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FINAL REPORT
FOR
BASIN/BIG HORN
REHABILITATION PROJECT LEVEL II

Prepared for
WYOMING WATER DEVELOPMENT COMMISSION
AND
TOWN OF BASIN, WYOMING

Prepared by
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November 2, 1990
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I. INTRODUCTION

The Town of Basin is the county seat of Big Horn County, Wyoming located on a bench along the west side of the Big Horn River. The area's climate is dry, receiving an annual average precipitation of 6.43 inches and an average annual lake evaporation of 42 inches. Extensive irrigation projects have enabled the area to become one of the top agricultural production areas in the state. The Big Horn Canal, one of the major canals in the area, was originally built around 1900 and delivers water to a majority of the Big Horn County farmers on the west side of the Big Horn River. The canal runs along the previously described bench just above and to the west of the Town of Basin.

As the canal passes along the west edge of the community it's earthen banks pass through silty sands, gravels and sandstone. In addition, along the southern and far northern portions of the town, several flood irrigated fields exist. From the canal the ground surface generally falls to the east with the major slope being over two or three terraces. The first two terraces are up next to the canal; the ground then slopes gently to the east until it reaches the railroad tracks on the east side of town where it again terraces down into the Big Horn River flood plain. The canal and fields saturate the ground with water and then the gradual slope of the terrain within the community results in high ground water table problems. Problems within the community vary from flooded basements and crawl spaces in homes to deteriorated asphalt on paved streets and severe pumping of graveled streets. Pumping is the roadway condition which results from wet and saturated soils deforming due to traffic loads. The street surface is typically rutted and soft and tends to compress as loads are applied to it and then expand back to its original state after the load is removed. This compression and expansion then "pumps" water from below up into the higher reaches of the soil until a saturated condition exists and traffic loads can no
longer be supported by the soil.

The ground water problems, although most severe during the summer irrigation season, do not all together disappear during the winter months. During a site visit by our personnel in early April, 1990, after which the canal had been shut down for over six months, water was observed in the drains around town and pumping of street surfaces was also observed. The town was directing the surface water from the drains into its sanitary sewer system as during the winter months the shallow drains in town tend to freeze, back up water and form ice sheets on the streets. The sanitary sewer system does not freeze as readily and therefore, to avoid hazards with the ice sheets, the water is diverted into the sanitary system.

With these problems facing the town, they requested assistance in evaluating their groundwater problems from the Wyoming Water Development Commission (WWDC). The WWDC was then authorized by the State Legislature to conduct a Level II Feasibility Study of the Basin/Big Horn Rehabilitation Project. The WWDC issued its Request for Proposals No. 90-10 and subsequently entered into an agreement with Crank Companies, Incorporated (CCI) to perform this study.

II. PURPOSE OF STUDY

The purpose of this study is to determine what specific areas are experiencing high ground water problems, identify what factors are contributing to the water problem, and propose methods in which the problem water can be reduced, eliminated or removed. In order to accomplish this the study was broken into two phases. Phase I was the identification of the problem areas and sources of the water and the preparation of a draft rehabilitation plan that outlined and prioritized the improvements needed to lower the groundwater table. The draft rehabilitation plan was presented as the culmination to Phase I of the project.

Phase II is the preparation of conceptual designs of the improvements
outlined in the draft rehabilitation plan which were determined to be acceptable solutions by the Town of Basin and the Wyoming Water Development Commission.

III. PHASE I

A. Scoping Meeting

On June 14, 1990, a brief scoping meeting was held at the Basin Town Hall. Those present included Mr. Bill Stoelk, Town of Basin crew supervisor, Mr. Jon Wade, WWDC staff member, and Mr. Bill Abriani and Tom Crank, both of CCI. Mr. Wade explained how the Wyoming Water Development Commission proceeds with their projects and then Mr. Crank explained CCI's intended procedures to determine where the water has become a problem and possible methods CCI feels may remedy the problems.

B. Field Inspection

As explained during the Scoping Meeting, CCI's approach in documenting the ground water problems in town would be door to door interviews of the town residents. Information from those interviews would then be plotted on scaled maps of the Town and problem areas then identified.

On June 20, 21 and 22, 1990, our personnel conducted door to door interviews at each building in town (excluding warehouses and trailer houses). During these field interviews, we attempted to inspect over 400 buildings, but were only able to complete interviews at approximately 200 locations as many residents were not home.

The results of the completed interviews were then plotted on aerial photographs of the Town of Basin. Areas in which a pattern of wet and flooded basements were becoming apparent then had questionnaires mailed to the residents from whom we were unable to complete personal field interviews. Of the 82 questionnaires mailed out 33 were completed and returned to us. The information provided on the returned questionnaires was then plotted on the aerial photos along with the completed door to
door interviews. This provided the majority of our information in preparing the draft rehabilitation plan. Copies of the aerial photographs with plotted interviews, drainage features, problem street areas and the proposed improvement areas identified are attached as Appendix "A" to this report. These maps contain a significant amount of information which is referred to in this report and should be studied closely. Copies of all completed interviews are available for review at our Kemmerer office.

The major problem areas identified from our interviews are:

1. South 5th Street and South 6th Street.

This area extends from approximately Mattson Avenue on the south, north to South Street. Of the 48 interviews completed in this area, twenty reported having experienced groundwater problems at their homes. South 5th Street is also experiencing extensive pumping and asphalt deterioration. The majority of the groundwater in this area appears to come from the canal and the drainage basin directly above it between canal stations 13+00 and 23+00, with additional water coming from the canal and flood irrigated fields below canal station 0+00 and 12+00.

Methods available to relieve the ground water problems in this area included:
   a. Subsurface infiltration
   b. Canal lining and/or enclosure

   Canal enclosures were deemed to be cost prohibitive by the Town, the Wyoming Water Development Commission and Crank Companies, Incorporated during the Phase I results presentation meeting, and were subsequently dropped from further investigation.

2. North 6th Street and North 7th Street.

This area extends from Hart Avenue south along North 7th Street to
"F" Street and south along North 6th Street to "G" Street. Of the 27 completed interviews in this area 17 residences reported having experienced groundwater problems or taken measures to relieve ground water at their homes. Both streets are also expected to be experiencing pumping problems.

All groundwater problems in this area are due to very little slope of the ground and flood irrigation of fields on the west, north and east sides of the area. The only method available to relieve the ground water problem here is seen as subsurface drainage.

3. South 9th Street and Big Horn Avenue

This area extends from the intersection of Montana Avenue and South 9th Street south to Big Horn Avenue and then east along Big Horn Avenue for approximately 950 feet.

