Benefits obtainable
from the
Narrows Reservoir
on the
South Platte River
near
Weldon Colorado

Robert E. Glover
Effect of Narrow Reservoirs

The narrow reservoir is located where the 58/58 range line crosses the Platte River. This is near the town of Welden, near the highway. The reservoir area is about 9.6 miles of river valley between the two gates. The reservoir area is 32,900 acres. The irrigated area is 32,900. Normal requirement for irrigation water taken to be 100. Irrigation water requirement for this area is 32,900 acre-feet.

Evaporation rates are 5.14, 2.64, and 4.21. Assuming storage of the beginning of the period in 1938 (200,000 acre-feet) and an evaporative loss of 100,000 acre-feet, the water requirement for this period is 200,000 acre-feet.

Water use is 2.177, with a consumptive use of 2.177. For Free water use, see page 19. For United States, see page 19. For Nevada, see page 19. For New Mexico, see page 19. For other locations, see page 19. For July 1950, see page 19. For Table 1. Miscellaneous stations—Page 19. To convert from acre-feet to feet (0.7112) = 0.058733.

<table>
<thead>
<tr>
<th>Month</th>
<th>Evaporation (feet)</th>
<th>Evaporation Area (acres)</th>
<th>Precipitation (inch)</th>
<th>Consumptive Use A.F.</th>
<th>Precipitation (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>-</td>
<td>2.93</td>
<td>5.26</td>
<td>3.66</td>
<td>1.65</td>
</tr>
<tr>
<td>Feb</td>
<td>-</td>
<td>1.70</td>
<td>1.52</td>
<td>2.13</td>
<td>1.02</td>
</tr>
<tr>
<td>Mar</td>
<td>2.64</td>
<td>5.14</td>
<td>2.62</td>
<td>6.42</td>
<td>3.27</td>
</tr>
<tr>
<td>Apr</td>
<td>2.76</td>
<td>10.02</td>
<td>5.33</td>
<td>1.25</td>
<td>2.00</td>
</tr>
<tr>
<td>May</td>
<td>2.36</td>
<td>22.08</td>
<td>8.55</td>
<td>16.17</td>
<td>9.50</td>
</tr>
<tr>
<td>Jun</td>
<td>3.26</td>
<td>16.04</td>
<td>10.75</td>
<td>15.60</td>
<td>9.26</td>
</tr>
<tr>
<td>Jul</td>
<td>4.02</td>
<td>32.16</td>
<td>13.35</td>
<td>12.53</td>
<td>8.68</td>
</tr>
<tr>
<td>Aug</td>
<td>3.77</td>
<td>30.16</td>
<td>17.45</td>
<td>2.47</td>
<td>3.78</td>
</tr>
<tr>
<td>Sep</td>
<td>3.12</td>
<td>24.96</td>
<td>7.32</td>
<td>8.13</td>
<td>1.98</td>
</tr>
<tr>
<td>Oct</td>
<td>1.80</td>
<td>14.40</td>
<td>1.87</td>
<td>170.32</td>
<td>89.18</td>
</tr>
</tbody>
</table>

Chances: 2.128 7.032 8.918

Notes: On 8,000 Acres 32,900 A. 32,900 A.

Precipitation gain on 32,900 A. Flow at Keystone (1953-1958)

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation gain on 32,900 A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>12.04</td>
</tr>
<tr>
<td>Feb</td>
<td>21.12</td>
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<tr>
<td>Mar</td>
<td>65.96</td>
</tr>
<tr>
<td>Apr</td>
<td>53.20</td>
</tr>
<tr>
<td>May</td>
<td>51.32</td>
</tr>
<tr>
<td>Jun</td>
<td>41.22</td>
</tr>
<tr>
<td>Jul</td>
<td>30.46</td>
</tr>
<tr>
<td>Aug</td>
<td>22.64</td>
</tr>
<tr>
<td>Sep</td>
<td>12.44</td>
</tr>
<tr>
<td>Oct</td>
<td>8.13</td>
</tr>
<tr>
<td>Nov</td>
<td>36.67</td>
</tr>
<tr>
<td>Dec</td>
<td>5.07</td>
</tr>
</tbody>
</table>

