AN INVESTIGATION WORTH ITS SALT: TARGETING SALINE INTRUSION

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ABSTRACT

Dunedin City Council (DCC) is in the process of delivering a $76 million upgrade of the Tahuna Wastewater Treatment Plant (WWTP) which will see 99% of the City's reticulated domestic wastewater receiving secondary treatment through High Rate Activated Sludge (HRAS) and UV disinfection processes.

The viability of these treatment processes and subsequent ability to comply with new consent conditions is significantly threatened by rapid variation of influent salinity.

Recent completion of a $1.6m sewer structural rehabilitation of around 5,500m of sewer ranging from 150-600mm in diameter produced significant a reduction in saline influence but the pilot plant was still experiencing unacceptable variation in the conductivity of influent, signalling the need for further investigation.

It was suspected that saline intrusion was occurring at unrepaired lateral junctions or through infiltration in the lateral themselves. A grab sample and flow monitoring programme was conducted in the rehabilitated area and subsequent CCTV inspection determined the exact location and nature of the intrusion.

The programme was then extended to investigate the entire coastal network.

This paper discusses the suite of challenges that an investigation of this nature presents with limited time windows for CCTV inspection and the countdown on for the completion of the Tahuna upgrade project; and reflects on the successes of a structured investigative approach.

KEYWORDS

Saline intrusion; Wastewater treatment; Conductivity; Sewer re-lining; Lateral junctions; Tides

1 INTRODUCTION

Dunedin is a broadly coastal city with a rich history of land reclamation stretching back to the gold rush of the late 1800's. Network infrastructure 'investment bubbles' ensued as Dunedin grew sporadically. To a great extent this infrastructure was laid in the highly prized, flat, low lying reclaimed land.

Approximately 35km of Dunedin's wastewater network is adjacent to Otago Harbour with a further 5km of network along the coast line with the Pacific Ocean (See Figure 1).

Today Dunedin has spread to the hills and Taieri Plains but much of the City's wastewater still gravitates to the reclaimed area that was once a mud-flat. Here, nestled behind a modified dune system, protected from the invading South Pacific sits the Tahuna Wastewater Treatment Plant (WWTP).

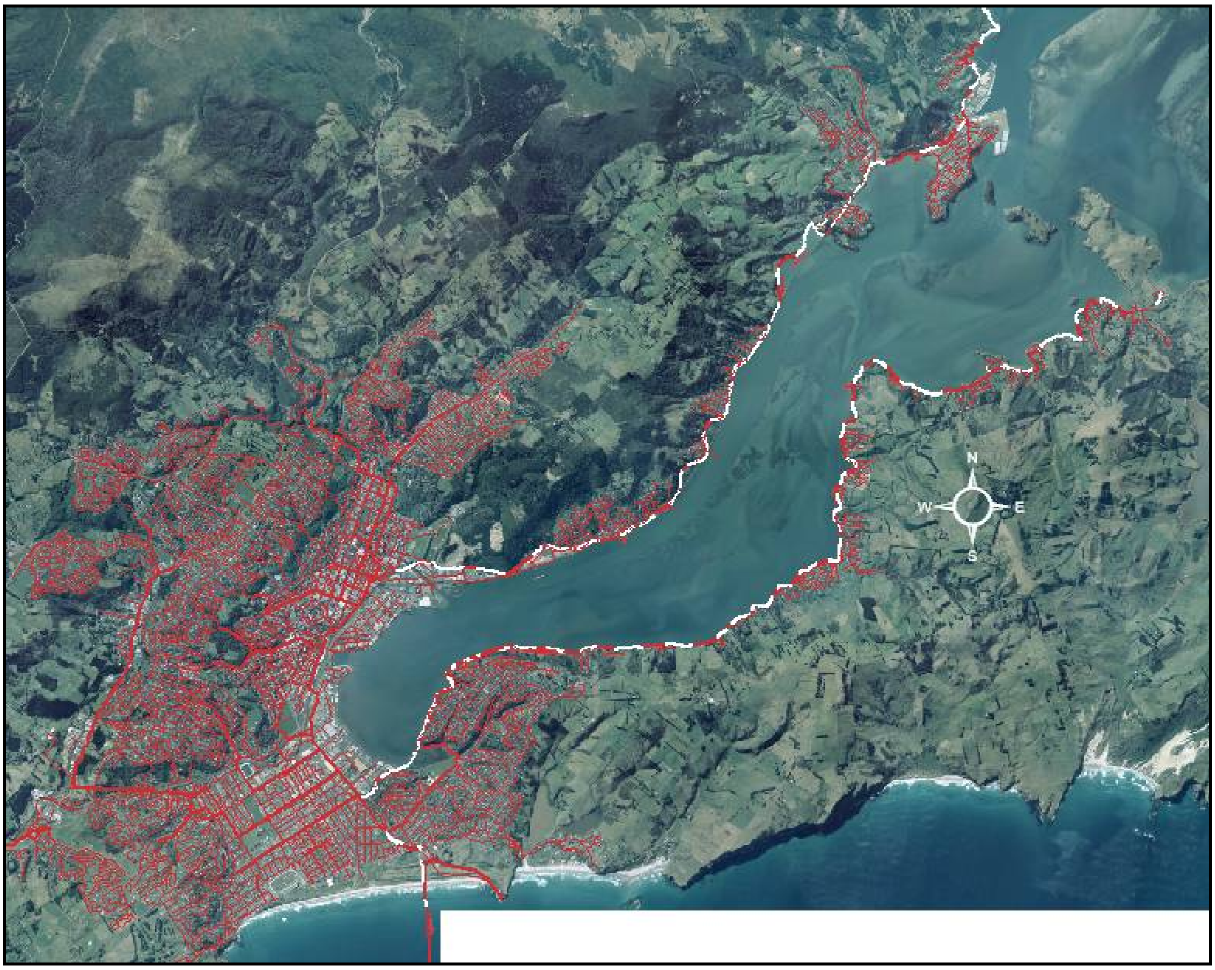


Figure 1 – Map showing the location of Dunedin's Wastewater Network and Otago Harbour

Community consultation and consent compliance have led Dunedin City Council (DCC) to the delivery of a $76 million upgrade of the Tahuna WWTP. This upgrade began with a 1.1km long ocean outfall, commissioned in 2009 and now continues to secondary treatment through High Rate Activated Sludge (HRAS) and UV disinfection processes. With annual flows in the region of 13 million cubic meters Tahuna takes approximately 70% of the City's wastewater and is currently Dunedin's only major treatment plant without secondary treatment.

