SWEATING THE ASSETS: A SMART INFRASTRUCTURE APPROACH FOR AN INTENSIFIED FUTURE

R.M. Seyb (Beca), A. Fullerton (Beca) & E. Lindsay (Beca)

ABSTRACT

Auckland's future will see a greater number of people living and working in the same urban area. There is a well-known shortage of suitable homes across the board but the shortage does hit some harder than others. One of the largest landowners in the city is Housing New Zealand Corporation (HNZ). Much of its housing stock is no longer fit for purpose, with a greater proportion of smaller homes now required, many dwellings at the end of their useful lives and no longer capable of providing the warm, dry, safe homes needed.

HLC is a wholly owned subsidiary of HNZ. HLC leads the redevelopment of large HNZ holdings that require an integrated, large scale, masterplanned approach. HLC is intensifying the number of homes on the HNZ landholdings to tackle the housing problems at scale across Auckland and provide a mix of social, affordable (including Kiwibuild) and market homes. Approximately 37,000 new homes are planned across Hobsonville Point, Mt Roskill, Mangere, Tamaki, Northcote and Oranga – with, on average, three new homes replacing one existing. The scale of the intensification presents an opportunity to provide better quality infrastructure and environmental improvements, but also faces a number of challenges.

All these additional homes put extra demand on infrastructure. In terms of the stormwater this means; moving into more marginal areas (eg. flood risk), placing more demand on networks and finding solutions for areas that have previously been poorly serviced (e.g providing new networks in areas previously relying on poor soakage). These brownfields situations present a large range of physical constraints - with lots of different infrastructure and services to be provided in small spaces while keeping existing networks operating to service the existing community. A large degree of coordination and integration is required.

Beca has prepared Infrastructure Masterplans for HLC to identify infrastructure constraints, projects, costs and sequencing. The Masterplans operate on a GIS platform which allows spatial tools to be used to identify overall constraints, prioritise projects, manage cost and funding and coordinate projects. The GIS platform includes:

- Traffic light mapping of constraints to identify quick wins
- Setting cost attributes for projects and linking these to individual sites to spatially map total infrastructure costs
- Linking infrastructure projects to the individual sites being serviced allowing equitable funding contributions to be determined between HLC growth / other development and existing sites
- Integration of projects across disciplines to allow coordinated sequencing

KEYWORDS

Intensification, GIS, infrastructure masterplanning

PRESENTER PROFILE

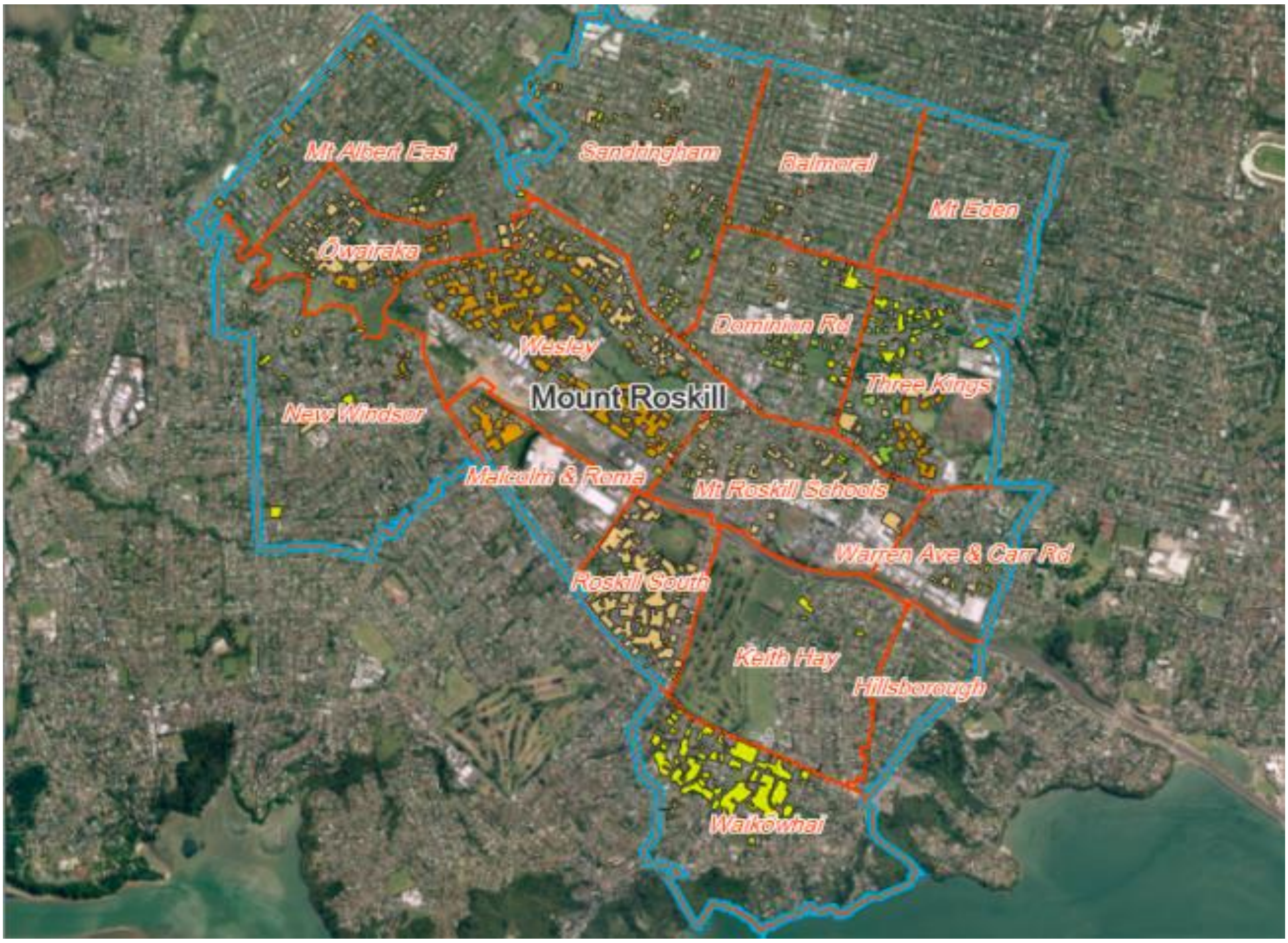
Roger Seyb is a Technical Director with Beca Ltd in Auckland. He has worked in with water resources and infrastructure for some 25 years. He is keenly interested in stormwater management and achieving good infrastructure outcomes for his work alongside client and community objectives.

