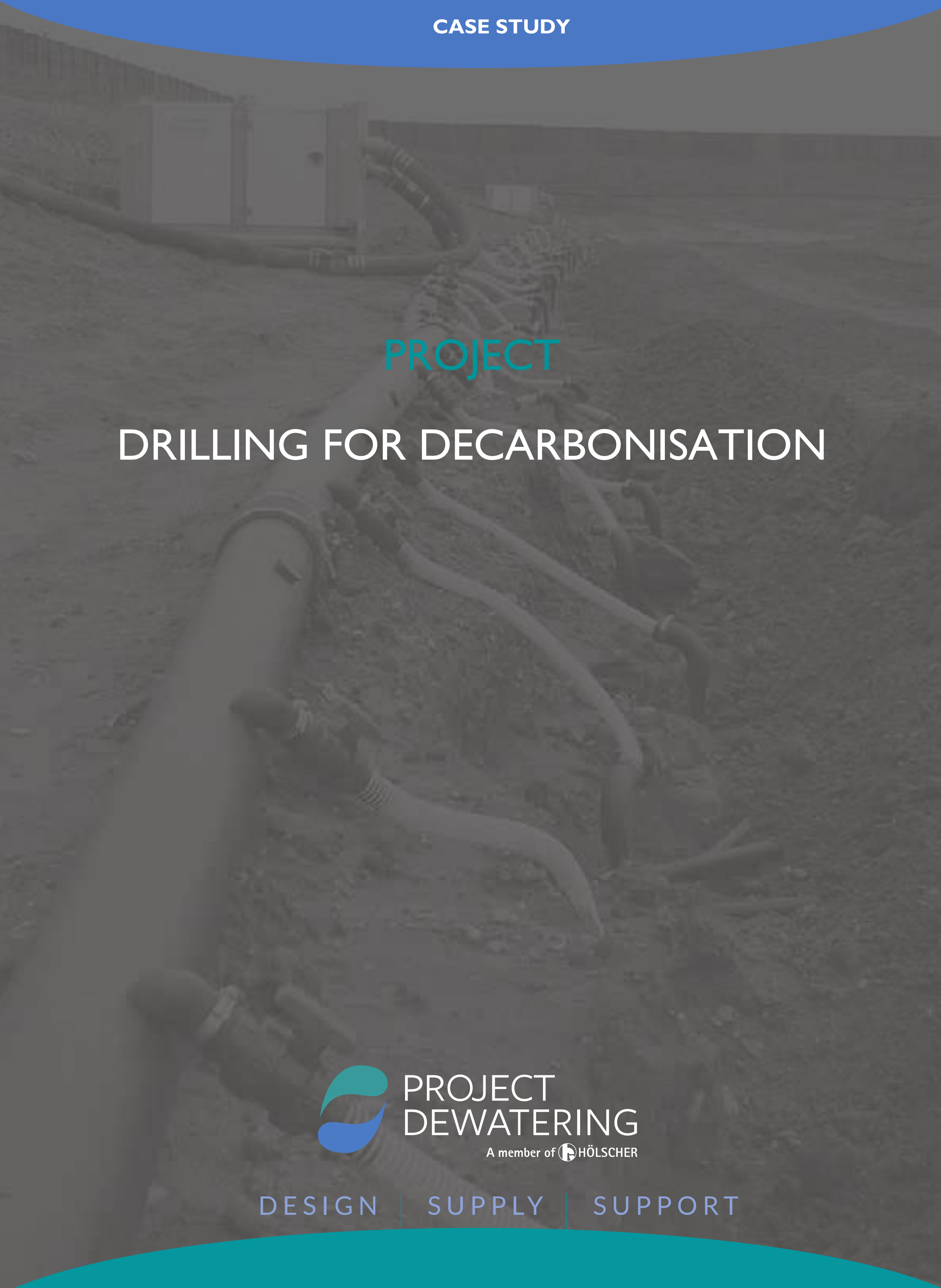
CASE STUDY



PROJECT

DRILLING FOR DECARBONISATION

PROJECT DEWATERING

A member of HÖLSCHER

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DRILLING FOR DECARBONISATION – CASE STUDY

SUMMARY

Decarbonisation is the process of reducing or eliminating carbon dioxide (CO_2) emissions from various sources to mitigate the impact of climate change. This entails moving away from fossil fuels and other high-carbon energy sources and embracing cleaner and more sustainable alternatives. One such alternative is the use of geothermal energy, a renewable and environmentally friendly energy source that taps into the Earth's natural heat reservoirs to supply heating, cooling, and electricity.

