APPLYING AGILE PROCESS MANAGEMENT TO FLOOD HAZARD MODELLING

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ABSTRACT (300 WORDS MAXIMUM)

Fast model builds are essential if Auckland Council is to keep pace with rapidly developing greenfield areas and adequately plan stormwater infrastructure in catchments like the Hingaia Stream. With no detailed catchment model available for the Hingaia Stream catchment, Auckland Council applied Agile Process Management techniques to develop a Flood Hazard Model (FHM) that would service both the needs of the developer and Council planners for a Plan Change Variation in just seven weeks. Council's Flood Planning Team leveraged off their Modelling Project Office to use multiple consultants and Council modellers to develop a fast and detailed 1D-2D coupled catchment model, utilising the latest LiDAR data. The FHM is suitable for Plan Change purposes and testing gross landform changes. The FHM model also provides the platform for subsequent model refinement for flood hazard mapping.

The Agile Management approach demonstrates that fit for purpose model builds can be achieved within significantly shorter timeframes and in a manner that provides better value to Auckland ratepayers, whilst maintaining quality. These achievements help to meet the city's objectives relating to enabling growth and helping making Auckland the world's most liveable City. In summary, by using Agile, Auckland Council achieved:

- A fit for purpose model in short time frame.
- New model build and review tools that will be usable on other model builds.
- An outcome-focused collaborative working environment.

KEYWORDS

Stormwater Modelling, Agile Process Management

PRESENTER PROFILE

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1 INTRODUCTION

The objective of this paper is to explore the benefits of applying Agile Process Management techniques to Flood Hazard Modelling (FHM) build projects. It outlines the approach by Auckland Council (AC) to develop a sufficiently detailed FHM in an accelerated timeframe. The Agile Approach leveraged off AC's Modelling Project Office (MPO) to improve collaboration between AC, suppliers and customers and has enabled better outcomes for both AC and developers (Nitsche *et al*, 2016). Agile Process Management has been used in software development and achieved significant benefits in terms of programme.

The following sections describe the FHM model context and the application of Agile Process Management to this project in further.

2 BACKGROUND

The Auckland Plan shapes how Auckland should develop to progress towards becoming the world's most liveable city. Auckland Council's key role is to identify and deliver development opportunities to meet the growing needs of the region. the Council's Healthy Waters Department operates and maintains the existing stormwater infrastructure. Planned network extensions and enhancements serve to manage flood risk and facilitate growth.

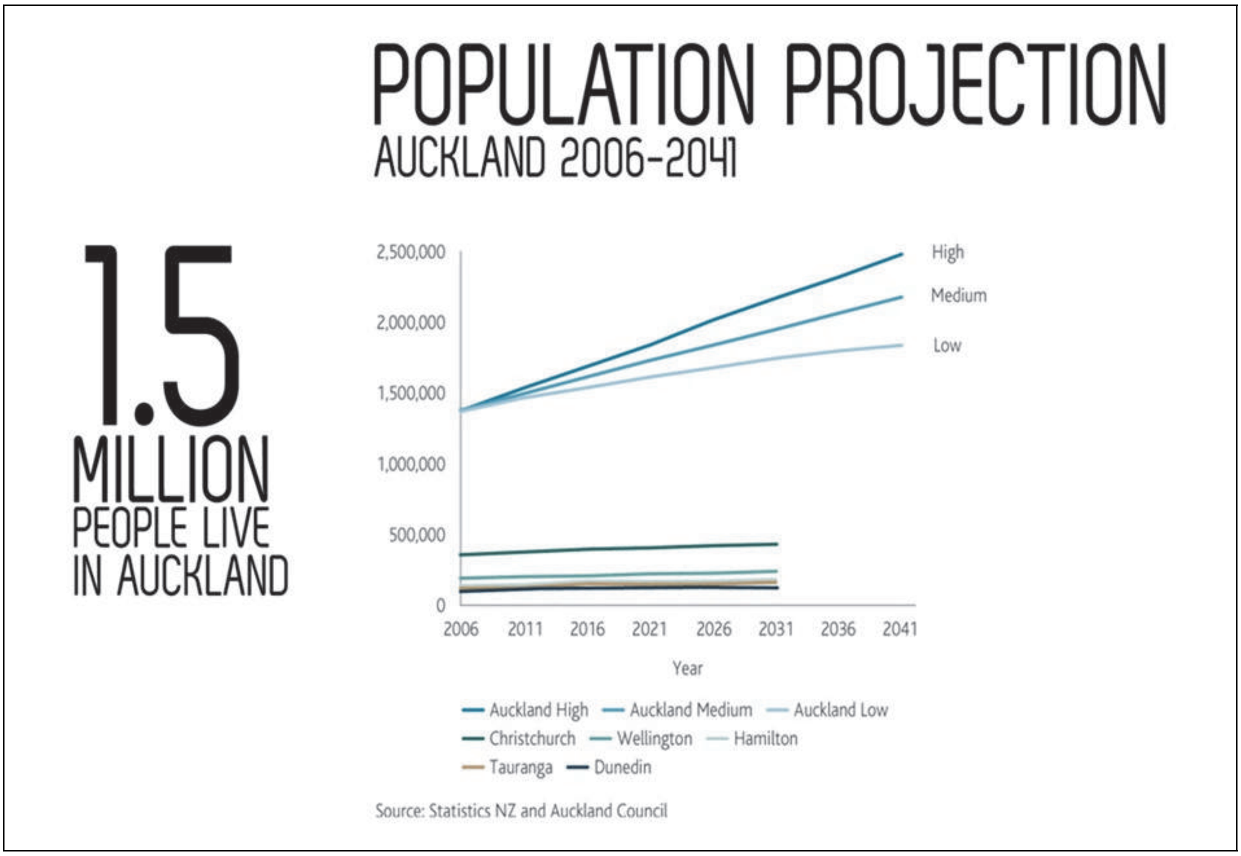
2.1 AUCKLAND GROWTH

Auckland is the fastest growing city in New Zealand with a forecast sustained population growth of 45,000 people per annum. While other major New Zealand cities are forecast to grow by 10% over the next 30 years, the Auckland population is increasing by 10% every three years. Over 60% of New Zealand's growth is forecast to occur in Auckland, with the region's population reaching 2.5 million by 2041 (Figure 1).

