A TRILLION DATA POINTS, ONE SOURCE OF TRUTH

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ABSTRACT

Auckland is experiencing a period of unprecedented growth, placing pressure on marginal areas, including some of the regions deepest and largest Flood Plains. 800 people per week are currently making Auckland their home. Demand for flood hazard information is high, whether for backyard subdivisions, or residential and industrial developments of many hundred hectares.

The Healthy Waters Department has embraced the Auckland Council driver to improve customer service. Detailed responses for flood hazard information are provided in a maximum window of as little as three days, to ensure Regulatory deadlines, and Council values are met. Results from stormwater modelling are often the best information available regarding flood hazard.

Auckland Council has good coverage of stormwater models across the region, however current storage across many legacy network drives presents a business risk with regard to consistency, accuracy, and speed of response to internal and external customers. The challenge is to present all modelling outputs in a controlled manner, in an easily accessible portal – to present one source of the truth.

Auckland Council is tackling this issue by mobilising modelling outputs with customised cloud based solutions. Models are being registered in an online cloud database, and the results presented in raster format in a cloud based portal. Mapped at $4m^2$, and with multiple models per catchment, this currently equates to tens of billions of data points, and will likely exceed a trillion points in the future – this demands innovative data storage and interrogation methodologies.

This paper shares aspects of the scalable solution Auckland Council is adopting, and how other Water Authorities may be able to adopt aspects of Auckland's solution, to optimise return on investment from modelling projects. The possibility exists for a nationwide model database, based on Auckland's investment in this area. Auckland Council brings one key message to other Water Authorities – start now!

KEYWORDS

Stormwater Modelling, Flood Hazard, Data Storage, Cloud, Business Process Management, Business Capability Maturity, Data Governance

PRESENTER PROFILE

Ken Williams, Principal - Flood Risk Modelling, Auckland Council – Ken has worked in stormwater modelling since 2001. Ken has worked across New Zealand, from the Far North, to Christchurch, and the Bay of Plenty. Ken shows most enthusiasm for management of modelling data to gain the most value for money and benefits realisation.

Tom Joseph - Technical Director – Data Analytics and Modelling, Mott MacDonald – Tom has a wide range of experience in New Zealand, including rain and flow gauging, hydraulic modelling, and computer coding. Tom holds a lead position on the Mott MacDonald Global Digital Strategy panel, and has a lead role in the development of the Auckland Council Healthy Waters Department data portal – Storm-i.

1 INTRODUCTION

Auckland Council is experiencing a period of unprecedented growth, with 800 people making New Zealand's largest city their home. Auckland is predicted to accommodate an additional 740,000 people, or three-fifths of New Zealand's population increase between 2013 and 2043, increasing the city's population by 50% from 1.5 million, to 2.2 million (Statistics New Zealand, 2017). Figure 1 shows the main growth areas across the region, which result from a number of Planning drivers, including Future Urban Land Supply Strategy, and Special Housing Areas.

The rapid growth will continue to place increasing pressure on marginal areas, including areas at risk of natural hazards, especially flooding. Auckland Council hold a regionwide set of models, which often present the best information around prediction of flood hazards in a catchment. It is essential for Auckland Council staff across many departments, the public and engineering community, to have access to the most up to date modelling information to guide development decisions, and in the future to implement initiatives such as flood forecasting and warning systems.

The challenge is considerable. The Auckland Region is split into 233 stormwater catchments for administrative purposes, and there are often many models per catchment. The region is 5500km^2, making the average catchment 23km^2, with an average 309ha per catchment of currently published Flood Plain.

The audience is large. Several departments across Council use the data. The Healthy Waters Department alone receives several hundred requests per year for information related to Flood Plains – and this is expected to grow considerably. The driver is not only to enable growth, but to deliver value for money. A focusing statement, is *to enable good, consistent decision making, quickly, and cost effectively.* Customer service will increase in ways additional to providing comprehensive information faster. This project will help lead other initiatives, such as flood warning systems.

