When and how much should I irrigate?

Gary Zoubek

&

Brandy VanDeWalle

Extension Educators

York & Fillmore Counties
Quick Investigation!

- What are the differences between these plants?

- What types of conditions (environmental or otherwise) do you think were present for each type of plant?

- What can we learn from these three plants?
Flowing right along...

- Irrigation 101
- What’s the right amount?
- Got the right tools?
Irrigation 101

- Irrigation Development
- Economic Impact
  - In 2003, a drought year, the impact of irrigated agriculture on Nebraska’s economy had a net total economic impact of more than $4.5 billion; adjusted to $3.6 billion for normal precipitation conditions.
- How do you know when to irrigate?
Irrigation 101

- Irrigation

“The artificial supply of water to land, to maintain or increase yields of food crops, a critical element of modern agriculture. Irrigation can compensate for the naturally variable rate and volume of rain”

(Britannica, 2010)
University of Nebraska–Lincoln
Proper Irrigation Management

- Maintains adequate soil moisture in the crop root zone for healthy plant growth and optimum yield.

- The objective of irrigation management is to establish proper timing and amount of irrigation for greatest effectiveness.

- It also reduces the potential for runoff and reduces soil erosion and pesticide movement into the surface and groundwater.
For proper irrigation...

1) Crop Water Use (or Evapotranspiration, ET)
(crop leaves and soil surface)

2) Soil Water Status
(below ground, soil profile)
Crop Water Use (Evapotranspiration, ET)

- Combined process of both evaporation from soil and plant surfaces and transpiration from plant canopies through the stomates to the atmosphere.
- “How much water is “lost” from leaves & soil surface” from the plant
Crop Water Use = Evapotranspiration (ET)

ET = Evaporation + Transpiration

\[ T = 70-80\% \]

\[ E = 20-30\% \]
When the crop is small, almost all ET is EVAPORATION.
When the crop fully shades the ground, 90 - 98% of ET is **TRANSPIRATION**.
What affects a crop’s ET?

Weather data:

- Solar Radiation
- Air Temperature
- Relative Humidity
- Wind Speed
Soil Water Status

- Amount of water present in the soil profile
- Take into account a crop’s root zone when monitoring
Soil water monitoring takes into account of all these factors.

University of Nebraska–Lincoln
How do we decide when to irrigate?

- ETgage – measure crop ET
- Watermark Sensors – measure soil water status
ATMOMETER (ETgage)

- #54 alfalfa canvas cover
- Bird spike
- Sight tube and scale
- Bellani plate (ceramic evaporation surface)
- Rubber stopper
- Suction tube
- 300 mm (11.8 in) capacity water reservoir
Actual crop water use = ETr x Kcr

From ETgage

From ETgage NebGuide
## Crop coefficient (Kc)

Table I. Alfalfa-based crop coefficients (Kc) at the beginning of each growth stage for corn, soybean, and wheat (High Plains Regional Climate Center, 2005).

<table>
<thead>
<tr>
<th>Growth Stage</th>
<th>Kc</th>
<th>Growth Stage</th>
<th>Kc</th>
<th>Growth Stage</th>
<th>Kc</th>
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<tbody>
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<td>Heading</td>
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<td>Grain Fill</td>
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<td>Stiff Dough</td>
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<td>Mature</td>
<td>0.10</td>
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<tr>
<td>Beginning dent</td>
<td>1.10</td>
<td>Full Maturity</td>
<td>0.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full dent</td>
<td>0.98</td>
<td>Mature</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black layer</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full maturity</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>
Crop Water Use by Growth Stage – Corn

Corn Growth Stages
2 leaf (V2): Two collars visible.
4 leaf (V4): Four collars visible.
6 leaf (V6): Growing point above ground, tassel forms.*
8 leaf (V8): Ear formation begins.
Silking (R1): Silks are visible outside husk.
Dough (R4): Endosperm milk turns thick and pasty.

* Paint/Mark V6 leaf to make counting easier!

