TEN Pilot Project
Basis of Design Report
NW Natural – Waterfront Gateway

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ACRONYMS & ABBREVIATIONS

ASHP – Air Source Heat Pumps
ATL – Ambient Temperature Loop
DHW – Domestic Hot Water
ETS – Energy Transfer Station
GLHX – Ground Loop Heat Exchange/Exchanger
GLD – Ground Loop Design, software for GLHX modeling
HDPE – High Density Polyethylene
SCADA – Supervisory Control and Data Acquisition
TEN – Thermal Energy Network
TRNSYS – Transient System Simulation, software for modeling ambient loop TENs
WET – Wastewater Energy Transfer, also known as sewage heat exchange, sewage heat recovery, wastewater heat recovery, etc.
WSHPs – Water Source Heat Pumps, also known as ground source heat pumps

THERMAL ENERGY NETWORK DESIGN

OVERVIEW

The recommended ambient thermal loop (ATL) location is a variation of the "Street Loop" option as presented in the pre-design report. The ATL will be routed in the right-of-way adjacent to the street with run-outs to each of the buildings.

Due to the significant available thermal production from an open loop geothermal system at this site, it is recommended that the City Hall open loop geothermal system be connected to the TEN system and an additional set of extraction and injection wells be installed on the west side of the site.

The ATL and the Open Loop Geothermal will need a pump station(s). The Open Loop Geothermal pump station is planned to be located in the parking garage. The 30% design shows two options for the ALT pump station. Option A is a vault located in the plaza on the East side of the site. Option B is for the ALT pump station to be located adjacent to the Open Loop pump station in the parking garage.

Each building will need an Energy Transfer Station (ETS) to separate the fluid in the TENs system from the fluid in the building system and to transfer heat between the systems. The exact location of the ETS in the new construction buildings will need to be coordinated with their building design team. They are currently shown near the planned mechanical rooms.

CIVIL

Project Design Parameters

The proposed civil/site systems will be designed in accordance with standard engineering practice and current code requirements.

Site Clearing/Demolition

- Prior to any excavation, erosion control measures will be installed to prevent the transmission of sediment laden runoff from the construction area.
- Where applicable, topsoil will be stripped and stockpiled with appropriate erosion controls applied to all disturbed areas.
- Clear and grub area within limits of the project including removal of trees, bushes, shrubs, stumps, fencing and other incidental materials not required for use on the site.
- Areas that will be left disturbed and exposed for a significant period of time shall be seeded for protection.
- Traffic control, signage, and barriers will be needed throughout the project for staging, phasing and protection of the public from construction activities.
- Conduct demolition in a manner that will prevent damage to adjacent structures, utilities, site improvements, and other facilities to remain. Surfaces to be demolished shall be clearly defined with perimeter saw cuts. All demolished materials must be properly handled and disposed of offsite.
- Remove all site improvements as required to allow installation of new utilities.
- Protect all existing site improvements and utilities that are to remain during all construction activities.

Site Earthwork

Provide excavation and backfill for utilities and surface restoration including temporary excavation and support as required per jurisdictional standards and specifications.

Site Grading, Excavation & Disposal

Prepare subgrades for walks, pavements, turf, and grasses. Provide proof-rolling of subgrades as well as any necessary dewatering systems.

Provide stockpiling of all suitable onsite materials required for reuse. The project area may contain polluted or contaminated soils. Soil testing will be conducted via geoenvironmental investigations. Monitoring of soils during excavation may be required. Polluted and contaminated soils shall be disposed of legally with all required permitting and manifests.

All hazardous waste removal shall be performed by a licensed Hazardous Waste Contractor. Include all necessary permitting and manifests required for the removal of hazardous waste.

Borrow Fill

Provide clean imported materials for sub-base and base courses for concrete and bituminous walks and pavements.

Provide clean imported material for subsurface utility trench bedding and backfill.

Site Dewatering

Provide all necessary dewatering systems to maintain a dry work area. Dewatering systems shall be designed and installed by licensed professionals in Washington State experienced with these systems.

Site Shoring

Provide all necessary temporary excavation support and protection to allow construction of proposed structures, improvements, and utilities. Temporary excavation support and protection systems shall be designed and installed by licensed professionals experienced with these systems.

