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Geothermal Resource Study

California State University
Office of the Chancellor

Final Report

April 3, 2026

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Revision History

Revision	Revision date	Details	Authorized date	Name	Position
01	02/27/26	Draft	02/26/26	Gordon Stewart	Project Manager
02	04/03/26	Final	04/03/26	Gordon Stewart	Project Manager

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Executive Summary

The California State University (CSU) Office of the Chancellor commissioned a preliminary desktop evaluation to assess the feasibility of geothermal energy systems across CSU campuses. This study provides a systemwide screening of relative opportunities and constraints using available geothermal resource indicators, subsurface proxies relevant to ground coupled geothermal (geoexchange) systems, campus infrastructure characteristics, and campus energy demand information. This assessment is intended to support comparative evaluation and prioritization and does not constitute site-specific feasibility, engineering design, or cost analysis.

The evaluation considered three geothermal technology options:

- Ground-coupled geothermal, referred to as geoexchange throughout this report, systems for building heating and cooling
- Direct use geothermal for thermal applications where hydrothermal resources are accessible
- Geothermal electricity generation, including conventional hydrothermal and emerging engineered approaches

Methodology: To ensure a consistent, transparent approach across campuses, AECOM developed a criteria-based screening framework that assessed for resource potential for both deep geothermal and geoexchange and suitability of campus infrastructure. Geothermal resource screening evaluated regional indicators such as proximity to volcanic features, thermal springs, Known Geothermal Resource Areas (KGRAs), faults, and relative temperature favorability at depth. Campus suitability screening prioritized infrastructure compatibility, with secondary consideration of load balance, energy cost savings potential, climatic context, geothermal performance advantage relative to air-source systems, and land availability for borefields. Criteria were scored on a 1–5 scale using defined thresholds, weighted, and aggregated to produce comparative campus-level indicators.

Implementation Considerations: The study also evaluated policy, permitting, construction considerations, and funding opportunities that may influence implementation, with a focus on conditions most relevant to closed-loop geothermal systems. Since closed-loop geothermal systems do not discharge to aquifers or surface water, they are typically regulated via construction standards and general environmental review, rather than through discharge or water rights permits. Though closed-loop systems minimally impact air or water quality, they must comply with well construction guidelines and drilling regulations to minimize soil disturbances and aquifer impacts. Additionally, availability of installation labor and licensed drilling contractors can shape design and construction schedules. Competitive grants may help defray system costs, but current federal tax credit opportunities are limited to geothermal electricity generation systems, not geoexchange. Further, AECOM's assessment of policy, regulatory, and implementation constraints does not surface any disqualifying conditions or restrictions on any campuses.

Results and Recommendations: Due to relative technological maturity and temperature requirements, closed-loop geoexchange systems are the most viable deployment pathway across the CSU portfolio under current conditions. For all campuses, a geoexchange system is technically feasible, however when conducting a comparative analysis three campuses score highest on the combination of suitable existing infrastructure and geothermal resource potential for geoexchange:

1. Cal Poly San Luis Obispo
2. CSU Channel Islands
3. Cal State San Marcos

However, technical feasibility does not automatically translate into implementation readiness, and it is important to distinguish between the two. A campus may rank highly from an engineering perspective, yet may not be positioned organizationally, financially, or strategically to advance a project of this scale. While this Geothermal Resource Study evaluates comparative technical feasibility, it does not assess institutional readiness. Thus, prior to a more detailed analysis at any one campus, AECOM recommends an implementation readiness assessment is conducted at several high scoring campuses to identify the suitability of each to progress with large infrastructure projects. Additional information can be found in Section 6

1. Introduction

The California State University (CSU) Office of the Chancellor commissioned a preliminary desktop evaluation to assess the feasibility of geothermal energy systems across all CSU campuses, along with two satellite locations. The study examines geothermal applicability using available resource data, campus infrastructure characteristics, and energy demand information.

This assessment provides a systemwide screening of relative opportunities and constraints associated with geothermal deployment. The analysis is intended to support planning, prioritization, and identification of campuses that may warrant more detailed investigation.

1.1 Objective

The objective of this study is to conduct a preliminary, criteria-based desktop evaluation of geothermal feasibility across CSU campuses. The assessment integrates regional geothermal resource indicators, subsurface and geotechnical proxies relevant to geoexchange systems, campus infrastructure characteristics, campus energy demand profiles, and policy and implementation considerations.

This study is intended to provide comparative, planning-level insights to support systemwide prioritization. It does not constitute a site-specific feasibility analysis, engineering design, or cost estimation.

1.2 Technologies Evaluated

This evaluation considers geothermal technologies relevant to campus-scale energy applications. Technologies reviewed include:

- **Ground-Coupled Geothermal (Geoexchange) Systems**
  Closed-loop ground source heat pump (GSHP) systems providing campus heating and cooling through shallow subsurface heat exchange.
- **Direct Use Geothermal**
  Utilization of naturally heated groundwater or geothermal fluids for thermal energy applications via deep geothermal bores.
- **Geothermal Electricity Generation**
  Power generation technologies requiring high-temperature subsurface resources, including conventional hydrothermal systems via deep geothermal bores and emerging engineered approaches.

The Geoexchange system utilizes relatively shallow depths in comparison to direct use or geothermal electricity generation, thus the latter two can be categorized as Deep Geothermal technologies. As technical requirements and geographic constraints vary significantly between the three technologies, the screening framework evaluates both deep geothermal resource indicators and shallow subsurface suitability. Within the CSU portfolio, closed-loop geoexchange systems represent the most broadly applicable near-term deployment pathway. Technical details on these technologies are included later in the following section.

2. Technologies Evaluated

Geothermal technologies encompass a wide range of system types that vary by operating temperature, depth, technical maturity, and end use. Geothermal applications fall into two categories: systems designed for electricity generation that rely on high-temperature subsurface resources, and ground-coupled systems that support building heating and cooling at lower temperature thresholds. The following sections describe these technologies in more detail.

2.1 Deep Geothermal Technologies

Geothermal technologies that leverage elevated subsurface temperatures can be applied either to provide usable thermal energy directly or to generate electricity. These applications typically rely on naturally occurring hydrothermal resources or engineered reservoirs that enable heat extraction at depth. These applications generally require higher temperatures, deeper drilling, and more specialized development and permitting pathways. As a result, they are geographically constrained and most viable where high geothermal gradients, thermal features, and/or proven geothermal resource areas are present.

2.1.1 Direct Use Geothermal

Direct use geothermal systems utilize naturally heated water or steam for thermal applications without converting the resource to electricity. Thermal energy can be delivered through heat exchangers to support district heating, domestic hot water preheating, industrial processes, agricultural applications (e.g., greenhouses), aquaculture, and other end uses that can accept moderate-temperature heat. In practice, direct use projects typically rely on hydrothermal resources where hot fluids are accessible and can be produced from wells at temperatures that are useful for the intended application. Direct use is often feasible at lower resource temperatures than electricity generation, but it still requires sufficient fluid temperature (generally a minimum of 100-120°F), sustainable flow rates, and appropriate water chemistry. Direct use applications are best suited to locations with proximity to established geothermal resource areas. While direct use can provide high-efficiency thermal energy, project feasibility is highly dependent on site-specific conditions.

2.1.2 Geothermal Electricity Generation

Geothermal power generation systems produce electricity by accessing subsurface heat at temperatures sufficient to drive thermal cycles. Conventional geothermal power systems rely on naturally occurring hydrothermal reservoirs where hot fluids circulate through permeable formations and can be brought to the surface for power generation. These systems are geographically constrained and are typically limited to regions with high geothermal gradients and active geothermal features such as volcanoes and thermal springs.

Next-generation geothermal power technologies expand the potential geographic reach of geothermal electricity by employing advanced drilling and reservoir engineering techniques. These include Enhanced Geothermal Systems (EGS), closed-loop geothermal systems designed for power generation, and superhot or supercritical geothermal concepts. These approaches access heat from deeper and hotter rock formations in areas without naturally productive hydrothermal resources.

Power generation technologies generally require substantially higher subsurface temperatures than building heating and cooling applications, often at depths of several kilometers. As a result, they involve deeper drilling, higher capital investment, and increased technical complexity. While recent advancements in drilling efficiency, subsurface modeling, and materials have improved the viability of geothermal power systems, particularly in parts of the western United States, these technologies remain best suited to locations with favorable thermal conditions and access to utility-scale infrastructure.

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2.2 Geoexchange Systems for Heating and Cooling

Geoexchange systems, commonly referred to as geothermal heat pump systems, utilize the relatively stable temperatures of the shallow subsurface to provide efficient heating and cooling for buildings. These systems exchange heat with the ground through sealed piping installed vertically or horizontally. Horizontal systems typically require large contiguous land areas and are more sensitive to surface constraints, making them less practical for most campuses. Vertical borefields are generally more suitable for campuses because they require significantly less surface area, allowing them to be installed under existing features such as parking lots, athletic fields, or landscaped areas.