1 INTRODUCTION

The greater Auckland region is anticipated to account for over half of New Zealand's population growth between 2013 and 2043, with a projected increase of 833,000 people. By 2043 it is estimated that Auckland's population could comprise 39% of New Zealand's population (Statistics New Zealand, 2017). Auckland is already facing a well-publicised shortage of suitable housing, with affordable housing being a particular point of interest for the current government. Housing New Zealand (HNZ) is the largest residential land owner in Auckland. A considerable portion of the HNZ housing stock is no longer fit for purpose, with many dwellings at the end of their useful lives and built on land that, under the increasing population demands of Auckland, is underutilised.

The Auckland Housing Programme (AHP) is a joint venture between HNZ and HLC to redevelop underutilised HNZ stock and deliver small, medium and large-scale housing developments across the Auckland region over the next 10-15 years. Approximately 37,000 new homes are planned across Hobsonville Point, Mt Roskill, Mangere, Tamaki, Northcote and Oranga. HLC's development strategy aims that, on average, three new homes will replace each existing one. Under this model, development aims to return land back to HNZ for roughly the same number of social housing units, but of higher quality and more fit for purpose than the current housing stock. At the same time, the intensification will create and activate additional lots which will be sold to the private sector for the development of affordable (including Kiwibuild) and market housing.

Figure 1: Mt Roskill Precinct and neighbourhoods, showing distribution of HNZ housing stock



This scale of housing intensification presents an opportunity to provide better quality infrastructure and environmental improvement, but also faces a number of challenges. All these planned additional homes put extra demand on the existing infrastructure services. The proposed development is largely to be undertaken in brownfields areas and these situations present a large range of physical constraints. Typical public infrastructure constraints that require consideration include:

- Available network capacity and flood risk associated with an increase in stormwater generation;
- Available network capacity increase in wastewater generation and potable water consumption from an intensified population;
- Increased vehicular traffic on existing roads and impact of intensified populations on existing and planned public transportation links; and
- Increased power, gas, telecommunications connections required to the existing network.

Geotechnical and land contamination issues also require consideration as they constrain development in terms of restricting the type of housing or creating additional costs (e.g. adapted foundation design, removal of waste material etc.). However, they do not require public infrastructure for development to progress.

Redeveloping brownfields areas for increased intensification means installation of different infrastructure and services will be required in small spaces, while still keeping existing networks operable to continue servicing the existing community. A large degree of coordination and integration is required. In conjunction with minimising disruption for local communities, coordination of different service upgrades is required to provide efficient construction and avoid unnecessary rework.

2 MASTERPLANNING

2.1 OVERVIEW

Beca has prepared Infrastructure Masterplans on behalf of HLC to identify the constraints facing this large scale brownfields development and develop solutions, associated costs and project sequencing. The masterplan was developed to be a dynamic document that lays out the intent of use for the long term at a higher than conceptual level. A masterplan includes analysis of different aspects of an area such as infrastructure or community facilities, or development intensification. It is based on analysis of current and future state, planning initiatives or social and economic changes. Beca has prepared two masterplans based on the location and demands of infrastructure as they relate to intensification of existing HNZ sites within the Mt Roskill and Mangere precincts.

The purpose of the masterplanning exercise was to identify constraints and opportunities within the existing infrastructure networks that will impact on the anticipated intensification of the precinct. HLC will use the information contained within the masterplans to help stage their intensification of land. The less constrained the land in respect to the three waters networks, transportation, geotechnical and contamination, the more likely the land can be developed in the early stages of the programme. Additional investigations will be needed at preliminary and detailed design phases in order to identify the specific constraints/opportunities of each developable parcel of land and out of neighbourhood infrastructure which will in-turn be used for consenting purposes. In addition to identifying constraints, the masterplans identified infrastructure projects that will provide for intensification. The cost, complexity, duration and interdependencies of each project were considered in setting an overall infrastructure masterplan and indicative project sequencing programme.

The masterplanning also assists the asset owners, Auckland Council, Auckland Transport and Watercare, to plan the expansion of their networks to enable growth and prioritise expenditure.

The masterplans operate on a Geographical Information System (GIS) platform. This allows spatial tools to be used to help identify overall constraints, prioritise projects, manage cost and funding, and coordinate projects. The development of the GIS masterplan platform allowed Beca to deliver an interactive and dynamic deliverable to HLC which included the following features:

- Traffic light mapping of constraints to identify quick wins;
- Identified infrastructure projects with associated cost estimates - allowing total infrastructure costs to be mapped spatially;
- Links from infrastructure projects to individual sites being serviced, allowing equitable funding contributions to be determined between HLC growth, other development and existing sites;
- Integration of projects across disciplines to allow coordinated sequencing.

The main body of this paper will discuss the development of infrastructure masterplans and the integration with GIS to provide an interactive spatial tool for HLC as a final deliverable. In particular, the discussion will focus on the approach and method undertaken to assess stormwater constraints and how the integration with GIS provided an effective tool for the client.

3 INTEGRATING INFRASTRUCTURE AND GIS

3.1 ESTIMATING DEVELOPMENT YIELDS

Isthmus Group urban designers provided the technical discipline teams with the locations of all HLC owned properties and the anticipated yields through intensification. Contiguous lots were grouped together to form likely "super-lots" to enable greater development yield and more flexibility in design. For the purposes of the masterplanning process, contiguous super-lots were grouped together into "mega-lots".

The basis for intensification was provided by the Auckland Unitary Plan (Operative in Part) (AUP(OP)). GIS analysis was used to work out theoretical maximum populations based on AUP(OP) residential zoning and Isthmus spatial analysis. Two methods were applied to assess the expected populations resulting from intensification:

- Auckland Transport's i11.3 population projections, adjusted for intensification allowed for in the AUP(OP);
- A linear ratio of existing to new properties of 3 times the dwelling population.

