 2008) and LandSat 7 satellite imagery with 30 m thermal resolution for calendar year 2002. Potential ET was estimated using methods employed by the USBR in the Lower Colorado River Accounting System (LCRAS) (USBR, 1996-2014). The average ratio of actual ET to potential ET across PVID was found to be 0.86. For alfalfa, the ratio was found to be 0.86.

The results of these studies support the alfalfa hay crop coefficient adjustments suggested by Jensen (1998). Thus, for this analysis, alfalfa crop ET, as computed using the Jensen (1998, 2003) alfalfa crop coefficients (published coefficients multiplied by a factor of 0.85 to account for less than ideal growth conditions) was taken as an estimate of actual alfalfa crop ET. For Sudan, small grains, and grass hay, actual crop ET was estimated to be 0.85 times potential crop ET. For cotton and higher value minor miscellaneous crops (garlic, onion, potato) a factor of 1.00 was assumed.

Growing season durations of the various crops are implicit in the daily crop coefficients prepared by Jensen (1998, 2003) and were adopted for this analysis.

The net irrigation water requirement (NIR) or net consumptive irrigation water use (NetCU) represents the quantity of water required at the farm field to supply the estimated irrigation water demand of a crop during its growth period over and above the amount of natural precipitation water available for crop use. NIR or NetCU is computed as the crop ET minus the effective precipitation. Effective precipitation is that portion of total precipitation which is available for crop use. NRCE
adopted the flat monthly multiplier approach to estimate effective precipitation (Jensen, 1993) as used in USBR LCRAS reporting of crop water use. Average annual precipitation measured at the AZMET Parker No. 2 Station is 3.96 inches for the period: 2014-2018 (AZMET, 2013-2018). Using the LCRAS method, effective precipitation on the Reservation is about 0.76 inches per year, or just less than about 20 percent of average annual precipitation, for the 2014-2018 period at this location.

For each year analyzed, the weighted average NIR or NetCU was determined based on acreages of the individual crop types and the NIR or NetCU of each crop for that year. Using this result, an overall average unit area net crop consumptive irrigation water use (AF/ac) for the 5-year study period was determined. This 5-year average unit area net crop consumptive irrigation water use is listed for each Farm Unit in Table 1. The 5-year average unit area net crop consumptive irrigation water use is multiplied by the maximum (for the 5-year study period) annual acres irrigated for the Farm Unit to determine the total volume of NetCU due to fallowing and listed for each parcel in Table 1.

**Diversion Requirements**

NRCE (2017) has performed water balance analyses at the conveyance/delivery system level to estimate the magnitude of conveyance system losses (seepage, evaporation, and operational spills) experienced with the current infrastructure and operational management of the Project. Farm gate deliveries were estimated. These analyses allowed an assessment of conveyance/delivery system efficiency. As well, farm field level water balance analyses comparing net crop irrigation water requirements (NIR) to the estimated field level supplies or farmgate deliveries were performed. These comparisons allowed an assessment of on-farm losses to ditch seepage, deep percolation and tailwater runoff and estimation of on-farm efficiency. The overall assessment comparing net crop irrigation water requirements (NIR) to diversions allowed estimation of Project irrigation efficiency.

For the proposed Farm Units served by the Project, the total irrigation diversion requirement at Headgate Rock Dam corresponding to the Farm Unit net consumptive irrigation water use was estimated by dividing the farm field (NIR or NetCU) by the estimated project irrigation efficiency (product of irrigation delivery system conveyance efficiency and on-farm application efficiency).
For the purposes of these analyses, an overall Project irrigation efficiency of 53.5% was applied (NRCE, 2017).

Farm Unit 9035 is not served by the Project. This site diverts irrigation water by pumping directly from the Colorado River. Water is distributed across the farm using concrete lined ditches. Irrigation for the period of study 2013-17 was by flood (low gradient border and furrow) irrigation, although in years prior to this period linear move sprinklers were used on parts of the lease, and CRIT’s future plans include leasing parts of the unit and irrigating with the linear move sprinkler again. An average application efficiency of about 65-66% for border and furrow irrigation on the Reservation is used. For Unit 9035, the conveyance losses to seepage and operational spill are minor compared to the Project. A conservative conveyance efficiency of 90% is assigned on this unit. This results in an irrigation efficiency estimate of 60% for the unit.

**Monthly Distribution**

The annual cropping patterns found for each Farm Unit illustrate varying acreages of the primary crops from year to year and from Unit to Unit. To normalize this variability, monthly distributions of the total average annual NetCU savings and total average annual diversion reductions for each Farm Unit were determined by computing a monthly proportion of the total annual volume based on the 5-year average monthly and annual alfalfa crop evapotranspiration computed using reference crop ET₀ from the AZMET Parker No. 2 electronic weather station and LCRAS crop coefficients for alfalfa.

**Verification**

During the fallowing period, in order to ensure that any vegetation remaining on the fallowed lands does not consumptively use Colorado River water by drawing water from the Colorado River aquifer, CRIT shall, at its expense, control and eradicate any green vegetation growth.

Weed control will likely performed using chemical applications. Records of weed control applications, including date, chemicals used, rates of application, etc. will be prepared and maintained. CRIT agrees to provide Reclamation, Arizona Department of Water Resources, and other applicable entities, with information and updates, when requested, regarding the vegetation eradication program. Stubble from previous cropping will be kept on field surface to the extent
possible to reduce wind erosion. USBR personnel will be granted access to the Farms to perform periodic on-site inspections to verify compliance.

The means of irrigation water deliveries to each Farm Unit proposed for fallowing are described for each respective Unit. Irrigation water deliveries can be completely curtailed through control of farm gate turnouts or through control of sublateral head gates. CRIT agrees to furnish and install padlocks to lock the farm gate turnouts on fields fallowed to the extent possible to do so. In the event that a turnout serves multiple fields of which not all are being fallowed, other practical mechanisms, including but not limited to, dirt berms in the portion of the irrigation ditch serving the fallowed field, or sealing the on-farm turnouts onto fallowed fields will be used to the extent possible to assure that no water deliveries can be made onto the fallowed fields.

Verification of Conserved Water Diversion Reduction from Approved Water Order

Total estimated diversion requirements on monthly and annual time steps for the actively irrigated areas of the proposed Farm Units that will be fallowed have been estimated. CRIT’s annual water order (as determined and approved through the 43 CFR, Part 417 (Part 417) consultation between the BIA, US Bureau of Reclamation and CRIT) will be reduced by the estimated annual diversion requirements of the Farm Units for the agreed fallowing periods. Estimated monthly net consumptive use and diversion requirements of the Farm Units have also been determined. These monthly estimates allow determination of partial year water conservation and diversion reductions when fallowing periods are not a full 12-month period. Total annual CRIT Project and other Arizona diversions (with the fallowing and diversion reduction in progress) will not exceed CRIT’s Colorado River annual water right allocation for Arizona as adjusted by the diversion reductions, and thereby avoid inadvertent overruns (diversions in excess of CRIT’s adjusted entitlement—decree AZ water right less the estimated diversion requirements of the fallowing program).

For Unit 9035, which diverts by direct pumping of water from the Colorado River, conserved water diversion reduction can be verified through routine monitoring of the electric power meter readings and account for the Unit’s pumping facilities.
D. Farm Unit: MTA 6693

Farm Description and Location

Farm Unit MTA 6693 is located on the Colorado River Indian Reservation within the Project service area with field parcels in three separate subunits located within Sections 20, 27, 28, and 29 Township 6N Range 21W and Sections 3 and 4 Township 5N Range 21W (Gila and Salt River Meridian), La Paz County, Arizona. Unit 6693 is bounded by Mohave Road on the west, Tsosie Road on the north, Mesa Drain on the east and on the south. Figure D1 is an overview map of the Unit. Gross land area is 1,343.59 acres. Approximately a maximum of 1,183.9 net field acres have been in irrigated crop production for at least the past 5 years. The acreage not in production is idle or occupied by buildings, hay and equipment storage yards, roads, canals, and drains.

The irrigated cropland on Unit MTA 6693 is served primarily by Sub-lateral 90-56 of the Project. This sublateral serves other farm fields in the area and thus cannot be turned off at the head gate. Farm gate turnouts on Sublateral 90-56 serving Unit MTA 6693 will be chained and locked.

CRIT Water Resources Dept. provided geospatial data (AGR05 shapefile and associated attribute table) of delineated irrigated field parcels across the Project. A total of up to 36 irrigated field parcels were identified within the actively irrigated area of Unit MTA 6693 (see Figure D1), although field parcel boundaries are noted to have changed with some consolidation or further subdivision apparent during the study period. Background aerial imagery in Figure D1 is dated 2017 and from the USDA National Agriculture Aerial Imagery Program (NAIP): (http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/). The CRIT field parcel delineations were found to show good agreement with the NAIP aerial imagery.
Figure D1. Overview Map of Farm Unit MTA 6693.
Cropping Patterns

Crop patterns/crop mix for field parcels on Farm Unit MTA 6693 for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD) and are summarized in Table D1. The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. The annual cropping pattern for Farm Unit MTA 6693 is mapped in Figures D2-D6, for years 2014-2018, respectively.

Table D1. Cropping Patterns/Crop Mix of Unit MTA 6693, 2014-2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated Crop Acreage</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
<th>Idle Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1183.9</td>
<td>21%</td>
<td>6%</td>
<td>0%</td>
<td>21%</td>
<td>51%</td>
<td>0%</td>
<td>63.9</td>
</tr>
<tr>
<td>2015</td>
<td>1183.9</td>
<td>81%</td>
<td>0%</td>
<td>0%</td>
<td>19%</td>
<td>0%</td>
<td>0%</td>
<td>63.9</td>
</tr>
<tr>
<td>2016</td>
<td>1183.9</td>
<td>47%</td>
<td>0%</td>
<td>31%</td>
<td>15%</td>
<td>0%</td>
<td>6%</td>
<td>63.9</td>
</tr>
<tr>
<td>2017</td>
<td>1127.1</td>
<td>90%</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>0%</td>
<td>0%</td>
<td>120.7</td>
</tr>
<tr>
<td>2018</td>
<td>1183.9</td>
<td>81%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>19%</td>
<td>0%</td>
<td>63.9</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>64%</td>
<td>1%</td>
<td>6%</td>
<td>13%</td>
<td>14%</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>
Figure D2. Cropping Pattern on Farm Unit MTA 6693 in 2014.
Figure D3. Cropping Pattern on Farm Unit MTA 6693 in 2015.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>955.49</td>
</tr>
<tr>
<td>Bermuda</td>
<td>228.45</td>
</tr>
<tr>
<td>Idle Land</td>
<td>63.87</td>
</tr>
</tbody>
</table>
Figure D4. Cropping Pattern on Farm Unit MTA 6693 in 2016.
Figure D5. Cropping Pattern on Farm Unit MTA 6693 in 2017.
Figure D6. Cropping Pattern on Farm Unit MTA 6693 in 2018.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>957.36</td>
</tr>
<tr>
<td>Fallow</td>
<td>63.87</td>
</tr>
<tr>
<td>Sudan</td>
<td>226.58</td>
</tr>
</tbody>
</table>
Estimated Crop Evapotranspiration

Table D2 below presents estimated annual and 5-year average reference ET₀ and crop ET (inches/year) for crops grown on the Reservation during the 5-year study period using weather data from the AZMET Parker No. 2 weather station.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET₀</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.9</td>
<td>37.7</td>
<td>24.5</td>
<td>49.6</td>
<td>44.6</td>
<td>44.9</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.2</td>
<td>39.1</td>
<td>23.0</td>
<td>49.7</td>
<td>43.8</td>
<td>44.5</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.9</td>
<td>43.2</td>
<td>24.3</td>
<td>53.7</td>
<td>46.4</td>
<td>48.0</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.5</td>
<td>40.5</td>
<td>23.6</td>
<td>50.9</td>
<td>46.2</td>
<td>46.2</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>69.7</td>
<td>40.1</td>
<td>24.5</td>
<td>50.5</td>
<td>46.2</td>
<td>46.1</td>
</tr>
<tr>
<td>Average (in)</td>
<td>70.0</td>
<td>40.1</td>
<td>24.0</td>
<td>50.9</td>
<td>45.4</td>
<td>45.9</td>
<td></td>
</tr>
<tr>
<td>Average (af/ac)</td>
<td>5.84</td>
<td>3.34</td>
<td>2.00</td>
<td>4.24</td>
<td>3.79</td>
<td>3.83</td>
<td></td>
</tr>
</tbody>
</table>

¹ Reference evapotranspiration of a short crop similar to 12-cm tall grass.

