



Qualitative Risk Assessment

March 8, 2021

For the purpose of this qualitative risk assessment, public health and safety and economic consequences resulting from flooding and impacts to critical resources in the Study Area were evaluated and are presented below.

1. Public Health and Safety

The four consequence criteria and associated thresholds for assessing public health and safety risks due to flood events are shown on Table 1. Criteria include the potential for death or injury due to flooding of residences and business; potential for death or injury due to flooding of ingress, egress, and travelways; potential exposure to sewage or hazardous sites that expose populations to vectors for illness; and the affected population’s access to resources during and following a flood event.

Table 1. Criteria and Thresholds for Public Health and Safety Consequences

Consequence Criteria		Thresholds		
		Initiation	Increasing	Most Severe
Health & Safety	Death or Injury Due to Flooding of Residence or Business (see Figure 1)	<u>Potential Nuisance</u> < 1 foot flooding, Development at Higher Elevation, Few Residences/ Businesses	<u>Potential Injury</u> 1-4 feet Flooding, Development at Higher Elevation, Many Residences/ Businesses	<u>Potential Death</u> > 4 feet Flooding, Rapid Flooding, Development at Lower Elevation, Many Residences/ Businesses
	Death or Injury Due to Disrupted Ingress, Egress, Hazardous Conditions (see Figure 2)	<u>Potential Nuisance</u> Multiple Evacuation Routes Upgradient, Shallow Roadway Flooding < 3 inches	<u>Potential Injury</u> Limited Routes, 3-12 inches roadway flooding, Dangerous Conditions	<u>Potential Death</u> No Routes due to Road Closure and Dangerous Conditions, > 1 -2 feet roadway flooding
	Potential for Illness Due to Exposure to Sewage, Hazardous Sites, Disruption of Utility Service (see Figure 3)	<u>Potential Unknown Exposure</u> No Known Exposure Source, Continuous Utility Service	<u>Potential Illness</u> Exposure to Single Known Source, Temporary Disruption of Utility Service, many residences/business	<u>Likely Illness</u> Exposure to Multiple Known Sources, Long-term Inaccessibility of Utility Services, many residences/business



	Potential for Displacement/ Homelessness Due to Lack of Resources Following Event (see Figure 4)	<u>Likely Recovery</u> Disadvantaged/Low Income, < 1 foot flooding	<u>Temporary Displacement</u> 1-4 feet Flooding, Disadvantaged/Low Income Community	Long Term Displacement/ Homelessness > 4 feet Flooding, Disadvantaged/Low Income Community
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1.1 Potential for Death or Injury Due to Flooding of Residence or Business

Flooding of residences and businesses may result in a range of consequences, from nuisance to death. The magnitude of consequence is evaluated based on the depth of flooding, the quantity of residential and business developments, general elevation of development compared to flood water elevation, and anticipated rate or velocity of flooding. Figure 1 provides an overview of the relative recurrence from most likely (8.8 feet) to least likely (13.6 feet) and is overlaid by the estimated magnitude of consequence, with a brief characterization of contributing impacts.

Cells B through H are largely undeveloped lands actively managed for agriculture. Development is typically along the fringes of these cells on higher elevation ground, while the interior is below typical tidal water levels. Due to the sparse development at higher elevations, the life safety consequence is generally categorized as “Potential Nuisance” and progresses to “Potential Injury” with greater flood depth associated with lower likelihood events. Cell I exhibits a higher population density than Cells B through H, with development at elevations above typical tidal water levels along the natural shoreline of Eureka Slough. Shallow flooding of many residences is categorized as “Potential Nuisance” and progresses to “Potential Injury” with moderate likelihood events that result in one to four feet of tidal flooding. Cell A, with the greatest density and amount of development, experiences the “Potential Death” consequences when water levels reach lower likelihood elevations of 11.6 feet and above due to the higher concentration of development. This area has some of the highest shoreline structures but is located at some of the lowest elevations in the Study Area. Flooding rapidly progresses from shallow to more than four feet deep as the overtopping extent of shoreline structures increases and the proximity of overtopping occurs closer to developed areas.

