

# Memorandum

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To: Ryan Kuchenig, Redwood City

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**Subject: Redwood City E. Bayshore Road Evacuation Assessment (Phase 1)**

*SJ21-2102*

The City of Redwood City has requested that Fehr & Peers, Jensen Hughes, and Dr. Stephen Wong (collectively, the Project Team) prepare an evacuation assessment for the E. Bayshore Road and Bair Island Road areas (hereinafter referred to as the “evacuation area”) located east of US 101 in Redwood City, California (see **Figure 1**). The City is evaluating development applications at 505 E. Bayshore Road and 557 E. Bayshore Road (hereinafter referred to as the “Project”) that will increase the population in the evacuation area and wants to better understand emergency access and evacuation options (including pedestrian, bicycle, vehicular and waterway egress) given that there is currently a single point of vehicular access and egress at the Whipple Avenue interchange.

This evacuation assessment was divided into the following two phases:

- **Phase 1** guided the City through:
  - Identification and evaluation (i.e., likelihood and consequence) of the potential hazards considered to present a threat to the evacuation area.
  - Identification of emergency evacuation/people management strategy for relevant hazards (e.g., shelter in place, evacuate to upper floors, or evacuate immediately).
  - Documentation of evacuation time estimate (ETE)<sup>1</sup> benchmarks for relevant hazards and evaluation of the “30-minute” evacuation benchmark.

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<sup>1</sup> An evacuation time estimate (ETE) is a metric that is used to identify the time it takes for a selected population to evacuate a hazardous area due to an emergency.



- **Phase 2** focused on the following efforts:
  - Identification of evacuation scenario definitions to be evaluated.
  - Identification of evacuation routes (including pedestrian, bicycle, vehicular and waterway egress, and options to temporarily provide additional capacity) and transportation network capacity available during each evacuation scenario.
  - Calculation of evacuation preparation and travel time estimates (last evacuee leaves the evacuation area) for each evacuation scenario.
  - Recommendation of potential strategies and mitigation measures the City could consider to decrease evacuation preparation and travel time estimates specific for the evacuation area.

This memorandum is the deliverable for **Phase 1** and presents the City a hazard and risk assessment for the evacuation area, corresponding summary of relevant literature on ETEs, and evaluation of the origin and appropriateness of the "30-minute" evacuation benchmark for the evacuation area. Due to the complexities and unique challenges of the evacuation area, the hazards and risk assessment presented in this memo is not intended to be a comprehensive, all-encompassing assessment of all potential risks that may, or may not, present a threat to life safety and/or property now or in the future. Instead, the hazards and risk assessment has been tailored to focus on specific emergency events that have the most realistic chance of requiring an evacuation of the evacuation area identified in coordination with staff from the City's Community Development and Transportation Departments along with staff from the Fire Department.




 Evacuation Area

Figure 1



## Redwood City E. Bayshore Road Evacuation Assessment - Evacuation Area Location



## Key Takeaways

Several key takeaways are presented below:

- Flooding (100-year storm/shoreline overtopping and severe weather), earthquakes (including tsunamis originating in the San Francisco Bay), post-earthquake fires, pipeline failure and exterior combustible fires were identified as potential risks to the evacuation area needing a people management strategy.
- King Tides, dam failure, landslide, wildfire, tsunami originating from the Pacific Ocean, drought, and hazardous materials release are either not relevant to the evacuation area or will not warrant an emergency people management strategy.
- Based on the hazardous materials inventory provided through the California Environmental Reporting System (CERS) of the industrial park, assumed worst case release scenarios did not result in direct impacts to the evacuation area. Further input regarding location of gas infrastructure is required to better understand the severity, degree, and speed-of-onset of potential hazards to better inform a people management strategy from PG&E gas infrastructure.
- The assumption of a 30-minute benchmark for this evacuation area is not supported by practice or research. There is no benchmark or rule of thumb for ETEs as they must be calculated for each specific situation and local context.

## Hazard and Risk Assessment

A hazards analysis includes identifying, screening, and profiling each potential hazard for a given study area. Hazards encompass natural, human-caused, and technological conditions that could result in an undesirable event. Natural hazards result from unexpected or uncontrollable natural events of significant size and destructive power. Human-caused hazards result from human activity and include technological hazards. Technological hazards are generally entirely accidental or result from events with unintended consequences (for example, an accidental hazardous materials release). This hazards analysis consists of the following two steps:

- Hazard identification and screening
- Hazard profiles

A risk analysis builds upon a hazard analysis and traditionally consists of understanding the answers to three simple questions:

1. What can happen? (i.e., what can go wrong?) [This is the hazard scenario]
2. How likely is it to happen? [This is the probability component of risk]
3. If it does happen, what are the consequences? [These are impacts and/or severity of the scenario]





The risk analysis in this memo is a qualitative risk assessment consisting of (1) identifying probability (likelihood of occurrence) for each hazard and (2) identifying potential impacts and/or consequences for each identified hazard, both using a relative ranking approach. A risk matrix is developed that combines the two criteria into a single visualization/decision-making tool.

## Hazard Identification and Screening

As an initial step in identifying and screening hazards that are relevant to the evacuation area, a review was made of local city and county planning and hazard analysis reports. This included the 2016 San Mateo County Multijurisdictional Local Hazard Mitigation Plan (LHMP) and the 2010 Redwood City General Plan, Public Safety Section (General Plan) (County of San Mateo, 2016; City of Redwood City, 2010).

The LHMP is developed and maintained by the County as a regional planning tool to reduce potential impacts of various hazard-induced disasters and includes a community profile, descriptions of the various hazards present in the region, and mitigation strategies at the county scale. In addition, the LHMP describes the relevant hazards specific to each city in the County, assigning a Hazard Risk Rating for each natural hazard discussed.

