October 9, 1981

Sweetwater County Association of Governments
Mr. Dennis Watt, Director
County Court House
P.O. Box 1132
Green River, WY 82935

RE: Water Availability Study, South Superior, Wyoming
Project No. 0607-1

Dear Mr. Watt:

Enclosed please find 15 copies of our water availability report for the town of South Superior. All revisions suggested in your recent letter have been incorporated herein.

One of the 15 enclosed reports is not bound. This report contains reproducibles of all plates and figures.

If you have any questions concerning this project, please feel free to contact our office.

Respectfully submitted,

Scott G. Mefford
Manager, Technical Operations

SGM:kh
enclosures
HYDROGEOLOGIC REPORT
ON THE WATER SUPPLY SITUATION
OF THE TOWN OF SOUTH SUPERIOR,
SWEETWATER COUNTY, WYOMING

Prepared For:
SWEETWATER COUNTY ASSOCIATION OF GOVERNMENTS
Green River, Wyoming

Project No. 0607-1
October, 1981
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENERAL COMMENTS</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Discussion of Illustrations</td>
<td>3</td>
</tr>
<tr>
<td>Water Quality-General Comments</td>
<td>3</td>
</tr>
<tr>
<td>CONCLUSIONS AND RECOMMENDATIONS</td>
<td>10</td>
</tr>
<tr>
<td>DESCRIPTION OF SOUTH SUPERIOR AREA</td>
<td>13</td>
</tr>
<tr>
<td>Location</td>
<td>14</td>
</tr>
<tr>
<td>Population and Water Demand</td>
<td>14</td>
</tr>
<tr>
<td>Ground-Water Development in the Vicinity of South Superior</td>
<td>15</td>
</tr>
<tr>
<td>Discussion of Photogeologic Map</td>
<td>18</td>
</tr>
<tr>
<td>Overview of Geologic History and Stratigraphy</td>
<td>19</td>
</tr>
<tr>
<td>Surface Geology</td>
<td>22</td>
</tr>
<tr>
<td>Geologic Structure and Ground-Water Movement</td>
<td>24</td>
</tr>
<tr>
<td>Discussion of South Superior Area Type</td>
<td></td>
</tr>
<tr>
<td>Electric Log</td>
<td>25</td>
</tr>
<tr>
<td>Future Water Development Alternatives</td>
<td>26</td>
</tr>
<tr>
<td>Areas of Critical Concern</td>
<td>29</td>
</tr>
<tr>
<td>Well 14 - Special Caution</td>
<td>32</td>
</tr>
<tr>
<td>Pump Testing</td>
<td>33</td>
</tr>
<tr>
<td>Operational Considerations</td>
<td>34</td>
</tr>
<tr>
<td>Quality of Water - Wells 14 and 15</td>
<td>35</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>37</td>
</tr>
<tr>
<td>GLOSSARY OF TERMS</td>
<td>38</td>
</tr>
<tr>
<td>APPENDIX A</td>
<td>40</td>
</tr>
<tr>
<td>Water Analysis Report - Well 14</td>
<td>42</td>
</tr>
<tr>
<td>Water Analysis Report - Well 15</td>
<td>43</td>
</tr>
<tr>
<td>Casing Diagram - Well 14</td>
<td>44</td>
</tr>
<tr>
<td>Casing Diagram - Well 15</td>
<td>45</td>
</tr>
<tr>
<td>Sketch Profile of South Superior</td>
<td></td>
</tr>
<tr>
<td>Water Distribution System</td>
<td>46</td>
</tr>
<tr>
<td>Well Location Map, Superior Wells 14 and 15, Sweetwater County, WY</td>
<td>47</td>
</tr>
<tr>
<td>APPENDIX B</td>
<td>48</td>
</tr>
<tr>
<td>Public Notice Regarding Radiation Content in Water</td>
<td>49</td>
</tr>
<tr>
<td>Plate 1 - Surface Photogeologic Map</td>
<td></td>
</tr>
<tr>
<td>Exhibit 1 - Well Log of UPRR Well</td>
<td></td>
</tr>
</tbody>
</table>

Plate 1 - Surface Photogeologic Map...........................................(in back pocket)
Exhibit 1 - Well Log of UPRR Well...........................................(in back pocket)
CONTENTS (CONTINUED)

FIGURES

1. Index Map of Southwestern Wyoming Showing Major, Structural Features and Project Locality ........... 2
2. Generalized Geologic Cross-Section Looking NW across Study Area Near South Superior, WY ....... 4
3. Area of Critical Concern Near South Superior, WY ...... 30
5. Water Analysis Report - Well 15 ........................................ 39
6. Casing Diagram - Well 14 ................................................. 40
7. Casing Diagram - Well 15 ................................................. 41
8. Sketch Profile of South Superior Water Distribution System ......................................................... 42
9. Well Location Map, Superior Wells 14 and 15, Sweetwater County, WY ..................................... 43

TABLES

1. Primary and Secondary Drinking Water Standards Established by U.S. Environmental Protection Agency (1976) ................................................................. 6
2. Significance of Chemical Properties in Ground Water ................................................................. 7
3. Estimated Water Supply Requirements for South Superior, WY .................................................. 16
4. Water Development in the Superior Area (as of 10-6-80) ............................................................. 17
GENERAL COMMENTS

Introduction
At the request of the Sweetwater County Association of Governments, the following report was prepared. The report covers, among other things, the present ground-water supply status of the town of South Superior. The presently producing wells are evaluated and various possible future developments are considered. The impacts of present and proposed mining activities are examined and limitations are recommended. The geology of the area is discussed from the standpoint of age, structure, and stratigraphy (Figure 1).

The people of South Superior are also justifiably concerned that present and planned mining activities in the vicinity might result in degradation of the quality of their present water supplies. It is the purpose of this report to indicate to the citizens of the community the steps they can take to assure that they have adequate, potable water supplies sufficient to meet the near-term and long-term needs of the town of South Superior.

