EXPLORATORY DRILLING PROGRAM REPORT

for

MANDERSON, WYOMING

February, 1983

Mayor: David D. Williams

Funding Agency: Wyoming Water Development Commission

Engineer: Buell Winter Mousel and Associates
Honorable Mayor and Town Council  
Town of Manderson  
Manderson, Wyoming 82432  

Re: Exploratory Drilling Program Report  
Water Supply Well  

Dear Mayor and Council:  

Presented herewith is the Exploratory Drilling Program Report for the proposed water supply well. This report is in accordance with the requirements of the Wyoming Water Development Commission.  

We appreciate the opportunity to serve you and are prepared to assist you further at your discretion.  

Sincerely,  

BUELL WINTER MOUSEL AND ASSOCIATES  

Jerry R. Hammerlun  
Office Director
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I. INTRODUCTION

The Town of Manderson, Wyoming currently uses one well for its water supply. This well, drilled in 1956, has a total depth of 1215 feet and was perforated at various elevations through the years. Pumping capacity of the well is estimated at 20 gallons per minute. In December 1982, flouride in excess of maximum safe limits was detected in Manderson's water system. A second source of water was determined to be desirable to provide a greater degree of reliability for the Town.

Manderson applied to the Wyoming Water Development Commission in 1981 for a grant to perform a feasibility study and ground water exploration. A Ground Water Exploration Grant Award Contract was awarded by the WDC and accepted by the Town on November 24, 1981.

The Feasibility Study was drafted in April of 1982 and submitted to the Water Development Commission. In June of 1982, the Town was authorized to proceed with the exploratory drilling program.

The test drill site was located in the southwest 1/4 of Section 32, T50N, R92W (map attached as Exhibit "A"). This site is U.S. Bureau of Land Management land. On June 17, 1982, the BLM granted the Town of Manderson, Wyoming a right-of-way, (Serial No. W-78380) 100 feet by 100 feet, for purposes of location of a new water well.

The test drill site was located in close proximity to Manderson's existing well and is accessible via Highway 20-16 and a graveled road.

Preliminary specifications were submitted to the Water Development Commission in July 1982, then revised and resubmitted on September 2, 1982. One bid on the revised specifications was received and exceeded the dollar amount of the grant. Subsequently, a second set of specifications were drafted and one bid was received for those specifications on November 9, 1982.

Exploratory drilling commenced in December 1982 and field work completed in the same month.

Data and data analysis from the exploratory drilling was assembled and compiled in January 1983 and the results are presented herewith by this Report.
II. CONCLUSIONS

The existing water supply well for the Town is producing a marginally adequate amount of water. Water quality is marginal when compared to Primary and Secondary Drinking Water Standards. A more reliable source of water is needed for the Town, and should be of a quantity and quality sufficient for Manderson's requirements. A new source producing at least 75 gallons per minute is desired. Secondary drinking water standards should be maintained, if possible.

An exploratory drilling program was initiated to ascertain the subsurface strata for water bearing aquifers. Location of the drill hole was predicated on the basis of encountering desirable geologic formations and the proximity to Manderson's existing water supply network.

Test drilling was advanced through the Lance and Meeteetse Formations and terminated in the Mesa Verde Formation. Water quality of the sample collected from a depth of 1610' was determined to be "borderline" for a domestic supply. Subsequent conversations with independent geologists indicate that the water quality of the Mesa Verde Formation may be questionable.

Electric logging of the hole indicated that the test hole penetrated several zones of potential water supply. Interpretation of the logs indicated a lack of water quality necessary to justify a full production well in the aquifers encountered.

Actual sample analysis of the Mesa Verde Formation in areas in which it is used for water supply can be summarized as typically having a total dissolved solids content greater than 1200 ppm and sulphate content greater than 300 ppm, either of which is higher than Secondary Drinking Water Standards.
III. RECOMMENDATIONS

1. Abandon the concept of penetrating the Mesa Verde Foundation for a water supply for Manderson, at the test hole drilling site.

2. File this Report with the Water Development Commission.

3. Consider other alternatives of water supply, including water treatment of Lance Formation water or penetrating a deeper formation such as the Madison with a new well.

4. Maintain contact with the Town of Worland regarding the possible connection of the Town of Manderson to the water supply line between Worland and its new Madison Formation well near Hyattville.

5. On February 3, 1983, Western Water Consultants, Inc., were contracted with by BUELL WINTER MOSELY AND ASSOCIATES to conduct an analysis of the geohydrologic data provided by the test hole drilled at Manderson in December of 1982. As a part of this analysis, WWC was also to present specific recommendations for municipal development of ground water aquifers in the Manderson area, including:

   a. The Madison Limestone Formation;
   b. Alluvium of the Nowood and/or Big Horn Rivers;
   c. Lance, Meeteetse and Mesa Verde Formations (single or multiple formation development);
   d. Repair of existing municipal well;
   e. Joint use of the City of Worland's municipal well near Hyattville.

The analysis and recommendations prepared by WWC are included in the Appendix.
IV. HYDROLOGIC AND GEOLOGIC REVIEW, ANALYSIS & DISCUSSION

The Town's geologist, L. Harris, provided a copy of the "Summary of Operations" from the existing well drilled in 1956. This report is included in the Appendix.

Mr. Harris completed a preliminary geologic report, "Exploratory Water Well Project" for the Feasibility study portion of the grant. A copy of this report is also included in the Appendix.

The existing stratigraphic column was reviewed by Mr. Harris from Pre-Cambrian rocks to the Quaternary Alluvium. Focus was upon the formations of the Cretaceous Age and in particular the Mesa Verde Formation. The Mesa Verde is overlaid by the Lance, Meeteetse and Fort Union Formations in the Manderson area.

The existing Manderson well penetrates the Lance Formation, which contains sandstone similar to the Mesa Verde but sands which are more concretionary and which have a higher iron content.

From the information received by Mr. Harris in the "Exploratory Water Well Project" report, the Mesa Verde formation was targeted for the main exploratory thrust. It was his contention that water from the Mesa Verde would be good water for use in the Town of Manderson. Data from the analysis of water from wells penetrating the Mesa Verde were presented as evidence of the probable quality of water from that formation.

The anticipated thickness of the Mesa Verde Formation in the area was given as 800 feet and was expected to include interbedded sandy shale with a few dark carbonaceous shale lenses. It was concluded that a hole drilled to a depth of 2500 feet in the area of interest would penetrate the entire Mesa Verde Formation.
V. GEOLOGY

From past records, it was determined that the Mesa Verde Formation should be penetrated in the exploratory program.

A surface geology map of the Manderson area was developed and is included in the "Exploratory Water Well Project" report. Areas in which specific formations formed the surface geology were displayed. A cross section of the strata in the area was developed and presented. The descending formation order was given at the targeted site as:

<table>
<thead>
<tr>
<th>Formation</th>
<th>Approximate Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lance Formation</td>
<td>830'</td>
</tr>
<tr>
<td>Meeteetse Formation</td>
<td>770'</td>
</tr>
<tr>
<td>Mesa Verde Formation</td>
<td>800'</td>
</tr>
</tbody>
</table>

The dominate structural feature of the area was designated as the plunging nose of the Manderson Anticline. A syncline exists north west of the anticline fold. Drilling a well between the anticline and the syncline would have resulted in potential problems due to the steeping of the dip in this area.

The Fort Union Formation to some extent and the Lance Formation to a greater extent, contain bentonite shales which have a tendency to swell and cave. Drilling in these formations is thereby decidedly treacherous and can cause problems removing tools and drill stem in uncased holes.

The Meeteetse Formation is softer than the Fort Union or the Lance, and it contains mainly shale. No potential for water bearing capacity was held for the Meeteetse, by Mr. Harris.

The Mesa Verde has good potential for water bearing sandstones and sands. One of the chief drawbacks of the Mesa Verde as an aquifer for domestic supply is the lack of water quality. These concerns are borne out by the test data on water wells drilling into the Mesa Verda and presented in the "Exploratory Water Well Project" report.
VI. DRILLING PROGRAM & SPECIFICATIONS

A copy of the "Application To Ground Water Exploration Grant Program", submitted to the Wyoming Water Development Commission, is included in the Appendix. Under the Exploration Phase, it is proposed to drill two test holes, each being approximately 2300 feet deep and 4 1/2 to 6 1/2 inches in diameter. The desirable test hole was then to be reamed, cased and test pumped with water samples taken at that time.

A copy of the "Feasibility Study for Water Well Supply", submitted to the Wyoming Water Development Commission, is included in the Appendix. Under the Methodology Phase, it is again proposed to drill two test holes of approximately 5 inches in diameter. The desirable hole would be reamed, cased and test pumped. At that time a full evaluation of the well would be made, including the extraction of water samples for analysis. Water quality and quantity was to be verified after completion of the well to the required depth, given in the Costs section as 2500 feet.

Plans and specifications were drafted and bid predicated on the proposals given above. A copy of the first set of plans and specifications is included in the Appendix. One bid was received on the bid date of October 5, 1982. The total cost of the approach proposed, based on the one bid recieved, substantially exceeded the amount of funds available.

Thereafter, and after consultation with the State Engineers Office, it was determined to split the contracts into two parts; the first being the test hole program and the second, depending on availability of funds, being the actual well construction. The intent was to obtain the maximum amount of information with a minimal investment. To that end, the number of test holes was reduced to one and the specifications drafted. A copy of these specifications is also included in the Appendix.

Drilling was to be by the cable tool or hydraulic mud rotary method. Information to be collected by the Contractor during drilling included:

1. Reference Point for all depth measurements.
2. Depth at which each change of formation occurs.
3. Depth at which the first water is encountered.
4. Depth at which each stratum is encountered.
5. Thickness of each stratum.
6. Identification of the Material of which each stratum is composed.
7. Depth Interval from which each water and formation sample is taken.
8. Depth at which hole diameters (bit sizes) change.
9. Depth to the static water level (SWL) and changes in SWL with well depth.
10. Total Depth of completed well.
11. Any and All Other Pertinent Information for a complete and accurate log, e.g., temperature, pH, and appearance (color) of any water samples taken.
12. Depth or Location of any lost drilling fluids, drilling materials, or tools.
In addition, the Contractor was to obtain water samples from each aquifer encountered and have those samples tested bacteriologically and chemically, including the tests for Federal Primary Drinking Water Standards plus hardness and alkalinity.

One bid was received at the second bid opening from Sargent Irrigation of Broken Bow, Nebraska and Casper, Wyoming. The cost involved was within the limits of available funds. Authorization to proceed with the Contract was given in late November 1982.

The Contractor moved into Manderson in early December and commenced the drilling portion of the Contract. Upon being advised of the activity, the Engineer contacted Mr. Harris regarding geological observation of the drilling. Mr. Harris declined to become involved but referred the work to one George Ashland. Arrangements were made with Mr. Ashland to observe the drilling, however Mr. Ashland became incapacitated and did not participate in the drilling observation. The Contractor logged the hole in accordance with his interpretation of the Contract Documents. Upon reaching a depth of 2040 feet, drilling operations were ceased by the Contractor because his rig could not effectively be used to drill deeper. The hole was electric logged and a sample of water obtained from a depth of 1610'.

Analysis of the water is presented on the following page and copies of the Electric Logging are included in the Appendix.

From these results, an analysis was made by Western Water Consultants, Inc. that is included in the Appendix.
VII. COST ESTIMATES

A. Cost for drilling program as bid October 5, 1982:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Approximate Quantity and Unit</th>
<th>Unit Price</th>
<th>Total Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mobilization for Test Hole Drilling</td>
<td>1 Job</td>
<td>$ 4,955.00</td>
<td>$ 4,955.00</td>
</tr>
<tr>
<td>2</td>
<td>4-inch Test Hole Drilling</td>
<td>5,000 V.F.</td>
<td>22.25</td>
<td>111,250.00</td>
</tr>
<tr>
<td>3</td>
<td>Logging and Log Analysis</td>
<td>5,000 V.F.</td>
<td>1.43</td>
<td>7,150.00</td>
</tr>
<tr>
<td>4</td>
<td>Mobilization for Test Well Drilling</td>
<td>1 Job</td>
<td>17,533.00</td>
<td>17,533.00</td>
</tr>
<tr>
<td>5</td>
<td>Test Well Reaming</td>
<td>2,500 V.F.</td>
<td>59.25</td>
<td>148,125.00</td>
</tr>
<tr>
<td>6</td>
<td>Insert 10-inch I.D. casing</td>
<td>2,500 V.F.</td>
<td>24.75</td>
<td>61,875.00</td>
</tr>
<tr>
<td>7</td>
<td>Formation Stabilization</td>
<td>500 V.F.</td>
<td>13.69</td>
<td>6,845.00</td>
</tr>
<tr>
<td>8</td>
<td>Grout as specified</td>
<td>35 V.F.</td>
<td>79.00</td>
<td>2,765.00</td>
</tr>
<tr>
<td>9</td>
<td>Screen (depth 2,000 feet)</td>
<td>500 V.F.</td>
<td>55.25</td>
<td>27,625.00</td>
</tr>
<tr>
<td>10</td>
<td>24-hour Test Pumping and Recovery as specified</td>
<td>1 Job</td>
<td>11,256.00</td>
<td>11,256.00</td>
</tr>
<tr>
<td>11</td>
<td>Water Analysis as specified</td>
<td>1 Job</td>
<td>489.00</td>
<td>489.00</td>
</tr>
</tbody>
</table>

TOTAL BASE BID
$399,868.00

12 Professional Fees (Engineer, Geologist)
$15,250.00

TOTAL PROJECT COSTS
$415,118.00

B. Cost for drilling program as bid November 9, 1982:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Approximate Quantity and Unit</th>
<th>Unit Price</th>
<th>Total Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mobilization for Test Well Drilling</td>
<td>1 Job</td>
<td>$ 5,500.00</td>
<td>$ 5,500.00</td>
</tr>
<tr>
<td>2</td>
<td>Test Hole Drilling including logging</td>
<td>1,000 V.F.</td>
<td>13.25</td>
<td>13,250.00</td>
</tr>
<tr>
<td>3</td>
<td>Drilling 1000 to 1250 including logging</td>
<td>250 V.F.</td>
<td>17.00</td>
<td>4,250.00</td>
</tr>
<tr>
<td>4</td>
<td>Drilling 1250 to 1500</td>
<td>250 V.F.</td>
<td>18.75</td>
<td>4,687.50</td>
</tr>
<tr>
<td>5</td>
<td>Drilling 1500 to 1750</td>
<td>250 V.F.</td>
<td>20.75</td>
<td>5,187.50</td>
</tr>
<tr>
<td>6</td>
<td>Drilling 1750 to 2000</td>
<td>250 V.F.</td>
<td>26.50</td>
<td>6,625.00</td>
</tr>
<tr>
<td>7</td>
<td>Drilling 2000 to 2040</td>
<td>40 V.F.</td>
<td>35.50</td>
<td>1,420.00</td>
</tr>
<tr>
<td>8</td>
<td>Water Sample and Analysis</td>
<td>1 Job</td>
<td>3,225.00</td>
<td>3,225.00</td>
</tr>
<tr>
<td>9</td>
<td>Logging = Gamma, S.P. &amp; Resistivity</td>
<td>2020 V.F.</td>
<td>1.00</td>
<td>2,020.00</td>
</tr>
</tbody>
</table>

TOTAL CONSTRUCTION COSTS
$ 46,165.00

10 Professional Fees (Engineer, Geologist)
$15,250.00

TOTAL PROJECT COSTS
$ 61,415.00
APPENDIX "A"

Groundwater Exploration Grant Application

"Summary of Operations"- Existing Well
September 8, 1981

Wyoming Water Development Commission  
Barrett Building  
Cheyenne, Wyoming  826002

ATTN: Mr. Michael Reese, Administrator

Dear Mr. Reese:

In behalf of the Town of Manderson, we are submitting this application for a groundwater Exploration Grant in aid for partial funding of a geotechnical study and exploration drilling.

The Town of Manderson appreciates your consideration of this request and is ready to supply any further information which maybe needed in review of this application.

Sincerely,

Town of Manderson

Harry Bennett, Mayor

ENCLS.
Resolution authorizing the filing of an Application for "Groundwater Exploration Grant Program of the Wyoming Water Development Commission".

WHEREAS, the Manderson Water System is inadequate to supply the needs of the Town of Manderson.

WHEREAS, the Town of Manderson requires partial help funding a geotechnical study and exploration drilling.

THEREFORE, be it resolved that the Town Council and the Mayor of the Town of Manderson file an application to the Wyoming Water Commission requesting funds for the Groundwater Exploration Grant Program to aid in funding costly exploration costs. Further, to authorize the Mayor and the Town of Manderson to sign and file the application.

ATTEST:

Harry Bennett, Mayor

Town Clerk
STATEMENT OF PROBLEM:

The Town of Manderson's water supply is provided by one (1) well, Manderson Town Water Well No. 2. The well was drilled in 1956 and perforated from 580 - 600 feet and 700 - 820 feet. In 1970 the water volume pumped decreased. Two additional zones were perforated, 438-448 feet and 482-492 feet, and additional water was obtained. The present estimated pumping capacity is less than 20 gallons per minute. Exhibit 1 in the Appendix contains additional information on the existing well.

The water quality of the combined four zones was obtained in 1973. The water supply meets primary drinking water standards for minerals. Herbicides, pesticides and radioactivity were not tested. Radioactivity is currently being sampled, however no data is available. Exhibit 2 in the Appendix contains the water quality analysis for 1973. The water well pumps into the distribution system. A 75,000 gallon reservoir located 4,600 feet from town floats on the system. The distribution system is relatively new with 6-inch and 4-inch water mains. The entire system is metered. The current water rates are $10.00 for the first 5,000 gallons and $1.00 for each 1,000 gallons thereafter. The present tapping fee is $20.00. The water mains and reservoir are in good repair.