The General Plan is a local planning document that focuses on public safety issues impacting the city and “promotes prevention, public education, and emergency preparedness as the approaches that will allow the community to minimize risks to life and property in the event of a disaster” (City of Redwood City, 2010). The General Plan covers a wider range of topics than does the LHMP, but includes a section specifically focused on hazards management.

Based on a review of existing local planning documents and feedback from the Redwood City Transportation and Fire Departments, one additional hazard – post-earthquake fire – has been added as a credible emergency incident for the region. As such, 16 hazards have been identified and summarized in **Table 1** on the next page. The hazards have been categorized as either natural or technological/human-caused hazards along with an indication of the hazard rating level (where provided in existing documentation).

**Table 1: Summary of Natural and Technological Hazards in Redwood City**

Hazard	Redwood City Hazard Risk Rating <sup>1</sup>
<b>Natural Hazards</b>	
Flooding - 100-yr Storm/ Shoreline Overtopping	Medium
Flooding - Severe Weather	High
Flooding - King Tides	-
Earthquake	High
Post-Earthquake Fire	-



**Table 1: Summary of Natural and Technological Hazards in Redwood City**

Hazard	Redwood City Hazard Risk Rating <sup>1</sup>
Landslide	Medium
Wildfire	High
Tsunami	Low
Drought	Low
<b><i>Technological or Human-Caused Hazards</i></b>	
Flooding - Dam Failure	Low
Hazardous Materials Release	-
Pipeline Failure	-
Exterior Combustible Fire	-
Terrorism	-
Cyber Threats	-
Aircraft Incidents	-

Notes:

1. The hazard risk ratings were extracted from the General Plan. Not all hazards were given a rating.  
Source: Jensen Hughes, 2021.

## Hazard Profiles

Detailed hazard profile descriptions have already been prepared in the LHMP and General Plan and therefore are not repeated herein. Additional discussion on the hazard profiles, as they relate to an evacuation need for the evacuation area is provided in the following sections.

## Site-Specific Hazard and Risk Analysis for the Evacuation Area

As the local city and county hazard analyses cover large geographic areas, not all hazards identified in existing documentation (summarized in **Table 1**) may be relevant at the site level strategy. As such, a site-specific hazard and risk analysis has been undertaken to not only identify the hazards relevant to the evacuation area, but also provide an indication of the potential likelihood of occurrence, degree of consequence to life safety and need for a people management strategy for each relevant hazard.

As a first step, a qualitative hazard analysis was conducted to identify hazards that present a threat to the evacuation area based on our understanding of site-specific environmental settings, our experience and knowledge working on projects of a similar nature and feedback from local emergency responders. Based on this analysis, flooding (King tides and dam failure), landslides, wildfires, tsunamis originating in the Pacific Ocean and hazardous materials release were all



identified as not presenting an immediate threat to the evacuation area. **Table 2** provides a summary of the rationalizations for these non-threatening hazards and are ordered by relevance to the evacuation area. Where our analysis differs from the LHMP or General Plan additional rationale is given.

**Table 2: Analysis of Hazards Not Considered a Threat to the Evacuation Area**

Hazard	Description
Flooding – King Tides	King Tides is a term used to describe exceptionally high tides. Based on the historic extent of King Tides, this hazard type does not present an immediate threat to the evacuation area. However, a King Tide coincident with a storm surge may present a threat. Sea-level rise due to climate change may also increase the impact of King Tides but does not present a need for immediate evacuations, as the onset of the hazard is long term.
Flooding – Dam failure	Redwood City has a low hazard rating for dam failures and the evacuation area is outside of dam inundation flood hazard areas.
Landslide	Although other areas of Redwood City are at risk of landslide, the evacuation area is in a low landslide hazard area due to its topography and surrounding geography.
Wildfire	Although Redwood City has an overall high risk of wildfire, the evacuation area has a very low wildfire hazard and based on its geography is likely to be a destination for people evacuating from a wildfire. The evacuation area is bounded by US 101 to the south and west and Redwood Creek to the east – all of which provide a barrier against the spread of wildfire. The Don Edwards San Francisco Bay National Wildlife Refuge to the north has a marshland vegetation type, which has experienced fires in the past, but due to the nature of the fuel loads (i.e., marshlands) is anticipated to present a low fire hazard severity.
Tsunami – Pacific Ocean origin	This evacuation area is outside the tsunami inundation area based on a tsunami originating in the Pacific Ocean. However, if an earthquake originates in the San Francisco Bay which triggers a tsunami, the evacuation area may be at risk. The tsunami originating in the San Francisco Bay will be addressed by the earthquake hazard and risk assessment.
Hazardous Materials Release	The Port of Redwood City is located approximately 1 mi. (straight line distance) from the evacuation area. It is understood that the Port, surrounding marine environment and proximate industrial facilities have a significant amount and variety of hazardous, toxic and flammable materials being transported to and from the location, as well as being stored on site. Based on the hazardous materials inventory provided through the California Environmental Reporting System (CERS) of the industrial park, assumed worst case release scenarios did not result in direct impacts to the evacuation area. This was based on a preliminary analysis of endpoints <sup>2</sup> for the largest quantities of toxic and flammable hazardous materials identified in the inventory provided. Refer to <b>Attachment A</b> and <b>Attachment B</b> for the hazardous materials analysis and inventory for details.