Geoexchange systems operate at much lower temperature ranges than geothermal power generation technologies, generally operating in typical shallow ground temperatures of 50-60°F, rather than anomalously high temperatures at traditional geothermal sites. In these systems, heat transfer occurs via conduction through the piping. Open-loop geothermal heat pump systems pump higher-temperature water or geothermal fluid directly from groundwater aquifers or wells. Some open-loop systems reinject the geothermal fluid into the same aquifer from which it was produced to prevent subsidence or maintain water levels. Closed-loop geothermal heat pump systems, on the other hand, physically isolate the circulating fluid from surrounding soils and groundwater. As a result, closed-loop geothermal heat pump systems do not require groundwater extraction or reinjection.

Because ground-coupled systems are not dependent on high-temperature geothermal resources, they can be deployed across a wide range of geologic and geographic conditions. Their scalability, relatively low environmental risk profile, and compatibility with building mechanical systems make them well suited to institutional and campus settings.

2.3 Temperature Thresholds and Technology Fit

These distinct geothermal technologies require very different subsurface temperatures for effective operation. Electricity generation technologies require high temperatures (generally above 180°F) to produce steam or drive binary power cycles, whereas geothermal heat pump systems use low and stable ambient ground temperatures to enable efficient heat exchange. In many locations, including much of California outside of known geothermal resource areas, subsurface temperatures at economically drillable depths are sufficient for ground-coupled heating and cooling applications but are not high enough to support electricity generation. Therefore, geothermal heat pump systems are the most broadly applicable geothermal technology for campus-scale energy use under current conditions.

2.4 Emerging and Future Geothermal Technologies

Ongoing technological innovation is expanding the range of potential geothermal applications over time. Advances in drilling techniques, subsurface imaging, and materials science are enabling deeper and hotter geothermal resources to be accessed more efficiently. Emerging geothermal technologies—including advanced closed-loop systems for power generation, EGS, and superhot geothermal concepts—have demonstrated promising results in pilot and early commercial projects.

These technologies illustrate the longer-term potential for geothermal energy to play a broader role in electricity generation, thermal energy supply, and grid support as technical and economic barriers continue to decline. While such applications are not yet widely deployable across institutional or campus settings, they provide important context for understanding how geothermal capabilities, temperature thresholds, and drilling feasibility may evolve in the future.

3. Project Methodology

The geothermal resource assessment was conducted as a desktop-level screening to evaluate the relative suitability of campuses. The methodology was designed to be consistent across campuses to support comparative evaluation and prioritization rather than to establish site-specific feasibility or design. The assessment integrates publicly available data sources, high-level campus information, and professional engineering judgment to identify relative opportunities and constraints associated with geothermal deployment.

3.1 Criteria-Based Screening Framework

A criteria-based screening framework was developed to evaluate the relative feasibility of geothermal deployment across CSU campuses in a consistent and transparent manner. The framework organizes key technical, geologic, and infrastructure-related factors that influence system suitability. This approach supports comparative evaluation and prioritization rather than site-specific feasibility determination.

3.1.1 Geothermal Resource

Geothermal resource criteria were established to assess the relative presence of subsurface thermal conditions that may influence geothermal applicability. Criteria for Deep Geothermal potential are described in Table 1, and evaluate potential geothermal resource indicators, known geothermal features, and temperature favorability at depth. Criteria for geoexchange systems are described in Table 2, and include geologic data which indicate levels of thermal conductivity in the subsurface.

Table 1: Criteria Descriptions for Deep Geothermal

Category	Criterion	Description	Weight
Potential for Viable Local Resource	**Proximity to Volcanoes**	Distance to volcanic heat source (magma/hydrothermal fluids) for development of geothermal power	20%
	Proximity to Thermal Springs	Distance to thermal springs hot water source (hydrothermal fluids) for development of geothermal power or direct use of hot water	20%
	Spring Temperatures	Temperatures of surface spring waters (°F); potential for electricity production minimum 180°F; potential for direct use minimum 120°F	20%
	Relative Temperature at Depth	Relative temperature at depth (3 to 10 km); higher temperatures equate to higher favorability for potential geothermal resource	20%
	Proximity to KGRAs	Distance to KGRAs with proven development capabilities	10%
	Proximity to Faults	Distance to geologic faults which may be potential geothermal resource at depth	10%

KGRA: Known Geothermal Resource Area

Table 2: Criteria Descriptions for Geoexchange

Category	Criterion	Description	Weight
Thermal Conductivity	**Depth to Bedrock**	Depth below ground surface (bgs) at which bedrock is encountered. Bedrock has higher thermal conductivity than soil so shallow bedrock is more favorable for geoexchange systems.	25%
	Rock Type/Thickness	Type of rock present (i.e. crystalline, sedimentary) and relative thickness (i.e. massive, thinly bedded). Thicker layers of dense rock types have higher thermal conductivity.	25%
	Soil Consistency	Density/hardness of soil present. More dense/hard/compact soils have higher thermal conductivity and are more favorable for geoexchange systems.	25%
	Depth to Groundwater/Soil Moisture	Depth at which groundwater is encountered and/or levels of soil moisture. Wet/saturated soils have higher thermal conductivity.	25%

3.1.2 Campus Infrastructure and Demand

AECOM evaluated each campus' existing infrastructure and heating and cooling demands to assess the feasibility of integration with a geoexchange system. AECOM identified three key categories—campus loads, infrastructure, and other considerations—and individual criteria in each. A summary of the evaluation criteria is provided in Table 3.

Table 3: Criteria Descriptions for Campus Infrastructure

Category	Criterion	Description	Weight
Campus Loads	**Campus Heating & Cooling Load Profiles**	An assessment of the hourly heating and cooling load profiles and their favorability to optimize a geothermal system. Balanced heating and cooling profile may be preferential as they will allow for a higher percentage of heat recovery, minimizing borefield sizing and thus costs.	5%
Campus Infrastructure	**Existing Enabling Infrastructure**	Ability of existing campus infrastructure to accommodate a centralized heating system. Campuses that have existing hydronic heating and cooling loops provide the greatest enabling infrastructure that reduces the cost to integrate a geoexchange system into a campus	30%
	Compatible Central Equipment	Ability of plant infrastructure to accommodate a heat pump and geothermal system. Systems with existing low temperature hot water boilers have a higher potential to be ready to integrate heat pumps into plant operations	20%
	Building Heating Temperatures	Existing heating hot water distribution temperatures	20%
	Age of Major Equipment	Assessment of whether existing plant equipment is at the end of its useful life	10%
Other Considerations	**Energy Cost Impact**	Cost impact from transitioning from natural gas to electricity as a heating sources	5%
	Operations & Maintenance (O&M) Impact: Air-Source vs. Ground Source System	Proximity of campus to the ocean, thus added operational and maintenance considerations for operating an air-source vs. ground-source system. This criterion is limited to maintaining and replacing the equipment only	2.5%
	Energy Impact: Air-Source vs. Ground-Source System	Consideration of outside air temperatures and the impact this has on the efficiency of an air-source vs ground-source system. This criterion is limited to operational energy cost analysis only	2.5%
	Land Availability for Borefields	Amount of open space on each campus to accommodate a geothermal borefield	5%

The screening framework applies relative weighting across criteria to reflect their influence on the feasibility and effectiveness of closed-loop geothermal deployment on a campus. The criterion-level weighting approach distinguishes primary feasibility drivers (heavily-weighted, as they affect near-term feasibility and constructability) from secondary considerations (which shape operational performance).

- **Load Profiles** weighted at 5%. Balanced heating and cooling loads can improve system efficiency, but closed-loop geothermal systems can accommodate a wide range of load profiles via appropriate sizing, configuration, and integration of thermal energy storage systems and control strategies. In addition, campus energy load data varied in resolution across the CSU system, with some campuses providing hourly data and others monthly or aggregated data. Given the design flexibility and data limitations, load balance was treated as a lower priority.
- **Existing Enabling Infrastructure** was weighted the highest at 30%, reflecting that compatible infrastructure is often the greatest limiting factor when determining geothermal feasibility or the capital cost of implementing a system. Campuses that score highly in this category are better suited to integrate a geoexchange system for heating and cooling. This is due to existing centralized mechanical equipment and hydronic piping distributed across campus, which may allow a geothermal borefield to be connected into existing infrastructure with reduced capital cost.
- **Compatible Central Equipment** and **Building Heating Temperatures** were each weighted at 20%, since both directly relate to whether the existing equipment can support a geothermal system. However, recent advancements in heat pump technology and refrigerants have expanded supply temperature ranges, and as a

result, higher-temperature hot water systems are becoming less restrictive than they were even in the past two to three years. Distribution temperature alone is no longer a primary limiting factor for geothermal integration, and the weight of this criterion may be updated as technology changes.

