Gillette Regional Water Supply Project

We Are All In This TOGETHER

Pre Design Report on the

Gillette Madison Pipeline Project

FINAL SUBMITTAL

for the

City of Gillette, Wyoming

Wyoming Water Development Commission

November 22, 2010

BMcD Project No. 54432

MMI Project No. 4776.001

Burns & McDonnell
SINCE 1898

MORRISON MAIERLE, INC.
An Employee-Owned Company

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prepared by

Burns & McDonnell Engineering Company, Inc.

Centennial, Colorado

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Gillette Wyoming

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1.0 OVERVIEW OF PROJECT

The City of Gillette (COG), Wyoming is experiencing aggressive population growth due to the energy development in Wyoming, especially in Campbell County. This growth is expected to continue in the future and has resulted in increased water demands. Currently during peak periods of usage, these increased demands are taxing Gillette's existing water supplies. This problem is expected to worsen with the future growth.

On January 17, 2007, the COG authorized Morrison-Maierle, and Burns and McDonnell Engineering Company Inc. to proceed with the preparation of the Long Term Water Supply, Level II Study. This study generally consisted of identifying and analyzing new water sources for the COG to supplement their existing water supply in order to meet future demands.

Based on the evaluation of all factors, it was concluded in the Level II study that use of the Madison formation as the source for additional water is the preferred alternative to meet the COG's long term water supply needs. Use of this source would require design and construction of the necessary wells, piping, treatment and pumping facilities.

On July 30, 2009 the COG authorized Burns & McDonnell and Morrison-Maierle to provide the design for the Gillette Regional Water Supply Project currently referred to as the Gillette Madison Pipeline Project (GMPP). The original agreement with the City of Gillette anticipated that the following facilities would be designed:

- Wells at the Madison Formation
- Well Field Piping
- Water Transmission Pipelines
- Pump Station(s)
- Storage Reservoir

- In-Town Piping

Prior to beginning the design for the GMPP facilities development of a pre-design report was required. The general purpose of the pre-design report is to better define the facilities that will be required to utilize the Madison formation water source, set the parameters to be used as the basis of the designs for these facilities, and to identify any further facilities that will be required.

2.0 SCOPE OF THE PRE DESIGN REPORT

Part 1 – Basic Services of the Contract includes paragraph A.1.02 Preliminary Design Phase. This paragraph makes reference to Appendix 1 to EXHIBIT A. Appendix 1 outlines the Scope of Services for both the Preliminary and Design Phases of the project. Following is the excerpt from the Scope for the Preliminary Phase as outlined in Appendix 1.

C. Preliminary Phase

1. Under the Preliminary Phase, the Engineer agrees to provide the following: (1) A report on the Madison Formation, (2) A Water System Plan for the regional water system, (3) A Pre-design Report for the facilities needed to import water from a well field tapping the Madison Formation, (4) A Project Management Manual, and (5) Field Surveys, Photogrammetric Surveys, and Legal Descriptions. Specifically, the Engineer shall perform the following services:
    a. Report on Madison Formation Wells.
        1) Review the Madison formation well recommendations in the Morrison-Maierle's 2007 Long Term Water Supply, Level II Report and existing Madison formation wells including: drilling, test data, and water quality. Provide a Technical Memorandum with recommendations for the test well(s) size, location, and discuss design considerations of the project test well (strata wells).
        2) Sample and analyze water from existing wells tapping the Madison Formation, if needed, and from the wells drilled as part of this project. **(Later removed from the Scope by pending contract amendment)**
        3) Determine the number of wells that will be required in the new well field area.
        4) The Engineer shall recommend to Owner if the well(s) to be drilled under this phase of the project should be a test well, a production well or a series of stratigraphic holes. The recommendation will include cost comparisons for each alternative considered.
        5) The Engineer shall provide bidding/contract documents to drill and test the new well into the Madison Formation as approved by the OWNER. Work associated with the test well includes:
            a) Provide ten (10) sets of contract documents for 10%, 50%, 90% contract document reviews and final contract documents. The Engineer should include costs to attend all review meetings in Gillette.
            b) Provide necessary legal surveys and descriptions for land and easement necessary to permit and complete the well. The OWNER will be responsible for negotiating well easements with the landowners.
            c) Prepare permits and applications to the State Engineer's Office and the Wyoming Department of Environmental Quality. Engineer will include contract language making NPDES permitting the responsibility of the Contractor. Any actual permit fees will be the responsibility of the Owner.
            d) Conduct a pre-bid meeting, address bidders questions and comments, assist the Owner with the bid opening, and provide an award recommendation to the Owner.
            e) Provide construction management services normally associated with construction administration including; RPR services, issuing change orders, field orders, reviewing contractor pay request, etc.

f) This scope includes the design and construction phase engineering services for the permanent well house for one (1) test well and the design phase services for the permanent well houses for five (5) production wells.
g) This scope assumes well completion to similar depths as the adjoining existing Madison field. Any substantial increases in depth requiring more time on site by the Engineer is not included in this scope.
h) Conduct a pre-construction conference including the Contractor, City of Gillette, WWDC, and any other key stakeholder and record minutes of the conference.
i) Collect and send water samples to the laboratory. The price for one complete battery of analytical tests for each well as shown below is included in this scope. Any further water quality testing is not included in this scope.
j) The hydrogeologist will:
    i. Provide on-site support during drilling.
    ii. Review and process the drift and alignment survey of the hole.
    iii. Oversee and interpret down-hole geophysical logs of the hole. This shall include gamma logs, Gamma-gamma and Neutron Density logs, Resistivity logs, Spontaneous Potential and Differential temperature logs, and a Caliper log, as appropriate.
    iv. Select water bearing zones.
    v. Finalize the screen design and filter pack design.
    vi. Specify well development techniques.
    vii. Supervise pumping tests to include a stepped rate test, a 24 hour constant rate test, and develop a spinner log.
    viii. Sample the groundwater for analytical chemistry tests.
k) Prepare a draft report of the well construction, development testing, and disinfection for each well.
l) Finalize design of down-hole pumping equipment and electrical systems, if well is to be made into a production well.
m) Provide full-time RPR services and construction administration services for the installation of permanent pump equipment, electrical systems, and connection of wells to the existing collection system if well is to be made into a production well.
n) Provide a final report detailing well construction, development, and disinfection after receiving owner and/or regulatory comments on draft report.
o) Provide two hard copies (11”x17” Mylar) and one electronic copy of record drawings and Certificates of Survey of all well construction.
p) Finalize WDEQ and SEO permits (including final reports) for each well.

6) Coordinate and manage work done by Engineer’s subcontractors.

7) Prepare report summarizing work done in the well field, giving cost estimates for future wells, evaluating the aquifer; determine well spacing, and discussing anticipated well-field behavior. Ten (10) copies of this report shall be furnished to the OWNER.

b. Water System Plan.
   1) Review reports (2007 Long Term Water Supply, Level II Report, and 2009 Gillette Regional Master Plan Level I Report), correspondence, test data, maps, drawings, records, operational data, and planning documents pertinent to the Owner's water system.
   2) Meet with the Owner's staff to discuss condition and operation of the Owner's water system.
   3) The Owner, in consultation with Campbell County and the WWDC, will determine the future service area boundaries for the project. Land use issues will be developed in close cooperation with the Owner's staff.
   4) The existing and future water requirements within the corporate limits of the Owner, the comprehensive planning boundary, and service area boundary in c. above based on production records, land use, and water duties, including average day, maximum day, peak hour, and fire flow demands shall be provided to the Engineer by the Owner without independent verification by the Engineer.
   5) Determine storage requirement for the Gillette Madison Pipeline Project.
   6) Conduct computer analyses of the Owner's existing major water system facilities and the proposed water system within the Owner's future service area for peak hour and maximum day plus fire flow conditions, surge analysis and mass-balance type water quality analysis showing the effects of blending strategies. The Engineer will only conduct computer analyses necessary to verify one (1) recommended in-town piping size and one (1) alignment provided by the Owner via the 2009 Gillette Regional Master Plan Level I Report. The computer analyses will not include modeling of alternative piping configurations and alignments for the north/south transmission piping. If the verification indicates that the Owner's recommended in-town piping size and alignment do not meet the water transmission requirements, additional computer analyses shall be considered additional professional services.
   7) Evaluate second Madison Booster Pump Station versus additional Madison Formation well hydraulic capacity and provide recommendation

c. Pre-design Report for Importation of Madison Well Water, including appurtenant water system facilities.
   1) Review reports (2007 Long Term Water Supply, Level II Report, 2009 Gillette Regional Water Supply Level I Report), other reports of water systems within the regional system, correspondence, test data, maps, drawings, records, and planning documents pertaining to the Gillette Madison Pipeline Project.
   2) Determine final pipeline alignment and diameters and prepare preliminary plans and specification outline for the pipeline between the Madison Formation well field and the terminal reservoir in Gillette. In

determining pipeline alignment and diameters, consideration shall be given to supply water to areas identified in the 2009 Gillette Regional Master Plan Level I Report.

3) In close coordination with the Owner's staff, select the recommended plan for the Gillette Madison Pipeline Project including pipeline alignments and sizes, locations and types of wells, connecting pipelines to the wells and regional water system, water booster pump station, and storage facilities.
4) Evaluate different pipeline materials and provide recommendations. Minimally, the analysis should include consideration of surge effects, construction techniques, contractor experience, cathodic protection requirements, recommended fitting types, and estimated installed cost per foot.
5) Prepare a detailed draft construct schedule including any proposals to phase project construction. Obtain input from the Owner and WWDC before including the schedule in the Pre-Design Report.
6) Prepare a draft Pre-design Report containing basic criteria, preliminary sketches, maps, and preliminary estimates of capital cost and operations and maintenance cost for the regional water system. Ten (10) copies of the draft Pre-design Report shall be furnished to the Owner.
7) Meet with Owner, regional water users, and WWDC to review draft Pre-Design Report comments.
8) Incorporate final comments in the final Pre-Design Report. Prepare and deliver ten (10) copies of the final Pre-Design Report to the Owner.
9) Obtain all necessary permits and variances including, but not limited to, Wyoming Department of Environmental Quality, Wyoming Department of Transportation, Crook County, and Campbell County. Provide an outline of the requirements to secure those permits and licenses.
10) Conduct necessary environmental, cultural resources, wetland, and threatened and endangered species assessments of the project and prepare report(s) of findings, conclusions, and recommendations. This task includes required surveying and mapping necessary for reports.
11) The Engineer shall participate in three public outreach meetings during the pre-design phase.

d. Project Management Manual.
   1) Prepare Project Management Manual consisting of procurement and contracting strategy, project budget (including operations and maintenance costs), cash flow requirements, project schedule, project organization chart, and division of responsibilities. Ten (10) copies of the Project Management Manual shall be furnished to the Owner.

e. Field Surveys, Photogrammetric Surveys, Mapping, Legal Descriptions, and Permitting.
   1) Establish horizontal and vertical ground control and make photogrammetric surveys of the pipeline alignment and of the locations of the other facilities after their locations have been approved by the OWNER. The photogrammetric survey shall be done with one foot (1') contour interval.

