Earth Source Heat Community Forum

Virtual Meeting

January 19, 2021

Welcome and Introductions

Joel Malina

Vice President, University Relations

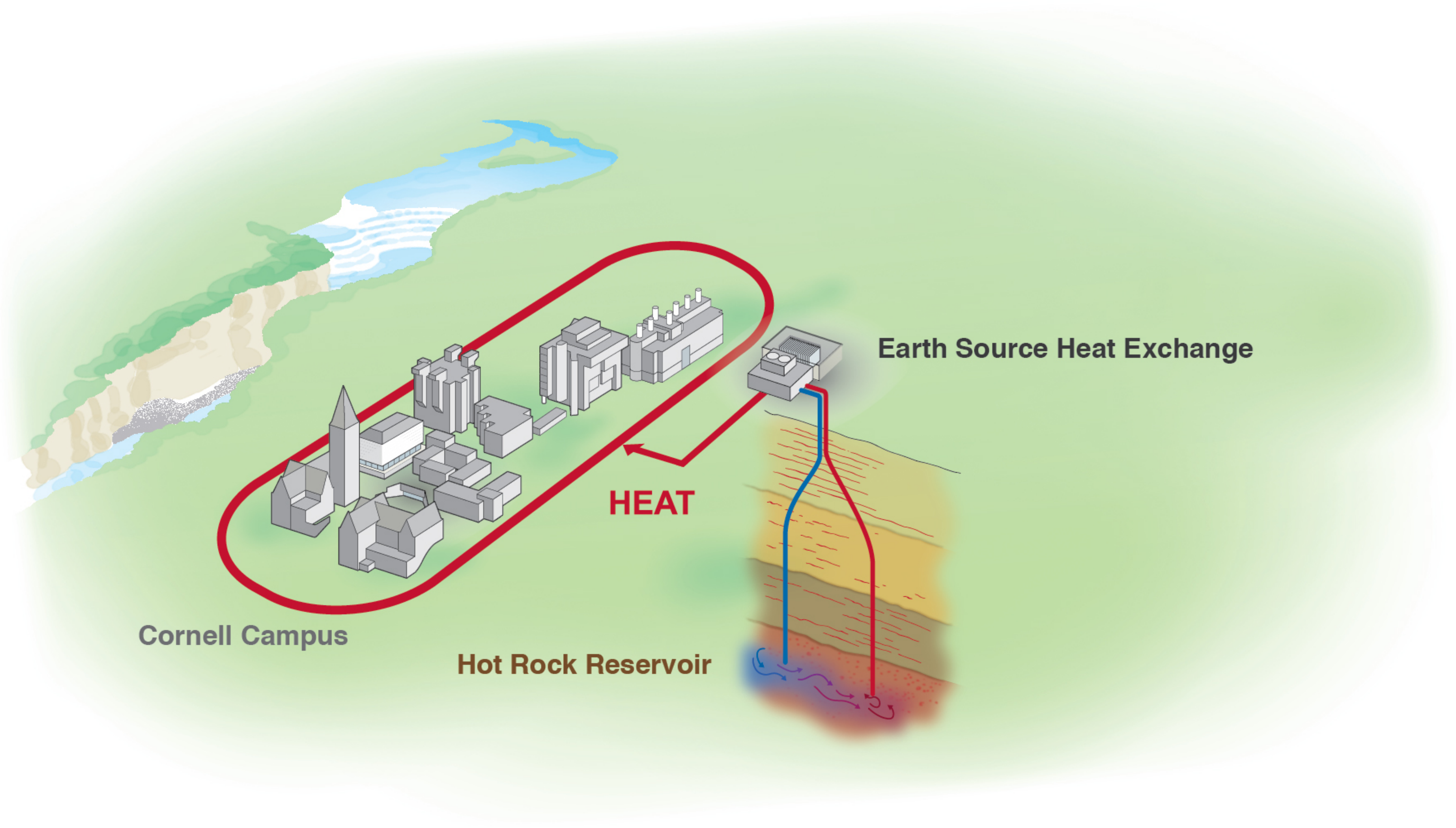
Cornell Panelists

- **Rick Burgess**, Vice President, Facilities and Campus Services
- **Teresa Jordan**, The J. Preston Levis Professor of Engineering, Earth and Atmospheric Sciences
- **Steve Beyers**, Environmental Engineer, Facilities and Campus Services
- **Tony Ingraffea**, The Dwight C. Baum Professor of Engineering Emeritus, Civil and Environmental Engineering

