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Scenario Planning for Building Coastal Resilience in the Face of Sea Level Rise: The Case of Jacobs Avenue, Eureka, CA

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Abstract

This article examines issues surrounding flood control measures for the Jacobs Avenue community located in Eureka, California. This area of northern California is experiencing some of the most rapid rates of sea level rise recorded throughout the state. Researchers conducted interviews with stakeholders, developed geospatial analyses, and reviewed policy documents in order to understand the social, environmental, and political context related to sea level rise planning for Jacobs Avenue. From this information we developed a scenario-based set of management options to guide stakeholders in future decision-making regarding the fate of Jacobs Avenue. We explored the potential challenges and benefits of three possible scenarios: no action, levee improvement, and strategic retreat. Our analysis reveals that there are no easy solutions. Lack of funding and lack of a clear political path towards retreat make it extremely difficult for planners to take proactive steps that might ultimately contribute to increased safety, as well as economic and environmental benefits, for flood-vulnerable communities. The scenario framework developed in this paper can be a useful tool for a wide range of coastal communities, in particular those of geographically isolated northern California and southern Oregon.

Introduction

Sea level rise represents a new kind of threat that will require localities to consider how they can adapt and plan for a future with higher seas. Strong evidence indicates that on a global scale sea level is rising and will continue to rise into the future (Church & White, 2006; IPCC, 2007; Overpeck et al., 2006; National Research Council, 2012). Current and projected sea level rise can have enormous implications for coastal communities, such as those geographically isolated in northern California and southern Oregon. Rising seas increase the likelihood of coastal flooding, coastal erosion, and storm surge inundation, threatening valuable coastal communities and infrastructure (National Research Council, 2012; Wu et al., 2002; Mimura, 1999). Sea level

rise will not be uniform across the globe, causing some areas to face greater levels of inundation and others less (see Figure 1). In the area that encompasses the "State of Jefferson," Humboldt Bay in northern California—home of the historic port city Eureka—has experienced the greatest rate of sea level rise recorded in the entire state of California (Laird, 2013). Land subsidence combined with rising seas has led to an average rate of relative sea level rise at 4.72 millimeters per year (18.6 inches per century) (Laird, 2013). Experts project that the sea level surrounding Humboldt Bay will rise 6 inches by 2030, 12 inches by 2050, and 36 inches by 2100 (Laird, 2013).

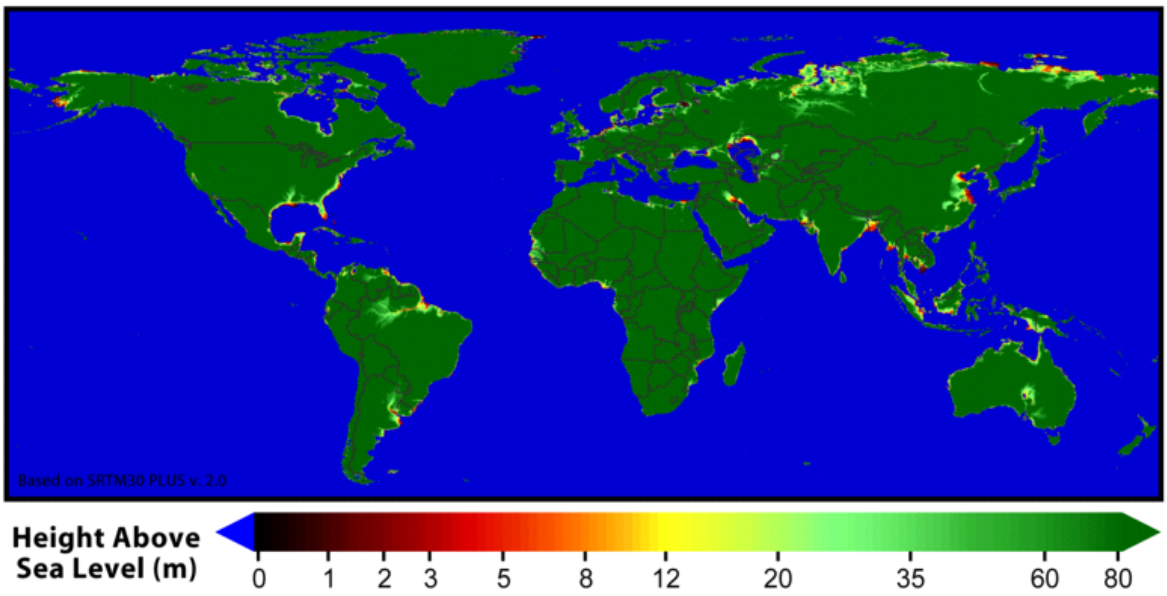

Figure 1. Global vulnerabilities to sea level rise showing the non-uniformity of coastal inundation (image from Rohde, 2014).

As a result of these projections, planners around Humboldt Bay have taken preliminary steps to prepare for future sea level rise. One of these steps has included the development of a sea level rise vulnerability assessment for Humboldt Bay (Laird, 2013). Among the local conversations about the bay's rising sea level, one geographic region has emerged as particularly vulnerable: a tract of land referred to as Jacobs Avenue. This low-lying peninsula is surrounded by Humboldt Bay to the north and Eureka Slough to the south and west (see Figure 2, next page). The protective levee surrounding the properties has structural challenges, making it vulnerable to possible flooding in the present as well as into a future with higher seas. This lack of structural integrity has resulted in the properties losing their accreditation for Federal Emergency Management Agency (FEMA) flood insurance (Mattson, 2011; Seemann, personal communication, 2013). The loss of accreditation places community members of Jacobs Avenue at a crossroads where they must decide how they plan to move forward with flood protection.

In addition to being at high risk for flooding, these properties are also an important site of social and economic activity for the local community. Jacobs Avenue contains 31 residential, commercial, and industrial parcels, which are home to many individuals and host some of Eureka's most lucrative businesses. A 2004 report indicates that the businesses from Jacobs Avenue produce 480 jobs and approximately 10% of the City of Eureka's total annual tax

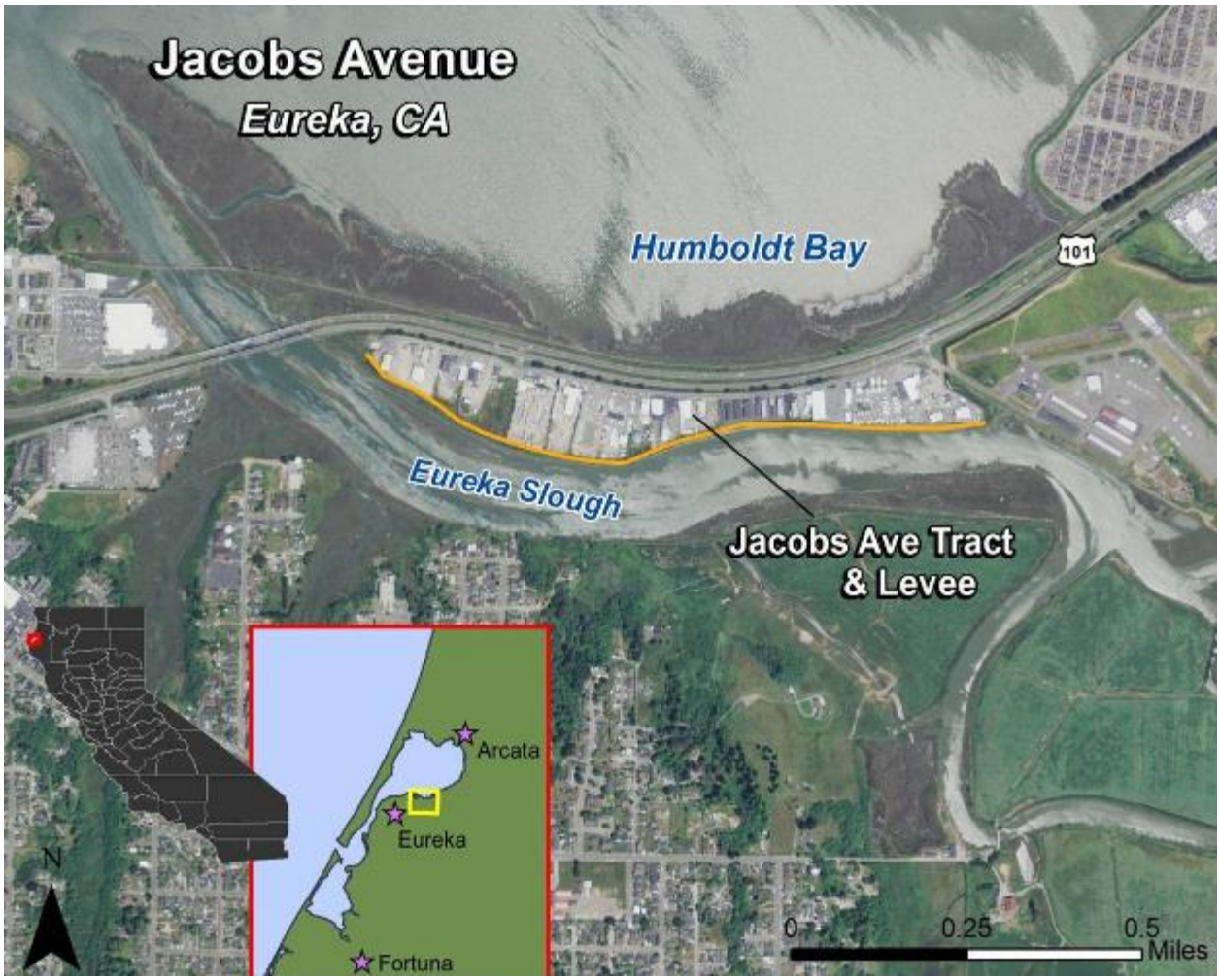

Figure 2. Locator map of Jacobs Avenue, Eureka, California. Jacobs Avenue is almost entirely surrounded by water, with Humboldt Bay to the north, Eureka Slough to the south and west, and a drainage ditch connecting to Eureka Slough to the east. The tract is armored by Highway 101, the levee in question, and an additional levee east of the tract, to defend against floods (map created by authors using NAIP data and Humboldt County GIS data).

revenue, equating to $760,000 (Harper, 2004). Damage to parcels from inundation or flooding could have serious implications for the city and the region as a whole. Effective sea level rise planning could be essential for protecting the residents, businesses, and revenue generated from businesses in Jacobs Avenue.

