Using Volunteered Information to Map the Queensland Floods

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ABSTRACT

The recent flood events and tropical cyclones in Queensland have dramatically impacted on people's lives across the State. Damage in excess of five billion dollars has been reported and the cost to the economy continues to rise. Although most of the flooding has receded, the clean-up and re-building will continue for years. The Queensland floods were characterised by the unprecedented use of social media to report events as they happened and was used very effectively by the main stream media. Social media networks such as Twitter and Facebook, not only informed people of the events as they unfolded, they have now also provided a historical archive for use in future planning and mapping. Although the Commonwealth and State governments and the private sector did a magnificent job in mapping the flood events where possible, a number of gaps still exist. This paper discusses the use of volunteered geographic information such as photographs and videos to assist in mapping the flood extents in regions where there was little or no mapping available. Through the integration of volunteered information with existing geographic information, hydrological data and local knowledge, flood extents can be re-constructed and hence mapped.

KEYWORDS: Spatial Information, Mapping, Floods, Volunteered Geographic Information

1 INTRODUCTION

During December 2010 to February 2011, the State of Queensland experienced a series of damaging floods which caused billions of dollars in damage and the loss of over 20 lives. Major flooding was experienced at over 30 cities, towns and rural communities over southern and western Queensland including significant inundation of agricultural crops and mining communities. Consistent rain during the Australian spring resulted in many of the large catchments becoming heavily saturated and the larger storage reservoirs and dams reaching capacity. These conditions were further exacerbated by the presence of a number of tropical cyclones which in addition to heavy rainfall result in significant property and landscape damage due to cyclonic winds.

As the varying flood events unfolded social media and crowd sourced geographic information played an important role in keeping people informed, especially as official channels of communication began to fail or were placed under extreme load. The government's management of the Queensland floods and especially the role of the community in their assistance were widely applauded. Information and communication technologies played a critical role during the disaster and its management via the conventional communication channels such as radio, television and newspapers but also through third party social media networks such as Twitter and Facebook. People who had never signed up to Facebook and Twitter started doing so and the Australian Broadcasting Commission (ABC) radio launched a link to crowd sourced reports on flooding.

This paper reviews the various forms of volunteered and shared information that occurred throughout the Queensland floods and their impacts. The potential of volunteered geographic information for post-disaster assessment including damage assessment, planning and official flood lines is examined.

2 FLOODS AND FLOOD MAPPING

Most of the major floods in Queensland occur in summer or early autumn due to tropical cyclones or intense monsoonal depressions. These systems are capable of producing excessive quantities of rainfall in short periods of time. For example at Bellenden Ker in North Queensland, tropical cyclone “Peter” caused 1,947mm of rain in January 1979 during a 48 hour period. In 1999 cyclone “Rona” produced 1,870mm in 48 hours at the same location (Bureau of Meteorology 2011a).

Prior to 1860 three major floods were reported for the Brisbane/Ipswich regions, with the January 1841 flood having the highest recorded level of 8.43m at Brisbane (Bureau of Meteorology 2011a). A further five major floods inundated Brisbane and Ipswich between 1885 and 1900. In this time period, the Brisbane River peaked at 8.3m, and the Bremer River at 24.5m – its highest recorded level (Centre for the Government of Queensland 2010). The Bremer River experienced an additional nine major floods between 1900 and 1972. It was not until 1974 however, that Brisbane and Bremer Rivers flooded to 5.45m and 20.7m respectively – the highest levels since 1893 (Bureau of Meteorology 2010).

The Queensland flood warning network derives its data from a series of rainfall and river height stations (Bureau of Meteorology 2011b). There are two types of rainfall station in use by the Bureau of Meteorology (BoM): Floodwarn and Daily Reporting. The Floodwarn rainfall stations are designed specifically for flood warning purposes. They are either manual or automatic, and report every 25 or 50mm, and every 1mm of rainfall respectively. Daily reporting rainfall stations consist of manual and automatic stations that report the rainfall received in a 24 hour period to 9am each day (Bureau of Meteorology 2011b). The Floodwarn river height stations have both manual and automatic varieties which report river levels whenever the water reaches a threshold height, and at regular intervals thereafter. The Bureau of Meteorology’s Flood Warning Centre receives the data provided by these stations, and uses it in hydraulic models to produce river height predictions. In the event of an expected flood, the Flood Warning Centre issues warnings to radio stations, Councils, emergency services and various other agencies involved in flood response activities.

