BUILDING A COMMUNITY ON A FOUNDATION OF FLOOD MANAGEMENT

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ABSTRACT

The topography and climate of the Kapiti Coast makes it particularly vulnerable to flooding. This natural hazard combines with one of the most rapidly developing regions in New Zealand to make the management of flood risk an imperative that influences almost every aspect of the core functions of the District Council (KCDC). Over the past 6 years SKM has worked closely with KCDC to model the majority of the open channels and stormwater pipe network in the district. This work involved the development of 5 large integrated models of the network, streams and floodplains within the urban centres on the Kapiti Coast. These 1D-2D coupled models have been used as the foundation for analysis to guide the decision and policy makers in their planning to address existing flood risks and guide future development.

This paper discusses how hydraulic modelling has been developed and utilised to inform floodplain planning including flood damage assessments, engineering upgrades, prioritising response, planning controls, community consultation, effects assessment and planning for climate change impacts. KCDC have applied a detailed understanding of flooding risk developed through hydraulic modelling as a powerful tool to shape the future of the Kapiti Coast.

KEYWORDS

Floodplain planning, hydraulic modelling, climate change, catchment management, flood damage assessment, community engagement

PRESENTER PROFILES

Ben Fountain is a Chartered Professional Engineer, and team leader of the SKM floodplain management team in New Zealand. Benhas undertaken a wide variety of modelling studies to quantify flood risk, identify flooding effects, map hazards, undertake flood damage analysis and design flood protection measures.

Blair Murray has been a Stormwater and Coastal Engineer with KCDC for the past 18 years. In that time he has been involved in nearly every emergency response to major flooding events in Kapiti and has had a hand in the planning and implementation of most of the flood protection projects. Over his career he has observed many and instigated some of the changes in methods and approach to floodplain management.

1 INTRODUCTION

The warm climate and relatively flat topography of the Kapiti Coast has long been an attractive quality that has led to this region being one of the fastest developing in New Zealand over the last two decades. However this same climate and topography also

makes this area vulnerable to rapid flooding. Much of the development on the Kapiti Coast is within undulating dune and swamp environments at the foot of steep westerly facing hills. Low lying areas within this environment are susceptible to ponding of runoff from high energy storms that gather moisture as they cross the Tasman Sea.

Severe flooding in 1998 and again in 2003, 2005 and 2008 has given emphasis to Kapiti Coast District Council's (KCDC) desire to manage the flood hazards within its District. Over the past 6 years KCDC have worked with SKM to undertake a comprehensive hydraulic modelling programme that is being used as the foundation for planning the management of this flood risk.

1.1 Hydrological and Hydraulic Modelling Background

The development of hydrology for the Kapiti Coast was based on the use of design rainfall recurrence isohyet maps, prepared by SKM for KCDC (SKM, 2008). The methodology employed the regional frequency analysis technique for determining the frequency distribution of annual maximum storm rainfalls. The parameter estimates are used to calculate the rainfall quantiles for each locality (station) within the region, and then rainfall recurrence isohyet maps have been generated over the region using Kriging geostatistical techniques. A range of climate change predictions have also been incorporated into the hydrology based on the Ministry for the Environment guidelines for local government (MfE, 2008). In the conversion of rainfall to runoff a unit hydrograph based methodology has been adopted. Hydrographs have been developed using the balanced storm methodology to help identify flooding relating to both discharge and volume.

A series of hydraulic models have been developed that cover the majority of the Kapiti Coast urban centres and their surrounds. The models have been developed in the DHI modelling package MikeFLOOD which allows for the linking between the pipe networks, open channels and floodplains. Through a combination of asset and cross-section surveys and LIDAR (Airborne laser scanning) the hydraulic models have incorporated a high level of detail of the primary and secondary flood flow paths and floodplains.

Once confidence in the models was established through calibration and verification against observed data the models were run for a wide range of rainfall events. The models' sensitivity to factors such as culvert blockages, rapid aggradation and varying predictions of climate change impacts were also investigated and used in the development of design scenarios and appropriate freeboard allowances.

