A LARGE INTEGRATED STORMWATER SOLUTION FOR OAKLEY FLOODING – AUCKLAND

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ABSTRACT (200 WORDS MAXIMUM)

Oakley is a fully urbanised catchment in Auckland which has suffered from wide-spread flooding for several decades. After extensive modelling and investigation a large scale flood mitigation project has been proposed to tackle this difficult problem. Proposed works include five new bridges, 3km of stream widening and naturalisation half of which is currently under way as part of a new $1.4 billion SH20 motorway.

This project integrates many needs including a large motorway project, parks, local community, Iwi, transport and greenways linkage and ecological function. It is one component of a catchment–wide flood mitigation strategy which has been through a BPO approach arriving at a construction project which will make a real difference on the ground. This paper presents Oakley stream widening as an example of the new Auckland Council's ability to tackle difficult and complex problems at a large scale.

KEYWORDS

Stream restoration, integrated planning, flood mitigation, greenway linkages, open channel hydraulics

PRESENTER PROFILE

Richard Smedley is a Senior Stormwater Catchment Planning Specialist within Auckland Council's Stormwater Unit. He has over 20 years experience in design and strategic planning across transport and water infrastructure. Most recently he has focussed on stormwater catchment planning in the Auckland central area championing many large scale flood mitigation projects.

1 INTRODUCTION

This paper covers the interesting political, geological and environmental history of Oakley catchment which led to it's flooding problems. It then describes the considerable opportunities to create one of the best amenity and natural assets for urbanized Auckland by addressing flooding problems.

If high flooding risk to residential property is to be addressed, a significant public investment in Oakley will be required. However, with good integration across parks amenity, transport and ecology function, a lot more value can be realized than reduction of property damage costs alone.

Whilst this concept is not new, its application is not widespread in fully urbanized catchments such as central Auckland. This is because large parts of Auckland streams tend to be privately owned. Oakley's large length of stream within publically owned land provides this uncommon opportunity for meaningful change.

2 CATCHMENT AND HISTORICAL CONTEXT

2.1 CATCHMENT DESCRIPTION

Oakley is a unique catchment in the Auckland Region. It has the last significant stream in the fully urbanized Auckland Isthmus area (old Auckland City Council) which remains largely un-piped.

It runs for a total of 12km from a point almost at the Manukau Harbour (Hillsborough) across the Isthmus to Waterview Inlet at the Waitemata Harbour. Whilst most catchments typically have steep upper topography leading to flatter slope in the lower areas, Oakley is the opposite (flat mid to upper catchment and steeper in the lower catchment).

This is possibly due to its unique geological history. "Upstream of Richardson Road Te Auaunga (Oakley Creek) flows between the basalt lava flows of Owairaka (Mt Albert), Te Tatua A Riukiuta (Three Kings) and Puketapapa (Mt Roskill). Historic records indicate the stream historically flowed through large swamp areas and open water lakes in this area" (Boffa Miskell 2011). This is shown in Figure 1 below.

