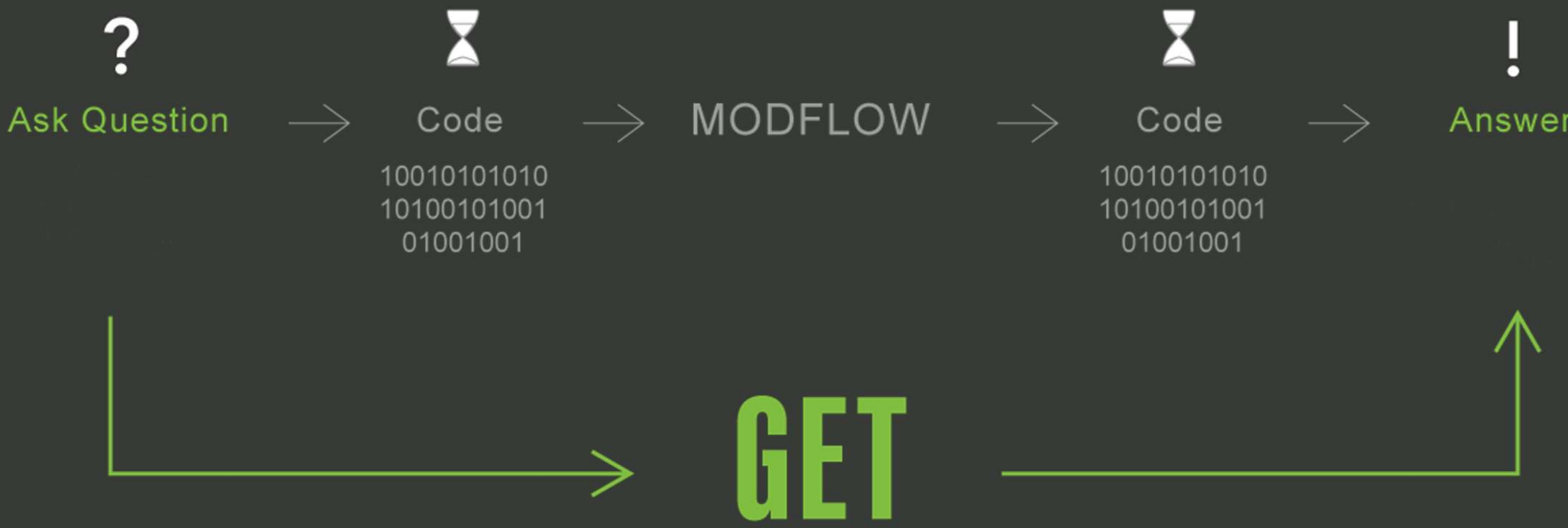
# Leveraging Existing Groundwater Models and Hydrogeologic Studies with the Groundwater Evaluation Toolbox

Colby Osborn, PG

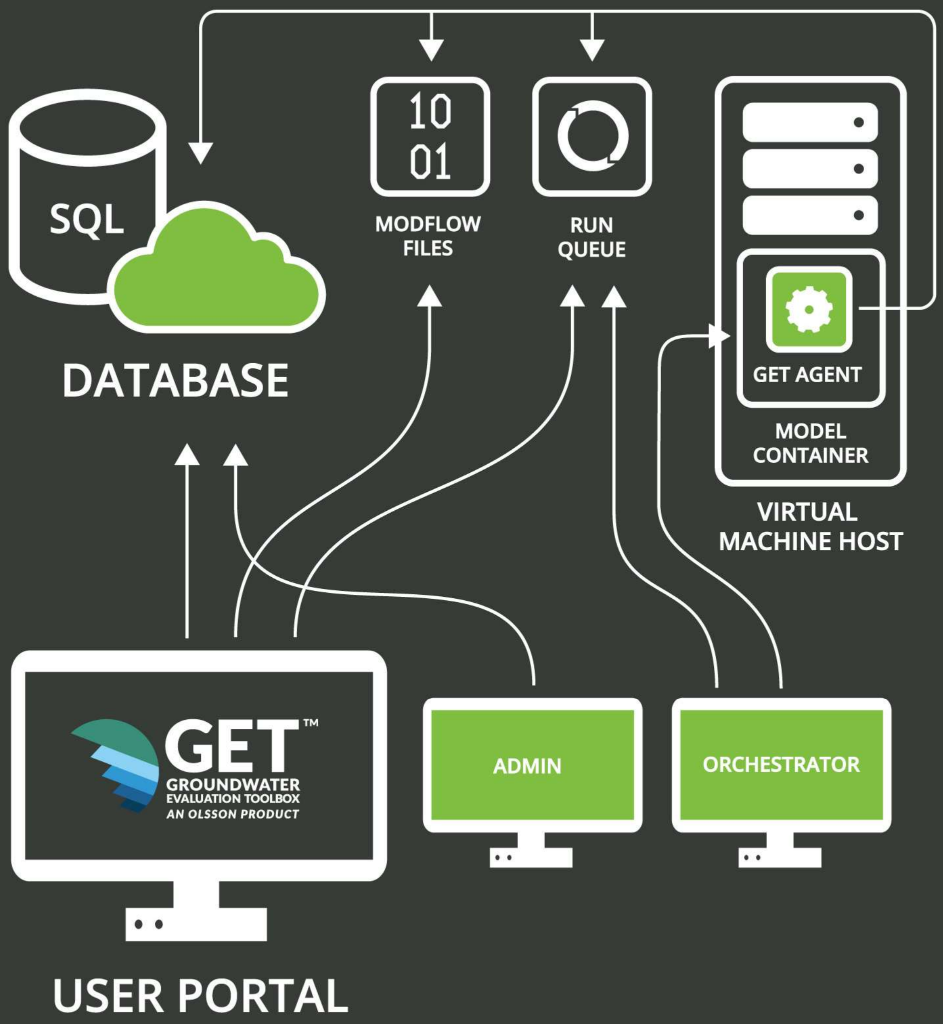
olsson

# What is the Groundwater Evaluation Toolbox (GET)



# GET

- Cloud-based platform for model automation
- Hardware and software managed for you.
- All you need is an internet connection and a browser.
- Data storage and recovery is never a problem.

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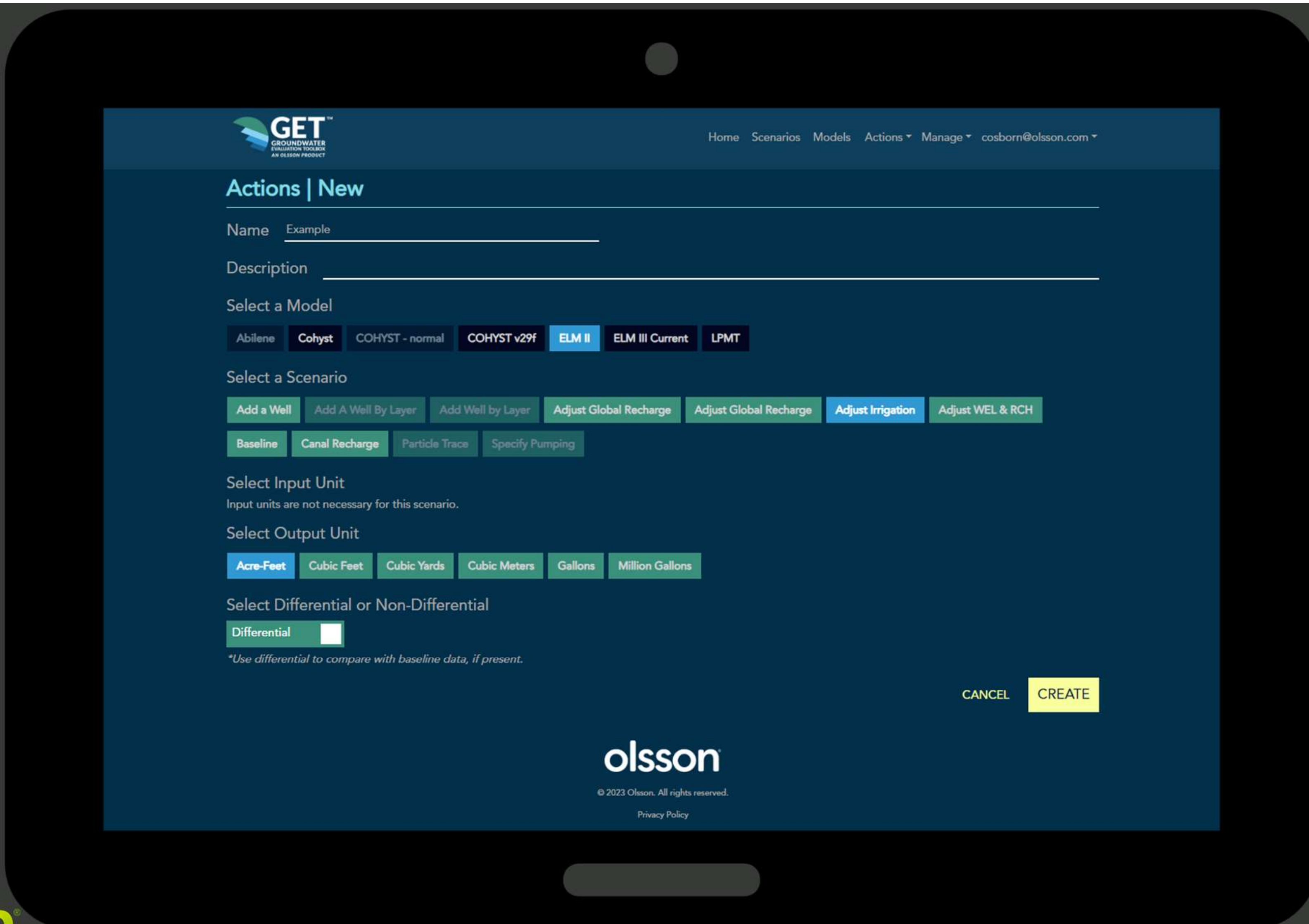
# GET Groundwater Modeling Example


GET
GROUNDWATER EVALUATION TOOLBOX
AN OLSSON PRODUCT
Home Scenarios Models Actions Manage cosborn@olsson.com
Actions | New
Name
Example
Description
Select a Model
Abilene
Cohyst
COHYST - normal
COHYST v29f
ELM II
ELM III Current
LPMT
Select a Scenario
Add a Well
Add A Well By Layer
Add Well by Layer
Adjust Global Recharge
Adjust Global Recharge
Adjust Irrigation
Adjust WEL & RCH
Baseline
Canal Recharge
Particle Trace
Specify Pumping
Select Input Unit
Input units are not necessary for this scenario.
Select Output Unit
Acre-Feet
Cubic Feet
Cubic Yards
Cubic Meters
Gallons
Million Gallons
Select Differential or Non-Differential
Differential
*Use differential to compare with baseline data, if present.
CANCEL
CREATE
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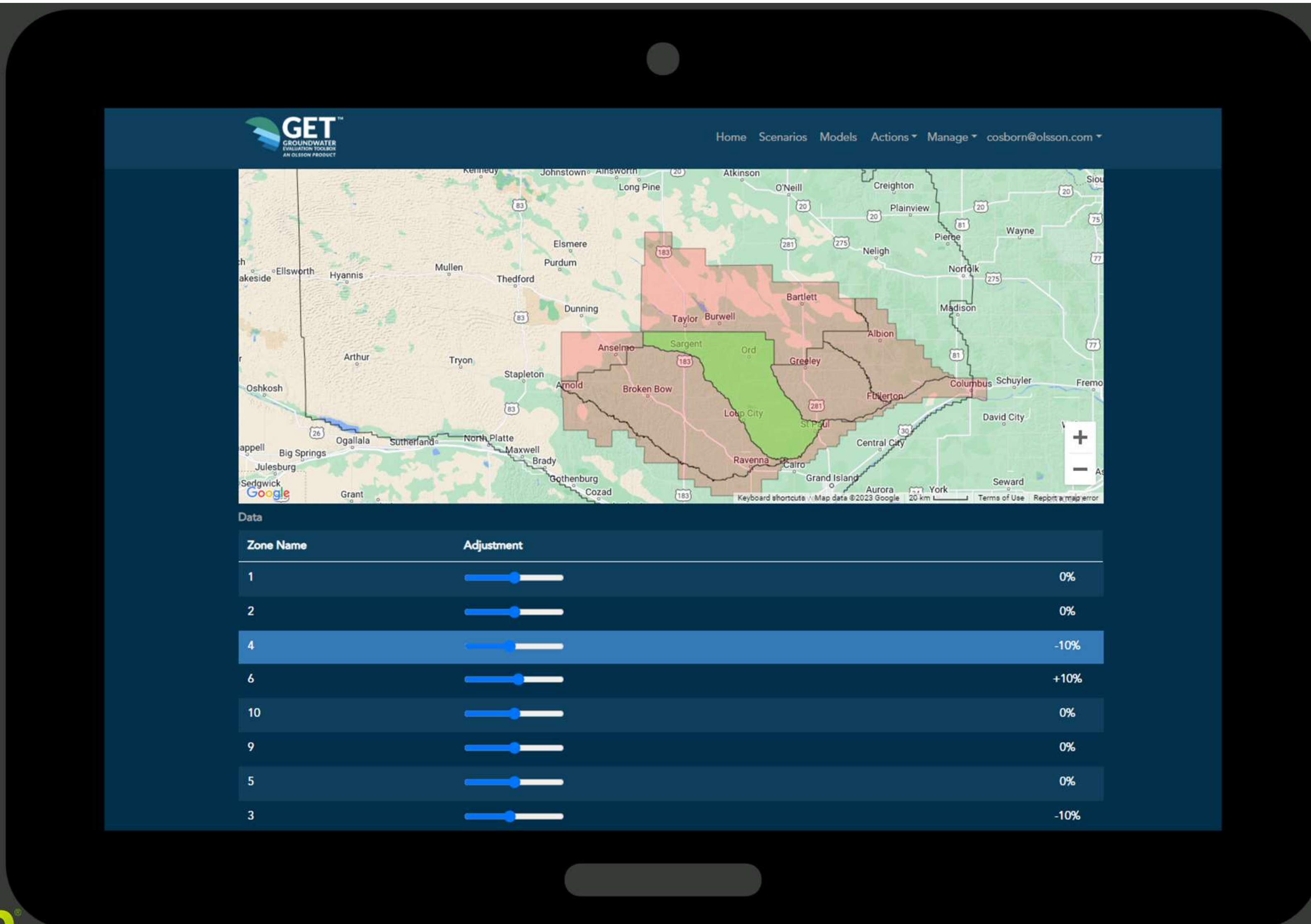
GET
GROUNDWATER EVALUATION TOOLBOX
AN OLSSON PRODUCT
Home
Scenarios
Models
Actions
Manage
cosborn@olsson.com
Johnstown
Ainsworth
Long Pine
Atkinson
O'Neill
Creighton
Plainview
Pierce
Wayne
Norfolk
Neligh
Elsmere
Purdum
Mullen
Hyannis
Ellsworth
Thedford
Dunning
Taylor
Burwell
Bartlett
Madison
Albion
Anselmo
Sargent
Ord
Greeley
Columbus
Schuyler
Arthur
Tryon
Stapleton
Arnold
Broken Bow
Fullerton
David City
Oshkosh
Loup City
St Paul
Central City
Ogallala
Sutherland
North Platte
Maxwell
Brady
Big Springs
Julesburg
Sedgwick
Gothenburg
Cozad
Ravenna
Cairo
Grand Island
Aurora
York
Seward
Grant
Data
Zone Name
Adjustment
1 0%
2 0%
4 -10%
6 +10%
10 0%
9 0%
5 0%
3 -10%

