HASTINGS OUTFALL PIPE INSPECTION

PREPARED FOR HASTINGS DISTRICT COUNCIL

20/09/2019

QUALITY STATEMENT

PROJECT MANAGER	**PROJECT TECHNICAL LEAD**
Roger Hulme	Wayne Hodson

PREPARED BY		
Ryan Abrey	....	20/09/2019
CHECKED BY		
Wayne Hodson	....	25/09/2019
REVIEWED BY		
Grant Shearer	....	24/09/2019
APPROVED FOR ISSUE BY		
Wayne Hodson	....	25/09/2019

HAWKES BAY
1st Floor, 100 Warren Street South, Hastings 4122
PO Box 13-052, Armagh, Christchurch 8141
TEL +64 6 873 8900, FAX +64 6 873 8901

REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
00	15/08	Draft for Comment	R. Abrey	W. Hodson	G. Shearer	W. Hodson
01	20/09	Final	R. Abrey	W. Hodson	G. Shearer	W. Hodson

Hastings District Council

Hastings Outfall Pipe Inspection

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1. Introduction

1.1 Scope

The Wastewater Treatment Plant (WWTP) outfall pipeline is a critical asset that disposes treated wastewater via a diffuser into Hawke Bay in accordance with the approved Resource Consent conditions. The outfall was constructed in 1980 and comprises several components: Land-based steel manifold section which is attached to the pump station; Land-based section of the concrete pipeline; Submarine section of the concrete pipeline and the diffuser over the last 300m of the pipeline.

This report focuses on the submarine section of the outfall pipeline as it requires a condition assessment to assist with the planning of future renewals and intervention works. The following scope is proposed as part of the initial phase of the condition assessment, as detailed in the signed offer of service dated 1 February 2019:

- Compile available reference information from earlier assessments and investigations
- Summarise details and position of key components and fittings, including historic repairs and notes from As-Built drawings
- Identify constraints and/or limitations for any inspection or investigation work
- Investigate available technology and methods for condition assessment of the pipeline, including the integrity of the reinforcing and prestressing strands
- Summarise findings and workshop with Hastings District Council (HDC)
- Develop a programme for investigation works based on available budgets and suitable technology/methods.

1.2 Background

A key component of the outfall is the approximately 2.5km long submarine section of concrete pipeline. The pipeline has a novel design with articulating joints which are tied together with prestressed steel strands. There is limited information available about the long-term performance of this type of pipeline and there is sparse original design material available, with only a more recent study by Opus of a joint from this pipeline which had been recovered during a repair in 2017.

This pipeline has experienced damage to three joints from what was suspected to be a trawler, with complete failure of one joint that caused a visible discharge plume approximately half-way along the outfall. Repairs were carried out in 2016 to seal the pipeline with stainless steel bands at each of the three damaged joints.

A key uncertainty for the long-term performance of the submarine outfall pipeline is the integrity or degradation/corrosion of the 12 prestressing strands that tie the pipeline together.

2. Summary of Fittings and Details

Refer to the As-Built drawings, provided in Appendix B. Summary information is tabulated below.

Table 1: Summary of pipe features

Item Description	Quantity	Comment
Pipe Strings	6 No.	Strings 4 to 6 are land-based String 4 is within the surf zone or within the beach
String Joints	5 No.	Excludes joints at downstream and upstream ends to diffuser and manifold
Manhole Access	4 No.	On nose pipe at each pipe string joint, except joint 5/6.
String 1	514m 210 pipes	3 by 70 pipes (171.2m) with anchor pipes connecting. Double anchor pipe and extra anchor pipe near upstream end.
String 2	1027.8m 420 pipes	6 by 70 pipes (171.2m) with anchor pipes connecting
String 3	1037.2m 424 pipes	1 by 74 pipes (180.9m) and 3 by 70 pipes (171.1m) with anchor pipes connecting
String 4	79.1m 32 pipes	
String 5	73.7m 30 pipes	Sloping down into sea
String 6	97.8m 40 pipes	
Repair Bands		Two on String 2 from construction Three on String 2 from repairs in 2016 One at String 2/3 joint

3. Constraints and Limitations

3.1 General

The submarine outfall always operates as a pressurised and therefore full pipeline due to being laid below sea level. The upstream land-based section of the outfall operates in part full gravity flow at times of lower flow and/or lower tide level as the top of pipeline is above low tide level.

3.2 Outfall Design Criteria

The severity level of possible pipe failures was established based on two primary design criteria for the ocean outfall:

1. Ensure that the wastewater is well assimilated in the ocean by using the assimilative capacity of the ocean (i.e., the extent to which the ocean can receive wastes discharged from the outfall without unacceptable impacts).

2. Ensure that the outfall pipe provides the required flow capacity to meet the needs of the wastewater system.

3.3 Flow Shutdown

The outfall pipeline normally operates continuously with wastewater pumped from the outfall pump station on a variable flow rate basis controlled by the pumping operation at the WWTP outfall pumping station. Actual flows can vary significantly, due to industrial processing seasons and wet-weather conditions causing higher flows.

During normal conditions the pump station flow and discharge out the outfall can be suspended for short periods by backing up the wastewater in the inland trunk sewers along Richmond Road. This storage volume is limited to 2-3 hours in favorable conditions and time of the day, being 9,30am to 12.30pm. Longer shutdowns would cause overflow to the environment.

An emergency beach overflow is to be recommissioned in 2019/20 that would allow overflow to the beach if the pump station or outfall was not operational for longer periods. Use of this facility is not favoured, especially for planned inspection or maintenance works.

The shutdown duration is a key constraint in any repair or inspection works planed on the outfall where complete flow shutdown is required.

3.4 Pipe Access

3.4.1 General

As the submarine outfall pipeline is located within Hawke Bay, the depth of water increases out into the bay with the downstream end within 10 to 12m depth of water.

Access to the external pipe generally requires divers as it would not be practical without significant temporary works to isolate the pipeline from the sea. The pipeline was buried during construction and hence divers may need to uncover the pipeline through dredging for inspection.

Internal pipe access is available with access points noted in Table 1 above however they may too be buried. Generally, access to any of these points would require a shutdown to the outfall pump station for the period that the access is open.

3.4.2 Manifold Pipe

The steel manifold section of the outfall includes two access hatches within the WWTP site. A smaller hatch below ground and within a concrete manhole is located near to the joint with the concrete outfall pipe.

Upstream from this is a 900mm ID steel flanged access tee constructed in 2016 that extends above ground. The above ground flanged plate is 700mm above the pipe soffit and has a smaller pipe for an air valve installed on this tee. This fitting provides a good access point into the upstream end of the outfall pipeline for inspections or condition investigation works.

3.4.3 Nose Pipe Access

Manhole access points are noted on the As-Built drawings on each of the nose pipes for most of the pipe strings at the underwater joints. These access points are recessed into the nose pipe, shown as a 25mm thick top plate which is 662mm by 862mm and fixed with 12 bolts. Clear opening through the pipe is 450mm by 650mm.

The drawings do not indicate any corrosion protection to the steel access points. It is likely that these would have significant corrosion and could be a point of future failure. They may also be of use for access for inspection or condition assessment.

It is recommended that a dive inspection to these points is carried out to:

- Check on condition and identify repair works required for access.
- Use as a reference to confirm the top of the pipeline so concrete pipe core samples can be taken with confidence away from the side tensioning strands.

3.4.4 Diffuser

At the either end of the diffuser there is the ability for internal access to the pipeline. The best access to the submarine outfall is through the flanged plate on the Wye fitting (start of the diffuser). This is a 1568mm internal diameter flanged opening with 16mm thick blind flange end plate connected with 10 bolts M20 bolts.

When the replacement diffuser was commissioned in 2017 the old fiberglass diffuser was not able to be completely removed from within the Wye and outfall pipe. There remains part of this old GRP diffuser pipe that is connected inside of the submarine concrete outfall pipe. The GRP pipe is 1067mm ID.

This fitting provides a good access point into the downstream end of the outfall pipeline for inspections or condition investigation works.

4. Condition Assessment Methods

4.1 Hastings Outfall Considerations

Refer to the attached report, see Appendix A, that details various condition investigation and assessment methods. Summary details are provided in this section.

The City of Hastings submarine outfall pipe represents a unique challenge for inspection due to its:

- unique design (reinforced concrete pipe segments connected utilizing short, staggered, unbonded prestress wires, flush fiberglass joints with rubber rings),
- environment (buried below sea level),
- distance between access locations (2,800 m, with downstream access 11 m below sea level) and,
- criticality (2-3 hours. storage time; no alternative outfall that can be deployed).

Based on the design attributes of the submarine outfall pipe the following potential deterioration mechanisms were identified and assigned a criticality level.

Table 2: Summary of Key Deterioration Mechanisms and Their Symptoms

Deterioration Mechanism	Manifestation / Symptoms	Criticality Level
Failure of the rubber rings at the joints	Exfiltration / infiltration	Low-to-Moderate
Corrosion/rupture of the post tensioning wires	Rupture of cables will create a clear distinct acoustic sound; severed cables likely to form a detectable anomaly in the secondary magnetic field created by induction of electrical current into the prestressing wires (corrosion in the wires is very difficult to detect/quantify). The release of tension may damage the pipe at the point of rupture and possible the anchor points	Moderate-to-High
Internal/external degradation of the concrete wall	Visual sign of corrosion, uneven internal surface, increase in internal diameter, exposed reinforcing steel and debris within the pipeline	Moderate-to-High
Failure of the anchoring blocks (resulting in loss of water tightness at the joints)	Visual corrosion of exfiltration / infiltration	Moderate-to-High
Corrosion of the reinforcing wires	Visual signs of exposed reinforcing wires where concrete spalling has occurred	Moderate-to-High
Open Joints	Visual observation of offset joints and deposits in pipeline	High
Damage to the pipe due to impact load (e.g., boat anchor)	Cracks/fracture/hole(s) in pipe wall, plume may be visible from the surface	High

4.2 Internal Inspection Methods

The associated symptoms were mapped to the detection capabilities of fourteen (14) commercially available condition assessment technologies as per the attached report, including:

- Acoustic monitoring (e.g., escaping fluids, breakage of a prestressing wire)
- Surface imaging (either by CCTV, LiDAR, or Sonar)
- Changes between input and output flows
- Detection of changes in an electromagnetic field
- Temperature monitoring

Of the fourteen condition assessment technologies reviewed, none of these technologies is capable of providing information regarding the presence and/or location of all deterioration mechanisms listed in Table 2. Two of the technologies are considered either not technically viable (tracer compound) or unable to provide location specific information (Magnetic Flowmeters). The technologies outlined below provide some useful information, as outlined, but also have limitations in other areas:

- SmartBall, Nautilus and Pipers technologies could provide useful information about leak detection but no structural integrity information. Additionally, only rough estimate of the location of leaks could be obtained unless active acoustic sources are installed on the pipe's outer wall at predetermined spacing, increasing the cost and complexity of the inspection.

- PipeDiver and SeeSnake are the only technologies capable of providing information regarding the presence/location of broken post-tensioned cables. As the cables are unbonded, failure will result in loss of all prestressing force in the wire and a relatively large gap between the two edges at the breakage location. Inspection could only be expected to provide useful data over the joints, as six of the twelves prestressed wires are terminated at each mid-joint. Furthermore, the PipeDiver is designed to detect wire breaks in a pre-cast concrete pipeline, where a single continuous prestressed cable is wrapped in a helical pattern around the circumference of the pipe (while SeeSnake is mainly used for detection of corrosion/pinholes in metallic pipes/cylinders). The unique arrangement of the prestressed wire in the submarine outfall pipeline will require the development of a custom calibration curve, likely utilizing full-scale testing either on the above ground section of the pipeline or a custom-fabricated mock setup. This is likely to significantly increase the cost of inspection using these methods.

- The utilization of a crawler with CCTV camera and LiDAR will require the flow to be bypassed and the isolation and dewatering of the pipe, as LiDAR cannot be used below water level. Information provided will be limited to internal wall corrosion and dewatering the pipe might not be possible if water tightness of the pipeline is compromised allowing infiltration of seawater within the prestressed concrete pipe section. Similar CCTV inspections at other NZ outfalls have led to damage of the equipment due to depth/pressure and hence specialised equipment will be required. Overall this option is not considered viable.

- Deployment of a bi-directional intelligent pig coupled with a smart gauge system will provide information on defects in the internal wall and leak detection while allowing the pipe to remain in service. A more conventional approach used in the municipal pipeline industry for obtaining similar information, potentially at lower cost, includes the MTA Pipe-Inspector and the DT340 submersible Pipe Crawler. None of these technologies can provide information regarding the condition of the prestressed wires (unless open joints are detected). Also, quality of the CCTV images is highly dependent on water clarity. Bacteria growth on the inner pipe wall or murky water could greatly detract from the information provided by CCTV images or render them useless.

- Multibeam profiling sonar is an effective technology to obtain information on the internal geometry of the pipe in less than optimal water clarity conditions. Commonly designed to be mounted on a remotely operated vehicle (ROV), sonar images augment information provided by CCTV images and are capable of providing a good understanding of the condition of the internal surface of the pipe, including the presence of wall corrosion, holes or open joints. Information regarding the presence of leaks and the condition of the prestressed wires cannot be obtained.

The above technologies are mainly intended to provide information on the condition of a pipeline at a given point in time. The life expectancy of a concrete marine pipeline is approximately 60 to 70 years, yielding a theoretical expected service life ending around 2040. However, there are no case studies, for similar pipelines, available to provide an indication if this estimate is valid. Failure of the prestress wires and third-party damage are some of the more severe risks to the functionality of the outfall pipeline. A fibreoptic system will enable continuous monitoring of prestressed wire breakage (including location) and potentially on-going leakage detection via acoustic and temperature monitoring. It will provide a continuous record for tracking and assessing the overall structural health of the outfall pipe, as well as actionable data. On the other hand, the installation of a fibreoptic cable involves a significant upfront capital cost, ongoing monitoring and maintenance costs, while it is also susceptible to damage from external third-party damage. Also, the system is unable to provide information regarding prior failures of prestressed wires or information regarding pipe wall corrosion.

A budgetary level opinion of probable cost (OPC) prepared for selected condition assessment methods is summarized in Appendix A: Table 3. Costs are based on previous projects completed in North America. Costs shown do not include costs associated with any required marine support/divers, isolation and dewatering of the outfall (if needed), and any civil work (these are typically considered owner's responsibility and should be estimated when the preferred approach is identified).

4.3 Failure Modes

Of the 7 Key Deterioration Mechanisms proposed in Table 2 above, the following failure mechanisms are to be considered and then possible investigation methodologies are described in section 5 below.

4.3.1 Internal/external degradation of the concrete wall

There may be degradation to the internal surface of the concrete pipe due to biological corrosion should gasses collect at a high point along the pipeline. It is noted that a portion of the concrete pipe on land just downstream from the steel pipe section has already required substantial refurbishment due to Hydrogen Sulphide build up. The surface may also be abraded due to debris flowing down the pipeline as well as any sediment movement over any exposed pipeline exterior surfaces. Chloride penetration where there is exposure to seawater could also degrade the concrete integrity.

The reduction in concrete thickness will reduce the cover to the reinforcing and the post tensioned wires hence exacerbating failure modes 4.3.3 and 4.3.5 below.

4.3.2 Failure of the rubber rings at the joints

A gap may form between two adjacent pipe sections should the rubber ring fail which will lead to pipe leakage and excessive joint deflection above the designed limit of 2 degrees. Any movement between the two sections will now cause abrasion between the two concrete surfaces, similar to failure mode 4.3.1 above.

A set of rubber rings, along with the GRP collar and titanium support ring, were recovered during a previous joint repair and then a study has been carried out by Opus in 2017 to assess the integrity of the joint. Their findings show that the risk of failure in the following 10 years is low due to "no evidence of deterioration in the sample examined" (Morris, 2017). However, this is a sample of one. They did note that the sand seal was starting to deteriorate and may fail at some point, but they deemed the detrimental effect of this, on the overall joint integrity, to be unlikely.

4.3.3 Corrosion/rupture of the post tensioning wires

It is understood that the 15 mm high tensile steel strands were coated with polyethylene which should protect the strand from corrosion. Should sea water reach the post tensioned wires weakening the strands until failure, the release in tension may cause sudden forces within the ducts which may burst through as seen in Figure 4-1 leading to further seawater infiltration.

Figure 4-1: Eruption of PT Tendons caused by Corrosion Failure (Vector Corrosion Technologies, 2019)

The broken strand can then no longer resist axial forces along the pipeline inducing increased stresses in the remaining strands. The joints however were designed such that the final load after creep of articulation bearings and strands was to be 180 tons which was equivalent to 47% of the ultimate stress of the strand. The anticipated pulling load was 75 tons with a max limited to 150 tons such that a generous margin of safety was allowed for bending during burial (Thomson). Hence, depending on the wave loading causing movement in the pipeline, there may be significant redundancy in these tendons should they only be restraining pressure forces, which can be explored in the next phase of the study.

4.3.4 Failure of the anchoring blocks (resulting in loss of water tightness at the joints)

Similar to 4.3.3 for the reinforcing wires, should the high tensile steel anchoring and coupling blocks fail, there could be some recoil in the lines damaging the concrete and possibly compromising the axial strength of the pipeline. This could lead to further corrosion and joints opening. The status of the anchor plate within the recesses, highlighted in Figure 4-2, can be inspected by a diver externally.