Eleven homes in this area reported groundwater problems. Three continuously running surface drains are also found in this area. These drains are located at:
   a. On the south side of Crescent Drive approximately 150 feet west of the intersection with South 9th Street.
   b. In the alley between Montana Avenue and Holdredge Avenue and just to the east of South 9th Street.
   c. On the north side of Big Horn Avenue approximately 450 feet west of South 6th Street.

Methods available to relieve the ground water problems in this area include subsurface infiltration and drainage with the surface drains also being tied into the subsurface drainage system. Canal lining may help elevate the problems in this area, but there are too many flood irrigated fields below the canal that also contribute to the water problem to make this option feasible by itself.

4. An additional concern to the Town of Basin residents are the
safety hazards related to a large open canal running through town. This concern is very real and justified in that the canal runs next to several homes and recreation facilities. Three such areas in which the canal enclosures were considered during Phase I of this study because of their proximity to homes and recreational facilities were:

a. Canal Station 6+50 to 12+00
b. Canal Station 23+00 to 52+00
c. Canal Station 71+00 to 79+40

These canal stations referred to are those shown on the aerial photographs of the town presented in Appendix "A" of this report. As stated earlier, canal enclosures with pipe were determined to be cost prohibitive during the Phase I results presentation meeting and were subsequently dropped from consideration. The other option then available to improve the safety for the community is the fencing of reaches of the canal so that children's access to the canal is limited. Currently there is very little fencing along the canal other than those installed for property line and livestock enclosure. Fencing of several reached of the canal was then incorporated into the conceptual designs of Phase II.

5. The Town of Basin operates both a municipal drinking water system and a raw irrigation water system. The possibility of either of these systems having leaks does exist and leaks may be contributing to the groundwater problems. It is CCI's understanding that there are no available records as to the Town's municipal drinking water system other than the information Mr. Stoelk has obtained over the years as he has repaired the system. The possibility of leaks within this system are very probable but records of total flow produced versus the total flow used (or billed) suggest that only minor leaks may exist.

The following is a monthly tabulation of the municipal drinking water produced and used by the Town during the first five months of 1990.
<table>
<thead>
<tr>
<th>Period</th>
<th>Water Produced (gal)</th>
<th>Water Billed (gal)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec. 15. 1989 -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan. 15, 1990</td>
<td>10,550,000</td>
<td>8,166,000</td>
<td>2,384,000 gal</td>
</tr>
<tr>
<td>Jan. 15, 1990 -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb. 15, 1990</td>
<td>10,161,000</td>
<td>9,215,000</td>
<td>946,000 gal</td>
</tr>
<tr>
<td>Feb. 15, 1989 -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March. 15, 1990</td>
<td>8,717,000</td>
<td>8,451,000</td>
<td>266,000 gal</td>
</tr>
<tr>
<td>March 15, 1990 -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 15, 1990</td>
<td>8,486,000</td>
<td>7,393,000</td>
<td>1,093,000 gal</td>
</tr>
<tr>
<td>April 15, 1990 -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 15, 1990</td>
<td>9,081.00</td>
<td>7,583,000</td>
<td>1,498,000 gal</td>
</tr>
</tbody>
</table>

The monthly differences very greatly and in some instances are dramatic, indicating that during some months major water leaks must have been experienced in the system. The lowest monthly difference is 266,000 gallons, which is a considerable volume of water, but spaced out during a months time would not represent a very large leak. A typical garden hose has a flow rate of about five gallons per minute, so if the hose was left running for 30 days, 216,000 gallons would pass through that hose. Relating this to the lowest monthly difference gives an indication that we may be looking at two or three small leaks within the system or that there are users tapped into the system without meters. An additional factor in the flow discrepancies may be the Town's metering equipment. The most likely condition being that there are small leaks, a few non-metered users and small flow measurement errors within the system.

As per our original proposal we had anticipated testing for chlorine residual in the basements and drains around the town. As part of our field interviews we asked if it would be possible to inspect the flooded basements in the homes. Most residents,
understandably, did not want a stranger coming door to door, entering their homes and wandering around in their basements. Of the homes we were physically able to inspect, most only had water stained walls and damp floors.

Of the three Town drains known to us, all are in areas where we would expect canal losses to be the source of the water. Therefore, at this time no chlorine residual testing has been done.

C. Draft Rehabilitation Plan

The draft rehabilitation plan was presented in August 1990 and followed by a results presentation meeting as indicated earlier. Those systems determined to be acceptable solutions to the Town's problems were then selected and Phase II, the preparation of conceptual designs, cost estimates and an economic analysis of the solutions was authorized to be performed.

IV. PHASE II. CONCEPTUAL DESIGNS AND COST ESTIMATES

A. GENERAL

Upon completion of the Phase I results presentation meeting, Crank Companies, Incorporated was authorized to prepare conceptual designs for two basic types of systems. The first system is a subsurface drainage system designed to elevate the ground water problems where they had been identified and the second system is the installation of a concrete canal lining to help elevate the problem from a major source, the Big Horn Canal.

Prior to the sizing of any subsurface drainage piping or canal lining, Crank Companies, Incorporated personnel measured the following flows in the Big Horn Canal at the following locations.
In addition to these flows in the canal, flows out of the Big Horn Canal at two locations were made between station -4+90 and Station 41+00. These flows totaled 0.20 cfs. The town's raw water intake system was shut off during the flow measurement period, as well as all other headgates between -4+90 and 79+50 with the exception of the cemetery sprinkler system which was regrettably overlooked at the time.

The flow was measured by dividing the canal cross section into three vertical strips at each location and then measuring the water velocity at 0.6 of the depth. The velocities were measured using a Marsh-McBirney Model 201 D velocity meter and a standard top-setting wading rod. The velocity measured and the area of the vertical strip of the cross section then gives a flow quantity for each vertical strip. The sum of the quantities for the three strips then equals the total flow in the canal at that particular location.

An estimate of canal seepage loss was then made based on the flows measured at Sta. -4+90 and Sta. 41+00 and the 0.20 cfs flow being diverted between the end points.

\[ 89.0 \text{ cfs} - 83.5 \text{ cfs} - 0.2 \text{ cfs} = 5.3 \text{ cfs total loss} \]

Length of canal loss occurred over = 4590 feet = 0.869 mi.

Seepage loss = 6.097 cfs/mi

This is a very large seepage loss and a comparison is needed so that one may determine if it seems practical. The U.S. Bureau of Reclamation in its publication "Design Standards No. 3, Canals and Related Structures" defines seepage loss as follows:
\[ S = 0.2 \sqrt{Q - V} \]

- \( S \) = Seepage loss in cfs per mile of canal
- \( Q \) = Canal discharge in cfs
- \( V \) = Average canal velocity
- \( C \) = Soil constant, cubic feet of water lost in 24 hours through each square foot of wetted area of canal prism.