- **Age of Major Equipment** was weighted at 10% to reflect its influence on project timing and integration opportunity. Campuses with equipment nearing the end of their useful life may be better positioned to integrate new systems as part of planned replacement cycles.
- **Energy Cost Impact** was weighted at 5% to capture the relative impact of fuel-switching opportunities and utility rate structures, while recognizing that detailed economic modeling was outside the scope of this effort.
- **Energy Impact: Air-Source vs. Ground-Source System** and **Operations & Maintenance (O&M) Impact: Air-Source vs. Ground Source System** were weighted the lowest at 2.5% each. Both influence relative efficiency and operational performance rather than technical feasibility.
- **Land Availability for Borefields** weighted at 5%. Land availability is a lower priority because land constraints may be addressed through advanced drilling technologies.

3.2 Feasibility Scoring Approach

A scoring methodology was applied to translate qualitative and quantitative screening criteria into comparable numerical values. Each criterion was assigned a score from 1 to 5 based on defined thresholds reflecting relative favorability. Scores were weighted and aggregated to produce campus-level feasibility indicators.

3.2.1 Geothermal Resource

Geothermal resource scores were assigned for deep geothermal using publicly available datasets describing regional thermal indicators, geothermal features, and subsurface temperature conditions. Scoring thresholds were defined to differentiate relative resource favorability among campuses. The resulting scores reflect comparative resource potential rather than confirmed geothermal capacity.

For geoexchange systems, resource scores were assigned using publicly available datasets on subsurface rock and soil properties that determine potential for thermal conductivity. All campus sites are potential candidates for viable geoexchange systems. Scoring thresholds were defined to differentiate the potential relative efficiency of geoexchange systems among campuses. The resulting scores reflect comparative efficiency of potential geoexchange systems.

Table 4: Criteria Scoring for Deep Geothermal

Category	Criterion	Score				
		1	2	3	4	5
Potential for Viable Local Resource	**Proximity to Volcanoes**	More than 100 miles from volcanic feature	Within 100 miles of volcanic feature	Within 75 miles of volcanic feature	Within 50 miles of volcanic feature	Within 25 miles of volcanic feature
	Proximity to Thermal Springs	More than 40 miles from thermal springs	Within 40 miles of thermal springs	Within 30 miles of thermal springs	Within 20 miles of thermal springs	Within 10 miles of thermal springs
	Spring Temperatures	70°F or lower	71 – 100°F	101 - 140°F	141 - 180°F	Higher than 180°F
	Relative Temperature at Depth	Very Low Favorability	Low Favorability	Moderate Favorability	High Favorability	Very High Favorability
	Proximity to KGRAs	More than 80 miles from KGRA	61 – 80 miles from KGRA	41 – 60 miles from KGRA	21 – 40 miles from KGRA	<20 miles from KGRA
	Proximity to Faults	More than 6 miles from a fault	3.1 – 6 miles from a fault	1 – 3 miles from a fault	<1 mile from a fault	Fault intersects campus

KGRA: Known Geothermal Resource Area

Table 5: Criteria Scoring For Geoexchange

Category	Criterion	Score				
		1	2	3	4	5
Thermal Conductivity	**Depth to Bedrock**	Bedrock >200 ft bgs	Bedrock 101-200 ft bgs	Bedrock 50-100 ft bgs	Shallow bedrock <50 ft bgs	Bedrock within 6 ft bgs
	Rock Type/Thickness	Porous/highly weathered bedrock	Thinly bedded sedimentary bedrock	Massive sedimentary bedrock	Thinly bedded crystalline bedrock	Massive crystalline bedrock
	Soil Consistency	Very loose/very soft	Loose/soft	Medium dense/firm	Dense/stiff	Very dense/hard
	Depth to Groundwater/ Soil Moisture	Very dry soil/very deep groundwater (>200 ft bgs)	Dry soil/deep groundwater (150-200 ft bgs)	Moist soil/moderate depth groundwater (75-150 ft bgs)	Wet soils/shallow groundwater (25-75 ft bgs)	Saturated soil/very shallow groundwater (<25 ft bgs)

bgs: Below ground surface

3.2.2 Campus Infrastructure and Demand

Feasibility was evaluated by assigning scores ranging from 1 to 5 to each criterion for every CSU campus. Descriptions of the scoring scales are summarized in Table 6. Results from the scoring framework were totaled to produce overall campus-level feasibility scores, which are presented in Section 4.2.

Table 6: Criteria Scoring for Campus Infrastructure

Category	Criterion	Score				
		1	2	3	4	5
Campus Loads	**Campus Heating & Cooling Load Profiles**	Heat recovery potential is absent as heating loads dominate annually, necessitating borefield sizing driven by heating demand.	Heat recovery potential is limited and annual heating and cooling loads are unbalanced, with significantly higher heating demand.	Heat recovery potential is limited and annual heating and cooling loads are unbalanced, with slightly higher heating demand.	Heat recovery potential is significant and annual heating and cooling loads are almost balanced	Heat recovery potential is significant and annual heating and cooling loads are balanced
Campus Infrastructure	**Existing Enabling Infrastructure**	No centralized connected infrastructure	Existing steam distribution	Centralized HTHW distribution	Centralized LTHW distribution only	Centralized LTHW & CHW distribution
	Compatible Central Equipment	Steam boilers	High-temperature HHW boilers	-	Non-condensing boilers	Condensing boilers
	Building Heating Temperatures	No heating hot water distribution	Design for HTHW (>200°F)	Design for and operate at 180°F	-	Currently operating at ~160°F or lower
	Age of Major Equipment	Equipment has 10+ years of expected useful life left	Equipment has 5+ years of expected useful life left	Equipment at end of useful life within 5 years	Equipment at end of useful life	Equipment beyond expected useful life
Other Considerations	**Energy Cost Impact**	Low natural gas costs High electricity costs <20% utility cost score	20%-40% utility cost score	40%-60% utility cost score	60%-80% utility cost score	High natural gas costs Low electricity costs >80% utility cost score
	O&M Impact: Air-Source vs. Ground Source System	Campus located within 2 miles of the ocean. Potential added capital and O&M costs for air-source equipment	-	Campus located within 5 miles of the ocean. Potential added capital and O&M costs for air-source equipment	-	No impact to capital and O&M costs for air-source equipment based upon campus location
	Energy Impact: Air-Source vs. Ground-Source System	Hourly air temperature favorable for ground source over an air-source system <20% annual hours	20%-40% annual hours	40%-60% annual hours	60%-80% annual hours	Hourly air temperature favorable for ground source over an air-source system >80% annual hours
	Land Availability for Borefields	Campus area available for geothermal borefield <20th percentile of all campuses	20th-40th percentile of all campuses	40th-60th percentile of all campuses	60th-80th percentile of all campuses	Campus area available for geothermal borefield >80th percentile of all campuses

HTHW: High-temperature Hot Water *CHW: Chilled Water* *HHW: Heating Hot Water*
LTHW: Low-Temperature Hot Water *O&M: Operations & Maintenance*

4. Integrated Feasibility Results and Findings

This section summarizes the results of the criteria-based screening analysis and presents the relative feasibility of closed-loop geothermal deployment across CSU campuses. Scores were developed using the methodology described in Section 2 and reflect a weighted sum of individual criterion scores for each campus.

The results are intended to support comparative evaluation and prioritization at a systemwide level. Scores represent relative favorability based on available information and do not indicate project-level feasibility or readiness for immediate implementation.

4.1 Geothermal Resources

Outlined in Table 7 and Table 8 is the weighted geothermal resource scores for each CSU campus, along with the underlying criterion-level scores that contribute to the overall results. Individual criterion scores range from 1 to 5, with higher values indicating more favorable conditions for deep geothermal and geoexchange, respectively. Criterion scores were multiplied by their respective weights and summed to produce an overall feasibility score for each campus. Campuses assigned a score of 0 indicate that there was insufficient data to assign an informed score for that criterion. In these cases, the criterion was excluded from the weighted total and did not affect the overall score.

For deep geothermal potential, higher-scoring campuses reflect stronger alignment with favorable geothermal resource indicators, including proximity to known geothermal resource areas, thermal features, and subsurface temperature gradients. Mid-range scores indicate moderate resource potential or mixed conditions. Lower scores generally correspond to campuses located in regions with limited geothermal indicators or lower relative temperature favorability at depth.

Geoexchange systems are not dependent on high temperature resources, and these systems would likely be viable at all campus sites. What varies is the potential efficiency of a geoexchange system at a given site, based on subsurface conditions. The thermal conductivity in the subsurface is the main factor in the efficiency of the heat exchange itself, so properties of the rock and soil impact the required design of the system. For instance, higher thermal conductivity may necessitate less extensive piping to achieve the required heating and cooling needs. Site-specific thermal conductivity testing and other site-specific data collection would be necessary to determine the most efficient design of a geoexchange system. Because there are no thermal conductivity test results available at the campus sites, the main geologic factors that determine thermal conductivity were used as indicators of the potential efficiency of geoexchange at the campus sites. Higher-scoring campuses have potentially higher thermal conductivity in the subsurface and thus may have potential for the highest efficiency systems. Campuses with mid-range and lower scores are still candidates for geoexchange systems but may require more extensive drilling and thus costs in order to meet heating and cooling loads.

