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1.1 Background

Over the past 50 years the City of Casper has developed and maintained water system master plans to efficiently and effectively plan and construct their water system to serve the residents in central Wyoming. The water system master plans have been utilized to direct the water system expansion by developers and to identify water system deficiencies which need to be addressed by the City of Casper. The previous water system master plan update was completed by Black and Veatch in 1997. It provided an update of the much more detailed 1982 master plan, also prepared by Black and Veatch. The 1982 master plan anticipated significant growth over a 20 year period mostly in the western regions of the system. Approximately two years after the completion of the 1982 master plan the local economy atrophied as a result of the oil and gas market. The 1997 master plan update was developed to address more reasonable growth projections resultant from the previous boom and bust cycle of the local economy. The 1997 master plan update also addressed some very significant growth pattern changes in the greater Casper area including the vast majority of the growth occurring along the eastern edge of the city. The 1997 master plan update also addressed the impact of the formation and development of the Central Wyoming Regional Water System (CWRWS) on the City of Casper’s water system.

In June of 2005 Civil Engineering Professionals, Inc. (CEPI) was contracted by the Wyoming Water Development Commission (WWDC) to complete the Casper Master Plan Level I Study (Master Plan) for the City of Casper and the WWDC. The scope of services for the Master Plan included water system growth projections, hydraulic modeling and system analysis, and recommendations for needed improvements to meet current and projected development in the system.

1.2 Service Area Description

There are three primary water providers in the greater Casper area: the CWRWS, the Town of Evansville and the Town of Mills. The CWRWS includes several member entities including: the City of Casper, the Wardwell Water and Sewer District, which includes the Town of Bar Nunn, the Pioneer Water and Sewer District, the Salt Creek Joint Powers Board (the towns of Midwest and Edgerton), Poison Spider Water District, Sandy Lake Estates Improvement and
Service District, Thirty-three Mile Road Improvement and Service District, and the Lakeview Improvement and Service District. The City of Casper serves residents within the Casper municipal city limits and several customers outside the City of Casper. The service area for the City of Casper and the adjacent water purveyors is graphically displayed in Figure ES-1. Figure ES-1 identifies the growth area boundaries for the adjacent communities including the town of Mills, the town of Evansville, and the Wardwell Water and Sewer District.

1.3 Population Projections

Historically, Natrona County and the City of Casper have seen radically differing growth rates based upon economic conditions in the state and more specifically the markets for oil, minerals and natural gas. The City of Casper Planning department and their consultant, Worthington, Lenhart and Carpenter, Inc. are estimating a 1-percent per year growth rate for the Casper Annexation Study currently being completed. This growth rate is consistent with the growth projection utilized for several studies completed for the City of Casper over the past several years. The Master Plan assumed a growth rate of 1.0 percent per year for population growth in the greater Casper area.

Table ES-1

City of Casper Water System Service Area Population

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
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</thead>
<tbody>
<tr>
<td>2005</td>
<td>54,000</td>
</tr>
<tr>
<td>2010</td>
<td>56,754</td>
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<tr>
<td>2015</td>
<td>59,650</td>
</tr>
<tr>
<td>2020</td>
<td>62,692</td>
</tr>
<tr>
<td>2025</td>
<td>65,890</td>
</tr>
<tr>
<td>2030</td>
<td>69,251</td>
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</table>

The current population for the City of Casper is estimated to be 51,738 people by the U.S. Census Bureau. The service area population for the City of Casper water system which includes several customers residing outside of the City of Casper corporate city limits is estimated to be approximately 54,000 people. The projected service area population for the City of Casper water system is summarized in Table ES-1.

1.4 Historical Water Usage

The CWRWS provides water to several different entities in Natrona County. All of the potable water supplied is pumped from the well fields or the water treatment plant located at the CWRWS water treatment plant site. The historical water production for the CWRWS water treatment plant and well field is summarized in Figure ES-2. The figure graphically
displays the water production from the CWRWS water treatment plant and well fields by month over the past six years.