Then given that \( S = 6.097 \text{ cfs/mi} \), \( Q = 89.0 \text{ cfs} \), and \( V = 2.3 \text{ fps} \), \( C \) can be calculated as follows:

\[ C = \frac{6.097}{0.2 \sqrt{89.0}} = 4.901 \text{ ft}^3/\text{day per ft}^2 \text{ per prism} \]

The wetted perimeter of canal = 16.91 ft²/ft

\[ C = \frac{4.901}{16.91} = 0.31 \text{ ft}^3/\text{day} \]

"Design Standard No. 3" also lists some typical values of \( C \) for various soil types. Some of them are:

<table>
<thead>
<tr>
<th>Type of Material</th>
<th>Value of C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cemented gravel and hardpan with sandy loam</td>
<td>0.34</td>
</tr>
<tr>
<td>Clay and clayey loam</td>
<td>0.41</td>
</tr>
<tr>
<td>Sandy soil with rock</td>
<td>1.68</td>
</tr>
<tr>
<td>Sandy and gravelly soil</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Our value of \( C = 0.31 \) seems reasonable or even less than one might expect as traveling along the canal the banks appear to be more of the sandy and gravely type soils.

The sizing of pipes for subsurface drainage systems is often a matter of personal judgement and experience, particularly when trying to intercept flows along slopes and drainages. The effectiveness of removing ground water from any area is dependent upon several factors, any one of which may control the ultimate success of the removal system. These factors
include, but are not limited to; the types of soils, the number of different soil types, the size, shape and slope of the area, and the amount of subsurface runoff and its rate of recharge.

Methods of estimating the expected flows that subsurface drainage systems can be expected to carry when draining relatively flat areas have been developed. The "Handbook of Steel Drainage and Highway Construction Products" published by the American Iron and Steel Institute identifies a means of determining the discharge capacity needed to drain flat areas as:

\[
Q = CA
\]

with

- \( Q \) = required discharge capacity (cfs)
- \( A \) = area to be subdrained
- \( C \) = subsurface runoff factor, converted to \( \text{ft}^3/\text{sec}/\text{acre} \).

Table 4-24 of the above mentioned handbook lists constants for subsurface runoff for various soil permeability types based on the depth of water to be removed in 24 hours. For the purpose of this study the soil permeability type selected was moderate to fast, the depth of water to be drained selected at 5/8" in 24 hours - thus giving a \( C \) value of 0.0262. The area to be drained then varied from pipe to pipe so that the drainage area covered the homes and streets which are experiencing the problems. Flow calculations then begin at the upper most reach of the system and incrementally work down through the system adding the expected flow from the bottom reach to the previously determined up stream reaches so that the pipes can be sized to handle the flow expected at its bottom point.

Field surveys were then conducted along the proposed pipe routes so that the existing ground profiles could be checked to make sure adequate slope was available to insure the system proposed will drain, and to determine pipe slopes and depths so that pipe sizes could be calculated based on the slopes available. Profiles of all lines proposed for the implementation of System #1 and #2 are attached as Appendix "B" of this
Along the selected pipe routes nine test pits were excavated to identify the subsurface material and ground water levels. The pits were excavated by the use of a backhoe. Elevations of the top of the ground were determined for each test pit. Datum for test pits #1, #2, #3, #4 and #5 is the top of the concrete headwall of the box culvert where Big Horn Canal crosses under the highway to Burlington. Base elevation of this point is 198.09. Datum for test pits #6, #7, #8 and #9 is a separate datum and base elevation is a nail in a power pole opposite pipe line station 0+00 on North 8th Street. Soil logs of the test pits are in Appendix "C". Locations of the test pits are also shown on the aerial photographs found in Appendix "A".

With the design flows and slope previously determined the pipes were then sized to carry the expected flows at one-half of full depth.

The subsurface drainage type of system was further divided into two independent systems. These systems, identified as systems #1 and #2, drain different areas of town. System #1 has been further broken down into three phases, in which the system could be built. System #1, Phase I, is the downstream section of System #1 and is designed to handle flows it receives from Phase II and III.

A typical perforated pipe detail is shown on page 13, as well as a typical concrete lined canal section. These details identify the major components of the systems proposed. Additional information as to system sizing and components is identified in the following system descriptions and components cost estimates that follow.

B. SYSTEM #1 DESCRIPTION AND COMPONENT COST ESTIMATES

A sketch of system #1 is shown on page 14. The system sketch shows the various phases of this system as well as the proposed pipe sizes, manhole locations, and areas of subsurface drainage. The areas of subsurface drainage are identified as pipe to be perforated. Additional
TYPICAL CONCRETE LINED CANAL SECTION
NO SCALE

TYPICAL PERFORATED PIPE DETAIL
NO SCALE

COMPACTED BACKFILL

TRENCH WALL OR SHORING TO CONFORM TO OSHA REGULATIONS.

WASHED GRANULAR FILL MATERIAL

PERFORATED PVC SEWER PIPE, DIAMETER VARIES

GEOFABRIC

1'-3'' VARIES

6'' VARIES
information as to line depths and locations are shown on the line profile sheets in Appendix "B" and on the aerial photos in Appendix "A".

System #1 will directly reduce the ground water problems to 26 homes for which interviews were completed and an estimated 17 other homes for which interviews were not completed. Homes which reported dry conditions are not included as benefitting. In addition, the pumping problems along South 5th Street and South 9th Street would be reduced or eliminated. Surface drains at the south east end of Crescent Avenue and at the intersection of Big Horn Avenue and South 6th Street would also be diverted into this system and thus keep these drains out of the sanitary sewer systems. The surface drain which comes from under South 9th Street between Montana Avenue and Holdridge may also be eliminated as the subsurface drain proposed in South 9th Street would divert some or all of this water.

In the draft rehabilitation plan submitted in August, 1990, the subsurface drain lines now shown in South 6th Street (North of Wyoming Avenue) and South 5th Street were identified as being in the alleys. During our survey work on these lines it was noted that there are existing sanitary sewer lines in these alleys and thus not enough room to construct these lines. The lines have thus been moved and are now proposed in the above mentioned streets.