<sup>2</sup>The distance to the endpoint (lowest concentration of concern) is the distance a toxic vapor cloud, heat from a fire, or blast waves from an explosion will travel before dissipating to the point that serious injuries from short-term exposures will no longer occur. Endpoints for regulated substances are specified in 40 CFR 68.22(a)



**Table 2: Analysis of Hazards Not Considered a Threat to the Evacuation Area**

Hazard	Description
Terrorism, Cyber Threats and Aircraft Incidents	Terrorism, cyber threats, and aircraft incidents are all beyond the scope of this analysis.

Source: Jensen Hughes, 2021

As the next step, a qualitative risk analysis was conducted to assess the risks associated with the remaining hazards that are considered to present a threat to the evacuation area. The potential likelihood and consequence of each, relevant hazard was evaluated using a combination of information provided in the local hazard planning documents, our understanding of the evacuation area environmental settings, engineering judgement, feedback from local emergency responders and the latest research in disaster risk management.

A relative ranking scale, ranging from very low to high, was used to rate likelihood and consequence of each relevant hazard. For example, a hazard with a likelihood of “medium” is expected to occur with more regularity than one with a likelihood of “low,” but these do not correspond to specific expected frequencies. The evaluation of relative consequence rankings considered the influence of available warning time to reduce potential impacts to life safety; sufficient warning time may be available to prepare for and respond to a given threat before it occurs. For the purposes of this analysis, “response” is based on ability to evacuate. Based on this risk analysis, flooding (100-year storm/shoreline overtopping and severe weather), earthquakes (including tsunamis originating in the San Francisco Bay), post-earthquake fires, pipeline failure and exterior combustible fires were identified as risks needing a people management strategy. A summary of the site-specific hazard and risk evaluation is provided in **Table 3**. The recommended evacuation strategies for the evacuation area for each relevant hazard are also summarized in **Table 3** and described in more detail in **Table 4**.





**Table 3: Hazard and Risk Analysis for Hazards Impacting the Evacuation Area**

Hazard	Threat to Evacuation Area? (Y/N)	Likelihood (very low, low, medium, high)	Consequence to Life Safety (very low, low, medium, high)	Warning Time (Y/N)	Need for People Management Strategy	Preliminary Emergency People Management Strategy
Flooding - 100-yr Storm/Shoreline Overtopping	Yes	Low	Medium	Yes	Yes	(1) Evacuate out of evacuation area, (2) shelter-in-place as last resort option
Flooding - Severe Weather	Yes	Medium	Very low	Yes	Yes	(1) Shelter-in-place in evacuation area (to avoid flooded roads), (2) evacuate as last resort option
Earthquake (including tsunamis originating in the San Francisco Bay)	Yes	Medium	Medium to High	No	Yes	(1) Shelter-in-place, (2) vertical evacuation (if Bay-side tsunami) or evacuation of evacuation area after event may be necessary
Post-Earthquake Fire	Yes	Low	High	No	Yes	(1) Shelter-in-place initially, (2) undertake rapid situational assessment then, (3) determine if shelter-in-place is adequate or if evacuating out of evacuation area is warranted due to urban conflagration concerns
Pipeline Failure <sup>1</sup>	Yes	Very low	Medium to High	No	Yes	Determine if shelter-in-place is adequate or if evacuation out of evacuation area is warranted due to nature of pipeline failure
Exterior Combustible Fire	Yes	Low	Low-Medium	Yes	Yes	(1) Shelter-in-place (2) evacuate as directed by emergency personnel

Notes:

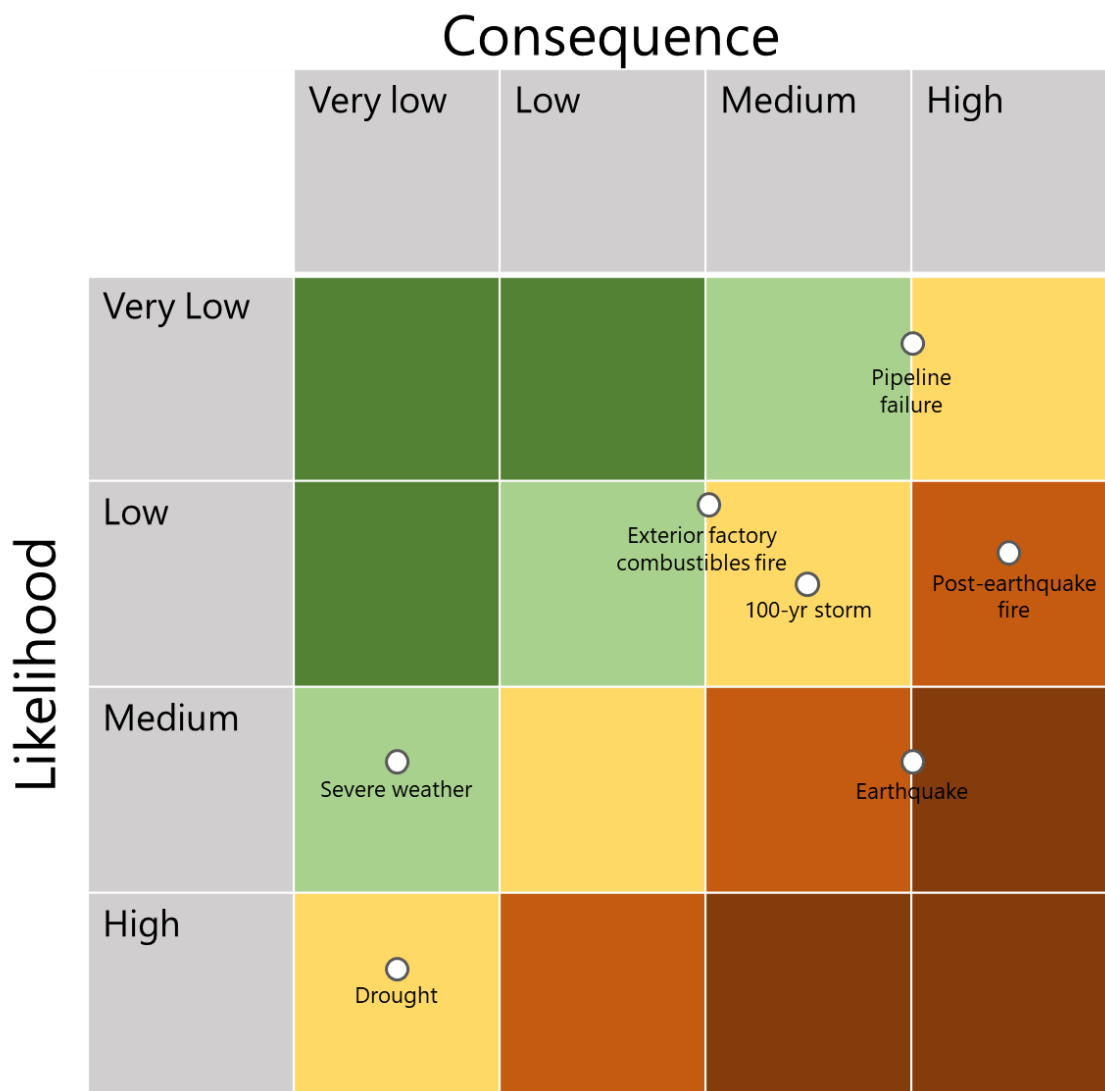
- As no specific information regarding use profiles, quantities, associated operations and/or location of infrastructure/materials has been provided, a worst-case failure scenario has been assumed.