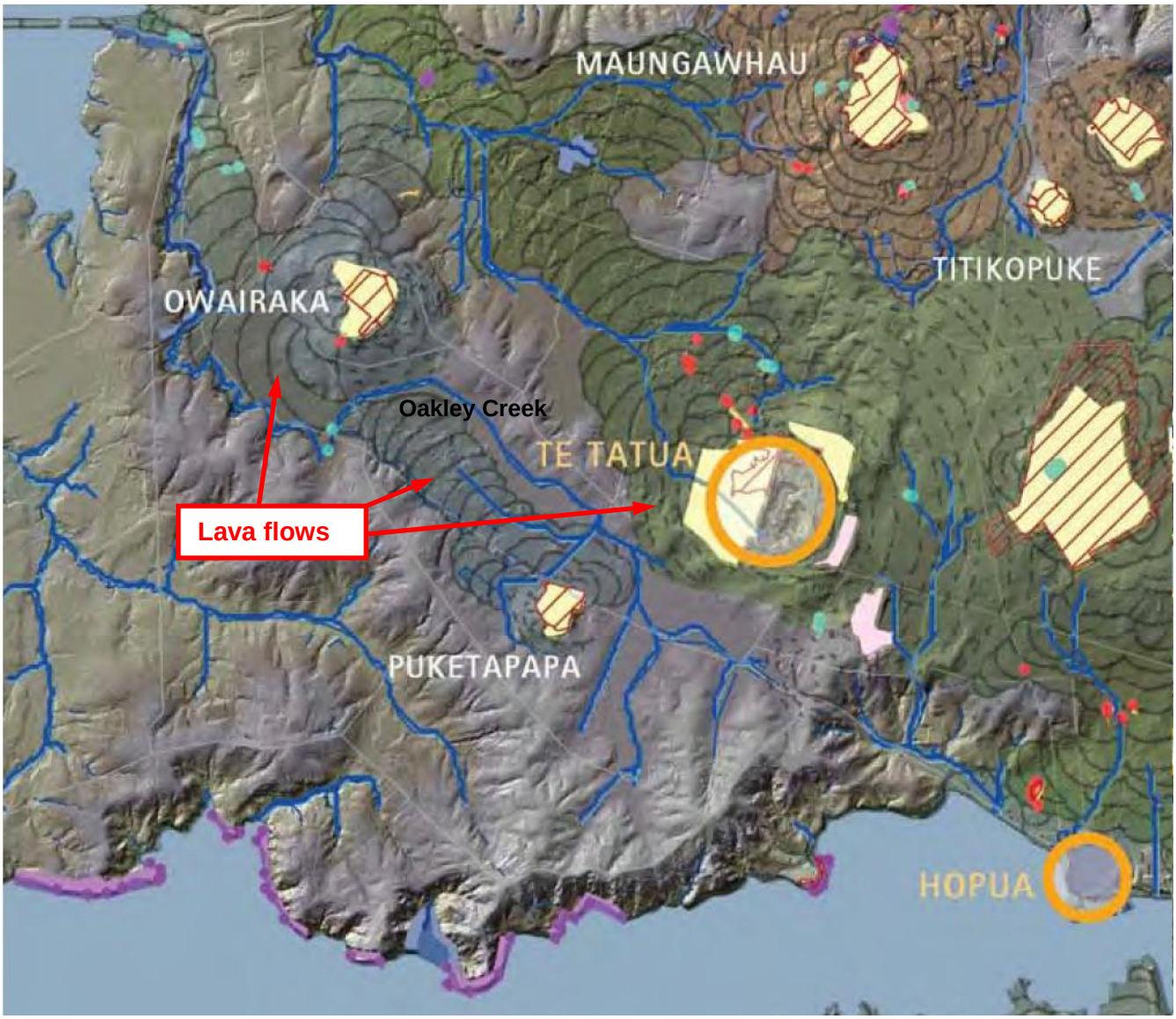

Figure 1: Extract from a heritage theme mapping showing the influence of lava flows on Oakley creek (ACC Boffa Miskell 2010)

2.2 POLITICAL HISTORY

Like much of early post war Auckland, infrastructure and housing in the Oakley catchment was developed under authority of the various small local Borough Councils (38 in total for the Auckland Isthmus alone until the local government reform in 1990). Oakley spanned three local boroughs (Mt Roskill, Mt Albert, Auckland City), with Auckland Regional Authority (ARA) responsible for stream and marine receiving environments.

This resulted in a fragmented approach to stormwater and stream management as the different boroughs had different visions, standards and priorities. The upper Mt Roskill area is characterized by narrow basalt brick lined channels with buildings very close to the edge of the channels, whereas the lower Oakley area of Mt Albert Borough has retained riparian margins in a natural state. Figure 2 below shows construction of a basalt brick lined channel circa 1932. Figure 3 shows the channel today.

Land for development was created in the Mt Roskill area by draining and reclaiming the flat swamp land areas east of Richardson Road and May Road which had formed behind lava flows.

Between 1990 and 2011 the overall catchment was administered by the Auckland City council and Auckland regional council. Since 2011 the catchment has been administered by Auckland Council alone.

Figure 2: A work relief scheme circa 1932 in Oakley (Auckland Public libraries 2011)

Figure 3: Upstream of Winstone Road (in Mt Roskill) showing basalt brick line channel with buildings either side.

3 FLOODING PROBLEMS

Recent MIKEFLOOD modelling has identified 445 habitable buildings at risk of flooding in a 100 year Annual Recurrence Interval (ARI) storm event allowing for ultimate development and climate change rainfall. A further 668 buildings have inadequate freeboard above the flood plain (<500mm above flood plain). The various areas at risk of flooding are shown in Figure 4 below. The pink areas show 100 year ARI flood extents while the red dots show habitable buildings at risk of flooding.

Two significant areas at risk of flooding are the O'Donnell Ave and Winstone Road areas. These areas were old alluvial swamps which had formed behind the lava flows. Following the rock cuts made in the 1930's to drain these swamps, there have been subsequent works to widen and deepen these channels in the mid 1950's and late 1980's to address the flooding of these areas.

Despite these works, a high risk of flooding to properties and buildings remains, predominantly due to creek overtopping in storm events greater than 2year ARI. This paper provides a description of the overall flood mitigation strategy for the catchment with a particular focus on the O'Donnell Ave area.