The adjustment of the i11.3 population projections were carried out as follows:

- Identification and removal of HNZ properties (located within the HLC projects areas) and their assumed populations from the base i11.3 data;
- Identification of reasonable intensified populations on HNZ land, taking into account factors such as likely amenity, urban design and community (note these were sometimes less than allowed in the AUP(OP));
- Addition of the HNZ intensified populations into the i11.3 data to give an i11.3 "enhanced" population data base. The resulting population was significantly more than the i11.3 data in some places.

3.2 TRAFFIC LIGHT MAPPING

Due to the different industry standards and local authority requirements influencing infrastructure design, each discipline had a different approach to assessing the potential constraints faced when considering housing intensification. However, in order to provide the client with a context for the level of severity of these constraints, and an indicator for a neighbourhood's "readiness" for development, each discipline undertook a current state evaluation.

Each current state evaluation was prepared closely with the respective regulatory body and utility companies; that is, Auckland Transport, Auckland Council, Watercare Services Limited, Vector and Chorus. The intensified future state based on the density envisioned in the Auckland Unitary Plan was then considered to define where the existing infrastructure presents a constraint. Based on this analysis, sites were ranked according to a traffic light system to indicate their readiness for development:

> **Red** – requires substantial upgrade or presence of infrastructure before development can take place;
> **Yellow** – ready for development but with some constraints;
> **Green** – ready for development.

The analysis included the anticipated impact of capital works already planned or underway; such as the Central Interceptor wastewater tunnel, proposed Light Rail from Auckland CBD to the airport and Oakley Creek stream rehabilitation and flood improvement.

3.3 ASSESSING INFRASTRUCTURE CONSTRAINTS

Assessment and categorisation using traffic light mapping presented itself differently depending on the infrastructure discipline. Ultimately, independent of the method, each discipline needed to categorise development readiness on a neighbourhood level.

Table 1: Example of traffic light categorisation by discipline and neighbourhood for Mt Roskill masterplan.

Neighbourhood	Yield	Geotechnical	Contamination	Transport (accessibility)	Water Supply	Wastewater	Stormwater	Utilities
Balmoral	104 (Red)	Green	Yellow	Yellow	Green	Orange	Green	Green
Dominion Road	310 (Yellow)	Green	Yellow	Light green	Green	Yellow	Green / Yellow	Green
Hillsborough	2 (Red)	Yellow	Yellow	Light green	Yellow	Orange	Yellow	Green
Keith Hay	31 (Red)	Yellow	Yellow	Light green	Yellow	Light green	Yellow	Green
Malcolm & Roma	484 (Yellow)	Yellow	Yellow	Orange	Yellow	Orange	Yellow	Yellow
Mt Albert East	395 (Yellow)	Green	Yellow	Light green	Red	Orange	Red	Yellow
Mt Eden	19 (Red)	Green	Yellow	Yellow	Yellow	Light green	Red	Green
Mt Roskill Schools	443 (Yellow)	Green	Yellow	Green	Yellow	Green	Yellow	Yellow
New Windsor	232 (Red)	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Green
Ōwairaka	851 (Green)	Green	Red	Yellow	Red	Orange	Orange	Yellow
Roskill South	1169 (Green)	Yellow	Red	Light green	Yellow	Red	Orange	Red
Sandringham	496 (Yellow)	Green	Yellow	Light green	Green	Orange	Light green / Red	Yellow
Three Kings	887 (Green)	Yellow	Red	Light green	Red	Yellow	Green / Yellow	Green
Waikōwhai	752 (Green)	Yellow	Yellow	Yellow	Red	Yellow	Orange	Green
Warren Ave & Carr Rd	104 (Red)	Green	Red	Green	Yellow	Yellow	Yellow	Green
Wesley	4434 (Green)	Green	Red	Light green	Red	Light green	Light green / Orange	Red

3.3.1 GEOTECHNICAL

Geotechnically, the traffic light categorisations correspond with quality of the underlying ground conditions across the catchment. Green corresponds to expected good ground condition – Auckland Volcanic Field (AVF) lava and tuff. Conversely, red corresponds to expected poor ground condition – recent swamps / Tauranga Group alluvium. Boundaries between different traffic light categorisation occur where distinct changes in geological strata occur. These occur independent of the masterplanning defined neighbourhood boundaries, however, within the GIS platform spatially overlapping the two shapefiles allowed for each neighbourhood to be assigned a categorisation.

3.3.2 CONTAMINATED LAND

Land contamination categorisation considers previous land use and contamination risk from existing structures. The GIS platform was used to map identified contaminated sites. The severity of the anticipated level of contamination concluded from a desktop study (no on-site investigations were undertaken) corresponds to the traffic light categorisation.

3.3.3 TRANSPORTATION

To determine the traffic light categorisation and inform neighbourhood sequencing with respect to transportation an accessibility assessment was undertaken. The assessment used the GIS platform to map zones of influence and assign scores to each area based on seven transport accessibility criteria and five land use accessibility criteria.

- Transport accessibility: proximity to the rapid transport network, to frequent bus services and to the cycle network, as well as the readiness of the traffic network to cope with additional traffic.
- Land use accessibility: proximity to town, local and neighbourhood centres, to community facilities and medical centres, and to primary, intermediate and secondary schools.

The impact of the zones of influence on the masterplanning neighbourhoods influenced the traffic light categorisation of each neighbourhood.

3.3.4 WATER SUPPLY

Masterplanning assessment of the water supply network focused on the distribution network. Beca used previously built hydraulic models of the water networks impacting the masterplanning precincts to assess the impact of HLC and infill growth. Results from the hydraulic model could be correlated back to a neighbourhood level to indicate the ability of a particular neighbourhood area to be serviced by the existing water supply network. Where a neighbourhood required substantial upgrades to the network prior to development this indicated a poor readiness for development and a red categorisation.

3.3.5 WASTEWATER

To understand the existing constraints within the Watercare network, Beca developed a GIS based model and calibrated this against flow data Watercare provided for selected points in the trunk network. The simplified GIS model was used to allow a quicker assessment than the development of a full hydro-dynamic model. The model allowed under capacity areas of the network to be identified at a pipe level. The proximity and influence of these pipes was considered against the location of HLC properties across the precincts and informed the categorisation of the neighbourhoods. For example, a neighbourhood may have contained a number of under capacity pipes but if this portion of the network did not service HLC properties the neighbourhood may still have been categorised green.

