# ATTACHMENT A

# GROUNDATER SOURCE EVALUATION
# BEAVER LAKE, NEBRASKA

October 31, 2006

Mr. Rick Rohan, P.E.
Snyder & Associates, Inc.
1800 West 22nd Street
Suite 200
Atlantic, IA 50022

**RE: Groundwater Source Evaluation**
**Beaver Lake, Nebraska**

Dear Mr. Rohan, P.E.:

Layne Christensen Company (Layne) was retained by Snyder and Associates (Snyder) to evaluate the available groundwater sources of supply near Beaver Lake, Nebraska (Site), located approximately five (5) miles south of Plattsmouth, NE. The objective of the Groundwater Source Evaluation is to identify an aquifer that can be used to supply approximately 2,000 gallons per minute (gpm) of groundwater to the Beaver Lake community.

Several sources of geologic and hydrogeologic data were used to evaluate the suitability of the aquifers near the Site as a groundwater source, including:

- Boring logs from test drilling activities performed by Layne in 1970/1971;
- Boring logs from test drilling activities performed by Layne in 2005;
- University of Nebraska Lincoln Conservation and Survey Division (UNLCSD) Water Survey Publications;
- Nebraska Department of Natural Resources (NDNR) 2006 Annual Evaluation of Availability of Hydrologically Connected Water Supplies – Lower Platte South NRD; and
- NDNR Registered Groundwater Wells Database.

## REGIONAL GROUNDWATER SOURCES

The UNLCSD has identified the study area as Groundwater Region 11, which includes all of Cass County. The description of the groundwater resources, as provided by UNLCSD, is included below:

> "Groundwater Region 11 occupies the glacial drift area of southeastern Nebraska. The base of the principal groundwater-bearing units in the northern and western parts of the region is the Dakota Group. The Dakota Group consists of variable amounts of interbedded sandstone and shale. In the extreme western part of the region, Cretaceous shales and limestone of the Greenhorn-Graneros and Carlile formations form the base of

the principal groundwater-bearing units. In the southeastern part of the region, the base of the primary groundwater system is the relatively impermeable Pennsylvanian and Permian limestone and shale. Overlying these bedrock units are Pleistocene deposits consisting of the debris from glacial ice sheets, streams, and wind deposition. Erosion created numerous ancient valleys (paleovalleys) that were usually filled with relatively coarse Pleistocene sand and gravel. In areas where valleys did not exist, they were filled with fine-grained materials, primarily glacial tills over which wind- blown silts or loess was deposited.

The primary units from which groundwater is obtained are sand and gravel deposits associated with paleovalleys and along some modern stream valleys; these are usually of limited extent. Nearly all major water supplies in this region come from the paleovalleys. The Dakota Group serves as a secondary source of groundwater where the primary Pleistocene sources are insufficient to meet water-supply needs. Because of its geologic variability, the Dakota Group's capacity to yield groundwater can differ over short distances; consequently, well yields can be difficult to predict. The thickness of the saturated groundwater-bearing units is generally less than 300 feet. Depth to the regional water table varies as a function of topographic location. In upland areas, depth to water may be greater than 200 feet, while it may be less than 50 feet in the bottomlands of the principal valleys. Depending on groundwater-bearing unit and its location, total dissolved solids may differ from 200 to more than 1,000 milligrams per liter (mg/L). In some areas, the Dakota Group may have total dissolved solids exceeding 5,000 mg/L."

Based on the description provided by the UNLCSD, the available options for groundwater supplies near the Site can be summarized as:

1. Unconsolidated aquifers
    a. Paleovalleys – also known as buried glacial valleys. These aquifers are associated with pre-glacial drainage systems that have been filled by clay, silt, sand, or gravel. These valleys have been buried by younger geologic materials and cannot be detected at the ground surface without the use of test drilling or geophysics.
    b. Alluvial valleys associated with present day streams.
2. Bedrock aquifers
    a. Dakota Group -- Generally consists of the Dakota Sandstone.
    b. Permian/Pennsylvanian Group – Consists of several limestone and shale formations.