Willard Owens Associates, Inc. appreciates the opportunity to prepare this study and trusts that it will prove useful to all concerned governmental agencies and to the general public.
Figure 1. Index Map of Southwestern Wyoming Showing Major Structural Features and Project Locality.
Discussion of Illustrations

A high-quality, detailed photogeologic map (Plate 1) is included in this report. It has been checked in the field and is intended to indicate the areal extent and structural configuration of individual geologic units. Where faulting or fracturing with significant displacement is mapped, the effects are explained in the detailed discussion of the area. A geologic cross section (Figure 2) has been included to add a third dimension and to assist in the visualization of the subsurface conditions.

The accompanying geophysical log (Exhibit A, in pocket) is correlated and interpreted to show the rock types or lithologies in the selected well. The log also provides accurate measurements of depth to, and thicknesses of, the various geologic units.

Water Quality - General Comments

The following explanations and standards are presented here to assist in understanding this vital aspect of water development.

Potable water is simply water that is suitable for drinking. Water is determined to be potable based on the dissolved chemical constituents in the water. In general, the lower the amount of dissolved constituents, the better the water quality.
Generalized Geologic Cross Section Looking NW Across Study Area Near South Superior, Wyoming

WOA 607
Geochemical factors that influence water quality include temperature, pressure, and relative residence times of the ground water. In general, long resident times (the amount of time that the water is in the ground), combined with high temperatures and pressures, cause water qualities to deteriorate.

Contamination of ground water may occur as a result of natural contaminants inherent to the aquifer or as a result of man-made pollution. There is little that can be done about naturally-occurring contaminant, whereas something can be done about man-made pollutants.

The lower the dissolved chemical constituents, the better the water quality. The U. S. Environmental Protection Agency (EPA) has established a list of chemical constituents most commonly found in water and has determined recommended safe limits. A list of the constituents and recommended concentrations (referred to as Primary and Secondary Drinking Water Standards) are presented in Table 1. A summary of the harmful effects of the chemical constituents is compiled on Table 2.

There are numerous ways to evaluate water quality; however, two of the most common methods are according to total dissolved
Table 1. Primary and Secondary Drinking Water Standards Established by U. S. Environmental Protection Agency (1976).

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Primary Drinking Water Standard</th>
<th>Secondary Drinking Water Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>0.05 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>Barium</td>
<td>1 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.01 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>Chloride</td>
<td>-</td>
<td>250 mg/l</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.05 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>Coliform Bacteria</td>
<td>1 colony/100 ml</td>
<td>-</td>
</tr>
<tr>
<td>Color</td>
<td>-</td>
<td>15 color units</td>
</tr>
<tr>
<td>Copper</td>
<td>-</td>
<td>1 mg/l</td>
</tr>
<tr>
<td>Fluoride</td>
<td>2.0 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>Iron</td>
<td>-</td>
<td>0.3 mg/l</td>
</tr>
<tr>
<td>Lead</td>
<td>0.05 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>Nitrate</td>
<td>10 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>pH</td>
<td>-</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.01 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>Sodium</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sulfate</td>
<td>-</td>
<td>250 mg/l</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>-</td>
<td>500 mg/l</td>
</tr>
</tbody>
</table>

NOTE: All concentrations in mg/l.
Table 2. Significance of Chemical Properties in Ground Water.

Bicarbonate - Produces alkalinity; forms scale in boilers and releases corrosive carbon dioxide gas; poor taste.

Calcium - Forms scale; soap consuming; increases hardness.

Chloride - Salty taste; increases corrosiveness of water.

Color - May indicate presence of organic material; unsightly.

Total dissolved solids - a measure of the collective concentration of constituents in the water; the higher the value, the higher the concentration. Generally, the lower the concentration, the better the water quality.

Fluoride - Reduces the incidence of tooth decay and enhances enamel calcification. Large concentrations cause discoloration and mottling of teeth.

Hardness - Consumes soap before lather forms, and deposits a soap film on sinks and bathtubs. Forms scale in boilers and heating pipes.

Iron - Tastes unpleasant and promotes growth of iron bacteria. Large concentrations stain laundry and utensils.

Magnesium - Forms scale; soap-consuming; increases hardness of water.

pH - a pH of 7 indicates a neutral liquid, whereas higher values indicate increasing alkalinity; lower values indicate increasing acidity.

Potassium - Salty taste when in combination with large chloride concentrations.

Selenium - Toxic in small quantities. Can cause gastrointestinal disturbance, hair loss, weakened nails, and listlessness.

Silica - Forms scale.

Sodium - Salty taste.

Specific conductance - A measure of the capacity of water to conduct an electric current. Large specific conductance generally indicates poor-quality water.

Sulfate - Large concentrations have a laxative effect; bitter taste; may form scale.
solids and according to hardness. Total dissolved solids are the sum of all the dissolved constituents in the water and are measured in milligrams per liter (mg/l). The hardness of the water refers to the amount of dissolved calcium-carbonate and is also measured in milligrams per liter. General classifications of water quality according to total dissolved solids and hardness are as follows:

<table>
<thead>
<tr>
<th>Total Dissolved Solids</th>
<th>Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration (mg/l)</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>Best</td>
</tr>
<tr>
<td>501-1,000</td>
<td>Acceptable</td>
</tr>
<tr>
<td>1,001-1,500</td>
<td>Poor-marginal use</td>
</tr>
<tr>
<td>1,500</td>
<td>Not advisable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hardness</th>
<th>Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration (mg/l)</td>
<td></td>
</tr>
<tr>
<td>0-60</td>
<td>Soft</td>
</tr>
<tr>
<td>61-120</td>
<td>Moderately hard</td>
</tr>
<tr>
<td>121-180</td>
<td>Hard</td>
</tr>
</tbody>
</table>

In addition to standards for principal cations and anions, standards have been established for radioactive parameters. The EPA has set, as a maximum acceptable level of alpha and beta
radiation the following limits:

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Alpha</td>
<td>15 pC/l (picocuries)</td>
</tr>
<tr>
<td>Gross Beta</td>
<td>50 pC/l</td>
</tr>
</tbody>
</table>

The Wyoming Department of Environmental Quality (DEQ) has established the following suggested limits:

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ra226 + Ra228</td>
<td>5 pC/l</td>
</tr>
<tr>
<td>Gross Alpha</td>
<td>15 pC/l</td>
</tr>
</tbody>
</table>
CONCLUSIONS AND RECOMMENDATIONS

As detailed in subsequent pages of this report, the following conclusions and recommendations are presented:

- Superior wells 14 and 15 are presently capable of supplying the town's present and near-term needs for water. The yield of these wells could be increased by 50% to 100% by installing larger capacity pumps.