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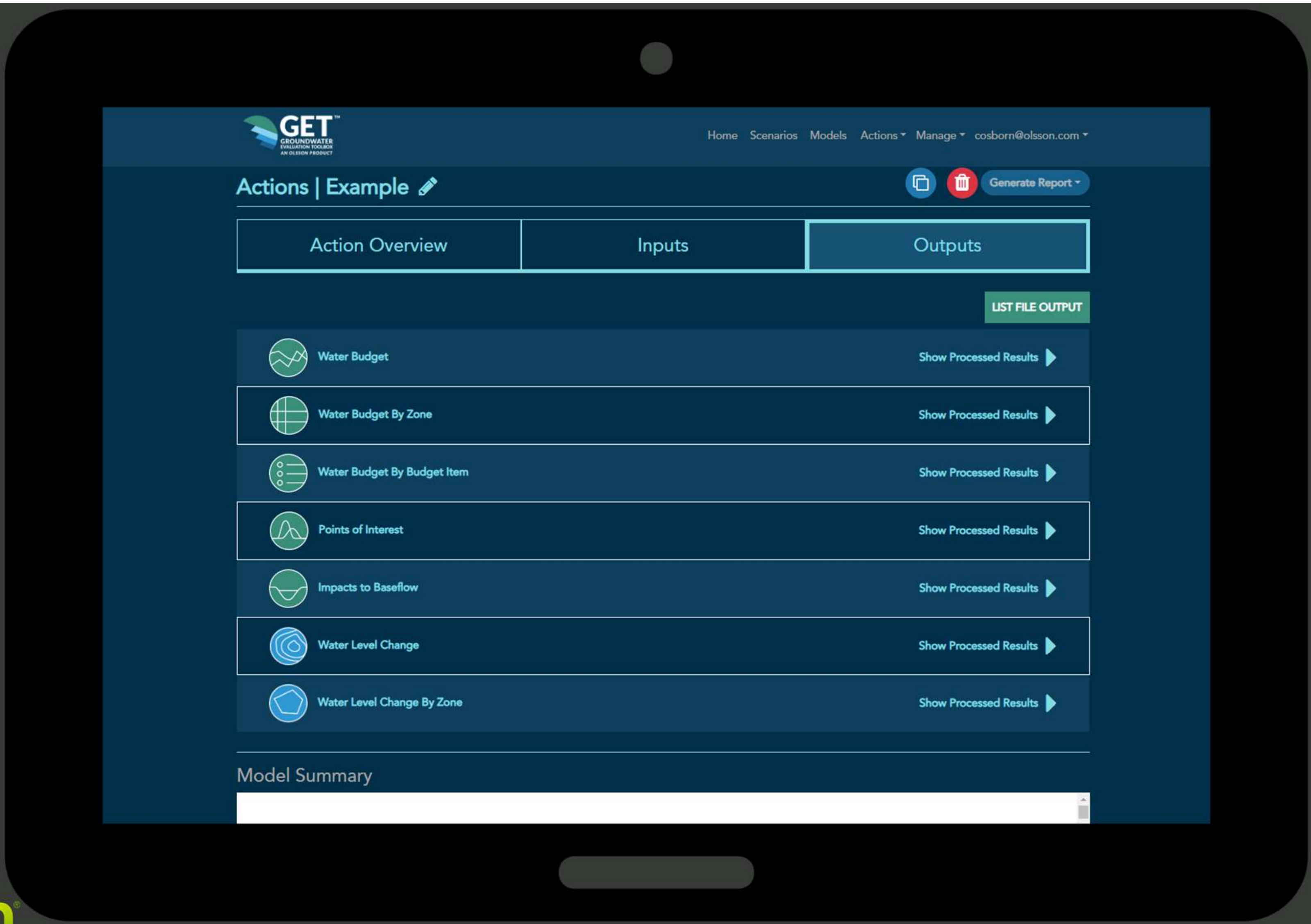
GET
GROUNDWATER EVALUATION TOOLBOX
AN OLSSON PRODUCT
Home Scenarios Models Actions Manage cosborn@olsson.com
Actions | Example
Generate Report
Action Overview
Inputs
Outputs
LIST FILE OUTPUT
Water Budget
Show Processed Results
Water Budget By Zone
Show Processed Results
Water Budget By Budget Item
Show Processed Results
Points of Interest
Show Processed Results
Impacts to Baseflow
Show Processed Results
Water Level Change
Show Processed Results
Water Level Change By Zone
Show Processed Results
Model Summary

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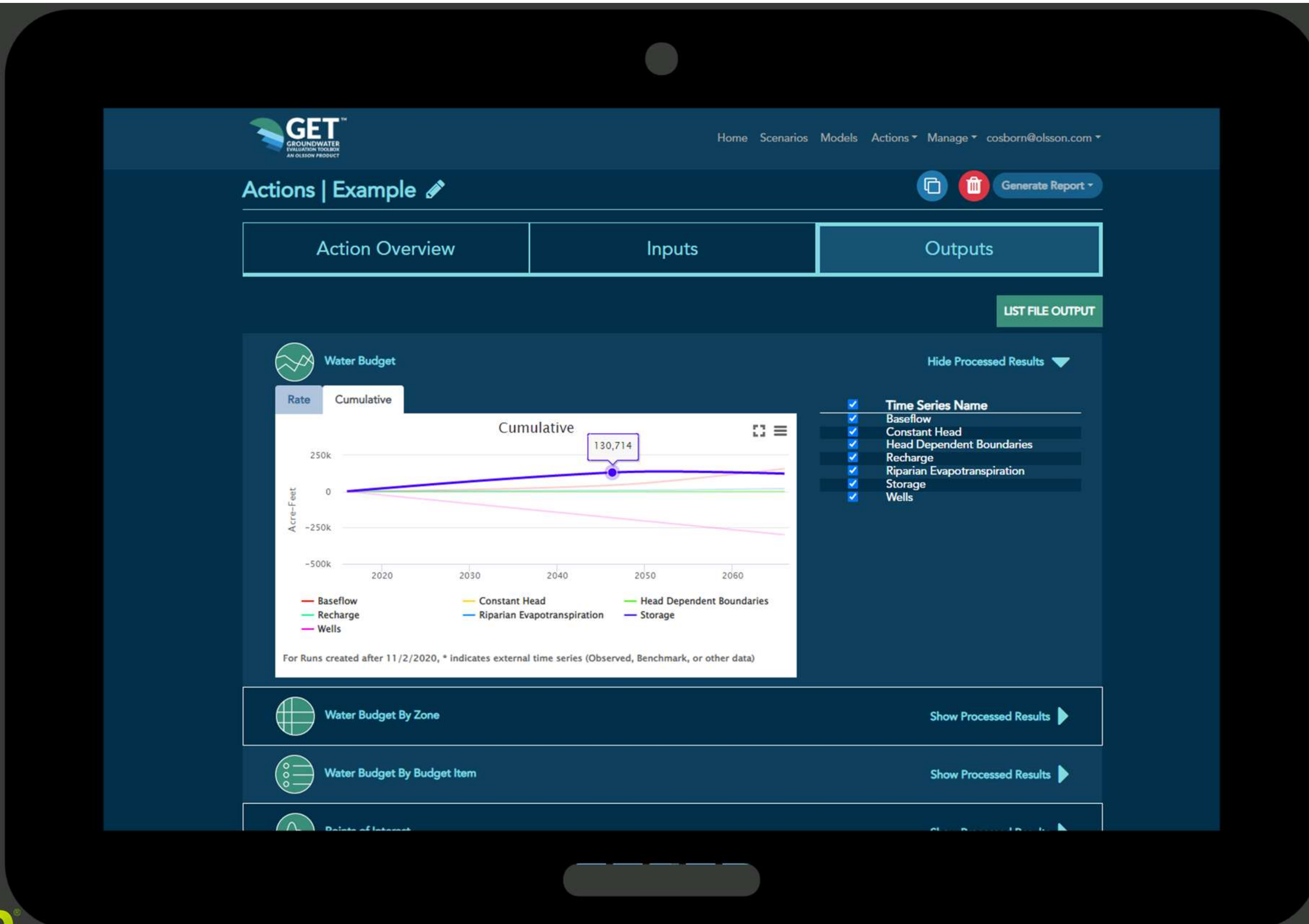
GET
GROUNDWATER EVALUATION TOOLBOX
Home
Scenarios
Models
Actions
Manage
cosborn@olsson.com
Actions | Example
Generate Report
Action Overview
Inputs
Outputs
LIST FILE OUTPUT
Water Budget
Hide Processed Results
Rate
Cumulative
Rate
Acre-Feet
1000
500
0
-500
-1000
2020
2030
2040
2050
2060
Baseflow
Constant Head
Head Dependent Boundaries
Recharge
Riparian Evapotranspiration
Storage
Wells
For Runs created after 11/2/2020, * indicates external time series (Observed, Benchmark, or other data)
Time Series Name
Baseflow
Constant Head
Head Dependent Boundaries
Recharge
Riparian Evapotranspiration
Storage
Wells
Water Budget By Zone
Show Processed Results
Water Budget By Budget Item
Show Processed Results


GET
GROUNDWATER EVALUATION TOOLBOX
Home
Scenarios
Models
Actions
Manage
cosborn@olsson.com
Actions | Example
Generate Report
Action Overview
Inputs
Outputs
LIST FILE OUTPUT
Water Budget
Hide Processed Results
Rate
Cumulative
Cumulative
130,714
250k
0
-250k
-500k
Acre-Feet
2020
2030
2040
2050
2060
Baseflow
Constant Head
Head Dependent Boundaries
Recharge
Riparian Evapotranspiration
Storage
Wells
For Runs created after 11/2/2020, * indicates external time series (Observed, Benchmark, or other data)
Time Series Name
Baseflow
Constant Head
Head Dependent Boundaries
Recharge
Riparian Evapotranspiration
Storage
Wells
Water Budget By Zone
Show Processed Results
Water Budget By Budget Item
Show Processed Results

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GET
GROUNDWATER EVALUATION TOOLBOX
Home Scenarios Models Actions Manage cosborn@olsson.com
Water Budget
Show Processed Results
Water Budget By Zone
Hide Processed Results
Rate
Cumulative
Rate
1000
500
0
-500
-1000
Acre-Feet
2020
2030
2040
2050
2060
Baseflow
Riparian Evapotranspiration
Storage
Wells
For Runs created after 11/2/2020, * indicates external time series (Observed, Benchmark, or other data)
Boone
Time Series Name
Baseflow
Constant Head
Head Dependent Boundaries
Recharge
Riparian Evapotranspiration
Storage
Wells
Water Budget By Budget Item
Show Processed Results
Points of Interest
Show Processed Results
Impacts to Baseflow
Show Processed Results
Water Level Change
Show Processed Results


GET
GROUNDWATER EVALUATION TOOLBOX
AN OLSSON PRODUCT
Home Scenarios Models Actions Manage cosborn@olsson.com
Water Budget
Show Processed Results
Water Budget By Zone
Show Processed Results
Water Budget By Budget Item
Hide Processed Results
Rate
Cumulative
Rate
1000
500
0
-500
-1000
Acre-Feet
2020
2030
2040
2050
2060
Boone
Custer
Sherman
For Runs created after 11/2/2020, * indicates external time series (Observed, Benchmark, or other data)
Storage
Time Series Name
Boone
Buffalo
Central Platte NRD
Custer
Garfield
Greeley
Hall
Howard
Lewis and Clark NRD
Loup
Lower Elkhorn NRD
Lower Niobrara NRD
Lower Platte North NRD
Merrick
Middle Niobrara NRD
Nance
North Platte NRD
Platte
Rock
Points of Interest
Show Processed Results
Impacts to Baseflow
Show Processed Results
Water Level Change
Show Processed Results

