What Happened Last Time – Lessons Without Experience, Chapter 1

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ABSTRACT
What happens when there is not enough information about the ground conditions or when designers do not refer to records of past experience?

Two case histories involving dewatering for excavations in unconfined aquifers adjacent to rivers are presented. The first concerns an addition to a sewage treatment plant where the geotechnical investigation was lacking and the relevance of a known condition was not investigated. This resulted in the redesign of the plant addition and the operation of a complicated dewatering system in conjunction with sheeting for a pumping station excavation. The second concerns an addition to a pumping station where significant lessons about past experience were not investigated. This led to a claim in which both contractor and owner blamed each other for past experience.

RÉSUMÉ
Que se passe-t-il quand il n'y a pas assez d'informations sur les conditions du sol ou que les concepteurs ne tiennent pas compte des expériences passées?

Deux études de cas seront présentées pour l'assèchement de fouilles dans des aquifères à nappe libre adjacents à des rivières. La première étude concerne un ajout à une station d'épuration des eaux usées où il n'y pas eu d'étude géotechnique et où la pertinence des conditions connues n'a pas été étudiée. Il en est résulté une révision de l'ajout à l'usine et la nécessité d'exploiter un système d'assèchement compliqué en même temps que des fouilles blindées pour l'excavation d'une station de pompage. La seconde étude concerne une addition à une usine où des leçons significatives sur l'expérience passée n'ont pas été prises en compte. Cela a conduit à une réclamation dans laquelle l'entrepreneur et le propriétaire se blâmaient mutuellement pour l'expérience passée.

1 THE RAW WATER PUMPING STATION ON BEDROCK

It was time to expand the sewage treatment plant which was located in a river valley in a northern city within the pre-Cambrian shield. The addition included a raw water pumping station plus new aeration tanks, clarifiers and miscellaneous structures. A geotechnical investigation was carried out which included putting down several boreholes using solids stem augers to advance the hole, split barrel sampling and, because the silty sands were heaving in the bottom of the borehole below 6 m in depth, cone penetration tests. The cones were driven to refusal consistently at a depth of 9 m which was the depth at which the new raw water pumping station was to be founded. As the water table was within 2 meters of ground surface, the hydrostatic forces acting on the structure were to be overcome by a number of rock anchors drilled below the base of the raw water pumping station and tied to the base slab.

The excavation for the pumping station was to extend through water-bearing silty sand so the contractor chose to install double walls of interlocking steel sheet piles which were to be driven around the excavation to the bedrock at 9 m depth to retain the soil and to cut off the groundwater seepage. The contractor, which had considerable experience across the country with similar projects, was faced with the difficulty of sealing the gaps between the tips of the steel sheeting and the bedrock. To minimize the risk of loss of ground from under the sheet, it was decided to install a groundwater control system between the two sheet pile walls to temporarily lower the water table.

In designing a dewatering system, it must be realized that a limitation of a system of wells, is its ability to control water between the wells where there is a perched condition (where sand overlies bedrock for example). If the aquifer (the silty sand) did not extend below the base of the excavation, then there was bound to be some perched water or “bleed through” between the wells under the sheeting. At this particular site the ground conditions had only been sampled to two-thirds of the depth of the proposed excavation. Therefore, it was not possible to design an efficient and effective groundwater control system without knowing the hydrogeological characteristics of the soil, particularly at the bottom and below the proposed pumping station excavation. It was decided to put down two test wells so that a pumping test could be conducted from which the aquifer parameters (transmissivity, hydraulic conductivity and storativity) could be determined. The deep wells were installed (Figure 1) using a dual rotary drill and 150 mm steel casing with wire-wrapped stainless steel screen. Much to the contractor’s, the consultants’ and the owner’s dismay, the wells were drilled to a depth of 56 meters all the while encountering silty sand and no bedrock. Pumping tests on several wells screened at about 10 m depth indicated that the