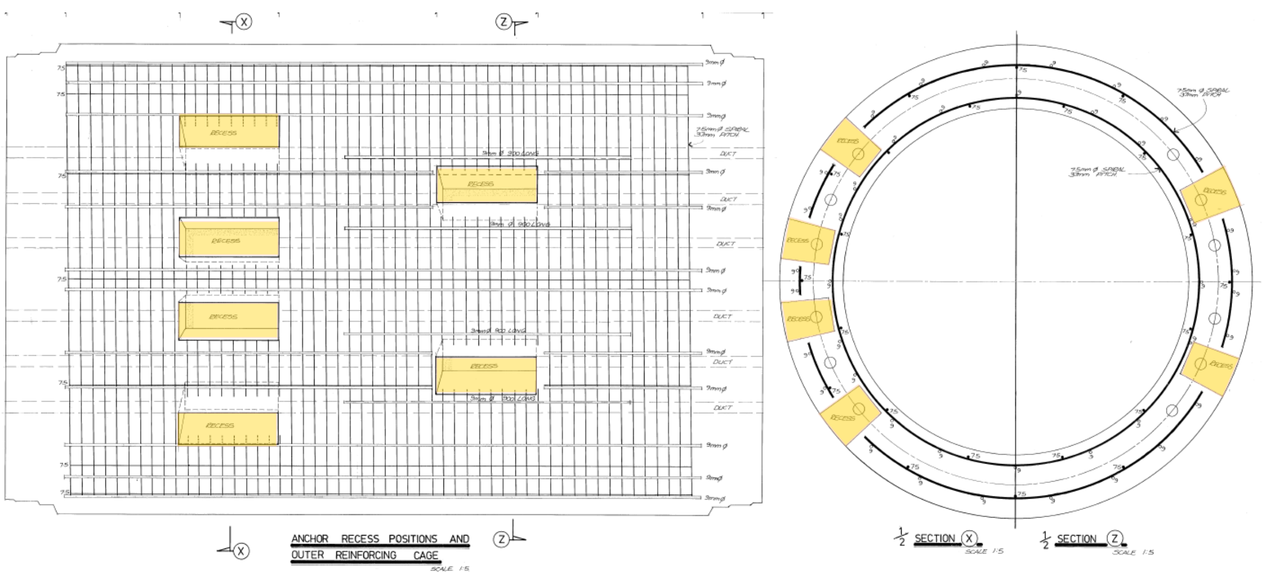
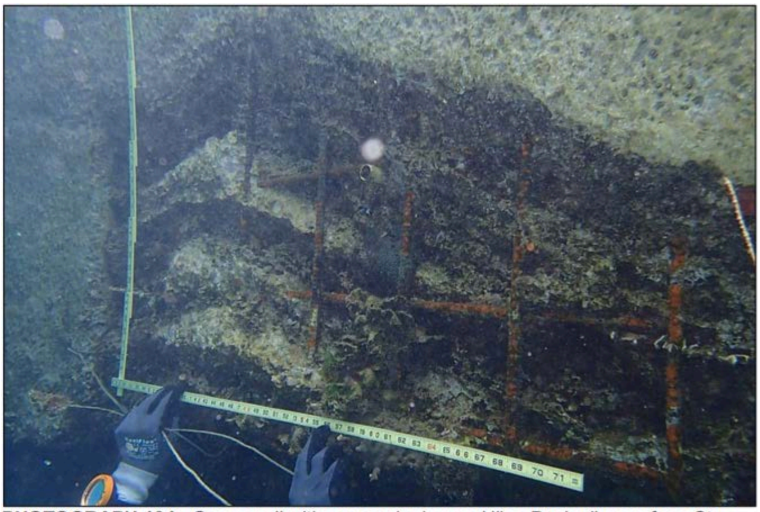


Figure 4-2: Anchor Pipe Detail

4.3.5 Corrosion of the reinforcing wires

Corrosion of the reinforcing wires could cause spalling, as in Figure 4-3, which will cause pieces of concrete to break off, further reducing the susceptibility to corrosion of the surround wires as well as reducing the strength of the pipeline as the wires no longer provide tension resistance. This could also cause leaks in the pipeline if a large portion of concrete breaks out. This would be visible early as rust forms on the surface of the concrete or bulging occurs.



PHOTOGRAPH 134: Open spall with exposed rebar on Uliga Dock pile cap from Sta. 07+46 to Sta. 07+51

Figure 4-3: Example of underwater spalling (Republic of the Marshall Islands Ports Authority, 2015)

4.3.6 Open Joints

Should a joint open due to one of the mechanisms outlined in Table 1, effluent would leak from the pipeline causing a plume as seen in Figure 4-4. This would likely occur as the pipe flexes due to subsidence or movement from wave loading. The pipe should be held in place by the surrounding soil where buried and bending would not be expected. The pressure in the pipeline may cause the joints to open up slightly should the prestressed reinforcing fail, however, as stated in Section 4.3.5 there may be some redundancy in the wires.

Figure 4-4: Plume on surface from damage to outfall

4.3.7 Damage to the pipe due to impact load (e.g. boat anchor)

An impact to the pipe, be it an anchor or drag net, could cause failure to the pipe in the following ways:

- Breaking opening a hole through the concrete pipe or fiberglass collar causing effluent leakage as with 4.3.6.
- Pulling the pipe out of alignment, putting excessive stress on the post tensioned wires and joints
- Damaging the external concrete surface leading to corrosion of the reinforcing wires
- An impact to the anchor pipe section could damage the anchor plates, compromising the structural integrity of the pipeline.

5. Initial List of Investigations

The following list of possible investigations was discussed at a workshop with HDC to determine priorities for possible initial investigations which feed into the next project phase. Currently no costs have been considered.

5.1 Seabed

As part of the outfall inspection contract there is provision for an annual scan of the outfall pipeline. This will provide information on any discontinuities in seabed along pipeline, such as scour from pipe leaks, that can be prioritized for dive inspection as well as determining which sections of the pipeline have are uncovered due to sediment movement.

Note the pipeline may be uncovered seasonally depending on the local sediment movement regime and hence the pipe exterior may need to be checked at different times of the year.

A buoyant dye may also be pumped into the outfall which would seep through the seabed at any pipe leakage points, such that a diver swimming the pipe route will be able to pick up the location.

If the pipe is buried for the entire length, a sub bottom profiler could be used in an attempt to detect the pipe below the seabed, see Figure 5-1. The vessel will survey paths perpendicular to the pipeline in order to pick up its location and depth at set intervals along the route. It should be noted that obstacles, such as trapped gas, could shield features below and reduce the effectiveness of this method.

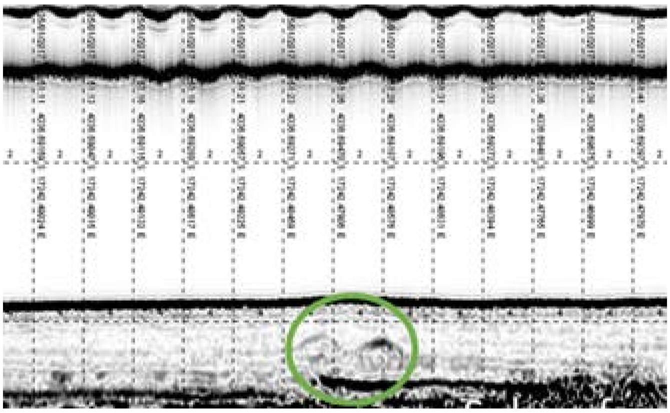


Figure 5-1: NIWA sub-bottom profiler section illustrating pipes buried ~0.5-1 m below the seafloor

5.2 Anchor Pipes

A diver inspection of the external surface of the pipeline will be able to assess the state of the anchor plates in the anchor pipes while also determining the orientation of the prestressed bands. If the entire length of pipeline is buried, an approximate location of the anchor pipes will need to be surveyed and then the pipe exposed by divers using air lift dredgers.

5.3 Historic Repair Bands

Along with the dive inspections proposed in 5.1 and 5.2, the following critical sections should be dived and exposed to assess the current status:

- Nose pipes with manhole access ports to determine if access is possible and corrosion state the steel covers
- Historic repair bands to determine the effectiveness and if any corrosion has occurred

5.4 Pipe Cores

Divers will be able to core concrete samples from the pipeline which will provide an indication if any degradation has occurred due to corrosion or abrasion as well assessing the extent of any chloride penetration.

Pipeline may have rotated during installation or operation, so the current top of pipe may not be as intended, and any investigation holes would need to confirm this alignment to avoid damaging prestressing cables. Locating where the nose pipes with manhole access would confirm the top of pipe and allow cores to be taken with better confidence in the immediate vicinity. Similarly, once the anchor pipes have been located, an inspection of the recesses will determine the orientation of the sides of the pipe.

An investigation into the redundancy of the prestressed wires may imply that the impact of accidentally damaging a tendon on the overall integrity of the pipe may be low and hence it may be beneficial to core out one of the tendons to assess the current corrosion.

5.5 Marine Traffic Survey

An investigation into the likelihood of another vessel dragging anchor or a fishing vessel dragging a net over the pipe, damaging the pipe. This could be an assessment of the historic vessel automatic identification system (AIS) records and possibly a navigation study to assess the risk of vessels over the pipeline.

Currently, a consent application is in progress by Stantec to extend the current navigation exclusion zone along with the possibility of additional navigation buoys along the pipe route.

6. Monitoring Works

In addition to direct inspections described in Section 5 above, there are some pipeline monitoring methods which can be deployed. The practicality of each method will be dependent on the requirements set out in the outfall consent and how quickly a failure will be picked up.

A nearfield dispersion modelling study can be carried out to estimate the flow at which it is likely that a plume will be visible on the surface, see Figure 6-1. This result can then be fed into scenarios of a combination of flows and locations of the break along the pipe for a far field dispersion model study to estimate what the concentration of effluent will be at the beach after a certain period. These results will indicate an acceptable window between the pipe break, the point at which it is picked up and then fixed.

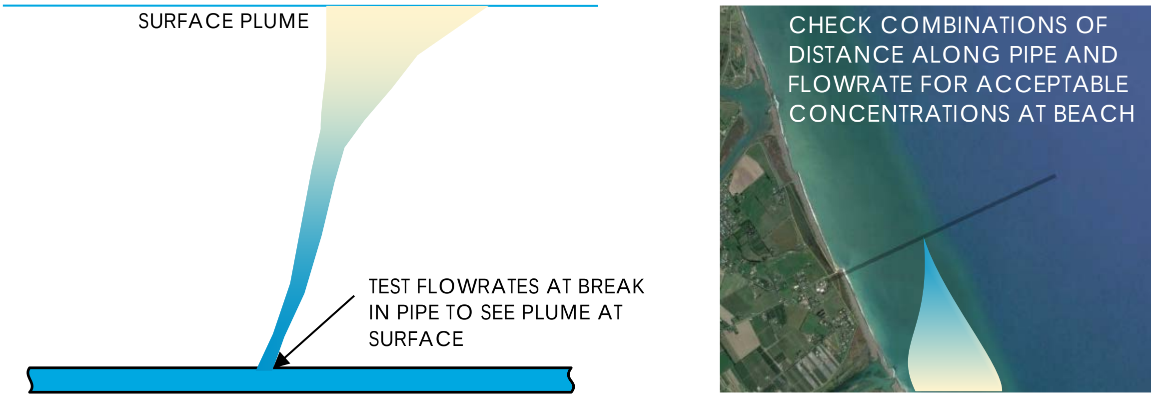


Figure 6-1: Near-field (left) and Far field (right) dispersion modelling

The following inspection methods would be able to pick up a plume on the surface:

6.1 Sea Surface Inspection

A vessel can sail along the length of the pipe to pick up if any plumes are noticed on the surface. Currently this is already carried out quarterly as part of the outfall dispersion monitoring regime.

6.2 Satellite Monitoring

The plume from the outfall is visible in satellite imagery, see Figure 6-2. A commercial satellite imagery supplier may be able to provide periodical views of the outfall, which can be used to monitor if there is a break in the pipe and a plume appears along the length of the outfall, seen on the right below. Initial discussions with a local provider, Critchlow Ltd. indicated that the satellite image for the area is available on average once a month.

Figure 6-2: Satellite image of outfall with 2019 end plume (left) & 2015 mid break plume (right) (Maxar Technologies, 2019)

6.3 Drone Technologies

Similar to the satellite monitoring, a drone could be flown along the length of the pipeline from shore to monitor the surface for plumes. This can be carried out by a local drone operator, or HDC could develop internal capabilities depending on the related costs. It should be kept in mind that the area in question is within the Napier Airport control zone as well as the required flight distance is "Out of Sight", hence an approved qualification for the operator as well as engagement with the CAA will be required. Operators have also indicated that the operation is risky and the loss of a drone will be priced into the inspection rate driving up costs.

7. Workshop Outcomes

A workshop with HDC was held at Stantec offices on the 22nd of August 2019. The following were in attendance:

- Les Collins – HDC 3 Waters Operations Manager
- David James – HDC Wastewater Manager
- Emile Klopper – HDC 3 Waters Project Engineer
- Wayne Hodson – Stantec Technical Lead
- Ryan Abrey - Stantec

During the workshop the proposals above were discussed, specifically the uncertainties and limited information available for this specific pipeline. HDC, stated that the preliminary investigations were already planned as part of New Zealand Diving and Salvaging's (NZDS) maintenance contract and it was suggested that initial cores were taken at this stage, most likely from the diffuser end of the pipeline, to provide an indication of the concrete condition. HDC also requested that monitoring requirements were assessed as described in Section 6 which would go together with an emergency maintenance plan by NZDS which will be implemented should damage take place.

It was agreed that after initial investigations during the NZDS diffuser maintenance (including scans and concrete cores) the further stages provided in Section 9, would be priced and programmed.

If additional funding is required for advancing investigations, then this should be confirmed for approval by the first quarter of 2020, for funding in the 2020/21 financial year.

8. Discussions and Findings

As the prestressed concrete pipe arrangement used for the Hastings outfall is a unique arrangement, it is difficult to estimate the remaining design life of the facility. While there are a number of technologies available to inspect pipelines, none are designed specifically for the application or materials used in this case. Hence a pragmatic approach, recommended below, is required to assess the pipeline condition while implementing an appropriate monitoring and contingency plan to address any damage to the pipeline in the interim.

9. Recommended Future Investigation Programme

It is recommended that the project will proceed in the following stages:

Stage 1 Proposed high level investigations:

- Pipe layout and burial – Data collected during NZDS diffuser maintenance contract
- Structural assessment of pipeline to determine pre-stressed tendons capacity
- Engage with NZDS to develop a repair contingency and procedure

Stage 2 These surveys will feed into a preliminary investigation and risk assessment study to determine the level of risk associated with the various elements if failure occurred with high level timeframes. This study should include an assessment of failure dispersion risks to feed into interim monitoring recommendations.

Stage 3 Prioritize more detailed work required for the risk elements to manage/mitigate risk based on the types of survey outlined in the report together with high level costs or more detailed work.

Highlighting that more detailed work could result in revealing further work and a review of priorities:

- Concrete condition – possible internal sonar inspection/diver cores
- Joint condition – If any leaks are detected, a diver inspection may be required
- Internal inspection via Sonar or Electro

Stage 4 Detail design and construction of work packages starting off with highest priority to minimize the risk of treated wastewater disposal via a diffuser into Hawkes Bay in accordance with the approved Resource Consent conditions being compromised.

Following this report Stantec will provide HDC an Offer of Service for Stages 1 and 2 such that once complete, stages 3 and 4 can be planned.

10. References

Maxar Technologies. (2019). Colorado: Google Earth.

Morris, J. (2017). *Inspection of GRP collar from concrete outfall pipeline.* Wellington: Opus.

Republic of the Marshall Islands Ports Authority. (2015, December 10). *Delap and Uliga Docks Inspection*. Retrieved from http://rmipa.com/delap-and-uliga-docks-inspection/

Thomson, A. K. (n.d.). *Submarine Sewer Outfall - Design and Construction.* Hastings: Hastings City Council.

Vector Corrosion Technologies. (2019, 08 01). *Post-Tensioned Concrete Corrosion & Repair*. Retrieved from https://www.vector-corrosion.com: https://www.vector-corrosion.com/post-tension-corrosion-solutions

HDC Acceptance of Report		
	Signature	**Date**
Preferred Option (Insert preferred option)		
	Signature	**Date**
Proceed to Next Phase **Please circle Yes / No** (Insert brief comment of next phase)		
	Signature	**Date**

Appendices

Appendix A Leak Detection Technologies Note

By. Erez Allouche, P.Eng., PhD

Stantec Tower, Edmonton, AB

April 24, 2019

To:	Wayne Hudson, CMEngNZ CPEng Level 1, 100 Warren Street South Hastings 4156 New Zealand	From:	Erez Allouche, P.Eng., PhD Stantec Tower, Edmonton, AB
File:	City of Hastings Submarine Outfall - Overview of Condition Assessment Technologies	Date:	April 24, 2019

Reference: 80510680 - City of Hastings Submarine Outfall

BACKGROUND

BC80101 has requested BC1101 to review the suitability of various condition assessment technologies for the inspection of the submerged portion of the City of Hastings outfall, an approximately 2.6 km long prestressed concrete pipeline extending offshore.

The following documents were reviewed as part of preparing this memorandum:

1. Wastewater Outfall Investigation Data Gathering and Initial Condition Review, prepared by MWH, April 2013.

   This report summarizes information gathered in the initial phase of the project, including emergency repairs undertaken in 2005, 2006 and 2007, and background of previous issues with the outfall pipeline.