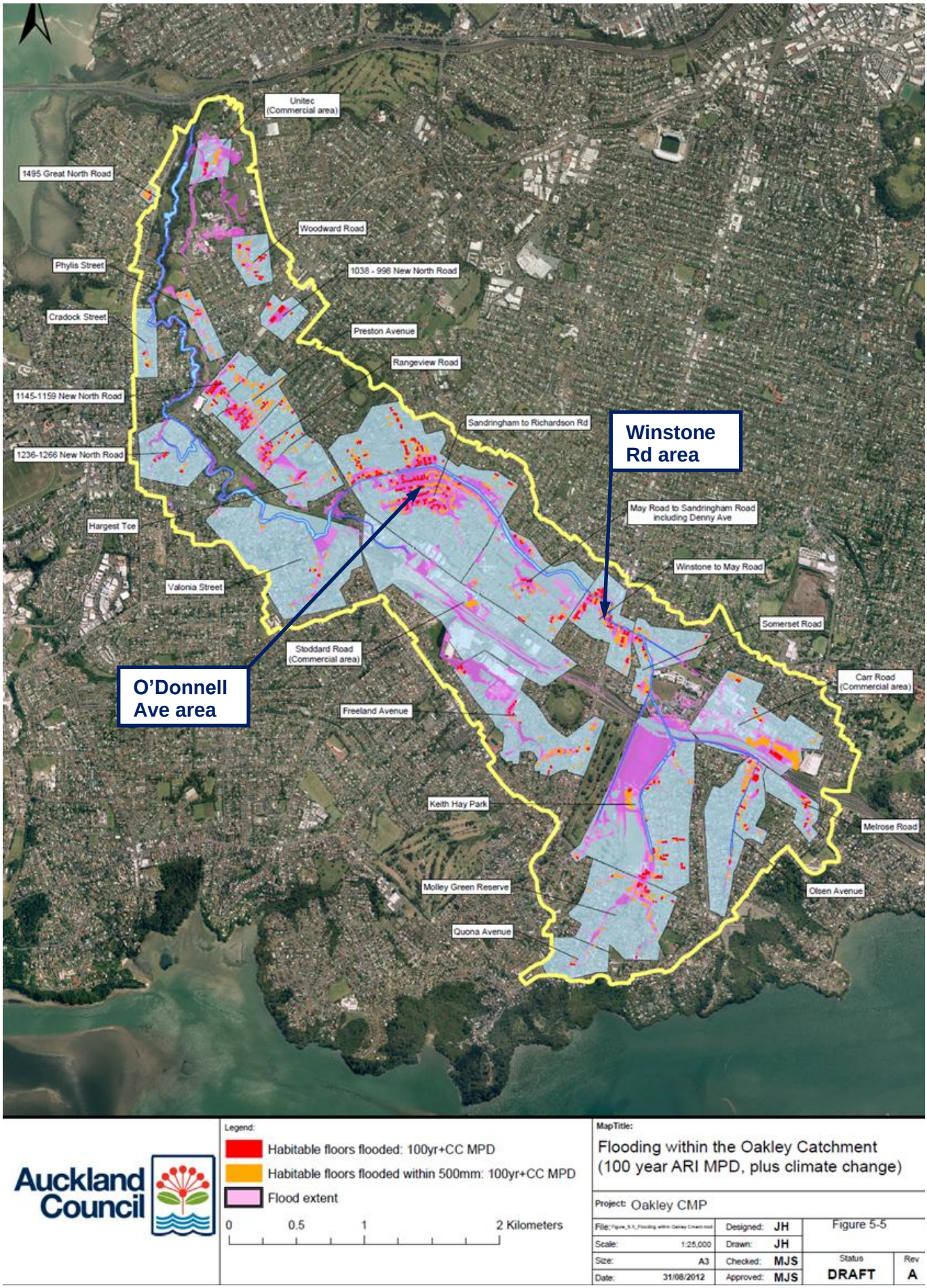

Figure 4 Oakley catchment boundary and areas of flooding

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For the purposes of optioneering work, the buildings at risk were further divided into two groups:

Creek Capacity (or water level) Related Issues:-

Areas where the capacity of the creek (or water level within the creek) directly causes flooding. This includes areas where buildings get flooded due to the creek overtopping its banks or as a result of local reticulation failure because of backwater effects from high creek water levels (i.e. manhole spilling due to tail water backup from the creek)

Local Issues: Flood areas independent of the water levels within the Oakley Creek (within the wider catchment):-

These areas are generally further way from the creek where a lack of capacity in the local reticulation, poor soakage, or overland flow is the cause of the flooding. Note that this includes those areas where lowering the creek water level will not resolve the flood risk. Reference (Smedley, AECOM, 2013)

163 of the 445 habitable buildings at risk relate to creek capacity and out of those, 101 are in the O'Donnell Ave area. This flooding area is the main discussion subject of this paper.

Historical records confirm that creek capacity has been the main cause of flooding in Oakley as illustrated in the photos below. "Whilst some previous works have increased conveyance capacity at various places during the last 30 years, this remains a key constraint in the stormwater network with flooding effects worsened over time due to urban intensification." (Draft Oakley CMP, 2013).

Photo 1 60 O'Donnell Ave 24 August 1961

It is interesting to note the increased flooding at O'Donnell Ave following the channel widening work (basalt blasting) upstream of this area designed to reduce flooding (West of Dominion Road).

Two large storm events in 1979 and 1981 illustrate the on-going flooding issues in the O'Donnell Ave area (refer to photos 2 and 3 below).

The cause of flooding can be directly attributed to historical man-made interventions: "Principle causes of flooding are the development of higher land increasing storm runoff and the draining of the two large swamps eliminating the original storage…" (Oakley Creek and Catchment Report, ARA, May 1981).

Photo 2 Flooding in Lorraine Ave (opposite O'Donnell Ave 1979

The Auckland Regional Water Board technical publication No.10 reported this storm to be a 10 year ARI event based on a 2 hour time of concentration. This time of concentration is typical for catchments of this size.

Photo 3 Flooding in Oakley Creek upstream of Wainwright Ave 1981

Further records of flooding are shown in the Herald news paper clippings from 1934, 1935 and 2010 (photo 4). These records show flooding being experienced despite works completed at various creek sections during this time period to open up creek throttle points (by widening channels and upgrading road culverts).

MONDAY, JULY 22, 1935.

HOUSES MAROONED IN TH

ALARM OF OCCUPANTS.

MT. ROSKILL FLOODING.

It is not a new experience for residents of part of the Mount Roskill district, in the vicinity of Winstone Road and Dominion Road extension, to have their houses marooned and a number of them watched the rising water with anxiety.

MONDAY, JULY 9, 1934.

CITY DRENCHED.

TORRENTIAL FALL.

FLOODING IN SUBURBS.

SEWERS OVERTAXED.

speedway for a flooded river. Another area that took over the appearance of a natural lake was that between Mount Albert and Mount Roskill known as Mission Swamp, even though the Oakley Creek was recently deepened and widened to help deal with such a flooding.

Gordon Fang tries to clear a drain on his Mt Roskill property after a storm drain was not able to cope with torrential rain. 1st June 2010

Photo 4 Mt Roskill flooding events reported in the NZ Herald 1934, 1935 and 2010

4 FLOOD MITIGATION OPTIONS ASSESSMENT

4.1 MODELLED OPTIONS AND RESULTS

A 3-way coupled MIKEFLOOD model[1] was used to assess a range of options to reduce the creek level at the two main problem areas of O'Donnell Ave and Winstone Road. The principle concepts were to "pass forward" flows by widening the stream and increasing the capacity of associated culverts, or diverting flows to either Manukau Harbour or to the adjacent Meola catchment. Additional detail can be found in the 2013 AECOM report "Oakley Options Refinement". The options are illustrated in figures 5 and 6 below.

All options considered maximising storage within the catchment, in particular using the existing storage or increasing storage in the upstream situated Keith Hay Park. It was found that increasing the storage in the park did not reduce the scale or cost of downstream works required.

Six options in total were investigated. Options 1 and 2 are variations of the "Pass forward" option (option 2 reduces the frequency that storage will start to operate in the Park playing fields). Options 3 to 5 are tunnel diversions to Manukau Harbour with each one starting further downstream in the creek.

