PW053105-19

Ferber Engineering Company, Inc.

- Civil Engineering
- Water Resources
- Transportation
- Land Surveying

NORTH RAPID HIGH LEVEL AND NORTH DEADWOOD AVENUE WATER SYSTEM EXPANSION STUDY RAPID CITY, SOUTH DAKOTA

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INTRODUCTION

Rapid City is experiencing growth in all directions. The provision of municipal water and sanitary sewer service in the Deadwood Avenue area has seen a change from mostly large lot industrial type development to increased densities and more commercial uses. Recent developments, including the proposed Farrar Business Park and the relocation of Black Hills Harley Davidson, have occurred that will spur growth to cross the boundary historically provided by I-90. The Rapid City Corporate Limits have also recently been extended to include land north of I-90 along Deadwood Avenue.

In an effort to provide adequate infrastructure planning to support the growth, the City of Rapid City contracted with Ferber Engineering Company, Inc. to prepare a conceptual layout for water and sanitary sewer service to the area north of Interstate 90 along Deadwood Avenue, including estimating future demand and identifying supply and storage facilities. The North Deadwood Avenue Water System Expansion Study was published in August 2003.

Recent developments east of the Deadwood Avenue Water Study caused the City to expand the scope of the original study to include an analysis of the North Rapid High Level Water System. Specifically, Ferber Engineering Company, Inc. was asked to evaluate whether or not the existing North Rapid High Level System had the capacity to adequately serve the rapidly expanding commercial and residential areas along Haines Avenue north of Interstate 90. We were also asked to modify our original study to reflect the draft North Deadwood Avenue Land Use Plan prepared by the Rapid City Future Land Use Committee.

OBJECTIVES

The specific objectives of this study include:

1. Using City Land Use Plans, estimate future potable water demand in a fully developed North Deadwood Avenue service area and North Rapid High Level service area, and to identify the source, storage, and distribution facilities needed to serve the demand.

2. Evaluate whether or not a new reservoir could be constructed on the east side of the Dakota Hogback Ridge instead of the location identified in the previous study.
3. Investigate alignment options for a proposed waterline connection across the Dakota Hogback Ridge to provide service to areas outside the service boundaries of the North Rapid High Level System.
4. Investigate relocating the proposed booster station from the Harmony Heights area to a location north of Interstate 90.
5. Evaluate the existing supply capacity of the North Rapid High Level system and determine the impact of adding 1400 new homes to the service area.
6. Evaluate the adequacy of the proposed location for the Sagewood booster station.

PROJECT PLANNING AREA

The project planning area included in this study is bounded by Interstate 90 on the south, Lacrosse Street/ Seger Drive/ 143rd Avenue/ Country Road/ and Lacrosse Street extended on the east, the Meade County / Pennington County line on the north, and Universal Drive / Sturgis Road on the west.

The total study area is 6,600 acres more or less. The study area includes the rapidly expanding commercial area surrounding the Rushmore Mall, as well as Mall Ridge Subdivision, Northridge Subdivision, and Auburn Hills Subdivision. The study area also includes substantial undeveloped property, both in the area north of the Rushmore Mall, and in the area north along Deadwood Avenue. Figure 1 is a map of the study area.

A significant geological feature of this study area is the Dakota (Inyan Kara) Hogback Ridge. The Dakota Hogback Ridge rises several hundred feet above the surrounding plains and is on the outer rim of the Black Hills uplift.

LAND USE

The study area includes parts of two separate Land Use Neighborhood Study Areas. East of the Dakota Hogback Ridge the area is included the Northeast Area Analysis published in June 2002.

