Oregon TECH
Oregon Institute of Technology

Meeting of the
Oregon Tech Board of Trustees
Virtually via Microsoft Teams
December 16, 2022
2:00pm – 3:30pm

Board of Trustees Meeting
Agenda

1. **Call to Order/Roll/Declaration of a Quorum** (2:00 pm) (5 min) *Chair Davis*

2. **Report**
   2.1 Fall 2022 Census Enrollment update (2:05 pm) (10 min) *Provost Mott*

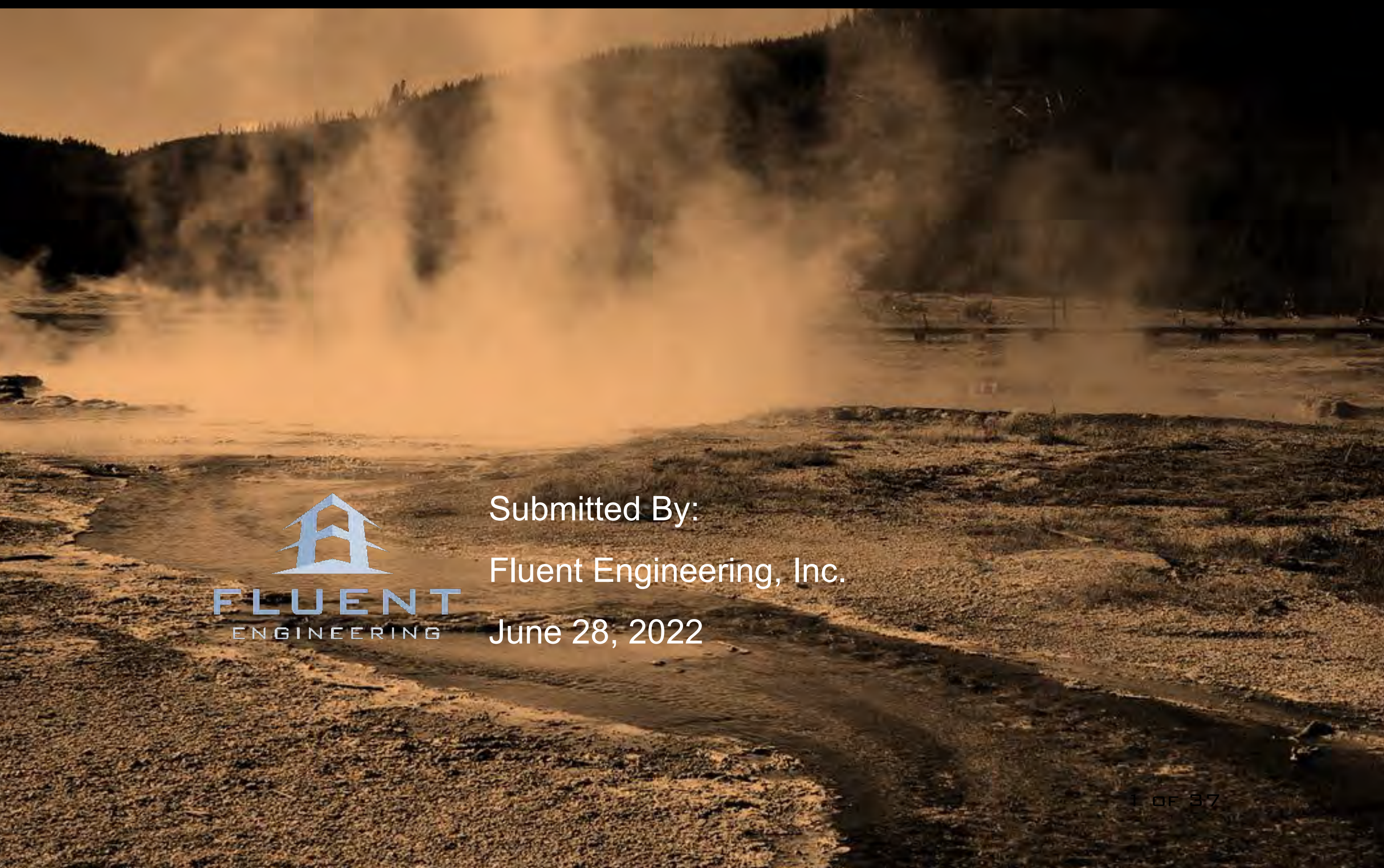
3. **Action Items**
   3.1 2022-2023 Institutional/President's Goals (2:15 pm) (15 min) *Chair Davis*
   3.2 President's Contract (2:30 pm) (15 min) *Chair Davis*

4. **Discussion Items**
   4.1 Oregon Tech Legislative Priorities (2:45 pm) (10 min) *Harman*
   4.2 Geothermal System Discussion (2:55 pm) (20 min) *VP Harman*
   4.3 Legislative Outlook (3:15 pm) (15 min) *VP Harman*

5. **Adjournment** (3:30 pm)

Attachment A

2022 OREGON TECH GEOTHERMAL CONDITION ASSESSMENT



Submitted By:

Fluent Engineering, Inc.

June 28, 2022

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Engineering Stamps

Report Sections Applicable to Brian Brown, PE Stamp and Signature: Mechanical

Report Sections Applicable to Matthew J. Cash, PE Stamp and Signature: Electrical

EXPIRES: 12/31/2023

Date Signed: 06/28/2022

Contents

Executive Summary

The geothermal heating system at the Klamath Falls Campus of Oregon Tech has been effective for over 60 years and is not only a unique renewable resource that benefits Oregon, but it is critical to the continued operation of Oregon Tech. Geothermal is the only heating source for almost all of the campus, and the majority of the system is beyond its service life. The consequences of not addressing the deficiencies of the system range from periodic with increasing frequency operational disruptions to a complete loss of assets at the entire Klamath Falls Campus. As evidenced approximately 3 weeks prior to the date of this report, a geothermal valve/pipe failed, resulting in a complete shutdown of the system. Fortunately, this occurred during non-freezing temperatures. The Geothermal system is critical to Oregon Tech's operations, and given that Klamath Falls is at or below freezing on average 7 months out of the year due to its higher elevation, loss of heat can result in complete loss of some/all buildings on campus. Comfort heating is required for at least 3 more months. It has snowed in July on several occasions in Klamath Falls.

The geothermal heating system is made up of wells, pumps, heat exchangers, heated air/water distribution systems, campus distribution piping, and injection wells that return the resource back to the ground. There are four crucial elements to the system which are described below. If any one of these crucial elements fails, the entire campus heating system at Oregon Tech- Klamath Falls will no longer function. The list and condition of these crucial elements are as follows:

Geothermal Wells

Description:
Wells in the ground produce the heated geothermal water that is distributed to the buildings and injection wells to return the geothermal water to the ground. Wells include casings, pumps, shafts, electrical, and piping.

Condition:
Most are in poor condition, do not meet current standards, and have exceeded expected service life. Cannot rely on redundant wells due to inability to increase flow without damage/debris.

Geothermal Mechanical Building Sediment Tank & Electrical

Description:
All the wells route the water to this building, where it is then distributed to the campus. The building also powers and monitors (controls) the wells and other parts of the geothermal system network.

Condition:
Tank- Unknown/Poor, undersized for the campus, and does not provide adequate protection from sediment esp. as existing wells fail. Tank is critical to system operation and therefore inspection windows are short/cannot risk a shutdown of the system for scheduled tank inspection. Tank is beyond expected service life.

Electrical- Fair Condition, but has no backup and does not meet current code. Additionally, is distributed such that multiple single failure points exist (should be consolidated with the ability to -bypass failure points).

Distribution Piping

Description:

Moves geothermal water across campus, to each building, snow melt, and back to Injection Wells. Includes Valves, supports, piping, etc.

Condition:

Mostly good to fair; however, this is due to correct material selection which is not present throughout the system, and there is no ability to isolate such that a small failure, and/or failure in one area results in a full campus shutdown for potentially extended periods of time. Areas with inferior materials will cause complete loss of the system that can result in loss of heat for extended periods (weeks to months).

Campus Main Electrical Gear & Distribution System

Description:

Provides power to all the buildings, and Geothermal controls, pumps, warm air distribution, etc. This is where the 12,470 Volt campus distribution system splits from the utility feed coming in, to each building, and consists of disconnects, breakers, transformers, and fuses.

Condition:

Main Electrical Equipment- Poor, life reduced due to previous damage, and Complex to replace. Has experienced flooding, and due to its location is subject to additional damage. Does not meet current code, or standards.

Campus distribution- Good. Due to recent investments, after the main electrical gear, the campus distribution system is poised to serve years into the future meeting modern standards.

In addition to the crucial elements above, the geothermal system also consists of the following important elements. Failure to the following systems, while serious, would be localized and not take down the entire campus heating system.

Building heat exchange

Description:

Transfers heat from the geothermal distribution system to the buildings for space heating and domestic hot water.

Condition:

Heat exchangers, pumps, and controls in older buildings are generally in poor condition or not optimized for efficient use of the geothermal resource

Snowmelt:

Description:

Transfers heat from the geothermal distribution system to exterior stairs and sidewalks for snow removal/deicing. The snowmelt serves the students, faculty, and staff by keeping sidewalks passable and de-iced which also provides removal of ADA barriers.

Condition:
Existing snowmelt equipment has been installed and is not connected to the Geothermal System. Some areas on campus do not have continuous paths between buildings, additional GEO snowmelt should be added to address the most commonly utilized pathways. Future snowmelt locations should also be identified as part of the overall system capacity and distribution upgrades. Older heat exchangers and pumps are no longer adequate and require replacement.

The geothermal system is an excellent renewable resource that has no harm to the natural biological environment and provides Oregon with protection from rising energy costs. According to a 2010 article on the uses of geothermal at Oregon Tech, former Oregon Tech Professor Dr. John Lund estimates that the return on investment is at least $1M/year in energy savings (Lund & Boyd, 2010).

If the deficiencies outlined in this report are corrected, the vulnerabilities in the systems listed above will be eliminated. In other words, the system would no longer be subject to these single points of failure and could continue to operate with electrical backup, and system isolation to fix issues that may arise. The estimated cost of the recommended actions in this report is $14,951,000. If these items are addressed, the Geothermal Heating system will continue to serve the campus for the next 60 years and beyond.

1. Introduction

1.1 Project Description and Scope

Fluent Engineering, Inc. was tasked with evaluating the hydrothermal (Geothermal) resources of the Oregon Tech – Klamath Falls Campus. The purpose of this task was to aid in the development of an emergency funding request to the Oregon Higher Education Coordinating Committee (HECC) to address immediate life safety and risk of failure concerns within the geothermal system of Oregon Tech.

The objectives of this project were as follows:

- Provide information used to develop an emergency funding request
- Provide Campus overview and history of the geothermal system
    - Describe the history of geothermal at Oregon Tech
    - How geothermal energy is integral, and critical to campus operation and ongoing development
- Provide a description of the existing geothermal system
    - Uses of geothermal energy at Oregon Tech
    - Determine System Capacity
- Describe environmental and financial benefits of geothermal
- Analyze concerns and consequences of system failure
    - Age and deterioration of critical components
        - Production wells and pumps
        - Pipelines
        - Injection wells
        - Heat exchangers in buildings
        - Isolation valves in distribution piping
    - Lack of resiliency to component failure (including geothermal distribution and supporting electrical power)
        - Loss of critical components can shut down the entire system and campus operations
        - No way to isolate a portion of the system while the rest continues to operate
        - Possible collateral damage to other systems or buildings
        - No other source of heat or hot water
    - Life safety risks
        - Risk of scalding with hot water in confined space utility tunnels
        - Equipment such as snowmelt systems in tunnels
        - No way to quickly respond to failure
        - Aging system in mechanical rooms
        - Failing/non-compliant wells
    - Environmental risks
    - Capacity
        - Ability to support planned campus growth
        - Ability to modulate system
- Provide recommended actions to address concerns

  - Identify and repair or replace critical components
  - Improve resiliency
  - Improve or optimize system capacity
    - Establish a plan for support of future buildings
    - Optimize the use of resources to allow more buildings to be served
    - Operation plan for production wells to meet capacity peaks
  - Improve Safety

This project served to complement a Facility Condition Assessment performed by Fluent Engineering in 2018 that examined elements of the campus geothermal system. That analysis addressed immediate and long-term concerns of the system. This analysis builds on that assessment to provide a comprehensive set of recommendations to address life safety concerns, improve system resiliency, support future campus growth, and address components that have either failed or reached the end of their expected life.

The analysis looked at the following systems and components:

- Central Plant / Heat Exchange Building
  - Storage
  - Settling Tank
  - Pumps
  - Valves
  - Strainers
  - Electrical Feeders Serving Geothermal Systems
- Geothermal Supply Well #6
- Geothermal Injection Wells #1 and #2
- Distribution Supply and Return Piping
- Heat Transfer Within Building (Heat-Exchangers)
- Snow-Melt System
- Electrical Distribution System

1.2 Project Team

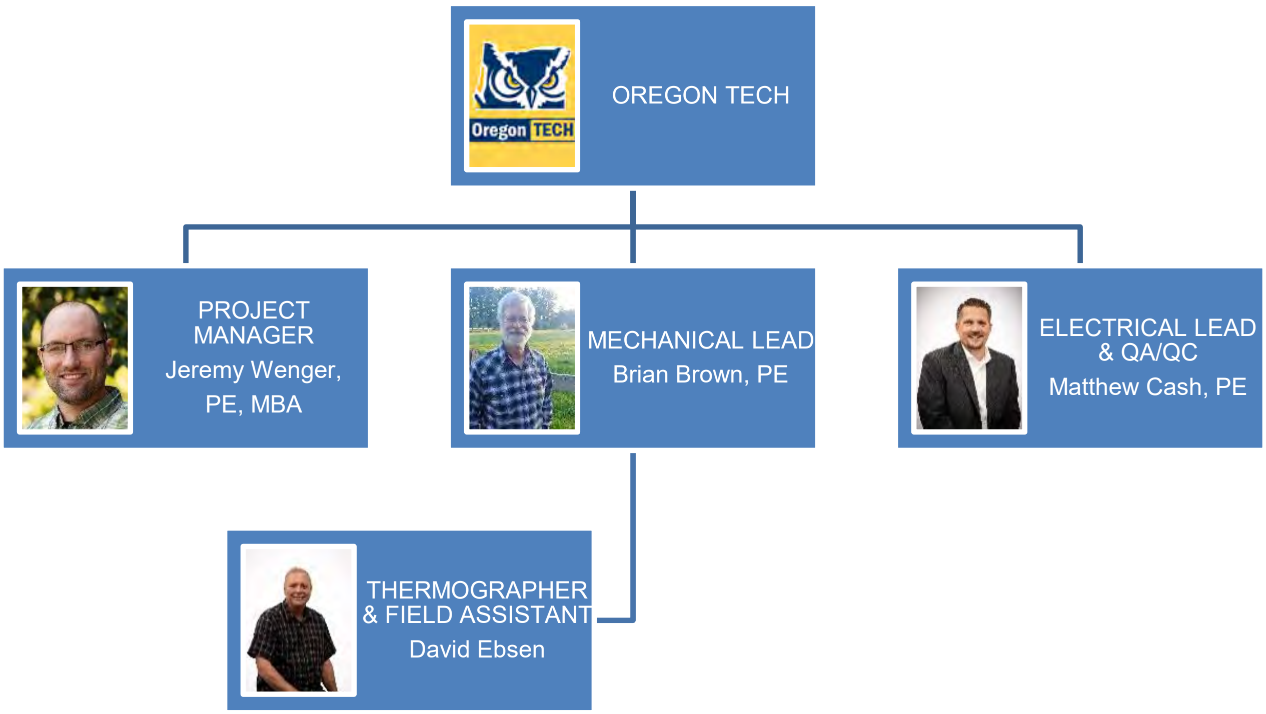
The Fluent Engineering project team consisted of the following individuals:

Jeremy Wenger, PE, MBA served as Fluent Engineering's Project Manager. Jeremy served as the Project Manager of a 2018 Facilities Condition Assessment of the Oregon Tech Campuses in Klamath Falls and Wilsonville.

Brian Brown, PE served as the lead engineer for the planning and evaluation of the geothermal system. Brian has over twenty-two years of experience working with the Oregon Tech geothermal systems and is an alumnus of Oregon Tech. Brian has provided engineering throughout the entire campus and has consistently assisted with the operation and provided engineering of the geothermal heating systems, geothermal power plants, fire water systems, domestic water system/irrigation, and central chilled water loop. Brian is currently Oregon Tech's on-call engineer for mechanical and plumbing systems.