3.3.6 UTLITIES

Information was obtained from Vector and Chorus on the current condition of the power, gas and telecommunications networks across the precinct areas. Information was also provided estimating the additional loading caused by the proposed HLC intensification on the network. For power in particular, Vector was able to advise which substations will be affected by the additional loading. Consequently, within the GIS platform the areas serviced by these substations could be identified and their readiness for development categorised appropriately.

4 WHAT DOES INTENSIFICATION MEAN FOR STORMWATER?

4.1 ASSESSING THE CONSTRAINTS

The additional demand on the stormwater infrastructure from intensification exhibits itself in facing moving housing into more marginalised areas (e.g. flood risk), placing more demand on existing networks and finding solutions for areas that have been previously poorly serviced.

Due to the piecemeal nature of the HNZ housing stock, it was recognised that two methods for developing solutions would be necessary. It was realised that where HLC has large contiguous land holdings there are opportunities for wide scale stormwater solutions. "Project areas" were identified across the precincts where HLC has a large number of properties within close proximity to one another. Conversely, where HLC doesn’t have large contiguous land holdings, public infrastructure upgrades are far less practicable. For those parcels of land it was assumed that on-site solutions would be applied at an individual level.

4.2 ISOLATED SITES

It was recognised that the solutions applying to individual sites were likely to vary considerably depending on what type of stormwater problem(s) had been identified. To address the potential solutions required for individual sites a “toolbox” of solutions was prepared. These solutions could be categorised into three main types – on-site flood risk, discharge from site, or water quality. Generally, these solutions were developed based on the following concepts:

- Risk of flooding to floor levels comes from two sources – floodplains or overland flow paths. Solutions are:
  - Setting floor levels above surrounding flood levels, or
  - Redirecting overland flow paths around new buildings;
- Runoff from intensification can be dealt with in a range of ways, either disposing of stormwater to soakage or to an existing public stormwater network;
- Stormwater treatment can be achieved on site through installation of treatment devices. Device selection will depend on the volume of runoff that

requires treatment, available space, available hydraulic grade and incorporation with other outcomes such as landscape, access and sustainability goals.

Ultimately the specific solution(s) for each site will be selected and applied in the detailed design process to suit the intended redevelopment and specific site constraints.

4.3 PROJECT AREAS

Within each area a project wide solution was developed that presented opportunities for more efficient, wide scale stormwater solutions involving upgrades or additions to public infrastructure. Solutions for each project area were developed with the following philosophy in mind:

- Any new dwellings to have freeboard above 100 year flood levels and new habitable floors allowing for maximum probable development;
- Any increase to habitable floor flooding in other properties is to be avoided;
- Consider maximum potential for intensification throughout. That is, greater than the 60 to 70% permitted in typical residential zonings under the Auckland Unitary Plan (Operative in Part) (AUP(OP)) and up to 90%. The purpose of taking this approach was to identify areas where higher intensification is simple to achieve in a stormwater sense to inform development decisions;
- Allow for diversion of existing public infrastructure around areas of redevelopment where practicable, acknowledging that existing alignments are unlikely to suit proposed building layouts and there is a preference for public assets to be placed in accessible areas;
- When public infrastructure is being diverted around development areas, allow for capacity upgrades;
- Include pipe capacity upgrades to support intensification that would at minimum maintain existing levels or service and ideally reach current code of practice standards.

Some of the proposed works in these project areas could be considered as "extra measures" to unlock the opportunity for further intensification by HLC in the project area. Those works have identified obstacles such as land acquisition, negotiation with external stakeholders, high associated costs or long approval timeframes. Depending on the proposed work and the potential benefits the additional restrictions may be considered too arduous for the additional intensification it gains, particularly if other disciplines in this infrastructure masterplanning process indicate the need for a lower intensity area or there are no particular drivers to intensify more in those areas.