It should be noted that rock has higher thermal efficiency than soil, so campuses with shallow bedrock may have potential for higher efficiency systems. Although drilling costs were not considered in detail in the geothermal resource scoring, drilling into bedrock requires more specialized equipment than drilling in soils, so can be more expensive; however bedrock drilling is generally not subject to borehole collapse that commonly leads to redrilling and elevated costs in soil borings.

Table 7: Campus Criteria Scores for Deep Geothermal

Category	Criterion	Weight	Bakersfield	Chico	Channel Islands	Dominguez Hills	East Bay	Fullerton	Fresno	Humboldt	Los Angeles	Long Beach	Maritime Academy	Monterey Bay	Northridge	Pomona	Sacramento	San Bernardino	San Diego	San Francisco	San Jose	San Luis Obispo	San Marcos	Sonoma	Stanislaus	East Bay Concord	CSUSB Palm Desert	SDSU Imperial Valley
Potential for Viable Local Resource	Proximity to Volcanoes	20%	2	3	1	1	2	1	3	1	1	1	3	1	1	1	2	1	2	2	1	1	2	4	2	2	3	5
	Proximity to Thermal Springs	20%	3	2	3	5	4	3	1	1	4	4	5	5	5	3	2	5	2	3	5	4	4	5	3	5	4	4
	Spring Temperatures	20%	0	2	3	3	2	3	2	2	2	3	2	3	2	2	1	5	2	2	2	2	2	2	2	0	3	3
	Temperature at Depth	20%	3	1	3	4	4	4	2	1	4	4	3	3	3	3	1	3	3	4	4	4	3	4	2	3	3	5
	Proximity to KGRAs	10%	3	3	4	3	2	4	1	1	3	3	3	1	4	4	2	5	1	3	1	1	1	5	1	3	3	5
	Proximity to Faults	10%	2	2	5	4	5	3	2	4	5	4	3	5	5	5	1	4	4	4	4	5	2	3	1	5	2	3
		100%	**2.6**	**2.1**	**2.9**	**3.3**	**3.1**	**2.9**	**1.9**	**1.5**	**3.0**	**3.1**	**3.2**	**3.0**	**3.1**	**2.7**	**1.5**	**3.7**	**2.3**	**2.9**	**2.9**	**2.8**	**2.5**	**3.8**	**2.0**	**3.5**	**3.1**	**4.2**

Table 8: Campus Criteria Scores for Geoexchange

Category	Criterion	Weight	Bakersfield	Chico	Channel Islands	Dominguez Hills	East Bay	Fullerton	Fresno	Humboldt	Los Angeles	Long Beach	Maritime Academy	Monterey Bay	Northridge	Pomona	Sacramento	San Bernardino	San Diego	San Francisco	San Jose	San Luis Obispo	San Marcos	Sonoma	Stanislaus	East Bay Concord	CSUSB Palm Desert	SDSU Imperial Valley
Thermal Conductivity	Depth to Bedrock	25%	1	0	5	0	5	4	4	4	5	0	5	0	5	5	1	0	5	5	0	5	5	1	1	5	1	1
	Rock Type/Thickness	25%	2	2	4	2	4	2	2	1	3	2	2	2	2	2	2	2	2	1	2	3	2	2	2	3	1	2
	Soil Consistency	25%	2	2	3	2	2	4	4	1	2	2	3	1	2	3	3	2	3	4	2	5	4	4	3	5	1	1
	Depth to Groundwater/ Soil Moisture	25%	3	3	5	4	4	3	3	5	3	4	5	2	3	3	4	2	3	5	5	5	4	5	4	0	2	0
		100%	**2.0**	**2.3**	**4.3**	**2.7**	**3.8**	**3.3**	**3.3**	**2.8**	**3.3**	**2.7**	**3.8**	**1.7**	**3.0**	**3.3**	**2.5**	**2.0**	**3.3**	**3.8**	**3.0**	**4.5**	**3.8**	**3.0**	**2.5**	**4.3**	**1.3**	**1.3**

4.2 Campus Infrastructure and Demand

Table 9 presents the weighted feasibility scores for each CSU campus, along with the underlying criterion-level scores that contribute to the overall results. Individual criterion scores range from 1 to 5, with higher values indicating more favorable conditions for geothermal deployment. Criterion scores were multiplied by their respective weights and summed to produce an overall feasibility score for each campus. Campuses assigned a score of 0 indicate that there was insufficient data to assign an informed score for that criterion. In these cases, the criterion was excluded from the weighted total and did not affect the overall score. A comprehensive ranking of the final campus scores is provided in Section 4.3.

Higher-scoring campuses represent stronger candidates for more detailed evaluation in subsequent phases of analysis. Mid-range scores may reflect campuses where geothermal deployment could be viable under specific conditions. Lower-scoring campuses are not precluded from geothermal deployment but may require more significant system transformation or longer-term planning to address existing constraints.

Table 9: Campus Criteria Scores for Campus Infrastructure

Category	Criterion	Weight	Bakersfield	Chico	Channel Islands	Dominguez Hills	East Bay	Fullerton	Fresno	Humboldt	Los Angeles	Long Beach	Maritime Academy	Monterey Bay	Northridge	Pomona	Sacramento	San Bernardino	San Diego	San Francisco	San Jose	San Luis Obispo	San Marcos	Sonoma	Stanislaus
Campus Loads	Heating & Cooling Load Profiles	5%	3	4	3	3	5	3	2	2	4	3	5	2	3	4	3	3	0	3	2	3	4	5	3
Campus Infrastructure	Existing Enabling Infrastructure	30%	5	2	5	5	1	5	5	1	3	5	1	4	5	3	2	5	2	4	1	5	5	5	5
	Compatible Central Equipment	20%	4	2	4	4	1	4	4	1	1	4	1	4	5	1	2	5	2	2	2	4	4	4	4
	Age of Major Equipment	10%	4	1	1	1	0	1	1	0	0	5	0	3	2	0	4	1	3	3	3	5	1	4	5
	Building Heating Temperatures	20%	3	1	5	2	3	3	3	3	3	5	3	5	5	3	1	5	1	3	1	3	5	5	3
Other Considerations	Energy Cost Impact	5%	1	2	5	2	1	3	4	2	3	4	4	1	3	2	5	3	5	1	5	4	3	1	5
	O&M Impact	2.5%	5	5	3	5	5	5	5	3	5	3	1	1	5	5	5	5	5	1	5	5	5	5	5
	Energy Impact	2.5%	2	4	2	1	4	1	3	5	1	1	3	5	2	3	4	4	1	5	5	3	2	5	3
	Land Availability for Borefields	5%	5	2	5	5	4	1	1	1	1	3	5	4	2	5	2	4	2	3	1	4	4	3	4
		100%	**3.9**	**1.9**	**4.2**	**3.5**	**2.0**	**3.5**	**3.6**	**1.7**	**2.5**	**4.4**	**2.1**	**3.8**	**4.3**	**2.7**	**2.3**	**4.3**	**2.1**	**3.0**	**1.9**	**4.2**	**4.1**	**4.4**	**4.2**

4.3 Overall Campus Feasibility Score

Table 10, 11 and 12 summarize campus rankings for deep geothermal and geoexchange resource potential, and campus infrastructure feasibility as it relates to integrating a geoexchange system into the campus. Table 13 synthesizes these results to provide an overall geoexchange feasibility ranking across CSU campuses

Three satellite campus locations, SDSU Imperial Vallet Campus, CSU San Bernardino Palm Desert Campus and East Bay Concord, were analyzed for Geothermal resource potential only. These locations were assessed due to their potential suitability for either Deep Geothermal or Geoexchange in the future. However, all three locations are significantly smaller than the main campus locations and do not have any centralized mechanical systems, thus an assessment of the Campus Infrastructure was not completed on each.