The total water usage was 7,795,000 gallons for January 1 through December 31, 1980 or an average of 21,356 gallons per day. The 31 day average for July 1981 was 27,290 gallons per day. The estimated peak day is projected to be approximately 38,200 gallons per day or 1.8 times the daily average. This is a reasonable factor considering that during the winter months no meter readings are taken, and residents are encouraged to run water to prevent freezing of service lines.

The Manderson High School and Grade School in 1980 used 1,437,000 gallons of water. The total annual usage less the Manderson Schools would be 6,358,000 gallons per year or 17,420 gallons per day average. This average usage includes several small commercial establishments. The average annual water usage per capita (not including the schools) would be 106 GPCPD.
PROJECTED NEEDS

The population projection for Manderson in the year 2000 is 200 people. The projected year 2000 out-of-town student enrollment would be 150 students. Assuming 106 GPCPD for domestic usage, 4,000 GPD for Manderson School, and an additional 3,000 GPD for out-of-town students, the average design flow would be 28,200 GPD.

The projected peak usage of 2.5 times average flow would yield 70,500 GPD. Assuming the well pump provides the flow in 16 hours, the desired well capacity would be 75 GPM.

Fire protection has not been considered in the above analysis. The existing 4- and 6-inch line from Well No. 2 would not significantly enhance delivery of additional water from a new well.
PROJECT PLAN

The following page entitled "METHODOLOGY" briefly describes the approach to the exploration program. Both a Feasibility Study and Exploration are desirable. Not enough geotechnical data is presently available to direct an exploration program.

After completion of the Feasibility Study and the concurrence of the Commission, the Exploration would begin. Monthly progress reports would be submitted on the 15th of the month to the Town of Manderson and the Commission. Based upon the exploration results, a supply acceptable both in quantity and quality will be located. As stated before, Manderson has only one water supply which is failing. If this existing well fails before the exploration work is completed and a new well constructed, Manderson will be without water.

The following page entitled "PROJECT COSTS" contains a line item budget. All work will be performed on a unit basis. For example, if the number of samples tested are reduced, the cost for sampling would be reduced proportionately. Please bear in mind that the costs for exploration are only our best projections. After the Feasibility Study, these costs will be refined to reflect the findings of the study. The costs for Exploration, specifically test drilling, may be bid to qualified drilling companies.

The last attempt to locate a water supply for Manderson was done in 1955. Expansion of the existing well by perforation was conducted in 1970. Copies of the work may be seen in Exhibit 2 of the Appendix.

The Town of Manderson will match the Groundwater Exploration Grant with Severance Tax monies. The costs of completion of the well, well house and transmission main would be financed through the Farm Loan Board with 50% grant and a 50% loan. The loan would be paid with annual Severance Tax monies. It is anticipated an application to the Farm Loan Board will be submitted in October 1981, to be reviewed in January 1982. Copies of the Town of Manderson's Annual Budgets for the last five years may be seen in Exhibit 3 of the Appendix.
METHODOLOGY

A. FEASIBILITY STUDY

1. Research Existing Records:
The State Engineer's records and the Oil and Gas Commission records would be reviewed along with other pertinent sources. The background information would be used to project potential test drilling sites.

2. Surface Reconnaissance:
The vicinity would be visited by a geologist. The geologist would review the sites, prepare a map of the vicinity and provide projections of the most desirable sites for test drilling. Review of stream water quality would also be conducted.

3. Land Access:
The respective land owners would be contacted. Those sites with reasonable access would be proposed for exploration.

4. Feasibility Study:
A report would be prepared covering the above three items. In addition revised cost specifically for exploration of potential water resources would be prepared.

B. EXPLORATION

1. Test Drilling:
Test Drilling would begin with a geologist on location. The geologist would classify the drillings as they are obtained. Two test holes each 4-1/2 to 6-1/2 inches in diameter would be used. Each test hole would be to a depth of 2,300 feet.

2. Pump Testing:
The desirable test hole would be reamed to 12 to 14 inches. An 8-5/8 inch diameter casing would be inserted. A packer would be inserted to obtain water samples, pump testing and recharge characteristics from each aquifer.

3. Exploration Study:
Final exploration work and recommendations for completion of the well to provide Manderson with a safe potable water supply would be prepared. An analysis of the water from each zone would also be provided in the report.

Final cost estimates for completion of a well, depth, type and specific design criteria would be provided.
PROJECT COSTS

Feasibility Study:
A. Professional Fees
   Geologist - $ 2,000.00
   Engineer - 2,000.00
B. Expenses
   Travel and Meals - $ 500.00
   Printing - 750.00
   Water Analysis (8 samples) - 2,600.00
   *Estimates (to be bid)

Total: $ 5,250.00

Exploration Study:
A. Professional Fees
   Geologist - $ 4,000.00
   Engineer - 6,000.00
B. Expenses
   Travel and Meals - $ 500.00
   Printing - 700.00
   Water Analysis (8 samples) - 2,600.00
C. Drilling
   Test Holes - *
   Reaming and Set Casing - *
   Packer Testing - *
   *Estimates (to be bid)
EXHIBIT 1

WELL INFORMATION
SUTLARY OF OPERATIONS

Town of Anderson Water Well

Location: Center of T2, section 32, T. 50 N., R. 92 W. (Approx.)

Elevation: 4045' (Approx.)

Previous Work

This well was drilled in 1956 with cable tools to a total depth of 1215'.

During the drilling, the various sands encountered were tested by bailing the hole and the results, both as to quantity and quality, were noted in the report written by Mr. Emerson L. Parks.

The following sequence of procedure, as gather from Mr. Parks, were:

Surface casing (13-5/8") was set at 19' and cemented with 8 sacks of cement.

The hole first encountered water in a sand, logged from sample, of from 80 to 185'. Drilling continued to a depth of 255' where a bailing test showed 15 bailers (40 bbls.) of water per hour. The analysis of this water (Sample Analysis No. 1) showed it to be good soft water of drinking quality.

Drilling continued to the depth of 417'. At this depth, 416' of 10-3/4" casing was landed as a water shut off. Drilling continued to 600' with water sands noted in the sample log at 445 to 455', and from 480 to 490' and 530 to 600'. At 600' a bailer test indicated about 15 bailers (30 bbls.) per hour of good water. (Sample Analysis No. 2.)

From 760 - 825' another sandstone was logged on the sample log and a bailer test at this depth indicated approximately 60 bailers (120 bbls.) of good water per hour. (Sample Analysis No. 3 not available in report by Mr. Parks.) The hole was then drilled to 860'. The 416' of 10-3/4" casing was pulled prior to running 872' of 9-5/8" casing cemented with 340 sacks of cement. This cement was allowed to set for 36 hours. Then drilling was resumed, hard cement was found in the casing at 840'. The hole was then drilled to a total depth of 1215' without encountering additional water sands. A bailer test of total depth (1215') showed only about 2/3 bbl. water per hour.
The 6-5/8" casing was then perforated with 20 shots from 520 - 600' and with 40 shots from 770-820'. No estimate of the amount of water available from these perforations is given. However it is stated in Mr. Parks' paper that the water level could not be lowered by bailing below a point through to be about 400' below the surface. The water analysis, of that produced from the combination of these two sands after perforation and any water from the hole which is open to 1215', is shown in Sample Analysis No. 4 to be good soft drinking water.

Early in September 1970, the well indicated a lowering of the fluid level and a marked decrease in volume of water pumped. After re-shooting the two zones previously perforated, the pump was still pumping fluid even after the pump was lowered to a position opposite the base of the perforations.

A study of the sample log and the well records as prepared by Mr. Parks indicated the quickest and least expensive method of obtaining additional water would be to perforate water sands which were logged and tested but which were behind the 6-5/8" casing.

Because of the possibility of missing these two relatively thin sands, due to the inherent discrepancies between drillers' measurements and shooting line measurements, it was recommended and decided that a Gamma Ray Log be run. The Gamma Ray Log run by Wireline indicated the two sands in question were at 436 to 454' and from 490 to 502' respectively.

Using the same line used in logging the hole, these two sands were perforated with 2 shots per foot (35 gram shaped charge) from 436 to 446' and from 482 to 492'.

The rods and tubing were run back in the hole and the well was put on the pump. After pumping for approximately 25 hours the standing valve became plugged with debris from the shots and it was necessary to pull the rods and tubing.

When the tubing was put back in the hole, one joint (approximately 22') was left out of the string. This raised the position of the pump relative to the perforations by approximately 22'. The fact that the well is still pumping in this location indicates a substantial increase in the water level in the hole. This additional water had to come from the newly perforated zones.

A study of the Gamma Ray Log will show still other potentially productive zones that are still sealed off by the well casing.

It is recommended that these sands, potentially water productive, be opened by perforations should the need for additional water arise.
September 15, 1955

Mr. Carl Dye,
Handerson,
Wyoming.

Dear Sir:

A description of the formations to be met in drilling at Henderson is submitted immediately. As can be seen there are numerous sandstones over fifteen feet thick, which can be reached by a well less than 1500 feet deep. A well East of the one already drilled will be more shall to any given sand. The depth depends on the location, since the formations dip Southwest about 15° on the average.

All the formations described are irregular in thickness and so cannot be predicted very far from the outcrop.

A well deeper than the base of the Lance is not advisable unless one drilled to the Mesaverde about 700 feet deeper. Probably the white sand about 200 feet above the base of the measured Section. This would be as deep as you would wish to go.

The quality of the waters to be found cannot be predicted. Water from the Lance is used by the Pure Oil Company Camp.

A more detailed discussion will be furnished as soon as I can work the information obtained over. It will not take as deep a well as I thought from first impressions.

Since waters of different quality in separate sands are likely, it is absolutely necessary to drill the well by methods that will enable you to test each water met.

Very truly yours,

E. M. Parks
**FORT UNION FORMATION**

*Lower Part*

Shale: dark, bedded with some sandstone streaks. This is the topmost formation, exposed by highway South of the Cemetery. Bedding more regular than rocks below 35 feet

Shale: gray with lenses of sandstone. At top a hard purplish carbonaceous bed 1\(\frac{1}{2}\) feet thick 25

Sandstone: gray, fine 1 ft. 6 in.

Shale: gray, sandy 23

Sandstone: gray, irregular in thickness 11

Shale: gray 4

Sandstone: light gray, fine 24

(Strike N 150 W, dip 170 SW)

Shale: thin bedded, light gray variable thickness 4

Sandstone: yellow, poorly bedded, medium grain micaceous, fossil wood fragments. In middle a harder bed with clay balls caps a ridge. 145

Covered, soft. Probably shale 20

Sandstone: yellow soft with some harder spots 12

Covered, soft. Probably shale 20

Sandstone: yellow, fine grained with two brown hard shells 25

(Strike N 500 W, dip 170 SW)

This is taken to be the base of the Fort Union formation. No pink or reddish beds here as described other places. No apparent unconformity or change in structure, but an unconformity further South, and again West of Greybull has been found.
LANCE FORMATION

Shale, sandy, soft

32 ft.

Sandstone, yellow, soft, porous, harder concretions in middle

38

Covered, probably sandy shale

40

Sandstone, yellow, fine porous, brown concretions at top

15

(Strike N. 65° W., dip 22° SW.)

Shale, sandy with one sandstone shell

64

Covered, soft probably sandy shale

21

Sandstone ledge, micaceous

4

Shale

69

Sandstone, micaceous

1 ft. 6 in.

Shale, soft sandy

22

Limestone shell, grey, weathers brown

6 in.

Sandstone, yellow, porous, soft

20

Sandstone ledge

2

Shale, sandy, bluish and gray

75

Sandstone ledge, fine brown weathering

15

Shale, soft

40

Sandstone, soft, white

6

Shale, soft

32

Sandstone, shell, brown weathering

4

Shale, soft, sandy

37

Sandstone, shell, brown weathering

3

Shale, gray, bentonitic, soft

75

Sandstone, conspicuously lighter colored, white to gray, medium grained, porous, harder shells in upper part.

45

(Strike N. 52° W., dip 22° SW.)

Shale, soft, sandy, carbonaceous at top

25

Shale, black, carbonaceous

8
Sandstone, soft, muddy
Shale, sandy
Sandstone, yellowish, porous
Shale, sandy, brown
Shale, black, carbonaceous
Sandstone, soft, light gray, large round concretions.

Shale, brown, thin bedded
Sandstone, light gray, round brown concretions in lower part.
Shale, brown, carbonaceous
Sand, gray, soft
Shale, dark, carbonaceous
Sandstone ledge, light gray
Shale, brown, thin bedded, quite lignitic at top
Shale, soft, gray, sandy

This Section ends at alluvial flat of Howood Creek, by an old cabin. A shallow drift in the lignitic shale.
September 16, 1955

PROSPECTS OF A WATER WELL AT MANDESON, WYOMING

A sketch map accompanies this report. The base is from a map furnished by the county engineer, the wells drilled for oil are taken from a map on file at the U.S.G.S. in Thermopolis. I measured a section of the rocks from the base of the Lance formation in the west side of Section 33, T. 50 N., R. 92 W. westward to the highway near the cemetery. The dips and strikes are from my own work.

The chief conclusion is that water fit to use will be found in the Lance formation if none of the sandstones of the Fort Union yield enough water of usable quality. Many of the sands will probably carry water, some will probably not be fit for domestic use, but the well at the Pure Oil Company East Camp found good water in the Lance. They furnished information on the log and a water analysis.

CITY WELL ALREADY DRILLED

No detailed log is available. My information is that only streaks of sand were met until a depth of 420 feet, but surface water was found at a few feet. A fine grained muddy sand was met from 420 to 452 feet, the total depth. It carried water, and a pumping test drew the water down 150 feet and the water is not good enough. It seems certain the surface water was not shut off for this test.

The casing is stuck at present.

One problem is whether to get smaller casing and reduce the size of the hole. If the hole is continued, I think the 8\ 1/2" casing must be pulled. At this location the depth might be 1200 feet or more and for one reason or another the size of the hole might have to be further reduced.

A location on the low ridge east of the cemetery seems practical and is discussed further in this report.

FORMATIONS

FORT UNION FORMATION. The surface at Manderson is alluvium and gravel of Big Horn River and No Wood Creek. Beneath this coating are dipping beds of the Fort Union. The city well is in Fort Union, probably bottomed in the sandstone that is exposed just east of the cemetery.

The Fort Union is a freshwater formation, about half shale beds and half sandstone. The old coal mine north of Manderson is in Fort Union, but the bed does not continue south of No Wood Creek. The base of the Fort Union is especially hard to determine here. At some places there is unconformity on the Lance with the Lance dipping a few degrees more than the Fort Union. The dips observed are a few degrees less in the upper part of the section than in the lower part but do not prove an unconformity, the difference being more likely due to a gradual decrease in dip to the southwest, instead a sudden change of dip at an unconformity.

The Fort Union is about 1000 feet thick. At the city well I estimate the bottom is about 225 feet above the base of the Fort Union.

There is no apparent reason why the Fort Union sands will not carry water.
but the Pure Oil made no attempt to develop water from the Fort Union, so perhaps we should not rely on it here.

**LANCE FORMATION.** There is no marked contrast between Lance and Fort Union, but the Lance tends to be darker and more sombre in color. Both are interbedded sandstone and shale with carbonaceous streaks, both have brown weathering concretionary lenses in the sandstone. Bone fragments and fossil wood are found in both. Commonly the Fort Union is a little more regularly bedded than the Lance, but not here. Both are freshwater formations. The sandstones in both contain mica flakes and grains of dark mineral. Some of the shales are bentonitic and this is more common in the Lance. Both are treacherous drilling because of “tendency” to cave. The sandstones are fine to medium grained, vary in thickness and tend to be clayey.

In the cores from the Pure Oil Company well they describe the sands as “coarse, grey, angular, glauconitic”.

**MEETEETSE FORMATION**

The Meeteetse is mainly shale and softer than the Lance above or the Mesaverde formation below. There is little use drilling far into it unless one wanted to test the Mesaverde below, which would require a well 1700 or more feet deep. It outcrops in the low valley west of the pumping station at the mouth of Sand Creek. Its thickness is reported as 650 feet.

**MESAVERDE FORMATION**

Schlumberger logs of Socony Vacuum wells north of No Wood Creek indicate a thickness of about 810 feet for this formation. It has thicker and cleaner sands than the formation above. It is mainly marine and better bedded than the freshwater beds above. I have no information at present on the quality of water it might contain, but it seems too deep to consider for this project.

**STRUCTURE**

The lower part of the section dips from 22° to 20° Southwest, and the dip decreases to about 15° or less near the cemetery. The average strike of the measured section is about N 53° W. No faulting was noticed.

The dip present increases the depth to any particular horizon about 5% over the true thickness.

**PURE OIL COMPANY WATERWELL**

They found four water sands from 1991 to 2171. Three of them were 22½, 20 and 24 feet. While swabbing it flowed 1½ gallons per minute when shutdown. They use about 200 barrels a day but the well will yield more if pumped to capacity.

The water contains very little impurity except soda and runs 670 parts per million (by evaporation) which is not very high and practically all soda and some sodium chloride. It has a slight taste. A soda water is soft.
DEPTH OF DRILLING

The well already drilled may not have been in condition to test the bottom water, but the draw down was rapid, so we assume a larger supply must be obtained.

A location east of the cemetery will not have the surface water which is generally poor in quality. It is high enough to give 40 to 50 pound pressure in Anderson.

The "conspicuously white sand" of my section, 45 feet thick is considered the most likely chance and the depth to the bottom will be 1050 feet, as nearly as I can estimate. This depth of 1050 is based entirely on my section and observations on dip.

A rough estimate from published structure maps would give about 1000 feet.

Any of the sandstones met deeper than 125 to 150 feet may carry water but probably not enough, even if good.

Two sands near the top of the Lance (38 feet and 15 feet) might be a source.

Any water below 150 feet should be isolated and tested for quality and yield.

NOTE. Two copies of the measured section of lower Fort Union and of the Lance previously submitted should be attached to this report.