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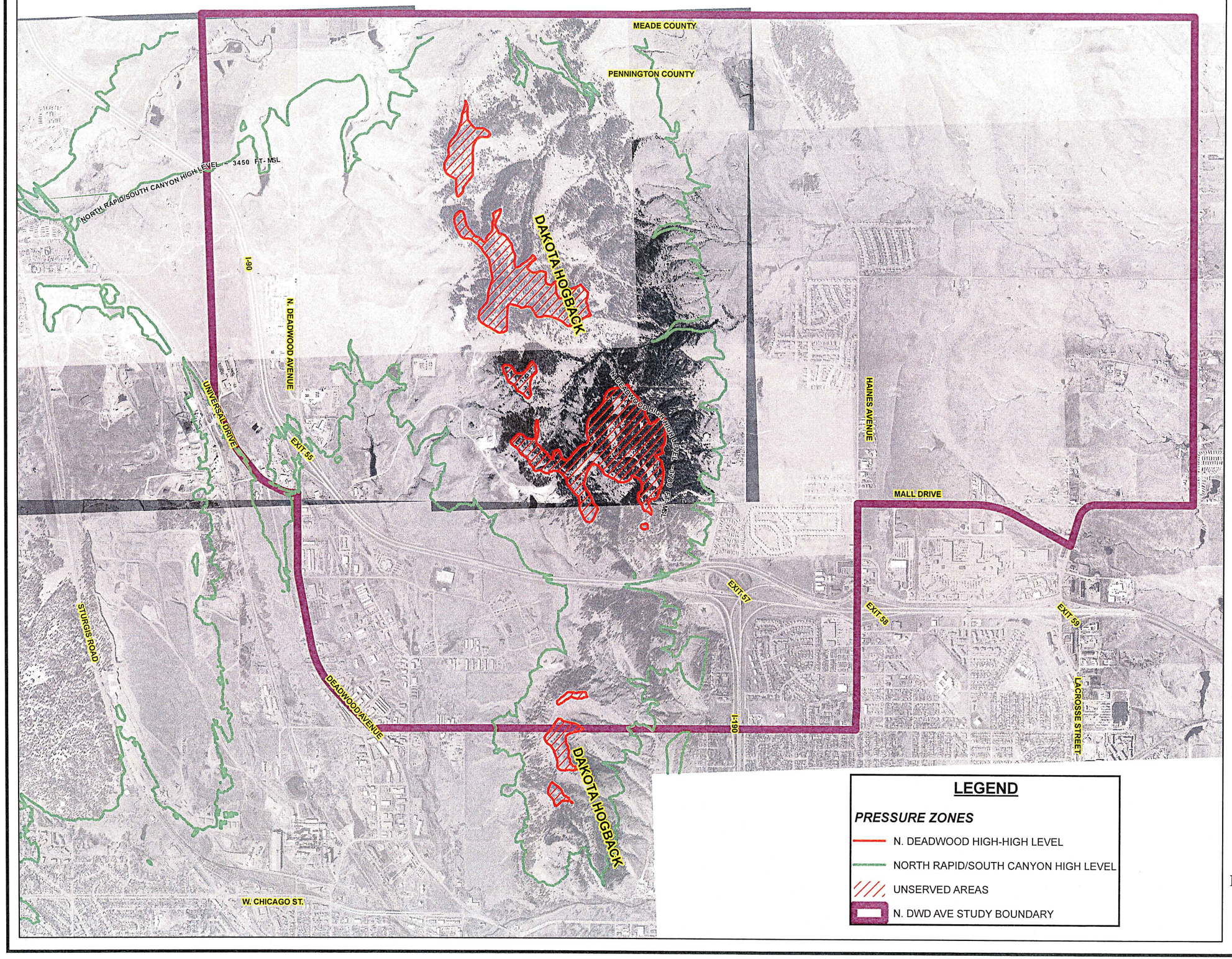

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The orthophotography and topography shown were collected in 2000 by the City of Rapid City. The data is horizontally referenced to the South Dakota State Plane Coordinate System, South Zone, North American Datum of 1983 (NAD83). Elevation is referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

FIGURE 1.

N. DEADWOOD AVE WATER STUDY

STUDY AREA

West of the Dakota Hogback Ridge, the area is included in the Deadwood Avenue Neighborhood. While not finalized, the *Draft* Land Use Plan was published in 2004.

Development of the 6,600 acres included within the study area is anticipated to include 76.5 acres of Business Park, 474 acres of General Commercial, 10 acres of Neighborhood Commercial, 65 acres of Office Commercial, 1249 acres of Low Density Residential, 340 acres of Medium Density Residential, 2872 acres of Planned Residential at a density of 1 DU/3Ac, 286 acres of Planned Residential at a density of 5 DU/Ac, 175 acres of Mobile Home Residential, 213 acres of public, 471 acres of Light Industry, and 134 acres of Mineral Extraction.

The total resident population within the study area is project to be 26,500 persons at full build out. Commercial and industrial buildings are projected to total 19,780,000 square feet at full build out. More than half of the projected growth of building area is expected to be general commercial. Figure 2 shows the *draft* future land uses within the study area.

EXISTING FACILITIES

The Deadwood Avenue area is served from the south via a series of mains, with the primary feed being an existing 12-inch line in Rand Road. The water supply system currently extends north through the Deadwood Avenue area to the intersection of Deadwood Avenue and Universal Drive. Main lines extend east along North Plaza Drive on the south side of Interstate 90. In 2002, a 12" main was extended across Interstate 90 to serve the newly constructed Black Hills Harley Davidson retail outlet. This line is fed by an existing 8-inch line in Pool Dr. Figure 2 is a map of the existing water facilities within the study area.

Water pressure for the Deadwood Avenue area is currently supplied from the South Canyon High Level Zone. The South Canyon and Arrowhead Reservoirs supply storage and static head at an overflow elevation of 3561.94 msl.

Water supply is primarily provided from Well #6 located adjacent to South Canyon Reservoir, Well #10, and the Hall Street Booster. The Hall Street Booster draws from the Low Level system.

