STRATEGIC FRAMEWORK FOR WATER MODEL DEVELOPMENT

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ABSTRACT

The strategic framework is a generic process to guide and record model development for three water (water, stormwater and wastewater) models for the region. The process is deliberately non-prescriptive and high level to enable framework documents to be prepared by others. The framework is to provide models that are "fit for purpose" or "appropriate for their intended use", support model development, and provide standardisation across Councils to promote efficiencies. The development of model stocktakes, software platforms, model objectives, specifications, management plans, and implementation plans forms part of the process.

Significant time, experience and money are invested in the development of models and the strategy is to ensure that models achieve the required objectives and that their integrity is maintained in the future. A number of models already exist and therefore the strategy focuses on the on-going management and development of existing models. The paper is to include lessons learned, challenges and strategy development.

The strategy is to ensure consistency between models, ensure models are defensible, allow for clear planning and budgeting, provide for economies in model development, ensure that key elements are not overlooked and build upon existing knowledge. As a living document the strategy will be improved and developed over time.

The framework is being implemented by Capacity Infrastructure Services Ltd (Capacity). Capacity is a CCO (council controlled organisation) that provides infrastructure services including three water modelling for Wellington City, Hutt City and Upper Hutt City Councils. Assets for the Councils comprise approximately 2,000km of water, 1,850km of wastewater and 1,400km of stormwater pipelines servicing approximately 350,000 people. All three Councils have developed hydraulic models for various purposes, standards and on various software platforms over the years. Many models have been further developed for applications outside their original intended use. Capacity has embarked on careful and structured model development and management required to maintain model integrity and confidence.

KEYWORDS

Model, modelling, stormwater, water supply, wastewater, strategic planning

1 INTRODUCTION

The strategic framework is a generic process to guide and record model development for three water (stormwater, wastewater and water supply) models for Capacity Infrastructure Services Ltd (Capacity). The process is deliberately non-prescriptive and high level to enable documents to be prepared by others. The framework is to provide models that are "fit for purpose" or "appropriate for their intended use", support model development and provide standardisation across Councils to promote efficiencies. The development of model stocktakes, software platforms, model objectives, specifications, management plans and implementation plans forms part of the process.

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2 CAPACITY MANAGED SYSTEM

Capacity is a council controlled organisation (CCO) servicing Wellington City Council (WCC), Hutt City Council (HCC) and Upper Hutt City Council (UHCC) and was set up to provide innovative, cost-effective stormwater, wastewater and water supply management including three water modelling as shown in *Figure 1*. Assets for the Councils comprise approximately 1,400km of stormwater, 1,850km of wastewater and 2,000km of water supply and pipelines, servicing approximately 350,000 people. Water supply assets include some 121 reservoirs and 175 pump stations.

On average 130,000m^3 of water is consumed each day; about a Westpac Stadium full every nine days (Hutt, Upper Hutt and Wellington). Water supply consumption is approximately 220 to 240 litres per person per day at home. Around $100 million a year is spent running and renewing stormwater, wastewater and water supply networks. Approximately 120,000m^3 of wastewater is produced each day for treatment at the Seaview, Western and Moa Point plants. Capacity manages one of the country's largest system control and data acquisition (SCADA) operations with over 350 remote telemetry sites, ten repeaters and seven base stations storing some 25,000 tags.