2) Locate by field survey methods property lines where they cross the pipeline right-of-way, if said pipeline right-of-way is outside existing rights-of-ways, and locate property lines at sites of other facilities.
3) Develop a methodology acceptable to affected entities for legal descriptions, surveys, and other information required for easements or parcels to be occupied for the entire project. Engineer to provide description of methodology in a letter report.
4) Following Owner approval of survey methodology, conduct necessary surveys to design the collection and transmission pipeline, pumping stations, storage tanks, necessary for the project including preparation of all necessary easement descriptions and exhibits.
5) Coordinate the use of Wyoming Department of Transportation and Crook County right-of-ways as necessary for the pipeline alignment.
6) Prepare ownership information, legal descriptions and maps for procurement of right-of-way and property to be obtained. This task is based on 180 parcels of land. Of these 180 parcels of land, 45 parcels were assumed to be "Easy" and 135 parcels were assumed to be "Moderate." The following definitions of Easy, Moderate, and Hard parcels to develop easements for were used to scope the project:
    a) Easy: Well defined legal descriptions with good ties.
    b) Moderate: Legal descriptions with minor ambiguities.
    c) Hard: Legal descriptions with ambiguities and/or bad or no ties to existing public land system.
    d) This scope assumes no "Hard" parcels. Parcels that qualify as "Hard" based on the level of effort described above are outside the scope of this work and subject to additional compensation as outlined in Appendix A, Section A.2.01.
7) Prepare maps showing surface topography and utilities along the selected pipeline alignment and at the well field, reservoir sites, and water booster pump station site.
8) Investigate location of existing utilities, surface and subsurface structures, and proposed future improvements of other agencies along and adjacent to the transmission pipeline and other facilities.
9) Determine actual depths of interfering utilities by field verification.
10) Deliver to the Owner following completion of construction, all aerial photographic models make for this project.
11) Prepare the application and any required supporting information for the required permits and licenses necessary to complete the project.
12) Coordinate and manage work done by ENGINEER subcontractors.

Upon entering the preliminary phase it was determined that much of the preliminary scope of work could most efficiently be completed through development of a series of Technical Memorandums (TM) covering specific topics. This would provide a format for each topic to be covered independently and in sufficient detail, as various pieces of necessary information were obtained and developed. It would also allow for efficient review and comment by all parties. The COG and Wyoming Water Development Commission (WWDC) agreed with this methodology. Once the TM's were finalized, they were reviewed by the COG and WWDC and a special Technical Memorandum meeting was held to discuss the review comments. The TM's were then finalized and used to develop the Preliminary Design Report.

The following table list the titles of the technical memorandums and identifies which portion of the scope of services, listed above, are covered in each. The scope items which are not covered by a specific TM are being completed under separate submittal shown on the following page.

TM #	Technical Memorandum Title	Scope Item(s) Covered
✓ = Scope Items completed as included in the TM		
TM-1	GMPP In-Town Piping Route	✓ C.1.c.2), C.1.c.3)
TM-2	GMPP Test Wells for Madison Well Field Expansion	✓ C.1.a.1), C.1.a.3), C.1.a.4), C.1.c.3)
TM-3	Population Projections, Demands and Source of Supply Requirements	✓ C.1.b.1), C.1.b.4), C.1.c.1)
TM-4	GMPP New Well Field Pumping Alternatives	✓ C.1.b.7), C.1.c.3)
TM-5	Water Quality and Blending Strategies	✓ C.1.c.3)
TM-6	Determination of Storage Requirements	✓ C.1.b.5), C.1.c.3)
TM-7	Hydraulic analyses	✓ C.1.b.6)
TM-8	10% Transmission Pipeline Alignment and Hydraulic Analysis	✓ C.1.c.2), C.1.c.3)
TM-9	Plan for Regional Water Supply	✓ C.1.b.3), C.1.b.4), C.1.c.1), C.1.c.3)
TM-10	Pipeline Material Evaluation and Recommendations	✓ C.1.c.4)
TM-11	Draft Construction Schedule and Phasing	✓ C.1.c.5)
TM-12	Water System Condition/Operational Review	✓ C.1.b.2)
TM-13	Evaluation of Disinfection Alternatives	This is a change from scope based on the COG's preference for use of on-site sodium hypochlorite generation.

Preliminary Scope Items Under Separate Submittal	
Item and Submittal Schedule	**Scope Item(s) Covered**
Test Well Drilling Contract Documents/Bidding • Final Drawings and Specification delivery ➢ scheduled for September 10, 2010 • Pre-Bid meeting/Award Recommendation ➢ scheduled for September 2010 • Construction management services ➢ scheduled for Sept – Dec 2010 • Conduct Preconstruction conference ➢ scheduled for September 2010 • Hydrogeologist services ➢ scheduled for Sept – Dec 2010 • Draft and Final report on test well ➢ scheduled January 2011	✓ C.1.a.5) ✓ a), b), c), f) ✓ d) ✓ e), f), i) ✓ h) ✓ j), i-viii ✓ k), n)
Report summarizing • Well field work • Cost estimates for future wells • Aquifer evaluations • Well spacing • Anticipated well behavior	✓ C.1.a.7)
Prepare draft Pre-Design Report (This Report) ➢ This document	✓ C.1.c.6)
Draft pre-design report meeting with COG/WWDC ➢ August 2010	✓ C.1.c.7)
Finalize pre-design report ➢ September 2010	✓ C.1.c.8)
Necessary Permits and Variances • To be performed as 50% and 90% designs proceed and information is available that is necessary for submittals.	C.1.c.9)
Environmental Assessments • Currently underway and to be completed as 50% and 90% designs proceed and final alignments are set. ➢ schedule for June 2010 – Dec 2010.	C.1.c.10)
Public Outreach Meetings • August 23, 2010	✓ C.1.c.11)

Preliminary Scope Items Under Separate Submittal (cont.)	
Item and Submittal Schedule	**Scope Item(s) Covered**
Project Management Manual • Version 2 of this document was prepared and presented to the COG and WWDC on 12/16/10. Currently the document covers project organization, division of responsibilities and various protocols for the project. As the project proceeds and necessary information is available the Manual will be updated to cover, procurement and contracting strategies, project budgets, and cash flow requirements.	✓ C.1.d.
Field surveys, photogrammetric surveys, mapping, legal descriptions, and permitting • Field surveys, photogrammetric surveys and mapping have now been complete. • Legal description and permitting are ongoing.	✓ C.1.e.

* * * * *

3.0 TECHNICAL MEMORANDUMS

Drafts of the Technical Memorandums listed in Section 2.0 were prepared and submitted to the COG and WWDC on April 30, 2010. On May 11, 2010 a special meeting was held at the City of Gillette (COG) offices to review questions and comments from the COG and WWDC staffs. The Technical Memorandums were then finalized to create this Pre-Design report. Copies of the final Technical Memorandums are included in Appendix A. This section provides a brief description of the purpose of each of the Technical Memorandums and the conclusions and recommendations derived from each.

3.1 TM 1 - GMPP IN-TOWN PIPING ROUTE

DESCRIPTION

This Technical Memorandum evaluates options for the design of the in-town piping routes. The new water supply from the Madison formation will be delivered into the Zone I – Reservoir IV (Z1- R4) Tank off of Southern Drive. The main goal of the in-town piping is to hydraulically tie tank Z1-R4 to the Zone I – Reservoir III (Z1-R3) tank which is just off of Westover Road and commonly referred to as the Dump Hill tank. The TM evaluates six alternative routes between the two tanks discussing the pros and cons of each. The main factors considered in the analysis include:

- **Hydraulics** –the memorandum considers potential hydraulic interferences that would be created by each routes resulting pipe elevation based on its relation to the operating levels in the Z1-R4 and Z1-R3 tanks.

- **Zone 1 – Reservoir 5 (Z1-R5) and service to West Gillette** – the potential of each route to connect to the Z1-R5 Tank and provide future service to the West Gillette development areas.

- **WYDOT Facility Avoidance** – the COG would like to avoid recently constructed WYDOT roadways such as Burma Road as well as planned WYDOT construction in Highway 50, between Westover Road and Lakeway Road.

  The descriptions and the length of associated pipe for the six alternative routes evaluated in the Technical Memorandum are indicated in the table on the following page.

RECOMMENDATIONS & CONCLUSIONS

During development of this Technical Memorandum there was much discussion on the ongoing WYDOT Highway 50 roadway project that will soon be constructed between Westover Road and Lakeway Road. A specific concern was the timing of the transmission line construction through this area should a route with this alignment be selected. It was concluded by WYDOT and the COG that a design for the transmission line section along Highway 50 between Westover Road and Lakeway Road would be prepared by WYDOT's engineering consultant. This would allow for construction of this section of transmission line to be installed with the highway improvements thereby eliminating future disruptions to the new Highway 50 construction.

Based on the evaluations of the pros and cons of each of the alternative in-town waterline routes, Technical Memorandum 1 provides the following conclusions and recommendations:

- The viable alternate alignments are #1, #3 and #5
- The recommended alternate route to be designed is Route 3 based on the following:
  - ✓ Route 3 does not have any major obstructions or grade conflicts.
  - ✓ Route 3 will be almost completely looped to reservoir Z1-R5
  - ✓ Based on the fact that WYDOT will now be constructing the section of the transmission line between Westover Road and Lakeway Road, additional easements will no longer be required through this area to avoid the highway construction.

Route	Alignment Description	Pros	Cons	Length (feet)
1	West along Southern Drive from reservoir Z1-R4 to Highway 50, then north along Highway 50 to Lakeway, then east on Lakeway to the new Lakeway/Burma Road intersection, then north along the new Burma Road to the Burma/Westover intersection and then east into the exiting Z1-R3 reservoir.	• Relatively unobstructed • Good looping to Z1-R5 with short spur required • Avoids Hwy 50 construction	• Disruption to Burma Rd • 800 ft section with potential hydraulic interference requiring deep construction.	40,075
2	West along Southern Drive from reservoir Z1-R4 to Highway 50, then north along Highway 50 to the future Box Elder extension, then east along the future Box Elder extension to the new Box Elder/Burma Road intersection, then north along the new Burma Road to the Burma/Westover intersection and then east in the existing Z1-R3 reservoir.	• Good looping to Z1-R5 with short spur required	• Encroachment with Hwy 50 • Encroachment along Burma Rd • 1,400 ft section with potential hydraulic interference requiring deep construction.	39,365
3	West along Southern Drive from reservoir Z1-R4 to Highway 50, then north along Highway 50 all the way to Westover, then east along Westover to the existing Z1-R3 reservoir. This alignment between Lakeway and Westover would be routed outside of the WYDOT Highway 50 project.	• No obstructions or grade conflicts • Nearly full looping to Z1-R5 • Avoids Hwy 50 construction if routed in private property	• Additional easement requirement for routing outside Hwy 50. • 700 ft section with potential hydraulic interference requiring deep construction.	40,870

Route	Alignment Description	Pros	Cons	Length (feet)
4	West along Southern Drive from reservoir Z1-R4 to tract of land extended south from Oakcrest Drive, then north to Oakcrest Drive and the Burma extension, continuing north to Westover, then east to the Z1-R3 reservoir.	• Second shortest overall pipe length • Avoids Hwy 50 construction	• Encroachment along Burma Rd • South extension of Oakcrest cuts through developed lots. • Requires a very long spur line to achieve looping to Z1-R5 • 800 ft section with potential hydraulic interference requiring deep construction	35,660
5	West along Southern Drive from reservoir Z1-R4 to Hwy 50, then north along Hwy 50 to West 4-J Road, then northeast along West 4-J Road to the intersection of Oakcrest/West 4-J Road, then north along Oakcrest and the Burma extension to Westover, and then east along Westover Road into reservoir Z1-R3	• Shorter pipe length than routes 1, 2, and 3 • Nearly full looping to Z1-R5 • Avoids Hwy 50 construction	• Encroachment along Burma Rd • 900 ft section with potential hydraulic interference requiring deep construction.	38,980
6	West along Southern Drive from reservoir Z1-R4 to the intersection with ENZI Drive, then north along Enzi Drive to the intersection of Enzi Road/Westover, and then northwest along Westover to reservoir Z1-R3	• Shortest overall pipe length • Avoids Hwy 50 construction • No hydraulic interferences	• Enzi Drive / 4-J Road corridor is well established increasing conflict issues • Requires a very long spur line to Z1-R5	31,600

3.2 TM 2 – GMPP TEST WELLS FOR MADISON WELL FIELD EXPANSION

DESCRIPTION

This technical memorandum presents factors considered for selection of two locations for Madison aquifer test wells to be drilled. The firm capacity of the COG Madison well field is currently 6,565 gpm. The Fort Union peak firm capacity is 1,906 gpm making the total peak firm capacity 8,471 gpm. The required firm capacity from COG aquifer sources by year 2040 is projected to be 24,500 gpm, including an increase of 16,000 gpm from the new Madison aquifer well field. Assuming new wells can produce the design rate of 1,400 gpm, a total of 13 new wells are required to satisfy the required firm capacity, if the existing wells remain in production at their existing rates.