**SYSTEM #1, PHASE I, COMPONENT COST ESTIMATE**

**PIPE**

<table>
<thead>
<tr>
<th>Size</th>
<th>Length (ft)</th>
<th>Rate ($/ft)</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot;</td>
<td>1060</td>
<td>15.00</td>
<td>15,900.00</td>
</tr>
<tr>
<td>8&quot;</td>
<td>740</td>
<td>20.00</td>
<td>14,800.00</td>
</tr>
<tr>
<td>10&quot;</td>
<td>420</td>
<td>33.00</td>
<td>13,860.00</td>
</tr>
<tr>
<td>12&quot;</td>
<td>760</td>
<td>35.00</td>
<td>26,600.00</td>
</tr>
<tr>
<td>18&quot;</td>
<td>1161</td>
<td>43.00</td>
<td>49,923.00</td>
</tr>
<tr>
<td>21&quot;</td>
<td>2133</td>
<td>48.00</td>
<td>102,384.00</td>
</tr>
<tr>
<td>36&quot;</td>
<td>348</td>
<td>325.00</td>
<td>113,100.00</td>
</tr>
</tbody>
</table>

**SUBTOTAL** = $336,567.00
GEOFABRIC AROUND PERF. PIPE

<table>
<thead>
<tr>
<th>Size (in.)</th>
<th>Area (yd²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot;</td>
<td>1119</td>
</tr>
<tr>
<td>8&quot;</td>
<td>849</td>
</tr>
<tr>
<td>10&quot;</td>
<td>499</td>
</tr>
<tr>
<td>12&quot;</td>
<td>1027</td>
</tr>
<tr>
<td>18&quot;</td>
<td>1784</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>5278</strong></td>
</tr>
</tbody>
</table>

Overlap/waste 10% = 528 yd²

Total = 5806 yd² @ $1.10/yd² = $6,387.00

GRANULAR BACKFILL AROUND PERF. PIPE

<table>
<thead>
<tr>
<th>Size (in.)</th>
<th>Volume (yd³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot;</td>
<td>140</td>
</tr>
<tr>
<td>8&quot;</td>
<td>106</td>
</tr>
<tr>
<td>10&quot;</td>
<td>69</td>
</tr>
<tr>
<td>12&quot;</td>
<td>151</td>
</tr>
<tr>
<td>18&quot;</td>
<td>265</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>731</strong></td>
</tr>
</tbody>
</table>

Waste/Extra 10% = 73 yd³

Total = 804 yd³ @ $18.00/yd³ = $14,472.00

48" Ø MANHOLES

19 Totaling 168.7 vertical feet @ $210.00/ft = $35,427.00

OUTLET HEADWALL

1 @ $1200.00 = $1,200.00

DRYING OF BACKFILL PRIOR TO PLACEMENT & COMPACTION

2065 yd³ @ $3.00/yard square = $6,195.00

ASPHALT STREET PATCHING

7160 yd² @ $12.00/yd² = $85,920.00

EXCAVATION.BACKFILL ROCK

50 yd³ @ $29.26/yd³ = $1,463.00

TOTAL CONSTRUCTION COST = $487,631.00
SYSTEM # 1, PHASE II, COMPONENT COST ESTIMATE

PIPE

<table>
<thead>
<tr>
<th>Size</th>
<th>Length</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; Ø</td>
<td>886 ft</td>
<td>$13,290.00</td>
</tr>
<tr>
<td>8&quot; Ø</td>
<td>1038 ft</td>
<td>$20,760.00</td>
</tr>
<tr>
<td>8&quot; Ø</td>
<td>552 ft</td>
<td>$9,384.00</td>
</tr>
<tr>
<td>10&quot; Ø</td>
<td>40 ft</td>
<td>$1,200.00</td>
</tr>
<tr>
<td>12&quot; Ø</td>
<td>323 ft</td>
<td>$10,336.00</td>
</tr>
</tbody>
</table>

Subtotal = $54,970.00

GEOFABRIC AROUND PERF. PIPE

<table>
<thead>
<tr>
<th>Size</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; Ø</td>
<td>935 yd²</td>
</tr>
<tr>
<td>8&quot; Ø</td>
<td>1192 yd²</td>
</tr>
</tbody>
</table>

Subtotal = 2127 yd²

Overlap/waste 10% = 213 yd²

Total = 2340 yd² @ $1.10/yd² = $2,574.00

GRANULAR BACKFILL AROUND PERF. PIPE

<table>
<thead>
<tr>
<th>Size</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; Ø</td>
<td>117 yd³</td>
</tr>
<tr>
<td>8&quot; Ø</td>
<td>150 yd³</td>
</tr>
</tbody>
</table>

Subtotal = 267 yd³

Waste/Extra 10% = 27 yd³

Total = 294 yd³ @ $18.00/yd³ = $5,292.00

48" Ø MANHOLES

9 Totaling 93.2 vertical feet @ $210.00/ft = $19,572.00

DRYING OF BACKFILL PRIOR TO PLACEMENT & COMPACTION

1030 yd³ @ $3.00/yard square = $3,090.00

ASPHALT STREET PATCHING

2825 yd² @ $12.00/yd² = $33,900.00

EXCAVATION/BACKFILL ROCK

50 yd³ @ $29.26/yd³ = $1,463.00

Total Construction Cost = $120,861.00
SYSTEM # 1, PHASE III, COMPONENT COST ESTIMATE

PIPE

<table>
<thead>
<tr>
<th>Size</th>
<th>Length</th>
<th>Rate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; Ø Perf.</td>
<td>664 ft</td>
<td>$15.00/ft</td>
<td>$9,960.00</td>
</tr>
<tr>
<td>6&quot; Ø</td>
<td>398 ft</td>
<td>$12.00/ft</td>
<td>$4,776.00</td>
</tr>
<tr>
<td>10&quot; Ø</td>
<td>943 ft</td>
<td>$30.00/ft</td>
<td>$28,290.00</td>
</tr>
</tbody>
</table>

**SUBTOTAL** = **$43,046.00**

GEOFABRIC AROUND PERF. PIPE

<table>
<thead>
<tr>
<th>Size</th>
<th>Area</th>
<th>Overlap/waste 10%</th>
<th>Total</th>
<th>Rate</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; Ø</td>
<td>701 yd²</td>
<td>70 yd²</td>
<td>771 yd²</td>
<td>$1.10/yd²</td>
<td>$848.00</td>
</tr>
</tbody>
</table>

GRANULAR BACKFILL AROUND PERF. PIPE

<table>
<thead>
<tr>
<th>Size</th>
<th>Volume</th>
<th>Waste/Extra 10%</th>
<th>Total</th>
<th>Rate</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; Ø</td>
<td>88 yd³</td>
<td>9 yd³</td>
<td>97 yd³</td>
<td>$18.00/yd³</td>
<td>$1,746.00</td>
</tr>
</tbody>
</table>

48" Ø MANHOLES

6 Totaling 46.9 vertical feet @ $210.00/ft = $9,849.00

DRIYING OF BACKFILL PRIOR TO PLACEMENT & COMPACTION

223 yd³ @ $3.00/yard square = $669.00

ASPHALT STREET PATCHING

2953 yd² @ $12.00/yd² = $35,436.00

EXCAVATION/BACKFILL ROCK

50 yd³ @ $29.26/yd³ = $1,463.00

**TOTAL CONSTRUCTION COST** = **$93,037.00**

C. SYSTEM # 2 DESCRIPTION AND COMPONENT COST ESTIMATES

A sketch of System #2 is shown on page 19. The system sketch again shows the various pipe sizes, manhole locations and areas of subsurface
SYSTEM NO. 2 SKETCH

SUBSURFACE DRAINAGE
drainage. This system will directly reduce ground water problems to 16 homes for which interviews were completed and an estimated seven other homes for which interviews were not completed. In addition, any street pumping which may be being experienced along North 6th Street and North 8th Street will be eliminated, as well as some or all of the pumping in North 7th Street.