3 MODEL INVESTMENT

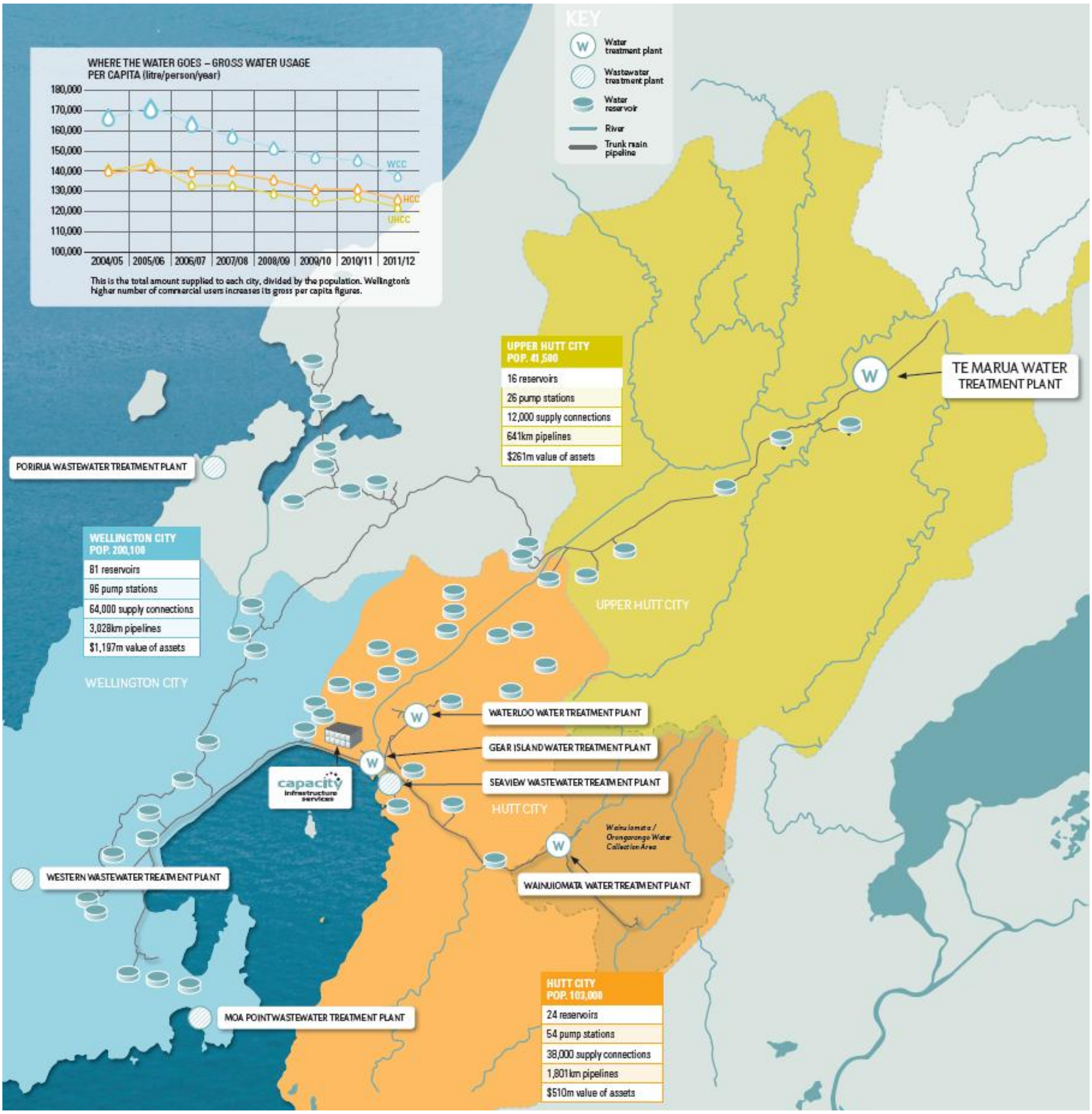
The objective of a model build is to produce a model that faithfully represents the real system that has the confidence of the users. As an essential business tool, modelling will identify present and future needs of network systems.

The user must be aware of the limitations of the model and take those into account with any modelling that is carried out. The model must be treated as an engineering tool and not a black box. Engineering judgment must always be applied before and after model use.

Three waters engineers use a range of models to support decision making. Network modelling is a key activity to:

- ➔ Understand how systems operate under various scenarios now and in the future,
- ➔ Assess system performance under normal and critical asset failure,
- ➔ Assess implications of: service standard changes, operational modifications, renewals, upgrades and developments, and
- ➔ Produce supporting information for planning and consenting studies.