Source: Jensen Hughes, 2021.



To evaluate the overall relative risk of each hazard and to provide a simple tool to support decision-making, the relating ranking scores for likelihood and consequence for each hazard identified as posing a threat to the evacuation area in **Table 3** were compared in a risk matrix. The risk matrix for site-specific hazards is provided in **Figure 2**.

**Figure 2: Likelihood and Consequence for Each Hazard Impacting the Evacuation Area**



Source: Jensen Hughes, 2021

Given the natural and physical characteristics of each hazard (e.g., speed of onset, impact to the physical environment, availability for early warning) as well as the potential risk to life safety and the built environment, a preliminary strategy for effectively managing people has been identified



for the relevant hazard types. For hazardous situations endangering the public, emergency responders have three primary options for managing people movement:

- Shelter-in-place,
- Phased evacuation, or
- Total evacuation

These options can be used on their own or in combination. For both the phased and total evacuation responses, additional evacuation options are available such as vertical evacuation within a building (in particular high-rise buildings), phased evacuation by floor level/building/city zones, building evacuation to outside, building evacuation to a specified distance, and building/site evacuation beyond the development area.

### Evaluation of Hazards

This section provides an evaluation of the potential risks to life safety per relevant hazard type and associated recommendations for safely and effectively managing people during an emergency. **Table 4** summarizes those hazards which present the highest risk to life safety and therefore necessitate an emergency evacuation/people management strategy. Although drought is responsible for loss of life and exacerbates the magnitude and severity of other hazards, drought itself does not require an emergency people management strategy and is omitted from **Table 4**.

**Table 4: Hazards Requiring an Emergency People Management Strategy**

Hazard	Description
Flooding - 100-yr Storm/ Shoreline Overtopping	The evacuation area is in one of the most flood-prone areas of Redwood City. A 50-year storm surge would result in 36 in. of flooding in the evacuation area and along the bike path/PG&E line north of the proposed development (Adapting to Rising Tides, 2017). A 100-year storm, climate change, or a storm coinciding with a seasonal King Tide would all increase flood levels further. It is recommended that in the case of severe flooding due to a storm the evacuation area is evacuated.
Flooding - Severe Weather	Heavy rains may cause flooding of roads and overrunning of storm drains in the evacuation area. Although Redwood City is assigned a rating of high for severe weather in the LHMP, based on our understanding of level of flooding during rain events (not storm surge, as discussed above) it is not expected to pose a risk to life safety if shelter-in-place is implemented. Individuals are encouraged to remain off roads and structures are expected to be designed in accordance with severe weather requirements.
Earthquake (including Tsunamis originating from the San Francisco Bay)	The evacuation area has a high likelihood of experiencing earthquakes and is built on fill that is moderately to highly susceptible to liquefaction. It is assumed that any new construction will be designed and constructed in accordance with applicable codes to withstand expected seismic loads. In the event of an earthquake, individuals should shelter-in-place. An earthquake could also trigger secondary hazards (e.g., hazardous materials release, tsunami – San Francisco Bay origin, fire) which would require different and additional emergency responses (see below).