## AVAILABLE LOCAL SOURCES

A detailed review of existing data was performed to evaluate the presence or absence of the identified regional groundwater sources at the Site. The following conclusions were obtained:

- No paleovalleys are located near the Site. The paleovalley closest to the Site that Layne has experience drilling in is located east of Union, NE.
- The Dakota Aquifer is not located near the Site. Figure 1, obtained from the NDNR, presents the bedrock geology of the study area. As shown on this figure, the Dakota Group is absent in the

study area, where the bedrock consists of relatively impermeable Pennsylvanian and Permian age limestone and shale.

- Several alluvial systems are located near the site. The primary alluvial systems are the flood plains of Rock Creek/Squaw Creek and the Missouri River.

Based on these findings, it was determined that the most reliable groundwater sources near the Site are the alluvial aquifers. Due to the proximity of the Site to the Missouri River, it is recommended that any future water supplies for the Site be obtained from the Missouri River alluvial aquifer.

## FUTURE EXPLORATION

Layne completed test drilling activities in 2005 which identified a suitable location for a full scale water supply well in the Missouri River alluvial aquifer. The test location was completed [redacted] This location appears to be an acceptable development site for a full scale water supply well.

The Missouri River alluvium is the groundwater source in the study area that is most likely to deliver a sustainable water supply at the flow rate required by the project. However, additional investigation of the [redacted], may yield alternative locations for a water supply well. If an acceptable location is found in this area, it could save approximately one half (½) to one (1) mile of transmission pipeline. It is recommended that any future investigations focus on the alluvial aquifer near the [redacted] Missouri River alluvial aquifer [redacted], as shown on Figure 2.

## DESIGN CONSIDERATIONS/SUSTAINABLE YIELD

### Well Design Considerations

A water supply well located near a surface water source could be classified as a groundwater under direct influence of surface water (GWUDI), which requires treatment for viruses and bacteria. Nebraska Health and Human Services (NHHS) regulations state that if a well is screened below 50 feet from the top of ground surface, the well will not be considered a GWUDI. It is recommended that any wells constructed in the alluvial systems be designed with a screen interval that is deeper than 50 feet below ground surface.

NHHS regulations also state that new water supply wells should be spaced a minimum of 1,000 feet from existing water wells. A search of the NDNR Registered Groundwater Wells Database shows that several domestic supply wells are located in Sections 16 and 17, near the potential investigation areas for future wells. The results of the NDNR database query have been included as Attachment A. Groundwater exploration in areas located within 1,000 feet of domestic supply wells should be avoided. Prior to construction of any permanent water supply wells, the location of the new well relative to existing domestic supply wells should be field verified. To minimize the potential for groundwater recirculation (pumping lake water), any new water supply wells should be located a minimum of 1,320 feet from Beaver Lake.

### Estimated Well Yield

Based on preliminary design parameters, a sustainable yield of 1,700 gpm was estimated for a pumping well completed in the Missouri River alluvial aquifer. The calculations presented are only an estimate developed using regional aquifer parameter values and should only be regarded as an estimated well yield. Site specific well yields could be calculated if an aquifer test is performed at the desired well location. Calculations are presented in Attachment B

## SUMMARY

The following summarizes the conclusions of the Groundwater Source Evaluation for Beaver Lake:

- The Missouri River alluvial aquifer is the groundwater resource most likely to meet the long term water supply needs for the project;
- An acceptable water supply well location has been identified through previous investigations [redacted];
- The overlapping flood plains of Rock Creek and Squaw Creek could provide a groundwater source alternative to the Missouri River alluvial aquifer. This could reduce the amount of transmission piping required. Additional test drilling/exploration is required to evaluate the potential viability of this source;
- Any new water supply wells should be constructed with a screen interval starting below 50 feet bgs to avoid water treatment issues associated with the GWUDI rule;
- New water supply wells should be located a minimum of 1,000 feet from other existing water supply wells; and
- The design yield of a new well constructed in the Missouri River alluvial aquifer is approximately 1,700 gpm

Layne appreciates this opportunity to work with Snyder and Associates on this important water supply projects. If you have any questions or concerns associated with this study, please contact the undersigned at (913) 321-5000.