On 32,900 A.
Evaporation AF
Precipitation on reservoir surface:
Consumptive use on 32900 ft 2/112 ft
Precipitation on 32900 ft
Yield of reservoirs

Computation of benefits from Narrow Reservoir

Present acreage:
Acres above the Narrow reservoir
Acres below the Narrow reservoir
Assumed flow past Julesburg
Supply needed by present acreage below Narrow

Estimated yield of reservoirs
Supply needed by present acreage
Additional acres which can be irrigated

Note: If 150000 AF/yr, julesburg the irrigable acreage would be 44,231 acres in addition to the present area.
The salinity would then be about 5200 ppm at the State line.

Estimated yield of reservoirs
Flow past Julesburg for salinity control
Acres irrigable below Narrow
Total acres irrigable below Jersey

Consumptive use following blinson (feet)

Water, applied AF/YR

Join
Feb 35
Mar 87
Apr 162
May 260
June 327
July 406
Aug 357
Sept 235
Oct 139
Nov 65
Dec 23
2123

Water supplied and consumed
Application allowance
Leaching allowance

\[
\frac{782863}{316381} = 2.492379 \text{ AF/yr}
\]

Application allowance
Leaching allowance

\[
\frac{466331}{314231} = 1.5 \text{ AF/yr}
\]

* See Correlation Computations
Distance between Rosay and Northern border 1137 miles
Distance between Rosay and Kuleburg 140-37 = 103 miles

Irrigation water required 1,00 0 AF/yr.

<table>
<thead>
<tr>
<th>Month</th>
<th>Consumptive use on 316331 &amp; 149940</th>
<th>Precipitation on 316331 &amp; 149940</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>5.05 AF/YR</td>
<td>115.78 AF/YR</td>
</tr>
<tr>
<td>Feb</td>
<td>1.1072 AF/YR</td>
<td>67.38 AF/YR</td>
</tr>
<tr>
<td>Mar</td>
<td>2.0056 AF/YR</td>
<td>2.0056 AF/YR</td>
</tr>
<tr>
<td>Apr</td>
<td>3.0344 AF/YR</td>
<td>1.0811 AF/YR</td>
</tr>
<tr>
<td>May</td>
<td>1.2643 AF/YR</td>
<td>1.0811 AF/YR</td>
</tr>
<tr>
<td>June</td>
<td>1.1072 AF/YR</td>
<td>1.0811 AF/YR</td>
</tr>
<tr>
<td>July</td>
<td>7.4338 AF/YR</td>
<td>279.2 AF/YR</td>
</tr>
<tr>
<td>Aug</td>
<td>2.0056 AF/YR</td>
<td>87.64 AF/YR</td>
</tr>
<tr>
<td>Sept</td>
<td>7.276 AF/YR</td>
<td>7.276 AF/YR</td>
</tr>
<tr>
<td>Oct</td>
<td>6.680924 AF/YR</td>
<td>5.537 AF/YR</td>
</tr>
<tr>
<td>Nov</td>
<td>3.52614 AF/YR</td>
<td>3.52614 AF/YR</td>
</tr>
<tr>
<td>Dec</td>
<td>3.22532 AF/YR</td>
<td>3.22532 AF/YR</td>
</tr>
</tbody>
</table>

Irrigation water required 4.1723 AF/YR

Check of water needed for irrigation and drainage.

<table>
<thead>
<tr>
<th></th>
<th>T</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.22532</td>
<td>4.1723 AF/YR</td>
</tr>
<tr>
<td></td>
<td>150 000</td>
<td>4.66331 AF/YR</td>
</tr>
<tr>
<td></td>
<td>4.72532 AF/YR</td>
<td>6.201 AF/YR</td>
</tr>
</tbody>
</table>

This is 6201 AF/YR greater than the estimated yield of the Narrows, Riverside, Empire and Jackson reservoirs.

Total water applied = 322532 + 316331 + 150 000 = 788863 4 AF/YR

Leaching application:

\[
\frac{150 000}{316331} = 0.474 \text{ ft/yr}
\]

Total application including precipitation = 2.112 + 0.474 = 2.586 ft/yr

This is less than is now applied. Practical considerations may dictate higher application to get the water down the furrows. Add an application of 1.0 ft.