Population growth places pressure on existing services and infrastructure. Careful planning can minimise the impact that growth can have on both the rural and urban environment. Auckland Council's challenge is to continue its transformational journey towards becoming the world's most liveable city while catering for this rapid change in population. The Auckland Plan and the Auckland Unitary Plan are frameworks for development which will help Auckland achieve the ecomonic and housing shortfall as a result of growth pressure.

The Auckland Plan, adopted in 2012, is the shared Auckland Vision to guide Auckland's development over the next 30 years. The Plan outlines where to build specific types of development within the Region while promoting compact, higher quality developments. The Auckland Plan also tackles issues such as reducing transport and housing shortages, creating jobs and protecting the environment. The aspirations outlined in the Auckland Plan have been translated into development rules in the Unitary Plan. The development time frames proposed by the Unitary Plan cater for the next 30 years of development.

Figure 1 Population Projection of Auckland to 2041



As well as rezoning areas for growth in 2016, the Unitary Plan includes "Future Urban" areas which will be live zoned and developed in future years. Proactive planning is essential to maximise the development opportunities when these areas come forward for development. An consolidated design approach that incorporates flood risk management as part of the strategic planning process will enable future growth while providing protection from flooding.

2.2 HINGAIA STREAM CATCHMENT

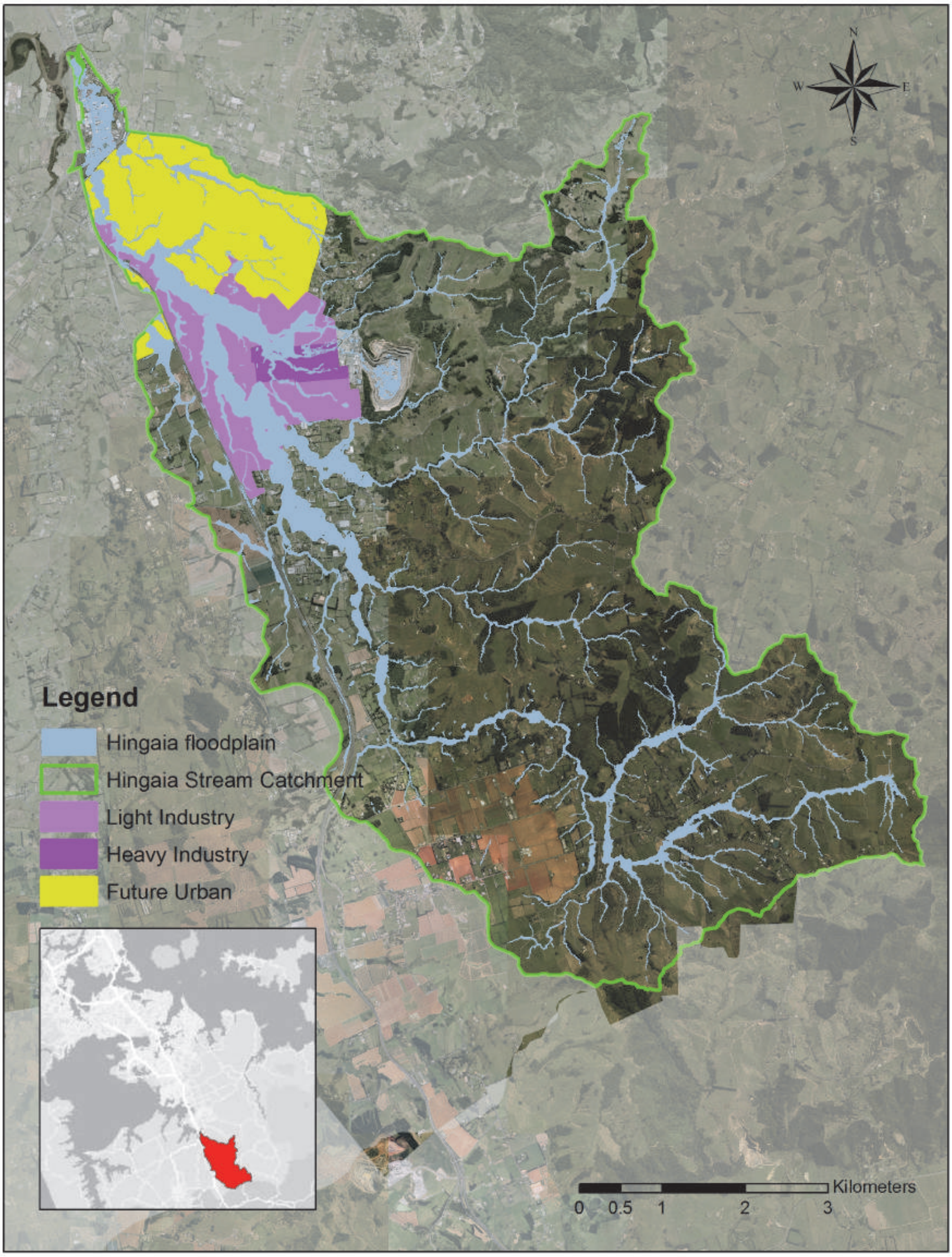
The Unitary Plan has identified extensive areas of rural land in the southern Auckland Region as "Future Urban" areas. This growth priority area is known as the Southern Initiative (FULSS, 2015). This Southern Initiative area is one of two significant areas prioritized for growth within Auckland.

The Hingaia Stream is one of the river catchments that falls within the Southern Initiative area. With its headwaters in the Hunua Ranges south of Auckland, the predominantly rural Hingaia Stream catchment (Figure 2) drains through the flat Ararimu area at Drury before flowing through Drury Township and discharging to the Manukau Harbour.

