

USE OF MODELS IN DECISION SUPPORT – CASE STUDIES IN URBAN RETICULATION AND FLOOD FORECASTING

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ABSTRACT

The use of hydraulic models by engineers, asset managers and planners is common place in every activity linked to analyzing and managing water flows. Most commonly, the models are used in establishing the system performance for various resource consent purposes, and in testing various capital works options in order to deliver the system that will meet certain requirements.

However, once developed, hydraulic models have another powerful use, that of a tool in a decision support system. The models can be used to investigate the different ways a system may be managed, both with and without significant capital works implemented. The potential benefits are vast. Model output aggregation and presentation is crucial when targeting different decision making audiences. Strategic planning requires highly processed and aggregated model outputs to identify growth milestones and stage the system upgrades while network operators need access to more detailed information, for example frequency of pump operations. Additionally, use of a hydraulic model in ‘decision support mode’ allows the operators to undertake ‘training’ in running the system in different “what-if” modes before implementing operational regimes or managing the system through a major flood event. It also enables a better assessment of the operational risks and effects of system failures.

This paper will present two NZ case studies where models are being utilized in the ongoing decision making process: the Hibiscus Coast Wastewater Network and Waikato River Flood Forecast system. The paper will highlight some of the techniques and tools used in enabling the model and its output to be used in this mode of operation.

KEYWORDS

Decision support system, Mike Urban, RTC, Hibiscus Coast Wastewater, Waikato Flood Forecast, FloodWatch

1 INTRODUCTION

As a term, ‘Decision Support System’ (DSS) has many definitions depending on the implementation. It is the nature of the problem the system is trying to represent, its complexity, its structure (or lack of), time constraints and audience that will shape the system to fit the problem.

In this paper we will give a brief overview of a Decision Support System, highlighting and describing in more detail the components most commonly found in DSS’s developed for managing water systems. We will then present two case studies, one for the Hibiscus Coast Wastewater System (Rodney District Council) and another for the Waikato River flood forecast system implemented with Environment Waikato. In addition to being applied in different areas of water management, those two cases are also in different stages of the DSS implementation.

2 DECISION SUPPORT SYSTEMS

Broadly defined, Decision Support Systems are a specific class of computerized information system that supports business and organizational decision-making activities. A properly-designed DSS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and assist in decision making.

In terms of DDS's applied to managing water systems, such system could be defined as an information system that combines data with models and graphics to make informed decisions combining some or all of the following:

- Good model representation of the relevant hydraulic processes and system connectivity;
- Model integration with asset management system and other spatial information;
- Real time access to relevant data and forecasts;
- Well defined presentation templates providing easy access to relevant level of detail, from overall system status to "drill down" detail for a specific location.

While the inclusion of the models as a core component in such a system is widely accepted, their full potential is rarely realized. It is only when the model is embedded into a broader infrastructure, that the benefits of well informed decisions are evident.

Figure 1 shows a possible configuration of a Decision Support System. Components mostly found in the systems applicable for management of water systems are encircled.

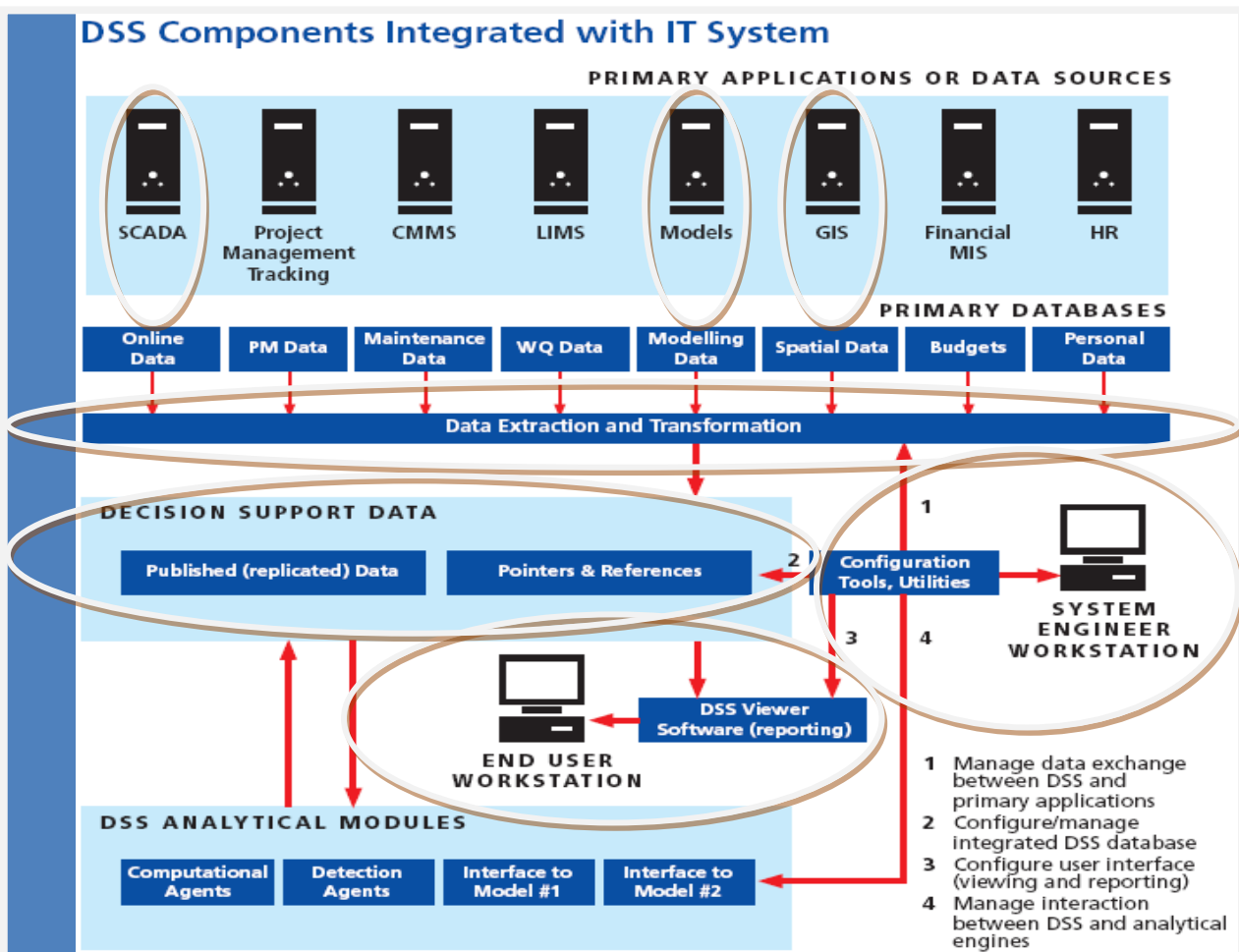


Figure 1 Possible DSS configuration

Many large scale systems have reasonably well developed individual components of the Primary layer with access to real-time telemetry data and good model representation often integrated (or linked) with spatial data.