There has been a significant amount of research done towards the creation of flood models, and associated topics. Much of the work between 1999 and 2005 focused on creating models that were tested in rural areas (Bates & De Roo 2000, Bates & Horritt 2001, Ervine & Macleod 1999). A number of these models were later utilised to predict flood inundation levels in urban areas (Bates & De Roo 2000, Yu & Lane 2006). A 1D model measures flood levels in the channel, whereas a 2D model measures flood depth for the extent of the floodplain.

A limit to raster-based flood models is the resolution of cells used in the model – if they are too small the computational requirements became restrictive (Haider *et al.* 2003). Yu and Lane (2006) investigated the effect of model cell size for models applied to urban areas, and concluded that even small variations in model resolution have significant effects on inundation extent. Accordingly, as processing power increases, using progressively smaller cell sizes will be a viable option. The accuracy of any flood model is dependent on the range of input data and the closeness of the model to the true behaviour of the flood water.

Mapping of the actual flood extents is often the best method of calibration of hydraulic models and allows models to be improved for future predictive purposes. The primary goal of flood mapping is to identify areas that are flooded or not flooded. This process consists of two steps – (1) determining wet/dry areas before and during a flood event, and (2) comparing these areas to determine which areas were flooded.

Three main data sources are used to map flood extents: optical data, radar data, and topographic and river gauge data (Wang 2002). Optical data include aerial photographs and satellite data such as from a Landsat Thematic Mapper (TM) sensor. With different reflectance responses of dry and wet/water surfaces, aerial photographs and TM data can easily distinguish between surfaces. Wang (2002) also concluded that using TM data for flood extent mapping is: 1)

Reliable and accurate; 2) Simply applied: georeference two TM images, identify wet/dry areas, and compare before/after imagery; and 3) Efficient and cost-effective.

However, there are limitations to using many satellite sensors. As satellites have a fixed orbit pattern, their revisit time (the time taken between the subsequent collection of data from the same location) may mean data is collected long after a flood has receded. The limited spatial resolution of satellite data may also be too coarse for identifying small flooded areas, particularly in vegetated, commercial, or residential areas. Additionally, the many sensors do not penetrate vegetation well, so flooding may not be reliably detected under the canopy (Wang 2002). Finally, both satellite imagery and aerial photography should be collected during the day and will not penetrate cloud cover.

The same basic principle to determine flood extent i.e. detection and comparison of wet/dry surfaces before and during a flood applies also to extent mapping when using radar data. The key advantage in using synthetic aperture radar (SAR) data over optical data is the ability of radar microwave to penetrate cloud cover and forest canopies (depending on wavelength). Because current SAR sensors are satellite-mounted, this system suffers from the same revisit time limitation as optical sensors.

Finally, using topography DEMs and river gauge data is perhaps the simplest of the three methods. It involves getting river levels before a flood, and during its peak for each gauge, and then flooding a DEM – once with the pre-flood levels, and once with peak levels. The inundated areas can then be compared to determine existing bodies of water, and flood extent (Wang 2002). Advantages of using this data include: 1) Data is reliable and accurate, 2) Methodology is simple, efficient, and economical, and 3) The data is easily updated. Its limitations include: only being able to map areas that have flood gauges, and it is sensitive to the accuracy of the input DEM.

This paper examines some of the information that was volunteered by citizens during the flood events in Queensland as part of the social networking and media activities. The imagery taken during the events was geocoded and used to determine the possible extents of the flooding by generating a flood level DEM. The benefits of volunteered information and the utility of these new data sources are discussed.

3 VOLUNTEERED INFORMATION/SOCIAL NETWORKING DURING THE FLOODS

Goodchild (2007) defines volunteered geographic information (VGI) as spatial information collected voluntarily by private citizens. Geo-tagged images submitted by individuals to the web may therefore be considered VGI. Goodchild outlines some popular examples of VGI, including: Wikimapia <http://wikimapia.org>, Flickr <http://www.flickr.com/>, and OpenStreetMap <http://www.openstreetmap.org/>. Wikimapia lets anyone with an internet connection select an area of the Earth's surface, and provide it with a description. Flickr allows users to upload photos and tag them with a latitude and longitude. OpenStreetMap is 'an editable map of the whole world, which is being built largely from scratch, and released with an open content license' (Openstreetmap 2011).