E. K. PARKS
EMERSON M. PARKS  
CONSULTING GEOLOGIST  
TEN SLEEP, WYOMING

WANDERSON TOWN WATER WELL NO. 2, BIG HORN CO., WYO. ELEVATION 4045
Spudded in Aug. 6 - 1956  
Completed Aug. 31 - 1956

Log compiled from driller's log, somewhat condensed, and notes in parentheses ( ) added.

Contractor, Weaver Drilling Co., Inc., Casper, Wyoming
Drillers: Pat Moon and Mike Beck.

<table>
<thead>
<tr>
<th>Sandstone with hard brown streaks</th>
<th>0 - 45</th>
<th>THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor pipe, 19 ft. of 13 3/8</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Set and cemented with 8 sacks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gumbo, yellow</td>
<td>45 - 80</td>
<td>35</td>
</tr>
<tr>
<td>Sandstone, salt and pepper</td>
<td>80 - 185</td>
<td>100</td>
</tr>
<tr>
<td>WATER at 185'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shale, blue</td>
<td>185 - 190</td>
<td>5</td>
</tr>
<tr>
<td>Gumbo, gray, sticky</td>
<td>190 - 235</td>
<td>45</td>
</tr>
<tr>
<td>Shale, gray</td>
<td>235 - 275</td>
<td>40</td>
</tr>
<tr>
<td>BAILING 18 bbls. per hour at 235 ft. depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SAMPLE NO. 1 ANALYSIS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandy shale</td>
<td>275 - 280</td>
<td>5</td>
</tr>
<tr>
<td>Shale, gray, sticky</td>
<td>280 - 370</td>
<td>90</td>
</tr>
<tr>
<td>Shale, brown</td>
<td>370 - 375</td>
<td>5</td>
</tr>
<tr>
<td>Shale, gray</td>
<td>375 - 417</td>
<td>42</td>
</tr>
<tr>
<td>Caving at 380 ft.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| CASING. Ran 417 ft. of 10 3/4 and got formation shutoff of water. Casing shoe 15" long.  
(Pulled later.) |
| (WATER above 417 ft. depth about 18 bailers for estimated about 40 bbls per hour. This water was excluded from deeper waters during drilling of deeper formations. ANALYSIS NO. 1 shows good soft water with some bicarbonate of soda) |
| Sandy shale                      | 417 - 440 | 23        |
| Sandy shale                      | 440 - 445 | 5         |
| WATER at 440                     |       |           |
| Sand (WATER)                     | 445 - 455 | 10        |
| Shale, sandy                     | 455 - 465 | 10        |
| Shale, gray                      | 465 - 480 | 15        |
| WATER SAND                       | 480 - 490 | 10        |
| Shale, gray                      | 490 - 555 | 65        |
| Sandy shale                      | 555 - 580 | 25        |
| WATER SAND (SHOT)               | 580 - 600 | 20        |
| (After running 8 5/8 and cementing this sand was shot with 20 shots. ANALYSIS NO. 2. A BAILING TEST of water from 440 and from the sand at 480-490 mingled indicated about 15 bailers production per hour or about 30 bbls. per hour. ANALYSIS NO. 2 was from waters below 417 to depth of 600 feet. Soft water with bicarbonate of soda.) |
MANDERSON WATER WELL NO. 2 (CONT'D)

Shale, Dark  600 - 605   5
Shale, gray   605 - 645   40
Shale, partly sandy  645 - 715   70
Shale, light to white, hard  715 - 720   5
Shale, grey and brown, hard at top  720 - 760   40
SAND and WATER, partly sandy shale  760 - 825   65

(ANALYSIS NO. 3. Good water with some bicarbonate of soda. Could not bail below 333 ft. below surface at rate of 60 bailers per hour or approximately 120 bbls. per hour. On standing ½ hour the water rose to 184 ft. of surface. This sand from 760-825 was shot with 40 shots between 770-820. This was after cementing 8 5/8 casing.)
Shale, black at top, brown below and sticky  825 - 855   30
Shale, gray   855 - 868   13
Shale, black   868 - 870   2
Shale, gray   870 - 880   10

(CASING. Ran 872 ft. of 8 5/8 casing with shoe. Got formation sutoff and bailed hole dry.

After drilling ahead to depth of 1215 with very little water from shoe of 8 5/8 to bottom, CEMENTED, with 340 sacks. Later measurement outside 8 5/8 indicated cement came to 150 ft. below surface.

Cement set 36 hours. Cement in pipe at 840 ft.)
Shale, gray   875 - 900   25
Shale, black and coal (lignitic shale)   900 - 905   5
Shale, black and brown   905 - 910   5
SAND trace and bentonitic clay   910 - 915   5
Shale, black and brown   915 - 950   35

"Lime," light gray, granular. (This was a rather coarse gray sand. At depth of about 950 ft. there was enough water to drill with. No good sample was obtained, but from 950 to bottom at 1215 the water did not rise and yield was not over about 3 bbls per hour.)
Shale, brown and black   955 - 970   15
Shale, gray   970 - 990   20
Sandy shale   990 - 1000   10
Sand   1000 - 1030   30
"Hard Calcite" (?) and sand   1030 - 1032   2
Clay bentonitic and sand   1032 - 1070   38
Shale, grey and clay, partly bentonitic   1070 - 1215   145

TOTAL DEPTH 1215
Producing "2/3 bbl. water per hour below 872, 290 ft. of water in 7 hours" (Before shooting)
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
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<tbody>
<tr>
<td>4100</td>
<td>Surface 4045</td>
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<tr>
<td>4000</td>
<td>Sandstone</td>
</tr>
<tr>
<td>3964</td>
<td>Salt &amp; Pepple Sandstone</td>
</tr>
<tr>
<td>3664</td>
<td>First Water 3664</td>
</tr>
<tr>
<td>3380</td>
<td>Sand, Medium Gr.</td>
</tr>
<tr>
<td>3350</td>
<td>Sandy Shale, Water Bearing</td>
</tr>
<tr>
<td>3300</td>
<td>Sand, Medium Gr.</td>
</tr>
<tr>
<td>3200</td>
<td>Sand, Medium Gr. Water Bearing</td>
</tr>
<tr>
<td>3100</td>
<td>Black &amp; Bect Shale</td>
</tr>
</tbody>
</table>

Geology by: E.M. Phelps
Bottom Hole 2840 Pounds
EMERSON M. PARKS  
CONSULTING GEOLOGIST  
TEN SLEEP, WYOMING  
MANDERSON TOWN WELL NO. 2  
SHOOTING RECORD

WATER SAND 580-600, shot 20 holes through 8 5/8 casing and cement, by "jet" system.

WATER SAND and sandy shale 760-825, shot 40 holes from 770-820.

After shooting 770-820 water rose to 375 ft. of surface in one hour.

Well was shot 6:00 P.M. to 7:40 P.M. Aug. 31, 1956. Water rose from depth of 925 before shooting to 375 ft. below surface by 8:20 P.M. On September 5, the water stood at 125 ft. below surface.

It is evident the ground water level is closely related to the elevation of NoWood Creek.

IMPORTANT. Two water sands are excluded by the 8 5/8 casing. The top water met at 185 had better not be shot, but from 440 to 490 a second water was found with 25 of shale in the middle. If this is shot it would be best to shoot from 445 to 455 and from 480 to 490.
MANDERSON TOWN WATER WELL NO. 2

RECOMMENDATIONS

1. If more water must be had the sands from 445-455 and 480-490 can be shot, but I would rather not have the water at 185 shot.

2. I believe a plunger pump submerged probably to 500 feet would produce this well successfully. Four (4") inch tubing and 7/8" or 1" rods and a pump such as can be run with 4 inch tubing seems best. I doubt if three (3") inch tubing would be adequate, but this should be investigated.

3. The well head is about 150\(\frac{1}{2}\) feet above the U. S. G. S. bench mark at the continental bulk station in Manderson. This would give 65 pounds static head in the lines at Manderson. Possibly a pipeline less than 6 inches would deliver as much pressure as needed. If 45 pounds pressure is enough there would be 20 pounds pressure available for friction of flow to a header for the distributing lines.

4. If the well completed is unable to supply the demand, I see no reason why a successful well cannot be drilled in the town and pumped into the same lines. But it must be finished to exclude surface waters.

5. The space between the conductor pipe and 8 5/8 casing should be filled with cements to exclude air. I measured the depth to top cement and a weight descended to 150 ft. depth. This annular space will probably require over 110 sacks of cement. A 1 inch pipe should be inserted to a depth of 140 feet or more and a pump used to force the cement is placed. Also no calcium chloride. By removing the clamp the 8 5/8 can be moved somewhat to help insert the 1 inch pipe.
S.W. 5° E.  A.W. 8° E. 32° T 50' 5' 11' 12' W

Handers in T.  W. 39.32 P

Nobol - O.R. - Oition - O

MANDERSON TOWN WATER WELL NO. 2

(After shooting well was bailed one hour until it could not be lowered further. Depth to water at end of this test not satisfactorily determined, probably about 400 feet.

SAMPLE NO. 4 ANALYSIS NO. 4. This water from the two sands shot from 580 to 600 and from 770 to 820 water from below 820 believed very little. Analysis shows a soft water with some bicarbonate of soda. This analysis very similar to sample No. 3 and shows that the small amount of water below 825 does not alter the mineral content appreciably.
EXHIBIT 2

WATER QUALITY ANALYSIS
**WATER ANALYSIS**

Wyoming Department of Agriculture
Division of Laboratories
P.O. Box 3228
Laramie, Wyoming 82070

Lab No. 4-5842

Number 80

City of Manderson

**SOURCE**

**LOCATION**

**DATE COLLECTED**

**DATE RECEIVED**

December 17, 1973

<table>
<thead>
<tr>
<th>CATIONS</th>
<th>meq/l</th>
<th>mg/l</th>
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<tbody>
<tr>
<td>Calcium</td>
<td>0.31</td>
<td>6.2</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.09</td>
<td>1.1</td>
</tr>
<tr>
<td>Sodium</td>
<td>15.35</td>
<td>353</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.81</td>
<td>1.2</td>
</tr>
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</table>

Total Cations: 15.76 mg/l

<table>
<thead>
<tr>
<th>ANIONS</th>
<th>meq/l</th>
<th>mg/l</th>
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</thead>
<tbody>
<tr>
<td>Carbonate</td>
<td>0.40</td>
<td>12</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>8.15</td>
<td>497</td>
</tr>
<tr>
<td>Sulfate</td>
<td>5.95</td>
<td>286</td>
</tr>
<tr>
<td>Chloride</td>
<td>1.85</td>
<td>66</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0.01</td>
<td>0.4</td>
</tr>
<tr>
<td>Fluoride</td>
<td>0.06</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Total Anions: 16.42 mg/l

**U.S. PUBLIC HEALTH STANDARD FOUND mg/l**

| Arsenic     | 0.01 Less than 0.007 |
| Chloride    | 250 66               |
| Copper      | 1 Less than 0.01     |
| Carbon      | 0.2                 |
| Cyanide     | 0.01 Less than 0.008 |
| Fluoride    | 1.1                 |
| Iron        | 0.3 0.12             |
| Manganese   | 0.05 Less than 0.05  |
| Nitrate     | 45 4 Less than 0.05  |
| Phenols     | 0.001 0.001         |
| Sulfate     | 250 66              |
| Total Dis. Solids | 500 976         |
| Zinc        | 5 Less than 0.02    |
| M.B.A.S.    | 0.5 Less than 0.01  |

**B.O.D. 5 days mg/l**

<table>
<thead>
<tr>
<th>Colom Bacilli, per 100 cc. M.P.N.</th>
</tr>
</thead>
</table>

**Date**

Jan. 3, 1974

**Charge**

N Charge

**Director or State Chemist**
APPENDIX "B"

Feasibility Study

Preliminary Geological Report
FEASIBILITY STUDY
FOR
WATER WELL SUPPLY
TOWN OF MANDERSON, WYOMING

BUELL WINTER MOUSEL AND ASSOCIATES
CONSULTING ENGINEERS
145 SOUTH DURBIN - SUITE 102
CASPER, WYOMING  82601
Wyoming Water Development Commission
Barrett Building
Cheyenne, Wyoming 8202

Attention: Mr. Michael Reese, Administrator

Dear Mr. Reese:

The Town of Manderson has reviewed and accepted the attached Feasibility Study by our engineer, Buell Winter Mousel and Associates.

We appreciate your consideration of this study and your prompt response. We look forward to receiving your approval to proceed with the Exploration Phase.

Sincerely,

TOWN OF MANDERSON

Harry Bennett, Mayor
I. INTRODUCTION

The Town of Manderson has received a groundwater Exploration Grant from the Wyoming Water Development Commission. Manderson is in need of a well having a capacity of at least 75 gallons per minute as described in the "Statement of Problem" included in the Application To Groundwater Exploration Grant Program submitted to the Water Development Commission.

The Proposed program is to consist of two main sub parts. First a Feasibility study in which probable sites of test well drilling are identified and second, the actual exploration.

The Feasibility Study is hereby submitted to cover the first phase of the approved program and includes the necessary information to proceed to the second phase. It is our intent to obtain approval of this phase from both the Town and the Water Development Commission prior to moving into the next phase. In order to proceed in a timely fashion we therefore respectfully request a propitious review of this document.
II. PROCEDURE

A. RESEARCH

The need for a water supply of greater capacity has been established for Manderson. The magnitude of increased capacity has been identified and this first phase determined whether it was likely that within the probable formations of the area a well of adequate capacity could be drilled within a reasonable distance from the Town of Manderson.

Records were reviewed of past borings including oil well logs and gas well logs. A geologist evaluated the records and through further research, the formations in and around the Manderson area were identified. The findings of this phase were verified by later site reconnaissance and the results tabulated in a report, included herein as Appendix A. This report includes:

- Description of stratigraphic column of the study area.
- An analysis of the subsurface structural geology.
- Review of reservoir consideration and water quality.
- Confirmation of the Mesa Verde formation as the probable water source for Manderson.
- Identification of the location of the test well site.
- Projected depth to the Mesa Verde formation at the proposed site.

The results of the Research phase are included in the "Stratigraphy" Section of the above referenced report. The Mesa Verde formation was targeted as the aquifer to be tapped for Manderson's water supply.

B. SURFACE RECONNAISSANCE

Extrapolating the data in the research phase resulted in the need for "On Site" verification. Field information was gathered and integrated into a series of maps included at the rear of the report. The Mesa Verde formation was confirmed as having the best quality water available at the most feasible drilling locations and depths. A proposed well site was spotted in on the map. It is within a reasonable distance of Manderson and should be accessible via highway and some gravelled roads. Electric power should be able to be brought to the site relatively easily. Placement of the constructed well will be in a well drained, level location.
C. LAND OWNERSHIP

Land ownership for the land upon which the proposed test drilling would take place was researched. Descriptions of various properties were compared with the possible drilling locations.

It was determined that the proposed test drilling site, the south west 1/4 of Section 32, T50N, R92W, is located upon United States Government Bureau of Land Management land. Permission for access to the site will be obtained from the Bureau of Land Management prior to commencement of actual drilling. Contact made with the Bureau of Land Management was made by the Town of Manderson, and steps to form an agreement between the Town of Manderson and the Bureau of Land Management has begun.
III. METHODOLOGY

Upon approval of this Study, plans and specifications will be drawn up to allow bidding for the test holes. A prescribed procedure would be required for drilling two or more test holes of an approximate diameter of 5 inches each. Bidding would be by the vertical foot. At the conclusion of bidding an award would be made to a contractor and actual drilling would be authorized. On-site observation of drilling would be accomplished with a geologist on location. Drilling samples would be analyzed in the field and a log of the drilling progress kept.

The most attractive test hole would be reamed, cased and then test pumped. A full evaluation of the well would be made and water samples extracted to be sent in for analysis. Water quality would be verified by laboratory testing. Probable well production and water quality would be compared with Manderson's goals. Costs for completion of a well at the required depth would be evaluated. A meeting would be conducted with the Town to ascertain the results of the field test drilling.

IV. COSTS

The projected costs to carry forward with the Exploration Study phase of this project are as follows:

A. Professional Fees
   Geologist $ 4,000.00
   Engineer 6,000.00

B. Expenses
   Travel and Meals $ 500.00
   Printing 700.00
   Water Analysis 2,600.00

C. Drilling (Actual prices known after bidding)
   Test Holes (2,500 foot depth)
      $ 70,000.00
   Reaming 30,000.00
   Casing and Backfilling 75,000.00
   Packer Testing 15,000.00
V. CONCLUSION AND RECOMMENDATIONS

A proposed well site has been identified and land ownership ascertained. Water of sufficient quantity and quality to meet the domestic (not fire flow) needs of the Town of Manderson is probably available at a reasonable distance from the town. Bids for drilling the test holes should proceed immediately in order that the entire project might be accomplished in 1982. Further water shortages in Manderson could then be avoided.

Buell Winter Mousel is prepared to proceed in an expedient manner to move forward with the project.
APPENDIX A

(Geologists Report)
TOWN OF

MANDERSON, WYOMING

EXPLORATORY WATER WELL PROJECT

Preliminary Geologic Report

by

L. E. Harris

Consulting Geologist
Because of the exploratory nature of this project, the entire stratigraphic column of the study area will be reviewed. Inasmuch as the objective for the first well is to be the sands of the Mesa Verde Formation, most of the material will be of little or no importance, and for this reason will be discussed very briefly.

BASEMENT (PRE-CAMBRIAN)

The Pre-Cambrian rocks, in the area of interest, should be grey to pinkish, felspathic, granitoid in nature. Due to the depth and lack of interest no wells have been drilled to look at these rocks in the study area.

CAMBRIAN AGE

The 1100 feet of sediments unconformably overlying the granite or basement are of Cambrian Age. They have been divided into three members.

The Flathead Sandstone /300 feet thick is a coarse arkosic sandstone, grading upward into finer, glauconitic sands and shales.

