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WM-T1-05, The use of trenchless to rehabilitate the sewers of Richmond

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1. ABSTRACT

The City of Richmond has started a 5-to-10-year project to replace and improve all the civil infrastructure in the community of Burkeville, Richmond, BC. The sewer system was built in the 1940's and the sanitary pipes are now at the end of life. Just as old buildings are replaced with more suitable housing, so does all infrastructure eventually need to be modernized, upgraded, and often upsized to manage a growing population.

In Richmond, utility replacement is a contentious issue. In the community of Burkeville in particular several of the sanitary sewers are in back yards and not under roads. This has understandably caused pushback from the residents on the proposed replacement works. The city is exploring various solutions to allow replacement of these sewers while taking the concerns of the residents into consideration. Additionally, a perpetually high-water table in the saturated granular materials can lead to conventional excavations becoming larger than perhaps originally intended.

These constraints make the use of trenchless solutions to these and other challenges attractive. While Richmond has been a promoter of trenchless technology in exceptional situations it is beginning to view these technologies more as a routine option rather than an extraordinary tool.

This paper demonstrates how trenchless technology, specifically pipe bursting can meet the challenges of renewing aging infrastructure while preserving the integrity of private property and therefore also preserving a long-standing cooperative relationship between the community and the City. The focus of this paper is on the sanitary upgrades.

2. BACKGROUND

Burkeville is a tight knit community of about 1,000 located on Sea Island which is mostly taken up by the Vancouver International Airport (YVR). Sea Island also boasts a small conservation area created as compensation for airport expansion, and a small part of the island is under the administration of the Musqueam Indian Band. The community was established in 1943 by the federal government to house people serving the aviation industry and as such, most of the streets are named for airplane manufacturers. The village was annexed by the City of Richmond (the City) in 1947. Figure 1 shows the community sandwiched between YVR and the Fraser River.

Figure 1. Burkeville, YVR is in the top of the photo, the Fraser River is below left.

Initially septic fields were located in the backyards of the residents. When the City started to install a modern sewer system it seemed like a good idea at the time to install the 8" vitrified clay pipes through the back lanes so as to easily connect with the existing sewer. Ten-inch vitrified clay pipe was installed through the Burkeville Neighbourhood Park which straddles the main road into and through the community.

Unrelated but of historical interest, there also remain a few functioning wood stave culverts in the community and, there are no storm sewers in Burkeville, only ditches. Residents have been infilling ditches and installing culverts in a haphazard way which is contributing to frequent flooding in the community. Most of the ditches in Burkeville will be filled in except for ditches along the park boundaries which are to be retained as habitat for Western Course Frogs, Beggar Tick shrubs, or where residents have expressed their wishes to retain the ditch on or near their property. Drainage improvements are an important part of this overall rehabilitation.

Even using non-invasive methods, every cut in the asphalt, every entry and exit pit will still degrade an existing road base to a certain degree, especially given the year-round high-water table to be expected in an estuary. Full road work and final capping will follow after the installations have been tested.

3. THE CHALLENGE

Fast forward seven decades and residents have largely taken over the legal right of ways (RoW) creating beautiful gardens, planting trees, installing sheds, building elaborate tree houses, fences, and decks and in one case even the stairs and porch to a house. While there is a legal RoW the City has accepted that over the decades by not enforcing the right to clear the RoW and maintain full access to the infrastructure, now in 2023 it must make allowances to preserve a good relationship with the community rather than simply imposing legal rights and destroying whatever happens to be encroaching. Figure 2 offers a typical example of RoW encroachment where the resident(s) over the years have been treating City RoW as their own personal property.

Figure 2. Shows the alignment of sanitary sewer between the manhole and middle of treehouse

Being such a small tight-knit community, the project team quickly discovered that a constant flow of information was going to be vital during all phases of this project. The project team has embraced this, and every technical decision has factored this into the overall infrastructure rehabilitation vision.

It is of critical importance to remember that Burkeville is just one community in a City of over 200,000 with other neighbourhoods facing similar challenges. This location was chosen because of the large number of breaks, complaints, overall concerns, as well as the age of the infrastructure.

This pipe bursting project is only Phase II of an VIII Phase renewal program for all the infrastructure including water mains, roads, drainage, and the sanitary sewers which are the focus of this paper. All the trenchless work on this project, including cast in place pipe lining (CIPP), horizontal directional drilling (HDD), pipe jacking and the pipe bursting to minimize disruption of 'private property' is being installed by specialty contactors. PW Trenchless is the contractor carrying out the pipe bursting for the sanitary work described in this paper. All the conventional infrastructure upgrades are carried out by City crews. Figure 3 shows the overall scope of this undertaking.