- Further increases in total water supplies can be achieved by deepening the existing well 15 by an additional 300 feet.

- Recent water quality analysis from South Superior wells 14 and 15 have identified radioactive parameters, principally Ra226, in excess of allowable quantities. The long term use of this water, without appropriate treatment or dilution of the water produced is not recommended. Selective cementing of contaminated zones in the well may reduce the radiation hazard.
- If radiation problems are resolved and the system demand increases to the point that the steps described fail to satisfy the needs of the town, a new well should be drilled. A site for this well should be selected only after an investigation of the extent of Ra226 contamination in the aquifer.

- The mining of leucite from Zirkel Butte will have no effect on the Ericson aquifer (which supplies the Superior wells).

- Mining of coal should be restricted to the upper 300 feet of the Almond Member in order to protect the underlying Ericson aquifer from possible contamination.

- The general area of outcrop of the Ericson Member, updip from the town wells, should be zoned as an "area of critical concern." No solid or fluid waste should be dumped or allowed to originate in this area, nor should mine effluents be permitted to drain across the area.

- No mining should be permitted within the Ericson outcrop area.
The potential for mercury contamination of the Ericson aquifer via Superior Well 14 must be considered possible. Extreme care must be taken to avoid any type of penetration past the present total depth in this well.
DESCRIPTION OF SOUTH SUPERIOR AREA

LOCATION
Location

The town of South Superior is located in section 28 and section 29, T. 21 N., R. 102 W. Access to the town is by Wyoming State Secondary Highway 430 which connects to Interstate Highway 80, seven miles to the south. This intersection is thirteen miles east of Rock Springs.

Because the town is situated in the midst of an area which has been intensively mined for coals of the Rock Springs member of the Mesaverde Formation, it was necessary to depend on wells located 7 miles to the east for all of their water supplies. At this latter locality, abundant potable water was developed from the Ericson Member of the Mesaverde Formation.

Population and Water Demand

The town of South Superior is dependent on two water wells located approximately 7 miles to the east of town. The water is pumped through a 10-inch pipeline to a system of three storage tanks located between the wells and the town. These wells have an estimated pumping capacity of 250 gpm. A duty cycle of 24 hours results in an effective yield rate of 250 gpm, or 360,000
gallons per day. However, due to antiquated and leaking portions of the delivery system, this figure is probably high. The town's requirements, including fire protection reserves, are approximately 357,200 gallons per day.

Ground-Water Development in the Vicinity of South Superior

There is no significant ground-water development in the vicinity of South Superior or anywhere near the town's wells in section 21, T. 21 N., R. 101 W. In section 33 of the same township, there are six shallow observation wells into the Almond Member. They vary in depth from 80 feet to 430 feet.

The nearest wells tapping the Ericson Member are 8 miles south and southwest of the South Superior wells. The deepest of the wells is 1,112 feet deep and is near the Union Pacific Railroad right-of-way. None of these wells, or any of the wells listed on Table 4, will affect the wells of South Superior.
Table 3 gives present and projected demand figures based on estimated population growth through the year 1989.

Table 3. Estimated Water Supply Requirements for South Superior, Wyoming.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Projected 1 Population</td>
<td>586</td>
<td>696</td>
<td>842</td>
<td>920</td>
<td>1,033</td>
<td>1,095</td>
</tr>
<tr>
<td>Water Supply Requirement 2</td>
<td>117.2</td>
<td>139.2</td>
<td>168.4</td>
<td>184.0</td>
<td>206.6</td>
<td>219.8</td>
</tr>
<tr>
<td>Fire Flow Requirement 3</td>
<td>240.0</td>
<td>240.0</td>
<td>240.0</td>
<td>240.0</td>
<td>240.0</td>
<td>240.0</td>
</tr>
<tr>
<td>Total Requirement 4</td>
<td>357.2</td>
<td>379.2</td>
<td>408.4</td>
<td>424.0</td>
<td>446.6</td>
<td>459.8</td>
</tr>
</tbody>
</table>

1 - projected population figures obtained from Sweetwater County, Population Projections, 1981-1989, (Revised) Sweetwater County Association of Governments.

2 - gallons per day, in thousands. Values for water requirements; 200 gpd/capita (gallons per day per person).

Table 4. Water Development in the Superior Area (as of 10-5-30).

