"FIRST PASS" METHODOLOGY OF CITYWIDE FLOOD INUNDATION MAPPING

R. VanDrie[1]*, M. Simon[2]

[1] *Shellharbour City Council, PO Box 155, Shellharbour City Centre, 2529 NSW, Australia*
e-mail rudy.vandrie@shellharbour.nsw.gov.au

[2] *Hydrotec Consulting Engineers GmbH, Bachstrasse 62-64, D-52066, Aachen, Germany*
e-mail m.simon@hydrotec.de

*Corresponding author

ABSTRACT
One of the primary responsibilities of local councils in Australia is to manage flood prone land. Management relates to identify hazard and risk, as well as identifying the potential for flood damage, risk to evacuation routes and the task to identify the suitability of future development areas.To date the standard methodology centres on setting up inundation maps using a hydrologic model of the entire catchment with a hydraulic model over a much smaller portion of the catchment to provide details of flow behaviour from flows entering the area of interest. Where ever flow behaviour is assumed to be critical - usually in the lower part of the catchment - a detailed 2-dimensional hydraulic model is set up to gain detailed information of the flood situation.

This process is required to be founded on accurate topographic data being acquired, collected and surveyed. Within NSW the experience over the last decade is that to provide this flood mapping capability usually results in an extended time frame (years) and a considerable budget ($50k - $300k) typically.

It is currently proposed (and being completed) that one local government will fast track the process adopting a new approach **"First Pass" assessment of flooding** which has come about and promises to provide several advantages.

KEYWORDS
Whole of Catchment , Combined Analysis, 2D-Hydrodynamic, Flood Modelling, Hydrology, Flo-2D, ANUGA

INTRODUCTION

Shellharbour City Council (SCC) covers an area of around 15,515 hectares in which 60,400 people live in around 21,500 households. Of those people around 15,000 work outside the city boundaries while, around 7,700 live and work there. An additional 4,700 people from out side the area come into the city boundaries for work. The total employed in the city is around 12,400. In addition 16,600 are below the age of 18 and 10,300 are above the age of 60.
Therefore during a flood event there are a considerable number of people potentially at risk. In order to provide a level of assessment of the risk the identification of the extent of flooding

is critical. Further details about the flooding behaviour such as flow depth and velocity is also very important.
SCC is located on the east coast of Australia, approximately 90km south of the centre of Sydney.