Matthew Cash, PE served as the lead engineer for evaluating the electrical system associated with the geothermal system. Matt has extensive historical and current knowledge of the campus power distribution system as it relates to capacity, limitations, lifespans, and interconnections for the purposes of master planning.

Organizational Chart



1.3 Limitations of the Evaluation

The scope of this project was limited to components that were readily accessible such as exposed piping, valves, fittings, pumps, heat exchangers, tanks, and electrical gear. Direct buried pipes were not accessible and no destructive or invasive testing methods were employed.

Some piping in the tunnels was evaluated but due to the confined nature of the tunnels and accessibility, not all of it was able to be viewed. Assumptions about those elements that were non-accessible were based on the known age of the equipment and those elements that were able to be observed.

The large electrical power plant consisting of powerplants Alpha and Bravo along with small power plant Charlie, along with the associated production Well #7 were excluded from the scope of this project.

The cost estimate produced in this report is reported in 2022 dollars. Due to current high inflation levels, with prices in April 2022 being 8.3% higher than the previous year, we recommend that the funding request should include a factor for inflation based upon when the funds will be made available (U.S. Bureau of Labor Statistics, 2022).

2 Oregon Tech Geothermal System

2.1 Overview of Geothermal

At its most basic level, geothermal energy is simply heat that is from the earth. Early civilizations used geothermal energy in the form of hot springs and fumaroles (steam discharges) for cooking, heating, and bathing. In modern times, in addition to the more ancient uses, geothermal energy is used to provide building heat, generate electricity, and provide chilled water through absorption refrigeration. Geothermal energy has provided renewable, clean, affordable, and reliable heating for commercial and residential buildings in the United States since the 1890s and has continued to expand to include utility-scale power generators, distributed or district-wide heating, and supporting various industrial processes (Mink, 2017).

Geothermal heat radiates from the Earth's hot core outward to the surface. The temperature at the center of the Earth is nearly 10,800°F which is nearly the same temperature as the surface of the sun (U.S. Department of Energy, 2019). Geothermal heat flows upward to the surface but the temperature of the earth at various locations changes based on the geological conditions including soil and rock types, locations of fault lines, proximity to magma chambers, and changes based on depth from the surface. Resources are typically accessed through the use of well-drilling which can be on the order of magnitude of tens of feet to up to 4 miles with current drilling technology.

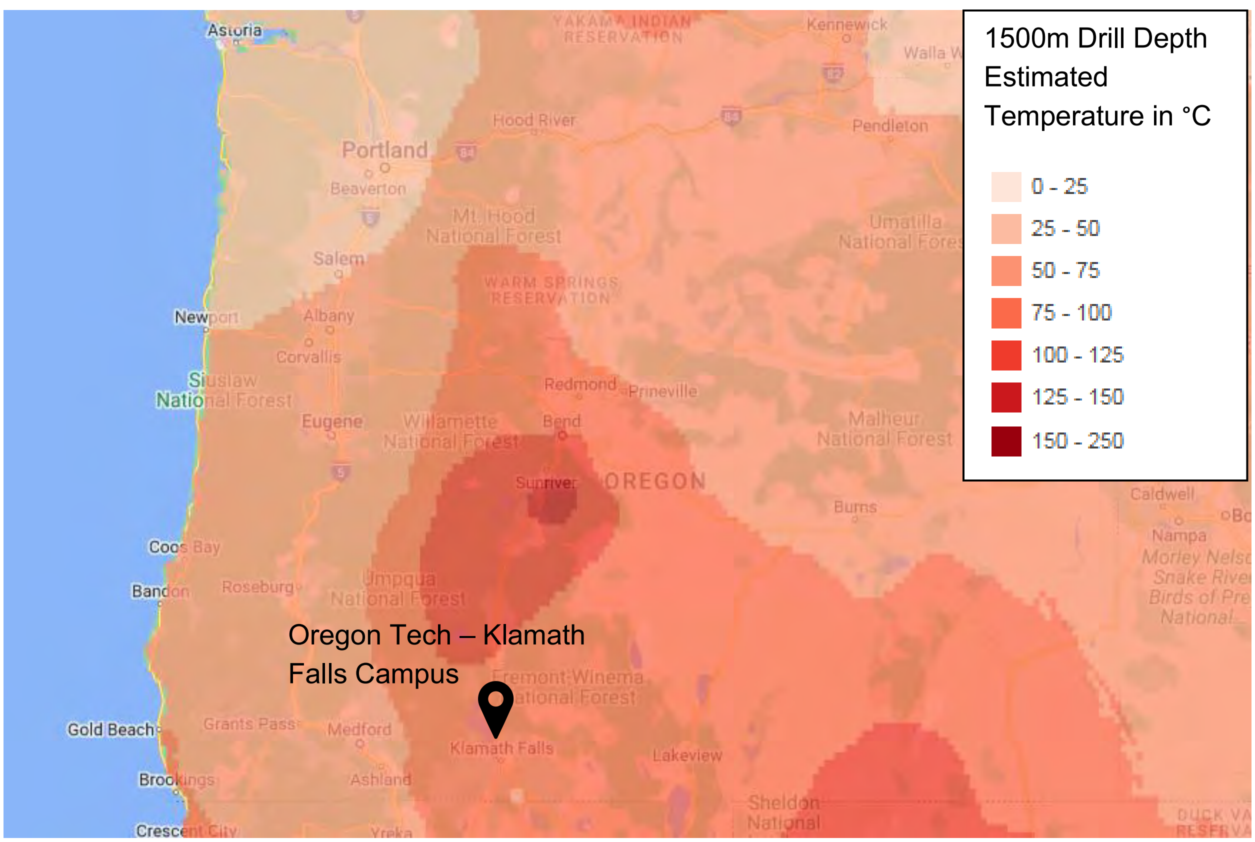


Figure 1: Map of estimated below-ground temperatures in Oregon at 1500m depth (source: NREL Geothermal Prospector Tool)

It is important to distinguish different types of Geothermal energy and common terms in order to understand the unique renewable resource at Oregon Tech. Oregon Tech utilizes Geothermal water that the US Department of Energy also calls "Hydrothermal".

Hydrothermal Renewable Resource(Commonly Referred to as "Geothermal" by Oregon Tech &What the Term "Geothermal" Used Throughout This Report Refers To):
Underground aquifers and groundwater [typically] deep below the Earth's surface can have temperatures ranging from just a few degrees above ambient surface temperatures to temperatures exceeding 700°F. This is the type of geothermal resource used in most geothermal heating and power generation applications today. Higher temperatures provide greater opportunities for power generation and better efficiency. The tradeoff is that higher temperatures are found at deeper well depths and are more costly to access.

DOE defined Hydrothermal as the type of resource utilized by Oregon Tech. Other areas of the state generally refer to "Geothermal" as a Heat-Pump Resource. Per DOE Geothermal Heat-Pump Resources:

Shallow soil, rock, and aquifers provide valuable thermal storage properties. At depths of around 30 ft, the ground temperature is stable all year round and can be used with ground-source heat pump (GHP) mechanical equipment for both heating and cooling. Heat can be pumped to and from the ground to provide both heating and cooling to buildings and are generally more efficient than air-based heat exchangers.

Ground Source Heat Pumps aka Heat-Pump geothermal can generally be implemented throughout Oregon with enough ground/depth surface area, where the Geothermal renewable resource at Oregon Tech is localized with nearer surface hot water.

2.2 History of Geothermal at Oregon Tech

The use of geothermal energy at Oregon Tech has been at the core of the university since the 1960s. The campus was relocated from a World War II military facility to its current location to take advantage of the geothermal hot water available at the campus' current location (Lund & Boyd, 2010). Below is a summarized timeline of the major milestones in the history of the campus geothermal system.

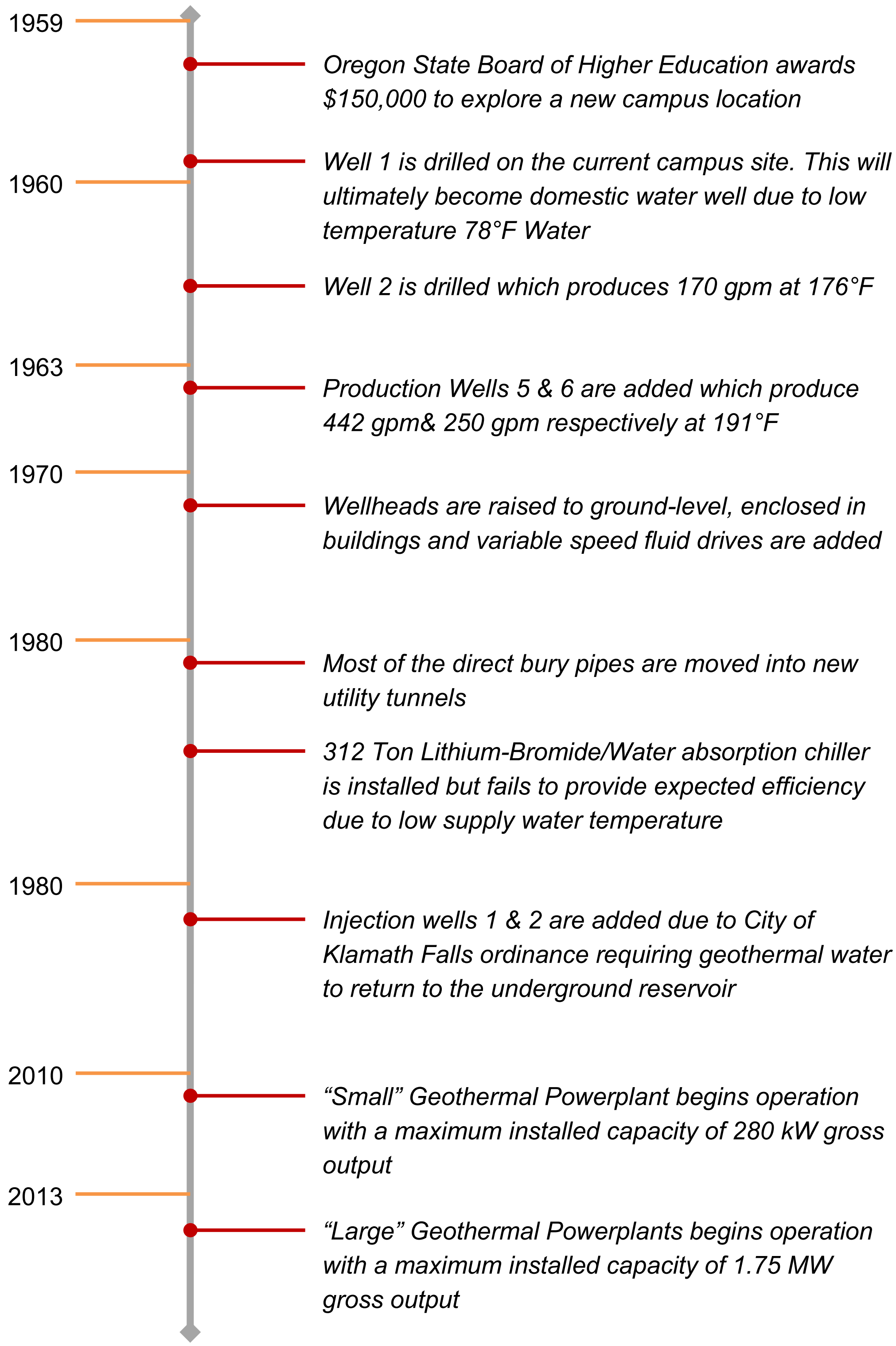


FIGURE 2: MAJOR MILESTONES IN THE HISTORY OF THE GEOTHERMAL SYSTEM AT OREGONTECH

A more thorough description of the history of the Oregon Tech Geothermal System can be found in former Oregon Tech Professor John W Lund’s report “Geothermal Uses and Projects on the Oregon

Institute of Technology Campus". This report was published in the May 2010 edition of the Geo-Heat Center Bulletin which can be found in the link below which is also listed in the References section of this report:

https://oregontechsfcdn.azureedge.net/oregontech/docs/default-source/geoheat-center-documents/quarterly-bulletin/vol-29/art3c37aee4362a663989f6fff0000ea57bb.pdf?sfvrsn=5edc8d60_4

2.3 Description and Condition of Existing System at Oregon Tech

2.3.1 Overview

The Oregon Tech campus utilizes a near-surface hot (~194°F) geothermal resource as the exclusive heat source for heating major campus buildings, major domestic hot water needs, and snowmelt/deicing of outside stairs and sidewalks. Additionally, the 194°F geothermal water is used to generate electricity that helps offset power demand by the well pumps and campus. The geothermal water is pumped from wells into a holding tank and flows from there by gravity. Supply piping conveys the geothermal water to heat exchangers where the heat is transferred to meet building, hot water, and snowmelt heat loads. The cooled geothermal water is collected by return/collection pipes and injected back into the ground into a similar aquifer.

2.3.2 Production Wells

The source of the geothermal energy used at the Oregon Tech campus is residual volcanic heat, transferred to the water that flows up from several thousand feet deep through a fault that crosses campus. Prior studies indicate that the source water temperature is in excess of 300°F. The source hot water mixes with cooler groundwater to provide water temperature for campus heat of about 192°-196°F. The main production wells for the campus heating system are wells #5 and #6, which have a nominal pumping capacity of 500 GPM and 350 GPM respectively. These geothermal wells were drilled in 1962 and 1963 to supply heat to the then-new Oregon Tech campus buildings.

Production Well #	ODWR Well #	Depth	Static Water Level	Casing Depth	Pump Flow Data
Well 5	KLAM 11830	1716 ft	358 ft below surface	12.75" from +1' to 529'3" 10.75" from +1' to 813'6" 8.625" from 790'6" to 1109' 6.625" from 1068' to 1716'	500 GPM @ 425' TDH 100 HP
Well #6	KLAM 11829	1805 ft	359 ft below surface	12.75" from +1' to 416'4" 10.75" from +1' to 867' 6" 8.625" from ~850' to ~1145' 6.625" from ~1127' to 1805'	325 GPM @ 630' TDH 100 HP

Table 1: Production Well Data

Condition of Wells:

Production Well #5

Well #5 exhibited considerable corrosion of the original 12" casing and 10" casing liner, resulting in cold groundwater intrusion into the well and sediment and scale interfering with pump operation. A contract to repair the well was issued in 2019. Repair and upgrades included:

- New casing with grouting per Oregon Department of Water Resources (ODWR) requirements
- Cleaning of the well to the original depth
- New deep well turbine pump
- Reconditioning of the pump motor
- New well house

PRODUCTION WELL #6

Well#6 is nearly the same age as Well #5 and is expected to have similar age-related problems. Verification of well condition will require removal of the pump and camera inspection of the well. The pump has likely lost efficiency as indicated by the power required to supply the maximum available flow. Existing pump efficiency is estimated to be 52%, compared to better than 75% for a new pump.

Recommendations:

PRODUCTION WELL #5

- No modifications needed

PRODUCTION WELL #6

- Remove pump for well inspection
- Replace casing as indicated per inspection. New work will be required to meet to current OWDR well standards
- Install new pump
- Install new or reconditioned pump motor
- Install new well house

Each well listed above is connected to the geothermal mechanical building's power distribution system. Refer to section 2.3.4 Geothermal Mechanical Building section below for further discussion.

2.3.3 Injection Wells

Originally, the geothermal water was used directly in the building heating equipment, with wastewater discharged to the storm sewer through building roof drains. In 1985 the City of Klamath Falls instituted an ordinance requiring that geothermal waters be reinjected into the same or similar aquifer to better conserve the resource. Oregon Water Resources regulations require the same for all new water rights issued for thermal energy extraction from groundwater. In response to the ordinance, Oregon Tech installed geothermal collection piping and injection wells #1 (1989) and #2 (1992) at the southwest corner of campus.

Condition of Wells:

INJECTION WELL #1:

The ODWR well log shows a 14" outer casing to 73', and a 10" inner casing to 1685', with perforations between 1450' and 1644' Inspection in 2018 showed that the well has significant deterioration of the near-surface outer casing and inner casing. Additionally, the well is significantly obstructed with scale.

INJECTION WELL #2:

The ODWR well log shows a 16" outer casing to 72', and a 10" inner casing to 950', with an open borehole to 992'. Inspection in 2018 showed that the well casing appears to be in good condition. There is some minor scale accumulation inside the casing.