2. Land-Based Outfall Pipe Condition Assessment Report, prepared by Stantec, December 2018. This report summarizes repairs and inspection efforts, as well as the repair of the 38 m section of the land based concrete pipe.
3. Outfall pipeline drawings – B1611 Sheets 1 to 15: This file contains the 15 sheets of construction drawings with “as-built” marked amendments and two sheets of additional details.
4. The Contractor (McConnell Dowell) drawings of joint and other details for the outfall pipeline.
5. As-built Drawings of the replacement diffuser installed in 2017. The drawings show the Wye fitting on the end of the concrete pipeline that can be used for internal access at the downstream end.
6. Images showing a stainless-steel joint repair band as well as the access hatch installed in 2017 upstream of the start of the concrete pipeline.

Hastings Wastewater is currently discharging into an outfall pipe which extends approximately 2,900 metres off-shore. Commissioned in 1981, the outfall has a capacity of approximately 2,400 l/s at 16 m head or 2,800 l/s at 23 m head. The outfall consists of four components, namely:

a) a 15 m steel manifold at the outfall pump station;

b) a 250 m long, 1,050 mm diameter, land-based prestressed reinforced concrete pipe section extending from the WWTP to the beach;

c) a 2,594 m long subsea section of the outfall, 1050 m diameter, prestressed reinforced concrete pipe; and,

d) a 304 m long, 1,067 mm and 915 mm diameter fiberglass diffuser section.

This report focuses on the submarine section of the outfall pipe. Constructed in 1978 and extending to a distance of 2,594 m from the shoreline, the submarine pipeline consists of approximately 1,076 segments of 2,410 mm long, 1,050 mm diameter, post-tensioned prestressed reinforced concrete pipeline. Two layers of 6 mm hard drawn deformed reinforcing wire at a 50 mm pitch provide circumferential reinforcing over 12 equally spaced 5 mm longitudinal wires at each of the two reinforcement cages. The reinforcing wires are located on each side of twelve post tensioning ducts, which are located on the sides of the pipe section, with six ducts located on each side. The pipeline sections are post-tensioned with 12 polyethylene covered prestressed wires, each located in a 38 mm diameter cable duct. Each set of the six prestressed wires extends over two adjacent pipe segments, and each pipe segment includes six anchor plates placed in recesses in the pipe's wall. Each wire was tensioned to 178 KN (40,000 lbs). The pipe's wall thickness is approximately 174 mm at the barrel and 133 mm at the joints. The internal concrete cover is approximately 25 mm to the internal reinforcing layer and the external concrete cover is approximately 55 mm to the external reinforcing layer.

The pipeline was constructed on land in six post-tensioned pipe columns, which were then floated out to sea and sunk into a trench. The cover above the pipeline is estimated to be 400 mm. The jointing system between pipe sections is a 330 mm wide by 19 mm thick fiberglass joint with a 1 mm internal titanium sleeve layer. The joint compresses 22 mm thick rubber rings on each spigot end and there is a secondary rubber ring on each end of the fiberglass joint. A 30 mm/50 mm tapered urethane bearing system provides for movement between pipe sections. The jointing system between the six post-tensioned concrete pipeline columns is assumed to be a custom designed fiberglass collar that was grouted in place. It was reported that two of the collars had to be repair during construction. The collar between columns 1 and 2 was damaged during launching and was repaired using a steel band, while the collar between columns 2 and 3 leaked during testing and was repaired using a steel band and a sealant.

The fiberglass diffuser had sustained considerable damage and a replacement HDPE diffuser pipe was installed in 2017. Design of the replacement section included Wye fitting at the transition from the concrete pipeline to the new diffuser section, providing an access location to the concrete pipe sat the downstream end.

This technical memorandum discusses considerations associated with the development of a condition assessment plan, as well as providing an overview of non-intrusive inspection technologies that might provide an insight into the structural integrity of the submarine 1,050 mm diameter prestressed reinforced concrete pipe.

CONSIDERATIONS AND CONSTRAINTS

An inspection of the land-based concrete pipe, performed in 2013, revealed significant wall thickness loss of over 50 mm in six (6) pipe segments, prompting the rehabilitation of a 38 m long section utilizing external glass fiber wrap and reinforced concrete encasement. A follow up sonar inspection performed in June of 2018 revealed internal wall loss of 62 mm or greater within the 32 m section downstream of the 700 mm diameter access hatch located at the WWTP.

In contrast to the multiple failures/issues observed along the land-based concrete pipe and the original fiberglass diffuser section, the submarine concrete pipeline is not known to have failed at this time, with the exception of the two collars that were damaged during installation and repaired at the time, and a leaking joint that was repaired by concrete encasement.

Typical life expectancy of a concrete marine pipeline is in the range of 60 to 70 years, yielding a theoretical expected service life ending around 2040 – 2050. However, the pipeline design is unique, making the design life difficult to assess. Also, the location for 5 of the 7 couplings could make repair difficult, making knowledge of the pipeline condition of significant value.

A key consideration for any condition assessment plan includes the challenges associated with taking the pipeline out of service for even a short time period. Current storage available in the wastewater network for a planned shutdown is estimated at only 2 to 3 hours. While a parallel line exists, a 50 m long outfall constructed in the 1960s and considered to be potentially available for emergency release, the use of this line is considered undesirable for supporting maintenance activities, such as the proposed inspection.

Assess is limited to a 700 mm diameter access hatch at the WWTP and a wye flange at the termination of the submarine concrete outfall pipe. These locations are approximately 2,800 m apart, and the location of the wye flange is 2,600 m off shore and 11 m below sea level.

Based on the design of the outfall pipeline, potential failure mechanisms include:

- Internal/external corrosion of the concrete wall
- Failure of the rubber rings at the joints
- Corrosion of the post tensioned wires/wires
- Failure of the anchoring blocks (resulting in loss of water tightness at the joints)
- Corrosion of the reinforcing wires
- Damage to the pipe due to impact load (e.g., boat anchor)

The above failure mechanisms could be divided into two main categories, namely water-tightness and structural integrity.

Reference: **80510680 - City of Hastings Submarine Outfall**

LEAK DETECTION TECHNOLOGIES

Water tightness of pipelines is typically evaluated using either an internal or external acoustic leak detection system, which utilizes listening devices (e.g. accelerometers, hydrophones, sonoscopes). These devices identify leaks in pressurized pipelines by detecting the sound or vibration produced by the leaks. As the submarine pipe is buried in a shallow trench, external conventional leak detection utilizing acoustic emission sensors (AES) attached to the outside of the pipeline is considered impractical and is not considered further in this report.

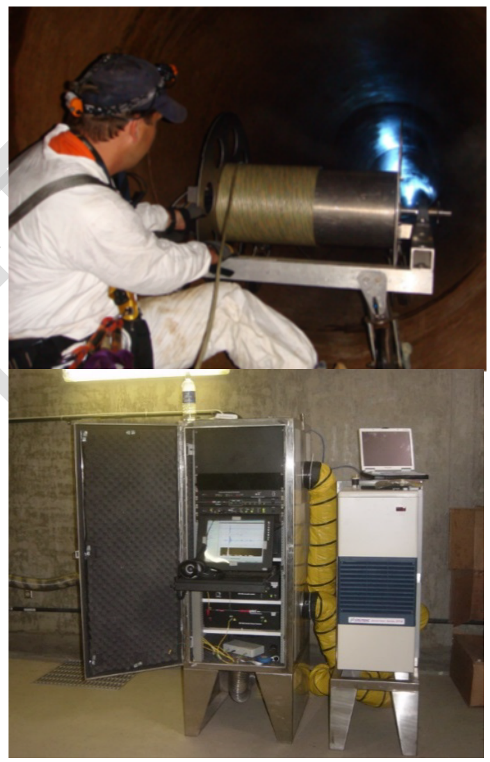


Figure 1. Installation of a fiberoptic system inside a pipe (top); Data acquisition system (bottom)

An alternative to acoustic microphones is **fiber optic**. This system would require installing a fiber optic cable, capable of picking up acoustic emissions, either within or alongside the existing pipeline. Stantec has experience working with OptaSense, who have developed a four-mode leak measure system using a fiber optic (FO) cable that needs to be installed within one metre of the pipe's location. A 40 mm HDPE conduit must be first installed at either 2 o'clock or 10 o'clock locations relative to the pipe, approximately one meter from the pipe. This system will detect and provide a relatively precise location of unbonded cable breakage and significant leaks. Systems such as OptaSense commonly utilize fusing information from multiple measurements to detect and classify events. Potential characteristics for the case of the Hastings submarine outfall pipeline include noise from a ruptured cable or an active leak, temperature change due to product in the seabed, and noise from turbulent flow through the leak orifice location. It is important to note that this system is used predominantly for monitoring land-based pipelines, and hydrostatic pressure exerted by the sea on an offshore pipeline might reduce the leakage rate, making leaks more difficult to detect. Also, the fiber optic cable might need to be replaced during its service life, which could be an issue for subsea application. A potential solution for these challenges is placing the fiber-optic internally within the outfall pipe utilizing a system such as SoundPrint® Acoustic Fiber Optic (AFO) Monitoring System or Integrated Smart Monitoring (iSMTM) fiber optic system with Atlantis Hydrotec® pipe-in-a-pipe solution by Craley Group (UK). **Figure 1** shows the installation of a fiber optic system for pipe inspection.

Another method which is gaining popularity for leak detection in hydrocarbon pipes involves inoculating the pipeline with a unique, nontoxic, and highly volatile **"tracer"** compound. The tracer is added at a concentration of a few parts per million to the pipeline contents. Vapor (soil gas) samples are collected using probes and are analyzed for the tracer using a gas chromatograph.

This tracer compound technology can locate leaks in pipelines to within a couple of metres. However, the applicability of this technology for subsea installations is considered limited.

Another approach for leak detection is **mass balance**. State-of-the-art magnetic flowmeters, such as the Rosemount 8750 WA Magnetic Flowmeter, can be placed at the pump discharge and a location near the end of the submarine concrete pipe. The Magmeters must be carefully calibrated in the factory for accurate measurement to within plus or minus 1.0% of actual flow. Challenges of this methodology include the operation and maintenance of a magnetic flowmeter at a subsea location, as well as the fact that data collected does not indicate the location of the leak. This approach is also not considered practical for the Hastings submarine outfall pipeline.

The **"SmartBall®"**, developed by Pure Technologies/ Xylem, is a free-flowing acoustic leak detection platform that operates while the pipeline remains in service. It is capable of completing long inspections in a single deployment and is equipped with an acoustic sensor that identifies acoustic anomalies associated with leaks and air pockets; the acoustic signature is then analyzed to determine if it is a leak, air pocket, or an external noise. The SmartBall is inside a 180 mm diameter compressible foam ball (see **Figure 2**) that can be inserted into the pipeline through a 100 mm diameter double valve port.

Figure 2. Image showing Pure Technologies SmartBall

The smartball is inserted into the product stream while in service and retrieved at the other end. A SmartBall catcher is required on the submerged end of the pipeline, to prevent it from migrating into the diffuser pipe. The ball travels in the pipeline at approximately 90% of the flow velocity. It is preferred to run the ball through at about 0.6m/second, so the ball has sufficient time to gather data as it flows through the pipe. There are several similar technologies offered by other vendors which provide similar data including the Nautilus System by Aganova Group (Spain) and Pipers® by Ingu Solutions (Canada). Several shortcomings of this technology include:

a) Leak detection is the only obtainable information, no direct information regarding the pipe's structural integrity could be expected;

b) The approximate locations of the events recorded by the free swim device are obtained by correlating the device position as a function of time with respect to acoustic omission sources placed at known locations on the pipe's outside wall.

Placing these sources on the exterior wall of the Hastings submarine outfall could be challenging.

A variation of the in-line leak detection system, which can also offer imagery data is the **MTA Pipe-Inspector** by Messtechnik GmbH (Austria), shown in **Figure 3**. It is a semi-autonomous multisensor pipeline inspection tool, including video, optical and acoustic inspection, coupled with leak detection capacity. The system provides visual, pressure, temperature, leak detection, as well as turbidity measurements. The device is introduced by a pig launching pad installed at existing risers, access locations or vents. The system allows for the continuous inspection of long sections of pipeline up to 50 km in length.

Figure 3. MTA Pipe Inspector

STRUCTURAL INTEGRITY ASSESSMENT TECHNOLOGIES

There are a number of commercially available non-destructive testing technologies designed to provide information regarding the structural integrity of pipelines. Each of these technologies is typically best suited toward a certain pipe material and can operate from within the pipe either under drained or flow conditions.

PipeDiver®, is a long distance, free-swimming condition assessment tool for the inspection of water and wastewater pipelines that operates while the pipeline remains in service. The PipeDiver is flexible, allowing it to travel through a variety of pipe configurations including butterfly valves and sharp bends and tees, and its deployment is via existing pipeline's appurtenances. PipeDiver uses electromagnetic technology to provide a qualitative assessment of metallic pipes. In PCCP for example, it can identify broken prestressed wire wraps, while in metallic pipes, it can identify localized areas of corrosion. It has the advantage of adding video capabilities for visualizing damage to the pipe's internal wall. **Figure 4** shows the initiation of pipe inspection using PipeDiver.

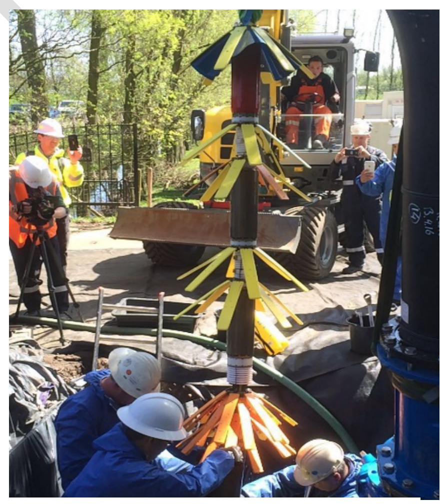


Figure 4 Image Showing Installation of Pure Technologies PipeDiver

The system generates eddy currents in the prestressed wires and detects where the field is altered by the presence of breaks. To create an electric current in the prestressed wire the electromagnetic system generates a magnetic field inside the PCCP. A signal generator outputs a low frequency alternating electric current (~ 100 Hz) into the exciter coil positioned near the inner surface of the pipe. The magnetic field generated by this coil extends through the concrete core, reinforcement cages and into the prestressed wire wraps. As the coil travels along the length of the pipe, the field moves as well, creating a localized magnetic field that then generates eddy currents in the wire. As long as there are no breaks in the prestressed wire, the current will flow uniformly along the wire; however, where a broken wire wrap exists, a discontinuity in the current forms. As the magnetic field passes over the section of the broken wire, currents are generated that form opposing magnetic field lines. Detectors placed opposite of the exciter coil record the variations in the magnetic field that are created when broken wire wraps interrupt the current flow. In the case of the Hastings outfall pipe, as six wires terminate near the center of each pipe segment discontinuity in the magnetic field is expected only near the center of each pipe joint, with analysis focusing on the continuity of the unbonded strands across the joints. The technology was developed for PCCP pipes, where a single steel cable is wrapped around the entire pipe segment with spacing of a 50 mm (or less) between each pair of adjacent wires. This configuration is vastly different from the six parallel individual short prestress wires running longitudinally across each joint in the outfall pipe. A full-scale test might be needed to develop a calibration curve to allow proper interpretation of the raw data collected from the Hastings outfall pipe.

The SeeSnake® shown in **Figure 5,** is a pipeline inspection tool from PICA. It utilizes a Remote Field Testing (RFT) technology to provide direct measurement of remaining wall thickness along the entire length of a metallic pipeline and around the pipe circumference. SeeSnake technology can measure through non-magnetic materials, such as concrete. Inspection speeds of 1 to 2 km/hour are normal in common pipe wall thicknesses. All corresponding inspection data is stored on board and is downloaded from a USB or Blue Tooth connection after the run. SeeSnake can potentially detect broken prestressed wires in the pipeline and they are expected to generate local variations in the magnetic permeability, which could be detected by the tool. Similar to PipeDiver, a full-scale test might be needed to develop a custom calibration curve to allow proper interpretation of field data collected from the Hastings outfall pipe.

Figure 5 Image showing SeeSnake being lowered into the pipe through a manhole

Intelligent pigs are commonly used in the oil and gas industry for internal inspection of pipelines. These tools utilize caliper logging, CCTV logging, magnetic flux logging or ultrasonic logging to detect leaks and integrity defects in the pipelines. One such sensing technology is **Propipe Trident Pinger** used with the **Trident SMART** gauge system which allows the detection of pipeline flaws such as excessive wall loss or a dent. The smart gauge system is designed to be fitted to a standard bi-directional pig, enhancing the gauging capability. The system is designed to allow the condition of a pipeline to be assessed without the need to recover the pig from the subsea receiver, saving significant time and costs. This technology could provide information regarding internal wall corrosion and possibly leaks, but limited information is anticipated regarding corroded or broken prestressed wires.

IMAGING TECHNOLOGIES

Imaging technologies rely on CCTV inspection, LiDAR and/or sonar to provide information regarding condition of the internal wall of a pipe, specifically corrosion of the pipe's wall, buildups, or an open joint. However, these technologies are unable to provide information on the condition of the prestressed wires or leaks not associated with gross joint or pipe wall defects. A short description of these technologies is provided below.

LiDAR (Laser and Light Detection and Ranging) technology use light and image processing algorithms to detect and quantify geometrical defects or changes in linear assets, that may have been caused by deformation/ovality, deflection, corrosion/wall loss, or siltation. Laser-based inspection can only be used to inspect the pipe's area above the water level. For the Hastings' submarine outfall pipeline, it will need to be taken out of service, isolated and drained, for such an inspection to be effective.