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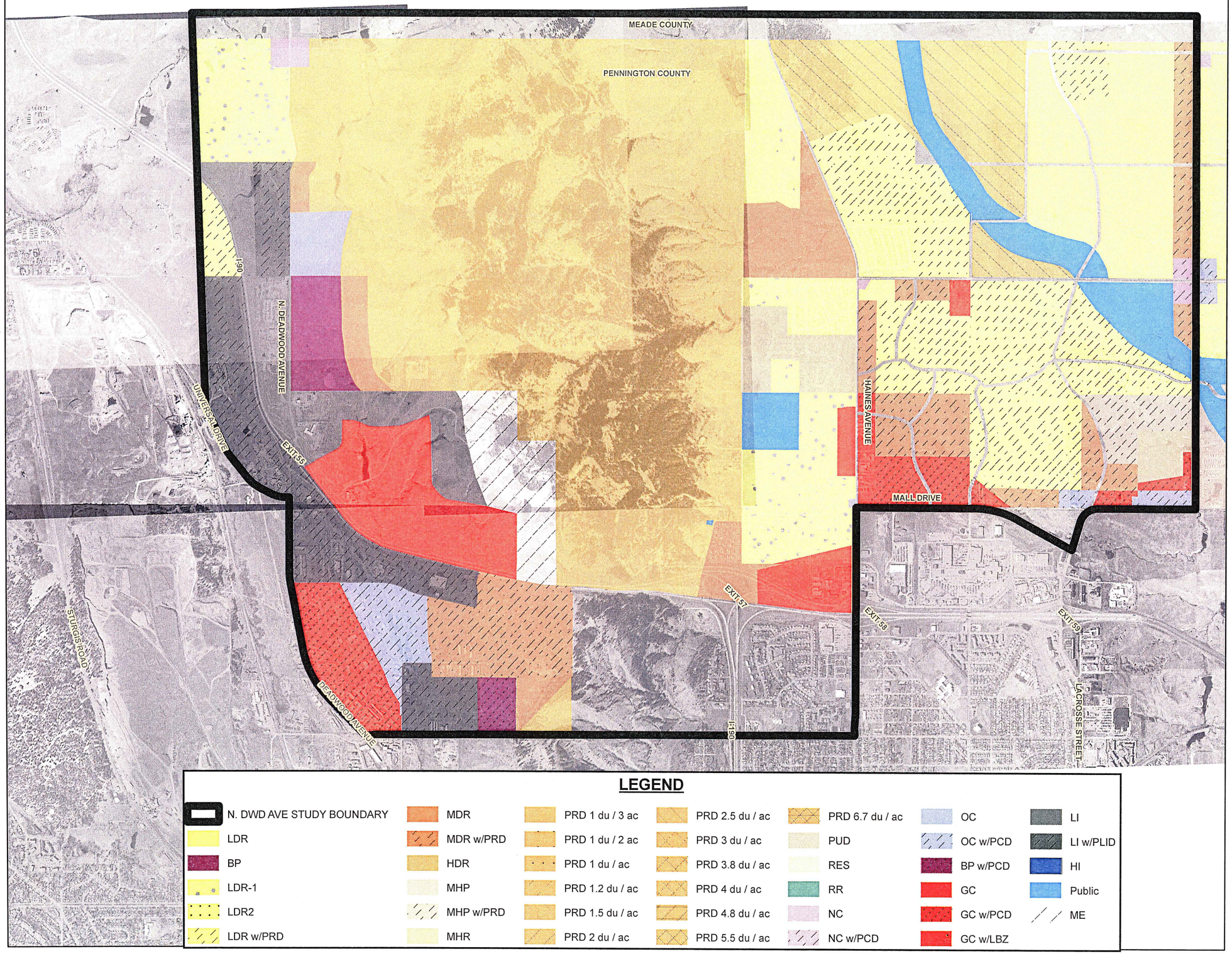

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NOTES:

FUTURE LAND USE PLANS for North Rapid, DRAFT Deadwood Avenue and Northeast Neighborhoods obtained from Rapid City GIS Department. Areas where data is incomplete was supplemented in the model using the respective hardcopy future land use plans.

The orthophotography and topography shown were collected in 2000 by the City of Rapid City. The data is horizontally referenced to the South Dakota State Plane Coordinate System, South Zone, North American Datum of 1983 (NAD83). Elevation is referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

FIGURE 2.

N. DEADWOOD AVE WATER STUDY

FUTURE LAND USE

Well #10 is the nearest well to the North Deadwood Avenue service area, and is controlled by the levels in Arrowhead Reservoir.

Water pressure for the North Rapid High Level system is supplied by the North Rapid Reservoir located on the east side of the Dakota Hogback Ridge north of Mall Drive. The 2.0 million gallon reservoir has an overflow elevation of 3543.0 msl.

The North Rapid High Level distribution system is centered on Haines Avenue with a 16-inch main providing the primary feed from Anamosa Street to Mall Drive. West of the intersection of Haines Ave. and Mall Dr., a 16-inch asbestos-cement (transite) main connects to the North Rapid Reservoir. In Haines Ave., the main size decreases at Mall Dr. to 12-inch that continues north to the Mallridge area. Six inch and 8-inch service mains distribute the water within the residential areas off Haines Ave. The Rushmore Mall area is currently served by a 10-inch main in Disk Drive that extends to Maple Ave. with a 10-inch loop around the perimeter of the Mall.

Water supply for the North Rapid High Level system is provided by Well 8, located adjacent to the North Rapid Reservoir, and the North Rapid Booster located in Anamosa St. west of Haines Ave. The North Rapid Booster draws water from the Low Level System

To improve fire flows in the Harmony Heights Area, a 14” emergency crossover main was recently constructed along the south side of I-90 to physically connect the South Canyon High Level Zone with the North Rapid High Level Zone. This crossover is valved at the proposed location of the Harmony Heights Booster/Control Station. The valves are set to allow water from the North Rapid High Level system to flow to the South Canyon System in the Harmony Heights area in the event of a major pressure drop in the Harmony Heights Area. A check valve prevents backflow.

For modeling purposes, the existing system was simplified to include only those major elements necessary to supply the existing system. Figure 3 shows the modeled existing system. Major changes included showing the South Canyon Reservoir connected to Node PJ-401. This simplification enabled us to model the function of a reservoir without the

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NOTES:

This figure provides the general existing water distribution facilities that affect the study area. Not all existing pipes may be shown.

The orthophotography and topography shown were collected in 2000 by the City of Rapid City. The data is horizontally referenced to the South Dakota State Plane Coordinate System, South Zone, North American Datum of 1983 (NAD83). Elevation is referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

LEGEND

WATER MAIN DIA (inches)		
6"	16"	PRESSURE JUNCTION
8"	20"	Study Boundary 2-16-05
10"	24"	
12"	RESERVOIR/WELL	
14"	PUMPS	

FIGURE 3.