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GET
GROUNDWATER EVALUATION TOOLBOX
Home
Scenarios
Models
Actions
Manage
cosborn@olsson.com
Water Budget
Show Processed Results
Water Budget By Zone
Show Processed Results
Water Budget By Budget Item
Show Processed Results
Points of Interest
Hide Processed Results
Points of Interest
Points of Interest
Elevation (feet)
0
1
2
3
4
2020
2030
2040
2050
2060
WQA_3_G-020442
WQA_3_G-020442*
For Runs created after 11/2/2020, * indicates external time series (Observed, Benchmark, or other data)
Time Series Name
WQA_1_A-008074
WQA_1_G-002400
WQA_1_G-006760
WQA_1_G-028385
WQA_1_G-032881
WQA_1_G-034041
WQA_1_G-034398
WQA_1_G-036050
WQA_1_G-037078
WQA_1_G-039446
WQA_1_G-044154
WQA_2_G-031256
WQA_3_G-020442
WQA_3_G-029741
WQA_3_G-031751
WQA_3_G-031809
WQA_3_G-032272
WQA_3_G-032707
WQA_3_G-032967
WQA_3_G-033213
WQA_3_G-037309
Impacts to Baseflow
Show Processed Results
Water Level Change
Show Processed Results

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GET
GROUNDWATER EVALUATION TOOLBOX
Home Scenarios Models Actions Manage cosborn@olsson.com
Water Budget By Zone
Show Processed Results
Water Budget By Budget Item
Show Processed Results
Points of Interest
Show Processed Results
Impacts to Baseflow
Hide Processed Results
Rate
Cumulative
Rate
Acre-Feet
500
250
0
−250
2020
2030
2040
2050
2060
South Loup River
Cedar Creek
Middle Loup River
For Runs created after 11/2/2020, * indicates external time series (Observed, Benchmark, or other data)
Time Series Name
Total
Bazile Creek
Oak Creek
Birdwood Creek
South Loup River
Spring Creek
Wood River
Beaver Creek
Cedar Creek
Elkhorn River
Loup River
Middle Loup River
Mud - Clear Creek
North Loup River
Water Level Change
Show Processed Results
Water Level Change By Zone
Show Processed Results

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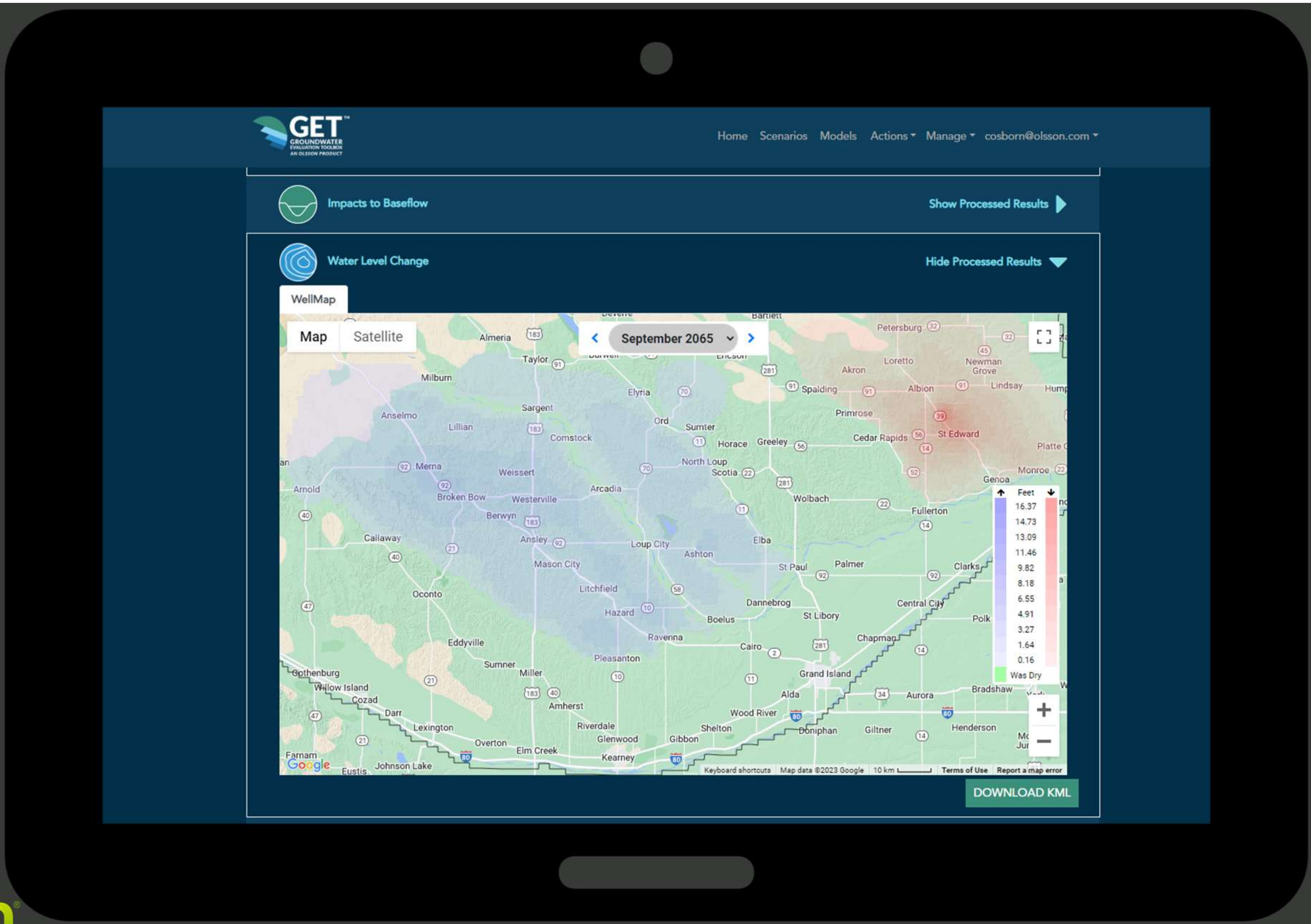
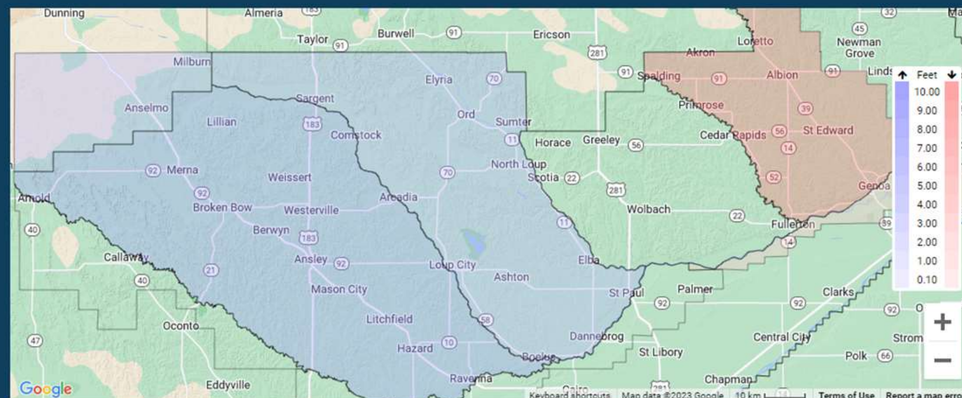

GET
GROUNDWATER EVALUATION TOOLBOX
Home
Scenarios
Models
Actions
Manage
cosborn@olsson.com
Impacts to Baseflow
Show Processed Results
Water Level Change
Hide Processed Results
WellMap
Map
Satellite
September 2065
Feet
16.37
14.73
13.09
11.46
9.82
8.18
6.55
4.91
3.27
1.64
0.16
Was Dry
DOWNLOAD KML

GET™ GROUNDWATER EVALUATION TOOLBOX AN OLSSON PRODUCT

Home Scenarios Models Actions ▾ Manage ▾ cosborn@olsson.com ▾




Click a Zone on the map or a row in the table to get started!

| Zone Name | Water Level Change (ft) | | |
|---|---|---|---|
| | Mean | Minimum | Maximum |
| 1 | -0.03 | 0 | -1.66 |
| 10 | -0.12 | 0 | -2.53 |
| 2 | 0.53 | 0.01 | 1.83 |
| 3 | 1.81 | 0 | 4.51 |
| 4 | 0.77 | 0 | 4.93 |
| 5 | 0 | 0 | 0.03 |
| 6 | -3.55 | 0 | -16.32 |
| 7 | 0.06 | 0 | 0.26 |

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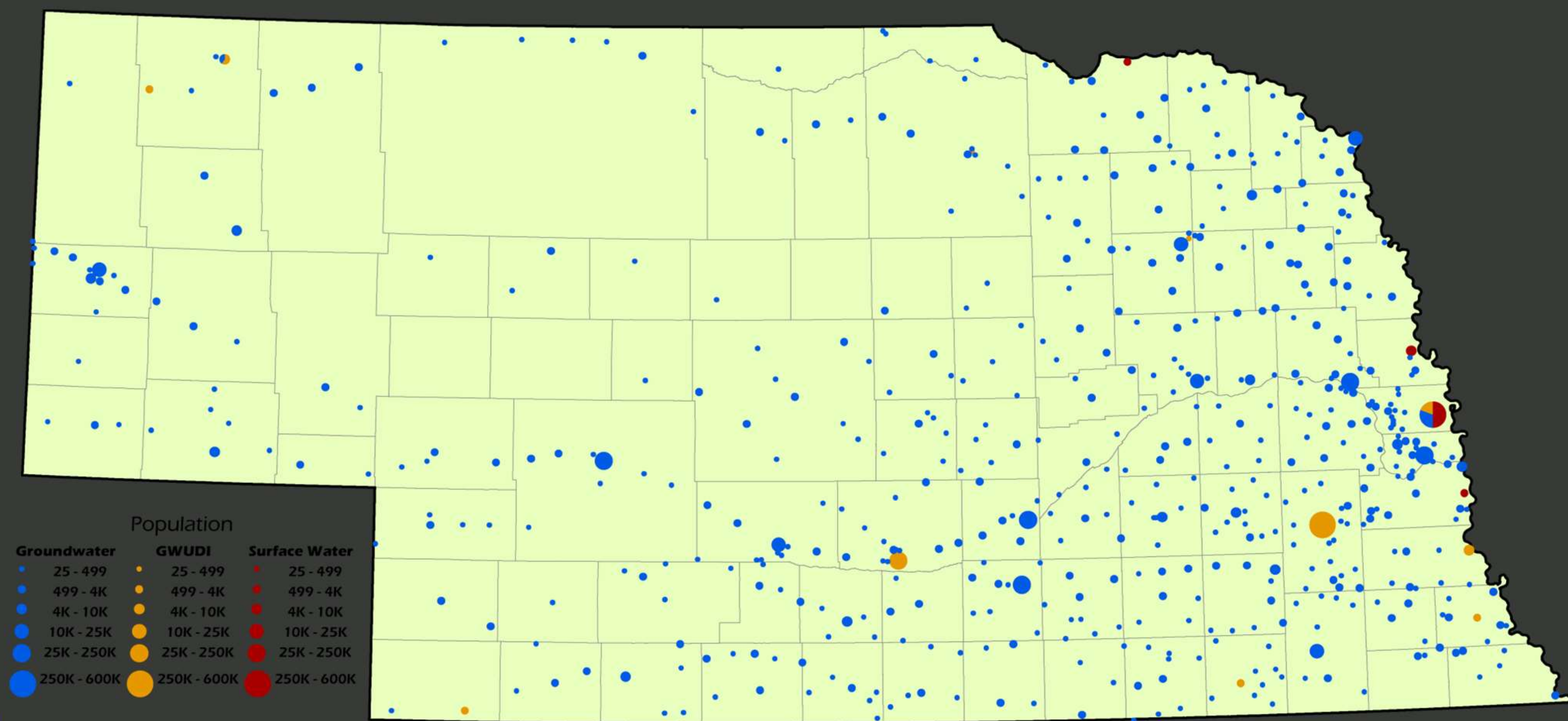
# Wellhead Protection Scenario