Sonar-based technology interprets changes in the reflected high frequency sound waves relative to the emitted sound waves to detect and/or estimate defects. These defects can be caused by geometrical changes due to deformation/sags, wall loss, erosion, off-set joints, holes, and sediment build-up below the water level in pipes. One of the most important criteria when considering use of sonar-based technology is the "acoustic frequency". Determination of the acoustic frequency to be used is partly influenced by two competing phenomena:

a) increase in signal loss due to frequency increases with decreasing background "noise"; and

b) image sensitivity and power draw due to frequency selection.

The use of a multi-frequency sonar unit is recommended to overcome this frequency related challenge, because it can adjust to changing conditions and still provide good-quality data. **Figure 6** shows a typical set of sonar inspection results.

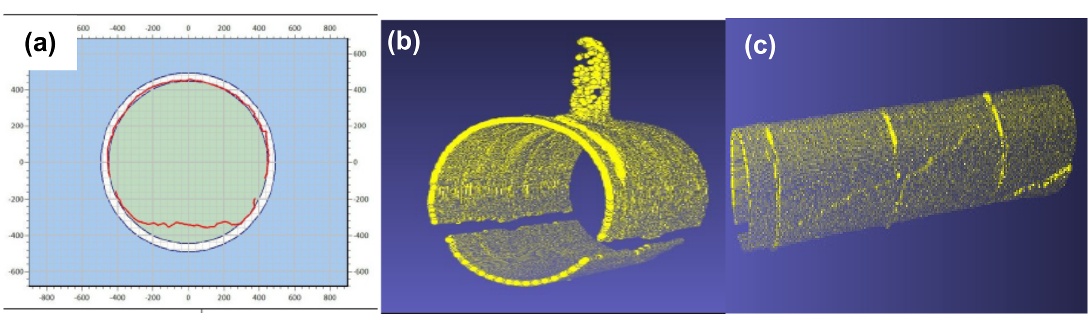


Figure 6 A combination of Sonar and Lidar inspection data (a) Sonar profile indicating sedimentation (b) A 3-D projection showing a tap (c) A 3-D projection showing longitudinal crack (Images from Stantec Projects, Canada).

Visual inspection by video technology is the most common approach for condition assessment of linear assets without the need for man entry. With CCTV, an operator will code the defects in real time as the camera passes through the pipe, pausing to zoom in to notable defects. Some CCTV recordings, however, allow for the pipe to be scanned first, with inspection and defect coding being completed in an office environment later. Corrosion can be identified from a CCTV inspection, but the amount of wall loss cannot be determined from video footage alone. The identification of defects and measurement of their degree of severity is highly dependent on the quality of the video and lighting.

For submerged applications remote controlled vehicles (ROVs) are used to transport CCTV cameras and sonar systems. One such unit, of suitable size to transverse the Hastings submarine outfall, is Seabotix LBV300XL (**Figure 7**). This vehicle can be ballasted to be neutrally buoyant. It uses four electric thrusters to propel itself through the water. Two axial horizontal thrusters are used for forward travel, while a vertical thruster and a lateral thruster enables the vehicle to move up and down or side to side, respectively, through the water column. It is equipped with two (2) high-intensity LED lights to illuminate the area of inspection for the high-resolution color camera. The system utilizes an umbilical cable which houses both signal and power conductors (fiber-optic and copper, respectively), along with a Kevlar strength member and abrasion-resistant protective jacket. The umbilical is neutrally buoyant in water to reduce drag and allow for further penetration distances. An ROV's operator controls the vehicle's movement, lighting, and camera position from the surface. The video signal is routed to the surface, displayed on a monitor and recorded.

Figure 7 Image of Seabotix LBV300XL: Remote-Controlled Vehicle (ROV)

A profiling sonar units is mounted to the bottom of the ROV to provide cross-sectional profiling capability. The sonar emits a narrow beam acoustic pulse (~1.4 degrees), providing detailed measurements. The ROV and profile sonar are aligned with the structure using navigation sonar to ensure cross-sectional profiles are collected perpendicular to walls of the structure. Typically, profile measurements are collected while the ROV is stationary against the crown of the structure.
The profiling beam of the sonar rotates a full 360 degrees, while collecting measurements along the circumference of the pipe, as shown on the left of **Figure 8**. On the right of **Figure 8** is a representative example of a profile scan inside a pipeline structure. The ROV's operator monitors these scans in real time on the PC display, and the data is recorded for reporting purposes.

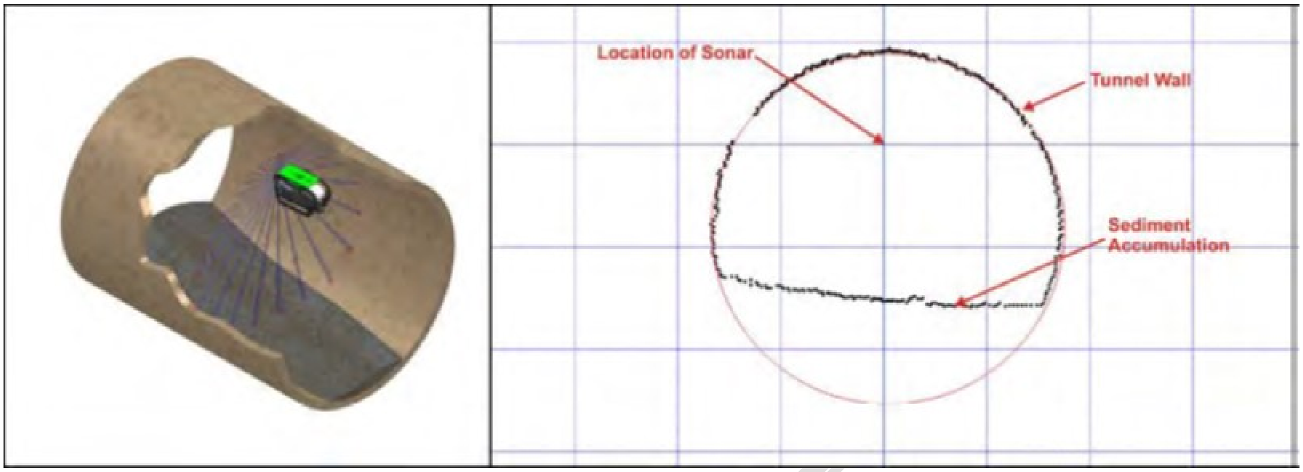


Figure 8: Profiling Sonar mounted on ROV

Table 1 presents a summary of the above discussed technologies in terms of their ability to detect the presence and locations of key symptoms associated with potential deterioration mechanisms.

Table 1. Summary of Selected Technologies for Condition Assessment and Monitoring of Linear Assets

Vendor/ Supplier	Technology	Flow Condition	Internal Wall Corrosion	Open Joint	Leak Detection	Prestressed Wire	Comment
Leak Detection Technologies							
OptaSense	Fiber Optic	Empty (During installation only)	No	Yes	Yes	Yes	Pipe condition at time of installation serves as baseline; information will be collected on a continuous basis moving forward
Multiple	Magnetic Flowmeters (Mass Balance)	Full	No	Yes	Yes	No	Technically viable, able to detect presence of a significant leak (> 1% of design flow) but not its location
Multiple	Tracer Compound	Full	No	Yes	Yes	No	Not viable for the Hastings subsea outfall
Pure Technologies	SmartBall	Full	No	Yes	Yes	No	Requires full pressure flow
MTA Messtechnik GmbH (Austria)	MTA Pipe-Inspector	Full	Yes	Yes	Yes	No	Minimum and maximum pressure requirements are 14.5 psi and 1450 psi respectively. The required flow rate ranges from 1.75 to 5 ft/s
Ingu Solutions (Canada).	Pipers	Full	No	Yes	Yes	No	
Aganova Group (Spain)	Nautilus	Full	No	Yes	Yes	No	Water speed between 0.4 and 1.6 meters per second required.
Structural Integrity Assessment Technologies							
Pure Technologies	PipeDiver	Full	Yes	Yes	No	Potentially	A custom calibration curve needs to be developed for both tools utilizing modelling and/or full-scale mockup of two pipe joints to enable accurate interpretation of field data Quality of CCTV data is highly dependent on clarity of discharge flow
PICA Corp.	SeeSnakeTool	Empty	Yes	Yes	No	Potentially	

Reference: **80510680 - City of Hastings Submarine Outfall**

ProPipe	Trident Pinger	Full	Yes	Potentially	Yes	No	To be deployed in combination with Trident SMART gauge system
Imaging Technologies							
Multiple	LiDAR	Empty	Yes	No	No	No	The pipe will need to be taken out of service, isolated and drained
	CCTV	Full or Empty	Yes	Yes	No	No	Submerged deployment requires utilization of a ROV; due to range limitations deployment likely needed from both, land and subsea ends of pipes to inspect entire 2,800 m Image quality highly depends on clarity of water
Deep Trekker	DT340 Submersible Pipe Crawler	Full or Empty	Yes	Yes	No	No	Hybrid between CCTV crawlers and ROCV technology; Battery operated
Tritech (Gemini 620pd) Teledyne Marine (BlueViewT2250)	Multibeam Profiling Sonar	Full	Yes	Yes	No	No	3D sonar units developed specifically for pipeline/tunnel scanning applications; these systems are designed to be mounted on ROV units

SUMMARY

Due to its unique design (reinforced concrete pipe segments connected utilizing short, staggered, unbonded prestress wires, flush fiberglass joints with rubber rings), environment (buried below sea level), distance between access locations (2,800 m, with downstream access 11 m below sea level) and criticality (2 hours. storage time; no alternative outfall that can be deployed), the City of Hastings submarine outfall pipe represents a unique challenge for inspection. Fourteen (14) commercially available condition assessment technologies developed for the inspection of municipal water pressure pipes and/or oil and gas pipelines were presented and evaluated in this technical memorandum.

Based on the design attributes of the submarine outfall pipe the following potential deterioration mechanisms were identified and assigned criticality level. The level of criticality was established based on two primary design criteria for ocean outfall:

1. Ensure that the wastewater is well assimilated in the ocean by using the assimilative capacity of the ocean (i.e., the extent to which the ocean can receive wastes discharged from the outfall without unacceptable impacts).
2. Ensure that the outfall pipe provides the required flow capacity to meet the needs of the municipality.

Table 2. Summary of Key Deterioration Mechanisms and Their Symptoms

Deterioration Mechanism	Manifestation / Symptoms	Criticality Level
Internal/external corrosion of the concrete wall	Visual sign of corrosion, uneven internal surface, increase in internal diameter, exposed reinforcing steel	Moderate-to-High
Failure of the rubber rings at the joints,	Exfiltration / infiltration	Low-to-Moderate
Corrosion/rupture of the post tensioning wires	Rupture of cables will create a clear district acoustic sound; severed cables likely to form a detectable anomaly in the secondary magnetic field created by induction of electrical current into the prestressing wires (corrosion in the wires is very difficult to detect/quantify)	Moderate-to-High
Failure of the anchoring blocks (resulting in loss of water tightness at the joints),	Visual corrosion of Exfiltration / infiltration	Moderate-to-High
Corrosion of the reinforcing wires	Visual signs of exposed reinforcing wires	Moderate-to-High
Open Joints	Visual observation of offset joints and deposits in pipeline	High
Damage to the pipe due to impact load (e.g., boat anchor)	Cracks/fracture/hole(s) in pipe wall	High

The associated symptoms were mapped to the detection capabilities of fourteen (14) commercially available condition assessment technologies, including:

- Acoustic monitoring (e.g., escaping fluids, breakage of a prestressing wire)

- Surface imaging (either by CCTV, LiDAR, or Sonar)
- Changes between input and output flows
- Detection of changes in an electromagnetic field
- Temperature monitoring

None of the fourteen technologies reviewed is capable of providing information regarding the presence and/or location of all deterioration mechanisms listed in Table 2. Two of the technologies are considered either not technically viable (tracer compound) or unable to provide location specific information (Magnetic Flowmeters).

SmartBall, Nautilus and Pipers technologies could provide useful information about leak detection but no structural integrity information. Additionally, only rough estimate of the location of leaks could be obtained unless active acoustic sources are installed on the pipe's outer wall at predetermined spacing, increasing the cost and complexity of the inspection.

PipeDiver and SeeSnake are the only technologies capable of providing information regarding the presence/location of broken post-tensioned cables. As the cables are unbonded, failure will result in loss of all prestressing force in the wire and a relatively large gap between the two edges at the breakage location. Inspection could only be expected to provide useful data over the joints, as six of the twelves prestressed wires are terminated at each mid-joint. Furthermore, the PipeDiver is designed to detect wire breaks in a PCCP, where a single continuous prestressed cable is wrapped in a helical pattern around the circumference of the pipe (while SeeSnake is mainly used for detection of corrosion/pinholes in metallic pipes/cylinders). The unique arrangement of the prestressed wire in the submarine outfall pipeline will require the development of a custom calibration curve, likely utilizing full-scale testing either on the above ground section of the pipeline or a custom-fabricated mock setup. This is likely to significantly increase the cost of inspection using these methods.

The utilization of a crawler with CCTV camera and LiDAR will require the flow to be bypassed and the isolation and dewatering of the pipe, as LiDAR cannot be used below water level. Information provided will be limited to internal wall corrosion and dewatering the pipe might not be possible if water tightness of the pipeline is compromised allowing infiltration of seawater within the prestressed concrete pipe section. This option is not considered viable.

Deployment of a bi-directional intelligent pig coupled with a smart gauge system will provide information on defects in the internal wall and leak detection while allowing the pipe to remain in service. A more conventional approach used in the municipal pipeline industry for obtaining similar information, potentially at lower cost, includes the MTA Pipe-Inspector and the DT340 submersible Pipe Crawler. None of these technologies can provide information regarding the condition of the prestressed wires (unless open joints are detected). Also, quality of the CCTV images is highly dependent on water clarity. Bacteria growth on the inner pipe wall or murky water could greatly detract from the information provided by CCTV images or render them useless.

Multibeam profiling sonar is an effective technology to obtain information on the internal geometry of the pipe in less than optimal water clarity conditions. Commonly designed to be mounted on a ROV, sonar images augment information provided by CCTV images and are capable of providing a good understanding of the condition of the internal surface of the pipe, including the presence of wall corrosion, holes or open joints. Information regarding the presence of leaks and the condition of the prestressed wires cannot be obtained.

The above technologies are mainly intended to provide information on the condition of a pipeline at a given point in time. The life expectancy of a concrete marine pipeline is approximately 60 to 70 years, yielding a theoretical expected service life ending around 2040. Failure of the prestress wires and 3td party damage are some of the more severe risks to the functionality of the outfall pipeline. A fiberoptic system will enable continuous monitoring of prestressed wire breakage (including location) and potentially on-going leakage detection via acoustic and temperature monitoring. It will provide a continuous record for tracking and assessing the overall structural health of the outfall pipe, as well as actionable data. On the other hand, the installation of a fiberoptic cable involves a significant upfront capital cost, and ongoing monitoring and maintenance costs. Also, the system is unable to provide information regarding prior failures of prestressed wires or information regarding pipe wall corrosion.

A budgetary level opinion of probable cost (OPC) prepared for selected condition assessment methods is summarized in Table 3. Costs are based on previous projects completed in North America. Costs shown do not include costs associated with any required marine support/divers, isolation and dewatering of the outfall (if needed), and any civil work (these are typically considered owner's responsibility and should be estimated when the preferred approach is identified).

Table 3. Budgetary Level Cost Estimate (USD)

Inspection Method	Deployment/Inspection Analysis/Reporting	Comments
SmartBall	$90,000	Cost include $25,000 for 4" SmartBall insertion port and valve assembly, and a catcher at the downstream end.
PipeDiver	$300,000[1]	Access required – 8"-12" insertion & retrieval points. Access through any existing hatch, etc.
SeeSnake	$250,000[1]	Cost include $25,000 for 12" insertion & retrieval assemblies.
Smart Pig	TBD	Requires a pig launching/receiving pit on the land side
Submersible Pipe Crawler w/ CCTV	$75,000[2]	Can be launched from existing access hatch
ROV with multibeam profiling sonar and CCTV	$100,000	Can be launched from existing access hatch
Installation of an Internal Fiberoptic sensor[3]	$585,000[4]	Wet or dry installation

[1] Additional costs might be accrued due to calibration costs; [2]Assuming local contractor; [3] Wet installation; [4] Annual fee for monitoring and reporting ~$40,000;

Reference: **80510680 - City of Hastings Submarine Outfall**

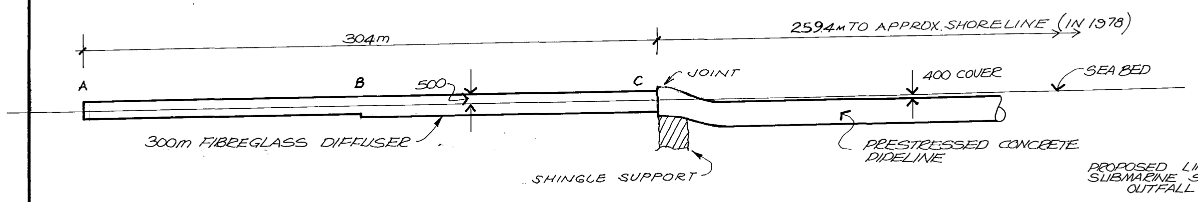
CLOSING

We hope this memo provides sufficient information to evaluate and determine your preferred inspection approach. If you have any questions or comments, please do not hesitate to contact the undersigned.

