LANDER WATER SUPPLY PROJECT
MASTER PLAN
LEVEL I REPORT

SUBMITTED TO:

WYOMING WATER DEVELOPMENT COMMISSION

1515 Ninth Street, Suite A
Rock Springs, Wyoming 82901
Phone (307) 362-7519
Fax (307) 362-7569
16 October 1996
Project No. 3908-95E

Mr. John W. Jackson
Administrator, Planning
Wyoming Water Development Commission
Herschler Building, 4th Floor West
122 West 25th Street
Cheyenne, WY 82001

Subject: Level I Report
Lander Master Plan Project

Dear Mr. Jackson:

We are transmitting herewith 23 copies of the Level I Report- Lander Master Plan. Two (2) additional copies are being sent to the City of Lander pursuant to our telephone conversation on October 14th.

Thanks for the assistance and consideration you provided during the course of this study.

Sincerely,

Robert E. Johnson, PE & LS
President, Project Manager

Amy M. Allen, PE
Project Engineer

cc: Hon. Gerald Heckart, Mayor City of Lander
    Mr. Laurence Ashdown, Director of Public Works
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<table>
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<th>Description</th>
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<tr>
<td>DBP</td>
<td>Disinfection By-Products</td>
</tr>
<tr>
<td>D-DBP</td>
<td>Disinfectant-Disinfection By-Product Rule</td>
</tr>
<tr>
<td>DOC</td>
<td>Dissolved Organic Carbon</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>ESWTR</td>
<td>Enhanced Surface Water Treatment Rule</td>
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<tr>
<td>HAA5</td>
<td>The five haloacetic acids monitored by the D-DBP Rule</td>
</tr>
<tr>
<td>MCL</td>
<td>Maximum Contaminant Level</td>
</tr>
<tr>
<td>MF</td>
<td>Microfiltration</td>
</tr>
<tr>
<td>MPA</td>
<td>Microscopic Particulate Analysis Test</td>
</tr>
<tr>
<td>NOM</td>
<td>Natural Organic Matter</td>
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<tr>
<td>SWTR</td>
<td>Surface Water Treatment Rule</td>
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<tr>
<td>SDWA</td>
<td>Safe Drinking Water Act</td>
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<tr>
<td>TDS</td>
<td>Total Dissolved Solids</td>
</tr>
<tr>
<td>THAA</td>
<td>Total Haloacetic Acids</td>
</tr>
<tr>
<td>TOC</td>
<td>Total Organic Carbon</td>
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<tr>
<td>TTHM</td>
<td>Total Trihalomethanes</td>
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<td>UF</td>
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I. **INTRODUCTION**

A. **Authorization and Purpose**

This Level I Report for the City of Lander Water Master Plan has been completed in accordance with a Contract between the Wyoming Water Development Commission and JFC Engineers, Architects, Surveyors of Rock Springs, Wyoming dated 2 June 1995. The purpose of this project was to complete a study and develop a master plan after evaluating the existing supply and distribution systems and determining areas outside of the present service area that can be served by expanding the present system. The Master Plan prioritizes improvements to the existing system to satisfy the needs of the community through the year 2020. Preliminary designs and cost estimates have been developed for preferred alternatives.

The tasks involved for the Scope of Work are as follows:

<table>
<thead>
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<td>Task 2</td>
<td>Service Area Delineation/Water Demand</td>
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<td>Task 3</td>
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<td>Task 4</td>
<td>Transmission, Storage and Distribution System</td>
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<td>Task 4b</td>
<td>Evaluation of Storage System</td>
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<td>Task 4c</td>
<td>Evaluation of Distribution System</td>
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<td>Task 5</td>
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<td>Task 8</td>
<td>Economic Analysis/Ability to Pay</td>
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<td>Task 9</td>
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<td>Task 10</td>
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<td>Task 11</td>
<td>Surveying</td>
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<td>Task 12</td>
<td>Results Presentation &amp; Public Hearing</td>
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<tr>
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B. **Technical Team**

The technical team assigned to this study consists of professional personnel from the following firms:

- JFC Engineers, Architects, Surveyors, Management/Prime Consultant, Rock Springs, WY
- TST Inc. Consulting Engineers, Water Treatment, Denver, CO
- Dana Consulting, Laramie, WY, Geology and Groundwater
C. Study Area

The City of Lander, Wyoming is located at the eastern foot of the Wind River Range in Fremont County, Wyoming. The study area includes the City of Lander and outlying areas as depicted on Figure I.1.

Lander is an incorporated municipality of 7023 residents according to the 1990 U.S. Census. The area is a ranching community and it is felt that it will experience growth due to people from other areas moving into this picturesque Rocky Mountain Region. The town’s water system and supply are presently adequate to satisfy peak flows; however, modifications need to be made to the existing system to bring it into compliance with current and pending EPA water quality regulations. Also, pressure problems exist in a few locations within the system. The following Master Plan addresses these problems.

Presently, Fremont County has no zoning restrictions and the only available data defining population in the study area outside of the city consists of platted subdivision maps. Population growth figures from the Fremont County Planning Office indicate an increase of 0.50% per year or 13% in the next 25 years (present repayment period). This growth factor was applied to the current population figures developed from the subdivision maps which considered 3.5 people per lot or parcel.

<table>
<thead>
<tr>
<th>Year</th>
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<tr>
<td>1995</td>
<td>35,030</td>
</tr>
<tr>
<td>1996</td>
<td>35,260</td>
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<tr>
<td>1997</td>
<td>35,460</td>
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<tr>
<td>1998</td>
<td>35,640</td>
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<tr>
<td>1999</td>
<td>35,800</td>
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<td>2000</td>
<td>35,870</td>
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<td>2001</td>
<td>36,030</td>
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<td>2002</td>
<td>36,140</td>
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<td>2003</td>
<td>36,250</td>
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<td>2004</td>
<td>36,390</td>
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<td>2005</td>
<td>36,580</td>
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<td>2006</td>
<td>36,780</td>
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<tr>
<td>2020</td>
<td>39,409</td>
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The increase for an eleven year period is 1750 or 0.45% per year (rounded to 0.5% per year). Growth for a 25 year period is 12.5% which was rounded to 13%.
D. Investigation, Field Work and Meetings

The investigation and field work was conducted from June 1995 through June of 1996. The investigation included data research, field reconnaissance and personal contacts in the study area with personnel from the City of Lander, the Lander Fire Department, WWDC and members of the Tweed Lane Water and Sewer District.

Meetings conducted during the course of work include:

1. Scoping Meeting in Lander held 22 June 1995 with members of the City Council, Fremont County Board of Commissioners, City Planning Commission, County Planning Commission, WWDC, City personnel, and the Mayor present.
2. Several other meetings with the City, Tweed Lane, and the Mayor were held throughout the course of the project.

E. Conclusions

1. Infiltration Gallery
   • The infiltration gallery presently supplies one half of the city's water supply.
   • The water from the infiltration gallery, at present, is slightly under the influence of surface water.
   • The water from the infiltration gallery will continue to be under the influence of surface water and the level of influence will increase over time.
   • The water from the infiltration gallery will not meet SDWA and SWTR regulations at some point in the future due to increased levels of surface water influence.
   • The implementation of a watershed management control plan to protect the water supply from the infiltration gallery is not practical.
   • Loss or curtailment of the supply from the infiltration gallery will impose greater reliance on the performance of the water treatment plant.

2. Water Treatment Plant
   • The water treatment plant does not perform to design capacity during periods of high turbidity in the Middle Fork of the Popo Agie River.
   • The water treatment plant cannot meet existing demands during periods of high turbidity levels in the river if the supply from the infiltration gallery is cut-off; therefore, the water treatment plant will have to be modified and upgraded to 5.2 MGD prior to abandonment of the infiltration gallery.
   • The water treatment plant can be expanded to treat a maximum of 7.2 MGD to meet future demands.
   • Capacity in the transmission pipeline from the river to the plant will limit further enlargement of the water treatment plant.
3. **Transmission Pipeline - River to Treatment Plant**
   - The transmission pipeline from the river to the treatment plant is experiencing deterioration due to scour and corrosion that is releasing asbestos fibers from the interior pipe wall. However, the amount of fibers is less than the minimum standard for safe drinking water.

4. **Transmission Pipeline - Treatment Plant to Mager Tank**
   - Capacity in the pipeline from the treatment plant to the Mager tank is inadequate to deliver water to the tank at the same flow rate that the treatment plant delivers water into the system. Therefore, clearwell storage is proposed to equalize flow between the plant and Mager tank.
   - The clearwell will also provide operational storage and maintain system pressure to those areas above the Rodeo tank that are served directly from the pipeline between the treatment plant and the Rodeo tank.

5. **Storage**
   - Clearwell or operational storage immediately downstream of the water treatment plant is necessary.
   - The existing one-million gallon storage tank is not functional as applicable to the operation of the distribution system.
   - The Rodeo tank can be left in service and supplemented by clearwell storage and a new tank at a higher elevation (referred to as the Nicol Hill tank). The Rodeo tank provides storage with adequate head to a portion of the distribution system to the southwest area of Lander.

6. **Distribution System**
   - Water demands exist outside of the existing distribution system service area and these demands will increase over time.
   - The existing distribution system can be expanded; however, there are hydraulic limitations to the expansion.

7. **Groundwater**
   - The potential to develop groundwater exists to supply water to the north and northwest portions of the study area outside of the hydraulic limits of the distribution system service area.
   - The development of groundwater in the north and northwest areas will require a production well, transmission pipeline, chlorination facility, storage tank and distribution systems pipelines.

8. **Priorities**
   - The measures, facilities and improvements to the City's waterworks can be scheduled for construction in conformance with a predetermined priority system.
9. **Potential Funding Sources**
   - The following funding sources should be considered in pursuing project development:
     
     a) Wyoming Water Development Commission (WWDC)
     b) Wyoming Farm Loan Board (WFLB)
     c) Abandoned Mine Lands Program (AML)

10. **Impacts on Water Rates**
    - Project funding from WWDC and WFLB will result in significantly higher water costs to the residents of Lander.
    - Project funding from AML will result in significantly lower water costs than those resulting from WWDC and WFLB funding.

11. **Threats to Public Health**
    - Water from the infiltration gallery is under the influence of surface water and therefore the potential for contamination of the water source exists. Consequently this constitutes a potential threat to public health.
    - The water treatment plant does not perform at design capacity during periods of high turbidity levels in the Middle Fork of the Popo Agie River. This situation poses a threat to public health.

12. **Impacts from Mining**
    - The City of Lander was severely impacted by the closure of the Atlantic City Iron Ore mine in 1983 due to the loss of more than 500 permanent jobs.
    - The City of Lander was significantly impacted by the closure of uranium mines in the Gas Hills.

F. **Recommendations**

1. **Priorities and Facilities**
   - The following priorities should be considered in developing and constructing the improvements and facilities addressed in this report:

<table>
<thead>
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<th>Priority</th>
<th>Facilities Proposed to be Constructed</th>
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   | I        | • Upgrade water treatment plant to 5.0 MGD  
             • 250,000 gallon clearwell/operational storage reservoir |
   | II       | • Nicol Hill storage reservoir  
             • Transmission pipeline to new tank |
   | III      | • Expand distribution system in study area as dictated by demands and growth  
             • Expand and upgrade water treatment plant to 7.2 MGD |
Priority Facilities Proposed to be Constructed

IV
- Drill exploration well
- Upgrade exploration well to production well
- Transmission pipeline from well to storage tank
- Chlorination facility
- Lander Hill storage tank

V
- Priority V features, measures and facilities are not considered to be constructed at this time. Additional study should be completed relative to Priority V recommendations as listed below.

- Perform physical inspection of the transmission line from the river to the water treatment plant.
- Lining of the Popo Agie 20 inch diameter transmission pipeline or pipeline replacement should be considered if it is found to be seriously corroded to the point of needing repair.
- Irrigation of the city parks should be monitored and adjusted if the City gets into a water treatment production problem. Irrigation of city parks should take place at night and it is recommended that meters be read to monitor water usage.
- Water rights should continue to be acquired as the City incorporates surrounding irrigation lands into the city.
- The water right at the infiltration gallery should be moved to the Popo Agie intake in the event of infiltration gallery abandonment.
- A separate system for city parks that would not use potable water could be considered if it is felt that the infiltration gallery should not be abandoned. This irrigation water could be supplied from the infiltration gallery.
- A schedule and program should be developed for valve exercising and replacement; tank maintenance, inspection and cleaning; meter maintenance; and pump station operation and maintenance.
- Immediate plans for improving the pressure situation at the hospital should be implemented including cross-connecting to the 12 inch Rodeo tank discharge line. This would also temporarily solve the lack of storage problem at the hospital.
- A reliable flow measurement system should be installed on the pipeline from the infiltration gallery.

2. Funding

- Funding under the Abandoned Mine Lands Program should be pursued before other funding sources are considered. Lander's match for funding under the AML Program is 6% of the project cost.

The priorities for the system development should be changed if funding is pursued from the AML Program. Priority I should be revised as follows:

⇒ Upgrade water treatment plant to 7.2 MGD.
Construct 250,000 gallon clearwell/operational storage reservoir downstream of treatment plant.

- Funding from WWDC should be considered as applicable if AML funding is not obtained.
- Funding from WFLB should be requested as applicable if AML funding is not obtained.
II. WATER SUPPLY

The City of Lander presently obtains its water from the following sources:

- Middle Fork Popo Agie River (surface water intake).
- An infiltration gallery near the Middle Fork Popo Agie River.
- A well near the water treatment plant.

Property owners outside the Lander city limits have historically used private wells as a water source. The well water ranges in quality from good, in wells to the west of Lander on the foothills of the Wind River Range, to poor in the areas north and east of Lander.

A. Middle Fork of the Popo Agie

The city obtains approximately 3.6 MGD peak day and 1.2 MGD average day directly from the Middle Fork of the Popo Agie River. This supply is directed into an intake facility and conveyed to the water treatment plant through approximately 2 miles of 20 inch diameter asbestos cement pipe.

1. Raw Water Quality

The Middle Popo Agie River water supply is fed by the snow melt from the Wind River Range. The results of water quality tests taken in August of 1995 indicate that the river is an excellent water supply. The supply is low in alkalinity, hardness, total dissolved solids and low in turbidity. The turbidity levels fluctuate seasonally and are typically much higher during the snow melt cycle within the watershed or during high intensity and localized rainstorms. The results from monitoring tests show that turbidities are normally low throughout most of the year and can be as low as 0.3 NTU during the winter months but increase to levels as high as 25 NTU during the snow melt.