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Table 10: Campus Ranking for Deep Geothermal

Deep Geothermal	
SDSU Imperial Valley	4.2
Sonoma	3.8
San Bernardino	3.7
East Bay Concord	3.5
Dominguez Hills	3.3
Maritime Academy	3.2
CSUSB Palm Desert	3.1
East Bay	3.1
Long Beach	3.1
Northridge	3.1
Monterey Bay	3.0
Los Angeles	3.0
Fullerton	2.9
San Jose	2.9
San Francisco	2.9
Channel Islands	2.9
San Luis Obispo	2.8
Pomona	2.7
Bakersfield	2.6
San Marcos	2.5
San Diego	2.3
Chico	2.1
Stanislaus	2.0
Fresno	1.9
Sacramento	1.5
Humboldt	1.5

Table 11: Campus Ranking for Geoexchange

Geoexchange	
San Luis Obispo	4.5
East Bay Concord	4.3
Channel Islands	4.3
East Bay	3.8
Maritime Academy	3.8
San Marcos	3.8
San Francisco	3.8
Los Angeles	3.3
Pomona	3.3
Fullerton	3.3
Fresno	3.3
San Diego	3.3
San Jose	3.0
Northridge	3.0
Sonoma	3.0
Humboldt	2.8
Long Beach	2.7
Dominguez Hills	2.7
Stanislaus	2.5
Sacramento	2.5
Chico	2.3
San Bernardino	2.0
Bakersfield	2.0
Monterey Bay	1.7
SDSU Imperial Valley	1.3
CSUSB Palm Desert	1.3

Table 12: Campus Ranking for Campus Infrastructure

Campus Infrastructure	
Long Beach	4.4
Sonoma	4.4
San Bernardino	4.3
Northridge	4.3
Stanislaus	4.2
Channel Islands	4.2
San Luis Obispo	4.2
San Marcos	4.1
Bakersfield	3.9
Monterey Bay	3.8
Fresno	3.6
Fullerton	3.5
Dominguez Hills	3.5
San Francisco	3.0
Pomona	2.7
Los Angeles	2.5
Sacramento	2.3
Maritime Academy	2.1
San Diego	2.1
East Bay	2.0
Chico	1.9
San Jose	1.9
Humboldt	1.7

Table 13: Overall Campus Ranking

Final Campus Scores	
San Luis Obispo	4.3
Channel Islands	4.2
San Marcos	4.0
Sonoma	3.7
Northridge	3.6
Long Beach	3.6
Fresno	3.4
Fullerton	3.4
San Francisco	3.4
Stanislaus	3.4
San Bernardino	3.2
Dominguez Hills	3.1
Pomona	3.0
Bakersfield	3.0
Maritime Academy	3.0
East Bay	2.9
Los Angeles	2.9
Monterey Bay	2.8
San Diego	2.7
San Jose	2.4
Sacramento	2.4
Humboldt	2.3
Chico	2.1

Higher overall feasibility scores indicate campuses where geologic conditions, infrastructure characteristics, and operational factors are most closely aligned to support closed-loop geothermal system implementation. The results presented in this section are intended to guide systemwide prioritization and planning. They do not constitute a determination of project-level feasibility, design suitability, or economic viability. Further analysis would refine these findings through detailed technical evaluation.

Tier 1 Campuses

Cal Poly San Luis Obispo, CSU Channel Islands and Cal State San Marcos are considered Tier 1 with an overall score of 4.0 or above. All three campuses score highly on both existing campus infrastructure and geothermal resource potential and based on this preliminary assessment are deemed the most suitable for a more detailed assessment to analyze geoexchange system feasibility.

Tier 2 Campuses

Sonoma State, Cal State Northridge, Cal State Long Beach, Cal State Fresno, Cal State Fullerton, SFSU and Stanislaus State fall under Tier 2 campuses. All of these campuses score highly in either the geothermal resource or existing campus infrastructure categories, however none score above 4.0 in both.

Tier 3 Campuses

Cal State San Bernardino, Cal State Dominguez Hills, Cal Poly Pomona, Cal State Bakersfield, Maritime Academy, Cal Stat East Bay, Cal State LA, Monterey Bay and SDSU all are considered Tier 3. Although some of these campuses may score highly in one category, this is offset by a lower score on the other.

Tier 4 Campuses

San Jose State, Cal State Sacramento, Cal Poly Humbolt and Chico State are all considered Tier 4 campuses. None of these campuses score above a 3.0 in either category and thus present the lowest Tiering of campus scores.

5. Implementation Considerations: Policy, Funding, and Construction Management

Beyond the technical resource potential and campus infrastructure, potential geothermal system deployment on CSU campuses must account for federal and state regulations, local construction considerations, and external funding options. Since the technical analyses above conclude that closed-loop geothermal for campus heating and cooling is the most feasible geothermal solution across campuses, this section focuses on the implementation considerations relevant to those systems. This section finds that these implementation considerations are quite navigable and would not jeopardize a project at an otherwise-suitable CSU campus, but they would influence the project's engineering design and construction schedule. This section covers:

- **Regulatory Context:** Since closed-loop geothermal systems do not discharge to aquifers or surface water, they are typically regulated via construction standards and general environmental review, rather than through discharge or water rights permits.
- **Regional Policy:** Certain campuses may be subject to additional coordination or review based on jurisdiction-specific concerns (e.g., coastal protection concerns, adjudicated groundwater basin governance, environmental remediation or contamination risks). The campuses shortlisted for project development would undergo more in-depth local policy assessments as part of a detailed feasibility study.
- **Funding and Financing:** Recent federal policy changes have greatly reduced federal funding for geothermal systems, but opportunities do exist.
- **Environmental Impact:** Closed-loop systems minimally impact air or water quality, but drilling activities must comply with regulations to minimize soil disturbances and aquifer impacts. Waste from drilling and operations (e.g., drill mud, refrigerants, antifreeze) must also be managed and disposed of properly.
- **Labor and Installation:** While the regulatory landscape for closed-loop geothermal systems is quite navigable, availability of installation labor and licensed well-drilling contractors can complicate implementation.

5.1 Regulatory and Policy Context

5.1.1 Federal Policy

At the federal level, two major laws can affect geothermal system deployment. Both likely would not apply to the specific closed-loop geothermal project(s) recommended for consideration by CSU:

- **The Clean Water Act**[1] regulates discharges to waters of the United States through the National Pollutant Discharge Elimination System (NPDES). Clean Water Act requirements are triggered primarily by surface water discharges. Closed-loop geothermal systems do not involve surface extraction, reinjection, or discharge and therefore generally avoid federal water permitting requirements.
- **The National Environmental Policy Act (NEPA)**[2] applies where federal funding, land, or agency approvals are involved.[3] A CSU-led geothermal project would likely only trigger a NEPA review if the project pursued federal funding.[4] NEPA is not otherwise a routine consideration for campus infrastructure projects.

[1] Clean Water Act, 33 U.S.C. §§ 1251–1387.
[2] United States Environmental Protection Agency, *NPDES Permit Program Basics*. https://www.epa.gov/npdes/npdes-permit-basics
[3] National Environmental Policy Act, 42 U.S.C. §§ 4321–4370h.
Establishes federal environmental review requirements applicable only where federal funding, land, or approvals are involved.
[4] Council on Environmental Quality, *NEPA Implementing Regulations*. https://www.energy.gov/nepa/articles/nepa-regulations

5.1.2 California State Regulation

California's regulatory framework promotes safe well construction, protects surface water and groundwater quality, and preserves coastal resources. For closed-loop geothermal systems, regulatory oversight focuses on preventing cross-aquifer migration and protecting groundwater quality during installation. Ongoing water use regulation, basin allocation requirements, and system operations permits are generally not triggered for closed-loop systems. (These would only apply to open-loop geothermal systems that extract and reinject groundwater.)

Two state authorities are most relevant to geothermal system development:

- **The State Water Resources Control Board (SWRCB)[5]** establishes water quality policies, which are implemented at the regional level. Statewide groundwater and surface water protection policies are further informed by California's anti-degradation policy.[6]
- **The California Department of Water Resources (DWR)[7]** administers well construction standards (Bulletin 74). These standards govern drilling methods, casing, sealing, and abandonment practices and form the baseline requirements applicable to subsurface geothermal boreholes across California.

Three California regulatory considerations can shape geothermal siting and development:

- **Well construction standards.** The California Department of Conservation's Geologic Energy Management Division (CalGEM) regulates the drilling, operation, and closure of energy resource wells, which includes geothermal resources. Closed-loop geothermal systems are also governed by statewide well construction standards (DWR Bulletin 74) that address drilling methods, casing, and sealing to protect groundwater during borehole installation. Because closed-loop's heat exchange fluid circulates within sealed piping and remains isolated from groundwater, underground injection or discharge permits are generally not required. Projects undergo well construction review and coordination with county well permitting agencies and a Regional Water Quality Control Board (RWQCB) to confirm groundwater protection. Open-loop systems that involve groundwater extraction, reinjection, or discharge would be subject to additional evaluation under the Underground Injection Control (UIC) Class V well framework.
- **Coastal resource protection.** The California Coastal Act[8] establishes additional statewide considerations for campuses located within the Coastal Zone. Development activities that involve grading, trenching, or subsurface disturbance may require a Coastal Development Permit depending on location and site conditions[9]. For closed-loop geothermal systems, Coastal Act review is typically associated with land disturbance and access considerations rather than water use, and compatibility is evaluated through siting, construction methods, and restoration measures.
- **General environmental review.** The California Environmental Quality Act (CEQA) provides the procedural framework for geothermal system implementation and requires evaluation of potential environmental impacts and coordination with relevant agencies through established review processes. Closed-loop geothermal systems are typically reviewed under CEQA as campus infrastructure upgrades, which often qualify for streamlined review pathways, particularly when installed within existing campus footprints. CEQA[10] therefore functions primarily as a disclosure and coordination process rather than a substantive barrier to implementation.[11]

