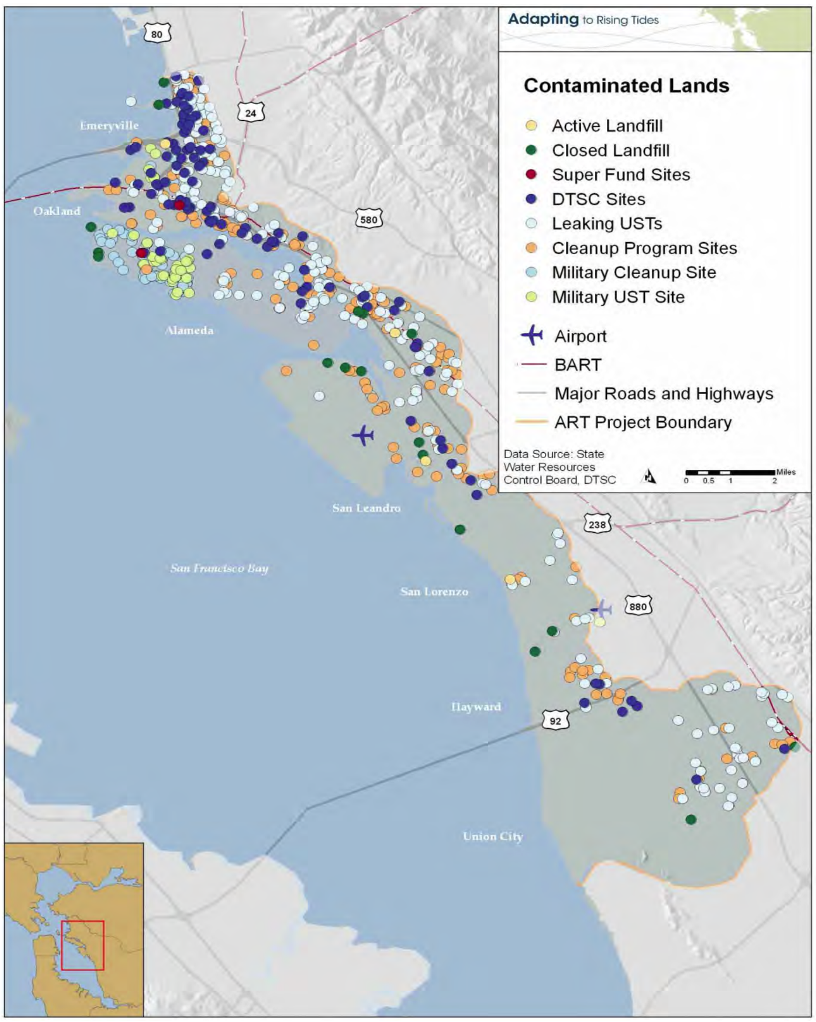
Chapter 14. Contaminated Lands

Contaminated lands are sites in the ART project area that are contaminated with materials that pose a hazard to people and/or the environment. In general, the threat posed by a contaminated site depends on its potential to release hazardous substances into the environment; the characteristics of the substances (e.g., toxicity and quantity); and people, ecosystems, and other sensitive receptors that would be affected by a release of hazardous substances.

This report identifies eight types of contaminated lands (See Figure 1 and Table 1): Federal Superfund sites; Site Cleanup Program[1] sites; Leaking Underground Storage Tanks (USTs), divided into military and non-military UST sites; Military Cleanup sites; Department of Toxic Substances Control (DTSC) sites, which include some Site Cleanup Program and UST sites; and closed and active landfills. There is some overlap across these types of sites – for example, a landfill could contain USTs, or a Superfund site could contain landfills – and agencies may share oversight responsibilities over individual sites.

Figure 1. Map of contaminated lands in ART project area, by type of site.