The next DSS layer, Data Extraction and Transformation is a crucial component in system integration, as it connects the data as generated at its source, to the end user and analysis tools. Very often this transformation is driven by the skills of the person performing the role of system engineer. Depending on the person's abilities and preferences, this function is often covered by a collection of ad-hoc tools with various levels of sophistication, starting from a most common spreadsheets, macros or simple programs. This is often tolerated because of the lack of proven tools flexible enough to handle different input-output data formats. What is often not assessed is the level of confidence in the process. It is very dangerous to implicitly trust the outputs of the tools which have not been methodically tested. It is even more dangerous to reuse the tools from one project to another without understanding vital assumptions, often hard-coded and undocumented.

While the extraction layer needs improvement, it is often the "End User" part of the system that is neglected or missing all together. This is especially true for a high level decision making audience which needs access to aggregated data. The most that the end users can hope to receive in the majority of cases is a well designed report at the right level of detail for the problem at hand. Asking a slightly different question will often mean going back to the system engineer and waiting for another report.

Developing a comprehensive decision support system requires significant long term commitment. It is therefore vital that the DSS is designed with two main characteristics in mind: a) Flexible structure; b) Staged implementation. With the present rate of development in IT, and particularly the way it is applied to practical problems, flexible DSS will ensure the inclusion of new technology and knowledge as they become available and affordable.

When we talk about staged implementation, we have to recognize that in order to enable a DSS system to function the "vertical" integration must be implemented, albeit minimal. We need to have a data source, the procedures and tool for accessing, extracting and transforming the data, a standardized way of presenting data and a way to handle ad-hoc queries. In the centre of it, we need well defined communication channels. In most cases, it is sufficient to start with a system engineer.

The additional growth of the system will then happen by increasing the extent of each of the layers. Implementing a DSS in stages provides all stakeholders, in particular the end users, to assess the system's potential and limitation, and adjust the further development accordingly.

3 HIBISCUS COAST WASTEWATER SYSTEM

3.1 BACKGROUND

The Hibiscus Coast Wastewater network is a significant regional collection system under pressure to provide services to one of the fastest growing regions in New Zealand. Significant capital investment work has been carried out in the last few years, with still more planned. The system incorporates more than 350 km of sewer gravity lines, over 30 km of pressurized pipelines (rising mains and inverted siphons) and 32 pump stations. The largest storage capacity is within the Army Bay Treatment Plant, where an excess of 18,000 m³ of treated sewerage can be stored. To balance the planned decommissioning of Orewa Ponds 1 and 2, a new 3,000 m³ underground off-line storage tank has been built at the site of the new Orewa Ponds pump station. In addition to those two facilities, there are three smaller storages associated with Stanmore Bay, Tindalls and Hobbs pump stations which can be utilized in wet weather conditions.

The basis for establishing a new strategy for network operation (Olivier & Macdonald, 2005), can be briefly summarised as follows:

- The substantial investment in a new pipeline down the peninsula will separate actively operated trunk from local gravity connections (base for pump stations operations);
- Excess incoming flow into the trunk can be temporarily stored in storages closely associated with the main pump stations (storage filling and emptying rules);
- The Army Bay plant also provides significant internal storage to balance outfall discharge; and

- A number of cross-connections and back-up connections are also available with main trunk flow diversion options available for Weiti and Bay Street pump stations.

A working group consisting of DHI, OPUS, RDC and Hughes Management has been formed to coordinate relevant aspects of the Strategic Planning for the Hibiscus Coast wastewater system. An integral tool for strategic planning is a hydraulic model of the trunk sewer network.

In order to keep all stakeholders informed and provide a panel for discussion, workshops are being held at major milestones. The workshops have been a valuable component in the decision making process, enabling frank exchange of ideas. Building a model representing such a large and significant infrastructure is driven by continuous multi-directional feedback loop. The model building process exposed to wider audience uncovers differences in understanding of how the system operates, promotes exchange of information and initiates new investigations.

3.2 HIBISCUS TRUNK SEWER MODEL

A hydraulic model of the Hibiscus Coast wastewater network has been developed by DHI (using the MIKE URBAN modelling software). The model is a trunk sewer model representing the core sewer network (both gravity and pressure main) running along the Whangaparaoa Peninsula from Hatfields Beach, north of Orewa, to the Army Bay WWTP. Additionally, the model includes a representation of the more significant local gravity reticulation, local pump stations and pressure mains feeding in to the trunk sewer system. Figure 2 shows the trunk model coverage and main storages.