The snow pack and the snow melt cycles also cause high levels of color. The presence of color is an indicator of dissolved organic carbon (DOC) or colloidal organic matter in the water supply. These reactive substances are potential precursors for the formation of disinfection by-products (DBP) when combined with chlorine. Within the aquatic ecosystems, the sources of DOC either enter the system from a terrestrial watershed or derived from the biota (e.g., algae, bacteria, macrophytes) growing within the water body. Most of the DOC originates from the degradation and leaching of organic material in the soils of the watershed which is transported by the overland flows, stream flows and shallow groundwater flows during the snow melt. Tests for organic carbon were conducted during May and June of 1996. Test results indicated total organic carbon (TOC) concentrations of 4 mg/l which is the threshold level that may trigger treatment processes or other technologies to reduce the concentrations of disinfection by-products (DPB) precursors. The results of the TOC tests may not be indicative of the typical concentrations. The treatment plant operators have indicated that color in the Popo Agie has been unusually low in 1996 and that the TOC concentrations may be much higher during a more typical year. The Disinfectants, Disinfection By-products Rule will be discussed in later sections of this report. See Appendix A for all water quality test data.
B. **Infiltration Gallery**

The City of Lander also obtains a significant portion of its potable water supply from an old infiltration gallery that is constructed in the alluvium of the Middle Popo Agie River. Approximately 1200 gpm of its water supply is collected by the infiltration gallery and conveyed by a gravity pipeline to a chlorination station that is located near the 2 million gallon storage tank where it is chlorinated. The storage tank provides chlorine contact time to achieve compliance with the disinfection requirements of the SDWA. See Figure I.1 for the infiltration gallery location.

The infiltration gallery is part of the City's original potable water system. It was installed at a depth of 22 feet. The alignment of the pipeline is partially in the flood plain of the Middle Popo Agie River while other portions of the facility traverse lands that are primarily residential. The sluice gate is 18" in diameter and approximately 1600 feet in length. The condition of the infiltration gallery has deteriorated and sections of the pipeline are vulnerable to contamination. Several residences are adjacent to or near the pipeline. The residences use septic systems for sanitary waste treatment and disposal and the septic systems' leach fields discharge to the same alluvium used for a water supply. Other sections of the pipeline have open or deteriorated manholes that provide access for contaminants to enter the water supply.

Infiltration galleries are generally classified by the Environmental Protection Agency (EPA) as groundwater under the direct influence of surface waters and therefore must comply with the requirements of the Surface Water Treatment Rule (SWTR). Groundwater supplies under the direct influence of surface waters must have treatment and disinfection systems that also achieve compliance with the SWTR. The specific SWTR criteria and requirements will be presented later within this report.

Public water systems that use groundwater under the direct influence of surface water can also be in compliance with the SWTR without the addition of filtration if the source meets the requirements of the filtration avoidance criteria and if the disinfection facilities achieve the inactivation efficiency stated above and also complies with the requirements defined within the SWTR.

1. **Criteria for Avoiding Filtration (40 CFR 141.71)**

   **Source Water Quality Conditions:**
   a. Fecal coliform concentrations < 20/100 ml and total coliform concentrations cannot exceed 100/100 ml.
   b. The turbidity level cannot exceed 5 NTU

   **Site Specific Conditions:**
   a. The public water system complies with the disinfection standards of the SWTR.
   b. The public water system must maintain a watershed management and control program that minimizes the potential for contamination by *Giardia lamblia* cysts and viruses in the source water. The public water system must demonstrate through written agreements
with the landowners within the watershed that it can control all human activity that will have adverse impact upon the microbiological quality of the water source. The public water systems that use groundwater under the direct influence of surface waters must have a wellhead protection plan which achieves the same objectives of a watershed management and control plan approved by EPA.

c. The public water system must be subject to annual on-site inspections to assess the watershed/wellhead control program and the disinfection treatment process.

d. The public water system cannot be identified as the source or cause of waterborne disease outbreak.

e. The public water system must comply with the MCL for total coliforms on an ongoing basis.

f. The public water system must comply with the total trihalomethane (TTHM) regulations (40 CFR 141.12 and 141.30) The current allowable TTHM concentration is 0.1 mg/l however it is proposed that this limit will be reduced to 0.04 mg/l by the pending D-DBP Rule.

The existing infiltration gallery may be under the direct influence of surface water. This is based on results of two MPA tests taken in the summer of 1995. One test indicated that there is a moderate influence of surface water into the infiltration gallery while the other test indicated a slight influence from surface water. These tests were taken in August when the stream flows in the Middle Popo Agie River are near seasonal lows and may not be an accurate indicator for surface water influence. EPA also does not consider the test that indicated a slight influence as a legitimate test because the test was not taken by a representative of the agency. A new test was taken when the flows in the river were near its maximum rate and when the turbidities were also at seasonal high levels. The results from the new test provided a better assessment of the condition of the infiltration gallery when it is under the greatest potential for the direct influence of surface water. This test was conducted in June of 1996. The test results indicated a slight influence of surface water which does not correlate with the results of the previous test. A third MPA test must now be taken to assess if the infiltration gallery is considered under the direct influence of surface water as defined by the protocol adopted by Region 8 of EPA and illustrated by Figure II.1.

Other evidence that the infiltration gallery may be under the direct influence of surface water occurred during the summer of 1995. The infiltration gallery was out of operation for an extended period of time because the pipeline was obstructed by root balls. The presence of roots within the gallery is clear evidence that pathways do exist from the surface to the pipeline and the pathways that are currently occupied by active root systems will eventually become conduits for surface water when the trees die.
MPA Interpretation Protocol
EPA Region VIII, Drinking Water Branch
Public Water System I & E. Section
July 1995

Hydraulic Connection Confirmed / Suspected?

YES

Collect Minimum Two MPA Samples During Critical Periods

NO

SWTR Does Not Apply

At Least One Sample Result \( \geq 20 \) ?

NO

Both Samples \( \leq 9 \)

YES

SWTR Does Not Apply

GWI

NO

Collect A 3rd MPA Sample

At Least One Sample Result \( \geq 20 \) Or \( \geq 2 \) Sample Results With Scores \( \geq 15 \) ?

NO

3 Out Of 3 Samples With Scores \( < 15 \) ?

YES

System Requires Further Evaluation

NO

GWI

SWTR Does Not Apply

Figure II.1
C. Well

A well at the treatment plant originally produced 120 gpm for use at the treatment plant. Presently the well is shut back to approximately 55 gpm and supplies water into the southwest Lander zone of the distribution system and satisfies treatment plant needs.

D. Water Rights

Table II-1 summarizes the City of Lander water rights.

E. Adequacy of Supply

The city has an adequate supply of surface water from the Middle Fork of the Popo Agie and storage water rights to meet demands into the 21st century. The water right for the infiltration gallery should be converted to a surface right in the river if the infiltration gallery is abandoned.

F. Development of Groundwater

A geological study was included in the Lander Master Water Plan scope of work and is included in Appendix B. This report includes a search for alternative water supplies. A review of potential sources was completed and it was concluded that groundwater is a significant and viable source, and further investigation for groundwater should be conducted.

A number of aquifers, west and north of the Lander city limits were considered as potential supplemental sources of water. These aquifers, which outcrop west of Lander, dip eastward and could be developed at various depths. Geological maps identifying potential sources of suitable groundwater are found in the Appendix B.
### SURFACE WATER

<table>
<thead>
<tr>
<th>Permit No.</th>
<th>Priority</th>
<th>Use</th>
<th>CFS</th>
<th>Acre-ft</th>
<th>Hq Location</th>
<th>Ditch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terr 1874</td>
<td>1</td>
<td>Mun</td>
<td>0.31</td>
<td>9-32-100</td>
<td>Olsen</td>
<td></td>
</tr>
<tr>
<td>Terr Spring 1884</td>
<td></td>
<td>Mun</td>
<td>0.29</td>
<td>9-32-100</td>
<td>Dutch Flat</td>
<td></td>
</tr>
<tr>
<td>Terr 05-04-1885</td>
<td></td>
<td>Mun</td>
<td>4.75</td>
<td>9-32-100</td>
<td>City Pipeline</td>
<td></td>
</tr>
<tr>
<td>5537 9/23/03</td>
<td>D, Mun</td>
<td></td>
<td>2.00</td>
<td>9-32-100</td>
<td>Water Supply Pipeline</td>
<td></td>
</tr>
<tr>
<td>4253E 10/16/20</td>
<td>D, I, Mun</td>
<td></td>
<td>2.40</td>
<td>9-32-100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5731E 5/10/54</td>
<td>I</td>
<td></td>
<td>0.48</td>
<td>3-32-100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Chitten Gulch**

<table>
<thead>
<tr>
<th>Permit No.</th>
<th>Priority</th>
<th>Use</th>
<th>CFS</th>
<th>Acre-ft</th>
<th>Hq Location</th>
<th>Ditch</th>
</tr>
</thead>
<tbody>
<tr>
<td>8936 8/18/82</td>
<td>I</td>
<td></td>
<td>2.71</td>
<td>20-33-099</td>
<td>Golf Course Reservoir</td>
<td></td>
</tr>
</tbody>
</table>

**Roaring Fork or Roaring Fork Creek**

<table>
<thead>
<tr>
<th>Permit No.</th>
<th>Priority</th>
<th>Use</th>
<th>CFS</th>
<th>Acre-ft</th>
<th>Hq Location</th>
<th>Ditch</th>
</tr>
</thead>
<tbody>
<tr>
<td>8186R 10/7/54</td>
<td>Mun</td>
<td></td>
<td>1395</td>
<td>32-32-101</td>
<td>Worthern Meadow Reservoir</td>
<td></td>
</tr>
<tr>
<td>6365R 5/1/56</td>
<td>Mun</td>
<td></td>
<td>108.6</td>
<td>32-32-101</td>
<td>1st Enl. Worthen Meadow Res</td>
<td></td>
</tr>
</tbody>
</table>

### GROUND WATER

<table>
<thead>
<tr>
<th>Permit No.</th>
<th>Priority</th>
<th>Permit Name</th>
<th>GPM</th>
<th>Hq Location</th>
<th>Quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td>P440G 1956</td>
<td>City of Lander</td>
<td>5500</td>
<td>33-100-35</td>
<td>NENE</td>
<td></td>
</tr>
<tr>
<td>P42338W</td>
<td>Infiltration Gallery</td>
<td>?</td>
<td>33-100-25</td>
<td>SESE</td>
<td></td>
</tr>
<tr>
<td>P42338W</td>
<td>Lander Field #3</td>
<td>?</td>
<td>33-100-25</td>
<td>SWSW</td>
<td></td>
</tr>
<tr>
<td>P42338W</td>
<td>Lander Field #2</td>
<td>Cancelled 33-100-25</td>
<td>SESW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P139C 1942</td>
<td>Lander Well #1</td>
<td>539</td>
<td>33-100-25</td>
<td>NESW</td>
<td></td>
</tr>
<tr>
<td>P6071W 1970</td>
<td>Lander City Golf Course #1</td>
<td>?</td>
<td>33-99-19</td>
<td>NENE</td>
<td></td>
</tr>
<tr>
<td>P5284W 1981</td>
<td>Park I</td>
<td>40</td>
<td>33-99-19</td>
<td>NENW</td>
<td></td>
</tr>
<tr>
<td>P71838W 1983</td>
<td>Park II</td>
<td>40</td>
<td>33-99-19</td>
<td>NENW</td>
<td></td>
</tr>
<tr>
<td>P91099W 1989</td>
<td>MW#2</td>
<td>?</td>
<td>33-99-18</td>
<td>SENE</td>
<td></td>
</tr>
<tr>
<td>P91100W 1989</td>
<td>MW#3</td>
<td>?</td>
<td>33-99-18</td>
<td>SENE</td>
<td></td>
</tr>
<tr>
<td>P91101W 1989</td>
<td>MW#4</td>
<td>?</td>
<td>33-99-18</td>
<td>SENE</td>
<td></td>
</tr>
<tr>
<td>P31247W 1975</td>
<td>City of Lander #1</td>
<td>?</td>
<td>32-100-3</td>
<td>NWNNW</td>
<td></td>
</tr>
<tr>
<td>P52717W 1979</td>
<td>Water Treatment Plant</td>
<td>130</td>
<td>32-100-3</td>
<td>NWNNW</td>
<td></td>
</tr>
<tr>
<td>P28683W 1974</td>
<td>City #2</td>
<td>?</td>
<td>32-100-9</td>
<td>NESW</td>
<td></td>
</tr>
</tbody>
</table>
III. STUDY AREA / SERVICE AREAS / POPULATION / WATER DEMANDS

A. Study Area

The study area boundaries were determined by the City of Lander and provided to JFC by WWDC. The study area includes the entire City of Lander and platted subdivisions near and surrounding the city. The area boundary is shown on Figure I.1.

B. Service Area - Lander Distribution System

1. In City

The existing distribution system includes four to ten inch cast iron and PVC pipes. It extends to the county garage building to the north, the State Training School to the east and to the BLM building to the south. The distribution system is shown on Map 1.

The distribution system is looped with adequately sized pipelines and has sufficient valves to isolate specific sections of the system for repairs and maintenance. The City performs some maintenance by flushing dead ends and other critical areas. The City has water meters on all service lines and reads them on a monthly basis.

The City distribution system is run as three separate zones. The main zone is supplied directly off of the 2 million gallon tank and encompasses most of the main city area. The main zone supplies water as far north as the County garage building. Approximately 88% of the city demands are part of the main city zone.

The Rodeo tank zone feeds the areas of west and south Lander and ends at the BLM building to the south of Lander. Approximately 6% of the city’s demands are in the Rodeo tank zone.

The Mager tank feeds the Harmony Hills area of West Lander. Approximately 60% of the city’s demands are in the Rodeo tank zone.

A map of Lander showing the platted subdivisions is presented as Map 2. A schematic of the water system is shown on Figure III.1. The general demand areas and zones are shown on the Cybernet model drawing in Map 3.

Approximately 72% of the presently subdivided lots in the city have water taps, or 2614 taps out of 3652 lots. If the entire city was built-out, an increase of 28% in total taps would occur.

2. Outside of City Limits

The existing system extends to a few locations outside of the city limits as shown on Map 1. The only available data for population numbers and potential service taps surrounding the City of Lander is the platted subdivision maps. A total of 907 lots are platted outside of the city limits in...
the study area. It is estimated that approximately 30% or 272 lots are presently occupied and use wells as their water supply.

3. Tweed Lane Water and Sewer District

Under this study, the feasibility of attaching the Tweed Lane Water and Sewer District on to the existing city system was evaluated. The Tweed Lane Water and Sewer District was formed with the specific objective of procuring and serving water from the City of Lander to the residents of the District. They presently do not own any water system facilities.

The District includes fourteen homes and businesses that would be added to the city system along Highway 287 northwest of the city. The City of Lander has a waterline that delivers water to the Fremont County garage which is located just to the north of Tweed Lane Water and Sewer District.

Modeling of the existing city system confirmed that it was feasible to connect the District onto the City of Lander’s main city system.

C. Population

1. In City

The population projections which were prepared for Fremont County were for the entire county and not broken down for the City of Lander. The previous studies projected growth rates within Fremont County by the year 2025 at approximately 13%. The current population of the City of Lander, 7023, only includes the city population and not the entire study area. The projected Lander population based on a 13% growth rate is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Population City of Lander</th>
<th>Total Taps</th>
<th>People per tap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>7023</td>
<td>2614</td>
<td>2.69</td>
</tr>
<tr>
<td>2025</td>
<td>7931</td>
<td>3652</td>
<td>2.17</td>
</tr>
</tbody>
</table>

2. Outside City Limits

The only existing information for growth in the study area is platted mapping from the county planner’s office. Based on the furthest expansion possible for the city’s treatment and distribution system, the total buildout as now platted is as follows:
Table III-2 Study Area Population Outside of the City of Lander

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Occupied Lots in Outlying Areas</th>
<th>People per lot</th>
<th>Total Population outside the City of Lander</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>272</td>
<td>2.69</td>
<td>732</td>
</tr>
<tr>
<td>2025</td>
<td>907</td>
<td>2.17</td>
<td>1968</td>
</tr>
</tbody>
</table>

D. Water Demands

1. Present

The City of Lander water records for 1995 were obtained and listed in the following table. These figures are based on recorded meter readings from 2614 services. The irrigation water used on city parks is not included in this table.