Estimated Net Consumptive Irrigation Water Use and Diversion Requirement

Table D3 below presents reference ET₀, area-weighted average crop ET, effective precipitation, area-weighted average net consumptive use (NetCU), and associated diversion requirement (diversion reduction) for each year of the study period, and as an average of the 5-year period: 2014-18, based on the crop acreage and cropping pattern/mix discussed above. The estimated average annual unit area consumptive use on this Farm Unit for 2014-2018 is 4.97 AF/acre. The total estimated volume of water conserved due to the proposed fallowing of a maximum acreage of 1183.9 acres on the Farm Unit is 5,886 AFY. Using an estimated average overall irrigation efficiency of 53.5%, the diversion requirement associated with this net water conservation is 11,001 AFY.
Table D3. Annual and 5-year Average Reference ET<sub>o</sub>, Area Weighted Crop ET, Effective Precipitation, Area Weighted Net CU and Diversion Reduction for 2014-2018. Farm Unit MTA 6693.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET&lt;sub&gt;o&lt;/sub&gt;,&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Weighted Average Actual Crop ET (ET&lt;sub&gt;a&lt;/sub&gt;),&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Effective Precip.</th>
<th>Weighted Average Net Consumptive Use</th>
<th>Net Crop Area Fallowed</th>
<th>Net Consumptive Use Demand&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Diversion Reduction&lt;sup&gt;4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td></td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(ac)</td>
<td>(AF)</td>
<td>(AF)</td>
</tr>
<tr>
<td>2014</td>
<td>75.11</td>
<td>50.16</td>
<td>0.30</td>
<td>50.01</td>
<td>1,183.9</td>
<td>4,934</td>
<td>9,223</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>64.62</td>
<td>0.93</td>
<td>63.69</td>
<td>1,183.9</td>
<td>6,284</td>
<td>11,745</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>53.67</td>
<td>1.03</td>
<td>52.67</td>
<td>1,183.9</td>
<td>5,197</td>
<td>9,713</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>68.48</td>
<td>0.82</td>
<td>67.66</td>
<td>1,127.1</td>
<td>6,355</td>
<td>11,878</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>65.20</td>
<td>0.70</td>
<td>64.63</td>
<td>1,183.9</td>
<td>6,377</td>
<td>11,919</td>
</tr>
<tr>
<td>Average</td>
<td>77.26</td>
<td>60.43</td>
<td>0.76</td>
<td>59.73</td>
<td>1,172.6</td>
<td>5,829</td>
<td>10,896</td>
</tr>
</tbody>
</table>

| Unit area Net CU (AF/ac) | 4.97 |
| Max acreage             | 1,183.9 | 5,886 | 11,001 |

<sup>1</sup> Reference evapotranspiration of a short crop similar to 12-cm tall grass.

<sup>2</sup> Estimated actual crop ET accounting for water stress and less than ideal growth conditions. Weighted average calculated using irrigated acreages.

<sup>3</sup> Column (5) divided by 12 and multiplied by Column (6)

<sup>4</sup> Column (8) divided by overall Project efficiency
The monthly distribution of the total average annual NetCU saving and total average annual diversion reduction for Farm Unit MTA 6693 is presented in Table D4.


<table>
<thead>
<tr>
<th>Month</th>
<th>Average annual Alfalfa Crop ET (in) for period of analysis</th>
<th>Monthly Net Consumptive Use Demand</th>
<th>Monthly Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(inches) % of total</td>
<td>(AF)</td>
<td>(AF)</td>
</tr>
<tr>
<td>January</td>
<td>2.02 2.88%</td>
<td>169.7</td>
<td>317.1</td>
</tr>
<tr>
<td>February</td>
<td>3.57 5.09%</td>
<td>299.7</td>
<td>560.2</td>
</tr>
<tr>
<td>March</td>
<td>4.82 6.87%</td>
<td>404.5</td>
<td>756.0</td>
</tr>
<tr>
<td>April</td>
<td>6.83 9.74%</td>
<td>573.1</td>
<td>1,071.3</td>
</tr>
<tr>
<td>May</td>
<td>7.93 11.31%</td>
<td>665.9</td>
<td>1,244.6</td>
</tr>
<tr>
<td>June</td>
<td>9.09 12.96%</td>
<td>762.7</td>
<td>1,425.6</td>
</tr>
<tr>
<td>July</td>
<td>9.20 13.13%</td>
<td>772.6</td>
<td>1,444.1</td>
</tr>
<tr>
<td>August</td>
<td>8.71 12.42%</td>
<td>731.2</td>
<td>1,366.6</td>
</tr>
<tr>
<td>September</td>
<td>7.80 11.12%</td>
<td>654.6</td>
<td>1,223.6</td>
</tr>
<tr>
<td>October</td>
<td>4.40 6.28%</td>
<td>369.5</td>
<td>690.7</td>
</tr>
<tr>
<td>November</td>
<td>2.72 3.88%</td>
<td>228.2</td>
<td>426.5</td>
</tr>
<tr>
<td>December</td>
<td>3.03 4.32%</td>
<td>254.1</td>
<td>475.0</td>
</tr>
<tr>
<td>Annual</td>
<td>70.12 100.00%</td>
<td>5,885.7</td>
<td>11,001.4</td>
</tr>
</tbody>
</table>
References


TECHNICAL MEMORANDUM

Date: July 15, 2019

To: Tribal Council, Colorado River Indian Tribes (CRIT)

Cc: Rebecca Loudbear, Attorney General, CRIT
    Margaret Vick, Esq., Special Counsel

From: Natural Resources Consulting Engineers, Inc.

PROPOSED LANDS FOR COMPENSATED SYSTEM CONSERVATION PROGRAM (SCP) AND EXTRAORDINARY CONSERVATION INTENTIONALLY CREATED SURPLUS (EC ICS)

C. Farm Unit: 6808

Overview

This technical memorandum provides summary information and technical analyses for proposed temporary fallowing of irrigated farm land on the Colorado River Irrigation Project (Project) and other lands outside the boundary of the Project, Colorado River Indian Reservation, State of Arizona. The proposed fallowing is recommended for consideration under the Compensated System Conservation (SC) Program and Extraordinary Conservation Intentionally Created Surplus (EC ICS) Program. Temporary agricultural land fallowing is recognized by the Programs as means for reducing consumptive use to result in conserved water stored in Lake Mead. Parcels of land will be designated for fallowing on an annual basis and described in a Creation Plan. At the time of designation each parcel will have a history of irrigation for at least three out of the most recent five years. Each parcel may be designated for fallowing for no more than five consecutive years.

Under this proposal, the Colorado River Indian Tribes (CRIT) would temporarily fallow irrigated cropland on nine different Farm Units. Summary data and information regarding the location of each Farm Unit, the crops produced, irrigated crop acreage, estimated crop evapotranspiration, effective rainfall, net crop consumptive use, and estimated total irrigation
diversion requirement averaged over the previous 5-year period for each Farm Unit is provided below. Fallowing is proposed to begin in calendar year 2019 and continue through 2022.

Project Description

CRIT proposes to forego irrigation water deliveries and reduce consumptive use of Colorado River water by temporarily fallowing irrigated cropland as described immediately below during the period 2019-2022. CRIT proposes to create Compensated System Conservation through fallowing of specific Farm Units and make the conserved water available to the Colorado River System to increase storage in Lake Mead during 2020-2022. CRIT proposes to create EC ICS through fallowing of specific Farm Units for various periods of time during 2019 and may designate part of the consumptive use not compensated as system conservation for EC ICS during 2020-2022.

Figure 1 is an overview map showing the locations of the Farm Units proposed for fallowing on the Colorado River Indian Reservation (Reservation) in the State of Arizona. The majority of these Farm Units are served by the Tribe’s Colorado River Irrigation Project (Project), which diverts Colorado River water for irrigation of about 80,000 acres of land on the Reservation. One Farm Unit is located outside of the Project service area and diverts water directly from the Colorado River by pumping.

Two of the proposed Farm Units are currently fallowed and participating in the Pilot System Conservation Program:

a. MTA 6627—October 1, 2018 to September 30, 2019
b. Quail Mesa 6808—January 1, 2019 to December 31, 2019

Estimated Conservation of Colorado River System Water

Estimated average annual consumptive use reduction due to fallowing, and the associated reductions in diversions at Headgate Rock Dam or by direct pumping for each Farm Unit are summarized in Table 1 below.

CRIT proposes to use the average annual consumptive use reduction during October-December for Unit MTA 6627 and the total average annual consumptive use reduction for Unit Rayner 9035 for EC ICS creation in 2019. CRIT proposes to use all sites listed in Table 1
Figure 1. Overview of CRIT farm units proposed for fallowing for SC and EC ICS.

### Summary of CRIT ICS for 2019

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Avg. Cropping Pattern</th>
<th>Net Consumptive Use</th>
<th>Efficiency Factor*</th>
<th>Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>6627*</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1884.0</td>
<td>85% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>1,470</td>
<td>0.501</td>
</tr>
<tr>
<td>9035**</td>
<td>Rayner</td>
<td>2013-17</td>
<td>1055.7</td>
<td>73% alfalfa 35% cotton 14% Bermuda (grass hay) 8% Sudan</td>
<td>4.55</td>
<td>4,804</td>
<td>0.501</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td>2,440</td>
<td></td>
<td></td>
<td>6,274</td>
<td></td>
</tr>
</tbody>
</table>

* Oct 1 2019-Dec 31 2019 only
** estimates in this table for 9035 are based on 2013-2017 USGS cropping data

### Summary of CRIT System Conservation and ICS for 2020 (System Conservation in excess of 50,000 AF will be considered ICS).

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Avg. Cropping Pattern</th>
<th>Total Net Consumptive Use</th>
<th>Net Consumptive Use</th>
<th>Diversion Reduction</th>
<th>Total Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>6627</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1884.0</td>
<td>80% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>10,157</td>
<td>9,459.7</td>
<td>706.2</td>
</tr>
<tr>
<td>6808</td>
<td>Quail Mesa</td>
<td>2014-18</td>
<td>3704.6</td>
<td>58% alfalfa 4% small grain 6% Bermuda (grass hay) 11% Sudan 21% Miscellaneous (onion, garlic, com, potato)</td>
<td>4.89</td>
<td>18,130</td>
<td>16,859.7</td>
<td>1,260.6</td>
</tr>
<tr>
<td>6693</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1183.9</td>
<td>61% alfalfa 1% cotton 8% small grain 13% Bermuda (grass hay) 14% Sudan 21% Miscellaneous (onion, garlic, com, potato)</td>
<td>4.97</td>
<td>5,886</td>
<td>5,476.3</td>
<td>409.2</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Victoria</td>
<td>2014-18</td>
<td>406.8</td>
<td>65% alfalfa 5% cotton 17% small grain 12% Bermuda (grass hay) 9% Sudan</td>
<td>4.61</td>
<td>1,877</td>
<td>1,746.5</td>
<td>130.5</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Friesland</td>
<td>2014-18</td>
<td>674.7</td>
<td>52% alfalfa 26% cotton 18% small grain 4% Sudan</td>
<td>4.37</td>
<td>2,951</td>
<td>2,745.4</td>
<td>205.2</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>CRIT II</td>
<td>2014-18</td>
<td>1238.7</td>
<td>73% alfalfa 19% cotton 0% small grain 2% Miscellaneous (onion, garlic, com, potato)</td>
<td>5.04</td>
<td>6,247</td>
<td>5,812.4</td>
<td>434.3</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>MTA 700</td>
<td>2014-18</td>
<td>465.8</td>
<td>56% alfalfa 7% cotton 3% Bermuda (grass hay)</td>
<td>5.50</td>
<td>2,562</td>
<td>2,383.8</td>
<td>178.1</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Shoal Creek Ranch</td>
<td>2014-18</td>
<td>439.5</td>
<td>69% alfalfa 30% cotton 2% Sudan</td>
<td>5.02</td>
<td>2,206</td>
<td>2,052.9</td>
<td>153.4</td>
</tr>
<tr>
<td>9035***</td>
<td>Rayner</td>
<td>2013-17</td>
<td>788.0</td>
<td>52% alfalfa 32% cotton 12% Bermuda (grass hay) 4% Sudan</td>
<td>4.72</td>
<td>3,721</td>
<td>3,462</td>
<td>259</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td>10,786</td>
<td></td>
<td></td>
<td>53,714</td>
<td>50,000</td>
<td>3,736</td>
</tr>
</tbody>
</table>

* based on Project overall average irrigation efficiency equal to 53.5%
** based on Project CU/Diversion ratio of 4.475 for 2018 using methodology designated in the LBOps ICS Exhibit S for CRIT.
*** estimates in this table for 9035 are based on 2013-2017 USGS cropping data with linear move sprinkler area removed;
and, for System Conservation diversion reduction, an overall average irrigation efficiency for direct pumping from River equal to 60%
to create up to 50,000 AF/year of Compensated System Conservation with any excess over 50,000 AF/year designated as EC ICS during the period 2020. The same farm units listed in Table 1 or different farm units may be designated for fallowing in 2021 and 2022.