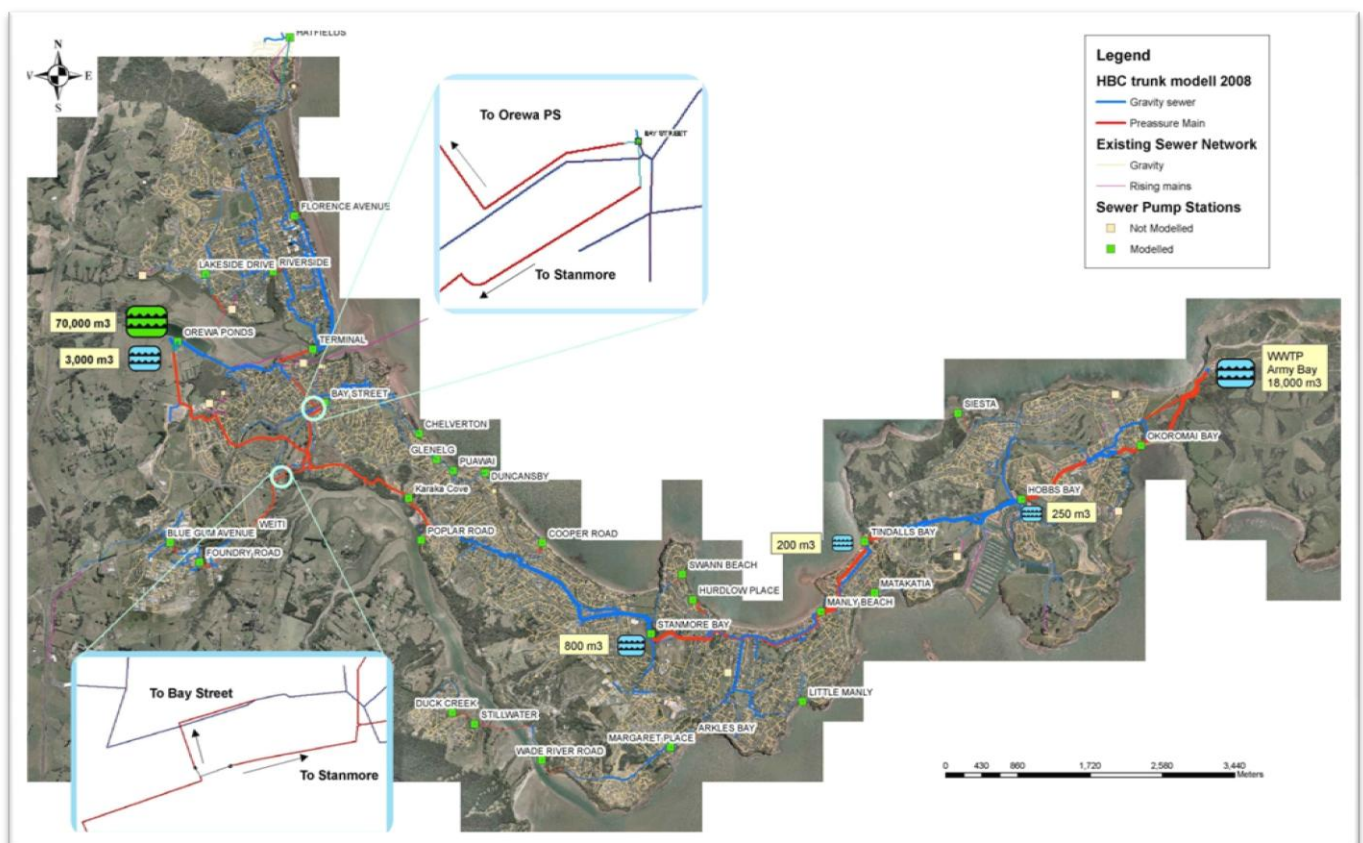


Figure 2 Hibiscus Coast Wastewater Trunk Model

The model was originally developed to represent the system (network and land use) as of 2001 to 2004, validated against derived flow data from a number of pump stations. Following the integration of Orewa and Whangaparaoa networks, the ‘2004 model’ was updated considerably to represent significant updates to the system. This model was further validated against known operational behavior. Overall, the qualitative validation of the model is good with the model generally being able to reproduce the performance of the trunk system and smaller sewer lines with a few exceptions. RDC are currently looking into deployment of flow loggers to obtain reliable gravity sewer flow data for use in quantitatively validating the model.

3.3 EVALUATION OF 2008 NETWORK OPERATING REGIMES

The inclusion of the new infrastructure which has been commissioned recently or is expected to be operational by the end of 2008 provides major new opportunities in network operation which needed to be investigated. These network additions include:

- New pumps at Hobbs and Stanmore pump stations
- Inclusion of new 600mm pipe from Doyly Drive to Stanmore Bay pump station (section of planned Poplar to Stanmore line upgrade)
- Inclusion of new 710mm line from Stanmore to Hobbs, bypassing Manly and Tindalls pump stations
- Operation of new 3 pipe inverted siphons from Alec Craig Way to Army Bay WWTP
- New inflow pipe to WWTP increasing the inflow capacity from current 360 l/s to 750 l/s. For the first round of regimes testing it was assumed that the plant can process continuous inflow of 750 l/s indefinitely, based on the screen design capacity.

The working group has decided to use a significant recorded storm event to test the regimes. It was acknowledged that the outputs of the testing are not to be used as definite assessment of the network performance, but simply a reasonable base for the regime evaluation and comparison. The use of a single storm event reduced model run times and provided a suitable framework for running the potentially large number of iterations required to test regimes. The long term rainfall records at Wairau Valley rain gauge sourced from North Shore City Council have been examined and a storm event for a period in October 2006 and was selected to be used as a “Test Storm”. While the statistical parameters of this event have not been determined, the storm is considered appropriate for regime testing in terms of network overflows frequency.

3.3.1 TESTING OBJECTIVES

It is widely understood that the overall system suffers from significant wet-weather inflow and infiltration, with overflows into the receiving environments at many locations. Although total containment is a desired benchmark, it is realistic to expect some overflows in extreme weather. A systematic evaluation of the environmental and aesthetic impact of existing and potential engineered overflow locations (to identify the most and least-preferred overflow locations) has not been undertaken, but the general agreement on the ranking has been agreed at the workshop.

The objective of the potential operational strategies is therefore to attempt to achieve, as far as practicable, three outcomes:

- Minimisation of the total volume of wastewater overflows from the system into the receiving environment;
- Overflow firstly out of the “most desirable” overflow location and lastly out of the “least desirable” or failing that,
- Minimisation of the volume overflowed out of the “least desirable” location

3.4 RTC MODULE

In order to enable model to be actively controlled, a Real Time Control module for Mike Urban has been used in advanced mode. A custom DLL (Dynamically Linked Library) has been developed by DHI to encapsulate the operational logic, obtain values for various control sensors within the system and to “override” the states for the controlled elements of the network. In this mode, the model is able to mimic the control of the network as performed by the operators (manual and automated).

The RTC DLL uses an external file for input parameters. This feature is very important in the iterative process of regimes testing as it enables changes of the control parameters without changing the model. An additional advantage is that the whole process is transparent and the state of the parameters used for a simulation is traceable and well documented. During the simulation, the DLL generates separate log files which can be inspected to confirm that the controlled devices in the model respond to the right triggers.

3.5 REGIMES TESTING

The current operation of the network is based on the extensive local knowledge of the network operators from Rodney Water and RDC. The SCADA system installed at Army Bay WWTP is mainly used to automatically control three balancing SBR tanks within the plant and ensure optimal treatment conditions.

The only location outside the WWTP that can be controlled remotely (manually) at present is the Bay Street pump station. Depending on the water levels in Stanmore storage tank, flows from Bay Street pump station can be allowed to go to Stanmore (default), or are diverted to the new Orewa Ponds pump station if overflow protection for Stanmore is required. The rest of the network has been operated manually. While the “best practice” operation of the network in wet weather conditions based on the experience is a valuable starting point, it is not directly applicable to the new infrastructure.

The working group has decided to start testing new network operations with “no manual control” mode and gradually increasing the number of controlled structures as and if required. The focus will be on controlling the trunk pumps and gates. Briefly, the operational components can be summarized as follows:

- Successively shutting down pumps on the main trunk line (Hobbs, Stanmore, Orewa Ponds)
- Utilize flow diversion options for Weiti and Bay Street pump stations

Several other alternatives are identified as potentially usable for improving operation of the ‘2008’ network:

- Controlling local inflow lines from Arkles Bay and Weiti;
- Limiting Hobbs output to protect WWTP
- Shutting down Tindalls instead/combined with Stanmore to protect Hobbs;

It is agreed that introducing new infrastructure into the model should commence once the working group is satisfied that the model loading (population growth and land use changes) has increased to the level which cannot be managed by changing the way network is operating.

3.5.1 REGIMES ITERATION PROCESS

The regimes testing process has started with two scenarios:

1. Regime 1 has been set up as a basic “uncontrolled” network operation. In this regime all installed pumps are available and driven by Start/Stop setpoints. The exception was inclusion of the remote manual SCADA control which can divert the flows to Orewa Ponds PS based on the level in Stanmore Bay storage tank.
2. Based on the past experiences, it was expected that the most problems will occur in the lower part of the network. Thus, the second scenario has been set up to shut the Orewa pumps early in the storm, as soon as Stanmore shows any sign of becoming overloaded.

As the first round of simulations was expected to give the working group insight in how the new main trunk functions under significant loading, the surcharges from the manholes are not modelled.

Before the testing took place, the working group has agreed on the model results presentation. A printed map of the whole network is to be produced showing maximum recorded water levels for manholes. To reduce the information overload, only the manholes with WL above the ground are to be shown, categorized and visually emphasized. Additional information on the map needs to show the accumulated overflow volumes at pump stations and maximum simulated water level in storages. This map was then used as a base for targeted detail analysis going directly into the result files.

When the first round of regimes was simulated with the “Test” storm, significant spills were observed at Bay Street, Weiti, Terminal and Glenelg pump stations. The issue around Glenelg overflow is set aside as being a local reticulation problem and the focus on improving the trunk performance was first placed on preventing overflows at Bay Street.

