FLOODZOOM – EMPOWERING INTELLIGENT FLOOD PLANNING AND RESPONSE

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Abstract

During 2010, 2011 and 2012 Victoria experienced significant floods across the majority of the state. More than 100 communities were affected with a damage bill exceeding $1.3 billion. The Victorian Government undertook the 2010-11 Flood Response and Warning Review lead by Neil Comrie. Amongst the Review's findings was the importance of timely, relevant and accurate flood warnings to prepare communities for impeding floods.

In response to this finding, the Victorian Government announced the FloodZoom initiative. The aim of the initiative is to improve quality, quantity and access to flood risk mapping and flood intelligence material. This material will in turn support locally tailored flood warnings and community education. The initiative has three components: improvements to flood warning gauges and systems, flood risk assessments and mapping and the FloodZoom Flood Intelligence Platform.

This paper focuses on the third component, FloodZoom – flood intelligent platform. The first and second components are briefly discussed.

FloodZoom is a web-based platform to provide an authoritative source of flood behaviour data and intelligence for agencies when responding to flood events, assessing land use planning application, and developing community education material.

This paper will examine the project drivers, key user requirements and stakeholder engagement. Examples of FloodZoom's functionality will be provided including outputs/products. Lessons learnt in the development of FloodZoom will be outlined,along with future FloodZoom platform development directions.

Introduction

2010-11 & 12 floods – overview of impact

From September 2010 to March 2012 parts of Victoria experienced some of the worst flooding on record. During the summer of 2010/11, one third of the State experienced flooding, with significant financial and socio-economic costs.

The largest flood occurred in January 2011, with nearly 4,000 houses damaged, 4,000 businesses and primary producers affected, and nearly $450 million in agricultural and tourism losses (Victorian Government, 2011). The total cost of the floods was estimated to be around $1.3 billion, taking into account costs to individuals, Local Government, Catchment Management Authorities (CMAs), government departments, agricultural losses, repair and restoration costs and other recovery (Victorian Government 2011). Figure 1 shows the flood severity for the January 2011 event. In

March 2012, another flooding event impacted some 40 towns, with significant socio-economic impacts across the North East Region.

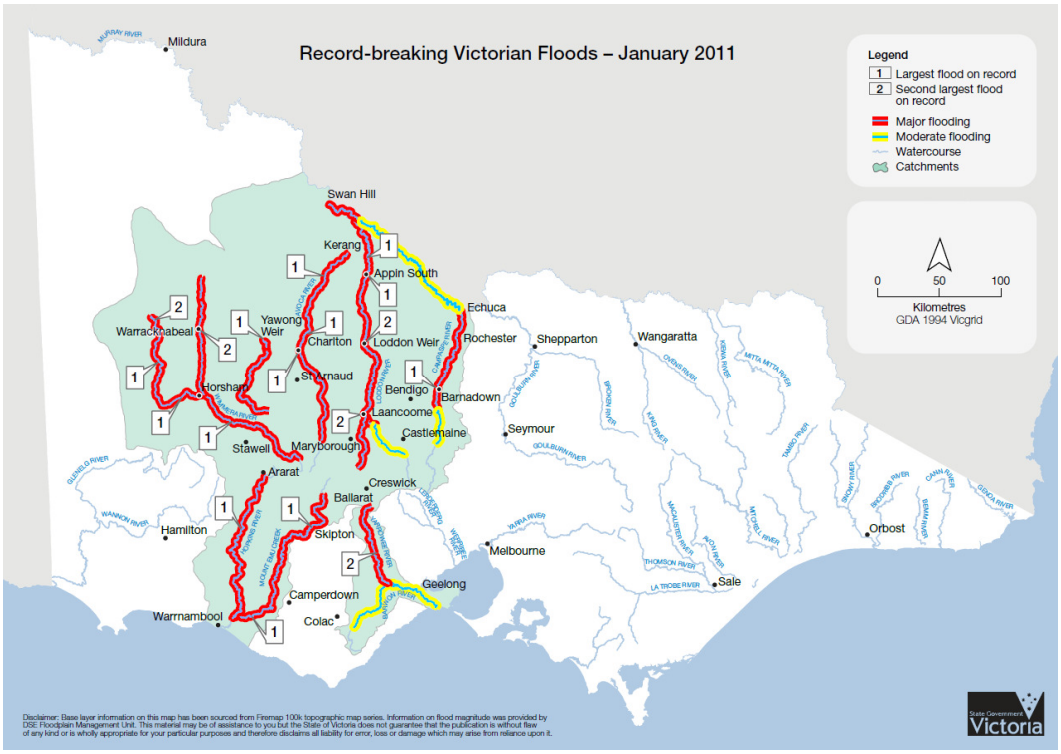

Figure 1 January 2011 flood event – Flood Severity (DEPI)