The two Superfund sites are the Alameda Naval Air Station, now known as Alameda Point, in Alameda, and the former AMCO Chemical Facility in West Oakland. The other types of contaminated lands are found throughout the ART project area, with clusters in certain neighborhoods or geographic areas. For example, most of the Military Cleanup Sites and Military USTs are found in Alameda Point, within and adjacent to the Alameda Naval Air Station Superfund site, or at or near the Oakland Army Base (also known as the Oakland Gateway Development site). Many of the Site Cleanup Program and DTSC sites are found in former industrial areas, such as Emeryville, West Oakland, and Downtown Oakland. A number of closed landfills are located directly along the shoreline and even protrude into the Bay. Some of them are now used as shoreline parks.

[1] Formerly called the Spills, Leaks, Investigation, Cleanup (SLIC) Program, the Site Cleanup Program is run by Regional Water Quality Control Boards and the State Water Resources Control Board.

Table 1. Types of contaminated lands addressed in this report and number of each type documented in the ART project area.

Type of Site	#	Description	Regulatory Agencies
Superfund	2	A federal Superfund site is an abandoned area where hazardous waste is located, possibly affecting local ecosystems or people. These areas have been designated on a National Priorities List through the federal Superfund cleanup program.	The US Environmental Protection Agency (US EPA) has primary jurisdiction over Superfund sites, with the involvement of the Regional Water Quality Control Board (RWQCB) and the State Department of Toxic Substances Control (DTSC).
Site Cleanup Program	303	Cleanup program sites are locations that have had unauthorized releases of pollutants that have contaminated soil or groundwater, and in some cases surface water and sediment.	California State Water Resources Control Board's (SWRCB) and RWQCB
Leaking UST	405	Leaking USTs are sites that have or had leaking USTs. The vast majority of leaking UST sites are contaminated with petroleum products associated with gasoline service station operation. Tetrachloroethylene (TCE) is another common contaminant from leaking USTs and is commonly associated with the dry cleaning process.	Generally under jurisdiction of SWRCB with RWQCB or DTSC as lead agency for cleanup.
Military UST	43	Military facilities with leaking USTs	SWRCB, RWQCB, and Department of Defense (DOD)
Military Cleanup	96	Sites at military facilities with water quality issues. The facilities that require environmental cleanups range from UST sites to Superfund sites, and can be part of other sites such as DTSC sites.	SWRCB, RWQCB, DOD, DTSC
DTSC	112	DTSC sites can be State Cleanup, leaking UST, or other contaminated lands sites for which the Department of Toxic Substances Control is the lead agency for cleanup.	DTSC
Landfill (closed)	15	A landfill is a solid waste management facility where waste is or once was disposed of on land or in tidal areas. Landfills do not include surface impoundments, waste piles, land treatment units, injection wells, or soil amendments. Some of the sites identified as active landfills in this report are waste treatment areas that are not permanently used for storing waste – for example, 5 sites are "processing" facilities such as green waste chipping and composting sites or sites where construction and demolition materials are processed before being transported elsewhere.	SWRCB and RWQCB with other state & local agencies such as CalRecycle, Counties, and Cities.
Landfill (active)	6		
Total	**982**		

Contaminants found in soil and groundwater in the ART project area include industrial solvents (such as acetone, benzene, and chlorinated solvents and their byproducts), acids, paint strippers, degreasers, caustic cleaners, pesticides, chromium and cyanide wastes, polychlorinated biphenyls (PCBs) and other chlorinated hydrocarbons, radium associated with dial painting and stripping, medical debris, unexploded ordnance, metals (e.g., lead, chromium, nickel), gasoline, diesel, and petroleum byproducts, and waste oils. Most of the contaminated lands sites are privately owned, although cities and municipalities often own closed landfills that are now used as parks and open space. The cleanup of contaminated lands is overseen by a number of agencies. The US Environmental Protection Agency (US EPA) is the lead regulatory agency for Superfund sites, and the Navy, DTSC, and the San Francisco Regional Water Quality Control Board (RWQCB) are also involved in the Alameda Point site. The State Water Resources Control Board (SWRCB), San Francisco RWQCB, and DTSC manage Site Cleanup Program sites, and UST sites are managed by the SWRCB, with the San Francisco RWQCB or DTSC often authorized with implementation of cleanup.