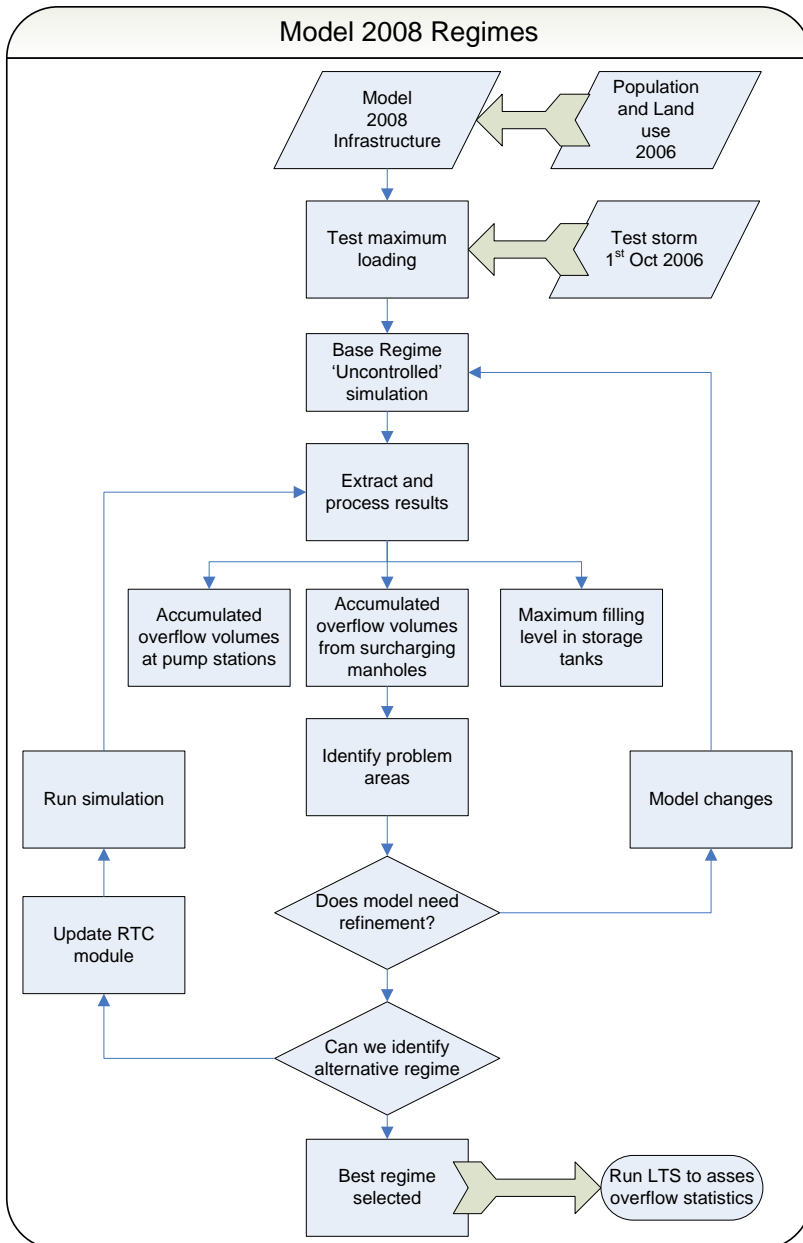


Figure 3 Regime testing plan

The second scenario, shutting down Orewa at the beginning of the ‘Test Storm’ did not seem to make much difference because Stanmore was coping well with new pumps installed and using the new direct line to Hobbs. Hobbs was also able to convey the incoming flow, although the off line storage tank was near full at the peak of the storm.

The results analysis of the first iteration has uncovered few areas with lower confidence. As model data was in agreement with RDC asset records, additional survey was conducted. The feedback has resulted in the asset data update, few model changes, and the testing of the first two regimes was repeated.

Further simulations were performed on an expanded set of control structures and trying different combinations. For example, enabling the assist pump at Terminal (normally not used) has removed the overflow at the pump station, but has exaggerated problems along the line to Orewa Pumps and at the Bay Street pump station. It was also found that Bay Street is able to pump more when going to Orewa pump station than it is when it pumps to Stanmore which is currently the default direction.

As a result of several iterations, the best performing regime during the ‘Test Storm’ was selected as follows:

1. No control required for Hobbs assuming sustained 750 l/s inflow capacity to WWTP at Army Bay
2. Stanmore should stop one pump to protect Hobbs and utilize the 800 m3 storage tank associated with the pump station
3. Orewa pump station should start trimming its output to Stanmore once the Stanmore Tank starts filling. When Stanmore tank is nearly full, Orewa should stop completely and utilize the largest storage in the system.
4. Weiti should be diverted to Bay Street permanently
5. Bay Street should pump to Orewa PS, instead to Stanmore

The selected regime was further simulated with addition of weirs on manholes. The results of this simulation were processed to extract total spills into the environment, both from constructed overflows and surcharging manholes. Figure 4 shows the processed results for the preferred regime. As it can be clearly seen, storage at Stanmore is not being used. As there was still some capacity available at Hobbs, it was decided to adopt the current regimes with possible further refinement in Stanmore Bay shutdown trigger levels.

