

WATER PERMIT NO. 2586-2

Name of Applicant: Rapid Valley Sanitary District – Water Service

Address: 4611 Teak Dr, Rapid City SD 57703 Phone: 605 393-1050

Amount of Water Claimed: 5.05 cfs Total Acres:

Source of Water Supply: Murphy Ditch

Water to be used for: suburban housing development County: Pennington

Type of Waste Disposal System:

Location:

PRIORITY Date Received: 5-8-06 Application/License Fee: \$100

Corrected Application Received: Period of Annual Use:

Remarks: transfer David Lamb Murphy Ditch shares to Rapid Valley Sanitary District

Diversion Point:

Land to be Irrigated:

Depth of Well: na

Well Driller:

Remarks:

Type of Map: aerial

Prepared by: Theodore Schultz, PE

Reviewed and the Number Assigned on: 5-9-06

By: **Karen Schlaak**

Notice of Hearing - date to intervene: \_\_\_\_\_

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FORM 2: Application for uses other than irrigation  
(type or print)

|                                                                                                                    |                                     |
|--------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| Mail to:<br>Water Rights Program<br>Joe Foss Building<br>523 E. Capitol<br>Pierre, SD 57501-3181<br>(605) 773-3352 | No. <u>2586-2</u> (office use only) |
|                                                                                                                    | Hydrologic Unit <u>10120110</u>     |
|                                                                                                                    | Basin <u>Upper Cheyenne</u>         |
|                                                                                                                    | Newspaper <u>Rapid City Journal</u> |

RECEIVED  
MAY - 8 2006  
WATER RIGHTS  
PROGRAM

## Application For Permit To Appropriate Water Within The State Of South Dakota

### Check use(s) of water:

- |                                                        |                                                      |                                          |                                          |
|--------------------------------------------------------|------------------------------------------------------|------------------------------------------|------------------------------------------|
| <input checked="" type="checkbox"/> Municipal          | <input checked="" type="checkbox"/> Suburban Housing | <input type="checkbox"/> Recreational    | <input type="checkbox"/> Institutional   |
| <input checked="" type="checkbox"/> Rural Water System | <input type="checkbox"/> Commercial                  | <input type="checkbox"/> Fish & Wildlife | <input type="checkbox"/> Geothermal Heat |
| <input type="checkbox"/> Domestic (over 18 gpm)        | <input type="checkbox"/> Industrial                  | <input type="checkbox"/> Other _____     |                                          |

### Type of Application: (check one)

- ☐ New ☒ Vested Right (Use predates Mar. 2, 1955) ☐ Future Use Reservation  
☐ Place to Beneficial Use Water Reserved by Future Use Permit No. \_\_\_\_\_  
☒ Amendment/Correction to Permit No. 1727-2

### Description of amendment/correction: (i.e. change diversion point(s), add diversion point(s), change use, etc.)

Transfer of David S. Lamb Murphy Ditch shares to Rapid Valley Sanitary District at new intake location south of Redwing Lane on Rapid Creek. Change use from irrigation to suburban housing/municipal.

- Name of Applicant Rapid Valley Sanitary District - Water Service Phone 605-393-1050  
(check one) ☒ Owner ☐ Tenant/lessee  
Mailing Address 4611 Teak Drive, Rapid City State SD 57703  
(Street, RR, or Box and City) (Zip Code)
- Amount of water claimed 5.05 \*CFS or 867 \*\*GPM AF  
(\*Cubic Feet per Second) (\*\*Gallons per Minute) (\*\*\*)Acre Feet - storage capacity of dam/dugout or annual use if applicable)
- Source of water supply Murphy Ditch - Rapid Valley Water Company, Inc.
- Location of point of diversion (example - 3 wells in SW 1/4 NE 1/4 section 12-T104N-R53W) County Pennington  
See attached Figure 1. Permanent RVSD raw water diversion point located in NE 1/4 NW 1/4 of Section 15, T1N, R8E, BHM, Pennington County, Lat. 44° 03' 04"N, Long. 103° 08' 46"W. The northwest temporary diversion point is located in the SW 1/4 SW 1/4 of Section 10, T1N, R8E, BHM, Pennington County at Lat. 44° 03' 25", Long. 103° 09' 10" W, The northeast temporary diversion point is located in the NE 1/4 of Section 15, T1N, R8E, BHM, Pennington County at Lat. 44° 03' 00" N, Long. 103° 08' 10" W as shown in Figure 1.
- County or counties where water will be used Pennington
- Annual period during which water is to be used April 15 through November 30
- Give a description of the project. When available, include any preliminary engineering report or other reports or information that will help explain the project. (Attach sheet if more space is needed)  
Refer to attached reports and information prepared by Leonard Rice Engineers and CETEC Engineering Services, Inc.

### STATE OF SOUTH DAKOTA)

SS

County of Pennington)

Attachments: Attach Form 2A if diversion is from a well or dugout, or if storage of water is proposed. Attach map and any other technical information. (see instructions)

I, Jim Jester, the applicant, certify that I have read this application, have examined the attached map and that the matters stated are true and that I intend, and am able to complete the necessary construction.

Applicant's signature \_\_\_\_\_

Subscribed and sworn to before me this 5th day of May 2006

\_\_\_\_\_  
Notary Public signature

**SOUTH DAKOTA**  
**WATER PERMIT NO. 2586-2**

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Date of first receipt of application May 8, 2006.

The Water Management Board approved Water Permit No. 2586-2 on August 23, 2006 for Rapid Valley Sanitary District, 4611 Teak Drive, Rapid City SD 57703 authorizing the construction of the water use system and the placing of water to beneficial use subject to the following limitations, conditions and qualifications:

1. Water Permit Application No. 2586-2 transfers a portion of Rapid Valley Water Company (aka Murphy Ditch) stockholder/landowner's use of Rapid Creek natural flows appropriated under Vested Water Right No. 1727-2 from Murphy Ditch. The transfer is for Rapid Creek water historically used to irrigation 368 acres at the Harney Peak Ranch owned by David Lamb. The portion of Rapid Creek natural flows to be transferred to the Sanitary District is 5.05 cubic feet of water per second (cfs) with an annual volume limitation of 867 acre feet of water.

Historically, the 5.05 cfs has been used to irrigation 368 acres located in portions of the SW  $\frac{1}{4}$  SW  $\frac{1}{4}$  Section 10, T1N, R8E and the W  $\frac{1}{2}$  NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$  NW  $\frac{1}{4}$ , S  $\frac{1}{2}$  NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$  and the SE  $\frac{1}{4}$  Section 15, T1N, R8E. The existing point on Rapid Creek for Murphy Ditch is located in the NE  $\frac{1}{4}$  SW  $\frac{1}{4}$  Section 8, T1N, R8E. This permit changes the diversion point for 5.05 cfs to a permanent diversion point for use by the Sanitary District to be located in the NE  $\frac{1}{4}$  NW  $\frac{1}{4}$  Section 15, T1N, R8E. The District is also authorized temporary diversion points located in the SW  $\frac{1}{4}$  SW  $\frac{1}{4}$  Section 10 and the NE  $\frac{1}{4}$  NE  $\frac{1}{4}$  Section 15; all in T1N, R8E as explained below. This permit does not authorize any new water appropriation from Rapid Creek.

The Sanitary District reserves the right to lease back a portion of the transferred water to Harney Peak Ranch for irrigation of property on a decreasing basis over a six year period from the date the permit is approved. The combined use by the Sanitary District and Harney Peak Ranch of the transferred amount proposed by this application is limited to 5.05 cfs diversion rate and annual volume limit of 867 acre feet of water including monthly volume limits. Upon termination of the lease back agreement, the landowner will no longer have the right to apply Rapid Valley Water Company, April 6, 1878, priority water on to the property from which it was transferred.

2. The water appropriated shall be used for the purpose of municipal, industrial, commercial, common distribution system, rural water system, suburban housing and domestic use purposes and may not exceed the amount of water needed for beneficial use.
3. The water is to be used during the following described annual period: January 1 – December 31.
4. The date from which applicant may claim right is April 6, 1878 (established by the Murphy Ditch vested water right for natural flow).
5. Water rights obtained in compliance with the laws of the State of South Dakota may not be unlawfully impaired by this appropriation.

(continued)

### QUALIFICATIONS

1. Permit No. 2586-2 is limited to a diversion rate of 5.05 cfs for a total annual volume of 867 acre feet. The Rapid Valley Sanitary District shall measure diversions at the Lamb property farm turnouts located on Murphy Ditch and diversion at the District's water treatment plant. The total monthly diversion shall not exceed the amount listed in the following table.

Monthly Volume Limitation

| <u>Month</u> | <u>(ac-ft)</u> |
|--------------|----------------|
| April        | 42             |
| May          | 105            |
| June         | 118            |
| July         | 158            |
| Aug          | 199            |
| Sept         | 147            |
| Oct          | 98             |
| Total        | 867            |

2. The Rapid Valley Sanitary District shall report to the Chief Engineer annually the amount of water withdraw each month at the Lamb property turnouts located on Murphy Ditch and diversion at the District's water treatment plant.
3. Permit No. 2586-2 authorizes diversion of only natural flow water by the Rapid Valley Sanitary District and does not include any right to stored irrigation water available under contract from Pactola Reservoir and Deerfield Reservoir.
4. The Water Management Board retains jurisdiction of Permit No. 2586-2 in the event that additional information shows that changes need to be made in the monthly or total annual volumes authorized by Permit No. 2586-2.
5. Diversion under Permit No. 2586-2 may not interfere with existing water rights in effect prior to approval of Permit No. 2586-2 or any domestic rights.
6. The amount of water with a April 6, 1878 priority date, which may be appropriated under Vested Water Right No. 1727-2, is reduced by 5.05 cfs.
7. Upon termination of the lease back agreement, the 368 acres of Harney Peak Ranch property owned by David Lamb, which has been historically irrigated under the Vested Water Right No. 1727-2, located in portions of SW ¼ SW ¼ Section 10 and portions of Section 15, T1N, R8E may not qualify for another new irrigation right from any water source.

### WATER MANAGEMENT BOARD

By: Garland Erbele

Garland Erbele, Chief Engineer  
Water Rights Program  
Department of Environment and Natural Resources

NOV 03 2003  
date





# RECEIPT

## WATER RIGHTS PROGRAM

South Dakota Department of Environment and Natural Resources

Date MAY 8, 20 06

RECEIVED OF CETEC Engineering Services Inc., PO Box 9014, Rapid City SD 57709

The following amount in fees for services rendered as provided for by law:

|                                                                                                                        |       |        |
|------------------------------------------------------------------------------------------------------------------------|-------|--------|
| Fee for Application for Permit No. <u>2586-6</u> to Appropriate Water, to construct and to put water to beneficial use | 50    | 00     |
| Fee for Application for Permit No. _____ to Appropriate Water for Future use                                           |       |        |
| Fee to retain Future Use Permit No. _____ after period of seven years.                                                 |       |        |
| Fee for Inspecting Constructed Works, confirming beneficial use and issuing Water License No. <u>2586-6</u>            | 50    | 00     |
| Fee for Filing Transfer Form _____                                                                                     |       |        |
| Fee for _____                                                                                                          |       |        |
| Fee for Issuing New Well Driller's License No. _____ for C.Y. _____                                                    |       |        |
| Fee for Renewal of Well Driller's License No. _____ for C.Y. _____                                                     |       |        |
| Fee for Issuing Well Pump Installer's License No. _____ for C.Y. _____                                                 |       |        |
| Fee for Renewal of Well Pump Installer's License No. _____ for C.Y. _____                                              |       |        |
| (Any Other Work Provided by Law)                                                                                       | TOTAL | 100.00 |

No.

By

Darlene White  
Chief Engineer gm

02433



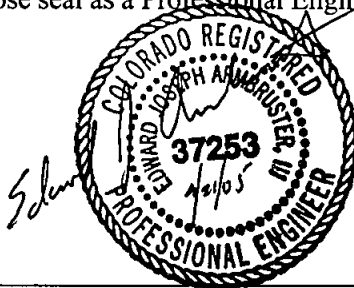


# ENGINEERING REPORT

## TRANSFER OF LAMB PROPERTY WATER RIGHTS

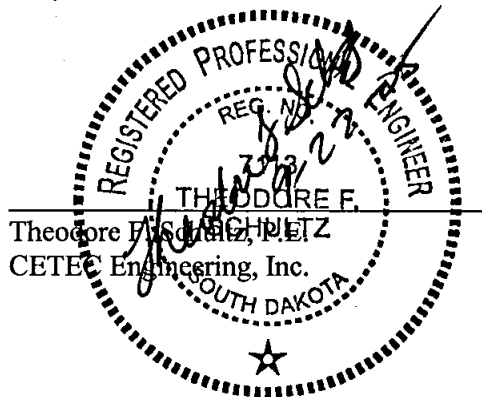
### 1878 MURPHY DITCH PRIORITY

The technical material in this report was prepared by or under the supervision and direction of the undersigned, whose seal as a Professional Engineer in Colorado is affixed below:



Edward J. Armbruster, P.E.  
Principal, Leonard Rice Engineers, Inc.

The technical material in this report was reviewed and approved by the undersigned, whose seal as a Professional Engineer in South Dakota is affixed below:



Theodore F. Schmitz, P.E.  
CETEC Engineering, Inc.

# **ENGINEERING REPORT**

## **TRANSFER OF LAMB PROPERTY WATER RIGHTS**

### **1878 MURPHY DITCH PRIORITY**

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## EXECUTIVE SUMMARY

This Engineering Report summarizes an evaluation of the historical use of water diverted from Rapid Creek under the 1878 Murphy Ditch agricultural water right on the Harney Peak Ranch. Approximately one-third of the water right was historically used on the Ranch to irrigate 368 acres of alfalfa and pasture lands. A detailed analysis was conducted to quantify historical water consumption, return flows and depletions to Rapid Creek resulting from agricultural uses of the water right.

The Rapid Valley Sanitary District provides drinking water to residents and businesses in rural portions of Pennington County east of Rapid City, South Dakota. The District is contemplating purchasing the Harney Peak Ranch portion of the Murphy Ditch water right. Future diversions water right, following a transfer proceeding with the South Dakota Department of Environment and Natural Resources, would occur at a District water treatment facility and supply a portion of its existing and future demand for potable water.

Historical diversions through the Murphy Ditch over the period 1950 through 2004 were estimated to average 4,387 acre-feet per year. Historical water deliveries from the Murphy Ditch to the Harney Peak Ranch were estimated to average 1,303 acre-feet per year. Of these Ranch water deliveries, an average of 703 acre-feet were consumed by agricultural crops, or approximately 1.91 acre-feet per acre. The remainder, 600 acre-feet, returned to Rapid Creek below the Ranch. A monthly pattern of depletions to Rapid Creek was developed that reflects diversions, consumptive use, and delayed subsurface return flows.

If irrigation on Ranch lands under the Murphy Ditch is discontinued, an average of 1,303 acre-feet per year could be diverted at an alternate point of diversion located at the District water treatment plant. This Report contains several terms and conditions on the future use of the Murphy Ditch water right by the District to protect other water rights owners on Rapid Creek.

## **I. INTRODUCTION**

This Engineering Report summarizes an evaluation of the historical use of water diverted from Rapid Creek under the April 6, 1878 Murphy Ditch water right for irrigation purposes on the Harney Peak Ranch (the Ranch). The Report documents the historical operation of the Murphy Ditch as it relates to delivery of irrigation water to the Ranch and quantifies the historical agricultural consumptive use and depletions to Rapid Creek resulting from irrigation on the Ranch.

Rapid Valley Sanitary District (the District) is currently negotiating with Harney Peak Ranch to acquire the Ranch's ownership interest in the 1878 Murphy Ditch water right. If acquired, the District would use the water right, following a transfer proceeding with the South Dakota Department of Environment and Natural Resources (SDDENR), to supply a portion of its existing and future demand for potable water. Following the transfer, the District would divert water under the 1878 water right at a treatment facility located approximately 3.5 river miles below the Ditch headgate on Rapid Creek. This Report also describes the amount of the 1878 Murphy Ditch water right that may transferred for diversion at the District's water treatment facilities such that other water right owners in the Murphy Ditch and along Rapid Creek are not adversely affected.

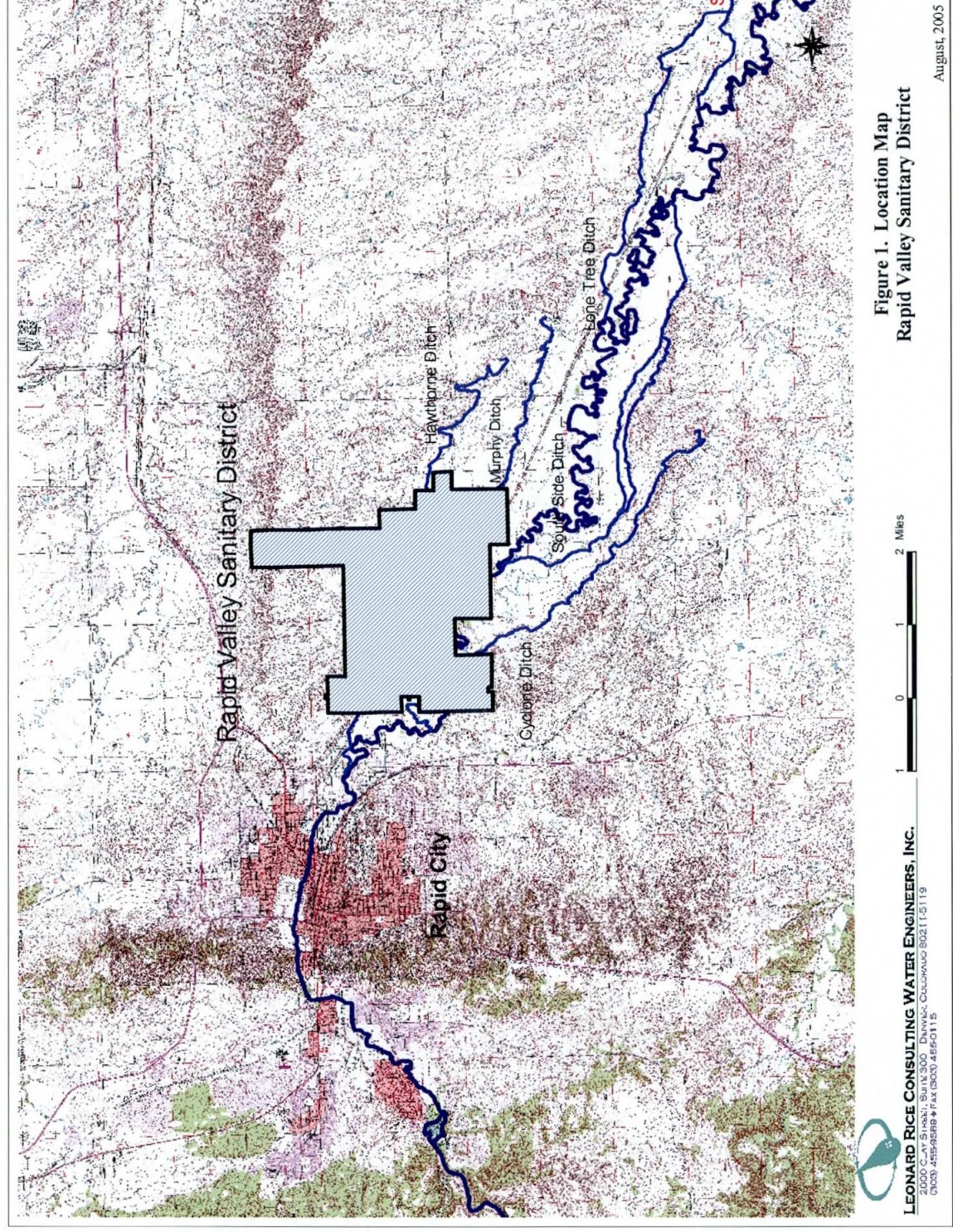
## **II. BACKGROUND**

### **II.1 Rapid Valley Sanitary District**

The Rapid Valley Sanitary District is located on the eastern edge of Rapid City in central Pennington County (**Figure 1**). The District was formed in the early 1960's to serve a growing population east of Rapid City in the plains area known as Rapid Valley and is the oldest organized rural water system in South Dakota.

The Rapid Valley area has seen steady growth and has grown from approximately 1,800 customers in 1988 to 3,100 customers in 2004. The late 1990's housing boom in Rapid Valley increased customers at a rate of 140 per year and has since slowed to an estimated 100 new customers per year. The area has been a popular location for new residential construction, and additional residential growth is expected in the undeveloped District area. The current customer base of 10,000 people is composed mainly of residential customers with commercial properties in the highway service areas.







The current District boundary includes approximately 3,850 acres with a 2004 service area of 1,700 acres or 44% of the possible system area. The recent development has been constructed at higher development densities, 3.0-3.5 dwelling units per acre, and typically uses more water during peak periods than development from the 1960's to the 1980's. The continued growth has caused growing pains for the RVSD water system and storage facilities. The District has had difficulty providing adequate supply and water storage during July and August peak water usage periods and continued growth and drought conditions will further strain the water system and cause water shortages.

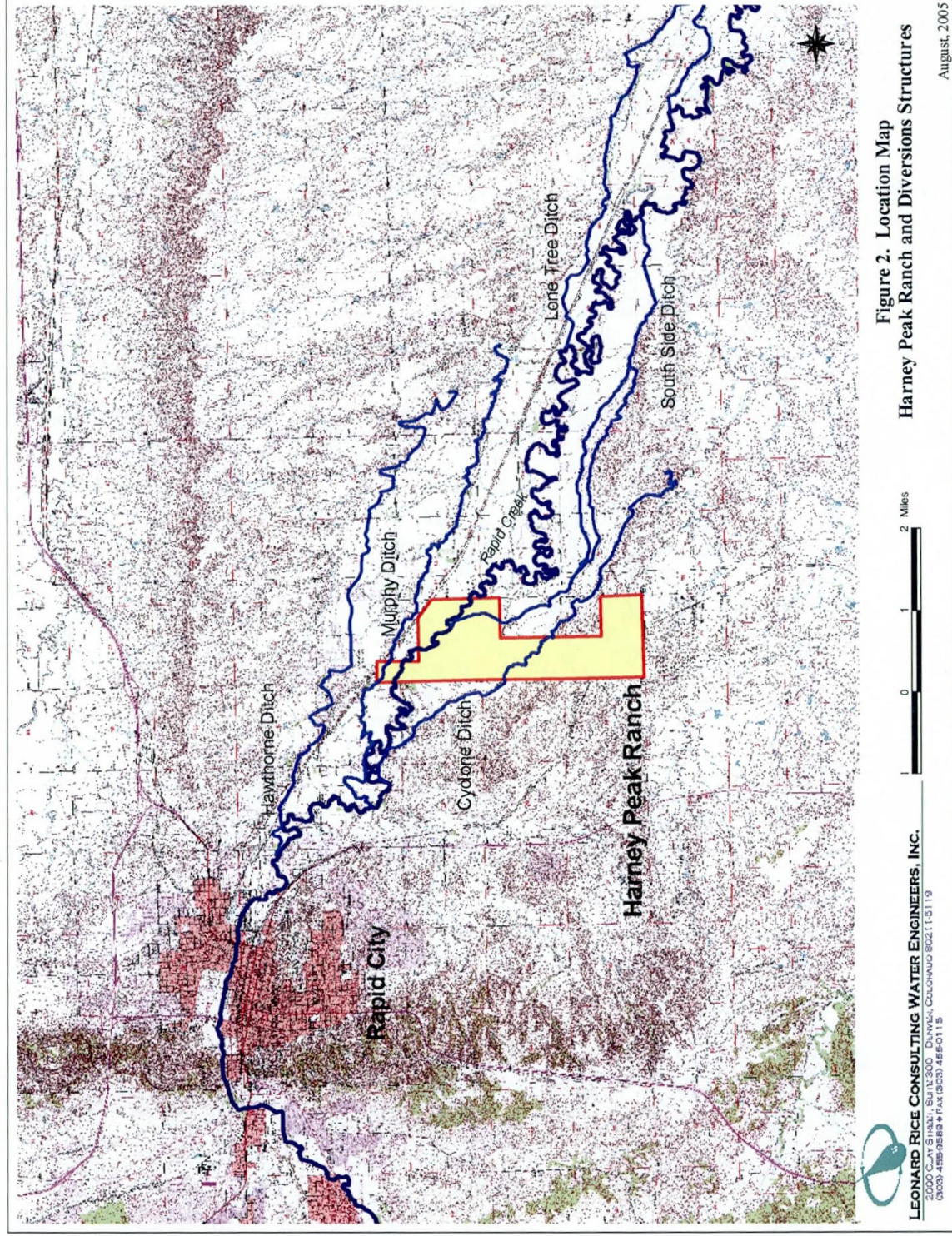
## **II.2 Harney Peak Ranch**

Harney Peak Ranch is a 2,500 acre parcel of land located approximately four miles southeast of Rapid City (**Figure 2**). Rapid Creek traverses the Ranch at its northern end. Agricultural operations at the Ranch include irrigation of alfalfa and pasture lands and support of over 700 head of cattle. The Ranch's irrigation water right permits, together with a system of pipelines, wells and dams support excellent water utilization and pasture development. The Ranch is currently owned by Mr. David Lamb and has been under ownership of the Lamb family for over 120 years.

### **II.2.1 Irrigation Water Supplies**

Water has historically been supplied to the Ranch via four irrigation structures. These include the Murphy Ditch, Cyclone Ditch, and the South Side Ditch. Water has also been delivered to the Ranch via a pump system from Rapid Creek operating under the Warren Lamb Lumber water right permit.

The ditches that supply water to the Ranch are generally small irrigation systems. In addition, their relative close proximity allows good communication between farmers within ditches and with interests in other ditches. There has been considerable flexibility by the water users on Rapid Creek and the State with respect to water right administration as opposed to operation under a strict priority system. The intercommunication and flexibility has allowed neighboring farmers and irrigation systems to work together to increase overall efficiencies of water use and maximize irrigation coverages with limited water supplies.





Following is a summary of irrigation water supplies for the Harney Peak Ranch. While this Report specifically addresses historical use of the Murphy Ditch, information concerning the Cyclone Ditch, Southside Ditch and Warren Lamb Lumber water rights is provided for additional background.

### II.2.1.1 Murphy Ditch

The Murphy Ditch (also known as the Rapid Valley Ditch or Rapid Valley Water Company) diverts water from the north side of Rapid Creek at a point located in the NE  $\frac{1}{4}$  of the SW  $\frac{1}{4}$  of Section 8, Township 1 North, Range 8 East of the Black Hills P.M, in Pennington County. The headgate of the Murphy Ditch is located approximately two miles south and east of Rapid City, and approximately three-quarters of a mile downstream of the U.S. Geological Survey stream flow gage ID 06418900 (Rapid Creek below Sewage Treatment Plant near Rapid City). The Ditch extends from its headgate approximately 8 miles to the south and east. Irrigation water from the ditch is supplied to lands on both sides of Rapid Creek. Diversions from Rapid Creek can be measured at a rated weir located down-ditch from headgate and above the first owner turnout.

The Murphy Ditch diverts water under two original water rights. Under Vested Water Right (Permit) No. 1727-2, and priority date of April 6<sup>th</sup>, 1878, the Murphy has the right to divert 17.0 cfs (**Appendix A**). This is the second most senior water right on Rapid Creek; the Leedy Ditch, located upstream within Rapid City, has the most senior right for 1.0 cfs, and a priority date of April 1, 1877. The Leedy Ditch right has been split into three components since its original permit was issued. The Murphy Ditch's junior priority, under Permit No., 1727-2 and priority date of April 26<sup>th</sup>, 1893, allows for diversion of an additional 3.0 cfs.

At times, the Murphy Ditch may also carry water diverted under several other permits, including Little Giant (Permit No. 653-2 for 2.4 cfs), Blanche Sedivy (Permit No. 1684-2 for 0.21 cfs), Warren Lamb Lumber (Permit No. 1461-2 for 1.25 cfs), Marty Rypkema (Permit No. 1784-2 for 0.71 cfs) and Jerry and Donna Olson (Permit No. 1788-2 for 0.50 cfs). These permits are for water in addition to the 17.0 cfs and 3.0 cfs rights of the Murphy Ditch. Additional information concerning the Warren Lamb Lumber permit is provided below.

The Murphy Ditch consists of an earthen channel over its entire course, and individual farmers are provided water via numerous turnouts. The Ditch is operated on an informal rotational basis whereby owners in the Ditch receive water in turn, based on their pro-rata interest. At times more than one owner may be provided water depending on the divertable flow rate at Rapid Creek. The ditch periodically receives inflow down-ditch of the diversion point on the river as natural drainage and/or return flows from lands lying to the north and west (further discussed below). Lands irrigated by the Hawthorne Ditch lie immediately above the Murphy Ditch and may contribute to these inflows.

The permit issued for the senior water right under the Murphy Ditch (17.0 cfs) identifies 1,103 irrigated acres. Of this total, 368 acres are irrigated within the boundary of Harney Peak Ranch. The pro-rata interest of this right by the Ranch is, therefore, approximately 33.4 percent (**Table 1**). The permit issued for the junior water right under the Murphy Ditch (3.0 cfs) identifies 189 irrigated acres. The Ranch has no ownership interest in the Murphy Ditch junior water right priority. The permit issued for this right contains the following language:

*Low flows as needed for downstream domestic use, including livestock watering, and prior water rights must be bypassed. Unappropriated water is available to reasonably satisfy this application only through contract between the Rapid Valley Conservancy District and Bureau of Reclamation covering releases from Deerfield and Pactola Reservoirs.*

Representatives from SDDENR have referred to the Murphy Ditch junior priority as “diversion authority”, i.e., it may divert purchased storage water but as a practical matter because of its junior priority status may not divert the natural flows of Rapid Creek.

Because of its senior status in the priority system of Rapid Creek, owners in the Murphy Ditch senior water right elected not to become a member of the Rapid Valley Water Conservancy District. Lands irrigated under the senior Murphy Ditch right are therefore not eligible to receive water from Pactola and Deerfield reservoirs.



**Table 1**  
**Murphy Ditch and Harney Peak Ranch Ownership Interest**

|                   | Permit No. / Amount | Permit Acreage | Percent Ownership |
|-------------------|---------------------|----------------|-------------------|
| Murphy Ditch      | 1727-2 / 17.0 cfs   | 1103           |                   |
| Harney Peak Ranch |                     | 368            | 33.4              |
| Murphy Ditch      | 1727-2 / 3.0 cfs    | 189            |                   |
| Harney Peak Ranch |                     | 0              | 0.0               |

The Ranch has several direct delivery points from the Murphy Ditch to serve irrigated fields. There are four primary delivery locations that feed a large number of separate conveyances that serve the Ranch under the ditch system. Included are two 15-inch piped diversions off of the main ditch and two surface diversion access points. The surface diversion points are able to divert larger amounts of water but not under the same dynamics as the full-flow conditions of the piped systems on the Ranch. There is also a fixed pump system with a pressurized capacity of approximately 800 gpm that can deliver Murphy Ditch water to portions of the Ranch. Metal liners have been placed in many portions of open-ditch segments of the conveyance system on the Ranch.

Water draining from higher elevation fields on the Ranch is collected by way of drainage ditches and an internal storage and transfer system of lagoons and channels. This collected water is then used and reused in various ways, either directly for irrigation on lower fields or to supply small reservoirs and then pumped for irrigation.

The Ranch is located near the top of the Murphy Ditch. In the event that excess flows threaten flooding in lower areas of Murphy Ditch system, the Ranch is frequently called upon to divert extra water before it can reach problems locations. Because of the periodic inflow potential to the Ditch below its headgate on Rapid Creek, there are several dedicated structures where excess water can be released out of the Ditch back to Creek (i.e., wasteways). Because of the large irrigated fields within the Ranch, however, there are often times when these higher flows can be used for beneficial irrigation.

There have been several transfers involving the 1878 Murphy Ditch water right since the early 1990s. It is our understanding that most, if not all of these transfers have been to Rapid City for use in the

City's municipal system. Of the original 17.0 cfs permitted for the 1878 priority, it is our understanding that approximately 13.0 cfs remain and continue to be diverted through the Murphy Ditch. The Harney Peak Ranch remains the largest and most consistent agricultural water user on the Ditch.

#### **II.2.1.2 Southside Ditch and Cyclone Ditch**

The Cyclone Ditch diverts water from the south side of Rapid Creek at a point located in the SE ¼ of the SE ¼ of Section 8, Township 1 North, Range 8 East of the Black Hills P.M, in Pennington County. The headgate of the Cyclone Ditch is located on Rapid Creek approximately one-half river mile below the Murphy Ditch headgate. The Cyclone Ditch extends from its headgate approximately 6 miles toward the south and east, and irrigates lands on the south side of Rapid Creek. The Cyclone Ditch diverts water under two original water rights. Under Permit No. 1736-2, and priority date October 31, 1887, the Cyclone has the right to divert 7.0 cfs. The Cyclone Ditch's junior priority, also under Permit No. 1736-2 and priority date of May 14<sup>th</sup>, 1890, allows for diversion of an additional 1.1 cfs. Harney Peak Ranch owns approximately 42.2 percent of the lands within the Cyclone Ditch water right permit.

The Southside Ditch diverts water from the south side of Rapid Creek at a point located in the NW ¼ of the SE ¼ of Section 15, Township 1 North, Range 8 East of the Black Hills P.M, in Pennington County. The headgate of the Southside Ditch is located on Rapid Creek approximately 4.5 river miles below the headgate of the Cyclone Ditch. The Southside Ditch extends from its headgate approximately 6 miles toward the south and east, and irrigates lands on the south side of Rapid Creek. The Southside Ditch diverts water under one original water right. Under Permit No. 2040-2, and priority date of May 3<sup>rd</sup>, 1880, the Southside has the right to divert 23.4 cfs. Harney Peak Ranch owns approximately 2.0 percent of the lands within the South Side Ditch water right permit.

Ranch lands irrigated by water from the Southside and Cyclone ditches are located to the south of lands irrigated from the Murphy Ditch. Both the Southside Ditch and Cyclone Ditch are members of the Rapid Valley Water Conservancy District and are therefore eligible to receive storage water deliveries from Pactola and Deerfield reservoirs.

### **II.2.1.3 Warren Lamb Lumber Permit**

The Ranch is able to divert supplemental water from Rapid Creek under a junior permit for 3.0 cfs. Of this permit, 1.25 cfs may be diverted through the Murphy Ditch and 1.00 cfs may be diverted through the Cyclone Ditch. The remaining 0.75 cfs may be diverted at the Ranch's own structure located near the center of Section 15, Township 1 North, Range 8 East of the Black Hills P.M, in Pennington County and used throughout the Ranch. As noted previously, use of this right is limited to the authority to divert water purchased from storage in Deerfield and/or Pactola reservoirs.

### **II.2.1.4 Rapid Valley Water Conservancy District**

The Rapid Valley Water Conservancy District was formed in 1948 and has historically operated under a contract with the U.S. Bureau of Reclamation for deliveries of water from Pactola and Deerfield Reservoirs to its member ditches. Pactola and Deerfield Reservoirs are part of the Rapid Valley Unit of the Pick Sloan Project. Combined, these reservoirs provide supplemental irrigation water to over 8,900 acres of farm land in the Conservancy District as well as municipal and industrial water to Rapid City.

The Conservancy District has as members all of the downstream ditches on Rapid Creek with the exception of the lands served by the senior priority in the Murphy Ditch (at the time of formation of the Conservancy District, owners in the Murphy Ditch elected not to become members because of their senior status and sufficient natural flows in Rapid Creek to meet their needs). Storage deliveries to member ditches of the Conservancy District are considered supplemental irrigation water supplies to the ditches own direct flow water rights. Supplemental water provided by the Conservancy District is not considered as part of the historical water supply that may be transferred to an alternate point of diversion.

### **II.2.1.5 Other Water Sources at the Harney Peak Ranch**

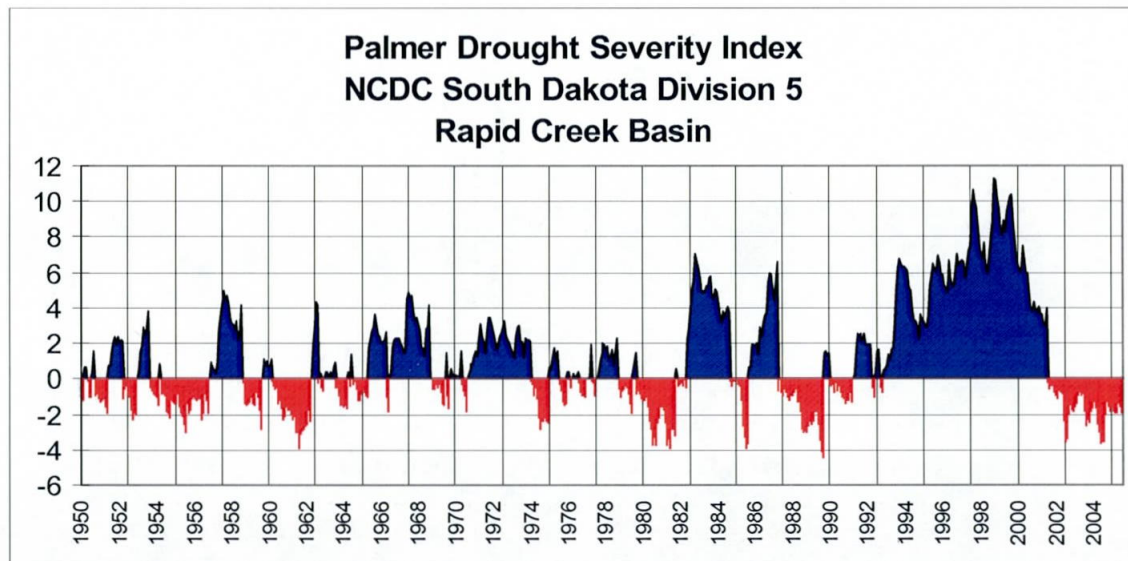
In addition to the water sources discussed above, the Ranch may periodically divert water under a junior water right from Dry Creek. This water right allows for diversions up to 3.0 cfs and for irrigation of between 300 to 500 acres located in Section 27 and 35, Township 1 North, Range 8 East. Although a very junior priority, it is the only existing water right on Dry Creek.

### III. HISTORICAL USE OF WATER AT HARNEY PEAK RANCH

#### III.1 Study Period

Historical use of the Murphy Ditch for irrigation on the Ranch was evaluated over the period January 1950 through December 2004. This study period was selected based on examination of historical climate and streamflow data and with the objective of representing conditions over a range of climatic and hydrologic conditions.

The principal climate parameters influencing water supply (and demand for irrigation water) are precipitation and temperature. An index that combines these parameters is the Palmer Drought Severity Index (PDSI) (Palmer, 1965; Alley, 1984). The National Climatic Data Center (NCDC) has developed an archive of monthly PDSI values from 1895 to the present for the Rapid Creek basin in South Dakota. The PDSI indicates the severity of a wet or dry spell, and generally ranges from -10.0 (very dry) to +10.0 (very wet). Monthly PDSI values for the Rapid Creek basin since 1950 are shown in **Figure 3**.



**Figure 3. Monthly PDSI Values for the Rapid Creek basin in South Dakota**

Available streamflow records were examined for gages located on Rapid Creek above Pactola Reservoir, SD (U.S.G.S. ID 06410500), below Pactola Dam, SD (U.S.G.S. ID 06411500), above Canyon Lake near Rapid City, SD (U.S.G.S. ID 06412500), at Rapid City, SD (U.S.G.S. ID



06414000), and below Sewage Treatment Plant Pipeline near Rapid City, U.S.G.S. ID 06418900). Records for these gages are generally available back through 1955 or earlier. All of these gages are influenced by upstream reservoir and/or irrigation operations, although the gage above Pactola Reservoir is fairly indicative of natural hydrologic conditions. Streamflow records from all of the gages generally agree with indications of wet or dry periods as suggested by the PDSI.

Based on our review of local climate and streamflow information, we believe the period extending from 1950 through 2004 is appropriate for evaluating water rights on Rapid Creek and represents sufficient natural variation in climatic and hydrologic conditions.

### **III.2 Overview of Methodology**

An analysis was performed to determine historical consumptive use and depletions to Rapid Creek resulting from irrigation under the Murphy Ditch on the Ranch. This analysis was performed on a monthly time-step for each year of the study period, requiring input data on monthly historical diversions, crop acreage and location of irrigated land, climate conditions, and soils. Geologic and ground water aquifer characteristics were also required to describe characteristics of subsurface return flows to Rapid Creek from irrigation on the Ranch. The analysis was conducted for the specific irrigated parcels within the Ranch that are served by the Murphy Ditch. The analysis was not performed for lands irrigated by the Southside and Cyclone ditches, and lands irrigated under the Warren Lamb Lumber permit.

The Modified Blaney-Criddle method was used to calculate the potential consumptive use of water by crops irrigated by the Murphy Ditch (Soil Conservation Service, 1970). Modified Blaney-Criddle is a widely accepted technique and has been used extensively throughout the United States, including South Dakota and the Rapid Creek area. Climate data from the Rapid City, South Dakota weather station were used for the Modified Blaney-Criddle computations. Crop irrigation water requirements were defined for the purposes of this Engineering Report as the net potential consumptive use of the crops after considering effective precipitation. Computing tools and spreadsheets were used to manage the data involved in the depletion analysis, to perform the mathematical computations, and to present results.

Additional details concerning information sources, input data for the analysis, and engineering estimates and assumptions are discussed below.

### **III.3 Information Sources, Data and Engineering Assumptions**

#### **III.3.1 Discussions with Water Managers and Review of Previous Engineering Reports**

Our investigations of historical use of irrigation water at the Harney Peak Ranch relied on discussions with several people familiar with local water management and administration, specifics of water rights and ditch operations, on farm irrigation water management, and other relevant matters. In addition, several reports were reviewed that had been prepared to support transfers of other water rights along Rapid Creek. The individuals and reports that have been relied upon for information include:

- Mr. Mark Rath, South Dakota Department of Environment and Natural Resources.
- Mr. Steve Murphy, Murphy Ditch Superintendent (Ditch Rider)
- Mr. Duane Scott, Rapid Creek Water Conservancy District, Rapid Creek Water Master
- Mr. Kevin Hamm, Rapid Creek Water Conservancy District, Rapid Creek Water Master
- Mr. Curt Anderson, U.S. Bureau of Reclamation, Pactola Reservoir
- Previous engineering reports that address irrigation ditches serving the Ranch, including:
  - Engineering Report for Transfer of Tyler Property Share of Validated 1878 Murphy Ditch Company, Wright Water Engineers, Inc. October, 1990.
  - Engineering Report for Transfer of Strommer Property Portion of Southside Ditch Water Rights, Wright Water Engineers, Inc. March, 1992.
  - Rapid Valley Water Management Study, U.S. Bureau of Reclamation, Great Plains Region, Belle Fourche Projects Office. July, 1990.
  - Technical Report for M.P. Carley Property Water Rights (Murphy Ditch) Transfer, Brown and Caldwell, May, 2003.

Our analysis also relied upon data on streamflows, climate conditions (temperature and precipitation), and soils, that were compiled from the U.S. Geological Survey, the National Climatic Data Center, and the Natural Resources Conservation Service.

### III.3.2 Ranch Operator Interview

Mr. David Lamb, current owner of the Ranch was interviewed on several occasions to obtain information concerning historical water use and farming operations. A site visit to the Ranch was conducted in December, 2003 (photographs are provided in **Appendix B**). The interviews of Mr. Lamb consisted of numerous questions aimed at developing an understanding of historical farming practices, cropping patterns, and water use and management. **Appendix C** is an affidavit signed by Mr. Lamb describing historical water use, irrigation practices, and crop yields on the Harney Peak Ranch.

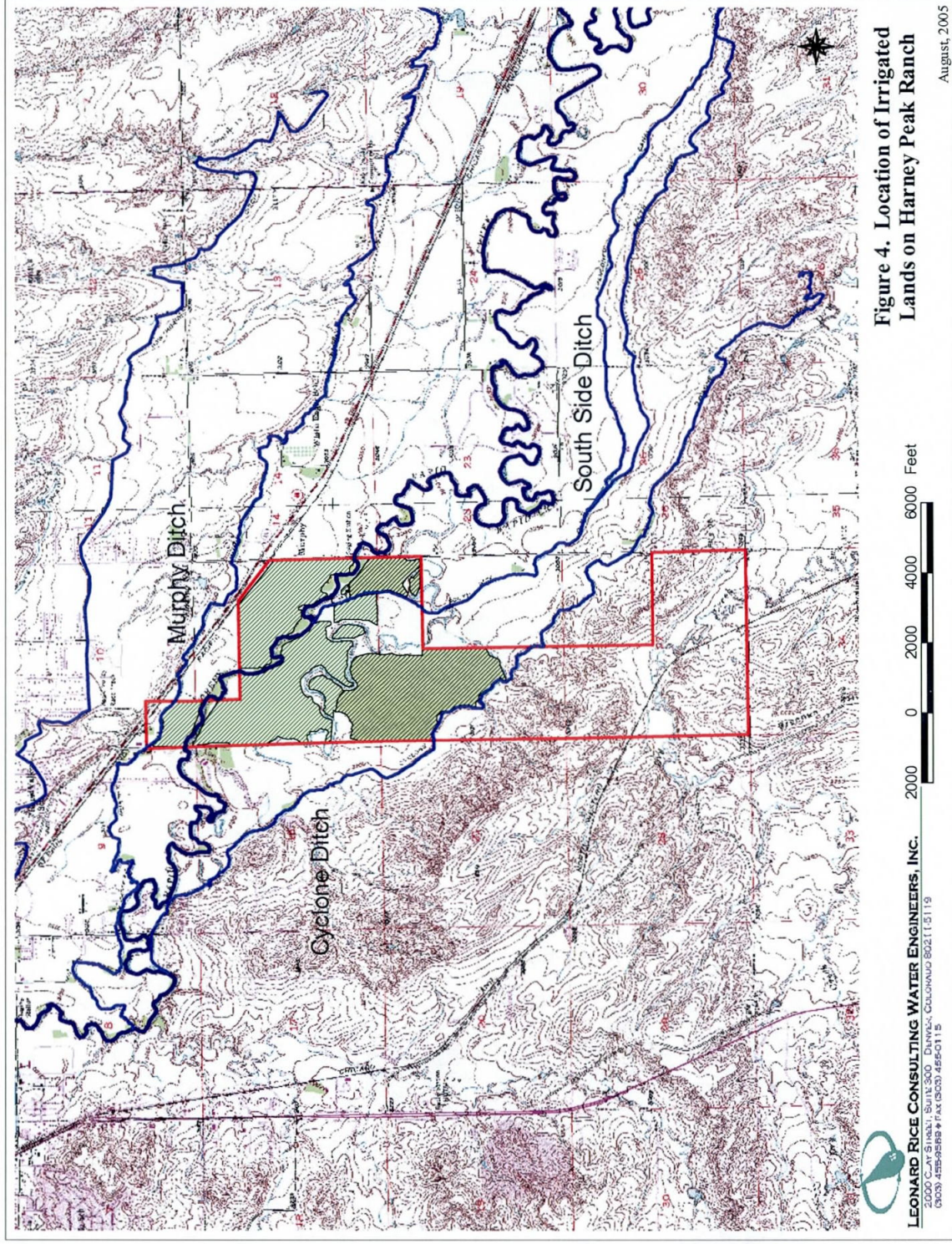
### III.3.3 Crop Consumptive Demands

This Section summarizes analyses that have been performed to determine historical cropping patterns and irrigated acreage, and to calculate potential consumptive use of irrigation water delivered under the Murphy Ditch senior water right.

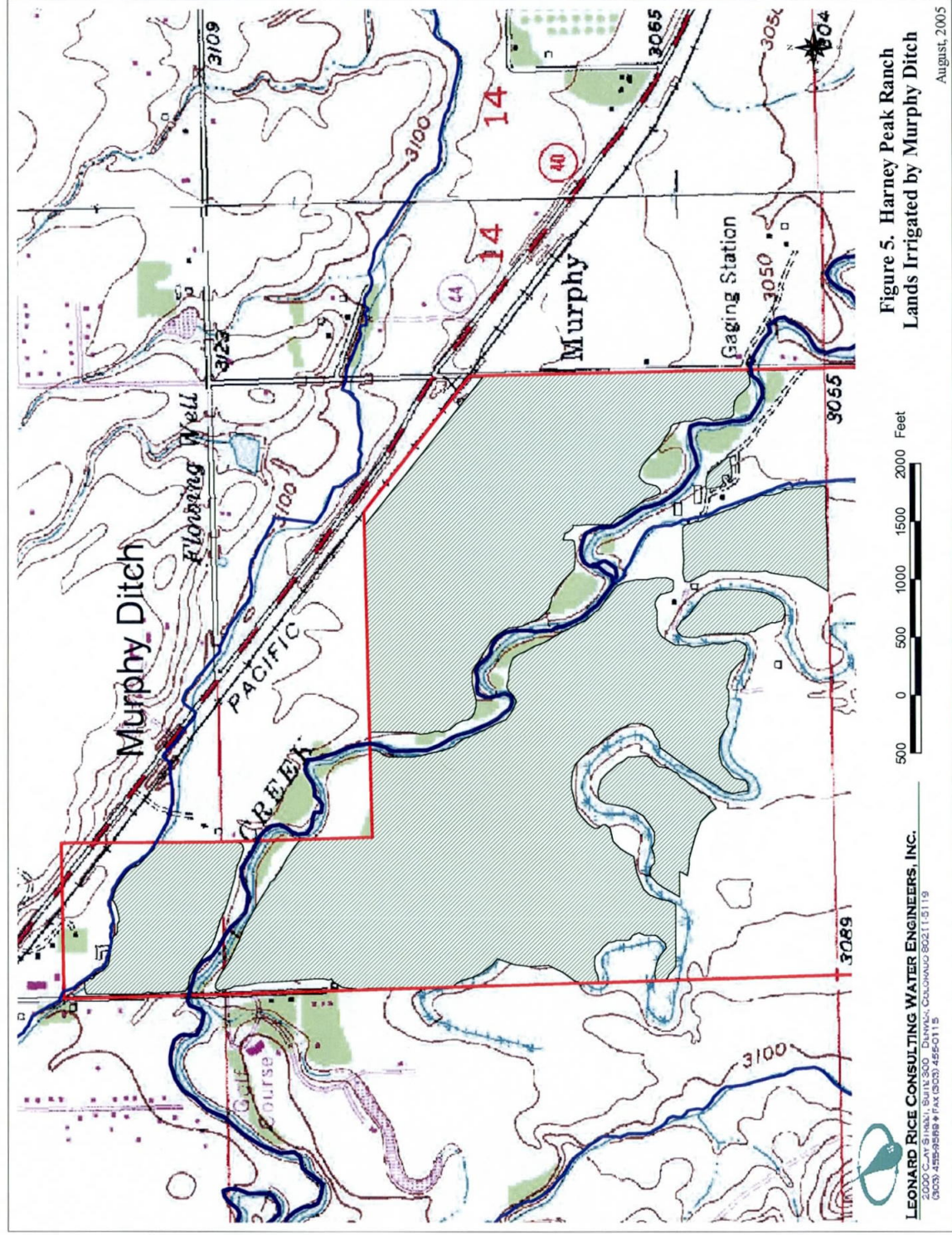
#### III.3.3.1 Irrigated Acreage

Historically irrigated areas on the Harney Peak Ranch were identified and delineated through site visits, an interview with the Ranch owner and operator and other persons familiar with historical farming practices, and review of aerial photographs from 1998. Irrigated areas were digitized using ArcView GIS, and hardcopy maps were produced that showed irrigated fields overlying aerial photographs. These maps were reviewed and boundaries of irrigated fields adjusted where appropriate based on comments from the Ranch owner and operator. Irrigated lands that were identified on the maps were then verified by comparing to locations noted within water right permits. **Figure 4** shows locations on the Ranch of lands irrigated by the Murphy Ditch (lands irrigated by Murphy Ditch are shaded in green; lands irrigated by other sources are shaded in black). **Figure 5** and **Figure 6** show only the lands on the Ranch irrigated by the Murphy Ditch.

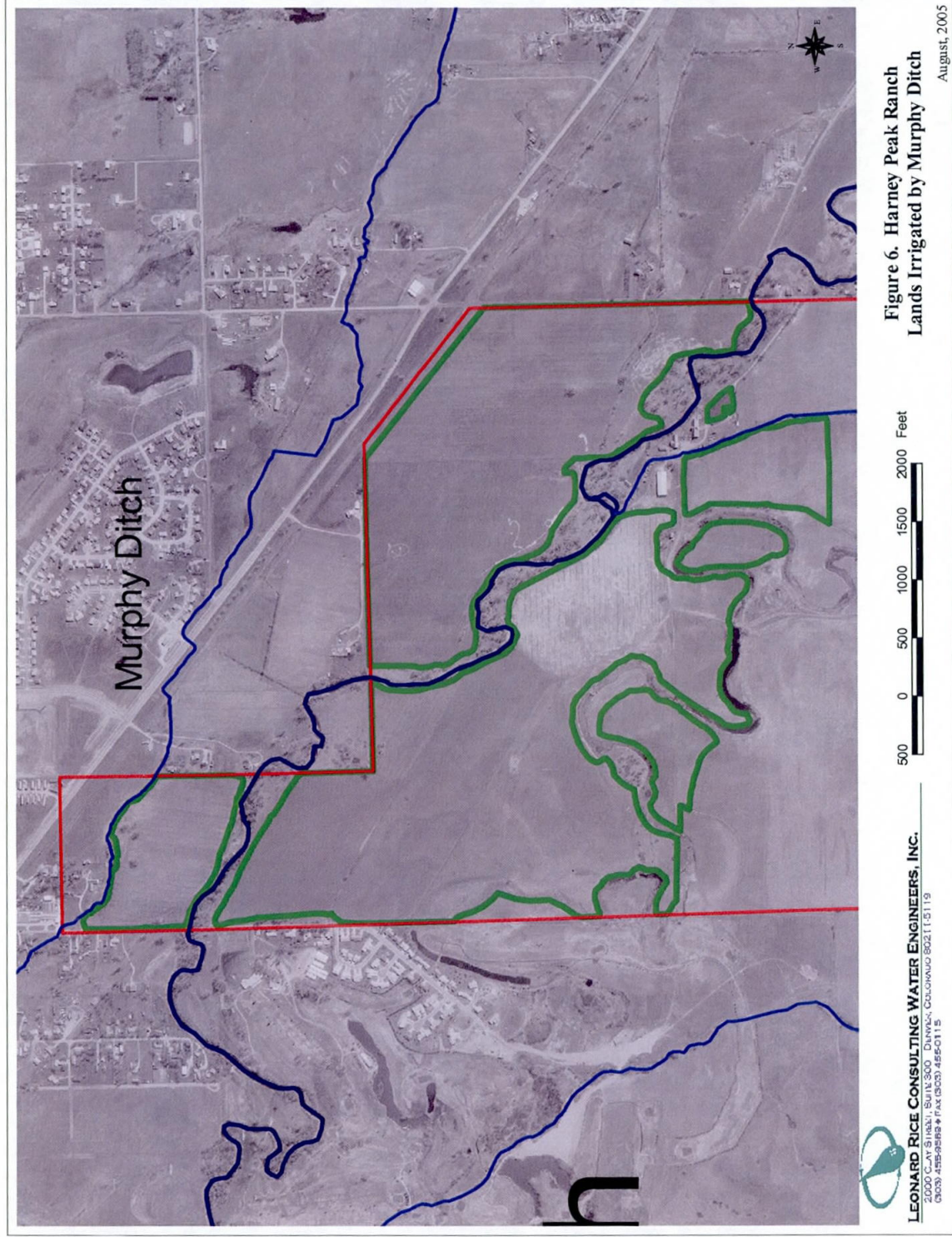












### III.3.3.2 Cropping Patterns

**Table 2** provides a summary of the cropping distribution used in the historical consumptive use analysis. This information was developed through analysis of aerial photographs and our interview with the Ranch operator. Alfalfa historically represented the predominant crop at the Ranch, averaging approximately 70 percent of irrigated lands. Pasture grasses comprise the remaining 30 percent of irrigated lands under the Murphy Ditch within the Ranch.

**Table 2**  
**Crops Irrigated on Ranch with Murphy Ditch**

|         | Alfalfa | Pasture Grass | Total   |
|---------|---------|---------------|---------|
| Acreage | 258 ac. | 110 ac.       | 368 ac. |
| Percent | 70%     | 30%           | 100%    |

### III.3.3.3 Climate Data

Historical climate data from the Rapid City weather station (NOAA Station 6937, Rapid City 4NW) were used in the Modified Blaney-Criddle analysis. **Table 3** presents temperature data at the Rapid City station. **Table 4** presents precipitation data at this same station.

### III.3.3.4 Potential Consumptive Use

**Table 5** summarizes annual potential consumptive use of each crop, as calculated using the Modified Blaney-Criddle methodology (Soil Conservation Service, 1967). In applying the Modified Blaney-Criddle method to develop the potential consumptive use for each crop, the crop growth stage coefficients ( $k_c$ ) were increased by 9.5 percent to reflect effects of elevation and aridity (Hill, et al., 1983; Burman, et al., 1982; Pochop, et al., 1984). **Table 6** shows average potential consumptive use on the Ranch lands irrigated under the Murphy Ditch.

### **III.3.4 Crop Irrigation Water Requirement**

Crop irrigation water requirement is determined by subtracting from potential consumptive use the amount of precipitation that may effectively be used by the crop (a portion of applied irrigation water percolated into the ground below the crop root zone and is unavailable for use by the plant). **Table 6** summarizes that portion of precipitation (volume) which is considered effective. Average crop irrigation water requirements (volume) are also shown in **Table 6**. The calculated historical crop irrigation water requirement averaged 713 acre-feet, or about 1.94 acre-feet per acre.

Detailed results of calculations of potential consumptive use, effective precipitation, and irrigation water requirement are provided in **Appendix D** of this Report.



**Table 3**  
**Average Monthly Temperature (degrees F) –Rapid City Weather Station (No. 6937)**

|         | Jan   | Feb   | Mar   | Apr   | May   | Jun   | Jul   | Aug   | Sep   | Oct   | Nov   | Dec   | Average |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|
| 1950    | 8.95  | 29.84 | 25.03 | 38.00 | 50.44 | 63.87 | 66.89 | 67.66 | 58.41 | 53.73 | 32.03 | 28.47 | 43.61   |
| 1951    | 20.73 | 27.70 | 33.83 | 40.62 | 56.26 | 65.00 | 71.04 | 69.50 | 55.83 | 46.63 | 33.12 | 17.42 | 44.81   |
| 1952    | 22.53 | 26.78 | 25.81 | 50.20 | 56.15 | 69.00 | 71.60 | 72.37 | 67.13 | 50.18 | 34.28 | 30.02 | 48.00   |
| 1953    | 31.26 | 25.73 | 36.65 | 38.33 | 52.53 | 66.77 | 72.44 | 72.47 | 63.13 | 55.84 | 41.70 | 30.37 | 48.94   |
| 1954    | 20.10 | 41.16 | 27.66 | 45.87 | 54.18 | 63.68 | 77.68 | 72.48 | 63.17 | 46.73 | 42.58 | 32.34 | 48.97   |
| 1955    | 23.92 | 19.25 | 28.61 | 49.82 | 59.19 | 62.18 | 76.94 | 76.15 | 62.18 | 51.76 | 24.67 | 21.79 | 46.37   |
| 1956    | 23.03 | 24.09 | 34.05 | 39.08 | 56.74 | 72.83 | 72.03 | 69.45 | 62.97 | 53.39 | 33.13 | 29.82 | 47.55   |
| 1957    | 10.74 | 27.57 | 33.65 | 40.97 | 53.97 | 62.26 | 75.26 | 71.58 | 59.17 | 47.42 | 35.42 | 34.90 | 46.08   |
| 1958    | 31.90 | 21.93 | 30.63 | 43.97 | 61.79 | 62.33 | 67.05 | 74.69 | 63.80 | 52.26 | 37.22 | 27.03 | 47.88   |
| 1959    | 20.61 | 21.71 | 37.90 | 43.32 | 53.71 | 70.05 | 73.76 | 75.66 | 58.82 | 44.45 | 27.87 | 34.19 | 46.84   |
| 1960    | 23.92 | 19.14 | 27.97 | 47.47 | 56.90 | 65.62 | 76.77 | 72.39 | 63.62 | 51.82 | 36.87 | 24.98 | 47.29   |
| 1961    | 27.32 | 33.18 | 39.40 | 41.75 | 55.73 | 71.28 | 73.08 | 77.18 | 55.60 | 49.84 | 34.88 | 22.95 | 48.52   |
| 1962    | 19.32 | 24.14 | 28.56 | 49.05 | 58.26 | 65.27 | 69.19 | 71.11 | 60.23 | 52.87 | 40.60 | 30.08 | 47.39   |
| 1963    | 12.27 | 30.18 | 39.65 | 44.52 | 56.95 | 68.07 | 74.35 | 73.74 | 66.48 | 59.42 | 39.58 | 22.69 | 48.99   |
| 1964    | 28.40 | 28.02 | 29.89 | 46.25 | 58.45 | 64.88 | 76.69 | 69.42 | 59.03 | 51.61 | 33.72 | 18.92 | 47.11   |
| 1965    | 25.42 | 25.61 | 21.19 | 46.97 | 54.66 | 64.48 | 72.13 | 70.66 | 49.73 | 54.74 | 38.15 | 33.29 | 46.42   |
| 1966    | 14.13 | 19.29 | 35.03 | 38.63 | 55.95 | 65.32 | 76.63 | 65.90 | 61.30 | 48.58 | 34.60 | 26.71 | 45.17   |
| 1967    | 27.92 | 27.52 | 35.16 | 44.03 | 49.79 | 59.95 | 70.58 | 70.61 | 63.35 | 50.13 | 34.58 | 22.50 | 46.34   |
| 1968    | 23.35 | 27.41 | 40.39 | 42.58 | 50.82 | 62.98 | 69.13 | 66.97 | 59.77 | 50.98 | 35.45 | 18.47 | 45.69   |
| 1969    | 15.94 | 25.41 | 27.81 | 49.58 | 57.42 | 59.78 | 70.95 | 73.74 | 64.75 | 40.58 | 38.72 | 28.21 | 46.07   |
| 1970    | 17.76 | 30.75 | 27.44 | 39.20 | 55.60 | 65.53 | 72.71 | 73.77 | 59.05 | 44.10 | 34.15 | 21.84 | 45.16   |
| 1971    | 17.52 | 22.59 | 32.61 | 45.97 | 53.61 | 66.32 | 67.98 | 73.84 | 57.40 | 46.06 | 34.50 | 23.26 | 45.14   |
| 1972    | 17.48 | 23.97 | 36.45 | 43.55 | 55.13 | 64.63 | 65.56 | 69.11 | 59.37 | 43.76 | 31.02 | 18.56 | 44.05   |
| 1973    | 26.74 | 28.84 | 37.42 | 42.83 | 53.73 | 64.65 | 70.69 | 74.24 | 57.07 | 51.32 | 32.33 | 25.31 | 47.10   |
| 1974    | 21.92 | 32.41 | 37.63 | 47.12 | 53.79 | 66.62 | 77.29 | 67.63 | 57.60 | 51.66 | 36.40 | 28.90 | 48.25   |
| 1975    | 23.65 | 17.63 | 27.56 | 40.52 | 53.95 | 62.18 | 74.68 | 70.27 | 58.50 | 49.15 | 33.80 | 29.40 | 45.11   |
| 1976    | 23.84 | 34.55 | 34.39 | 46.90 | 55.34 | 64.25 | 72.73 | 72.58 | 63.27 | 45.35 | 31.73 | 26.82 | 47.65   |
| 1977    | 12.68 | 34.54 | 36.40 | 49.48 | 60.23 | 69.00 | 73.35 | 65.97 | 60.97 | 48.81 | 33.27 | 21.84 | 47.21   |
| 1978    | 10.98 | 15.32 | 35.39 | 45.17 | 55.03 | 65.03 | 71.08 | 69.66 | 66.20 | 50.47 | 29.17 | 17.03 | 44.21   |
| 1979    | 7.35  | 16.73 | 35.37 | 44.40 | 53.56 | 65.32 | 70.39 | 68.47 | 66.25 | 50.82 | 32.95 | 33.11 | 45.39   |
| 1980    | 20.98 | 27.03 | 31.45 | 48.85 | 57.37 | 67.03 | 74.89 | 68.53 | 61.58 | 48.82 | 39.23 | 30.23 | 48.00   |
| 1981    | 32.61 | 29.30 | 40.03 | 51.50 | 54.87 | 64.88 | 71.94 | 70.00 | 63.53 | 47.66 | 40.40 | 25.81 | 49.38   |
| 1982    | 12.13 | 24.20 | 32.97 | 42.07 | 53.32 | 59.62 | 70.69 | 70.19 | 58.65 | 47.15 | 32.67 | 28.60 | 44.36   |
| 1983    | 32.11 | 37.25 | 36.35 | 40.65 | 51.95 | 63.08 | 73.65 | 77.95 | 60.75 | 49.39 | 34.87 | 8.06  | 47.17   |
| 1984    | 28.03 | 36.12 | 34.24 | 43.80 | 53.58 | 62.77 | 72.23 | 74.79 | 57.17 | 47.15 | 37.42 | 21.40 | 47.39   |
| 1985    | 21.55 | 23.84 | 35.87 | 51.98 | 61.76 | 62.10 | 74.56 | 69.03 | 55.52 | 47.26 | 16.02 | 20.98 | 45.04   |
| 1986    | 29.81 | 21.48 | 42.98 | 44.15 | 54.92 | 67.63 | 70.84 | 69.63 | 54.92 | 48.74 | 30.60 | 30.53 | 47.19   |
| 1987    | 31.03 | 32.41 | 32.58 | 51.35 | 59.44 | 67.12 | 75.40 | 68.11 | 61.37 | 47.13 | 40.28 | 28.87 | 49.59   |
| 1988    | 21.61 | 26.86 | 35.53 | 47.10 | 59.94 | 75.58 | 76.03 | 72.48 | 60.37 | 49.61 | 36.33 | 28.39 | 49.15   |
| 1989    | 28.66 | 14.38 | 31.06 | 45.77 | 55.32 | 63.97 | 76.97 | 73.08 | 61.03 | 48.79 | 36.43 | 19.39 | 46.24   |
| 1990    | 32.34 | 28.89 | 36.35 | 44.95 | 53.19 | 66.55 | 71.68 | 73.71 | 65.88 | 48.19 | 40.42 | 17.71 | 48.32   |
| 1991    | 18.34 | 35.93 | 38.44 | 46.33 | 56.56 | 67.15 | 72.90 | 73.98 | 61.13 | 46.42 | 29.95 | 32.66 | 48.32   |
| 1992    | 33.61 | 36.29 | 40.84 | 47.10 | 57.44 | 62.57 | 64.26 | 65.84 | 62.55 | 49.21 | 32.37 | 19.02 | 47.59   |
| 1993    | 16.00 | 15.14 | 37.56 | 43.53 | 56.13 | 60.33 | 65.06 | 68.58 | 56.60 | 48.23 | 32.38 | 31.42 | 44.25   |
| 1994    | 22.42 | 19.80 | 40.45 | 45.97 | 60.16 | 68.48 | 70.69 | 73.31 | 65.43 | 49.69 | 35.53 | 30.26 | 48.52   |
| 1995    | 29.16 | 31.82 | 33.15 | 40.30 | 51.76 | 62.83 | 70.60 | 73.58 | 60.02 | 46.48 | 33.67 | 25.40 | 46.56   |
| 1996    | 14.87 | 27.34 | 26.19 | 43.27 | 50.53 | 65.45 | 70.81 | 73.18 | 59.75 | 47.70 | 24.25 | 17.87 | 43.43   |
| 1997    | 18.10 | 28.79 | 36.65 | 38.67 | 52.82 | 66.25 | 70.90 | 68.71 | 62.50 | 48.58 | 33.15 | 30.31 | 46.29   |
| 1998    | 24.29 | 34.86 | 27.94 | 46.18 | 56.16 | 58.70 | 72.66 | 72.26 | 67.02 | 47.81 | 36.43 | 26.76 | 47.59   |
| 1999    | 25.60 | 36.61 | 36.27 | 42.60 | 52.97 | 62.58 | 71.29 | 71.42 | 55.62 | 49.87 | 41.70 | 33.30 | 48.32   |
| 2000    | 26.15 | 33.19 | 38.63 | 43.03 | 56.00 | 62.10 | 73.55 | 74.40 | 63.35 | 49.82 | 27.02 | 16.68 | 46.99   |
| 2001    | 29.73 | 16.91 | 34.34 | 45.98 | 56.15 | 64.05 | 74.76 | 74.40 | 62.50 | 47.84 | 39.41 | 28.89 | 47.91   |
| 2002    | 27.34 | 31.06 | 23.10 | 45.42 | 53.07 | 70.95 | 79.53 | 72.61 | 62.99 | 40.15 | 36.95 | 30.96 | 47.85   |
| 2003    | 26.20 | 22.58 | 35.81 | 48.84 | 55.97 | 63.20 | 78.19 | 77.57 | 60.41 | 52.76 | 28.79 | 29.41 | 48.31   |
| 2004    | 22.07 | 27.75 | 40.57 | 49.04 | 57.52 | 63.30 | 73.64 | 68.58 | 63.10 | 50.18 | 37.16 | 31.27 | 48.68   |
| Average | 22.48 | 26.96 | 33.80 | 44.81 | 55.43 | 65.04 | 72.52 | 71.55 | 60.87 | 49.07 | 34.40 | 25.92 | 46.90   |

**Table 4**  
**Total Monthly Precipitation (inches) – Rapid City Weather Station (No. 6937)**

|         | Jan  | Feb  | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  | Total |
|---------|------|------|------|------|------|------|------|------|------|------|------|------|-------|
| 1950    | 0.25 | 0.06 | 2.66 | 1.63 | 2.43 | 0.90 | 1.62 | 2.74 | 2.79 | 0.40 | 0.35 | 0.04 | 15.87 |
| 1951    | 0.12 | 0.10 | 1.02 | 0.51 | 1.87 | 3.00 | 1.61 | 2.92 | 1.46 | 0.88 | 0.21 | 0.53 | 14.23 |
| 1952    | 0.01 | 0.65 | 0.81 | 0.32 | 3.75 | 3.04 | 1.51 | 0.70 | 0.21 | 0.01 | 0.15 | 0.08 | 11.24 |
| 1953    | 0.75 | 2.46 | 0.66 | 2.76 | 1.68 | 4.05 | 1.32 | 0.94 | 0.37 | 0.23 | 0.84 | 0.18 | 16.24 |
| 1954    | 0.18 | 0.34 | 2.28 | 0.27 | 2.68 | 3.18 | 1.24 | 2.11 | 0.20 | 1.92 | 0.64 | 0.25 | 15.29 |
| 1955    | 0.46 | 0.88 | 0.63 | 1.55 | 1.70 | 2.14 | 2.14 | 1.65 | 3.08 | 0.26 | 0.36 | 0.68 | 15.53 |
| 1956    | 0.47 | 0.52 | 0.75 | 1.69 | 2.09 | 1.32 | 2.27 | 3.15 | 0.30 | 0.10 | 1.48 | 0.36 | 14.50 |
| 1957    | 0.40 | 0.29 | 0.66 | 2.06 | 7.05 | 3.43 | 2.01 | 1.03 | 0.69 | 1.29 | 0.39 | 0.04 | 19.34 |
| 1958    | 0.43 | 0.84 | 1.08 | 3.03 | 1.04 | 3.86 | 4.49 | 0.26 | 0.03 | 0.22 | 0.42 | 0.37 | 16.07 |
| 1959    | 0.39 | 0.63 | 0.60 | 1.89 | 3.25 | 2.79 | 0.67 | 0.36 | 2.37 | 0.22 | 1.18 | 0.26 | 14.61 |
| 1960    | 0.16 | 0.85 | 0.78 | 1.21 | 2.23 | 2.19 | 0.70 | 1.24 | 0.68 | 0.00 | 0.39 | 0.80 | 11.23 |
| 1961    | 0.10 | 0.22 | 0.75 | 1.53 | 1.29 | 0.76 | 2.11 | 0.43 | 0.98 | 0.94 | 0.36 | 0.51 | 9.98  |
| 1962    | 0.51 | 0.98 | 1.28 | 0.69 | 6.90 | 4.01 | 4.53 | 1.03 | 0.67 | 1.63 | 0.08 | 0.19 | 22.50 |
| 1963    | 1.03 | 0.92 | 1.60 | 3.80 | 1.18 | 5.47 | 2.03 | 1.32 | 1.21 | 0.77 | 0.12 | 0.32 | 19.77 |
| 1964    | 0.35 | 0.83 | 0.63 | 1.24 | 2.52 | 4.69 | 0.77 | 1.87 | 0.69 | 0.50 | 0.30 | 0.78 | 15.17 |
| 1965    | 0.61 | 0.22 | 0.46 | 1.50 | 6.97 | 3.56 | 0.60 | 1.46 | 1.46 | 0.57 | 0.15 | 0.12 | 17.68 |
| 1966    | 0.24 | 1.00 | 1.78 | 2.50 | 0.33 | 1.31 | 3.93 | 3.24 | 2.84 | 1.50 | 0.95 | 0.79 | 20.41 |
| 1967    | 0.47 | 0.59 | 0.82 | 5.16 | 3.20 | 6.78 | 1.07 | 0.95 | 2.10 | 0.28 | 0.28 | 0.89 | 22.59 |
| 1968    | 0.43 | 0.35 | 0.21 | 1.82 | 1.68 | 7.00 | 2.44 | 2.46 | 0.89 | 0.14 | 0.46 | 0.58 | 18.46 |
| 1969    | 0.11 | 0.73 | 0.66 | 1.60 | 2.20 | 2.04 | 6.13 | 0.31 | 0.35 | 0.85 | 0.35 | 0.57 | 15.90 |
| 1970    | 0.73 | 0.54 | 1.48 | 4.63 | 2.41 | 2.16 | 1.04 | 0.67 | 1.57 | 1.23 | 0.80 | 0.61 | 17.87 |
| 1971    | 1.18 | 1.00 | 1.25 | 2.86 | 3.70 | 1.92 | 1.46 | 0.52 | 2.32 | 2.02 | 0.79 | 0.15 | 19.17 |
| 1972    | 0.22 | 0.44 | 0.47 | 2.78 | 3.28 | 4.11 | 1.67 | 2.49 | 0.24 | 0.77 | 0.38 | 0.34 | 17.19 |
| 1973    | 0.11 | 0.31 | 2.71 | 2.69 | 2.37 | 0.64 | 1.46 | 0.74 | 1.44 | 1.38 | 0.73 | 0.54 | 15.12 |
| 1974    | 0.16 | 0.30 | 0.34 | 1.55 | 1.32 | 1.10 | 0.68 | 1.37 | 0.88 | 1.18 | 0.12 | 0.12 | 9.12  |
| 1975    | 1.05 | 0.35 | 2.45 | 1.37 | 1.23 | 5.63 | 1.57 | 0.87 | 0.03 | 0.69 | 0.57 | 1.65 | 17.46 |
| 1976    | 0.28 | 0.47 | 0.33 | 2.70 | 2.74 | 4.81 | 1.05 | 1.31 | 0.28 | 0.21 | 0.61 | 0.41 | 15.20 |
| 1977    | 0.83 | 0.25 | 2.63 | 1.57 | 2.49 | 1.76 | 2.98 | 1.79 | 2.86 | 1.06 | 0.82 | 0.36 | 19.40 |
| 1978    | 0.19 | 0.84 | 0.40 | 2.19 | 3.12 | 2.01 | 4.08 | 1.42 | 0.18 | 0.26 | 0.63 | 0.25 | 15.57 |
| 1979    | 0.49 | 0.33 | 0.47 | 0.31 | 1.17 | 3.60 | 4.11 | 2.32 | 0.07 | 0.90 | 0.15 | 0.07 | 13.99 |
| 1980    | 0.20 | 0.51 | 0.86 | 1.13 | 1.58 | 4.75 | 1.78 | 2.38 | 0.48 | 2.28 | 0.57 | 0.66 | 17.18 |
| 1981    | 0.14 | 0.09 | 0.12 | 0.32 | 2.81 | 1.89 | 4.47 | 1.74 | 0.16 | 1.81 | 0.23 | 0.35 | 14.13 |
| 1982    | 0.39 | 0.37 | 1.35 | 0.69 | 6.50 | 2.89 | 1.81 | 4.83 | 2.69 | 3.82 | 0.27 | 0.36 | 25.97 |
| 1983    | 0.34 | 0.18 | 0.84 | 1.00 | 2.18 | 3.01 | 1.94 | 2.39 | 0.33 | 1.74 | 1.07 | 0.47 | 15.49 |
| 1984    | 0.10 | 0.18 | 0.69 | 3.10 | 1.57 | 4.72 | 1.57 | 1.00 | 0.74 | 0.67 | 0.51 | 0.38 | 15.23 |
| 1985    | 0.46 | 0.06 | 1.55 | 0.32 | 1.24 | 1.58 | 1.03 | 1.86 | 1.57 | 0.98 | 2.22 | 0.77 | 13.64 |
| 1986    | 0.49 | 0.92 | 0.88 | 4.74 | 1.43 | 4.56 | 0.91 | 1.32 | 3.14 | 1.64 | 1.40 | 0.01 | 21.44 |
| 1987    | 0.04 | 1.71 | 1.14 | 0.02 | 3.39 | 1.37 | 0.83 | 2.37 | 0.68 | 0.26 | 0.30 | 0.31 | 12.42 |
| 1988    | 0.17 | 0.34 | 0.52 | 0.60 | 3.25 | 1.09 | 0.38 | 1.98 | 0.56 | 0.76 | 0.81 | 0.46 | 10.92 |
| 1989    | 0.02 | 0.34 | 0.96 | 1.46 | 1.40 | 1.04 | 0.82 | 1.70 | 3.09 | 1.49 | 0.43 | 0.82 | 13.57 |
| 1990    | 0.22 | 0.37 | 1.17 | 0.77 | 4.87 | 1.42 | 1.94 | 1.87 | 2.44 | 0.61 | 0.44 | 0.33 | 16.45 |
| 1991    | 0.32 | 0.77 | 0.63 | 2.99 | 4.40 | 3.27 | 1.97 | 0.58 | 0.59 | 1.00 | 0.73 | 0.04 | 17.29 |
| 1992    | 0.29 | 0.16 | 1.92 | 0.71 | 2.47 | 2.17 | 3.25 | 0.47 | 0.42 | 0.68 | 0.39 | 0.57 | 13.50 |
| 1993    | 0.68 | 0.61 | 0.82 | 3.05 | 2.16 | 3.39 | 4.31 | 1.18 | 1.46 | 0.90 | 0.70 | 0.53 | 19.79 |
| 1994    | 0.45 | 0.66 | 0.37 | 1.20 | 1.47 | 0.67 | 0.64 | 0.92 | 0.27 | 2.84 | 0.66 | 0.35 | 10.50 |
| 1995    | 0.09 | 0.55 | 0.79 | 2.57 | 4.03 | 4.50 | 2.87 | 0.46 | 0.86 | 2.42 | 0.42 | 0.13 | 19.69 |
| 1996    | 0.85 | 0.10 | 1.06 | 1.63 | 8.18 | 1.24 | 0.52 | 1.85 | 1.55 | 1.07 | 0.07 | 1.25 | 19.37 |
| 1997    | 0.65 | 0.28 | 0.20 | 4.80 | 5.35 | 3.43 | 3.67 | 3.93 | 0.78 | 0.47 | 0.19 | 0.08 | 23.83 |
| 1998    | 0.15 | 1.24 | 1.32 | 0.28 | 2.34 | 5.59 | 1.26 | 1.42 | 1.50 | 5.60 | 1.13 | 0.06 | 21.89 |
| 1999    | 0.21 | 0.02 | 1.32 | 2.45 | 3.74 | 5.24 | 3.68 | 0.47 | 0.85 | 0.11 | 0.43 | 0.21 | 18.73 |
| 2000    | 0.23 | 0.15 | 1.37 | 3.95 | 2.40 | 1.60 | 2.06 | 0.70 | 0.45 | 1.54 | 0.47 | 0.11 | 15.03 |
| 2001    | 0.24 | 0.17 | 0.42 | 2.16 | 1.73 | 3.57 | 2.46 | 1.59 | 0.91 | 0.97 | 0.07 | 0.00 | 14.29 |
| 2002    | 0.34 | 0.41 | 1.43 | 1.59 | 2.10 | 0.82 | 1.05 | 1.90 | 2.67 | 1.00 | 0.32 | 0.35 | 13.98 |
| 2003    | 0.66 | 0.74 | 1.57 | 2.34 | 2.28 | 2.77 | 1.01 | 1.00 | 1.47 | 0.81 | 0.94 | 0.49 | 16.09 |
| 2004    | 0.48 | 0.76 | 1.07 | 0.78 | 2.10 | 1.41 | 2.45 | 1.36 | 2.90 | 1.64 | 0.47 | 0.27 | 15.68 |
| Average | 0.38 | 0.55 | 1.04 | 1.89 | 2.82 | 2.93 | 2.04 | 1.54 | 1.20 | 1.08 | 0.55 | 0.40 | 16.41 |

**Table 5**  
**Average Potential Consumptive Use for Crops Grown**  
**on Harney Peak Ranch under Murphy Ditch (1950-2004)**

|                         | <b>Irrigated<br/>Acreage</b> | <b>Percent of<br/>Total</b> | <b>Potential CU<br/>(acre-ft/ac)</b> |
|-------------------------|------------------------------|-----------------------------|--------------------------------------|
| <b>Alfalfa</b>          | 258                          | 70                          | 2.74                                 |
| <b>Pasture Grass</b>    | 110                          | 30                          | 2.40                                 |
| <b>Weighted Average</b> | 368                          |                             | 2.64                                 |

**Table 6**  
**Summary of Potential Crop Consumptive Use and**  
**Irrigation Water Requirement (acre-feet)**  
**(Average over the Period 1950 – 2004)**

|                                     | <b>Jan</b> | <b>Feb</b> | <b>Mar</b> | <b>Apr</b> | <b>May</b> | <b>Jun</b> | <b>Jul</b> | <b>Aug</b> | <b>Sep</b> | <b>Oct</b> | <b>Nov</b> | <b>Dec</b> | <b>Total</b> |
|-------------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|--------------|
| <b>Potential Consumptive Use</b>    | 0          | 0          | 0          | 20         | 122        | 197        | 254        | 219        | 121        | 39         | 0          | 0          | 972          |
| <b>Effective Precipitation</b>      | 0          | 0          | 0          | 7          | 54         | 68         | 54         | 40         | 26         | 11         | 0          | 0          | 260          |
| <b>Irrigation Water Requirement</b> | 0          | 0          | 0          | 13         | 68         | 129        | 200        | 179        | 96         | 28         | 0          | 0          | 713          |

### **III.3.5 Murphy Ditch Water Supply to Harney Peak Ranch**

This Section of the Engineering Report summarizes an analysis of historical diversion records for the Murphy Ditch, discusses problems with historical diversion data, summarizes discussions with several water users and water managers familiar with ditch operations, examines upstream hydrologic conditions, and describes adjustments that were made to provide better estimates of historical water supplies to the Harney Peak Ranch.