Most of the contaminated lands in the ART project area are at various stages of remediation, ranging from being under investigation to determine the risk to water quality and human and environmental health to active cleanup. Sites that have been remediated and closed – i.e., where contaminants have been fully removed – are not included in this analysis. Sites that have been remediated by leaving contaminants in place and containing them through capping or other methods are included in this report. This includes closed landfills, which, once they stop receiving waste, are meant to remain in place. Of the 21 landfills identified in this report, only one is actively receiving solid waste for permanent storage, while there are five active “processing” facilities. These sites receive waste such as construction and demolition materials or green waste, process it onsite, and then send it elsewhere. There are 15 closed solid waste storage sites, including a dredge disposal site, a steel company’s disposal site, and many former “dumps” or landfills that existed prior to the passage of regulations requiring permits for such facilities. Many of these earlier, pre-regulation landfills are not lined; however, waste at closed Bay margin landfills is generally well isolated, due to the low permeability of the native deposits (Bay mud) underlying them. This means that even if a landfill cap is not watertight and surface water comes into contact with the buried waste, the resulting leachate should not be released into the groundwater at a significant rate. To guard against this possibility, however, groundwater and surface waters at the landfills are monitored regularly, and many landfills have leachate collection systems.

For the purposes of this assessment, the goal of contaminated lands management is to prevent the release and spread of the hazardous substances with which the land is contaminated. The release of hazardous substances occurs through four primary pathways: groundwater migration, surface water flow, soil exposure, and release to the air (vaporization). These pathways affect receptors indirectly, through contamination of drinking water and food chains, as well through direct exposure of human populations and sensitive ecosystems (US EPA, Hazard Ranking System). This assessment evaluates the vulnerability of contaminated lands with regard to how well current management can prevent the release and spread of contaminants in the face of sea level rise.

Exposure

Exposure is the extent to which an asset – such as a leaking UST, landfill, or Superfund site – experiences a specific climate change impact such as storm event flooding, tidal inundation, or elevated groundwater. This report analyzes exposure of the eight types of contaminated lands identified in the ART project area to two sea level rise projections and three Bay water levels. The two sea level rise projections, 16 inches (40 cm) and 55 inches (140 cm), correlate approximately to mid- and end-of-century. These projections were coupled with three Bay water levels: the highest average daily high tide represented by mean higher high water (MHHW), hereafter “high tide” or “daily high tide;” the 100-year extreme water level, also known as the 100-year stillwater elevation (100-year SWEL), hereafter “100-year storm” or “storm event;” and the 100-year extreme water level coupled with wind-driven waves, hereafter “storm event with wind waves” or “wind waves.” These water levels were selected because they represent a reasonable range of potential Bay conditions that will affect flooding and inundation along the shoreline. For more information about sea level rise projections and Bay water levels evaluated see Chapters 1 and 2.

The exposure of contaminated sites was analyzed for a circular 164-foot (50-meter) diameter footprint centered on the point location of the site (see Appendix C). This approach was verified as being representative of the approximate footprint of most assets evaluated in this manner. The exposure of each type of contaminated lands to the daily high tide, storm event flooding, and wind waves was evaluated in a binary, i.e., yes versus no, analysis. Whether each site is within a disconnected low-lying area[2] was also evaluated and recorded as yes or no.

Table 2 shows the number of each type of site exposed. With 16 inches of sea level rise, only 14 of the 982 sites will be exposed to the new daily high tide, and 19 sites are in disconnected low-lying areas that could be exposed. Sixty sites will be exposed to storm event flooding, and 48 are in disconnected low-lying areas that could be exposed to this impact. The 60 sites exposed to storm event flooding will also be exposed to wind waves, and 345 additional sites will be exposed to wind waves only.