This system was originally proposed to have drained into the large ditch between "D" Street and "E" Street; but during our field survey it was determined that the pipe depths necessary to drain from Hart Avenue south to the ditch would be in excess of 20 feet deep. The system was then rerouted as shown to drain across the highway and railroad tracks in line with Hart Avenue and then drain down into the swamp on the south side of Basin's sewage treatment lagoon. This route is considerably more expensive than originally proposed but is the only viable route to drain the area.

**SYSTEM # 2, COMPONENT COST ESTIMATE**

<table>
<thead>
<tr>
<th>PIPE</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; Ø Perf.</td>
<td>1963 ft</td>
<td>$29,445.00</td>
</tr>
<tr>
<td>8&quot; Ø Perf.</td>
<td>1827 ft</td>
<td>$36,540.00</td>
</tr>
<tr>
<td>10&quot; Ø Perf.</td>
<td>747 ft</td>
<td>$24,651.00</td>
</tr>
<tr>
<td>12&quot; Ø</td>
<td>844 ft</td>
<td>$27,008.00</td>
</tr>
<tr>
<td>24&quot; Ø Steel Casing Bored</td>
<td>260 ft</td>
<td>$63,700.00</td>
</tr>
</tbody>
</table>

**GEOFABRIC AROUND PERF. PIPE**

<table>
<thead>
<tr>
<th>GEOFABRIC</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; Ø</td>
<td>2072 yd²</td>
</tr>
<tr>
<td>8&quot; Ø</td>
<td>2097 yd²</td>
</tr>
<tr>
<td>10&quot; Ø</td>
<td>927 yd²</td>
</tr>
<tr>
<td>Subtotal</td>
<td>5096 yd²</td>
</tr>
<tr>
<td>Overlap/waste 10%</td>
<td>510 yd²</td>
</tr>
<tr>
<td>Total</td>
<td>5606 yd² @ $1.10/yd² = $6,167.00</td>
</tr>
</tbody>
</table>
GRANULAR BACKFILL AROUND PERF. PIPE

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Volume (yd³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; Ø</td>
<td>259</td>
</tr>
<tr>
<td>8&quot; Ø</td>
<td>263</td>
</tr>
<tr>
<td>10&quot; Ø</td>
<td>128</td>
</tr>
<tr>
<td>Subtotal</td>
<td>650</td>
</tr>
<tr>
<td>Waste/Extra 10%</td>
<td>65</td>
</tr>
<tr>
<td>Total</td>
<td>715         @ $18.00/yd³ = $12,870.00</td>
</tr>
</tbody>
</table>

48" Ø MANHOLES

17 Totaling 147.9 vertical feet @ $210.00/ft = $31,059.00

DRIYING OF BACKFILL PRIOR TO PLACEMENT & COMPACTION

2100 yd³ @ $3.00/yard square = $6,300.00

ASPHALT STREET PATCHING

2490 yd² @ $12.00/yd² = $29,880.00

EXCAVATION/BACKFILL ROCK

50 yd³ @ $29.26/yd³ = $1,463.00

TOTAL CONSTRUCTION COST = $269,083.00

D. SYSTEM # 3 DESCRIPTION AND COMPONENT COST ESTIMATES

System #3 is the concrete canal lining from station -4+50 to 79+50, as identified on the aerial photos in Appendix "A". It should be pointed out that the stationing shown on the aerial photos is scaled and the photos are not of very good quality in terms of being to scale. The actual distance measured between the beginning and ending stations is 7995 feet measured along the east bank of the canal. This distance was measured by locating various points along the east canal bank using electronic distance measuring equipment and a theodolite. The points were then plotted and coordinates determined. The sum of inverse of the distance between the points is 7995 feet. The canal lining has therefore been estimated to be 8000 feet in length.
The concrete canal lining is designed to carry 1.5 times the average flow. With the average flow assumed to be the 89 cfs as measured at Station -4+50.

\[ 89 \text{ cfs} \times 1.5 = 133.5 \text{ cfs.} \]

Rounded to the nearest 5 cfs = 135 cfs.

The slope of the existing canal water surface was measured at 0.054%. The depth of uniform flow for the concrete lined canal section necessary to carry this flow was then determined to be 3.1 feet. Then adding 1.0 foot minimum freeboard the total concrete canal lining depth necessary was selected at 4.2 feet. This concrete section requires 26 cubic yards of concrete per 100 feet of lining. This volume of concrete, as well as the labor and equipment necessary to prepare the subgrade and place the concrete, were then estimated and a price per foot of lining was determined to be $44.35 per foot.

The canal as determined earlier is losing 6.097 cfs/mi. The major area of the canal expected to be contributing to the Town's groundwater problem is from station -4+50 to approximately station 28+00 or nearly 3250 feet or 0.616 miles. This gives an expected seepage loss which is directly impacting the community south of "A" Street of 3.75 cfs. This volume of water could be nearly eliminated with the lining of the canal.

The canal is not, however, seen as the entire problem. Below the canal between stations -4+50 to 6+00 are three flood irrigated fields. Just the two fields below canal stations 0+00 and 6+00 cover approximately 7.9 acres.

If this ground is flood irrigated and assumed to have the same seepage loss as the canal per square foot of wetted area, this area could be recharging the groundwater at a rate of 23.5 cfs. Thus, our conclusion is that, although the canal lining will certainly help, it will in no way completely eliminate the problem.

A brief outline of System #3 component costs is as follows. The chain link fence and appurtenances have been added in areas in which safety to
the community can be readily improved.

