CHELSEA ESTATE HERITAGE PARK. MANAGING STORMWATER RENEWAL WITHIN A MULTI-USE HISTORIC PARK.

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ABSTRACT

SKM, working with Auckland Council, have completed an assessment of replacement options for two large diameter stormwater pipes passing through the historic landfill at Chelsea Estate Heritage Park. The assessment has included extensive stakeholder consultation and a robust assessment of options to determine the most environmentally beneficial and economically viable solution. This paper presents the challenges and outcomes of the design process and provides details on the complex issues of stormwater asset management in the Chelsea Estate Heritage Park.

KEYWORDS

Stormwater, Urban, Renewal, Heritage, Landfill

PRESENTER PROFILE

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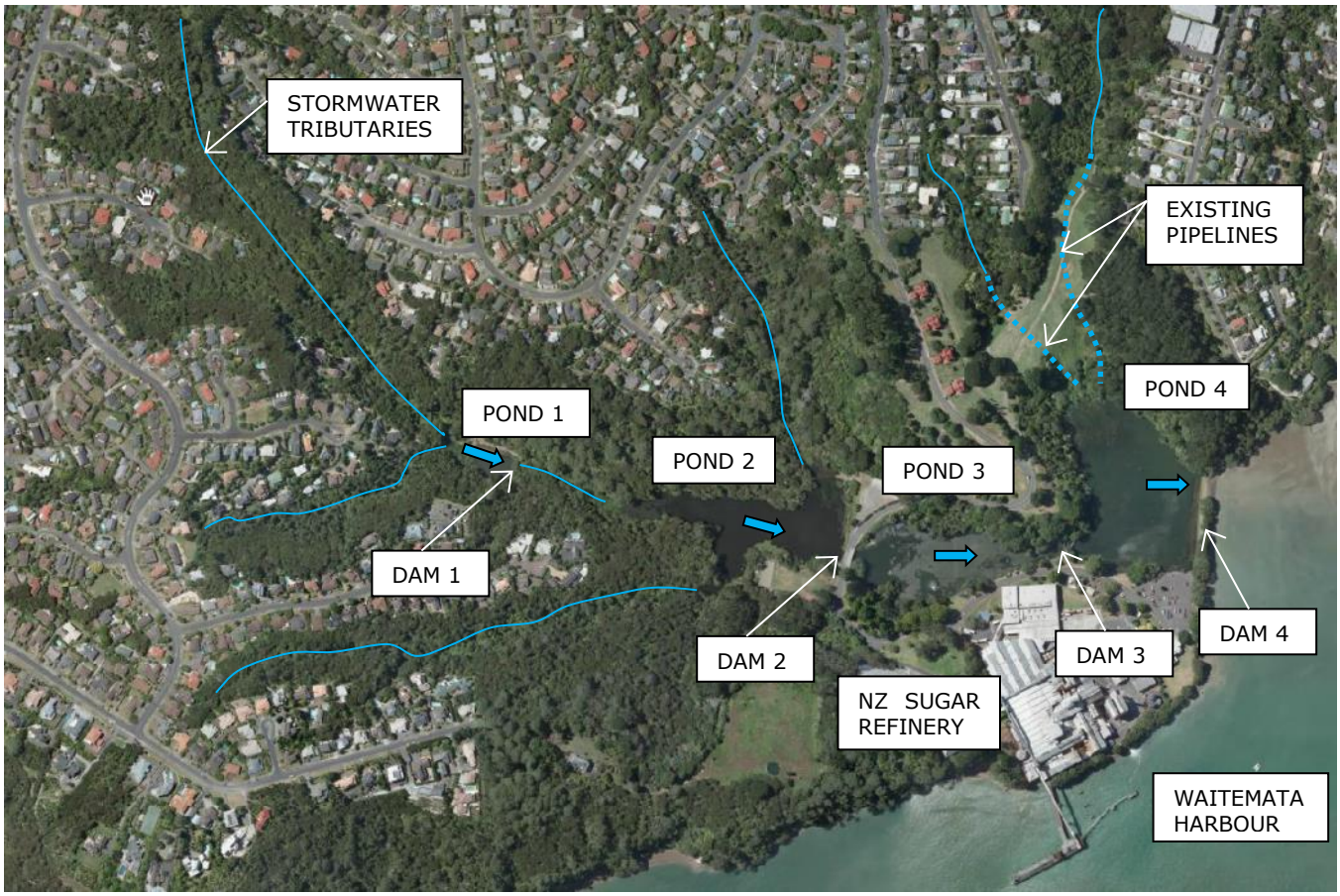
1 INTRODUCTION

A sugar refinery has been operating for the last 125 years in The Chelsea Estate Heritage Park in the Birkenhead area of North Shore. The site is at the lower end of the Duck Creek Catchment. In the 1950's pipelines were constructed in the channels of 2 tributaries and a landfill was established over the pipelines to dispose of ash and filter mud from the refinery.