Flood reviews – relevant findings

In response, the Victorian Government established a review to examine the adequacy and efficacy of the State's arrangements for flood response, flood recovery, emergency warnings and evacuations. The Review of the 2010/11 Flood Warnings and Response (Victorian Floods Review), led by Mr Neil Comrie AO APM, was provided to the Premier on 1 December 2011.

On 8 December 2011, the Premier and Deputy Premier released the final report of the review. The majority of the report's 93 recommendations relate to how Victoria can better prevent, mitigate, respond to and recover from major flood events.

The Victorian Floods Review (VFR) recommendations concerning flood warnings identified four general areas of weakness:

- Limited community involvement in many aspects of flood warning systems.
- Lack of clarity over the roles, ownership and accountabilities of flood warning systems.
- Gaps in the flood warning system network across the state.
- Out-of-date flood plans and inconsistent flood planning.

Two further reviews were undertaken by the Office of Emergency Services Commissioner (OESC) following flooding across North East in February-March 2012 and the Gippsland Region in June 2012. These two reviews found similar weaknesses as above.

Flood reviews – initiative and response

FloodZoom, a $25 million flood warning repair and improvement initiative, was launched in May 2011. FloodZoom is addressing many of the recommendations made in the VFR. The four-year program features three key elements:

- Flood warning system improvements
- Flood mapping and risk assessments
- Flood intelligence platform (FloodZoom)

The Victorian Government responded to flood warning related recommendations in December 2012 through the "Improving flood Warning Systems Implementation Plan" (Victorian Government 2012). This implementation plan built upon the FloodZoom Initiative.

This paper focuses on the third component, FloodZoom – Flood Intelligence Platform. The first and second components are briefly discussed.

Floodplain/flood management roles – During floods and between floods

In Victoria, the identification, assessment and prevention of flood risk is the responsibility of:

- The Department of Environment and Primary Industries (DEPI) at a state level
- CMAs, Melbourne Water and Local Government at a regional andlocal level

Typical activities include flood mapping, and mitigation measure assessments and implementation. Mitigation measures can consist of land use planning controls, total flood warning system design, and structural works. The Victoria State Emergency Service (VICSES) have the responsibility for flood response planning and operations, and community education.

During flood response operations, VICSES employ the Australasian Inter-service Incident Management System (AIIMS) structure for command and control arrangements. Within this AIIMS structure, DEPI/CMAs fulfil a "flood specialist" function in the Intelligence Cell. For significant flood events, VICSES also engage external consultant hydrologists in the flood specialist role. During a major flood event, technical flood specialists are involved to interpret the flood height forecasts into flood behaviour and consequence (extents/depths/velocity/duration). This then informs flood response activities and community messaging.

This paper focuses on the needs of the flood specialist and how FloodZoom can support this role.

FloodZoom – Flood Intelligence Platform

Concept - Long time in the making

The Total Flood Warning System (TFWS) concept has a number of interdependent elements to enable effective application. EMA Manual 21 Flood Warning (Australian Government 2009) notes the elements of a "total flood warning system" are:

- Monitoring of rainfall and river flows that may lead to flooding,
- prediction of flood severity and the time of onset of particular levels of flooding,

- interpretation of the prediction to determine the likely flood impacts on the community;
- construction of warning messages describing what is happening and will happen, the expected impact and what actions should be taken;
- dissemination of warning messages;
- response to the warnings by the agencies involved and community members, and;
- review of the warning system after flood events.

A number of authors have examined the effective of the TFWS in an Australian context (Pfister (2002), Anderson-Berry (2002) and Soste and Glass (1996)). Generally these papers conclude that the TFWS fails due a limited system view of the design, performance and operation of the TFWS. The investment in TFWS elements focused on the data collection and prediction elements without due regard of the other elements. Also, these papers point to a lack of understanding and/or ability to interpret predicted flood heights into local consequences and response actions.

