Bulletin No. 66 - Irrigation Investigations on the North Platte River in 1904

University of Wyoming Agricultural Experiment Station

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Irrigation Investigations on the North Platte River in 1904.

By the Irrigation Engineer.

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Agricultural Experiment Station.

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Irrigation Work on the North Platte River.

BY B. P. FLEMING.

During the season of 1904 this Station co-operated with the Hydrographic Division of the U. S. Geological Survey in a study of irrigation conditions on the North Platte River. The object of the study was to secure data which might be used in the design of irrigation works on this river under the terms of the so-called Reclamation Act. The investigation as planned was to include determinations of the amount of water used per acre in already irrigated districts along the river, measurements of seepage from canals in use and other observations on the use, distribution and value of water. While the field of work of the Wyoming Experiment Station necessarily must be restricted to Wyoming, yet it was found that no suitable locality for the investigation could be found along the river in this state. However, just across the line in Nebraska was found a large body of land in a high state of cultivation and irrigated by an extensive system of canals, some of which have their headgates in Wyoming. In soil and climate, conditions in this district are representative of a large body of land adjacent to the river in Wyoming and which will probably be included in the government project.

Considering the applicability of the results to Wyoming conditions, it was decided to undertake the investigation. By the terms of the agreement under which the work was carried on, the writer had charge of and carried out all field work, the necessary expenses being borne by the Geological Survey.

GENERAL CHARACTERISTICS OF THE DISTRICT.

The district embraced in the investigation extends from the Wyoming line, some twenty-five miles into Nebraska,
stretching along both sides of the river. Familiarly, the locality is known as the Mitchell District. On the north side of the river the land is watered chiefly by the Farmers' and the Enterprise Canals. Much of the land on this side is in the river bottom, the remainder on the first plain above. The soil in general is excessively sandy, in some places not enough humus being present to prevent the injurious erosion of fields when plowed, by the high winds which often blow. A large area is given over to the growth of native hay; particularly is this true of the river bottom. Corn is grown, though with indifferent success, while alfalfa and the small grains, especially oats, do remarkably well. On the south side of the river is found the Mitchell and Gering Joint Canal, the largest on the river, and irrigating an extensive body of highly productive land. This canal presents certain interesting features of construction and ownership, which will be described later.

The soil on the south side is sandy, but differs from that on the north side in that it contains considerable quantities of gypsum, washed down from a range of bluffs which extend parallel to and some ten miles from the river. In the Mitchell Valley, which is separated from the river by low sand hills, is found perhaps the richest land in the district, and the country, as one drives through it, is strongly suggestive of prosperous farming districts in Iowa and Illinois. Alfalfa, corn, wheat, oats and potatoes are extensively grown.

Both on the north and south sides of the river a crop is produced which is perhaps characteristic of the locality, but which could undoubtedly be grown with equal success in similar parts of Wyoming. This is the native hay crop. This hay consists almost entirely of the native wheat-grasses, induced by careful irrigation to give a yield of from one to two tons per acre. This hay sells for about six dollars per ton and is highly esteemed in the Denver markets. Because of the comparatively short seasons and high winds, fruits do not do well either on the north or south sides, although a few orchards are found in the district, these being in the more protected local-
Irrigation Work on the North Platte River.

...advantage of the district, consequently the chief sale of farm products is for the purpose of cattle feeding in the immediate locality.

The entire district has been developed within the past fifteen years. Previous to that time the country was considered fit only for the grazing of cattle, and what is now a large part of the fertile Mitchell Valley was once the "bull pasture" of a large cattle company. This district, in common with other portions of Western Nebraska, suffered that retardation in development which followed the rush of settlers to the region from 1880 to 1890, the majority of whom, failing to raise crops under the scanty rainfall, moved away and carried with them their discouraging impressions of the country. A square patch of ground on a barren hillside which, by its color and absence of the native turf, shows that it was once plowed, together with a rusted pump and the remnants of a shack, are all that now remain of the pathetic attempt of the early settler to gain a foothold in this region by the farming methods of the east. Nearly all of the present canals were projected and built by those of these early settlers who perceived the possibilities of the country in the way of agriculture when practiced under irrigation, and many of the canals are the product mainly of their own labor. These canals are now organized under the Irrigation District Law of Nebraska, which seems to operate satisfactorily, though the ability of the districts to meet their bonds has not yet been tested, as most of the districts are comparatively young.