Methodology

This section provides a brief description of the data and methods used to estimate:
- the amount of water conserved due to fallowing of irrigated cropland on each Farm Unit for each year of analysis; this is the net consumptive irrigation water use savings due the cropland fallowing; and,
- the associated irrigation water diversion required to provide that amount of water at the farm field.

Results are presented for each proposed Farm Unit in individual succeeding sub-sections of this technical memorandum.

Farm Unit Description and Location

Location data and legal description (PLSS) for each Farm Unit proposed for fallowing were obtained from CRIT Realty and/or CRIT Farms, the Tribal farming enterprise. This information generally included total gross and net acreage of the unit. Net irrigated crop acreage on each field of each Unit was determined using CRIT Water Resources Department (WRD) AGR05 field parcel polygon shapefile. The maximum net irrigated field acreage in any single year of the study period was used to determine the total volume of consumptive use savings due to fallowing.

Information on the Colorado River Irrigation Project (Project) irrigation delivery system was generally available from the US Bureau of Indian Affairs (BIA), the Federal agency that owns and operates the Project on behalf of CRIT. NRCE has prepared a detailed assessment of the Project (NRCE, 2016; NRCE, 2017).

Cropping Patterns

Crops typically produced on the Reservation include alfalfa (for hay), cotton, small grains (wheat, oats, barley), Bermuda and other grass hay, Sudan grass, and variety of minor miscellaneous crops (onions, garlic, corn, potato) (NRCE, 2016).
Crop patterns/crop mix for field parcels on the Farm Units for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD). The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. For Unit 9035, cropping pattern data were not available from the CRIT WRD. For this unit, cropping pattern data collected by the USGS for the period 2013-2017 were made available by the USBR (Jeremy Dodds, USBR, personal communication, July 12, 2019). Unit 9035 has not been farmed since May 2018, and thus 2018 is not included in the analysis. The USGS crop pattern data are 100% coverage, on the ground crop survey data collected annually on the Rayner unit for USBR during 2013-17. Cropping pattern/crop mix maps for all Farm Units for the respective years analyzed are included in the subsection for each Farm Unit. A table summarizing the cropping pattern/crop mix for each Farm Unit for each year and average for the period analyzed is included.

Estimation of Consumptive Use

The factors considered in estimating crop consumptive use include cropped area and cropping patterns, reference evapotranspiration, crop coefficients, and precipitation. Crop evapotranspiration ($ET_c$) or crop consumptive use (crop CU) is defined as the evapotranspiration rate from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under given climatic conditions (Allen et al., 1998). Potential crop water use or crop evapotranspiration estimates for the period 1996 to present for the Colorado River Irrigation Project service area have been prepared (NRCE, 2016).

For the purposes of this study, $ET_c$ estimates using the single (mean) crop coefficient-reference evapotranspiration approach. Under this approach, reference crop evapotranspiration for a hypothetical green surface of actively transpiring vegetation is multiplied by a crop coefficient for a specific crop to estimate crop ET on a daily or monthly basis:

$$ET_c = K_c \times ET_o$$

where:

$ET_c$ = crop evapotranspiration (inches or mm);
\( K_c \) = crop coefficient (dimensionless);

\( ET_o \) = grass reference crop evapotranspiration (inches or mm)

The reference ET-crop coefficient method is widely used due to its simplicity, reproducibility, relatively good accuracy, and transportability among locations and climates.

For this analysis, reference ET (ET of an extensive area of short crop similar to 12-cm grass not short of water, \( ET_o \)) was computed using the ASCE Standardized Reference Evapotranspiration Equation (ASCE, 2005). The ASCE Standardized Reference ET Equation for a short (grass) reference surface is:

\[
ET_o = \frac{0.408\Delta R_n + \gamma \frac{900}{T + \frac{273}{273}} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34u_2)}
\]

where:

\( ET_o \) = standardized reference crop evapotranspiration for (grass) short crop

\( \Delta \) = slope of the saturation vapor pressure-temperature curve

\( R_n \) = net radiation at the crop surface

\( \gamma \) = psychrometric constant

\( T \) = mean daily air temperature measured at 1.5-2 m above ground level

\( u_2 \) = mean daily wind speed measured at 2 m above ground level

\( e_s \) = saturation vapor pressure

\( e_a \) = mean actual vapor pressure

This equation is the same as the ASCE Penman-Monteith Equation (Jensen et al., 1990 and Jensen and Allen, 2016) but with several simplifying “standardized” methods employed to compute several of the variables and parameter used in the Equation as given in ASCE (2005).

Jensen et al. (1990) report and summarize results of a comprehensive study comparing evapotranspiration estimates from different estimating methods to measurements of
evapotranspiration made at 11 different lysimeter sites around the world representing a wide range of climatic conditions from humid to arid, and elevations from below sea level to 9100 ft MSL. Nineteen methods were compared to lysimeter measurements on a monthly basis, and thirteen methods were compared on a daily basis. The ASCE Penman-Monteith method as given in Jensen et al. (1990) was determined to provide the overall best estimates of seasonal ET and average peak monthly ET with the least error as compared to lysimeter measurements across all ranges of climate and elevation.

The ASCE Reference ET Equation (ASCE, 2005) is a physically-based approach accounting for energy available for evaporation and aerodynamic transport of moisture away from the evaporating surface. Because of this physically-based formulation, it requires detailed weather measurements including air temperature, relative humidity, incoming total solar radiation, and wind speed. Such weather measurements are available from the Arizona Meteorological Network (AZMET) operated by the University of Arizona College of Agriculture and Life Sciences and Arizona Cooperative Extension (https://cals.arizona.edu/AZMET/). Two AZMET electronic weather stations are currently in operation in the Parker Valley and both stations are located on the Colorado River Indian Reservation (https://www.usbr.gov/lc/region/g4000/wtracct.html):

- **Parker No. 1 (site 8)**, Latitude 33.964296, Longitude -114.485501, Elev. 322 ft above MSL
- **Parker No. 2 (site 35)**, Latitude 33.863015, Longitude -114.472974, Elev. 302 ft above MSL

Daily weather and ET₀ data from the AZMET Parker No. 2 Station for the respective 5-year period of analysis were used in this study (AZMET, 2013-2018).

The crop coefficient, Kc, integrates the effects/differences of specific crop characteristics that affect water use of the specific crop to the water use of the reference crop. This methodology for estimated crop ET assumes the crop is growing under ideal conditions, and not stressed for water or nutrients, and thus, is considered the potential crop ET or potential consumptive use. Actual crop ET in farm fields is typically less than potential crop ET due to factors such as water stress, salinity, insect and disease pressure, etc.

Daily crop coefficient values for the primary crops comprising around 90% of the total irrigated crop acreage [alfalfa, cotton, small grains (wheat, oats, rye, barley, millet), Bermuda hay,
Sudan grass) grown on the Reservation were obtained from reports on crop coefficients prepared for the USBR LCRAS (https://www.usbr.gov/lc/region/g4000/wtracct.html#LCRAS) program (Jensen, 1998 and Jensen, 2003). Several minor “miscellaneous” crops have been and currently are produced on small acreage on the Reservation. Over the period 2013-2018, these minor crops have comprised an average of only 3.52% of the total irrigated crop acreage on the Project. These include but are not limited to corn, onions, garlic, crucifers, lettuce, and other small vegetable and melon crops. Most often these crops are produced for seed (crucifers, lettuce) or dehydration (onion, garlic) or animal feed (corn silage) and not as fresh market produce. Crop coefficients for a “miscellaneous” crop category were assumed to be equal to the average of the primary crops. This process is explained in more detail in Appendix B of NRCE (2016).

In the case of alfalfa, Jensen (1998, Appendix C) recognized the published crop coefficients for alfalfa hay represent potential (maximum) alfalfa ET under conditions where harvest and removal of hay is not delayed, and crop water stress does not occur. Jensen (1998) estimated the coefficients were about 15% too high for normal farm practices when hay may not be removed right after cuttings, some water stress might occur, non-uniformity of crop conditions, etc. To adjust for these effects and provide alfalfa hay consumptive use estimates closer to actual conditions, Jensen (1998) applied a factor of 0.85 to the alfalfa hay crop coefficients.

The differences between actual ET occurring under the field conditions of the PROJECT and potential ET from crop coefficient-reference ET approach can be estimated using a remote sensing approach which allows for the determination of actual evapotranspiration from both vegetated and bare soil surfaces by solving the full surface energy balance using remotely sensed visible and thermal band data. While this type of study has not been performed on the Project service area, two such studies have been conducted on large irrigation districts in the region and the results provide some insight on the differences between actual and potential crop consumptive use that may be occurring on the Project:

- Clark et al. (2008) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different combinations of soils, on-farm irrigation method, and crop types, found on Imperial Irrigation District (IID). In this case, the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, 1998) and
LANDSAT satellite imagery with 30 m thermal resolution for water year 1998 was used to estimate actual ET. Potential ET was estimated using the dual crop coefficient approach presented in Allen et al. (1998). The results were presented as ratios of actual ET to potential ET. Across IID the average ratio was found to be 0.85. For graded border and graded furrow irrigation of mature alfalfa and new alfalfa on all soil types, the IID ratio of actual ET to potential ET ranged from 0.83 to 0.87.

- Elhaddad and Garcia (2014) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different crop types found on Palo Verde Irrigation District (PVID). In this case, actual ET was estimated using the ReSET Raster method (Elhaddad and Garcia, 2008) and LANDSAT 7 satellite imagery with 30 m thermal resolution for calendar year 2002. Potential ET was estimated using methods employed by the USBR in the Lower Colorado River Accounting System (LCRAS) (USBR, 1996-2014). The average ratio of actual ET to potential ET across PVID was found to be 0.86. For alfalfa, the ratio was found to be 0.86.

The results of these studies support the alfalfa hay crop coefficient adjustments suggested by Jensen (1998). Thus, for this analysis, alfalfa crop ET, as computed using the Jensen (1998, 2003) alfalfa crop coefficients (published coefficients multiplied by a factor of 0.85 to account for less than ideal growth conditions) was taken as an estimate of actual alfalfa crop ET. For Sudan, small grains, and grass hay, actual crop ET was estimated to be 0.85 times potential crop ET. For cotton and higher value minor miscellaneous crops (garlic, onion, potato) a factor of 1.00 was assumed.

Growing season durations of the various crops are implicit in the daily crop coefficients prepared by Jensen (1998, 2003) and were adopted for this analysis.

