THREE TRENCHLESS TECHNIQUES PROVIDE SOLUTIONS FOR THE NEW LYNN BRANCH SEWER

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ABSTRACT

The trunk sewer capital works programme for the New Lynn catchments in West Auckland has successfully improved the environment. The wastewater upgrades eliminated a number of wet weather overflows and also allowed provisions for future population growth.

The project involved the diversion of the existing West Lynn Branch Sewer and construction of a new South Lynn Branch Sewer. The West Lynn Diversion Sewer is a 600/1050 gravity pipeline laid predominately along road reserve at depths ranging from 3 to 12 metres. The South Lynn Branch Sewer was replaced with a new 375/300 gravity pipeline positioned deeper to allow for removal of pipebridges. A short section of 250mm network sewer was also constructed, relieving the existing under capacity pipeline.

The new pipelines were all installed utilising a combination of directional drilling, mircotunnelling of PE pipes, and pipe jacking methodology. Technical challenges of the project included the depth of the pipelines and associated manholes, installing the pipelines at shallow grades, working within numerous private properties and conquering the variable ground conditions. The first stage and first contract of the project along Clark St was successfully coordinated with the New Lynn Train Station and roads upgrade contracts. The South Lynn catchment upgrades were delivered in two contracts and were completed in late 2013.

This paper outlines the technical challenges and how the solutions the team developed met those challenges.

KEYWORDS

Trenchless, microtunnelling, pipe jacking, HDD, hybrid methods, PE pipes

1 INTRODUCTION

The New Lynn catchment in West Auckland is serviced by the New Lynn, West Lynn and South Lynn Branch Sewers.

The South Lynn and West Lynn Branch Sewers were constructed in the 1950's. Over the past 60 years the New Lynn area has developed significantly. Large lots previously serviced by the West Lynn and South Lynn Branch Sewers have been subdivided into much smaller residential lots. As a consequence both the West Lynn and South Lynn Branch Sewers experienced frequent overflows during wet weather at a greater frequency than the two overflows per catchment per annum allowed as a permitted activity under the Air, Land and Water Plan.

The New Lynn area has also been designated as a future growth node in Auckland, with further intensive growth planned within the catchment. Network modelling undertaken in 2006 identified that the existing branch sewers did not have capacity to service the existing populations and future planned growth.

New Lynn was within the former Waitakere City Council area prior to Auckland Council amalgamation. The area is generally serviced by the local network sewers previously maintained by the former Waitakere City feeding into the Watercare owned and maintained branch sewers. The South Lynn catchment was running the undersized and poor condition network pipes the full length parallel to the South Lynn Branch Sewer with limited interconnection between the two systems. Watercare is now responsible for the entire wastewater network.

As a consequence of the planned growth and under capacity pipelines, Watercare elected to reassess the proposed trunk sewer capital works programme for the New Lynn catchment.

A detailed investigation was completed to assess the available network upgrade options and concluded that two new wastewater pipelines should be constructed, the West Lynn Branch Diversion Sewer and the South Lynn Branch Diversion Sewer.