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>USE</th>
<th>DEPTH OF WELL (FEET)</th>
<th>STATIC WATER LEVEL</th>
<th>AQUIFER</th>
<th>YIELD (GPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21N 101W 21SE 3/4NE 1/4</td>
<td>mun</td>
<td>1,200</td>
<td>120</td>
<td>Ericson</td>
<td>250</td>
</tr>
<tr>
<td>21N 101W 21SE 3/4NE 1/4</td>
<td>mun</td>
<td>1,235</td>
<td>120</td>
<td>Ericson</td>
<td>250</td>
</tr>
<tr>
<td>21N 101W 26SE 3/4SE 1/4</td>
<td>observ</td>
<td>87</td>
<td>71</td>
<td>Almond</td>
<td>0.0</td>
</tr>
<tr>
<td>21N 101W 33NE 3/4SW 1/4</td>
<td>observ</td>
<td>154</td>
<td>unknown</td>
<td>Almond</td>
<td>0.0</td>
</tr>
<tr>
<td>21N 101W 33SE 3/4NE 1/4</td>
<td>observ</td>
<td>238</td>
<td>91</td>
<td>Almond</td>
<td>0.0</td>
</tr>
<tr>
<td>21N 101W 33SE 3/4NE 1/4</td>
<td>observ</td>
<td>150</td>
<td>57</td>
<td>Almond</td>
<td>0.0</td>
</tr>
<tr>
<td>21N 101W 33SW 1/4NE 1/4</td>
<td>observ</td>
<td>431</td>
<td>340</td>
<td>Almond</td>
<td>0.0</td>
</tr>
<tr>
<td>21N 101W 34NE 3/4SW 1/4</td>
<td>observ</td>
<td>233</td>
<td>77</td>
<td>Almond</td>
<td>0.0</td>
</tr>
<tr>
<td>21N 101W 35NE 3/4NE 1/4</td>
<td>observ</td>
<td>80</td>
<td>45</td>
<td>Almond</td>
<td>0.0</td>
</tr>
<tr>
<td>20N 101W 27NW 3/4SW 1/4</td>
<td>rail</td>
<td>1,112</td>
<td>17</td>
<td>Ericson</td>
<td>100</td>
</tr>
<tr>
<td>20N 101W 27NW 3/4SW 1/4</td>
<td>rail</td>
<td>480</td>
<td>15</td>
<td>Ericson</td>
<td>100</td>
</tr>
<tr>
<td>20N 101W 27NE 3/4SW 1/4</td>
<td>dom</td>
<td>90</td>
<td>15</td>
<td>Almond</td>
<td>11</td>
</tr>
<tr>
<td>20N 101W 27NE 3/4SW 1/4</td>
<td>dom</td>
<td>340</td>
<td>25</td>
<td>Ericson</td>
<td>100</td>
</tr>
<tr>
<td>20N 101W 27SW 1/4SW 1/4</td>
<td>dom</td>
<td>305</td>
<td>30</td>
<td>Almond</td>
<td>15</td>
</tr>
<tr>
<td>20N 102W 28SW 1/4SW 1/4</td>
<td>dom</td>
<td>240</td>
<td>45</td>
<td>Rk Sorgs</td>
<td>20</td>
</tr>
<tr>
<td>20N 102W 28SW 1/4SW 1/4</td>
<td>dom</td>
<td>220</td>
<td>140</td>
<td>Rk Sorgs</td>
<td>20</td>
</tr>
</tbody>
</table>

Key:
- rail - railroad
- dom - domestic
- com - commercial
- mun - municipal
- observ - observation
Discussion of Photogeologic Map

The surface photogeologic map (Plate 1) of the area surrounding South Superior encompasses approximately 169 square miles. This area is situated on the northeast flank of the Rock Springs Uplift. Throughout the mapped area, the rocks dip to the east-northeast at an average angle of 4 1/2°. Except for the extreme southwest and the northeast portions of the area, all the rocks are members of the Upper Cretaceous, Mesaverde Formation. The sequence and rock types of the entire geologic section are as shown on the log section, Exhibit A.

The critical member of this sequence is the Ericson Member, which is predominantly sandstone and is the best water bearing member available. The surface outcrop of this aquifer is outlined in blue on Plate 1.

In the southern and eastern portions of the map area, numerous faults of small to moderate displacement are present. There are normal or gravity fractures which result from tension caused by the deep-seated forces which upwarped the earth's crust and created the Rock Springs Uplift.
Overview of Geologic History and Stratigraphy

Five formations are exposed in the South Superior study area. In order of age, from youngest to oldest, they are:

- Igneous flows and plugs
- Lewis Formation
- Almond Formation
- Ericson Formation
- Rock Springs Formation

All the geologic structures and formations present at the surface in the study area are of Cretaceous age, with the exception of Tertiary intrusives, alluvium, and eolian deposits. In the latter half of the Cretaceous age, the Rock Springs, Ericson, Almond, and Lewis Formations were deposited horizontally. At the end of the Cretaceous and during Early Tertiary times, this sedimentary sequence of rocks was subjected to uplifting, and subsequently, tilted to the northeast. Associated stresses due to uplifting caused east-west trending, high-angle faults and fractures.

Intrusive rocks dissected the gently dipping sedimentary rocks, while extrusive rocks capped the sedimentary rocks during Tertiary time.
Presently, sand, silt, mud, and gravel are being deposited in low lying areas as the result of water and wind erosion. Except for the igneous flows and plugs, all formations dip approximately 5° to the northeast. A cross section of the formations, looking northwest, is shown in Figure 2.

The oldest rock unit considered in the study is the Rock Springs Formation. Deposited during the Cretaceous age, the Rock Springs Formation involved the deposition of rocks in several types of environments. Marine shales are interbedded with inland coal deposits and deltaic, river channel sands. The sequence consists of fine-grained to medium-grained sandstones that are white to yellowish in color. They are interbedded with lignitic shales, coals, and clays. Total thickness of the Rock Springs Formation in this area is approximately 1,420 feet. The town of South Superior is situated on top of the Rock Springs Formation.

The next youngest rock unit is the Ericson Formation, deposited during late Cretaceous time in an inland flood-plain type of environment. The Ericson Formation consists of fine grained to coarse grained sandstones, that are white to rusty in color. The upper portion of the formation is a conglomeratic white sandstone. The middle members contain interbedded siltstones and
shales. The Ericson Formation is a well known aquifer in this area and stores vast amounts of water. The Ericson Formation is approximately 850 feet thick. This member forms the highest ridge just east of South Superior and forms the gray sandstone cliff behind the community of Point of Rocks on Interstate Highway 80.

