CITY OF NEWPORT BEACH
100 Civic Center Drive
Newport Beach, California 92660
949 644-3001 | 949 644-3020 FAX
newportbeachca.gov

September 6, 2017

Mr. Ed Curtis, P.E., CFM
Risk Analysis Branch
FEMA Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607

Re: Additional Technical Analyses to Support the Appeal for revision of the Preliminary FIRM
Community No.: 060227
Case No.: 12-09-1324S
Docket No. FEMA-B-1673

Dear Mr. Curtis:

On August 30, 2017, we submitted our Letter of Appeal to FEMA to request that the Preliminary FIRM and BFEs be revised. In the letter, we provided additional data not used in the FIS, and proposed the use of a scientifically better method for both data analyses and flood mapping to support our request for map revision. For the Newport Coast (VE Zone), we requested the use of average beach slope to calculate the BFEs for each shoreline reach (or beach zone) and consideration of the City's beach berm program to establish the flood extent. With this letter, we provide additional analyses regarding the data used in the OPC Study and the use of hydrodynamic modeling, to further support our assertion that application of the OPC backshore overtopping analysis at Newport Beach significantly over-predicts the flooding extent associated with the 1% annual chance total water level (TWL).

<u>Over-prediction of the Flood Extent by the OPC Study</u>

In Figure 1, we compare the annual maximum TWLs determined in the OPC Study to the foreshore beach crest elevations and the selected backshore elevations for Transects 17, 18, 20, 21 and 22. As shown in the figure, all 50 annual maximum TWLs for the beach zone represented by Transect 20 are above both the foreshore and backshore crests. This means that flooding of properties in Newport Beach for this beach zone would have occurred ***every year*** from 1961 – 2009 based on the OPC Study methodology for estimating overtopping and inundation extent. Furthermore, beach zones represented by Transects 18 and 21 would have been flooded ***more than every other year***. In reality, properties along these areas were rarely, if ever, flooded during the past several decades. This means that the OPC method of projecting the TWL across the beach to map the flood extent along the Newport Coast is not reasonable because it significantly overestimates the likelihood of flooding along the Newport Coast.

Recent studies of wave overtopping events in Southern California have shown that using TWLs to estimate inundation extent leads to inaccurate predictions (Gallien et al. 2014; Gallien 2016). Specifically, comparison of observed flooding extent to flooding extent predicted using TWL methodology revealed that TWL methodology significantly over-predicts inundation extent. This finding held true for a 2010 wave overtopping event in Newport Beach, CA (Gallien et al. 2014) and a 2014 event in Imperial Beach, CA (Gallien 2016). Instead of using TWLs to estimate flooding extent, the authors recommend dynamic overland flow (hydrodynamic) modeling parameterized with overtopping volumes to accurately predict wave-driven flooding extent.

Alternative Overtopping Analysis for the Newport Coast (VE Zone)

We have used the scientifically more accurate method described in Gallien et al. (2014 and 2016) to estimate the flood extent along the Newport Coast that is caused by wave overtopping. First, we estimated the wave overtopping flow rates and durations associated with the 1% TWL for each beach zone. Then, instead of using the 1% TWL to delineate the VE Zone boundary, we injected the overtopping flow rates at source locations along the Newport Coast into a two-dimensional (2D) hydrodynamic model to evaluate the flood extents along Newport Coast (VE Zone).

Overtopping Analysis

We used the Hedges and Reis (HR) irregular wave overtopping model (Reis et al. 2008) to estimate the overtopping flow rates associated with the 1% annual chance TWLs. The HR overtopping model was selected because of its simplicity and geometric consistency with the beach dune system in Newport Beach (Gallien et al. 2014). In addition, Gallien et al. (2016) showed that predicted flooding extents are not sensitive to the selected overtopping model, and suggested that backshore topography and flow dynamics are the primary factors controlling the flood extents.

In the HR model, the mean overtopping rate per unit width, q, is calculated as a function of beach profile geometry and wave runup:

$$q = \sqrt{gR_{max}^3}\, A\left(1 - \frac{R_c}{R_{max}}\right)^B \qquad \text{(Equation 1)}$$

$$A = 0.0033 + 0.0025\cot\alpha$$
$$B = 2.8 + 0.65\cot\alpha$$

where g represents gravitational acceleration, R_{max} is the maximum expected runup, α is the angle between the horizontal and the foreshore slope, and R_c is the freeboard or height between the beach crest and the still water level (SWL). A sketch showing the application of the HR model and variables used in Equation 1 is provided in Figure 2.

For our analysis, the SWL was defined as the average SWL ($\overline{\text{SWL}}$) that occurred during the 50 annual maxima events of the OPC Study, based on the SWL values from the OPC Study tables with runup values (IDS3, Appendix C). The maximum expected runup of the overtopped reaches, R_{max}, was defined as the difference between the revised 1% TWL calculated based on the average beach slope for each zone (described in our Letter of Appeal) and the corresponding $\overline{\text{SWL}}$ at the shoreline of that zone.

The actual overtopping flow rate resulting from wave event runup is dependent upon local beach geometry. Variability in beach geometry within the five shoreline reaches (or zones) assessed under this application was captured for 159 across-shore transects, taken at 100 ft. intervals along the shoreline, where beach elevations were extracted from the OPC terrain data at 1 ft. intervals along each transect. The extracted transect elevations were used to define the foreshore slopes (α) and the foreshore beach crests. The freeboard (R_c,) was then defined as the difference between the foreshore beach crest and $\overline{\mathrm{SWL}}$ for each extracted transect. This methodology results in a q (see Eq. 1) value for each transect, that was used as input into the hydrodynamic model described in the next section of this letter.

The q values determined from Equation 1 represent the peak overtopping rates expected during the 1% TWL event. In reality, the SWL and wave forcing vary temporally. Therefore, values of q will also change as a function of time. Since the 1% TWL is determined from the distribution of annual maximum TWLs (OPC Study), however, there are no temporally varying SWLs or wave forcing variables associated with this water level. Thus, it is not possible to calculate an unsteady hydrograph associated with the 1% TWL. For our analysis, we used the conservative assumption that the peak overtopping rate persists for the typical overtopping duration of the annual maximum events.

To estimate the overtopping duration (OD) for each beach zone, we first used the tidal data recorded at the Port of Los Angeles (NOAA Station No. 9410660) to determine the TWL twelve hours before and after the annual maximum TWLs reported in the runup tables of the OPC Study (IDS3, Appendix C). Then, we calculated the OD for each annual maximum event. Specifically, the OD represents the length of time during which the TWL was greater than the foreshore beach crest defined at each OPC transect. An example of how the OD was calculated for one of the annual maximum TWLs for Transect 17 is illustrated graphically in Figure 3.