# Community Public Water Systems

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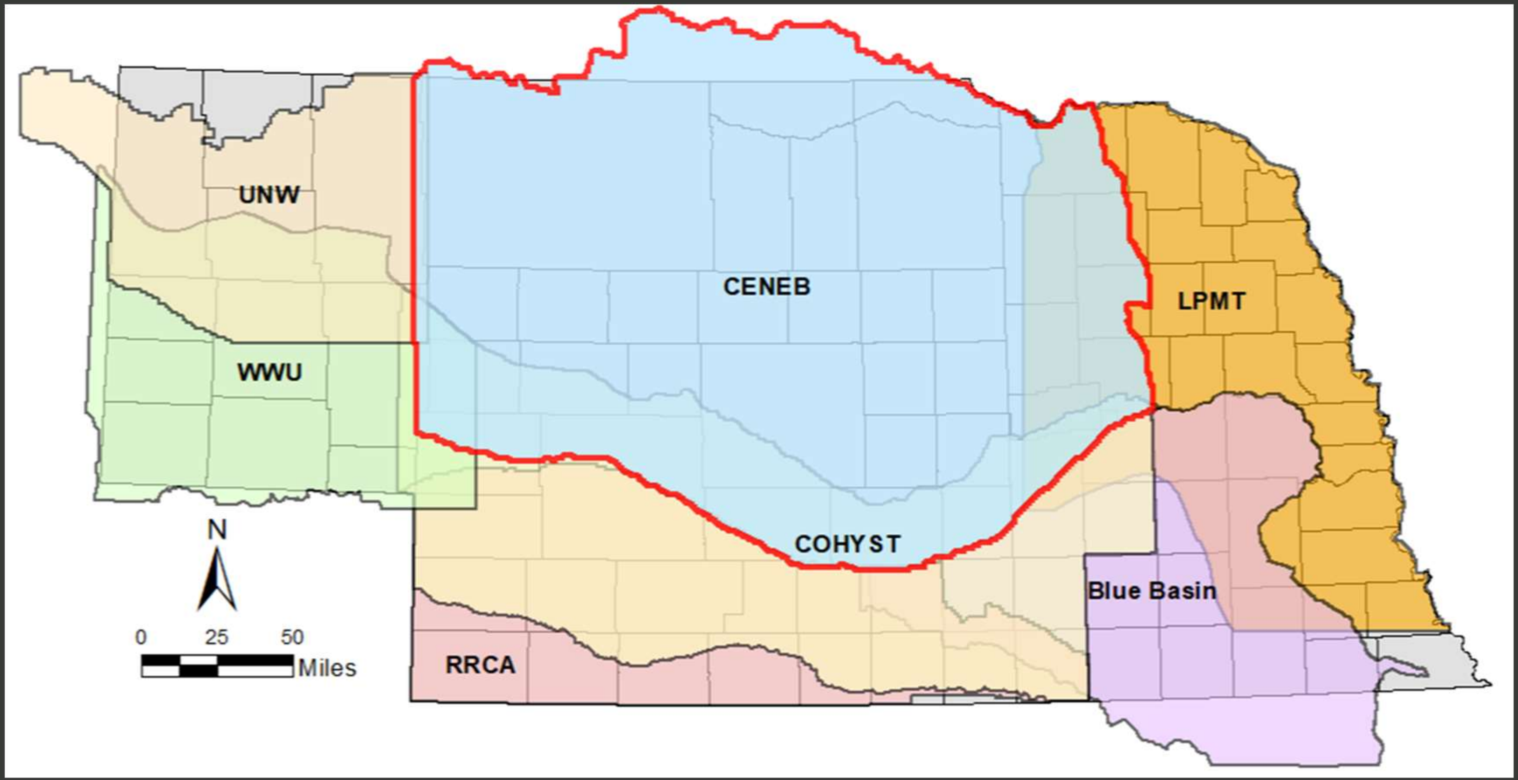
# Behind The Tool

- MODFLOW
- MODPATH
- Numerical
- Data utilization
- Time and money

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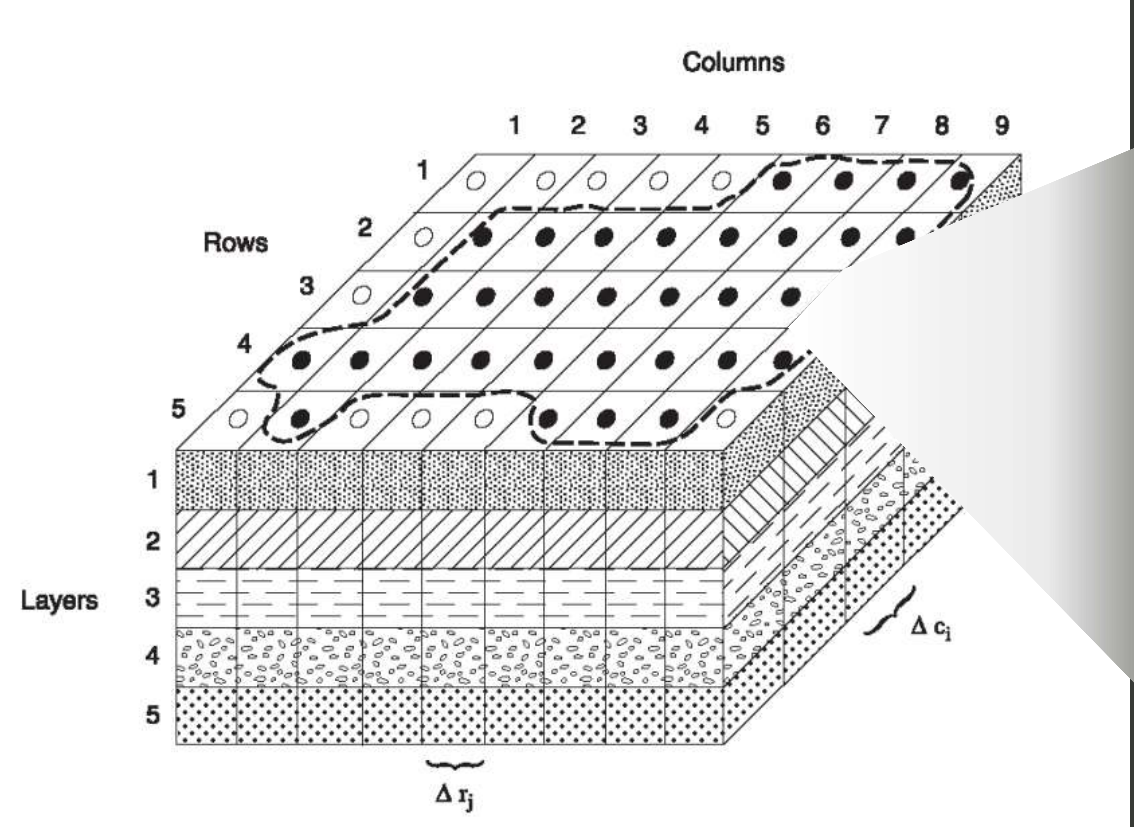
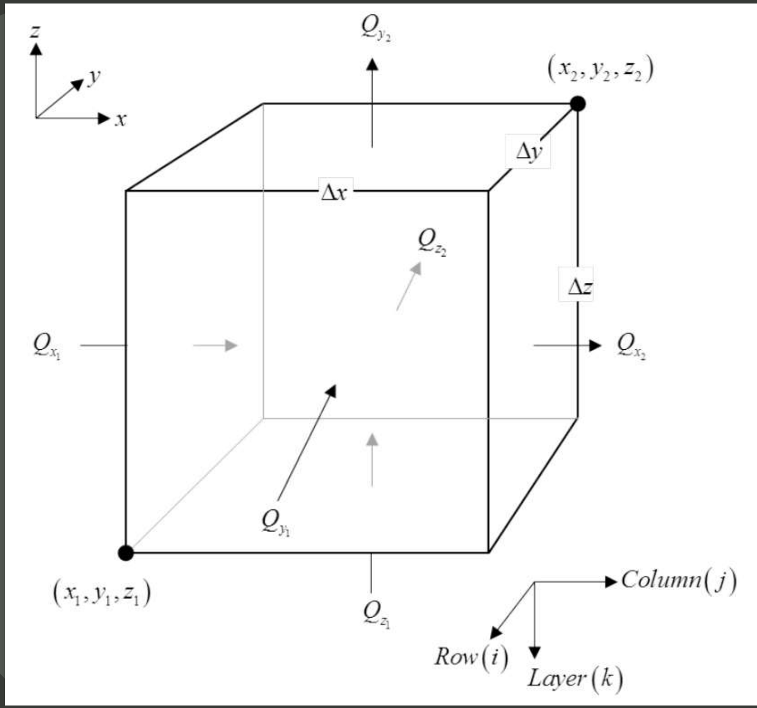
# MODFLOW Grid Cell Showing Volumetric Flow Components




Pollock 2016



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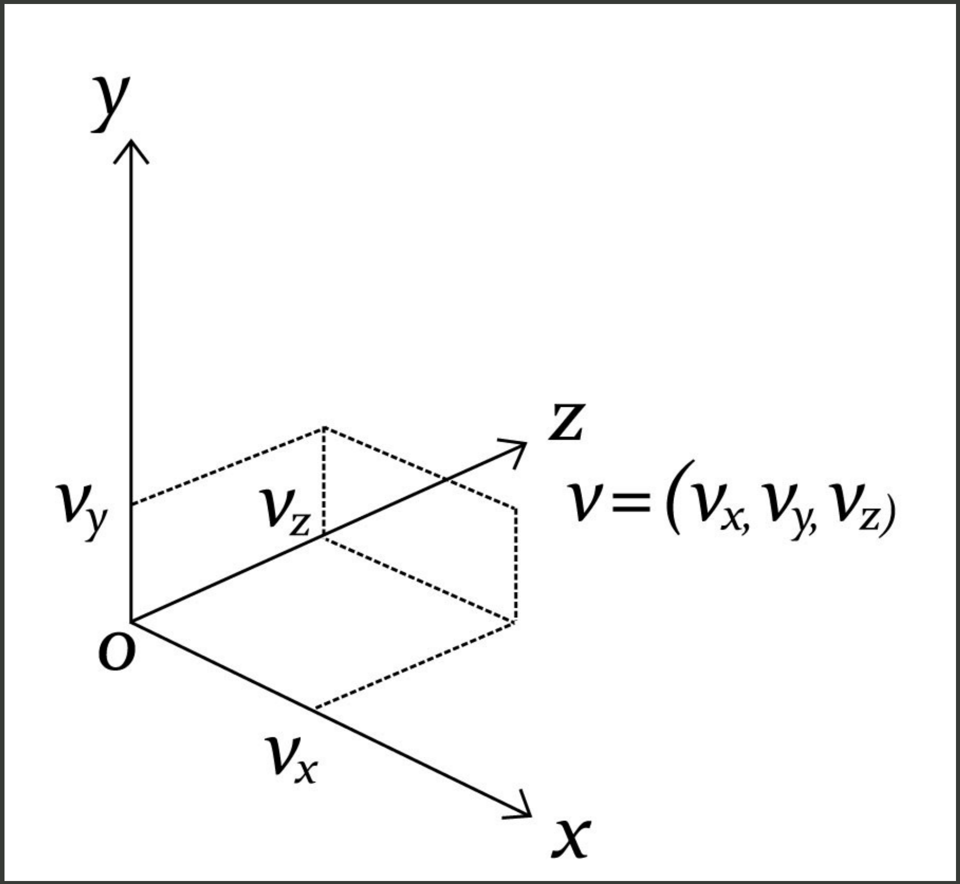
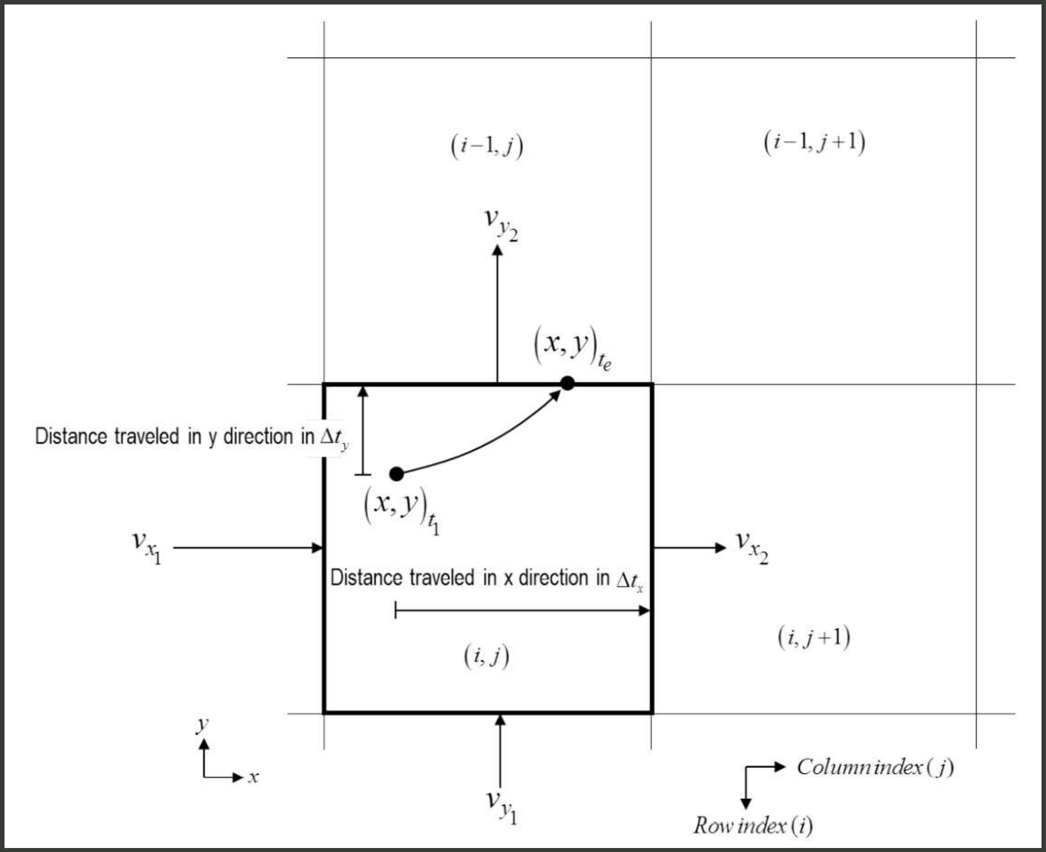
# Compute Average Linear Velocity Component




$$v_x = \frac{Q_x}{(n\Delta y\Delta z)} \qquad v_y = \frac{Q_y}{(n\Delta x\Delta z)} \qquad v_z = \frac{Q_z}{(n\Delta x\Delta y)}$$