The Almond Formation overlies the Ericson Sandstone. The Almond sequence of rocks consist of lowland and shallow marine deposits. The formation consists of sandstone (brown to light gray), siltstones, carbonaceous shales, and several coal seams. The Almond Formation may contain considerable amounts of water in the sandstone zones. The Almond Formation is about 750 feet thick.

An advancing sea covered the area during Late Cretaceous time and deposited the Lewis Formation on top of the Almond Formation. The Lewis Formation consists of marine shales which are light to dark gray, calcareous and carbonaceous. Beds contain very fine grained sandstones with interbedded siltstones. The Lewis Formation contains no water or coal, and is approximately 425 feet thick in the study area.

The valley which is immediately east of the Superior water wells (section 21, T. 21N., R. 101W.) and which extends on south to the
Jim Bridger Power Plant is formed on the gently dipping Lewis Formation.

At the close of the Cretaceous period, the flat lying sedimentary rocks of the study area were subjected to uplifting. Stresses accompanying the uplift activity generated high-angle faults across the area, which trend east-west. South Superior is located on the eastern flank of this uplift, and beds in this area dip gently towards the northeast.

During the Late Tertiary, igneous intrusive and extrusive rocks were emplaced north of Rock Springs. These rocks are very resistant to weathering and form topographic high points in the area. They contain very little water, and since they are younger in age and intrusive in nature, they probably intrude across all the sedimentary formations at depth in the study area. Figure 2 shows the sloping beds, several faults, and the intrusive body.

Surface Geology
The surface geology, as shown in Plate I, shows the outcrop patterns and structure, and the orientation of fault traces on the land surface.
In addition to the formations already discussed, other formations shown on the map should be mentioned here. Other than to show the lateral extent of the faulting, however, they have no influence on the present or future prospects for potable water in the South Superior area.

In the southwest corner of the map, Plate 1, the Baxter Formation and the basal Blair Member of the Mesa Verde Formation are present.

The Baxter Formation is the oldest formation present within the mapped area. It is a very thick (approximately 3,600 feet thick) shale and is devoid of significant aquifers.

Overlying the Baxter Formation is the Blair Member of the Mesa Verde Formation. It consists of fine sands and siltstones in its lower portion and grades into shales at the top. It has a total thickness of approximately 900 feet, and the small amount of water it yields (60 gallons per minute (gpm) average) is highly mineralized. The basal sandstone of the Rock Springs Member overlies the Blair Member.
In the northeast corner of the map, the Lance Formation is present. It is overlain by the lower part of the Fort Union Formation. In this area, these formations yield water only in small quantities.

Formations dip approximately $5^\circ$ to the northeast, with the strike (a horizontal line on the bedding plane surface) being generally northwest-southeast. East-west faulting trends become more numerous to the south and to the east of the town of South Superior.

**Geologic Structure and Ground-Water Movement**

In the southern and eastern portions of the study area, the Rock Springs, Ericson, and Almond formations are crosscut by nearly vertical faults that are oriented parallel to the direction of dip. Vertical displacements along these faults have been as much as 750 feet, but average vertical offsets are approximately 40 feet in the study area.

There are as many theories concerning the effects of faults on the movements of ground water as there are faults in the South Superior area. Basically, these theories stem from opinions regarding whether faults act as barriers or conduits to
ground-water movement. Depending on the area and the formations involved, examples can be cited to support either case.

In the South Superior area, the long, productive history of the town's wells seems to indicate that the fault displacements in the area have not been sufficient to cause a barrier condition. However, the only method of proving this would be by recording and plotting pumping levels in the wells for an extended period of time.

Discussion of South Superior Area Type Electric Log
The sample logs of wells 14 and 15 are not sufficiently detailed to determine positively their correlation with electrical logs of other wells in that general vicinity. However, it is safe to assume that the bottom sandstone logged from 788 feet to 1,200 feet and from 788 feet to 1,235 feet in the Superior wells correlates with the zone from 720 feet to 1,160 feet in the Union Pacific Railroad (UPRR) well No. 23-17 in the Zirkel Butte Area, NE1/4 SW1/4, section 17, T. 21 N., R. 101 W. This dry hole is located approximately 9,000 feet, or 1.7 miles, northwest of the Superior wells. Both of the Superior wells started at the top of the Almond Member and encounter nearly identical strata.
The log of the UPRR well (Exhibit A, in pocket), therefore, has been selected to show the types of strata which are probably present in the Superior wells. The log has been annotated to indicate the sandstone sections and the interbedded shale and coal zones. The probable position of the perforated 6-inch pipe in the Superior wells is also indicated. With a net sand zone aggregating approximately 350 feet, it is not surprising that the Superior wells have been excellent, long-lived, 200+ gpm wells.

It is also important to note that the basal 230 feet of the overlying Almond Member is predominantly shale with some thin interbedded coals. It is this zone and the top 150 feet of the Almond Member (not shown on the electric log) which are the impermeable zones, or aquacludes, which have protected the Ericson aquifers from contamination throughout recent geological time.

**Future Water Development Alternatives**

The radiation content observed in water from both wells 14 and 15 is unacceptably high for long term use and this problem must be resolved if continued use of these wells is planned. The principal contaminent appears to be Radium 226 which appears in well 14 in the range of 20-25 pC/l and in well 15 in the range of
130 to 150 pc/l. Radiation analysis of water from these wells conducted August 28, 1981, is as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Well #14</th>
<th>Well #15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ra226</td>
<td>25 pC/l (#3)</td>
<td>130 pC/l (10)</td>
</tr>
<tr>
<td>Gross Alpha</td>
<td>22 pC/l (#5)</td>
<td>130 pC/l (10)</td>
</tr>
<tr>
<td>Ra228</td>
<td>0</td>
<td>2.9 pC/l</td>
</tr>
<tr>
<td>Uranium</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The EPA recommends the gross alpha content should not exceed 15 pc/l.