The Hingaia Stream catchment is is 55km^2 in area, produces over 10,500,000 m^3 of runoff in a 1% AEP event and contains one of the deepest floodplains in the Auckland Region. The stream is highly constrained through the urbanised Drury Township at the downstream end of the catchment. As a result, Drury Township suffers from frequent and extensive flooding. The Southern Initiative areas in Drury and Ararimu are also subject to flooding and management of flooding and minimizing effects on others is an important consideration for developments located here.

A private plan change application for a 361 Hectare industrial area, called Drury South, has brought development in the catchment forward. In addition, the Unitary Plan identifies another 370 Hectares of "Future Urban" area in the Hingaia Stream catchment. The extent of the Industrial zoned plan change area and the Future Urban area are also shown in Figure 2.

Figure 2 Hingaia Stream Catchment



2.3 DRURY SOUTH

The Drury South development area is located upstream of Drury Township and partly within the floodplain of the Hingaia Stream catchment. The original Private Plan change comprised of 361 Hectares of entirely industrial development.

To maximise development yield for the Industrial zone, extensive earthworks are proposed to consolidate the floodplain to provide large, flat land parcels suitable for industrial development. The proposed manipulation of the floodplain requires up to date flood modelling to test the feasibility of these modifications to ensure there is no increase in flood risk to Drury Township downstream or any areas beyond the plan change boundary. The assessment of effects would need to consider flood frequency, depth and flows.

The original Plan Change application was made using a legacy model to assess the development effects on surrounding areas. It was not possible to use this legacy model for assessing effects in low order events. A further effects assessment, including at low order events was required by rules in the Plan Change.

A Plan Change Variation for a residential component within the Drury South industrial area is more recent and has been approved under the Housing Accords and Special Housing Areas (HASHA) legislation. The HASHA legislation enabled the assessment of Special Housing Areas (SHA's) and required a condensed six month assessment timeframe for greenfield developments. Notification and Appeal are limited under HASHA legislation.

The model described in this paper was used to support the SHA application. Subsequently, the SHA was granted and it and the Drury South Business Park have been included in the operative Auckland Unitary Plan.

3 FLOOD MODELLING

A detailed FHM is a robust way to assess development effects in a complex catchment. In this case, the FHM needed to be suitable for the developer to rapidly test options within their SHA application timeframes.

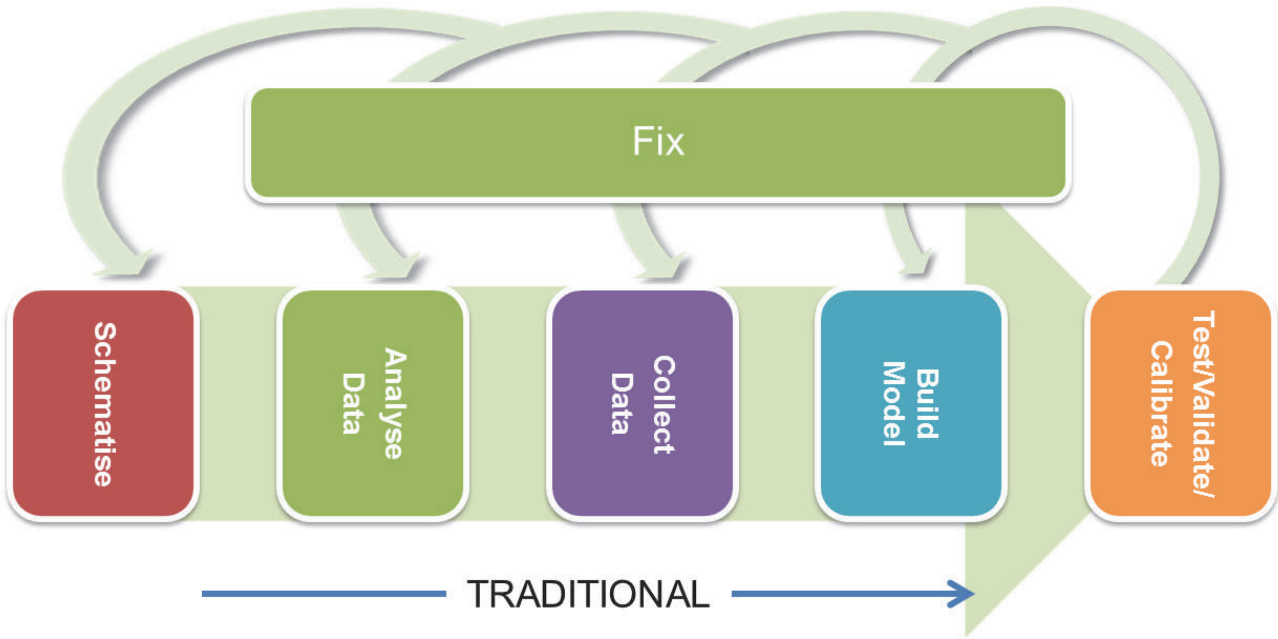
A detailed, 3-way coupled FHM for the Hingaia Stream catchment was being developed during the SHA Plan Variation application. The FHM model relied on an extensive classic mesh 2D domain which had unworkable run times for options assessments being carried out by the developer. In an effort to reduce model runtime, the model's 2D domain was converted from classic to flexible mesh. A review identified significant technical issues following the mesh conversion. These issues delayed the FHM programme, making it impossible to complete the FHM in time for the SHA application.

With no detailed catchment model available for the Hingaia Stream catchment, Auckland Council applied Agile Process Management techniques to develop an FHM that would service both the needs of the developer and Council planners for this Plan Change Variation in just seven weeks. Council's Flood Planning Team leveraged off their Modelling Project Office to use multiple consultants and Council modellers to develop a fast and detailed 1D-2D coupled catchment model, utilising the latest LiDAR data. The process Auckland Council used to achieve this outcome is outlined in the following sections.