Table III-3 Water Records - City of Lander

<table>
<thead>
<tr>
<th>Month of 1995</th>
<th>Usage Gallons</th>
<th>Usage MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 1994</td>
<td>24,349,140</td>
<td>0.79</td>
</tr>
<tr>
<td>December 1994</td>
<td>27,928,490</td>
<td>0.90</td>
</tr>
<tr>
<td>January</td>
<td>24,578,830</td>
<td>0.88</td>
</tr>
<tr>
<td>February</td>
<td>24,712,340</td>
<td>0.80</td>
</tr>
<tr>
<td>March</td>
<td>28,985,520</td>
<td>0.97</td>
</tr>
<tr>
<td>April</td>
<td>27,599,749</td>
<td>0.89</td>
</tr>
<tr>
<td>May</td>
<td>64,219,340</td>
<td>2.14</td>
</tr>
<tr>
<td>June*</td>
<td>79,509,603</td>
<td>2.56</td>
</tr>
<tr>
<td>July*</td>
<td>99,424,893</td>
<td>3.21</td>
</tr>
<tr>
<td>August*</td>
<td>134,190,878</td>
<td>4.50</td>
</tr>
<tr>
<td>September*</td>
<td>33,607,853</td>
<td>1.08</td>
</tr>
<tr>
<td>October</td>
<td>24,875,940</td>
<td>0.83</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>593,982,576</strong></td>
<td><strong>1.6 (average)</strong></td>
</tr>
</tbody>
</table>

* Does not reflect city park irrigation of approximately 1200 gpm.

Water treatment plant production for 1995 is shown in the following table. The infiltration gallery production is not included in these figures.
Table III-4 Treatment Plant Production

<table>
<thead>
<tr>
<th>Month 1995</th>
<th>Days in Service</th>
<th>Production MG</th>
<th>Average per Day MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>9</td>
<td>4.4</td>
<td>0.14</td>
</tr>
<tr>
<td>February</td>
<td>9</td>
<td>4.3</td>
<td>0.15</td>
</tr>
<tr>
<td>March</td>
<td>8</td>
<td>4.1</td>
<td>0.13</td>
</tr>
<tr>
<td>April</td>
<td>13</td>
<td>6.8</td>
<td>0.23</td>
</tr>
<tr>
<td>May</td>
<td>9</td>
<td>3.3</td>
<td>0.11</td>
</tr>
<tr>
<td>June</td>
<td>20</td>
<td>43.5</td>
<td>1.45</td>
</tr>
<tr>
<td>July</td>
<td>30</td>
<td>92.4</td>
<td>2.98</td>
</tr>
<tr>
<td>August</td>
<td>31</td>
<td>76.6</td>
<td>2.47</td>
</tr>
<tr>
<td>September</td>
<td>21</td>
<td>32.1</td>
<td>1.04</td>
</tr>
<tr>
<td>October</td>
<td>9</td>
<td>3.4</td>
<td>0.11</td>
</tr>
<tr>
<td>November</td>
<td>8</td>
<td>3.2</td>
<td>0.11</td>
</tr>
<tr>
<td>December</td>
<td>9</td>
<td>3.1</td>
<td>0.10</td>
</tr>
<tr>
<td>Totals</td>
<td>176</td>
<td>277.2</td>
<td>1.6</td>
</tr>
</tbody>
</table>

2. Infiltration Gallery

The two significant unknowns in the present system are: the amount of production from the infiltration gallery and the amount of irrigation applied to the city parks during the peak summer months. Several methods were used to determine these two unknowns.

A drawdown test was performed on the 2 million gallon tank to determine the amount of water the infiltration gallery was supplying. The test was performed on 18 March 1996. Since the water usage in March is close to the average for water consumption, and not during a peak period, the water treatment plant was not in use. The valve from the infiltration gallery to the 2 million gallon tank was closed and the tank was allowed to draw down over a 24 hour period. Approximately 800,000 gpd was used. However, the valve closing off the infiltration gallery was leaking and it was felt that actual usage was higher.

The manometer on the infiltration gallery was read on the 22 March 1996. It read 7½" which corresponds to approximately 1200 gpm or 1.7 gpd. This may be a much more accurate figure for infiltration gallery production; however, some debate exists about the accuracy of the manometer.

On 19 June 1996, the production rate of the treatment plant was way below average for this time of year. City personnel felt that this was due to increased flow from the gallery after the removal of the root ball from the infiltration gallery last summer. Water production from the infiltration gallery was predicted to be from 1200 to 1400 gpm.
3. Irrigation Demands

The City of Lander has approximately 106.5 acres of parks. The City has meters on city park taps, however, these meters are never read since the City does not charge itself for water usage. After speaking with the parks commissioner, it was assumed that the City applies one inch of water per week and irrigates 8 hours every day. This would account for 1271 gpm unmetered usage during peak summer months. However, the City uses wells which account for approximately 80 gpm. Therefore it is estimated Lander is applying approximately 1190 gpm irrigation from the distribution system during the peak summer months. See Appendix D for irrigation calculations.

4. Total Demands - Present

The following water demand was determined by including estimates for the infiltration gallery and irrigation of city parks. See Appendix E for water usage information from the City.

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Daily MGD</th>
<th>Maximum Daily MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>1.6</td>
<td>5.2</td>
</tr>
</tbody>
</table>

5. Total Demands - Future

The following “best estimate” of water demands was arrived at based on the study area and growth figures previously described. This demand is projected over the 25 year study period and the table assumes approximately 2.65 people per residence.

<table>
<thead>
<tr>
<th>Year</th>
<th>Existing Taps in the City of Lander</th>
<th>Total Existing Taps Outside of City in Study Area</th>
<th>Total Service Area Population</th>
<th>Usage per Capita (GPD)</th>
<th>Peak Day MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>2614</td>
<td>0</td>
<td>7023</td>
<td>740</td>
<td>5.2</td>
</tr>
<tr>
<td>2020</td>
<td>3025</td>
<td>545</td>
<td>9459</td>
<td>740</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Over the next 25 years, this demand chart assumes a 15% growth increase.

However, if the area were to experience an extensive increase in growth, the following numbers would be the maximum demands based on this growth:

<table>
<thead>
<tr>
<th>Year</th>
<th>Existing Taps in the City of Lander</th>
<th>Total Existing Taps Outside of City in Study Area</th>
<th>Total Service Area Population</th>
<th>Usage per Capita (GPD)</th>
<th>Peak Day MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post 2020</td>
<td>3652</td>
<td>907</td>
<td>12163</td>
<td>740</td>
<td>9.0</td>
</tr>
</tbody>
</table>
IV. FACILITIES

A. Transmission Supply Pipeline (River to Plant)

Water is transmitted from the Popo Agie river to the treatment plant in a 20 inch asbestos cement (AC) pipeline. This was installed in the late 1970's.

The capacity of the existing transmission pipeline from the Popo Agie to the treatment plant is approximately 4883 gpm for a velocity of 5 fps. This is approximately 7,000,000 gpd which will meet the projected growth rate for the study area during the next 25 years.

B. Water Treatment Plant

The Lander water treatment plant was constructed in 1978-79. It utilizes a direct filtration process which is effective when turbidities are constant in the raw water supply and turbidity levels change gradually. The turbidity in the Middle Fork of the Popo Agie is fairly constant during most of the year; however, turbidity levels change significantly over short periods of time during the spring and early summer runoff. The spring runoff results primarily from snow melt bringing with it high turbidities and water color levels. The presence of natural organic matter (NOM) is indicated by changes in water color. NOM is a precursor to disinfection by-products (DBP) (trihalomethanes). Dissolved organic carbon (DOC) results from the degradation and leaching of organic detritus in watershed soils. Snow melt, storm runoff and intense rainfall cause DOC to enter streams and shallow groundwater.

The existing treatment plant does not operate at design levels during the spring and early summer runoff because it does not adequately remove turbidity and color during that period of time. Applied surface loading on the filters are reduced to 50% of the design factor to maintain effluent turbidity readings in conformance with the primary drinking water regulations. Plant operating records indicate that during the spring runoff, periods of operational difficulty exist. Turbidity levels are consistently higher in treated water effluent during these periods. Many water utilities have adopted a voluntary limit for effluent turbidities of <0.1 NTU for surface water. This voluntary limit is not consistently met during snow melt periods; however, turbidity levels remain within current regulatory levels during the same time periods.

Disinfection is achieved by chlorination in the existing treatment process and it will continue to be used. Removal of DBP precursors present in the raw water will be achieved by plant modifications discussed later in the report. DOC removal will be achieved by installing unit processes such as granular activated carbon (GAC) nanofiltration or enhancing coagulation, flocculation and sedimentation processes.

Improved particulate removal will result from enhanced coagulation, flocculation and sedimentation. This will produce effluent water with lower turbidity to achieve full compliance with the SWTR and higher probability for compliance with pending ESWTR.
Current Regulations - Safe Drinking Water ACT (SDWA) - Surface Water Treatment Rule (SWTR)

- Turbidity - 0.1 NTU voluntary limit
- Giardia - 3 log removal and inactivation
- viruses - 4 log removal and inactivation

Pending Regulations - Enhanced Surface Water Treatment Rule (ESWTR) - Disinfectant/Disinfection By-Product Rule (DIDBP)

- Cryptosporidium - 3 log removal
- Total Trihalomethanes (TTHM) - 9.98 mg/l
- Haloacetic acids (HAA5) - 0.06 mg/l
- Total organic carbon (TOC) - 50% reduction

The existing treatment plant will comply with current and pending (foreseeable) surface water treatment regulations by improving coagulation, flocculation, and sedimentation processes in the plant. Improved coagulation, flocculation and sedimentation will be accomplished by converting Flocculation Basin No. 2 to an adsorption clarifier which consists of an upflow pre-treatment process combining coagulation, flocculation and clarification into a single spatial process. This process is explained in detail in Section VI, Water Treatment Plant, of this report.

C. Infiltration Gallery / Transmission Line

1. Gallery

The infiltration gallery is an underground water intake system situated in the alluvium of the Middle Popo Agie River. The infiltration gallery is made up of 1600 feet of 24 inch perforated steel pipe approximately 22 feet deep which then flows into a manhole with an 18 inch sluice gate. It has an overflow which flows back into the Middle Popo Agie River.

2. Pipeline

The pipeline from the infiltration gallery to the 2 million gallon tank is an 18 inch steel pipe which turns into and 18 inch AC pipe at the Ellis Lower Field Connection. The water is chlorinated before it reaches the 2 million gallon tank.

3. Chlorination

A gas chlorination system exists on the upstream side of the 2 million gallon tank on the infiltration gallery line and also at the treatment plant. Contact time is achieved in the 2 million gallon tank. The chlorination seems to be adequate for the system; however, some residences in the Popo Agie valley area obtain their water prior to chlorination, which is in violation of SWDA.

D. Storage Tanks

Four tanks exist in the present system and are shown on the schematic in Figure III.1.
1. **Ellis (2 million)**

   The 2 million gallon tank is the storage reservoir for the main city zone. It is fed by a 20 inch asbestos cement pipe from the water treatment plant and is located at an elevation of approximately 5550 feet.

2. **Mager (0.5 million)**

   The Mager is a 0.5 million gallon tank which serves the Harmony Hills area of Lander. It is the highest tank in the city at 5609 feet. It is fed by an 8 inch PVC line out of the 2 million gallon tank.

   The treatment plant must be run to fill the tank since it cannot be gravity fed from the infiltration gallery. The tank is fed by an 8 inch PVC line which has limited capacity.

3. **Rodeo Tank (0.5 million)**

   The Rodeo tank has a 0.5 million gallon capacity and is at 5588 feet and feeds the south and southeast Lander zone. It is fed by a 12 inch cast iron CI pipe from the treatment plant and well at the treatment plant.

4. **One Million**

   The one million gallon tank has recently been refurbished with Wyoming Farm Loan Board funding. The tank is backfilled through a 12 inch line coming from the main city zone. If the valve tying it to the hospital and airport areas is open, these zones have a tendency to lose pressure. The primary use for this tank is storage for fire flows during peak summer demand months.

E. **Pipeline from Treatment Plant to Tanks**

   The pipeline from the treatment plant to the tanks was installed in 1978 and is a 20 inch diameter AC pipe. This pipeline tends to be very brittle. The City felt that the pipe has a tendency to break when exposed or worked on so they did not want to perform destructive testing to determine the extent of corrosion.

F. **Pump Stations**

   Two pumping stations exist within the city’s distribution system. Water is pumped in the east Lander zone up to the cemetery. This pump has recently been replaced with a PACO 9000 triplex flow pump and is in good condition.

   The second pumping system is on the main city zone and pumps water up to the hospital when the pressure is reduced in the hospital loop. These pumps are in good condition and need no repair.
V. INFILTRATION GALLERY

The current and pending SDWA regulations will have a major impact upon the use of the infiltration gallery as a treated water supply. We have presented the issues regarding the infiltration gallery and its relationship with the SDWA regulations throughout this report. The issues are complex and dependent upon whether the infiltration gallery is or is not under the direct influence of surface water. Unfortunately, this determination is not conclusive and will require a third MPA test to determine the influence of surface water upon the infiltration gallery. The specific issues related to groundwater and the requirements for compliance with the SDWA regulations were stated earlier and are summarized below.

A. Groundwater Under the Direct Influence of Surface Water

1. If the MPA tests show that this supply is a groundwater source that is under the direct influence of surface water, this supply is regulated as a surface water and must comply with the SWTR and the criteria that regulates unfiltered water systems. Under the final rule a public water system using surface water must use filtration unless it satisfies the filtration avoidance criteria. These requirements are defined in Section IV.E of this report.

2. The infiltration gallery system does not or will not comply with the current or future standards of the filtration avoidance criteria. More specifically, the existing infiltration gallery will have difficulty complying consistently with the following provisions of the filtration avoidance criteria.

   a. The disinfection standards of the SWTR
   b. The development and enforcement of a watershed management and control plan for the Middle Popo Agie River watershed upstream of the infiltration gallery.
   c. Compliance with the TTHM regulations of the SDWA or the more restrictive standards proposed by the pending D-DBP Rule.

3. If the results of the third MPA test and the application of the EPA protocol define the infiltration to be under the direct influence of surface water, it is recommended that this facility be abandoned and all the water treatment for the city be transferred to the existing water treatment plant which will be upgraded and expanded.

B. Groundwater Not Under the Direct Influence of Surface Water

1. If the results of the MPA tests show that the infiltration gallery is not under the direct influence of surface water, this source will be regulated by the criteria applicable for typical groundwater sources. Disinfection is applied to inactivate viruses and not surface water contaminants such as *giardia* and *cryptosporidium*. Viruses are easily destroyed by chlorination and will be effectively inactivated by the existing disinfection system.
2. The natural filtration provided by the infiltration gallery cannot effectively remove the TOC that are the precursors to the formation of disinfectant by-products such as TTHM and HAA5. The TOC concentrations within the water supply can exceed the limits prescribed by the pending D-DBP Rule and will require processes in addition to filtration for this source to be in compliance with the SDWA. These pending regulations will be applicable for water systems serving populations less than 10,000 people until 2002. It is recommended that a sampling and testing program be implemented to measure the TOC prior to disinfection and the TTHM after disinfection in the infiltration gallery system. This information will be used to assess the DBP formation prior to the promulgation of the D-DBP Rule.