We repeated this for each annual maximum event at the beach zones corresponding to Transects 17, 18, 20, 21, and 22 from the OPC Study. This resulted in a distribution of OD values for each shoreline reach. We then defined the OD value associated with the 1% TWL event as the expected value of the OD distributions, $E[OD]$, which is simply the average overtopping time for each shoreline reach. The peak q values are then used as input for the hydrodynamic model—described in the following section of this letter—for a duration equal to $E[OD]$. Table 1 provides a summary of the parameters and results of our overtopping analysis. Note that this methodology likely overestimates the total overtopping volume since q represents the peak overtopping rate expected during the 1% TWL event.

Table 1.

Summary of Shoreline Reach Parameters, Averaged Overtopping Rates, and Overtopping Durations

Reach ID (FEMA TS number)	Average Foreshore Crest Elev. (ft., NAVD88)	Average Transect Slope	1% TWL (ft., NAVD88)	Still water level, SWL (ft., NAVD88)	Average Overtopping Rate (ft.^{3}/s/ft.)	Overtopping Duration (hr)
17	11.90	0.064	14.7	5.80	5.73×10^{-2}	3.26
18	9.32	0.040	12.8	6.26	2.46×10^{-1}	4.85
20	14.91	0.136	17.7	5.36	1.99×10^{-2}	3.98
21	15.83	0.152	20.9	5.41	6.19×10^{-2}	7.96
22	16.93	0.146	18.4	5.65	1.15×10^{-3}	2.32

Hydrodynamic Modeling

The 2D hydraulic model BreZo (Sanders et al. 2010) was used for overland routing of the overtopping rate, q. BreZo is a 2D Godunov-type finite volume model that solves shallow-water equations over complex topography, where mobile wet/dry fronts, hydraulic jumps, and any combination of sub-critical and super-critical flow can occur. The model calculates flows over a mesh of unstructured triangles with ground elevations assigned at vertices of each triangle in the mesh. BreZo was previously applied to model tidal flooding in Newport Beach (Gallien et al. 2011), and has also been adopted to validate predicted flooding extent driven by wave overtopping at Newport Beach and Imperial Beach sites in California (Gallien et al. 2014, Gallien et al. 2016).

The BreZo model has been validated with a flooding event along the Newport Beach shoreline that was caused by wave overtopping. Gallien et al. (2014) used the BreZo model to simulate the impacts of beach wave overtopping at Newport Beach for a swell event which occurred on August 31st 2011. During this event, a southern swell arrived earlier than forecasted, and coincided with a 5.9 ft., NAVD88 high tide at 11:20 AM LST. Waves overtopped the beach for approximately 1 hour near Balboa Pier, causing localized flooding between B Street and Adams Street that measured up to approximately 1 m in depth (flood extent shown by solid black line in Figure 4). Gallien et al. (2014) adopted two empirical wave overtopping models to estimate temporally variable overtopping flows, including the HR model shown in Equation 1 and the EurOtop model (Pullen et al. 2007). Overtopping flow rates resulting from each model were then injected into the hydraulic model BreZo, which was set up to simulate flow propagation at the Balboa Pier site, in order to compare predicted flood extents to observed ones. Gallien et al. (2014) found that the HR model and the EurOtop model performed very similarly, with the HR model approach producing slightly more conservative results than that of the EurOtop model. Figure 4 shows the observed versus predicted flood extent, based on the methodology adopting the HR and BreZo models, for the August 2011 wave overtopping event. In general, the model-predicted flood extent matches well with the observed flood extent, as can be seen in the figure.

For our study, the elevations of the BreZo mesh vertices for the Newport Beach coastline were defined by the OPC Study terrain data. The values of q were input to the hydraulic model at 100 ft. intervals, coinciding with the location of each transect within the shoreline zones, for durations equal to $E[OD]$—where the value of $E[OD]$ depends on which shoreline zone the transect is within. Notice that Equation 1 produces an overtopping flow rate per unit length (m^2/s); hence, each value of q was multiplied by a width equivalent to 100 ft. (50 ft. spacing on either side of each transect) to produce volumetric flow rates (m^3/s). The injection locations were situated 1 ft. landward of the foreshore beach crest to ensure that overtopping volumes propagated landward rather than seaward. We used the conservative assumption that overtopped flows would not infiltrate into the sand of the backshore beach, which meant that all overtopped flows would propagate through the backshore beaches. Figure 5*a* illustrates the general placement of flow sources for hydraulic model forcing, while Figure 5*b* shows the actual placements of flow source locations at the foreshore crest along transects near 34th Street at Newport Beach. Hydrodynamic model simulations for each shoreline zone were run independently, to ensure that the resulting flood extents and depths could be attributed to overtopping flows from each individual shoreline zone.

Model-Predicted Flood Extents along Newport Coast

The BreZo model results are presented for the beach zones corresponding to Transects 17, 18, 20, 21, and 22 from the OPC Study. Zones corresponding to Transects 16, 19, 23 and 24, were not modeled because the revised 1% TWLs in those reaches resulting in no wave overtopping. Outputs from each model run were gridded on BreZo's unstructured mesh using Inverse Distance Weighted (IDW) interpolation at 10 ft. resolution, with shallow flows less than 0.03 ft. (1 cm) in depth masked to improve the visual clarity of the results. Impacts of wave overtopping at each of the modeled zones are summarized below.

Zone 17

Figure 6*a* shows the area affected by wave overtopping for Zone 17, which was represented by beach Transect 17 in the OPC Study. Due to the high elevation of the backshore relative to that of the foreshore crest for most of the reach, the area affected by wave overtopping from the 1% TWL is limited primarily to the southern portion of the reach where the foreshore crest represents the highest terrain on the beach (see Figure 5*b*). Figure 6*b* provides a magnified view of the affected area between 33rd Street and 36th Street, where approximately 3.25 hours of overtopping resulted in a moderate flood depth prediction of less than 1 ft. between 34th Street and 35th Street on the boardwalk, and less than 0.5 ft. elsewhere.

Zone 18

At Zone 18, represented by Transect 18 in the OPC Study (Figure 7), the backshore elevation is again largely higher than that of the foreshore crest. This resulted in limited impacts from wave overtopping at Zone 18, which still experienced the greatest overtopping rate out of all the analyzed reaches (average of 2.46×10^{-1} ft.^{3}/s/ft. [see Table 1]). Most of the predicted flooding affected the foreshore area, where overtopped flow volumes flowed back toward the ocean as sheet flow. Due to the close proximity of the foreshore crest to the backshore north of the Newport Pier parking lot, up to 0.25 ft. of flooding is predicted along the boardwalk at 25th Street. South of this parking lot, flood depths of up to 0.5 ft. are shown near the Dory Fishing Fleet Market. However, the actual parking lot was not predicted to be affected by the 1% TWL wave overtopping event.

Zone 20

At Zone 20, represented by Transect 20 in the OPC Study (Figure 8), beach geometries are concave between the foreshore crest and backshore, which resulted in wave overtopping that ponded on the beach face and reached depths of up to 1.6 ft.. Flooding was not predicted to occur at any of the backshore infrastructure.

