Technical Memorandum

To: KPFF Consulting Engineers

From: Larry Karpack P.E.

Date: March 24, 2020

Re: North Shore Levee West Segment, Hoquiam, WA –BFE Determination

INTRODUCTION

Watershed Science & Engineering (WSE) was retained by KPFF Consulting Engineers on behalf of the City of Hoquiam to provide hydraulic engineering support for design of the proposed North Shore Levee, West Segment in Hoquiam, WA. The proposed levee will provide flood protection for areas of the City located north of Grays Harbor, and south and west of the Hoquiam River, downstream of the confluence with the Little Hoquiam River. Figure 1 shows the project area, location of the proposed levee, and the potential flooding sources.

Portions of the City of Hoquiam that are within the "effective" Federal Emergency Management Agency (FEMA) 100-year floodplain would be protected by the North Shore Levee West Segment from flooding during the 1% annual chance flood. A Conditional Letter of Map Revision (CLOMR) request is being submitted to FEMA to document the effect of the proposed levee on floodplain extents and request FEMA concurrence with the analysis and floodplain mapping. To support the levee design and CLOMR submittal, WSE determined the current base flood elevation (BFE) along the length of the proposed levee and mapped the effects of the levee on floodplain extents.

There are two potential flooding sources along the proposed North Shore Levee West Segment; Grays Harbor (coastal flooding) and Hoquiam River (riverine flooding). Therefore, both coastal and riverine hydraulic conditions were evaluated to determine the current BFEs along the proposed levee and inundation limits after the levee is constructed. WSE's evaluation is described below.

FLOODING SOURCES AND PAST STUDIES

As noted above, there are two potential flooding sources in proximity to the proposed West Segment of the North Shore Levee: Grays Harbor coastal flooding and Hoquiam River riverine flooding. Both of these flooding sources have been previously studied and mapped by FEMA. The effective floodplain mapping for Grays Harbor was recently updated as part of FEMA's Grays Harbor County Flood Insurance Study (effective February 3, 2017). Data from that study were obtained by WSE for a previous study of the North Shore Levee (WSE, 2017b). The effective mapping for the Hoquiam River was completed in 1975. A request was made to FEMA for data, modeling, or mapping related to that study but FEMA could not provide any information beyond what is reported in the Flood Insurance Study (FIS).

POTENTIAL FOR COASTAL FLOODING FROM GRAYS HARBOR

Coastal flood frequency analyses for Grays Harbor were recently updated by the Strategic Alliance for Risk Reduction (STARR) for FEMA. STARR determined the 100-year tidal stillwater elevation in Grays Harbor to

Grays Harbor County, WA

North Shore Levee West Segment
Project Area and
Proposed Levee Location

0 1,000 2,000 Feet

N

Scale: 1:18,000
NAD 1983 HARN
StatePlane Washington
South FIPS 4602 Feet

10 Feb 2020

WATERSHED SCIENCE & ENGINEERING

C:\Egnyte\Private\marissa\Projects\19-004 North Shore Levee West Segment\GIS\MXD\Figure 1 - Project Location Overview.mxd 2/10/2020 10:03:29 AM

be 12.0 feet $NAVD_{88}$. STARR further determined the Coastal Total Water Level (TWL) along the shoreline of Grays Harbor at Hoquiam to be 13.0 feet $NAVD_{88}$. (FEMA, 2017). The current effective FEMA mapping for Hoquiam shows base flood elevations of 13.0 feet $NAVD_{88}$ along the shoreline of Grays Harbor transitioning to 14.0 feet $NAVD_{88}$ upstream of the first railroad bridge on the Hoquiam River. It is believed that the change from the 13.0 to 14.0 foot BFE is a mapping error as described in detail in Appendix A.

The proposed North Shore Levee West Segment will not change coastal stillwater elevations, as stillwater elevations are a function of astronomical tides and meteorological conditions and are not affected by terrestrial features. Also, because the proposed levee is set far back from the shoreline of Grays Harbor, the levee will not affect wave setup or runup. Therefore, for this analysis, it can be assumed that the proposed levee will not affect total water levels or BFEs.