SYSTEM # 3, COMPONENT COST ESTIMATE

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Cost per Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Canal lining</td>
<td>8000 ft</td>
<td>$44.35/ft</td>
<td>$354,800.00</td>
</tr>
<tr>
<td>Bridge @ W. &quot;B&quot; St</td>
<td></td>
<td></td>
<td>$ 6,000.00</td>
</tr>
<tr>
<td>Bridge @ Sta. 9+15±</td>
<td></td>
<td></td>
<td>$ 1,500.00</td>
</tr>
<tr>
<td>Replace Headgates 5 @ $2,000.00/each</td>
<td></td>
<td></td>
<td>$ 10,000.00</td>
</tr>
<tr>
<td>Total lining and appurtenances</td>
<td></td>
<td></td>
<td>$ 372,300.00</td>
</tr>
</tbody>
</table>

Safety fencing

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Cost per Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 foot chain link @ $28.77/ft</td>
<td>5480 ft</td>
<td></td>
<td>$157,660.00</td>
</tr>
<tr>
<td>Cattle guards @ $3,000/each</td>
<td>7</td>
<td></td>
<td>$ 21,000.00</td>
</tr>
<tr>
<td>Total fence system</td>
<td></td>
<td></td>
<td>$ 178,660.00</td>
</tr>
</tbody>
</table>

TOTAL CONSTRUCTION COST = $ 550,960.00

E. FINAL COST ESTIMATES

Final cost estimates for the project have been developed following the guidelines stipulated in our Basin/Big Horn Canal Rehabilitation Project - Level II contract with the Wyoming Water Development Commission.

TOTAL COST ESTIMATE

SYSTEM #1, PHASE I

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Final Designs and Specifications</td>
<td>$ 28,540.00</td>
</tr>
<tr>
<td>Permitting and Mitigation</td>
<td>$ 2,682.00</td>
</tr>
<tr>
<td>Legal Fees</td>
<td>$ 3,600.00</td>
</tr>
<tr>
<td>Acquisition of Access and Rights-of-Way</td>
<td>$ 900.00</td>
</tr>
<tr>
<td>Construction Cost Subtotal #1</td>
<td>$ 487,037.00</td>
</tr>
</tbody>
</table>

(See Description and Component Cost for more detail)
Engineering Costs = CCS#1
  x 10% $ 48,704.00
Subtotal #2 $ 535,741.00
Contingency = Subtotal #2 x 15% $ 80,361.00
  Construction Cost Total $ 616,102.00
  Project Cost Total $ 651,824.00

SYSTEM #1, PHASE II

Preparation of Final Designs and Specifications $ 14,719.00
Permitting and Mitigation $ 712.00
Legal Fees $ 500.00
Acquisition of Access and Rights-of-Way $ 3,000.00

Construction Cost Subtotal #1 $ 120,861.00
(See Description and Component Cost for more detail)
Engineering Costs = CCS#1
  x 10% $ 12,086.00
Subtotal #2 $ 132,947.00
Contingency = Subtotal #2 x 15% $ 19,942.00
  Construction Cost Total $ 152,889.00
  Project Cost Total $ 171,820.00

SYSTEM #1, PHASE III

Preparation of Final Designs and Specifications $ 8,750.00
Permitting and Mitigation $ 0.00
Legal Fees $ 0.00
Acquisition of Access and Rights-of-Way $ 0.00
Construction Cost Subtotal #1 $ 93,037.00
(See Description and Component Cost for more detail)
Engineering Costs = CCS#1
\[ \times 10\% \quad \$ 9,304.00 \]
Subtotal #2 \[ \$ 102,341.00 \]
Contingency = Subtotal #2 \( \times 15\% \) \[ \$ 15,351.00 \]
\[ \text{Construction Cost Total} \quad \$ 117,692.00 \]
\[ \text{Project Cost Total} \quad \$ 126,442.00 \]

SYSTEM #2

Preparation of Final Designs and Specifications \[ \$ 14,780.00 \]
Permitting and Mitigation \[ \$ 2,682.00 \]
Legal Fees \[ \$ 3,600.00 \]
Acquisition of Access and Rights-of-Way \[ \$ 2,000.00 \]

Construction Cost Subtotal #1 \[ \$ 269,083.00 \]
(See Description and Component Cost for more detail)

Engineering Costs = CCS#1
\[ \times 10\% \quad \$ 26,908.00 \]
Subtotal #2 \[ \$ 295,991.00 \]
Contingency = Subtotal #2 \( \times 15\% \) \[ \$ 44,399.00 \]
\[ \text{Construction Cost Total} \quad \$ 340,390.00 \]
\[ \text{Project Cost Total} \quad \$ 363,452.00 \]

SYSTEM #3

Preparation of Final Designs and Specifications \[ \$ 21,022.00 \]
Permitting and Mitigation \[ \$ 2,376.00 \]
Legal Fees \[ \$ 4,100.00 \]
Acquisition of Access and Rights-of-Way \[ \$ 0.00 \]

Construction Cost Subtotal #1 \[ \$ 550,960.00 \]
(See Description and Component Cost for more detail)
Engineering Costs = CCS#1 
\[ \times 10\% \] $ 55,096.00 
Subtotal #2 $ 606,056.00 
Contingency = Subtotal #2 \times 15\% $ 90,908.00 
Construction Cost Total $ 696,964.00 
Project Cost Total $ 724,462.00 

COMBINED TOTAL PROJECT COSTS 

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>TOTAL COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM #1, PHASE I (Subsurface Drainage)</td>
<td>$ 651,824.00</td>
</tr>
<tr>
<td>SYSTEM #1, PHASE II (Subsurface Drainage)</td>
<td>$ 171,820.00</td>
</tr>
<tr>
<td>SYSTEM #1, PHASE III (Subsurface Drainage)</td>
<td>$ 126,442.00</td>
</tr>
<tr>
<td>SYSTEM #2 (Subsurface Drainage)</td>
<td>$ 363,452.00</td>
</tr>
<tr>
<td>SYSTEM #3 (Canal Lining and Fencing)</td>
<td>$ 724,462.00</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>$2,038,000.00</td>
</tr>
</tbody>
</table>

Total of Subsurface Drainage Systems (System #1 and System #2) = $ 1,313,538.00

The Town of Basin is approaching the Wyoming Farm Loan Board for funding for a street improvement project that would pave the streets in the community. As this study has pointed out, to reduce the groundwater problem in the town both the lining of the canal and the installation of a subsurface drain system is required. If the replacement of the asphalt surfacing that will be removed during the installation of the subsurface drains were eliminated from the cost of the subsurface drain project the total cost reduction to the project would be approximately $234,198.00 following the same format for estimating total project costs. The breakdown is as follows.