TM 2 discusses historic test results from the COG Madison well field and the benefits of potentially large yields from wells aligned in a regional fracture due to its linear flow aquifer response and associated high specific capacity. Accordingly, the TM recommends an exploration strategy for expanding the Madison well field based on an evaluation of fracture patterns in the area in an effort to simulate the historical existing Madison specific capacities. In doing so, four sites were identified that exhibited these favorable fracture patterns. The four sites were ranked based on the most favorable geologic conditions for high-capacity wells based on potential geologic fracture features. The four sites in order of best ranking are as follow (please see the TM in the Appendix :

- Oil Butte Anticline - An area on State land in Section 36 on the south end of the Oil Butte.
- Pine Ridge Anticline - An area along the crest and western flank of the Pine Ridge anticline.
- Eastern Exploration Area - An area contiguous to and east and south of the existing Madison well field.

- Structural Saddle - An area in the saddle between the Oil Butte and Pine Ridge anticlines (considered a wild cat effort)

Under scope item C.1.a.4) the COG has requested that a recommendation be made as to whether the well(s) to be drilled under this phase of the project should be a test well, a production well or a series of stratigraphic holes. The TM explains that the design of the exploration well depends on its purpose, which generally falls into one or more of the following categories:

- To obtain samples of a formation for well screen design or strata sequence.
- To verify the presence and depth of water bearing strata before a more expensive well is drilled.
- To obtain a sample of the groundwater to determine chemistry and quality or to measure the static water elevation.
- To determine the local yield of an aquifer and the factors that affecting that yield. These might be considered test wells rather that exploration wells.

The wells for the expansion of the COG Madison well field essentially fall into the last category, however, the fact that part of their purpose is to attempt to locate zones of enhanced aquifer yield for high-capacity wells within broader areas of average aquifer properties would also make them considered exploration wells. The only purpose of drilling exploration wells before expanding the new Madison aquifer well field is to attempt to find the areas where the aquifer properties have been enhanced with the secondary openings in rock due to fractures and solution enlargement of such fractures. The yield and hydraulic performance of these zones must be evaluated if found and as a result the exploration well must become a test well with a large enough diameter casing to accept the pumping equipment that will provide the desired yields. To determine a reasonable yield for a high-capacity production wells in a linear flow aquifer system like those of this project, the test well in that aquifer needs to be pumped at a rate equal to or greater than the desired design flow. Although there are theoretically ways to project

estimates of this information with testing at lower aquifer/well yields there are many factors explained in the TM that complicate the process and why it is not recommended for this project. As such the wells to be drilled for testing will be designed as and eventually completed as full production wells. Finally the TM explores the necessary design parameters required of the exploration/production wells.

RECOMMENDATIONS & CONCLUSIONS

Based on the specific flow requirements of this project, evaluations of existing well information, evaluation of potential well field locations and the results desired from the test well, TM 2 provides the following conclusions and recommendations:

- Two exploration/production wells will be designed at the Oil Butte anticline location on State land Section 36. The goal will be to drill at major fracture alignments and /or fracture intersections.
- The exploration wells will be designed and drilled as full production wells.
- The exploration wells will be designed to produce 1,400 gpm each. This design production rate is based on the future demand projections required for the total well field production of 16,000 gpm. The plan would be to have a total of 13 wells to ultimately meet this firm capacity.
- The design parameters for the exploration/production wells shall be as follows:
  - pumping chamber with a depth of 1,800 feet.
  - 16-inch casing to 1,800 feet
  - 10 ¾ inch casing from 1,800 feet to the top of the Madison formation at an estimated depth of 2,500 feet.
  - 9 ¾ inch diameter hole thought the Madison below 2500 feet.

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3.3 TM 3 – POPULATION PROJECTIONS, DEMANDS AND SOURCE OF SUPPLY REQUIREMENTS

DESCRIPTION

Prior to designing the facilities required to utilize additional Madison aquifer water supplies, it is vital to ensure that the data and projections used to develop the parameters for the design of the facilities are understood and agreed to by the entire team. The COG has had a number of engineering studies performed over the years to analyze population trends and to make future population predictions from their data. Due to the population fluctuations of this energy-driven community, many of these previous studies are no longer indicative of the current population composition and trends in the Gillette area. The two most recent engineering studies, listed below with their intended scopes, address population and demand projections and are considered the most accurate and most valid due to their close tracking with actual population trends over recent years.

- Level II - 2007 City of Gillette Long Term Water Supply, Level II Study by Morrison Maierle, Inc. and Burns & McDonnell (Level II)
  Scope – evaluate long term water supply options for the COG.

- GRMP - 2009 Gillette Regional Master Plan Level I Study by HDR Engineering, Inc.
  Scope – evaluate the potential of a regional system which includes the needs of the COG using both population and land use trends.

One of the objectives Technical Memorandum 3 is to compare and contrast these two studies to determine what population and resulting flow projections will be used as the basis for this project. The population and flow demands developed based on these two previous population studies were extended to the year 2040.

RECOMMENDATIONS & CONCLUSIONS

Comparison and evaluation of these studies in Technical Memorandum 3 resulted in the following conclusions and recommendations:

- A required firm capacity of 16,000 gpm (23.10 MGD) will be used for planning and design purposes for the source of the GMPP.
- The following excerpt from TM 3 identifies the demands to be utilized for the design and planning of other non-water source elements of the project.

Table 3
Total Demand

	Demand (MGD)	Demand (gpm)
Minimum Day	5.35	3,717
Average Day	10.30	7,155
Peak Day	35.29	24,500

- The design of the pump station and pipeline facilities will need to be evaluated in conjunction with the existing facilities to determine design flow requirements. The flow requirements for these items will be discussed in more depth separately as the team works through the 10% and 50% designs for those elements.
- It is anticipated that the design flows for the pump station and pipeline facilities will be less than the 23.10 MGD (16,000 gpm) required of the new source since those facilities are not the limiting factor of the system on a firm capacity basis.

* * * * *

3.4 TM 4 – GMPP NEW WELL FIELD PUMPING ALTERNATIVES

DESCRIPTION

As described in Technical Memorandum 2, an important task for the GMPP project is the determination of the optimum location for the new well field in the Madison formation. The main factor in the selection of the well field is potential for production. This production based well field siting will impact the pumping requirements for the project. For instance, the existing Madison formation wells utilize low-head pumps that each pump to a common pump station at the Madison pump station and reservoir site. All of the production well water is then transferred to the Pine Ridge tanks from the Madison pump station. The flow is then gravity fed to the Donkey Creek pump station at an intermediate location along the existing transmission line which conveys the water into the City of Gillette. The City of Gillette Long Term Water Supply, Level II Study did not definitively identify the preferred strategy for delivering water from the new proposed Madison well field to the Pine Ridge Reservoir since the final location of the well field was yet to be determined at the time. Preliminary alternatives included using higher-head well pumps to pump directly from the wells to the Pine Ridge storage or using lower head well pumps coupled with an intermediate pump station similar to the existing system. At that time, it was anticipated that the new Madison well field would be in close proximity to the existing Madison well field. This arrangement would have produced a very similar pumping condition to the existing layout. One of the main considerations when comparing the two concepts is whether a second pump station utilizing vertical turbine or horizontal centrifugal pumps, with higher efficiencies than submersible well pumps, would result in power costs savings compared to the capital and incremental O&M costs of a second pump station.

The objective of Technical Memorandum 4 is to utilize the results of TM 2 regarding the preferred location for the test wells at the Madison formation and with that information to evaluate the Madison pumping requirements for the project.

RECOMMENDATIONS & CONCLUSIONS

Technical Memorandum 4 resulted in the following conclusions and recommendations:

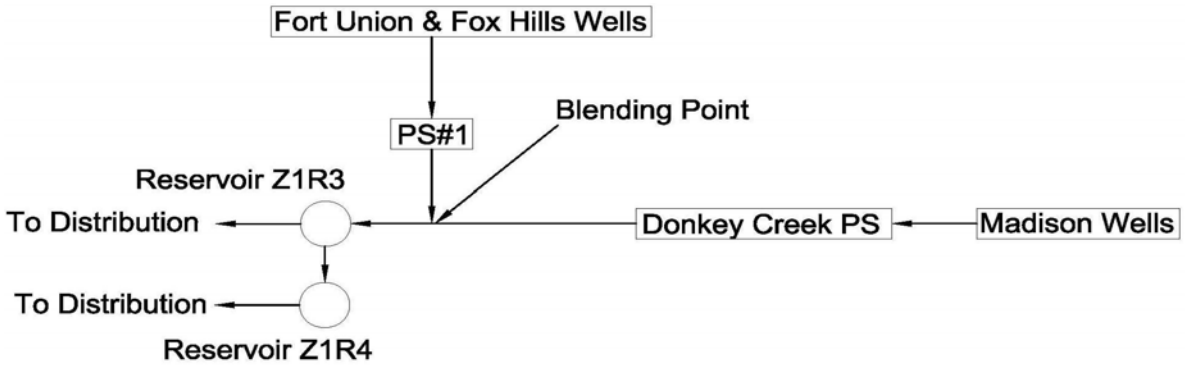
- The results of TM 2 determined that the test wells for the project will be drilled on State Section 36 property.
- Based on the topography and location of the Section 36 site compared to the Pine Ridge tank site, any configuration of the well field piping would generally run downhill.
- Based on this gravity flow scenario, there is no additional head that would warrant the need for a second pump station as the highest head location is at the land surface of the wells.
- There is no efficiency and consequent power cost savings that would justify a second intermediate pump station.
- If the test wells at Section 36 yield favorable results and a determination is made to use this site for the drilling of all the GMPP wells, it is recommended that the well pumps be sized appropriately to pump the water directly to the Pine Ridge tank and that a second intermediate pump station be excluded from consideration.
- If this location is not ultimately utilized due to low test well production, the consideration of a second pump station should be revisited based on the ultimate well field location.
- The original scope included an add alternate for design of an additional pump station if warranted. If well production at the Section 36 well site is as expected this add-alternate would not be exercised.
- The City of Gillette has since requested use of on-site hypochlorite generation for disinfection. Technical memorandum #13 details this disinfection discussion. Although a second pump station may not be needed, a facility of similar size and construction will need to be designed to house the hypochlorite generation equipment.

* * * * *

3.5 TM 5 – WATER QUALITY AND BLENDING STRATEGIES

DESCRIPTION

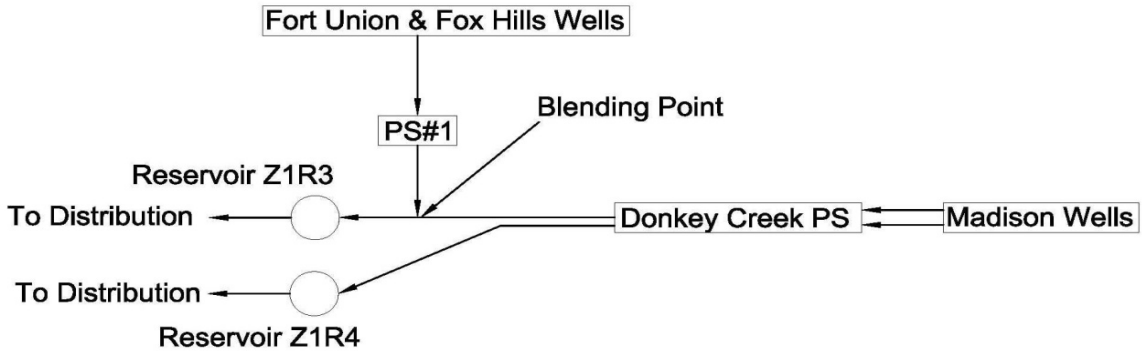
When any municipality is considering an additional water source for their system, it is important to evaluate the quality of the additional source itself as well as how it will be integrated into the overall distribution strategy. As discussed in previous Technical Memorandums, the additional source of water for the COG under the GMPP will be obtained from the Madison formation with incorporation of another Madison well field. Since the Madison formation source is already being utilized by the COG, there is not as much concern with the quality of the additional water source as there is concern about where it is delivered within the City's distribution system. Under the City's current operating strategy, the existing Madison well field water is blended with Fort Union & Fox Hills (when used) water from Pump Station #1 and this blended source is then delivered to Reservoir Z1-R3 (Dump Hills). The water is also transported to Reservoir Z1R4 which also feeds the distribution system.