Zone 21

At Zone 21, represented by Transect 21 in the OPC study (Figure 9), the beach reaches its narrowest point along the shoreline stretch bordering the Balboa Pier parking lots. Although Lidar beach geometries used for hydraulic modeling reported a 4 ft. tall beach berm adjacent to the parking lot, flow volume from almost 8 hours of wave overtopping was predicted to flow around the berm and penetrate the parking lots at their north and south corners. From there, flooding first ponded on the parking lot, reaching depths between 0.25-1.6 ft. The flooding then continued north along Adams Street, Palm Street, and Main Street toward the Balboa Fun Zone, and into the residential neighborhood near Bay Island. Flood depths up to 1 ft. were predicted along East Bay Avenue, in addition to several of its side streets including Coronado, Fernando, and Cypress Street. Flooding was also predicted to reach 1 ft. in depth at the intersection of East Balboa Avenue and B Street.

Flooding extents predicted for the 1% TWL event closely match those predicted by Gallien et al. (2014), which resulted from wave overtopping at Zone 21 on August 31st, 2011 (see Figure 2).

Zone 22

Finally—at Zone 22, represented by Transect 22 in the OPC Study, minimal flooding was predicted to occur as a result of wave overtopping (Figure 10). At this location, the beach is wide and has a well-developed dune system. The overtopping duration (2.4 hours) and flow rate (average of $1.15\text{x}10^{-3}$ $\text{ft.}^3/\text{s}/\text{ft.}$) at Zone 22 are among the smallest of the predicted values (see Table 1).

CLOSURE

We have conducted additional analyses to evaluate the flooding potential along the Newport Coast. Despite our use of very conservative assumptions in estimating the wave overtopping flows throughout the wave overtopping duration, excluding our consideration of the City's beach berm program, and in assuming that none of the overtopped flow would infiltrate the beach sand, we still found that very limited flooding would occur along the Newport Coast. As such, we request that the significantly over-predicted flooding extent of the Newport Coast (VE Zone) be completely revised, based on our requested revision presented in our previously submitted Letter of Appeal.

Sincerely,

Seimone Jurjis

Seimone Jurjis, PE, CBO
Community Development Director

c: Rick Sacbibit, Chief, Engineering Services Branch

Attachments:
- Exhibits – Figures 1-10
- Additional Private Property Appeal Forms
- Revised Map of Private Property Appeals and City Owned Property

REFERENCES

Gallien, T.W., Schubert, J.E. and Sanders, B.F. (2011). Predicting Tidal Flooding of Urbanized Embayments: A Modeling Framework and Data Requirements. *Coastal Engineering*, 58(6), 567-577.

Gallien, T. W., Sanders, B. F., and Flick, R. E. (2014). Urban coastal flood prediction: Integrating wave overtopping, flood defenses and drainage. *Coastal Engineering*, *91*, 18-28.

Gallien, T. W. (2016). Validated coastal flood modeling at Imperial Beach, California: Comparing total water level, empirical and numerical overtopping methodologies. *Coastal Engineering*, *111*, 95-104.

Reis, M. T., Hu, K., Hedges, T. S., and Mase, H. (2008). A comparison of empirical, semiempirical, and numerical wave overtopping models. *Journal of Coastal Research*, *24*(sp2), 250-262.

Pullen, T., Allsop, N.W.H., Bruce, T., Kortenhaus, A., Schüttrumpf, H., and Van der Meer, J.W. (2007). EurOtop: wave overtopping of sea defences and related structures: Assessment manual. Available at https://www.researchgate.net/publication/256197945_EurOtop_Wave_Overtopping_of_Sea_Defences_and_Related_Structures_Assessment_Manual.

Sanders, B. F., Schubert, J. E., and Detwiler, R. L. (2010). ParBreZo: A parallel, unstructured grid, Godunov-type, shallow-water code for high-resolution flood inundation modeling at the regional scale. *Advances in Water Resources*, *33*(12), 1456-1467.