3.1 TRADITIONAL MODELLING APPROACH (NOT USED)

The traditional modelling approach follows a systematic but linear process which has a series of sequential tasks (Figure 3). Under this approach, Model Schematisation is followed by a Data Gap Analysis, Data Collection, Model Build and finally confirmed by model Validation or Calibration based on actual recorded data. Issues with the model are best picked up at the Test/Validate/Calibrate stage. There are programme risks associated with only identifying significant issues at the end of the process. This results in further model amendments or 'rework' and results in delays. These changes sometimes require more survey or changes in model build processes which are very flexible and user specific. Sometimes the model needs to be reschematised. When project timeframes are short, the testing phase can be rushed, resulting in a poor quality model deliverable. The short available time frame for this model build demanded a different approach to minimize rework and having to retest the model.

Figure 3 Traditional Modelling Process is linear



3.2 AGILE PROCESS MANAGEMENT

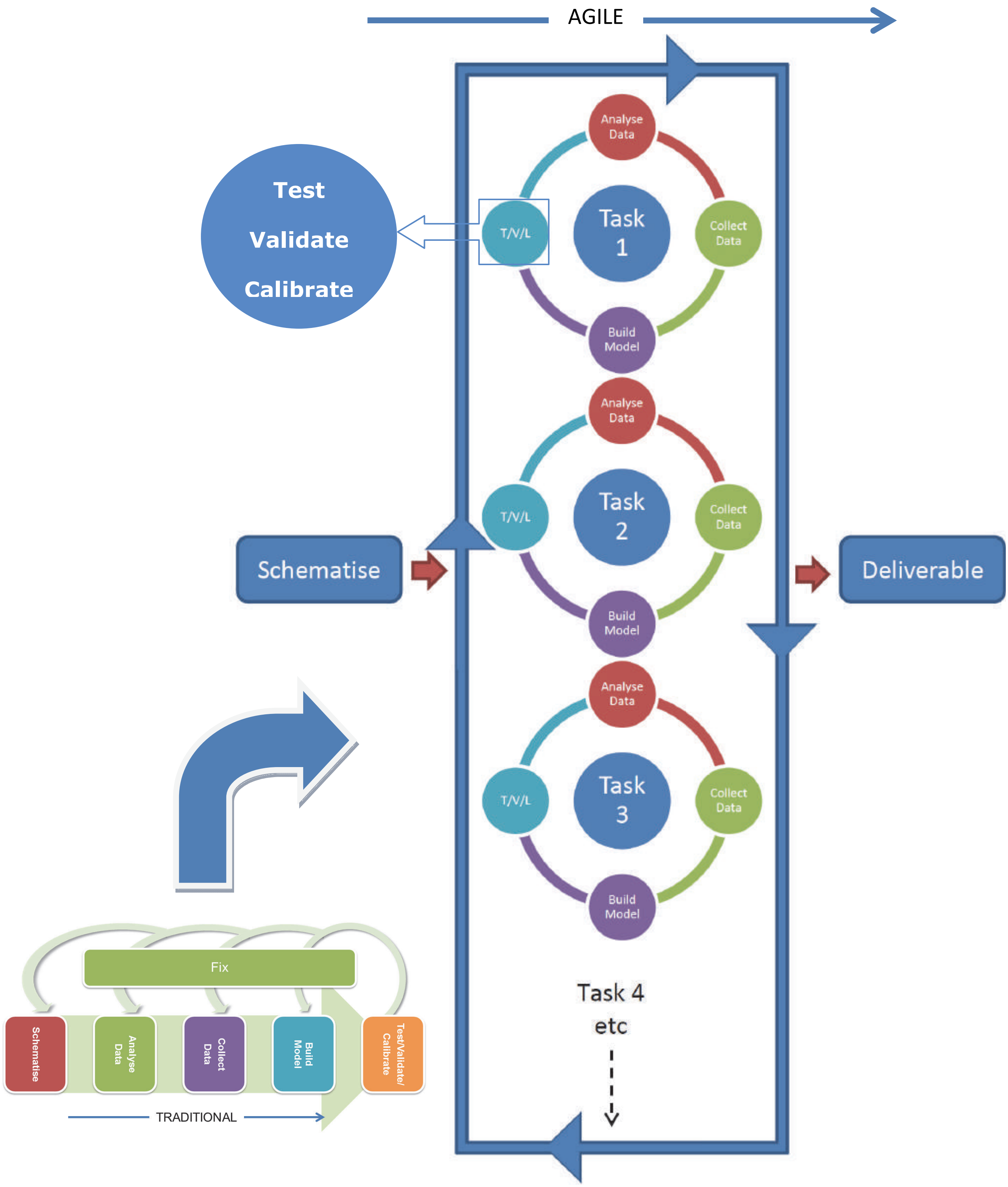
Agile software development techniques were applied to the Hingaia Stream catchment model build. Agile Process Management refers to a toolbox of software development methodologies that are based on iterative processes and parallel workstreams. This approach to model development enables solutions to evolve quickly and concurrently throughout the development process, rather than being planned upfront and amended late as with a traditional approach. Many of the risks associated with the traditional model build process are minimised through this approach. The Agile approach includes frequent parallel review and being highly adaptable. The Agile philosophy fosters collaboration, self-organisation and accountability to rapidly develop a high quality end product.

The Agile process differs from the traditional approach by identifying tasks and maintaining flexibility between these tasks which occur continuously rather than sequentially. The Agile toolbox methodology applied to this model is represented visually in Figure 5. The continuous evolution/feedback of all tasks in the model build process has multiple benefits including:

- Model testing and Quality Assessment starts from the first day

- Confidence in the project timeframe improves. When you're halfway through the model build process, you're halfway through producing a fit for purpose delivereable.
- Parallel review and early feedback significantly reduces risks around programme.
- Parallel tasks mean quicker model build.

