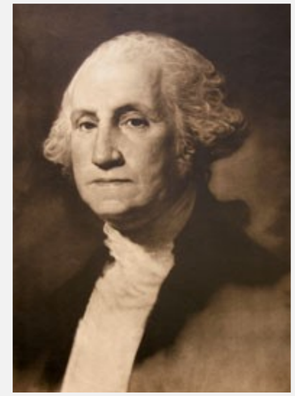
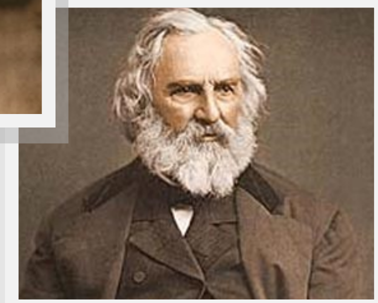
Geothermal Restoration Of Longfellow National Historic Site

5 Year Performance Review

NATIONAL PARK SERVICE





Headquarters for George Washington

From July 1775 to April 1776 George Washington occupied the Cambridge mansion (later to become poet Henry Wadsworth Longfellow's home) that had been abandoned by Loyalist John Vassall and his family. Washington used this house as his headquarters while the Continental Army lay siege to the city of Boston.

National Historic Site

Today, the Longfellow House is a national historic site maintained by the National Park Service (NPS). The house and grounds are considered to be one of the most revered historical sites in America.

Unfortunately for the site, its heating and air system was facing severe mechanical and technical difficulties. The geothermal system was having great difficulty in maintaining appropriate temperature and humidity levels for one of the nation's finest examples of Mid-Georgian architecture.

Due to its age and almost exclusively wooden structure, maintaining temperature and humidity control was critical in preserving the integrity of the structure and its historical artifacts.

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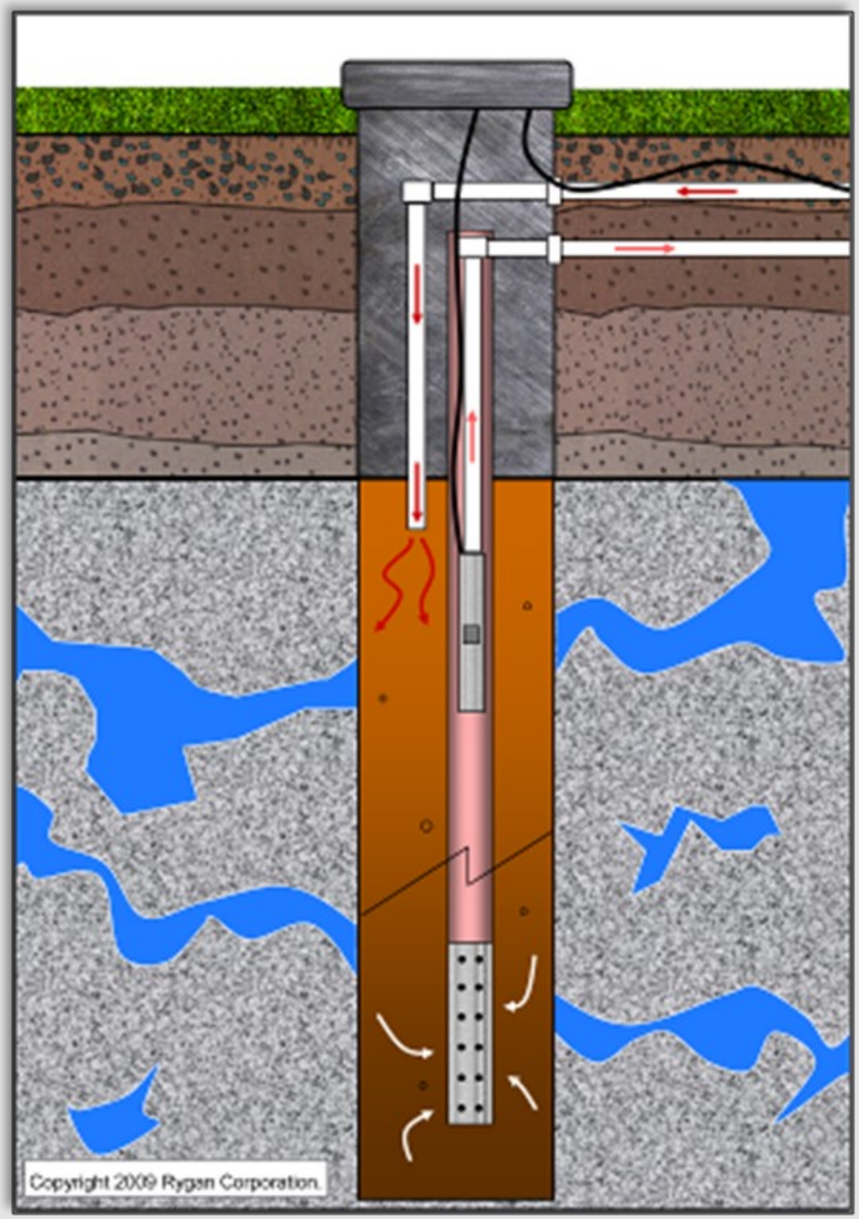
Geothermal system failure at Longfellow