5 USING GIS TO CREATE A SPATIAL STORMWATER MODEL

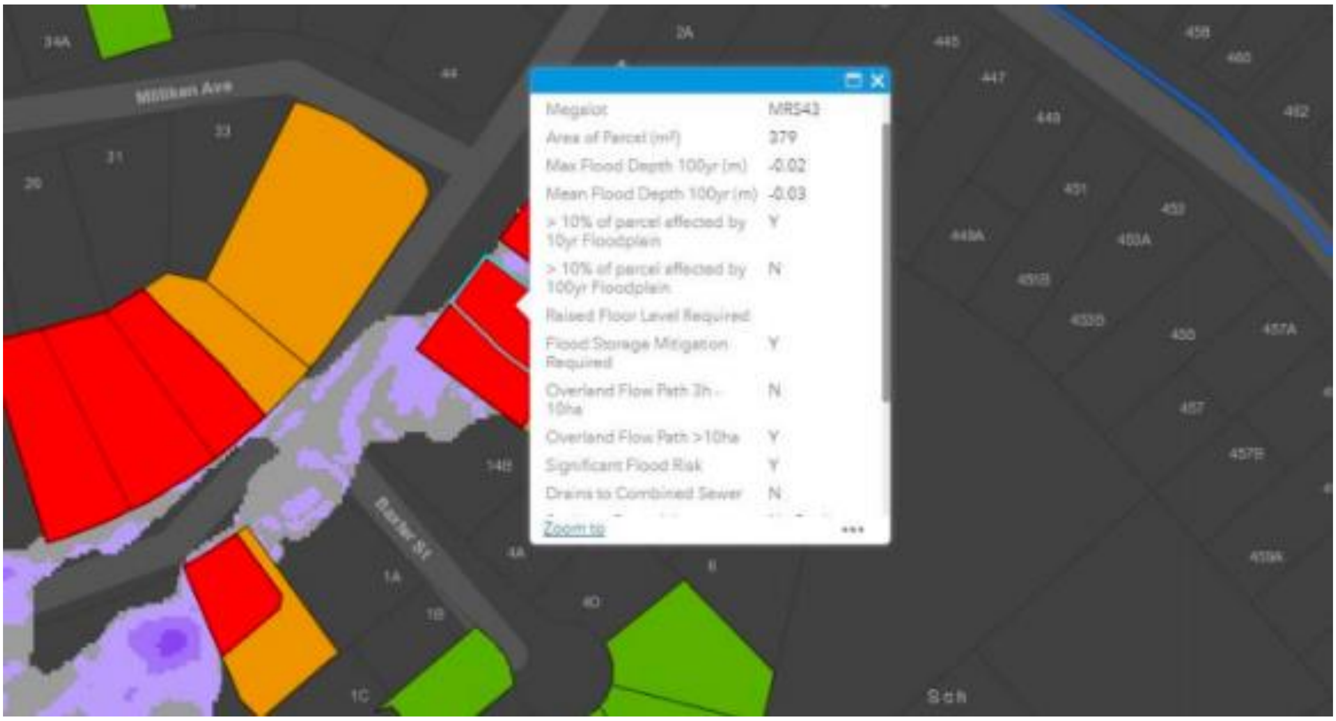
5.1 DECISION TREE

A “decision tree” flow chart was developed to identify how each property could be categorised into the traffic light system. The decision tree considered constraints such as flood risk, soakage potential as a method of stormwater discharge and the position of a single property within the catchment to categorise the level of constraint.

The integration of the GIS platform with stormwater technical assessment allowed the structure created with the decision tree to be applied to a large dataset. By translating this flow chart model into GIS, a spatial model was developed to process the large number of properties contained in a precinct in an efficient manner. The deliverable produced from this model was an interactive map allowing for quick identification of constrained and unconstrained properties. The platform allowed each property to be interrogated individually and display the reason that property had been categorised a particular colour.

In particular, by categorising isolated sites in this manner, it allowed for quick identification of the constraints; and in turn, quick identification of which on-site solution corresponded to that issue.

Figure 2: Screenshot of interactive GIS platform showing interrogation of an HNZ property.



A series of stormwater constraints contributed to the structure of the decision tree. The GIS platform has been used to assess each HLC property against 10 and 100 year floodplain depths and extents, potential overland flow paths, position in the catchment and disposal method to categorise the level of constraint. The development of this GIS model also carries that benefit that its base structure could theoretically be applied to other areas in the future, provided the relevant technical input shapefiles are available.

5.2 FLOOD RISK

5.2.1 FLOOD PLAINS

Flood risk provides a significant constraint in the Auckland region as housing intensification requires further development in areas that are already considered marginal due to flood risk. An increase in impervious coverage across the catchment, coupled with increased precipitation due to the effects of climate change results in greater stormwater discharge across the catchment. Understanding this increase in stormwater generation and its impact on existing floodplains was important to understand which HLC developments may be impacted by increased flood risk as a result of the overall intensification development.

To assess flood risk within the precinct areas, information was utilised from previous modelling studies undertaken in the relevant stormwater catchments. By integrating flood depth shapefiles into the GIS platform the categorisation of properties could consider not only whether the properties were within a flood plain or not, but also what the severity of the flooding experienced by that property was in terms of depth. However, to quantify any given property's vulnerability in this way a couple of assumptions were required. A property was considered to be vulnerable to flood risk if:

- Greater than 10% of the property area is contained within the floodplain; and
- The maximum depth of flooding is greater than 150 mm.

For example, if both these statements were deemed to be **true** for a property in the 10 year flood plain then that property would be categorised red. If these statements were deemed **false** for the 10 year flood plain but **true** for the 100 year flood plain then that property would be categorised yellow.

5.2.2 LOCATION WITHIN THE CATCHMENT

Understanding the increase in stormwater generation and its impact on existing floodplains is important to ensure intensification of HNZ housing stock does not adversely impact privately owned existing dwellings downstream of HLC developments. As a general rule, in order to avoid adverse effects downstream, any development occurring in a floodplain must not displace the floodplain or it must provide equivalent mitigation of any floodplain that is displaced.

There are situations where depending on the location of the property in the catchment mitigating a loss of storage in the floodplain may not be required. For example, within the Oakley Creek catchment, technical evidence provided during the resource consent process for *Te Awa Auaunga: Walmsley and Underwood Reserves* (Jones, 2015) displacing the floodplain in this location will not negatively impact properties downstream. Similarly, in Mangere's Tararata Creek catchment, a high-level HEC-RAS model built during the Mangere stormwater masterplanning process indicated that due the location of the Tararata Creek floodplain within the catchment, raising floor levels in this area would not cause adverse effects on properties further downstream.

Flooding studies such as these allow for a user-defined area to be specified within the GIS decision tree model to identify areas where loss of flood plain storage mitigation is not required. This iteration within the decision tree model was not a step that produced an assigned colour as an outcome. Rather, where a colour had already been assigned it provided an annotation to the interactive map so an informed decision could be made about how to construct building foundations for any given property.

5.2.3 OVERLAND FLOW

An additional consideration for flood risk was whether a major overland flow path passes through a property or not. The GIS decision tree model categorises a property as **yellow** if the overland flow path has an upstream catchment of greater than 3 ha.

5.3 STORMWATER DISPOSAL

5.3.1 SOAKAGE POTENTIAL

Runoff and soakage potential are governed by underlying geology and vary across the catchment. This variability influences the options available for stormwater discharge within the catchments. Due to the volcanic nature of the Auckland region, there are neighbourhoods where historical basalt lava flows may provide the opportunity for discharge to ground. Disposal of stormwater to soakholes on site are a good option for managing increased runoff from intensification.

Using a soakage potential map for the Auckland Region (Strayton & Lillis, 2013) the GIS platform allowed identification of which properties were underlain by fractured basalt and may provide suitable conditions for discharge to soakage.