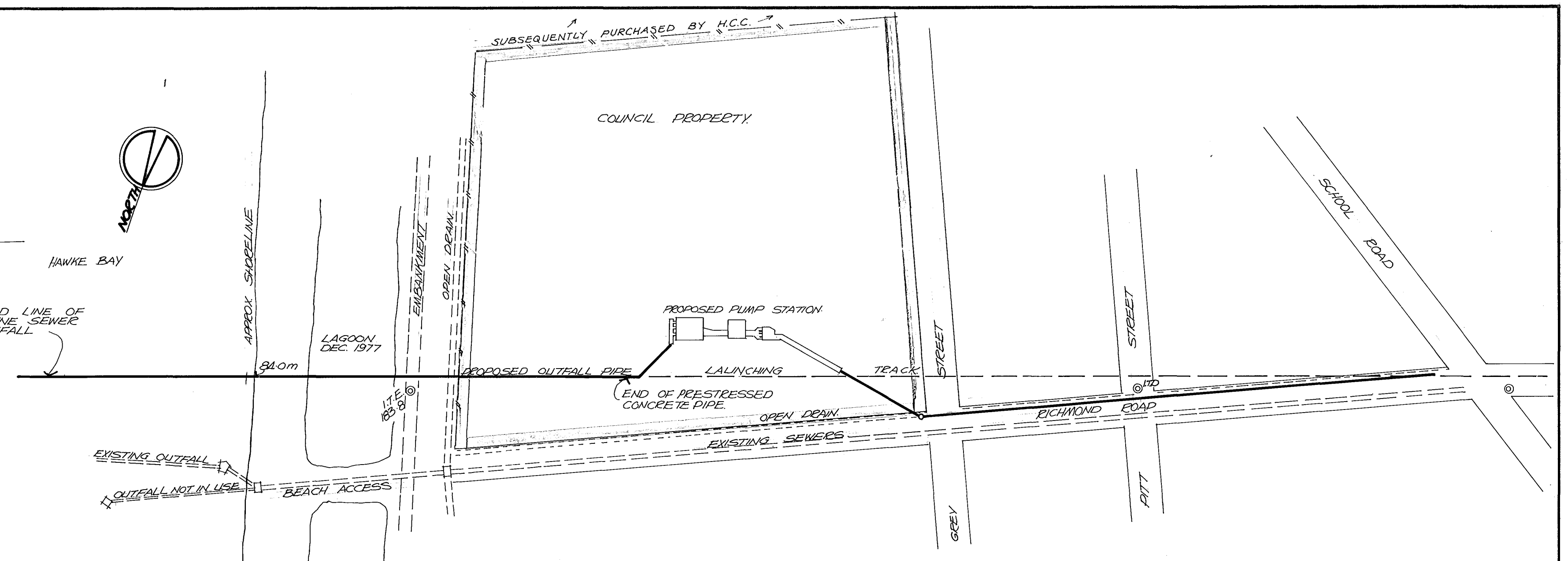
Stantec Consulting Ltd.

Erez Allouche, P.Eng., PhD
Tunneling and Trenchless Practice Technology Leader - Trenchless Technologies
Phone: 780 917 7093
Erez.Allouche@stantec.com

Appendix B As-built Drawings

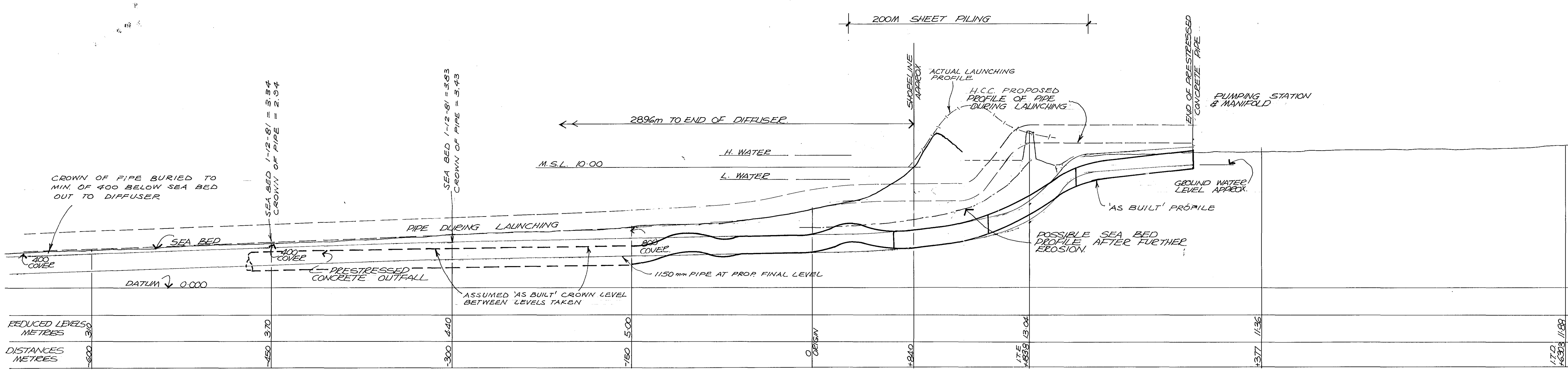


ELEVATION OF DIFFUSER SECTION

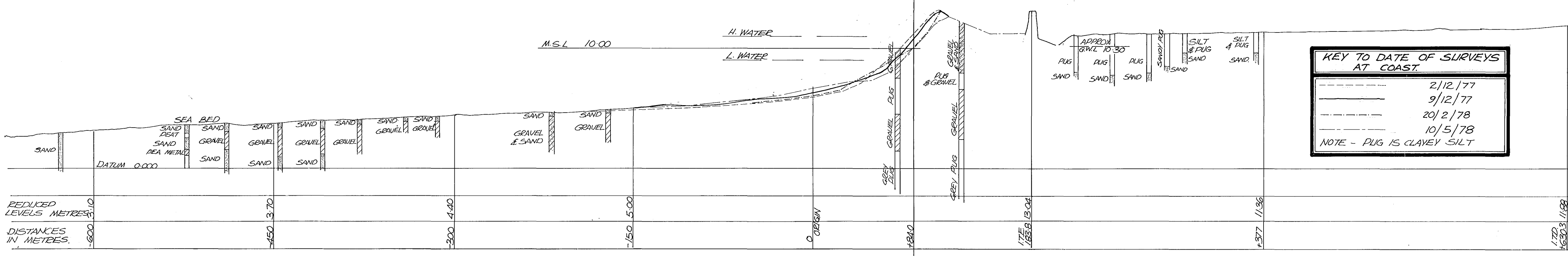


PLAN

SCALE 1:2000



ELEVATION OF PIPELINE



ELEVATION SHOWING INITIAL INVESTIGATION HOLES

SCALE :- HORIZONTAL 1:2000
VERTICAL 1:200

NOTE. FOR MORE DETAIL INFORMATION ON SEABED MATERIALS SEE SHEET 6.

AMENDMENTS:-

LAUNCHING PROFILE RAISED	15-11-78	
LAUNCHING PROFILE 'AS USED'	A.K.T.	7/83
JOINT-CONC. PIPE TO DIFFUSER	A.K.T.	7/83
'AS BUILT' PIPE LEVELS ADDED	A.K.T.	7/83

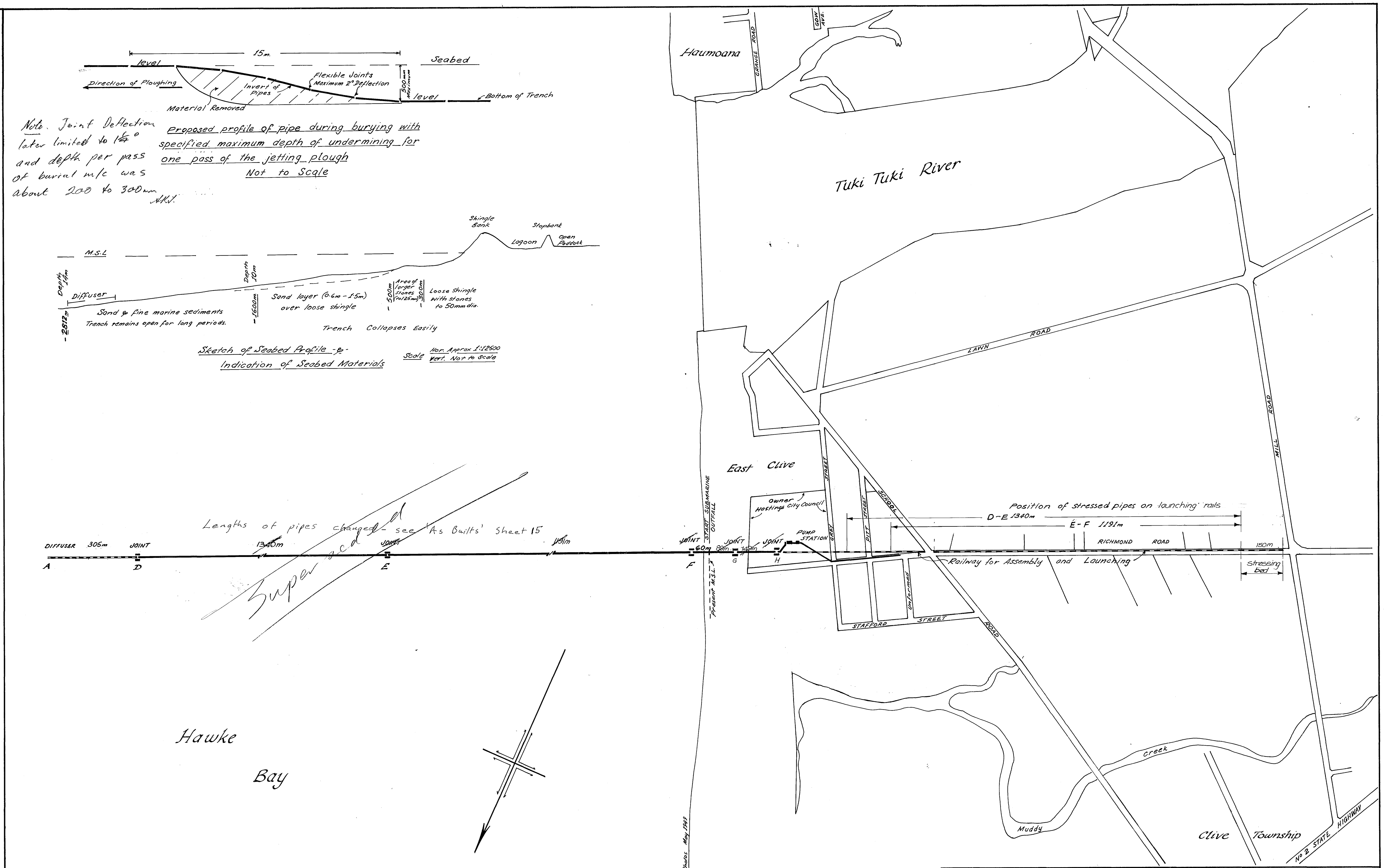
A. H. SELLES
M.N.Z.I.E.
City Engineer
25 : 5 : 1978

Prepared	R.E.R. & A.K.T.	MAY 1978
Drawn	R.E.R.	" "
Traced	S.G.S.	" "
Supervised	A.K.T.	" "

THE CITY OF HASTINGS

SUBMARINE SEWER OUTFALL 'As built'
PLANS AND ELEVATIONS AT COAST
PROPOSED LAUNCHING AND FINAL PROFILES

Scales	"AS SHOWN"		B 1611
F B	L B	Sheet No. 1 of 15 sheets	



A. H. SELLES
M.N.Z.I.E.
City Engineer
25 : 5 : 1978

THE CITY OF HASTINGS

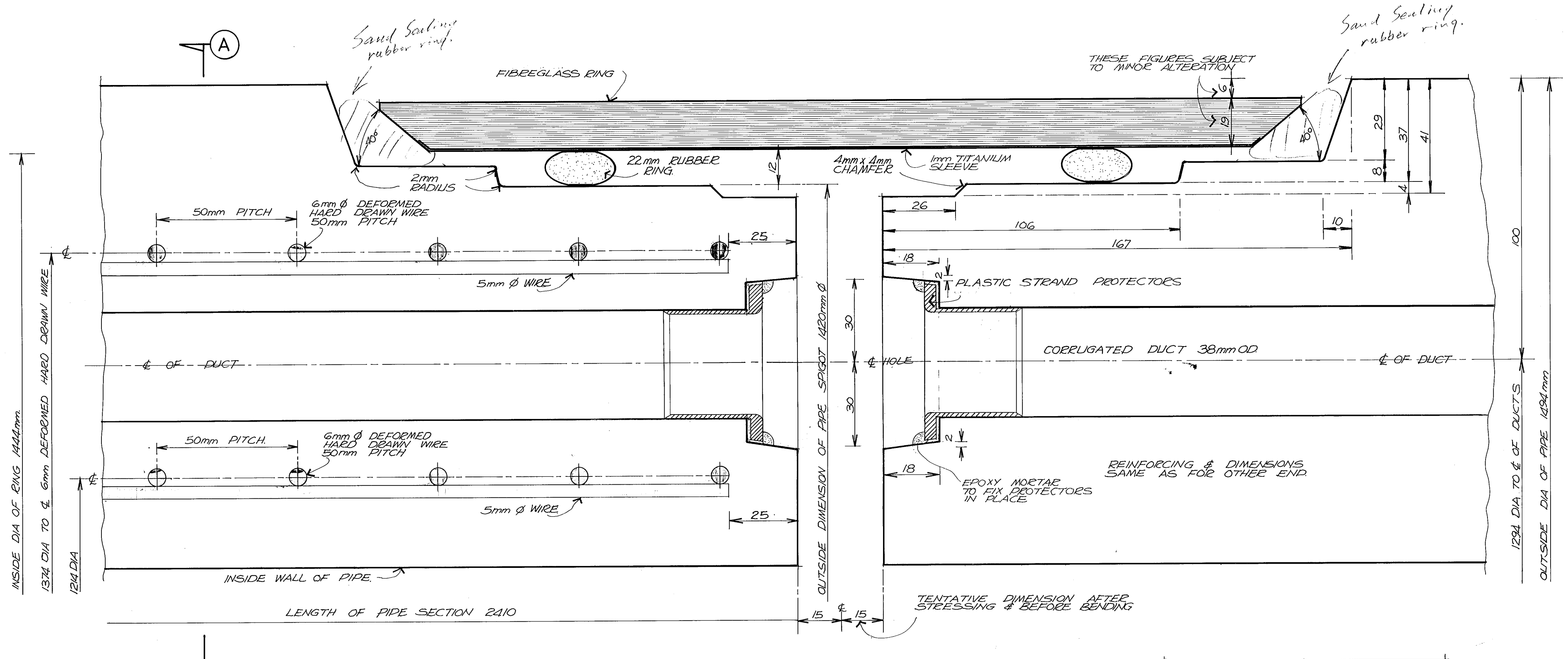
SUBMARINE SEWER OUTFALL

ALIGNMENT & FINAL POSITION OF PIPELINE SHOWING JOINTS, LAUNCHING RAILS & PRE-LAUNCHING POSITIONS

Prepared		
Drawn	R.E. Rippon	May 1978
Traced	R.E. Rippon	May 1978
Checked	A.K. Thomson	May 1978

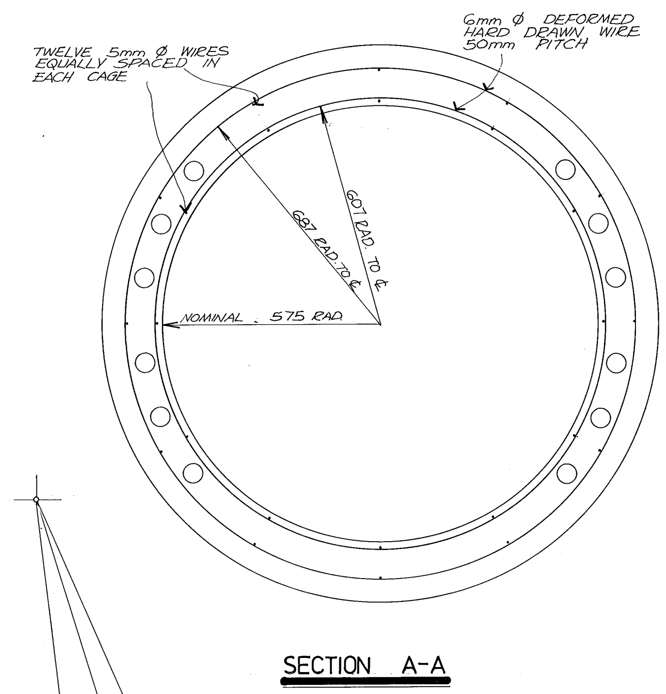
Scales 1 : 6000 & A. Shown
F B | L B | Sheet No. 3 of 15 sheets