In particular, Keys and Cawood (2009) noted:

> ".. that the biggest weaknesses in flood warning practice in this country lie in the utilisation of the Bureau's warning products rather than in their development. The responsibility for making these improvements lies with agencies like the State and Territory Emergency Service (S/TES) organisations and with local government, the specific roles of these entities varying somewhat between jurisdictions. What is needed in most areas is a strengthened capability within them as regards the interpretation of and adding value to the Bureau's flood forecasts and a more effective dissemination of warning information".

The VFR (Victorian Government 2011) along similar lines noted:

> "There are gaps in the gauging network, however, more flood gauges will be of limited benefit without communities knowing what warnings mean for them so that they can take the necessary steps to ensure their safety and reduce property damage. Enhanced flood risk planning, including coverage and quality of mapping, coupled with community education is required" (p4).

These comments highlight the inter-dependencies within the TFWS to enable effective application. A flood intelligence system/platform plays a critical role in the "interpretation of the prediction to determine the likely flood impacts on the community". Without an effective intelligence system/platform the content of the flood warning message can be compromised, and so in turn the agency and community responses can be too compromised.

Again, EMA Manual 21 Flood Warning (Australian Government 2009) notes "Flood intelligence systems are required to add local context and meaning to flood predictions. Where quantitative predictions are provided, this means linking impacts to the numbers" (p28).

There are several flood intelligence systems in use across Australia (Gissing et al 2004, Morgan et al 2013, Mirfenderesk 2009). In particular, NSWSES has developed a flood intelligence system consisting of a flood intelligence database, Local Flood Plans, a library and associated spatial data (Morgan et al 2013). FloodZoom's origins were found in these flood intelligence systems.

Scope and objectives

FloodZoom aims to integrate flood behaviour predictions with asset data to inform decision making for flood planning, response and recovery by communities and agencies.

There are three fundamental objectives for FloodZoom:

- To collate and access flood behaviour and consequences related material.
- To assess flood behaviour and consequence related material for use in locally specific flood warning and advice.
- To share flood related warnings and advices between agencies for use in community messaging, flood response actions and decision making.

Accordingly the scope includes the following aspects areas:

- Acquisition of real-time and historical rain and stream gauges data.
- Collation and storage of flood related behaviour information, such as historical and modelled flood extents, depths, flood levels, study reports, observed flood impacts
- Sharing flood intelligence products between agencies during an event.
- Assessment of land use planning activities and permits for locations subject to inundation.
- Initial focus on riverine flooding, with potential to extend coastal, storm water and tsunami related flooding in the future.

Stakeholder consultation and engagement

Stakeholder and user groups

The project scope and objectives required the engagement with a broad group of stakeholders/users. To aid the engagement process, stakeholders were broken into two groups that defined the level of access and role they would play within FloodZoom; namely, content creators and content consumers.

The content creator group primarily consisted of principal users in the flood response and land use planning aspects. Gissing et al (2010) notes these two user groups as flood emergency managers (VICSES) and floodplain managers (Catchment Management Authorities). Further, Gissing et al (2010) highlights the benefits from close collaboration between these groups. Also in the flood response user group are consultant flood specialists.

The content creator group have been consulted through regular workshops and informal discussions. This group has a primary role in shaping FloodZoom's functions and useability. The consultation processes has helped to strengthen understanding between the flood emergency managers and floodplain managers.

The content consumer group consists of emergency services and other agencies who require flood related information for operations and community messaging during flood events. Generally this group has been informed through presentations and demonstrations.

Business and user requirements

The collection and refinement of user requirements has evolved over the project life. Initial engagements with the content creator group yielded general requirements of functions, data and access. In total 124 user requirements have been identified to date.

The definition of the user requirements generally narrowed with continued engagement.

The user requirements were prioritised by the content creator group based on need to fulfil flood interpretation/intelligence services. The initial focus is to support the collation and access to the flood related material in the first set of FloodZoom releases. Subsequent releases will expand into the assessment tool and sharing capabilities. The land use planning related requirements are currently being refined in conjunction with CMAs.

A primary requirement that emerged from early engagements was a web-based delivery of the platform. This requirement has driven the accessibility of flood related material across numerous Incident Control Centres (ICCs) during an event, and the business need for a state level solution.

A further primary requirement centred around the user roles and privileges. As discussed, the users have been grouped as content creators or content consumers. The content creators will be have the ability to create, approve and publish products for the other users. This approval process ensures appropriate products are provided for use in response planning and messaging.