The foundation of this project is a reliable and complete database of models, updated rapidly with new models as they are delivered. Auckland Council initiated this project two years ago, with a manual stocktake of models, and a semi-automated scanning of all network drives, to heuristically identify potential models. This exercise was a success, identifying around 500 models. This number is of course growing every week, as new models are built, and there is specific knowledge of models held with people, not identified in the data sweep. The project started with building a cloud hosted database, allowing multiple users to collate model files, and enter database records simultaneously.

In parallel with constructing this database, a proof of concept was undertaken, to allow display and interrogation of basic model outputs (depth, level, flow). Given the large amount of data that will be stored in the long term, and the wide audience, a portal allowing centralised storage, and decentralised but regulated access is required. At this time, the platform tested is Storm-i, this has performed well in terms of cost of storing data (Amazon S3), speed of display and data interrogation, and for decentralised access and user control. With a list of models, a database to register them in, and a portal to present them in, it appears the ingredients to complete the project are in place. Council are taking this to a new level however, running every model before it is put into the database, and checking the reproducibility of results. Such checks will in future enhance peer review processes, before the models are accepted, showing how this project will also lead to a 360-degree improvement of modelling processes.

Model results reproducibility checking has presented a new challenge as it is found only around 1 in 5-10 delivered models are complete (all files delivered), and a similar proportion show good results reproducibility. A model is not worth a lot if the file set is incomplete, and the results cannot be reproduced – so these processes are essential, but we must find smarter ways of managing this.

This brings about some reflection on the methodology to date, and moving forward, some clear messages for other Councils looking to organise and publish modelling results as Auckland Council intend to do.

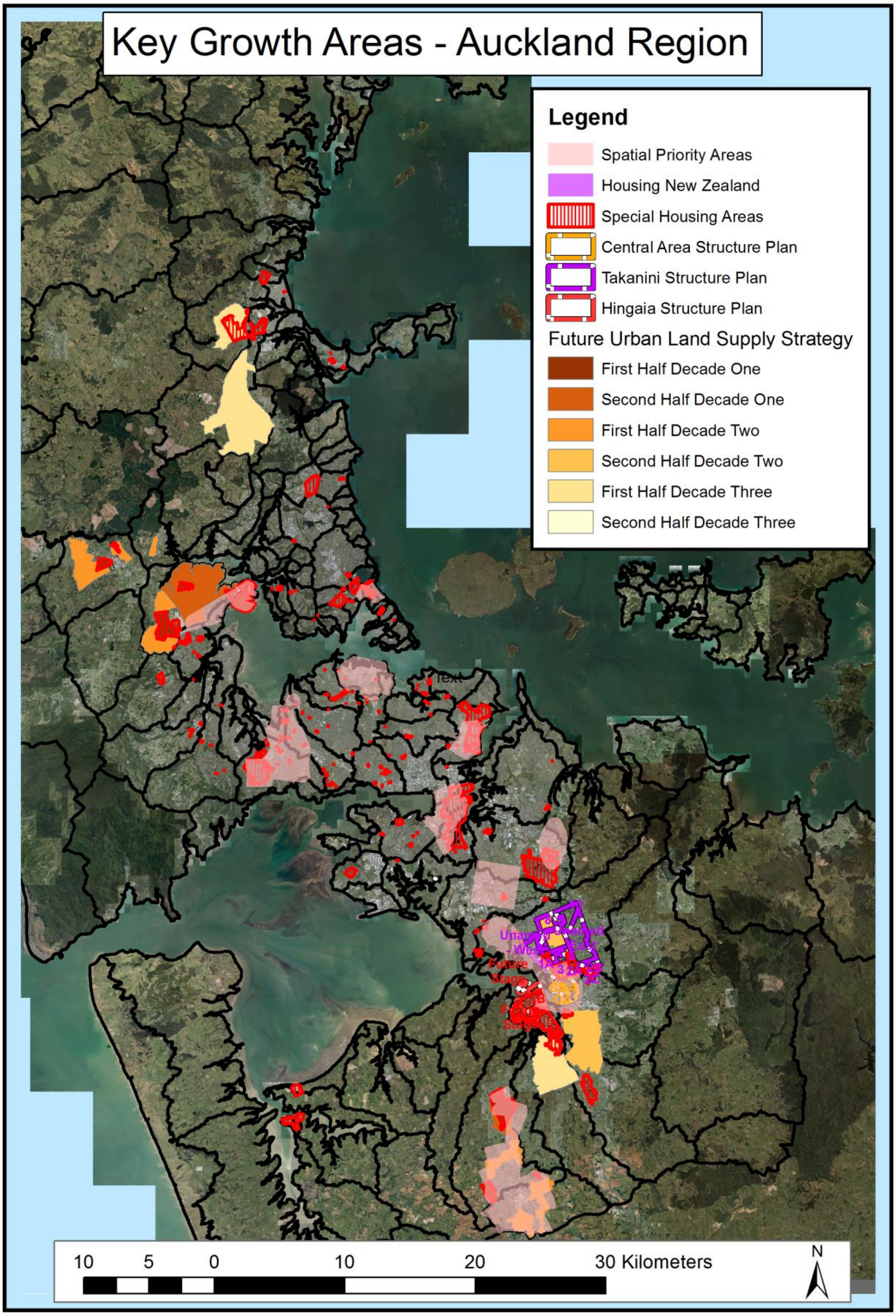
Start now, but look forward. Address the models being delivered now, and new contracts being let for outsourced work. Define the deliverables well, adopt systems for reviewing, and testing the delivered products, consider quality grading systems, and how to communicate the reliability of information. Systems are easy to implement, such as cloud based databases and other interfaces. Solutions are harder to implement, include thought leadership at key stages, and adoption of concepts such as Business Process Management (BPM) and Business Capability Maturity (BCM).