Then the total application is 1.115 + 1.00 + 1.00 + 0.474 = 3.59 AF/yr

Make the application 2.414 ft/yr

Irrigation water consumed = 322532 AF/yr

The return flow factor will be

\[
\frac{316331 + 149940}{322532} = 1.44566
\]
<table>
<thead>
<tr>
<th>Month</th>
<th>Net return flow, AP</th>
<th>Reservoir released to supply Nebraska demand, AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>314.09 AF</td>
<td>1.296 AF</td>
</tr>
<tr>
<td>Feb</td>
<td>248.66 AF</td>
<td>1.2515 AF</td>
</tr>
<tr>
<td>Mar</td>
<td>157.23 AF</td>
<td>1.2261 AF</td>
</tr>
<tr>
<td>Apr</td>
<td>58.44 AF</td>
<td>242.81 AF</td>
</tr>
<tr>
<td>May</td>
<td>51.37 -</td>
<td>132.45 AF</td>
</tr>
<tr>
<td>Jun</td>
<td>101.21 AF</td>
<td></td>
</tr>
<tr>
<td>Jul</td>
<td>169.03 -</td>
<td></td>
</tr>
<tr>
<td>Aug</td>
<td>58.67 -</td>
<td></td>
</tr>
<tr>
<td>Sept</td>
<td>137.60 AF</td>
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<tr>
<td>Oct</td>
<td>267.85 AF</td>
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<tr>
<td>Nov</td>
<td>341.71 AF</td>
<td></td>
</tr>
<tr>
<td>Dec</td>
<td>354.11 AF</td>
<td>685.98 AF</td>
</tr>
</tbody>
</table>

Total irrigation water applied.  

Irrigation water consumed: 
Application allowance
Leaching allowance

Application allowance
Leaching allowance
Applied water reaching the water table

\[ \frac{788.863}{316331} = 2.493 \text{ ft} \]

Note: Application of 2.493 ft/year implies that some of the return flow has not been diverted.
<table>
<thead>
<tr>
<th>Month</th>
<th>Applied Water Reaching the Water Table A.F.</th>
<th>Seasonal Fluctuation of Return Flow A.F.</th>
<th>Return Flow A.F.</th>
<th>Rediversion in Consumptive Use Pattern A.F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>62.65</td>
<td>50.51</td>
<td>338.05</td>
<td>23.96</td>
</tr>
<tr>
<td>Feb</td>
<td>104.28</td>
<td>87.48</td>
<td>301.08</td>
<td>52.42</td>
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<tr>
<td>Mar</td>
<td>168.29</td>
<td>101.02</td>
<td>287.54</td>
<td>130.31</td>
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<tr>
<td>Apr</td>
<td>272.10</td>
<td>87.48</td>
<td>301.08</td>
<td>242.64</td>
</tr>
<tr>
<td>May</td>
<td>751.92</td>
<td>50.51</td>
<td>338.05</td>
<td>389.42</td>
</tr>
<tr>
<td>June</td>
<td>1,143.26</td>
<td>439.07</td>
<td>437.04</td>
<td>489.77</td>
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<tr>
<td>July</td>
<td>1,059.58</td>
<td>476.04</td>
<td>489.77</td>
<td>608.10</td>
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<tr>
<td>Aug</td>
<td>651.21</td>
<td>468.58</td>
<td>534.71</td>
<td>534.71</td>
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<tr>
<td>Sep</td>
<td>321.02</td>
<td>476.04</td>
<td>551.98</td>
<td>208.19</td>
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<tr>
<td>Oct</td>
<td>124.40</td>
<td>439.07</td>
<td>97.36</td>
<td>97.36</td>
</tr>
<tr>
<td>Nov</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec</td>
<td>4,662.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean rate of return flow: 
\[
\frac{4,662.71}{12} = 388.56 \text{ A.F. per mo}
\]

Amplitude of seasonal variation: 
\[
(388.56)(0.26) = 101.02 \text{ A.F. per mo}
\]

Summary A.F.: 
\[
1,142.31
685.98
456.38
\]

Water made available by Narrows Nebraska demand. Net benefit from Narrows.