Cornell's Earth Source Heat Project

Rick Burgess

Vice President, Facilities and Campus Services


Earth Source Heat Exchange
HEAT
Cornell Campus
Hot Rock Reservoir

Designed in Stages to Mitigate Risks

DISCOVERY & DESIGN

- Data collection, including subsurface imaging, background seismic, and water monitoring
- Single borehole and subsurface analysis (DOE)
- System design

DEMONSTRATE

- Create functioning well-pair
- Continued risk analysis
- Connect to district heating system

DEPLOY

- Technology de-risked, new industries created
- Private-sector deploy across the state at sites with existing district heating systems and appropriate geological subsurface

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- 2016 – present
- Exploration & observation borehole – coming in 2021

- Subject to funding, 2-3 years
- Rigorous risk analysis to determine system efficacy

- Subject to funding, 3-5 years, after successful demonstration full deployment to campus and beyond

Undertaking Rigorous Risk Analysis to Determine System Efficacy

- What is the level of risk of unintended consequences, can they be mitigated, and how? For example:
  - Induced felt earthquakes
  - Water pollution
- Can sufficient heat be produced to meet Cornell's Climate Action Plan goal at an acceptable cost?
- Can heat production be sustained over many years to justify investment?
- Can an ESH project succeed through the stages of regulatory permits and community acceptance?

Academic Studies of the Subsurface-Borehole Observatory

Teresa Jordan

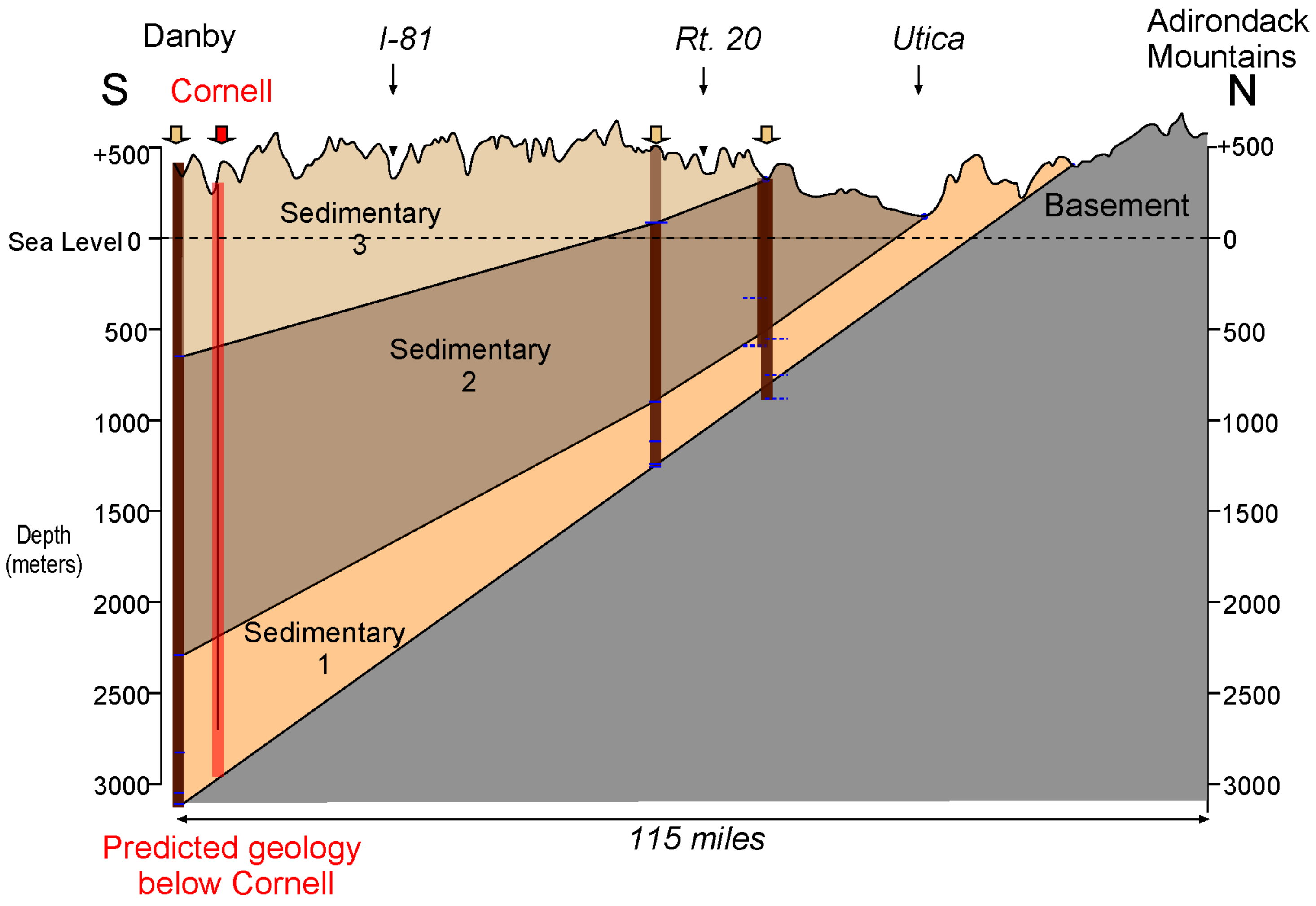
J. Preston Levis Professor of Engineering,