[5] State Water Resources Control Board, *Water Quality Control Plans and Policies*.
https://www.waterboards.ca.gov/plans_policies/
Establishes statewide water quality protection framework implemented through Regional Water Quality Control Boards.
[6] State Water Resources Control Board, Resolution No. 68-16, *Statement of Policy with Respect to Maintaining High Quality of Waters in California*.
https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/1968/rs68_016.pdf
[7] California Department of Water Resources, *Bulletin 74: California Well Standards*.
https://water.ca.gov/Programs/Groundwater-Management/Bulletin-74
Governs drilling, casing, sealing, and abandonment standards applicable to geothermal boreholes.
[8] California Coastal Act, California Public Resources Code §§ 30000–30900.
[9] California Coastal Commission, *Coastal Development Permits*.
https://www.coastal.ca.gov/permits/
[10] California Environmental Quality Act, California Public Resources Code §§ 21000–21189.
[11] California Governor's Office of Planning and Research, *CEQA Guidelines*.
https://opr.ca.gov/ceqa/

These statewide regulations establish the baseline framework for geothermal system review. While they are set at the state level, many are implemented by regional and local agencies. Additionally, specific regions or campuses may come with location-specific policy considerations: these are described in Section 5.1.3.

Table 14: State and National Regulatory Context for Closed-Loop Geothermal Systems

Regulatory Focus Area	Governing Framework	Regulatory Relevance for Closed-Loop Geothermal Systems
Safe Well Construction & Groundwater Protection	California DWR Bulletin 74, CalGEM, and statewide groundwater policies	**High.** Governs borehole drilling, casing, and sealing standards during construction
Coastal Resource Protection	California Coastal Act	**High.** Coastal Development Permit may be required for projects located within the Coastal Zone involving ground disturbance
Environmental Review	California Environmental Quality Act	**Medium.** Environmental review required for discretionary actions; typically focused on construction-related impacts
Underground Injection Control	Safe Drinking Water Act; State Water Board Class V well program	**Low.** Generally not applicable to sealed closed-loop systems; typically implemented through county well permitting and Regional Water Quality Control Board coordination, rather than separate injection permits
Federal Environmental Review	National Environmental Policy Act	**Low.** Applies only where federal funding, land, or approvals are involved
Federal Water Regulation	Clean Water Act	**Low.** Discharge permitting requirements generally not triggered where systems do not discharge to surface waters

5.1.3 Regional Policy Considerations

The statewide regulations described in Section 5.1.2 are implemented through regional and local agencies. For instance, counties are responsible for granting well permits and ensuring adherence to statewide construction standards. Individual counties' variable permit review timelines, documentation requirements, and inspection procedures may influence project coordination and scheduling.

Implementation specifics can differ by locality due to local hydrogeology, urbanization level, and other factors. Some campuses may have additional site-specific constraints. For instance, coastal campuses may be more affected by regional and local coastal protection ordinances. Campuses in highly urbanized areas may face additional construction or well restrictions. Some campuses—most notably CSU Channel Islands—may require more extensive Tribal consultation or cultural resource analyses. Campuses like CSU Monterey Bay, with its history of military activity and environmental contamination, would need to account for environmental quality monitoring activities and/or restricted subsurface zones. Table 15 summarizes known regional and campus-level considerations.

Table 15: Regional Policies Affecting Closed-Loop Geothermal Systems

Region	CSU Campuses	Primary Regional Policies	Region- or Campus-Specific Considerations
ALL	ALL	• County well construction ordinances • CEQA reviews by local lead agency	Coordination with county well permitting, RWQCB staff, and city or county CEQA authorities will affect construction
North Coast (RWQCB Region 1)	Humboldt	• North Coast Basin Plan • Coastal Act and Local Coastal Programs	• Coastal Development Permit may apply to subsurface construction within Coastal Zone • Environmental review may consider sensitive coastal resources during installation
San Francisco Bay Area	San Francisco, Cal	• San Francisco Bay Basin Plan	• Urban campuses face tight footprints and dense buried utilities, increasing logistics constraints on borefield layout and drilling

(RWQCB Region 2)	Maritime, East Bay, San Jose, Sonoma		• Brownfield and fill conditions may require more detailed geotechnical and environmental review to address contaminated soil or shallow groundwater.
Central Coast (RWQCB Region 3)	Monterey Bay, San Luis Obispo	• Central Coast Basin Plan • Coastal Act and Local Coastal Programs	• Coastal Development Permit may apply to subsurface construction within Coastal Zone • Coastal groundwater protection and seawater intrusion concerns focus review on borefield siting, loop depth, and grouting. • Sensitive coastal habitats or dune systems may affect construction access and layout
Central Coast (RWQCB Region 3)	Monterey Bay		• Former military use and resulting environmental land-use controls • Restricted subsurface zones and monitoring wells may decrease land availability and increase site-specific clearance and mapping needs for geothermal installation
Los Angeles Region (RWQCB Region 4)	Northridge, Los Angeles, Long Beach, Dominguez Hills, Pomona, Channel Islands	• Los Angeles Basin Plan • Adjudicated basin management frameworks	• Urban campus constraints and known groundwater contamination plumes can require careful borefield siting, documentation of drilling and grouting, and potential coordination with cleanup programs. • Highly managed groundwater basin conditions may require coordination during subsurface construction • CEQA and local construction permitting may add conditions related to subsurface utilities, noise, and management of contaminated soil/groundwater during drilling.
Los Angeles Region (RWQCB Region 4)	Channel Islands		• Cultural resource sensitivity and Tribal consultation requirements may affect CEQA review and may require earlier and closer coordination with Tribal and regulatory stakeholders • Potential archaeological monitoring or documentation requirements may affect construction sequencing and schedule
Central Valley (RWQCB Region 5)	Fresno, Bakersfield, Stanislaus, Sacramento, Chico	• Central Valley Basin Plans	• Agricultural utilities and irrigation infrastructure near some campuses may influence drilling access and staging • Note: The Sustainable Groundwater Management Act (SGMA) applies to groundwater extraction in Central Valley basins, but would not constrain closed-loop systems
Lahontan / High Desert (RWQCB Region 6)	San Bernardino	• Lahontan Basin Plan	• Arid-region hydrogeology may influence drilling design and monitoring
Santa Ana Region (RWQCB Region 8)	Fullerton	• Santa Ana Basin Plan and regional basin management policies	• Highly managed groundwater basin conditions may require coordination during subsurface construction • Urban campus constraints may influence borefield layout and staging
San Diego Region (RWQCB Region 9)	San Diego, San Marcos	• San Diego Basin Plan	• Variable coastal and inland aquifer conditions may influence borehole depth and spacing

5.2 Funding & Financing

Federal and state grants, federal tax credits, and local jurisdictional and/or utility incentives can defray the costs of geothermal system installation. This section summarizes grant and tax credits that are more broadly applicable to geothermal systems. Locally-specific funding and partners could be further cataloged for the highest-priority CSU campuses.

5.2.1 Grants

The U.S. Department of Energy and California Energy Commission have previously awarded competitive grants that may apply to geothermal projects, such as the Grid Resilience and Innovation Partnerships (GRIP) grant program or the Geothermal Grant and Loan Program. Depending on the scope of the award, CSU geothermal projects may be eligible for grant funding.

Historically, geothermal-related grants have gone to projects that add value to the broader geothermal field, such as projects that included grid modeling studies, supported industrial processes, or demonstrated feasibility in various geological conditions. For example, ARPA-E's SUPERHOT program focuses on supporting projects that develop novel technologies for energy production from super-hot reservoirs. Based on research of past and present grants, CSU may be a more competitive grant applicant if it considers innovative geothermal implementation applications or partnerships with local jurisdictions and/or nonprofit organizations.

5.2.2 Tax Credits

The landscape of federal tax credits for energy and energy-efficiency projects has changed dramatically since the One Big Beautiful Bill Act (OBBBA) modified key Inflation Reduction Act (IRA) energy provisions. As of early 2026, there are no significant federal tax incentives for future geothermal heat pump installations. However, geothermal electricity generation projects can still qualify for significant federal tax credits such as the 48E Investment Tax Credit (ITC) or 45Y Production Tax Credit (PTC) if they begin construction by 2033.[12] These programs offer a base tax credit, which can be supplemented by additional credits for projects that meet additional stipulations. The ITC and PTC are exclusive for the same facility, which means CSU cannot claim both credits for the same individual facility. The final updated rules for eligibility are still under development by the U.S. Department of Treasury.

5.3 Construction Considerations

5.3.1 Groundwater quality and waste management

A geothermal system uses heat transfer fluids, which can threaten environmental quality. These fluids, which range from antifreeze to refrigerants, must be appropriately managed when installing, operating, or decommissioning heat pump systems. Antifreeze is considered a hazardous waste. While many refrigerants are not toxic, they may have high global warming potential and should be stored and disposed of responsibly.