DUTY OF WATER DETERMINATIONS AND KINDRED DATA.

The investigations of the amount of water used were carried on upon all the large canals in the district and also upon an individual farm. To determine the amount of water used under the canals as a whole, rating stations were established near the heads of each as far above the irrigated lands as was possible, while at the same time securing a suitable place for a rating station. Observers were hired to make daily readings
of the gages, and frequent measurements of flow were made during the season, from which rating curves were drawn. Difficulty was encountered in making up the tables of discharge, due to the fact that the canal sections were in a constant state of change, due to erosion, shifting and filling in of the canal bottom. All gage heights were, therefore, corrected by Prof. Stout's method, and with these corrections in gage height made, the diagrams following were prepared. The flow in all canals will be found to be quite irregular, due not only to rise and fall of the river, and the opening and closing of head gates to accommodate the demand for water, but also to breaks in the canals, necessitating several shut-downs for repairs during the season.

In considering the duty of water determinations, each canal will be considered by itself, and all the facts necessary to an understanding of conditions under it will be included.

**THE MITCHELL AND GERING CANAL.**

This canal is on the south side of the river and irrigates a considerable area in the Mitchell Valley and in the vicinity of Gering, the county seat of Scottsbluff County. As a matter of fact, the canal is a joint affair, being controlled by two distinct irrigation districts. The original canal, the Mitchell, has its headgate in Wyoming and has a length of about twenty-five miles. Construction upon it commenced August 18, 1890, and water was first turned into it July 20, 1891. Its original cost was $37,500, of which ninety per cent was contributed in the form of labor by farmers interested. Some years subsequent
to the completion of the Mitchell Canal, holders of land in the Gering District being desirous of irrigating these lands, entered into an agreement with the Mitchell management by which they were to enlarge the canal of the latter and build an extension from the Mitchell Canal into the Gering District. Water right complications being anticipated, by reason of the location of the head of the original canal in Wyoming, the Gering management constructed a branch leading to the river about three miles below the headgate of the original canal, and in Nebraska. Consequently, we find the somewhat unique condition of a canal with two distinct heads, from either one or both of which water may be drawn.

Both canals are managed under the district system, the Mitchell District being bonded for $56,100 and the Gering for $217,000. The Mitchell Canal was originally in control of a stock company, but the usual difficulty was encountered when assessments for maintenance of canal were levied upon holders of stock who were not landholders. Hence the organization under the irrigation district system, brought about in 1898. The average assessment in 1904 in the Mitchell District was 61.24 cents per acre. In the Gering District, $1.98.

Water Measurements. During the entire season a continuous record was kept of the flow of water in the main canal and likewise in the Gering extension. The gaging station in the main canal was about one hundred yards below the junction of the separate heads, so that all water entering the district was measured, with the exception of that used upon one or two small farms whose laterals were above the junction. The difference between the amount brought in by the main canal and that flowing in the Gering extension is obviously that used in the Mitchell District. The daily flow in the main canal and that in the extension is shown graphically in diagram on page 6. The flow is seen to be quite irregular, due chiefly to breaks in the canal. The worst break was due to an unusually heavy rain storm; the other was probably due to an overtaxing of
Irrigation Work on the North Platte River.

Irrigation. Work on the North Platte River. 7

the capacity of the canal. A particularly bad break in the Gering extension necessitated a complete shut-down for about two weeks in the early part of July, a circumstance which probably worked seriously to the disadvantage of crops in the Gering District.

Use of Water. The amount of water used and the actual acreage to which it was applied, including the time of irrigation, has been investigated in this district, as well as in the Enterprise District, across the river. The acreage and dates of irrigation, etc., were ascertained by an individual canvass of the district, and from the unusually complete replies obtained, the accompanying diagram has been drawn. Aside from data as to the amount of water used, an important object of the investigation was to determine at what time during the season water is most required. While the flow of the canal (being varied to suit the requirements of irrigators) shows this point to some extent, a more definite idea may be obtained from a study of the amount of land actually under irrigation daily or weekly during the season. This will show the relative necessity for water probably more accurately than will the flow of the canal, which represents the ability of the system to meet the requirements, rather than the actual requirement itself. In the diagram is shown the weekly flow of the canal in acre feet, together with such percentage as this may be of the total flow during the season. In dotted line is shown the percentage of the total acreage irrigated for which water was desired each week.