Earth and Atmospheric Sciences

De-risking Earth Source Heat Requires Obtaining Information about the Subsurface, Now and Into the Future

- Risks of unintended consequences and mitigation planning?
    - Mechanical conditions and fluid conditions
- Can sufficient heat be produced?
    - Natural fluids flow, fracture pathways, and temperature
- Can heat production be sustained over many years?
    - Volume of rock in which fluid might circulate
- Can an ESH project achieve permits and public acceptance?
    - Changing conditions and mitigate possibilities

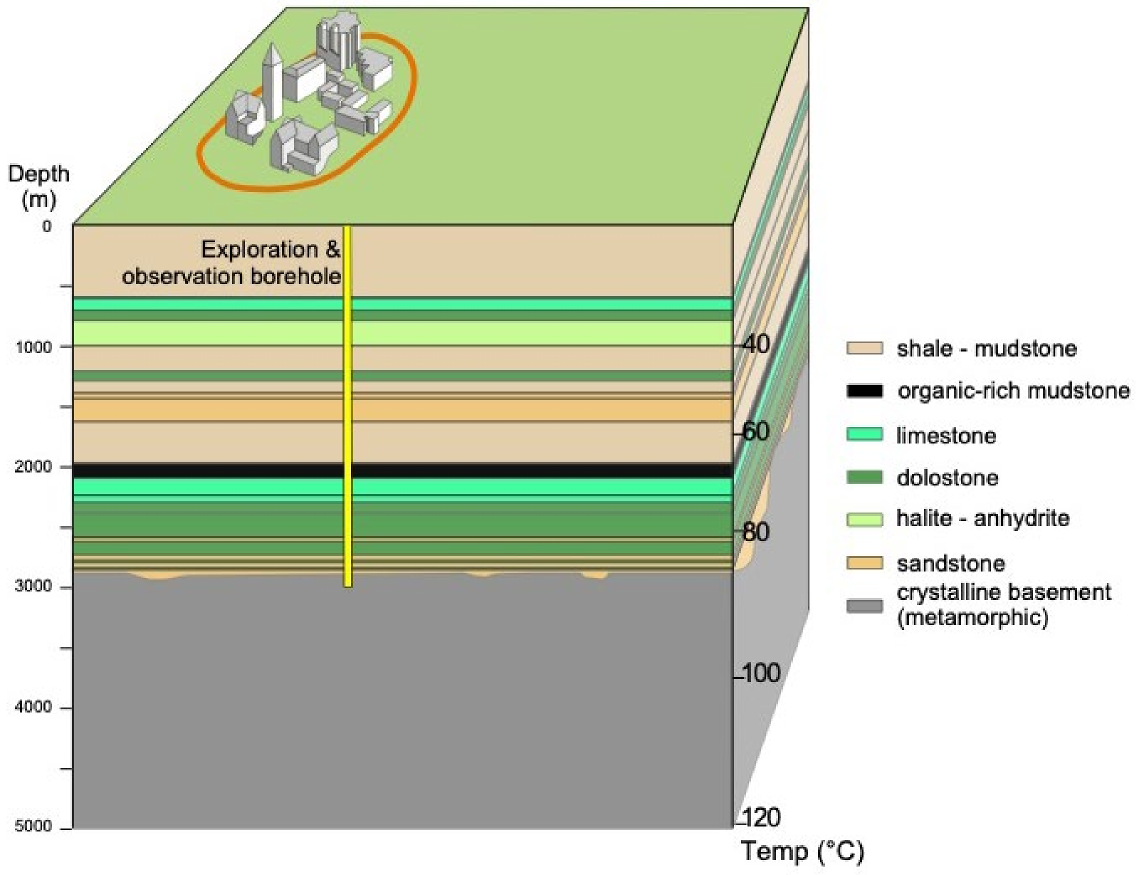
Solid Rock Compositions and Temperatures have been Deduced Based on Surface Geology and Old Boreholes