It should be noted that although FEMA estimates a stillwater elevation of 12.0 feet NAVD and a Total Water Level of 13 feet $NAVD_{88}$ along Grays Harbor west of the mouth of the Hoquiam River, those values may underestimate the true potential for coastal flooding. In a previous study for the City of Aberdeen WSE did its own analysis of coastal stillwater and total water levels for Grays Harbor (WSE, 2017a). That analysis estimated a stillwater level of 13.1 feet for the north shore of Grays Harbor near Hoquiam and TWLs ranging between 13.8 feet and 15.1 feet. TWL varies by location depending on the orientation, geometry, ground cover, wind, and wave conditions and other factors. The highest estimated TWL in the 2017 study was for a location near the mouth of the Hoquiam River on the east bank of the river (Transect 2). At that location there is a long fetch length perpendicular to the shore in the direction of the predominant southwest winds, resulting in “worst case” conditions for wave runup. The proposed North Shore Levee West Segment is on the opposite side of the Hoquiam River and is set well back from the shoreline as shown in Figure 1. Therefore, as stated previously, the proposed levee is not expected to affect wave runup or TWLs.

POTENTIAL FOR RIVERINE FLOODING FROM THE HOQUIAM RIVER

The Hoquiam River flows generally south to its mouth at Grays Harbor as shown in Figure 1. FEMA was unable to locate any supporting documentation for the effective FEMA study of the Hoquiam River. Therefore it is not possible to review previous modeling or analysis from the effective study. However, the effective study report indicates that the entire length of the Hoquiam River, at least as far upstream as the Little Hoquiam River, is controlled by tidal flooding from Grays Harbor. The proposed North Shore Levee West Segment would prevent Hoquiam River overflows (from tidal or riverine sources) from reaching the portion of the City of Hoquiam south and west of the Hoquiam River. WSE conducted a preliminary hydraulic analysis of the Hoquiam River and the West Segment levee using the hydraulic model developed for the earlier Aberdeen-Hoquiam North Shore Levee CLOMR. Like the effective FEMA study, WSE’s analysis found that the highest water levels in this area are controlled by tides and not riverine conditions.

BASE FLOOD ELEVATIONS AND REQUIRED LEVEE FREEBOARD

Coastal flooding from Grays Harbor produces the controlling BFE throughout the project area. FEMA has estimated the 100-year BFE as 13.0 feet $NAVD_{88}$ and the 100-year stillwater level as 12.0 feet $NAVD_{88}$ throughout the area of the proposed West Segment Levee. The 100-year TWL of 13.0 feet was used by FEMA to map the 100-year floodplain along the entire shoreline of Hoquiam. For purposes of this study it was assumed that the transition shown on the effective FEMA maps at the railroad bridge, from elevation 13 to elevation 14, was an error and the upstream BFE was assumed to be 13 feet. This is consistent with

the finding in the effective study and WSE's modeling that tidal flooding controls BFEs throughout the entire study area.

FEMA requirements for levee freeboard in coastal floodplains require a minimum of one foot of freeboard above TWL or two feet of freeboard above the stillwater level (USACE, 2010). Therefore, the required design crest elevation for the North Shore Levee West Segment using the FEMA coastal mapping data is be 14.0 feet $NAVD_{88}$ or higher.

As noted previously WSE previously estimated different stillwater and total water levels than FEMA. WSE estimated the 100-year stillwater level to be 13.1 feet and the 100-year TWL to be as high as 15.1 feet or higher in some locations. Based on those values the proposed levee would need to be a minimum of 15.1 feet throughout its length (based on stillwater level plus 2 feet). Since the proposed levee is set well back from the shoreline, it will not be subject to wave runup and therefore the TWL plus 1 foot design criteria is not applicable.

REVISED FLOODPLAIN MAPPING FOR THE CLOMR REQUEST

The hydraulic effect of the proposed North Shore Levee West Segment will be to prevent tidal or riverine floodwaters from reaching areas landward of the levee, as shown on Figure 2. Figure 2 shows the corrected effective BFE of 13 feet upstream of the railroad bridge on the Hoquiam River. In addition to areas protected from flooding by the levee, one area near the mouth of the Hoquiam River was found to be subject to flooding by the FEMA effective BFE. This is shown in the hatched area north and west of the Hoquiam River mouth on Figure 2.

SUMMARY

Conclusions drawn from previous hydraulic analyses are presented here to support the design and mapping of the North Shore Levee West Segment in Hoquiam, WA. The 100-year base flood elevation along the proposed levee is controlled by coastal flooding from Grays Harbor. FEMA estimates the stillwater level in this area to be 12 feet $NAVD_{88}$ and the total water level to be 13.0 feet $NAVD_{88}$ (FEMA, 2017). Based on FEMA's BFE's the proposed levee would need to have a design crest elevation of 14.0 feet $NAVD_{88}$ or higher. WSE estimates the stillwater level along the proposed levee to be 13.1 feet (WSE, 2017a). Based on WSE's previous analysis the proposed levee would need to have a design crest elevation of 15.1 feet $NAVD_{88}$ throughout its length, along the Hoquiam River. The same design elevation would is also appropriate along Grays Harbor as the proposed levee is set back away from the wave runup zone. Final levee design elevations may be set higher to provide additional freeboard to allow for settling of the levee and/or to account for potential effects of climate change.