Auckland Council have explored these concepts around the differences between systems and solutions, and the workload and investment required, at, what still represents the early stages of the project. Auckland Council is as such in a position to share the learnings so far, and to identify challenges still ahead, and how these are likely to be addressed.

Another lesson is to dream big. Auckland Council have embraced the model registration project, as a part of a wider project – Storm-i. Storm-i is the consolidation of all Healthy Waters in one portal. This allows rapid display, interrogation, mashing of datasets together, and rapid, informed decision making. This project is a huge success to date, including rain gauged data, rain radar, pipe condition CCTV, and more.

In summary, the message is focus on the basics, but dream big – identify the key components, and quantify how they will be executed – and start now.

Figure 1: Key Growth Areas, Auckland Region



2 THE CHALLENGE – HOW MUCH MODELLING DATA?

The challenge is to have all modelling results available on a centralised platform, for interrogation of basic output parameters such as flow, depth, and water level.

This stands to present considerable improvements to customer service, both internal and external. Financial savings are also expected to be significant, with less staff time being required to answer queries. Future essential initiatives such as flood forecasting, are dependent on the model registration project.

There is no option. Consolidation and publication of models and their results must be achieved. The drivers are simple – improved customer service, value for money. A key challenge is the volume of data.

We're not talking about one or two models here:

- The initial data sweep (heuristics) identified at least 500 models across 233 catchments. People hold knowledge of other models not identified in the data sweep. It is estimated there are up to 1000 models at this stage.
- Around 100 modelling projects (flood hazard modelling, and options) are to be finalised in 2017 alone.
- Aside from the number of models, the volume of data points is significant. Assuming an average of 309ha of Flood Plain per each of 233 catchments (based on the average area of published Flood Plain), 4 models per catchment at $4m^2$ resolution, this equates over 1 trillion (1 million million) data points for the Auckland Region. The calculation is detailed in Table 1.

  Data has to be centralised and easily accessed, which drives the design and location of data hosting and accessibility platforms:

- A centralised and flexible database is required, with a spatial component to allow spatial interrogation of models in a certain area.
- The audience is diverse, from resource consent and regulatory staff, to experienced engineers and modellers. Specialist software skills cannot be a prerequisite, and a simple software distribution / licensing framework is required.
- Access must be enabled across a range of locations. Auckland Council has at least 17 buildings in 5 areas of Auckland, it is desirable that staff be able to access the data in the field.
- Storage has to be cost competitive, as data is likely to rise to hundreds of terabytes, if not petabytes in the next 10-years.
- As the project has progressed, it has also become evident a key issue is locating, and managing the deliverables from models. The magnitude of this issue has now become evident, and is bigger than first thought.