The Perils of Direct Geological Exposure - *This SCW diagram illustrates iron fouling, a result of direct exposure to groundwater with iron content. Pumps exposed to poor water chemistry are vulnerable to bio-fouling and clogging which result in perennial maintenance.*

Standing Column Wells (SCW)s and the Longfellow House

The geothermal heating and cooling for the Longfellow House was driven by two standing column wells (SCWs). SCWs pump water from a source well(s) where it is circulated directly through a heat pump and then deposited back into the same well. Because SCWs re-circulate the same water, they are particularly susceptible to common water quality problems. Brackish water, water with iron or manganese oxides, bacteria or air entrapment can compromise performance with encrustation or bio-fouling.

After 10 years of problematic operation, the two Longfellow SCWs ultimately failed due to iron fouling and broken shrouds. Because the SCWs couldn't deliver the thermal energy required by the heat pumps they were forced to rely on back-up electrical strip heating. Massive electrical use and cost was the consequence.

The wells became contaminated with iron and suspended solids which plugged the system's heat exchangers and pipes.

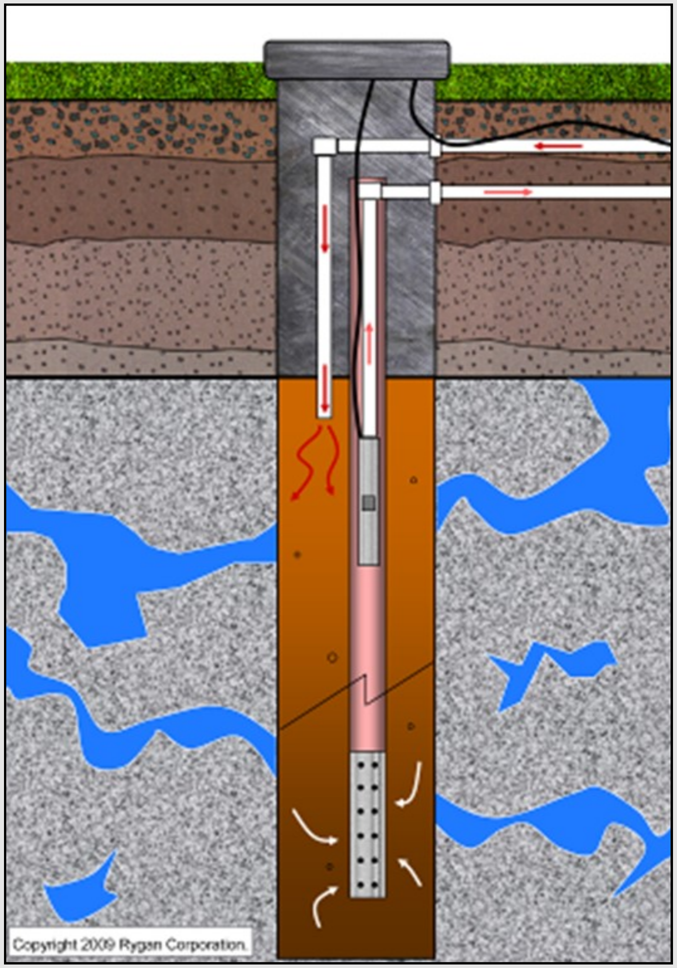
This pump was ruined within two years due to iron deposits.

No Place to Go

The site grounds presented numerous constraints and archeological barriers to drilling or land disruption. Replacing the failed SCW's with a traditional polyethylene based, closed loop system would have required drilling and trenching for 20 well bores - an impossibility for the site.