Social networking also played a major role in keeping people informed during the January 2011 flood. Ushahidi is a non-profit technology company that specialises in developing free and open source software for information collection, visualisation and interactive mapping (Ushahidi 2011). Crowdmap is an on online interactive mapping service, based on the Ushahidi platform (Crowdmap 2011). It offers the ability to collect information from cell phones, email and the web, aggregate that information into a single platform, and visualise it on a map and timeline. The Australian Broadcasting Corporation launched QLD FLOOD CRISIS MAP – a crowdmap of the Queensland floods in January 2011 (ABC 2011). This crowdmap allowed individuals to send flood-related information via email, text message, Twitter, or via the website itself (Australian Broadcasting Commission 2011). This information was then available to anyone with an internet connection. The Courier Mail also provided a similar service, though only allowing people to submit photos, via email (Courier Mail 2011).

The social networking service Twitter <www.twitter.com> allowed people to post and receive short text based updates about the flood in real time. Photos and videos were also able to be attached to these updates. Similarly, the website Facebook <www.facebook.com> allowed groups such as the Queensland Police Service to provide flood information updates to anyone who browsed to their Facebook page. Finally, YouTube <www.youtube.com> provided a forum for people to connect and inform through the use of user-generated and contributed videos.

At the peak of the Queensland floods there were between fourteen and sixteen thousand tweets per hour on the 'qldfloods hashtag' which was used to coordinate the conversation around the flood event itself. These peaked at around the time Brisbane and the surrounding areas began to become inundated. Agencies and organisations alongside members of the community began using the Twitter platform as a place to distribute 'raw' footage and information, but then began to trust and 'follow' particular accounts. Some of the most dramatic flooding occurred in Toowoomba and the Lockyer Valley on 10 January 2011 during a flash flood event that claimed a number of lives. The flood waters from the Brisbane catchment moved progressively towards the coast and the cities of Ipswich and Brisbane which peaked around two to three days after the flash flood events.

The response to the Queensland floods by both the full levels of government and the community were widely applauded and recognized as being above and beyond their respective call of duty. State and local government staff in particular worked long hours under difficult conditions to, firstly, meet the critical emergency response needs, and then to provide critical information to enable the re-building exercises to get underway. Information and mapping on the extents of the various floods across Queensland have been pivotal in prioritizing resources, distributing emergency relief and clarifying the inevitable insurance issues.

Under international disaster agreements, the Australian and Queensland governments were able to access a variety of mapping resources including satellite imagery during and after the floods. This information was utilized together with high resolution imagery from providers such as Nearmap to rapidly generate flood extent maps. Nearmap, in particular, flew missions at times near the peak of the floods in Brisbane and other regional areas to produce very high resolution imagery of the actual floods. This imagery was available to the public with hours of the mission and being used by the community to assist in the emergency efforts (Figure 1).

The Queensland Government utilized the Nearmap imagery to begin the process of mapping the flood extents and making them available. Under International Emergency Agreements the Queensland Government also had access to a range of other data including satellite imagery from commercial and government agencies around the world. A special agency called the Queensland Reconstruction Authority launched an interactive map (Figure 2) which detailed the areas which were flooded or inundated. This was a valuable source of information for individuals, community organizations, governments and private sector organizations such as insurance firms.

Figure 1: Nearmap imagery showing Suncorp Stadium and surrounds (Source: Nearmap 2011)