**Table 4: Hazards Requiring an Emergency People Management Strategy**

Hazard	Description
Post-Earthquake Fire	A major earthquake in the evacuation area may impact infrastructure, such as breaking water lines making roads impassable by vehicles, impacting gas lines and/or electrical transmission and distribution resulting in structure fires. In this multi-hazard scenario, firefighters and other first responders may not be available to perform typical firefighting or search and rescue services, potentially leading to building-to-building fire spread (i.e., urban conflagration) and/or impeded emergency vehicles access. In the event of a major earthquake, the evacuation area may require a combination of people management strategies with an initial shelter-in-place policy immediately after the earthquake, followed by a rapid situational assessment that could determine if immediate evacuation of the evacuation area is warranted due to high potential for secondary hazards, such as urban conflagration.
Pipeline Failure	PG&E maintains a Natural Gas Pipeline (30" diameter) which runs down Winslow St. and Industrial Way. This is on the opposite side of US 101 from the evacuation area and is approximately 2,000 ft. from the evacuation area to its nearest point. The pressure of the pipeline is unknown, but the PG&E standard for this type of pipeline is 60 psi (PG&E, 2021). Based on this diameter and pressure maximum, the evacuation area is outside of the recommended evacuation zone of the Pipeline Association for Public Awareness (2020). That said, with no specific information regarding other gas related infrastructure, further studies of loss of containment mechanisms, whether loss of piping integrity or primary containment failure is necessary. Special emergency response procedures for pipe failure should be drafted as lack of maintenance, corrosion, and accidental vehicle impact, amongst others, may all be causes of unintended releases that require immediate evacuation of adjacent areas.
Exterior Combustible Fire	Industrial processes and operations may result in fires that may necessitate adjacent roads and highways to be cleared due to smoke, air quality, or other factors. In the event of an industrial fire, factory-adjacent public facilities and/or roads may require cordoning off followed by a rapid situational assessment that determines if immediate evacuation of the area is warranted due to the health hazards of materials involved in the fire (if fire involves toxic contaminants or by combustion by-products). In the event of an exterior combustible fire, individuals should shelter-in-place until otherwise notified by emergency personnel.

Source: Jensen Hughes, 2021

## Climate Change

Climate change is a serious future concern addressed at length in both the LHMP and the General Plan. Climate change is likely to have a future impact on the hazards discussed above. Sea level rise is expected to increase the severity of flooding and changes in weather patterns are likely to result in more severe storms. Climate change is also expected to change wildfire risk patterns and may increase wildfire incidents proximate to the evacuation area. Uncertainty about the magnitude of climate change impacts and the timing of these changes make it difficult to predict when and how these changes will manifest. Additionally, future mitigating actions may reduce the impact of climate change.





## Evacuation Time Estimates

An evacuation time estimate (ETE) is a metric that is used to identify the time it takes for a selected population to evacuate a hazardous area due to an emergency. The quantitative metric was first used to assess the time to evacuate areas surrounding nuclear power plants after the Three Mile Island Nuclear Power Plant accident (Urbanik et al., 1980). Since then, ETEs have been considered and calculated for other types of hazards including hurricanes (e.g., Lindell and Prater, 2007a) and wildfires (e.g., Zhao and Wong, 2021). However, the metric remains most widely used by nuclear power plant licensees, which supports protective action recommendations in the case of an accident (Herrera et al., 2019). The general purpose of ETEs is to identify risks for evacuating populations and determine possible strategies that could decrease the time it takes to evacuate from a hazard. ETEs, at their fundamental level, require a comparison of the evacuation population's demand for a transportation facility and the capacity of that facility (Urbanik, 2000)<sup>3</sup>.

ETEs are not generally considered as a single time. This is because the many factors listed above can produce a wide range of scenarios with varying ETEs. As explained by Urbanik (2000) for nuclear power plant accidents:

"The wide range of possible accidents and responses makes it impossible to provide a single ETE, on the one hand, and impractical to provide ETEs for each of the many possibilities that could occur. Therefore, it is appropriate to develop a range of ETEs as part of the planning basis for a given site."

Consequently, there is no evidence that a single ETE benchmark is appropriate in all conditions. Even for the same location, the hazard and the behavioral response of people to the hazard can dramatically change ETEs. In the case of this evacuation area, a 30-minute benchmark is not based on research, empirical evidence, or common understanding of evacuations. Every ETE calculation is specific to the above factors and local context, which inhibits the development of any recognized benchmarks or common rules of thumb. **The assumption of a 30-minute benchmark for this evacuation area is not supported by practice or research.** It is the responsibility of the local jurisdictions to determine if an identified ETE (or range of ETEs) is acceptable. Otherwise, transportation response strategies may be necessary to reduce ETEs.

## Next Steps

The next steps consist of completing **Phase 1** by City staff in determining the appropriate hazards and ETE (see details below) and beginning **Phase 2** with the scenario definition, modeling the

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<sup>3</sup> Evacuation time estimates are sometimes called evacuation clearance times. We use ETEs here as they are more commonly accepted in the literature.



scenarios, and estimation/reporting the results of the proposed Project development implications on ETEs.

Using the information presented in this memo, City staff will decide on what is considered the appropriate hazard(s) and appropriate response(s) as the basis for design for estimating the evacuation travel time (including intermediate times and capacities) for the evacuation area. Since ETEs are influenced by multiple factors as explained extensively in Urbanik (2000), Lindell and Prater (2007a), and Herrera et al. (2019), the Project Team will coordinate with the City to identify key factors of evacuation events and develop a range of evacuation modeling scenarios for further study. To help facilitate this conversation, below is a list of commonly used factors when considering ETEs, though not all factors will have data sources and assumptions will be required.

- Size or impact area of identified hazards
- Characteristics of the road network and other transportation facilities (e.g., bike, pedestrian), including capacity and traffic controls
- Trip generation characteristics including:
  - Population size, density, and distribution of residences (including number of people per household) and businesses (including trip generation rate based on business type/size)
  - Number of evacuating vehicles, including their spatial distribution based on population and business characteristics
  - Size and distribution of public transit dependent population
  - Size and distribution of transient population
  - Evacuation rate
- Notification time between the start of the hazard and the issuance of an evacuation order
- Preparation time between knowledge of the hazard or order and the time it takes to leave
- Departure timing distribution for all populations considered
- Destination of evacuees
- Route choice on the transportation network

In addition to these factors, ETEs can be impacted by events that occur during the hazard. For example, evacuation traffic flow may degrade if a stalled vehicle is blocking evacuating lanes or if the hazard hinders traffic (e.g., flooding, fallen trees). Other impacts on ETEs, such as shadow evacuations (e.g., people deciding to evacuate without receiving a mandatory evacuation order), driver behavior, and background traffic have also been considered in the latest guidance on calculating ETEs (Wolshon et al., 2020).