The 100-year riverine flood on the Hoquiam River results in water surface elevations lower than 13.0 feet $NAVD_{88}$. Tidal stillwater elevations control BFEs throughout the project area. As such, the proposed North Shore Levee West Segment will not change BFEs or the effective FEMA floodplain mapping with the exception of the removal from the Special Flood Hazard Area (SFHA) of areas protected from flooding by the levee, and the small area of additional flooding near the mouth of the river noted previously. Figure 2 shows the FEMA floodplain map taking the proposed levee into consideration.

Panel 0881

Panel 0882

Panel 0901

Grays Harbor County
Unincorperated Areas
530057

City of Hoquiam
530061

ZONE A

ZONE A

ZONE AE
CORRECTED EL 13.0

ZONE AE
CORRECTED EL 13.0

ZONE AE
EL 13.0

ZONE AE
EL 13.0

ZONE AE
EL 12.0

HWY 101

LITTLE HOQUIAM RIVER

HOQUIAM RIVER

GRAND AVE

LINCOLN ST

16TH ST

FILLMORE ST

EMERSON AVE

Area protected by
proposed levee

HOQUIAM

K ST

8TH ST

HWY 101

HWY 101

HWY 101

AIRPORT WAY

GRAYS HARBOR

LEGEND

- Levee Centerline (Proposed)
- Levee Centerline (Effective FIRM)
- Existing High Ground
- Road
- Railroad
- 100-year Flood Zone (revised)
- Area Added to 100-year Floodplain
- Area to Remove from 100-year Floodplain

PANELS
0881, 0882, 0901

Comparison of Effective and Revised 100-year Floodplains

CITY OF HOQUIAM
CLOMR APPLICATION

Effective FIRM Panels
53027C0881D
53027C0882D
53027C0901D

N

0 1,000 2,000
Feet

All Elevations NAVD88

Figure 2

REFERENCES

Federal Emergency Management Agency, 2017. Flood Insurance Study, Grays Harbor County, Washington and Incorporated Areas, Washington, D.C., Effective February 3, 2017.

U. S. Army Corps of Engineers, 1971. Flood Plain Information, Chehalis, Wishkah, and Hoquiam Rivers, Aberdeen, Hoquiam, and Cosmopolis, Washington, Seattle, June 1971.

U.S. Department of the Army, Corps of Engineers, 2010. USACE Process for the Evaluation of the National Flood Insurance Program (NFIP) Levee System Evaluation, Engineering Circular EC 1110-2-6067, 31 August 2010.

Watershed Science & Engineering, 2017a. Grays Harbor Tide and Total Water Level Modeling. File Memo. May 5, 2017.

Watershed Science & Engineering, 2017b. North Shore Levee, Aberdeen and Hoquiam WA – Hydraulic Analysis and Mapping. Memo to KPFF Consulting Engineers, May 9, 2017.

Watershed Science & Engineering, 2014. Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species – Development and Calibration of Hydraulic Model, Technical Memorandum. July 22, 2014.

Appendix A: Observations on Effective FEMA Mapping near Grays Harbor

The currently effective FEMA floodplain mapping of the areas along Grays Harbor and the Wishkah and Hoquiam Rivers near Hoquiam and Aberdeen WA appears to be inconsistent with the effective flood studies for Grays Harbor and the Wishkah River. The current maps reflect numerous different studies completed from the early 1970s through 2016. Based on a thorough review of the data sources and studies used to prepare the current FEMA maps the following observations were made:

1) Prior to the recent release of the new effective study for Grays Harbor County (on February 3, 2017) the study area we are interested in for the North Shore Levee project (as shown on Figure 1) was all mapped based on either a coastal floodplain mapping study conducted by the US Army Corps of Engineers in the 1970s or a riverine hydraulic study of the Wishkah River conducted in the early 1980s by CH2M Hill. Figure 2 shows a FIRMETTTE produced from the original FEMA mapping that was replaced by the new mapping earlier this year. Of particular note on this map is that the entire mapping area, up to Arthur Street on the Wishkah River, is mapped at elevation 10 feet NGVD (which corresponds to 13.5 feet NAVD). This is the 100-year coastal flood elevation determined by the USACE in their 1970s era study. It is also significant to note that there is a white "gutter line" on the Wishkah River near Arthur Street near the first BFE on the Wishkah River. This gutter line is likely the breakpoint between the Coastal mapping and the Riverine mapping.