Figure ES-2
CWRWS Historic Water Production (Monthly)

<table>
<thead>
<tr>
<th>Year</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
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<tr>
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<td>2001</td>
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<td></td>
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<td></td>
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<tr>
<td>2005</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1.5 Peaking Factors
The average day demand (ADD) for the City of Casper is approximately 9.5 Million gallons per day. This is calculated by taking the average water usage over the past five years (3,468,575,129) and dividing it by 365 days. There are two other water usage figures that are important in the design and analysis of water systems: maximum day demand (MDD), and peak hour demand (PHD). In general the maximum day demand factor, which is maximum day demand divided by average day demand (MDD/ADD), ranges from 2.5 to 2.9. The average over the past six years is 2.62; for the purpose of the Master Plan and in the interest of being conservative a maximum day demand factor of 2.75 was utilized for the development of the Master Plan. Peak hour demand is a function of the diurnal (daily) demand variance in the water system. The peak hour factor for the CWRWS is approximately 1.45; that is, the peak hour flows on the maximum day are approximately 1.45 times the average hourly flow.
on that day. Given the MDD factor derived above, 2.75, and applying the peak hour factor of 1.45 results in a peak hour demand (PHD) factor of 4.0.

1.6 Per Capita Water Usage

Per capita water usage is simply derived by dividing the water usage in the system by service area population. Historically, Casper’s per capita water usage has ranged from 200 to 220 gallons per capita per day (gpcd). This figure has remained reasonably steady over the past 25 years with reasonable variations for temperatures and precipitation levels.

Table ES-2 provides the per capita water usage for all of the CWRWS member entities. Over the past five years the average day demand in the City of Casper and the CWRWS has dropped significantly. Accordingly, the per capita water usage has also declined. Based upon the past five years water usage and the current service area population a conservative per capita water usage figure of 190 gallons per capita per day was utilized for the development of the Master Plan.

1.7 Water System Infrastructure

Water system infrastructure includes: waterlines, pump stations, water storage tanks, and valves. With the help of the City of Casper’s GIS waterline shapefile, the water system infrastructure model was developed. The waterline shapefile was simplified by removing components that would not be used, such as fire hydrant leads, abandoned pipes and short dead-end pipelines. Once simplified, the shapefile’s material and size attributes were thoroughly reviewed and cross-checked against the City of Casper’s Atlas Sheets. The CWRWS water system components were added to the shapefile. The final shapefile was then
imported into WaterCAD as the waterline network. The attribute information, including diameter, material, and installation year, were all imported. During this process, WaterCAD also created nodes at the pipe junctions and the ends of the pipes. In WaterCAD, elevations and demands are assigned to nodes. The elevations were assigned to the nodes using the contours shapefile from the City of Casper’s GIS and record drawings, contour maps and USGS maps for the CWRWS components.

In order to develop pump station information for the water model, every station was visited to collect pump information and flow test recordings. Each pump was flow tested individually and in conjunction with other running pumps. This information was used to develop standard three-point performance curves for each pump and to verify the accuracy of the record performance curves. The three-point performance curves were incorporated into WaterCAD for each pump in every pump station; a simplified piping configuration was also developed and incorporated into WaterCAD for each pump station. In WaterCAD, water storage tanks require the following four attributes to be modeled: overflow elevation, base elevation, tank diameter, and piping configuration. The attributes were collected from the City of Casper based upon record drawings and site visits and then incorporated into the model.

1.8 Demand Allocation

For the 2005 CWRWS hydraulic water model, demands were allocated to individual nodes using two different methods. The first method, which was used for the City of Casper system, utilized actual demands from the City of Casper’s billing records and imported the records into the hydraulic model. The billing records were linked with an address shapefile to the City of Casper’s GIS. The water system shapefile was placed over the top of the address shapefile and the billing records were assigned to the nearest node in the system. The second method, which was used for the CWRWS components and member entities, utilized the CWRWS records for the regional systems. The average day demand over the past five years was calculated and distributed evenly to the appropriate district’s nodes.
1.9 Model Calibration

The 2005 CWRWS water model was calibrated using two methods. The first method used a “static” calibration to verify the node elevations in the model were correct by comparing measured static pressures against modeled static pressures. To obtain measured static pressures, fire hydrant pressure tests were randomly performed throughout the City of Casper. SCADA information on tanks levels and pump station status was gathered, and for each calibrated test, the WaterCAD model was updated to emulate the system. The modeled pressure was then compared to the measured pressure. The results showed that the modeled pressures were all within five pounds per square inch (psi) of the measured pressures, and the majority of the modeled pressures were within two to three psi of the measured pressured.