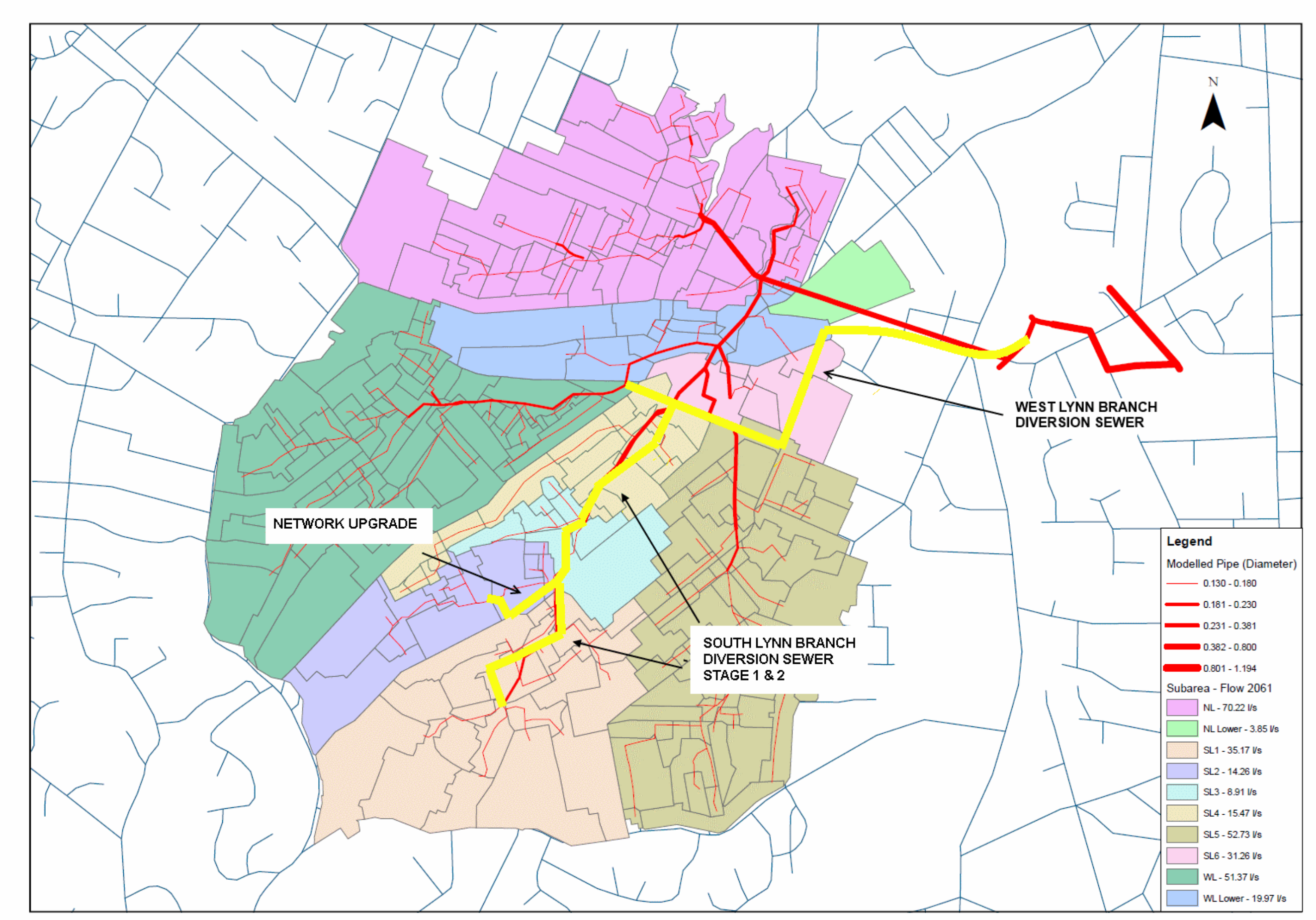
The West Lynn Branch Diversion Sewer involved diverting flows from the existing West Lynn Branch Sewer at 21 Titirangi Road and the existing South Lynn Branch Sewer at opposite 13 Margan Avenue to the confluence of the New Lynn and Titirangi Branches at New Lynn Branch Sewer MH01 located in Olympic Park.

The South Lynn Branch Diversion Sewer involved the construction of a new branch sewer from Parker Avenue to Margan Avenue. The new sewer followed alongside the Manawa Stream, predominately through private residential property. Cross connections were made to the existing local network sewer in numerous locations reducing flows within this network sewer.

The proposed sewer upgrades were divided into three stages and three contracts as described below:

- The West Lynn Branch Diversion Sewer was advanced to coincide with the Clark Street road upgrades, the railway line lowering and the train station construction. This was let as one contract in mid-2009.
- The West Lynn Branch Diversion Sewer along Margan Avenue from Titirangi Road to the South Lynn Branch Diversion Sewer and the South Lynn Branch Diversion Sewer Stage 1 between Margan Ave and Willerton Avenue were let as one contract in late 2009.
- The South Lynn Branch Diversion Sewer Stage 2 between Willerton Avenue and Parker Avenue and network sewer upgrades were let as another contract in late 2012.