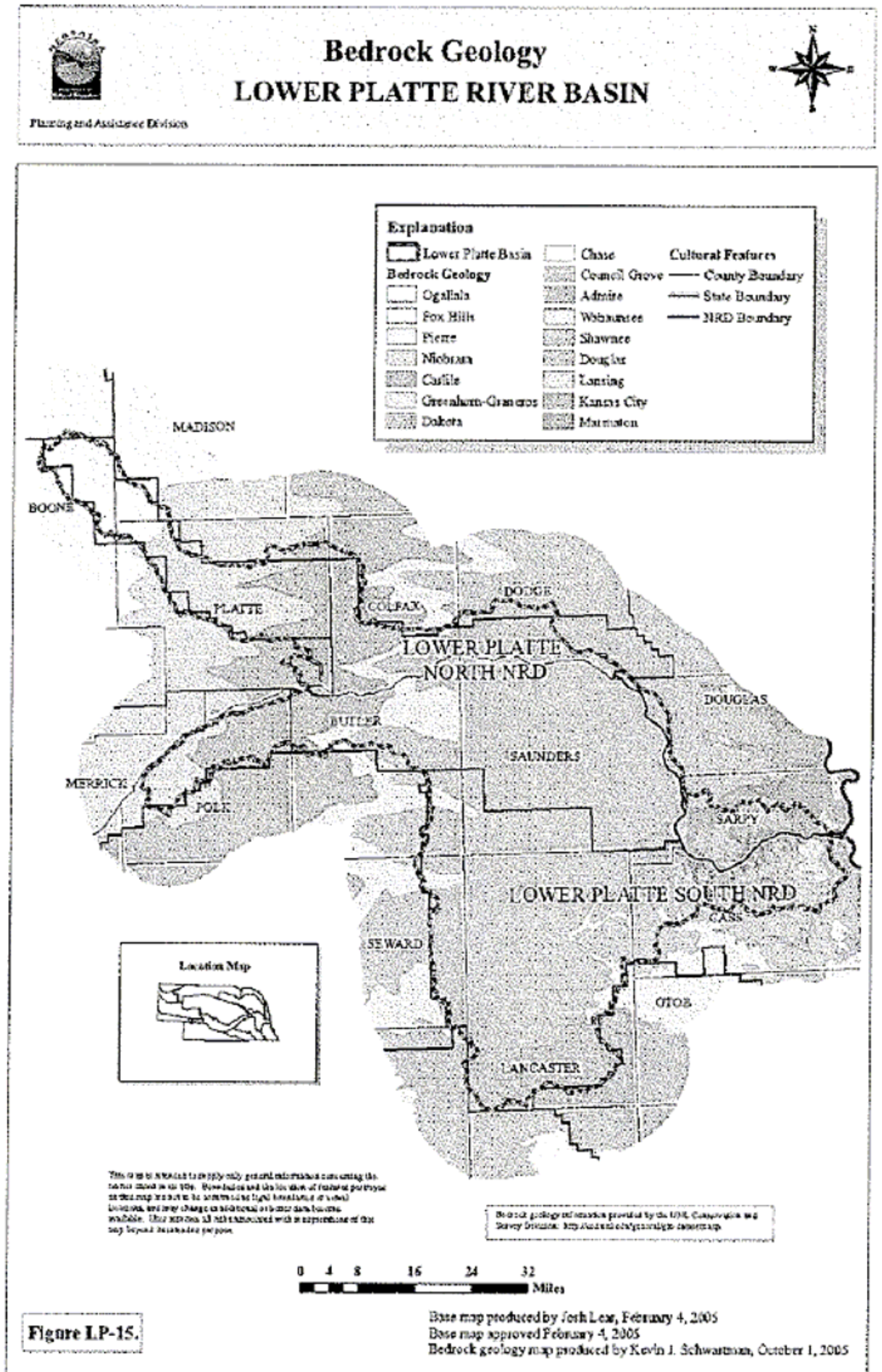
Sincerely,

Luca DeAngelis, P.E., R.G.