The Ra226 problem may be able to be resolved through selectively cementing contaminated zones in the wells or through treatment of the water itself. To determine if work on the wells themselves could reduce Ra226 content in the water produced, the pumps should be pulled and natural gamma logs run in each well. If these gamma logs indicate that radioactive contaminants are entering the well from relatively thin contaminated zones in the aquifers, the wells may be selectively cemented or "squeezed" in these areas to seal out the bad water. If the Ra226 does not appear localized other means of controlling it must be considered. The Ra226 can be removed by a simple water softening process, however, such processing of all of the town's water could entail considerable expense.
All evidence to date indicates that the existing Superior wells are capable of continuing to produce water at their present rate virtually indefinitely. If, the radiation problems can be resolved and a marked increase in water demand is experienced, larger pumps could be installed in the existing wells. The exact size of this increased capacity can only be determined by a prolonged (possibly 7-day) pump test of one of the wells using a 500 gpm pump.

It would also be possible to deepen well 15 by approximately 300 feet and to install a perforated 50-inch liner in order to draw water from the lower, untapped series of Ericson sands. It is estimated that such a program could result in an immediate increase in yield in excess of 100 gpm. If done in conjunction with the replacement of the pump, the cost of drilling deeper may be very economical.

Should it be found that neither well reconstruction (selective cementing of contaminated zones) nor water treatment is a feasible solution to radiation problems, a new well will have to be considered. Since the Ericson is the most prolific aquifer in the vicinity, a new Ericson well should first be considered. Superiors' wells 14 and 15 are close together, yet the Ra226 content in well 14 is significantly lower than that of well 15.
This suggests that the mineralization contributing to the Ra226 content in the wells may be localized and might not be encountered in other properly designed Ericson wells. Although there are not many other Ericson wells in the immediate vicinity, we suggest sampling the nearest Ericson wells and running radiation analyses on the water. If other Ericson wells appear free of radiation, a new Ericson well should be considered by the town.

If the Ericson aquifer appears contaminated on a regional basis, other aquifers must be considered. The most likely source of water would be the Rock Springs Formation which directly underlies the Ericson. A well penetrating the Rock Springs Formation in the vicinity of the existing town pipeline would have to be 2,000-2,500 feet in depth. The Rock Springs formation contains numerous coals and water in this unit may be high in iron and other minerals. Because of the mining in this formation in the immediate vicinity of South Superior, water quality in the outcrop area of the Rock Springs Formation is expected to be especially poor. Consequently, if wells penetrating this formation are considered, we would recommend that they be constructed 4 to 7 miles east of town.

**Area of Critical Concern**

An "area of critical concern" has been outlined on a copy of the photogeologic map (Figure 3). This outline encompasses the
Figure 3

Area of Critical Concern Near South Superior, Wyoming

Scale 1" = 4000'

- PROPOSED LEASING AREAS
outcrop area of the Ericson Member, which is the recharge area for the town wells. This area is one in which limitation on development should include, but not be limited to, the following:

- No official or unofficial sanitary land fills or dumps permitted.
- No septic tanks or any type of sewage effluent permitted.
- No mine effluents permitted to drain through the area.
- No mining within the area.

The cross-hatched areas to the northwest of the critical concern area are being proposed for coal leasing by the Bureau of Land Management (BLM). One 160-acre tract (SE/4, section 10, T. 21 N., R. 102 W.) covered in this proposal falls within the area of concern. It is recommended that action be taken to have the tract deleted from the areas proposed for leasing.

If an area of critical concern is established, and if the aforementioned controls are enforced, the aquifers should be adequately protected to continue serving the citizens of the South Superior area.
Well 14 - Special Caution

In the course of replacing a submersible pump in well 14 in 1977, a Byron-Jackson, oil field-type pump was being installed. This pump was dropped to the bottom of the well, approximately 1,200 feet deep. Despite efforts by two different contractors, the pump was never retrieved.

This event is important because the pump dropped in the well contained a mercury seal. So long as the pump does not disintegrate due to decomposition of its metallic parts by naturally occurring chemical action, it is not a hazard to the aquifer. However, the presence of the pump in the hole precludes any drilling to deepen the hole and also means that any "clean out" operations must be carefully controlled to avoid damaging the pump body.

It is virtually beyond comprehension why no efforts were made to emplace cement in the hole to surround the pump when all retrieval efforts failed. It may be assumed that by now (1981) a few feet of sand covers the pump.

Because of this situation, we recommend that the bottom portion of well 14 remain undisturbed. Further, we recommend that periodic chemical analyses of the commingled waters from wells 14
and 15 be made to check for mercury in the water.

This is another reason to provide sufficient distance between the two existing wells and any new well which might be drilled in the future.

**Pump Testing**

On May 20, 1981, an attempt was made to perform an aquifer test in the two South Superior town water wells. Well 15, located 630 feet south of well 14, was used as the pumped well because it had an operational water meter. Both wells were equipped with air lines which were intended to be used to determine water-level during pumping.

Both pumps had been off for more than 10 hours prior to starting the pump in well 15. The rate of flow stayed constant at 230 gallons per minute for the duration of the test. There was a drawdown of 4.6 feet in the first 5 minutes of pumping, but continuous pumping for the next 14 hours showed no further drop in pumping level.

There was no access to either well head, except for the air lines. There was one electric-powered air compressor available to measure pressures, and therefore, water levels. When the air
compressor was started up at well 14 (the intended observation well), it immediately blew the fuses in the 110-volt line.

There were no problems obtaining readings at well 15; however, because the pump at this well was only capable of causing a 4.6 foot drawdown in the pumping well, it was assumed that the drawdown at well 14 (625 feet away) would be negligible and the testing continued.

The static water (non-pumping) level recorded in 1943 in both wells was 120 feet. The static water level in May, 1981 was 231 feet in well 15. This means that in the intervening 38 years there has been a drop of 111 feet, or an average of 2.9 feet per year, in well 15.