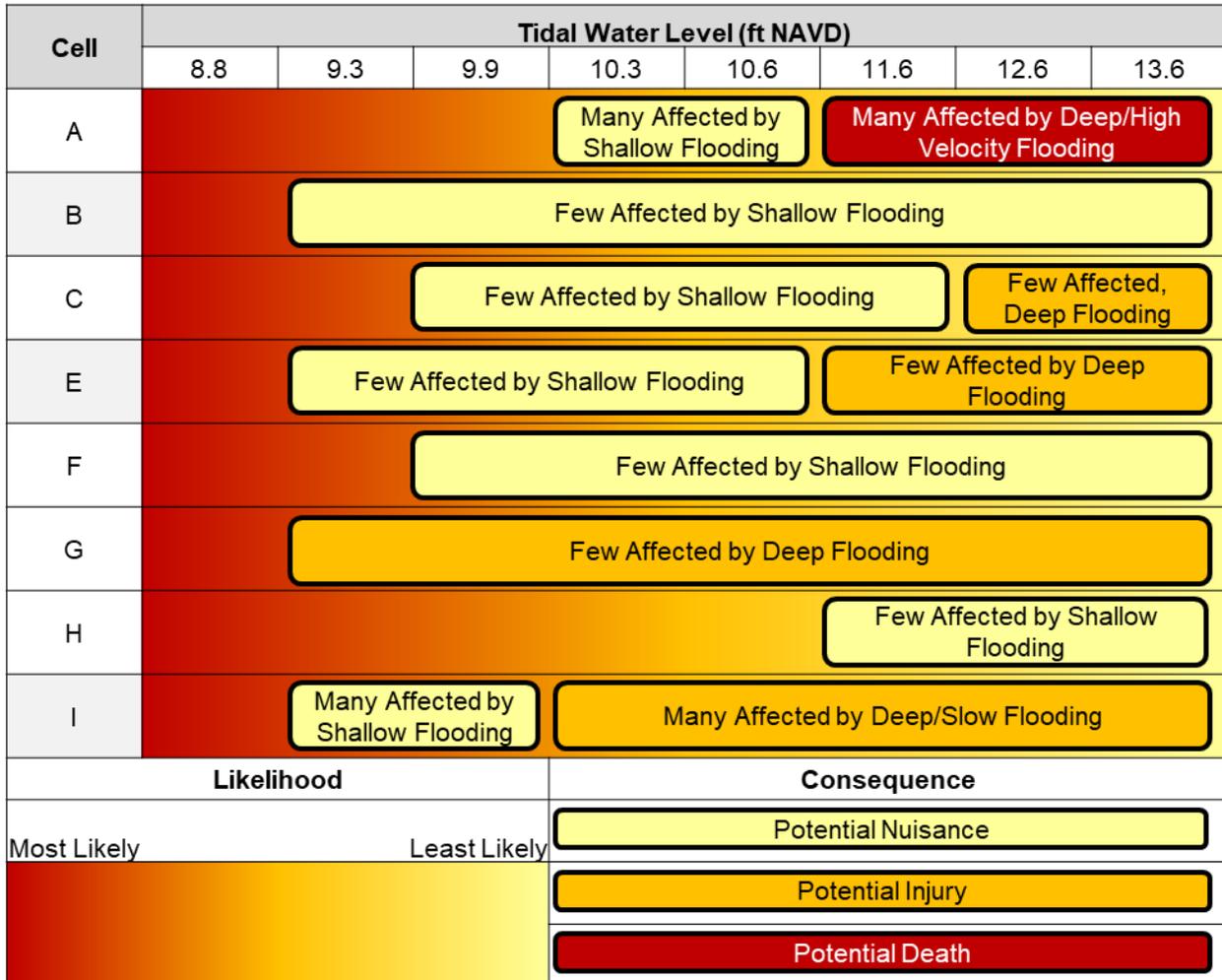


Figure 1. Potential for Death or Injury Due to Flooding Depth at Residence or Business