Many more sites will be exposed to the new Bay water levels with 55 inches of sea level rise. One hundred thirteen sites will be exposed to the new daily high tide, with an additional 18 sites in disconnected low-lying areas potentially exposed. Three hundred forty three sites will be exposed to storm event flooding, and eight sites in disconnected low-lying areas could be exposed to this impact. The 343 sites exposed to storm event flooding will also be exposed to wind waves, and 145 additional sites will be exposed to wind waves only.

[2] Disconnected low-lying areas are at the same elevation or are lower than an adjacent inundated area. Assets in these areas are not considered exposed because a topographic feature such as a railroad or road embankment should prevent inundation. However, they could be exposed if the protective feature fails. See Chapter 2 for a more detailed explanation.

Table 2. Number of contaminated lands sites exposed to the daily high tide and storm event flooding with 16 and 55 inches of sea level rise.

		16" SLR			55"SLR		
		Daily High Tide	Storm Event		Daily High Tide	Storm Event	
Type of Asset	**Total number of sites**	**Number exposed**	**Number exposed**	**Number exposed to wind waves only**	**Number exposed**	**Number exposed**	**Number exposed to wind waves only**
Superfund	2			2		1	1
Site Cleanup Program	303	7	17	77	34	85	41
Leaking UST	405	3	11	98	21	92	50
Military UST	43		4	35	8	32	7
Military Cleanup	96	1	18	64	28	73	12
DTSC	112	1	5	63	16	49	30
Landfill	21	2	5	6	6	11	4
Total	**982**	**14**	**60**	**345**	**113**	**343**	**145**

The majority of the exposed sites contain petroleum products such as gasoline, diesel, and waste oils, and many of the exposed sites have already contaminated the local groundwater, which is being remediated under the supervision of federal, state, and local agencies. At least one site contains PCBs, while several others contain industrial solvents and/or metals. Two of the exposed sites are former landfills that have been turned into parks – Point Emory Park and Oyster Bay Regional Park.

Sensitivity and Adaptive Capacity

The sensitivity and adaptive capacity of contaminated lands in the ART project area was assessed for three potential climate impacts that could occur due to sea level rise and storm events. The three climate impacts considered are:

- More frequent floods or floods that last longer due to storm events
- Permanent or frequent inundation by the daily high tide
- Elevated groundwater levels and saltwater intrusion

Sensitivity is the degree to which an asset or entire system (e.g., landfills, UST sites, or management capacity of DTSC, SWRCB, and the San Francisco RWQCB) would be physically or functionally impaired if exposed to a climate impact. Adaptive capacity is the ability for an asset or system to accommodate or adjust to a climate impact and maintain or quickly resume its primary function. The sensitivity of the contaminated lands varies by type of site, the contaminants present, their mobilization pathways, and the degree of remediation.

Across all categories of sites, the types of contaminants present affect sensitivity. Contaminants that are bound to sediments, such as PCBs, could be mobilized into the Bay or other areas if the sediments to which they are bound are disturbed and relocated, for example, due to wave action during storms. Other types of contaminants, such as solvents, are often present as soil gas and could go into solution if exposed to water – this could occur due to rising groundwater or infiltration of Bay water during high tides or storms. Another source of sensitivity common to all types of sites is the shortage of funding for cleanup. In some cases, the landowner cannot be located or is unable to pay for or participate in cleanup; while public funds may be available in such cases, additional agency intervention may be necessary, extending the timeline for cleanup.

Another source of sensitivity across the system is the proximity of the ART project area to seismic faults. Earthquakes could compromise the integrity of caps and liners, and could also cause liquefaction, which occurs when loose sediments are shaken and can result in widespread lateral displacement of the land surface. Rising groundwater increases the risk of liquefaction, which is already very high in the ART project area. Displacement of the ground due to liquefaction in a seismic event could compromise the stability of waste containment facilities, such as landfill caps or liners, caps over remediated sites, and slurry walls constructed to contain contaminants. Sensitivity to climate impacts for the different categories of contaminated lands is discussed below.