Proof of Concept Development
The initial user requirements shaped the technical requirements and identified possible technology stacks. Several proof of concept solutions were developed to test functionality against the user requirements. Additionally some technical requirements were shaped by existing DEPI arrangements. Some details of the selected technical solution is provided later in this paper.

Familiarisation and training
As part of fostering familiarisation and ownership of FloodZoom upon its first production release, content creators and content consumers will participate in FloodZoom familiarisation sessions and training.

Familiarisation sessions will be extended to all users of FloodZoom, whereas training will be refined and tailored according to user access, primarily focusing on the specialised role of content creators.

Both the familiarisation sessions and training will also outset ongoing feedback and consultation on its useability and going development to ensure the platform meets the needs and overall objectives of its content creators and content consumers.

Technical aspects

FloodZoom is a web-based, interoperable platform for the provision of Flood Intelligence to authorised audiences anywhere on the Internet. Built with the Emergency Services in mind, it is designed to be a highly available and disaster recoverable in order to ensure dependability during a flood event. To achieve this level of reliability FloodZoom is distributed across three data centres so that the platform can continue to function, even if a location were lost.

The architecture was also designed to be scalable. Over time it is expected that the platform will offer a wide range of business as usual functionality to assist with flood planning and managing referrals for flood and waterways building referrals.

The platform has been built in-house at DEPI utlising a number of mainstream software packages. The platform has been developed using Microsoft's .Net framework, SQL 2012 database, SharePoint 2013 and ESRI ArcGIS Server. The user interface has been developed in Silverlight to ensure support for both older and newer web browsers.

FloodZoom has been designed around a security architecture which ensures access is restricted to identified authorised users from CMAs, VICSES and flood specialist consultants. This security approach allows the tools and data within the system to be restricted to the different audiences based on job role, as discussed earlier. That is, some roles will be able to create content, while others will only be able to view content created by other roles such as forecast event products. An additional role, referred to as content publisher, will be able to authorise the distribution of content developed by content creators (including to external systems such as VINE, eMap and OSOM). Distribution to other platforms will be through secure interoperable interfaces. Figure 2 shows the high level architecture.

