

CONCEPT DESIGN AND PRELIMINARY FEASIBILITY STUDY FOR GLASSHOUSE GEOTHERMAL HEATING

WESTERN BAY OF PLENTY, NEW ZEALAND

Prepared For:
Tomatoes NZ
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ABBREVIATIONS

Acronym	Term
ASHP	Air Source Heat Pump
BOPRC	Bay of Plenty Regional Council
COP	Coefficient of Performance – Heating (kWth / kWe)
DHW	Domestic Hot Water – Potable
EER	Energy Efficiency Ratio – Cooling (kWth / kWe)
FLA	Full Load Amps per phase
GSHP	Ground Source Heat Pump
HTHP	High Temperature Heat Pump for Very Hot Water or Steam
kWe	Electrical Load (kW)
kWth	Thermal Capacity (kW) (Cooling or Heating Capacity)
RLA	Run Load Amps at typical design conditions
RMA	Resource Management Act
ROI	Return on Investment
RTE	Renewable Thermal Energy
TBC	To be confirmed
TGS	Tauranga Geothermal System
UTES	Underground Thermal Energy Storage
VRF	Variable Refrigerant Flow
VRV	Variable Refrigerant Volume
WSHP	Water Source Heat Pump

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EXECUTIVE SUMMARY

GeoExchange NZ Limited (GXNZ) was requested by Tomatoes NZ to assess the feasibility of a geothermal heating (geoheat) system to replace the existing heating systems for an example growing facility located in the western Bay of Plenty.

The assessment considered the available groundwater resource (ambient, medium, and high temperature) and evaluated multiple system configurations for technical feasibility, energy performance, carbon reduction potential, and financial viability.

There is a known geothermally enhanced aquifer beneath the example site that may be able to be used directly as a heat source. However, to obtain certainty on the exact depths, temperatures and flow rates will require a test well to be drilled. The general process for considering and installing a geoheat system for a glasshouse is summarised as follows:

Step 1. Preliminary desktop feasibility study based on glasshouse operations and available resource data analysis
Step 2. Drill test well (requires drilling consent)
Step 3. Use actual data from test well to finalise detailed design and costs for deployment; submit 'take and use' consent application
Step 4. Installation, including operationalising the test well
Step 5. Operation and system optimisation

The costs for drilling a test well are included in the total capital costs presented. In the absence of this information, this report assesses possible options based on available resource data that include:

- Direct use where the groundwater temperature is >70°C to align with the capacity of the existing heat pipe system; or
- Indirect use systems where the geothermally enhanced groundwater is <70°C and either supplementary heat is required or the heat distribution pipes require augmentation.

For the purposes of this assessment, adopted groundwater temperatures are 70°C (Option 1), 40°C (Option 2) and 20°C (Option 3). As per above, the options are to be updated once actual groundwater temperatures are confirmed via a test well.

Table ES1: Summary of Proposed System Options with Groundwater Resource	
Option ID	**Heating**
Option 1: **High Groundwater Temperature (T_{GW} ≥ 70°C)**	Direct use is possible with existing heat pipes configuration.
Option 2: **Medium Groundwater Temperature (40°C ≤ T_{GW} < 70°C)**	**2a: Direct use with additional hydronic pipes (40°C ≤ T_{GW} < 70°C):** ▪ 60°C ≤ T_{GW} < 70°C: 1.5 x existing hydronic pipes ▪ 50°C ≤ T_{GW} < 60°C: 2.0 x existing hydronic pipes ▪ 40°C ≤ T_{GW} < 50°C: 3.0 x existing hydronic pipes
	2b: Direct use with supplementary heating equipment. Options include: ▪ High-Temperature Ground source heat pump (GSHP), ▪ High-Temperature Air source heat pump (ASHP), ▪ Electric boiler, ▪ Gas, ▪ Waste oil, ▪ Biomass, or ▪ Solar thermal.
Option 3: **Low Groundwater Temperature (T_{GW} < 20°C)**	Ground Source Heat Pump system using shallow, ambient groundwater as thermal source.
Option 4: **Complete Air Source Heat Pump (ASHP) System**	Air Source Heat Pump System providing hot water to hydronic pipes

Table ES2 summarises the analysis from the energy and carbon analysis from a savings perspective, and demonstrates significant reductions across all geoheat scenarios compared to existing gas heating. Direct-use options (Options 1 and 2a) achieved the highest savings, with up to 99% energy savings and 100% carbon savings.

Table ES2: Summary of Energy and Carbon Savings – 1 Year											
	Existing Gas Heaters	Option 1	Option 2a	Option 2b Direct use combined with:						Option 3	Option 4
		Direct use T_{GW} 70°C	Direct use T_{GW} 40°C	GSHP	ASHP	Elec-tric Boiler	Gas Boiler	Waste Oil	Bio-mass	GSHP with T_{GW} 20°C	Complete ASHP
Annual Energy (kWhr)	1,350,463	7,455	7,455	208,951	330,665	723,896	803,999	851,118	822,204	350,025	544,998
Energy savings		1,343,008 (99%)	1,343,008 (99%)	1,141,512 (85%)	1,019,797 (76%)	626,566 (46%)	546,464 (40%)	499,345 (37%)	528,258 (39%)	1,000,438 (74%)	805,465 (60%)
Carbon Emissions (kg CO_2e)	294,617	522	522	14,627	23,147	50,673	174,960	164,477	158,877	24,502	38,150
Carbon Savings (kg CO2e)		294,095 (100%)	294,095 (100%)	279,990 (95%)	271,470 (92%)	243,944 (83%)	119,657 (41%)	130,140 (44%)	135,740 (46%)	270,115 (92%)	256,467 (87%)

Financial Analysis

The financial analysis summarised in Table ES3 indicates that simple bore-only options provide the quickest returns. Biomass and GSHP systems present a strong balance between capital cost and long-term savings potential.

The Levelised Cost of Heat (LCOH) shows how much it really costs to produce heat, on average, once you include all setup and running expenses. The LCOH analysis presents that Options 1 and 2a are the most cost effective over a 25 year operating life with value of 5 and 6 c/kWh respectively compared to 35 c/kWh for the existing gas system and 22 c/kWh for the ASHPs.

Table ES3: Summary of Energy and Carbon Savings – 1 Year											
	Exist-ing Gas Heat ers	Option 1	Option 2a	Option 2b Direct use combined with:						Option 3	Option 4
		Direct use T_{GW} 70°C	Direct use T_{GW} 40°C	GSHP	ASHP	Electric Boiler	Gas Boiler	Waste Oil	Biomass	GSHP with T_{GW} 20°C	Complete ASHP
Addi-tional In-vest ment	-	$1,470,000	$1,750,000	$2,220,000	$2,205,000	$2,470,000	$1,680,000	$1,630,000	$1,660,000	$1,300,000	$1,050,000
First Year Cost Saving		$369,488	$369,488	$317,436	$266,384	$140,944	$150,346	$330,780	$298,428	$260,209	$198,012
25 Year Cost Saving		$12,001,278	$11,721,278	$9,353,482	$7,507,177	$2,668,701	$3,801,504	$10,430,003	$9,220,460	$8,187,015	6,169,384
Investment Payback (Years)		3.8	4.5	6.4	7.5	14.3	9.8	4.7	5.2	4.7	5.0
Notes: 1: Includes cost allocation for upgrade to power supply											

Financed Options

The upfront capital cost required to install geoheat systems can sometimes delay or deter investment in the most efficient long-term solution for a facility. To address this, a project finance analysis has been included to demonstrate how financing arrangements can influence overall project economics.

While Options 1 and 2a require the highest upfront investment, a financed geoheat solution remains cost-competitive when compared with existing gas operations. When operating costs, maintenance, and capital repayments over a 15-year term are combined:

- **Option 1** reduces annual costs by approximately 60% compared with current gas operating costs; and
- **Option 2a** achieves a 52% reduction.

This approach allows the facility to repay the new systems through the ongoing annual savings they generate. To explore financing and delivery options in more detail, GeoExchange NZ can be contacted directly.

Consenting and Regulatory Process

The proposed activity will require a resource consent from Bay of Plenty Regional Council, the consenting authority. There is a defined process for the consent application that is available from the Council website. Consultation with Council and / or a planning consultant is recommended.

Recommendations

Based on the above conclusions, the following actions are recommended:

- Undertake a test bore to determine site-specific groundwater conditions and refine the selection of replacement heating system options;
- Pursue Options 1 or 2a – Direct Use as the preferred options subject to test bore results;
- Engage with the Bay of Plenty Regional Council to confirm consent requirements and obtain any necessary approvals; and
- Prepare the final system design and develop procurement documentation in line with project and regulatory requirements.

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1. INTRODUCTION

GeoExchange NZ Limited (GXNZ) was requested by Tomatoes NZ to assess the feasibility of replacing an existing gas heating system with a geothermal heating (geoheat) system at a growing facility in the western Bay of Plenty.

The objective of this report is to assess the potential for geothermal technologies to be deployed to meet the heating demand of the modelled greenhouse as well as to present the analysis in a way that provides an understanding of broader application of geoheat for other growers.

This assessment is based on client-supplied information (Tomatoes NZ), received via email on 24 June 2025.

The feasibility analysis focuses on the potential energy and cost savings achievable by installing a geothermal system at the site. This is assessed in comparison to both an existing gas heating systems and the typical alternative of air source heat pumps (ASHPs).

1.1 Structure of this Report

This report commences with an outline of the proposed project and renewable thermal energy and heat pump systems before focusing on the application of a selection of heat pump systems. This includes an energy and feasibility comparative analysis.

2. SCOPE OF WORKS

In accordance with correspondence with the Client and a review of background information, the following scope of works will be adopted for assessment:

- Review of available information, including future buildings and typical facilities for other growers;
- Calculate heat loads for the site based on agreed design conditions such as area of greenhouse, its construction and indoor set point temperature. Additional results will also be calculated for up to 3 climate zones, building fabrics, humidity control and whether items such as thermal screens are installed;
- Review of geological and geothermal conditions underlying the proposed site and their potential to provide the required heating and cooling requirements of the facility. The review will also include the range of geological and geothermal conditions in the main tomato growing areas so that a selection of open and closed loop ground heat exchangers and temperature conditions are assessed;
- Provide commentary on the consenting considerations for the options reviewed;
- Assess ground source heat pump options (if required) and associated plant, including benefits of thermal storage;
- Commentary will be provided here on typical electrical requirements for heat pump systems and what growers should be aware of when electrifying;
- Estimate budget for proposed systems based on results from the above;
- Conduct a comparative analysis with existing and alternative heating systems, including financials, payback, energy and CO_2 emissions;
- Provide concept schematic and drawings showing the possible location(s) of plant and equipment. A series of indicative schematics for some of the other options reviewed will also be provided. For example, a typical plant room with GSHPs, a direct use setup etc;
- Produce a report summarising the above for the broader industry; and
- Present a webinar to the client and industry summarising the results of the study.

3. RENEWABLE THERMAL ENERGY AND HEAT PUMPS

This section provides a brief outline of renewable thermal energy (RTE) systems and their various components to provide background information.

Renewable thermal energy sources are either direct or indirect in nature. Examples of direct renewable thermal energy (RTE) are geothermally heated waters utilised in a hot springs facility or high temperature wastewater from an industrial facility that is used for lower temperature heating requirements. In such instances a heat pump is not required, although only heating or cooling is usually possible and not both.

However, the majority of RTE sources are of the indirect variety and do require a heat pump to meet the temperatures required for the application.

These systems consist of the RTE source, the heat pump and the building services (Figure 1).

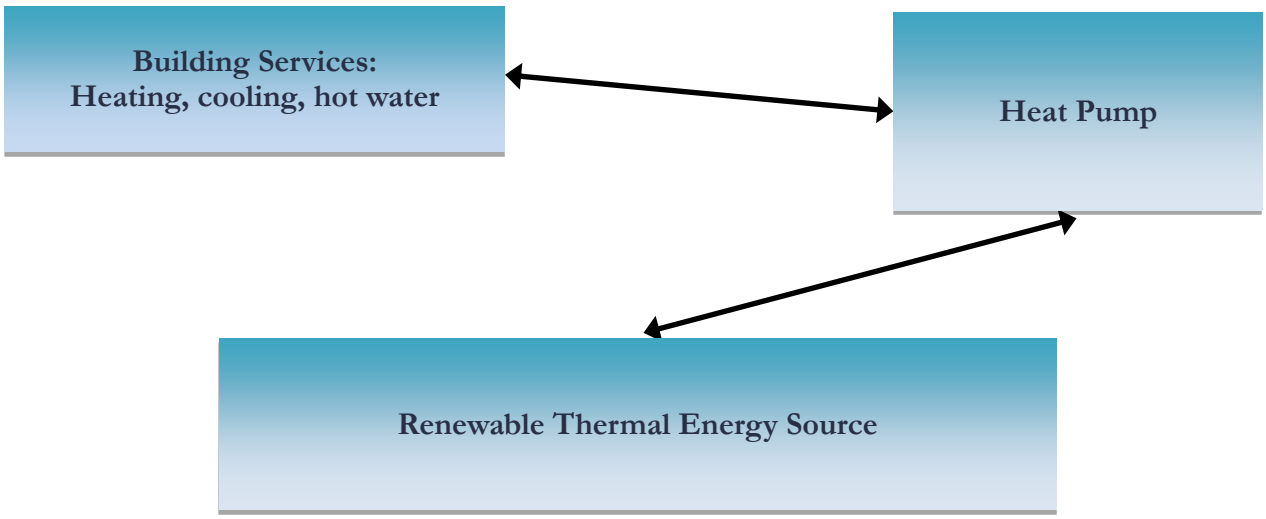
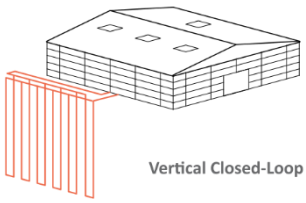
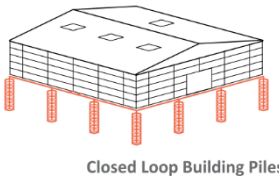
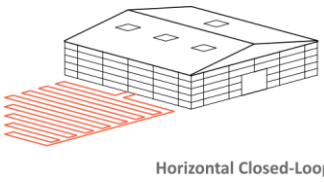
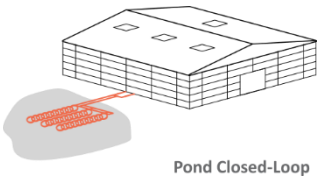
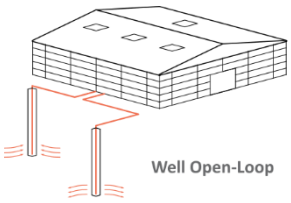
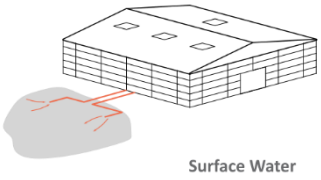
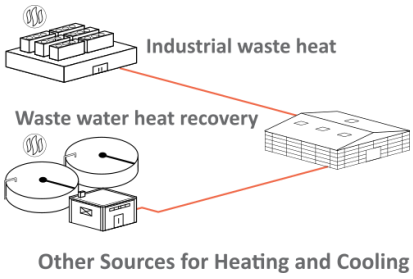


Figure 1: Components of a Renewable Thermal Energy System.

