

City of Richmond Rehab - Box Culverts

By: Tonia Jurbin, P.Eng. (Retired) (for: PW Trenchless Construction Inc.)

Underneath the City of Richmond, a network of some 60kms of cast in place box culverts are slowly but surely leaking, sinking and causing the roads built on top of them to settle as the surrounding backfill slowly infiltrates into the culverts rather than staying around the outside as originally installed. 'It's like building a road on a trampoline' is how David O'Sullivan President of PW Trenchless puts it.

Richmond, located at the mouth of the Fraser River is made up of several islands in the estuary. The underlying soils generally consist of river gravel, sand, silt, clay, swamp and peat bogs, all of highly variable thicknesses and densities. In this environment post construction differential settlement estimates are often given over a 25 year period because not only is there much variation, many of the soil layers are also highly compressible under loading.

SOME BACKGROUND

From the late 1960s to the late 1970s, the City installed the precast box culverts at a rate of about 22m a week

“Very few things are truly waterproof in BC's lower mainland.”

to fill in the many large ditches that made up the drainage system for this low lying island city. Also relevant, the box culvert segments were poured with additional joints in the floor at the mid-section, or, roughly every 11m.

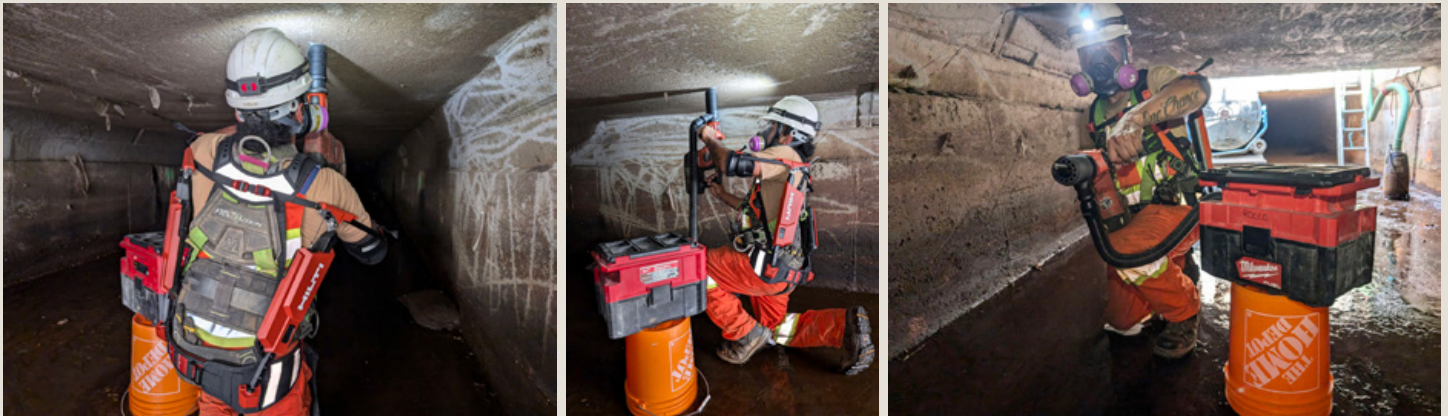
Over the years the compressible soils continue to settle under the loading of the concrete which is much heavier than what was excavated to build it. The joints start to separate, and the sediment carrying water infiltrates the culvert. This slowly starts to shift and settle, causing voids around the structure which in turn leads to potholes and settlement in the roads.

It is fair to speculate given the slow continual growth of leaks and infiltration, especially during the infamous heavy rains in the region, that unaddressed, the damage to the overlying roads will continue, and likely accelerate over time.

THE INVESTIGATION

Fast forward to 2017 when the City retained MJP & Associates of Richmond, BC to do a walk through, or more like a 'slouch-through' inspection of a 2.4 km section of the ageing system. To facilitate the inspection, the City also retained PW Trenchless of Surrey, BC, trenchless rehabilitation specialists, to set up the safety and support for these inspections. This included confined space equipment and rescue cover, radio checks, lighting, site access and accompanying the team through the process to ensure the safe collection of useful information.

The findings set the stage for a rehabilitation program that sliced the work up into several phases. The project under discussion here is the third and most recent phase of the work. In 2024, the City retained PW Trenchless to rehabilitate an 800m



Respirator, dust suppression system and Exo Skeleton



Close up of floor foam



Close up of grout return



One of many service pipes into the box culvert

section of culvert along No. 4 road, from Alderbridge Way to Westminster Highway. The contract included an optional item to extend the work from Alderbridge Way to Granville Avenue, which was awarded and is underway in 2025. In the earlier phases of this maintenance work, culverts were rehabilitated using sliplining techniques with Glass Reinforced Pipe (GRP), and traditional open cut methods were used on the earliest phase.

During this third phase the average 3.4m wide x 1.37m culvert with 76 joints over 800 metres underwent rehabilitation from the inside of the culvert. The plan was to install a barrier, a sort of foamy grout curtain around the outside of all of the joints without digging up 800 metres of road to do it.

THE LATEST SOLUTION

The first step was to isolate the length of the tunnel to be rehabilitated by installing dams at both ends. The next step was to clean out all the sediment using mostly high pressure water to move the material to one of the two access hatches, or one of the 15 existing manholes, and then remove it by vacuum excavation. The team removed some 50 years' worth of sediment – enough to fill about 35 hydrovac trucks.

