

# Vulnerability and Consequence Statements

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## ADAPTING TO RISING TIDES PROGRAM

### This guide helps with...

Summarizing assessment information into clear, outcome-oriented vulnerability and consequence statements.

## Definitions: Statements and Classifications

Once the hard work of gathering assessment answers is complete it can be a struggle to summarize the information into clear findings that describe the vulnerability and consequences identified. One trick to creating a cogent “story” is to transform the information into brief statements – referred to as vulnerability and consequence statements.

To make the process of writing these statements more approachable, the ART assessment questions are organized by the characteristics of vulnerability and consequences often observed. These characteristics, or classifications, include: information, governance, functional and physical challenges, and effects on the economy, the environment and people where they live, work, or recreate.

### Using the statements

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The ART approach to adaptation planning uses profile sheets to communicate and share assessment findings with the project working group as well as other stakeholders. The vulnerability and consequence statements are added to the profile sheets. See the [How-to Guide: Profile Sheets](#) (📄) for an explanation of the different components of a profile sheet.

There are example vulnerability and consequence statements at the end of this guide and in the [Hayward Shoreline Resilience Project Profile Sheets](#) (📄) and [Oakland/Alameda Resilience Study Example Profile Sheets](#) (📄).

The classifications help jump-start the process of summarizing the assessment answers into brief statements, and makes it easier to identify similarities and differences among the assets, sectors and services evaluated.

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## CHARACTERISTICS OF VULNERABILITY AND CONSEQUENCE: THE ART CLASSIFICATIONS

### VULNERABILITY

- Information** – Challenges in obtaining information necessary to understand or resolve issues
- Governance** – Challenges with management, regulatory authority or funding options that create barriers to adaptation
- Physical** – Conditions or design aspects of an asset that make it very sensitive to impacts
- Functional** – Aspects of an asset's function, relationships and/or dependencies on other assets that limit its adaptive capacity

### CONSEQUENCE

- People** – Effects on people where they live, work, access key services and conduct other day-to-day activities; includes consideration of equity in disproportionate impacts to community members
- Ecosystem Services** – Consequences on services provided by the environment, including biodiversity, flood and erosion control, water quality and carbon sequestration
- Economy** – Consequences on important drivers of economic health, impacts to goods movement, commuting, employment centers and business sectors

## Preparing Statements

### 1. Review and organize

The first step in writing vulnerability and consequence statements is to review the answers to the assessment questions. It is often the case that a number of assets will have similar characteristics, conditions and challenges, so it makes sense to read through and reflect on all of the answers before beginning to summarize. As you review the answers consider if there are assets that have very similar vulnerabilities. For example:

- Those that rely on the same vulnerable shoreline protection that is managed by another entity.
- Those that have critical water or salt-sensitive components at- or below-grade.
- Those that are owned or managed by a single agency and, therefore, may have similar information and governance challenges.
- Those that are owned or managed by different entities but face similar information and governance challenges.

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In these cases, the vulnerabilities may be similar, and one well-written vulnerability statement may be applicable to a number of assets evaluated. As a lot of information may be gathered during the assessment, looking for similarities and differences can make the process of summarizing more manageable.

## 2. Summarize the assessment information

The second step is to use the answers to the assessment questions to write brief summary statements describing the vulnerabilities and consequences identified. Depending on the project and the scale of the assessment (i.e., the level of detail of the assessment information), the statements can summarize the assessment findings for: individual assets; particular sectors and services evaluated; the project or study area as a whole; or the agencies and organizations assessed.

When writing these statements, it is helpful to consider what constitutes a vulnerability or consequence that rises to the level of needing a separate statement. Whether to write a separate statement may depend on the scope and scale of the project. Generally speaking these vulnerabilities and consequences:

- Can have (or describe, in the case of a consequence statement) broad or wide ranging effects on society and equity including impacts to a large geographic area, people where they live, or people with specific characteristics or special needs
- Can have environmental effects, including reducing ecosystem benefits provided by natural areas, such as flood risk reduction, water quality improvement, and supporting biodiversity
- Can affect the economy at multiple scales, including local, regional, statewide and national
- Are urgent because the effects will occur in a shorter timeframe than it takes to address the issue at hand. For example, there may be a stretch of shoreline that will allow inland areas to flood either with small amounts of sea level rise or under current storm conditions, but addressing this issue requires a long lead time due to complexities in ownership, management, financing, and regulatory oversight.
- Can cause cascading effects on other assets, services, or sectors. This is particularly the case for networked assets, such as transportation, utilities, and shoreline protection, which are interconnected in a manner such that failure of one part of the system will disrupt the rest of the system. This will also be an issue for assets that rely on others to maintain functionality, such as hospitals, nursing homes, and wastewater treatment plants that rely on uninterrupted power supplied by others.
- Can lead to loss of an irreplaceable service, having severe effects on one or more sustainability frames. For example, the loss of managed ponds could affect bird species that rely on them, which would be particularly problematic if there is no equivalent open water habitat nearby.

## Example Vulnerability Statements

	Assessment Question	Answer	Vulnerability
Information	Is planning-level or project-level information available to assess vulnerability, e.g., existing conditions reports, as-built drawings, monitoring or inspection reports, etc.?	<p><b>State Route 92, California Department of Transportation</b></p> <p>There are varying degrees of data types and quality available in various formats for different assets and asset components. For most assets, planning data, such as storm drain and outfall locations is available and fairly accessible. Up-to-date design and survey-grade data, such as structure elevation is hard to find because it tends to be created on a project-by-project basis. Even for a single asset it can be hard to find the correct project files because the information is not geocoded and there is no shared numbering or naming system to follow.</p>	There is a lack of detailed, easily accessible design and survey level information that is necessary to assess the vulnerability of State Route 92.
Governance	If the asset is protected from flooding by land or assets owned or managed by others (e.g., natural areas, structural protection, roadways), what is the relationship between the asset owner/manager and these entities? Do they coordinate information, funding or decision-making?	<p><b>Coliseum Amtrak Station, Capitol Corridor Joint Policy Agency (CCJPA)</b></p> <p>The station is not protected from sea level rise by any structures such as a levee. An underground pumping station was installed near the end of the cul-de-sac on 73rd Ave, the road that provides access to the station and the adjacent parking lot, as part of the Amtrak Platform project and the 73rd Ave improvements. Disruption of this pump station, which sits below grade, could cause local flooding that would interrupt passenger or maintenance crew access to the station and parking lot. The pumping station is owned and operated by Alameda County Flood Control and Water Conservation District (ACFCWCD). CCJPA does not have direct relationship with ACFCWCD, rather the City of Oakland works with the County as the city stormwater systems drain to the county flood control assets. ACFCWCD coordinates with the City of Oakland on flood control issues.</p>	CCJPA does not have control over the storm and flood drainage infrastructure that helps maintain access to the Coliseum Amtrak Station. Ensuring the station remains accessible will require coordination with the City of Oakland and the Alameda County Flood Control and Water Conservation District (ACFCWCD).
Functional	What external services, such as power, roads, clean water, and safe food supplies, does the asset rely on? What is the relationship between the asset manager and the organizations that provide these external services? If these external services were interrupted, are there back-up supplies ready and in place, and how long would they last?	<p><b>Fire Station 29, City of Oakland</b></p> <p>This fire station includes accommodations for one officer and 3 crew members. This 2-bay structure houses 1 triple combination pumper and 1 spare pumper. The station also has a kitchen and break area for use by the assigned crew. In addition, to firefighting and fire prevention services, the crews provide first aid/emergency medical response. In order to carry out its function, Fire Station #29 needs vehicle access, which is at grade. Not only is the access important at the station itself, but also between the station and any emergency to which the station is responding. The major streets near Fire Station #29 are San Leandro St. and International Blvd. The fire station also requires electricity and fuel. Information on the source of electricity is currently unavailable; the station has a fuel storage tank with a capacity of 60 gallons, which is sufficient for 20 hours of emergency generator operation.</p>	<p>Fire Station 29 will not be able to maintain operations if power is interrupted longer than 20 hours, or if additional fuel to run the station's back up power is not obtained.</p> <p>Fire Station 29 will not be able to provide emergency response services if the at-grade access to the station or the local roads that provide entry and egress to the station are flooded.</p>
Physical	For managed ponds and managed marshes, can the water control infrastructure such as berms, levees, and tide gates be adjusted to maintain system function as sea level rises?	<p><b>Triangle Marsh, Hayward Area Recreation and Parks District</b></p> <p>Tidal flow from SF Bay is controlled using adjustable gates; however the shoreline is retreating (3 ft/year) and the outboard levees are eroding. Sedimentation in the tidal channels has restricted tidal exchange. Levees and tide gates were repaired in 2012 to address some of these management challenges.</p>	Maintaining muted tidal action in Triangle Marsh has been difficult in the past, and sea level rise will make controlling water levels more challenging, requiring additional engineering to preserve tidal circulation, sediment transport, and gravity drainage, all of which maintain marsh elevations relative to sea level