These curves show that two periods of maximum requirement occur, one in the early part of May and the other about the middle of July. The early requirement is more particularly for facilitating spring plowing and for the irrigation of the first crop of alfalfa. The second period is for the second crop of alfalfa and small grains. The native hay crop is frequently irrigated the entire summer, and this, together with the irrigation of gardens and the few orchards, tends to flatten out the
curve. The acreage as represented at the lower depressions in the curves may be considered to represent the area of native hay under irrigation at that time. As will be seen from the diagram, approximately twenty per cent of the entire acreage was watered from the 2d to 27th of April, and about eighteen per cent from the 15th to 20th of July.

In the following table is shown the average dates of irrigation of the commoner crops grown in the district. The practice of different irrigators varies widely, some irrigating alfalfa only once during the season, others three or four times. Potatoes may be irrigated by some farmers five or six times. In the table is given the average practice:

<table>
<thead>
<tr>
<th>Crop</th>
<th>First Irrigation</th>
<th>Second Irrigation</th>
<th>Third Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>April 25</td>
<td>July 15</td>
<td>September 15</td>
</tr>
<tr>
<td>Native hay</td>
<td>May 5</td>
<td>June 27</td>
<td>September 15</td>
</tr>
<tr>
<td>Corn</td>
<td>June 13</td>
<td>July 29</td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>June 8</td>
<td>July 7</td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td>June 18</td>
<td>Aug. 1</td>
<td></td>
</tr>
</tbody>
</table>

Irrigation subsequent to the last of September is usually for fall irrigation, which is a more or less common practice in the district.

Summarizing the values derived from measurement of amount of water used in the district, we find the following facts:

The total amount of water used was 38,640 acre feet. This amount of water was applied to an actual area of 7,440 acres. This places the amount of water used as sufficient from irrigation alone to have covered the land to a depth of 5.19 feet.

The total value of crops produced as the result of the application of this water amounted to $97,900, from which it is found the water has an earning value of $2.53 per acre foot. Based upon the total area under the canal assessed for water, amounting to 13,490 acres, the amount of water used would be 2.86 acre feet per acre.
THE ENTERPRISE CANAL.

This canal extends along the north side of the river, its course being shown on the accompanying map. Its length is about twenty-five miles and it irrigates an area of about 6,500 acres. The soil is sandy, and the crops grown are native hay, alfalfa, corn, the small grains and potatoes.

HISTORY. The canal was first constructed by the farmers themselves under a corporation named the "Enterprise Ditch Company." This company was capitalized at $100,000. The ditch cost $30,000, and of this amount probably ninety per cent was contributed by the farmers themselves in the form of labor and the remainder in cash. For the labor contributed, stock in the company was issued. The canal was completed and water first applied to the land in 1890. The original company assessed the holders of stock, some of whom were non-resident and not landholders, for the maintenance of the canal. This was held unconstitutional by Nebraska courts. (Ent. Ditch Co. vs. Moffit, 58 Neb., 642.) Water was then rented to landholders, but this was not found profitable to owners of cash stock, who demanded some returns upon their investment, and it was then decided to organize under the district system. The company was, therefore, dissolved and the Enterprise Irrigation District formed, which bought out the interests of the company for $43,000. The deal was consummated July 31, 1899. Under the district law, bonds to the amount of $45,000 were then issued, and at the present time all have been sold.

COST OF WATER. Under the assessment of stock plan, water was very cheap, enough being obtained at the rate of $2.50 to $4.00 per $100 share per year. Under the rental system, an "inch" of water, supposed to be sufficient for the irrigation of an acre of ground, was obtained at the rate of 65 cents to $1.00 per year. Under the district system, the assessments have been as found in the following table:
Irrigation Work on the North Platte River.

