MIKE BY DHI CASE STORY

ANALYSING FLOOD REDUCTION MEASURES

Using coupled hydraulic modelling of unsteady flow to prevent severe flood events

The Corte Madera Creek watershed, also named the Ross Valley watershed, is located about 20km north of San Francisco in California. Due to its location, the area is naturally prone to flooding, causing flood events that threaten residents, local businesses and public safety. As part of the 'Ross Valley Watershed Flood Protection Program', Stetson Engineers analysed alternatives for reducing flood damage in the area. For this purpose, they chose to apply MIKE by DHI hydraulic modelling tools to simulate the flood events and to create floodplain mapping for education of the surrounding community.

RISK ASSESSMENT OF CORTE MADERA CREEK - A NATURAL FLOOD PRONE AREA

Due to its exposed location, the geologic and geomorphic settings of the Corte Madera Creek watershed (also known as the Ross Valley watershed) cause:

- intense rainfall
- shallow soils with limited absorption capacity
- steep slopes
- entrenched and narrow stream channels with relatively little in-channel storage capacity

In addition to these natural causes, increased residential, commercial and institutional development in the Ross Valley has created extensive impermeable areas along the creek. As this development encroached onto the banks of the channel, it supplanted the natural flood reducing capacity of the floodplain. Thus, the effects of creekside structures have been superimposed on this naturally flood prone system.

FLOODING HISTORY OF CORTE MADERA CREEK

Over the years, the severity of flooding along the Corte Madera Creek has been varying. The most severe floods occurred in 1982 and 2005. During these flood events, peak discharges were approximately 7,200 cubic feet per second (cfs) and 6,800cfs - approximately twice the normal capacity of the creek. The annual-chance -floods (the chance in percentage of a flood being equalled or exceeded any given year) were approximately 0.6% and 1%, respectively - the latter corresponding to a 100 year flood event.

The current capacity of Corte Madera Creek at the US Geological Survey (USG) stream flow gaging station in the town of Ross is about 3,600cfs. This corresponds to about the 17% annual-chance-flood (i.e. six-year recurrence flood).

SUMMARY

CLIENT

Stetson Engineers Inc.

CHALLENGE

- Flooding of surrounding areas along the Ross Valley watershed
- Alterations of the banks of the channel, diminishing flood reducing capacity of the floodplain
- Increased safety risks to the local community

SOLUTION

- Coupled hydraulic modelling of flood events
- Provision of high quality and accurate data for analysis and decision making

VALUE

- Identification of possible flood occurrences
- High quality site-specific data enabling accurate flood forecasts and risk assessment
- Enhanced emergency response management
- Cost savings and increased safety

LOCATION/COUNTRY

San Francisco, United States

SOFTWARE USED

- MIKE FLOOD
- MIKE 11
- MIKE 21

MARKET AREA

Water Resources

FLOODING REPORTED IN THE AREA

In February 1951, US Geological Survey (USGS) established a stream flow gaging station on the Corte Madera Creek in the town of Ross. Since then, floods have been recorded in the following years: 1951, 1955, 1958, 1967, 1969, 1970, 1982, 1983, 1986, 1994 and 2005.

At some locations, floodwaters breaking out of the creek return back to the creek a short distance downstream of the constraint. At other locations, floodwaters may escape and flow as a separate side-stream, apart from the main channel flow, for extended distances over the floodplain.

COUPLED MODEL FOR HIGH RESOLUTION AND ACCURACY

Stetson Engineers selected our MIKE FLOOD software for flood hydraulic modelling and floodplain mapping. The model domain for Ross Valley consisted of three parts:

- a one-dimensional (1D) MIKE 11 model
- a two-dimensional (2D) MIKE 21 model
- a coupling of the two using lateral links

By using a coupled approach, Stetson Engineers was able to utilise both 1D and 2D models. In doing so, they could avoid many of the limitations in resolution and accuracy, which are often encountered when using the models separately. As a result of the 2D flow pattern in the Ross Valley floodplain, the software could directly compute the flow pattern based on topography, building placement and resistance.

1D MODELLING OF THE MAIN STEM OF THE CREEK

The 1D model, was used to cover the main stem of Corte Madera Creek. This starts at the San Francisco Bay, upstream to the San Anselmo Creek. From here, it flows together with Deer Park Creek, which is located about 600 feet upstream of the Fairfax Creek confluence and the lower portions of four major tributaries: Fairfax Creek, Sleepy Hollow Creek, Sorich Creek and Ross Creek.

2D MODELLING OF THE RIVER BASIN AND FLOODPLAIN

The 2D MIKE 21 model was implemented using detailed digitised topographic data for the river basin and the river floodplain. This was done at a grid cell size of 10 m by 10 m. The cells were mostly occupied by buildings within the MIKE 21 model domain (more than 50% of the cell was occupied by building footprint). They were deactivated by setting a high elevation in the Digital Elevation Model (DEM). The MIKE 21 model domain was oriented in the main flow direction along the San Anselmo Avenue in downtown San Anselmo.

The MIKE 11 and MIKE 21 models were coupled using lateral links, such as lateral weir structures, along the top of the banks of the creek.

Flooding of San Anselmo Avenue during an approximate 100 year flood event on 31 December, 2005. Photo: © Stetson Engineers.

CALIBRATION AND VERIFICATION AGAINST OBSERVED WATER MARKS

Finally, the MIKE FLOOD model was calibrated to the observed 100 high water marks for the flood event on 31 December, 2005. It was then verified with the observed 80 high water marks for the flood event on 4 January, 1982. The flow inputs for the MIKE FLOOD model were generated by the Stetson-developed HEC-HMS hydrologic model application for the Ross Valley watershed.

The calibrated and verified MIKE FLOOD model was used to simulate the extent and depth of flood inundation. This was made under existing and capital improvement plan conditions for a range of recurrence/probability floods. In order to map the extent of floodplain inundation, they utilised ArcGIS to intersect the MIKE FLOOD computed water surface DEM with the floodplain topographic surface DEM.

PRESENTING RESULTS TO THE GENERAL PUBLIC

For presenting the results to the surrounding community and general public, Stetson Engineers utilised the animation capability that is available in our MIKE by DHI software. This proved very helpful when educating the public about the inundation extent and source and time of flooding.

MIKE FLOOD

Our MIKE FLOOD software is one of the tools approved by the US Federal Emergency Management Agency (FEMA) for the National Flood Insurance Program (NFIP).

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