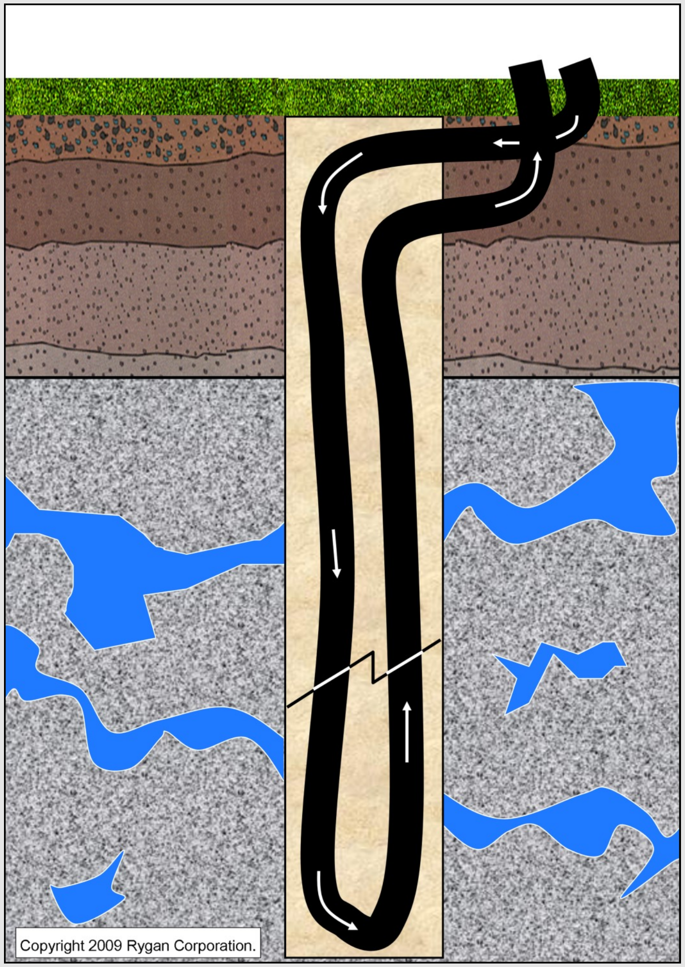
The National Park Service was faced with filling in the existing SCW's and then exploring alternate systems. This would mean the loss of a substantial drilling investment and potentially having the site's aesthetics negatively altered by outdoor condensing units. The NPS commissioned AMEC Foster Wheeler to design a closed loop solution that was compatible with the site constraints. AMEC recognized the composite based HPGX (High Performance Geo Exchange) system from Rygan Corporation as the only one capable of meeting the requirement. The systems superior heat transfer capabilities coupled with it's ability to deploy to depths of 1,000 feet (305 meters) or more meant it could provide the required capacity within the space available to drilling.

Comparison of ground loop heat exchange systems



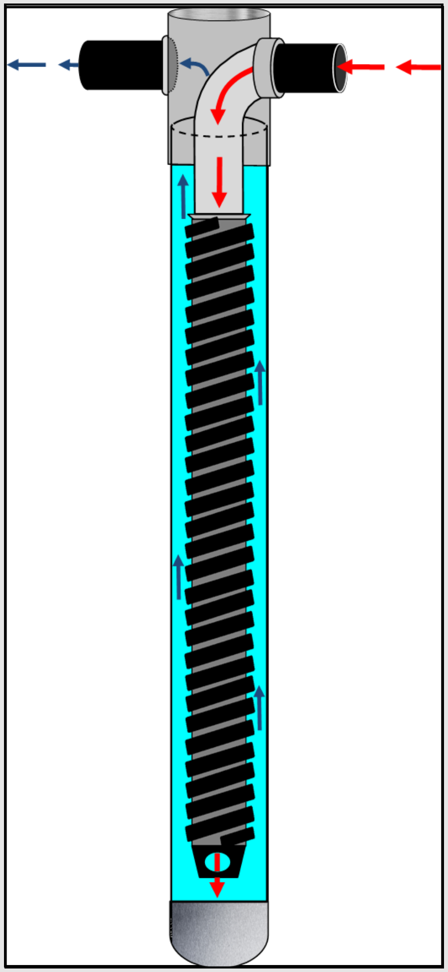
SCW - Open

The open or standing column well ranks highest in thermal performance but provides zero protection against ground water elements. These systems are only viable in formations with soft, non mineral laden water at adequate production rates.



