Refining Procedures for Evaluating Fully Appropriated Conditions

Literature Review TM

TO: Ron Bishop, General Manager, CPNRD
Jim Schneider, Deputy Director, Nebraska DNR

COPY: File

FROM: HDR-TFG Project Team

DATE: January 10, 2011

This Technical Memorandum (TM) discusses and summarizes the background and purpose of this project, the Nebraska Revised Statutes and the current Nebraska Department of Natural Resources (DNR) Rules[1] and procedures that provide the framework within which water supply analyses are conducted. Finally, methodologies for analyzing available water supply being employed elsewhere in the country that may have applicability to Nebraska river basins will be summarized.

1.0 Background and Project Purpose

The hydrologic variations inherent to Nebraska's river basins require that the refined fully appropriated evaluation procedures must have flexibility to handle the varied surface water and ground water conditions. Significant hydrologic variability with such conditions as annual precipitation, growing season duration, mean and extreme temperatures, cropping pattern, soil type, land use, and topography, can be observed in the individual river basins that extend across the state. Likewise the physical characteristics of the underlying aquifer within a river basin can vary greatly, impacting ground water hydrology and therefore the analyses of available water supply. This variation across the state may exceed the reasonable limits of flexibility of certain procedures and warrant consideration of analysis methods that also vary geographically.

In addition to addressing the spatial variations in physical hydrologic characteristics that directly impact surface and ground water resources, the evaluation procedures must also be robust enough to handle the temporal variations in hydrologic conditions.

The purpose of this project is to refine Nebraska DNR's evaluation methodology to achieve two related goals:

1. Allow Nebraska DNR's evaluation procedures to compute fully appropriated levels of development to serve as a baseline for use in the development of integrated management plans for overappropriated basins.
2. Include additional standards of interference for non-irrigation rights, such as storage, hydropower, and instream flow rights in the procedures.

[1] Rules for Surface Water, State of Nebraska Department of Natural Resources, June 27, 2008

2.0 Revised Nebraska Statutes

The passage of LB 962[2] by the Nebraska Unicameral in 2004 established a framework for integrated water resources management, as well as requiring a proactive approach in anticipating and preventing conflicts between surface water and ground water users. Where conflicts already exist, LB 962 attempted to establish principles and timelines for resolving those conflicts. Some of the key provisions of LB 962 relevant to this project that are part of current Statutes include:

- The Department of Natural Resources must make an annual determination by January 1 of each year as to which basins, subbasins, or reaches not previously designated as fully appropriated or overappropriated have since become fully appropriated. The Department must also complete an annual evaluation of the expected long-term availability of hydrologically connected water supplies in the basins, subbasins, or reaches and issue a report describing the results of the evaluation.
- When a basin, subbasin, or reach is determined to be fully appropriated, stays on new uses of ground water and surface water are automatically imposed. The Department and the natural resources districts (NRDs) involved are required to develop and implement jointly an integrated management plan (IMP) within three to five years of that determination.
- A key goal of each IMP must be to manage all hydrologically connected ground water and surface water for the purpose of sustaining a balance between water uses and water supplies so that the economic viability, social and environmental health, safety, and welfare of the basin, subbasin, or reach can be achieved and maintained for both the near and long term. In the overappropriated portions of the state, the IMP must provide goals and objectives with the purpose of sustaining a balance between water uses and water supplies.

Currently, the Nebraska DNR conducts annual reviews of areas not yet designated as fully appropriated or overappropriated to determine if they should be added to the list of fully appropriated regions. This evaluation is performed through a procedure outlined in State statute, and more fully defined in subsequent rules promulgated by DNR. Generally speaking, these rules lay out procedures which use irrigation rights as the principal focus. Further discussion of these procedures is provided in Section 3.0 of this TM.

The general criteria for the fully appropriated determination are established in Neb. Rev. Stat. § 46-713 (3):

[2] Signed into Law April, 2004

> A river basin, subbasin, or reach shall be deemed fully appropriated if the department determines based upon its evaluation conducted pursuant to subsection (1) of this section and information presented at the hearing pursuant to subsection (4) of section 46-714 that then-current uses of hydrologically connected surface water and ground water in the river basin, subbasin, or reach cause or will in the reasonably foreseeable future cause (a) the surface water supply to be insufficient to sustain over the long term the beneficial or useful purposes for which existing natural-flow or storage appropriations were granted and the beneficial or useful purposes for which, at the time of approval, any existing instream appropriation was granted, (b) the streamflow to be insufficient to sustain over the long term the beneficial uses from wells constructed in aquifers dependent on recharge from the river or stream involved, or (c) reduction in the flow of a river or stream sufficient to cause noncompliance by Nebraska with an interstate compact or decree, other formal state contract or agreement, or applicable state or federal laws.

The DNR's fully appropriated evaluation methodology also plays a key role in the development of integrated management plans for those basins designated as overappropriated. As stated in Neb. Rev. Stat. § 46-715 (5) (c):

> Any integrated management plan developed under this subsection shall identify the overall difference between the current and fully appropriated levels of development. Such determination shall take into account cyclical supply, including drought, identify the portion of the overall difference between the current and fully appropriated levels of development that is due to conservation measures, and identify the portion of the overall difference between the current and fully appropriated levels of development that are due to water use initiated prior to July 1, 1997, and to water use initiated on or after such date.

The difference between current and fully appropriated level of development being defined by Neb. Rev. Stat. § 46-706 (27) as:

> Overall difference between current and fully appropriated levels of development means the extent to which existing uses of hydrologically connected surface water and ground water and conservation activities result in the water supply available for purposes identified in subsection (3) of section 46-713 to be less than the water supply available if the river basin, subbasin, or reach had been determined to be fully appropriated in accordance with section 46-714.

This passage, in essence, states that the DNR fully appropriated evaluation is the basis for determining the offset targets in water use to move from overappropriated to fully appropriated status as required by Statute and as implemented through the integrated management plans.

A more complete description of the statutory requirements can be found in the Nebraska Ground Water Management and Protection Act (Neb. Rev. Stat. §§ 46-701 through 46-754).

3.0 Current Nebraska DNR Rules and Procedures

The general procedures used by DNR in their annual evaluation process is outlined in the flow chart on page 22 of their 2010 report (DNR 2009)[3], included here as Appendix A. As shown, there is a series of four criteria used in the evaluation of current development, along with a separate criterion for the evaluation of future development that does not have a direct impact on the determination. For Criteria #1 and #2, if the 65/85 is not able to be met, a subsequent check is performed to see if junior surface water irrigation rights have been eroded. A short summary of the five criteria used in the evaluation is included below:

Criterion #1: The 65/85 Irrigation Rule with Current Development – the first evaluation criterion involves determining if a junior irrigator has sufficient access to water supplies under current development conditions to meet a certain threshold of reliability.

Criterion #2: The 65/85 Irrigation Rule with Current Development and 25 Years of Lag Impact – this criterion is similar to the first, with additional consideration of the lag impacts that would be expected following 25 years of ground water pumping.

Criterion #3: Erosion of Non-Irrigation Surface Water Rights – this criterion determines if the reliability of meeting instream flow targets, or other non-irrigation rights, has been eroded since the date of their appropriation.

Criterion #4: Compliance with State and Federal Laws – the final criterion considers compliance with State and Federal laws and agreements.

Criterion #5: The 65/85 Irrigation Rule with Current Development and 25 Years of Lag Impact and predicted lag impacts – this criterion is similar to the second, with additional consideration of the lag impacts that would be expected following 25 years of ground water pumping from current wells, in addition to predicted lag impacts from future well development. This criterion does not play a direct role in the determination, and is more for planning purposes.

A complete description of the methodology used by the DNR in their annual evaluation process is provided in SECTION 4.0 METHODOLOGY of their 2010 report (DNR 2009).

[3] 2010 Annual Evaluation of Availability of Hydrologically Connected Water Supplies, Nebraska Department of Natural Resources, December 18, 2009

As referenced in DNR rule 457 N.A.C. 24.001.01B[4], the DNR is also tasked with developing additional standards of interference for non-irrigation rights, such as storage, hydropower, and instream flow rights.

4.0 Literature Review of State Methodologies

Current methodologies being employed in other parts of the country were reviewed. The focus of the review was to identify approaches, criteria, and methods of water supply analysis and determine if they may have applicability to the river basins of Nebraska. The review focused primarily on western states, where the use of the prior appropriation doctrine for administration of water rights is prevalent.

4.1. Sources

Four primary sources of data were utilized in the methodology literature review effort.

4.1.1 Western States Water Council (WSWC)

The WSWC has compiled and prepared several reports[5] documenting water supply planning strategies and activities in the western United States. In addition to reviewing WSWC reports, Tony Willardson, WSWC Executive Director, was contacted regarding specific WSWC reports that may be relevant to this effort. Mr. Willardson indicated that WSWC did begin a survey in 2004 amongst its member states. However WSWC found the states, for the most part, did not have the information to complete an accurate picture of present and future water availability. Subsequent surveys or data collection efforts have not been initiated by WSWC.

4.1.2 Bureau of Land Management (BLM)

The BLM's National Operations Center Division of Resource Services (NOC-DRS), formerly the National Science and Technology Center (NSTC), compiled a water rights fact sheet for the majority of the Western states in 2001[6] that discusses key aspects and approaches to water management employed by each state.

4.1.3 State and Local Agency Water Administrative Authorities

State departments and local agencies with water administration authority within each individual state were identified. Publications and website materials provided by these entities were reviewed.

4.1.4 Personal Communication with Water Administration Practitioners

Practicing professional colleagues from the public and private sectors were contacted directly to discuss current water administration practices in specific states.

[4] Rules for Surface Water, State of Nebraska Department of Natural Resources, June 27, 2008

[5] Reader is referred to organization website: www.westernstateswater.org

[6] Reader is referred to BLM's website for access to individual fact sheets: www.blm.gov

4.2. General Findings

Through the review of information gathered from the sources above, several general findings were noted. Attachment 2 contains a summary of key aspects for several Western States.

4.2.1 Water Administration Authority

The majority of states have a common authority responsible for administration of both surface water and ground water usage.

4.2.2 Water Administration Approaches

Generally the states with a common authority administer the surface and ground water rights under the same priority system. These states typically do very little analysis upfront in the evaluation and granting of new water appropriations, relying heavily on the enforcement of the priority system to administer water during shortages. In the instances where upfront analyses in support of new use applications are conducted, it is very general in nature. A few states, like Nebraska, have priority surface water administration with correlative ground water administration.

4.2.3 Closed Basin Declarations

For those states that have basins or areas declared closed to future surface or ground water uses, the majority of declarations have been made by legislative decree. The reasons for closure vary from environmental concerns to declining ground water tables. General technical criteria or analysis of water supply/demand as an indicator for basin closure in these states were not found.

4.2.4 Lack of Integrated/Total Water Budget Approaches

Integrated assessments of surface and ground water systems were generally lacking. Triggers for ground water management were typically declining ground water levels or interference with adjacent wells independent from any consideration of surface water interactions. In many cases this may be justified based on the aquifer characteristics and the lack of physical connection between surface and ground water systems.

4.2.5 Exempt Uses

The majority of states have a minimum threshold below which new uses are exempt from regulation. These typically are for uses such as stock wells or individual household water supply uses. However, the State of Montana is currently revisiting their water administration code to potentially address the cumulative impacts on ground water resources by entire subdivisions, each with exempt individual wells.

4.2.6 Standards of Interference

Most states aggregate irrigation and non-irrigation rights under a single beneficial use when administering under the priority system. While a preference hierarchy may exist for drinking water, municipal/industrial, irrigation, hydropower, instream flows, etc., varying standards of interference or criteria based on type of use for administering water rights under the priority system were not found.

4.3. Specific State Summaries

Several states were identified that have specific approaches and methodologies that may have some applicability to Nebraska's integrated management planning. Those states and approaches are detailed in this section.

4.3.1 California

The California Water Code provides some information regarding "fully appropriated" conditions. Specifically, Section 1205(b) defines fully appropriated status as:

> "A declaration that a stream system is **fully appropriated** shall contain a finding that the supply of water in the stream system is being **fully** applied to beneficial uses where the board finds that previous water rights decisions have determined that no water remains available for appropriation."

Section 1228.2 discusses an annual review process of the appropriation status of surface water in California:

> "(c) On or before June 30, 1989, and annually thereafter, the Division of Water Rights shall prepare and submit to the board a report summarizing the location, nature, and amount of water **appropriated** pursuant to this article. The report shall include a description of the availability of unappropriated water in those stream systems which may become **fully appropriated** within the next reporting period.
> (d) Whenever it can be reasonably anticipated that a stream system may become **fully appropriated** within the next reporting period, the board shall, following notice and hearing, determine whether that stream system should be declared **fully appropriated** pursuant to Article 1.3 (commencing with Section 1205)."

It is uncertain whether the evaluation is in fact being conducted annually. In practice, the State of California utilizes a "Fully Appropriated Steams Systems" list, maintained by its State Water Resources Control Board (SWRCB). The list includes information on the critical reaches and seasons for which the "fully appropriated" condition applies. The list is developed as new applications are brought forward, and the applicant is responsible for preparing a "Water Availability Analysis" as part of the application process. This analysis is required by state water code, and must include "sufficient information to demonstrate a reasonable likelihood that unappropriated water is available for appropriation."[7] There is no set time period (i.e. last 20 years) over which the analysis is conducted – that is dependant in part on the period over which gage records are available.

As new applications come forward, separate technical evaluations are done in each situation, and determined on a case-by-case basis. If, in the course of these analyses, it is shown that additional water is no longer available for appropriation – whether for a particular new area or for an additional time period – these new conditions are added to the fully appropriated list[8]. There is no formal variance process, but exceptions do occur when circumstances warrant.

Reaches or time periods can also be removed from the fully appropriated list. Recently, a section of the Kern River was removed from the list, when it was found that certain pre-1914 water rights on the river were no longer valid. A portion of the Santa Anna River in southern California was also opened to accept special applications for capture of flood flows, which occur only infrequently.

Hydrologic connectivity with ground water wells is a complicated regulatory area, and is also handled on a case-by-case basis. If a ground water well is taking water from a natural channel such as an underground stream channel or an adjacent stream, it is technically under the appropriative rights administrative system. Wells not linked to a natural channel are unregulated.

4.3.2 Kansas

The Kansas Water Appropriation Act (May 2010)[9], with further revision forthcoming) dedicates all surface water and ground water within the state for use by the people of the state, subject to control and regulation by the state. Two of the key principles in the act are that beneficial use of water is to be facilitated while avoiding adverse impacts to other water rights and the public interest.

The Act defines Conjunctive Use as the "the safe-yield management and operation of an aquifer in coordination with a surface water system to enhance the use of the total water supply availability in accordance with the provisions of the water appropriation act." While Safe Yield is defined as "the long-term sustainable yield of the source of supply, including hydraulically connected surface water or groundwater."