Once the tunnel was sealed at both ends and cleaned out, 14 holes ranging from

10mm to 15mm were strategically arranged in a staggered pattern along both sides of the 76 joints at the top, sides and bottom of the culvert. This prep work took the PW crews about 2 ½ weeks.

Enter Infrastruct Products and Services based out of Mission, BC to start sealing the leaks. This work started by isolating each of the joints by injecting a two-part poly urethane resin expanding foam into each of the holes creating a sort of grout curtain around the joint. The product used for this stage of the work expands up to 18X the initial volume and cures to a 'rigid' finish.

This process 'sealed' the majority of the infiltration at each joint, very few things are truly waterproof in BC's lower mainland, but the process sealed the majority of infiltration at each joint. The density of this product once cured is about 3.5 pounds/ft³ so not a major contributor to further settlement. It takes about 8 hours for a full cure but the working time is only about 35 seconds. Confirmation of the delivery is done during the application by watching for foam return in the adjacent drill holes. Some finesse is required for this work, as over-injecting can cause heave. On this project the injection was done to rejection and by watching for return from adjacent holes.

While these holes were being injected the PW crews were busy removing the upper 4 inches of lumber in the floor joints. The floor joint lumber might have been 2X6's or 2x8's or 2x10's but only 4 inches had to be removed. Once done the edges of the floor joints were chipped to remove any loose



Typical Working Conditions



Access Hatch



Floor joint cleaned out then stuffed with oakum



Strutting placed on floor joint after application of resin and oakum

concrete and to allow a better bond for the next step. The chipped concrete and excess water was removed by creating a mini dam on either side of the floor joint, and using a shopvac with a floor pump to remove all the debris and most of the water. The joint did not need to be bone dry as the final step does require some moisture for everything to set together.

The floor joints were then stuffed with resin-soaked oakum, a modern twist on an old ship repair technique. Historically oakum was made from untwisting old ropes which were covered in tar and used as caulking, mostly for ships but also used in plumbing applications for sealing couplings. In modern times the oakum is made from hemp or jute. Again,

this work has to be done quickly as the hydrophilic resin used sets in about 5 minutes. Once the joint is filled with the resin impregnated oakum the crews worked quickly to get forms on top of the joint and tighten the whole system with wedges and struts. The resin Infrastruct uses expands about 9X by volume and cures overnight. The result is a flexible adhesive gasket which is not diggable but can be cut if necessary.

The City provided a list of cracks and other defects including any exposed rebar along the length of the tunnel. During the final inspection, any remaining defects found during the joint treatment were corrected. The cracks or leaks causing active infiltration were sealed

with another product, a hydrophobic resin that follows the water path, reacts with the water in the cracks and sets in seconds. The exposed rebar was coated with cementitious grout.

When Infrastruct demobilized, PW used CCTV cameras to inspect all the connecting services into the culvert. The data from this final inspection was submitted to the City for further consideration. The last step was to form the hatch lids that were cast on site, lowered into place and backfilled.

HEALTH & SAFETY

Low headroom presented some unique health and safety challenges. With barely 1.37m, or less than 3 ½ feet, it can be back



Oakum Sample



Dam at end of project



Sediment in culvert beyond the dam

“ *Low headroom presented some unique health and safety challenges.* ”

breaking work drilling the holes in the roof of the culvert. The overhead holes were drilled from a seated or kneeling position and the workers were outfitted with EXO skeletons to assist supporting their backs, arms and shoulders. The EXO skeleton suits used weigh about 2.4 Kilograms (5.3 pounds) and cost \$1,860 CDN. All the workers rotate all the jobs, drilling, mucking, moving materials etc. There was also a dust suppression kit attached to the hammer drills and the crews were outfitted with full face respirators as well.

Microbreaks for stretching are important and were emphasized during tailgate meetings. A microbreak in this case could be as simple as slouch walking to one of the access hatches or manholes where one can stand, or sitting, or even lying back on

one of the materials carts for a little back stretch. Of course, all confined space rules apply along with the fall arrest harnesses which are more for rescue than risk of falling.

FINALLY.....

Without giving too much away regarding the contract details, we can divulge that the results speak loudly for themselves. The 2024 phase of the project cost about 25 percent of the earlier GRP sliplining phase, and less than 8 percent of the earliest phase open cut attempt. The other very obvious advantages to doing this work as a trenchless project was the minimal disruption to the travelling public as well as considerably lower GHG emissions when

compared to the traditional open cut work.

In 2025, the City awarded an optional item from the 2024 contract, which extended this work from Alderbridge Way to Granville Avenue. The work is well underway and is scheduled for completion in October 2025. ✚

ALL PHOTOS COURTESY OF TONIA JURBIN P.ENG. (Retired)

ABOUT THE AUTHOR:



PW Trenchless Construction Inc. is an experienced General Contractor established in January 2000, specializing in

both trenchless and traditional open cut utility construction methodologies. The company has pioneered trenchless technologies in BC throughout its history and stands apart from other trenchless contractors in the local marketplace by completing all civil works for trenchless projects in-house, using own equipment and forces.



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