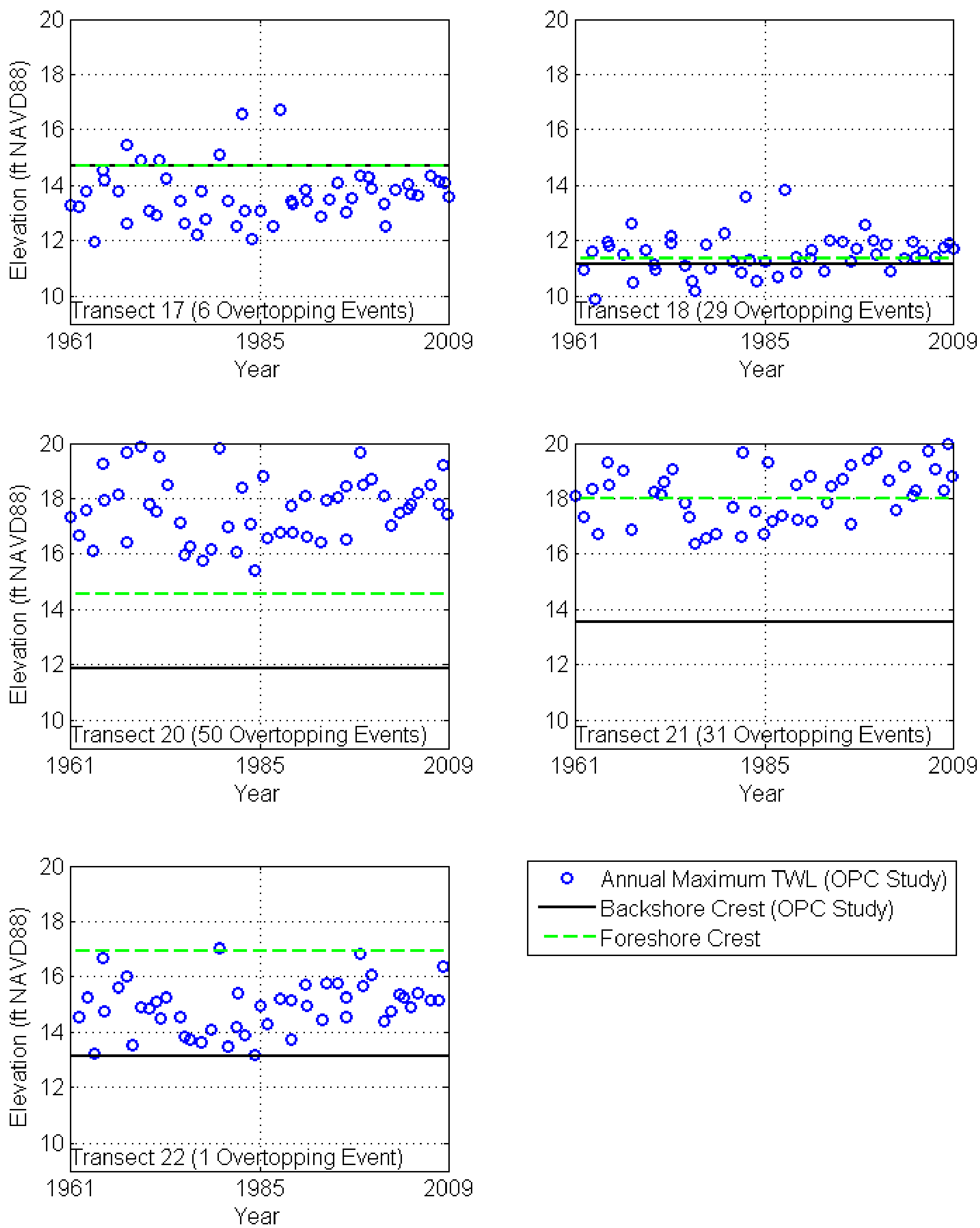


Figure 1. Comparison of OPC Study TWLs to foreshore beach crest elevations and selected backshore feature elevations for Transects 17, 18, 20, 21, and 22. Projection of the annual maximum TWL to the backshore crest would result in flooding of properties at least every year from 1961 – 2009 for Transects 18, 20, and 21.

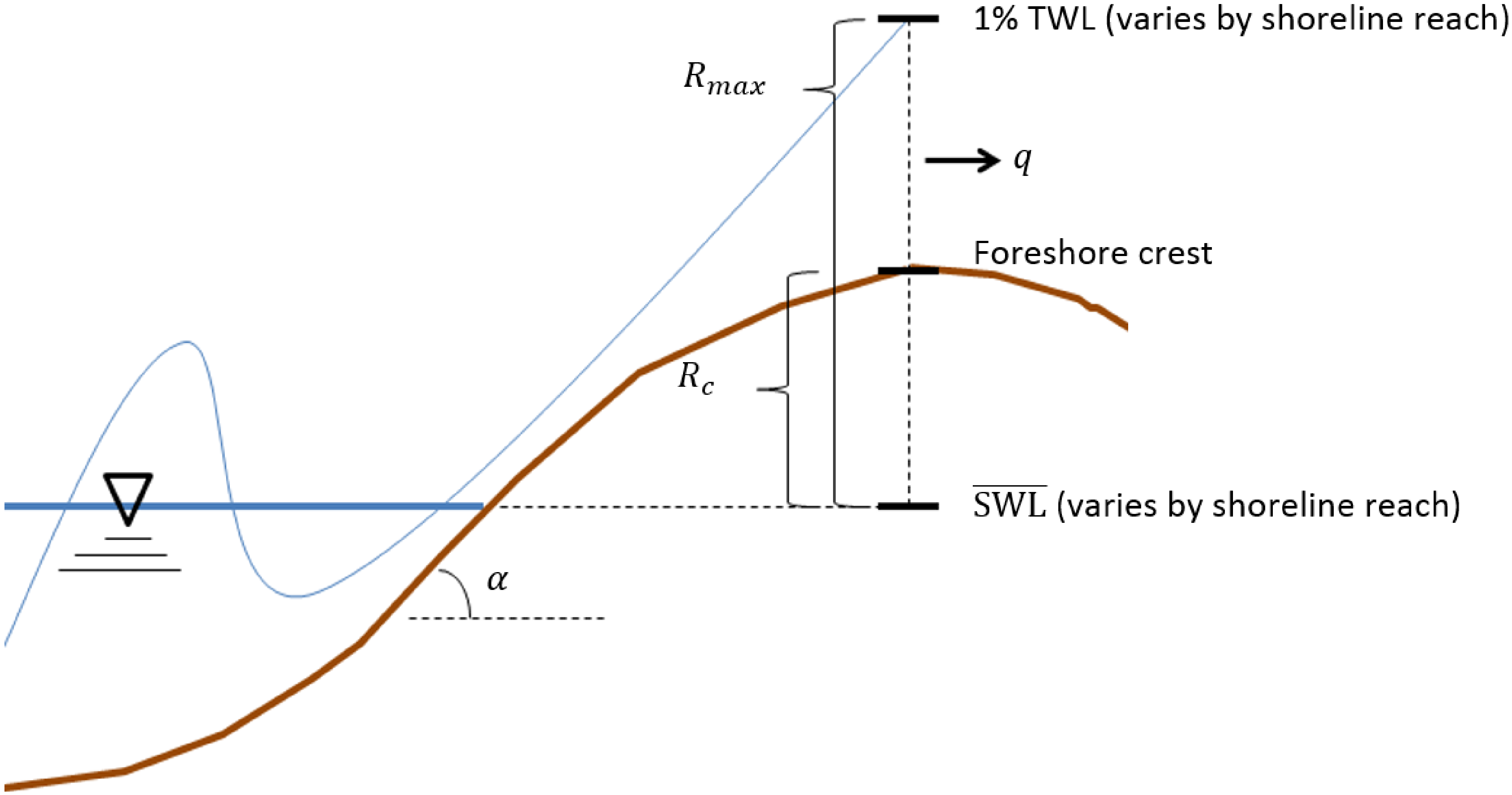


Figure 2. Application of the HR overtopping model. Notice that the 1% TWL and $\overline{\text{SWL}}$ each vary as a function of shoreline reach. All other variables are unique to each transect generated at 100 ft intervals.