Poly U-bends - Closed

Provides low cost protection against ground water elements but has poor heat transfer characteristics. Additional bores are required to overcome the high resistance and thermal mass of polyethylene and it's clay backfill.



HPGX - Closed

Composite based HPGX provides superior strength to poly with the ability to deploy at greater depths. The materials low thermal resistance provides performance similar to a SCW without a bleed.

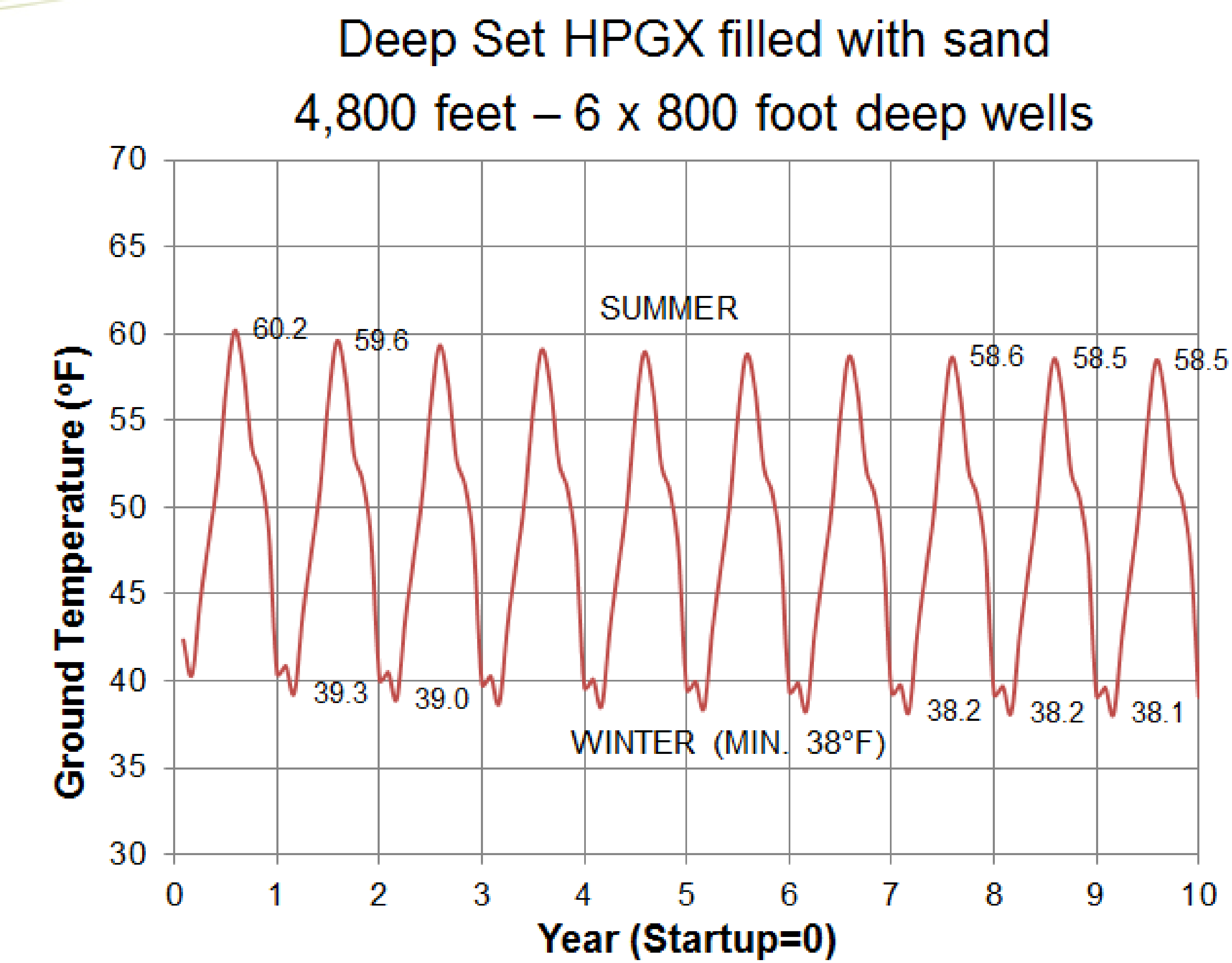
Collapsed porter shrouds of the failed system being removed, note the orange stain from iron fouling

HPGX casing being lowered into a well bore

A stainless steel Rygan well head specially configured for data collection and monitoring.