Schematic of Existing System

Under the current scenario, the entire City receives the same blended source of water and therefore similar quality as shown above. The main concern that the COG staff has raised

regarding the additional source under the GMPP, is the potential to have different water qualities in various sections of their distribution system due to different blending scenarios. For instance, as shown below, the original concept that was being considered would route the Madison water from the new well field directly to Reservoir Z1-R4. As such this water would not be blended with any other sources resulting in varying water qualities for residents and businesses depending on whether they are served from Reservoir Z1-R3 or Z1-R4.



Schematic of Proposed System without Blending

The objectives of Technical Memorandum 5 are as follows:

- Present the existing groundwater sources and their production capacity.
- Evaluate historic water quality from each ground water source.
- Review water quality standards and COG water quality goals.
- Review projected system water demands from 2010 to 2040 to illustrate when increased reliance on the Madison source is necessary to supplement the fixed capacity of the existing COG wells.
- Evaluate potential future blending scenarios, the resulting water quality, and the affect (difference) on distribution system water quality.

Each of these objectives is summarized in the following tables:

Existing Groundwater Sources

Groundwater Source	Average Day		Peak Day	
	Capacity (gpm)	Capacity (MGD)	Capacity (gpm)	Capacity (MGD)
Fort Union[1,2]	930	1.34	1,906	2.74
Fox Hills/Lance[3]	0	0	0	0
Madison[4]	6,565	9.45	6,565	9.45
Total	**7,495**	**10.79**	**8,471**	**12.19**

Notes:
1. Fort Union average capacity is limited by annual State Engineers Office cap, not system capacity.
2. Fort Union peak capacity is limited by firm capacity of the well system.
3. The Fox Hills/Lance source will not be used as a primary groundwater source.
4. Madison capacity is limited by the firm capacity of the well field

Existing Groundwater Source Water Quality

Well Identification	Total Capacity (gpm)	Fluoride (mg/L)	TDS (mg/L)	Hardness (mg/L as $CaCO_3$)	Sulfate (mg/L)
Fort Union	2,306	2.03	471	24	0
Existing Fox Hill/Lance	1,650	7.64	1,192	0	24
New/Existing Madison	23,987	0.97	632	486	278

Notes:
1. Capacity for wells S-9, S-17, S-18, S-19, and S-27 are estimated future capacities after "re-drilling" activities. For the purposes of this analysis, the water quality of these wells is assumed to be the same.
2. Data Source: December 2004 City of Gillette Water Master Plan Report
3. Data Source: August 2007 City of Gillette Long Term Water Supply Level II Study

Water Quality Standards or Goals

Parameter	Primary Standard (mg/L)	Secondary Standard (mg/L)	Water Quality Goal (mg/L)
Fluoride	4.0	2.0	2.0
Hardness	--	--	500
TDS	--	500	500
Sulfate	--	250	250
Iron	--	0.3	0.3
Sodium	--	250	250

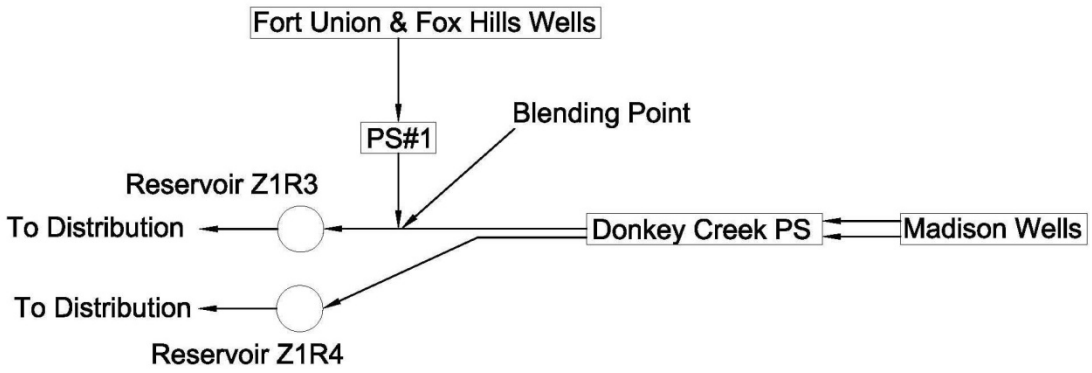
Projected Water Demands from 2010 to 2040

Year	Minimum Day Demand (gpm)	Average Day Demand (gpm)	Peak Day Demand (gpm)
2010[2]	2,200	4,500	14,000
2020[2]	2,700	5,400	17,500
2030[2]	3,200	6,400	21,000
2040[1]	3,717	7,155	24,500

Source:
1. Technical Memorandum #3
2. 2007 City of Gillette Long-Term Water Supply, Level II Study

Potential Future Blending Scenarios, Resulting Water Quality, and the Effect (difference) on Distribution System Water Quality

Blending Scenario 1: Reservoir Z1-R4 (Southern) would be supplied solely by Madison water and Reservoir Z1-R3 (Dump Hills) would be supplied by a blend of Madison water and Fort Union water. The existing blending point at US Highway 14/16 and S. Butler Spaeth Road would be maintained as it currently exists and the new Madison parallel transmission line would follow the proposed routing and discharge to Z1-R4.



Schematic of Blending Scenario 1

Blending Scenario 1 Resulting Water Qualities:

Reservoir Z1-R4

Year	Fluoride mg/L	Hardness mg/L as $CaCO_3$	TDS mg/L	Sulfate mg/L
All Demands				
2010	0.97	486	632	278
2020	0.97	486	632	278
2030	0.97	486	632	278
2040	0.97	486	632	278

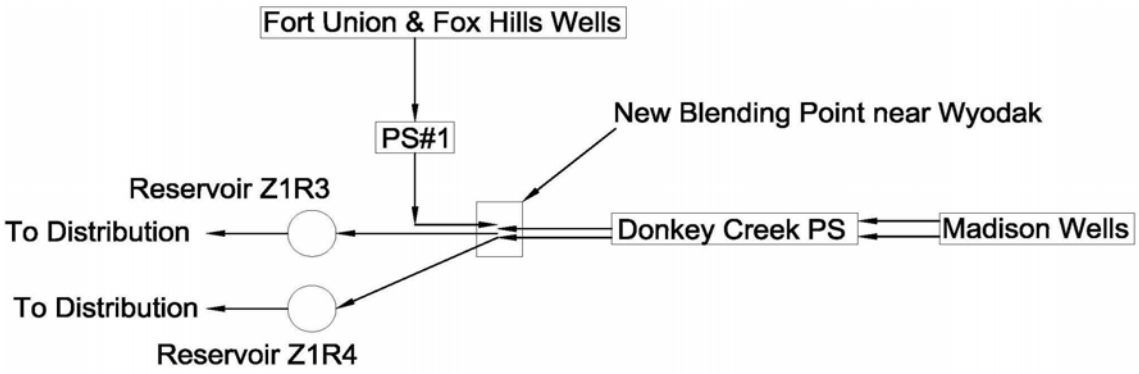
Reservoir Z1-R3

Year	Total Demand	Madison Supply	Fort Union Supply	30-inch Line Demand	42-inch Line Demand	Fluoride	Hardness	TDS	Sulfate
	gpm	gpm	gpm	gpm	gpm	mg/L	mg/L as $CaCO_3$	mg/L	mg/L
Minimum Demand									
2010	2,200	1,500	700	525	975	1.58	222	540	119
2020	2,700	2,000	700	700	1,300	1.50	255	551	139
2030	3,200	2,500	700	875	1,625	1.44	280	560	154
2040	3,717	3,017	700	1,056	1,961	1.39	302	568	167
Average Demand									
2010	4,500	3,570	930	1,250	2,321	1.42	289	563	159
2020	5,400	4,470	930	1,565	2,906	1.37	313	572	174
2030	6,400	5,470	930	1,915	3,556	1.32	335	579	187
2040	7,155	6,225	930	2,179	4,046	1.29	348	584	195
Peak Demand									
2010	14,000	12,094	1,906	4,233	7,861	1.30	342	582	191
2020	17,500	15,594	1,906	5,458	10,136	1.25	366	590	206
2030	21,000	19,094	1,906	6,683	12,411	1.21	383	596	216
2040	24,500	22,594	1,906	7,908	14,686	1.18	396	600	224

Blending Scenario 1 Affect (Difference) Water Qualities Reservoir Z1-R3 vs. Z1-R4:

Year	Fluoride mg/L	Hardness mg/L as $CaCO_3$	TDS mg/L	Sulfate mg/L
Minimum Demand				
2010	0.60	264	92	158
2020	0.53	231	80	139
2030	0.47	205	71	123
2040	0.42	184	64	111
Average Demand				
2010	0.45	197	68	118
2020	0.39	172	60	103
2030	0.34	151	52	91
2040	0.32	138	48	83
Maximum Demand				
2010	0.33	144	50	86
2020	0.27	120	42	72
2030	0.23	103	36	62
2040	0.20	90	31	54

Blending Scenario 2: Transmission modifications would be completed to facilitate the blending of in-town well water into the new parallel transmission line at a location near the WYODAK Power Plant. Reservoirs Z1-R3 and Z1-R4 would be supplied by a blend of Madison water and Fort Union water. The new blending point would be located where the water splits between Reservoir Z1-R3 and Z1-R4, near WYODAK and Highway 51. This blending alternative would require an additional 18" PVC pipeline for approximately five miles from the intersection of Butler Spaeth Road and US Highway 14/16 to WYODAK. There would also be capital and maintenance costs associated with the blending structure. This cost would be substantial requiring additional capital funds that are not currently within the identified capital plan.



Schematic of Blending Scenario 2

Blending Scenario 2 Resulting Water Qualities:

Reservoir Z1-R3 and Z1-R4

Year	Total Demand	Madison Supply	Fort Union Supply	Fluoride	Hardness	TDS	Sulfate
	gpm	gpm	gpm	mg/L	mg/L as $CaCO_3$	mg/L	mg/L
Minimum Demand							
2010	2,200	1,500	700	1.31	339	580	189
2020	2,700	2,000	700	1.25	366	590	206
2030	3,200	2,500	700	1.20	385	596	217
2040	3,717	3,017	700	1.17	399	601	225
Average Demand							
2010	4,500	3,570	930	1.19	389	598	220
2020	5,400	4,470	930	1.16	405	604	230
2030	6,400	5,470	930	1.13	418	608	237
2040	7,155	6,225	930	1.11	425	611	242
Peak Demand							
2010	14,000	12,094	1,906	1.12	421	610	240
2020	17,500	15,594	1,906	1.09	434	614	247
2030	21,000	19,094	1,906	1.07	443	617	252
2040	24,500	22,594	1,906	1.06	449	619	256

Blending Scenario 2 Affect (Difference) Water Qualities Reservoir Z1-R3 vs. Z1-R4: As reflected in the table above, under this scenario the water supplied to both Reservoir Z1-R3 and Z1-R4 would come from the same blending point and, therefore, there would not be a difference in the water quality.