Weekly ETgage® Change in Inches

| Crop Stage | Ke 1.00 | 1.10 | 1.20 | 1.30 | 1.40 | 1.50 | 1.60 | 1.70 | 1.80 | 1.90 | 2.00 | 2.10 | 2.20 | 2.30 | 2.40 | 2.50 | 2.60 | 2.70 | 2.80 | 2.90 | 3.00 |
|------------|---------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| V2         | 0.10    | 0.11 | 0.12 | 0.13 | 0.14 | 0.15 | 0.16 | 0.17 | 0.18 | 0.19 | 0.20 | 0.21 | 0.22 | 0.23 | 0.24 | 0.25 | 0.26 | 0.27 | 0.28 | 0.29 | 0.30 |
| V4         | 0.18    | 0.22 | 0.25 | 0.27 | 0.30 | 0.32 | 0.34 | 0.36 | 0.38 | 0.40 | 0.42 | 0.44 | 0.45 | 0.47 | 0.49 | 0.50 | 0.52 | 0.53 |
| V6         | 0.35    | 0.41 | 0.47 | 0.53 | 0.59 | 0.65 | 0.71 | 0.77 | 0.83 | 0.89 | 0.95 | 1.01 | 1.07 | 1.13 | 1.19 | 1.25 | 1.31 | 1.37 | 1.43 | 1.50 |
| V8         | 0.51    | 0.61 | 0.71 | 0.81 | 0.91 | 1.01 | 1.11 | 1.21 | 1.31 | 1.41 | 1.51 | 1.61 | 1.71 | 1.81 | 1.91 | 2.01 | 2.11 | 2.21 | 2.31 | 2.41 |
| V10        | 0.60    | 0.71 | 0.82 | 0.93 | 1.04 | 1.15 | 1.26 | 1.37 | 1.48 | 1.59 | 1.70 | 1.81 | 1.92 | 2.03 | 2.14 | 2.25 | 2.36 | 2.47 | 2.58 | 2.69 |
| V12        | 0.88    | 0.97 | 1.06 | 1.16 | 1.26 | 1.36 | 1.46 | 1.56 | 1.66 | 1.76 | 1.86 | 1.96 | 2.06 | 2.16 | 2.26 | 2.36 | 2.46 | 2.56 | 2.66 | 2.76 |
| V14        | 1.01    | 1.11 | 1.21 | 1.31 | 1.41 | 1.51 | 1.61 | 1.71 | 1.81 | 1.91 | 2.01 | 2.11 | 2.21 | 2.31 | 2.41 | 2.51 | 2.61 | 2.71 | 2.81 | 2.91 |
| V16, Silking, Bristle, Dough, Begin Dent. | 1.10 | 1.21 | 1.32 | 1.43 | 1.54 | 1.65 | 1.76 | 1.87 | 1.98 | 2.09 | 2.20 | 2.31 | 2.42 | 2.53 | 2.64 | 2.75 | 2.86 | 2.97 | 3.08 | 3.19 |

This chart can be used with readings from an ETgage® or other ET reference. First, identify the stage in the ET curve that has the singular row. Then, compare the growth stage in the left column. Some stages may be difficult to see, depending on the stage of growth. The ET value is the water use for each crop stage.
Crop Water Use by Growth Stage – Soybeans

Soybean Growth Stages
VC: Cotyledon leaves with unifoliate leaves unrolled. 
V1: 1st node containing trifoliate leaf fully expanded. 
V2: 2nd node containing trifoliate leaf fully expanded. 
V3: 3rd node containing trifoliate leaf fully expanded. 
R1: At least one flower on any node. 
R3: A pod 3/16 inch on one of the uppermost nodes. 
R6: Seed is 1/8 inch long in a pod of the upper four nodes. 
Begin Maturity: one brown leaf on main stem.