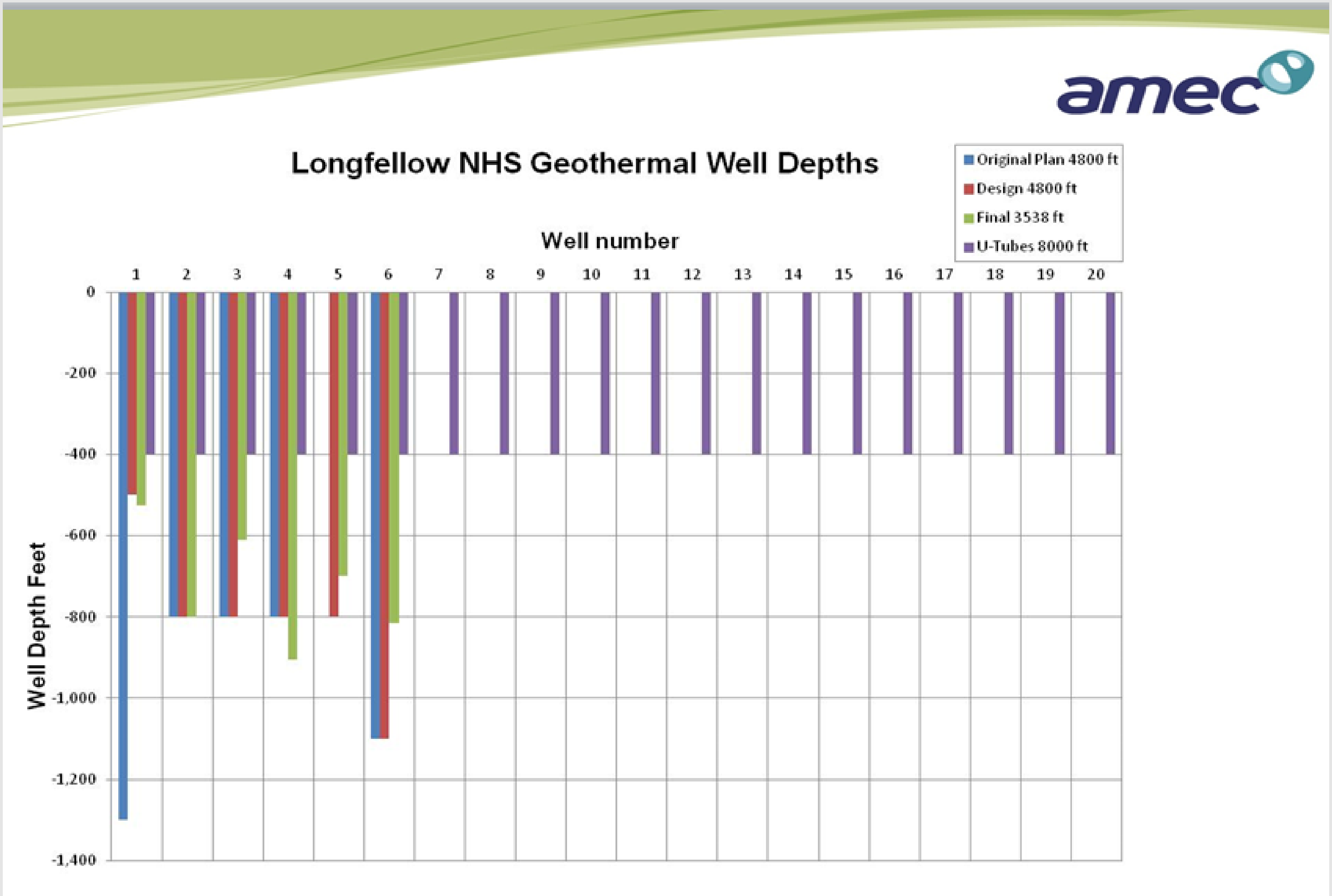
Projected performance - Design and computer simulation of long term well field capacity

AMEC utilized the computer modeling program GLHE-Pro to determine the number and depth of HPGX wells needed to service the 40 ton (140kw) heat load. The program suggested 6 HPGX wells at 800ft. to provide adequate capacity for four, 10 ton heat pumps as shown in the graph below. A common 1.25" u-bend was projected to need 10,250' linear feet or 25 bores at 410ft.