N. DEADWOOD AVE WATER STUDY

EXISTING FACILITIES

complex hydraulic connections of the existing system. We also showed the existing North Rapid Booster Station being supplied by a constant grade reservoir located immediately upstream of the pumps.

WATER USAGE

The entire Rapid City water system delivered an average of 12.98 MGD in 2002.

Because of limited existing service, no estimate of existing water usage was made for the North Deadwood Avenue study area. At full build-out, we project that the area will demand an average of 3,160 GPM, or 4.6 MGD on the average day.

The North Rapid High Level service area used an average of 953 GPM or, 1.4 MGD in 2004. At full build-out, we predict that out the North Rapid High Level service area will use 3,750 GPM, or 5.4 MGD on the average day.

The combined area included in this study, at build-out, as predicted in the Draft Land Use Plans, will demand 6910 GPM, or 10.0 MGD. This total represents the equivalent of 77 percent of the average day water use for all of Rapid City in 2002.

ANALYSIS AND FINDINGS

The objective of this study is to estimate future potable water demand in a fully developed North Deadwood Avenue service area and North Rapid High Level service area, and to identify the source, storage, and distribution facilities needed to serve the demand.

We were asked to also evaluate adequacy of existing facilities to serve existing demand, and to identify interim facilities that could be developed to support partial growth in the area. We used Haestad Methods WaterCad v7.0 as our modeling software, using the Hazen-Williams Equation for friction loss.

Modeling Parameters

City officials indicated that the *Northeast Area Analysis Final Report* June 2002, estimated the anticipated mode of growth for the North Rapid area, and also approximates the anticipated mode of growth for the Deadwood Avenue area north of Interstate 90. After review of the demand criteria used in the *Northeast Area Analysis Final Report*, and discussions with City officials, the following parameters were assigned to this study:

Demand:

Residential

Persons per dwelling unit – 2.71.

Average Daily Demand per person – 120 gallons per capita day.

Commercial

Demand for all commercial areas in the study – 5 gallons per minute per acre.

Industrial

We used half the Commercial rate for industrial areas –2.5 gallons per minute per acre.

Fire Flow:

City engineering officials suggested a minimum of 2,500 – 3,000 gpm for residential areas and 2,500 for non-commercial, non-industrial areas. Fire department officials advised using 4,000 gpm for commercial and industrial areas. We used 4,000 gpm for commercial and industrial, and 2,500 for residential areas.

Pipe Velocity:

The Draft Rapid City Utility Design Criteria Manual specifies that water mains be sized to limit velocities with peak day and fire flow to less than 12 ft/sec.

Peaking Factors:

After review of the Northeast Area Analysis and discussions with city engineering officials the following peaking factors were assigned:

Table 1. Peaking Factors

LAND USE	PEAK DAY	PEAK 2-HOUR
Residential	3	10
Commercial	2	3
Industrial	2	3

MODEL ANALYSIS

Hazen-Williams C-factors

C-factors for the various pipe materials as shown in *Water Distribution Modeling 1st ed. Hastead, et al. 2001* and *WaterCad v5.0* are as follows:

Table 2. Peaking Factors

PIPE MATERIAL	C-FACTOR *(Water Distribution Modeling)*	C-FACTOR *(Water Cad)*	C-FACTOR Used in the model
PVC	140	150	140
Asbestos-Cement	147-150	140	140
Ductile Iron	145	130	130
Cast Iron – est. 30 years old	58-112	75-90	85

Model Layout

We began our layout by constructing the South Canyon High Level and North Rapid High Level zones as they exist, by including the major mains to closely model the flow through the system. We included wells, booster stations and reservoirs, using data obtained from the Rapid City Water Department. Pump curves were input from existing well pump data.

Well #10 and The Hall Street Booster are controlled by the Arrowhead Reservoir. These facilities are outside the South Canyon High Level Zone. An extensive model of the Rapid City water distribution network would have been required to use these elements. After discussion with Rapid City Engineering Personnel, it was agreed that modeling the complicated South Canyon Zone including the South Canyon Reservoir, Hall Street Booster, and Arrowhead Reservoirs as an infinite reservoir with an elevation of 3562.94 msl would adequately represent the supply. We modeled the reservoir as a direct connection to the existing 16" PVC located in Deadwood Avenue.

The North Rapid High Level System was modeled based upon existing water maps, as well as construction plans for some of the more recent development projects within the area. Well 8 is controlled by water levels in the North Rapid Reservoir, as is the North Rapid Booster.

Model Calibration

Pressure readings were taken during the summer of 2002 by City of Rapid City summer interns at various hydrants in the South Canyon High Level zone. Pressures were randomly sampled at various times of the day. The time and date of the pressure readings were not recorded. We ran a steady-state analysis of the existing Canyon Lake High Level zone and compared the model pressures with the readings taken. The static pressures in the model were within 1% - 10% of the noted readings.

We also compared the existing water usage within the North Rapid service area to pumping records from the Rapid City Water Utility. Peak day usage was projected to be slightly higher than actual. We modified our model parameters to reflect actual usage.