<table>
<thead>
<tr>
<th>Year</th>
<th>Assessed</th>
<th>Per Acre</th>
<th>Valuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>6,736</td>
<td>.65</td>
<td>$54,525</td>
</tr>
<tr>
<td>1901</td>
<td>6,736</td>
<td>.68</td>
<td>$54,525</td>
</tr>
<tr>
<td>1902</td>
<td>6,736</td>
<td>.81</td>
<td>59,682</td>
</tr>
<tr>
<td>1903</td>
<td>7,056</td>
<td>.85</td>
<td>67,277</td>
</tr>
<tr>
<td>1904</td>
<td>7,956</td>
<td>.85</td>
<td></td>
</tr>
</tbody>
</table>

The Value of Land. Although assessed on a basis of about $10 per acre, the land is valued at an average of about $48 per acre, exclusive of land included in the villages of Mitchell and Scottsbluff.

Water Supply. Until the year 1904, a scarcity of water was felt each season during June and July. In the spring of this year a pile dam was built across the river at the headgate, and likewise a system of gates and sluices, which free the head of the canal from the drifting sand which each year previously had tended to block it up. These measures have completely obviated the difficulty.

The Use of Water. The percentage of water used weekly and relative water requirement as measured by the acreage irrigated weekly is shown in the accompanying diagram. The total amount of water entering the canal during the season was 28,370 acre feet. This amount of water was used on an actual acreage of 2,370 acres, as determined by personal inquiry amongst the irrigators. This means that, excluding rainfall, sufficient water was applied to the land under this canal to have covered it to a depth of 11.95 feet. This amount appears excessive, but to the acreage of land actually irrigated must undoubtedly be added a considerable body of hay land, which, while not actually irrigated by water conveyed in laterals from the canal, yet is irrigated by the seepage from it. The acreage of land irrigated in this way, while considerable, is not ascertainable. In the absence of definite information on this point, it will be necessary to confine ourselves to actual facts. The value of products grown upon the acreage by the application of the water at the prevailing prices was $26,900.
Upon this basis the water of the Enterprise Canal has an earning value of about 95 cents per acre foot. The cost per acre at the assessment given above would be about seven cents per acre foot. The approximate dates at which different crops are irrigated upon land under this canal is shown in the following table:

<table>
<thead>
<tr>
<th></th>
<th>First Irrigation</th>
<th>Second Irrigation</th>
<th>Third Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native hay</td>
<td>May 1</td>
<td>Aug. 15</td>
<td></td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>May 1</td>
<td>June 15</td>
<td>August 25</td>
</tr>
<tr>
<td>Corn</td>
<td>July 1</td>
<td>Aug. 1</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>June 15</td>
<td>July 10</td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>June 25</td>
<td>July 15</td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td>July 1</td>
<td>July 15</td>
<td></td>
</tr>
</tbody>
</table>

The native hay included in the table refers to the crop of wheat-grass which is irrigated with considerable care. A large area is meadow, which is kept flooded during much of the season.

IRRIGATION ON THE HAIG FARM.

This farm is located near the end of the Mitchell Canal, and is owned by Mr. H. W. Haig, president of the Board of Directors of the Mitchell Irrigation District. The soil of this farm is characteristic of that found largely throughout the Mitchell Valley, being a deep sandy loam, permeated with considerable quantities of gypsum. The presence of this latter material and the fairly heavy slope of the land toward the river cause the soil to wash very easily, and consequently all the laterals running with the slope of the land are provided with drops at frequent intervals. The farm comprises a solid area of about 600 acres, of which about 550 acres are irrigated. This entire tract is supplied from one main lateral entering the farm at the southwest corner. By the permission and with the co-operation of Mr. Haig, arrangements were made to measure the amount of water entering upon the farm through the season, and he agreed to keep careful memoranda of the tracts irrigated, dates, time required, etc. Accordingly, a gage was placed in the lateral about 300 feet below its head-gate, a gage heights register installed and an observer, Mr. E.
E. Ewing, hired to read the gage and attend to the register. The writer wishes here to acknowledge the excellent service rendered by both of the gentlemen mentioned, to whose interest in the work is mainly due such results as were obtained.

Frequent gagings of the flow of the lateral were made during the season, and from these, together with the record of gage heights, the discharge diagram has been drawn. This diagram is shown on page 12.

The total amount of water entering the farm during the season was 2,740 feet. According to Mr. Hagg's figures, this water was applied during the season to an area of 555.5 acres. This places the actual average depth to which water was applied at 4.94 feet. The rainfall during the season was .59 foot, hence the total amount of water received by the farm during the five months would have submerged it to a depth of 5.53 feet.