3. If the results of the third MPA tests and the EPA protocol define the infiltration gallery not to be under the direct influence of surface water, there will be no regulatory requirement to abandon the infiltration gallery and the City can continue to use this source as part of its treated water system for the near future. The presence of root balls and physical condition of portions of the facilities, however, indicate that the system remains vulnerable to contamination and that the remaining useful life of the facility is limited. It is therefore also recommended that this system be monitored routinely for giardia, cryptosporidium, TOC and TTHM. It is also recommended that a source water protection plan be implemented to delineate and control the sources of pollution within the watershed. This plan will be similar to wellhead protection plans for groundwater supplies and is a program that is encouraged but is currently based on a voluntary participation by water providers in the state of Wyoming.

The regulatory status of the infiltration gallery is undefined until the results from the third MPA test are known and the influence of surface water determined by the EPA protocol. Regardless of the outcome of the MPA test, it is our recommendation that the City consider the infiltration gallery a short term facility and begin planning for its eventual abandonment. The facility is old and in poor condition. The presence of roots in the piping systems indicate that there is a surface influence even though this influence is not in the form of the regulated microbial contaminants.
VI. WATER TREATMENT PLANT

A. Evaluation of the Existing Water Treatment Plant

The existing treatment plant is a direct filtration process. Direct filtration is an effective process when influent turbidities remain relatively constant and when variations in the turbidity levels occur gradually without extreme changes. The water quality of the Middle Popo Agie River remains relatively constant for most of the year except during the snow melt months within the watershed. Snow melt brings high turbidities and high levels of color. Color is an indicator of the presence of natural organic matter (NOM) which are precursors to disinfection by-products (DBP) such as trihalomethanes.

Anecdotal evidence indicate that the existing treatment plant experiences difficulty removing turbidity and color during the snow melt season. The surface loading rates applied to the filters are normally reduced below the design value to maintain effluent turbidity levels within the primary drinking water regulations. A review of the plant records confirm that the snow melt periods present operational difficulties for the available treatment processes. Effluent turbidities are consistently higher during this period. The effluent turbidities remain within the current regulatory requirements but cannot consistently meet the voluntary limits of <0.1 NTU that is standard of filtration performance adopted by many water providers of surface water in anticipation of stricter surface water treatment standards that may be written within the pending Enhanced Surface Water Treatment Rule (ESWTR). The ESWTR is a pending EPA regulation that is drafted to protect consumers of public water supplies from the protozoan, Cryptosporidium. A more detailed discussion of the proposed ESWTR will be presented later during this report.

The existing water treatment plant is well maintained and has consistently produced potable water that complies with current SDWA regulations. The treatment plant is classified as a direct filtration process and is equipped with four dual media filter basins with a total combined filter area is 741 sq. feet. The theoretical production capacity of the plant is 5.3 MGD without allowances for the production lost for backwashing filters.

Direct filtration is an established technology that was developed because dual and mixed media filters are capable of processing higher influent turbidities without the sedimentation process. Direct filtration is applicable for systems with high quality and seasonally consistent influent supplies. Direct filtration can perform effectively within the following general influent parameters:

1. Less than 500 total coliform per 100 ml
2. Less than 14 NTU of turbidity
3. Less than 40 color units
While the direct filtration process is able to operate satisfactorily with influent turbidities as high as 14 NTU, optimally, influent turbidities should be less than 5 NTU. Effective direct filtration operations remove 90-99 percent of virus contamination and 90-99.99 percent of the *Giardia*.

**B. Coagulation and Flocculation**

Alum is added as the primary coagulant with moderate success. The Popo Agie River is low in alkalinity and total dissolved solids (TDS) with raw water temperatures ranging from 19° C in the summer to 2° C in the winter. Optimum coagulation of the raw water has been very difficult because the process is influenced by several variables. For a given raw water supply, there will be an interrelated set of conditions such as pH, turbidity, chemical composition, type of coagulant, and physical factors as temperature and mixing conditions that influence the efficiency of the coagulation process. The interrelationships are so difficult to define that the proper dosage of coagulants and the physical conditions for coagulation must be determined empirically. Bench scale tests were performed by coagulation and water chemistry specialists to determine the optimum dosage of coagulants. These tests illustrated that the Popo Agie water source is very difficult to coagulate and to maintain an insoluble floc.

The existing treatment plant has two flocculation basins that use hydraulic mixing for the flocculation process and do not have sedimentation or solids removal capabilities. The existing flocculation processes are ineffective and flocc formation is not detectable in the flocculation basins. The flocculation basins also serve the unintended function of a presedimentation basin. Sand and gravel carried during the seasonally high run-off flows in the Popo Agie River enter, settle and deposit in the flocculation basin. The basins are not equipped with solids removal facilities therefore the removal of the accumulated solids is extremely tedious and a difficult manual operation.

**C. Filtration**

Direct filtration plants depend totally upon the filters for the removal of the suspended particulate in the surface water supply. The monitoring tests of effluent turbidities show that turbidities from the treatment plant have never exceeded the 0.5 NTU required by the SWTR and indicate that the existing process is capable of compliance with the current SDWA regulations. However, the treatment plant operators have indicated that the existing processes have difficulty meeting the standards during the spring runoff. The watershed at this time of year has increased stream flows and turbidities and often color is at its seasonal high levels. The filtration process must be reduced below the design capacity of the plant in order to maintain effluent turbidities within the compliance standards of the SWTR. Test results show that the influent turbidities can be as high as 23 NTU. The monitoring results also show that the turbidity of the combined effluent from all four filters never exceeded 0.5 NTU. However, turbidities of individual filter effluent occasionally exceeded the turbidity standards and demonstrate that uniform filtration efficiency no longer exists between the individual filters. The operators have also indicated that some filters have noticeable evidence of sand boils during the backwash cycle. Other filters have shorter filter runs and require more frequent backwashes. The filter media is the original media that was placed when the plant was constructed and has deteriorated after years of operation. The inconsistencies described above are indicators that the media profile has changed from the
original installation and that a uniform flow across the total projected area of each filter no longer exists.

D. Plant Hydraulics
The water treatment plant is located at elevation 5800 and is well above the elevation of the potable water storage reservoirs that provide reserve and emergency storage for the City of Lander. The plant is operated at a constant rate to restore the storage volumes in the reservoirs. Product water from the treatment plant flows by gravity from the plant to each of the existing storage reservoirs. The potable water supply is distributed and transferred from the main transmission line to the individual reservoirs by connecting pipelines. The volume of treated water is distributed to individual reservoirs in accordance with the hydraulic capacity of the connecting pipelines. Capacity limitations of the 8 inch PVC pipeline that supplies the Mager storage tank frequently restricts the distribution and transfer of the product water and causes a transmission line surcharge and backup into the plants clearwell. The clearwell therefore overflows before the storage in all the reservoirs is restored. The operation of the plant can be improved by constructing clearwell storage to balance flow between the plant and storage reservoirs.

E. Safe Drinking Water Act (SDWA) Regulations

1. Current Regulations

Surface Water Treatment Rule (SWTR)
These regulations establish the criteria under which filtration is required for public systems which are supplied by surface water supplies. This regulation also establishes the treatment and disinfection techniques and criteria for the removal or inactivation of Giardia lamblia, viruses, heterotrophic plate count bacteria, Legionella, and turbidity. The SWTR require that public water systems that are supplied by surface water or ground water under the direct influence of surface water comply with the following standards.

1. Reduction or inactivation of Giardia - 99.9%
2. Reduction or inactivation of enteric viruses - 99.99%
3. Residual chlorine in the distribution system - 0.2 mg/l
4. Filtered water turbidities shall be less than 0.5 NTU in 95% of the monitored samples taken every month.

The most immediate impact of the SWTR will be upon the continued use of the infiltration gallery as an unfiltered water supply. If the MPA test show that the infiltration gallery is in fact ground water under the direct influence of surface water this source must comply fully with the requirements of the SWTR including the development and enforcement of a watershed management and control plan. The watershed upstream of the infiltration gallery contains many...
separate land ownerships and land use activities that contribute to contamination of the Popo Agie River. The implementation of a watershed management and control plan may be politically impossible for the City and the abandonment of the infiltration gallery as a source of supply may be the eventual alternative in order to comply with the SWTR. Approximately one half of the city's total annual production is produced from the infiltration gallery and must be absorbed within the capacity of the existing filtration plant. The current treatment plant's operations which experiences difficulty removing turbidity and color during portions of the year will be impacted by the increased production which will be required from the treatment plant.

**The Lead and Copper Rule**
The Corrosion Rule (Lead and Copper Rule) was adopted by EPA in May of 1991. This rule set the maximum contaminant levels for lead and copper at 15 ppb and 1.3 mg/l respectively. The levels of these metals in the potable water must be met at the consumers tap. Elevated lead and copper levels in the drinking water are usually related to the use of lead solder and copper service lines. Lead and copper enter the water systems through corrosion. The City's water supply is chemically dilute; low in hardness, low in alkalinity, low in total dissolved solids, and low to neutral pH. The City presently stabilizes the corrosivity of their water by adding soda ash to the treated water. The first series of lead and copper monitoring tests showed complete compliance with the Lead and Copper Rule which indicates that the current practice for corrosivity treatment is effective. Theoretical assessments and calculations will be made by using data from existing water quality records to determine if the current water stabilization practices will be compatible with the process modifications which are developed to improve turbidity, color, and microorganism removal.

2. **Pending Regulations**

**The Enhanced Surface Water Treatment Rule**
Recent outbreaks of cryptosporidiosis, such as the events reported in Milwaukee, Wisconsin, have raised questions regarding the SWTR and the effectiveness of this regulation in protecting the public from the acute symptoms of this disease. Approximately 400,000 residents of this community became infected by the protozoan, *Cryptosporidium parvum*. The community's water supply was filtered and it is significant to note that before and during the outbreak all water quality standards were met. *Cryptosporidium* is resistant to normal disinfectants at normal treatment concentrations. The public's protection is therefore totally dependent upon properly and efficiently operated filtration plants. *Cryptosporidium* is commonly found where livestock graze and calving activity occurs. Humans and human wastes are also contributors to the presence of this parasite. Both livestock and human activities exist within the watershed of the Middle Popo Agie River and can expose the city's water supply to contamination. Growth and development within this watershed will also increase human activity and increase the probability of contamination from human sources.

The implementation of this regulation will have immediate impact upon the continued use of the infiltration gallery because disinfection cannot be considered adequate protection against infection from this microbial parasite. The chlorine dose required to inactivate *Cryptosporidium* is 8000 to 16,000 mg/l -- a level too high for human consumption. The resistance of
Cryptosporidium to chlorination places new emphasis on the traditional "multiple barrier" approach to drinking water supply:

1. Watersheds must be protected against contamination.

2. Filtration facilities must perform flawlessly.

3. Once treated, the water quality must not be allowed to degrade within the distribution system.

The existing direct filtration plant was evaluated to assess its effectiveness to remove this microbial contaminant. The American Water Works Association (AWWA) which is a national organization of water suppliers, have responded to the challenges presented by Cryptosporidium by recommending a 12-Point Action Plan. This plan contains several recommendations pertaining to treatment plant operations and performance. It is recommended that the City review the plan and incorporate the applicable sections into their water treatment operation.

1. Increase vigilance in detecting disease causing organisms through Cryptosporidium testing, turbidity monitoring, and particle counting.

2. Optimize the water treatment processes, remove particulate matter and maintain finished water turbidity levels 0.1 NTU. Water treatment processes currently in use are not specifically designed to remove the small, chlorine resistant oocyst of Cryptosporidium, however there is significant correlation between turbidity reduction and the removal of this organism.
   a. Maintain stable flow rates through the filters.
   b. Do not introduce water into the system immediately after backwashing the filters.
   c. Do not start a dirty filter and immediately introduce the water into your system. On start up, filter to waste before introducing the filtered water into the system.

The Disinfectant, Disinfection By-Product Rule (D-DBP)
The D-DBP rule will regulate disinfectants and their by-products which are formed when disinfectants react with organic compounds within the water supply. Stage 1 of the D-DBP regulations for surface water systems serving communities with populations less than 10,000 are expected to be implemented by the year 2000. Chlorine is an effective disinfectant for water supplies and its reaction with the naturally occurring organic matter (NOM) in the surface water supplies results in the formation of halogenated and oxidized compounds. NOM can be divided into humic and nonhumic fractions and are comprised of humic and fluvic acids, proteins, amino acids and carbohydrates. NOM are often grouped and their presence in water supplies quantified as concentrations of total organic carbon (TOC). The most extensively researched of the chlorination by-products are the trihalomethanes (bromoform, bromodichloromethane, chloroform, and dibromochloromethane) and the haloacetic acids. The total combined
concentrations of the four trihalomethanes are expressed total trihalomethanes or TTHM and the combined concentrations of 5 haloacetic acids is expressed as HAA5. Stage 1 of the proposed D-DBP Rule recommends maximum contaminant level for TTHM and HAA5 to be 0.080 mg/l and 0.060 respectively. Stage 2 will reduce the maximum contaminant level further to 0.040 and 0.030.

In addition to meeting the MCL, water suppliers may also be required to meet treatment requirements to control the organic matter in the raw water that combines with the disinfectant to form the DBPs. Systems using conventional treatment are required to control disinfection byproduct precursors as measured by TOC by using enhanced coagulation. Systems must remove a certain percentage of the TOC (based upon raw water quality) prior to the point of continuous disinfection.

Conventional treatment systems must use enhanced coagulation to reduce TOC unless they meet one of the following criteria:

1. The system's treated water TOC level prior to the point of continuous disinfection is less than 2.0 mg/l.

2. The system's source TOC level prior to any treatment is less than 4.0 mg/l; the alkalinity is greater than 60 mg/l; and not later than the effective dates of compliance for the system, either the TTHM annual average is no more than 0.040 mg/l and HAA5 annual average is no more than 0.030 mg/l.

3. The system's annual average is no more than 0.040 mg/l and the THAA annual average is no more than 0.030 mg/l and the system uses only chlorine for disinfection.

4. Systems practicing softening and removing at least 10 mg/l of magnesium hardness as (CaCO₃), except those that use ion exchange, are not subject to the performance criteria to remove TOC.

The Middle Popo Agie River has seasonally high levels of TOC which are precursors to the formation of DBPs. The results of recent water quality tests indicate that TOC levels are 4.0 mg/l which is the threshold concentration for the implementation of processes to reduce DBP precursors.