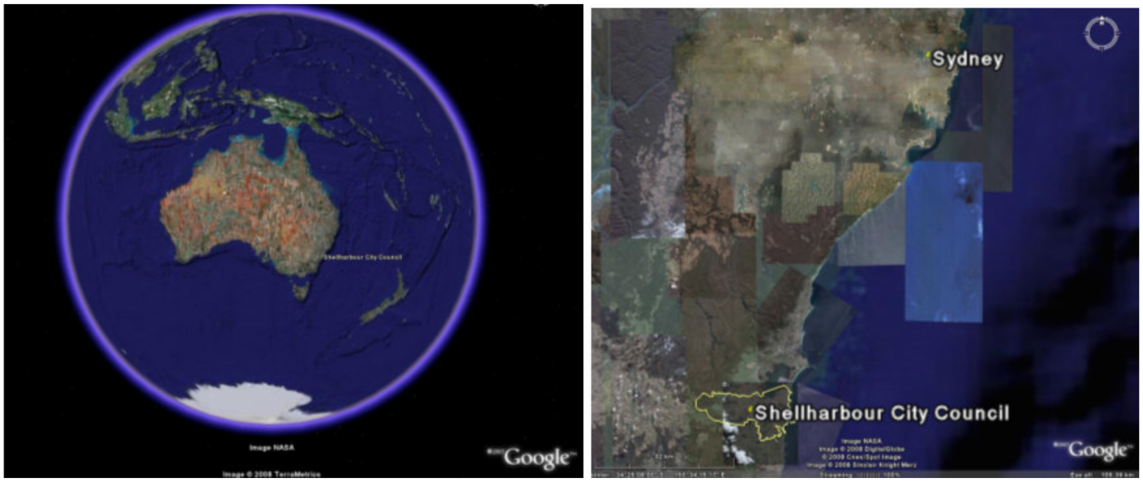

Figure 1. Locality of Shellharbour City Council

It has a 700m high escarpment on its western fringes, a considerable salt water lake fringing much of its northern boundary and the eastern boundary is the Pacific Ocean. There is on average around 1300mm of rainfall per year. As this runs off the escarpment toward the Lake an Ocean there can be significant flash flooding and general flooding.

One of the primarily responsibilities of local councils in Australia is to manage Flood Prone land. This is clearly stated for instance in the NSW Governments Flood Prone Land Policy.
(http://www.dnr.nsw.gov.au/floodplains/manual.shtml)
Management relates to identify hazard and risk, as well as identifying the potential for flood damage, risk to evacuation routes and the task to identify the suitability of future development areas.

To date the standard methodology is focussed on setting up inundation maps using a hydrologic model of the entire catchment with a hydraulic model over a much smaller portion of the catchment to provide details of flow behaviour from flows entering the area of interest. Where ever flow behaviour is assumed to be critical - usually in the lower part of the catchment - a detailed 2-dimensional hydraulic model is set up to gain detailed information of the flood situation.

This process is required to be founded on accurate topographic data being acquired, collected and surveyed. Within NSW the experience over the last decade is that to provide this flood mapping capability usually results in an extended time frame (years) and a considerable budget ($50k - $300k) typically per catchment.

In addition in the past it has been found that often the original extents have had to be increased to fully describe flooding properly. This has incurred additional costs and also resulted in a much longer time frame to complete the studies.

When – finally – the study is finished it can be that the “Status Quo” or the “Future Conditions” as modelled out are possibly not longer representative. Quite often within the time frame of these lengthy studies there is considerable change being considered or physically underway that render the outcome of the studies as being limited.

It is currently proposed (and being completed) that one local government will fast track the process adopting a new approach **"First Pass" assessment of flooding** which has come about and promises to provide several advantages.

METHODS:

It is proposed that a "First Pass" methodology be adopted where by the initial estimate of the extent of flood prone land is identified by modelling the entire catchments with a 2D model, and very limited inclusion of drainage structures such as culverts, bridges and major piped drainage systems.

This focuses on providing a "First Pass" using only topography, and only the more dominant structures being included in the model. The methodology utilizes the best available topographic (laser scan) data and the most robust modeling (Finite Volume) approach available. Therefore it is likely that the order of accuracy will be extremely good on the assumption that the majority (or all) of the piped drainage system is blocked or hydraulically overloaded.
Where possible the models can be validated against other model findings to point out the accuracy to some extent.

The methodology requires the identification of all catchments, and then grouping them based on location so as to provide manageable chunks of highly detailed topography. Generally a 1x1 or 2x2m grid of the topography will be used. The grid data will be derived from very dense scattered Airborne Laser Scanning data.