Recommendations:

INJECTION WELL #1

- Clean accumulated scale from inside of the well casing
- Camera inspection of cleaned casing and perforations
- Replace a portion of the inner and outer casing as indicated by the inspection
- Clean perforations as indicated by inspection

INJECTION WELL #2

- Clean accumulated scale from inside of the well casing
- Camera inspection of cleaned casing
- Additional work as indicated by inspection

2.3.4 Geothermal Mechanical Building

The geothermal mechanical building (AKA Heat Exchanger Building) is located at the southwest corner of campus, near the production wells.

The building houses:

- 4000 gal receiving/storage/settling tank receiving flow from the well pumps
- Circulation pump to supply GEO to Crystal Terrace (GEO heat sales customer)
- 280 kW UTC geothermal power generator
- Electrical power supply for well pumps, with variable frequency drives to control pump speed and flow
- Controls to operate wells, pumps, and GEO power generation

The storage tank is a vented tank that receives all the flow from the production wells. A tank level controller attached is used to control pump speed and flow to maintain a tank level setpoint. GEO supply to all uses on campus flows from the tank by gravity, with the total flow determined by the sum of flow demand at each individual heat load.

The geothermal power generator is an Organic Rankine Cycle power plant manufactured by United Technologies Corp. (UTC) that uses geothermal heat to generate electrical power. The power plant generates enough power to operate the production pumps which heat the campus and supply additional power to the campus electrical grid. The heat input for power generation is derived by cooling the geothermal water from about 194°F input to about 165° delivered to campus for heating.

The electrical system for the geothermal mechanical building supports the production well pumps. Should any portion of the geothermal mechanical building's power distribution system fail, heat throughout the campus will be unavailable for the duration of the failure or normal power outage. The

Geothermal Mechanical Building's power distribution system consists of a building service feeder, building transformer, building feeder, building main distribution board, fuses, and manual switches.

Condition of the Geothermal Mechanical Building:

- GEO storage tank:
  - Tank is steel, is open to oxygen from the air through the tank vent, and likely has significant corrosion. There is evidence of leaking from the tank under the insulation.
  - Tank provides only about 5 minutes of storage at the design campus GEO flow
  - Small tank size results in instability in the tank level and production pump control loop
  - Tank elevation is inadequate to supply the new student housing (Center for Sustainable Living) at design heating flow. That resulted in the need for a booster pump station.
  - Tank size does not allow for effective settling and separation of fine sand in the geothermal water, resulting in sediment accumulation in downstream heat exchange equipment.
- Crystal Terrace pump: The pump is in serviceable condition, however, the configuration of the piping leads to inadequate flow to the pump under some conditions.
- UTC power plant: The power plant was installed in 2009 and is still operable. However, there is little technical or maintenance support available as the equipment is no longer manufactured. Evaluation of power production is outside the scope of this study, but the design of improvements to the GEO supply system needs to accommodate power production in some form.
- Electrical System: Generally in good condition; however, does not meet current code, or industry protection standards. Additionally, there are unnecessary fuses, breakers, and a power train that has additional but not redundant equipment. There are multiple points of failure in the system. Some variable frequency drives (VFD) are nearing the end of service life, and/or are no longer manufactured.

Recommendations:

- Replace the GEO tank with a larger approximately 45,000 gallon, in-ground insulated concrete tank located further up the hill. Features/Benefits:
  - More pressure head to supply uses at higher elevations on campus. Eliminates the need for booster pump serving Villages and accommodates the proposed new residence hall
  - More storage volume, ~45 minutes of available heating water
  - More stable level and pump control
  - Corrosion-resistant
  - Better sand separation
- Replace piping and valves
- Replace older pump VFDs
- Consolidate electrical equipment to reduce failure points. Include backup power generation, bypass, and servings switches as part of the consolidation.

2.3.5 Distribution System

The geothermal distribution system is the piping that conveys the hot geothermal fluid from the production wells to point of beneficial heat use and thence to the injection wells for disposal of the cooled fluid. Specific components of the distribution system include:

- Piping from the production wells to a storage and settling tank in the geothermal building
- Gravity flow supply piping from the tank to heat transfer equipment in the buildings
- Gravity flow return/collection piping from the buildings to an injection collection tank
- Pumped or gravity flow from the collection tank to the injection wells

Supply Piping

The original design in the 1960s used direct-buried steel piping, insulated with rigid "foamglass" insulation to distribute the geothermal fluid to the buildings. The experience over the first 17 years of operation was that thermal expansion of the piping created cracks in insulation, introducing groundwater and surface runoff with deicing salts to the exterior of the steel pipe, causing extensive corrosion. The resolution was to replace the steel pipe with fiberglass pipe (FRP) and to route the piping through utility tunnels within the campus (Boyd, March 1999). Currently, the piping from the wells to the heat exchanger building still uses the original steel pipe. There is also some direct-buried steel piping between the heat exchanger building and the campus tunnel system, and some steel pipe within the tunnel. The balance of the GEO supply piping is FRP.

The GEO supply piping includes valves at building connections and strategic locations in the tunnels or outside vaults to isolate sections of the distribution system.

Condition of Supply Piping:

- Wells to Geothermal Mechanical Building: Buried original steel pipe; condition unknown. No leaks have been observed. Well #6 piping is now inaccessible under a new parking lot.
- Geothermal Mechanical Building to campus: Buried, believed to be fiberglass with some sections of steel. Condition unknown, no leaks have been observed
- Supply valve vault in the lawn between Snell and Residence Hall: Fiberglass pipe, butterfly valve is in poor condition, inadequate temporary thrust restraint
- Isolation valves: Generally in poor condition or non-functional. The lack of isolation valves requires that the entire system be shut down and drained to work on the system
- FRP pipe in tunnels: Generally in good condition. Minor leaks at some joints

Recommendations:

- Replace steel piping between wells and Geothermal Mechanical Building
- Repair/ replace piping and valve in supply vault
- Remove GEO valves and connections located above electric panels in the chiller building; replace with continuous pipe section and relocate valve.
- Replace building and in-line isolation valves in tunnels. Consider motorized valves that can be operated without entering tunnels
- Consider a new main 8" supply feed from the Heat Exchanger building, past the site of the proposed new residence hall, to tie into the existing tunnel piping between LRC and Cornett. Add isolation valves so any building can be isolated and adjacent buildings can be fed in

either direction through the supply piping loop. This new supply would add resiliency so a single point of failure is less likely to cause a complete system failure.

Return Piping and Collection System

In the original 1960s design, the geothermal fluid was discharged directly to the building roof drain/ storm sewer system after extracting heat for space heating. A waste geothermal collection system was installed in the late 1980s to collect the water and route it to a 5000-gallon collection tank west of Purvine Hall. The collection system piping is mostly FRP and is mostly installed in the tunnels. There is a short section of 6" steel pipe in the tunnel near the Residence Hall and College Union buildings.

A GEO injection pump station near the collection tank provides additional pressure as needed to discharge the waste GEO into the injection wells. The pumps were replaced in 2018, and the controls were upgraded to variable speed pump control to better match the required flow and pressure boost. If the injection system fails, the collection tank overflows into the storm sewer.

Condition of Return Piping and Collection System:

- Leaking and corrosion in the steel pipe, on the return from the Residence Hall
- FRP pipe in tunnels: Generally in good condition. No leaks were noted.
- Isolation valves at buildings are not operable
- Injection pumps are new and in good shape

Recommendations:

- Replace approximately 30 feet of 6" steel piping in the tunnels
- Replace isolation valves, consider motorized valves to allow isolation of a leak without entering the tunnels

2.3.6 Building Heat Exchange System

The GEO is used for heating the buildings and domestic hot water. Originally, building heat was provided by using the geothermal water directly in the coils of heating equipment. That led to coil failure due to the corrosive nature of the geothermal water. The design was modified to isolate the GEO from a closed-loop building heating water system with a heat exchanger.

A typical building heating system consists of:

- A heat exchanger to transfer heat from the GEO to the building heating water
- Circulation pumps to circulate the building heating water
- A water-to-air heat transfer coil to deliver heat to the building air. A control valve limits the heating water flow based on air temperature
- A fan to circulate the heated air to the rooms
- Electrical power at each building to operate the heating water circulation pumps, fans, and controls

All stages of the building heating process provide opportunities for optimizing the use of renewable geothermal energy to protect buildings and maintain occupant comfort. The building heating systems were generally designed to use 190°F supply water temperature and reduce the water temperature by about 40°F to heat air to maintain a building air temperature of about 72°F. The objective of maintaining 72°F can be accomplished at a lower water temperature by improving the effectiveness of the heat transfer.

At Oregon Tech, most of the buildings were designed to operate on 192°F water from the well. However, they have operated successfully on 165°F supply water leaving the power plant. Newer buildings on the lower (west) end of campus, including Dow, Purvine, and CEET were designed to operate on reduced-temperature return water from the building higher on campus. The heating system at Purvine was designed to operate using 130°F geothermal water.

Planning for future buildings at the Oregon Tech campus needs to consider both available flow and temperature. Improvements to delivery piping and production and injection wells can increase the available flow to campus. Optimizing flow to existing buildings can make existing flow capacity available for new loads. Designing for GEO with lower supply and discharge temperature will make more heat available without increasing flow demand.

Building heat is required for:

- Heating to replace heat loss through the building envelope to the cold outside. Heat demand is proportional to the temperature difference divided by the envelope insulation value.
- Heating of ventilation air
- Heating for morning warm-up after a setback in space temperature when the building is unoccupied.

The campus heating system was designed in the 1960s to support 1960s buildings with relatively minimal insulation and ventilation control. As buildings are upgraded with improved insulation the heat requirement for the building envelope is reduced. Building ventilation improvements such as demand-controlled ventilation and ventilation heat recovery reduce the heat requirement for ventilation. More efficient buildings free up GEO capacity to serve additional buildings.

One significant component of the existing building load is morning warm-up from a night setback. Currently, the maximum GEO system demand occurs during the morning warm-up. Night setback reduces energy use because the temperature difference between the inside of the building and the ambient air is reduced during the setback period. In a conventional heating system, with natural gas or oil as the heat source, then the energy savings directly results in energy cost savings. In the geothermal heating system, the energy itself does not cost anything. What costs money is the power needed to run the pumps and fans to deliver the energy.

In a closed-loop heating water or heating air delivery system, with variable speed pumps and fans, the power to operate the pumps and fans is proportional to the cube of the speed. At 25% speed, the power is 0.25 x 0.25 x 0.25 = 0.0156; or less than 2% of the power at full speed. Operating the system overnight at minimum speed will require less power than operating at full speed for one to two hours for morning warm-up.

Eliminating the night setback and morning warm-up will reduce cooling and heating stress on the buildings and will reduce the maximum heating demand on the GEO heating system. It will also likely reduce the cost of heating.

Details of the condition of specific geothermal building systems are in Table 2 below.

Building	Geothermal Equipment		Heating water		Air Handling	Domestic Hot Water	
	HX	*Piping*	*Pumps*[1]	*Pump Type*	*Fan Type*	*HX*	*Storage Tanks*
Villages	GOOD	GOOD	1 EACH BLDG	CV	CV	GOOD	GOOD
Residence Hall	POOR	GOOD	1	CV	CV	GOOD	GOOD
College Union	GOOD	GOOD	2	CV	VV	GOOD	GOOD
PE	GOOD	GOOD	1	CV	CV	GOOD	GOOD
LRC	POOR	POOR	2	CV	CV	NA/Electric	
Cornett	GOOD	GOOD	2	VV	CV	NA/Electric	
Facilities	POOR	POOR	1	CV	CV	NA/Electric	
Snell	FAIR	FAIR	1	CV	CV	NA/Electric	
Owens	POOR	POOR	1	CV	VV	POOR	POOR
Dow	GOOD	POOR	2	VV	VV	GOOD	GOOD
Semon	GOOD	GOOD	1	CV	CV	GOOD	GOOD
Boivin[2]	GOOD	GOOD	2	VV	VV	GOOD	GOOD
Purvine	GOOD	GOOD	1	CV	VV	NA/Electric	
CEET	GOOD	GOOD	2	VV	VV	GOOD	GOOD

Table 2: Building Heating System Condition Overview

[1]Heating Water Pumps: 2 parallel pumps with VFD, with lead/lag control is recommended
[2]Boivin condition reflects upgrades currently under construction

Pump and Fan Type Legend:

CV: Constant volume. Consider upgrading to a variable volume system
VV: Variable volume; preferred for optimum geothermal efficiency

Rating Descriptions:

GOOD: Likely service life > 10 years
FAIR: Nearing the end of service life, consider replacing
POOR: Active corrosion or leaking, beyond service life, replace now

For the Geothermal System to distribute heat throughout each building, electrical power is required. Each building is fed from the 12,470 Volt campus power distribution system. There is only one piece of equipment that controls the entire campus distribution from the incoming utility feeder line. Should this one unit fail, get damaged, and/or otherwise become inoperable, there will be a loss of campus power. This single unit is currently located in the chiller building that houses various piping systems including large, main geothermal lines. In the past, those lines/chillers have leaked and started to flood the electrical equipment. Due to the slight elevation of the equipment (approx. 4 inches above the floor), quick notice and reaction of Oregon Tech facilities staff, and ability at the time to shut down the water flow, the equipment "survived" past flood events. The electrical equipment still experienced water intrusion/damage/dampness, and additionally is beyond its service life, and does not meet current industry standards and codes. Relocation of the chillers, geothermal, cooling towers, and the like is more expensive than relocation and replacement of the electrical equipment, especially since the electrical equipment requires replacement already.

Condition of Building Heating System:

- Heat exchangers at some buildings are currently leaking and need to be replaced; others are new and in good condition.
- Piping and valves associated with heat exchangers are leaking or corroded in some buildings
- Most buildings have a single constant speed, constant flow heating water pump
- Building air handling systems are a mix of constant airflow for older systems and variable airflow for newer systems
- Electrical equipment in the chiller building is beyond its service life and does not meet current code and standards

Recommendations:

- Replace leaking heat exchangers. Size new replacements to accommodate lower GEO supply water temperature.
- Replace leaking or corroded piping and valves associated with heat exchangers.
- Upgrade heating water pumping system to variable-flow with VFD-controlled circulation pumps, lead/lag pumps, and 2-way valves at air handlers
- Upgrade air handling systems to variable air-flow
- Modify controls to minimize morning warm-up heat demand by minimizing night setbacks
- Upgrade air handler ventilation control to provide demand-controlled ventilation
- Replace & relocate electrical equipment currently in the chiller building as noted above.

2.3.7 Snowmelt System

Oregon Tech experiences several snowfall events each winter, and about seven months per year when conditions could be conducive to snow or ice accumulation on outdoor sidewalks and steps. Geothermally-heated thermal snowmelt/de-icing systems are installed in many of the sidewalks and steps which provide these benefits:

- Reduced risk of slip and fall due to icy walking surfaces
- Reduced concrete deterioration from freeze-thaw cycles
- Reduced concrete deterioration and environmental risk from de-icing salt

A thermal snowmelt system works by maintaining a concrete surface temperature of about 38°F; warm enough to melt fresh snow and prevent ice accumulation. The heat load to maintain a clear sidewalk depends on snowfall rate, wind speed, and temperature. The existing snowmelt systems at Oregon Tech and in Klamath Falls are designed for a heat output of about 80 Btu per square ft (Btu/ft^2). That heat output is not adequate to keep up with heavy snowfall but will catch up in a reasonable time. It does prevent ice from sticking to the concrete, making manual removal much easier if needed. 80 Btu/ft^2 is also not able to keep the concrete surface above 32°F in extremely cold weather with high wind. However, snowfall in Klamath Falls does not usually occur in those conditions so the sidewalk would likely be dry.

Snowmelt is a lower priority than building heat, so in cold weather, it may be necessary to curtail snowmelt operation to adequately supply building heat. A standby mode snowmelt operation can maintain some heat in the concrete at a lower heat output than would be required for active melting.

The snowmelt mechanical system consists of a heat exchanger, circulation pump, supply and return mains, distribution headers, and PEX tubing embedded in the sidewalk concrete. The mechanical equipment for the newer, larger, existing snowmelt systems is located in building mechanical rooms. These larger snowmelt systems total about 60,000 ft^2 and include:

- Dow Hall
- Cornett Hall
- CEET
- Center for Sustainable Living

Several smaller, generally older, snowmelt systems are supplied by mechanical equipment located in the utility tunnels. These systems total about 5,000 ft^2 and include:

- Snell steps
- College union and residence hall steps
- Owens steps
- Bovin Ramp

About 40,000 ft^2 of snowmelt tubing has been installed in sidewalks but is not connected to pumps or heat exchange equipment. Most of the supply mains are stubbed into the tunnels, with the original intent of installing equipment in the tunnel to supply the heat.