Figure 1: Capacity managed system (diagrammatic)



4 EXISITING MODELS

All three Councils have developed hydraulic models based on various purposes, standards and software platforms over the years. A summary of existing three waters hydraulic models across the region is shown in *Table 1*. There are approximately 50 models across the region in four software platforms of various versions. With models built at different times and for various purposes their usefulness is significantly variable emphasising the importance of a careful and structured model development programme.

Table 1: Existing models

STORMWATER			
	HCC	**UHCC**	**WCC**
Model Summary	Two small catchment models.	One city-wide model.	Seven catchment models.
% of total network modelled	<1% (detailed)	100% (detailed)	~ 20% (detailed)
Status	Purpose built small models.	Fully built, currently being calibrated and upgraded to a 2D model	All fully built, various asset updates and upgrades required. Two partially calibrated.
WASTEWATER			
	HCC	**UHCC**	**WCC**
Model Summary	Six detailed catchment models, three trunk models.	One city-wide detailed model.	Five detailed catchment models, two trunk models (Interceptor and Karori).
% of total network modelled	100% (trunk) ~ 30% (detailed)	100% (detailed)	100% (trunk) ~20% (detailed)
Status	Two detailed models recently calibrated, remainder are historic models.	Fully calibrated.	Historic models. 50% of Interceptor calibrated.
WATER SUPPLY			
	HCC	**UHCC**	**WCC**
Models	City-wide model.	City-wide model.	Fifteen zone models, covering entire city.
% of total network modelled	100%	100%	100% (>75mm diameter).
Status	Under review.	Fully calibrated.	Updated, being verified and calibrated.

4.1 STORMWATER

In the mid to late 90's WCC began using specialist hydraulic modelling software to develop catchment-wide stormwater models. Since 1997, a number of stormwater catchment models (predominantly piped networks with some simplified open channels) were built using 1D hydraulic modelling software. In addition, two 1D stream models were built using open channel software.

Most of the models were originally developed as part of WCC's stormwater catchment management plans, following several severe flood events in the city in the mid to late 90's. A comprehensive review of the existing drain capacities for the main stormwater outfalls (greater than 750mm size) was carried in 1995. This review prioritised investigations to catchments with the highest perceived risk of serious flooding in a significant rainfall event.

The models for the catchment management plans were used primarily to identify major system deficiencies and to investigate upgrade options. Flood hazard maps were also produced using manual floodplain storage calculations. Some of the models have been further developed in recent years to update the flood hazard maps using separate 2D modelling.

There are early spreadsheet models that are not readily accessible and are considerably out of date. Given the lack of compatibility between the spreadsheet models and current modelling software and the comparative ease of data transfer to and from WCC's asset management system there is little benefit in attempting to update these spreadsheet models to current modelling software.

One stream model and one pipe network model have been built for Hutt City, the stream model in 2004 and the network model in 2011. Both models were built to investigate solutions to existing flooding issues.

A city-wide 1D stormwater network model has been developed for Upper Hutt City. The model amalgamated nine previous separate models into one detailed network model. That model is now being calibrated and 2D model being developed. A stream model is being prepared for the Pinehaven Stream as a joint project between Greater Wellington and UHCC.

4.2 WASTEWATER

Model development for WCC has been over the last 15 years. In 2001, an interceptor system model was built of the trunk network that conveys sewage to the Moa Point treatment plant. The model was used for development and evaluation of upgrading options. The model outputs were used to reinforce the renewal of the treatment plant consents. Similarly, wastewater models were built for the trunk sewers of Karori and Island Bay catchments. Reticulation models were often built as required to evaluate network performances but have not been maintained.

The bulk wastewater system is jointly administered by HCC and UHCC by way of a joint committee called the Hutt Valley Services Committee (HVSC). The Hutt Valley is served by two bulk sewers, the original Hutt Valley Main Sewer (HVMS) and the more recent Upper Valley Main Sewer (UVMS). HVSC built a trunk model in 2002. As part of the overflow management planning project two catchments, Wainuiomata and Waiwhetu, were modelled recently.