Geology and site conditions did not permit the planned design

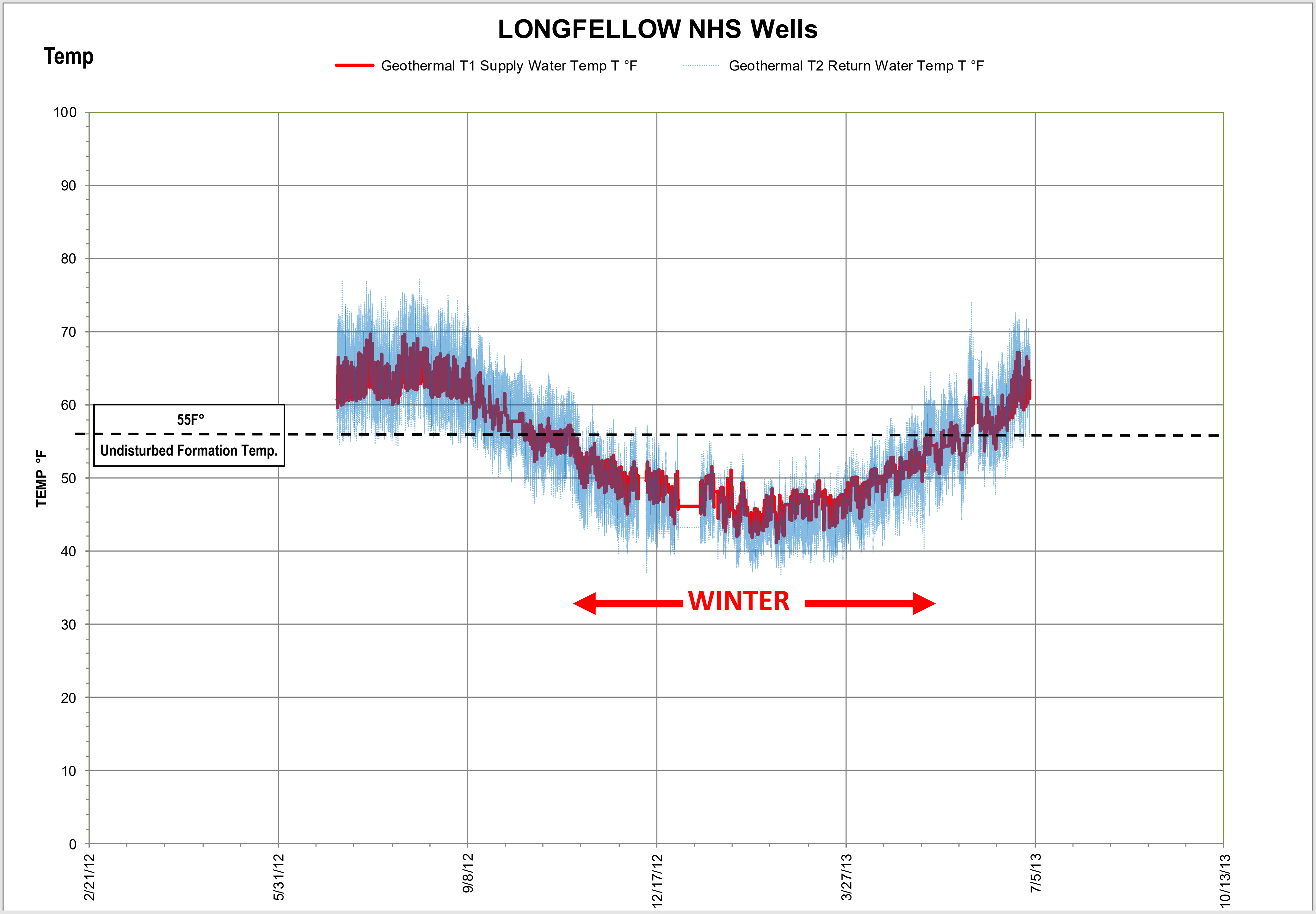
Failed porter shrouds and geologic conditions prevented drilling to 800’ on three of the wells. One well was drilled slightly deeper than designed. Ultimately 3,500’ feet was installed, 25% less than the intended, software based design.   The installed well field was 87 linear feet per ton rather than the intended 120 foot per ton.