Leaking USTs tend to contaminate soil and groundwater in their vicinity. Therefore, they are sensitive to rising groundwater, since this impact could expose more groundwater to contaminants. Saltwater intrusion into groundwater could also corrode underground storage tanks (Titus, 2009) and cause additional leaking. USTs are less likely to be sensitive to storm-related flooding unless floodwaters are very high-energy and scour contaminated soils, exposing and possibly moving the tank. Floodwater that remains for a long time period could infiltrate through the soil or enter the tank and become contaminated, or cause empty tanks to "float" and pop out of the ground. Tidal inundation could pose more of a problem, due to the frequency and duration of exposure, which could result in greater likelihood of contact with contaminated soils and tank contents, leaching through contaminants to groundwater below, or causing empty tanks to float.

One source of adaptive capacity for some leaking USTs is the possibility of removing them, which would at least prevent additional contamination of the area. Further remediation would need to take place to remove contaminants that have already released. One approach for some types of contaminants, such as solvents, is to treat contaminated groundwater in situ. Where this is an option, it contributes to adaptive capacity, and these techniques may be increasingly necessary as groundwater tables rise and more groundwater interacts with contaminants. Monitoring tanks so that leaks are detected early also adds to adaptive capacity.

Site Cleanup Program and DTSC sites have historically been remediated in two ways: removal and in-place remediation. Sites where contaminants have been completely removed and the site is considered closed are not included in this report. Some sites are remediated in place because there is nowhere to take the material, or it is deemed to be a less environmentally harmful approach – for example, trucking loads of contaminated materials contributes to GHG emissions, and digging up and transporting contaminated soil could create new opportunities for exposure. Most sites that have been remediated in place are covered with one to three feet of clean soil under a cap of concrete or other material (sometimes in the form of a road or building). While this method is intended to contain contaminants, such sites are sensitive to flooding and rising groundwater. For example, water-soluble substances, such as solvents, could become mobilized in floodwaters in sites with compromised caps that do not prevent the infiltration of Bay water, and rising groundwater could also become contaminated with water-soluble substances.

Sites where contaminants can be completely removed have greater adaptive capacity than those that must have in-place remediation. Adaptive capacity also comes from regulatory requirements and procedures. For example, upon discovery of a contaminated site, DTSC and RWQCB coordinate to determine which agency is most appropriate to lead the cleanup. The lead agency then conducts a preliminary environmental assessment, carries out a remedial investigation to determine the extent of contamination, and develops a cleanup plan. This process can take years from initiation to the implementation of cleanup, and the cleanup itself can take many years, depending on the nature and extent of the contamination, cooperation of site owner(s), and resources available. While the long timeframe adds to sensitivity, the thorough documentation and remediation planning contribute to adaptive capacity. DTSC policy also requires periodic monitoring of sites where contaminated materials have been remediated in place, and requires that such sites be checked after a disaster such as an earthquake or a flood to ensure that the containment method is still operating as intended.

Landfills could be sensitive to sea level rise, depending on the type and location of the site. Closed permanent storage facilities, like the remediated sites discussed above, are generally capped by an impermeable or low permeability layer, such as clay, and underlain by the native geologic material, which for landfills on the Bay margin is a type of clay called Bay Mud (Figure 2). The caps are designed to prevent the vertical migration of water from above the landfill, into and through the waste, and down to the groundwater table. However, tidal inundation or storm event flooding could contribute to the creation of leachate where caps are not watertight. Leachate production could also occur if rising groundwater migrates into the waste, which would necessitate greater leachate removal at some sites where it is already necessary, or the installation of a leachate collection system at sites where it has previously not been necessary.