# Compute a Particle's Location at Time t




$$\Delta t_x = \frac{1}{A_x} \ln \left[ \frac{v_{x_2}}{(v_x)_t} \right]$$

$$\Delta t_y = \frac{1}{A_y} \ln \left[ \frac{v_{y_2}}{\left(v_y\right)_{t_1}} \right].$$

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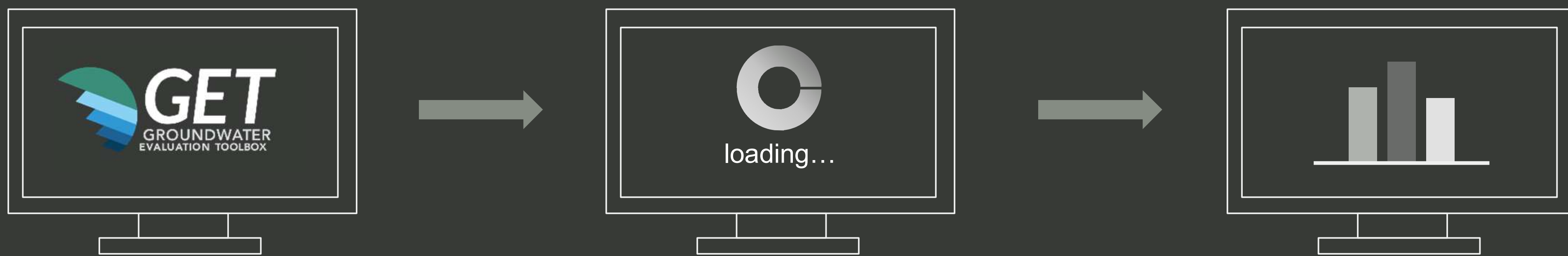
# Wellhead Protection Mapping with GET

**MINUTES TO COMPLETE**

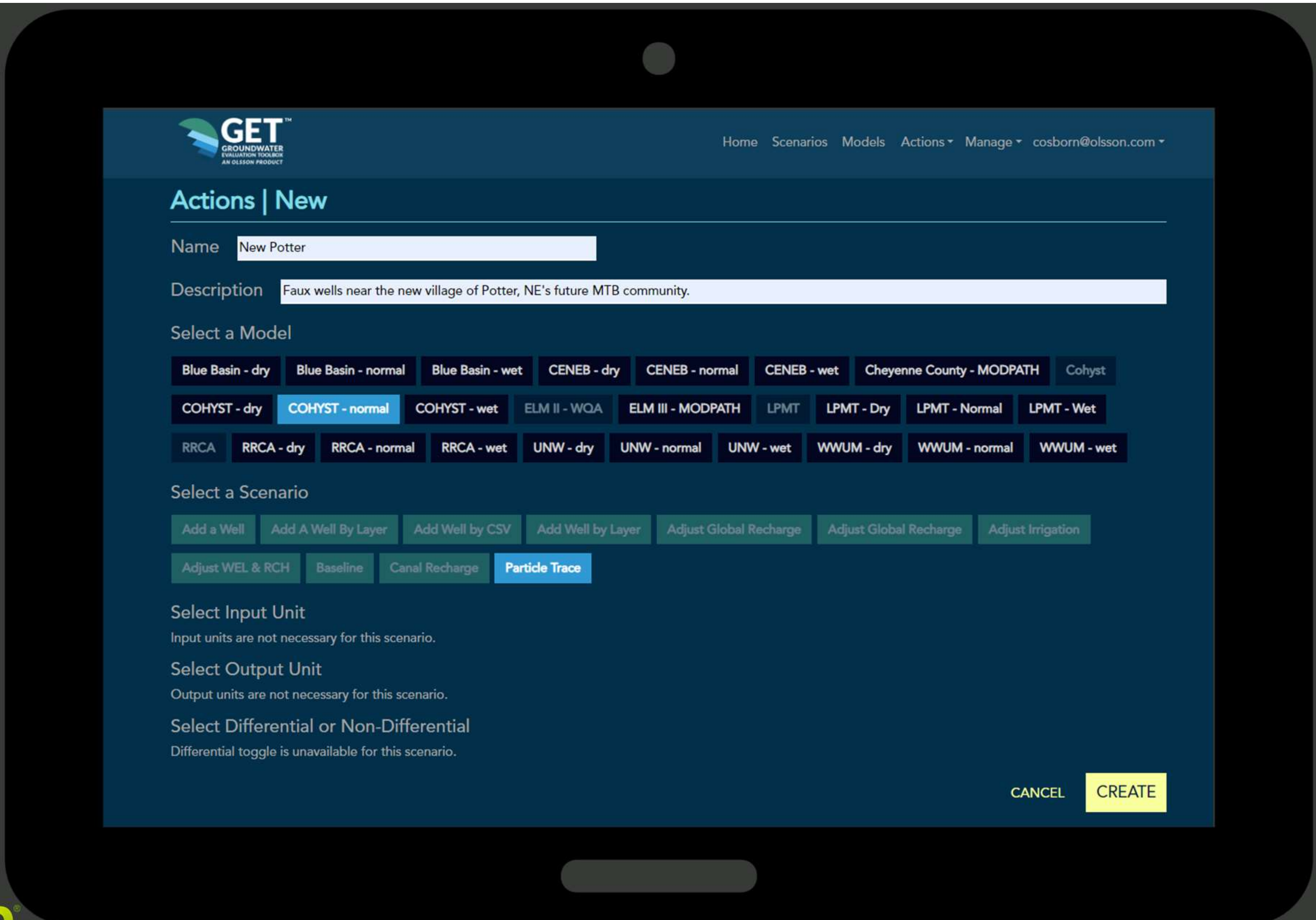
**Select water supply well locations**

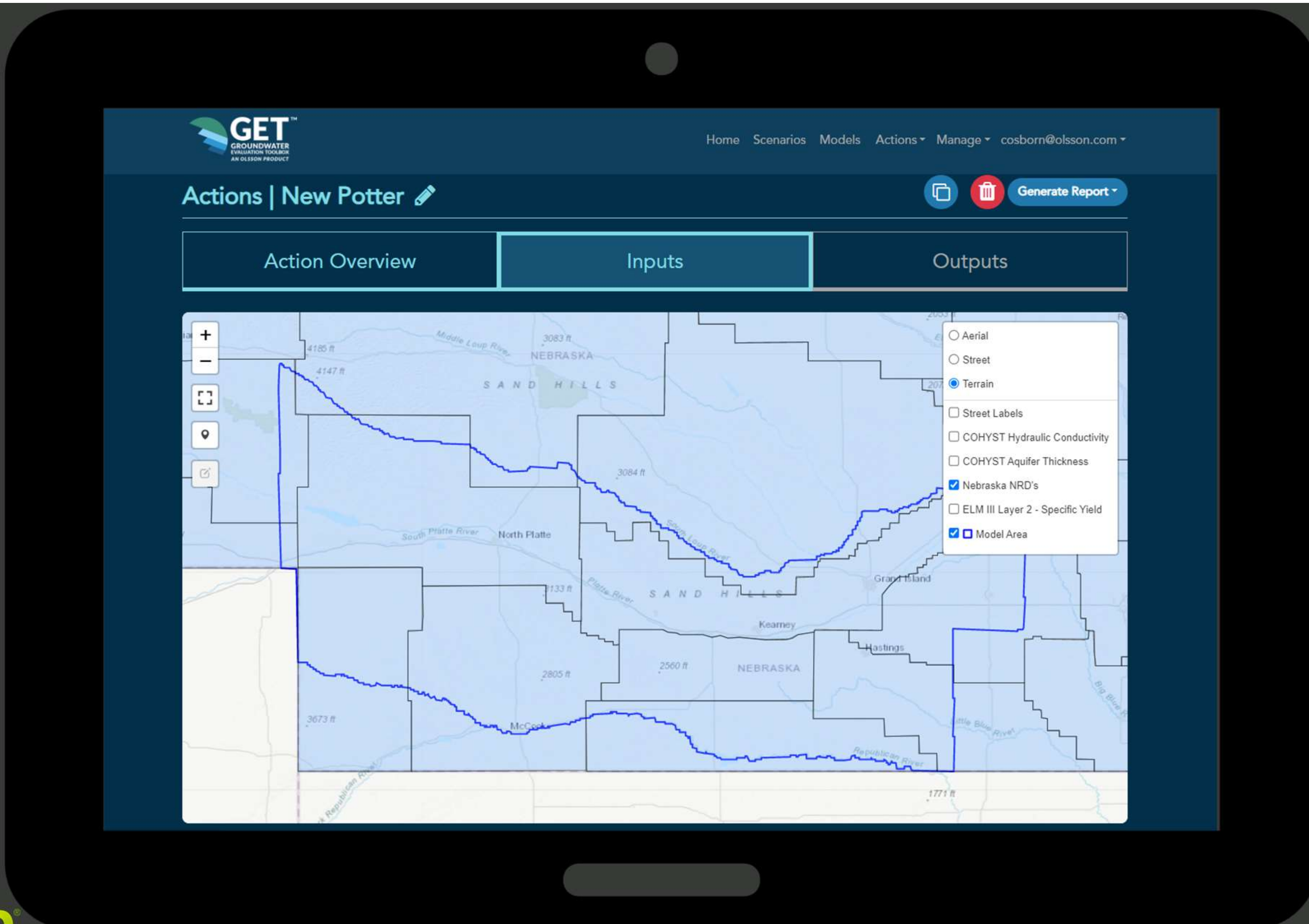
**Program enters data and runs MODPATH**

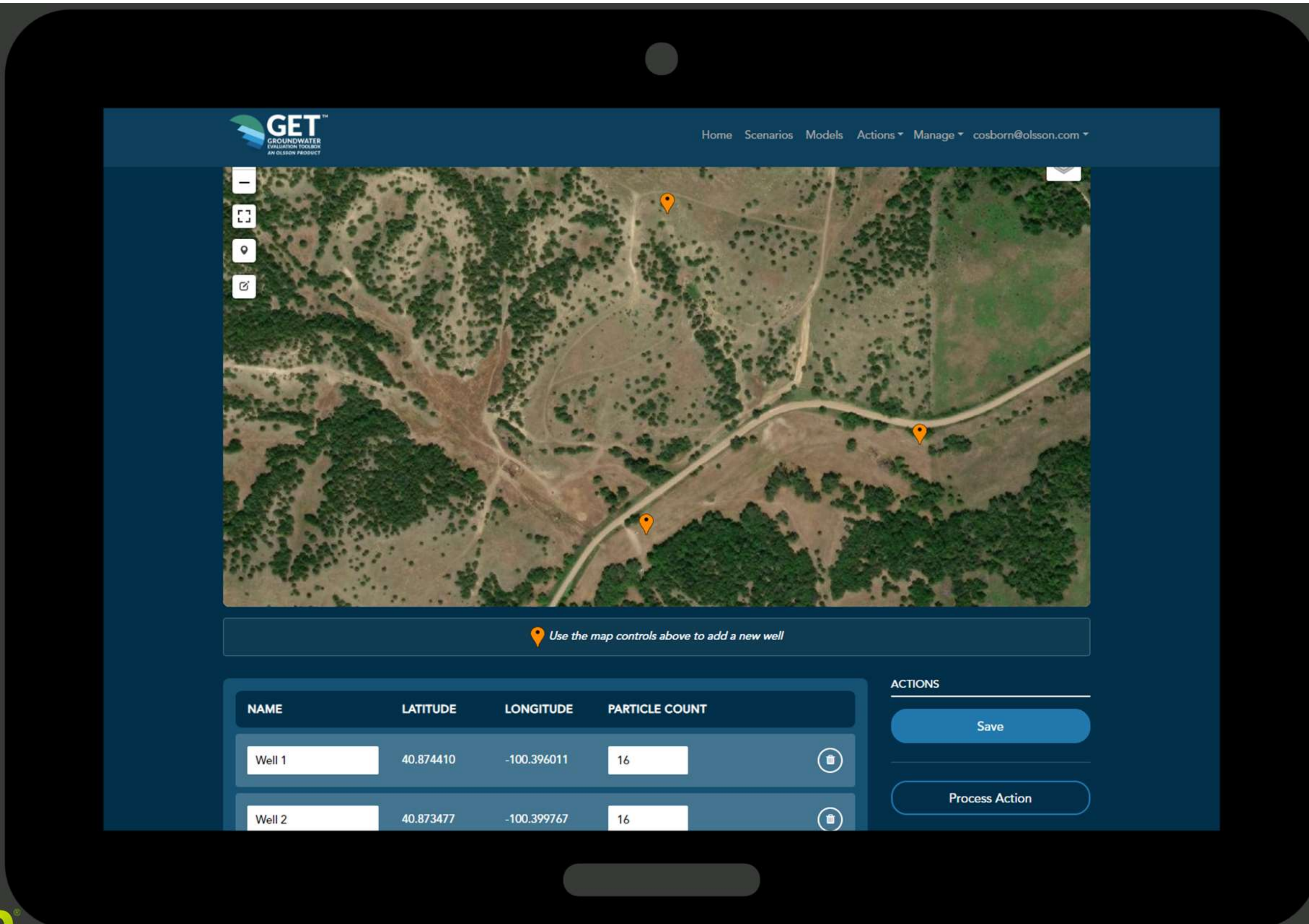
**Results Displayed**



# Particle Tracking Example


GET™
GROUNDWATER EVALUATION TOOLBOX
AN OLSSON PRODUCT
Home Scenarios Models Actions Manage cosborn@olsson.com
Actions | New
Name
New Potter
Description
Faux wells near the new village of Potter, NE's future MTB community.
Select a Model
Blue Basin - dry
Blue Basin - normal
Blue Basin - wet
CENEB - dry
CENEB - normal
CENEB - wet
Cheyenne County - MODPATH
Cohyst
COHYST - dry
COHYST - normal
COHYST - wet
ELM II - WQA
ELM III - MODPATH
LPMT
LPMT - Dry
LPMT - Normal
LPMT - Wet
RRCA
RRCA - dry
RRCA - normal
RRCA - wet
UNW - dry
UNW - normal
UNW - wet
WWUM - dry
WWUM - normal
WWUM - wet
Select a Scenario
Add a Well
Add A Well By Layer
Add Well by CSV
Add Well by Layer
Adjust Global Recharge
Adjust Global Recharge
Adjust Irrigation
Adjust WEL & RCH
Baseline
Canal Recharge
Particle Trace
Select Input Unit
Input units are not necessary for this scenario.
Select Output Unit
Output units are not necessary for this scenario.
Select Differential or Non-Differential
Differential toggle is unavailable for this scenario.
CANCEL
CREATE