The pump is reportedly set at 345 feet. This means that the pump is set 114 feet below the static water level and 109.4 feet below the water level while pumping.

**Operational Considerations**

Allowing a safety factor of 50 feet of submersion for the existing pump, it is estimated that, barring electro-mechanical problems, the pump can remain undisturbed for approximately 20 years.
It should be noted that a 60-foot drop in pumping level will be reflected by a corresponding drop in flow rate. This is because the pump has to work harder to consume more horsepower to raise the water that additional height.

It is of extreme importance, however, that complete historical records be maintained on these wells. These should include:

- Daily recorded hours of operation.
- Daily and monthly water production totals.
- Monthly static water and pumping level readings. Weekly would be even better.
- Quarterly or semi-annual voltage and amperage checks with a clamp-on type meter should be read and recorded. These may indicate impending electro-mechanical problems before they occur.

These data will provide the South Superior Town Maintenance Department with information regarding the condition of the wells and the pumping equipment. Further, if it becomes necessary to call out a pump service company, these data will assist them in diagnosing problems.

**Quality of Water - Wells 14 and 15**

The waters analyzed from wells 14 and 15 are very similar in character. Energy Analytical Laboratory of Casper, Wyoming, ran these analyses. In their opinion, these waters are of good
quality and within the range of limits established by the U.S. Environmental Protection Agency (EPA). Further, in their opinion the range of differences are so slight as to indicate that the waters are from the same aquifer (Figures 4 & 5).

In addition to the fact that these waters "taste good," the total dissolved solids of 354 mg/l (well 14) are well below the less than 500 mg/l limit set by public health agencies for "best" quality waters. In Wyoming, the next items of most concern are the sulfate and chloride anions, and the sodium cation. In this case, these components are all less than half of the established standard maximums. The extremely low sodium content indicates the water poses no hazard to persons with heart problems. The bicarbonate is easily treatable with standard water-softening techniques.

Although the standard anion and cation concentrations in this water are low, there remains the problem with Ra226 as previously discussed. The public notice identifying this problem and presenting the radiation levels identified in the first sampling is included, see Appendix B.

1 Personal Communication, Warco Pump Co.
REFERENCES


GLOSSARY OF TERMS

Aquifer - A water-saturated geologic unit that will yield water to wells or springs in quantities sufficient to be a practical source of water supply.

Artesian aquifer - An aquifer with a confining formation overlying it and with a pressure within sufficient to cause water to rise above the confining layer when penetrated by drilling.

Water table aquifer - An aquifer wherein the water level is below any confining layer. (Example: flood plain wells.)

Piezometric surface - An imaginary surface representing the artesian pressure, or hydraulic head or levels, to which water will rise above the artesian aquifer zone.

Porosity - The volume of a rock or formation: that is, void space or pore space.

Permeability - The capacity of a porous medium to transmit water.

Coefficient of transmissivity (T) - The rate of flow in gallons per day through a vertical section of an aquifer whose height is the thickness of the aquifer and whose width is 1 foot when the hydraulic gradient is 1.0.

Coefficient of storage (S) - The volume of water released from storage, or taken into storage, per unit of surface area of the aquifer per unit change in head.

Specific capacity - Yield per unit of drawdown of a well, usually expressed as gallons per minute per foot of drawdown.

Static water level (SWL) - The level of water in a well under non-pumping conditions.

Pumping level - The level of water in a well when pumping is in progress.

Drawdown - The difference in water level between the static and pumping level.
Formation - A gross geologic unit capable of being differentiated from other units either in surface outcrop or in geophysical logs of wells. May be composed of varying rock types.

Member - A subordinate unit of a formation which can be differentiated in surface outcrop or in geophysical logs or wells.
APPENDIX A
WATER-QUALITY ANALYSES
CASING DIAGRAMS, PROFILE
OF DISTRIBUTION SYSTEM
Discussion of Schematic Casing Diagrams

The schematic casing diagrams on the following pages (figures 6 and 7) illustrate the details of the casings and present the amount of open hole to the best of our knowledge. These diagrams are based on old records and fragmentary documentation of recent remedial activities. Copies of the available source documents are included.

Well to Town Distribution System

It is beyond the scope of this report to discuss the South Superior water system beyond the well heads. However, a sketch profile (figure 8) was provided by Mr. Robert Johnson, P.E., of Johnson, Fermelia & Crank, Rock Springs, Wyoming, and is included here in the interest of clarity and for future reference.

Well Location Map

The well location map (figure 9) is a plat of the locations of wells 14 and 15 as taken from the original surveyor's description taken from well records filed with the Wyoming State Engineer in 1943.
ENERGY ANALYTICAL LABORATORY  
826 EAST 'A' STREET  
CASPER, WYOMING

WATER ANALYSIS REPORT

OPERATOR  Willard Owens & Associates  
WELL NO.  #14 S. Superior Sec. 21  
FIELD  
COUNTY  Wyoming  
STATE  Wyoming  
WATER ANALYSIS REPORT  
DATE RECEIVED  5/15/81  
LAB NO.  599-1

LOCATION  
FORMATION  
INTERVAL  
SAMPLE POINT  

OTHER PERTINENT DATA:  Sampled 5/13/81

<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>
<td>8</td>
<td>0.3480</td>
<td>SULFATE</td>
<td>118</td>
<td>2.4544</td>
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<tr>
<td>POTASSIUM</td>
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<td>CHLORIDE</td>
<td>6</td>
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<tr>
<td>CALCIUM</td>
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<td>CARBONATE</td>
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<td>0.0</td>
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<tr>
<td>MAGNESIUM</td>
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<td>BICARBONATE</td>
<td>283</td>
<td>4.6412</td>
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<tr>
<td>IRON</td>
<td></td>
<td></td>
<td>HYDROXIDE</td>
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Total equivalents of cations  7.9561  
Total equivalents of anions  7.2648  
Equivalent Balance Percentage  4.5%

REMARKS:

Total Dissolved Solids @ 180° C. (mg/l)  434
Observed pH  6.85
Specific Resistance @ 68° F. (ohm-meters)  780

WATER ANALYSIS PATTERNS

LOGARITHMIC

STANDARD

Figure 4.