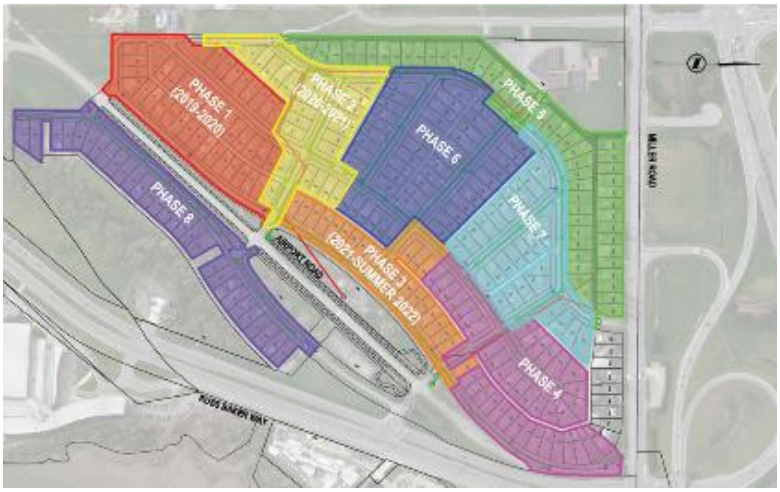

Figure 3. Burkeville Drainage, water main and sanitary sewer upgrades phasing

4. MINIMIZING CUSTOMER DISRUPTION AND COST

In Phase II of this rehabilitation project, less than 10%, or only about 260m of pipe was installed using pipe bursting. While less than 10% may not seem like much to design engineers, to the residents, the care taken to not destroy their additions and improvements that encroach on the legal RoW, means the world to the people who live there, and the measures taken to remain sensitive to those issues is appreciated. In fact, these improvements and additions were likely completed long before the current residents bought the properties.

Trenchless technology was chosen to minimize disruption to residents and the park. Additionally, a cost benefit analysis of using open cut construction showed that conventional methods would have been more expensive. There are limited circumstances where open cut construction is more cost effective depending on the depth of the works, but this is not the case for the majority of sewer rehabilitation projects in the City due to a high-water table and existing infrastructure including ongoing residential development.

The pipe bursting throughout this phase has thus far has been used to replace the vitrified clay sanitary sewers. Vitrified clay pipes used in the mid to late 1900's around the lower mainland typically came in 2m lengths, are obviously brittle and do not have a particularly effective seal between sections. It's almost impossible to imagine, especially in the saturated granular soils of the estuary how these pipes could function as sanitary pipes at all let alone survive intact over the decades due to their brittle properties and the largely ineffective nature of the joints.

Fortunately, there were many site conditions and design decisions that contributed to the smooth installation of the replacement HDPE pipes. The Fraser River Estuary is made up primarily of saturated Fraser River sediments of varying grain size and density. Some clays were also encountered during construction. The soil strength turned out to be optimal for this method of installation.

Pipe inverts were retained as is normal during pipe bursting. While upsizing the 8" and 10" pipes was possible during the upgrade the extra capacity was not needed, so the pipes were replaced with like for like sizing. No major conflicts were encountered that would have required the design alignment to be changed. The pipe inverts matched up perfectly at every manhole. Entry and exit pits were primarily carried out at existing manholes that were located on City property.

Some trees had to be removed or relocated. Some immature trees were removed, stored, and cared for at the City nursery and later replanted. On one such property a tree was relocated a few feet away from the immediate work around the manhole in the residents' front lawn that happened to be City property. This tree is shown along the left edge of Figure 2.

Also fortunately, there was a budget allowance for the manholes built in the 1940's and 1960's to be rehabilitated. All the manholes were all pumped out, cleaned, inspected and found to be acceptable. While the pipes were full of leaks and roots, the manholes required minimal modifications, only the ladder rungs were replaced. This demonstrates the mismatching of the life spans of materials. The concrete manholes can have a life expectancy in excess of 100 years not so for the vitrified clay pipes. In these soil conditions the clay pipes proved to be susceptible to cracking and joint separation. The use of the existing manholes does reinforce the benefit of staying within the existing alignment, a common benefit of most trenchless methods. An open cut solution might have required a new alignment abandoning both the poor pipe and good manholes. Figures 4 shows the condition of a typical manhole and Figure 5 shows a typical entry / exit pit, only 6 of which were needed on this Phase of the project.