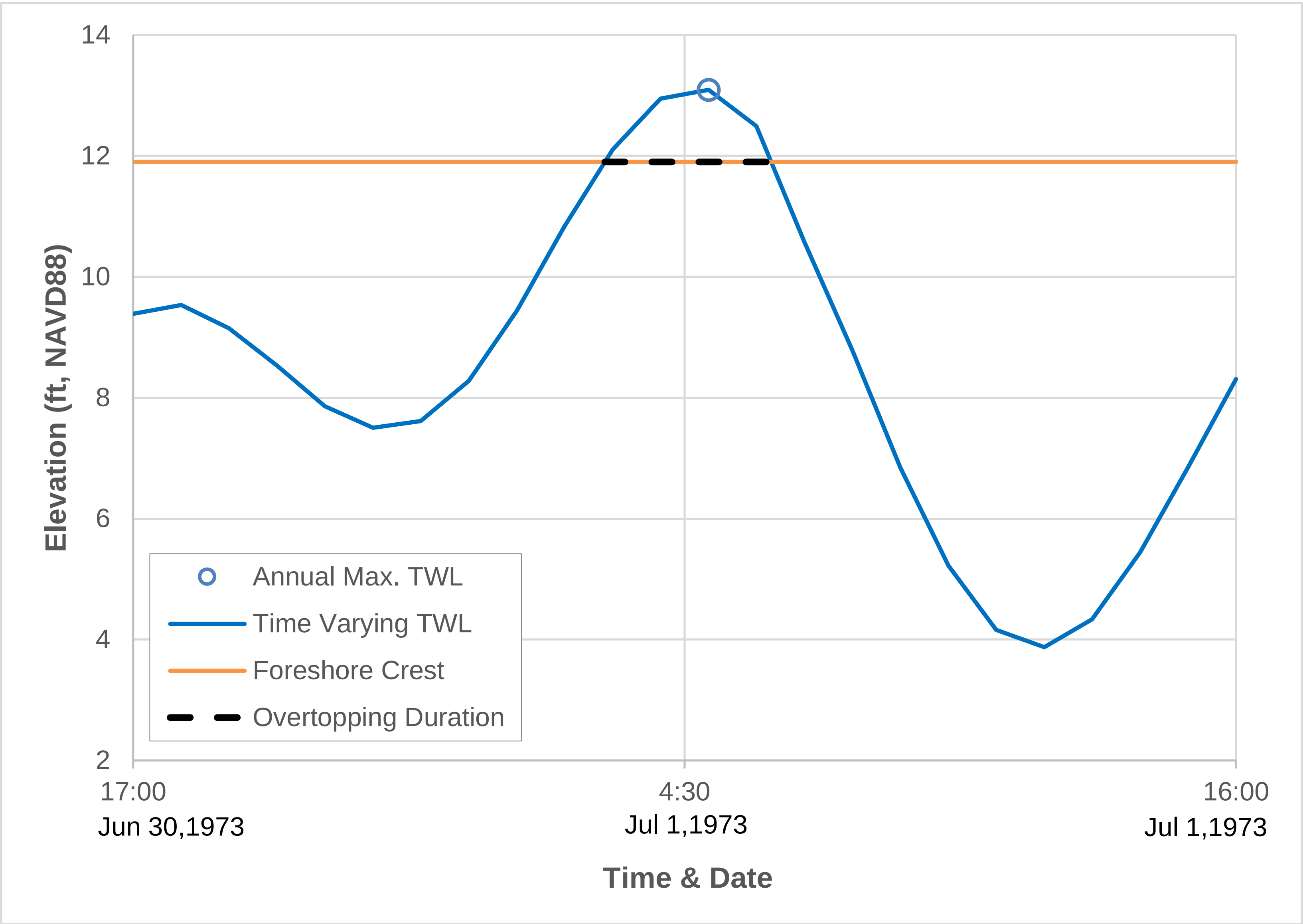


Figure 3. Example illustrating calculation of Overtopping Duration for one of the annual maximum TWLs for Transect 17.