The second method used was a “dynamic” calibration used to assign friction losses to waterlines. Friction losses are determined by the material and the age of the waterline; they are modeled in WaterCAD using the Hazen-Williams Equation. This equation uses a roughness coefficient, or “C-Factor”, to equate the amount of friction loss in a waterline. To determine the “C-Factors” for the hydraulic water model, random fire hydrant flushing tests were performed throughout the City of Casper. This process included flushing a fire hydrant and recording the pressure and flow rate at that fire hydrant and the pressures at two adjacent fire hydrants. The field flow testing was then emulated in the hydraulic model. The results from this test provided the pressure drop through the waterline for a known velocity. The data was used to adjust the C-factors in the hydraulic model based upon the material of construction and age of the pipeline. The results are shown in Table ES-3.

<table>
<thead>
<tr>
<th>Material</th>
<th>Year</th>
<th>C Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>All</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>2000’S</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>1990’S</td>
<td>136</td>
</tr>
<tr>
<td></td>
<td>1980’S</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>1970’S</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>1960’S</td>
<td>109</td>
</tr>
<tr>
<td>DIP</td>
<td>1950’S</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>2000-Present</td>
<td>150</td>
</tr>
<tr>
<td>STEEL</td>
<td>1960’S</td>
<td>112</td>
</tr>
<tr>
<td>CI</td>
<td>1950’S &amp; 1960’S</td>
<td>105</td>
</tr>
<tr>
<td>AC</td>
<td>1960’S</td>
<td>130</td>
</tr>
</tbody>
</table>
1.10 Future Conditions Hydraulic Models

Two models were developed to analyze the capability of the existing water distribution system to meet the demands from anticipated growth in the system. The two models are the 10-year (2015) and 25-year (2030) models. The first model developed was the 2030 model. This model utilized the growth data prepared for annexation study completed by Worthington, Lenhart and Carpenter, Inc. (WLC). The WLC study clearly detailed the proposed areas of growth in the greater Casper area for the next 20 years. The calculated Master Plan per capita average day water demand for the City of Casper is 190 gallons per capita per day. The WLC map and an estimated population of 3.5 people per new home were used to estimate projected water usage in projected new developments. For projected commercial and industrial developments, an average day demand of 1,200 gallons per acre per day was utilized. These demands were assigned to the nearest node; in the few instances there was not a node nearby so a new waterline and node were added to the model.

1.11 Transmission and Distribution Analysis

The hydraulic water models analyzed the system’s ability to meet the current and projected water system demands for average day demand, maximum day demand, peak hour demand, fire flow scenarios, and tank replenishment scenarios. The general minimum guidelines for the operation of a water system are: maintain 35 psi in the system under all “normal” operating conditions (peak hour); maintain 20 psi in the system during maximum day demands with fire flows; and keep velocities below 8 to 10 feet per second in the transmission and distribution mains. The majority of the transmission and distribution system meet these criteria for the current and projected conditions. However, the following transmission and distribution improvements are needed in each zone.

- **Zone 1**
  - transmission system redundancy, west and central Zone 1
  - change pressure zone boundary (Zone 1 to Zone 2), central and west Zone 1
  - projected future growth waterline, west Zone 1
- **Zone 2**
  - transmission system redundancy, throughout Zone 2
  - change pressure zone boundary (Zone 2 to Zone 3), west-central Zone 2
  - projected future growth waterlines, throughout Zone 2
- **Zone 3**
CASPER MASTER PLAN LEVEL I STUDY - EXECUTIVE SUMMARY

- transmission system redundancy, throughout Zone 3
- new pumping and storage to accommodate growth in Zone 3

- Zone 4
  - transmission system redundancy, central Zone 4
  - raise Sunrise III tank to increase upper Zone 4 pressures

- Zone 2A
  - projected future growth waterlines south Zone 2A

- Zone 2B
  - new pump station and transmission mains east Zone 2B
  - projected future growth, new pressure zone north of Zone 2B