The stormwater pipelines discharge into the Chelsea pond (Pond 4) and onto the Waitemata Harbour. An assessment of the pipes in 2009 by Sinclair Knight Merz/Opus determined the pipes to be in poor condition. The investigation showed that the 'Western' Pipe was partially collapsed, with joint separation, crushing, possible contaminated leachate infiltration, and risk of blockage along both the Western and Eastern pipelines. Blockage of these pipelines could lead to a buildup of stormwater at the inlet structures causing destabilisation of the landfill. As a result of these findings, Auckland Council determined that an investigation into options to renew both pipelines was required.

SKM was appointed in February 2012 to undertake a concept assessment of replacement options, to undertake investigations, identify a preferred location, route and level for replacement stormwater pipes, and identify outline costs and risks of each option.

- *Figure 1: Plan showing approximate catchment area.*



- *Figure 2: Plan showing pond locations, outlets and flow direction.*

2 PROJECT OBJECTIVES

2.1 PROBLEM DEFINITION – HISTORY OF PIPE FAILURE

Although few records remain, the existing stormwater pipes were likely to have been installed by New Zealand Sugar Company (formerly Colonial Sugar Refining Co Ltd) in the mid to late 1950's, to allow continued use of the upstream catchments as the valley was used as a landfill by the company. The landfill is up to 20m deep over the pipelines.

In 2006, prior to the change of ownership of the land, SKM was commissioned by North Shore City Council (NSCC), on behalf of the Chelsea Park Trust Board, to produce an environmental due diligence report. This outlined a number of risks relating to features of the landfill, including the stormwater pipes. Two of the potential risks to the landfill were:

a) Blockages of the pipes and subsequent risk of land slip.

b) Collapse of pipes (which pass through the landfill) and the potential ensuing destabilisation of the landfill due to the back–up of stormwater. The report also noted that significant deterioration of the pipes or partial collapse, while not necessarily resulting in backing up of water against the embankment, is highly likely to lead to soil loss from around the pipe, and subsidence and instability of the embankment. At the time the risk was considered to be medium to high.

The report also noted that, "overall the pipes are in, at best, fair to poor condition. Parts of the pipes are obviously distressed to the state where deformation and gradual collapse is in progress. Catastrophic failure of the pipes is possible."

In 2006 a CCTV inspection of the Eastern Pipe was undertaken on behalf of NSCC. A further CCTV inspection of both the Eastern (1200mm dia.) and Western Pipes (1050mm dia.) was undertaken in 2009 to provide a comparison to the 2006 inspection.

A downstream section of the Western Pipe was discovered to be partially collapsed in 2009 and, following SKM's investigation, was repaired in 2010. In addition to the collapse in the Western Pipe, both pipes had evidence of joint separation, crushing, possible contaminated infiltration, and were subject to partial blockage by foreign material.

There is evidence of significant past and present water ingress, particularly at joints, due to the presence of stalactites which suggests that the water has some level of contamination (which may include biomass, sugar, or landfill leachate). Both pipes have significant crushing deformation, with a maximum deformation of 69 mm for the Eastern Pipe and 64 mm for the Western Pipe.

In conclusion, the pipes are failing and failure would have consequential risk therefore they require renewal or replacement.

3 CONSIDERATIONS AND CONSTRAINTS

There are a wide variety of considerations and constraints applicable to the site which influenced the design options. These are listed below along with the approach taken to manage and incorporate considerations into the design process.