Figure 1: New Lynn Branch Sewer Upgrades Overview Plan



2 WEST LYNN BRANCH DIVERSION SEWER

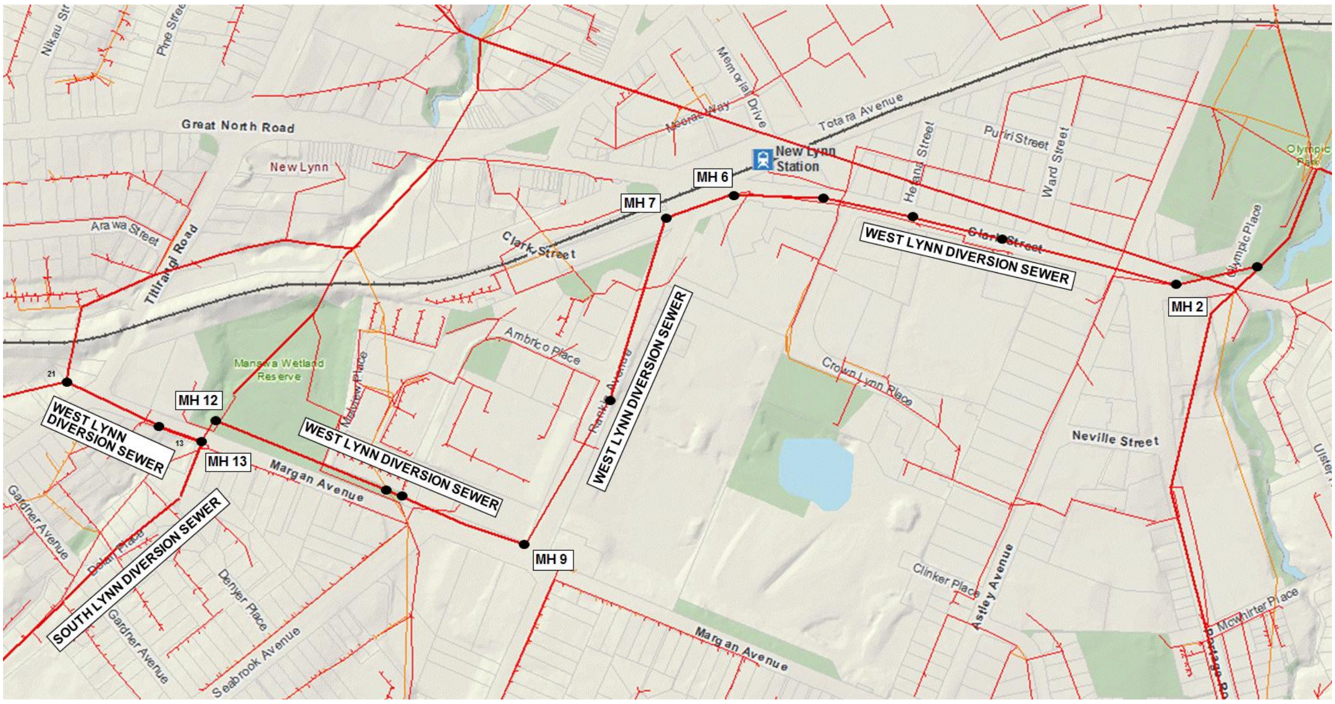
2.1 EXTENT OF WORKS, INVESTIGATIONS AND DESIGN

2.1.1 EXTENT OF WORKS

This stage comprised a new 600mm diameter gravity sewer pipeline from the Manawa Wetland Reserve at Margan Avenue to a new discharge manhole on the Titirangi Branch Sewer within the Wolverton Esplanade Reserve below Olympic Park.

The pipeline route, starting at the upstream manhole within the Manawa Reserve, runs parallel to Margan Avenue in front of the retail properties at the north end of Seabrook Avenue before turning into Rankin Avenue. It then runs the full length of Rankin Avenue to Clark Street before turning eastwards to cross Portage Road and enter Wolverton Esplanade Reserve.

Figure 2: West Lynn Branch Sewer Contract 1



Construction of the pipeline was anticipated to be ahead of the New Lynn road network upgrades in and around Clark Street.

Due to the depth of the new pipeline and the very shallow design grade the preferred methodology for construction was microtunnelling / pipe jacking.

Alternative alignments were considered but longer routes and deeper manholes detracted from those alternatives. The longer routes would mean flatter pipe grades and also would mean higher construction costs.

A total of 1560m of main pipeline was installed, 11 manholes and 6 network connections with satellite manholes and associated pipework.

Two live connections were carried out, one at the Titirangi Branch Sewer in Wolverton Esplanade Reserve and second at the existing sewer in the Manawa Wetland Reserve.

2.1.2 INVESTIGATIONS AND GROUND CONDITIONS

The geotechnical investigation comprised mainly of machine boreholes at approximately 200m spacing and hand augers within the Manawa Wetland Reserve.

The ground conditions, as encountered in the boreholes, generally comprised an approximately 1.2 m thick layer of fill overlying a succession of alluvial clays, silts, sands and peat. These are underlain in the west at depths of between approximately 9 m and 12 m below ground level (bgl) by completely weathered to highly weathered siltstones and sandstones.

The alluvium was generally comprised of firm to very stiff, grey, highly plastic silty clay to loose to medium dense clayey sand with occasional interlayers of organic black to dark brown, firm to stiff clayey silts to silty clays (peat). Typical SPT ‘N” values of N=0 to N=15 were recorded. Undisturbed shear vane values between 20 kPa to 115 kPa were recorded.

2.1.3 DESIGN

The pipeline design firmly directed the vertical alignment and the minimum internal diameter, all connection points and maximum spacing of manholes. It was left open to tenderers to propose construction methodology, the final position of manholes, to design all temporary works including the intermediate shafts and propose pipe material that suited their microtunnelling equipment.

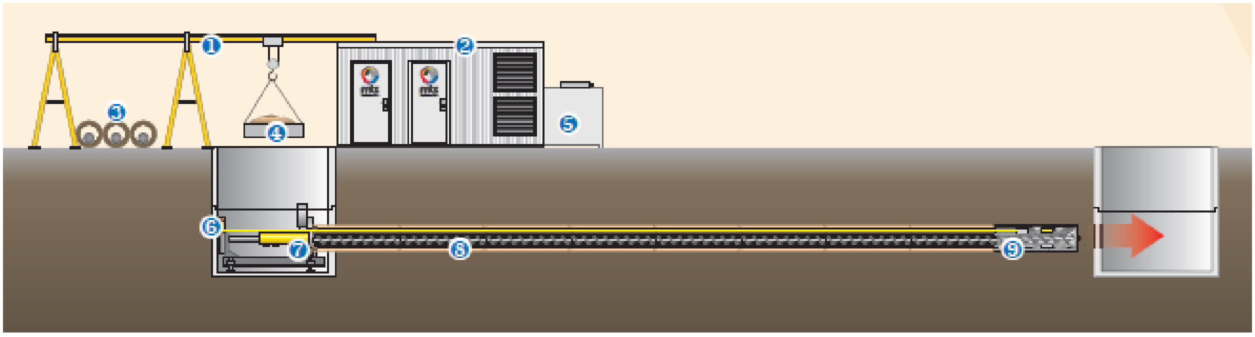
Speed of construction became important as coordination with timing of other contracts became increasingly demanding. Refurbishment of the Clark St had its own tight programme and completion of the sewer was required ahead of the road works.