The biological treatment processes of the upgraded treatment plant; and subsequently the ability to comply with new consent conditions is particularly sensitive to rapid variation in the salinity of influent. During testing of the pilot plant salinity 'spikes' were shown to denature the bacteria used to treat the sewage to a secondary level. Plant recovery time following such an event ranged from days to weeks depending on the severity of the event. Following a collapse of the biological processes it is not possible to gain adequate clarity of effluent for the UV disinfection process to be effective – potentially resulting in poorly treated, non-compliant effluent.

The pilot studies suggested that the plant configuration appeared resistant to conductivities up to 6000µS/cm, monitoring of influent however showed a clear and significant variation in salinity closely mirroring the tidal phase with conductivity spikes up to 10,500µS/cm (see Figure 2). Typical sewage is estimated to have conductivity no greater than 3000µS/cm and in Dunedin most commonly between 1000-2000µS/cm.

In addition to the technical issues that saline intrusion causes the plant, the data presented in Figure 2 suggests that; based on the conductivity range of the Otago Harbour being 40,000µS/cm to 60,000µS/cm; 10-20% of the instantaneous influent flow rate at Tahuna WWTP during a spring tide event could be pure harbour water. With a pure operating cost at approximately $0.50 per cubic metre, a considerable cost saving could be realised by eliminating saline intrusion.

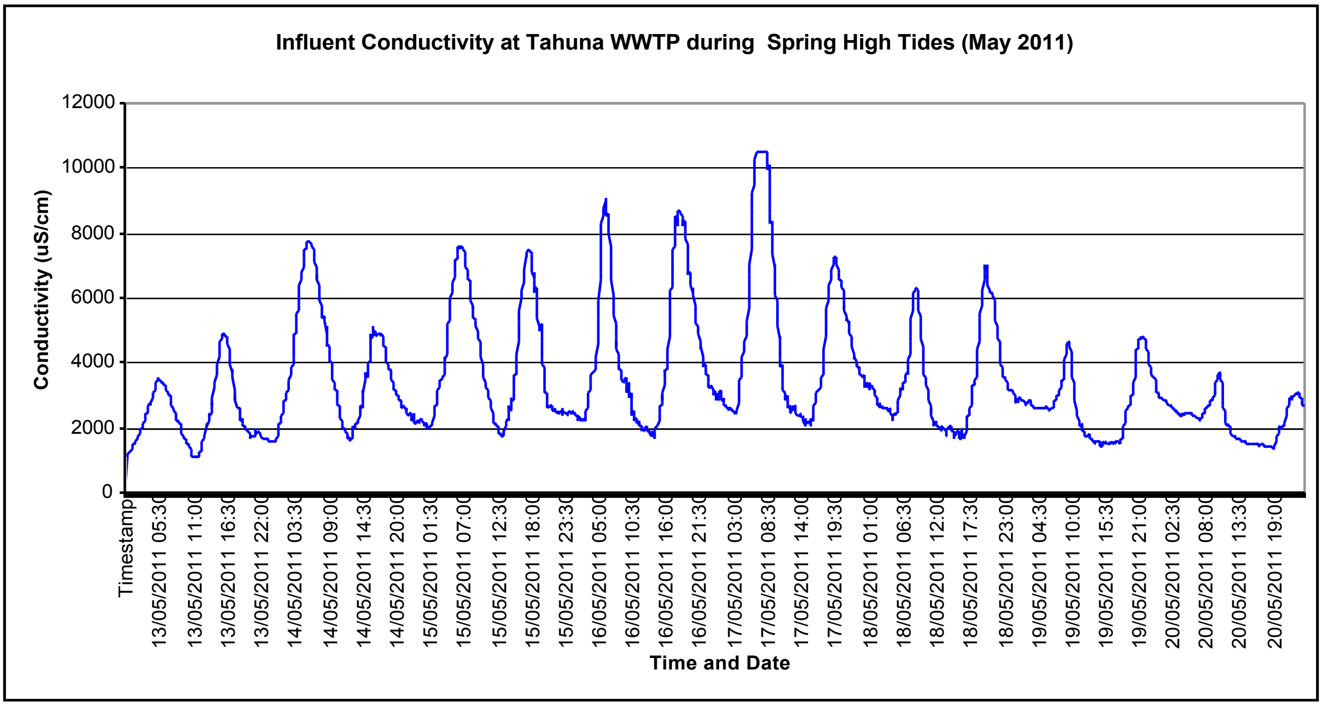


Figure 2 – Typical influent conductivity at Tahuna WWTP over spring high tides

An initial study was carried out in early 2009, sampling conductivity at a range of sites over a tidal cycle. This study highlighted several areas where saline intrusion appeared to be contributing to wastewater flows. CCTV inspection of the 'Fryatt Street' catchment, a large industrial area located on reclaimed land beside the Otago Harbour confirmed that saline intrusion was endemic in around 5,500m of sewer, which ranged from 150mm to 600mm in diameter. Much of the area was in urgent need of structural rehabilitation, with sections of severely deteriorated sewer on the point of collapse and some historic sedimentation and industrial waste deposits that were unable to be jetted.

Believed to be the smoking gun of the salinity issue a $1.6m sewer rehabilitation contract was awarded to Interflow for completion by June 2010.

The majority of the contracted work was completed on time and whilst a reduction in saline influence was observed, the pilot plant was still experiencing unacceptable variation in the conductivity of influent. The sewer relining work itself was completed in full but a large number of the lateral junction repairs had not been completed under the original contract due to time constraints; access constraints (a stadium was being constructed in the vicinity); or due to the oblique geometry of the lateral meaning that custom built cured in place pipe (CIPP) sleeves would need to be manufactured off-site.

2 THE STORY SO FAR……….

2.1 FRYATT STREET LATERALS

2.1.1 2.1.1 – THE ISSUE

Following the completion of the sewer relining there was still significant saline intrusion occurring within the Fryatt Street catchment. It was suspected to be originating at the lateral junctions that were unable to be sealed; or through infiltration in the laterals themselves. The large number of unrepaired lateral junctions that were scattered throughout the rehabilitated area called for an investigation to be initiated to narrow down the areas for further investigation (see Figure 3).