Figure 2. Oyster Bay Regional Shoreline is a closed landfill that has been capped and turned into a park.

Swiftly flowing floodwaters in a storm event could scour the sides of landfills and expose buried wastes. Older landfills may be particularly sensitive to climate impacts, as some were constructed, filled, and capped prior to regulations regarding linings, caps, leachate collection, and other design principles. However, they are closely monitored and managers are required to take corrective action if there is a threat to water quality or human or environmental health. While waste processing sites should not be sensitive to tidal inundation and rising groundwater because materials can be moved from these facilities, they could be sensitive to storm event flooding if there is insufficient time to remove materials.

Adaptive capacity derives from the guidelines and rules regulating the management of contaminated lands. For example, the SWRCB issues Waste Discharge Requirements (WDRs) that guide site management practices for landfills. WDRs are periodically updated, which gives the SWRCB the ability to identify vulnerabilities and modify management plans over time. As part of these updates, the SWRCB is now requiring site owners to plan for sea level rise. While WDRs may only be updated every 5-15 years for any given site, potential sea level rise effects, among other issues, are evaluated every five years. If necessary, a similar clause could be included in Cleanup and Abatement Orders, the primary regulatory tool for cleanup cases.

Also contributing to adaptive capacity in the case of landfills is the requirement for immediate remediation if a release of contaminants is discovered. Because each site is already characterized – that is, regulators know the contents of the landfill and are aware of nearby sensitive receptors – regulators and owners know the risks associated with a release and should therefore be well equipped to take action. Landfill owners are also required by law to maintain stable slopes on landfills, which contribute to adaptive capacity with regard to erosion potential. Management practices such as monitoring groundwater, pumping leachate, building and maintaining levees around sites (such as landfills in or directly adjacent to the Bay), using stormwater ditches to route surface water, and developing disaster response plans all contribute to adaptive capacity.

Figure 3. Alameda Point Superfund site. (Source: Telstar Logistics', Flickr Commons)

The Superfund sites in the ART project area contain most of the types of sites discussed above, including landfills, USTs, and cleanup sites, and thus have the same types of sensitivity and adaptive capacity. Their size, complexity, and the variety of contaminants present, however, make them particularly sensitive. For example, in addition to multiple UST sites and landfills, Alameda Point has a plume of contaminated groundwater and unexploded ordnance (Figure 3). While the federal funding and EPA support that comes with a Superfund designation should contribute to adaptive capacity, Superfund has a backlog of sites to clean up and is woefully underfunded (U.S. PIRG, 2005).[3]

In addition to the sensitivity of each contaminated lands site, the system of contaminated lands is sensitive to sea level rise. One form of sensitivity is related to the concentration of each contaminant in the environment, which determines the extent of the consequences. The exposure and release of contaminants from multiple sites could have greater impacts than isolated releases. For example, in the case of PCBs, should multiple sites release this contaminant into the Bay, it could affect overall concentrations to a greater degree than a single release. Another sensitivity of the system is the challenge of responding to multiple exposures; should asset owners and managers become overwhelmed, for example, in preventing releases from their sites in the event of a large storm, the system as a whole would be vulnerable. Likewise, coordinating among all of the agencies responsible for contaminated lands if there is a large event could prove challenging (See Box on Hurricane Katrina).

The sensitivities and sources of adaptive capacity discussed in this section are specific to the types of contaminated lands identified in this report. However, there are other types of contaminated lands that are not considered here, such as residential properties with lead contamination from old paint that has flaked off onto the grounds. Such sites pose additional challenges, as they are undocumented, have not been remediated, and are likely to be present on the land surface, where mobilization could more easily occur than documented sites under remediation.

[3] While this is a problem for many Superfund sites, including the AMCO site, the cleanup of Alameda Point is funded by the Navy, so the Superfund budget is less of a concern in this case.