This case study details Project Dewatering Limited's involvement in drilling geothermal wells deep beneath the City of London to contribute to the City's vision of a carbon-neutral future. The wider project involves the installation of a ground source heat pump system which takes groundwater sent from the boreholes, which work in conjunction with existing Combined Heat and Power (CHP) boilers and chillers. It is anticipated that this system will reduce carbon dioxide emissions by up to 50%, meeting the requirements of the City of London and the Greater London Authority. Furthermore, this system will expand capacity, lower operational costs, and enhance air quality by reducing NOx emissions.

INTRODUCTION

Project Dewatering Limited was responsible for the supply, installation, testing, furnishing, and commissioning of the three boreholes This included all necessary plant, equipment, traffic management and temporary works. The full scope comprised the drilling of three boreholes to 200 m below ground level at a nominal 450 mm finished diameter. The boreholes, drilled at 670 mm diameter to the top of the chalk formation (assumed to be approximately 50 mbgl) were installed with 12 mm wall thickness steel casing to this depth. The boreholes were then drilled open hole to full depth, at a nominal 450mm diameter. Once drilled the boreholes were developed using airlift techniques both before and after acidization. Permanent pumps and pipework installed are capable of pumping at up to 30 L per second with 150 mm abstraction and recharge pipework. The pumping tests undertaken on all three wells following installation of the permanent pump infrastructure were then completed.

The works can be broadly divided into the following activities (the list is shown for one well only to show the sequence of events).

- Off site organization & setup of traffic diversion signs and implementation of the one-way system
- Fencing off the compound area to segregate the works from live traffic and public areas.
- Temporary civil works to break through the pavement, brick arch structure and basement slab.

Works includes the following:

- Provision of temporary surface support for drilling works.
- Setup of the drilling equipment.
- Installation of steel casing from ground level to below basement slab.
- Commence drilling to top of chalk at minimum 600 mm diameter.
- Install and grout permanent casing to top of chalk.
- Continue drilling to 200 m below ground level at minimum 450 mm diameter.

- Develop well using airlift techniques.
- Treat the well with acid.
- Redevelop well using airlift techniques.
- Install permanent pump riser pipe and recharge pipe together with wellhead.
- Undertake pump tests and submit pump test report.

METHODOLOGY

Project Dewatering Ltd proposed to drill the wells at the Decarbonisation Project using Reverse Circulation drilling methods. In Reverse Circulation water flush drilling, the fines free water from the settlement tanks was allowed to circulate down the annulus of the borehole to the drill bit. As such, the water in contact with the borehole wall did not have significant entrained soil particles (fines). At the base of the borehole, the water collected the drill cuttings and then using airlift or suction, depending on the depth, the water with associated cuttings was lifted to surface inside the drill rods. Using this methodology, the drill cuttings were not exposed to the borehole wall, and therefore the likelihood of blinding the permeability of the borehole was reduced in comparison to traditional direct mode flush (where the clean water was pressure injected down the inside of the rods and then carried the cuttings up the annulus in contact with the borehole face). This method was also attributed to provide improved borehole stability during drilling operations. In addition, this Reverse Circulation methodology typically generated cuttings that more easily settled in the above-ground settlement tanks, allowing for more cost-effective disposal of waste (this was discussed later in this proposal). The Reverse Circulation methodology was particularly suited to the specification on this project due to the diameter and depth of the boreholes (where traditional direct flush drilling required very high injection flow rates to successfully lift cuttings to surface).