1. **Heritage and Stakeholders.** Chelsea Park Trust Board Incorporated (the Trust, setup by North Shore City Council, now Auckland Council) acquired the Chelsea Estate land and ponds adjacent to the Chelsea Sugar Works in 2006 with the intention of creating public open space. NZ Sugar retained the refinery land and a number of properties at the upstream end of the existing stormwater pipelines. The public has access to, amongst other areas, the large grassed area of park above the pipelines. Auckland Council has responsibility for maintaining the site.

   The Chelsea Sugar Refinery and Estate is registered with the New Zealand Historic Places Trust (NZHPT) as a Category I Historic Place due to its "unusually large and well-preserved historic landscape", and its rarity in reflecting "changing industrial and other work practices in the same place for 125 years".

   An archaeologist was engaged to assess the potential impact of proposed works in the area, which included reviewing geotechnical bore logs during field investigations.

   During the Concept Design stage SKM was engaged by Auckland Council to take on the additional role of Project Management for the Chelsea Estate Investigations and Studies. This role included regular liaison with Council's stakeholders such as Parks, Land & Coastal Remediation. External stakeholders included the Kaipatiki Local Board, Watercare, Auckland Transport and NZ Sugar. Iwi affected by the proposed works were also investigated.

   This consultation process allowed for the risks, considerations and wishes of the stakeholders to be accounted for in the analysis and selection of the preferred option in the concept design report.

2. **Technical.** Numerous technical inputs other than the actual pipeline design needed to be investigated and considered.

   There are 4 ponds within the Chelsea Estate which were created for the purpose of supplying freshwater to the refinery (between 1881 and 1918, when Dam 4 was completed) by damming Duck Creek in four places (refer Figure 2). Pond 1 receives the western tributary and is upstream of the other ponds. Flows entering Pond 1 discharge to Pond 2, by weir. In addition to flows from Pond 1, Pond 2 receives flow from a small side tributary on the north bank which enters via a small wetland forebay. Pond 2 discharges to Pond 3, via weir, and subsequently to Pond 4. The two existing stormwater pipelines to be renewed discharge to the northern side of Pond 4. Flows from Pond 4 pass to the coast in Chelsea Bay via an overflow weir. The sugar refinery currently takes process water from Pond 3 via an intake point located adjacent to the dam between Ponds 3 and 4. Changes to the stormwater network have the potential to affect the area's water quality, hydrology, and ecology.

   The water quality in Chelsea Ponds has been an issue for the past 40 years. Monitoring data indicates that there are ongoing problems with low dissolved

oxygen (DO) in the ponds, in particular Ponds 3 and 4. The low DO can lead to the water becoming anoxic and cause odour issues as well as affecting the fish and other animals using the ponds. Aerators installed in Ponds 3 and 4 have improved the DO levels over the last 8-10 years, but it continues to be a problem.
The ponds also contain elevated nutrient concentrations causing issues with algal growth in summer. There are regular instances of bird deaths on the ponds each summer due to issues such as avian botulism. An assessment was carried out on the effect of redirecting stormwater flows from one pond to another, as proposed in some of the option alignments.

There are two areas of observed ponding on the landfill surface, in the vicinity of the existing pipes. Both areas are at the interface of the landfill and natural ground, with surface water ponding, then slowly soaking into the landfill. Surface water was directed to the landfill surface from nearby roads adding to surface water issues. Investigation was undertaken into these overland flows and a recommendation given to resolve these issues as part of the stormwater renewal project.

The landfill material presented risks including collapse of the tunnelling face, landfill gas, accuracy of pipe gradient, and possibly, instability of the landfill itself. To mitigate these risks new pipelines are required to be beneath the landfill material or be routed around it into suitable ground. Construction methodologies available for this project include either Horizontal Directional Drilling (HDD) or Micro-tunnelling. The depth of the pipelines would mitigate possible effects on surrounding trees and minimise the construction impact on the park surface.

Given the location of the stormwater inlet structures, redundancy was investigated to provide a backup stormwater system. This would maintain some flow, albeit reduced, should the main stormwater pipes become blocked. The option considered installing smaller ancillary pipes in addition to the new pipelines, or reusing the existing (rehabilitated) pipes was considered. However, should the main inlet structure was blocked the backup inlet would also likely to be blocked. There would also be considerable capital cost to construct a backup system. It was therefore determined that if the primary system was appropriately designed (including secondary inlets, such as domed inlets) and that regular maintenance was carried out, the risk of blockage would be mitigated so a secondary system was not required.