1.2 Potential for Death or Injury Due to Disrupted Ingress, Egress, Hazardous Travel Conditions

Flooding of roadways poses public health and safety consequences, from nuisance to death. The magnitude of consequence may be a result of the inability or delay of ingress and egress for evacuation and emergency services, and for travellers along roadways who are exposed to flooding. Figure 2 provides an overview of the relative recurrence from most likely (8.8 feet) to least likely (13.6 feet) and is overlaid by the estimated magnitude of consequence, with a brief characterization of contributing impacts.

Cells A and G exhibit the greatest consequences, “Potential Death,” during moderate to lower likelihood events due to flooding of the only ingress and egress routes. Businesses and residents in the Jacobs Avenue area to Brainard, within Cell A, are dependent on the local roadways and Highway 101 to access higher ground, above tidal flooding. Additionally, travellers along Highway 101 are exposed to hazardous conditions during moderate likelihood water levels, rapidly progressing to more severe consequences with increasing water levels. Park Street provides the only evacuation route for the few residences at lower elevations of Cell G. All other cells maintain or exhibit alternate evacuation routes and the ability to move to



higher elevation by roadway. Travelers are able to find high ground or avoid flooding along the exterior of cells along Myrtle Avenue.

Cell	Tidal Water Level (ft NAVD)								
	8.8	9.3	9.9	10.3	10.6	11.6	12.6	13.6	
A	Partial Closures, Dangerous Conditions				No Evacuation Route, Roadway Flooding > 1 ft				
B						Partial Closures, Alternate Routes			
C						Partial Closures, Alternate Routes			
E						Partial Closures, Alternate Routes			
F						Partial Closures, Alternate Routes			
G	Partial Closure, Dangerous Conditions		No Evacuation Route, Roadway Flooding > 2 ft						
H	Roadways Not Affected								
I	Upslope Evacuation Available					Partial Closures, Alternate Routes			
Likelihood				Consequence					
Most Likely		Least Likely		Potential Nuisance					
				Potential Injury					
				Potential Death					

Figure 2. Tidal Flooding and Disrupted Ingress, Egress, and Hazardous Conditions Travel Conditions



1.3 Potential for Illness Due to Exposure to Sewage, Hazardous Sites, Disruption of Utility Service

Flooding of sewer pump stations and hazardous sites can create vectors for illness for people exposed to these potentially contaminated flood waters. In addition, the loss of utility services, such as water, sewer, power, and gas can create unsanitary conditions that may contribute to the presence of illness vectors. Potential illness during and following flood events is evaluated based on the amount of flooding that would result in a discharge of a known pollution source, including flooding of a sewer pump station and sites containing hazardous materials. Disruption to utility services such as sewer, drinking water, electricity, and gas may result from the inability of utility crews to access buried pipes or utility poles that are flooded. Figure 3 provides an overview of the relative recurrence from most likely (8.8 feet) to least likely (13.6 feet) and is overlaid by the estimated magnitude of consequence, with a brief characterization of contributing impacts.

Cell A contains multiple sewer pump stations, businesses that involve hazardous waste, former leaking underground storage tank (LUST) sites, and current Cleanup Program Sites receiving remediation. Additionally, water, sewer, gas and power utilities also exist within the cell. Flooding associated with moderate likelihood events results in potential temporary disruption of utility services due to the potential lack of ability for utility providers to maintain their facilities under flooded conditions. Consequences progress rapidly with more extensive flooding for lower likelihood events that mobilize sewage and hazardous materials within the higher density developed areas. The City of Eureka's water supply intersects Cells C and G. Extended disruption of the City's ability to maintain this line could result in community-wide illness as nearly the entire population of the City would be affected. Cell I is impacted during more frequent events, but the natural topography provides elevation protection. No known public utilities or hazardous sites are located in Cells B, E, F or H and therefore do not exhibit potential illness vectors.