Each of the issues raised above is discussed in more detail, with the solutions currently being tested by Auckland Council, and remaining challenges to address in the future.

Table 1: Potential Number of Data Points in Auckland Regional Modelling Data Set

Aspect of model	Ref.	Mathematical relationship	Quantity (numerical)	Quantity (in words)
Average Flood Plain area per Catchment currently published	A		309 ha	3 hundred
	B	=A	3,090,000 m^2	3 million
Resolution of 2D model	C		4 m^2	
Number of 2D cells in a Flood Plain	D	=B/C	772500	< 1 million
Duration of results recording for model simulation (hours)	E		12	
Recording interval (minutes)	F		5	
Number of time steps recorded per simulation	G	=E(60/F)	144	
Data points per simulation (2D domain cells x number of time steps)	H	=DG	111,240,000	111 million
Data points for simulation matrix of 12 simulations	I	=12H	1,334,880,000	1.3 billion
Data points for 4 models per each of 233 catchments	J	=233.4.I	1,244,108,160,000	1.2 trillion

3 MANAGEMENT OF MODELLING DELIVERABLES

A key learning from going through this project is the importance of managing modelling deliverables. Auckland Council has a modelling specification, detailing how models should be delivered, including a defined directory structure. GIS shapefiles, the model log, and other files around the model build are also specified to be delivered.

One would take it for granted that models are delivered in a complete form.

This project has revealed however the importance of getting back to basics, and managing how peer review is undertaken, when a wide pool of outsourced consultants, and in house staff are involved.

On running the models and attempting to reproduce results, it has been found only around 1 in 5- 10 delivered models have the complete file set allowing the simulation to be run. Further, when the models are rerun, and the results are compared to those delivered, less than 50% are found to be reproducible.

The magnitude of this problem is larger than expected, and the focus has now turned to further defining the deliverables requirements in the specification, and supporting staff involved in peer review to better monitor this.

By identifying the problem, and pushing back at project managers, and modelers, this problem is now being addressed.

4 MODEL REGISTER

In its simplest form, a model register is a database of models. This can be as simple as an excel spreadsheet, or it can be a detailed database. A database can be purely based on attributes, or can have a spatial component. The value in maintaining a model register is difficult to challenge.

4.1 VALUE, AND NEGLECT OF MODELS

The value in having a model register cannot be underestimated. Models represent a considerable investment in staff time and/or expenditure in outsourced resources. Models are used to make both strategic and operational decisions, often for infrastructure worth tens, or hundreds of millions of dollars.

Models are however rarely treated in the same way as any other high value asset would be. To draw an analogy, organisations also spend a considerable amount on corporate vehicles. The investment in a vehicle is likely considerably less than a detailed catchment model, and the vehicle will not be used to direct strategic input into multimillion dollar decisions. The following contrasts can be drawn:

1. Investment - a heavy duty 4x4 commercial vehicle, such as a ute, may cost around $50,000.

2. Security - The vehicle is likely placed in a locked yard, managed in an asset register. It is also likely fitted with an alarm.

3. Maintenance – Most vehicles are serviced regularly, and likely washed regularly to look after the image of the company.

4. Cost profile – Vehicles are depreciated so to be replaced when required. Vehicles are insured to allow replacement in the event of loss.

5. Tracking – Fleet vehicles are generally tracked by GPS, and the speed and usage monitored. At any time, someone can locate the vehicle, and consequently have a fair idea of where the driver may be.

6. Fitness for purpose – Vehicles undergo a fitness for purpose check, at least every 12-months.

7. Contingency – Vehicles are maintained to prevent serious breakdown, but in event of breakdown or loss, the cost of hiring a vehicle is generally small, and covered by insurance or corporate policy. Roadside service is often included in insurance, as a business continuity and convenience measure.