The net irrigation water requirement (NIR) or net consumptive irrigation water use (NetCU) represents the quantity of water required at the farm field to supply the estimated irrigation water demand of a crop during its growth period over and above the amount of natural precipitation water available for crop use. NIR or NetCU is computed as the crop ET minus the effective precipitation. Effective precipitation is that portion of total precipitation which is available for crop use. NRCE
adopted the flat monthly multiplier approach to estimate effective precipitation (Jensen, 1993) as used in USBR LCRAS reporting of crop water use. Average annual precipitation measured at the AZMET Parker No. 2 Station is 3.96 inches for the period: 2014-2018 (AZMET, 2013-2018). Using the LCRAS method, effective precipitation on the Reservation is about 0.76 inches per year, or just less than about 20 percent of average annual precipitation, for the 2014-2018 period at this location.

For each year analyzed, the weighted average NIR or NetCU was determined based on acreages of the individual crop types and the NIR or NetCU of each crop for that year. Using this result, an overall average unit area net crop consumptive irrigation water use (AF/ac) for the 5-year study period was determined. This 5-year average unit area net crop consumptive irrigation water use is listed for each Farm Unit in Table 1. The 5-year average unit area net crop consumptive irrigation water use is multiplied by the maximum (for the 5-year study period) annual acres irrigated for the Farm Unit to determine the total volume of NetCU due to fallowing and listed for each parcel in Table 1.

**Diversion Requirements**

NRCE (2017) has performed water balance analyses at the conveyance/delivery system level to estimate the magnitude of conveyance system losses (seepage, evaporation, and operational spills) experienced with the current infrastructure and operational management of the Project. Farm gate deliveries were estimated. These analyses allowed an assessment of conveyance/delivery system efficiency. As well, farm field level water balance analyses comparing net crop irrigation water requirements (NIR) to the estimated field level supplies or farmgate deliveries were performed. These comparisons allowed an assessment of on-farm losses to ditch seepage, deep percolation and tailwater runoff and estimation of on-farm efficiency. The overall assessment comparing net crop irrigation water requirements (NIR) to diversions allowed estimation of Project irrigation efficiency.

For the proposed Farm Units served by the Project, the total irrigation diversion requirement at Headgate Rock Dam corresponding to the Farm Unit net consumptive irrigation water use was estimated by dividing the farm field (NIR or NetCU) by the estimated project irrigation efficiency (product of irrigation delivery system conveyance efficiency and on-farm application efficiency).
For the purposes of these analyses, an overall Project irrigation efficiency of 53.5% was applied (NRCE, 2017).

Farm Unit 9035 is not served by the Project. This site diverts irrigation water by pumping directly from the Colorado River. Water is distributed across the farm using concrete lined ditches. Irrigation for the period of study 2013-17 was by flood (low gradient border and furrow) irrigation, although in years prior to this period linear move sprinklers were used on parts of the lease, and CRIT’s future plans include leasing parts of the unit and irrigating with the linear move sprinkler again. An average application efficiency of about 65-66% for border and furrow irrigation on the Reservation is used. For Unit 9035, the conveyance losses to seepage and operational spill are minor compared to the Project. A conservative conveyance efficiency of 90% is assigned on this unit. This results in an irrigation efficiency estimate of 60% for the unit.

**Monthly Distribution**

The annual cropping patterns found for each Farm Unit illustrate varying acreages of the primary crops from year to year and from Unit to Unit. To normalize this variability, monthly distributions of the total average annual NetCU savings and total average annual diversion reductions for each Farm Unit were determined by computing a monthly proportion of the total annual volume based on the 5-year average monthly and annual alfalfa crop evapotranspiration computed using reference crop $ET_0$ from the AZMET Parker No. 2 electronic weather station and LCRAS crop coefficients for alfalfa.

**Verification**

During the fallowing period, in order to ensure that any vegetation remaining on the fallowed lands does not consumptively use Colorado River water by drawing water from the Colorado River aquifer, CRIT shall, at its expense, control and eradicate any green vegetation growth.

Weed control will likely performed using chemical applications. Records of weed control applications, including date, chemicals used, rates of application, etc. will be prepared and maintained. CRIT agrees to provide Reclamation, Arizona Department of Water Resources, and other applicable entities, with information and updates, when requested, regarding the vegetation eradication program. Stubble from previous cropping will be kept on field surface to the extent
possible to reduce wind erosion. USBR personnel will be granted access to the Farms to perform periodic on-site inspections to verify compliance.

The means of irrigation water deliveries to each Farm Unit proposed for falling are described for each respective Unit. Irrigation water deliveries can be completely curtailed through control of farm gate turnouts or through control of sublateral head gates. CRIT agrees to furnish and install padlocks to lock the farm gate turnouts on fields fallowed to the extent possible to do so. In the event that a turnout serves multiple fields of which not all are being fallowed, other practical mechanisms, including but not limited to, dirt berms in the portion of the irrigation ditch serving the fallowed field, or sealing the on-farm turnouts onto fallowed fields will be used to the extent possible to assure that no water deliveries can be made onto the fallowed fields.

Verification of Conserved Water Diversion Reduction from Approved Water Order

Total estimated diversion requirements on monthly and annual time steps for the actively irrigated areas of the proposed Farm Units that will be fallowed have been estimated. CRIT’s annual water order (as determined and approved through the 43 CFR, Part 417 (Part 417) consultation between the BIA, US Bureau of Reclamation and CRIT) will be reduced by the estimated annual diversion requirements of the Farm Units for the agreed falling periods. Estimated monthly net consumptive use and diversion requirements of the Farm Units have also been determined. These monthly estimates allow determination of partial year water conservation and diversion reductions when falling periods are not a full 12-month period. Total annual CRIT Project and other Arizona diversions (with the falling and diversion reduction in progress) will not exceed CRIT’s Colorado River annual water right allocation for Arizona as adjusted by the diversion reductions, and thereby avoid inadvertent overruns (diversions in excess of CRIT’s adjusted entitlement—decreed AZ water right less the estimated diversion requirements of the falling program).

For Unit 9035, which diverts by direct pumping of water from the Colorado River, conserved water diversion reduction can be verified through routine monitoring of the electric power meter readings and account for the Unit’s pumping facilities.
C. Farm Unit: 6808

Farm Description and Location

Farm Unit 6808 (aka Quail Mesa Farm) is located on the Colorado River Indian Reservation within the Project service area with field parcels located within Sections 4, 5, 8, 9, 10, 16, 17, 20, 21, 29, and 32, Township 5N Range 21W (Gila and Salt River Meridian), La Paz County, Arizona. Physically, Quail Mesa Farm is bounded by Mohave Road on the west, Beeson Road on the north, and undeveloped desert land on the east and south. Figure C1 is an overview map of the Unit. Tyson Wash divides the Farm into a north area and a south area. Gross land area of Quail Mesa Farm is 3,999.7 acres. Approximately 3,705.1 net field acres have been in irrigated crop production for at least the past 5 years. The acreage not in production is occupied by buildings, hay and equipment storage yards, roads, canals, and drains.

The irrigated cropland on Quail Mesa is the terminal farming unit served by Sub-lateral 90-56 of the Project. Irrigation water deliveries can be effectively shut off at the Quail Mesa heading which is Check 4 on Sublateral 90-56 just upstream of the pipe culvert crossing of the sublateral over Mesa Drain.

CRIT Water Resources Dept. provided geospatial data (AGR05 shapefile and associated attribute table) of delineated irrigated field parcels across the Project. A total of 78 irrigated field parcels were identified within the actively irrigated area of Quail Mesa Farms (see Figure C1). Background aerial imagery in Figure C1 is dated 2017 and from the USDA National Agriculture Aerial Imagery Program (NAIP): [http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/](http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/). The CRIT field parcel delineations were found to show good agreement with the NAIP aerial imagery.
Figure C1. Overview Map of Farm Unit 6808.
Cropping Patterns

Crop patterns/crop mix for field parcels on Farm Unit 6808 for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD) and are summarized in Table C1. The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. The annual cropping pattern for Farm Unit 6808 is mapped in Figures C2-C6, for years 2014-2018, respectively.


<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated Crop Acreage</th>
<th>Alfalfa - Perennial</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
<th>Idle Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>3592.1</td>
<td>64%</td>
<td>0%</td>
<td>12%</td>
<td>6%</td>
<td>0%</td>
<td>18%</td>
<td>110.4</td>
</tr>
<tr>
<td>2015</td>
<td>3665.0</td>
<td>61%</td>
<td>0%</td>
<td>9%</td>
<td>4%</td>
<td>0%</td>
<td>25%</td>
<td>37.5</td>
</tr>
<tr>
<td>2016</td>
<td>3702.5</td>
<td>63%</td>
<td>0%</td>
<td>0%</td>
<td>16%</td>
<td>0%</td>
<td>21%</td>
<td>0.0</td>
</tr>
<tr>
<td>2017</td>
<td>3704.6</td>
<td>59%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>41%</td>
<td>0.0</td>
</tr>
<tr>
<td>2018</td>
<td>3704.6</td>
<td>44%</td>
<td>0%</td>
<td>0%</td>
<td>3%</td>
<td>54%</td>
<td>0%</td>
<td>0.0</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>58%</td>
<td>0%</td>
<td>4%</td>
<td>6%</td>
<td>11%</td>
<td>21%</td>
<td></td>
</tr>
</tbody>
</table>
Figure C2. Cropping Pattern on Farm Unit 6808 in 2014.
Figure C3. Cropping Pattern on Farm Unit 6808 in 2015.
Figure C4. Cropping Pattern on Farm Unit 6808 in 2016.
Figure C5. Cropping Pattern on Farm Unit 6808 in 2017.
Figure C6. Cropping Pattern on Farm Unit 6808 in 2018.
Estimated Crop Evapotranspiration

Table C2 below presents estimated annual and 5-year average reference ET<sub>0</sub> and crop ET (inches/year) for crops grown on the Reservation during the 5-year study period using weather data from the AZMET Parker No. 2 weather station.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET&lt;sub&gt;0&lt;/sub&gt;</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.9</td>
<td>37.7</td>
<td>24.5</td>
<td>49.6</td>
<td>44.6</td>
<td>44.9</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.2</td>
<td>39.1</td>
<td>23.0</td>
<td>49.7</td>
<td>43.8</td>
<td>44.5</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.9</td>
<td>43.2</td>
<td>24.3</td>
<td>53.7</td>
<td>46.4</td>
<td>48.0</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.5</td>
<td>40.5</td>
<td>23.6</td>
<td>50.9</td>
<td>46.2</td>
<td>46.2</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>69.7</td>
<td>40.1</td>
<td>24.5</td>
<td>50.5</td>
<td>46.2</td>
<td>46.1</td>
</tr>
<tr>
<td>Average (in)</td>
<td></td>
<td>70.0</td>
<td>40.1</td>
<td>24.0</td>
<td>50.9</td>
<td>45.4</td>
<td>45.9</td>
</tr>
<tr>
<td>Average (af/ac)</td>
<td></td>
<td>5.84</td>
<td>3.34</td>
<td>2.00</td>
<td>4.24</td>
<td>3.79</td>
<td>3.83</td>
</tr>
</tbody>
</table>

<sup>1</sup>Reference evapotranspiration of a short crop similar to 12-cm tall grass.