A number of basins have been closed to further development and have been determined by the chief engineer to be fully appropriated citing the safe yield criteria, although the designations have been largely through statute. Specific

[7] California Water Code section 1260(k).

[8] The actual "formal" Fully Appropriated Streams Systems list maintained by SWRCB must be approved in its entirety by the board before it can be changed – something which has not taken place since 1998 – but the additions made as a result of more recent individual applications are still incorporated in an unofficial list.

[9] K.S.A 82a-701 through 82a-737 and 82a-740 through 82a-742 and K.S.A. 42-303 and 42-313

criteria for fully appropriated designation based on safe yield were not found. Even with close basin designation, the chief engineer has broad ranging authority to consider new or modified permits under the Act within the basin.

In 1978, the Kansas Legislature amended the Kansas Groundwater Management District Act[10] to include specific provisions for initiating proceedings for designating Intensive Groundwater Use Control Areas (IGUCA). These statutes allow the chief engineer to implement corrective control provisions in areas where it is determined, through a public hearing process, that groundwater levels are declining excessively, the rate of groundwater withdrawal exceeds the rate of groundwater recharge, unreasonable deterioration of groundwater quality has occurred or may occur, or other conditions exist that warrant additional regulation to protect public interest. Eight IGUCAs have been designated under these provisions. The agency currently is working with groundwater management districts and other stakeholders to develop regulations to specify procedures for initiating and reviewing IGUCAs. These regulations will add greater assurance of due process and provide more opportunities for public input.

Flex accounts are a concept for flexible water management options for Kansas water users. Multiyear flex accounts are available to allow flexibility in the annual maximum authorized quantity of water, in exchange for conserving water over a five-year period. The authorized quantity is based on actual annual water use from 1992 through 2002, multiplied by five, less 10 percent for conservation. The deadline to apply for a flex account is October 15, for use the following year. This program allows users to exceed the authorized quantity of the water right in dry years in anticipation of a decrease in use in normal years within the five-year period. The program also could allow full irrigation in some years and no irrigation in the remainder of the five-year period for water rights with authorized quantities that were not fully perfected and are substantially lower than the net irrigation requirements.

4.3.3 Arizona

Arizona adopted the Ground Water Management Code[11] (Code) in 1980. The Code designated five Active Management Areas (AMA) within the state, requiring specific, mandatory management practices to preserve and protect ground water supplies. In addition, two Irrigation Non-Expansion Areas (INA) were designated with a third INA subsequently added. Similar to the typical closed basins protocol referenced in Section 4.2.3, the designation of the AMAs and INAs were through legislative action based on general aquifer declines. New AMAs or INAs can be designated by the Arizona Department of Water Resources (ADWR), but specific criteria to be used by ADWR were not found. Additionally, new areas may be designated on the basis of public vote. Ground water usage and development outside of the specially designated areas does not require a permit.

---

[10] K.S.A. 82a-1020 through 82a-1041

[11] Enacted in 1980, administered by Arizona Department of Water Resources

The general statutory management goal of the AMAs is to achieve and maintain safe-yield of the aquifer. Safe-yield conditions imply that the amount of ground water pumped from the AMA on an average annual basis does not exceed the amount of water naturally or artificially recharged.

The Code requires that the state prepare and periodically update a comprehensive Management Plan for each AMA. The Management Plans include a historical analysis of water demands and supplies, as well as a projection of future uses to evaluate safe yield conditions. In addition the Management Plan identifies management strategies that include conservation/reduction of current uses, as well as increasing the use of other renewable water supply sources in lieu of ground water.

Established ground water uses in place prior to the 1980 adoption of the Code are grandfathered rights. However, these grandfathered rights are still required to comply with the conservation practices identified in the AMA Management Plan. New use applications require that certain criteria be met based on the type of usage. New uses for subdivisions must demonstrate five conditions:

1) Adequate water quality
2) Supply that will be physically, legally, and continuously available for the next 100 years
3) Supply that is consistent with AMA management goal
4) Consistency with the Management Plan
5) Financial means to ensure the construction of necessary water storage, treatment, delivery, etc.

Non-subdivision uses must comply with Management Plan goals but the burden of proof on the applicant is much less onerous.

The Management Plans prepared by ADWR contain a fairly rigorous water budget analysis. The analysis benefits from the metering and reporting requirements of all ground water withdrawals per the Code, and employs regional ground water modeling tools. The period of record used in the water budget analysis for the latest round of Management Plans extends from 1985 to 2006. The selection of this period is based on the availability of meter data and usage reports.

The water budget representation used by ADWR is fairly robust, with the basic components of the water budget analysis including demand, supply, artificial recharge, and offsets to aquifer overdraft. Each component is sub-divided into several detailed categories, with demand and supply components discretely represented in the annual aquifer overdraft calculations. Furthermore, ADWR has recently departed from perfect or near perfect forecasting (simple repetition of historic observations) in predicting future supply and demand scenarios in the safe-yield analyses, and incorporated forecasts accounting for climate variability.

It in noted that the AMA and INA areas have a very small surface water component in their analysis.

4.3.4 Oregon

The Oregon Administrative Rules provide the following definitions related to "over-appropriated" in Section 690-400-0010 (11):

> (a) "Over-Appropriated" means a condition of water allocation in which:
> (A) The quantity of surface water available during a specified period is not sufficient to meet the expected demands from all water rights at least 80 percent of the time during that period; or
> (B) The appropriation of groundwater resources by all water rights exceeds the average annual recharge to a groundwater source over the period of record or results in the further depletion of already over-appropriated surface waters.
> (b) The standards for determining over-appropriation described in paragraph (A) of this subsection shall apply to water availability determination for permit applications submitted after July 17, 1992.

Oregon has established basin programs in which all land area, surface water bodies, aquifers, and tributaries that drain into major rivers are to be managed in an integrated fashion. All but two of the 20 major river basins have adopted basin programs. The state also has a Water Resources Commission that has the ability to close basins to future development as well as declare Critical Ground Water Areas. The designation of Critical Ground Water Areas is intended to consider both well interference as well as erosion of senior surface water rights.

While the basin programs are intended to manage water resources in an integrated fashion, approaches and methods for conducting integrated analyses have yet to be developed.

The State of Oregon has developed and maintains a database of surface water availability indicators at various diversion points for the majority of streams in the state. The available surface water determination is based on statistical analysis of historic data from stream flow gages, as well as storage in the upper watershed, consumptive uses, and in-stream uses. Oregon has set standards for both out-of-stream and in-stream appropriations using natural flow[12]. These standards are applied by month and refer to stream flow over a period of many years (Water Years 1958 to 1987), not to any one month or other short period of time:

- Out-of-stream: the sum of the consumptive use portion of the diversions and any in-stream demands cannot be more than the natural stream flow occurring at least 80 percent of the time.

[12] Determining Surface Water Availability in Oregon, Open File Report SW 02-002, State of Oregon Water Resources Department, June 2002.

- In-stream: the amount of water left in the stream cannot be more than the natural stream flow that occurs as least 50 percent of the time.

The 30-yr base period length for the evaluation (WY 1958 to 1987) is a common length of record for hydrologic analysis, recommended by Searcy (1959)[13], and is used by the Oregon Climate Service in its estimation of climate variables such as mean annual temperature and precipitation. The period 1958 to 1987 was selected based on analysis of flow duration curves using two gages with long-term records. The flow duration curves for various 30-yr periods were compared to the long-term flow duration curve. The 30-yr period that best matched the long-term results was then selected.

An assessment of ground water resources has been completed for the majority of basins as well. These assessments are primarily focused on well hydrographs and long-term ground water elevation trends. The link to surface water flows is acknowledged generally in the assessment, but as referenced previously, development of integrated tools to jointly assess surface and ground water resources has yet to occur. In many of the basins, the physical characteristics largely limit surface/ground water interaction with the exception of those ground water wells immediately adjacent to the stream.

5.0 Literature Review of Compact Accounting Methods

Water accounting methods used to satisfy interstate compacts were also reviewed. The focus of the review was again to identify approaches and methods to water supply analysis for potential applicability to the river basins of Nebraska. Compact accounting methods identified that may have some applicability are detailed in this section.

5.1. Arkansas River (Colorado, Kansas)

The Arkansas River Compact [14] between the states of Colorado and Kansas stipulates the portion of Arkansas River flows and John Martin Reservoirs releases allocated to each state. The annual accounting of surface water supplies and allocation of those water supplies to the states uses relatively straight-forward water supply accounting procedures outlined in the Compact.

In response to 1985 litigation by the state Kansas regarding depletions to Arkansas River flows from ground water development in Colorado, the Compact accounting now also considers and has developed accounting procedures for the effects of ground water depletions. The Hydrologic-Institutional Model (H-I Model) is the tool used to compute depletions to Arkansas River flows at the Colorado/Kansas state line from ground water usage in Colorado.

---

[13] Flow-Duration Curves: USGS WSP 1542-A, J.K. Searcy, 1959.

[14] Signed by Colorado, Kansas, and United States representatives December 14, 1948. Compact document may be accessed at the following website: water.state.co.us/SurfaceWater/Compacts/ArkansasRiverCompact

The H-I model simulates both ground and surface-water processes and their interaction. The model extends from Pueblo, Colorado to the state line. Two model runs are simulated over the 1950-present period. The first run is the historic run and contains historic supply and usage conditions. The second run simulates historic conditions, with the exception of ground water pumping from wells constructed after the 1948 Compact date. The difference in flows at the state line between the two runs is then the depletion due to ground water pumping. The cumulative depletion/accretions over the ten years immediately prior are then used to determine compliance with the Compact.

5.2. Republican River (Colorado, Kansas, Nebraska)

The Republican River Compact [15] allocates the average annual water supply of the Republican River, 11% to the State of Colorado, 49% to Nebraska and 40% to Kansas. Under the Compact, the total allocation given to each State is to be derived from the listed tributaries, and for Nebraska and Kansas, from the main stem of the Republican River. Final Settlement Stipulations (FSS) from a 2003 Supreme Court settlement did not change the original compact among the states, or the percentages of water supply allocated to each state by the original compact. However, the amount of water allocated to each State varies annually depending on stream flows in nine specifically identified tributaries, all other small tributaries and the main stem of the Republican River.

The annual variability of Republican River flows is captured using the Republican River Compact Administration (RRCA) Accounting Procedures, described in Appendix C of the FSS. Appendix C describes the definitions, procedures, basic formulas, specific formulas, and data requirements and reporting formats to be used by the RRCA to compute the Virgin Water Supply (VWS), Computed Water Supply, Allocations, Imported Water Supply Credit and Computed Beneficial Consumptive Use. These computations are used to determine supply, allocations, use and compliance with the Compact according to the FSS. While the reader is referred to the details of the FSS for a full description of the process, the Virgin Water Supply definition is worth noting. By definition the VWS is the water supply within the basin undepleted by the activities of man. Simply put, the VWS estimates what would have been the expected water supply sans the impact of man's use of water. The VWS provides for an interesting and unique approach in compact accounting.

The basic formulas for calculating VWS and other key Compact data, Computed Water Supply, Imported Water Supply, Allocations and Computed Beneficial Consumptive Use, are discussed in detail in the Appendix C procedures. One of the key components for determining Computed Beneficial Consumptive Use comes from using the RRCA groundwater model developed by the three states as part of the settlement. While ground water and surface water are included in the Compact accounting, they are not explicitly linked. Many other sources of annual data are required to be submitted by each state to complete the accounting. Final accounting is currently performed using a spreadsheet tool. A five year average is the baseline for compliance evaluation, with shorter terms used when the water-short year triggers identified in the Compact occur.

A key point of this accounting is that it is done in arrears. It requires data from the previous year be completed and available in order to determine allocations and ultimately whether a state is in

[15] Formally signed by representatives of Kansas, Colorado, Nebraska, and the United States on December 31, 1942. Compact document may be accessed at the following website: water.state.co.us/SurfaceWater/Compacts/RepublicanRiver/Pages/RepublicanRiverCompactDocs.aspx

compliance with its allocation. While not a requirement of the Compact or the FSS, Nebraska has incorporated a forecasting tool into its planning process to facilitate its ability to meet Compact obligations.

5.3. Pecos River (Texas, New Mexico)

The Pecos River Compact[16] (1948) allocates Pecos River flows between the states of Texas and New Mexico. The Compact accounting is completed using a complex methodology originally submitted in Texas v. New Mexico Supreme Court litigation as Texas Exhibit No. 108 in 1987. The methodology is incorporated in the Pecos River Master's Manual, included in Attachment 3 or this TM. This Manual has been amended several times, with the current version dated July 28, 2003.

Pecos River Compact accounting is completed for the preceding water year each spring. Provisional gage and reservoir data is compiled throughout the year. Finalized data are transmitted to the Pecos River Master in the spring of the following year. By May 15th, the River Master submits to New Mexico and Texas his Preliminary Compact Accounting Report.

The Compact accounting uses an Index Flow approach, where the average of the flows from the current year and the two prior years is compared to the 1947 Index Flow to determine compliance with Compact deliveries.

In order to manage its augmentation program, New Mexico has developed a forecasting tool to predict total Carlsbad Irrigation District water supply available for given target dates. The technical memo documenting the procedures is also included in Attachment 3. While the water budget terms and methods used in this forecasting tool are somewhat simplified, it does provide an example of a flexible tool used in projecting future water supplies.