Alternative Development

Both the North Rapid High Level service area and the North Deadwood Avenue service area included in this report have been previously modeled. The North Rapid High Level system was most recently modeled as part of the Northeast Area Analysis, and the North Deadwood Avenue system was recently modeled as part of the North Deadwood Avenue study. For this study, we were asked to combine the two existing models, make modifications reflecting the *Draft* Land Use Plans, including additional service areas, and investigate cross connecting the two systems across the Dakota Hogback Ridge. We were also asked to move the eastern boundary between the North Rapid High Level System and Low Level System to the east approximately one-half mile.

We evaluated three different scenarios within this study. The Base Conditions scenario is a simplified model of the existing system. The second model we evaluated is the Partial East and West Model. The Partial East and West Model is a model of some immediate improvements that are either in planning, or are needed immediately. The third model we evaluated is the Full Build-out Model that predicts the major improvements to support full development within the planning area.

Model #1: Base Conditions

The first model scenario we investigated is the Base Model. Figure 4 shows a schematic of the Base Model. Appendix A contains the results of the base model. It also includes results following some suggested modifications to the existing system to improve fire protection.

We ran four scenarios for the Base Model. These scenarios included Peak Day with Fire Flow, and Peak 2-hr flows. We ran the models with and without the Bunker Street connection.

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NOTES:

This model represents BASE CONDITIONS and reflects the EXISTING CONDITIONS of the North Deadwood Ave and North Rapid service areas.

The orthophotography and topography shown were collected in 2000 by the City of Rapid City. The data is horizontally referenced to the South Dakota State Plane Coordinate System, South Zone, North American Datum of 1983 (NAD83). Elevation is referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

LEGEND

WATER MAIN DIA (inches)
- 6"
- 8"
- 10"
- 12"
- 14"
- 16"
- 20"
- 24"

- PRESSURE JUNCTION
- PUMPS
- RESERVOIR/WELL
- STUDY BOUNDARY

FIGURE 4.

N. DEADWOOD AVE WATER STUDY

BASE MODEL

The existing system is capable of meeting existing demand and satisfying pressure requirements. However, our model predicts that both the North Rapid High Level System and the north end of the existing South Canyon System in the Deadwood Avenue area are unable to satisfy the 2500/4000 gpm fire flow requirements. In all, 76 out of 113 nodes fail to satisfy.

In the North Rapid High Level System, the nodes failing fire flow requirements are located around the Rushmore Mall, and in the residential areas north along Haines Avenue. The City has recommended construction of a new 14-inch main in Bunker St. to connect the North Rapid Reservoir to the Rainbow Ridge development. With the proposed 14-inch line in place, only 19 nodes fail to satisfy, of which, only 4 are in the residential areas along Haines Avenue. Four of these nodes are located in the upper elevations of the Rainbow Ridge development. The rest are around the Rushmore Mall, and in the north Deadwood Avenue area.

The failing nodes in the North Deadwood Avenue area are along Universal Drive and in the vicinity of the existing I-90 crossing. The elevations of these failing nodes is close to the operating elevation in the system. The extension of the 14-inch main in Deadwood Avenue to North Plaza Drive will help to alleviate the problem. It will also be necessary to replace an existing section of 8-inch main in Pool Drive east of Deadwood Avenue.

Model #2: Partial East and West Conditions

One of the primary goals of this study is determining how much additional development the existing systems could support within the study area. The recent move of Black Hills Harley Davidson north of Interstate 90 has created interest in additional commercial development in the North Deadwood Avenue area. There has been significant new commercial development in the area of the Rushmore Mall in the North Rapid area. The North Haines residential area, including Mallridge, Rainbow Ridge, Amber Hills subdivisions is experiencing dramatic residential growth.

To address these development pressures, the City has undertaken the extension of water across I-90 to serve Black Hills Harley, and is planning on constructing new water mains in Mall Drive between Haines Avenue and Lacrosse Street, as well as in Disk Drive between Lacrosse St and the Rushmore Mall. These extensions will further stimulate growth in all these areas. The City has also undertaken an expansion of the Mallridge lift station to increase it's capacity to handle the additional residential growth in the Mallridge, Rainbow Ridge, Auburn Hills area.

We created a partial expansion model for the combined North Deadwood Avenue and North Rapid service areas. This partial model includes all of the proposed main extensions in the Rushmore Mall area, and east along Country Road, as well as mains in the area surrounding Black Hills Harley Davidson, and Tatanka Drive. The partial model extends up Deadwood Avenue to the proposed Farrar Business Park.

We were specifically asked to determine the feasibility of connecting the North Deadwood Avenue System to the North Rapid High Level System across the Dakota Hogback Ridge. We investigated two alternatives routes to make the cross connection, and incorporated the recommended North Deadwood Avenue reservoir and well. This model is labeled Partial East and West, and is displayed in Fig 5.

We ran a number of different scenarios for the Partial East and West Model. We looked at Peak Day plus fire flows, and peak 2-hour flows, for the existing development, for 20% additional development, and for 40% additional development. Because of the lack of source water as well as storage, we stopped at 40% and didn't further investigate the growth of the partial system. The results of this modeling are presented in Appendix B.

Model #3: Fully Developed Conditions

Figure 6 shows a schematic of the fully developed system. Pipe diameters are set to supply the study area with fully developed 2-hour peak flows, holding velocities below 12 ft/sec. Appendix C contains the results of this model, including suggested modifications to the existing system to improve service to the northernmost extent of the South Canyon High Level Zone.

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NOTES:

This model represents INTERIM CONDITIONS and reflects a partial expansion for the combined North Deadwood Ave and North Rapid service areas.