B 1611



DETAIL OF SPIGOT ENDS

FULL SIZE



SECTION A-A

SCALE 1:10

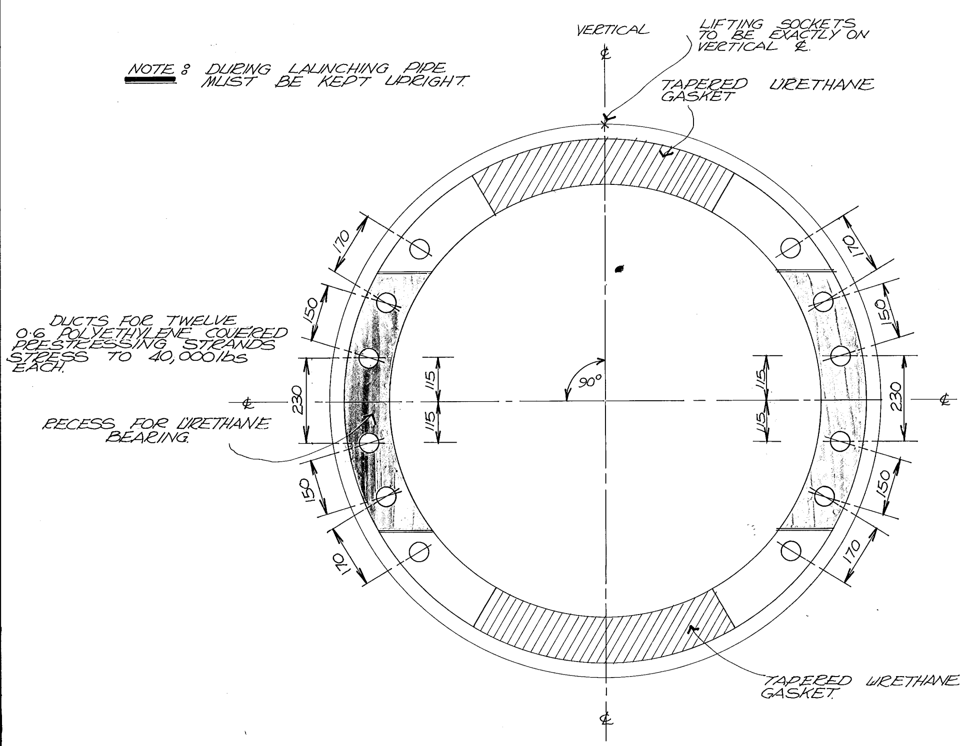
COPYRIGHT

CONFIDENTIAL – NOT TO BE REPRODUCED WITHOUT AUTHORISATION

PATENT PENDING

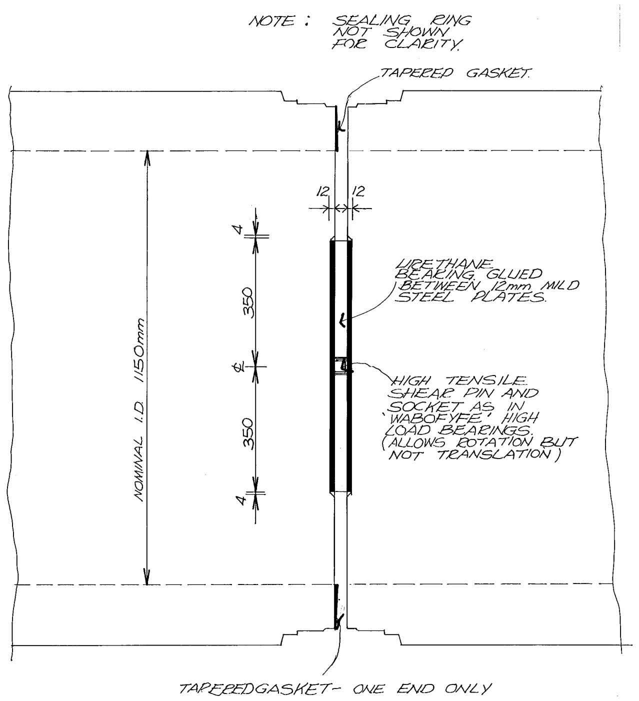
NEW ZEALAND & OVERSEAS.

NOTE: DURING LAUNCHING PIPE MUST BE KEPT UPRIGHT.



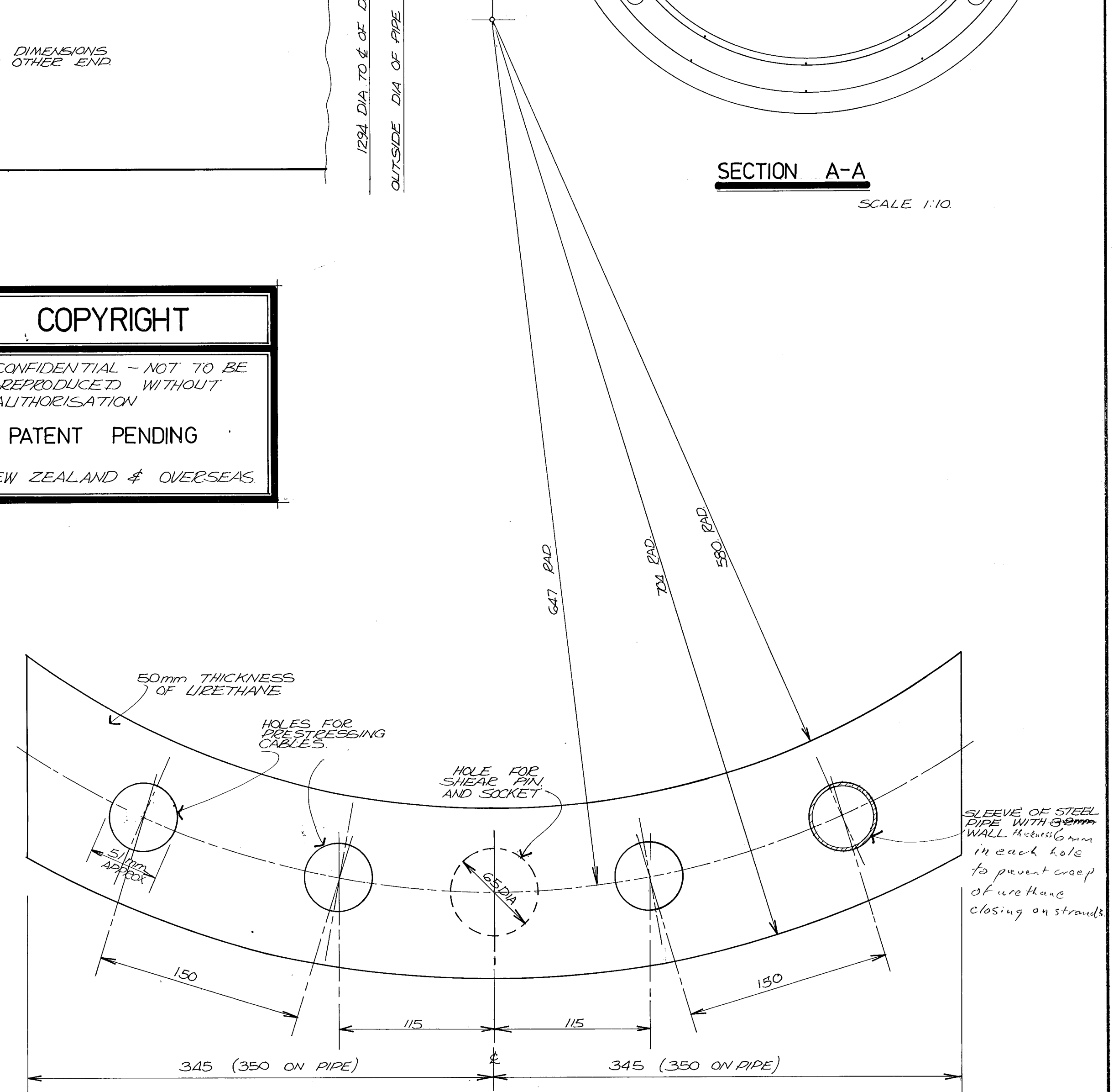
SECTION OF PIPE AT JOINT

SCALE 1:10



ELEVATION OF JOINT

SCALE 1:10



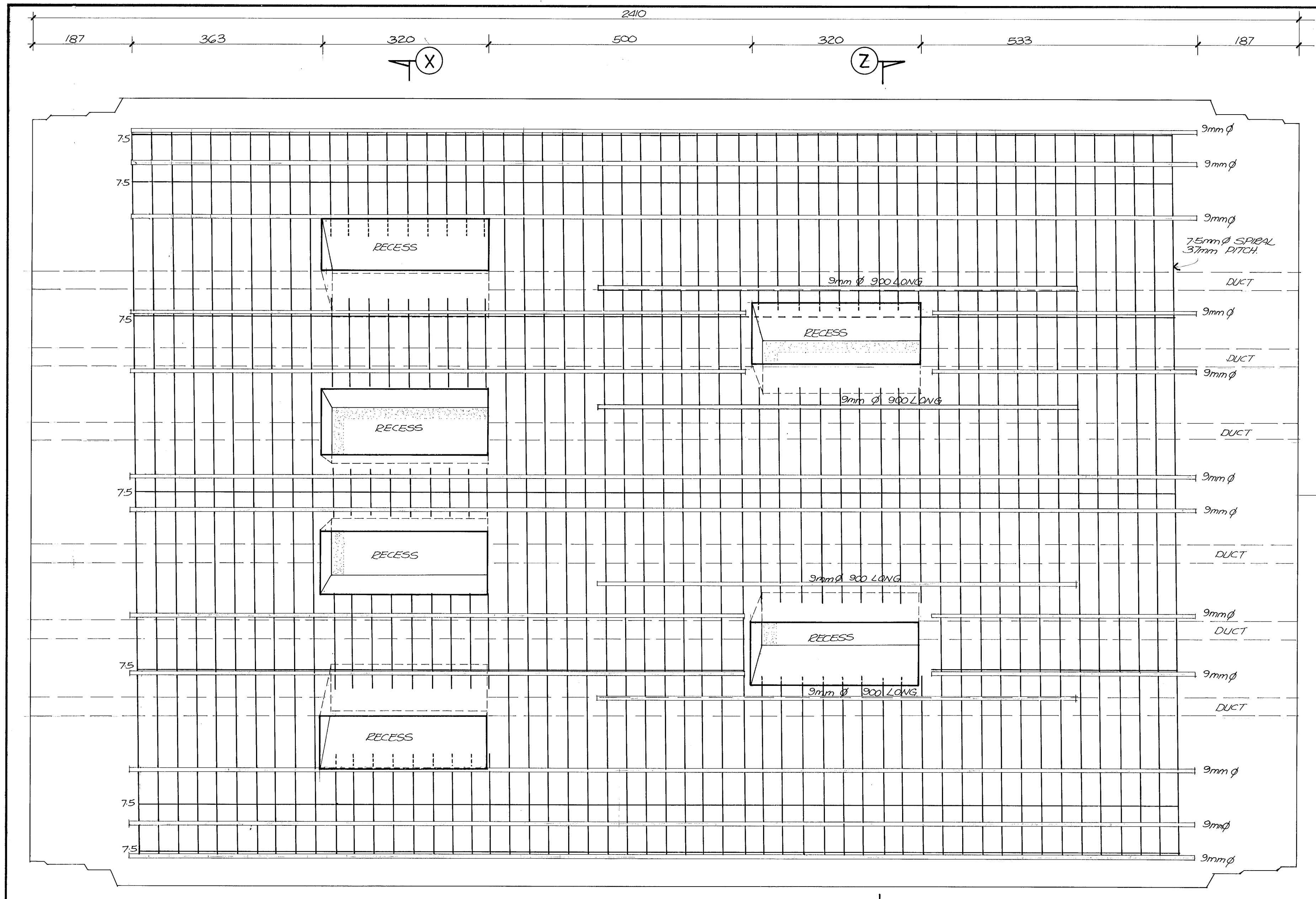
URETHANE BEARING

SCALE 1:25

A. H. SELLES M.N.Z.I.E. City Engineer 25 : 5 : 1978		**THE CITY OF HASTINGS**
		SUBMARINE SEWER OUTFALL See D1689 for minor variation ARTICULATED JOINT DETAIL AND PIPE REINFORCING 'As built'

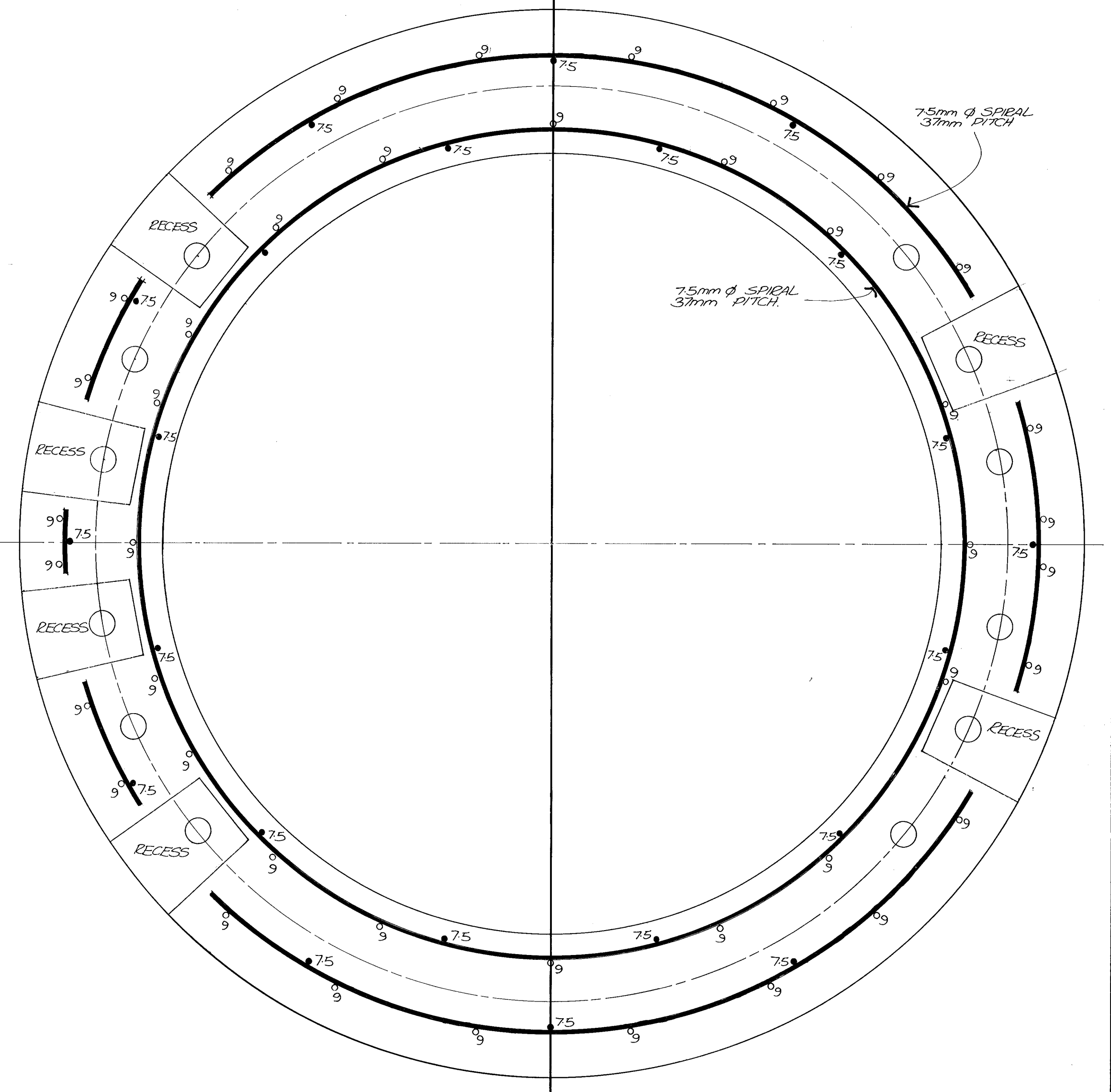
AMENDMENTS			
MINOR ALTERATIONS TO WORDING A.K.T. 22-5-78			
Designed	A.K. THOMSON	MARCH 78	
Drawn	S.G.S/REMOB	" "	
Traced	SGS	" "	
Checked	AKT.	" "	

Scales	AS SHOWN		
F B	L B	Sheet No. 4 of 5 sheets	B 1611



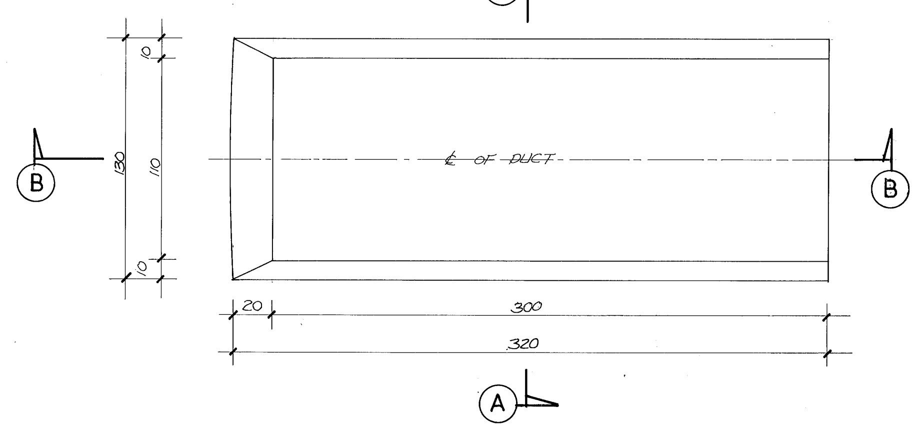
ANCHOR RECESS POSITIONS AND OUTER REINFORCING CAGE

SCALE 1:5



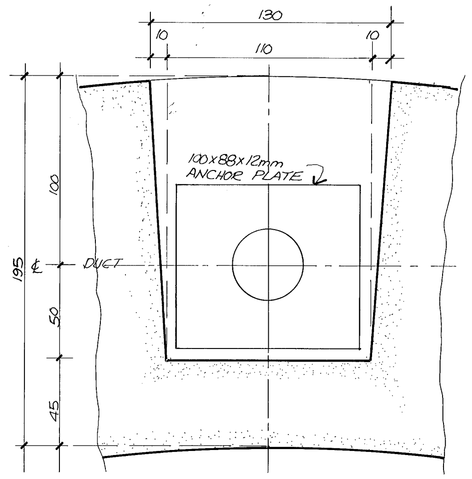
½ **SECTION X** SCALE 1:5

½ **SECTION Z** SCALE 1:5



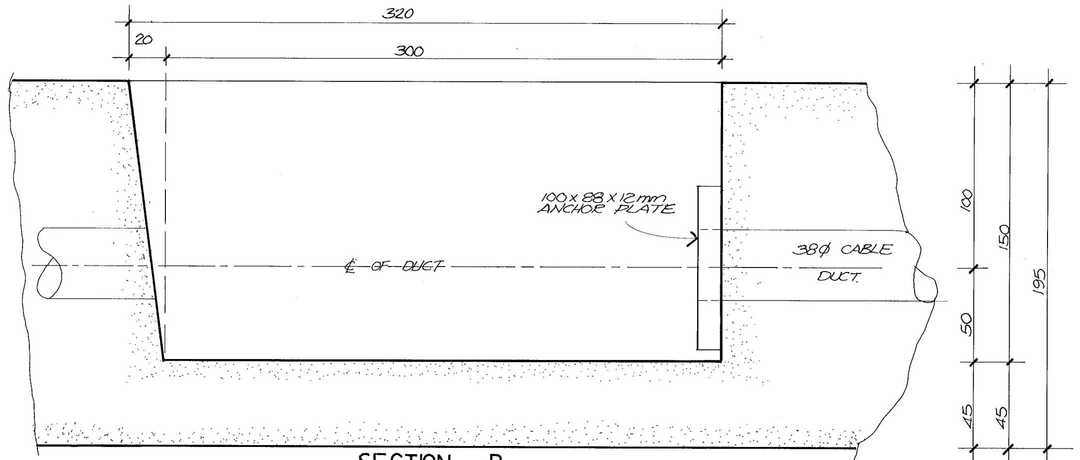
PLAN OF COUPLING RECESS

SCALE ½ F.S.