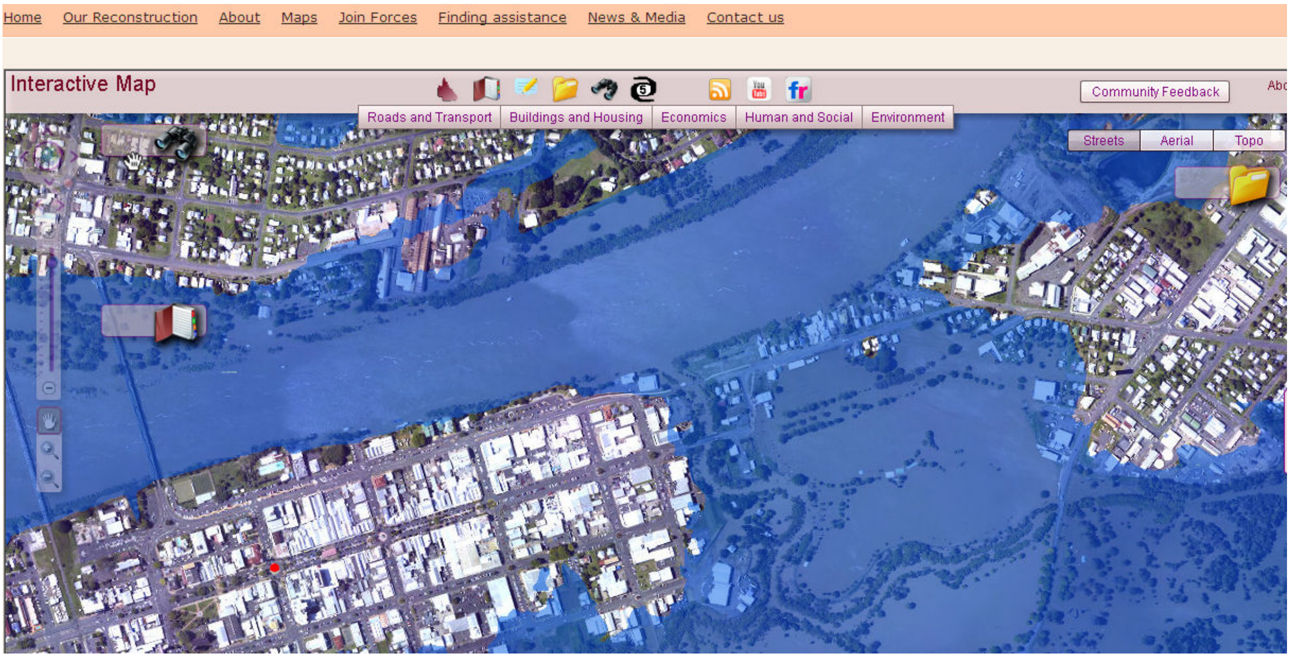

Figure 2: Queensland Reconstruction Authority Interactive Map (Queensland Government 2011)

4 USING VGI TO MAP THE FLOOD EXTENTS

The Australian Broadcasting Corporation launched QLD FLOOD CRISIS MAP – a crowdmap of the Queensland floods based on the Ushahidi platform in January 2011 (Figure 3). This crowdmap allowed individuals to send flood-related information via email, text message, Twitter, or via the website itself. This information was then available to anyone with an internet connection. This service proved to be very popular and the servers struggled at times during the crisis to keep up with the demand.