5.3.2 COMBINED SEWER

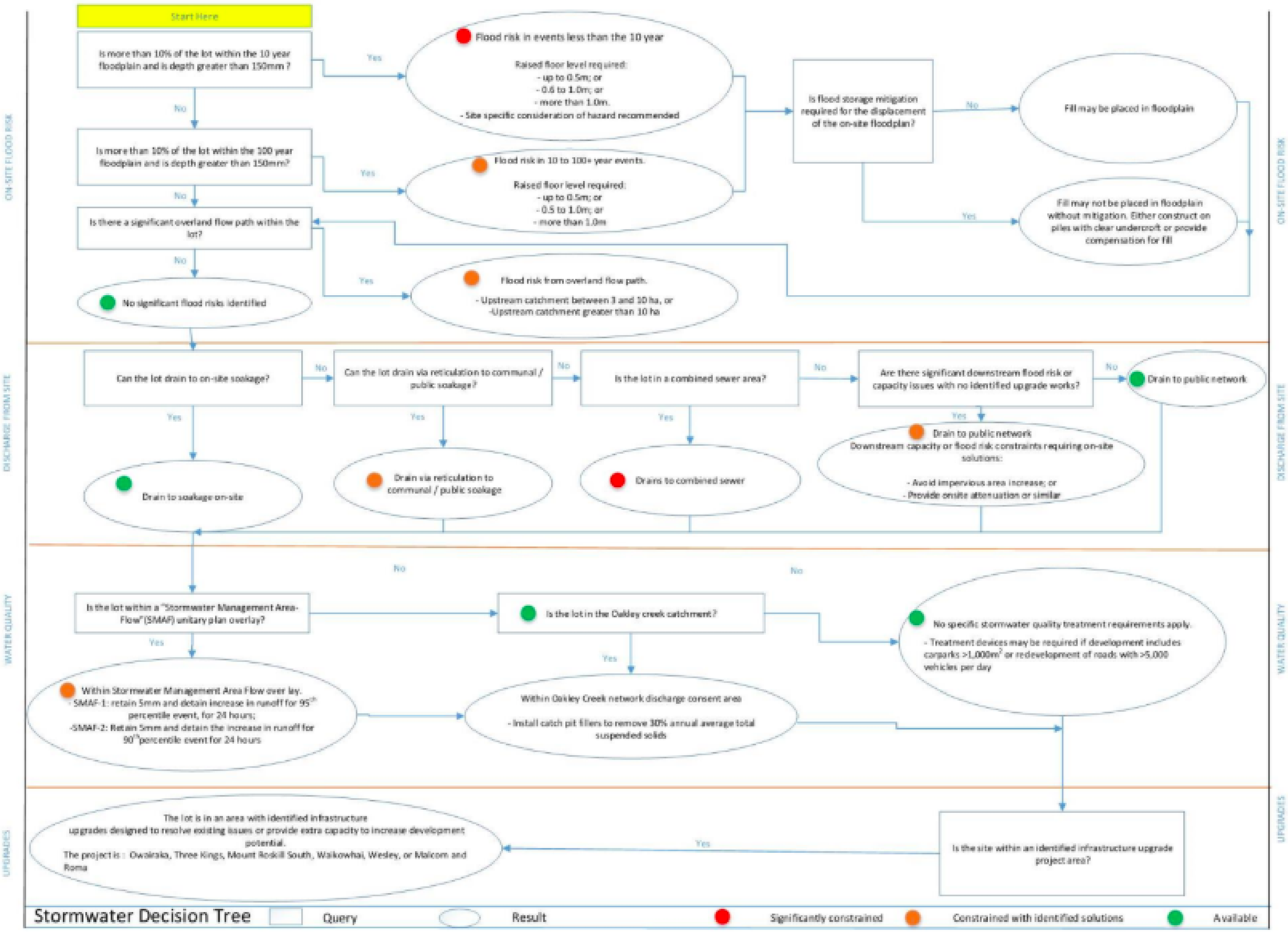
The level of constraint provided by the discharge method for stormwater was another aspect considered by the decision tree. Due to the age of Auckland three waters infrastructure, not all neighbourhoods are serviced by a dedicated stormwater network. When preparing the Mt Roskill infrastructure masterplan consideration had to be given to neighbourhoods such as Owairaka and Three Kings that had combined sewer networks.

It was recognised that difficulties connecting intensified properties to the combined network were likely to arise due to local authority requirements to discharge at a rate lower than the existing runoff. Shapefiles showing the extent of areas serviced by combined sewer networks were obtained from Auckland Council, allowing properties that are likely already serviced by a combined sewer network to be identified.

5.3.3 CATEGORISATION

These categories of the decision tree only applied in the Mt Roskill masterplan (the Mangere Precinct does not have any combined sewer networks or areas identified as having soakage potential). The combined sewer and soakage potential areas experienced a significant portion of overlap, therefore, categorisation of properties in these areas considered both methods of stormwater discharge to determine their traffic light categorisation. For example, only properties that were identified as discharging to a combined sewer and were not identified as being able to discharge to soakage were categorised as red by the GIS decision tree model.

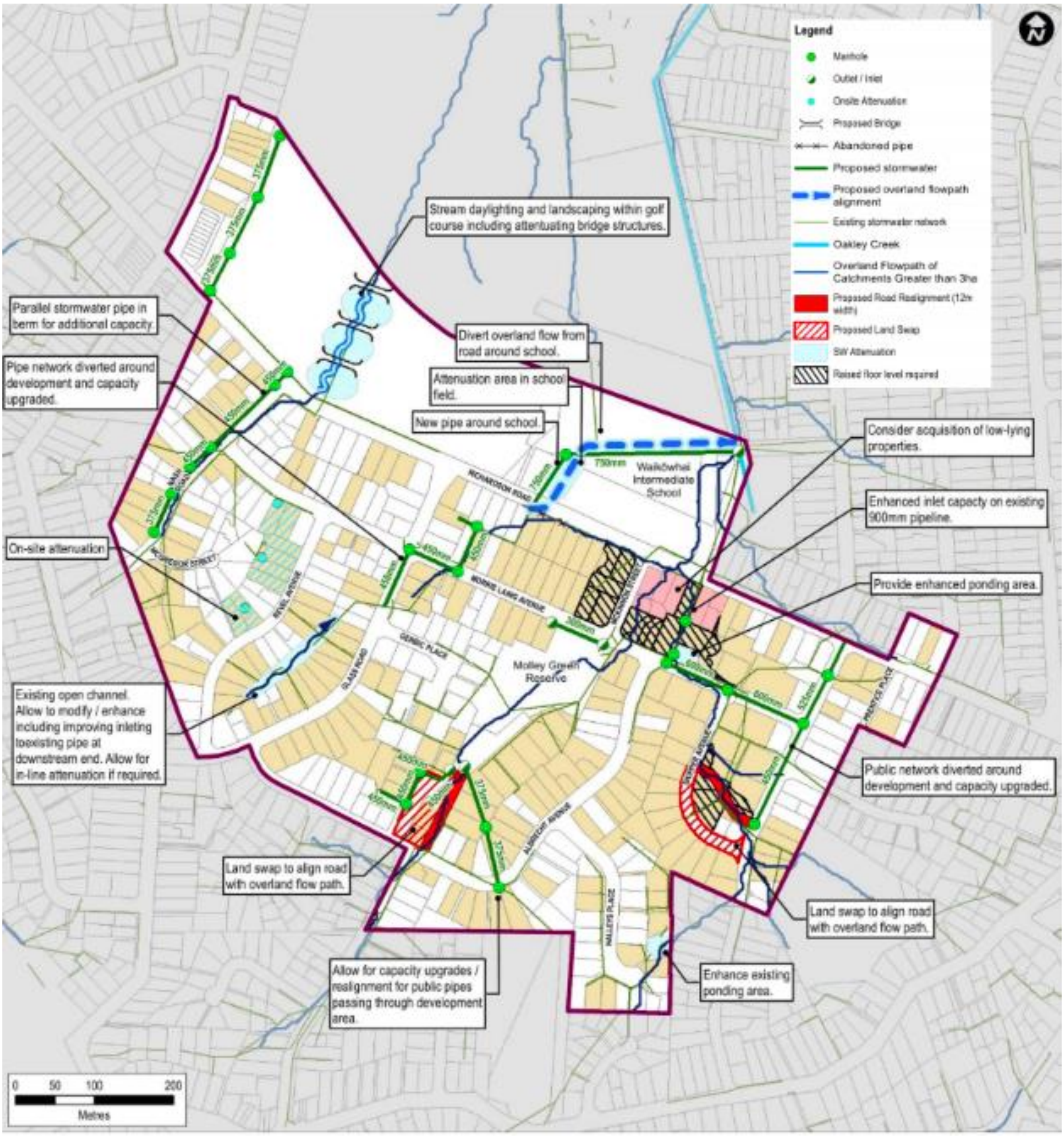
Figure 3: Stormwater decision tree flow chart used to build GIS model for the Mt Roskill masterplanning