Notes: In December and January, the natural precipitation is in excess of the consumption use. This is the reason no figures for applied water appear in the tabulations for irrigation water used and consumed and applied water reaching the water table.

The benefits of the reservoir may be summarized as follows:

Acre-feet irrigated below Narrows
= Acre-feet irrigated above Narrows
Total acre-feet irrigated = Acre-feet irrigated below Narrows + Acre-feet irrigated above Narrows + Additional acre-feet irrigable with Narrows

With a consumptive use of one foot per year of irrigation water, this represents 1142.31 acre-feet of new water made available by Narrows reservoir.
With 300,000 acres irrigated below Nebraska the area just Julesburg could be used to

127784 + 16331 = 144115 AF/yr

The salinity would then be \((300000)(1600) = 3330 \text{ ppm}\)

144115

The case would be tolerable. The irrigated area could then be 300,000 + 32,900 = 332,900

The increased acreage would be 97900 AF/yr. This would imply 979,000 AF/yr, or the yield

of 97900 AF/yr. No deviation

Nov 8, 1968

---

Calendar year,

1947 - 61

229,700 AF Julesburg

315,000 Westmce

109,700 AF Benefit

From Huntley

Region 7

Nov 8, 1968
A.F.

Consumptive use (following Munson)
2.112 A/yr

Irrigation water consumed

Precipitation
1.1 A/yr

10 A/yr

For 3163.1 Acres.
## AREA CAPACITY DATA—NARROWS RESERVOIR, COLORADO

<table>
<thead>
<tr>
<th>CONTROL POINT</th>
<th>INITIAL AREA IN ACRES</th>
<th>CAPACITY (\text{acre-ft}) INITIAL</th>
<th>INCREMENT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ELEV. IN FEET</strong></td>
<td><strong>ITEM</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4453.0</td>
<td><strong>TOP OF DAM</strong></td>
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</tr>
<tr>
<td>4447.0</td>
<td><strong>MAX. W.S.</strong></td>
<td>39,628</td>
<td></td>
<td>1,548,553</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>4428.5</td>
<td><strong>SURCHARGE 18.5'</strong></td>
<td>575,373</td>
<td>973,185</td>
<td></td>
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<tr>
<td></td>
<td><strong>Spillway Elev. 3'</strong></td>
<td></td>
<td></td>
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<tr>
<td>4404.3</td>
<td><strong>FLOOD CONTROL</strong></td>
<td>475,000</td>
<td>498,185</td>
<td></td>
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<tr>
<td>4399.0</td>
<td><strong>JOINT USE</strong></td>
<td>75,000</td>
<td>423,185</td>
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<tr>
<td>4351.0</td>
<td><strong>CONSERVATION</strong></td>
<td>373,025</td>
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<td></td>
<td><strong>INACTIVE</strong></td>
<td>32,810</td>
<td>17,350</td>
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<tr>
<td>4307.0</td>
<td><strong>DEAD</strong></td>
<td>0</td>
<td>17,350</td>
<td>0</td>
</tr>
</tbody>
</table>

**NOTES:**

\(\wedge\) Elevation of sill of canal outlet works and sill of river outlet works

*March 1966 Narrows Unit Report Appendix I Design Notes*
Gudgeon. Huntley USBR Reg.

7-11 NW 7 FF Morton
sec 7 81/2 4N R 58 W
13, 23, 25, 25 1/2, 34N 125 9 sec.

Where is the site of the proposed power plant?

What is the significance of the survey data?

What is the spillway crest length? 100 ft.

What is the spillway crest elevation? 4428.5

What provision for sloughing, siltation, and errosion? 3.5 to 4.5 ft above reservoir level.
Surplus pumping is allowed to continue until the return flow is 1/2 of the water applied. The consumption of surface water, 1/4 of devermin, generated by 1/3 of amount pumped. Let \( q \) represent the amount of water pumped.

\[
\frac{3}{4} \cdot \frac{3}{4} = \frac{9}{16}
\]

Water consumed \( \frac{9}{16} \) of \( q \) divided by \( 1/3 \) of amount pumped.