2.2 CONSTRUCTION PLAN

2.2.1 MICROTUNNELLING EQUIPMENT

The successful tenderer was Harker Underground Ltd with the proposed MTS Perforator, 600 NB Auger Microtunnelling machine and Naylor Denlok Vitclay pipes. The auger system was laser guided with a steerable head and jacking rams powered by an electromotor.

Figure 3: Typical Microtunnelling – auger boring setup



The limitation of length in one drive was approximately 110m. A number of temporary shafts were required for the construction and at the end every second shaft had a manhole installed within it. That methodology also increased a need for accuracy of the tunneling alignments, both horizontal and vertical, as the ends of drives needed to match accurately.

Figure 4: Microtunnelling equipment

 The TBM units	 The cutter	 TBM setup within shaft

 The auger	 The auger cone	 The auger conveyance system through centre of pipes

2.3 HOW THE SEWER WAS CONSTRUCTED

2.3.1 CONSTRUCTION CHALLENGES

The contractor started in Clark St where depths were between 8m and 10m. The interbedded silts of Puketoka formation proved to be difficult for the old auger machine. Progress was slow as frequent equipment breakdowns occurred. The jacking forces came close to the limits and a number of pipes did not withstand the compression. Remedial works were required to take out the cracked pipes and push in more pipes to complete the string.

Figure 5: Microtunnelling construction photos

 Pipes ready for installation	 A full skip on way out from shaft	 A new pipe lowered and joined

It became apparent that completion of the pipeline with the Auger TBM system would not be within the project timeframe. The construction programme was seriously affected and needed a second crew to start in Rankin Ave.

2.3.2 PLAN B – PIPE JACKING

An additional 600 NB TBM to suit the ground conditions couldn't be found at the time. The contractor proposed pipe jacking of 1050 mm Reinforced Concrete Skid Ring Joint (RC SRJ) pipes from MH06 to MH11 with total length of 678m. The remaining length of 241m from MH11 to the South Lynn branch sewer was constructed by open cut as originally planned.

An open face pipe jacking is not the quickest method of trenchless installation. However it has its own advantages as it provides an opportunity to deal with any obstructions which are encountered. The ground conditions in Rankin Ave were expected to change to highly weathered sandstones of the East Coast Bays

Formation. Those sandstones consist of stiff to very stiff clays and silts with typical N values between 10 and 35.

The shafts for pipe jacking were larger and of a rectangular shape, with 'H' piles and timber boards between, and steel waler beams. The pipe jacking method was able to achieve longer drives. Two drives over 200m were successfully completed.

Figure 6: Pipe Jacking along Rankin Ave

 Reaction wall construction	 A new pipe lowered	 A skip of excavated materials coming out from the drive front

Figure 7: Open trench within berm in Margan Ave

 Trench shield in combination with sheet piles used for shoring	 Pipe bedding in preparation	 600mm RC RRJ pipes laid