Erosion and Sediment Control

The project will require a permit from US EPA for a Stormwater Permit for Construction Activity prior to the planned commencement of construction. This permit includes requirements for a Stormwater Pollution Prevention Plan (SWPPP) prior to the commencement of construction and Plan Implementation Inspections during construction performed by a qualified person. The permittee shall provide all necessary “Qualified Inspectors” and “Qualified Professionals” as defined in the permit regulations.

Erosion and sediment control measures will consist of, but shall not be limited to, inlet protection, silt fence, compost filter socks, construction entrances, sediment control ponds, etc.

The installation and maintenance of all erosion and sedimentation control measures shall be in accordance with the SWPPP provided with the Stormwater Permit mentioned above.

Utilities Trenching

Place and compact backfill in excavations on subgrades free of mud, frost, snow, or ice. Individual compacted layers shall be compacted to minimum dry densities as follows:

- Under Equipment Pads, Structures, and Pavements (Other Than Stone Base): 95 percent.
- Under and Around Utilities (Other Than Stone): 95 percent.
- Under Walkways: 95 percent.
- Under Lawn or Unpaved Areas: 90 percent.

Site Surface Improvements

- Bituminous Pavement
  - Bituminous concrete paving that is removed to allow for the installation of proposed utility shall be reinstalled to match existing conditions.

- Roadway Paving and Surfacing
  - The bituminous concrete paving section will consist of no less than 7.2” of asphalt over 8 inches of aggregate base material., specifically hot mix asphalt Class ½” PG 58H-22 constructed in accordance with Section 5-04 of the WSDOT Standard Specifications.
- Painted Lines and Markings
  - Pavement markings shall comply with the City of Vancouver. Washington standards and Specifications.
- Pedestrian Paving
  - Sidewalks removed to allow for the installation of proposed utility and surface improvements will be reinstalled to match existing conditions.
- ADA Site Elements
  - ADA ramps, signage, and striping removed to allow for the installation of proposed utility and surface improvements will be reinstalled to match existing conditions.
- Sidewalks
  - Concrete sidewalks will consist of 4-inch-thick, normal weight concrete with 3,000 psi (CL 3000) minimum, 28-day compressive strength, maximum 3-1/2” slump. Concrete sidewalks will be installed over 3” gravel base material.
- Curbing
  - Site curbing removed to allow for the installation of proposed utility will be reinstalled to match existing conditions. Site curbing will consist of precast concrete curbing or cast-in-place curbing to match existing conditions.
  - Precast concrete curbing will be 6 inches wide by 18 inches minimum depth, and curbing will extend 6 inches above adjacent roadway surfaces.
- Retaining Walls
  - Site retaining walls removed to allow for the installation of proposed geothermal system will be reinstalled to match existing conditions. Site retaining walls will consist of reinforced, cast-in-place retaining walls to match existing conditions.

Planting

Planting beds removed to allow for the installation of proposed utility and surface improvements will be replaced in kind to match existing conditions and plant species. All other disturbed softscape areas of the site will be lawn seed mixes or sod.

STRUCTURAL

Existing (City Hall)

Utility penetrations shall be cored through any existing concrete foundation walls at each building entry point. Existing walls shall be scanned prior to coring in order to locate the position of existing reinforcing steel. Avoid coring through or within 2 inches of existing reinforcing steel. Since adjustments to the location of the cores may be required after scanning, coordination with the exterior utility layout will be critical to ensure proper alignment. The coring process shall employ diamond-tipped core drills mounted on stable rigs or to the exterior face of the foundation walls. Provide a clear distance between adjacent cores and existing wall penetrations of one core diameter. Notify engineer of record if existing reinforcing steel cannot be avoided or if minimum spacing between cores cannot be maintained and allow for additional design team review and directives prior to coring. Exterior wall waterproofing shall be repaired to match the existing conditions.

New Construction

Penetration for new construction will be coordinated during design.

MECHANICAL

Operational Narrative

The Thermal Energy Network (TEN) system will likely have an open loop geothermal system. An open loop geothermal system is connected to an ambient temperature loop (ATL) pipe through a set of heat exchangers that distributes energy throughout the community to the heat pumps located within each building. Each of the open loop wells will be served by its own heat exchanger and pump station that includes (2) heat exchangers and (2) pumps. The heat exchangers are designed to provide approximately 75% of the maximum flow from the open loop wells and the pumps are sized to be fully redundant. The pumps are included to circulate the geothermal fluid through the heat exchangers to transfer heat to/from the ATL as needed. Refer to the Pump Infrastructure section in this narrative for additional information regarding equipment requirements associated with the ATL pump station.

