Exhibit 1

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

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

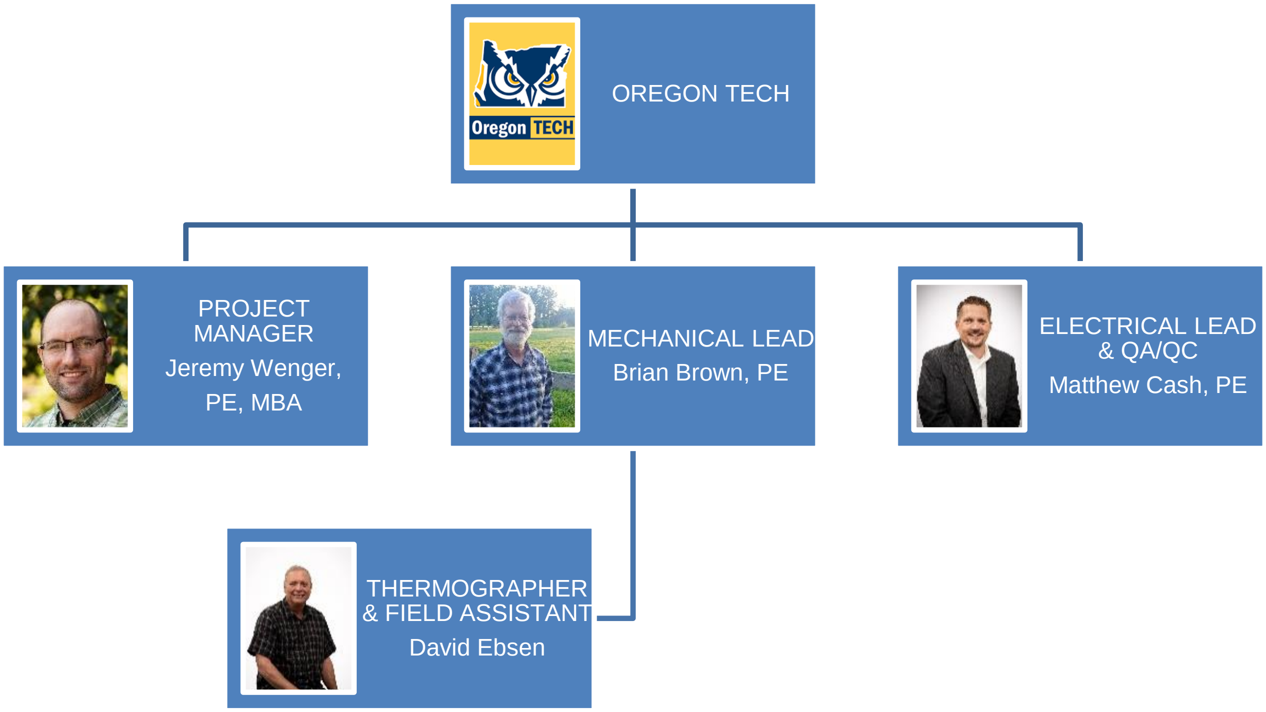
The Fluent Engineering project team consisted of the following individuals:

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.