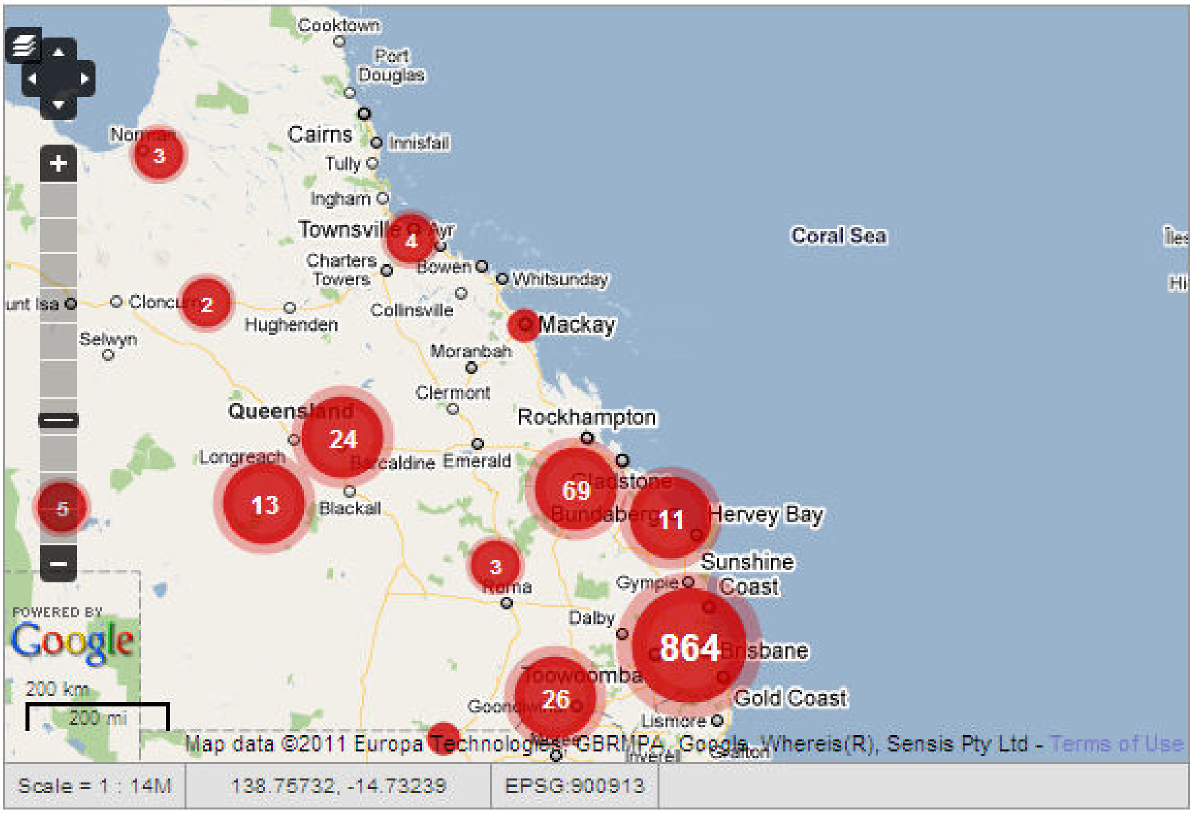

Figure 3: Ushahidi Crowdmap of the Queensland Floods

Photography and imagery of the floods across different regions were posted on sites such as Flickr which were linked at each location through the crowdmap. Individuals had the opportunity to add comments and additional information regarding the context of the images. The posting time is also time stamped by the system. These images provide an excellent historic and current record of the flood events and features in the imagery can easily be used to reference flood heights at a particular time (Figure 4).

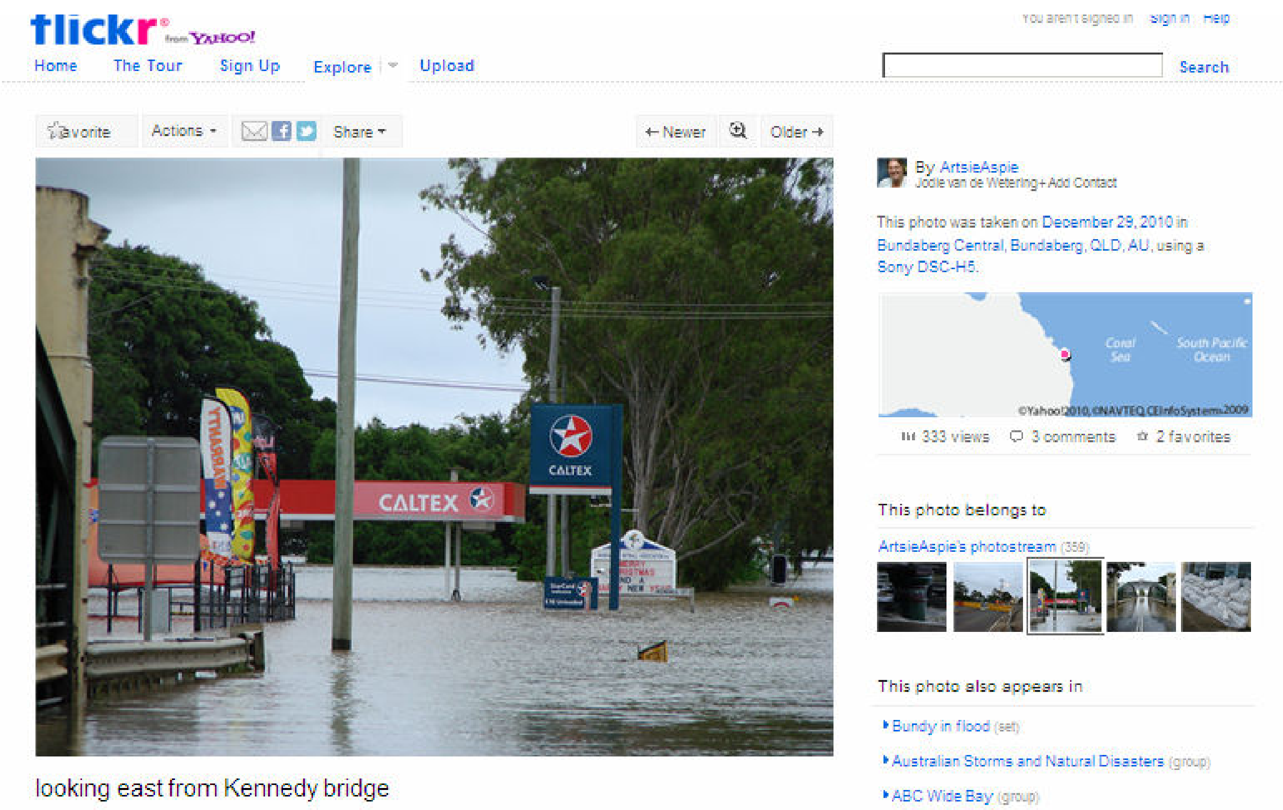

Figure 4: Example of flood photography around Bundaberg in December 2010.