**Layne Western**

***a division of Layne Christensen Company***

# FIGURES




LP-26

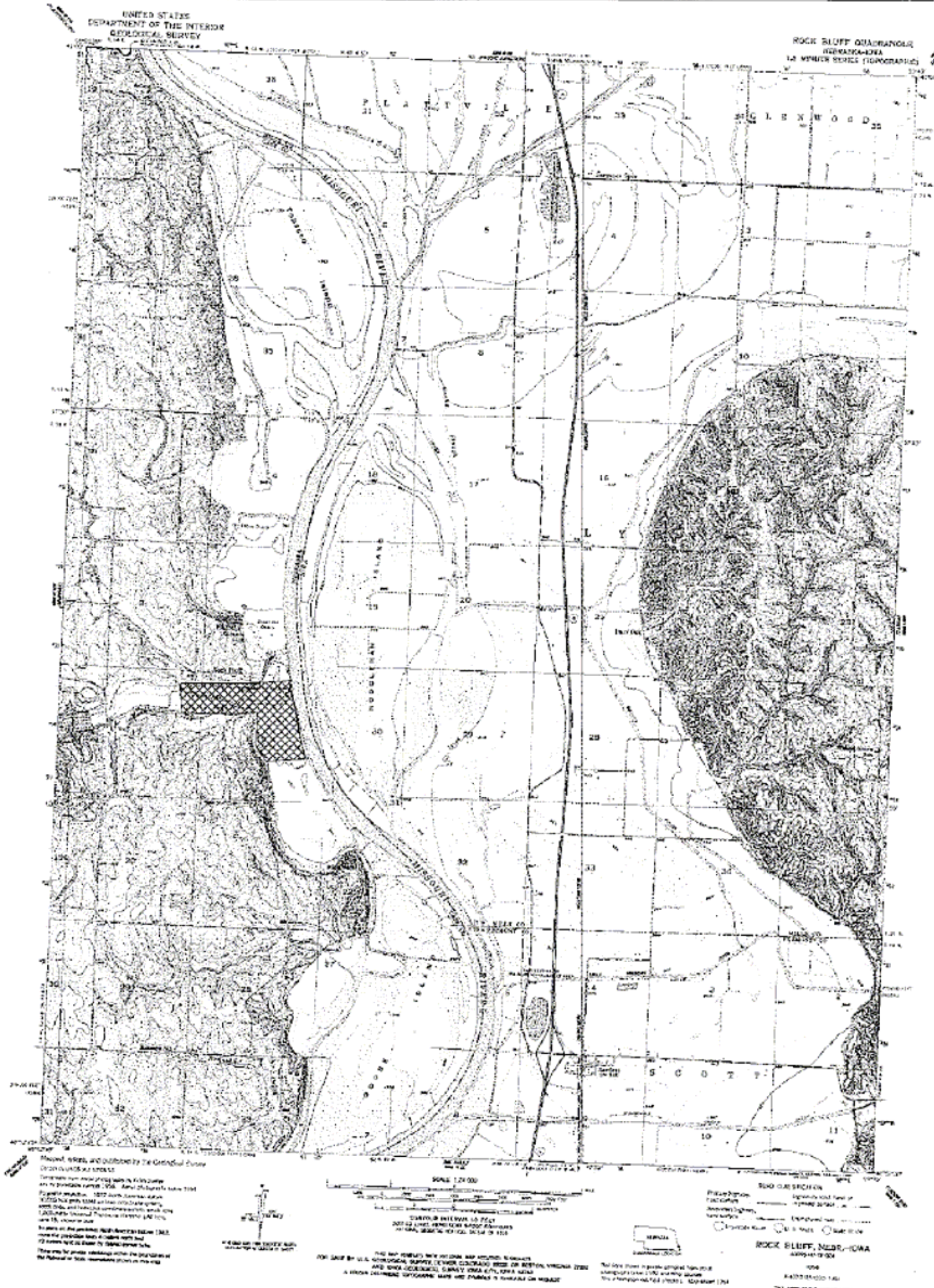
Not to Scale

Note:
Figure obtained from the
2006 Annual Evaluation of Availability of
Hydrologically Connected Water Supplies
Lower Platte River Basin Annual Report (NDNR, 2006)