Geothermal well drilling also produces drill cuttings and drill mud (fluid) that can contain heavy metals and other hazardous materials. According to the California Code of Regulations (Title 2 Section 2138), drill cuttings and drill mud must follow special disposal processes that are approved by RWQCBs.[13] Since the nine RWQCBs are regional bodies, hazardous waste disposal requirements may vary regionally.

5.3.2 Drilling disturbances: soil and subsurface interaction risks

Geothermal heat pump operations do not significantly disturb subsurface conditions, but the process of drilling boreholes to depths of several hundred feet will impact the soil and can penetrate drinking water aquifers. Several CalGEM regulations apply to the drilling process:

- **Regulations to ensure site stability.** If construction of drilling sites could cause slumping, landslides, or unstable earth conditions, the operator must submit a written analysis prepared by a certified engineering

[12] Congress's "One Big Beautiful Bill" Will Shrink Renewable Energy Investments—Yet Some Technologies Are Preserved | Council on Foreign Relations
[13] https://www.law.cornell.edu/regulations/california/2-CCR-2138

geologist prior to any construction or permit approval (CalGEM Subchapter 4, Article 3 Section 1931.5). CalGEM regulations also prohibit well drilling in unstable areas, though this is unlikely to apply to CSU campuses given their distance from geysers or hot springs (CalGEM Subchapter 4, Article 4 Section 1942.1).

- **Regulations to minimize drilling impacts.** Wells must be drilled in a manner to protect or minimize damage to the environment and usable ground waters (CalGEM Subchapter 4, Article 3 Section 1930).[14]

If installed properly by licensed well drillers using appropriate techniques, the proposed closed-loop geothermal systems should be able to avoid major soil disturbance and contamination of soil or aquifers.

5.3.3 Access needs for drilling, construction, and operation

Compared to horizontal closed-loop systems, vertical closed-loop systems take up less surface areas but may reach borehole depths of several hundred feet, depending on the amount of piping required. Mineral rights grant their owner the legal authority to extract and utilize resources beneath the surface so long as they adhere to state and federal laws governing resource extraction. Surface rights grant ownership and use of the land's surface and resources. As the CSU Board of Trustees owns all real property of the CSU system, which includes mineral and surface rights, CSU does not need to establish land or drilling access through another party.[15]

Additional access considerations include subsurface utility assets, such as water lines, sewer lines, natural gas pipelines, underground power lines, and telecommunication lines. Vertical closed-loop geothermal heat pump siting will require coordination with relevant utilities to avoid conflicts with utility rights-of-way.

5.3.4 Equipment and labor availability

One of the largest implementation bottlenecks for geothermal projects is the supply of licensed, qualified drilling contractors. Geothermal drillers must have a C-57 Well Drilling Contractor license from the California Contractors State License Board.[16] This license allows a well drilling contractor to install and repair water wells and pumps. There are approximately 700 licensed C-57 contractors in California, most of whom do not specialize in vertical-bore geothermal construction.[17] Heat pump contractors are also required to have a C-20 Warm-Air Heating, Ventilating, and Air-Conditioning license or a C-36 Plumbing license for installation in California.[18]

Geothermal projects also need to account for long lead times to reserve or purchase drilling equipment and heat pump systems. Installing closed-loop geothermal heat pumps requires specialized equipment, such as drilling rigs, casings, coil insertion units, thermally-enhanced grout, and loop piping. Drilling technologies continue to advance, which may diversify CSU's installation options but add complexity to the contracting and implementation process. The supply chains for the heat pump itself are less geographically concentrated and thus subject to fewer bottlenecks, but raw materials may experience shortages, resulting in delays for key heat pump components.[19] Furthermore, industry shifts towards refrigerants with lower global warming potentials may lead to supply chain challenges with the new refrigerants and their associated parts.

[14] https://www.conservation.ca.gov/calgem/geothermal
[15] https://www.calstate.edu/csu-system/doing-business-with-the-csu/capital-planning-design-construction/operations-center/Pages/real-property-records-transactions.aspx
[16] https://www.cslb.ca.gov/about_us/library/licensing_classifications/Licensing_Classifications_Detail.aspx?Class=C57
[17] CSLB Public Data Portal
[18] https://www.cslb.ca.gov/Resources/GuidesAndPublications/2023/Fast_Facts_for_Heat_Pump_Water_Heaters_and_HVAC_Heat_Pumps.pdf
[19] https://www.iea.org/commentaries/is-a-turnaround-in-sight-for-heat-pump-markets

6. Recommendations

The findings of the criteria-based analysis indicate that the three campuses with the highest overall technical feasibility for implementation of a geoexchange system are Cal Poly San Luis Obispo, CSU Channel Islands and Cal State San Marcos, with several over showing good favorability for geoexchange.

When looking at the individual campus ranking for Geothermal Resource and Campus Infrastructure separately (Table 11 and Table 12) several additional campuses demonstrate strong potential, particularly on the Campus Infrastructure scoring. The final scoring criteria in these tables summarize projected system efficiency and infrastructure compatibility, rather than the broader conditions required to implement a geothermal system. Therefore, campuses that score highly, particularly in Campus Infrastructure, should be viewed as technically strong candidates.

However, technical feasibility does not automatically translate into implementation readiness, and it is important to distinguish between the two. A campus may rank highly from an engineering perspective, yet may not be positioned organizationally, financially, or strategically to advance a project of this scale. While this Geothermal Resource Study evaluates comparative technical feasibility, it does not assess institutional readiness, capital prioritization, leadership alignment, risk tolerance, or stakeholder support, each of which can materially influence whether a technically feasible project ultimately advances. Successful implementation will require alignment across technical conditions, capital planning cycles, executive sponsorship, facilities staffing capacity, and long-term decarbonization priorities. Even a technically favorable site may not move forward if these conditions are not present. Accordingly, prior to initiating detailed feasibility studies, AECOM recommends conducting a structured campus readiness assessment to confirm leadership commitment, risk appetite, and integration with existing capital plans.

Thus, AECOM recommends the following process is undertaken to assess institutional readiness prior to initiation of a more detailed feasibility study.

- All Tier 1 campuses are considered for progression into Phase 2, as follows:
    - Cal Poly Pomona
    - CSU Channel Islands
    - Cal State San Marcos
- All campuses that score 3.8 or higher on the Campus Infrastructure scoring should be considered for progression into Phase 2. This includes:
    - Cal State Long Beach
    - Sonoma State
    - Cal State San Bernardino
    - Cal State Northridge
    - Stanislaus State
    - Cal State Bakersfield
    - Cal State Monterey Bay
- The resulting group of ten campuses participate in structured engagement discussions, led by the Chancellors Office, to better understand current decarbonization initiatives, capital planning priorities, infrastructure modernization timelines, and overall institutional interest in advancing a geoexchange system
- Based on the results of this readiness review, the highest-ranking campus(es) demonstrating both strong technical suitability and institutional alignment be selected to proceed with a more detailed feasibility analysis under Phase 2 of this project.

Appendix A

A.1 Geothermal Resource Methodology

The methodology applied to assess the Geothermal Resource potential that is outlined in this study utilized desktop research with publicly available resources, as well as geotechnical reports provided for some campuses. Developing detailed site-specific geothermal resource availability would require field investigations that are beyond the scope of this report.

Deep Geothermal Systems

Deep Geothermal Systems assessed in this report include both *Direct Use Geothermal*: the utilization of naturally heated groundwater or geothermal fluids for thermal energy applications via deep geothermal bores; and *Geothermal Electricity Generation*: power generation technologies requiring high-temperature subsurface resources, including conventional hydrothermal systems via deep geothermal bores and emerging engineered approaches.

- Deep geothermal systems are dependent on favorable geothermal conditions to be feasible.
- Feasibility for deep geothermal resource development is highly site-specific, with viability varying significantly by location.

Criteria-Based Screening Framework

Background: Deep geothermal resources require three main geologic components: heat, circulating fluid, and permeability.

1. **Heat**: Heat sources for conventional geothermal systems are generally associated with magma or shallow crust with high geothermal gradients (a rapid increase in temperature with depth). Magma is found at depth beneath volcanic features. Thermal springs are often found in volcanic regions close to magma, but can also be a result of deep circulation of fluids in areas with a high geothermal gradient
2. **Fluid**: Geothermally heated fluids serve to transport heat from depth to the surface. These fluids are generally naturally occurring groundwater or geothermal brines, but external fluids can also be introduced into geothermal systems to enhance their viability (such as the injection of treated wastewater at the Geysers geothermal site).
3. **Permeability**: Fluids must have a pathway to flow from depth to the surface where they can be utilized as a geothermal resource. This permeability is usually by way of naturally occurring faults or fractures in the subsurface. Geothermal fluids circulate along deep faults and are heated by magmatic sources or by hot rock in areas with an elevated geothermal gradient in order to serve as geothermal resources.