3.1 Renewable Thermal Energy Source

Table 1 provides a summary of each of the most common sources of RTE.

Table 1: Summary of Sources of Renewable Thermal Energy		
Type	**Figure**	**Description**
Closed Loop		Closed vertical GHXs are typically installed in wells 50 to 200 metres deep but could be deeper in certain applications. These systems use polyethylene (PE) pipe filled with a water-anti-freeze (or brine) mixture that by circulating around either absorb heat from (heating) or reject heat to (cooling) the ground. A GSHP then delivers heating and/or cooling as required by the application. GHXs are highly efficient, suitable for various building sizes and types, including space-limited and different lithologies and can have high initial costs. They can be installed beneath buildings, are a form of thermal energy storage and perform best when they have a mix of heating and cooling.
		Vertical closed-loop systems can also be installed in the existing building infrastructure and integrated into building piles. Often called energy piles, these systems are generally only able to cover some of the building's heating and cooling requirements. The performance of these systems is determined in particular by the soil moisture and whether the piles are located in the groundwater zone. The advantage of these systems is that they can be installed at relatively low additional cost if a foundation is required anyway. In addition to the building, the base plate and earth-covered side walls can also be thermally activated.
		A closed horizontal GHX is typically installed to a depth of 1-2 metres. Types include surface, trench and spiral collectors. They utilise the seasonal temperature fluctuations in the ground and are suitable for areas with plenty of space, such as rural residential areas. They work best in clayey, moisture-rich soils that allow for optimal heat transfer and regeneration. They can be a capital cost effective heating and cooling solution for rural residential properties that have suitable areas of land available.
		In areas with accessible bodies of water, a closed loop GHX can also be submerged and anchored to concrete supports to ensure proper positioning above the pond bottom. Installation is quicker and less costly compared to other types of closed loop GHX. Minimum water body depths of 2-3 metres are required while the water body needs to be sufficiently large (and permanent) for the heating and cooling requirements of the application. Installation can be relatively quick and easy using PE loops or purpose built plate heat exchangers.

<table>
<tr><td rowspan="2">Open Loop</td><td>
</td><td>Open loop groundwater systems require an aquifer of sufficient quality and capacity to sustainably supply groundwater to a heat pump, which then typically re-injects it into the aquifer. This process benefits from the stable temperatures of the groundwater (10°C to 14°C) and its high heat capacity, resulting in high COPs. Higher temperatures can be achieved in the TGS with an open loop system, as the local underground temperature can be elevated, leading to a higher heating COP. The drilling depth is determined by the aquifer and the water table. An appropriate distance between the extraction and reinjection wells is important to avoid recirculation of the heated or cooled water. A groundwater extraction permit is required in most areas and larger systems will require thermal-hydraulic modelling to ensure they operate efficiently and sustainably. In addition to quantity, groundwater quality is also important as poor quality groundwater will damage the installed infrastructure, leading to increased maintenance costs. Water analysis and specialised expertise are required for system design.</td></tr>
<tr><td>
</td><td>If surface water is available, it can be used as a source via an open loop system with heat exchangers similar to those described above. Open surface water loops, usually require a secondary heat exchanger. The suitability of a surface water source depends on its availability, the source size and the sensitivity of the receiving ecosystem to temperature fluctuations and different water chemistry.</td></tr>
<tr><td>Other Sources</td><td>
</td><td>In addition to the sources already discussed, which can be used for heat exchange with the closed and open loop systems outlined above, other sources are available that can be integrated into the building's heating and cooling systems. These include, for example, heat recovery from industrial processes and heat recovery from waste water and sewage treatment plants. These processes contain a considerable amount of thermal energy that can be reused either directly or via heat pump systems. This requires the relevant sources to be located in the immediate vicinity of the end customer in order to reduce possible pipeline lengths. The overall goal is to find the most economical and ecologically sustainable way of utilizing thermal energy or other environmental heat.</td></tr>
</table>

3.2 Heat Pumps

In accordance with Figure 1, heat pumps are the central component of the RTE system and are its controlling element. Heat pumps can be air, water or ground sourced and deliver thermal energy into the building as either water or air. Refrigerant is often used as an intermediary to air delivery in the common variable refrigerant volume (VRV) or variable refrigerant flow (VRF) systems.

Basic nomenclature follows the format of, for example, air to water heat pump for an air sourced heat pump (ASHP) that delivers hot water for hydronic heating, hot water or pool heating.
A ground source (or geothermal) heat pump (GSHP) is an extended range water source heat pump (WSHP) that has been designed to operate in the wider range of source temperatures that are typically present within a closed loop GHX or where open loop systems have colder source temperatures.

A brief description of the three main types of GSHP are as follows:

- Water to air: Ducted packaged units;
- Water to water: Hydronic heating, cooling, hot water, pool; and
- Water source VRF: As per conventional split or refrigerant units but with GHX connection.

Water to air heat pump is a packaged unit that it would be connected directly to the GHX and then delivering hot/cool air through designed ductwork (mostly in the ceiling) to indoor zones. Depending on various manufacturers, those units generally have limited supply of DHW capacities.

Water to water heat pumps connect directly to the GHX and then deliver hot water or chilled water to various internal terminals for heating or cooling (buffer or storage tanks are generally required). Water to water heat pumps is able to supply all DHW requirements using a separate storage tank as well as pool / spa heating if required. Their inclusion of thermal storage in the form of buffer tanks provides enhanced efficiencies and the potential for generating thermal storage during periods of low electricity costs (eg. off peak or solar PV). However, this does require additional plant room space.

Water sourced VRF utilises a refrigerant as a heat transfer medium between a single water sourced condensing unit and either single or multiple indoor units. They are a GHX connected version of the VRF/V style systems that are dominant in conventional systems. The main difference is that the heat pump or condensing unit is located within a plant room rather than externally or in a ventilated space.

4. THE PROJECT SITE

The site is located in the western Bay of Plenty region, focusing on known geothermally enhanced zones near Te Puke.

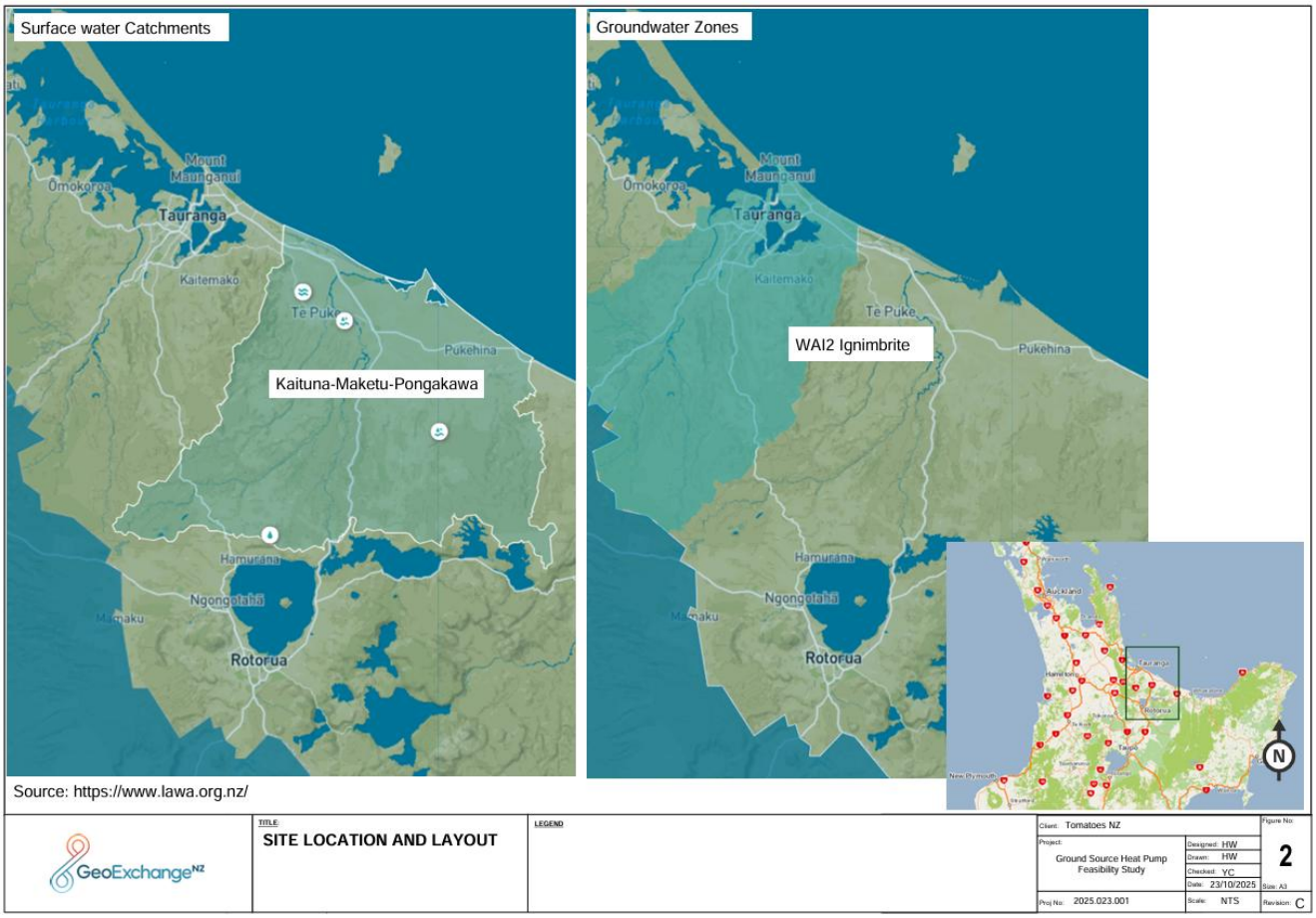


Figure 2: Example site location is near Te Puke. This figure shows the location and layout of this area.

4.1 Buildings and Facilities

The site infrastructure includes a single large glasshouse with a total area of approximately 8000 m², divided into nine bays—four bays of approximately 800 m² each and five bays of approximately 950 m² each.

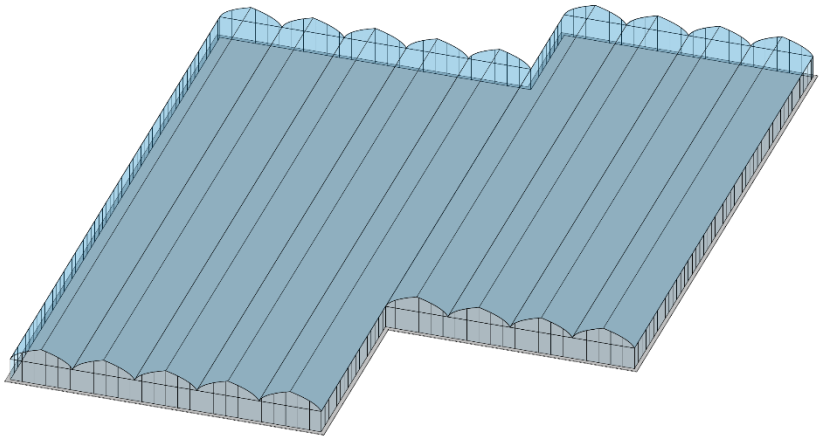


Figure 3: Modelled layout of glasshouse on site.

4.2 Environmental Site Setting

Site conditions have been obtained from readily available published sources and are referenced in the text where appropriate.

4.2.1 Geography / Geomorphology

The chosen site has an elevation of c. 5 metres above sea level (masl) and is located in the flat coastal plain, located in an area of highly modified agricultural and managed landscape. No significant stands of native vegetation are located within close proximity to the park.

4.2.2 Regional Geology and Geothermal Setting

The Tauranga Geothermal System (Figure 3) sits in the Tauranga Basin, a tensional graben formed about 2-3 Ma (Davis and Healy, 1993). It is bounded to the west by the Kaimai Mountain range which is part of the volcanic chain of the Coromandel Volcanic Zone (CVZ) and to the south east by the Taupo Volcanic Zone. Within the basin, old andesitic lavas and breccias from the CVZ are overlain by several ignimbrite deposits, and numerous dacite-rhyolite domes or dome complexes (Briggs et al., 2005). Mt Maunganui (252 m) is one of these domes. Volcanic deposits are overlain by a series of sediments classified as the Tauranga Group Sediments. They consist of alluvial and estuarine sediments, tephra, postglacial sand dunes, estuarine deposits and alluvial fans. The regional mapped geology and TGS is shown on Figure 4.

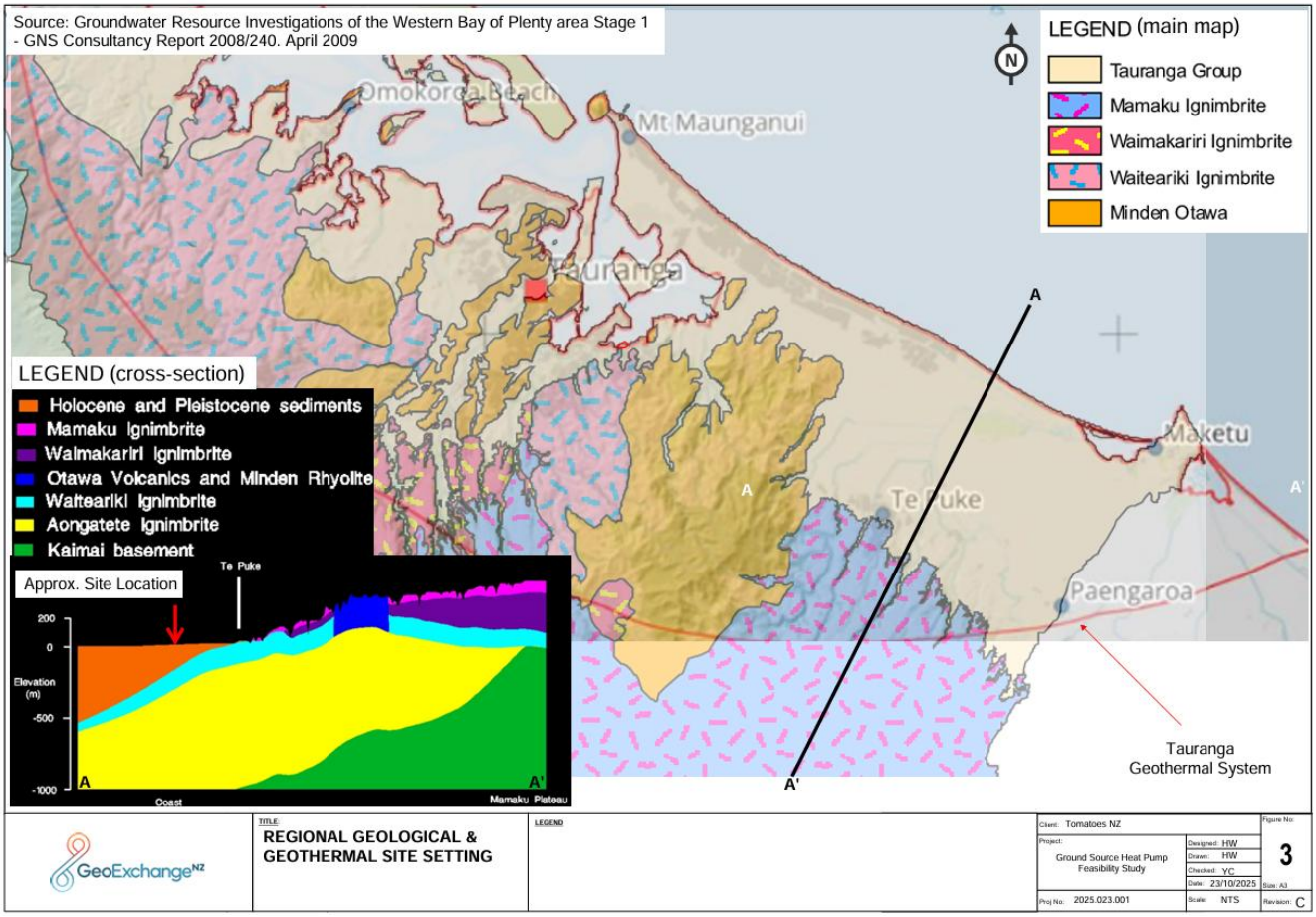


Figure 4: Regional Geological and Geothermal Site Setting

Figure 5 shows the site to be underlain by Tauranga Group sediments and Mamaku Ignimbrites outcropping inland, towards the southwest. A geological cross-section through the site has been created by GNS (Geology Beneath Our Feet https://data.gns.cri.nz/ebof/ accessed 30/06/2025) and is also shown on Figure 5.

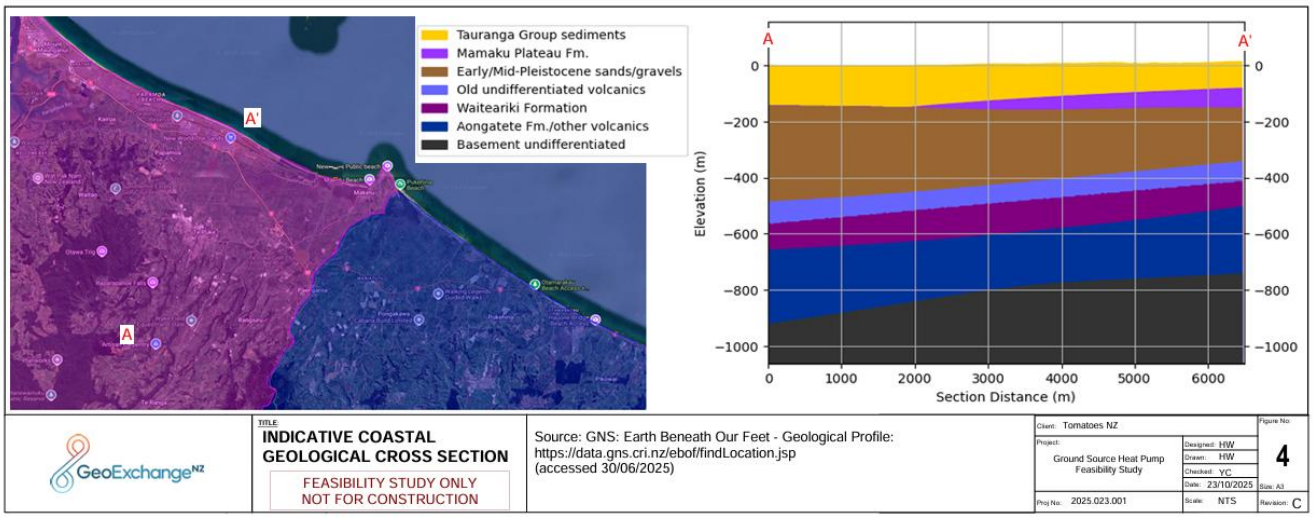


Figure 5: Regional Geological Cross-Section

Figure 6 shows the geological sequence to c.1,000 metres below ground level (mbgl) to be fairly consistent, and dipping gently. A representative geological sequence at the site is provided in Figure 6.

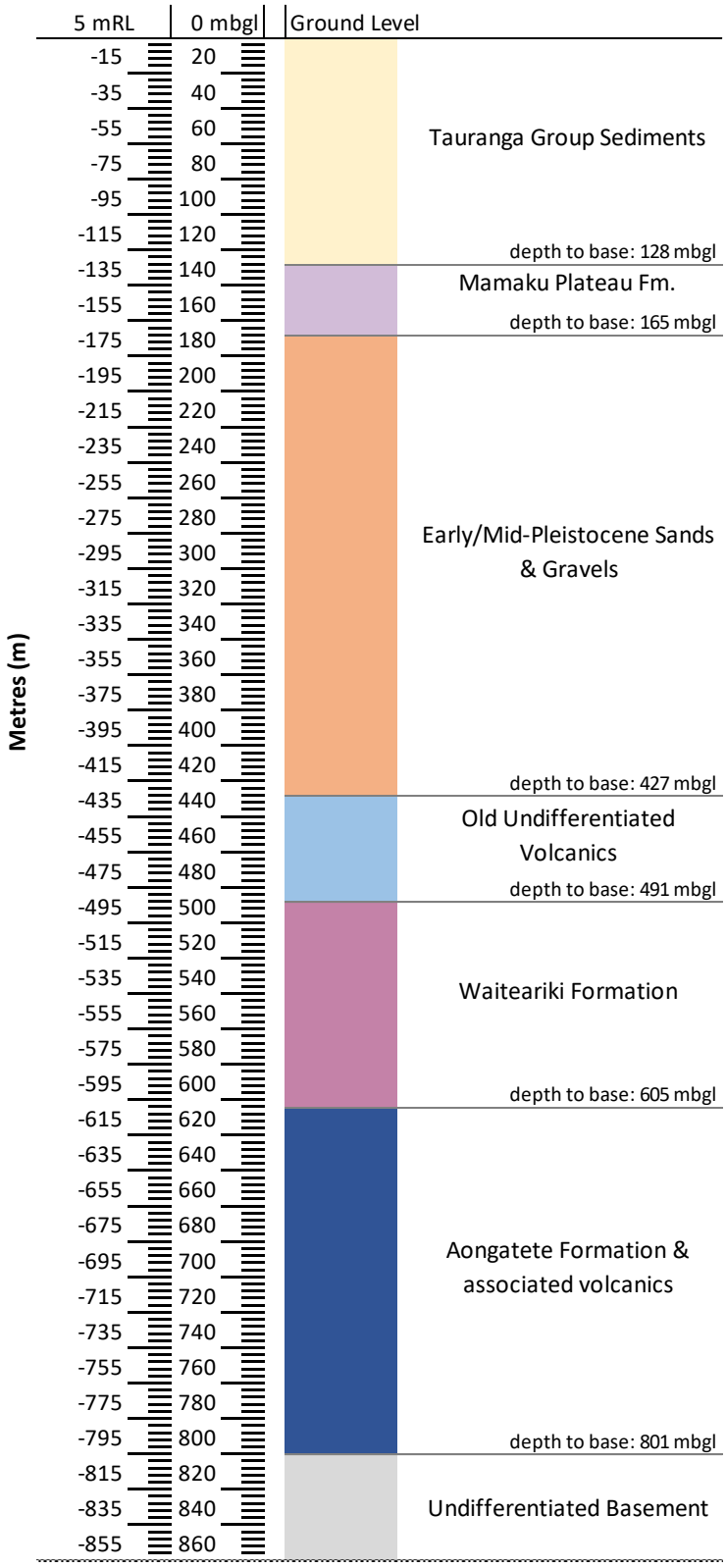


Figure 6: Indicative Geological Profile at the Site

The site is located in the TGS Key Development Location of the Eastern Centre (Geoheat Potential of the Tauranga Geothermal System, GeoExchange NZ, July 2024) as summarised on Figure 7.

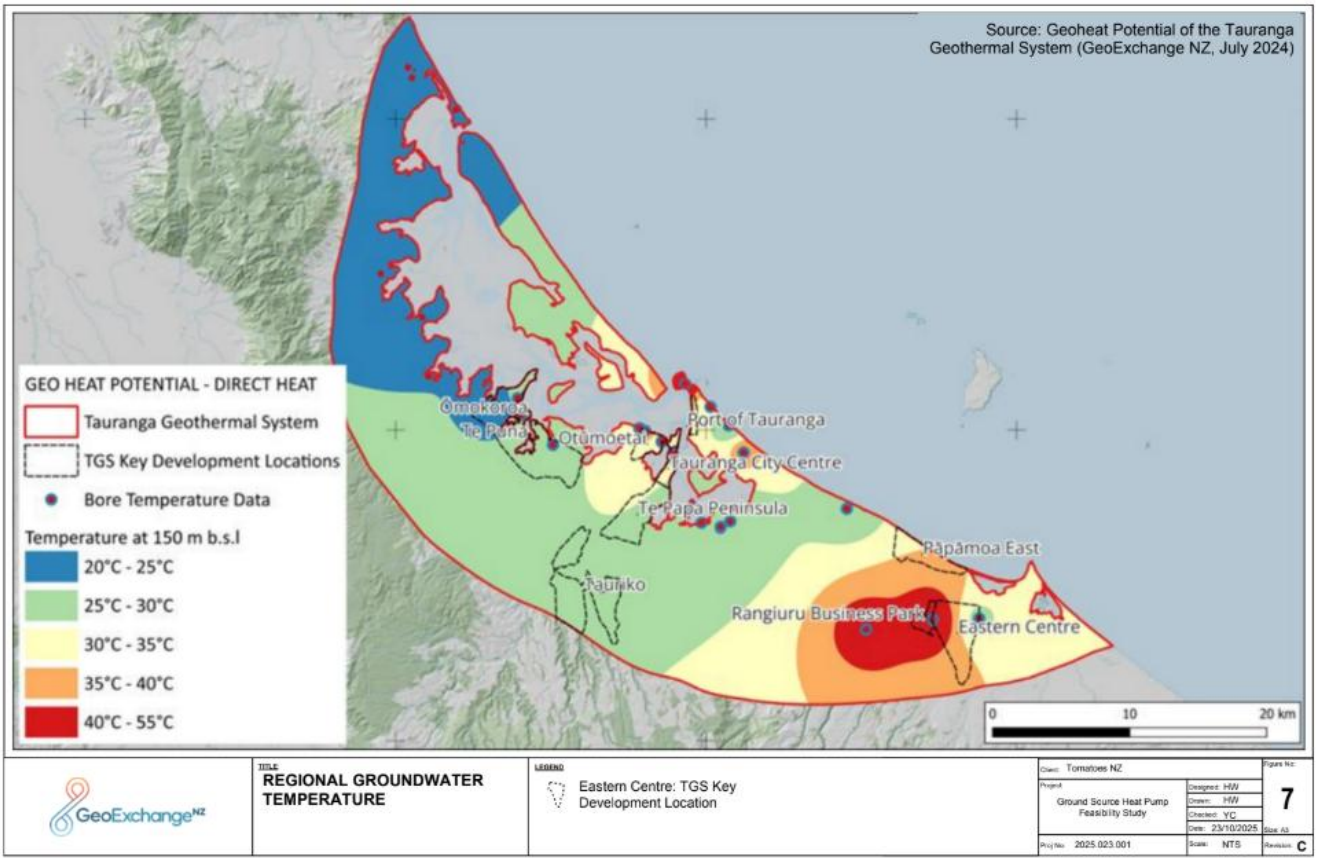


Figure 7: Regional Groundwater Temperature

Figure 7 shows the groundwater temperature to be in the order of 30 to 40°C at 150 mRL. A review of the local bore consents was also undertaken to investigate groundwater temperature with depth in the vicinity of the site.

Table 2 lists all the warm water bore consents in the vicinity of the chosen site. There are 10 bores recorded as having warm water. Table 2 corroborates the TGS Geoheat Potential report (2024) in that warm water (>30°C) can be obtained from <150 m depth. It is also likely that higher temperatures can be obtained from deeper drilling, as the deepest bore is only at a depth of 128 m.

Table 2: Local Warm Well Database							
BOPRC Ref	X	Y	Water Temp (°C)	Bore Depth (m)	Casing Depth (m)	Year Drilled	Rest Water Level (mbgl)
BN-10060	1,902,136	5,811,930	30	93	81	2000	2
BN-1652	1,902,017	5,810,927	30	98	84	1984	2.3
BN-2988	1,903,314	5,813,632	40	18	10	1991	4
BN-3022	1,902,913	5,814,031	44	37	36	1970	1.2
BN-1015	1,903,223	5,814,362	40	35	33	1985	1.5
BN-10057	1,898,127	5,813,154	30	100	80	2000	4.6
BN-3899	1,898,800	5,813,813	36	114	93	2004	1.91
BN-12002	1,898,635	5,813,968	38	128	104	2011	2.08
BN-11815	1,898,878	5,814,175	40	109	99	2016	0.7
BN-1000125	1,899,944	5,810,400	Not Known	121	Not Known	1971	Not Known

Notes:
1. Cold water can often mean <30°C as per definition of geothermal or hot in the RMA.
2. X,Y coordinates given in NZTM
3. Bore References underlined indicate bore records targeting the Tauranga Group Sediments

Warm water bores within c.3 km of the site also have the following characteristics:

- Rest Water Level has a mean average level of 2.3 mbgl (n=9) likely to be representative of the Tauranga Group Sediments. This is in good agreement with GNS (2009) which also records the groundwater level in the underlying undifferentiated volcanics as being within 2 to 4 metres of ground level;
- All bores are noted as being active (with the exception of BN-10057);
- Three bores have a recorded target aquifer of the Tauranga Group Sediments (underlined in Table 2) are between 93 to 114 m deep. This is consistent with the geological cross-section (Figure 4) and indicative geological profile of the site (Figure 5); and
- Based on the recorded depths and temperatures of the bores within c.3 km of the site, it is assumed that all local bores target the Tauranga Group Sediments. No flow rates are provided in the well records for these bores.

Both cold water and warm water wells target the Tauranga Group Sediments. This suggests a temperature profile within the aquifer; whereby groundwater at <30°C may be obtained from a shallow bore (estimated to be <60 m deep) and groundwater at >30°C may be obtained from a deep bore (estimated to be >100 m deep). There is some correlation between groundwater temperature and bore depth in the vicinity of the site. It is likely that the geothermal gradient is controlled by deeper sourced groundwater upwelling beneath the base of the Tauranga Group Sediments, or other similar discrete 'Hot Spot' features at depth.

4.2.3 Indicative Site Target Aquifers

Based on a review of the hydrostratigraphy, the following are considered to be three potential target layers, based on their aquifer properties, for a geothermal system (Figure 8):

- Tauranga Group Sediments: SHALLOW BORE from ground level to 128 mbgl;
- Pleistocene Sand and Gravel: INTERMEDIATE BORE from 165 to <420 mbgl; and
- Undifferentiated volcanics (ignimbrites): DEEP BORE (not shown) from 428 to 800 mbgl.