Alfalfa is the principal crop grown upon the farm, and the use of water in the irrigation of the crop is shown in the following table:

<table>
<thead>
<tr>
<th>Date of Irrigation</th>
<th>Amount of Water Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acre Feet</td>
</tr>
<tr>
<td>Beginning</td>
<td>End</td>
</tr>
<tr>
<td>May 6</td>
<td>May 17</td>
</tr>
<tr>
<td>May 27</td>
<td>June 8</td>
</tr>
<tr>
<td>June 30</td>
<td>July 20</td>
</tr>
<tr>
<td>July 30</td>
<td>Aug. 4</td>
</tr>
<tr>
<td>Aug. 15</td>
<td>Sept. 1</td>
</tr>
<tr>
<td>Sept. 15</td>
<td>Sept. 30</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

The total area of alfalfa was 260 acres. It is seen, therefore, 4.56 acre feet were used per acre upon this crop. This, with rainfall, makes the total depth to which it would have been covered as 5.15 feet.

The next crop in importance on the farm was native hay, and the amount of water applied to the crop is shown following:
### Irrigation Work on the North Platte River

<table>
<thead>
<tr>
<th>Date of Irrigation</th>
<th>Amount of Water Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning</td>
<td>End</td>
</tr>
<tr>
<td>May 17</td>
<td>May 27</td>
</tr>
<tr>
<td>June 8</td>
<td>June 17</td>
</tr>
</tbody>
</table>

**Total** ........................................ 279.2

As the area in this case was 115 acres, we find the duty to be 2.43 acre feet per acre, or a depth covered, including rainfall, of 3.02 feet.

The remaining crops grown were corn, wheat, oats and potatoes, but the separate amounts of water used upon each cannot be given. The manner in which the demand for water on this farm is distributed through the season is shown on the diagram, in which the dotted irregular line shows the amount of water used each week as percentage of the total used during the season. It is seen that this seems to vary with the amount of water available for use, although during the month of June and July a period of maximum use and demand is found.

The produce raised upon the farm by irrigation had a market value of about $6,000 at prevailing prices. Taking the farm as a whole, we, therefore, find that the value of the water was about $2.19 per acre foot. Taking the average assessment of 61.24 cents per acre, and considering the number of acre feet used per acre, as given above, of 4.94 feet, it is seen that the water actually cost 12.4 cents per acre foot. The net earning value of the water would, therefore, be $2.07 per acre foot in this particular case.

### Financial Conditions

Generally Eastern farmers regard with some surprise the fact that, with the cost of irrigation added to other operating expenses and taxes, the cultivation of irrigated land can be made profitable. In order to determine about what this increased cost might be, an extended inquiry was made amongst the farmers of the district. The first expense necessary after acquiring the land is grading, if the land is uneven, as much
of it is, and the construction of main laterals from the canal
and branch laterals along contours to aid in the proper distri-
bution of water. The preparation of the land depends
largely upon its condition. As found from the inquiry re-
ferred to, the actual cost of preparation varied from 50 cents
to $10 per acre under the Enterprise Canal, the average being
$3.25. In the Mitchell District the limits are lower, being
from 25 cents to $5.00 per acre, the average as placed by
ninety farmers being $1.85. The next item, that of labor in
irrigating, is placed by farmers in the Mitchell District as 70
cents and in the Enterprise District as 95 cents per acre. In
figuring upon this item, it is usual to allow that, with a suf-
cient amount of water and with the land in good condition,
a skilled man can irrigate about ten acres per working day.
With the other items must be considered the expense for
water. This, under the Irrigation District Law, is the pro
rata share of the expense of maintenance of canal and pro-
vision for sinking fund. It is assessed as is a tax and is col-
lectable by the same means. In the Enterprise District this
tax for the year 1904 averaged 84 cents per acre, and
in the Mitchell District varied from 26 to 78 cents per acre,
according to the value of the land. In the Gering District
the tax was $1.98 per acre. Hence the necessary expense
entailed by irrigation, in addition to the usual expense of cul-
tivation, will be about $1.50 per acre. The expense incident
upon getting the land in shape and bringing the water upon it
is generally necessary but once, and, although it may amount
to considerable, it is always the case that by such expense
land which was formerly worth little over $1.50 per acre will
afterward sell at twenty times as much. The average value
of farming land in the Enterprise District is $48, the value
ranging from $30 to $75. In the Mitchell District the range
is $25 to $75, the average being $47.
The crops grown, the average yield and price obtained
for same is shown in the following table:
Irrigation Work on the North Platte River.