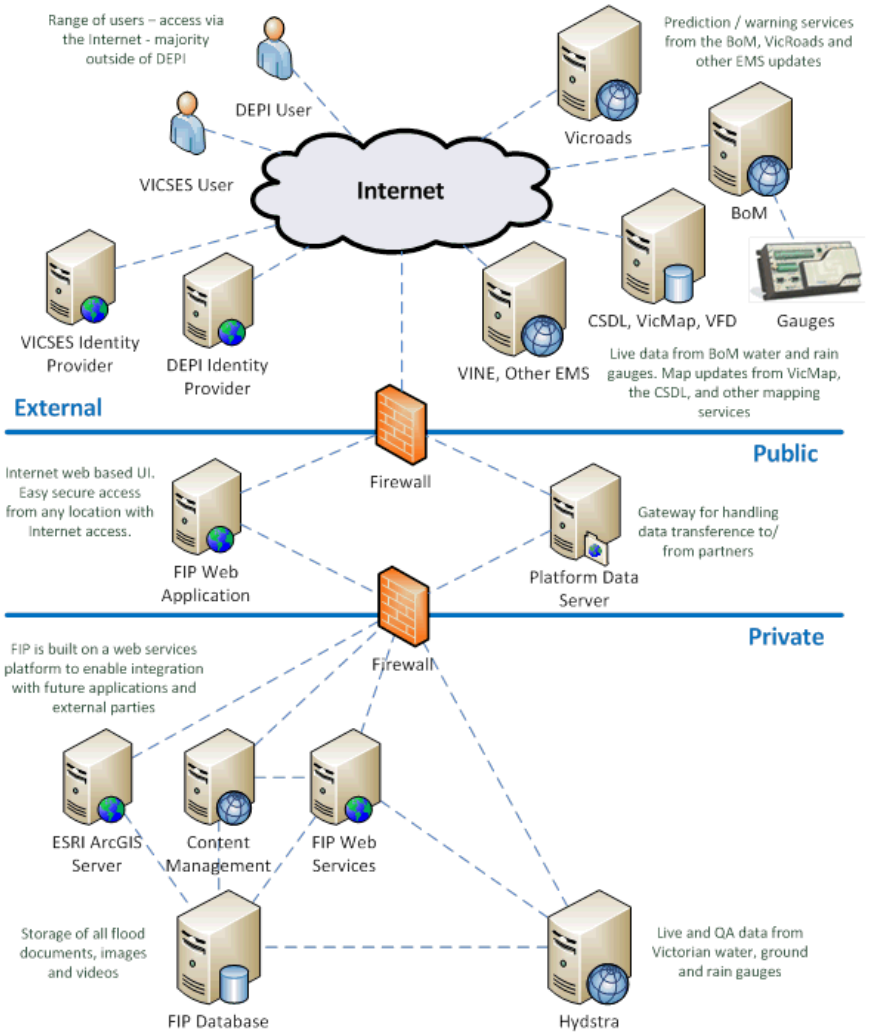

Figure 2 High level architecture

Key functions

Spatial flood data discoverability and assessment
A primary FloodZoom objective was the collation and access to flood spatial data. The Victoria Flood Database (VFD) is the principal spatial flood data source for FloodZoom. The VFD is a series of spatial layers depicting flood information from both actual flood events and statistical, modelled and designed flood events across the state of Victoria. Some flood related infrastructure (e.g. levees) is also included. The VFD is updated with the new flood information from both flood studies and data collected during flood events.

The first version of FloodZoom enables access to the current VFD. The user can search for available VFD layers via design AEP and/or location. Figure 3 displays an example design flood extent for the Gippsland Lakes near Paynesville.

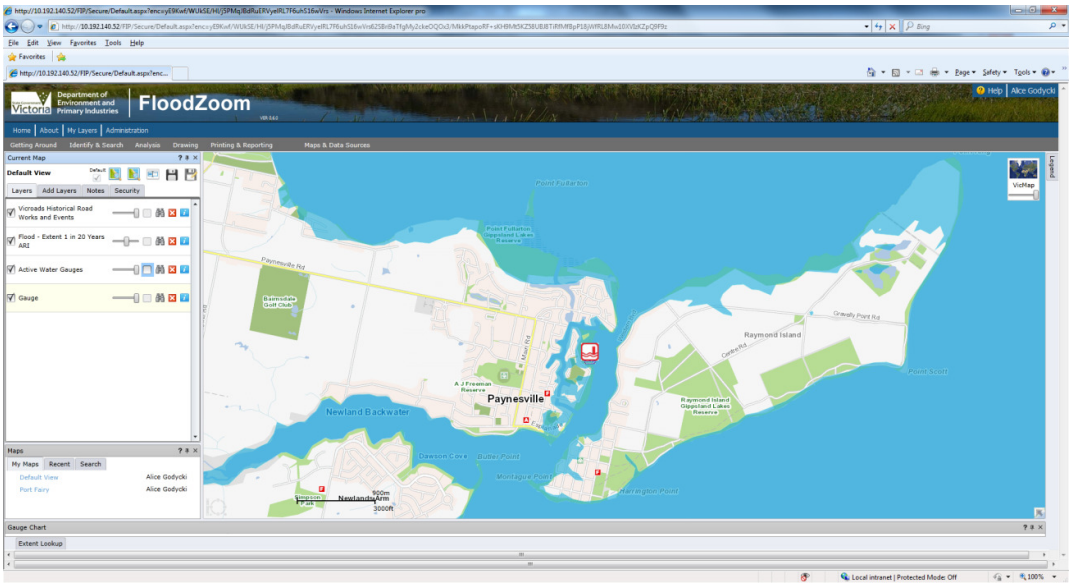

Figure 3 Flood extent display

An extensive re-structure of the VFD is underway to enable alternative search and discover avenues. A new "Model Extent" layer is proposed to capture relevant metadata on the available flood related data, both spatial and text. Design flood extent data is being referenced to local flood warning gauges and a specified gauge height. This reference enables flood warnings to be quickly linked to appropriate flood extents and therefore enables faster response. The VFD is being expanded to include gridded flood model outputs (e.g. depths, flood levels, velocities).

Textural flood document discoverability and assessment
Often important information of flood behaviour and consequences is contained within flood study reports, Municipal Flood Emergency Plans (MFEPs) and flood intelligence cards. DEPI in conjunction with CMAs and VICSES has collated an extensive library of these documents. In one of the first releases, FloodZoom will catalogue and enable access to these documents in PDF format.

Further work is underway to extract relevant information from these documents for more ready and smarter access in FloodZoom.