[1] A 3-way coupled model models the surface water, the creek water and the pipe water dynamically. It therefore provides an understanding of all drainage systems and how they interact.

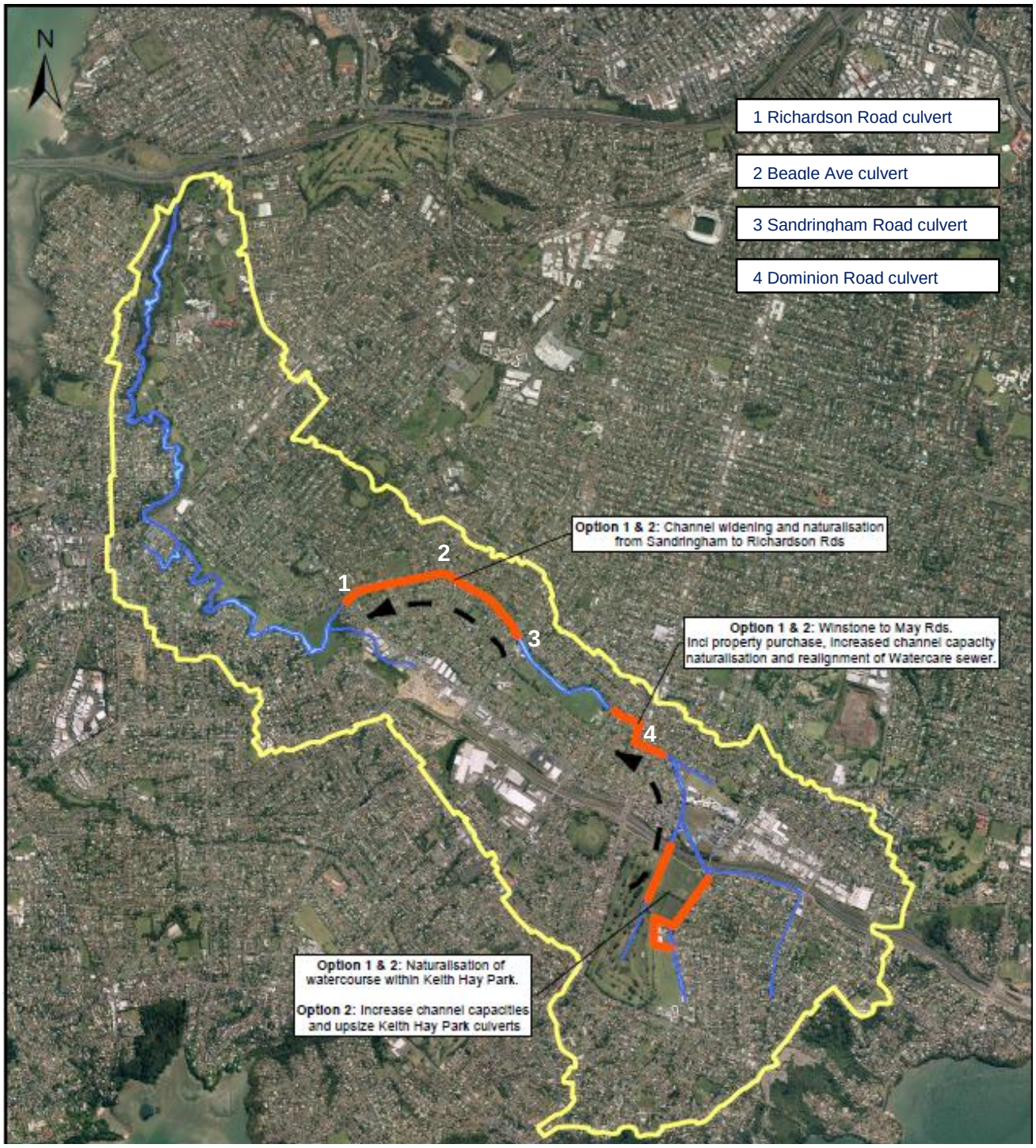

Figure 5 "Pass Forward" option showing the locations of proposed stream widening and naturalisation

The pass forward option initially allowed for a duplication of creek capacity and removal or reduction of hydraulic control points at key culverts in the mid to upper Oakley catchment. This is discussed further in Section 6.