<table>
<thead>
<tr>
<th></th>
<th>Mitchell District.</th>
<th>Enterprise District.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Per Acre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>3.5 tons $3.00</td>
<td>3.1 tons $3.00</td>
</tr>
<tr>
<td>Alfalfa seed</td>
<td>2.3 bu. $10</td>
<td>2.3 bu. $10</td>
</tr>
<tr>
<td>Native hay</td>
<td>1.2 tons 5.90</td>
<td>1.3 tons 6.0</td>
</tr>
<tr>
<td>Corn</td>
<td>18.8 bu. .50</td>
<td>23.4 bu. .50</td>
</tr>
<tr>
<td>Wheat</td>
<td>15.4 bu. .80</td>
<td>14.5 bu. .78</td>
</tr>
<tr>
<td>Oats</td>
<td>49.0 bu. .32</td>
<td>35.0 bu. .32</td>
</tr>
<tr>
<td>Potatoes</td>
<td>170.0 bu. .25</td>
<td>117.0 bu. .25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acreage Grown</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>4,010</td>
<td>1,019</td>
</tr>
<tr>
<td>Alfalfa seed</td>
<td>392</td>
<td>192</td>
</tr>
<tr>
<td>Native hay</td>
<td>870</td>
<td>185</td>
</tr>
<tr>
<td>Corn</td>
<td>563</td>
<td>330</td>
</tr>
<tr>
<td>Wheat</td>
<td>298</td>
<td>108</td>
</tr>
<tr>
<td>Oats</td>
<td>1,156</td>
<td>320</td>
</tr>
<tr>
<td>Potatoes</td>
<td>435</td>
<td>175</td>
</tr>
</tbody>
</table>

*Per pound.

Considering alfalfa hay, which is the crop most generally grown, we find that it yields about $10.50 per acre. Subtracting from this the expense for water and labor of about $1.50 per acre, there remains $9.00 out of which to pay for cutting and stacking and return a profit to the grower. For other crops the net return will be about the same. Whether this compares favorably with profits under similar conditions in communities where irrigation is unnecessary seems an open question, when taking into consideration the certainty of the crop, whatever it may be as grown under irrigation, as compared with that not so favored.

Pure farming, or the raising of the staple crops for market in the district at the present time, is a practice which has been doubted. A majority of those who were questioned in regard to the matter answered in the affirmative, but others gave most emphatic negative answers. Considering the distance from large markets and relatively poor transportation facilities, it would seem that, for some time at least, pure farming will not be found highly profitable except when carried on in connection with the raising of live stock. To do this requires some outside range facilities. While the use of range adjacent to this locality is not as troublesome a question as it is in other localities, yet with a further influx of settlers the question might become irritating. Large numbers of cattle are now pastured upon the adjacent ranges during the summer months, and brought in to the farms for feeding during
the winter. The average number of cattle so kept in the Mitchell District is about 6,000 and of sheep 4,000. Without the outside range, the difficulty of supporting cattle would be great, so that it may be said that the prosperity of the district depends largely upon the free use of the outside range.

SEEPAGE MEASUREMENTS.

In connection with the other observations upon canals, considerable attention was paid to the question of seepage losses. It was thought that in a country the soil of which was, in general, of such a sandy character, the seepage losses from canals might be considerable. In order to verify this idea, and, if possible, to secure some reliable quantitative information on the matter, a series of measurements were conducted upon several canals in the district, these including the Mitchell, Gering, Enterprise and Farmers'. Measurements were made upon all of the four early in May. Again in the early part of September a second series were made upon the Mitchell and Gering. In the prosecution of the work the canal was traversed by boat, starting from the headgate in each case and ending when the canal became too small for further progress. In general, three measurements were made during each day of the work, at morning, noon and night, the distance between measurements depending somewhat upon the difficulties encountered and the number of laterals which required to be measured. By the method of traveling by boat, thus keeping up with the flow, and by investigating an independent section each day, errors due to fluctuation of the water level in canal were largely avoided. The measurements of flow of canal were made from boat usually with a small electric current meter, using sections from two to three feet in width. The measurements of laterals were made with a small hand current meter. Distances traversed were determined by noting landmarks and locating therefrom the position on a map. In the results which follow, the loss or gain found is expressed, not only as per cent of flow and
Irrigation Work on the North Platte River.

gain or loss per mile, but also as the gain or loss in cubic feet per second from 10,000 square feet of wetted perimeter. The wetted perimeter in some sections would probably be slightly in excess of that considered in working up the results, due to the fact that on several of the canals gulleys intersecting the canal were crossed by building a large embankment and allowing the water to back up into the gulley.