GET
GROUNDWATER EVALUATION TOOLBOX
AN OLSSON PRODUCT
Home
Scenarios
Models
Actions
Manage
cosborn@olsson.com
Actions | New Potter
Generate Report
Action Overview
Inputs
Outputs
Aerial
Street
Terrain
Street Labels
COHYST Hydraulic Conductivity
COHYST Aquifer Thickness
Nebraska NRD's
ELM III Layer 2 - Specific Yield
Model Area
NEBRASKA
SAND HILLS
North Platte
Grand Island
Kearney
Hastings
McCook


GET
GROUNDWATER EVALUATION TOOLBOX
Home
Scenarios
Models
Actions
Manage
cosborn@olsson.com
Use the map controls above to add a new well
NAME
LATITUDE
LONGITUDE
PARTICLE COUNT
Well 1
40.874410
-100.396011
16
Well 2
40.873477
-100.399767
16
ACTIONS
Save
Process Action

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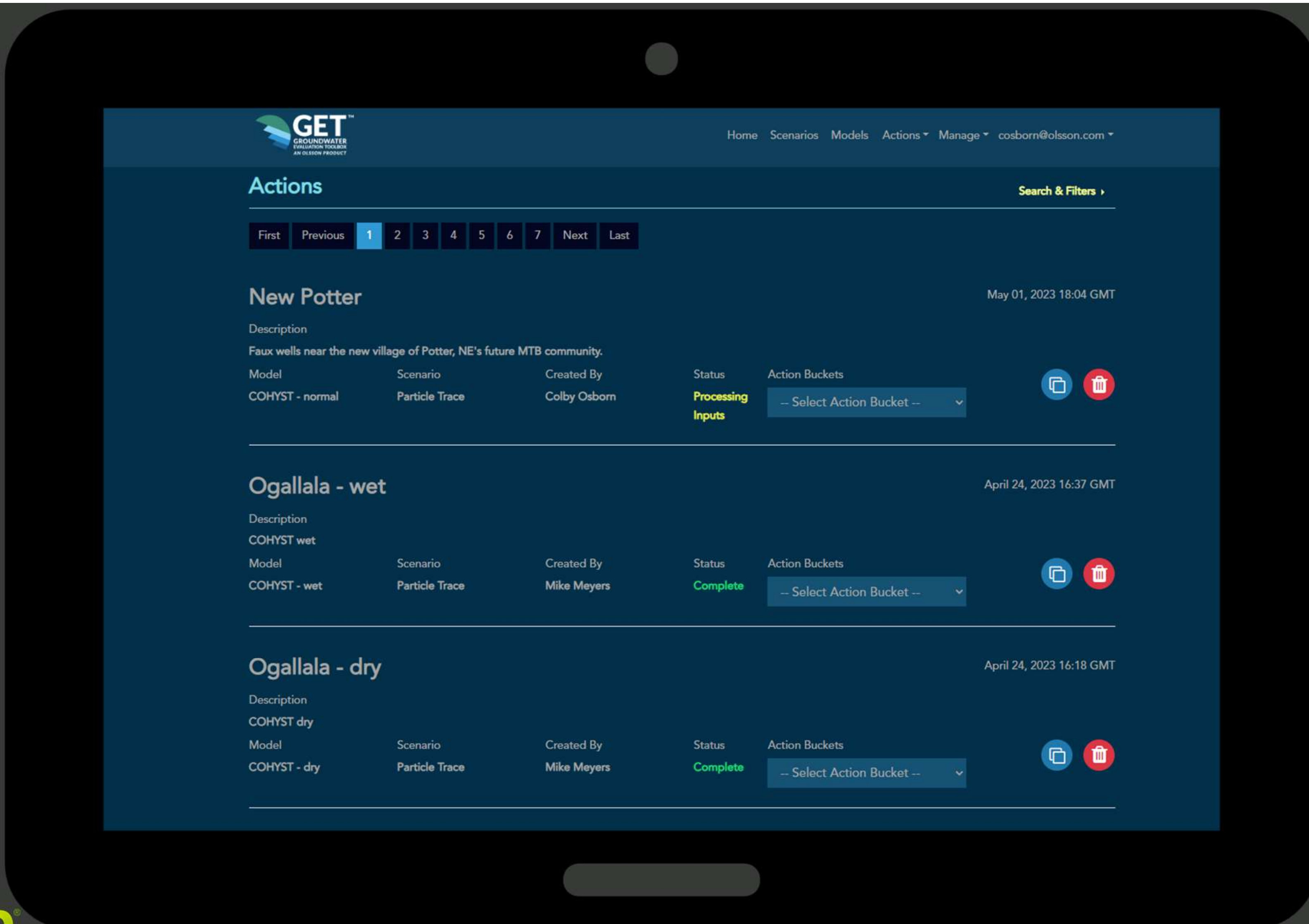
GET
GROUNDWATER EVALUATION TOOLBOX
AN OLSSON PRODUCT
Home Scenarios Models Actions Manage cosborn@olsson.com
Actions
Search & Filters
First Previous 1 2 3 4 5 6 7 Next Last
New Potter
May 01, 2023 18:04 GMT
Description
Faux wells near the new village of Potter, NE's future MTB community.
Model
COHYST - normal
Scenario
Particle Trace
Created By
Colby Osborn
Status
Processing Inputs
Action Buckets
-- Select Action Bucket --
Ogallala - wet
April 24, 2023 16:37 GMT
Description
COHYST wet
Model
COHYST - wet
Scenario
Particle Trace
Created By
Mike Meyers
Status
Complete
Action Buckets
-- Select Action Bucket --
Ogallala - dry
April 24, 2023 16:18 GMT
Description
COHYST dry
Model
COHYST - dry
Scenario
Particle Trace
Created By
Mike Meyers
Status
Complete
Action Buckets
-- Select Action Bucket --

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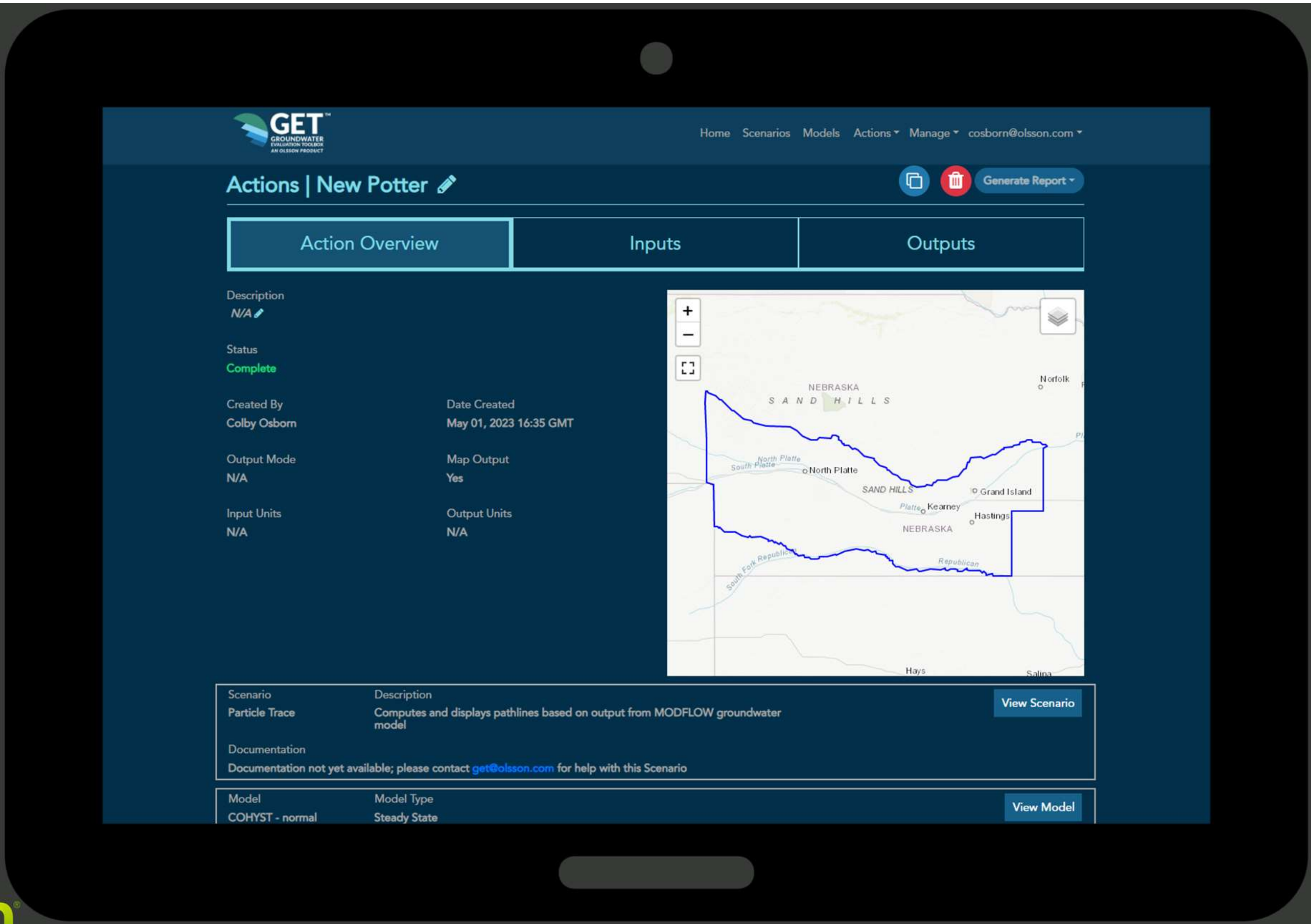
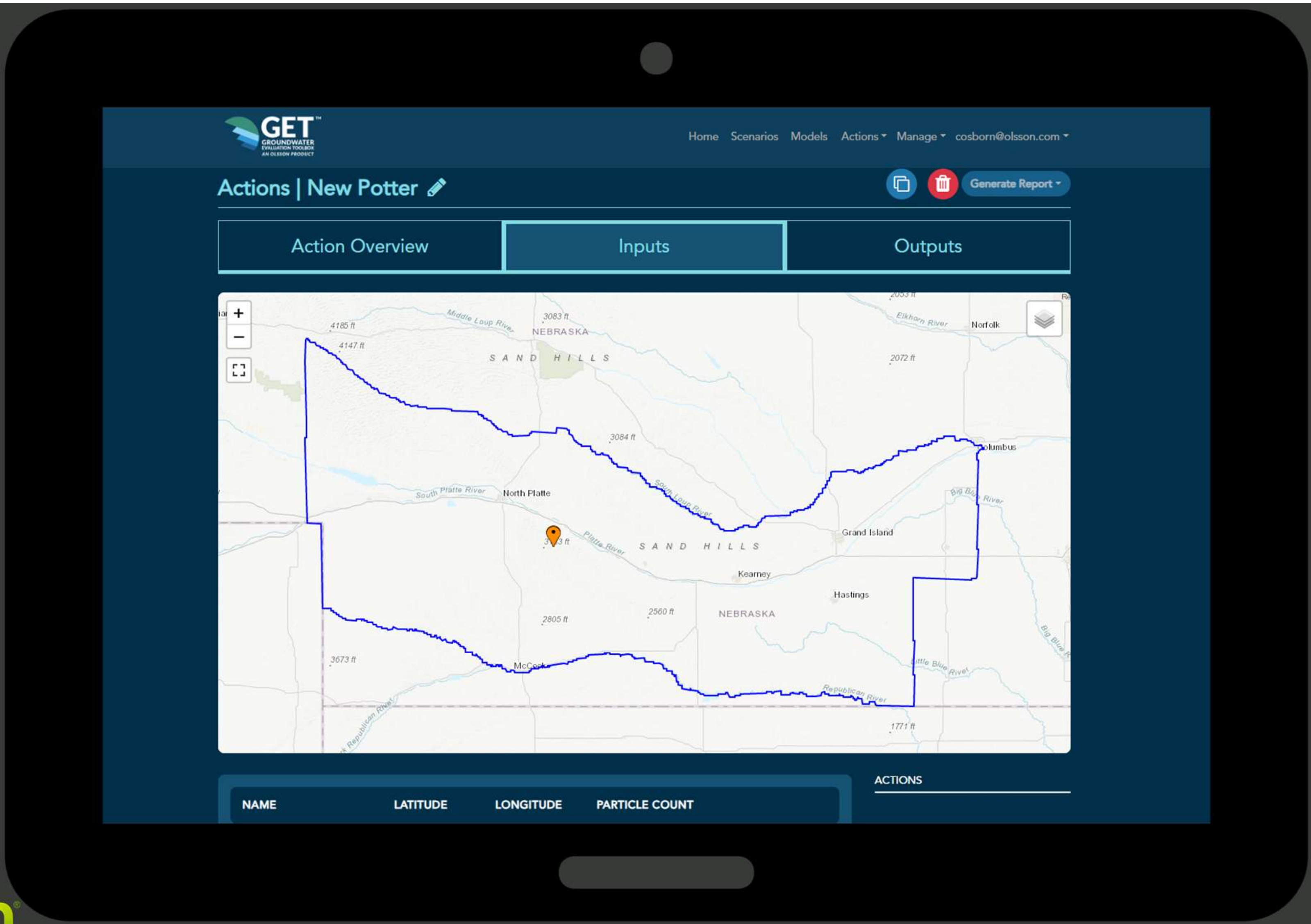
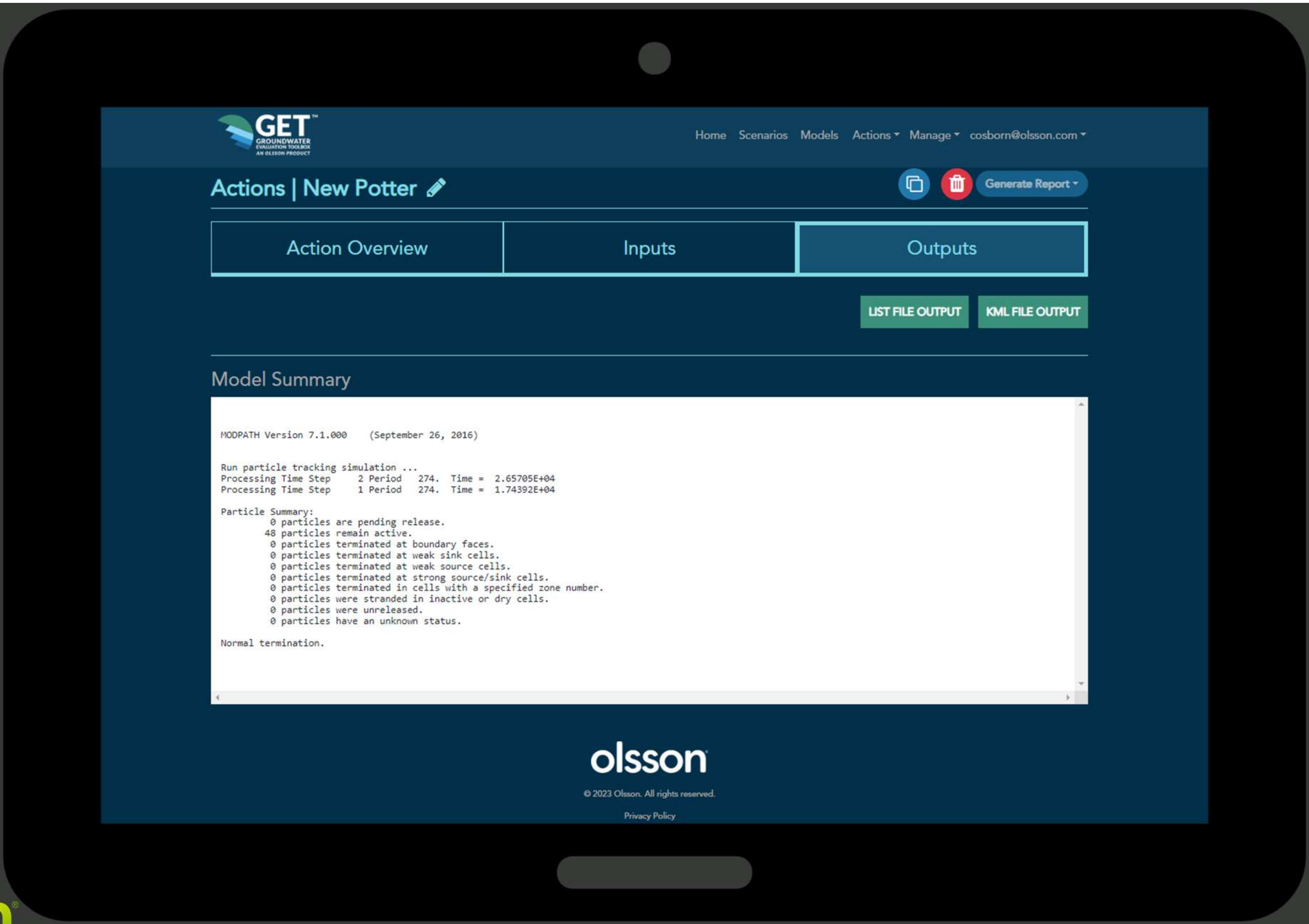