Each of the buildings will be served by a dedicated Energy Transfer Station (ETS) which includes circulation pumps and a heat exchanger that pulls fluid from the ATL to deliver energy to the building. As the heat pumps within each building extract heat from or reject heat to the ATL, the ATL pumps speed up to provide more flow, and the thermal asset pumps speed up to transfer more heat to/from the ATL to satisfy each heat pump’s needs.

Each building will be equipped with isolation valves and a bypass line that will facilitate phasing and construction timing by allowing the isolation of each building from the ATL. Refer to flow diagrams on mechanical plans for additional information. Each building’s ETS heat exchanger will isolate the ATL from the building and provide a demarcation between Utility infrastructure and building systems. This also allows each building to connect without shutting down the ATL.

The ATL will be filled with 100% water solution with a small amount of chemical treatment that inhibits corrosion and bacteria growth. Since the ATL is a closed loop, it does not need significant fluid/water once it is filled and operational, however as any air is removed via the air elimination system or as fluid is lost due to expansion and pressure relief, a small amount of fluid will be added via automatic feed stations to maintain the pressure, thus keeping the pumps primed and operating. The system operating pressure will be confirmed during a later phase, however, is expected to be below 100 PSI.

A SCADA control system will be provided to control, monitor, and meter the ATL, open loop wells, and ETS systems.

Operational Parameters

The following presents the basis of design for the geothermal system:

- Outdoor Air Design Conditions:
  - Vancouver, WA
    - Summer: 87.7°F DB, 66.1°F MCWB (ASHRAE 1.0%)
    - Winter: 24.4°F DB (ASHRAE 99.6%)
- Delivery supply water temperatures:
  - 32°F minimum heating mode supply water temperature to the building side of the ETS.
  - 93°F maximum cooling mode supply water temperature to the building side of the ETS.
  - 3°F approach temperature on the ETS.
  - The ATL supply water temperature differential from one energy source to the next energy source shall not be more than 10°F (at design conditions). This will provide a consistent operational efficiency for all heat pumps served by the ATL system.
- Operational system pressure shall be designed to maintain minimum suction pressure at each pump to prevent pump cavitation and to limit pressure to within piping and component pressure ratings.
- ATL flow rate shall be designed to maintain the specified maximum temperature differentials between the energy source input manifolds. The heat exchanger flow rates shall be designed at 3GPM/Ton of capacity required.
- Pipe sizing Requirements:
  - The ATL pipe size will be standard pipe sizes based upon required flow. Flow rates to achieve proper temperature differences and pressure drop shall be primary design criteria for pipe sizing.

Infrastructure Piping and Materials

- Piping Materials:
  - All ATL piping shall be constructed of HDPE.
    - All pipe and heat fused materials shall be manufactured from a virgin polyethylene extrusion compound material. Pipe shall be manufactured to outside diameters, wall thicknesses and respective tolerances as specified in ASTM D-3035, D-2447, or F-714.

  - The material shall be PE4710 HDPE with minimum cell classification 445474C, with a UV stabilizer of C, D, or E as specified in ASTM D3350 and is listed by the Plastic Pipe Institute in PPI TR-4 with HDB ratings of 1600 psi at 73°F (23°C) and 1000psi at 140°F (60°C).
  - All PE4710 HDPE pipe shall have DR rating based on determined system pressures.
- High Density Polyethylene (HDPE) Pipe Fittings:
  - Pipe fittings shall be of the same material designation as detailed above and shall meet the requirements of ASTM D2683 (for socket fusion) or ASTM D3261 (for butt/saddle fusion). Each fitting shall be identified with the manufacturer's name, nominal size, pressure rating, relevant ASTM standard(s) and date of manufacture.
  - All piping shall be hydrostatically pressure tested to ASTM standards before burial and follow PPI and manufacturer pressure testing guidelines for HDPE pipe.
- A minimum 50-year limited warranty will be specified for HDPE piping.
- All pipe and fitting joining methods shall be either butt, socket, or saddle type heat fusion processes. No mechanical joints shall be allowed underground unless located within a sub-surface vault.
- Transitions from HDPE to pump volutes, valves, etc. shall be 4 or 6 bolt flanged ductile cast iron back up rings with HDPE fitting type connection for any below ground connections and flanged schedule 40 steel for any above grade connections.
- Where possible, ATL and geothermal piping will have a minimum 3', 360° clearance around the pipe from any other infrastructure running parallel to this service. If the geothermal piping is run parallel (within 3' distance) with either water or sewer lines for more than 3', then the geothermal infrastructure piping shall be insulated with 1" thickness EPDM insulation for the entire length the piping is running with the other infrastructure. Buried insulation shall be protected with HDPE jacket and sealed to prevent water intrusion.
- All ATL and geothermal piping shall have a minimum 1', 360° clearance around the pipe from any other infrastructure crossing perpendicular to this service.
- Tracer wire shall be installed on all non-metallic pipes with fiber tape placed at 10' intervals. All tracer wire and location tape shall conform to all local and provincial regulations and standards. All tracer wire termination points will at their respective manifold or ETS. The maximum distance between termination points is not to exceed 500'. Tracer wire termination points will not be placed above ground in pedestals.