The Upper Hutt wastewater model was first built in February 2006 and updated in July 2006. The third update was done in 2009 as part of the system performance assessment work. The extent of the model was based on a complete GIS asset data set and is considered suitably accurate and sufficiently detailed to assess the performance of the existing catchments.

4.3 WATER SUPPLY

Between 2002 and 2008 a fully calibrated extended period model was developed for the entire WCC water network system. The model was built for separable zones in a staged manner. A non-calibrated water model for Hutt City was constructed over a number of years. A fully calibrated extended period hydraulic model for the Upper Hutt was completed in 2005.

5 HISTORICAL CONSIDERATIONS

Historically models were developed for specific purposes such as a mains upgrade, storage provision or reservoir siting. Often model development was very focused due to either a lack of time and or budget. System wide all mains models, apart from WCC water models and UHCC three water models, has generally not been a large driver. The construction of models has spanned long periods up to say fifteen years during which time there have been significant changes in:

- Computing: computer processor speed, software, data storage capability, cost reductions;
- Monitoring: site monitoring equipment, implementation of real time telemetry systems on a wide scale, telecommunication systems, data storage, cost reductions, accuracy improvements, general wider availability of systems;
- Legislative changes;
- Network data: ability to access and store network data, changes to the network by way of upgrades, developments or renewals;

- Software: algorithm improvements, boundary condition improvements, more extensive capability (e.g. 2D models), better verification and calibration processes; and

- Organisational strategic direction changes: changing model builds and maintenance requirements.

As a result models, while being built with considerable skill and care, may be of unknown quality and out of date. This results in a loss of confidence undermining the model purpose of providing a faithful representation of the system. In some cases older models have been abandoned and new ones built from scratch. Typically key areas of model build improvement, as is often found in the industry, include the need for:

- A consistent model build specification,

- A strategic plan to guide development,

- A model management plan,

- Model evolvement with software development/upgrades,

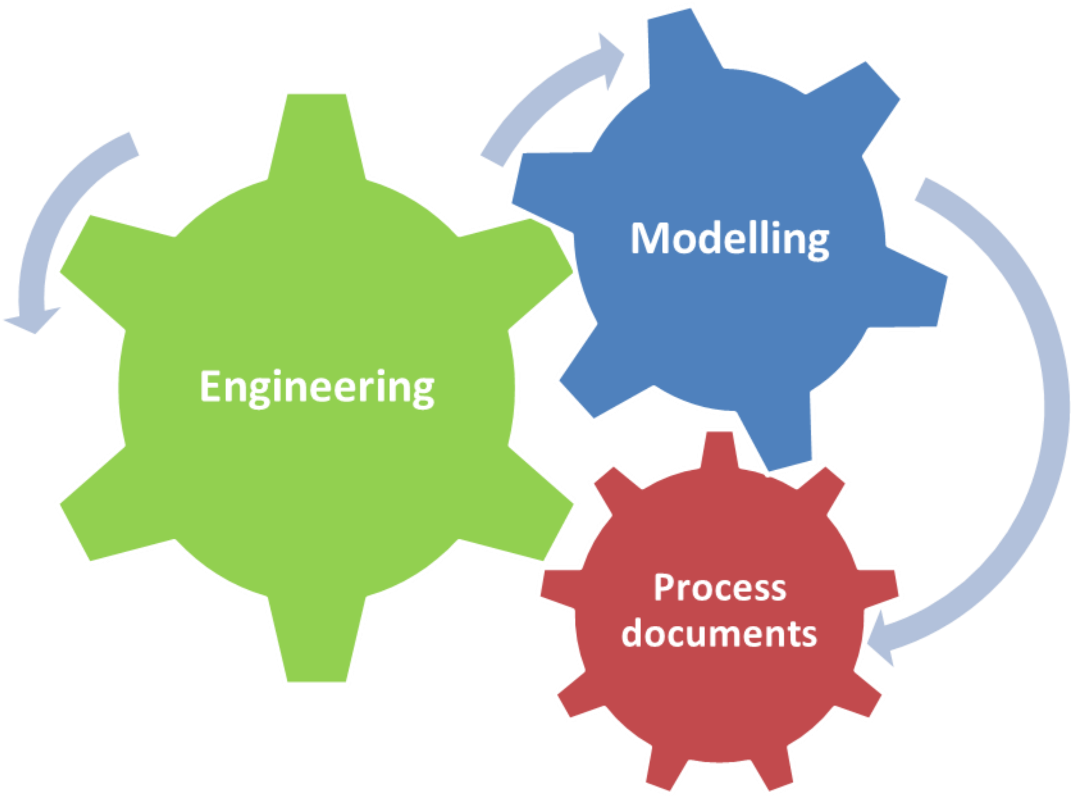
- Model asset data build records and/or methodology, and