CCS - Cost of asphalt patching
a) SYSTEM #1, Phase I, Construction Cost = $ 85,920.00 
b) SYSTEM #1, Phase II, Construction Cost = $ 33,900.00
c) SYSTEM #1, Phase III, Construction Cost = $ 35,436.00

d) SYSTEM #2, Construction Cost = $ 29,880.00

Construction Cost Subtotal #1 = $ 185,136.00

Engineering Costs = CCS #1 x 10% = $ 18,514.00

Subtotal #2 = $ 203,650.00

Contingency = Subtotal #2 x 15% = $ 30,548.00

Total cost associated with asphalt patching = $ 234,198.00

The total revised project cost for all the subsurface drainage systems and canal lining and fencing is therefore $1,803,802.00, provided the asphalt patching can be eliminated and incorporated into a street paving project.

F. ECONOMIC ANALYSIS

The following items have been taken into consideration in developing the economic analysis:

1. Decrease in home property value due to structure damage by flooding.
2. Cost to repair structure due to water damage.
3. Cost of pumping water by the use of sump pumps, both in basements and crawl spaces.
4. Additional cost of street maintenance related to high ground water condition.
5. The reduced life of asphalt surfaced streets due to pumping action related to the high ground water.

In evaluating the decrease in home property values related to the high ground water problem, contact was made with several real estate agencies and property appraisers familiar with Basin. The value of the basement or other portions of the structure varies depending upon age, how well the property has been maintained, the quality of the improvements and other items. Because of this a blanket statement as to the property value loss for the properties in question cannot be made. The appraisers contacted have stated that in some cases the damage to the
structures has been so extensive that structural failure has occurred to the foundation. Under these extreme conditions the basement area is considered to have a zero value when determining the overall value of the property. In each case of this type the appraiser must exercise good judgement in determining the value of the rest of the structure since a failure of the foundation very likely will result in damage to some or all of the rest of the structure.

In developing the cost to replace the basement or crawl space of those structures that the water damage ultimately results in the need to replace the entire basement or crawl space, we have assumed that the basement or crawl space structure needs to be replaced every 20 years and the cost of the replacement is $15,000 for the basement and $5,000 for the crawl space. A conservative interest rate of 5% per year has been assumed to compute the annual cost for each condition. The annual cost factor for 20 years at 5% interest is 0.0302, which is multiplied by the replacement cost for each type of structure to obtain the annual cost for each one. The annual decrease in property values due to structure damage by flooding is:

- Basements: $15,000 x (0.0302) = $453.00 per year
- Crawl Spaces: $5,000 x (0.0302) = $151.00 per year

Our interviews, questionnaires and on site surveys indicate that as many as 25 basements and 29 crawl spaces are affected by the high ground water table and could be helped by the project. The annual cost is calculated to be:

- Basements: 25 at $453.00 = $11,325.00
- Crawl Spaces: 29 at $151.00 = $4,379.00

From our interviews we estimate that five basements need repairs each year due to water damage related to the high water table and the average cost for these repairs is $3,000. Normally home owners insurance does not cover flooding due to high ground water or from streams or rivers unless the community is covered under the National Flood Insurance Program. Basin is not covered under the National Flood Insurance Program. The cost of these repairs must be borne by the property
owners. Therefore, the average annual cost of repairs due to the high ground water is $15,000.

To estimate the annual cost to the residents necessary to install, maintain and to pump the water associated with the high ground water we have assumed that the average sump pump is a 1/3 HP unit and that the pump is 85% efficient. We have also assumed that each pump will operate for 15 minutes of each hour for the following time period; one third of the month of April, all of the months of May, June, July, August, September and for one half of the month of October. For this time period each sump pump will operate a total of 1068 hours. Our interviews and returned questionnaires indicate 14 such sump pumps. Allowing for at least one more not identified, the estimated total number of pumps in operation is 15. At 85% efficiency the total estimated kilowatt hours used during the period is 4511. Assuming a cost per kilowatt hour of $0.075 the cost for power associated with pumping the high ground water would be about $340.00 per year. In addition we have assumed that the average life of these sump pumps is two years and the replacement cost is $120.00 each. The resulting average annual cost of sump pump replacement is $900.00.

The Town of Basin budgets $2,300.00 per year for all streets and alley maintenance. Mr. Bill Stoelk, Town Superintendent states that on the average the town crew spends about 12 days fixing North 7th Street and North 5th Street utilizing a motor grader and operator. It appears to us that the maintenance budget is insufficient to properly maintain the streets. We have estimated that the following is a more realistic budget. With limited funds available to communities today budgets do not necessarily reflect what is needed but more like what can be afforded. Therefore, the budget proposed here does not reflect in any way a criticism of the Town's budget, but has been developed to indicate what we feel would be budgeted if sufficient monies were available to the Town.

1. Motor grader and dump truck work - four weeks per year on the water related street problems:
Motor grader cost $ 8,800
Grader operator cost $ 2,400
Gravel replacement $ 4,375
Dump truck cost $ 2,400
Driver cost $ 1,200

2. Asphalt street patching
   Dump truck cost $ 1,200
   Driver cost $ 600
   Laborer $ 600
   Compactor $ 1,000
   Asphalt $ 900
   TOTAL $23,475

Therefore, the total estimated annual cost for street maintenance and replacement of asphalt related to the high ground water problem is $23,475.

The combined total estimated annual cost to the town and the residents is:

   1. Decrease in property values
      Basements $11,325
      Crawl Spaces $ 4,379
   2. Repairs to structures $15,000
   3. Cost of sump pumps
      Power $ 340
      Pump replacement $ 900
   4. Street maintenance and asphalt patching $23,475
   TOTAL $55,419

This represents the estimated annual cost to the Town of Basin and the residents if the ground water problem is not eliminated or reduced.

The estimated costs of the improvements to reduce the high ground water problem are:
The annual cost associated with each of the above improvements has been developed as follows: The Canal lining and fencing meets the guidelines for funding of the Wyoming Water Development Commission. This portion of the project is eligible for a grant in the amount of 50% of the total cost and a loan on the balance at an interest rate of 4% per year for a term of 25 years. Based on the information presented by representatives of the WWDC during the meeting reviewing the Phase I Draft Report the subdrainage system is not eligible for funding under WWDC guidelines.

Annual cost for the Canal lining and fencing is $23,182.78 ($362,231.00 x 0.0640).

As stated previously the Town of Basin has applied to the Wyoming Farm Loan Board for funds to pave the Town's streets. Present funding guidelines of the Wyoming Farm Loan Board provide 50% grant and 50% loans to approved projects. Interest rate and terms on WFLB loans are 8.5% and 30 years respectively. Therefore, the annual cost for the WFLB loan for the subsurface drainage system would be $61,146.00 ($656,779.00 x 0.0931). The total annual cost for both installations is therefore $84,328.90.