For this paper, we conducted an in-depth exploration of the unique social, political, economic, environmental, and infrastructural factors connected to potential sea level rise planning and adaptation for Jacobs Avenue. From this research, we developed a scenario-planning analysis exploring the potential advantages and disadvantages and implications of three different sea level rise planning scenarios. Our analysis draws from the coastal resilience framework, which examines factors that can reduce a coastal community's vulnerability to disturbances such as sea level rise. It is our goal that this scenario planning can provide important information for local planners, residents, businesses, and landowners concerned with the fate of Jacobs Avenue. However, we also believe that the scenario-planning framework

developed in this paper is a tool that could be useful for sea level rise planning in other regions. Given the State of Jefferson's history of environmental activism, Humboldt Bay has the potential to be a leader in the area of effective sea level rise adaptation and planning.

Coastal Resilience and Hazard Management

Coastal resilience is an emerging concept within the field of coastal planning that provides a conceptual framework through which to evaluate coastal planning projects as well as to establish goals for the development and continuation of robust and vibrant coastal communities (Beatley, 2009; Klein et al., 2003; Nicholls & Branson, 1998). C. S. Holling defines resilience as "the capacity of a community to absorb and utilize or even benefit from disturbances and changes that affect it, in doing so the community is able to persist without a qualitative change in its structure" (quoted in Beatley, 2009, p. 3). Coastal resilience applies the theory of resilience to coastal communities. The concept of coastal resilience is particularly relevant when attempting to plan for communities that can better respond and adapt to natural hazards such as coastal storms, flooding, and tidal inundation—all of which are likely to increase as a result of sea level rise.

Resilience is understood to be an interdisciplinary concept encompassing environmental, social, economic, and political aspects of a given community or region. In his framework for coastal resilience, Beatley (2009) highlights four key planning dimensions: land use and built environment, ecological, social, and economic dimensions. In this analysis, we look at the potential for various scenarios to contribute to the coastal resilience of the City of Eureka by evaluating the different alternatives through an interdisciplinary lens that touches upon all the key planning dimensions.

In the broader field of hazard management, planners and scholars have focused on two main and often competing strategies to reduce impacts from natural hazards and sea level rise: (1) rebuild/fortify threatened infrastructure and (2) strategic retreat (Adger et al., 2013; Young, 2013). Under the rebuild/fortify model—the more traditional approach to hazard management—communities are rebuilt in the same locations following natural disasters, and areas vulnerable to such hazards are fortified or made less vulnerable through engineering projects such as the improvement of levees or the building of sea walls (Young, 2013). However, the option of strategic retreat in the face of coastal hazards has begun to gain traction in the planning community (Abel et al., 2011). Under this model efforts are made to move residences and infrastructure out of vulnerable locations and those areas are then converted into open space or coastal wetlands. One of the highest profile examples of the strategic retreat model is New York Governor Cuomo's post-Hurricane Sandy plan, which included voluntary buyouts for homeowners who reside in areas vulnerable to hurricane impacts with the intention to convert the properties into open space (NYS Homes and Community Renewal, 2013).

The fortify and strategic retreat approaches to coastal hazards management come with various advantages and disadvantages depending on the context of the community. Many recent high profile coastal plans, such as New York's and Louisiana's, contain some elements of both models (NYS Homes and Community Renewal, 2013; Coastal Protection and Restoration Authority, 2012). The scenario-planning framework set forth in this paper explicitly provides planners with a means to visualize the various costs and benefits associated with different approaches to flood and hazard management of a particular parcel of land.

Methods

We utilized three primary methods to develop this sea level rise planning analysis of the Jacobs Avenue parcels: (1) interviews with key stakeholders connected to the parcel, (2) document review of key planning and historical documents related to the site, and (3) GIS spatial analysis of the parcel and its particular vulnerabilities.

We interviewed seven individuals selected purposively for their expertise and perspectives on Jacobs Avenue and its vulnerability to sea level rise. Respondents included two business and property owners of the Jacobs Avenue district, an official of the Army Corps of Engineers, a tenant of the Lazy J mobile home complex situated on Jacobs Avenue, and three individuals who agreed to the use of their names: Hank Seemann, Deputy Director (Environmental Services) of the Humboldt County Public Works Department; Aldaron Laird, an environmental planner familiar with the Humboldt Bay region; and Bob Merrill, district manager of the North Coast District Office of the California Coastal Commission. Interviews provided important information about the social and political context in which planning for Jacobs Avenue takes place.

We conducted an extensive review of materials relating to flood management in the Jacobs Avenue parcel, including government records, historical documents, policy documents, climate change models, and scholarly literature. We supplemented this analysis with a review of case studies and literature related to flood zone management and sea level rise planning more broadly, looking for examples to draw from in the consideration of planning for Jacobs Avenue. Additionally, spatial datasets were acquired from Humboldt County, the National Agriculture Imagery Program (NAIP), and the National Oceanic and Atmospheric Administration (NOAA). We utilized these datasets and performed geospatial analysis to query for and delineate particularly vulnerable areas along the Jacobs Avenue levee as well as other land use features.

Finally, we brought these three types of information together utilizing a scenario-planning framework. Scenario planning involves bringing together the best information to project potential futures for a particular place based on a range of possible scenarios or planned activities. “The goal of developing scenarios,” as Carpenter (2005, p. xxi) explains, “is often to support more informed and rational decision-making that takes both the known and the unknown into account.”

We developed a scenario-planning framework with three distinct and plausible scenarios for the Jacobs Avenue parcel:

- **No Action**, in which little to no action would be taken towards minimizing flood risks for the parcel and the voluntary and disjointed management of the current levee would continue to be the norm.
- **Levee Upgrade**, in which steps would be taken to significantly upgrade and strengthen the existing Jacobs Avenue levee and its management structure. The scenario draws from the rebuild/fortify model of hazard management.
- **Strategic Retreat**, in which businesses and residents are incentivized to migrate away from of the Jacobs Avenue location over a 20-year timeframe. This scenario draws from the emerging strategic retreat model of hazard management.

We explore the potential future for Jacobs Avenue under each scenario, and analyze the strengths and weaknesses of each approach.

Jacobs Avenue and Its Legislative Context

In many ways it is not surprising that Jacobs Avenue is facing flood concerns. Historically the property was a coastal wetland (see Figures 3 and 4). It first became isolated from Humboldt Bay to the north with the construction of the railroad and later Highway 101 (Laird, personal communication, 2014). In the 1930s, Frank Herrick, the initial landowner of the tract, constructed a mile-long levee on the south side of the property to drain the area and isolate it from Eureka Slough (Mattson, 2011). After the parcel was diked and drained, it was utilized

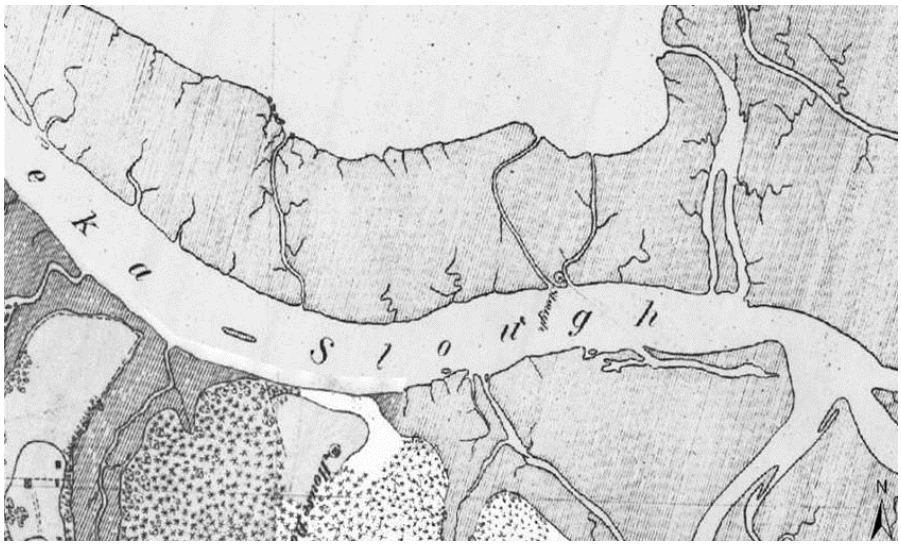

Figure 3. An 1870 US Coast Survey of Jacobs Avenue depicting wetlands and numerous tidal veins connecting the landscape (image from Laird, 2007).