Hurricane Katrina and Contaminated Lands

Recent events demonstrate some of the challenges posed by the flooding of contaminated lands and provide examples of adaptive capacity and governance issues. Hurricane Katrina passed over 18 Superfund National Priority List sites and more than 400 industrial facilities that store or manage hazardous materials, and caused the release of over 7 million gallons of oil in Louisiana and Mississippi (US EPA, 2006). The US EPA sampled Superfund sites, sediments, and drinking water during and after the flood and coordinated with state and local agencies to share testing data and communicate with the public – for example, issuing temporary boil orders where drinking water was unsafe.

In a summary of the incident, the agency states that tests of floodwaters and Lake Pontchartrain did not indicate a higher level of contaminants post-flood than existed before, and they determined that contaminants did not pose a human health risk in most areas. Likewise, testing after the floodwaters receded of sediments spread throughout the city did not indicate a general increased risk from contaminants (Reible et al., 2006). However, certain areas of the city near specific sites or events, such as the failure and spill of the Murphy Oil crude oil tank and the Agriculture Street Landfill (a closed Superfund site), tested above acceptable levels for certain contaminants including Polycyclic Aromatic Hydrocarbons (PAHs), which are carcinogens, and arsenic (NRDC, 2005; US EPA, 2008). Katrina highlights the sensitivity of contaminated lands to flooding – even those that have been cleaned up – as well as the potential consequences to human health and the environment when contaminants are released.

Consequences

The potential consequences of the climate impacts on contaminated lands are considered for the ART project area. Consequences are the magnitude of the economic, social, environmental, and governance effects if an impact occurs. Factors that inform the magnitude of the potential consequences include the severity of the impact on Operations and Maintenance or capital improvement costs, the size and demographics of the population affected, the types of natural resources affected, and the type, extent, and severity of the effects on humans and the environment.

Economy

There are potential direct and indirect economic consequences related to the exposure of contaminated land to climate impacts. Direct consequences include the costs of containment efforts, such as sandbagging, digging trenches, and pumping leachate, and cleanup of damaged property. Indirect economic consequences include losses if the contaminants were to affect an industry such as fisheries or tourism. If human health is affected, productivity losses, increased health care costs, or liability claims could also occur. A longer-term economic impact could occur if contaminants are redistributed onto new sites, reducing the availability of productive, usable land and increasing the number of sites requiring cleanup.

Society

Much of the contaminated land in the ART project area contains materials that are harmful to human health. The actual health consequences of a release of contaminants would depend on the substances released and the proximity of the sites to sensitive receptors, such as residential areas, schools, hospitals, and housing for the elderly. It also depends on the mode of contamination. For example, lead – one of the contaminants found in the ART project area – is commonly ingested by children playing in soils that contain lead-based paint chips; the children unknowingly ingest it, which can cause developmental and other health problems. Lead in contaminated sediment that is redistributed by tidal action or storm events associated with sea level rise could increase the potential for exposure through this same pathway. PCBs, on the other hand, are more of a concern for human health if they are suspended in the water column and consumed by fish (and then by people), since they reach high concentrations in wildlife at the top of the food chain where they can cause developmental abnormalities, growth suppression, endocrine disruption, impairment of immune system function, and cancer. Structures built over a site contaminated with solvents can experience indoor air problems when contaminants are dissolved in groundwater. Contaminants that come into contact with groundwater would pose an additional threat to human health if the water were used for drinking; as mentioned above, many leaking USTs in the ART project area have already contaminated the groundwater near them, but this water is not used for drinking at this point and it is undergoing remediation. Unexploded ordnance at military cleanup sites poses an entirely different set of consequences for society – namely, that its redistribution could result in the undocumented presence of dangerous explosive material in unlikely places.