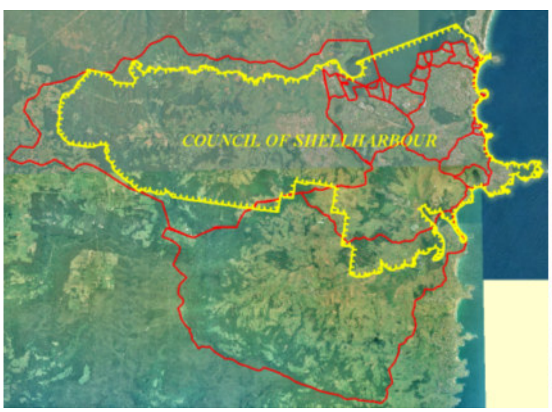

Figure 2. Council area, 25 catchments

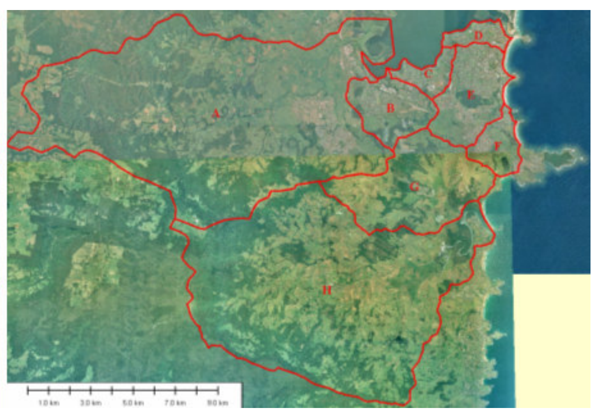

Figure 3. catchment grouping

There are 25 individual catchments within or that cross the city boundary. Some catchment are entirely contained within the city boundary others have small segments just beyond the city boundary while one has only a small portion within the city boundary. In total these 25 catchments make up around 26,400ha of area that will need to be modelled.

The aim is provide details of inundation for two severe storm events, the 1% event and the PMF event for these catchments and then present the results in a variety of formats there are suitable for a web (internet) based concept than a static report. Several options of presentation are available;

a. Council Geographical Information System (GIS)
b. Council mapping interface
c. Google Earth

The extended aim is to provide details of flood levels and flood velocity for every flood affected parcel of land within the city boundary and provide this information through the GIS interface.

TOPOGRAPIC DATA:

The most vital data for this exercise is the need for very good definition of the topography. The council has acquired around 8700hectares of Airborne Laser Scan (ALS) data covering mainly the urban areas within the city. In addition it was able to negotiate the acquisition of around an additional 5000ha of ALS data. For the remaining area only 5m and 25m Digital Elevation Model (DEM) data was available.

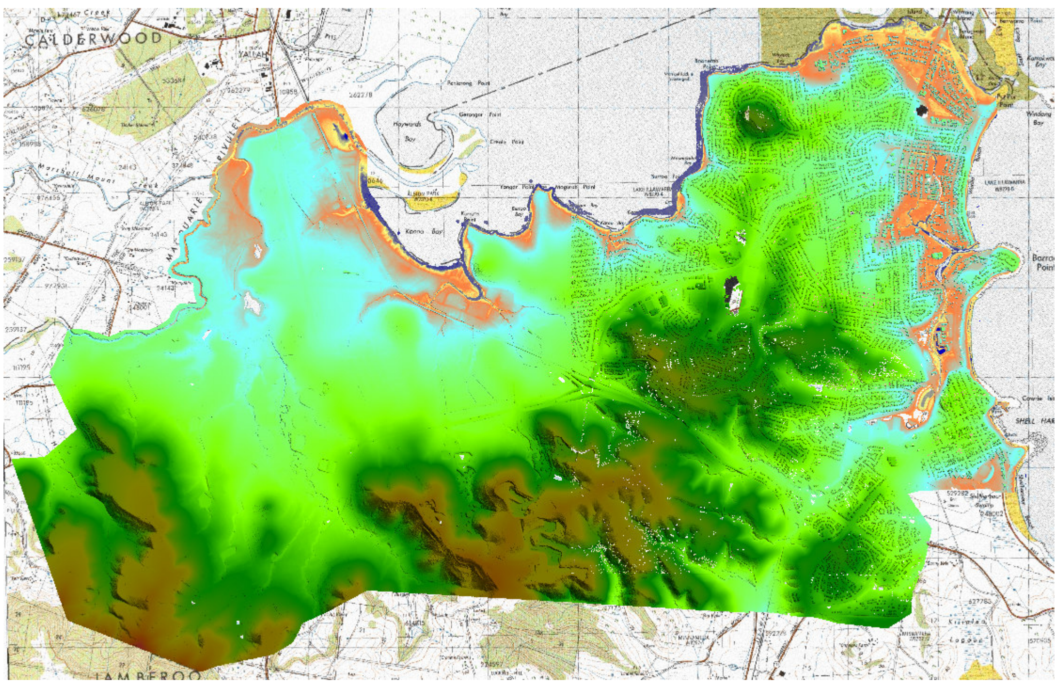

Figure 4. Initial extent of ALS data (Note buildings are shown on Eastern half)