RECOMMENDATIONS & CONCLUSIONS

The effect of the GMPP project on the current water quality is a very important factor to be considered for the designed improvements. Public perception can often play a vital role in these considerations. If the water quality changes significantly or there is a significant difference in the quality of water provided to residential and/or commercial users, this could lead to criticism. The evaluation of the blending strategies and their resulting impact on water quality is therefore necessary to determine the direction for the design of the GMPP improvements. Technical Memorandum 5 presented the following conclusions and recommendations:

- Regardless of the blending scenario selected, the primary and secondary water quality standards are being met except for sulfate which is over the secondary standard for both scenarios.
- In meetings with the City staff regarding this evaluation, it was determined that the hardness was the water quality attribute of most importance to the public. The table below summarizes how hardness will be affected by the different blending scenarios.
- It is important to note that as the water demand increases, the difference in water quality between reservoirs Z1R3 and Z1R4 will decrease due to a greater reliance on the Madison aquifer water supply.
- Initially the team felt that the differences in hardness between reservoir Z1R4 and Z1R3 under Scenario 1 would not be significant enough to warrant changing the existing blending point. The cost weighed against the benefit seemed high since a lot of capital

costs would be incurred to construct additional piping and a new blending facility to achieve the same hardness throughout the system.

Year	Scenario 1		Scenario 2	Difference between Scenario 1 & 2	
	Z1R4	Z1R3	Z1R4 & Z1R3	Z1R4	Z1R3
Minimum Demand					
2010	486	222	339	-147	117
2020	486	255	366	-120	111
2030	486	280	385	-101	104
2040	486	302	399	-87	97
Average Demand					
2010	486	289	389	-97	101
2020	486	313	405	-81	92
2030	486	335	418	-68	83
2040	486	348	425	-61	77
Maximum Demand					
2010	486	342	421	-65	79
2020	486	366	434	-52	68
2030	486	383	443	-43	59
2040	486	396	449	-37	53

- COG staff stressed during the May 11, 2010 meeting the importance for them to have the same water quality (especially hardness) delivered throughout their system even if additional cost were incurred to build the improvements necessary to achieve this goal. The philosophy is that since the GMPP is such a large, costly project, they do not want to be put in the position with the general public to have to explain why the improvements created a scenario with varying water qualities.
- Based on COG staff input, the design of the GMPP will pursue Blending Scenario 2 to provide consistent water quality. A significant amount of funding for design and construction of an additional 18" PVC pipeline for approximately five miles and the capital and maintenance cost of the blending structure will be required. As such,

Blending Scenario 2 will require additional capital funds that are not currently within the identified capital plan. The scope of this project will also require amendment for the design of these facilities.

- It should be noted that although the net effect of Blending Scenario 2 will provide consistent water qualities, based on the above table the net effect on the hardness for reservoir Z1-R3 will be increased. This effect will decrease over time with increased demand and more reliance on the Madison formation source.

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3.6 TM 6 – DETERMINATION OF STORAGE REQUIREMENTS

DESCRIPTION

Technical Memorandum 2 recommends the addition of thirteen (13) new Madison formation production wells to the COG system. The addition of these wells must take into consideration additional transmission main storage requirements. The ten (10) existing Madison wells currently feed to a 1.1 million gallon (MG) tank and a 0.2 MG tank which sit next to each other at the Madison Pump Station site. The water from the existing wells is chlorinated prior to entering these two storage tanks. The tanks then feed the Madison Pump Station which delivers the water to two storage reservoirs at the Pine Ridge site which have capacities of 0.8 MG and 0.2 MG. From the Pine Ridge storage reservoirs the water flows by gravity to the Donkey Creek Pump Station where it is once again "boosted" to the City of Gillette. The general setup is shown schematically in Figure 1.

The findings of TM 2 provide recommendations for the new Madison Well Field (NMWF) to be located on State Section 36, which is just northwest of the existing Pine Ridge tanks site. The purpose of this TM is to determine what additional storage will be required with consideration of this NMWF site and both the hydraulic and disinfection contact time requirements of the project. The storage volume requirement for the disinfection contact time will be calculated with the storage volume at the minimum water level in the reservoir. Figure 2 illustrates the storage requirements in one reservoir. As seen by the diagram, the portion of the storage reservoir above the minimum water level would satisfy the hydraulic storage requirement and the portion of the storage volume below the minimum water level would satisfy the disinfection contact time requirement.

Figure 1 Existing Madison and Pine Ridge Facilities

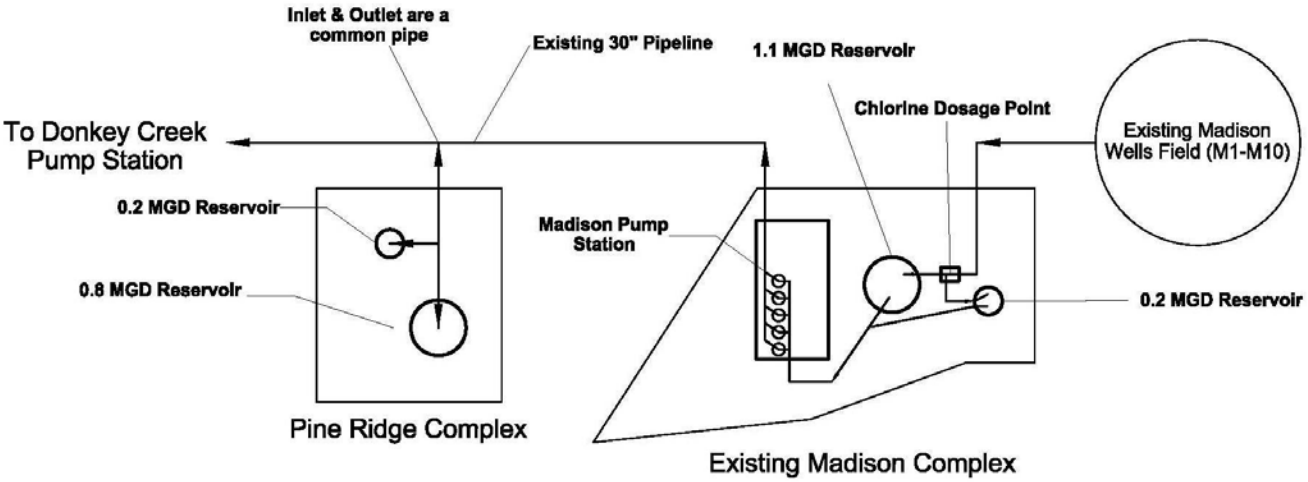
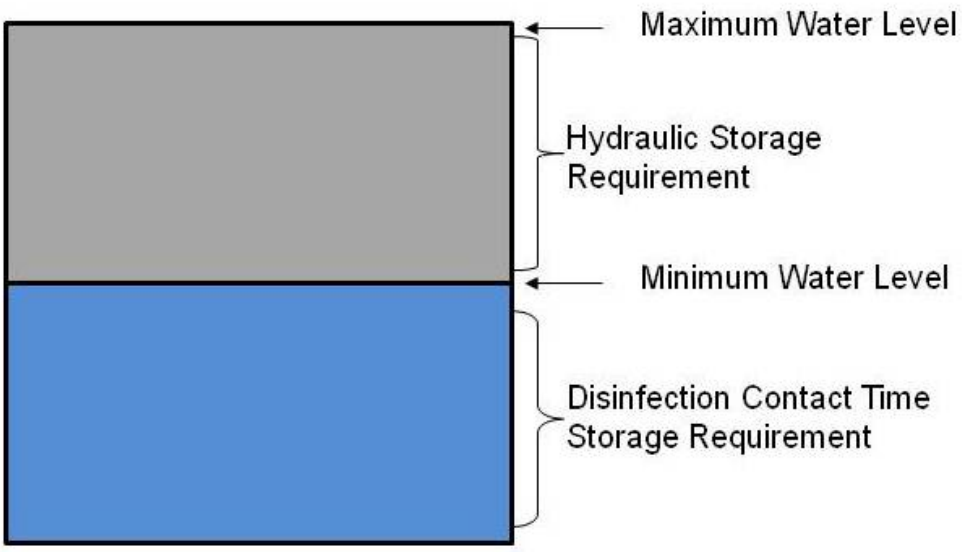


Figure 2 Diagram of Storage Requirements



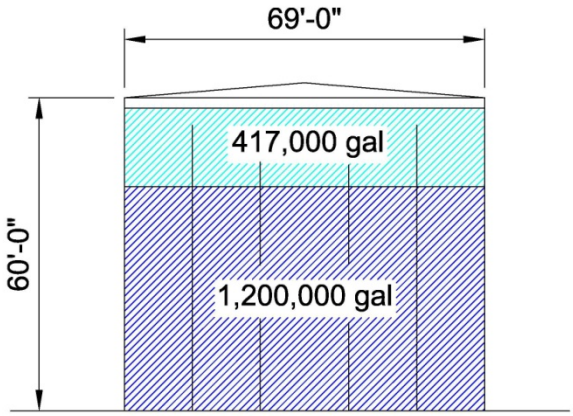
Technical Memorandum 13 provides an evaluation of the disinfection alternatives for the GMPP. The TM discusses that the new Madison Well Field will require either a dedicated disinfection

system or a larger overall disinfection system to provide a chlorine residual for the entire Madison supply. The conclusions of TM 13 recommend the design and construction of an on-site sodium hypochlorite facility at the Pine Ridge site to eventually disinfect all of the COG Madison formation wells. These conclusions were factored into the disinfection portion of the storage tank sizing considerations.

Evaluation of both the hydraulic and disinfection requirements for this project yielded the following table which shows the total capacity of the new Pine Ridge Reservoir if the disinfection contact time is achieved through a new reservoir. The reservoir was calculated with 30 minutes of disinfection contact time below the minimum water level for disinfection contact time requirements and 15 minutes of storage between the minimum and maximum water levels for hydraulic requirements.

Storage	Volume (gals)
Disinfection Contact Time	1,200,000
Hydraulic Storage	217,500
Total	**1,417,500**

The disinfection contact time volume is required below the minimum water level (elevation 4528.90) and the hydraulic storage volume is required between the minimum water level elevation (4528.90) and the high water elevation (4543.50). Due to the elevation requirement for each storage category to provide the necessary function, combining the two storage reservoirs as one makes the hydraulic storage portion of the volume considerably greater than required due to the footprint of the reservoir and the required geometry of the tank. The figure below represents the size of a storage tank that would need to be built with consideration for hydraulics, disinfection and geometry. The resulting capacity would be 1,617,000 gallons resulting in 199,500 gallons of unnecessary additional storage considering that only 1,417,500 gallons are required.



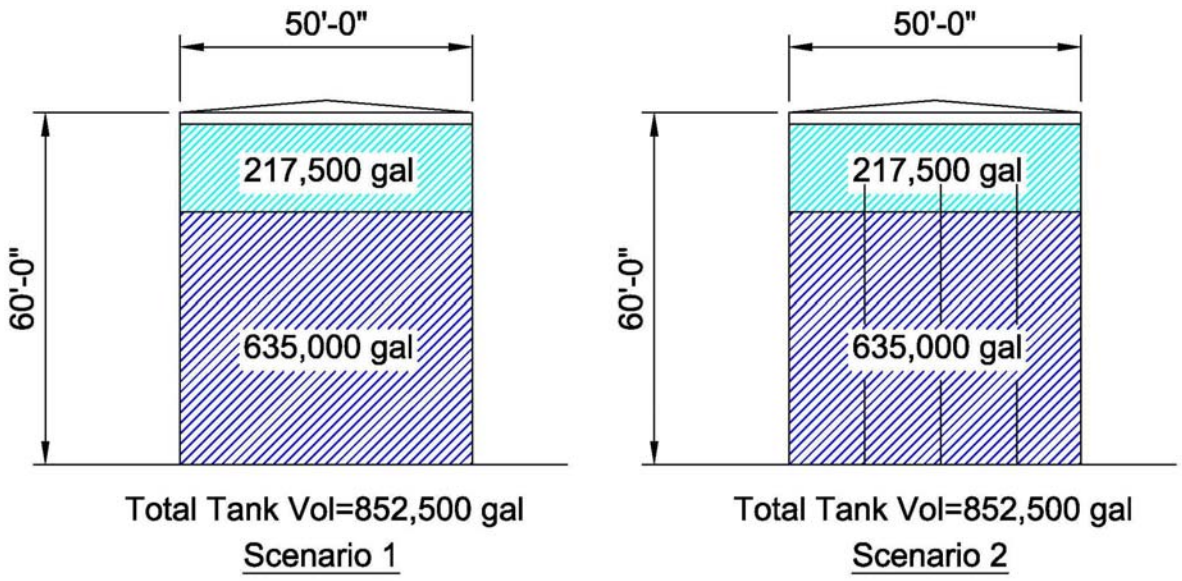
In an effort to reduce the size of the tank and eliminate the unnecessary storage, other potential scenarios were developed for consideration to achieve both the volume required for disinfection contact time and hydraulics as follows:

Scenario 1

A. Proposes installation of a new reservoir (~0.85 MG) at the Pine Ridge site for only hydraulic considerations.
B. Utilize the existing 30-inch and new 42-inch discharge lines from the existing and new tanks, for the first 7,600 feet, to allow 30 minutes of contact time in order to achieve the disinfection requirements to the first customers.
C. Connect a new 8-inch or 12-inch distribution main to the 42-inch and/or 30-inch transmission lines at the 7,600 foot location. Extend the distribution piping for approximately 11,550 feet to serve existing services including the service near the existing Madison site.

Scenario 2

A. Install baffling in both the 0.2 MG and 0.8 MG existing reservoirs at Pine Ridge.
B. Separate the inlet and outlet of the Pine Ridge reservoirs.
C. Install a new reservoir (~0.85 MG) at Pine Ridge that is well-baffled.

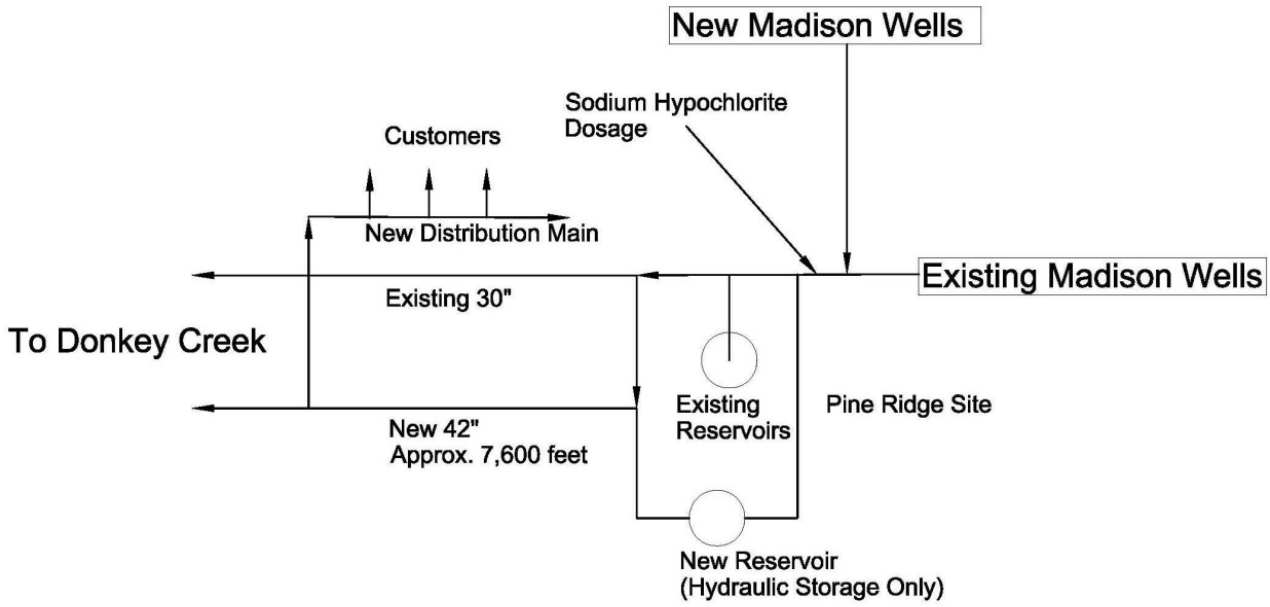


RECOMMENDATIONS & CONCLUSIONS

- Based on recommendations in TM 2 regarding the NMWF location, the additional storage facilities will be located near the Pine Ridge site.
- The improvements described in Scenario 1 will be designed to achieve the required disinfection contact time and hydraulic storage at the Pine Ridge site for the following reasons:
  - Capital Cost - Scenario 1 has no reservoir baffles, whereas Scenario 2 requires baffling in both the existing tanks and the new tank. The retrofitting of the existing tanks with baffling would be a significant challenge. The cost difference in reservoir baffling is considerably more than the cost of 11,550 feet of additional 8" to 12" distribution main for customers near Pine Ridge and Madison.
  - Operating and Maintenance Cost – The additional operation and maintenance costs associated with a baffled tank are considerable. Therefore, maintaining the Scenario 1 reservoir will be less than maintaining both the existing tanks with their new baffles along with the new baffled tank required under Scenario 2.
  - Cathodic Protection: The baffling requirements under Scenario 2 will require significantly more considerations for cathodic protection considering the additional

metallic surfaces. This additional baffling also needs to be monitored and maintained in the future.

- The schematic of the recommendations under Scenario 1 are shown below:



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3.7 TM 7 – HYDRAULIC MODELING

The GMPP requires the addition of many different components involving piping, pumping, and storage. The interaction and sizing of these components is vital to the overall function of the GMPP system. As such, a hydraulic evaluation is required to confirm these interactions and determine the design parameters for these components moving forward into their design. The purpose of Technical Memorandum 7 is to discuss the hydraulic modeling performed to make these sizing determinations with regards to both existing and proposed facilities. The TM provides an overview of how the GMPP model was developed and discussion of the analysis and results. Issues discussed include the model properties, the model alternatives, and the model analysis of those alternatives. The water model used for the GMPP modeling originated from the 2009 City of Gillette Water Model updated by Morrison Maierle, Inc. (MMI) in December 2009. The 2009 MMI model is the product of a number of evolutionary adjustments and updates to the model, which has been worked on by numerous consultants. Four alternatives were modeled to evaluate different blending scenarios between the traditionally "soft" water from Pump Station #1, and the "hard" water from the existing Madison line and the proposed GMPP transmission main. As presented earlier, Technical Memorandum 5 discusses the blending issues in great detail.

Modeling Property Derivations:

- Demands

  The following table shows the total average day demands (ADD) and peak day demands (PDD) considered in the modeling for the GMPP projection period.

COG DEMANDS

Year	ADD (gpm)	PDD (gpm)
2010	4,981	17,058
2020	5,749	19,688
2030	6,414	21,964
2040	7,155	24,504

Technical Memorandum 9, Plan for Regional Water Supply, presented later evaluates regionalization issues and potential users along the transmission line to be constructed as part of the GMPP. The following table identifies the possible interconnects to be considered and their anticipated demands over the GMPP projection period.

REGIONAL TRANSMISSION MAIN CONNECTIONS

Location	2010 ADD (gpm)	2020 ADD (gpm)	2030 ADD (gpm)	2040 ADD (gpm)
Crestview Line	50.96	56.85	63.42	70.74
Antelope Valley Line	151.99	169.55	189.15	211.01
Central Campbell Cty Line 1	33.31	37.16	41.46	46.25
Nickelson Farms Line	37.18	41.48	46.27	51.62
Meadow Springs Line	72.45	80.82	90.16	100.58
Ward Creek Line 1	60.63	67.64	75.45	84.18
Ward Creek Line 2	2.15	2.39	2.67	2.98

The following table identifies the future in-town demand growth breakdown, which were placed at three nodes in the model along the new in-town piping alignment.

Location	2010 ADD (gpm)	2020 ADD (gpm)	2030 ADD (gpm)	2040 ADD (gpm)
Future Growth West	72.42	187.92	287.97	399.41
Future Growth Southwest	144.84	375.86	575.94	798.80
Future Growth South	144.84	375.86	575.94	798.80

- Existing Model Changes – in order to simplify the model, all of the old scenarios and alternatives from prior years were cleared from the model and only the correct model framework and demands developed as part of this project combined with the calibration efforts performed in the 2009 modeling effort remained.

- Fire Flow Determinations – were set as follows:
  - Residential fire flows = 1,500 gpm
  - Commercial fire flows = 2,500 gpm
  - Industrial fire flows at 3,500 gpm
  - A fire flow scenario was set up during peak day demand for each of the four years modeled
  - Fire flows were modeled for legislated durations.

- Tank Connections – modeling setup for the following tanks is discussed:
  - Pine Ridge Tanks
  - Reservoir Z1-R3 (Dump Hill)
  - Reservoir Z1-R4 (Sunburst or Southern Tank)
  - Reservoir Z1-R5 (Hidden Valley)

- Alignment – alignments for new piping are based on 10% designs and alignment for the existing piping is based on GIS information.

- Pump Curves – new pump design is based on 6 pumps with a firm capacity of 15,300 gpm.

Modeling Alternatives:

- Alternative 1 – Existing Layout (City Existing GIS with 10% Design Proposed)
- Alternative 2 – Reverse Flow Through Existing 30” Madison Line (to satisfy 2040 PDD)
- Alternative 3 – Reverse Flow Through Existing 30” Madison Line (to satisfy 2020 PDD)

- Alternative 4 – New 18" Line to WYODAK (as part of Alternative 1) for blending purposes to achieve consistent water quality. See TM5.

RECOMMENDATIONS & CONCLUSIONS

- Pipe configurations for both Alternatives 1 and 4 would satisfy demands through the 2040 peak day.
- Pipe configurations under alternatives 2 and 3 require upsizing of the in-town beyond the WYDOT-imposed size restriction of 36-inch and as such are not considered feasible.
- Alternative 1 provides the most cost effective means of delivering water quantity to the service area, but it does not deliver consistent water quality across the system.
- Alternative 4 provides consistent blended water quality across the system, but requires an additional 26,250 linear feet of 18" pipe at cost that could run $5.25 to $7.1 Million.
- In all prior meetings the COG has stressed the desire to have consistent water quality throughout their system. They do not want to expend the capital on all of the improvements being constructed under the GMPP only to end up with the potential for complaints associated with inconsistent water in various parts of Town.
- Alternative 4 is therefore the recommended piping configuration based on the following:
  - The hydraulic needs of the system up to and including the 2040 peak day are met.
  - Consistent water quality across the system can be achieved.
  - The 36-inch pipeline restriction set by WYDOT is met.

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3.8 TM 8 – 10% TRANMISSION PIPELINE ALIGNMENT AND HYDRAULIC ANALYSIS

DESCRIPTION

The proposed Madison well field site is remote from the City of Gillette distribution system and will require almost 44 miles of transmission piping to bring the water from this source to the COG. The existing Madison pipeline currently delivers flows to the distribution system via a 30-inches diameter transmission line from the existing Madison well field. As such, corridors utilized for the existing 30-inch transmission line should be the first considered for the new waterline. The purpose of TM 8 is to provide a preliminary overview of the alignment to be considered for the 10% design submittal, discuss potential diameters requirements for the line with consideration of a 21 MGD flow capacity and to provide preliminary information for easements that might be required for the construction of the preferred alignment.

The general alignment for the proposed transmission pipeline is shown in Exhibit A of TM 8 which can be found in the appendix. The COG has directed the consultant team to pursue the alternative alignment shown on Drawing A1 and A2 for the sections of the transmission line between Southern Drive and Highway 59. The overall alignment from the COG distribution system to the Madison well field site can generally be described as follows:

- Begins at the Z1-R4 tank located on Southern Drive
- East along Southern Drive to Swanson Road
- South along Swanson Road to the Elsner property
- East through the Elsner property to Schoonover Drive
- East on Schoonover Drive to Patty Avenue
- North on Patty Avenue to the NBI Development property
- East through the NBI Development and Department of Interior property to Highway 59
- South along Highway 59 to Union Chapel Road
- East along Union Chapel Road to the Pickrel Land & Cattle Co, Inc property

- North and north east through the Pickerel Land & Cattle Co, Inc. property and the WYODAK Resources Development Corp. property to Highway 51 near the WYODAK Mine
- East along Highway 51 to the Donkey Creek Pump Station
- East from the Donkey Creek Pump Station along Highway 51 through the Town of Rozet
- East along Highway 51 to County Road D
- North along County Road D to the Robinson Family Limited Partnership (RFLP) property
- Northeast through the RFLP property, Bureau of Reclamation property, and Schuricht Land and Real Estate Limited Partnership property to US Highway 14
- North and east along US Highway 14 to the Pine Ridge tank site

The majority of the alignment will be within or adjacent to Wyoming Department of Transportation (WYDOT) right-of-way including the following areas:

ALIGNMENT SECTIONS WITHIN WYDOT ROW
State Highway 59 from Southern Drive to Union Chapel Road
State Highway 51 from WYODAK to D Road
US Highway 14 from the Schuricht property to the Pine Ridge tank site

WYDOT has indicated that they will allow the waterline to be placed within their right-of-way with the proper license agreements and review of the design drawings. The City of Gillette may also need to obtain “blanket easements” or “utility easements” from the adjacent landowners should WYDOT only hold easements for portions of the property over roadway areas.