Figure 4. A 1931 Aerial Mosaic of Jacobs Avenue depicting early settlements in Eureka to the southwest, with Highway 101 transecting the image and undeveloped tidally influenced land where Jacobs Avenue currently lies (image from Laird, 2007).

primarily for agricultural purposes. In addition, the Murray Field Airport was constructed on land adjacent to Jacobs Avenue just after World War II (Laird, personal communication, 2014). Deeds from the Humboldt County office indicate that in the early 1950s descendants of Herrick subdivided the tract into smaller individual parcels. The subdivision signaled the transition from agricultural uses of the property towards the commercial and industrial uses that dominate the property today (see Figures 4 and 5). The tract currently supports a diversity of uses, including a mobile home park, a used car and auto wrecking facility, a vehicle rental outlet, a storage facility, and agricultural and industrial supply stores.

Figure 5. A 1958 Aerial Mosaic of Jacobs Avenue depicting a growing Eureka and parcels with infrastructure upon the newly created Jacobs Avenue (image from Laird, 2007).

Jacobs Avenue has maintained flood protection from the bay to the north by the raised railroad bed and the Highway 101 corridor. On the south side, the original levee constructed in the 1930s is still the primary source of flood protection. The levee is maintained by individual property owners, each responsible for his or her own section of the levee. This has led to a system of uneven management in which some landowners have invested in upgrades, maintenance, and repairs while others have not. In the 1980s, several landowners worked with the City of Eureka to conduct a significant upgrade on the eastern portion of the levee. Through various initiatives, the landowners, the city, and the county have attempted to move towards the development of a levee district to oversee maintenance of the levee protecting Jacobs Avenue, but this effort has been encumbered by political and legal complications (Mattson, 2011).

The history of Jacobs Avenue has also been marked by the development and evolution of federal flood management policies. In 1968, the US Congress created the National Flood Insurance Program (NFIP) to provide government subsidized flood insurance to residents living

in areas prone to flooding hazards. Two important factors led to the creation of this program—citizen concerns over the consequences of hurricanes and flooding, and the refusal of private companies to provide insurance to residents living in flood prone areas. The NFIP has been criticized by many planners and scholars for promoting and subsidizing continued residence and development within hazardous areas (King, 2011; Burby, 2006). Under the NFIP, the Federal Emergency Management Agency (FEMA) is charged with developing flood zone maps that delineate location of land areas that are vulnerable to experiencing an extreme flooding event at least every 100 years. These designations are depicted on FEMA's Flood Insurance Rate Maps (FIRM). As a part of this mapping process, FEMA evaluates the quality of levees, dikes, and other flood protection structures.

The catalyst for raising awareness on Jacobs Avenue and its levee occurred in 2004, when FEMA began the process of updating its national FIRM. On the previous FIRM, Jacobs Avenue was categorized in Flood Zone "C," meaning FEMA believed the existing levee protected the property from a 100-year flood event. The new 2004 FIRM process required flood control structure owners to obtain evidence from a licensed engineer stating that their levee or dike "meets and will continue to meet minimum standards related to hydraulic, structural, operational and maintenance aspects of levee performance" in order for it to be accredited (Mattson, 2011, p. 2). Flood control structures that lack an engineering assessment or fail to pass minimum standards result in FEMA non-accreditation, signifying an unsafe area where residents are required to purchase and hold flood insurance.

Jacobs Avenue landowners were notified about the pending change to their flood zone status in 2004, however an engineering assessment was never performed. Due to the lack of a viable assessment of the levee, FEMA changed the status of Jacobs Avenue to "Zone A-Special Flood Hazard Area" (Seemann, personal communication, 2013; Mattson, 2011) (see Figure 6, next page). Through this new designation, FEMA indicated that it was not convinced the levee could provide adequate protection against the 100-year flood mark (9.37 feet). This new flood designation introduced new costs and new considerations of risk to the Jacobs Avenue landowners. In particular, a national condition for property owners within "Zone A" is the requirement to purchase flood insurance—which is quite costly—for any property with a federally backed mortgage. As a result, landowners, planners, and the public have begun conversations about the future of the tract. This watershed moment provides a great opportunity for a scenario-based analysis of the property so landowners can consider the consequences of various planning strategies. Below we provide an interdisciplinary analysis of three flood management scenarios for Jacobs Avenue.

Scenario 1: No Action

> *"I don't really feel any better that we've maintained our levee, it just makes me more aware of everything that hasn't been maintained."* (Jacobs Avenue landowner, personal communication, 2013)

Under the no action scenario planners and landowners would take very few steps to reduce flood hazards in the Jacobs Avenue tract. This alternative assumes a continuation of current land use policies, specifically: non-uniform levee management among landowners, and a failure to address the area's downgraded status in FEMA's FIRM. Taking steps to improve the flood infrastructure or change the use of hazard prone areas can be incredibly challenging. Not only

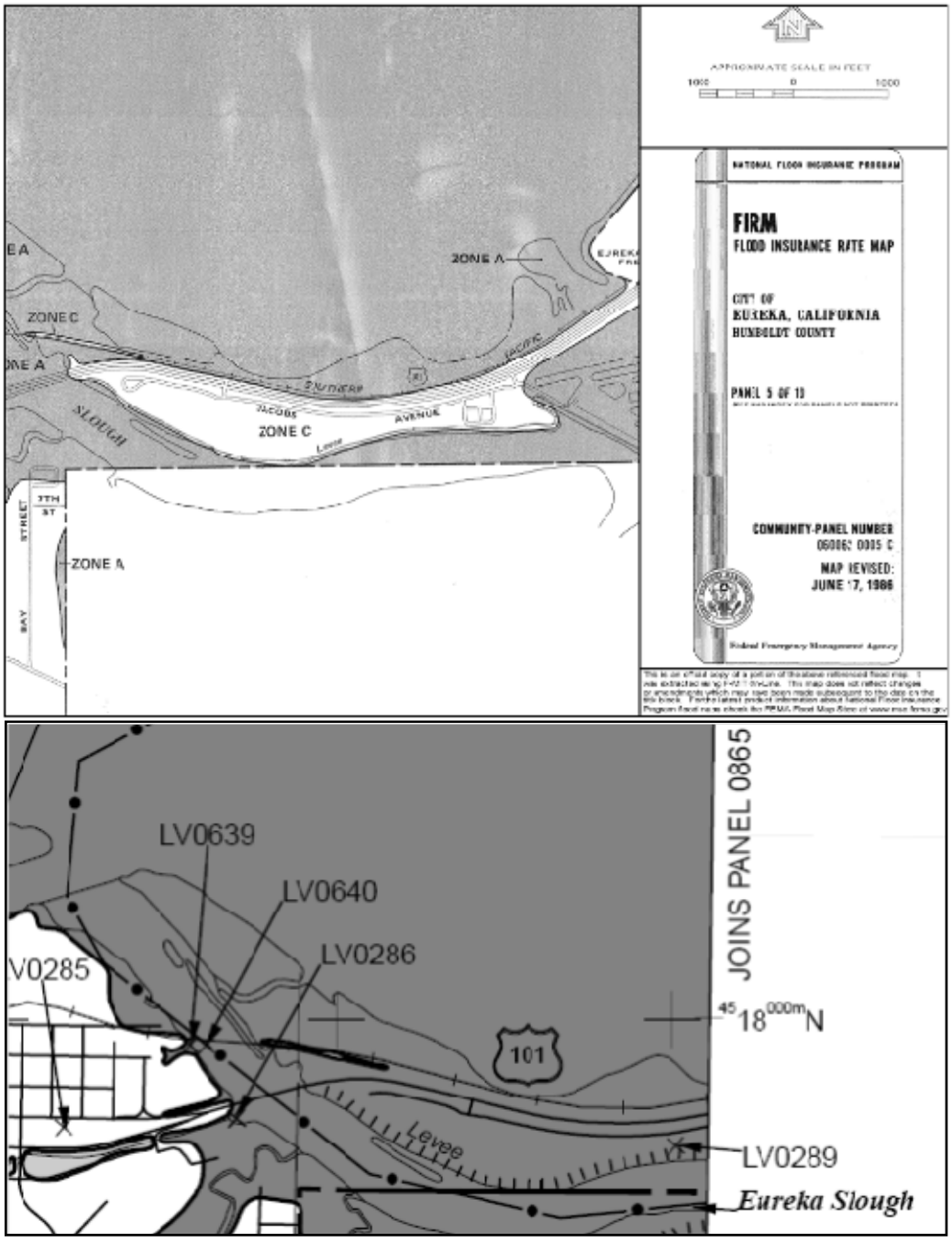

Figure 6. Top: FEMA's 1986 Flood Insurance Rate Map (FIRM) depicting Jacobs Avenue within Zone C (white), an area in which levees provide adequate protection from the 100-year flood (Humboldt County Public Works Department, 2012). Bottom: FEMA's 2009 Draft FIRM changing Jacobs Avenue designation to Zone A (shaded region) (Humboldt County Public Works Department, 2012). As outlined in LeFever (2001, p. 2), "Areas subject to inundation by the 100-year flood event. Mandatory flood insurance requirements apply."

are infrastructure upgrades very expensive, but they also require a lengthy and uncertain process of permitting. In addition, any changes to land use management in hazardous areas can be encumbered by political opposition from stakeholders who prefer the status quo. As a result, no action can be seen as the easiest—or with lack of suitable funding the only—option for management of flood prone areas. Therefore it is important to evaluate and consider the possible consequences if no action is taken in the management of Jacobs Avenue.

Social Considerations: Levee Management and Potential Conflict

Many social and economic factors are important in the consideration of the no action scenario. To start, it is important to understand the social and political aspects related to levee management. An important facet of Jacobs Avenue is the lack of a single levee owner; rather, the levee is a shared responsibility among all parcel owners. Over 30 businesses and numerous residents on Jacobs Avenue are responsible for the upkeep of the levee (Seemann, personal communication, 2013). There has been communication among landowners to create a centralized levee district to solve the disjointed management issue; however, specifics regarding the powers of residents relative to business owners within the California Water Code have negated the possibility of the levee district forming.