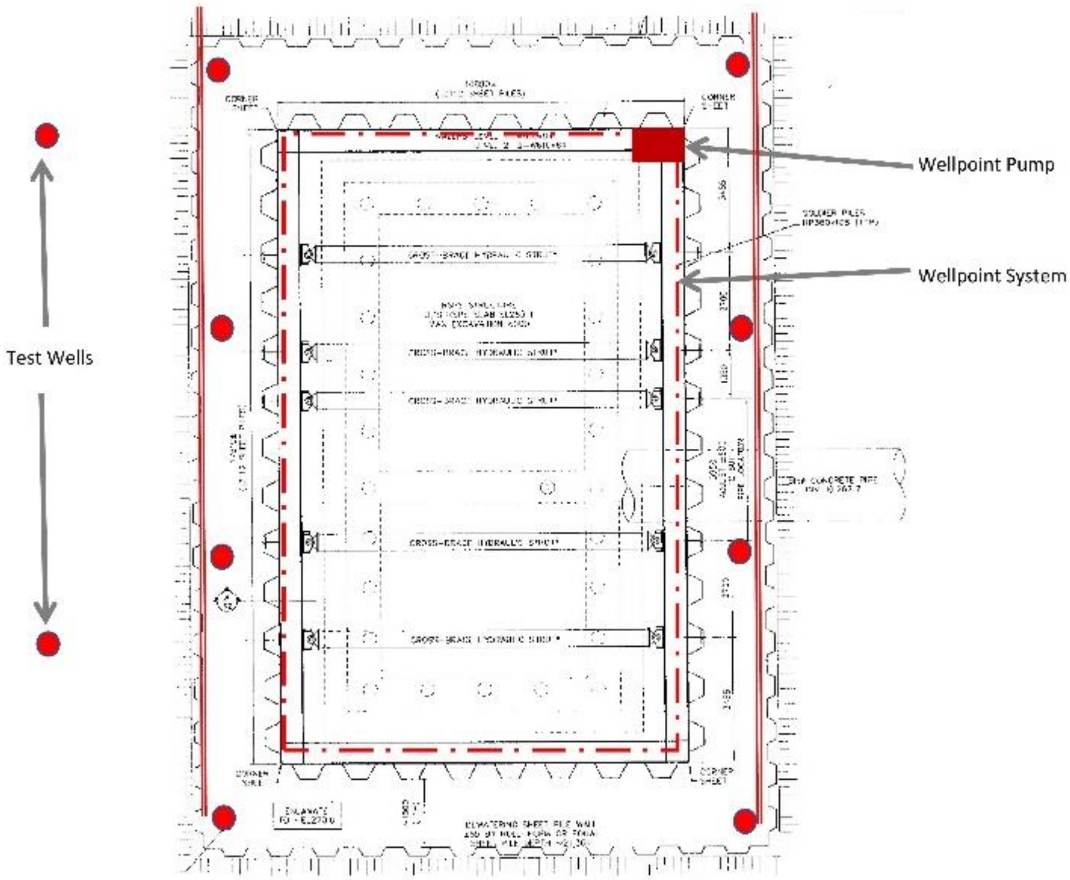

Figure 1 Plan view

Transmissivity of the ground was in the range of 7 to 10 m^2/day.

For a dewatering contractor, substantial depth of aquifer below the base of an excavation can be a beneficial situation. In aquifers of medium to high hydraulic conductivity, deep wells usually provide the most cost-effective means to lower the water table. However, where the hydraulic conductivity is low, the spacing between wells must be smaller and other means, such as vacuum wellpoint systems, may be more economical.

Given that the water level had to be lowered by more than 6 meters (the limit of a vacuum wellpoint system), it was decided to temporarily lower the water table within the sheeted excavation by means of a combination of relatively shallow 100 mm diameter wells with submersible pumps to create a partial drawdown and then install a vacuum wellpoint system with wellpoints at 2 meter centers within 5 meters of the base of the excavation. (Figure 2) Wells of 100 mm diameter were installed at 6 meter centers and this created a drawdown of about 3 meters. Wellpoints of 32 mm diameter were then installed by jetting at 2 meter centers. This arrangement satisfactorily controlled the water seeping up from the bottom of the excavation.