6.0 Summary

The results of the literature review illustrate the varied approaches to water administration throughout the western states and often are a reflection of the unique physical, administrative and political factors present. A summary of the findings of this literature review as it pertains to criteria, approaches, and methods with potential applicability to the basins of Nebraska:

- Most basin closures in the western states have been by legislative decree and not exceedance of a defined "trigger" or criteria that indicates supplies have exceeded uses;
- Most western states have surface and groundwater administration under common authority and administer both sources under the prior appropriation doctrine;
- Generally, there is a lack of consideration of integrated surface and ground water sources, in some cases this is due to physical or geologic controls;
- Elements that may be applicable to the basins of Nebraska include:
    - Use of flow duration/frequency analyses, similar to that used by the State of Oregon

[16] Signed by representatives of New Mexico, Texas, and the United States on December 3, 1948. Compact document may be accessed at the following website: wrri.nmsu.edu/wrdis/compacts/Pecos-River-Compact.pdf

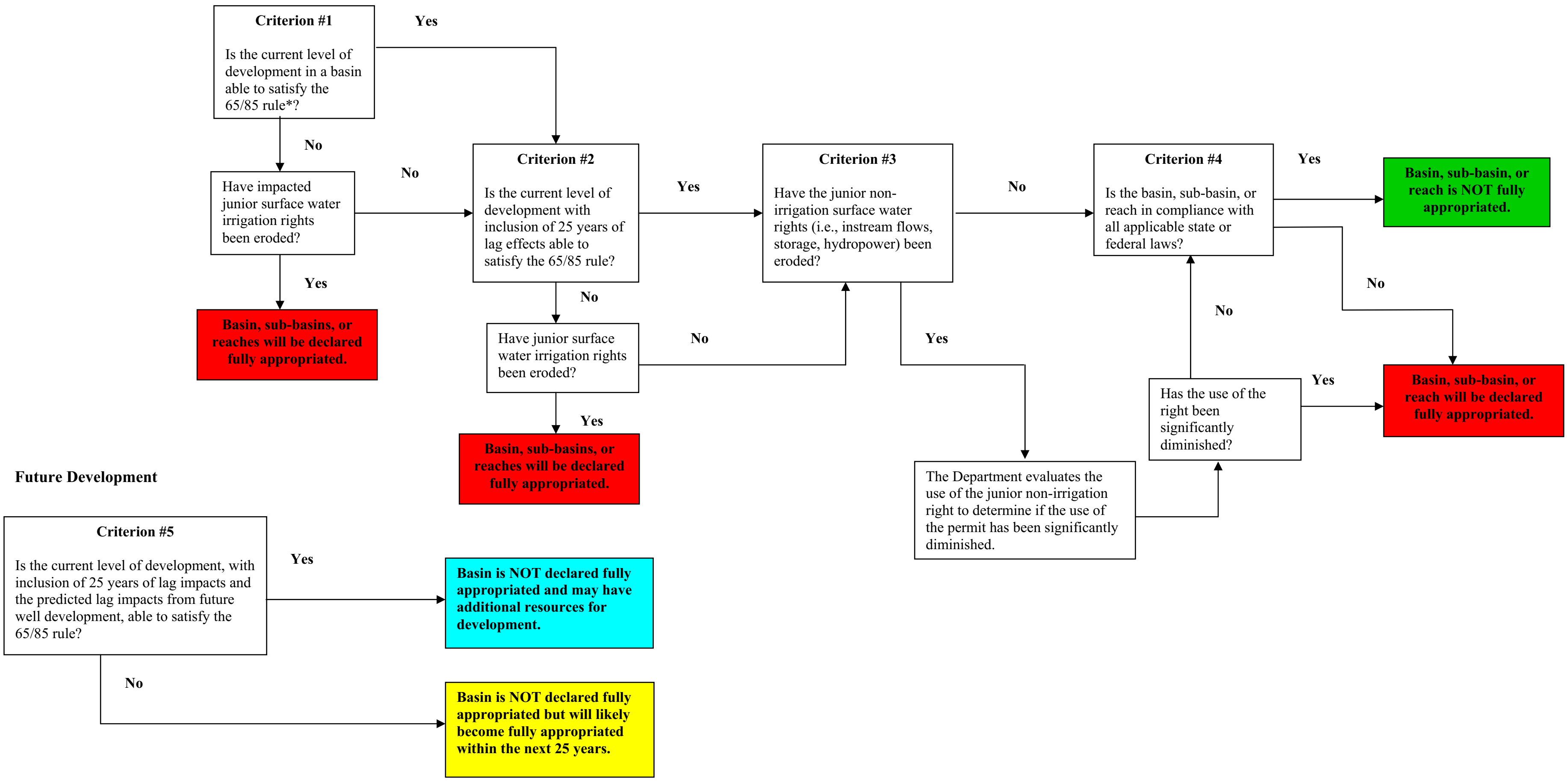
  - Methods of accounting for supplies and uses employed by the Republican River and Pecos River compacts.

Attachments

Attachment 1 – DNR Methodology Flow Chart
Attachment 2 – Summary of Other State Methodologies
Attachment 3 – Pecos River Master's Manual and New Mexico Water Supply Projections Procedure

Attachment 1 – DNR Evaluation Flow Chart

Evaluation of the Status of a Basin



- **In general terms, the 65/85 rule states that the surface water supply is deemed to be insufficient if, at current levels of development, the most junior irrigation right in a basin, sub-basin, or reach has been unable to divert sufficient surface water over the last twenty years to provide 85% of the amount of water a corn crop needs (the net corn crop irrigation requirement) during the irrigation season (May 1 through September 30), or if the most junior irrigation right in a basin, sub-basin, or reach is unable to divert 65% of the amount of water a corn crop needs during the key growing period of July 1 through August 31.**

Figure 4-1. Basin evaluation flow chart.

Attachment 2 – Summary of Other State Methodologies

State	Administrative Framework (Who Administers)	Riparian or Priority	Fully Appropriated Analysis and Designations	Notes
Alaska	• The Alaska Department of Natural Resources, Division of Mining, Land, and Water (the Division), administers water rights (SW and GW) in Alaska.	• Priority since 1966 (riparian transferred to priority at that time)	• Yes – restricted ground water areas exist, primarily based on saltwater intrusion. Dept. makes general assessment of water availability when considering new uses.	• Water for public water supplies may be granted as a preferred use in Alaska. • Prior appropriation water right is not absolute based on preferences • Water right holder must be compensated for the loss if re-appropriated. • Water law is contained in the Alaska Water Use Act, Alaska Statute 46.15. • Water rights are regulated by Alaska Administrative Code 11 AC 93. • 49% of state is federal land. Federal reserved water rights not quantified. • http://dnr.alaska.gov/mlw/water/hydro/index.htm

Arizona	• The Arizona Department of Water Resources (ADWR) is responsible for ensuring that dependable, long-term water supplies are available for Arizona.	• Dual System (some vestiges of riparian system exist)	• Yes – AMAs and restricted basins designated. Fairly robust water budget approach of GW and aquifer accounting procedures.	• 4 categories of water supplies available in Arizona:
				  • Colorado River water- allocated through the law of the river and Arizona's water banking program
				  • Surface water other than Colorado River water-"first in time, first in right"
				  • Ground water- vary depending on location
				  • Effluent
				• An owner of a water right may voluntarily abandon the right, or the right may be found to have been forfeited if no use is made of the water for five consecutive years.
				• Arizona water code is located in Title 45 of the Arizona Revised Statutes.
				• http://www.azwater.gov/azdwr/default.aspx

California	• The State Water Resources Control Board (State Water Board) - water rights and water quality • The California courts - the use of percolating ground water, riparian use of surface waters, and the appropriate use of surface waters initiated prior to 1914. • The Department of Water Resources - planning the use of state water supplies, and develops, in consultation with the California Water Commission, rules and regulations for this purpose.	• Dual System	• Yes – case dependent	• Riparian rights result from the ownership of land bordering a surface water source • Pueblo rights are derived from Spanish law whereby Spanish or Mexican pueblos could claim water rights. As a result, pueblo rights are paramount to the beneficial use of all needed, naturally occurring surface and subsurface water from the entire watershed of the stream flowing through the original pueblo. • The state does not have a comprehensive groundwater permit process to regulate ground water withdrawal. • An appropriative water right in California can be maintained only by continuous beneficial use, and can be lost by five or more continuous years of non-use. Riparian rights, on the other hand, cannot be lost through non-use. • California's water law is contained in the California Code of Regulations, Title 23 • http://www.waterboards.ca.gov/waterrights/
Colorado	• Established through a water court system. There are 7 water courts-one for each major river basin • Each water court has an appointed water judge and water referee who hear all water related matters within their jurisdiction. • The State Engineer administers and distributes the state's waters and is responsible for issuing and denying permits to construct wells and divert groundwater • The Colorado Ground Water Commission is a regulatory and an adjudicatory body authorized to manage and control designated groundwater resources. • Finally, the Colorado Water Conservation Board (CWCB) oversees conservation and development in the state and is responsible for the state's instream flow program.	• Priority system	• Colorado Groundwater Commission has authority to regulate GW usage in designated basins	• Colorado water law is contained in the State Constitution Article XVI sections 5 and 6 and in the Colorado Revised Statutes, sections 37, articles 80 through 92. • First state to provide for the distribution water by public officials • Water rights in Colorado are established through a water courts system. Every water right application must go through the water courts, and must be handled by an attorney. • In order to obtain a right to either surface or groundwater, an application must be filed with one of the seven water courts in the state. • Upon publication in the resume and paper, a statement of opposition can be filed by any person. The referee makes a ruling. • Protests to the referee's ruling, can be filed with the court. If a protest is filed, a hearing is held before the water judge. • Water rights in Colorado (both surface and groundwater) can be either absolute or conditional. • A conditional water right can be considered abandoned if the holder fails to show diligence to complete the necessary project. Any water right can be considered abandoned if it is not used for a period of ten years. • http://water.state.co.us/
Idaho	• Idaho Department of Water Resources is the agency responsible for the allocation of surface and groundwater within the state. • 8 member board appointed by the Governor and confirmed by the state senate, assists in the management of the state's water. The board provides guidance to the IDWR, is responsible for administering certain water programs, and is responsible for applying for and holding new appropriations for instream flow rights.	• Priority	• Yes – part of adjudication. Generally IDWR tasked with limiting aquifer pumpage to safe-yield.	• Idaho's water laws are contained in Idaho Code, Title 42 • Since May 20, 1971, the only one way to establish a water right is by following the application/permit/license procedure. Prior to May 20, 1971, rights to surface waters were established by simply diverting water and putting it to beneficial use • A water right can be lost in Idaho by abandonment or forfeiture. • http://www.idwr.idaho.gov/

Montana	• Shared by the district court (including the water court) and the Water Resources Division of the Montana Department of Natural Resources and Conservation (DNRC).	• Priority	• Yes – designation of Controlled Groundwater Areas, generally based on declining aquifer levels.	• Montana water law is contained in the Montana Water Use Act (Title 85, Chapter 2, MCA) of 1973. • All water rights existing prior to July 1, 1973, are to be finalized through a statewide adjudication process in state courts. • A permit system was established for obtaining water rights for new or additional water developments. • An authorization system was established for changing water rights. • A centralized records system was established • A system was provided to reserve water for future consumptive uses and to maintain minimum instream flows for water quality, fish, and wildlife. • A water right under a permit can be abandoned if it is not used and there is an intent to abandon. If an appropriator ceases to use all or part of an appropriation with the intention to abandon, the right is considered abandoned. In addition, a right is considered to be abandoned if it is not used for ten consecutive years . • http://dnrc.mt.gov/wrd/default.asp
Nevada	• The Nevada Water Resources Division, headed by the State Engineer, is responsible for the administration and enforcement of Nevada's water law.	• Priority	• Yes – restrictions can be made based on general assessments. Safe-yield concept used.	• Nevada water law is set forth in the Nevada Revised Statutes, Chapters 532 through 538. • A water right in Nevada can be lost only by abandonment. • http://ndwr.state.nv.us/
New Mexico	• The Water Resources Allocation Program (WRAP) with The State Engineer, appointed by the Governor and confirmed by the State Senate, has broad authority over the supervision, appropriation and distribution of New Mexico's surface and groundwater.	• Priority	• Yes – State Engineer may designate underground water basins and impose restrictions	• The state's water law is presently in force in New Mexico Statutes Chapter 72. • There are five basic components of a water right in New Mexico: Point of diversion (or constructed work), place of use, purpose of use, owner, and quantity. • A water right in New Mexico can be lost by forfeiture. • http://www.seo.state.nm.us/water_info_index.html
Oregon	• Water use in Oregon (both surface and groundwater) is administered by the Water Resources Department which is responsible for implementing Oregon's water policy. This general water policy is set by the seven-member Water Resources Commission which is appointed by the Governor.	• Dual System	• Yes – Progressing toward integrated analysis, but currently have independent GW and SW analysis. Have developed SW availability database for nearly every stream.	• Oregon's water laws are contained in Oregon Revised Statutes , Chapters 536 through 541 • The dominant system in Oregon, is prior appropriation • Priority - The water right priority date determines who gets water in a time of shortage. The more senior the water right, the longer water is available in a time or shortage. • Appurtenancy - A water right is attached to the land where use was established. If the land is sold, the water right goes with the land to the new owner. • Must be used - Once established, a water right must be used as provided in the water right at least once every five years. With some exceptions established in the law, after five years of non-use, the right is considered forfeited and is subject to cancellation. • http://www.wrd.state.or.us/OWRD/LAW/index.shtml
Utah	• The State Engineer, through the Division of Water Rights, is responsible for the administration of water rights, including the appropriation, distribution, and management of the state's surface and groundwater.	• Priority	• N/A	• A complete "water code" was enacted in 1903 and was revised and reenacted in 1919. This law, as amended, is presently in force as Utah Code, Title 73 • A water right in Utah can be lost by either abandonment or forfeiture. • http://www.waterrights.utah.gov/
Wyoming	• Wyoming is divided into four water divisions for administration purposes. Each of these divisions is headed by a superintendent who administers the waters of each water division. These four superintendents and the State Engineer comprise the Wyoming Board of Control. The Board of Control meets quarterly to adjudicate water rights and to consider other matters pertaining to water rights and water appropriation.	• Priority	• Yes - Control Area designation have been established with special regulations.	• Wyoming's water law is contained in Title 41, Wyoming Statutes Annotated, 1977 • Prior to statehood in 1890, a water right could be established by the use of water and the filing of a claim with the territorial officials. Water rights with priority dates before 1890 are termed "territorial" rights. • Since statehood, however, the only way to obtain a surface or a ground water right, is by filing an application with the State Engineer. • A water right in Wyoming can be lost by abandonment. • http://seo.state.wy.us/

Attachment 3 – Pecos River Master's Manual and New Mexico Water Supply Projection Procedure

THE PECOS RIVER MASTER'S MANUAL

July 28, 2003

THE PECOS RIVER MASTER'S MANUAL

July 28, 2003

FOREWORD

July 28, 2003 Version

This revised edition of the Pecos River Master's Manual was compiled from the edition dated November 30, 1987, which was marked as "Texas Exhibit No. 108." In the revised edition, modifications have been added to the text of the Manual and a few minor changes in presentation style have been made. The edition was prepared by the River Master and submitted to the Technical Representatives of New Mexico and Texas for review and approval. Comments received in a joint letter from the states dated May 14, 2003 have been incorporated into the revision.

INTRODUCTION

This manual contains the procedures to be used by the River Master to make the calculations provided for in the decree of the United States Supreme Court in Texas vs. New Mexico, No. 65 Original. These calculations include determination of negative or positive departures from New Mexico's delivery obligation.

The computational procedures and the computer programs required to make the computations are described in detail in Texas Exhibit no. 79.