Should the renewal options for the existing pipes preclude repair, a plan to abandon and decommission the pipes will be required once they are out of service. There are risks involved in concrete/grout filling the pipes with potential continued migration of the fill material outside the pipes, and the issue of existing voids and ground water flow paths parallel to the pipes.

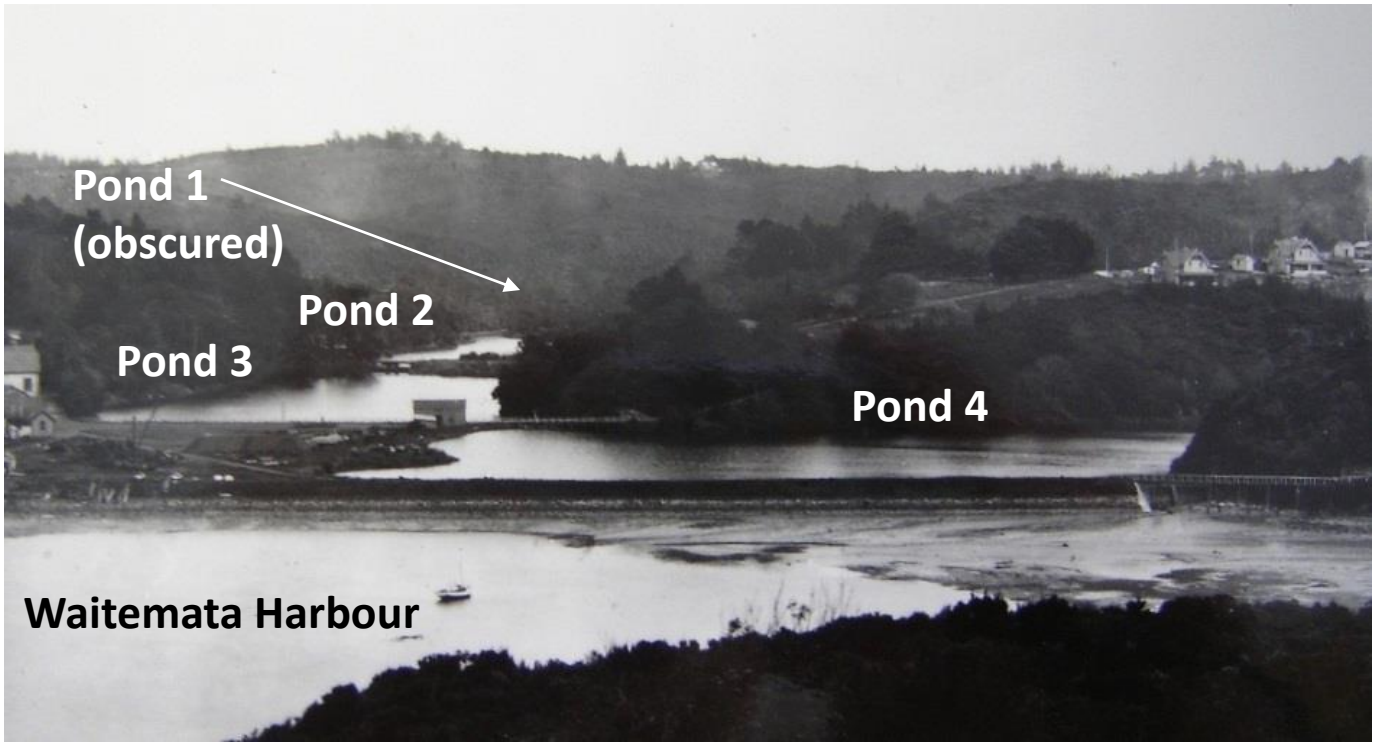
A tree assessment highlighted that while the project would not affect any notable trees there is a concern with the tall pine trees on the east of the site that could affect safety during construction. This risk precluded one of the alignment options from progressing past the option assessment stage.

3. **Landfill, Geotechnical and Consenting.** Knowledge of the landfill's depositional history is limited. However, it is generally agreed that from the 1880s to early 1970s approximately 800 tonnes per annum of ash and filter mud were deposited in a number of locations in the Chelsea area. From the 1970s onwards the annual

waste volume put into the landfill was reduced. The geotechnical investigations undertaken by SKM found that the landfill material was mostly boiler ash and filter mud (associated with the sugar refinery process). Methane, carbon dioxide gas, soil contamination and possible leachates were also detected.