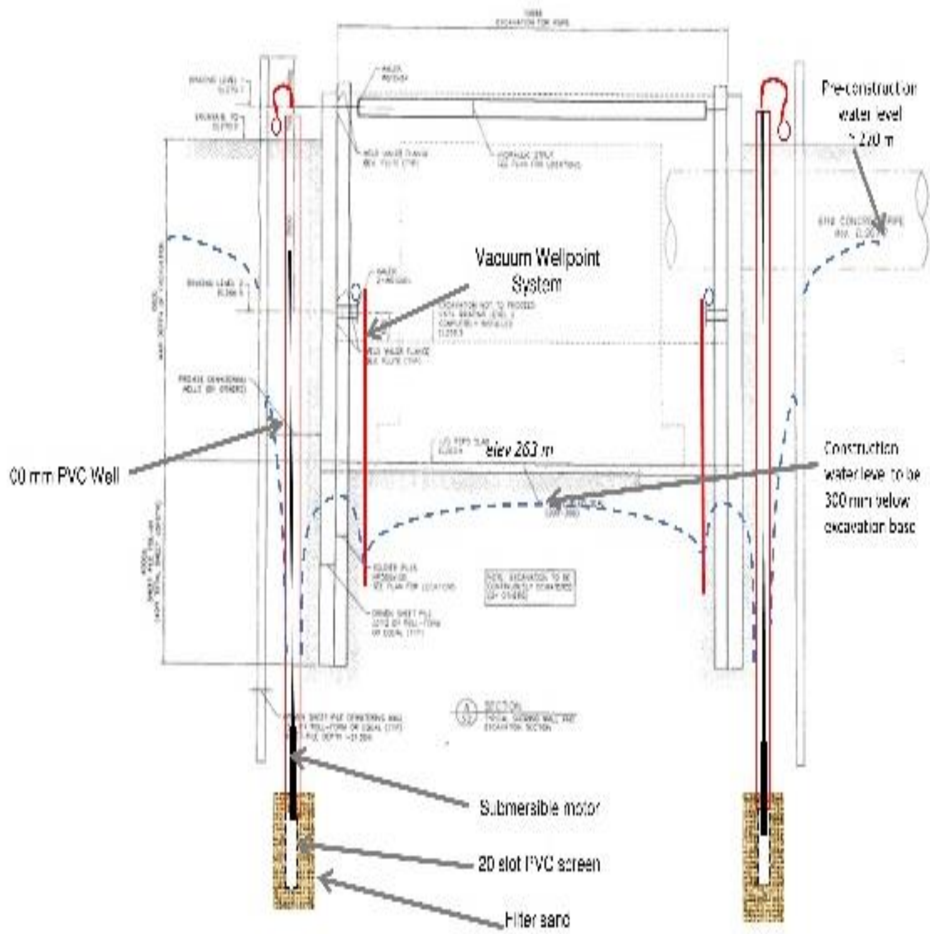

Figure 2 Section view

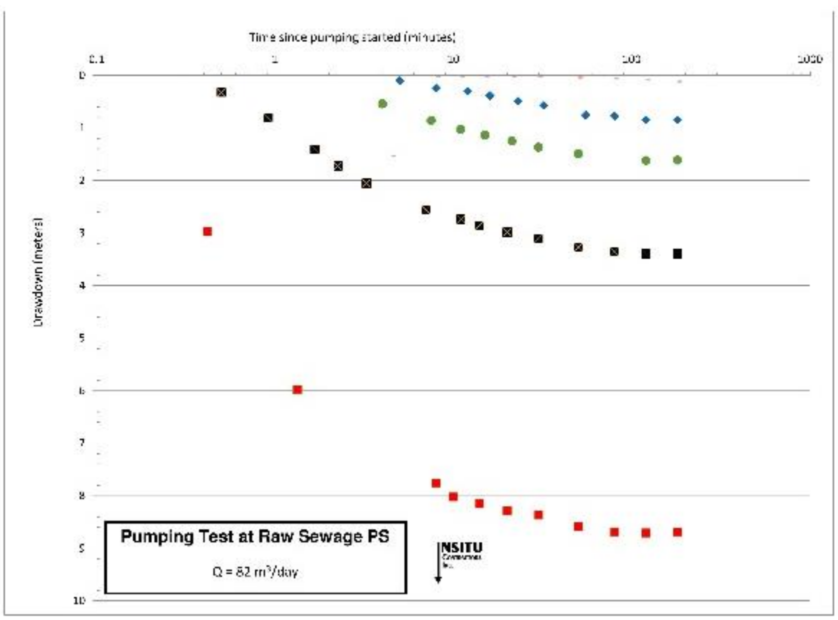

Figure 3 Time versus Drawdown Curve

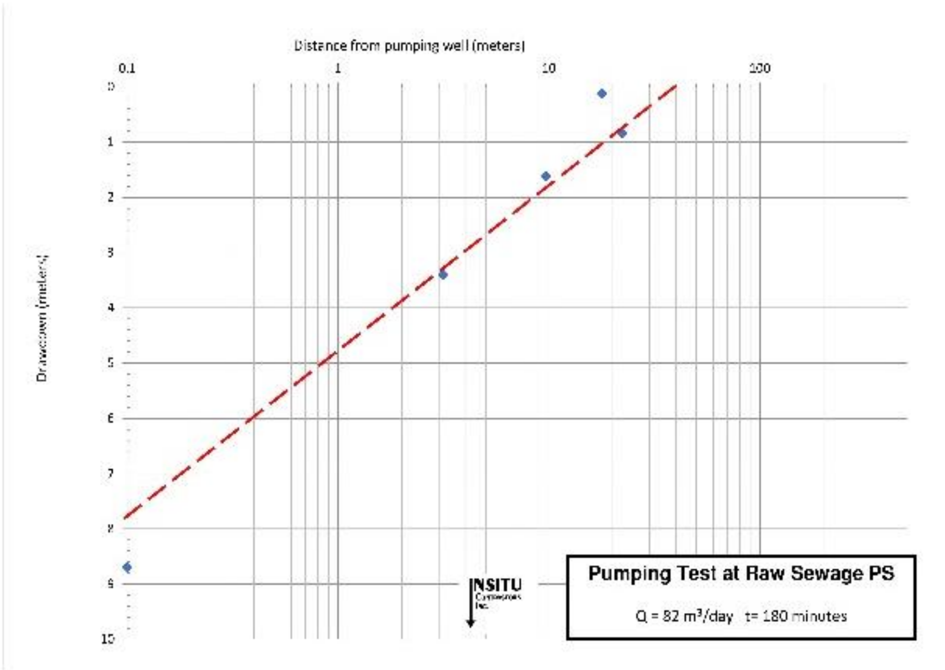

Figure 4 Distance vs Drawdown Curve

1.1 Summary

The unexpected ground conditions not only precipitated a change in the design of the excavation methodology for the raw water pumping station but required a redesign of the aeration tanks and clarifiers due to concerns about potential settlement of the structures. Settlement was minimized by ground improvement using stone columns/dynamic compaction. This change caused a delay on ten months in the completion of the works and a cost overrun of about three million dollars.

Could the different ground conditions have been expected? It was unfortunate that the geotechnical consultant did not ask the question "What happened last time?". Had they asked for the geotechnical reports and construction records for the original plant, they would have realized that the existing plant was founded on timber friction piles. A survey of the water well records would have revealed that local wells proved a depth of more than 60 m of sand in the river valley.

2 THE OPEN CUT EXCAVATION NEAR THE RIVER

Upgrades to a wastewater treatment plant located in a river valley required excavation into gravel and cobbles which were hydraulically connected to the river which was fed by glacial meltwater. The geotechnical conditions had been investigated at the time of the original plant design and this was augmented by a few boreholes by a different consultant. Sand, gravel and cobbles were encountered to depths of 12 meters with the water table at a depth of 3 meters. As the excavation was to go to a depth of 5 meters, temporary lowering of the water table to 0.5 m below the base of the excavation was required. Seasonal fluctuations in the river level and the groundwater levels were forecast.

Due to the presence of cobbles and boulders, support of the excavation walls and hydraulic cut-off of the groundwater by a sheet piled wall was not considered to be feasible. The contractor's method of dewatering would be conventional pumping from the open excavation using submersible or self-priming pumps and a substantial allowance of less than $100,000 was made to complete the dewatering of the excavation. In very coarse soils (cobbles and boulders) it is cost effective to use an open pumping method to dewater an excavation as long as the loss of ground caused by seepage pressures can be controlled and the suspended solids in the pumped water are suitable for discharge to the environment.

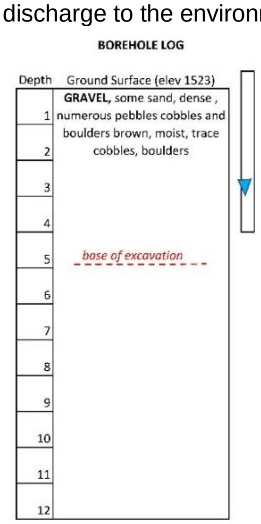

Figure 5 Sample borehole log from geotechnical investigation