3 SOUTH LYNN BRANCH DIVERSION SEWER STAGE 1 & 2

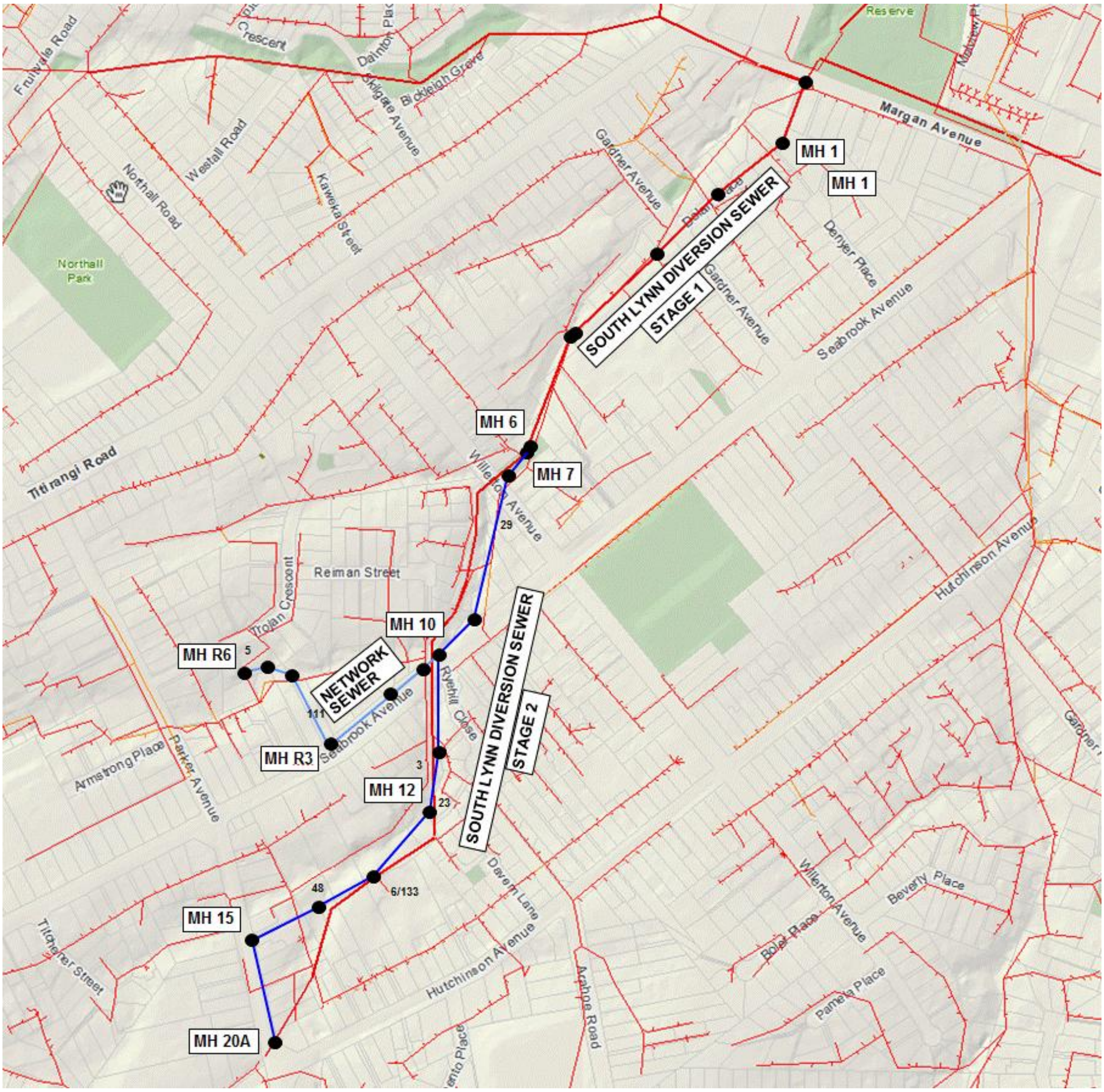
3.1 EXTENT OF WORKS, INVESTIGATIONS AND DESIGN

3.1.1 EXTENT OF WORKS

The South Lynn branch diversion sewer (Stage 1 and 2) consisted of a new gravity sewer pipe from Margan Avenue through predominately private property up to the intersection of Hutchinson Avenue/Parker Avenue, total length 1,330 metres comprising of 960 metres of 375mm diameter and 370 metres of 300mm diameter pipe.

The South Lynn branch diversion pipeline route started in Margan Avenue, connecting to the new West Lynn Branch Sewer Diversion. The pipeline follows parallel to and under the Manawa Stream for most of its length. From Margan Avenue the new sewer passes along a public walkway to Dolan Place, along Dolan Place, across Gardiner Avenue and through private property to Willerton Avenue. From Willerton Avenue the new sewer passes through private property on the diagonal to Seabrook Avenue. At Seabrook Avenue a new 250mm diameter network sewer branches off and continues up to 111 Seabrook Avenue, before turning 90 degrees north, down through private properties into 5 Trojan Crescent, total length 285 metres. The South Lynn branch diversion sewer continues south through private properties bordering Ryehill Close and Seabrook Avenue, following the stream to 48 Parker Avenue. 48 Parker Avenue is access via a long driveway. At this property the pipeline deviates from the stream and follows along under the driveway to Parker Avenue, turns south along Parker Avenue connecting into the existing South Lynn branch sewer at the intersection of Parker Avenue and Hutchinson Avenue.

Figure 8: South Lynn Diversion Sewer – Stage 1 & 2



Both the South Lynn Branch Diversion Sewer and the new network sewer were constructed in close proximity to residential housing, accessed predominately from long shared right of way driveways. The new sewers were constructed on flat grades, at varying depths. The deepest section on the Branch Diversion Sewer was 8 metres deep (MH13) with vehicle access only from 6/133 Hutchinson Avenue via a long driveway. The deepest section of the network sewer was at MHR3 on Seabrook Avenue outside number 111. This manhole was 10.5 metres deep. Pipe grades varied from 0.43% to 9.8%.

Due to the depth and shallow design grades the preferred methodology for construction was microtunnelling/HDD technology. The PBA machines can drill pilot bores accurately almost to zero tolerance. In uniform ground conditions pipe grades of 0.10% can be achieved. In variable ground conditions grades of 0.2-0.5% could be successfully achieved. The traditional HDD technology typically cannot reliably achieve grades flatter than 1%. Microtunnelling also has the advantage of having a small footprint, commonly setup within the small shaft or even manhole at the invert level of pipes. That is beneficial when working within private properties, between houses and close to streams. Traditional HDD requires the drill to be set up some distance away from the proposed manhole resulting in much large area requirements.