2 HYDRAULIC MODELLING FOR FLOODPLAIN PLANNING

The high level of detail that has been achieved through the modelling investigations has provided KCDC with models as powerful tools for developing appropriate responses to manage the flood risks. The core objectives of the responses are to address the existing flood risks and to limit the increase of the risk by controlling future development. In working towards achieving these goals the information that can be obtained from the hydraulic modelling has initiated or enhanced a range of opportunities including broadening the scope of management planning, flood damage cost analysis, tightening development controls, assessing a community's resilience to flooding, and engagement with the public.

2.1 COMPREHENSIVE FLOOD RISK MANAGEMENT

Through the assessment of a wide range of rainfall scenarios the hydraulic modelling has provided insight into the link between the likelihood, magnitude and the consequences of flooding, including the cultural, social, environmental and economic impacts. This has led KCDC towards a holistic approach to the management of the full flood risk profile. Similar to the terminology commonly used in health and safety legislation KCDC are applying the Eliminate, Isolate and Minimise approach to flood risk management.

Within New Zealand much of the flood risk profile is managed through private insurance. Repeated flooding can jeopardise this important risk management tool. Avoidance of regular inundation of floor levels is an imperative to meet Territorial Authorities' mandate to promote the wellbeing of a community as well as being a requirement of the Building Act for new development. In the absence of clear direction from the insurance industry, KCDC are seeking to eliminate flooding of floor levels for residential and commercial buildings in a 10% AEP event as a minimum level of service. This is largely achieved through providing sufficient capacity in the primary networks to prevent the interface of the hazard with people or property. Minimum levels of service are an important counter to a fully risk based management approach as they help to provide equity across the diverse regions of the district.

Minimum levels of service help to prioritise urgent upgrades to address existing flooding issues and are a useful tool for communicating with the community and managing their expectations. However on the Kapiti Coast the minimum actual levels of service are well below the Council's target levels of service for new development. Furthermore in many areas of the District there is a desire for much higher levels of protection to be implemented. An example of this is the main commercial area in Paraparaumu which KCDC has recognised as vital to the life of the community and an important centre to provide with a high level of protection. Through engagement the community's various values, priorities and willingness to fund upgrades have been distilled and used to inform a multi-criteria approach to prioritising responses over and above the minimum levels of service. A programme of works is being developed to isolate people and property from the flood risks. Historically this has been implemented through capital works projects such as stopbanks or building up the low lying land, more recently the focus has been on identifying and maintaining secondary flowpaths, protecting or creating compensatory storage and requiring new development to integrate with the natural systems. 2D modelling of the floodplain surface can help define secondary flowpaths to within a few metres and can provide a high level of accuracy to locations of storage.

KCDC has recognised that works to isolate the community from flooding tend to cover only the lower part of the risk profile. It has begun developing responses to minimise the flood risks predicted in extreme events greater than the 1% AEP flood. These responses include education, emergency response planning and early warning systems. The model results have been used to calculate the product of flood depth and velocity to locate areas of high risk to life, property damage or environmental impact. This information has been overlaid onto locations of known high vulnerability such as retirement villages, schools, hazardous goods and medical centres to help inform the response. Threats to vital service lines and transport corridors have also been mapped.

2.2 FLOOD DAMAGE ANALYSIS

Quantifiable risks, costs and benefits are needed to implement a risk-based prioritisation of upgrades through a multi-criteria approach. One of the most useful applications of the

results from 2D modelling is the rapid assessment of potential flood damages. KCDC has undertaken floor level surveys of nearly all habitable and commercial buildings identified as potentially flood prone in a 1%AEP event. When this information is combined with the peak water surface levels for a range of predicted flood events the flood damage costs can be calculated. The flood damage analysis model for the Kapiti Coast has been constructed using updated depth-damage curves that were originally developed and reported in the *Hutt River Flood-Plain Management Plan* (Agricultural Engineering Institute, 1992). The damage costs in this report were based on research following severe flooding in the Hutt Valley in 1992. While these values have been analysed and updated to today's costs there is little available information to verify them against more recent or local data. This highlights an information gap within the practice of floodplain management in New Zealand and presents an opportunity for a multiparty collaborative investigation, including insurance companies, councils and infrastructure asset managers.