Cell	Tidal Water Level (ft NAVD)								
	8.8	9.3	9.9	10.3	10.6	11.6	12.6	13.6	
A	Potential Temporary Disruption to Utility Services				Flooding of Sewer Stations and Hazardous Sites				
B	No Apparent Vector								
C	Potential Temporary Disruption to Utility Services				Potential Long Term Disruption to Utility Services				
E	No Apparent Vector								
F	No Apparent Vector								
G	Potential Temporary Disruption to Utility Services				Flooding of Sewer Station, Disruption to Utility Services				
H	No Apparent Vector								
I	Potential Temporary Disruption to Utility Services				Sewer Station, Utility Services				
Likelihood				Consequence					
Most Likely		Least Likely		Potential Unknown Exposure					
				Potential Illness from Known Vector					
				Likely Illness from Multiple Known Vectors					

Figure 3. Utility Disruption and Flooding of Hazardous Sites

1.4 Potential for Displacement/Homelessness Due to Lack of Resources Following Event

The ability of the affected community to recover following a flood event is dependent on the resources available. The potential for displacement and homelessness is evaluated based on estimated resources, as measured by whether or not the community is designated as a disadvantaged community. Figure 4 provides an overview of the relative recurrence from most likely (8.8 feet) to least likely (13.6 feet) and is overlaid by the estimated magnitude of consequence, with a brief characterization of contributing impacts.

Cells A, B and I contain areas designated as disadvantaged communities. Rapid recovery is expected in the event of shallow flooding, less than 1 foot in depth near structures. Cells A and I are the most densely populated cells and the communities within these cells have the fewest resources. When flooding exceeds 1 foot, temporary displacement is expected. When flood water exceeds four feet, significant damage to homes in these cells is anticipated to result in long term displacement and potential homelessness.



Cell	Tidal Water Level (ft NAVD)								
	8.8	9.3	9.9	10.3	10.6	11.6	12.6	13.6	
A				Damage to Lands	Damage to Many Structures				
B					Damage to Lands	Damage to Structures			
C	Not a Disadvantaged Community								
E	Not a Disadvantaged Community								
F	Not a Disadvantaged Community								
G	Not a Disadvantaged Community								
H	Not a Disadvantaged Community								
I				Damage to Some Structures	Damage to Many Structures				
Likelihood				Consequence					
Most Likely		Least Likely		Rapid Recovery					
				Temporary Displacement					
				Long Term Displacement/Homelessness					

Figure 4. Potential displacement of communities due to flooding



2. Economy

Economic risk due to flood events is evaluated based on three consequence criteria and the associated thresholds of impact with regards to the potential loss of economic services and deliveries; loss of commercial structures, goods, services and jobs; and loss of agricultural lands, goods, services and jobs. General descriptions of the criteria and thresholds for potential economic consequences are provided in Table 2.

Table 2. Consequence Criteria and Thresholds of Economic Risk

Consequence Criteria		Thresholds		
		Initiation	Increasing	Most Severe
Economy	Loss of Economic Services & Deliveries (see Figure 5)	<u>Disruption of Local Services</u> Local Road Flooding	<u>Disruption of Community Services</u> Arterial and Collector Road Flooding	<u>Disruption of Regional Services</u> Interstate, Freeway/Expressway Flooding
	Loss of Structures, Goods, Services & Jobs (see Figure 6)	<u>Disruption of Services</u> < 1 foot flooding, Gradual Flooding, Few Structures	<u>Temporary Closure</u> 1-4 feet Flooding Gradual to Rapid Flooding, Many Structures	<u>Long Term Closure</u> > 4 feet Flooding Rapid Flooding, Many Structures
	Loss of Agricultural Lands, Goods, Services & Jobs (see Figure 7)	<u>Brief Disruption of Land Use</u> < 1 day tidal flooding, No to Minor Loss	<u>Temporary Disruption to Land Use</u> 1 day to 1 week tidal flooding, Potential Longer-term Recovery of Lands	<u>Permanent Change to Land Use</u> > 1 week tidal flooding/High Potential for Breach, Loss of Land Use