Estimated Net Consumptive Irrigation Water Use and Diversion Requirement

Table C3 below presents reference ET<sub>0</sub>, area-weighted average crop ET, effective precipitation, area-weighted average net consumptive use (NetCU), and associated diversion requirement (diversion reduction) for each year of the study period, and as an average of the 5-year period: 2014-18, based on the crop acreage and cropping pattern/mix discussed above. The estimated average annual unit area consumptive use on this Farm Unit for 2014-2018 is 4.89 AF/ac. The total estimated volume of water conserved due to the proposed fallowing of a maximum acreage of 3704.6 acres on the Farm Unit is 18,130 AFY. Using an estimated average overall irrigation efficiency of 53.5%, the diversion requirement associated with this net water conservation is 33,888 AFY.
Table C3. Annual and 5-year Average Reference ET₀, Area Weighted Crop ET, Effective Precipitation, Area Weighted Net CU and Diversion Reduction for 2014-2018. Farm Unit 6808: Quail Mesa.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET₀</th>
<th>Weighted Average Actual Crop ET (ETa)</th>
<th>Effective Precip.</th>
<th>Weighted Average Net Consumptive Use</th>
<th>Net Crop Area Fallowed</th>
<th>Net Consumptive Use Demand³</th>
<th>Diversion Reduction⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>75.11</td>
<td>57.38</td>
<td>0.30</td>
<td>57.09</td>
<td>3,592.1</td>
<td>17,089</td>
<td>31,942</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>57.15</td>
<td>0.93</td>
<td>56.24</td>
<td>3,665.0</td>
<td>17,178</td>
<td>32,108</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>65.24</td>
<td>1.03</td>
<td>64.21</td>
<td>3,702.5</td>
<td>19,811</td>
<td>37,030</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>60.56</td>
<td>0.82</td>
<td>59.74</td>
<td>3,704.6</td>
<td>18,443</td>
<td>34,474</td>
</tr>
<tr>
<td>2018</td>
<td>76.86</td>
<td>56.61</td>
<td>0.70</td>
<td>56.28</td>
<td>3,704.6</td>
<td>17,374</td>
<td>32,475</td>
</tr>
<tr>
<td>Average</td>
<td>77.26</td>
<td>59.39</td>
<td>0.76</td>
<td>58.71</td>
<td>3,673.7</td>
<td>17,979</td>
<td>33,606</td>
</tr>
</tbody>
</table>

| Unit area Net CU (AF/ac) | Max acreage | 3,704.6 | 18,130 | 33,888 |

¹ Reference evapotranspiration of a short crop similar to 12-cm tall grass.
² Estimated actual crop ET accounting for water stress and less than ideal growth conditions.
³ Weighted average calculated using irrigated acreages.
⁴ Column (8) divided by overall Project efficiency
The monthly distribution of the total average annual NetCU saving and total average annual diversion reduction for Farm Unit 6808 is presented in Table C4.


<table>
<thead>
<tr>
<th>Month</th>
<th>Average annual Alfalfa Crop ET (in) for period of analysis</th>
<th>Monthly Net Consumptive Use Demand</th>
<th>Monthly Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(inches) % of total</td>
<td>(AF)</td>
<td>(AF)</td>
</tr>
<tr>
<td>January</td>
<td>2.02 2.88%</td>
<td>522.6</td>
<td>976.9</td>
</tr>
<tr>
<td>February</td>
<td>3.57 5.09%</td>
<td>923.2</td>
<td>1,725.6</td>
</tr>
<tr>
<td>March</td>
<td>4.82 6.87%</td>
<td>1,245.9</td>
<td>2,328.8</td>
</tr>
<tr>
<td>April</td>
<td>6.83 9.74%</td>
<td>1,765.4</td>
<td>3,299.9</td>
</tr>
<tr>
<td>May</td>
<td>7.93 11.31%</td>
<td>2,051.1</td>
<td>3,833.9</td>
</tr>
<tr>
<td>June</td>
<td>9.09 12.96%</td>
<td>2,349.3</td>
<td>4,391.2</td>
</tr>
<tr>
<td>July</td>
<td>9.20 13.13%</td>
<td>2,379.9</td>
<td>4,448.3</td>
</tr>
<tr>
<td>August</td>
<td>8.71 12.42%</td>
<td>2,252.2</td>
<td>4,209.7</td>
</tr>
<tr>
<td>September</td>
<td>7.80 11.12%</td>
<td>2,016.4</td>
<td>3,769.0</td>
</tr>
<tr>
<td>October</td>
<td>4.40 6.28%</td>
<td>1,138.2</td>
<td>2,127.5</td>
</tr>
<tr>
<td>November</td>
<td>2.72 3.88%</td>
<td>702.9</td>
<td>1,313.9</td>
</tr>
<tr>
<td>December</td>
<td>3.03 4.32%</td>
<td>782.8</td>
<td>1,463.2</td>
</tr>
<tr>
<td>Annual</td>
<td>70.12 100.00%</td>
<td>18,130.0</td>
<td>33,887.9</td>
</tr>
</tbody>
</table>
References


TECHNICAL MEMORANDUM

Date: July 15, 2019

To: Tribal Council, Colorado River Indian Tribes (CRIT)

Cc: Rebecca Loudbear, Attorney General, CRIT
    Margaret Vick, Esq., Special Counsel

From: Natural Resources Consulting Engineers, Inc.

PROPOSED LANDS FOR COMPENSATED SYSTEM CONSERVATION PROGRAM (SCP) AND EXTRAORDINARY CONSERVATION INTENTIONALLY CREATED SURPLUS (EC ICS)

B. FARM UNIT: RAYNER 9035

Overview

This technical memorandum provides summary information and technical analyses for proposed temporary fallowing of irrigated farm land on the Colorado River Irrigation Project (Project) and other lands outside the boundary of the Project, Colorado River Indian Reservation, State of Arizona. The proposed fallowing is recommended for consideration under the Compensated System Conservation (SC) Program and Extraordinary Conservation Intentionally Created Surplus (EC ICS) Program. Temporary agricultural land fallowing is recognized by the Programs as means for reducing consumptive use to result in conserved water stored in Lake Mead.

Parcels of land will be designated for fallowing on an annual basis and described in a Creation Plan. At the time of designation each parcel will have a history of irrigation for at least three out of the most recent five years. Each parcel may be designated for fallowing for no more than five consecutive years.

Under this proposal, the Colorado River Indian Tribes (CRIT) would temporarily fallow irrigated cropland on nine different Farm Units. Summary data and information regarding the location of each Farm Unit, the crops produced, irrigated crop acreage, estimated crop evapotranspiration, effective rainfall, net crop consumptive use, and estimated total irrigation...
diversion requirement averaged over the previous 5-year period for each Farm Unit is provided below. Fallowing is proposed to begin in calendar year 2019 and continue through 2022.

**Project Description**

CRIT proposes to forego irrigation water deliveries and reduce consumptive use of Colorado River water by temporarily fallowing irrigated cropland as described immediately below during the period 2019-2022. CRIT proposes to create Compensated System Conservation through fallowing of specific Farm Units and make the conserved water available to the Colorado River System to increase storage in Lake Mead during 2020-2022. CRIT proposes to create EC ICS through fallowing of specific Farm Units for various periods of time during 2019 and may designate part of the consumptive use not compensated as system conservation for EC ICS during 2020-2022.

Figure 1 is an overview map showing the locations of the Farm Units proposed for fallowing on the Colorado River Indian Reservation (Reservation) in the State of Arizona. The majority of these Farm Units are served by the Tribe’s Colorado River Irrigation Project (Project), which diverts Colorado River water for irrigation of about 80,000 acres of land on the Reservation. One Farm Unit is located outside of the Project service area and diverts water directly from the Colorado River by pumping.

Two of the proposed Farm Units are currently fallowed and participating in the Pilot System Conservation Program:

- a. MTA 6627—October 1, 2018 to September 30, 2019
- b. Quail Mesa 6808—January 1, 2019 to December 31, 2019

**Estimated Conservation of Colorado River System Water**

Estimated average annual consumptive use reduction due to fallowing, and the associated reductions in diversions at Headgate Rock Dam or by direct pumping for each Farm Unit are summarized in Table 1 below.

CRIT proposes to use the average annual consumptive use reduction during October-December for Unit MTA 6627 and the total average annual consumptive use reduction for Unit Rayner 9035 for EC ICS creation in 2019. CRIT proposes to use all sites listed in Table 1
Figure 1. Overview of CRIT farm units proposed for following for SC and EC ICS.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Ave. Cropping Pattern</th>
<th>Net Consumptive Use</th>
<th>Efficiency Factor*</th>
<th>Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average AF/ac</td>
<td>Annual AFY</td>
<td>Annual AFY</td>
</tr>
<tr>
<td>6627*</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1884.0</td>
<td>82% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>1,470</td>
<td>0.301</td>
</tr>
<tr>
<td>9035**</td>
<td>Rayner</td>
<td>2013-17</td>
<td>1055.7</td>
<td>43% alfalfa 33% cotton 14% Bermuda (grass hay) 8% Sudan</td>
<td>4.55</td>
<td>4,804</td>
<td>0.301</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,942</td>
<td>6,274</td>
<td></td>
</tr>
</tbody>
</table>

* Oct 1, 2019-Dec 31, 2019 only
** estimates in this table for 9035 are based on 2013-2017 USGS cropping data

Summary of CRIT System Conservation and ICS for 2020 (System Conservation in excess of 50,000 AF will be considered ICS).

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
<th>Time Period</th>
<th>Max. Net Irrigated Acreage</th>
<th>Ave. Cropping Pattern</th>
<th>Total Net Consumptive Use</th>
<th>Net Consumptive Use Proration</th>
<th>Diversion Reduction Proration</th>
<th>Total Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total Net AF/c</td>
<td>System Conservation AFY</td>
<td>System Conservation ICS AFY</td>
<td>Annual AFY</td>
</tr>
<tr>
<td>6627</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1884.0</td>
<td>82% alfalfa 20% Sudan grass</td>
<td>5.39</td>
<td>10,157</td>
<td>9,450.7</td>
<td>706.2</td>
</tr>
<tr>
<td>6808</td>
<td>Quail Mesa</td>
<td>2014-18</td>
<td>3790.6</td>
<td>58% alfalfa 4% small grain 6% Bermuda (grass hay) 11% Sudan 21% Miscellaneous (onion, garlic, corn, potato)</td>
<td>4.89</td>
<td>18,130</td>
<td>16,859.7</td>
<td>1,250.6</td>
</tr>
<tr>
<td>6693</td>
<td>MTA Farms</td>
<td>2014-18</td>
<td>1183.9</td>
<td>64% alfalfa 1% cotton 6% small grain 13% Bermuda (grass hay) 14% Sudan 21% Miscellaneous (onion, garlic, corn, potato)</td>
<td>4.97</td>
<td>5,886</td>
<td>5,476.3</td>
<td>409.2</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Victoria</td>
<td>2014-18</td>
<td>406.8</td>
<td>60% alfalfa 2% cotton 17% small grain 12% Bermuda (grass hay) 5% Sudan</td>
<td>4.61</td>
<td>1,877</td>
<td>1,746.5</td>
<td>130.5</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Frinana</td>
<td>2014-18</td>
<td>674.7</td>
<td>52% alfalfa 26% cotton 18% small grain 4% Sudan</td>
<td>4.37</td>
<td>2,951</td>
<td>2,745.4</td>
<td>205.2</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>CRIT B</td>
<td>2014-18</td>
<td>1238.7</td>
<td>73% alfalfa 19% cotton 6% small grain 2% Miscellaneous (onion, garlic, corn, potato)</td>
<td>5.04</td>
<td>6,247</td>
<td>5,812.4</td>
<td>434.3</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>MTA 700</td>
<td>2014-18</td>
<td>465.8</td>
<td>80% alfalfa 7% cotton 7% Bermuda (grass hay)</td>
<td>5.50</td>
<td>2,562</td>
<td>2,383.8</td>
<td>178.1</td>
</tr>
<tr>
<td>CRIT Farms</td>
<td>Shawler Ranch</td>
<td>2014-18</td>
<td>439.5</td>
<td>69% alfalfa 30% cotton 2% Sudan</td>
<td>5.02</td>
<td>2,206</td>
<td>2,052.9</td>
<td>153.4</td>
</tr>
<tr>
<td>9035***</td>
<td>Rayner</td>
<td>2013-17</td>
<td>788.0</td>
<td>32% alfalfa 32% cotton 12% Bermuda (grass hay) 4% Sudan</td>
<td>4.72</td>
<td>3,721</td>
<td>3,462</td>
<td>259</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10,786</td>
<td>53,736</td>
<td>50,000</td>
<td>3,736</td>
</tr>
</tbody>
</table>

* based on Project overall average irrigation efficiency equal to 53.5%
** based on Project CU Diversion ratio of 0.475 for 2018 using methodology designated in the LBOips ICS Exhibit S for CRIT.
*** estimates in this table for 9035 are based on 2013-2017 USGS cropping data with linear move sprinkler area removed;
and, for System Conservation diversion reduction, an overall average irrigation efficiency for direct pumping from River equal to 60%
to create up to 50,000 AF/year of Compensated System Conservation with any excess over 50,000 AF/year designated as EC ICS during the period 2020. The same farm units listed in Table 1 or different farm units may be designated for fallowing in 2021 and 2022.