Figure 4 Agile Process concept

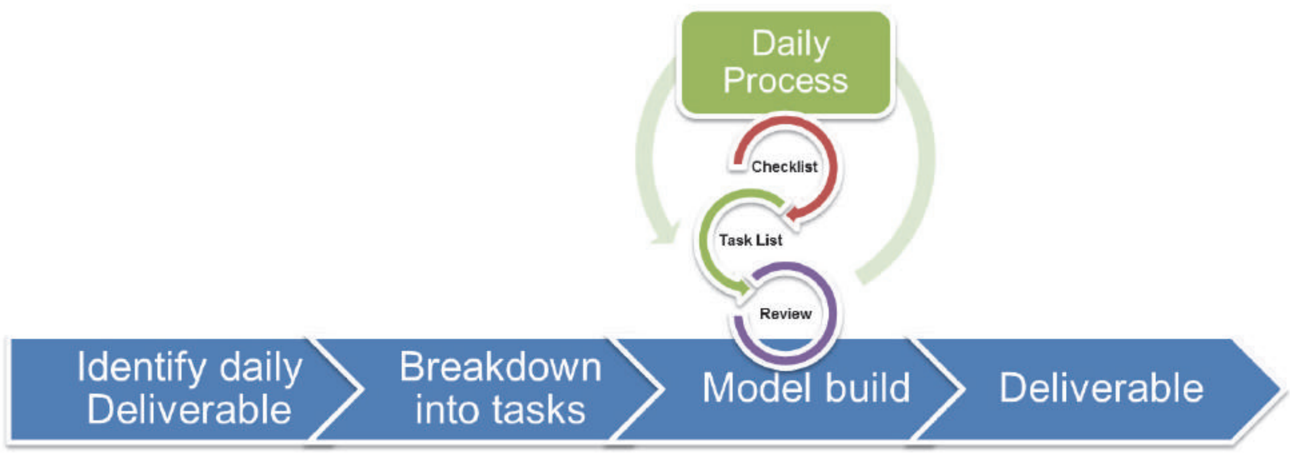


At the beginning of the project the deliverable was clearly identified. To help define the necessary deliverable, the potential model components were sorted as Essential, Aspirational and Unnecessary. For example, the existing pipe network in Drury Township did not need to be included in the catchment model to support the SHA application and was defined as unnecessary. A 2D mesh, 1D channel/structures and lateral links were essential. This enabled the team to streamline the model build.

The Agile process normally does not have a completion deadline in place. However, in this case, Auckland Council had a seven week timeframe to complete the model build. Each model component was given a rough deadline so that the overall model build could be completed within the timeframe. However, a detailed task list was never developed upfront. This is how Agile distinctly differs from traditional approaches. The task list instead evolves daily as issues are resolved or new issues are identified.

On a daily basis a Checklist, Tasklist and Review process was undertaken (Figure 5). Checklist is a quick 15 minute morning meeting where each team member confirms what they completed the day before. The team outlines what they plan to do for the rest of the day. The Team lists their issues, but these are not necessarily discussed or resolved. The modelling team then work on their planned Tasklist for the day. The project manager resolves non-technical issues and manipulates individual task lists to resolve technical issues. The modellers immediately pass all completed tasks in for Review. Review is undertaken on a daily basis in parallel to the model build process to avoid rework and speed up the model build. The daily process is repeated to achieve the final delivereable.

Figure 5 Agile daily process as applied to Hingaia Stream model build



3.3 HINGAIA STREAM MODEL DEVELOPMENT APPROACH

At the start of the seven-week model build timeframe, there were a number of possible approaches that could be taken to produce a fit for purpose model for the Plan Change variation. The initial approach chosen was to fix the issues with the partially completed FHM model that had severe issues with 1D – 2D coupling issues and longer run times. The 1D-2D issues was related to the lateral links. Resolving the lateral links issue was the first priority followed by reducing the overall run time. The objectives of the project were:

- To produce a model capable of predicting water levels and flows for extreme events across the catchment.
- Develop a model that is fit for the purpose of testing gross landform changes at the Drury South Structure Plan Area.

- Validate the model performance against historic storm events.

- Develop a base model that can be further developed for catchment planning purposes.

A hydrological and hydraulic model of the Hingaia Stream Catchment was developed using the Mike Flood suite of modelling software. The model is based on ARC TP108 rainfall-runoff modelling methodology and is a dynamic coupled 1-D and 2-D model. The 1D model contains all hydraulic structures and the main stream channels; the 2D model represents the floodplain conveyance and storage.

The catchment was studied in detail to reduce the 2D extent to improve model run times by:

- Completely including the major lowland floodplain extent from a Rapid Flood within the 2D domain.

- Ensuring cross sections for the 1D channel outside the 2D domain were wide enough to store and convey all flows.

- Reresenting overflows for structures in 1D using weirs.

- Reducing the number of mesh elements (over 3 million mesh elements in the original model) by approximately 80%.

- Reducing the number of couples from the 1D model by approximately 80% and reducing dependence on CPU processing.

- Changing from Classic to Flexible Mesh to reduce model run times and enable the ability to use GPU to process the 2d mesh.

A variety of tools were developed as a part of this project to capture anomalies in the model easily without much manual intervention. GIS outputs and WaterRide were used to identify issues easily which helped fix them quickly.