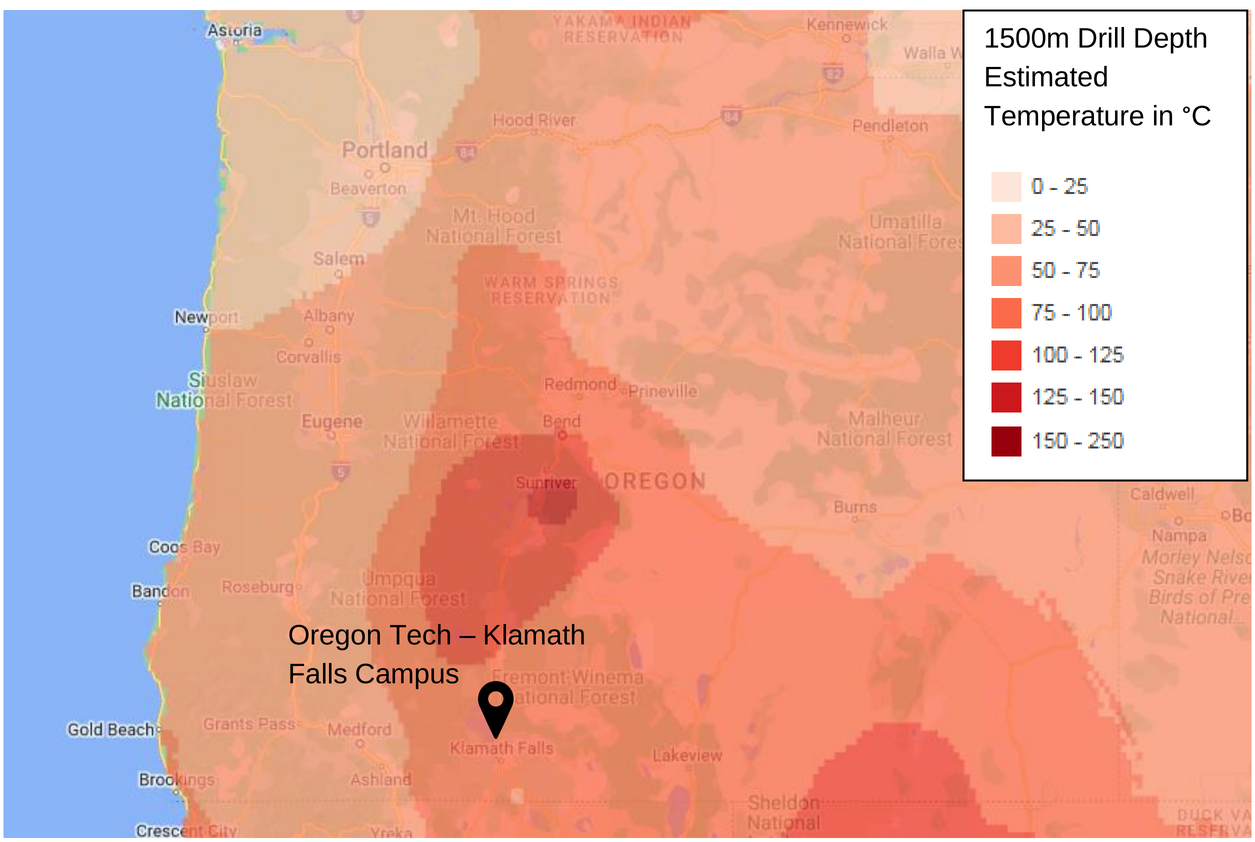


FIGURE 1: MAP OF ESTIMATED BELOW-GROUND TEMPERATURES IN OREGON AT 1500M DEPTH (SOURCE: NREL GEOTHERMAL PROSPECTOR TOOL)

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.