TABLE OF CONTENTS

	Page
A. General	1
B. Procedures to Compute Departures of State Line Flows of the Pecos River from the 1947 Condition	2
1. General	2
2. Determination of Alamogordo Reservoir Releases and Spills	5
3. Determination of Flood Inflows, Alamogordo Dam to Artesia	5
4. Determination of Flood Inflows, Artesia to Carlsbad	13
5. Determination of Flood Inflows, Carlsbad to New Mexico–Texas State Line	18
C. Adjustments to Computed Departures	21
1. Adjustments for Depletions Above Alamogordo Dam	21
2. Depletions Due to McMillan Dike	24
3. Salvage Water Analysis Criteria and Procedures	25
4. Unappropriated Flood Waters Analysis Criteria and Procedures	26
5. Texas Water Stored in New Mexico Reservoirs	26
6. Beneficial Consumptive Use of Waters of Delaware River by Texas	26
Appendices	27

LIST OF FIGURES

1	Pecos River Basin, Pecos River Compact, New Mexico – Texas	6
2	Diagram of Pecos River Near Pecos to Alamogordo Dam	7
3	Diagram of Sumner Dam to New Mexico-Texas State Line Reach	8
4	Diagram of Red Bluff – Girvin area	9
5	Idealized Flood Inflow Computation Procedures, Carlsbad to New Mexico-Texas State Line Reach	20

LIST OF TABLES

1	Pecos River Compact. Alamogordo (Sumner) Dam to Artesia reach. Pecos River Basin, New Mexico. Estimated Flood Inflows in 1000 Acre–Feet units, 1950-1983.	12

LIST OF APPENDICES

A-1	Compilation of modifications to the River Master's Manual	28

MANUAL OF PROCEDURES

TO COMPUTE PECOS RIVER COMPACT COMPLIANCE

A. General

A. General

1. The so–called "annual flood inflow" for the Sumner Dam[1] to state line reach is defined as the sum of the measured flow of the Pecos River below Sumner Dam plus the estimated flood inflows from the Sumner Dam to Artesia, Artesia to Carlsbad, and Carlsbad to state line reaches. The current year's "annual flood inflow" is averaged with the annual flood inflows for the two prior years. This three–year average quantity is termed the "Index Inflow" and is used as "x" in the equation

$$y = 0.0489892\,(x)^{1.42318}$$

in order to determine the "Index Outflow," or "y," New Mexico's three–year average 1947 Condition delivery obligation at the New Mexico–Texas state line. This Index Inflow–Index Outflow equation was approved June 11, 1984 by the U.S. Supreme Court in the Texas vs. New Mexico Pecos River Compact Litigation, No. 65 Original. This equation will be used to determine New Mexico's 1947 condition delivery obligation imposed by the Pecos River Compact. A comparison of the Index Outflow with the three year average historical outflow will identify any delivery depletions from the 1947 Condition which might have occurred.

2. There are several factors which, under terms of the Pecos River Compact, might at times increase or decrease New Mexico's obligation to deliver Pecos River water at the state line. When appropriate, the following factors may need to be employed to adjust the computed departures in the Compact compliance computations:

[1] On October 17, 1974, Alamogordo Dam was renamed Sumner Dam by the U.S. Congress under Public Law 93–447. In the original manual, Sumner Dam was usually referenced as Alamogordo Dam. In the revision dated July 28, 2003, the references were changed to Sumner Dam because data is delivered under that name.

a. Adjustments for Depletions Above Sumner Dam

b. Depletions Due to McMillan Dike

c. Salvage Water in New Mexico

d. Unappropriated Flood Waters

e. Texas Water Stored in New Mexico Reservoirs

f. Beneficial Consumptive Use of Waters of Delaware River by Texas

B. Procedures to Compute Departures of State Line Flows of the Pecos River from the 1947 Condition

1. General

a. Compute Index Inflow, Sumner Dam to New Mexico–Texas state line as follows:[2]

(1). The annual flood inflow is computed as follows:

(a) Gaged flow of the Pecos River below Sumner Dam, plus

(b) Computed flood inflow, Sumner Dam to Artesia reach, plus

(c) Computed flood inflow, Artesia to Carlsbad reach, plus

(d) Computed flood inflow, Carlsbad to state line reach.

[2] All computations are to be performed in units of 1,000 acre–feet rounded to the nearest 1 acre–foot. (Modified by Joint Motion, approved by the River Master, June 6, 2002).

(2). The Index Inflow for one year is the average of the annual flood inflow for that year and the two prior years.

b. Determine New Mexico's 1947 Condition delivery obligation at the New Mexico–Texas state line (Index Outflow). The 1947 Condition Index Outflow is determined by the equation:

$$y = 0.0489892(x)^{1.42318}$$

Where (x) is the Index Inflow and Y is the 1947 Condition outflow in units of 1,000 acre–feet.

c. Determine the three–year running average historical outflow at the New Mexico–Texas state line.

(1). The annual historical outflow is computed as follows:

(a) Gaged flow of the Pecos River at Red Bluff, New Mexico.

(b) Gaged flow of the Delaware River near Red Bluff, New Mexico.

(c) The total annual metered diversions under New Mexico State Engineer Permit Number 3254 into C-2713 (approved April 24, 2001), currently held by the Red Bluff Water Power Control District, not to exceed a total of 845 acre–feet per annum. [3]

(d) Subparagraph B.1.c.(1)(c) will continue in effect for an initial term beginning on the date this amendment is approved by the River Master and extending until the end of Water Year 2007. Thereafter, unless rescinded as provided herein, Subparagraph B.1.c.(1)(c) will continue in effect for successive six (6) year terms coinciding with Water Years. Subparagraph B.1.c.(1)(c) may be rescinded by agreement of Texas and New Mexico, or Subparagraph B.1.c.(1)(c) may be rescinded by either Texas or New Mexico if the Average Daily Brine Inflow of the Pecos River between the United States Geological Survey ("USGS") Gage at Pierce Canyon and the USGS Gage at Malaga exceeds a total dissolved solids load of 367.7 tons per day, i.e., seventy-five percent (75%) of the Base Number.

(e) For purposes of this Paragraph, the Base Number shall be 490.3 tons per day of total dissolved solids.

[3] Sections B.1.c.(1)(c) through B.1.c.(1)(j) were added by Joint Motion of the states as approved by the River Master on June 6, 2002 for use in accounting for Water Year 2002 and thereafter.

(f) For purposes of this Paragraph, the Average Daily Brine Inflow will be determined as follows. A daily average of total dissolved solids in tons per day will be used, calculated by the USGS and based on the difference between measurements at the USGS Gage on the Pecos River at Pierce Canyon Crossing near Malaga, New Mexico (Station No. 08407000) and at the USGS Gage on the Pecos River near Malaga, New Mexico (Station No. 08406500) during the first five (5) years of the current six–year term described in Subparagraph B.1.c.(1)(d) above.

(g) Either Texas or New Mexico may rescind Subparagraph B.1.c.(1)(c) at the end of any Water Year, if during the year the brine well being operated under Permit Number 3254 into C-2713 is not being operated for a period of twenty (20) consecutive calendar days or for more than thirty (30) total (exclusive of holidays and weekends) days in any calendar year.

(h) Either Texas or New Mexico may rescind Subparagraph B.1.c.(1)(c) at the end of any Water Year, if adequate precautions to prevent brine removed from the aquifer from reentering the Pecos River are not being taken.

(i) Either Texas or New Mexico may rescind Subparagraph B.1.c.(1)(c) at the end of any Water Year if the annual diversion exceeds 645 acre–feet.

(j) Any State wishing to rescind Subparagraph B.1.c.(1)(c) must first provide the River Master and the other State with written notice of rescission at least thirty (30) days prior to the Water Year in which the rescission is to be effective.

(2). The three–year average historical outflow for any year is the average of the annual historical outflow for that year and the two prior years.

d. Compute annual departures of state line flows of the Pecos River from the 1947 Condition. Compute each annual departure by subtracting the annual 1947 Condition delivery obligation (Index Outflow) from the corresponding three–year average historical outflow. Add algebraically the adjustments to the computed departures as determined under the provisions of Part C herein. A negative departure indicates an underdelivery at state line and a positive departure indicates an overdelivery.

Figure 1 shows the approximate boundary of the Pecos River Basin from its headwaters in New Mexico to the gaging station of the Pecos River near Girvin, Texas. Figures 2, 3 and 4 are stick diagrams of the main stem of the

Pecos River showing important tributaries, gaging stations, diversion facilities and reservoirs in New Mexico and Texas.

2. Determination of Sumner Reservoir Releases and Spills

Use the monthly United States Geological Survey (USGS) streamflow records for the gaging station, Pecos River below Sumner Dam, as the measure of releases and spills from the reservoir.

3. Determination of Flood Inflows, Sumner Dam to Artesia

The computational items used to estimate the flood inflows to this 197.8 river mile reach of the Pecos River are listed below, followed by an explanation for each computation to be made. Monthly quantities for each item will be measured or computed, and the annual quantity will be the sum of the monthly quantities.

Streamflow below Sumner Dam (see 3.a. below).
Fort Sumner Irrigation District diversion (see 3.b. below)
Fort Sumner Irrigation District return flow (see 3.c. below)
Streamflow past Fort Sumner Irrigation District (see 3.d. below)
Channel loss, Sumner Dam to Acme (see 3.e. below)
Computed residual flow at Acme (see 3.f. below)
Base Inflow, Acme to Artesia (see 3.g. below)
River pump depletions (see 3.h. below)
Residual flow at Artesia (see 3.i. below)
Streamflow, Pecos River near Artesia (see 3.j. below)
Flood inflow, Sumner Dam to Artesia (see 3.k. below)

a. Streamflow below Sumner Dam

Use the monthly USGS streamflow records for the gaging station, Pecos River below Sumner Dam, N.M.

b. Fort Sumner Irrigation District diversion

Use the monthly USGS discharge records for the gaging station, Fort Sumner Main Canal near Fort Sumner, N.M.

c. Fort Sumner Irrigation District return flow

Use 53 percent of the total annual diversion (item b. above) and distribute on a monthly basis as follows:

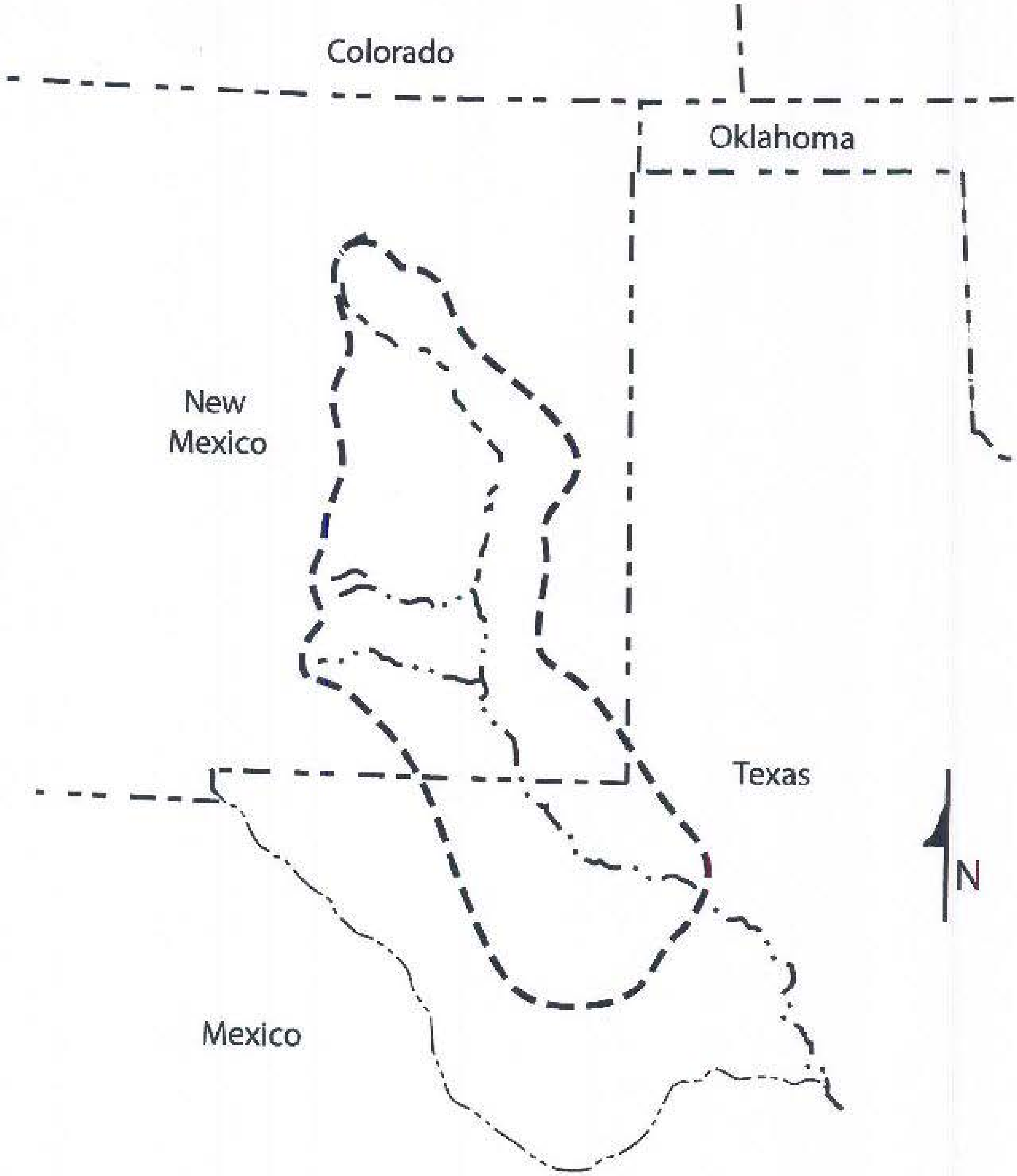


Figure 1
Pecos River Basin
Pecos River Compact
New Mexico -Texas

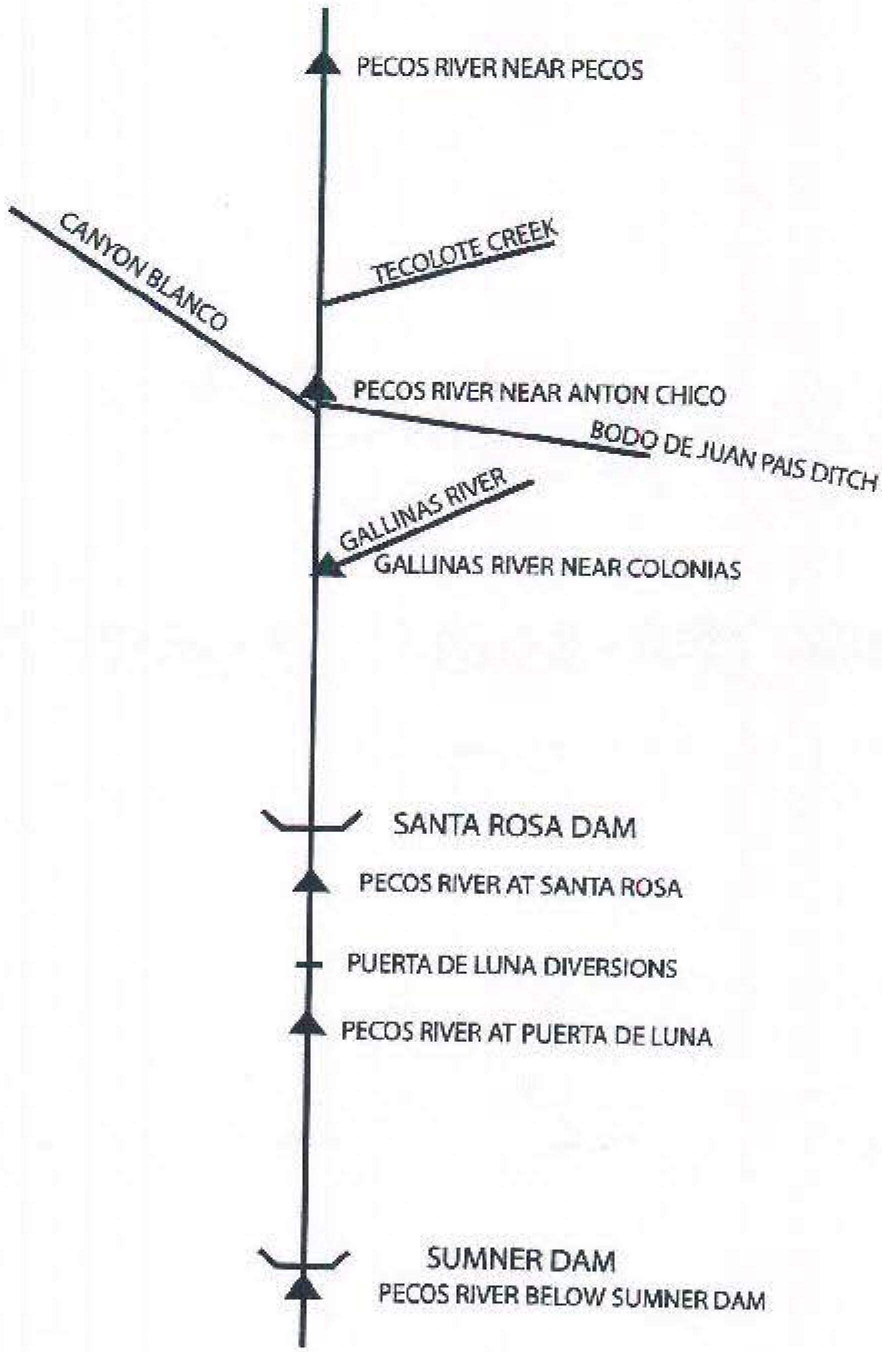


Figure 2
Diagram of Pecos River Near Pecos
to Sumner Dam

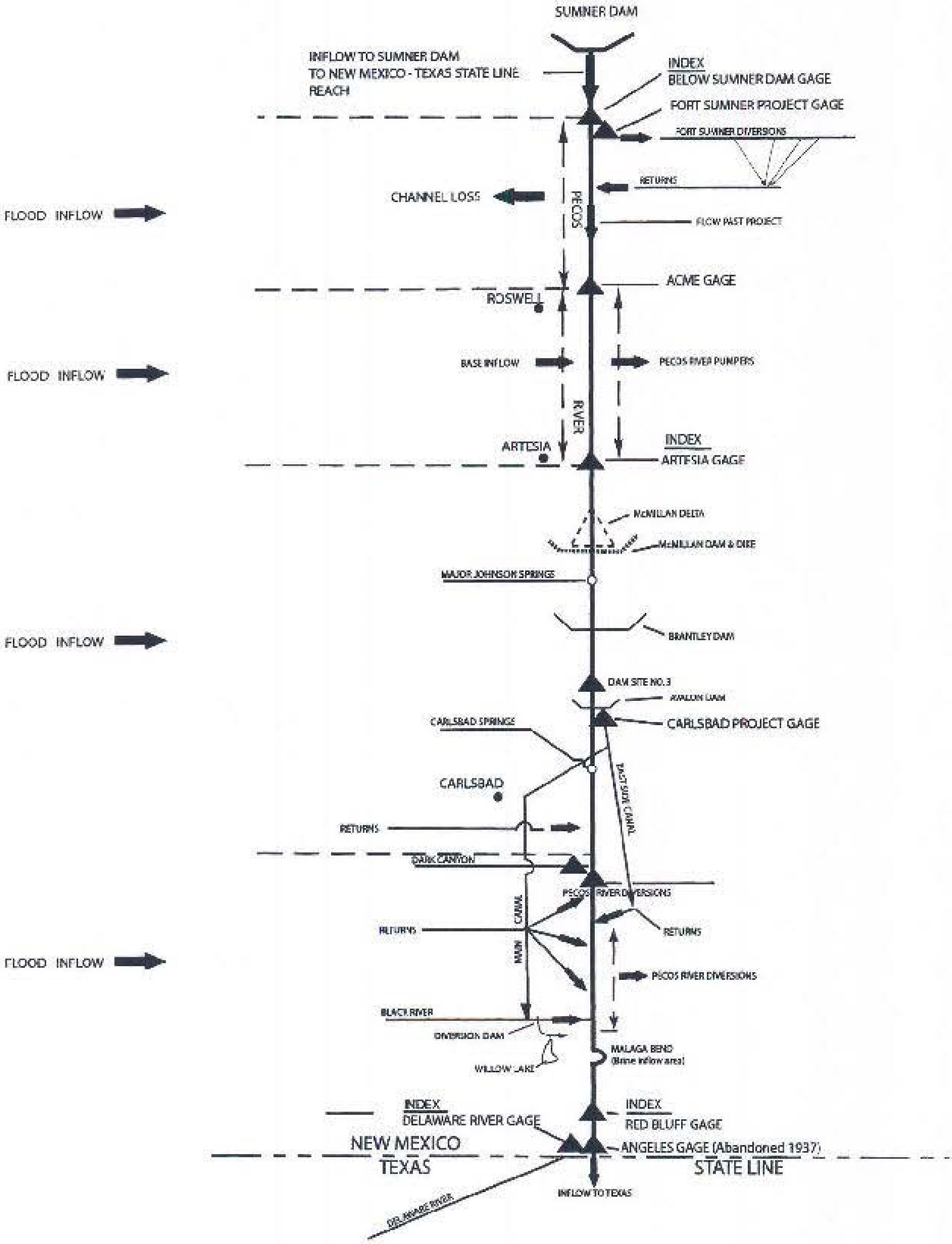


Figure 3
Diagram of Sumner Dam to New Mexico-Texas State Line Reach

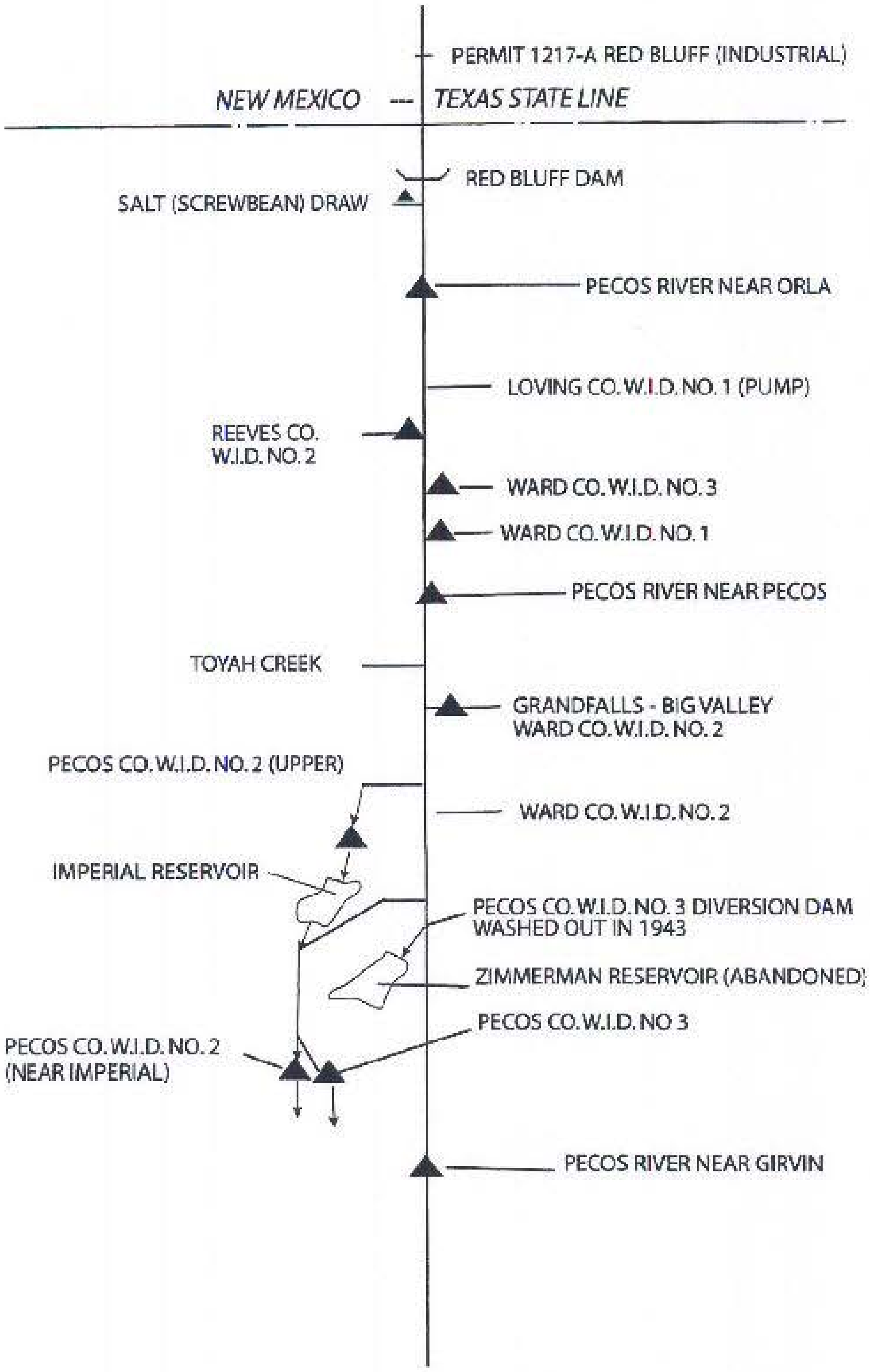


Figure 4
Diagram of Red Bluff - Girvin Area

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
PERCENT	4	3	7	8	12	12	12	12	11	10	5	4

d. Streamflow past Fort Sumner Irrigation District

From the streamflow below Sumner Dam (item 3.a.), subtract the Fort Sumner Irrigation District diversions (item 3.b.), and add the Fort Sumner Irrigation District return flows (item 3.c.). Whenever the computed flow past the District is less than the return flow, set the flow past the District (item 3.d.) equal to the return flow (item 3.c.).

e. Channel loss, Sumner Dam to Acme[4]

Compute the monthly river channel losses using the equations below, where X is the flow past the Fort Sumner Irrigation District in units of 1000 acre–feet (item 3.d.). Whenever the computed loss exceeds the calculated flow past the District, the channel loss (item 3.e.) is set equal to the flow past the District (item 3.d.). Any computed negative channel loss is set equal to zero.

Month	Channel Loss "L" by Month in 1000 Acre–Feet
Jan, Feb, Dec	L = .057X + 0.097
Mar	L = .177X + 0.227
Apr, May	L = .118X + 1.098
Jun	L = .163X + 0.784
Jul	L = .137X + 0.632
Aug	L = .088X + 1.350
Sep, Oct	L = .127X + 0.499
Nov	L = .132X + 0.448

f. Computed residual flow at Acme

Item 3.d. – Item 3.e.

g. Base Inflow, Acme to Artesia[5]

For the River Master's Preliminary Report use the monthly base inflow quantities determined and furnished by the USGS. USGS will utilize the

[4] Modified by Joint Motion of New Mexico and Texas, October 26, 1993.
[5] Modified through Modification Determination, effective December 26, 1990.

best available data and methods to estimate the total monthly base inflows accruing to the Acme to Artesia reach. In their report USGS will describe the data and methods used to estimate the base inflows and describe any unusual hydrologic events that occurred during the water year. After review of any objections to the USGS estimates by the states the River Master will make any adjustments deemed necessary to the base inflow estimates and determine the base inflow quantities for the Final Report. If no monthly base inflow quantities are determined and furnished by USGS the River Master will prepare the estimates for the Preliminary Report.

h. River pump depletions, Acme to Artesia

Use monthly river pump diversion quantities compiled by USGS based upon river pumping from the Pecos River in the Acme to Artesia reach as reported by the New Mexico Pecos River Water Master.

i. Residual flow at Artesia

Item 3.f. + Item 3.g. – Item 3.h.

j. Streamflow, Pecos River near Artesia

Use the monthly USGS streamflow records for the gaging station, Pecos River near Artesia, N.M.

k. Flood inflow, Sumner Dam to Artesia

Item 3.j. – Item 3.i.

Table 1 shows sample computations for years 1982 and 1983 extracted from Texas Exhibit 79.

Table 1

Pecos River Compact. Sumner Dam to Artesia Reach. Pecos River Basin, New Mexico
Estimated Flood Inflows in 1000 Acre–Feet Units, 1950–1983

Year		Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1982	(1)	Gaged flow below Sumner Dam	0.1	0.1	5.5	44.6	5.9	0.1	36.3	7.1	36.2	4.1	0	0	140.0
	(2)	Ft Sumner Diversions	0	0	4.7	4.7	5.3	4.9	5.1	5.9	5.8	3.6	0.2	0	40.2
	(3)	Ft Sumner Return Flow	0.9	0.6	1.5	1.7	2.6	2.5	2.5	2.6	2.3	2.1	1.1	0.9	21.3
	(4)	Flow Past Project	1	0.7	2.3	41.6	3.2	5.7	33.7	3.8	32.7	2.6	0.9	0.9	129.1
	(5)	Channel Loss, Ft Sumner-Acme	0.4	0.2	0.7	6	1.5	2	5.1	1.7	4.7	0	0.3	0.3	22.9
	(6)	Computed Residual Flow at Acme	0.6	0.5	1.6	35.6	1.7	3.7	28.6	2.1	28	1	0.6	0.6	104.6
	(7)	Base Inflow Acme-Artesia	2.8	2.7	2.2	1.4	1.5	1.1	0	0.8	0.9	1.3	1.6	2.4	18.7
	(8)	River Pump Depletion	0	0.2	0.4	2.3	1.3	0.7	2.4	1.1	1.1	0.2	0.1	0	9.8
	(9)	Residual Flow at Artesia	3.4	3	3.4	34.7	1.9	4.1	27	1.8	27.8	2.9	2.1	3	115.1
	(10)	Pecos River Near Artesia	4.2	3	2.2	24.5	9.3	0.6	29.1	1.2	27.3	7.6	3.2	3.9	116.1
	(11)	Flood Inflow	0.8	0	-1.2	-10.2	7.4	-3.5	2.1	-0.6	-0.5	4.7	1.1	0.9	1.0

Year		Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1983	(1)	Gaged flow below Sumner Dam	0	0	3.2	4.2	39.6	11.4	59.6	14.5	27.7	3.8	0	0	164.0
	(2)	Ft Sumner Diversions	0	0	2.8	3.7	5.8	5.5	6.4	5.7	4.9	2.8	0	0	37.6
	(3)	Ft Sumner Return Flow	0.8	0.6	1.4	1.6	2.4	2.3	2.4	2.4	2.2	2	1	0.8	19.9
	(4)	Flow Past Project	0.8	0.6	1.8	2.1	36.2	8.2	55.6	11.2	25	3	1	0.8	146.3
	(5)	Channel Loss, Ft Sumner-Acme	0.3	0.2	0.6	1.4	5.4	2.4	8.5	2.5	3.7	0.8	0.3	0.3	26.4
	(6)	Computed Residual Flow at Acme	0.5	0.4	1.2	0.7	30.8	5.8	47.1	8.7	21.3	2.2	0.7	0.5	119.9
	(7)	Base Inflow Acme-Artesia	2.6	2.1	1.7	1.2	1.1	0.7	0.6	0.6	0.9	1.5	2	2.5	17.5
	(8)	River Pump Depletion	0	0	0.2	0.5	2	1.2	2.6	1.6	1.9	0.2	0	0	10.2
	(9)	Residual Flow at Artesia	3.1	2.5	2.7	1.4	29.9	5.3	45.1	7.7	20.3	3.5	2.7	3	127.2
	(10)	Pecos River Near Artesia	4	3	2.1	2.1	28.6	1.5	40.8	2.2	25.4	7.7	9.9	4.2	131.5
	(11)	Flood Inflow	0.9	0.5	-0.6	0.7	-1.3	-3.8	-4.3	-5.5	5.1	4.2	7.2	1.2	4.3

Explanation of rows

(1) Gaged streamflow at USGS index gaging station, Pecos River Below Sumner Dam
(2) From Table A-5-3, page S-16, RBD prior Mar 1954, measured diversions thereafter
(3) Computed from 53 percent of annual quantity row (2) times monthly distribution from page 5-11 RBD
(4) Row (1) – Row (2) + Row (3)
(5) Computed from row 4 using monthly stipulated loss equations of July 3, 1985 (page A-5 of Appendix A)
(6) Row (4) – Row (5)
(7) Table A-18-1, page 8-5, RBD 1950-56, and 1957-83 as determined by USGS
(8) Table A-7-6, pages 7-20 & 21, RBD 1950-56, and 1957-83 as tabulated by USGS from New Mexico diversion records
(9) Row (6) + Row (7) – Row (8)
(10) Revised USGS streamflow records Pecos River near Artesia
(11) Row (10)- Row 9

4. Determination of Flood Inflows, Artesia to Carlsbad[6]

The flood Inflows for the Artesia to Carlsbad reach are computed as the sum of the flood inflows to the Artesia to Dam Site #3 reach and the flood Inflows to the Dam Site #3 to Carlsbad reach. Monthly quantities for each item will be measured or computed, and the annual quantities will be the sum of the monthly quantities. The computational items used to estimate the flood inflows for this 45.3 river mile reach of the Pecos River are listed below, followed by an explanation of each computation to be made:

Flood Inflow, Artesia to Dam Site #3
Flood Inflow, Dam Site #3 to Carlsbad
Total inflow to the Dam Site #3 to Carlsbad Reach
Streamflow, Pecos River at Dam Site #3
Carlsbad Springs New Water
Total outflow from the Dam Site #3 to Carlsbad Reach
Lake Avalon Evaporation Loss
Lake Avalon Change in Storage
Net Carlsbad Irrigation District Diversions
Other Depletions
Streamflow, Pecos River at Carlsbad
Flood Inflow, Artesia to Carlsbad

a. Flood Inflow, Artesia to Dam Site #3

Use the sum of the monthly flood flow quantities determined by hydrograph scalping of the daily USGS streamflow records for:

(1) Rio Penasco at Dayton, NM;
(2) Fourmile Draw near Lakewood, NM;
(3) South Seven Rivers near Lakewood, NM;
(4) Rocky Arroyo at Highway Bridge near Carlsbad, NM.

b. Flood Inflow, Dam Site #3 to Carlsbad

Compute the total inflow to the reach (item B.4.c.) and the total outflow from the reach (item B.4.d.). Subtract the total inflow from the reach (item c) from the total outflow (item d).

c. Total inflow to the Dam Site #3 to Carlsbad Reach

Total inflow to the Dam Site #3 to Carlsbad Reach is computed as the sum of items (1) and (2) below:

[6] Modified by Modification Determination dated December 7, 1992.

(1) Use USGS streamflow records for the Pecos River at Dam Site 3, near Carlsbad, N.M.

(2) Carlsbad Springs New Water

Use the following procedure to compute the monthly new water discharge quantities rounded to the nearest 100 acre-feet.

(a) Use the annual streamflow records (expressed in cfs) furnished by the USGS for the gaging station, Pecos River below Dark Canyon, at Carlsbad, N.M.

(b) Subtract tributary inflow from Dark Canyon Draw, furnished by USGS for the Dark Canyon Draw at Carlsbad gaging station.

(c) Subtract releases and spills from Lake Avalon, which are furnished by USGS for gaging station, Pecos River below Avalon Dam, N.M.

(d) Add 2 cfs for the annual depletions from the Pecos River from the Carlsbad canal flume to the Carlsbad gage. These depletions are caused by the power plant consumptive use, evaporation from Tansil and Bataan Lakes, and all diversions including the Carlsbad golf course, F.V. Dowling and E.J. Hines.

(e) Subtract the lagged seepage from the main CID canal in cfs, which is computed to be 7 percent of the CID diversions measured at Avalon Dam by USGS for gaging station, Carlsbad Main Canal at Head, Carlsbad, N.M. This seepage will have a lagged distribution as follows: one-half in the current quarter; one-third in the following quarter; and one-sixth in the next quarter.

(f) Subtract one cfs to represent the average annual return flow from surface water irrigation between Avalon Dam and the gaging station Pecos River at Carlsbad.

(g) Subtract lagged leakage from Lake Avalon. The leakage from Lake Avalon is estimated by using the mean monthly gage height (H) in feet for Lake Avalon (published by USGS for Lake Avalon Near Carlsbad, N.M.), in the equation: Avalon leakage in cfs = 4.78 (H) - 62.0. One half of this leakage is assumed to appear at Carlsbad Springs during the current quarter; with one-third to appear during the following quarter; and one-sixth during the next quarter.

(h) Subtract 3 cfs to represent the average seepage loss from the Pecos River in the reach between Major Johnson Springs and the Dam Site No. 3 gage.

(i) The annual new water in cfs is: (a) - (b) - (c) + (d) - (e) - (f) - (g) - (h).

(j) Convert the new water in cfs, item (i) above, to units of 1000 acre-feet, and distribute equally to each month of the year.

d. Total outflow from the Dam Site #3 to Carlsbad Reach is computed as the sum of items (1) through (5) below:

(1). Lake Avalon Evaporation Loss

(a) Compute the monthly evaporation loss by multiplying the net monthly evaporation rate times the average monthly surface area for Lake Avalon.

(b) Use the USGS elevation, area and capacity relationship for Lake Avalon to estimate the average monthly surface area for the lake. The 1997 area-capacity table based on the 1996 United States Bureau of Reclamation (USBR) sediment survey for Lake Avalon (Table 3) is to be used until a revised area-capacity table based on a new sediment survey performed by the USBR, the U.S. Army Corps of Engineers, USGS, U.S. Soil Conservation Service or a state-registered engineer is available.[7]

(c) For Lake Avalon evaporation and precipitation, use U.S. National Weather Service (USNWS) evaporation and precipitation data for Brantley Dam. When the U.S. National Weather Service data are not available, use USBR evaporation or precipitation data for Brantley Dam. If neither USNWS nor USBR precipitation data are available, use precipitation data from Carlsbad or Carlsbad Federal Aviation Administration Airport in that order.

[7] Table 3 is not included because a revised area–capacity table has been issued by the US Bureau of Reclamation. The following note appeared on the original Table 3: "The gage height of 26.1 feet corresponds to an elevation of 3267.7 feet above the mean sea level with the datum of gage at 3241.6 feet above mean sea level."

(d) Missing monthly evaporation data at Brantley Reservoir are to be computed using the following equation:

$$EL = 2.5*[(p*T/100)*(114-H)/100] - 1.5$$

where EL is the lake evaporation in inches, p is the percentage of daytime hours at the approximate location of Avalon Reservoir, as given in the table below; T is the mean monthly temperature in degrees F, average of Artesia and Carlsbad; H is the average percent humidity for the month computed from the data at 5AM, 11AM, 5PM and 11PM furnished by the National Weather Service.

Table of Percentage of Daytime Hours for Avalon Reservoir

January	7.17	July	9.80
February	6.95	August	9.29
March	8.36	September	8.34
April	8.76	October	7.92
May	9.65	November	7.08
June	9.62	December	7.02

If Brantley Reservoir evaporation data are not available, and humidity data at Roswell and other data are not available for estimating evaporation at Lake Avalon, and there is not more than one month missing between months for which data are available, estimate the evaporation by interpolation between monthly data. If complete evaporation data are missing for more than one month and data for all the above described methods are not available, find the average daily evaporation that is published for that month and estimate total evaporation by multiplying the average daily evaporation times the number of days in the month.

(e) Monthly net evaporation in feet for Lake Avalon is determined by multiplying pan evaporation in inches by 0.77 to determine monthly lake surface evaporation, subtracting the monthly precipitation in inches, then converting to feet by dividing by 12.[8]

[8] In the future, if pan evaporation and precipitation data are available at the Brantley Dam site, use these data in estimating the evaporation rates. If data are not available for Brantley Reservoir, use the procedures described in B.4.d.(1). (Note modified by agreement between the States June 14, 1989. Section B.4.d.(1) was labeled B.4.f. in previous version of the Manual).

(2). Lake Avalon Change in Storage

Use data from USGS gage height records for Lake Avalon near Carlsbad, N.M., and gage height-area-capacity relationships shown in Table 3.[9]

(3). Net Carlsbad Irrigation District Diversions

Use 93 percent of the USGS published records for the gaging station, Carlsbad Main Canal at Head, Near Carlsbad, N.M.

(4). Other Depletions

For other depletions referenced in B.4.c.(1)(d) add 100 acre-feet for all months except July and August and 200 acre-feet for July and August.

(5). Streamflow, Pecos River at Carlsbad

Use the USGS gaging station records for Pecos River below Dark Canyon, at Carlsbad, N.M., minus the gaged streamflow at the USGS gaging station, Dark Canyon Draw at Carlsbad, N.M.

In 1970, the USGS discontinued the gaging station Pecos River at Carlsbad, N.M., and moved it to a new site about 0.8 mile downstream. The new "Carlsbad gage" was renamed Pecos River below Dark Canyon Draw and it now measures tributary inflow from Dark Canyon Draw that was not previously measured at the Carlsbad site. The total flow of Dark Canyon must be subtracted from the total flow Pecos River below Dark Canyon Draw in order to arrive at the equivalent total flow at the old location at Carlsbad.

e. Flood Inflow, Artesia to Carlsbad

Add items (a) and (b) above.

[9] See previous note about Table 3.

B. 5. Determination of Flood Inflows, Carlsbad to New Mexico–Texas State Line[10]

Because of the lack of sufficient data to accurately compute flood inflow in the Carlsbad to State Line reach by the inflow–outflow method, the flood inflow for this reach is to be determined by the hydrograph scalping method. Figure 5 shows the factors to be considered in scalping flood flows from the hydrographs. The computational items used to estimate flood inflows to the 54 river mile reach of the Pecos River are listed below, followed by an explanation of each computation to be made. Monthly quantities for each item will be computed from daily streamflow quantities. The annual quantities will be the sum of the computed monthly flood inflow quantities.

Flood inflow, Carlsbad to State Line not including Delaware River flood inflow (see a. below)
Flood inflow, Delaware River (see b. below)
Total flood inflow, Carlsbad to State Line (see c. below)

a. Flood Inflow, Carlsbad to USGS Gage at Red Bluff, N.M.

Use the following procedure:

(1). Prepare hydrographs for daily flows at the USGS gaging stations Pecos River below Dark Canyon, at Carlsbad, New Mexico, and Pecos River at Red Bluff, New Mexico.

Identify apparent flood inflow events by correlating periods of significant daily precipitation within the reach or its tributaries with distinct hydrograph rises. Normally precipitation is considered significant when 0.05 inches or more has occurred in the Carlsbad - Red Bluff area, but other flood-inducing factors such as total areawide precipitation and antecedent moisture shall also be considered. On the hydrographs plot the rainfall in the area to aid in separating genuine periods of flood inflow from periods of operational rises. Study gaged tributary flows from Dark Canyon Draw at Carlsbad, N.M., Black River above Malaga, N.M., and Delaware River near Red Bluff, N.M. to aid in identifying flood periods caused by rainfall in the tributary drainage areas.

(2). Compute the quantities of flood inflows by hydrograph scalping techniques. Compute the monthly flood inflows occurring between the upstream and downstream gaging stations as the difference between the scalped flood flow quantities of the two hydrographs. If the difference is a negative quantity set the flood inflow to zero.

[10] Modified through Modification Determination dated November 25, 1991.

(3). Identify the periods when gaged inflows from Dark Canyon Draw are greater than zero. Determine for these periods if the difference in scalped flood flow quantities from (2) above is positive, zero or negative. If positive or zero add the gaged flows of Dark Canyon Draw to the difference in scalped flood inflows. If they are negative subtract the daily Dark Canyon Draw flows from the Pecos River Below Dark Canyon hydrograph and perform the scalping operation again to obtain adjusted flood inflows for these periods. If the difference in adjusted flood inflows is still negative set it to zero; if it is positive use it for this period of Dark Canyon Draw inflows.

b. Flood Inflow, Delaware River

Use the daily records furnished by the USGS for the gaging station, Delaware River near Red Bluff, N.M. and select flood inflows by inspection of daily data.

c. Flood Inflow, Carlsbad to State Line

Add the estimated flood inflows from item 5.a. to that quantity determined in item 5.b.

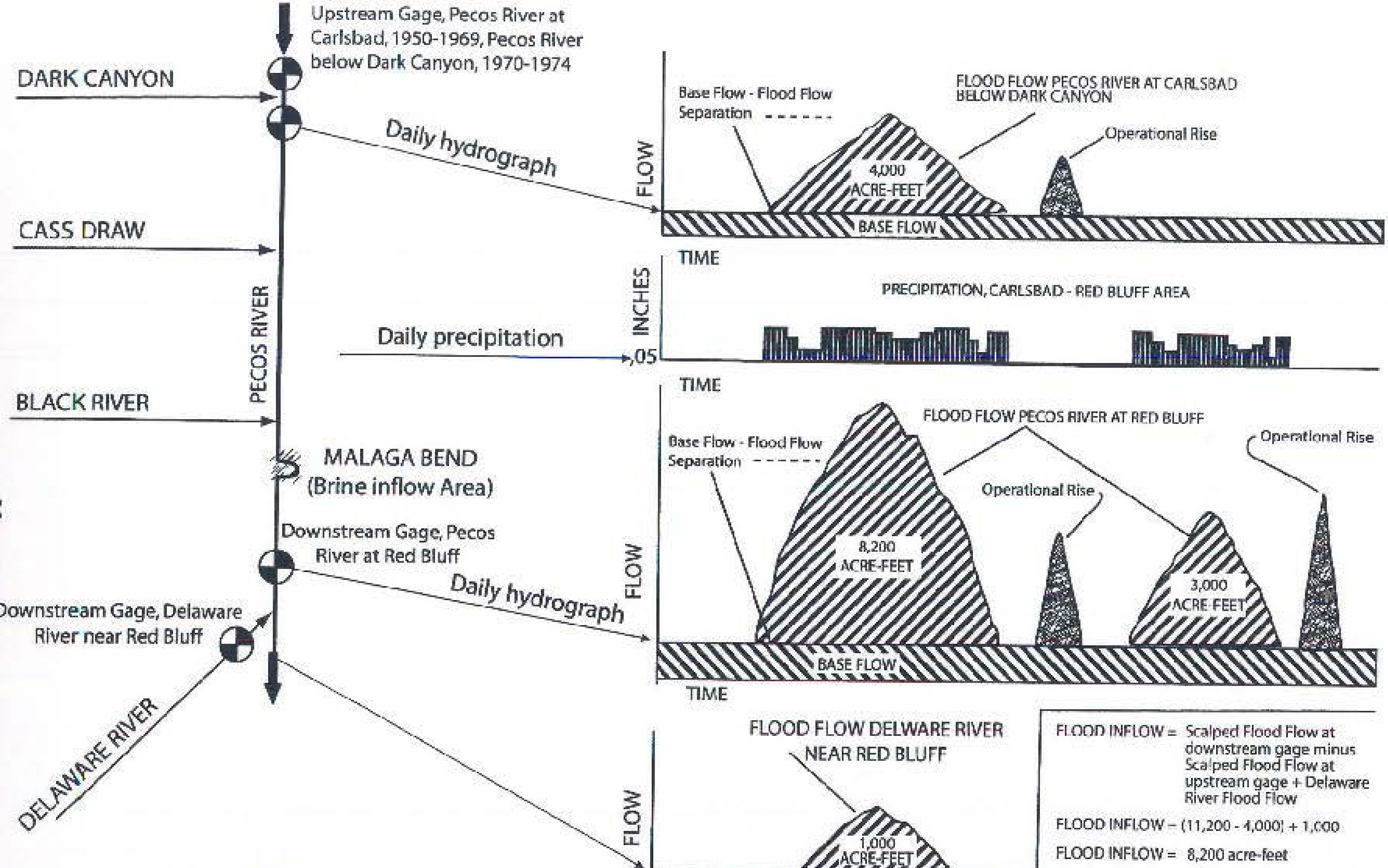


FIGURE 5
Idealized Flood Inflow Computation Procedures
Carlsbad to New Mexico - Texas State Line Reach

C. Adjustments to Computed Departures

1. Adjustments for Depletions above Sumner Dam

a. Adjustments due to irrigation

(1). In computing the total irrigated acreage in the Upper Reach, above Sumner Dam, to which surface and/or groundwater has been applied during any time of the year, use the irrigated acreage shown on the most recent irrigation inventory as reported by New Mexico. If any water right acreage in the Upper Reach is converted to another use, the depletion will be computed as if the use was irrigation use.

(2). Determine the consumptive use of irrigated acreage by multiplying the irrigation acreage determined in 1.a.(1) by the unit depletion rate for the year in question in acre–feet/acre. The unit depletion rate is determined as follows:

(a) Tabulate the monthly precipitation furnished for the Las Vegas Federal Aviation Administration Airport, Pecos Ranger Station and Santa Rosa for the months April through October. Find the effective precipitation for each station for each month using Figure A-7-2, page 7-11, of Stipulated Exhibit No. 8.

(b) Compute the average effective precipitation of the three stations for each month in inches. Convert the monthly effective precipitation in inches to feet.

(c) Using the following distribution of monthly unit consumptive use of 1.77 acre–feet per acre, subtract the estimated effective precipitation determined in Step 2 from the monthly unit consumptive use.

DISTRIBUTION OF MONTHLY UNIT CONSUMPTIVE USE[11]
(acre–feet per acre)

Apr	May	Jun	Jul	Aug	Sep	Oct	TOTAL
.19	.36	.36	.30	.27	.18	.11	1.77

(d) If the monthly effective precipitation estimated in Step 2 equals or exceeds the total monthly consumptive use, set the streamflow depletion equal to zero. If the monthly effective precipitation is less than the consumptive use, the difference is the streamflow depletion. Add the estimated streamflow depletion computed

[11] Monthly distribution of 1.77 acre–feet annual consumptive use calculated from table shown on page 41 of Stipulated Exhibit 11b.

each month April through October to determine the annual streamflow depletion rate to be applied to the historic irrigated acreage for the water year.

(e) Multiply the streamflow depletion rate determined in Step 4 by the irrigated acreage for the water year to determine the total streamflow depletion of the irrigated lands in the upper reach.

(3). Compare the 1947 Condition irrigation consumptive use (14,600 acres x 0.74 acre–feet/acre = 10,804 acre–feet per year) with Item (2). If the 1947 Condition use exceeds the actual use during the year computed in (2), the gaged streamflow below Sumner Dam will be reduced by the difference.

(4). If the actual use computed in (2) exceeds the 1947 Condition use, i.e., 10,804 acre–feet per year, then add the difference to the gaged streamflow below Sumner Dam.

Recompute New Mexico's 1947 Condition delivery obligation and departures at the state line using the revised streamflow of Pecos River below Sumner Dam.

b. Depletions Due to Operation of Santa Rosa Reservoir

(1). Determine the average monthly contents of Santa Rosa and Sumner Reservoirs and add these two contents to obtain the sum of contents. Use the gage height–area–capacity tables for each reservoir as shown in Appendices A-1 and A-3 of this Manual.

(a) Use the latest gage height–area–capacity tables for Sumner Reservoir as published by the U.S. Bureau of Reclamation and in Appendix A-1 to this Manual until another survey is undertaken and area–capacity tables are published by the U.S. Bureau of Reclamation.

(b) Use the latest gage height–area–capacity tables for Santa Rosa Lake (Lake Los Esteros) as published by the U.S. Army Corps of Engineers, Albuquerque District, August 1980, and extracted and shown in Appendix A-3 to this Manual, and currently used by the USGS until another sediment survey is undertaken and area–capacity tables published.

(2). Compute the monthly historic evaporation losses from Sumner Reservoir using the historic average surface area of Sumner Reservoir by multiplying it by the net evaporation rate at Sumner Dam. Compute the monthly net evaporation rate at Sumner Dam as 0.77

times the monthly pan evaporation rate at Sumner Dam minus the monthly precipitation at Sumner Dam.

(3). Compute the monthly historic evaporation losses from Lake Santa Rosa using the historic average surface area of Lake Santa Rosa multiplying it by the net monthly evaporation rate at Lake Santa Rosa. Compute the net monthly evaporation rate at Lake Santa Rosa as 0.77 times the monthly pan evaporation rate at Lake Santa Rosa minus the monthly precipitation at Lake Santa Rosa.

New Mexico is to provide the pan evaporation and precipitation data for Lake Santa Rosa and Sumner Reservoir.

(4). Add the two net monthly historic evaporation losses from Sumner and Santa Rosa Reservoirs computed in (2) and (3) above.

(5). Compute the 1947 Condition net monthly evaporation loss from Sumner Reservoir by assuming its contents equal to the total historic contents of Lake Santa Rosa and Sumner Reservoirs determined in (1) above. Use the same net evaporation rate from Sumner Reservoir as computed in (2) above. (Use Table 3 of Texas Exhibit 68 for Sumner Reservoir). Use a limit of 4,600 acres for the maximum surface area for Sumner Reservoir in calculating the 1947 Condition.[12]

(6). Subtract 1947 Condition net monthly evaporation loss from Sumner Reservoir computed in (5) above from the total historic net monthly evaporation loss from Sumner and Santa Rosa Reservoirs computed in (4) above. Add the 12 monthly values algebraically to make the annual adjustment for excess evaporation.

(7). Compute the excess water held in these two reservoirs during the year over and above the 1947 Condition storage of 129,300 acre–feet by the following procedure:

(a) Determine the end of the year combined contents for Santa Rosa and Sumner Reservoirs for the current year and the previous year. If both quantities are equal or less than 129,300 acre–feet then the adjustment for excess storage is zero;

(b) If both end of year combined contents are in excess of 129,300 acre–feet, then subtract algebraically the previous year's combined end of year contents from the current year's combined end of year contents;

[12] Last sentence added by Joint Motion, October 27, 1992.

(c) If the current year's end of year combined contents are less than 129,300 acre–feet and the previous year's end of year combined contents are in excess of 129,300 acre–feet, then subtract algebraically the previous year's combined end of year contents from 129,300 acre–feet; and

(d) If the current year's end of year combined contents are in excess of 129,300 acre–feet but the previous year's end of year combined contents are less than 129,300 acre–feet, then subtract 129,300 acre–feet from the current year's combined end of year contents.

(8). Add algebraically the adjustment for excess evaporation loss computed in (6) above to the adjustment for excess storage held in these two reservoirs, computed in (7) above.

(9). Add algebraically the adjustment computed in (8) to the annual gaged flow below Sumner Dam for computing the Index Inflows.

(10). Recompute New Mexico's 1947 Condition delivery obligation and departures at the state line using the adjusted Index Inflows.

c. Transfer of Water Use by New Mexico to the Upper Reach Upstream from Sumner Dam

Add to the streamflow of the Pecos River below Sumner Dam, the effect of the amount of water diverted by New Mexico upstream of Sumner Dam transferred from the reach below Sumner Dam to the state line as reported by New Mexico. If the amount of the diversions is not reported by New Mexico by March 1, each year, assume the diversion equals the amount of water authorized for transfer in the permit.

Recompute New Mexico's 1947 Condition delivery obligation and departures at the state line using the revised streamflow of Pecos River below Sumner Dam.

2. Depletions Due to McMillan Dike

Credit the computed departures in B.1.d. with the quantities of depletions caused by the McMillan Dike.

Compute the depletions caused by the McMillan Dike using the following procedures:

a. Use the Sumner Dam to New Mexico–Texas state line Index Inflow computed in B.1.a(2) for the computation year and compute the 1947 Condition outflow with McMillan Dike using the following equation:

$$Y = 0.046399\ (X)^{1.430603}$$

where X is the Index Inflow and Y is the 1947 Condition outflow in units of 1000 acre–feet.

b. Subtract the outflow computed in 2.a. above from the outflow quantity computed in B.1.b.

c. Credit the departures in state line flows computed in B.1.d. by the quantity computed in 2.b. above.

3. Salvage Water Analysis Criteria and Procedures

a. The term "water salvaged" means that quantity of water which may be recovered and made available for beneficial use and which quantity of water under the 1947 Condition was non–beneficially consumed by natural processes.

b. The water salvaged in New Mexico, measured at or near Avalon Dam, through the construction and operation of a project or projects by the United States or by joint undertakings of Texas and New Mexico is apportioned by the Compact as follows:
forty–three percent (43%) to Texas and fifty–seven percent (57%) to New Mexico.

c. Any other water salvaged by New Mexico is apportioned by the Compact to New Mexico but will not have the effect of diminishing the quantity of water available to Texas under the 1947 Condition. Therefore the annual compact compliance computations are only concerned with the water salvage resulting from projects participated in by the United States or from joint Texas–New Mexico projects.

d. Study each water salvage project participated in by the United States and/or each joint Texas–New Mexico project. Determine the amount of water salvaged, if any, and convert it to a three–year running average quantity.

e. Route the water salvaged from place of occurrence to Avalon Dam, considering only non–beneficial consumption by natural processes. Forty–three percent (43%) of the routed water salvaged reaching Avalon Dam is apportioned to Texas. Add the total quantity of water salvaged that is apportioned to Texas to the delivery obligation of New Mexico at the New

Mexico–Texas state line.

4. Unappropriated Flood Waters Analysis Criteria and Procedures

   The River Master shall determine and apportion any unappropriated flood waters using methodologies not inconsistent with applicable provisions of the Compact and this Manual.

5. Texas Water Stored in New Mexico Reservoirs

   If a quantity of the Texas allocation is stored in facilities constructed in New Mexico at the request of Texas, then to the extent not inconsistent with the conditions imposed pursuant to Article IV(e) of the Compact, this quantity will be reduced by the amount of reservoir losses attributable to its storage, and, when released for delivery to Texas, the quantity released less channel losses is to be delivered by New Mexico at the New Mexico–Texas state line.

6. Beneficial Consumptive Use of Waters of Delaware River by Texas

   Add to the computed departures at the New Mexico–Texas state line the amount of beneficial consumptive use of waters of the Delaware River by Texas. These uses shall by furnished by Texas by March 1 each year.

APPENDICES[13]

A–1 Compilation of modifications to the River Master's Manual

Table A-1-1 presents a compilation of modifications made to the River Master's Manual since the original version was published on November 30, 1987.

Effective date	Modification	Summary
June 14, 1989	Joint Motion	Add phrase to Section B.4.f.(3)(c)
Dec 26, 1990	New Mexico's Amended First Motion	Modifies Section B.3.g. as to how River Master computes Base Inflow, Acme to Artesia.
Nov 25, 1991	New Mexico's Sixth Motion	Modifies Section B.5.a., Flood Inflow, Carlsbad to Red Bluff.
Oct 27, 1992	Joint Motion	Modifies Section C.1.b.(5) relating to 1947 Condition of Sumner Reservoir area.
Dec 7, 1992	New Mexico's Third Motion and Texas' Cross Motion	Replaces Section B.4 with language to account for water after construction of Brantley Reservoir.
Oct 26, 1993	Joint Motion to replace New Mexico's Fifth Motion and related motions	Modification of Section B.3.e. for computation of Channel Loss, Sumner Dam to Acme.
June 6, 2002	Agreed Request to Modify Section B.1.c.(1). Also includes modification to footnote in B.1.a.	Provides changes for salt harvesting project near Malaga, NM. Changes footnote to require rounding to 1 acre–foot rather than 100 acre–feet.

[13] The tables listed below were published in the appendices of the River Master's Manual dated November 30, 1987 but not included in this version of the Manual. Tables for Lake Sumner and Lake Santa Rosa are not included in this version because they have been superceded by newer versions, which are updated periodically by the U.S. Bureau of Reclamation and U.S. Army Corps of Engineers. The current tables are incorporated by reference into this River Master's Manual. The tables for Brantley Reservoir are not included because they are not presently used in Compact accounting. Tables included as appendices in the original Manual were:

A–1 Gage Height–Area–Capacity Tables for Lake Sumner (Alamogordo Reservoir). Published by the US Bureau of Reclamation, November 1973.
A–2 Gage Height–Area–Capacity Tables for Brantley Reservoir. Published by the US Bureau of Reclamation, August 1981.
A–3 Gage Height–Area–Capacity Tables for Santa Rosa Reservoir. Published by the US Army Corps of Engineers, August 1980.