An extensive exercise was undertaken to merge the various data sets. This exercise identified several areas of significant “digital holes”, areas where one data set was poorly matched to the adjoining or overlying data set, creating an artificial dam. Luckily this only occurred in areas quite removed from current development. In fact only areas close to the escarpment and in adjoining large catchment were affected. However these “digital holes” were corrected so as to ensure the hydrologic response of the streams were not impacted.

The result of this exercise was to produce a very high quality (generally) and totally encompassing terrain data set for all of the catchments.
As mentioned the 25 catchments were then grouped into 8 groups as shown in figure 3.
For each of the groups a detailed 2D hydrodynamic model was constructed using 2 different models. The Flo-2D (O’brien, 2004) model was used as was the new ANUGA (Nielsen et al, 2008) model. The primary reason for this was due to the lack of validation data. In addition

these two models use two different approaches, one being a structured grid model the other an unstructured grid model.

RESULTS:

The topography for each of the eight groups (A –H) was used to construct a detailed 2-D hydrodynamic model. Terrain roughness has been defined by families of polygons representing various ground cover / land use. Various rainfall temporal patterns were applied directly to the 2D grid. Limited data relating to structures (bridges and culverts) has been used. Only the large major stream structures (culverts and bridges) have been included. The minor drainage system has been largely ignored. A sample of the resulting plots of gridded results are shown in the following figures.