Methodology

This section provides a brief description of the data and methods used to estimate:

- the amount of water conserved due to falling of irrigated cropland on each Farm Unit for each year of analysis; this is the net consumptive irrigation water use savings due the cropland falling; and,

- the associated irrigation water diversion required to provide that amount of water at the farm field.

Results are presented for each proposed Farm Unit in individual succeeding sub-sections of this technical memorandum.

Farm Unit Description and Location

Location data and legal description (PLSS) for each Farm Unit proposed for falling were obtained from CRIT Realty and/or CRIT Farms, the Tribal farming enterprise. This information generally included total gross and net acreage of the unit. Net irrigated crop acreage on each field of each Unit was determined using CRIT Water Resources Department (WRD) AGR05 field parcel polygon shapefile. The maximum net irrigated field acreage in any single year of the study period was used to determine the total volume of consumptive use savings due to fallowing.

Information on the Colorado River Irrigation Project (Project) irrigation delivery system was generally available from the US Bureau of Indian Affairs (BLA), the Federal agency that owns and operates the Project on behalf of CRIT. NRCE has prepared a detailed assessment of the Project (NRCE, 2016; NRCE, 2017).

Cropping Patterns

Crops typically produced on the Reservation include alfalfa (for hay), cotton, small grains (wheat, oats, barley), Bermuda and other grass hay, Sudan grass, and variety of minor miscellaneous crops (onions, garlic, corn, potato) (NRCE, 2016).
Crop patterns/crop mix for field parcels on the Farm Units for the years 2014-2018 inclusive were available from annual crop survey work performed by the CRIT Water Resources Department (WRD). The cropping pattern on the Project is determined by field survey each year and spatially referenced on Project maps using WRD’s AGR05 field parcel polygon shapefile. For Unit 9035, cropping pattern data were not available from the CRIT WRD. For this unit, cropping pattern data collected by the USGS for the period 2013-2017 were made available by the USBR (Jeremy Dodds, USBR, personal communication, July 12, 2019). Unit 9035 has not been farmed since May 2018, and thus 2018 is not included in the analysis. The USGS crop pattern data are 100% coverage, on the ground crop survey data collected annually on the Rayner unit for USBR during 2013-17. Cropping pattern/crop mix maps for all Farm Units for the respective years analyzed are included in the subsection for each Farm Unit. A table summarizing the cropping pattern/crop mix for each Farm Unit for each year and average for the period analyzed is included.

_Estimation of Consumptive Use_

The factors considered in estimating crop consumptive use include cropped area and cropping patterns, reference evapotranspiration, crop coefficients, and precipitation. Crop evapotranspiration ($ET_c$) or crop consumptive use (crop CU) is defined as the evapotranspiration rate from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under given climatic conditions (Allen et al., 1998). Potential crop water use or crop evapotranspiration estimates for the period 1996 to present for the Colorado River Irrigation Project service area have been prepared (NRCE, 2016).

For the purposes of this study, $ET_c$ estimates using the single (mean) crop coefficient-reference evapotranspiration approach. Under this approach, reference crop evapotranspiration for a hypothetical green surface of actively transpiring vegetation is multiplied by a crop coefficient for a specific crop to estimate crop ET on a daily or monthly basis:

$$ET_c = K_c \times ET_o$$

where:

$ET_c$ = crop evapotranspiration (inches or mm);
$K_c$ = crop coefficient (dimensionless);

$ET_o$ = grass reference crop evapotranspiration (inches or mm)

The reference ET-crop coefficient method is widely used due to its simplicity, reproducibility, relatively good accuracy, and transportability among locations and climates.

For this analysis, reference ET (ET of an extensive area of short crop similar to 12-cm grass not short of water, ETo) was computed using the ASCE Standardized Reference Evapotranspiration Equation (ASCE, 2005). The ASCE Standardized Reference ET Equation for a short (grass) reference surface is:

$$ET_o = \frac{0.408\Delta R_n + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34u_2)}$$

where:

$ET_o$ = standardized reference crop evapotranspiration for (grass) short crop

$\Delta$ = slope of the saturation vapor pressure-temperature curve

$R_n$ = net radiation at the crop surface

$\gamma$ = psychrometric constant

$T$ = mean daily air temperature measured at 1.5-2 m above ground level

$u_2$ = mean daily wind speed measured at 2 m above ground level

$e_s$ = saturation vapor pressure

$e_a$ = mean actual vapor pressure

This equation is the same as the ASCE Penman-Monteith Equation (Jensen et al., 1990 and Jensen and Allen, 2016) but with several simplifying “standardized” methods employed to compute several of the variables and parameter used in the Equation as given in ASCE (2005).

Jensen et al. (1990) report and summarize results of a comprehensive study comparing evapotranspiration estimates from different estimating methods to measurements of
evapotranspiration made at 11 different lysimeter sites around the world representing a wide range of climatic conditions from humid to arid, and elevations from below sea level to 9100 ft MSL. Nineteen methods were compared to lysimeter measurements on a monthly basis, and thirteen methods were compared on a daily basis. The ASCE Penman-Monteith method as given in Jensen et al. (1990) was determined to provide the overall best estimates of seasonal ET and average peak monthly ET with the least error as compared to lysimeter measurements across all ranges of climate and elevation.

The ASCE Reference ET Equation (ASCE, 2005) is a physically-based approach accounting for energy available for evaporation and aerodynamic transport of moisture away from the evaporating surface. Because of this physically-based formulation, it requires detailed weather measurements including air temperature, relative humidity, incoming total solar radiation, and wind speed. Such weather measurements are available from the Arizona Meteorological Network (AZMET) operated by the University of Arizona College of Agriculture and Live Sciences and Arizona Cooperative Extension (https://cals.arizona.edu/AZMET/). Two AZMET electronic weather stations are currently in operation in the Parker Valley and both stations are located on the Colorado River Indian Reservation (https://www.usbr.gov/lc/region/g4000/wtracct.html):

Parker No. 1 (site 8), Latitude 33.964296, Longitude -114.485501, Elev. 322 ft above MSL
Parker No. 2 (site 35) Latitude 33.863015, Longitude -114.472974, Elev. 302 ft above MSL

Daily weather and ET₀ data from the AZMET Parker No. 2 Station for the respective 5-year period of analysis were used in this study (AZMET, 2013-2018).

The crop coefficient, Kᵦ, integrates the effects/differences of specific crop characteristics that affect water use of the specific crop to the water use of the reference crop. This methodology for estimated crop ET assumes the crop is growing under ideal conditions, and not stressed for water or nutrients, and thus, is considered the potential crop ET or potential consumptive use. Actual crop ET in farm fields is typically less than potential crop ET due to factors such as water stress, salinity, insect and disease pressure, etc.

Daily crop coefficient values for the primary crops comprising around 90% of the total irrigated crop acreage [alfalfa, cotton, small grains (wheat, oats, rye, barley, millet), Bermuda hay,
Sudan grass) grown on the Reservation were obtained from reports on crop coefficients prepared for the USBR LCRAS (https://www.usbr.gov/lc/region/g4000/wtracct.html#LCRAS) program (Jensen, 1998 and Jensen, 2003). Several minor “miscellaneous” crops have been and currently are produced on small acreage on the Reservation. Over the period 2013-2018, these minor crops have comprised an average of only 3.52% of the total irrigated crop acreage on the Project. These include but are not limited to corn, onions, garlic, crucifers, lettuce, and other small vegetable and melon crops. Most often these crops are produced for seed (crucifers, lettuce) or dehydration (onion, garlic) or animal feed (corn silage) and not as fresh market produce. Crop coefficients for a “miscellaneous” crop category were assumed to be equal to the average of the primary crops. This process is explained in more detail in Appendix B of NRCE (2016).

In the case of alfalfa, Jensen (1998, Appendix C) recognized the published crop coefficients for alfalfa hay represent potential (maximum) alfalfa ET under conditions where harvest and removal of hay is not delayed, and crop water stress does not occur. Jensen (1998) estimated the coefficients were about 15% too high for normal farm practices when hay may not be removed right after cuttings, some water stress might occur, non-uniformity of crop conditions, etc. To adjust for these effects and provide alfalfa hay consumptive use estimates closer to actual conditions, Jensen (1998) applied a factor of 0.85 to the alfalfa hay crop coefficients.

The differences between actual ET occurring under the field conditions of the PROJECT and potential ET from crop coefficient-reference ET approach can be estimated using a remote sensing approach which allows for the determination of actual evapotranspiration from both vegetated and bare soil surfaces by solving the full surface energy balance using remotely sensed visible and thermal band data. While this type of study has not been performed on the Project service area, two such studies have been conducted on large irrigation districts in the region and the results provide some insight on the differences between actual and potential crop consumptive use that may be occurring on the Project:

- Clark et al. (2008) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different combinations of soils, on-farm irrigation method, and crop types, found on Imperial Irrigation District (IID). In this case, the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, 1998) and
LandSat satellite imagery with 30 m thermal resolution for water year 1998 was used to estimate actual ET. Potential ET was estimated using the dual crop coefficient approach presented in Allen et al. (1998). The results were presented as ratios of actual ET to potential ET. Across IID the average ratio was found to be 0.85. For graded border and graded furrow irrigation of mature alfalfa and new alfalfa on all soil types, the IID ratio of actual ET to potential ET ranged from 0.83 to 0.87.

- Elhaddad and Garcia (2014) reported the results of comparisons of actual ET (as determined by remote sensing energy balance methods) to potential ET (as determined by the crop coefficient-reference ET approach) for several different crop types found on Palo Verde Irrigation District (PVID). In this case, actual ET was estimated using the ReSET Raster method (Elhaddad and Garcia, 2008) and LandSat 7 satellite imagery with 30 m thermal resolution for calendar year 2002. Potential ET was estimated using methods employed by the USBR in the Lower Colorado River Accounting System (LCRAS) (USBR, 1996-2014). The average ratio of actual ET to potential ET across PVID was found to be 0.86. For alfalfa, the ratio was found to be 0.86.

The results of these studies support the alfalfa hay crop coefficient adjustments suggested by Jensen (1998). Thus, for this analysis, alfalfa crop ET, as computed using the Jensen (1998, 2003) alfalfa crop coefficients (published coefficients multiplied by a factor of 0.85 to account for less than ideal growth conditions) was taken as an estimate of actual alfalfa crop ET. For Sudan, small grains, and grass hay, actual crop ET was estimated to be 0.85 times potential crop ET. For cotton and higher value minor miscellaneous crops (garlic, onion, potato) a factor of 1.00 was assumed.

Growing season durations of the various crops are implicit in the daily crop coefficients prepared by Jensen (1998, 2003) and were adopted for this analysis.

The net irrigation water requirement (NIR) or net consumptive irrigation water use (NetCU) represents the quantity of water required at the farm field to supply the estimated irrigation water demand of a crop during its growth period over and above the amount of natural precipitation water available for crop use. NIR or NetCU is computed as the crop ET minus the effective precipitation. Effective precipitation is that portion of total precipitation which is available for crop use. NRCE
adopted the flat monthly multiplier approach to estimate effective precipitation (Jensen, 1993) as used in USBR LCRAS reporting of crop water use. Average annual precipitation measured at the AZMET Parker No. 2 Station is 3.96 inches for the period: 2014-2018 (AZMET, 2013-2018). Using the LCRAS method, effective precipitation on the Reservation is about 0.76 inches per year, or just less than about 20 percent of average annual precipitation, for the 2014-2018 period at this location.

For each year analyzed, the weighted average NIR or NetCU was determined based on acreages of the individual crop types and the NIR or NetCU of each crop for that year. Using this result, an overall average unit area net crop consumptive irrigation water use (AF/ac) for the 5-year study period was determined. This 5-year average unit area net crop consumptive irrigation water use is listed for each Farm Unit in Table 1. The 5-year average unit area net crop consumptive irrigation water use is multiplied by the maximum (for the 5-year study period) annual acres irrigated for the Farm Unit to determine the total volume of NetCU due to fallowing and listed for each parcel in Table 1.