As a final note, ETEs are highly dependent on the departure of the last individual from the hazardous area. Given this limitation, other metrics can be considered, such as the average evacuation time, the number of exposed vehicles (to the hazard) at a given time, or the average distance from the hazardous area (see Zhao and Wong, 2021 for some of these examples).



If ETEs are deemed too high, several strategies are available to decrease evacuee risk and improve evacuation outcomes. These strategies can be divided between demand-side, supply-side, and information-side response strategies. For informational purposes, **Table 5** presents commonly used strategies, which was adapted from Lindell et al. (2019) and Wong (2020). Other literature, including Lindell and Prater (2007), and Pel et al. (2010), Li et al. (2019), Herrera et al. (2019), and Zhao and Wong (2021), helped inform this table.

In addition to these response strategies, infrastructure changes may also be required. Expansion of roadways may be necessary in certain situations to reduce key bottlenecks. However, due to the cost of expansion and sustainability issues that arise, this option is generally not recommended. In lieu of roadway expansion, jurisdictions could also consider flexible infrastructure (as noted in several supply-side strategies) that temporarily increase roadway capacity in the event of an emergency.

**Table 5: Common Transportation Response Strategies to Reduce ETEs**

Strategies	Description
<b><i>Demand-Side</i></b>	
Timely departures	Encouraging residents to evacuate in a timely manner to reduce last-minute evacuation or rapid loading of the road network
Phased evacuation	Issuing mandatory evacuation orders and releasing evacuees by pre-designated zone to reduce rapid loading of the road network
Triggered evacuations	Issuing mandatory evacuation orders based on characteristics of the hazard, such as fire spread characteristics
Vehicle reduction	Encouraging residents to take only one or two vehicles (based on household size) to reduce the number of evacuating vehicles
<b><i>Supply-Side</i></b>	
Contraflow	Switching all or some lanes of a highway or other road to flow away from the hazard to increase roadway capacity
Shoulder usage	Allowing vehicles to drive on the side of a road (typically a highway) to increase roadway capacity
Ramp closures	Closing ramps to highways to reduce bottlenecks and improve travel speeds of vehicles on the highway
Route closures	Closing routes to reduce vehicle movements into the hazardous area or reduce conflict with non-evacuees (e.g., freight)
Turn restrictions	Restricting turning at an intersection to increase flow through the intersection or prioritize evacuating vehicles
Signal priority	Setting traffic signals to prioritize certain traffic movements to increase flow through the intersection or prioritize evacuating vehicles
Manual traffic control	Controlling the flow of traffic through an intersection manually to increase flow through the intersection or prioritize evacuating vehicles



**Table 5: Common Transportation Response Strategies to Reduce ETEs**

Strategies	Description
Public transit	Using high-capacity public transit vehicles to reduce the use of single-occupancy vehicles and increase the number of evacuees
Mode shift	Identifying faster and more efficient means of evacuating large populations of people (context and geography dependent), such as carpooling, shared mobility, cycling, or walking
Parking restrictions	Restricting parking periodically or permanently along roadways to reduce pinch points and increase flow of vehicles
<b>Information-Side</b>	
Rapid information delivery	Reducing the notification time between hazard detection and the issuance of mandatory evacuation orders by obtaining and transmitting information quickly and making informed, quick decisions
Evacuation preparation	Encouraging residents to prepare for an evacuation, such as making a household evacuation plan or making a go-bag with essential documents and emergency supplies
Route preparation	Presenting possible route options for evacuees in advance of disasters through educational campaigns or physical infrastructure (e.g., evacuation signs)
Dynamic route guidance	Providing evacuees with guidance on safe and efficient routes along with dynamic rerouting information to decrease travel times and reduce congestion on highly-traveled roads (can include GPS-routing systems)
System monitoring	Monitoring traffic using intelligent transportation system (ITS) technology to identify accidents and problem areas, determine the effectiveness of responses, and change responses as needed
Travel information	Communicating traffic and service information to evacuees before and during the evacuation to convey shelter locations, alternate evacuation routes, congestion alerts, and location of services

Source: Dr. Stephen Wong, 2021

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## Attachments

**Attachment A:** Hazardous Materials Analysis

**Attachment B:** Hazardous Materials Inventory List



# Attachment A: Hazardous Materials Analysis

Based on a review of 1,034 hazardous materials inventory items reported through the California Environmental Reporting System (CERS) by businesses near the study area, chemicals present in quantities that may be of concern off-site were identified. There were no chemicals that were particularly hazardous from the toxicity perspective, except one, which was present in very small amounts. Note that this preliminary and high-level analysis does not take into account the operations being conducted with the hazardous materials or parameters that may accelerate their release (high temperatures or pressures), incompatible reactions with other materials on site or other site-specific factors. The original inventory list was filtered, and a majority of the chemicals were excluded for several reasons:

- Gases were excluded if they were only simple asphyxiants since they would not pose a threat to adjacent sites if released, such include inert gases like Nitrogen, Carbon Dioxide, Helium, Argon and Air.
- Large quantities of fuel such as gasoline or diesel at gas stations were excluded as they are necessary for everyday operation and also do not pose an evacuation threat.
- Toxic liquids or solids that do not have a potential to be released into the air outside the site boundary were not included. One example of this was toxic waste at local hospitals, solid toxic waste from several factories and toxic solids in general.
- Small quantities of highly toxic, toxic or highly flammable liquids or gases were not considered since there is no credible release scenario where they could be released in a manner reaching the study area.