#### **III.3.5.1 Historical Diversion Records**

The amount of water diverted by ditches from Rapid Creek has periodically been recorded over time by the State, the Conservancy District, the Bureau of Reclamation and possibly others. The purpose of measuring diversion amounts has been twofold: to assist the State in administration of natural flows in Rapid Creek according to the prior appropriation system, and to assist the State,

Conservancy District, and Bureau of Reclamation in management and operation Pactola Reservoir and storage water releases that provide supplemental water supplies to Conservancy District members.

Strict water rights administration of natural flows on Rapid Creek according to the prior appropriation system on Rapid Creek has not historically occurred. This has largely been due to the high level of historical cooperation among ditches and to some degree, the ability for many water right owners to receive contracted storage water. As opposed to many circumstances in an over appropriated stream system, water users on Rapid Creek have historically been willing to share in times of shortages. Contracted storage releases have further eased the situation in times of reduced natural flow levels.

The intra- and inter-ditch cooperation has allowed considerable flexibility in use of limited supplies from Rapid Creek for irrigation. This resulted in a reduced need for measurement of diversion amounts. It is our opinion this is reflected in the diversion records by a lack of information for many past years. Furthermore, we believe that when available, the records are of questionable accuracy. It is our opinion that historical records must be carefully viewed as an approximation of the actual supply realized from the water rights, and if necessary, adjustments should be made to develop better estimates of actual irrigation water supplies.

Monthly diversion records were obtained for the Murphy Ditch from previous engineering reports that addressed water right transfers from other properties and from several documents developed by the U.S. Bureau of Reclamation in relation to operation of Pactola Reservoir. These records generally cover the period from 1946 through about 1994, although there are several years during this period when data are not available. It should be noted that transfers by Rapid City of portions of the Murphy Ditch water right also affect the amount of water carried by and recorded for the Ditch starting in the early 1990s.

Records of historical monthly diversions by the Murphy Ditch are presented in **Table 7**. As shown, historical diversions for the Murphy Ditch averaged approximately 2,951 acre-feet per year from 1946 through 1988 (prior to the Rapid City transfers).



**Table 7**  
**Historical Diversions Records for Murphy Ditch (acre-feet)**

| YEAR      | APR | MAY | JUN  | JUL  | AUG  | SEP  | OCT | ANNUAL |
|-----------|-----|-----|------|------|------|------|-----|--------|
| 1946      |     |     |      |      | 994  | 614  | 404 |        |
| 1947      |     | 421 | 547  | 517  | 730  | 1560 | 687 |        |
| 1948      | 6   | 513 | 522  | 348  | 999  | 826  | 654 |        |
| 1949      |     | 185 | 480  | 425  | 1130 | 876  | 220 |        |
| 1950      |     | 34  | 1020 | 1150 | 798  | 673  | 300 |        |
| 1951      | 314 | 902 | 470  | 297  | 803  | 84   | 51  |        |
| 1952      | 101 | 998 | 393  | 555  | 1140 | 660  | 1   |        |
| 1953      |     |     | 236  | 888  | 1030 | 1100 |     |        |
| 1954      |     |     | 477  | 960  | 904  | 770  |     |        |
| 1955      |     |     |      |      |      |      |     |        |
| 1956      |     | 322 | 858  | 720  | 450  | 376  |     |        |
| 1957      |     | 126 | 0    | 206  | 716  | 334  |     |        |
| 1958      |     | 686 | 648  | 438  | 542  | 558  |     |        |
| 1959      |     | 620 | 450  | 614  | 778  | 436  |     |        |
| 1960      |     |     |      |      |      |      |     |        |
| 1961      |     |     |      |      |      |      |     |        |
| 1962      |     |     |      |      |      |      |     |        |
| 1963      |     | 298 | 288  | 768  | 718  | 240  |     |        |
| 1964      |     | 378 | 135  | 516  | 814  | 360  |     |        |
| 1965      |     | 171 | 250  | 510  | 796  | 630  |     |        |
| 1966      |     | 282 | 588  | 686  | 214  | 120  |     |        |
| 1967      |     | 40  | 0    | 147  | 304  | 120  |     |        |
| 1968      |     | 210 | 96   | 242  | 606  | 130  |     |        |
| 1969      |     |     |      |      |      |      |     |        |
| 1970      |     |     | 229  | 294  | 307  | 93   |     |        |
| 1971      |     | 180 | 230  | 294  | 306  | 116  |     |        |
| 1972      |     | 176 | 60   | 52   | 600  | 215  |     |        |
| 1973      |     | 96  | 310  | 552  | 510  | 240  |     |        |
| 1974      |     | 744 | 900  | 960  | 904  | 752  |     |        |
| 1975      |     | 366 | 98   | 520  | 968  | 960  |     |        |
| 1976      |     | 328 | 392  | 440  | 620  | 608  |     |        |
| 1977      |     | 196 | 514  | 592  | 668  | 342  |     |        |
| 1978      |     | 30  | 180  | 440  | 460  | 632  |     |        |
| 1979      |     | 328 | 708  | 498  | 368  | 460  |     |        |
| 1980      |     | 430 | 600  | 820  | 520  | 300  |     |        |
| 1981      |     |     |      |      |      |      |     |        |
| 1982      |     |     |      |      |      |      |     |        |
| 1983      |     |     |      |      |      |      |     |        |
| 1984      |     | 220 | 110  | 580  | 636  | 600  |     |        |
| 1985      |     | 640 | 240  | 520  | 480  |      |     |        |
| 1986      |     |     |      |      |      |      |     |        |
| 1987      |     |     |      |      |      |      |     |        |
| 1988      |     |     |      |      |      |      |     |        |
| 1989      |     | 550 | 600  | 540  | 480  | 400  |     |        |
| 1990      |     |     |      |      |      |      |     |        |
| 1991      |     |     |      |      |      |      |     |        |
| 1992      |     |     |      |      |      |      |     |        |
| 1993      |     |     |      |      |      |      |     |        |
| 1994      |     | 220 | 540  | 550  | 600  | 280  |     |        |
| Avg 46-88 | 140 | 348 | 403  | 533  | 690  | 506  | 331 | 2951   |

Notes 1946-1950 "USDI Definite Plan Report - Rapid Valley Unit" Bureau of Reclamation  
 1951-1952 "WRIR 97-4288 - Streamflow Characteristics for Black Hills of South Dakota" Lisa Miller and Daniel Driscoll, USGS, 1993, Section B  
 1953-1985 "Status of Water Use on Rapid Creek" John Hamak, DWNr, SD, December, 1980, App. IV  
 1986-2004 Water Master Letter to Bruce Laymon (Bureau of Reclamation)  
 No data available

**Table 8** shows the average daily diversion rate for each month of the irrigation season implied from the volumetric amounts shown in **Table 7**. The bottom of **Table 8** shows the average daily diversion rate for each month as a percentage of the senior water right in the ditch (17.0 cfs). Records indicate



average daily diversion rates during the irrigation season ranged from a low of 2.36 cfs in the month of April to a high of only 10.95 cfs during the month of August. The data suggest there are very few instances when the ditch diverted the full amount of its senior right, i.e., 17.0 cfs.

**Table 8**  
**Historical Diversions Records for Murphy Ditch (cfs)**

| YEAR        | APR  | MAY   | JUN   | JUL   | AUG   | SEP   | OCT   | ANNUAL |
|-------------|------|-------|-------|-------|-------|-------|-------|--------|
| 1946        |      |       |       |       | 16.17 | 10.32 | 6.57  |        |
| 1947        |      | 6.85  | 9.19  | 8.41  | 11.87 | 26.22 | 11.17 |        |
| 1948        | 0.10 | 8.34  | 8.77  | 5.66  | 16.25 | 13.88 | 10.64 |        |
| 1949        |      | 3.01  | 8.07  | 6.91  | 18.38 | 14.72 | 3.58  |        |
| 1950        |      | 0.55  | 17.14 | 18.70 | 12.98 | 11.31 | 4.88  |        |
| 1951        | 5.28 | 14.67 | 7.90  | 4.83  | 13.06 | 1.41  | 0.83  |        |
| 1952        | 1.70 | 16.23 | 6.60  | 9.03  | 18.54 | 11.09 | 0.02  |        |
| 1953        |      |       | 3.97  | 14.44 | 16.75 | 18.49 |       |        |
| 1954        |      |       | 8.02  | 15.61 | 14.70 | 12.94 |       |        |
| 1955        |      |       |       |       |       |       |       |        |
| 1956        |      | 5.24  | 14.42 | 11.71 | 7.32  | 6.32  |       |        |
| 1957        |      | 2.05  | 0.00  | 3.35  | 11.64 | 5.61  |       |        |
| 1958        |      | 11.16 | 10.89 | 7.12  | 8.81  | 9.38  |       |        |
| 1959        |      | 10.08 | 7.56  | 9.99  | 12.65 | 7.33  |       |        |
| 1960        |      |       |       |       |       |       |       |        |
| 1961        |      |       |       |       |       |       |       |        |
| 1962        |      |       |       |       |       |       |       |        |
| 1963        |      | 4.85  | 4.84  | 12.49 | 11.68 | 4.03  |       |        |
| 1964        |      | 6.15  | 2.27  | 8.39  | 13.24 | 6.05  |       |        |
| 1965        |      | 2.78  | 4.20  | 8.29  | 12.95 | 10.59 |       |        |
| 1966        |      | 4.59  | 9.88  | 11.16 | 3.48  | 2.02  |       |        |
| 1967        |      | 0.65  | 0.00  | 2.39  | 4.94  | 2.02  |       |        |
| 1968        |      | 3.42  | 1.61  | 3.94  | 9.86  | 2.18  |       |        |
| 1969        |      |       |       |       |       |       |       |        |
| 1970        |      |       | 3.85  | 4.78  | 4.99  | 1.56  |       |        |
| 1971        |      | 2.93  | 3.87  | 4.78  | 4.98  | 1.95  |       |        |
| 1972        |      | 2.86  | 1.01  | 0.85  | 9.76  | 3.61  |       |        |
| 1973        |      | 1.56  | 5.21  | 8.98  | 8.29  | 4.03  |       |        |
| 1974        |      | 12.10 | 15.12 | 15.61 | 14.70 | 12.64 |       |        |
| 1975        |      | 5.95  | 1.65  | 8.46  | 15.74 | 16.13 |       |        |
| 1976        |      | 5.33  | 6.59  | 7.16  | 10.08 | 10.22 |       |        |
| 1977        |      | 3.19  | 8.64  | 9.63  | 10.86 | 5.75  |       |        |
| 1978        |      | 0.49  | 3.02  | 7.16  | 7.48  | 10.62 |       |        |
| 1979        |      | 5.33  | 11.90 | 8.10  | 5.98  | 7.73  |       |        |
| 1980        |      | 6.99  | 10.08 | 13.34 | 8.46  | 5.04  |       |        |
| 1981        |      |       |       |       |       |       |       |        |
| 1982        |      |       |       |       |       |       |       |        |
| 1983        |      |       |       |       |       |       |       |        |
| 1984        |      | 3.58  | 1.85  | 9.43  | 10.34 | 10.08 |       |        |
| 1985        |      | 10.41 | 4.03  | 8.46  | 7.81  | 0.00  |       |        |
| 1986        |      |       |       |       |       |       |       |        |
| 1987        |      |       |       |       |       |       |       |        |
| 1988        |      |       |       |       |       |       |       |        |
| 1989        |      | 8.94  | 10.08 | 8.78  | 7.81  | 6.72  |       |        |
| 1990        |      |       |       |       |       |       |       |        |
| 1991        |      |       |       |       |       |       |       |        |
| 1992        |      |       |       |       |       |       |       |        |
| 1993        |      |       |       |       |       |       |       |        |
| 1994        |      | 3.58  | 9.07  | 8.94  | 9.76  | 4.71  |       |        |
| Average     | 2.36 | 5.80  | 6.71  | 8.69  | 10.95 | 8.38  | 5.38  | 6.90   |
| % Full 17.0 | 14%  | 34%   | 39%   | 51%   | 64%   | 49%   | 32%   | 41%    |

Notes 1946-1950 "USDI Definite Plan Report - Rapid Valley Unit" Bureau of Reclamation  
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 1953-1985 "Status of Water Use on Rapid Creek" John Hamak, DWNr, SD, December, 1980, App. IV  
 1986-2004 Water Master Letter to Bruce Laymon (Bureau of Reclamation)  
 No data available

### III.3.5.2 Discussions with Water Users and Water Managers

To further investigate the issue of historical diversions by the Murphy Ditch, we have had discussions with several people very familiar with operations of the Murphy Ditch, including Mr. Steve Murphy (Ditch Rider and 6<sup>th</sup> generation property owner/farmer under the Murphy Ditch), Mr. David Lamb (owner of Harney Peak Ranch), Mr. Duane Scott (former Rapid Creek Water Master), and Mr. Kevin Hamm (current Rapid Creek Water Master). We have also contacted the Bureau of Reclamation and discussed operations and accounting associated with Pactola Reservoir with Mr. Curt Anderson.

Mr. Murphy, who is responsible for ditch maintenance and helping with water deliveries to individual farms under the ditch, indicated that the Murphy Ditch, despite the diversion records shown in **Tables 6 and 7** typically diverts its full senior priority amount of 17.0 cfs during most of the irrigation season. At times Mr. Murphy has reduced diversions from Rapid Creek if there is substantial drainage water entering the ditch below the headgate, although this is reportedly uncommon. Mr. Murphy stated his belief that the ditch historically and regularly ran bank full during most of the irrigation season, and historically carried its full permit amount (17.0 cfs) 95 percent of the time. In more recent years, this has been reduced because of the Rapid City transfers.

Mr. Dave Lamb also reported that the Ranch water deliveries from the Murphy Ditch are very consistent with pro-rata interest in the full 17.0 cfs water right: the Ranch is entitled to receive approximately 5.5 cfs of delivery out of the 17.0 cfs senior water right, and that 5.5 cfs is typically delivered to the Ranch during irrigation months (**Appendix C**). Mr. Lamb also noted that he would not be able to achieve his reported high alfalfa and pasture crop yields without receiving his full pro-rata entitlement under the Murphy Ditch. Mr. Murphy confirmed that irrigation on the Harney Peak Ranch is the most intensive use of Murphy Ditch water and occurs very regularly throughout the irrigation season. Mr. Murphy also confirmed that water deliveries to the Ranch are regularly about 5.0 cfs throughout the irrigation season.

Both Mr. Murphy and Mr. Lamb confirmed that measurements of the ditch are not made every day and they expressed doubt with regard to the accuracy of the historical records. Mr. Murphy believed

that the amount of water that the Murphy Ditch was historically entitled to divert was never less than 17.0 cfs unless natural flows above Pactola Reservoir were very low, perhaps 3 to 4 cfs (natural inflows to Pactola Reservoir are discussed below). Mr. Murphy stated that more recent operations of the Ditch involve receiving computations of natural flows conditions on Rapid Creek above Pactola Reservoir from either the Bureau of Reclamation or Rapid City. This information has apparently been provided to Mr. Murphy each Monday, and determines the allowable diversion rate through the Murphy Ditch for the following week.

Mr. Scott stated that he believes the Murphy Ditch historically diverted an average of approximately 12 cfs between April and November of each year. This estimate includes lower diversion rates during the early (April) part of the irrigation season and in the early fall months.

Mr. Hamm, who became Water Master on Rapid Creek this past year, told us the Murphy Ditch was recently shut down due to low computed natural flows (August, 2005). He also provided information indicating the Murphy Ditch diversions during the 2005 irrigation season have averaged approximately 7.0 cfs. Although 2005 has been a relatively dry year, the Murphy Ditch has been able to divert roughly 53.8% of the remainder of the 1878 Murphy Ditch water right priority (approximately 4.0 cfs has been transferred to Rapid City).

#### **III.3.5.3 Upstream Hydrology**

It is our understanding from discussions with Mr. Curt Anderson (Bureau of Reclamation) and Mr. Murphy that a computation of natural inflows above Pactola Reservoir in large part determines the supply that will be available for diversion at the Murphy Ditch. This computation includes consideration of inflows from tributaries and flow regulation and evaporation resulting from upstream storage (**Appendix E**). Mr. Anderson provided copies of spreadsheet computations for several recent dry years. While the computations are not made for the entire irrigation season, during drier periods it appears that computed natural flows occasionally may drop below 5 cfs during the mid-summer months. This suggests the Murphy Ditch may be shut down during these periods, although these computations do not account for potential gains below Pactola from natural drainage and irrigation return flows.



We have reviewed several studies conducted by the U.S. Geological Survey and others that characterize the flow regime of Rapid Creek from its headwaters to the confluence with Cheyenne River. Several of these studies examined the issue of gains and losses along Rapid Creek as it flows from the canyon below Pactola Reservoir, through Rapid City, and across agricultural areas.

We have also reviewed stream gage records of the U.S. Geological Survey for several measurement points along Rapid Creek (**Figure 7**). **Appendix F** summarizes percentile flows for seven of these gages. It should be noted that all of these gages reflect some level of upstream regulation and water use, including releases of contract water from Deerfield and/or Pactola Reservoirs. The upper-most of these gages, located above Pactola Reservoir, is one of the monitoring points used in calculations of natural flow conditions below Pactola Reservoir.

#### **III.3.5.4 Adjustments and Summary of Water Supply for Historical Use Analysis**

Historical diversion records for the Murphy Ditch have been adjusted to estimate historical water supplies available for irrigation on the Harney Peak Ranch. This adjustment has been made based on the following information:

- Communications with Mr. Steve Murphy regarding typical flow rates in the Murphy Ditch during the irrigation season. Mr. Murphy indicated that the river conditions rarely such that the Murphy Ditch cannot divert its full water right amount.
- Communications with Mr. Dave Lamb regarding typical delivery rates from the Murphy Ditch. Mr. Lamb indicated that he believes he receives his appropriate proportionate share of the full water right amount for the Murphy Ditch, and that his delivery rate indicates much higher diversion rates at the headgate of the Murphy as compared to historical records.
- Review of historical diversion records, which indicate that the ditches typically divert much less than they are entitled under their rights.
- Review of U.S. Geological Survey records of streamflows at several upstream gages, which indicate flows available for diversion during much of the irrigation season.
- Review of historical irrigation practices on the Harney Peak Ranch, and information concerning crop yields, which suggest much greater water supplies than are indicated by historical diversion records.





- Review of natural flow computations provided by the Bureau of Reclamation, and statements from Mr. Murphy, Mr. Scott and Mr. Hamm regarding the use of natural flows in the determination of Murphy Ditch divertable supply.
- Comments from Mr. Dave Lamb and Mr. Steve Murphy concerning drainage waters into the Murphy Ditch from small tributaries and upper irrigated fields that effectively increase the water supply to users in the ditch (it was also noted that this situation may, at times, require curtailment of diversions at the river headgate).
- Qualitative comments by Mr. Steve Murphy, Mr. Dave Lamb, Mr. Duane Scott and Mr. Kevin Hamm concerning the strictness of water rights administration on Rapid Creek, and implications as to the accuracy of diversion records.
- Recent (2005) diversion information provided by Mr. Kevin Hamm for the Murphy Ditch.

Historical water supply to the Ranch was estimated by starting with actual historical diversion records for the Murphy Ditch. Average monthly volumes were then determined for each month from April through October. An average daily flow rate (cfs) was determined from the average monthly volume, and a ratio computed by comparing the average daily flow rate to the full water right of 17.0 cfs. Average recorded diversions were then scaled upward by a maximum of 50 percent (**Table 9**). This process resulted in an average annual adjusted diversion amount for the Murphy Ditch of 4,427 acre-feet. The resulting average diversion rate during the irrigation season is 10.41 cfs, which is still only about 61 percent of the full permit amount of the Murphy Ditch 1878 priority, but more consistent with information developed from water users and water managers.

**Table 9**  
**Adjustments to Historical Diversion Records for Murphy Ditch**

|                               | Apr  | May   | Jun   | Jul   | Aug   | Sep   | Oct   | Annual |
|-------------------------------|------|-------|-------|-------|-------|-------|-------|--------|
| Average (1946-1988) (af)      | 140  | 348   | 403   | 533   | 690   | 506   | 331   | 2951   |
| Avg. Div Rate (cfs)           | 2.36 | 5.67  | 6.77  | 8.66  | 11.22 | 8.51  | 5.38  | 6.94   |
| Percent of Full               | 14%  | 33%   | 40%   | 51%   | 66%   | 50%   | 32%   |        |
| Factor Applied                | 0.50 | →     | →     | →     | →     | →     | →     |        |
| Adjusted (af)                 | 211  | 523   | 604   | 799   | 1035  | 759   | 497   | 4427   |
| Resulting Avg. Div Rate (cfs) | 3.54 | 8.50  | 10.15 | 13.00 | 16.83 | 12.76 | 8.07  | 10.41  |
| Max Rate Observed (cfs)       | 5.28 | 16.23 | 17.14 | 18.70 | 18.54 | 26.22 | 11.17 |        |

Historical flows in Rapid Creek as measured at the U.S. Geological Survey gage above Pactola Reservoir were next used to develop an estimated historical time series of Murphy Ditch diversions. Monthly streamflows during the study period were evaluated to characterize each month as either “wet”, “dry” or “average” based on the monthly volumetric flow deviations from monthly averages over the period. This process was intended to capture the year-to-year and month-to-month variability in diversion amounts resulting from differences in hydrologic conditions. Detailed results of this process are provided in **Appendix G**.

#### **III.3.5.5 Estimated Historical Water Supply**

**Table 10** shows estimated historical water supply available to the Harney Peak Ranch from diversions through the Murphy Ditch. The values in **Table 10** reflect 1) a 33.4 percent pro-rata ownership interest in all diversions through the Ditch, and 2) a reduction of total headgate diversions by 11 percent to account for seepage losses from the ditch prior to reaching the Ranch (Wright Water Engineers, 1990). Estimated water deliveries to the Ranch averaged 1,303 acre-feet per year.

#### **III.3.6 Irrigation Practices and Efficiencies**

Irrigation water application efficiencies were estimated by considering the following:

- Water application techniques and facilities;
- Slope of the irrigated lands;
- Soil types on irrigated lands;
- Water conveyance and control systems;
- Tailwater collection systems;
- Crop distributions; and
- Irrigation management.

Water delivery systems to and within the Ranch consist of ditches and pipe systems. Water application to fields uses pipes to help manage flow rates across fields. Fields on portions of the Ranch are laid out such that tailwater from one field is available to irrigate lower fields. Slopes on the Ranch generally range from 0.5 to 1 percent, and irrigated fields are typically laid out to minimize cross slope, which reduces the amount of tailwater. Tailwater pits have been constructed in some areas to collect tailwater at the end of furrows.



**Table 10**  
**Estimated Historical Water Deliveries to Harney Peak Ranch (af)**

|         | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1951    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1952    | 0   | 0   | 0   | 63  | 233 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1392  |
| 1953    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1954    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 74  | 0   | 0   | 1241  |
| 1955    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1956    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 113 | 147 | 0   | 0   | 1202  |
| 1957    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1958    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1959    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1960    | 0   | 0   | 0   | 63  | 155 | 179 | 119 | 154 | 113 | 147 | 0   | 0   | 930   |
| 1961    | 0   | 0   | 0   | 31  | 78  | 90  | 119 | 154 | 113 | 74  | 0   | 0   | 657   |
| 1962    | 0   | 0   | 0   | 31  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1283  |
| 1963    | 0   | 0   | 0   | 63  | 155 | 269 | 237 | 307 | 225 | 147 | 0   | 0   | 1404  |
| 1964    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1965    | 0   | 0   | 0   | 63  | 233 | 269 | 310 | 310 | 300 | 221 | 0   | 0   | 1707  |
| 1966    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1967    | 0   | 0   | 0   | 63  | 155 | 179 | 310 | 307 | 225 | 147 | 0   | 0   | 1388  |
| 1968    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1969    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1970    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1971    | 0   | 0   | 0   | 94  | 155 | 179 | 237 | 307 | 225 | 221 | 0   | 0   | 1419  |
| 1972    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1973    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1974    | 0   | 0   | 0   | 63  | 155 | 179 | 119 | 154 | 113 | 147 | 0   | 0   | 930   |
| 1975    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 154 | 225 | 147 | 0   | 0   | 1161  |
| 1976    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1977    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1978    | 0   | 0   | 0   | 63  | 233 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1392  |
| 1979    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1980    | 0   | 0   | 0   | 63  | 155 | 179 | 119 | 154 | 225 | 147 | 0   | 0   | 1042  |
| 1981    | 0   | 0   | 0   | 31  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1283  |
| 1982    | 0   | 0   | 0   | 63  | 155 | 179 | 310 | 310 | 300 | 147 | 0   | 0   | 1466  |
| 1983    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1984    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1985    | 0   | 0   | 0   | 63  | 155 | 179 | 119 | 307 | 225 | 147 | 0   | 0   | 1196  |
| 1986    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 221 | 0   | 0   | 1388  |
| 1987    | 0   | 0   | 0   | 63  | 155 | 179 | 119 | 307 | 225 | 147 | 0   | 0   | 1196  |
| 1988    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 113 | 147 | 0   | 0   | 1202  |
| 1989    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 154 | 225 | 147 | 0   | 0   | 1161  |
| 1990    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 154 | 113 | 74  | 0   | 0   | 974   |
| 1991    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1992    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1993    | 0   | 0   | 0   | 63  | 155 | 269 | 237 | 307 | 225 | 147 | 0   | 0   | 1404  |
| 1994    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 1995    | 0   | 0   | 0   | 63  | 233 | 269 | 310 | 307 | 225 | 147 | 0   | 0   | 1555  |
| 1996    | 0   | 0   | 0   | 94  | 155 | 269 | 237 | 307 | 225 | 221 | 0   | 0   | 1509  |
| 1997    | 0   | 0   | 0   | 94  | 233 | 269 | 310 | 310 | 300 | 221 | 0   | 0   | 1738  |
| 1998    | 0   | 0   | 0   | 94  | 155 | 269 | 310 | 310 | 300 | 221 | 0   | 0   | 1660  |
| 1999    | 0   | 0   | 0   | 94  | 155 | 269 | 310 | 310 | 300 | 221 | 0   | 0   | 1660  |
| 2000    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 2001    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 2002    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 2003    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1315  |
| 2004    | 0   | 0   | 0   | 63  | 155 | 179 | 119 | 154 | 113 | 147 | 0   | 0   | 930   |
| Average | 0   | 0   | 0   | 64  | 161 | 191 | 231 | 285 | 218 | 153 | 0   | 0   | 1303  |

Pumps located throughout the Ranch used to deliver the tailwater for irrigation. As previously discussed, the Ranch's internal storage and transfer system of lagoons and channels is used to collect water which can then be used and reused in various ways. This ability to use and reuse irrigation water on the Ranch improves application efficiencies that would otherwise be achievable (Colorado State University, 1998). For purposes of estimating historical consumptive use and depletions, a maximum application efficiency of 65 percent has been used for all areas of the Ranch.

### **III.3.7 Soil Properties and Soil Moisture Reservoir**

In evaluating historical consumptive use of irrigation water, it is important to consider soil properties and the ability of the soil to act as a reservoir. The soil moisture reservoir is the amount of water that is stored in soils and that is available for use by plants, and the size of this reservoir is a function of the capacity of the soil to hold water. At times when direct application of irrigation of water is insufficient to meet crop needs, this reservoir may be drawn from to help supply the crops. Similarly, when excess water is applied, the soil profile may be filled up to the soil moisture holding capacity. The capacity of the soil to hold water is dependent on the type of soil and the crop types that are present. Specifically, soil moisture capacity and the size of the soil moisture reservoir are a function of the rooting depths of different crops that are present. For this analysis, rooting depths taken from the Soil Conservation Service and other published reports were used with crop distribution information to calculate a weighted rooting depth for Ranch lands (Wright Water Engineers, 1990, 1992). The calculated soil moisture capacity for irrigated lands on the Ranch is approximately 0.80 feet.

### **III.3.8 Return Flows**

Return flows are that portion of the irrigation water supply that returns to Rapid Creek. Of this water, a portion runs off fields and may directly re-enter Rapid Creek or other surface channels. The remainder seeps into the ground below the crop root zone and returns to Rapid Creek over a period of time.

Tailwater, as a percent of farm losses was estimated to be 50 percent of deliveries to the Ranch. Furthermore, it was estimated that the tailwater returns accrue to Rapid Creek in the same month in which diversions occurred and water was applied on the Ranch. The remaining 50 percent of return

flows was estimated to occur via groundwater. The timing of these groundwater returns was estimated using data on soil properties, the locations of the irrigated lands relative to Rapid Creek, and an analytical methodology known as the Glover technique (Glover, 1960).

#### III.4 Conclusions of Depletion Analysis

- Deliveries of water to the Harney Peak Ranch under the 1878 water right of the Murphy Ditch averaged 1,303 acre-feet from 1950 through 2004.
- Consumptive use by crops resulting from irrigation on the Harney Peak Ranch under the Murphy Ditch averaged 703 acre-feet from 1950 through 2004.
- Farm return flow (from both tailwater delayed groundwater) that historically accrued to Rapid Creek averaged 600 acre-feet per year from 1950 through 2004.
- Depletions associated with use of water from the Murphy Ditch on the Harney Peak Ranch averaged 703 acre-feet per year. Over the long-term, the average depletion is the same as the calculated historical consumptive use, i.e., 703 acre -feet per year. The timing of the depletion, however, differs from that of the consumptive use because of the lagged nature of groundwater return flows.

**Table 11**  
**Harney Peak Ranch Historical Farm Depletion Analysis – Murphy Ditch**  
**(Average over the Period 1950 – 2004)**

|                                       | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| <b>Diversions<sup>(1)</sup></b>       | 0   | 0   | 0   | 72  | 181 | 214 | 260 | 320 | 245 | 172 | 0   | 0   | 1464  |
| <b>Ranch Deliveries<sup>(2)</sup></b> | 0   | 0   | 0   | 64  | 161 | 191 | 231 | 285 | 218 | 153 | 0   | 0   | 1303  |
| <b>Consumptive Use</b>                | 0   | 0   | 0   | 13  | 69  | 126 | 197 | 175 | 96  | 28  | 0   | 0   | 703   |
| <b>Return Flows</b>                   | 8   | 6   | 6   | 36  | 71  | 76  | 81  | 98  | 92  | 91  | 23  | 12  | 600   |
| <b>Depletions<sup>(3)</sup></b>       | -8  | -6  | -6  | 28  | 90  | 114 | 150 | 187 | 126 | 61  | -23 | -12 | 703   |

- Notes
1. Estimated based on historical diversion records and adjustment as previously discussed. Reflects Ranch interest of 33.4 percent of Murphy Ditch diversions
  2. Reflects estimated ditch loss of 11 percent.
  3. Negative values indicate net accretion to stream.

#### IV. TRANSFERRABLE AMOUNT OF WATER RIGHT

##### IV.1 Future Use of Murphy Ditch Water Right by Rapid Valley Sanitary District

If acquired by the District, 33.4 percent of the 1878 Murphy Ditch water right would be transferred from the Murphy Ditch to an alternate point of diversion. The alternate point of diversion would be at a new water treatment facility located as shown in **Figure 8**. As a result of this transfer, the District's acquired interest in the Murphy Ditch would no longer be diverted for irrigation purposes on Harney Peak Ranch.

##### IV.1.1 District Water Use

Water use by the District follows seasonal patterns typical of municipal systems (**Table 12**). Water use during the months of July, August and September is typically higher than other months of the year because of increased landscape irrigation. During these periods, we have estimated that indoor uses and outdoor irrigation are in approximately equal proportions. Furthermore, we have estimated that 5 percent of indoor use is consumptively used, i.e., 95 percent of indoor water use returns to Rapid Creek via waste water treatment systems. In addition, we estimate that 80 percent of outdoor water use (lawn and other irrigation) is consumed, i.e., 20 percent of outdoor water use returns to Rapid Creek via subsurface drainage pathways.

**Table 12**  
**Average RVSD Monthly Water Use Pattern**

|             | Jan  | Feb  | Mar  | Apr  | May  | Jun   | Jul   | Aug   | Sep   | Oct  | Nov  | Dec  | Total  |
|-------------|------|------|------|------|------|-------|-------|-------|-------|------|------|------|--------|
| Total       | 6.0% | 6.0% | 6.0% | 6.0% | 7.0% | 10.0% | 12.0% | 14.0% | 12.0% | 9.0% | 6.0% | 6.0% | 100.0% |
| Indoor      | 6.0% | 6.0% | 6.0% | 6.0% | 6.0% | 6.0%  | 6.0%  | 6.0%  | 6.0%  | 6.0% | 6.0% | 6.0% | 72.0%  |
| Outdoor     | 0.0% | 0.0% | 0.0% | 0.0% | 1.0% | 4.0%  | 6.0%  | 8.0%  | 6.0%  | 3.0% | 0.0% | 0.0% | 28.0%  |
| Depletion % | 5%   | 5%   | 5%   | 5%   | 16%  | 35%   | 43%   | 48%   | 43%   | 30%  | 5%   | 5%   | 26%    |
| Return %    | 95%  | 95%  | 95%  | 95%  | 84%  | 65%   | 58%   | 52%   | 58%   | 70%  | 95%  | 95%  | 74%    |



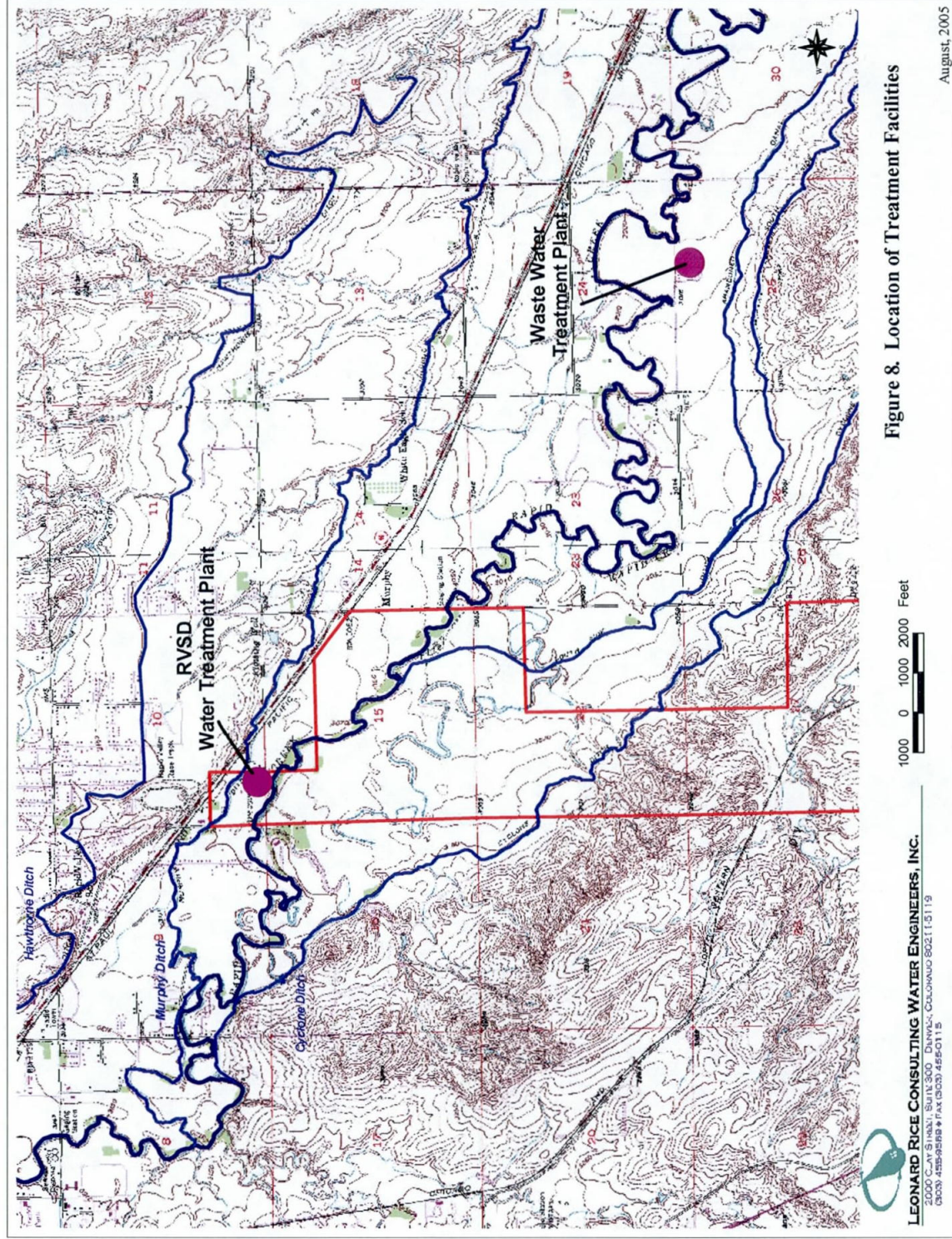


Figure 8. Location of Treatment Facilities

**Table 12** also shows the depletion and return percentages associated with total water use by the District. These percentages have been calculated by considering 1) the percentage of indoor and outdoor use for each month, and 2) a 5 percent and 80 percent consumptive factor for indoor and outdoor uses, respectively. We estimate that water uses by the District are on average 26 percent consumptive. The remaining 74 percent of water use by the District returns to Rapid Creek via waste water treatment facilities or subsurface drainage.

Consumptive water uses by the District are highest during the summer months due to outdoor irrigation. As a percentage of water availability, the consumptive percentage is highest in the month of August (48 percent of water deliveries); this coincides with the highest period of outdoor uses. Note that during all months, consumptive percentages for water use by the District are lower than the consumption rates that historically occurred when the Murphy Ditch rights were used for agricultural irrigation (approximately 65 percent).

#### **IV.1.2 District's Use of Murphy Ditch Right**

In order to protect other water rights on Rapid Creek, it may be appropriate to limit the rate and amount that the District may use the Murphy Ditch right when transferred to another location.

##### **IV.1.2.1 Diversion Season**

Water may be diverted under the Murphy Ditch 1878 priority only during the historical irrigation season. This period is generally from April 15<sup>th</sup> through November 30<sup>th</sup>. The permit for the 1878 priority of the Murphy Ditch allows diversions from April 15<sup>th</sup> through November 30<sup>th</sup>.

##### **IV.1.2.2 Maximum Rate of Diversion**

The maximum rate of diversion should not exceed the District's prorata interest in the water right. In addition, this amount must be reduced to account for ditch losses that will continue to occur – this will protect remaining shareholders in the ditches from an increased burden on bearing losses. Ditch losses must be "left in the ditch." The calculated maximum allowable diversion rate for the Murphy Ditch is shown in **Table 13**.

**Table 13**  
**Maximum Diversion Rate of Transferred Right**

| <b>Ditch</b>        | <b>Water Right</b> | <b>District Interest</b> | <b>Ditch Loss</b> | <b>Allowable Diversion Rate</b> |
|---------------------|--------------------|--------------------------|-------------------|---------------------------------|
| <b>Murphy Ditch</b> | 17.0 cfs           | 33.4%                    | 11.0%             | 5.05 cfs                        |

#### **IV.1.2.3 Seasonal Diversion Rate Limits**

The seasonal rate of diversion under the District's interest in the Murphy Ditch should be limited to the District's prorata interest in instantaneous rate at which the ditch is diverting water, less the appropriate reduction to account for ditch loss that is left in the ditch.

#### **IV.1.2.4 Volumetric Diversion Limits**

The running 10-year average volumetric amount of water diverted should not exceed the historical long term volume of water diverted. The District's interest in the long-term average diversions of the Murphy Ditch is shown in **Table 14** (the values shown reflect reduction from headgate diversions to account for ditch losses).

**Table 14**  
**Volumetric Limit on Long-Term Average Diversions**

|                     | <b>Apr</b> | <b>May</b> | <b>Jun</b> | <b>Jul</b> | <b>Aug</b> | <b>Sep</b> | <b>Oct</b> | <b>Total</b> |
|---------------------|------------|------------|------------|------------|------------|------------|------------|--------------|
| <b>Murphy Ditch</b> | 64         | 161        | 191        | 231        | 285        | 218        | 153        | 1303         |

The District will be responsible for monitoring monthly and annual volumetric diversions under the Murphy Ditch right, determining the running 10-year average, and making appropriate reporting to the State.

#### **IV.1.2.5 Depletion Limits**

As noted previously in this Report, the portion of water used by the District that is consumed varies by month and ranges from a low of 5 percent during the winter months to a high of approximately 48 percent during the month of August. Because District water use is less depletive than occurred historically under agricultural uses, no depletion limit on the future use of the water right is required if the District will already be limited to a volumetric diversion limit.

#### **IV.1.2.6 Other Terms and Conditions**

In addition to the limits discussed above, lands historically irrigated on Harney Peak Ranch by the transferred Murphy Ditch water right must be removed from irrigation to ensure that agricultural depletions cease as the water begins to be used by the District. Such a condition, commonly referred to as “dry-up” of the irrigated lands, prevents an expansion of the use of the water right over historical conditions and will protect other vested water right owners on Rapid Creek.

#### **IV.1.2.7 Interim Water Use by the Ranch Following Transfer Proceedings**

As negotiations between Harney Peak Ranch and the District have progressed, Mr. David Lamb has expressed interest in continuing to use a portion of the 1878 priority Murphy Ditch water right for a period of 12 years (from 2006 through 2017). As contemplated, this would be accomplished following the sale through a leaseback schedule that declines from roughly 50 percent use of the water right in 2006 to zero use on the Ranch in 2017.

It is our opinion that a partial leaseback arrangement with Mr. Lamb can be accomplished and still be protective of other water users on Rapid Creek so long as appropriate measurement and accounting is performed by the District. Such an arrangement must include measurement of deliveries under the Murphy right at both delivery points (Ranch and District intake). Diversion flow rate and volumetric diversion limits discussed above would then apply to the combined diversions by both the Ranch and the District.



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# **APPENDIX A**

**Water Permit  
Murphy Ditch**

## WATER LICENSE NO. 1727-2.

(1) WHEREAS, On the 7th day of January A.D. 19 80  
Rapid Valley Water Company, Inc.

made Water Right Application No. 1727-2 Vested Right  
 for a permit to use 20 cubic feet per second of the waters  
 of Rapid Creek

County of Pennington, State of South Dakota, for irrigation

purposes; and -

ested ight (2) WHEREAS, On the 25th day of September A.D. 19 80  
 Permit No. 1727-2, with a date of priority of 17 cfs from 1878 and 3 cfs  
 was issued to said applicant S recognizing  
 supply system therein described ~~xxxxxx~~ the completion of construction of the water  
 application to beneficial use of said water ~~xxxxxx~~ and for the

and:

(3) WHEREAS, It is hereby certified that the applicant has complied with the provisions of the laws of the State of South Dakota  
 relating to completion of the construction of the water supply system and is entitled to divert 20 cubic feet  
 per second of water for beneficial use and,

(4) WHEREAS, It is hereby certified that the applicant has complied with the provisions of the laws of the State of South Dakota  
 relating to the application of water to beneficial use of the following extent, 1893 Priority:

- |                                   |                                                                                                                                                                                                     |                                                                                                                                              |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| 1) Guy Simons                     | 45 acres E $\frac{1}{2}$ SW $\frac{1}{4}$ , Sec. 9-T1N-R8E                                                                                                                                          | 23) Rosanne Heavlin- 41 acres in the<br>SE $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 19, and NE $\frac{1}{4}$ NE $\frac{1}{4}$<br>Sec. 30-T1N, R9E |
| 2) C.E. Morris                    | 64 acres W $\frac{1}{2}$ SE $\frac{1}{4}$ , Sec. 9-T1N-R8E                                                                                                                                          |                                                                                                                                              |
| 13) C.E. Morris                   | 66 acres Sec. 24-T1N-R8E                                                                                                                                                                            | 24) Merlin Stromer- 125 acres in the<br>SW $\frac{1}{4}$ of Sec. 20, and NW $\frac{1}{4}$ Sec.<br>29-T1N-R9E                                 |
| 14) C.E. Morris                   | 38 acres $\frac{1}{2}$ of the 76 acres in<br>Sec. 24-T1N-R8E                                                                                                                                        | 25) James Bloom- 38 acres SW $\frac{1}{4}$ SE $\frac{1}{4}$<br>Sec. 20 and NW $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 29-<br>T1N-R9E             |
| 3) R.W. Lamb                      | 187 acres SW $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 10,<br>NW $\frac{1}{4}$ & N $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 15, T1N-R8E                                                                        |                                                                                                                                              |
| 4) R.W. Lamb                      | 130 acres in the S $\frac{1}{2}$ NE $\frac{1}{4}$ and N $\frac{1}{2}$ SE $\frac{1}{4}$<br>Sec. 15;<br>90 acres in the S $\frac{1}{2}$ Sec. 15, NW $\frac{1}{4}$ NE $\frac{1}{4}$<br>Sec. 20-T1N-R8E | <b>Total - 1425 acres</b>                                                                                                                    |
| 4) R.W. Lamb                      | 38 acres in the NW $\frac{1}{4}$ SW $\frac{1}{4}$ , Sec. 14, T1N, R8E                                                                                                                               |                                                                                                                                              |
| 5) A.K. Walker                    | 8 acres in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 14-T1N-R8E                                                                                                                                    |                                                                                                                                              |
| 7) Jim Long                       | 10 acres in the NE $\frac{1}{4}$ SW $\frac{1}{4}$ and SE $\frac{1}{4}$ NW $\frac{1}{4}$ , Sec. 14-T1N-R8E                                                                                           |                                                                                                                                              |
| 6) David Murphy Est.              | 43 acres in the W $\frac{1}{2}$ , Sec. 14-T1N-R8E                                                                                                                                                   |                                                                                                                                              |
| 8 & 9) Cora & Kenneth<br>Buckholz | 10 acres in the W $\frac{1}{2}$ of center quarter of<br>Sec. 14-T1N-R8E                                                                                                                             |                                                                                                                                              |
| 10) Elsie Higgins                 | 121 acres in the SE $\frac{1}{4}$ of Sec. 14; and SW $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 13-T1N-R8E                                                                                                 |                                                                                                                                              |
| 11) Wayne Anderson                | 12 acres in the SE $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 13-T1N-R8E                                                                                                                                   |                                                                                                                                              |
| 12) Dale Wileman                  | 6 acres in the SW $\frac{1}{4}$ SE $\frac{1}{4}$ of Sec. 13-T1N-R8E                                                                                                                                 |                                                                                                                                              |
| 16) John Sweeney                  | 1 acre NW $\frac{1}{4}$ NE $\frac{1}{4}$ of Sec. 24-T1N-R8E                                                                                                                                         |                                                                                                                                              |
| 15) Doug Peters                   | 28 acres $\frac{1}{2}$ of 8 and 48 acres in the W $\frac{1}{2}$ NE $\frac{1}{4}$ of Sec. 24-T1N-R8E                                                                                                 |                                                                                                                                              |
| 17) Raymond Tyler                 | 65 acres in the W $\frac{1}{2}$ NW $\frac{1}{4}$ Sec. 19-T1N-R9E                                                                                                                                    |                                                                                                                                              |
| 19) M.P. Carley                   | 145 acres in Sec. 19-T1N-R9E                                                                                                                                                                        |                                                                                                                                              |
| 20) Bruce Webber                  | 63 acres in SW $\frac{1}{4}$ Sec. 19, NW $\frac{1}{4}$ Sec. 30-T1N-R9E                                                                                                                              |                                                                                                                                              |
| 21) Dr. Ahrlin                    | 51 acres in SE $\frac{1}{4}$ Sec. 19, NE $\frac{1}{4}$ Sec. 30, T1N-R9E                                                                                                                             |                                                                                                                                              |

1878 PRIORITY DATE



| Land<br>Parcel<br>Number | Legal<br>Description    | Acreage |
|--------------------------|-------------------------|---------|
| 1                        | NE1/4 SW1/4 S9-T1N-R8E  | 20      |
|                          | SE1/4 SW1/4 S9-T1N-R8E  | 25      |
| 2                        | NW1/4 SE1/4 S9-T1N-R8E  | 29      |
|                          | SW1/4 SE1/4 S9-T1N-R8E  | 35      |
| 3                        | SW1/4 SW1/4 S10-T1N-R8E | 25      |
|                          | NW1/4 NW1/4 S15-T1N-R8E | 31      |
|                          | SW1/4 NW1/4 S15-T1N-R8E | 38      |
|                          | NW1/4 SW1/4 S15-T1N-R8E | 30      |
|                          | SE1/4 NW1/4 S15-T1N-R8E | 32      |
|                          | NE1/4 SW1/4 S15-T1N-R8E | 31      |
|                          | SW1/4 NE1/4 S15-T1N-R8E | 38      |
|                          | NW1/4 SE1/4 S15-T1N-R8E | 29      |
|                          | SE1/4 NE1/4 S15-T1N-R8E | 25      |
|                          | NE1/4 SE1/4 S15-T1N-R8E | 38      |
|                          | SW1/4 SW1/4 S15-T1N-R8E | 1       |
|                          | SE1/4 SW1/4 S15-T1N-R8E | 11      |
|                          | SW1/4 SE1/4 S15-T1N-R8E | 24      |
|                          | SE1/4 SE1/4 S15-T1N-R8E | 15      |
| 5                        | SW1/4 NW1/4 S14-T1N-R8E | 5       |
| 6                        | SW1/4 NW1/4 S14-T1N-R8E | 32      |
| 7                        | SE1/4 NW1/4 S14-T1N-R8E | 6       |
|                          | NE1/4 SW1/4 S14-T1N-R8E | 4       |
| 8                        | SE1/4 NW1/4 S14-T1N-R8E | 3       |
|                          | NE1/4 SW1/4 S14-T1N-R8E | 2       |
| 9                        | SE1/4 NW1/4 S14-T1N-R8E | 3       |
|                          | NE1/4 SW1/4 S14-T1N-R8E | 2       |
| 10                       | NW1/4 SE1/4 S14-T1N-R8E | 28      |
|                          | SW1/4 SE1/4 S14-T1N-R8E | 31      |
|                          | SE1/4 SE1/4 S14-T1N-R8E | 32      |
|                          | NE1/4 SE1/4 S14-T1N-R8E | 3       |
|                          | SW1/4 SW1/4 S13-T1N-R8E | 27      |
| 11                       | SE1/4 SW1/4 S13-T1N-R8E | 2       |
| 12                       | SW1/4 SE1/4 S13-T1N-R8E | 5       |



|    |                                  |             |    |
|----|----------------------------------|-------------|----|
| 13 | 104 ACRES OF THE TOTAL 142 ACRES |             |    |
|    | NE1/4 NW1/4                      | S24-T1N-R8E | 36 |
|    | SE1/4 NW1/4                      | S24-T1N-R8E | 40 |
|    | NW1/4 NE1/4                      | S24-T1N-R8E | 32 |
|    | SW1/4 NE1/4                      | S24-T1N-R8E | 34 |
| 14 | NW1/4 NE1/4                      | S24-T1N-R8E | 1  |
| 15 | 28 ACRES OF THE TOTAL 56 ACRES   |             |    |
|    | NE1/4 NE1/4                      | S24-T1N-R8E | 31 |
|    | SE1/4 NE1/4                      | S24-T1N-R8E | 25 |
| 16 | NW1/4 NW1/4                      | S19-T1N-R9E | 12 |
|    | SW1/4 NW1/4                      | S19-T1N-R9E | 37 |
| 17 | NE1/4 NW1/4                      | S19-T1N-R9E | 2  |
|    | SE1/4 NW1/4                      | S19-T1N-R9E | 32 |
|    | NE1/4 SW1/4                      | S19-T1N-R9E | 10 |
|    | SW1/4 NE1/4                      | S19-T1N-R9E | 25 |
|    | NW1/4 SE1/4                      | S19-T1N-R9E | 24 |
|    | SW1/4 SE1/4                      | S19-T1N-R9E | 2  |
|    | SE1/4 NE1/4                      | S19-T1N-R9E | 11 |
|    | NE1/4 SE1/4                      | S19-T1N-R9E | 39 |
| 18 | NE1/4 SW1/4                      | S19-T1N-R9E | 12 |
|    | SE1/4 SW1/4                      | S19-T1N-R9E | 39 |
|    | NE1/4 NW1/4                      | S30-T1N-R9E | 12 |
| 19 | SW1/4 SE1/4                      | S19-T1N-R9E | 31 |
|    | NW1/4 NE1/4                      | S30-T1N-R9E | 20 |

---

|       |      |
|-------|------|
| Total | 1103 |
|-------|------|

1893 PRIORITY DATE

|    |             |             |    |
|----|-------------|-------------|----|
| 20 | SE1/4 SE1/4 | S19-T1N-R9E | 14 |
|    | NE1/4 NE1/4 | S30-T1N-R9E | 12 |
| 21 | NW1/4 SW1/4 | S20-T1N-R9E | 25 |
|    | SW1/4 SW1/4 | S20-T1N-R9E | 34 |
|    | NE1/4 SW1/4 | S20-T1N-R9E | 7  |
|    | SE1/4 SW1/4 | S20-T1N-R9E | 39 |
|    | NW1/4 NW1/4 | S29-T1N-R9E | 2  |
|    | NE1/4 NW1/4 | S29-T1N-R9E | 18 |
| 22 | SW1/4 SE1/4 | S20-T1N-R9E | 18 |
|    | NW1/4 NE1/4 | S29-T1N-R9E | 20 |

---

|       |     |
|-------|-----|
| Total | 189 |
|-------|-----|



# **APPENDIX B**

## **Harney Peak Ranch Photographs**



**Rapid Creek near Harney Peak Ranch**



**Rapid Creek at U.S.G.S. Gage**



**Murphy Ditch**



**Murphy Ditch**





**Harney Peak Ranch – NE ¼ Section, Township 1N, Range 8E**



**Harney Peak Ranch – NE ¼ Section 21, Township 1N, Range 8E**





**Harney Peak Ranch – NE ¼ Section 22, Township 1N, Section 8E**



**Harney Peak Ranch – NE ¼ Section 22, Township 1N, Section 8E**





**Harney Peak Ranch – NE ¼ Section 10, , Township 1N, Ranch 8E**



**Harney Peak Ranch – SW ¼ Section 10, Township 1N, Ranch 8E**





**Harney Peak Ranch – SW ¼ of Section 10, Range 1N, Township 8E**



**Harney Peak Ranch – SW ¼ of Section 15, Range 1N, Township 8E**



# **APPENDIX C**

**Affidavit  
David Lamb**

## AFFIDAVIT

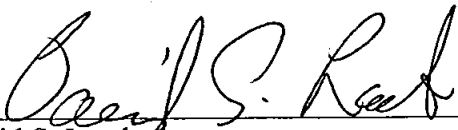
State of South Dakota     )  
                                          )ss.  
County of Pennington     )

I, David S. Lamb, being duly sworn, do hereby state and affirm as follows:

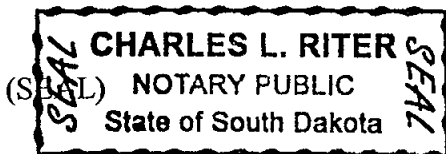
1. I am over 21 years of age and make this affidavit based upon my own personal knowledge and belief.
2. I am the sole owner of Harney Peak Ranch and approximately 33.4 percent of the 1878 water right permitted for the Rapid Valley Water Company, Inc. a/k/a Murphy Ditch ("Murphy Ditch") and diverted into the Murphy Ditch from Rapid Creek.
3. My family first arrived in Rapid Valley in 1876 and has been involved in ranching and farming here for the 129 years since that time. I began working at Harney Peak Ranch in the late 1950s, assumed management in 1975 and became sole owner of the lands and water rights in 1990.
4. My family began expanding lumber, industrial and agricultural asset ownership in Rapid City from about 1907. The lands of the Harney Peak Ranch, including 368 acres irrigated under the 1878 priority date, were acquired after that time.
5. The lands now known as Harney Peak Ranch and irrigated through Murphy Ditch are the same lands that have been irrigated by the 33.4 percent of the 1878 water right since that time.
6. I am actively involved in the management and farming of the Harney Peak Ranch, including management of water supplies for irrigation. I have also been involved in the management of the Rapid Valley Water Conservancy District and several irrigation entities, including the Murphy Ditch.
7. My entitlement of water diverted through Murphy Ditch under the 1878 priority date, based upon my ownership percentage, is approximately 5.7 cubic feet per second.
8. I have regularly requested, received and applied my full entitlement of water diverted through the Murphy Ditch, or close thereto, during the period from April through October of each year. I estimate that, during each irrigation season, I regularly received at least 4.5 to 5.7 cfs of water. At no time have I not used or abandoned any water right.

9. Diversions of water through the Murphy Ditch of the 1878 water right have been used for irrigation of about 368 acres under intensive cropping such as sugar beet, cane and alfalfa production. During my tenure at Harney Peak Ranch, the 368 acres have been irrigated primarily for alfalfa and forage production.
10. My family has implemented numerous improvements on Harney Peak Ranch to minimize transit and application losses and improve water use efficiencies. The multiple high-capacity pumped and pipeline diversion points of Harney Peak Ranch allow high diversions under the Murphy Ditch rotational-uses systems.
11. Water received on Harney Peak Ranch under the 1878 priority water right during my employment, management and ownership has generally been sufficient to meet intensive crop irrigation needs.
12. Harney Peak Ranch's ability to fully meet irrigation water requirements is demonstrated by the high quality crops and crop yields historically achieved on the Ranch. Historic yields from irrigated alfalfa have averaged 3.5 to 5 tons per acre with 7 ton yields common on newer stands.

Dated this 28<sup>th</sup> day of September, 2005.

  
\_\_\_\_\_  
David S. Lamb

Subscribed and sworn to before me this 28<sup>th</sup> day of September, 2005.



  
\_\_\_\_\_  
Notary Public – South Dakota  
My Commission Expires **My Commission Expires**  
**October 16, 2008**



# **APPENDIX D**

## **Detailed Results of Consumptive Use and Depletion Computations**

Harney Peak Ranch (Murphy Ditch) - Summary of Historical Consumptive Use Analysis

| Year    | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |     |             |           | Soil Moisture Contents | Efficiency Calculation |                           |                |                    | Estimated Crop CU |                   |     |
|---------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----|-------------|-----------|------------------------|------------------------|---------------------------|----------------|--------------------|-------------------|-------------------|-----|
|         |                   |                         |                                    |                             |                         | Historical Diversion       | CU  | Destination |           | Non-Consumed           | Div to CU and SM       | Calculated Efficiency (%) | From Diversion | From Soil Moisture | Total             | Total CU Per Acre |     |
|         |                   |                         |                                    |                             |                         |                            |     | Soil Zone   | Soil Zone |                        |                        |                           |                |                    |                   |                   |     |
| 1950    | 821               | 229                     | 502                                | 0                           | 562                     | 1315                       | 531 | 233         | 550       | 765                    | 58                     | 531                       | 61             | 592                | 161               |                   |     |
| 1951    | 561               | 265                     | 632                                | 0                           | 632                     | 1315                       | 582 | 50          | 582       | 50                     | 48                     | 582                       | 345            | 50                 | 632               | 172               |     |
| 1952    | 1075              | 222                     | 859                                | 0                           | 859                     | 1303                       | 754 | 61          | 572       | 815                    | 81                     | 572                       | 304            | 58                 | 853               | 233               |     |
| 1953    | 871               | 201                     | 770                                | 0                           | 770                     | 1315                       | 706 | 98          | 568       | 838                    | 81                     | 568                       | 708            | 62                 | 770               | 208               |     |
| 1954    | 1910              | 250                     | 780                                | 0                           | 780                     | 1241                       | 656 | 83          | 563       | 738                    | 58                     | 563                       | 105            | 105                | 768               | 207               |     |
| 1955    | 1859              | 285                     | 803                                | 0                           | 803                     | 1315                       | 707 | 126         | 488       | 827                    | 62                     | 488                       | 345            | 56                 | 803               | 218               |     |
| 1956    | 1021              | 227                     | 794                                | 0                           | 794                     | 1262                       | 608 | 119         | 475       | 727                    | 62                     | 475                       | 506            | 187                | 764               | 215               |     |
| 1957    | 930               | 304                     | 626                                | 0                           | 626                     | 1315                       | 583 | 131         | 583       | 583                    | 53                     | 583                       | 583            | 53                 | 626               | 176               |     |
| 1958    | 1001              | 241                     | 759                                | 0                           | 759                     | 1315                       | 616 | 74          | 555       | 759                    | 58                     | 555                       | 610            | 74                 | 759               | 203               |     |
| 1959    | 1002              | 218                     | 784                                | 0                           | 784                     | 1315                       | 616 | 155         | 550       | 784                    | 58                     | 550                       | 345            | 345                | 868               | 233               |     |
| 1960    | 1260              | 164                     | 876                                | 0                           | 876                     | 1315                       | 521 | 69          | 340       | 589                    | 63                     | 340                       | 21             | 389                | 67                | 456               | 124 |
| 1961    | 1027              | 156                     | 871                                | 0                           | 871                     | 1315                       | 521 | 385         | 38        | 230                    | 65                     | 230                       | 265            | 870                | 23                | 590               | 162 |
| 1962    | 906               | 406                     | 590                                | 0                           | 590                     | 1263                       | 570 | 284         | 445       | 834                    | 65                     | 445                       | 342            | 720                | 68                | 788               | 213 |
| 1963    | 1058              | 303                     | 765                                | 0                           | 765                     | 1404                       | 726 | 143         | 765       | 542                    | 61                     | 765                       | 342            | 840                | 111               | 751               | 204 |
| 1964    | 1014              | 263                     | 751                                | 0                           | 751                     | 1315                       | 640 | 113         | 561       | 754                    | 57                     | 561                       | 345            | 440                | 111               | 751               | 204 |
| 1965    | 919               | 308                     | 613                                | 0                           | 613                     | 1315                       | 581 | 31          | 1053      | 612                    | 36                     | 344                       | 344            | 561                | 32                | 613               | 167 |
| 1966    | 949               | 302                     | 648                                | 0                           | 648                     | 1315                       | 581 | 68          | 668       | 648                    | 48                     | 648                       | 345            | 561                | 85                | 648               | 178 |
| 1967    | 860               | 291                     | 589                                | 0                           | 589                     | 1368                       | 583 | 6           | 813       | 583                    | 41                     | 583                       | 345            | 563                | 6                 | 583               | 155 |
| 1968    | 839               | 319                     | 520                                | 0                           | 520                     | 1315                       | 511 | 9           | 794       | 520                    | 40                     | 520                       | 345            | 511                | 9                 | 520               | 141 |
| 1969    | 986               | 282                     | 704                                | 0                           | 704                     | 1315                       | 677 | 27          | 610       | 704                    | 54                     | 610                       | 345            | 877                | 27                | 704               | 181 |
| 1970    | 950               | 290                     | 750                                | 0                           | 750                     | 1315                       | 635 | 115         | 564       | 750                    | 57                     | 564                       | 345            | 635                | 115               | 750               | 204 |
| 1971    | 922               | 255                     | 687                                | 0                           | 687                     | 1420                       | 581 | 85          | 753       | 687                    | 47                     | 753                       | 345            | 581                | 85                | 687               | 181 |
| 1972    | 866               | 263                     | 583                                | 0                           | 583                     | 1315                       | 583 | 3           | 731       | 583                    | 44                     | 583                       | 345            | 583                | 3                 | 583               | 158 |
| 1973    | 920               | 176                     | 753                                | 0                           | 753                     | 1315                       | 631 | 121         | 562       | 753                    | 57                     | 562                       | 345            | 631                | 121               | 753               | 205 |
| 1974    | 950               | 158                     | 822                                | 0                           | 822                     | 1315                       | 486 | 67          | 397       | 562                    | 61                     | 486                       | 345            | 486                | 327               | 822               | 220 |
| 1975    | 912               | 223                     | 689                                | 0                           | 689                     | 1161                       | 532 | 222         | 408       | 755                    | 65                     | 408                       | 150            | 632                | 157               | 689               | 187 |
| 1976    | 985               | 255                     | 731                                | 0                           | 731                     | 1315                       | 681 | 194         | 460       | 854                    | 65                     | 460                       | 274            | 681                | 70                | 731               | 199 |
| 1977    | 1034              | 320                     | 714                                | 0                           | 714                     | 1315                       | 681 | 168         | 530       | 854                    | 60                     | 530                       | 345            | 681                | 67                | 714               | 194 |
| 1978    | 970               | 257                     | 703                                | 0                           | 703                     | 1315                       | 625 | 168         | 530       | 854                    | 60                     | 530                       | 345            | 625                | 29                | 703               | 191 |
| 1979    | 943               | 280                     | 683                                | 0                           | 683                     | 1315                       | 662 | 20          | 651       | 703                    | 50                     | 651                       | 345            | 662                | 1                 | 683               | 186 |
| 1980    | 1026              | 324                     | 720                                | 0                           | 720                     | 1315                       | 662 | 118         | 388       | 853                    | 63                     | 388                       | 345            | 536                | 183               | 720               | 198 |
| 1981    | 1014              | 291                     | 723                                | 0                           | 723                     | 1283                       | 643 | 141         | 433       | 793                    | 62                     | 433                       | 345            | 643                | 74                | 723               | 196 |
| 1982    | 859               | 419                     | 440                                | 0                           | 440                     | 1486                       | 441 | 0           | 1022      | 440                    | 30                     | 440                       | 345            | 440                | 0                 | 440               | 120 |
| 1983    | 953               | 256                     | 707                                | 0                           | 707                     | 1315                       | 654 | 53          | 658       | 707                    | 54                     | 658                       | 345            | 654                | 53                | 707               | 192 |
| 1984    | 929               | 239                     | 686                                | 0                           | 686                     | 1315                       | 623 | 66          | 625       | 686                    | 52                     | 625                       | 345            | 623                | 66                | 686               | 187 |
| 1985    | 1008              | 155                     | 813                                | 0                           | 813                     | 1196                       | 573 | 205         | 419       | 777                    | 65                     | 419                       | 345            | 573                | 241               | 813               | 221 |
| 1986    | 920               | 288                     | 632                                | 0                           | 632                     | 1388                       | 572 | 96          | 632       | 668                    | 48                     | 632                       | 345            | 572                | 60                | 632               | 172 |
| 1987    | 1056              | 211                     | 846                                | 0                           | 846                     | 1196                       | 585 | 187         | 420       | 776                    | 65                     | 420                       | 257            | 585                | 257               | 846               | 230 |
| 1988    | 1104              | 154                     | 846                                | 0                           | 846                     | 1202                       | 680 | 121         | 421       | 781                    | 65                     | 421                       | 115            | 680                | 289               | 940               | 253 |
| 1989    | 1010              | 217                     | 703                                | 0                           | 703                     | 1161                       | 553 | 202         | 406       | 755                    | 65                     | 406                       | 184            | 553                | 154               | 703               | 195 |
| 1990    | 994               | 284                     | 700                                | 0                           | 700                     | 974                        | 558 | 127         | 341       | 633                    | 65                     | 341                       | 97             | 558                | 194               | 700               | 190 |
| 1991    | 1016              | 283                     | 734                                | 0                           | 734                     | 1315                       | 681 | 203         | 460       | 854                    | 65                     | 460                       | 345            | 681                | 82                | 734               | 195 |
| 1992    | 887               | 217                     | 670                                | 0                           | 670                     | 1315                       | 580 | 137         | 518       | 797                    | 61                     | 518                       | 218            | 580                | 10                | 670               | 183 |
| 1993    | 931               | 301                     | 531                                | 0                           | 531                     | 1404                       | 531 | 0           | 873       | 531                    | 38                     | 531                       | 345            | 531                | 0                 | 531               | 144 |
| 1994    | 1001              | 143                     | 916                                | 0                           | 916                     | 1315                       | 741 | 90          | 480       | 854                    | 63                     | 480                       | 261            | 741                | 178               | 916               | 240 |
| 1995    | 886               | 293                     | 596                                | 0                           | 596                     | 1355                       | 575 | 105         | 875       | 596                    | 44                     | 875                       | 345            | 575                | 21                | 596               | 162 |
| 1996    | 903               | 224                     | 679                                | 0                           | 679                     | 1509                       | 606 | 71          | 1509      | 679                    | 45                     | 1509                      | 345            | 606                | 71                | 679               | 179 |
| 1997    | 906               | 375                     | 533                                | 0                           | 533                     | 1738                       | 533 | 0           | 1200      | 533                    | 31                     | 1200                      | 345            | 533                | 0                 | 533               | 145 |
| 1998    | 973               | 316                     | 657                                | 0                           | 657                     | 1680                       | 641 | 16          | 1003      | 657                    | 40                     | 1003                      | 345            | 641                | 16                | 657               | 179 |
| 1999    | 884               | 307                     | 577                                | 0                           | 577                     | 1680                       | 573 | 3           | 1084      | 576                    | 35                     | 1084                      | 345            | 573                | 4                 | 577               | 157 |
| 2000    | 908               | 203                     | 783                                | 0                           | 783                     | 1315                       | 654 | 90          | 531       | 784                    | 56                     | 531                       | 345            | 694                | 89                | 783               | 213 |
| 2001    | 1018              | 276                     | 739                                | 0                           | 739                     | 1315                       | 691 | 48          | 575       | 739                    | 56                     | 575                       | 345            | 691                | 48                | 739               | 201 |
| 2002    | 1055              | 208                     | 835                                | 0                           | 835                     | 1315                       | 607 | 179         | 529       | 786                    | 60                     | 529                       | 345            | 607                | 228               | 835               | 227 |
| 2003    | 1062              | 241                     | 841                                | 0                           | 841                     | 1315                       | 680 | 165         | 460       | 841                    | 65                     | 460                       | 345            | 680                | 152               | 841               | 229 |
| 2004    | 1006              | 277                     | 729                                | 0                           | 729                     | 939                        | 517 | 87          | 325       | 804                    | 65                     | 325                       | 184            | 517                | 212               | 729               | 198 |
| Average | 972               | 259                     | 713                                | 0                           | 713                     | 1303                       | 605 | 98          | 550       | 704                    | 55                     | 550                       | 605            | 98                 | 703               | 191               |     |

Harney Peak Ranch (Murphy Ditch) - Detail of Historical Consumptive Use Analysis

| Month | Year    | Potential Crop<br>EY | Effective<br>Precipitation | Irrigation Water<br>Requirement<br>(IWR) | EOM Winter<br>Precip<br>Carryover | IWR After<br>Winter<br>Precip | River Diversion Accounting |     |           |                  | Soil<br>Moisture<br>Contents | Estimated Crop CU            |                       |       |
|-------|---------|----------------------|----------------------------|------------------------------------------|-----------------------------------|-------------------------------|----------------------------|-----|-----------|------------------|------------------------------|------------------------------|-----------------------|-------|
|       |         |                      |                            |                                          |                                   |                               | Historical<br>Diversion    | CU  | Soil Zone | Non-<br>Consumed | Div to CU and<br>SM          | Calculated<br>Efficiency (%) | From Soil<br>Moisture | Total |
| Jan   | Average | 0                    | 0                          | 0                                        | 0                                 | 0                             | 0                          | 0   | 0         | 0                | 0                            | 0                            | 0                     | 0     |
| Feb   | Average | 0                    | 0                          | 0                                        | 0                                 | 0                             | 0                          | 0   | 0         | 0                | 0                            | 0                            | 0                     | 0     |
| Mar   | Average | 0                    | 0                          | 0                                        | 0                                 | 0                             | 0                          | 0   | 0         | 0                | 0                            | 0                            | 0                     | 0     |
| Apr   | Average | 20                   | 7                          | 13                                       | 0                                 | 13                            | 64                         | 11  | 43        | 21               | 32                           | 32                           | 11                    | 13    |
| May   | Average | 122                  | 54                         | 68                                       | 0                                 | 68                            | 181                        | 85  | 85        | 76               | 76                           | 47                           | 85                    | 3     |
| Jun   | Average | 197                  | 68                         | 129                                      | 0                                 | 129                           | 191                        | 104 | 5         | 84               | 107                          | 86                           | 104                   | 22    |
| Jul   | Average | 254                  | 54                         | 206                                      | 0                                 | 206                           | 231                        | 142 | 87        | 87               | 144                          | 62                           | 142                   | 56    |
| Aug   | Average | 219                  | 40                         | 179                                      | 0                                 | 179                           | 235                        | 152 | 15        | 168              | 177                          | 62                           | 162                   | 13    |
| Sep   | Average | 121                  | 26                         | 96                                       | 0                                 | 96                            | 218                        | 93  | 28        | 97               | 121                          | 56                           | 93                    | 3     |
| Oct   | Average | 38                   | 11                         | 28                                       | 0                                 | 28                            | 153                        | 26  | 3         | 85               | 56                           | 38                           | 26                    | 28    |
| Nov   | Average | 0                    | 0                          | 0                                        | 0                                 | 0                             | 0                          | 0   | 0         | 0                | 0                            | 0                            | 0                     | 0     |
| Dec   | Average | 0                    | 0                          | 0                                        | 0                                 | 0                             | 0                          | 0   | 0         | 0                | 0                            | 0                            | 0                     | 0     |
| Total | Average | 972                  | 263                        | 713                                      | 0                                 | 713                           | 1303                       | 605 | 57        | 599              | 704                          | 353                          | 605                   | 702   |