Alternative alignments were considered following the road reserves. These alternative alignments were deeper and longer. In addition the major design consideration was to maximize the number of cross connections between the existing South Lynn branch sewer and the existing poorly performing network sewer to the new South Lynn Branch Diversion Sewer to minimize future overflows. The alternative alignments did not achieve the desired number of cross connections.

In total 960 metres of 375mm diameter pipe, 370 metres of 300mm diameter pipe and 285m metres of 250 diameter pipe, 21 transmission manholes, 11 network manholes, 4 rodding eyes and numerous smaller cross connections were constructed as part of this contract.

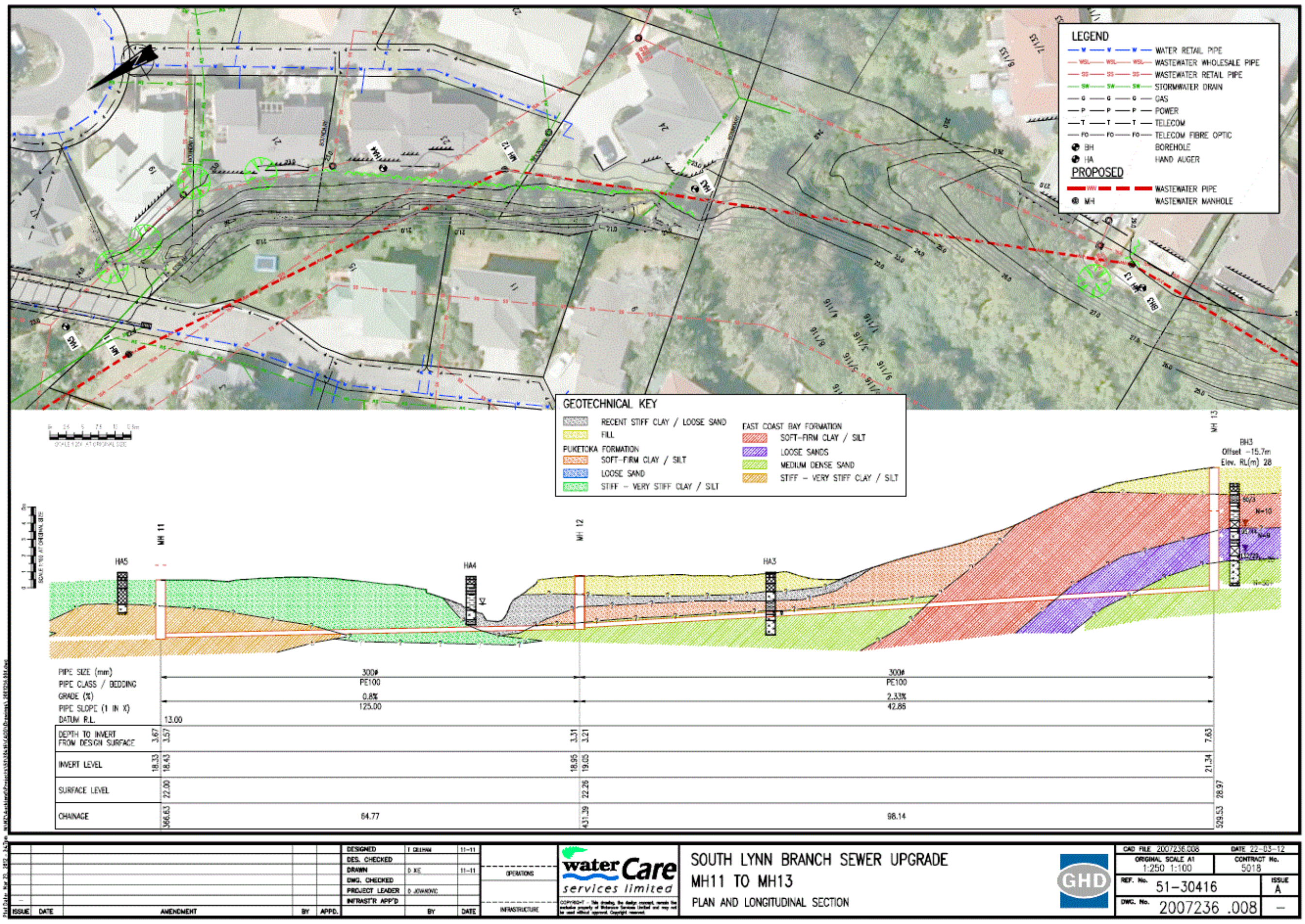
3.1.2 INVESTIGATIONS AND GROUND CONDITIONS

The geotechnical investigation comprised 13 machine boreholes at approximately 150 metre spacing interspaced with 15 hand auger boreholes where the space limitations dictated.