De-risking ESH: Subsurface information

CUBO: Planned to monitor subsurface conditions later, if ESH moves forward to demonstration

CUBO: Designed to gather data in order to analyze risks



CUBO will Provide Data about Fluids, Stress, Mechanical Conditions, and Temperature

- Can sufficient heat be produced and for how long?
  - Depths with natural capacity for water flow through rocks
  - Fluid compositions
  - Natural stress magnitudes, orientations, and variations
  - Natural fractures patterns
  - Temperatures at increasing depths
- Risks of unintended consequences and mitigation planning?
  - Natural stress magnitudes, orientations, and variations
  - Natural fractures patterns
  - Fluid compositions

CUBO Monitoring will Enhance Safety

Cornell plans to use CUBO to monitor the subsurface now and into the future. CUBO monitoring tools include:

- Temperatures along length of borehole (fiber optic cable)
- Strain along length of borehole (fiber optic cable)
- Time-series sampling of fluids
- Borehole seismometer at bottom

Cornell Project to Explore Earth Source Heat

Steve Beyers

Environmental Engineer, Facilities and Campus Services

How Did We Get Here?

- **2017-2019**: **U.S. DOE funds Cornell feasibility study**. Site-specific study advances ESH design to incorporate high-performance district heat pumps (heat recovery chillers).
- **Jan. 2020**: **International Continental Drilling Science Program** (ICDP) funds workshop to refine ESH scientific objectives; Cornell University Borehole Observatory (CUBO) concept is recommended.
- **2020**: **Cornell notified of DOE award** for the **Cornell University Borehole Observatory**—National test case for deep-enhanced geothermal heating.