The orthophotography and topography shown were collected in 2000 by the City of Rapid City. The data is horizontally referenced to the South Dakota State Plane Coordinate System, South Zone, North American Datum of 1983 (NAD83). Elevation is referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

FIGURE 5.

N. DEADWOOD AVE WATER STUDY

PARTIAL EAST-WEST MODEL

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NOTES:

This model represents FULL BUILDOUT CONDITIONS and reflects a the ANTICIPATED DENSITIES EXPECTED the North Deadwood Ave and North Rapid service areas.

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LEGEND

WATER MAIN DIA (inches)		
6"	20"	RESERVOIR/WELL
8"	24"	PUMPS
10"	27"	STUDY BOUNDARY
12"	PRESSURE JUNCTION	
14"	PRV	
16"		

FIGURE 6.

N. DEADWOOD AVE WATER STUDY

FULL BUILDOUT MODEL

We expanded the proposed service area for the North Rapid High Level system by moving the eastern boundary to 143rd Street. We also increased the sizes of some of the existing and proposed lines in the North Rapid System. We upsized the connection between Haines Avenue and the North Rapid Reservoir to 20-inch and 24-inch from the existing 16-inch mains because of the expansion in the service area boundary and the amount of anticipated commercial development in the Rushmore Mall Area.

The City also asked us to also model a conceptual future demand of 6,000 GPM at the intersection of Sturgis Road and Universal Drive. This conceptual demand is intended to represent partially developed conditions in the St. Martins / Kingswood area. Adding this demand will require some size upgrades of the main trunk line. This line would allow for future cross connection to a reservoir in the Saint Martins area with an overflow elevation matching the South Canyon Reservoir.

We were also tasked with evaluating the capacity of the existing system to supply current demand, and to estimate the amount of additional growth that could be allowed to occur in the areas without causing major service problems. In an effort to estimate interim demand within the combined service areas, we created a table estimating demand growth. This table, contained in Appendix D, estimates existing demand as the base condition, then assumes fully developed conditions. The difference between these is then allowed to increase in 20% increments. The table estimates average day, peak day, and peak 2-hr demand at each of the planned nodes.

Standards Review

The following standards were referenced in the course of our study:

Draft Design Criteria Manual for Water Distribution and Sewer Collection Systems for the City of Rapid City, January 2002

Recommended Standards for Water Works (Ten States Standards), 1997

1. **Supply – 10 States Standards**

"The total developed groundwater source capacity shall equal or exceed the design maximum day and equal or exceed design average day with the largest producing well out of service."

The capacity of the existing South Canyon High Level System to supply the Deadwood Avenue area is beyond the scope of this study. The other sources of water to supply the combined North Rapid High Level and North Deadwood Avenue systems are listed as follows:

Well 10 Design……..	***1650 gpm***	***2.38 mgd***
Well 10 Current Operation……	***1300 gpm***	***1.87 mgd***
Well 8……	***700 gpm***	***1.01 mgd***
North Rapid Booster Station…….	***1400 gpm***	***1.96 mgd***
North Rapid Booster Station Optimized……	***2400 gpm***	***3.36 mgd***
Total Capacity Current Operation……..	***3400 gpm***	***4.90 mgd***
Total Capacity Optimal Operation……	***4750 gpm***	***6.84 mgd***
Added Capacity Proposed Well 1……	***1500 gpm***	***2.16 mgd***
Added Capacity Proposed Well 2	***2000 gpm***	***2.88 mgd***
Total Capacity Optimal Operation W/ 2 Wells	***8250 gpm***	***11.88 mgd***

We estimate the existing demand in the combined North Deadwood Avenue and North Rapid systems to be 2.3 mgd average day, and 5.0 mgd peak day. Fully developed, we estimate the demand for the combined service area to be 13.0 mgd average day, and 31.0 mgd peak day.

Conformance to Standard:

Average Day: With optimal operation, the existing system is able to supply some growth in demand within the area. The partial system described in Model #2 at 20% of full buildout density will require approximately 4.4 mgd average day. The partial system at 40% of full buildout will require approximately 6.6 mgd average day. For full buildout, supply of approximately 13.0 mgd will be required for average day.

Peak Day: With optimal operation, the existing system is able to supply some growth in demand within the area. The partial system described in Model #2 at 20% of full buildout density will require approximately 10.2 mgd peak day. The partial system at 40% of full buildout will require approximately 15.4 mgd peak day. For full buildout, supply of approximately 31 mgd will be required for peak day.

Pump Station– 10 States Standards

- *Readily Accessible at all times.*
- *Have adequate space* –(design issue).
- *Have at least two pumps sized equally* - as described in this report.
- *Be located such that intake pressure shall be a minimum of 20 psi when pump is in normal operation.*

Conformance to Standard:

The North Rapid Booster currently conforms to this standard. To optimize performance, we suggest modifying the operation to run both pumps in parallel almost doubling the pumping capacity. However, doing so will mean that the pump station no longer conforms to the standard and is susceptible to service disruption. The solution is to add a third pump that can be used if service work is needed on either of the existing pumps.

The proposed Harmony Booster was originally anticipated to be constructed in the Harmony Heights area in conformance with the standard. At the City's request, we investigated moving the booster to the north side of Interstate 90 north of the original location. Provided the booster station is constructed at an elevation of 3470 or below, it appears the station can be constructed in accordance with the standard at the northern location.

2. Storage– 10 States Standards

Storage facilities should have sufficient capacity, as determined from engineering studies, to meet domestic demand, and where fire flow is provided, fire flow demands.