Some slopes at the site were assessed to have 'marginal' stability' because of their steep sides. The areas surrounding and below the landfill are 'relatively consistent' East Coast Bays Formation (ECBF) material. Due to the 'marginal' stability' and the highly variable properties of the fill material, predicting the performance of the landfill material is difficult. Therefore the design approach has to be relatively conservative.

An area of surface subsidence in the grassed area above the Eastern pipeline was noted during the geotechnical investigation. SKM were subsequently engaged by the land owner (NZ Sugar) to carry out settlement monitoring.As part of the concept design stage a limited soil contamination investigation and landfill gas monitoring was undertaken to assess potential contaminated land risks. These risks included human health risks, relating to construction. There are specific requirements under The National Environmental Standards (NES) for Assessing and Managing Contaminants in Soil to Protect Human Health that need to be assessed. While the precise extents of the Chelsea landfill are not clearly defined, it is likely that the excavation works for the renewal project will be partially in landfill, which is covered under the NES. Further consultation to assess if and how the NES requirements apply will be undertaken with Auckland Council Closed Landfill and Contaminated Land teams for further design phases.



- *Figure 3: Looking west towards Chelsea Ponds in the 1920s.*

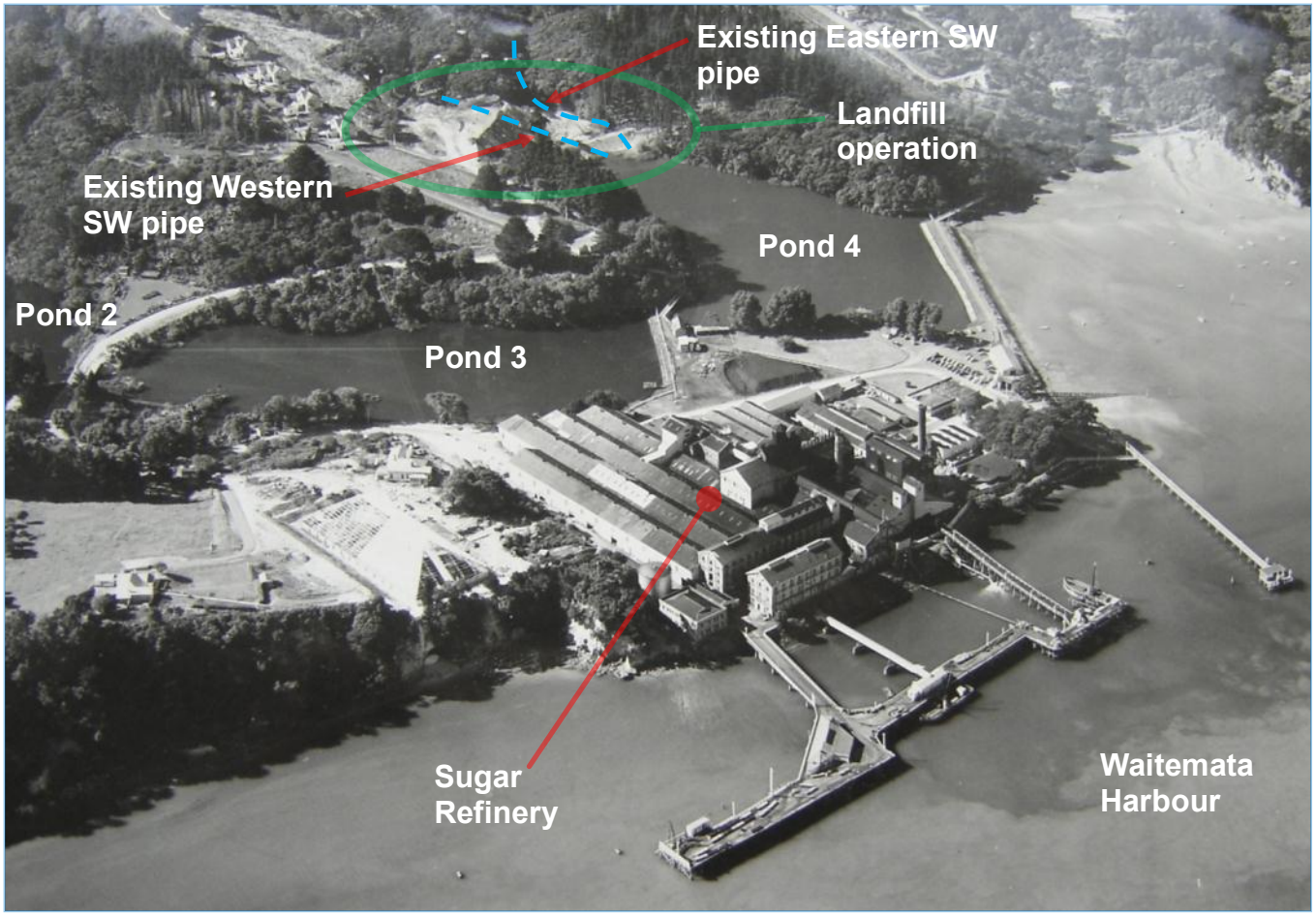


Figure 4: Chelsea Ponds in the 1960s.

4 OPTION ASSESSMENT FOR STORMWATER MANAGEMENT