Once individual imagery was collected then flood heights at a particular point could be identified and measured. This required field visits to verify the exact locations and to accurately locate the flood point with respect to horizontal and vertical position. In the case of this study RTK GPS was employed to capture 35 points from a variety of locations around the Brisbane flood areas. This data was then utilised to generate a DEM surface of the flood in the locality which represented the actual flood surface.

The DEM also included a number of actual river gauge stations where they were available to improve the quality of the data along the river. The river gauges are linked to the Australian Height Datum (AHD) and the peak heights can be incorporated into the DEM. Figure 5 provides an example of the plotted gauge data at various stations linked to rainfall.

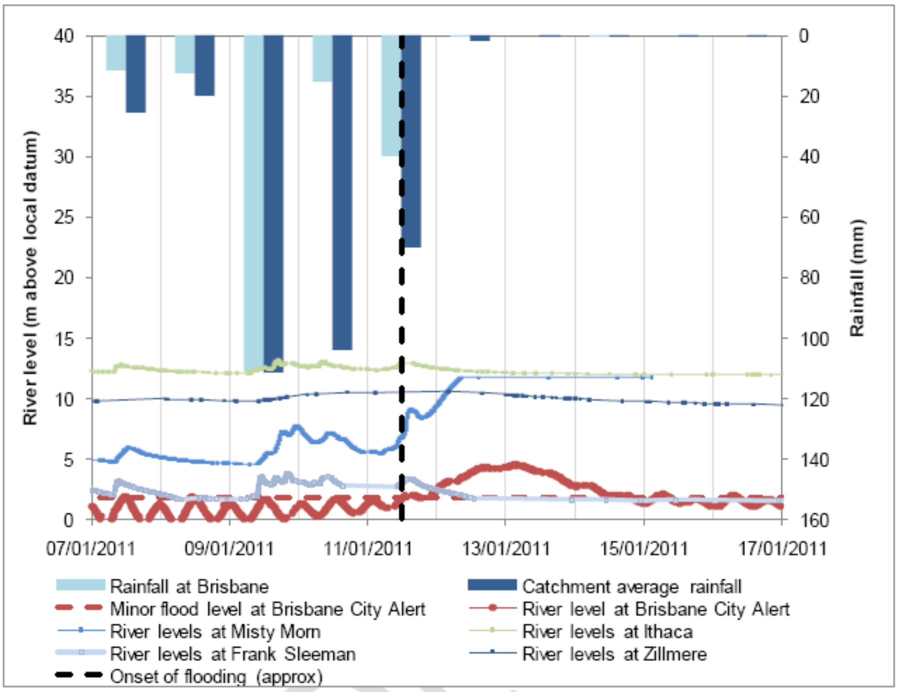

Figure 5: River gauge and rainfall plots along the Brisbane River

Once the DEM of the flood surface has been calculated it can then be intersected with the DEM of the existing or natural surface. The intersection of these two surfaces provides a reasonable estimate of the flood extents over a local area. Figure 6 illustrates the points which were measured from the identified imagery and the final flood surface that was calculated from the two DEMs.

Figure 6: Example of the computed flood extents from volunteered information

5 DISCUSSION

The use of social media provided the opportunity for people from a wide range of varying backgrounds to participate and contribute to the dissemination of information throughout the Queensland flood events. The benefits of the current technology were immediately obvious and within minutes of the event people were sending emails, photos and videos to their friends to update them about the evolving crisis. Twitter and Facebook sites facilitated the wider dissemination of the crisis to others within their network including the mainstream media. Members of the media obtained their early information from the emails, tweets and Facebook postings from friends and colleagues. The media and emergency services quickly identified the power of this resource and began to establish channels to support and build their communication and information collection.