The total installed snowmelt system area is about 105,000 ft^2. As additional sidewalks are replaced over time, the intent is to include snowmelt in most of the sidewalks. It is likely that an additional 100,000 ft^2 of existing sidewalks could be added, bringing the total to about 200,000 ft^2, not including a new residence hall or other new buildings. At 80 Btu/ft^2, the potential snowmelt heat load would be 16,000,000 Btu/hr.

As buildings become more efficient and as snowmelt area is increased, it is likely that snowmelt will be the largest heat load on the system. Location of the snowmelt systems centralized in building mechanical rooms provides more ability to control snowmelt operation or shed snowmelt load as needed to meet the higher priority building heating load. Also, the removal of snowmelt mechanical equipment from the tunnels will reduce the safety concern of a hot water leak in the tunnel's confined space. Snowmelt supply and return mains can be routed through the tunnels to the service snowmelt connections.

Recommendations:

- Supply snowmelt connections from building mechanical rooms, eliminating pumps and heat exchangers in tunnels
- Connect new and existing tunnel-fed snowmelt systems to new snowmelt supply and return mains routed through the tunnels

- Expand the snowmelt system from the main SW parking lot to the Physical Education building to improve accessibility for athletic events
- Generally supply snowmelt systems from GEO return piping, reducing the impact on required system GEO flow
- Provide controls with the ability to shed snowmelt heating load when required to meet building heating requirements

2.3.8 Domestic Hot Water Systems

GEO heat is used to heat potable water for domestic hot water demands. The major hot water demands are in the residence halls, PE building, and College Union food services. Those heat exchangers and storage tanks are relatively new or have been upgraded recently.

Recommendations:

- The hot water tank and heat exchanger in Owens Hall is in poor condition and should be replaced.

2.4 Critical Nature of Geothermal System to Campus Operations

Virtually all elements of the geothermal system are critical to campus operations. The geothermal system serves as the ONLY source of heating for all significant buildings on campus. Below is a graph of the yearly average temperatures in Klamath Falls:

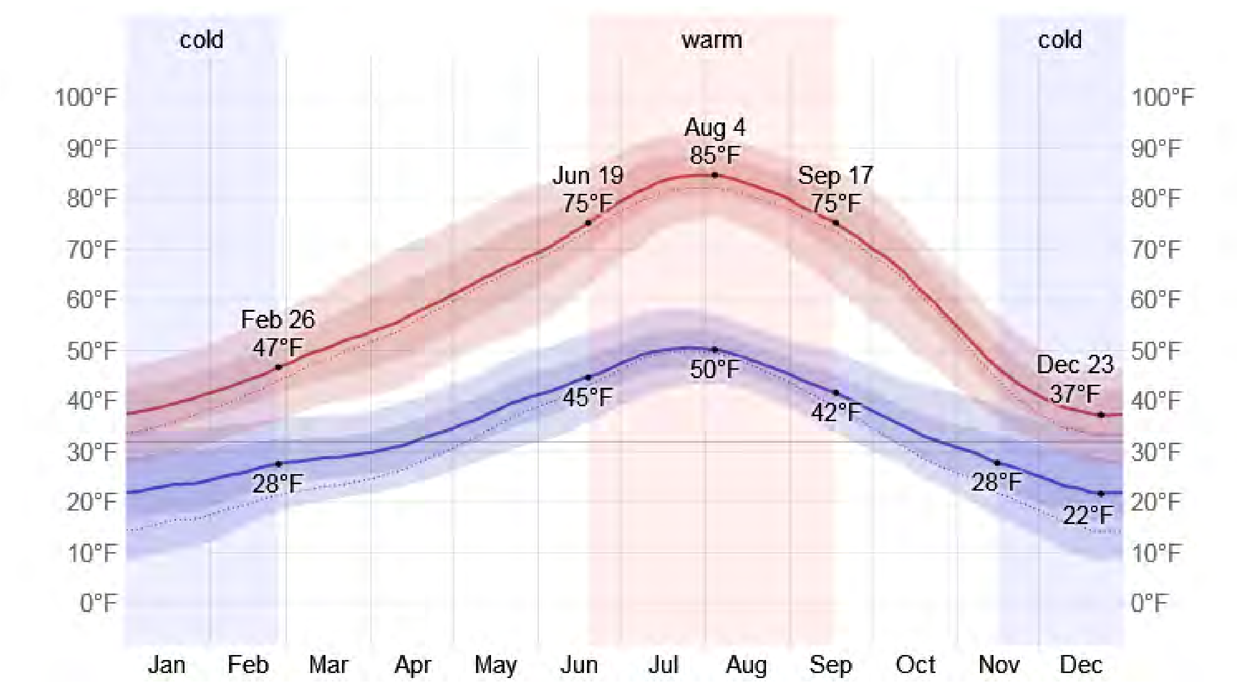


FIGURE 3: AVERAGE YEARLY TEMPERATURES IN KLAMATH FALLS, OR. (SOURCE: WEATHERSPARK.COM)

As can be seen in the above graph, average low temperatures are below freezing for nearly 7 months out of the year. Any downtime or loss of the geothermal heating system during the cold months would have catastrophic consequences not only on the educational function and operation of the campus but would likely result in severe damage to building components and systems resulting in potentially millions of dollars worth of damage.

Below is a list of the major elements of the geothermal system and the resulting consequence if a failure occurs in any one of these elements:

Geothermal Wells

- The loss of both of the production wells would result in no heating water to the campus.
- A loss of just one of the wells would substantially reduce the system capacity and could result in freezing conditions in one or more buildings
- A loss of electrical power at the wells would disable the pumping system resulting in the inability to distribute heat to the buildings.

Geothermal Mechanical Building (AKA Heat Exchanger Building)

- Loss of the GEO storage tank and piping system can lead to the inability to heat campus buildings. There is no backup or standby heating system.

Geothermal Distribution Piping

- Loss of the supply piping system can lead to the inability to heat campus buildings. There is no backup or standby heating system.
- Loss of a section of the piping or a fitting leak can result in loss of the entire system due to a lack of isolation capacity and alternate flow routing.

An example of this occurred on June 14th, 2022. A break from a corroded section of pipe ruptured leaving the campus without water for building heating or domestic hot water.

Figure 4: Ruptured Pipe in Tunnel

- Leaks in the tunnels can lead to personnel life safety risks due to the high temperature and confined space
- Large leaks in the tunnels can lead to building or electrical service flooding

Building Heat Exchange System

- Loss of building heat exchange system can lead to the inability to heat the specific campus building. There is no backup or standby heating system.

3 Sustainability & Financial Benefits of Geothermal

The hot geothermal water source provides a unique benefit to the Oregon Tech and helps reduce educational costs by maintaining a system to fully heat Oregon Tech's entire campus for a nearly insignificant electrical cost to various pumps and wells. The energy source is renewable because the amount of water removed equals the amount of water placed back in.

Provided the system utilizes appropriate materials and is maintained and operated effectively there is no reason to believe the system would not last for another 60 years between major overhauls. The geothermal resource provides a nearly perfect balance for energy because a) what is removed is re-injected, b) there are no emissions, and c) there are no known resource impacts on any biological/ecological systems.

Maintaining the system and addressing the deficiencies is substantially cheaper than replacing the system.

For additional geothermal sustainability, and renewable benefits, see the DOE's GeoVision Report.

4 Summarized Recommendations with Estimated Costs

Note: A more detailed list of the recommended actions and costs can be found in Appendix C.

Production & Injection Wells

Recommended actions include:

- Rebuilding production well #6
- Cleaning and repairing injection well #1
- Cleaning and inspecting injection well #2

The estimated cost for these projects, including construction costs, soft costs, contingency, and other costs is estimated to be $2,553,000

Geothermal Mechanical Building and Main Geothermal Storage and Pumping System

Recommended actions for the production include:

- Replacement of the geothermal water storage tank
- Replacement of piping and valves inside the Geothermal Mechanical Building
- Replacing end-of-life pump speed controllers
- Adding a backup generator to supply power to the geothermal pumping system and controls to maintain heat during power outages

The estimated cost for these projects, including construction costs, soft costs, contingency, and other costs is estimated to be $2,235,000

Geothermal Distribution System

Recommended actions for the production include:

- Replacing the piping between production wells 5 & 6 and the geothermal mechanical building
- Repairing the supply piping and valves near Snell Hall
- Replacing and supplementing the distribution supply and return isolation valves to be able to isolate sections of the system in case of leaks
- Adding a new supply main and return line to the north side of campus to add system redundancy

The estimated cost for these projects, including construction costs, soft costs, contingency, and other costs is estimated to be $5,382,000

Building Heat Exchange System

Recommended actions for the production include:

- Repairing and replacing leaking heat exchangers in the Residence Hall, Learning Resource Center, Facilities, Snell Hall, and Owens Hall
- Upgrading building heating water equipment to provide variable flow circulation with added system monitoring and controls
- Replace the domestic hot water heat exchanger and storage tank in Snell Hall

The estimated cost for these projects, including construction costs, soft costs, contingency, and other costs is estimated to be $1,152,000

Campus Snowmelt System

Recommended actions for the production include:

- Move snowmelt pumps and heat exchangers out of the tunnels into the Purvine mechanical room for most of the system with other building mechanical rooms used as needed.
- Connect snowmelt systems that were installed but never connected, and provide for future snowmelt as sidewalks and stairs are replaced.
- Expand the snowmelt system to improve access between the main SW parking lot and the Physical Education building

The estimated cost for these projects, including construction costs, soft costs, contingency, and other costs is estimated to be $1,697,000

Campus Main Electrical Equipment

Recommended actions for the production include:

- Relocate, and replace the main campus power distribution system switchgear that is located in the same room as a geothermal and chilled water piping system

The estimated cost for these projects, including construction costs, soft costs, contingency, and other costs is estimated to be $1,932,000

The total estimated cost of all recommendations is $14,951,000 including construction costs, soft costs, contingency, and other costs.

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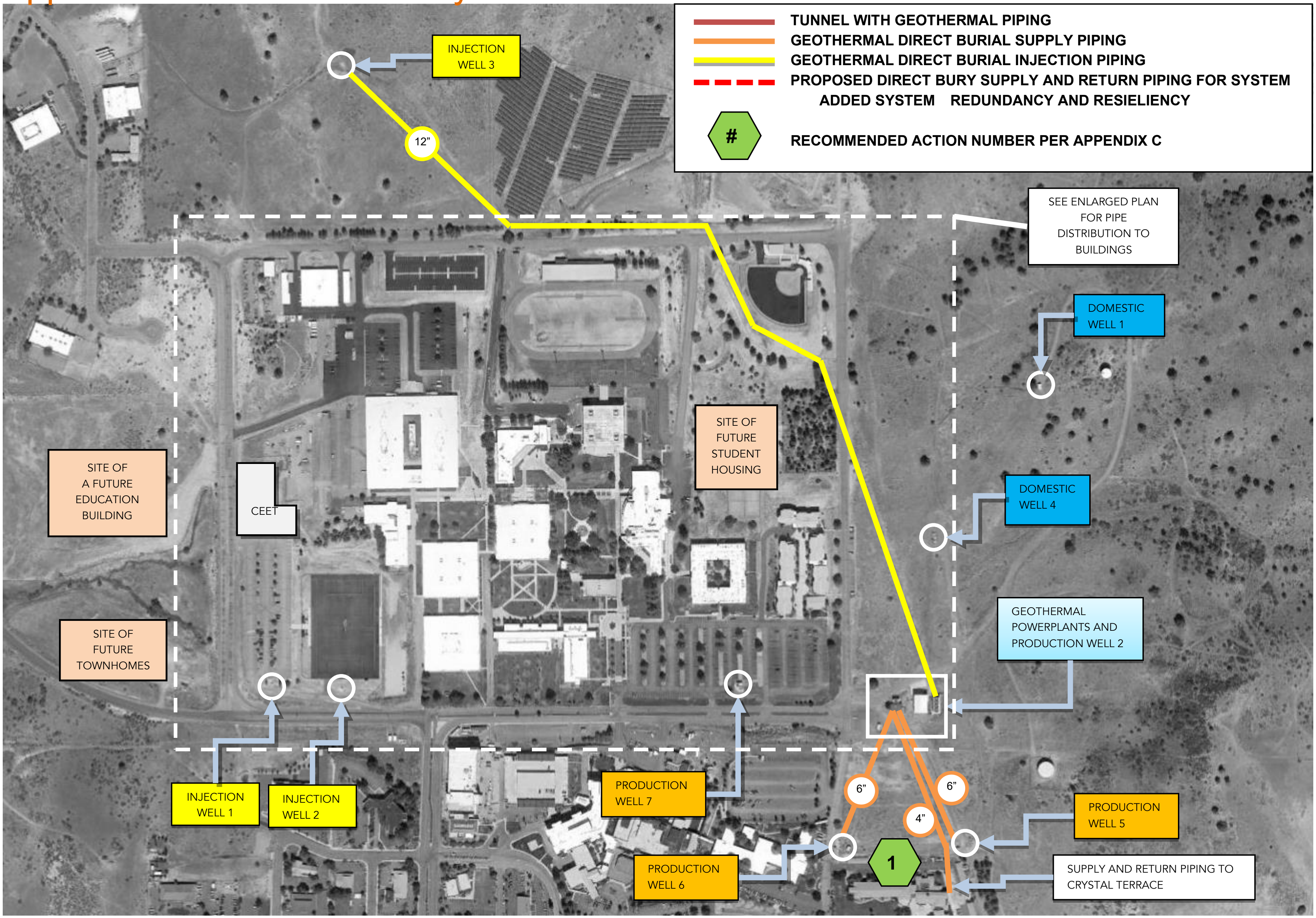
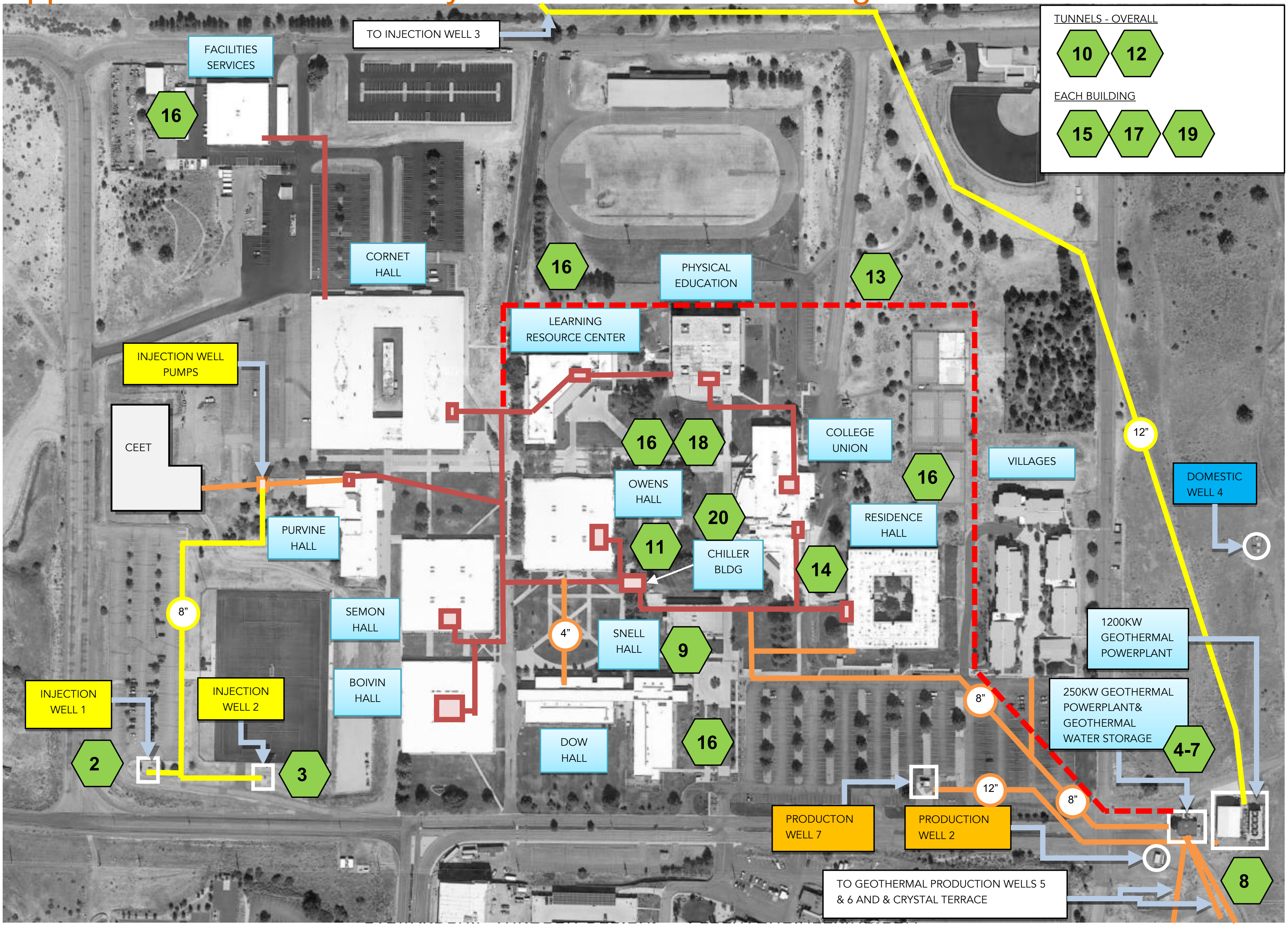
Appendix A: Acronyms