Excavation and dewatering commenced in the late summer. At first, a 50 mm pump was used to dewater the excavation but this was not sufficient. Then 100 mm and 150 mm pumps were installed with little success. The water was discharged directly to the river but the high volumes necessitated that the discharge point be moved. A change order was issued to cover the relocation of the discharge point.

Further attempts to dewater the site were made with a variety of pumps and it ultimately required up to 3 pumps of 250 mm discharge size with appropriate diesel generators to provide power to enable the excavation to be made. The discharge points were changed many times due to the large quantities of water. Lock blocks (gravity retain wall segments) were used to minimize the ravelling of the base of the excavation slopes.

As a result of the very high pumping rates needed to complete the excavation, the contractor incurred costs which were substantially more than allowed for in the bid price. Citing the change order to pump the water farther from the site as being an acknowledgement of changed conditions, the contractor claimed against the owner for the extra cost of dewatering. The owner, in defense of the claim, objected to the contractor's argument on the basis that the very same contractor had built the original treatment plant and would have encountered the ground conditions on the previous work. In other words, the contractor had experience at the site and should have known better. The contractor argued that the staff from the original construction were no longer available and their old job files were not accessible. Furthermore, the contractor claimed, that, since the owner also had experience from the original construction, the owner should have fore warned the contractors bidding on the project of the anticipated difficult ground conditions.

The dispute was resolved in the contractor's favour and provides a lesson for all contractors, owners and their consultants. At the time of tendering for the work, contractors should only bid on the basis of the documents provided by the owner and not on the basis of past experience. If a contractor with no site experience had undertaken the work, they too would have encountered the difficult dewatering conditions, been provided with the change order and consequently would have made a claim for changed ground conditions. The lesson to be learned is that owners should provide as much information about past experience at a site as they have available in order to provide a "level playing field" for contractors bidding on the work. Owners and their consultants would do well to provide information about "What Happened Last Time".

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