Figure 3 – Map of the Fryatt Street catchment

Prior works in the catchment had shown clear connectivity between the groundwater and the adjacent harbour and indicated that the groundwater was clearly tidal. Subsequently lateral inverts were examined first to determine whether they were within the range of mean high water springs (MHWS) and therefore potentially susceptible to saline intrusion. A grab sample and flow monitoring programme was instigated aimed to determine which areas of the network required CCTV inspection. The CCTV inspection was directed at examining the lateral junctions and focusing on the lower lateral itself to determine the exact location and nature of the intrusion.

It should be noted that a failed lateral is the responsibility of the property owner; whereas a compromised junction following a sewer relining is the responsibility of DCC. It was concluded that should the intrusion be clearly occurring from the lateral itself, then the property owner would be contacted and given the option of works being carried out by either DCC or a private contractor with DCC inspection. With a vast number of laterals across the city approaching the end of their remaining useful life it was important not to set a precedent that private laterals would be repaired by the Council.

The window for CCTV inspection of the problem areas was limited to three hour time slots, from approximately 1 hour before high tide to approximately 2 hours after. Furthermore, it was important that the assessment occurred on only the highest spring tides to ensure that a lateral was not pronounced ‘clear’ imprudently. These tides occur for just three to four days each month and Delta, the CCTV contractor often had to set-up at obscure times to fit this tide window.

The invert levels, sampling data and CCTV were used in concurrence to determine 'if we cared'. In the CCTV, infiltration was clear but with the addition of the sampling data we were able to determine the level of saline intrusion and at what tide heights this occurred.

The sewers in this area are deep and laid in unstable, reclaimed land with high associated dig-up costs. Subsequently where high salinity readings were coupled with very low flows the sewer was 'flagged' as an area to monitor but not to be immediately addressed as the overall contribution to the saline influent at Tahuna WWTP was low.

Figure 4 shows the correlation between the total flow and the tidal cycle that was typically found for the Fryatt Street catchment.

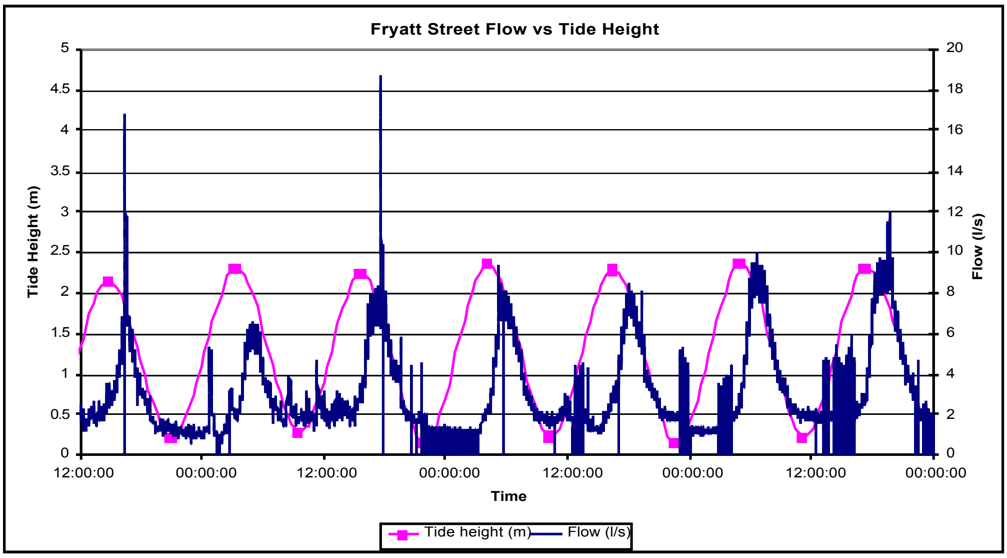


Figure 4 – Correlation between tidal cycle and flow in the Fryatt Street catchment

Conductivity readings at the FSM11799 (the catchment monitoring point as shown in Figure 2) were up to 32,000µS/cm at peak concentration. The conductivity of water in the harbour adjacent to this catchment ranges from 40,000µS/cm – 50,000µS/cm as the harbour is heavily influenced at this point by flows of the Leith.

Therefore it could be concluded that sampling results were consistent with the expected range of harbour water diluted to a concentration of 60-80%. The additional flow contribution averaged over a spring tide cycle was calculated to be in the order of 3.2l/s or equivalent to around 70m^3 over 6 hours.

Typical flows over low tide events were compared with flows from high tide events. Data was used from multiple events to prevent bias. The data available suggested that an average peak tidal flow contribution would be in the order of 8l/s (see Figure 5). This peak flow may account for around 1-2% of the instantaneous influent flow rate at Tahuna WWTP during a spring tide event being pure harbour water. Clearly 'we cared'.

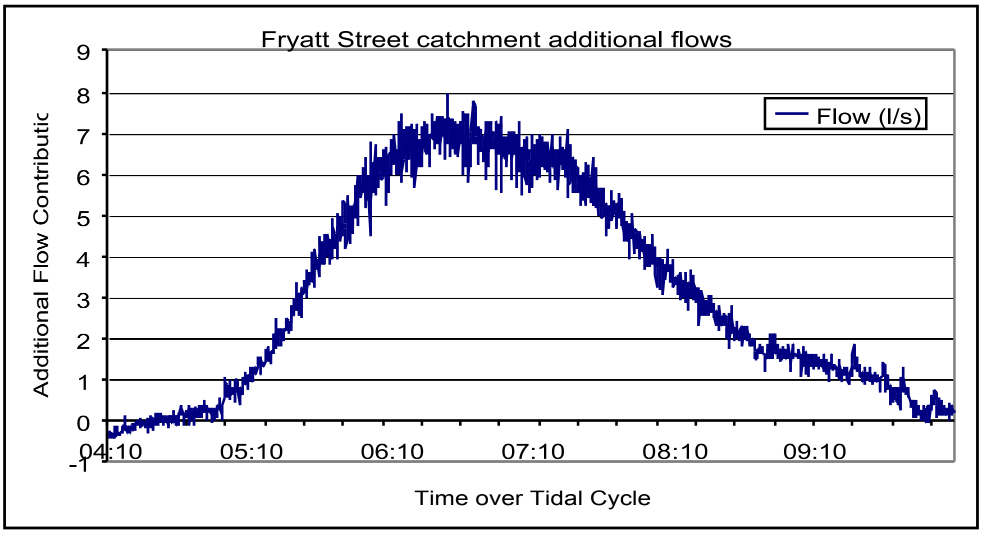


Figure 5 – Additional flow contribution in the Fryatt Street catchment

2.1.2 THE SOLUTION

The bulk of the saline intrusion was able to be tracked back to 23 laterals / lateral junctions on two streets (see Figure 2). It was unsurprising to find saline intrusion originating from the laterals on Fryatt Street itself, adjacent to the harbour at no more than 40m from the waters edge. However, 7 separate points of saline intrusion were also located on Cresswell Street, set back as far as 190m from the harbours edge. This was a concerning discovery showing to just what extent inland saline groundwater could influence the sewer network.