Layne - Western
*a division of Layne Christensen Company*

Investigation Area
Bedrock Geology

Figure 1




N

Not to Scale

Proposed Investigation Area

Layne - Western

*a division of Layne Christensen Company*

Proposed Investigation Area

Figure 2

# ATTACHMENT A
# NDNR REGISTERED WELLS

Not available on this website

ATTACHMENT B

CALCULATIONS

**Estimated Vertical Well Calculation Sheet - Beaver Creek, NE**

| Calulation Input Parameter | VALUE |
|---|---|
| $B_{DIA}$ = Borehole diameter (inches) | 42 |
| $S_D$ = Screen diameter (inches) | 20 |
| $S_L$ = Screen length feet | 35 |
| $S_I$ - Screen interval = 75 – 110 ft bgs | |
| SLOT = Screen slot size (inches) | 0.09 |
| OPEN AREA = Johnson screen opening ($in^2/ft$) | 306.5 |
| BF = Blockage factor | 0.5 |
| K = Hydraulic conductivity (ft/day) | 200 |
| $O_{EV}$ = Optimal entrance velocity (ft/sec) | 0.1 |
| From Transmissivity of Aquifer | |

## CALCULATION 1

*Entrance velocity yield calculation (Maximum theoretical pumping rate)*

Formula:

$$Q = S_L * OPEN\ \ AREA * BF * O_{EV}$$

Q (gpm) = 1,683 Includes conversion from (ft in2/sec) to gpm

## CALCULATION 2

*Laminar flow Limit calculation (No turbulent flow – minimum rate)*

Formula:

$$Q_L = \pi * B_{DIA} * S_L * K$$

$Q_L$ (gpm) = 400 Includes conversion from (in*ft2/day) to gpm

$Q_L$ (gpm) *2.35 = 940

## CALCULATION 4

*Drawdown in Pumping Well calculation (Maximum operating rate)*

$$Q = s_{100} * \left( \frac{T}{264 \log \frac{0.3Tt}{r^2 S}} \right)$$

| Where: | VALUE |
|---|---|
| $s_{100}$ = drawdown in the pumped well (feet) - 100% Efficient | Presented below |
| T = aquifer Transmissivity (gal/day/foot) | 100,000 |
| Q = well pumping rate (gal/min) | NA |
| t = estimated time to reach steady state (days) | 263.7 |
| S = aquifer storage (dimensionless) | 0.2 |
| r = radius of pumping well borehole (feet) | 2 |

Calcluate allowable "real world" drawdown

$s_{real}$ = Top of Screen - Depth to Water - 10 feet (safety factor)

| | |
|---|---|
| Top of Screen | 75 |
| Depth to Water | 20 |
| sreal = | 45 |

Calculate corresponding drawdown in a 100% efficient well

$s_{100} = s_{real} * 0.7$

$s_{100}$ = 31.5

Calculate Max operating Rate

$Q_{design}$(gpm) = 1,706

## CALCULATION 3 - use near recharge source

*Time to reach equilibrium near recharge source*

$$t_e = \frac{a^2 S}{1.12 T \varepsilon \log\left(\frac{2a}{r}\right)^2}$$

| Value | |
|---|---|
| | $t_e$ = time required to reach approximate equilibrium (years); |
| 2640 | a = distance from pumped well to line source of recharge (feet); |
| 100 | r = distance from pumped well to observation point (feet); |
| 0.2 | S = coefficient of storage (dimensionless); |
| 100,000 | T = coefficient of transmissivity (gpd/ft); |
| 0.05 | ε = deviation from absolute equilibrium (generally assumed to be 0.05). |

Calculate time

0.722482 years

263.7 days