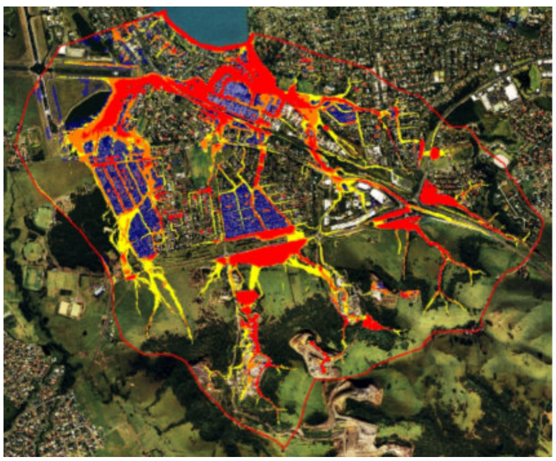

Figure 5. Group B Catchment Result

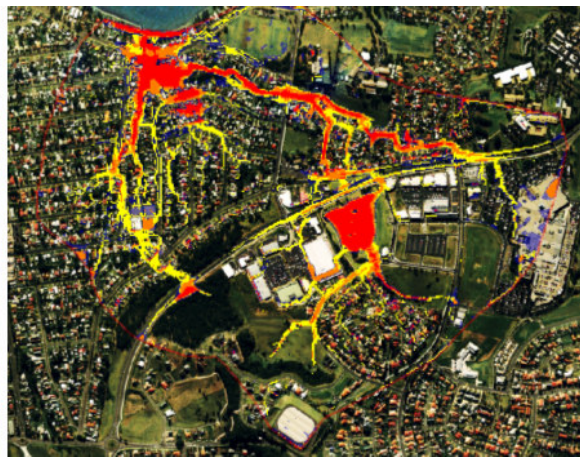

Figure 6. Group C Catchment Result

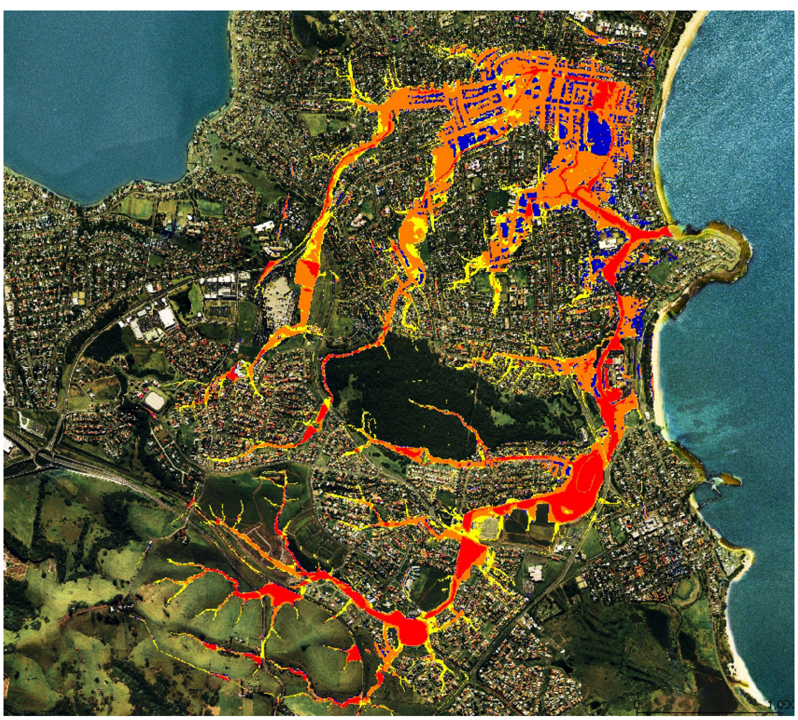

Figure 7. Group “E” Catchment result

Effectively there are 8 tiles of grid data for the resulting flood level and the velocity of flood water that now cover the entire city extent. These tiles will be merged to create single layers for the 1:100 year flood level and velocity and similarly 2 additional layers for the Probable Maximum Flood (PMF) event. This will provide excellent representation of the extent of flooding in the council GIS system and provide a considerable level of knowledge about the flood behaviour. The layers will also be provided as Google-Earth compatible files so as to provide the council with the option of making this data publicly available.