This pending regulation will also influence the continued dependence upon the infiltration gallery. While MPA tests show that this facility is moderately effective in the reduction of suspended particulate matter, natural filtration alone cannot reduce the TOC and other precursors of DBP formation. TTHM tests were not conducted on the chlorinated effluent of the infiltration gallery and we cannot conclude accurately the levels of DBP that are formed at this facility. Unfiltered systems currently must comply with the TTHM regulations of the SDWA that limit TTHM concentrations to 0.1 mg/l. Current regulations apply to systems serving more than 10,000 people, however the pending D-DBP rule will apply to systems serving smaller populations. In addition, in accordance with the above discussion, future allowable maximum
contaminant levels will be lowered to 0.04 mg/l. Those unfiltered systems that do not comply will be required to install filtration.
VII. WATER TREATMENT PLANT - MODIFICATION/EXPANSION

A. Plant Upgrades

Our evaluation of the existing treatment plant produced information that demonstrates that the existing operation has consistently produced a potable water supply that complies with the current SDWA standards. This success is achieved despite the fact that the existing plant is a direct filtration plant and has inherent process limitations. Future SDWA regulations will require additional treatment processes and improved treatment efficiency to satisfy the drinking water standards defined within the ESWTR and D-DBP rules. In addition, our recommendation to abandon the infiltration gallery as a potable water supply will result in the transfer of demand for approximately 1.0 MGD of additional treated water to the existing water treatment plant. Improvements to the existing water treatment plant are therefore required to comply with the standards of pending SDWA regulations, to expand the plant's production to replace the production of the infiltration gallery and to increase the treatment capacity to meet the water demands of the projected population of the city.

B. Presedimentation Basin

The water supply for the water treatment plant is a direct diversion from the Middle Popo Agie River. The spring runoff not only brings high turbidities and color, but also high sediment loads that are carried into the plant processes. These settleable solids currently accumulate in the stilling basin and the flocculation basins. The accumulation in the stilling basin is controlled by periodic flushing through the drain valve while the flocculation basins must be cleaned manually. It is estimated that 5-10 yards by volume of sand and gravel must be removed annually. Even though these conditions occur only during high river flows, they do place a significant demand upon the water plant's operating staff.

The proposed improvements include the addition of a presedimentation basin to remove the settleable solids by a facility that is equipped to manage and dispose of the solids. Figure VII.1 illustrates the concept and the location of the presedimentation basin. This improvement proposes to by-pass the existing stilling basin and control valve by connecting onto the existing influent pipeline and diverting the flow through a new control valve to a circular presedimentation that is located in the southwest corner of the City's property. This structure will be located on the highest location of the property and will also serve as a basin to maintain a constant and stable hydraulic condition upstream of the treatment plant. The heavier solids will settle and accumulate in the bottom of the proposed basin and the overflow will return to the treatment plant to be treated by other treatment processes. The settled solids will be disposed of in the existing solids ponds located north of the treatment plant.

C. Adsorption Clarifier

Chlorination will remain the most common disinfection practice and the enhanced removal of DBP precursors that are present in the raw water represents the most practical option for reducing the potential for chlorination by-products formation. The removal of DOC can be achieved by
providing additional unit processes, such as granular activated carbon (GAC), nanofiltration, or by enhancing the existing coagulation, flocculation, and sedimentation processes.

Enhancing the coagulation, flocculation and sedimentation process will also improve particulate removal resulting in a lower product water turbidity and therefore achieving full compliance with the SWTR and improving the probability of compliance with the pending ESWTR.

Improving the coagulation flocculation and sedimentation processes will enable the existing treatment plant to comply with the current and the foreseeable requirements of pending surface water treatment regulations. The selected alternative will improve the coagulation, flocculation, and sedimentation process by converting Flocculation Basin No. 2 into an adsorption clarifier. This modification is illustrated by Figure VII.2. The adsorption clarification process is an upflow pre-treatment process that combines coagulation, flocculation, and clarification into a single process space. Chemically coagulated water passes upward through angular, buoyant, plastic media, resulting in contact flocculation and clarification. Flocculation is accomplished through the turbulence as the water passes through the adsorption media. In addition, flocculation is enhanced by contact between the flocculated materials and the floc coated media. The coagulated particles are adsorbed onto the surfaces of the media and other collected particles and removed from the process stream. Research has shown that this process has achieved results that are comparable to conventional flocculation and settling processes and can achieve 90% removal at a design loading rate of 10 gpm/sq. ft.

Adsorption clarifiers are cleaned by combinations of air-scouring followed by water flushing. The air scouring starts the cleansing of the plastic media. Air introduced under the adsorption media causes a vigorous scrubbing action. The scrubbing action dislodges solids which are washed away by the flow of incoming water. The clarifier cleaning cycle is initiated on a time or head loss basis and is much more frequent than the filter backwash cycle because more solids are removed by the clarification process. Adsorption clarifiers use untreated water during the cleaning cycle. Although these cycles are more frequent, the net plant production will increase because filter backwashing with treated water will be reduced and greater solids removal efficiency ahead of the filters will extend the length of the filter runs.

The adsorption clarifier will:

1. Restore the treatment capacity of the existing plant to its design capacity by removing up to 90% of the particulate load in the adsorption clarifier. The turbidity loading onto the filters will therefore be lowered and more consistent from season to season. The lost capacity of the infiltration gallery can therefore be contained within the existing treatment plant.

2. Enhance the coagulation followed by effective flocculation and sedimentation which are proven unit processes to remove precursors of DBP and therefore will reduce the probability of DBP during chlorination. This process can be achieved within the adsorption clarifier and will enable the treatment plant to comply with the anticipated requirements of the pending D-DBP Rule.
FLOCCULATION BASIN MODIFICATIONS

FLOCCULATOR NO. 1

FLOCCULATOR NO. 2

NOTE:
1. Filter inlet needs splash baffle.
2. Pipe A/C waste to sump.
3. A/C water and air piping need to be oversized.

SECTION "A"

SECTION "B"

JFC/TST INC. OF DENVER
3. Produce lower and more consistent water quality loadings onto the filter which will improve the quality and consistency of the product water and achieve the voluntary turbidity levels 0.01 NTU which are recommended as a voluntary turbidity standard by other water providers from surface water sources for compliance with the ESWTR.

4. Improved unit processes will be added without placing significant operational and maintenance requirements onto existing plant staff.

5. Efficient solids removal ahead of the filtration process will extend the length of the filter runs between backwashes and result in an increase in the net production from the treatment plant.

D. Filters

The SWTR, ESWTR, and the D-DBP rule rely upon effective filtration for the removal of microorganisms, turbidity and DBP precursors. The effectiveness of filter systems in removing microbial contamination is heavily related to influent turbidity which will be improved and stabilized by the addition of the adsorption clarifiers. A generally accepted operating principle within the water provider industry is to achieve the lowest possible effluent turbidity to maximize microbial removal. Studies of the relationship between filter effluent turbidity and the cyst removal of *giardia* and *cryptosporidium* by filtration clearly show that filtered water turbidity below 0.1 NTU contained almost no cysts. Filtered water with turbidity of 0.1 NTU or less is the voluntary limit adopted by many water providers and may soon be the turbidity standard for all filtered water systems. This voluntary standard can be consistently met by well operated and maintained conventional filtration plants and will be an effective barrier against the entry of contaminants such as *giardia* and *cryptosporidium* into the potable water supply.

The filters are also a very effective process to remove the DBP precursors once chemical coagulants are added to the raw water supply. The precursor removal by coagulation occurs by charge neutralization of colloidal organic matter, the precipitation as humates or fluvates, and by colloidal adsorption and entrapment in the coagulant precipitate. The removal of the precursors from the process stream will occur within the adsorption clarifier and by the filters. The treatment objective for the removal of DBP precursors is TOC concentrations of less than 2.0 mg/l prior to the point of continuous disinfection. TOC's less than 2.0 mg/l generally produce TTHM and THAA levels upon chlorination that are less than the proposed Stage 2 standards of 40 and 30 mg/l respectively.

The addition of the adsorption clarifiers ahead of the filters will convert the existing plant from a direct filtration to the more reliable conventional filtration process. The filtration process will be further improved by a complete replacement of the existing media with new mixed media. The media replacement will restore the efficiency of the filters. Other modifications to the filters are not proposed. The existing filters are equipped with a filter to waste and other contemporary design features and will be able to consistently comply with future filtered water standards.
E. Disinfection System

This report recommends that chlorine remain as the primary disinfectant at the water treatment plant for the near future. The proposed upgrades to the filtration system will produce a very reliable barrier for microscopic contaminants such as giardia and cryptosporidium. When filtration is combined with disinfection the treatment processes provide an effective two barrier system to prevent the entry of disease causing contaminants into the City’s water supply. We have previously stated that cryptosporidium is resistant to chlorination and that the ESWTR is specifically written to control this organism. This regulation is in its draft phases and the criteria for disinfection that will be defined by the final regulation is unknown. Many water providers are anticipating stricter disinfection requirements and preparing for the conversion to ozone as the primary disinfectant. We are recommending that very little improvements be invested into the City’s existing disinfection system until the disinfection requirements are defined by the final draft of the ESWTR. Ozone is described in greater detail within Section G.1 of this section of the report.

F. Plant Modification/Expansion

1. Modify to 5.2 MGD

The timing and phasing of future improvements to expand the capacity of the existing water treatment plant is dependent upon the determination of whether the infiltration gallery is under the direct influence of surface water and whether regulatory standards dictate that this facility cease production. Production records show that the single maximum day production from the existing plant was 4.1 MGD. Abandoning the infiltration gallery as a potable water treatment facility will transfer approximately 1.0 MGD of treated water production upstream to the existing plant. Combining the historical production of the infiltration gallery with the maximum single day production from the treatment plant gives us a fairly accurate information that the current maximum day use for the city is 5.2 MGD. The current maximum day water demand of the city is close to the 5.2 MGD theoretical capacity of the existing filters and illustrates that the treatment plant will require expansion in the near future if the infiltration gallery is no longer used. Conversely, if the infiltration gallery is not under the direct influence of surface water, the expansion of the treatment plant can be delayed until the voluntary monitoring tests show that the facility is unreliable or until new and more restrictive regulations dictate that the facility be removed from operation.

2. Expand to 7.2 MGD

Previous sections within this report describe the modifications to the existing treatment plant and the conversion of the existing flocculation basins into adsorption clarifiers. It is recommended that future treatment plant expansions preserve the adsorption clarifier technology to maintain similar treatment processes throughout the entire facility. This study recommends that the treatment capacity be expanded to 7.2 MGD by constructing two 1.0 MGD treatment modules. These modules will be factory fabricated and assembled with adsorption clarifiers and multimedia filtration and delivered to the project site for installation. The prefabricated filter units will be constructed of aluminum to minimize maintenance and will be of similar construction to the units in the existing plant.
The plant expansion will include the enlargement of the filter building to house the two new filter modules plus the appurtenant piping, electrical and instrumentation additions. The building expansion will extend to the west and is illustrated schematically by Figure VII.1.

G. Other Treatment Alternatives

Several other alternatives were considered during the development of the selected alternatives. The present status of the SDWA regulations and the possibility of stricter regulations being promulgated in the future require that all treatment technologies be considered. Two specific processes that will receive more consideration in the future as regulations require greater levels of protection for the water consumers are ozone disinfection and membrane filtration. This section of the report will describe these processes and whether the processes must be included within the future facilities of the city.

1. Ozone

Ozone is a widely used for disinfection and oxidation in other parts of the world but is relatively new in the United States. Ozone is a very powerful oxidizing agent, second only to elemental fluorine among the readily available chemical supplies. Because it is such a strong oxidant it is also a powerful disinfectant. Ozone is becoming a much more widely accepted disinfectant within the drinking water industry because it is very effective in the destruction of viruses, giardia, and cryptosporidium. Ozone’s effectiveness against cryptosporidium provides the second barrier against this contaminant and this process can be retrofitted and added to most filtration systems.

Ozone is very costly to produce. Ozone is very unstable and must be generated on site by using very costly ozone generation equipment that consumes large amounts of electricity. Ozone’s half life in water is extremely short and its dissolved residual is extremely unstable. Chlorination facilities are therefore required to maintain minimum disinfectant residuals in the water distribution system.

The addition of ozone facilities is not an immediate recommendation, however this alternative may be a legitimate consideration after the ESWTR is finalized.

2. Membrane Filtration

The previous discussions regarding filtration show that the filters must perform flawlessly to be the primary barrier for the removal of cryptosporidium. The recent focus and emphasis upon cryptosporidium underscores the need to evaluate alternative technologies to conventional water treatment. Low pressure membrane filtration, particularly microfiltration (MF) and ultrafiltration (UF) have received significant consideration as an alternative to conventional filtration. Microorganism removal is achieved by a barrier membrane filtration technology. Final water quality is achieved in a single pass irrespective of changes in the turbidity, micro-organism burden, algae, temperature, salinity, pH, or operator interaction. A complex and operator intensive chemical feed system is generally not required to meet the particulate standards of water quality regulations. The primary mechanism of removal for low-pressure membranes include:
1. Sieving or size exclusion

2. Adsorption onto the membrane surface.

3. Attachment of the particles in the water and the subsequent removal by the membrane surface.

4. Removal by the cake layer that is formed on the membrane surface.

Low pressure membranes can be backwashed to remove and scour the contaminants that have accumulated on the membrane surface to restore the filtration capacity of the system.

The pore size of MF membranes range from 0.1-0.5 microns and the pore size for UF membranes is normally 0.02 microns. Pore size diameters for MF and UF are orders of magnitude smaller than the giardia cyst or the cryptosporidium oocyst which are 7-17 microns and 4-6 microns respectively. The removal of giardia and cryptosporidium by low pressure membranes is absolute as long as the membranes remain intact. Low pressure membrane processes, however, cannot remove the precursors of DBPs and therefore are not considered a technology with the process flexibility to address the city’s future water treatment needs.
VIII. STORAGE FACILITIES

A. Existing System

The existing water system in the Lander area is shown on Map 1 and a schematic elevation view of the system is shown on Figure III.1. Water is supplied from the Middle Popo Agie River through an intake structure at the mouth of Sinks Canyon. Water is also supplied through an underground infiltration gallery on the Middle Popo Agie and is fed into the 2 million gallon tank.

The Rodeo tank provides storage for east Lander. The Ellis (2 million gallon) tank and the one million gallon tank supply the main city zone and the Mager tank serves the Harmony Hills area of Lander.

Pressure problems occur in the airport hill and hospital area. The hill is fed out of the Rodeo tank and does not have enough pressure head due to the elevation of the Rodeo tank. The hospital receives its water from the 12 inch line which feeds the Rodeo tank. When this line is not pressured due to the water treatment plant not running, the hospital loses pressure and must pump its water from the main city system.

B. Future Storage Requirements

1. Nicol Hill Tank

Recently the 1 million gallon tank has been repaired with WFLB funding. These repairs were completed to accommodate high demand months of July and August. The repairs to this tank are temporary and replacement of part of its storage capacity will eventually be required. This can be accomplished by constructing clearwell storage and a new tank, the Nicol Hill Tank, at a higher elevation in the east Lander area. The tank would be fed by gravity from clearwell storage downstream of the treatment plant. This will remedy the pressure problems in the airport/hospital hill area.

2. Operational Storage

An analysis was also undertaken to determine how much storage would be necessary in the system to allow the water treatment plant to operate at full capacity for eight hours a day during off peak periods. The demand curve shown on Figure VIII.1 was used to complete the analysis. Areas 2 and 3 on Figure VIII.1 would be plant output during eight hours which totals 2,330,000 gallons. Storage capacity would be required to meet demands (Areas 1 and 4 on Figure VIII.1) totaling 1,490,000 gallons. The system presently has the following storage:

- Ellis ........................................... 2,000,000
- 1 M Tank ................................ 1,000,000 (to be abandoned)
- Rodeo tank ............................... 500,000
- Mager ....................................... 500,000
- Total ....................................... 4,000,000
The one million gallon tank is considered for replacement or abandonment. This would leave a total of 3,000,000 gallons of storage which is greater than the 1,490,000 gallons required to run the plant eight hours a day during off peak periods.