NOTE:  Mg/l = Milligrams per liter  
Meq/l = Milliequivalents per liter  
Sodium chloride equivalent by Dunlap & Hawbourn calculation from components
# ENERGY ANALYTICAL LABORATORY
826 EAST 'A' STREET
CASPER, WYOMING

WATER ANALYSIS REPORT

OPERATOR: Willard Owens & Associates
WELL NO.: 015 S. Superior Sec. 21
FIELD: 
COUNTY: 
STATE: Wyoming

DATE RECEIVED: 5/15/81
LAB NO.: 599-2
LOCATION: 
FORMATION: 
INTERVAL: 
SAMPLE POINT: 

OTHER PERTINENT DATA: Sampled 5/12/81

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<tr>
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<td>POTASSIUM</td>
<td>14</td>
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<tr>
<td>CALCIUM</td>
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<tr>
<td>MAGNESIUM</td>
<td>21</td>
<td>1.7262</td>
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<tr>
<td>IRON</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total equivalents of cations: 6.3235
Total equivalents of anions: 6.0966
Equivalent Balance Percentage: 1.8%

<table>
<thead>
<tr>
<th>ANIONS</th>
<th>mg/l</th>
<th>meq/l</th>
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<tbody>
<tr>
<td>SULFATE</td>
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<td>CHLORIDE</td>
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<td>CARBONATE</td>
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<tr>
<td>BICARBONATE</td>
<td>278</td>
<td>4.5592</td>
</tr>
<tr>
<td>HYDROXIDE</td>
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<td></td>
</tr>
</tbody>
</table>

Total Dissolved Solids @ 180° C. (mg/l): 354
Observed pH: 6.61
Specific Resistance @ 68° F (ohm-meters): 590

REMARKS:

WATER ANALYSIS PATTERNS

LOGARITHMIC

STANDARD

![Graphs showing water analysis patterns](Image)

(Notes: Mg/l = Milligrams per liter, Meq/l = Milligram equivalents per liter. Sodium chloride equivalent is by Dulan & Hawthorne calculation from components.)
Figure 6. Casing Diagram, Well 14.

-44-
UPRR - Superior No. 15
NE NE Sec.21, T. 21 N., R. 101 W.
Drilled Sept., 1943

SURFACE

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>60'</td>
<td>Surface</td>
</tr>
<tr>
<td>215'</td>
<td>Sandstone &amp; Shale</td>
</tr>
<tr>
<td>330'</td>
<td>Sandstone</td>
</tr>
<tr>
<td>350'</td>
<td>Shale</td>
</tr>
<tr>
<td>450'</td>
<td>Sandstone &amp; Shale</td>
</tr>
<tr>
<td>787'</td>
<td>Shale</td>
</tr>
<tr>
<td>793'</td>
<td>12&quot; casing</td>
</tr>
<tr>
<td>787'</td>
<td>8&quot; diameter hole</td>
</tr>
<tr>
<td>1,235'</td>
<td>6&quot; perforated casing</td>
</tr>
<tr>
<td>1,235'</td>
<td>T.D.</td>
</tr>
</tbody>
</table>

Horizontal scale: 1" = 10'
Vertical scale: 1" = 200'

Figure 7. Casing Diagram, Well 15.
WEST

APPROXIMATELY SEVEN MILES TO TOWN

EAST

150,000 GAL. STEEL TANK

TO CITY DISTRIBUTION SYSTEM

100,000 GAL. TANK

VALVE

10" PIPELINE

30,000 GAL. UNDERGROUND TANK

BOOSTER STATION

2 40 h.p. pumps

CONTROL

WELL #14

WELL #15

Both wells pumping 230 gpm with submersible pumps

Each well pump runs 24 hours on alternate days.

Total tank storage 280,000 gallons

Figure 8. Sketch Profile of South Superior Water Distribution System.
Figure 9. Well Location Map, Superior Wells 14 and 15, Sweetwater County, Wyoming.
APPENDIX B

PUBLIC NOTICE REGARDING
RADIATION CONCENTRATIONS
IN WATER SUPPLY
The Town of South Superior, in compliance with the Safe Drinking Water Act, announces that samples taken and analyzed from the town wells Nos. 14 and 15 have been found to possibly be in excess of the Maximum Contaminant Level for Gross Alpha and Gross Beta radioactivity. There was information contained in the analyses that have raised question of their validity. The town, at the request of the Environmental Protection Agency, has resampled the wells and forwarded the samples to the Environmental Protection Agency for analysis.

The levels found within the water system are:

- Gross Alpha: 144 pico-Curies (pC)
- Gross Beta: 39 pico-Curies (pC)

The allowable Maximum Contaminant Level for these two parameters has been established by the Environmental Protection Agency to be:

- Gross Alpha: 15 pC
- Gross Beta: 50 pC

There is no immediate public health hazard from this water. Radioactivity levels in excess of the Maximum Contaminant Level have not been yet verified. If levels in excess of the Maximum Contaminant Level are verified, there is no short-term exposure danger. Excess radiation in the very small amount found in this water would take many years of continuous exposure to be harmful.

Although there is no significant health hazard from short-term consumption of this water, the town will make an alternate source of drinking water available for those who do not wish to consume the well water. The results of the confirming analyses will not be available for two to three weeks. The town is exploring alternative water sources should the confirming samples prove to be in excess of the Maximum Contaminant Level.

Clifford W. Overy
Mayor
AERIAL PHOTO OVERLAY SHOWING
SURFACE FEATURES IN VICINITY OF SOUTH SUPERIOR,
SWEETWATER COUNTY, WYOMING
SPOHTANEOUS POTENTIAL

EXHIBIT A