With a significant package of work now determined the relining contractor Interflow and DCC Utilities contractor Delta were invited to tender for the work; an interesting chance to compare the benefits of dig and lay against trenchless.

Whilst trenchless was unequivocal in price and convenience for the 5.5km of relining previously completed; the complexity of the remaining junction repairs led to the dig up option being cheaper and probably more reliable, even given that the connections were in as much as 3m of cover and difficult ground conditions.

The sewers being repaired, in some cases, were old earthenware hosting an old PE liner which in turn hosted the spiral wound liner recently installed by Interflow. The preferred method of connection was to remove the crumbling old earthenware host pipe from the area; Hume bond the connection between the new liner and the PE liner (to stop water from tracking in behind the spiral wound liner); and then PE weld a Y-connection on to the outside of the PE.

This method is shown in Photograph 1 and 2, where the connection is conveniently located on the lateral connection belonging to the buildings of Progressive Plastics, who completed the PE weld. The junction was then strapped for additional security and connected on to the existing lateral well above the level of MHWS.

Photograph 1 and 2 – The lateral junction repair on the Progressive Plastics lateral

2.2 MARNE STREET SEWER

2.2.1 THE ISSUE

Whilst work was underway in the Fryatt Street catchment, a flow monitoring programme was being conducted in the separate catchment of "Marne Street" for the purpose of model calibration. The monitoring identified a flow pattern which also appeared to closely mimic the tidal cycle of the Upper Harbour, a sample of which is shown in Figure 6.

A grab sampling programme in this area confirmed that the additional flow contribution was highly saline.

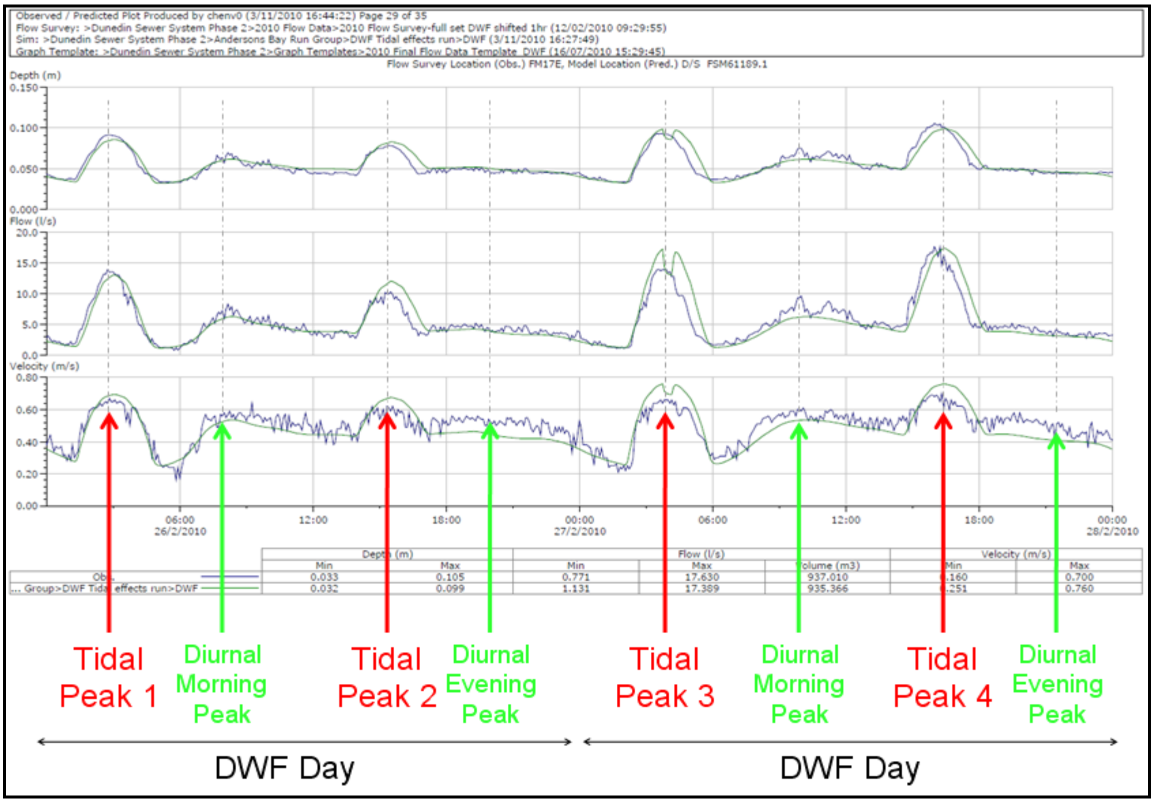


Figure 6 – Results from flow monitoring of Marne Street

Conductivity readings at the Marne Street site were almost 40,000µS/cm at peak concentration. This is within the conductivity range of waters of the Upper Otago Harbour and suggested that flow at this point and time was predominantly influenced by the water body. At this sampling point the contributing catchment is approximately 450 domestic properties and it was thought unlikely to be any significant saline influence from other sources.

Flow data from January 2010 to June 2010 was analysed in conjunction with conductivity readings in order to determine the likely effect on Tahuna. Flows from multiple low tide events that coincided with the timing of the sampled events were compared with flows from multiple high tide events of the same timing. The long period of data allowed analysis over different dry weekday events; enabling robust data analysis and preventing bias.

'Typical' flow cycles were then determined for low tide events; high tide events <2.0m and high tide events >2.0m. From this the flow rate; and subsequent volume of water being contributed purely by inflow/infiltration was determined for each tidal cycle.