Because the landowners are predominantly business owners, not residents, they cannot form a levee district and instead the Jacobs Avenue tract has been classified as a flood subzone area, which allows interested individuals to participate as a unit with Humboldt County Public Works department as the group's representative (Seemann, personal communication, 2013; Humboldt County Board Orders, 1955). Designation of a flood subzone also authorizes landowners to pay assessments on their property taxes, which go into a fund to pay for improvements and other beneficial activities related to flood protection (Seemann, personal communication, 2013). Under this subzone formation, landowners and business owners are only able to conduct indirect management of their levee using Humboldt County as a proxy for their issues and demands. For any action to take place with regards to management of the area's levees landowners and the county will have to engage in productive dialogue. Under a no action strategy, this kind of relationship-building and joint decision-making would not be required.

While the no action strategy would not require the engagement in complex social and political negotiations necessary to make changes to the levee or flood management, it could also produce important social challenges. Namely, the no action strategy has the potential to lead to serious conflict among landowners and business owners about the relative upkeep of their respective sections of the levee. Jacobs Avenue is basin shaped with Highway 101 sitting approximately 12 feet above the ground level of the tract and the levees ranging from 10 to 12 feet above ground level (see Figures 7 and 8, next page). This topography was created to protect the economic resources on the tract, however due to the uneven levee it is possible that even a small levee breach could inundate the entire area. This situation can create social pressures and conflict because improper management of just one section of the levee by just one landowner can create vulnerability for the entire neighborhood. One land and business owner said,

> I don't really feel any better that we've maintained our levee, it just makes me more aware of everything that hasn't been maintained. Though we feel better that there is less likelihood that we will be liable for a breach...it's questionable if they will be blamed for the breach. (Property owner, personal communication, 2013)

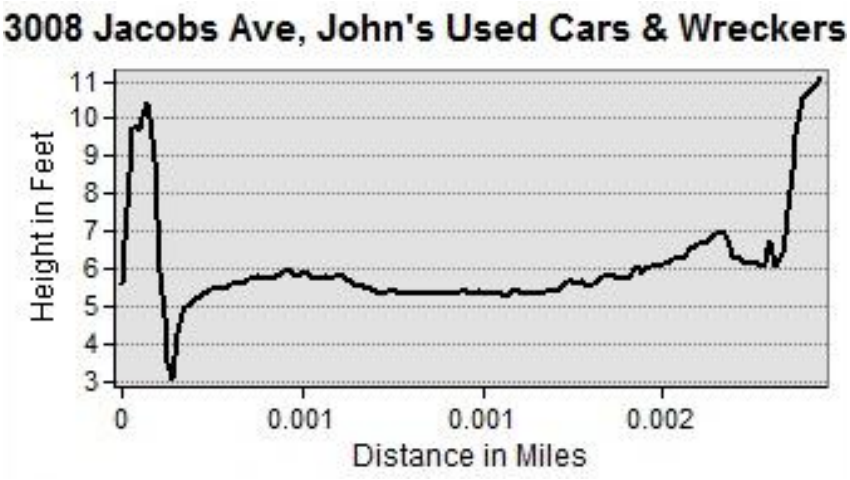

Figure 7. A cross section depicting the basin-like topography of Jacobs Avenue. The peak on the left side of the chart represents the levee and the peak on the right represents the Highway 101 corridor. The height of the levee is approximately 10.5 feet, a mere 14 inches above the expected 100-year flood event. With tides regularly inching towards the 9.37-foot threshold, the 100-year flood level is losing significance (data derived from NOAA LiDAR, 2011; NAIP imagery; and ArcMap software).

Figure 8. A photograph taken from atop Jacobs Avenue levee depicting the Lazy J mobile home complex below the levee top and the Eureka Slough separated to the right (south) (photograph by Evan Wisheropp).

Socioeconomics: Distribution of Costs and Risk

There are also potential political and equity challenges related to who is responsible for the upkeep of the levee compared to who might experience the most harm from the flood event. Under the current model, landowners are responsible for the upkeep and maintenance of the levee. It is possible that after assessing the situation, the landowners may decide that it is too economically risky to invest in levee upgrades, leaving tenants and other occupants vulnerable to their decision. The expense of building additions to levees as well as the difficulty of obtaining permits for construction can provide a disincentive to landowners in taking proactive steps to improve flood management at their property. However, many of the properties on Jacobs Avenue are leased and this situation may not be agreeable to the residents and tenants of properties who are unwittingly placed at risk. A resident of the Lazy J mobile home complex explained, "I think that an owner [of the Lazy J] has a responsibility to inform the tenants of the conditions that they are living under and the safety of the levee... I can tell you that I don't remember ever being informed [of] anything about the conditions or risks or hazards" (Lazy J resident, personal communication, 2013). If no action is taken towards protection, property and business owners would be putting employees, residents, and infrastructure at risk for potential flooding and danger.

There are economic costs to consider under the no action alternative. When a flood does occur under the no action alternative, if landowners purchased national flood insurance it is likely that FEMA will provide financial assistance to them to cover the cost of damages. However, FEMA's intention is not to make landowners whole again, but rather to aid them during a calamitous time (Chabel, 2013). Historically, this passive approach has been seen as an effective gamble compared to the hassle and expense of levee buildup. Additionally, while the expense of proactive measures to improve levees for potential flooding and sea level rise would likely be borne by local (county or city) sources, which are often financially burdened, post-disaster emergency funds from FEMA would come from the federal government (Burby, 2006; King, 2011). Economically, under the no action alternative, the local city and county government would benefit from not needing to finance large-scale levee improvement projects. Both the City of Eureka and Humboldt County have limited and stretched budgets, so this could be seen as a major benefit to this scenario. If the landowners purchase federal flood insurance there is at least some guarantee of federal support following a flood event.

Under the no action scenario, there is also the option neither to pay flood insurance nor proactively keep flood protection structures accredited. If a flood causes damage and the flood protection structures are neither accredited nor flood insurance held, FEMA will provide limited financial relief; specifically, the aid FEMA can offer is capped at $30,000 (Chabel, 2013). As a result we would recommend that even under the no action scenario landowners make sure to purchase the insurance given the flood vulnerability of the property. However, even with the purchase of flood insurance landowners have no guarantee that they will receive the high levels of flood assistance given to communities by the federal government in the past. Total reliance on FEMA and the NFIP contains an embedded false sense of security because FEMA has limitations to its responsibilities. Due to the economic recession of 2008 the federal government has been struggling to pay off debt while simultaneously trying to preserve programs such as emergency management. There will be significant pressures in the coming years at all levels of government to scale down spending in a variety of sectors (FEMA [5], 2011). A 2011 FEMA document stated that "[a]s a result of these budget pressures, a significant number of emergency management programs have already experienced budget

freezes or reductions...some think tanks have suggested cutting Federal Homeland Security grants (including emergency management)" (FEMA [5], 2011). Property owners that are confident in FEMA's expected level of aid during a flood event may be caught surprised if they are not paying attention to such reports (Lee, 2006).

It is important to consider the economic costs the community might incur in the event a flood does occur in Jacobs Avenue. Given the current vulnerability of the area and the conditions of rising seas, this is a near certainty under the no action alternative. The Jacobs Avenue business district is important to Eureka because of the large revenue it supplies, approximately $760,000 annually in sales tax; it would be risky to allow for no action to be taken. Assuming the occurrence of an inundation, Eureka would lose tax revenue and jobs until the land is drained and repaired, which could take months or even years. It may not be straightforward to drain and repair land after it is inundated. As sea levels rise groundwater will also rise, so drainage will need to be modified to accommodate a higher water table, increasing the scope of work necessary to recover from floods. As mentioned above, FEMA may cover some of these costs, but not all of them, and likely not the cost of the lost tax revenue while repairs were being completed. It is important for Eureka to consider the costly rebuilding procedures including the additional complications caused by climate change, such as higher groundwater levels, greater frequency and intensity of storms, and the powerful tidal movements of Humboldt Bay, when considering taking no action regarding Jacobs Avenue's levee.

Environmental Considerations

In addition to safety concerns surrounding the high flood risk under the no action scenario, there could be long-term negative environmental impacts of taking no action. Jacobs Avenue is an industrial sector; in the event of a flood, waters could mix with chemicals used at the various automobile and machinery yards and enter Eureka Slough and Humboldt Bay. Chemicals typically found in automobile salvage yards include: acetylene gas, automotive fluids, degreasing agents, gasoline, hydraulic oils, fuel additives, diesel gasoline, asbestos, lead, and sulfuric acid (EPA, 2013). The abundant marine life in Humboldt Bay would be subject to ingestion of such chemicals, which is likely to cause bioaccumulation up the food chain in the local ecosysem (Oost et al., 2003). Some of the toxins on site could have considerable half-lives and the longer a chemical's half-life, the greater the risks are to the host organism, even in low chemical concentrations (Bryan et al., 1979).