Geo-exchange field installed under the circle drive with no disruption to site grounds

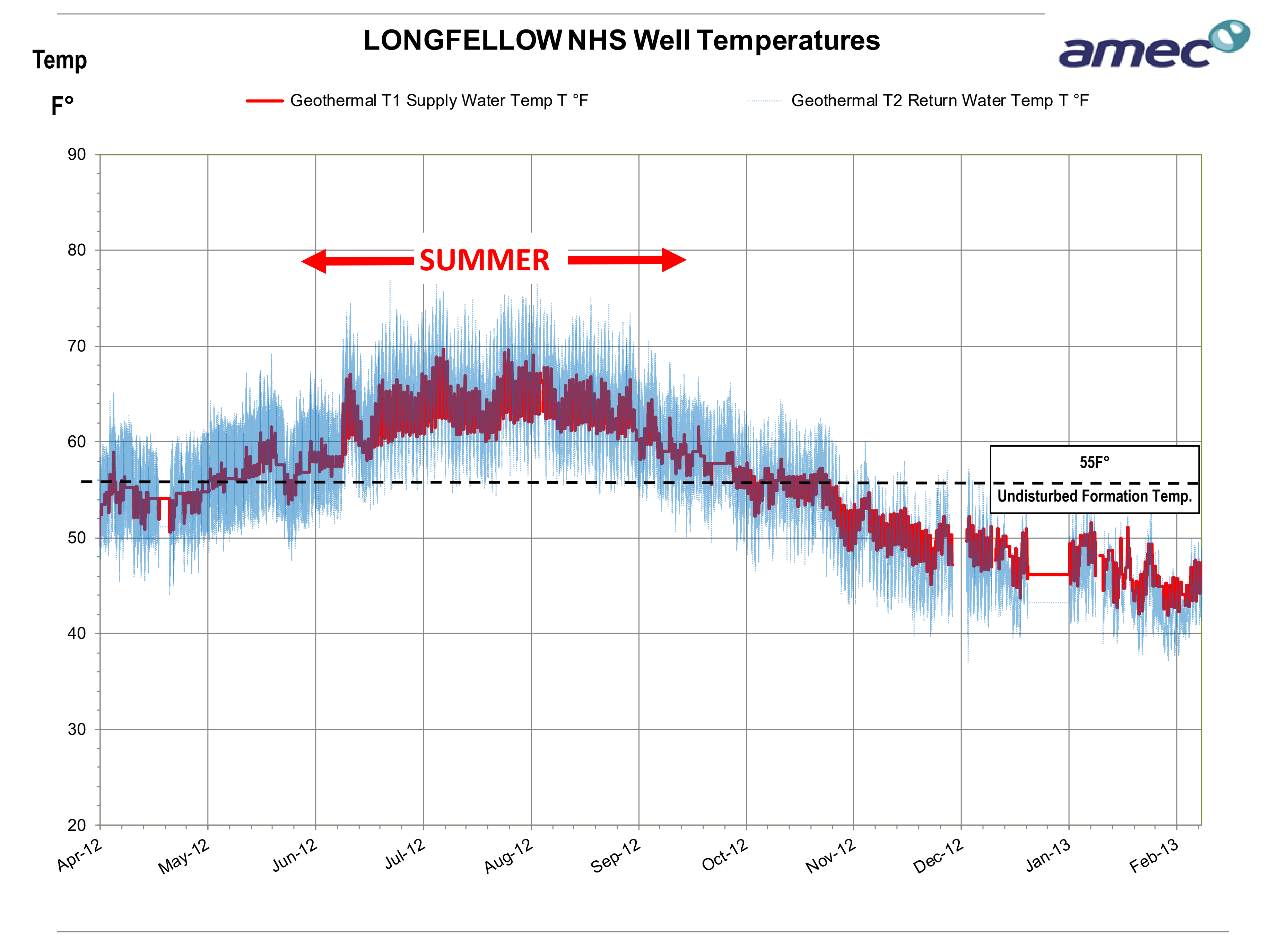
Performance on 87' per ton

Even though the well field system was 25% less than the original design, it's thermal performance exceeds the original computer based projections.   .