The rapid increase to peaked flow at approximately 1 hour after high tide, lack of 'flat top' and the more gradual tail, with additional flow evident to approximately 4 hours after high tide suggested that the source of the additional flow was more likely to be multiple infiltration points than a single point inflow.

Grab samples were correlated with the flow data. Figure 7 shows the correlation between conductivity readings of the grab samples flow against the additional flow data over the same time period.

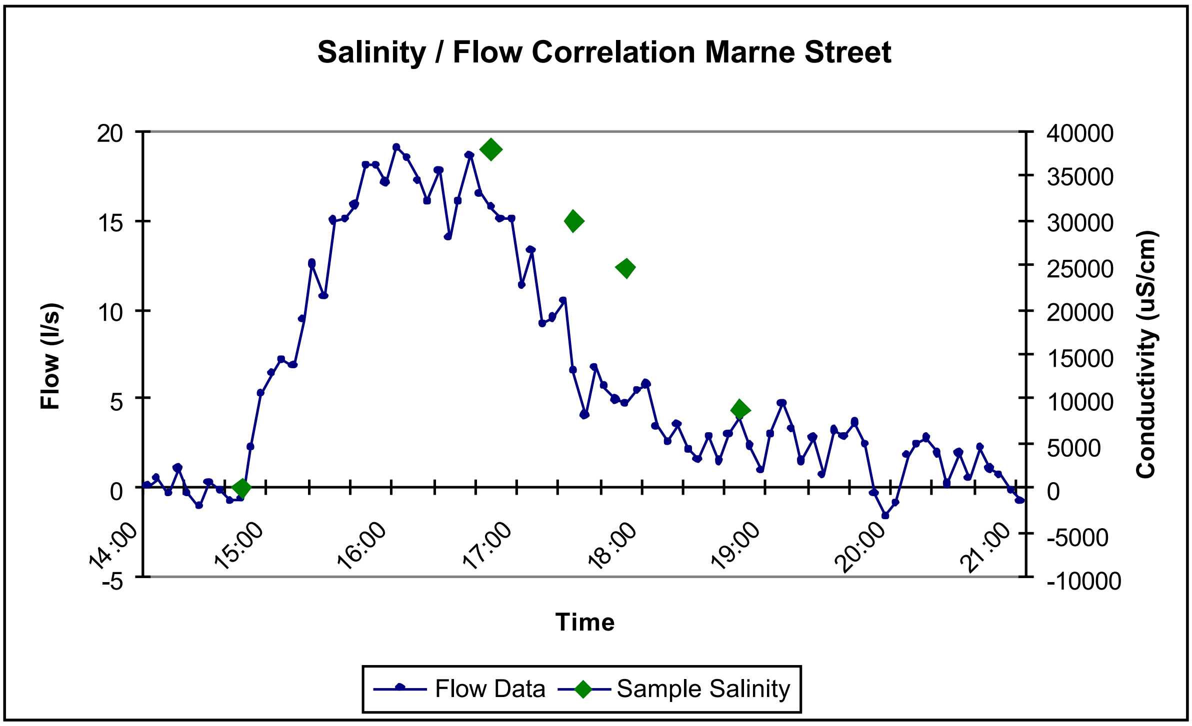


Figure 7 – Salinity / flow correlation

The strong correlation between conductivity and volume of additional flow suggests that it is almost exclusively attributable to saline inflow/infiltration.

The base flow to additional flow ratio also strongly reflected this. For example where 25% of flow was attributed to base flow and 75% to additional flow; the conductivity reading was approximately 30,000µS/cm. A reading you would expect from a 75% harbour water solution.

In terms of volume the height of the tide was shown to be highly significant. For example, a >2.0m high tide event was shown to attribute approximately 20l/s of additional peak flow. This peak flow accounted for around 4-5% of Tahuna WWTP's instantaneous influent flow rate during a spring tide event. When averaged over an entire tidal cycle; the additional flow rate was approximately 8l/s or equivalent to 160m^3 of harbour water to the wastewater system over 6 hours.

A <2.0m high tide contributes considerably less flow, averaged at around 6l/s but still estimated to be in the region of 100m^3 of harbour water over the high-tide cycle.

In total this flow may account for up to 1% of the annual average influent to Tahuna. Again, clearly 'we cared'.

Subsequent CCTV inspection at high tide identified the cause. Multiple points of saline intrusion were visible along the 1.4km of sewer, with almost every joint contributing at least some volume (see Photograph 3).

Photograph 3 – Still image from CCTV of the Marne Street line

2.2.2 THE SOLUTION

The initial relining contract in the Fryatt Street area had been generally successful. The Marne Street area comprised of 1.4km of sewer that needed rehabilitation with only 10 connections, subsequently the contract was awarded to Interflow to apply the same technology.

A key benefit of using trenchless technology for this project was the limited disruption caused to traffic with the work was completed within 3 weeks.

Portobello Road (see Figure 8) is the main road which services the harbour communities along the peninsula and as such prolonged road closures was not a viable option.

The works were carried out at night to ensure minimal disruption and was also timed between high tides.

Figure 8 – Map showing Marne Street catchment area

2.2.3 MANHOLES

Following the completion of the works both the flow and conductivity of the sewer was significantly reduced; however, there was still an element of saline influence evident, manifested in readings as high as 10,000µS/cm, suggesting a 20% to 25% solution of harbour water (see Figure 9).