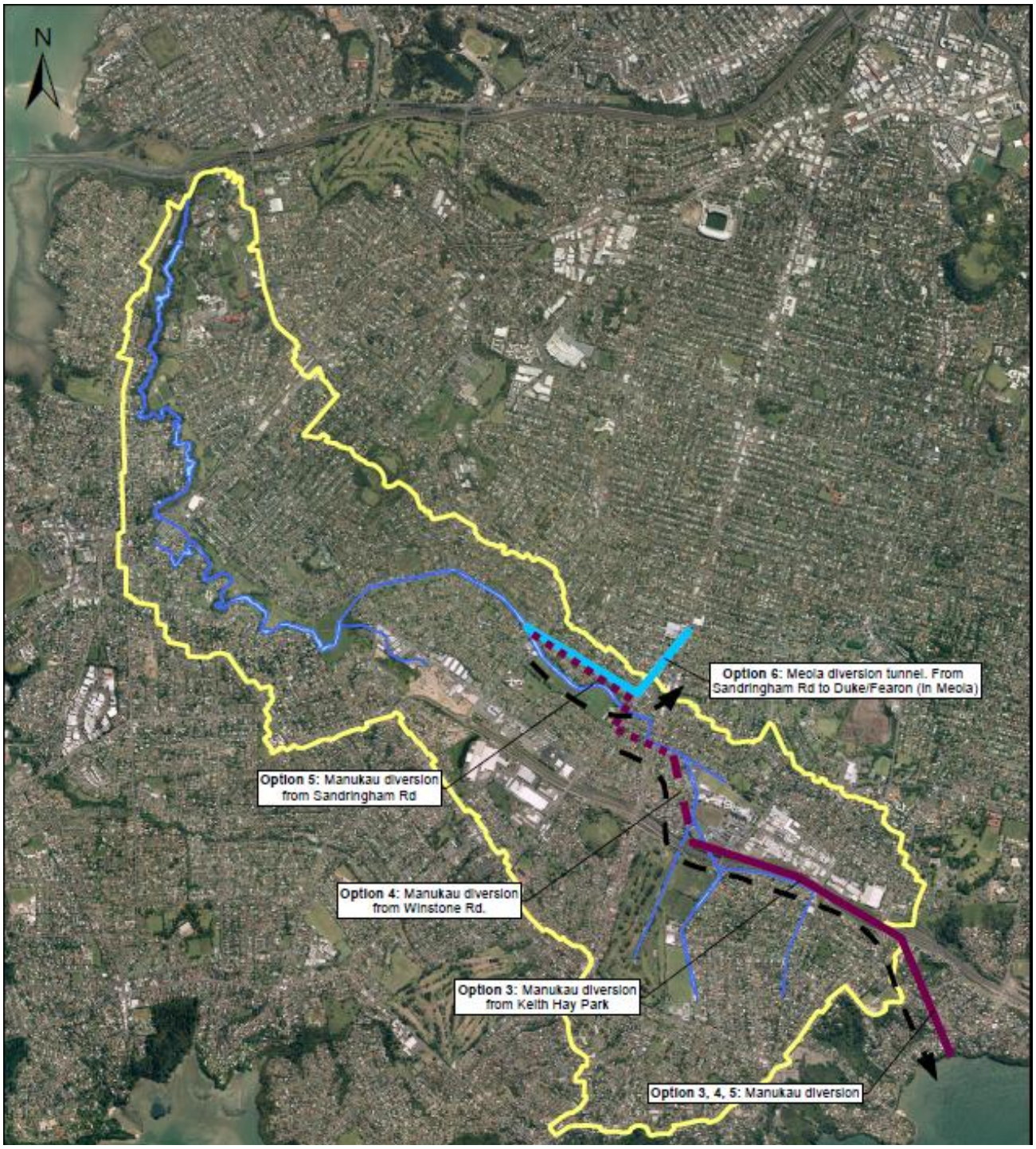

Figure 6 "Diversion" options showing the locations of proposed diversions to either Manukau Harbour or Meola.

Figure 7 shows the results of the modelling work. The red dots are habitable buildings at risk pre and post "pass forward" option. The green dots are those buildings at risk which will be resolved independently of the creek options through improved soakage, provision of overland flow paths and upgrading of localised reticulation. The "Pass forward" option is unable to resolve the risk of flooding to 9 of the habitable buildings. These will require non-infrastructure interventions such as raising buildings, purchase of properties or insurance arrangements.

Figure 7 Pre and post pass forward option flood extent and habitable buildings at risk in a 100 year ARI storm event for the O'Donnell Ave area.

Whilst the flood levels are lowered below the floor level of habitable buildings, extensive property flooding is still likely to occur. However that property flooding will occur at much higher ARI storm events than they would with the existing creek.

It should be noted that the overall strategy for Oakley flood mitigation is to address creek capacity issues first, enabling subsequent upstream localised issues to be addressed (largely by increasing local reticulation to the creek).

4.2 DECISION CRITERIA FOR PREFERRED OPTION

The six options were analysed against a number of parameters including:

- cost,
- hydraulic performance (creek water level reduction and resolving habitable flood flooding risks),
- environmental effects and consenting difficulty
- construction risk, and
- ability to stage construction and achieve benefits

The table below shows the six options plus a do nothing option. Option 1 was found to be the best option against all criteria. Options 3 & 4 still required widening of the creek between Sandringham and Richardson Roads albeit at a reduced scale. Option 1 requires increased conveyance between Sandringham Road and Richardson Road by widening the stream bed and removing the existing culvert flow constraints at Sandringham Road, Beagle Avenue and Richardson Road (by changing them to bridges). Option 1 also provided the best opportunity to stage works to achieve incremental benefits and spread costs over multiple years.

Table 1 below shows the results of the multicriteria assessment. Criteria were graded on a scale of 1 to 6, 1 being best and 6 worst. Detailed descriptions for each score can be found in the 2013 AECOM report "Oakley Options Refinement"

Criteria	Option 0 - Do Nothing	Option 1 - "Pass Forward" with Existing Keith Hay Park Culverts	Option 2 - "Pass Forward" with Upgraded Keith Hay Park Culverts	Option 3 - Tunnel diversion from Keith Hay Park to Manukau Harbour	Option 4 - Tunnel diversion from Winstone Road to Manukau Harbour	Option 5 - Tunnel diversion from Sandringham Road to Manukau Harbour	Option 6 - Diversion to Meola Catchment
Cost	0	1	2	4	4	6	3
Hydraulic Performance	6	1	2	4	4	3	3
Environmental Effects	5	1	1	4	4	6	5
Consenting	6	1	1	5	5	5	5
Construction Risk	1	3	3	6	6	6	6
Ability to Stage	1	1	1	4	4	4	4
Reduction of habitable floors at Risk and within 500mm	6	1	1	1	1	1	1
Total	25	9	11	28	28	31	27
Toal Cost ($Mill NZD)	0	36	38	58	57	69	46

Table 1 Multicriteria matrix results

Overall, the preferred option ("Pass Forward") directly resolves flooding to 135 habitable buildings. 92 of these are located in the O'Donnell Ave area.

5 INTEGRATION WITH TRANSPORT, ECOLOGY AND PARKS AMENITY

The 3km length of Oakley creek between Bollard Ave and Sandringham Road is highly modified. It has a brick lined channel with grassed open banks and very limited shading (Refer photo 5). This entire length lies within the publically owned land areas of Alan Wood, Walmsley and Underwood reserves which offers a unique opportunity for widening and naturalisation of an urban stream without the issues faced by many other streams associated with multiple land owners.