Then the land irrigated by \( q \) plus area irrigated by surface devermin.

The salinity would be about 3200 ppm, that \( 1600 \) ppm rain, and the present salinity is \( 3000 \) ppm.

For lands served by surface devermin, water is applied at the rate of \( 4 \) ft.

Nebraska demand \( 120,000 \) cfs April 1 to Oct 15 198 days.

\[
198 \times 0.98347 \times 120 = 198 \times 238 = 47127 \text{ AFY} / \text{AF}
\]

This is the total area served by pumps.

\[
\frac{1}{2} \times 47127 = 23563.5 \text{ AFY} / \text{AF}
\]

This is the total area served by pumps divided by 1.25.

\[
\frac{47127}{1.25} = 37702 \text{ AFY} / \text{AF}
\]

This is the total area served by pumps divided by 1.25.

\[
\frac{37702}{1.25} = 29360 \text{ AFY} / \text{AF}
\]

This is the total area served by pumps divided by 1.25.

Actually, \( 316331 + 158000 = 466331 \text{ AFY} / \text{AF} \) must be diverted. (This is a little more than the short estimate)

\[
466331 \times \frac{1}{4} = 116583 \text{ AFY} / \text{AF}
\]

Return flow

\[
466331 \times \frac{3}{4} = 116583 = 233165 \text{ return flow}
\]

Of this 166330 \( \frac{1}{4} \) AFY / AF can be rediverted.

\[
166330 \times \frac{1}{4} = 41582 \text{ AFY} / \text{AF}
\]

Summary

\[
(158165)(2) = 316330 \text{ acre, irrigated}
\]

\[
(466331 + 166330) \times \frac{1}{4} = 158165 \text{ acre, irrigated from canal}
\]

\[
116583 + 41582 = 158165 \text{ acre, irrigated by pump}
\]

\[
233165 - 166330 + 8315 = 150000 \text{ AFY} / \text{AF} \text{ return flow}
\]
Reservoir releases
Rediversion
Total applied

\[
\frac{632660}{158165} = 4.000 \frac{f}{yr}
\]
One half of area supplied from well. 150,000 AFNet return.

<table>
<thead>
<tr>
<th>Acres above Narrow</th>
<th>Acres below Narrow</th>
<th>Total acres below Julesburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.350.00</td>
<td>3.29.00</td>
<td>2.021.00</td>
</tr>
<tr>
<td>1.500.00</td>
<td>3.521.00</td>
<td>3.521.00</td>
</tr>
<tr>
<td>4.663.31</td>
<td>3.521.00</td>
<td>2.421.13</td>
</tr>
<tr>
<td>9.001.8T</td>
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<td></td>
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</tbody>
</table>

Estimated yield of reservoirs.
Supply needed by present acreage.
Nebraska demand.
Additional acres which can be irrigated.

Check computation

<table>
<thead>
<tr>
<th>Acres above Narrow</th>
<th>Acres below Narrow</th>
<th>Total acres below Julesburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.163.31</td>
<td>3.29.00</td>
<td>2.492.31</td>
</tr>
<tr>
<td>2.350.00</td>
<td>1.14231</td>
<td>2.421.13</td>
</tr>
<tr>
<td>9.001.8T</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Assumed acres irrigable below Narrow.
Assumed acreage above Narrow.
Assumed total acreage irrigable.

Nebraska demand.
Additional acres irrigable with Narrow reservoir in operation.