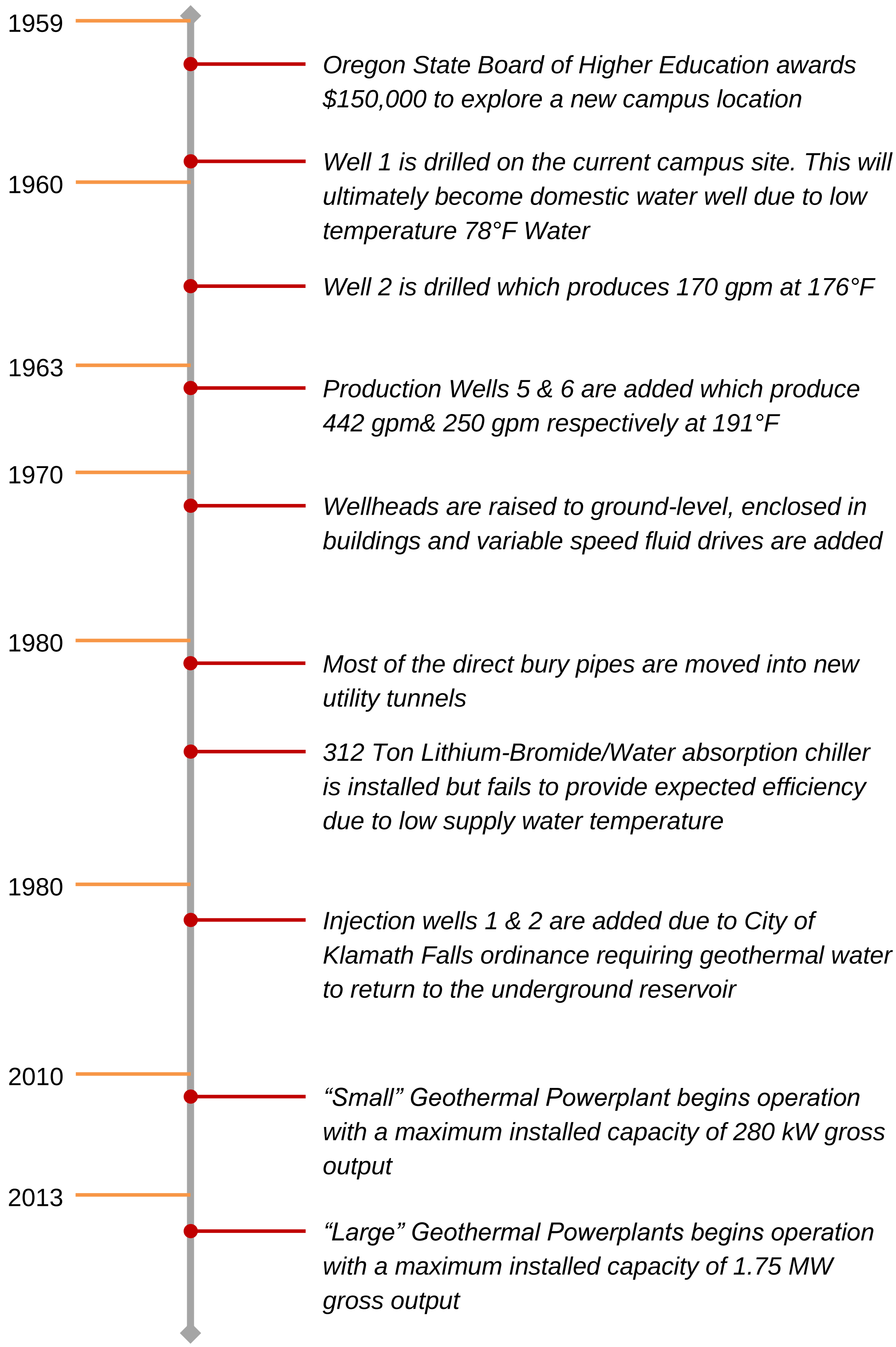


FIGURE 2: MAJOR MILESTONES IN THE HISTORY OF THE GEOTHERMAL SYSTEM AT OREGONTECH

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

<u>Pump and Fan Type Legend:</u>

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

<u>Rating Descriptions:</u>

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:

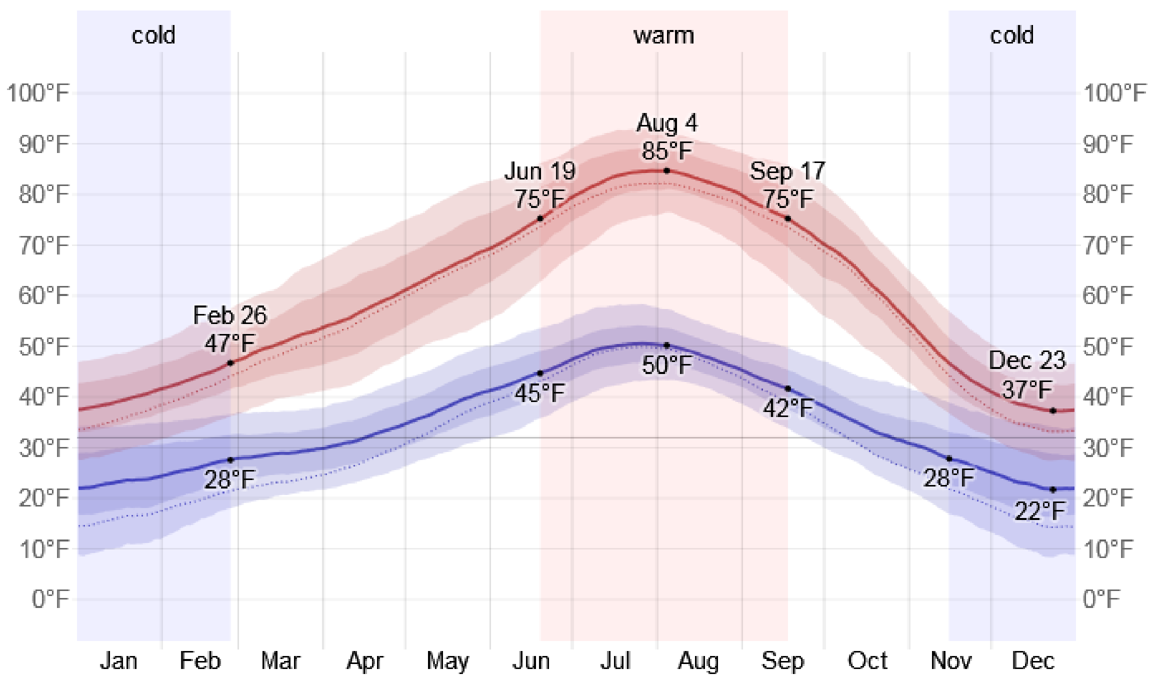


FIGURE 3: AVERAGE YEARLY TEMPERATURES IN KLAMATH FALLS, OR. (SOURCE: WEATHERSPARK.COM)