Overlying the Flathead are about 380 feet of interbedded thin, glauconitic sandy shales and thin sandy limestones. This middle member of the Cambrian is known as the Gros Ventre.

Deposited on the Gros Ventre are the 465 feet of the Gallatin member. The most prominent unit of this member is the 50 to 60 foot limestone, called the Gallatin Limestone.

ORDOVICIAN AGE

The Big Horn Dolomite should be approximately 300 feet thick. It is a grey, usually granular massive dolomite. This horizon has good inter-crystalline porosity and in places develops vugs and cavities which make it an important aquifer.

DEVONIAN AGE

Any rocks of Devonian Age, present in the study area are not thought to be important as aquifers. The 50 to 100 feet of light grey shales interbedded with thin white limestones would probably be considered with either the underlying Big Horn Dolomite or the overlying Madison Limestone.
MISSISSIPPIAN AGE

The slightly over 600 feet of sediments deposited on the Devonian rocks are known as the Madison Limestone. This formation is chiefly cherty, dolomitic limestone. It is usually vuggy with caves and caverns developed which enhances the porosity and makes this formation a very important aquifer.

PENNSYLVANIAN AGE

The rocks of Pennsylvanian Age of this area are divided into two formations:

Amsden Formation Unconformably overlying the Mississippian is the Amsden Formation. The Amsden is divided into roughly three members. Lowermost of the three is the Amsden Sandstone. This sand is not present in all localities, and it seems to fill depressions in the eroded surface of the Madison. Where present this sandstone member has been measured up to about 100 feet in thickness. In localities where the sand is found it could be an important aquifer. The next member of the Amsden, in an ascending order, is the 50 feet of light pinkish, slightly cherty limestone.

Tensleep Formation This formation is basically sandstone. Being flat-bedded and limey at the base, grading into massive cross-bedded sand at the top. This formation, some 220 feet thick (counting both members), is a well known aquifer.

PERMIAN AGE

The Phosphoria Formation, in the area of interest, is composed of red anhydritic shales with thin anhydrites in the lower part and light-colored dolomitic limestone in the upper. The entire formation should be about 230 feet thick. It is not considered to be a good aquifer because of the high sulphur content of the water.

TRIASSIC AGE

Dinwoody Formation This formation, 75 feet thick, rests conformably on the Phosphoria. The Dinwoody consists of pale green-grey anhydritic shale with finely decimated pyrite. No potential value as an aquifer are given to these beds.

Chugwater Formation Known, throughout the Basin, as the red beds will be about 700 to 800 feet thick. These beds are red, silty and sandy, slightly anhydritic shale. Few zones of silty porosity in the formation carry water which is usually too high in sulphates for human use.
JURASSIC AGE

Gypsum Springs Formation About 50 feet of massive gypsum and anhydrite beds with pinkish to maroon shale partings comprise the Gypsum Springs Formation. It is not considered an aquifer in the study area.

Sundance Formation This olive drab series of thin limestone, sandstones and sandy shales from 200 to 300 feet thick, is deposited on the Gypsum Springs. The Sundance beds are given their greenish cast by the pebbles of glauconite prevalent throughout the formation. These beds also contain numerous fossils in the lower portion. The Sundance is not considered an aquifer in this area.

Morrison Formation The varicolored shales, light-colored sandstones and a few thin impure limestone of lacustrine or shallow water origin form the Morrison Formation. This group of sediments (300 - 350 feet thick) are not considered to be a potential source for water.

CRETACEOUS AGE

The shallow sea deposits of Morrison time continued into Lower Cretaceous time. For this reason there is no distinct barrier or marker between the two ages in this Basin.

Cloverly Formation In parts of the Basin the Cloverly Formation can be divided into four units. The lowermost unit is the Lakota Sandstone. This is (where present) a rather coarse conglomeritic sand that makes a rather good aquifer. Second in ascending order is the varicolored to pinkish shale known as the Fuson Shale. On the Fuson is deposited the Dakota Sandstone. This member being a clean light-colored sand makes a good aquifer under favorable conditions. The uppermost member of the Cloverly Formation are the Rusty Beds or the Cloverly Silt Zone. These beds are brown, silty, sideritic, sandy with shale partings.

The Cloverly Formation, being of relatively shallow sea deposition is extremely lenticular. This feature makes long distant correlation almost impossible. For this reason it has become fairly common practice to call the top of the Cloverly Silt Zone, the top of the Cloverly-Morrison Undifferentiated.

Thermopolis Shale (Lower Thermopolis) About 200 feet of black fissile, slightly bentonitic shale overlies the Cloverly.

Muddy Sandstone Varying from nothing to about 50 feet in thickness the aptly named silty, bentonitic sandstone. Because of the lenticular character of this sand it is not deposited in many localities. Where it is absent the horizon is usually marked by a zone of slightly lighter and silty and sandy character.
Cretaceous Age (Continued)

Shell Creek Shale 200 feet of black fissile shale overlie the Muddy Sand horizon.

Mowry Shale The hard, grey, thin-bedded siliceous shale forms the high bluffs over the valleys eroded into the softer dark shales below. Bentonite beds occur near the top of this formation and are mined extensively in the Basin.

Frontier Formation The series of sandstone and dark shales overlying the Mowry are very lenticular. Usually there is a basal member of about 50 to 150 feet thick, called the Peay Sand. At the top of the formation, a sand, locally called the Torchlight, is sometimes present. Most of the sand lenses present in this sequence of sands and shales are slightly silty and glauconitic. In most instances the water found in these sands is brackish in taste and not suitable for use by humans.

Cody Shale The rather uniform grey silty shale, from 2000 to almost 3000 feet thick overlies the Frontier Formation. Only the upper few hundred feet of this shale are seen along the eastern edge of Exhibit No. 1 (Surface Map) with this report. On Exhibit No. 3 the Cody Shale is seen to underlie the other sediments shown in the cross-section.

Mesa Verde Formation Overlying the Cody Shale are the beds of the Mesa Verde Formation. These sediments are the ones of principal interest in this study. Approximately 800 feet of sandstone with interbedded sandy shale with a few dark carbonaceous shale lenses comprise the Mesa Verde Formation in the area of interest. From a study of the Schlumberger Log of the Mobil Producing Company's well No. T-34-32-P (SW SE NW, sec. 32, T. 50 N., R. 92 W.) it is seen that the thicker better developed sands are in the lower part of the formation. However, any of the sands in this formation that show porosity on an electric log should be considered as potential source for water in the contemplated exploratory well.

Meeteetse Formation This group of sediments comprised of dark silty and sandy shales interbedded with thin lignitic coals and dark carbonaceous shales, rest on the Mesa Verde rocks. The beds of the Meeteetse Formation will be about 650 feet thick.

Lance Formation The surface beds of the proposed location are the Lance Formation and the last or topmost rocks of Cretaceous Age in the locality. At a depth of 820 feet on the Gamma Ray Log run in the present well, it would appear the base of the Lance Formation was reached. With the additional 300 feet of Lance outcropping to the West of the present well, a total thickness of about 900 to 1000 feet
Cretaceous Age (Continued)

would be established for this formation. The sandstones of the Lance Formation are very similar to those of the objective horizon (Mesa Verde). The sands of the Lance are slightly more concretionary and seem to be a little browner from iron stain than the sands of the Mesa Verde.

TERTIARY AGE

Fort Union Formation The youngest consolidated sediments in the study area are the dark carbonaceous, sandy shales and the thin brownish sandstones, with occasional lignitic beds of the Fort Union of Tertiary Age. The outcrop of these beds may be seen in the southwestern part of Exhibit No. 1

RECENT AGE

Quaternary Alluvium The loose unconsolidated deposits of wash in the stream valleys of No Wood Creek and the Big Horn River comprise these sediments. From Exhibit No. 1, they are seen superimposed over the other formations of the area. Since the proposed well will not penetrate any of these beds, no further discussion of them is necessary at this time.
STRUCTURAL GEOLOGY
Exhibit #2 is a structure map of the area of study (T. 50 N., R. 92 W.). The mapped horizon is on the top of the Frontier Formation with contour intervals of 500 feet (From U.S.G.S. Oil & Gas Investigation Preliminary Map #77).

The dominate structural feature of the area is seen to be the northwest plunging nose of the Manderson Anticline. The rather weak syncline is seen just northeast of the anticlinal fold. To the North and West are seen the much steeper dips into the deeper portion of the Big Horn Basin. It should be noted that the proposed water well will be drilled in relatively steep dips along the south-western flank of the Manderson Anticline.

To the northwest this steepening of dip would add to the depth and contribute to drilling problems if a well were to be drilled too far northwest of the town of Manderson.
RESERVOIR

And

CRITERIA
RESERVOIR CONSIDERATIONS

Looking at Exhibit #1 (Surface Geology Map) it is seen that the valley of the NoWood Creek cuts across the axis of the Manderson Anticline. This valley erosion cuts through at least part of all the formation from the Cody-Shale (Lowermost Formation) to the Fort Union (Uppermost Formation) in the mapped area. Exhibit #3 shows the relative positions of these formations in cross-section. The Mesa Verde Formation is exposed to the waters of the NoWood Creek by this erosion. This exposure of the Mesa Verde Formation to the waters of the NoWood Creek, a perennial stream, would be considered a very reliable source of recharge, or point of entry for water in the Mesa Verde sands. As this exposure is covered by alluvial stream deposits, its exact elevation is not know. However, it is safe to assume this elevation to be close to 4000 feet above sea level. Using this assumption, it is seen that a well drilled in the proposed location (approx. NE SW, sec. 32, T. 50 N., R. 92 W.) will not flow, but will have to be pumped. The fact that the NoWood Creek is a perennial stream will provide a continuous source of recharge, which should provide an assured water supply if the rate of withdrawal is not excessive.

In the study area there is only one well listed as producing water from the Mesa Verde. This well was drilled in the NW SE NE of sec. 36, T. 50 N., R. 92 W. The well was drilled to a total depth of 122 feet. Nothing is known as to the completion of the well, but records show that water came to within 9 feet of the surface. From the analysis of this water as shown in (Chemical Analysis of Ground Water in the Big Horn Basin, Northwestern Wyoming. Prepared by USGS Water Resources Division and published by Wyoming Department of Economic Planning and Development, 1972) is of good drinkable quality but would be classed as rather hard. These tables give two analyses from the same well. The first analysis was made in 1947 and shows much better water than the second analysis taken in 1967. It is thought that the disparity in values could be caused by contamination due to deterioration of the pipe or other physical aspects of the well.

Because of lack of information concerning the quality of water from the Mesa Verde formation in the study area, wells outside were sought out.

Five wells were found to have made drill stem tests in the Mesa Verde. The tabulation of the results of these tests are seen on the data sheet with this report. For the most part, these tests are too far from the area of interest to be of much importance to the study. However they all indicate formation pressure in the Mesa Verde. In preparing the data sheet the Shut-In Pressure of the test was used to find the head of water available at the particular well.
The actual amount of water recovered in each test is the result of a number of factors: the amount of time the tool was open; the condition of the hole; and, the size of the downhole choke - are a few of these factors.

However the pressure of the formation indicates what recovery could be expected with favorable hole conditions.

From the above tests it would seem that the Mesa Verde Formation will be a very good objective for a water source for the Town of Manderson.
WATER PURITY

From available information it is expected that the water from the Mesa Verde Formation will be good water for use in the Town of Manderson.

The water analysis from the relatively close shallow well (discussed previously) would bear this out.

Only one other water analysis from the Mesa Verde was found. This analysis from a drill stem test in a well (Altus Exploration Co., Slick Creek #12-3, SE NE sec 12, T. 46 N., R. 92 W.) also indicates good water that would be considered only slightly hard as far as total dissolved solids are concerned. However because this analysis is from a well some twenty miles away, the results may not be applicable to the area of interest.

CONCLUSIONS

From the above discussion of the study area it is seen that a well drilled at the proposed site (approx. NE SW, sec 32, T. 50 N., R. 92 W.) to a depth of about 2500 feet will penetrate the entire section of the Mesa Verde Formation. Such a well would be expected to provide ample water for the Town of Manderson. Perhaps it should be emphasized that a well drilled at the above location cannot be expected to flow, but if the well is drilled to sufficient diameter for the installation of a large pump, sufficient water production should result.
DATA SHEETS
### Compiled Data for Mesa Verde Tests

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<th>Well Name and Number</th>
<th>Location</th>
<th>Elev</th>
<th>Mesa Verde</th>
<th>Datum</th>
<th>Total head of</th>
<th>Surf. Head</th>
<th>Datum</th>
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<td>4484</td>
<td>3603</td>
<td>+ 881</td>
<td>10,669</td>
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<td>Wagon Fork No. 18-1</td>
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<td>DST 4390-4425 Rec. 389' SMCW</td>
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**Upper Mesa Verde Test**
## Comparative Water Analysis Data

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<td>36-50N-92W</td>
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### Cations (mg/l)

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### Anions (mg/l)

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### Total dissolved solids

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<td>976.0</td>
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EXHIBIT NO. 1
TOWN OF MANDERSON
EXPLORATORY WATER WELL PROJECT

SURFACE GEOLOGY MAP
EXHIBIT NO. 3
TOWN OF MANDERSON
EXPLORATORY WATER WELL PROJECT
CROSS SECTION A-B

APPROXIMATE POSITION OF PROPOSED EXPLORATORY WELL IN RELATION TO CROSS SECTION.
APPENDIX "C"

Specifications
PROJECT MANUAL
FOR THE
TOWN OF MANDERSON
MANDERSON    WYOMING

TEST WELL DRILLING
BWMA PROJECT NO. 5110382
SEPTEMBER 7, 1982

BUELL WINTER MOUSSEL AND ASSOCIATES
OF WYOMING, P.C.
123 WEST FIRST STREET    SUITE C-70-37
CASPER    WYOMING    82601

5110382    © 1982 Buell Winter Mousel and Associates of Wyoming, P.C.
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Table: Preliminary Geologic Report, 15 pages, 3 maps
NOTICE TO CONTRACTORS

Town of Manderson
Manderson, Wyoming 82432
BWMA Project No. 5110382

Sealed Bids will be received by the Mayor and Town Council for Test Well Drilling for the Town of Manderson, Wyoming.

Description of Work:

- 5,000 V.F. 4-inch Test Well
- 2,500 V.F. 4-inch Test Well reamed to accommodate 10-inch casing
- 2,500 V.F. 10-inch Casing

Bids for Test Well Drilling will be received until 7:30 PM, local time, on Tuesday, October 5, 1982, at the Town Council Chambers, at which time they will be publicly opened and read aloud. Bids received after this time will not be accepted.

The Work shall be started within thirty (30) calendar days from the date of the Contract and completed within one hundred eighty (180) calendar days thereafter.

If the Contractor neglects, fails, or refuses to complete the Work within the Contract Time or an extension as determined by the Architect-Engineer, the Contractor shall pay the Owner the sum of fifty dollars ($50.00), not as a penalty but as liquidated damages for such breach of Contract, for each and every calendar day that the Contractor defaults after the time stipulated for completing the Work.

Each Bidder shall submit, with his Bid, a certified check or Bid Bond in a separate sealed envelope, in an amount not less than five percent (5%) of the total amount of his Base Bid.

No Bidder may withdraw his Bid for at least sixty (60) calendar days after the scheduled closing time for the receipt of Bids.

Bidding Documents may be obtained from Buell Winter Mousel and Associates of Wyoming, P.C., on payment of a deposit of fifty dollars ($50.00) which will be refunded upon the return of the Bidding Documents to the Architect-Engineer, in good condition, within ten (10) days after the opening of Bids.

Bidding Documents may also be examined at the following exchanges:

F.W. DODGE DIVISION, McGRAW-HILL INFORMATION SYSTEMS COMPANY, 101 University Boulevard, Suite 260, Denver, Colorado 80206
INTERMOUNTAIN CONTRACTORS, 444 South 300 West, Salt Lake City, Utah
BID CENTER, 133 West 6th, P.O. Box 302, Casper, Wyoming 82602
Preference is hereby given to materials, supplies, equipment, machinery, and provisions produced, manufactured, supplied, or grown in Wyoming, quality being equal to articles offered by the competition outside of the state.

The Owner may require any Bidder to submit to the Architect-Engineer, prior to the date of the Bid opening, a properly executed Contractor's Qualification Statement, AIA Document A305, and/or that his Bid be accompanied with a signed certificate from a surety company licensed in the State of Wyoming that the surety company shall provide the Bidder, if awarded the Contract, with a Performance Bond and a Labor and Material Payment Bond in the amount of one hundred percent (100%) of the Contract Sum.

The Owner reserves the right to reject any or all Bids and to waive informalities in Bids received.

ATTEST:

Rhea Paxton, Town Clerk

By: Harry Bennett, Mayor
BID FOR TEST WELL DRILLING

Town of Manderson
Manderson, Wyoming 82432
DLRA Project No: 5110382

Bid of ________________________________,
☐ a corporation organized and existing under the laws of the State of _______
______________________________________________________________;
☐ a partnership consisting of ________________________________
______________________________________________________________, partners; or
☐ a sole proprietor;
hereinafter called the Bidder.

To: Manderson Town Council
Town of Manderson
Manderson, Wyoming 82432

The undersigned acknowledges that he has received, and has familiarized himself with the following:

Project Manual
Drawings: Sheet 1
Addenda: No. __________ through __________

The undersigned further acknowledges that he has visited the site, and has familiarized himself with local conditions affecting the cost of the Work at the place where the Work is to be done.

In submitting this Bid, the undersigned agrees:

1. To furnish all material, labor, tools, expendable equipment, and all utility and transportation services necessary to perform and complete, in a workmanlike manner, all of the Work required for Test Well Drilling, in accord with the Bidding Documents prepared by Buell Winter Mousel and Associates of Wyoming, P.C., for the consideration hereinafter set forth.