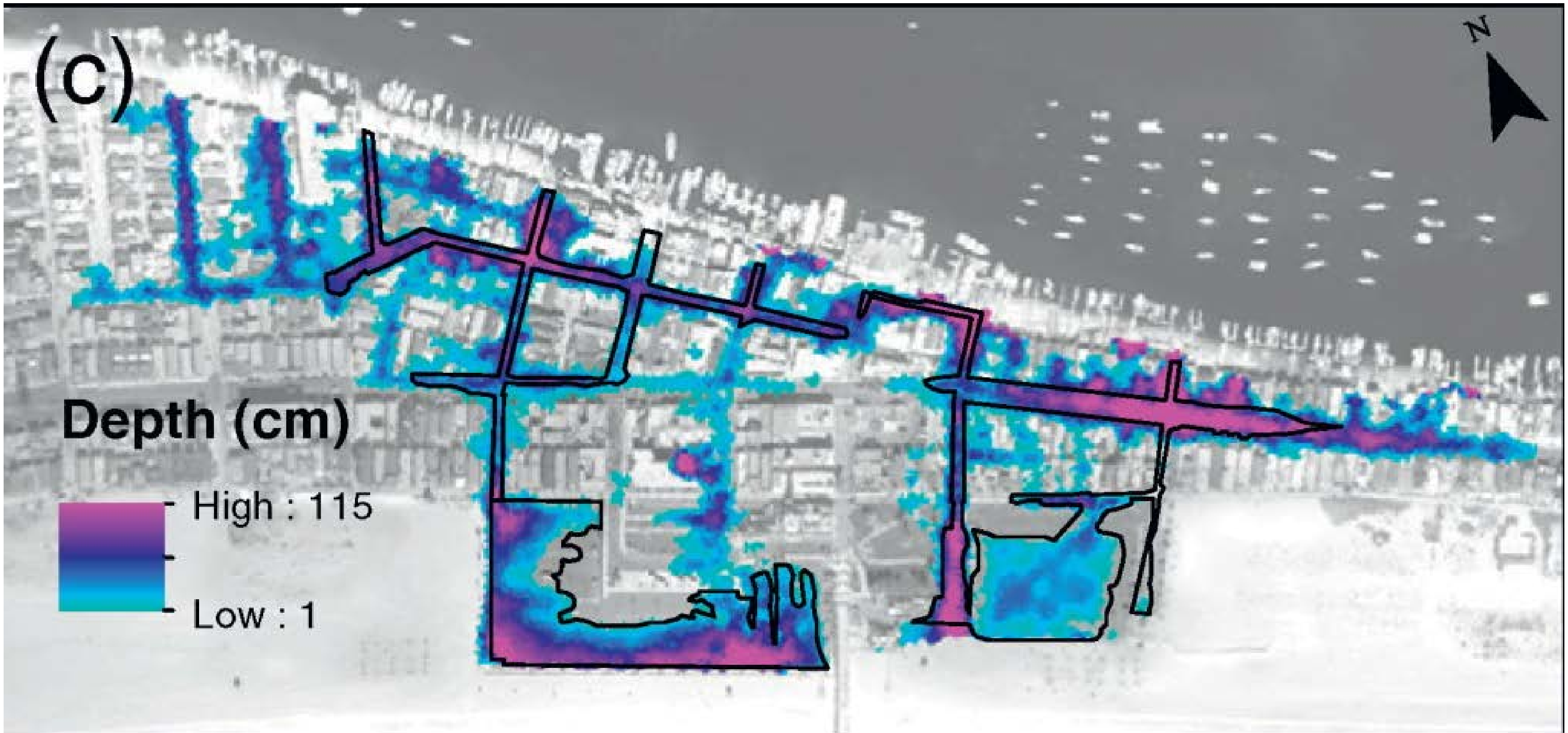
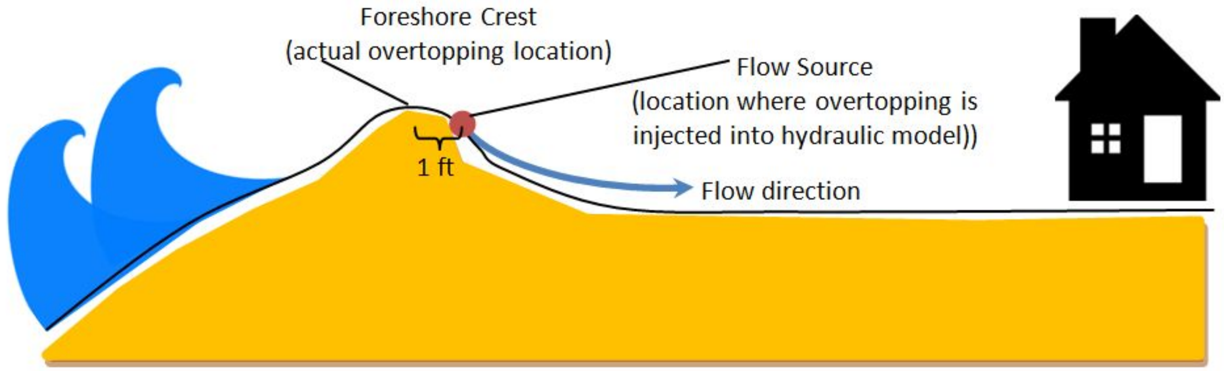
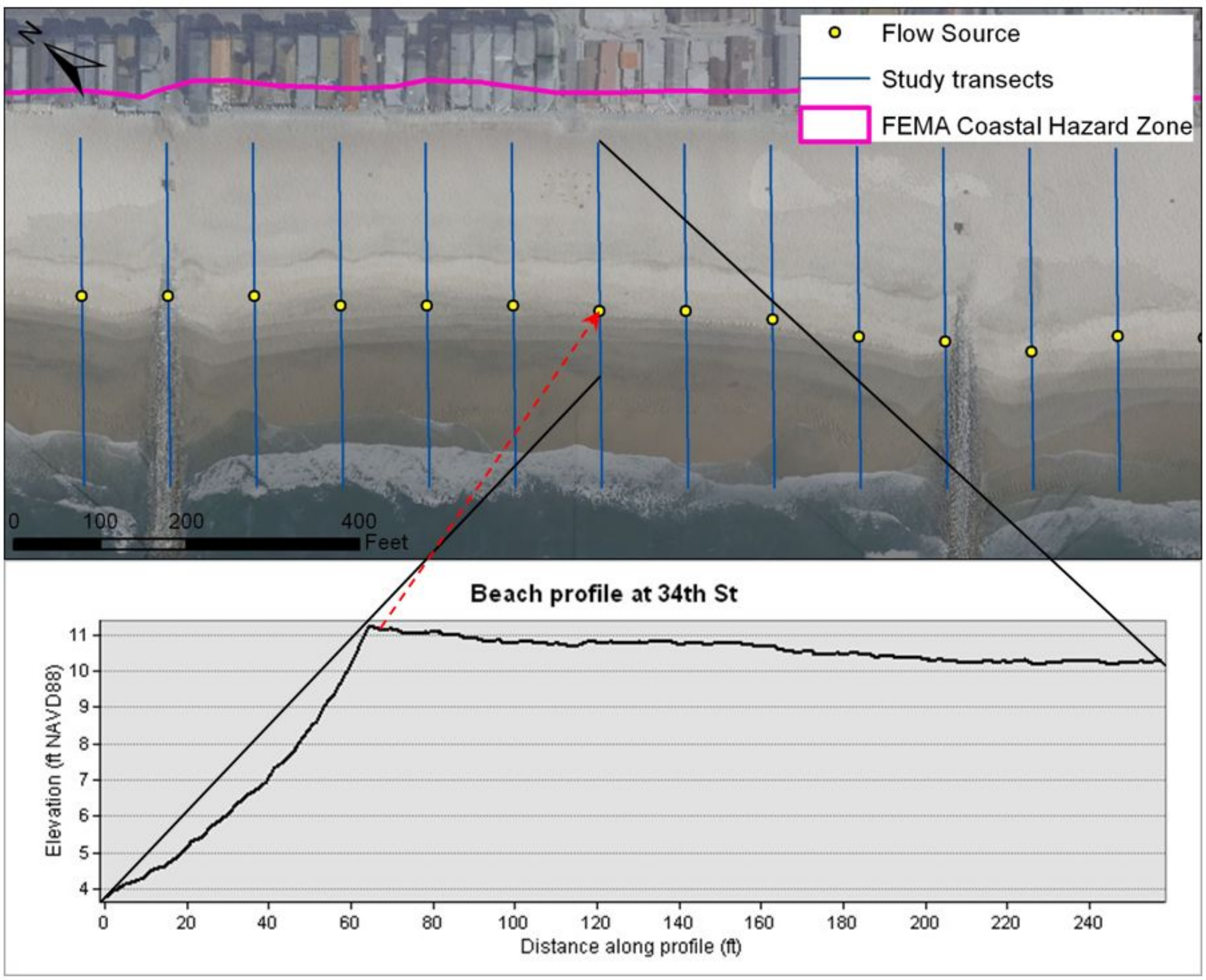