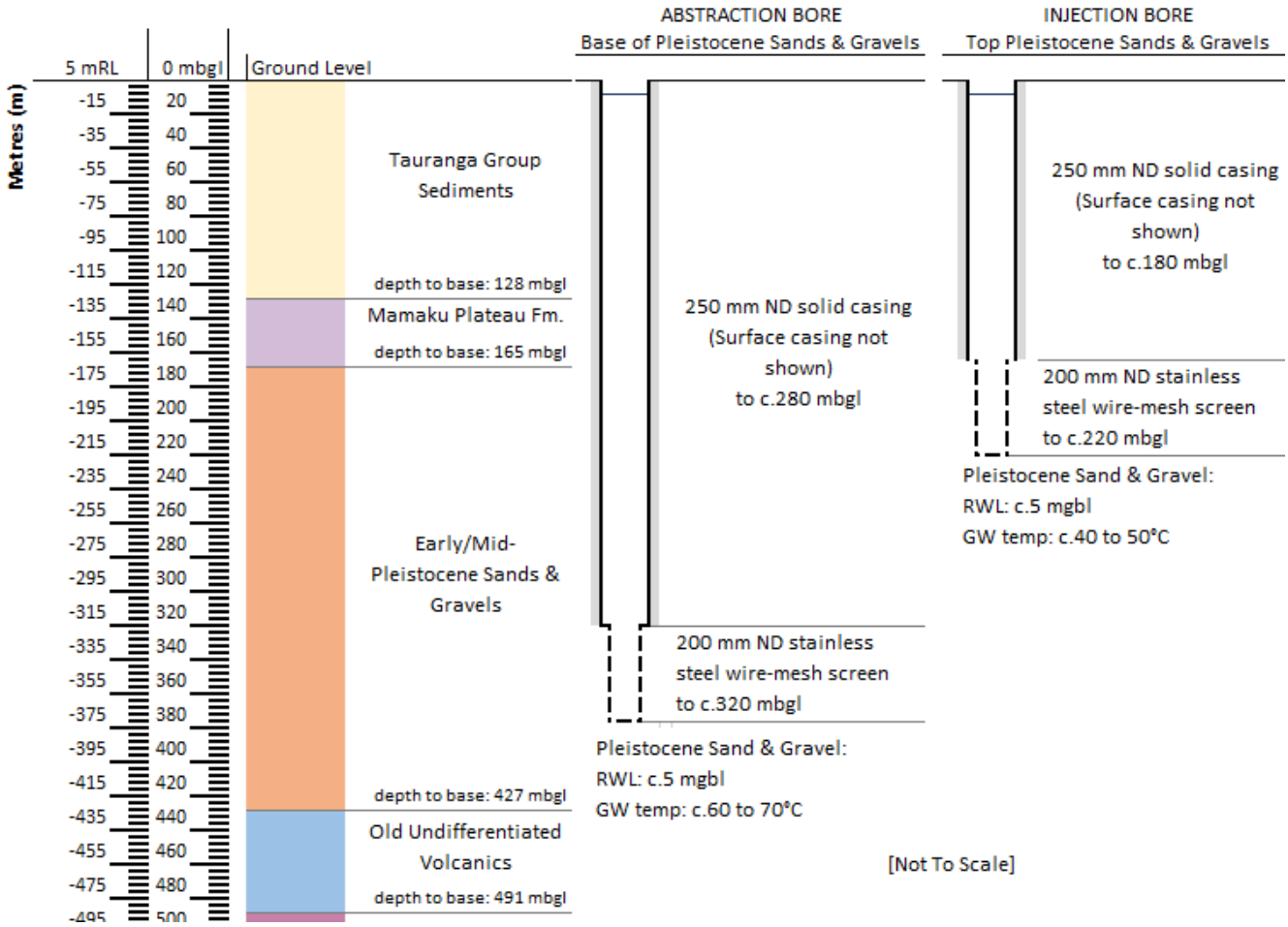


Figure 8: Indicative Bore Targets

Based on GNS mapping, groundwater flow in each target layer will be towards the northeast. Groundwater levels are expected to be near-surface.

Low permeability layers may be present in the Tauranga Group Sediments. The presence and hydraulic integrity of aquitard layers should be investigated during drilling and testing, as these can form usable hydraulic barriers between abstraction and injection target layers, or aid pressurisation of the bore for injection.

Anticipated bore performance is summarised as follows:

- Tauranga Group Sediments: SHALLOW BORE from ground level to 128 mbgl:
  - A single abstraction bore with a peak yield of c.20 L/s (±10 L/s) can be expected;
  - Multiple abstraction bores with a peak yield of 15 L/s (±10 L/s) can be expected;
  - Pressurised injection bores will have a peak flow rate of approx. <50% of the peak abstraction;
  - Groundwater temperature is likely to be <20°C;
  - Specific Capacity of the well in the order of 1 L/s/m (based on BoPRC Well Test details (in-house records).
- Pleistocene Sand and Gravel: INTERMEDIATE BORE from 165 to approx. 420 mbgl:
  - A single abstraction bore with a peak yield of c.30 L/s (±10 L/s) can be expected;
  - Multiple abstraction bores with a peak yield of 20 L/s (±10 L/s) can be expected; and
  - Pressurised reinjection bores will have a peak flow rate of approx. <50% of the abstraction bores;
  - Groundwater temperature is likely to be 60°C (±20°C).
- Undifferentiated volcanics (ignimbrites): DEEP BORE (not shown) from 428 to 800 mbgl:
  - This option has a high level of uncertainty and will have a higher drilling cost. It will only be considered further if there is an opportunity for government support on the drilling costs.

Based on the above, the Pleistocene Sand and Gravel is the target aquifer and the below works are based on the assumption that the Pleistocene Sand and Gravel is layered, and vertical separation of the abstraction and injection within that layer is beneficial, summarised as follows:

- A single abstraction bore, screened from c.280 to 320 mbgl, and with a peak yield of c.30 L/s (±10 L/s);
- Two injection bores, screened from c.180 to 220 mbgl, and with a combined peak of c.30 L/s (±10 L/s).

It may be beneficial to modify the target depth of the bores within the Pleistocene Sand and Gravel. It will be necessary to confirm this once a pilot bore has been drilled and tested.

4.2.4 Test Bore Process

The first step in any geoheat project is drilling a test bore. This establishes the actual flow rates and temperatures available at specific depths. The data gathered is then used to refine this desktop study and confirm the system design and expected performance.

The cost of the test bore in this study is estimated at $500,000–$700,000, depending on the final drilling depth that is undertaken. A grower may independently engage a driller to undertake this process or complete it in conjunction with a geoheat specialist.

Costs include bore design, the consent to drill (drilling is a discretionary activity that precludes a take-and-use consent), drilling supervision, health and safety requirements, and analysis and reporting of the test bore results.

The test bore is not wasted, it is converted into a production bore that becomes part of the final system and this is accounted for in the total costs presented in this study.

5. EXISTING HEATING SYSTEMS

The simulated annual heating demand for this glasshouse is 1,198,995 kWh, which represents the energy required to maintain an indoor temperature of 18 °C 24/7.

The chosen site is modelled as running on nine AIRFARM 6000 gas-fired heaters, each serving an individual glasshouse bay. These units have a rated heating capacity ranging from 85.0 kW to 106.0 kW per unit, depending on operating conditions such as gas quality, combustion efficiency, and ambient air temperature.

Collectively, the total available heating capacity from the existing system is approximately 765 kW to 954 kW. This capacity provides space heating across the full glasshouse complex and is likely sized to meet peak winter heating demand. Each heater operates independently, offering zone-level control but also representing a decentralised and fossil-fuel-dependent system.

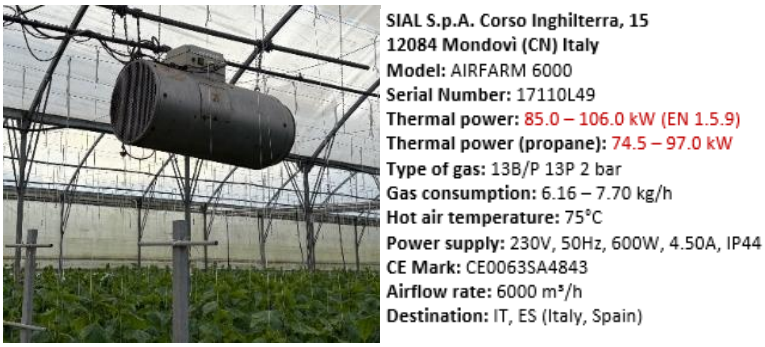


Figure 9: AIRFARM 6000 gas-fired heater.

5.1 Existing Hydronic Pipes for Radiant Heating

Radiant heating delivery pipes are partially installed across the site. The installed pipework consists of mild steel pipes, with the following specifications:

- Outer Diameter (OD): 48.3 mm
- Wall Thickness: 2.5 mm
- Length per Section: 5.8 m
- Coating: Red oxide paint for corrosion protection



Figure 10: Installed hydronic pipes.

Each glasshouse bay is assumed to contain 12 hydronic pipes, each approximately 90 metres long, resulting in a total of 1,080 metres of radiant pipework per bay. With 9 bays in total, the cumulative length of installed hydronic pipework is approximately 9,720 metres (Figure 11).

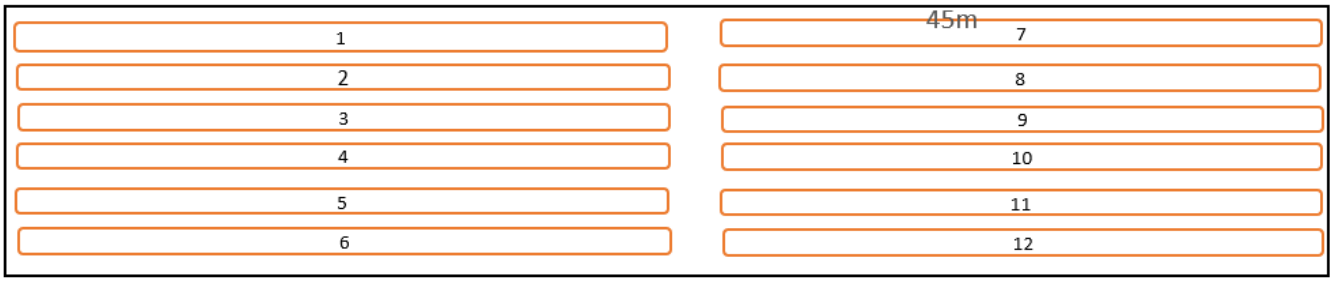


Figure 11: Assumed No. of hydronic pipes per bay: 12 pipes, each at 90m.

Table 4 below summarises the estimated heating output from the existing hydronic mild steel pipe network installed for radiant heating in the glasshouse bays. The analysis assumes each bay is equipped with 12 pipes, each 90 m in length, resulting in a total of 1,080 metres of pipework per bay and approximately 9,720 metres across the full nine-bay site.

These figures demonstrate that the existing pipework has the potential to meet or supplement the site's heating demand when supplied with sufficiently high-temperature water—either from a boiler or alternative renewable energy low-emissions source such as geothermal.

Table 3: Existing Hydronic Pipes Heating Output Estimation	
Installed Hydronic Mild Steel Pipe OD	48 mm
Installed Hydronic Mild Steel Pipe Wall Thickness	2.5 mm
Indoor cold air temperature	18 °C
Hydronic Pipe Length per Bay	1080 m
Total Bay No	9

Total Hydronic Pipe Length x 9 Bays (Approx.)	9720 m
Total Hydronic Heating Output at 40°C Supply	321 kW (~33.0 W/m)
Total Hydronic Heating Output at 50°C Supply	520 kW (~53.5 W/m)
Total Hydronic Heating Output at 60°C Supply	727 kW (~74.8 W/m)
Total Hydronic Heating Output at 70°C Supply	943 kW (~97.0 W/m)

The heating performance of the existing hydronic system has been assessed at various supply water temperatures to determine its capacity to meet seasonal heating demand as per Figure 12:

- The simulated glasshouse peak heating load is ~952 kW and annual heating demand as 1,198,995 kWh;
- At 40°C supply temperature, the system delivers approximately 321 kW, suitable for partial heating coverage during December only;
- At 50°C, output increases to 520 kW, allowing for coverage across December to March;
- At 60°C, output increases to 727 kW, which is sufficient to meet most of the months peak heating demands; and
- At 70°C, the system provides up to 943 kW, which is sufficient to meet year-round heating demand.

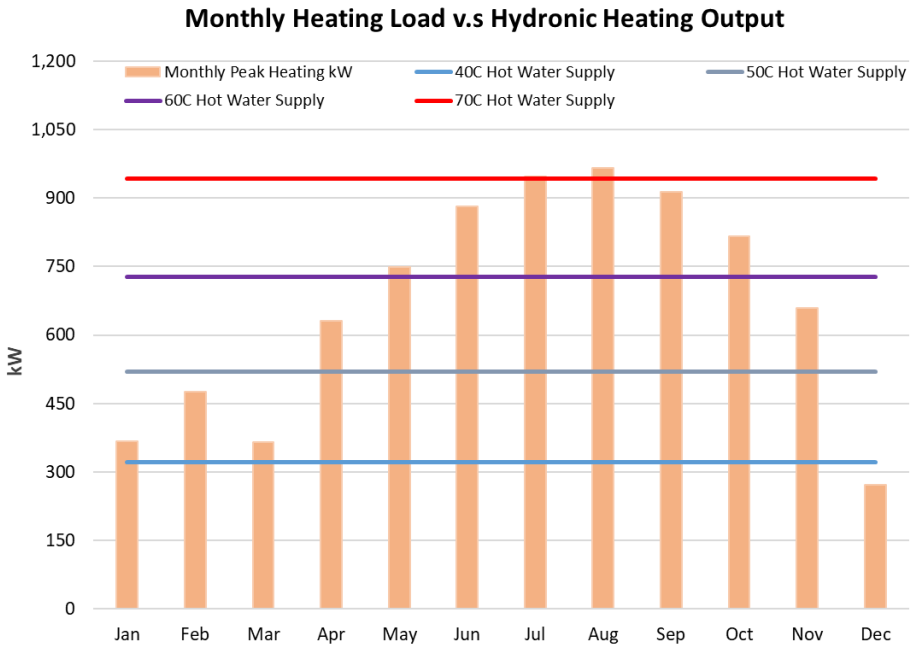


Figure 12: Existing hydronic pipes max. heating output at different supply hot water temperatures

To meet a peak heating load of approximately 952 kW, the following pipe requirements apply:

- At 70°C supply: Existing hydronic pipes sufficient;
- At 60°C supply: 1.5 x the existing hydronic pipes would be necessary to achieve the same output;
- At 50°C supply: 2.0 x the existing hydronic pipes would be necessary to achieve the same output; and
- At 40°C supply: 3.0 x the existing hydronic pipes would be necessary to achieve the same output.

5.2 Electrical Infrastructure

The site electricity capacity is limited to 48.4 kVA, which would restrict the use of heat pumps—either ground sourced or air sourced, as their electrical demand is likely to exceed the available supply, particularly during peak demand operations. This has been included as having limited spare electrical capacity is a typical scenario for rural locations.

Electric boiler will typically require a kVA rating significantly higher up to approximately 800 kVA to provide up to 700 kW of peak heating for the supplementary heating option.

Air source heat pumps are estimated to require up to 400kVA to provide up to 700 kW of peak heating output in winter for the supplementary heating option.

Ground source heat pumps are estimated to require up to 330 kVA to provide up to 952 kW of peak heating output in winter for the 100% heating option. Higher ground water temperatures could reduce this estimate down to around 280 kVA.