2. To hold his Bid open for sixty (60) calendar days after the receipt of Bids and to accept the provisions of the Instructions to Bidders regarding disposition of Bid Security.

3. To enter into and execute a Contract, if awarded on the basis of this Bid, to furnish a Performance Bond and a Labor and Material Payment Bond in accord with the General Conditions and General Requirements of this Contract, and to deliver executed Contracts and Bonds to the Architect-Engineer within ten (10) calendar days after notice of award.
4. To complete the Work within one hundred eighty (180) calendar days from the starting date issued in the Owner's Notice to Proceed.

5. Acknowledges that he has reviewed and read the Drawings, Specifications, and General Conditions, and that there are no errors in, or omissions from, the Drawings and Specifications. In the event there are errors in, or omissions from, the Drawings and Specifications, he nevertheless accepts same as is.

6. That if he neglects, fails, or refuses to complete the Work within the Contract Time, or an extension as determined by the Architect-Engineer, he shall pay the Owner the sum of fifty dollars ($50.00), not as a penalty but as liquidated damages for such breach of Contract, for each and every day that he defaults after the time stipulated for completing the Work, as provided in Section 15 of the General Conditions.
BID SCHEDULE: The quantities listed are estimated. Unit Prices are for the complete installation of each item and related work thereto. (Amounts shall be shown in both Unit Prices and Total Amounts. In case of discrepancy, Unit Prices shall govern.)

The undersigned agrees to perform all of the Work required to complete the Test Well Drilling for the following Unit Prices:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Approximate Quantity and Unit</th>
<th>Unit Price</th>
<th>Total Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mobilization for Test Hole Drilling</td>
<td>1 Job</td>
<td>$_________</td>
<td>$___________</td>
</tr>
<tr>
<td>2</td>
<td>4-inch Test Hole Drilling</td>
<td>5,000 V.F.</td>
<td>_________</td>
<td>____________</td>
</tr>
<tr>
<td>3</td>
<td>Logging and Log Analysis</td>
<td>5,000 V.F.</td>
<td>_________</td>
<td>____________</td>
</tr>
<tr>
<td>4</td>
<td>Mobilization for Test Well Drilling</td>
<td>1 Job</td>
<td>_________</td>
<td>____________</td>
</tr>
<tr>
<td>5</td>
<td>Test Well Reaming</td>
<td>2,500 V.F.</td>
<td>_________</td>
<td>____________</td>
</tr>
<tr>
<td>6</td>
<td>Insert 10-inch I.D. Casing</td>
<td>2,500 V.F.</td>
<td>_________</td>
<td>____________</td>
</tr>
<tr>
<td>7</td>
<td>Formation Stabilization</td>
<td>500 V.F.</td>
<td>_________</td>
<td>____________</td>
</tr>
<tr>
<td>8</td>
<td>Grout as specified</td>
<td>35 V.F.</td>
<td>_________</td>
<td>____________</td>
</tr>
<tr>
<td>9</td>
<td>Screen (depth 2,000 feet)</td>
<td>500 V.F.</td>
<td>_________</td>
<td>____________</td>
</tr>
<tr>
<td>10</td>
<td>24-hour Test Pumping and Recovery as specified</td>
<td>1 Job</td>
<td>_________</td>
<td>____________</td>
</tr>
<tr>
<td>11</td>
<td>Water Analysis as specified</td>
<td>1 Job</td>
<td>_________</td>
<td>____________</td>
</tr>
</tbody>
</table>

TOTAL BASE BID

$_________

Add/Deduct per vertical foot of 4-inch Test Hole Drilling $_________

Add/Deduct per vertical foot of Test Well Reaming $_________
The undersigned has submitted the required Bid Security and other items required in the Instructions to Bidders.

The undersigned proposes to furnish equipment or products manufactured by the following firms:

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casing</td>
<td></td>
</tr>
</tbody>
</table>

**PRIME SUBCONTRACTORS:** The undersigned proposes the following Prime Subcontractors:

<table>
<thead>
<tr>
<th>Subcontractor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Dated this ________ day of ________________, 19__

Respectfully submitted,

Name of Bidder

Address of Bidder

Authorized Officer

Area Code/Telephone Number
SECTION 01010

SUMMARY OF THE WORK

1.0 THIS CONTRACT includes all material, labor, tools, expendable equipment, utility and transportation services, and all incidental items necessary to perform and complete, in a workmanlike manner, the Work required for Test Well Drilling, Manderson, Wyoming.

2.0 WORK ON SUNDAYS AND HOLIDAYS. Except for strictly emergency work, or for protection of property or work required by these Specifications, no work shall be performed on Sundays or holidays without permission from the Architect-Engineer. The intent of this requirement is that the public or any individuals shall not be unduly disturbed by the construction operations on the said days.

3.0 MOVE SIGNS, MAILBOXES, OR OTHER ITEMS removed during construction and replace in a condition equal to that prior to the beginning of construction.

4.0 BOUNDARIES AND RIGHTS-OF-WAY

4.01 RIGHTS-OF-WAY necessary for construction of the Project will be provided by the Owner. The Contractor shall confine his construction operations to the immediate vicinity of the location shown on the Drawings, or as required by permit or easement, and shall use due care in placing construction tools, equipment, excavated materials, and pipe line materials and supplies so as to cause the least possible damage to property and interference with traffic.

4.02 THE CONTRACTOR shall be responsible for damage to crops and other property outside the boundaries of the rights-of-way, and shall make satisfactory settlement for such damage directly with the property owner and tenant involved as their interests in such damage may require prior to causing said damage.

4.03 IF IT IS NECESSARY OR DESIRABLE to use or occupy land outside of the Owner's rights-of-way, obtain written consent from, or execute a written agreement with, the owner and tenant of such land permitting such occupation; do not enter for pipe delivery, or occupy for any other purposes, with men, tools, equipment, construction materials, or materials excavated from the pipe trench, any private property outside the designated right-of-way boundaries without such written permission from the owner and tenant of the entered or occupied property. Each owner and tenant of land or other property so notified shall be informed not less than five (5) days prior to such occupation.

4.04 THE CONTRACTOR shall make himself cognizant of all property line locations, utilities, easement boundaries, and permit requirements prior to starting work. If there are any locations where the Contractor is unsure of the property line, he shall contact a registered land surveyor to provide such information. Any questions concerning easements should be directed to the Owner's legal counsel.
SECTION 01150

PROJECT MEETINGS

1.0 PRECONSTRUCTION CONFERENCE. The Contractor shall attend a preconstruction conference to discuss and clarify contract administration procedures, requirements under which the construction operation is to proceed, and the obligations imposed upon the Contractors. The Owner and the Architect-Engineer will also attend. The Architect-Engineer will notify the Contractor of the date, time, and location of the conference.
SECTION 02010

SUBSURFACE INFORMATION

1.0 GENERAL

1.01 PRELIMINARY GEOLOGIC REPORT
1.01.1 PRELIMINARY GEOLOGIC REPORT has been made, and a complete report of the investigations is included in these Specifications. The Architect-Engineer will not assume responsibility for variations of subsoil quality or conditions at locations other than the places shown and at the time investigations were made.

Attachment: Preliminary Geologic Report, 15 pages, 3 maps
SECTION 02540

TEST HOLE DRILLING

1.0 GENERAL

1.01 TEST HOLE LOCATION AND PURPOSE
1.01.1 CONSTRUCT TEST HOLES at the approximate locations shown on the Drawings to obtain information regarding the depth, thickness, and water yielding potential of the formation encountered. Work shall be performed in accord with the Manual of Water Well Construction Practice, EPA-570/9-75-001, or latest revision.

2.0 PRODUCTS

3.0 EXECUTION

3.01 DRILLING METHODS
3.01.1 PROVIDE ALL EQUIPMENT that will assure proper execution of the test drilling and sampling program specified herein. The Calk-Tool or Hydraulic Mud Rotary Method of test hole drilling shall be used. A minimum of two test holes shall be advanced--one of which shall be reamed and cased in accord with Section 02570, Test Well Drilling.

3.02 DRILLER'S LOGS AND REPORTS
3.02.1 DURING THE DRILLING OF THE TEST HOLES, prepare and keep a complete log setting forth the following:
   .1 Reference Point for all depth measurements
   .2 Depth at which each change of formation occurs
   .3 Depth at which the first water is encountered
   .4 Depth at which each stratum is encountered
   .5 Thickness of each stratum
   .6 Identification of the Material of which each stratum is composed
   .7 Depth Interval from which each water and formation sample is taken
   .8 Depth at which hole diameters (bit sizes) change
   .9 Depth to the static water level (SWL) and changes in SWL with well depth
   .10 Total Depth of completed well
   .11 Any and All Other Pertinent Information for a complete and accurate log, e.g., temperature, pH, and appearance (color) of any water samples taken
   .12 Depth or Location of any lost drilling fluids, drilling materials, or tools
3.02 GEOPHYSICAL/MECHANICAL LOGS
3.02.1 PERFORM OR HAVE PERFORMED the following logs (including logging analysis):
   .1 Spontaneous-Potential Logging
   .2 Resistivity Logging

3.03 FORMATION SAMPLING METHODS
3.03.1 METHOD OF SAMPLING will be left to the discretion of the Contractor as approved by the Owner's representative; however, he must collect, identify, and store representative samples, as specified hereafter, collected with sufficient frequency and at sufficient increments of depth to permit a thorough evaluation of the water-bearing properties of the formations encountered in drilling the test hole.

3.04 FORMATION SAMPLING INTERVAL
3.04.1 COLLECT FOUNDATION SAMPLES at each 5 feet, starting at ground surface, and at any pronounced change of formation. Special care shall be used for collecting samples from zones expected to be producing zones.

3.05 FORMATION SAMPLE HANDLING AND IDENTIFICATION
3.05.1 OBTAIN TWO SETS OF REPRESENTATIVE SAMPLES from each sampling interval. In most instances, more cuttings will be recovered than required. The total volume of cuttings shall be thoroughly mixed and quartered until the number of samples required are obtained as a residual.

3.05.2 IMMEDIATELY AFTER RETRIEVAL, place formation samples in approved containers, securely close to avoid spillage and contamination, and clearly label with the following information:
   .1 Location of test hole
   .2 Name or Number of test hole
   .3 Depth Interval represented by the sample
   .4 Date Taken
   .5 Time Taken

3.05.3 LABEL FORMATION SAMPLES CLEARLY, immediately after placing in a container, either directly on the container or on a tag attached thereto, using ink, indelible pencil, or other medium that is resistant to moisture and sunlight. The label shall not be readily removable from the container. The Contractor shall be responsible for the safe storage of formation samples until such times as they are accepted by the Owner or the Architect-Engineer.

3.05.4 SELECT ONE TEST HOLE for the final test well drilling in accord with Section 02570, Test Well Drilling.
SECTION 02570

TEST WELL DRILLING

1.0 GENERAL

1.01 DESCRIPTION

1.01.1 WELL DRILLING shall include the reaming, casing, screening, formation stabilization, developing, testing, and capping of a test water well and site clean-up, all in accord with these Specifications and Drawings and with the Manual of Water Well Construction Practices, EPA-570/9-75-001, or latest revision thereof.

1.01.2 THE EXACT LOCATION of the test well shall be determined and approved by the Architect-Engineer before commencement of work.

1.01.3 THE PROJECT CONTRACT shall reflect the complete drilling and developing of a test water well to an average depth of 2,500 feet as follows:

.1 Ream desirable test hole.

.2 Insert 10-inch I.D. steel casing (10-3/4-inch O.D.), including non-continuous mill slotted steel screen.

.3 Grout upper 50 feet of well, less upper 15 feet.

.4 The total area of openings shall be such that the design entrance velocity shall not exceed 6 feet per minute.

.5 Insert packer and test pump each formation encountered. Collect three water samples during test pumping of each formation at 8 hours, 16 hours, and 24 hours into the test.

.6 Forward samples to the Wyoming Department of Agriculture for appropriate testing.

.7 Cap the well casing with 1/8-inch thick, continuous weld cap.

However, payment shall be made according to the actual lineal footage of reaming, casing, screen, and grouting, and the actual time of developing and test pumping necessary to produce a well of acceptable quality as determined by the Architect-Engineer.

1.02 QUALITY CONTROL

1.02.1 SHOW EVIDENCE OF EXPERIENCE IN DRILLING at least ten wells of comparable diameter and depth. Equipment must be capable of drilling a minimum 14-inch diameter hole to a depth of 2,500 feet. If the Contractor does not have experience in grouting at least three wells in the manner specified herein, the grouting must be done by a competent crew experienced in such work.

1.03 SUBMITTALS

1.03.1 SUBMIT SHOP DRAWINGS AND MANUFACTURER’S LITERATURE to the Architect-Engineer in accord with the General Conditions and General Requirements. These shall include, but not necessarily be limited to, the following:

Steel Well Casing and Screen
Water Test Results

- 5 -
1.03.2 WELL LOGS shall be carefully and accurately kept for the hole drilled, with entries made in sequence so that each can be correlated with the depth of the hole at that time. It shall be brought up-to-date at the end of each working day, and shall be furnished to the Architect-Engineer within one week after the performance of all work on the well. The well log shall record the following:

.1 Site Name and Number

.2 Location of the Well by section, range, township, and quarter section, in accord with the USGS standard well location system

.3 Depth, Thickness, Type, General Characteristics, and Drilling Characteristics of each material encountered

.4 Time Required to drill each foot of depth, along with the speed of rotation, when a rotary rig is used for drilling in rock foundations

.5 Depth, Thickness, and Static Water Level of each water-bearing formation encountered

.6 Order, Number, Diameter, Gauge Thickness, Type of Material, and Lengths of the individual pieces of well casing installed

.7 Well Casing Type, Size, and Manufacturer

.8 Well screen size, material, length, manufacturer, connections, screen slot opening size, formation stabilizer and location

.9 Test Pumping Data

.10 Method and Date of water sampling

1.03.3 SUBMIT PUMP TEST RESULTS to the Architect-Engineer for approval within one week after the completion of each test.

1.03.4 SUBMIT CHEMICAL AND BACTERIOLOGICAL TEST RESULTS to the Architect-Engineer within three days after they are received by the Contractor.

2.0 PRODUCTS

2.01 DRILLING FLUID

2.01.1 DRILLING FLUID used in the conventional (mud) rotary drilling shall conform to the tentative NWWA Specifications. A sodium bentonite base drilling fluid, such as Bayroid Quik-Gel or equal, or self-destroying polymer drilling fluid, such as Revert or equal, are both acceptable.

.1 Bentonite Fluids. Unless otherwise approved in writing by the Architect-Engineer, bentonite fluids shall have the following properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Fluid Weight - lbs/gal</td>
<td>9.5</td>
</tr>
<tr>
<td>Maximum Marsh Funnel Viscosity</td>
<td>45 sec</td>
</tr>
<tr>
<td>Maximum Filter Cake Thickness</td>
<td>3/32 inch</td>
</tr>
<tr>
<td>Maximum 30-minute Water Loss</td>
<td>15 cc</td>
</tr>
<tr>
<td>Maximum Sand Content</td>
<td>5% by volume</td>
</tr>
</tbody>
</table>
Any Additives to the drilling fluid must be approved by the Architect-Engineer.
Sodium Bentonite Base and Self-Destroying Polymer Drilling Fluids shall not be mixed unless approved by the Architect-Engineer.

.2 Self-Destroying Polymer Drilling Fluid shall have the following properties:
- Fluid Weight - 10.0 pounds per gallon, maximum
- Marsh Funnel Viscosity - 65 seconds, maximum
- Filter Cake Thickness - 2/32 inch, maximum
- Water Loss - 25 cc per 30 minutes, maximum
- Sand Content of Drilling Fluid Entering Pump - four percent by volume, maximum

Additives to Fluid approved by the Architect-Engineer

2.02 STEEL WELL CASING
2.02.1 STEEL WELL CASING used as a permanent part of the well structure shall be steel pipe conforming to FS WW-P-406d, Weight A, Class I. It shall be of standard brand manufacture, and have the brand name clearly printed on each length of pipe. Permanent steel casing shall be 10-inch nominal diameter with an internal diameter of 10 inches and a minimum wall thickness of 3/8 inch, and a minimum weight of 32 pounds per foot. Lengths of casing shall be connected with either screwed couplings or approved welds. Welded joints shall be made in accord with the provisions of this Section.

2.02.2 DRIVE SHOES, required if permanent steel casing is to be installed by driving methods, shall be of the type and weight determined by the Contractor and approved by the Architect-Engineer.

2.03 CEMENT GROUT
2.03.1 GROUT MATERIAL shall be proportioned of portland cement and the least quantity of water (not over 6 gallons per cubic foot of cement) required to give a mixture of such consistency that it can be forced through the grout pipes. Three percent to five percent (by weight) of bentonite clay may be added to the grout mixture in order to improve its flow properties. The mixture, method of mixing, and consistency shall be approved by the Architect-Engineer before the grouting of wells.

2.04 FORMATION STABILIZER
2.04.1 FORMATION STABILIZER shall be used when undesirable overlying materials may collapse downward into the annulus around the screen during the development process. Material used for formation stabilizer shall be clean, well rounded, coarse sand, pea gravel, or other material approved by the Architect-Engineer.

2.05 WELL SCREEN
2.05.1 WELL SCREEN shall be designed to produce a minimum loss of head between the water-bearing stratum and well, and shall be of the punched slot design fabricated of mild steel. The well screen shall meet the following requirements:
   .1 Manufacturer. The screen and accessories required for installation shall be commercial products of a manufacturer regularly engaged in the production of such equipment.
.2 Openings in the Well Screen shall be of the proper width to permit the maximum practical sandfree yield after development. The size of the slot shall be that recommended by the manufacturer, based on a sieve analysis of a representative sample of the water-bearing formation submitted (or analyzed) by the driller. Openings shall be of a geometric shape to permit maximum transmitting capacity without clogging or jamming.