The estimated project cost of the paving project is $4,000,000 not including the subsurface drain system or canal lining outlined in this study. In order to preserve the integrity of the street project it would be necessary to install the drain systems and line the canal as described herein. If it is assumed that the cost of the asphalt pavement portion of the street improvement project is approximately 60% of the cost of the paving project the cost of the pavement would be $2,400,000. The subsurface drain system and the lining of the canal would effect 70% of the streets or approximately $1,680,000 of the street project.

By not installing the subsurface drain system and not lining the canal it is estimated that the life of the pavement will be reduced by at
least 25% or from 20 years to 15 years. Again using an interest rate of 5% the difference in annual cost between installing the subsurface drainage system and lining the canal and the cost of not installing the system or lining the canal is as follows:

1. No improvements \(1,680,000 \times 0.0963 = 161,784.00\)
2. Install subdrainage & line canal \(1,680,000 \times 0.0802 = 134,736.00\)

TOTAL ANNUAL COST SAVINGS $ 27,048.00

This amount added to the total annual benefit of $55,419 results in a total annual benefit of $82,467.00. This is still less than the total estimated annual cost of $84,328.90, but not by a significant amount. If the subsurface drainage system would be eligible for funding through the WWDC the annual cost for the subdrainage system would reduce to $42,033.86 ($656,779.00 \times 0.0640) and the total annual cost would be $65,216.64. The annual benefit would exceed the annual cost by $17,250.36.

Based on the annual cost analysis it appears that the project is very close to being feasible from a benefit-cost stand point. A cost item that is not included in the above analysis and one that would be difficult, if not impossible to quantify, is the effect the high ground water table has on the saleability of property in the community. How many homes and businesses were not able to be sold simply because there is a real prospect of a flooded or damaged basement due to the high ground water table.

In order for the Town of Basin to repay the loans for the improvements proposed herein a local improvement district could be created for the subsurface drainage system. This district could be created for the subsurface drainage improvements proposed herein or for these improvements and the proposed street paving project. Repayment would be made from assessments levied against the property benefitting from the improvements. Wyoming Statutes Title 15, Chapter 15-6-101, subparagraph (a)(iv) defines improvement as "means any lawful local improvement of any kind, which the governing body finds to be of special benefit to the property proposed to be assessed for the cost thereof". A layman's
interpretation of this definition would preceive that the Town could also create a local improvement district to fund the proposed lining of the canal. However, we recommend that the Town consult with their attorney on this point. If this is the case the Town could fund the lining of the canal through a local improvement district.

Since the lining of the canal will definitely benefit the Big Horn Canal Company in the form of less water loss in the lined stretch, less maintenance required in the lined stretch, and improved safety along the fenced section that reduces the liability exposure, that organization should be contacted regarding financial contribution to the project.

G. PERMITTING

The following permits will be required for the construction of the improvements presented herein.

SYSTEM # 1
1. Rights of way across two pieces of private property west of South 9th Street.
2. Permit to cross US Highway 16/20 from Wyoming Highway Department.
3. Permit to cross Burlington/Northern railroad.
4. Surface water discharge permit from US Environmental Protection Agency.
5. Possible permit required from Big Horn County to install system in Antelope Street.

SYSTEM # 2
1. Right of way across private property east of railroad near lagoon area.
2. Permit to cross US Highway 16/20 from Wyoming Highway Department.
3. Permit to cross Burlington/Northern railroad.
4. Surface water discharge permit from US Environmental Protection Agency.
SYSTEM # 3
1. Permit from Big Horn Canal Company to improve canal by lining.
3. Possible permit and/or exchange of wet lands.

H. CONCLUSIONS AND RECOMMENDATIONS

The lowering of the ground water table any significant amount will require both the lining of the canal and the installation of the subsurface drain systems proposed herein. Without the subdrainage systems the life of the surfacing of the proposed street paving project will be reduced substantially and maintenance costs of those paved areas will increase dramatically. If the canal is not lined, nor the subsurface drainage systems installed, the Town of Basin is faced with the same continuing problem, i.e., soft mushy streets requiring more and more maintenance and continued deterioration of basements and crawl spaces to the homes and businesses of the community. As the value of the property drops the tax revenue to the community will also decrease. This is evident from the assessed valuation of the community over the last two years. In 1989 the assessed valuation was $2,481,259. The 1990 assessed valuation is $2,392,845.

It is recommended that the Town of Basin pursue funding from the Wyoming Water Development Commission for the canal lining and to explore in more detail the possibility of the subsurface drainage systems being eligible for funding also from the Wyoming Water Development Commission. Any funding not eligible from the WWDC should be pursued through the Wyoming Farm Loan Board in the form of grants and loans. The Town should also contact the Big Horn Canal Company for financial assistance to complete the project.
APPENDIX "A"
APPENDIX "B"
PROFILE S. 6TH STREET
WYOMING AVE. TO "A" ST.

VERT SCALE: 1"=5'
VERT SCALE: 1"=5'
HORIZ SCALE: 1"=100'

115 120 125 130 135

0+00 2+00 4+10 6+00 8+00 10+00
APPENDIX "C"
TEST PIT NO. 1

- Silty Sand
- Saturated soil @ 7.0 ft, assumed water table
- Sandy gravel, free flowing water into Test Pit
- Unstable vertical walls

TEST PIT NO. 2

- Silty sand, tan
- Saturated soil @ 5.5 ft, assumed water table
- Sandy gravel, free flowing water into Test Pit
- Unstable vertical walls

TEST PIT NO. 3

- Silty sand, tan
- Assumed water table @ 7.8 ft
- Sandy gravel, free flowing water into Test Pit

TEST PIT NO. 4

- Silty sand, brown
- Saturated soil @ 7.0 ft, assumed water table
- Walls unstable from depth of 7.0 ft

TEST PIT NO. 5

- Silty sand, brown
- Saturated soil @ 7.0 ft, assumed water table

NOTE: Test Pits 2, 3, 4, 5, 6, 7 are on the same vertical datum, with BSL 100 being top of head. Site is on Benning Canal or top of concrete head wall of Box Culvert under Highway to Burlington & the Horn Canal being BSL 100.00.

TEST PIT LOGS
Test Pit No. 6

Walls unstable from depth test down

Test Pit No. 7

Clay and silty sand are same color; transition gradual & not visible in pit wall

Test Pit No. 8

In general softer hard to dig
Gravel found no noticeable change of material however. No saturated soil encountered

Test Pit Logs

Note: Test Pits 4, 5, 7, 8, 9 are on same vertical datum, with elev. 500 being N.A.'s 100 X 107 St.