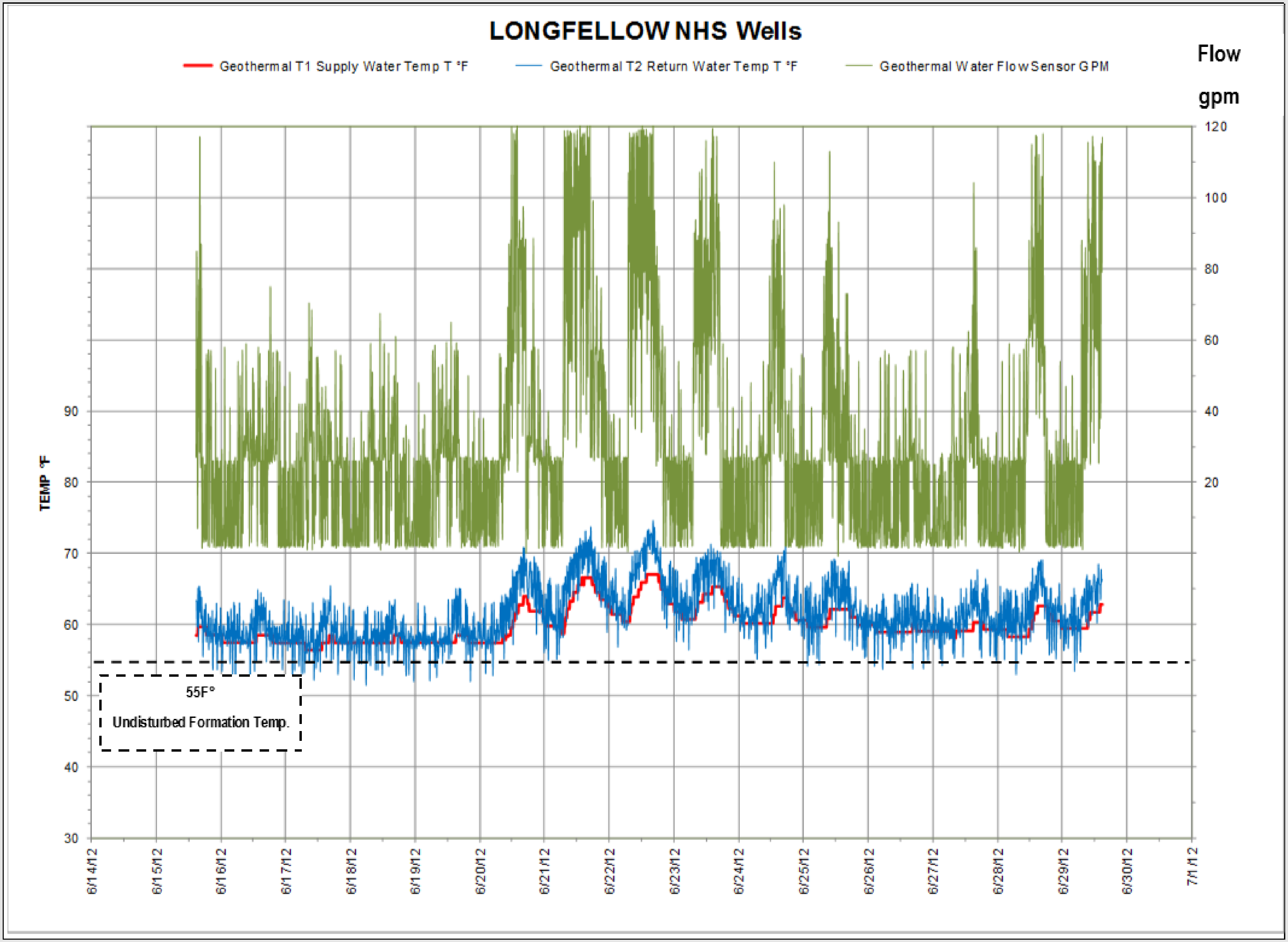
High Performance, year after year

The heat pumps at Longfellow not only have the protection of a closed system, it's performance is so efficient that glycol is not needed in the well field. Even though there is a back up boiler, the water supplied by the field has never dipped below 42F in the winter and has never exceeded 70F in the summer.



System Flow Rates

System flow rates increase as more heat pumps are called on to support the building loads. The graph below illustrates how field temperatures respond sympathetically to increased flow rates.



Award winning technology

The HPGX system at Longfellow was commissioned in May of 2011 and throughout it's five years of operation, field performance has been unprecedented for a closed loop system. The entering water temperature (EWT) has averaged 52°F year over year, roughly the formations beginning and undisturbed temperature.

In 2012 the ACEC (American Council of Engineering Companies) awarded AMEC / Foster Wheeler the Excellence in Engineering award for the Rygan based geothermal restoration of the Longfellow National Historic Site.

Awarded for Excellence in Engineering

2012

ACEC

American Council of Engineering Companies

100 Years of Excellence

HPGX Geothermal - Longfellow House

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