.3 Joints. If it is necessary to join several screens together, the joints connecting the screen sections shall be butt-type couplings of the same material as the screens.

.4 Length of the Well Screen shall be determined by the Architect-Engineer, based on the thickness of the water-bearing formation(s) and the method of installation.

3.0 EXECUTION

3.01 DRILLING

3.01.1 DRILLING may be accomplished by a cable tool or conventional hydraulic (mud) rotary drilling machine. Equipment used shall be in good repair and capable of drilling to the depths specified.

3.01.2 DIAMETER OF DRILL HOLE shall be sufficient to install the 10-3/4-inch casing without undue effort. The top of the drill hole must be of sufficient size to allow for grouting.

3.01.3 WHEN DRILLING IN A SANDSTONE FORMATION or other potential aquifer and conventional rotary drilling is used, the Contractor may be required by the Architect-Engineer to periodically stop drilling, remove the mud from the hole, and check for yield using either compressed air or a bailer. This checking shall be considered a normal part of the drilling procedure and no additional payment will be made for it.

3.01.4 REAMING FOR CASING. When exploratory drilling indicates a satisfactory aquifer is present, ream the drill hole to sufficient diameter to install the 10-3/4-inch casing without undue effort. No reaming shall be done without the approval of the Architect-Engineer.

3.01.5 THE COMPLETED WELL shall be of single cased construction, complete with perforated casing, formation stabilizer, and grout.

3.01.6 PLUMBNESS AND ALIGNMENT. The well shall not deviate from the vertical by more than 2-1/2 inches in each 100 feet of depth.

3.02 STEEL WELL CASING

3.02.1 INSTALL STEEL WELL CASING to the depth specified by the Architect-Engineer and grout in place. The length of casing required depends on the depth of the water-bearing formation and overlying materials. Cut off the top of the casing 3 feet above natural ground.
3.02.2 WELDING

.1 Preparation. Surfaces to be welded shall be free from loose scale, rust, grease, paint, and other foreign material except for mill scale which withstands vigorous wire brushing. Joint surfaces shall be free from fins and tears.

.2 Standards. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall conform to normally accepted standards of workmanship.

.3 Temperature of Material to be Welded. No welding shall be done when the temperature of the base metal is lower than 0°F. At temperatures between 0°F and 32°F, heat the surfaces of areas within 3 inches of the edges to be welded until too hot to touch before welding is started.

.4 Alignment. Welded sections of steel casing shall be true to line and free from twists, bends, offsets, and open joints. Welded joints shall be watertight.

3.02.3 CASING BOTTOM. The bottom of the screen and casing assembly shall be plugged tight by welding on a steel plate at least 1/2 inch thick. The welded seam shall be continuous.

3.03 FORMATION STABILIZER

3.03.1 PLACE FORMATION STABILIZER in the annular space around the well.

3.04 WELL DEVELOPMENT

3.04.1 DEVELOP THE WELL by methods which will effectively extract from the water-bearing formation the maximum practical quantity of drilling mud, fine sand, silt, or other fine materials. Develop the well to obtain the maximum yield per foot of drawdown and sandfree water at the maximum pumping rate.

.1 Methods. Neither bailing nor pumping shall be considered to be adequate development methods under this Contract. One of the following methods shall be used:

- Compressed air
- High velocity jetting
- Surge plungers

.2 Pump the Well Continuously for a period of 24 hours with a pump having a pumping capacity of from 75 gpm to 150 gpm. Furnish and use appropriate apparatus for measuring the rate of discharge, drawdown, and recovery, and keep and submit accurate records of said data to the Architect-Engineer upon completion of the test.

.3 Precautions. Develop the well in a manner that does not cause undue settlement of the stratum above the water-bearing formation. Take every precaution to avoid development of the well in a manner which introduces unconsolidated material lying above the aquifer into the water-producing zone.

.4 Continue Development of the Well until water pumped from the well, at the rate determined by the Architect-Engineer, is clear and free of sand
and silt. Water shall be considered sandfree when samples taken at the determined pumping rate contain less than two parts per million (by weight) of sand.

.5 Additional Development Work, as directed by the Architect-Engineer, to further improve the specific capacity of the well may be required. Such additional work, excluding chemicals, will be paid for at the same hourly rate as the normal development work.

.6 Methods. If a conventional hydraulic (mud) rotary rig is used, develop the water-bearing formation with high velocity jetting equipment using a polyphosphate solution such as tetrasodium pyrophosphate, sodium hexametaphosphate, and sodium septaphosphate in concentrations of 5 pounds per 100 gallons of jetting water. If a self-destroying polymer drilling fluid is used, develop the well with plain water.

.7 Develop High Velocity Jetting Equipment and the Well with phosphates if cable tool and air rotary drilling methods and drilling mud are used for drilling through the water-bearing stratum. Development shall not be considered as test pumping.

3.05 GROUTING OF WELL CASING

3.05.1 PLACE CEMENT GROUT in the annular space between casing and drill hole for each well determined by the Architect-Engineer to be suitable for completion. Grout the well from a distance of 50 feet below the surface up to 15 feet below the top of the casing. Maintain a minimum grout thickness of 1-1/2 inches between the well casing and the drill hole. If the sandstone formation is encountered within 20 feet of the ground, use cement grout from the formation to the bottom of the pitless unit.

3.05.2 TEMPORARY CASING. If necessary, install a temporary casing to insure the minimum specified wall thickness of grout. This casing shall be withdrawn as the grout is placed. No payment shall be made for any temporary casing left in place.

3.05.3 PLACING GROUT. Before placing grout, secure the approval of the Architect-Engineer of the proposed method of placing grout. No method will be approved that does not specify the forcing of the grout under pressure from the bottom of the space to be grouted toward the surface. Grout continuously and in a manner that insures the filling of the entire annular space with grout in a single operation.

3.05.4 CURING. Allow grout to cure at least 72 hours before drilling, test pumping, or performing other work in the well. If quick set cement is used, the curing period may be reduced to 24 hours upon approval by the Architect-Engineer.

3.06 CAPPING

3.06.1 CAP THE WELL by a method approved by the Architect-Engineer. Attach a cap to the top of the casing to protect the well from the entrance of foreign materials.

3.07 FIELD QUALITY CONTROL

3.07.1 CHECKING DRILLING FLUID. Control of the drilling fluid shall be accomplished by sampling the fluid at least once an hour, or when a new mud system is started, changed, or added to, when specific formations are penetrated that could
drastically alter the mud properties, or when directed by the Architect-Engineer. Record the results and the time of the test and include the records with the well logs.

3.07.2 PLUMBNESS AND ALIGNMENT TESTS

.1 Test. Run a straightness and alignment test on questionable wells after the well is cased. This consists of running a pipe of 40-foot length, and whose outside diameter is between 1/4 inch and 1/2 inch smaller than the casing, to the bottom of the well.

.2 Rejection. If the test pipe binds, does not pass through the well casing freely, or is bent as a result of testing procedure, the Architect-Engineer has the authority to reject the well as drilled and cased, with no payment to the Contractor, until the deficiency is corrected to the satisfaction of the Architect-Engineer.

.3 Install the String of Casing and Screen and keep plumb. Under no circumstances will the well be given final acceptance if it is found to be out of plumb to the extent that any part of the permanent deep well turbine pump should touch the casing when the pump assembly is installed plumb.

3.07.3 TAKE SAMPLES OF THE FORMATION, as drilling progresses, and furnish to the Architect-Engineer. Samples shall not be washed, and shall be kept in cloth bags. When an aquifer is encountered, take a sample of sufficient volume and have it analyzed, by the manufacturer of the well screen or by the driller, to determine the required slot size of the well screen. Samples shall be taken as follows:

.1 Cable Tool Drilling. As each water-bearing stratum is encountered, keep an accurate record of the location of the top and bottom of each stratum penetrated and the elevation to which the water level stabilizes. Samples taken from each 5 feet of drilling and at every change in formation shall be placed and saved in cloth bags. If so directed by the Architect-Engineer, the driller may be required to take samples at 1-foot intervals in a potential aquifer.

.2 Conventional Hydraulic (Mud) Rotary Drilling. Because the hydrostatic water level of aquifers encountered cannot readily be determined during rotary drilling methods and because of the relatively high speed of penetration of rotary methods of drilling, take samples during drilling at 5-foot intervals and at every change in formation. If so directed by the Architect-Engineer, the driller may be required to take samples at 1-foot intervals when a potential aquifer is encountered.

3.07.4 CHEMICAL TESTS. Take water samples near the end of the test pumping period and analyze for chemical composition as related to Safe Drinking Water Standards.

3.08 PRECAUTIONS DURING CONSTRUCTION

3.08.1 TAKE PRECAUTIONS NECESSARY OR REQUIRED to permanently prevent contaminated water or water having undesirable physical or chemical characteristics from entering the well. Also take precautions during construction to prevent contamination or pollution from the ground surface.
3.09 TESTING OF WATER SAMPLE
3.09.1 WATER SAMPLES. After the well has been flushed, take water samples from the well and submit to the Wyoming Department of Agriculture for bacteriological analysis and complete chemical analysis including, but not limited to, tests for PH, alkalinity, total and carbonate hardness, Na, Fe, Ca, Mg, K, F, Mn, Cl, SO₄, NO₃ and total dissolved solids. If bacteriological results obtained are unsatisfactory, repeat the well disinfection and take samples until bacteriologically satisfactory samples are obtained. Sample analysis (both acquisition and payment) shall be by the Contractor. The Contractor must submit copies of the chemical and bacteriological test results to the Architect-Engineer before payment for the well will be made.

3.10 TESTING FOR YIELD AND DRAWDOWN
3.10.1 FURNISH LABOR, EQUIPMENT, MATERIALS, AND POWER REQUIRED for test pumping to the satisfaction of the Architect-Engineer, including temporary pumping facilities to be removed from the well at the end of the test pumping operation, necessary piping for conducting the water away from the test site to a suitable location as determined by the Architect-Engineer, and necessary equipment for measuring the water level in the well and the rate of pump discharge. Equipment considered suitable are electrical probes or air line for well level measurement and an orifice meter, weir, or a calibrated water meter for flow measurement.

.1 Test Pumping Equipment shall be capable of pumping at least 200 gpm at a pumping water depth of 2,000 feet. Also install suitable valving devices in the discharge line to allow the head on the pump to be varied.

.2 Perform a Preliminary Pumping Test of approximately two hours duration with drawdown measurements recorded at ten-minute intervals. The purpose of this test is to determine approximately the pumping rate at which the final pumping test will be conducted. Whenever the rate is changed more than 25 gpm, allow the well to recover before proceeding at the new rate. The recovery time shall be approved by the Architect-Engineer. Record the time it takes the water to recover to the original static water level prior to resuming testing.

.3 Once the Preliminary Test Pumping is Complete, allow the well to rest for 12 hours prior to initiating the final pumping test. Results of the preliminary test shall be given to the Architect-Engineer for determination of the final test pumping rate.

.4 Once the Preliminary Test is Complete and the Well has Rested for at least 12 hours, proceed with the final test pumping at a rate determined by the Architect-Engineer.

.5 Duration of Test Pumping shall be for 24 hours with drawdown measurements at five-minute intervals for the first half hour, 15-minute intervals for the next 3-1/2 hours, and 30-minute intervals for the remaining 20 hours. Test pumping equipment onsite should be capable of operating continuously for a period of 48 hours, if necessary. Standby equipment shall be made available by the Contractor. In the event of an equipment breakdown during the test, and unavailability of alternate equipment, abandon the test and rerun it as directed by the Architect-Engineer. No payment shall be made for time spent on the uncompleted test.
.6 Upon Completion of the Test Pumping, shut down the test pump equipment and take recovery measurements for a period of 24 hours or as otherwise authorized by the Architect-Engineer. The intervals for these measurements are the same as for the test pumping, except the measurements are to be taken every minute for the first ten minutes.

.7 If it is determined by the Architect-Engineer that the final pumping rate must be modified more than 10 gpm, shut the pump down and allow the well to recover. The recovery time shall be equal to the period of time the well was pumped at the original rate. After recovery, record the depth of water to insure that the well has recovered to the original static water level.

3.11 ABANDONMENT OF WELL
3.11.1 ABANDONMENT. In the event the well is not accepted by the Owner and/or the Architect-Engineer for completion, due to insufficient capacity, unsatisfactory chemical or bacteriological quality, or abandoned because of poor alignment, loss of tools, or any other cause, the Contractor shall, as directed by the Architect-Engineer, pull the casing and screen and fill the well hole with the excavated material up to within 12 feet of the top and then fill the remaining 12 feet with well compacted clay material. In this event, the Contractor shall be paid for said well only in the amount of his actual reasonable cost of labor, expended materials, and equipment rental or its equivalent, plus ten percent to cover overhead and all other expenses and profit. The casing and screen shall be salvaged and used by the Contractor under his Contract in a new well to be built at another location. In the event of damage to the casing or screen during pulling operations, where the Contractor is not at fault, the Owner will replace the damaged parts at its expense. If conditions at the jobsite are such that, in the Architect-Engineer's opinion, it is extremely difficult, or not feasible, to pull the casing with normally supplied equipment after the Contractor has made every reasonable effort to do so, then he will be excused from further efforts to pull the casing. The Contractor shall adhere to the State Health Department rules and regulations for well abandonment.

3.12 MOBILIZATION AND DEMOBILIZATION
3.12.1 ONE MOBILIZATION AND DEMOBILIZATION CHARGE is allowed under this Contract. Mobilization consists of moving the drilling rig into the area in which the work is to be done.

3.13 TEMPORARY SEAL
3.13.1 TEMPORARILY SEAL THE WELL upon completion of the well construction by attaching a steel cover plate at least 1/8-inch thick on the top of the casing. The plate shall be tight fitting and spot welded to the casing. The well shall be left sealed until the deep well turbine pump is installed, at which time, the Pump Contractor shall remove the steel cover plate.
PROJECT MANUAL
FOR THE
TOWN OF MANDERSON
MANDERSON  WYOMING

TEST WELL DRILLING
BWMA PROJECT NO. 5110382

BUELL WINTER MOUSSEL AND ASSOCIATES
OF WYOMING, P.C.
123 WEST FIRST STREET  SUITE C-70-37
CASPER  WYOMING  82601

© 1982 Buell Winter Mousel and Associates of Wyoming, P.C.
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<td></td>
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<tr>
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<td></td>
</tr>
</tbody>
</table>

| Drawings:                                                                          |       |
| Well Location Map                                                                  | 1 of 1 |
NOTICE TO CONTRACTORS

Town of Manderson
Manderson, Wyoming 82432
BWMA Project No. 5110382

Sealed Bids will be received by the Mayor and Town Council for Test Well Drilling for the Town of Manderson, Wyoming.

Description of Work:

2,500 V.F. 4-inch Test Well

Bids for Test Well Drilling will be received until 7:30 PM, local time, on Tuesday, November 9, 1982, at the Town Council Chambers, at which time they will be publicly opened and read aloud. Bids received after this time will not be accepted.

The Work shall be started within thirty (30) calendar days from the date of the Contract and completed within ninety (90) calendar days thereafter.

If the Contractor neglects, fails, or refuses to complete the Work within the Contract Time or an extension as determined by the Architect-Engineer, the Contractor shall pay the Owner the sum of fifty dollars ($50.00), not as a penalty but as liquidated damages for such breach of Contract, for each and every calendar day that the Contractor defaults after the time stipulated for completing the Work.

Each Bidder shall submit, with his Bid, a certified check or Bid Bond in a separate sealed envelope, in an amount not less than five percent (5%) of the total amount of his Base Bid.

No Bidder may withdraw his Bid for at least sixty (60) calendar days after the scheduled closing time for the receipt of Bids.

Bidding Documents may be obtained from Buell Winter Mousel and Associates of Wyoming, P.C., on payment of a deposit of fifty dollars ($50.00) which will be refunded upon the return of the Bidding Documents to the Architect-Engineer, in good condition, within ten (10) days after the opening of Bids.

Bidding Documents may also be examined at the following exchanges:

F.W. DODGE DIVISION, McGRAW-HILL INFORMATION SYSTEMS COMPANY, 101 University Boulevard, Suite 260, Denver, Colorado 80206
INTERMOUNTAIN CONTRACTORS, 444 South 300 West, Salt Lake City, Utah
BID CENTER, 133 West 6th, P.O. Box 302, Casper, Wyoming 82602
Preference is hereby given to materials, supplies, equipment, machinery, and provisions produced, manufactured, supplied, or grown in Wyoming, quality being equal to articles offered by the competition outside of the state.

The Owner may require any Bidder to submit to the Architect-Engineer, prior to the date of the Bid opening, a properly executed Contractor's Qualification Statement, AIA Document A305, and/or that his Bid be accompanied with a signed certificate from a surety company licensed in the State of Wyoming that the surety company shall provide the Bidder, if awarded the Contract, with a Performance Bond and a Labor and Material Payment Bond in the amount of one hundred percent (100%) of the Contract Sum.

The Owner reserves the right to reject any or all Bids and to waive informalities in Bids received.

ATTEST: Town of Manderson, Wyoming

Rhea Paxton, Town Clerk

By: Harry Bennett, Mayor
BID FOR TEST WELL DRILLING

Town of Manderson
Manderson, Wyoming 82432
DLRA Project No. 5110382

Bid of ____________________________________________________________,
☐ a corporation organized and existing under the laws of the State of ______
________________________, partners; or
☐ a sole proprietor;
hereinafter called the Bidder.

To: Manderson Town Council
   Town of Manderson
   Manderson, Wyoming 82432

The undersigned acknowledges that he has received, and has familiarized himself with the following:
   Project Manual
   Drawings: Sheet 1
   Addenda: No. ______ through ______

The undersigned further acknowledges that he has visited the site, and has familiarized himself with local conditions affecting the cost of the Work at the place where the Work is to be done.