Detail - Historical Consumptive Use Analysis

| Dean: Historical Contingency Use Analysis |      |                   |                         |                                    |                             |                         |                            |             |           |                        |                |                        |                    |       |              |
|-------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|------------------------|----------------|------------------------|--------------------|-------|--------------|
| Month                                     | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |                        |                | Soil Moisture Contents | Estimated Crop CU  |       |              |
|                                           |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Efficiency Calculation | From Diversion |                        | From Soil Moisture | Total |              |
|                                           |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |                        |                |                        |                    |       | Non-Consumed |
| Jan                                       | 1950 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0              | 0                      | 0                  | 0     | 0            |
| Feb                                       | 1950 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0              | 0                      | 0                  | 0     | 0            |
| Mar                                       | 1950 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0              | 0                      | 0                  | 0     | 0            |
| Apr                                       | 1950 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0              | 0                      | 0                  | 0     | 0            |
| May                                       | 1950 | 77                | 36                      | 41                                 | 0                           | 41                      | 155                        | 41          | 60        | 54                     | 101            | 65                     | 213                | 41    | 0            |
| Jun                                       | 1950 | 188               | 23                      | 165                                | 0                           | 165                     | 179                        | 117         | 0         | 0                      | 117            | 65                     | 273                | 117   | 45           |
| Jul                                       | 1950 | 209               | 42                      | 167                                | 0                           | 167                     | 237                        | 154         | 0         | 0                      | 154            | 65                     | 212                | 154   | 167          |
| Aug                                       | 1950 | 151               | 66                      | 126                                | 0                           | 126                     | 307                        | 126         | 74        | 108                    | 206            | 65                     | 286                | 126   | 0            |
| Sep                                       | 1950 | 105               | 56                      | 59                                 | 0                           | 59                      | 225                        | 52          | 59        | 113                    | 110            | 49                     | 345                | 52    | 0            |
| Oct                                       | 1950 | 47                | 5                       | 42                                 | 0                           | 42                      | 147                        | 43          | 0         | 105                    | 42             | 26                     | 345                | 42    | 0            |
| Nov                                       | 1950 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0              | 0                      | 345                | 0     | 0            |
| Dec                                       | 1950 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0              | 0                      | 345                | 0     | 0            |
| Total                                     | 1950 | 821               | 230                     | 593                                | 0                           | 593                     | 1313                       | 832         | 234       | 552                    | 765            | 403                    | 532                | 61    | 593          |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        | Soil Moisture Contents | Estimated Crop CU         |                |                    |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|------------------------|---------------------------|----------------|--------------------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                        |                           |                |                    |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       |                        | Calculated Efficiency (%) | From Diversion | From Soil Moisture |
| Jan   | 1951 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                    | 0                         | 0              | 0                  |
| Feb   | 1951 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                    | 0                         | 0              | 0                  |
| Mar   | 1951 | 6                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                    | 0                         | 0              | 0                  |
| Apr   | 1951 | 4                 | 1                       | 4                                  | 0                           | 4                       | 63                         | 4           | 0         | 59           | 4                      | 6                      | 345                       | 4              | 4                  |
| May   | 1951 | 127               | 42                      | 87                                 | 0                           | 87                      | 155                        | 87          | 0         | 69           | 87                     | 56                     | 345                       | 87             | 0                  |
| Jun   | 1951 | 156               | 72                      | 124                                | 0                           | 124                     | 179                        | 117         | 0         | 63           | 117                    | 65                     | 337                       | 117            | 7                  |
| Jul   | 1951 | 241               | 45                      | 197                                | 0                           | 197                     | 237                        | 154         | 0         | 63           | 154                    | 65                     | 295                       | 154            | 42                 |
| Aug   | 1951 | 204               | 71                      | 133                                | 0                           | 133                     | 307                        | 133         | 50        | 125          | 182                    | 59                     | 345                       | 133            | 0                  |
| Sep   | 1951 | 86                | 31                      | 66                                 | 0                           | 66                      | 225                        | 66          | 0         | 159          | 66                     | 26                     | 345                       | 66             | 0                  |
| Oct   | 1951 | 31                | 6                       | 22                                 | 0                           | 22                      | 147                        | 22          | 0         | 125          | 22                     | 15                     | 345                       | 22             | 0                  |
| Nov   | 1951 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                      | 345                       | 0              | 0                  |
| Dec   | 1951 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                      | 345                       | 0              | 0                  |
| Total | 1951 | 901               | 269                     | 633                                | 0                           | 633                     | 1313                       | 583         | 50        | 683          | 632                    | 285                    | 583                       | 49             | 633                |



| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |             |           |              |                        |                           |                        |                   |                    |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|-------------------|--------------------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | NWR After Winter Precip | River Diversion Accounting |             |           |              |                        | Estimated Crop CU         |                        |                   |                    |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           |              | Efficiency Calculation |                           | Soil Moisture Contents | Estimated Crop CU |                    |
|                                              |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        | From Diversion    | From Soil Moisture |
| Jan                                          | 1956 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |
| Feb                                          | 1956 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |
| Mar                                          | 1956 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |
| Apr                                          | 1956 | 4                 | 2                       | 2                                  | 2                           | 2                       | 63                         | 2           | 61        | 2            | 3                      | 345                       | 2                      | 0                 | 2                  |
| May                                          | 1956 | 126               | 44                      | 86                                 | 0                           | 96                      | 155                        | 88          | 70        | 86           | 55                     | 345                       | 86                     | 0                 | 86                 |
| Jun                                          | 1956 | 256               | 38                      | 218                                | 0                           | 218                     | 179                        | 117         | 63        | 117          | 65                     | 243                       | 117                    | 102               | 218                |
| Jul                                          | 1956 | 249               | 62                      | 187                                | 0                           | 187                     | 337                        | 154         | 83        | 154          | 154                    | 210                       | 154                    | 33                | 187                |
| Aug                                          | 1956 | 203               | 76                      | 127                                | 0                           | 127                     | 307                        | 127         | 72        | 108          | 202                    | 283                       | 127                    | 67                | 127                |
| Sep                                          | 1956 | 131               | 6                       | 125                                | 0                           | 125                     | 113                        | 73          | 39        | 73           | 65                     | 231                       | 73                     | 52                | 125                |
| Oct                                          | 1956 | 45                | 0                       | 45                                 | 0                           | 45                      | 147                        | 49          | 47        | 52           | 96                     | 65                        | 49                     | 0                 | 49                 |
| Nov                                          | 1956 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 278                       | 0                      | 0                 | 0                  |
| Dec                                          | 1956 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 278                       | 0                      | 0                 | 0                  |
| Total                                        | 1956 | 1021              | 228                     | 754                                | 0                           | 754                     | 1201                       | 609         | 119       | 476          | 728                    | 383                       | 609                    | 187               | 754                |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | NWR After Winter Precip | River Diversion Accounting |             |           |              |                        | Estimated Crop CU         |                        |                   |                    |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|-------------------|--------------------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           |              | Efficiency Calculation |                           | Soil Moisture Contents | Estimated Crop CU |                    |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        | From Diversion    | From Soil Moisture |
| Jan   | 1957 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 278                       | 0                      | 0                 | 0                  |
| Feb   | 1957 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 278                       | 0                      | 0                 | 0                  |
| Mar   | 1957 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 278                       | 0                      | 0                 | 0                  |
| Apr   | 1957 | 4                 | 3                       | 1                                  | 0                           | 1                       | 63                         | 1           | 39        | 22           | 41                     | 317                       | 1                      | 0                 | 1                  |
| May   | 1957 | 108               | 108                     | 0                                  | 0                           | 155                     | 155                        | 0           | 28        | 127          | 28                     | 18                        | 345                    | 0                 | 0                  |
| Jun   | 1957 | 177               | 78                      | 99                                 | 0                           | 99                      | 179                        | 99          | 81        | 99           | 55                     | 345                       | 99                     | 0                 | 99                 |
| Jul   | 1957 | 276               | 276                     | 0                                  | 0                           | 276                     | 337                        | 154         | 83        | 154          | 154                    | 281                       | 154                    | 63                | 276                |
| Aug   | 1957 | 216               | 28                      | 188                                | 0                           | 188                     | 307                        | 190         | 5         | 108          | 200                    | 291                       | 190                    | 0                 | 190                |
| Sep   | 1957 | 113               | 15                      | 97                                 | 0                           | 97                      | 225                        | 340         | 49        | 79           | 147                    | 65                        | 97                     | 0                 | 97                 |
| Oct   | 1957 | 36                | 14                      | 20                                 | 0                           | 20                      | 147                        | 20          | 5         | 122          | 25                     | 17                        | 345                    | 20                | 20                 |
| Nov   | 1957 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |
| Dec   | 1957 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |
| Total | 1957 | 931               | 304                     | 625                                | 0                           | 625                     | 1319                       | 561         | 132       | 622          | 684                    | 350                       | 551                    | 63                | 625                |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |             |           |              |                        |                           |                        |                |                    |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|----------------|--------------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        | Estimated Crop CU         |                        |                |                    |       |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |
|                                              |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       | Calculated Efficiency (%) |                        |                |                    |       |
| Jan                                          | 1958 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Feb                                          | 1958 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Mar                                          | 1958 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Apr                                          | 1958 | 24                | 17                      | 7                                  | 7                           | 63                      | 7                          | 63          | 7         | 55           | 7                      | 12                        | 7                      |                |                    |       |
| May                                          | 1958 | 165               | 26                      | 140                                | 165                         | 140                     | 165                        | 101         | 54        | 101          | 85                     | 306                       | 140                    |                |                    |       |
| Jun                                          | 1958 | 177               | 87                      | 91                                 | 91                          | 91                      | 177                        | 332         | 91        | 63           | 117                    | 65                        | 91                     |                |                    |       |
| Jul                                          | 1958 | 210               | 105                     | 105                                | 0                           | 105                     | 237                        | 105         | 13        | 118          | 118                    | 50                        | 105                    |                |                    |       |
| Aug                                          | 1958 | 241               | 6                       | 235                                | 0                           | 235                     | 307                        | 200         | 108       | 200          | 65                     | 305                       | 235                    |                |                    |       |
| Sep                                          | 1958 | 135               | 0                       | 135                                | 135                         | 225                     | 135                        | 135         | 11        | 79           | 147                    | 65                        | 135                    |                |                    |       |
| Oct                                          | 1958 | 45                | 2                       | 43                                 | 0                           | 43                      | 43                         | 46          | 24        | 77           | 70                     | 48                        | 46                     |                |                    |       |
| Nov                                          | 1958 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Dec                                          | 1958 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Total                                        | 1958 | 1000              | 243                     | 756                                | 0                           | 756                     | 1313                       | 665         | 74        | 555          | 760                    | 370                       | 756                    |                |                    |       |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        | Estimated Crop CU         |                        |                |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|----------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       | Calculated Efficiency (%) |                        |                |                    |       |
| Jan   | 1959 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Feb   | 1959 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Mar   | 1959 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Apr   | 1959 | 7                 | 4                       | 3                                  | 3                           | 3                       | 3                          | 3           | 60        | 3            | 5                      | 3                         | 3                      |                |                    |       |
| May   | 1959 | 110               | 61                      | 49                                 | 0                           | 49                      | 155                        | 49          | 106       | 49           | 32                     | 345                       | 49                     |                |                    |       |
| Jun   | 1959 | 234               | 72                      | 162                                | 0                           | 162                     | 175                        | 117         | 63        | 117          | 65                     | 300                       | 162                    |                |                    |       |
| Jul   | 1959 | 263               | 26                      | 244                                | 0                           | 244                     | 237                        | 154         | 83        | 154          | 65                     | 210                       | 244                    |                |                    |       |
| Aug   | 1959 | 248               | 9                       | 239                                | 0                           | 239                     | 307                        | 200         | 108       | 200          | 65                     | 171                       | 239                    |                |                    |       |
| Sep   | 1959 | 111               | 50                      | 61                                 | 0                           | 61                      | 235                        | 61          | 83        | 147          | 65                     | 256                       | 61                     |                |                    |       |
| Oct   | 1959 | 28                | 1                       | 27                                 | 0                           | 27                      | 147                        | 27          | 69        | 52           | 98                     | 65                        | 27                     |                |                    |       |
| Nov   | 1959 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Dec   | 1959 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Total | 1959 | 1001              | 217                     | 785                                | 0                           | 785                     | 1313                       | 611         | 154       | 551          | 766                    | 302                       | 785                    |                |                    |       |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |             |           |                        |                   |                        |                           |                |                    |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|------------------------|-------------------|------------------------|---------------------------|----------------|--------------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |                        | Estimated Crop CU |                        |                           |                |                    |       |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Efficiency Calculation |                   | Soil Moisture Contents | Estimated Crop CU         |                |                    |       |
|                                              |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone | Non-Consumed           | Div to CU and SM  |                        | Calculated Efficiency (%) | From Diversion | From Soil Moisture | Total |
| Jan                                          | 1960 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0                 | 325                    | 0                         | 0              | 0                  |       |
| Feb                                          | 1960 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0                 | 325                    | 0                         | 0              | 0                  |       |
| Mar                                          | 1960 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0                 | 325                    | 0                         | 0              | 0                  |       |
| Apr                                          | 1960 | 31                | 10                      | 22                                 | 0                           | 22                      | 63                         | 22          | 19        | 22                     | 41                | 65                     | 344                       | 22             | 0                  | 22    |
| May                                          | 1960 | 135               | 49                      | 86                                 | 135                         | 66                      | 155                        | 85          | 1         | 65                     | 85                | 56                     | 345                       | 85             | 0                  | 85    |
| Jun                                          | 1960 | 200               | 55                      | 148                                | 0                           | 148                     | 179                        | 117         | 63        | 117                    | 65                | 316                    | 117                       | 29             | 145                | 0     |
| Jul                                          | 1960 | 289               | 21                      | 266                                | 0                           | 266                     | 119                        | 77          | 42        | 77                     | 65                | 125                    | 77                        | 191            | 288                | 0     |
| Aug                                          | 1960 | 224               | 34                      | 190                                | 0                           | 190                     | 154                        | 100         | 54        | 100                    | 65                | 35                     | 100                       | 91             | 191                | 0     |
| Sep                                          | 1960 | 134               | 16                      | 119                                | 0                           | 119                     | 113                        | 73          | 39        | 73                     | 65                | 73                     | 73                        | 35             | 108                | 0     |
| Oct                                          | 1960 | 46                | 0                       | 46                                 | 0                           | 46                      | 147                        | 46          | 43        | 52                     | 96                | 65                     | 46                        | 46             | 0                  | 46    |
| Nov                                          | 1960 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0                 | 49                     | 0                         | 0              | 0                  | 0     |
| Dec                                          | 1960 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0                 | 49                     | 0                         | 0              | 0                  | 0     |
| Total                                        | 1960 | 1035              | 185                     | 877                                | 0                           | 877                     | 530                        | 521         | 69        | 341                    | 590               | 445                    | 521                       | 346            | 866                | 0     |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |                        | Estimated Crop CU |                        |                           |                |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|------------------------|-------------------|------------------------|---------------------------|----------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Efficiency Calculation |                   | Soil Moisture Contents | Estimated Crop CU         |                |                    |       |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone | Non-Consumed           | Div to CU and SM  |                        | Calculated Efficiency (%) | From Diversion | From Soil Moisture | Total |
| Jan   | 1961 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0                 | 49                     | 0                         | 0              | 0                  | 0     |
| Feb   | 1961 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0                 | 49                     | 0                         | 0              | 0                  | 0     |
| Mar   | 1961 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0                 | 49                     | 0                         | 0              | 0                  | 0     |
| Apr   | 1961 | 6                 | 3                       | 3                                  | 0                           | 3                       | 31                         | 3           | 17        | 11                     | 20                | 65                     | 67                        | 3              | 0                  | 3     |
| May   | 1961 | 125               | 28                      | 96                                 | 0                           | 96                      | 78                         | 50          | 50        | 27                     | 50                | 65                     | 21                        | 50             | 48                 | 98    |
| Jun   | 1961 | 244               | 22                      | 222                                | 0                           | 222                     | 54                         | 56          | 56        | 31                     | 58                | 65                     | 0                         | 58             | 21                 | 79    |
| Jul   | 1961 | 258               | 99                      | 159                                | 0                           | 159                     | 119                        | 77          | 77        | 42                     | 77                | 65                     | 0                         | 77             | 0                  | 77    |
| Aug   | 1961 | 260               | 12                      | 248                                | 0                           | 248                     | 154                        | 100         | 54        | 100                    | 65                | 6                      | 100                       | 0              | 100                | 0     |
| Sep   | 1961 | 97                | 21                      | 76                                 | 0                           | 76                      | 113                        | 73          | 38        | 73                     | 65                | 73                     | 73                        | 0              | 73                 | 0     |
| Oct   | 1961 | 36                | 11                      | 27                                 | 0                           | 27                      | 74                         | 27          | 21        | 26                     | 48                | 65                     | 21                        | 27             | 0                  | 27    |
| Nov   | 1961 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0                 | 0                      | 21                        | 0              | 0                  | 0     |
| Dec   | 1961 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0                      | 0                 | 0                      | 21                        | 0              | 0                  | 0     |
| Total | 1961 | 1028              | 158                     | 870                                | 0                           | 870                     | 659                        | 368         | 35        | 230                    | 426               | 455                    | 336                       | 67             | 403                | 0     |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |             |                  |              |                           |                        |                   |                    |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|------------------|--------------|---------------------------|------------------------|-------------------|--------------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EQM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |                  |              |                           | Soil Moisture Contents | Estimated Crop CU |                    |       |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |                  | Non-Consumed | Efficiency Calculation    |                        | From Diversion    | From Soil Moisture | Total |
|                                              |      |                   |                         |                                    |                             |                         | CU                         | Soil Zone   | Div to CU and SM |              | Calculated Efficiency (%) |                        |                   |                    |       |
| Jan                                          | 1962 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0                | 0            | 0                         | 21                     | 0                 | 0                  |       |
| Feb                                          | 1962 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0                | 0            | 0                         | 21                     | 0                 | 0                  |       |
| Mar                                          | 1962 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0                | 0            | 0                         | 21                     | 0                 | 0                  |       |
| Apr                                          | 1962 | 46                | 0                       | 38                                 | 38                          | 38                      | 20                         | 0           | 11               | 20           | 65                        | 3                      | 20                | 18                 |       |
| May                                          | 1962 | 143               | 10                      | 133                                | 10                          | 10                      | 10                         | 90          | 54               | 101          | 69                        | 93                     | 10                | 10                 |       |
| Jun                                          | 1962 | 184               | 93                      | 93                                 | 105                         | 0                       | 105                        | 105         | 12               | 63           | 117                       | 105                    | 105               | 0                  |       |
| Jul                                          | 1962 | 227               | 109                     | 118                                | 118                         | 0                       | 118                        | 118         | 37               | 83           | 154                       | 85                     | 142               | 0                  |       |
| Aug                                          | 1962 | 215               | 167                     | 118                                | 187                         | 187                     | 187                        | 12          | 108              | 230          | 65                        | 154                    | 187               | 0                  |       |
| Sep                                          | 1962 | 118               | 103                     | 103                                | 103                         | 147                     | 78                         | 103         | 44               | 78           | 147                       | 196                    | 103               | 0                  |       |
| Oct                                          | 1962 | 48                | 21                      | 27                                 | 48                          | 2                       | 27                         | 69          | 52               | 96           | 65                        | 267                    | 27                | 0                  |       |
| Nov                                          | 1962 | 2                 | 0                       | 2                                  | 0                           | 2                       | 0                          | 0           | 0                | 0            | 0                         | 265                    | 2                 | 0                  |       |
| Dec                                          | 1962 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0                | 0            | 0                         | 265                    | 0                 | 0                  |       |
| Total                                        | 1962 | 997               | 407                     | 590                                | 590                         | 590                     | 570                        | 204         | 450              | 835          | 450                       | 570                    | 570               | 20                 |       |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EQM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        |                           | Estimated Crop CU      |                |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|----------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       | Calculated Efficiency (%) |                        |                |                    |       |
| Jan   | 1963 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 265                       | 0                      | 0              | 0                  | 0     |
| Feb   | 1963 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 265                       | 0                      | 0              | 0                  | 0     |
| Mar   | 1963 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 265                       | 0                      | 0              | 0                  | 0     |
| Apr   | 1963 | 16                | 15                      | 1                                  | 1                           | 63                      | 1                          | 39          | 22        | 41           | 65                     | 324                       | 0                      | 0              | 0                  | 1     |
| May   | 1963 | 135               | 27                      | 108                                | 108                         | 155                     | 101                        | 54          | 101       | 65           | 237                    | 101                       | 101                    | 7              | 108                | 0     |
| Jun   | 1963 | 219               | 126                     | 92                                 | 92                          | 269                     | 92                         | 47          | 129       | 140          | 52                     | 385                       | 92                     | 92             | 0                  | 0     |
| Jul   | 1963 | 265               | 58                      | 210                                | 210                         | 327                     | 154                        | 83          | 154       | 65           | 289                    | 154                       | 154                    | 52             | 210                | 0     |
| Aug   | 1963 | 234               | 36                      | 198                                | 198                         | 307                     | 198                        | 2           | 108       | 200          | 65                     | 291                       | 198                    | 198            | 0                  | 0     |
| Sep   | 1963 | 140               | 26                      | 120                                | 140                         | 225                     | 120                        | 26          | 79        | 147          | 65                     | 317                       | 120                    | 120            | 0                  | 0     |
| Oct   | 1963 | 64                | 11                      | 53                                 | 53                          | 147                     | 53                         | 28          | 57        | 61           | 56                     | 345                       | 53                     | 53             | 0                  | 0     |
| Nov   | 1963 | 3                 | 0                       | 3                                  | 3                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 342                       | 0                      | 0              | 3                  | 3     |
| Dec   | 1963 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 342                       | 0                      | 0              | 0                  | 0     |
| Total | 1963 | 1088              | 322                     | 765                                | 765                         | 1403                    | 715                        | 142         | 542       | 864          | 432                    | 719                       | 719                    | 65             | 735                | 0     |



| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |           |              |                        |                           |                        |                |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----------|--------------|------------------------|---------------------------|------------------------|----------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |           |              |                        |                           | Estimated Crop CU      |                |       |
|                                              |      |                   |                         |                                    |                             | Historical Diversion    | Destination                |           |              | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | Total |
|                                              |      |                   |                         |                                    |                             |                         | CU                         | Soil Zone | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        |                |       |
|                                              |      |                   |                         |                                    |                             |                         |                            |           |              |                        |                           |                        |                |       |
| Jan                                          | 1964 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0              | 0     |
| Feb                                          | 1964 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0              | 0     |
| Mar                                          | 1964 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0              | 0     |
| Apr                                          | 1964 | 26                | 0                       | 19                                 | 0                           | 19                      | 63                         | 19        | 2            | 41                     | 22                        | 35                     | 19             | 19    |
| May                                          | 1964 | 144               | 56                      | 88                                 | 0                           | 88                      | 155                        | 88        | 0            | 67                     | 88                        | 57                     | 88             | 88    |
| Jun                                          | 1964 | 196               | 106                     | 69                                 | 196                         | 85                      | 179                        | 85        | 0            | 56                     | 89                        | 50                     | 89             | 89    |
| Jul                                          | 1964 | 288               | 23                      | 265                                | 0                           | 265                     | 237                        | 154       | 63           | 154                    | 253                       | 154                    | 111            | 253   |
| Aug                                          | 1964 | 203               | 48                      | 155                                | 0                           | 155                     | 307                        | 155       | 44           | 108                    | 200                       | 65                     | 278            | 155   |
| Sep                                          | 1964 | 112               | 15                      | 97                                 | 0                           | 97                      | 225                        | 97        | 50           | 79                     | 147                       | 65                     | 326            | 97    |
| Oct                                          | 1964 | 46                | 4                       | 37                                 | 0                           | 37                      | 147                        | 37        | 17           | 93                     | 54                        | 37                     | 37             | 37    |
| Nov                                          | 1964 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0              | 0     |
| Dec                                          | 1964 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0              | 0     |
| Total                                        | 1964 | 1013              | 253                     | 751                                | 0                           | 751                     | 1313                       | 640       | 114          | 561                    | 754                       | 374                    | 840            | 751   |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |           |              |                        |                           | Estimated Crop CU      |                |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----------|--------------|------------------------|---------------------------|------------------------|----------------|-------|
|       |      |                   |                         |                                    |                             | Historical Diversion    | Destination                |           |              | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | Total |
|       |      |                   |                         |                                    |                             |                         | CU                         | Soil Zone | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        |                |       |
|       |      |                   |                         |                                    |                             |                         |                            |           |              |                        |                           |                        |                |       |
| Jan   | 1965 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0              | 0     |
| Feb   | 1965 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0              | 0     |
| Mar   | 1965 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0              | 0     |
| Apr   | 1965 | 21                | 0                       | 13                                 | 0                           | 13                      | 63                         | 13        | 0            | 50                     | 13                        | 20                     | 13             | 13    |
| May   | 1965 | 122               | 83                      | 109                                | 0                           | 109                     | 233                        | 109       | 0            | 233                    | 109                       | 0                      | 0              | 0     |
| Jun   | 1965 | 192               | 83                      | 109                                | 192                         | 105                     | 269                        | 109       | 0            | 163                    | 105                       | 41                     | 345            | 109   |
| Jul   | 1965 | 250               | 17                      | 233                                | 0                           | 233                     | 310                        | 202       | 202          | 63                     | 314                       | 202                    | 31             | 233   |
| Aug   | 1965 | 212               | 39                      | 173                                | 0                           | 173                     | 310                        | 173       | 28           | 109                    | 202                       | 65                     | 342            | 173   |
| Sep   | 1965 | 21                | 50                      | 43                                 | 0                           | 43                      | 300                        | 43        | 3            | 255                    | 46                        | 15                     | 345            | 43    |
| Oct   | 1965 | 46                | 7                       | 41                                 | 0                           | 41                      | 221                        | 41        | 0            | 180                    | 41                        | 18                     | 345            | 41    |
| Nov   | 1965 | 1                 | 0                       | 1                                  | 0                           | 1                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0              | 0     |
| Dec   | 1965 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0              | 0     |
| Total | 1965 | 919               | 386                     | 613                                | 613                         | 613                     | 1706                       | 581       | 31           | 1028                   | 613                       | 224                    | 551            | 613   |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |     |           |                        |                  |                           |                        |                    |                    |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----|-----------|------------------------|------------------|---------------------------|------------------------|--------------------|--------------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EQM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |     |           |                        |                  |                           | Estimated Crop CU      |                    |                    |       |
|                                              |      |                   |                         |                                    |                             |                         | Destination                |     |           | Efficiency Calculation |                  |                           | Soil Moisture Contents | From Soil Moisture |                    |       |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | CU  | Soil Zone | Non-Consumed           | Div to CU and SM | Calculated Efficiency (%) |                        | From Diversion     | From Soil Moisture | Total |
| Jan                                          | 1966 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0                      | 0                | 0                         | 344                    | 0                  | 0                  | 0     |
| Feb                                          | 1966 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0                      | 0                | 0                         | 344                    | 0                  | 0                  | 0     |
| Mar                                          | 1966 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0                      | 0                | 0                         | 344                    | 0                  | 0                  | 0     |
| Apr                                          | 1966 | 3                 | 2                       | 1                                  | 0                           | 1                       | 63                         | 1   | 1         | 81                     | 2                | 3                         | 345                    | 1                  | 0                  | 1     |
| May                                          | 1966 | 120               | 6                       | 114                                | 0                           | 114                     | 155                        | 101 | 54        | 101                    | 65               | 332                       | 332                    | 101                | 13                 | 114   |
| Jun                                          | 1966 | 198               | 34                      | 164                                | 0                           | 164                     | 179                        | 117 | 63        | 117                    | 65               | 284                       | 284                    | 117                | 48                 | 184   |
| Jul                                          | 1966 | 286               | 108                     | 180                                | 0                           | 180                     | 237                        | 154 | 63        | 154                    | 65               | 258                       | 258                    | 154                | 26                 | 180   |
| Aug                                          | 1966 | 180               | 75                      | 105                                | 0                           | 105                     | 307                        | 105 | 86        | 116                    | 192              | 62                        | 345                    | 105                | 6                  | 105   |
| Sep                                          | 1966 | 63                | 60                      | 63                                 | 0                           | 63                      | 225                        | 83  | 63        | 163                    | 83               | 26                        | 345                    | 83                 | 6                  | 63    |
| Oct                                          | 1966 | 38                | 17                      | 21                                 | 0                           | 21                      | 147                        | 21  | 126       | 126                    | 21               | 14                        | 345                    | 21                 | 0                  | 21    |
| Nov                                          | 1966 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0                      | 0                | 0                         | 345                    | 0                  | 0                  | 0     |
| Dec                                          | 1966 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0                      | 0                | 0                         | 345                    | 0                  | 0                  | 0     |
| Total                                        | 1966 | 950               | 302                     | 648                                | 0                           | 648                     | 1313                       | 562 | 87        | 662                    | 662              | 302                       | 345                    | 562                | 87                 | 648   |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EQM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |           |              |                        |                           | Estimated Crop CU      |                |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----------|--------------|------------------------|---------------------------|------------------------|----------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Destination                |           |              | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |
|       |      |                   |                         |                                    |                             |                         | CU                         | Soil Zone | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        |                |                    |       |
| Jan   | 1967 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 345                       | 0                      | 0              | 0                  | 0     |
| Feb   | 1967 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 345                       | 0                      | 0              | 0                  | 0     |
| Mar   | 1967 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 345                       | 0                      | 0              | 0                  | 0     |
| Apr   | 1967 | 7                 | 7                       | 0                                  | 0                           | 0                       | 63                         | 0         | 0            | 63                     | 0                         | 0                      | 0              | 0                  | 0     |
| May   | 1967 | 66                | 42                      | 26                                 | 0                           | 26                      | 155                        | 26        | 130          | 130                    | 26                        | 17                     | 345            | 26                 | 26    |
| Jun   | 1967 | 181               | 137                     | 25                                 | 0                           | 25                      | 179                        | 25        | 158          | 158                    | 25                        | 14                     | 345            | 25                 | 23    |
| Jul   | 1967 | 237               | 30                      | 207                                | 0                           | 207                     | 310                        | 109       | 202          | 109                    | 202                       | 65                     | 339            | 202                | 6     |
| Aug   | 1967 | 212               | 25                      | 186                                | 0                           | 186                     | 307                        | 198       | 116          | 198                    | 192                       | 62                     | 345            | 192                | 6     |
| Sep   | 1967 | 133               | 47                      | 86                                 | 0                           | 86                      | 225                        | 86        | 139          | 139                    | 86                        | 35                     | 345            | 86                 | 86    |
| Oct   | 1967 | 42                | 3                       | 39                                 | 0                           | 39                      | 147                        | 39        | 108          | 108                    | 29                        | 27                     | 345            | 39                 | 39    |
| Nov   | 1967 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 345            | 0                  | 0     |
| Dec   | 1967 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 345            | 0                  | 0     |
| Total | 1967 | 862               | 251                     | 559                                | 0                           | 569                     | 1386                       | 564       | 820          | 570                    | 223                       | 0                      | 345            | 564                | 6     |

| Detail - Historical Consumptive Use Analysis |              |                   |                           |                                    |                             |                         |                            |     |             |     |                        |                        |                   |                    |       |     |
|----------------------------------------------|--------------|-------------------|---------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----|-------------|-----|------------------------|------------------------|-------------------|--------------------|-------|-----|
| Month                                        | Year         | Potential Crop ET | Effective Precipitation   | Irrigation Water Requirement (IWR) | EQM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |     |             |     |                        | Soil Moisture Contents | Estimated Crop CU |                    |       |     |
|                                              |              |                   |                           |                                    |                             |                         | Historical Diversion       | CU  | Destination |     | Efficiency Calculation |                        | From Diversion    | From Soil Moisture | Total |     |
| Soil Zone                                    | Non-Consumed | Div to CU and SM  | Calculated Efficiency (%) |                                    |                             |                         |                            |     |             |     |                        |                        |                   |                    |       |     |
| Jan                                          | 1960         | 0                 | 0                         | 0                                  | 0                           | 0                       | 0                          | 0   | 0           | 0   | 0                      | 345                    | 0                 | 0                  | 0     |     |
| Feb                                          | 1960         | 0                 | 0                         | 0                                  | 0                           | 0                       | 0                          | 0   | 0           | 0   | 0                      | 345                    | 0                 | 0                  | 0     |     |
| Mar                                          | 1960         | 0                 | 0                         | 0                                  | 0                           | 0                       | 0                          | 0   | 0           | 0   | 0                      | 345                    | 0                 | 0                  | 0     |     |
| Apr                                          | 1960         | 4                 | 3                         | 2                                  | 2                           | 0                       | 63                         | 2   | 0           | 61  | 2                      | 3                      | 345               | 2                  | 0     | 2   |
| May                                          | 1960         | 62                | 27                        | 55                                 | 55                          | 0                       | 155                        | 55  | 0           | 101 | 55                     | 35                     | 345               | 55                 | 0     | 55  |
| Jun                                          | 1960         | 146               | 146                       | 36                                 | 36                          | 0                       | 175                        | 36  | 0           | 144 | 36                     | 20                     | 345               | 36                 | 0     | 36  |
| Jul                                          | 1960         | 163               | 63                        | 163                                | 0                           | 163                     | 237                        | 154 | 0           | 83  | 154                    | 65                     | 336               | 154                | 0     | 163 |
| Aug                                          | 1960         | 137               | 50                        | 127                                | 0                           | 127                     | 307                        | 127 | 0           | 171 | 127                    | 44                     | 345               | 127                | 0     | 127 |
| Sep                                          | 1960         | 115               | 20                        | 95                                 | 0                           | 95                      | 225                        | 95  | 0           | 130 | 95                     | 35                     | 345               | 95                 | 0     | 95  |
| Oct                                          | 1960         | 43                | 0                         | 42                                 | 0                           | 42                      | 147                        | 42  | 0           | 105 | 42                     | 23                     | 345               | 42                 | 0     | 42  |
| Nov                                          | 1960         | 0                 | 0                         | 0                                  | 0                           | 0                       | 0                          | 0   | 0           | 0   | 0                      | 0                      | 345               | 0                  | 0     | 0   |
| Dec                                          | 1960         | 0                 | 0                         | 0                                  | 0                           | 0                       | 0                          | 0   | 0           | 0   | 0                      | 0                      | 345               | 0                  | 0     | 0   |
| Total                                        | 1960         | 839               | 319                       | 520                                | 0                           | 520                     | 1313                       | 511 | 0           | 785 | 520                    | 238                    | 0                 | 511                | 0     | 520 |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EQM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |           |              |                  |                           |                        | Estimated Crop CU |                        |                |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----------|--------------|------------------|---------------------------|------------------------|-------------------|------------------------|----------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | CU        |              | Destination      |                           | Efficiency Calculation |                   | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |
|       |      |                   |                         |                                    |                             |                         |                            | Soil Zone | Non-Consumed | Div to CU and SM | Calculated Efficiency (%) |                        |                   |                        |                |                    |       |
| Jan   | 1961 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                | 0                         | 0                      | 345               | 0                      | 0              | 0                  |       |
| Feb   | 1961 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                | 0                         | 0                      | 345               | 0                      | 0              | 0                  |       |
| Mar   | 1961 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                | 0                         | 0                      | 345               | 0                      | 0              | 0                  |       |
| Apr   | 1961 | 45                | 18                      | 30                                 | 0                           | 30                      | 63                         | 30        | 0            | 32               | 30                        | 48                     | 345               | 30                     | 0              | 30                 |       |
| May   | 1961 | 136               | 49                      | 85                                 | 0                           | 85                      | 155                        | 85        | 0            | 68               | 85                        | 57                     | 345               | 85                     | 0              | 85                 |       |
| Jun   | 1961 | 180               | 160                     | 112                                | 0                           | 112                     | 179                        | 112       | 0            | 67               | 112                       | 63                     | 345               | 112                    | 0              | 112                |       |
| Jul   | 1961 | 240               | 145                     | 96                                 | 0                           | 96                      | 237                        | 96        | 0            | 142              | 96                        | 40                     | 345               | 96                     | 0              | 96                 |       |
| Aug   | 1961 | 234               | 7                       | 227                                | 0                           | 227                     | 307                        | 227       | 0            | 108              | 227                       | 65                     | 318               | 227                    | 0              | 227                |       |
| Sep   | 1961 | 140               | 7                       | 133                                | 0                           | 133                     | 225                        | 133       | 0            | 75               | 133                       | 85                     | 332               | 133                    | 0              | 133                |       |
| Oct   | 1961 | 25                | 7                       | 17                                 | 0                           | 17                      | 147                        | 17        | 0            | 117              | 17                        | 31                     | 345               | 17                     | 0              | 17                 |       |
| Nov   | 1961 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                | 0                         | 0                      | 345               | 0                      | 0              | 0                  |       |
| Dec   | 1961 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                | 0                         | 0                      | 345               | 0                      | 0              | 0                  |       |
| Total | 1961 | 904               | 281                     | 704                                | 0                           | 704                     | 1313                       | 677       | 0            | 611              | 705                       | 359                    | 0                 | 677                    | 27             | 704                |       |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |             |           |              |                        |                           |                |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|----------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              | Soil Moisture Contents | Estimated Crop CU         |                |       |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                           | From Diversion | Total |
|                                              |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       | Calculated Efficiency (%) |                |       |
| Jan                                          | 1970 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0              | 0     |
| Feb                                          | 1970 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0              | 0     |
| Mar                                          | 1970 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0              | 0     |
| Apr                                          | 1970 | 3                 | 0                       | 0                                  | 0                           | 0                       | 63                         | 0           | 0         | 63           | 0                      | 0                         | 0              | 0     |
| May                                          | 1970 | 118               | 48                      | 71                                 | 0                           | 71                      | 155                        | 71          | 0         | 85           | 71                     | 45                        | 71             | 71    |
| Jun                                          | 1970 | 200               | 54                      | 146                                | 0                           | 146                     | 179                        | 117         | 0         | 63           | 117                    | 65                        | 117            | 146   |
| Jul                                          | 1970 | 255               | 30                      | 224                                | 0                           | 224                     | 237                        | 154         | 0         | 83           | 154                    | 65                        | 154            | 224   |
| Aug                                          | 1970 | 234               | 19                      | 215                                | 0                           | 215                     | 307                        | 200         | 0         | 108          | 200                    | 65                        | 230            | 215   |
| Sep                                          | 1970 | 76                | 34                      | 42                                 | 0                           | 42                      | 78                         | 78          | 0         | 69           | 78                     | 65                        | 78             | 78    |
| Oct                                          | 1970 | 20                | 12                      | 8                                  | 0                           | 8                       | 147                        | 16          | 0         | 47           | 34                     | 42                        | 16             | 16    |
| Nov                                          | 1970 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0              | 0     |
| Dec                                          | 1970 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0              | 0     |
| Total                                        | 1970 | 650               | 200                     | 751                                | 0                           | 751                     | 1313                       | 636         | 116       | 565          | 752                    | 347                       | 636            | 751   |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              | Soil Moisture Contents | Estimated Crop CU         |                |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|----------------|-------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                           | From Diversion | Total |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       | Calculated Efficiency (%) |                |       |
| Jan   | 1971 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0              | 0     |
| Feb   | 1971 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0              | 0     |
| Mar   | 1971 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0              | 0     |
| Apr   | 1971 | 12                | 10                      | 2                                  | 0                           | 2                       | 94                         | 2           | 0         | 92           | 2                      | 2                         | 2              | 2     |
| May   | 1971 | 117               | 42                      | 75                                 | 0                           | 42                      | 155                        | 42          | 0         | 113          | 42                     | 27                        | 42             | 42    |
| Jun   | 1971 | 205               | 48                      | 156                                | 0                           | 156                     | 179                        | 117         | 0         | 63           | 117                    | 65                        | 117            | 156   |
| Jul   | 1971 | 217               | 58                      | 178                                | 0                           | 178                     | 237                        | 154         | 0         | 83           | 154                    | 65                        | 154            | 178   |
| Aug   | 1971 | 235               | 14                      | 221                                | 0                           | 221                     | 307                        | 200         | 0         | 108          | 200                    | 65                        | 200            | 221   |
| Sep   | 1971 | 105               | 49                      | 56                                 | 0                           | 56                      | 225                        | 66          | 0         | 65           | 84                     | 63                        | 56             | 56    |
| Oct   | 1971 | 31                | 20                      | 11                                 | 0                           | 11                      | 221                        | 11          | 0         | 210          | 11                     | 5                         | 11             | 11    |
| Nov   | 1971 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0              | 0     |
| Dec   | 1971 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0              | 0     |
| Total | 1971 | 522               | 255                     | 688                                | 0                           | 688                     | 1418                       | 582         | 65        | 753          | 687                    | 297                       | 582            | 688   |



Detail - Historical Consumptive Use Analysis

ET Precip Req'd Winter Precip Soil Moisture

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |             |           |              |                        |                        |                   |                    |       |                           |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|------------------------|-------------------|--------------------|-------|---------------------------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        | Soil Moisture Contents | Estimated Crop CU |                    |       |                           |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                        | From Diversion    | From Soil Moisture | Total |                           |
|                                              |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       |                        |                   |                    |       | Calculated Efficiency (%) |
| Jan                                          | 1972 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 34.5                   | 0                 | 0                  | 0     |                           |
| Feb                                          | 1972 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 34.5                   | 0                 | 0                  | 0     |                           |
| Mar                                          | 1972 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 34.5                   | 0                 | 0                  | 0     |                           |
| Apr                                          | 1972 | 8                 | 6                       | 2                                  | 0                           | 2                       | 63                         | 2           | 63        | 61           | 2                      | 34.5                   | 2                 | 0                  | 2     |                           |
| May                                          | 1972 | 123               | 67                      | 57                                 | 0                           | 57                      | 155                        | 57          | 95        | 95           | 57                     | 36                     | 34.5              | 57                 | 0     |                           |
| Jun                                          | 1972 | 193               | 94                      | 59                                 | 0                           | 59                      | 179                        | 59          | 60        | 60           | 99                     | 55                     | 34.5              | 99                 | 0     |                           |
| Jul                                          | 1972 | 154               | 43                      | 157                                | 0                           | 157                     | 237                        | 154         | 83        | 154          | 154                    | 65                     | 34.5              | 154                | 0     |                           |
| Aug                                          | 1972 | 261               | 61                      | 140                                | 0                           | 140                     | 307                        | 140         | 3         | 165          | 142                    | 48                     | 34.5              | 140                | 0     |                           |
| Sep                                          | 1972 | 114               | 4                       | 110                                | 0                           | 110                     | 225                        | 110         | 116       | 110          | 110                    | 49                     | 34.5              | 110                | 0     |                           |
| Oct                                          | 1972 | 27                | 7                       | 20                                 | 0                           | 20                      | 147                        | 20          | 0         | 128          | 20                     | 13                     | 34.5              | 20                 | 0     |                           |
| Nov                                          | 1972 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                      | 34.5              | 0                  | 0     |                           |
| Dec                                          | 1972 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                      | 34.5              | 0                  | 0     |                           |
| Total                                        | 1972 | 605               | 282                     | 553                                | 0                           | 525                     | 1313                       | 592         | 3         | 732          | 594                    | 266                    | 583               | 3                  | 585   |                           |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        | Soil Moisture Contents | Estimated Crop CU |                    |       |                           |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|------------------------|-------------------|--------------------|-------|---------------------------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           |              | Efficiency Calculation |                        | From Diversion    | From Soil Moisture | Total |                           |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone | Non-Consumed | Div to CU and SM       |                        |                   |                    |       | Calculated Efficiency (%) |
| Jan   | 1973 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                    | 0                 | 0                  | 0     |                           |
| Feb   | 1973 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                    | 0                 | 0                  | 0     |                           |
| Mar   | 1973 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                    | 0                 | 0                  | 0     |                           |
| Apr   | 1973 | 5                 | 5                       | 1                                  | 1                           | 1                       | 63                         | 1           | 61        | 1            | 2                      | 345                    | 1                 | 1                  | 1     |                           |
| May   | 1973 | 109               | 46                      | 63                                 | 63                          | 63                      | 165                        | 63          | 92        | 63           | 40                     | 345                    | 63                | 63                 | 63    |                           |
| Jun   | 1973 | 177               | 16                      | 177                                | 0                           | 177                     | 179                        | 117         | 63        | 117          | 65                     | 234                    | 117               | 60                 | 177   |                           |
| Jul   | 1973 | 238               | 40                      | 156                                | 0                           | 156                     | 237                        | 154         | 83        | 154          | 65                     | 241                    | 154               | 44                 | 198   |                           |
| Aug   | 1973 | 217               | 21                      | 200                                | 0                           | 200                     | 307                        | 200         | 108       | 200          | 65                     | 224                    | 200               | 17                 | 217   |                           |
| Sep   | 1973 | 103               | 31                      | 72                                 | 0                           | 72                      | 225                        | 72          | 75        | 75           | 147                    | 65                     | 72                | 0                  | 72    |                           |
| Oct   | 1973 | 41                | 16                      | 25                                 | 0                           | 25                      | 147                        | 25          | 47        | 76           | 72                     | 49                     | 25                | 0                  | 25    |                           |
| Nov   | 1973 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                    | 0                 | 0                  | 0     |                           |
| Dec   | 1973 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                    | 0                 | 0                  | 0     |                           |
| Total | 1973 | 928               | 176                     | 753                                | 0                           | 753                     | 1313                       | 632         | 122       | 562          | 754                    | 351                    | 632               | 121                | 753   |                           |

| Detail - Historical Consumptive Use Analysis |      |                           |                         |                                    |                             |                         |                            |             |           |              |                        |       |
|----------------------------------------------|------|---------------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|-------|
| Month                                        | Year | Potential Crop ET         | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              | Estimated Crop CU      |       |
|                                              |      |                           |                         |                                    |                             |                         | Historical Diversion       | Destination |           |              | Soil Moisture Contents | Total |
|                                              |      |                           |                         |                                    |                             |                         |                            | CU          | Soil Zone | Non-Consumed |                        |       |
|                                              |      |                           |                         |                                    |                             |                         |                            |             |           |              |                        |       |
|                                              |      |                           |                         |                                    |                             |                         |                            |             |           |              |                        |       |
|                                              |      |                           |                         |                                    |                             |                         |                            |             |           |              |                        |       |
| Div to CU and SM                             |      | Calculated Efficiency (%) |                         |                                    |                             |                         |                            |             |           |              |                        |       |
| Jan                                          | 1978 | 0                         | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0     |
| Feb                                          | 1978 | 0                         | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0     |
| Mar                                          | 1978 | 0                         | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0     |
| Apr                                          | 1978 | 13                        | 0                       | 0                                  | 5                           | 5                       | 63                         | 5           | 58        | 5            | 5                      | 0     |
| May                                          | 1978 | 124                       | 65                      | 59                                 | 0                           | 59                      | 233                        | 59          | 174       | 25           | 59                     | 59    |
| Jun                                          | 1978 | 196                       | 102                     | 146                                | 146                         | 146                     | 178                        | 117         | 63        | 117          | 117                    | 25    |
| Jul                                          | 1978 | 241                       | 102                     | 139                                | 0                           | 139                     | 237                        | 139         | 15        | 65           | 139                    | 0     |
| Aug                                          | 1978 | 205                       | 37                      | 165                                | 0                           | 165                     | 307                        | 165         | 14        | 59           | 159                    | 0     |
| Sep                                          | 1978 | 148                       | 2                       | 145                                | 145                         | 145                     | 225                        | 145         | 80        | 145          | 145                    | 0     |
| Oct                                          | 1978 | 43                        | 2                       | 41                                 | 0                           | 41                      | 147                        | 41          | 107       | 41           | 41                     | 41    |
| Nov                                          | 1978 | 0                         | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0     |
| Dec                                          | 1978 | 0                         | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0     |
| Total                                        | 1978 | 970                       | 263                     | 703                                | 0                           | 703                     | 1391                       | 674         | 26        | 656          | 674                    | 25    |
|                                              |      |                           |                         |                                    |                             |                         |                            |             |           |              |                        |       |
| Month                                        | Year | Potential Crop ET         | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              | Estimated Crop CU      |       |
|                                              |      |                           |                         |                                    |                             |                         | Historical Diversion       | Destination |           |              | Soil Moisture Contents | Total |
|                                              |      |                           |                         |                                    |                             |                         |                            | CU          | Soil Zone | Non-Consumed |                        |       |
|                                              |      |                           |                         |                                    |                             |                         |                            |             |           |              |                        |       |
|                                              |      |                           |                         |                                    |                             |                         |                            |             |           |              |                        |       |
|                                              |      |                           |                         |                                    |                             |                         |                            |             |           |              |                        |       |
| Div to CU and SM                             |      | Calculated Efficiency (%) |                         |                                    |                             |                         |                            |             |           |              |                        |       |
| Jan                                          | 1979 | 0                         | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0     |
| Feb                                          | 1979 | 0                         | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0     |
| Mar                                          | 1979 | 0                         | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0     |
| Apr                                          | 1979 | 5                         | 1                       | 0                                  | 0                           | 0                       | 63                         | 0           | 54        | 0            | 0                      | 0     |
| May                                          | 1979 | 111                       | 25                      | 87                                 | 0                           | 87                      | 155                        | 87          | 69        | 87           | 87                     | 0     |
| Jun                                          | 1979 | 188                       | 65                      | 113                                | 113                         | 113                     | 178                        | 113         | 66        | 113          | 63                     | 113   |
| Jul                                          | 1979 | 236                       | 102                     | 134                                | 0                           | 134                     | 237                        | 134         | 103       | 134          | 57                     | 0     |
| Aug                                          | 1979 | 197                       | 57                      | 140                                | 0                           | 140                     | 307                        | 140         | 166       | 140          | 45                     | 0     |
| Sep                                          | 1979 | 148                       | 0                       | 148                                | 148                         | 148                     | 225                        | 147         | 79        | 147          | 65                     | 344   |
| Oct                                          | 1979 | 44                        | 11                      | 33                                 | 0                           | 33                      | 147                        | 33          | 113       | 35           | 23                     | 33    |
| Nov                                          | 1979 | 0                         | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0     |
| Dec                                          | 1979 | 0                         | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0     |
| Total                                        | 1979 | 843                       | 281                     | 663                                | 0                           | 663                     | 1313                       | 662         | 652       | 664          | 662                    | 1     |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |           |              |                        |                           |                        |                   |                    |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----------|--------------|------------------------|---------------------------|------------------------|-------------------|--------------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | ECM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |           |              |                        |                           | Soil Moisture Contents | Estimated Crop CU |                    |       |
|                                              |      |                   |                         |                                    |                             |                         | Destination                |           |              | Efficiency Calculation |                           |                        | From Diversion    | From Soil Moisture | Total |
|                                              |      |                   |                         |                                    |                             |                         | CU                         | Soil Zone | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        |                   |                    |       |
| Jan                                          | 1962 |                   | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0                 | 0                  |       |
| Feb                                          | 1960 |                   | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0                 | 0                  |       |
| Mar                                          | 1960 |                   | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 0                         | 0                      | 0                 | 0                  |       |
| Apr                                          | 1960 | 43                | 12                      | 31                                 | 31                          | 31                      | 63                         | 31        | 31           | 50                     | 345                       | 31                     | 0                 | 31                 |       |
| May                                          | 1960 | 36                | 102                     | 102                                | 155                         | 102                     | 54                         | 101       | 65           | 344                    | 102                       | 1                      | 102               | 0                  |       |
| Jun                                          | 1960 | 211               | 110                     | 101                                | 179                         | 101                     | 76                         | 101       | 86           | 345                    | 101                       | 0                      | 101               | 0                  |       |
| Jul                                          | 1960 | 273               | 52                      | 221                                | 119                         | 77                      | 77                         | 77        | 65           | 201                    | 77                        | 144                    | 221               | 0                  |       |
| Aug                                          | 1960 | 187               | 59                      | 136                                | 136                         | 136                     | 136                        | 136       | 100          | 65                     | 162                       | 136                    | 136               | 0                  |       |
| Sep                                          | 1960 | 124               | 10                      | 114                                | 0                           | 114                     | 225                        | 114       | 147          | 65                     | 165                       | 114                    | 0                 | 114                |       |
| Oct                                          | 1960 | 40                | 27                      | 13                                 | 147                         | 13                      | 83                         | 52        | 96           | 65                     | 276                       | 12                     | 0                 | 13                 |       |
| Nov                                          | 1960 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 276                       | 0                      | 0                 | 0                  |       |
| Dec                                          | 1960 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 276                       | 0                      | 0                 | 0                  |       |
| Total                                        | 1960 | 1026              | 306                     | 721                                | 721                         | 721                     | 1042                       | 537       | 383          | 653                    | 431                       | 537                    | 164               | 721                |       |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | ECM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |           |              |                        |                           | Soil Moisture Contents | Estimated Crop CU |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----------|--------------|------------------------|---------------------------|------------------------|-------------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Destination                |           |              | Efficiency Calculation |                           |                        | From Diversion    | From Soil Moisture | Total |
|       |      |                   |                         |                                    |                             |                         | CU                         | Soil Zone | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        |                   |                    |       |
| Jan   | 1981 |                   | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 276                       | 0                      | 0                 | 0                  |       |
| Feb   | 1981 |                   | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 276                       | 0                      | 0                 | 0                  |       |
| Mar   | 1981 | 2                 | 0                       | 2                                  | 0                           | 2                       | 0                          | 0         | 0            | 0                      | 276                       | 0                      | 2                 | 0                  |       |
| Apr   | 1981 | 66                | 61                      | 61                                 | 61                          | 61                      | 31                         | 20        | 26           | 83                     | 236                       | 20                     | 41                | 61                 |       |
| May   | 1981 | 59                | 59                      | 64                                 | 155                         | 64                      | 37                         | 54        | 101          | 83                     | 272                       | 64                     | 0                 | 61                 |       |
| Jun   | 1981 | 148               | 47                      | 148                                | 0                           | 148                     | 117                        | 117       | 117          | 65                     | 241                       | 117                    | 31                | 148                |       |
| Jul   | 1981 | 218               | 112                     | 136                                | 0                           | 136                     | 83                         | 83        | 237          | 154                    | 65                        | 136                    | 0                 | 136                |       |
| Aug   | 1981 | 162               | 45                      | 162                                | 162                         | 162                     | 37                         | 162       | 202          | 256                    | 162                       | 162                    | 0                 | 162                |       |
| Sep   | 1981 | 134               | 2                       | 132                                | 0                           | 132                     | 14                         | 132       | 147          | 132                    | 311                       | 132                    | 0                 | 132                |       |
| Oct   | 1981 | 39                | 21                      | 17                                 | 0                           | 17                      | 34                         | 56        | 52           | 34                     | 345                       | 17                     | 0                 | 17                 |       |
| Nov   | 1981 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |       |
| Dec   | 1981 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |       |
| Total | 1981 | 1014              | 296                     | 722                                | 722                         | 722                     | 1281                       | 648       | 494          | 791                    | 425                       | 648                    | 74                | 722                |       |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |             |           |              |                        |                           |                        |                   |   |     |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|-------------------|---|-----|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        |                           | Estimated Crop CU      |                   |   |     |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                           | Soil Moisture Contents | Estimated Crop CU |   |     |
|                                              |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       | Calculated Efficiency (%) |                        |                   |   |     |
| Jan                                          | 1962 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      | 0                 | 0 | 0   |
| Feb                                          | 1962 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      | 0                 | 0 | 0   |
| Mar                                          | 1962 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      | 0                 | 0 | 0   |
| Apr                                          | 1962 | 5                 | 4                       | 4                                  | 4                           | 4                       | 63                         | 4           | 4         | 59           | 4                      | 6                         | 345                    | 4                 | 4 | 4   |
| May                                          | 1962 | 104               | 103                     | 1                                  | 64                          | 1                       | 155                        | 1           | 0         | 154          | 1                      | 1                         | 345                    | 1                 | 1 | 1   |
| Jun                                          | 1962 | 156               | 85                      | 71                                 | 64                          | 94                      | 179                        | 94          | 0         | 85           | 94                     | 52                        | 345                    | 94                | 0 | 94  |
| Jul                                          | 1962 | 238               | 49                      | 189                                | 0                           | 189                     | 310                        | 189         | 0         | 121          | 189                    | 61                        | 345                    | 189               | 0 | 189 |
| Aug                                          | 1962 | 209               | 111                     | 97                                 | 0                           | 97                      | 310                        | 97          | 0         | 213          | 97                     | 31                        | 345                    | 97                | 0 | 97  |
| Sep                                          | 1962 | 110               | 86                      | 24                                 | 0                           | 24                      | 350                        | 54          | 0         | 246          | 54                     | 18                        | 345                    | 54                | 0 | 54  |
| Oct                                          | 1962 | 34                | 34                      | 0                                  | 0                           | 0                       | 147                        | 0           | 0         | 147          | 0                      | 0                         | 345                    | 0                 | 0 | 0   |
| Nov                                          | 1962 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 345                    | 0                 | 0 | 0   |
| Dec                                          | 1962 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 345                    | 0                 | 0 | 0   |
| Total                                        | 1962 | 850               | 419                     | 439                                | 0                           | 439                     | 1462                       | 439         | 0         | 1025         | 439                    | 166                       | 345                    | 439               | 0 | 439 |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Water Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        |                           | Soil Moisture Contents | Estimated Crop CU |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|-------------------|--------------------|-------|
|       |      |                   |                         |                                    |                            |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                           |                        | From Diversion    | From Soil Moisture | Total |
|       |      |                   |                         |                                    |                            |                         |                            | CU          | Soil Zone |              | Div to CU and SM       | Calculated Efficiency (%) |                        |                   |                    |       |
| Jan   | 1963 | 0                 | 0                       | 0                                  | 0                          | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |       |
| Feb   | 1963 | 0                 | 0                       | 0                                  | 0                          | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |       |
| Mar   | 1963 | 0                 | 0                       | 0                                  | 0                          | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |       |
| Apr   | 1963 | 2                 | 1                       | 2                                  | 0                          | 2                       | 63                         | 2           | 0         | 61           | 2                      | 345                       | 2                      | 0                 | 2                  |       |
| May   | 1963 | 84                | 53                      | 37                                 | 53                         | 53                      | 155                        | 53          | 0         | 102          | 53                     | 345                       | 53                     | 0                 | 53                 |       |
| Jun   | 1963 | 182               | 70                      | 112                                | 0                          | 112                     | 179                        | 112         | 0         | 67           | 112                    | 345                       | 112                    | 0                 | 112                |       |
| Jul   | 1963 | 252               | 55                      | 207                                | 0                          | 207                     | 237                        | 154         | 0         | 83           | 154                    | 292                       | 154                    | 53                | 207                |       |
| Aug   | 1963 | 268               | 67                      | 199                                | 0                          | 199                     | 307                        | 199         | 0         | 106          | 199                    | 292                       | 199                    | 0                 | 199                |       |
| Sep   | 1963 | 120               | 6                       | 114                                | 0                          | 114                     | 225                        | 114         | 33        | 79           | 147                    | 325                       | 114                    | 0                 | 114                |       |
| Oct   | 1963 | 39                | 20                      | 20                                 | 0                          | 20                      | 147                        | 20          | 0         | 108          | 20                     | 345                       | 20                     | 0                 | 20                 |       |
| Nov   | 1963 | 0                 | 0                       | 0                                  | 0                          | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |       |
| Dec   | 1963 | 0                 | 0                       | 0                                  | 0                          | 0                       | 0                          | 0           | 0         | 0            | 0                      | 345                       | 0                      | 0                 | 0                  |       |
| Total | 1963 | 961               | 296                     | 707                                | 0                          | 707                     | 1313                       | 654         | 53        | 608          | 707                    | 321                       | 654                    | 53                | 707                |       |





| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |             |           |              |                        |                           |                        |                |                    |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|----------------|--------------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        | Estimated Crop CU         |                        |                |                    |       |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           |              | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |
|                                              |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        |                |                    |       |
| Jan                                          | 1966 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Feb                                          | 1966 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Mar                                          | 1966 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Apr                                          | 1966 | 9                 | 9                       | 0                                  | 0                           | 0                       | 63                         | 0           | 36        | 26           | 36                     | 58                        | 0                      |                |                    |       |
| May                                          | 1966 | 123               | 32                      | 91                                 | 0                           | 91                      | 155                        | 91          | 64        | 91           | 59                     | 345                       | 91                     |                |                    |       |
| Jun                                          | 1966 | 215               | 107                     | 108                                | 0                           | 108                     | 179                        | 108         | 0         | 71           | 108                    | 60                        | 108                    |                |                    |       |
| Jul                                          | 1966 | 240               | 26                      | 214                                | 0                           | 214                     | 237                        | 154         | 63        | 154          | 65                     | 285                       | 60                     |                |                    |       |
| Aug                                          | 1966 | 205               | 35                      | 198                                | 0                           | 176                     | 307                        | 170         | 30        | 108          | 200                    | 170                       | 170                    |                |                    |       |
| Sep                                          | 1966 | 64                | 62                      | 32                                 | 0                           | 32                      | 223                        | 32          | 30        | 164          | 62                     | 27                        | 345                    |                |                    |       |
| Oct                                          | 1966 | 33                | 17                      | 17                                 | 0                           | 17                      | 221                        | 17          | 0         | 204          | 17                     | 8                         | 17                     |                |                    |       |
| Nov                                          | 1966 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Dec                                          | 1966 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Total                                        | 1966 | 921               | 283                     | 630                                | 0                           | 630                     | 1387                       | 872         | 56        | 720          | 608                    | 342                       | 630                    |                |                    |       |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        | Estimated Crop CU         |                        |                |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|----------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           |              | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        |                |                    |       |
| Jan   | 1967 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Feb   | 1967 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Mar   | 1967 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Apr   | 1967 | 64                | 64                      | 0                                  | 0                           | 0                       | 63                         | 41          | 0         | 22           | 41                     | 65                        | 23                     |                |                    |       |
| May   | 1967 | 150               | 74                      | 77                                 | 0                           | 77                      | 155                        | 77          | 23        | 55           | 100                    | 84                        | 77                     |                |                    |       |
| Jun   | 1967 | 211               | 36                      | 175                                | 0                           | 175                     | 175                        | 117         | 63        | 117          | 65                     | 256                       | 175                    |                |                    |       |
| Jul   | 1967 | 277               | 25                      | 252                                | 0                           | 252                     | 119                        | 77          | 42        | 77           | 65                     | 175                       | 252                    |                |                    |       |
| Aug   | 1967 | 194               | 56                      | 136                                | 0                           | 136                     | 307                        | 136         | 64        | 108          | 206                    | 136                       | 136                    |                |                    |       |
| Sep   | 1967 | 123               | 15                      | 108                                | 0                           | 108                     | 225                        | 108         | 39        | 79           | 147                    | 108                       | 108                    |                |                    |       |
| Oct   | 1967 | 36                | 2                       | 34                                 | 0                           | 34                      | 147                        | 34          | 62        | 52           | 96                     | 68                        | 34                     |                |                    |       |
| Nov   | 1967 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Dec   | 1967 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 0                      |                |                    |       |
| Total | 1967 | 1055              | 210                     | 846                                | 0                           | 846                     | 1195                       | 590         | 188       | 421          | 778                    | 454                       | 846                    |                |                    |       |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |                  |                           |           |              |                        |                        |                   |                    |       |  |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|------------------|---------------------------|-----------|--------------|------------------------|------------------------|-------------------|--------------------|-------|--|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |                  |                           |           |              |                        | Soil Moisture Contents | Estimated Crop CU |                    |       |  |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | CU               |                           | Soil Zone | Non-Consumed | Efficiency Calculation |                        | From Diversion    | From Soil Moisture | Total |  |
|                                              |      |                   |                         |                                    |                             |                         |                            | Div to CU and SM | Calculated Efficiency (%) |           |              |                        |                        |                   |                    |       |  |
| Jan                                          | 1988 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0                | 0                         | 0         | 0            | 275                    | 0                      | 0                 | 0                  | 0     |  |
| Feb                                          | 1988 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0                | 0                         | 0         | 0            | 275                    | 0                      | 0                 | 0                  | 0     |  |
| Mar                                          | 1988 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0                | 0                         | 0         | 0            | 275                    | 0                      | 0                 | 0                  | 0     |  |
| Apr                                          | 1988 | 35                | 35                      | 35                                 | 0                           | 35                      | 63                         | 36               | 11                        | 22        | 41           | 65                     | 266                    | 36                | 0                  | 36    |  |
| May                                          | 1988 | 153               | 71                      | 82                                 | 0                           | 82                      | 152                        | 82               | 19                        | 54        | 101          | 65                     | 305                    | 82                | 0                  | 82    |  |
| Jun                                          | 1988 | 247               | 33                      | 214                                | 0                           | 214                     | 176                        | 117              | 6                         | 63        | 117          | 65                     | 175                    | 117               | 0                  | 117   |  |
| Jul                                          | 1988 | 243               | 30                      | 213                                | 0                           | 213                     | 237                        | 154              | 0                         | 83        | 154          | 65                     | 57                     | 154               | 0                  | 154   |  |
| Aug                                          | 1988 | 173               | 25                      | 148                                | 0                           | 148                     | 307                        | 173              | 27                        | 108       | 200          | 65                     | 84                     | 173               | 0                  | 173   |  |
| Sep                                          | 1988 | 116               | 12                      | 104                                | 0                           | 104                     | 113                        | 73               | 38                        | 35        | 73           | 65                     | 52                     | 73                | 0                  | 73    |  |
| Oct                                          | 1988 | 40                | 9                       | 31                                 | 0                           | 31                      | 147                        | 31               | 65                        | 52        | 96           | 65                     | 116                    | 31                | 0                  | 31    |  |
| Nov                                          | 1988 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0                | 0                         | 0         | 0            | 0                      | 116                    | 0                 | 0                  | 0     |  |
| Dec                                          | 1988 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0                | 0                         | 0         | 0            | 0                      | 116                    | 0                 | 0                  | 0     |  |
| Total                                        | 1988 | 1132              | 192                     | 941                                | 0                           | 941                     | 1201                       | 660              | 122                       | 421       | 782          | 455                    | 680                    | 680               | 281                | 941   |  |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        |                           | Soil Moisture Contents | Estimated Crop CU |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|-------------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                           |                        |                   |                    |       |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       | Calculated Efficiency (%) |                        | From Diversion    | From Soil Moisture | Total |
| Jan   | 1983 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 116                       | 0                      | 0                 | 0                  |       |
| Feb   | 1983 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 116                       | 0                      | 0                 | 0                  |       |
| Mar   | 1983 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 116                       | 0                      | 0                 | 0                  |       |
| Apr   | 1983 | 16                | 6                       | 9                                  | 0                           | 9                       | 63                         | 5           | 31        | 22           | 41                     | 65                        | 148                    | 9                 | 0                  | 9     |
| May   | 1983 | 128               | 32                      | 94                                 | 0                           | 94                      | 155                        | 94          | 7         | 54           | 101                    | 65                        | 154                    | 94                | 0                  | 94    |
| Jun   | 1983 | 189               | 27                      | 162                                | 0                           | 162                     | 178                        | 117         | 63        | 63           | 117                    | 65                        | 169                    | 117               | 45                 | 162   |
| Jul   | 1983 | 201               | 26                      | 175                                | 0                           | 175                     | 266                        | 237         | 154       | 83           | 154                    | 65                        | 104                    | 154               | 109                | 253   |
| Aug   | 1983 | 223               | 46                      | 183                                | 0                           | 183                     | 354                        | 154         | 100       | 54           | 100                    | 65                        | 84                     | 100               | 0                  | 100   |
| Sep   | 1983 | 121               | 64                      | 57                                 | 0                           | 57                      | 225                        | 147         | 69        | 75           | 147                    | 65                        | 89                     | 57                | 0                  | 57    |
| Oct   | 1983 | 39                | 17                      | 21                                 | 0                           | 21                      | 147                        | 21          | 74        | 52           | 56                     | 65                        | 164                    | 21                | 0                  | 21    |
| Nov   | 1983 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 164                    | 0                 | 0                  | 0     |
| Dec   | 1983 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 164                    | 0                 | 0                  | 0     |
| Total | 1983 | 1011              | 217                     | 782                                | 0                           | 782                     | 1160                       | 552         | 201       | 407          | 756                    | 455                       | 552                    | 552               | 154                | 706   |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |     |           |              |                  |                           |                   |                |                    |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----|-----------|--------------|------------------|---------------------------|-------------------|----------------|--------------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |     |           |              |                  | Soil Moisture Contents    | Estimated Crop CU |                |                    |       |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | CU  | Soil Zone | Non-Consumed | Div to CU and SM | Calculated Efficiency (%) |                   | From Diversion | From Soil Moisture | Total |
| Jan                                          | 1990 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 0                 | 0              | 0                  | 0     |
| Feb                                          | 1990 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 0                 | 0              | 0                  | 0     |
| Mar                                          | 1990 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 0                 | 0              | 0                  | 0     |
| Apr                                          | 1990 | 10                | 3                       | 0                                  | 6                           | 6                       | 63                         | 8   | 33        | 22           | 41               | 63                        | 157               | 6              | 0                  | 6     |
| May                                          | 1990 | 110               | 89                      | 21                                 | 0                           | 21                      | 155                        | 21  | 60        | 54           | 101              | 65                        | 277               | 21             | 0                  | 21    |
| Jun                                          | 1990 | 207               | 37                      | 170                                | 0                           | 170                     | 178                        | 117 | 0         | 63           | 117              | 65                        | 223               | 117            | 53                 | 170   |
| Jul                                          | 1990 | 246               | 53                      | 193                                | 0                           | 193                     | 237                        | 154 | 0         | 83           | 154              | 65                        | 185               | 154            | 39                 | 193   |
| Aug                                          | 1990 | 234               | 50                      | 183                                | 0                           | 183                     | 154                        | 100 | 0         | 54           | 100              | 65                        | 101               | 100            | 84                 | 183   |
| Sep                                          | 1990 | 146               | 50                      | 81                                 | 0                           | 81                      | 113                        | 73  | 0         | 39           | 73               | 65                        | 83                | 73             | 18                 | 91    |
| Oct                                          | 1990 | 41                | 6                       | 39                                 | 0                           | 33                      | 74                         | 33  | 15        | 26           | 46               | 65                        | 97                | 33             | 0                  | 33    |
| Nov                                          | 1990 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 0                 | 0              | 0                  | 0     |
| Dec                                          | 1990 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 0                 | 0              | 0                  | 0     |
| Total                                        | 1990 | 694               | 295                     | 699                                | 0                           | 699                     | 975                        | 506 | 128       | 341          | 634              | 435                       |                   | 506            | 194                | 699   |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        |                           | Estimated Crop CU      |                |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|----------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       | Calculated Efficiency (%) |                        |                |                    |       |
| Jan   | 1991 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 97                        | 0                      | 0              | 0                  | 0     |
| Feb   | 1991 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 97                        | 0                      | 0              | 0                  | 0     |
| Mar   | 1991 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 97                        | 0                      | 0              | 0                  | 0     |
| Apr   | 1991 | 25                | 19                      | 6                                  | 6                           | 6                       | 63                         | 6           | 35        | 22           | 41                     | 65                        | 132                    | 6              | 0                  | 6     |
| May   | 1991 | 133               | 90                      | 44                                 | 0                           | 44                      | 155                        | 44          | 57        | 54           | 101                    | 65                        | 189                    | 44             | 0                  | 44    |
| Jun   | 1991 | 212               | 60                      | 132                                | 0                           | 132                     | 176                        | 117         | 0         | 63           | 117                    | 65                        | 174                    | 117            | 15                 | 132   |
| Jul   | 1991 | 256               | 50                      | 206                                | 0                           | 206                     | 237                        | 154         | 0         | 83           | 154                    | 65                        | 127                    | 154            | 47                 | 201   |
| Aug   | 1991 | 236               | 16                      | 220                                | 0                           | 220                     | 307                        | 203         | 0         | 108          | 200                    | 65                        | 107                    | 200            | 20                 | 220   |
| Sep   | 1991 | 132               | 13                      | 106                                | 0                           | 106                     | 225                        | 108         | 38        | 79           | 147                    | 65                        | 145                    | 108            | 6                  | 156   |
| Oct   | 1991 | 33                | 11                      | 23                                 | 0                           | 23                      | 147                        | 23          | 73        | 52           | 96                     | 65                        | 218                    | 23             | 0                  | 23    |
| Nov   | 1991 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 218                    | 0              | 0                  | 0     |
| Dec   | 1991 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 218                    | 0              | 0                  | 0     |
| Total | 1991 | 1017              | 284                     | 735                                | 0                           | 735                     | 1313                       | 653         | 203       | 461          | 856                    | 435                       |                        | 653            | 82                 | 735   |



| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |     |           |              |                  |                           |                        |                |                    |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----|-----------|--------------|------------------|---------------------------|------------------------|----------------|--------------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EQM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |     |           |              |                  | Soil Moisture Contents    | Estimated Crop CU      |                |                    |       |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | CU  | Soil Zone | Non-Consumed | Div to CU and SM | Calculated Efficiency (%) | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |
| Jan                                          | 1992 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 216                    | 0              | 0                  | 0     |
| Feb                                          | 1992 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 216                    | 0              | 0                  | 0     |
| Mar                                          | 1992 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 216                    | 0              | 0                  | 0     |
| Apr                                          | 1992 | 33                | 6                       | 26                                 | 0                           | 26                      | 63                         | 26  | 14        | 22           | 41               | 65                        | 232                    | 26             | 0                  | 26    |
| May                                          | 1992 | 84                | 84                      | 0                                  | 0                           | 84                      | 155                        | 84  | 17        | 84           | 101              | 84                        | 250                    | 84             | 0                  | 84    |
| Jun                                          | 1992 | 176               | 52                      | 127                                | 0                           | 127                     | 178                        | 117 | 63        | 117          | 65               | 117                       | 246                    | 117            | 10                 | 127   |
| Jul                                          | 1992 | 150               | 76                      | 76                                 | 0                           | 76                      | 237                        | 114 | 40        | 83           | 154              | 65                        | 286                    | 114            | 0                  | 114   |
| Aug                                          | 1992 | 168               | 11                      | 168                                | 0                           | 168                     | 307                        | 168 | 32        | 108          | 200              | 65                        | 312                    | 168            | 0                  | 168   |
| Sep                                          | 1992 | 129               | 9                       | 120                                | 0                           | 120                     | 225                        | 120 | 27        | 79           | 147              | 65                        | 338                    | 120            | 0                  | 120   |
| Oct                                          | 1992 | 39                | 8                       | 32                                 | 0                           | 32                      | 147                        | 32  | 7         | 109          | 38               | 28                        | 345                    | 32             | 0                  | 32    |
| Nov                                          | 1992 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 345                    | 0              | 0                  | 0     |
| Dec                                          | 1992 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 345                    | 0              | 0                  | 0     |
| Total                                        | 1992 | 887               | 216                     | 671                                | 0                           | 671                     | 1313                       | 681 | 137       | 518          | 768              | 418                       | 661                    | 661            | 10                 | 671   |

| Month | Year | Potential Crop Et | Effective Precipitation | Irrigation Water Requirement (IWR) | EQM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        |                           | Estimated Crop CU      |                |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|---------------------------|------------------------|----------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       | Calculated Efficiency (%) |                        |                |                    |       |
| Jan   | 1993 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     |
| Feb   | 1993 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     |
| Mar   | 1993 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     |
| Apr   | 1993 | 6                 | 7                       | 1                                  | 0                           | 1                       | 63                         | 1           | 0         | 61           | 1                      | 2                         | 345                    | 1              | 0                  | 1     |
| May   | 1993 | 131               | 46                      | 83                                 | 0                           | 83                      | 155                        | 83          | 72        | 83           | 83                     | 54                        | 345                    | 83             | 0                  | 83    |
| Jun   | 1993 | 154               | 75                      | 68                                 | 0                           | 68                      | 269                        | 88          | 0         | 181          | 88                     | 33                        | 345                    | 88             | 0                  | 88    |
| Jul   | 1993 | 196               | 99                      | 60                                 | 0                           | 60                      | 337                        | 97          | 0         | 140          | 97                     | 41                        | 345                    | 97             | 0                  | 97    |
| Aug   | 1993 | 196               | 31                      | 167                                | 0                           | 167                     | 307                        | 167         | 0         | 140          | 167                    | 64                        | 345                    | 167            | 0                  | 167   |
| Sep   | 1993 | 101               | 31                      | 69                                 | 0                           | 69                      | 225                        | 65          | 0         | 152          | 65                     | 31                        | 345                    | 65             | 0                  | 65    |
| Oct   | 1993 | 35                | 10                      | 25                                 | 0                           | 25                      | 147                        | 25          | 0         | 123          | 25                     | 17                        | 345                    | 25             | 0                  | 25    |
| Nov   | 1993 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     |
| Dec   | 1993 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     |
| Total | 1993 | 831               | 301                     | 530                                | 0                           | 530                     | 1403                       | 530         | 72        | 873          | 530                    | 232                       | 530                    | 530            | 0                  | 530   |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |     |           |              |                  |                           |                   |                    |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----|-----------|--------------|------------------|---------------------------|-------------------|--------------------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |     |           |              |                  | Soil Moisture Contents    | Estimated Crop CU |                    |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | CU  | Soil Zone | Non-Consumed | Div to CU and SM | Calculated Efficiency (%) | From Diversion    | From Soil Moisture |
| Jan                                          | 1994 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 0                 | 0                  |
| Feb                                          | 1994 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 0                 | 0                  |
| Mar                                          | 1994 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 0                 | 0                  |
| Apr                                          | 1994 | 30                | 0                       | 21                                 | 0                           | 21                      | 63                         | 21  | 0         | 42           | 21               | 33                        | 345               | 21                 |
| May                                          | 1994 | 155               | 35                      | 120                                | 0                           | 120                     | 155                        | 101 | 0         | 54           | 101              | 65                        | 328               | 101                |
| Jun                                          | 1994 | 222               | 16                      | 204                                | 0                           | 204                     | 176                        | 117 | 0         | 63           | 117              | 65                        | 233               | 117                |
| Jul                                          | 1994 | 238               | 15                      | 221                                | 0                           | 221                     | 237                        | 154 | 0         | 83           | 154              | 65                        | 173               | 154                |
| Aug                                          | 1994 | 231               | 26                      | 205                                | 0                           | 205                     | 200                        | 108 | 0         | 108          | 200              | 65                        | 167               | 200                |
| Sep                                          | 1994 | 144               | 5                       | 139                                | 0                           | 139                     | 225                        | 139 | 0         | 79           | 147              | 65                        | 139               | 139                |
| Oct                                          | 1994 | 42                | 32                      | 10                                 | 0                           | 10                      | 147                        | 10  | 0         | 52           | 96               | 65                        | 251               | 10                 |
| Nov                                          | 1994 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 0                 | 0                  |
| Dec                                          | 1994 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                         | 0                 | 0                  |
| Total                                        | 1994 | 1062              | 143                     | 920                                | 0                           | 920                     | 1313                       | 742 | 53        | 451          | 836              | 423                       | 742               | 178                |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |           |                  |              |                           |     | Soil Moisture Contents |                    | Estimated Crop CU |     |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----------|------------------|--------------|---------------------------|-----|------------------------|--------------------|-------------------|-----|
|       |      |                   |                         |                                    |                             |                         | Destination                |           |                  | Non-Consumed | Efficiency Calculation    |     | From Diversion         | From Soil Moisture | Total             |     |
|       |      |                   |                         |                                    |                             |                         | CU                         | Soil Zone | Div to CU and SM |              | Calculated Efficiency (%) |     |                        |                    |                   |     |
| Jan   | 1995 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0                | 0            | 0                         | 0   | 261                    | 0                  | 0                 | 0   |
| Feb   | 1995 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0                | 0            | 0                         | 0   | 261                    | 0                  | 0                 | 0   |
| Mar   | 1995 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0                | 0            | 0                         | 0   | 261                    | 0                  | 0                 | 0   |
| Apr   | 1995 | 2                 | 0                       | 0                                  | 0                           | 0                       | 63                         | 40        | 22               | 41           | 65                        | 301 | 0                      | 0                  | 0                 | 0   |
| May   | 1995 | 67                | 62                      | 25                                 | 0                           | 25                      | 233                        | 25        | 154              | 44           | 154                       | 65  | 345                    | 25                 | 0                 | 25  |
| Jun   | 1995 | 181               | 100                     | 81                                 | 0                           | 81                      | 269                        | 81        | 188              | 81           | 188                       | 65  | 345                    | 81                 | 0                 | 81  |
| Jul   | 1995 | 236               | 75                      | 163                                | 0                           | 163                     | 310                        | 163       | 147              | 163          | 163                       | 65  | 345                    | 163                | 0                 | 163 |
| Aug   | 1995 | 230               | 12                      | 221                                | 0                           | 221                     | 307                        | 206       | 108              | 307          | 206                       | 65  | 324                    | 200                | 21                | 221 |
| Sep   | 1995 | 117               | 18                      | 97                                 | 0                           | 97                      | 225                        | 97        | 21               | 107          | 118                       | 52  | 345                    | 97                 | 0                 | 97  |
| Oct   | 1995 | 33                | 24                      | 9                                  | 0                           | 9                       | 147                        | 9         | 139              | 345          | 9                         | 6   | 345                    | 9                  | 0                 | 9   |
| Nov   | 1995 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0                | 0            | 0                         | 0   | 345                    | 0                  | 0                 | 0   |
| Dec   | 1995 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0                | 0            | 0                         | 0   | 345                    | 0                  | 0                 | 0   |
| Total | 1995 | 831               | 293                     | 566                                | 0                           | 566                     | 1654                       | 575       | 105              | 875          | 861                       | 501 | 575                    | 21                 | 559               | 559 |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |             |              |                        |                           |                        |                |                    |       |     |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|--------------|------------------------|---------------------------|------------------------|----------------|--------------------|-------|-----|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EQM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |              |                        |                           | Estimated Crop CU      |                |                    |       |     |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |              | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |     |
|                                              |      |                   |                         |                                    |                             |                         | CU                         | Soil Zone   | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        |                |                    |       |     |
| Jan                                          | 1996 |                   | 0                       | 0                                  | 0                           | 0                       | 0                          |             | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Feb                                          | 1996 |                   | 0                       | 0                                  | 0                           | 0                       | 0                          |             | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Mar                                          | 1996 |                   | 0                       | 0                                  | 0                           | 0                       | 0                          |             | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Apr                                          | 1996 | 5                 | 3                       | 0                                  | 0                           | 3                       | 0                          | 3           | 61           | 0                      | 3                         | 345                    | 3              | 3                  | 3     | 3   |
| May                                          | 1996 | 79                | 79                      | 0                                  | 0                           | 0                       | 0                          | 155         | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Jun                                          | 1996 | 156               | 32                      | 167                                | 0                           | 167                     | 167                        | 102         | 0            | 167                    | 62                        | 345                    | 167            | 0                  | 0     | 167 |
| Jul                                          | 1996 | 239               | 14                      | 225                                | 0                           | 225                     | 154                        | 83          | 0            | 154                    | 65                        | 274                    | 154            | 71                 | 225   | 71  |
| Aug                                          | 1996 | 230               | 50                      | 180                                | 0                           | 180                     | 307                        | 180         | 19           | 108                    | 200                       | 65                     | 293            | 180                | 0     | 180 |
| Sep                                          | 1996 | 115               | 34                      | 81                                 | 0                           | 81                      | 225                        | 61          | 52           | 133                    | 59                        | 345                    | 61             | 0                  | 61    | 61  |
| Oct                                          | 1996 | 34                | 11                      | 23                                 | 0                           | 23                      | 23                         | 0           | 196          | 23                     | 10                        | 345                    | 23             | 0                  | 23    | 23  |
| Nov                                          | 1996 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Dec                                          | 1996 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Total                                        | 1996 | 901               | 223                     | 678                                | 0                           | 678                     | 608                        | 71          | 833          | 558                    | 264                       | 0                      | 608            | 71                 | 679   | 679 |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EQM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |              |                        |                           | Estimated Crop CU      |                |                    |       |     |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|--------------|------------------------|---------------------------|------------------------|----------------|--------------------|-------|-----|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |              | Efficiency Calculation |                           | Soil Moisture Contents | From Diversion | From Soil Moisture | Total |     |
|       |      |                   |                         |                                    |                             |                         | CU                         | Soil Zone   | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) |                        |                |                    |       |     |
| Jan   | 1997 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          |             | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Feb   | 1997 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          |             | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Mar   | 1997 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          |             | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Apr   | 1997 | 1                 | 1                       | 0                                  | 0                           | 0                       | 0                          | 1           | 94           | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| May   | 1997 | 57                | 84                      | 13                                 | 0                           | 13                      | 13                         | 0           | 233          | 13                     | 2                         | 345                    | 13             | 0                  | 13    | 13  |
| Jun   | 1997 | 206               | 82                      | 123                                | 0                           | 123                     | 259                        | 123         | 146          | 123                    | 48                        | 345                    | 123            | 0                  | 123   | 123 |
| Jul   | 1997 | 240               | 90                      | 147                                | 0                           | 147                     | 310                        | 147         | 163          | 147                    | 47                        | 345                    | 147            | 0                  | 147   | 147 |
| Aug   | 1997 | 168               | 91                      | 107                                | 0                           | 107                     | 312                        | 107         | 203          | 107                    | 34                        | 345                    | 107            | 0                  | 107   | 107 |
| Sep   | 1997 | 129               | 16                      | 111                                | 0                           | 111                     | 300                        | 111         | 190          | 111                    | 37                        | 345                    | 111            | 0                  | 111   | 111 |
| Oct   | 1997 | 36                | 5                       | 33                                 | 0                           | 33                      | 33                         | 0           | 188          | 33                     | 15                        | 345                    | 33             | 0                  | 33    | 33  |
| Nov   | 1997 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Dec   | 1997 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0            | 0                      | 0                         | 345                    | 0              | 0                  | 0     | 0   |
| Total | 1997 | 908               | 374                     | 534                                | 0                           | 534                     | 1737                       | 534         | 1204         | 534                    | 184                       | 0                      | 534            | 0                  | 534   | 534 |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |              |                        |                           |                        |                    |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|--------------|------------------------|---------------------------|------------------------|--------------------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |              |                        |                           | Estimated Crop CU      |                    |
|                                              |      |                   |                         |                                    |                             |                         | Destination                |              | Efficiency Calculation |                           | Soil Moisture Contents |                    |
|                                              |      |                   |                         |                                    |                             |                         | CU                         | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) | From Diversion         | From Soil Moisture |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | Sol Zone     |                        |                           |                        |                    |
|                                              |      |                   |                         |                                    |                             |                         |                            |              |                        |                           |                        |                    |
|                                              |      |                   |                         |                                    |                             |                         |                            |              |                        |                           | Estimated Crop CU      |                    |
|                                              |      |                   |                         |                                    |                             |                         |                            |              |                        |                           | From Diversion         | From Soil Moisture |
|                                              |      |                   |                         |                                    |                             |                         |                            |              |                        |                           | Total                  |                    |
| Jan                                          | 1958 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0            | 0                      | 0                         | 0                      | 0                  |
| Feb                                          | 1958 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0            | 0                      | 0                         | 0                      | 0                  |
| Mar                                          | 1958 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0            | 0                      | 0                         | 0                      | 0                  |
| Apr                                          | 1958 | 21                | 19                      | 0                                  | 0                           | 0                       | 0                          | 76           | 19                     | 21                        | 345                    | 0                  |
| May                                          | 1958 | 131               | 51                      | 80                                 | 0                           | 80                      | 0                          | 80           | 80                     | 51                        | 345                    | 0                  |
| Jun                                          | 1958 | 153               | 114                     | 39                                 | 0                           | 39                      | 0                          | 39           | 39                     | 14                        | 345                    | 0                  |
| Jul                                          | 1958 | 254               | 36                      | 218                                | 0                           | 218                     | 0                          | 109          | 202                    | 65                        | 329                    | 0                  |
| Aug                                          | 1958 | 223               | 36                      | 185                                | 0                           | 185                     | 0                          | 185          | 201                    | 185                       | 345                    | 0                  |
| Sep                                          | 1958 | 152               | 35                      | 117                                | 0                           | 117                     | 0                          | 117          | 117                    | 39                        | 345                    | 0                  |
| Oct                                          | 1958 | 35                | 0                       | 0                                  | 0                           | 0                       | 0                          | 221          | 0                      | 0                         | 345                    | 0                  |
| Nov                                          | 1958 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0            | 0                      | 0                         | 345                    | 0                  |
| Dec                                          | 1958 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0            | 0                      | 0                         | 345                    | 0                  |
| Total                                        | 1958 | 973               | 314                     | 658                                | 0                           | 658                     | 1559                       | 642          | 658                    | 255                       | 642                    | 19                 |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |              |                        |                           | Estimated Crop CU      |                    |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|--------------|------------------------|---------------------------|------------------------|--------------------|
|       |      |                   |                         |                                    |                             |                         | Destination                |              | Efficiency Calculation |                           | Soil Moisture Contents |                    |
|       |      |                   |                         |                                    |                             |                         | CU                         | Non-Consumed | Div to CU and SM       | Calculated Efficiency (%) | From Diversion         | From Soil Moisture |
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Sol Zone     |                        |                           |                        |                    |
|       |      |                   |                         |                                    |                             |                         |                            |              |                        |                           |                        |                    |
|       |      |                   |                         |                                    |                             |                         |                            |              |                        |                           | Estimated Crop CU      |                    |
|       |      |                   |                         |                                    |                             |                         |                            |              |                        |                           | From Diversion         | From Soil Moisture |
|       |      |                   |                         |                                    |                             |                         |                            |              |                        |                           | Total                  |                    |
| Jan   | 1959 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0            | 0                      | 0                         | 0                      | 0                  |
| Feb   | 1959 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0            | 0                      | 0                         | 0                      | 0                  |
| Mar   | 1959 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0            | 0                      | 0                         | 0                      | 0                  |
| Apr   | 1959 | 6                 | 4                       | 0                                  | 0                           | 0                       | 0                          | 92           | 1                      | 1                         | 345                    | 0                  |
| May   | 1959 | 100               | 65                      | 35                                 | 0                           | 35                      | 0                          | 120          | 35                     | 23                        | 345                    | 0                  |
| Jun   | 1959 | 175               | 113                     | 66                                 | 0                           | 66                      | 0                          | 203          | 66                     | 24                        | 345                    | 0                  |
| Jul   | 1959 | 243               | 94                      | 149                                | 0                           | 149                     | 0                          | 161          | 149                    | 149                       | 345                    | 0                  |
| Aug   | 1959 | 217               | 12                      | 205                                | 0                           | 205                     | 0                          | 109          | 202                    | 65                        | 341                    | 0                  |
| Sep   | 1959 | 97                | 18                      | 78                                 | 0                           | 78                      | 0                          | 216          | 82                     | 78                        | 345                    | 0                  |
| Oct   | 1959 | 41                | 0                       | 41                                 | 0                           | 41                      | 0                          | 180          | 41                     | 19                        | 345                    | 0                  |
| Nov   | 1959 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0            | 0                      | 0                         | 344                    | 0                  |
| Dec   | 1959 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0            | 0                      | 0                         | 344                    | 0                  |
| Total | 1959 | 664               | 306                     | 578                                | 0                           | 578                     | 1559                       | 1594         | 578                    | 207                       | 578                    | 4                  |



| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |           |                        |                  |                        |                           |                |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----------|------------------------|------------------|------------------------|---------------------------|----------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |           |                        |                  |                        | Estimated Crop CU         |                |       |
|                                              |      |                   |                         |                                    |                             |                         | Destination                |           | Efficiency Calculation |                  | Soil Moisture Contents | From Soil Moisture        |                |       |
|                                              |      |                   |                         |                                    |                             |                         | CU                         | Soil Zone | Non-Consumed           | Div to CU and SM |                        | Calculated Efficiency (%) | From Diversion | Total |
| Jan                                          | 2000 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0                      | 0                | 0                      | 344                       | 0              | 0     |
| Feb                                          | 2000 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0                      | 0                | 0                      | 344                       | 0              | 0     |
| Mar                                          | 2000 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0                      | 0                | 0                      | 344                       | 0              | 0     |
| Apr                                          | 2000 | 7                 | 7                       | 0                                  | 0                           | 0                       | 63                         | 0         | 62                     | 1                | 1                      | 345                       | 0              | 0     |
| May                                          | 2000 | 130               | 52                      | 78                                 | 0                           | 78                      | 155                        | 78        | 78                     | 50               | 50                     | 345                       | 78             | 78    |
| Jun                                          | 2000 | 176               | 39                      | 136                                | 176                         | 136                     | 179                        | 117       | 63                     | 117              | 65                     | 325                       | 135            | 23    |
| Jul                                          | 2000 | 261               | 58                      | 204                                | 237                         | 204                     | 237                        | 154       | 83                     | 154              | 65                     | 276                       | 154            | 45    |
| Aug                                          | 2000 | 239               | 20                      | 219                                | 239                         | 219                     | 307                        | 200       | 108                    | 200              | 65                     | 256                       | 200            | 29    |
| Sep                                          | 2000 | 133               | 10                      | 123                                | 123                         | 123                     | 225                        | 123       | 79                     | 147              | 65                     | 260                       | 123            | 0     |
| Oct                                          | 2000 | 40                | 17                      | 23                                 | 23                          | 23                      | 147                        | 23        | 59                     | 84               | 63                     | 345                       | 23             | 23    |
| Nov                                          | 2000 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0                      | 0                | 0                      | 345                       | 0              | 0     |
| Dec                                          | 2000 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0         | 0                      | 0                | 0                      | 345                       | 0              | 0     |
| Total                                        | 2000 | 988               | 203                     | 783                                | 783                         | 783                     | 1313                       | 635       | 832                    | 785              | 371                    | 895                       | 89             | 783   |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |     |           |              |                                            |                        |                           |                |                    |       |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----|-----------|--------------|--------------------------------------------|------------------------|---------------------------|----------------|--------------------|-------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |     |           |              |                                            | Soil Moisture Contents | Estimated Crop CU         |                |                    |       |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | CU  | Soil Zone | Non-Consumed | Efficiency Calculation<br>Div to CU and SM |                        | Calculated Efficiency (%) | From Diversion | From Soil Moisture | Total |
| Jan                                          | 2002 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                                          | 345                    | 0                         | 0              | 0                  |       |
| Feb                                          | 2002 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                                          | 345                    | 0                         | 0              | 0                  |       |
| Mar                                          | 2002 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                                          | 345                    | 0                         | 0              | 0                  |       |
| Apr                                          | 2002 | 10                | 5                       | 5                                  | 5                           | 63                      | 63                         | 5   | 57        | 5            | 8                                          | 345                    | 5                         | 0              | 5                  |       |
| May                                          | 2002 | 111               | 43                      | 67                                 | 67                          | 67                      | 155                        | 67  | 89        | 67           | 43                                         | 345                    | 67                        | 0              | 67                 |       |
| Jun                                          | 2002 | 241               | 23                      | 218                                | 218                         | 218                     | 179                        | 117 | 63        | 117          | 65                                         | 244                    | 117                       | 101            | 218                |       |
| Jul                                          | 2002 | 313               | 32                      | 281                                | 281                         | 281                     | 237                        | 154 | 83        | 154          | 65                                         | 117                    | 154                       | 127            | 281                |       |
| Aug                                          | 2002 | 226               | 50                      | 176                                | 176                         | 176                     | 307                        | 175 | 108       | 206          | 65                                         | 141                    | 175                       | 0              | 175                |       |
| Sep                                          | 2002 | 131               | 58                      | 73                                 | 73                          | 73                      | 228                        | 73  | 79        | 147          | 65                                         | 214                    | 73                        | 0              | 73                 |       |
| Oct                                          | 2002 | 23                | 9                       | 15                                 | 15                          | 15                      | 147                        | 15  | 52        | 96           | 65                                         | 235                    | 15                        | 0              | 15                 |       |
| Nov                                          | 2002 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                                          | 295                    | 0                         | 0              | 0                  |       |
| Dec                                          | 2002 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                                          | 295                    | 0                         | 0              | 0                  |       |
| Total                                        | 2002 | 1055              | 220                     | 834                                | 834                         | 834                     | 1313                       | 806 | 178       | 530          | 760                                        |                        | 606                       | 228            | 834                |       |

| Month | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |             |           |              |                        | Soil Moisture Contents | Estimated Crop CU         |                |                    |       |
|-------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-------------|-----------|--------------|------------------------|------------------------|---------------------------|----------------|--------------------|-------|
|       |      |                   |                         |                                    |                             |                         | Historical Diversion       | Destination |           | Non-Consumed | Efficiency Calculation |                        |                           |                |                    |       |
|       |      |                   |                         |                                    |                             |                         |                            | CU          | Soil Zone |              | Div to CU and SM       |                        | Calculated Efficiency (%) | From Diversion | From Soil Moisture | Total |
| Jan   | 2003 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                      | 0                         | 0              | 0                  | 0     |
| Feb   | 2003 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                      | 0                         | 0              | 0                  | 0     |
| Mar   | 2003 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                      | 0                         | 0              | 0                  | 0     |
| Apr   | 2003 | 42                | 23                      | 18                                 | 18                          | 18                      | 63                         | 18          | 22        | 22           | 41                     | 65                     | 318                       | 18             | 0                  | 18    |
| May   | 2003 | 130               | 50                      | 80                                 | 80                          | 80                      | 155                        | 80          | 21        | 54           | 101                    | 60                     | 335                       | 80             | 0                  | 80    |
| Jun   | 2003 | 183               | 65                      | 118                                | 118                         | 118                     | 179                        | 117         | 0         | 63           | 117                    | 65                     | 338                       | 117            | 0                  | 117   |
| Jul   | 2003 | 301               | 31                      | 271                                | 271                         | 271                     | 237                        | 154         | 0         | 83           | 154                    | 65                     | 221                       | 154            | 116                | 271   |
| Aug   | 2003 | 253               | 26                      | 226                                | 226                         | 226                     | 307                        | 200         | 0         | 108          | 200                    | 65                     | 187                       | 200            | 34                 | 234   |
| Sep   | 2003 | 118               | 33                      | 86                                 | 86                          | 86                      | 225                        | 86          | 61        | 79           | 147                    | 65                     | 244                       | 86             | 0                  | 86    |
| Oct   | 2003 | 49                | 10                      | 39                                 | 39                          | 39                      | 147                        | 35          | 61        | 52           | 96                     | 65                     | 309                       | 35             | 0                  | 35    |
| Nov   | 2003 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                      | 305                       | 0              | 0                  | 0     |
| Dec   | 2003 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0           | 0         | 0            | 0                      | 0                      | 305                       | 0              | 0                  | 0     |
| Total | 2003 | 1082              | 241                     | 842                                | 842                         | 842                     | 1313                       | 850         | 165       | 461          | 856                    | 453                    |                           | 690            | 151                | 842   |

| Detail - Historical Consumptive Use Analysis |      |                   |                         |                                    |                             |                         |                            |     |           |              |                  |                        |                           |                |
|----------------------------------------------|------|-------------------|-------------------------|------------------------------------|-----------------------------|-------------------------|----------------------------|-----|-----------|--------------|------------------|------------------------|---------------------------|----------------|
| Month                                        | Year | Potential Crop ET | Effective Precipitation | Irrigation Water Requirement (IWR) | EOM Winter Precip Carryover | IWR After Winter Precip | River Diversion Accounting |     |           |              |                  | Soil Moisture Contents | Estimated Crop CU         |                |
|                                              |      |                   |                         |                                    |                             |                         | Historical Diversion       | CU  | Soil Zone | Non-Consumed | Div to CU and SM |                        | Calculated Efficiency (%) | From Diversion |
| Jan                                          | 2004 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 30.6                   | 0                         | 0              |
| Feb                                          | 2004 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 30.6                   | 0                         | 0              |
| Mar                                          | 2004 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 30.6                   | 0                         | 0              |
| Apr                                          | 2004 | 50                | 10                      | 40                                 | 0                           | 40                      | 63                         | 40  | 1         | 22           | 41               | 65                     | 40                        | 0              |
| May                                          | 2004 | 139               | 47                      | 92                                 | 0                           | 92                      | 155                        | 92  | 5         | 54           | 101              | 65                     | 92                        | 0              |
| Jun                                          | 2004 | 184               | 35                      | 146                                | 0                           | 146                     | 179                        | 117 | 0         | 63           | 117              | 65                     | 117                       | 32             |
| Jul                                          | 2004 | 262               | 66                      | 194                                | 0                           | 194                     | 119                        | 77  | 0         | 42           | 77               | 65                     | 170                       | 117            |
| Aug                                          | 2004 | 198               | 35                      | 162                                | 0                           | 162                     | 154                        | 100 | 0         | 54           | 100              | 65                     | 100                       | 63             |
| Sep                                          | 2004 | 132               | 82                      | 70                                 | 0                           | 70                      | 113                        | 70  | 4         | 39           | 73               | 65                     | 111                       | 70             |
| Oct                                          | 2004 | 43                | 20                      | 23                                 | 0                           | 23                      | 147                        | 23  | 73        | 52           | 96               | 65                     | 23                        | 0              |
| Nov                                          | 2004 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                      | 184                       | 0              |
| Dec                                          | 2004 | 0                 | 0                       | 0                                  | 0                           | 0                       | 0                          | 0   | 0         | 0            | 0                | 0                      | 184                       | 0              |
| Total                                        | 2004 | 1008              | 277                     | 725                                | 0                           | 725                     | 930                        | 519 | 87        | 326          | 602              | 455                    | 515                       | 212            |
|                                              |      |                   |                         |                                    |                             |                         |                            |     |           |              |                  |                        |                           | 725            |

Historical Diversions (in)

|         | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1951    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1952    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1391  |
| 1953    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1954    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1240  |
| 1955    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1956    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1201  |
| 1957    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1958    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1959    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1960    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1961    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1962    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1281  |
| 1963    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1403  |
| 1964    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1965    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1706  |
| 1966    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1967    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1386  |
| 1968    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1969    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1970    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1971    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1410  |
| 1972    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1973    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1974    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 937   |
| 1975    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1166  |
| 1976    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1977    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1978    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1391  |
| 1979    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1980    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1042  |
| 1981    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1261  |
| 1982    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1464  |
| 1983    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1984    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1985    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1165  |
| 1986    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1387  |
| 1987    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1195  |
| 1988    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1201  |
| 1989    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1165  |
| 1990    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 976   |
| 1991    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1992    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1993    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1403  |
| 1994    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1995    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1554  |
| 1996    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1525  |
| 1997    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1737  |
| 1998    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1659  |
| 1999    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1655  |
| 2000    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 2001    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 2002    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 2003    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 2004    | 0   | 0   | 0   | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 0   | 0   | 937   |
| Average | 0   | 0   | 0   | 64  | 161 | 190 | 231 | 265 | 218 | 152 | 0   | 0   | 1352  |

Water Supply at Harney Peak Ranch (a)

|         | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1951    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1952    | 0   | 0   | 0   | 63  | 233 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1391  |
| 1953    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1954    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1242  |
| 1955    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1956    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1201  |
| 1957    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1958    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1959    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1960    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1961    | 0   | 0   | 0   | 31  | 78  | 90  | 119 | 154 | 113 | 74  | 0   | 0   | 656   |
| 1962    | 0   | 0   | 0   | 31  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1281  |
| 1963    | 0   | 0   | 0   | 63  | 155 | 285 | 237 | 307 | 225 | 147 | 0   | 0   | 1403  |
| 1964    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1965    | 0   | 0   | 0   | 63  | 233 | 266 | 310 | 310 | 360 | 221 | 0   | 0   | 1706  |
| 1966    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1967    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1396  |
| 1968    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1969    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1970    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1971    | 0   | 0   | 0   | 94  | 155 | 178 | 237 | 307 | 225 | 221 | 0   | 0   | 1438  |
| 1972    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1973    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1974    | 0   | 0   | 0   | 63  | 155 | 178 | 116 | 154 | 113 | 147 | 0   | 0   | 936   |
| 1975    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 154 | 225 | 147 | 0   | 0   | 1160  |
| 1976    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1977    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1978    | 0   | 0   | 0   | 63  | 233 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1301  |
| 1979    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1980    | 0   | 0   | 0   | 63  | 155 | 178 | 116 | 154 | 225 | 147 | 0   | 0   | 1042  |
| 1981    | 0   | 0   | 0   | 31  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1281  |
| 1982    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1983    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1984    | 0   | 0   | 0   | 63  | 155 | 178 | 119 | 307 | 225 | 221 | 0   | 0   | 1195  |
| 1985    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1387  |
| 1986    | 0   | 0   | 0   | 63  | 155 | 178 | 119 | 307 | 225 | 147 | 0   | 0   | 1196  |
| 1987    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 113 | 147 | 0   | 0   | 1201  |
| 1988    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 154 | 225 | 147 | 0   | 0   | 1162  |
| 1989    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 975 | 113 | 74  | 0   | 0   | 975   |
| 1990    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1991    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1992    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1403  |
| 1993    | 0   | 0   | 0   | 63  | 155 | 268 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 1994    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1554  |
| 1995    | 0   | 0   | 0   | 63  | 233 | 268 | 310 | 307 | 225 | 221 | 0   | 0   | 1506  |
| 1996    | 0   | 0   | 0   | 94  | 155 | 268 | 237 | 307 | 225 | 221 | 0   | 0   | 1737  |
| 1997    | 0   | 0   | 0   | 94  | 233 | 268 | 310 | 310 | 300 | 221 | 0   | 0   | 1859  |
| 1998    | 0   | 0   | 0   | 94  | 155 | 268 | 310 | 310 | 300 | 221 | 0   | 0   | 1859  |
| 1999    | 0   | 0   | 0   | 94  | 155 | 268 | 310 | 310 | 225 | 147 | 0   | 0   | 1313  |
| 2000    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 2001    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 2002    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 2003    | 0   | 0   | 0   | 63  | 155 | 178 | 237 | 307 | 225 | 147 | 0   | 0   | 1313  |
| 2004    | 0   | 0   | 0   | 63  | 155 | 178 | 119 | 154 | 113 | 147 | 0   | 0   | 936   |
| Average | 0   | 0   | 0   | 64  | 161 | 180 | 231 | 285 | 218 | 152 | 0   | 0   | 1307  |



| Potential Consumptive Use (af) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|--------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950                           | 0   | 0   | 0   | 0   | 77  | 189 | 209 | 241 | 191 | 109 | 47  | 0   | 421   |
| 1951                           | 0   | 0   | 0   | 4   | 127 | 156 | 241 | 264 | 241 | 58  | 31  | 0   | 501   |
| 1952                           | 0   | 0   | 0   | 53  | 131 | 226 | 246 | 224 | 131 | 153 | 44  | 0   | 1077  |
| 1953                           | 0   | 0   | 0   | 1   | 54  | 206 | 252 | 225 | 132 | 132 | 55  | 3   | 971   |
| 1954                           | 0   | 0   | 0   | 13  | 120 | 187 | 297 | 225 | 132 | 132 | 36  | 0   | 1013  |
| 1955                           | 0   | 0   | 0   | 52  | 149 | 176 | 293 | 252 | 132 | 132 | 43  | 0   | 1065  |
| 1956                           | 0   | 0   | 0   | 4   | 129 | 256 | 249 | 233 | 131 | 131 | 49  | 0   | 1021  |
| 1957                           | 0   | 0   | 0   | 4   | 108 | 177 | 275 | 218 | 135 | 135 | 33  | 0   | 931   |
| 1958                           | 0   | 0   | 0   | 24  | 165 | 177 | 210 | 241 | 135 | 135 | 48  | 0   | 1003  |
| 1959                           | 0   | 0   | 0   | 7   | 110 | 234 | 263 | 248 | 111 | 111 | 28  | 0   | 1001  |
| 1960                           | 0   | 0   | 0   | 31  | 135 | 200 | 269 | 224 | 134 | 134 | 46  | 0   | 1059  |
| 1961                           | 0   | 0   | 0   | 6   | 125 | 244 | 258 | 250 | 97  | 97  | 38  | 0   | 1028  |
| 1962                           | 0   | 0   | 0   | 46  | 143 | 193 | 227 | 215 | 118 | 118 | 48  | 2   | 987   |
| 1963                           | 0   | 0   | 0   | 19  | 135 | 219 | 268 | 234 | 149 | 149 | 54  | 3   | 1048  |
| 1964                           | 0   | 0   | 0   | 26  | 144 | 234 | 268 | 234 | 112 | 112 | 43  | 0   | 1013  |
| 1965                           | 0   | 0   | 0   | 21  | 122 | 192 | 250 | 212 | 73  | 73  | 46  | 1   | 915   |
| 1966                           | 0   | 0   | 0   | 3   | 120 | 198 | 268 | 185 | 123 | 123 | 38  | 0   | 959   |
| 1967                           | 0   | 0   | 0   | 7   | 68  | 181 | 207 | 212 | 133 | 133 | 42  | 0   | 864   |
| 1968                           | 0   | 0   | 0   | 4   | 82  | 193 | 226 | 167 | 115 | 115 | 43  | 0   | 839   |
| 1969                           | 0   | 0   | 0   | 49  | 138 | 160 | 240 | 234 | 140 | 140 | 25  | 0   | 986   |
| 1970                           | 0   | 0   | 0   | 3   | 118 | 200 | 255 | 234 | 112 | 112 | 28  | 0   | 950   |
| 1971                           | 0   | 0   | 0   | 12  | 117 | 205 | 217 | 235 | 105 | 105 | 31  | 0   | 922   |
| 1972                           | 0   | 0   | 0   | 8   | 123 | 193 | 199 | 201 | 114 | 114 | 27  | 0   | 865   |
| 1973                           | 0   | 0   | 0   | 6   | 109 | 193 | 238 | 238 | 103 | 103 | 41  | 0   | 928   |
| 1974                           | 0   | 0   | 0   | 21  | 117 | 208 | 293 | 191 | 105 | 105 | 44  | 0   | 979   |
| 1975                           | 0   | 0   | 0   | 4   | 105 | 176 | 271 | 209 | 110 | 110 | 38  | 0   | 913   |
| 1976                           | 0   | 0   | 0   | 25  | 126 | 181 | 255 | 248 | 132 | 132 | 32  | 0   | 887   |
| 1977                           | 0   | 0   | 0   | 54  | 155 | 226 | 260 | 180 | 121 | 121 | 38  | 0   | 1034  |
| 1978                           | 0   | 0   | 0   | 13  | 124 | 156 | 241 | 205 | 148 | 148 | 43  | 0   | 970   |
| 1979                           | 0   | 0   | 0   | 9   | 111 | 198 | 226 | 197 | 145 | 145 | 44  | 0   | 943   |
| 1980                           | 0   | 0   | 0   | 43  | 138 | 211 | 273 | 197 | 124 | 124 | 40  | 0   | 1026  |
| 1981                           | 0   | 0   | 2   | 66  | 123 | 195 | 248 | 207 | 134 | 134 | 39  | 0   | 1014  |
| 1982                           | 0   | 0   | 0   | 5   | 104 | 159 | 238 | 209 | 110 | 110 | 34  | 0   | 858   |
| 1983                           | 0   | 0   | 0   | 2   | 50  | 182 | 262 | 266 | 120 | 120 | 39  | 0   | 961   |
| 1984                           | 0   | 0   | 0   | 8   | 111 | 180 | 251 | 242 | 103 | 103 | 34  | 0   | 929   |
| 1985                           | 0   | 0   | 0   | 70  | 165 | 176 | 270 | 201 | 96  | 96  | 31  | 0   | 1006  |
| 1986                           | 0   | 0   | 0   | 8   | 123 | 215 | 240 | 205 | 94  | 94  | 35  | 0   | 921   |
| 1987                           | 0   | 0   | 0   | 64  | 150 | 211 | 277 | 194 | 123 | 123 | 36  | 0   | 1055  |
| 1988                           | 0   | 0   | 0   | 35  | 153 | 216 | 262 | 225 | 118 | 118 | 40  | 0   | 1132  |
| 1989                           | 0   | 0   | 0   | 16  | 126 | 229 | 291 | 231 | 121 | 121 | 39  | 0   | 1011  |
| 1990                           | 0   | 0   | 0   | 10  | 110 | 207 | 246 | 234 | 146 | 146 | 41  | 0   | 994   |
| 1991                           | 0   | 0   | 0   | 25  | 133 | 212 | 256 | 236 | 122 | 122 | 33  | 0   | 1017  |
| 1992                           | 0   | 0   | 0   | 33  | 138 | 176 | 190 | 179 | 126 | 126 | 30  | 0   | 887   |
| 1993                           | 0   | 0   | 0   | 6   | 131 | 164 | 196 | 158 | 101 | 101 | 36  | 0   | 833   |
| 1994                           | 0   | 0   | 0   | 30  | 155 | 222 | 238 | 231 | 144 | 144 | 42  | 0   | 1082  |
| 1995                           | 0   | 0   | 0   | 2   | 67  | 181 | 238 | 233 | 117 | 117 | 33  | 0   | 891   |
| 1996                           | 0   | 0   | 0   | 5   | 79  | 196 | 239 | 230 | 115 | 115 | 34  | 0   | 907   |
| 1997                           | 0   | 0   | 0   | 1   | 97  | 262 | 240 | 196 | 129 | 129 | 38  | 0   | 908   |
| 1998                           | 0   | 0   | 0   | 21  | 131 | 153 | 254 | 223 | 152 | 152 | 39  | 0   | 973   |
| 1999                           | 0   | 0   | 0   | 6   | 106 | 176 | 243 | 217 | 97  | 97  | 41  | 1   | 884   |
| 2000                           | 0   | 0   | 0   | 7   | 130 | 176 | 261 | 239 | 133 | 133 | 40  | 0   | 996   |
| 2001                           | 0   | 0   | 0   | 21  | 131 | 186 | 272 | 239 | 129 | 129 | 38  | 0   | 1016  |
| 2002                           | 0   | 0   | 0   | 10  | 111 | 241 | 313 | 226 | 131 | 131 | 23  | 0   | 1055  |
| 2003                           | 0   | 0   | 0   | 42  | 130 | 183 | 301 | 253 | 118 | 118 | 45  | 0   | 1065  |
| 2004                           | 0   | 0   | 0   | 50  | 139 | 184 | 262 | 199 | 132 | 132 | 43  | 0   | 1008  |
| Average                        | 0   | 0   | 0   | 20  | 122 | 197 | 254 | 219 | 121 | 121 | 35  | 0   | 972   |

Effective Precipitation (in)

|         | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | 0   | 0   | 0   | 0   | 35  | 23  | 42  | 68  | 58  | 5   | 0   | 0   | 230   |
| 1951    | 0   | 0   | 0   | 0   | 1   | 72  | 45  | 71  | 31  | 5   | 0   | 0   | 265   |
| 1952    | 0   | 0   | 0   | 0   | 3   | 76  | 77  | 42  | 19  | 3   | 0   | 0   | 222   |
| 1953    | 0   | 0   | 0   | 0   | 1   | 30  | 96  | 26  | 8   | 2   | 0   | 0   | 200   |
| 1954    | 0   | 0   | 0   | 0   | 1   | 57  | 24  | 37  | 55  | 23  | 0   | 0   | 255   |
| 1955    | 0   | 0   | 0   | 0   | 19  | 40  | 51  | 48  | 65  | 2   | 0   | 0   | 286   |
| 1956    | 0   | 0   | 0   | 0   | 2   | 44  | 38  | 62  | 78  | 0   | 0   | 0   | 226   |
| 1957    | 0   | 0   | 0   | 0   | 3   | 108 | 78  | 58  | 28  | 15  | 0   | 0   | 304   |
| 1958    | 0   | 0   | 0   | 0   | 17  | 26  | 67  | 105 | 8   | 2   | 0   | 0   | 243   |
| 1959    | 0   | 0   | 0   | 0   | 4   | 61  | 72  | 20  | 50  | 1   | 0   | 0   | 217   |
| 1960    | 0   | 0   | 0   | 0   | 10  | 49  | 55  | 21  | 34  | 16  | 0   | 0   | 184   |
| 1961    | 0   | 0   | 0   | 0   | 2   | 28  | 22  | 59  | 12  | 11  | 0   | 0   | 155   |
| 1962    | 0   | 0   | 0   | 0   | 3   | 161 | 53  | 109 | 26  | 21  | 0   | 0   | 407   |
| 1963    | 0   | 0   | 0   | 0   | 15  | 27  | 126 | 56  | 29  | 11  | 0   | 0   | 302   |
| 1964    | 0   | 0   | 0   | 0   | 9   | 58  | 106 | 48  | 15  | 6   | 0   | 0   | 265   |
| 1965    | 0   | 0   | 0   | 0   | 6   | 122 | 83  | 17  | 39  | 30  | 0   | 0   | 335   |
| 1966    | 0   | 0   | 0   | 0   | 2   | 34  | 108 | 75  | 60  | 17  | 0   | 0   | 305   |
| 1967    | 0   | 0   | 0   | 0   | 7   | 42  | 137 | 39  | 25  | 47  | 0   | 0   | 281   |
| 1968    | 0   | 0   | 0   | 0   | 3   | 27  | 146 | 63  | 59  | 20  | 0   | 0   | 315   |
| 1969    | 0   | 0   | 0   | 0   | 18  | 49  | 145 | 71  | 20  | 7   | 0   | 0   | 281   |
| 1970    | 0   | 0   | 0   | 0   | 3   | 48  | 54  | 30  | 19  | 34  | 0   | 0   | 233   |
| 1971    | 0   | 0   | 0   | 0   | 10  | 75  | 49  | 39  | 14  | 43  | 0   | 0   | 253   |
| 1972    | 0   | 0   | 0   | 0   | 6   | 67  | 84  | 43  | 61  | 4   | 0   | 0   | 262   |
| 1973    | 0   | 0   | 0   | 0   | 5   | 46  | 16  | 40  | 21  | 31  | 0   | 0   | 175   |
| 1974    | 0   | 0   | 0   | 0   | 9   | 28  | 29  | 20  | 35  | 19  | 0   | 0   | 156   |
| 1975    | 0   | 0   | 0   | 0   | 2   | 24  | 120 | 46  | 23  | 8   | 0   | 0   | 223   |
| 1976    | 0   | 0   | 0   | 0   | 17  | 58  | 107 | 30  | 36  | 5   | 0   | 0   | 264   |
| 1977    | 0   | 0   | 0   | 0   | 20  | 57  | 47  | 80  | 44  | 12  | 0   | 0   | 325   |
| 1978    | 0   | 0   | 0   | 0   | 8   | 65  | 50  | 102 | 37  | 2   | 0   | 0   | 282   |
| 1979    | 0   | 0   | 0   | 0   | 1   | 25  | 85  | 102 | 57  | 11  | 0   | 0   | 281   |
| 1980    | 0   | 0   | 0   | 0   | 12  | 35  | 110 | 52  | 19  | 0   | 0   | 0   | 306   |
| 1981    | 0   | 0   | 0   | 0   | 4   | 59  | 47  | 112 | 45  | 21  | 0   | 0   | 296   |
| 1982    | 0   | 0   | 0   | 0   | 1   | 103 | 65  | 49  | 56  | 34  | 0   | 0   | 415   |
| 1983    | 0   | 0   | 0   | 0   | 1   | 37  | 70  | 55  | 67  | 6   | 0   | 0   | 250   |
| 1984    | 0   | 0   | 0   | 0   | 7   | 32  | 154 | 44  | 28  | 16  | 0   | 0   | 236   |
| 1985    | 0   | 0   | 0   | 0   | 4   | 30  | 39  | 31  | 47  | 33  | 0   | 0   | 194   |
| 1986    | 0   | 0   | 0   | 0   | 9   | 32  | 107 | 26  | 35  | 62  | 0   | 0   | 289   |
| 1987    | 0   | 0   | 0   | 0   | 0   | 74  | 36  | 25  | 58  | 15  | 0   | 0   | 210   |
| 1988    | 0   | 0   | 0   | 0   | 5   | 71  | 33  | 10  | 52  | 12  | 0   | 0   | 182   |
| 1989    | 0   | 0   | 0   | 0   | 6   | 32  | 27  | 25  | 46  | 64  | 0   | 0   | 217   |
| 1990    | 0   | 0   | 0   | 0   | 3   | 89  | 37  | 53  | 50  | 55  | 0   | 0   | 295   |
| 1991    | 0   | 0   | 0   | 0   | 19  | 50  | 80  | 55  | 18  | 11  | 0   | 0   | 284   |
| 1992    | 0   | 0   | 0   | 0   | 6   | 54  | 52  | 76  | 11  | 8   | 0   | 0   | 216   |
| 1993    | 0   | 0   | 0   | 0   | 7   | 48  | 75  | 99  | 31  | 31  | 0   | 0   | 301   |
| 1994    | 0   | 0   | 0   | 0   | 9   | 38  | 18  | 26  | 5   | 32  | 0   | 0   | 143   |
| 1995    | 0   | 0   | 0   | 0   | 1   | 62  | 150 | 75  | 19  | 24  | 0   | 0   | 253   |
| 1996    | 0   | 0   | 0   | 0   | 3   | 79  | 32  | 14  | 50  | 11  | 0   | 0   | 223   |
| 1997    | 0   | 0   | 0   | 0   | 1   | 84  | 82  | 93  | 91  | 5   | 0   | 0   | 374   |
| 1998    | 0   | 0   | 0   | 0   | 1   | 51  | 114 | 36  | 38  | 39  | 0   | 0   | 314   |
| 1999    | 0   | 0   | 0   | 0   | 4   | 65  | 113 | 94  | 12  | 18  | 0   | 0   | 306   |
| 2000    | 0   | 0   | 0   | 0   | 7   | 52  | 30  | 58  | 20  | 10  | 0   | 0   | 203   |
| 2001    | 0   | 0   | 0   | 0   | 12  | 39  | 82  | 69  | 44  | 21  | 0   | 0   | 286   |
| 2002    | 0   | 0   | 0   | 0   | 5   | 43  | 23  | 50  | 58  | 9   | 0   | 0   | 226   |
| 2003    | 0   | 0   | 0   | 0   | 23  | 50  | 31  | 29  | 33  | 10  | 0   | 0   | 241   |
| 2004    | 0   | 0   | 0   | 0   | 10  | 47  | 36  | 68  | 62  | 20  | 0   | 0   | 277   |
| Average | 0   | 0   | 0   | 0   | 7   | 54  | 54  | 40  | 25  | 11  | 0   | 0   | 259   |

| Irrigation Water Requirement (in) |     |     |     |     |     |     |     |     |     |     |     |     |       |
|-----------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
|                                   | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
| 1950                              | 0   | 0   | 0   | 0   | 41  | 165 | 167 | 126 | 52  | 42  | 0   | 0   | 593   |
| 1951                              | 0   | 0   | 0   | 0   | 66  | 134 | 197 | 133 | 66  | 22  | 0   | 0   | 633   |
| 1952                              | 0   | 0   | 0   | 49  | 53  | 149 | 203 | 205 | 149 | 44  | 0   | 0   | 855   |
| 1953                              | 0   | 0   | 0   | 0   | 65  | 113 | 215 | 199 | 124 | 53  | 21  | 0   | 771   |
| 1954                              | 0   | 0   | 0   | 13  | 63  | 112 | 259 | 170 | 129 | 15  | 0   | 0   | 761   |
| 1955                              | 0   | 0   | 0   | 33  | 139 | 125 | 227 | 206 | 62  | 41  | 0   | 0   | 803   |
| 1956                              | 0   | 0   | 0   | 2   | 86  | 219 | 187 | 127 | 125 | 49  | 0   | 0   | 784   |
| 1957                              | 0   | 0   | 0   | 1   | 0   | 96  | 218 | 190 | 97  | 20  | 0   | 0   | 825   |
| 1958                              | 0   | 0   | 0   | 7   | 140 | 61  | 105 | 236 | 135 | 48  | 0   | 0   | 754   |
| 1959                              | 0   | 0   | 0   | 3   | 49  | 162 | 244 | 239 | 61  | 27  | 0   | 0   | 785   |
| 1960                              | 0   | 0   | 0   | 22  | 85  | 148 | 268 | 190 | 119 | 46  | 0   | 0   | 877   |
| 1961                              | 0   | 0   | 0   | 3   | 56  | 222 | 193 | 248 | 75  | 27  | 0   | 0   | 876   |
| 1962                              | 0   | 0   | 0   | 38  | 101 | 155 | 118 | 187 | 103 | 27  | 21  | 0   | 594   |
| 1963                              | 0   | 0   | 0   | 1   | 108 | 92  | 210 | 199 | 120 | 53  | 3   | 0   | 755   |
| 1964                              | 0   | 0   | 0   | 19  | 89  | 85  | 235 | 156 | 97  | 37  | 0   | 0   | 751   |
| 1965                              | 0   | 0   | 0   | 13  | 0   | 109 | 233 | 173 | 43  | 41  | 1   | 0   | 613   |
| 1966                              | 0   | 0   | 0   | 1   | 114 | 184 | 185 | 105 | 63  | 21  | 0   | 0   | 846   |
| 1967                              | 0   | 0   | 0   | 0   | 26  | 25  | 207 | 186 | 85  | 39  | 0   | 0   | 566   |
| 1968                              | 0   | 0   | 0   | 2   | 53  | 36  | 163 | 127 | 95  | 42  | 0   | 0   | 523   |
| 1969                              | 0   | 0   | 0   | 35  | 89  | 112 | 96  | 227 | 133 | 17  | 0   | 0   | 704   |
| 1970                              | 0   | 0   | 0   | 0   | 71  | 145 | 224 | 216 | 78  | 15  | 0   | 0   | 751   |
| 1971                              | 0   | 0   | 0   | 2   | 42  | 156 | 178 | 221 | 56  | 11  | 0   | 0   | 694   |
| 1972                              | 0   | 0   | 0   | 2   | 57  | 99  | 157 | 140 | 110 | 20  | 0   | 0   | 581   |
| 1973                              | 0   | 0   | 0   | 1   | 63  | 177 | 188 | 217 | 72  | 25  | 0   | 0   | 753   |
| 1974                              | 0   | 0   | 0   | 12  | 88  | 179 | 273 | 156 | 86  | 29  | 0   | 0   | 823   |
| 1975                              | 0   | 0   | 0   | 2   | 81  | 56  | 225 | 166 | 110 | 30  | 0   | 0   | 694   |
| 1976                              | 0   | 0   | 0   | 8   | 68  | 83  | 224 | 190 | 127 | 30  | 0   | 0   | 736   |
| 1977                              | 0   | 0   | 0   | 34  | 50  | 176 | 180 | 136 | 61  | 26  | 0   | 0   | 715   |
| 1978                              | 0   | 0   | 0   | 5   | 56  | 146 | 136 | 148 | 145 | 41  | 0   | 0   | 703   |
| 1979                              | 0   | 0   | 0   | 8   | 87  | 113 | 134 | 140 | 148 | 33  | 0   | 0   | 663   |
| 1980                              | 0   | 0   | 0   | 31  | 102 | 101 | 221 | 139 | 114 | 13  | 0   | 0   | 721   |
| 1981                              | 0   | 0   | 0   | 61  | 64  | 148 | 156 | 162 | 132 | 17  | 0   | 0   | 722   |
| 1982                              | 0   | 0   | 0   | 4   | 1   | 94  | 189 | 97  | 54  | 0   | 0   | 0   | 435   |
| 1983                              | 0   | 0   | 0   | 2   | 53  | 112 | 207 | 199 | 114 | 20  | 0   | 0   | 707   |
| 1984                              | 0   | 0   | 0   | 1   | 78  | 76  | 206 | 214 | 87  | 27  | 0   | 0   | 684   |
| 1985                              | 0   | 0   | 0   | 65  | 135 | 137 | 235 | 153 | 63  | 21  | 0   | 0   | 813   |
| 1986                              | 0   | 0   | 0   | 6   | 91  | 108 | 214 | 170 | 32  | 17  | 0   | 0   | 832   |
| 1987                              | 0   | 0   | 0   | 64  | 77  | 175 | 252 | 158 | 108 | 34  | 0   | 0   | 846   |
| 1988                              | 0   | 0   | 0   | 30  | 62  | 247 | 272 | 173 | 106 | 31  | 0   | 0   | 941   |
| 1989                              | 0   | 0   | 0   | 9   | 94  | 162 | 269 | 183 | 57  | 21  | 0   | 0   | 752   |
| 1990                              | 0   | 0   | 0   | 8   | 21  | 170 | 193 | 183 | 91  | 33  | 0   | 0   | 655   |
| 1991                              | 0   | 0   | 0   | 4   | 44  | 133 | 201 | 229 | 109 | 23  | 0   | 0   | 735   |
| 1992                              | 0   | 0   | 0   | 26  | 84  | 127 | 114 | 168 | 129 | 32  | 0   | 0   | 611   |
| 1993                              | 0   | 0   | 0   | 1   | 83  | 88  | 97  | 167 | 69  | 23  | 0   | 0   | 531   |
| 1994                              | 0   | 0   | 0   | 21  | 120 | 204 | 221 | 205 | 139 | 10  | 0   | 0   | 923   |
| 1995                              | 0   | 0   | 0   | 0   | 25  | 81  | 163 | 221 | 97  | 9   | 0   | 0   | 594   |
| 1996                              | 0   | 0   | 0   | 3   | 0   | 167 | 225 | 180 | 61  | 23  | 0   | 0   | 679   |
| 1997                              | 0   | 0   | 0   | 0   | 13  | 123 | 147 | 107 | 111 | 33  | 0   | 0   | 534   |
| 1998                              | 0   | 0   | 0   | 19  | 0   | 39  | 218 | 165 | 117 | 65  | 0   | 0   | 655   |
| 1999                              | 0   | 0   | 0   | 1   | 35  | 66  | 149 | 205 | 78  | 41  | 1   | 0   | 571   |
| 2000                              | 0   | 0   | 0   | 0   | 78  | 136 | 204 | 219 | 123 | 23  | 0   | 0   | 783   |
| 2001                              | 0   | 0   | 0   | 9   | 92  | 166 | 202 | 155 | 108 | 28  | 0   | 0   | 735   |
| 2002                              | 0   | 0   | 0   | 5   | 67  | 218 | 261 | 175 | 73  | 15  | 0   | 0   | 834   |
| 2003                              | 0   | 0   | 0   | 18  | 80  | 116 | 271 | 234 | 65  | 35  | 0   | 0   | 842   |
| 2004                              | 0   | 0   | 0   | 40  | 92  | 148 | 164 | 182 | 98  | 23  | 0   | 0   | 721   |
| Average                           | 0   | 0   | 0   | 13  | 69  | 129 | 200 | 179 | 98  | 28  | 0   | 0   | 713   |

Historical Consumptive Use (in)

|         | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | 0   | 0   | 0   | 0   | 41  | 165 | 197 | 126 | 52  | 42  | 0   | 0   | 593   |
| 1951    | 0   | 0   | 0   | 0   | 4   | 87  | 124 | 197 | 66  | 22  | 0   | 0   | 633   |
| 1952    | 0   | 0   | 0   | 49  | 53  | 145 | 203 | 205 | 149 | 44  | 6   | 0   | 892   |
| 1953    | 0   | 0   | 0   | 0   | 6   | 65  | 113 | 215 | 184 | 53  | 2   | 0   | 711   |
| 1954    | 0   | 0   | 0   | 13  | 63  | 112 | 259 | 170 | 129 | 15  | 6   | 0   | 761   |
| 1955    | 0   | 0   | 0   | 33  | 109 | 175 | 227 | 208 | 62  | 41  | 0   | 0   | 603   |
| 1956    | 0   | 0   | 0   | 2   | 28  | 218 | 167 | 127 | 129 | 49  | 0   | 0   | 794   |
| 1957    | 0   | 0   | 0   | 1   | 0   | 99  | 218 | 190 | 97  | 20  | 0   | 0   | 623   |
| 1958    | 0   | 0   | 0   | 7   | 140 | 91  | 105 | 236 | 135 | 46  | 0   | 0   | 766   |
| 1959    | 0   | 0   | 0   | 3   | 49  | 162 | 239 | 61  | 27  | 0   | 0   | 0   | 763   |
| 1960    | 0   | 0   | 0   | 22  | 66  | 146 | 258 | 190 | 108 | 46  | 0   | 0   | 892   |
| 1961    | 0   | 0   | 0   | 3   | 96  | 73  | 77  | 100 | 73  | 27  | 0   | 0   | 455   |
| 1962    | 0   | 0   | 0   | 38  | 10  | 135 | 118 | 187 | 103 | 27  | 2   | 0   | 594   |
| 1963    | 0   | 0   | 0   | 1   | 108 | 92  | 210 | 159 | 120 | 53  | 3   | 0   | 783   |
| 1964    | 0   | 0   | 0   | 19  | 68  | 85  | 265 | 156 | 97  | 37  | 0   | 0   | 751   |
| 1965    | 0   | 0   | 0   | 13  | 0   | 109 | 233 | 173 | 43  | 41  | 1   | 0   | 613   |
| 1966    | 0   | 0   | 0   | 1   | 114 | 184 | 180 | 166 | 63  | 21  | 0   | 0   | 647   |
| 1967    | 0   | 0   | 0   | 0   | 38  | 25  | 207 | 138 | 86  | 39  | 0   | 0   | 566   |
| 1968    | 0   | 0   | 0   | 2   | 55  | 35  | 163 | 127 | 95  | 42  | 0   | 0   | 520   |
| 1969    | 0   | 0   | 0   | 30  | 89  | 112 | 96  | 227 | 133 | 17  | 0   | 0   | 704   |
| 1970    | 0   | 0   | 0   | 0   | 71  | 148 | 224 | 216 | 78  | 16  | 0   | 0   | 751   |
| 1971    | 0   | 0   | 0   | 2   | 42  | 156 | 178 | 221 | 56  | 11  | 0   | 0   | 666   |
| 1972    | 0   | 0   | 0   | 2   | 57  | 94  | 157 | 140 | 110 | 20  | 0   | 0   | 583   |
| 1973    | 0   | 0   | 0   | 1   | 63  | 177 | 198 | 217 | 72  | 25  | 0   | 0   | 753   |
| 1974    | 0   | 0   | 0   | 12  | 68  | 178 | 273 | 156 | 66  | 28  | 0   | 0   | 823   |
| 1975    | 0   | 0   | 0   | 2   | 81  | 56  | 225 | 196 | 110 | 30  | 0   | 0   | 694   |
| 1976    | 0   | 0   | 0   | 8   | 68  | 83  | 224 | 190 | 127 | 30  | 0   | 0   | 734   |
| 1977    | 0   | 0   | 0   | 34  | 99  | 176 | 180 | 136 | 61  | 28  | 0   | 0   | 715   |
| 1978    | 0   | 0   | 0   | 5   | 59  | 146 | 139 | 168 | 145 | 41  | 0   | 0   | 703   |
| 1979    | 0   | 0   | 0   | 8   | 87  | 113 | 134 | 140 | 146 | 33  | 0   | 0   | 663   |
| 1980    | 0   | 0   | 0   | 31  | 102 | 101 | 221 | 139 | 114 | 13  | 0   | 0   | 721   |
| 1981    | 0   | 0   | 2   | 61  | 64  | 148 | 136 | 162 | 132 | 17  | 0   | 0   | 722   |
| 1982    | 0   | 0   | 0   | 4   | 1   | 94  | 169 | 97  | 54  | 0   | 0   | 0   | 434   |
| 1983    | 0   | 0   | 0   | 2   | 53  | 112 | 207 | 169 | 114 | 20  | 0   | 0   | 707   |
| 1984    | 0   | 0   | 0   | 1   | 78  | 76  | 206 | 214 | 87  | 27  | 0   | 0   | 686   |
| 1985    | 0   | 0   | 0   | 65  | 135 | 137 | 239 | 153 | 63  | 21  | 0   | 0   | 813   |
| 1986    | 0   | 0   | 0   | 0   | 91  | 106 | 214 | 170 | 32  | 17  | 0   | 0   | 632   |
| 1987    | 0   | 0   | 0   | 64  | 77  | 175 | 252 | 136 | 108 | 34  | 0   | 0   | 844   |
| 1988    | 0   | 0   | 0   | 30  | 82  | 247 | 272 | 173 | 106 | 31  | 0   | 0   | 941   |
| 1989    | 0   | 0   | 0   | 9   | 64  | 162 | 263 | 160 | 57  | 21  | 0   | 0   | 705   |
| 1990    | 0   | 0   | 0   | 8   | 21  | 176 | 193 | 183 | 91  | 33  | 0   | 0   | 656   |
| 1991    | 0   | 0   | 0   | 6   | 44  | 130 | 201 | 109 | 109 | 23  | 0   | 0   | 715   |
| 1992    | 0   | 0   | 0   | 28  | 84  | 127 | 114 | 168 | 120 | 32  | 0   | 0   | 671   |
| 1993    | 0   | 0   | 0   | 21  | 120 | 204 | 221 | 205 | 139 | 10  | 0   | 0   | 821   |
| 1994    | 0   | 0   | 0   | 1   | 83  | 88  | 97  | 167 | 69  | 23  | 0   | 0   | 531   |
| 1995    | 0   | 0   | 0   | 0   | 25  | 81  | 163 | 221 | 97  | 8   | 0   | 0   | 594   |
| 1996    | 0   | 0   | 0   | 3   | 0   | 167 | 225 | 190 | 61  | 23  | 0   | 0   | 676   |
| 1997    | 0   | 0   | 0   | 0   | 13  | 123 | 147 | 107 | 111 | 33  | 0   | 0   | 534   |
| 1998    | 0   | 0   | 0   | 19  | 89  | 35  | 218 | 165 | 117 | 0   | 0   | 0   | 654   |
| 1999    | 0   | 0   | 0   | 1   | 35  | 66  | 149 | 205 | 78  | 41  | 1   | 0   | 576   |
| 2000    | 0   | 0   | 0   | 0   | 78  | 136 | 204 | 219 | 123 | 23  | 0   | 0   | 783   |
| 2001    | 0   | 0   | 0   | 9   | 92  | 106 | 202 | 155 | 108 | 26  | 0   | 0   | 738   |
| 2002    | 0   | 0   | 0   | 5   | 67  | 216 | 231 | 175 | 73  | 15  | 0   | 0   | 834   |
| 2003    | 0   | 0   | 0   | 18  | 80  | 118 | 271 | 234 | 46  | 35  | 0   | 0   | 841   |
| 2004    | 0   | 0   | 0   | 40  | 92  | 146 | 194 | 152 | 70  | 23  | 0   | 0   | 721   |
| Average | 0   | 0   | 0   | 13  | 69  | 126 | 197 | 173 | 98  | 28  | 0   | 0   | 704   |

Historical Return Flows (unlagged) (af)

|         | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | 0   | 0   | 0   | 22  | 54  | 63  | 83  | 105 | 115 | 105 | 0   | 0   | 552   |
| 1951    | 0   | 0   | 0   | 59  | 69  | 69  | 83  | 125 | 125 | 125 | 0   | 0   | 693   |
| 1952    | 0   | 0   | 0   | 22  | 171 | 171 | 83  | 105 | 79  | 52  | 0   | 0   | 574   |
| 1953    | 0   | 0   | 0   | 25  | 90  | 90  | 83  | 105 | 79  | 52  | 0   | 0   | 505   |
| 1954    | 0   | 0   | 0   | 43  | 92  | 87  | 83  | 105 | 79  | 26  | 0   | 0   | 503   |
| 1955    | 0   | 0   | 0   | 22  | 54  | 63  | 83  | 105 | 79  | 29  | 0   | 0   | 485   |
| 1956    | 0   | 0   | 0   | 61  | 70  | 63  | 83  | 105 | 59  | 52  | 0   | 0   | 476   |
| 1957    | 0   | 0   | 0   | 22  | 127 | 81  | 83  | 105 | 79  | 122 | 0   | 0   | 622   |
| 1958    | 0   | 0   | 0   | 55  | 54  | 63  | 119 | 105 | 79  | 77  | 0   | 0   | 555   |
| 1959    | 0   | 0   | 0   | 60  | 106 | 63  | 83  | 105 | 79  | 52  | 0   | 0   | 551   |
| 1960    | 0   | 0   | 0   | 22  | 69  | 63  | 42  | 54  | 39  | 31  | 0   | 0   | 341   |
| 1961    | 0   | 0   | 0   | 11  | 27  | 31  | 42  | 54  | 39  | 26  | 0   | 0   | 230   |
| 1962    | 0   | 0   | 0   | 11  | 54  | 63  | 83  | 105 | 79  | 52  | 0   | 0   | 452   |
| 1963    | 0   | 0   | 0   | 22  | 54  | 129 | 63  | 105 | 79  | 67  | 0   | 0   | 542   |
| 1964    | 0   | 0   | 0   | 41  | 67  | 90  | 63  | 105 | 79  | 93  | 0   | 0   | 561   |
| 1965    | 0   | 0   | 0   | 59  | 233 | 160 | 105 | 105 | 255 | 180 | 0   | 0   | 1056  |
| 1966    | 0   | 0   | 0   | 61  | 84  | 63  | 83  | 115 | 163 | 126 | 0   | 0   | 565   |
| 1967    | 0   | 0   | 0   | 63  | 130 | 155 | 105 | 115 | 138 | 168 | 0   | 0   | 822   |
| 1968    | 0   | 0   | 0   | 32  | 101 | 144 | 83  | 171 | 130 | 105 | 0   | 0   | 793   |
| 1969    | 0   | 0   | 0   | 61  | 66  | 67  | 142 | 105 | 79  | 117 | 0   | 0   | 611   |
| 1970    | 0   | 0   | 0   | 63  | 85  | 63  | 83  | 105 | 79  | 85  | 0   | 0   | 563   |
| 1971    | 0   | 0   | 0   | 92  | 113 | 83  | 83  | 105 | 84  | 210 | 0   | 0   | 752   |
| 1972    | 0   | 0   | 0   | 61  | 99  | 60  | 63  | 155 | 116 | 128 | 0   | 0   | 732   |
| 1973    | 0   | 0   | 0   | 61  | 92  | 63  | 83  | 105 | 79  | 56  | 0   | 0   | 562   |
| 1974    | 0   | 0   | 0   | 51  | 67  | 63  | 42  | 54  | 39  | 38  | 0   | 0   | 386   |
| 1975    | 0   | 0   | 0   | 22  | 54  | 63  | 63  | 54  | 54  | 52  | 0   | 0   | 407   |
| 1976    | 0   | 0   | 0   | 22  | 54  | 63  | 83  | 105 | 79  | 52  | 0   | 0   | 461   |
| 1977    | 0   | 0   | 0   | 22  | 54  | 63  | 83  | 105 | 79  | 122 | 0   | 0   | 531   |
| 1978    | 0   | 0   | 0   | 56  | 174 | 63  | 83  | 125 | 80  | 107 | 0   | 0   | 668   |
| 1979    | 0   | 0   | 0   | 54  | 83  | 86  | 105 | 188 | 79  | 113 | 0   | 0   | 662   |
| 1980    | 0   | 0   | 0   | 31  | 54  | 78  | 42  | 54  | 79  | 52  | 0   | 0   | 393   |
| 1981    | 0   | 0   | 0   | 11  | 54  | 63  | 83  | 105 | 79  | 96  | 0   | 0   | 494   |
| 1982    | 0   | 0   | 0   | 59  | 154 | 85  | 121 | 213 | 245 | 147 | 0   | 0   | 1022  |
| 1983    | 0   | 0   | 0   | 61  | 102 | 87  | 83  | 105 | 79  | 109 | 0   | 0   | 603   |
| 1984    | 0   | 0   | 0   | 62  | 77  | 103 | 83  | 105 | 79  | 114 | 0   | 0   | 622   |
| 1985    | 0   | 0   | 0   | 22  | 54  | 63  | 42  | 105 | 79  | 52  | 0   | 0   | 422   |
| 1986    | 0   | 0   | 0   | 26  | 84  | 71  | 83  | 105 | 164 | 204 | 0   | 0   | 723   |
| 1987    | 0   | 0   | 0   | 22  | 55  | 63  | 42  | 105 | 79  | 52  | 0   | 0   | 421   |
| 1988    | 0   | 0   | 0   | 22  | 54  | 63  | 83  | 105 | 35  | 52  | 0   | 0   | 421   |
| 1989    | 0   | 0   | 0   | 22  | 54  | 63  | 83  | 54  | 52  | 52  | 0   | 0   | 407   |
| 1990    | 0   | 0   | 0   | 22  | 54  | 63  | 83  | 54  | 39  | 26  | 0   | 0   | 341   |
| 1991    | 0   | 0   | 0   | 22  | 54  | 63  | 83  | 105 | 79  | 52  | 0   | 0   | 461   |
| 1992    | 0   | 0   | 0   | 22  | 54  | 63  | 83  | 105 | 79  | 105 | 0   | 0   | 516   |
| 1993    | 0   | 0   | 0   | 61  | 72  | 181 | 140 | 140 | 156 | 123 | 0   | 0   | 673   |
| 1994    | 0   | 0   | 0   | 42  | 54  | 63  | 83  | 105 | 79  | 52  | 0   | 0   | 461   |
| 1995    | 0   | 0   | 0   | 22  | 164 | 188 | 147 | 105 | 107 | 139 | 0   | 0   | 872   |
| 1996    | 0   | 0   | 0   | 91  | 155 | 102 | 83  | 105 | 93  | 198 | 0   | 0   | 893   |
| 1997    | 0   | 0   | 0   | 64  | 220 | 145 | 163 | 203 | 190 | 188 | 0   | 0   | 1204  |
| 1998    | 0   | 0   | 0   | 75  | 76  | 236 | 139 | 139 | 184 | 221 | 0   | 0   | 1084  |
| 1999    | 0   | 0   | 0   | 92  | 120 | 203 | 161 | 105 | 219 | 180 | 0   | 0   | 1084  |
| 2000    | 0   | 0   | 0   | 62  | 78  | 63  | 83  | 105 | 79  | 59  | 0   | 0   | 532   |
| 2001    | 0   | 0   | 0   | 53  | 63  | 73  | 83  | 105 | 79  | 116 | 0   | 0   | 571   |
| 2002    | 0   | 0   | 0   | 57  | 89  | 63  | 83  | 105 | 79  | 52  | 0   | 0   | 532   |
| 2003    | 0   | 0   | 0   | 22  | 54  | 63  | 83  | 105 | 79  | 52  | 0   | 0   | 481   |
| 2004    | 0   | 0   | 0   | 22  | 54  | 63  | 42  | 54  | 39  | 38  | 0   | 0   | 329   |
| Average | 0   | 0   | 0   | 43  | 85  | 84  | 87  | 105 | 97  | 95  | 0   | 0   | 600   |



Surface Water Returns (mm/day) (a)

|         | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 58  | 53  | 0   | 0   | 275   |
| 1951    | 0   | 0   | 0   | 30  | 35  | 32  | 42  | 63  | 80  | 83  | 0   | 0   | 342   |
| 1952    | 0   | 0   | 0   | 11  | 88  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 342   |
| 1953    | 0   | 0   | 0   | 13  | 45  | 33  | 42  | 54  | 40  | 26  | 0   | 0   | 285   |
| 1954    | 0   | 0   | 0   | 24  | 46  | 34  | 42  | 54  | 46  | 13  | 0   | 0   | 256   |
| 1955    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 224   |
| 1956    | 0   | 0   | 0   | 31  | 35  | 32  | 42  | 54  | 20  | 26  | 0   | 0   | 235   |
| 1957    | 0   | 0   | 0   | 11  | 64  | 41  | 42  | 54  | 40  | 61  | 0   | 0   | 311   |
| 1958    | 0   | 0   | 0   | 29  | 27  | 32  | 60  | 54  | 40  | 39  | 0   | 0   | 278   |
| 1959    | 0   | 0   | 0   | 30  | 53  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 276   |
| 1960    | 0   | 0   | 0   | 11  | 35  | 32  | 21  | 27  | 20  | 26  | 0   | 0   | 171   |
| 1961    | 0   | 0   | 0   | 6   | 14  | 16  | 21  | 27  | 20  | 13  | 0   | 0   | 116   |
| 1962    | 0   | 0   | 0   | 6   | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 222   |
| 1963    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 271   |
| 1964    | 0   | 0   | 0   | 21  | 34  | 45  | 42  | 54  | 128 | 90  | 0   | 0   | 548   |
| 1965    | 0   | 0   | 0   | 25  | 117 | 60  | 55  | 55  | 82  | 63  | 0   | 0   | 333   |
| 1966    | 0   | 0   | 0   | 31  | 27  | 32  | 42  | 54  | 82  | 63  | 0   | 0   | 356   |
| 1967    | 0   | 0   | 0   | 32  | 65  | 78  | 55  | 58  | 70  | 54  | 0   | 0   | 416   |
| 1968    | 0   | 0   | 0   | 31  | 51  | 72  | 42  | 86  | 55  | 53  | 0   | 0   | 386   |
| 1969    | 0   | 0   | 0   | 16  | 33  | 34  | 71  | 54  | 40  | 59  | 0   | 0   | 366   |
| 1970    | 0   | 0   | 0   | 32  | 43  | 32  | 42  | 54  | 40  | 43  | 0   | 0   | 283   |
| 1971    | 0   | 0   | 0   | 46  | 57  | 32  | 42  | 54  | 42  | 105 | 0   | 0   | 377   |
| 1972    | 0   | 0   | 0   | 31  | 50  | 40  | 42  | 54  | 58  | 64  | 0   | 0   | 365   |
| 1973    | 0   | 0   | 0   | 31  | 46  | 32  | 42  | 54  | 40  | 38  | 0   | 0   | 281   |
| 1974    | 0   | 0   | 0   | 26  | 34  | 32  | 21  | 27  | 20  | 26  | 0   | 0   | 184   |
| 1975    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 231   |
| 1976    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 204   |
| 1977    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 204   |
| 1978    | 0   | 0   | 0   | 25  | 67  | 32  | 42  | 63  | 40  | 61  | 0   | 0   | 285   |
| 1979    | 0   | 0   | 0   | 27  | 35  | 33  | 52  | 64  | 46  | 57  | 0   | 0   | 345   |
| 1980    | 0   | 0   | 0   | 16  | 27  | 38  | 21  | 27  | 40  | 26  | 0   | 0   | 328   |
| 1981    | 0   | 0   | 0   | 6   | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 155   |
| 1982    | 0   | 0   | 0   | 30  | 77  | 43  | 61  | 107 | 123 | 74  | 0   | 0   | 447   |
| 1983    | 0   | 0   | 0   | 31  | 51  | 34  | 42  | 54  | 54  | 54  | 0   | 0   | 513   |
| 1984    | 0   | 0   | 0   | 31  | 39  | 52  | 42  | 54  | 40  | 57  | 0   | 0   | 344   |
| 1985    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 313   |
| 1986    | 0   | 0   | 0   | 13  | 32  | 36  | 42  | 54  | 82  | 102 | 0   | 0   | 380   |
| 1987    | 0   | 0   | 0   | 11  | 26  | 32  | 21  | 54  | 42  | 26  | 0   | 0   | 211   |
| 1988    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 20  | 26  | 0   | 0   | 211   |
| 1989    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 20  | 26  | 0   | 0   | 204   |
| 1990    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 20  | 26  | 0   | 0   | 171   |
| 1991    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 231   |
| 1992    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 40  | 55  | 0   | 0   | 255   |
| 1993    | 0   | 0   | 0   | 31  | 36  | 91  | 70  | 70  | 76  | 62  | 0   | 0   | 437   |
| 1994    | 0   | 0   | 0   | 21  | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 241   |
| 1995    | 0   | 0   | 0   | 11  | 82  | 54  | 74  | 54  | 54  | 70  | 0   | 0   | 438   |
| 1996    | 0   | 0   | 0   | 46  | 78  | 51  | 42  | 54  | 47  | 59  | 0   | 0   | 419   |
| 1997    | 0   | 0   | 0   | 47  | 110 | 73  | 82  | 102 | 55  | 54  | 0   | 0   | 602   |
| 1998    | 0   | 0   | 0   | 38  | 36  | 116 | 55  | 55  | 52  | 111 | 0   | 0   | 582   |
| 1999    | 0   | 0   | 0   | 46  | 60  | 102 | 81  | 55  | 110 | 50  | 0   | 0   | 542   |
| 2000    | 0   | 0   | 0   | 31  | 35  | 32  | 42  | 54  | 40  | 58  | 0   | 0   | 285   |
| 2001    | 0   | 0   | 0   | 27  | 32  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 231   |
| 2002    | 0   | 0   | 0   | 29  | 44  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 263   |
| 2003    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 40  | 26  | 0   | 0   | 231   |
| 2004    | 0   | 0   | 0   | 11  | 27  | 32  | 42  | 54  | 20  | 26  | 0   | 0   | 163   |
| Average | 0   | 0   | 0   | 22  | 43  | 42  | 44  | 54  | 46  | 47  | 0   | 0   | 303   |

Groundwater Returns (Lagged) (in)

|          | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950     | 6   | 6   | 4   | 4   | 8   | 18  | 24  | 31  | 40  | 45  | 47  | 24  | 283   |
| 1951     | 8   | 6   | 5   | 5   | 17  | 27  | 28  | 33  | 45  | 58  | 58  | 13  | 325   |
| 1952     | 9   | 7   | 6   | 10  | 13  | 44  | 43  | 37  | 43  | 33  | 17  | 10  | 265   |
| 1953     | 7   | 6   | 5   | 10  | 10  | 30  | 34  | 34  | 39  | 26  | 17  | 10  | 260   |
| 1954     | 7   | 5   | 5   | 15  | 35  | 31  | 34  | 42  | 39  | 26  | 13  | 8   | 257   |
| 1955     | 7   | 5   | 5   | 8   | 18  | 24  | 32  | 45  | 38  | 37  | 19  | 10  | 245   |
| 1956     | 7   | 5   | 5   | 17  | 27  | 28  | 33  | 41  | 39  | 26  | 15  | 8   | 243   |
| 1957     | 6   | 5   | 6   | 5   | 34  | 37  | 37  | 42  | 39  | 47  | 25  | 13  | 292   |
| 1958     | 8   | 6   | 6   | 16  | 23  | 26  | 40  | 46  | 35  | 35  | 20  | 10  | 320   |
| 1959     | 8   | 6   | 6   | 17  | 35  | 33  | 35  | 42  | 39  | 32  | 17  | 9   | 277   |
| 1960     | 7   | 5   | 5   | 6   | 22  | 26  | 13  | 24  | 22  | 24  | 13  | 7   | 185   |
| 1961     | 6   | 4   | 4   | 6   | 11  | 13  | 17  | 21  | 37  | 30  | 15  | 8   | 134   |
| 1962     | 4   | 3   | 3   | 5   | 16  | 23  | 31  | 39  | 37  | 30  | 15  | 8   | 215   |
| 1963     | 6   | 4   | 4   | 5   | 18  | 38  | 43  | 42  | 39  | 35  | 18  | 9   | 266   |
| 1964     | 7   | 5   | 5   | 13  | 23  | 32  | 36  | 42  | 40  | 40  | 21  | 10  | 272   |
| 1965     | 7   | 6   | 5   | 15  | 60  | 68  | 57  | 51  | 80  | 85  | 41  | 19  | 494   |
| 1966     | 13  | 9   | 8   | 20  | 26  | 28  | 34  | 44  | 58  | 60  | 30  | 15  | 344   |
| 1967     | 10  | 7   | 7   | 19  | 42  | 56  | 54  | 52  | 57  | 55  | 28  | 15  | 452   |
| 1968     | 11  | 8   | 7   | 18  | 35  | 50  | 46  | 60  | 61  | 54  | 26  | 15  | 394   |
| 1969     | 11  | 8   | 7   | 13  | 24  | 29  | 47  | 50  | 42  | 48  | 26  | 13  | 317   |
| 1970     | 10  | 7   | 7   | 19  | 32  | 31  | 35  | 43  | 40  | 40  | 23  | 11  | 293   |
| 1971     | 8   | 6   | 6   | 25  | 41  | 35  | 36  | 43  | 41  | 67  | 36  | 16  | 383   |
| 1972     | 11  | 8   | 7   | 19  | 35  | 36  | 38  | 56  | 54  | 55  | 30  | 14  | 364   |
| 1973     | 10  | 6   | 6   | 19  | 33  | 32  | 35  | 43  | 40  | 38  | 20  | 11  | 297   |
| 1974     | 8   | 6   | 6   | 16  | 28  | 28  | 29  | 23  | 23  | 24  | 14  | 8   | 209   |
| 1975     | 6   | 5   | 5   | 8   | 18  | 24  | 32  | 29  | 31  | 29  | 15  | 8   | 212   |
| 1976     | 6   | 6   | 5   | 9   | 18  | 24  | 32  | 40  | 38  | 31  | 16  | 9   | 231   |
| 1977     | 6   | 5   | 5   | 9   | 18  | 24  | 31  | 40  | 38  | 46  | 25  | 11  | 258   |
| 1978     | 8   | 6   | 5   | 17  | 49  | 41  | 37  | 47  | 42  | 45  | 24  | 12  | 331   |
| 1979     | 8   | 6   | 6   | 16  | 26  | 29  | 38  | 57  | 47  | 47  | 26  | 13  | 315   |
| 1980     | 9   | 6   | 6   | 12  | 20  | 29  | 28  | 25  | 31  | 29  | 15  | 8   | 218   |
| 1981     | 6   | 5   | 5   | 6   | 17  | 24  | 31  | 40  | 36  | 41  | 22  | 10  | 245   |
| 1982     | 7   | 5   | 5   | 17  | 45  | 43  | 47  | 71  | 90  | 79  | 37  | 18  | 463   |
| 1983     | 12  | 9   | 9   | 19  | 36  | 34  | 36  | 43  | 40  | 45  | 25  | 12  | 321   |
| 1984     | 9   | 7   | 7   | 6   | 30  | 38  | 40  | 41  | 40  | 48  | 25  | 12  | 321   |
| 1985     | 9   | 7   | 7   | 6   | 19  | 25  | 24  | 26  | 37  | 31  | 16  | 9   | 231   |
| 1986     | 7   | 5   | 5   | 10  | 21  | 28  | 30  | 41  | 35  | 31  | 16  | 9   | 231   |
| 1987     | 11  | 8   | 7   | 10  | 20  | 28  | 28  | 36  | 37  | 31  | 16  | 9   | 233   |
| 1988     | 7   | 5   | 5   | 8   | 15  | 26  | 24  | 32  | 31  | 26  | 15  | 8   | 221   |
| 1989     | 8   | 6   | 5   | 9   | 18  | 24  | 32  | 41  | 35  | 28  | 15  | 8   | 215   |
| 1990     | 6   | 5   | 4   | 8   | 18  | 24  | 31  | 29  | 31  | 18  | 10  | 6   | 182   |
| 1991     | 5   | 4   | 4   | 8   | 17  | 24  | 31  | 40  | 37  | 31  | 15  | 8   | 224   |
| 1992     | 6   | 4   | 4   | 8   | 18  | 24  | 31  | 40  | 38  | 43  | 23  | 11  | 285   |
| 1993     | 7   | 5   | 5   | 17  | 27  | 53  | 61  | 59  | 63  | 60  | 30  | 15  | 402   |
| 1994     | 10  | 7   | 7   | 14  | 22  | 26  | 33  | 41  | 39  | 32  | 17  | 10  | 250   |
| 1995     | 7   | 5   | 5   | 5   | 42  | 65  | 66  | 56  | 50  | 57  | 31  | 15  | 405   |
| 1996     | 10  | 6   | 6   | 7   | 25  | 46  | 43  | 46  | 45  | 46  | 37  | 18  | 404   |
| 1997     | 11  | 8   | 8   | 26  | 65  | 67  | 69  | 70  | 82  | 84  | 43  | 21  | 583   |
| 1998     | 14  | 10  | 10  | 24  | 34  | 57  | 64  | 67  | 87  | 86  | 43  | 21  | 583   |
| 1999     | 14  | 10  | 10  | 28  | 45  | 68  | 74  | 61  | 87  | 86  | 43  | 21  | 583   |
| 2000     | 15  | 11  | 11  | 22  | 33  | 63  | 37  | 44  | 32  | 36  | 20  | 12  | 312   |
| 2001     | 9   | 7   | 7   | 17  | 26  | 31  | 36  | 43  | 42  | 47  | 26  | 13  | 303   |
| 2002     | 9   | 7   | 7   | 18  | 33  | 31  | 35  | 43  | 40  | 33  | 17  | 10  | 281   |
| 2003     | 8   | 6   | 6   | 10  | 19  | 25  | 33  | 41  | 38  | 25  | 17  | 9   | 244   |
| 2004     | 7   | 5   | 5   | 7   | 19  | 25  | 23  | 24  | 22  | 24  | 13  | 7   | 184   |
| Average* | 8   | 6   | 6   | 14  | 26  | 34  | 37  | 43  | 43  | 44  | 23  | 12  | 306   |

Total Returns (Lagged) (a)

|         | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | 6   | 4   | 4   | 19  | 45  | 56  | 73  | 94  | 103 | 99  | 24  | 11  | 536   |
| 1951    | 8   | 6   | 5   | 46  | 61  | 59  | 75  | 107 | 121 | 121 | 29  | 13  | 667   |
| 1952    | 6   | 7   | 6   | 21  | 130 | 71  | 78  | 97  | 79  | 59  | 17  | 10  | 584   |
| 1953    | 7   | 6   | 5   | 22  | 72  | 63  | 75  | 96  | 78  | 62  | 17  | 10  | 514   |
| 1954    | 7   | 5   | 5   | 35  | 78  | 56  | 76  | 96  | 79  | 99  | 13  | 8   | 508   |
| 1955    | 7   | 5   | 5   | 20  | 45  | 56  | 73  | 94  | 78  | 77  | 19  | 10  | 486   |
| 1956    | 7   | 5   | 5   | 48  | 62  | 59  | 75  | 95  | 50  | 52  | 15  | 8   | 481   |
| 1957    | 6   | 5   | 5   | 20  | 97  | 75  | 78  | 96  | 78  | 108 | 25  | 12  | 608   |
| 1958    | 8   | 6   | 6   | 44  | 50  | 57  | 100 | 100 | 79  | 78  | 20  | 10  | 502   |
| 1959    | 8   | 6   | 5   | 47  | 68  | 64  | 76  | 96  | 79  | 58  | 17  | 9   | 555   |
| 1960    | 7   | 6   | 5   | 20  | 55  | 59  | 45  | 51  | 41  | 50  | 13  | 7   | 356   |
| 1961    | 6   | 4   | 4   | 11  | 24  | 24  | 38  | 48  | 40  | 30  | 6   | 5   | 248   |
| 1962    | 4   | 3   | 3   | 11  | 43  | 54  | 72  | 93  | 77  | 56  | 15  | 8   | 440   |
| 1963    | 6   | 4   | 4   | 19  | 46  | 45  | 61  | 98  | 78  | 69  | 18  | 9   | 531   |
| 1964    | 7   | 5   | 5   | 33  | 57  | 77  | 77  | 96  | 78  | 87  | 21  | 10  | 553   |
| 1965    | 7   | 6   | 5   | 40  | 177 | 148 | 111 | 106 | 208 | 175 | 41  | 19  | 1042  |
| 1966    | 13  | 9   | 6   | 50  | 53  | 59  | 76  | 102 | 140 | 123 | 30  | 15  | 677   |
| 1967    | 10  | 7   | 7   | 51  | 107 | 134 | 109 | 110 | 128 | 109 | 28  | 15  | 812   |
| 1968    | 11  | 8   | 7   | 50  | 86  | 120 | 66  | 145 | 128 | 107 | 28  | 15  | 730   |
| 1969    | 11  | 8   | 7   | 29  | 57  | 82  | 118 | 104 | 91  | 106 | 25  | 13  | 632   |
| 1970    | 10  | 7   | 7   | 51  | 74  | 63  | 78  | 97  | 83  | 82  | 22  | 11  | 578   |
| 1971    | 8   | 6   | 6   | 71  | 96  | 67  | 78  | 97  | 83  | 172 | 38  | 16  | 740   |
| 1972    | 11  | 8   | 7   | 49  | 84  | 76  | 79  | 138 | 113 | 120 | 30  | 14  | 733   |
| 1973    | 10  | 8   | 7   | 49  | 79  | 63  | 77  | 97  | 79  | 76  | 20  | 11  | 578   |
| 1974    | 8   | 6   | 6   | 41  | 59  | 59  | 46  | 52  | 42  | 50  | 14  | 8   | 353   |
| 1975    | 6   | 5   | 5   | 20  | 45  | 56  | 73  | 56  | 71  | 56  | 15  | 8   | 415   |
| 1976    | 6   | 5   | 4   | 20  | 45  | 56  | 73  | 54  | 77  | 57  | 16  | 9   | 462   |
| 1977    | 6   | 5   | 5   | 20  | 45  | 56  | 73  | 54  | 77  | 57  | 16  | 9   | 462   |
| 1978    | 8   | 6   | 5   | 43  | 135 | 72  | 78  | 108 | 82  | 96  | 24  | 12  | 676   |
| 1979    | 8   | 6   | 6   | 46  | 61  | 62  | 69  | 141 | 87  | 104 | 26  | 13  | 645   |
| 1980    | 9   | 6   | 6   | 22  | 47  | 38  | 47  | 52  | 70  | 55  | 15  | 8   | 411   |
| 1981    | 6   | 5   | 5   | 12  | 44  | 33  | 73  | 94  | 77  | 86  | 22  | 10  | 400   |
| 1982    | 7   | 5   | 5   | 45  | 122 | 86  | 108 | 177 | 213 | 153 | 37  | 18  | 977   |
| 1983    | 12  | 6   | 8   | 50  | 67  | 68  | 78  | 97  | 60  | 99  | 25  | 12  | 625   |
| 1984    | 9   | 7   | 6   | 50  | 68  | 60  | 81  | 98  | 60  | 103 | 25  | 12  | 625   |
| 1985    | 9   | 7   | 6   | 21  | 46  | 57  | 45  | 90  | 77  | 57  | 18  | 9   | 441   |
| 1986    | 7   | 5   | 5   | 23  | 53  | 63  | 75  | 95  | 136 | 177 | 39  | 16  | 694   |
| 1987    | 11  | 8   | 7   | 21  | 47  | 57  | 45  | 90  | 77  | 57  | 16  | 9   | 442   |
| 1988    | 7   | 5   | 5   | 20  | 46  | 56  | 73  | 95  | 45  | 52  | 15  | 6   | 431   |
| 1989    | 6   | 5   | 5   | 20  | 45  | 56  | 73  | 56  | 71  | 55  | 15  | 6   | 414   |
| 1990    | 6   | 5   | 5   | 19  | 45  | 55  | 73  | 56  | 42  | 51  | 10  | 6   | 352   |
| 1991    | 5   | 4   | 4   | 19  | 44  | 55  | 73  | 54  | 77  | 57  | 15  | 8   | 454   |
| 1992    | 6   | 4   | 4   | 19  | 45  | 55  | 73  | 54  | 77  | 57  | 23  | 11  | 505   |
| 1993    | 7   | 5   | 5   | 47  | 63  | 143 | 131 | 139 | 141 | 122 | 30  | 15  | 638   |
| 1994    | 10  | 7   | 5   | 35  | 49  | 88  | 75  | 85  | 78  | 58  | 17  | 10  | 493   |
| 1995    | 7   | 5   | 5   | 20  | 124 | 155 | 140 | 110 | 104 | 127 | 31  | 15  | 647   |
| 1996    | 10  | 8   | 7   | 71  | 128 | 100 | 85  | 100 | 91  | 166 | 37  | 16  | 819   |
| 1997    | 11  | 8   | 8   | 73  | 175 | 140 | 150 | 181 | 177 | 178 | 43  | 21  | 1165  |
| 1998    | 14  | 10  | 10  | 61  | 72  | 162 | 118 | 108 | 159 | 197 | 46  | 21  | 959   |
| 1999    | 14  | 10  | 10  | 74  | 105 | 165 | 154 | 115 | 186 | 174 | 42  | 21  | 1075  |
| 2000    | 15  | 11  | 10  | 53  | 72  | 84  | 78  | 98  | 81  | 65  | 20  | 12  | 578   |
| 2001    | 9   | 7   | 7   | 44  | 58  | 87  | 77  | 97  | 80  | 106 | 26  | 13  | 591   |
| 2002    | 9   | 7   | 7   | 46  | 76  | 76  | 76  | 97  | 79  | 59  | 17  | 10  | 547   |
| 2003    | 6   | 5   | 6   | 21  | 46  | 67  | 74  | 95  | 78  | 56  | 17  | 9   | 475   |
| 2004    | 7   | 5   | 5   | 20  | 46  | 56  | 44  | 51  | 41  | 50  | 13  | 7   | 347   |
| Average | 8   | 6   | 6   | 38  | 71  | 76  | 81  | 98  | 92  | 91  | 23  | 12  | 602   |

Historical Depletions (in)

|         | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | -6  | -4  | -4  | -4  | 110 | 123 | 164 | 213 | 122 | 48  | -24 | -11 | 772   |
| 1951    | -8  | -6  | -5  | -5  | 17  | 120 | 162 | 206 | 88  | 26  | -29 | -13 | 848   |
| 1952    | -6  | -6  | -6  | -4  | 103 | 106 | 159 | 210 | 106 | 88  | -17 | -10 | 807   |
| 1953    | -7  | -6  | -5  | -5  | 41  | 83  | 116 | 162 | 147 | 85  | -17 | -10 | 785   |
| 1954    | -7  | -5  | -5  | -5  | 24  | 78  | 161 | 211 | 146 | 35  | -13 | -8  | 732   |
| 1955    | -7  | -5  | -5  | -5  | 43  | 110 | 133 | 164 | 147 | 70  | -19 | -10 | 824   |
| 1956    | -7  | -5  | -5  | -5  | 15  | 93  | 120 | 162 | 63  | 59  | -15 | -8  | 720   |
| 1957    | -6  | -5  | -5  | -5  | 43  | 88  | 101 | 159 | 148 | 39  | -25 | -12 | 763   |
| 1958    | -8  | -5  | -6  | -6  | 19  | 105 | 122 | 207 | 148 | 71  | -20 | -10 | 757   |
| 1959    | -6  | -6  | -5  | -5  | 16  | 67  | 115 | 161 | 148 | 89  | -17 | -8  | 760   |
| 1960    | -7  | -5  | -5  | -5  | 13  | 99  | 121 | 211 | 148 | 97  | -13 | -7  | 571   |
| 1961    | -6  | -4  | -4  | -4  | 26  | 54  | 61  | 156 | 73  | 44  | -9  | -5  | 411   |
| 1962    | -4  | -3  | -3  | -3  | 20  | 112 | 125 | 165 | 148 | 91  | -15 | -8  | 841   |
| 1963    | -6  | -4  | -4  | -4  | 44  | 110 | 167 | 211 | 147 | 79  | -16 | -9  | 872   |
| 1964    | -7  | -5  | -5  | -5  | 36  | 66  | 102 | 160 | 147 | 60  | -21 | -10 | 761   |
| 1965    | -7  | -5  | -5  | -5  | 23  | 56  | 121 | 159 | 62  | 46  | -41 | -19 | 684   |
| 1966    | -13 | -6  | -8  | -8  | 13  | 102 | 120 | 161 | 85  | 24  | -30 | -15 | 636   |
| 1967    | -10 | -7  | -7  | -7  | 12  | 48  | 45  | 201 | 197 | 36  | -26 | -15 | 574   |
| 1968    | -11 | -8  | -7  | -7  | 13  | 65  | 57  | 143 | 66  | 40  | -28 | -15 | 531   |
| 1969    | -11 | -8  | -7  | -7  | 34  | 98  | 117 | 159 | 144 | 41  | -28 | -13 | 680   |
| 1970    | -10 | -7  | -7  | -7  | 12  | 61  | 116 | 210 | 146 | 83  | -22 | -11 | 735   |
| 1971    | -8  | -6  | -6  | -6  | 23  | 57  | 112 | 159 | 142 | 49  | -38 | -16 | 678   |
| 1972    | -11 | -8  | -7  | -7  | 14  | 71  | 103 | 168 | 112 | 27  | -50 | -14 | 583   |
| 1973    | -10 | -8  | -7  | -7  | 14  | 76  | 116 | 160 | 148 | 71  | -20 | -11 | 735   |
| 1974    | -8  | -6  | -6  | -6  | 22  | 96  | 120 | 173 | 122 | 97  | -14 | -8  | 537   |
| 1975    | -6  | -5  | -5  | -5  | 43  | 110 | 123 | 164 | 154 | 92  | -15 | -8  | 745   |
| 1976    | -6  | -5  | -5  | -5  | 43  | 110 | 123 | 164 | 148 | 50  | -16 | -9  | 851   |
| 1977    | -6  | -5  | -5  | -5  | 43  | 110 | 123 | 164 | 148 | 40  | -25 | -11 | 790   |
| 1978    | -8  | -6  | -6  | -6  | 17  | 97  | 107 | 159 | 143 | 49  | -24 | -12 | 715   |
| 1979    | -8  | -6  | -6  | -6  | 20  | 94  | 117 | 148 | 138 | 43  | -26 | -13 | 666   |
| 1980    | -9  | -6  | -6  | -6  | 56  | 108 | 124 | 164 | 155 | 52  | -15 | -8  | 631   |
| 1981    | -8  | -5  | -5  | -5  | 19  | 111 | 124 | 164 | 148 | 55  | -22 | -10 | 701   |
| 1982    | -7  | -5  | -5  | -5  | 17  | 33  | 93  | 202 | 133 | 87  | -37 | -18 | 487   |
| 1983    | -12 | -9  | -6  | -6  | 13  | 68  | 111 | 159 | 145 | 48  | -25 | -12 | 688   |
| 1984    | -9  | -7  | -6  | -6  | 13  | 87  | 88  | 156 | 145 | 44  | -25 | -12 | 688   |
| 1985    | -9  | -7  | -6  | -6  | 42  | 109 | 122 | 174 | 148 | 60  | -16 | -9  | 754   |
| 1986    | -7  | -5  | -5  | -5  | 40  | 102 | 116 | 162 | 148 | 44  | -39 | -16 | 693   |
| 1987    | -11 | -8  | -7  | -7  | 42  | 108 | 122 | 174 | 148 | 50  | -16 | -9  | 754   |
| 1988    | -7  | -5  | -5  | -5  | 43  | 109 | 123 | 164 | 148 | 55  | -15 | -8  | 776   |
| 1989    | -6  | -5  | -5  | -5  | 43  | 110 | 123 | 164 | 154 | 92  | -15 | -8  | 748   |
| 1990    | -6  | -5  | -5  | -5  | 44  | 110 | 124 | 164 | 148 | 43  | -10 | -6  | 623   |
| 1991    | -5  | -4  | -4  | -4  | 44  | 111 | 124 | 164 | 148 | 90  | -15 | -8  | 858   |
| 1992    | -6  | -4  | -4  | -4  | 44  | 111 | 124 | 164 | 148 | 50  | -23 | -11 | 804   |
| 1993    | -7  | -5  | -5  | -5  | 16  | 62  | 106 | 178 | 84  | 26  | -30 | -15 | 565   |
| 1994    | -10 | -7  | -7  | -7  | 28  | 106 | 121 | 162 | 147 | 88  | -17 | -10 | 814   |
| 1995    | -7  | -5  | -5  | -5  | 43  | 109 | 110 | 170 | 147 | 20  | -31 | -15 | 707   |
| 1996    | -10 | -8  | -7  | -7  | 25  | 77  | 159 | 152 | 123 | 55  | -37 | -16 | 688   |
| 1997    | -11 | -8  | -8  | -8  | 21  | 58  | 129 | 129 | 123 | 43  | -43 | -21 | 572   |
| 1998    | -14 | -10 | -10 | -10 | 33  | 63  | 87  | 182 | 141 | 24  | -45 | -21 | 691   |
| 1999    | -14 | -10 | -10 | -10 | 20  | 50  | 100 | 156 | 114 | 47  | -42 | -21 | 564   |
| 2000    | -15 | -11 | -11 | -11 | 10  | 63  | 115 | 159 | 144 | 82  | -20 | -12 | 735   |
| 2001    | -9  | -7  | -7  | -7  | 15  | 97  | 112 | 160 | 145 | 42  | -26 | -13 | 722   |
| 2002    | -6  | -7  | -7  | -7  | 12  | 76  | 116 | 161 | 146 | 88  | -17 | -10 | 766   |
| 2003    | -8  | -6  | -6  | -6  | 42  | 109 | 123 | 163 | 147 | 89  | -17 | -10 | 835   |
| 2004    | -7  | -5  | -5  | -5  | 43  | 109 | 123 | 163 | 147 | 97  | -13 | -7  | 863   |
| Average | -8  | -4  | -4  | -4  | 28  | 90  | 114 | 150 | 126 | 61  | -23 | -12 | 700   |

# **APPENDIX E**

## **Computation of Natural Flows – Rapid Creek U.S. Bureau of Reclamation**



JUN 7 1989

Mr. Duane Scott, Watermaster/Secretary  
Rapid Valley Water Conservancy District  
Rural Rte. 5, Box 750  
Rapid City SD 57701

Subject: Determination of Natural Flows at Deerfield and Pactola  
Reservoirs (Water Supply)

Dear Mr. Scott:

This letter is in response to your request to Jim Nafziger, Pactola Reservoir Superintendent, for an explanation of our method of computing natural flows at both Deerfield and Pactola Reservoirs. When we refer to "natural flows" at these reservoirs we are describing the naturally occurring stream flows in both Castle and Rapid Creeks as they enter Deerfield and Pactola Reservoirs, respectively.

In our method of determining the rate and quantity of these flows we utilize the principle of "net inflow" into these reservoirs. Net inflow into a reservoir can be computed on a daily basis by adding the quantity of water released from the reservoir over a 24-hour period to the change in storage in the reservoir over that same period. Thus, if the total release over a 24-hour period was 100 acre feet and the reservoir storage increased over that same period by 100 acre feet, the net inflow would be computed as 200 acre feet ( $100+100$ ). On the other hand, if the total daily release was 100 acre feet and the reservoir storage decreased over the 24-hour period by 50 acre feet, the net inflow would be computed as 50 acre feet [ $100+(-50)$ ].

This method is employed because it allows us to utilize measurement equipment in-place at the dams and is the only method which accounts for all inflow into the reservoirs regardless of the source. If we were to monitor and utilize the U.S. Geological Survey gaging stations above both reservoirs to determine inflow rates we would not be able to take into account any inflow directly into the reservoirs from sources other than Castle and Rapid Creeks. Thus, significant snow and rainfall runoff from the lands surrounding the reservoirs would not be included. Furthermore, since these gaging stations cannot be monitored remotely as we are able to do with the instruments at each of our dams, the Reservoir Superintendent would have to

visit both stations whenever natural flow computations were necessary. With the present schedule of water orders this requirement could result in several hours of travel time every week.

As discussed in the past, the principle of net inflow does not take into account the quantity of water which is lost from the reservoir in seepage and evaporation. Understandably, these losses in the reservoir should be significantly greater than those which would be experienced in the length of stream which once passed through the reservoir area.

To compensate for the loss of water from evaporation we are now employing an evaporation correction to the natural flow computations. This correction factor is based on a review of the 23 years of evaporation data available from the U.S. Weather Service Pactola Weather Station located at the Reservoir Superintendent's residence. By using this data and applying it to both Pactola and Deerfield Reservoirs we can estimate the average monthly evaporation from these facilities and apply this quantity as a credit to the natural flow computations. The monthly correction will be directly dependent on the water surface area of each reservoir at the beginning of each month. For May 1989 we have been using a total evaporation credit for both reservoirs of 4 cubic feet per second (cfs) which is added daily to the net inflow computations. For June this figure will increase to 6 cfs. Seepage from the reservoirs is assumed to re-enter the streams at some location downstream from the reservoirs and thus is not treated as a loss.

Natural flows required to be bypassed to prior water right holders during the irrigation season are computed for two separate and distinct areas in the Pactola-Deerfield Reservoir system. The first area, Area No. 1, covers only the Deerfield watershed and takes into account all natural flows above Deerfield Dam. Area No. 2 includes all natural flows in the Pactola watershed exclusive of Area No. 1. Natural flow quantities for Area No. 1 are computed at Deerfield Reservoir with those for Area No. 2 being computed at Pactola Reservoir.

Although natural flows are determined separately for each area, we must take into account any releases from Deerfield Reservoir to eliminate the possibility of "double-counting" these releases when the total Deerfield-Pactola natural flow is computed. The Deerfield releases are either the result of natural flows above the reservoir being bypassed to Pactola or reservoir storage releases from Deerfield Dam. In both cases the Deerfield release must be deducted from the computed net inflow at Pactola to eliminate these storage releases and bypassed natural flows from the natural flow computations for Area No. 2.

To calculate the natural flows for Area No. 1 the Deerfield evaporation credit is added to the computed net inflow at that reservoir. For Area No. 2 the evaporation credit for Pactola is

added to the computed net inflow for that reservoir to obtain the total Pactola inflow. The Deerfield release is then subtracted as explained above to provide the natural flows for this area. The natural flows computed for each area are then added to obtain the total natural flow figure for the Pactola-Deerfield system.

Following is a formula which illustrates this calculation:

|                                                    |    |              |
|----------------------------------------------------|----|--------------|
| Deerfield Reservoir Net Inflow                     | -- |              |
|                                                    |    | - Area No. 1 |
| + Deerfield Reservoir Evaporation Credit           | -- |              |
| + Pactola Reservoir Net Inflow                     | -- |              |
| - Deerfield Reservoir Release                      |    | - Area No. 2 |
| + Pactola Reservoir Evaporation Credit             | -- |              |
| -----                                              |    |              |
| = Total Natural Flows for Pactola-Deerfield System |    |              |
| (at Pactola Reservoir)                             |    |              |

This formula takes into account all sources of inflow and the estimated evaporation impact at both reservoirs. In addition, it eliminates the potential for errors created by storage releases or natural flow bypasses at Deerfield Reservoir by treating both reservoirs as one. This is the "pooled storage" concept agreed to in both the Rapid City and District contracts with Reclamation. The natural flow figure which is provided to you by Jim Nafziger during water order requests is the total of both the Deerfield and Pactola natural flows as computed by this formula.

We hope that this letter provides the explanation you require. If we can be of further assistance please let us know.

Sincerely,

Richard E. Brohl

Richard E. Brohl  
Project Manager

cc: Mr. John Hatch, Chief Engineer  
Water Rights Division  
Joe Foss Bldg  
Pierre SD 57501

bc: Regional Director  
Attn: GP-450

|                     |        |
|---------------------|--------|
| BF-100              | BF-430 |
| BF-400              | BF-433 |
| BF-400 Reading File |        |

FILE: C:\OTHER\WP\LETTERS\WATER\NATFLOWS.WCD

# **APPENDIX F**

## **Analysis of Historical Streamflow Records**

## USGS 06410500 RAPID CR ABOVE PACTOLA RES AT SILVER CITY, SD

Period of Record 1953-2005

| Percentile —> | 50% | 75% | 90% | 95% | Average | No.Obs. |
|---------------|-----|-----|-----|-----|---------|---------|
| Apr           | 52  | 39  | 28  | 23  | 67.5    | 1556    |
| May           | 64  | 42  | 30  | 26  | 94.7    | 1612    |
| Jun           | 60  | 35  | 24  | 21  | 99.1    | 1560    |
| Jul           | 43  | 28  | 21  | 18  | 57.9    | 1612    |
| Aug           | 38  | 27  | 20  | 17  | 47.1    | 1603    |
| Sep           | 33  | 24  | 19  | 15  | 40.1    | 1530    |
| Oct           | 25  | 20  | 16  | 14  | 33.1    | 1612    |
| Nov           | 20  | 15  | 12  | 10  | 24.7    | 1559    |

## USGS 06411500 RAPID CR BELOW PACTOLA DAM SD

Period of Record 1929-2005

| Percentile —> | 50% | 75% | 90% | 95% | Average | No.Obs. |
|---------------|-----|-----|-----|-----|---------|---------|
| Apr           | 34  | 17  | 12  | 8   | 51.6    | 1860    |
| May           | 63  | 42  | 20  | 16  | 91.5    | 1953    |
| Jun           | 64  | 40  | 21  | 14  | 100.7   | 1890    |
| Jul           | 70  | 49  | 32  | 21  | 80.4    | 1930    |
| Aug           | 56  | 39  | 30  | 25  | 61.8    | 1944    |
| Sep           | 36  | 28  | 22  | 19  | 42.6    | 1860    |
| Oct           | 25  | 15  | 13  | 11  | 28.1    | 1922    |
| Nov           | 18  | 14  | 11  | 8   | 23.6    | 1860    |

## USGS 06412500 RAPID CR ABOVE CANYON LAKE NEAR RAPID CITY SD

Period of Record 1948-2005

| Percentile —> | 50% | 75% | 90% | 95% | Average | No.Obs. |
|---------------|-----|-----|-----|-----|---------|---------|
| Apr           | 27  | 12  | 4   | 2   | 47.5    | 1770    |
| May           | 58  | 36  | 21  | 15  | 94.1    | 1829    |
| Jun           | 64  | 41  | 24  | 18  | 115.7   | 1770    |
| Jul           | 68  | 46  | 30  | 23  | 83.8    | 1829    |
| Aug           | 51  | 36  | 26  | 20  | 59.2    | 1851    |
| Sep           | 32  | 22  | 16  | 12  | 37.3    | 1770    |
| Oct           | 16  | 10  | 6   | 4   | 23.6    | 1829    |
| Nov           | 13  | 7   | 4   | 2   | 18.4    | 1770    |

## USGS 06414000 RAPID CR AT RAPID CITY SD

Period of Record 1942-2005

| Percentile —> | 50% | 75% | 90% | 95% | Average | No.Obs. |
|---------------|-----|-----|-----|-----|---------|---------|
| Apr           | 49  | 30  | 20  | 15  | 68.8    | 1890    |
| May           | 77  | 53  | 38  | 30  | 114.4   | 1953    |
| Jun           | 80  | 54  | 38  | 30  | 139.8   | 1890    |
| Jul           | 78  | 57  | 44  | 35  | 95.1    | 1904    |
| Aug           | 59  | 45  | 35  | 28  | 69.5    | 1975    |
| Sep           | 45  | 34  | 27  | 24  | 52.0    | 1890    |
| Oct           | 35  | 26  | 22  | 18  | 42.5    | 1953    |
| Nov           | 33  | 26  | 22  | 20  | 39.3    | 1890    |

## USGS 06418900 RAPID CR BL SEWAGE TREATMENT PL NR RAPID CITY, SD

Period of Record 1981-2005

| Percentile —> | 50% | 75% | 90% | 95% | Average | No.Obs. |
|---------------|-----|-----|-----|-----|---------|---------|
| Apr           | 21  | 12  | 6   | 4   | 23.9    | 62      |
| May           | 77  | 55  | 41  | 32  | 98.5    | 109     |
| Jun           | 51  | 37  | 29  | 17  | 61.8    | 120     |
| Jul           | 75  | 56  | 34  | 32  | 78.2    | 108     |
| Aug           | 55  | 34  | 24  | 19  | 51.4    | 93      |
| Sep           | 39  | 27  | 24  | 20  | 41.0    | 90      |
| Oct           | 14  | 10  | 8   | 8   | 15.6    | 62      |
| Nov           | 20  | 19  | 16  | 15  | 20.7    | 60      |

## USGS 06418900 RAPID CR BL SEWAGE TREATMENT PL NR RAPID CITY, SD

Period of Record 1981-2005

| Percentile —> | 50% | 75% | 90% | 95% | Average | No.Obs. |
|---------------|-----|-----|-----|-----|---------|---------|
| Apr           | 71  | 41  | 32  | 28  | 100.8   | 720     |
| May           | 78  | 47  | 28  | 23  | 141.8   | 744     |
| Jun           | 73  | 40  | 26  | 23  | 160.2   | 720     |
| Jul           | 69  | 41  | 28  | 24  | 104.6   | 744     |
| Aug           | 51  | 33  | 23  | 20  | 84.2    | 735     |
| Sep           | 44  | 26  | 20  | 18  | 60.3    | 698     |
| Oct           | 40  | 28  | 20  | 18  | 58.2    | 744     |
| Nov           | 48  | 36  | 29  | 24  | 62.1    | 720     |

## USGS 06421500 RAPID CR NEAR FARMINGDALE SD

Period of Record 1948-2005

| Percentile —> | 50% | 75% | 90% | 95% | Average | No.Obs. |
|---------------|-----|-----|-----|-----|---------|---------|
| Apr           | 65  | 40  | 21  | 13  | 91.1    | 1736    |
| May           | 64  | 19  | 6   | 3   | 121.6   | 1798    |
| Jun           | 62  | 22  | 9   | 5   | 141.5   | 1740    |
| Jul           | 35  | 14  | 5   | 2   | 69.1    | 1798    |
| Aug           | 24  | 10  | 2   | 0   | 42.6    | 1820    |
| Sep           | 28  | 13  | 2   | 0   | 37.8    | 1740    |
| Oct           | 36  | 22  | 10  | 2   | 46.3    | 1798    |
| Nov           | 46  | 34  | 27  | 21  | 52.3    | 1739    |



# **APPENDIX G**

## **Process for Estimating Historical Time Series of Diversions**

## USGS 06410500 RAPID CREEK ABOVE PACTOLA (af)

|             | Jan  | Feb  | Mar  | Apr   | May   | Jun   | Jul   | Aug   | Sep  | Oct  | Nov  | Dec  | Total |
|-------------|------|------|------|-------|-------|-------|-------|-------|------|------|------|------|-------|
| 1950        | 1067 | 958  | 1396 | 5512  | 6718  | 3152  | 3358  | 1974  | 1904 | 1569 | 1022 | 1038 | 29669 |
| 1951        | 819  | 823  | 1123 | 1672  | 2664  | 3372  | 2180  | 2424  | 2009 | 1341 | 937  | 887  | 20252 |
| 1952        | 847  | 895  | 1359 | 4265  | 18320 | 6678  | 3543  | 2801  | 2140 | 1880 | 1084 | 971  | 44781 |
| 1953        | 1309 | 1313 | 1896 | 2297  | 5042  | 4447  | 2531  | 2291  | 1557 | 1382 | 1063 | 1081 | 26210 |
| 1954        | 1055 | 1049 | 1502 | 2210  | 2471  | 1997  | 2757  | 2464  | 1462 | 934  | 817  | 815  | 19534 |
| 1955        | 748  | 712  | 1113 | 3596  | 3541  | 3013  | 3412  | 2692  | 2005 | 1103 | 837  | 776  | 23546 |
| 1956        | 877  | 768  | 2224 | 1787  | 2586  | 2860  | 2545  | 2281  | 1055 | 1619 | 1129 | 881  | 20609 |
| 1957        | 702  | 754  | 1178 | 1868  | 3820  | 4352  | 2118  | 2378  | 1329 | 1055 | 950  | 902  | 21408 |
| 1958        | 756  | 875  | 1252 | 1732  | 2325  | 3043  | 2497  | 2136  | 1987 | 1533 | 1057 | 811  | 20004 |
| 1959        | 823  | 922  | 1412 | 2719  | 2914  | 2680  | 3104  | 3915  | 4084 | 1091 | 720  | 770  | 25155 |
| 1960        | 625  | 597  | 1624 | 1704  | 1555  | 1644  | 1109  | 875   | 746  | 1874 | 740  | 766  | 13859 |
| 1961        | 688  | 748  | 1063 | 980   | 891   | 877   | 936   | 710   | 627  | 625  | 615  | 478  | 9237  |
| 1962        | 530  | 734  | 742  | 1144  | 4146  | 10368 | 3900  | 2444  | 1369 | 1256 | 934  | 829  | 28394 |
| 1963        | 611  | 621  | 1801 | 4021  | 6462  | 15848 | 5072  | 2402  | 2101 | 1392 | 1297 | 1091 | 42719 |
| 1964        | 1228 | 1212 | 1373 | 3860  | 5857  | 10161 | 5726  | 3846  | 3213 | 2434 | 1486 | 1496 | 41892 |
| 1965        | 1539 | 1448 | 1392 | 3666  | 16870 | 17300 | 9604  | 4923  | 4249 | 4522 | 1779 | 1428 | 68720 |
| 1966        | 1260 | 1452 | 3521 | 4130  | 3566  | 2299  | 1924  | 1966  | 3418 | 1821 | 1248 | 1059 | 27662 |
| 1967        | 1196 | 1045 | 2586 | 3199  | 4354  | 11169 | 6797  | 3685  | 3681 | 1847 | 1400 | 1216 | 42177 |
| 1968        | 1339 | 1299 | 1954 | 2465  | 2467  | 2924  | 2339  | 1803  | 2406 | 2039 | 970  | 994  | 22999 |
| 1969        | 1141 | 1018 | 1581 | 3566  | 4124  | 2422  | 2924  | 2424  | 3237 | 1232 | 1067 | 932  | 25666 |
| 1970        | 1065 | 1093 | 1333 | 6895  | 10368 | 6125  | 2898  | 2924  | 2709 | 1174 | 990  | 865  | 38438 |
| 1971        | 994  | 1240 | 1866 | 10259 | 9303  | 7053  | 2739  | 2079  | 3182 | 3392 | 1621 | 1115 | 44841 |
| 1972        | 992  | 1148 | 3120 | 2880  | 3608  | 5314  | 3707  | 3174  | 3094 | 2797 | 1238 | 1119 | 32190 |
| 1973        | 1164 | 1016 | 1507 | 4512  | 6782  | 3985  | 2587  | 2581  | 2586 | 2079 | 1325 | 1258 | 31381 |
| 1974        | 813  | 688  | 922  | 2354  | 2333  | 1531  | 1331  | 1434  | 1228 | 1305 | 946  | 836  | 15722 |
| 1975        | 603  | 495  | 893  | 5320  | 7287  | 4560  | 2711  | 1505  | 1521 | 1517 | 1069 | 1178 | 28661 |
| 1976        | 924  | 948  | 1761 | 2910  | 2999  | 8126  | 3739  | 2059  | 1942 | 2406 | 1113 | 970  | 29897 |
| 1977        | 881  | 1277 | 1730 | 6714  | 5905  | 2446  | 1989  | 2460  | 1557 | 1440 | 1073 | 1333 | 28804 |
| 1978        | 1127 | 1081 | 2275 | 3334  | 15876 | 5970  | 3545  | 2957  | 2489 | 2364 | 1349 | 1224 | 43591 |
| 1979        | 922  | 1908 | 2757 | 3164  | 2834  | 2803  | 3285  | 2878  | 2789 | 2495 | 1345 | 658  | 27838 |
| 1980        | 838  | 908  | 1347 | 3366  | 3410  | 2337  | 1299  | 1206  | 1803 | 2108 | 803  | 758  | 20183 |
| 1981        | 633  | 534  | 838  | 1305  | 2545  | 1456  | 1726  | 2388  | 1837 | 1244 | 655  | 604  | 15764 |
| 1982        | 560  | 579  | 889  | 3247  | 6317  | 6153  | 6839  | 6238  | 4384 | 2206 | 2035 | 1247 | 40695 |
| 1983        | 1323 | 1440 | 2388 | 5030  | 9937  | 5209  | 2626  | 2227  | 1490 | 1545 | 1303 | 775  | 35294 |
| 1984        | 1297 | 1295 | 1747 | 3295  | 8583  | 7236  | 4011  | 3316  | 2001 | 2104 | 1408 | 1156 | 37450 |
| 1985        | 1152 | 1148 | 2186 | 3061  | 2043  | 1517  | 1410  | 2071  | 1628 | 1533 | 1008 | 917  | 19675 |
| 1986        | 633  | 825  | 2519 | 3630  | 4810  | 3257  | 2196  | 1684  | 2676 | 3527 | 2178 | 1273 | 29205 |
| 1987        | 1144 | 1248 | 2846 | 4348  | 3856  | 2103  | 1402  | 1906  | 1412 | 1960 | 1263 | 599  | 24086 |
| 1988        | 532  | 817  | 1325 | 2757  | 3223  | 1613  | 1761  | 1654  | 1234 | 1139 | 1037 | 626  | 17717 |
| 1989        | 589  | 487  | 1335 | 2083  | 2372  | 1480  | 1442  | 1422  | 1283 | 1188 | 731  | 737  | 15150 |
| 1990        | 586  | 528  | 1452 | 3429  | 4136  | 2404  | 1488  | 1381  | 1194 | 1018 | 757  | 577  | 18948 |
| 1991        | 838  | 670  | 1043 | 2527  | 6052  | 11897 | 3285  | 2372  | 1900 | 1073 | 1156 | 1004 | 33817 |
| 1992        | 827  | 857  | 2019 | 2275  | 2243  | 2112  | 2543  | 2011  | 1585 | 1113 | 831  | 684  | 19101 |
| 1993        | 643  | 463  | 1275 | 3324  | 9273  | 13287 | 6282  | 3733  | 3084 | 2469 | 1331 | 1448 | 46612 |
| 1994        | 1065 | 902  | 3182 | 6252  | 8428  | 4203  | 2985  | 2531  | 1742 | 1547 | 1275 | 1131 | 35243 |
| 1995        | 1089 | 2358 | 4873 | 3229  | 16193 | 16465 | 6911  | 3798  | 2604 | 2545 | 2440 | 1559 | 64065 |
| 1996        | 1519 | 1805 | 7275 | 8634  | 11603 | 15061 | 5387  | 3850  | 3683 | 3342 | 3693 | 2249 | 68103 |
| 1997        | 2553 | 2456 | 6853 | 13797 | 19809 | 15791 | 8773  | 12605 | 5949 | 4655 | 3261 | 2944 | 99445 |
| 1998        | 3122 | 2844 | 6496 | 8999  | 5738  | 15900 | 14136 | 11548 | 6978 | 8220 | 7666 | 6321 | 97969 |
| 1999        | 5147 | 3800 | 5397 | 12224 | 13000 | 19609 | 9983  | 6710  | 4653 | 3800 | 3471 | 3055 | 90850 |
| 2000        | 3186 | 3662 | 3888 | 5232  | 7113  | 4550  | 3705  | 2844  | 2275 | 2477 | 2003 | 2198 | 43133 |
| 2001        | 2604 | 2594 | 3187 | 4653  | 3681  | 2787  | 3523  | 2311  | 1791 | 2079 | 2075 | 1628 | 32914 |
| 2002        | 1394 | 1682 | 1982 | 3975  | 3265  | 2235  | 1611  | 1557  | 1791 | 1688 | 1194 | 1144 | 23479 |
| 2003        | 1220 | 1258 | 2757 | 2817  | 6224  | 4401  | 2301  | 1593  | 1482 | 1390 | 1490 | 1279 | 28211 |
| 2004        | 1085 | 1101 | 1978 | 2362  | 1791  | 1285  | 1269  | 1091  | 1194 | 1258 | 1025 | 0    | 15440 |
| Avg 50-85   | 957  | 1001 | 1657 | 3446  | 5578  | 5067  | 3188  | 2554  | 2245 | 1785 | 1123 | 979  | 29580 |
| Stdev 50-85 | 261  | 312  | 646  | 1844  | 4252  | 3870  | 1773  | 1047  | 963  | 743  | 308  | 230  | 11680 |

## HYDROLOGIC PATTERN SERIES

|      | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|
| 1950 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1951 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1952 | AVG | AVG | AVG | AVG | WET | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1953 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1954 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | DRY | AVG | AVG | AVG    |
| 1955 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1956 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | DRY | AVG | AVG | AVG | AVG    |
| 1957 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1958 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1959 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | DRY | AVG | AVG    |
| 1960 | DRY | DRY | AVG | AVG | AVG | AVG | DRY | DRY | DRY | AVG | DRY | AVG | DRY    |
| 1961 | DRY | AVG | AVG | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY    |
| 1962 | DRY | AVG | DRY | DRY | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1963 | DRY | DRY | AVG | AVG | AVG | WET | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1964 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | WET | AVG    |
| 1965 | WET | AVG | AVG | AVG | WET | WET | WET | WET | WET | WET | WET | AVG | WET    |
| 1966 | AVG | AVG | WET | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1967 | AVG | AVG | AVG | AVG | AVG | AVG | WET | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1968 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1969 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1970 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1971 | AVG | AVG | AVG | WET | AVG | AVG | AVG | AVG | AVG | WET | AVG | AVG | AVG    |
| 1972 | AVG | AVG | WET | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1973 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1974 | AVG | DRY | DRY | AVG | AVG | AVG | DRY | DRY | DRY | AVG | AVG | AVG | DRY    |
| 1975 | DRY | DRY | DRY | AVG | AVG | AVG | AVG | DRY | AVG | AVG | AVG | AVG | AVG    |
| 1976 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1977 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1978 | AVG | AVG | AVG | AVG | WET | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1979 | AVG | WET | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | DRY | AVG    |
| 1980 | AVG | AVG | AVG | AVG | AVG | AVG | DRY | DRY | AVG | AVG | DRY | AVG | AVG    |
| 1981 | DRY | DRY | DRY | DRY | AVG | AVG | AVG | AVG | AVG | AVG | DRY | DRY | DRY    |
| 1982 | DRY | DRY | DRY | AVG | AVG | AVG | WET | WET | WET | AVG | WET | AVG | AVG    |
| 1983 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1984 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1985 | AVG | AVG | AVG | AVG | AVG | AVG | DRY | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1986 | DRY | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | WET | WET | AVG | AVG    |
| 1987 | AVG | AVG | AVG | AVG | AVG | AVG | DRY | AVG | AVG | AVG | AVG | DRY | AVG    |
| 1988 | DRY | AVG | AVG | AVG | AVG | AVG | AVG | AVG | DRY | AVG | AVG | DRY | DRY    |
| 1989 | DRY | DRY | AVG | AVG | AVG | AVG | AVG | DRY | AVG | AVG | DRY | DRY | DRY    |
| 1990 | DRY | DRY | AVG | AVG | AVG | AVG | AVG | DRY | DRY | DRY | DRY | DRY | AVG    |
| 1991 | AVG | DRY | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1992 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | DRY | AVG    |
| 1993 | DRY | DRY | AVG | AVG | AVG | WET | AVG | AVG | AVG | AVG | AVG | WET | AVG    |
| 1994 | AVG | AVG | WET | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 1995 | AVG | WET | WET | AVG | WET | WET | WET | AVG | AVG | AVG | WET | WET | WET    |
| 1996 | WET | WET | WET | WET | AVG | WET | AVG | AVG | AVG | WET | WET | WET | WET    |
| 1997 | WET | WET | WET | WET | WET | WET | WET | WET | WET | WET | WET | WET | WET    |
| 1998 | WET | WET | WET | WET | AVG | WET | WET | WET | WET | WET | WET | WET | WET    |
| 1999 | WET | WET | WET | WET | AVG | WET | WET | WET | WET | WET | WET | WET | WET    |
| 2000 | WET | WET | WET | AVG | AVG | AVG | AVG | AVG | AVG | AVG | WET | WET | AVG    |
| 2001 | WET | WET | WET | AVG | AVG | AVG | AVG | AVG | AVG | AVG | WET | WET | AVG    |
| 2002 | AVG | WET | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 2003 | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG | AVG    |
| 2004 | AVG | AVG | AVG | AVG | AVG | AVG | DRY | DRY | DRY | AVG | AVG | DRY | DRY    |

ESTIMATED DIVERSIONS CORRESPONDING TO HYDROLOGIC CONDITION

|                          | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Total |
|--------------------------|------|------|------|------|------|------|------|-------|
| Full <sup>(1)</sup>      | 1012 | 1045 | 1012 | 1045 | 1045 | 1012 | 1045 | 7216  |
| Avg 50-85 <sup>(2)</sup> | 211  | 523  | 604  | 799  | 1035 | 759  | 497  | 4427  |
| Dry <sup>(3)</sup>       | 105  | 261  | 302  | 400  | 517  | 380  | 248  | 2213  |
| Wet <sup>(4)</sup>       | 316  | 784  | 906  | 1045 | 1045 | 1012 | 745  | 5853  |

- Notes:
- 1 Diversion amount under full 17.0 cfs 1878 water right.
  - 2 Average diversions prior to Rapid City transfers.
  - 3 One-half times average.
  - 4 One and one-half times average.

ESTIMATED MURPHY DITCH DIVERSIONS (AF)

|         | Apr | May | Jun | Jul  | Aug  | Sep  | Oct | Total |
|---------|-----|-----|-----|------|------|------|-----|-------|
| 1950    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1951    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1952    | 211 | 784 | 604 | 799  | 1035 | 759  | 497 | 4688  |
| 1953    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1954    | 211 | 523 | 604 | 799  | 1035 | 759  | 248 | 4179  |
| 1955    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1956    | 211 | 523 | 604 | 799  | 1035 | 380  | 497 | 4047  |
| 1957    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1958    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1959    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1960    | 211 | 523 | 604 | 400  | 517  | 380  | 497 | 3130  |
| 1961    | 105 | 261 | 302 | 400  | 517  | 380  | 248 | 2213  |
| 1962    | 105 | 523 | 604 | 799  | 1035 | 759  | 497 | 4322  |
| 1963    | 211 | 523 | 906 | 799  | 1035 | 759  | 497 | 4729  |
| 1964    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1965    | 211 | 784 | 906 | 1045 | 1045 | 1012 | 745 | 5748  |
| 1966    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1967    | 211 | 523 | 604 | 1045 | 1035 | 759  | 497 | 4673  |
| 1968    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1969    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1970    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1971    | 316 | 523 | 604 | 799  | 1035 | 759  | 745 | 4780  |
| 1972    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1973    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1974    | 211 | 523 | 604 | 400  | 517  | 380  | 497 | 3130  |
| 1975    | 211 | 523 | 604 | 799  | 517  | 759  | 497 | 3910  |
| 1976    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1977    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1978    | 211 | 784 | 604 | 799  | 1035 | 759  | 497 | 4688  |
| 1979    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1980    | 211 | 523 | 604 | 400  | 517  | 759  | 497 | 3510  |
| 1981    | 105 | 523 | 604 | 799  | 1035 | 759  | 497 | 4322  |
| 1982    | 211 | 523 | 604 | 1045 | 1045 | 1012 | 497 | 4936  |
| 1983    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1984    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1985    | 211 | 523 | 604 | 400  | 1035 | 759  | 497 | 4027  |
| 1986    | 211 | 523 | 604 | 799  | 1035 | 759  | 745 | 4675  |
| 1987    | 211 | 523 | 604 | 400  | 1035 | 759  | 497 | 4027  |
| 1988    | 211 | 523 | 604 | 799  | 1035 | 380  | 497 | 4047  |
| 1989    | 211 | 523 | 604 | 799  | 517  | 759  | 497 | 3910  |
| 1990    | 211 | 523 | 604 | 799  | 517  | 380  | 248 | 3282  |
| 1991    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1992    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1993    | 211 | 523 | 906 | 799  | 1035 | 759  | 497 | 4729  |
| 1994    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 1995    | 211 | 784 | 906 | 1045 | 1035 | 759  | 497 | 5237  |
| 1996    | 316 | 523 | 906 | 799  | 1035 | 759  | 745 | 5083  |
| 1997    | 316 | 784 | 906 | 1045 | 1045 | 1012 | 745 | 5853  |
| 1998    | 316 | 523 | 906 | 1045 | 1045 | 1012 | 745 | 5592  |
| 1999    | 316 | 523 | 906 | 1045 | 1045 | 1012 | 745 | 5592  |
| 2000    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 2001    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 2002    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 2003    | 211 | 523 | 604 | 799  | 1035 | 759  | 497 | 4427  |
| 2004    | 211 | 523 | 604 | 400  | 517  | 380  | 497 | 3130  |
| Average | 214 | 542 | 643 | 780  | 981  | 734  | 515 | 4387  |

# HARNEY PEAK PRORATA MURPHY DITCH DIVERSIONS (af)

Harney Peak Ownership

33.36%

|         | Apr | May | Jun | Jul | Aug | Sep | Oct | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1951    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1952    | 70  | 262 | 202 | 267 | 345 | 253 | 166 | 1564  |
| 1953    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1954    | 70  | 174 | 202 | 267 | 345 | 253 | 83  | 1394  |
| 1955    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1956    | 70  | 174 | 202 | 267 | 345 | 127 | 166 | 1350  |
| 1957    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1958    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1959    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1960    | 70  | 174 | 202 | 133 | 173 | 127 | 166 | 1044  |
| 1961    | 35  | 87  | 101 | 133 | 173 | 127 | 83  | 738   |
| 1962    | 35  | 174 | 202 | 267 | 345 | 253 | 166 | 1442  |
| 1963    | 70  | 174 | 302 | 267 | 345 | 253 | 166 | 1578  |
| 1964    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1965    | 70  | 262 | 302 | 349 | 349 | 338 | 248 | 1918  |
| 1966    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1967    | 70  | 174 | 202 | 349 | 345 | 253 | 166 | 1559  |
| 1968    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1969    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1970    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1971    | 105 | 174 | 202 | 267 | 345 | 253 | 248 | 1595  |
| 1972    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1973    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1974    | 70  | 174 | 202 | 133 | 173 | 127 | 166 | 1044  |
| 1975    | 70  | 174 | 202 | 267 | 173 | 253 | 166 | 1304  |
| 1976    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1977    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1978    | 70  | 262 | 202 | 267 | 345 | 253 | 166 | 1564  |
| 1979    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1980    | 70  | 174 | 202 | 133 | 173 | 253 | 166 | 1171  |
| 1981    | 35  | 174 | 202 | 267 | 345 | 253 | 166 | 1442  |
| 1982    | 70  | 174 | 202 | 349 | 349 | 338 | 166 | 1647  |
| 1983    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1984    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1985    | 70  | 174 | 202 | 133 | 345 | 253 | 166 | 1344  |
| 1986    | 70  | 174 | 202 | 267 | 345 | 253 | 248 | 1560  |
| 1987    | 70  | 174 | 202 | 133 | 345 | 253 | 166 | 1344  |
| 1988    | 70  | 174 | 202 | 267 | 345 | 127 | 166 | 1350  |
| 1989    | 70  | 174 | 202 | 267 | 173 | 253 | 166 | 1304  |
| 1990    | 70  | 174 | 202 | 267 | 173 | 127 | 83  | 1095  |
| 1991    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1992    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1993    | 70  | 174 | 302 | 267 | 345 | 253 | 166 | 1578  |
| 1994    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 1995    | 70  | 262 | 302 | 349 | 345 | 253 | 166 | 1747  |
| 1996    | 105 | 174 | 302 | 267 | 345 | 253 | 248 | 1696  |
| 1997    | 105 | 262 | 302 | 349 | 349 | 338 | 248 | 1953  |
| 1998    | 105 | 174 | 302 | 349 | 349 | 338 | 248 | 1866  |
| 1999    | 105 | 174 | 302 | 349 | 349 | 338 | 248 | 1866  |
| 2000    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 2001    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 2002    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 2003    | 70  | 174 | 202 | 267 | 345 | 253 | 166 | 1477  |
| 2004    | 70  | 174 | 202 | 133 | 173 | 127 | 166 | 1044  |
| Average | 72  | 181 | 214 | 260 | 320 | 245 | 172 | 1464  |



## HARNEY PEAK PRORATA MURPHY DITCH DELIVERIES (af)

Ditch Loss

11.00%

|         | Apr | May | Jun | Jul | Aug | Sep | Oct | Total |
|---------|-----|-----|-----|-----|-----|-----|-----|-------|
| 1950    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1951    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1952    | 63  | 233 | 179 | 237 | 307 | 225 | 147 | 1392  |
| 1953    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1954    | 63  | 155 | 179 | 237 | 307 | 225 | 74  | 1241  |
| 1955    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1956    | 63  | 155 | 179 | 237 | 307 | 113 | 147 | 1202  |
| 1957    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1958    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1959    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1960    | 63  | 155 | 179 | 119 | 154 | 113 | 147 | 930   |
| 1961    | 31  | 78  | 90  | 119 | 154 | 113 | 74  | 657   |
| 1962    | 31  | 155 | 179 | 237 | 307 | 225 | 147 | 1283  |
| 1963    | 63  | 155 | 269 | 237 | 307 | 225 | 147 | 1404  |
| 1964    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1965    | 63  | 233 | 269 | 310 | 310 | 300 | 221 | 1707  |
| 1966    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1967    | 63  | 155 | 179 | 310 | 307 | 225 | 147 | 1388  |
| 1968    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1969    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1970    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1971    | 94  | 155 | 179 | 237 | 307 | 225 | 221 | 1419  |
| 1972    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1973    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1974    | 63  | 155 | 179 | 119 | 154 | 113 | 147 | 930   |
| 1975    | 63  | 155 | 179 | 237 | 154 | 225 | 147 | 1161  |
| 1976    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1977    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1978    | 63  | 233 | 179 | 237 | 307 | 225 | 147 | 1392  |
| 1979    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1980    | 63  | 155 | 179 | 119 | 154 | 225 | 147 | 1042  |
| 1981    | 31  | 155 | 179 | 237 | 307 | 225 | 147 | 1283  |
| 1982    | 63  | 155 | 179 | 310 | 310 | 300 | 147 | 1466  |
| 1983    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1984    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1985    | 63  | 155 | 179 | 119 | 307 | 225 | 147 | 1196  |
| 1986    | 63  | 155 | 179 | 237 | 307 | 225 | 221 | 1388  |
| 1987    | 63  | 155 | 179 | 119 | 307 | 225 | 147 | 1196  |
| 1988    | 63  | 155 | 179 | 237 | 307 | 113 | 147 | 1202  |
| 1989    | 63  | 155 | 179 | 237 | 154 | 225 | 147 | 1161  |
| 1990    | 63  | 155 | 179 | 237 | 154 | 113 | 74  | 974   |
| 1991    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1992    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1993    | 63  | 155 | 269 | 237 | 307 | 225 | 147 | 1404  |
| 1994    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 1995    | 63  | 233 | 269 | 310 | 307 | 225 | 147 | 1555  |
| 1996    | 94  | 155 | 269 | 237 | 307 | 225 | 221 | 1509  |
| 1997    | 94  | 233 | 269 | 310 | 310 | 300 | 221 | 1738  |
| 1998    | 94  | 155 | 269 | 310 | 310 | 300 | 221 | 1660  |
| 1999    | 94  | 155 | 269 | 310 | 310 | 300 | 221 | 1660  |
| 2000    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 2001    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 2002    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 2003    | 63  | 155 | 179 | 237 | 307 | 225 | 147 | 1315  |
| 2004    | 63  | 155 | 179 | 119 | 154 | 113 | 147 | 930   |
| Average | 64  | 161 | 191 | 231 | 285 | 218 | 153 | 1303  |

May 5, 2006

RECEIVED

MAY - 8 2006

Mr. Garland Eberle and Mr. Mark Rath  
S.D. Dept. of Environment & Natural Resources  
Water Rights  
Joe Foss Building  
523 E. Capitol  
Pierre, SD 57501-3182

WATER RIGHTS  
PROGRAM

Re: **Murphy Ditch Water Rights Application**

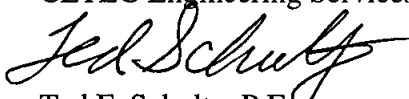
Dear Mr. Eberle and Mr. Rath:

I am forwarding a completed water rights transfer application for the Murphy Ditch Permit No. 1727-2. Please review and process this application and contact me with any questions. The following is included in this submittal:

1. Application For Permit To Appropriate Water Within The State of South Dakota.
2. Leonard Rice Engineers, Inc. letter to Garland Eberle dated May 4, 2006.
3. Figure 1 RVSD Lamb and Murphy Water Right Diversion Points.
4. 1878 Priority Date Land Parcel description for David S. Lamb 368 acres.
5. Draft City of Rapid City Resolution for return flows to Rapid Creek. This resolution is in progress at this time.
6. Application fee of \$100.00, CETEC check number 34393.
7. Water Rights Sale Agreement (Short Form).

I would be interested in meeting with Don Straub next week to discuss the water diversion measurements. Historically water rights have been measured at the Murphy Ditch headgate on Rapid Creek. The reduction of flows could be performed at the Murphy Ditch weir and the Ditch Master could continue to monitor flows at the Rapid Creek Murphy weir. I would suggest that logistical issues could be coordinated and discussed with the Rapid Valley Water Company Ditch Master in cooperation with the Rapid Valley Conservancy District. Thank you for your assistance with this application and please contact me with any questions.

Sincerely,  
CETEC Engineering Services, Inc.



Ted F. Schultz, P.E.  
Principal

cc: David S. Lamb  
Chuck Riter, Bangs, McCullen, Butler, Foye & Simmons, LLP  
Jim Jester, Rapid Valley Sanitary District-Water Service  
Brian Hagg, Whiting, Hagg & Hagg, LLP  
Ed Armbruster, Leonard Rice Engineers, Inc.

1830 West Fulton St.  
PO Box 9014  
Rapid City, SD  
57709-9014

[www.cetecengineering.com](http://www.cetecengineering.com)

**cetec**  
ENGINEERING SERVICES, INC.

03135.01/5/5/2006

® 605.341.7800

® 605.341.7864

## WATER LICENSE NO. 1727-2

(1) WHEREAS, On the 7th day of January, A.D. 1980Rapid Valley Water Company, Inc.Vested Right  
Vested Right Application No. 1727-2 for permit to use 20 cubic feet per second of the waters of Rapid CreekCounty of Pennington, State of South Dakota, for irrigation purposes; andVested Right  
(2) WHEREAS, On the 25th day of September, A.D. 1980  
Permit No. 1727-2, with a date of priority of 17 cfs from 1873 and 3 cfswas issued to said applicant<sup>5</sup> for the diversion of said water, and <sup>recognizing</sup> the completion of construction of the water supply system therein described ~~XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX~~ and for the application to beneficial use of said water ~~XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX~~

and:

(3) WHEREAS, It is hereby certified that the applicant has complied with the provisions of the laws of the State of South Dakota relating to completion of the construction of the water supply system and is entitled to divert 20 cubic feet per second of water for beneficial use and:

(4) WHEREAS, It is hereby certified that the applicant has complied with the provisions of the laws of the State of South Dakota relating to the application of water to beneficial use of the following extent:

- |                                |                                                                                                                                                                                              |                                                                                                                                        |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| 1) Guy Simons                  | 45 acres E $\frac{1}{2}$ SW $\frac{1}{4}$ , Sec. 9-T1N-R9E                                                                                                                                   | 1893 Priority: 3                                                                                                                       |
| 2) C.E. Morris                 | 64 acres W $\frac{1}{2}$ SE $\frac{1}{4}$ , Sec. 9-T1N-R9E                                                                                                                                   | 23) Rosanne Heavlin- 41 acres in the SE $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 19, and NE $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 30-T1N, R9E |
| 13) C.E. Morris                | 66 acres Sec. 24-T1N-R9E                                                                                                                                                                     | 24) Merlin Storer- 125 acres in the SW $\frac{1}{4}$ of Sec. 20, and W $\frac{1}{2}$ NW $\frac{1}{4}$ Sec. 29-T1N-R9E                  |
| 14) C.E. Morris                | 38 acres $\frac{1}{2}$ of the 76 acres in Sec. 24-T1N-R9E                                                                                                                                    | 25) James Bloom- 30 acres SW $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 20 and NW $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 29-T1N-R9E              |
| 3) R.W. Lamb                   | 187 acres SW $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 10, NW $\frac{1}{4}$ & W $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 15, T1N-R9E                                                                    | Total- 1425 acres                                                                                                                      |
| 4) R.W. Lamb                   | 130 acres in the SE $\frac{1}{4}$ NE $\frac{1}{4}$ and W $\frac{1}{2}$ SE $\frac{1}{4}$ Sec. 15; 90 acres in the SE $\frac{1}{4}$ Sec. 15, NW $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 20-T1N-R9E |                                                                                                                                        |
| 7) R.W. Lamb                   | 38 acres in the NW $\frac{1}{4}$ SW $\frac{1}{4}$ , Sec. 14, T1N, R9E                                                                                                                        |                                                                                                                                        |
| 5) A.K. Walker                 | 8 acres in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 14-T1N-R9E                                                                                                                             |                                                                                                                                        |
| 7) Jim Long                    | 10 acres in the NE $\frac{1}{4}$ SW $\frac{1}{4}$ and SE $\frac{1}{4}$ NW $\frac{1}{4}$ , Sec. 14-T1N-R9E                                                                                    |                                                                                                                                        |
| 6) David Murphy Est.           | 43 acres in the W $\frac{1}{2}$ , Sec. 11-T1N-R9E                                                                                                                                            |                                                                                                                                        |
| 8 & 9) Cura & Kenneth Buckholz | 10 acres in the W $\frac{1}{2}$ of center quarter of Sec. 14-T1N-R9E                                                                                                                         |                                                                                                                                        |
| 10) Elsie Higgins              | 121 acres in the SE $\frac{1}{4}$ of Sec. 14; and SW $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 13-T1N-R9E                                                                                          |                                                                                                                                        |
| 11) Wayne Anderson             | 12 acres in the SE $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 13-T1N-R9E                                                                                                                            |                                                                                                                                        |
| 12) Dale Wileman               | 6 acres in the SW $\frac{1}{4}$ SE $\frac{1}{4}$ of Sec. 13-T1N-R9E                                                                                                                          |                                                                                                                                        |
| 16) John Sweeney               | 1 acre NW $\frac{1}{4}$ NE $\frac{1}{4}$ of Sec. 24-T1N-R9E                                                                                                                                  |                                                                                                                                        |
| 15) Doug Peters                | 28 acres $\frac{1}{2}$ of 8 and 48 acres in the W $\frac{1}{2}$ NE $\frac{1}{4}$ of Sec. 24-T1N-R9E                                                                                          |                                                                                                                                        |
| 17) Raymond Tyler              | 65 acres in the W $\frac{1}{2}$ NW $\frac{1}{4}$ Sec. 19-T1N-R9E                                                                                                                             |                                                                                                                                        |
| 19) R.P. Carley                | 145 acres in Sec. 19 T1N-R9E                                                                                                                                                                 |                                                                                                                                        |
| 20) Bruce Hepper               | 63 acres in SW $\frac{1}{4}$ Sec. 19, NW $\frac{1}{4}$ Sec. 30-T1N-R9E                                                                                                                       |                                                                                                                                        |
| 21) Dr. Martin                 | 51 acres in SE $\frac{1}{4}$ Sec. 19, NE $\frac{1}{4}$ Sec. 30, T1N-R9E                                                                                                                      |                                                                                                                                        |

(5) NOW, THEREFORE, By the virtue of the authority vested in us by the laws of the State of South Dakota, We hereby grant and confirm to Rapid Valley Water Company Inc.

of Rapid City, South Dakota  
the holder S and owner S Vested Right 1727-2 a water right, dating from 17 cfs from 1870 and  
3 cfs from 1893 to use of 20 cubic feet per second of the waters  
of Rapid Creek

in the County of Pennington and State of South Dakota, or so much thereof as may be necessary for the  
purposes hereinbelow mentioned, to be diverted at a point on Rapid Creek in the SW $\frac{1}{4}$ , Section 8 - T1N - R8E

and conducted to and upon \_\_\_\_\_  
lands described on the  
face of this License

for the purpose of irrigation

This Water License No. 1727-2 is based on a Vested Right claim recorded and filed by the  
Water Management Board.

Subject to any limitations listed in Water Right Permit No. 1727-2 and subject to the laws of the State of South Dakota.

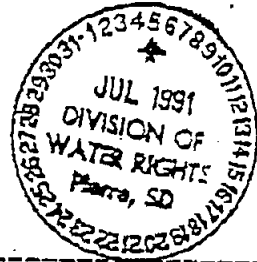
WITNESSE, My hand and seal of our office at Pierre, South Dakota  
this 31st day of March A.D.  
Nineteen hundred and Eighty-one

WATER MANAGEMENT BOARD

By:

John Hatch  
Chief Engineer, Executive Officer  
JOHN HATCH

1878 PRIORITY DATE



Land  
Parcel  
Number

Legal  
Description

Acreage

|   |                            |                          |          |
|---|----------------------------|--------------------------|----------|
| 1 | NE1/4 SW1/4<br>SE1/4 SW1/4 | S9-T1N-R8E<br>S9-T1N-R8E | 20<br>25 |
| 2 | NW1/4 SE1/4<br>SW1/4 SE1/4 | S9-T1N-R8E<br>S9-T1N-R8E | 29<br>35 |

David S. Lamb

|   |             |             |    |
|---|-------------|-------------|----|
| 3 | SW1/4 SW1/4 | S10-T1N-R8E | 25 |
|   | NW1/4 NW1/4 | S15-T1N-R8E | 31 |
|   | SW1/4 NW1/4 | S15-T1N-R8E | 38 |
|   | NW1/4 SW1/4 | S15-T1N-R8E | 30 |
|   | SE1/4 NW1/4 | S15-T1N-R8E | 32 |
|   | NE1/4 SW1/4 | S15-T1N-R8E | 31 |
|   | SW1/4 NE1/4 | S15-T1N-R8E | 38 |
|   | NW1/4 SE1/4 | S15-T1N-R8E | 29 |
|   | SE1/4 NE1/4 | S15-T1N-R8E | 25 |
|   | NE1/4 SE1/4 | S15-T1N-R8E | 38 |
|   | SW1/4 SW1/4 | S15-T1N-R8E | 1  |
|   | SE1/4 SW1/4 | S15-T1N-R8E | 11 |
|   | SW1/4 SE1/4 | S15-T1N-R8E | 24 |
|   | SE1/4 SE1/4 | S15-T1N-R8E | 15 |

David S. Lamb Total 368 acres

|    |                                                                         |                                                                         |                           |
|----|-------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------|
| 5  | SW1/4 NW1/4                                                             | S14-T1N-R8E                                                             | 5                         |
| 6  | SW1/4 NW1/4                                                             | S14-T1N-R8E                                                             | 32                        |
| 7  | SE1/4 NW1/4<br>NE1/4 SW1/4                                              | S14-T1N-R8E<br>S14-T1N-R8E                                              | 6<br>4                    |
| 8  | SE1/4 NW1/4<br>NE1/4 SW1/4                                              | S14-T1N-R8E<br>S14-T1N-R8E                                              | 3<br>2                    |
| 9  | SE1/4 NW1/4<br>NE1/4 SW1/4                                              | S14-T1N-R8E<br>S14-T1N-R8E                                              | 3<br>2                    |
| 10 | NW1/4 SE1/4<br>SW1/4 SE1/4<br>SE1/4 SE1/4<br>NE1/4 SE1/4<br>SW1/4 SW1/4 | S14-T1N-R8E<br>S14-T1N-R8E<br>S14-T1N-R8E<br>S14-T1N-R8E<br>S13-T1N-R8E | 28<br>31<br>32<br>3<br>27 |
| 11 | SE1/4 SW1/4                                                             | S13-T1N-R8E                                                             | 2                         |
| 12 | SW1/4 SE1/4                                                             | S13-T1N-R8E                                                             | 5                         |

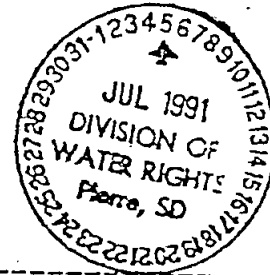
EXHIBIT

tabbles

A



1878 PRIORITY DATE



Land  
Parcel  
Number

Legal  
Description

Acreage

|   |             |            |    |
|---|-------------|------------|----|
| 1 | NE1/4 SW1/4 | S9-T1N-R8E | 20 |
|   | SE1/4 SW1/4 | S9-T1N-R8E | 25 |
| 2 | NW1/4 SE1/4 | S9-T1N-R8E | 29 |
|   | SW1/4 SE1/4 | S9-T1N-R8E | 35 |

David S. Lamb

|   |             |             |    |
|---|-------------|-------------|----|
| 3 | SW1/4 SW1/4 | S10-T1N-R8E | 25 |
|   | NW1/4 NW1/4 | S15-T1N-R8E | 31 |
|   | SW1/4 NW1/4 | S15-T1N-R8E | 38 |
|   | NW1/4 SW1/4 | S15-T1N-R8E | 30 |
|   | SE1/4 NW1/4 | S15-T1N-R8E | 32 |
|   | NE1/4 SW1/4 | S15-T1N-R8E | 31 |
|   | SW1/4 NE1/4 | S15-T1N-R8E | 38 |
|   | NW1/4 SE1/4 | S15-T1N-R8E | 29 |
|   | SE1/4 NE1/4 | S15-T1N-R8E | 25 |
|   | NE1/4 SE1/4 | S15-T1N-R8E | 38 |
|   | SW1/4 SW1/4 | S15-T1N-R8E | 1  |
|   | SE1/4 SW1/4 | S15-T1N-R8E | 11 |
|   | SW1/4 SE1/4 | S15-T1N-R8E | 24 |
|   | SE1/4 SE1/4 | S15-T1N-R8E | 15 |

David S. Lamb Total 368 acres

|    |             |             |    |
|----|-------------|-------------|----|
| 5  | SW1/4 NW1/4 | S14-T1N-R8E | 5  |
| 6  | SW1/4 NW1/4 | S14-T1N-R8E | 32 |
| 7  | SE1/4 NW1/4 | S14-T1N-R8E | 6  |
|    | NE1/4 SW1/4 | S14-T1N-R8E | 4  |
| 8  | SE1/4 NW1/4 | S14-T1N-R8E | 3  |
|    | NE1/4 SW1/4 | S14-T1N-R8E | 2  |
| 9  | SE1/4 NW1/4 | S14-T1N-R8E | 3  |
|    | NE1/4 SW1/4 | S14-T1N-R8E | 2  |
| 10 | NW1/4 SE1/4 | S14-T1N-R8E | 28 |
|    | SW1/4 SE1/4 | S14-T1N-R8E | 31 |
|    | SE1/4 SE1/4 | S14-T1N-R8E | 32 |
|    | NE1/4 SE1/4 | S14-T1N-R8E | 3  |
|    | SW1/4 SW1/4 | S13-T1N-R8E | 27 |
| 11 | SE1/4 SW1/4 | S13-T1N-R8E | 2  |
| 12 | SW1/4 SE1/4 | S13-T1N-R8E | 5  |



## LEONARD RICE ENGINEERS, INC.

2000 CLAY STREET, SUITE 300, DENVER, COLORADO 80211-5119  
(303) 455-9589 ♦ (800) 453-9589 ♦ FAX (303) 455-0115

GREG ROUSH  
GREGG TEN EYCK  
LESLIE BOTHAM  
JON FORD  
ERIN WILSON  
ED ARMBRUSTER  
DENNIS MCGRANE  
JANET WILLIAMS

May 4, 2006

Mr. Garland Erbele  
South Dakota Department of Environment and Natural Resources  
523 East Capitol Building  
Pierre, South Dakota 57501-3182

RE: Proposed Transfer of Murphy Ditch Water Rights.

Dear Mr. Erbele:

This letter summarizes our findings with respect to investigations of water rights historically used on the Harney Peak Ranch and proposed terms and conditions of future use of the water rights following a transfer to the Rapid Valley Sanitary District (RVSD or District). The summary reflects several documents provided to and by South Dakota Department of Environment and Natural Resources (SDDENR) and telephone conference discussions, including:

1. Report titled *Transfer of Lamb Property Water Rights – 1878 Murphy Ditch Priority*, September 21, 2005, Leonard Rice Engineers, Inc.
2. Letter to Mr. Mark Rath, SDDENR, November 16, 2005, from Leonard Rice Engineers, Inc. re. Additional Information on Harney Peak Ranch Study.
3. Letter to Mr. Jim Jester, RVSD, January 23, 2006, from Mr. Garland Erbele, SDDENR, re. information on Harney Peak Water Rights Transfer.
4. Letter to Mr. Mark Rath, SDDENR, February 22, 2006, from Leonard Rice Engineers, Inc. re. Letter from Mr. Garland Erbele re. Murphy Ditch Transfer.
5. Telephone conference discussions in November, 2005 and April 5<sup>th</sup>, 2006 between SDDENR and RVSD regarding technical information provided on historical Murphy Ditch water rights, future use of the rights by RVSD, and statutory transfer process and requirements.

### Rapid Valley Sanitary District

RVSD is located on the eastern edge of Rapid City in central Pennington County. The District was formed in the early 1960's to serve a growing population east of Rapid City in the plains area known as Rapid Valley and is the oldest organized rural water system in South Dakota. This area has seen steady growth from approximately 1,800 customers in 1988 to 3,100 customers in 2004. The current customer base of 10,000 people is composed mainly of residential customers with commercial properties in the highway service areas. As this growth has occurred, the District has had difficulty providing adequate supply and water storage during July and August peak water usage periods.

Expected continued growth and drought conditions will further strain the water system and may cause water shortages.

The District is negotiating with Harney Peak Ranch (Mr. David Lamb) to acquire the Ranch's ownership interest (33.4 percent) in the 1878 Murphy Ditch water right on Rapid Creek. The District will use the water right, following a transfer proceeding with SDDENR, to supply a portion of its existing and future demand for potable water. Following the transfer, the District will divert water under the 1878 water right at a treatment facility located approximately 3.5 river miles below the Murphy Ditch headgate on Rapid Creek.

### **Murphy Ditch – 1878 Priority**

The Murphy Ditch (also known as the Rapid Valley Ditch or Rapid Valley Water Company) diverts water from the north side of Rapid Creek at a point located in the NE  $\frac{1}{4}$  of the SW  $\frac{1}{4}$  of Section 8, Township 1 North, Range 8 East of the Black Hills P.M, in Pennington County. The headgate of the Murphy Ditch is located approximately two miles south and east of Rapid City, and approximately three-quarters of a mile downstream of the U.S. Geological Survey stream flow gage ID 06418900 (Rapid Creek below Sewage Treatment Plant near Rapid City). The Ditch extends from its headgate approximately 8 miles to the south and east. Irrigation water from the ditch is supplied to lands on both sides of Rapid Creek. Diversions from Rapid Creek can be measured at a rated weir located down-ditch from the headgate and above the first owner turnout.

Water may be diverted into the Murphy Ditch under two original water rights. Under Vested Water Right (Permit) No. 1727-2, and priority date of April 6<sup>th</sup>, 1878, the Murphy has the right to divert 17.0 cfs. The Murphy Ditch's junior priority, under Permit No., 1727-2 and priority date of April 26<sup>th</sup>, 1893, allows for diversion of an additional 3.0 cfs. The permit issued for the senior water right under the Murphy Ditch (17.0 cfs) identifies 1,103 irrigated acres. Of this total, 368 acres are irrigated within the boundary of Harney Peak Ranch. The pro-rata interest of this right by the Ranch is, therefore, approximately 33.4 percent.

### **Depletions Resulting from Historical Irrigation on Harney Peak Ranch**

Historical depletions resulting from irrigation on the Harney Peak Ranch using the Murphy Ditch 1878 priority water right were quantified using a water budget approach. The water budget tracked historical water supply to the ranch, consumptive water use by crops and return flows to Rapid Creek. The data, estimates and assumptions related to the calculations to estimate historical depletions were based on published information, site visits and interviews as documented in prior reports. Adjustments to original estimates of depletions have been made to reflect comments received from SDDENR. **Table 1** provides a summary of the historical water budget for irrigation on the Ranch using water from the Murphy Ditch.



**Table 1**  
**Harney Peak Ranch Historical Farm Depletion Analysis – Murphy Ditch (AF)**

|                                       | Jan  | Feb  | Mar  | Apr   | May   | Jun   | Jul   | Aug   | Sep   | Oct   | Nov   | Dec  | Total  |
|---------------------------------------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|------|--------|
| <b>Diversions<sup>(1)</sup></b>       | 0.0  | 0.0  | 0.0  | 139.4 | 354.1 | 396.5 | 531.1 | 669.1 | 495.8 | 328.9 | 0.0   | 0.0  | 2915.0 |
| <b>Ranch Deliveries<sup>(2)</sup></b> | 0.0  | 0.0  | 0.0  | 42.0  | 105.0 | 118.0 | 158.0 | 199.0 | 147.0 | 98.0  | 0.0   | 0.0  | 867.0  |
| <b>Consumptive Use<sup>(3)</sup></b>  | 0.0  | 0.0  | 0.0  | 27.3  | 68.3  | 76.7  | 102.7 | 129.4 | 95.6  | 63.7  | 0.0   | 0.0  | 563.6  |
| <b>Return Flows<sup>(4)</sup></b>     | 4.0  | 3.0  | 3.0  | 18.2  | 35.9  | 38.4  | 41.0  | 49.6  | 46.5  | 46.0  | 11.6  | 6.1  | 303.5  |
| <b>Depletions<sup>(5)</sup></b>       | -4.0 | -3.0 | -3.0 | 23.8  | 69.1  | 79.6  | 117.0 | 149.4 | 100.5 | 52.0  | -11.6 | -6.1 | 563.6  |

- Notes: 1. Based on historical diversion records and adjustments per discussions with SDDENR.  
2. Reflects Ranch interest of 33.4 percent of Murphy Ditch, and estimated ditch loss of 11 percent.  
3. Reflects water application efficiency of 65%.  
4. Reflects immediate return flows (50%) and delayed return of deep percolation (50%).  
5. Negative values indicate net accretion to stream.

### **Future Use of the Murphy Ditch Rights by RVSD**

If acquired by the District, 33.4 percent of the 1878 Murphy Ditch water right would be transferred from the Murphy Ditch to a new point of diversion. As a result of this transfer, the District's acquired interest in the Murphy Ditch would no longer be diverted for irrigation purposes on Harney Peak Ranch.

Water use by the District follows seasonal patterns typical of municipal systems (Table 2). Water use during the months of July, August and September is typically higher than other months of the year because of increased landscape irrigation. During these periods, estimated indoor uses and outdoor irrigation are in approximately equal proportions. Indoor uses are estimated to be 5 percent consumptive, i.e., 95 percent of indoor water use returns to Rapid Creek via waste water treatment systems. Outdoor uses (lawn and other landscape irrigation) are estimated to be 80 percent consumptive, i.e., 20 percent of outdoor water use returns to Rapid Creek via subsurface drainage pathways.

**Table 2**  
**Average RVSD Monthly Water Use Pattern**

|                    | Jan  | Feb  | Mar  | Apr  | May  | Jun   | Jul   | Aug   | Sep   | Oct  | Nov  | Dec  | Total  |
|--------------------|------|------|------|------|------|-------|-------|-------|-------|------|------|------|--------|
| <b>Total</b>       | 6.0% | 6.0% | 6.0% | 6.0% | 7.0% | 10.0% | 12.0% | 14.0% | 12.0% | 9.0% | 6.0% | 6.0% | 100.0% |
| <b>Indoor</b>      | 6.0% | 6.0% | 6.0% | 6.0% | 6.0% | 6.0%  | 6.0%  | 6.0%  | 6.0%  | 6.0% | 6.0% | 6.0% | 72.0%  |
| <b>Outdoor</b>     | 0.0% | 0.0% | 0.0% | 0.0% | 1.0% | 4.0%  | 6.0%  | 8.0%  | 6.0%  | 3.0% | 0.0% | 0.0% | 28.0%  |
| <b>Depletion %</b> | 5%   | 5%   | 5%   | 5%   | 16%  | 35%   | 43%   | 48%   | 43%   | 30%  | 5%   | 5%   | 26%    |
| <b>Return %</b>    | 95%  | 95%  | 95%  | 95%  | 84%  | 65%   | 58%   | 52%   | 58%   | 70%  | 95%  | 95%  | 74%    |



**Table 2** also shows the depletion and return percentages associated with total water use by the District. These percentages have been calculated by considering 1) the percentage of indoor and outdoor use for each month, and 2) a 5 percent and 80 percent consumptive factor for indoor and outdoor uses, respectively. Water uses by the District are on average estimated to be 26 percent consumptive. The remaining 74 percent of water use by the District returns to Rapid Creek via waste water treatment facilities or subsurface drainage.

Consumptive water uses by the District are highest during the summer months due to outdoor irrigation. As a percentage of water availability, the consumptive percentage is highest in the month of August (48 percent of water deliveries); this coincides with the highest period of outdoor uses. Note that during all months, consumptive percentages for water use by the District are lower than the consumption rates that historically occurred when the Murphy Ditch rights were used for agricultural irrigation (65 percent).

#### **Terms and Conditions on Transfer**

The District and SDDENR have discussed the issue of terms and conditions on the transfer of the Murphy Ditch 1878 priority water right in order to be protective of other water right owners on Rapid Creek. These terms and conditions are summarized as follows:

1. Future use by RVSD limited to the historical season of use, i.e. April 15<sup>th</sup> through November 30<sup>th</sup>.
2. Maximum rate of diversion by RVSD limited to the prorata interest in Murphy Ditch 1878 priority, less ditch loss, i.e., 5.05 cfs. This reflects 33.4 percent ownership in the 1878 priority for 17.0 cfs, less a ditch loss of 11 percent.
3. Rate of diversion by RVSD limited to the prorata interest of daily diversion amount available in priority to the Murphy Ditch 1878 priority, less ditch loss.
4. Monthly and annual volumetric limits (acre-feet) on diversions by RVSD based on long-term average deliveries to the Ranch as follows:

| Month                | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| RVSD Diversions (AF) | 0   | 0   | 0   | 42  | 105 | 118 | 158 | 199 | 147 | 98  | 0   | 0   | 867   |

5. Discontinuation of water deliveries from the Murphy Ditch to 368 acres of the Harney Peak Ranch identified in Permit No. 1727-2 and dry-up of these lands.
6. Measurement, monthly accounting, and annual reporting of water use under the transferred water right.

#### **Temporary Use of Water Rights for Irrigation**

The District may negotiate terms of their purchase of the Murphy Ditch 1878 water right that include temporary continued use in the future of a portion of the water right by Harney Peak Ranch for irrigation. As currently contemplated, the District may lease back to Harney Peak Ranch a decreasing portion of the water right over a six year period, as follows:





| Year | % Amount Available to RVSD | % Amount Available to Harney Peak Ranch | Acre-Feet Amount Available to RVSD | Acre-Feet Amount Available to Harney Peak Ranch | Acre-Feet Annual Total |
|------|----------------------------|-----------------------------------------|------------------------------------|-------------------------------------------------|------------------------|
| 2007 | 60                         | 40                                      | 520                                | 347                                             | 867                    |
| 2008 | 65                         | 35                                      | 564                                | 303                                             | 867                    |
| 2009 | 70                         | 30                                      | 607                                | 260                                             | 867                    |
| 2010 | 70                         | 30                                      | 607                                | 260                                             | 867                    |
| 2011 | 75                         | 25                                      | 650                                | 217                                             | 867                    |
| 2012 | 80                         | 20                                      | 694                                | 173                                             | 867                    |
| 2013 | 100                        | 0                                       | 867                                | 0                                               | 867                    |

Should a portion of the water right be leased to Harney Peak Ranch by the District, diversions by both entities should be measured and accounted for as required by SDDENR. The combined use of the water right by the District and Harney Peak Ranch should be limited to the instantaneous diversion rates, and monthly and annual volumetric limits discussed above.

#### Summary

Engineering efforts and discussions with SDDENR have quantified and characterized the historical depletive affect on Rapid Creek resulting from irrigation on the Harney Peak Ranch, and specifically, use of 33.4 percent of the Murphy Ditch 1878 priority water right. These studies and discussions have resulted in reasonable estimates of historical diversions, consumptive use, return flows and net depletive effects from such use. The water rights can be transferred to the Rapid Valley Sanitary District and used, pursuant to the terms and conditions described above such that there is no injury to other water right owners along Rapid Creek.

Very truly yours,

LEONARD RICE ENGINEERS, INC. ■



Ed Armbruster, P.E., C.C.E.  
Principal

eja/eja  
1161RVS02



DUPLICATE ORIGINAL

**WATER RIGHTS SALE AGREEMENT  
(Short Form)**

THIS AGREEMENT made and entered into this 5th day of May, 2006, by and between David S. Lamb, of 4555 Reservoir Road, Rapid City, Pennington County, South Dakota 57703 (hereafter "Seller"), and Rapid Valley Sanitary District - Water Service, a duly existing and organized governmental entity, of 4611 Teak Drive, Rapid City, Pennington County, South Dakota 57703 (hereafter "Buyer" or "RVSD").

**WITNESSETH:**

For good and valuable consideration, the receipt and adequacy of which is hereby acknowledged by the respective parties hereto, the parties have entered into an agreement for the sale and purchase of certain water rights owned by Seller, generally described as the David S. Lamb Murphy Ditch Water Rights, a 33.4% interest therein, Permit No. 1727-2 (1878 priority) issued by the State of South Dakota, which are pertinent to the real property described on Exhibit A attached hereto and incorporated herein by this reference (the "Water Rights"). Seller is not selling and the Buyer is not purchasing the real property described on said Exhibit A.

**Terms and Conditions on Transfer**

RVSD and South Dakota Department of Environment and Natural Resources (hereafter "SDDENR") have discussed the issue of terms and conditions on the transfer of the Murphy Ditch 1878 priority water right in order to be protective of other water right owners on Rapid Creek. These terms and conditions are summarized as follows:

- (1) Future use by RVSD limited to the historical season of use, i.e., April 15 through November 30.
- (2) Maximum rate of diversion of RVSD limited to the prorata interest in Murphy Ditch 1878 priority, less ditch loss, i.e., 5.05 cfs. This reflects 33.4 percent ownership in the 1878 priority for 17.0 cfs, less a ditch loss of 11 percent.
- (3) Rate of diversion by RVSD limited to the prorata interest of daily diversion amount available in priority to the Murphy Ditch 1878 priority, less ditch loss.
- (4) Monthly and annual volumetric limits (acre-feet) on diversions by RVSD based on long-term average deliveries to the Ranch as follows:

| Month                | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| RVSD Diversions (AF) | 0   | 0   | 0   | 42  | 105 | 118 | 158 | 199 | 147 | 98  | 0   | 0   | 867   |

- (5) Discontinuation of water deliveries from the Murphy Ditch to 368 acre of the Harney Peak Ranch identified in Permit No. 1727-2 and dry-up of these lands.
- (6) Measurement, monthly accounting, and annual reporting of water use under the transferred water right.

### **Possession**

Subject to regulatory approval of SDDENR, Buyer shall assume possession of the water rights at time of closing, which is scheduled on or before July 14, 2006.

### **Title**

Seller shall sign and execute such documents as may be reasonably necessary to transfer title to the water rights to Buyer, including, but not limited to, the transfer forms required by the State of South Dakota, and the stock assignment and water rights transfer agreement, and ancillary instruments

### **Temporary Diversion Rights**

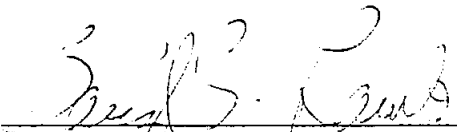
Seller shall be entitled to temporary diversion rights in accordance with Application for Permit to Appropriate Water Rights Within the State of South Dakota submitted in conjunction with this short form Water Rights Sale Agreement.

### **Miscellaneous**

This Agreement shall be construed and interpreted in accordance with the laws of the State of South Dakota. Further provisions which are an integral part of this transaction shall be set forth in the Water Rights Sale Agreement between the parties dated as of even date herewith, which Sale Agreement still must be completed and executed by the parties before the Sale Agreement is a completed contract and binding on them.

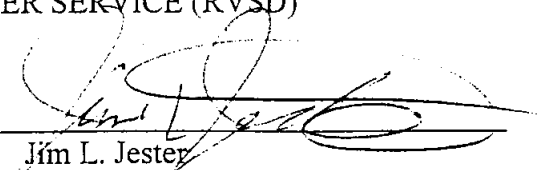
Dated this 5<sup>th</sup> day of May, 2006.

**SELLER:**

  
\_\_\_\_\_  
David S. Lamb

**BUYER:**

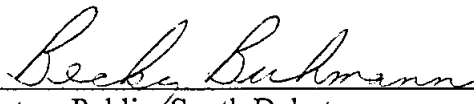
RAPID VALLEY SANITARY DISTRICT -  
WATER SERVICE (RVSD)

By   
\_\_\_\_\_  
Jim L. Jester  
Its General Manager

State of South Dakota       )  
                                          )ss.  
County of Pennington       )

On this the 5<sup>th</sup> day of May, 2006, before me, the undersigned notary public, personally appeared David S Lamb, known to me or satisfactorily proven to be the person whose name is subscribed to the within instrument, as Seller, and acknowledged that he executed the same for the purposes therein contained.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

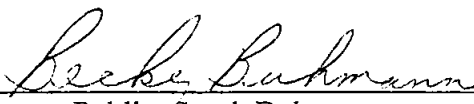
  
\_\_\_\_\_  
Notary Public, South Dakota

My Commission Expires: 1-15-11  
(SEAL)

State of South Dakota       )  
                                          )ss.  
County of Pennington       )

On this the 5<sup>th</sup> day of May, 2006, before me, the undersigned officer, personally appeared Jim L. Jester, who acknowledged himself to be the General Manager of Rapid Valley Sanitary District - Water Service, a duly existing and organized governmental entity, and that he as such General Manager, being authorized so to do, executed the foregoing instrument for the purposes therein contained, by signing the name of the entity by himself as such General Manager.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

  
\_\_\_\_\_  
Notary Public, South Dakota

My Commission Expires: 1-15-11  
(SEAL)



David Lamb  
4555 Reservoir Road  
Rapid City, SD 57703

DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES

JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

June 23, 2003

Dear Mr. Lamb:

This letter is in regards to your telephone request for information concerning a possible transfer of irrigated land from the Rapid Valley Water Company to the South Side Ditch. During our conversation you expressed some concerns about the issues that need to be addressed prior to a transfer occurring.

From the information I have been given concerning this proposed transfer it would involve transferring irrigation from 50.55 acres of Rapid Valley Water Company land irrigated with 1893 priority date water. In 1990, the Water Management Board validated a total of 189 acres associated with this priority date. It appears the full 50.55 acres fall within the acres validated by the Water Management Board. The amount of water available to this property, based upon pro-rata share of the 3.0 cfs, would be 0.80 cfs. Although you indicated the amount of irrigated water, on this portion of the irrigation ditch, may be allocated based upon the number of shares in the ditch company. This may change the amount of water available to be transferred.

One other thing to be aware of is when the city of Rapid City transferred water rights off of the Rapid Valley water company ditch they were required to leave the carriage loss with the ditch company water right. Our records indicate this amount was 11%. The Rapid Valley Water Company should consider whether the carriage loss needs to remain or if this requirement can be waived.

I have told the potential applicants I want a letter from the ditch company, included with the application, addressing the ditch company's position on these issues.

If you have any additional questions, please contact me at phone (605) 773-3352.

Sincerely,

Mark D. Rath  
Natural Resources Engineering Specialist  
Water Rights Program



## **LEONARD RICE ENGINEERS, INC.**

2000 CLAY STREET, SUITE 300, DENVER, COLORADO 80211-5119  
(303) 455-9589 ♦ (800) 453-9589 ♦ FAX (303) 455-0115

GREG ROUSH  
GREGG TEN EYCK  
LESLIE BOTHAM  
JON FORD  
ERIN WILSON  
ED ARMBRUSTER

November 16, 2005

Mr. Mark Rath  
South Dakota Department of Environment and Natural Resources  
523 East Capitol Building  
Pierre, South Dakota 57501-3182

RE: Additional information on Harney Peak Ranch Study

Dear Mr. Rath:

Thank you for taking time in our telephone conference November 8<sup>th</sup>, 2005 to discuss aspects of our report on the transfer of the David Lamb Property water rights. Your comments and input are very welcome.

As noted in our conversation, an objective of our study was to characterize historical use of the 1878 Murphy Ditch water right priority on the Harney Peak Ranch (Lamb Property). We also quantified the amount of water derived from Mr. David Lamb's ownership that can be used by the Rapid Valley Sanitary District in the future such that other water rights on Rapid Creek (including remaining Murphy Ditch owners) are protected from injury. In developing the information we had no interest in steering the final results in a particular direction. We made every attempt to be objective, impartial, and produce a study that relies on factual evidence.

You have offered comments in several different areas, and the following addresses these areas separately. We are also sending several attachments to this letter that provides additional information, explanation and reference material.

### **Process Used to Quantifying Historical Consumptive Use and Depletions**

Included in your comments were questions related to the calculations and accounting of historical water use. You also expressed concern that our approach was not consistent with the "process" followed by engineers in support of earlier water right transfers. We have put together a summary of our approach, inputs and assumptions, and compared to the prior engineering efforts for transfer of the Tyler Property water rights from the Murphy Ditch (**Attachment 1**). It is our opinion that our approach (i.e., process) is consistent, although several of the inputs and assumptions are necessarily different because we are addressing historical use of water on a different ranch.

Our approach to quantifying historical water use on the Harney Peak Ranch was to create a "water budget" or "water balance." This water budget tracks inflows, outflows and change in storage. Inflows are the historical water supply to the ranch. Outflows include consumptive water use by crops and return flows to Rapid Creek. The storage component is essentially the ranch itself, which



can store or release water from the soil. This is a very standard approach to evaluating historical water use on ranches, and we feel very confident this is the same approach followed by the engineers that studied the Tyler Property.

Our water budget relied on the use of a computer program developed by the State of Colorado ("StateCU"). Engineers practicing in water rights evaluations (and historical use) rely on many different "tools" to do these evaluations – some are spreadsheet based developed by individual firms, and others rely on computer programs that are either privately developed or made available through public agencies. StateCU was developed by the Colorado Division of Water Resources and Colorado Water Conservation Board. Leo Eisel's firm (Brown & Caldwell) routinely uses StateCU in their analyses, although it appears from his report that he may have used a spreadsheet for his work on the M.P. Carley Property. We are providing a copy of the executable StateCU program, documentation, and input and output files used for the Harney Peak Ranch evaluation as **Attachment 1** (CD-ROM). We feel confident that whether a spreadsheet or computer program is used, they all do pretty much the same thing, i.e. create a water budget and track inflows, outflows and change in storage.

Please note that the StateCU program performs the Modified Blaney-Criddle computations in addition to doing the water budget accounting. It appears that the work of Wright Water Engineers on the Tyler Property utilized two spreadsheets: one for the Modified Blaney-Criddle computations, and one for the water budget accounting.

The primary output file from the StateCU application is called Harney.dwb, which provides the detailed accounting of the water budget. We have created an Excel spreadsheet (DWB Explanation.xls – **Attachment 1**) that describes in more detail the contents of this output file.

### **Data, Estimates and Assumptions Related to Calculations**

We have made what we feel were very significant efforts towards gathering information related to historical water uses at Harney Peak Ranch. We visited the Harney Peak Ranch, toured irrigated lands, and conducted numerous interviews by telephone with Water Masters, Ditch Superintendents, the property owner, Bureau of Reclamation staff, and SDDENR staff. The information gathered was closely evaluated in light of our many years of experience in these types of investigations. We continue to think the data, estimates and assumptions used in our analysis for the Lamb Property are very reasonable and factually based.

**Attachment 2** provides a summary discussion of the inputs required to create our ranch water budget, estimate historical consumptive use, and characterize historical depletions. We have included a comparison to the information used by Wright Water Engineers in their evaluation of the Tyler Property.

### **Water Supply**

As I mentioned in our conversation, we believe the most significant difference between our work and efforts from prior transfers of the Murphy Ditch water rights is the treatment of historical diversion records and development of estimated water supply derived from the rights. For several reasons discussed in our report, we believe that the historical records do not accurately characterize

the historical water supply at Harney Peak Ranch. We were very diligent in contacting people who might have knowledge of ditch operations and the feedback we received was that 1) observations of diversion levels were very infrequent; 2) the records of monthly volumes were inaccurate, and 3) historical diversions through the ditch were higher than indicated by the records. We do not believe that prior engineering studies on the Murphy Ditch went to such great lengths to uncover this type of information, but that it is essential to developing a factual basis for quantifying historical consumptive use and depletions.

We have included in **Attachment 1** (CD-ROM) the spreadsheets that contains the calculations used in developing the water supply for our analysis. Note that we have estimated diversions under the 1878 Murphy Ditch priority historically averaged approximately 10.3 cfs during the irrigation season. We feel this is reasonable in light of the comment by Mr. Duane Scott (former Water Master) that diversions through the ditch historically averaged about 12 cfs from April through November. Our dry-year estimated average diversion rate is approximately 5.8 cfs, which is also consistent with what we were told by the current Water Master (Mr. Kevin Hamm) that diversions through the ditch during 2005 (a dry year) averaged about 7 cfs.

In prior discussions with you we talked about information provided by Mr. David Lamb that he generally received his full water right amount. We also talked about his (and his family's) ability to regularly achieve good crop yields on Harney Peak Ranch using Murphy Ditch water. It was our understanding that you were in agreement that this fact supported higher ditch diversions than are indicated by the records. Mr. Lamb's affidavit concerning historical water use was provided as an appendix in our engineering report. 2

We have given additional thought in regard to water carried in the Murphy Ditch in excess of the 1878 priority water right. We continue to believe it appropriate to allocate the total water in the ditch according to water right priority, i.e., attribute water to the Murphy 1878 priority up to 17 cfs (or less after prior transfers), then to Little Giant, Sedivy and others. 2 \*

We recognize that allocating water to senior rights may result in little or no water being allocated to the more junior rights, and believe there are two explanations. First, the junior priorities simply were not in priority to divert river water. Second, water carried by these structures resulted from either drainage into the Murphy Ditch below the headgate and/or water diverted under the 1878 Murphy Ditch priority was delivered to these structures. We have been told that 1) significant inflows to the Murphy Ditch occur, resulting primarily from storm events and seepage from irrigation under the Hawthorne Ditch, and 2) other owners in the Murphy Ditch did not use their water as regularly as Mr. Lamb did on Harney Peak Ranch – this would allow water due to these other Murphy Ditch owners to be used by the other ditches diverting at the Murphy headgate, including Little Giant. \*

The two years for which we have diversion records and river diversions (as opposed to total diversions) are indicated, "free water" through the Little Giant Ditch averaged only 157 acre-feet. For years when there are records that do not distinguish between Project water and river water, recorded diversions averaged approximately 600 acre-feet per year. However, much of this water was likely taken through the original Little Giant Ditch headgate (below Murphy), and not under the rights transferred to the Murphy Ditch.



We have also further considered the issue of "Project" water, i.e. water delivered to ditches from Pactola Reservoir. While we understand that the Murphy Ditch *per se* does not receive Project water, we also understand that the other rights (Little Giant, etc.) may at times take such delivery. We have no records that specifically state the amount of Project water delivered to Little Giant, although our understanding is that the amount of Project water delivered through the Murphy was small. Again, drainage inflows to the Murphy Ditch may have actually been the source of water supplied to the Little Giant and others.

claim  
drainage  
water

### Irrigation Application Efficiency

You also commented that for flood irrigated lands, prior engineering studies have utilized a maximum water application efficiency of 50%. **Attachment 3** provides reference information with respect to irrigation application efficiencies.

Our experience is that efficiencies depend on numerous factors related to water management, and that it is not appropriate to assign an efficiency based only on a nominal descriptor such as "flood." We have seen situations where efficiencies on "flood irrigated" lands ranged from less than 30% to over 75%. The low efficiency situations are due to much less control of applied water. The higher efficiencies result from use of piping and valves on the ranch, siphon tubes or cutouts along ditches, field leveling to promote uniform distribution of water, gated pipe, and other features. Field layout within a ranch also affects efficiency when tailwater from upper fields can be collected and used on lower fields. Ranches may also utilize tailwater ponds to capture this water and reuse the water via gravity or pumps. These reuse systems have been demonstrated to greatly improve efficiencies.

The irrigation system on the Harney Peak Ranch includes many features that serve to improve application efficiencies. We do not characterized water application on the Ranch as "flood irrigation." It would generally be appropriate to say the Lamb's have practiced "furrow irrigation" although the Lamb's have also utilized two big-gun sprinklers that irrigate 200 foot radius circles, and over 10,000 feet of tow-line (with sprinklers approximately every 30 feet). Approximately 100 acres under the Murphy Ditch have been leveled and bordered.

SHOW  
where  
this  
occurs

We believe the irrigation control features historically used on the Harney Peak Ranch are quite advanced and result in considerable improvements to water application efficiency. The literature contained within **Attachment 3** support this. As such, we continue to think an efficiency of 65% is reasonable, and perhaps conservative, for use in evaluating historical use of water from the Murphy Ditch.

We want to reiterate that our engineering efforts conducted for Rapid Valley Sanitary District were objective and that we were in no way directed toward particular findings in our analyses. The information we present is based on factual evidence and our professional experiences in several western states. We believe our findings are accurate with respect to quantifying the amount, location and timing of consumptive use and depletions associated with the historical use of the 1878 Murphy Ditch priority on the Harney Peak Ranch. We continue to believe that our engineering report describes terms and conditions on a transfer of the Murphy Ditch rights to the District that will adequately protect other water right owners.



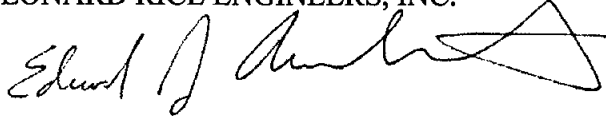
Mr. Mark Rath  
November 16, 2005  
Page 5

We hope that this information is helpful in your continued review of our report and consideration of the transfer process by Rapid Valley Sanitary District. It is our understanding that Mr. David Lamb may also be preparing additional information concerning historical water supplies and irrigation practices at Harney Peak Ranch.

Please let me know if you have further questions.

Very truly yours,

LEONARD RICE ENGINEERS, INC.



Ed Armbruster, P.E., C.C.E.  
Principal

cc. Jim Jester  
Ted Schultz  
Brian Hagg  
Chuck Riter

eja/eja  
1161RSV02

Enclosures



## Water Rights Program - DENR

### File Documentation

County: *Pennington*

**Name of Person:** *Ted Schultz, Cetec Engineering*

**Address:** *PO Box 9014 Rapid City SD 57709*

**Date:** *12/13/2005*      **Telephone:** *605-341-7800*

**RE:** *Draft Transfer Proposal Report for Rapid Valley Sanitary District*

#### **Comments:**

*Don Stroup and I participated on a telephone call with Ted Schultz concerning additional information we are going to need from the Sanitary District to support the water right transfer proposal. I told him we identified four assumptions that we would like additional supporting evidence. First is the irrigation efficiency increase from 50% to 65%. We would like to have the land identified where the sprinkler and big gun versus flood irrigation occurred. Second is the factor to increase consumptive use due to increased elevation, I reviewed the paper provided but I wanted to know if any other research verified these results. Third, I still question the number of acres the delivered historical irrigation was pro-rated over. Fourth, I still question the 50% increase in the historic reported water supply.*

*I said we would be sending a formal letter requesting this additional information and justification of assumptions.*



Mark D Rath

Natural Resources Engineering Specialist

## Water Rights Program - DENR

### File Documentation

County: Pennington

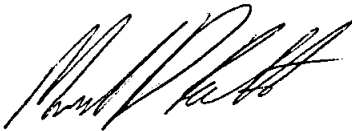
**Name of Person:** Ed Armbruster, Leonard Rice Engineering

**Date:** 12/21/2005    **Telephone:** 303455-0155

**RE:** Draft Transfer Proposal Report for Rapid Valley Sanitary District

#### Comments:

*Lynn Beck and I participated on a telephone call with Armbruster concerning additional information we are going to need from the Sanitary District to support the water right transfer proposal. I explained we intended to send him a letter with a formal data request, but it would not be sent until after the New Years. I told him we identified four assumptions that we would like additional supporting evidence. First is the irrigation efficiency increase from 50% to 65%. We would like to have the land identified where the sprinkler and big gun versus flood irrigation occurred. Second is the factor to increase consumptive use due to increased elevation, I reviewed the paper provided but I wanted to know if any other research verified these results. Third, I still question the number of acres the delivered historical irrigation was pro-rated over. I told Ed that I identified some water rights diverting from Murphy Ditch that were not in the irrigation district and could not purchase stored water from the Reservoirs, also felt proposal did not address wetter year diversion by non-Murphy Ditch water rights. Fourth, I still question the 50% increase in the historic reported water supply. I felt the 3.54 Ac-ft per acre amount proposed was unreasonably high. Ed agreed this needed to be looked at. I cited a thesis report on well watered irrigation delivery for the Belle Fourche District which I agreed to fax to him. Ed said he would send me some additional data on the elevation adjustment and a David Lamb memo on irrigation practices*



Mark D Rath  
Natural Resources Engineering Specialist





**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

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January 23, 2006

Jim Jester  
Rapid Valley Sanitary District  
4611 Teak Drive  
Rapid City, SD 57703

Dear Mr. Jester:

This letter is in reference to the draft application and engineering report you provided concerning a potential irrigation water rights transfer to the Rapid Valley Sanitary District. As you recall during our November 8, 2005 conference call, Water Rights staff voiced concern about the need to document the basis for many of the assumptions used in determining the transferable amount of water.

In response to that, on November 16, 2005 Water Rights received a package from Ed Armbruster with Leonard Rice Engineers containing some of the additional documentation. After reviewing the supplementary information we request the following data.

First in the report, the consultant calculated crop consumptive use based off an irrigation efficiency of 65% which is an increase from 50% the Water Management Board has accepted as the appropriate efficiency for flood irrigation. In the November 16 letter that accompanied the supplemental information, Mr. Armbruster stated David Lamb practiced "furrow irrigation" along with using two big-gun sprinklers, 10,000 feet of tow line sprinklers, and leveled and bordered 100 acres of the property. The supporting documentation provided indicates efficiencies can be increased with different irrigation practices. Please provide legal descriptions where these practices occurred, identify which practices applied to which land and identify how long each of these practices has been in place.

Second, the documentation provided includes a factor to increase crop consumptive use due to increased elevation. We have reviewed the papers provided to justify this increase (Pochop papers). Please provide any other research reference that was relied on for your analysis.

Third, the Water Rights Program still questions the number of acres historically irrigated under the water rights sought to be transferred. After considering Mr. Armbruster's response, we went back and looked at the location of the land covered by the various other water rights diverting at the Murphy ditch headgate. We found some of these lands lying outside the irrigation district boundaries and thus during water short years would have been unable to purchase water from Pactola or Deerfield Reservoirs. However, some of the other water rights had the ability to purchase water during the dry years and did make the purchases in some of those years. In either

case, Mr. Armbruster's logic attributes all non-1878 priority Murphy water right use to being supplied by drainage and return runoff contributions into Murphy Ditch. This disregards the fact there were years when there was sufficient water such that purchased water was not needed. There were other years when some of the water rights having the ability to purchase stored water releases did exercise that right. Please provide an analysis as to why the junior water right holders would be limited to drainage and return runoff contributions.

Fourth, the Water Rights Program continues to question the 50% increase in the historic reported water supply. This increase allows for a proposed transfer amount of 1303 AF annually. This is equal to 3.54 acre-feet of water delivered to each acre of land which in our opinion is excessive as compared to amounts reported for irrigated land located on the Belle Fourche Irrigation District, located 45 miles to the northwest and the Angostura District, 50 miles to the south. Also, this amount is more than double the amount transferred in earlier water right transfers from Murphy Ditch lands. Please provide any additional documentation you have on this issue. Also please demonstrate the legal authority allowing the volume diversion to exceed the limit set forth in SDCL 46-5-6 or to otherwise account for the 3.54 acre-foot per acre delivered to the land.

The amount of water proposed to be transferred can be split into two components. First, the crop consumptive use component and second is the return flow component. As was discussed during the November 8 conference call, we would require a resolution by the Rapid City Council agreeing to continually return the District's effluent at the treatment plant outfall as replacement water for the return flow component. Otherwise our recommendation will be only the portion associated with the crop consumptive use may be transferred.

Scheduling this matter for a March 2<sup>nd</sup> hearing before the Water Management Board is probably unreasonable due to time constraints. The public notice needs to be sent to the newspaper by January 27<sup>th</sup>. Instead I suggest that we work towards bringing the application before the Board at their May 3<sup>rd</sup> and 4<sup>th</sup> meeting.

If you have any questions, please contact Mark Rath of the Water Rights Program at phone (605) 773-3352.

Sincerely,

A handwritten signature in cursive script, appearing to read "Garland Erbele".

Garland Erbele, Chief Engineer  
Water Rights Program

Cc: Ted Schultz, Cetec Engineering Services Inc.  
Ed Armbruster, Leonard Rice Engineers, Inc.



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

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April 19, 2006

Jim Jester  
Rapid Valley Sanitary District  
4611 Teak Drive  
Rapid City, SD 57703

Dear Mr. Jester:

This letter is in regards to a April 14, 2006 telephone request we received from Ted Schultz and Ed Armbruster concerning the proposed water right transfer. It is our understanding you recently met with David Lamb concerning the proposed transfer. During your discussion a couple of issues arose that you would like to have addressed prior to finalizing your agreement with Mr. Lamb.

We understand that Mr. Lamb prefers the option of being able to lease-back irrigation water over a period of five years. Each year, more water would be utilized by the Rapid Valley Sanitary District and less available for irrigation. If the proposed transfer is approved, the District would be restricted to a monthly volume of water that can be used. This would require the Sanitary District specify the amount of water Mr. Lamb would be leasing each month. We would require the installation of measuring devices at the District's raw water intake, and at any of Mr. Lamb's pump sites and lateral turn-outs from the Rapid Valley Water Company (Murphy) Ditch to continually monitor the water diverted to ensure over appropriation does not occur. Limiting the volume of water used on Mr. Lamb's property rather than the number of acres is allowable.

A second issue is the status of the Warren Lamb Lumber Company water permits Nos. 1461-2 and 1461A-2. These two permits combined authorize irrigation of much of the same land on Mr. Lamb's property that are covered by Murphy Ditch, Cyclone Ditch and South Side Ditch water rights including the land proposed in the transfer. The Warren Lamb Lumber Company rights have a priority date of August 25, 1914, making them relatively junior water rights for Rapid Creek. This means, except under extremely wet conditions, there is no natural flow available in the Rapid Creek for diversion by these water permits. This was addressed in both permits when they were issued with the following qualification:

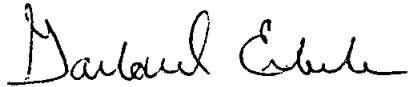
Low flows as needed for domestic use, including livestock watering and prior water rights must be by-passed. Unappropriated water is available in Rapid Creek to reasonably satisfy

this application only through contract between the Rapid Valley Conservancy District and Bureau of Reclamation covering releases from Deerfield and Pactola Reservoirs.

Because the land associated with the proposed transfer from Murphy Ditch are not part of the Rapid Valley Water Conservancy District, purchased project water from Deerfield and Pactola Reservoirs cannot be used to irrigate lands located outside of the Rapid Valley Water Conservancy District boundaries.

If you have any questions, please contact Mark Rath of the Water Rights Program at phone (605) 773-3352.

Sincerely,

A handwritten signature in cursive script, appearing to read "Garland Erbele".

Garland Erbele, Chief Engineer  
Water Rights Program

Cc: Ted Schultz, Cetec Engineering Services Inc.  
Ed Armbruster, Leonard Rice Engineers, Inc.

March 28, 2006

RECEIVED

MAR 29 2006

WATER RIGHTS  
PROGRAM

Mr. Mark Rath  
S.D. Dept. of Environment & Natural Resources  
Water Rights  
Joe Foss Building  
523 E. Capitol  
Pierre, SD 57501-3182

Re: **Murphy Ditch Water Rights**

Dear Mark:

I am writing to discuss the additional Murphy Ditch Water Rights information that was submitted earlier this month. I would like to schedule a meeting in Pierre between March 30 and April 7 to discuss the water rights application.

The Board of Trustees would like to establish a set schedule for the water rights application and review process. Please call and we can set up a meeting on this matter.

Sincerely,

CETEC Engineering Services, Inc.



Ted F. Schultz, P.E.  
Principal

TFS/sjf

cc: Jim Jester, Rapid Valley Sanitary District  
Brian Hagg, Whiting, Hagg & Hagg, LLP  
Ed Armbruster, Leonard Rice Engineers, Inc.  
Chuck Riter, Bangs, McCullen, Butler, Foye & Simmons, LLP

1830 West Fulton St.  
PO Box 9014  
Rapid City, SD  
57709-9014

[www.cetecengineering.com](http://www.cetecengineering.com)

**cetec**  
ENGINEERING SERVICES, INC.

03135.01/3/28/2006

Ⓢ 605.341.7800  
Ⓢ 605.341.7864

**SUPPLEMENTAL INFORMATION  
TO  
ENGINEERING REPORT  
*TRANSFER OF LAMB PROPERTY  
WATER RIGHTS 1878  
MURPHY DITCH PRIORITY***

**Dated September 21, 2005**

**Prepared by:**

**Leonard Rice Engineers, Inc.**

**RECEIVED  
MAR 14 2006  
WATER RIGHTS  
PROGRAM**

**PREPARED BY**

**cetec**  
ENGINEERING SERVICES, INC.

PO Box 9014  
Rapid City, SD  
57709-9014

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[www.cetecengineering.com](http://www.cetecengineering.com)

**March 9, 2006  
Revised**



March 9, 2006

Mr. Mark Rath  
S.D. Dept. of Environment & Natural Resources  
Water Rights  
Joe Foss Building  
523 E. Capitol  
Pierre, SD 57501-3182

**Re: Murphy Ditch Water Rights on Harney Peak Ranch**

Dear Mr. Rath:

On behalf of Rapid Valley Sanitary District, I am forwarding additional information requested in Mr. Garland Erbele's letter dated January 23, 2006.

This information addresses the items described in the letter and provides supplemental data and background information on the irrigation methods utilized on the Harney Peak Ranch.

The map and photos in Section 4 and Section 6 were prepared during an on-site meeting and tour of the property with Mr. David Lamb. Mr. Lamb has also provided additional written documentation located in Section 5 of this submittal. The following attachments are included in this submittal package:

1. Leonard Rice Engineers, Inc. Letter dated February 22, 2006.
2. Irrigating Alfalfa in South Dakota, Cooperative Extension Service, SDSU and USDA.
3. An Efficient Irrigation Technology for Alfalfa Growers, Journal of Extension.
4. Harney Peak Ranch Photos, January 2006.
5. Draft Resolution by City of Rapid City. Presented to City for review.
6. Figure 6 Harney Peak Ranch Lands, Irrigated by Murphy Ditch.

Please review this supplemental information and feel free to contact me with any questions. We look forward to working with you to complete this application as soon as possible.

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57709-9014

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Mr. Mark Rath  
S.D. Dept. of Environment & Natural Resources  
March 6, 2006  
Page 2.

Sincerely,

CETEC Engineering Services, Inc.



Ted Schultz, P.E.  
Project Manager

TS/sjf

Enclosures

cc: Jim Jester, Rapid Valley Sanitary District – Water Service  
Ed Armbruster, Leonard Rice Engineers, Inc.  
David Lamb, Harney Peak Ranch  
Chuck Riter, Bangs, McCullen, Butler, Foye and Simmons, LLP  
Brian Hagg, Whiting, Hagg & Hagg, LLP

1830 West Fulton St.  
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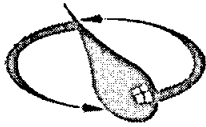
[www.cetecengineering.com](http://www.cetecengineering.com)

**cetec**  
ENGINEERING SERVICES, INC.

03135.01/03/06/06

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**1. Leonard Rice Engineers, Inc.  
Letter dated February 22, 2006**



## LEONARD RICE ENGINEERS, INC.

2000 CLAY STREET, SUITE 300, DENVER, COLORADO 80211-5119  
(303) 455-9589 ♦ (800) 453-9589 ♦ FAX (303) 455-0115

GREG ROUSH  
GREGG TEN EYCK  
LESLIE BOTHAM  
JON FORD  
ERIN WILSON  
ED ARMBRUSTER  
DENNIS MCGRANE  
JANET WILLIAMS

February 22, 2006

Mr. Mark Rath  
South Dakota Department of Environment and Natural Resources  
523 East Capitol Building  
Pierre, South Dakota 57501-3182

RE: Letter from Mr. Garland Erbele re. Murphy Ditch Transfer

Dear Mr. Rath:

We have received a copy of the letter sent to Mr. Jim Jester (Rapid Valley Sanitary District) by SDDENR (Mr. Garland Erbele) dated January 23, 2006 concerning water rights historically used on the Harney Peak Ranch. Thank you for the additional comments. The following attempts to answer several questions raised by SDDENR in the letter.

### **Irrigation Water Application Efficiency**

The State has asked that we provide additional documentation concerning water management practices on Harney Peak Ranch, and specifically, the locations where sprinklers were used for irrigation water application, fields that have been leveled, and bordered areas. We have contacted Mr. David Lamb and he is working with the District to prepare a map showing the location of irrigation features. Physical irrigation water management features at the Ranch include:

- Water delivery through grade-pressurized 15-inch main lines and 12-inch distribution lines or 8-inch high-pressure pumped pipeline systems designed by the USDA;
- Leveled and bordered fields designed by the USDA;
- 10,000 feet of 4-inch sprinkler towlines;
- Two traveling big guns sprinklers;
- Aluminum pressure distribution lines;
- Several reuse reservoirs; and
- Several pumps systems.

We have copies of engineering reports that supported two prior water right transfers involving the Murphy Ditch. One of these transfers involved the M.P. Carley property, where it was reported that the historical application efficiency was 50% (no additional information was provided). The second transfer involved the Tyler property, where an 80% application efficiency was reported based on historical use of sprinklers (side-roll system). Another engineering report supporting the transfer of South Side Ditch water rights (Stromer property) reported a 50% application efficiency for historical

“flood” irrigation. These studies illustrate that application efficiencies not only vary between ditch systems, but within the same ditch system depending on physical facilities and water management practices of individual ranchers.

It is our opinion that the method of irrigation water application and many other water management improvements by Mr. Lamb and his family on the Harney Peak Ranch justify use of a maximum application efficiency of at least 65%. The most significant of these improvements included the use of sprinklers on portions of the ranch and the ability to capture and reuse tailwater runoff.

Note that in our study, we define 65% as the maximum irrigation water application efficiency that can be achieved. In months when there may have historically been excess supply (after ditch loss), the actual achieved efficiency would have been less than 65%. In fact, over the 55 year period we examined, actual achieved efficiencies ranged from 32% (April) to 62% (July and August) on an average monthly basis, and averaged 54% on an annual basis. This is to be expected – in general, when water supply is greater than crop demand, achieved efficiencies will be lower. When demand exceeds supply, efficiencies will be higher, up to the maximum achievable efficiency that has been defined (i.e., 65%).

Our previous letter (November 16, 2005) included several attachments that contained reference information related to irrigation efficiencies. We can provide many more if needed, and please let us know if you have questions on the material already provided.

Again, it is our understanding that Mr. Lamb is working with the District to prepare additional information to help clarify the historical irrigation practices on Harney Peak Ranch and this information will be forwarded to you as soon as possible.

#### **Determination of Potential Crop Consumptive Use**

In November we also provided several reference documents concerning the adjustment of crop coefficients for use in the Modified Blaney-Criddle method for determining potential consumptive use. The adjustment is intended to account for differences in elevation for the site being examined and the site where original coefficients were developed. Because Modified Blaney-Criddle is a simple temperature based method, lower temperatures during the night time may skew downward the average daily temperature more significantly at higher elevations. We have found that applying this adjustment brings the results of applying the Modified Blaney Criddle method into good agreement with results of applying more sophisticated techniques.

There appears to be consensus among scientists and engineers that use of more advanced techniques, so called combination equations, result in more accurate estimates of crop water requirements than estimates developed using the Modified Blaney-Criddle approach. However, the combination equations, e.g., Penman-Montheith, Kimberly-Penman, etc., are much more data intensive, requiring information not only on temperature, but daily data on wind, vapor pressure, and solar radiation. Sophisticated climate stations are being installed in many areas to allow such data collection but even for the older stations data are available only for about 10 years. A common practice when a reasonable period of data are available is to apply a combination equation, apply Modified Blaney Criddle over the same period, then adjust the Modified Blaney-Criddle crop coefficients until the Modified Blaney-Criddle results match the combination equation results. Then, use these



“calibrated” coefficients within Modified Blaney Criddle over a longer period back in time when data required for the combination equation are not available.

We have found that a simple elevation based adjustment to the crop coefficients serves much the same purpose and does a good job of increasing the annual calculated potential consumptive use amount and maintaining the same seasonal pattern.

We want to point out that the South Dakota Office of Climatology provides information via their web site on crop potential consumptive use based on use of a Penman based equation. Data at the Caputa station are available starting in 2003. For the period 2003 through 2005, and for the months May through September, irrigation water requirement (i.e., potential consumptive use minus effective precipitation) for alfalfa at the Caputa station averaged about 2.89 acre-feet per acre. Over the period 1950 through 2004, our analyses indicate irrigation water requirement for alfalfa averaged 2.10 acre-feet per acre at the NOAA weather station near Rapid City. The difference, in part, is likely due to the lower precipitation, higher temperatures and lower humidity during the 2003 – 2005 period as compared to the longer term average. It may also be that even with the elevation adjustment, the Modified Blaney-Criddle approach still underestimates potential consumptive use. Nevertheless, we continue to feel our application of the elevation adjustment is appropriate, and perhaps conservative.

With respect to information from the South Dakota Office of Climatology, their web site address is [http://climate.sdstate.edu/w\\_info/et/etnew.shtm](http://climate.sdstate.edu/w_info/et/etnew.shtm). We are attaching two additional reference documents containing information on water requirements for alfalfa (**Attachment 1**). One of the articles (*Irrigating Alfalfa in South Dakota*) contains some interesting water use information as related to alfalfa yields. As reported in this reference, alfalfa production in South Dakota requires about 4.5 – 6.0 inches of water for every ton of hay. If we use an average of 5.25 inches per ton, and consider Mr. Lamb’s report of approximately five tons per acre, this would require approximately 2.18 acre-feet of water per acre. Note that to apply 2.18 acre-feet of water per acre, at a application efficiency of 65% and a ditch loss of 11% would require diversion of approximately 3.77 acre-feet per acre.

#### **Allocating Diversions through the Murphy Ditch**

The letter from SDDENR states that the Water Rights Program “still questions the number of acres historically irrigated under the water rights sought to be transferred.” It is not clear to us if there is a question specifically about the amount of land historically irrigated using the Murphy Ditch water right on the Harney Peak Ranch, or if the question pertains to other lands not owned by Mr. Lamb. It is only the Harney Peak Ranch portion of the Murphy Ditch rights owned by Mr. Lamb that are involved in the transfer. With respect to other lands irrigated via the Murphy that are not owned by Mr. Lamb, we have not investigated whether they are inside or outside of any irrigation district. It is, however, our understanding that lands must lie within irrigation district boundaries to be eligible to purchase water from Pactola and Deerfield reservoirs.

It is our understanding that several water rights may be delivered through the Murphy Ditch. Included are the original rights associated with the Murphy (1878 priority for 17.0 cfs, and 1893 priority for 3.0 cfs), the Little Giant (Permit No. 653-2 for 2.4 cfs), Blanche Sedivy (Permit No. 1684-2 for 0.21 cfs), Warren Lamb Lumber (Permit No. 1461-2 for 1.25 cfs), Marty Rypkema





(Permit No. 1784-2 for 0.71 cfs) and Jerry and Donna Olson (Permit No. 1788-2 for 0.50 cfs). It is our understanding that the Murphy Ditch elected not to become a member of the Rapid Valley Water Conservancy District, and its irrigated lands are therefore not eligible to receive water from Pactola and Deerfield reservoirs. Other rights diverting through the Murphy may be eligible to purchase reservoir water.

In our analyses of the Harney Peak Ranch we were required to develop an estimate of historical water supplies available as derived from 33.4% ownership in the Murphy Ditch. Unfortunately the carriage of other water rights in addition to the Murphy Ditch rights complicates a simple proration of total diversions by ownership percentage. This issue has come up fairly frequently in water right cases in Colorado (also a prior appropriation State). The only approach we have seen and used to "allocate" total water diversions through a structure permitted to carry multiple water rights is by the water right priority. The underlying assumptions are that 1) there is a demand for the water under the senior right; 2) the more senior rights would take their full water right amount if it were available; and 3) the senior rights are entitled by law to take the water first because of their priority over junior appropriators.

We believe the allocation of total diversions through a ditch by priority of the water rights is a fundamental principal in water rights engineering. This is the position accepted by the Colorado Division of Water Resources, numerous attorneys and engineers specializing in water right matters, and the various water courts responsible for adjudicating water rights.

Allocation of total diversions through the Murphy Ditch to senior rights first may result in little or no water being allocated to the more junior rights. This is not to say that junior rights associated with the Murphy Ditch never received water. As noted in our previous letter, significant drainage into the Murphy below the river headgate and measuring point occurs due to storm events and more regularly from irrigation under other ditches whose lands lie above the Murphy Ditch. This drainage has likely precluded the necessity and the ability to fully divert water right amounts at the headgate on Rapid Creek. Note that a feature of the Murphy Ditch is a return flow structure located below the headgate that allows conveyance of water back to Rapid Creek if tributary drainage causes total flows to exceed ditch capacity. None of the tributary inflow to the Murphy Ditch would be included within the available diversion records. We understand that these issues have been studied in the past by a special drainage commission.

We have also pointed out that other owners of the Murphy Ditch senior right likely did not use their water entitlement as fully as Mr. Lamb. This would result in unused Murphy Ditch water being made available for use by the junior right owners. Mr. Lamb has repeatedly commented to us that historically there has been good intra-ditch cooperation where ranchers are willing to share in times of shortages.

We do not claim in any way that the junior water rights in the Murphy Ditch are legally limited to drainage and runoff contributions to the ditch. Our understanding is that the junior water rights have the legal right to divert water from Rapid Creek like any other water right, i.e. subject to physical availability and legal availability (in priority).

A final point we want to make with respect to the allocation of diversions to various water rights relates to historical diversion records (also discussed below). It is our opinion that the diversion



records available for the Murphy Ditch do not accurately reflect what was actually diverted from Rapid Creek, i.e., the records significantly understate actual diversion amounts. We believe our opinion is supported by information and comments received from Mr. David Lamb, the Bureau of Reclamation, the Rapid Creek Water Conservancy District, and two Water Masters for Rapid Creek. Our understanding is that historically, the purpose of record keeping on Rapid Creek was not driven by a need for tight water right administration and potential water right disputes – there was very much a cooperative environment among ranchers and water right owners. Instead, diversion recording was driven more by the need to track reservoir water deliveries – the Murphy Ditch decision not to participate in the Conservancy District may have put even less importance on accurate record keeping for the Murphy.

### **Historical Water Supply**

As discussed above, it is necessary to adjust historical diversion records for the Murphy Ditch to more accurately reflect actual diversions and ultimately the depletive burden on Rapid Creek due to irrigation on the Harney Peak Ranch. We have previously provided information as to our methodology for making these adjustments, and continue to feel the adjustment is appropriate for the Murphy Ditch 1878 priority and perhaps conservative with respect to total diversions through the Ditch under all water rights.

On an annual basis over the period 1950 – 2004 we have estimated diversions attributable to the Murphy Ditch 1878 priority and delivered to Harney Peak Ranch to average 1,303 acre-feet, and range from 657 acre-feet to 1,738. The estimated annual average delivery of 1,303 acre-feet reflects an average diversion rate from Rapid Creek of about 3.6 cfs, or only 64% of the 5.7 cfs Mr. Lamb own in the Murphy Ditch 1878 priority. For 368 irrigated acres on the Harney Peak Ranch under the Murphy Ditch, this equates to diversion from Rapid Creek of roughly one cubic foot per second per 102 acres. The amount permitted for Mr. Lamb's in Permit No. 1727-2 (and presumably the legal authority) equates to roughly one cubic foot per second per 65 acres.

With respect to the volume of water historically applied at Harney Peak Ranch, we will again point out the information we have developed with respect to irrigation water requirement and information from the South Dakota Office of Climatology, the South Dakota Cooperative Extension Service, and others regarding crop water demands. We believe Mr. Lamb and his family applied good water management in their ranching operations, i.e., they did not waste water – it was not in their interests to apply more water than was necessary to achieve good crop yields.

We can offer little in the way of comments on the information provided concerning the Belle Fourche Irrigation District. It appears to us that this study (Masters Thesis by Cheryl Roland, South Dakota School of Mines and Technology) was aimed at identifying potential water conservation opportunities in order to increase water deliveries to ranchers, improve water quality, and enhance wildlife and recreation at Belle Fourche Reservoir. The study was not specifically aimed at determining necessary irrigation water requirements to achieve good crop yields. We will point out, however, that records of historical “project” water deliveries may be a poor indicator of the amount of water ranchers want delivered because there is a cost associated with each acre-foot of delivery. River water diverted under the prior appropriation system, by contrast, is free of charge.



We will note that while extreme care is taken in the State of Colorado with respect to recording and maintaining information on diversions from surface streams and rivers, much less information has historically been recorded for groundwater pumping by wells. In the case of alluvial wells with direct connection to surface streams, and which effectively are administered the same as ditch water rights, the State and others have routinely used demand based estimates of historical pumping during water right transfer cases. That is, crop demand (based on one of the techniques discussed above) is used along with an estimated application efficiency (typically 65% - 80% depending on technique) to back into estimated groundwater withdrawal. Pilot studies where this method has been applied even though meters are installed on the wells indicate good agreement between estimated and measured pumping. Again, this indicates that ranchers recognize the importance of applying the appropriate amount of irrigation water.

### **Return Flow Locations**

We agree that maintenance of return flows associated with use of the Murphy Ditch 1878 priority water right in the amount, timing and location is necessary for protection of other water rights diverting from Rapid Creek. It is our understanding that Rapid Valley Sanitary District is working directly with the State to address this concern.

### **Terms and Conditions on Transfer**

In some of our past conversations with the State we have discussed the issue of terms and conditions on the transfer of Mr. Lamb's water rights in order to be protective of other water right owners on Rapid Creek. We think we are in agreement that terms and conditions are necessary. Our September 21, 2005 report described several terms and conditions we thought were appropriate. These terms and conditions are summarized as follows:

1. Future use limited to the historical season of use, i.e. April 15<sup>th</sup> through November 30<sup>th</sup>.
2. Maximum rate of diversion limited to the prorata interest in Murphy Ditch 1878 priority, less ditch loss, i.e., 5.05 cfs.
3. Rate of diversion limited to the prorata interest of daily diversion amount attributable to the Murphy Ditch 1878 priority, less ditch loss.
4. 10-year monthly and annual volumetric limits on diversions based on long-term monthly and annual averages.
5. Dry-up of lands historically irrigated with transferred water rights.
6. Measurement, accounting and reporting of water use.

It will also be necessary to ensure historical return flows from future use by Rapid Valley Sanitary District are maintained in quantity, timing and location to protect other water rights that may have relied on those accretions to Rapid Creek. We believe this will be accomplished through the volumetric limitations described above, the reduced depletive effect from municipal use of the water rights, and the location of the treatment facility receiving waste water from the District.

Prior transfers on Rapid Creek have included a condition that limits diversions to long-term annual and monthly averages. In our opinion, limiting each year's diversion amount to the long-term average annual amount will result in the District never being able to realize the historical yield of the water right. We have proposed that the volumetric limit be based on a 10-year running average



derived from the long-term average. In other words, if the long-term average annual amount is 1,303 acre-feet, then over a period of 10 years, the District may not divert more than 13,030 acre-feet. We would like to discuss this and other terms and conditions further with the State.

We will also point out that because future use of the Murphy Ditch 1878 priority water right by the District will be less depletive (on average 31% from April through October) than has occurred historically under irrigation on Harney Peak Ranch, and because volumetric limits will constrain the amount the District can divert, there will actually be less depletive burden on Rapid Creek following the transfer. This will be a net benefit, following the transfer, to other water right owners on Rapid Creek.

### Summary

Our engineering efforts have been aimed at quantifying and characterizing the historical depletive burden on Rapid Creek resulting from irrigation on the Harney Peak Ranch, and specifically, use of Mr. David Lamb's ownership in the Murphy Ditch 1878 priority water right. In our studies we have developed reasonable estimates of historical diversions, consumptive use, return flows and net depletive effects from such use. We have relied on a variety of data and we were required to develop estimates of in some areas. Our client, Rapid Valley Sanitary District, in no way influenced decisions we made regarding our approach, use of data, or estimates we developed, nor did they otherwise encourage particular findings. We continue to believe our study is reasonable and accurate with respect to conclusions regarding depletive effect from irrigation on Harney Peak Ranch. We also believe the water rights can be transferred to the Rapid Valley Sanitary District and used, pursuant to the terms and conditions outlined in our report dated September 21, 2005 and summarized above, such that there is no injury to other water right owners along Rapid Creek.

Very truly yours,

LEONARD RICE ENGINEERS, INC.



Ed Armbruster, P.E., C.C.E.  
Principal

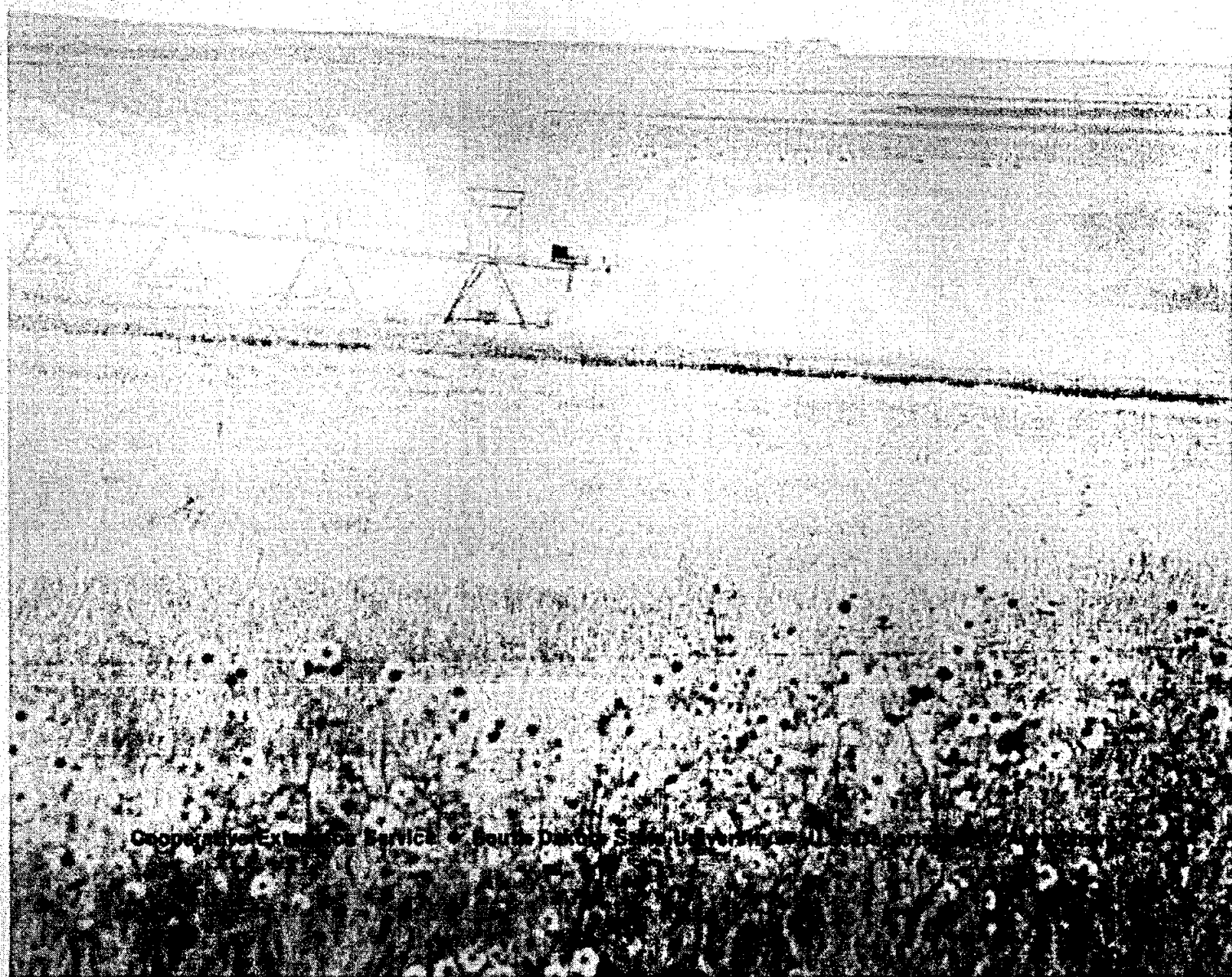
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Attachments



## **2. Irrigating Alfalfa in South Dakota**

# Irrigating Alfalfa in South Dakota



Cooperative Extension Service • South Dakota State University • Brookings, S.D. 57007



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# Irrigating Alfalfa in South Dakota

James R. Johnson, Charles R. Krueger,  
Lyle A. Derscheld, Darrel D. Pahl, and  
Paul L. Carson

Alfalfa performs admirably as an irrigated crop in South Dakota—so well that it is often neglected. When given attention, it can realistically maintain irrigated yields of 6 to 7 T/A each year in most of South Dakota where 1 to 2 T are produced on dryland.

Irrigated land that will produce 100-130 bu corn will produce 5-7 T alfalfa. On poorer irrigated land that produces 50-70 bu corn, one can expect 3-5 T alfalfa.

Alfalfa has higher water requirements for peak yields than most other crops. It may not reach its full potential yield in any part of the state without irrigation.

Alfalfa is produced on 2.2 million acres (dryland and irrigated combined) in every county in South Dakota. By contrast, even when corn is irrigated, it is adapted to only about two thirds of the state. If the marketing problems of transportation and fluctuating prices are overcome, alfalfa could become the state's number one irrigated crop.

## Variety Selection

The customary dryland alfalfa varieties may not be the best choices for irrigation.

No single variety has all the characteristics necessary for best results under all conditions (Table 1). For example, we need a winterhardy and drought tolerant variety like Vernal on dryland. But with irrigation on a poorly drained soil, Vernal is not the best choice because it does not have rapid regrowth or phytophthora root rot resistance.

Careful variety selection is often more important for

Table 1. Selected variety characteristics and their importance for dryland and irrigated production.

| Variety characteristic           | Important for dryland | Important for irrigation |
|----------------------------------|-----------------------|--------------------------|
| Winterhardiness                  | Yes                   | Desirable                |
| Drought tolerance                | Yes                   | No                       |
| Common leaf spot resistance      | No                    | Desirable                |
| Bacterial wilt resistance        | Yes                   | Yes                      |
| Insect resistance                | Desirable             | Desirable                |
| Regrowth ability                 | Not always            | Yes                      |
| Phytophthora root rot resistance | Seldom                | Yes                      |
| Seedling vigor                   | Yes                   | Yes                      |

irrigation than for dryland production. Since production costs are greater under irrigation than on dryland, the wrong variety can substantially reduce profits. Additional information on varieties is given in FS 529, Alfalfa varieties for South Dakota.

**Common or South Dakota Common.** This category of seed alfalfa does not guarantee varietal purity.

It is of unknown breeding; the buyer cannot predict performance. One sack labeled "common" may be excellent for irrigation, while another one may result in stand loss in 2 years.

"Common" or "South Dakota Common" seed is not a wise choice for irrigation unless the buyer can be positive that it originated from a variety known to perform well under irrigation.

**Public versus Private Varieties.** In the past, most alfalfa varieties were developed and released by state agricultural experiment stations and by USDA. Varieties from

these sources are known as "public" varieties.

However, in recent years private industry has gained an active role in breeding and selecting hay varieties. Privately developed varieties are called "proprietary."

When a variety meets agronomically important requirements, it does not matter whether that variety is a public or private release, as long as the grower can be confident that the advertised characteristics of the variety are actually present.

**Flemish versus Standard Regrowth Types.** In recent years Flemish strains from northern and western Europe have become popular in humid regions and in semi-arid regions where irrigation effectively creates a long growing season.

Flemish types have more rapid regrowth than non-Flemish strains, and are better able to utilize the full growing season when irrigated. Most recent Flemish varieties have improved winter hardiness and disease resistance.

The need for extreme levels of winter hardiness or drought resistance that exists for much of South Dakota is offset to some extent by irrigation. With irrigation, plants can be managed to go into winter with a high level of vigor. Winter injury will be less severe unless frost heaving or ice sheet formation occurs; then differences in winter hardiness probably are not related to survival.

Several standard (non-Flemish) varieties produce well under irrigation. Flemish types may have an edge where growers are pushing for peak production.

However, experiences to date in South Dakota show that several standard varieties are just as productive as Flemish strains. It is appropriate to consider planting some of both, especially where large acreages are irrigated.

A 5-year trial at Redfield (Table 2) showed comparable irrigated production from Iroquois (standard), Vernal (standard), and Saranac (Flemish). In 1974 Iroquois and Saranac yielded better than Vernal which is an excellent dryland variety. There were no real differences in any other year.

In a 20-variety irrigated trial at Nisland, Butte County (Table 3), several standard and Flemish varieties produced a 3-year average of 7.2 T/A. Only four varieties (Vernal, Ladak 65, Iroquois, and Siberian) were substantially less productive than most of the other 16.

The point is that many varieties have high yield potential; it is often more meaningful to select varieties on the basis of other characteristics.

**Winter hardiness (and related drought tolerance) and bacterial wilt resistance are more important than minor yield differences.**

Wilt resistance is especially important under irrigation where there is often a risk of early stand loss with wilt susceptible varieties. For long life under irrigation, varieties should also

Table 3. Nisland (Butte County) irrigated alfalfa trial showing 10 of the 20 varieties under test.

| Variety*           | Source                  | Winter hardiness and drought tolerance | Bacterial wilt resistance | Phytophthora root rot resistance | Hay yield, 1975-77** | Stand, August 1978 |
|--------------------|-------------------------|----------------------------------------|---------------------------|----------------------------------|----------------------|--------------------|
| Vernal (S)         | Public, Wisc Ag Exp Sta | High                                   | Resistant                 | Susceptible                      | T/A 6.7              | % 60               |
| Dawson (S)         | Public, Neb Ag Exp Sta  | High                                   | Susceptible               | Susceptible                      | 7.1                  | 69                 |
| Agate (S)          | Peterson                | High                                   | Resistant                 | Resistant                        | 7.6                  | 76                 |
| Ladak 65 (S)       | Public, Mont Ag Exp Sta | High                                   | Resistant                 | Susceptible                      | 6.5                  | 61                 |
| Iroquois (S)       | Agway                   | High                                   | Resistant                 | Susceptible                      | 6.5                  | 68                 |
| Siberian (S)       | Foster's Yellow Blossom | Very High                              | ?                         | Susceptible                      | 5.4                  | 52                 |
| J-80 (F)           | Jacques                 | Moderate                               | ?                         | ?                                | 7.5                  | 70                 |
| Thor (F)           | Northrup-King & Co      | Moderate                               | Resistant +               | Susceptible                      | 7.7                  | 77                 |
| Americana (F)      | Teweles Seed Co         | ?                                      | Susceptible               | Susceptible                      | 7.6                  | 70                 |
| Superstar (F)      | Teweles Seed Co         | Moderate +                             | Resistant                 | Mod. resistant                   | 7.8                  | 70                 |
| 20 variety average |                         |                                        |                           |                                  | 7.2                  |                    |

\* (S) Standard variety, (F) Flemish variety

\*\* Trial established in 1974

be at least moderately winter hardy and drought tolerant.

For soils that are poorly drained or periodically inundated, phytophthora root rot resistance is highly desirable. Some resistant varieties are Agate (Peterson Seed Co.), Apollo (North American Plant Breeders), and Phylor (Northrup-King Co.).

On poorly drained soil at Arpan, only resistant varieties, Apollo and Agate, maintained satisfactory stands after two growing seasons (Table 4). Phytophthora root rot organisms were isolated in yellowed and stunted susceptible plants.

## Establishment

By contrast to dryland, irrigated alfalfa is easier to establish. This is especially true in drier parts of the state or during dry spells anywhere.

Three essentials of establishment are (1) seed in a firm seedbed, (2) seed at a uniformly shallow depth, and (3) hold early weed competition to a minimum.

Details on stand establishment are discussed in FS 503. Planting

same pastures and hayland. Additional information specific to irrigation and some supporting data are given below.

**Careful seedbed preparation** pays handsomely in establishment.

Fall plowing and discing will often permit seeding in early spring, especially on fine textured soils that require weathering to be mellow or on those that have an existing stand of old alfalfa or sod.

Final preparation should destroy germinating weeds, break and level large clods, and leave a firm clean seedbed. A cultipacker seeder will often create such a seedbed. Other seeders may require additional tillage.

Cloddy seedbeds can result in poor stands unless excessive amounts of seed are used. If the seedbed is not firm, air pockets may form, causing young seedlings to lose contact with soil moisture and die.

If weeds are not a problem, seeding with a grassland drill directly into small grain or row crop stubble frequently eliminates the need for seedbed preparation.

Table 2. Yields of irrigated alfalfa varieties at Redfield.

| Variety             | Year |      |      |      |      | Total |
|---------------------|------|------|------|------|------|-------|
|                     | 1973 | 1974 | 1975 | 1976 | 1977 |       |
|                     |      |      | T/A  | ***  | ***  |       |
| Vernal (standard)   | 3.4  | 5.4  | 7.2  | 5.6  | 3.8  | 25.4  |
| Iroquois (standard) | 3.8  | 6.6  | 7.2  | 5.6  | 3.9  | 27.1  |
| Saranac (Flemish)   | 3.6  | 6.5  | 7.6  | 5.8  | 3.8  | 27.3  |

\* Stand established

\*\* Only year where real differences in production occurred among varieties.

\*\*\* Irrigation water shortage resulted in half the normal amount applied.



Alfalfa production trials are farming on a small scale. Plots are located throughout the state to



match soils and climates that growers face. Careful mowing, collecting, weighing, and



sampling in the plots insure accurate results which are passed on as variety recommendations.

As with dryland plantings, the best date of establishment is early spring, generally about April 15 to May 15. Fields may be irrigated the previous fall.

Late summer establishment (August 1-September 1) can be quite satisfactory. Prepared seedbeds or small grain stubble can be irrigated. Seeding should be done as soon afterwards as possible for rapid germination and sufficient growth for overwintering vigor. Planting as late as September 15 can be successful, but risks of winter kill will increase.

Late fall plantings (after November 1) into dry seedbeds run the risk of germination so early in the spring that seedlings may be killed by frost. Late fall (dormant season) seedlings are not recommended for alfalfa.

Companion crops or nurse crops can be used to excellent advantage with new seedlings: (1) They provide protection from weeds and supply shade, (2) Small grains used this way can be harvested for hay or grain, (3) Companion crops permit earlier irrigation than would be possible if no companion crop were used.

With flood irrigation, companion crops help to prevent erosion and lessen the "baking effect" that can kill alfalfa seedlings. With sprinkler systems, the added benefit of breaking the impact of water droplets can be important.

To prevent excessive shading or moisture competition, the seeding rate of small grain companion crops should be substantially reduced. Full seeding rates can result in

excessive competition and failure of the alfalfa seeding.

The following rates are recommended, depending on soil moisture and weather. The higher rates should be used in anticipation of favorable growing conditions:

oats, 25-30 lb/A  
barley, 30-45 lb/A  
standard height spring wheat, 25-50 lb/A  
semi-dwarf spring wheat, 30-50 lb/A

Recent establishment method trials with irrigation at Brookings compared companion crops and herbicide systems.

The primary yield differences were found in the seedling (first) year. The tradeoffs are readily apparent in Table 5.

Method of establishment did not affect alfalfa yields in following years.

When producers are primarily interested in contracting alfalfa for dehydration or in selling alfalfa hay, a preplant herbicide can obtain more alfalfa the seedling year. When properly done, nearly pure alfalfa can be obtained approximately 10 weeks after planting.

On the other hand, seeding a small grain and harvesting as forage will yield more total forage and be less costly. When a small grain companion crop is planted for forage, protein content of the first harvest will be lower than for pure stands.

Table 4. Arpan (Butte County) irrigated alfalfa trial with Phytophthora root rot confirmed.

| Variety            | Phytophthora root rot | Hay production, 1977* |     |     |       | Stand evaluation, September 1977** |
|--------------------|-----------------------|-----------------------|-----|-----|-------|------------------------------------|
|                    |                       | 1st                   | 2nd | 3rd | Total |                                    |
| Apollo             | Resistant             | 1.8                   | 1.3 | 1.3 | 4.4   | Good                               |
| Agate              | Resistant             | 1.5                   | 1.2 | 1.2 | 3.9   | Good                               |
| Local seed***      | Unknown               | 1.6                   | 1.3 | 1.0 | 3.9   | Fair—                              |
| Weathermaster A-77 | Unknown               | 1.9                   | 1.2 | 0.8 | 3.8   | Poor                               |
| Irquois            | Susceptible           | 1.7                   | 1.2 | 0.9 | 3.8   | Poor +                             |
| Cossack            | Susceptible           | 1.8                   | 1.1 | 0.8 | 3.6   | Poor +                             |
| Thor               | Susceptible           | 1.5                   | 1.1 | 0.8 | 3.4   | Poor +                             |
| Vernal             | Susceptible           | 1.5                   | 1.0 | 0.8 | 3.3   | Poor +                             |

\*Planted April 1976. All varieties had excellent stands in 1975.

\*\*Good = Good stand, appears healthy. Fair = Good stand, 0-20% plants yellowed, somewhat stunted. Poor = Stand thinning 20-50% plants yellowed, some stunted.

\*\*\*The "local seed" was from an old nearby field thought to have originated from Cossack.

Table 5 Irrigated alfalfa trials using four establishment methods at Brookings.\*

| Establishment method                             | Seeding year<br>weed-free hay<br>t/A | Plus grain<br>harvested<br>bu/A | Plus straw<br>harvested<br>t/A |
|--------------------------------------------------|--------------------------------------|---------------------------------|--------------------------------|
| Check (no<br>companion crop<br>or herbicide)     | 4.4                                  | 0                               | 0                              |
| Herbicide (Pre-<br>plant Eptam)                  | 4.8                                  | 0                               | 0                              |
| Oat forage (Kota<br>oats harvested<br>as forage) | 5.9                                  | 0                               | 0                              |
| Oat grain (Kota<br>oats harvested<br>as grain)   | 2.0                                  | 60                              | 2.0                            |

\* The check, herbicide, and oat forage treatments were harvested three times, and the oat grain treatment was cut twice, once for grain and once for regrowth alfalfa forage. Average of three varieties (LSA 6 Hybrid, Saratoga and Vernal).

Satisfactory equipment for seeding varies considerably. The ideal piece of equipment has features which insure that (1) the correct amount of seed is planted, (2) seed is placed at the best depth, and (3) the seedbed is firmly packed.

Seeding equipment includes cultipackers, grassland drills, press drills, grain drills or broadcast seeders; no one seeder works best under all conditions.

Cultipacker seeders are excellent, except on sands where seed may be placed too shallow or on clays with damp surfaces. Seed tubes on grain drills having legume boxes and press wheels are also satisfactory when depth can be controlled. A detailed discussion of seeding equipment is given in FS 503, Planting tame pastures and haylands.

Depth of seeding is more critical with small seed than with large. The small size of alfalfa seed may prevent emergence if the seed is below the surface by as much as  $\frac{3}{4}$  inch. In fine textured soils,  $\frac{1}{2}$ - $\frac{3}{4}$  inch is ideal; in light soil,  $\frac{1}{2}$ - $\frac{3}{4}$  inch is best. Surface planting on a firm bed can work well if there is sufficient rain followed by ideal growing conditions.

Fertilization at seeding time is recommended only when (1) soil tests show extremely low levels of nitrogen or phosphorus, and

(2) it is possible to side band or bottom band about 2 inches from the seed, or (3) fertilizer can be applied prior to planting and worked in. This would be especially necessary for phosphorus. Nitrogen can be broadcast on the surface.

Some tests have shown drastic stand reductions when fertilizer has been placed in the furrow with the seed. Recent research on the Belle Fourche Irrigation District in Butte County has shown that phosphate or nitrogen, when concentrated in the furrow and placed in contact with the seed, was of questionable benefit. Large amounts of either nutrient often reduce stands quite drastically.

If potassium is used, even though it is rarely needed in South Dakota, it should be side banded rather than banded below the seed. If a companion crop is used, more than 15 lb/A nitrogen may stimulate the companion crop at the expense of the alfalfa.

Inoculating alfalfa seed with the appropriate bacterium is necessary for alfalfa to produce its own nitrogen.

Inoculation should be done even if buying pre-inoculated seed. Research at SDSU has shown that inoculum already on

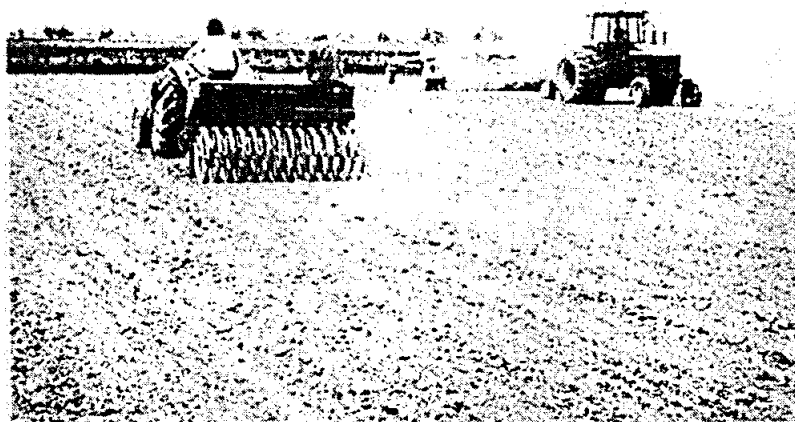
the seed is often not effective because storage conditions (which can exceed 60° F) can destroy the bacteria. See FS 601, Pre-inoculation and field inoculation.

Fresh inoculum is readily available and costs about \$1/bu.

At planting time, seed can be moistened slightly so that the inoculum will stick better, or it can be put on dry and mixed in the drill box. The dry method would require  $1\frac{1}{2}$  times the recommended rate.

Inoculation may not always be necessary for the stand to live, but it can be beneficial in several ways: (1) increased yields, (2) higher protein, (3) longer stand life, (4) better growth of the companion grass crop, (5) increased soil nitrogen, and (6) elimination of nitrogen fertilizer applications.

Lime coatings for alfalfa seed have recently gained attention. Coated seed is surrounded by lime based material, and sometimes contains Rhizobia for nodulation and nitrogen production. Minnesota research by the USDA at seven sites on non-acid soils showed no advantage for establishment, nodulation (an index for nitrogen production potential), or for hay yields. At this time, seed coating



The seedbed must receive careful attention. Floating, packing, and seeding is being done here in the spring. A firm seedbed allows this

pony press with legume box to place seed at the correct depth.



A cultipacker seeder is commonly used to seed alfalfa. Although some seed is placed at improper depths, satisfactory seeding can be done. The twin row of cultipackers helps to give a firm seedbed.

of alfalfa seed is not recommended.

Seeding rate information from South Dakota trials support earlier recommendations for planting 8 lb of pure live seed (PLS)\* an acre. A farmer planning to harvest two or more crops of forage the seedling year should use about 12 lb/A.

The primary difference in yield among seeding rates is in the seedling year (Table 6). In this trial a grain drill with double-disc openers, depth bands, and packer wheels was used. Satisfactory stands were obtained at all rates. By the second year there was virtually no difference among the seeding rates although more weeds were present at the 4-lb rate.

If equipment, seedbed, and growing conditions are ideal, the 4-lb rate can be adequate (although not recommended) and offers considerable savings. On the other hand, if planting and growing conditions are marginal, 16-20 lb/A may not be enough.

The importance of proper seeding equipment was illustrated in a trial which required vastly different quantities of PLS to obtain the same stand (Table 7).

**New seeding management** with irrigation is relatively simple. Moisture levels should be kept adequate at all times to

Table 6. Alfalfa seeding rate trial with irrigation at Brookings.\*

| Seeding rate<br>PLS<br>lb/A | Seeding year<br>(1971)       | Second year<br>(1972) | Third year<br>(1973) | Fourth year<br>(1974) | Total<br>(1971-74) |
|-----------------------------|------------------------------|-----------------------|----------------------|-----------------------|--------------------|
|                             | T/A                          |                       |                      |                       |                    |
| 4                           | 3.7                          | 6.3                   | 7.9                  | 7.0                   | 21.2               |
| 8                           | 4.3                          | 6.5                   | 8.1                  | 7.5                   | 22.1               |
| 12                          | 4.5                          | 6.5                   | 8.2                  | 7.6                   | 22.3               |
| 16                          | 4.6                          | 6.4                   | 8.3                  | 7.7                   | 22.4               |
|                             | alfalfa plants/square foot** |                       |                      |                       |                    |
| 4                           | 14                           | 13                    | 7                    | 6                     |                    |
| 8                           | 26                           | 24                    | 11                   | 10                    |                    |
| 12                          | 38                           | 34                    | 16                   | 11                    |                    |
| 16                          | 49                           | 40                    | 26                   | 11                    |                    |

\*Average of three varieties (13X-8 hybrid, Saranac, and Vernal).  
\*\*Plant counts were made in June 1971 (16 weeks after planting) and in October 1972, 1973, and 1974.

enable rapid root and top growth.

If weeds are a problem, mow the field as close as practical. Remove residue from the field as soon as it is dry enough to manage as hay. Windrows left for much longer than 5 days may severely damage young stands.

If a companion crop of grain is taken, maintain adequate soil moisture to prevent drought stress of the alfalfa seedlings. If straw residue is left, it should be spread as uniformly as practical to avoid "smothering."

If phosphorus and/or potash are to be used on the established stand, they can be applied after removal of the first crop or the companion crop.

Table 7. Seeding equipment trial at Brookings with quantities of PLS required to obtain equivalent stands. All were seeded with small grain companion crop.

| Seeder                                                                 | Pure live seed<br>for same stand<br>(lb/A) |
|------------------------------------------------------------------------|--------------------------------------------|
| Cultipacker                                                            | 8.0                                        |
| Grassland drill with depth bands and packer wheels                     | 8.9                                        |
| Grain drill with small seed box and front mounted, free hanging spouts | 10.7                                       |
| Grain drill with small seed box rear mounted, free hanging spouts      | 11.4                                       |
| Grain drill with alfalfa seed mixed with grain                         | 13.3                                       |
| Broadcast                                                              | 16.0 +                                     |

\*PLS = purity x germination

## Water Management

Yields of alfalfa hay are about in proportion to available water supply when the nutrient supply is adequate.

In South Dakota, alfalfa requires about 4.5 to 6 inches of water for every ton of hay. If we assume the water is applied by irrigation systems which are 80% efficient, we would have to apply 5.6 to 7.5 inches of irrigation water for each ton.

**Irrigation scheduling** is an integral part of alfalfa management. The rate of water use is low immediately after harvest, increases sharply, and reaches a peak at the pre-bud stage. Water required per ton of hay peaks in July and August.

These patterns of water use are quite predictable with variations due largely to weather and harvest schedules. Figure 1 shows an alfalfa water consumption curve for four cuttings; a three cutting curve would have the same type of pattern.

If we assume a normal soil and a normal growing season, the following example illustrates the critical nature of intensive irrigated alfalfa management. As shown by Table 8, if cuttings are delayed by a few days throughout the season, the last cutting (whether there are three, four, or five planned) may not be possible.

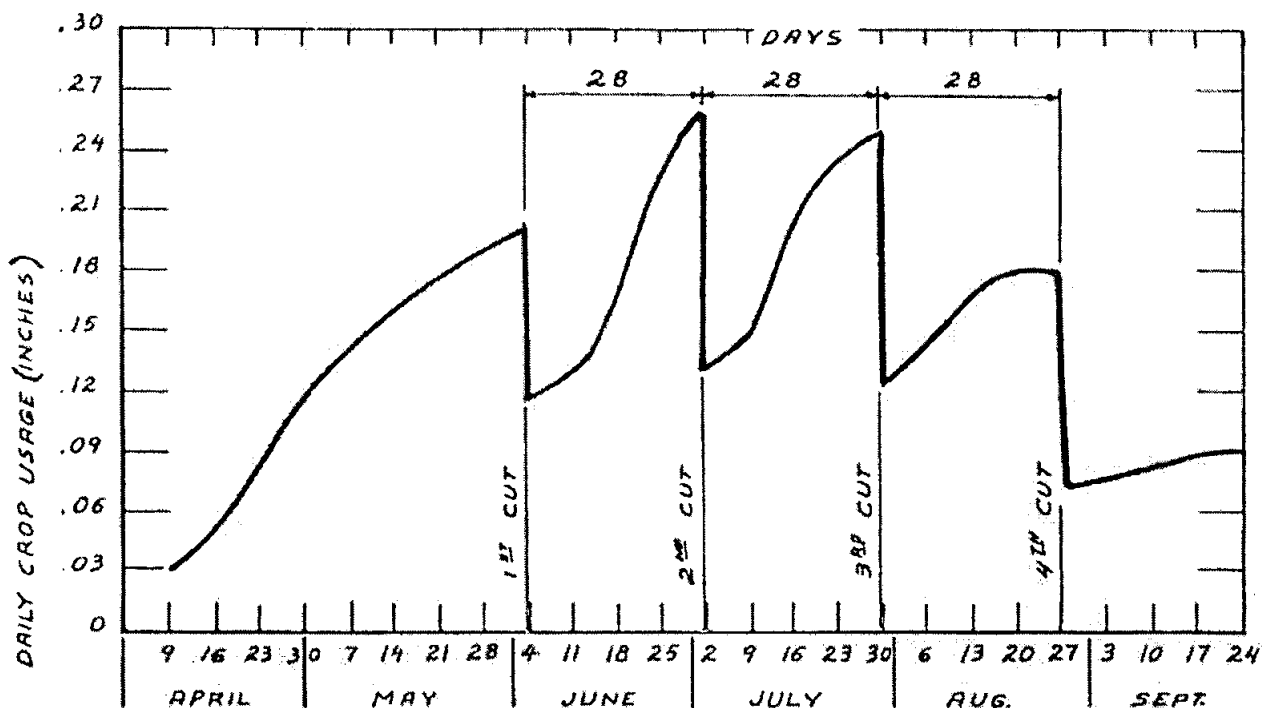
It is especially difficult in most of South Dakota to obtain four cuttings during the growing season and still maintain a productive, healthy stand.

When center pivots are used, irrigation scheduling is more critical than with flood systems. Pivots require a greater amount of time for application of water, thereby reducing flexibility.

A 130-acre center pivot operating at 800 gallons per minute with 80% efficiency will apply 0.26 inches per acre daily (Table 9). A cutting of alfalfa may consume 6 to 15 inches of water, depending on



Fig 1. Seasonal water consumption for alfalfa grown in South Dakota, four cuttings.\*



\*After Del Brier, SDSU Water Resources Institute

temperature, stand, maturity, etc. Assuming the crop will demand 6 inches of water in 28 days, the 800-gal system at 80% would need to operate for 23 days to meet crop needs. In this case, carryover subsoil moisture is imperative.

The most critical irrigation is the late summer or autumn irrigation. Good levels of soil moisture at this time (1) permit foliage regrowth and root carbohydrate accumulation for good overwintering, (2) lessen rapid temperature changes which damage roots, (3) prevent crown and root drying, and (4) provide stored moisture for the next growing season.

Fall or spring applications of water insure good first cutting production. Spring applications should be delayed sufficiently so that growth is not depressed by wet, cold soil.

Table 8. Example of intensive irrigated alfalfa management scheduling and water budgeting.

| Date          | Event                    | Projected yield<br>T/A | Amount consumed<br>Inches | Water budget                         |              |
|---------------|--------------------------|------------------------|---------------------------|--------------------------------------|--------------|
|               |                          |                        |                           | Source                               | Inches       |
| Before June 1 | Fertilize<br>Irrigate    |                        |                           | Stored available<br>Rain<br>Irrigate | 5<br>12<br>4 |
| May 25-June 1 | 1st cutting              | 2.50                   | 15                        | Carryover                            | (6)          |
|               | 5-10 days to cure        |                        |                           | Rain                                 | 4            |
|               | 17 days to irrigate      |                        |                           | Irrigate                             | 2            |
|               | 7 days to dry soil       |                        |                           | Irrigate                             | 4            |
| July 6        | 2nd cutting              | 2.00                   | 12                        | Carryover                            | (4)          |
|               | 5 days to cure           |                        |                           | Rain                                 | 1            |
|               | 21 days to irrigate      |                        |                           | Irrigate                             | 4            |
|               | 6 days to dry soil       |                        |                           | Irrigate                             | 4            |
| August 7      | 3rd cutting              | 1.50                   | 9                         | Carryover                            | (4)          |
|               | 5 days to cure           |                        |                           | Rain                                 | 2            |
|               | 20 days to irrigate      |                        |                           | Irrigate                             | 3            |
|               | 6 days to dry soil       |                        |                           | Irrigate                             | 4            |
| Sept. 8       | 4th cutting              | 1.25                   | 8                         | Carryover                            | (5)          |
| Oct. 8        | 30 days fall<br>regrowth | Possible<br>grazing    | 3                         | Irrigate                             | 3            |
| Total         |                          | 7.25                   | 47                        | Stored                               | 5            |

(19 rain + 28  
irrigation)



Early spring growth on an experimental alfalfa field shows the effectiveness (left) of autumn irrigation in initiating growth. The right side

received no autumn water. The soils are clay and slopes are steep, greater than 5%.

Recent research in Butte County has demonstrated a 0.9 T/A increase in yield on clay soils from a late May irrigation during a dry spring. By contrast, an additional fall plus spring application on a sandy loam soil resulted in a 2-year average increase of only 0.5 T/A.

For maximum production, it often is necessary to irrigate more than once between each cutting. However, restricted applications between cuttings generally will result in satisfactory yields, especially on deep soils with stored moisture.

Over irrigation can be costly and damaging. As long as a deep soil has about 25 to 35% of the available water remaining, additional irrigations may be of little benefit. On soils with low water holding capacity, available

water should be nearer 50%.

Ponding or raised water tables can occur after excess irrigation. Damage to roots can result from disease or simply a lack of air. This can produce reduced growth rate or stand loss. Damaging salt accumulations also frequently occur with over irrigation, leaky ditches, or poor soil or water quality.

To guard against over or under irrigation, it is desirable to keep track of total water applied (irrigation plus precipitation) and alfalfa water use rates. This type of moisture accounting can be conducted on a field-by-field basis using generalized alfalfa water use rates (Fig 1). An alternative is to use moisture measuring devices placed at 1-ft and 3-ft depths in

representative field locations. One such common device is the tensiometer discussed in FS 602. For timely irrigation: tensiometers.

## Fertility

Proper water management alone may not sustain high economic levels of alfalfa production.

The advantage of combining good water and fertility management has been demonstrated in recent Butte County trials (Figure 2). With "normal" water management the yearly yield increase from the addition of 60 lb/A P<sub>2</sub>O<sub>5</sub> was 0.7 T [4.1 vs 4.8]; when both additional water and fertility (90 lb of P<sub>2</sub>O<sub>5</sub>) were applied, the increase over the least intensive management was 1.4 T (4.1 vs. 5.4). Additional water without fertilizer did not significantly increase production.

Alfalfa uses large amounts of plant food elements in its growth when it is compared with other commonly grown irrigated crops (Table 10).

Although nitrogen requirements of alfalfa are extremely high, nitrogen fertilizer seldom increases yields because inoculated alfalfa has the ability to utilize atmospheric nitrogen.

Recent western South Dakota trials showed 60 lb nitrogen per year did not increase yields and tended to suppress yields over a 3-year period. This is consistent with other research in the state.

A small amount of nitrogen (10-15 lb/A) as a starter fertilizer, however, has been shown to aid in stand establishment.

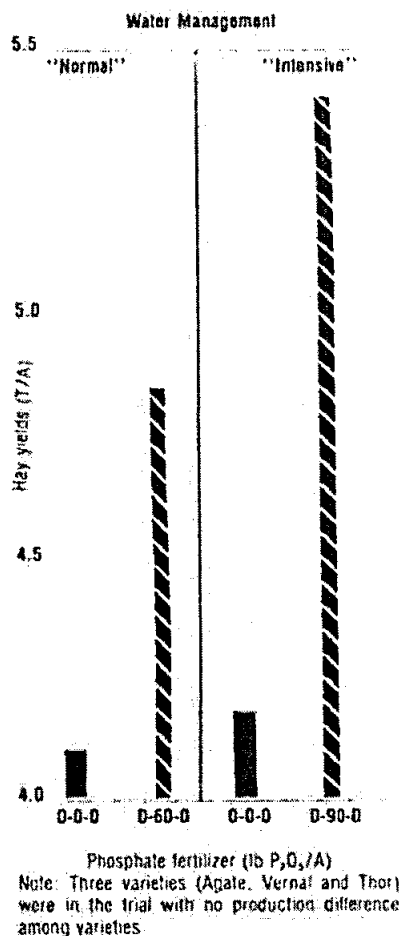
Phosphate fertilizer greatly increases alfalfa yields on many South Dakota soils.