5.4 USING GIS TO FACILITATE PROJECT AREA INFRASTRUCTURE DESIGN

Using the spatial drawing tools available in GIS, project area boundaries were defined and the solutions drawn directly into the GIS platform. This allowed all asset variables (such as pipe diameter, material, length) to be collated within the GIS platform as the solutions were developed. This would prove to be great asset when the proposed solutions came to be costed later in the masterplanning process.

Figure 4: Example of GIS platform output for the proposed solution in Waikowhai (Mt Roskill masterplan)



6 GIS: AN INTERACTIVE DELIVERABLE

6.1 PROVIDING COST ESTIMATION INTEGRATION

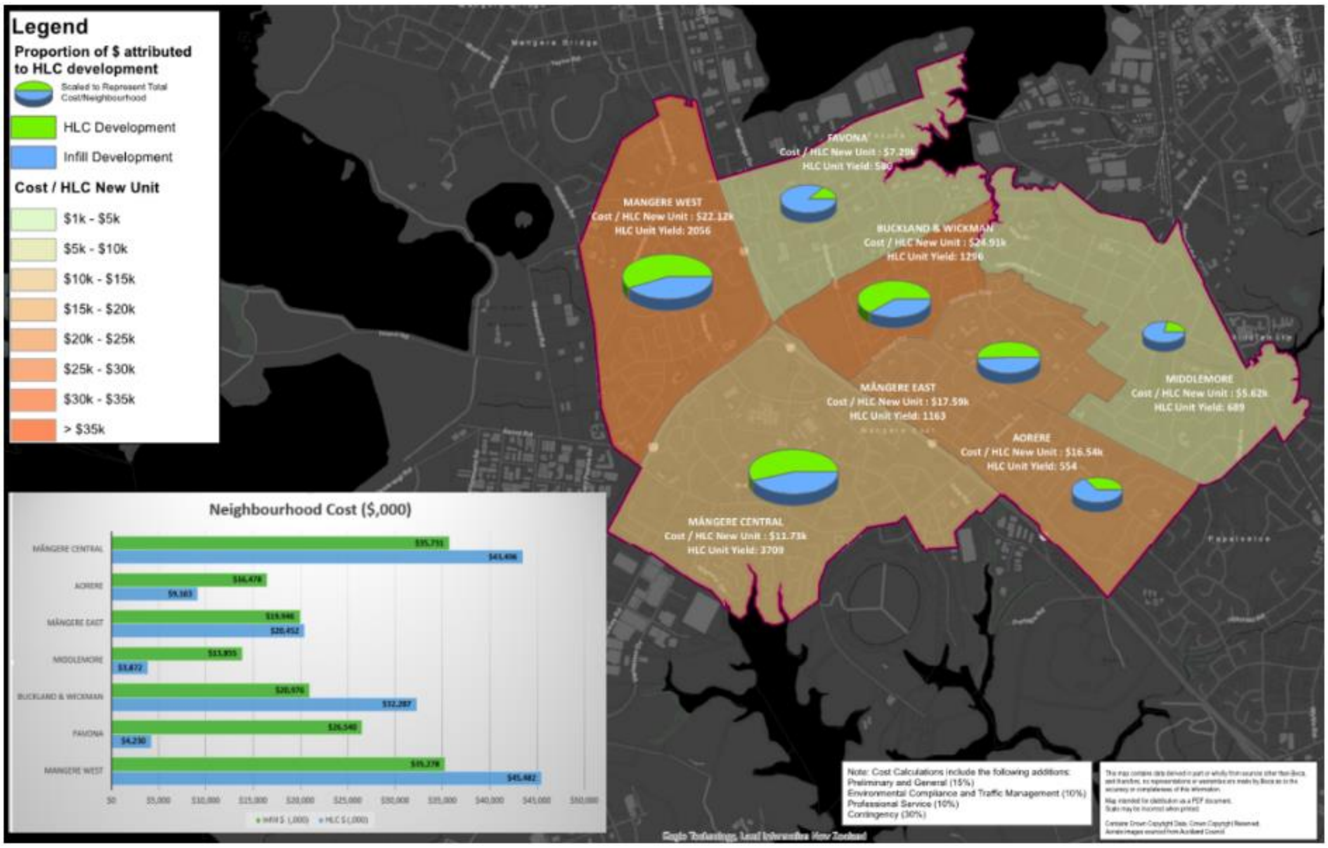
A cost estimation exercise was carried out as part of the infrastructure masterplanning to evaluate the costs associated with providing infrastructure solutions for intensification of HLC sites. The costs could be categorised three ways – public infrastructure upgrade costs, infrastructure costs that directly serviced individual sites, and on-site costs associated with private development.