BLM	Bureau of Land Management (U.S. Department of the interior)
Btu	british thermal units
CAPEX	capital expenditure
CEET	Oregon Tech Center for Excellence in Engineering and Technology
CO_2	carbon dioxide
COP	coefficient of performance
DOE	U.S. Department of Energy
EER	energy efficiency ratio
EPA	Environmental Protection Agency
FRP	fiberglass reinforced plastic
FORGE	Frontier Observatory for Research in Geothermal Energy
GEO	geothermal or referring to the geothermal system
GHG	greenhouse gas(es)
GHP	geothermal heat pump
GHX	ground heat exchanger
HVAC	heating, ventilation, and air conditioning
HX	heat exchanger
kW	kilowatt(s)
NO_x	nitrogen oxides
ODWR	Oregon Department of Water Resources
PEX	cross-linked polyethylene
ROI	Return on investment
SO_2	sulfur dioxide
TDH	total dynamic head
TES	thermal energy storage
USGS	U.S. Geological Survey
VAV	variable-air volume
VFD	variable frequency drive

Appendix B1: Geothermal System Distribution – Overall Site



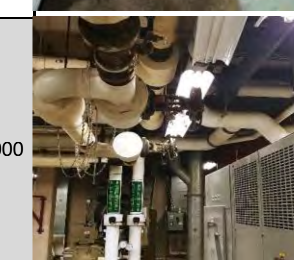
Appendix B2: Geothermal System Distribution – Enlarged

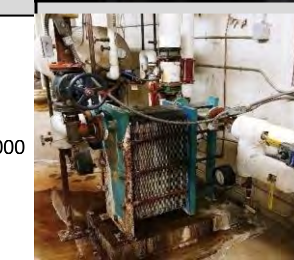
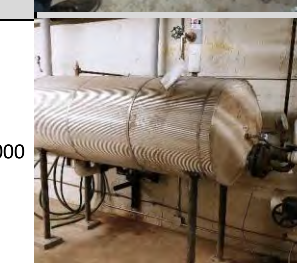


Appendix C: Detailed Evaluation Cost Estimates

Oregon Tech - Geothermal System Evaluation and Estimates

		Observed Issues and Recommended Remedy	Rationale for Recommendation	Benefits of Recommended Action				Cost to Implement (in 2022 Dollars) Total rounded to nearest $5,000 increment					Supporting Photos
Item #	Location/System Element	Description of Recommended Action	Why is this recommended	Improved Safety	Improves System Resiliency & Redundancy	Increases System Capacity	Reduces System Maintenance Costs	Construction Estimate	Design/Soft Costs	Contingency	Other Costs	TOTAL COSTS	Photos
1	Production and injection wells	Rebuild Well #6: new casing as required, new pump, new or reconditioned pump motor, new wellhouse.	Deterioration of well presents reliabilty problems, End of life	-	YES	POTENTIALLY	YES	$ 1,000,000	$ 200,000	$ 120,000	$ 60,000	$ 1,380,000	
2	Wells	Clean/ repair Inj Well #1. Access for repair will probably require replacement of the well vault.	Well is unuseable die to plugging and casing corrosion.	YES	YES	YES	YES	$ 750,000	$ 150,000	$ 90,000	$ 45,000	$ 1,035,000	 
3	Wells	Clean Inj Well #2	Remove scale accumulation in well	-	YES	-	-	$ 100,000	$ 20,000	$ 12,000	$ 6,000	$ 138,000	
4	Geothermal Mechanical Building	New concrete GEO storage/settling tank, to be located in-ground at about 20' higher elevation.	Existing tank is corroded and at risk of failure. New tank will provide more capacity, more head to better serve campus, better sand removal	YES	YES	YES	YES	$ 850,000	$ 170,000	$ 102,000	$ 51,000	$ 1,173,000	
5	Geothermal Mechanical Building	Replace piping and valves inside geothermal building. Accommodate power generation, heat sales to Crystal Terrace, second supply main to campus	Existing piping has been in service for 60 years. Removal of tank will allow reconfiguration of piping	YES	YES	YES	YES	$ 180,000	$ 36,000	$ 21,600	$ 10,800	$ 248,000	
6	Geothermal Mechanical Building	Replace older well pump speed controllers (variable frequency drives) as needed	End of life and reliability	-	YES	YES	YES	$ 40,000	$ 8,000	$ 4,800	$ 2,400	$ 55,000	

		Observed Issues and Recommended Remedy	Rationale for Recommendation	Benefits of Recommended Action				Cost to Implement (in 2022 Dollars) Total rounded to nearest $5,000 increment					Supporting Photos
Item #	Location/System Element	Description of Recommended Action	Why is this recommended	Improved Safety	Improves System Resiliency & Redundancy	Increases System Capacity	Reduces System Maintenance Costs	Construction Estimate	Design/Soft Costs	Contingency	Other Costs	TOTAL COSTS	Photos
7	Geothermal Mechanical Building Electrical	Provide ~500kW backup electrical generator at building supplying the Geothermal Heating Wells. Generator will also connect to head-end Geothermal controls. Replace electrical panels.	No campus heating will be available if a single building loses power, and/or has electrical equipment failure. Power at heat-exchange building is critical to entire system operation.	YES	YES	YES	YES	$ 550,000	$ 110,000	$ 66,000	$ 33,000	$ 759,000	 
8	GEO Supply Piping	Replace steel piping between wells #5, #6 and Geothermal Mechanical Building. Re-route Well #6 piping around parking lot. Include power and communications conduits.	Piping is about 60 years old, and may be significantly corroded.	YES	YES	YES	YES	$ 400,000	$ 80,000	$ 48,000	$ 24,000	$ 552,000	
9	GEO Supply Piping	Repair GEO supply piping and valve in the 8" GEO supply pipe vault near Snell Hall	Valve is inoperable, pipe connections are questionable	YES	YES	-	-	$ 450,000	$ 90,000	$ 54,000	$ 27,000	$ 621,000	
10	GEO Supply Piping	Replace GEO isolation valves in tunnels. Use power operated valves to allow isolation of a leak without entering the tunnel.	Allows work on a segment of the supply system without shutting off entire system.	YES	YES	-	YES	$ 235,000	$ 47,000	$ 28,200	$ 14,100	$ 324,000	
11	GEO Supply Piping	Remove three (3) 6" valves in geothermal piping located above the electrical switchgear in chiller building. Replace with continuous pipe.	Improved safety by ruducing chance of a leak above the main electrical switchgear. See also Item #20.	YES	-	-	YES	$ 45,000	$ 9,000	$ 5,400	$ 2,700	$ 62,000	
12	GEO Supply Piping	Repair leaks in fiberglass piping joints in tunnels, ~20 places	Improved safety, reduce moisture in tunnels	YES	-	-	YES	$ 15,000	$ 3,000	$ 1,800	$ 900	$ 21,000	

		Observed Issues and Recommended Remedy	Rationale for Recommendation	Benefits of Recommended Action				Cost to Implement (in 2022 Dollars) Total rounded to nearest $5,000 increment					Supporting Photos
Item #	Location/System Element	Description of Recommended Action	Why is this recommended	Improved Safety	Improves System Resiliency & Redundancy	Increases System Capacity	Reduces System Maintenance Costs	Construction Estimate	Design/Soft Costs	Contingency	Other Costs	TOTAL COSTS	Photos
13	GEO Supply and Return Piping	Add new 8" supply main from Geothermal Mechanical Building to the North side of campus. Connect into existing piping in tunnel between LRC and Cornett. Add valves to allow building to feed either direction through a loop. Include 6" return pipe starting at Villages connection.	Provides increased capacity, improved resiliance. Could facilitate supplying hotter geothermal water to select buildings for adsorption cooling. Will supply capacity for planned residence hall and other potential future buildings.	YES	YES	YES	YES	$ 2,700,000	$ 540,000	$ 324,000	$ 162,000	$ 3,726,000	
14	GEO Return Piping	Replace about 30' of 6" steel return pipe with FRP pipe and fittings in tunnel where return from residence hall joins return from College Union.	This is the only steel pipe in the tunnel; the rest is FRP. Pipe is corroded, and will continute to be subject to corrosion. Changing to FRP pipe will orevent corrosion and have a longer lifespan.	YES	-	-	-	$ 30,000	$ 6,000	$ 3,600	$ 1,800	$ 41,000	
15	GEO Return Piping	Replace building isolation valves	Valves are non-functional. Required to allow working on building piping without shutting off entire system.	YES	-	-	YES	$ 25,000	$ 5,000	$ 3,000	$ 1,500	$ 35,000	
16	Building Heating	Repair or replace leaking heat exchangers in Residence Hall, Learning Resource Center, Facilities, Snell Hall, and Owens Hall buildings. Replace associated GEO piping and valves	Leaking is a safety hazard, introduces moisture in buildings. Leaking heat exchangers prevent operation of power generation because the leakage is worse at lower water temperature.	YES	YES	YES	YES	$ 350,000	$ 70,000	$ 42,000	$ 21,000	$ 483,000	
17	Building Heating	Upgrade building heating water equipment and controls to provide variable-flow heating water circulation; with 2-way valves at heating coils, lead-lag variable-speed heating water pumps	Improved reliability and better utilization of available GEO resource, reduced pumping power	YES	YES	YES	YES	$ 440,000	$ 88,000	$ 52,800	$ 26,400	$ 607,000	
18	Owens Building Domestic Hot Water	Replace domestic hot water heat exchanger and storage tank at Owens	Tank is likely to fail due to corrosion	YES	YES	YES	YES	$ 45,000	$ 9,000	$ 5,400	$ 2,700	$ 62,000	

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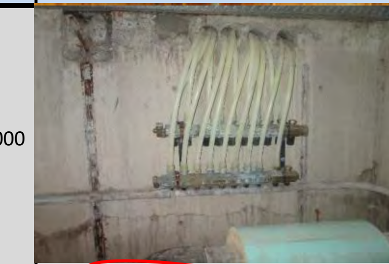
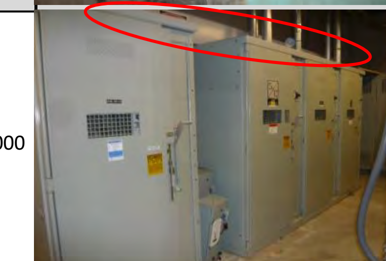
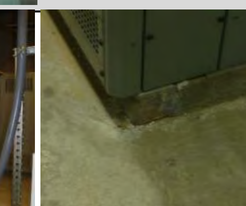
Item #	Location/System Element	Description of Recommended Action	Why is this recommended	Improved Safety	Improves System Resiliency & Redundancy	Increases System Capacity	Reduces System Maintenance Costs	Construction Estimate	Design/Soft Costs	Contingency	Other Costs	TOTAL COSTS	Photos
19	Snowmelt	Move snowmelt pumps and heat exchangers out of the tunnels into building mechanical rooms, connect snowmelt systems that were installed and never connected, expand the snowmelt system from the main SE parking lot to the Physical Education building. Includes 35,000 SF of additional snowmelt.	Improved safety by moving equipment out of the confined-space tunnels, Improved control, increased capacity by allowing use of return water	YES	YES	YES	YES	$ 1,230,000	$ 246,000	$ 147,600	$ 73,800	$ 1,697,000	
20	Campus Main Electrical Gear in Chiller Building	Relocate, and Replace the Main Campus Power Distribution System Switchgear that is located in the same room as a geothermal and chilled water piping system. Some Geothermal piping is routed over the switchgear which is not permitted by current code. Addtionally, electrical equipment is at end of expected service life. This equipment is for the 12,470 Volt Power Distibution System.	The campus main electrical equipment has begun to flood in the past; and is subject to complete failure bringing down the majority of the campus. End of Life electrical gear does not meet current code, industry standards, and subjects all connected facilities to extended power loss, and heat distribution failure.	YES	YES	-	-	$ 1,400,000	$ 280,000	$ 168,000	$ 84,000	$ 1,932,000	 
							TOTALS	**$ 10,835,000**	**$ 2,167,000**	**$ 1,300,200**	**$ 650,100**	**$ 14,951,000**	

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MEMO

TO: JOHN HARMAN , VP OF FINANCE & ADMINISTRATION
THOM DARRAH, DIRECTOR OF FACILITIES
OREGON TECH

FROM: MATTHEW CASH, PE
JEREMY WENGER, MBA, PE
BRIAN BROWN, PE

DATE: NOVEMBER 8TH, 2022

JOB#: 22-162

SUBJECT: DRAFT CAMPUS GEOTHERMAL CONVERSION TO ALTERNATE FUEL ESTIMATE

Fluent Engineering Inc. was asked to support Oregon Tech's request for emergency funding for the geothermal system by providing a rough order of magnitude cost estimate for replacing the geothermal system with either an electric or natural gas source for campus heating, domestic hot water, and snowmelt systems.

This summary write-up provides a brief description of the geothermal resource, evaluates the cost per British thermal unit (BTU) for both natural gas and electricity, describes the capital improvements required for switching resources, estimates the annual cost of the lower cost alternative, and includes a brief discussion on the decommissioning required. Assumptions made are listed in the analysis.

Geothermal Resource:

Geothermal energy has been used since the 1960s to provide primary heating to the Klamath Falls campus and was the primary factor for locating the campus where it is today. Oregon Tech pumps hot water (≈195°F) from below the earth's surface via multiple wells to a storage tank, where it then flows by gravity to various parts of the campus through both underground and tunnel-encased piping.

The geothermal water is used to provide heating for campus buildings, snow melting for sidewalks providing ADA pathways, and domestic hot water. The geothermal resource is the only source of heating for most of the campus.

Analysis of Fuel Types

As a possible future replacement for geothermal energy, an analysis of the current BTU cost of both natural gas and electricity is described below.

Natural Gas

Gas Utility: **Avista**
Current Rate Schedule: **420- Small Commercial & Industrial** (Nov 1st, 2022 Rates)
Cost per Therm: $**1.36814** (1 Therm = 100,000 BTU)

Potential Rate Schedule[1]: **424- Large Commercial & Industrial** (Nov 1st, 2022 Rates)
Cost per Therm: $**0.85081**

Electric

Electric Utility: **Pacific Power**
Rate Schedule: **Unknown, cost per kWh estimated based on current utility bills**
Cost per kWh: **$0.090**
Equivalent Cost per Therm: **$2.6376** (1 Therm = 29.307 kWh)

Estimated Campus Heating Usage & Utility Costs

Heating Usage

- Building Heating: 284,000 Therms/yr
- Snowmelt: 119,000 Therms/yr
- Domestic Hot Water: 44,000 Therms/yr

TOTAL = 440,000 Therms/yr

Utility Costs per Fuel Type

Natural Gas

- Estimated Gas Equipment Efficiency: 85%[2]
- Est. Utility Therms per yr = Total/Eff. = 440,000/.85 = 518,000 Therms/yr
- **Estimated Gas Utility Cost: $710,000/yr**
    - Estimated CO^2 emissions[3]: 2700 tons/yr

Electric

- Estimated Electrical Equipment Efficiency: 99%
- Est. Utility Therms per yr = Total/Eff = 440,000/.99 = 444,000 Therms/yr
- **Estimated Electric Utility Cost: $1,170,000/yr**
    - Estimated CO^2 emissions[4]: 7100 tons/yr

Capital Improvement Requirements

Based on the higher annual utility costs calculated above and the higher cost of the required capital improvements, Fluent has determined that moving to an electric heating system would be more cost prohibitive than a natural gas system, therefore, the

[1] Depending on how gas distribution is configured, it may be possible to change to the Large Commercial and Industrial Rate Schedule for some meters, this requires a minimum of 29,000 therms per meter.
[2] Expected avg lifetime efficiency for condensing type boilers. Some periods of lower efficiency, non-condensing usage is expected during peak demand periods and efficiency can decrease with time.
[3] Based on EPA Greenhouse gas calculator Greenhouse Gas Equivalencies Calculator | US EPA
[4] Based on Pacific Power 2021 Integrated Resource Plan

remainder of the analysis includes only elements necessary for converting to a natural gas system.