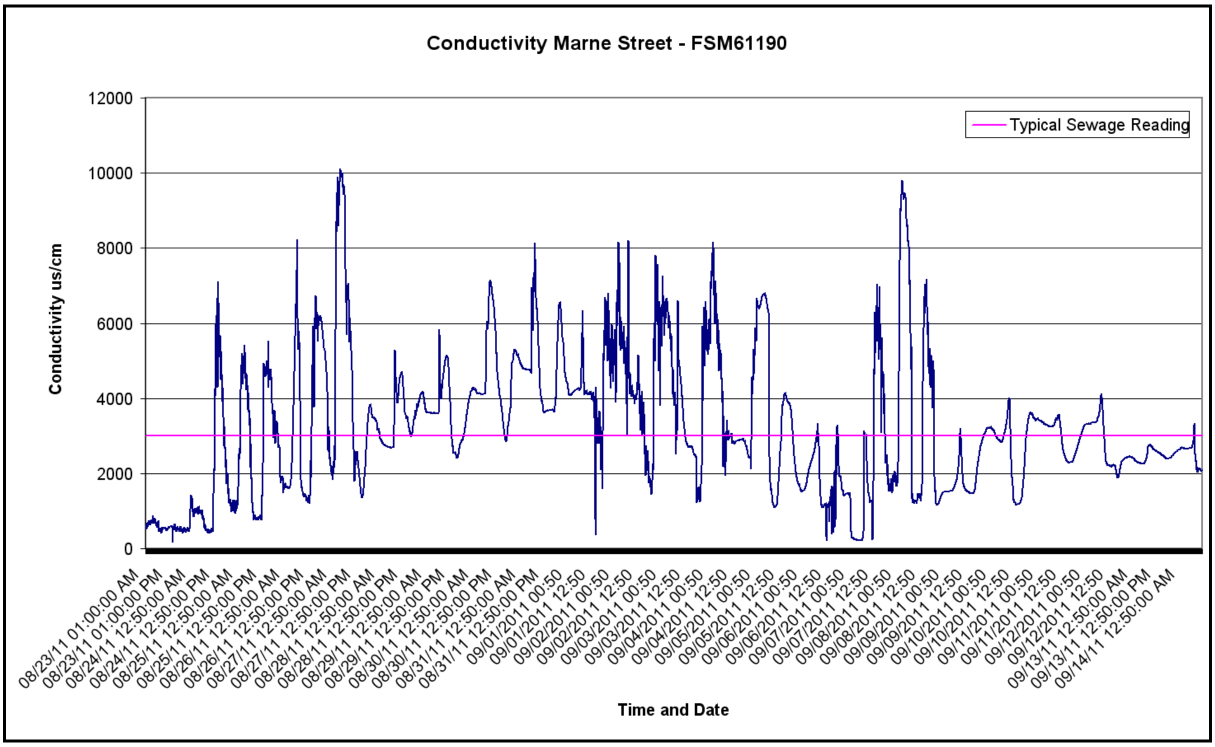


Figure 9 – Marne Street conductivty following relining works

Although the flow was considerably reduced it was determined that we 'still cared' and so investigations continued.

It was noted during the relining and subsequent re-sampling works that a number of manholes were the cause of infiltration. Initial repair work consisting of copious grouting was carried out as a temporary fix on the manholes that were assessed as being in the worst condition.

This temporary measure was followed up with a further assessment of the infiltration locations to allow a package of manhole renewal work to be tendered. In addition; the lateral connections on the line were prioritised based on their invert relative to sea level.

It was interesting to note that whilst the relining work eliminated a huge proportion of saline intrusion; the manholes that were built 60 + years ago could also be contributing to the problem. Further inspection of the Fryatt Street area during the lateral junction repairs also found manholes with seepage through the walls to be addressed.

2.3 FURTHER SAMPLING

To complement the work being carried out in the known problem areas a proactive search was commenced to track down further areas of saline intrusion. Initially a desk top study was undertaken to review the gravity wastewater sewers adjacent to the harbour and investigate their upstream catchment and topography using GIS and the InfoWorks CS model where applicable. The upstream catchment size gave a good indication as the normal flow for any given area and the topography review ensured site visits were optimised.

This work presented two main challenges: A vast network of potential intrusion areas and a tight time frame in which to test. To ensure that problem areas were not injudiciously disregarded, site checks were limited to spring high tide events, with only a 2-3 hour sampling window over 3 to 4 days per month. These sampling windows were dictated by a more celestial authority than that which dictate convenient working hours!

The desk top study focused on establishing manageable catchments to review during these sampling windows. The first round of testing involved taking a conductivity meter to site and testing each sample as it was retrieved. Taking samples involved a piece of simply engineered capped pipe on a string; excellent alignment skills and great patience (see Photograph 4, 5 and 6). Results were noted against the sample time, location and commentary on the flow conditions. This method covered a significant catchment area and highlighted issues for further investigation. However, a single reading was not sufficient other than to signal further investigations and a low conductivity result could not always be completely ignored as the timing of some samples was critical.

Photograph 4, 5 and 6 – Sampling procedure

After the initial round of sampling smaller catchments were selected and a cyclical sampling regime was set up in order to obtain a clear picture over the tidal cycle. Generally these catchments consisted of 4 or 5 sample locations with feasible manholes pre-established. Sites were visited before the tidal window and selected manholes reviewed, opened, checked and marked. This ensured that during the small tidal window that time was not wasted trying to locate or open problematic manholes.

During this more detailed sampling regime conductivity was not measured on site. To save time samples were taken in bottles which were labelled with location, time of sample and a note of flow condition and stored in a fridge. The samples were then able to be tested in due course at the DCC Network Operations Centre.

A series of results for each site enabled trending over the tidal cycle and results could be reviewed against 'typical' sewage conductivity readings which were estimated to be no more than 3000µS/cm. If all results from a specific location were below 3000µS/cm then the area was not investigated further. Where results exceeded 3000µS/cm an assessment of the upstream catchment was initiated.

An important element of the sampling programme is the assessment of flow conditions. A sample with a very high conductivity reading but very little flow is of less concern than a lower conductivity reading and a significant flow. The modelling review of upstream catchments gave a steer on the expected flow and enabled significant flows to be highlighted and questioned.

The structured approach worked well with sampling in month one, followed by CCTV inspection during the second month's high tide events. Issues were then addressed and works carried out, in many cases this enabled re-testing the site in month three to establish how successful the work had been.

2.4 LONG TERM MONITORING

During the period of assessing monthly grab samples for specific locations it was determined that it would be beneficial to understand long term trends in conductivity at various points of interest. It was agreed that 20 conductivity monitors would be bought and strategically placed around the city.

The benefits were two fold in that it would enable assessment of sites that had lower conductivity readings; and it would enable the severity of the intrusion to be established across a longer timeframe. In addition these monitors would provide confirmation that works carried out at specific locations had successfully reduced conductivity (see Figure 10).

A further significant benefit of long term conductivity monitors is the ability to watch tends and identify if there is a 'new' issue in a catchment. For example, were a junction to fail or sewer collapse in the Fryatt Street area it would be evident on the next conductivity download.

The monitors purchased were easy to install and download data from but only capable of logging conductivity and not flow. As discussed it is important to understand if the catchment was a high priority based on volume of inflow and so at certain locations where this was unclear; a flow meter was also installed.