MITCHELL CANAL.

FIRST SERIES OF MEASUREMENTS, MAY 16 TO SEPTEMBER 15, 1904.

Headgate, Mitchell branch ........................................ 100.05
Laterals ........................................................................ 2.60

Bridge near Newell's ranch ........................................... 157.45

Just above junction of heads ........................................... 156.65

Loss ............................................................................... 0.80
Distance, 1/4 mile.
Per cent lost per mile, 0.297.
Loss per 10,000 square feet wetted perimeter, 0.029.

Gaging station, 200 yards below junction of heads .............. 263.60
Laterals ........................................................................ 10.8

Bridge near Powell's ranch ............................................. 252.8
Laterals ........................................................................ 255.5

Gain ............................................................................... 2.7
Distance, 6 1/2 miles.
Per cent loss per mile, 0.165.
Loss per 10,000 square feet wetted perimeter, 0.022.

Bridge near Powell's ranch ............................................. 276.30
Laterals ........................................................................ 16.3

Bridge at Newell's ranch ................................................ 260.0

Loss ............................................................................... 8.4
Distance, 12 miles.
Per cent lost per mile, 0.292.
Loss per 10,000 square feet wetted perimeter, 0.038.
Wyoming Experiment Station.

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance (miles)</th>
<th>Loss (Per cent)</th>
<th>Loss per 10,000 sq ft wetted perimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge near Newell's ranch</td>
<td>4.2</td>
<td>9.4</td>
<td>.121</td>
</tr>
<tr>
<td>Laterals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bridge on Mitchell road</td>
<td>2.0</td>
<td>5.9</td>
<td>.16</td>
</tr>
<tr>
<td>Just above division of canals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near headgate of Mitchell branch</td>
<td>1 3/4</td>
<td>6.3</td>
<td>.227</td>
</tr>
<tr>
<td>Laterals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gaging station, 200 yards below junction of heads</td>
<td>1 1/2</td>
<td>6.7</td>
<td>.241</td>
</tr>
<tr>
<td>Quarter mile below Caldwell P. O.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The large loss in this section, as compared with the corresponding measurement, made earlier in the season, may be attributed to the lower stage of water in the river at this time and consequent lowering of the ground water plane.
Irrigation Work on the North Platte River.

Quarter mile below Caldwell P. O. .............................................. 264.0
Laterals ................................................................. 7.4

Near Russell’s ranch ..................................................... 257.2
Gain ............................................................ 0.6
Distance, 7 miles.

The gain in this section is probably due to the seepage of water from lands irrigated from Horse Creek, which the canal crosses in this section. No lands were being irrigated from Horse Creek at the time of previous measurement of the canal in this section.

Bridge near Newell’s ranch ............................................. 266.0
Laterals ................................................................. 30.3

Bridge at Mitchell road ................................................. 235.7
Loss ............................................................ 20.4
Distance, 4.2 miles. Per cent lost per mile, 2.25
Loss per 10,000 square feet wetted perimeter, .263

GERING CANAL.
FIRST SERIES, MAY 14.

At head of Gering extension ............................................. 142.2
Laterals ................................................................. 16.7

End of bad lands .......................................................... 109.3
Loss ............................................................ 16.2
Distance, 8 miles. Per cent lost per mile, 1.62.
Loss per 10,000 square feet of wetted perimeter, .119

SECOND SERIES, SEPTEMBER 12-13.

At head of Gering extension ............................................. 172.7
Laterals and waste .......................................................... 7.0

End of bad lands .......................................................... 156.6
Loss ............................................................ 9.1
Distance, 8 miles. Per cent lost per mile, 0.67.
Loss per 10,000 square feet of wetted perimeter, .067.
It is surprising that the loss in this section is not larger, as all the conditions seem favorable to excessive seepage, due to the extremely difficult side hill construction in the section.