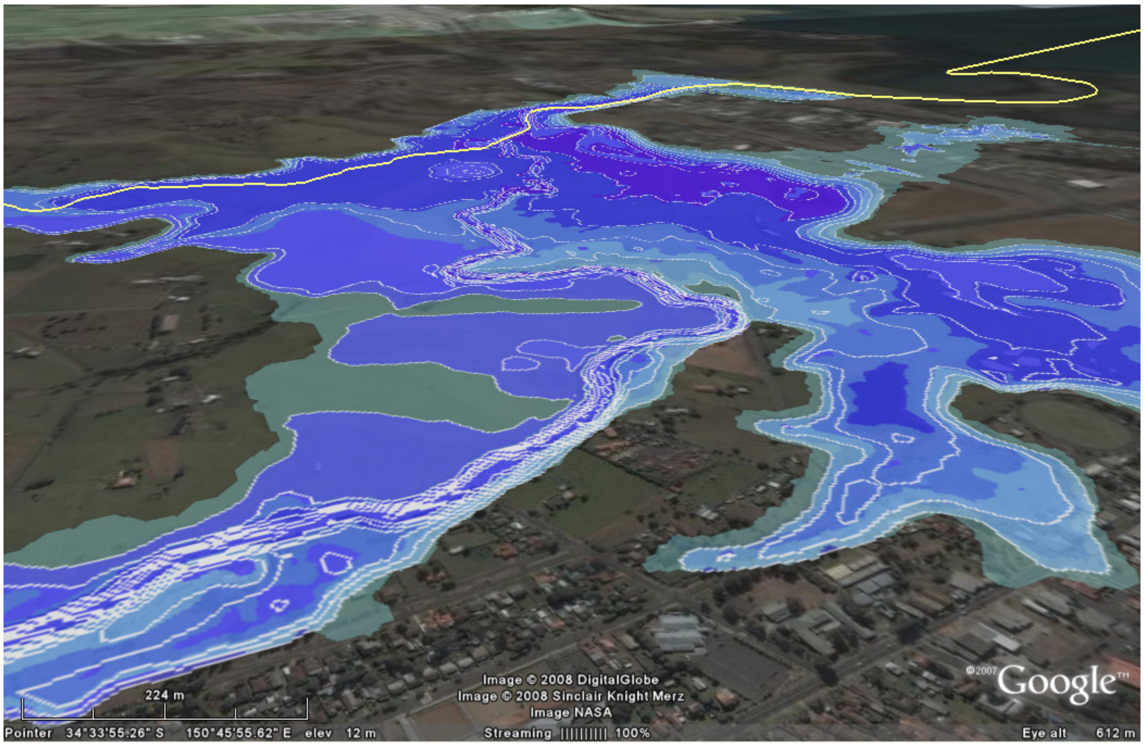

Figure 8. Typical Google Earth representation of segment of inundated area

Of course it is possible to create all manner of colour graded plots for depth, velocity, momentum and any other derived quantity. The resolution and the range of values and colours is highly configurable.

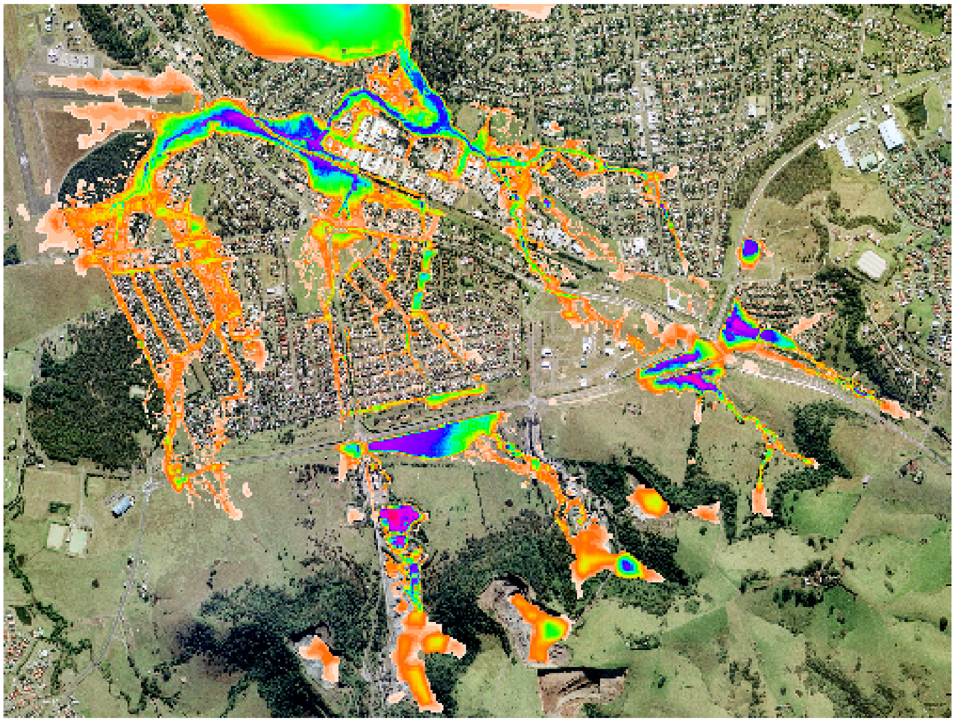

Figure 9. Typical colour graded depth image overlain an air photo of the catchment

However in order to present findings to the general public the ANUGA viewing interface provides 3D animation of the flood event. This provides an invaluable tool for presenting and conveying the message regarding flooding to the public who have little technical appreciation and/or have difficulty interpreting the meaning of the results.