The TM identifies criteria that were used to develop the layout for the new transmission line, which will be given consideration throughout the project. These include the following:

LAYOUT CRITERIA	
Utilize existing ROW and easements	**Avoid open cut construction in Campbell County**
Mirror existing Madison Transmission line when possible	**Optimize access to the transmission line with consideration for maintenance**
Minimize disturbance to affected areas	**Minimize railroad crossings and avoid longitudinal encroachments**
Avoid environmentally sensitive areas	**Limit to a 60 foot wide permanent and 40 foot wide temporary easement where possible**
Minimize road crossings	**Provide a 100 foot separation from high voltage power where possible**

The TM provides the following summary tables:

- **Table 1 – 10% Transmission Pipeline Alignment**. Provides a general narrative for each drawing including the pipeline area, existing Madison Transmission line location, new alignment considerations, and proposed alignment location.
- **Table 2 – 10% Transmission Pipeline Easements.** Provides preliminary information for each drawing regarding the property owners from whom permanent easements, blanket easements, license agreements, and crossing agreements may be required. This is based strictly on the best available assessor's information.

The TM also discusses the materials that might be allowed for the transmission piping understanding that Technical Memorandum 10 "Pipeline Material Evaluations and Recommendations" will be dedicated to this topic.

Finally, a hydraulic grade line exercise is presented to provide very preliminary estimates of possible pipeline diameters and pressure classes for a number of different pipeline material combinations. The results of the hydraulic modeling in TM 7 will be used to determine the size (diameter) as well as the thickness and pressure class requirements of the piping for the project.

RECOMMENDATIONS & CONCLUSIONS

- The general alignment described above will be utilized to prepare the 10% Water Transmission Line design for the GMPP. The Technical Memorandum evaluates some minor alternatives along certain areas of the alignment. The complete TM can be found in the Appendix along with the drawings of the main alignment and alternatives.

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3.9 TM 9 – PLAN FOR REGIONAL WATER SUPPLY

DESCRIPTION

The water transmission pipeline to be constructed under the Gillette Madison Pipeline Project GMPP will cover almost 44 miles and will pass by several communities between the City of Gillette and the Madison well field. Construction of a pipeline of this length and size presents opportunities for consideration of how a system like this might fit into the current and future plans of these regional communities. The following recent studies have been performed for the COG:

- 2007 City of Gillette Long Term Water Supply Level II Study, (Level II)
- Gillette Regional Master Plan Level I Study, August 2009 (GRMP)
- Regional System Participant Connections Study, May 2010 (RSPCS)

The GRMP and RSPCS both evaluated this regional concept at different levels with varying results. The COG requested a review of these documents and interpretation of how the information from each should come together to formulate the design parameters for the GMPP components. The purpose of Technical Memorandum 9 is to summarize the regional water supply plan considerations that will have an impact on design of the GMPP. The scope of the GMPP relative to the regional water supply includes:

- Consideration of the 2040 water demands for potential regional system participants within the possible regional water system service area
- Inclusion of regional connection stubs with valves for potential regional participants along the proposed Madison transmission pipeline

The TM briefly describes the approaches for each of the above studies. The City requested that the design of this project consider all potential regional participants listed in the RSPCS, which includes regional participants within both the possible and probable service areas. The RSPCS projected peak day demands and recommended regional connection locations are evaluated in this TM for use in the regional water supply plan for the GMPP.

The TM covers the following areas in making determinations regarding which participants (communities) should be considered, what demands should be factored into the capacity considerations for the GMPP and where these participants might connect.

- Potential Regional Participants and Proposed Connection Lines
- Regional Water Demands and Class of Service
- Regional Water Storage Considerations
- Regional Water Quality Considerations
- Regional Service Connection Implementation and Phasing

RECOMMENDATIONS & CONCLUSIONS

- Comparisons of the regional demand projections in the Level II study, RSPCS and Technical Memorandum 3 differed by less than 3%.
- The regional demand projection from the Level II study is 5,114 gpm
- The regional demand projection from the RSPCS is 4,806 gpm.
- The more conservative Level II future regional demand projection of 5,114 gpm will be used for the design of the pipeline.
- The connection locations proposed in the RSPCS appear to be compatible with the transmission waterline alignments presented in TM 8 and will be used for the preliminary layout of the connection stubs with the exception of the Antelope Valley and Crestview connections.
- The connection stubs for Antelope Valley and Crestview will be designed along the revised alignment (see TM8) at or near the intersection of Schoonover Street and Patty Avenue.
- Currently, the scope of this project includes connection stubs for the Class B participants, (Class B – Shared water service with water sold from the participant's water supply to the regional system, with the capability for providing full water service without fire

protection from the regional system). However, it does not consider connection of the class B participants to contribute excess water supply to the system. Similarly, the scope of this project includes connection stubs only to the potential regional participants located along the proposed pipeline alignment. Stub-outs for potential regional participants not located along the pipeline alignment are not included in the GMPP and are anticipated to be addressed in separate regional projects.

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3.10 TM 10 – PIPELINE MATERIAL EVALUATION AND RECOMMENDATIONS

DESCRIPTION

For a project consisting of almost 44 miles of large transmission line construction, materials selection is a key component to its success. There are many variables that will affect what materials should be specified for any pipeline project including:

- Material conveyed
- Pipe diameter availability
- External pressures due to depths, traffic, or other items that increase dead load
- Internal Pressures (including test pressure)
- Corrosion resistance and compatibility with existing soils and groundwater conditions
- Expected pipeline life span.

The existing Madison water transmission line has had some severe maintenance issues over the years. A separate project was conducted by the COG, under separate contract, to evaluate these issues, titled the Gillette Madison Pipeline Internal Pilot Study. The study evaluated the cathodic protection of the existing line and issues related to the very corrosive soils in this region in an effort to determine and correct the deficiencies. These concerns and review of existing soils information placed corrosion considerations as a major factor in the selection of materials for this project. As such, the scope of work for the GMPP requires an evaluation of different pipeline material and recommendations for materials that will be allowed to bid on the project. Based on the corrosion concerns on the existing lines, a part of this evaluation is to include cathodic protection considerations and requirements. The purpose of this technical memorandum is to provide the procedure and framework to be utilized to make determinations on how to proceed with cathodic evaluations and subsequently what materials will be allowed in the bids for the GMPP.

Cathodic Protection

Understanding the importance that cathodic protection will have in the success of this project, the services of experts with cathodic protection design will be necessary to assure that the existing conditions are properly assessed and that each pipe material allowed is specified to provide a full service life under these conditions. As such a Cathodic Protection workshop was held on June 10, 2010 with two reputable cathodic protection design firms. Members of the COG and WWDC staffs participated in this workshop. The purpose of the workshop was to accomplish the following:

- Provide a comprehensive discussion from 2 different perspectives of the technical and economical issues associated with cathodic protection in general.
- Gain a better understanding of the cathodic protection system designs that are available for the GMPP and what will best suit the project based on cost, pipe protection and operation.
- Determine which firm would best serve the COG for the cathodic protection designs for the GMPP.

The firms presenting, their representatives and the topics covered are as follows:

- Rust Not – Mr. Bill Spickelmire
- AC&C teamed with Corrpro – Mr. Charles Waits

CATHODIC WORKSHOP DISCUSSION TOPICS
Cathodic Protection Methodology for Each Pipe Material
Soil Conditions Noted in Old Geotechnical Reports Provided to Each Firm for Review
Joint Bonding Requirements
High Voltage Line Considerations
Construction Inspection and Testing
Lessons Learned from Existing Madison Pipeline Failures

Meeting minutes from the workshop along with copies of the presentations from each of the cathodic protection firms can be found in the complete copy of TM 10 in the Appendix.

Pipeline Manufacturers Workshop

The Cathodic Workshop included valuable information regarding the cathodic protection requirements for various materials currently utilized for water transmission pipelines. This material was utilized as a lead in to discussions regarding the materials that should be included in the specifications for the GMPP. The manufactures of various pipe materials were invited to a Pipeline Manufacturer's Workshop held on June 11, 2010, to discuss their products and how they might fit into consideration for the GMPP project. The project team discussed which products should be represented at the Workshop. Burn & McDonnell then contacted manufacturers representing these projects and sent letter invitations to each. Manufacturers representing the following pipe materials were sent a letter inviting them to present at the workshop and the firms accepting are noted along with reasoning from those manufacturers that did not desire to participate:

Pipe Material	Pipe Manufacturer	Presented	Reason for not presenting
Steel	Northwest Pipe	Yes	
DIP	American Ductile Iron	Yes	
DIP	US Pipe	Yes	
PVC	North American Pipe	Yes	
FRP	Hobas	No	Do not have a restrained joint system approved within the USA
PCCP	Hanson Pipe	No	Not able to present
HDPE	Performance Pipe a Division of Chevron Phillips	No	Not able to present

Each manufacturer was allowed 45 minutes to discuss their product followed by a question and answer period. They were requested to cover the following topics at a minimum:

PIPE MANUFACTURER WORKSHOP DISCUSSION TOPICS
Product History
Expected Service Life
Pipe Jointing Requirements
Restrain Joint Types
Cathodic Protection Requirements
Fittings
Pressure Class or Thickness Class Design
Linings/Coatings
Installation Procedure
Service Connection Type and Requirements
Production and Delivery Lead Times/Concerns
Advantages of Product for Use on the GMPP
Disadvantages of the Product for Use on the GMPP
Nearest Manufacturing Facility and Transport Requirements

Meeting minutes from the workshop along with the presentations from each of the pipeline manufacturer can be found in the full copy of TM 10 which is included in the Appendix.

RECOMMENDATIONS & CONCLUSIONS

- The recommendations from the workshops are that the following pipe material should be allowed into the specifications for the project.
  - Steel – Transmission and In-Town Piping
  - Ductile Iron – Transmission and In-Town Piping
  - PVC – Only as pressures allow, with DIP boded coated fittings

- Rust- Not, under the management of Mr. Bill Spickelmire, will be retained to perform the cathodic protection design for the GMPP. Bill is the most familiar with the system as he is performing the design of the modifications to the existing Madison water transmission line cathodic protection system. Since consideration of the cathodic design on the existing line is an important consideration for the GMPP there are synergistic opportunities available with utilizing Rust-Not that will benefit the GMPP.

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3.11 TM 11 – DRAFT CONSTRUCTION SCHEDULE AND PHASING (WITH CONSIDERATION FOR POTENTIAL FUNDING)

DESCRIPTION

The scope of work for the GMPP requires that a draft construction schedule including any proposals to phase project construction be developed. As part of this process, we were to obtain input from the COG and WWDC before including the phasing concepts in the Pre-Design Report. The purpose of this Technical Memorandum (TM) is to provide the framework of the phasing and scheduling of the project to date as they correlate to potential funding availability. The funding time frame is the critical factor in this evaluation because the improvements can only be constructed as the funding becomes available. Since the funding for the project is subject to decisions made by the legislature in any given year it is agreed that the scheduling and phasing will need to be revisited each time the funding scenarios unfold.

