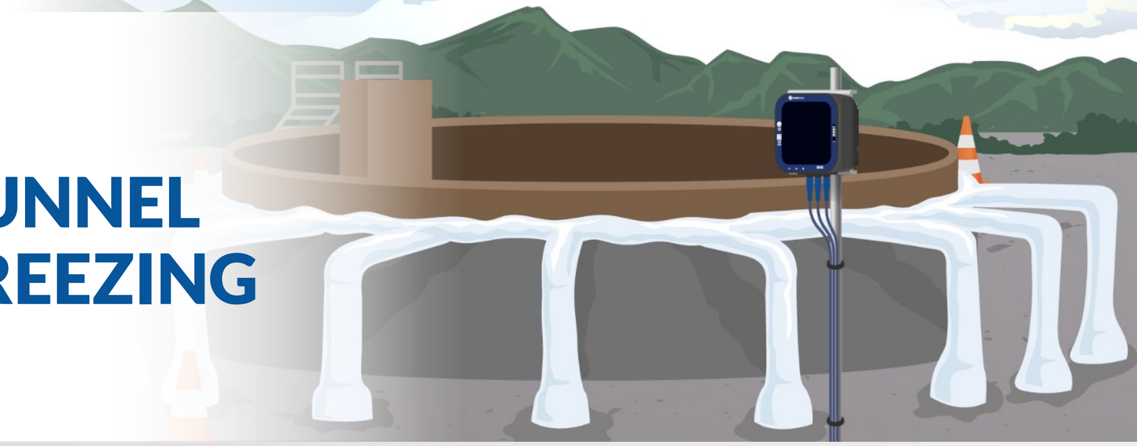

OUTFALL TUNNEL GROUND FREEZING

CASE STUDY

KELLER

New York, USA

The shafts for an outfall tunnel in New York required shoring for excavation support and groundwater control. Since there was limited room at site, ground freezing was selected to provide the shoring, instead of a diaphragm wall.

*Ground temperature monitoring was a critical component, to allow for modeling of the freeze bulbs and to verify when it was safe to begin excavation of the shaft. **beaded**stream Digital Temperature Cables allowed Keller to monitor the ground temperatures with tight sensor spacing, while using their preferred data logger.*

Application

Due to site restrictions at the wastewater treatment plant, there was not room to construct a diaphragm wall at the launch shaft of a 2.6 mile (4.2km) long outfall tunnel. Keller provided temporary excavation support and groundwater control for both the launch and receiving shafts via ground freezing, which required less room to implement.

The launch shaft was 125ft (45.7m) deep, 35ft (10.7m) diameter. It required 49 freeze pipes to be drilled around the circumference at 3ft (0.9m) centers and an additional 9 within the shaft footprint. Each freeze pipe was 150ft (45.7m) deep, deeper than the shaft itself, as a bottom plug was required to freeze permeable sands in this zone. For 6 weeks, -22°F (-30°C) chilled brine fluid was circulated through the pipes to freeze the ground. A similar process was used for the 102ft (31.1m) deep, 30ft (9.1m) diameter receiving shaft.

Ground temperature profiles provided important data to allow the project team to model and analyze the progress of the freeze bulbs, prior to approving the excavation of the shafts.

A Digital Temperature Cable in the foreground with the launch shaft in the background.

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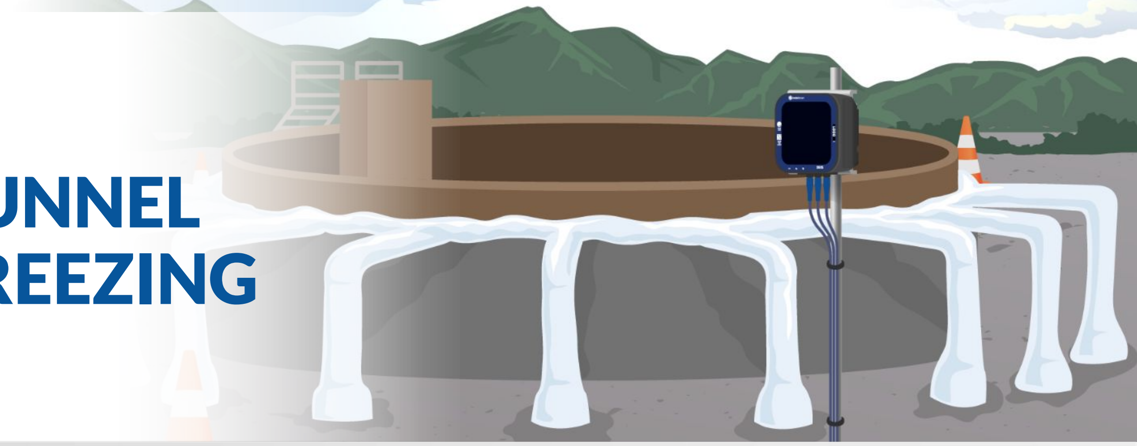


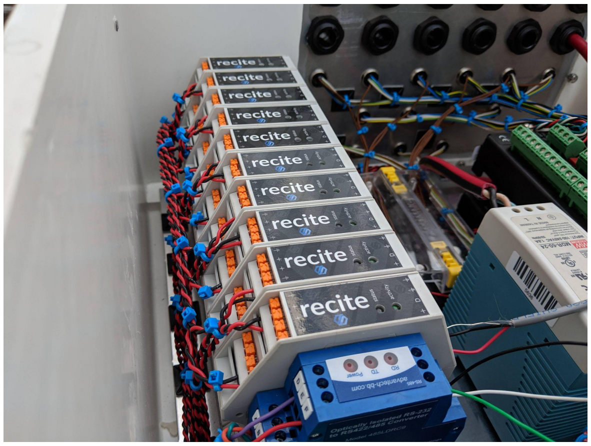
beadedstream Solution

To monitor the progression of the freeze bulb in the ground, Keller used 7x 170ft (51.8m) **beaded**stream Digital Temperature Cables with 31 sensors each for the launch shaft and 7x 140ft (42.7m) Digital Temperature Cables with 25 sensors each for the receiving shaft. For each shaft, there were 4 cables directly inside the freeze pipe circle and an additional 3 cables outside the frozen shaft.

To monitor the heat transfer through the freeze pipes, they used an additional 3 cables at each shaft for monitoring the chilled fluid temperature. Each cable had 20 stainless steel sensors that were offset from the main cable via a wye-mold and were inserted into a thermowell on the pipes themselves.

All of the cables were terminated into **beaded**stream Recite Interfaces, which were connected to a Campbell Scientific Data Logger, via the SDI-12 digital protocol.

A Digital Temperature Cable within the frozen perimeter.



Recite interfaces inside a Campbell Scientific Data Logger enclosure.

beadedstream Solution Benefits

To adequately monitor the freeze bulb and freeze pipe heat transfer, Keller deployed at least 20 sensors for each cable. Our digital cables easily accommodated each monitoring location sensors on a single 0.28in. (7mm) diameter, 3 conductor cable.

They were able to easily configure our cables into their Campbell Scientific Data Logger via Recites interfaces. Each cable required only 1 data logger channel. They monitored other sensors such as vibrating wire piezometers and flow meters with the same data logger.

The digital cables replaced analog thermistor strings, which increased in diameter as more sensors are added, were limited to 15-20 sensors maximum per string and required 1 data logger channel per sensor. This allowed Keller to streamline their processes and collect the required data.