- Further documentation and record keeping.

6 STRATEGIC FRAMEWORK

Modelling is a very complex interacting process as shown in *Figure 2* that requires a smart careful methodology to ensure the model investment is maintained and maximised. The process is a long term and continuous process.

Figure 2: Modelling interactions

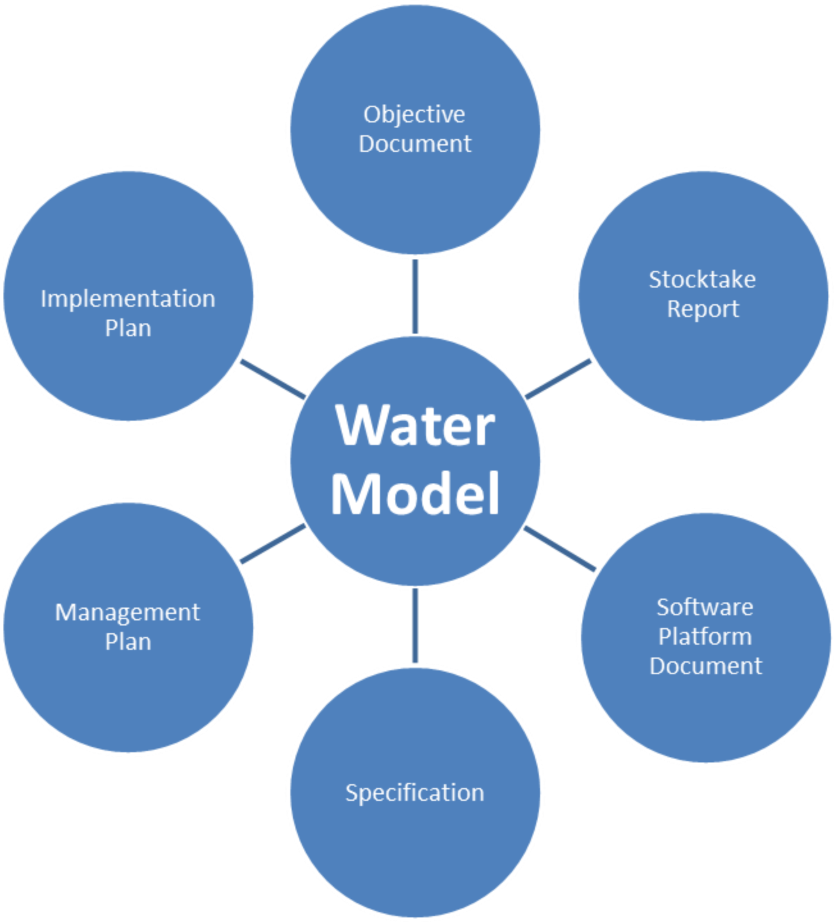


A strategic framework, as a generic process, was prepared to *guide and record model development for three water models to guide and record model development for each of the Councils to enable a long term* *systematic model development process*. The generic framework is deliberately at a non-prescriptive level to enable the framework documents for each Council to be prepared by others. The framework is to:

- Be “fit for purpose” or “appropriate for their intended use”,
- Support model development, and
- Provide standardisation across Councils to promote efficiencies.