Additionally, a cycleway route is proposed for this length which can be incorporated into the overall design connecting people with waterways and supporting Local Boards proposals to create "Greenways" linkages.

Photo 5 Highly modified existing Oakley creek with little ecological function

A concept plan was developed by Boffa Miskell on behalf of Council to integrate a number of key drivers including:

- Hydrology and hydraulics
- Parks amenity
- Landscape and cultural values,
- Ecology and sustainable natural systems.

5.1 INTEGRATION WITH STATE HIGHWAY 20

Downstream of the O'Donnell Ave area a large motorway project (SH20 Waterview Connection) is under construction. This project required major stream diversions and a new motorway bridge. Early in the motorway design process, Council worked closely with NZTA's motorway drainage designers to ensure drainage works could incorporate the preferred flood conveyance option "Pass Forward"). NZTA's modellers and Council's consultants worked collaboratively and iteratively using Council's MIKE Flood model running catchment-wide options scenarios including the motorway drainage and proposed stream diversion. This was a key task to ensure appropriate Environmental Protection Agency (EPA) consent conditions.

As part of the environmental effects mitigation required under the motorway project, Oakley creek would also be naturalised to provide ecological function for a 1.5km length from the Stoddard Road tributary to Bollard Ave. Council used the same consultants and approach to ensure a similar restoration of Oakley creek's ecological function could be incorporated into the O'Donnell Ave flood mitigation project (see Section 6 Below).

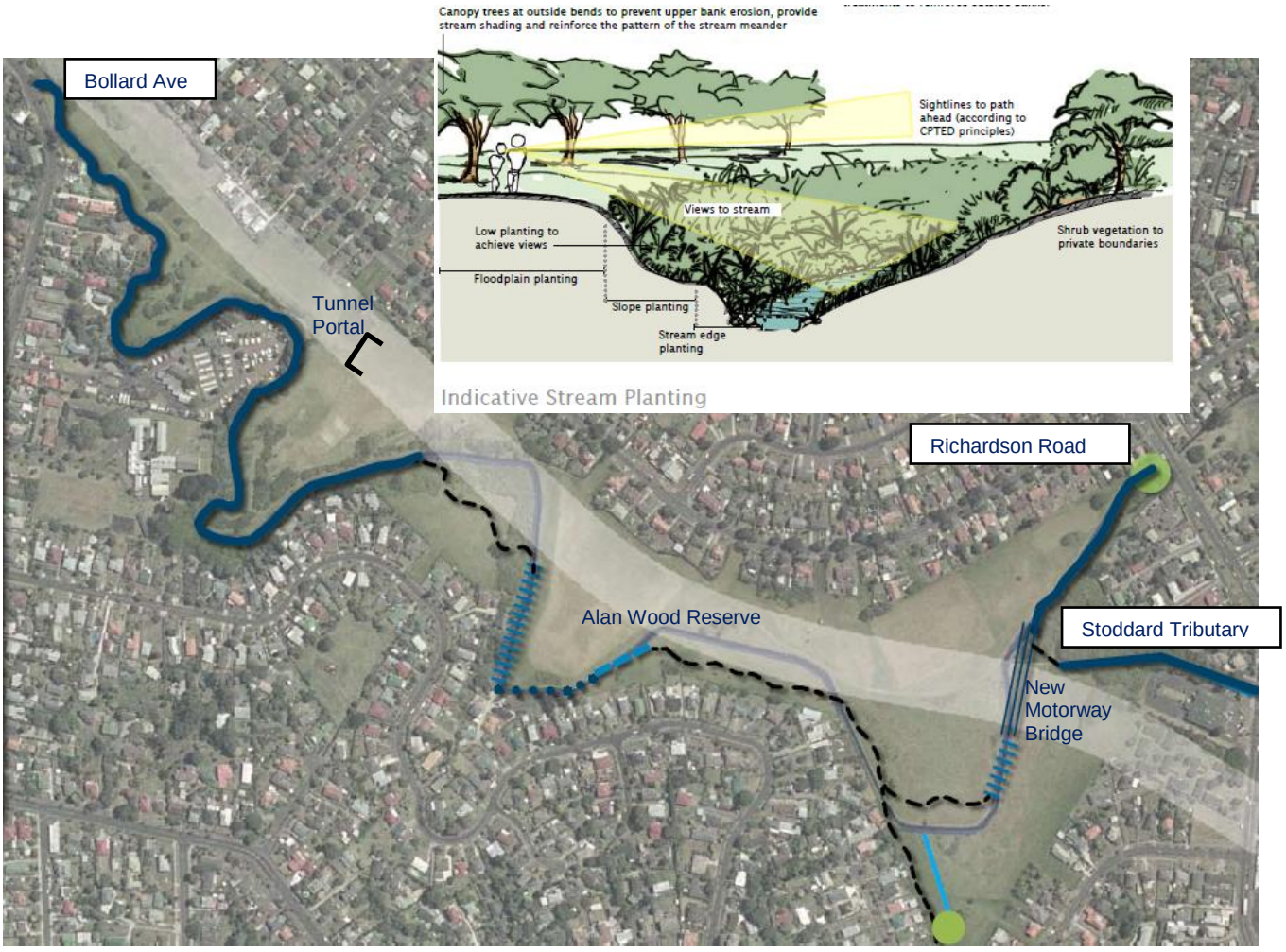

Figure 8 Motorway surface route with stream diversions and indicative stream profile and planting.

Council's model was also used to design the parks field storage concept and wetland areas within Alan Wood Reserve. The wetland areas were designed to provide treatment for motorway runoff to remove 75% of suspended solids annually.

5.2 INTEGRATION WITH ECOLOGICAL FUNCTION

The MIKEFLOOD hydraulic model was used to ensure improved ecological function could be compatible with flood mitigation objectives. The main concern was the effects of stream variations (meanders, rock riffle pool runs) and increased stream bed roughness on water level. For the existing stream, a Mannings roughness values of 0.023 for the grassed and concreted channel section, and 0.0375 for the basalt brick lined channel section was assumed in the model. This had been verified against actual flooding. For the naturalised stream, a composite value of 0.04 was assumed. This was based on a weighted roughness considering the anticipated land coverage and flows.