2) Hydraulic modeling for the Wishkah River Study was performed in 1981 by CH2M Hill using HEC-2. The modeling assumed a downstream boundary condition on the Wishkah River equal to the 10-year coastal flood or 8.8 feet NGVD (which corresponds to 12.3 feet NAVD). Using that starting water level the Wishkah River model reached an elevation of 10 feet NGVD between model cross sections C and D which is at about the same location as the 10 foot NGVD BFE on the Wishkah River. This fact supports the assumption that the gutter line shown on the earlier effective maps was there to differentiate between the coastal and riverine studies.

3) At some point the earlier effective studies were converted from NGVD to NAVD. This was done by adding the conversion factor (approximately 3.5 feet) and then rounding the converted elevations to whole foot increments. Thus the 10 foot NGVD BFE on the original FEMA maps was converted to 14 feet NAVD. Figure 3 shows a section of the new effective maps showing a 14 foot NAVD BFE line in approximately the same location as the previous 10 foot NGVD BFE, just downstream of Wishkah River model cross section D.

4) In about 2013 FEMA contracted with STARR to produce a new Coastal Floodplain Mapping study of the southwest Washington Coast including Grays Harbor. The STARR Analysis determined a 100-year stillwater level of 12.0 feet in Grays Harbor and a 100-year Total Water Level (TWL) of 13.0 feet for the shoreline between Hoquiam and Aberdeen. The 13.0 foot TWL was mapped as the new Coastal BFE throughout much of the Aberdeen Hoquiam North Shore Levee project area. This included the north shore of Grays Harbor between Hoquiam and Aberdeen and

extending up the Hoquiam River to the first railroad bridge (see Figure 4) and up the Wishkah River to the East Wishkah Street Bridge (see Figure 5). Gutter lines on the new effective maps indicate that area upstream of these bridges were mapped based on some other data source.

5) Upstream of the East Wishkah Street Bridge on the Wishkah River, the new effective maps show a BFE of 14 feet NAVD. The Flood Insurance Study Report indicates that the upstream mapping was done based on riverine studies. However, the above observations suggest the mapping upstream of East Wishkah Street to Arthur Street on the Wishkah River is actually a remnant of the earlier coastal study (with the rounded conversion from NGVD to NAVD). Upstream of the 14 foot BFE shown in Figure 3 the new mapping corresponds fairly closely to the 1981 Wishkah River model.

6) Upstream of the railroad bridge on the Hoquiam River the new effective maps also show a BFE of 14 feet NAVD. The FIS Report does not identify the source of these data. Unfortunately FEMA does not have documentation or any of the modeling and analysis conducted for the Hoquiam River so it is not possible to review that to see where the riverine hydraulics would start to have an effect on Hoquiam River BFEs. However, new riverine hydraulic analyses conducted for the Aberdeen-Hoquiam North Shore Levee indicates that the tidal boundary condition controls water levels in the Hoquiam River to at least 3 miles upstream of the mouth.

7) Although the 1981 Wishkah River Hydraulic Model study used the 10-year tide level as a downstream boundary condition current FEMA guidance (see screen shot below) suggests that for modeling of river-coastal zones the downstream boundary of the riverine model should be taken as Mean Higher High Water (which in Grays Harbor is 8.47 feet NAVD). Modeling of the Wishkah and Hoquiam Rivers using a downstream boundary condition of MHHW would push the boundary between the coastal and riverine mapping even further upstream, such that the entire floodplain within the proposed Aberdeen-Hoquiam North Shore Levee Project area would be well within the Coastal Mapping Zone, with the newly determined 13.0 foot BFE.

Guidelines and Specifications for Flood Hazard Mapping Partners [November 2009]

- The arrival times of flood peaks are similar for the two combining watersheds; and
- The likelihood of both watersheds being covered by the storm being modeled is high.

If gage records are available for the basins, the Mapping Partner performing the hydraulic analysis should obtain guidance from the RPO on coincidence of peak flows using streamflow records.

When the downstream boundary of a modeled stream is within a coastal tidal reach, the tidal boundary of the model is taken as equal to the Mean Higher High Water (MHHW) level of the nearby tide station. Location of tide station(s) must be verified to represent true downstream conditions. The tide level can be transferable to other locations along open coast; however, tide level at an estuary station is not transferable to locations beyond the estuary.