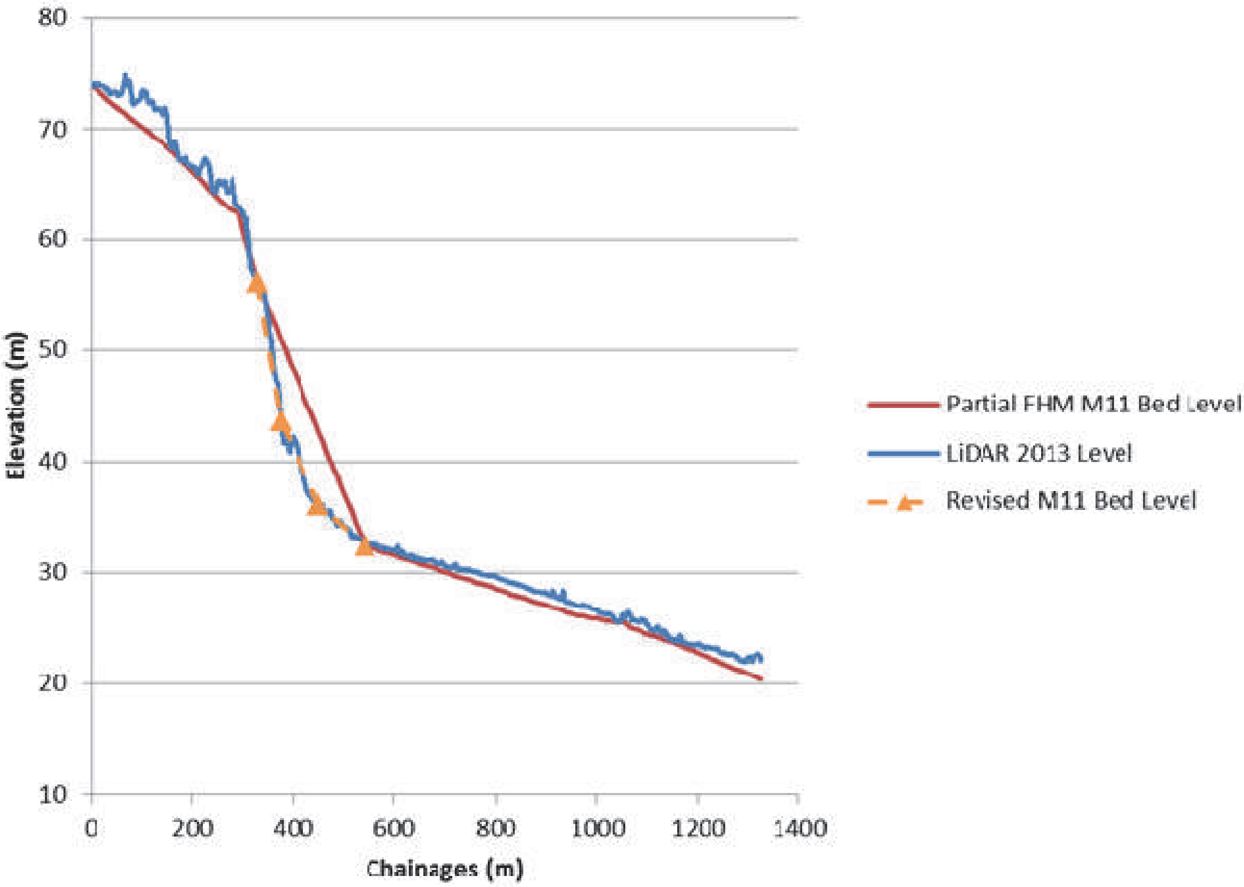
Auckland Council utilised a high spec, custom build modelling computer that included twin GeforceGTX graphics cards to process the 2d mesh efficiently and further reduce model run times.

3.4 HINGAIA STREAM MODEL BUILD PROCESS

The modelling processes for this 7-week model build are summarised below.

1. Surveyed cross sections for the model were imported into a new cross section database and interpolated cross sections were added wherever necessary. Due to the large distances between surveyed cross sections in the Mike 11 model, changes in gradient of the channel inverts were often not represented well by the interpolated cross-sections. In some cases Mike 11 inverts were higher than the linked bathymetry on the banks. In areas where LiDAR levels were lower than the interpolated cross sections, the interpolated cross sections were shifted down until invert levels matched the lowest point. An example of modifications made to the Mike 11 channel bed level is shown in Figure 6 below.

Figure 6 Modifications to the Mike 11 Channel Bed Levels



2. An overflow was added to every structure to ensure appropriate representation of overtopping for large events.

3. The 2015 model was updated to reduce the 2D mesh extent to reduce run time and increase stability. The maximum mesh element size used for meshing was $20m^2$. The lateral links between 1D open channels and 2D domain were kept unchanged in locations where they were stable and modified where necessary following parallel review.

4. The 1D river channel extent was revised from the partial FHM model to match LiDAR 2013 accurately. The 2D model domain was reduced to cover the RFHA flood extent only and the upstream channels were represented in 1D only without any lateral linking to 2D. The final 2D mesh extent was reduced representing some of the upstream channels in 1D only without any lateral linking to 2D (Figure 7). This reduced the number of mesh elements from 3,173,881 to 633,482.

5. Lateral Link issues like those in the partial FHM had not been encountered before, there was a risk in assuming the lateral link issues could be resolved within the available timeframe. To minimise this risk, a new catchment model was also developed from scratch in parallel with fixing the existing, partially completed FHM. Common model build componants were shared between the two models where possible to reduce doubling up on work.

6. For some aspects of the new model build and corrections to the old model, both automated tools and manual methods were used. In some cases new automated tools new methodologies were developed.

Automated tools were developed for supporting:

- Mike 11 runoff model build.
- CN calculations using different GIS sources to calculate imperviousness within each subcatchment.

New methodologies and workflows were established for:

- checking and rectifying coupling between 1D open channels and 2D floodplain levels and results.
- slope analysis to relate mesh element sizes with ground slopes to avoid massive differences in adjacent elements.

7. Lateral links were rebuilt and special attention was given to the following points while confirming the location of lateral links:

    - Lateral links did not have vertices within the no mesh zone used for Mike 11 in 1D.
    - Lateral links were present in locations where 1D-2D interaction was expected.
    - Additional interpolated cross sections related to every lateral link were added. This avoided problems associated with widely spaced cross sections being unable to preserve elevation.
    - The elevations at lateral links were the same as the cross section bank markers.
    - In Mike Couple, lateral links were set with the default exponential smoothening factor of 1, structure type of weir and M21 source type.

8. A live model log was developed to keep track of the multiple work streams and models under development. A summary of part of the model log is shown in Figure 8 below. The model log was colour coded to represent the status of each model run.