It was expected that some compromise between flood conveyance and ecological function would be required. At one extreme a very wide straight and smooth channel would provide very good reduction in flood level but low ecological value, whilst a meandering stream with increased roughness and more vegetation would do the opposite.

The results of modelling the new stream based on the Boffa Miskell concept for improved ecological function showed that ecology did not have to be compromised far. Whilst a minor increase in stream cross-section was required in some localised places, overall the realigned and naturalised stream still offered sufficient flood water reduction to achieve the required protection levels to habitable buildings at risk. Any additional widening of the creek (thereby further reducing flood water levels) would not achieve sufficient additional protection to justify the cost.

Figure 9 and Photo 6 show the concept of the rock riffle pool run variation of the stream which has been proposed as part of the stream widening works.

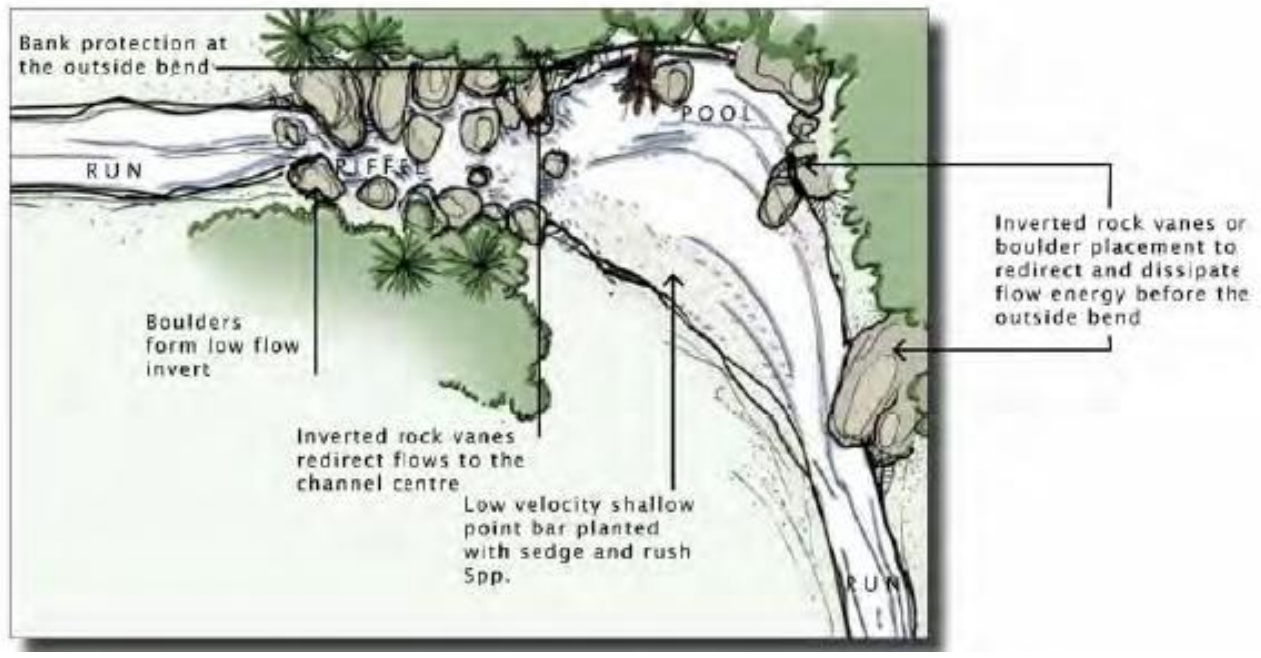

Figure 9 Rock riffle pool run sequence integrated with the stream meander (extracted from Oakley Creek – Te Auaunga Rehabilitation Guideline, Boffa Miskell 2011)

Whilst Photo 6 below shows the typical stream bed feature of the design, the planting will be a combination of low and tall stature planting to ensure views to the stream while providing shade.

Photo 6 Natural basalt boulder stream (extracted from Oakley Creek – Te Auaunga Rehabilitation Guideline, Boffa Miskell 2011)

5.3 INTEGRATION WITH PARKS AMENITY FUNCTION

Additional features incorporated into the design were cycleway routes, pedestrian connections, play facility areas, viewsheds and reinstatement of historical Kahikatea swamp forest areas. Appendix A shows the resulting concept plan.

The recommendations from the Parks Landscape and Management Plans were incorporated into the concept plan. An example of this is seen in Figure 9 where pedestrian linkages, viewsheds to the volcanoes and an outdoor classroom opportunity were factored into the design. This can be seen in the concept in Appendix A where viewsheds are protected next to the reinstated Kahikatea swamp forest and the stream alignment meanders around an area suitable for the outdoor classroom concept.