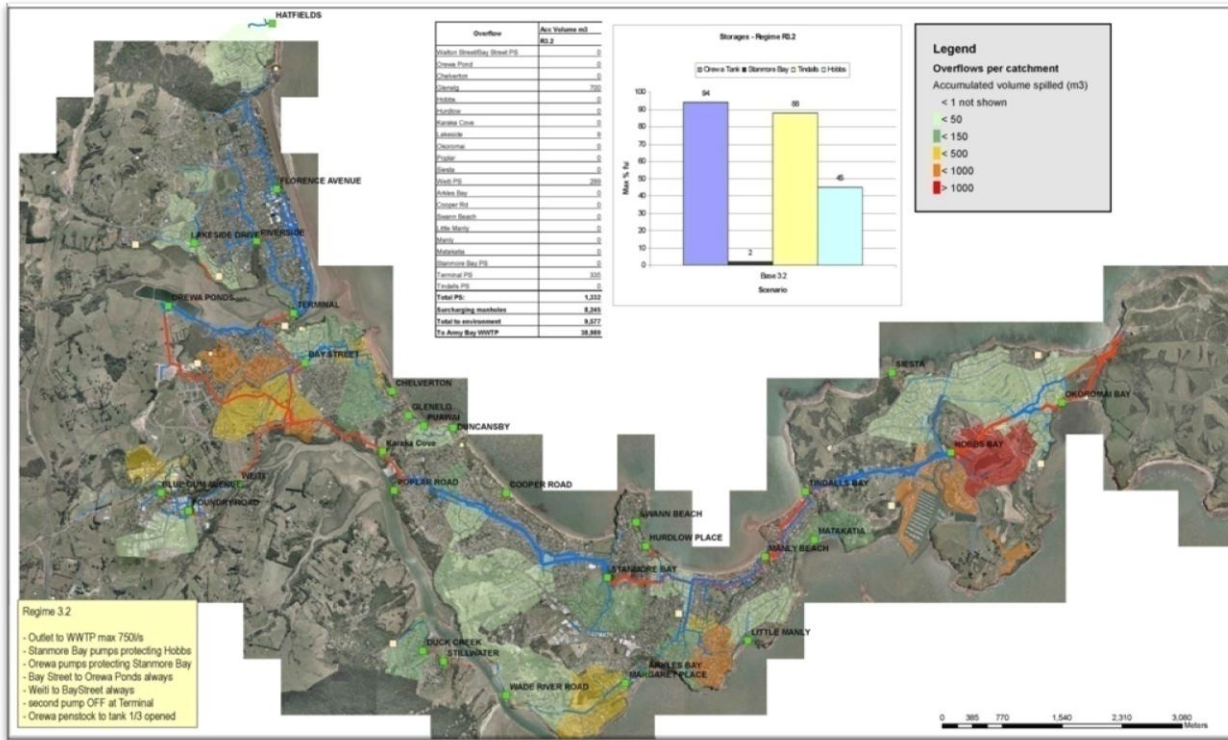


Figure 4 Presentation of overall results for the preferred regimes

Detailed information on testing iterations and outcomes was presented to all stakeholders at a workshop, where it was decided to move on to the next stages of the model development. As a first priority, the storage utilization within WWTP will be modeled and its effects on the selected regime will be investigated. Further regime refinement may be necessary, especially controlling Hobbs PS output. Once the new optimal regime for ‘Test Storm’ has been identified, the next stage is to assess the statistical performance of the network, i.e. the frequency and volume of spills into the environment over a given period.

3.5.2 FURTHER DEVELOPMENT

It is widely accepted by all stakeholders that the current stage in model development is only the first step towards more comprehensive system that would support decisions at all levels. The second stage for which the work has already been planned will include:

- Development of the results presentation environment which would provide access to level of detail required for the problem being investigated. A web based solution developed by DHI, Dashboard Manager (DBM) will be implemented on the RDC Intranet. The DBM will provide access to simulated results at the different levels, from overall system performance in terms of overflows and storage capacity, to details on pump operations and time series at specific locations.
- Deployment of flow meters to provide calibration data and increase confidence in model outputs.
- Investigating impact of waste water overflows into the marine environment.

4 WAIKATO FLOOD FORECAST SYSTEM

4.1 BACKGROUND

Accurate and reliable flow forecasting system forms an important basis for efficient real-time river management, including flood control, flood warning, reservoir operation and river regulation. In order to achieve this objective, it has become a common practice to apply GIS based software that integrates data management and forecast modelling tools in a single environment known as a data management and forecast modelling shell. Such shells incorporate the ability to configure links to telemetry, manage and examine real-time data, register forecast modelling tools, carry out manual or scheduled forecast simulations, examine the results and publish selected data to a range of media; including web, fax, e-mail and SMS for mobile phones. Moreover, the systems can be used to carry out scenario analyses to provide early flood warnings, flood alleviation and other.

The combination of a resilient and robust forecast modelling shell and a forecast model tool that incorporates an accurate and fast updating technique constitutes a strong tool that can be used by flood managers to provide vital, sometimes life saving, information to local authorities.

4.2 INTEGRATED DATA MANAGEMENT AND FORECAST MODELLING SHELL

Based on the concept for the existing MIKE FLOODWATCH, which has been applied in numerous projects world-wide, DHI Water & Environment has developed a new, modern and extremely robust forecast modelling shell with the objective to integrate data management, forecast models and dissemination methodologies in a single system, thus providing a base of a decision support system.

The system, which is based on the common water resources relational database for management and storage of data, is fully integrated into ArcMap GIS from ESRI, hence taking advantage of the newest GIS technology available on the market including modern scripting facilities and fast and robust methods for visualisation and processing of geographical data.

Real-time data including meteorological forecasts, radar imagery and telemetry data can be imported into the database and used as input to hydrologic and hydraulic forecasting models.

In order to ensure a high level of openness and flexibility, the forecasting shell system makes consistent use of the EUROTAS industry file format for model interfacing. The systems may be used to execute any model type including meteorological weather models, hydrologic models, hydraulic and hydrodynamic models, advection-dispersion models, water quality models, forecasting models, error forecast models and others. Alternatively, models from other suppliers may be registered with MIKE FLOODWATCH and run within this environment.

System tasks such as import of real-time data from remote data acquisition stations, execution of forecast modelling tasks or dissemination of selected results to relevant parties (Figure 5) are handled consistently using a task scheduler that facilitates definition of the above tasks as well as common system tasks such as database maintenance and deletion of old instances of forecast modelling tasks, log messages etc.

Access restrictions can be defined for each user or group of users, hence making it possible to ensure that only suitably qualified and experienced staff can gain access to the parts of the system that require particular know-how. In turn, this adds to the philosophy of offering an extremely robust system that can operate in a range of user environments.

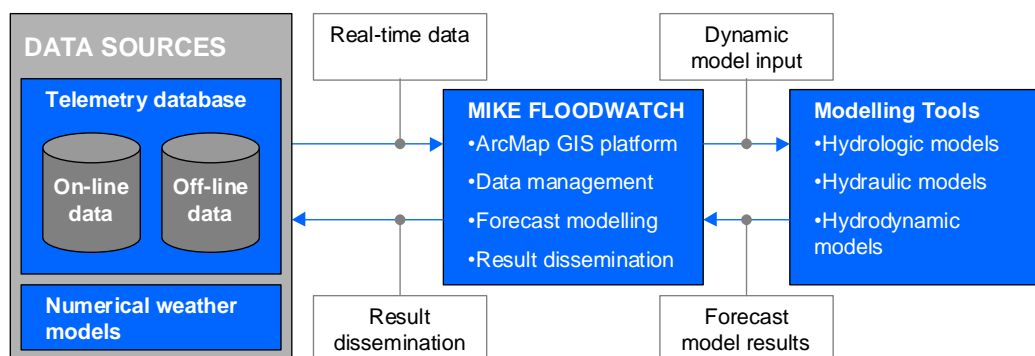


Figure 5 MIKE FloodWatch links telemetry to models and automatically runs forecast operations

4.3 FORECAST APPLICATION TO THE WAIKATO RIVER

The Waikato River is New Zealand's longest River. Located in the country's North Island, the river has its headwaters in Lake Taupo, from where it flows through a cascade of nine hydropower stations before emerging from Lake Karapiro just upstream of Cambridge. Approximately 65% of its 14,250 km² catchment is regulated

through hydropower generation. Flows originating from the hydro power cascade are generally regulated, though flood storage within the system is not sufficient to completely prevent floods.

In contrast, the uncontrolled Waipa catchment, which has an area of 2935 km² and forms around 55% of the total unregulated catchment, is a source of concern for flooding in its own catchment and in the lower catchment downstream of Hamilton. One of the prime objectives of flood management is to utilise flood storage within the hydro system to ensure that peak flows from the Waikato and Waipa Rivers do not coincide. Third catchment incorporated in the system is PIAKO, covering 1315 km² of mainly farmland. PIAKO model has not been yet calibrated.

Major floods have occurred in 1958, 1998, 2004 and most recently August 2008, causing millions of dollars in damage as well as significant social costs.