In this methodology the damage costs to residential buildings are assessed utilising a flood level relative to the floor level and commercial and industrial building are assessed by also considering the flooded floor area. During the survey of floor levels additional information on the age and condition of the house was also collected and used to refine the flood damage model.

This process has been undertaken across the district to quantify the direct damages to buildings during a range of flood events. This data is then combined to calculate the average annual damages that can be expected and quantify a Net Present Value (NPV), or total expected damage costs over a given timeframe. The NPV assessment has proven to be a valuable tool when planning and communicating flood mitigation options to the public. It provides an early indication of an appropriate scale of mitigation measures that should be considered and informs the economic analysis in the multi-criteria analysis used to prioritise upgrades.

This process has also been undertaken to quantify the damages associated with climate change impacts. In representative locations across the district the model results have been used to calculate the damages for a wider range of sea level rise and increased rainfall scenarios. This analysis has helped highlight the challenges that climate change and, particularly for Kapiti, sea level rise presents. The modelling has identified key trigger levels associated with historical building standards around the coast when damages rapidly escalate. This understanding highlights the need for taking a long term and risk averse approach to new development. It is also helping inform appropriate responses to climate change risks both in timing and method.

2.3 LONGTERM VULNERABILITY MANAGEMENT

The recent acknowledgement of the risks of climate change has confirmed the need for long term planning while also challenging floodplain managers to consider broader ranges of mitigation measures. KCDC has recognised that the predicted changes in rainfall and sea level rise are likely to intensify the flooding risks in this already vulnerable region. The Council has been proactive in using its available resources to quantify the impacts of a range of climate change predictions, including the upper ranges of those predictions, and to develop appropriate responses.

Future upgrades, recommended building levels and new developments are required to be assessed using a minimum of 0.8m of sea level rise and 16% increase in rainfall depths and intensities as is the MfE guidelines for local government (MfE, 2008). In addition to this, much of the long term planning, particularly where changes are required to the

District Plan, is being undertaken with consideration of 40% increases in rainfall and sea level rise measured in metres. The uncertainty surrounding the potential impacts has led the Council to shift away from the historical reliance on hard engineering such as pipe networks and towards more adaptable flood mitigation measures such as securing overland flowpaths, valuing areas of flood storage and avoiding low lying and coastal locations. It has also been a driver behind KCDC broadening its assessment of flooding from just threat to life and property to also assessing a community's resilience to flooding.

The hydraulic modelling investigations have identified that many flood prone locations will become difficult to protect and long term solutions such as managed retreat will need to be considered. KCDC's exploration of managed retreat has emphasised the need for close co-operation of the Territorial and Regional Councils as rules in District Plans cannot be used to control existing use rights. Buildings constructed before new rules come into effect have existing use rights under section 10 of the RMA. Property owners can modify and in some cases even rebuild where the effects are the same in character and scale to the previous building (even where new buildings are a prohibited activity). However the Regional Plan can control both existing and proposed development on land but not subdivisions. Section 20A of the RMA limits existing use rights when a new regional rule becomes operative.

2.4 FREEBOARD

The application of freeboard onto modelled peak water levels is an essential tool in the management of risk and uncertainty. Traditionally freeboard has often been applied as a fixed depth across the flooding extent. However as hydraulic models become more detailed and there is a shift towards implementing risk-based floodplain management practices, there is a need to undertake a higher level of analysis in the application of freeboard. Climate change uncertainty is another driver behind rethinking how freeboard is applied. While climate variability has always been one of the factors that has been considered in setting freeboard levels this uncertainty is increased and in many locations eclipsed by the wide range of long term predictions around sea level rise and increased extreme rainfall.

KCDC has utilised its hydrological and hydraulic models to assess a wide range of scenarios to help quantify in greater detail the risks and uncertainties. Variations assessed include event based geomorphological changes, hydrological variations, sea levels, land use, blockages and ground water. Informed by this analysis a dynamic freeboard has been applied that varies across the catchment. Typically, lower freeboard allowances are applied in the upper catchment or on the margins of the floodplain, while greater allowances are applied at locations of changes in grade, in storage areas or in reaches near the coast. For the purposes of communication with the public a risk-based approach dictates that there should be no distinction between freeboard and the published peak water levels.