The following is a high-level, non-exhaustive list summarizing the campus modifications that would be required for converting from the existing geothermal heating resource to a natural gas-based heating system. Assumptions for this analysis are listed in the proceeding sections.

Required Equipment for Natural Gas-based Heating System

- New gas boilers in each building
    - Includes multiple boilers for sequencing
    - Requires building fire rating, and emergency shut-down system modifications
    - Domestic hot water may be produced from the heating system boiler
    - Snowmelt system would require dedicated boilers
- Boiler venting
    - Requires new building penetrations and exhaust vents/stacks
- Boiler appurtenances such as:
    - Expansion tanks
    - Air separators
    - Chemical treatment system
    - Valves and fittings
- New primary circulation pumps for each building
- New domestic water storage tanks[5]
- New hot water piping from the boiler and domestic water heater tank to existing builing hydronic and snowmelt systems
- New gas distribution piping from the utility meter to the gas-fired equipment
    - Cost depends on the location of utility meters
- HVAC control system upgrades/updates for the removed geothermal system and new equipment
- Building modifications to accommodate new equipment

Geothermal System Decommissioning

- Remove the production well pumps
- Decommission and cap existing production and injection wells (3 each)
- Remove the geothermal storage tank
- Remove the injection well pumps
- Remove the small geothermal powerplant
- Remove the large geothermal powerplant
- Remove the electrical serving the well houses, pumps, or geothermal controls
- Remove existing heat exchangers and geothermal piping in the buildings
- Cap geothermal piping at tunnel entrances
- Site work for new outdoor piping installations or existing pipeline modifications

Net Present Value Cost Analysis

Fluent evaluated the Net Present Value of the following three alternatives:

A. Converting geothermal to a natural gas heating system
B. Converting geothermal to an electric heating system

[5] Also required for recommended geothermal system upgrades

C. Keeping the existing geothermal system and providing the recommended improvements based on costs outlined in a recent analysis

Basic Assumptions:

- Discount Rate:8%
- Inflation Rate: 4% (applies to both maintenance and utility costs)
- Timeline: 40 years (based on minimum 40-year expected geothermal system life)
- Annual maintenance cost is based on 1% of the initial capital cost for the geothermal system and 2% of the initial capital cost for electrical and natural gas systems due to added system complexity of boiler systems
- Utility bills are based on current rate schedules
- Capital costs include geothermal system decommissioning
- Assumes no additional capacity or loads are added to the system[6]

A. Natural Gas System

Estimated Initial Capital Cost: $15,000,000
Est. Annual Maintenance Cost[7]: $300,000 in year 1
Estimated Utility Cost[7]: $710,000 in year 1
Capital Renewals:

- $10,000,000 spent in year 20 for boiler and other system replacements

Net Present Value: -$37,000,000

B. Electric System

Estimated Initial Capital Cost: $20,000,000
Est. Annual Maintenance Cost[7]: $400,000 in year 1
Estimated Utility Cost[7]: $1,170,000 in year 1
Capital Renewals:

- $10,000,000 spent in year 20 for boiler and other system replacements

Net Present Value: -$53,000,000

C. Existing Geothermal System

Estimated Initial Capital Cost[8]: $18,000,000
Est. Annual Maintenance Cost[5]: $180,000 in year 1
Estimated Utility Cost[5]: $20,000 in year 1
Capital Renewals:

- $100,000 spent in year 10 for pump and other system replacements
- $125,000 spent in year 20 for pump and other system replacements
- $150,000 spent in year 30 for pump and other system replacements

Net Present Value: -$22,000,000

Conclusion

Of the two alternate heating sources examined, natural gas has the least operating expenses and intitial construction cost. The cost to convert the campus to natural gas heating is estimated to be not less than $15M and assumes the gas utilty will pay for the

[6] Future campus expansion plans are unknown and utility costs will increase proportionally with all systems and therefore do not significantly affect the final recommendation.
[7] Year 1 cost shown. Annual cost will increase based on inflation rate.
[8] As based on original geothermal FCA estimate

distribution piping to each building as part of the revenue in providing natural gas. This assumption also results in Oregon Tech having to grant utility easments and created an inability to build on those easments. If the utility does not distribute to each building, and instead provides service only to the property line of campus, the capital cost will increase by at least $2M to a total of $17M. In either case, the campus will have a yearly utility cost increase of $700,000 to $1M (dependent upon the rate schedule assignments).

Based on the net present value analysis performed, keeping the existing geothermal system is the preferred choice for Oregon Tech's heating needs. To address the current geothermal system deficiencies, $18 Million is being requested for investment to repair and improve the existing system. This option has a lower investment cost and annual costs compared to the other fuel options by a large margin.

In addition to the financial benefits of keeping the geothermal system, it also has many benefits from an environmental and practical level compared to the other options including:

- No direct greenhouse gas emissions
- No fire or explosion hazards
- Fewer campus interruptions from new utility installations
- Existing system is known to maintenance staff
- Geothermal system can pay for its own operation with the use of existing powerplants

Assumptions & Limitations

The following assumptions and limitations were used in the basis of this analysis:

- Existing buried pipes will be abandoned in place.
- Existing building shells including wells, well houses, and the geothermal mechanical building will remain. Equipment within these buildings will be removed.
- Water resource rights, loss of rights use, etc. were not included.
- The natural gas utility can be taken by the utility up to the campus buildings. Analysis does not include costs for utility piping from the street to individual buildings
- Existing hydronic HVAC equipment such as air handlers and coils will be reused
- Snowmelt systems will still utilize hot water and will not be switched to electric cables which would require landscape, hardscape, and other surface-level modifications.
- Geothermal supply to Crystal Terrace will be discontinued or provided by a 3rd party and loss of that income was not be considered. Analysis assumes no early termination fees apply.
- Geothermal Power Production will no longer be used, and not factored into the analysis (i.e. loss of power generation savings). If the geothermal power system is used, it can provide the required electrical power for the geothermal system.

- The 2MW solar field has no bearing on the analysis for savings because the power it produces is already consumed by existing electrical loads. The existing electrical loads will not be reduced as a result of utilizing another fuel source (i.e. solar savings is already utilized by lighting, receptacles, etc. and is not impacted by adding new boilers, or other heating equipment).
- Natural gas and electricity are significantly less expensive than trucked oil/diesel, and/or trucked LPG (Propane).
- New equipment may require building modifications for space needs or to meet current code requirements. Costs for this will vary by building and specific costs were not included in this analysis.
- The use of a central plant was not analyzed because the existing geothermal distribution piping would still have to be upgraded and it is assumed the costs for a central plant would be higher with the pipe upgrades than the costs presented.
- Analysis does not include campus expansion or future buildings

Issued By,

Matthew Cash, PE   Jeremy Wenger, PE   Brian Brown, PE

Oregon Institute of Technology

Geothermal Infrastructure and Heating System Funding Request

December 16, 2022

Table of Contents

Oregon TECH
Oregon Institute of Technology
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December 16, 2022

Oregon Legislature
Legislative Fiscal Office
900 Court St. NE, H-178
Salem, OR 97301

Subject: Emergency Funding Request – Geothermal Infrastructure and Heating System on Klamath Falls Campus

The Oregon Institute of Technology (Oregon Tech) respectfully submits this emergency funding request for significant repairs to our geothermal infrastructure and heating system (system) on the Klamath Falls, Oregon campus. The pervasive nature of significant deficiencies in the system, which is about 60 years old, including repeated, dangerous multiple single points of failure, requires immediate action. This emergency funding is critical to reduce life safety risks and to prevent a complete loss of the geothermal infrastructure and heating system function to some or all buildings on the Klamath Falls campus. Such a failure, in turn, would necessitate a complete campus closure.

More than 2,000 students and 326 regular faculty and staff call the Oregon Tech Klamath Falls campus home. Oregon Tech's Klamath Falls campus is fortunate and unique in having a renewable geothermal resource used extensively on campus. As a result, loss of geothermal heat can lead to the complete loss of use of some or all buildings on campus. Klamath Falls is at or below freezing on average for seven months of the year due to its high elevation on the eastern slope of the Cascade Mountains. Comfort heating is also required for an additional three months of the year.

The critical nature of the system's current condition is a genuine life safety risk with severe implications for student and employee safety and the university's operations. During the last few years, many buildings have been taken off-line from time to time due to intermittent geothermal system failure.

We are beginning to reach a point where the entire campus geothermal heating system at Oregon Tech is at risk of no longer functioning. Oregon Tech's only option is to address this emergency immediately. Unfortunately, no other funding source of this magnitude is available to the university to handle this emergency.

In June 2022, Oregon Tech commissioned an engineering geothermal condition assessment to objectively determine the system's emergency status. This request is based on that assessment, including detailed descriptions of life safety risks and the poor condition of system components. The assessment is included in its entirety as Exhibit 1 and Appendices A, B, and C.

Attachment C

With the approval of our emergency funding request, Oregon Tech will be better positioned to serve its students' basic needs, promote student success, and provide a safe and reliable infrastructure well into the future. We respectfully request your favorable consideration of our funding proposal.

Sincerely,

Attachment C

Executive Summary

Overview:
The Oregon Institute of Technology (Oregon Tech) is seeking emergency funding for its geothermal infrastructure and heating system (the system) in Klamath Falls, Oregon, a residential campus. The current condition of Oregon Tech's geothermal system is critical and requires immediate action. The system's current status presents day-to-day student safety and other life safety risks.

The entire campus geothermal heating system at Oregon Tech is at risk of no longer functioning. Loss of geothermal heat can result in complete loss of some or all buildings on campus. Klamath Falls is at or below freezing on average seven months of the year due to its higher elevation on the eastern slope of the Cascade Mountains. Comfort heating is required for an additional three months of the year. Consequences of not addressing deficiencies of the system range up to a complete loss of the geothermal heating system, requiring campus closure.

Emergency Status:
A geothermal condition engineering assessment was commissioned in June 2022 as part of the university's assessment of the emergency status of the geothermal heating system. This request is based on that assessment and is included in full as Exhibit 1 and Appendixes A – C.

Per the geothermal condition engineer's assessment, "virtually all elements of the geothermal heating system are critical to campus. Loss of the geothermal heating system during the cold months, with the system used 10-months of the year, would result in catastrophic consequences not only on the educational function and operation of campus, but would also likely result in severe damage to building components and systems resulting in potentially millions of dollars' worth of damage".

Emergency Repair:
Emergency repair to the system's four critical elements addresses:
- Life safety risks
- Age and deterioration of critical system components including those that have either failed, or reached the end of expected life
- System resiliency
- Capacity concerns

System failure and breakdown are occurring with increased frequency. Ongoing system failures have created an emergency situation, presenting life safety risks, interruption of campus operations and significant potential for university shutdown.

Geothermal Background:
The geothermal infrastructure and heating system is located throughout the university's residential campus in Klamath Falls, serving 17 buildings totaling approximately 884,686 gross sq. ft. The geothermal infrastructure and heating system is made up of wells, pumps, heat exchangers, heated air/water distribution systems, campus distribution piping, and injection wells returning the renewable resource back to the ground.

On an annual basis, the geothermal heating system saves the campus approximately $600,000 in energy costs. An excellent renewable resource, the system provides the university with protection from rising energy costs. The system has been reliable and effective for over 60 years and is a unique renewable resource benefitting the university and state. However, now a majority of the geothermal infrastructure and heating system is beyond its serviceable life.

The six critical system elements requiring emergency repair are essential for student safety and day-to-day operations of the Klamath Falls campus:

- Production and injection wells (geothermal wells)
- Geothermal mechanical building and main geothermal storage and pumping system
- Geothermal distribution system (distribution piping)
- Campus main electrical gear and distribution system (building heat exchange system)
- Geothermal System - Campus Snowmelt System
- Geothermal System - Campus Main Electrical Equipment

Budget and Timeline:
Requested emergency funding totals $17,956,151 for all six critical geothermal system elements:

- Production and injection wells (geothermal wells): $3,066,153
- Geothermal mechanical building and main geothermal storage and pumping system: $2,684,235
- Geothermal distribution system (distribution piping): $6,463,782
- Campus main electrical gear and distribution system (building heat exchange system): $1,383,552
- Geothermal System - Campus Snowmelt System: $2,038,097
- Geothermal System - Campus Main Electrical Equipment: $2,320,332

Requested funding includes engineering, construction, contingency and other costs.

The timeline for expected emergency repair would require 36 months, taking place between July 2023 and June 2026. This is partially due to system complexity, but also because the project must be completed in phases to minimize campus disruption.

Expected Outcomes and Positive Impact:
Through emergency funding, the condition of the six critical elements would be significantly improved, mitigating life and safety issues, enhancing reliability and preventing operational shutdown.

- Production and injection wells (geothermal wells)
  - Current condition: Poor
  - Goal: Bring to current standards with reliance on redundant wells with ability to increase flow without damage/debris
- Geothermal mechanical building and main geothermal storage and pumping system
  - Current condition: Poor/Unknown
  - Goal: Provide adequate protection from sediment; bring equipment within expected service life; bring electrical to code; eliminate multiple single failure points through consolidation with ability to bypass failure points
- Geothermal distribution system (distribution piping)
  - Current condition: Good to Fair
  - Goal: Replace inconsistent, inferior materials having potential to cause complete loss of the system for extended periods of time; consistent material selection throughout system
- Campus main electrical gear and distribution system (building heat exchange system)
  - Current condition: Poor to Good
  - Goal: Reduce flooding risk mitigating additional damage; bring to current code and standards
- Geothermal System - Campus Snowmelt System

- Current condition: Poor
- Goal: Improve condition and optimize for efficient use of geothermal resource

- Geothermal System - Campus Main Electrical Equipment
    - Current condition: Inadequate to incomplete
    - Goal: Replace older heat exchangers and pumps; connect existing snowmelt equipment to geothermal system; add additional geothermal snowmelt to create continuous pathways between buildings

Addressing deficiencies of the current geothermal infrastructure and heating system will eliminate emergency life and safety issues and also eliminate single points of failure within the system. The system would be able to operate with electrical backup, and isolate system issues for future repair as they arise. Emergency repair of the current system will allow it to serve the Klamath Falls campus for the next 60 years and beyond.

Attachment C

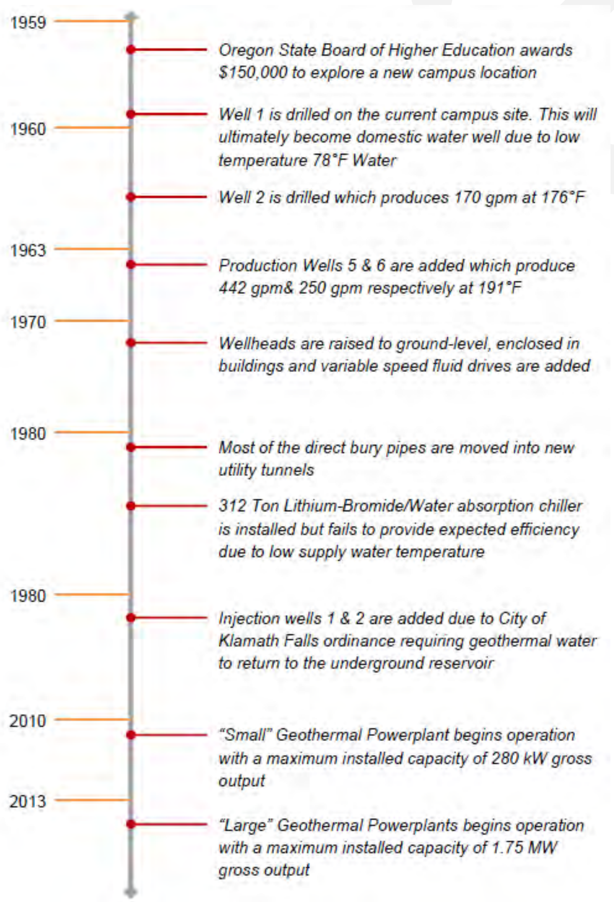
<u>University and Geothermal Background</u>

Founded in 1947, originally as a vocational rehabilitation school for World War II veterans, the university has grown immensely in size and scope as it has become *"Oregon's Polytechnic University".* As Oregon's polytechnic university, we take pride in our mission to deliver an exceptional quality education with a highly recognized superb return on investment. We continually partner with industry leaders to ensure that at the baccalaureate and master's level we adapt to new technology and that our high-quality programs and classes prepare students to meet workforce demands. Oregon Tech is known as "industry's university" because of our intense focus on meeting workforce and economic needs in the state and region.