DRILLING RIG

Project Dewatering Ltd proposed using a Nordmeyer DSB 3 Drilling Rig, supplied by PDL’s parent company, Holscher International GmbH (Europe’s largest groundwater engineering contractor). The rig was available for work in the UK but needed some modifications to improve the exhaust emissions and meet the strict government requirements. PDL proposed the use of this rig because it is very powerful and had been proven undertaking projects at greater diameters and to greater depths, yet it was also very compact and was suited to this space-constrained site both due to its relatively small footprint and due to the fact that the flushing pumps required for reverse circulation drilling were located on the rig itself. This reduced the need for additional plant in the works area, optimising the available space.

INSTALLATION OF BASEMENT CASING

PDL proposed an engineering solution that allowed drilling of the boreholes from the street level through the vaults beneath the road surface. It was initially proposed by the clients’ advising engineers that the road structure would need to be substantially modified using steel beams to build a platform to support the rig before opening of the arch vaults was allowed. This process was not only expensive but practically difficult given the nature of working in a busy London Street. The client requested a design and build solution for the drilling works which included the supporting of the rig whilst drilling through the vault arches. PDL devised an engineering strategy which negated the requirement of the expensive steel supports and opted for and engineering solution which comprised of a sand and timber beam bed & opening small cores through the vault arches. This approach meant that the project was more financially and practically viable.

PDL used a 700 mm temporary casing to isolate the basement from the drilling works. The 700 mm casing was lowered using the rig winch and once seated through the basement slab (now broken out to expose the underlying made ground), it was sealed into the basement slab with concrete and was also welded to the base plate located at surface, and on which the rig feet seat. All three plates and basement steel casings were installed at the beginning of the project. The 700 mm casing was installed sufficiently into the made ground, beneath the basement slab, to ensure that a watertight seal was achieved and the possibility of leaks into the basement could not occur. In addition, to provide further confidence, a bund was provided on the basement floor around the outside of the 700 mm casing and installed with a leak detection water sensor. This sensor was linked to a telemetry system to allow immediate notification of the drilling team in the event of any water leaks. PDL was confident that no leaks to the basement would occur given the seal provided on the 700 mm casing, however this leak detection system was intended to provide additional confidence to the main contractor. The 700 mm casing, once sealed into the basement slab, acted as the outer casing for the reverse circulation drilling.

DRILLING TO CHALK

A 670 mm diameter drill drag bit was lowered through the casing to commence drilling to the top of chalk. Once the chalk was encountered and proved, the drag bit was removed and replaced with a 670 mm tricone rock and roller (either steel tooth or tungsten carbide bit). Drilling continued for 3 to 5 m into competent chalk, to provide a seat for the casing. It was estimated that drilling to this depth could be achieved used suction (supplied by a rig mounted pump) on the central drill rod string, to lift the drill cuttings. At depths deeper than this, airlift techniques needed to be used to pull the water flush and cuttings up the central rods.

INSTALLATION OF THE PERMANENT CASING

Once the chalk had been proved, the permanent casing was installed. The casing was a 580 mm outside diameter steel casing with a 12 mm wall thickness and suitable spacers. The casing was lowered to the top of the chalk formation. A grout shoe was installed at the bottom of the casing and the casing lowered to depth. A Tremie pipe was tied to the outside of the casing to allow grout to be pumped to the annulus at the base. Grouting continued until the full depth of the casing was sealed up to the base of the 700 mm temporary casing. Once grouting was commenced it was continued until the works were complete to ensure a competent seal on the casing. The grout was then allowed to set for a minimum of 24 hours. The grout used comprised sulphate resistant cement and samples were taken of the grout at regular intervals and placed underwater to assess setting times. In addition, PDL proposed to undertake a cement bond log as part of the geophysical testing programme. This cement bond log confirmed the integrity of the grout seal.