2.5 HYDRAULIC NEUTRALITY

In 2010 KCDC updated the District Plan and subdivision guidelines to include much tighter controls on new development. Central to the changes was the desire for new development to achieve 'hydraulic neutrality' as close as is practicably possible. This is an aspirational target that seeks no increase to the surrounding flood risk by minimising the hydraulic impacts as a result of the development. The changes included the requirement for new developments to assess their impacts on flood storage, primary and secondary flow paths and the changes in land use under both current and future climates. Subdivision applications were required to include detail of how hydraulic neutrality would be achieved. They are required to produce their own hydraulic modelling within their development and look at upstream and downstream effects. This is often peer reviewed at the applicant's expense with failure to meet the required standard likely to result in refusal to grant Consent under Section 106 of the Resource Management Act.

The Council's ownership of the comprehensive hydraulic models of the region provides the foundation to set the baseline from which assessments of effects can be made as well as providing a powerful tool to assess or confirm the effects and the proposed mitigation measures.

These measures have proven to be particularly timely as three of the proposed Roads of National Significance projects are either in part or fully within the Kapiti Coast district.

2.6 COMMUNITY ENGAGEMENT

An important aspect of managing flood risk is engagement with the community in the process of identifying hazards and developing and prioritising appropriate responses. Often the strong technical foundation on which floodplain management plans are developed is undermined by ineffective sharing of the information with the community. Rather than offering a "black box" to the public, with some manipulation and clear visual mapping, hydraulic modelling results can be a valuable tool for communication with the community. Over many years of flood related community engagement on the Kapiti Coast the following points have been compiled:

- Long term residents have much valuable information on flood behaviour that can be used to strengthen the modelling validation process. Engaging the community in the process of identifying and mapping flood hazards also builds community acceptance of the outcomes and helps to avoid challenges during the updating of the district plan.
- There is a brief period following a damaging storm event, measured in months rather than years, where flooding will be at the forefront of the collective communities' mind. Take advantage of these windows to engage with the public.
- Communication of flooding risks and management often requires taking the information to the public by vehicles such as community events, schools and residents associations.
- A combination of the complex concepts and potentially high personal impact means that the public often require one on one interaction.
- KCDC effectively utilises interactive GIS spatial tools to communicate with the public, providing information on ground levels, flooding extents and depths and recommended building levels.
- Many Councils are using the internet to inform the public of the flood risks. There could be significant benefits, as described in the first bullet point in this section, in

using this medium to engage the community in the process of identifying and analysing hazards and developing flood risk management plans.

- The daily interaction with waterways is often prioritised by a community over the risks associated with rare flood events. An integrated approach is therefore required to meet the demands of water quality and stream enhancements while also providing or at least securing long term flood protection measures.
- Climate change impacts are a driver towards local authorities considering a broader and longer term approach to floodplain management. This is enabling implementing flood mitigation measures such as house raising or managed retreat which can be implemented incrementally over a long-term period of successive financial cycles. However these measures need to be carefully positioned and presented to the community.
- It is essential to utilise a structured prioritisation process to implement upgrades using defendable methods such as a community influenced multi-criteria approach. This helps to avoid the inevitable community pressure to address the most recent flooding issues rather than those with the highest potential risk.

3 CONCLUSIONS

The advances in computer power, modelling and spatial software and aerial survey have opened the door to a much greater understanding of flood behaviour than has previously been accessible to most local authorities in New Zealand. These advances in technology have coincided with the growing concerns about the long term climate trends which are driving changes in the way flood risks are addressed. Kapiti Coast District Council has embraced these opportunities and is utilising detailed hydraulic modelling as a foundation to address the considerable challenges that face the region. The high level of understanding of flood behaviour has enabled the Council to work towards management of the whole of the flood risk profile and it has the tools to limit increases in flood risk as the region develops.

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