Undertaking Rigorous Risk Analysis to Determine System Efficacy

- What is the level of risk of unintended consequences, can they be mitigated, and how? For example:
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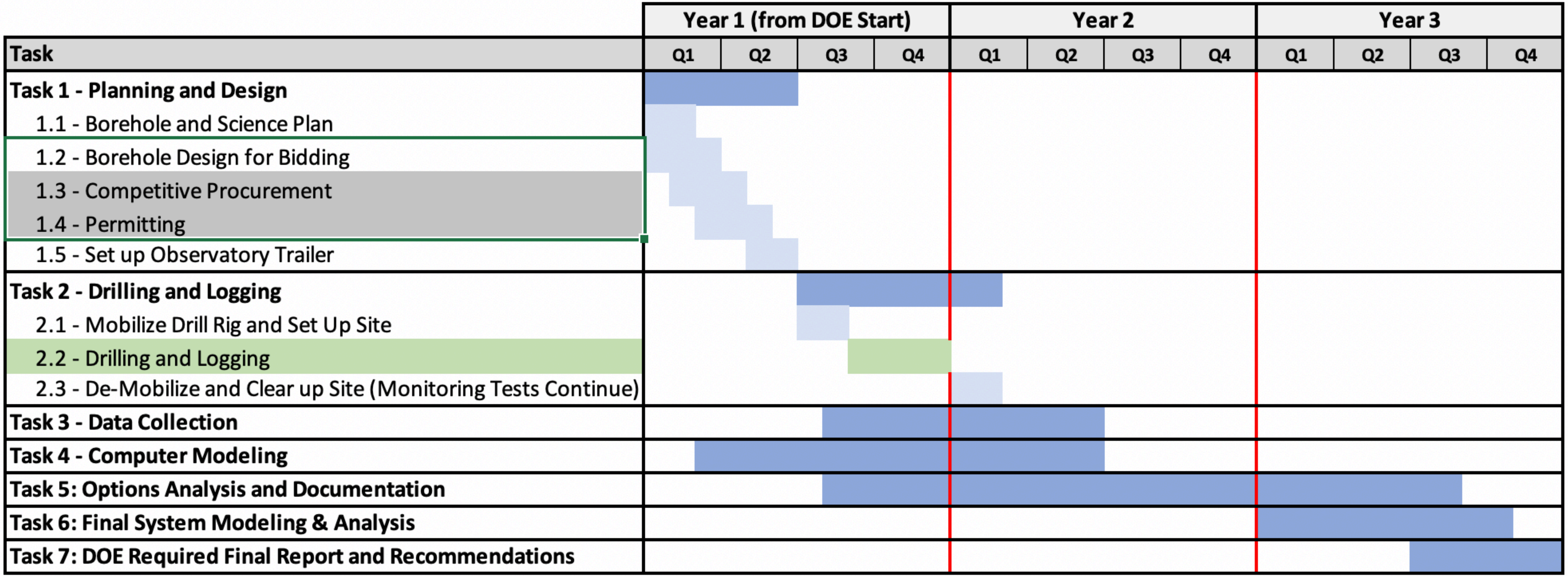
Cornell University Borehole Observatory (CUBO): Technical and Program Goals

- Safety considerations
- Ground truthing: Predict specific site performance vs. "range of possible performances"
- Geothermal systems approach (based on CUBO results)
- Other technical information for planning and design

Cornell University Borehole Observatory (CUBO) Proposed Schedule (per DOE Scope)



Proposed Borehole Observatory

- Proposed Borehole Site
- Surface Seismometers
- Borehole Seismometers
- Cornell Land
- Aquifer
- ½ mile radius
- ¼ mile radius