Key strategic plan framework documents are shown in *Figure 3*. The strategic plan is to be externally peer reviewed by a competent and experienced modeller. Other information to be provided within the strategic plan is an: executive summary, report purpose, background, report peer review, references (including earlier model reports), version control, task list for implementation, documents and reports.

Figure 3: Framework documents



6.1 OBJECTIVE DOCUMENT

The key purpose of the objective document is to *outline proposed model use and outcomes to drive development*.

What is the question to be solved by the model and how do you propose to answer the question? Proposed model use and outcomes drives the investment required for the model build including asset data, system data and calibration requirements. Over scoping model complexity results in large budget commitments. Under-scoping model complexity results in a model that is not fit for purpose. Objectives need to be agreed with shareholders.

The proposed use of the model including output accuracies and limitations are to be clearly stated. Key issues include:

- Model update process- is GIS update required,
- Model use requirements,
- Distribution analysis requirements, and
- Adopting a steady or dynamic state model.

All model builds provide an additional benefit of data improvements by way of cleansing and collection. Objectives will be dependent on model limitations and uncertainties that will be determined for each model. While it is important to identify model build objectives, it is equally important to identify what objectives the model will not be built for.

The user needs to be aware of the model limitations including the data sources, model demand build, calibration limitations and the proposed model use. The accuracy of the model should be considered along with a sensitivity analysis for any modelling work.

6.1.1 STORMWATER OBJECTIVES

At a strategic level the adopted stormwater model build objectives are:

- Asset knowledge; establish the performance of the existing stormwater system and to identify deficiencies in the level of service,
- Strategic network planning; determine and plan for the effects of future climate change (potential increases in extreme rainfall and sea level rise), determine and plan for the effects of future development, investigate and compare the effectiveness of options to mitigate flooding issues, comparative/defensible assessment of priorities to develop works programmes and assist with the production of integrated catchment management plans, and
- Development control; develop (broad scale) floodplain/flood hazard maps, identify secondary (overland) flow paths, and assist with setting land use controls and minimum building floor levels as appropriate, to assist Council in undertaking its responsibilities under the Resource Management Act and Building Act.

But not for:

- Detailed design,
- Water quality or sediment modelling, and
- Detailed analysis such as modelling individual sumps (except for critical areas where necessary) or predicting manhole surcharges.

6.1.2 WASTEWATER OBJECTIVES

At a strategic level the adopted wastewater model build objectives are:

- Strategic network planning: asset knowledge, establish the operational performance/level of service of the existing network system and to identify deficiencies in the level of service, growth scenario planning, identification of high risk asset and climate change impacts,
- Development of the renewal programme,
- Development of the inflow infiltration control programme,

- RMA compliance assessment, and
- Long term upgrading programme development, option development and prioritisation.

6.1.3 WATER SUPPLY OBJECTIVES

At a strategic level the adopted water supply model build objectives are:

- Strategic planning,
- Operations performance and assessment,
- Localised growth scenarios,
- Inter zone water transfers,
- Valve management,
- Identification of critical fire hydrants for further fire flow testing,
- Long term upgrade planning, and
- Impact assessments.

But not for:

- Detailed design,
- Critical fire hydrant flow testing, and
- Water quality.

6.2 STOCKTAKE REPORT

The key purpose of preparing the stocktake report is to *summarise previous work, document and establish the status of all prior models and a carry out a gap analysis for further model development*.

Fundamentally the model stocktake is to: make the best use of previous models that are often significant Council asset investments, to prioritise model development, maximise the use of existing model assets and facilitate the best and most economic way forward. Essentially the stocktake document becomes a critical and valuable organisational document that is a register of all historic model developments.

A model stocktake is required to, assemble all paper key reports and documentation, assemble all model electronic files and summarise all previous work for each separate model. Often model paper and electronic records are stored within project files rather than designated model storage areas. Those project files are often large and soon become archived and lost to easy future access.

Documentation for each model should include and not be limited to: the extent of the modelled system, the objectives/purpose of the model, status of each model development, software operating platform/version, availability of the software version and a model build detailed gap analysis. The status would indicate the data source and validity, has the model been calibrated, has the model been verified, build and update status and limitations.