In general, if a soil test is "low," a profitable yield response can be expected. Yield increases from phosphate fertilizer do not always occur

Table 9. Center pivot capacity and efficiency impact on irrigation time requirements.

| Flow capacity<br>of system<br>(gal/minute) | 130-acre Pivot system |                  |                                       |                  |
|--------------------------------------------|-----------------------|------------------|---------------------------------------|------------------|
|                                            | Inches of water/A/day |                  | Days required to apply<br>20 inches/A |                  |
|                                            | 70%<br>efficient      | 80%<br>efficient | 70%<br>efficient                      | 80%<br>efficient |
| 500                                        | 14                    | 15               | 140                                   | 123              |
| 600                                        | 17                    | 20               | 117                                   | 102              |
| 700                                        | 20                    | 23               | 100                                   | 88               |
| 800                                        | 23                    | 26               | 88                                    | 77               |
| 900                                        | 26                    | 29               | 78                                    | 68               |

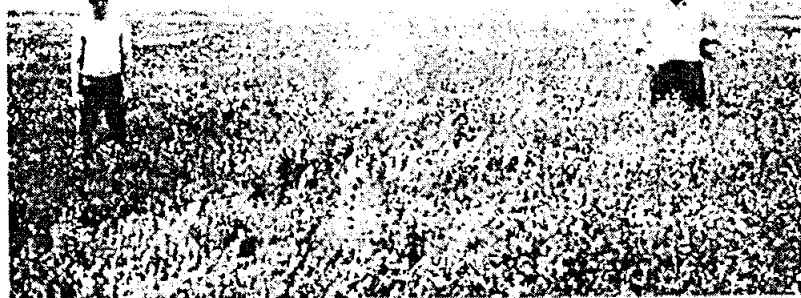
Fig 2. Response of three alfalfa varieties to differences in water management and fertilizer on clay soil, Butte County, 1976-78.



when the phosphorus soil test is in the "medium" and "high" range.

We are unable to accurately predict expected fertilizer response at the higher soil test levels for many reasons. Two of the more important are weather and the phosphate holding-yielding capacity of soil.

Even though phosphate tests are not always as accurate as desired, they provide the best method of evaluation available today. Soil tests and check strips (areas without fertilizer) in the field can provide a good understanding of phosphate needs and requirements on each alfalfa field.



Adding water without having the fertility up does not appear to significantly increase alfalfa production. Combined fertility and intensive

water management increase second cutting by more than 0.5 T/A on the right side, as compared to the left

Available potassium levels in most South Dakota soils are high. This means that additions of potash fertilizer will seldom profitably increase yields.

A limited number of soils, primarily in the eastern part of the state, are deficient in potassium. Soils having lower potassium supplying abilities are for the most part lighter textured (sandy) or poorly developed. [However, most sandy soils have adequate available potassium.]

Soil tests are an excellent guide for potash fertilizer recommendations. Small fertilized strips can be a reliable field test for potassium needs.

Secondary or micronutrient levels in most South Dakota soils are high.

However, with long-term intensive agriculture on irrigated soils, deficiencies may occur or may now exist in small areas. Deficiencies in other regions have been seen for sulfur, boron, copper, manganese, zinc, and iron, but production responses have not occurred in South Dakota.

The best prescription for fertilizing alfalfa is to soil test and follow the recommendation for fertilizer amendments from the laboratory which made the test.

Do not have a soil test analysis made at one lab and follow the recommendation for fertilizer from another lab. Because of differences in laboratory procedure or reporting approaches, laboratory test results cannot be interchanged with recommendations from other labs.

Whenever a laboratory makes a recommendation for nitrogen or micronutrients, a soil test analysis from another lab should be sought. In the case of phosphorus and potash, local field experience may be necessary to insure profitable responses.

For additional information on fertilizing see FS 425, Fertilizing pasture and hayland.

Table 10. Approximate amounts of plant nutrients removed by crops.

|                          | N   | P <sub>2</sub> O <sub>5</sub><br>lb/A | K <sub>2</sub> O |
|--------------------------|-----|---------------------------------------|------------------|
| Alfalfa (hay)*           |     |                                       |                  |
| (7 T)                    | 385 | 84                                    | 392              |
| (5 T)                    | 275 | 60                                    | 280              |
| (1 T)                    | 55  | 12                                    | 56               |
| Corn (grain + stover)    |     |                                       |                  |
| (130 bu for 20 T silage) | 200 | 65                                    | 170              |
| (100 bu for 14 T silage) | 140 | 50                                    | 130              |
| (1 T silage)             | 10  | 3.2                                   | 9.3              |
| Soybeans (grain)*        |     |                                       |                  |
| (40 bu)                  | 128 | 14                                    | 48               |
| (1 bu)                   | 3.2 | 0.3                                   | 1.2              |

\*Both alfalfa and soybeans are legumes which have the capability of using atmospheric nitrogen

## Cutting Schedules

An alfalfa harvesting schedule is a compromise based on weather, plant vigor, water availability, insect infestations, quantity versus quality, stand longevity, and calendar date. Some discussion is given in FS 52B (rev), Alfalfa management on dryland.

**Root carbohydrates** or reserves determine the ideal cutting schedule. Carbohydrates provide the energy needed to over winter and initiate growth in the spring and after each harvest. In perennial plants, root carbohydrates are stored during certain periods of above ground plant growth.

With alfalfa, plant height has to reach about 6-10 inches before carbohydrate use stops and accumulation begins. If stands are harvested substantially before the

flowering stages indicated in Fig 3, root reserves can be expected to decrease, accompanied by regrowth delays, reduced production, and thinned or killed stands.

Delayed harvests do build up additional stored carbohydrates but do not increase production, as growth rates decrease rapidly after flowering. Furthermore, with delayed harvests, the amounts of digestible protein and energy decrease and the relative amount of fiber increases.

The timing of **first harvest** is critical. Delays can reduce the total number of harvests taken during the year. Take the first cutting as soon as it is ready, weather permitting. This is normally at the late bud to first flower stage. It is equally important to remove the first harvest as soon as possible to allow for irrigation and regrowth. Cutting for greenchop

or haylage in wet springs can be good insurance against delayed schedules.

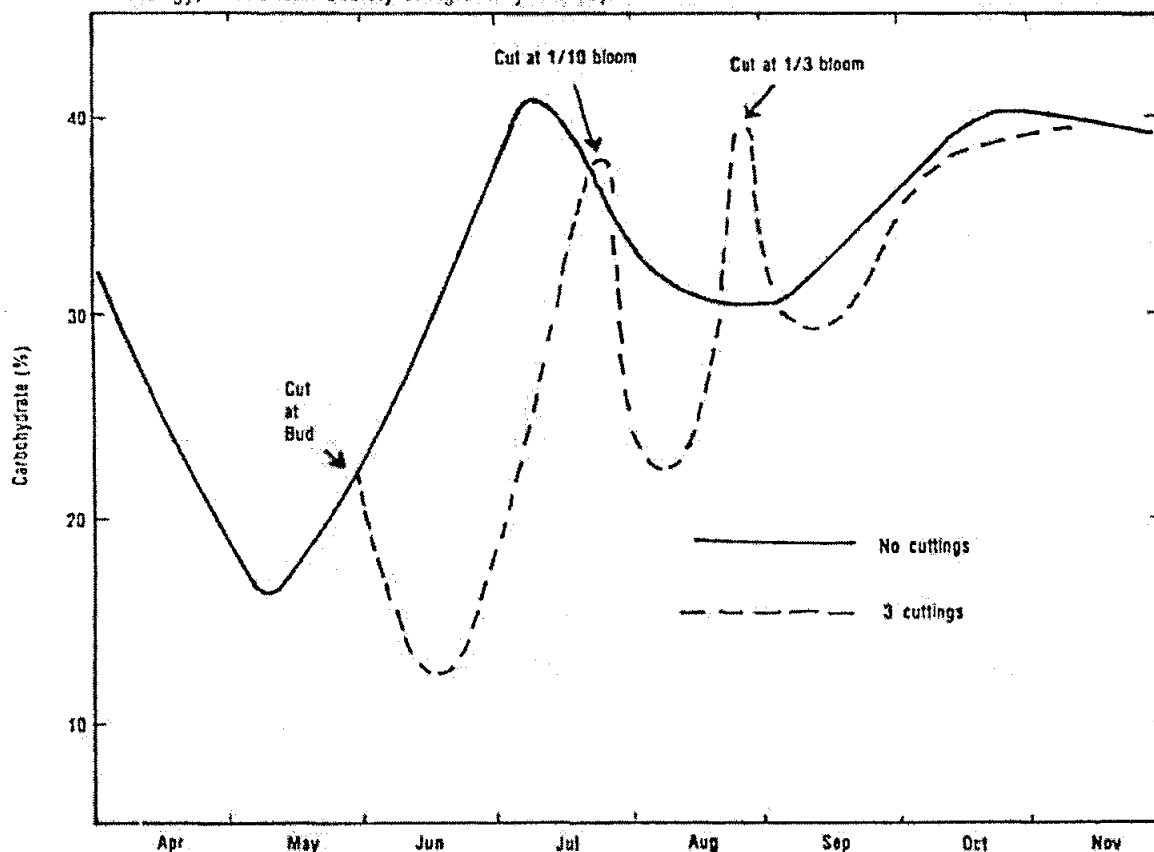
Circumstances that can affect spring schedules are

| Condition                | Time the harvest:        |
|--------------------------|--------------------------|
| Normal spring            | Late bud to first flower |
| Killing frost            | Immediately              |
| Heavy insect infestation | Early                    |
| Drought                  | Early                    |
| Winter injured stand     | Delay                    |

**Killing frosts** in the spring can prevent further growth of alfalfa plants and cause leaf drop. Immediate harvesting can salvage some to nearly all of the first cutting; however, removing the top growth may not hasten regrowth.

Fields with **heavy insect infestations** may require insecticide. With alfalfa weevils, early harvest can minimize insect damage, eliminate the

Fig 3. Seasonal trends of alfalfa root carbohydrates. (After Dale Smith in "Alfalfa Science and Technology," American Society of Agronomy No. 15).



need for spraying, and often prevent severe reinfestations later in the season.

**Spring drought** conditions periodically occur even with irrigation. By the time drought is evident (blue-green color of foliage), additional growth may only be possible from new shoots. For this reason, it is generally best to harvest drought stricken fields early and irrigate as soon as possible for the second cutting.

**Winter injured stands** may have root or crown damage, as well as reduced levels of stored carbohydrates. Such stands often are slow to make major growth in the spring. Delayed cutting can result in better stand maintenance and production through healthier roots and improved levels of stored nutrients.

In some cases, especially after first harvest, flowering is erratic. In such cases, development of **basal shoots** indicates when root reserves are adequate to maintain vigor and production.

When basal shoots are present, yield and quality components are also at a high level. A satisfactory harvesting guideline is to have 3/4-inch basal

shoots on about 60% of the plants. Mow before basal shoots are tall enough to be cut off, or subsequent harvest will be delayed.

In terms of stand maintenance and productivity, fall management is more critical than management at any other time during the growing season.

It is difficult to predict when the first killing frost will prevent further growth. Plants need 6-10 inches of green growth before frost to store adequate carbohydrates for overwintering and vigorous spring growth. It is for this reason that recommendations for dryland alfalfa are to harvest before mid-September. The last cutting date for irrigated alfalfa, however, can come in late September in many years in much of the state without serious consequences. The good winter soil moisture provided by irrigation will protect roots and crowns from winter injury.

Heavy fall grazing of alfalfa stands can be as detrimental as late cuttings. Fall grazing, if necessary, should be delayed until the plants are completely dormant and the soil firm enough so that trampling does not cause root compaction and crown damage. At least 6 inches of

stubble should be left to provide snow catch for insulation.

There is an obvious relationship between the **number of harvests**, alfalfa yields, and quality.

If cuttings are too frequent, root carbohydrates will be depleted, yields will suffer even though more harvests are made, and stands may be thinned.

In a 1974 irrigated trial at Redfield, harvesting at full bloom produced the highest yield (Table 11).

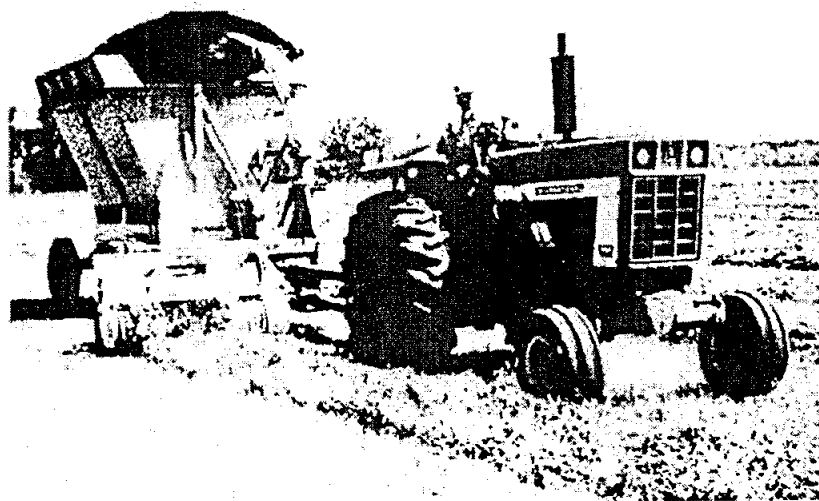
However, full bloom harvests cannot be expected to produce the most digestible protein or total digestible nutrients (TDN). Based on standard values and the Redfield data, crude protein and TDN yields do not increase with delayed harvest dates. The increase in hay yields is due largely to the increase in fiber and cellulose. Actual quality of the hay decreases with maturity even though TDN and protein yields remain rather constant.

In a Wisconsin report (Fig 4) protein yield did not increase after 1/10 bloom while cellulose (a fiber component) increased, thereby greatly decreasing the nutritive value of the alfalfa. Losses result when lower and older leaves drop. Hay yields may increase to the green pod stage, due mostly to increases in fiber which in turn decreases digestibility of the quality components.

The best compromise between quality and quantity is near the first flower or 1/10 bloom stage.

**Delayed harvests set back livestock performance.**

Digestible dry matter yield increases from vegetative stages to full bloom, but the digestible percentage decreases with maturity. In an Indiana study, cows fed early cut hay consumed 15 lb of digestible dry matter compared to 8 lb for late cut hay. Lowered voluntary intake with more mature hay is believed to have a greater effect on animal performance than does digestibility.



In wet springs, cutting for haylage or greenchop shortens the curing time (Table 8) and helps to

bring the field back onto optimum cutting and irrigation schedules.

Table 11. Yields and quality of alfalfa harvested at different stages of maturity at Redfield.

| Harvest stage | Cutting dates |        |         |         | Yields |     |      |     |     |
|---------------|---------------|--------|---------|---------|--------|-----|------|-----|-----|
|               | 1st           | 2nd    | 3rd     | 4th     | Hay    | CP* | TON* | CF* |     |
| Bud           | June 3        | Jul 3  | Jul 24  | Aug 28  | 5.6    | 1.1 | 3.5  | T/A | 1.6 |
| 1/10 bloom    | June 14       | Jul 9  | Aug 5   | Sept 20 | 6.2    | 1.1 | 3.6  |     | 1.9 |
| Full bloom    | June 21       | Jul 11 | Sept 20 | —       | 6.4    | 1.0 | 3.6  |     | 2.1 |

\*Values are estimates based on National Research Council figures. Headings are crude protein, total digestible nutrients, and crude fiber.

Lambs were fed first cut alfalfa-bromegrass hay in a Wisconsin trial. Alfalfa maturity stages were vegetative, first flower, full bloom, and green seed pod; and the lambs gained less on the more mature hay. From the least to most mature hay, daily lamb gains in pounds were 0.38, 0.21, 0.15, and 0.05.

In other Wisconsin research, harvesting three or four times a season at early bloom was compared to harvesting twice at full bloom. The more frequent harvests increased hay yields by 15-25%, total digestible nutrient

yields by 30-40%, and crude protein yields by 45-60%.

Harvest schedules that are based on plant development rather than calendar date are preferable because of differences between years, locations, and varieties. Calendar date harvest schedules may reduce hay quality and quantity and may damage stands.

First harvest alfalfa loses quality with maturity much more rapidly than do later cuttings. Because of this and because delayed harvests in the spring

can result in cancellation of later cuttings, it is important to take the first cutting at an early stage of plant development.

Variations in management that are forced by delays are shown in Table 12. The most common reason for delay is winter injury, in which case delayed cuttings may aid in stand recovery. Later harvests should be based on plant readiness.

As a practical matter, it is important to remember which fields were cut last or most frequently during the year. In the following year, it is best if those fields can be harvested last in spring and/or less frequently.

## Harvest Losses

The method of harvest can influence scheduling, yields, and quality. The way the harvested alfalfa will be used obviously dictates the harvest method. There is variation within methods that is important in both yield and quality.

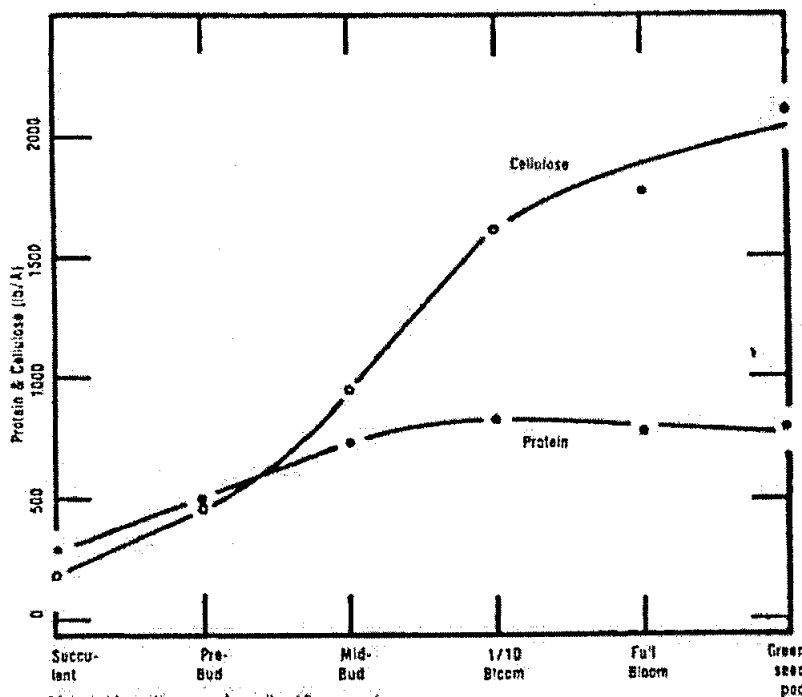
Three harvest methods were compared in eastern South Dakota (Table 13). Green chop alfalfa was considered to have no loss (100% yield). Haylage and baled hay produced satisfactory results in most cases, but weather caused considerable variation for the baled hay. In one case, two rain showers required two hay rakings, reducing yields to 54%. When baled during a dry afternoon, hay yield was 77%, compared to 90% when baled in the evening.

Leaf losses were primarily responsible for decreases, occurring principally when tissue levels were below 20% moisture.

## Profitability

Alfalfa is one of the best adapted feed crops for irrigated land in South Dakota. It can be highly profitable, depending on the management and financial

Fig 4. Yield per acre of protein and fiber for Vernal alfalfa at various stages of growth.\*



\*Adapted from Wisconsin Agricultural Experiment Station Research Report, R 1741, December 1977



Table 12. Common optimum harvest schedule alternatives as influenced by weather variations.

| South Dakota region | Condition                            | First   | Second                     | Third          | Fourth                                |
|---------------------|--------------------------------------|---------|----------------------------|----------------|---------------------------------------|
| Northern            | Normal spring, no winter injury      | Bud*    | Late bloom**               | By Sept. 1     | —                                     |
| Southern            | Normal spring, no winter injury      | Bud*    | Early bloom                | Full bloom**   | By Sept. 20                           |
| Northern            | Normal spring, winter injury evident | Full*** | Full*<br>Mid to full bloom | By Sept. 1**** | By Sept. 20****<br>or late fall graze |
| Southern            | Normal spring, winter injury evident | Full*** | Full*<br>Mid to full bloom | Early bloom    | By Sept. 20****<br>or late fall graze |

\* In healthy stands, early, high quality harvests set the stage for full production and good stand maintenance.  
 \*\* In healthy stands, full or late bloom harvest in the next to last cutting will help assure high levels of carbohydrates at the critical last harvest.  
 \*\*\* Delayed harvests will help recovery of wintered injured stands.  
 \*\*\*\* Final harvests may be less productive than normal, or they might be eliminated entirely.

Table 13. Yield and quality as influenced by harvest methods in an eastern South Dakota trial.\*

| Harvest method | Yield | Leaves | Gross Protein |
|----------------|-------|--------|---------------|
| Green-chop     | 100   | 58     | 20            |
| Haylage        | 95    | 55-57  | 19            |
| Baled (small)  | 54-90 | 44     | 18            |

\*From research by the SDSU Dairy Science Department.

commitments of operators.

Data in Figure 5 were derived from a research project on Class I and II land in Butte County. In calculating costs and returns, consideration was given to variable field costs and fixed production costs. Costs for management and interest on investment have been included.

In going from 5 to 7 T/A (the normal range of production) costs increase primarily due to increased fertilizer and labor.\* As long as returns from increased yields exceed additional production costs, more intensive management will give a greater return. At 5 T/A, \$30 alfalfa would barely break even; at 7 T, nearly \$50/acre is returned above expenses.

Another index of profitability is a comparison of other crops at comparable yield levels. In Butte County trials with a given yield and 1977 cost structure, alfalfa can be competitive with corn

(Table 14). Comparative production costs between alfalfa and corn would not be expected to get narrower—if anything, corn production costs will become relatively higher as nitrogen costs increase. This being the case, the only thing that would prevent alfalfa from being competitive with corn would be a failing price for alfalfa while corn prices hold, or a relatively high price of corn.

For additional information on comparative alfalfa and corn

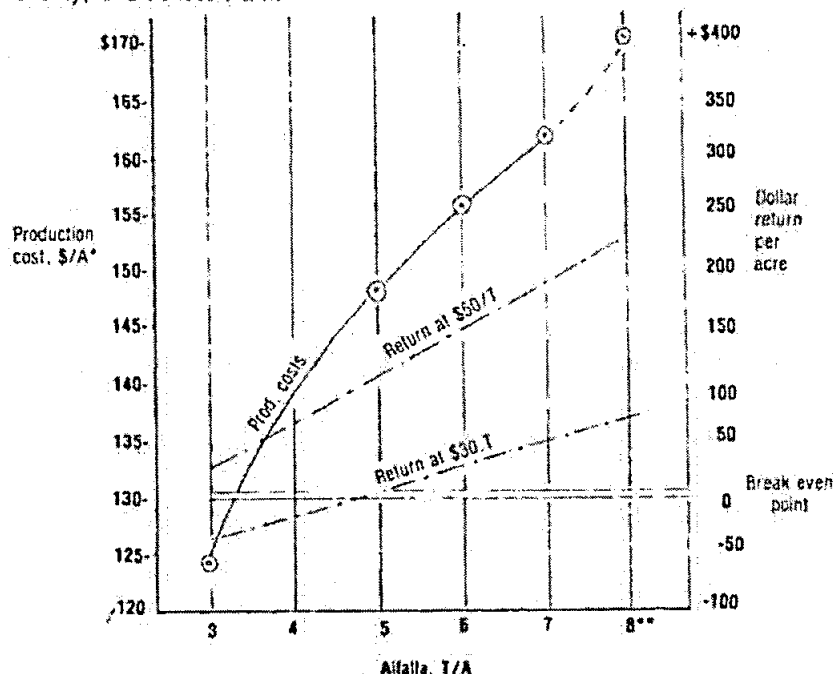
production economics see EC 722, Alfalfa: an economic alternative to corn? and FS 755, Irrigated crop production costs: Big Sioux and Vermillion river basins.

## Other Publications

For additional information on alfalfa management, consult the following South Dakota Cooperative Extension Service publications:

- EC 731, Alfalfa seed production
- EC 772, Alfalfa: an economic alternative to corn?
- FS 276, Alfalfa weevil
- FS 302, Grazing management based on how grasses grow
- FS 422 (rev), Interseeding and modified renovation
- FS 425 (rev), Fertilizing pasture and hayland
- FS 426, Chemical weed control in pasture, range and hayland
- FS 503 (rev), Planting tame pastures and hayland
- FS 528 (rev), Alfalfa management on dryland
- FS 529 (rev), Alfalfa varieties for South Dakota
- FS 601, Pre-inoculation and field inoculation
- FS 602, For timely irrigation: tensiometers
- FS 755, Irrigated crop production costs: Big Sioux and Vermillion river basins

Fig 5. Estimated costs and returns from irrigated alfalfa trials (1974-77) Butte County, land classes I & II.



\*Water costs were held constant, because water charges in Butte County are based on land capability rather than amount of water used.

\*Includes annual  $P_2O_5$  @ 17 c/lb with 0, 60, 90, 120, and 150 lbs used for yields of 3, 5, 6, 7 and 8 T respectively.

\*\*Consistent production of 8 T/A is not likely for most sections of South Dakota.

Table 14. Estimated returns per acre over production costs for Class I and II irrigated land in Butte County.\*

| Price/l  | Total production cost | Return after cost | Total production cost | Return after cost |
|----------|-----------------------|-------------------|-----------------------|-------------------|
|          | 51                    | Alfalfa hay       | 77                    |                   |
| \$65     | \$147                 | \$178             | \$163                 | \$292             |
| 55       | 147                   | 128               | 163                   | 222               |
| 45       | 147                   | 78                | 163                   | 152               |
| 35       | 147                   | 28                | 163                   | 82                |
| Price/bu | Shelled corn          |                   |                       |                   |
|          | 100 bu                |                   | 138 bu                |                   |
| \$2.80   | \$160                 | \$120             | \$174                 | \$190             |
| 2.50     | 160                   | 90                | 174                   | 151               |
| 2.10     | 160                   | 50                | 174                   | 99                |
| 1.80     | 160                   | 20                | 174                   | 60                |

\*51 alfalfa vs. 100 bu corn and 77 vs. 138 bu require similar management intensities. Primary production cost variables are fertilizer and labor. Assumed 90 lb/A and 120 lb of P<sub>2</sub>O<sub>5</sub> for 51 and 77 alfalfa respectively. Assumed 125-60-0 for A and 175-80-0 for 100 bu corn yields. Nitrogen calculated at 204/lb and P<sub>2</sub>O<sub>5</sub> at 17g.

B 544 (rev), Alfalfa leafcutting bee  
PS 47, Alfalfa performance trials 1972-78  
(for most recent Plant Science report)

### Acknowledgment

At the time of preparation of the manuscript, the authors were research agronomist with the SDSU West River Agricultural Research and Extension Center in Rapid City, head of the Plant Science Department, Extension agronomist, irrigation specialist, and professor—soils, all with SDSU. Johnson is presently SDSU range management specialist; Krueger is assistant director, Ohio Agricultural Research and Development Center, Wooster, Ohio. 44691.

Grateful acknowledgment is extended to all persons who contributed to the research information contained in this circular. Much of the information was collected from the Butte County irrigated alfalfa project which was supported by local contributions, by the SDSU Agricultural Experiment Station, and by the Farmers Union Central Exchange Foundation. Local committee members were Mel Pittman, Norm Fenton, Gerald Keil, P.J. Cook, Harvey Knuteson, Pete Johnson, and Leo Langley.

Farmer cooperators were the Fenton Farms, Mel Pittman, Ted Cook, Don Keil, Oliver Gerkin, Dick Espenscheid, and Dave Winkler. Those Extension Service and Experiment Station personnel who helped in design, collection, and analyses of field plot data were Harry Geise, Mel Rumbaugh, Vern Mosely, Ron Steg, Dave Howlett, Arnold Bateman, Tim Larson, Richard Butterfield, and Clair Stymiest.

Agricultural Experiment Station data also came from the Brookings agricultural

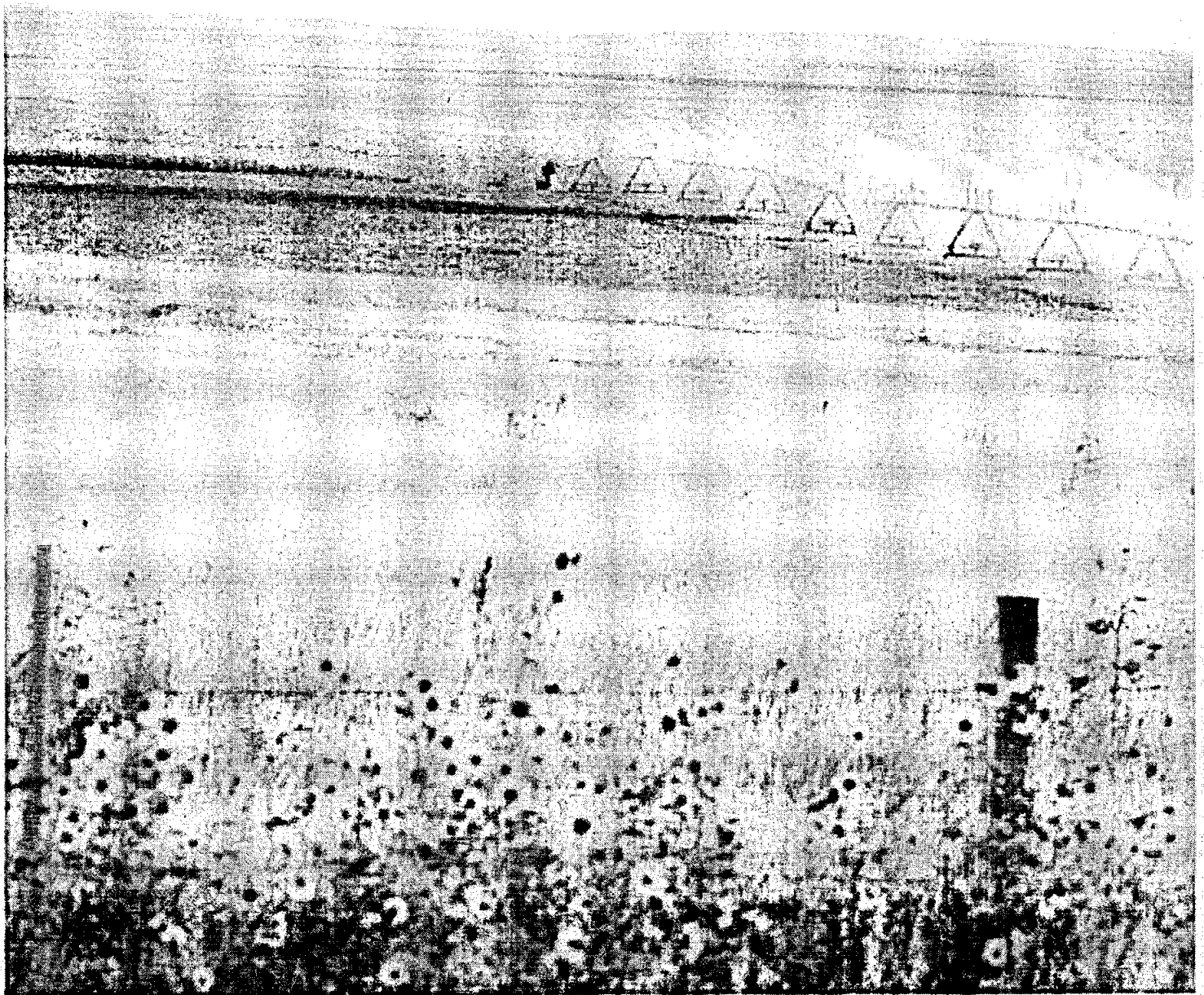
engineering research farm and the Redfield irrigation substation. Personnel involved included Thomas Klosterman, Joe Giles, Ray Ward, and Lloyd Hanson.

Manuscript reviewers not otherwise credited were Jim Ross, Ron Gelderman, Earl Adams, and Ed Williamson.

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### **3. An Efficient Irrigation Technology for Alfalfa Growers**



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## An Efficient Irrigation Technology for Alfalfa Growers

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### Background

Alfalfa (*Medicago sativa* L) acreage has been rising steadily in 13 western states of the U.S. The states with an increase are Arizona, Colorado, Idaho, Indiana, Kansas, Montana, Nevada, New Mexico, North and South Dakota, Texas, Utah, and Wyoming. More than a million acres have been added during the last decade (National Agriculture Statistics Service, USDA). Production agriculture in the arid western states predominantly depends on irrigation.

Alfalfa is a high water use crop. The consumptive use can exceed 46 inches. Most of this amount needs to be supplemented by irrigation, and an irrigation diversion of 30 to 36 inches is quite common. These western states depend on

both surface water diversions and groundwater from wells. Agriculture is by far the biggest water user at this time. Competition for limited water resources is increasing for other uses such as industry, municipality, recreation, aquatic and wildlife habitat maintenance, etc.

The states depending on groundwater aquifers such as the Ogallala are experiencing declines in the water table. The cost of pumping is also going up due to rising energy costs. Thus, the efficient use of available water is necessary to produce a high water use crop such as alfalfa.

Techniques like surge irrigation and sprinklers have improved efficiency and conserved water. Producers are constantly looking for new technology to improve irrigation efficiency and reduce operating costs. Drip irrigation for arid climates has reduced water loss from evaporation, run-off, and deep percolation.

Drip irrigation has proven to be most effective for high dollar cash crops like fruits and vegetables. In Kansas, subsurface drip irrigation (SDI) has been shown to be a feasible technology for the irrigation of field crops like corn (Lamm, Manges, Stone, Khan, & Rogers, 1995). Economic studies for irrigated corn have shown that SDI is economically competitive to flood and center pivot irrigation systems for small fields and potentially competitive for larger fields (O'Brien, Rogers, Lamm, & Clark, 1998).

Subsurface drip irrigation is a viable alternative irrigation technology that offers the potential to reduce the amount of water used to irrigate alfalfa. Given the increased interest in alfalfa as a feed crop, research on SDI could provide needed information for irrigated alfalfa producers in the western United States. However, little information on the use of SDI for alfalfa is available in the scientific literature.

A previous study in California has shown increased alfalfa yield due to the use of SDI when compared to furrow irrigation (Hutmacher et al., 1992). One aspect of yield improvement is that the scalding of alfalfa leaves that can happen under sprinkler irrigation is reduced (Henggeler, 1995).

The critical stage to meet the water needs of alfalfa is after harvest when the crop starts regrowth. SDI allows irrigation to continue during or right after harvest to encourage quick regrowth. There is no need to suspend irrigation for a soil dry down period before harvest or while the hay is curing, since the water is applied below the soil surface.

The lack of surface wetting eliminates evaporation loss and helps reduce the competition from annual weeds that may germinate with surface wetting from sprinkler irrigation. The scope of losses due to deep percolation and surface evaporation is greatly reduced in SDI. Research from Kansas State University indicates that it is possible to save 25 percent of total water diverted in a season by using SDI in corn (Lamm et al., 1995).

### Objectives



The objectives of the study reported here were to:

- Demonstrate SDI for alfalfa in a cooperators field,
- Measure alfalfa dry matter yields for SDI drip tape spacings and depths,
- Compare yields of SDI to a nearby sprinkler-irrigated field, and
- Measure soil water content to observe the spread of water.

### Materials and Methods

The SDI system was installed in the corner of a center pivot sprinkler irrigated cornfield. The site is located south of Garden City, Kansas, south of the Arkansas River valley. The soil belongs to the Otero-Ulysses complex and has undulating slopes. The soil texture is sandy loam. The field had been previously leveled for flood irrigation.

Drip tapes were plowed in using a deep shank ripper equipped with a tube guide in September 1998. The largest expense for an SDI system is the drip tape. The closer the spacing of the drip tapes, the more drip tapes are needed to irrigate a given area and thus the greater the cost for the system. The treatments were spacing and the depth of placement of drip tapes as follows:

- 60 inches spacing by 18 inches depth,
- 60 inches spacing by 12 inches depth,
- 40 inches spacing by 18 inches depth,
- 40 inches spacing by 12 inches depth,
- 30 inches spacing by 18 inches depth, and
- A nearby center pivot irrigated field that served as control.

Nelson drip tape of 7/8-inch diameter and 24-inch emitter spacing was installed. The emitter flow rate is 0.372 gallons  $\text{hr}^{-1}$  per emitter at 8 psi. A 200-mesh disk filter system provided by Rain Bird was installed to meet filtration requirements. Fluidyne vortex flow meters operated by 12-volt DC batteries were installed along with a solar panel for continuous recharging.

Alfalfa was seeded using 6-inch row spacing in the fall of 1998. Yield data was collected in 1999 and 2000. Four harvest samples were collected from each of the six treatment plots to obtain dry matter yield. An area of 11  $\text{ft}^2$  was harvested as a sample. The harvest samples were hand clipped during the growing season. The harvest area was randomly selected across the block.

Gypsum block soil water sensors were installed at the midpoint between two laterals to monitor the spread of water. The depth of placement was at 12, 24, and 36 inches below the soil surface. The soil water readings provided insight as to the distance of water movement away from the drip tape.

### Results

The climate differed between 1999 and 2000. The first year of study started with a cool, wet spring, whereas the second year was hot and dry. The irrigation

period was prolonged in 2000, and the numbers of harvest operations were five, compared to four in 1999. The results on water use and yields are presented separately by year.

### 1999

The total water budget from July 1 through September 29, 1999 was:

- Irrigation by
  - SDI: 13.50 inches (average 0.15 inches/day)
  - Sprinkler: 19.80 inches (average 0.22 inches/day)
- Rainfall: 6 inches
- Estimated modified Penman ET: 20.70 inches (average 0.23 inches/day)

Dry matter yields for 1999 are presented in Table 1. The results are non-replicated samples and therefore cannot be statistically compared.

**Table 1.**  
Alfalfa Yields of SDI and Sprinkler Irrigated Plots

| Date of Harvest and Dry Matter Yield, ton ac. <sup>-1</sup> |         |         |         |          |       |          |
|-------------------------------------------------------------|---------|---------|---------|----------|-------|----------|
| Treatment                                                   | 6-22-99 | 7-23-99 | 8-27-99 | 10-01-99 | Total | Total B* |
| 60 inch spacing (S) by 18 inch depth (D)                    | 1.90    | 0.62    | 1.14    | 0.94     | 4.60  | 2.08     |
| 60" (S) by 12" (D)                                          | 1.51    | 0.92    | 1.36    | 0.94     | 4.73  | 2.30     |
| 40" (S) by 18" (D)                                          | 1.65    | 1.06    | 1.20    | 1.25     | 5.16  | 2.45     |
| 40" (S) by 12" (D)                                          | 1.73    | 1.04    | 1.25    | 1.03     | 5.05  | 2.28     |
| 30" (S) by 18" (D)                                          | 1.48    | 1.00    | 0.86    | 1.12     | 4.46  | 1.98     |
| Sprinkler (Center Pivot)                                    | ---     | ---     | 1.03    | 0.75     | ---   | 1.78     |
| *Total B--Total for last two harvests.                      |         |         |         |          |       |          |

The first two harvests for center pivot are not included, because of weed pressure during the initial harvest. Comparisons of corresponding total yields for the last two cuttings indicate a lower yield for sprinkler-irrigated alfalfa. The 40-inch drip tape spacing treatment with 18-inch depth of placement had the highest total yield at 5.16 ton ac.<sup>-1</sup>.

### 2000

The total water budget from May 10, 2000 through September 21, 2000 was:

- Irrigation by
  - SDI: 21.5 inches (average 0.16 inches/day)
  - Sprinkler: 25 inches (average 0.19 inches/day)
- Rainfall: 5.51 inches
- Estimated modified Penman ET: 41.76 inches (average 0.31 inches/day)

Dry matter yields of individual harvests within the 2000 season, including those from the sprinkler-irrigated center pivot field, are presented in Table 2. The 40-inch spacing treatment at 12-inch depth of placement had the highest total yield for the season at a little over 9 ton ac.<sup>-1</sup>. The center pivot sprinkler treatment yield was slightly lower than the 40-inch spacing treatments, but slightly higher than the 60-inch spacing treatments. Drip tape spacing of 30 inches showed no yield advantage over 40-inch spacing.

**Table 2.**  
Dry Matter Yield of SDI and Sprinkler Irrigated Alfalfa for 2000

| Date of Harvest and Dry Matter Yield, ton ac. <sup>-1</sup> |         |         |         |         |         |       |
|-------------------------------------------------------------|---------|---------|---------|---------|---------|-------|
| Treatment                                                   | 5-22-00 | 6-23-00 | 7-28-00 | 8-25-00 | 9-26-00 | Total |
| 60 inches spacing (S) by 18 inches depth (D)                | 2.34    | 1.57    | 1.83    | 1.14    | 1.10    | 7.98  |
| 60" (S) x 12" (D)                                           | 2.18    | 1.45    | 1.42    | 1.13    | 1.00    | 7.18  |
| 40" (S) x 18" (D)                                           | 2.40    | 1.90    | 1.74    | 1.40    | 1.21    | 8.65  |
| 40" (S) x 12" (D)                                           | 2.61    | 1.63    | 2.05    | 1.38    | 1.35    | 9.02  |
| 30" (S) x 18" (D)                                           | 2.70    | 1.61    | 1.58    | 1.30    | 1.27    | 8.46  |
| Sprinkler (Center Pivot)                                    | 1.63    | 1.99    | 1.92    | 1.58    | 1.26    | 8.38  |

**Figure 1.**  
Dry Matter Yield as Affected by Drip Tape Spacing

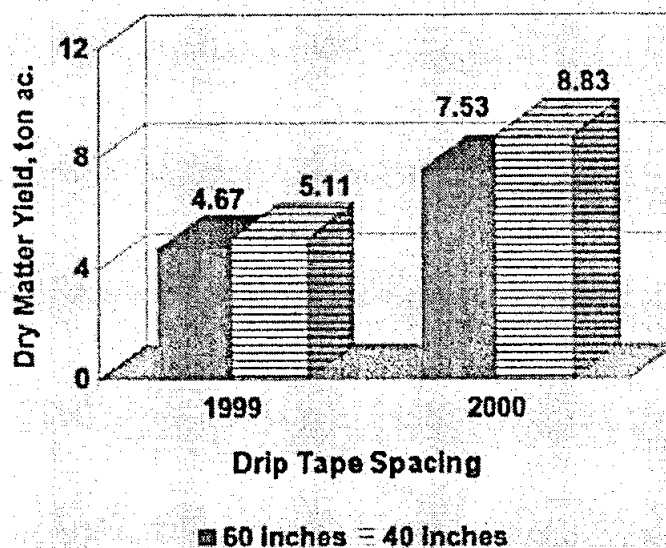
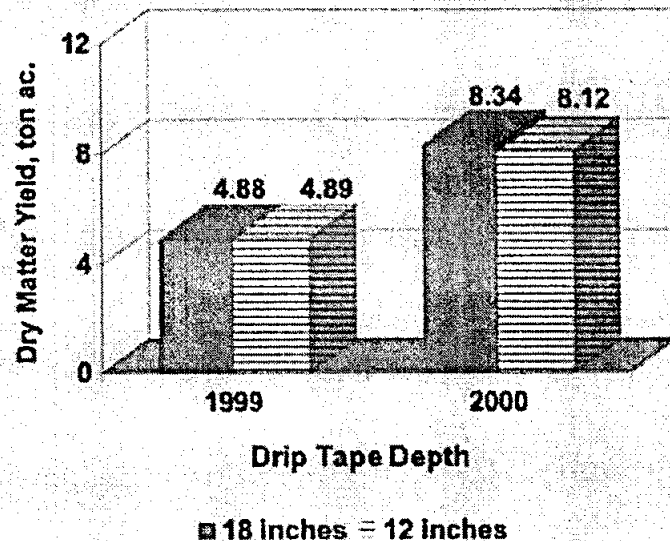


Figure 1 shows that, compared to the 60-inch spacing, the 40-inch drip tape spacing had a yield advantage of 0.44 and 1.25 tons ac.<sup>-1</sup> for 1999 and 2000, respectively. The difference is perhaps due to having a cool and wet spring in 1999, but a hot and dry spring and summer in 2000. This indicates that the closer spacing would be more beneficial in dry years.

Hay quality tests were done for random samples taken from each block, and the analysis was done in an independent laboratory certified annually by the National Hay Testing Association. The average RFV for 40-inch spacing was 164 (good dairy quality hay), compared to 134 (dairy quality hay) for 60-inch spacing. The RFV value for center pivot irrigated field was also 134. Although the samples were obtained randomly, the irrigation trial was on blocks and non-replicated, and as such the results were not statistically compared.

**Figure 2.**  
Dry Matter Yield as Affected by Depth of Drip Tape Placement



The yields from two different depth of placement of the drip tapes showed similar dry matter yields for both the years (Figure 2). Thus, the depth of placement had a little effect on yield.

Gypsum block meter readings for the 60-inch spacing and 18-inch depth treatment in 1999 are presented in Figure 3. The gypsum blocks were buried at 12, 24, and 36 inches in the root-zone located at the midpoint between the drip tapes. A reading of 99 to 95 indicates that the soil water status is between 85-100 percent of availability. A reading of 60 indicates that available soil water has fallen below 50 percent and requires replenishment.

It is evident from the data presented that the water level at the midpoint between two drip tapes for the 60-inch spacing treatment remained below optimum growing condition. The yield was lower, and "striping" appearance was visible.

**Figure 3.**  
Gypsum Block Readings at the Midpoint for Drip Tape at 60-inch Spacing

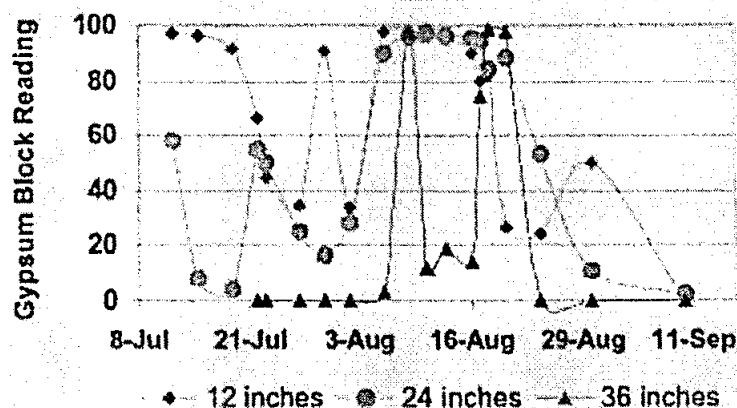
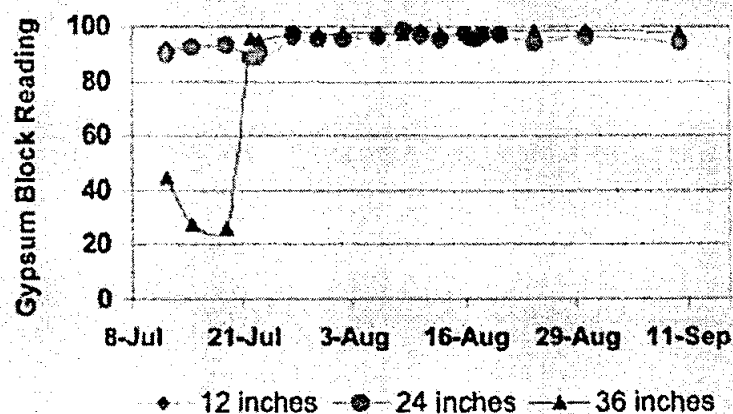


Figure 4.  
Gypsum Block Readings at the Midpoint for Drip Tape at 40-inch Spacing



Drip tape spacing of 40 inches placed at 12-inch depth provided a better water distribution for soils at 1- and 2-feet depths from the beginning of the season, and improved for soils at a 3-foot depth within a short period (Figure 4). Irrigation application amount was maintained at the same level for all treatments. A similar pattern of water distribution was observed in 2000 (data not presented due to space limitations).

### Economic Implications

A net present value (NPV) analysis was completed to determine which SDI spacing was the best investment alternative for alfalfa, taking into account that SDI was economical to start with (O'Brien, et al., 1998). The major difference between the 40-inch and 60-inch drip tape spacing is the additional cost for closer spacing. Compared to the 60-inch spacing, the total length of drip tape required for the 40-inch spacing is increased by 4,356 ft per acre. The number of fittings required also increased. Consequently, the cost of the 40-inch spacing at \$1,037 per acre is about \$250 per acre more than the 60-inch spacing. However, yields were 0.44 to 1.25 ton ac<sup>-1</sup> higher for the 40-inch spacing, and the relative feed value (RFV) was 30 points higher.

Given the higher cost of the 40-inch spacing, the NPV analysis indicates that the

40-inch spacing would need to yield about  $0.75 \text{ tons ac}^{-1}$  higher than 60-inch spacing in order to have an equal NPV. This assumes a 15-year useful life and an alfalfa price of  $\$70 \text{ ton}^{-1}$ . As the length of useful life and (or) alfalfa price increases, the additional yield needed for the 40-inch spacing to equal the NPV of the 60-inch spacing decreases.

It is expected that an SDI system will last for 20 years under good management. The SDI systems installed at the Kansas State University Southwest and Northwest Research-Extension Centers are 11 years old and functioning without any symptom of plugging or deterioration (Lamm and Trooien, 1999).

Kansas county Extension agents used the field on which the research was conducted for educational tours, and as a result producers of four counties are now using SDI for alfalfa. This trial helped meet a need that was unavailable from traditional research. Research on alfalfa irrigation in a replicated random design demands resources in terms of land, equipment, labor, and funding. This trial has shown that Extension professionals may fill in with the help of innovative and cooperative producers.

### Summary

Alfalfa emergence was affected adversely at the 60-inch spacing for this site with sandy loam soil. Some uneven emergence or "striping" was observed in the first year during the establishment period. Yields were reduced slightly for the drip tape spacing of 60 inch. Yields for 40-inch spacing treatment remained consistently higher. The spacing of 30 inches did not show any additional advantage over a spacing of 40 inches. Depth of placement of drip tapes did not affect the yields; they were similar for depths of 12 inch and 18 inch. The second year observations showed similar results, although increasing the frequency of irrigation in SDI treatment reduced the striping appearance.

### Acknowledgments

We thank the landowner, Steve Stone, for providing the land on which the research was conducted and covering most of the installation cost. Partial funding assistance was received from the Southwest Kansas Groundwater Management District No. 3, and material assistance from Gigot, Nelson, Rain Bird, and Western irrigation companies. This paper is a contribution from the Kansas State University, Research and Extension, No. 01-355-J.

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**4. Harney Peak Ranch Photos  
January 2006**



**Borders near Jolly Lane**



**Borders at 50 feet**



**Jolly Lane – 18" Irrigation**



**Alfalfa Valve**





**Hydrants**



**West Reservoir**



**West Reservoir**



**Murphy Intake at Jolly Lane**





**Murphy at Jolly Lane**



**Murphy Ditch**



**Northeast Pump Station**



**Intake Screen**





**Northeast Pump and Intakes**



**Irrigation Pump**



**Piping**



**Big Gun**





**Irrigation Hose**



**Central Reservoirs**



**Central Reservoirs**



**Central Reservoirs**





**Big Gun**



**Big Gun**



**Irrigation Piping**



**Dam between Reservoirs**





**Reservoirs**



**Small Irrigation Ditch**



**Central Valves and Borders**



**50 foot Borders**





**Valves**



**Borders East**



**Borders Central**



**Valves**





**Valves / Hydrants**



**Pipe at Reservoir**



**Pipe at Reservoir**



**Pipe at Reservoir**



**Central Reservoir**



A vertical dashed line consisting of short black rectangular segments spaced evenly along the left margin of the page.

## **5. David S. Lamb Overview Summary of 1878 Water Rights Transfer**

-----Original Message-----

**From:** David S. Lamb [<mailto:info@harneypeak.com>]

**Sent:** Tuesday, November 15, 2005 11:27 AM

**To:** Armbruster, Edward

**Subject:** Draft Overview Summary: RVWCo, Inc. 1878 transfer issues/proofs

Dear Mr. Armbruster,

I will attempt to list and annotate the issues and deficits that may interfere with the most accurate water transfer under the SD DENR procedures. The key issue is not, necessarily, the procedure, which I am not expert enough to comment upon, in any event.

Many of the crucial problems follow from shortcomings or errors in the past procedures. There has just not been anyone from the state there to document many things and there are some problems from apparent lapses and errors in documentation. A prime example is the errors in the Harney Peak Ranch irrigated lands listings that you discovered.

I will be trying to identify these issues separately in a quick form to give you my impressions of what needs to be corrected and how useful that may be. Most would require the SD DENR to correct past errors or deficits, which is another issue of analysis: Will they do so? This factor is undoubtedly the largest overarching issue in correcting past shortfalls.

**Diversion Records:** From 1876, diversions in Rapid Valley have occurred with very little actual consistent or accurate recording. Mr. Steve Murphy tells me that he used to file an annual report of the acres irrigated, but probably no quantity component. He is not required, evidently, to do this anymore. Individual water rights holders, however, are. His reports stated that all lands were irrigated. What reports of diversions are available and how detailed? There should not be much detail in early reports, especially if detailed accounting of times checked and how measured is included. There was not much of a measurement structure when I started

12/9/2005

helping..

The diversion points were, originally, quite naturally, in descending order of priority. Prior to having stored water available, a shortage of water would simply mean that the lower priority users would not receive any water. In prospect, no records needed nor kept.

After construction of Pactola Reservoir, there was still no need to keep much track until water became short and "bought" water needed to be accounted for. I believe that there was no formal weir structure on the Murphy ditch until I helped install one about 20 years ago. Water was probably just measured informally at a flood bypass about a half mile below the diversion point.

This was necessary because the Murphy diversion point is very exposed to seepage, runoff and flooding. It is an actual river channel which probably just ran from the diversion and the excess was diverted back to Rapid Creek at the first flood diversion bypass, where informal measurement originally took place. However, during high flows, water will run back into this canal and into the canal, overriding any estimated measurement. This still occurs, and more so, because the measurement point is above this structure.

**Proof:** It is difficult to prove a negative, except by the evidence of these facts. However, the proof available might be the details of the diversion measurement records, or lack thereof. Murphy ditch also has a longer irrigation season than the Conservancy District and no one from the regulatory system, typically, bothered to measure anything early and late, before and after the summer haying season. Lower down the valley, few irrigated early or late: swampy, sub-irrigated ground eliminated the need. We have always had to supplement, however. This is the keystone deficit in the transfer system, of course. **Harney Peak Ranch 1878 irrigated lands are not fully listed and recorded:** This is, given the obvious "holes" created by incomplete and incorrect recordings of irrigated lands by the SD DENR, a very obvious deficit that should be correctable. This is such an obvious error, although it was not discovered until your firm analyzed the listings, that it should be correctable and should add to the water usage.

**Proof:** Irrigators submitted maps, not legal descriptions, to the SD DENR and tried to correct earlier errors by this method as well. Since the land omitted would, in many cases, be impossible **not** to irrigate while irrigating the other listed lands, the situation is obvious. Since the SD DENR did the recording, they should, by common sense, be willing to correct the record. Will the SD DENR do so? This I do not know.

I believe that SD DENR may have had early software at the time, based on errors in SD DENR maps of irrigated distributed of irrigated lands here in Rapid Valley. These maps show lands that are not and could not be irrigated, due to graphics or entry errors, presumably. These and the original maps submitted by irrigators would be amongst the proofs, along with topographical analysis of the impossibility of not irrigating much of the lands left out.

**Water Reuse System 15% Substantiation:** The storage dams for the reuse system are located in an old channel of Rapid Creek and, unavoidably, intercept most water used to irrigate Harney Peak Ranch. The 1878 water right areas north of Rapid Creek do return water to the channel, except when they flow into the Little Giant Ditch at some points.

**Proof:** The location and capacity of the approximately six storage dams for water reuse would be one key proof. The inventory of pumped irrigation equipment used for irrigation in general, but which is particularly appropriate for reuse water distribution, fulfils, in part the SD DENR request for a description of this system.

The pumps, pipelines, towlines and big guns we acquired over the last few decades were not so prevalent in the past. As the largest water user, Warren-Lamb Lumber Company, Inc. would have had the best equipment for the

times. However, raising the pool in these dams frequently creates sub-irrigation support and there is some evidence of ditches that were been positioned to re-distribute water as well.

The later water right moved from Warren-Lamb Lumber Company, Inc. to the ranch was totally pumped until transfer after the 1972 flood and was diverted substantially by pump and sprinkler directly from Rapid Creek after transfer. In addition to direct runoff, the storage reservoirs have been used as a place to drain flooding on the Murphy Ditch. Our location below the highest Rapid Valley north-side drainage basin and also the earlier-described flood diversion made Harney Peak Ranch the natural place to intercept higher natural/flood flows in the Murphy Ditch.

**Unmeasured water inputs into Murphy Ditch:** There are two more old flood-drainage "waste-ditch" canals lower down that return waters from lower flood drainages and irrigation recharges to Rapid Creek. The interrelationship between the three main water inputs along the ditch and the three corresponding and intercepting "waste" points for excess water, Harney Peak Ranch and the two lower "waste-ditch" diversions are proofs of the water available, mostly below the diversion and later weir point, to the Murphy Ditch and Harney Peak Ranch. "Surges" from sudden, unannounced Rapid City water diversions also impacts the Rapid Valley Water Company, Inc. diversion, by nature of its location, design and topography. It will end to intercept water surges due to its naturally-efficient "creek channel" location and its lower flood diversion gate location that can intake sudden high water.

**Proof:** Our own diversions, used to irrigate, fill the reuse reservoirs and intercept excess water, are by 15" pipelines in modern times. The lower ones beyond us, which do not intercept the unmeasured excess diversions from the head-gate area, are still open ditch. We do have one "full-emergency" point we can use to divert flooding, at Harney Peak Ranch but we have had enough diversion capacity here so that I have never seen it used. In fact, it has no actual ditch.

Precipitation or the unplanned surges from sudden releases mentioned above can All contribute excess inflows but precipitation records or protests to the SDDENR by irrigators might be the only indicator. The converse proof could be an analysis of the SD DENR records system and reports. They should, if available, have no great detail of personnel historically recording levels nor record of any accurate, frequent method of measurement. There was no early need.

**Flood irrigation efficiency calculations:** virtually all 1878 (and most other) irrigation water is delivered through grade-pressurized **15-inch main lines, 12-inch distribution lines or 8-inch high-pressure pumped pipeline systems** designed by the USDA. This water and most other are applied to lands that have been leveled into border systems designed by the USDA or leveled to slope as appropriate by our own equipment.

The 1878-priority irrigation water is applied primarily to leveled or bordered fields laid out by the USDA. The USDA designed approximately **150 acres** of bordered irrigation where appropriate. About **100 acres** of the 1878-watered lands were amenable to leveling to grade and all lands were worked with equipment to improve grade and level. This was the most extensive project of its kind in Rapid Valley.

There was some tiling done early on in the limited areas where it was productive in the times when irrigation was substantially furrow-application to the sugar beet and row crops that predated my working life here. The Rapid Valley Beet Elevator for loading trains from that time period was located adjacent to the Harney Peak Ranch at Murphy Siding.

**Proof:** Extensive row-crop furrow irrigation in earlier times was a form of flood irrigation, but a very intensive form of the technology. During my tenure, as the technology became available, we have added pipelines, **10,000 feet of 4-inch sprinkler towlines, two traveling big guns, 8,6&4-inch aluminum pressure**

**distribution lines, 1500 feet 12-inch surface pipe and several diesel, PTO and also 40 HP electrical pumps (2).**

**Multiple Reuse:** These are used in all irrigated areas, particularly for reuse applications. It should be noted that the water applied through reuse functions is still, until it makes its way downstream from Harney Peak Ranch, may be reused more than once.

**Multiple Re-irrigations:** The latest issue of Farm Journal Magazine, November 2005, Page 34: ConservationNow, discusses the benefits of irrigation cycles that are much faster under piped irrigation than conventional flood. This translates directly into multiple re-irrigation applications where only one application was typical under ditch irrigation.

This ability, also available with intensive row-crop systems and sprinkler/big gun systems, was a key aspect of the improvements developed under USDA plans, of the record results Harney Peak Ranch achieved as the pilot adopter of efficiency technology.

**Multiple Diversion Points:** Harney Peak Ranch, under the informal rotation used by Murphy Ditch, has employed its multiple historic diversion points to facilitate the extra water applications needed under the USDA and South Dakota University Agricultural Extension Service crop improvement guidelines.

These diversion points also allowed the ranch to divert excess flows to prevent flooding and to conserve water for storage in the irrigation reuse reservoirs. As a result, to the best of my knowledge, Murphy Ditch has never had to utilize the Rapid Valley Drainage commission floodway gates they installed in case of excess flooding.

The Harney Peak Ranch's diversions that are appurtenant to the Murphy 1878-priority water right and its other water rights carried in that canal consist of the following: **Two 15-inch Gravity-pressurized lines, One Forty-Horsepower Electrical Pump and several surface diversions.**

**Early and Late Irrigation Applications:** The pre-existing topography and hydrology of the lands below Harney Peak Ranch creates substantial poorly-drained, saturated soil area. In addition, higher dryer areas, if irrigated too aggressively, will create runoff into the swampy bottoms. This restricted and impeded much irrigation in those areas. Without the better ditch gradients and causeways that even early-day Harney Ranch employed, irrigation flow dynamics were restricted there.

Harney Peak Ranch occupies a zone where Rapid Creek has cut below the adjoining lands, resulting in good drainage, generally, especially with the leveling and improvements in place. As a result, little early or late irrigation can be done on the majority of the lands under the Murphy Ditch. Harney Peak Ranch, conversely, has consistently irrigated early and late when resources were available. Our modern higher-production seed stocks required the water input to produce.

**Soil Characteristics:** Soil research and mapping, in conjunction with the previously mentioned soil drainage, hydrology and storage reservoirs, indicate that Harney Peak Ranch occupies the best alluvial delta geologic zone between the western shale uplift and the alluvial clays to the east.

This results in Harney Peak Ranch having the highest soil classifications (Class 2 in the best areas) in Rapid Valley and, possibly, the surrounding region. This results, in addition to fertility, in the best-drained soils with the best water storage characteristics in the area, facilitating extra irrigation cycles and increased production. Quite logically, these were the first-irrigated lands from pioneer times: They were the most suitable and most

productive areas in 1876 when pioneers first established themselves. Crop awards are one indication. Sod cultivators choose our lands because sod could not easily be cut from the sticky higher-clay soils to the east.

**Documentation of Proof:** Sources for the above include soil surveys (Pennington County Soil Map Reverence) , hydrology studies, documentation and engineering studies for the Rapid Valley Drainage Commission (may not be the exact title), SD DENR and Leo Eisel canal seepage studies for previous 1878 Murphy and similar Southside Ditch transfers: These last may indicate the higher seepage rates lower down on Murphy Ditch, if sufficiently detailed.

**Rapid Creek Measurement Issues:** A different issue is the probable deficits in measuring natural flows and describing creek losses. For example, large standard deductions for water loss above Canyon Lake should, perhaps, be attributed to the nearby galleries Rapid City uses as storage. This would leave a lot more natural flow for all water rights holders, but, most specifically, 1878 water right holders, since this "loss" comes off the top. This might be addressed at some point, if valid

Other resources are mentioned above. You are conversant with hydrology and technical resources as a whole, of course. There may be specific support from authorities or knowledgeable people you are aware of or may identify as well. The Bureau of Reclamation has tried to do some historical work, with what outcome I do not know. Ditch studies have been done in the course of settling some legal disagreements over the past century and a quarter and in cooperation, probably, with the SD DENR in recent years. This is my best consolidation of past information, observations of past irrigation works, etc., and my recollections going back many years of the changes that have taken place. Supporting documentation you may acquire will be important. The cost-benefit of any specific challenge to the SD DENR is, of course, another level of analysis.

Steve Murphy, about my age, told me that he helped pile willow brush and manure hauled in by wagon, in the Rapid Creek annually to create, repair and maintain diversion weirs. That is an indication of how different things are today and also how hard they were to just make work in the not-too-distant past. It is hard to imagine that much worry was put into measuring water in those days. They were lucky just to get it into some of the ditches, amidst floods and other natural obstacles.

Sincerely,  
David S. Lamb  
Harney Peak Ranch  
605 393-0093



**6. Draft Resolution  
by City of Rapid City  
Presented to City for Review**

**CITY OF RAPID CITY, SOUTH DAKOTA**  
**A Municipal Corporation**

**RESOLUTION \_\_\_\_\_**

**WHEREAS**, the Rapid Valley Sanitary District - Water Service (hereinafter RVSD) currently collects waste water and sends it to the City trunk sewer outfall and to the City Wastewater Treatment Plant located on Rapid Creek, east of the City of Rapid City; and

**WHEREAS**, the City treats said wastewater collected and produced by the RVSD and returns it to Rapid Creek; and

**WHEREAS**, the City of Rapid City is in agreement with continuing its treatment of the sewer outflow accordingly back into Rapid Creek;

**NOW, THEREFORE**, upon motion duly made and passed by the majority of the City Counsel of the City of Rapid City,

**BE IT RESOLVED**, that the City of Rapid City, shall, after it treats the wastewater collected and produced by RVSD, continually return it to Rapid Creek at the Treatment Plant outfall, in accordance with its standard procedures.

Dated this \_\_\_\_\_ day of February, 2006.

**ATTEST:**

**CITY OF RAPID CITY**

By: \_\_\_\_\_  
Its. City Finance Officer  
City of Rapid City

By: \_\_\_\_\_  
Mayor Jim Shaw  
City of Rapid City

**7. Figure 6**  
**Harney Peak Ranch Lands**  
**Irrigated by Murphy Ditch**

RECEIVED

MAY 25 2006

WATER RIGHTS  
PROGRAM

**RESOLUTION ADOPTING A POLICY WHEREBY CITY OF RAPID CITY WILL  
TREAT WASTEWATER COLLECTED AND PRODUCED BY RAPID VALLEY  
SANITARY DISTRICT AND RETURN IT TO RAPID CREEK**

WHEREAS, the Rapid Valley Sanitary District, hereinafter referred to as RVSD, currently collects waste water and sends it to the City of Rapid City trunk sewer outfall and to the City Water Reclamation Facility located on Rapid Creek, east of the City; and

WHEREAS, the City currently treats the above-described wastewater collected and produced by RVSD and returns said wastewater to Rapid Creek; and

WHEREAS, the Rapid City Common Council is in agreement with and deems it in the best interest of the City to continue its discharge of the sewer outflow as above-described.

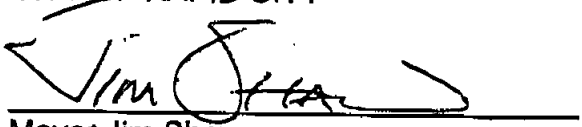
NOW THEREFORE, BE IT RESOLVED, by the City of Rapid City that it shall, after treating the wastewater collected and produced by RVSD, continually return said wastewater to Rapid Creek at the Water Reclamation Facility outfall in accordance with its standard procedures.

Dated this 15<sup>th</sup> day of May, 2006.

ATTEST:

  
James F. Preston, Finance Officer

CITY OF RAPID CITY

  
Mayor Jim Shaw

(SEAL)



Revised on  
6/23/06

**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

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**RECOMMENDATION OF CHIEF ENGINEER FOR WATER PERMIT  
APPLICATION NO. 2586-2, Rapid Valley Sanitary District**

Pursuant to SDCL 46-2A-2, the following is the recommendation of the Chief Engineer, Water Rights Program, Department of Environment and Natural Resources concerning Water Permit Application No. 2586-2, Rapid Valley Sanitary District, c/o Jim Jester, 4611 Teak Drive, Rapid City SD 57703

The Chief Engineer is recommending APPROVAL of Application No. 2586-2 because 1) the proposed diversion can be developed without unlawful impairment of existing rights, 2) the proposed use is a beneficial use and 3) it is in the public interest with the following qualifications:

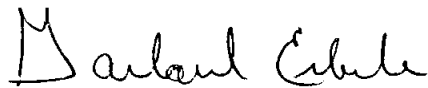
1. Permit No. 2586-2 is limited to a diversion rate of 5.05 cfs for a total annual volume of 867 acre feet. The Rapid Valley Sanitary District shall measure diversions at the Lamb property farm turnouts located on Murphy Ditch and diversion at the District's water treatment plant. The total monthly diversion shall not exceed the amount listed in the following table.

| Monthly Volume<br>Limitation |         |
|------------------------------|---------|
| Month                        | (ac-ft) |
| April                        | 42      |
| May                          | 105     |
| June                         | 118     |
| July                         | 158     |
| Aug                          | 199     |
| Sept                         | 147     |
| Oct                          | 98      |
| Total                        | 867     |

2. The Rapid Valley Sanitary District shall report to the Chief Engineer annually the amount of water withdraw each month at the Lamb property turnouts located on Murphy Distch and diversion at the District's water treatment plant.
3. Permit No. 2586-2 authorizes diversion of only natural flow water by the Rapid Valley Sanitary District and does not include any right to stored irrigation water available under contract from Pactola Reservoir.

4. The Water Management Board retains jurisdiction of Permit No. 2586-2 in the event that additional information shows that changes need to be made in the monthly or total annual volumes authorized by Permit No. 2586-2.
5. Diversion under Permit No. 2586-2 may not interfere with existing water right in effect prior to approval of Permit No. 2586-2 or any domestic rights.
6. The amount of water with a April 6, 1878 priority date which may be appropriated under Vested Water Right No. 1727-2 is reduced by 5.05 cfs.
7. Upon termination of the lease back agreement, the 386 acres of Harney Peak Ranch property owned by David Lamb, which has been historically irrigated under the Vested Water Right No. 1727-2, located in portions of SW  $\frac{1}{4}$  SW  $\frac{1}{4}$  Section 10 and portions of Section 15, T1N, R8E may not qualify for another new irrigation right from any water source.

See report on application for additional information.

A handwritten signature in black ink, appearing to read "Garland Erbele". The signature is written in a cursive, flowing style.

Garland Erbele, Chief Engineer

June 6, 2006





**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

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**REVISED RECOMMENDATION OF CHIEF ENGINEER FOR WATER PERMIT  
APPLICATION NO. 2586-2, Rapid Valley Sanitary District**

Pursuant to SDCL 46-2A-2, the following is the revised recommendation of the Chief Engineer, Water Rights Program, Department of Environment and Natural Resources concerning Water Permit Application No. 2586-2, Rapid Valley Sanitary District, c/o Jim Jester, 4611 Teak Drive, Rapid City SD 57703

The Chief Engineer is recommending APPROVAL of Application No. 2586-2 because 1) the proposed diversion can be developed without unlawful impairment of existing rights, 2) the proposed use is a beneficial use and 3) it is in the public interest with the following qualifications:

1. Permit No. 2586-2 is limited to a diversion rate of 5.05 cfs for a total annual volume of 867 acre feet. The Rapid Valley Sanitary District shall measure diversions at the Lamb property farm turnouts located on Murphy Ditch and diversion at the District's water treatment plant. The total monthly diversion shall not exceed the amount listed in the following table.

| Monthly Volume<br>Limitation |         |
|------------------------------|---------|
| Month                        | (ac-ft) |
| April                        | 42      |
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| June                         | 118     |
| July                         | 158     |
| Aug                          | 199     |
| Sept                         | 147     |
| Oct                          | 98      |
| Total                        | 867     |

2. The Rapid Valley Sanitary District shall report to the Chief Engineer annually the amount of water withdraw each month at the Lamb property turnouts located on Murphy Distch and diversion at the District's water treatment plant.
3. Permit No. 2586-2 authorizes diversion of only natural flow water by the Rapid Valley Sanitary District and does not include any right to stored irrigation water available under contract from Pactola Reservoir and Deerfield Reservoir.

4. The Water Management Board retains jurisdiction of Permit No. 2586-2 in the event that additional information shows that changes need to be made in the monthly or total annual volumes authorized by Permit No. 2586-2.
5. Diversion under Permit No. 2586-2 may not interfere with existing water right in effect prior to approval of Permit No. 2586-2 or any domestic rights.
6. The amount of water with a April 6, 1878 priority date which may be appropriated under Vested Water Right No. 1727-2 is reduced by 5.05 cfs.
7. Upon termination of the lease back agreement, the 386 acres of Harney Peak Ranch property owned by David Lamb, which has been historically irrigated under the Vested Water Right No. 1727-2, located in portions of SW  $\frac{1}{4}$  SW  $\frac{1}{4}$  Section 10 and portions of Section 15, T1N, R8E may not qualify for another new irrigation right from any water source.

See report on application for additional information.

A handwritten signature in black ink, appearing to read "Garland Erbele". The signature is fluid and cursive, with the first name "Garland" being more prominent than the last name "Erbele".

Garland Erbele, Chief Engineer  
June 23, 2006

Report on Water Permit Application No. 2586-2  
Rapid Valley Sanitary District  
June 2, 2006

Application No. 2586-2, Rapid Valley Sanitary District, proposes to transfer an annual volume of 867 acre-feet of water (ac-ft), from irrigation use to municipal, common distribution system, rural water system, suburban housing, and domestic uses for the Rapid Valley Sanitary District. The maximum diversion rate proposed for this transfer is 5.05 cubic feet of water per second (cfs) from the natural flows of Rapid Creek at the District's water treatment plant. Application No. 2586-2 proposes to transfer Rapid Valley Water Company (a.k.a. Murphy Ditch) stockholder/landowner's water which has been historically used to irrigate 368 acres as authorized by Vested Water Right No. 1727-2 located in the SW  $\frac{1}{4}$  SW  $\frac{1}{4}$  of Section 10 and portions of Section 15 all in T1N-R8E, known as the David Lamb property.

The source of water for the proposed transfer is from the natural flow of Rapid Creek, when available, through the Murphy ditch. The location of the Sanitary District's diversion point for the proposed transfer is in the NE  $\frac{1}{4}$  NW  $\frac{1}{4}$  Section 15 T1N-R8E. This application does not request any new water appropriation from Rapid Creek and the validated priority date of April 6, 1878 is to be retained by the sanitary district.

Review of Existing Water Rights

The water to be transferred was appropriated under validated Vested Water Right No. 1727-2 Rapid Valley Water Company, authorizes the irrigation of 368 acres of the David Lamb property located in the SW  $\frac{1}{4}$  SW  $\frac{1}{4}$  of Section 10 and portions of Section 15 all in T1N-R8E

The Rapid Valley Water Company holds Vested Water Right Nos. 1727-2, 2239-2, 2240-2, 2241-2 and 2242-2 for irrigation out of Rapid Creek. Since the time of validation of these vested water rights, there have been portions of these rights transferred from irrigation to municipal use by the City of Rapid City. If this transfer is approved, Rapid Valley Water Company will only have 7.81 cfs for irrigating 493 acres under the April 6, 1878 priority date portion of these vested rights remaining.

There are 95 existing water rights/permits appropriating 251.45 cfs on Rapid Creek between Pactola Reservoir and the confluence with the Cheyenne River. Of these three, water rights which appropriate 3.37 cfs have priority dates which are senior to April 6, 1878.

Review of the Proposed Transfer

The water available for transfer is only from the natural flow in Rapid Creek and does not include stored water or stored water releases from the Deerfield - Pactola Reservoirs. South Dakota Codified Law, SDCL 46-5-34.1 states that no transfer can occur unless the transfer can be made without detriment to existing rights, or to individual domestic use rights. SDCL 46-2A-12 allows a change in use "only if the change does not unlawfully impair existing rights and is for a beneficial use and in the public interest." Calculations

using accepted scientific methods and available climatic and cropping data have been made to insure that the proposed change does not unlawfully impair or adversely affect existing water rights.

The proposed diversion rate transfer is based on water beneficially used as described under SDCL 46-1-8. Water in the ditch is shared by the users as needed. Based on actual past operations, the calculated diversion rate transfer is based on a pro rata share of the ditch diversion rate under the April 6, 1878 priority right. The transferable diversion rate is based on the pro rata share of water decreased by the 11 percent carriage loss that remains in the ditch. The carriage loss is the water lost to seepage in transporting water from the creek headgate along the ditch. The pro-rata share of the diversion rate minus carriage loss is equal to 5.05 cfs.

Historical depletions to Rapid Creek from irrigation on the David Lamb property using the Murphy Ditch 1878 priority water right were quantified by means of a water budget approach. The water budget tracked historical water supply available to the ranch, the consumptive water used by crops, the precipitation contribution and the return flows to Rapid Creek.

The Modified Blaney-Criddle method, adjusted for elevation, was used to calculate the potential consumptive use of water by crops irrigated from the Murphy Ditch. This method utilizes historic climatic data, crop type and elevation to calculate the volume of water consumed by the crop on a monthly basis. This is compared to the amount of water that was available for the actual crop's use based on historical ditch diversions, transportation losses, irrigation efficiency, and the total acreage irrigated annually from the ditch. For this proposed transfer, the average amount of water calculated to have been consumed by the crop is 563.6 ac-ft of water annually. A portion of the water historically diverted for irrigation to the Lamb property was not utilized by the crop but returned to Rapid Creek either as direct surface runoff from the field or underground percolation through the alluvium. This results in an irrigation application efficiency of 65%. The amount of return flow was calculated to be 303.5 ac-ft annually. Water which had historically returned to Rapid Creek through irrigation activities will now be returned to Rapid Creek by the Rapid Valley Sanitary District through the Rapid City waste water treatment system. The amount of water proposed to be diverted at Rapid Valley Sanitary District's water system intake is 867 ac-ft annually. This volume of water includes the amount of water consumed by the crop plus the return water to Rapid Creek. (Leonard-Rice Engineers, 2006; Cetec Engineering Services, Inc., 2006).

Rapid Valley Sanitary District contracts with the City of Rapid City to treat the Sanitary District's effluent at the City's sewage treatment facility. The applicant has submitted a signed resolution from the city council of Rapid City committing to continuing to discharge Rapid Valley Sanitary District's treated effluent to Rapid Creek downstream of the proposed project. This allows existing downstream water rights to divert this water based upon priority availability. If in the future the Rapid Valley Sanitary District, through the City of Rapid City, stops returning effluent to Rapid Creek, then the diversion proposed by this water permit will need to be recalculated to reflect that

condition.

SDCL 46-5-34.1 also states "No land which has had an irrigation right transferred from it pursuant to this section may qualify for another irrigation right from any water source. The landowner, Mr. Lamb, currently holds two existing water permits covering some of the same irrigated land that is tied to this transfer request. As discussed in this report, only a portion of Vested Water Right No 1727-2 is proposed to being transferred. Water Permit Nos. 1461-2 and 1461A-2 are not being transferred. Water Permit Nos. 1461-2 and 1461A-2, both having a priority date of August 5, 1914, are for providing supplemental irrigation from Rapid Creek to other land covered by other existing water rights.

This transfer has no affect on Water Permit Nos. 1461-2 and 1461A-2 and they will remain in place subject to the established priority dates. Further, SDCL 46-5-34.1 does not require retirement of Water Permit Nos. 1461-2 and 1461A-2. That statute states "No land which has had an irrigation right transferred from it pursuant to this section may qualify for another irrigation right from any water source." SDCL 46-5-34.1 applies only when a landowner transfers a water right from property and attempts to obtain a new water right for the same property. In this case Water Permit Nos. 1461-2 and 1461A-2 are already in existence and the last sentence of SDCL 46-5-34.1 does not apply.

This section would prohibit granting any new water permit applications for irrigation of the lands involved in this transfer if those applications are filed after this transfer is approved.

Also, Water Permit Nos. 1461-2 and 1461A-2 are relatively junior in priority for Rapid Creek and except under extremely wet conditions, there is no natural flow available in the Rapid Creek for diversion by these water permits. This lack of natural flow availability was addressed when both permits were issued with the following qualification:

*Low flows as needed for domestic use, including livestock watering and prior water rights must be by-passed. Unappropriated water is available in Rapid Creek to reasonably satisfy this application only through contract between the Rapid Valley Conservancy District and Bureau of Reclamation covering releases from Deerfield and Pactola Reservoirs.*

Because the land associated with the proposed transfer from Murphy Ditch is not part of the Rapid Valley Water Conservancy District, purchased project water from Deerfield and Pactola Reservoirs cannot be used to irrigate lands located outside of the Rapid Valley Water Conservancy District boundaries.

Approval of a water permit by the Water Management Board under SDCL 46-2A-7 and 46-2A-8 allows for a 5 year construction period and an additional 4 years to put to beneficial use. The District does not have an immediate need for the entire amount of water transferred because of water treatment plant construction and time to bring the system up to full capacity. The District intends to phase in the entire proposed transferred over approximately six years. During this time frame, Mr. Lamb will phase

out irrigating his hay land covered by this transfer request through a lease back agreement with the District. To ensure that the monthly amount of water diverted does not exceed the allowable monthly volume limitation, the permit should contain the following qualification:

The Rapid Valley Sanitary District shall measure diversions at the Lamb property farm turnouts located on Murphy Ditch and diversion at the water treatment plant. The total monthly diversion shall not exceed the amount listed in the following table.

| Monthly Volume<br>Limitation |         |
|------------------------------|---------|
| Month                        | (ac-ft) |
| April                        | 42      |
| May                          | 105     |
| June                         | 118     |
| July                         | 158     |
| Aug                          | 199     |
| Sept                         | 147     |
| Oct                          | 98      |
| Total                        | 867     |

The diversion records shall be submitted annually to the Chief Engineer.