MEMORANDUM
INTERSTATE STREAM COMMISSION
Pecos Bureau

DATE: April 8, 2010

TO: Greg Lewis

FROM: Kristin Green

CC: ISC Pecos Bureau Staff

SUBJECT: Pecos Settlement Carlsbad Project Water Supply Projection Procedure

Summary
The Pecos Settlement Agreement, in Paragraph 9.(A), requires that the New Mexico Interstate Stream Commission (ISC), in good-faith consultation with the Carlsbad Irrigation District (CID), the United States, and the Pecos Valley Artesian Conservancy District (PVACD) (collectively, the Settlement Parties), estimate the total Carlsbad CID Project Water Supply that will be available on prescribed Target Dates as summarized in Table 1. If the projected Project Water Supply for a given Target Date is less than the corresponding Target Supply, then ISC shall deliver water to the Pecos River from its augmentation well fields and/or Hagerman Canal as necessary to meet the Target Supply.

Projection Date	Target Date	Target Supply (AF)
November 1	March 1	50,000
March 1	May 1	60,000
May 1	June 1	65,000
June 1	July 15	75,000
July 15	September 1	90,000

Table 1. Settlement Triggers for Augmentation Pumping

The purpose of this memorandum is to provide step-by-step instructions for completing the Project Water Supply projections. The format and description for the projection output data are shown in Table 2, and a sample calculation is provided in Table 3. All tables and recent projections are located in the *Projections* spreadsheet on the Office of the State Engineer's (OSE) website (http://www.ose.state.nm.us/) as *Pecos Settlement Implementation* in 'Hot Topics' and on the Pecos Basin page (http://www.ose.state.nm.us/isc_pecos_river_compact.html) under 'Pecos Basin Links.' This memorandum breaks down the calculations contained in Table 2 into separate steps as follows:

1. Total and Available Storage at Time of Projection
2. Projected Releases to the State Line
3. CID Delivery
4. Fort Sumner Irrigation District (FSID) Delivery/Allotments
5. Projected Evaporative Losses
6. Average Inflow
7. Total Projected Storage and Settlement Target Determinations

Row	Description	Source of Value	Equation
1	Projection Date	NA	NA
2	Target Date for Projection	ISC	NA
3	Avalon Total Storage on Projection Date	CID	NA
4	Brantley Total Storage on Projection Date	USACE	NA
5	Sumner Total Storage on Projection Date	USACE	NA
6	Santa Rosa Total Storage on Projection Date	USACE	NA
7	Avalon Elevation (rounded to nearest tenth)	CID	NA
8	Brantley Elevation (rounded to nearest tenth)	USACE	NA
9	Sumner Elevation (rounded to nearest tenth)	USACE	NA
10	Santa Rosa Elevation (rounded to nearest tenth)	USACE	NA
11	Total Available Storage (reduced to Brantley) on Projection Date	Calculated	([3]-min pool-seds) + ([4]-min pool-seds) + ([5]-min pool-seds)*0.75 + ([6]-min pool-seds)*0.65
12	Projected releases to state line	ISC	NA
13	CID allotments (prior to projection date)	CID or USGS	NA
14	FSID allotments (through projection time frame)	OSE or USGS	calculated based on 20-yr average data [see FSID tab]
15	Avalon Evaporative Losses	ISC	calculated based on average data & reservoir elevation [see Evaporation tab]
16	Brantley Evaporative Losses	ISC	calculated based on average data & reservoir elevation [see Evaporation tab]
17	Sumner Evaporative Losses	ISC	calculated based on average data & reservoir elevation [see Evaporation tab]
18	Santa Rosa Evaporative Losses	ISC	calculated based on average data & reservoir elevation [see Evaporation tab]
19	Total Evaporative Losses for all 4 Reservoirs	Calculated	[15] + [16] + [17] + [18]
20	Santa Rosa Streamflow Forecast (% of average)	NRCS	NA
21	Projected Inflow to Brantley Reservoir	ISC	calculated based on average data [see Inflow tab]
22	Projected Inflow to Sumner Reservoir	ISC	calculated based on average data [see Inflow tab]
23	Projected Inflow to Santa Rosa	ISC	calculated based on average data & streamflow forecast [see Inflow tab]
24	Total Projected Storage (reduced to Brantley) for projection prior to Nov.1 for the following calendar year	Calculated	[11] - [12] - [13] - [14] - [19] + [22] + [23]*0.75 +[24]*0.65
25	Total Projected Storage (reduced to Brantley) for projection between Nov. 1 and Oct. 31	Calculated	[11] - [12] + [13] - [14] - [19] + [22] + [23]*0.75 +[24]*0.65
26	Settlement Target	ISC	NA
27	Augmentation Pumping?	Calculated	if [26] > [27], 'No', if [27] > [26], 'Yes'
28	How much pumping is required (AF)?	Calculated	[27] - [26]

*Units are acre-feet (AF) unless otherwise noted

USACE United States Army Corps of Engineers

USGS United States Geological Survey

NRCS United States Department of Agriculture National Resource Conservation Service

Table 2. Reservoir Storage Projection Description Table

Reservoir Storage Projections for Pecos Settlement

Row	Description	Projection
1	Projection Date	3/30/2010
2	Target Date for Projection	May 1
3	Avalon Total Storage on Projection Date	3,106
4	Brantley Total Storage on Projection Date	22,391
5	Sumner Total Storage on Projection Date	30,408
6	Santa Rosa Total Storage on Projection Date	25,322
7	Avalon Elevation (rounded to nearest tenth)	3,175.8
8	Brantley Elevation (rounded to nearest tenth)	3,248.4
9	Sumner Elevation (rounded to nearest tenth)	4,257.8
10	Santa Rosa Elevation (rounded to nearest tenth)	4,715.9
11	Total Available Storage (reduced to Brantley) on Projection Date	55,168
12	Projected releases to state line	0
13	CID delivery (prior to projection date)	0
14	FSID delivery/allotments (through projection time frame)	5,211
15	Avalon Evaporative Losses	665
16	Brantley Evaporative Losses	1,848
17	Sumner Evaporative Losses	1,755
18	Santa Rosa Evaporative Losses	788
19	Total Evaporative Losses for all 4 Reservoirs	5,056
20	Santa Rosa Streamflow Forecast (% of average or NA)	106%
21	Brantley Average Inflow (20-yr average excluding block releases)	4,619
22	Sumner Average Inflow (20-yr average excluding block releases)	6,452
23	Santa Rosa Average Inflow (20-yr average)	9,759
24	Total Projected Storage (reduced to Brantley) for projection prior to Nov.1 for the following calendar year	NA
25	Total Projected Storage (reduced to Brantley) for projection between Nov. 1 and Oct. 31	60,702
26	Settlement Target	60,000
27	Augmentation Pumping?	No
28	How much pumping is required (AF)?	0

*Units are acre-feet (AF) unless otherwise noted

input cells

Table 3. Reservoir Storage Projection Table

Step 1: Total and Available Storage at Time of Projection

To start, open the *Projections* spreadsheet, click on the *Projections* tab and enter information into rows 1 through 10. Cells highlighted in orange are the only cells where data should be manually entered. The total reservoir storage for Santa Rosa Lake, Sumner Lake, and Brantley Reservoir can be found on the US Army Corps of Engineers' (USACE) website at http://www.spa.usace.army.mil/wc/adbb/pecrt.htm. Click on the respective reservoir storage links. Once the storage plot loads, click on the *Tabulated Data* link to obtain the elevation and corresponding storage volume for the projection date at midnight or other appropriate time.

If a block release is taking place, use reservoir storage data prior to the start. These data can be found on the USACE website back a short time period or in the Pecos River Operations binder or Excel file on the Pecos server. To obtain the total storage and elevation at Avalon, contact the CID at (575) 236-6390. Enter the total storage values in rows 3 through 6 and elevations in rows 7 through 10. Once entered, Excel will calculate the total available storage (reduced to Brantley) on the projection date (row 11) based on entitlement storage values and historical conveyance losses using the following equations:

Available storage (AF) = Current total storage (AF) - minimum pool (AF) – estimated sediment accumulation since last survey (AF)

Total Available Storage (reduced to Brantley) = Avalon + Brantley + Sumner*0.75 + Santa Rosa*0.65

The minimum pool and the estimated sediment accumulation since last survey values for each reservoir are determined by the Bureau of Reclamation (BOR). Each March, BOR sends a letter to the State Engineer with this information. Table 4 shows the 2010 entitlements storages. This information can also be found in the *Projections* spreadsheet.

Reservoir	Entitlement Storage (AF)	Minimum Pool (AF)	Estimated Sediment Accumulation Since Last Survey (AF)	Total Conservation Storage (AF)	Conservation Elevation (ft)
Santa Rosa	92,604	0	5,060	97,664	*4,745.16*
Sumner	40,030	2,500	396	42,926	*4,262.88 (NAVD 88)*
Brantley	40,000	2,000	1,533	43,533	*3,256.41 (NAVD 88)*
Avalon	3,866	600	0	4,466	3,177.35
Total	**176,500**				

Table 4. 2010 Entitlement Storages.

Step 2: Projected Releases to the State Line
Determine if all the state line deliveries have been made by checking the Pecos Basin website (http://www.ose.state.nm.us/isc_pecos.html). If there are any scheduled state line deliveries, they will be listed in the *News* section. If they are already complete and no other releases will occur within the projected time period then enter zero. Otherwise enter the calculated release into row 12 on the Reservoir Storage Projection Table.

Step 3: CID Delivery
During the irrigation season, the CID delivery information will be updated weekly based on USGS stream gage data and cross-checked with values calculated monthly by the CID. The *CID Diversion Calculations* spreadsheet can be found on the Pecos Server under the *CID folder* (Table 5) or by contacting Markus Malessa at (505) 827-4029. Enter the value in row 13 of the Reservoir Storage Projection Table and this value will be added to the Total Projected Storage (reduced to Brantley) in row 25.

CID Diversion Calculations				
Source*	**Start Date**		**End Date**	**Diversion (AF)**
CID	as of		9/8/09	43710
USGS	9/9/09	-	9/15/09	2017.22
USGS	9/16/09	-	9/22/09	2181.85
USGS	9/23/09	-	9/29/09	3036.74
USGS	9/30/09	-	10/6/09	2334.59
Running Total				**53,280.40**

**CID data are verbally provided by the CID Manager, USGS data is taken from the USGS website for the Carlsbad Main Canal gage (08403500).*

Table 5. Sample CID Diversion Calculations for 2009

If making the March 1 projection prior to November 1 and when irrigation is still occurring (e.g. October projection for March 1):
Contact CID to determine the amount remaining in storage that will be delivered. Enter this value in row 13 of the Reservoir Storage Projection Table. As this water will be delivered after the projection date and prior to the target date the formula used for the Total Projected Storage (reduced to Brantley) will be row 26 instead of row 25 as the CID allotment water will be subtracted instead of added to the total. Rows 27 and 28 will need to be altered to reflect the new total.

Step 4: FSID Delivery/Allotments
Table 6 shows the average monthly values for the FSID diversions from 1989-2008. These values are based on flows recorded at USGS gage number 08385000 (Fort Sumner Main Canal near Fort Sumner, NM). These data, along with conversions to AF can be found in the *Projections* spreadsheet under the *FSID* tab. The FSID delivery/allotment value will be calculated automatically based on the projection date, target date and historical values. The calculated value in row 14 will be multiplied by 0.75 and then subtracted from the total projected storage (reduced to Brantley).

Average FSID Flows (1989-2008)				AF during projection period
Month	Avg Flow (cfs)	AF/Day	AF/month	
Jan	3	5.94	184.14	0
Feb	20	39.6	1108.8	0
Mar	71	140.58	4357.98	281.16
Apr	83	164.34	4930.2	4930.2
May	85	168.3	5217.3	0
Jun	87	172.26	5167.8	0
Jul	79	156.42	4849.02	0
Aug	75	148.5	4603.5	0
Sep	83	164.34	4930.2	0
Oct	81	160.38	4971.78	0
Nov	1	1.98	59.4	0
Dec	0	0	0	0
				5211.36

Table 6. FSID average monthly flows based on 20 years of data and a sample calculation for a projection date of March 30 and target date of May 1.

Step 5: Projected Evaporative Losses

This section uses the RiverWare model data to calculate monthly evaporative losses. The data have been copied into the *Projections* spreadsheet under the *Elev_Area* tab. Area will be determined automatically based on the elevations entered into rows 7 through 10. Calculations for evaporation rates are located in the *Evaporation* tab. The evaporation rates listed in the table are from the *'Revised Pecos RiverWare Model Report'* p. 87. Total evaporation rates for each reservoir during the projection period are shown in rows 15 through 18 of the Reservoir Storage Projection Table.

Step 6: Average Inflow

The average monthly inflow (AF) was calculated based on 20 years of data. A brief summary of methods can be found in '*Inflow Memokgedits*' dated January 30, 2009 and is located on the Pecos Server. Table 7 has the calculated monthly values for the three reservoirs. During the winter and spring months, it is important to use the streamflow forecast for the Santa Rosa Lake inflow in order to get a more accurate inflow projection. To locate these projections go to http://www.wcc.nrcs.usda.gov/cgibin/bor.pl, choose the information from the drop down menu and then click *Retrieve*. If an error occurs, it is most likely because the requested data has not been posted yet. If this is the case, choose the prior month and retrieve the data. Scroll down to the Pecos River Basin Outlook Report and enter the number listed under 50% of average Santa Rosa Lake Inflow into row 20 of the Reservoir Storage Projection Table. The streamflow forecast will be used to refine the average monthly inflow value for Santa Rosa Lake for the forecasted months.

Average Monthly Inflow (AF) based on 20 years of data (1989-2008) *data excludes block releases			
Month	Santa Rosa Reservoir	Sumner Reservoir	Brantley Reservoir
Jan	1,337	5,211	5,781
Feb	1,582	4,992	3,762
Mar	3,919	5,993	6,243
Apr	8,954	6,065	4,216
May	20,559	8,109	4,051
Jun	13,098	9,674	5,439
Jul	7,880	7,399	5,702
Aug	14,987	8,354	4,933
Sep	6,261	7,619	5,543
Oct	2,998	6,171	7,337
Nov	2,489	5,004	5,149
Dec	1,394	5,568	5,806
Total Inflows during projection period	9,759	6,452	4,619

Table 7. Average Monthly Inflows (AF) based on 20 years of data and the Santa Rosa streamflow forecast for a projection date of March 30 and target date of May 1.

Step 7: Total Projected Storage and Settlement Target Determinations

Once all the required information has been added to the Reservoir Storage Projection Table the Total Projected Storage (reduced to Brantley) will be calculated. Compare the targeted value with the total projected storage. The target value for the settlement can be found in the *Projections* spreadsheet or in Table 1.

After all the data has been entered into the reservoir storage projection table, make sure the formulas have been copied correctly. Review the values and make any necessary adjustments.