Also the clearwell and Nicol Hill Tank will provide an additional 750,000 gallons of storage raising the total system storage to 3,750,000.

3. **Clearwell Storage**

Presently, the water treatment plant encounters problems with back surge. This situation exists because the Mager tank is the last tank to fill and pipeline capacity from the plant to the tank is less than the output of the plant. Therefore, a 250,000 gallon clearwell storage tank is proposed to alleviate this problem. Clearwell storage will also improve water system pressure in the airport/hospital hill area.

A modeling analysis of clearwell storage requirements indicated that a minimum of 117,500 gallons of clearwell storage would be necessary just downstream of the water treatment plant. The peak capacity of the water treatment plant will be 5000 gpm when it is enlarged to 7.2 MGD. The pipeline capacity to the Mager tank will be 3417 gpm. The tank will fill in 9-1/2 hours; net storage requirements in the clearwell at the treatment plant will then be 117,500 gallons. Storage capacity of 250,000 gallons is proposed to allow operational flexibility.

4. **Regulatory Storage**

An analysis was made to determine statutory storage requirements. DEQ regulations require storage capacity of 25% of the peak day plus two hours fire flow storage. Applying this criteria to the 7.2 MGD peak day capacity of the treatment plant results in a requirement of 2,160,000 gallon system storage capacity.

Required long term storage capacity is as follows:

<table>
<thead>
<tr>
<th>Existing</th>
<th></th>
<th>Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellis tank</td>
<td></td>
<td>2,000,000</td>
</tr>
<tr>
<td>Mager tank</td>
<td></td>
<td>500,000</td>
</tr>
<tr>
<td>Rodeo tank</td>
<td></td>
<td>500,000</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>3,000,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Future</th>
<th></th>
<th>Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearwell Storage</td>
<td></td>
<td>250,000</td>
</tr>
<tr>
<td>Nicol Hill Tank</td>
<td></td>
<td>500,000</td>
</tr>
<tr>
<td>Subtotal Future</td>
<td></td>
<td>750,000</td>
</tr>
<tr>
<td>Total Storage</td>
<td></td>
<td>3,750,000</td>
</tr>
</tbody>
</table>

Adequate storage exists now and in the future to satisfy statutory storage requirements.
5. **Lander Hill Tank**

If the groundwater system is developed to service the north section of the study area, (see Section XI - Groundwater Development) then additional tankage is needed to gravity feed well water to the north and east of Lander. This tank, referred to as the Lander Hill Tank, would have a capacity of approximately 1 million gallons. Transmission lines from the Baldwin Creek well to the tank would also have to be developed. Three feasible locations for this tank are shown on Figures VIII.2 and VIII.3.

C. **Storage and Demands**

The existing storage is unevenly distributed among the system's demands. Presently, 88 percent of the demands are on the 2 million gallon tank. However, the 2 million gallon tank is 67% of the present storage capacity of the system. Only 12 percent of the demands are on the Mager and Rodeo tanks. This causes ineffective and unused storage in both the Mager and the Rodeo tanks.

The high airport, hospital and rodeo areas are presently being served by pumping water from the main city zone or the rodeo zone. These areas can be better served from clearwell storage and a new Nicol Hill tank as shown on Figure VIII.2. This tank would provide a constant pressure zone for these areas. The hospital could also be included in this zone. This would provide a constant and reliable source for the hospital.

It should be noted that growth should be monitored and no individual zone should expand beyond its present storage limits. If expansion to 7.0 MGD occurs in the lower Rodeo, Main and Mager zones, the lower tanks will never recover enough to allow a higher tank to be filled. This would then cause a lack of storage supply in the airport, hospital and rodeo areas.
IX. CHLORINE CONTACT TIME

The requirements for chlorine contact have and will continue to be satisfied because of:

- the extent of water treatment
- long transmission pipelines from the water treatment plant to storage tanks and/or the point of consumption
- the amount of storage capacity in the system.

A. Non-Chlorinated Areas

At least one residence is tapped into the infiltration gallery supply line prior to chlorination and is therefore in violation of the EPA rules and regulations.
X. DISTRIBUTION SYSTEM

A. Modeling

The Cybernet computer program was used to model the City of Lander’s present distribution system. The water treatment plant and storage model were developed using a separate data set. These models represent all piping and storage associated with the system. Pressure tests were used to calibrate the model to existing conditions and the model was compiled using information provided by City personnel and JFC field reconnaissance.

The distribution system was modeled as three separate zones, each fed by a separate tank. Though these zones are connected with PRV’s and piping, the valving is presently closed and the City is operating the system as separate zones. The system is shown on Map 3. A complete discussion of model runs is presented in Appendix C.

A fire flow simulation run was performed with the model which indicated that zones exist within the service area which are below the minimum 1000 gpm fire flow. These are shown on the Fire Flow Contour Map - Map 4. Fire flows are virtually non-existent in the hospital/airport/rodeo area. The output from this run is also shown in Appendix C.

Transmission and distribution system problems that were reflected in the model include areas of low pressure in the airport, hospital and rodeo arena.

The lack of line capacity in the pipeline to the Mager tank causes difficulty in filling, and backflowing occurs into the treatment plant. Clearwell storage is recommended to alleviate this problem.

The foregoing problems have been evident to City personnel. The pressure problems which exist in the rodeo area of the city are due to the lack of pressure head in that zone. Clearwell storage and the Nicol Hill Tank, which was previously discussed, higher in the distribution system would alleviate these pressure problems.

As previously discussed, the hospital receives its water from the same 8 inch line that fills the Rodeo tank. If the altitude valves on the Rodeo and 2 million gallon tanks are closed, water is fed directly from the treatment plant and treatment plant well to this zone.

Also, low pressure in the hospital zones turns on pumps from the main city zone to pump water to the hospital if the water treatment plant is not running. The hospital ends up with no water if there is a problem with these pumps. This situation occurred during July and was remedied by running the treatment plant. However, the hospital needs a reliable water source. Tying the hospital temporarily into the 12 inch discharge of the Rodeo tank would provide storage source to the hospital, though not much pressure head. This may be a temporary solution to the problem. A storage facility would exist on the 8 inch line if the clearwell storage is installed at the water treatment plant. Another option is the construction of the Nicol Hill Tank to remedy pressure problems.
The Cybernet model was used to simulate what effect expansion to the north will have on the present system. Through several model runs, a northern limit that occurs approximately in the Squaw Creek Valley was determined for the existing water distribution system and shown on Map 3. This limit assumes that growth would occur in pipeline loops of eight inch diameter pipes. Further expansion to the north of Lander outside of this limit would have to be accommodated with additional zones supplied directly from the water treatment plant or from another water source since a loss of pressure occurs in the main city zone when water is delivered beyond this limit.

The Mager tank zone could also be expanded to the west since there is capacity that is not being utilized in this tank. Expansion could include subdivisions to the west of the Harmony Hills area, and the base of the foothills to the west. See Figure III.1. A PRV must be added if the zone is expanded to areas of lower elevation than Harmony Hills.

B. **Water System Capacity**

The limits of the system discussed above assume that the treatment plant is enlarged to accommodate the growth to the north and south of the city, or 7.2 MGD.
XI. GROUNDWATER DEVELOPMENT

A. Feasibility and Service Area

The most feasible alternative for groundwater would be a well or well field in the Baldwin Creek valley approximately 2200 feet deep. The surface elevation of the well would be approximately 5900 feet. Wells currently produce artesian flows of up to 200 gpm in this area. This supply would then be piped to a new tank located on Lander Hill or another hill to the west of Lander at approximately 5800 feet in elevation to allow gravity feed into the tank. The Lander Hill Tank could then gravity feed into areas north and east of Lander that cannot be supplied by expanding the existing distribution system.

It should be noted that growth to the north can be served to some degree by the present distribution system; however, the north area can also be served by a Baldwin Creek well. Growth to the south of Lander will be limited if the existing distribution system is expanded extensively to the north. Since the area south of Lander is not easily supplied by groundwater it would have to be supplied by expanding the existing distribution system and enlarging the treatment plant. Servicing the north area by expanding the distribution system and not developing groundwater will cause water supplies in the southern part of the study area to be limited.

B. Well or Well Fields

The following sites for test wells are proposed as the result of the geologic work sites conducted during the course of this study:

1. Alternate I

Alternative I includes drilling a test well into the Tensleep Sandstone at a site located in the NE\textsubscript{1/4} NE\textsubscript{1/4} of Section 17, T33N, R100W. The hole would be drilled in the Baldwin Creek watershed and it could be located on either side of the drainage. The proposed test should penetrate the Tensleep Sandstone which has a total thickness of 450 feet. A minimum 200 feet into the formation should produce artesian flow to the surface.

The location of this test well is about two miles (10,000 feet) from the outcrop; water quality should be good to excellent. Four other Tensleep water wells, one farther west in the Baldwin Creek watershed valley and three in the Squaw Creek basin have been drilled at distances of 8000 to 10,500 feet northeast and directly down-dip from the Tensleep Sandstone outcrop. All four wells are producing good quality water in excess 200 gpm and the three in Squaw Creek basin are presently servicing multi-dwelling housing projects.

The projected depth of the hole is no greater than 2200 feet which includes 200 feet of the Tensleep Sandstone Formation. This depth is about one half the estimated depth of the hole proposed later under Alternative II.
Information from the Tensleep water producing wells in Squaw Creek Valley can be utilized in planning and drilling the test well in the Baldwin Creek Drainage since the holes are only two miles apart and nearly at the same elevation of 5900 feet.

A three mile transmission pipeline from the well to the storage tank is required if storage facilities are located on Lander Hill in Section 2, T33N, R100W. The elevation of storage facilities on Lander Hill is at about 5640 feet so water will flow from well to storage by gravity.

The test well at this location will also require the following:

a. permits to drill, both landowner and State Engineer's
b. construction of a drill location pad and a lined mud pit
c. surface casing of about 150 feet

2. Alternate II

Depth projections for a Tensleep Sandstone Water test well located on a hill (Lander Hill on topographic maps) in the SE¼ of the NW¼ of Section 2, T33N, R100W are based on depths of holes previously drilled into the Tensleep Sandstone including outcrop distances and known dip and strike.

This proposed test well should penetrate a minimum of 200 feet into the 450 foot Tensleep Sandstone Formation. This will allow artesian flow to the surface. The drilling of a test well will allow evaluation of both the volume and quality of water for use by the City of Lander. Since the proposed drill location of the test well is about five miles (26,000 feet) directly down-dip from the outcrop, water quality may be suspect. The test well will provide data on the water quality. The hole is projected to produce a discharge of several hundred gallons per minute flow to the surface by artesian flow. This is based on the artesian flow characteristics of all previous Tensleep Sandstone wells drilled and producing in the area. The projected depth of the test well is between 4500 and 5000 feet. The Tensleep hole closest to the area is 18,500 feet to the southwest.

The test well will require the following because of the depths involved:

a. landowner and State Engineer's permits to drill
b. construction of a drill location pad and a lined mud pit
c. 150 feet of surface casing

Minimal transmission lines would be needed if storage facilities are located on Lander Hill in Section 2, T33N, R100W because of its close proximity to the well. The elevation of storage facilities on Lander Hill is at about 5640 feet so water will flow by gravity to the east and north Lander areas.

C. Production Well

There are certain requirements that should be adhered to in drilling the test well to insure that the test well can be upgraded to a production well if the test well is successful in producing water of
the quantity and quality anticipated. Equipment used in drilling the test well should be suitable
to drill a straight borehole. This is absolutely necessary to insure that the borehole can be reamed
out to accommodate the installation of production casing. The production casing should be set
into the top of the Tensleep Formation and properly cemented in place.

A pump will have to be installed in the well if the artesian flow is insufficient to meet anticipated
demands.

Though not required, a Wellhead Protection Plan is recommended for the new source well. A
description of a plan has been previously discussed in Section II.A.1.

D. Chlorinator
An inline gas chlorinator must be installed upstream of the Lander Hill Tank. To comply with
EPA standards, the Lander Hill Tank would provide sufficient chlorine contact time.

E. Distribution System
The water from the well would then be distributed throughout the north and east Lander area
through a series of 8 and 10 inch pipeline loops.

F. Pressure Reduction Equipment (PRV's)
The existing distribution system should continue to operate under separate pressure zones.
Additional new pipelines from the Lander Hill Tank serving the area in the north portion of the
study area outside of the existing service area could be connected to the city system by installing
a PRV in the vicinity of the county garage. This new zone (supplied from the Lander Hill Tank)
could serve as a back up to the city system in the event of the loss of the treatment plant or
failure of the pipelines supplying water from the treatment plant.
XII. RIVER TO TREATMENT PLANT TRANSMISSION PIPELINE

A. Asbestos Analysis

The City of Lander felt that destructive testing of the transmission pipeline from the Popo Agie to the Water Treatment Plant was not feasible due to the age and condition of the pipeline. However, asbestos sampling was performed on the water at the mouth of the intake structure and again on the water entering the treatment plant. These tests showed that the water entering the system had virtually no asbestos, yet the water tested at the treatment plant showed the presence of asbestos fibers. Though this level of asbestos is far below the minimum allowed by national guidelines for safe drinking water (see Appendix F), it does prove that asbestos is entering the system due to the deterioration of the asbestos cement pipeline to an indeterminate degree. The tests were performed on the piping segment that is exposed to the most corrosive water which has the lowest pH. The pH is lowest above the treatment plant.

The level of asbestos was also compared to asbestos testing performed on the system in 1982. The new tests showed a marked increase in the amount of asbestos in the drinking water since 1982. However, location of the sample point (before or after treatment) is unknown for the 1982 tests.

Replacement of the asbestos cement piping from the river to the treatment plant should be considered if it is found to be severely corroded through additional testing. Asbestos testing on the water flowing into the treatment plant revealed that the water entering the pipeline was virtually asbestos free, while asbestos appeared in the water supply at the plant. Though way below national guidelines for safe drinking water, this asbestos indicates that the pipeline is degrading and will eventually need to be replaced. An additional transmission line may eventually be needed.

B. Non-Destructive Testing

As stated earlier, the City did not want to perform destructive testing of the asbestos-cement transmission pipeline. Destructive testing methods involve removing a piece (wafer) of pipewall to inspect the condition of the interior of the pipe and measure the thickness of the pipewall. This can be done to determine if erosion of the interior of the pipe has progressed to a serious degree. A saddle with clamps is used to reseal the pipe. This method is one type of destructive testing.