PUMP INFRASTRUCTURE

Structural

New mechanical equipment shall be placed on new concrete housekeeping pads in existing utility rooms. Housekeeping pads shall be pinned to the existing slabs with #4 dowels spaced at 18 inches on center around the perimeter edge of the housekeeping pad. Dowels shall be drilled and installed with epoxy adhesive 3 inches into the existing slab-on-grade. Pads shall be reinforced with #4 reinforcing bars spaced at 12 inches on center in each direction. Concrete for new housekeeping pads shall have a minimum 28-day compressive strength of 4,000 psi.

Mechanical

The pump stations are intended to locate all the equipment required to operate the ATL and all of the thermal resources, including ground loop heat exchanger(s). The equipment requirements for each pump station are listed below. Refer for schedules on drawings for pump sizes and operational requirements.

Pump Station Equipment

- ATL Pump Station
  - Option A – Below Grade Vault
    - Vehicle load rated precast concrete vault located near city hall. Refer to drawings for approximate location and more information.
  - Option B – Above Grade
    - Located within future parking garage in the same location as open loop pump stations. Refer to drawings for approximate location and more information.
  - 2 Pumps (N+1 redundancy) utilizing ECM/VFD control.
  - Air-Dirt Separator.
  - Expansion Tank.
  - Makeup water connection and meter.
- Open Loop Pump Stations – Located to be determined.
  - 2 Pumps (N+1 redundancy) utilizing ECM/VFD control.
  - Open Loop, stainless steel, double wall Heat Exchanger
- Energy Transfer Stations (ETS) – Located in Buildings 1, 2, 4 and City Hall.
  - Plate and Frame Heat Exchanger with a 3°F approach temperature.
  - Source / ATL Side of HX
    - 2 Pumps (N+1 redundancy) utilizing ECM/VFD control.
    - 2 Pipes entering/exiting the structure.
    - 1 Energy Monitoring Station. Includes 1 display/BTU meter, 1 flow meter, 1 supply temperature sensor, and 1 return temperature sensor.
  - Load / Building Loop Side of Heat Exchanger (All components on this side of HX shall be provided by the mechanical contractor responsible for the building side system.)
    - 2 Pumps (N+1 redundancy) utilizing ECM/VFD control.
    - 1 supply temperature sensor, and 1 return temperature sensor.
    - Air- Separator
    - Expansion Tank
    - Glycol Feed System

SCADA CONTROL SYSTEM

- Control instrumentation for the ATL, Open Loop Geothermal, and ETS systems will be provided and will include but not limited to on/off and modulating controls, actuators, water pressure switches, differential pressure transduces and transmitters, temperature and pressure sensors/transmitters, electromagnetic water flow meters, BTU energy meters, current transducers, temperature control panels, and low-voltage power supplies.

- Automatic temperature control devices and instrumentation will be provided with a complete interface to a SCADA system with overall system architecture and communications protocol to be determined upon further review and discussion. As a minimum, TEN will operate independently of the connected buildings to provide source water based on building demand feedback temperature and flow rate monitoring. All TEN equipment will be monitored, controlled, alarmed, and trended via the SCADA. The system will include a web-based operator interface. Heating and cooling energy transfer to/from the geothermal ground source heat exchangers will be monitored and trended using electromagnetic flow meters, temperature transmitters, and BTU energy meters.
- System shall include the following:
  - ATL
    - Leaving and Entering Water Temperature at every source connection
    - ATL flow rate
    - ATL pump speed
  - ETS
    - Leaving and Entering Water Temperature at the source and load side of the ETS
    - Source side pump speed
    - Source side flow rate
    - Source side BTU metering
  - Open Loop Geothermal
    - Water Temperature at each well
    - Flow rate
    - Pump speed
    - BTU metering

OPEN LOOP GEOTHERMAL

Hydrogeologic Conditions

The aquifer selected for the open loop system is the Unconsolidated Sedimentary Aquifer (USA). The USA is assumed to extend from ~30 ft to ~100 ft below ground, to be confirmed by the test drilling program.