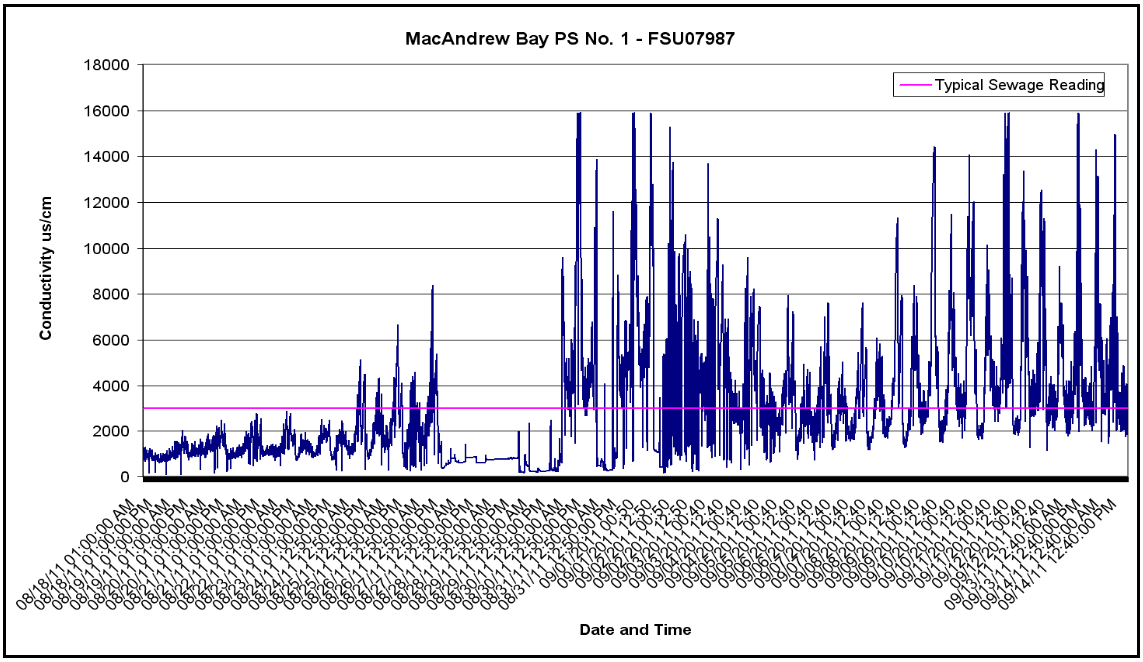


Figure 10 – Example data from the long term monitoring

In a number of locations; the first set of results that were retrieved showed readings that were beyond the conductivity range of the meters, manifested as 'flat tops' on the graphs. The long term monitors were based on an existing model located at the Tahuna WWTP and hence were not equipped to measure highly concentrated saline water. In order to monitor the anticipated reduction in conductivity as repair work was completed a number of locations had a second monitor installed to cover a higher range of conductivity.

During review of downloaded data a number of apparent 'blips' of single random spikes of high salinity were observed. Initially it was thought that these were logging errors but further discussion and research into possible explanations led to the hypothesis that these could in fact be true readings.

Large quantities of mineral salt can be discharged into the wastewater system quite genuinely through both trade and domestic activities. These 'spikes' are most readily observed when monitoring small domestic catchments with relatively low flows where these activities are not well masked. In some of the smaller monitored catchments serving around 500 houses; as little as 500g of salt being discharged to the sewer over the course of 2-3 minutes would produce sewage with the same conductivity as pure harbour water.

Some examples of these genuine domestic activities that use large quantities of salt include:

- Dying of fabrics. Generally 500g of salt is added to a washing machine load during dying as the salt opens up the pores of the fabric and allows the dye to be absorbed. This load would enter the system instantaneously when the washing machine empties and could easily give you a 'false' reading for a period of several minutes past a logger.

- Salt-curing meat. In making cured meats such as bacon or dry-cured hams several kilos of salt may be used to draw the moisture out of the meat. Used salt could quite feasibly be washed down the drain, again giving a 'false' reading for long sufficient time for a logger to pick up the reading.

- Hide salting. Hunters may salt animal hides to preserve them prior to tanning; again large quantities of salt are used in the process and would be discharged when the hide is rinsed.

2.5 BIRCH STREET

The catchment known as 'Birch Street' was investigated following high conductivity readings in the sampling programme (see Figure 11). This area was also subject to a trade waste query following the site visit as the elevated conductivity at low tide seemed to be related to a trade flow.

Figure 11 – The Birch Street Area

The flow in the sewer was a milky colour and investigation was required to determine if the salinity was generated from the known trade waste customer located upstream or whether there was a saline intrusion issue from the harbour at various states of tide. The answer was the later.

It was noted that a stormwater line ran parallel to a section of the wastewater sewer and it was queried whether the stormwater outlet was tidally influenced and if a cross connection existed. CCTV filming was undertaken and it became evident that it was two sections of sewer located adjacent to the wharf that were the issue. Again, filming was planned to coincide with spring high tides over a two hour time slot.

The short turnaround required for this project and the availability of Interflow resulted in relining not being a viable option. A dig and lay contact was awarded to Delta and at the time of writing the replacement of 80m of 225mm diameter sewer is in its fourth week.

This project has been slow work due to the poor ground conditions; particularly the running sand which visibly ‘oozed’ up underneath the trench shield. These conditions are clearly evident in Photograph 7 and 8 with the ground literally opened up. The 300mm diameter distribution water main that can be seen crossing the trench had to be shut down and temporary feeds set up. The original sewer was installed on B haunching of reinforced concrete and rather than remove this altogether the old pipe was removed and the new ceramic pipe was installed in its place using the original bedding.