Weekly ETgage® Change in Inches

<table>
<thead>
<tr>
<th>Crop Stage</th>
<th>1.00</th>
<th>1.10</th>
<th>1.20</th>
<th>1.30</th>
<th>1.40</th>
<th>1.50</th>
<th>1.60</th>
<th>1.70</th>
<th>1.80</th>
<th>1.90</th>
<th>2.00</th>
<th>2.10</th>
<th>2.20</th>
<th>2.30</th>
<th>2.40</th>
<th>2.50</th>
<th>2.60</th>
<th>2.70</th>
<th>2.80</th>
<th>2.90</th>
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<td>0.15</td>
<td>0.16</td>
<td>0.17</td>
<td>0.18</td>
<td>0.19</td>
<td>0.20</td>
<td>0.21</td>
<td>0.22</td>
<td>0.23</td>
<td>0.24</td>
<td>0.25</td>
<td>0.26</td>
<td>0.27</td>
<td>0.28</td>
</tr>
<tr>
<td>V1 1st Node</td>
<td>0.20</td>
<td>0.20</td>
<td>0.22</td>
<td>0.24</td>
<td>0.26</td>
<td>0.28</td>
<td>0.30</td>
<td>0.32</td>
<td>0.34</td>
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<td>0.38</td>
<td>0.40</td>
<td>0.42</td>
<td>0.44</td>
<td>0.46</td>
<td>0.48</td>
<td>0.50</td>
<td>0.52</td>
<td>0.54</td>
<td>0.56</td>
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<tr>
<td>V2 2nd Node</td>
<td>0.40</td>
<td>0.40</td>
<td>0.44</td>
<td>0.48</td>
<td>0.52</td>
<td>0.56</td>
<td>0.60</td>
<td>0.64</td>
<td>0.68</td>
<td>0.72</td>
<td>0.76</td>
<td>0.80</td>
<td>0.84</td>
<td>0.88</td>
<td>0.92</td>
<td>0.96</td>
<td>1.00</td>
<td>1.04</td>
<td>1.08</td>
<td>1.12</td>
</tr>
<tr>
<td>V3 3rd Node</td>
<td>0.60</td>
<td>0.60</td>
<td>0.66</td>
<td>0.72</td>
<td>0.78</td>
<td>0.84</td>
<td>0.90</td>
<td>0.96</td>
<td>1.02</td>
<td>1.08</td>
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<td>1.20</td>
<td>1.26</td>
<td>1.32</td>
<td>1.38</td>
<td>1.44</td>
<td>1.50</td>
<td>1.56</td>
<td>1.62</td>
<td>1.68</td>
</tr>
<tr>
<td>R1 Begin Bloom</td>
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<td>0.80</td>
<td>0.88</td>
<td>1.08</td>
<td>1.17</td>
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<td>1.35</td>
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<td>1.62</td>
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<td>2.20</td>
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<td>2.40</td>
<td>2.50</td>
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<tr>
<td>R3 Begin Pod</td>
<td>1.00</td>
<td>1.00</td>
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<td>1.20</td>
<td>1.30</td>
<td>1.40</td>
<td>1.50</td>
<td>1.60</td>
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<td>2.60</td>
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<tr>
<td>R5 Begin Seed</td>
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<td>1.21</td>
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<td>1.87</td>
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<td>0.17</td>
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<tr>
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<td>1.08</td>
<td>1.12</td>
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</tbody>
</table>

This chart can be used with readings from an ETgage® or other ET meters. First, identify the change in the ET rate across the corn row and then identify the current growth stage in the left column. Follow the row down to the point where you intersect to identify the ET rate in your irrigation scheduling. When planning irrigation, account for soil moisture, growth stage, weather conditions, and the ET rate for each growth stage of your crop.

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Example

Corn is at **12-leaf growth stage** and the water level in the ETG (with a No. 54 canvas cover) sight tube decreased **1.30 inches** during the 7-day period since the last irrigation. Determine the actual crop ET (**ETc**), net irrigation requirement (**NIR**), and the gross irrigation requirement (**GIR**) if irrigation is applied with a center pivot with an application efficiency of **85%** (**AE = 0.85**). Rainfall = 0.

\[ \text{ETr} = 1.30 \text{ inches (reference ET from the ETG)} \]
\[ K_c = 0.88 \text{ (from table for 12-leaf stage)} \]

\[ \text{ETc} = \text{ETr} \times K_c \]

\[ \text{ETc} = 1.30 \text{ inches } \times 0.88 = 1.1 \text{ inches} \]

\[ \text{NIR} = \text{ETc} - \text{Rainfall} \]

\[ \text{NIR} = 1.1 \text{ inches } - 0 = 1.1 \text{ inches} \]

\[ \text{GIR} = \frac{\text{NIR}}{\text{IE}} \]

\[ \text{GIR} = \frac{1.1 \text{ inches}}{0.85} = 1.3 \]
40” above soil and 12-24” above canopy.
More information on how to use an ETgage for irrigation management