6. PROPOSED GEOTHERMAL DESIGN

6.1 Location and Design of the GHX

Shallow and intermediate abstraction bores drawing groundwater from within c.3 km of the site indicate that:

1. Groundwater flow is approximately towards the northeast, towards the coast;
2. Groundwater temperature increases with depth such that:
    a. Tauranga Group Sediments bores <130 m deep are anticipated to produce water <20°C;
    b. Pleistocene Sand and Gravel bores >130 m and <420 m deep are anticipated to produce water at c.60°C [±20°C]; and
    c. Undifferentiated volcanics (ignimbrite) bores >420 m deep are anticipated to produce water ≥60°C (with temperature likely to further increase with increasing bore depth).
3. Typically, abstraction and reinjection bore pairs would be anticipated to target the same aquifer.

Based on the above assumptions, the preferred Open Loop GHX layout is to have a single abstraction bore up-hydraulic gradient (on the southern side of the site) and two reinjection bores on the down-gradient (northern side) of the site (Figure 13). It may be preferable to set the abstraction bore deeper than the injection bores, but whilst staying with the same Pleistocene Sand and Gravel aquifer to simplify consenting requirements.

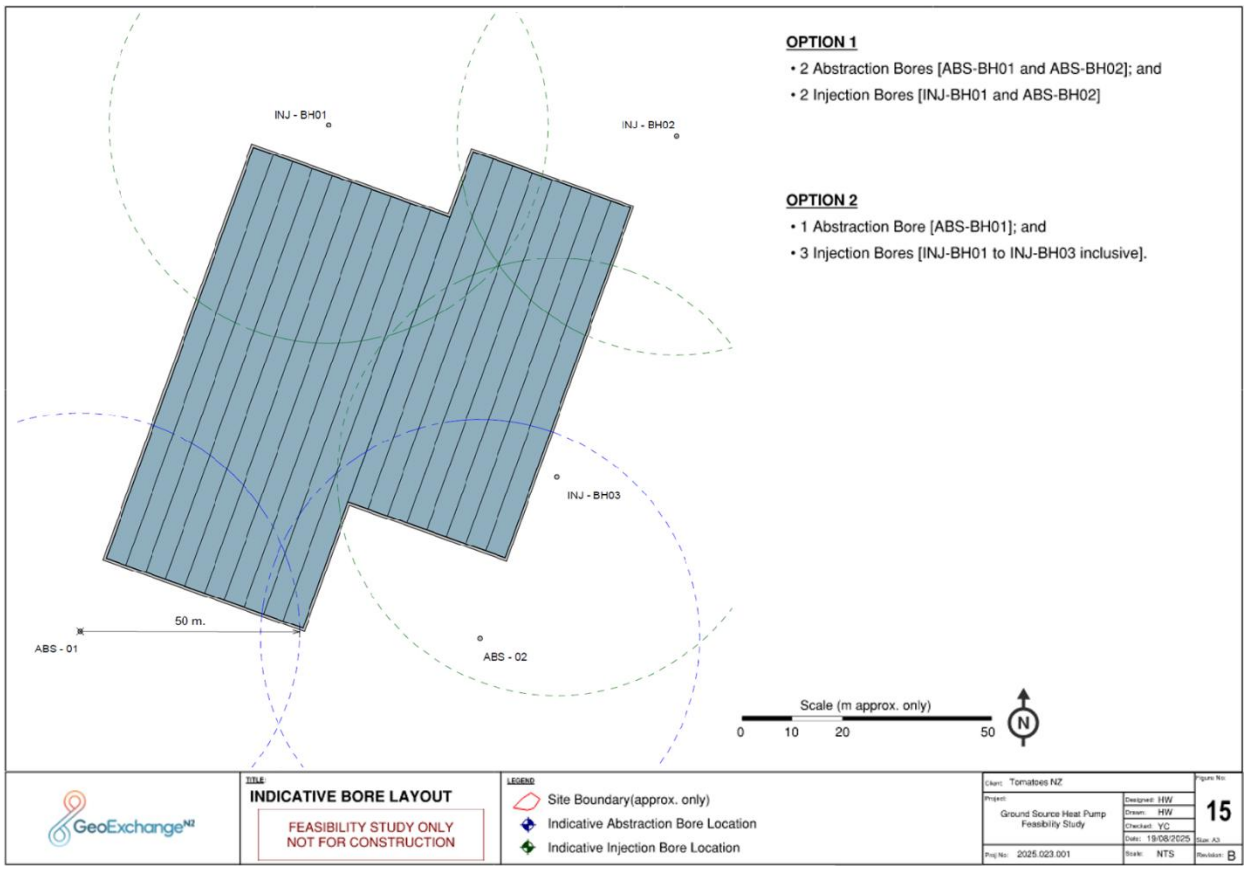


Figure 13: Indicative Bore Layout

Note that Figure 13 illustrates a scenario with two abstraction bores and three injection bores. This is to show the maximum spacing and capacity that may be required if test-bore results indicate lower-than-expected sustainable flow rates. However, the actual design for this site is based on a single abstraction bore and two reinjection bores as desktop analysis indicates this will meet site requirements.

Due to the shallow groundwater, reinjection potential will be more constrained than abstraction. Therefore, it may be prudent to consider deeper abstraction wells with multiple shallower reinjection wells, dependant on the local Resource Consent and water quality constraints of moving water between aquifer units. If possible, vertically separating the abstraction and reinjection bores has the advantage of:

1. Reducing the risk of thermal interference while maintaining the source abstraction temperature;
2. Increases the abstraction potential of an individual open loop bore;
3. Shallower injection bores are cheaper and more can be drilled at lower costs; and
4. Reduces the risk of surface water flooding and liquefaction potential.

The spacing and number of bores are dependent on groundwater flow and occurrence and hydraulic properties of the target layers, as well as the temporal distribution of heating loads.

We have used available information for the purposes of this Feasibility Study design and layout. However, all assumptions will need to be refined as the project progresses, and more information becomes available. For example, from drilling a test well.

Based on the following selected parameters, an estimate of drawdown and mounding has been made for the open loop bores (Table 5) assuming the allowable spacing within the site (Figure 13) and targeting the Pleistocene Sand and Gravel aquifer only.

Table 4: Assumed Open Loop Design Parameters

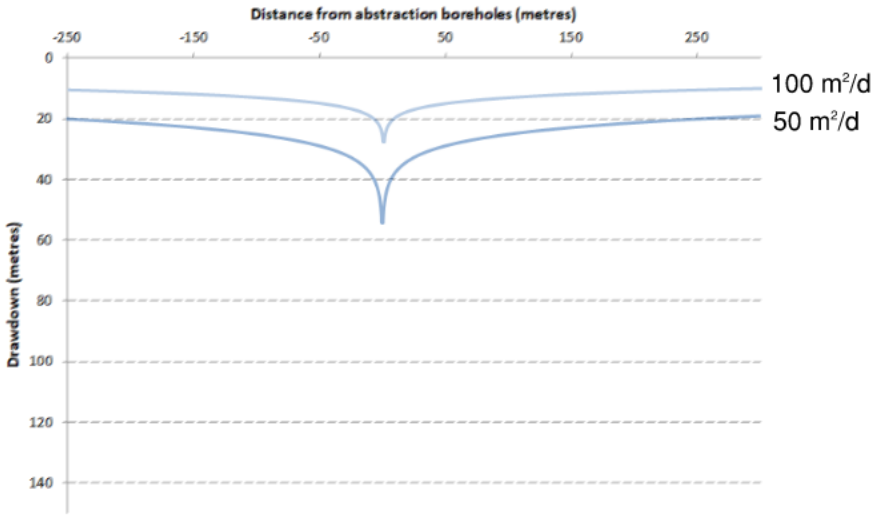
Input Parameter		**Pleistocene Sand and Gravel**
Transmissivity (m^2/d)	Pessimistic	50
	Likely	100
	Optimistic	200
Storage Coefficient		$1.0x10^{-6}$ to $1.0x10^{-3}$ (average used: $5.0x10^{-5}$)
Number and Spacing of Abstraction Wells		1 No. Abstraction Bores <320 m deep
Number and Spacing of Reinjection Wells		2 No. Injection bores <220 m deep and c.75 m apart
Flow Rate		Up to 30 L/s [±10 L/s]

	(Design based on 20 L/s)

Based on the indicative Open Loop Bore layout, simple drawdown and mounding analysis has been undertaken for the Pleistocene Sand and Gravel (Figure 14). This assumes the following peak flow rates:

- Abstraction at 20 L/s;
- Injection at 20 L/s across two bores.

Noting that 30 L/s has been recorded nearby in bores targeting the same aquifer, a conservative peak flow has been assumed for Feasibility Study purposes. Furthermore, it is noted that shallow and deep bores may interact in more complex ways than assumed here, further influencing the peak flow rate achievable. However, this is a reasonable worst-case assumption at this stage.



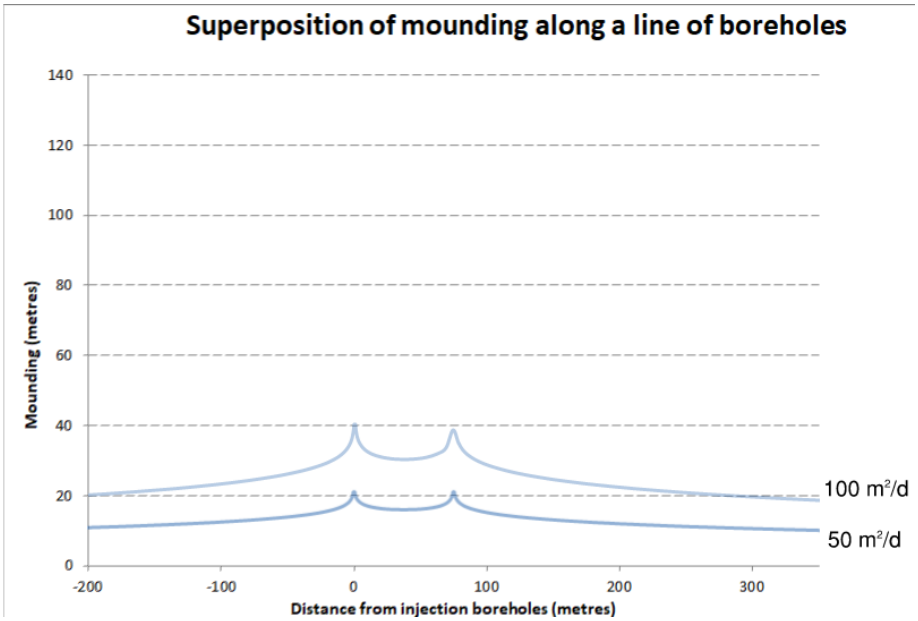


Figure 14: Estimated Drawdown and Mounding: Pleistocene Sand and Gravel

A preliminary Open Loop GHX design has been conducted using the Pleistocene Sand and Gravel as the target unit (Table 6).

This should not be considered as a final design at this stage as it is pending the results of a test borehole and in-situ aquifer test pump program and water quality monitoring, to confirm ground conditions from a thermal and practical drilling perspective.

Table 5: Preliminary Open Loop Ground Heat Exchanger Design			
Design Scenario	**Peak Drawdown (m)**	**Peak Mounding (m)**	**Design Outcome**
Pleistocene Sand and Gravel **1 No. abstraction bore:** **2 No. reinjection bores:** **Total Peak Flow Rate:** ▪ **c.20 L/s (total)**	Estimated range of <60 m (Likely c.20 m ± 10 m)	Estimated range of <40 m (Likely c.20 m ± 10 m)	Calculated drawdown and mounding is generally acceptable, although the most pessimistic estimates result in potentially problematic injection pressures / elevation of mounding. These outcomes are dependent on the rest water level in the Pleistocene Sand and Gravel and the degree of confinement from overlying volcanic units. It is likely that final flow rate will be a function of thermal interference rather maintaining peak mounding. This is difficult to define at this stage and will be refined as the design progresses. However, the indicative design is considered

			representative and suitably conservative at this stage.

The most suitable system therefore is considered to be an open loop GHX within the Pleistocene Sand and Gravel comprising:

- 1 No. abstraction boreholes with a target (screened) interval of 280 to 320 mbgl at 20 [± 5] L/s and water at c.60°C;
- 2 No. injection boreholes with a target (screened) interval of 180 to 220 mbgl at c.7 L/s [± 4] L/s each.
- Net total abstraction of zero (with a combined peak simultaneous abstraction and injection flow rate of c.20 L/s; and
- Targeting groundwater temperatures of c.60°C.

It is important to note that the final depths and abstraction temperature will require site specific assessment based on exploration drilling. The final balance of abstraction and reinjection flow rates and bore depths will be a function of the hydrostratigraphy encountered. The geology of this region is noted as being laterally and vertically variable, and site conditions and bore performances are estimated.

Results from the preliminary GHX design as presented in Table 7, indicates the following:

- The preferred option is abstraction from the Pleistocene Sand and Gravel and injection split between the same units;
- The final sustainable flow rates will likely be a function of the hydraulic properties of the Pleistocene Sand and Gravel. Further analysis of the existing bore on site and additional site investigation as the project progresses (e.g., based on the drilling and testing of pilot boreholes at the site) will inform this;
- It may be possible to alter the design (in terms of abstraction and reinjection boreholes) dependent on preliminary testing and design of the heating system; and
- A temperature differential of 15°C for both the median and optimistic estimates as well as 10°C for optimistic meets the peak heating of 952 kW.

Table 6: Estimated Peak and Total Heating Loads of Aquifer

Number of Wells	**Direct Use**		**Peak Heating (kW)**		
	Range of Likely Flow Rates (L/s)		**Scenario**		
			ΔT (°C)	ΔT (°C)	ΔT (°C)
			5	10	15
1 No. ABS-BH 2 No. INJ-BH	Pessimistic	10	210	420	630
	Median Estimate	20	420	**840**	**1260**

	Optimistic Estimate	30	630	**1260**	**1890**

6.2 Proposed Heating System Options

The baseload heating system is proposed to be a single 300m deep well that provides 30 L/s at 60°C. This will need to be verified from the results of a test well.

With the focus on utilising the aquifer as the heat source, and with consideration to locally available options and service support, the following options in Table 8 and Figures 15-19 have been considered for this assessment.

Table 7: Summary of Heat Pump Options and GHX Requirements

Option ID	Heating	GHX Requirements
Existing	9 x LPG gas heaters	Not Applicable
Option 1: High Groundwater Temperature (T_{GW} ≥ 70°C)	Direct use is possible with existing heat pipes configuration with temperatures above 70°C.	1 No. ABS-BH 2 No. INJ-BH (Intermediate Bores)
Option 2: Medium Groundwater Temperature (40°C ≤ T_{GW} < 70°C)	**2a: Direct use with additional hydronic pipes (40°C ≤ T_{GW} < 70°C):** ▪ 60°C ≤ T_{GW} < 70°C: 1.5 x existing hydronic pipes ▪ 50°C ≤ T_{GW} < 60°C: 2.0 x existing hydronic pipes 40°C ≤ T_{GW} < 50°C: 3.0 x existing hydronic pipes	1 No. ABS-BH 2 No. INJ-BH (Intermediate Bores)
	2b: Direct use with supplementary heating equipment. Options include: ▪ High-Temperature Ground source heat pump (GSHP), ▪ High-Temperature Air source heat pump (ASHP), ▪ Electric boiler, ▪ Gas, ▪ Waste oil, ▪ Biomass, or Solar thermal.	1 No. ABS-BH 2 No. INJ-BH (Intermediate Bores)
Option 3: Low Groundwater Temperature (T_{GW} < 20°C)	Ground Source Heat Pump system using shallow, ambient groundwater as thermal source.	1 No. ABS-BH 2 No. INJ-BH (Shallow Bores)

Option 4: Complete ASHP	Air Source Heat Pump System providing hot water to hydronic pipes	-

Option 1: High Groundwater Temperature (T_{GW} ≥ 70°C)

At T_{GW} ≥ 70°C direct use of geothermal heat is feasible. Heat can be delivered directly into the existing hydronic heat-pipe network without additional heat-pump equipment. This approach minimises plant complexity and electrical demand because heat is transferred from the abstraction bore(s) to the distribution system with only pumping and basic control requirements.