## Example Consequences Statements

### ASSET: STATE ROUTE 92 IN HAYWARD, CA; CALIFORNIA DEPARTMENT OF TRANSPORTATION

SR-92 was constructed 1967 and carries six lanes of traffic. The portion of the state route under consideration includes the toll plaza and eastern approach to the San Mateo-Hayward Bridge from the Clawiter Road on-ramps. SR-92 is managed by Caltrans.

	Assessment Questions	Answers	Consequences
Society and Equity	<p>(a) Does the asset serve vulnerable communities (low-income, disadvantaged, low mobility, transit dependent, etc.)? Critical facilities (hospitals, transportation, fire stations, etc.)?</p> <p>(b) Is the asset part of emergency response / management?</p> <p>(c) Are there any hazardous materials at the asset site that could pose a risk to public health? What is their mobilization potential in floodwater? How close are they to sensitive receptors (e.g., schools, elderly housing, hospitals)?</p> <p>(d) Does the asset provide public access to the shoreline or other recreational opportunities?</p>	<p>(a) This section of SR-92 is adjacent to the Hayward / Union City area and the Ashland / Cherryland / San Leandro area, which are identified as a Communities of Concern.</p> <p>(b) No</p> <p>(c) Elevated tanks that store fuel. Not near sensitive populations.</p> <p>(d) No</p>	<p>SR-92 carries transit riders to and from MTC Communities of Concern in Hayward and Union City. If SR-92 is damaged or disrupted, these riders may not be able to access jobs or other services since no alternative transportation options serve this corridor. Therefore even temporary disruptions or closures could have significant local impacts to low-income, disadvantaged communities.</p>
Environment	<p>(a) Is the asset near wetlands, parks, or other protected natural resources?</p> <p>(b) Are there any hazardous materials at the asset site that could pose a risk to the environment?</p>	<p>(a) The asset is near the Hayward Shoreline Interpretive Center and marsh areas.</p> <p>(b) Elevated tanks that store fuel are near Bay and marshes.</p>	<p>Elevated tanks that store fuel for Caltrans maintenance vehicles at the SR-92 toll plaza could pose a risk to local water quality and habitat if they were to topple over or fail during a storm event.</p>
Economy	<p>(a) What is the value of the asset to the local economy? Does it contribute to major economic activity or employment centers, generate revenue, provide jobs, etc.?</p> <p>(b) Are there sunk costs in the asset? That is, have new investments been made in the asset that would be lost if rebuilding or relocating were necessary?</p> <p>(c) What is the scale of economic costs if the asset were to experience service disruptions or damage? Would they be local, regional, state, or federal?</p>	<p>(a) Daily: 86,000 passengers, 1,600 transit riders, 6,000 trucks. Provides access to major employment areas on both sides of the Bay. Primary morning commute direction is from east to west, as east bay residents travel to employment centers on the peninsula.</p> <p>(b) Continued maintenance and upkeep. Replacement cost for bridge, \$45-132M.</p> <p>(c) This section of SR-92 is used primarily by commuters and some large trucks. Any disruptions to the facility would have an impact at all four scales, but primarily locally and regionally.</p>	<p>SR-92 carries 86,000 passengers, 1,600 transit riders and 6,000 trucks each day. Even a temporary closure of the road would have significant impacts on regional commuter movement since there is no local alternative. If the SR-92 Hayward-San Mateo Bridge needed to be replaced, Caltrans estimates it could cost \$45 - 132 Million dollars.</p>