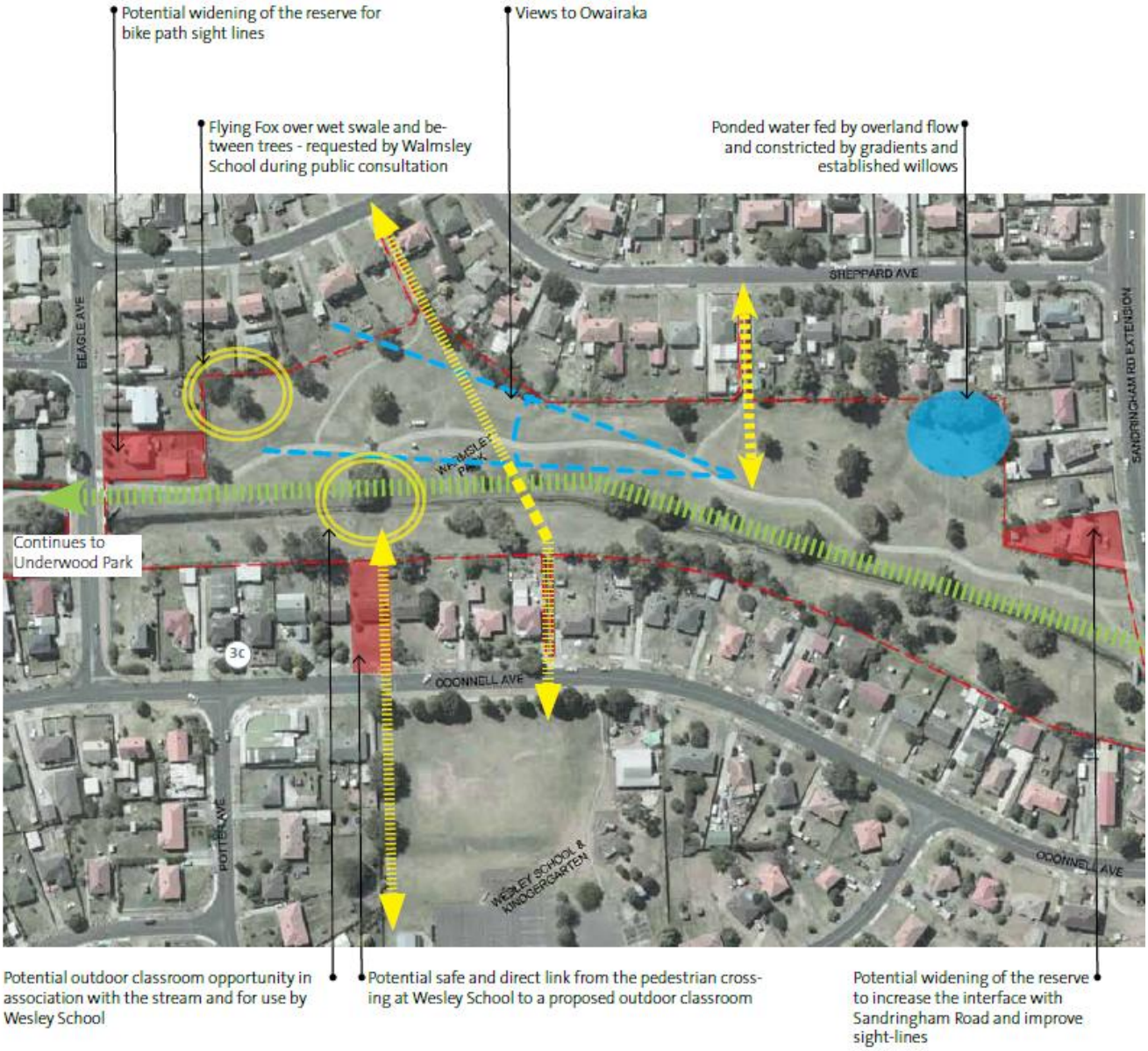

Figure 9 Socio-cultural issues ad opportunities in Walmsley Reserve (extracted from Oakley Creek – Te Auaunga Rehabilitation Guideline, Boffa Miskell 2011)

6 CAN WE BUILD IT?

A detailed feasibility and concept design report was prepared to ensure a reliable cost and construction risk profile before proceeding to implementation. This was identified as an important task for the planning phase of the project so that any construction, consenting and cost risks could be addressed in the concept. This work included topo survey, preliminary geotechnical assessment and an earthworks cut to fill model.

Key findings were:

- A requirement to purchase 2 properties,
- three new bridges required which are a more optimal solution than culvert upgrades
- 25,000 m^3 of earthworks including 9,500m^3 of basalt rock (by rock blasting)
- Relocation of a range of utility services

The total cost of the "Pass forward" option is estimated to be $36 million. The Sandringham Road to Richardson Road section of the work is estimated to be $21 million.

The experience of the stream realignment construction works by SH20 currently in progress in Alan Wood reserve was used to inform the feasibility study.

Photo 6 Stream realignment and restoration as part of SH20 works showing early stages of riparian planting and rock riffle pool runs with basalt outcrop retained.

7 CONCLUSIONS

The Oakley catchment has long standing flooding issues which remain today despite various localised stream works implemented over the last 50 years. Recent modelling capability has allowed a catchment-wide strategy to be identified which can be better implemented under Auckland regionalised political structure.

The preferred solution requires major stream works to increase stream conveyance capacity at two narrow sections where rock cuts were constructed early in Oakley's history to drain former swamp areas.

The preferred option has been factored into the stream works required for a large motorway project (SH20) as part of the catchment–wide solution strategy. This required modelling tools and concept plans to be developed in time to take the opportunity to influence the motorway works. This was important to achieve continuity of outcomes for a significant length of Oakley Stream.

Significant effort was made to achieve integrated planning across multiple benefit areas. This included integration with motorway drainage works, parks amenity and pedestrian routes, and ecological function. A key outcome of this process was to achieve a naturalised stream with good public access connecting an urban community with their waterways. This required Council and NZTA working collaboratively ensuring input from parks and other stakeholders.

Planning work involved skill sets from many of the legacy Council's storm water teams to promote an integrated solution to a difficult flooding issue. This was easier under the amalgamated Council as teams have become more regionalised promoting knowledge sharing.

DISCLAIMER

The work presented in this paper was funded by the Auckland Council. Views expressed in this paper are those of the authors and do not necessarily represent policy or position of the Auckland Council.

ACKNOWLEDGEMENTS

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REFERENCES

Boffa Miskell (October 2011) 'Oakley Creek – Te Auaunga Rehabilitation Guideline'.

Auckland Council (2013) Draft Oakley Catchment Management Plan.

AECOM (2013) 'Oakley Options Refinement'.

APPENDIX A - WALMSLEY AND UNDERWOOD PARKS CONCEPT PLAN