Water storage analysis is based upon a methodology for sizing distribution system Supply Storage facilities that includes Fire Reserve and Operating Storage.

SSR = FR + OS

Both of the areas studied in this report have substantial commercial and industrial development. For this report, Fire Reserve is calculated to include 3,500 gpm x 3 hours. The required Fire Storage thus calculated is 630,000 gallons.

Typically, Operating Storage is a function of diurnal water use patterns and input pumping rates. Because of the preliminary nature of the data input into this study, we are unable to calculate Operating Storage in this manner. In order to conservatively size the required storage facilities in this study, we estimate the operating storage requirement to be 25% of peak day use.

Using the equation, we calculate the required storage for the North Deadwood Avenue area as follows:

Existing Conditions West	.63 + .45 = 1.08 million gallons
20% Partial West	.63 + .82 = 1.45 million gallons
40% Partial West	.63 + 1.22 = 1.85 million gallons
60% Partial West	.63 + 1.62 = 2.25 million gallons
80% Partial West	.63 + 2.02 = 2.65 million gallons

Using the equation, we calculate the required storage for the North Rapid High Level System as follows:

Existing Conditions East	.63 + .80 = 1.43 million gallons
20% Partial East	.63 + 1.3 = 1.93 million gallons
40% Partial East	.63 + 1.8 = 2.43 million gallons
60% Partial East	.63 + 2.3 = 2.93 million gallons
80% Partial East	.63 + 2.8 + 3.43 million gallons

Using the equation, we calculate the required storage for the entire area at full Buildout as follows:

Full Buildout	1.26 + 7.75 = 9.01 million gallons

Conformance to Standard:

Currently, the 2.0 million gallon North Rapid Reservoir is the only reservoir inside the service area. This is sufficient for the North Rapid Area. By our calculations, there is an existing need for 1.08 million gallons in the North Deadwood Avenue area. These storage needs will increase as development proceeds. For 20% partial growth in the North Rapid Area, the storage requirement increases to 1.93 million gallons, and at 40% growth, the need rises to 2.43 million gallons. In the North Deadwood Avenue Area, the storage requirement increases to 1.45 million gallons for 20% growth, and 1.85 million gallons for 40% growth.

With the recommended cross connection, the recommended 5.0 million gallon North Deadwood Avenue Reservoir could provide adequate storage for partial development

of both areas. Ultimately, an additional 5.0 million gallon reservoir will be needed in the North Rapid System.

3. **Distribution System – 10 States Standards**

All water mains, including those not designed to provide fire protection, shall be sized after a hydraulic analysis based on flow demands and pressure requirements. The system shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in the distribution system under all conditions of flow. The normal working pressure in the distribution system should be approximately 60-80 psi and not less than 35 psi.

Conformance to Standard:

As shown on Figures 5 and 6, system mains are sized to satisfy these requirements. The working pressures in the system will exceed the 60-80 psi recommended in the standard. The model shows some nodes in excess of 150 psi, however, this reflects the general nature of the recommended main locations. At the time of installation, decisions can be made concerning the exact locations for these mains, and the pressures within the system.

DISCUSSION / RECOMMENDATIONS

The existing Rapid City Water supply and distribution system is versatile and interconnected, with wells and boosters controlled by remote reservoirs. Modeling the existing system in the west half of the City would require an extensive, comprehensive water model, well beyond the scope of this project. However, simplifications to the existing system necessary to model the proposed improvements were sufficient to show the needed additional capacity and water mains to supply the study area.

This study started with some specific objectives. The first objective was to estimate future potable water demand in the fully developed North Deadwood Avenue and North Rapid service areas. We have used the existing land use plans to accomplish this objective. The results are surprising. When fully developed, this area will incorporate a demand that equals

77% of the existing demand for the entire City in 2002. Water source development will need to be a priority if water is not to be a limiting factor for this development. At the current time, water is supplied by two wells within the service area, Well 8 with a capacity of 700 gpm, and Well 10 with a current capacity of 1350 gpm. The total capacity of these two sources is 3.3 mgd. The majority of the water for this area is currently provided by the Hall Street Booster Station and the North Rapid Booster Station. While there is currently some excess capacity in the Low Level System, the continued reliance on this source for continued development in this area is unwise. When fully developed, the demand in this area is estimated to be 13 mgd average, with a peak day demand estimated to be 31 mgd. Source development within the area is critical. We recommend that the City work to identify additional source locations within the area north of I-90 and schedule the development of new water sources to coincide with future development.

We have reviewed the full buildout models for both the North Deadwood Avenue and North Rapid areas. The distribution system envisioned in this report will provide adequate flows to meet peak demands, as well as provide an adequate measure of fire protection. As new development occurs in the study area, mains should be extended in a logical progression as shown in this report. We have included specific new and replacement lines in the Recommended Improvements Section of this report.

The shortfall that occurs during peak demands in the South Canyon High Zone north of Interstate 90 is partially a result of elevation, and partly a result of design. Except for Well 10, the entire Deadwood Avenue area receives water from the south through a single connection to the Rapid City system. The shortfall can be partially mitigated continuing the 14-inch main on the west side of Deadwood Avenue to North Plaza Drive as well as replacement of the section of 8-inch main in Pool Drive with 12-inch PVC. The shortfall can be further improved by increasing source capacity at the north end of the zone, possibly increasing output or increasing head from Well #10. A cross connection between the North Deadwood Avenue High level system with the South Canyon system in this area would allow water to be drawn from the North Deadwood Avenue system in the event of emergencies.