6.3 SOFTWARE PLATFORM DOCUMENT

The key purpose of the software platform document is to *review, recommend and establish the software platform/s*.

A decision making process is required to select the desired model platform. The choice of a platform will have long term implications for up-skilling of staff, model build costs, software purchase costs, maintenance costs and model deliverables. Often multiple software platforms are selected due to historic model build reasons and there is insufficient justifiable reason to rebuild the models to a single new platform. In an ideal world where there is unlimited resources and funding a single platform of the user's choice would prevail.

The platform can be reviewed from time to time as the software market changes and evolves. Consideration is given to requirements, preferences and the desire to standardise software platforms across Capacity's shareholders and Council to improve efficiencies.

6.4 SPECIFICATION

A model building specification is *to implement a clear direction for multiple users to build and maintain models to a consistent standard*. For competitively tendered projects, clear specifications that are not over or under prescriptive.

Specifications are living documents that will be updated over time and have and will continue to involve collaboration with other Councils. Independent peer review has formed an important part of the document creation process. The typical specification components are:

- Background,
- Modelling objectives and purpose,
- Model software,
- Modelling processes including model diary, file formats, model extents,
- Definition of model network extents including existing models,
- Data including but not limited to: standardisation of features and attributes, data accuracies and assumptions, handling of missing data, data capture,
    a. Stormwater hydrological data including but not limited to: catchments, time of concentration, runoff, design storms, rainfall monitoring, flow monitoring,
    b. Wastewater inflow, infiltration, flows and patterns, rainfall monitoring and flow monitoring, and
    c. Water demand flows and patterns.
- Model build,
- Model validation and calibration,
- System performance and scenario modelling,
- Deliverables,
- References, and
- Version control.

6.5 MANAGEMENT PLAN

The key purpose of the management plan is to *guide development of on-going model standards, use and maintenance. The plan is a critical document to ensure the model asset maintains it's useful and value to the organisation.*

The management plan is generally a brief document that could form an ISO 9001 process if appropriate. That plan would include: a document purpose; model update, model maintenance requirements, model responsibility, storage (electronic and paper), model diary, model recalibration, software details including license details; users (definition of roles and responsibilities), model use guidelines, and management plan review requirements.

6.6 IMPLEMENTATION PLAN

The implementation plan key purpose is to *provide a guide and timeframe for model development implementation*.

The plan is to identify the strategic issues, how those issues are addressed and the timeframe for addressing those issues. Budget and resource requirements should be identified in the implementation plan. For individual catchments a model build plan will be required.

Development timeframes should include but not limited to: as necessary, annual, short term (one to three years), medium term (three to five years) and longer term (over five years).

7 LEARNING POINTS

Whilst the framework is deliberately non-prescriptive and high level it has proved very helpful in focussing on key issues in the model build process. The top ten lessons from the framework implementation were:

- Treat documents as ‘living documents’ that can be and should be continually improved increasing their organisational value,
- Clearly separate data from the model build process. Data or the lack of credibility often skews the timeliness and costs of the model build. Models rely on creditable data but dependant on their objectives do not necessarily need a full 100% data gathering exercise that can and does make the implementation of model builds beyond budget reach,
- Focus on the objectives not the detail,
- Focus on the need for work to be tendered and well scoped,
- Focus on clarity of delivery requirements,
- Implementation is to be independent of budget. The speed of implementation is dependent on the available budget. Changes in budget should speed or slow the implementation rather than terminate or change a model build standard,
- Model builds require organisational commitment recognising the model value,
- Work in small packages so progress is achieved; Yard by yard is hard but inch by inch is a cinch,
- Model maintenance helps maximises the investment by ensuring the model has a long life span, and
- The model framework and its implementation must be subject to flexibility and not idealism.

8 CONCLUSIONS

Significant time, experience and money are invested in the development of models and the framework is to ensure that models achieve the required objectives and their integrity is maintained in the future. The framework focuses on the on-going management and development of existing models and not just new builds.