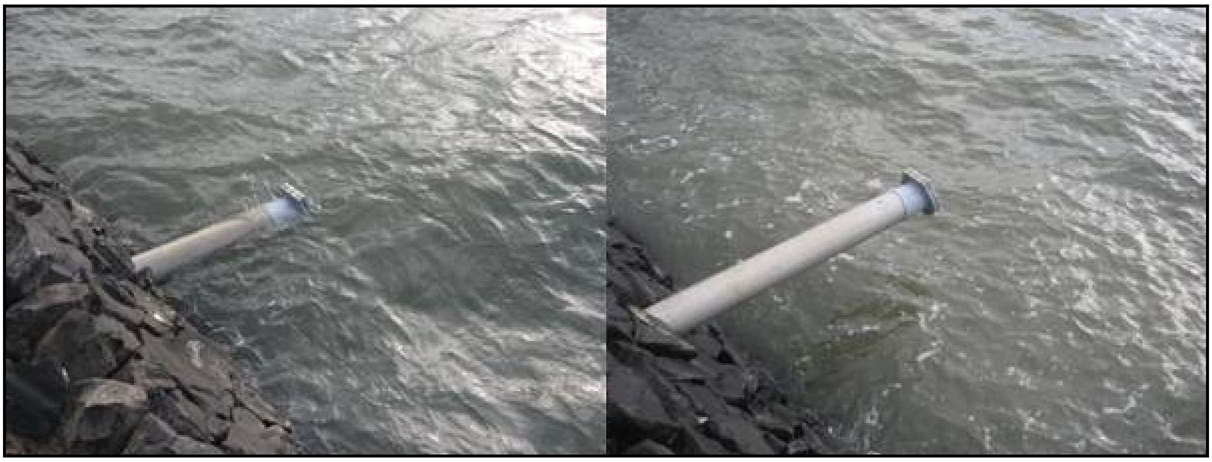
The trench fills with water and then drains again with the rising and falling tide but interestingly the salinity of the trench water varies significantly. This suggests that groundwater is forced up into the trench initially, followed by the saline harbour water as the tide rises. This relationship is likely to vary between wet and dry periods and would therefore dictate conclusions from sampling results taken at these different times.

Photograph 7 and 8 – Photos of the Birch Street dig and lay of 80m of 225mm foul sewer

2.6 OTAGO HARBOUR PUMPED CATCHMENTS

A number of catchments along the Otago Harbour are made up from small gravity networks that drain to a local pump station. Flows are then pumped up and gravity fed into the downstream catchment. In these catchments it was important to understand saline intrusion in any gravity sewer that ran adjacent to the harbour front in addition to the pump stations themselves.

Emergency overflows at a number of pump stations were perceived to be an issue; the concern being that harbour water could enter the wet well during high tides via the outfall. None of the pump stations that have been surveyed to date appear to be tidally influenced via the emergency overflows. In a number of cases this is likely to have been a historical issue but flap gates have since been fitted (see Photograph 9 and 10). Interestingly, despite this evidence there was still strong feeling that these overflows should be valved off; based on past experiences with flap valves becoming jammed open by debris.



Photograph 9 and 10 – Emergency overflows at two different pump stations. The overflow on the left is submerged at high tide

A key factor affecting the vulnerability of overflows that do not have flap gates is the actual height of a given tide once atmospheric conditions are considered. For example, in July a predicted high tide of 2.1m eventuated at 2.4m; due to the very low barometric pressure. The barometer read at 980mbar enhanced the predicted tide by around 300mm.

Areas at risk during these high tides today have been earmarked as a potentially increasing risk in the future. Climate change and rising mean sea level may also introduce new areas to the influence of tidally driven saline intrusion.

Site visits to obtain samples at high tides also revealed other obvious issues. At one particular pump station location it was evident that ground water (potentially saline) was bubbling up through the surface, ponding and draining through manhole covers. A sample was take and resulted in a reading of 55,500µS/cm – significantly saline. During the site visit the bubbling ground water did dissipate and stop draining through the manhole covers. Without being at this specific location at the peak point of a high tide this aspect could have been missed. Discussions with operational staff during this visit resulted in confirmation that this had been seen in the past and was a known issue. This pump station also has wet well and upstream manhole issues so further investigations are being under taken (see Photograph 11).

During sampling of another pumping station wet well it was clearly visible that the joint of the wet well with a large diameter storage line had significant infiltration. A sample was taken and resulted in a reading of 55,700µS/cm. This pump station is undergoing further investigation to review the wet well for points of infiltration other than the clearly visible location (see Photograph 12).

Photograph 11 and 12 – Upwelling of tidally influenced groundwater and saline infiltration in a wet well

2.7 EMERGENCY CROSS CONNECTIONS

Like many old wastewater networks Dunedin has a number of locations of historical cross connections. These locations are valved off and have not been used in many years but do still exist and are perceived by many, like the pump station overflows, to be causing problems. Checks have been carried out to prove that the wastewater network in these locations does not have high conductivity however the adjacent stormwater ranges from 19,000 – 22,500µS/cm as these locations are tidally influenced.

3 LESSONS LEARNED

- Always repair lateral junctions when re-lining if you want to prevent infiltration
- The height of the tide can be critical – ensure you always sample at the highest possible tides
- Be aware of the role that groundwater can play in saline infiltration
- Ensure you measure flow <u>and</u> conductivity to determine 'if you care'
- Future proof – earmark areas that are likely to become an issue with sea level rise
- Make sure all involved parties are using the same units of measurement
- Involve the operators directly and explain why they are sampling, you get much better results
- Highly saline results can be attributed to genuine domestic or trade activities – take multiple samples
- Ensure you clearly specify the required range when purchasing conductivity monitors
- Planning is key; but always have a back-up plan – particularly when it comes to sampling locations as you never know what might stop you from accessing a site (see Photograph 13)

Photograph 13 – A large sea lion obstructing access to a pump station

4 CONCLUSIONS

In response to the threat posed to wastewater treatment plant processes the Dunedin City Council recently embarked on a structured investigation to eliminate saline intrusion from its wastewater network. At the time of writing the investigation and subsequent actions have significantly reduced the saline content of the influent at the wastewater treatment plant and current indication is that the plant is running well.

The structured investigative approach ensured that a vast length of network was able to be analysed for saline intrusion where time was limited and sampling opportunities were highly restricted. Subsequent works were able to be prioritised based on the extent of saline intrusion that was occurring at a given location.

Whilst the initial driver for the investigation was to reduce the rapid variation in the salinity of influent numerous other benefits have resulted including:

- A reduction in total influent volume and corresponding treatment costs;
- Reduced pumping electricity costs;
- Alleviation of capacity caused flooding issues at high tide; and
- Extended pump and sewer lives.

The Dunedin City Council now has around 20 permanent conductivity monitor located at strategic points around the coastal network. These will continually monitor both areas with a history of saline issues and those which initial sampling flagged as marginal.

In addition, at the time of writing it is estimated that the equivalent of 120,000m^3 per year of saline intrusion has been removed from the wastewater system. This should realise approximately $60,000 per year in operational cost savings.

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