D.G. 11-26-68
Total return flow is \( 316330 + 8365 = 316335 \) AF/yr

\[ \frac{316330}{12} = 26361 \text{ AF/Mo} \]

Amplitude is \( (26361)(0.26) = 6854 \text{ AF/Mo} \)

Amount is diverted is 166330 AF/yr. This reduced flow

\[ \frac{166338}{2.112} = 78755 \]

<table>
<thead>
<tr>
<th>Month</th>
<th>Return flow AF</th>
<th>Nebraska demand AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>-</td>
<td>47.93</td>
</tr>
<tr>
<td>Feb</td>
<td>-</td>
<td>104.64</td>
</tr>
<tr>
<td>Mar</td>
<td>-</td>
<td>260.61</td>
</tr>
<tr>
<td>Apr</td>
<td>-</td>
<td>485.28</td>
</tr>
<tr>
<td>May</td>
<td>-</td>
<td>778.84</td>
</tr>
<tr>
<td>Jun</td>
<td>-</td>
<td>979.54</td>
</tr>
<tr>
<td>Jul</td>
<td>-</td>
<td>1216.19</td>
</tr>
<tr>
<td>Aug</td>
<td>-</td>
<td>1069.41</td>
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<tr>
<td>Sep</td>
<td>-</td>
<td>703.95</td>
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<tr>
<td>Oct</td>
<td>-</td>
<td>416.58</td>
</tr>
<tr>
<td>Nov</td>
<td>-</td>
<td>194.71</td>
</tr>
<tr>
<td>Dec</td>
<td>-</td>
<td>68.90</td>
</tr>
</tbody>
</table>

\[ 242.13 + 6326.58 = 7200 \]
(Acre feet)

100,000

Effect of Narrows reservoir

Acres irrigated by Surface water 158,165.
Acres irrigated by pumps 158,165.
Irrigation water consumed 1.0 A/yr
Precipitation 1.115 A/yr

50,000

Consumptive use 2.115 A/yr.

Water diverted for irrigation and leaching.

63,266.1 AF

31,633.1
32,900
349,231
235,000
242,138

316,331
329,000
349,231
235,000
242,138

Acres irrigable below Narrows.
Acres above Narrows.
Total acres irrigable.
Present acreage.
Nebraska demand.
Additional acres irrigable with Narrows reservoir in operation.
90,000.

Net return flow?

150,000 AF

Nebraska demand.

24,200 AF
Lower South Platte Water Supplies

This memorandum is an effort to add a little basic information about what happens to the water that passes Kersey and supplies the systems in Water Districts One and Sixty-four.

The study is based on tabulations of stream flows, consumptive uses and return flows in the 140 mile valley between Kersey and the State line near Julesburg.

The basic data was compiled from reports of the State Engineer, U.S.C.S., records of the Water Commissioners of Districts One and Sixty-four, and of some of the irrigation systems.

Monthly and yearly averages of the various tabulations were computed. Stream discharges at Kersey, Balsac and Julesburg since about 1905 were tabulated by months and averaged.

With more records available, similar studies for the past 20 years included diversions for both direct use and storage, consumptive uses and return flows. "Years" are "water years" from October 1 to the following September 30.

Some of the data was included in a report to the Directors of Northern Colorado Water Conservancy District about a year ago.

It may be stated here that for practical purposes, Water District One is nearly coextensive with Morgan County and District Sixty-four includes the irrigated areas in Washington, Logan and Sedgwick counties.

Taking a brief look at the long-time records we find an annual average of 532,000 acre-feet at Kersey, 250,000 at Balsac and 340,000 at Julesburg.
Balzac is 47% of Kersey, Julesburg is 64% of Kersey and 130% of Balzac. There were 24 years above the average at Kersey and 34 years below. No cycle or pattern is apparent in the wide variation of flow.

The maximum was 1,580,000 acre-feet in 1914 and the minimum 159,000 in 1955. There were five years above 1,000,000 acre-feet and fifteen years below 300,000 acre-feet.

During a thirteen year period (1929-1941) only one year exceeded slightly the 58 year average and the average for this period was only 330,000 acre-feet. The recent short four year period (1953-1956) averaged only 198,000 acre-feet.

There is little apparent difference in the regimen or performance of the river in the early years of the century and in recent decades. The ratio of Julesburg flow to Kersey in the second decade (1911-1920) of 55% compares to 57% in the last ten years.

It may be noted here that the basic supplies at Kersey, except in periods of flash floods or occasional surplus runoff from the upper Districts, are also return flows. While no accurate estimate seems possible, probably about 90% of the usable Kersey discharges are return waters from the upper irrigated areas.

With more data available, this "memo" will try to explain what the records show for the past 20 years only, starting with District No. One.