Significance of Above Observations for North Shore Levee Hydraulic Analysis

Given the above observations, it can be concluded that the entire area of the proposed levee project is within the coastal flood study area and not within a riverine study area. The proposed Aberdeen-Hoquiam North Shore Levee will not cause any changes to coastal stillwater or total water levels in Grays Harbor because the proposed levee is set sufficiently far from the shoreline as to not be subjected to any waves (and stillwater levels are independent of shore features). Thus, no revised modeling or analysis of the Coastal Floodplain is needed.

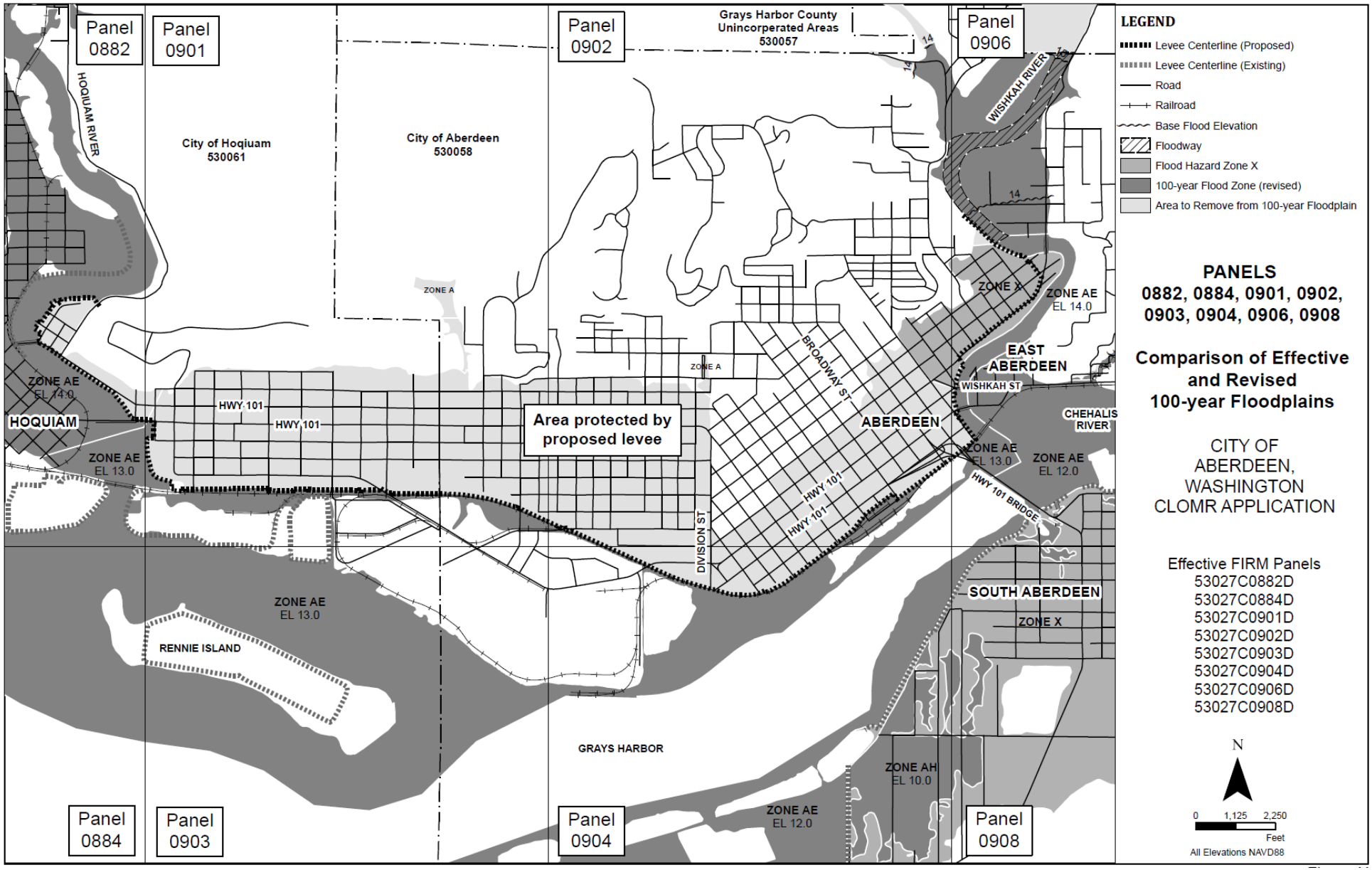


Figure 1: Study Area for Proposed Aberdeen-Hoquiam North Shore Levee

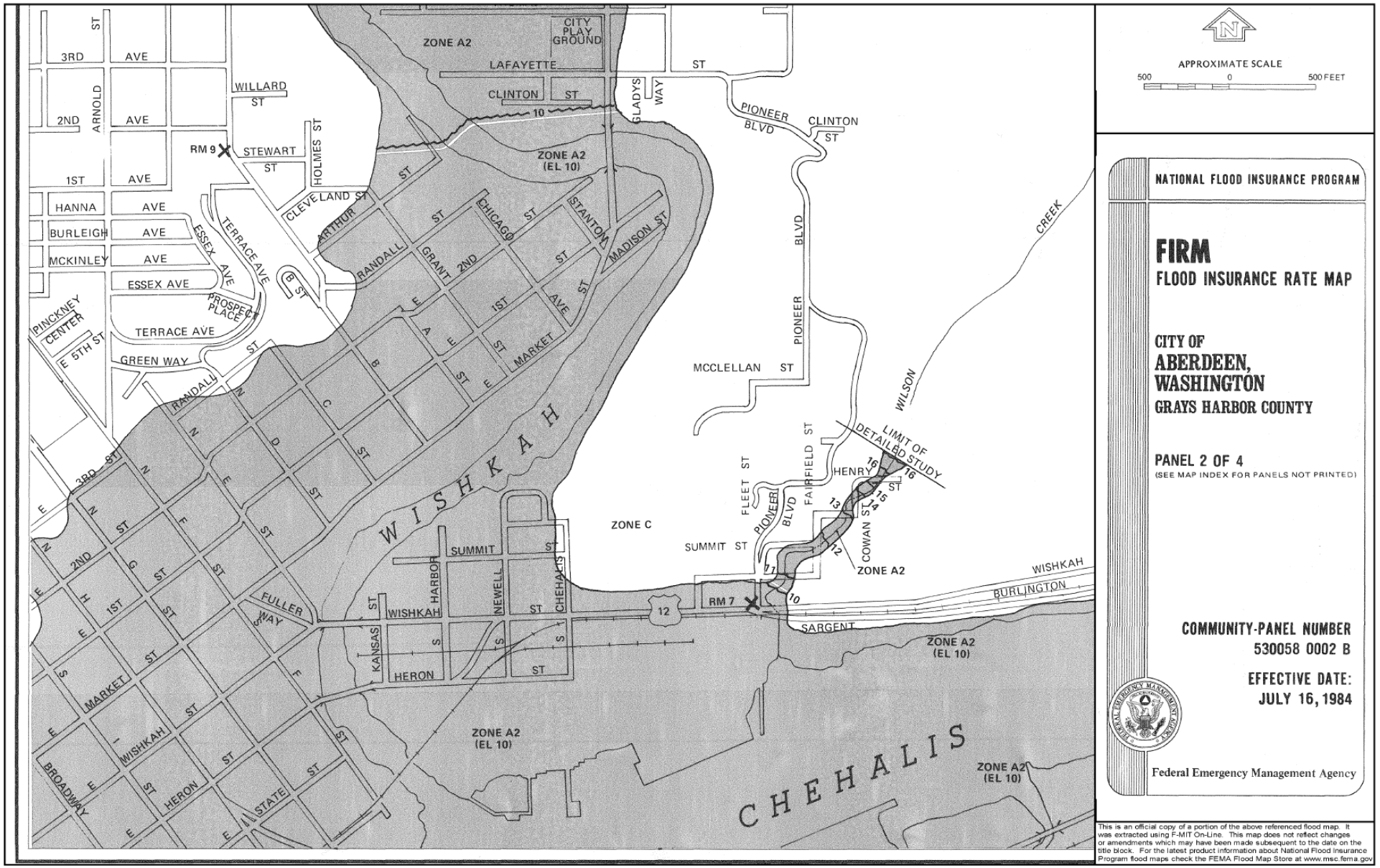


Figure 2: FIRMETTE for Wishkah River portion of study area based on previously (pre 2017) effective FIS