Renewal options identified and recommended the most practical option to convey stormwater from the two inlets north of the closed landfill to the Chelsea ponds. The options investigated were as follows:

1) Rehabilitation of Existing Pipes. Re-using the existing pipes either through lining, pipe cracking or sleeving a new pipe through the existing pipes. The rehabilitation options were discounted due to not meeting the requirements of hydraulic performance, risks associated with access and landfill gas, in addition to lining the pipes and pipe cracking being unsuitable for this application.

2) Pump Station. Rather than Pumping stormwater outside of the landfill area was an option briefly considered. Due to the considerable construction expense, ongoing running/maintenance costs and having no suitable gravity stormwater networks nearby to pump to, this option was discounted.

3) Daylighting. While the Daylighting options has some merit, in returning the area to its pre-landfill environment the earthworks and contaminated material disposal cost would be prohibitive. It would also remove the current level grassed park which the public enjoys.

4) New Pipe Alignments. New pipe alignments through the site, with options for either keeping the western and eastern flows separate or combining the two. This option fulfilled the performance requirements, and addressed most, if not all, of the considerations and constraints applicable to the site.

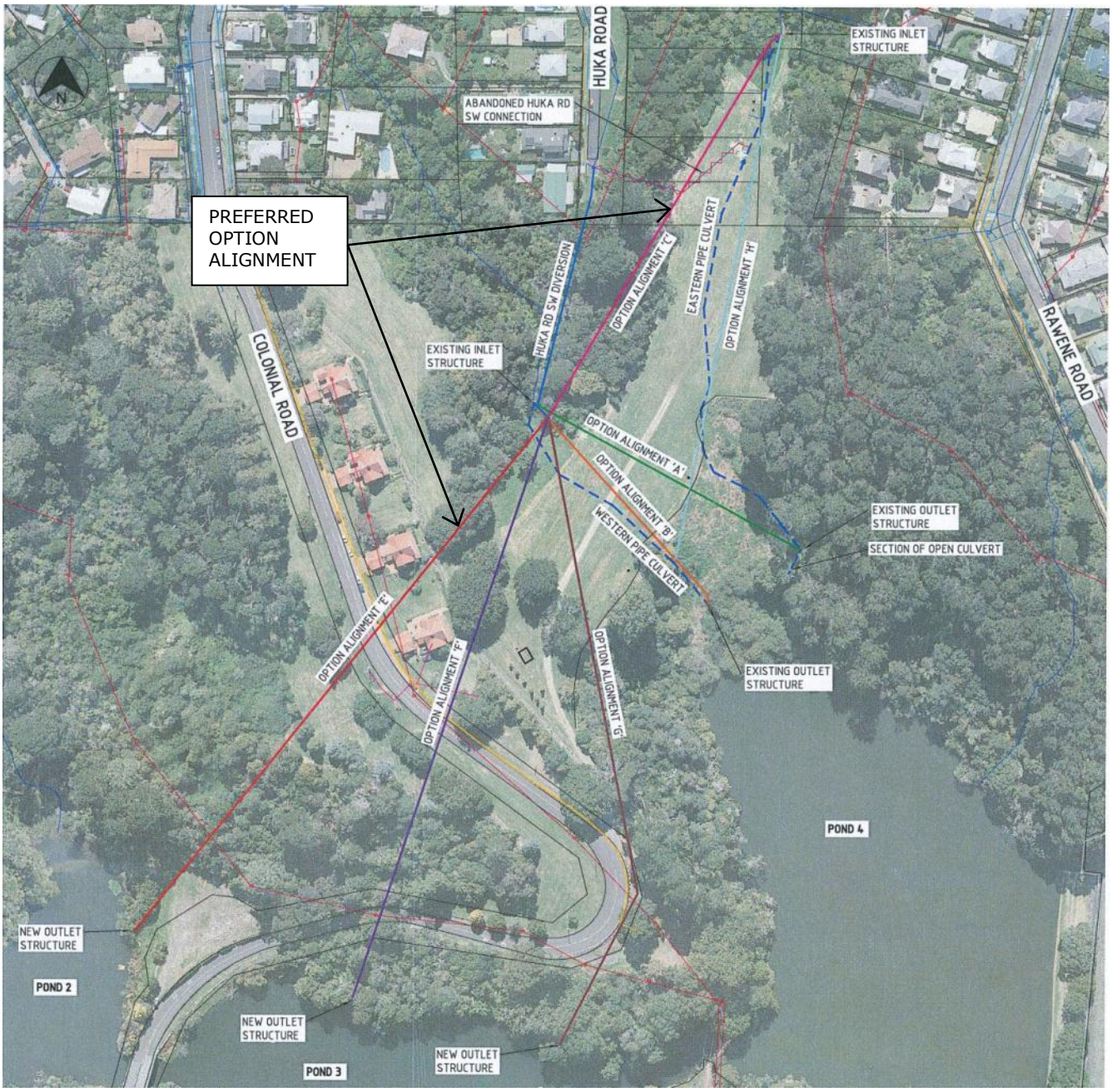
In summary, the option of new pipe alignments was progressed to a more detailed analysis of a number of alignment options.