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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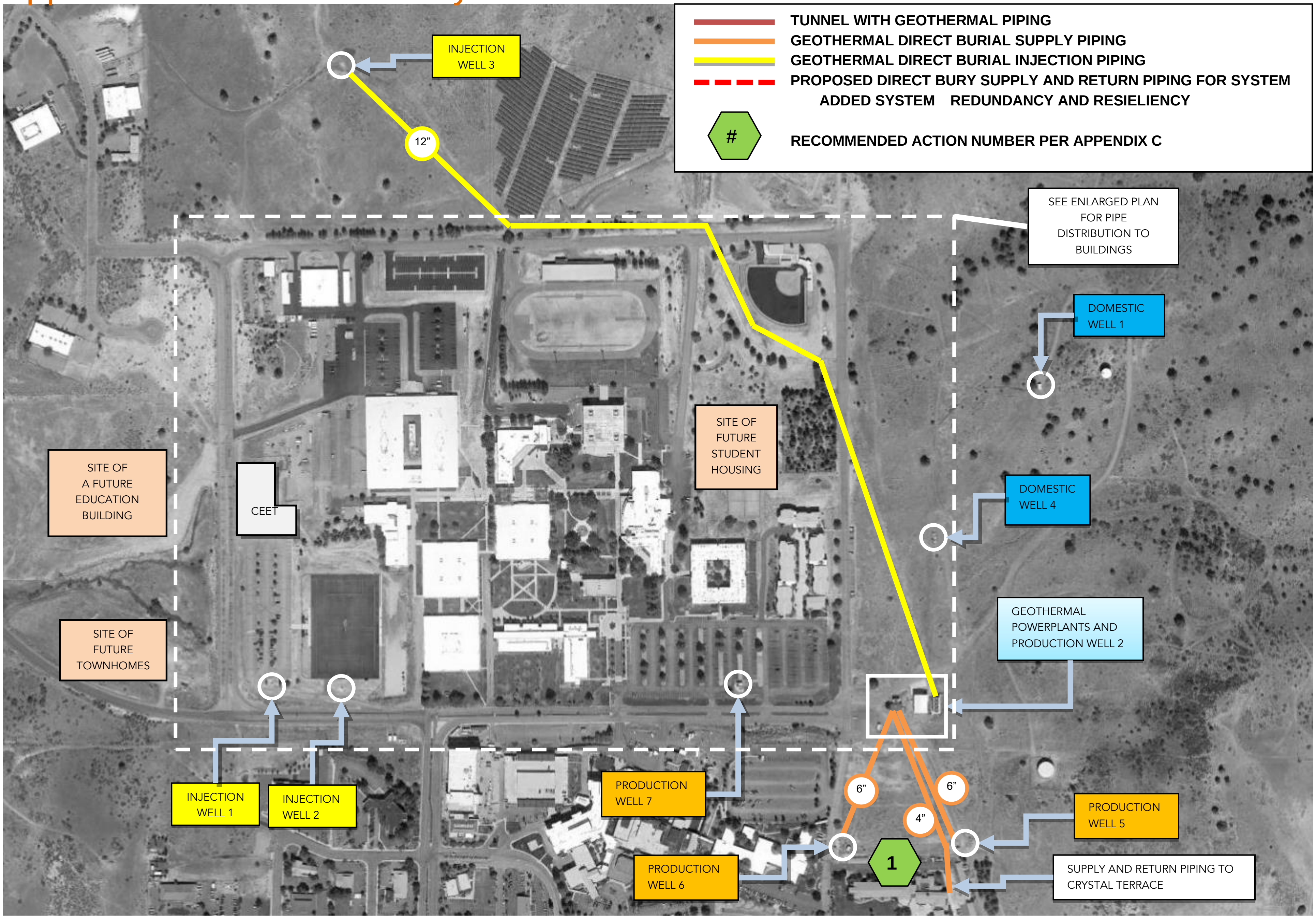
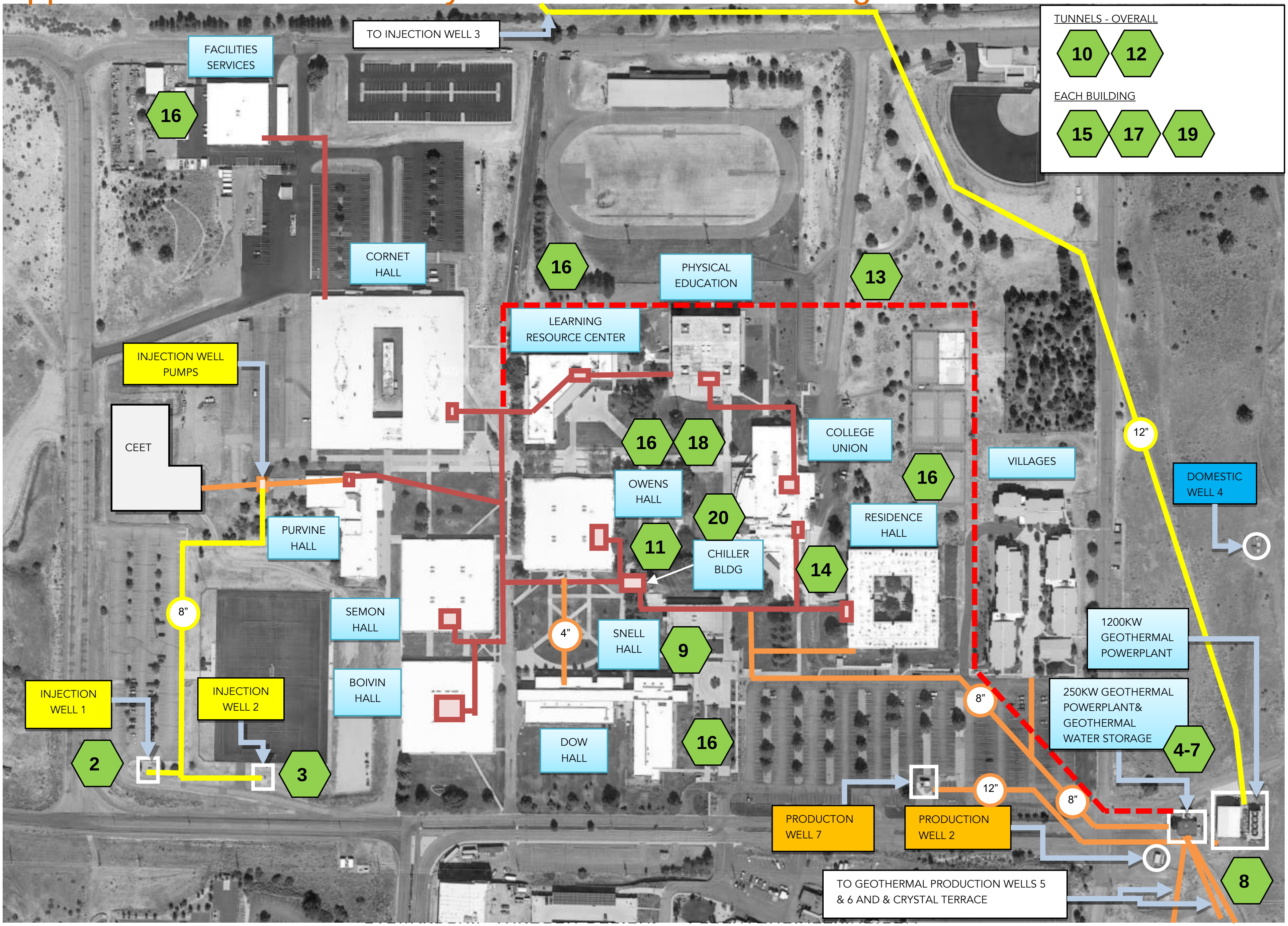
Appendix A: Acronyms

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



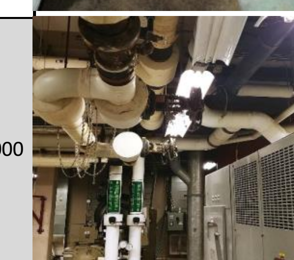
Appendix B2: Geothermal System Distribution – Enlarged

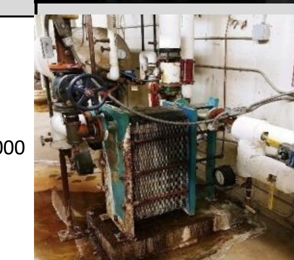
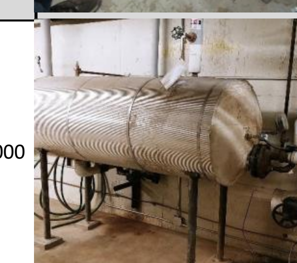


Appendix C: Detailed Evaluation Cost Estimates

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**	