Environment Waikato is the regional authority charged with the management of the rivers within its jurisdiction. Flood control works comprise a series of stopbanks (levees), flood gates, spillways and pumping stations. One of largest flood control schemes is the Rangiriri-Lake Waikere scheme. This scheme utilizes the potential storage of Lake Waikere as a buffer to mitigate flood levels in the Waikato River downstream of Rangiriri. The scheme operates by allowing flood waters to pass over a spillway (totalling 1.8 km in length) built into the stopbanks and flow overland into the lake. Once flood discharges in the river have receded, water stored in Lake Waikere is returned to the river via a set of radial gates at the northern end of the lake, which allows flows to pass into a floodway and ultimately via the Whangamarino Wetland back into the Waikato river at Meremere.

Spillway flows must pass over the main State Highway No. 1, linking Auckland to Hamilton. Efficient operation of the scheme as well as the need to warn road users of impending highway closure are key reasons for the implementation of a flood forecasting system for the Waikato-Waipā catchment, and most recently Piako catchment. Other key reasons are to provide general flood warnings for flood prone rural and urban areas, and to enable management of the hydro power cascade to minimise flooding downstream. The latter is done in conjunction with Mighty River Power Ltd, the manager of the hydro system.



Photograph 1: Cars on State Highway 1 during the operation of the Rangiriri spillway

4.3.1 FORECAST MODELS

The basis for the flood forecasting system are three hydrological and hydrodynamic models based on the MIKE 11 modelling system, developed by DHI:

- Waipa catchment upstream of the Waikato confluence at Ngaruawahia;
- Waikato from the end of the hydropower cascade at Karapiro to the river mouth; and
- Piako catchment

Hydrological catchments are modelled using the NAM continuous rainfall-runoff model, which has been calibrated against observed flows.

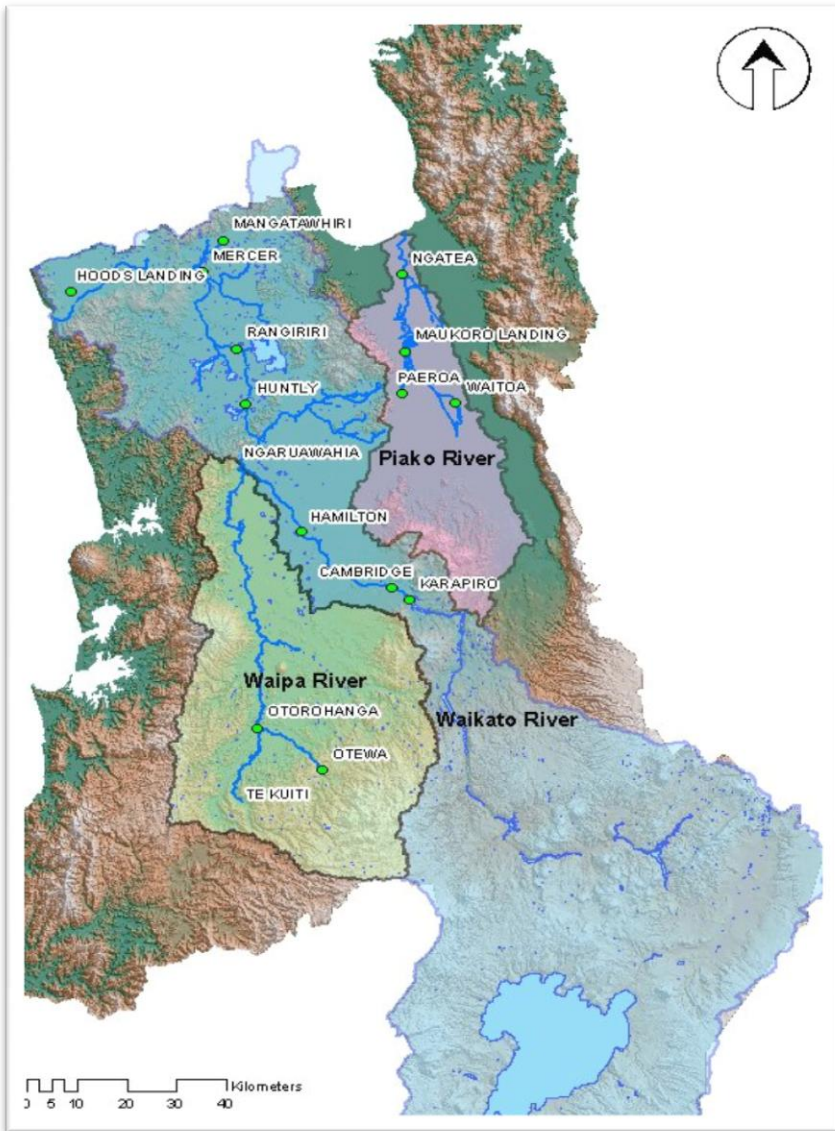


Figure 6 Waikato, Waipa and Piako Catchments location

The hydrodynamic model of the Waipa catchment covers the Waipa river from the Waikato confluence at Ngaruawahia, up to Te Kuiti, as well as major tributaries the Pinui and the Mangaokewa. River inflows are computed from the NAM hydrological model, while the downstream boundary is specified as the measured/forecast level at the Whatawhata gauge.

The Waikato River hydrodynamic model includes a number of smaller tributaries in its lower reaches including the Mangawara and Whangamarino Streams. The Rangiriri-Lake Waikere flood control scheme is described in detail in the model, including the spillways, lake storage and dynamic operation of the lake outlet gates. The downstream model boundary comprises predicted tidal levels computed from 14 astronomical constituents.

The Piako hydrodynamic model covers Piako River with Waitoa, Awaiti, Waikaka and Mangawhero tributaries. Open water level boundary is applied at Tarau based on predicted tide.

4.3.2 IMPLEMENTATION

The Waikato Flood Forecasting System was implemented at the Environment Waikato headquarters in Hamilton in 2004. Further update of the system was done in 2008 including:

- Addition of Piako model and definition of the external references to telemetry data;
- Refinement of forecast reporting including Dashboard Manager installation;
- Additional forecast statistics module; and
- Establishing a shadow system in DHI Auckland office

A real time telemetry system, HydroTel, continuously collects rainfall, river level and flow data throughout the region. Within the Waikato-Waipā and Piako catchment, real time data are available at 23 rainfall, 36 level and 32 discharge locations. Forecast rainfall is made available through New Zealand’s MetService, as is provided as point forecast data at each of the real time rain stations. Forecasts are available at 6 hour intervals for 72 hours into the future.

The real-time flood forecasting system is based on MIKE FLOOD WATCH, which is responsible for managing a range of fully automated tasks, including:

- Collection, quality assurance and processing of real-time data.
- Estimation of model forcings, including upstream inflow boundaries, precipitation boundaries and downstream water level boundaries. The derivation of each model input time series is accomplished using a data hierarchy that provides the best input time series possible given the data available at the time of the forecast.
- Initiation of the forecast model runs
- Export of selected flow and flood forecasts to the HydroTel server.

The above tasks steps are outlined in Figure 7, which illustrates the process of passing data between the HydroTel server, the forecasting shell and the forecast models.