Cost estimates were prepared for all public infrastructure projects and some key on-site costs; these being geotechnical investigations and related works (e.g. piles and foundations), remediation of contaminated land and on-site stormwater solutions where applicable.

Generally, to maintain a level of uniformity and allow for more straightforward manipulation, costs were tied to mega-lots. Cost attributes were set for all identified infrastructure projects and then linked to individual sites to spatially map total infrastructure costs. However, there were some cases where costs needed to be spread across portions of one or more neighbourhoods. For example, the costs associated with an arterial road intersection upgrade that bordered multiple neighbourhood boundaries. This approach meant the GIS platform allowed interrogation by discipline, neighbourhood, on a mega-lot basis (HLC and other), or on a per-unit basis (also HLC and other). Linking infrastructure projects to the individual sites being serviced allowed equitable funding contributions to be determined between HLC growth / other development and existing sites

In a similar approach to the traffic light mapping categorisation undertaken for the infrastructure disciplines, costs were integrated to create heat maps. The heat maps illustrated the cost of infrastructure development per new HLC unit, with red indicating more greater cost and green a lower cost. Generally, this meant the heat maps also illustrated where development areas were more straightforward versus areas that had more complex infrastructure.

Figure 5: Example of GIS platform output for a Mangere Precinct infrastructure cost heat map



6.2 RESIDUAL COSTING RISKS

It is important to note the high level nature of a masterplanning assessment and the long duration associated with HLC's planned development does result in a reasonable margin of risk regarding costing. Development from conceptual solutions to fully designed infrastructure is likely to change costs and changes in practice overtime are likely to have an influence as well.

Some key considerations that emerged from the integration with GIS included:

- On-site costs only include land contamination remediation and foundation costs (which were included in the masterplanning study as they affect constraints and therefore timing) and some stormwater infrastructure (where on-site solutions have been applied as an alternative to public infrastructure upgrades). Otherwise costs apply to public infrastructure works to the lot boundary;
- There are opportunities to share costs of infrastructure projects servicing wider areas as well as the opportunity to fund part of the infrastructure upgrades through renewals programmes. Conversely, due to timing or to slow infill growth, there is a risk that the greater proportion of infrastructure costs may be borne by HLC than assumed in this masterplan. Different scenarios of this can be tested throughout the GIS platform;
- Specific allowance has not been made for realignment of services (water supply, wastewater, power, communications or stormwater) through sites so as not to cross final building platforms. This, however, could be a reasonable cost and higher than the typical on-site servicing costs for a greenfield development. There are ways of minimising this additional cost in

a site development approach, such as foundations that bridge over existing services or building layouts that avoid existing services. Some of the services will be public, in particular gravity wastewater and stormwater lines.

6.3 SEQUENCING

The use of a GIS platform meant the different discipline outcomes and cost estimations undertaken could be integrated to inform the client on development sequencing. Given the large number of properties HLC has undertaken to redevelop across the Precincts, developing an informed sequencing plan is essential. The interactive platform allowed HLC to interrogate certain properties and aspects of the GIS platform and see what constraints are likely to occur and where.

The traffic light mapping system allowed for rapid identification of an areas readiness for development and therefore inform the sequencing of development within a precinct. By integrating the constraints and solutions in the GIS platform additional external factors that may impact the level of readiness of a given neighbourhood could be identified. For example, the construction of the Central Interceptor (CI) wastewater tunnel could dramatically alter certain neighbourhood’s readiness for development from a wastewater standpoint. A local network could be under capacity for the projected development if it were to occur prior to the construction of the CI; however, if it were to be developed after CI the existing network may be sufficient and require minimal or no upgrade to service the intensified development.

7 WHERE TO FROM HERE?

Further to what has been developed during the Mt Roskill and Mangere masterplanning stages, there is significant potential to continue developing the GIS platform. The masterplanning activity has developed an initial method for development sequencing. As design progresses and decisions are made by HLC this could be further developed to provide a staging platform, for both design work and construction.

There is the opportunity to expand the platform into a means of coordinating infrastructure design and construction. At this stage the platform provides high level solutions for infrastructure upgrades. As developed and detailed designs are undertaken these could be fed into the GIS platform, providing a geographically referenced design within an interactive map. Interrogative attributes could be expanded to include items such as timing, duration, and progress tracking. By utilising the GIS as a live platform this would allow up to date tracking of design, construction and stakeholder engagement.

8 CONCLUSIONS

The integration of GIS with infrastructure masterplanning has enabled Beca to produce a powerful tool for HLC in their redevelopment of HNZ housing stock. The use of GIS allowed constraints assessments to be undertaken for a range of infrastructure disciplines on a large scale (10,000+ properties). The development of a traffic light mapping approach enabled rapid identification of constraints and allowed neighbourhoods to be categorised according to their readiness for development, both by discipline and overall.

In the stormwater discipline in particular, the use of a GIS platform allowed a decision tree flow chart to be adapted into a spatial model. The base structure of which could theoretically be applied to other areas in the future, provided the technical input shapefiles are available.

The interactive format of the platform allowed for user interrogation of specific items (e.g. traffic light categorised properties or proposed infrastructure projects) so specific attributes could be displayed concerning that item. Interrogation of constraints generated from the decision tree model allowed the user to view why a property had been categorised a certain way.

Costs were able to be integrated into the platform, becoming an assigned attribute to infrastructure projects. GIS allowed the costs to be attributed back to a mega-lot level, providing the ability to present the costs in different scales or formats, depending on the requirement of the data.

At this masterplanning level the GIS platform has allowed Beca to produce an interactive tool to help HLC make informed decisions regarding the potential readiness of development across the neighbourhoods of Mt Roskill and Mangere. As HLC development progresses over the next 10-15 years the platform has the opportunity to provide ongoing benefits. There is the opportunity to expand the GIS masterplanning platform to include progress tracking for design, construction and infrastructure works staging.

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