Upon termination of the lease back agreement, the landowner will no longer have the right to apply Rapid Valley Water Company, April 6, 1878, priority water under Water Right 1727-2 on the property from which it was transferred.

If this transfer is approved, the diversion rate and acreage authorized by the April 6, 1878 priority date of Water Right No. 1727-2, Rapid Valley Water Company, should be decreased by 5.05 cfs and 368 acres due to the transfer.

To insure that the transfer of the water can be made without detriment to existing water rights, the Water Management Board should monitor the management and operation of the proposed transfer.

#### Conclusions

1. SDCL 46-5-34.1 allows for the transfer of irrigation water rights apart from the



land to municipal use when the transfer can be made without causing detriment to existing rights. SDCL 46-2A-12 allows a change in use only if the change does not unlawfully impair existing rights and is for a beneficial use and in the public interest."

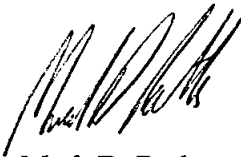
2. The water has been historically used to irrigate 368 acres.
3. The priority date of April 6, 1878, should be retained.
4. The diversion rate to be transferred is 5.05 cfs, and is based on the pro-rated share of the total ditch diversion rate minus the 11 % carriage loss for the main ditch.
5. The amount of water requested to be transferred, 867 ac-ft annually is reasonable.
6. Upon termination of the lease back agreement, the landowner will no longer have the right to apply Rapid Valley Water Company, April 6, 1878, priority water under Water Right 1727-2 on the property from which it was transferred.
7. If application No. 2586-2 is approved, the authorized diversion rate and acreage for the Water Right No. 1727-2 under the April 6, 1878 priority date should be decreased by 5.05 cfs and 368 acres.
8. The Water Management Board should retain jurisdiction in order to monitor the management and operation of the proposed transfer.
9. Approval of Application No. 2586-2, only approves transfer of natural flow water and does not include any rights to stored irrigation water available under contract with the Bureau of Reclamation from Pactola and Deerfield reservoirs.
10. Because natural flow water has not been available for Water Right No. 1727-2 during lower flow periods, approval of Application No. 2586-2 does not guarantee that natural flow water will be available.
11. To ensure that the monthly amount of water diverted does not exceed the allowable monthly volume limitation the permit should contain the following qualification:

The Rapid Valley Sanitary District shall measure diversions at the Lamb property farm turnouts located on Murphy Ditch and diversion at the water treatment plant. The total combined monthly diversion shall not exceed the amount listed in the following table.

| Monthly Volume<br>Limitation |         |
|------------------------------|---------|
| Month                        | (ac-ft) |
| April                        | 42      |

|       |     |
|-------|-----|
| May   | 105 |
| June  | 118 |
| July  | 158 |
| Aug   | 199 |
| Sept  | 147 |
| Oct   | 98  |
| Total | 867 |

The diversion records indicating diversion location and the diversion amount from each location shall be submitted annually to the Chief Engineer.



Mark D. Rath  
Natural Resources Engineering Specialist

#### References

1. Leonard-Rice Engineers Inc., 2005. Engineering Report Transfer of Lamb Property Water Rights 1878 Murphy Ditch Priority.
2. U.S. Bureau of Reclamation. 1990. Rapid Valley Water Management Study. U.S. Bureau of Reclamation, Belle Fourche Projects Office, Newell, South Dakota.
3. Cetec Engineering Services, Inc. 2006. Supplemental Information to Engineering Report Transfer of Lamb Property Water Rights 1878 Murphy Ditch Priority.
4. S.D. Department of Environment and Natural Resources. Water Rights Program records.

Form 8

## PROOF OF PUBLICATION

STATE OF SOUTH DAKOTA )  
County of Pennington ) SS

I, Patricia K. Van Datten

certify that the attached printed Notice was  
taken

from the Rapid City Journal

printed and published in Rapid City

County of Pennington and

state of South Dakota. The notice was  
published

in the newspaper on the following two dates:

June 14, 2006

June 21, 2006

Cost of Printing Two hundred thirty-four  
dollars and eight cents (\$234.08)

Patricia K. Van Datten  
(Signature)

Legal Advertising Rep.  
(Title)

06/26/06  
(Date Signed)

RECEIVED  
JUN 28 2006  
WATER RIGHTS  
PROGRAM

June 14, 21 L2312873

### NOTICE OF HEARING ON APPLICATION NO. 2586-2 TO TRANSFER USE

Notice is given that the Rapid Valley Sanitary District, c/o Jim Jester, 4611 Teak Drive, Rapid City, SD 57703, has filed Water Permit Application No. 2586-2 pursuant to SDCL 46-5-34.1 to transfer the use of a portion of Rapid Creek natural flows appropriated for irrigation use to municipal, rural water system and suburban housing purposes by the Sanitary District.

Water Permit Application No. 2586-2 proposes to transfer a portion of Rapid Valley Water Company (aka Murphy Ditch) stockholder/landowner's use of Rapid Creek natural flows appropriated under Vested Water Right No. 1727-2 from Murphy Ditch. The transfer is for Rapid Creek water historically used to irrigate 368 acres at the Harney Peak Ranch owned by David Lamb. The portion of Rapid Creek natural flows to be transferred to the Sanitary District is 5.05 cubic feet of water per second (cfs) with an annual volume limitation of 867 acre feet of water. The permit, if approved, will be conditioned with monthly volumetric limits (acre-feet) on diversion by the Sanitary District based on long-term average deliveries to the Harney Peak Ranch.

Historically, the 5.05 cfs has been used to irrigate 368 acres located in portions of the SW $\frac{1}{4}$ SW $\frac{1}{4}$  Section 10, T1N, R8E and the W $\frac{1}{2}$ NW $\frac{1}{4}$ , SE $\frac{1}{4}$ NW $\frac{1}{4}$ , S $\frac{1}{2}$ NE $\frac{1}{4}$ , SW $\frac{1}{4}$  and the SE $\frac{1}{4}$  Section 15, T1N, R8E. The existing point on Rapid Creek for Murphy Ditch is located in the NE $\frac{1}{4}$ SW $\frac{1}{4}$  Section 8, T1N, R8E. This application is to change the diversion point for 5.05 cfs to a permanent diversion point for use by the Sanitary District to be located in the NE $\frac{1}{4}$ NW $\frac{1}{4}$  Section 15, T1N, R8E. The District also requests temporary diversion points located in the SW $\frac{1}{4}$ SW $\frac{1}{4}$  Section 10 and the NE $\frac{1}{4}$ NE $\frac{1}{4}$  Section 15; all in T1N, R8E as explained below. This application does not authorize any new water appropriation from Rapid Creek. This application, if approved, will retain the April 6, 1878, priority date established by the Murphy Ditch vested water right for natural flow.

The Sanitary District reserves the right to lease back a portion of the transferred water to Harney Peak Ranch for irrigation of property on a decreasing basis over a six-year period from the date the permit is approved. The combined use by the Sanitary District and Harney Peak Ranch of the transferred amount proposed by this application is limited to 5.05 cfs diversion rate and annual volume limit of 867 acre feet of water including monthly volume limits. Upon termination of the lease back agreement, the landowner will no longer have the right to apply Rapid Valley Water Company, April 6, 1878, priority water on to the property from which it was transferred.

Pursuant to SDCL 46-2A-2, the Chief Engineer recommends APPROVAL of Application No. 2586-2 because 1) existing rights will not be unlawfully impaired, 2) it is a beneficial use of water, and 3) it is in the public interest.

Any person interested in opposing or supporting this application must file a written petition with BOTH the applicant and Chief Engineer. The applicant must also file a petition if opposed to the Chief Engineer's recommendation. The Chief Engineer's address is "Water Rights Program, Foss Building, 523 E. Capitol,

Pierre, SD 57501 (605-773-3352)" and the applicant's mailing address is given above. A petition filed by either an interested person or the applicant must be filed by July 3, 2006. The petition may be informal but must include a statement describing the petitioner's interest in the application, the petitioner's reasons for opposing or supporting the application, and the signature and mailing address of the petitioner or the petitioner's legal counsel, if legal counsel is obtained.

The Water Management Board will consider this application at 10:30 a.m. on July 12, 2006, in the Floyd Matthew Training Center, 523 E. Capitol Avenue, Pierre, S.D. The Chief Engineer's recommendation is not final or binding upon the Board. The Board is authorized to 1) approve, 2) approve with qualifications, 3) defer, or 4) deny this application based on the facts presented at the public hearing. The July 12, 2006, hearing date will be automatically delayed for at least 20 days upon written request to the Chief Engineer from the applicant or any interested person opposing the application. The request for an automatic delay must be filed by July 3, 2006.

Any hearing will be an adversary proceeding. Any person filing a petition and/or the applicant have the right to be represented by a lawyer and may present evidence or cross-examine witnesses according to SDCL 1-26. These and other due process rights will be forfeited if not exercised. Decisions of the Board may be appealed to the Circuit Court and State Supreme Court as provided by law. Contact Eric Gronlund by July 3, 2006, at the above Water Rights Program address to request copies of information pertaining to this application, to assure access to the hearing by the handicapped or to obtain an interpreter for the hearing impaired.

Since this application does not involve a monetary controversy in excess of \$2,500.00 or termination of a property right in accordance with SDCL 1-26-18.3, the Chief Engineer has determined this contested case may not be referred to the Office of Hearing Examiners. If any party disagrees with this determination, the Chief Engineer shall be notified by July 3, 2006.

This application is made pursuant to SDCL 46-1-1 thru 46-1-9, 46-1-12 thru 46-1-16; 46-2-3.1, 46-2-9, 46-2-11, 46-2-13, 46-2-17; 46-2A-1 thru 46-2A-10, 46-2A-12, 46-2A-14, 46-2A-15, 46-2A-20, 46-2A-21; 46-5-1 thru 46-5-11, 46-5-13 thru 46-5-15, 46-5-24, 46-5-25, 46-5-30.2, 46-5-30.4, 46-5-31; 46-5-33 thru 46-5-35; and Board Rules ARSD 74-02:01:01 thru 74-02:01:15.

Steven M. Pirmer, Secretary  
Department of Environment  
and Natural Resources

Instruction to Newspaper - Publish first Notice on June 14, 2006 with the second publication 7 days later. The applicant is responsible for payment.

---

### NOTICE OF HEARING on Application No. 2586-2 to Transfer Use

Notice is given that the Rapid Valley Sanitary District, c/o Jim Jester, 4611 Teak Drive, Rapid City SD 57703 has filed Water Permit Application No. 2586-2 pursuant to SDCL 46-5-34.1 to transfer the use of a portion of Rapid Creek natural flows appropriated for irrigation use to municipal, rural water system and suburban housing purposes by the Sanitary District.

Water Permit Application No. 2586-2 proposes to transfer a portion of Rapid Valley Water Company (aka) Murphy Ditch) stockholder/landowner's use of Rapid Creek natural flows appropriated under Vested Water Right No. 1727-2 from Murphy Ditch. The transfer is for Rapid Creek water historically used to irrigate 368 acres at the Harney Peak Ranch owned by David Lamb. The portion of Rapid Creek natural flows to be transferred to the Sanitary District is 5.05 cubic feet of water per second (cfs) with an annual volume limitation of 867 acre feet of water. The permit, if approved, will be conditioned with monthly volumetric limits (acre-feet) on diversion by the Sanitary District based on long-term average deliveries to the Harney Peak Ranch.

Historically, the 5.05 cfs has been used to irrigate 368 acres located in portions of the SW  $\frac{1}{4}$  SW  $\frac{1}{4}$  Section 10, T1N, R8E and the W  $\frac{1}{2}$  NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$  NW  $\frac{1}{4}$ , S  $\frac{1}{2}$  NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$  and the SE  $\frac{1}{4}$  Section 15, T1N, R8E. The existing point on Rapid Creek for Murphy Ditch is located in the NE  $\frac{1}{4}$  SW  $\frac{1}{4}$  Section 8, T1N, R8E. This application is to change the diversion point for 5.05 cfs to a permanent diversion point for use by the Sanitary District to be located in the NE  $\frac{1}{4}$  NW  $\frac{1}{4}$  Section 15, T1N, R8E. The District also requests temporary diversion points located in the SW  $\frac{1}{4}$  SW  $\frac{1}{4}$  Section 10 and the NE  $\frac{1}{4}$  NE  $\frac{1}{4}$  Section 15; all in T1N, R8E as explained below. This application does not authorize any new water appropriation from Rapid Creek. This application, if approved, will retain the April 6, 1878 priority date established by the Murphy Ditch vested water right for natural flow.

The Sanitary District reserves the right to lease back a portion of the transferred water to Harney Peak Ranch for irrigation of property on a decreasing basis over a six year period from the date the permit is approved. The combined use by the Sanitary District and Harney Peak Ranch of the transferred amount proposed by this application is limited to 5.05 cfs diversion rate and annual volume limit of 867 acre feet of water including monthly volume limits. Upon termination of the lease back agreement, the landowner will no longer have the right to apply Rapid Valley Water Company, April 6, 1878, priority water on to the property from which it was transferred.

Pursuant to SDCL 46-2A-2, the Chief Engineer recommends APPROVAL of Application No. 2586-2 because 1) existing rights will not be unlawfully impaired, 2) it is a beneficial use of water, and 3) it is in the public interest.

Any person interested in opposing or supporting this application must file a written petition with BOTH the applicant and Chief Engineer. The applicant must also file a petition if opposed to the Chief Engineer's recommendation. The Chief Engineer's address is "Water Rights Program, Foss Building, 523 E Capitol, Pierre SD 57501 (605 773-3352)" and the applicant's mailing address is given above. A petition filed by either an interested person or the applicant must be filed by July 3, 2006. The petition may be informal, but must include a statement describing the petitioner's interest in the application, the petitioner's reasons for opposing or supporting the application, and the signature and mailing address of the petitioner or the petitioner's legal counsel, if legal counsel is obtained.

The Water Management Board will consider this application at 10:30 AM on July 12, 2006 in the Floyd Matthew Training Center, 523 E. Capitol Avenue, Pierre SD. The Chief Engineer's recommendation is not final or binding upon the Board. The Board is authorized to 1) approve, 2) approve with qualifications, 3) defer, or 4) deny this application based on the facts presented at the public hearing. The July 12, 2006 hearing date will be automatically delayed for at least 20 days upon written request to the Chief Engineer from the applicant or any interested person opposing the application. The request for an automatic delay must be filed by July 3, 2006.

Any hearing will be an adversary proceeding. Any person filing a petition and/or the applicant have the right to be represented by a lawyer and may present evidence or cross-examine witnesses according to SDCL 1-26. These and other due process rights will be forfeited if not exercised. Decisions of the Board may be appealed to the Circuit Court and State Supreme Court as provided by law. Contact Eric Gronlund by July 3, 2006, at the above Water Rights Program address to request copies of information pertaining to this application, to assure access to the hearing by the handicapped or to obtain an interpreter for the hearing impaired.

Since this application does not involve a monetary controversy in excess of \$2,500.00 or termination of a property right in accordance with SDCL 1-26-18.3, the Chief Engineer has determined this contested case may not be referred to the Office of Hearing Examiners. If any party disagrees with this determination, the Chief Engineer shall be notified by July 3, 2006.

This application is made pursuant to SDCL 46-1-1 thru 46-1-9, 46-1-12 thru 46-1-16; 46-2-3.1, 46-2-9, 46-2-11, 46-2-13, 46-2-17; 46-2A-1 thru 46-2A-10, 46-2A-12, 46-2A-14, 46-2A-15, 46-2A-20, 46-2A-21; 46-5-1 thru 46-5-11, 46-5-13 thru 46-5-15, 46-5-24, 46-5-25, 46-5-30.2, 46-5-30.4, 46-5-31; 46-5-33 thru 46-5-35; and Board Rules ARSD 74:02:01:01 thru 74:02:01:15. Steven M. Pirner, Secretary, Department of Environment and Natural Resources.



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

NOTE: TO BE SURE OF PUBLICATION ON  
THE CORRECT DATES, CONTACT  
THE NEWSPAPER RIGHT AWAY.

June 7, 2006

Rapid Valley Sanitary District  
% Jim Jester  
4611 Teak Drive  
Rapid City SD 57703

Dear Mr. Jester:

Water Permit Application No. 2586-2 for suburban housing development use has been examined and found to comply with the South Dakota Water Laws and applicable rules. A notice has been sent to the Publisher of the Rapid City Journal printed at Rapid City, SD (Ph # 605-394-8300). You will need to contact the newspaper and authorize publication of this notice. For your information, a copy of the notice, the recommendation of the Chief Engineer and a report on the application are enclosed. Please review the notice prior to publication and notify this office, if you have any corrections or questions.

Be sure to contact the above newspaper to authorize publication of your Notice and to arrange for payment. Early contact with the paper can eliminate delays. Upon receiving authorization, the publisher has been instructed to publish your notice once each week for two consecutive weeks. The newspaper has also been instructed to send us the Proof of Publication. We must receive Proof of Publication before action can be taken on the application.

Sincerely,

Eric Gronlund  
Natural Resources Engineer  
(605) 773-3352

enclosures

NOTE: If you plan to contest any part of the Chief Engineer's recommendation, you must file a petition pursuant to the procedures outlined in the attached notice of hearing. The Water Management Board will then consider your concerns during a hearing on the application.





DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES

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PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

June 7, 2006

Rapid City Journal  
PO Box 450  
Rapid City SD 57703

ATTENTION: Legal Public Notice

Enclosed is a Notice on Application No. 2586-2 to Appropriate Water to be published twice. Please publish the first notice on June 14, 2006 with the second publication 7 days later. The text of the notice can be e-mailed to your paper by contacting Karen Schlaak at (605) 773-3352.

The applicant must verify to you that the notice is to be published, before you make the first publication. **Please BILL the APPLICANT for the cost of publication.** The APPLICANT is Rapid Valley Sanitary District – Water Service, 4611 Teak Drive, Rapid City (Ph # 605-393-1050).

**Please send the Water Rights Program the first publication immediately.** The publication is checked for accuracy so any corrections can be made in the second publication. You may use the form below or fax a copy of the first publication. Any fax should be sent to the attention of Karen Schlaak at (605) 773-4068. Publication errors can invalidate the public notice.

After the second publication, **please send us an affidavit or use the enclosed Proof of Publication form.** The applicant pays the cost of publication, but the Water Rights Program records require an affidavit or Proof of Publication. Delays in receiving the affidavit can be costly to the applicant.

Sincerely,

Eric Gronlund  
Natural Resources Engineer  
605 773-3352

enclosures

-----CUT HERE-----

No. 2586-2

TO: Eric Gronlund  
Water Rights Program  
Joe Foss Building  
Pierre SD 57501-3181

Date \_\_\_\_\_

We are in receipt of your letter of June 7, 2006 enclosing Notice to Appropriate Water by Application No. 2586-2 which was first published in our issue of \_\_\_\_\_. ENCLOSED IS A COPY OF THIS FIRST PUBLICATION.

\_\_\_\_\_  
Name

\_\_\_\_\_  
Newspaper



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

June 8, 2006

Curt Anderson  
Bureau of Reclamation  
515 9<sup>th</sup> Street, Room 101  
Rapid City SD 57701

Dear Curt:

Enclosed is a copy of the report, recommendation and public notice for Water Permit Application No. 2586-2 file by Rapid Valley Sanitary District. The notice is being published in the Rapid City Journal on June 14<sup>th</sup> and 21<sup>st</sup>. The application is scheduled to be considered by the Water Management Board on July 12, 2006 as set forth in the notice.

This is being sent to you to keep the Bureau aware of water right permitting issues involving Rapid Creek. If you have any questions, please call Mark Rath at (605) 773-3352.

Sincerely,

Eric Gronlund  
Water Rights Program, DENR  
(605) 773-3352

enclosures



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

June 8, 2006

John Wagner, Water Superintendent  
City of Rapid City  
300 6<sup>th</sup> Street  
Rapid City SD 57701

Dear Mr. Wagner:

Enclosed is a copy of the report, recommendation and public notice for a Water Permit Application No. 2586-2 file by Rapid Valley Sanitary District. The notice is being published in the Rapid City Journal on June 14<sup>th</sup> and 21<sup>st</sup>. The application is scheduled to be considered by the Water Management Board on July 12, 2006 as set forth in the notice.

This is being sent to you to keep the city aware of water right permitting issues involving Rapid Creek. If you have any questions, please call Mark Rath at (605) 773-3352.

Sincerely,

Eric Gronlund  
Water Rights Program, DENR  
(605) 773-3352

enclosures



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

June 8, 2006

Jerry Hammerquist  
Rapid Valley Conservancy District  
P.O. Box 26  
Caputa, SD 57725

Dear Mr. Hammerquist:

Enclosed is a copy of the report, recommendation and public notice for Water Permit Application No. 2586-2 file by Rapid Valley Sanitary District. The notice is being published in the Rapid City Journal on June 14<sup>th</sup> and 21<sup>st</sup>. The application is scheduled to be considered by the Water Management Board on July 12, 2006 as set forth in the notice.

This is being sent to keep you informed of water right permitting issues involving Rapid Creek. If you have any questions, please call Mark Rath at (605) 773-3352.

Sincerely,

Eric Gronlund  
Water Rights Program, DENR  
(605) 773-3352

enclosures



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

June 8, 2006

David Lamb  
4555 Reservoir Road  
Rapid City SD 57701

Dear Mr. Lamb:

Enclosed is a copy of the report, recommendation and public notice for Water Permit Application No. 2586-2 file by Rapid Valley Sanitary District. The notice is being published in the Rapid City Journal on June 14<sup>th</sup> and 21<sup>st</sup>. The application is scheduled to be considered by the Water Management Board on July 12, 2006 as set forth in the notice.

This is being sent to keep to you because the transfer involves land you own. If you have any questions, please call Mark Rath at (605) 773-3352.

Sincerely,

Eric Gronlund  
Water Rights Program, DENR  
(605) 773-3352

enclosures



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

June 8, 2006

Keith Ham  
15567 Hammerquist Road  
Caputa SD 57725

Dear Mr. Ham:

Enclosed is a copy of the report, recommendation and public notice for Water Permit Application No. 2586-2 file by Rapid Valley Sanitary District. The notice is being published in the Rapid City Journal on June 14<sup>th</sup> and 21<sup>st</sup>. The application is scheduled to be considered by the Water Management Board on July 12, 2006 as set forth in the notice.

This is being sent to keep you informed of water right permitting issues involving Rapid Creek. If you have any questions, please call Mark Rath at (605) 773-3352.

Sincerely,

Eric Gronlund  
Water Rights Program, DENR  
(605) 773-3352

enclosures





**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

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523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

June 8, 2006

Kevin Ham  
Rapid Valley Water Master  
3724 Freedom Ct.  
Rapid City SD 57701-7639

Dear Mr. Ham:

Enclosed is a copy of the report, recommendation and public notice for a Water Permit Application No. 2586-2 file by Rapid Valley Sanitary District. The notice is being published in the Rapid City Journal on June 14<sup>th</sup> and 21<sup>st</sup>. The application is scheduled to be considered by the Water Management Board on July 12, 2006 as set forth in the notice.

This is being sent to keep you informed of water right permitting issues involving Rapid Creek. If you have any questions, please call Mark Rath at (605) 773-3352.

Sincerely,

Eric Gronlund  
Water Rights Program, DENR  
(605) 773-3352

enclosures



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

June 8, 2006

Jaynell Higgins  
4080 Apple Tree Road  
Rapid City SD 57703-9391

Dear Ms. Higgins:

Enclosed is a copy of the report, recommendation and public notice for Water Permit Application No. 2586-2 file by Rapid Valley Sanitary District. The notice is being published in the Rapid City Journal on June 14<sup>th</sup> and 21<sup>st</sup>. The application is scheduled to be considered by the Water Management Board on July 12, 2006 as set forth in the notice.

This is being sent to keep you informed of water right permitting issues involving Rapid Creek. In this case the transfer from irrigation use to use by the District involves water appropriated by Vested Water Right No. 1727-2 for Murphy Ditch. If you have any questions, please call Mark Rath at (605) 773-3352.

Sincerely,

Eric Gronlund  
Water Rights Program, DENR  
(605) 773-3352

enclosures



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

July 24, 2006

**NOTICE**

TO: Jim Jester  
Rapid Valley Sanitary District  
4611 Teak Drive  
Rapid City SD 57703

FROM: Garland Erbele, Chief Engineer  
Water Rights Program *Garland Erbele*

SUBJECT: Preparation of Findings of Fact, Conclusions of Law and Final Decision

The Water Management Board directed Board Attorney John Guhin to prepare proposed Findings of Fact, Conclusions of Law and a Final Decision in the matter of Water Permit Application No. 2586-2. The Board approved Water Permit No. 2586-2 on July 12, 2006 pending adoption of findings.

The Board will conduct a telephone conference call to consider the proposed Findings, Conclusions and Final Decision at 2:00 PM, on Wednesday, August 23, 2006. The Parties may participate in the conference call by contacting Eric Gronlund or Brenda Binegar at (605) 773-3352 by August 12, 2006 with a direct telephone number. Due to limitations of the state's computerized conference call system, a direct phone number is required.

The Board requested that a copy of the proposed Findings, Conclusions and Final Decision be mailed to each Board member and the District by August 11, 2006. Written objections or comments in support of the proposed Findings, Conclusions and Final Decision, or alternative Findings, Conclusions and Final Decision are to be mailed to each Board member, the Board attorney and Water Rights Program counsel (mailing list enclosed) by August 18, 2006.

The public hearing was completed on July 12, 2006. No additional testimony will be received on August 23, 2006.

Enclosure

c: John Guhin, Deputy Attorney General  
Diane Best, Assistant Attorney General  
Ted Schultz, CETEC Engineering, Box 9014, Rapid City SD 57709-9014  
Brian Hagg, Whiting, Hagg & Hagg, PO Box 8008, Rapid City SD 57709  
Chuck Riter, Bangs McCullen Law Firm, PO Box 2670, Rapid City SD 57709-2670

## **WATER MANAGEMENT BOARD MEMBERS**

Francis E. Brink  
1214 South Wells Street  
Aberdeen, SD 57401-7351

Leo Holzbauer, Vice Chairman  
29416 395<sup>TH</sup> Avenue  
Wagner, SD 57380

Rodney Freeman, Jr.  
P.O. Box 176  
Huron, SD 57350-0176

Bernita Loucks, Secretary  
219 42<sup>nd</sup> Street  
Rapid City, SD 57702-0240

Dwayne Rollag  
320 Lincoln Lane S  
Brookings SD 57006-2741

James Hutmacher, Chairman  
802 East 7<sup>th</sup> Street  
Oacoma SD 57365

Everett Hoyt  
4422 Carriage Hills Dr  
Rapid City SD 57702-6874

## **BOARD ATTORNEY**

John Guhin, Deputy Attorney General  
Office of Attorney General  
Natural Resources Section  
State Capitol Building  
Pierre, SD 57501

## **WATER RIGHTS PROGRAM**

Department of Environment and  
Natural Resources  
Garland Erbele, Chief Engineer  
Water Rights Program  
Joe Foss Building  
523 East Capitol  
Pierre, SD 57501-3181

## **STAFF ATTORNEY**

Diane Best, Assistant Attorney General  
Office of Attorney General  
Natural Resources Section  
State Capitol Building  
Pierre, SD 57501

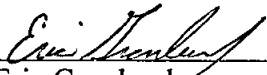
# CERTIFICATION

I hereby certify that on July 24, 2006, I have personally deposited with the United States mail at Pierre, South Dakota, first class postage, prepaid envelopes containing a Notice dated July 24, 2006, regarding preparation of findings of fact, conclusions of law and final decision in the matter of Water Permit Application No. 2586-2, Rapid Valley Sanitary District, addressed as stated below.

Jim Jester, Rapid Valley Sanitary District, 4611 Teak Drive, Rapid City SD 57703  
Ted Schultz, CETEC Engineering, Box 9014, Rapid City SD 57709-9014  
Brian Hagg, Whiting, Hagg & Hagg, PO Box 8008, Rapid City SD 57709  
Chuck Riter, Bangs McCullen Law Firm, PO Box 2670, Rapid City SD 57709-2670

## A copy of the Notice was sent Inter-office to:

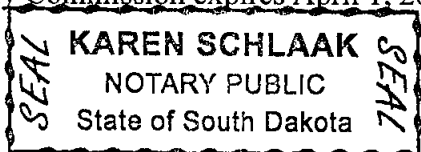
John Guhin, Deputy Attorney General  
Diane Best, Assistant Attorney General

  
Eric Gronlund  
Natural Resource Engineer  
Water Rights Program

STATE OF SOUTH DAKOTA     )  
                                          ) SS  
COUNTY OF HUGHES         )

Sworn to, before me, this 25<sup>th</sup> day of July, 2006.

  
Karen Schlaak  
Notary Public  
My Commission expires April 1, 2007





# BANGS McCULLEN

— LAW FIRM —

Reply to Rapid City Office

Writer's e-mail address: [criter@bangsmccullen.com](mailto:criter@bangsmccullen.com)

July 25, 2006

RECEIVED

JUL 27 2006

WATER RIGHTS  
PROGRAM

## RAPID CITY

Thomas H. Foye  
Thomas E. Simmons  
Charles L. Riter  
Allen G. Nelson  
James P. Hurley  
Michael M. Hickey  
Terry L. Hofer  
Rod Schlauger  
Daniel F. Duffy  
Jeffrey G. Hurd  
John H. Raforth  
Terry G. Westergaard  
Steven R. Nolan  
Gregory J. Erlandson  
Eric J. Pickar  
Sara L. Larson  
Thomas J. Von Wald  
Riley J. Wilson

## SIOUX FALLS

Michael A. Hauck  
John P. Mullen  
Brian K. Kirby  
Victoria M. Duehr  
Patrick J. Knecht

*Attorneys also admitted in  
Nebraska, North Dakota,  
Iowa and Minnesota.*

Mr. Garland Erbele  
Chief Engineer - Water Rights Program  
Department of Environment  
and Natural Resources  
PMB 2020  
Joe Foss Building  
523 East Capital  
Pierre, SD 57501-3182

Re: David S. Lamb/Rapid Valley Sanitary District

Dear Mr. Erbele:

Would you please add me to the mailing list for a copy of the  
proposed Findings, Conclusions, and Final Decision.

Thank you very much.

Very truly yours,

BANGS, McCULLEN, BUTLER,  
FOYE & SIMMONS, L.L.P.

Charles L. Riter

CLR:smb  
Enclosure  
cc: David S. Lamb

## RAPID CITY

First Western Gateway  
333 West Boulevard  
Suite 400  
P.O. Box 2670  
Rapid City, South Dakota  
57709-2670  
P: (605) 343-1040  
F: (605) 343-1503

## SIOUX FALLS

100 North Phillips Avenue  
Suite 610  
P.O. Box 949  
Sioux Falls, South Dakota  
57101-0949  
P: (605) 339-6800  
F: (605) 339-6801



STATE OF SOUTH DAKOTA



OFFICE OF ATTORNEY GENERAL

1302 East Highway 14, Suite 1  
Pierre, South Dakota 57501-8501

Phone (605) 773-3215

FAX (605) 773-4106

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**LARRY LONG**  
ATTORNEY GENERAL

**MARK BARNETT**  
CHIEF DEPUTY ATTORNEY GENERAL

RECEIVED  
AUG 21 2006  
WATER RIGHTS  
PROGRAM

---

MEMORANDUM

---

**TO:** Members of the Water Management Board and Interested Parties

**FROM:** Diane Best *DB*

**SUBJECT:** DENR Response to Proposed Findings of Fact, Conclusions of Law and Final Decision in Water Permit Application No. 2586-2, Rapid Valley Sanitary District

**DATE:** 08/18/2006

---

Consistent with previous notices, I am enclosing the DENR Response to Proposed Findings of Fact, Conclusions of Law and Final Decision in the above-entitled matter.

DB/sk

STATE OF SOUTH DAKOTA

WATER MANAGEMENT BOARD

IN THE MATTER OF WATER PERMIT )      DENR RESPONSE TO PROPOSED  
APPLICATION NO. 2586-2, RAPID )      FINDINGS OF FACT, CONCLUSIONS  
VALLEY SANITARY DISTRICT      )      OF LAW AND FINAL DECISION

COMES NOW the South Dakota Department of Environment and Natural Resources, Water Rights Program ("DENR") and makes its comments to the proposed Findings of Fact and Conclusions of Law drafted by Board counsel.

1. Finding of Fact No. 20 refers to an analysis of SDCL 46-5-34.1. The last sentence appears to contain a typographical error in citing to that statute. Accordingly, the DENR asks that the statute number be changed to SDCL 46-5-34.1.

2. The DENR asks that the Board make additional findings regarding the history and effect of overlapping irrigation rights for some of the lands involved in this proceeding. The DENR's proposed Findings are as follows:

This transfer involves 25 acres historically irrigated in SW1/4 SW14 Section 10, T 1N R8E and 343 acres historically irrigated in Section 15, R 8E, T1N, for a total of 368 acres. The irrigation right transferred in this proceeding has historically overlapped with two water permits (Water Permit Nos. 1461-2 and 1461A-2).

Water Permit Nos. 1461-2 and 1461A-2 originated with a 1914 permit for use at the Warren Lamb Lumber Co. mill. Subsequently, in 1976 the Lambs sought authority to change the use of the 1914 water right to provide irrigation for various property including 413.5 acres in Section 15, R 8E, T1N. The change in

use was approved. Of those 413.5 acres in Section 15, 334 acres are involved in this transfer.

To the extent that Water Permit Nos. 1461-2 and 1461A-2 applied to the same property (334 acres in section 15) as the water right sought to be transferred here, the combined use from all three rights is necessarily constrained by SDCL 46-5-6 which limits the maximum annual volume of water for each irrigated acre. In 1976 when the transfer of use occurred and the water rights coverage doubled up, SDCL 46-5-6 provided that the maximum annual volume for each acre of irrigated land was 3 acre feet per acre. Thus, the beneficial use of water for all permits combined for the 334 acres has been capped at 3 acre feet for approximately 30 years; there can be no claim to continuous use or other legal claim to a greater quantity now. This application seeks to transfer 867 acre feet to the Sanitary District or 2.36 acre feet per acre for the 368 acres involved. This leaves the irrigation of 334 acres of the Lamb property in Section 15 with a maximum volume limitation of .64 acre feet per year once the 2.36 acre feet has been transferred from the property. This was explained at the hearing and no objections were made.

3. In Conclusions of Law 7 and 8, the statutory citations should be SDCL 46-5-34.1. Once again, it appears that the incorrect statutory citation results from a typographical error.

4. The DENR asks that the Board adopt an additional Conclusion of Law which states as follows:

As set forth in the foregoing Findings of Fact, the irrigation right sought to be transferred in this proceeding has historically overlapped with two other water permits (Water Permit Nos. 1461-2 and 1461A-2) for 34 acres in Section 15. Like any other water rights for irrigation, the 334 acres were limited by the water use restrictions in SDCL 46-5-6 which limits the maximum annual volume of water for each irrigated acre. This Board concludes that the maximum annual

volume for each acre of irrigated land involved in this matter has historically been 3 acre feet per acre and pertained to the combined use for all three of the water permits applying to the 334 acres. Because the beneficial use of water for all these permits has been capped at 3 acre feet for many years for the 334 acres, there can be no claim to continuous use or other legal claim to a greater quantity now. Thus, the total combined volume allowed by law for all these permits is still capped by the total volume limitation of 3 acre feet per acre annually. After subtracting the 2.36 acre feet per acre involved in this transfer that is now severed from the property for use by Rapid Valley Sanitary District, this leaves .64 acre feet per acre annually for the 334 acres in Section 15.

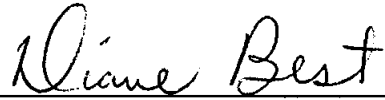
5. The Final Decision, No. 5, makes a legal conclusion regarding existing water rights. In that context, the word "right" should be plural.

6. The Final Decision, No. 7, lists the total acreage involved in this application. The acreage involved is 368 acres. This is a typographical error which appears to have been carried forward from a typographical error in one of the Exhibits to the proceeding. The testimony and hearing, however, clearly demonstrates that the acreage involved is, in fact, 368 acres.

7. Other than the foregoing proposed changes, the DENR urges that the proposed Findings of Fact, Conclusions

of Law and Final Decision be adopted as drafted by Board  
counsel.

Dated this 18<sup>th</sup> day of August, 2006.



---

Diane Best  
Assistant Attorney General  
1302 E. Highway 14, Ste. 1  
Pierre, SD 57501-8501  
Telephone: (605) 773-3215

s-pld.db Response to FOF & COL, Water Board (Rapid Valley Sanitary District)

CERTIFICATE OF SERVICE

The undersigned hereby certifies that true and correct copies of the DENR Response to Proposed Findings of Fact, Conclusions of Law and Final Decision In the Matter of Water Permit Application No. 2586-2, Rapid Valley Sanitary District was served upon each of the following by enclosing the same in envelopes with first class postage, prepaid and affixed thereto, and depositing said envelopes in the United States mail at Pierre, South Dakota, on this 18<sup>th</sup> day of August, 2006:

Francis E. Brink  
1214 S. Wells St.  
Aberdeen, SD 57401-7351

James Hutmacher  
802 E. 7th St.  
Oacoma, SD 57365

Bernita Loucks  
219 42nd St.  
Rapid City, SD 57702-0240

Dwayne Rollag  
320 Lincoln Lane S.  
Brookings, SD 57006-2741

Rodney Freeman, Jr.  
P.O. Box 176  
Huron, SD 57350-0176

Leo Holzbauer  
29416 395th Ave.  
Wagner, SD 57380

Everett Hoyt  
4422 Carriage Hills Dr.  
Rapid City, SD 5702-6874

Jim Jester  
Rapid Valley Sanitary District  
4611 Teak Dr.  
Rapid City, SD 57703

Ted Schultz  
CETEC Engineering  
P.O. Box 9014  
Rapid City, SD 57709-9014

Brian Hagg  
Whiting, Hagg & Hagg  
P.O. Box 8008  
Rapid City, SD 57709-8008

Chuck Riter  
Bangs, McCullen Law Firm  
P.O. Box 2670  
Rapid City, SD 57709-2670

Greg Erlandson  
Bangs, McCullen Law Firm  
P.O. Box 2670  
Rapid City, SD 57709-2670

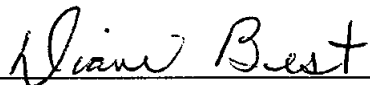


and sent on the same date by interoffice mail to:

Garland Erbele, Chief Engineer  
Water Rights Program  
Department of Environment  
and Natural Resources  
Foss Building  
Pierre, SD 57501-3181

and by hand delivery on the same date to:

John P. Guhin  
Assistant Attorney General  
1302 E. Hwy. 14, Ste. 1  
Pierre, SD 57501-8501

  
\_\_\_\_\_  
Diane Best  
Assistant Attorney General



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

September 5, 2006

**NOTICE**

TO: Jim Jester  
Rapid Valley Sanitary District  
4611 Teak Drive  
Rapid City SD 57703

FROM: Garland Erbele, Chief Engineer  
Water Rights Program *Garland Erbele*

SUBJECT: Adoption of Findings of Fact, Conclusions of Law and Final Decision

This is to notify you that the Final Decision, including Findings of Fact and Conclusions of Law, were adopted August 23, 2006, by the Water Management Board approving Water Right Permit No. 2586-2 filed by Rapid Valley Sanitary District. A copy of the signed Findings of Fact, Conclusions of Law and Final Decision is enclosed.

Enclosure

c: John Guhin, Deputy Attorney General  
Diane Best, Assistant Attorney General  
Ted Schultz, CETEC Engineering, Box 9014, Rapid City SD 57709-9014  
Brian Hagg, Whiting, Hagg & Hagg, PO Box 8008, Rapid City SD 57709  
Chuck Riter, Bangs McCullen Law Firm, PO Box 2670, Rapid City SD 57709-2670

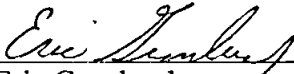
## CERTIFICATION

I hereby certify that on September 5, 2006, I have personally deposited with the United States mail at Pierre, South Dakota, first class postage, prepaid envelopes containing a Notice dated September 5, 2006, regarding adoption of findings of fact, conclusions of law and final decision in the matter of Water Permit Application No. 2586-2, Rapid Valley Sanitary District, addressed as stated below.

Jim Jester, Rapid Valley Sanitary District, 4611 Teak Drive, Rapid City SD 57703  
Ted Schultz, CETEC Engineering, Box 9014, Rapid City SD 57709-9014  
Brian Hagg, Whiting, Hagg & Hagg, PO Box 8008, Rapid City SD 57709  
Chuck Riter, Bangs McCullen Law Firm, PO Box 2670, Rapid City SD 57709-2670

### A copy of the Notice was sent Inter-office to:

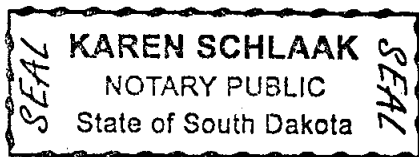
John Guhin, Deputy Attorney General  
Diane Best, Assistant Attorney General

  
Eric Gronlund  
Natural Resource Engineer  
Water Rights Program

STATE OF SOUTH DAKOTA     )  
                                          ) SS  
COUNTY OF HUGHES         )

Sworn to, before me, this 6<sup>th</sup> day of September, 2006.

  
Karen Schlaak  
Notary Public  
My Commission expires April 1, 2007



STATE OF SOUTH DAKOTA

BEFORE THE WATER MANAGEMENT BOARD

IN THE MATTER OF WATER PERMIT )  
APPLICATION NO. 2586-2, RAPID )  
VALLEY SANITARY DISTRICT )

FINDINGS OF FACT,  
CONCLUSIONS OF LAW  
AND FINAL DECISION

FINDINGS OF FACT

1. This is an application to transfer Vested Water Right No. 1727-2, held by Rapid Valley Water Company, to Rapid Valley Sanitary District.

2. Vested Water Right No. 1727-2 authorizes the irrigation of 368 acres of the David Lamb property. The Vested Water Right has a priority of April 6, 1878.

3. The application proposes to transfer this Vested Water Right and an annual volume of 867 acre feet of water from irrigation use by the Water Company to municipal, common distribution system, rural water system, suburban housing and domestic uses by the Sanitary District.

4. The source of water for the proposed transfer is natural flows of Rapid Creek, when available, through Murphy Ditch. No part of the right proposed to be transferred includes stored water or stored water releases from Deerfield-Pactola Reservoirs.

5. The Rapid Valley Sanitary District seeks to upgrade a facility built in the 1960s so that it may treat up to two million gallons of water per day at a facility on Rapid Creek.

6. The diversion rate which may, under statute, be transferred must be calculated based on water beneficially used.

7. The first step is to determine carriage loss. The Rapid Valley Water Company holds Vested Water Rights Nos. 1727-2, 2239-2, 2240-2, 2241-2 and 2242-2. Water subject to these rights flows in the ditch maintained by Rapid Valley and is shared by users as needed. There is, however, a loss of water in the ditch to the carriage system. The actual loss has been calculated at eleven percent.

8. The diversion rate which may be transferred therefore must be reduced by eleven percent to 5.05 cfs.

9. Next to be calculated is the actual use of water for crops. This is accomplished by means of a water budget which tracks historical water supply available to the ranch, the consumptive water use of the crops, the precipitation contribution and the return flows to Rapid Creek.

10. The amount of water consumed by the crops was determined by use of the Modified Blaney-Criddle method, adjusted for elevation. The method utilizes historical climatic data, crop type and elevation to calculate the volume of water

consumed by the crop on a monthly basis. The crops at issue in this controversy are alfalfa and hay.

11. The potential consumptive use as determined by use of the Modified Blaney-Criddle method is then compared to the water that was actually available for the crops use based on historical ditch diversions, transportation losses, irrigation efficiency and the total acreage irrigated annually from the ditch. The actual use of water on a monthly basis is then calculated.

12. For this proposed transfer, the average amount of water calculated to have been consumed by the crop is 563.6 acre feet of water annually.

13. A substantially higher amount of water was diverted than was utilized by the crop. The portion of the water historically diverted to the property but not utilized by the crop was returned to Rapid Creek either as direct surface runoff from the field or underground percolation through the alluvium. The amount of return flow was calculated at 303.5 acre feet annually.

14. The amount of water proposed to be transferred to Rapid Valley Sanitary District and diverted at its intake is 867 acre feet annually, the sum of 563.6 acre feet of water utilized by the crops and the return flow of 303.5.

15. The table set forth immediately below sets forth the monthly and annual volume limitations which are justified by the calculations identified above:

| Month | Volume Limitations<br>(ac-ft) |
|-------|-------------------------------|
| April | 42                            |
| May   | 105                           |
| June  | 118                           |
| July  | 158                           |
| Aug   | 199                           |
| Sept  | 147                           |
| Oct   | 98                            |
| Total | 867                           |

16. The Board next considers the rights of downstream water users who historically have used the water returned by the irrigation activities to Rapid Creek. It is proposed that the same amount of water which historically had been returned to Rapid Creek through the irrigation activities will now be returned to Rapid Creek through the Rapid City Waste Water System.

17. The mechanism by which this is proposed to be accomplished is as follows: the Rapid Valley Sanitary District presently contracts with Rapid City to treat the Sanitary District's effluent at the City's sewage treatment facility. Rapid City has, by Resolution of its governing body, committed to continue to discharge the Sanitary District's treated effluent to Rapid Creek downstream of the proposed project. The



Board finds that, because the amount of water to be released in this process is the same as has been returned to Rapid Creek by the irrigation activities, the process will adequately protect the rights of existing downstream water users.

18. The Board also finds that if, in the future, the Rapid Valley Sanitary District, through the City of Rapid City, stops returning effluent to Rapid Creek in quantities sufficient to protect the rights of downstream users to the extent that they were protected before the transfer approved today, then the diversion proposed by this water permit is required to be recalculated to reflect this condition and the permit may otherwise be amended.

20. Some controversy has arisen with regard to the application of SDCL 46-5-34.1. This statute provides generally that lands which had an irrigation right transferred from them pursuant to this section cannot qualify for another irrigation right from any other water source. Mr. Lamb has two existing water permits other than that at issue here which cover some of the same irrigated land. These two water permits have a priority of August 5, 1914, and provide for supplemental irrigation from Rapid Creek to the land irrigated by the 1878 right at issue and to other land. Because the 1914 water rights

predate SDCL 46-5-34.1, that statute does not affect their validity.

21. After considering the submissions of the Division, the Board makes three additional Findings regarding the overlapping irrigation rights.

22. This transfer involves 25 acres historically irrigated in SW1/4 SW1/4 Section 10, T1N, R8E and 343 acres historically irrigated in Section 15, R8E, T1N, for a total of 368 acres. The irrigation right transferred in this proceeding has historically overlapped with two water permits (Water Permit Nos. 1461-2 and 1461A-2).

23. Water Permit Nos. 1461-2 and 1461A-2 originated with a 1914 permit for use at the Warren Lamb Lumber Co. mill. Subsequently, in 1976 the Lambs sought authority to change the use of the 1914 water right to provide irrigation for various property including 413.5 acres in Section 15, R8E, T1N. The change in use was approved. Of those 413.5 acres in Section 15, 334 acres are involved in this transfer.

24. To the extent that Water Permit Nos. 1461-2 and 1461A-2 applied to the same property (334 acres in Section 15) as the water right sought to be transferred here, the combined use from all three rights is necessarily constrained by SDCL 46-5-6 which limits the maximum annual volume of water for each

irrigated acre. In 1976 when the transfer of use occurred and the water rights coverage doubled up, SDCL 46-5-6 provided that the maximum annual volume for each acre of irrigated land was 3 acre feet per acre. Thus, the beneficial use of water for all permits combined for the 334 acres had been capped at 3 acre feet for approximately 30 years; there can be no claim to continuous use or other legal claim to a greater quantity now. This application seeks to transfer 867 acre feet to the Sanitary District or 2.36 acre feet per acre for the 368 acres involved. This leaves the irrigation of 334 acres of the Lamb property in Section 15 with a maximum volume limitation of .64 acre feet per year once the 2.36 acre feet has been transferred from the property. This was explained at the hearing and no objections were made.

25. The District intends to phase in the proposed transfer over approximately 6 years. During this 6-year time period, Mr. Lamb will phase out irrigating his hay land through a lease back agreement with the District.

26. To ensure that the monthly amount of water diverted does not exceed the monthly allowable volume limitation, the permit should contain an appropriate qualification, by month, setting forth a monthly volume limitation as set forth in the Final Decision.

## CONCLUSIONS OF LAW

1. The Board has jurisdiction of this matter.
2. The Applicant's request for a change in use can be made without detriment to or impairment of existing rights when developed as set forth in the Findings, especially Findings 16-18, and when accomplished as set forth in the Final Decision.
3. The uses proposed by the Sanitary District are beneficial uses and the proposed change is in the public interest.
4. The priority date of April 6, 1878, which is the priority date of Vested Water Right No. 1727-2, is retained for the transferred water right.
5. The diversion rate to be transferred is 5.05 cfs.
6. Additional information may be made available to the Board with regard to seepage rates, hydrology, the matters referred to in Findings 16-18 or other matters within the jurisdiction of the Board which may require adjustment of monthly or total annual volume for diversion rates authorized by this permit. Therefore, the Board should retain jurisdiction to make these and other appropriate adjustments to the permit.
7. Water Permit Nos. 1461-2 and 1461A-2 have priority dates of August 5, 1914. The operation of SDCL 46-5-34.1 was not intended to, and does not, affect these water rights.

8. SDCL 46-5-34.1 prohibits the granting of any new water permit applications for irrigation of the land transferred in this transfer after the date of the approval of this permit.

9. As set forth in the foregoing Findings of Fact, the irrigation right sought to be transferred in this proceeding has historically overlapped with two other water permits (Water Permit Nos. 1461-2 and 1461A-2) for 34 acres in Section 15. Like any other water rights for irrigation, the 334 acres were limited by the water use restrictions in SDCL 46-5-6 which limits the maximum annual volume of water for each irrigated acre. This Board concludes that the maximum annual volume for each acre of irrigated land involved in this matter has historically been 3 acre feet per acre and pertained to the combined use for all three of the water permits applying to the 334 acres. Because the beneficial use of water for all these permits has been capped at 3 acre feet for many years for the 334 acres, there can be no claim to continuous use or other legal claim to a greater quantity now. Thus, the total combined volume allowed by law for all these permits is still capped by the total volume limitation of 3 acre feet per acre annually. After subtracting the 2.36 acre feet per acre involved in this transfer that is now severed from the property for use by Rapid

Valley Sanitary District, this leaves .64 acre feet per acre annually for the 334 acres in Section 15.

10. Approval of this application approves only the transfer of natural flow water and does not include any rights to stored irrigation water.

11. The amount of water requested to be transferred, 867 acre feet annually, is reasonable.

#### FINAL DECISION

The Application for Water Permit No. 2586-2 is approved subject to the following qualifications:

1. Permit No. 2586-2 is limited to a diversion rate of 5.05 cfs for a total annual volume of 867 acre feet. The Rapid Valley Sanitary District shall measure diversions at the Lamb property farm turnouts located on Murphy Ditch and diversion at the District's water treatment plant. The total monthly diversion shall not exceed the amount listed in the following table:

| Month | Volume Limitations<br>(ac-ft) |
|-------|-------------------------------|
| April | 42                            |
| May   | 105                           |
| June  | 118                           |
| July  | 158                           |
| Aug   | 199                           |
| Sept  | 147                           |
| Oct   | 98                            |
| Total | 867                           |

2. The Rapid Valley Sanitary District shall report to the Chief Engineer annually the amount of water withdraw each month at the Lamb property turnouts located on Murphy Ditch and diversion at the District's water treatment plant.

3. Permit No. 2586-2 authorizes diversion of only natural flow water by the Rapid Valley Sanitary District and does not include any right to stored irrigation water available under contract from Pactola Reservoir and Deerfield Reservoir.

4. The Water Management Board retains jurisdiction of Permit No. 2586-2 in the event that additional information shows that changes need to be made in the monthly or total annual volumes authorized by Permit No. 2586-2, or that other changes are required.

5. Diversion under Permit No. 2586-2 may not interfere with existing water rights in effect prior to approval of Permit No. 2586-2 or any domestic rights.

6. The amount of water with an April 6, 1878 priority date which may be appropriated under Vested Water Right No. 1727-2 is reduced by 5.05 cfs.

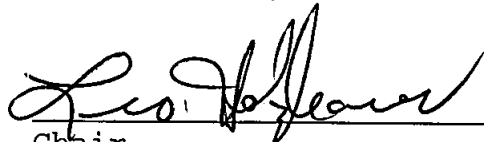
7. Upon termination of the lease back agreement, the 368 acres of Harney Peak Ranch property owned by David Lamb, which has been historically irrigated under the Vested Water Right No. 1727-2, located in portions of SW1/4 SW1/4 Section 10 and



portions of Section 15, T1N, R8E may not qualify for another new irrigation right from any water source.

Dated this 29 day of August 2006.

BY THE BOARD:

  
Chair

s-pld.jpg FOF & COL, Water Board (Rapid Valley Sanitary District)



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

NOV 03 2006

2586-2

Rapid Valley Sanitary District  
c/o Jim Jester  
4611 Teak Drive  
Rapid City SD 57703

Dear Mr. Jester:

Enclosed is Water Permit No. 2586-2 authorizing your water diversion system and beneficial use of the water, not exceeding the limits as specified in the Water Permit.

We will schedule an inspection so that the Water License may be issued to you, thus completing your acquisition of a Water Right.

Sincerely,

Garland Erbele, Chief Engineer  
Water Rights Program  
(605) 773-3352

enclosures



The Service You Are Entitled To

November 02, 2006

RECEIVED  
NOV - 6 2006  
WATER RIGHTS  
PROGRAM

PMB 2020  
SD DENR  
Joe Foss Building  
523 E. Capitol  
Pierre, SD 57501

RE: Water Rights Program  
Pennington County  
Our file # P-118202

Gentlemen:

Enclosed please find a certified copy of the Bill of Sale, Assignment, and Transfer to Rapid Valley Sanitary District, with a date and time receipt from the Pennington County Register of Deeds. We have also enclosed a check in the amount of \$2.50 for the filing fee.

Thank you for the opportunity to be of service. Should you need anything further for your file, please contact our office.

Sincerely,

PENNINGTON TITLE COMPANY

Gretchen Jackson  
Executive Assistant  
to the Vice President & Escrow Officer

Enclosures

**NOV 2 AM 8:43**

Document prepared by:  
Chuck L. Riter, Esq.  
Bangs, McCullen, Butler, Foye & Simmons, L.L.P.  
333 West Boulevard Suite 400; P.O. Box 2670  
Rapid City, SD 57709  
(605) 343-1040

**BILL OF SALE, ASSIGNMENT, AND TRANSFER**

David S. Lamb, for One Dollar (\$1.00) and other good and valuable consideration, sells, transfers, assigns, sets over, and conveys to Rapid Valley Sanitary District, a governmental subdivision of the state of South Dakota, and public body, corporate and politic, in accordance with SDCL §34A-5-514, 4611 Teak Drive, attention Mr. Jim Jester, Rapid City, South Dakota, 57703, all of his right, title, and interest in and to David E. Lamb's 33.4% interest in Water Rights 1727-2 (1878 Priority), currently also referenced as Water Right No. 02586-2, issued by the state of South Dakota appurtenant to the real property described on Exhibit A attached hereto and incorporated herein by this reference (the "Water Rights").

The Seller warrants and represents that the Water Rights described herein are:

(1) In good standing with the state of South Dakota and have not been forfeited or abandoned and are not subject to any judgment, suit, lien, receivership or any other encumbrance whatsoever;

(2) Free and clear of all liens, security interests, mortgages, pledges, encumbrances, ditch fees, taxes and assessments, and charges or claims of any nature whatsoever;

(3) According to the official records of the state of South Dakota, he owns all rights, title, and interest in and to the Water Rights;

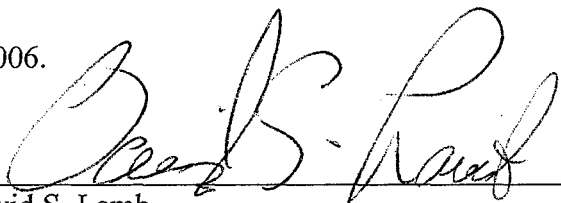
(4) He is the sole owner of ninety (90) shares of common stock in Rapid Valley Water Company, Inc., which represents the entirety of his interest; and stock in the corporation. *DSF*

(5) He has no knowledge of any outstanding judgments against him that would in any manner affect the consummation of this transaction or constitute any cloud upon the title to the Water Rights; and

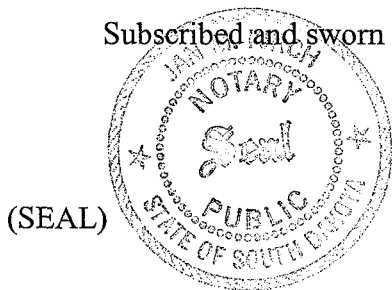
(6) He has no knowledge of any pending litigation, proceedings, or investigations, or any threats of litigation, proceedings or investigations, or any threats of litigation, proceedings or investigations, which might result in any cloud upon the title to the Water Rights.

This Bill of Sale, Assignment, and Transfer may be recorded with the Pennington County Register of Deeds, Rapid City, South Dakota, but only as a miscellaneous document. This document does not sell, convey, alter or affect any of the Seller's right, title, and interest in and to the real property described or Exhibit A attached hereto and incorporated herein by this reference.

Dated this 1<sup>ST</sup> day of November, 2006.

  
\_\_\_\_\_  
David S. Lamb

Subscribed and sworn to before me this 1<sup>ST</sup> day of November, 2006.



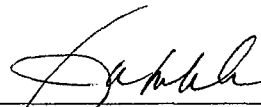
  
\_\_\_\_\_  
Notary Public, South Dakota  
My Commission Expires: 1-4-2010

Exhibit A

REAL PROPERTY

David S. Lamb:

|             |             |    |
|-------------|-------------|----|
| SW1/4 SW1/4 | S10-TIN-R8E | 25 |
| NW1/4 NW1/4 | S15-TIN-R8E | 31 |
| SW1/4 NW1/4 | S15-TIN-R8E | 38 |
| NW1/4 SW1/4 | S15-TIN-R8E | 30 |
| SE1/4 NW1/4 | S15-TIN-R8E | 32 |
| NE1/4 SW1/4 | S15-TIN-R8E | 31 |
| SW1/4 NE1/4 | S15-TIN-R8E | 38 |
| NW1/4 SE1/4 | S15-TIN-R8E | 29 |
| SE1/4 NE1/4 | S15-TIN-R8E | 25 |
| NE1/4 SE1/4 | S15-TIN-R8E | 38 |
| SW1/4 SW1/4 | S15-TIN-R8E | 1  |
| SE1/4 SW1/4 | S15-TIN-R8E | 11 |
| SW1/4 SE1/4 | S15-TIN-R8E | 24 |
| SE1/4 SE1/4 | S15-TIN-R8E | 15 |

|                     |           |
|---------------------|-----------|
| David S. Lamb Total | 368 acres |
|---------------------|-----------|



**DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES**

PMB 2020  
JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182  
[www.state.sd.us/denr](http://www.state.sd.us/denr)

November 8, 2006

1727-2  
2586-2

Gretchen Jackson  
Pennington Title Company  
725 Kansas City St  
Rapid City SD 57701

Dear Ms. Jackson:

We have received the Bill of Sale, Assignment and Transfer document you forwarded to us prepared by Bangs, McCullen, Butler, Foye & Simmons LLP.

Vested Water Right No. 1727-2 and Water Permit No. 2586-2 were applied for and issued under the name of Rapid Valley Sanitary District. David Lamb's stock interest in the District may have been conveyed to Rapid Valley Sanitary District; however since Nos. 1727-2 and 2586-2 are already listed in the district's name, the ownership change will not be necessary.

We will place a copy of the document you forwarded in each of the files but a filing fee will not be required. Enclosed is the title company's check in the amount of \$2.50.

If you have any questions, please contact Mark Rath with our program at 605 773-3352.

Sincerely,

Genny McMath  
Environmental Scientist  
Water Rights Program  
(605) 773-3352  
email: [genny.mcmath@state.sd.us](mailto:genny.mcmath@state.sd.us)

c: Chuck Riter, w/Bangs McCullen, Butler, Foye & Simmons LLP



**Water Rights Program - DENR**

**File Documentation**

**File No.** 2586-2

**County:** *Pennington*

**Name of Person:** Rapid Valley Sanitary District (*Rusty Schmid*)

**Address:** *Rapid City SD*

**Date:** 3/13/07    **Telephone:**

**RE:** *Reporting Requirements*

**Comments:**

*Rusty Schmidt with the Rapid Valley Sanitary District called concerning the reporting requirements for No. 2586-2. He said the District would not be using any water this summer because the new treatment plant would not be operating until December 2007. I told him they did not need to report the water use by the District and Mr. Lamb this year.*



Mark D Rath

Natural Resources Engineering Specialist

| DAVID LAMB WATER RIGHTS |            |                   |               | 2009     |
|-------------------------|------------|-------------------|---------------|----------|
| YEAR                    | MONTH      | ACRE FEET/allowed | MONTHLY USAGE | COMMENTS |
| 2009                    | APRIL      | 13                | none          | rainfall |
|                         |            |                   |               |          |
| 2009                    | MAY        | 32                | none          | rainfall |
|                         |            |                   |               |          |
| 2009                    | JUNE       | 35                | none          | rainfall |
|                         |            |                   |               |          |
| 2009                    | JULY       | 47                | 13.4af        |          |
|                         |            |                   |               |          |
| 2009                    | AUGUST     | 60                | 41.9af        |          |
|                         |            |                   |               |          |
| 2009                    | SEPTEMEBER | 44                | 30af          |          |
|                         |            |                   |               |          |
| 2009                    | OCTOBER    | 29                | 21.4af        |          |
|                         |            |                   |               |          |
|                         |            |                   |               |          |

enough natural flows/no murphy rights required for 2009

# Rapid Valley Water Rights

| 2009   |                  |                        |          |            |              |
|--------|------------------|------------------------|----------|------------|--------------|
|        | murphy<br>rights | little giant<br>rights | bor/city | ac/ft used | comments     |
| april  | none             | none                   | none     | 53         | natural flow |
|        |                  |                        |          |            |              |
| may    | none             | none                   | none     | 74         | natural flow |
|        |                  |                        |          |            |              |
| june   | none             | none                   | none     | 71         | natural flow |
|        |                  |                        |          |            |              |
| july   | none             | none                   | none     | 107        | natural flow |
|        |                  |                        |          |            |              |
| august | none             | none                   | none     | 105        | natural flow |
|        |                  |                        |          |            |              |
| sept   | none             | none                   | none     | 87         | natural flow |
|        |                  |                        |          |            |              |
| oct    | none             | none                   | none     | 56         | natural flow |

no water rights used all natural flows

# Rapid Valley Water Rights

| 2010   |                  |                        |          |            |              |
|--------|------------------|------------------------|----------|------------|--------------|
|        | murphy<br>rights | little giant<br>rights | bor/city | ac/ft used | comments     |
| april  | none             | none                   | none     | 62         | natural flow |
|        |                  |                        |          |            |              |
| may    | none             | none                   | none     | 70         | natural flow |
|        |                  |                        |          |            |              |
| june   | none             | none                   | none     | 79         | natural flow |
|        |                  |                        |          |            |              |
| july   | none             | none                   | none     | 124        | natural flow |
|        |                  |                        |          |            |              |
| august | none             | none                   | none     | 119        | natural flow |
|        |                  |                        |          |            |              |
| sept   | none             | none                   | none     | 91         | natural flow |
|        |                  |                        |          |            |              |
| oct    | none             | none                   | none     | 74         | natural flow |

no water rights used all natural flows

NOV 17 2010

WATER RIGHTS  
PROGRAM

| DAVID LAMB WATER RIGHTS |           |                   |               | 2010     |
|-------------------------|-----------|-------------------|---------------|----------|
| YEAR                    | MONTH     | ACRE FEET/allowed | MONTHLY USAGE | COMMENTS |
| 2010                    | APRIL     | 13                | none          | rainfall |
|                         |           |                   |               |          |
| 2010                    | MAY       | 32                | none          | rainfall |
|                         |           |                   |               |          |
| 2010                    | JUNE      | 35                | none          | rainfall |
|                         |           |                   |               |          |
| 2010                    | JULY      | 47                | none          | rainfall |
|                         |           |                   |               |          |
| 2010                    | AUGUST    | 60                | 21.5af        |          |
|                         |           |                   |               |          |
| 2010                    | SEPTEMBER | 44                | 43af          |          |
|                         |           |                   |               |          |
| 2010                    | OCTOBER   | 29                | 25.9af        |          |
|                         |           |                   |               |          |
|                         |           |                   |               |          |

enough natural flows/no murphy rights required for 2010

**Permit No. 2586-2**  
**Upper Cheyenne River - Water District**

**Report of Examination of Works and/or Application of Water to Beneficial Use**

TO: Chief Engineer, Water Rights Program, DENR, Foss Bldg., Pierre, SD 57501

I have on this day, 6/6/2012, conducted a thorough examination of the water use system constructed by Rapid Valley Sanitary District, 4611 Teak Drive, Rapid City, SD 57703, holder of Permit No. 2586-2, bearing the priority date of April 6, 1878. Permit No. 2586-2 is authorized to appropriate a total of 5.05 cfs with an annual volume limitation of 867 acre-feet of surface water from Rapid Creek for commercial, domestic, industrial, municipal, rural water system and suburban housing development purposes in Pennington County.

Inspection contact and relationship to  
permit holder, if applicable:

**Rusty Schmidt,**  
**District Manager**

A. Works used to divert the water:

**Infiltration gallery consisting of 2 intakes and 3 submersible pumps.**

B. Works used to transport water to place of use:

**Municipal distribution lines.**

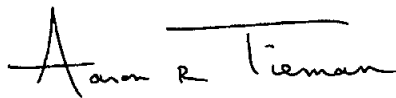
The system is in the following condition good. The point of diversion (well) is located specifically at Lat/Lon – N44.050785/W-103.146189 which is the approximately 735 feet south and 1375 feet east of the NW corner of Section 15, T1N-R8E. The works are capable of diverting 5.5 cfs which is to be used for commercial, domestic, industrial, municipal, rural water system and suburban housing development purposes.

Water has been put to beneficial use to the maximum extent and the license should be issued for 5.05 cfs with an annual volume limitation of 867 acre-feet.

All structures, wells and lands on map Y

Exceptions to compliance are: none.

Comments: Water Permit No. 2586-2 changes the diversion point location and transfers a portion of Rapid Valley Water Company (aka Murphy Ditch) stockholder/landowner's use of Rapid Creek natural flows appropriated under Vested Water Right No. 1727-2 from Murphy Ditch. The transfer is for Rapid Creek water historically used to irrigate 368 acres at the Harney Peak Ranch owned by David Lamb. The portion of Rapid Creek natural flows to be transferred to Rapid Valley Sanitary District is 5.05 cfs with an annual volume limitation of 867 acre-feet of water.



Aaron R. Tieman  
Natural Resources Engineer II  
DENR, Water Rights Program

Date report completed: June 29, 2015

## FIELD INVESTIGATION REPORT FOR PERMIT NO. 2586-2

|                                                                     |                                                                           |
|---------------------------------------------------------------------|---------------------------------------------------------------------------|
| DATE OF INVESTIGATION:                                              | June 6, 2012                                                              |
| NAME & ADDRESS OF PERMIT HOLDER                                     | Rapid Valley Sanitary District<br>4611 Teak Drive<br>Rapid City, SD 57703 |
| INVESTIGATION CONTACT/ RELATIONSHIP TO PERMIT HOLDER, IF APPLICABLE | Rusty Schmidt<br>(District Manager)                                       |
| DIVERSION POINT LEGAL LOCATION                                      | NE¼ NW¼ Section 15, T1N-R8E                                               |
| WATER SUPPLY SOURCE                                                 | Surface water, Rapid Creek                                                |

Other permit(s) associated with the project: Vested Water Right No. 1727-2 (See comments below).

### Water Treatment Plant:

#### Pump #1:

- 1) Make: Goulds
- 2) Model: VLT-CAFM
- 3) Capacity: 700 GPM

#### Motor:

- 1) Make: US Motors
- 2) Model: 20069462-100
- 3) Horsepower rating: 25 hp

#### Pump #2:

- 4) Make: Goulds
- 5) Model: VLT-CAFM
- 6) Capacity: 700 GPM

#### Motor:

- 4) Make: US Motors
- 5) Model: 20096462-100
- 6) Horsepower rating: 25 hp

#### Pump #3:

- 7) Make: Goulds
- 8) Model:
- 9) Capacity: 1100 GPM

#### Motor:

- 7) Make: US Motors
- 8) Model: DT93
- 9) Horsepower rating: 40 hp

### DISTRIBUTION LINES OR CANALS:

- 1) Type: Municipal distribution lines.

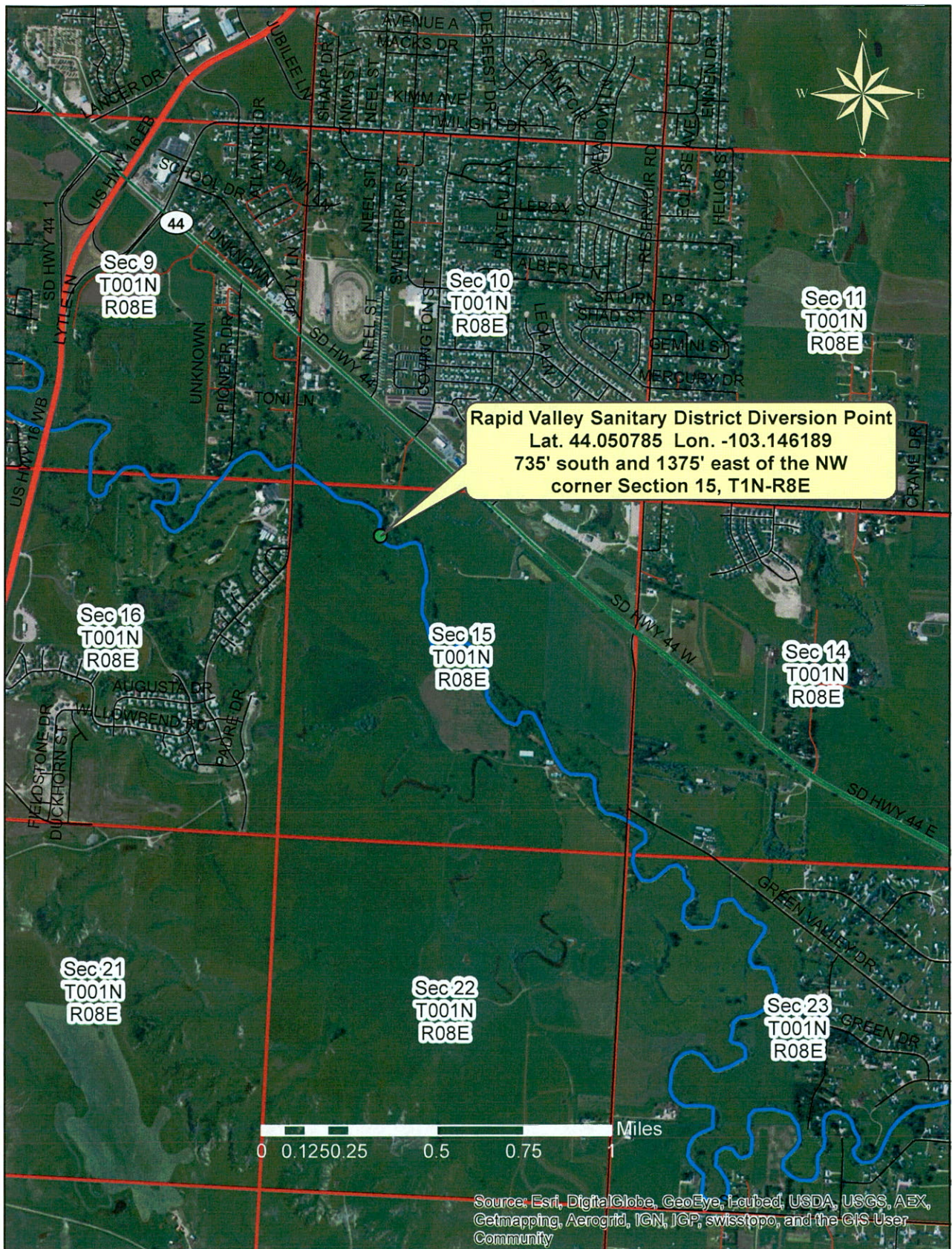
### PERMIT QUALIFICATIONS:

- 1) Special qualifications to permit being abided by Yes
- 2) All structures, wells and lands on map Yes

**COMMENTS: Water Permit No. 2586-2 changes the diversion point location and transfers a portion of Rapid Valley Water Company (aka Murphy Ditch) stockholder/landowner's use of Rapid Creek natural flows appropriated under Vested Water Right No. 1727-2 from Murphy Ditch.**



Water Right 2586-2  
Rapid Valley Sanitary District  
June 6, 2012



*Aaron R. Tieman*

Aaron Tieman  
Natural Resources Engineer II  
DENR Water Rights Program





TO: JEANNE GOODMAN, P.E., CHIEF ENGINEER  
WATER RIGHTS PROGRAM

FROM: AARON TIEMAN, ENGINEER II  
WATER RIGHTS PROGRAM

SUBJECT: INSPECTION OF IRRIGATION DIVERSION POINT ABANDONMENT FOR RAPID VALLEY  
SANITARY DISTRICT, PENNINGTON COUNTY, SOUTH DAKOTA.

RAPID VALLEY SANITARY DISTRICT (RVSD) HAS OBTAINED THE FOLLOWING WATER RIGHTS FROM IRRIGATORS SERVED BY RAPID CREEK LOCATED IN THE RAPID VALLEY AREA:

|               |               |
|---------------|---------------|
| <b>2586-2</b> | <b>2671-2</b> |
| <b>2641-2</b> | <b>2672-2</b> |
| <b>2670-2</b> |               |

A PERMIT CONDITION OF THESE WATER RIGHT TRANSFERS IS THAT THE HOLDER OF THE PERMIT SHALL PERMANENTLY RENDER INOPERABLE THE STRUCTURAL MEANS OF DIVERTING WATER TO LAND THAT IS NO LONGER SUBJECT TO THE WATER PERMIT. THE ABANDONMENT OF THE AFOREMENTIONED DIVERSION STRUCTURES WAS PERFORMED AND COMPLETED BY RVSD. ONCE COMPLETED, RVSD NOTIFIED THE WATER RIGHTS PROGRAM AND EACH SITE WAS INSPECTED AND DOCUMENTED TO VERIFY COMPLIANCE OF THE PERMIT CONDITION.

IT SHOULD BE NOTED THAT THE DIVERSION STRUCTURES ASSOCIATED WITH WATER PERMIT No. 2586-2 (TWO DIVERSION STRUCTURES) AND WATER PERMIT No. 2671-2 (ONE DIVERSION STRUCTURE) WERE LEFT IN PLACE DUE TO EXISTENCE OF DOWNSTREAM IRRIGATORS THAT ARE STILL ABLE TO RECEIVE WATER THAT UTILIZE THESE DIVERSION STRUCTURES.

AARON TIEMAN, ENGINEER WITH THE WATER RIGHTS PROGRAM, CONDUCTED THE SITE INSPECTIONS AND WAS ACCOMPANIED BY RUSTY SCHMIDT, MANAGER OF RVSD.



DEPARTMENT of ENVIRONMENT  
and NATURAL RESOURCES

JOE FOSS BUILDING  
523 EAST CAPITOL  
PIERRE, SOUTH DAKOTA 57501-3182

[denr.sd.gov](http://denr.sd.gov)

JUL 01 2016

Rusty Schmidt, District Manager  
Rapid Valley Sanitary District  
4611 Teak Drive  
Rapid City SD 57703

RE: Water License Nos. 2586-2, 2641-2, 2670-2, 2671-2 & 2672-2

Dear Mr. Schmidt:

Enclosed are Water License Nos. 2586-2, 2641-2, 2670-2, 2671-2 & 2672-2. They are the final water right documents completing the process of obtaining Water Rights. Included with each license is a map prepared by the staff engineer who conducted the field investigation.

As long as you use the water beneficially, as stated in the Water Licenses, State Water Laws provide that you have a continuing right to use the water.

Sincerely,

Jeanne Goodman, Chief Engineer  
Water Rights Program  
(605) 773-3352

enclosures

**STATE OF SOUTH DAKOTA  
WATER LICENSE NO. 2586-2**

---

(1) The Rapid Valley Sanitary District, 4611 Teak Drive, Rapid City SD 57703 made Application No. 2586-2, May 8, 2006 for a water permit to transfer a portion of Rapid Valley Water Company (aka Murphy Ditch) stockholder/landowner's use of Rapid Creek natural flows appropriated under Vested Water Right No. 1727-2 from Murphy Ditch. The transfer was for Rapid Creek water historically used to irrigate 368.0 acres at the Harney Peak Ranch owned by David Lamb. The portion of Rapid Creek natural flows transferred to the Sanitary District was 5.05 cubic feet of water per second (cfs) with an annual volume limitation of 867.0 acre feet of water.

Water Permit No. 2586-2, with a priority date of April 6, 1878, (established by the Murphy Ditch vested water right for natural flow) also changed the existing diversion point on Rapid Creek for Murphy ditch to a permanent diversion point for use by the Sanitary District. Permit No. 2586-2 did not authorize a new appropriation from Rapid Creek and is limited to 5.05 cfs for purposes of municipal, industrial, commercial, common distribution system, rural water system, suburban housing and domestic use in Pennington County.

(2) It is certified that the permit holder has complied with the provisions of South Dakota State Law and is entitled to divert 5.05 cubic feet of water per second for beneficial use with an annual volume limitation of 867.0 acre feet of water. The location of the diversion point is approximately 735 feet south & 1,375 feet east of the NW corner of Section 15, T1N, R8E (NE ¼ NW ¼).

(3) The permit holder has complied with the provisions of South Dakota State Law relating to the application of water to beneficial use.

(4) Pursuant to South Dakota Water Law 46-5-30.1 Rapid Valley Sanitary District, 4611 Teak Drive, Rapid City SD 57703 the holder and/or owner of Water Right No. 2586-2 is issued a license to appropriate water, the right to use 5.05 cubic feet of water per second from Rapid Creek with a priority date of April 6, 1878 from the location specified in (2) of this license for municipal, industrial, commercial, common distribution system, rural water system, suburban housing and domestic use purposes.

This license is subject to South Dakota Water Law, any limitations or conditions listed in Water Right No. 2586-2 and subject to the following qualifications:

- Permit No. 2586-2 is limited to a diversion rate of 5.05 cfs for a total annual volume of 867 acre feet. The Rapid Valley Sanitary District shall measure diversions at the Lamb property farm turnouts located on Murphy Ditch and diversion at the District's water treatment plant. The total monthly diversion shall not exceed the amount listed in the following table.

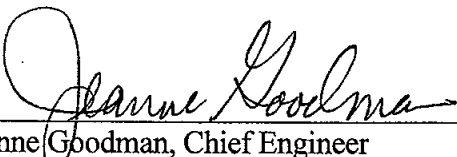
Monthly Volume Limitation

| Month        | acre feet    |
|--------------|--------------|
| April        | 42.0         |
| May          | 105.0        |
| June         | 118.0        |
| July         | 158.0        |
| August       | 199.0        |
| September    | 147.0        |
| October      | 98.0         |
| <b>TOTAL</b> | <b>867.0</b> |

continued

**Water Permit No. 2586-2**  
**Rapid Valley Sanitary District**  
**Page 2**

- The Rapid Valley Sanitary District shall report to the Chief Engineer annually the amount of water withdraw each month at the Lamb property turnouts located on Murphy Ditch and diversion at the District's water treatment plant.
- Permit No. 2586-2 authorizes diversion of only natural flow water by the Rapid Valley Sanitary District and does not include any right to stored irrigation water available under contract from Pactola Reservoir and Deerfield Reservoir.
- The Water Management Board retains jurisdiction of Permit No. 2586-2 in the event that additional information shows that changes need to be made in the monthly or total annual volumes authorized by Permit No. 2586-2.
- Diversion under Permit No. 2586-2 may not interfere with existing water rights in effect prior to approval of Permit No. 2586-2 or any domestic rights.
- The amount of water with a April 6, 1878 priority date, which may be appropriated under Vested Water Right No. 1727-2, is reduced by 5.05 cfs.
- Upon termination of the lease back agreement, the 368 acres of Harney Peak Ranch property owned by David Lamb, which has been historically irrigated under the Vested Water Right No. 1727-2, located in portions of SW ¼ SW ¼ Section 10 and portions of Section 15, T1N, R8E may not qualify for another new irrigation right from any water source.

  
\_\_\_\_\_  
Jeanne Goodman, Chief Engineer  
Water Rights Program  
Department of Environment and Natural Resources

**JUL 01 2016**  
\_\_\_\_\_  
date