The following chemicals in **Table A-1** were identified for initial review for their potential to pose a hazard off-site. The original list of 1,034 chemicals is provided by the City of Redwood City is included as **Attachment B**.

**Table A-1: Inventory of Hazardous Materials**

Facility Name	Chemical Name	Hazard Class	Physical State Label	Max Daily Amount	Average Daily Amount
CEMEX CONST. MATERIALS PAC LLC	Acetylene	Flammable Gases	Gas	2600-12999 Cubic Feet	0-2599 Cubic Feet
GRANITE ROCK ASPHALT	Black Cat 236	Flammable Liquid	Liquid	12000-59999 Gallons	3000-5999 Gallons



**Table A-1: Inventory of Hazardous Materials**

Facility Name	Chemical Name	Hazard Class	Physical State Label	Max Daily Amount	Average Daily Amount
SEAPORT REFINING & LLC	Diesel	Combustible Liquid, Class 2	Liquid	60000-119999 Gallons	12000-59999 Gallons
SEAPORT REFINING & LLC	Ethanol	Flammable Liquid	Liquid	12000-59999 Gallons	3000-5999 Gallons
Propel Fuels, Inc.	Ethanol Gasoline - E85	Flammable Liquid	Liquid	3000-5999 Gallons	3000-5999 Gallons
SEAPORT REFINING & LLC	Gasoline	Flammable Liquids	Liquid	120000-1199999 Gallons	60000-119999 Gallons
Revolution Medicine	Hydrogen	Flammable Gases	Gas	0-2599 Cubic Feet	0-2599 Cubic Feet
PG&E: BAIR SUBSTATION	Petroleum Hydrocarbon	Combustible Liquid, Class 2	Liquid	12000-59999 Gallons	12000-59999 Gallons
SIMS METAL MANAGEMENT	Propane	Flammable Gases	Liquid	26000-129999 Cubic Feet	26000-129999 Cubic Feet
Arana Therapeutics, Inc.	Sodium Azide	Highly Toxic	Liquid	0-99 Pounds	0-99 Pounds
AI LLC	Sulfuric Acid	Corrosives	Liquid	1000-4999 lbs	1000-4999 lbs
SEAPORT REFINING & LLC	Transmix	Flammable Liquid	Liquid	120000-1199999 Gallons	60000-119999 Gallons
GRANITE ROCK CORP	Verifi	Toxic Liquid	Liquid	0-2599 Cubic Feet	0-2599 Cubic Feet

The Environmental Protection Agency (EPA) has defined a worst-case scenario as the release of the largest quantity of a regulated substance from a single vessel or process line failure that results in the greatest distance to an endpoint. The distance to the endpoint is the distance a toxic vapor cloud, heat from a fire, or blast waves from an explosion will travel before dissipating to the point that serious injuries from short-term exposures will no longer occur. Therefore, this preliminary evaluation will focus on consequences from toxic releases, intense fires and explosion overpressures. ***This does not consider other tanks or containers not reported on the CERS platform.***

EPA's offsite consequence analysis provides distances to endpoints for toxic substances that range from 0.1 miles to 25 miles. For flammable vapors, the worst-case scenario would be an endpoint to an overpressure of 1 psi from vapor cloud explosions. Alternative, less consequential scenarios include the lower flammability limit of a vapor or the radiant heat level of 5 kW/m<sup>2</sup> from fires. The following values are provided:





- The distance to an endpoint for a worst-case release scenario (1 psi overpressure) for propane tanks with a volume between 1,751-7,000 gal is 0.2 miles. Public areas within a distance to the 1 psi overpressure from a worst-case release would be considered a risk. The largest amount of propane in the inventory had a total quantity of approximately 3,614 gallons. Therefore, a 1-mile distance from a factory location would not be affected by a worst-case release. Note that it was conservatively assumed that the entire 3,614 gal was in a single tank.
- The distance to an endpoint for a worst-case release scenario (vapor cloud explosion) of 2,000 lbs of acetylene or hydrogen would be 0.1 miles. The largest quantity of acetylene in the inventory was ~880 lb, which is less than the quantity that would cause an overpressure at 0.1 miles. The largest single quantity of hydrogen was approximately 14 lbs.
- There were several corrosive and toxic liquids in smaller quantities that had low vapor pressures, which would not pose a threat to the public in storage conditions or loss of vessel integrity.

All other materials were flammable and combustible liquids, in moderate to large amounts, that are subject to the OSHA Process Safety Management (PSM) regulations. These were mainly diesel, gasoline and ethanol. Compliance with the California Fire Code, NFPA 30 and OSHA PSM for facilities storing such amounts results in very low failure rates of tanks and storage sites.

Therefore, based on the review of the hazardous materials inventory list, there was no single vessel or tank sizes that following a catastrophic release, would negatively impact the study area. Based on preliminary review, the farthest impact that would result from a catastrophic release would be at a distance of 0.2 miles.