<table>
<thead>
<tr>
<th>Location</th>
<th>Loss</th>
<th>Distance</th>
<th>Per cent lost per mile</th>
<th>Per cent lost per mile of wetted perimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>End of bad lands</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laterals</td>
<td>162.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At point due south of Gering</td>
<td>135.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Distance, 5½ miles            | 7.1  | 50 miles  | 0.954                  | 0.087                                     |
| Rating station                | 55.6 |          |                        |                                           |
| Rating station                | 55.6 |          |                        |                                           |
| Laterals                      | 4.9  |          |                        |                                           |
| Bridge near Logan farm        | 50.7 |          |                        |                                           |

| Distance, 4½ miles            | 4.0  | 40 miles  | 54.2                   | 26.2                                     |
| Bridge near Logan farm        | 54.2 |          |                        |                                           |
| Laterals                      | 26.2 |          |                        |                                           |
| End of section                | 28.0 |          |                        |                                           |
| Gain                          | 28.1 |          |                        |                                           |

The gains in the flow of this canal are undoubtedly due to the fact that a considerable amount of water finds its way into the canal by seepage and otherwise from the Farmers'
Canal, which lies above it. The gains in this way probably offset the losses which may occur from it by seepage.

**FARMERS’ CANAL.**

<table>
<thead>
<tr>
<th>Rating station, 1 mile below headgate</th>
<th>87.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laterals</td>
<td>50.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Loss</th>
<th>11.9</th>
</tr>
</thead>
</table>

Distance, 11 miles.
Per cent lost per mile, 2.9.
Loss per 10,000 square feet wetted perimeter, .082.

The canal was in very bad condition, due to lack of attention, the original cross section being almost obliterated by deposits of sediment and detritus.

**CONCLUSIONS.**

From the investigations made in this district, it is thought that the following conclusions may be drawn:

**AMOUNT OF WATER USED.** As measured at the headgate, the amount of water used on a sandy soil containing gypsum is about 5.2 acre feet per acre, when the acreage actually watered is considered, and not the acreage assessed. For an open, sandy soil the amount used is much greater, being about 11.9 acre feet per acre. These figures are from canals irrigating lands upon which alfalfa is the crop most generally grown.

As measured on an individual farm, alfalfa requires about 4.5 acre feet per acre and native hay about 3, the land upon which both were grown having considerable, though not excessive, slope, and consisting largely of sand and gypsum.

**TIME OF USE.** In designing canals for districts such as that investigated, in which the principal crop is alfalfa and native hay, the engineer should allow for the irrigation of about nineteen per cent of the total acreage during one week.
in the latter part of April, or about eighteen per cent during one week in the middle of July.

SEEPAGE. For a canal situated as is the Enterprise, with one or more canals above it, the gain in flow, due to seepage from the canals above, may exceed considerably the loss from itself. For a high-line canal, situated as is the Mitchell and Gering, and in which the alignment is good, gullies are crossed by one bank on the lower side, and the soil sandy, with gypsum, the average loss to be expected may be about 1.2 per cent of the flow per mile, or .10 cubic foot per second per 10,000 square feet of wetted perimeter.

Finally, under an irrigation system where the water assessments run from 60 cents to $1.98 per acre per year, and land has an average valuation of about $47 per acre, agriculture can be made to pay, even though the district may be comparatively remote from large markets, but it will probably be found to be most profitable in connection with cattle raising.
in the latter part of April, or about eighteen per cent during
one week in the middle of July.

Serration. For a canal situated as is the Enterprise, with
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from the canals above, may exceed considerably the loss from
main. For a highline canal, situated as is the Mitchell and
Gering, and in which the alignment is good, gullies are crossed
by one bank on the lower side, and the soil sandy, with gypsum,
the average loss to be expected may be about 1.2 per cent of
the flow per mile, or 0.02 cubic foot per second per (100)
square feet of wotted perimeter.

Finally, under an irrigation system where the water as-
sements run from 60 cents to $1.50 per acre per year, and
land has an average valuation of about $47 per acre, agri-
culture can be made to pay, even though the district may be
comparatively remote from large markets, but it will probably
be found to be most profitable in connection with cattle rearing