- Pioneer
  - no improvements needed

- Sandy Lake
  - no improvements needed

1.12 Pump Station Analysis

In general, a pump station is designed to meet 25 year projected maximum day demands for the pressure zone it supplies and the pressure zones at higher elevations redundant to its zone. The pump station’s firm pumping capacity is designed to meet these 25 year maximum day demands. The current pumping capacities for the majority of the pressure zones adequately meet the required 2030 maximum day demand. Projected future growth will require new pump stations to serve the east side of Zone 2B, the east side of Zone 3, a new pressure zone north of Zone 2B, and an upgrade to the existing Zone 3 pump station. The firm pumping capacity of the Zone 3 pump stations, Sunrise I and Mountain Road, is undersized by approximately 600 gpm for the desired 2030 maximum day demand. Additionally, Sunrise I Pump Station is nearly 50 years old. The building is failing and there are serious concerns regarding the condition of the buried pipelines under the pump station as well as the mechanical and electrical equipment. There are also concerns about the Airport Line Pump Station which is nearly 30 years old, has no flow meter, and aging mechanical and electrical equipment.

1.13 Water Storage Tank Analysis

Water storage tanks are designed to provide water storage for varying water system demands and allow for the cyclical operation of the pumping facilities. Water storage tanks consist of three storage components: emergency storage, equalization storage, and fire flow storage.
Historically, water storage tanks were significantly oversized to provide an excess of storage and reduce the burden on the pump stations. However, Casper has experienced significant problems with water stagnation. In order to reduce this problem, water storage tanks are currently sized as conservatively as possible with additional reliance on booster pumping stations. The majority of the water storage tanks have adequate storage to meet storage requirements through the year 2030. However, the existing storage for Zone 3 should be increased to meet the 2030 storage requirements. Also, as mentioned in section 1.11, Sunrise III tank should be raised to provide adequate pressure to the higher elevations in Zone 4, and a new tank will be needed to meet future developments north of Bar Nunn.

1.14 Proposed Improvements

Conceptual designs were completed for all of the system deficiencies identified above and to address anticipated growth throughout the CWRWS water system. The proposed improvements are graphically identified on Figure ES-3. The figure identifies all of the proposed improvements throughout the system. Some of the improvements will be addressed by the city of Casper to meet current and anticipated demands, others will be constructed by developers to allow for development in the community.

The immediate improvements needed in the system are primarily in Zone 3. The City of Casper has submitted a request for Level III funding to the WWDC for the proposed Zone 3 improvements. The Zone 3 improvements include a new pump station to replace the aging Sunrise I pump station, a new water storage tank to parallel the existing Sunrise II tank, and a redundant transmission pipeline between the tank and pump station. The proposed improvements will cost approximately $3.36 Million for design, permitting, construction and construction administration. If funding can be obtained from the WWDC design will begin in 2007 and construction will be completed in late 2008.
FIGURE ES-3
RECOMMENDED FUTURE IMPROVEMENTS

P pipe Diameter

<table>
<thead>
<tr>
<th>Zone</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
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<td>ZONE 1</td>
<td>&lt;= 6</td>
</tr>
<tr>
<td>ZONE 2</td>
<td>&lt;= 8</td>
</tr>
<tr>
<td>ZONE 2A</td>
<td>&lt;= 12</td>
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<tr>
<td>ZONE 2B</td>
<td>&lt;= 16</td>
</tr>
<tr>
<td>ZONE 3</td>
<td>&lt;= 20</td>
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<tr>
<td>ZONE 4</td>
<td>&lt;= 24</td>
</tr>
<tr>
<td>ZONE 5</td>
<td>&lt;= 36</td>
</tr>
</tbody>
</table>

Symbols:
- Future Waterline
- Future Booster Station
- Future Water Storage Tank
- Pressure Reducing Valve
- Water Treatment Plant

Pressures Zones:
- Zone 1
- Zone 2A
- Zone 2B
- Zone 2
- Zone 3
- Zone 4

Notes:
- New Zone 3 Water Storage Tank
- New Zone 3 Booster Station
- New 12" Waterline
- New 16" Waterline
- Replace Airport Line Booster Station
- Convert to Pressure Zone 2
- Convert to Pressure Zone 3

North Platte River
Wyoming Blvd
Casper Mountain Rd / Wolcott St
15th St