GET
GROUNDWATER EVALUATION TOOLBOX
AN OLSSON PRODUCT
Home Scenarios Models Actions Manage cosborn@olsson.com
Actions | New Potter
Generate Report
Action Overview
Inputs
Outputs
Description
N/A
Status
Complete
Created By
Colby Osborn
Date Created
May 01, 2023 16:35 GMT
Output Mode
N/A
Map Output
Yes
Input Units
N/A
Output Units
N/A
NEBRASKA
SAND HILLS
Norfolk
North Platte
Grand Island
Kearney
Hastings
NEBRASKA
Hays
Scenario
Particle Trace
Description
Computes and displays pathlines based on output from MODFLOW groundwater model
View Scenario
Documentation
Documentation not yet available; please contact get@olsson.com for help with this Scenario
Model
COHYST - normal
Model Type
Steady State
View Model


GET
GROUNDWATER EVALUATION TOOLBOX
Home Scenarios Models Actions Manage cosborn@olsson.com
Actions | New Potter
Generate Report
Action Overview
Inputs
Outputs
NEBRASKA
SAND HILLS
North Platte
Grand Island
Kearney
Hastings
Norfolk
Columbus
NAME
LATITUDE
LONGITUDE
PARTICLE COUNT
ACTIONS


GET
GROUNDWATER EVALUATION TOOLBOX
Home
Scenarios
Models
Actions
Manage
cosborn@olsson.com
Actions | New Potter
Generate Report
Action Overview
Inputs
Outputs
LIST FILE OUTPUT
KML FILE OUTPUT
Model Summary
MODPATH Version 7.1.000 (September 26, 2016)
Run particle tracking simulation ...
Processing Time Step 2 Period 274. Time = 2.65705E+04
Processing Time Step 1 Period 274. Time = 1.74392E+04
Particle Summary:
0 particles are pending release.
48 particles remain active.
0 particles terminated at boundary faces.
0 particles terminated at weak sink cells.
0 particles terminated at weak source cells.
0 particles terminated at strong source/sink cells.
0 particles terminated in cells with a specified zone number.
0 particles were stranded in inactive or dry cells.
0 particles were unreleased.
0 particles have an unknown status.
Normal termination.
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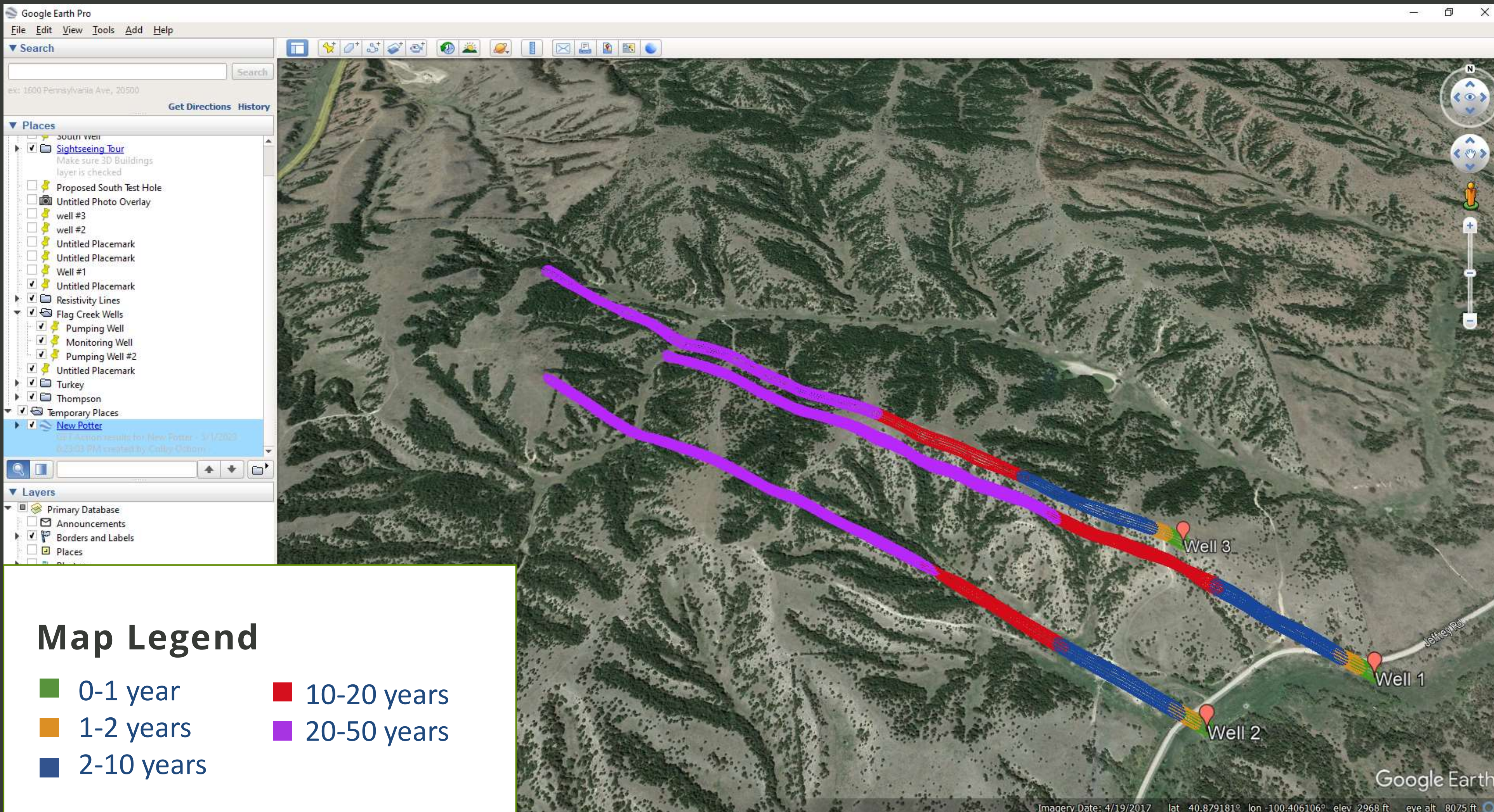

Google Earth Pro
File Edit View Tools Add Help
Search
Get Directions History
Places
Sightseeing Tour
Proposed South Test Hole
Untitled Photo Overlay
well #3
well #2
Untitled Placemark
Untitled Placemark
Well #1
Untitled Placemark
Resistivity Lines
Flag Creek Wells
Pumping Well
Monitoring Well
Pumping Well #2
Untitled Placemark
Turkey
Thompson
Temporary Places
New Potter
Layers
Primary Database
Announcements
Borders and Labels
Places
Well 3
Well 1
Well 2
Google Earth
Imagery Date: 4/19/2017 lat 40.879181° lon -100.406106° elev 2968 ft eye alt 8075 ft
Map Legend
0-1 year
1-2 years
2-10 years
10-20 years
20-50 years

# Dynamic Reports

# Traditional Reports

- Typically completed by one person
- 1-4 weeks per report
- Investigation of local geology

## Modeling Groundwater Time-of-Travel Paths to Facilitate the Creation of a Wellhead Protection Plan for the [insert name of municipality]