DRILLING TO DEPTH

After the grout had set, confirmed by the underwater sample setting time, drilling continued with a 450 mm diameter tricone steel-tooth rock roller drill bit until the full depth of the well was reached, at 200 m below ground level. Drilling at this depth required the use of airlift to pull the water and cuttings up the central rod string. In Reverse Circulation drilling, the rod had a twin wall arrangement, allowing air to be injected between the outer and inner walls, which was then fed into the inside of the rod just above the drill bit. This air injection into the central rod annulus allowed the lifting of water and cuttings up the inner rod to surface from these depths.

INITIAL AIRLIFTING OF THE BOREHOLE

Once the full depth of the borehole was achieved, the initial phase of airlifting, which was anticipated to take one day, was used with the existing drilling rod string. As with the Reverse Circulation drilling method, air was injected in the annulus between the dual rod walls and injected into the inner rod annulus just above the drill bit. Airlifting using this technique was continued until the waters brought to the surface were essentially free of fines. Once airlifting was completed, the drill bit and rods were removed, and the drilling rig was demobilised from this location and relocated to the next borehole. As part of this process, the 700 mm casing was disconnected from the base plate and lifted to the surface using the drilling winch. Both the base plate and the temporary 700 mm diameter casing were removed. Once the drilling rig had been demobilised from the location, the well was prepared for acid treatment.

ACIDISATION

The main difficulty was using this controlled substance in a very public space. An incident in such a crowded space was not acceptable. The basic method was that a remote acid head was utilised, and acid was then fed from street level into the vault. More detailed method follows: A 2-inch plastic pipe was installed into the well to a depth of approximately 10 m below the permanent steel casing (which was assumed to be around 60 m below ground level). The 2-inch piping was connected to a wellhead assembly that was welded to the permanent 508 mm casing. This wellhead assembly had a manual valve, a pressure relief valve, and a pressure gauge. It was proposed to acidize the borehole with 5 m^3 of hydrochloric acid (32%). This acid was discharged into the borehole 1 m^3 at a time. During this process, if evidence of a pressure increase was observed, the manual bleed valve was opened to control the release of pressure. Gas/fluids were discharged to the same partially water-filled holding tank as referenced below. The discharge pipe was secured below water level to ensure any gas emitted was dissolved in the water. Once all the acid had been discharged into the borehole and sufficient time had passed to accommodate any off-gassing pressure increase, the manual valve was opened, and the waters in the holding tank were neutralised with hydrated lime, as required. The pressure relief valve was set at 3 bar as this was considered to be a maximum acceptable pressure that borehole grouts could be subjected to. In the event that, due to an unforeseen event, the borehole pressure increased to 3 bar, this pressure relief valve would open and gas and/or fluids would be discharged to the water-filled holding tank (with a minimum freeboard of at least 5 m^3 to allow for collection of fluid volumes from the well should this be required). The wellhead assembly was pressure rated to 16 bar.

POST ACIDISATION AIRLIFTING

A 100mm plastic pipe was installed to the base of the well (1 m from the base of the well to prevent entrainment and blockage with sludge). An airline from a compressor passed from the outside of the airlift plastic pipe through the pipe wall into the annulus with an upturned fitting. This attachment was installed at around 120 mbgl. Compressed air, delivered through this attachment, allowed airlifting of waters from the base of the well. Airlifting continued until waters ran clear. During all airlifting activities, the abstracted waters were passed through a Turbidex filter, prior to discharge to sewer. Turbidex is a natural mineral media that has a very high surface area and is very effective at straining fine particulates entrained in water. The Turbidex filter aimed to remove any residual fines down to a 5-um size. The use of this filter ensured that all waters were suitable for discharge to sewer.

INSTALLATION OF THE PERMANENT PUMP, RISER PIPE AND REINJECTION PIPE

While drilling continued at the second location, the permanent pump, riser pipe and reinjection pipe were installed in the first borehole. The wheel-mounted excavator and pipe clamps were used to lower the equipment to the required level in the borehole. Once installed, the equipment was connected to the wellhead assembly, and an equipment test was undertaken.