The ground conditions encountered in the boreholes generally comprised of Puketoka Formation Alluvium overlying East Coast Bays Formation soils. Fill was encountered overlying the natural soils in a number of locations. Ground water was found in all boreholes, depths varying from 0.44 metres below ground level in low lying areas to 5.32 metres below ground level in elevated areas.

At the proposed pipeline invert levels the geotechnical investigation revealed variable ground conditions, from soft alluvium with the possibility of encountering tree trunks through to East Coast Bays Formation medium to dense sands with cemented horizons. A sample geotechnical long section is shown below.

Figure 9: South Lynn sample of geotechnical long section



3.1.3 DESIGN

The pipeline design firmly directed the vertical alignment, the minimum internal diameter, all connection points, pipe material and the manhole positions. It was left to tenderers to propose a construction methodology, pipe class, design of all temporary works including intermediate shafts if required and staging of the works.

The Contractors construction methodology had to minimize adverse effects on the stream. At three locations the new pipelines pass directly underneath the streams with minimal (500mm) cover. These stream crossing were all drilled.

Watercare had organised and gained all entry consents required to enable the Contractor to undertake the works. In total 64 entry consents were required for Stage 1 and 42 entry consents were required for Stage 2. A number of the properties were also tenanted and these tenants also had to be notified.

3.2 CONSTRUCTION PLAN

3.2.1 CONSTRUCTION EQUIPMENT

The successful tenderer for both Stage 1 and Stage 2 Contracts was Kerry Drainage Limited. Stage 1 was drilled using a Perforator PBA85 horizontal thrust boring machine. For Stage 2 Kerry Drainage purchased a new larger machine, Perforator PBA155 horizontal thrust boring machine. The PE100 SDR13.6 pipe was selected.

The PBA horizontal thrust boring machines (PBA's) have an Optic Electronic Navigation system for precise steering of pilot rods enabling the machine to pilot down to 0% grades if required. PBA 85 is capable of drilling pipes up to 560mm OD, maximum drill length reported to be approximately 80 metres. PBA155 is capable of drilling pipes up to 1000mm diameter, maximum drill length approximately 110 metres.

Kerry Drainage had a range of other plant on site including a smaller directional drill, the large Environmental Truck, a number of various sized excavators, trench shoring, trucks and pumps.

Figure 10: Kerry Drainage's Plant and Equipment

		
PBA155 Horizontal Thrust boring machine above ground with power pack, gantry crane sitting alongside. Used for drilling Stage 2	1m long drill rods and gantry crane for PBA155 horizontal thrust boring machine	PBA85 Horizontal Thrust boring machine used for drilling Stage 1

3.3 HOW THE SEWER WAS CONSTRUCTED

Twenty one out of twenty four shots were drilled using the PBA machines. The general drilling methodology is similar for each drill shot. The PBA was set up within a shaft. To ensure accuracy the PBA was surveyed into position before welding and anchoring against the shaft. The large shafts were generally positioned at every second manhole. The PBA would pilot downstream to the next manhole. Once successfully piloted the drill rods would be exposed at the downstream manhole. A manhole would be sunk as a caisson at this location. Alternatively a steel circular shaft would sometimes be positioned at this location. On the longer and more difficult drill lengths, often where hard ground conditions were encountered, back cutting of the pilot bore would be required before the pipe could be pulled into position. A direction drill machine would pilot towards the downstream manhole from the opposite direction. The PBA drill rods would then be coupled directly to the directional drill rods. This methodology ensures that the pilot bore is never lost and allows backcutting of the pilot bore to form a larger hole before pulling pipe. For simpler drill shots in softer ground often no back cutting was undertaken and the pipe was pulled directly into position.

A lead in trench from ground level to the downstream manhole invert level is then drilled using a direction drill. PE pipe is welded and then connected to the PBA155 drill rods. The pipe is then pulled into position using the PBA. All pipes were pulled with an open front. This allowed drilling fluid and mud to move into the pipe during pulling, vastly reducing the risk of undesirable spillage into the environment. This methodology resulted in the pipes requiring cleaning. The PBA drill rods were again pushed through the inside of the pipe, a pig attached to flush the muds back towards the PBA shaft. The Environmental truck was then used to suck and remove all drilling muds.

The PBA was then repositioned within the shaft and piloted up towards the upstream manhole, with the same methodology repeated.

The flattest grade that the PBA85 machine drilled on the Contract was 0.12%. The flattest grade that the PBA155 machine drilled was 0.43%.

Three drill shots were drilled with a traditional directional drill machine. Stage 1 had a short directional drill shot along Margan Avenue, 53 metres long on a 1.73% grade, with an average depth of 4.3 metres. Stage 2 had two directional drill shots. The first directional drill shot was 115 metres long with a 1.15% grade and a 5m average depth along Parker Avenue. The second directional drill shot was along Seabrook Avenue. This drill shot was 91m long, with the depth ranging between 6.5m – 10.5m and drilled on a 1.05% grade.

Due to the varying ground conditions there were a number of obstacles that the Contractor had to overcome. These obstacles included:

- A large pocket of boulders (varying sizes up to 1m diameter) buried over a short length between MH7 and MH8. The boulders had to be dug up and removed.