Overall

There are several benefits to a no action scenario with regards to Jacobs Avenue. Landowners would not be required to work together with county officials to regulate and improve the infrastructure of their levees. If the landowners purchased national flood insurance, it is also likely that FEMA would pay for the damages and reconstruction following a flood event. However, the no action scenario also provides a significant safety and economic risk for the individuals and businesses residing on at the tract in the event of flooding. It also presents an environmental risk, as flooding would mobilize any toxins or chemicals present at the site. Finally, evidence indicates that the no action gamble is becoming increasingly risky. With sea level rising, the frequency of flood events at Jacobs Avenue is likely to increase. Even if the tract recovers from one flood event, it would still be vulnerable to successive events thereafter. In addition, given the financial situation of the federal government, citizens may no longer be able to rely upon large-scale assistance from the federal government following such flood

events. If a no action scenario is pursued in Jacobs Avenue, it is recommended that at the very least the landowners purchase flood insurance so they remain eligible for federal assistance once a flood occurs.

Scenario 2: Levee Improvement

> *"It's a real possibility that we could have two, three feet of water in the buildings here if there were a failure of the levees."* (Jacobs Avenue landowner, personal communication, 2013)

The levee improvement alternative would invest in upgraded flood protection by combining proactive planning with a commitment to current infrastructure. This alternative assumes that plans to build the levee protecting Jacobs Avenue would ensue regardless of whether the engineer assessment found the levee to be compliant or noncompliant with NFIP standards. Additional height and base width would need to be added to the levee in order to bring the levee up to NFIP standards of protection against the 100-year flood and to build proactively against sea level rise. Due to the levee's uneven heights, it is predicted that the upgrade would take place in sections rather than in the levee's entirety, with construction efforts prioritizing the lower and more vulnerable sections of the levee (see Figure 9).

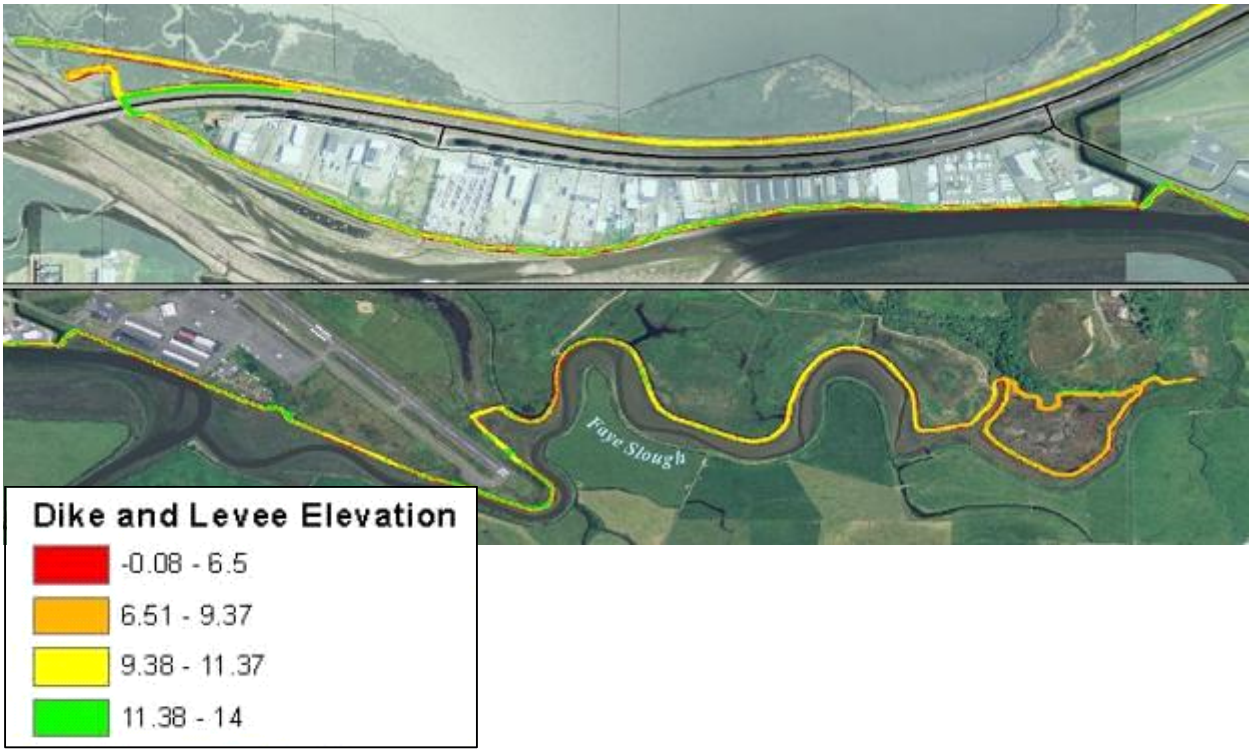

Figure 9. Map depicting the elevations along the Jacobs Avenue (top) and Faye Slough (bottom) levees. Elevations below the 100-year flood mark of 9.37 feet are red and orange. Elevations below 2 feet of freeboard are yellow; elevations in compliance with NFIP standards are green. Sections of red, orange and yellow are throughout the north and south sides of the property. The interspersed colors on the south side highlight the unevenness of protection from the Jacobs Avenue levee (data from Department of Commerce, 2012; Chinmaya, 1995).

Permitting Considerations

Conversations with landowners and planners from the region indicate that there could be several logistical and political challenges involved with the implementation of this scenario. Numerous permits would be required before a levee improvement project could take place. A coastal development permit (CDP) is a major component of this project and is administered by the California Coastal Commission. Currently, the Coastal Commission contains a "no further armoring" policy in many flood protection structure's CDPs, meaning that the expansion of the levees into new areas would be extremely challenging to permit. However, the California Coastal Act, which is upheld by the California Coastal Commission, includes language indicating that that landowners and planners have an inherent right to maintain and repair structures already in place (Coastal Act, 2006). This "inherent right" clause creates a less arduous pathway for obtaining coastal development permits for the improvement of existing levees when compared to what the process might be to permit the establishment of new levees.

However, there is a fine legal line between what would constitute maintenance or repair of an existing levee and what would constitute new levee development. As Bob Merrill of the California Coastal Commission stated, "There's always the question of when does repair and maintenance become replacement?" The general policy of the California Coastal Commission is that an existing structure is considered to undergo new development if additional volume is built upon it, or if 50% of the existing structure is replaced with different materials (B. Merrill, personal communication, 2013). Under this standard, the improvement and fortification of the Jacobs Avenue levees, particularly if they are to be of a height and strength to withstand potential sea level rise, would be considered "new development" because additional volume would be added to the height and base of the levees. Therefore, this levee improvement option would likely require review by the Coastal Commission and a coastal development permit, which would not only be costly and time-consuming but also would present an uncertain outcome.

In its consideration of granting a permit for the fortification of the Jacobs Avenue levees, the Coastal Commission would also need to consider possible wetlands fill that could result from the project. The current levees' structures are located on Eureka Slough wetlands, so any expansion of the base would require increased fill of these wetlands as well as potential disturbance of these ecologically fragile sites. The California Coastal Commission is hesitant to approve projects that result in wetlands fill, potentially adding another challenge to the permitting process.

Economic Considerations

Economically, the various components of a levee upgrade project could total millions of dollars. An average, each linear foot of levee construction costs $31.70 (NMFS, 2012), and the Jacobs Avenue levee is approximately one mile. The desired additional height would ultimately be up to the County of Humboldt, but the minimum freeboard height increase would be approximately 1-1.5 feet to reach at least 11.37 feet. Freeboard is the space between the water level and the levee top; in this case the 100-year flood mark is the level of significance from which freeboard is measured. This minimum height increase would meet the NFIP standards of 2 feet of freeboard above the 100-year flood threshold of 9.37 feet (King, 2011). The county and landowners may want to raise the levee heights 2-2.5 feet to account for future sea level rise. A levee to accommodate sea level rise might be 12.37 feet which would include 2 feet of freeboard above the 100-year flood level with an added 12 inches of sea level rise as is

predicted by 2050 (Laird, 2013). Given these figures, the approximate estimate of the levee construction is $167,376-$418,440, depending on the additional heights desired. This cost reflects the construction of the levee only and does not take into account the cost of environmental impact assessments, erosion stabilization, endangered species surveys, or permit applications. The project in its entirety could cost several million dollars. State grants are available but often require privately matched funding, which would place the financial burden on Humboldt County Public Works department and landowners. The levee improvement scenario would be extremely expensive, and the county or the city would be required to contribute significant funds to pay for the improvements. This might be a worthwhile investment for Eureka, considering that the tract contributes $760,000 of tax revenue to the city each year. However, if the landowners and county agree that the necessary fundraising is not realistic, the levee improvement scenario may not even be an option they could pursue.

Environmental and Structural Considerations

The levee improvement alternative would also bring about several immediate and long-term environmental impacts (Laird, personal communication, 2013). The land Jacobs Avenue lies upon is historically tidal marshland and is by nature transient. A levee upgrade scenario will need to plan for three important environmental considerations: king tides, groundwater rise, and the hydrologic unit concept.

King tides are the most extreme tides of the year, which take place between December and early February. In December 2012, king tides in Humboldt Bay reached a stage height of 8.77 feet, just 7.2 inches below the 9.73-foot 100-year flood threshold of significance (California King Tides Tide Chart, 2013). King tides are projected to become more extreme with rising sea levels, and they will continue to pose a threat to Jacobs Avenue infrastructure and people. As one resident of the Lazy J mobile home complex said, “Dealing with sea level rise on Jacobs Avenue is pretty scary because the water is pretty doggone high at times” (Lazy J resident, personal communication, 2013). A benefit of levee improvement is that it could provide landowners and residents with added security in these high water conditions. A comparison of vulnerable and structurally sound sections of levee can be found in Table 1 and Figure 10 (next page). Under the levee improvement strategy, the vulnerability of properties behind the levee would likely be significantly reduced.