There is another method of testing that can be pursued which is non-destructive. This method employs an x-ray device that can be used to measure the existing thickness of the pipewall. This measurement can then be compared to the original thickness of the pipewall to ascertain the degree or extent of corrosion in the interior of the pipe. This method requires exposing the pipe with a clear distance of three feet around the pipe at various intervals along its length and at critical points such as bends, angles, and significant changes in grade to perform the x-ray procedures. The pipeline can remain in service during the entire testing operation.
The approximate costs to complete this type of non-destructive testing on the pipeline from the river to the treatment plant are estimated at $20,000 to $30,000. One company that does this type of work is:

Consumers Applied Technologies  
P.O. Box 8208  
Kalispell, MT  59904-1208  

Phone: 1-800-347-8959  
1-406-756-2603  

Another method of examining the condition of the pipeline would be to salvage a section of pipe in the event of a pipeline break. The pipe section could be examined and measured to determine the thickness of the pipewall. The thickness of the existing pipewall could be compared to the thickness of the pipewall when it was new to achieve a comparison that will indicate the amount of corrosion and scour that has occurred in the pipeline.

C.  Insertion of Liner  

Lining of the existing asbestos transmission lines was investigated as a feasible alternative. There are companies that install HDPE (high density polyethylene) liners in existing pipelines. These vary in quality depending on whether structural strengthening is required or simply lining to protect the interior of the pipeline from corrosion and wear. The structural grade liners are much thicker and a reduction in pipeline capacity will be encountered if a structural liner is installed. The thin wall liners do not provide structural strength and less pipeline capacity is sacrificed when they are installed.

The liners are quite expensive to install and the pipeline has to be exposed and cut at intervals of 1000 feet or so; therefore, the pipeline has to be taken out of service for a period of time. Approximate costs to install two different grades of liners are presented in the Feasibility Analysis, Priority V Section XIV.D.5.

The following company installs liners:

PIM Corporation  
201 Circle Drive No. Suite 106  
Piscataway, NJ 08854  

Phone: 908-469-6224
XIII. MASTER PLAN

The following priorities have been developed after studying the existing facilities, distribution system, feasibility and potential for future growth:

A. Priority I

The infiltration gallery is apparently under the influence of surface water and it is therefore imperative that the treatment plant be able to handle the additional loading that will result if the infiltration gallery has to be abandoned. Upgrading the treatment plant is essential to consistently meet the 5.2 MGD demand. This retrofitting will include reducing the surface loading on the existing filters during high flow, turbid months and adding a 0.25 MG clearwell to the plant. This clearwell storage will allow the plant to be run at a constant flow rate and fill all tanks without a backflow problem.

The items included in this priority are as follows:

- Upgrade water treatment plant to 5.2 MGD
- Construction of 250,000 gallon clearwell / operational storage

The construction of the clearwell storage facility will require the acquisition of access and right-of-way. A detailed research of property ownership should be completed after the final location of the clearwell storage facility has been established. This work could be completed as a Phase II effort under this study or a Level II study authorized at some future date.

B. Priority II

The pressure problems in the rodeo arena/hospital/airport area will be alleviated by the replacement of the 1 million gallon tank with clearwell storage and a tank higher in the system. This higher tank can then serve the south Lander area. Transmission lines to service areas will also need to be installed.

The items included are as follows:

- Abandonment of the 1 million gallon tank
- Build 500,000 gallon Nicol Hill tank
- Expand the transmission system to accommodate the new tank

The construction of the Nicol Hill tank and transmission pipeline from the water treatment plant to the tank will require the procurement of access and right-of-way. A detailed research of property ownership should be completed after the final alignment of the pipeline has been selected. This work could be completed during a later phase relative to constructing the Priority II facilities.

C. Priority III

The retrofitted treatment plant will increase the capacity of the plant to 5.2 MGD. Any future growth in the area will need to be accommodated with expansion of the treatment plant to 7.2
MGD. Room exists at the existing treatment plant for this expansion. The 20 inch transmission lines to and from the plant have an existing capacity of 7,000,000 GPD with 5 fps velocity and could reach 7.2 MGD with a slightly higher velocity. Any further expansion would require additional line capacity.

The items included are as follows:

- Expand the distribution system within limits as dictated by demands in areas of growth and development
- Upgrade/expand water treatment plant to 7.2 MGD

The extension of distribution system pipelines should be accomplished after subdivision platting has been approved. The plans should identify public streets and roadways in which distribution pipelines should be installed. Access and right-of-way will have to be acquired if dedicated streets and roadways are not identified. The access and right-of-way requirements should be identified at some future level of study at such time as demand and service areas are well defined.

Also, a policy addressing pipeline access, easement and right-of-way could be defined in a Level II study and the policy could then be forwarded to the Fremont County Planning Office for adoption by the County. The policy would then enable the City to extend water lines in an orderly fashion.

The policy could also address and define subdivision responsibilities and financial obligation relative to water system extension, pipelines and facilities.

D. Priority IV

A level II groundwater study is recommended in the Baldwin Creek area. Previously, wells into the Tensleep formation have produced artesian wells of good quality at 200 gpm. A test well at the recommended location will prove if groundwater is a feasible alternative for supply to the North Lander Area. If proven that potable water can be supplied, this well could feed into a tank at one of the three recommended North Lander locations. The service area would include North and East Lander, to the north boundary of the study area.

The items included are as follows:

- Drill exploratory well.
- Develop exploratory well to production well.
- Construct transmission pipeline from well to storage tank site.
- Construct chlorinator facility.
- Construct Lander Hill water storage tank.

The drilling and development of an exploratory/production well will require access and right-of-way as will the construction of a pipeline, chlorination facility and storage tank as part of this priority. Property ownership should be researched after the final location and alignment of the

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-56-
facilities considered under this priority are fixed. This determination should be made under a future level of study.

E. Priority V
Several other items need to be included in an overall Master Plan including the following:

- Perform physical inspection of the transmission line from the river to the water treatment plant.
- Lining of the Popo Agie 20 inch diameter transmission pipeline or pipeline replacement should be considered if it is found to be seriously corroded to the point of needing repair.
- Irrigation of the city parks should be monitored and adjusted if the City gets into a water treatment production problem. Irrigation of city parks should take place at night and it is recommended that meters be read to monitor water usage.
- Water rights should continue to be acquired as the City incorporates surrounding irrigation lands into the city.
- The water right at the infiltration gallery should be moved to the Popo Agie intake in the event of infiltration gallery abandonment.
- A separate system for city parks that would not use potable water could be considered if it is felt that the infiltration gallery should not be abandoned. This irrigation water could be supplied from the infiltration gallery.
- A schedule and program should be developed for valve exercising and replacement; tank maintenance, inspection and cleaning; meter maintenance; and pump station operation and maintenance.
- Immediate plans for improving the pressure situation at the hospital should be implemented including cross-connecting to the 12 inch Rodeo tank discharge line. This would also temporarily solve the lack of storage problem at the hospital.
- A reliable flow measurement system should be installed on the pipeline from the infiltration gallery.
XIV. CAPITAL COSTS AND FUNDING

The following facilities and works are considered for construction in each priority previously described in this report.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Facilities Proposed to be Constructed</th>
</tr>
</thead>
</table>
| I        | • Upgrade water treatment plant to 5.0 MGD  
          | • 250,000 gallon clearwell/operational storage reservoir |
| II       | • Nicol Hill storage reservoir (500,000 gallons)  
          | • Transmission pipeline to new tank |
| III      | • Expand distribution system in study area as dictated by demands and growth  
          | • Expand and upgrade water treatment plant to 7.2 MGD |
| IV       | • Drill exploration well  
          | • Upgrade exploration well to production well  
          | • Transmission pipeline from well to storage tank  
          | • Chlorination facility  
          | • Lander Hill storage tank |
| V        | Priority V features or facilities are not considered for construction at this time. Additional study should be completed for the plans listed in Section XIII.E.V under Priority V; however lining the transmission pipeline from the river to the treatment plant has been suggested in this report. Cost estimates for lining the pipeline are commented on under this priority. |

A. Construction Costs

The following costs are a summary of construction costs for each of the above priorities:

<table>
<thead>
<tr>
<th>Priority</th>
<th>Total Construction Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>$1,394,800</td>
</tr>
<tr>
<td>II</td>
<td>$1,276,300</td>
</tr>
<tr>
<td>III</td>
<td>$1,233,400</td>
</tr>
<tr>
<td>IV</td>
<td>$2,988,700</td>
</tr>
</tbody>
</table>

B. Project Features Qualifying for WWDC Funding

Costs to construct the following project features qualify for funding from WWDC:
- Water storage facilities
- Transmission pipelines
- Exploration wells
- Production wells

The following terms and conditions apply to project funding from WWDC:

- Grant ................................................................. 67% of project cost
- Loan ................................................................. 37% of project cost
- Interest on loan.................................................. 4.0%
- Loan repayment period ...................................... 30 years

C. Project Features Qualifying for WFLB Funding

Costs to construct the following project features qualify for funding from the Wyoming Farm Loan Board (WFLB):

- Water treatment plant modifications and retrofits
- Distribution system
- Chlorination equipment

The following terms and conditions apply to project funding from WFLB:

- Grant ................................................................. 50% of project cost
- Loan ................................................................. 50% of project cost
- Interest on loan.................................................. 7.25%
- Loan repayment period ...................................... 30 years

D. Capital Costs/Debt Service

I. Priority I

Costs Qualifying for WWDC Funding
- Preparation of final designs & specifications ........................................... $11,000.00
- Permitting and mitigation ................................................................. $3,000.00
- Legal fees ......................................................................................... $2,000.00
- Acquisition of access and rights-of-way .......................................... $10,000.00
- Construction cost of project components:
  250,000 Clearwell ........................................................................... $125,000.00

Construction cost subtotal ......................................................... $125,000.00
Engineering (10%) ........................................................................ $12,500.00
Subtotal ......................................................................................... $137,500.00
Contingency (15%) ...............................................................

$20,600.00
$158,100.00

Construction Cost Total ..............................................................

$158,100.00

Total Capital Cost ...........................................................................

$184,100.00

67% Grant ....................................................................................

$123,300.00

33% Loan ....................................................................................

$60,800.00

Annual Debt Service:

WWDC - 30 years @ 4% ...................................................................

$3,500.00

Costs Qualifying for WFLB Funding

- Preparation of final designs & specifications ................................
  $83,100.00
- Permitting and mitigation ...........................................................
  $3,000.00
- Legal fees ..................................................................................
  $1,000.00
- Acquisition of access and rights-of-way .......................................
  $0.00
- Construction Cost of project components:
  Upgrade water treatment plant to 5.2 MGD .................. $977,600.00

Construction cost subtotal ............................................................

$977,600.00

Engineering (10%) .......................................................................

$97,800.00

Subtotal .......................................................................................

$1,075,400.00

Contingency (15%) .................................................................

$161,300.00

$1,236,700.00

Construction Cost Total ..............................................................

$1,236,700.00

Total Capital Cost ...........................................................................

$1,323,800.00

50% Grant ...................................................................................

$661,900.00

50% Loan ....................................................................................

$661,900.00

Annual Debt Service:

WFLB - 30 years @ 7.25% ............................................................

$54,700.00

Total Debt Service - Priority I

WWDC .......................................................... $3,500.00
WFLB .......................................................... $54,700.00

Total Annual Debt Service ...........................................................

$58,200.00

2. Priority II

Costs Qualifying for WWDC Funding

- Preparation of final designs & specifications ......................... $81,000.00
- Permitting and mitigation ...................................................... $7,000.00
- Legal fees .............................................................................................................. $4,000.00
- Acquisition of access and rights-of-way.......................................................... $20,000.00
- Construction cost of project components:
  Nicol Hill Storage Tank .......................................... $222,400.00
  Transmission Line to Nicol Hill Tank ................. $490,000.00
  Transmission Line from Tank to Distribution System ... $296,500.00

Construction cost subtotal ................................................ $1,008,900.00
Engineering (10%) .............................................................. $100,900.00

Subtotal ............................................................................ $1,109,800.00
Contingency (15%) ................................................................ $166,500.00
$1,276,300.00

Construction Cost Total ............................................................................... $1,276,300.00

Total Capital Cost ................................................................................................ $1,388,300.00

67% Grant ................................................................. $930,200.00
33% Loan ................................................................. $458,100.00

Annual Debt Service:
  WWDC - 30 years @ 4% .............................................. $26,500.00

Costs Qualifying for WFLB Funding
Priority II project components do not include any features that would qualify for WFLB funding. All Priority II work would be funded by WWDC.

Total Debt Service - Priority II
  WWDC ....................................................................................... $26,500.00
  WFLB ................................................................................. $0.00
  Total Annual Debt Service ....................................................... $26,500.00
3. **Priority III**

**Costs Qualifying for WWDC Funding**
Priority III project facilities do not include any that qualify for WWDC funding.

**Costs Qualifying for WFLB Funding**
- Preparation of final designs & specifications .................................................... $83,000.00
- Permitting and mitigation .................................................................................... $6,000.00
- Legal fees .............................................................................................................. $2,000.00
- Acquisition of access and rights-of -way ............................................................ $10,000.00
- Construction Cost of project components:
  - Distribution system expansion (3000' of 8" dia. pipe) ............................................ $90,000.00
  - Enlarge and upgrade water treatment plant to 7.0 MGD ........................................ $885,000.00

  Construction cost subtotal ........................................... $975,000.00
  Engineering (10%) .................................................. $97,500.00
  Subtotal ................................................................ $1,072,500.00

  Contingency (15%) ................................................................ $160,900.00
  $1,233,400.00

Construction Cost Total .................................................................................... $1,233,400.00

Total Capital Cost ................................................................................................ $1,334,400.00

50% Grant ........................................................................................................ $667,200.00
50% Loan ........................................................................................................ $667,200.00

Annual Debt Service:
- WFLB - 30 years @ 7.25% ........................................................................... $55,124.00

**Total Debt Service - Priority III**
- WWDC ........................................................................................................... $0.00
- WFLB ........................................................................................................... $55,124.00
- Total Annual Debt Service ............................................................................ $55,124.00
4. Priority IV

**Costs Qualifying for WWDC Funding**

- Preparation of final designs & specifications ................................................... $198,300.00
- Permitting and mitigation ................................................................. $8,000.00
- Legal fees ....................................................................................... $5,000.00
- Acquisition of access and rights-of-way ............................................ $15,000.00
- Construction cost of project components:
  - Exploratory Well ........................................................................... $193,000.00
  - Upgrade exploratory well to production well .......................... $128,400.00
  - Transmission line from well to storage tank ......................... $776,200.00
  - 1 million gallon storage tank ................................................ $252,400.00
  - Pipeline tying into existing system ...................................... $982,500.00

  Construction cost subtotal ......................................................... $2,332,500.00
  Engineering (10%) ........................................................................ $233,300.00

  Subtotal ......................................................................................... $2,565,800.00
  Contingency (15%) ........................................................... $384,900.00

  Construction Cost Total ........................................................................ $2,950,700.00

  Total Capital Cost ................................................................................ $3,177,000.00

  67% Grant ................................................................................ $2,128,600.00
  33% Loan ................................................................................ $1,048,400.00

  Annual Debt Service:
  WWDC - 30 years @ 4% .................................................................. $60,600.00

**Costs Qualifying for WFLB Funding**

- Preparation of final designs & specifications ........................................ $3,000.00
- Permitting and mitigation .......................................................... $1,000.00
- Legal fees .................................................................................... $0.00
- Acquisition of access and rights-of-way ......................................... $0.00
- Construction Cost of project components:
  - Chlorinator .............................................................................. $30,000.00

  Construction cost subtotal ........................................................ $30,000.00
  Engineering (10%) ........................................................................ $3,000.00

  Subtotal ......................................................................................... $33,000.00
  Contingency (15%) ........................................................... $5,000.00

  Construction Cost Total ........................................................................ $38,000.00
Total Capital Cost .................................................................................................... $42,000.00

50% Grant ................................................................................................................. $21,000.00
50% Loan ................................................................................................................... $21,000.00

Annual Debt Service:
WFLB - 30 years @ 7.25% ............................................................................ $1,700.00

Total Debt Service - Priority IV
WWDC ................................................................................................................. $60,600.00
WFLB ................................................................................................................... $1,700.00
Total Annual Debt Service .............................................................................. $62,300.00

5. Priority V

As stated earlier, no project features addressed in Priority V are considered for construction at this time. However, the following cost figures are presented relative to non-destructive testing and inserting a liner in the transmission pipeline from the river to the water treatment plant. Non-destructive, x-ray testing of the transmission pipeline as addressed earlier is estimated to cost $20,000 to $30,000.