8. Consequence – Poorly managing a vehicle would reduce its life, but the consequences are likely minor in the first 3-5 years of life. Vehicles are rarely the pivotal tool used to make strategic decisions for significant investment and long term planning, yet management of the asset is rigorous.

Compare this to models:

1. A detailed model may cost up to $300,000 depending on the size and complexity of the catchment.

2. They are delivered, and likely thrown in a location on a network drive somewhere. When talking to people on this topic it is not uncommon to hear "Is the model still on your external hard drive, do you think we should back it up on the network?".

3. The work Auckland Council is doing shows the model file set is complete only in the minority of cases, and results reproducibility represents several challenges.

4. They are generally not maintained to upgrade to new software versions, and the maintenance to upgrade the drainage network is less frequent than it should be.

4.2 WHAT SHOULD A MODEL REGISTER DO?

A model register can take many forms to fulfill a wide range of functions. The key is to define the stakeholders, the objectives, the available budget, and then to design a fit for purposes solution within these constraints.

The minimum functionality is to:

- Record all models, and their status (current, superseded, under construction)

- Record the storage location of the model.

Above this minimum functionality, a screed of additional functions can be included, storing information on data governance, model limitations, etc.

Auckland Council has considerably higher demands than the minimum outlined above, due to the expectations of stakeholders, corporate values, and the way models will provide input to future initiatives. At a high level of business function and value, the function of the model register and surrounding digital infrastructure is to

- Provide excellent customer service (fast, comprehensive and accurate responses), and

- To deliver value for money to ratepayers.

The stakeholders are Auckland Council Healthy Waters staff, other departments in Council, and every ratepayer and resident of the Auckland Region.

The model register is pivotal to the publication of outputs, and metadata. Detailed outputs and metadata are required to meet the demands of Auckland Council stakeholders. There are also data management and legal considerations. The role of the model register is therefore to:

1. Enable Auckland Council Healthy Waters Department to spatially query the models available for a catchment, for basic parameters such as flow, depth and water level.

2. Allow rapid identification of the storage location of models with confidence of sourcing the correct information, and to understand the status of the model.

3. Facilitate cost effective storage, and data governance.

4. Understand the limitations of each model, and to have this summarised in a score out of 100 for the model results overall.

5. Enable stakeholders to immediately see the scenarios modelled and results availability, and to know when new models being constructed are due for delivery and the results will be available.

6. Be able to identify and source the model from the published Flood Plain on the GIS Viewer.

7. Enable Council to fulfill legal requirements.

   Under Section 44 of the Local Government Information and Meetings Act, territorial authorities are required to make information relating to inundation, and to provide this in the form of a Land Information Memorandum. Flooding predictions from models are often the best information available.

   The legal requirement to present information could extend to requests for the supporting model by means of an Official Information Request. It is expected the environment around this data will become increasingly political, and this information will be handled in an increasingly litigious manner, as insurance companies weight premiums based on the available.

   Legal requirements around copyright and licensing of modelling data, deliverables, and derivatives also needs to be covered. These are being worked through now using the NZ GOAL framework (New Zealand Government Open Access and Licensing).

8. Enable data management in the short and long term. The storage cost, legal requirements, and long term accessibility of data need to be considered, to form a data governance policy. This will address:

   - Data retention period.

   - Data format, and reducing obsolescence from software and data format changes.

   - Keep models in an accessible version of the modelling software. This involves upgrading models periodically with newer versions of the software. This may be prompted by changes in the version of the modelling software, or operating systems.

   - Ensure data is not unnecessarily stored, or ensure it is cost effectively stored, to manage storage costs, and reduce the administration required to manage the data set.

4.3 IMPLEMENTING A MODEL REGISTER

As outlined above, it is essential to identify the objectives, stakeholders, budget, and develop a fit for purpose solution within those constraints. Auckland Council has high demands, and is developing a comprehensive solution to meet these demands.