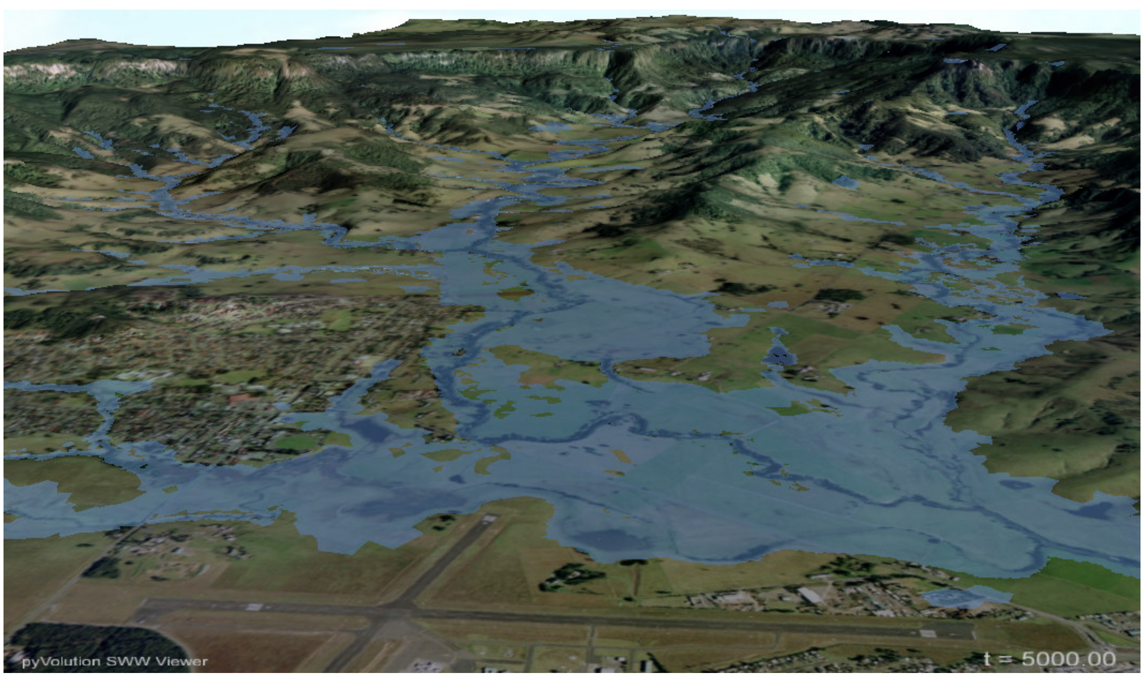

Figure 10. Snap shot from the live 3D model that is able to be flown over whilst the flood event is progressing

In addition by using the cadastre layer on the GIS and querying the output from the hydrodynamic model, a table has been produced such that every flood prone block of land is identified. In addition, specific detail of flooding is provided in this table such as the range of depth and velocity for the events analysed.

CONCLUSIONS:

There are numerous advantages to this approach. The most obvious being the saving in direct:- Cost and Direct:- Time in getting the result. The secondary benefits relate to other functions of local government and the time frame in which vital planning information can be provided to the community. Typically the process that Council has been locked into takes at least 1 or more years to produce results for each catchment or study area. A study based on the “First Pass” methodology has been be finished in months. Further this will also allow a much better brief or scoping document to be produced for any subsequent more formal flood study that council will conduct in the future, thereby providing much greater control of costs.

The final and quite wide ranging benefit relates to the flow on effect of having this information available to other council officers and also the public particularly the development industry. The fact that the councils GIS now not only identifies every flood effected lot but also provides specific details about the range of flood depth and velocity is a monumental leap forward in the provision of this type of information.

Shellhabour City Council has just completed a Citywide Flood Inundation Mapping” based on “First Pass” the methodology. The NEW methodology is also unique in several other facets:

1. The model ownership is vested in the council
2. The aim is to continually improve on the model
3. This provides a much more dynamic capability
4. The presentation of the results is focused more on a web (internet) based concept than a static report.
5. Several options of presentation are available
    a. Council GIS System
    b. Council Mapping interface
    c. Google Earth

The methodology is seen as providing a very beneficial input into the overall “Flood Plain Risk Management Process”. It will ensure that detailed study briefs that direct these studies are written to include the full extent of detailed modelling required to complete the task thoroughly and completely. This will result in a very significant saving in time and costs.