**Diversion Requirements**

NRCE (2017) has performed water balance analyses at the conveyance/delivery system level to estimate the magnitude of conveyance system losses (seepage, evaporation, and operational spills) experienced with the current infrastructure and operational management of the Project. Farmgate deliveries were estimated. These analyses allowed an assessment of conveyance/delivery system efficiency. As well, farm field level water balance analyses comparing net crop irrigation water requirements (NIR) to the estimated field level supplies or farmgate deliveries were performed. These comparisons allowed an assessment of on-farm losses to ditch seepage, deep percolation and tailwater runoff and estimation of on-farm efficiency. The overall assessment comparing net crop irrigation water requirements (NIR) to diversions allowed estimation of Project irrigation efficiency.

For the proposed Farm Units served by the Project, the total irrigation diversion requirement at Headgate Rock Dam corresponding to the Farm Unit net consumptive irrigation water use was estimated by dividing the farm field (NIR or NetCU) by the estimated project irrigation efficiency (product of irrigation delivery system conveyance efficiency and on-farm application efficiency).
For the purposes of these analyses, an overall Project irrigation efficiency of 53.5% was applied (NRCE, 2017).

Farm Unit 9035 is not served by the Project. This site diverts irrigation water by pumping directly from the Colorado River. Water is distributed across the farm using concrete lined ditches. Irrigation for the period of study 2013-17 was by flood (low gradient border and furrow) irrigation, although in years prior to this period linear move sprinklers were used on parts of the lease, and CRIT’s future plans include leasing parts of the unit and irrigating with the linear move sprinkler again. An average application efficiency of about 65-66% for border and furrow irrigation on the Reservation is used. For Unit 9035, the conveyance losses to seepage and operational spill are minor compared to the Project. A conservative conveyance efficiency of 90% is assigned on this unit. This results in an irrigation efficiency estimate of 60% for the unit.

**Monthly Distribution**

The annual cropping patterns found for each Farm Unit illustrate varying acreages of the primary crops from year to year and from Unit to Unit. To normalize this variability, monthly distributions of the total average annual NetCU savings and total average annual diversion reductions for each Farm Unit were determined by computing a monthly proportion of the total annual volume based on the 5-year average monthly and annual alfalfa crop evapotranspiration computed using reference crop ET$_o$ from the AZMET Parker No. 2 electronic weather station and LCRAS crop coefficients for alfalfa.

**Verification**

During the fallowing period, in order to ensure that any vegetation remaining on the fallowed lands does not consumptively use Colorado River water by drawing water from the Colorado River aquifer, CRIT shall, at its expense, control and eradicate any green vegetation growth.

Weed control will likely performed using chemical applications. Records of weed control applications, including date, chemicals used, rates of application, etc. will be prepared and maintained. CRIT agrees to provide Reclamation, Arizona Department of Water Resources, and other applicable entities, with information and updates, when requested, regarding the vegetation eradication program. Stubble from previous cropping will be kept on field surface to the extent
possible to reduce wind erosion. USBR personnel will be granted access to the Farms to perform periodic on-site inspections to verify compliance.

The means of irrigation water deliveries to each Farm Unit proposed for fallowing are described for each respective Unit. Irrigation water deliveries can be completely curtailed through control of farm gate turnouts or through control of sublateral head gates. CRIT agrees to furnish and install padlocks to lock the farm gate turnouts on fields fallowed to the extent possible to do so. In the event that a turnout serves multiple fields of which not all are being fallowed, other practical mechanisms, including but not limited to, dirt berms in the portion of the irrigation ditch serving the fallowed field, or sealing the on-farm turnouts onto fallowed fields will be used to the extent possible to assure that no water deliveries can be made onto the fallowed fields.

**Verification of Conserved Water Diversion Reduction from Approved Water Order**

Total estimated diversion requirements on monthly and annual time steps for the actively irrigated areas of the proposed Farm Units that will be fallowed have been estimated. CRIT’s annual water order (as determined and approved through the 43 CFR, Part 417 (Part 417) consultation between the BIA, US Bureau of Reclamation and CRIT) will be reduced by the estimated annual diversion requirements of the Farm Units for the agreed fallowing periods. Estimated monthly net consumptive use and diversion requirements of the Farm Units have also been determined. These monthly estimates allow determination of partial year water conservation and diversion reductions when fallowing periods are not a full 12-month period. Total annual CRIT Project and other Arizona diversions (with the fallowing and diversion reduction in progress) will not exceed CRIT’s Colorado River annual water right allocation for Arizona as adjusted by the diversion reductions, and thereby avoid inadvertent overruns (diversions in excess of CRIT’s adjusted entitlement—decreed AZ water right less the estimated diversion requirements of the fallowing program).

For Unit 9035, which diverts by direct pumping of water from the Colorado River, conserved water diversion reduction can be verified through routine monitoring of the electric power meter readings and account for the Unit’s pumping facilities.


**B. Farm Unit Rayner 9035**

Farm Description and Location

Farm Unit Rayner 9035 (aka Rayner Farm) is located on the Colorado River Indian Reservation outside the Project service area with field parcels located within Sections 14, 15, 22, and 23, Township 4N Range 22W (Gila and Salt River Meridian), La Paz County, Arizona. Physically, Rayner Farm is close to Ehrenburg AZ, and is bounded by the Colorado River on the north, west, and southwest, and undeveloped land on the east and southeast. Figure B1 is an overview map of the Unit. Gross land area of Unit 9035 is about 1,140.7 acres. Approximately, a maximum of 1,055.7 net field acres have been in irrigated crop production during 2013-17. A portion of the farm will be leased out in 2020 to a private grower. That area, approximately 270 acres, will be irrigated by a linear move sprinkler irrigation system. Figure B2 shows the remaining irrigated area that will be fallowed, approximately a maximum of 788 net field acres have been in irrigated crop production during 2013-17 with the linear move sprinkler fields removed. The acreage not in production is occupied by buildings, hay and equipment storage yards, corrals, roads, canals, and drains.

The irrigated cropland on Rayner Farm is irrigated by direct pumping from the Colorado River. The pump station on the River is located on the north side of the Unit. Irrigation water deliveries can be effectively shut off from the fallowed lands by closing all sub-lateral headgates.

This Farm Unit has not been previously mapped by CRIT Water Resources Dept. Delineated irrigated field parcels on the Unit were determined using supplemental PLSS parcel description data provided from CRIT Realty and Google Earth imagery. A total of approximately 30 irrigated field parcels were identified within the actively irrigated area of Rayner Farm (see Figure B1), although field parcel boundaries are noted to have changed with some consolidation or further subdivision apparent during the study period. Background aerial imagery in Figure B1 is dated 2017 and from the USDA National Agriculture Aerial Imagery Program (NAIP): [http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/](http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/). The CRIT field parcel delineations show good agreement with the NAIP aerial imagery.
Figure B1. Overview Map of Farm Unit Rayner 9035.
Figure B2. Overview Map of Farm Unit Rayner 9035 with the Area under the Linear Move Sprinkler System Removed.
Cropping Patterns

For Farm Unit Rayner 9035, cropping pattern data were not available from the CRIT WRD. For this unit, cropping pattern data collected by the USGS for the period 2013-2017 were made available by the USBR (Jeremy Dodds, USBR, personal communication, July 12, 2019). Unit 9035 has not been farmed since May 2018, and thus 2018 is not included in the analysis. The USGS crop pattern data are 100% coverage, on the ground crop survey data collected annually on the Rayner unit for USBR during 2013-17. Results (with the fields under the linear move sprinkler system removed) are summarized in Table B1. The annual cropping pattern for Farm Unit Rayner 9035 is mapped in Figures B3-B7, for years 2013-2017, respectively.


<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated Crop Acreage</th>
<th>Alfalfa - Perennial</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/ Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
<th>Idle Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>785.8</td>
<td>47%</td>
<td>43%</td>
<td>0%</td>
<td>10%</td>
<td>0%</td>
<td>0%</td>
<td>21.6</td>
</tr>
<tr>
<td>2014</td>
<td>785.8</td>
<td>54%</td>
<td>35%</td>
<td>0%</td>
<td>10%</td>
<td>0%</td>
<td>0%</td>
<td>21.6</td>
</tr>
<tr>
<td>2015</td>
<td>622.1</td>
<td>42%</td>
<td>45%</td>
<td>0%</td>
<td>13%</td>
<td>0%</td>
<td>0%</td>
<td>185.4</td>
</tr>
<tr>
<td>2016</td>
<td>785.8</td>
<td>56%</td>
<td>19%</td>
<td>0%</td>
<td>24%</td>
<td>0%</td>
<td>0%</td>
<td>21.6</td>
</tr>
<tr>
<td>2017</td>
<td>788.0</td>
<td>61%</td>
<td>19%</td>
<td>0%</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
<td>21.6</td>
</tr>
<tr>
<td>Average</td>
<td>788.0</td>
<td>52%</td>
<td>32%</td>
<td>0%</td>
<td>12%</td>
<td>4%</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>
Figure B3. Cropping Pattern on Farm Unit Rayner 9035 in 2013.
Figure B4. Cropping Pattern on Farm Unit Rayner 9035 in 2014.
Figure B5. Cropping Pattern on Farm Unit Rayner 9035 in 2015.
Figure B6. Cropping Pattern on Farm Unit Rayner 9035 in 2016.
Figure B7. Cropping Pattern on Farm Unit Rayner 9035 in 2017.
Estimated Crop Evapotranspiration

Table B2 below presents computed annual and 5-year average reference ET$_o$ and crop ET (inches/year) for crops grown on the Reservation during the 5-year study period: 2013-2017 using weather data from the AZMET Parker No. 2 weather station.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference ET$_o$</th>
<th>Alfalfa</th>
<th>Cotton</th>
<th>Small Grains</th>
<th>Grass (Bermuda/ Rye)</th>
<th>Grass (Sudan)</th>
<th>Misc. Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>76.18</td>
<td>69.1</td>
<td>38.0</td>
<td>25.2</td>
<td>49.8</td>
<td>45.0</td>
<td>45.4</td>
</tr>
<tr>
<td>2014</td>
<td>75.11</td>
<td>67.9</td>
<td>37.7</td>
<td>24.5</td>
<td>49.6</td>
<td>44.6</td>
<td>44.9</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>68.2</td>
<td>39.1</td>
<td>23.0</td>
<td>49.7</td>
<td>43.8</td>
<td>44.5</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>73.9</td>
<td>43.2</td>
<td>24.3</td>
<td>53.7</td>
<td>46.4</td>
<td>48.0</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>70.5</td>
<td>40.5</td>
<td>23.6</td>
<td>50.9</td>
<td>46.2</td>
<td>46.2</td>
</tr>
<tr>
<td>Average (in)</td>
<td></td>
<td>69.9</td>
<td>39.7</td>
<td>24.1</td>
<td>50.7</td>
<td>45.2</td>
<td>45.8</td>
</tr>
<tr>
<td>Average (af/ac)</td>
<td></td>
<td>5.83</td>
<td>3.31</td>
<td>2.01</td>
<td>4.23</td>
<td>3.77</td>
<td>3.82</td>
</tr>
</tbody>
</table>

Reference evapotranspiration of a short crop similar to 12-cm tall grass.