Figures 4. Typical manhole ready for reuse

Figure 5. Typical entry/exit pit, only 6 were needed for Phase II

5. GROUND WATER CONTROL

Another overriding issue in Richmond generally is the high-water table. The water table is 1.5m to 2.4m below the ground surface. When working in granular non-cohesive materials such as loose saturated sand and silt deposits managing water becomes crucial. The gradation of the river sand and its porosity require well pointing when going any deeper than about 300mm below the water table. Trenchless solutions can minimize the well point requirements to very localized areas. This at times allows single wells rather than continuous well pointing systems to be used. The original work carried out decades before was completed in green fields without any nearby structures or regard for existing infrastructure. Other risks associated with continuous well pointing, there is potential to induce significant settlement of buildings within the drawdown curve. The significant volume of water resulting from continuous well point dewatering is also a consideration as present-day environmental regulations require groundwater treatment before release into either the storm system or drainage ditches. Pipe bursting itself could be completed below the water table, however the access pits require ground water control for the pipe work pre and post bursting.

As an experiment of an innovative solution to controlling the ground water, PW Trenchless and infraStruct attempted to passively control water flow using foam injection points to create the equivalent of a slurry wall. The foam injections were battered to create a sealed bottom shaped like a 'V'. The initial thought was to place the injection points at 900mm spacings, unfortunately, it was discovered that the columns did not join in any manner that would have contained the water. The next attempt was to half the spacing to 450mm, which did develop a meaningful wall, however, the cost for this solution became prohibitive. The projected cost to install the tighter spacing would have been $80,000.00 per pit, which could not compete with a well pointing solution. The passive system has the potential to allow excavation below the water table without the groundwater drawdown and its consequences. This is a solution for other circumstances[1].

6. COMMUNUITY ENGAGEMENT

The City has been committed from the start of the project in 2019 to community engagement by working with the community in an active way. Richmond has been upfront, transparent, and receptive to community concerns. The City and their design consultant McElhanney have also participated in community events such as Burkeville Daze, project information sessions, submitted content for the community newsletter and even knocked on doors and taken questions from residents individually. Every query by a resident has been responded to. The project team has been keeping the community information boards up to date as well. The City has also been committed to leaving the sites in a clean and safe condition before every community celebration such as the annual Halloween.

7. LESSONS LEARNED & CONCLUSIONS

1. **Communications between the consultant, owner and residents is key**.

Most residents recognize that like any product their sewers have a life span. Most of the general public are not overly concerned about underground utilities and the challenges of maintaining civil infrastructure. When the once in a lifetime issue of the replacement or rehabilitation of these utilities arises, it must be handled in such a way as to minimize disruption to the public including impacts to private property. The public needs to be fully informed about such disruptions. Most people understand these upgrades are necessary and appreciate the City and its representatives are working hard to minimize inconvenience and permanent impacts to the neighbourhood.

2. Additional thought could have been given to laydown areas.

As with any construction, even for trenchless solutions, some areas in the vicinity of the construction will be required to store and park materials, equipment, and vehicles. Further consideration could have been given, especially in this residential area to minimize that impact. One of the benefits of pipe bursting is that the pipe can be assembled (fused) elsewhere and transported in lengths of up to 150m, possibly more.

3. Trenchless methods impact extends further than the actual direct costs of construction.

When dealing with the cost of any good or especially a service it is challenging to quantify the total cost including unanticipated costs. For instance, the long-term cost of installing a utility in an existing paved road, even with a properly designed and installed pavement patch the asphalt and the underlying structure will still degrade. Most maintenance personnel now recognize that any cut in asphalt will shorten the life of the existing pavement. This degradation is substantially reduced when employing trenchless technologies.

4. Carbon emissions.

The excavation work required for pipe bursting is approximately 10% of that of traditional open cut construction and therefore the associated carbon emissions are correspondingly reduced. As discussed earlier, because the concrete manholes had not shown significant aging and were reused, those savings in carbon emissions were also realized on this project.

5. Existing structures over the pipes.

The trenchless approach in this project allowed the rehabilitation to be completed without excavating the trench line and not requiring the removal and replacement of existing fences, sheds, well established gardens, and other structures. Not only were there great cost savings for the City, there were minimal disruptions for the residents.

6. The challenge of quantifying indirect benefits of using Trenchless technology for utility upgrades

The more difficult items to put a price to are the psychological human costs, that is the savings in disruption to the residents, which included leaving most aspects of private property undisturbed, and dealing with the inconvenience of ongoing road closures and other disruptions caused by large impact open cut projects. While those costs are difficult to quantify one can estimate the hours of additional planning, community engagement and site restoration.

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