2.1 Loss of Economic Services and Deliveries

The availability of transportation routes drives the means by which economic services and deliveries are provided. The potential for loss of economic services and deliveries is evaluated based on the depth of flooding and roadway functional classification. Shallow flooding (less than three inches) does not have a significant effect on economic services, as roadways remain open with travellers reducing speeds. Flooding of more than three inches begins to create potentially hazardous conditions and flooding in excess of one



foot likely results in roadway closures. The functional classification of roadways in the Study Area spans local road to interstate. Economic activity that depends on local roads affects local services, typically on the scale of one to many blocks. Arterial and collector roads, such as Myrtle Avenue, provide the ability to move between communities around Humboldt Bay. Highway 101 is utilized for regional economic activity between counties and states.

As shown in Figure 5, Highway 101 in Cell A affects economic services at the regional level during moderate likelihood events. Access is reduced with lane closures and lower speeds during moderate events and progresses to complete closure of the highway during lower likelihood events. Myrtle Avenue, along the higher elevations and exterior of Cells B through H continues to provide access between communities during moderate events with sections closed during low likelihood events. Local roads are affected in Cell I during moderate likelihood events and eventually affect Highway 101 in lower likelihood events.

Cell	Tidal Water Level (ft NAVD)								
	8.8	9.3	9.9	10.3	10.6	11.6	12.6	13.6	
A	Reduced Access Hwy 101 and 255				Closure of Hwy 101 and 255				
B							Reduced Access/Closure of Myrtle Ave.		
C							Reduced Access/Closure Myrtle Ave		
E							Reduced Access/Closure Myrtle Ave		
F							Reduced Access/Closure Myrtle Ave		
G	Reduced Access/ Closure Park St.								
H	Roadways Not Affected								
I	Reduced Access/Closure 2 nd , Y, Tydd, Hoover, Bay Streets				Closure of Hwy 101/4 th /5 th St				
Likelihood				Consequence					
Most Likely		Least Likely		Disruption of Local Services					
				Disruption of Community Services					
				Disruption of Regional Services					

Figure 5. Roadway Flooding Affecting Regional, Community and Local Economic Services



2.2 Loss of Structures, Goods, Services & Jobs

Flooding of residential and commercial properties may result in varying levels of damage and temporary or permanent loss of goods, service and jobs directly or indirectly. The potential consequences are evaluated based on the depth of flooding, amount of damage to residential and commercial structures, and number of structures affected.

As shown in Figure 6, Cell A and Cell I have the greatest number of structures affected by flooding. Cell A contains a mix of commercial and residential properties and structures, while Cell I primarily contains residential structures that are affected. The flooding in Cell A has the greatest consequence to structures, with the deepest flooding for lower likelihood events. Shallower flooding affects Cell I commercial structures, with areas of deeper flooding in residential locations. As previously stated, development in Cells B through G are generally at higher elevations along the perimeter of the cells in much lower numbers compared to Cells A and I.

Cell	Tidal Water Level (ft NAVD)								
	8.8	9.3	9.9	10.3	10.6	11.6	12.6	13.6	
A	Shallow Flooding, Many Structures				Deep Flooding, Many Structures				
B	Few Structures								
C	Few Structures								
E	Few Structures								
F	Few Structures								
G	Shallow Flooding, Few Structures								
H	No Structures Affected								
I	Shallow Flooding, Many Residences				Shallow to Deep Flooding, Many Structures				
Likelihood				Consequence					
Most Likely		Least Likely		Disruption of Services/Few Structures					
				Temporary Business Closure/Few Structures					
				Long term Business Closure/Many Structures					

Figure 6. Consequences of flooding to structures, goods, services and jobs.