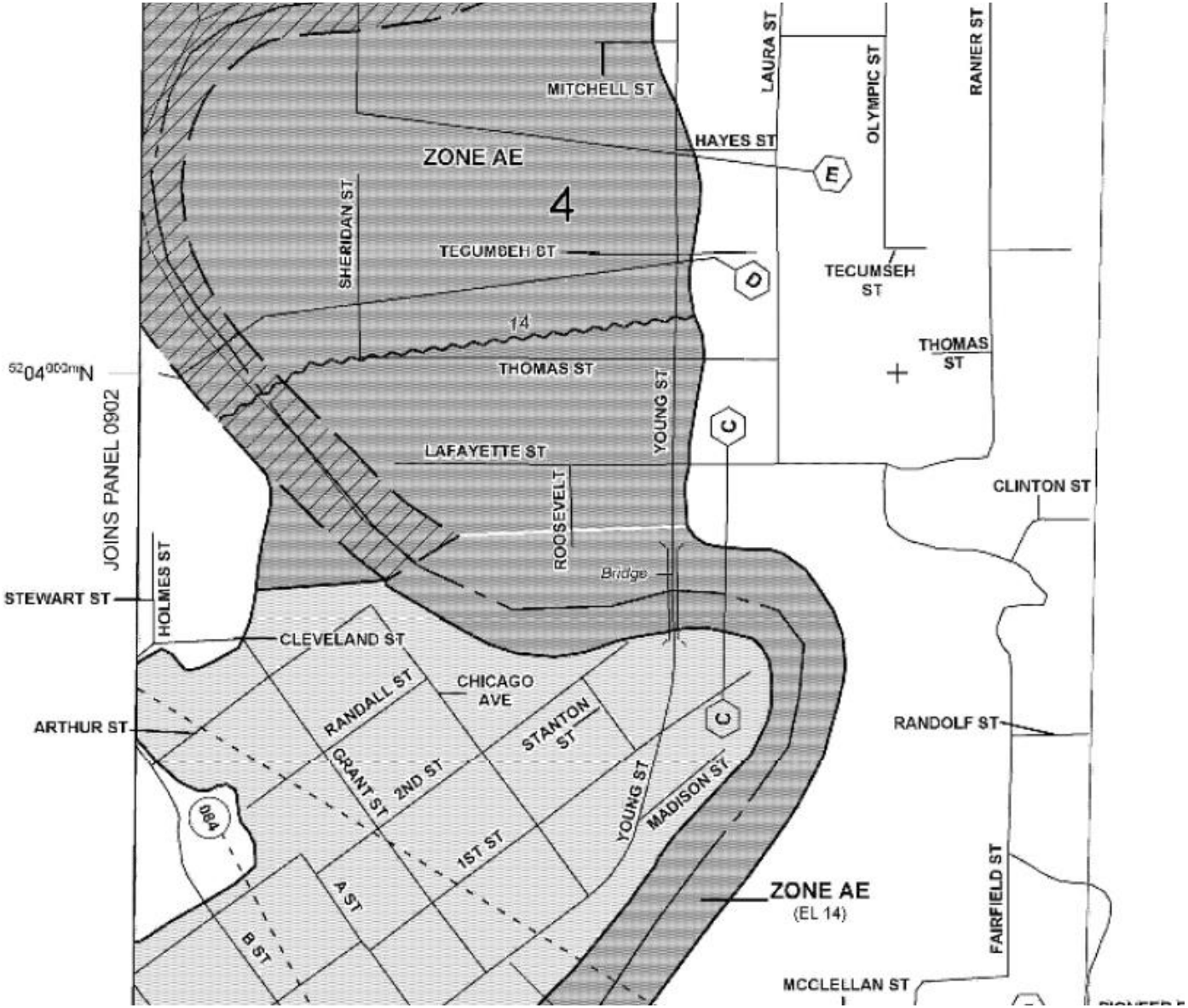
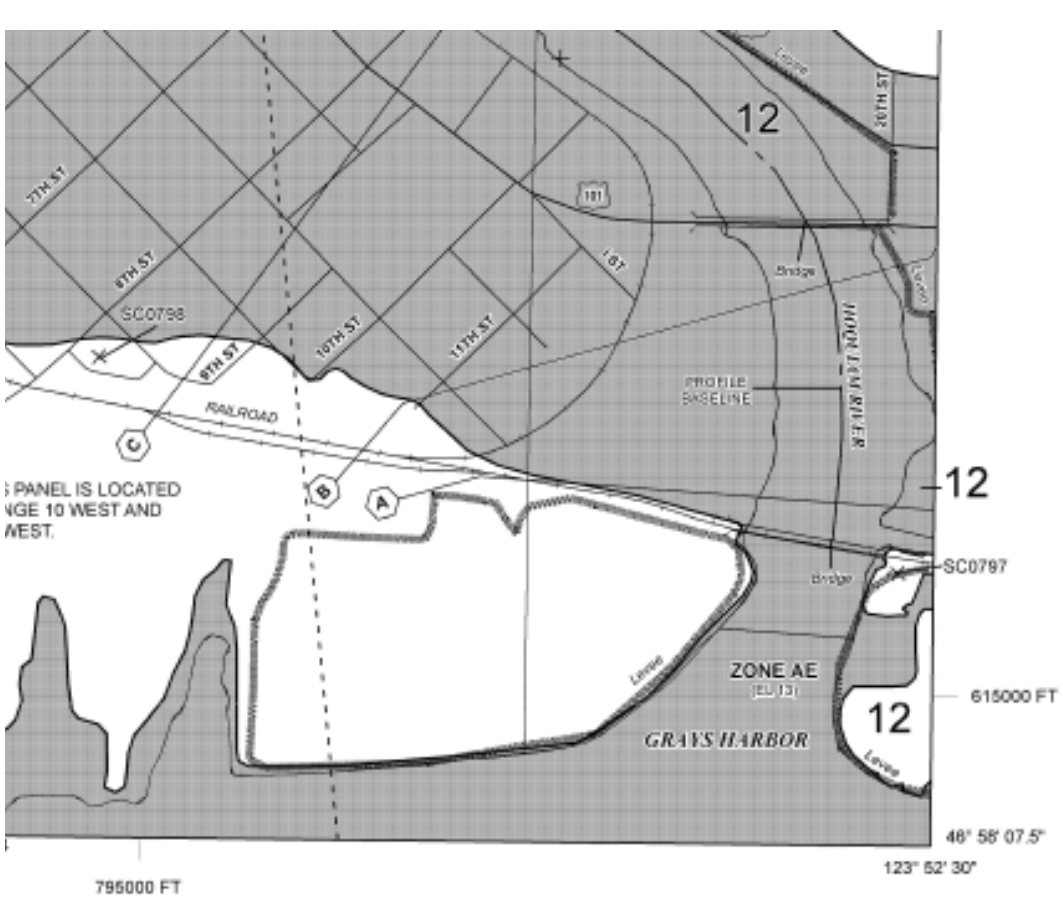
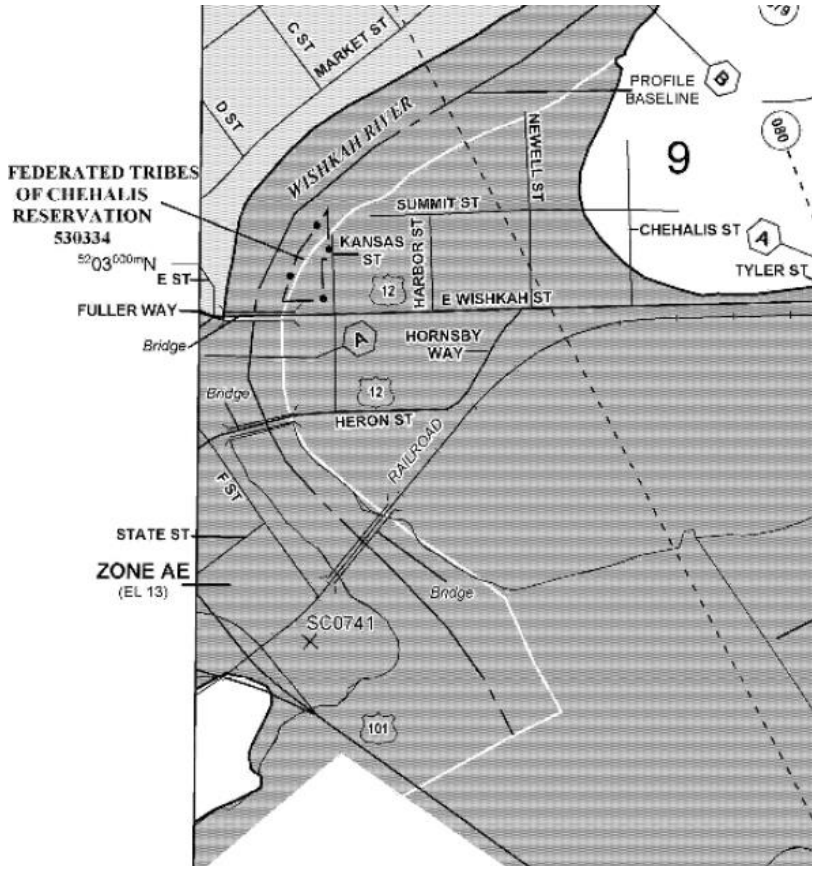


Figure 3: Screen Shot of February 3, 2017 Effective FEMA Maps showing 14 Foot BFE





Figures 4 and 5: New Effective Mapping for Grays Harbor showing 13.0 foot BFE extending upstream on Hoquiam and Wishkah Rivers