Using Modified Atmometers (ETgage®) for Irrigation Management

Suat Irmak, José O. Payero and Derrel L. Martin
Extension Water Resources /Irrigation Engineers

This NebGuide describes the atmometer (evapo-transpiration gage) and explains how it can be used for irrigation scheduling. Examples are provided to show how information collected with an atmometer can be used to estimate crop water use for corn and soybean.
Soil Water Monitoring

Key to applying the optimum amount of irrigation
For effective irrigation, must know water applied
Watermark soil water sensors

- Electrodes
- Sensor collar
- Stainless steel sleeve
- Hand-held meter

University of Nebraska–Lincoln
Installed in the row

1, 2, 3 feet deep
The irrigation trigger point changes with soil type because each soil holds different amount of water under a given matric potential value measured with Watermark sensors.

Table 1. Depletion (in/ft) in available water versus soil matric potential and suggested range of irrigation trigger point for different soil textures.

<table>
<thead>
<tr>
<th>Soil matric potential (kPa)</th>
<th>Silty clay loam topsoil, Silty clay subsoil (Sharpsburg)</th>
<th>Silt-loam topsoil, Clay loam subsoil (Keith)</th>
<th>Upland silt loam topsoil, Silty clay loam subsoil (Hastings, Crete, Holdrege)</th>
<th>Bottom land silt-loam (Wabash, Hall)</th>
<th>Fine sandy loam</th>
<th>Sandy loam</th>
<th>Loamy sand (O’Neill)</th>
<th>Fine sand (Valentine)</th>
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<td>0.70</td>
<td>1.40</td>
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<td>N/A</td>
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<td>N/A</td>
<td>N/A</td>
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<td>0.95</td>
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<td>1.30</td>
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<td>N/A</td>
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</tbody>
</table>

Water holding capacity (in/ft) | 1.8-2.0 | 1.8-2.0 | 2.20 | 2.00 | 1.80 | 1.40 | 1.10 | 1.00 |

*Suggested range of irrigation trigger point (kPa) | 75-80 | 80-90 | 90-100 | 75-80 | 45-55 | 30-33 | 25-30 | 20-25 |

(*) The trigger points were calculated with the assumption of no sensor malfunction. The trigger points were calculated based on the 35% depletion of the total soil water holding capacity per foot of soil layer. The sensor readings and the trigger points should be verified/checked against the crop appearance in the actual field conditions during the season. Trigger point should be the average of first 2 feet of sensors prior to crop reproductive stages and 3 feet once crop reaches the reproductive stage. However, for the sandy soils, the average of top 2 sensors should be used as a trigger point at all times. (N/A) Not available
## Table 1
Depletion (in/ft) in available water versus soil matric potential and suggested range of irrigation trigger point for different soil textures.

<table>
<thead>
<tr>
<th>Soil matric potential (kPa)</th>
<th>Silty clay loam topsoil, Silty clay subsoil (Sharpsburg)</th>
<th>Silt-loam topsoil, Clay loam subsoil (Keith)</th>
<th>Upland silt loam topsoil, Silty clay loam subsoil (Hastings, Crete, Holdrege)</th>
<th>Bottom land silt-loam (Wabash, Hall)</th>
<th>Fine sandy loam</th>
<th>Sandy loam</th>
<th>Loamy sand (O’Neill)</th>
<th>Fine sand (Valentine)</th>
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<tr>
<td>0</td>
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(N/A) Not available
Which soil depth to consider for irrigation management?

**Corn:**
- Average of top 2 ft until tassel
- Average of top 3 ft after tassel

**Soybeans:**
- No irrigation before R3 stage. Average of top 3 ft thereafter.

*Trigger irrigation when the average matric potential is between 90 and 100 kPa for both crops grown in silt-loam soils.*
Example: change in soil water status
Example: change in soil water status
Example: change in soil water status
More information on how to use Watermark sensors for irrigation management?

Watermark Granular Matrix Sensor to Measure Soil Matric Potential for Irrigation Management

Suat Irmak, Irrigation and Water Resources Engineer; Jose O. Payero, Irrigation Engineer; Dean E. Eisenhauer, Hydrologic and Irrigation Engineering; William L. Kranz, Irrigation Specialist; Derrel L. Martin, Irrigation and Water Resources Engineer; Gary L. Zoubek, Extension Educator; Jennifer M. Rees, Extension Educator; Brandy VanDeWalle, Extension Educator; Andrew P. Christiansen, Extension Educator; Dan Leininger, Water Conservationist, Upper Big Blue NRD

University of Nebraska–Lincoln
Too much of a good thing?
Plants need O2 also!!!
UNL Research showed...