Figure 7 Final Hingaia Stream catchment model schematisation

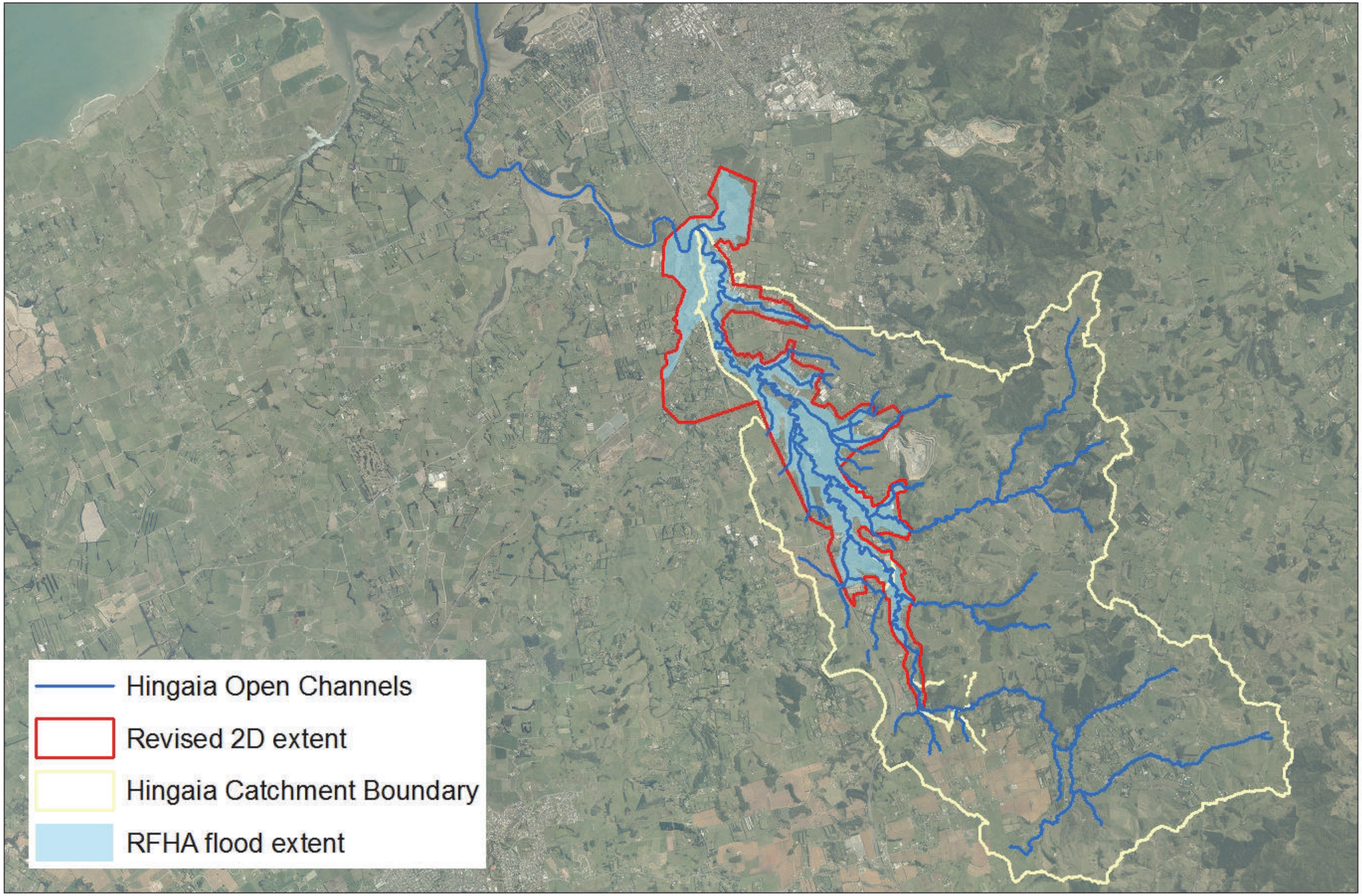
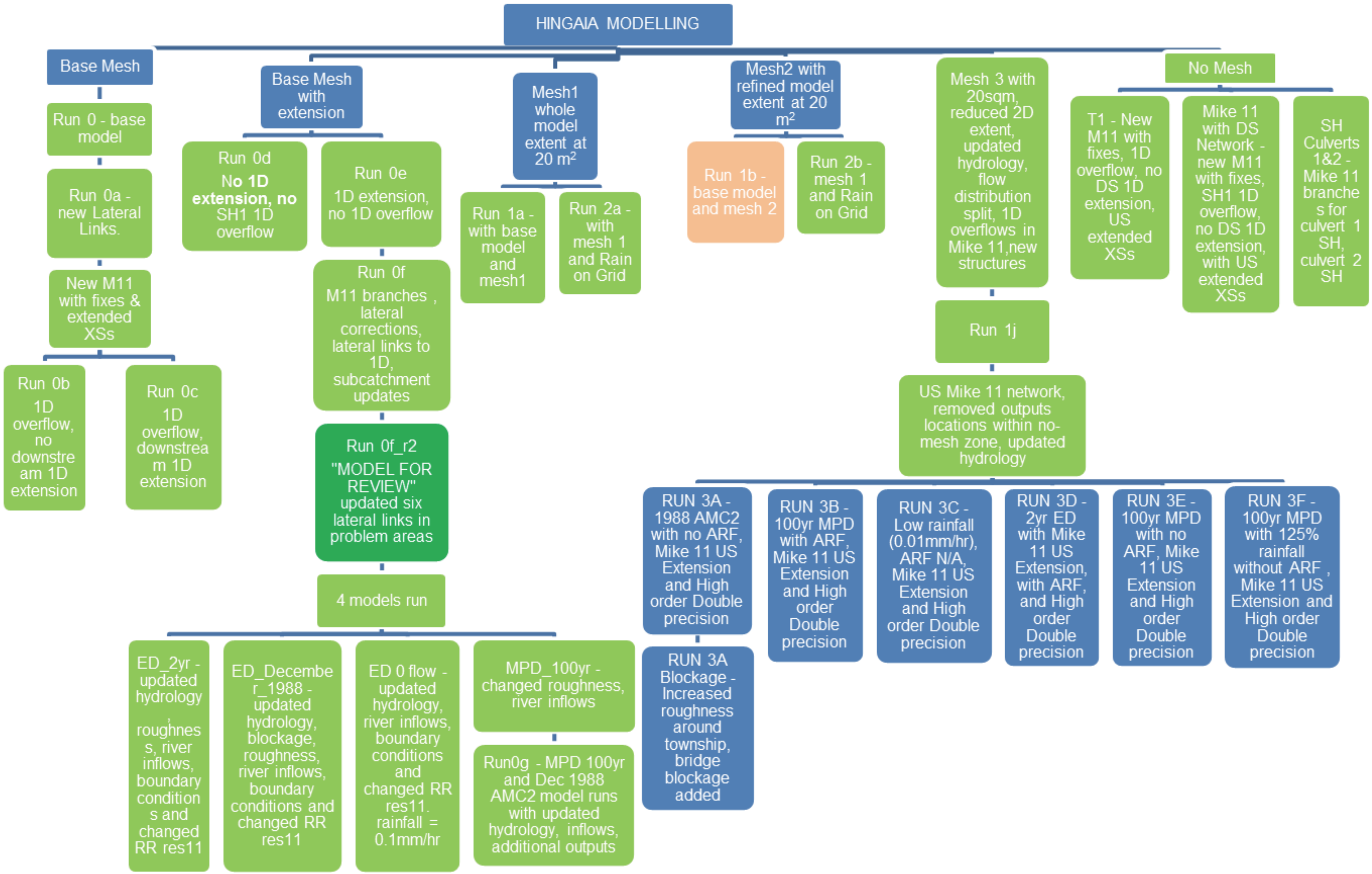