Figure 4. Observed flood extent (solid black line) vs. flood extent predicted using the HR and BreZo modeling methodology, for the August 2011 wave overtopping event at Newport Beach. Extracted from Gallien et al. (2014).



(a) Profile view of injection locations for hydraulic model forcing



(b) Plan view of flow source locations at foreshore crest locations along beach.

Figure 5. Schematic to illustrate injection of overtopping flow at Newport Beach

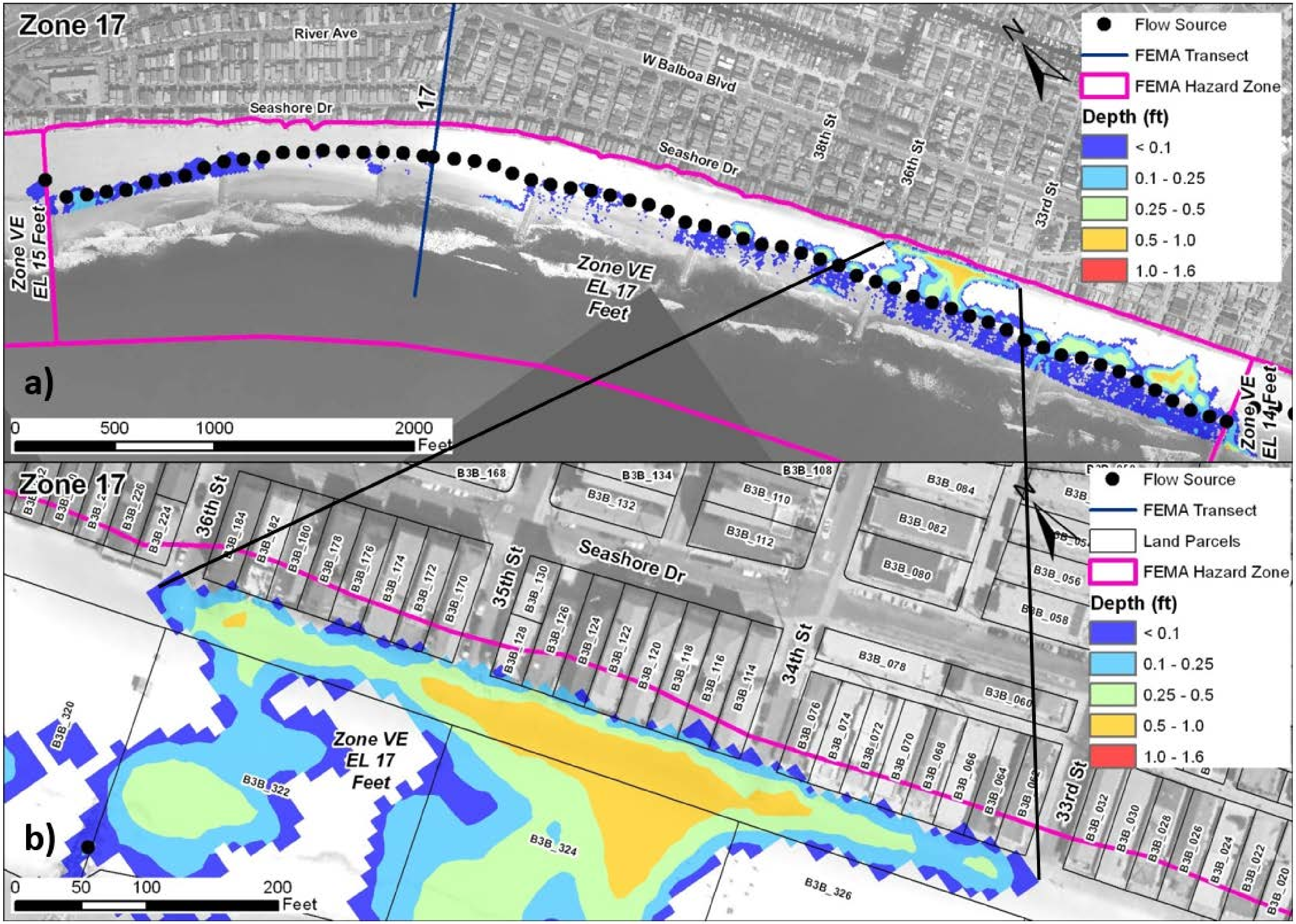


Figure 6. Wave overtopping at Zone 17. a) Overview of shoreline reach and b) magnified view between 33rd and 36th St.

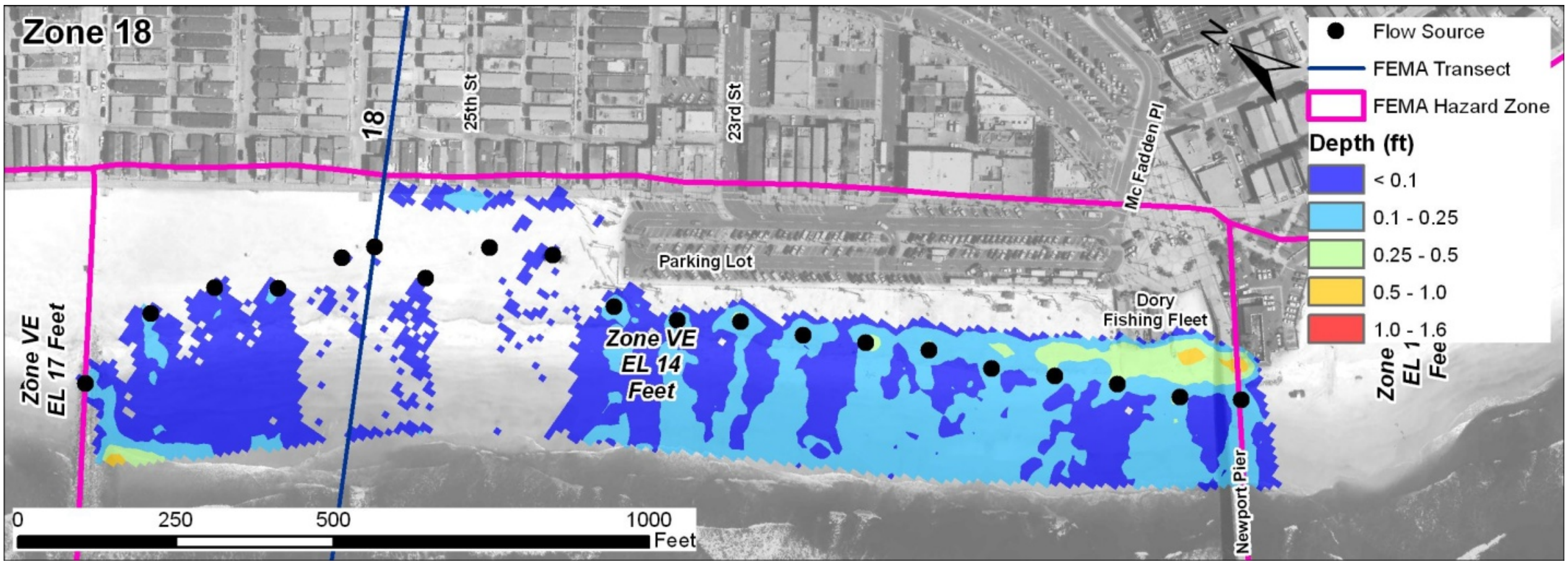


Figure 7. Wave overtopping at Zone 18.

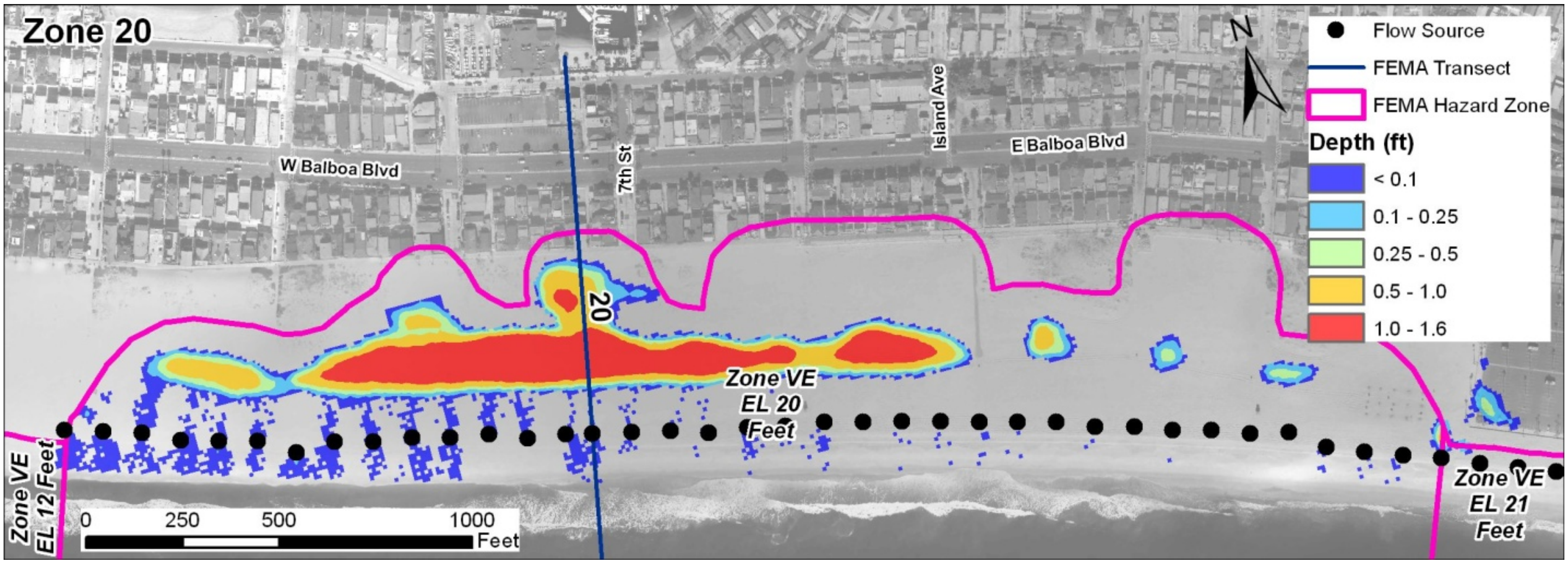


Figure 8. Wave overtopping at Zone 20.