<table>
<thead>
<tr>
<th>Irrigation levels at</th>
<th>yielded:</th>
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<tbody>
<tr>
<td>50%</td>
<td>194 bu/acre</td>
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<tr>
<td>75%</td>
<td>213 bu/acre</td>
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<tr>
<td>100%</td>
<td>217 bu/acre</td>
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<tr>
<td>125%</td>
<td>205 bu/acre</td>
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</table>
To achieve proper irrigation management...

Nebraska Ag Water Mgmt Demonstration Network

- To transfer high quality research-based information to farmers’ fields
- Implement tools to address and enhance crop water use efficiency and energy savings.
Collaborative Effort!

Little Blue Natural Resources District

NRCS Natural Resources Conservation Service

Producers & Consultants

University of Nebraska–Lincoln
NAWMDN Website

http://water.unl.edu/cropswater/nawmdn
UNL Water
Your natural resource for reliable water information.

NAWMDN - Enabling producers to use water and energy resources efficiently.

Contact: Gary Zoubek, Extension Educator, York County

The Nebraska Agricultural Water Management Demonstration Network (NAWMDN) ETgage project is one part of a system for testing cutting-edge technologies and creating a network with growers, UNL Extension, NRCS, crop consultants, and other interested partners, that will enable the adoption of water and energy conservation practices.

What is an ETgage?
Atmometers (ETgages) are designed to simulate evapotranspiration (ET) from a plant canopy in a way that agrees with a plant’s resistance to ET. The ETgage is a tool that can be used to mimic ET rates and this information can be utilized for irrigation management. The simplicity of use and interpretation of the ETgage data, as well as the economic feasibility, make it easy for farmers and consultants to monitor crop water use and irrigation needs. For more information please see the "Using ETgage for Irrigation Management" Extension publication.

ETgage data Information
Participating producers, consultants, NRCS personnel and Extension Educators across Nebraska are uploading weekly ETgage information to this site. If you’d like to see the data from your area, simply go to the to see the data from your area, simply go to the View Weekly ETgage data page and click on your county. You will then see a Google™ Map view of county that has the ETgage sites marked.

Questions? Please contact:
Gary Zoubek, Extension Educator, York County,
gzoubek1@unl.edu
402-362-5508
UNL Water
Your natural resource for reliable water information.

Weekly ETgage Site Data

Use this interactive ETgage map to access weekly information provided by growers, consultants, NRD staff and Extension Educators. To view the data, click on the county you’d like to view the data from. You will then see a Google™ Map view of the county that has the ETgage sites marked as balloons, simply click on the balloon near your location. You will then go to a page that includes the weekly ETgage change along with weekly rainfall amounts. The ETgage change along with your crop’s stage of growth can be used to estimate your crop’s water use.
UNL Water
Your natural resource for reliable water information.
Survey Says..
Survey says…

- In 2008, the NAWMDN has grown from 15 producers (in 2005) to over 300 active partners.

- Average water savings for corn of 2.6 inches is associated with a savings of $24.00/acre and 2.1 inches in soybeans is associated with a savings of $19.40/acre. (2007)
  - This results in total energy savings of $2,808,000 and $2,269,800 for corn and soybeans, respectively over 117,000 acres.
What overall impact has the NAWMDN had on you?

• I've learned from it! Confident that this technology is helpful.
• More focused on reducing water use on growing crops.
• Makes you more aware of the need to schedule irrigation based upon facts vs. a gut feel to irrigate.
Know how. Know now.

We flowed right along...

- Irrigation 101
- What’s the right amount?
- Got the right tools?
When and how much should I irrigate?

Gary Zoubek
&
Brandy VanDeWalle
Extension Educators
York & Fillmore Counties
Brandy VanDeWalle, Extension Educator
University of Nebraska-Lincoln Extension
Fillmore County
972 G St
Geneva, NE 68361-2005

Phone: (402) 759-3712

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Email: bvandewalle2@unl.edu

University of Nebraska–Lincoln