Table 1. Varying sections of levee along Jacobs Avenue.

Business:	**Levee Elevation (ft):**
Johns Used Cars and Wreckers	10.5
The Farm Store	14
United Rentals	13.75
Humboldt County Heavy Equipment	10.75

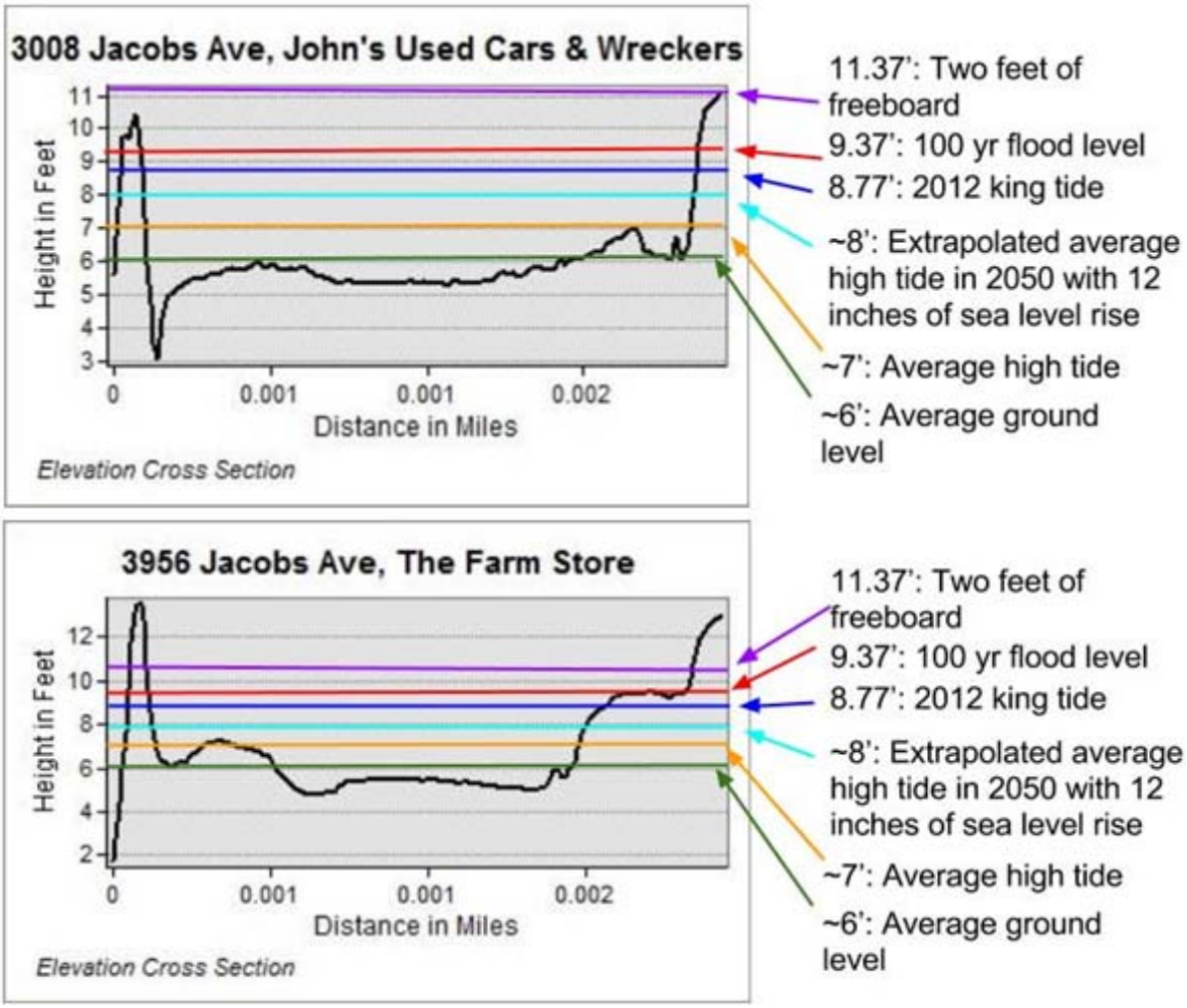

Figure 10. Cross sections of vulnerable (John's Used Cars & Wreckers) and structurally sound (The Farm Store) portions of levee with associated thresholds of significance. Satellite imagery and a 1-meter resolution Digital Elevation Model (DEM) of the landscape shows the average ground height in the Jacobs Avenue basin to be approximately 6 feet. High tide stage heights at the Eureka Slough Bridge record at 4.75-8.5 feet, varying throughout the year, placing the high tide at approximately 7 feet (ProTides, 2011) (representation created using NAIP imagery and NOAA LiDar data).

The Jacobs Avenue tract already has challenges with storm water drainage. During a site visit to Jacobs Avenue shortly after a storm event, our research team observed that water had visibly collected in the streets and stood stagnant due to the absence of stormwater infrastructure. As sea levels are projected to continue to rise, groundwater levels will also rise and further complicate the stormwater drainage problems of Jacobs Avenue (Laird, personal communication, 2013). Currently precipitation is only able to drain from the parcel at lower tides when the tide gates are open. If the groundwater table and the sea level rise, it is foreseeable that this method of drainage will be defunct and the parcel would not be able to drain, creating flood conditions. "They are at the bottom of a bowl... They rely on it draining out at low ride, so if you have rising tides and groundwater it is going to be a problem... Even if

the shoreline wasn't breached by a high tide…drainage is really going to become the thing that puts them out" (Laird, personal communication, 2013). This means that in addition to improvements to the levee infrastructure, stakeholders are likely also going to need to improve the stormwater infrastructure in order to protect the tract from flood risks. These improvements likely would add increased costs, permitting requirements, and environmental impacts.

Under the levee upgrade scenario, landowners would still need to consider the cumulative impacts of the surrounding hydrologic unit. There is a degraded levee upstream of Jacobs Avenue located at Faye Slough, which is vulnerable to overtopping during high tides, floods, and tsunamis (see Figure 9). If a levee breach were to occur there, properties within Jacobs Avenue could experience flood impacts through the eastern unarmored portion of the Jacobs Avenue levee (Laird, personal communication, 2013) (see Figure 11). Extending cooperative management to include the Faye Slough levee would substantially increase the costs and permitting requirements associated with the project.

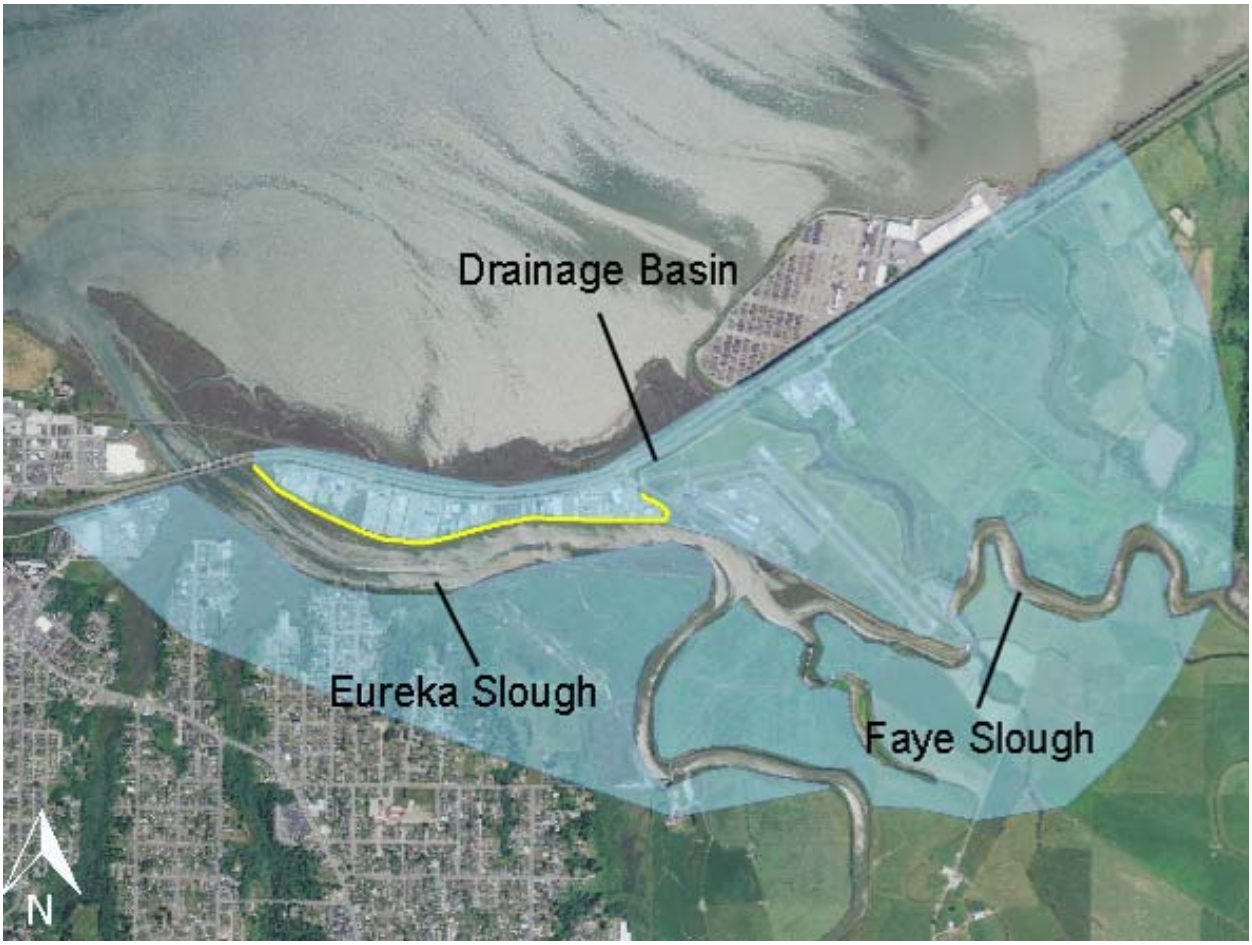

Figure 11. Eureka Slough hydrologic unit, an area of interconnected waterways experiencing shared impacts of tidal fluctuations. A levee failure in Faye Slough could bring about flooding on Jacobs Avenue regardless of levee improvement efforts due to the unarmored eastern edge and the tract's basin-like topography (data derived from NAIP imagery; NOAA LiDar; Laird, 2013; and Laird, personal communication, 2013).

Overall

The levee upgrade alternative would provide important benefits to the community. It would increase their security and protection in the event of an almost guaranteed future flood event. Given how close the water has already come to overtopping the levee infrastructure, this is an important consideration. However, the levee upgrade would require considerable permitting hurdles and economic investment, some of which might not be feasible for the current landowners. The levee upgrade scenario would provide important safety and property protection benefits to the tract in the near future; however, it is unclear how this scenario might fare in the long term. As sea levels continue to rise, the upgraded levees may no longer be sufficient to withstand the higher water conditions. When considering this scenario, stakeholders would need to ponder seriously whether it is worthwhile to spend the political, social, and economic capital to improve the levees when at some point in the future these levees would need to be upgraded again, or quite possibly the water level would rise to such an extent that fortifying and inhabiting the tract no longer remains a viable possibility.

Scenario 3: Strategic Retreat

> *"If you have no skin in the game, it's easy to say 'let's just abandon it'."* (Jacobs Avenue business owner, personal communication, 2013)

In the face of imminent sea level rise, tsunamis, and the troubling prospects of taking no action or spending millions of dollars to upgrade levees, planners have begun to consider an additional alternative for coastal management: a planned strategic retreat where at-risk residents, businesses, and infrastructure are relocated to less vulnerable locations (McGuire, 2013). Strategic retreat is the least codified of these possible alternatives for Jacobs Avenue. Few other localities have conducted strategic retreat, so there are not many existing models or pathways for how this goal could be accomplished. As a result this process would require a certain creativity and ingenuity among planners. In addition, relocating so many landowners, businesses, and residences is likely to encounter significant political, economic, and logistical challenges. However, given the persistent nature of sea level rise and the changes rising seas are likely to bring to coastal landscapes, this is an essential scenario for planners to consider.

This scenario-planning alternative assumes movement away from the tract would take place over a 20-year time span, in order to create the necessary framework to incentivize this type of movement and also to allow optimal parcels to become available within the City of Eureka. Contiguous properties would be preferable because they would preserve the community's character, however the acquisition of sufficient tracks of property may be difficult and not entirely necessary.

Environmental and Social Benefits

The strategic retreat scenario has the potential to deliver important environmental benefits. Historically, the Jacobs Avenue property was salt marsh wetlands. Research indicates that wetlands such as those at Jacobs Avenue provide important ecological services to the coastline including the provision of estuarine habitat for marine resources, the filtration of water and pollutants entering the marine environment, and the alleviation flood impacts by storing and filtering varying amounts of water (Randolph, 2012). In the event of strategic

Figure 12. Photograph of the tract's coastal wetlands while facing Eureka Slough Bridge at low tide (photograph by Evan Wisheropp).

retreat, the Jacobs Avenue tract could be converted back to wetland habitat, which could provide numerous ecological and social benefits (see Figure 12).

A major benefit of the strategic retreat scenario is the reduction in coastal hazards. Numerous concerns such as personal safety, flood insurance, levee maintenance, and threats of sea level rise would no longer have to be managed by landowners. While implementing a strategic retreat framework for businesses would require lengthy planning, the outcome would ensure that lives and property would no longer be at risk.

Challenges of Facilitating Retreat

A key challenge to the strategic retreat scenario will be the development of a fair and legal mechanism to relocate residents and businesses off the vulnerable property. Measures to incentivize movement could include enacting building restrictions or tax penalties on properties opposing movement, as well as making financial benefits available to landowners willing to move. Governor Cuomo's post-Sandy buyout plan offers a possible model for this type of program. His plan facilitated retreat through a voluntary mechanism where eligible property owners were offered the option either to take the pre-storm fair market value of their property and move, or to remain in their post-flood desecrated location. The program incentivized mass movements away from vulnerable areas by offering each property owner within an entire block of houses an additional 10% to their pre-storm fair market value offer if everyone in the block decided to take the buyout and move (NYS Homes and Community Renewal, 2013). Any efforts to relocate businesses or landowners would need to consider the legal implications for private property owners on the tract. Under property law, the development of policies that render particular properties unusable or unbuildable by their private owner could be considered a "takings" and the government would be required to compensate landowners (Ruhl et al.,

2007). For this reason voluntary incentive-based relocation programs may be more legally feasible and socially acceptable.

Interviews with individuals connected to Jacobs Avenue indicate that they have significant attachments to the place, such that relocating them would likely be met with resistance. For the single group of residents in the Lazy J mobile home complex, much of their sense of place comes from the fact that the park is very clean and safe, conveniently located with beautiful views of the water on both sides. As one resident said,

> The Lazy J is pretty nice, it's a unique, small park. It's a sweet location…10 minutes to south Eureka and 10 minutes to Arcata, it's perfect. It's right in the middle of everywhere you want to go in that area. This place is pretty slim pickings as far as RV parks [go]… There really is no place else to go for the tenants. (Lazy J resident, personal communication, 2013)

Business owners describe how important the convenient location—right off the highway—of Jacobs Avenue is for the vitality of their businesses. As one business owner said, "You have clear visibility coming from both directions on the highway" (Personal communication, business owner, 2013).

An initial exploration of vacant properties in Eureka indicates that it is unlikely the planners could locate another parcel for relocation that would have similar amenities and convenience of Jacobs Avenue. Our preliminary analysis indicates that available land is limited to the areas depicted in Figure 13. Currently, the available contiguous parcels within Eureka large enough for the businesses of Jacobs Avenue are located within the tsunami zone.

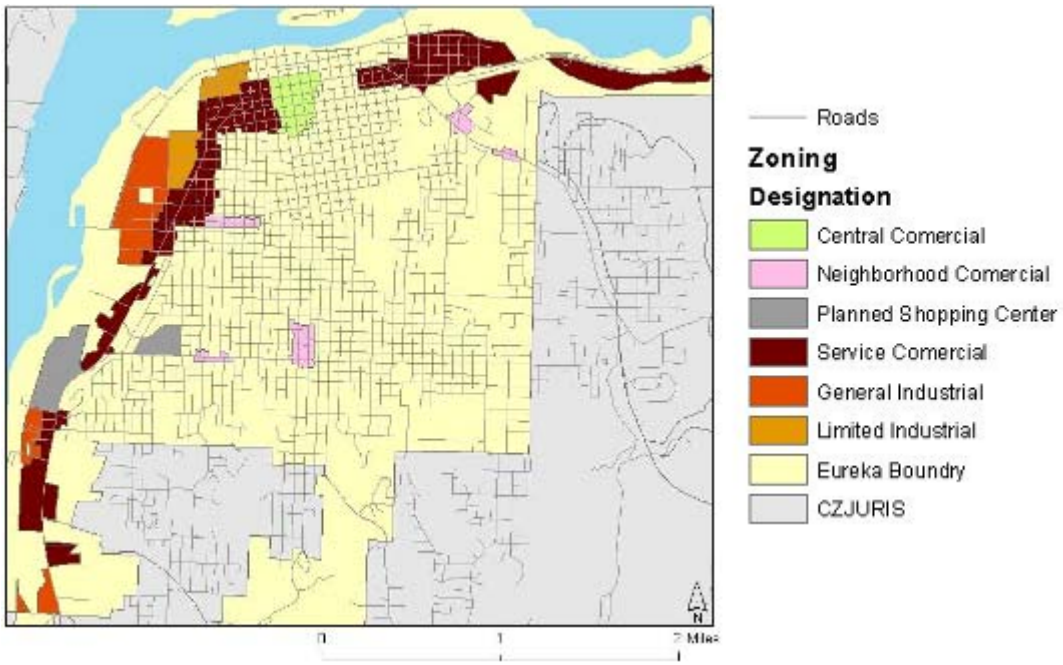

Figure 13. Industrial and commercial zoning classifications within the City of Eureka (Department of Commerce, 2012; Chinmaya, 1995; USDA, 2012; Withers, 2009). Most industrial and commercial parcels are within the tsunami hazard zone, thus strategically retreating the Jacobs Avenue businesses to these parcels would not achieve a complete hazard-free transition (data derived using ArcMap software).

Relocation to these parcels might not be wise because it would simply mean moving valuable infrastructure and human communities from one area of hazard to another. Currently the only suitable vacant parcels within Eureka are scattered. However, within the 20-year timeframe of strategic retreat it is possible that more parcels within Eureka could become available. Under this scenario, the city would need to work to set aside and appropriately zoned parcels of land for relocation.

This scenario would require a proactive strategic retreat—attempts would be made to relocate residents and businesses prior to a major flood event. This adds an additional layer of social complexity. A disaster or flood can be an important motivating event to stimulate significant action such as relocation. Governor Cuomo's buyout program was successful and feasible in large part because residents of the areas had recently experienced the effects of a significant disaster and as a result may have been more motivated to take action. Jacobs Avenue has not had the same experience.