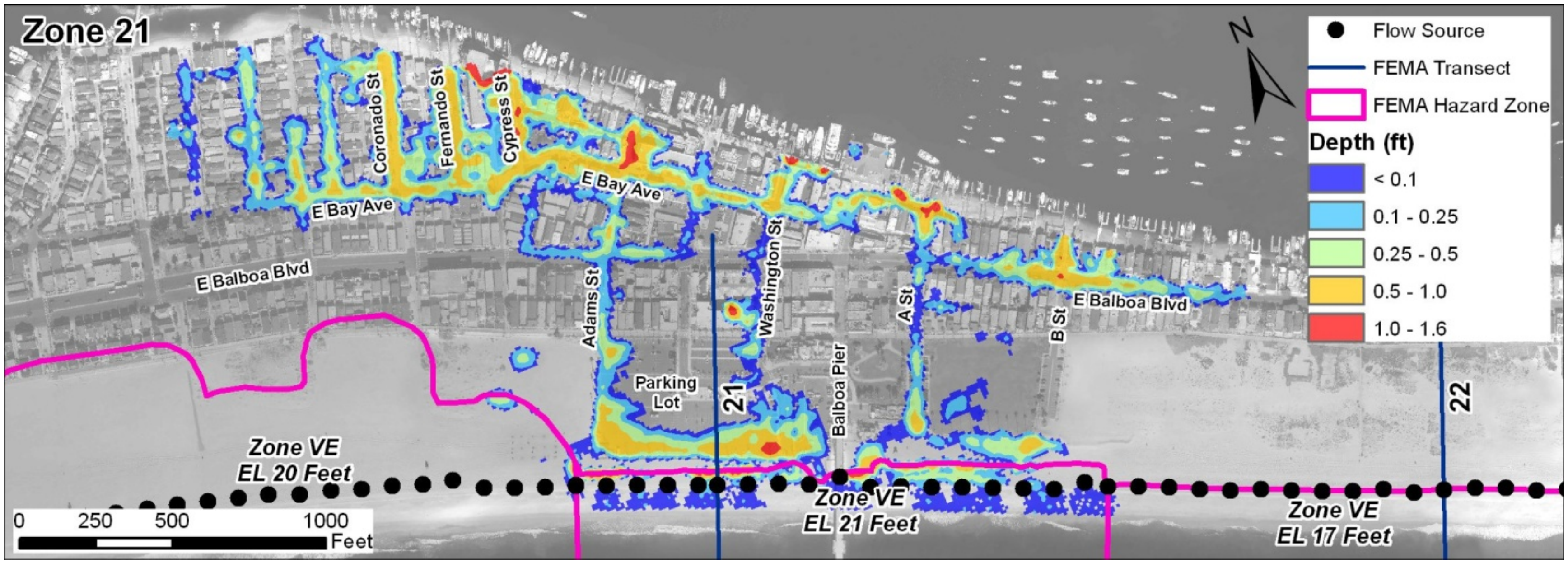


Figure 9. Wave overtopping at Zone 21.

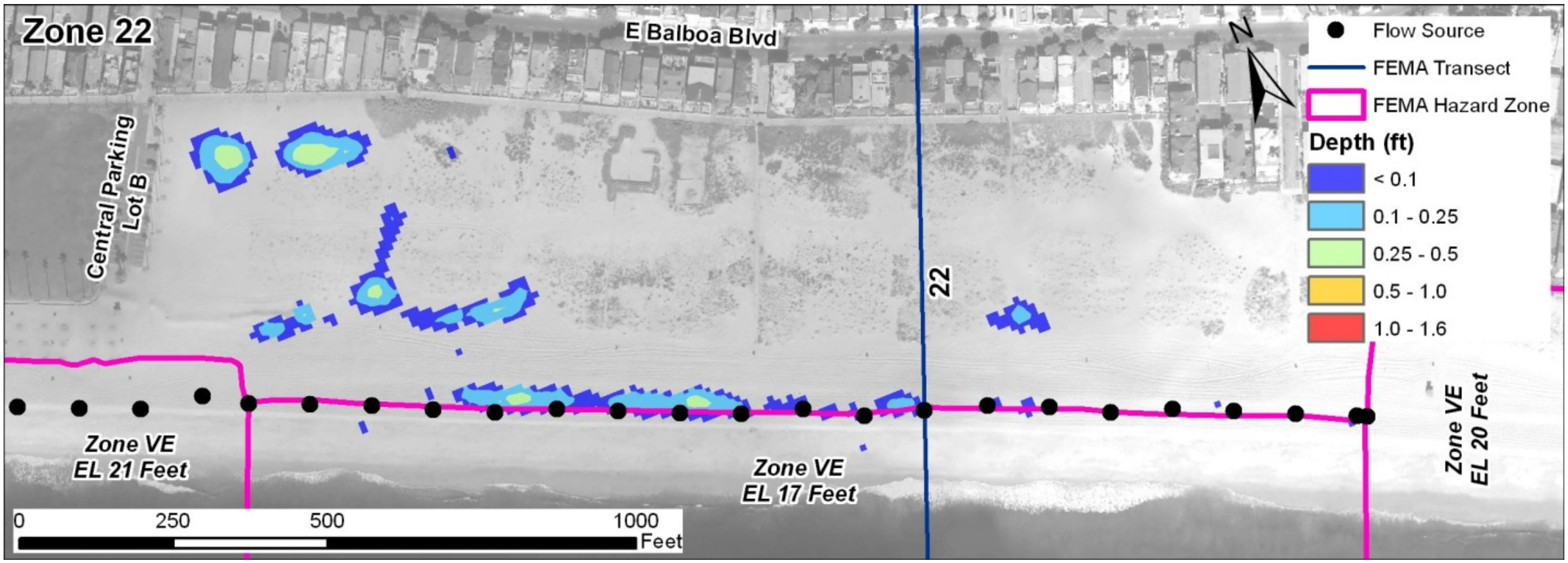


Figure 10. Wave overtopping at Zone 22.