2.3 Loss of Agricultural Lands, Goods, Services & Jobs

Flooding of agricultural lands and other areas managed for freshwater habitat are generally resilient to temporary inundation of tidal and brackish waters but cannot be maintained for current use if tidal inundation persists. Levee breaches pose the greatest impact to agricultural lands, as ground elevations are typically below mean high water and tidal waters would inundate the property daily. Consequences to agricultural lands are evaluated based on the duration of tidal flooding and the potential for levee failure due to overtopping.

Figure 7 shows that there is a high potential for tidal flood during the most likely events and the potential for breach occurs in high to moderate likelihood events in Cells B, C, E and G. Levee failures that go unrepaired are expected to result in a permanent change to land use.

Cell	Tidal Water Level (ft NAVD)							
	8.8	9.3	9.9	10.3	10.6	11.6	12.6	13.6
A	Brief Tidal Flooding		High Potential for Levee Failure					
B	Brief Tidal Flooding	High Potential for Levee Failure						
C	High Potential for Levee Failure							
E	Tidal Flooding	High Potential for Levee Failure						
F	Brief Tidal Flooding		High Potential for Levee Failure					
G	Brief Tidal Flooding	High Potential for Levee Failure						
H						Brief Tidal Flooding	High Potential for Levee Failure	
I	No Agricultural Lands Affected							
Likelihood				Consequence				
Most Likely		Least Likely		Brief Disruption of Land Use				
				Temporary Disruption of Land Use				
				Permanent Change to Land Use				

Figure 7. Consequences of flooding and levee failure to agricultural lands.



3. Summary

The qualitative assessment of the likelihood of hazardous flood events and the magnitude of the consequences presented above provides decision-support information to assess risk and identify locations for further investigation and investment in developing adaptation strategies. Key findings from the qualitative risk assessment with regards to public health and safety and the economy are outlined below and shown in Exhibit 7-4.

Cell A consistently exhibits the most severe potential consequences to public health and safety and the economy. These consequences are typically associated with flood events considered to have moderate to low likelihood. The primary contributing factors to the evaluation of most severe consequences is due to the importance of Highway 101 as a regional transportation route and local evacuation route; the density of residential and commercial development at low elevations; the disadvantaged community status indicating a lack of resources to support recovery; and the presence of sewer pump stations, active and closed contaminated sites, and regional utilities. The likelihood of flooding to Cell A is generally less than other cells, but the magnitude of consequences are consistently much greater than other cells. Populated areas of Cell A, including the Jacobs Avenue area, and Highway 101 are considered to exhibit the greatest risk in the Study Area, due to the number of people, structures, and transportation facilities impacted by flooding.

The water supply pipeline for the City of Eureka and other major utilities such as natural gas pipeline and overhead electrical power lines are present in Cells C and G. In the event of a levee breach, which may occur during a moderate likelihood event, access to these utilities would be severely limited. In the event of a failure of a utility line without rapid reconstruction of the levee, maintenance on the utilities may not be feasible without substantial additional cost, leaving large populations vulnerable to the loss of utility services. Based on the moderate likelihood and severe consequence of losing these facilities, the risk to these facilities is high.

Similar to Cell A, Cell I contains higher density development and infrastructure, but at higher elevations. However, initial impacts begin at higher likelihood events compared to Cell A due to the natural shoreline elevation along Cell I, which is not protected by levees. The result is that consequences are typically less severe than in Cell A.

Cells B through H are primarily managed for agriculture, with sparse development and at higher elevations compared to Cells A and I. While flooding is initiated during more likely events, the consequences are not as severe as in Cells A and I, as agricultural lands may be temporarily inundated with tidal water and can recover overtime with rainfall infiltration and few residences, businesses and transportation routes are impacted.