Further the ability for council to finally be in a position to identify “all potentially flood liable property” within the city, places this council well ahead of many other councils.
It is concluded that benefits of this “First Pass” approach more than compensate for the costs associated with producing it.

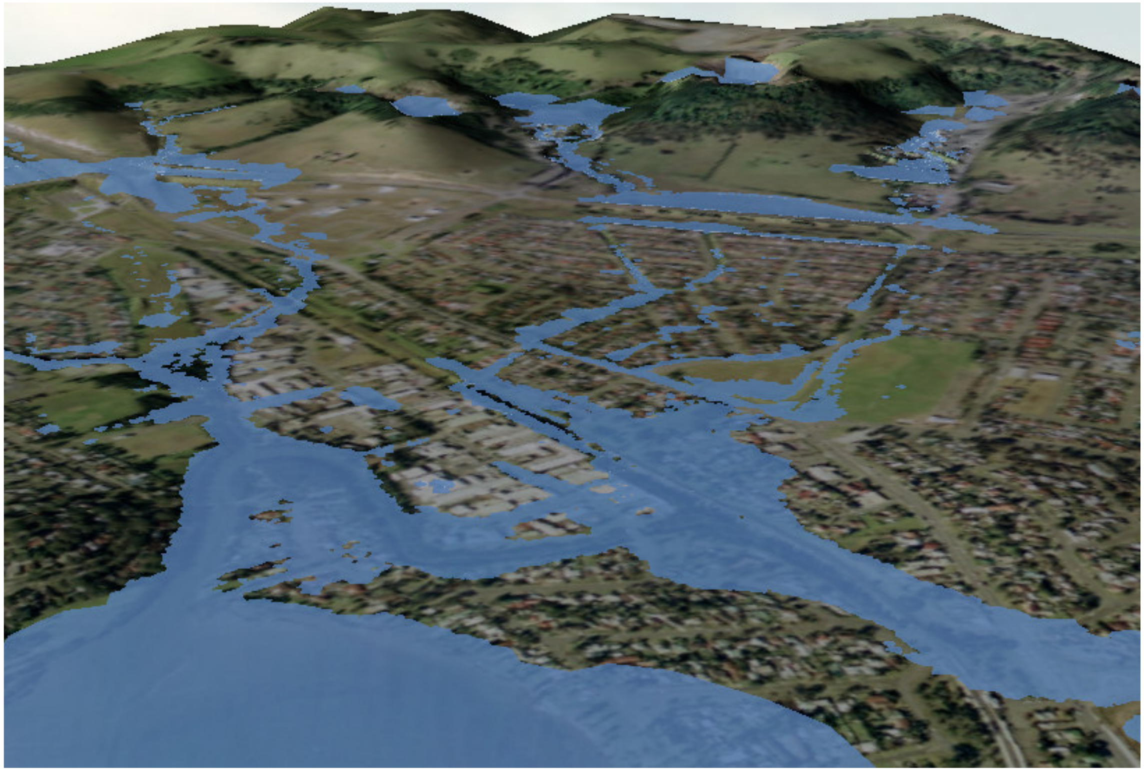

Figure 11. Recap 3D Fly over capability of 2D images produced in Figures 5 & 9.

ACKNOWLEDGEMENTS:

Hydrotec acknowledges the significant role Shellharbour City Council took in this project.

REFERENCES:

Nielsen O. (2006). ANUGA Ver1.0 User Manual Release 1 (https://sourceforge.net/projects/anuga/).

O'Brien J. (2004). Flo-2D User Manual Version 2006.01.(http://www.flo-2d.com/)