The next requirement is to assign responsibility. There are no doubt people reading this paper that have done their best, often in their own time, to sort out the models for an organisation, collated the information in a spreadsheet, only to then move on from the organisation, and see their efforts undermined by lack of ongoing data maintenance. Additional to assigning responsibility, business continuity also has to be considered.

Additional to responsibility, and business continuity, Business Capability Maturity (BCM) is a key concept. In simple terms, BCM is the process of identifying stakeholder expectations, identifying the requirements and challenges in implementing a solution, with a roadmap on how this will be achieved. BCM is a well-documented process outlined by many authors. In brief, an initial business state is often described as 'ad-hoc', and progresses through developing processes that become repeatable, defined, managed, and finally, optimised. Optimised represents minimised human involvement, minimised cost, and speed of execution and service.

Let's face it, most data oriented business initiatives are born in a spreadsheet. Somebody reaches a point of frustration with something, opens a spreadsheet, and starts writing equations, lookup tables, and drop down validation lists.

Auckland Council started with a spreadsheet, and very quickly realised with more than two people working on the model registration project, this was inadequate. The issues are version control, accessibility between Council staff and contractors, and the potential for those involved to change field structure, and enter inconsistent attributes. In summary, a spreadsheet does not offer a scalable, robust, or reproducible solution. Scalability is discussed later, as a truly scalable solution has to cater for many needs and challenges.

Council quickly progressed to a cloud database. Council has used a third party supplier, so as full support is available. There are however many free or relatively cheap online database solutions, which may be appropriate depending the needs and size of the project.

At this stage the Auckland Council model register has achieved the reproducible stage in terms of BCM. The information is complete, and serves the basic required functions. In summary, the fields included are:

1. General info – Catchment, project title, type of model, model purpose

2. Limitations – A short summary of limitations around input terrain data, primary network data, methodology and schematic, hydrology, and how these manifest in the results

3. People – Consultant and Council modeler and project manager, and reviewers

4. Software version (major and minor release), indicative simulation time (hours, days)

5. Scenarios – ARI design storms run, and climate and development assumptions

6. Storage – Total size of model, whether alternative results formats are stored, and the size of these

7. Process – Checklist for which parts of the process have been completed

8. Spatial – Each model has a shapefile showing the spatial extent. Limitations will also be supported by polygons noting the main limitations in specific areas

9. Data fields to be added in the future will be around data governance and retention and currency, and model quality scoring, for which a prototype study is being has been successfully undertaken.

The above have lifted Auckland Council practice to a repeatable level in terms of BCM. This means different people, with the help of a defined database structure and supporting material, can register a model to a consistent standard, after sufficient training.

The process is currently slow however, due to a lack of scalability. To meet the business demands of Auckland Council, a truly scalable solution is required. There are many facets to this, which are discussed below.

5 ACHIEVING A FULLY SCALABLE SOLUTION

It is important to understand what scalable means. An immediate assumption is the number of models registered.

Scalable in the context of Auckland Council's requirements has a wider meaning. The core question is what are the limits and bottlenecks in achieving the desirable end point, and how to overcome these. At the outset, not all limits are visible, so the approach also needs to be agile.

To achieve scalability and to progress from a repeatable to an optimised Business Capability Maturity state at Auckland Council, at least the following need to be addressed:

1. Decentralised, but regulated access to the model register. Access to the model register needs to be provided in a simplified spatial platform, rather than requiring specific knowledge on how to use the database itself
2. Accessibility to Auckland Council Catchment Managers, and other departments, who cannot be expected to develop specialist software skills. Results must be presented in a platform staff are familiar with, rather than requiring development of considerable new skills
3. Process interdependency – in this case mainly dependency of the Flood Plain update process on model registration
4. Computing (processing) resource
5. Data storage capacity, governance, and retention
6. Capability of the results presentation portal to handle large volumes of data
7. Data movement bandwidth between different systems (intranet, internet)
8. Human resource and capability
9. Process documentation, reproducibility and enablement
10. Process familiarity, so as not to become dependent on the project manager
11. Software licensing
12. Financial constraints.
13. Agility, to adapt to unforeseen issues or magnitude of challenges.