Data Sources: State and National datasets were used for the criteria screening. Specific datasets used are noted below for each criterion. These datasets are available on the Interactive Map included with this study deliverables.

Geologic Criteria and Feasibility Scoring Approach for Deep Geothermal Systems

The following criteria were used to assess the potential for deep geothermal system viability across the CSU campus sites:

Proximity to Volcanoes

Distance to a volcanic heat source (magma/hydrothermal fluids) for development of geothermal power is a key criterion. Most geothermal power plants around the world are located at or very near volcanic sites (the Geysers geothermal site being a notable exception). Thus the scoring approach assigns high scores to sites that are close to volcanoes, and lower scores are assigned with increasing distance from volcanoes.

Data source: https://www.arcgis.com/apps/dashboards/edc977dddeb9468999c95cd5d32a3f69

Proximity to Thermal Springs

As with volcanoes, the distance to thermal springs hot water (hydrothermal fluids) for development of geothermal power or direct use of hot water is a key criterion. Thus the scoring approach assigns high scores to sites that are close to thermal springs, and lower scores with increasing distances.

Data source: https://caltrans-gis.dot.ca.gov/arcgis/rest/services/CHhqenvi/DEA_Mineral_Hazard/FeatureServer/3

Spring Temperatures

Temperatures of surface spring waters (°F) are an indicator of potential hydrothermal fluid temperatures at depth. Deep, circulating hydrothermal fluids can mix with cooler shallow groundwater. Springs that have moderate temperatures at the surface may be connected to deeper reservoirs of higher temperature fluids. Potential for electricity production generally starts at a minimum of 180°F; potential for direct use starts at a minimum of 100-120°F. The scoring approach thus assigns high scores to springs with higher temperatures, and lower scores to springs with lower temperatures.

Data source: https://caltrans-gis.dot.ca.gov/arcgis/rest/services/CHhqenvi/DEA_Mineral_Hazard/FeatureServer/3

Temperature at Depth

Relative temperature at depth (3 to 10 km) is also an indicator of a potential geothermal resource for development, even in the absence of hydrothermal systems (fluid) at depth. Higher temperatures equate to higher favorability for potential geothermal resources. Top scores are assigned to sites designated (as per the NREL data set) to have Very High Favorability, with lower scores assigned for successively Lower Favorability.

Data source: https://services5.arcgis.com/njRHYVhl2CMXMsap/arcgis/rest/services/EGS_Favorability/FeatureServer

Proximity to KGRAs

Distance to Known Geothermal Resource Areas (KGRAs) with proven development capabilities is another correlation to geothermal resource potential. There are several KGRAs across the state of California. Sites that are located closer to these known/developed resources are more likely to have potential for development of geothermal resources. Thus higher scores are assigned to sites that are a short distance from KGRAs, and successively lower scores are assigned to sites that are a greater distance from KGRAs.

Data source: https://cecgis-caenergy.opendata.arcgis.com/documents/CAEnergy::known-geothermal-resource-areas/explore?path=

Proximity to Faults

Faults serve as pathways for thermal fluids to reach the surface and thus are a key component to geothermal systems. Distance to geologic faults is thus an important criterion. For the scoring approach, sites closer to faults received higher scores, and lower scores were assigned with increasing distance from faults.

Data source: https://maps.conservation.ca.gov/cgs/gmc/

Geoexchange Systems

Geoexchange systems utilize the relatively stable temperatures of the shallow subsurface to provide efficient heating and cooling for buildings. These systems exchange heat with the ground through sealed piping installed vertically or horizontally.

- Closed-loop ground source heat pump systems can provide campus heating and cooling through shallow subsurface heat exchange.
- Geoexchange is feasible almost anywhere, but efficiency varies based on subsurface conditions (rock and soil type).

Criteria-Based Screening Framework

Background: Geoexchange systems take advantage of the nearly constant temperatures encountered within the shallow subsurface. In California, on average at depths of 10 to 15 feet below ground surface, temperatures are generally around 55°F. During the winter, ground temperatures are often warmer than ambient air temperatures, so the ground heat can serve as a *heat source* for indoor heating. During the summer, the ground temperatures are generally cooler than the air temperatures, so the ground can serve as a *heat sink*. Note that the ground is not actually providing cool air to buildings like an air conditioner, but rather, heat is pushed out of buildings into the ground, in the way that heat is pushed out of refrigeration units.

This transfer of heat through the ground, known as the *conduction* of heat through the subsurface, is one of the key parameters for a geoexchange system. The ability of the subsurface to transfer heat is referred to as *thermal conductivity*. Dense and moist materials conduct heat more efficiently than loose or dry materials. Thus, rocks have higher thermal conductivity than soil. Hard, crystalline rocks such as granite or metamorphic rock conducts heat more efficiently than soft, friable rocks such as sandstone or other sedimentary rocks. In like manner, dense, moist soils conduct heat more efficiently than loose dry soils.

Thermal conductivity can be measured by various tools in the field at specific sites. Thermal conductivity testing would be a necessary step at a given site to determine the required design of a geoexchange system for the given heating and cooling demand. Thermal conductivity testing may include the use of heat-flow meters, transient line source probes, transient plane source sensors, or testing with various needle heat probes. More advanced thermal response testing would be conducted with circulating fluids once a borehole has been drilled. Prior to site-specific testing, however, subsurface data on rock and soil types can provide an approximation of thermal conductivity.

For this Phase of the study, rock and soil data were reviewed across the campus sites to determine the relative potential thermal conductivity at the sites. Note that the rock and soil data can vary within a campus property, and at this Phase, the potential project sites on a given campus are not yet defined. So thermal conductivity potential can vary even within a campus location.

Data Sources: Site-specific data on subsurface rock and soil types were available from geotechnical reports for some campus locations, and that data was preferentially used when available. However, site-specific subsurface data was not available for most campuses. Thus, State and National datasets were used for most of the criteria screening. Specific datasets used are noted below for each criterion and are available on the Interactive Map included with this study deliverables.

Geologic Criteria and Feasibility Scoring Approach for Geoexchange Systems

The following criteria were used to approximate thermal conductivity across the CSU campus sites:

Depth to Bedrock

The depth below ground surface (bgs) at which bedrock is encountered directly relates to subsurface thermal conductivity. Bedrock has higher thermal conductivity than soil so shallow bedrock is more favorable for geoexchange systems. Shallow bedrock generally provides the highest efficiency for geoexchange systems. Thus bedrock at or near the surface received the highest score, with lower scores given for increasing depth of bedrock.

Note that the cost of borehole drilling is not assessed herein with geologic feasibility. Bedrock drilling requires more advanced drilling equipment compared to drilling in soils, so the cost to drill in bedrock can be greater. However, boreholes drilled in soils are more prone to collapse and often require re-drilling, so in some cases, drilling in soils can be equally costly. The economics of drilling would be assessed in future phases of this CSU project.

Data source: https://landscape11.arcgis.com/arcgis/rest/services/USA_Soils_Bedrock_Depth/ImageServer

Rock Type / Thickness

Type of rock present (i.e. crystalline, sedimentary) and relative thickness (i.e. massive, thinly bedded) directly relates to thermal conductivity. Thicker layers of dense rock types have higher thermal conductivity. Thus for the scoring approach, thick (massive) layers of hard, crystalline rock (such as granite or metamorphic rock) received the highest scores. Thinner beds of crystalline rock and massive sedimentary bedrock received lower scores, followed by thin sedimentary rock and porous or highly weathered rock receiving the lowest feasibility score.

Data source: https://maps.conservation.ca.gov/cgs/gmc/

Soil Consistency

The soil consistency criterion considered the soil type, and the density/hardness of soil present. More dense/hard/compact soils have higher thermal conductivity and are more favorable for geoexchange systems. Soils that are dense/hard/compact thus received the highest score, with decreasing scores for softer/looser soils. Very loose or soft soils such as dune sand received the lowest scores.

Site-specific field data collected for future work could include “Standard Penetration Testing” which measures soil/sediment density.

Data source: https://casoilresource.lawr.ucdavis.edu/gmap/

Depth to Groundwater / Soil Moisture

The depth at which groundwater is encountered and/or levels of soil moisture impact thermal conductivity in the subsurface. Wet/saturated soils have higher thermal conductivity than dry soils, because heat conducts more efficiently through soil pore spaces that are filled with water rather than air. For this phase of the study, groundwater levels were used as a proxy for soil moisture. Sites with measured shallow groundwater scored higher, and scores were lower in sites with increasing depth to groundwater.

Note that there is not always well data with depth to groundwater data available for the exact campus locations, so in some cases, data was extrapolated from the nearest tested well adjacent to the campus. Note also that groundwater levels vary throughout the year, and can vary greatly across short distances. Assessing soil moisture and groundwater conditions can be highly complex and would need to be assessed more closely with site-specific study in future phases of the project.

Data source: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels