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Sea-level Rise Risk Assessment Components

By Wayne Rasmussen

Uncertainty about climate change and the resulting sea-level rise is a matter of increasing concern to many people. Recent studies by the United Nations Intergovernmental Panel on Climate Change (IPCC) indicate that greenhouse gas (GHG) emissions have and will continue to contribute to an accelerated rate in the rise of average global temperature long into the future. It is believed that this will in turn trigger significant increases in the frequency and intensity of storms and a rise in sea level. If IPCC projections prove to be accurate, the adverse impacts on shoreline areas could be substantial, and major environmental and land-use adaptations will be necessary. The need to understand these risks in advance of committing investment funds to shoreline-area development will similarly be important for investors.

Historically, the risk of climate change and sea-level rise has only rarely been taken into account in land valuations, investment decisions, and development project planning. However, as a result of recent scientific studies and planning efforts in California, the level of concern within the state is reaching the point where regulatory agencies and private investors are beginning to actively respond. The important questions going forward will be: (1) what are the potential risks, (2) at what point might they become significant enough to take into account, and (3) how might this impact the value of specific sites?

The purpose of this article is to focus on the assessment of potential physical risks and regulatory issues that are evolving along with the emergence of climate change and sea-level rise. The San Francisco Bay Area is used as an example of how local governments are dealing with these problems on a more localized level. Scientific information developed in recent years for the Bay Area is used to provide a context pertaining to physical issues. The San Francisco Bay Conservation and Development Commission (BCDC) is similarly used as an example for conveying the kinds of regulatory safety measures being enacted to protect against future flood damage. These examples provide information helpful in understanding the kinds of risks that land investors, developers, and others should consider during their preliminary investment assessments.

THE CURRENT SCIENTIFIC AND REGULATORY ENVIRONMENT

During the past 25 years, the United Nations IPCC has been involved in assembling and assessing scientific information relating to climate change. During this time it has produced a series of technical and methodology reports that have become standard reference documents used worldwide by policymakers, scientists and other experts. Of particular importance is a series of recent reports relating to projections of future global development scenarios as a result of climate change. In each scenario, the key activities that influence global development rates were varied to create a range of future development patterns. These were then used to quantify the GHG emissions each would generate. This work relied upon the use of global climate models for projections. Although the IPCC studies concluded that a reduction in the recent rate of GHG emissions could reduce the degree of long-range impacts, they similarly concluded that it is inevitable during the coming centuries that global temperatures will continue to rise along with the sea level. Adapting to climate change and its impacts is therefore unavoidable and essential.

State Planning

Based on concerns about climate change, the State of California used the IPCC scenarios for an additional study of its own regarding climate change impacts at the state level. While the IPCC studies relied upon global models, the task of adapting to climate change and sea-level rise at the regional geographic level required a more detailed approach that was unique to the state's shoreline conditions. The state relied on the IPCC scenario projections and assumed a sea-level rise of 16 inches by the year

2050 and 55 inches by 2100. Subsequently, in 2006 the State Legislature passed the Global Warming Solutions Act that requires a reduction of GHG emissions to 1990 levels by 2020 and to 80 percent below 1990 levels by 2050.

Regional Planning

Concerns by San Francisco Bay Area citizens over climate change and sea-level rise led to action at a more local level by BCDC. BCDC is a regional planning agency responsible for the long-term protection and enhancement of the San Francisco Bay and its shorelines. The commission was established by the state in 1965. Membership consists of representatives appointed by various federal, state, regional, and county governmental entities. The work of BCDC during recent years provides helpful insights for drawing conclusions about the potential future influence of climate change on private land investments around the Bay.

BCDC is guided by a strategic plan known as the San Francisco Bay Plan.[1] This comprehensive planning document was adopted in 1968 and contains policies that guide future uses of the Bay and shoreline and maps that apply these policies. The plan was last amended in October 2011 to reflect recent climate change study results and projected sea-level rise in the San Francisco Bay region.

The San Francisco Bay Plan calls for BCDC to formulate a regional climate change and sea-level rise adaptation strategy. More specifically, it notes: "[I] ideally, the regional strategy will determine where and how existing development should be protected and infill development encouraged, where new development should be permitted, and where existing development should eventually be removed to allow the Bay to migrate inland."[2] To do this, BCDC will rely on the state's sea-level rise projections of 16 inches by 2050 and 55 inches by 2100. In the meantime, it will evaluate each development project proposed in vulnerable areas on a case-by-case basis. It is recognized that the IPCC sea level-rise projections are evolving and changing due in part to the evolving nature of the science, and that this will need to be monitored by BCDC over time.

The Bay Plan states that the areas vulnerable to inundation by sea-level rise in the year 2050 roughly correspond to the current 100-year flood plain. However, it further notes that "the coincidence of intense winter storms, extreme high tides, and high runoff, in combination with higher sea level, will increase the frequency and duration of shoreline flooding long before areas are permanently inundated by sea-level rise alone."

Finally, the Bay Plan requires the preparation of risk assessments for certain large development projects in conjunction with the submission of permit applications. Assessments are required to "identify all types of potential flooding, degrees of uncertainty, consequences of defense failure, and risks to existing habitat from proposed flood protection devices."

Local Planning

Planning for sea-level rise at the local level within the jurisdictions that surround the San Francisco Bay remains very limited. The reason for this is cited by BCDC: "staffing is a major barrier to gathering and identifying climate change information."[3] For example, local governments lack sufficient staff resources to analyze information, staff time to gather information, and technical assistance from state and federal government. These shortcomings have become particularly more difficult during the past several years due the ongoing recession.

RISK ASSESSMENT

The assessment of climate change and sea-level rise risk is generally applicable to large-scale private land investments in shoreline areas that are vulnerable to projected future flood damage. The nature and extent of risk assessments depend on the vulnerability of a site to physical damage, and the scope of regulations posed by the governmental agencies having authority over the area. Risk assessments can be used to identify and prioritize potential flood safety and property damage issues as well as regulatory concerns that may be important to consider prior to committing to an investment.

Assessments require the assimilation of information pertaining to the site characteristics and the worst-case sea-level rise/maximum storm scenario at critical time periods, such as at the projected end of the life of the investment. Assessments should address the capacity of the site to adapt to climate change impacts and the resilience of the development to flooding. Jurisdictional variables such as land-use and environmental controls, development impact mitigation fees, exactions, and existing

and planned public safety projects also need to be considered. Additional factors include the existing and potential future insurance cost increases for shoreline properties. These are all important variables that many investors will wrestle with as they consider investing in shoreline areas.

As climate change evolves to create a credible threat, more technical and comprehensive risk assessments will be needed. Civil engineering experience in coastal processes will be required to assess climate change, sea-level rise projections, and technical regulations. Land-use professionals may also be needed to advise with regard to land-use and environmental implications, as well as governmental and permitting processes.

PHYSICAL RISK

Maximum flood damage to shoreline areas typically results from the combination or coincidence of storm water runoff, storm surge, winds blowing onshore, high tides, and sea-level rise. Risk assessments are used to identify the nature and extent of potential flooding, damage vulnerabilities, consequences of flood defense failures, and degrees of uncertainty. Assessments often pertain to the life of prospective investments but can also be useful in identifying the extent of vulnerabilities beyond that point to help investors glean the potential future condition of properties at the anticipated time of resale.

Physical risk assessments can perhaps most efficiently and reliably be conducted by using the 100-year flood maps provided by the Federal Emergency Management Agency (FEMA) as the base high water level metric. These maps can then be overlaid with sea-level rise projection maps for specific target years (i.e., 2030, 2050, 2070, 2100, etc.). Overlay maps should utilize the best available science-based sea-level rise projections. That information is most commonly available through studies conducted by IPCC and state and regional governments. To the extent possible, it is important that sources of information be combined to address the maximum flood damage scenario.

In conjunction with addressing potential site vulnerabilities to flood damage, it is also important to factor in any existing or planned static flood protection measures that might help to reduce or prevent future flood damage. These commonly include seawalls, rip-rap, revetments, and levees. Structural shoreline protection of these kinds can hold floodwaters back from the shoreline areas.

Depending on existing site conditions and planned development, the kinds of storm damage vulnerabilities a given site or development might face will vary. Some of the more common areas of concern include:

- Personal injury and loss of life
- Damage to buildings and other structures
- Damage to utilities
- Damage to low-lying areas of fill near the shoreline that are subject to future consolidation or compaction of soft fill materials, and thus vulnerable to subsidence. Subsidence issues may also exist in low-lying areas where the extraction of subsurface groundwater or natural gas has occurred.
- Temporary loss of emergency vehicle access
- Health risks created by potential off-site contamination and wastewater treatment plant releases during major storms and flooding
- Beach and cliff erosion
- Damage to existing on-site and off-site storm water protection barriers and the impacts this could create
- Loss of vegetation
- Damage to beach recreation opportunities
- Damage to on-site and off-site views
- Impact of business downtime resulting from flooding

Upon understanding the range of risks, land development can be planned to minimize potential flood damage. The safety of proposed projects can be achieved in a variety of ways. Locating buildings and other critical structures and infrastructure back from or above the 100-year flood plain, taking sea-level rise into account for the expected life of the project, is the most effective way of guarding against flood damage. Where this is not feasible, structures might be engineered to tolerate periodic flooding or planned to be temporary and removable. Storm drainage systems should be constructed to ensure

that they will drain by gravity to accommodate the target-year storm event.

Other technical protection measures include raising the shoreline to reduce the frequency of wave overtopping and installing storm drain pumps. A cobblestone beach can be constructed to limit overtopping and create a public use amenity. Another technique is to construct a series of embankments that increase in height as they are situated back from the water. The land between the embankments can be utilized to hold periodic wave overtopping that then drains back out between high tides while creating habitat.

REGULATORY ISSUES

Government at all levels will have a vital interest in ensuring the protection of people, property, and the environment from the harmful effects that climate change could pose in the future. This will no doubt lead to, among other things, expanded regulatory processes. Adaptive management strategies for development in vulnerable shoreline areas can be expected, including: (1) requiring the construction of buildings and other structures and infrastructure to be resilient or adaptable to flooding over time; (2) discouraging new permanent development where adaptive strategies are not capable of protecting public safety; (3) permitting only new uses that can be phased out or removed as flooding threats increase if adaption strategies are not capable of protecting public safety; and (4) removing or relocating existing development over time, and as appropriate, where public safety cannot otherwise be achieved. Overall, climate change regulations could also tend to limit the type, intensity, and location of land use in undeveloped vulnerable areas while increasing the costs of construction.

At the federal level, agencies such as the National Oceanic and Atmospheric Administration, Federal Emergency Management Agency, and the U.S. Army Corps of Engineers are presently taking the lead. Also, given the fragile ecology of coastal and other shoreline areas, the U.S. Environmental Protection Agency and the U.S. Fish and Wildlife Service can be expected to play increasing roles in the protection of threatened shoreline areas for wildlife and habitat use.

Like the federal government, state governments and agencies will face increased responsibilities. California's recently enacted Global Warming Solutions Act[4] is a good example of a state-level response to the sustainability and climate change issues of the times. Federal and state responses will further filter down to regional environmental agencies that have regulatory authority in shoreline areas, such as the California Coastal Commission and BCDC.

Climate change protection measures are also taking place at the local level in some city and county governments and special districts. This is occurring primarily through the preparation and implementation of climate action programs aimed at reducing GHG emissions, environmental review and mitigation, and implementation of related local public safety projects.

Removal or Relocation of Existing Development

The combination of future sea-level rise and increased storm intensity may result in a need for the removal or relocation of certain existing shoreline and subsiding fill area development. The conditions for this arise in situations where public safety cannot otherwise be ensured. Typical examples include unprotected low-lying structures such as bridges and other encroachments into drainage channels that are subject to collapse and blocking storm water flow. Other examples include roadways and buildings that are being severely undercut by erosion, developments in slide areas that are being undercut by erosion, and engineered storm drain channels that become unable to drain due to sea-level rise or increased flood water elevations.

Another cause for the removal or relocation of existing development is to allow rising waters to migrate inland. This condition may exist where no feasible solutions can be found to prevent developed areas from becoming inundated. It may also exist where critical ecosystem restoration land is needed. In other cases landowners may be allowed to develop, but with the expectation that the improvements will be removed prior to facing a safety risk posed by sea-level rise and intensive storms.

Dedications

The required dedication in fee simple title or by permanent easement for access to shoreline areas by local governments is a common consideration during the permitting process for subdivisions and development project applications. The most common types of required dedications include floodway access roads for emergency and maintenance vehicles, conservation of protective natural buffers and

other open space, floodways, and relocated or new public access for pedestrian trails.

Development Impact Fees

In situations where on-site flood protection or other regulatory requirements resulting from project impacts cannot be adequately met, the developer may be required to pay in-lieu mitigation fees to help defray the cost of constructing related public improvement projects elsewhere. Developers may have to pay fees that help to cover the costs of such items as future off-site shoreline protection devices, public access to shoreline areas, flood-proofing the infrastructure that serves the new development, potential emergency response efforts, or mitigating impacts on natural resources and the local ecology.

Levee Widening

Levees are generally constructed of fill and used as a barrier to regulate water levels and protect against flooding. As the sea level rises and storms intensify, existing levees may become inadequate in terms of height and strength to provide the intended protection against flooding. In addition, shoreline levees are subject to dynamic wave energy that works to undermine their base and erode their seaward walls.

In the future, the need for higher and stronger levees is anticipated. This will necessitate wider bases to accommodate these larger structures. The permitting agencies can generally be expected to require an increased right-of-way width on the land side for future widening so that no levee fill will have to be placed on the seaward side. This may therefore have the potential to somewhat decrease the land area of the subject property.

Public Access

The protection, replacement, and development of public access to beaches and other shoreline areas are important considerations for public agencies having shoreline regulatory authority. Substantial access to and along shorelines presently exists under public ownership, including parks, public beaches, trail easements, connections linking public streets to shorelines, etc. Many jurisdictions have the authority to require developers of new projects to provide further public access as a condition of development permit approval. In addition, common law doctrines provide legal mechanisms to preserve public access to beaches or other areas traditionally used by the public through implied dedication, custom, and prescription.

Accelerated flooding from sea-level rise and more intensive storms can be expected to negatively impact existing shoreline public access. This would result in increased public safety issues, increased repair and maintenance costs, new shoreline protection measures, and some permanent access closures. In most cases, new and replacement public access routes will need to be constructed farther back inland and at higher elevations than the existing ones. This would result in the need for additional inland areas. It would also create additional development issues relating to usable land area, site planning, security, environmental protection, and so forth.

Rolling Jurisdictional and Access Easement Boundaries

In California, state ownership rights of tidelands and submerged lands are based on common law principles that "the state owns all tidelands below the ordinary high water mark and holds such lands in trust for the public, and as the land along a body of water generally builds up or erodes, the ordinary high water mark necessarily moves and thus the mark or line of mean high tide, i.e., the legal boundary, also moves."[5] This is commonly known as a "rolling jurisdictional boundary." Since the shoreline boundary is subject to moving landward with sea-level rise, it may be important in some cases for investors to understand the possible future extent of this movement. The potential exists that low-lying land, such as fill areas, could be subject to public ownership as the sea level rises.

This landward boundary movement not only involves state ownership rights but also can pertain to other jurisdictional boundaries. For example, the area subject to BCDC's authority is also based upon the mean high tide level and will thus move landward with sea-level rise. In 1994, this aspect of BCDC's jurisdiction was recognized by the California court system as "ambulatory" when the court held that "if the sea level does rise [due to global warming], so will the level of mean high tide."[6]

Unlike the BCDC boundary, the California Coastal Commission's jurisdictional boundary is fixed

geographically and is not subject to landward movement with sea-level rise. This distinction is very important because it can play a major role in determining the extent of regulatory involvement in the permitting process for certain development projects and other land investments, particularly over longer periods of time.

BEST PRACTICES

The method of assessing the risks of site-specific sea-level rise is a new practice that is evolving along with the science of climate change. Some of the key areas of concern to the developers of large-scale development projects in the future have already become clear, however. These consist of the following items that will need to be assessed in advance of making major investment decisions:

- Personal injury, loss of life and other health risks
- Damage to structures and utilities
- Beach and cliff erosion and other loss of land
- Damage to protective on-site and off-site storm water protection barriers
- The level of governmental permitting involvement in the planning of development projects
- Reduced land-use potential
- Removal or relocation of existing development
- Dedication of land or easements
- Increased development impact fees
- Public access requirements

CONCLUSION

If the United Nations IPCC projections regarding climate change and sea-level rise generally prove to be accurate over time, then the impact on shoreline areas could be substantial, and major environmental and land-use adaptations will be necessary. Based on the present state of scientific study and recent planning efforts in California and the San Francisco Bay Area, it is clear that the level of public concern here is significant. The need to understand the risks of climate change and sea-level rise in advance of committing investment funds to shoreline area projects may similarly become important to investors as the extent of this risk becomes evident during the coming years.

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Notes

1. San Francisco Bay Conservation and Development Commission. 1968. *San Francisco Bay Plan*

2. San Francisco Bay Conservation and Development Commission. *Resolution Number 11-08*. October 6, 2011. Page 18

3. San Francisco Bay Conservation and Development Commission. *Living with a Rising Bay: Vulnerability and Adaption in San Francisco Bay and on Its Shoreline*. Page 114.

4. State of California. 2006. *Assembly Bill 32: Global Warming Solutions Act*

5. *Lechuza*, 70 Cal. Rptr. 2d 399, 410 and 418 (1997)

6. *Littoral Development*, 24 Cal. App. 4th at 1050, note 5.