In submitting this Bid, the undersigned agrees:

1. To furnish all material, labor, tools, expendable equipment, and all utility and transportation services necessary to perform and complete, in a workmanlike manner, all of the Work required for Test Well Drilling, in accord with the Bidding Documents prepared by Buell Winter Mousel and Associates of Wyoming, P.C., for the consideration hereinafter set forth.

2. To hold his Bid open for sixty (60) calendar days after the receipt of Bids and to accept the provisions of the Instructions to Bidders regarding disposition of Bid Security.

3. To enter into and execute a Contract, if awarded on the basis of this Bid, to furnish a Performance Bond and a Labor and Material Payment Bond in accord with the General Conditions and General Requirements of this Contract, and to deliver executed Contracts and Bonds to the Architect-Engineer within ten (10) calendar days after notice of award.
4. To complete the Work within ninety (90) calendar days from the starting date issued in the Owner's Notice to Proceed.

5. Acknowledges that he has reviewed and read the Drawings, Specifications, and General Conditions, and that there are no errors in, or omissions from, the Drawings and Specifications. In the event there are errors in, or omissions from, the Drawings and Specifications, he nevertheless accepts same as is.

6. That if he neglects, fails, or refuses to complete the Work within the Contract Time, or an extension as determined by the Architect-Engineer, he shall pay the Owner the sum of fifty dollars ($50.00), not as a penalty but as liquidated damages for such breach of Contract, for each and every day that he defaults after the time stipulated for completing the Work, as provided in Section 15 of the General Conditions.
**BID SCHEDULE:** The quantities listed are estimated. Unit Prices are for the complete installation of each item and related work thereto. (Amounts shall be shown in both Unit Prices and Total Amounts. In case of discrepancy, Unit Prices shall govern.)

The undersigned agrees to perform all of the Work required to complete the Test Well Drilling for the following Unit Prices:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Approximate Quantity and Unit</th>
<th>Unit Price</th>
<th>Total Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mobilization for Test Hole Drilling</td>
<td>1 Job</td>
<td>$5,500</td>
<td>$5,500</td>
</tr>
<tr>
<td>2</td>
<td>4-inch Test Hole Drilling including Logging and Log Analysis</td>
<td>1,000 V.F.</td>
<td>13.25</td>
<td>13,250</td>
</tr>
<tr>
<td>3</td>
<td>Water Analysis as specified</td>
<td>1 Job</td>
<td>3.25</td>
<td>3,225</td>
</tr>
</tbody>
</table>

**TOTAL BASE BID**

$21,975

Add per vertical foot for 4-inch Test Hole Drilling, logging, log analysis and water analysis as specified from 1,000 feet to 1,250 feet of depth. $17.00 $4,250

Add per vertical foot for 4-inch Test Hole Drilling, from 1,250 feet to 1,500 feet of depth. $18.75 $4,625.50

Add per vertical foot for 4-inch Test Hole Drilling, from 1,500 feet to 1,750 feet of depth. $20.75 $5,185.60

Add per vertical foot for 4-inch Test Hole Drilling, from 1,750 feet to 2,000 feet of depth. $26.50 $4,625

Add per vertical foot for 4-inch Test Hole Drilling, from 2,000 feet to 2,500 feet of depth. $35.60 $17,750
The undersigned has submitted the required Bid Security and other items required in the Instructions to Bidders.

PRIME SUBCONTRACTORS: The undersigned proposes the following Prime Subcontractors:


Dated this ____________ day of __________________, 19___

Respectfully submitted,

Name of Bidder

Address of Bidder

Authorized Officer

Area Code/Telephone Number
SECTION 01010

SUMMARY OF THE WORK

1.0 THIS CONTRACT includes all material, labor, tools, expendable equipment, utility and transportation services, and all incidental items necessary to perform and complete, in a workmanlike manner, the Work required for Test Well Drilling, Manderson, Wyoming.

2.0 WORK ON SUNDAYS AND HOLIDAYS. Except for strictly emergency work, or for protection of property or work required by these Specifications, no work shall be performed on Sundays or holidays without permission from the Architect-Engineer. The intent of this requirement is that the public or any individuals shall not be unduly disturbed by the construction operations on the said days.

3.0 MOVE SIGNS, MAILBOXES, OR OTHER ITEMS removed during construction and replace in a condition equal to that prior to the beginning of construction.

4.0 BOUNDARIES AND RIGHTS-OF-WAY

4.01 RIGHTS-OF-WAY necessary for construction of the Project will be provided by the Owner. The Contractor shall confine his construction operations to the immediate vicinity of the location shown on the Drawings, or as required by permit or easement, and shall use due care in placing construction tools, equipment, excavated materials, and pipe line materials and supplies so as to cause the least possible damage to property and interference with traffic.

4.02 THE CONTRACTOR shall be responsible for damage to crops and other property outside the boundaries of the rights-of-way, and shall make satisfactory settlement for such damage directly with the property owner and tenant involved as their interests in such damage may require prior to causing said damage.

4.03 IF IT IS NECESSARY OR DESIRABLE to use or occupy land outside of the Owner's rights-of-way, obtain written consent from, or execute a written agreement with, the owner and tenant of such land permitting such occupation; do not enter for pipe delivery, or occupy for any other purposes, with men, tools, equipment, construction materials, or materials excavated from the pipe trench, any private property outside the designated right-of-way boundaries without such written permission from the owner and tenant of the entered or occupied property. Each owner and tenant of land or other property so notified shall be informed not less than five (5) days prior to such occupation.

4.04 THE CONTRACTOR shall make himself cognizant of all property line locations, utilities, easement boundaries, and permit requirements prior to starting work. If there are any locations where the Contractor is unsure of the property line, he shall contact a registered land surveyor to provide such information. Any questions concerning easements should be directed to the Owner's legal counsel.
SECTION 01150

PROJECT MEETINGS

1.0 PRECONSTRUCTION CONFERENCE. The Contractor shall attend a preconstruction conference to discuss and clarify contract administration procedures, requirements under which the construction operation is to proceed, and the obligations imposed upon the Contractors. The Owner and the Architect-Engineer will also attend. The Architect-Engineer will notify the Contractor of the date, time, and location of the conference.
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>02010</td>
<td>Subsurface Information</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Attachment: Preliminary Geologic Report,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 pages, 3 maps</td>
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<tr>
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<td>Clearing</td>
<td>2</td>
</tr>
<tr>
<td>02540</td>
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</tr>
</tbody>
</table>
1.0 GENERAL

1.01 PRELIMINARY GEOLOGIC REPORT
1.01.1 PRELIMINARY GEOLOGIC REPORT has been made, and a complete report of the investigations is included in these Specifications. The Architect-Engineer will not assume responsibility for variations of subsoil quality or conditions at locations other than the places shown and at the time investigations were made.

Attachment: Preliminary Geologic Report, 15 pages, 3 maps
SECTON 02540
TEST HOLE DRILLING

1.0 GENERAL

1.01 TEST HOLE LOCATION AND PURPOSE
1.01.1 CONSTRUCT TEST HOLE at the approximate locations shown on the Drawings to obtain information regarding the depth, thickness, and water yielding potential of the formation encountered. Work shall be performed in accord with the Manual of Water Well Construction Practice, EPA-570/9-75-001, or latest revision.

2.0 PRODUCTS

3.0 EXECUTION

3.01 DRILLING METHODS
3.01.1 PROVIDE ALL EQUIPMENT that will assure proper execution of the test drilling and sampling program specified herein. The Calk-Tool or Hydraulic Mud Rotary Method of test hole drilling shall be used. A minimum of one test hole shall be advanced.

3.02 DRILLER'S LOGS AND REPORTS
3.02.1 DURING THE DRILLING OF THE TEST HOLES, prepare and keep a complete log setting forth the following:
   .1 Reference Point for all depth measurements
   .2 Depth at which each change of formation occurs
   .3 Depth at which the first water is encountered
   .4 Depth at which each stratum is encountered
   .5 Thickness of each stratum
   .6 Identification of the Material of which each stratum is composed
   .7 Depth Interval from which each water and formation sample is taken
   .8 Depth at which hole diameters (bit sizes) change
   .9 Depth to the static water level (SWL) and changes in SWL with well depth
   .10 Total Depth of completed well
   .11 Any and All Other Pertinent Information for a complete and accurate log, e.g., temperature, pH, and appearance (color) of any water samples taken
   .12 Depth or Location of any lost drilling fluids, drilling materials, or tools
3.02 GEOPHYSICAL/MECHANICAL LOGS
3.02.1 PERFORM OR HAVE PERFORMED the following logs (including logging analysis):
   .1 Spontaneous-Potential Logging
   .2 Resistivity Logging

3.03 FORMATION SAMPLING METHODS
3.03.1 METHOD OF SAMPLING will be left to the discretion of the Contractor as approved by the Owner's representative; however, he must collect, identify, and store representative samples, as specified hereafter, collected with sufficient frequency and at sufficient increments of depth to permit a thorough evaluation of the water-bearing properties of the formations encountered in drilling the test hole.

3.04 FORMATION SAMPLING INTERVAL
3.04.1 COLLECT FOUNDATION SAMPLES at each 5 feet, starting at ground surface, and at any pronounced change of formation. Special care shall be used for collecting samples from zones expected to be producing zones.

3.05 FORMATION SAMPLE HANDLING AND IDENTIFICATION
3.05.1 OBTAIN TWO SETS OF REPRESENTATIVE SAMPLES from each sampling interval. In most instances, more cuttings will be recovered than required. The total volume of cuttings shall be thoroughly mixed and quartered until the number of samples required are obtained as a residual.

3.05.2 IMMEDIATELY AFTER RETRIEVAL, place formation samples in approved containers, securely closed to avoid spillage and contamination, and clearly label with the following information:
   .1 Location of test hole
   .2 Name or Number of test hole
   .3 Depth Interval represented by the sample
   .4 Date Taken
   .5 Time Taken

3.05.3 LABEL FORMATION SAMPLES CLEARLY, immediately after placing in a container, either directly on the container or on a tag attached thereto, using ink, indelible pencil, or other medium that is resistant to moisture and sunlight. The label shall not be readily removable from the container. The Contractor shall be responsible for the safe storage of formation samples until such times as they are accepted by the Owner or the Architect-Engineer.

3.05.4 CONTRACTOR shall backfill test hole after completion of work.
to the Project Manual
for
Manderson Test Well Drilling
Manderson, Wyoming
BWMA Project No.5110382

NOTICE TO BIDDERS: The Project Manual for the above project are hereby amended as follows:

ITEM NO. 1 - SECTION 02540 - TEST HOLE DRILLING

a) Add paragraph 3.03.2 as follows: "Water samples shall be obtained from each water bearing aquifer. The samples shall be taken to an independent water testing laboratory and tested for bacteriological analysis and complete chemical analysis including but not limited to tests for the Federal Primary Drinking Water Standards along with hardness, alkalinity and their break-down. Sample analysis costs shall be paid by the contractor."
ADDENDUM NO. 2

to the Project Manual
for
Manderson Test Well Drilling
Manderson, Wyoming
BWMA Project No. 5110382

Buell Winter Mouse and Associates
Consulting Engineers
123 W. First Suite C70-37
Casper, WY 82601
November 8, 1982

NOTICE TO BIDDERS: The Project Manual for the above project is hereby amended in accordance with the telephone addendum of November 8, 1982 and as follows:

PROJECT MANUAL

ITEM NO.1. SECTION 02540 - TEST HOLE DRILLING

a) Delete Paragraph 3.05.4 in its entirety and substitute the following:

"3.05.4 THE CONTRACTOR shall, as directed by the Architect/Engineer, fill the test hole with clay, puddled clay, or concrete. The contractor shall adhere to the Wyoming State Department on Environmental Quality rules and regulations for abandonment of wells.

This is to acknowledge Addendum No.2 dated November 8, 1982 for the above referenced project and that the Base Bid submitted by Sargent Irrigation on November 9, 1982 for $21,975.00 does include Addendum No.2.

Dick A. Taylor - Authorized Representative
Chas. Sargent Irrigation, Inc.
P.O. Box 627
Broken Bow, Nebraska 68822
APPENDIX "D"

Water Analysis Report
WATER ANALYSIS REPORT

OPERATOR: Sargent Irrigation Co.
WELL NO: Drinking water
FIELD: Manderson Area
COUNTY: Big Horn
STATE: Wyoming

DATE: 12-16-82
LAB NO.: 42035

LOCATION: Sargent Irrigation Co.
FORMATION: Mesa Verde
INTERVAL: 2040 feet
SAMPLE FROM DST (Packer at 1610 feet)

REMARKS & CONCLUSIONS:
Total hardness as CaCO₃, mg/l ------------ 51
This water does not balance as well as it should. The data indicates
"borderline" for suitability as domestic supply. The type of sample
may have influenced this data.

<table>
<thead>
<tr>
<th>Cations</th>
<th>mg/l</th>
<th>meq/l</th>
<th>Anions</th>
<th>mg/l</th>
<th>meq/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
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<td>18.11</td>
<td>Sulfate</td>
<td>324</td>
<td>6.74</td>
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<tr>
<td>Potassium</td>
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<td>0.54</td>
<td>Chloride</td>
<td>210</td>
<td>5.92</td>
</tr>
<tr>
<td>Lithium</td>
<td>-</td>
<td>-</td>
<td>Carbonate</td>
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<td>0.16</td>
<td>Hydroxide</td>
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<tr>
<td>Iron</td>
<td>-</td>
<td>-</td>
<td>Hydrogen sulfide</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Total Cations: 19.66
Total Anions: 19.66

Total dissolved solids, mg/l - 1200
NaCl equivalent, mg/l - 1012
Observed pH - 7.9

Specific resistance @ 68°F:
Observed - 5.20 ohm-meters
Calculated - 5.90 ohm-meters

WATER ANALYSIS PATTERN

Sample above described

Scale
MEQ per Unit

(Na value in above graph includes Na, K, and Li)

NOTE: Mg/l = Milligrams per liter  Meq/l = Milligram equivalents per liter

Sodium chloride equivalent by Dunlap & Hawthorne calculation from components
APPENDIX "E"

Test Well Logging
Sargent Irrigation Company
Broken Bow Office
Test Well Log
Manderson, Wyoming

0- 40  Fine Sand
40- 100 Sandy Clay
100- 110 Shale
110- 155 Fine Sand
155- 180 Shale
180- 300 Shale Fine Sand Layers
300- 320 Shale Fine Sand Layers
320- 340 Shale Fine Sand Layers
340- 360 Shale Some Fine Sand
360- 380 Shale Some Fine Sand
380- 400 Shale Some Fine Sand
400- 420 Shale Some Fine Sand
420- 440 Shale Some Fine Sand
440- 460 Shale Fine Black Sand
460- 480 Packed Black Sand
480- 500 Packed Sand
500- 520 Shale Sand
520- 540 Shale Sand
540- 560 Shale Sand
560- 580 Shale Sand
580- 600 Shale Hard Layers
600- 620 Shale Sand
620- 640 Shale
640- 660 Shale Fine Sand Layers
660- 680 Shale 12, Fine Sand 4, Shale 4
680- 700 Shale
700- 720 Shale
720- 740 Shale
740- 760 Shale 8, Sand Fine Sand Layers 12
760- 780 Fine Sand Clay Mix
780- 800 Fine Sand Shale Mix
800- 820 Fine Sand Shale Mix8, Shale 12
820- 840 Shale
840- 860  Shale
860- 880  Shale
880- 900  Shale
900- 920  Shale
920- 940  Shale & Sand Layers
940- 960  Shale & Sand Layers
960- 980  Shale & Sand Layers
980-1000  Shale
1000-1020 Shale
1020-1040 Shale Layer Coal
1040-1060 Shale
1060-1080 Shale
1080-1100 Shale
1100-1120 Shale Small Sand (Fine) Layers
1120-1140 Shale Small Fine Sand Layers
1140-1160 Shale Sand Layers
1160-1180 Shale
1180-1200 Shale
1200-1220 Shale
1220-1240 Shale
1240-1260 Shale
1260-1280 Shale
1280-1300 Shale
1300-1320 Shale
1320-1340 Shale
1340-1360 Shale
1360-1380 Shale
1380-1400 Shale
1400-1420 Shale
1420-1440 Shale
1440-1460 Shale
1460-1480 Shale
1480-1500 Shale
1500-1520 Shale
1520-1540 Shale
1540-1560 Shale
**Manderson, Wyoming**

<table>
<thead>
<tr>
<th>Period</th>
<th>Description</th>
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<tr>
<td>1560-1580</td>
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</tr>
<tr>
<td>1580-1600</td>
<td>Shale &amp; Fine Sand</td>
</tr>
<tr>
<td>1600-1620</td>
<td>Shale &amp; Fine Sand</td>
</tr>
<tr>
<td>1620-1640</td>
<td>Shale</td>
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<tr>
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<tr>
<td>1700-1720</td>
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</tr>
<tr>
<td>1720-1740</td>
<td>Shale</td>
</tr>
<tr>
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<td>Shale Some Fine Sand</td>
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<td>1900-1920</td>
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<td>1920-1940</td>
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<td>2000-2020</td>
<td>Shale</td>
</tr>
<tr>
<td>2020-2040</td>
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</tr>
</tbody>
</table>

Drilled 12 inch hole 0-80
Set 80 ft. 8 5/8 surface casing and cemented in
Drilled 6 1/4 inch hole 80-2040
Back filled hole and cemented top
APPENDIX "F"

Sand Analysis
January 27, 1983

Thomas C. Werblow  
Buell, Winter, Mousel & Associates  
219 Parkade Plaza  
PO Box 1305  
North Platte NE 69101  

CITY OF MANDERSON  
WYOMING

Dear Tom

During a recent phone conversation we discussed potential water quality problems with water from formations above 1800 ft. in depth. Therefore, we concentrated our analysis of this potential well to depths greater than 1800 ft.

I have enclosed copies of the sieve analysis as determined by our laboratory of the samples you sent us. The samples contained a very high percentage of clay and required using "wet" sieving techniques to adequately analyze the sands in these samples.