Many parts of the puzzle have been put in place. We have a model register, a cloud based results data portal which appears capable of handling the volume of data. Computer processing and storage facilities can be provisioned in-house, with a local provider, or in an overseas data centre. Bandwidth is not a concern, tests overnight show the ability to move 60GB per hour into the cloud (2.4TB was uploaded over one weekend in testing) – bandwidth is also soon set to double with changes to Council internet specifications. Budget is available, as are software licenses.

The main limitations are availability of human resource, and the amount of material and process each person has to be familiar with the complete process for registration of a model.

Registration of models involves gathering the model, checking the completeness of files, running the model, checking results reproducibility (which requires specialist software skills), filling in technical details in the model register – and uploading the model to the cloud based results browser.

As the project and surrounding process have been developed and quantified, it is now clear the size of the project exceeds the capacity of the systems in place to monitor and manage it. Currently the process is divorced from Healthy Waters Catchment Managers – the project managers of modelling projects, due to the specialist skills involved. Due to manual execution of tasks, which can be automated, the process also takes too long, and diverts resource from other modeling tasks. It is also difficult, if not impossible for the project manager to effectively maintain an oversight of delivery dates for registration of any given model – there are 60 models in the process at this time, this number is likely to increase.

The magnitude of the project now dictates the need for Business Process Management (BPM). BPM involves a systematic approach to guide the pathway to BCM, and to make workflows more efficient. BPM is now the focus, with use of smart technology to maintain effective oversight of each model being registered, workflow, tasks, and responsibilities:

- BPM software is being tested at this time. This will be like applying for insurance online, where you open a link, start filling in details, attach relevant information, and push submit. This carries considerable benefits in that this task can be completed collaboratively by the project manager and modeler – keeping ownership and responsibility for this task with the people who have the knowledge.

- Model Registration project management – BPM will allow the project manager to keep an overview on how the project is progressing, without having to have significant input to guide catchment managers and modellers on how to initiate and progress the process.

- Automation of key tasks – automation was not a possibility at the outset, as the nature of the tasks was not clearly defined. Automation of tasks around another process – Flood Plain Updating in GeoMaps, is currently being tested using Visual Studio and Arc Objects. This test is going well, and it is hopeful similar methodology can be applied around sending simulations to computers with specific versions of software, deployment of virtual machines, checking completeness of deliverables, and in particular model results reproducibility.

- Improved peer review – Whilst the above automation tasks are being undertaken on legacy models at this time, development of these tools allows use by those involved in modelling, prior to submitting models, and during peer review. To use a colloquial description, this is moving the ambulance from the bottom of the cliff, and installing a fence at the top.

It will take time to develop the above measures. As such, a high priority is being placed on BPM, to develop and maintain momentum in the project. The momentum is reduced, in recognition of the focus on developing process at this time. In parallel, further development can go into the cloud results portal, model register, and model quality scoring at this time.

It is inevitable also more issues around scalability of the solution will also come to light as the project continues, emphasising the importance of an agile approach and regular review.

6 FUTURE OPPORTUNITIES – STORM i

One of the main drivers of the model registration project, is the opportunities enabled. Creating opportunities by consolidating and mashing datasets together is the key driver of Storm-i. Storm-i is bringing together all Healthy Waters Department data into an easy to use, cloud based platform. This includes survey data, pipe condition CCTV, rain radar, modelling, and more. The outcomes so far are mind blowing – in terms of customer service, financial savings, and placing the Healthy Waters Department as a world leader in the Water Services Association of Australia benchmarking. The model registration project will unleash a whole new suite of tools and possibilities.

1. The immediate outcomes will be delivery on the core Council values, of excellent customer service, and value for money. A typical customer query requires Council to provide modelled flood flow, water level, and the associated modelling report for a property. Such a query can take a considerable time to answer at this time. The target is to be able to answer such a query in 15-minutes in future. Other initiatives are also being implemented to contribute to this– modelling reports will shortly be linked to Flood Plain polygons on the GeoMaps Viewer, allowing internal staff to access these directly – this will then shortly after be released to the public.