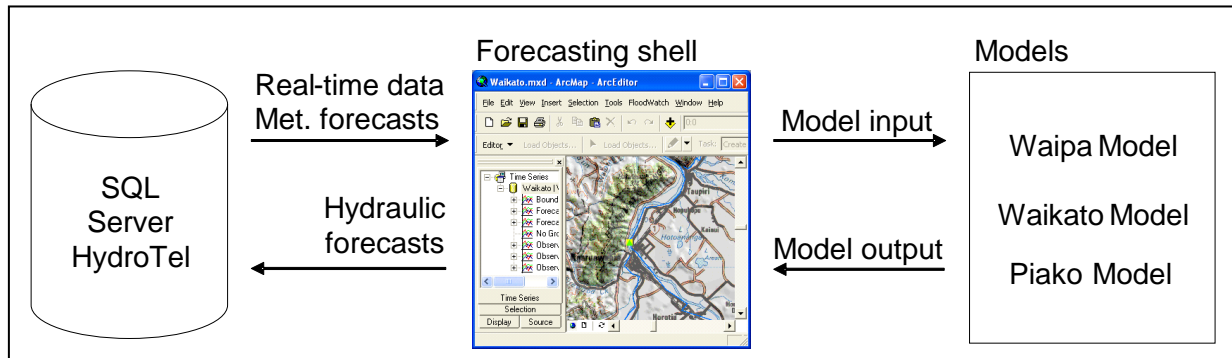


Figure 7 Forecast Modelling Schematics

Model forecasts are posted back to the HydroTel database, which allows users to view the model forecasts as a second “sensor” at each forecast point, the primary sensor being the observed data. It is envisaged that in the future the system can be extended upstream to include the hydro reservoirs up to Lake Taupo.

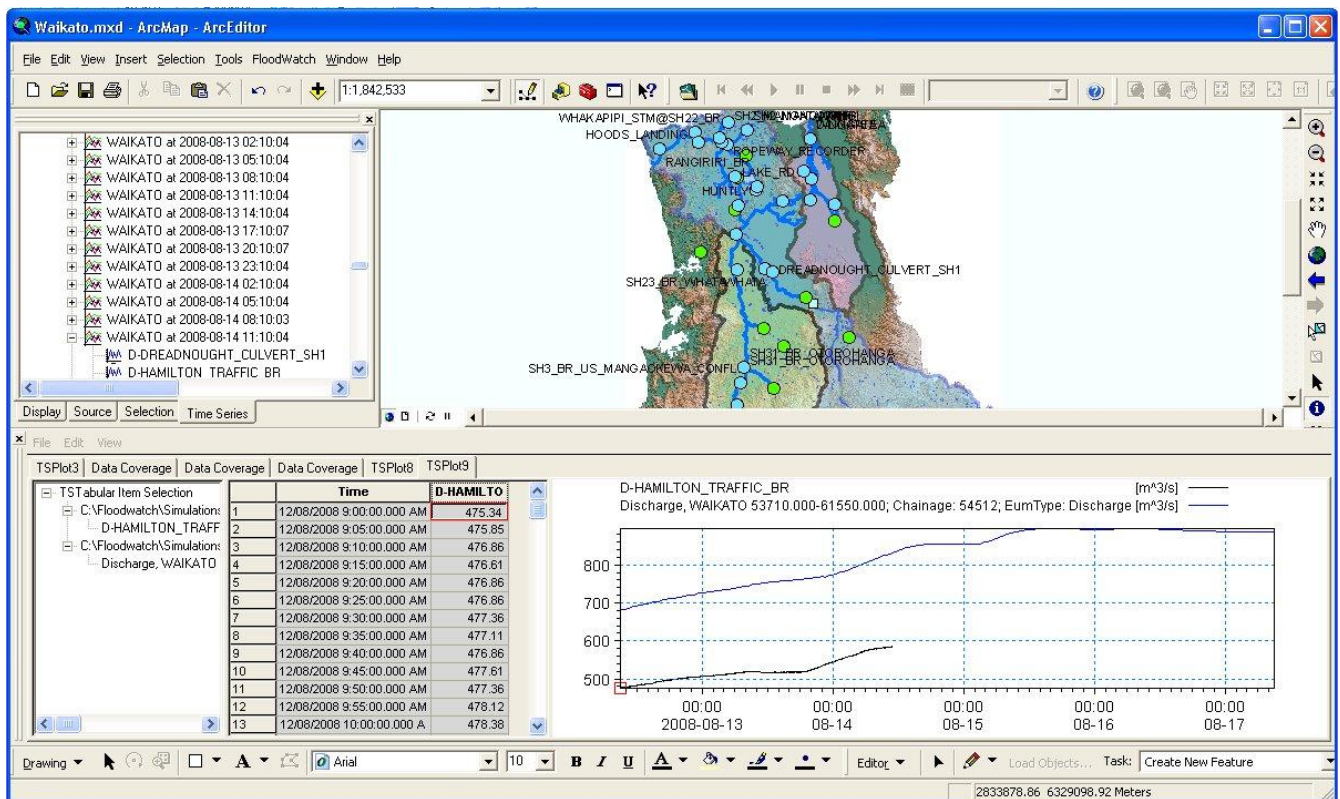


Figure 8 GIS interface to Flood Watch

In addition to the automated forecasting mode, the system can be used in manual mode to perform scenario analyses aimed at operating the power plants to mitigate incoming flood. The forecast system provides several features for comparison of observed and forecasted time series and visualisation of the full forecast results in the GIS environment. A sample of the latter is shown in Figure 8, which displays discharge observations at one of the updating stations and predicted flow at downstream location within the GIS environment. A number of timeseries can be added to the same plot

One of the important features of FloodWatch being utilized at different levels of the decision making is its capability to incorporate custom build analysis tools. Various scripts can be developed to process and aggregate data providing the users with valuable additional insight into the system. Waikato flood forecasting system can be tailored to publish its forecasts in number of different ways. The above described feedback to HydroTel is an example of system's flexibility in terms of outputs. One of the possible ways of publishing the forecast is by web pages. Figure 9 shows the web page outputs designed for Waikato.