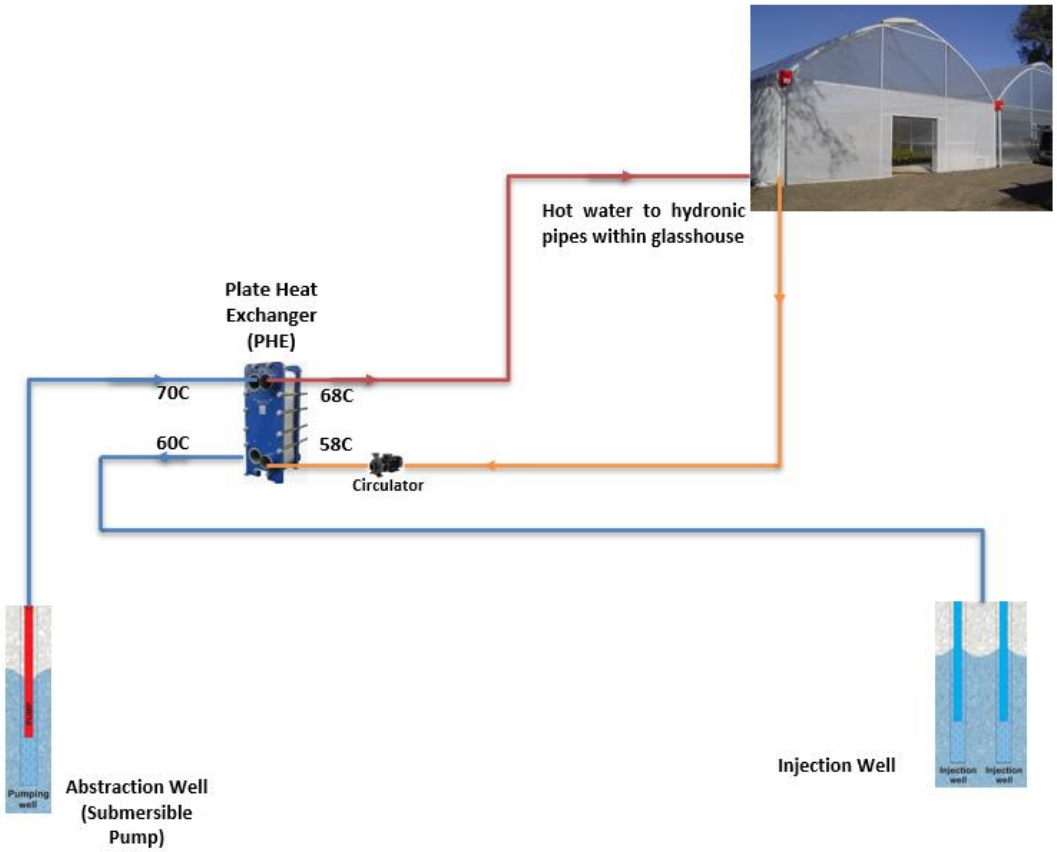


Figure 15: Illustrative system schematic – Option 1

Option 2: Medium Groundwater Temperature (40°C ≤ T_{GW} < 70°C)

This range is treated in two sub-cases depending on the exact temperature and required distribution temperature.

Option 2a: Direct use with increasing the existing hydronic pipes (no heat-pump)

If the aquifer temperature is in this band, it may still be possible to supply heat directly, but the distribution network must be upsized to deliver the same thermal energy at lower source temperature. While the current heat pipe system is sized at 70°C water, international practice commonly uses 40-45°C temperatures. This is

achieved by increasing the surface area of the heat pipes. The recommended multipliers for the existing hydronic pipe length are temperature-band dependent and shown in Table 8.

The main operating cost is again the electricity for submersible pumps in the abstraction bore(s).

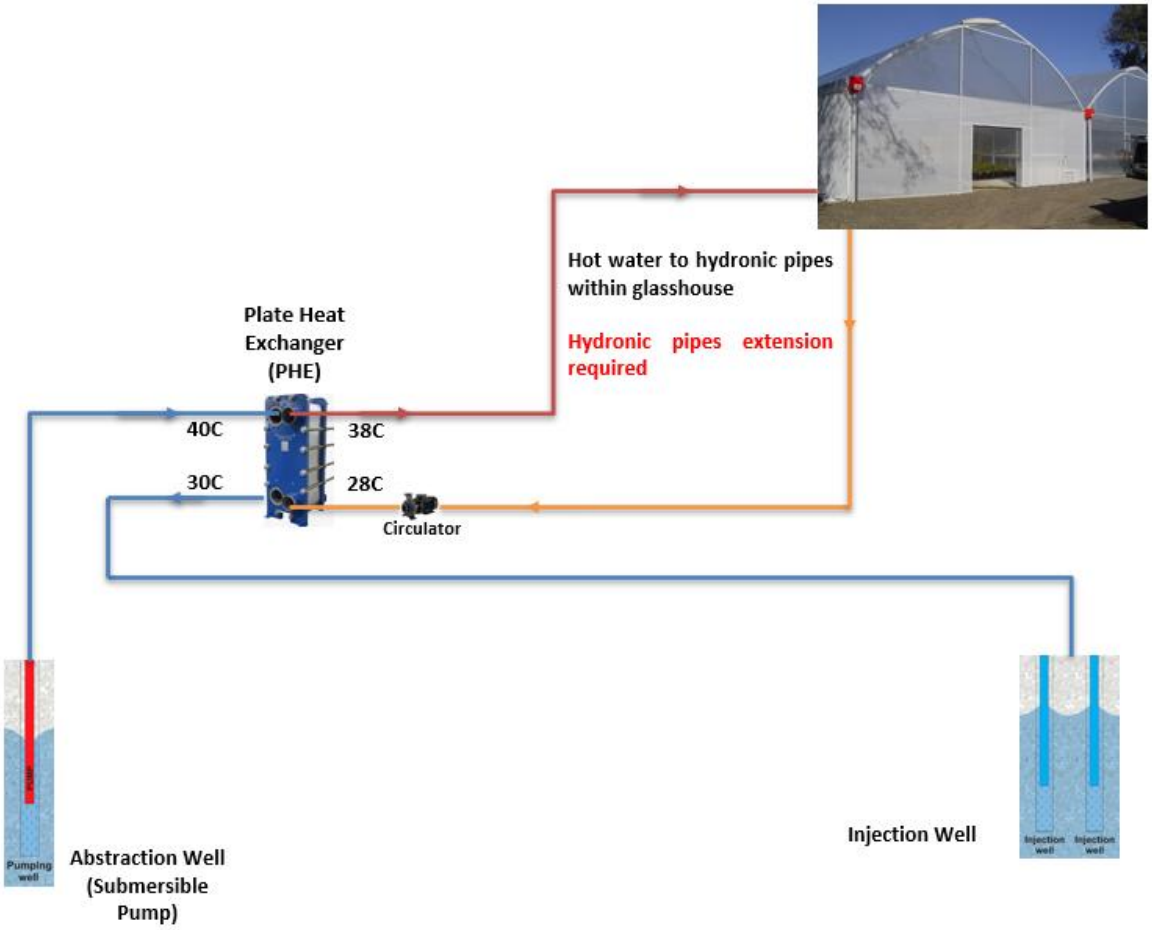


Figure 16: Illustrative system schematic – Option 2a

2b: Hybrid direct use with supplementary heating equipment

If upsizing the hydronic network alone is impractical (or uneconomical), one or more supplementary heating options may be required to meet peak loads or higher distribution temperatures. Candidate technologies include: ground-source heat pumps (GSHP), electric boilers, air-source heat pumps (ASHP), gas boilers, waste-oil boilers, biomass boilers and solar thermal collectors. Selection will be constrained by local resource and site conditions:

- **Electrical supply limits:** heat pumps and electric boilers require significant electrical capacity; site distribution and tariff constraints may limit installed capacity or require network upgrades.
- **Solar thermal:** performance depends on available roof/land area, insolation, and seasonal alignment with demand; may need large collectors or thermal storage to be effective for winter heating.

- **Waste oil / biomass:** availability, fuel logistics, emissions controls and permitting determine feasibility; these are only viable where reliable fuel supply and appropriate emissions management exist.

The operating cost includes both submersible pump electricity and the energy consumption of supplementary heating equipment.

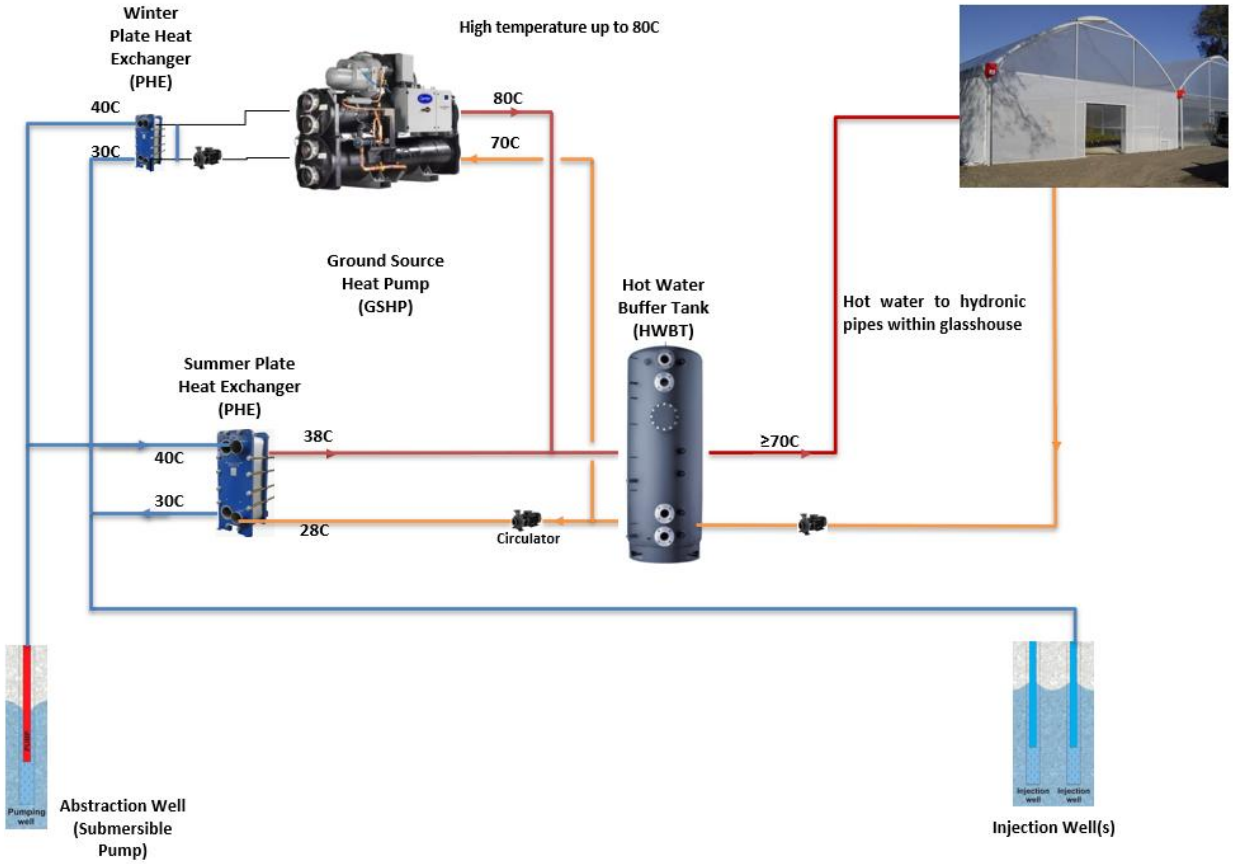


Figure 17: Illustrative system schematic – Option 2b (Supplement via GSHP)

Option 3: Low Groundwater Temperature (T_{GW} < 20°C)

At low source temperatures, direct use is not possible. An indirect approach using a high-temperature ground-source heat pump (GSHP) is required to raise the water to distribution temperatures. This approach imposes higher electrical demand and requires an appropriately sized abstraction/injection bore field to sustain seasonal loads.

It is noted the high temperature heat pump market is still evolving rapidly to meet future net zero emissions targets. It is recommended to review the available options during detailed design phase as further options are expected to become available.

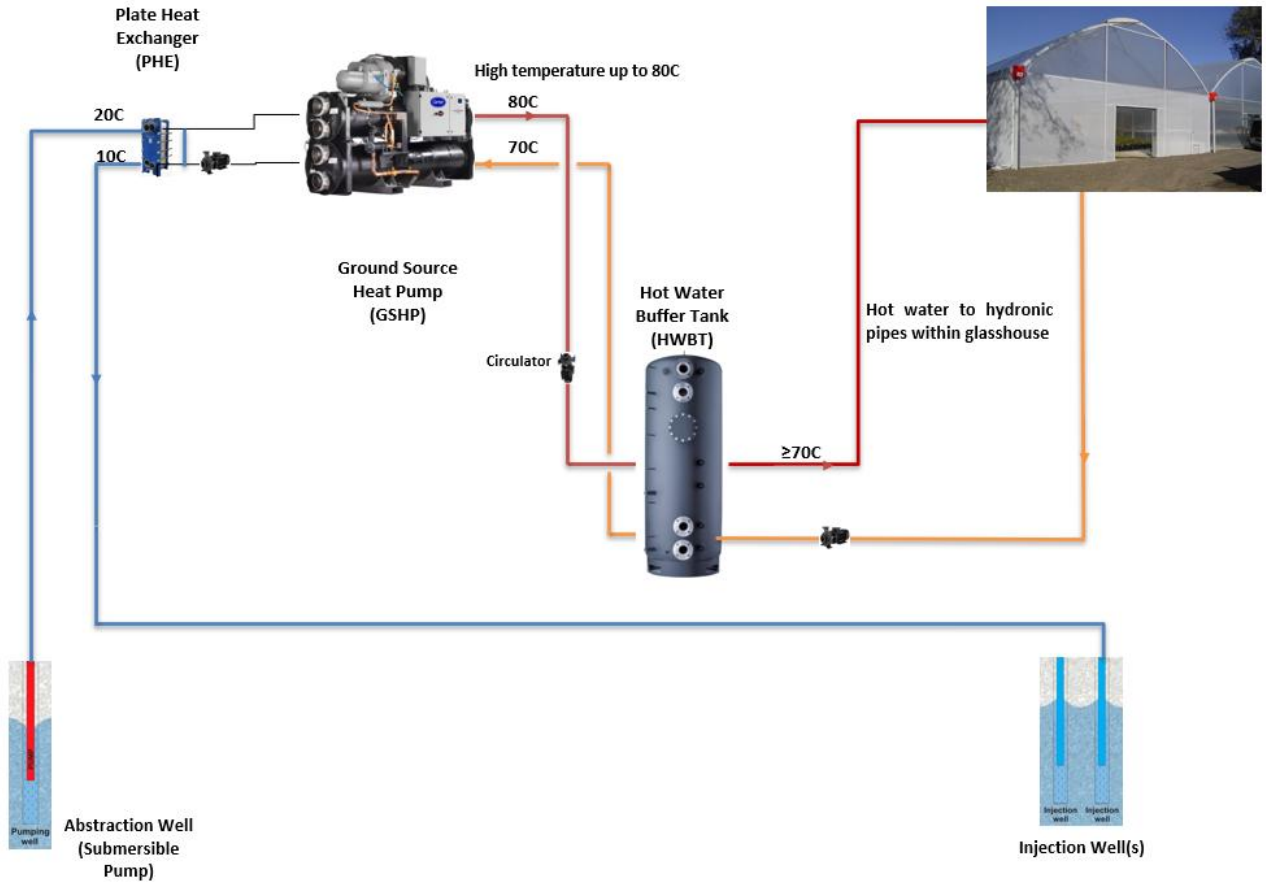


Figure 18: Illustrative system schematic – Option 3

Option 4: Complete Air Source Heat Pump (ASHP)

If no groundwater resource is feasible, a complete ASHP system is an alternative. High-temperature ASHPs are also still developing to align with net-zero targets, and their performance and availability are expected to improve. A review of the latest options should be undertaken during the detailed design phase.