Due to the fact that most of the storage for District No. Sixty-four reservoirs is diverted in District One makes it a little awkward to explain the diversions and uses in the two Districts separately.

The twenty year averages for District No. One show that 509,000 acre-feet entered the District at Kersey and 258,000 passed Balzac - a difference of 251,000 acre-feet.
Average diversions in the District were 206,000 acre-feet for direct use and 349,000 for storage, a total of 555,000 acre-feet.

Adding this figure to the recorded Balzac discharge and deducting the Kersey flow of 509,000, we get 304,000 acre-feet as the average annual return flow in the 65 miles of river in District One. These returns vary from 384,000 acre-feet, or 8.1 C.F.S. per mile in 1946 to a minimum of 102,000 acre-feet or 2.2 C.F.S. in 1955 — the lowest of the recent four year "drought" period. Also, these flows fluctuate widely during the year due largely to interception of the returns during the growing season by the hundreds of irrigation wells.

However, 132,000 of the storage diversions were for North Sterling and Prewitt reservoir in District Sixty-four. Subtracting this from the total diversion of 555,000 leaves 423,000 diverted for use in District One.

If we add the figure of 132,000 acre-feet to the recorded Balzac flow of 258,000 getting 390,000 and then subtract this from the Kersey flow of 509,000, we find that only 119,000 acre-feet was actually consumed in District One.

Or, if we deduct the 304,000 acre-feet return flow from the 423,000 diverted for District One use, we get the same figure of 119,000 acre-feet or 25% of the diversions.

Apparently, on the face of these figures and ignoring rainfall effects, this use includes evaporation on reservoirs and canals and the consumptive use of the water pumped from wells as well as the actual transpiration and evaporation from surface supplies on the crops in the fields under the ditches.

Available figures on irrigated acreage are not entirely accurate but assuming 130,000 acres (including about 35,000 acres above the ditches and supplied by wells) the consumption would be about nine-tenths of an acre-foot per acre.
The records of the four reservoirs show an average annual discharge of 77,000 acre-feet out of the 216,000 diverted from the river.

The following table is a summary of these storage operations. The large losses are mostly seepage returns to the river, adding to the supplies to the systems below.

These reservoirs may be of more value to users down the river than to the people who built and paid for them.

<table>
<thead>
<tr>
<th></th>
<th>Capacity</th>
<th>Diversions</th>
<th>Discharge</th>
<th>% Cap.</th>
<th>% Div.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverside</td>
<td>57,500</td>
<td>93,100 *</td>
<td>37,310</td>
<td>65</td>
<td>40</td>
</tr>
<tr>
<td>Empire</td>
<td>37,700</td>
<td>68,800</td>
<td>15,600</td>
<td>40</td>
<td>23</td>
</tr>
<tr>
<td>Jackson L.</td>
<td>35,600</td>
<td>39,900</td>
<td>22,500</td>
<td>63</td>
<td>56</td>
</tr>
<tr>
<td>Bijou No. 2</td>
<td>9,200</td>
<td>14,700</td>
<td>1,600</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>140,000</td>
<td>216,500</td>
<td>77,000</td>
<td>55</td>
<td>36</td>
</tr>
<tr>
<td>* Storage Only</td>
<td></td>
<td>Loss</td>
<td>139,500</td>
<td>45</td>
<td>64</td>
</tr>
</tbody>
</table>

Adding the 206,000 acre-feet of direct use diversions to the 77,000 of reservoir discharge, we get 283,000 acre-feet as the average annual gravity supply to the 95,000 acres under the ditches, a headgate average of about 3.0 acre-feet per acre. Delivery losses are heavy.

In the 12 ditches or systems they vary from 10 or 15% to 50% or more under poor conditions in the Riverside and Bijou systems.

Pump discharges from the wells on the 35,000 acres above the ditches vary from less than an acre-foot per acre in the upper tributary valleys to 2 to 3 acre-feet nearer the main valley. Assuming an average of 2 acre-feet would mean 70,000 acre-feet annually. Also, the hundreds of wells supplying supplemental water on lands under the ditches probably utilize an equal amount of ground water in an average season.