The various channels of communication provided a near real time coverage of the event that was rich in information including continuous commentary, voice, photographs and video. Early in the event the information was accurate and often breath-taking, putting all of us in the position of the observer. However, after the early stages of the event, a number of spurious postings began to appear including duplications of photography and misinformation regarding the flooding events.

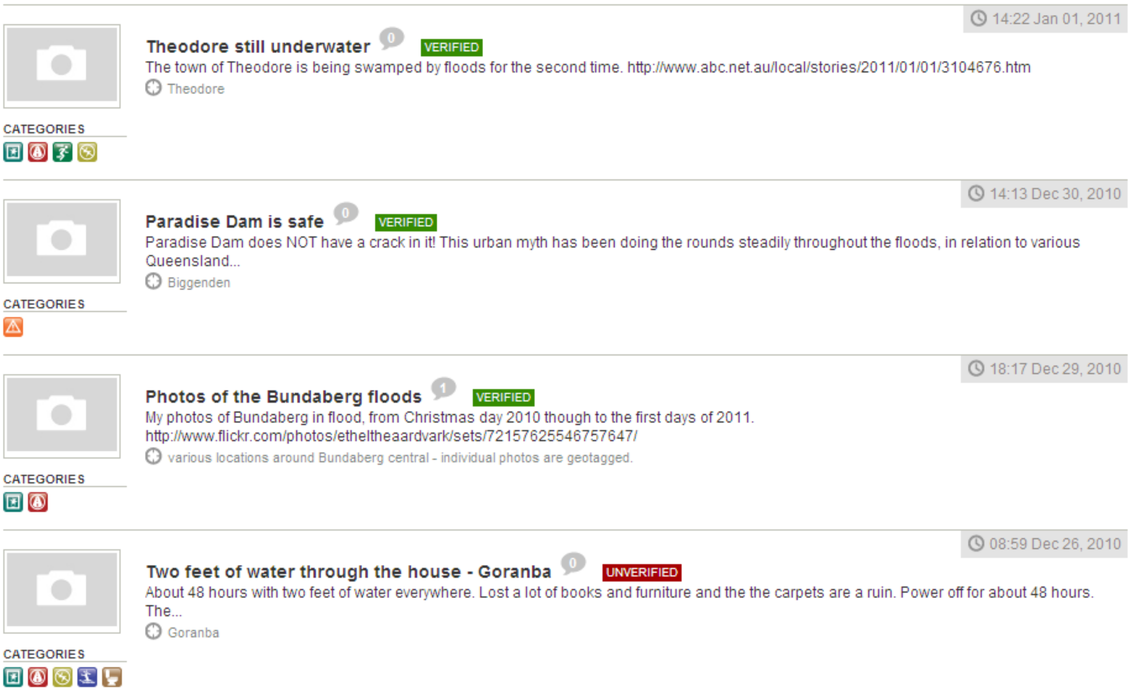

Figure 7: Moderation of the ABC Crowdmap

Verifying information is an important element of crowd mapping if you want the users to continue to have confidence in the information. This has always been one of the key issues with volunteered information and there are a number of mechanisms that can be used to improve the veracity of the information. Trust is an important commodity within these environments and a trusted source, just like a media source, is well respected by the community of users. Just like with Wikipedia, the entries are available for all to scrutinise and to edit, and so it becomes a self moderating community.

In the case of the crowdmap users could vote up and down on the reports as they came through which improved the veracity of the information. Information that was not challenged or came from a trusted sourced was marked as verified whilst new reports or distrusted sources are identified as unverified (Figure 7). However, the community of users must still rely on a degree of common sense with these sites and preferably have some local knowledge to validate the reports.

The techniques for the reconstruction of flood extents are very dependent on the amount and quality of the imagery that is available. Most imagery was taken from various ground based vantage points and provides a good indication of the behaviour of the flood waters at that particular location. In other cases, media reports in the form of television footage may be available to analyse from an aerial vantage point. This provides the opportunity to directly map the flood boundary at a particular point in time using a combination of ground truthing and digitising.

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6 CONCLUSIONS

In conclusion, the use of social media has now added another dimension to volunteering information and its value is undeniable in respect to its immediacy and depth of information. The imagery and related data that is available through crowdmaps and sites such as Flickr provide a ready resource to begin mapping flood extents in the absence of other aerial or satellite data. These maps can provide valuable data for the improvement in hydrological modelling of flood events and planning for future emergencies. However, the harnessing of this information including it veracity and validation still remains a challenge for those who need accurate and reliable information.

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