The draft of TM 11 was prepared and submitted to the COG and WWDC and discussed during our May 11, 2010, meetings in Gillette. It will be important to make any determinations regarding phasing of the project up front, because once design documents are complete it is inefficient costly to break out only sections of each package for bid. In conversations with the COG, they shared this view point as well. The TM begins with a brief discussion of the current plan for packaging the projects; ties this project packaging into the phased funding estimate presented in the 2007 "Gillette Long-Term Water Supply Phasing Plan" , examines alternative phasing approaches and makes recommendations with consideration for current funding predictions. The proposal submitted to the COG for the GMPP assumes that the various components of the project will be phased as follows:

BASIS OF AWARD PROJECT PACKAGING	
PACKAGE NUMBER	**PROJECT COMPONENT**
P1	Wells
P2	Well Field Piping
P3	In-Town
P4	Water Transmission Piping
P5	Pump Station
P6	Storage Reservoir
P 7 (Pending)	On-Site Sodium Hypochlorite Generation

The TM, which can be found in the Appendix, presents the "ESTIMATE OF GILLETTE MADISON PIPELINE PROJECT COSTS – PHASED FUNDING PLAN 6" Table. The Table is broken into the following phases with assigned funding:

- Phase I: Spring 2011 (Design, Administration, Test Wells and Easement/Permit Acquisition)
- Phase II: 2011-2012 (Construction)
- Phase III: 2013-2014 (Construction)
- Phase IV: 2015-2016 (Construction)

Packages P1 through P6 are assigned to the Phases where we currently felt they would fit in best with the City's overall plans and need for the facilities. Based on these assignments a couple Phasing/Packaging approaches are discussed in the TM with the following table representing the recommended approach.

BID YEAR	DESIGN PACKAGE
Spring 2011	• P1 - Wells • P2 - Well Field Piping • P3 - In-Town Piping
End 2012	• P4a -Transmission Piping Segments 3 (Donkey Creek PS to WYODAK) & 4 (WYODAK to Southern Tank) • P5 - Donkey Creek Pump Station and Hypochlorite Facility • P6 – Pine Ridge Storage Facility (Tank or Clearwell)
End 2014	• P4b – Transmission Piping Segments 1 (Madison to Moorcroft) & 2 (Moorcroft to Donkey Creek PS)

RECOMMENDATIONS & CONCLUSIONS

The construction schedule and phasing was presented in the TM to provide a beginning point for discussions on how the packages might be built. In their review comments and during the meeting, the City expressed their current prioritization desires as follows:

PRIORITY CLASSIFICATION	PORTION OF WORK TO COMPLETE
FIRST	• Complete Madison Wells • Well Field Piping and Appurtenances • SW Gillette Treated Transmission Loop
SECOND	• New Electric Substation and Distribution at Pine Ridge • Hypochlorite Facility at Pine Ridge • Storage at Pine Ridge • Segment 4 Transmission Piping
THIRD	• Electric Transmission to Donkey Creek PS • New Substation at Donkey Creek PS • Segment 1, 2, 3 Transmission Piping • Donkey Creek Pump Station
LOWEST RANKING	• In-Town Storage Tanks • Regional Extensions (separate)

Following are some of the other items discussed during the May 11 meetings:

- The City indicated that there is no guarantee on funding timing, however, Phase 1 and 2 are funded. It was agreed that the TM would be dynamic and change as knowledge of funding unfolds with each legislative session.
- The electrical distribution needs are immediate. In-town piping and the transmission loop to WYODAK would allow the City to connect into the existing 30" Madison line right away.
- The $226 Million is still the overall target funding.
- The current $40 million funding is for non-construction activities, test wells, and in-town piping.
- The City would like to combine as much transmission piping as possible from Madison to WYODAK as funding allows understanding that the Sections from WYODAK to the Southern Drive tank would be another contract.
- There is currently no funding for electric distribution and no routing has been started by the City.

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3.12 TM 12 – WATER SYSTEM CONDTION/OPERATIONAL REVIEW

DESCRIPTION

The preliminary phase scope of work for the Gillette Madison Pipeline Project (GMPP) includes a Water System Plan. Part of that plan is the COG requirement for the design team to meet with their operations staff to discuss condition and operational requirements for the water system. The first step in this progress began during the December 17, 2009, Meeting 3 (Progress Meeting 1) held at the City of Gillette offices. During that meeting our team visited with several members of the City's operations staff to discuss current issues and desires for the future systems.

This Technical Memorandum starts off with a *Discussions to Date* section which describes most of the items that have been shared to date. A meeting was held at the City of Gillette's offices on May 12, 2010 with the COG operational staff to further discuss the preferences to be used as the basis for design of major components of this project including the Pump Station(s), Storage Reservoir(s), and Water Transmission Pipeline facilities. During this meeting we went through our *Pre-Design Checklist & Questionnaires* which outlines items for the City staff to comment on during the meeting. During the meeting we reviewed these lists and added to them as the conversations dictated. The TM was used as the basic outline for the meeting agenda and the minutes for that meeting were distributed to the entire team including the COG and WWDC. As such the meeting minutes serve as the finalization of this TM and are included in the Appendix.

RECOMMENDATIONS & CONCLUSIONS

Please see the Final TM 12 in the Appendix, for design decisions made for various components of the GMPP. The TM includes the meeting minutes from our May 12, 2010 meeting.

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3.13 TM 13 – EVALUATION OF DISINFECTION ALTERNATIVES

DESCRIPTION

The City of Gillette previously held internal discussions regarding alternative disinfection methods including gaseous chlorine, bulk sodium hypochlorite delivery, and on-site sodium hypochlorite generation disinfection. Based on these discussions, the City determined that on-site sodium hypochlorite generation was strongly preferred for this project primarily due to safety considerations. In response, Burns and McDonnell prepared Technical Memorandum 13 which develops design criteria and alternatives for the implementation of an on-site sodium hypochlorite facility to chlorinate the water associated with the GMPP.

The system will be designed with the design criteria summarized below for the ultimate build out of the system.

DESIGN CRITERIA	
Generator Size	**Two (2) or more systems** **Peak Day Flow = 40.2 MGD** **Maximum Dosage = 5 mg/L**
Brine Storage	**Two (2) FRP Tanks** **30 Days**
Sodium Hypochlorite Storage	**Two (2) FRP Tanks** **2 Days** **Capable of storing 12.5% bulk delivery**
Chemical Metering Pumps	**0.5 mg/L at 0.13 MGD** **5 mg/L at 40.2 MGD** **No turndown <20% of feed range.**

One major design consideration is the material usage and waste from the system. The systems require approximately 3 lbs of salt, 2 kW-hrs of electricity, and 15 gallons of water for each pound of chlorine produced. The most significant waste resulting from sodium hypochlorite generation systems is produced during the water softener regeneration cycle. The general relationship of waste produced per pound of sodium hypochlorite generated will be approximately 0.7-1.0 gallons of waste water per pound of sodium hypochlorite created. Therefore, at 40.2 MGD, the softener will discharge approximately 1,500 gallons per day of waste water. The regeneration solution water quality will be approximately 5,000 mg/L of calcium, 3,000 mg/L of magnesium, 200 mg/L of sodium, and the salt required to regenerate the softener.

Disposing of this waste at remote locations may prove problematic. One potential solution is to inject the softener regeneration water back into the transmission pipeline downstream of the sodium hypochlorite injection point. Karen Farley of the WDEQ indicated they would consider allowing injection of the softener recharge back into the pipeline. The volume of this waste is approximately 0.004% of the total flow and would not affect the overall quality of the water.

Five sites and chemical dosage locations were evaluated as follows:

ON-SITE SODIUM HYPOCHLORITE GENERATION ALTERNATIVES	
ALTERNATIVE 1	• One generation facility at Madison for disinfection of the existing Madison wells. • One generation facility at the new well field for disinfection of the new Madison wells.
ALTERNATIVE 2	• One generation facility at the new well field for disinfection of the new Madison wells • Long sodium hypochlorite dosage line to the existing Madison Complex.

ON-SITE SODIUM HYPOCHLORITE GENERATION ALTERNATIVES (continued)	
ALTERNATIVE 3	• One generation facility at the Madison Complex for disinfection of the existing Madison wells • Long sodium hypochlorite dosage line to the new Madison wells.
ALTERNATIVE 4	• One generation facility at the Pine Ridge site. • The existing Madison wells and new Madison wells would combine at the Pine Ridge site where sodium hypochlorite would be dosed.
ALTERNATIVE 5	• One generation facility near the new well fields. • The existing Madison wells would be pumped to the new Madison well field and both water supplies would be chlorinated in a new reservoir near the new Madison wells.

RECOMMENDATIONS & CONCLUSIONS

- Our team recommends Alternative 4 for the implementation of the on-site sodium hypochlorite facility due to the following advantages:
  - Only one sodium hypochlorite system and building needs to be maintained.
  - Construction of one on-site sodium hypochlorite system is less expensive than two.
  - The chemical feed system is simplified.
  - As opposed to Alternative 5, the Pine Ridge site is more easily accessible than the well field site and the terrain is more conducive to truck deliveries.
- **Project Phasing** - A phased construction approach corresponding to the construction of the new wells is recommended for design of the sodium hypochlorite storage and feed system. However, it is recommended that the building be sized for the total system capacity (40.2 MGD) at a dosage of 5 mg/L.

Phase 1

- Construct yard piping, civil construction, and the building for the total flow rate (40.2 MGD) and dosage (5 mg/L).
- The brine storage tank and sodium hypochlorite storage tanks will be designed within the building for the total system capacity (40.2 MGD).
- The generator and dosage pumps will be sized for the five (5) new Madison wells.
- During this period, the existing gas chlorine facility will be used for the existing Madison wells.
- Below is the design criteria and component sizing for Phase 1 of construction.

COMPONENT	DESIGN
Generator Size	**One (1) system** **Phase 1 Flow: 10 MGD** **Dosage: 5 mg/L** **Generator Size: 500 lbs/day**
Brine Storage	**Two (2) FRP Tanks (>8,200 gallons)** **Total Flow: 40.2 MGD** **Dosage: 5 mg/L** **30 Days**
Sodium Hypochlorite Storage	**2 FRP Tanks (>25,200 gallons each)** **2 Days** **Total Flow: 40.2 MGD** **Dosage: 5 mg/L** **Capable of storing 12.5% bulk delivery**
Chemical Metering Pumps	**0.5 mg/L at 0.13 MGD** **5 mg/L at 10 MGD** **No turndown <20% of feed range**

Phase 2

- Upon decommissioning of the Madison gas chlorine system the on-site sodium hypochlorite system will be used for the disinfection of the existing Madison wells along with the five (5) new Madison wells for a total flow rate of 21.2 MGD.
- One additional 500 lb/day sodium hypochlorite generation system skid would used to produce the required amount of sodium hypochlorite.
- Additional chemical pumps would be added to the system for a flow rate of 21.2 MGD at a dosage of 5 mg/L.
- No additional storage would be required since it was sized for the total capacity in Phase 1.

Phase 3

- Upon completion of the remaining new Madison wells, the disinfection system will need to be capable of a total flow rate of 40.2 MGD at a dosage of 5 mg/L.
- An additional 700 lb/day generation system skid would used to produce the required amount of sodium hypochlorite.
- Additional chemical pumps would be added to the system for a flow rate of 40.2 MGD at a dosage of 5 mg/L.
- No additional storage would be required since it was sized for the total capacity in Phase 1.

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4.0 SUMMARY

The previous sections describe the Technical Memorandums that have been finalized for this Pre Design Report. The TM's each provide recommendations and conclusions for the facilities that will be designed under the GMPP. The attached exhibit provides a visual for the location of these recommendations and is labeled according to which Technical Memorandums apply. Section 2 provides a summary of the scope required under the Pre-Design report along with a check list of where each scope item is addressed for easy reference by the COG and WWDC. Results from the Pre-Design report have already been incorporated into the 10% designs for the GMPP facilities and will serve as the basis of design as the design team moves into the 50% and 90% design phases.

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APPENDIX A – TECHNICAL MEMORANDUMS 1 THROUGH 13

APPENDIX B – ENGINEERS OPINION OF PROBABLE COST ESTIMATES