The second objective of this study was to evaluate whether or not a new reservoir could be constructed on the east side of the Dakota Hogback Ridge instead of the location identified in the previous North Deadwood Avenue study. The reservoir site on the west side of the ridge is at an elevation of 3855 ft msl. This elevation was chosen to enable the maximum area to be served. The topographic maps for the area show that there are no sites on the east slope of the ridge that meet the 3855 elevation. If the reservoir is moved east, the elevation of the proposed reservoir would have to be lowered, and larger areas on the ridge would be excluded from service. We recommend constructing a new 5.0 million gallon reservoir at the 3855 elevation.

The third objective of the study was to investigate alignment options for a proposed waterline connection across the Dakota Hogback Ridge to connect the North Deadwood Avenue system to the North Rapid High Level System. Using aerial topography, we identified two possible routes for the connection. One route follows the ridge and the other route follows the saddle. We prefer the saddle route. The saddle route grades uphill from east to west without any major high or low points. The ridge route has a significant hi point on its profile. The saddle route is shown on the fully developed model. The route is mostly through an existing meadow, and appears to be constructible. We recommend constructing a new 14-inch main connecting the North Deadwood Avenue High Level System to the North Rapid High Level System along the alignment shown in the report.

The fourth objective of the study is investigating the relocation of the proposed Harmony Heights Booster Station from the original identified location to an area north of I-90. This booster station will take water from Well 10 and pump it to serve the proposed North Deadwood Avenue reservoir. Our analysis shows that the booster station can be moved, provided it is constructed at an elevation of 3470 msl or below.

The fifth objective of this study is evaluation of the existing supply capacity of the North Rapid system, and the impact of adding 1400 new homes to the system. The growth of residential neighborhoods in the North Rapid Area is occurring rapidly. In order to allow continuation of this growth, significant investment in infrastructure in this area is recommended. When we ran a fire flow analysis of the existing distribution system in the

North Rapid system, the majority of the nodes fail to satisfy the fire flow requirements. With the proposed 14-inch water main in Bunker Street, the number of failing nodes drops to 4. This connection should be constructed as soon as possible. This single project will dramatically improve fire protection within the neighborhood. We recommend the construction of the 14-inch water main in Bunker Street be completed in the short term.

The sixth objective identified for this study is evaluating the adequacy of the proposed location for the Sagewood Booster station. Our analysis shows that the Sagewood site is adequate for construction of a booster station.

The final three objectives listed for this study involve the adequacy of supply for the continued expansion of water service to the study area. Objective 4 deals with the Harmony Heights Booster, Objective 5 relates to water supply in the North Rapid High Level System, and Objective 6 relates to the proposed placement of the Sagewood Booster Station. The purpose of both booster stations is to provide service into the High Level Service Zone above the South Canyon Zone and the North Rapid Zone. These booster stations, are intended to be constant pressure booster stations. They will provide capacity for domestic consumption and fire flow, but will provide no storage, and will be dependant on supply from the lower zones.

In order to allow significant growth within the study area, it will be necessary to develop water sources and storage capacity. We recommend the City proceed with the construction of the North Deadwood Avenue Reservoir at an elevation of 3855. To supply the reservoir, we recommend that the City construct one new Madison Well within the North Deadwood Avenue area. We recommend that this well and reservoir be cross connected as described in this report to the North Rapid System. As the area North of Deadwood Avenue develops west of the Hogback Ridge, the additional reservoir and supply capacity can be used to supplement the North Rapid High Level System, as well as providing fire protection to the upper streets in the Rainbow Ridge development. Ultimately, a second well will be required to serve the North Deadwood Avenue Area, as well as an additional reservoir and well capacity to serve the North Rapid Area.

We recommend that the booster stations, be designed to enable them to be converted to provide backup source to the recommended North Deadwood Avenue Reservoir and Wells.

RECOMMENDED IMPROVEMENTS

1. Construct 14-inch main in Bunker Road between Mall Drive and Gladys Street.
2. Improve North Rapid Booster to allow parallel pump operation with adequate backup.
3. Construct 14-inch watermain in Mall Drive between Lowe's and North Maple intersection.
4. Construct 14-inch watermain in Mall Drive between North Maple and Lacrosse Street.
5. Construct 14-inch watermain in Disk Drive between Lacrosse Street and North Maple Avenue.
6. Construct 14-inch watermain on west side of Deadwood Avenue between Samco Road intersection and North Plaza Drive intersection.
7. Replace existing 8-inch watermain in Pool Drive with 12-inch.
8. Construct North Deadwood Avenue Reservoir at elevation 3855 feet and construct new Madison Formation well in vicinity to supply.
9. Construct connection between new North Deadwood Avenue Reservoir and North Rapid High Level System.
10. Replace existing 16-inch transite (asbestos cement) watermain in Mall Drive west of Haines Avenue with new 20-inch watermain.
11. Replace existing 16-inch transite watermain in Bunker Drive north of Mall Drive with new 24-inch watermain.
12. Replace existing 16-inch transite watermain between Bunker Drive and North Rapid Reservoir with new 24-inch watermain.
13. Construct 12-inch PVC watermain in Haines Avenue north of Auburn Drive.

14. The City should work to identify additional source locations within the area north of I-90 and schedule the development of new water sources to coincide with future development.

15. The balance of the facilities identified in this study were sized to provide adequate Peak 2-hr demand at full buildout. These facilities should be constructed as shown coincident with development activities in the area.