Whitney L. Lätt

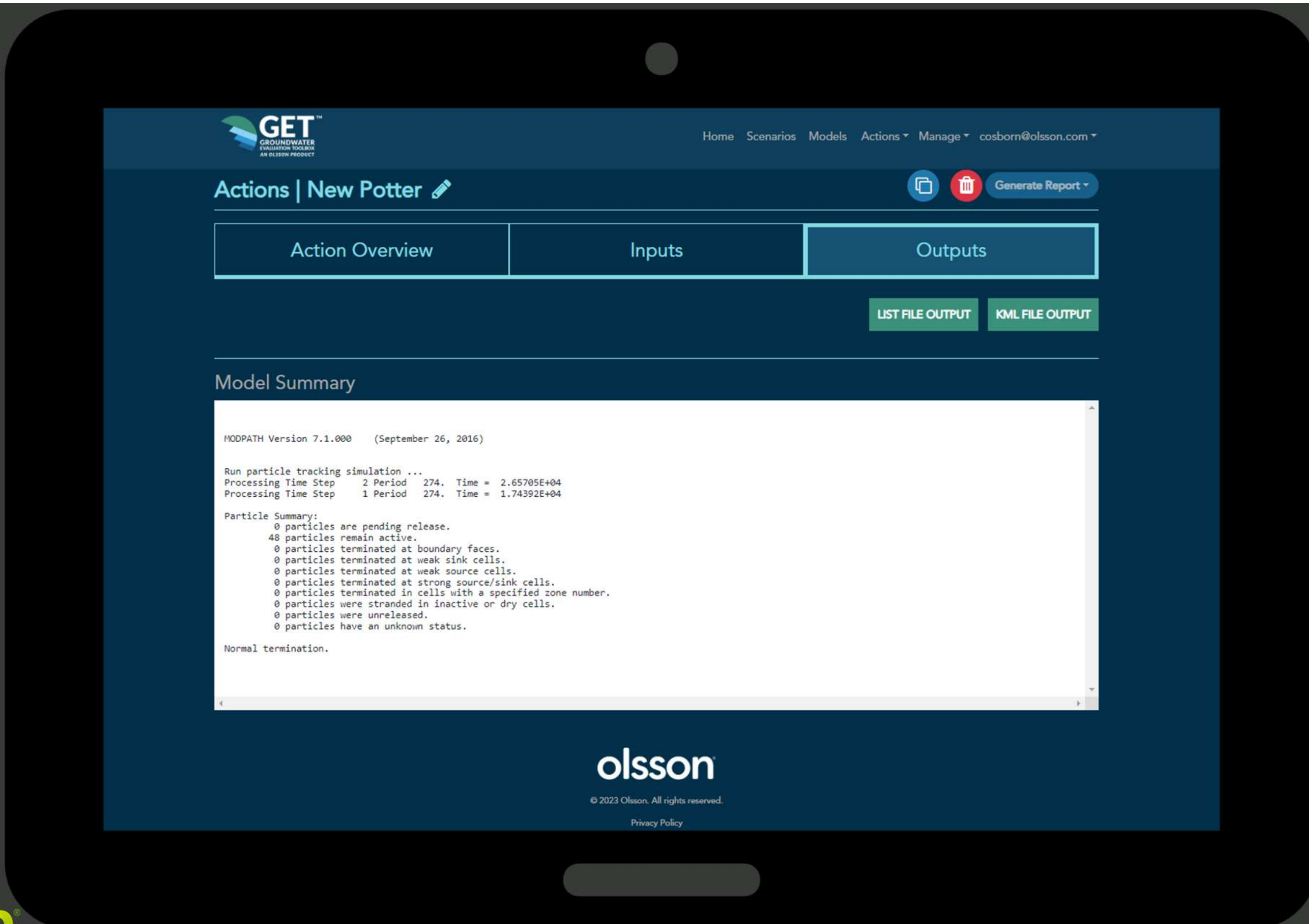
**Abstract**: A groundwater modeling program called Wellhead Analytic Element Model (WhAEM) was used to generate twenty year Time-of-Travel paths reflecting the direction and distance of subsurface flow to municipal wells. Aquifer characteristics including thickness, stratigraphy, and lithology were obtained by analysis of DNR geologic logs and well registration records. Head-specified wells obtained from DHHS and DNR records were then imported into the model to generate water table elevation data. Hydraulic conductivity (K) was estimated for the aquifer based on lithology using tables published by the United States Geologic Survey and the University of Nebraska at Lincoln. Groundwater Time-of-Travel paths modeled were compared with 1979 and 1995 water table elevations and the gradient of the aquifer base to gage the fidelity of the model to local hydrogeology.

### Geospatial Analysis

The Village of Harrison is situated over Tertiary and Quaternary marine and fluvial sedimentary deposits of Oligocene to Recent age. The Miocene aged Arikaree Group is pervasive throughout the area as the dominant bedrock (**Fig. 1**). The lithology of the group is generally coarse-detrital sand with a secondary volcanic ash component. Some minor occurrence of clastic sedimentary conglomerates may also be observed (Burchett, 1986).

Rocks of the Oligocene aged White River Group are preserved starting approximately 6 miles to the north and 20 miles to the east of the village, with the Late-Cretaceous Pierre Shale persisting at lower elevations, starting approximately 10 to 12 miles north of Harrison.

The primary aquifer is also absent to the north and east at similar latitudes and longitudes to the the White River Group and Pierre Shale. The White River Group itself was determined to make up the base of the High Plains Aquifer (DNR, 2014). The local portion of the High Plains aquifer is there confined to rocks of the Arikaree Formation.


GET
GROUNDWATER EVALUATION TOOLBOX
AN OLSSON PRODUCT
Home Scenarios Models Actions Manage cosborn@olsson.com
Actions | New Potter
Generate Report
Action Overview
Inputs
Outputs
LIST FILE OUTPUT
KML FILE OUTPUT
Model Summary
MODPATH Version 7.1.000 (September 26, 2016)
Run particle tracking simulation ...
Processing Time Step 2 Period 274. Time = 2.65705E+04
Processing Time Step 1 Period 274. Time = 1.74392E+04
Particle Summary:
0 particles are pending release.
48 particles remain active.
0 particles terminated at boundary faces.
0 particles terminated at weak sink cells.
0 particles terminated at weak source cells.
0 particles terminated at strong source/sink cells.
0 particles terminated in cells with a specified zone number.
0 particles were stranded in inactive or dry cells.
0 particles were unreleased.
0 particles have an unknown status.
Normal termination.
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Particle Trace Documentation Report for the Community of

# New Potter

Report Generated by Colby Osborn
at the Nebraska Department of Environment and Energy
5/1/2023 6:23:03 PM

This report was generated using the
**Groundwater Evaluation Toolbox®**
Wellhead Protection Scenario developed for the
Nebraska Department of Environment and Energy
by Olsson

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### a. Spatial Resolution

Boundaries of the model were determined using drainage divides between basins, rivers in adjoining basins, and at defined upstream and downstream aquifer limits. The COHYST model was developed with grid cells that are approximately ¼ mile by ¼ mile, or 160 acres in size. The grid was aligned with cardinal directions in North American Datum or NAD 1983 Nebraska State Plane (Feet) coordinates and contains 504 columns and 275 rows. There are 138,600 cells in total, of which 77,339 are active.

### b. Temporal Resolution

The COHYST model uses a 1947-2010 timeframe to represent pre-development conditions through recent years. The time period from 1985-2010 was used for calibration during model development because of the comparative abundance of data available for those years. A monthly stress period was determined to be appropriate to show inter- and intra-annual variations. The calibration model time frame beginning in October 1984 (to provide a start that reflects a complete water year) used 315 monthly stress periods to end in December 2010.

### c. Hydrogeologic Model Layers

The COHYST model represents the High Plains Aquifer in the model area as a single layer. The base of aquifer coverage was constructed from a database of test hole logs from historical drilling programs conducted by the Nebraska Conservation and Survey Division (CSD) and the USGS. Thirty-four new test holes were drilled by the CSD for the purpose of the COHYST model construction. Land surface elevation for the top of the model was taken from 10-meter Digital Elevation Models (DEM).

## 2. Groundwater Model Parameters

The following section describes specific parameters used in the COHYST groundwater model as described in the model documentation report (COHYST 2017). As stated above, the COHYST model was developed in conjunction with the NDNR to simulate groundwater flow conditions in central Nebraska. Because MODPATH uses water budget information from a MODFLOW model, the model parameters are essential in estimating how a particle behaves in the flow field. An understanding of how MODFLOW model parameters were developed can help in reviewing MODPATH output. It should be noted that the model parameters incorporated in the COHYST model were not modified by GET during development of the TOT paths.

### a. Aquifer Properties

Hydraulic conductivity values were calculated using data from Nebraska's database of registered wells. The ratio of specific capacity and developed aquifer thickness was found by dividing the well pumping rate by the static pumping level and well depth. Kriging was then used to develop a distribution of values across the model area from the well point data. Initial hydraulic conductivity zones were determined by grouping similar values. These initial zones were manually edited to address issues of small, isolated zones and adjacent areas with highly contrasting values.

Hydraulic conductivity values were adjusted during calibration by using computed and observed water levels for reference. The final calibrated hydraulic conductivity values used in the model range from 20 ft/day to 150 ft/day (see Figure 2).



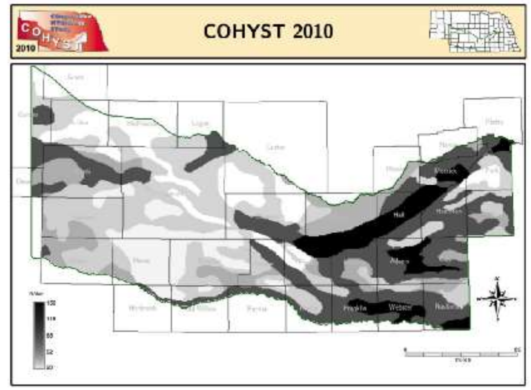


*Figure 2 Calibrated horizontal hydraulic conductivity values used in the COHYST model (COHYST 2017)*

### b. Groundwater Pumping

Groundwater pumping for irrigation was determined using land use data and crop irrigation requirements. The land use dataset developed for COHYST was created to represent irrigated and dryland acres through time and be validated at the county scale. The dataset was not meant to represent actual land use on a farm-by-farm basis. Land use for the model was developed for the years 1950 to 2007 and compared to Census of Agriculture information. To determine dryland and irrigated parcels, the COHYST model developers used data from the Center for Advanced Land Management Information Technologies (CALMIT) and remote sensing. Certified acres were used to determine if an irrigated parcel was irrigated using groundwater. In places where certified acres datasets were not available, taxable irrigated land information was obtained from the county assessor's office. Adjustments were made to land use based on the county-wide Census of Agriculture data.

Crop net irrigation requirements (NIR) are estimates of the water required to grow a specific crop type. The watershed model used by COHYST computed NIR in inches for each crop type by model cell on a monthly basis. The NIR calculations used precipitation records from nearby weather stations to account for dry and wet periods. By combining land use data and NIR, volumetric groundwater pumping rates were computed. Average annual groundwater pumping for irrigation amounts to just over 1.9 million acre-feet per year model-wide.

Municipal, domestic, and industrial pumping in the model were included based on a dataset consisting of monthly pumping values. Information to build this dataset was gathered from the following sources:

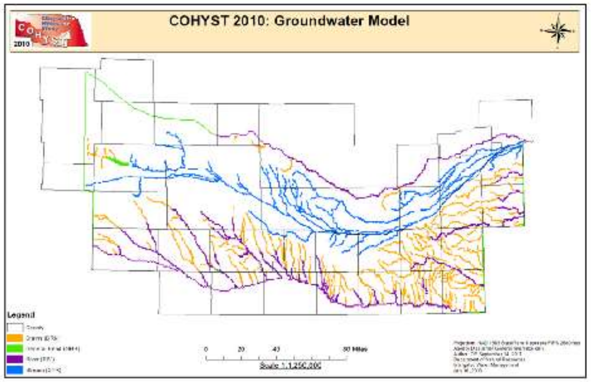


*Figure 7 Boundary conditions specified the COHYST model (COHYST 2017)*

## 3. Model Baseline Scenarios

As stated above, each groundwater model in GET has been set up to include three baselines with separate climatic conditions: wet, dry, and normal. Wet and dry baselines were determined by reviewing the model water budget and identifying a particularly wet or dry stress period throughout the simulation. The normal baseline is defined by a stress period that represents average conditions. GET uses the model files from these identified stress periods to create a flow field in which the TOT lines are calculated. The COHYST model was set up in GET using the wet month of June 1993, the dry month of July 2002, and the normal month of July 2007.

It was determined during the QA/QC analysis of GET that the difference in TOT lines produced by the wet, dry and normal baselines were not significant (Olsson 2018). Small variations in TOT line length and orientation between the tested cases were attributed to differences in groundwater pumping and recharge during wet and dry periods. It is Olsson's recommendation that during development of WHP areas, the areas are drawn to incorporate this variability in TOT line length and orientation by including approximately ¼ to ½ mile beyond the normal year TOTs.



# Particle Trace Information

## 1. User-defined Input

The TOT paths developed by GET were based on input entered into GET by Colby Osborn. At the location of each water supply well, a specific number of particles was input for GET to trace the particle along the groundwater flow path. The GET solution was run using the wells listed in Table 1 as the focal point. The particles were placed at the location of the well along a 45-foot radius. To simulate current and future flow conditions, a total of 40 particles were tracked for 50 years.

*Table 1 User Input Information to GET*

| Name | Latitude | Longitude | Particle Count |
|---|---|---|---|
| Well 1 | 40.8744101620774 | -100.396011471748 | 16 |
| Well 2 | 40.8734772105835 | -100.399766564369 | 16 |
| Well 3 | 40.8768033253561 | -100.399476885796 | 16 |

## 2. COHYST Model Specified Parameters

At each user-defined well location, the aquifer parameters in the COHYST model are unique. Table 2 documents the model parameters at the specified locations.

*Table 2 Model Parameters in User Selected Model Cells*

| Name | Aquifer Thickness (ft) | Horizontal Hydraulic Conductivity (feet per day) | Transmissivity (square feet per day) | Porosity |
|---|---|---|---|---|
| Well 1 | Find on GET map | Find on GET map | Thickness * K | Find on GET map |
| Well 2 | Find on GET map | Find on GET map | Thickness * K | Find on GET map |
| Well 3 | Find on GET map | Find on GET map | Thickness * K | Find on GET map |

## 3. Simulation Results

The results of the GET simulation are presented in TOT paths for each user-defined water supply well. The results are not included in this report but are saved in the GET platform as simulated by Colby Osborn titled New Potter. The results are available for review using Google Earth. This report is intended to provide information on the model used to develop travel time paths and to document the specific parameters defined in the model at the user-defined water supply well locations.



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