Asset and infrastructure data assessment
The identification and assessment of flood consequences is a primary business requirement. The first release will contain a number of asset and infrastructure data

held by other agencies. This infrastructure and asset data will have some common elements with information employed by the Fire Agencies.

The identification of properties at risk of inundation can be undertaken by spatial queries with flood extents and available asset and property information. Additional asset data, such as floor height will be available in later FloodZoom releases. Figure 4 displays the selection of properties by flood extent.

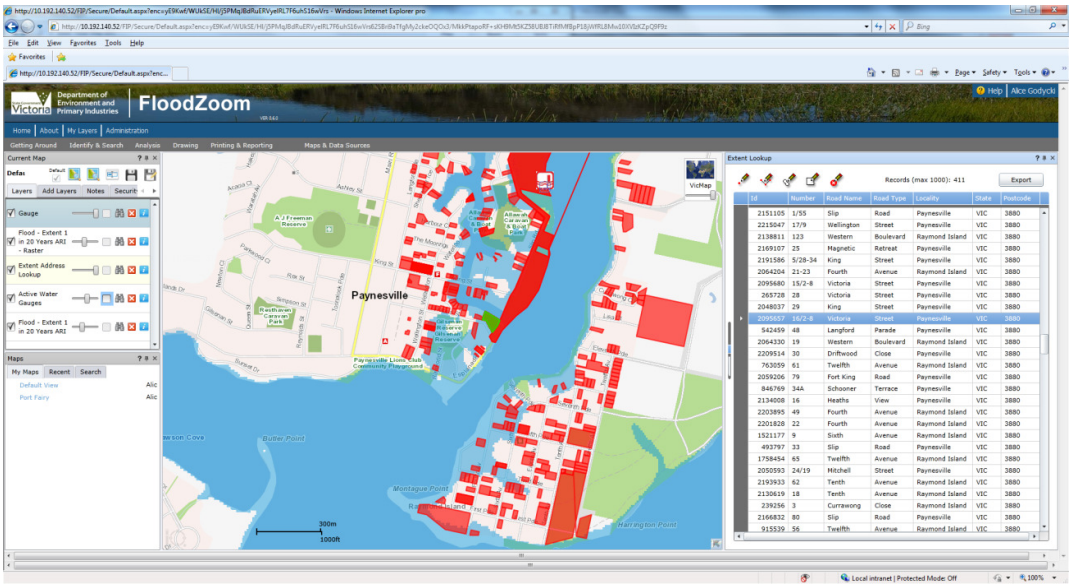

Figure 4 Flood affected properties selection display (Example only)

In Victoria, VicRoads operates a website showing current road closures. FloodZoom will consume live road closures and provide access to historical road closure information. The access to historical road closure can improve understanding of potential road closures in flood response planning. Figure 5 displays the current road closure information.