5 NEW PIPELINE OPTIONS

Various alignment options were investigated to convey flows from the western and eastern catchments, with options for combining the flows from both catchments or keeping them separate being considered (refer Figures 5 & 6).

Western pipeline options followed either the existing route through the landfill or new alignments into other ponds. Eastern pipeline options considered were to keep the flow separate (following the existing route through the landfill) or combining the flow with the western flows.

- *Figure 5 : Plan of New Alignments – Separate Eastern/Western Pipelines*



- *Figure 6 : Plan of New Alignments – Combined Eastern/Western Pipelines*

In terms of the landfill and geotechnical considerations, all of the proposed alignments which passed through the landfill were discounted due to the associated construction risks. This narrowed down the options to those that avoided the landfill material and, coincidently, combined the stormwater flows. The stakeholder and heritage constraints were considered equal for all of the new alignment options, with no preference given.

Of the remaining combined flow options, only one alignment had an easily accessible outlet location for construction purposes. Stormwater flows for this option would be redirected from Pond 4 into Pond 2, so an assessment of the impact on the water quality in the ponds was undertaken. This highlighted that changing the water flows in the ponds could lead to less through-flow and greater risk of water quality problems. It was also noted that the proposed discharge point would need an energy dissipating structure and consideration given to the nearby wetland and forebay structure.

6 CONCLUSION

The preferred option is a combined flow pipeline from the Eastern inlet to the Western inlet then directed to Pond 2 to the south west. This alignment is routed around and underneath the landfill material. In addition to meeting the geotechnical and landfill constraints it also covers the majority of the technical constraints and, based on liaison to date, addresses stakeholder concerns.

7 NEXT STEPS

The concept design process highlighted a large number of environmental, constructability, ecological, financial, geotechnical and heritage risks and constraints for what is essentially a simple stormwater renewal project.

Working through these challenges with the affected stakeholders, while time consuming, helped steer the concept design towards a successful outcome. It also presented opportunities to address issues in the wider catchment, presented landowners with valuable asset information, and highlighted the need to keep a balance between recreational and operational activities in the historic park. This stakeholder consultation should be ongoing with particular attention given to the local community and property owners.

The next step for the stormwater renewal project is to move forward into detailed design. This design should include the redirection of overland flows to address the ponding issue on the landfill surface and revisit the concerns on water quality. In the interim, ongoing maintenance and observation of the existing stormwater pipes and network is imperative.

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