## Attachment B: Hazardous Materials Inventory List

[illegible]

STOCK TICKER

COMPANY NAME

INDUSTRY

MARKET CAP

PERF. 1D

PERF. 1W

PERF. 1M

PERF. 3M

PERF. 6M

PERF. 1Y

PERF. 3Y

PERF. 5Y

PERF. 10Y

PERF. 15Y

PERF. 20Y

PERF. 25Y

PERF. 30Y

PERF. 35Y

PERF. 40Y

PERF. 45Y

PERF. 50Y

PERF. 55Y

PERF. 60Y

PERF. 65Y

PERF. 70Y

PERF. 75Y

PERF. 80Y

PERF. 85Y

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PERF. 675Y

PERF. 680Y

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PERF. 700Y

PERF. 705Y

PERF. 710Y

PERF. 715Y

PERF. 720Y

PERF. 725Y

PERF. 730Y

PERF. 735Y

PERF. 740Y

PERF. 745Y

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PERF. 3355Y

PERF. 3360Y

PERF. 3365Y

PERF. 3370Y

PERF. 3375Y

PERF. 3380Y

PERF. 3385Y

PERF. 3390Y

PERF. 3395Y

PERF. 3400Y

PERF. 3405Y

PERF. 3410Y

PERF. 3415Y

PERF. 3420Y

PERF. 3425Y

PERF. 3430Y

PERF. 3435Y

PERF. 3440Y

PERF. 3445Y

PERF. 3450Y

PERF. 3455Y

PERF. 3460Y

PERF. 3465Y

PERF. 3470Y

PERF. 3475Y

PERF. 3480Y

PERF. 3485Y

PERF. 3490Y

PERF. 3495Y

PERF. 3500Y

PERF. 3505Y

PERF. 3510Y

PERF. 3515Y

PERF. 3520Y

PERF. 3525Y

PERF. 3530Y

PERF. 3535Y

PERF. 3540Y

PERF. 3545Y

PERF. 3550Y

PERF. 3555Y

PERF. 3560Y

PERF. 3565Y

PERF. 3570Y

PERF. 3575Y

PERF. 3580Y

PERF. 3585Y

PERF. 3590Y

PERF. 3595Y

PERF. 3600Y

PERF. 3605Y

PERF. 3610Y

PERF. 3615Y

PERF. 3620Y

PERF. 3625Y

PERF. 3630Y

PERF. 3635Y

PERF. 3640Y

PERF. 3645Y

PERF. 3650Y

PERF. 3655Y

PERF. 3660Y

PERF. 3665Y

PERF. 3670Y

PERF. 3675Y

PERF. 3680Y

PERF. 3685Y

PERF. 3690Y

PERF. 3695Y

PERF. 3700Y

PERF. 3705Y

PERF. 3710Y

PERF. 3715Y

PERF. 3720Y

PERF. 3725Y

PERF. 3730Y

PERF. 3735Y

PERF. 3740Y

PERF. 3745Y

PERF. 3750Y

PERF. 3755Y

PERF. 3760Y

PERF. 3765Y

PERF. 3770Y

PERF. 3775Y

PERF. 3780Y

PERF. 3785Y

PERF. 3790Y

PERF. 3795Y

PERF. 3800Y

PERF. 3805Y

PERF. 3810Y

PERF. 3815Y

PERF. 3820Y

PERF. 3825Y

PERF. 3830Y

PERF. 3835Y

PERF. 3840Y

PERF. 3845Y

PERF. 3850Y

PERF. 3855Y

PERF. 3860Y

PERF. 3865Y

PERF. 3870Y

PERF. 3875Y

PERF. 3880Y

PERF. 3885Y

PERF. 3890Y

PERF. 3895Y

PERF. 3900Y

PERF. 3905Y

PERF. 3910Y

PERF. 3915Y

PERF. 3920Y

PERF. 3925Y

PERF. 3930Y

PERF. 3935Y

PERF. 3940Y

PERF. 3945Y

PERF. 3950Y

PERF. 3955Y

PERF. 3960Y

PERF. 3965Y

PERF. 3970Y

PERF. 3975Y

PERF. 3980Y

PERF. 3985Y

PERF. 3990Y

PERF. 3995Y

PERF. 4000Y

PERF. 4005Y

PERF. 4010Y

PERF. 4015Y

PERF. 4020Y

PERF. 4025Y

PERF. 4030Y

PERF. 4035Y

PERF. 4040Y

PERF. 4045Y

PERF. 4050Y

PERF. 4055Y

PERF. 4060Y

PERF. 4065Y

PERF. 4070Y

PERF. 4075Y

PERF. 4080Y

PERF. 4085Y

PERF. 4090Y

PERF. 4095Y

PERF. 4100Y

PERF. 4105Y

PERF. 4110Y

PERF. 4115Y

PERF. 4120Y

PERF. 4125Y

PERF. 4130Y

PERF. 4135Y

PERF. 4140Y

PERF. 4145Y

PERF. 4150Y

PERF. 4155Y

PERF. 4160Y

PERF. 4165Y

PERF. 4170Y

PERF. 4175Y

PERF. 4180Y

PERF. 4185Y

PERF. 4190Y

PERF. 4195Y

PERF. 4200Y

PERF. 4205Y

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PERF. 4235Y

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PERF. 4245Y

PERF. 4250Y

PERF. 4255Y

PERF. 4260Y

PERF. 4265Y

PERF. 4270Y

PERF. 4275Y

PERF. 4280Y

PERF. 4285Y

PERF. 4290Y

PERF. 4295Y

PERF. 4300Y

PERF. 4305Y

PERF. 4310Y

PERF. 4315Y

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PERF. 4325Y

PERF. 4330Y

PERF. 4335Y

PERF. 4340Y

PERF. 4345Y

PERF. 4350Y

PERF. 4355Y

PERF. 4360Y

PERF. 4365Y

PERF. 4370Y

PERF. 4375Y

PERF. 4380Y

PERF. 4385Y

PERF. 4390Y

PERF. 4395Y

PERF. 4400Y

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PERF. 4430Y

PERF. 4435Y

PERF. 4440Y

PERF. 4445Y

PERF. 4450Y

PERF. 4455Y

PERF. 44