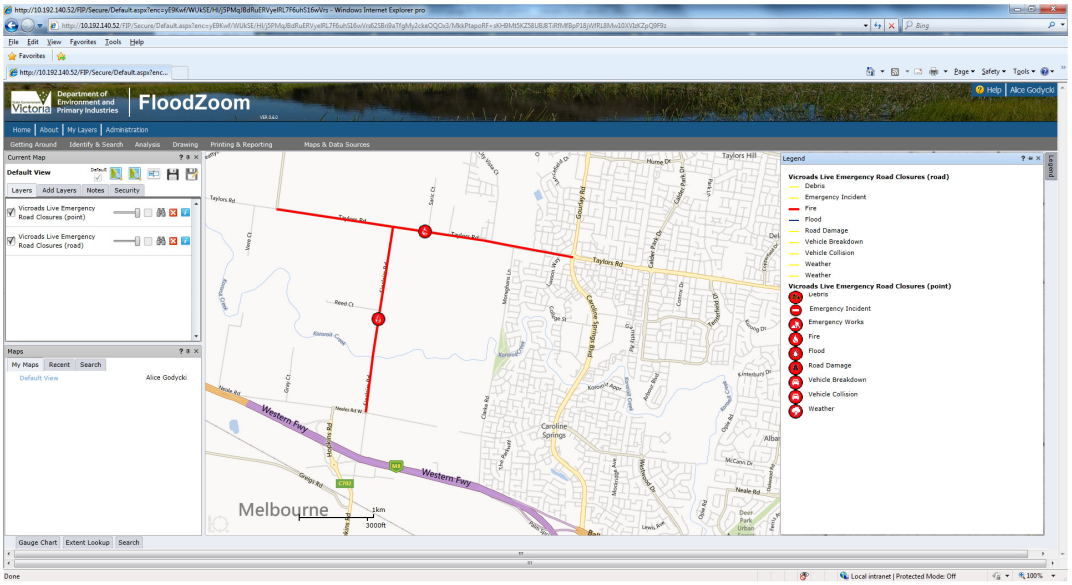

Figure 5 Road closure information display

Streamflow/rainfall data access and assessment
The access to streamflow and rainfall data, both real time and historical, promotes situation awareness and assessment of flood severity relative to previous flood events. Comparisons to previous floods assists in community messaging and warning. FloodZoom accesses real time data via data sharing with the Bureau of Meteorology (BoM), Melbourne Water and other data providers/services. For historical streamflow/rainfall data, FloodZoom will access DEPI's surface water data archive via the Water Measurement Information System (WMIS).

Key related functions include:

- Charting streamflow/rainfall time-series (real time and historical)
- Charting time-series at multiple gauge locations
- Viewing stage – discharge curves
- Viewing data quality and observed measurements for historical data
- Charting Flood Class Levels and status
- Viewing current operational gauge status

Figure 6 displays an example of river height data for the Gippsland Lakes near Paynesville.

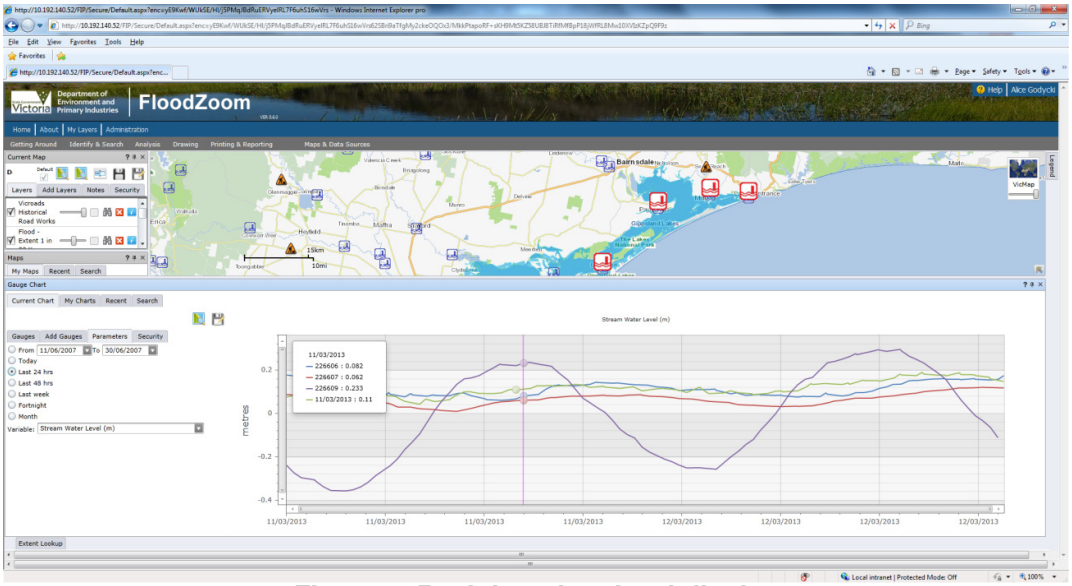

Figure 6 Real time river level display

Future developments

Interfaces with other Emergency Management systems
FloodZoom provides a toolbox for the flood specialist during flood response operations. As discussed, a number of agencies and general community require specific flood information to inform their own responses.

DEPI in conjunction with CFA have developed eMap for incident mapping and management across all hazards. eMap includes incident nature and location, resourcing tracking and field observations FloodZoom will share flood related information for publication in eMap. Also, field observations may be shared from eMap to FloodZoom.

In Victoria, a single website of community warning and information, VicEmergency, has been established. FloodZoom will share flood related information with VicEmergency.

Land use planning applications
CMAs have a referral role for flood related land use applications to Local Government. This role involves the assessment of flood behaviour and its impacts on proposed development and land use. CMAs provide advice to local government regarding suitability of the development given the flood behaviour, and may propose development conditions.

Consultations with CMAs are underway to establish user requirements for FloodZoom's potential application in land use planning assessment. Preliminary requirements identified include workflow management for referrals, templates for responses and access to available spatial flood data.