Oregon Tech's residential campus is located in Klamath Falls on the eastern slope of the Cascade Mountains. The campus has an enrollment of more than 2,000 students and employs nearly 326 faculty and staff. The original geothermal heating system supports the 303-acre campus serving 17 buildings totaling approximately 884,686 gross sq. ft. Temperatures are at or below freezing on average seven months of the year due to its higher elevation on the Cascade Mountains. Comfort heating is required for an additional three months of the year.

The university's Klamath Falls campus was constructed in the 1960's with the site specifically selected for its geothermal renewable hot water resource. Geothermal wells and system infrastructure were constructed primarily between the 1960's-70's. However, additional features adding capacity and function have been added as recently as 2013.

Major milestones in the history of the geothermal infrastructure and heating system at Oregon Tech:



Attachment C

<u>History of System Breakdown and Failure</u>

The geothermal utility system presents imminent life safety risks. Additional risks include total breakdown of the system, significantly affecting operations to the point of multiple building loss or complete campus closure.

System breakdowns have occurred as recently as September 2022 and June 2022, with escalating severity. In each respective incident, geothermal disruption affected the ability to deliver and maintain hot water in campus buildings, including the Residence Hall. These incidents underscore serious deficiencies within the current system, including multiple single points of failure.

Over the decades, Oregon Tech has consistently invested in its geothermal heating system. Oregon Tech's funding does not provide resources adequate to address the emergency nature of the system. The needed emergency repairs and frequency of breakdowns is negatively affecting operations, student safety and causing life safety risks.

Below is an outline of the three most recent system failures, and the university's investment in its geothermal system over the last five years.

Incident - September 14, 2022:
<u>Owens Hall Geothermal Heat Exchanger</u> – Critical condition of heat exchangers in Owens Hall.

- Requires immediate replacement to prevent breakdowns during the academic year to avoid classroom disruption.
- Equipment life beyond serviceable repair.

Figure 1 - Owens Hall heat exchanger, beyond useful life, from incident on September 14, 2022

Figure 2 - Owens Hall heat exchanger, beyond useful life, from incident on September 14, 2022

Attachment C

Incident – September 7, 2022:
Well #6 – Main pipe from geothermal Well #6 ruptured at the foundation footing of the Heat Exchange Building.

- Well #6 shut-off, running on Well #5. Well #5 unable to keep up with campus demand.
- Began lubricating column shaft on Well #7 in order to meet campus demand. Up to 24 hours needed to start Well #7.
- Until Well #7 operating, campus too cold in spots and struggled to keep hot water in the Residence Hall.

Figure 1 - Main pipe from Well #6 ruptured at building foundation footing, from incident on September 7, 2022

Figure 2 –Well #6 main pipe rupture flooding, from incident on September 7, 2022

Incident – June 14, 2022:
Geothermal Distribution Piping – A break in a corroded section of pipe ruptured leaving the campus without water for building heating or domestic hot water.

- Ruptured pipe occurred in a tunnel.
- Leaks in the tunnels can lead to personnel life safety risks due to the high temperature in a confined space.
- Large leaks in the tunnels can lead to building and/or electrical service flooding.

Figure 3 - Ruptured pipe, from incident on June 14, 2022

Attachment C

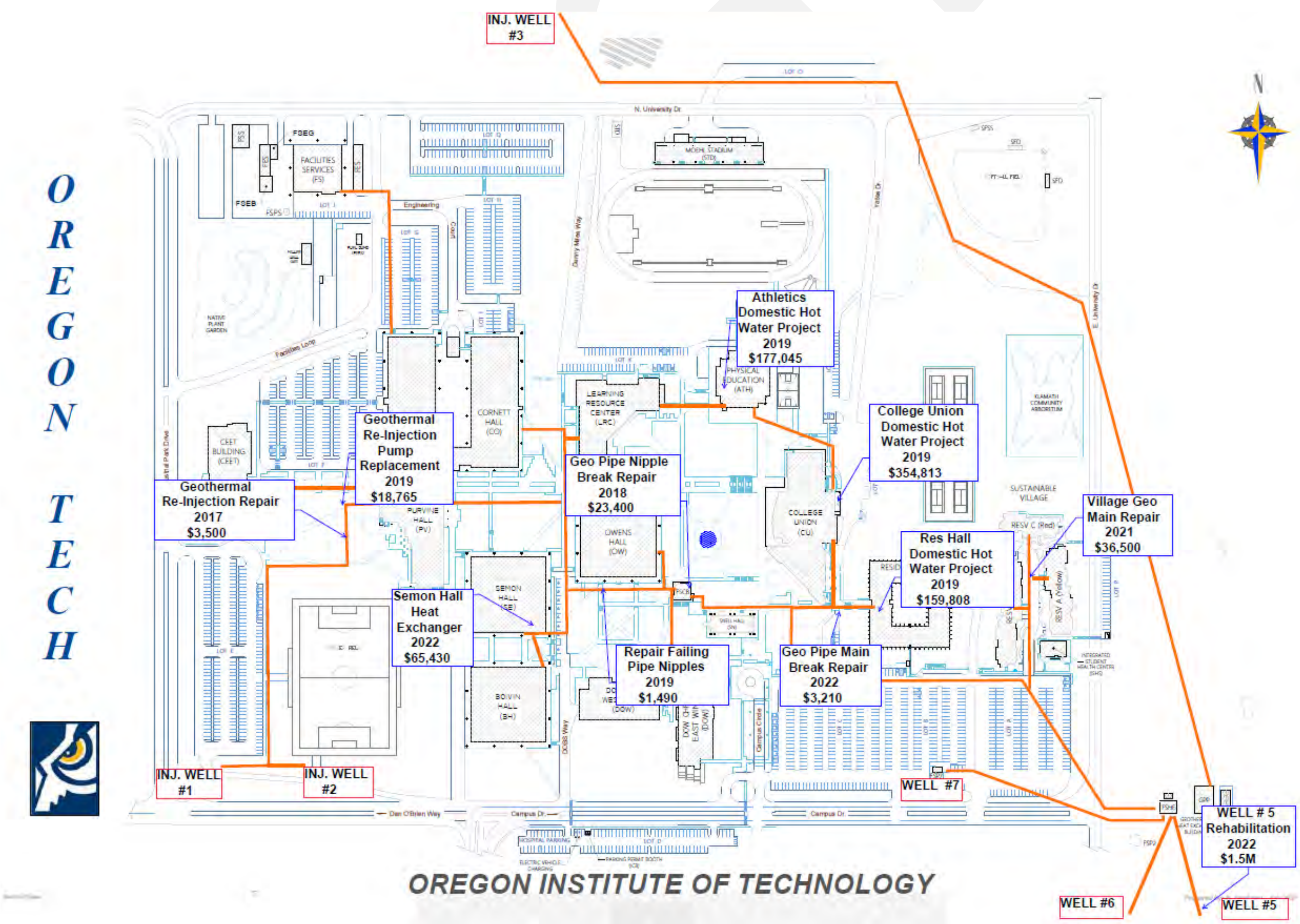
University Investment in the Geothermal System over the Last Five Years:

Over the past five years Oregon Tech has invested $2,343,961 in its geothermal heating system:

- 2022 - Well 5 Rehabilitation: $1,500,000
- 2022 - Semon Heat Exchange Replacement: $65,430
- 2021 - Village Geo Supply Main Repair: $36,500
- 2019 - Res Hall Domestic Hot Water Project: $159,808
- 2019 – Athletics Domestic Hot Water Project: $177,045
- 2019 – CU Domestic Hot Water Project: $354,813
- 2022 – Geo Main Line Repair: $3,210
- 2019 - Repair failing Geo Pipe Nipples: $1,490
- 2018 – Geo Pipe Nipple Repair: $23,400
- 2019 – Geo Re-Injection Pump Replacement: $18,765
- 2017 – Geo Re-Injection Repair: $3,500

Not shown on the map are multiple on-going geothermal projects (with anticipated costs), including:

- 2022 - Owens Heat Exchanger Replacement: $40,000
- 2022 - Well 6 Supply Line Break Repair: $30,000



Attachment C

Emergency Status

As listed in the recent geothermal condition engineering assessment performed by an external professional engineering firm, any downtime or loss of the geothermal heating system during the cold months would have catastrophic consequences on: (1) educational function, (2) operation of the campus, (3) likely result in severe damage to building components and systems resulting in potentially millions of additional dollars' worth of damage. Oregon Tech's Klamath Falls campus experiences below freezing temperatures seven months of the year.

The sudden and pervasive nature of significant deficiencies in the system, dangerous results of failure, and multiple single points of failure give rise to Oregon Tech determining its geothermal heating system is in emergency condition requiring immediate action.

Oregon Tech's only option is to immediately address this emergency. No other funding source for the emergency is available to the university.

In addition to dangerous life safety risks, a significant number of buildings could be taken off-line at any time, and at the same time, due to any one of multiple areas of great engineering concern.

<u>Below is a list of major elements of the geothermal heating system and the consequence of failure:</u>

Production and Injection Wells (Geothermal Wells)

- Loss of both production wells would result in no heating water to campus
- Loss of just one well would substantially reduce system capacity and could result in freezing conditions in one or more buildings
- Loss of electrical power at the wells would disable the pumping system resulting in the inability to distribute heat to the buildings

Geothermal Mechanical Building (Heat Exchanger Building)

- Loss of the GEO storage tank and piping system can lead to inability to heat campus buildings; there is <u>no backup</u> or standby heating system

Geothermal Distribution System (Distribution Piping)

- Loss of supply piping system can lead to inability to heat campus buildings; there is <u>no backup</u> or standby heating system
- Loss of a section of piping or fitting leak can result in <u>loss of the entire system</u> due to a lack of isolation capacity and alternate flow routing
- Leaks in the tunnels can lead to personnel life safety risks due to the high temperature and confined space
- Large leaks in the tunnels can lead to building or electrical service flooding

Campus Main Electrical Gear and Distribution System (Building Heat Exchange System)

- Loss of building heat exchange system can lead to the inability to heat the specific camps building; there is <u>no backup</u> or standby heating system

Attachment C

<u>Emergency Funding Request</u>

To prevent total system failure and life safety risks, $17,956,151 of emergency funding is requested.

Emergency funding would repair the following six critical elements of the geothermal heating system:

- Production and injection wells (geothermal wells): $3,066,153
- Geothermal mechanical building and main geothermal storage and pumping system: $2,684,235
- Geothermal distribution system (distribution piping): $6,463,782
- Campus main electrical gear and distribution system (building heat exchange system): $1,383,552
- Geothermal System - Campus Snowmelt System: $2,038,097
- Geothermal System - Campus Main Electrical Equipment: $2,320,332

Each critical element is described on the following pages with budget information.

Additional detailed descriptions, including additional budget information is included as part of Exhibit C *Detailed Cost Evaluation Matrix,* prepared by Fluent Engineering, Inc. as part of their *2022 Oregon Tech Geothermal Condition Assessment.* Exhibit C lists individual system elements, with summary of recommended action and supporting photos.

Figure 4 - Geothermal Mechanical Building; existing pipping has been in service for 60 years.

Attachment C

Production and Injection Wells (Geothermal Wells):

Production Wells:

The source of geothermal energy used at the Oregon Tech campus is residual volcanic heat, transferred to water that flows up from several thousand feet deep through a fault that crosses campus. Prior studies indicate that the source water temperature is in excess of 300°F. Source hot water mixes with cooler groundwater to provide water temperature for campus heat of about 192°-196°F. The main production wells for the campus heating system are wells #5 and #6, which have a nominal pumping capacity of 500 gpm and 350 gpm, respectively.

Injection Wells:

Originally, the geothermal water was used directly in the building heating equipment, with wastewater discharged to the storm sewer through building roof drains. In 1985 the City of Klamath Falls instituted an ordinance requiring that geothermal waters be reinjected into the same or similar aquifer to better conserve the resource.

Critical Nature of System:

Loss of production or injection capacity can lead to inability to heat campus buildings. There is no backup or standby heating system.

Oregon Tech Action:

An engineering firm will be hired to complete the well rehabilitation designs and work with the governing agency, Oregon Water Resources (OWR) on project approval. With emergency funding Oregon Tech will be able to rehabilitate this portion of critical infrastructure and significantly reduce deferred maintenance costs for the next twenty years. The attached engineer's assessment outlines the condition and recommendation for each of the geothermal wells (Exhibit A). Exhibit B includes a campus map identifying the Oregon Tech geothermal well locations.

Detailed Budget:

PRODCUTION AND INJECTION WELLS (GOTHERMAL WELLS)		
	2022 Dollars	Construction Cost Increase
Architecture & engineering costs @ 10%	$ 255,300	$ 306,615
Construction costs	1,787,100	2,146,307
Contingency @ 15%	382,950	459,923
Other @ 5%	127,650	153,308
Total	$ 2,553,000	$ 3,066,153

Figure 7 - Well #1 in need of cleaning and repairs

Figure 8 - Well #6, end of life

Geothermal Mechanical Building and Main Geothermal Storage and Pumping System:

The geothermal storage and pumping building are located at the southwest corner of campus, near the production wells. The building houses:

- 4000 gal receiving/storage/settling tank receiving flow from the well pumps
- Circulation pump to supply GEO to Crystal Terrace (GEO heat sales customer)
- 280 kW UTC geothermal power generator
- Electrical power supply for well pumps, with variable frequency drives to control pump speed and flow
- Controls to operate wells, pumps, and GEO power generation

The storage tank is a vented tank that receives all the flow from the production wells. A tank level controller attached is used to control pump speed and flow to maintain a tank level setpoint. GEO supply to all uses on campus flows from the tank by gravity, with the total flow determined by the sum of flow demand at each individual heat load.

Critical Nature of System:

- Loss of the GEO storage tank and pumping system can lead to inability to heat campus buildings; there is no backup or standby heating system
- Loss of power for the wells results in loss of campus heat

Oregon Tech Action

An engineering firm will be hired to complete the HX Rehabilitation design and work with Oregon Tech through completion of construction. With emergency funding Oregon Tech will be able to renovate this critical infrastructure and significantly reduce deferred maintenance costs for the next twenty years. The attached engineer's assessment outlining the condition and recommendation for each of the geothermal wells (Exhibit A). Exhibit B includes a campus map identifying the heat Exchanger Building location.

Detailed Budget:

RENOVATION OF CAMPUS HEAT EXCHANGE SYSTEMS		
	2022 Dollars	Construction Cost Increase
Architecture & engineering costs @ 10%	$ 223,500	$ 268,424
Construction costs	1,676,250	2,013,176
Contingency @ 15%	223,500	268,423
Other @ 5%	111,750	134,212
Total	$ 2,235,000	$ 2,684,235

Figure 9 - Existing storage tank corroded and at risk of failure

Geothermal Distribution System (Distribution Piping):

The geothermal distribution system is the piping that conveys the hot geothermal fluid from the production wells to point of beneficial heat use and then to the injection wells for disposal of the cooled fluid. Currently, the piping from the wells to the heat exchanger building still uses the original steel pipe. There is also some direct-buried steel piping between the heat exchanger building and the campus tunnel system, and some steel pipe within the tunnel. The balance of the GEO supply piping is FRP. Specific components of the distribution system include:

- Piping from the production wells to a storage and settling tank in the geothermal building
- Gravity flow supply piping from the tank to heat transfer equipment in the buildings
- Gravity flow return/collection piping from the buildings to an injection collection tank
- Pumped or gravity flow from the collection tank to the injection wells

Critical Nature of System:

Loss of the GEO distribution system can lead to inability to heat campus buildings. There is no backup or standby heating system.

- Loss of a section of the piping or a fitting leak can result in loss of the entire system due to lack of isolation capacity and alternate flow routing
- Leaks in the tunnels can lead to personnel life safety risk due to the high temperature and confined space
- Large leaks in the tunnels can lead to building or electrical service flooding

Oregon Tech Action:

An engineering firm will be hired to complete the geothermal piping renovation project and work with Oregon Tech through completion of construction. With emergency funding Oregon Tech will be able to renovate this critical infrastructure and significantly reduce deferred maintenance costs for the next twenty years. The attached engineer's assessment outlines the condition and recommendations for the geothermal distribution system (Exhibit A). Exhibit B includes a campus map identifying the Oregon Tech geothermal piping, including both direct bury and tunnel piping.