SECTION A

SCALE ½ F.S.



SECTION B SCALE ½ F.S.

A. H. SELLES
M.N.Z.I.E.
City Engineer
18 : 10 : 1978

Prepared	AKT	OCT 78
Drawn	SGS	" "
Traced	SGS	" "
Checked	AKT	" "

THE CITY OF HASTINGS

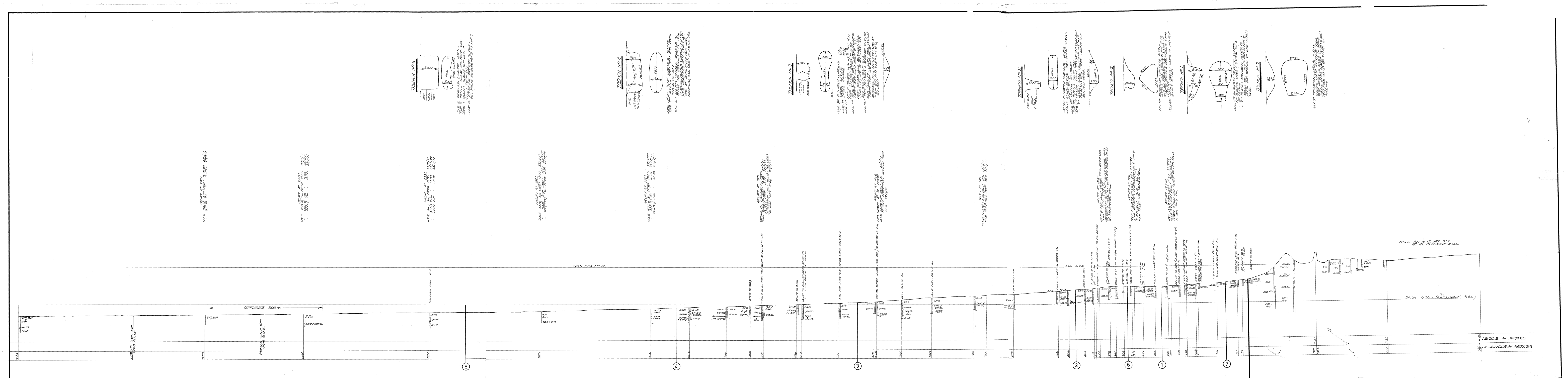
SUBMARINE SEWER OUTFALL

ANCHOR PIPE 'As built'

Scales AS SHOWN

FB | LB | Sheet No. 6 of 15 sheets

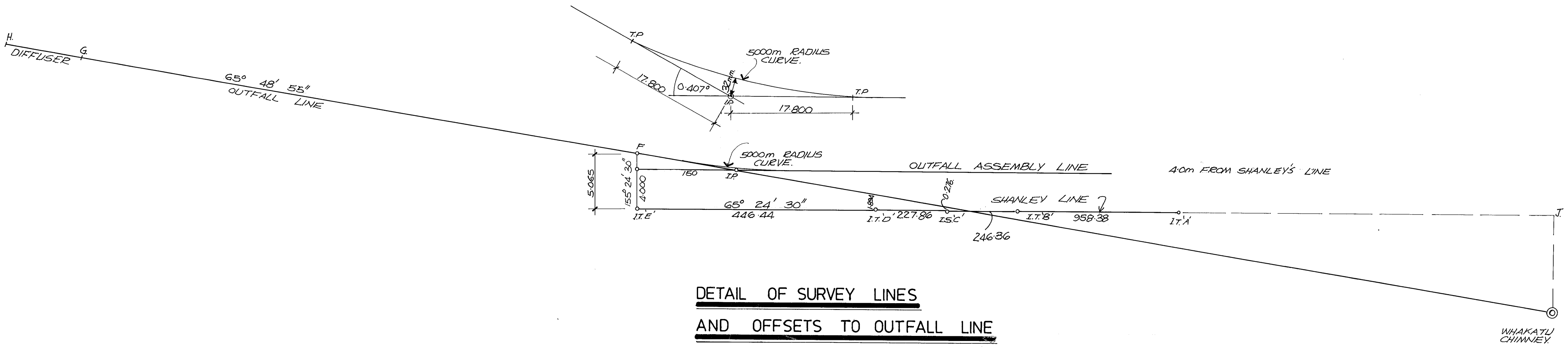
B 1611



LONGITUDINAL ELEVATION OF SEABED

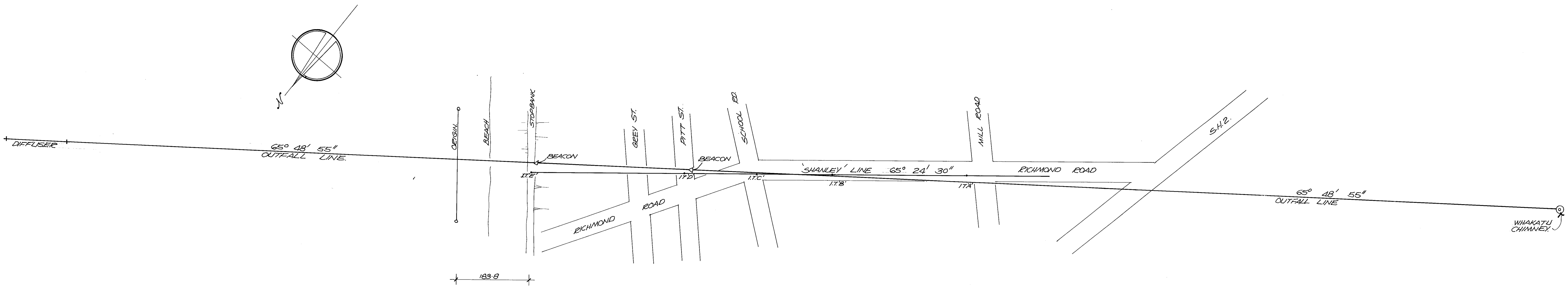
SCALES HORIZ. 1:2000
VERT. 1:200

A. H. SELLES M.N.Z.I.E. City Engineer 18 : 10 : 1978			THE CITY OF HASTINGS
Prepared	RER & AKT	1977-78	SUBMARINE SEWER OUTFALL
Drawn	RER	" "	INVESTIGATION BORES AND TRENCHES
Traced	S.G.S	" "	Scales 1:2000 HORIZ. 1:200 VERT. / 15 — B 1611
Checked	A.K.T	" "	FB — LB — Sheet No. 8 of [illegible] sheets



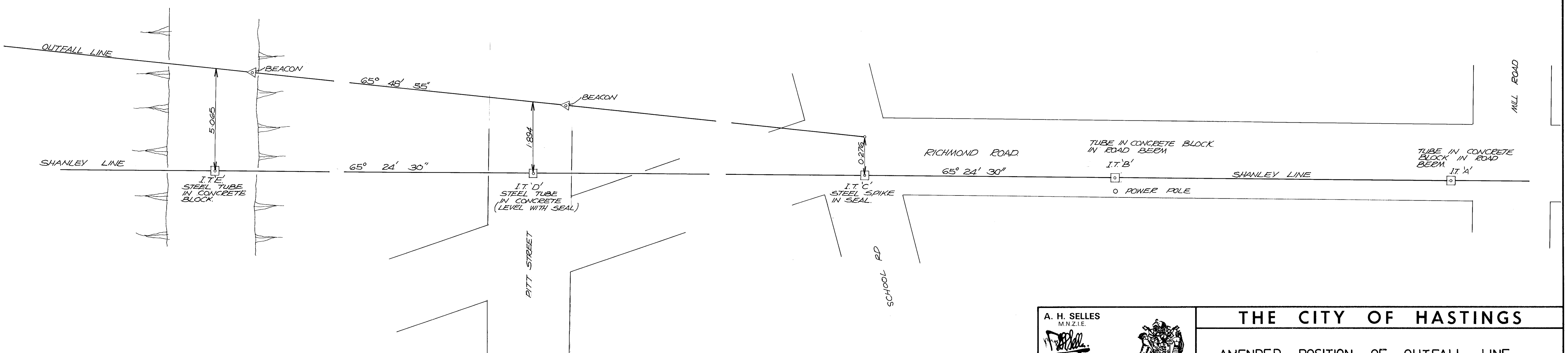
DETAIL OF SURVEY LINES AND OFFSETS TO OUTFALL LINE

NOT TO SCALE



OVERALL PLAN

NOT TO SCALE



DETAIL POSITION OF SURVEY MARKS

NOT TO SCALE

A. H. SELLES
M.N.Z.I.E.
City Engineer
5 : 3 : 1979

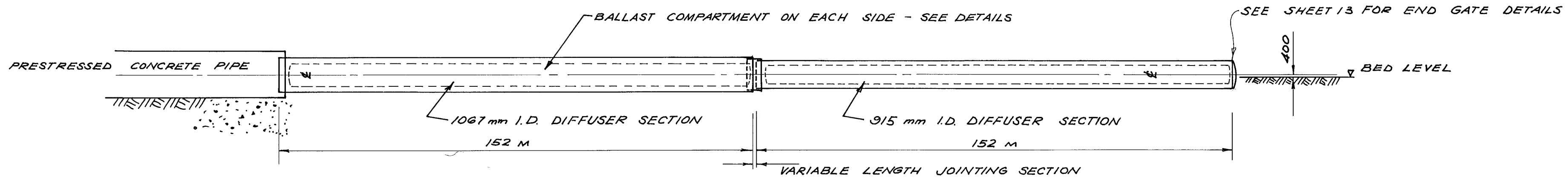
Prepared	KGH	FEB 79
Drawn	KGH	" "
Traced	S.G.S	" "
Checked	A.K.T.	" "

THE CITY OF HASTINGS

AMENDED POSITION OF OUTFALL LINE WITH OFFSETS TO SURVEY MARKS

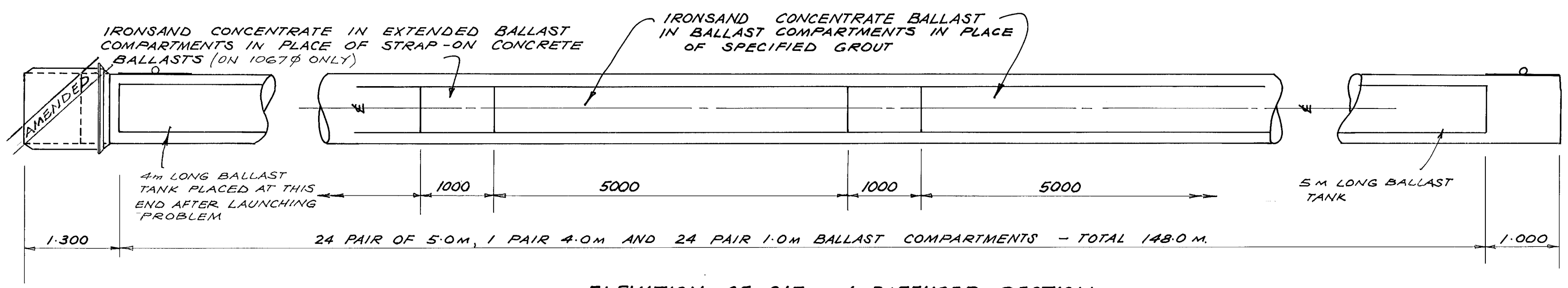
'As built'

Scales: NOT TO SCALE | F B | L B | Sheet No. 9 of 15 sheets | B 1611



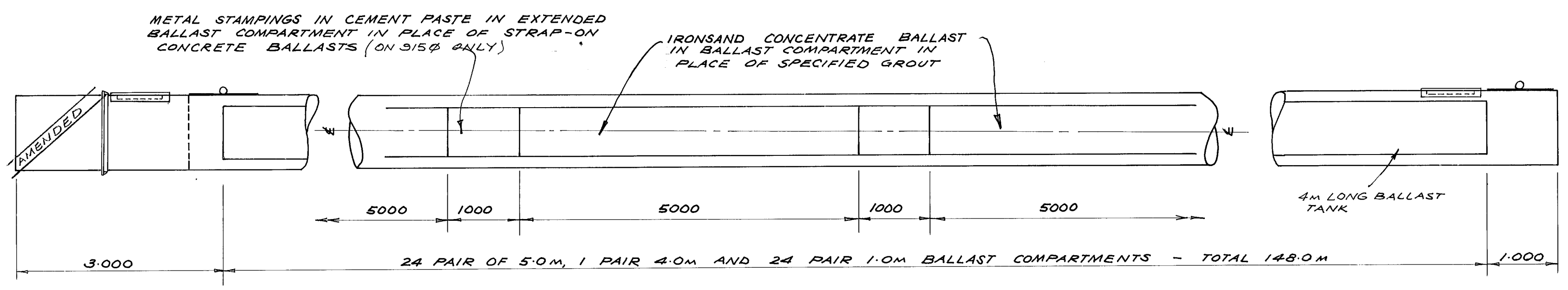
ELEVATION OF DIFFUSER SECTION

SCALE:- HORIZONTAL 1:1000
VERTICAL 1:100



ELEVATION OF 915mm Ø DIFFUSER SECTION

SCALE: 1:50



ELEVATION OF 1067 mm Ø DIFFUSER SECTION

SCALE: 1:50

Note. After mishap on launching 1st Section, each of the two above lengths were cut into three sections and towed out from Napier Port to be lowered into position & jointed on the seabed - See Macdow's plans.

AMENDMENT
1. 'AS BUILT' NOTES ADDED A.K.T. 7/83

A. H. SELLES
M.N.Z.I.E.
City Engineer

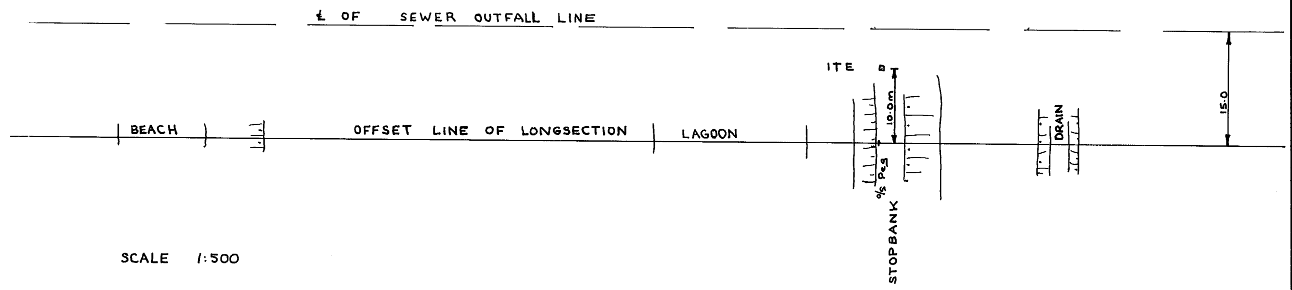
Prepared		
Drawn		
Traced	I. A. TAYLOR	AUG. 1979
Checked	B.H.W.	9/79

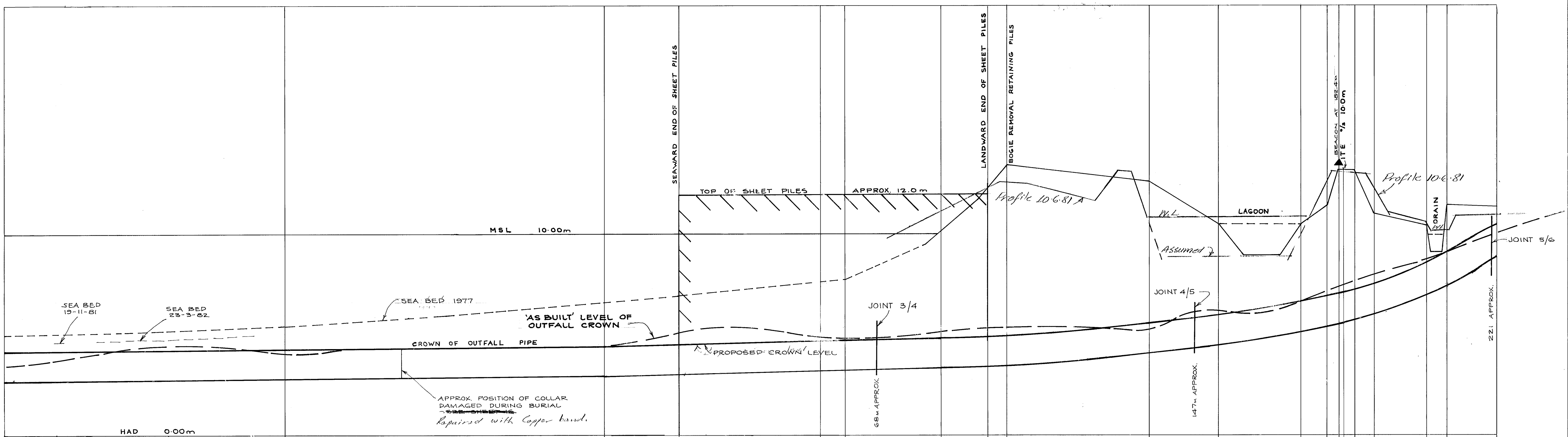
THE CITY OF HASTINGS

SUBMARINE SEWER OUTFALL
DIFFUSER SECTION

BALLAST ARRANGEMENT 'As built' apart from lengths see note ←.