Links with Bureau of Meteorology and Geoscience Australia
The BoM are currently introducing a new flood forecasting system (HYFS). This system aims to improve flood forecast capability by integrating with weather forecasts and establishing a national consistency.

Geoscience Australia in conjunction with the Commonwealth Attorney – General's Department are developing the National Flood Risk information Portal (NFRIP). The aim of the portal is to enable access to flood spatial data.

Initial exploratory discussions are underway to assess potential FloodZoom-HyFS-NFRIP interfaces.

Flood Warning Arrangements and Gauge improvements

Institutional Arrangements and Service level

The VFR (Victorian Government 2011) noted a lack of clarity around agencies roles in the delivery of the Total Flood Warning System (TFWS). The VFR Recommendation Number 1 put forward the need to revise roles and responsibilities to improve clarity. Further the VFR (Victorian Government 2011) noted that some communities were without flood warning services. The VFR Recommendation Number 3 required the documentation of total flood warning service for all catchments and definition of performance indicators (service levels).

The Victorian Government response to VFR "Improving Flood Warning Implementation Plan" (Victorian Government 2012) allocated the champion role for total flood warning systems to DEPI. In fulfilling this role, DEPI is consulting with key stakeholders to develop service levels for the TFWS. The intent of the service levels is to clarify the nature of service across all TFWS elements for local communities. Service levels are being developed to align service complexity with flood risk.

Gauges improvements

The VFR (Victorian Government 2011) noted significant gaps in the flood warning gauge network. DEPI through the Regional Water Monitoring Partnerships (RWMP) are engaging with interested partners to identify and assess the nature of flood warning

upgrades. The focus of the gauge upgrades is to improve access to reliable river height and rainfall for flood forecasting and monitoring purposes. Typically upgrades have included new and/or replacement telemetry (3G/ETRS) and replacement data loggers. To date some 170 upgrades have been completed with a further 50 identified for completion by June 2015.

Twenty portable gauge units have been constructed. These portable units consist of sensor, data logger and 3G modem, and can be employed to complement the fixed gauging network. The portable units were extensively used during the Broken Creek floods in February-March 2012.

The recent floods exceeded the available stage-discharge rating tables at a number of gauges. A significant number of rating curves were extended and revised using observed measurements where possible.

Flood risk assessment, mapping and intelligence

The Floodzoom – flood intelligence platform builds a foundation and tools for the access, assessment and distribution of flood related intelligence. However, the platform's useability expands with newly available reliable flood behaviour modelling and mapping. The Victorian Government is therefore investing in the expansion of reliable flood mapping information. This investment is complemented by Local Governments and Australian Government through the Natural Disaster Resilience Grants Scheme (NDRGS).

Local flood risk assessments

Since July 2011, twenty-six local flood risk assessments have commenced across regional Victoria, with 14 completed as at March 2014. There is potential for further flood risk assessments to commence in conjunction with 2013/14 and 2014/15 NDRGS rounds. These local assessments typically centre on townships.

As part of these flood risk assessments, VICSES has provided specifications of flood intelligence outputs. These outputs assisted in the preparation of MFEPs and local community flood guides, known as Local FloodSafe Guides. Also, flood intelligence outputs had been derived from flood studies completed prior to July 2014.

DEPI has utilised a panel of independent technical experts to review the suitability of technical approach and deliverables. These reviews have assisted CMAs and Local Governments to gain confidence in the study's outputs.

Regional flood risk assessments

To enhance flood mapping availability and reliability along rural floodplains, DEPI is exploring a range of flood mapping techniques. These techniques look to deliver flood mapping products (extents, depths and velocities) for use in land use planning decision making, emergency management planning and operations, community education and awareness, and flood insurance considerations.

A number of pilot studies are underway to investigate a variety of flood modelling techniques.

Conclusions

Timely and reliable assessment of flood behaviour and potential consequences can empower effective agency and community responses during and between floods. The FloodZoom initiative is investing to improve the quality and quantity of flood behaviour and consequence information.

FloodZoom – Flood Intelligence Platform enables this timely and reliable assessment. Consultation and engagement with a diverse range of potential users identified a long list of requirements. This long list proposed challenges to manage expectations and to deliver a fit for purpose platform. The technical aspects require expert attention to obtain a robust solution. However, the importance of user engagement must take a primary position and focus.

Acknowledgements

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