Estimated Net Consumptive Irrigation Water Use and Diversion Requirement

Table B3 below presents reference ET$_o$, area-weighted average crop ET, effective precipitation, area-weighted average net consumptive use (NetCU), and associated diversion requirement (diversion reduction) for each year of the study period, and as an average of the 5-year period: 2013-17, based on the crop acreage and cropping pattern/mix discussed above. The estimated average annual unit area consumptive use on this Farm Unit for 2013-2017 is 4.72 AF/ac. The total estimated volume of water conserved due to the proposed fallowing of a maximum acreage of 788 acres on the Farm Unit is 3,721 AFY. Using an estimated average overall irrigation efficiency of 60%, the diversion requirement associated with this net water conservation is 6,202 AFY.
Table B3. Annual and 5-year Average Reference ET₀, Area Weighted Crop ET, Effective Precipitation, Area Weighted Net CU and Diversion Reduction for 2013-2017. Farm Unit Rayner 9035.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference $ET₀$₁</th>
<th>Weighted Average Actual Crop ET (ETa)²</th>
<th>Effective Precip.</th>
<th>Net Actual Consumptive Use</th>
<th>Net Crop Area Fallowed</th>
<th>Net Actual Consumptive Use Demand³</th>
<th>Diversion Reduction at Direct Pumping from River⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(in)</td>
<td>(ac)</td>
<td>(AF)</td>
<td>(AF)</td>
</tr>
<tr>
<td>2013</td>
<td>76.18</td>
<td>53.79</td>
<td>0.16</td>
<td>53.70</td>
<td>785.8</td>
<td>3,517</td>
<td>5,861</td>
</tr>
<tr>
<td>2014</td>
<td>75.11</td>
<td>55.27</td>
<td>0.30</td>
<td>55.05</td>
<td>785.8</td>
<td>3,605</td>
<td>6,009</td>
</tr>
<tr>
<td>2015</td>
<td>75.19</td>
<td>52.73</td>
<td>0.93</td>
<td>52.06</td>
<td>622.1</td>
<td>2,699</td>
<td>4,498</td>
</tr>
<tr>
<td>2016</td>
<td>81.43</td>
<td>63.01</td>
<td>1.03</td>
<td>62.16</td>
<td>785.8</td>
<td>4,071</td>
<td>6,785</td>
</tr>
<tr>
<td>2017</td>
<td>77.70</td>
<td>59.90</td>
<td>0.82</td>
<td>59.40</td>
<td>788.0</td>
<td>3,900</td>
<td>6,500</td>
</tr>
<tr>
<td>Average</td>
<td>77.12</td>
<td>56.94</td>
<td>0.65</td>
<td>56.47</td>
<td>753.5</td>
<td>3,558</td>
<td>5,931</td>
</tr>
</tbody>
</table>

Max acreage: 788.0, 3,721, 6,202

₁ Reference evapotranspiration of a short crop similar to 12-cm tall grass.

₂ Estimated actual crop ET accounting for water stress and less than ideal growth conditions.

  Weighted average calculated using irrigated acreages.

₃ Column (5) divided by 12 and multiplied by Column (6)

₄ Column (8) divided by overall Project efficiency
The monthly distribution of the total average annual NetCU saving and total average annual diversion reduction for Farm Unit Rayner 9035 is presented in Table B4.

Table B4. Monthly Distribution of Net Consumptive Use and Associated Diversion Reduction, Farm Unit Rayner 9035, 2013-2013.

<table>
<thead>
<tr>
<th>Month</th>
<th>Average annual Alfalfa Crop ET (in) for period of analysis</th>
<th>Monthly Net Consumptive Use Demand</th>
<th>Monthly Diversion Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(inches)</td>
<td>% of total</td>
<td>(AF)</td>
</tr>
<tr>
<td>January</td>
<td>2.09</td>
<td>2.99%</td>
<td>111.2</td>
</tr>
<tr>
<td>February</td>
<td>3.64</td>
<td>5.21%</td>
<td>194.0</td>
</tr>
<tr>
<td>March</td>
<td>4.91</td>
<td>7.04%</td>
<td>262.0</td>
</tr>
<tr>
<td>April</td>
<td>6.96</td>
<td>9.97%</td>
<td>371.1</td>
</tr>
<tr>
<td>May</td>
<td>8.06</td>
<td>11.56%</td>
<td>430.1</td>
</tr>
<tr>
<td>June</td>
<td>9.00</td>
<td>12.90%</td>
<td>479.9</td>
</tr>
<tr>
<td>July</td>
<td>8.88</td>
<td>12.73%</td>
<td>473.6</td>
</tr>
<tr>
<td>August</td>
<td>8.56</td>
<td>12.27%</td>
<td>456.4</td>
</tr>
<tr>
<td>September</td>
<td>7.80</td>
<td>11.19%</td>
<td>416.2</td>
</tr>
<tr>
<td>October</td>
<td>4.24</td>
<td>6.08%</td>
<td>226.4</td>
</tr>
<tr>
<td>November</td>
<td>2.75</td>
<td>3.94%</td>
<td>146.5</td>
</tr>
<tr>
<td>December</td>
<td>2.88</td>
<td>4.13%</td>
<td>153.5</td>
</tr>
<tr>
<td>Annual</td>
<td>69.76</td>
<td>100.00%</td>
<td>3,721.0</td>
</tr>
</tbody>
</table>
References


EXHIBIT B – FUNDING AGREEMENT
EXHIBIT B

AGREEMENT BETWEEN THE ARIZONA DEPARTMENT OF WATER RESOURCES AND THE ENVIRONMENTAL DEFENSE FUND, INC. TO FUND THE CREATION OF SYSTEM CONSERVATION WATER IN LAKE MEAD BY THE COLORADO RIVER INDIAN TRIBES

PREAMBLE: The Colorado River Indian Tribes ("CRIT") have agreed to fallow sufficient irrigable farmland on the Colorado River Indian Reservation in Arizona ("CRIR") to create 50,000 acre-feet of System Conservation Water in Lake Mead ("CRIT Proposal") in each of three years beginning January 1, 2020 and ending December 31, 2022 ("Fallowing Period"). CRIT will forego irrigation water deliveries and fallow approximately 10,000 acres of farmland in exchange for receiving from the Arizona System Conservation Fund ("Fund") $247.20 per acre-foot of water in 2020, with a 3% annual escalator, for up to 150,000 acre-feet conserved in Lake Mead and available to the Lower Colorado River System to maintain lake levels ("Project").

The Arizona Department of Water Resources ("ADWR"), the U.S. Bureau of Reclamation ("Reclamation"), and the Central Arizona Water Conservation District ("CAWCD") will enter an agreement setting forth the terms for CRIT's creation of System Conservation Water in Lake Mead ("CRIT Agreement"). This Exhibit B will be part of the CRIT Agreement. To fund the Project, the State of Arizona has appropriated $30,000,000 in FY 2019/2020 for deposit into the Fund pursuant to Laws 2019, Chapter 1, Sec. 21. Contingent on this funding agreement becoming effective as set forth in Section XI below, EDF has agreed to deposit a total of $2,000,000 into the Fund by January 31, 2020 and use best efforts to contribute an additional $6,000,000 into the Fund no later than July 15, 2021.

This Agreement ("Funding Agreement") is intended to describe the State of Arizona’s and EDF’s commitment to contribute monies to the Fund to assist in funding the Project during the Fallowing Period such that CRIT receives compensation from the Fund in accordance with Section 8 of the CRIT Agreement.

I. **Key Terms:** The defined terms in the CRIT Agreement shall have the same meaning in this Funding Agreement.

II. **Cost of Project:** The total cost for the conservation of 150,000 acre-feet of water in Lake Mead by CRIT is $38,160,000, which includes $160,000 of interest that will accrue in the Fund from monies contributed to the Fund for the purpose of funding the Project by the State of Arizona and EDF, and others if necessary, during the Fallowing Period.

III. **Financial Contributions by State of Arizona:** To fund the Project, the State of Arizona has appropriated $30,000,000 in FY 2019/2020 for deposit into the Fund pursuant to Laws 2019, Chapter 1, Sec. 21. ADWR expects that these monies will be deposited by the State into the Fund by July 31, 2019. No other monies shall be deposited into the Fund by the State of Arizona to complete its obligation to the CRIT pursuant to the CRIT Agreement. Interest accrued on the
monies deposited into the Fund by the State of Arizona will accrue to the benefit of CRIT and will be paid to CRIT in accordance with the terms of Section 8 of the CRIT Agreement up to the total amount of funding for CRIT to create 150,000 acre-feet of System Conservation Water. Any monies remaining in the Fund including accrued interest, after the final payment to CRIT, shall be returned to the State of Arizona and EDF according to each party’s contribution to the Fund. Any monies contributed to the Fund by a party other than the State of Arizona and EDF, shall not be included in the distribution of monies remaining in the Fund to the State and EDF.

IV. Financial Contributions by EDF:

EDF shall make financial contributions to the Fund according to the Table below:

<table>
<thead>
<tr>
<th>Contributions</th>
<th>Due Date</th>
<th>EDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contribution 1</td>
<td>On or before July 31, 2019</td>
<td>$1,000,000.00</td>
</tr>
<tr>
<td>Contribution 2</td>
<td>On or before January 31, 2020</td>
<td>$1,000,000.00</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>$2,000,000.00</td>
</tr>
</tbody>
</table>

Interest accrued on the monies deposited into the Fund by EDF for the purpose of funding the Project will accrue to the benefit of CRIT and will be paid to CRIT in accordance with the terms of Section 8 of the CRIT Agreement. Any monies remaining in the Fund including accrued interest, after final payment to CRIT, shall be returned to EDF and the State of Arizona according to each party’s contribution to the Fund. Any monies contributed to the Fund by a party other than the State of Arizona and EDF, shall not be included in the distribution of monies remaining in the Fund to the State and EDF.

V. Additional Contributions by EDF: In addition to EDF’s agreement to contribute $2,000,000 to the Fund according to the provisions set forth in Section IV herein, EDF has made significant progress toward raising $2,000,000 to $3,000,000 to be contributed to the Fund by January 31, 2021. EDF will use best efforts to raise an additional amount of money to be contributed to the Fund on or before July 15, 2021 in an amount equal to the difference between $8,000,000 and the total amount of monies previously contributed to the Fund by EDF. Any monies contributed by EDF to the Fund pursuant to this Section shall be used to fund the Project under the terms of the CRIT Agreement. Notwithstanding any other provision in this Funding Agreement, the total amount of contributions that EDF will endeavor to make to the Fund during the Fallowing Period shall not exceed $8,000,000.

VI. Notice: EDF agrees that should it be unable to meet any of its funding commitments as set forth in Sections IV and V herein, it shall provide written notice to ADWR and CRIT no later than July 1, 2021 stating the reason for, and the amount of, its funding shortfall. EDF shall not be held
liable by any of the parties to the CRIT Agreement in the event that EDF is unable to raise funds beyond its $2,000,000.00 commitment herein.

VII. Invoicing: ADWR will invoice EDF for its $1,000,000 contribution due on or before January 31, 2020 at least sixty (60) days prior to the final due date listed in the table in Section IV herein.

VIII. Payments to CRIT by ADWR: Payments from the Fund by ADWR to CRIT shall be made in accordance with the terms of the CRIT Agreement.

IX. Third-Party Beneficiary: CRIT is a third-party beneficiary to this Funding Agreement.

X. Performance Metrics: Specific performance metrics are set forth in Sections 6 and 8 of the CRIT Agreement and must be met prior to payment from the Fund by ADWR to CRIT. ADWR will provide these performance metrics to EDF in the same manner that it was provided to ADWR within 45 days of ADWR’s receipt of such metrics. The terms of the CRIT Agreement govern the implementation of this Funding Agreement.

XI. Effective Date: This Funding Agreement becomes effective upon the occurrence of the latter of: (1) signing of this Agreement by ADWR and EDF, and (2) signing of the CRIT Agreement by all of the parties to that agreement.

XII. Termination Date: This Funding Agreement shall terminate upon fulfillment of the obligations set forth herein and in the CRIT Agreement. ADWR is supportive of establishing a program to create additional system conservation water in Lake Mead to protect lake levels if participants and funders are willing and able to participate.

ADWR and EDF’s signature below indicates agreement with the terms of this Funding Agreement. This Funding Agreement may be signed in counterparts, each of which shall be an original and all of which, together shall constitute Exhibit B of the CRIT Agreement.

**ADWR:**

By: [Signature]

Its: Director

Date: 7-19-19

**ENVIRONMENTAL DEFENSE FUND, INC.**

By: [Signature]

Its: [Position]

Date: 7-30-19

Approved as to form:

By: [Signature]

Its: [Position]

Date: [Signature]

Approved as to form:

By: [Signature]

Its: [Position]

Date: [Signature]