Detailed Budget:

RENOVATION OF GEOTHERMAL DISTRIBUTION SYSTEM (DISTRIBUTION PIPING)		
	2022 Dollars	Construction Cost Increase
Architecture & engineering costs @ 10%	$ 538,200	$ 646,378
Construction costs	3,767,400	4,524,648
Contingency @ 15%	807,300	969,567
Other @ 5%	269,100	323,189
Total	5,382,000	$ 6,463,782

Figure 10 - Geothermal supply piping; valve inoperative, pipes questionable

Attachment C

Campus Main Electrical Gear and Distribution System (Building Heat Exchange System):
The geothermal hot water is used for heating all campus building and domestic hot water.

Building heating systems:

- Stainless steel heat exchanger to transfer heat from the GEO to the building heating water, with a control valve to limit the GEO flow based on heating water temperature
- Pumps to circulate the building hot water; control valves limit the heating water flow based on demand
- A water-to-air heat transfer coil to deliver heat to the building air
- Fans circulate heated air to rooms.

Domestic Hot Water Systems:

- Geothermal water is used to heat potable water for domestic hot water demands in all campus buildings
- Domestic hot water is heated using heat exchangers and hot water storage tanks

Critical Nature of System:

- The loss of building heat exchange systems will directly impact the ability to heat and use the effected building(s); there is no backup or standby heating system
- A planned renovation of building heat exchange systems will allow work to be scheduled for the summer months to not adversely affect building use.

Oregon Tech Action

An engineering firm will be hired to complete the building heat exchange renovations and work with Oregon Tech through completion of construction. With emergency funding Oregon Tech will be able to renovate this critical infrastructure and significantly reduce deferred maintenance costs for the next ten to fifteen years. The attached engineer's assessment outlines the condition and recommendations for the building heat exchange system (Exhibit A). Exhibit B includes a campus map identifying the Oregon Tech buildings that require renovation of existing heat exchange systems.

Detailed Budget:

RENOVATION OF BUILDING HEAT EXCHANGE SYSTEMS		
	2022 Dollars	Construction Cost Increase
Architecture & engineering costs @ 10%	$ 115,200	$ 138,355
Construction costs	864,000	1,037,664
Contingency @ 15%	115,200	138,355
Other @ 5%	57,600	69,178
Total	$ 1,152,000	$ 1,383,552

Figure 11 - Heat Exchanger; leaking a safety hazard, needing repair/replacement based on respective building

Attachment C

Geothermal System – Campus Snowmelt System:

Oregon Tech's snowmelt system provides improved campus access and safety during inclement weather while reducing the cost of snow removal. Upgrades and expansion of the campus snowmelt system will help reduce campus closures and the risk of potential injuries.

Critical Nature of System:

- Reduce the cost of snow/ice removal and limit campus closures due to winter weather conditions
- Reduce the risk of potential injuries

Oregon Tech Action

An engineering firm will be hired to complete the snowmelt system upgrades design and work with Oregon Tech through completion of construction. With emergency funding Oregon Tech will be able to complete upgrades to this critical infrastructure and improve campus safety and reduce snow removal costs moving forward. The attached engineer's assessment outlines recommendations (Exhibit A). Exhibit B includes a campus map identifying areas on the Oregon Tech campus that are priorities for snowmelt system upgrades.

Detailed Budget:

REPLACE AND EXPAND CAMPUS SNOWMENT SYSTEMS		
	2022 Dollars	Construction Cost Increase
Architecture & engineering costs @ 10%	$ 169,700	$ 203,810
Construction costs	1,272,750	1,528,573
Contingency @ 15%	169,700	203,810
Other @ 5%	84,850	101,904
Total	$ 1,697,000	$ 2,038,097

-

Figure 12 - Snowmelt; confined space - improved safety and control

Attachment C

Geothermal System – Campus Electrical Equipment:

Oregon Techs main power distribution switchgear is located in the same building and directly under geothermal supply piping. Any failure in the geothermal piping could result in a disruption of power to campus as well as major safety concerns. Relocation and replacement of the campus main switchgear will help prevent campus closures and reduce the risk of potential injuries.

Critical Nature of System:

- Prevent campus closures due to disruption of power distribution
- Reduce the risk of potential injuries

Oregon Tech Action

An engineering firm will be hired to complete the electrical system upgrade design and work with Oregon Tech through completion of construction. With emergency funding Oregon Tech will be able to complete upgrades to this critical infrastructure and improve campus safety moving forward. The attached engineer's assessment outlines the condition and recommendations for the campus electrical systems (Exhibit A). Exhibit B includes a campus map identifying the Oregon Tech buildings that require renovation of existing heat exchange systems.

Detailed Budget:

RELOCATE AND REPLACE CAMPUS MAIN ELECTRICAL DISTRBUTION SWITCHGEAR		
	2022 Dollars	Construction Cost Increase
Architecture & engineering costs @ 10%	$ 193,200	$ 232,033
Construction costs	1,449,000	1,740,249
Contingency @ 15%	193,200	232,033
Other @ 5%	96,600	116,017
Total	$ 1,932,000	$ 2,320,332

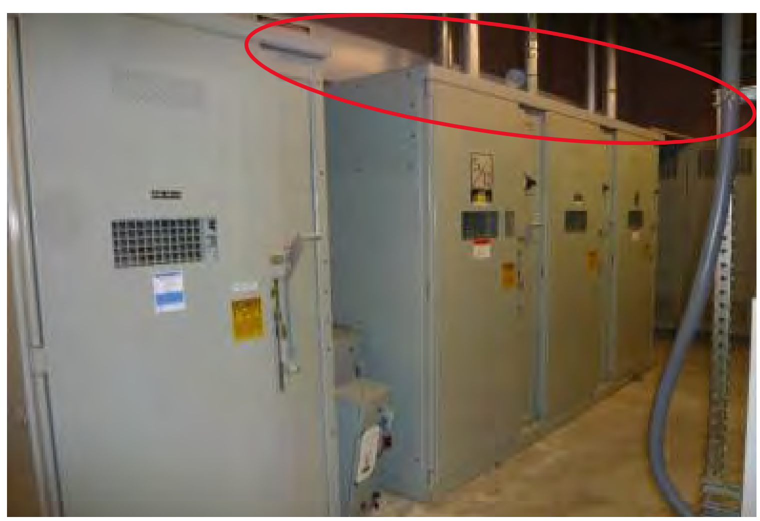


Figure 13 - Campus main electrical equipment; subject to complete failure and prone to flooding

Attachment C

Emergency Project Timeline

The estimated time of completion for all elements and phases of emergency repairs is anticipated to be up to 36 months. If emergency funding is granted, Oregon Tech anticipates emergency repairs to start summer of 2023 with completion estimated to be summer 2026.

Because the Oregon Tech geothermal system infrastructure is complex, the repairs will need to be made in distinct phases so as to minimize disruptions to campus. The university is able to complete much of its repair activity during the summer months, when the majority of residential students are not on campus. Some repair activity could take place when classes are in session, but at a reduced rate.

Geothermal Heating System Annual Savings

Annual Utility Costs

Oregon Tech estimates that annual utility costs savings because of the geothermal heating system is approximately $604,000. This is a conservative estimate, based on an on-line geothermal savings calculator. Source: *climatemaster.com/residential/geothermal-savings-calculator.*

Geothermal heating system utility savings over the next 20 to 30 years is estimated to be approximately $11,800,000 to $17,700,000 in today's dollars.

Deferred Maintenance Costs

The University estimates that future deferred maintenance costs would be significantly reduced over the next 20 years through funding of the emergency request. This could be as much as $6,000,000 over the next five years, which is currently unfunded due to the sudden emergency nature of the system.

Assumptions used to develop utility cost and deferred maintenance savings is included under section "Assumptions".

Return on Investment

Emergency funding of the geothermal heating system would address imminent life safety risks and also result in a return on investment for the university and state.

Return on investment could reach 38.90% over 30 years. This is a conservative estimate based on annual geothermal utility cost savings, and deferred maintenance savings over the first five years of the project.

Assumptions used to develop utility cost and deferred maintenance savings included under section "Assumptions".

Life safety risks are most important to the emergency repair of the geothermal infrastructure and heating system. However, the return on investment supports the continued viability and use of the university's existing geothermal heating system.

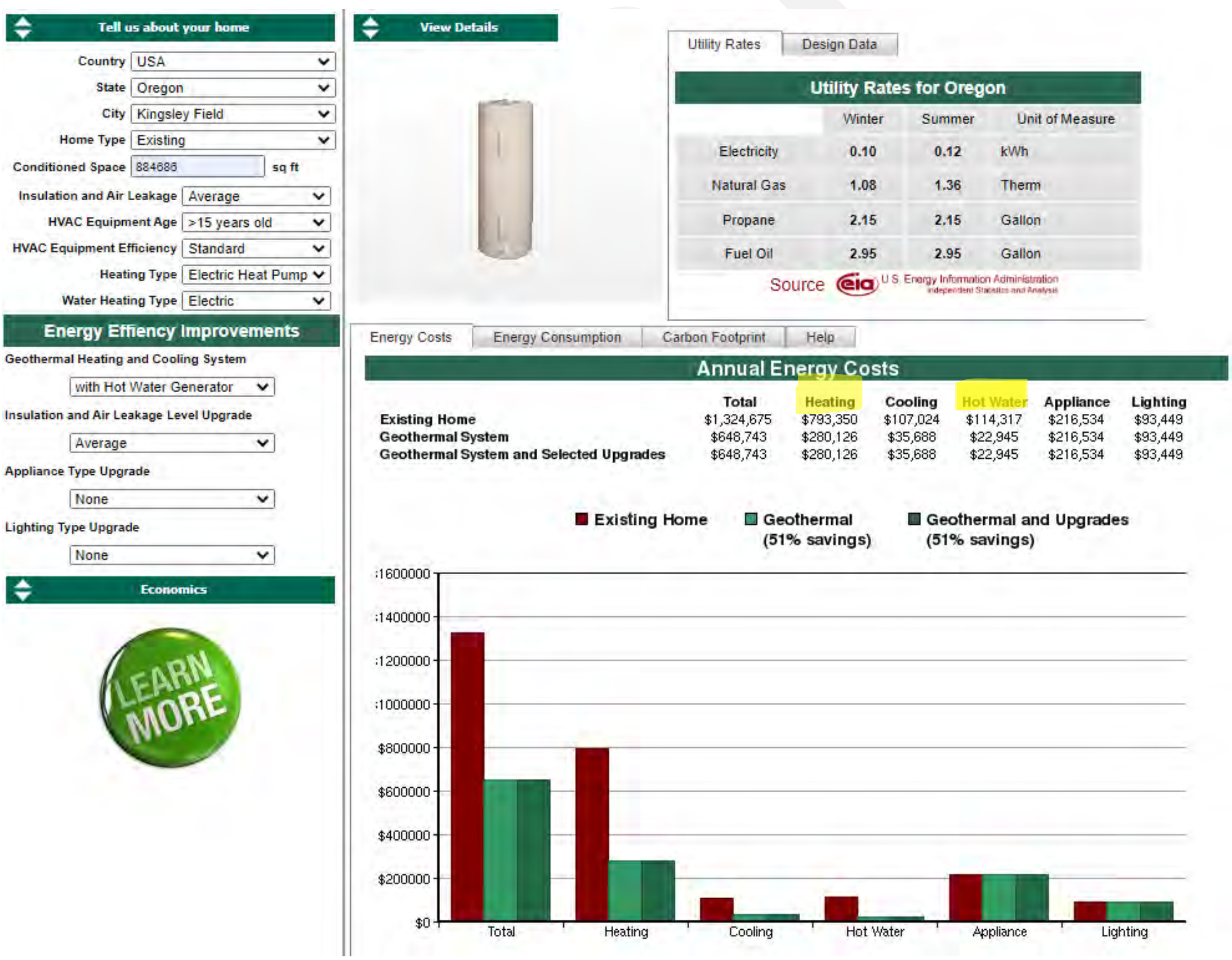
Attachment C

<u>Assumptions</u>

Outlined below are assumptions developed for estimating (1) Geothermal System Savings, (2) Project Budget, and (3) Return on Investment.

Geothermal System Savings:
An online geothermal calculator was used to estimate annual utilities cost savings. Utility costs for (a) heating, and (b) hot water were included in the cost savings estimate. Source:
https://www.climatemaster.com/residential/geothermal-savings-calculator/sc01.php

	Annual Energy Costs		
Source	**Heating**	**Hot Water**	**Sub-Total**
Electric	$ 793,350	$ 114,317	$ 907,667
Geothermal	280,126	22,948	303,074
Difference - Estimated Savings	$ 513,224	$ 91,369	$ 604,593



Attachment C

Project Budget:
The overall project budget was developed as part of the engineering assessment report commissioned by Oregon Tech in June 2022. Those figures were developed by the engineering firm in 2022 dollars and include (1) construction costs, (2) soft costs, (3) contingency, and (4) other costs.

Oregon Tech applied an estimate for project construction cost increases over the project period. Source: *https://www.cbre.com/insights/books/2022-us-construction-cost-trends*

CRBE's Construction Cost Index forecasts:

- 14.10% year-over-year increase in construction costs by year-end 2022
- 2.00% - 4.00% increases in 2023 and 2024, respectively

Based on CRBE's Construction Cost Index, construction costs are estimated to increase 20.10% over the life of the project.

	2022 Dollars	Project Period Dollars
Total:	$ 14,951,000	$ 17,956,151
Project Components:		
Production & Injection Wells	$ 2,553,000	$ 3,066,153
Geothermal Mechanical Building and Main Geothermal Storage and Pumping System	2,235,000	2,684,235
Geothermal Distribution System	5,382,000	6,463,782
Building Heat Exchange System	1,152,000	1,383,552
Geothermal System - Campus Snowmelt System	1,697,000	2,038,097
Geothermal System - Campus Main Electrical Equipment	1,932,000	2,320,332
	$ 14,951,000	$ 17,956,151
Project Period Dollars, Estimated Increase from July 2022		20.10%

Return on Investment:
Return on investment (ROI) was calculated based on estimates for (a) geothermal annual utility cost savings and (b) deferred maintenance costs saved within the first five years after emergency project completion.

ROI calculation:

- Present value of future savings of geothermal annual utility costs
  - 30 years: $17,695,405
- Deferred maintenance cost savings within first five years of emergency project completion
  - $6,000,000
- Internal borrowing rate
  - 2.50%
- Emergency Project Funding (amount invested)
  - $17,956,151
- Number of years
  - 20-30 based on expected life of geothermal infrastructure

Attachment C

Summary Statement

Oregon Tech believes this emergency funding request is essential to protecting student safety, life safety risks, and to prevent complete loss of the geothermal infrastructure and heating system, which would necessitate campus closure.   Klamath Falls campus operations, including academic buildings and student housing, are wholly dependent on the geothermal infrastructure and heating system ten months out of the year. The critical nature of necessary improvements requires immediate action and an urgent investment in repairs to avoid the dire consequences of geothermal system shutdown, hence the emergency status designation.

As part of the university's emergency assessment of its geothermal heating system, an engineering geothermal condition assessment was performed in June 2022 by Fluent Engineering, Inc. Much of the justification for our emergency funding request is based on that assessment, including detailed descriptions of safety risks and condition of system components. That assessment is included in its entirety as Exhibit 1 and Appendixes A – C.

Of the commissioned engineering geothermal condition assessment, Oregon Tech believes Appendix B2 *Geothermal System Distribution - Enlarged* and Appendix C *Detailed Cost Evaluation Matrix* are most informative. Together, they provide a snapshot of detailed information throughout the entire geothermal infrastructure and heating system.

- Appendix B2: Provides a campus map, overlaid with the geothermal distribution system identifying the location of each system element requiring emergency repair.
- Appendix C: For *each* system element, lists detailed evaluation cost estimates (in 2022 dollars) as well as information regarding: system safety, system resiliency, effect on system capacity, effect on future system maintenance costs, and supporting photos.
- Numbering of system elements on Appendixes B2 and C tie to one another. Together, the map and system element listing provide a visual and narrative on the pervasive nature of emergency repairs throughout the entire geothermal heating system.

Oregon Tech deeply appreciates the time and consideration of the Oregon Legislature and the Legislative Fiscal Office for our emergency funding request. The university would also like to acknowledge and thank the HECC for their guidance with this submission.

Please do not hesitate to contact us should you have any questions or would like additional detail about this request. We welcome any questions and requests you may have.

Contact Information

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