Economic Considerations

The strategic retreat strategy could also be very expensive. The City of Eureka or Humboldt County would likely need to compensate landowners for their property, at least to some extent. A representation of property values in Jacobs Avenue is displayed in Figure 14—the total value for all parcels is estimated at just over $11.5 million dollars. It is unlikely the city or county would be able to bear this price tag. It is likely that ity and county planners would not have access to the billions of dollars of hurricane relief that were available to the State of New York to support Cuomo's buyout plan. A local planner indicated the need for financial support of relocation:

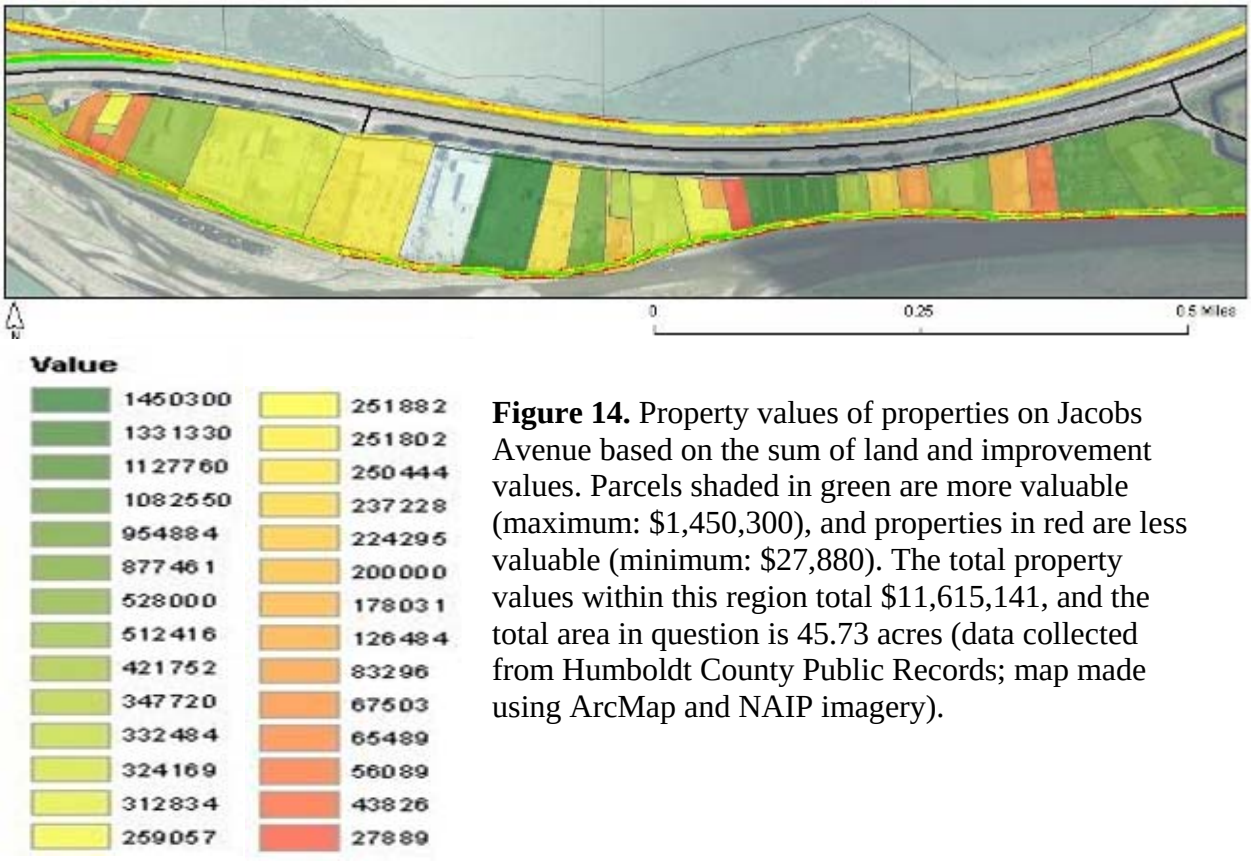

Figure 14. Property values of properties on Jacobs Avenue based on the sum of land and improvement values. Parcels shaded in green are more valuable (maximum: $1,450,300), and properties in red are less valuable (minimum: $27,880). The total property values within this region total $11,615,141, and the total area in question is 45.73 acres (data collected from Humboldt County Public Records; map made using ArcMap and NAIP imagery).

> I think that they are going to have to get money to help these people relocate because I think at some point FEMA is going to stop insuring them...and if they can't get insurance they won't be able to get bank loans and they won't be able to improve their businesses. (Laird, personal communication, 2013)

Until recently few funding sources were available to support relocation efforts as part of a hazard mitigation strategy. As of 2013, FEMA's Hazard Mitigation Assistance grant programs have made available funding streams to support pre-disaster mitigation and flood mitigation assistance through individual states—relocation is a possible activity supported by these programs (FEMA, 2013). Planners may want to contact FEMA as well as the California governor's Office of Emergency Services to see if money might be available for relocation or levee upgrade. These grant programs are new, so it is unclear if and how they could be utilized to support an effort like strategic retreat from Jacobs Avenue.

It is possible that businesses choosing to relocate would suffer initial economic hardships because of the change in venue. Many Jacobs Avenue businesses consider the convenient location of the tract as an important factor in their success. Relocation could result in lower revenues for businesses and the city of Eureka. The success of relocated businesses would depend on the viability of the new locations. Planners should consider this factor if and when developing sites for relocation.

Overall

It may not be feasible to implement strategic retreat immediately, but phased out over time this approach could be achievable. Once funding is secured, the parcels could be prioritized by landowner's willingness to move and levee heights. A stakeholder meeting could take place between landowners, Humboldt County, and the City of Eureka to inform landowners of the opportunity to relocate with financial compensation. Landowners would then be able to express interest or decline and remain where they are and take their chances with flood insurance. Through a phased retreat these buyout opportunities could be made available every five years or so to allow landowners to gauge their risk comfort level as storms visit the area and sea level gradually rises. Strategic retreat may prove easier to implement as properties pass hands into the next generation of ownership, allowing heirs to gauge if they would rather receive a payout or continue the business where it currently resides. As the rate of sea level rise increases and understanding of the matter grows, so does the government's responsibility to enact funding to allow for this type of dialogue to take place. Strategic retreat would set a precedent for future generations, emphasizing the importance of questioning current conditions of coastal development and the long-term resilience people's livelihoods, property, and safety.

Conclusion

This scenario-based analysis reveals that sea level rise adaptation presents a nearly intractable problem with few easy solutions. Each of the three scenarios comes with significant challenges and drawbacks. The no action alternative would continue to leave people and infrastructure vulnerable to flood impacts, the levee upgrade alternative would come with high costs and permitting challenges and may only be a temporary solution as sea level rises, and the strategic retreat alternative lacks a clear political path, would require a large scale mobilization of resources and people, and would likely be met with social resistance.

Having completed this analysis we would recommend that Jacobs Avenue move forward with some hybrid of both the no action and strategic retreat scenarios. For the near future we recommend that landowners purchase flood insurance and make only small-scale individual investment in levee reinforcement. In the meantime, we recommend that landowners along with city and county officials begin conversations to develop a fair process for planned retreat from the area. This would need to be a participatory process that includes stakeholders in Jacobs Avenue as significant drivers in the conversation about their properties' fate. Strategic retreat would likely take many years, but given the timeframe of sea level rise projections now is a great time to begin the process.

An important finding of this analysis was just how appealing the no action strategy could be, despite the fact that it would put people, infrastructure, and the environment at risk. If landowners bought flood insurance they could be assured of some government assistance following a flood event, whereas assistance for flood management activities such as a levee upgrade or strategic relocation would be difficult to attain. While the strategic retreat alternative offers the best long-term safety, economic, and environmental benefits, the political path and financing for this option remain murky at best. This analysis reveals that government policies surrounding flood management can provide a huge disincentive, in some cases even a barrier, to proactive flood and sea level rise planning. If landowners can only get compensation for mitigation or relocation after a flood event occurs, they are left with little choice but to sit and wait for that flood to arrive. This conundrum points to the need for a significant alteration of the government's funding and incentives structures surrounding hazard management.

Recent changes in FEMA's grant program as well as to the National Flood Insurance Program indicate that the government is considering this transition. The 2013 FEMA Hazard Mitigation Assistance grant program establishes potential funding mechanisms for proactive flood management, which possibly could include strategic retreat. The 2012 Biggert-Waters NFIP Reform act made significant changes in flood insurance policies in the US, including a phasing in of increased flood insurance rates for properties in high-risk zones and a call for strategic remapping of the nation's flood zones. This reform has since been amended by the 2014 Homeowner Flood Insurance Affordability Act, which requires gradual increases to flood insurance rates rather than immediate increases. The HFIA Act arguably slows the momentum of flood insurance reform and foils the acceptance of unorthodox approaches like strategic retreat via preserving subsidized insurance rates (FEMA [9], 2014). As the policies of this 2012 and 2014 reform are phased in, many landowners across the nation are going to face the same situation as the Jacobs Avenue community—they will discover that they are now located in flood zone areas and that their insurance rates are eventually going to be considerably higher. These changes could provide an important flashpoint for community members to take stock and engage in some long-range planning regarding flood hazard management. The scenario-planning framework outlined in this paper could be a valuable tool to allow stakeholders to consider possible actions and to plan for a better future.

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