2. Risk to habitable floors is currently assessed from design storms of 2- 100 year return period, based on modelling results. The frequency with which each floor is predicted to flood is documented in the modelling report.

   The limitation is update of this information, and consolidation into a regionwide dataset. The need is to update this dataset in response to updates to the building footprint dataset, and models, across the region. This can be achieved on completion of the model registration project, due to the consolidation of models, and results, into a regionwide raster inundation dataset for all modelled scenarios.

3. Considerable investment has been made in consolidating gauged rainfall and flow data into Storm-i, the same portal as modelling results will be mobilised into. This has followed with a live feed of Metservice rain radar into Storm-i, as quantitative depth and intensity data.

   The combination of these two datasets, and regular updates of regionwide habitable floor risk, will lead to experimentation around developing a flood warning system.

   With 233 catchments, short times of concentration, and little warning around heavy rain, recording rain and then running models to flood forecast is not an option in Auckland. Interaction between modelled results, rain radar now-casting, and antecedent moisture condition data, will be tested to determine viability for flood forecasting, by relating rainfall depth to modelled habitable floor flooding risk.

4. Understanding of real events is expected to be enhanced. With rainfall and flow gauge data now in Storm-i, loading of a regionwide 2-100 year flood modelling dataset will allow comparison of modelled flows, to real event flows.

   This will be a powerful tool when trying to determine the ARI of rated flow measurements, to consider how variable rainfall across catchments related to the flow generated.

5. Model maintenance and confidence – With models consolidated, and software versions recorded in a database, models can be easily maintained and updated.

   An ambitious but realistic goal is to interrogate rainfall data to produce rainfall hyetographs for all subcatchments in models. After significant events, there exists the opportunity to automatically run models, and compare these results to gauged data. This allows real data to be used to gain increasing confidence in a model over time, increasing the value of that tool. This will use tools under development now for use in model registration, around automatically sending models to specified machines to run simulations, and tools to compare two datasets to test model reproducibility.

7 CONCLUSIONS

Auckland is experiencing a period of unprecedented growth, resulting in increased demand for a wide range of information supporting land development. The Healthy Waters department is experiencing high demand for flooding related information.

Auckland Council's goal is to have all modelling related outputs available in a cloud based portal, to allow rapid and cost effective access by staff, and to mash this with other datasets providing an insightful and dynamic analysis of stormwater related datasets. This will without doubt deliver value, both financial, and in terms of faster and comprehensive customer service.

The challenge is considerable. The dataset could expand to over a trillion points (1 million million), and extend to petabytes of storage. It is estimated there are up to 1,000 legacy models, and high resolution models are being produced at a rate not seen before.

The components are a model register, metadata such as model quality scoring, and surrounding process requirements such as data governance and retention policy. There are challenges around providing sufficient computer processing power, and software licenses, which have been met, but are likely to need revision in future.

Many parts of the puzzle have been put in place, and will be developed further in future. The issue is now scalability, mainly around human resource, and consistency and speed of applying process.

The focus has moved to Business Process Management – the optimisation of process, and automation of tasks, to help Council achieve an optimised Business Capability Maturity state in this area. Given the scale of Auckland Council's operation, without a shift in focus, the progress of the project is expected to be limited.

The question many ask is the value of this project. Even if limited to improved customer service, the project has considerable value. Aside from better serving the public, the savings in staff time and other costs will be considerable.

The most value may well be in the flow on projects. It is the linking of datasets, and flow on effects from consolidating and managing input that is at the heart of the Healthy Waters Storm-i project. Flood forecasting, automated and regular model validation and maintenance, and improved understanding of real events is likely to result. For Auckland Council, the value is unquestionable.

At any scale, or any level of sophistication, consolidation and management of models will deliver value. This can vary from having one person responsible for management of a spreadsheet, to an easily interrogated cloud solution as Auckland Council are implementing.

The message to others, is start now. Such a project sounds easy, and the individual components are simple – but it all takes time. Don’t delay.

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