Borehole Observatory: Seismic and Water Monitoring, Well Design

Tony Ingraffea

Dwight C. Baum Professor of Engineering Emeritus,

Civil and Environmental Engineering

Proposed Borehole Observatory

Proposed Borehole Site

Surface Seismometers

Borehole Seismometers

Cornell Land

Aquifer

½ mile radius

¼ mile radius

Seismic Monitoring

- Proposed Borehole Site
- Surface Seismometers
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- Cornell Land
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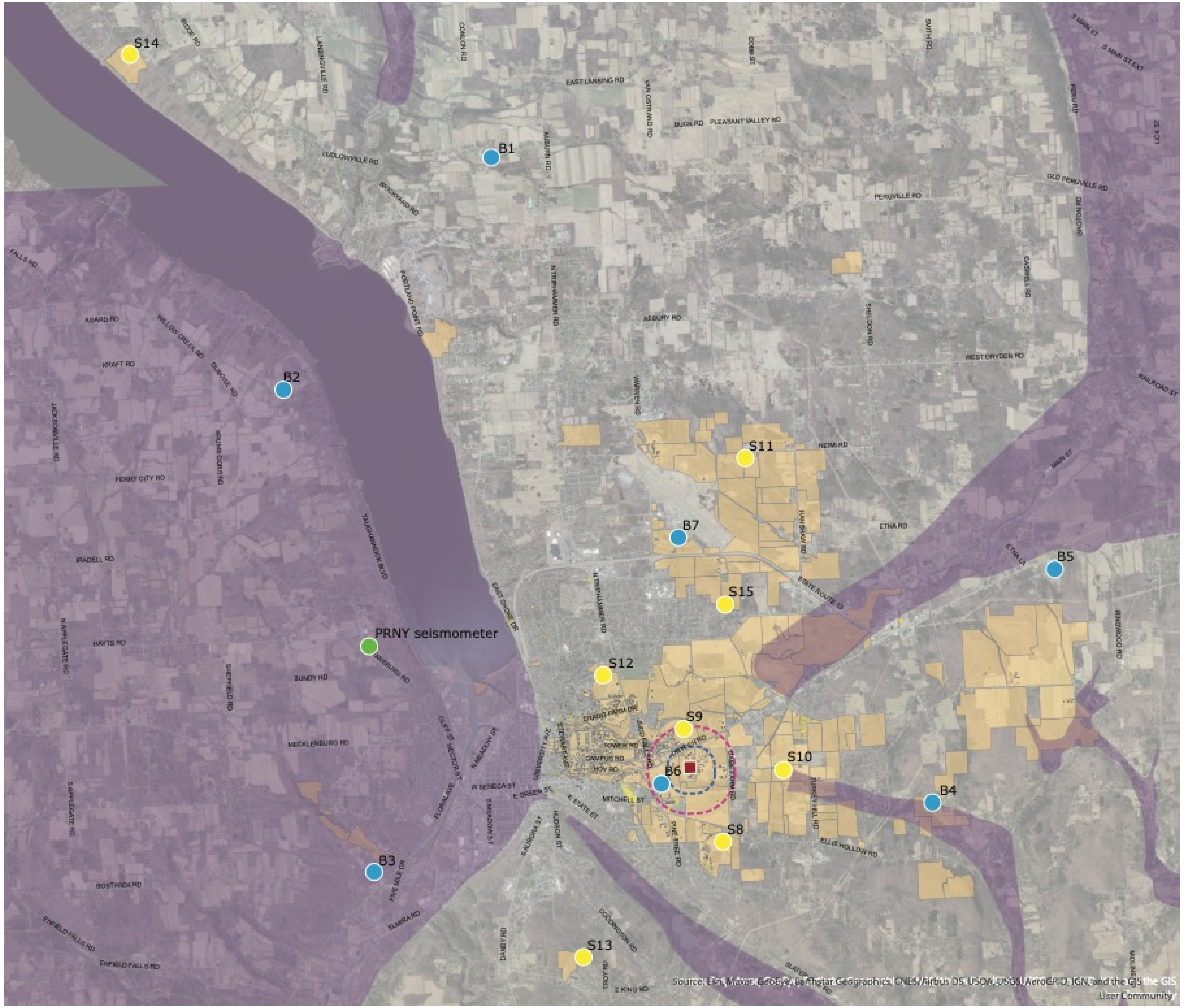
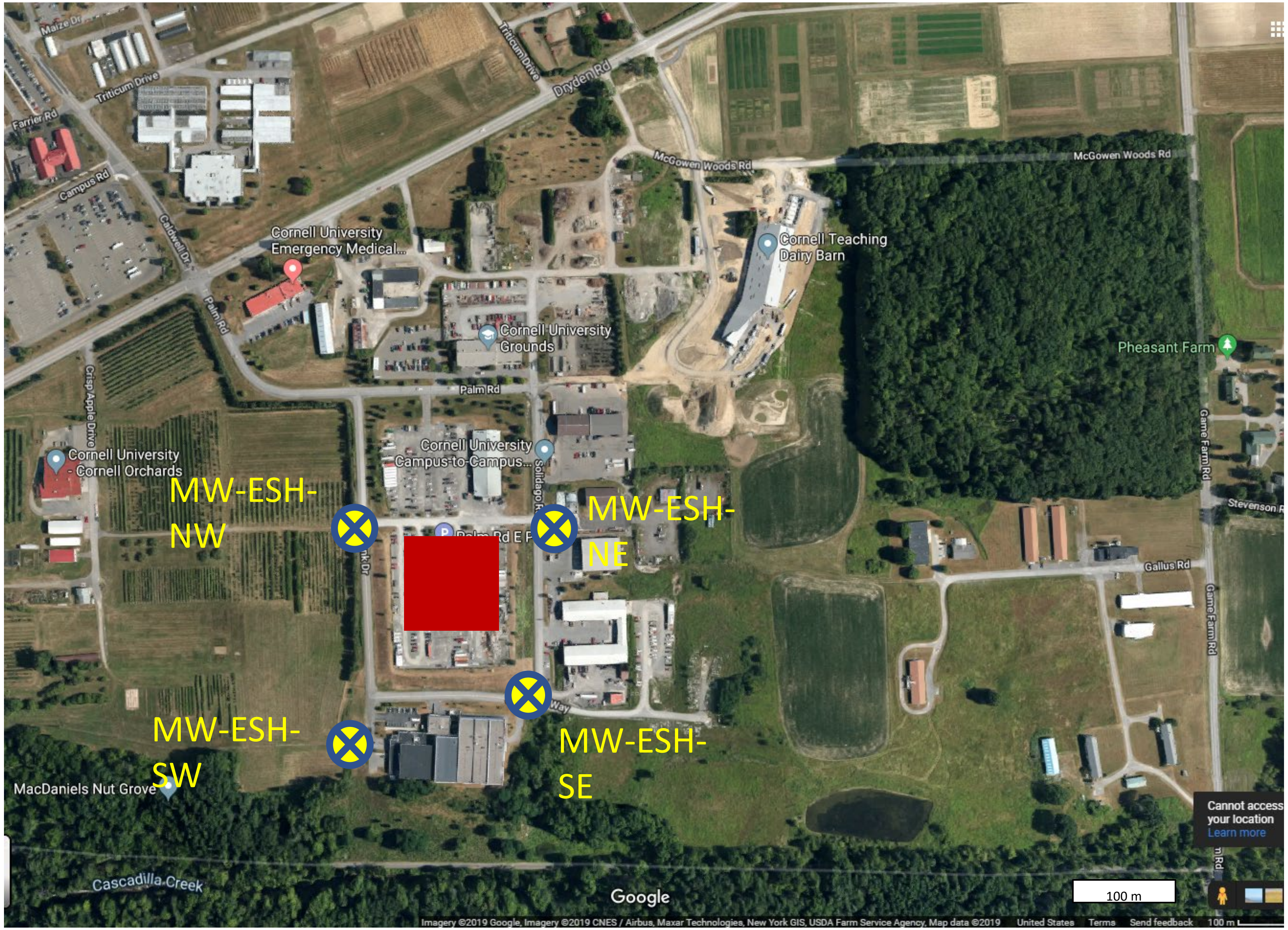
- ½ mile radius
- ¼ mile radius