Figure 8 Hingaia Stream Modelling Log



4 MODELLING PROJECT OFFICE

The AC Healthy Waters department has implimented the Modelling Project Office (MPO), consisting of Council staff and seconded modeling consultancies (Nitsche et al, 2016). Projects run through the MPO have improved collaboration and innovation as well as providing increased value for AC's ratepayers. The procurement process is far quicker through the MPO than through the normal tender process as the secondees are already procured. This modelling project leveraged off the MPO to minimise the project start up time so that the entire 7 weeks could be spent on the modelling work.

The MPO gives the Healthy Waters department access to multiple consultancies and enables close collaboration between AC staff and the consultants. Two modellers for this particular project were selected based on their skill sets. As these key modelling consultants were already working on other Council projects, it was necessary to reprioritise and divert them onto this project full time. This enabled the key modelling resources to stay focussed on this particular project rather than balancing several projects at once. Some aspects of the modelling work required additional resourcing on a temporary basis. This was possible at very short notice through the MPO, and at times up to 11 Council modellers and MPO consultancy modellers from up to three companies were working on this project.

5 THE OUTCOMES OF THE AGILE PROCESS

5.1 KEEP FLEXIBLE (AGILE)

Daily progress and review allows quick changes of direction and to minimise the model build time.

5.2 FASTER DECISION MAKING

Leveraging off the MPO allows for in-house collaboration (Nitsche, 2016) and promotes trust. This enables different consultancies to work together and extend their knowledge to others within the MPO as well as their own home offices. This collaborative working approach enabled input from all our consultants which supported fast decision making.

5.3 TOOLS DEVELOPMENT

The Agile approach resulted in the development of several new tools and automated processes. Some of these tools have since been further refined and will be utilised in the future on other AC modelling projects.

5.4 PROGRAMME

The Agile Approach has no project deadline but typically results in deliverables being produced faster than following the traditional approach. A non-negotiable seven week deadline was imposed on this project, which resulted in the need for overtime. If no deadline had been in place and no overtime work undertaken, the model programme would have been extended by less than 50% This is still significantly quicker than following a traditional linear gantt approach. Carrying out tasks in parallel rather than sequentially and carrying out ongoing testing and review throughout the model build contributed to a significantly accelerated programme. The project was heavily resourced to further accelerate the programme.

5.5 INTENSIVE REVIEW

The parallel review approach enabled issues to be picked up early and before model build progressed too far. A more intensive review approach was taken on this project, which reduced the risk of unexpected delays through rework. The intensive review approach was more costly but was necessary to meet the project timeframes.

5.6 PROJECT COST

The overall project cost was in the order of 60% of of the typical cost to develop a model of this type and size. This includes the increased cost associated with the parallel review, which was offset by the savings made from avoiding rework.

5.7 MANAGEMENT SUPPORT

Agile inherently does not have a known or planned program deadline. The Agile approach is beneficial where scope is not known and allows managers and clients to change their mind throughout the development process. However, Agile only works with management support and buy in.

Agile is very flexible and allows constant evaluation of progress, milestone achievement and risk. The traditional linear approach gives the illusion of an achievable and known scope, programme and cost. The reality is that the planned deliverable is seldom achieved within the original scope, programme and cost. The Agile approach does not plan the scope and programme up front, but rather relies on constant prioritisation of the deliverable requirements. To use the Agile approach, managers need to buy in to an unknown outcome up front and trust the modellers and project manager to deliver a quality outcome.

Managers are more used to the traditional approach with a planned programme deadline, even though they are aware of the delays with this approach. This model build would have taken approximately 12-18 months to complete by following the traditional, linear modelling approach.

6 CONCLUSION

The Agile Management approach demonstrates that fit for purpose model builds can be achieved within shortened delivery times and in a manner that provides better value to Auckland ratepayers, whilst maintaining quality. These achievements help to meet the city's objectives relating to enabling growth and helping making Auckland the world's most liveable City. In summary, by using Agile Process Management techniques, Auckland Council achieved:

- Delivery of a fit for purpose model in short time frame.
- New model build and review tools that will be usable on other model builds.
- An outcome-focused collaborative working environment.
- Value for Auckland ratepayers and developers.

ACKNOWLEDGEMENTS

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