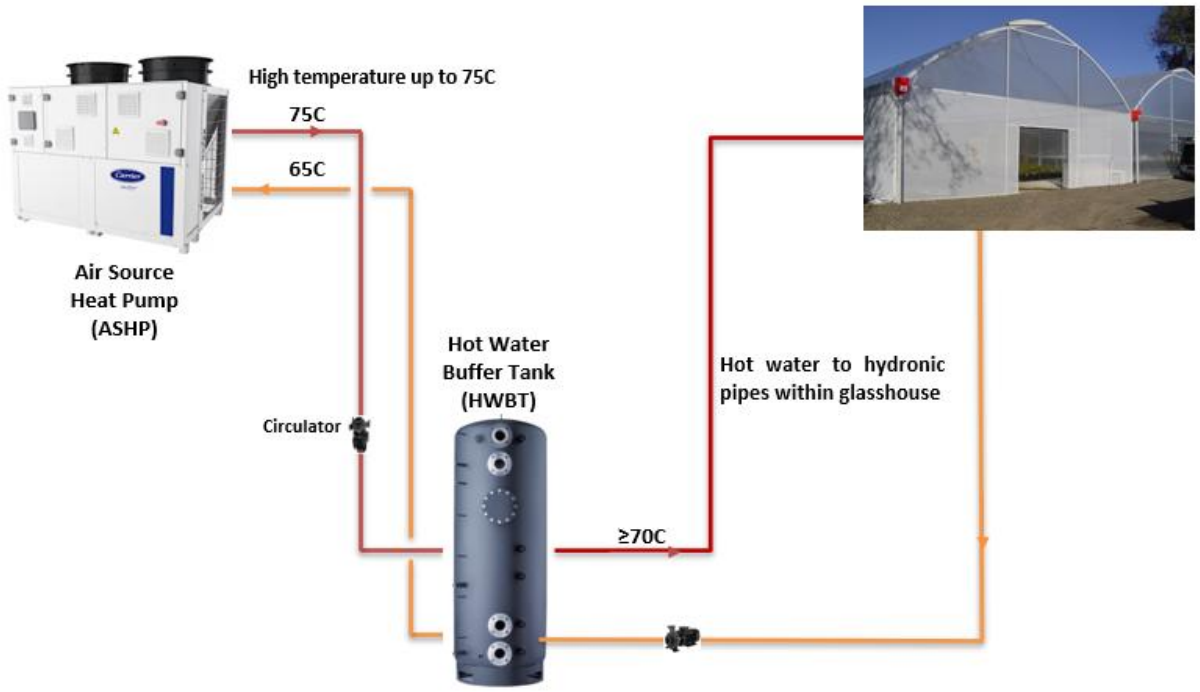


Figure 19: Illustrative system schematic – Option 4

6.2.1 Indicative Plant Room with Ground Source Heat Pump (GSHP).

Figure 20 below shows an indicative plant room layout for a large-capacity Ground Source Heat Pump (GSHP) installation, illustrating the spatial arrangement of a 1000 kW high-temperature water-to-water heat pump, 5000 L buffer tank, plate heat exchanger, and associated end suction pumps. The plan, section, and 3D views show typical clearances and equipment positioning required to facilitate installation, operation, and maintenance.

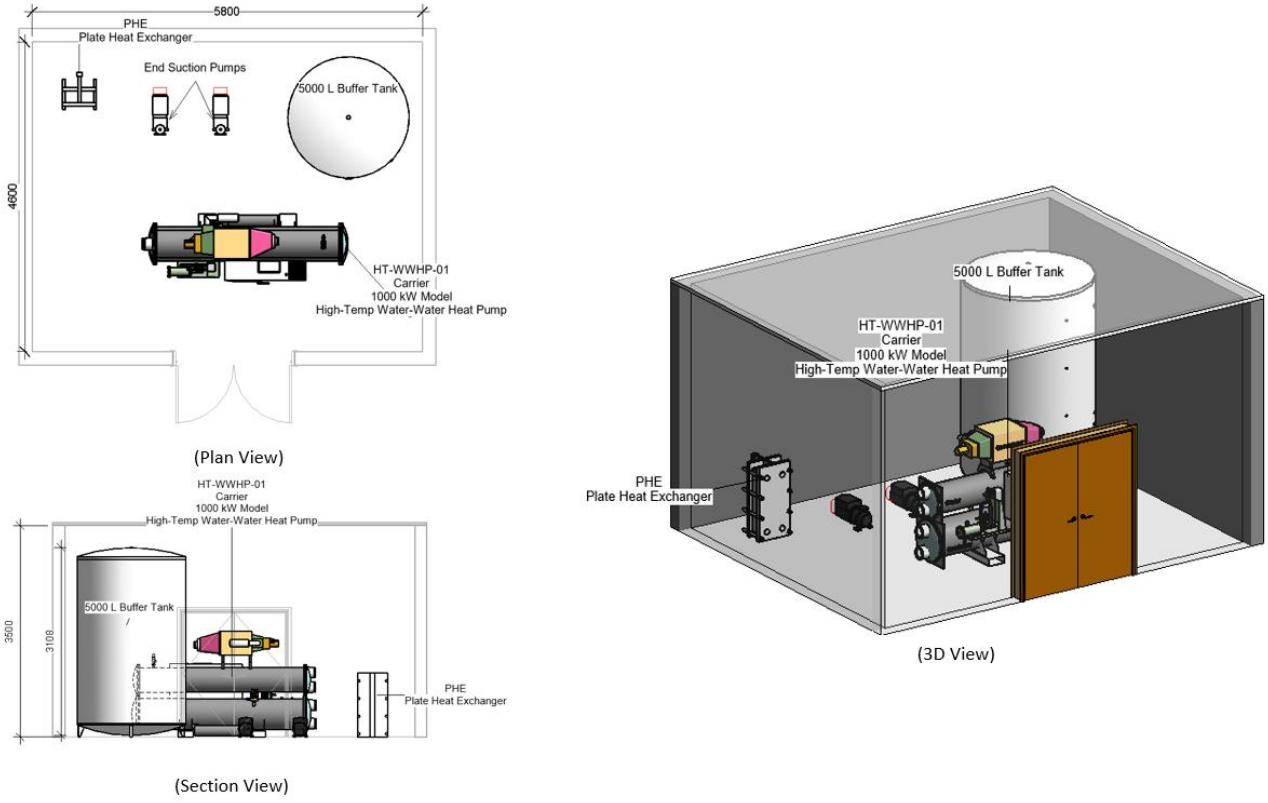


Figure 20: Indicative plant room set-up with GSHP.

7. ENERGY AND FINANCIAL ANALYSIS

A summary of the energy consumption and cost for the proposed system options (Table 9) is provided below. In accordance with the proposed business as usual approach, the comparative analysis was against the existing natural gas heaters.

The purpose of this analysis is to demonstrate the potential for utilising groundwater thermal resources to reduce fossil fuel dependence, lower operational costs, and improve glasshouse indoor temperature stability.

The following assumptions have been adopted:

- LPG Gas Cost: $1.9/L (Provided by client)
- Electricity Cost: $0.319/ kWhr (Provided by client)
- Waste Oil Cost: $0.50 / L (Provided by client)
- Biomass Cost: $0.088 / kWh (Based on wood pellet cost from another project)
- Energy Inflation: 5 % per annum
- Analysis period: 25 years
- Replacement: ASHP 15 years, GSHP 25 years
- Plant Operation: 24/7 availability

The following summarises the results of the energy and financial analyses undertaken. Although there will be some differences depending on the final system installed, given the preliminary nature of the calculations and implied assumptions, the below are considered to equally apply regardless of the final system.

7.1 Energy Analysis

The two main considerations for the energy analysis are Peak Electrical Demand (PED) and annual energy usage.

7.1.1 Peak Electrical Demand

In this context, Peak Electrical Demand (PED) is the maximum electrical supply required by the heating systems during periods of peak heating demand. In many instances it is the determining factor of total building or site electrical demand. PED is an important consideration for developments as it is a significant contributor to the electrical infrastructure required at a site and can be a determining factor on electrification projects. It is also a significant contributor to peak demand charges.

At this early design stage, PED calculations remain indicative. As outlined in Section 5.3:

- Electric Boiler: Estimated to require up to 800 kVA to deliver 700 kW of peak winter heating output.
- Air Source Heat Pumps (ASHPs): Estimated to require up to 500 kVA to deliver up to 1000 kW of peak winter heating output
- Ground Source Heat Pumps (GSHPs): Estimated to require up to 350 kVA for 951kW heating output, with higher groundwater temperatures potentially reducing this to ~280 kVA.

7.1.2 Energy Analysis

Annual energy usage is simply the amount of energy used to provide the required heating per annum. To assist the annual energy usage assessments, some simplifications and assumptions are adopted for the system options presented in Table 10.

Option 1: High Groundwater Temperature (T_{GW} ≥ 70 °C)

In this scenario, thermal energy from the groundwater can be utilised directly via the existing hydronic heat pipe network without the need for heat pump systems or additional heat pipe.

- Primary operating cost: Electricity for submersible pumps installed in the abstraction bore(s).

Option 2: Medium Groundwater Temperature (40 °C ≤ $_{TGW}$ < 70 °C)

For the analysis, a groundwater temperature (T_{GW}) of 40 °C is used as the baseline case for Option 2.

Option 2a: Direct Use with Increasing the Existing Hydronic Pipes (No Heat-Pump)

When the groundwater temperature falls within this range and the existing network capacity is increased, heating demand can be met without supplementary heating equipment.

- Primary operating cost: Electricity for submersible pumps in the abstraction bore(s).

Option 2b: Direct Use with Supplementary Heating Equipment

If the increased capacity of existing hydronic pipe system is not feasible, additional heating systems are required.

The total operating cost includes electricity for submersible pumps and the energy consumption of supplementary heating equipment. Typical performance values are:

- High-Temperature Ground Source Heat Pump (GSHP): Heating COP = 4.3
- High-Temperature Air Source Heat Pump (ASHP): Heating COP = 2.2
- Electric Boiler: Heating efficiency = 100%
- Gas Boiler: Heating efficiency = 90%
- Waste Oil Boiler: Heating efficiency = 85%
- Biomass Boiler: Heating efficiency = 88%

Option 3: Low Groundwater Temperature (T_{GW} < 20°C)

At low or ambient source temperatures, direct thermal use is not practical. Heating is achieved via a GSHP system as follows:

- Primary operating cost: Electricity for the GSHP, operating at a lower COP of 3.5 as in Option 2b due to the lower groundwater temperature.

Option 4: Complete Air Source Heat Pump (ASHP)

If no groundwater resource is feasible, a complete ASHP system is an alternative. Heating is achieved via a ASHP system as follows:

- Primary operating cost: Electricity for the ASHP, operating at the same COP of 2.2 as in Option 2b.

Table 8: Annual Energy and Carbon Emission Analysis

System Option	Annual Energy Use (kWh)	Energy Savings vs. Existing	Annual Carbon Emissions (kg CO_2e)	Carbon Savings vs. Existing
Existing Gas Heaters	1,350,463	–	294,617	–
Option 1: Direct Use (T_{GW} ≥ 70 °C)	7,455	1,343,008 (99%)	522	294,095 (100%)
Option 2a: Direct Use (T_{GW} = 40 °C, increased hydronic capacity)	7,455	1,343,008 (99%)	522	294,095 (100%)
Option 2b: Direct Use + Supplementary Heating				
– with GSHP	170,629	1,179,834 (87%)	11,944	282,673 (96%)
– with ASHP	330,665	1,019,797 (76%)	23,147	271,470 (92%)
– with Electric Boiler	723,896	626,566 (46%)	50,673	243,944 (83%)
– with Gas Boiler	803,999	546,464 (40%)	174,960	119,657 (41%)
– with Waste Oil	851,118	499,345 (37%)	164,477	130,140 (44%)
– with Biomass	822,204	528,258 (39%)	158,877	135,740 (46%)
Option 3: GSHP (T_{GW} < 20 °C)	350,025	1,000,438 (74%)	24,502	270,115 (92%)
Option 4: Complete ASHP	544,998	805,465 (60%)	38,150	256,467 (87%)

As can be seen from Table 9, the Existing System has a 1.35 GWh/year energy use and the alternative options compare as follows:

- **Option 1** (T_{GW} ≥ 70°C, direct use): Energy use reduced to 7.5 MWh/year (~99 % savings), as electricity for submersible pumps is the main factor.
- **Option 2a** (T_{GW} = 40°C, direct use with increased hydronic capacity): Achieves similar energy savings to Option 1 but requires increased hydronic pipe capacity.
- **Option 2b** (T_{GW} = 40°C, direct use + supplementary heating): Total energy consumption varies significantly depending on the supplementary heating technology used. Ground Source Heat Pumps (GSHP) achieve the lowest energy consumption, while electric and gas boilers have higher energy usage.

- **Option 3** (T_{GW} < 20°C, GSHP only): Provides moderate energy savings compared to the existing system but consumes substantially more energy than the higher-temperature groundwater options.
- **Option 4 ASHP** Achieves ~60% energy and ~87% carbon savings compared to existing gas.

Direct use of groundwater (Options 1 and 2a) provides the greatest energy and cost savings. Supplementary heating should prioritise GSHP technology for efficiency. Lower-temperature groundwater (Option 3) remains viable but offers less benefit.

7.2 Financial Analysis

The financial analysis presented in Table 10 and 11 is based on the available information from the Client (Tomatoes NZ), the available information, estimates and should not be considered as final costs.