Environment

As is the case for human health, many of the materials contained in contaminated lands are also hazardous to the environment. Section 303(d) of the Federal Clean Water Act requires that states develop a list of water bodies that do not meet water quality standards, establish priority rankings for waters on the list and develop action plans to improve water quality. For San Francisco Bay, the RWQCB proposes a list of primary pollutants or stressors every two years. Several of the pollutants found in contaminated lands in the ART project area, such as PCBs, nickel, lead, chromium, cyanide, and pesticides are on the 2010 303(d) list for San Francisco Bay. Some of these pollutants, such as PCBs, affect the health of wildlife just as they do people.

Governance

Many contaminated lands sites are privately owned, although municipalities own some sites, such as many of the landfills. A number of entities are responsible for directing cleanups, developing and enforcing operational requirements, and inspecting and monitoring sites. Multiple agencies may have authority over the same site in some cases, especially if several types of contaminant sources are present on one site. Such joint jurisdiction is handled through contracts. The current complex system of site management could cause delays or other inefficiencies in developing strategies and priorities, or responding to problems; on the other hand, the large number of agencies regulating contaminated lands and their cleanup, each from a different perspective, should help to catch any problems that may arise, which could ultimately create a more resilient system. However, with current funding levels of clean up efforts insufficient to keep pace with newly identified sites, if sea level rise impacts mobilize contaminants along pathways to sensitive receptors, it is possible that exposure rates to humans, wildlife and habitats could increase.

Key Findings

There are nearly 1,000 contaminated lands sites in the ART project area. Most are not exposed to the daily high tide or storm events with 16 inches of sea level rise, although approximately one third are exposed to wind waves. Even with 55 inches of sea level rise, the majority of contaminated lands are not exposed to the daily high tide; 261, or approximately 25%, are exposed to storm events, with an additional 163 exposed to wind waves only. The most common sites in the ART project area are leaking USTs and Site Cleanup Program sites; these are also the sites most commonly exposed to sea level rise.

Different types of contaminated lands are vulnerable to sea level rise in different ways. Sites contaminated with solvents, for example, are sensitive to rising groundwater because solvents can go into solution in groundwater and spread underground and/or cause air quality problems in buildings constructed on top of the site. Sites with PCBs, on the other hand, may be more sensitive to storm event flooding because PCBs bind to sediment; if floodwaters cause erosion of contaminated sediments, PCBs could be carried to the Bay, where they are already a problem for wildlife and people who consume fish caught in the Bay.

Where contaminants can be removed, vulnerability is lower. Sites with contaminants that cannot be removed due to technical challenges, environmental risks, or funding issues, must be remediated in place. This involves caps, liners, pumps, in situ groundwater treatment, and other measures to ensure that contaminants are contained. These sites are subject to regular monitoring as well as special checks after natural disasters such as floods and earthquakes. More frequent flooding and rising groundwater could result in the need for more checks and improved containment measures.

Because most contaminated land sites are privately owned, the pace of cleanup depends in part on being able to locate property owners, and on the availability of funding either from property owners or public sources. Regulatory agencies mandate certain practices – such as the SWRCB's Waste Discharge Requirements (WDRs) requiring site owners to plan for sea level rise – that contribute to adaptive capacity, and they may prioritize cleanup among the sites under their purview. However, there is no single database that the public can use to track and understand the condition of contaminated sites that may be vulnerable to sea level rise and other risks.

While the majority of contaminated lands are not exposed to sea level rise, the sheer number of sites in the ART project area means that the small percentage adds up to a large number of sites that are exposed. As a category, contaminated lands have moderate vulnerability. While the absolute number of sites exposed to sea level rise is fairly high, most are not exposed to 16 inches of sea level rise. The existence of sites that cannot be removed makes the category fairly sensitive, but technology such as pumping and in situ treatment contributes to adaptive capacity. The network of agencies involved contributes both to sensitivity and adaptive capacity; while having more "eyes on the ground" can help prevent sites from slipping through the cracks, it could create complications in coordinating cleanup, and the many agencies involved, combined with the fact that most sites are privately owned, means that there is no centralized entity positioned to prioritize cleanup across all types of sites based on risks from sea level rise.

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