The following costs are presented relative to inserting a liner in the existing transmission pipeline from the river to the water treatment plant. A liner would be considered in the event that information is obtained relative to serious deterioration of the interior of the pipeline due to the erosion of the asbestos cement interior.

A high density polyethylene (HDPE) liner could be installed in the pipe. Two different liners could be considered:

<table>
<thead>
<tr>
<th>Type Liner</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin wall - 3/8&quot;</td>
<td>$92.00/ft.</td>
</tr>
<tr>
<td>Structural - 1.29&quot; 110 p.s.i 17.5&quot; I.D.</td>
<td>$122.00/ft.</td>
</tr>
</tbody>
</table>

There are other grades of liners available that could be considered depending on the degree of deterioration in the pipe. The two above are given to provide an indication of the cost involved. Obviously, lining the pipe is expensive and it would require shutting the pipeline down.

Additional study should be done to compare the cost of lining the existing pipe to that of installing a second parallel pipeline that would provide a back up in the event that the existing line were to fail. The cost of new line is estimated to be about $90 to $100 per foot.
XV. IMPACTS ON WATER RATES

A. Debt Service

Total annual debt service (WWDC and WFLB) from the previous sections is summarized as follows:

Table XV-1 Annual Debt Service by Priority

<table>
<thead>
<tr>
<th>Priority</th>
<th>Total Annual Debt Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>$58,200.00</td>
</tr>
<tr>
<td>II</td>
<td>$26,500.00</td>
</tr>
<tr>
<td>III</td>
<td>$55,124.00</td>
</tr>
<tr>
<td>IV</td>
<td>$62,300.00</td>
</tr>
</tbody>
</table>

The above numbers are developed on the basis of 1996 dollars and it is not known at what point in time the facilities considered in each priority will be constructed. Costs will be inflated over time; therefore, the impact on water rates must be calculated to take inflation into account while at the same time incorporating an estimate in the increase in the number of water users in the service area.

B. Water Revenues

The following table shows the number of water meters by size and the total monthly minimum charge for all meters as of December 31, 1995.

Table XV-2 Water Revenues - Month of December 1995

<table>
<thead>
<tr>
<th>Rate Table</th>
<th>Title</th>
<th>Number of Customers</th>
<th>Number of Units</th>
<th>Total Monthly Charge Base/Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>5.30</td>
<td>7</td>
<td>7</td>
<td>37.10</td>
</tr>
<tr>
<td>104</td>
<td>Water - Senior Cits. - 11%</td>
<td>5</td>
<td>5</td>
<td>73.45</td>
</tr>
<tr>
<td>105</td>
<td>Water - Senior Cits. - 14%</td>
<td>3</td>
<td>3</td>
<td>42.57</td>
</tr>
<tr>
<td>106</td>
<td>Water - Senior Cits. - 24%</td>
<td>2</td>
<td>2</td>
<td>25.08</td>
</tr>
<tr>
<td>107</td>
<td>Water - Senior Cits. - 25%</td>
<td>4</td>
<td>4</td>
<td>49.52</td>
</tr>
<tr>
<td>108</td>
<td>Water - Senior Cits. - 28%</td>
<td>1</td>
<td>1</td>
<td>11.88</td>
</tr>
<tr>
<td>110</td>
<td>5/8&quot; Meter</td>
<td>2,264</td>
<td>2,264</td>
<td>43,914.00</td>
</tr>
<tr>
<td>116</td>
<td>Water - Senior Cits. - 50%</td>
<td>6</td>
<td>6</td>
<td>49.50</td>
</tr>
<tr>
<td>118</td>
<td>5/8&quot; Meter - Rural Rate</td>
<td>12</td>
<td>12</td>
<td>432.00</td>
</tr>
<tr>
<td>120</td>
<td>3/4&quot; Meter</td>
<td>10</td>
<td>10</td>
<td>277.50</td>
</tr>
<tr>
<td>130</td>
<td>1&quot; Meter</td>
<td>39</td>
<td>39</td>
<td>1,725.75</td>
</tr>
<tr>
<td>140</td>
<td>1-1/2&quot; Meter</td>
<td>15</td>
<td>15</td>
<td>1,158.75</td>
</tr>
<tr>
<td>150</td>
<td>2&quot; Meter - Training School</td>
<td>26</td>
<td>26</td>
<td>2,646.00</td>
</tr>
<tr>
<td>160</td>
<td>3&quot; Meter</td>
<td>4</td>
<td>4</td>
<td>1,332.00</td>
</tr>
<tr>
<td>175</td>
<td>6&quot; Meter</td>
<td>1</td>
<td>1</td>
<td>829.50</td>
</tr>
<tr>
<td>180</td>
<td>8&quot; Meter - Training School</td>
<td>1</td>
<td>1</td>
<td>1,160.00</td>
</tr>
<tr>
<td>210</td>
<td>5/8&quot; Pit Meter</td>
<td>162</td>
<td>162</td>
<td>3,139.50</td>
</tr>
<tr>
<td>220</td>
<td>3/4&quot; Pit Meter</td>
<td>14</td>
<td>14</td>
<td>388.50</td>
</tr>
</tbody>
</table>
Total monthly revenue from base/minimum charges equals $59,016.85 for the month of December 1995. Rounding this to $59,000/month produces a yearly total of $708,000. Revenue to meet debt service obligations can be presented as a percentage increase of this figure.

C. Annual Debt Service and O&M Costs

Debt service obligations and estimated annual operations and maintenance costs for each priority are shown in the following table.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Annual Debt Service</th>
<th>Estimated O&amp;M</th>
<th>Total Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>$58,200</td>
<td>$45,000</td>
<td>$103,200</td>
</tr>
<tr>
<td>II</td>
<td>$26,500</td>
<td>---</td>
<td>$ 26,500</td>
</tr>
<tr>
<td>III</td>
<td>$55,124</td>
<td>$95,000</td>
<td>$150,124</td>
</tr>
<tr>
<td>IV</td>
<td>$62,300</td>
<td>---</td>
<td>$ 62,300</td>
</tr>
</tbody>
</table>

These figures will increase depending on the time that each priority is constructed. The increased costs will result from inflation. As stated earlier, the revenue required to meet the above costs can be calculated as a percentage of annual water revenues; however, water revenues will also increase over time even without developing any of the project features in any of the priorities.

D. Water Costs

Water revenues will increase due to inflation and growth in demands. Historically the weighted average annual percentage increase in water rates has been 7.7% per year between 1962 and 1995. During this period, a number of water projects have been built that are being or have been paid for by revenues from water costs. Therefore, the 7.7% average annual increase does not present a true indication of inflation and growth.

A methodology was developed to obtain an estimate of monthly water costs taking into account inflation and growth. A more detailed explanation of the methodology used and tabulated data is presented in the Appendix G. An overview is presented here.

Water rate projections were developed using current revenues data and monthly charges and the following factors:
The inflation factor was taken from the 25 December 1995 issue of the *Engineering News Record (ENR)*. The growth factor is the same as that used to develop the water demand figures used in this report.

Base monthly water charges were then developed by applying the 2.9%/year factor to the current monthly cost of $19.50/month for a 5/8" meter. The graph (Figure XV.1) on the following page was produced.

A methodology was developed and completed to produce the graph presented as Figure XV.2 showing the increase in monthly basic charges for a 5/8" meter over time for each of the four priorities considered. The analysis used to prepare this graph incorporated the following factors:

- Construction cost inflation factor ........... 3.2%/yr.
- Labor inflation factor .................................. 2.9%/yr.
- Growth factor ......................................... 0.5%/yr.

The construction cost and labor inflation factors were taken from the 25 December 1995 issue of ENR and, as stated earlier, the growth factor is the same as used to develop demand figures. An explanation and tabulated data used in this analysis is presented in Appendix G. The analysis assumes that all revenue required to meet project costs is derived from the basic monthly water charges for meters.

These two graphs can be used to obtain an estimate of the monthly basic water charge for any of the priorities considered for construction at different times. For example, assume the following:

<table>
<thead>
<tr>
<th>Priority</th>
<th>Time of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1999</td>
</tr>
<tr>
<td>II</td>
<td>2005</td>
</tr>
<tr>
<td>III</td>
<td>2010</td>
</tr>
<tr>
<td>IV</td>
<td>2015</td>
</tr>
</tbody>
</table>

The following numbers are taken from each graph:
ESTIMATED MONTHLY BASIC WATER CHARGES
5/8" METER

YEAR

INCREASE IN MONTHLY BASIC CHARGE
5/8" METERS

$0.00

$10.00

$20.00

$30.00

$40.00


FIGURE XV.1
INCREASE IN MONTHLY BASIC
CHARGE PER PRIORITY

PRIORITY I
PRIORITY II
PRIORITY III
PRIORITY IV

$8.00
$7.00
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00
$0.00

YEAR THAT PROJECT IS BUILT

FIGURE XV.2
Table XV-4 Basic Monthly Water Cost 5/8" Meter

<table>
<thead>
<tr>
<th>(1) Year</th>
<th>(2) Priority Developed</th>
<th>(3) Basic Monthly Charge</th>
<th>(4) Increase in Monthly Basic Charge*</th>
<th>Total</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>I</td>
<td>$20.60</td>
<td>$3.02</td>
<td>$23.62</td>
<td>21</td>
</tr>
<tr>
<td>2005</td>
<td>II</td>
<td>$23.90</td>
<td>$3.02</td>
<td>$27.80</td>
<td>43</td>
</tr>
<tr>
<td>2010</td>
<td>III</td>
<td>$26.80</td>
<td>$3.02</td>
<td>$36.28</td>
<td>86</td>
</tr>
<tr>
<td>2015</td>
<td>IV</td>
<td>$29.60</td>
<td>$3.02</td>
<td>$41.63</td>
<td>114</td>
</tr>
</tbody>
</table>

* The increase in water costs resulting from the development or construction of any phase should remain fairly constant throughout the pay-off period applicable to funding; whereas the basic monthly charge (column 3) will continue to inflate over time.

The foregoing cost figures apply to a 5/8" meter service only. The following "multipliers" can be applied to the water rates for a 5/8" meter to determine the rate applicable to meters of other sizes.

Table XV-5 Multiplier (Ratio) 5/8" Meter to all Others

<table>
<thead>
<tr>
<th>Meter Size</th>
<th>Basic Monthly Charge</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8</td>
<td>$19.50</td>
<td>1.00</td>
</tr>
<tr>
<td>3/4</td>
<td>$27.75</td>
<td>1.42</td>
</tr>
<tr>
<td>1</td>
<td>$44.25</td>
<td>2.27</td>
</tr>
<tr>
<td>1-1/2</td>
<td>$77.25</td>
<td>3.96</td>
</tr>
<tr>
<td>2</td>
<td>$110.25</td>
<td>5.65</td>
</tr>
<tr>
<td>3</td>
<td>$333.00</td>
<td>17.08</td>
</tr>
<tr>
<td>4</td>
<td>$498.00</td>
<td>25.54</td>
</tr>
<tr>
<td>6</td>
<td>$829.50</td>
<td>42.54</td>
</tr>
<tr>
<td>8</td>
<td>$1160.10</td>
<td>59.49</td>
</tr>
</tbody>
</table>

The following monthly basic charges would result for each meter size in applying the above multipliers to the water rates in Table XV- 5 (5/8 inch meter). Table XV-6 shows these multipliers applied to the assumed schedule of development shown in Table XV-4.
Table XV-6 Basic Monthly Water Charge

<table>
<thead>
<tr>
<th>Meter Size</th>
<th>Multiplier</th>
<th>1999</th>
<th>2005</th>
<th>2010</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8</td>
<td>1.00</td>
<td>(1) 23.62</td>
<td>(2) 27.80</td>
<td>(3) 36.28</td>
<td>(4) 41.63</td>
</tr>
<tr>
<td>3/4</td>
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XVI. ALTERNATIVE FUNDING

A. Increased Water Rates

The water cost projections presented in the foregoing section clearly demonstrate that water rates will increase significantly in achieving the objectives and works defined in each of the priorities identified. The cost figures are based on the assumption that funding would be provided by either the Wyoming Water Development Commission (WWDC) and Wyoming Farm Loan Board (WFLB).

Table XV-4 shows that water rates nearly double when Priority I, II and III have been completed. This is an extreme increase in cost to the water user. Other alternative funding sources should be seriously considered to reduce or minimize any increase in water rates to the residents of Lander.

B. Abandoned Mine Lands (AML) Funding

Lander has been impacted by mining operations in Fremont County. The uranium mines in the Gas Hills area provided many jobs to people in Lander when they were in operation but the closure of the Atlantic City iron ore mine had a greater impact on Lander. More than five hundred jobs were lost when the Atlantic City mine closed in October of 1983. The mine operated from 1962 to 1983, a period of 21 years.

The closing of the mine not only resulted in the loss of jobs, but also caused a significant decrease in property values in the town; therefore, Lander should have a meaningful basis to pursue AML funding from the Abandoned Mine Lands Division of the Wyoming Department of Environmental Quality.

This report clearly demonstrates that the infiltration gallery supplies up to 50 percent of the city's water supply requirements. The infiltration gallery was the original source of the Town's water supply and its loss will have a major impact on the development and upgrading of the water treatment plant which is addressed in the Priority I recommendations.

The infiltration gallery will be abandoned at such time that it is found to be out of compliance with EPA criteria and regulations. This subject is described in detail in this report. The water supplied from the gallery already demonstrates problems in complying with SWDA and SWTR.

The inability of the water treatment plant to perform at its operational design capabilities when turbidity levels are high in the Middle Fork of the Popo Agie River has been discussed in detail in this report. The failure of the plant to provide adequate water treatment during these periods also poses a public health threat.

The fact that the water supply from both the infiltration gallery and water treatment plant are in non-compliance with the SWTR, SWDA and ESWTR raises issues related to public health and welfare; therefore, funding from AML could be requested on this basis in addition to financial hardship that to a large degree is based on impacts from past mining operations.
Ninety-four percent of project costs will be paid for under the Abandoned Mine Lands Program if a project is authorized accordingly. Lander would then pay six percent of the project cost. The Lander share could be funded through a loan from the Wyoming Farm Loan Board. Water rates would be significantly lower over the long term if a project is authorized and paid for by AML.

Project priorities should be revised from that previously described in this report in pursuing AML approvals. Revised Priority I features should include:

- Upgrading the water treatment plant to 7.2 MGD.
- Constructing clearwell/operational storage.