Scales	AS SHOWN		B 1611
F B	L B	Sheet No. 10 of 15 sheets	





PIPE CROWN LEVEL	4.200	4.300	4.400		4.700	4.800		4.900	5.550		6.650		7.050		7.500		9.000	10.400
GROUND REDUCED LEVEL	5.000		6.600					13.350	12.550	10.430	10.400	11.300	13.110	13.110	10.890	10.320	9.950	
DISTANCE	-150	-80	0	+19	+60	+84	96	100.3	135.8	152.8	173.3	179.8	182.6	183.8	191.5	204.5	209	222.2

SCALES Horizontal 1:500
Vertical 1:100

AS BUILT LEVEL OF CROWN ADDED A.K.T. 7/83
Additional Profile 12.6.81 R.E.R.

A. H. SELLES
M.N.Z.I.E.
City Engineer
4 : 12 : 1979

Prepared	RVL	11/79
Drawn	RVL	11/79
Traced		
Supervised	A.K. Thomson	3/12/79

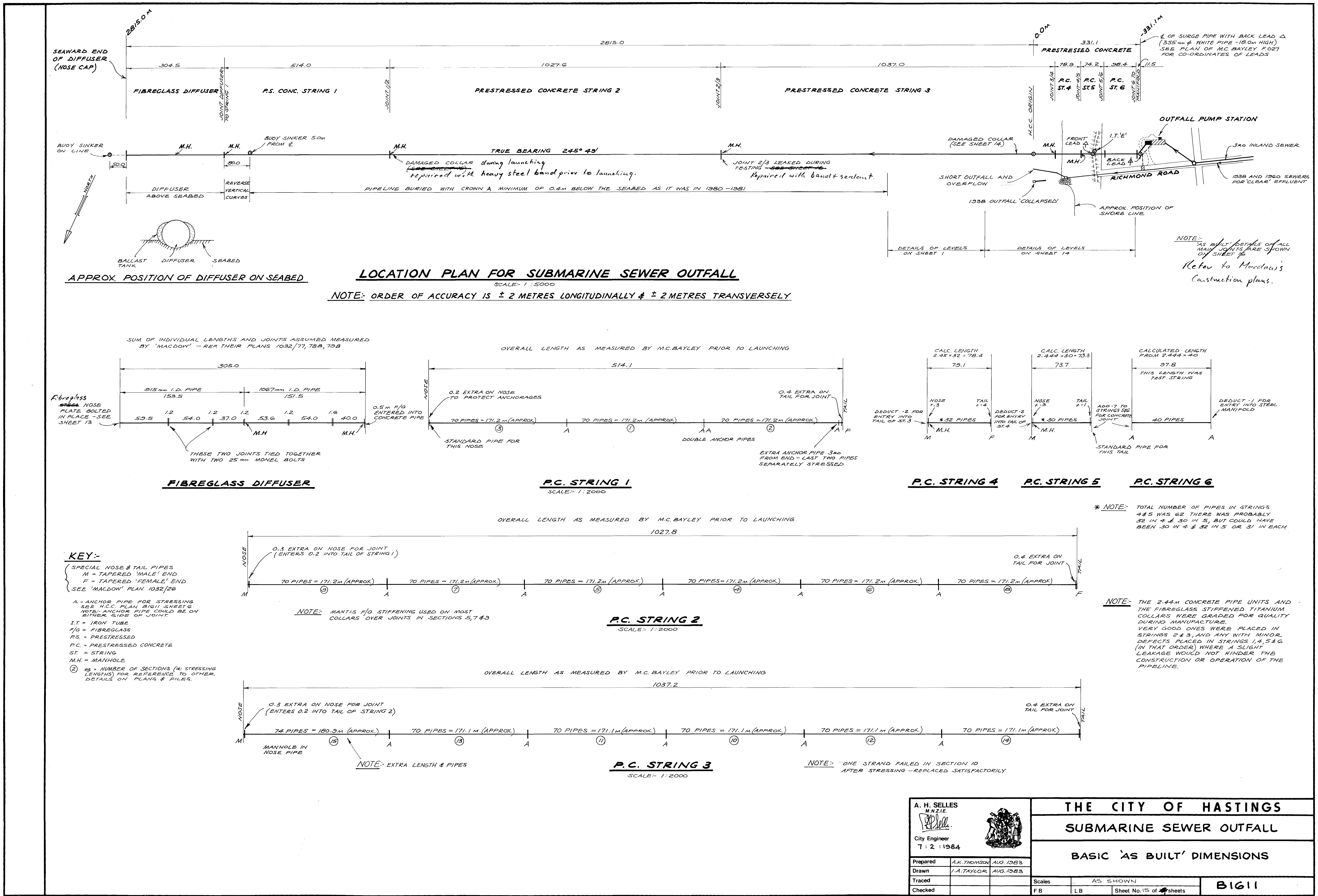
THE CITY OF HASTINGS

SUBMARINE SEWER OUTFALL LONGSECTION ON OUTFALL LINE THROUGH COAST

'As Built'

Scales | FB | LB | Sheet No. 14 of 15 sheets | B 1611

PREVIOUSLY SHEET 13


2815.0m
SEAWARD END OF DIFFUSER (NOSE CAP)
2815.0
304.5
514.0
1027.6
1037.0
FIBREGLASS DIFFUSER
JOINT DIFFUSER/ TO STRING 1
P.S. CONC. STRING 1
JOINT 1/2
PRESTRESSED CONCRETE STRING 2
JOINT 2/3
PRESTRESSED CONCRETE STRING 3
0.0m
-331.1m
331.1
PRESTRESSED CONCRETE
78.9
74.2
98.4
11.5
H.C.C. ORIGIN
JOINT 3/4
JOINT 4/5
JOINT 5/6
JOINT 6 TO MANIFOLD
P.C. ST.4
P.C. ST.5
P.C. ST.6
℄ OF SURGE PIPE WITH BACK LEAD △ (355mm ɸ WHITE PIPE -18.0m HIGH) SEE PLAN OF M.C. BAYLEY F.027 FOR CO-ORDINATES OF LEADS
OUTFALL PUMP STATION
BUOY SINKER ON LINE
M.H.
M.H.
BUOY SINKER 5.0m FROM ℄
M.H.
TRUE BEARING 245° 49'
M.H.
DAMAGED COLLAR (SEE SHEET 14)
M.H.
FRONT LEAD △
I.T.'E'
BACK LEAD △
M.H.
3RD INLAND SEWER
50.0
80.0
DAMAGED COLLAR during launching (SEE SHEET 16) repaired with heavy steel band prior to launching.
JOINT 2/3 LEAKED DURING TESTING SEE SHEET 16 Repaired with band & sealant.
SHORT OUTFALL AND OVERFLOW
RICHMOND ROAD
1938 AND 1960 SEWERS FOR 'CLEAR' EFFLUENT
1938 OUTFALL 'COLLAPSED'
APPROX. POSITION OF SHORE LINE
NORTH
DIFFUSER ABOVE SEABED
REVERSE VERTICAL CURVES
PIPELINE BURIED WITH CROWN A MINIMUM OF 0.4m BELOW THE SEABED AS IT WAS IN 1980-1981
DETAILS OF LEVELS ON SHEET 1
DETAILS OF LEVELS ON SHEET 14
BALLAST TANK
DIFFUSER
SEABED
APPROX. POSITION OF DIFFUSER ON SEABED
NOTE:- 'AS BUILT' DETAILS OF ALL MAIN JOINTS ARE SHOWN ON SHEET 16
Refer to Macdow's Construction plans.
LOCATION PLAN FOR SUBMARINE SEWER OUTFALL
SCALE:- 1:5000
NOTE:- ORDER OF ACCURACY IS ± 2 METRES LONGITUDINALLY & ± 2 METRES TRANSVERSELY
SUM OF INDIVIDUAL LENGTHS AND JOINTS ASSUMED MEASURED BY 'MACDOW' - REF THEIR PLANS 1032/77, 788, 798
305.0
915mm I.D. PIPE
153.5
1067mm I.D. PIPE
151.5
Fibreglass STEEL NOSE PLATE BOLTED IN PLACE - SEE SHEET 13
59.5
1.2
54.0
1.2
37.0
1.2
53.6
1.2
54.0
1.6
40.0
M.H
M.H.
0.5m F/G ENTERED INTO CONCRETE PIPE
THESE TWO JOINTS TIED TOGETHER WITH TWO 25mm MONEL BOLTS
FIBREGLASS DIFFUSER
OVERALL LENGTH AS MEASURED BY M.C.BAYLEY PRIOR TO LAUNCHING
514.1
NOSE
0.2 EXTRA ON NOSE TO PROTECT ANCHORAGES
0.4 EXTRA ON TAIL FOR JOINT
TAIL
70 PIPES = 171.2m (APPROX)
3
A
70 PIPES = 171.2m (APPROX)
1
AA
70 PIPES = 171.2m (APPROX)
2
A
F
STANDARD PIPE FOR THIS NOSE
DOUBLE ANCHOR PIPES
EXTRA ANCHOR PIPE 3RD FROM END - LAST TWO PIPES SEPARATELY STRESSED
P.C. STRING 1
SCALE:- 1:2000
CALC. LENGTH 2.45 x 32 = 78.4
79.1
NOSE +.3
TAIL +.4
DEDUCT .2 FOR ENTRY INTO TAIL OF ST.3
✱32 PIPES
M.H.
M
F
CALC. LENGTH 2.444 x 30 = 73.3
73.7
NOSE +.3
TAIL +.1
DEDUCT .2 FOR ENTRY INTO TAIL OF ST.4
✱30 PIPES
M.H.
M
ADD .7 TO STRINGS 5 & 6 FOR CONCRETE JOINT
STANDARD PIPE FOR THIS TAIL
CALCULATED LENGTH FROM 2.444 x 40
97.8
THIS LENGTH WAS TEST STRING
40 PIPES
A
A
DEDUCT .1 FOR ENTRY INTO STEEL MANIFOLD
P.C. STRING 4
P.C. STRING 5
P.C. STRING 6
✱ NOTE:- TOTAL NUMBER OF PIPES IN STRINGS 4 & 5 WAS 62. THERE WAS PROBABLY 32 IN 4 & 30 IN 5, BUT COULD HAVE BEEN 30 IN 4 & 32 IN 5 OR 31 IN EACH
OVERALL LENGTH AS MEASURED BY M.C.BAYLEY PRIOR TO LAUNCHING
1027.8
NOSE
0.3 EXTRA ON NOSE FOR JOINT (ENTERS 0.2 INTO TAIL OF STRING 1)
0.4 EXTRA ON TAIL FOR JOINT
TAIL
70 PIPES = 171.2m (APPROX)
9
70 PIPES = 171.2m (APPROX)
7
70 PIPES = 171.2m (APPROX)
5
70 PIPES = 171.2m (APPROX)
4
70 PIPES = 171.2m (APPROX)
6
70 PIPES = 171.2m (APPROX)
8
M
A
A
A
A
A
F
NOTE:- MANTIS F/G STIFFENING USED ON MOST COLLARS OVER JOINTS IN SECTIONS 5, 7 & 9
P.C. STRING 2
SCALE:- 1:2000
KEY:-
SPECIAL NOSE & TAIL PIPES
M = TAPERED 'MALE' END
F = TAPERED 'FEMALE' END
SEE 'MACDOW' PLAN 1032/26
A = ANCHOR PIPE FOR STRESSING SEE H.C.C. PLAN B1611 SHEET 6 NOTE:- ANCHOR PIPE COULD BE ON EITHER SIDE OF JOINT.
I.T. = IRON TUBE
F/G = FIBREGLASS
P.S. = PRESTRESSED
P.C. = PRESTRESSED CONCRETE
ST. = STRING
M.H. = MANHOLE
2 eg = NUMBER OF SECTIONS (ie: STRESSING LENGTHS) FOR REFERENCE TO OTHER DETAILS ON PLANS & FILES.
NOTE:- THE 2.44m CONCRETE PIPE UNITS AND THE FIBREGLASS STIFFENED TITANIUM COLLARS WERE GRADED FOR QUALITY DURING MANUFACTURE. VERY GOOD ONES WERE PLACED IN STRINGS 2 & 3, AND ANY WITH MINOR DEFECTS PLACED IN STRINGS 1, 4, 5 & 6 (IN THAT ORDER) WHERE A SLIGHT LEAKAGE WOULD NOT HINDER THE CONSTRUCTION OR OPERATION OF THE PIPELINE.
OVERALL LENGTH AS MEASURED BY M.C.BAYLEY PRIOR TO LAUNCHING
1037.2
NOSE
0.3 EXTRA ON NOSE FOR JOINT (ENTERS 0.2 INTO TAIL OF STRING 2)
0.4 EXTRA ON TAIL FOR JOINT
TAIL
74 PIPES = 180.9m (APPROX.)
15
70 PIPES = 171.1m (APPROX.)
13
70 PIPES = 171.1m (APPROX.)
11
70 PIPES = 171.1m (APPROX.)
10
70 PIPES = 171.1m (APPROX.)
12
70 PIPES = 171.1m (APPROX.)
14
M
A
A
A
A
A
MANHOLE IN NOSE PIPE
NOTE:- EXTRA LENGTH & PIPES
P.C. STRING 3
SCALE:- 1:2000
NOTE:- ONE STRAND FAILED IN SECTION 10 AFTER STRESSING - REPLACED SATISFACTORILY
A. H. SELLES M.N.Z.I.E.
City Engineer
7:2:1984
Prepared A.K. THOMSON AUG. 1983
Drawn I.A. TAYLOR AUG. 1983
Traced
Checked
THE CITY OF HASTINGS
SUBMARINE SEWER OUTFALL
BASIC 'AS BUILT' DIMENSIONS
Scales AS SHOWN
FB
LB
Sheet No. 15 of 16 sheets
B1611
15


standard pipe 2410 long.
bolts protrude 140
125
8 No 25φ U bolts set in pipe
stressing ducts as on B1611 sheet 4.
Replaced by 12 Mavel Bolts
24 holes tapped 16φ UNC.
standard spigot end
Note Holes reduced to 12
56R
100
50
TAIL PIPE - 4 OFF
Section a-a
PLAN.
standard pipe 2410 long.
bolts protrude 270
manhole.
1205
662
862
6mm ℓ.
165 check
12φ reo bars. at 200 crs bars 200 long ex deformed reinforcing bar.
weld reinforcing to sides.
450
650
CROSS SECTION
Section b.b.
MANHOLE DETAILS 1:5.
NOSE PIPE 4 OFF
24 No 18φ holes.
100 crs
MANHOLE LID - 4 OFF. EX 25 ℓ.
MACDOW
issue
revision
CITY OF HASTINGS - SUBMARINE SEWER OUTFAL
UNDERWATER PIPE JOINT
NOSE & TAIL PIPES Except Nose of
designed P. POPE approved
drawn L. Dunloo date 6.79
scale 1:10, 5.
drawing number 1032.30

380
280
50
100
25
16
15R
21
60 dia
28 No holes
28 No drill & tap 25ø
See alternative
12 No 25ø
16 No 32ø
1410 dia
1364 dia
1297 PCD
1294 / 1297 PCD
1580 dia
1400 dia
1100 dia
1160 PCD
10 dia holes to 12 No 25ø only.
28 No drill & tap 25ø
16 No 32 dia
12 No 25 dia
10 dia holes to 12 No 25 dia only.
Threaded insert with dowel key for 7/8"ø H.T.S bolt.
51/64"ø hole
ALTERNATIVE TO DRILL & TAP HOLES.
MALE END
16 No 32ø on 1297 PCD
28 No 25ø drill & tap on 1160 PCD
12 No 25ø on 1294 PCD with connecting 10ø 'horiz.'
Note. Where alternative to drill and tap holes is used, 10ø holes will have to be skewed to pass no closer than 10 mm from 51/64"ø holes & inserts.
NOTE
✓ machin
MACDOW
CITY OF HASTINGS - SUBMARINE SE
UNDERWATER PIPELINE JOINT
RING DETAILS
designed P POPE
drawn L JUURLOO
approved
date 5 79

Hawkes Bay
1st Floor, 100 Warren Street South
Hastings 4122
PO Box 13-052, Armagh
Christchurch 8141
Tel +64 6 873 8900
Fax +64 6 873 8901

Stantec