Both GSHP and ASHP options have also been compared to the existing Gas heating for interest and to show the total capital investment estimates for each option.

Capital costs presented are considered to be Class 3 as per cost estimate classification 18R-97 (Table 9). In addition, the capital cost values below do not include estimates for any required building works or local MSSB electrical upgrades that may be required. This approach has proven effective in previous early stage assessments and can be refined as the design evolves. The analysis is based on a typical project-based delivery model and can be modified to suit the project financial model as appropriate.

Table 9: Cost Estimate Classification Matrix

Estimate Class	Maturity Level of Project Definition Deliverables % of complete definition	End Usage Typical purpose of estimate	Methodology Typical estimating method	Expected Accuracy Range Typical variation in low and high ranges at an 80% confidence interval
Class 5	0% to 2%	Concept screening	Capacity factored, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorisation or control	Semi-detailed unit costs with line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/ tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/ tender	Detailed unit cost with forced detailed take-off	L: -3% to -10% H: +3% to +15%

Table 10: Capital Cost Breakdown – Assumptions				
System Option	**Estimated Equipment Cost**	**Electricity Upgrade**	**Well Bore**	**Total**
Option 1: Direct use T_{GW} 70°C	–	-	$1,470,000	**$1,470,000**
Option 2a: Direct use T_{GW} 40°C	Hydronic Pipe Extension $280,000	-	$1,470,000	**$1,750,000**
Option 2b: Direct Use + Supplementary Heating				
– with GSHP	700kW High-Temp GSHP $350,000	$350,000	$1,470,000	**$2,220,000**
– with ASHP	700kW High-Temp ASHP $420,000	$350,000	$1,470,000	**$2,205,000**
– with Electric Boiler	700kW Electric Boiler $300,000	$700,000	$1,470,000	**$2,470,000**
– with Gas Boiler	700kW Gas Boiler $210,000	-	$1,470,000	**$1,680,000**
– with Waste Oil	700kW Waste Oil Boiler $160,000	-	$1,470,000	**$1,630,000**
– with Biomass	700kW Biomass Burner $190,000	-	$1,470,000	**$1,660,000**
Option 3: Indirect use T_{GW} 20°C with GSHP	952kW High-Temp GSHP $500,000	$350,000	$450,000	**$1,300,000**
Option 4: Complete ASHP	952kW High-Temp ASHP $600,000	$450,000	-	**$1,050,000**

Table 11: Summary of Financial Analysis					
System Option	**Capital Investment**	**First Year Cost Saving**	**25 Year Cost Saving**	**Payback (Years) Investment**	**Levelised Cost of Heat (LCOH) (25 years)**
Existing Gas Heaters	$580,000*	-	-	-	$0.35
Option 1: Direct Use (T_{GW} ≥ 70 °C)	$1,470,000	$369,488	$12,001,278	3.8	$0.05
Option 2a: Direct Use (T_{GW} = 40 °C, increased hydronic capacity)	$1,750,000	$369,488	$11,721,278	4.5	$0.06
Option 2b: Direct Use with Supplementary Heating					
– with GSHP	$2,220,000	$317,436	$9,353,482	6.4	$0.12
– with ASHP	$2,205,000	$266,384	$7,507,177	7.5	$0.16
– with Electric Boiler	$2,470,000	$140,944	$2,668,701	14.3	$0.28
– with Gas Boiler	$1,680,000	$150,346	$3,801,504	9.8	$0.25

– with Waste Oil	$1,630,000	$330,780	$10,430,003	4.7	$0.09
– with Biomass	$1,660,000	$298,428	$9,220,460	5.2	$0.13
Option 3: GSHP (T_{GW} < 20 °C)	$1,300,000	$260,209	$8,187,015	4.7	$0.14
Option 4: Complete ASHP	$1,050,000	$198,012	$6,169,384	5.0	$0.22
*The cost to install new gas boilers, in anticipation that a replacement would need to occur in the 25 year lifetime analysis					

As can be seen from the above table summary:

- Compared with the existing gas heaters, most system options offer less than a 10 year payback period, likely due to the relatively high local gas price provided;
- Option 1 and Option 2a involve direct use of groundwater at temperatures of 70°C and 40°C respectively. Option 1 achieves a shorter payback period as Option 2a has the additional cost of augmenting the existing heat pipe network to address the lower geothermal temperature;
- Among all Option 2b systems:
  - GSHP, ASHP, and electric boilers have longer payback periods than otherwise due to the need for an electrical upgrade, especially for the electric boiler;
  - In contrast, the waste oil boiler and biomass boiler options offer shorter paybacks of 4.7 and 5.2 years respectively;
  - The gas boiler option avoids electrical upgrade costs but still has a longer payback period due to the high price of local LPG gas price;
  - GSHP vs. ASHP: The GSHP (Option 2b) delivers slightly greater lifetime savings and a faster payback compared to the ASHP;
  - Electric and gas boilers have moderate upfront costs but offer significantly lower lifetime savings than renewable options, as demonstrated by the highest LCOH over a 25 year period.
- Option 3 (shallow bore wells with a complete GSHP system) achieves a 4.7-year payback and is worthy of consideration if site electrical capacity is sufficient (shorter payback avoiding the electric upgrade) and no high-temperature groundwater resources are encountered; and
- Option 4 (Complete ASHP system) achieves a 5.0-year payback. Where site electricity supply is adequate, the payback could be even shorter if electrical upgrades are avoided.

Overall, the analysis highlights that direct use and renewable or waste-based systems (GSHP, ASHP, biomass, waste oil) represent the most financially advantageous pathways.

7.3 Project Finance

The above financial analysis excludes third party finance on the project capital cost as it assumes that the works would be completed within an available budget. However, noting that the upfront capital cost required to install

geoheat systems can delay or deter investment in the best long-term system for a facility, a project finance analysis has been included to represent how finance may influence the project economics.

A financed approach can significantly reduce or eliminate upfront capital costs with the repayments being covered by the resulting energy savings. GeoExchange NZ offers energy-saving contingent finance for our geoheat designs, in this scenario we would also provide system servicing, maintenance, and performance guarantees for the agreed contract period. This model is known as an Energy Service Company (ESCO) arrangement and is well established in overseas markets.

Table 12 has been produced using the results from this report to represent how this differs from a non-financed approach. The ESCO model estimates annual costs, incorporating both operating expenses and capital repayment for each of the replacement options over a 15 year term. Although electricity would be paid separately to the financed solution, it has been included to show total system costs. Inputs such as rate, term and whether it is a full or partial finance solution will vary in a final package so the below should be considered as indicative only. The important element is the comparison of annual costs for the various technology solutions.

To explore financing and delivery options in more detail, GeoExchange NZ can be contacted directly.

Table 12. ESCO Model – Small Commercial Greenhouse

	Financed Capital Investment	Annual Opex	Opex + ESCO Repayments
Existing gas heating	NA	$371,867	NA
Option 1: Direct Use (TGW ≥ 70 °C)	$1,470,000	$2,378	$149,009
Option 2a: Direct Use (TGW = 40 °C, increased hydronic capacity)	$1,750,000	$2,378	$176,897
Option 2b: Direct Use with Supplementary Heating			
– with GSHP	$2,220,000	$54,431	$280,590
– with ASHP	$2,205,000	$105,482	$334,882
– with Electric Boiler	$2,470,000	$230,923	$498,355
– with Gas Boiler	$1,680,000	$221,521	$409,397
– with Waste Oil	$1,630,000	$41,086	$207,244
– with Biomass	$1,660,000	$73,439	$245,586
Option 3: GSHP (TGW < 20 °C)	$1,300,000	$111,658	$286,907
Option 4: Complete ASHP	$1,050,000	$173,854	$294,561
Assumptions: ESCO contract term is 15 years, includes O&M, a CPI of 2%, an electricity transmission upgrade where required, and the asset life is estimated for 20 years minimum.			

Delivering energy solutions in a service model shifts the focus from energy procurement to energy performance, aligning with sustainability and cost saving goals.

8. CONSENTING AND REGULATORY PROCESS

New Zealand's geothermal systems are currently managed under the Resource Management Act of 1991 (RMA), which has the overall purpose of sustainable management of natural and physical resources. Under the RMA, Bay of Plenty Regional Council (BOPRC) has the responsibility of regulating the taking and use of geothermal water, heat and energy, and the discharges of geothermal water and geothermal discharges to air.

Drilling of a test bore is a discretionary activity that requires a consent. Once the resource is proven and a design of the geoheat system can be finalised, a geothermal take and use consent requirements are then activated. The Bay of Plenty Regional Policy Statement provides for extractive use of the geothermal system, where the adverse effects of the activity can be avoided, remedied or mitigated. Discharge of geothermal fluid must be managed to avoid significant adverse effects on surface water and stormwater.

As the proposed activity requires a groundwater and / or geothermal water allocation that is outside of permitted activity, we understand this project will require a resource consent from the BOPRC, the consenting authority.

The Council has a series of Application Forms to complete as part of the approval process. We have identified that the following consents and forms may be required for each system (Table 13).

Table 9: Summary of Consent Requirements

System Comparison	Consents that may be required	Comments
Option 1: Direct use T_{GW} 70°C	Resource Consent application (Form A) Land use consent for drilling (Form 2C) Consent for take and discharge of geothermal water (Form 6A)	
Option 2a: Direct use T_{GW} 40°C **Option 2: GSHP Warm Aquifer**	Resource Consent application (Form A) Land use consent for drilling (Form 2C) Consent for take and discharge of geothermal water (Form 6A)	
Option 2b: Direct use T_{GW} 40°C combined with top up heating	Resource Consent application (Form A) Land use consent for drilling (Form 2C) Consent for take and discharge of geothermal water (Form 6A)	A resource consent may be required for a new boiler (biomass, gas, and waste oil options), especially if it involves a discharge to air.
Option 3: Indirect use T_{GW} 20°C with GSHP	Resource Consent application (Form A) Land use consent for drilling (Form 2C) Consent for take and discharge of geothermal and non geothermal water (Form 6A and Form 5B)	Permitted activity for water takes (non geothermal) less than 35m3/day, and heat takes to meet reasonable domestic needs. Permitted activity rule and standards may apply for discharges.
Option 4: Complete ASHP	Not applicable	

Their consenting system operates on the user pays principle, meaning that if your activity requires a consent then costs associated with assessing and monitoring the consent and maintaining records are borne by the consent holder.

The system specific forms, Forms 2C, 5B and 6A, have a number of questions related to the aquifer take, discharge, and system design, the answers to these questions will be supplied within our design report. The application requires public consultation and statutory assessment of planning provisions, which we recommend is completed with the support of a planning consultant to ensure the application is complete and accurate.

The intention of this process is to ensure sustainable management of the resource and minimise environmental effects, these considerations are taken into account with our design and our expert understanding of groundwater systems. As such, we will work with you and a planning consultant to ensure that this point is clearly communicated to the regulatory authority in the application.

We have endeavoured to provide as much information on the likely consent process as possible at this stage of the project. However, note that a planning professional or staff member at BOPRC may inform that additional forms are required for this application.

9. CONCLUSIONS

GeoExchange NZ Limited (GXNZ) was requested by Tomatoes NZ to assess the feasibility of a geothermal heating (geoheat) system to replace the existing heating systems for a western Bay of Plenty growing facility. In addition, the focus was for this to be a retrofit that would utilise the existing heating distribution piping network.

The results of this assessment are summarised below.

Heating Requirements

- The glasshouse heating load was simulated using EnergyPlus via the Revit Energy Analysis Engine, with results cross-checked against existing gas usage data to ensure consistency.
- Peak heating demand is approximately 952 kW during winter.
- The site currently operates nine AIRFARM 6000 gas heaters, each rated between 85.0 kW and 106.0 kW, with one unit serving each bay.
- This provides a total available heating capacity of ~765 kW to 954 kW, which aligns closely with the simulated peak load, confirming that the current system sizing aligns with modelled demand.

Existing Hydronic Pipework Requirements

To meet a peak heating load of approximately 952 kW, the following pipe requirements apply:

- At 70°C supply: Existing hydronic pipes sufficient
- At 60°C supply: 1.5 x the existing hydronic pipes would be necessary to achieve the same output
- At 50°C supply: 2.0 x the existing hydronic pipes would be necessary to achieve the same output
- At 40°C supply: 3.0 x the existing hydronic pipes would be necessary to achieve the same output

Source of Thermal Energy

- New groundwater bores at both shallow and intermediate depths were assessed to have sufficient thermal capacity to meet the glasshouse heating demand.
- Depending on the groundwater temperature range (to be confirmed via test well results), different system configurations were proposed, including:
    - Option 1 & 2a: Direct-use high or medium-temperature groundwater.
    - Option 2b: Indirect use of medium-temperature groundwater with high-temperature GSHP, high-temperature ASHP, or boilers (electric, gas, waste oil, biomass).
    - Option 3: Indirect use of cold-temperature groundwater with high-temperature GSHP.
    - Option 4: Compete ASHP.

Heat Pump Locations and Plant Rooms

- Plant rooms proposed to be near bore locations to minimise thermal losses and pumping energy.

Electrical Connections

- Peak Electrical Demand analysis indicates that the site may require an electrical upgrade to facilitate electrification to new heat pump systems. Requested information was not available at the time of this report and will need to be investigated further as part of detailed design; and
- Air Source HP: up to 500 kVA PED for 952 kW output.
- Ground Source HP: up to 330 kVA PED (reduced to ~280 kVA with higher groundwater temperature).
- Electrical capacity constraints may influence choice between ASHP and GSHP.
- Bore-only options have lowest electrical impact.

Energy and Carbon Analysis

- Direct use of groundwater (Options 1 & 2a) provides the greatest energy and cost savings and have lowest electrical impact.
- Supplementary heating should prioritise GSHP technology for efficiency but has higher site electricity requirements.
- Lower-temperature groundwater (Option 3) remains viable but offers less benefit.

Financial Analysis

- The financial assessment indicates that simple bore-only direct-use systems (Options 1 and 2a) deliver the fastest payback periods, driven by minimal operating costs and near-complete carbon abatement
- Among Option 2b systems with renewable-based supplementary heating, the GSHP option provides a strong balance between initial capital investment and long-term energy savings. In contrast, gas and biomass boilers have lower upfront costs but deliver limited lifetime benefits in both energy and carbon reductions.
- Lower-temperature groundwater (Option 3) remains a viable alternative when high-temperature groundwater is unavailable, though with slightly extended payback.
- Overall, groundwater-based heating solutions, particularly those using direct-use or GSHP technology, present the most efficient, cost-effective, and low-carbon strategy for meeting the site's glasshouse heating demand.

Consenting and Regulatory Process

Most of the proposed options will require a resource consent. There is a defined process for the consent application that is available from the Bay of Plenty Regional Council website, the consenting authority. Consultation with Council and / or a planning consultant is recommended.

10. RECOMMENDATIONS

Based on the above conclusions, the following actions are recommended:

- Undertake a test bore to determine site-specific groundwater conditions and refine the selection of replacement heating system options;
- Pursue Options 1 or 2a – Direct Use as the preferred options subject to test bore results;
- Engage with the Bay of Plenty Regional Council to confirm consent requirements and obtain any necessary approvals; and
- Prepare the final system design and develop procurement documentation in line with project and regulatory requirements.

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