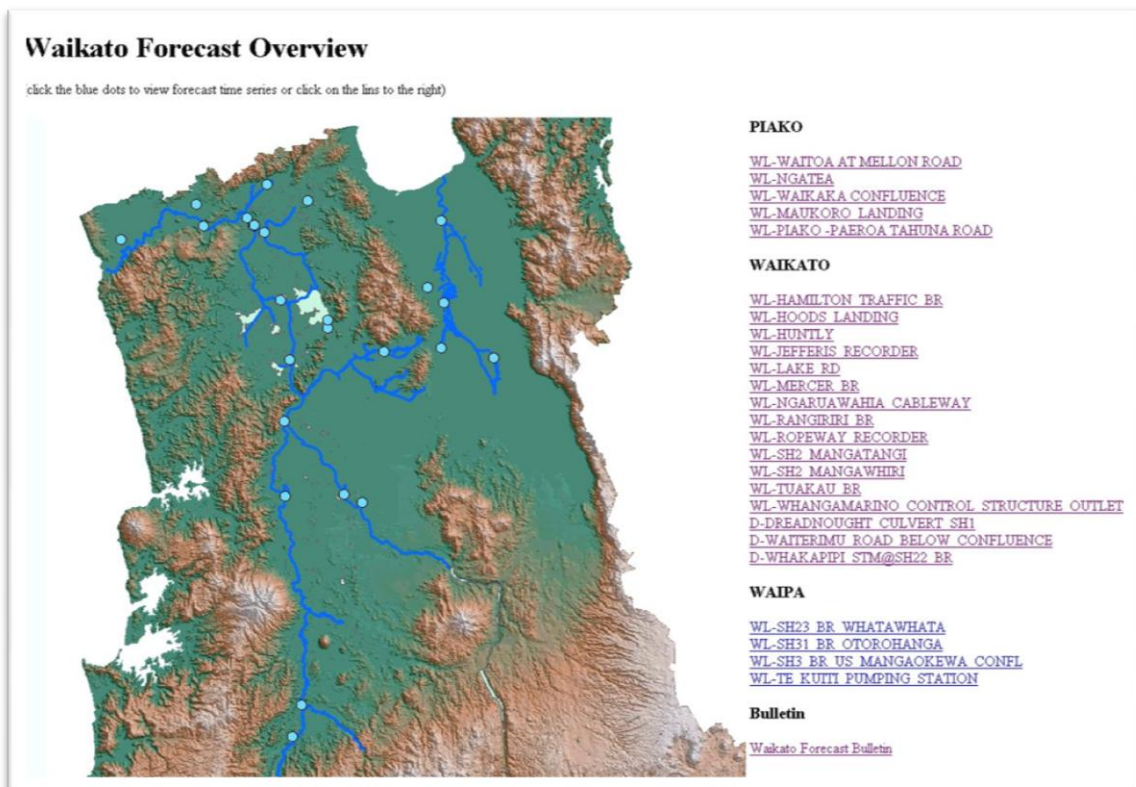


Figure 9 Waikato flood forecast bulletin

4.3.3 DASHBOARD MANAGER FOR FLOOD WATCH

A state of the art interface to FloodWatch has been developed using Dashboard Manager, a software solution developed by DHI that provides users with a platform for building web user interface. It uses common, familiar feel, visual objects (symbols) such as gauges, flags, dials, coloured lines, and maps to represent complex spatial-temporal data (e.g. simulation outputs) overlaid on to a familiar map background. More specialized controls, e.g. time series graphs; and hydraulic grade profiles can also be defined within the DBM interface.

The data used to populate the controls in the web pages can come from different sources. In addition to native access to the DHI products, it provides support for connections to most database systems via ADO.

Through Dashboard Manager interface the FloodWatch users have access to all components of the forecasting system including:

- Viewing the past simulations status and outputs including individual time series
- Event execution log
- Scenario simulations (shown in Figure 10)
- Executing individual tasks defined in the system

Events | **Scenarios** | Simulations | Status | Tasks | Time Series | Log out

Please select a scenario to view
 karapiro_guess

Scenario Information

ScenarioName: karapiro_guess
 Forecast settings alternative: WAIKATO
 Time of forecast (yyyy-MM-dd HH:mm):
 Hindcast period (HH:mm): 48
 Forecast period (HH:mm): 72
 Real-time mode: True
 Input hierarchy alternative: karapiro
 Output data alternative: WAIKATO
 Other files alternative: WAIKATO

Run Scenario

Select date and time: 13-08-2008 13:51:06
 Enter start in days: -3
 Enter end in days: 0
 Approve simulation: True
 User ID:
 Password:

Execute

Export To Excel

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Figure 10 DBM Scenario execution page

4.3.4 FLOOD WATCH – JULY/AUGUST 2008 EVENT

The flood event of late July/early August 2008 was the Waikato Region’s most severe flood event since February 2004. The event was in the order of a 10 – 20 year Annual Recurrence Interval (ARI) event in terms of flow in the Waipa River at Whatawhata, and the same in the Waikato River at Ngaruawahia, Huntly and Rangiriri. It was in the order of a 20 – 50 year ARI event in the Waikato River at Mercer. The extent of flooding from the Waikato River at Mercer is shown in photograph 2.



Photograph 2: Lower Waikato, Mercer

Throughout the event, Environment Waikato used a DHI Floodwatch system to predict the timing and extent of flood peaks in the Region's major rivers. Of particular concern was the timing of the peaks in the Waipa and the Waikato Rivers and when these were predicted to reach the confluence of the two rivers at Ngaruawahia.

Environment Waikato worked closely with Mighty River Power, to ensure that the middle Waikato hydro scheme and the outflow from the Karapiro Dam were managed to ensure that the peak from the Waikato River wouldn't coincide with the peak from the Waipa River at Ngaruawahia. The Floodwatch forecasts were invaluable for this process.

Environment Waikato was also able to run various outflow scenarios at Karapiro to see what effect this would have on the peak in the Waikato River at Ngaruawahia. Through this modelling work, Environment Waikato was able to consult with Mighty River Power about various recommended management strategies for the Karapiro Dam outflow. Floodwatch forecasts also helped in decision making around the balancing of risks between the level of Lake Taupo and the flows and levels in the Lower Waikato River system.

The forecasts have also been useful to monitor the recession of the flood peaks in the Waikato River. An informed decision could be made about when the Flood Rules in the High Flow Management Plan (an agreement that outlines how the hydro scheme on the Central Waikato River will be managed during flood events) no longer apply.

Environment Waikato has invaluable in-house experience and knowledge that can be drawn upon to estimate peaks and travel times in the Region's major rivers. In the past, during major events (before Floodwatch was up and running) key technical staff were relied upon to make decisions around flood scheme operations including the outflow from Karapiro. The process of calculating all required parameters, as experienced in previous flood events, was time consuming, drawing the most experienced staff away from other important tasks. Utilizing Floodwatch, 3-hourly published forecasts provided the management team with confidence required in implementing mitigating measures.

During the event, the accuracy of the forecasts was checked against the observed data, and based on this high level of confidence could be reached about the accuracy of the forecasts. Flexibility of the system was demonstrated when extended forecast was required for Waipa River due to the nature of the slow response time to peak. In less than an hour, the forecast period was extended from 48 hours to 72 hours providing more useful information for decision making purposes.

5 CONCLUSIONS

In the last decade or so we have witnessed an increase of data collection activity, modeling of the major water systems and development of specialized results analysis tools. Sophisticated modelling studies have been undertaken to obtain a better understanding of the complex systems, often driven by major capital works. However, many of the developed models have not been used to their full potential. The lack of integration in the overall management and decision making process has seen numerous models being shelved and never used again. An assessment of all potential uses of a model has to be the first, not the last step in model development, as it will shape the required detail its overall design. A well integrated model assists different decision making processes including strategic planning through various growth scenarios, finding the best way to operate existing infrastructure, investigating consequences of system failures (e.g. due to power cuts) or making timely informed decisions during the emergency situations like flood event.

A number of integration platforms are currently available, most commonly integrating models with spatial information through GIS. The new generation platforms go a step further by providing a flexible shell linking various data sources, models, scripts, scheduled tasks lists, results analysis tools and output presentation templates.

In order to promote the extended use of the models, an overall decision support framework has to be defined within an organization with the models being at its core. The system needs to be flexible, with defined sources of raw data, processing applications, and data exchange. The results presentation has to be suitable for different levels of decision making.

By taking ownership of a model and providing integration with other parts of the organization, the investment in model development will pay high dividends. The increased understanding of the natural or man-made systems under management is the first step towards its optimal use.

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