- An unexpected 60m wide pocket of Parnell Grit underneath 29 Willerton Avenue. Initially the Contractor had problems sinking a planned intermediate shaft at the site of the Parnell Grit. The drill head was modified to enable drilling through the Parnell Grit. The Contractor then experienced problems with the pilot bore sinking and losing the alignment when exiting the Parnell Grit and entering the softer alluvium material. This was overcome by using no water and no rotation of the drilling rods.

- Tree stumps encountered underneath a stream crossing. The stream was temporary bypassed pumped to allow digging out the tree stumps and a third drill machine was employed to drill the correct alignment from the opposite direction.

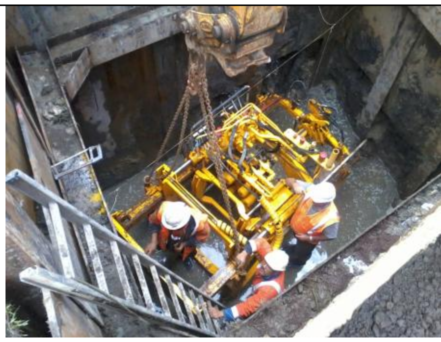
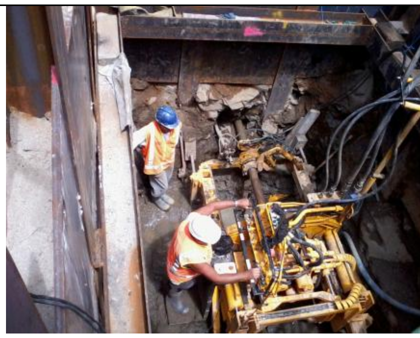
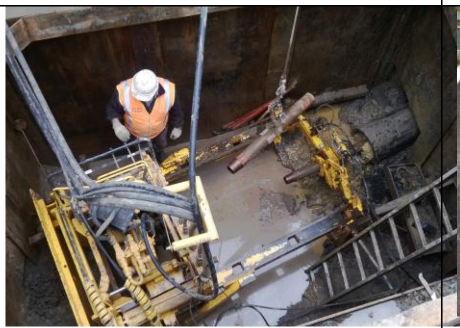
- East Coast Bay soils were in places sticky, causing the drill rods to cement and became difficult to unscrew. This soil was identified in the geotech investigation. A special excavator mounted spanner was fabricated to assist with undoing the drill rods.

- Four shafts situated within 10 metres of houses located on private property. The houses were surveyed to monitor for movement and no movement was found during the work. These residents were especially patient and understanding during the construction works. The properties were fully reinstated on completion of the work to the satisfaction of the property owner.

- Pipelines drilled very close to houses. Houses were monitored for movement during the construction of the pipelines. The pipes were pulled into position using an open front reducing pressure. There was no movement of ground surface during the drilling.

- Drilling very close to streams. To avoid streams contamination the Contractor predrilled relief holes for the drilling muds to escape, with sediment controls in place to contain escaped drilling muds. The pipe was pulled with an open end which allowed the drilling mud to enter the pipe. The Environmental (sucker) truck was always on standby during pipe pulling. The drilling methodology employed ensured no contamination of the stream.

Figure 11: South Lynn Branch Diversion Sewer under construction

 Construction of shaft on Seabrook Avenue	 Lowering PBA155 into shaft	 Piloting with the PBA155
 Pulling pipe – lead in trench has been drilled using the HDD machine	 Cleaning the pipe with the PBA155	 Receiving manhole. Steel circular shaft has been used in this instance. Alternatively a manhole sunk as a caisson can be used.
 Forming manhole at base of shaft	 Typical set up above ground around shafts	 An example of how close the work occurred next to houses and the stream. A major shaft was constructed in this property in front of the excavator.

4 CONCLUSIONS

The trunk sewer capital works programme for the New Lynn catchments has improved the environment. The wastewater upgrades have successfully eliminated a number of existing wastewater overflows within the community while allowing for future planned growth.

The project started with investigations and planning in 2006. The construction was staged from 2009 to 2013 and it was completed within the overall project programme. The total cost was within the planned budget.

The drilling methodologies were adjusted to suit ground conditions, minimise effects on the environment but also minimise effects on the residents and business' and in particular the traffic in Clark St. The entire new pipelines are in ground and old pipe bridges have been removed. The streams were not affected by the works and the residents will benefit from reduction of sewerage overflows.

A new drilling machine and a relatively new technology was tested and proved to be successful.

The project was difficult, working in and around tight space restraints in close proximity to houses. There were no significant health and safety breaches during the works. Both Harkers and Kerry Drainage cooperated and worked with others to ensure the project succeeded. All private properties were reinstated at completion of the works to the owner's satisfaction.

ACKNOWLEDGEMENTS

We acknowledge Harker Underground Construction Ltd and Kerry Drainage Ltd for their workmanship in execution of the contracts' works.

REFERENCES

MTS Perforator Tunnelling Systems, AugerPro System, Product brochure