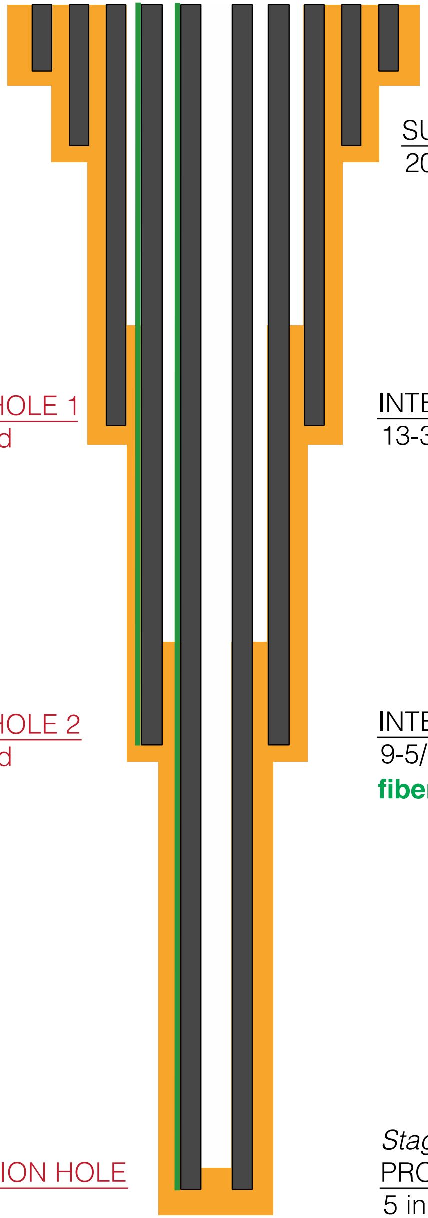
Location of New Water Monitoring Wells Near Drill Site



Monitoring well location

Borehole site

Cornell Borehole Observatory Well Design



ORANGE = Cement
GREY = Steel
GREEN = Fiber optic cable

NOT TO SCALE

Open Q&A

Thank You

For More Information, Please Visit:

earthsourceheat.cornell.edu