Review of the drillers logs, geophysical logs and samples indicates the zone from 1860 to 1960 ft. appears to be the best zone for production below 1800 ft. in depth. The logs and samples indicate the presence of dirty sand in this zone. Review of the present design of the well indicates modifications may reduce the material and drilling costs of the well by reducing the overall well diameter from 8 to 5 in. screen. If the formation is capable of producing the desired yield, a 5 in. pipe size screen would perform satisfactorily.

An estimate of the corrosive or incrusting tendency of a water sample can be obtained by using the Ryznar Stability Index (RSI). Using the results of the water analysis from this well we calculate an RSI for this water to be 9.2. This indicates the water is mildly corrosive. Since the referenced well is for a municipal water supply and very deep, we recommend using Type 304 stainless steel screen.

The entire section of the formation from 1860 to 1960 ft. in depth should be screened. The depth of this well requires extra strength construction and we recommend using double extra strong column and collapse strength 5 in. pipe size or triple extra strong collapse, double extra column strength...
8 in. pipe size stainless steel screen. We recommend gravel packing this well with a 16-20 Colorado Silica or similar gravel pack in conjunction with #30 slot (0.030-in.) screen.

Tom, we estimate the installed screen price of $90 and $137 per ft. for 5 and 8 in. screen, respectively. If we can be of any further assistance, please contact us.

JOHNSON DIVISION UOP INC.

Kurt Geiser  
Engineer

Enc.
Sample sent in by: Buell, Winter, Mousel & Associates

Town: North Platte State: NE Zip: 18 Jan. '83

From well of: City of Manderson, WY


U.S. STANDARD SIEVE NUMBERS

SLOT OPENING AND GRAIN SIZE, IN THOUSANDS OF AN INCH

<table>
<thead>
<tr>
<th>SIEVE NO.</th>
<th>SIEVE OPENING (INCHES)</th>
<th>SIEVE OPENING (MM)</th>
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<td>6</td>
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<td>0.42</td>
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<td>70</td>
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<tr>
<td>100</td>
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<td>0.15</td>
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</table>

Notes:

Recommended Slot Opening: ___________________

Recommended Screen: Dia. _______ in. Length _______ Ft.

By:____________________

SO MANY CONSIDERATIONS ENTER INTO THE MAKING OF A GOOD WELL THAT, WHILE WE BELIEVE SLOT SIZES FURNISHED OR RECOMMENDED FROM SAND SAMPLES ARE CORRECT WE ASSUME NO RESPONSIBILITY FOR THE SUCCESSFUL OPERATION OF JOHNSON WELL SCREENS.
Sample sent in by ____________________________

Town ____________________________ State ______ Zip ______ Date ______

From well of ____________________________

Remarks:

________________________________________________________

U.S. STANDARD SIEVE NUMBERS

<table>
<thead>
<tr>
<th>U.S. SIEVE</th>
<th>SIEVE OPENING</th>
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</tr>
<tr>
<td>100</td>
<td>0.006</td>
<td>0.052</td>
</tr>
</tbody>
</table>

SLOT OPENING AND GRAIN SIZE, IN THOUSANDTHS OF AN INCH

Wet Sieved
Mostly Coal

1840-1850
1860-1870

Notes:

Recommended Slot Opening: ____________________________

Recommended Screen: Dia. ________ in. Length ________ Ft.

By: ____________________________
### U.S. Standard Sieve Numbers

<table>
<thead>
<tr>
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<tr>
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</tbody>
</table>

**Recommended Slot Opening:**

---

**Recommended Screen:** Dia. in. Length Ft.

---

**Notes:**

---

**By:**

---

*SO MANY CONSIDERATIONS ENTER INTO THE MAKING OF A GOOD WELL THAT, WHILE WE BELIEVE SLOTS SIZES FURNISHED OR RECOMMENDED FROM SAND SAMPLES ARE CORRECT WE ASSUME NO RESPONSIBILITY FOR THE SUCCESSFUL OPERATION OF JOHNSON WELL SCREENS.*
SO MANY CONSIDERATIONS ENTER INTO THE MAKING OF A GOOD WELL THAT, WHILE WE BELIEVE SLOT SIZES FURNISHED OR RECOMMENDED FROM SAND SAMPLES ARE CORRECT WE ASSUME NO RESPONSIBILITY FOR THE SUCCESSFUL OPERATION OF JOHNSON WELL SCREENS.
APPENDIX "G"

Western Water Consultants, Inc.
(Analysis and Recommendations)
REPORT TO BUELL, WINTER, MOUSEL
AND ASSOCIATES ON TOWN OF MANDERSON
GROUND WATER STUDY

Prepared for
Buell, Winter, Mousel and Associates
123 West First Street
Suite C-70-37
Casper, Wyoming 82601

Prepared by
Western Water Consultants, Inc.
P.O. Box 3042
Sheridan, Wyoming 82801

February 8, 1983
February 8, 1983

Mr. Tom Werblow
Buell, Winter, Mousel and Associates
123 West First Street
Suite C-70-37
Casper, Wyoming 82601

Dear Mr. Werblow:

Please find enclosed our report with conclusions and recommendations derived from analysis of the hydrogeologic data gathered in the Manderson, Wyoming ground-water development study.

I believe that this report contains the information and fulfills the requirements of work discussed in our meeting and described in our letter of agreement, dated February 3, 1983.

Please do not hesitate to call me or Mr. Doyl Fritz of this office if you have any questions or comments in review of the report, or if we may be of any further assistance.

Sincerely yours,

Joe Gerlach, Hydrogeologist

JG/cas
The current water supply for the Town of Manderson, Wyoming is obtained from a water well developed in the Lance Formation. The capacity of the well has decreased markedly since it was completed in 1956, and is presently estimated to be less than 20 gpm. Under a grant from the Wyoming Water Development Commission the Town of Manderson has retained the firm of Buell, Winter, Mousel and Associates to complete a feasibility study and exploratory drilling program for development of ground water as a source of municipal supply. The projected water requirement for Manderson is approximately 70,500 gallons per day (75 gpm per 16 hour pumping day).

A ground-water feasibility study was completed in the fall of 1982. This report concluded that the Mesaverde Formation should be further explored, and recommended a drilling site about 1½ miles from Manderson. Following approval of the feasibility report the drilling firm of Sargent Irrigation, Inc. was subcontracted, and work on the exploratory well commenced in the late fall of 1983. Problems with drilling and testing were encountered, and drilling ceased before the Mesaverde Formation was entirely penetrated. The well was backfilled and abandoned. On February 3, 1983 the firm of Western Water Consultants, Inc. was contracted to evaluate the existing data and recommend a course of action to help redirect and complete the ground-water exploration program.

This report was prepared for, and at the request of Mr. Thomas Werblow of Buell, Winter, and Mousel and Associates, Casper, Wyoming.

This report contains WWC's analysis of geohydrologic data gathered by Buell, Winter, Mousel and Associates (BWMA) in their ground-water development study and exploratory drilling program performed for the Town of Manderson. In addition, this report recommends specific actions that should be taken to help insure successful development of an economical ground-water production well suitable for municipal use. The data reviewed in preparation of this analysis includes:

* Preliminary geologic reports by Loy Harris, geologist;
* Feasibility study geologic report by BWMA;
* Test hole geophysical, drill cutting, and ground-water quality data provided by BWMA;
* Analysis of drill hole cuttings for well screen selection, by Johnson Division, UOP, Inc.;
* Published water quality, yield and geologic data
Evaluation of Geohydrologic Data

This portion of the report contains an evaluation of the Town of Manderson's Ground-Water Grant Program Preliminary Geologic Report, the Feasibility Study Report, and the exploratory drilling project subsequently undertaken by BWMA of Casper, Wyoming.

The Preliminary Geologic Report written by Mr. L.E. Harris provided a general overview of the stratigraphy of the Bighorn Basin, the geologic structure in the Manderson area, and a brief review of hydrologic and water quality data from the Mesaverde aquifer. The report recommended development of a well in the Mesaverde Formation at a selected site for the Manderson water supply.

The Preliminary Geologic Report was utilized by BWMA as the research phase (Part II A) of the Feasibility Study. It is the opinion of the reviewer that the geologic report written by Mr. Harris does not provide sufficient screening criteria for all of the aquifers in the area to be regarded as a complete feasibility study.

In the Preliminary Geologic Report, several critical components of a hydrogeological analysis were not addressed. They include the following:

* Saturated thickness of the aquifer;
* Potentiometric surface gradients of the aquifer from which recharge and discharge areas may be determined;
* Aquifer parameters such as transmissivity; permeability, storage coefficient and specific capacity;
* Types of permeability such as intergranular, fracture, etc.;
* Sources of recharge to the aquifer; and
* Structural influence on aquifer yield and water quality.

Had the above items been addressed in the Feasibility Study, the conclusion concerning the objective aquifer may have been different, and the investigation would have necessarily considered other aquifers.

Water quality data available from the Bighorn Basin (Lowry and Lines, 1972, Chemical Analyses of Ground Water in the Bighorn Basin, Northwestern Wyoming: USGS and Wyoming State Engineer's Office) indicate that the waters of the Mesaverde Formation exceed the National Interim Primary Drinking Water Standards for sulfate (250 mg/l) and total dissolved solids concentrations (500 mg/l). At eight wells
within the Bighorn Basin sulfate concentrations range from 104 to 1630 mg/l. Sulfate concentrations at seven of the wells exceed 437 mg/l. Total dissolved solids concentrations at the same eight wells range from 923 to 2620 mg/l. Although the drinking water standards are only recommendations it is apparent that the quality of water in the Mesaverde Formation near Manderson may be unfavorable for municipal use.

Other, more suitable, aquifers may exist in the Manderson area and it is logical that the ground-water development study must identify all aquifers potentially suitable for municipal supply. Once the initial identification procedures are complete a test drilling site may be selected in consideration of economic constraints such as drilling costs, operating and water transmission costs, land acquisition, etc. In this manner, the aquifer(s) best suited for the most economical development may be selected for exploratory drilling and testing. If the results of the aquifer tests are favorable, final well development may proceed.

Exploratory Drilling Program

The exploratory drilling program carried out by BWMA and their contractor, Sargent Irrigation Company, provided much additional information on the lithology, water bearing properties, and water quality of the Mesaverde Formation. This information was briefly analyzed in the preparation of this report.

Though a geologist was not on site to record the lithology of the drill cuttings, the well driller did a commendable job of describing the cuttings at 20 foot intervals. With the exception of some minor discrepancies the driller's log correlates closely to the geophysical logs.

Gamma ray, spontaneous potential, and resistivity logs were run on the exploration hole to the total depth of 2040 feet. Two separate logging runs were performed at the test hole. The first run included spontaneous potential (S.P.) and resistivity logs. Water bearing sands were identified by this reviewer at the following depth intervals: 461-473 ft., 535-583 ft., 609-614 ft., 635-651 ft., 655-659 ft., 661-666 ft., 728-731 ft., 736-791 ft., 1441-1451 ft.; scattered thin sand units between 1545 and 1692 ft., 1729-1744 ft., and 1750-2020 ft.

The second run included gamma, S.P. and resistivity logs. The gamma ray log was run at a very small scale and provided poor lithologic definition, making interpretation very difficult. The S.P. log was inaccurate and thus was
not correlatable with the resistivity log. Very little information was provided by the second run in the test hole.

One water sample was obtained from the Mesaverde Formation between 1610 and 2040 feet in the interval of relatively thin sandstone units identified previously. A drill stem test tool was used, but only about 1 pint of water was retrieved. The results of this analysis are provided in the following tabulation along with a water sample analysis reported for Manderson's existing water supply well.

<table>
<thead>
<tr>
<th>Chemical Constituent</th>
<th>Concentration in Present Supply Well (mg/l)</th>
<th>Concentration in Test Hole (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Dissolved Solids</td>
<td>976</td>
<td>1,200</td>
</tr>
<tr>
<td>Fluoride</td>
<td>1.1</td>
<td>--</td>
</tr>
<tr>
<td>Sulfate</td>
<td>386</td>
<td>324</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>497</td>
<td>427</td>
</tr>
<tr>
<td>Chloride</td>
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<td>210</td>
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<tr>
<td>Carbonate</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Sodium</td>
<td>353</td>
<td>416</td>
</tr>
<tr>
<td>Calcium</td>
<td>6.2</td>
<td>17</td>
</tr>
</tbody>
</table>

The analyses above show that sulfate and total dissolved solids (TDS) concentrations of the water in both wells exceed the National Drinking Water Standards. It is likely that the high sodium-chloride and sulfate concentrations of the test hole water would exhibit a bitter, saline taste objectionable to the user. Because of the small amount of water recovered in the drill stem tool it is possible that the test hole sample represents a composite of water from aquifers above the tested interval mixed with drilling fluid water. The TDS content and chemical composition of the test hole water, however, are characteristic of most ground water in the Mesaverde Formation in the Bighorn Basin. Higher quality water does exist in the Mesaverde Formation where geologic structure provides rapid ground water movement and recharge. Such favorable conditions are normally restricted to zones of fracture enhanced permeability located adjacent to fresh water streams and mountain-flank outcrop sources of recharge.

Johnson Division, UOP, performed sieve analyses of the drill cuttings from the Manderson test hole. Their conclusions and recommendations for screen size, screen type, and gravel pack are satisfactory and should be followed if a Mesaverde Formation water well is installed at the test hole drilling site.

It is the conclusion of this reviewer that the waters
of the Mesaverde Formation at the location of the test hole are of poor quality and alternate sources of ground water for the Town of Manderson should be investigated. A thorough feasibility study should be conducted as part of this investigation. Recommendations for the scope of the study are included in the remainder of this report.

Recommendations For Further Work

This section of the report provides a methodology on site screening criteria that can be used to assess the ground water development potential for the various aquifers in the Manderson area. Additionally, specific aquifers believed to have development potential are identified.

The objective of the screening procedure is to determine the locations of and relative prioritization of test drilling sites with aquifers most favorable for municipal development. The procedure involves an orderly step-by-step method of identifying the geologic and hydrologic characteristics of all water-bearing units. The methodology of the process is summarized below.

A. Identify water-bearing stratigraphic units on the basis of spring and seep locations and productive zones encountered in existing wells.

B. Identify and map tectonic structures or other fracture zones that potentially increase the fracture permeability of the saturated rocks.

C. Prepare structure contour maps for the base of producing stratigraphic units. This map would be used to compute drilling depths and the approximate hydraulic gradients and zones of stratigraphically trapped water.

D. Prepare total dissolved solids contour maps of the productive water-bearing units.

E. Prepare potentiometric surface maps of the productive water-bearing units. These maps would be used to approximate ground-water flow directions and sources of aquifer recharge and for estimating static water level depths at favorable drilling sites.

Based upon the results of the analyses described above an exploratory drilling site would be selected in consideration of the constraints associated with well construction and water conveyances costs, potential water rights conflicts, land acquisition, etc. If the results of exploratory well drilling and hydraulics/water quality testing are favorable, final production well construction may proceed.
It is the opinion of the reviewer that each of the analytical procedures outlined above is critical to the successful and economic completion of a municipal supply well. A comprehensive hydrogeologic investigation of the Manderson area may indeed show that the Mesaverde Formation has development potential in selected areas. For instance, it is possible that the fracture permeability of the formation is enhanced and ground-water circulation and water quality are favorable along the crest of the Manderson Anticline approximately 1 to \( \frac{1}{4} \) miles northeast of the existing test hole site. Similarly, enhanced fracture permeabilities and good water quality may exist in the Madison Limestone Formation at depths of approximately 3,000 feet along the crest of the Bonanza Anticline about 6 miles northeast of Manderson.

It is probable that a comprehensive geohydrologic analysis of the Manderson area will identify other aquifers potentially suitable for test drilling and development. It is suggested that the study examine the possibility of developing the alluvial deposits of the Nowood and Bighorn Rivers. The primary source of recharge to these deposits, however, is very likely stream flow already appropriated by other users. It is known that wells 2,000 to 2,300 feet deep in the Madison Limestone Formation about 12 miles east of Manderson (T.49N., R.91W., Sec. 12 and T.50N., R.91W., Sec. 12) have flowing yields ranging from 1,000 to 14,000 gpm. These wells are developed in areas where the permeability of the aquifer has been enhanced by fractures associated with anticlinal and synclinal folds. The quality of these waters is excellent, with total dissolved solids contents less than 500 mg/l.

Manderson should examine other alternatives for applicability to the project. No mention has been made of the possibility of working-over the existing supply well. If the present problem with the well is only scaling and corrosion, an oil field service company such as Halliburton or Dowell should be contacted to discuss the possibility of acidizing and jetting the well. In addition, the Town of Worland, Wyoming has extremely productive wells completed in the Madison Limestone. Manderson should consider the possibility of tapping in on the Worland supply line. For budgeting purposes, however, it should be mentioned that the existing water development grant would not provide for any pipeline construction or well servicing fees.

Development of a well in the Mesaverde Formation near Manderson may be the most economical option since pipeline construction and conveyance costs would be minimized. If Manderson pursues this option it is crucial that the most favorable drilling site be selected in consideration of the effects geologic structure has on aquifer recharge, permeability and water quality. The existing data strongly
indicate that the quality of the water in the Mesaverde aquifer is poor for municipal use at the test hole location.

It is recommended that a competent geologist be on site during the drilling of any test or production well. The geologist would compile a log description of the drill cutting samples, review the geophysical logs and select preferential zones for drill stem testing and/or screen completion.

Conclusions

The geologic study which preceded the attempted construction of a test well in the Mesaverde Formation near Manderson was insufficient to identify the optimum aquifer or drilling location. A complete feasibility study, utilizing all available data, should be conducted. If the Mesaverde is selected following such a study a new test site should be selected and drilled on the basis of favorable geologic structure (e.g., near the crest of the Manderson Anticline) and hydrogeologic characteristics yet to be determined.