The USA is capable of sustainable yields of more than 2000 GPM to/from a single well. A single supply and injection well completed in the USA is sufficient to satisfy 100% of the total heating and cooling requirements of the Thermal Energy Network (including the City Hall).

The groundwater is assumed to flow toward the Columbia River in a south southwest (SSW) direction.

Well Details

- Well Layout:
  - The intention is to maximize efficiency of the supply wells by limiting the effect of drawdown on an adjacent supply well (or wells). It also prevents, or limits, the effect of the injection temperature on the ambient temperature near the supply wells.

    - Generally, supply wells are located up-gradient of the groundwater flow direction and / or injection wells are located down-gradient of the supply wells.
- Well Spacing:
    - Spacing between adjacent supply wells and adjacent injection wells (if more than one is required) is based on the aquifer characteristics.
    - Spacing between a supply well and its nearest injection well are based on aquifer characteristics, the temperature of the groundwater being injected, and the flow rate going into the well. Higher temperature difference and flow will result in the need for greater spacing.
- Well Depths:
    - All wells will extend to the bottom of the USA. The grain size analysis will inform whether the depth can be decreased.
- Well Capacities:
    - The capacity of an open loop well will depend on the depth of the well, diameter of the well screen, slot size of the well screen, and requirements of the TEN.
    - Well details are to be confirmed by the test drilling program.

Operational Parameters

- The open loop geothermal system will constitute a non-consumptive use of groundwater.
- The ambient groundwater temperature is assumed to be ~52°F.
- The typical temperature drop across a HX in an open loop system for heating is ≤12°F, to ensure freeze protection of the returning water. The typical temperature rise for cooling is ≤25°F, to maintain energy efficiency of the heat pump. The resulting HX leaving water temperatures are a minimum of 40°F and maximum of 77°F.
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- Redundancy:
    - A fully redundant well is optional, to be confirmed by the owner.

Submersible Pumps for Open Loop Wells

The supply wells will be equipped with a submersible pump. The size of the pump is based on the flow requirements for satisfying the loads of the TEN and the pressure head requirements (friction losses and pumping elevation lift).

Typically, a pump control panel with Variable Frequency Drive (VFD) will be utilized and is supplied by the manufacturer of the submersible pump.

ELECTRICAL

- All applicable national, state, local and jurisdictional codes shall be followed for the installation.
- The new Electrical Systems will be designed in accordance with the requirements of the following codes and standards.
    - 2021 Washington State Building Code.
    - 2021 International Building code

  - 2020 National Electrical Code
  - NFPA 72, National Fire Alarm code
  - Clark Public Utility material and installation specs.
  - City of Vancouver
- Power for City Hall Open Loop Pump Station and Transfer Station to be powered via a 225,3P,4W Panelboard fed via the existing building service distribution. Provide separate sub-meter as required.
- Power for Building One Transfer Station to be powered via the building service via a dedicated 225A,3P,4W panel and sub-meter.
- Power for Building Two Transfer Station to be powered via the building service via a dedicated 225A,3P,4W panel and sub-meter.
- Power for Building Four Transfer Station to be powered via the building service via a dedicated 225A,3P,4W panel and sub-meter.
- Power for Building Five Open Loop Pump Station via the building service via a dedicated 225A,3P,4W panel and sub-meter..
- Power to ATL Pump Station Vault (option A) shall be fed via an underground duct bank to a pad mounted transformer feeding a pedestal mounted meter cabinet and 225A, 3P, 4W panelboard for power to pumps. Option B 1 Pump House to be fed via an underground duct bank to a pad mounted transformer and metering feeding a 225A, 3P, 4W panelboard for power to pumps

APPENDICES

- 30% Design Drawings
- Energy Report
- Closed Loop Analysis Report
- Open Loop Geothermal Feasibility Study (for reference)
- Wastewater Energy Transfer (WET) Concept (for reference)