EARTH

AFFECTED ENVIRONMENT

SEISMIC HAZARDS

Overview

A June 2005 study prepared for Washington State, "*Scenario for a Magnitude 6.7 Earthquake on the Seattle Fault*" by the Earthquake Engineering Research Institute (EERI) illustrates the potentially widespread consequences of a major earthquake. Potential losses from a magnitude 6.7 shallow earthquake could be ten times worse than the 2001 Nisqually earthquake, with thousands of lives lost, destruction of buildings, disruption of transportation and utilities, and severe economic disruption. Given South Downtown's historic buildings and transportation systems, seismic risks and protective strategies should be understood.

Geologic Conditions and Seismic-Related Ground Failure

The Seattle Fault zone runs through Puget Sound, Seattle, Bellevue and Issaquah, roughly parallel to Interstate 90. Shallow earthquakes could occur in this fault or five other known surface fault zones. Over 50 years, there is a 2% probability that severe ground motion could occur, based on all potential earthquake sources—and "*the projected ground motions are some of the highest in the country.*" (EERI, 2005).

A substantial portion of South Downtown and the Duwamish vicinity have poor soils, reflecting prior mud flats and subsequent filling. These poor soils generally extend as far as Chinatown/I.D. within one block of Airport Way S., angling northwest toward Second Avenue Extension. These are identified as "liquefaction hazard areas" meaning that during earthquakes the soils may behave like a liquid and experience shaking and accelerated movement.

Seismic ground failures in a shallow earthquake could include surface ruptures, landslides, loss of bearing capacity, ground settlement, lateral spreading and local flooding. Lateral spreading causes liquefied ground masses to move downward—the EERI analysis estimates such movement in South Downtown of at least 1 to 3 feet, more near shorelines. Buildings could settle or tip over due to loss of soil bearing capacity. Water ejected from soils could cause local flooding (EERI, 2005). A tsunami or flooding might also occur—perhaps 10 feet or higher, if a major earthquake deforms the Puget Sound seafloor.

Types of Potential Seismic Damage

Commercial, Industrial and Residential Buildings

Buildings most at risk for severe seismic damage are those built with "unreinforced masonry" (URM). South Downtown neighborhoods contain the largest concentration of such URM buildings in the region. These are at risk due to inadequate structural qualities, such as inadequate wall anchorage, unstable parapets, weak masonry walls, and risk of deflections, twisting or wall collapse. This includes older industrial buildings built before 1973.

The potential for damage from a magnitude 6.7 earthquake in the Seattle Fault would be high, due to "*very strong ground motions that generate forces far in excess of those experienced during the 2001 Nisqually earthquake."* (EERI, 2005). Approximately 3,900 commercial and industrial buildings in the region would experience moderate-to-extensive structural damage, amounting to $10.5 billion in losses. "*In addition…about $15.3 billion in damage to single- and multi-family residential structures* [would occur], *temporarily displacing more than 46,000 households.*" Extensive damage to local buildings

would severely affect the social and economic functioning of the study area's neighborhoods, as well as the historic resources that define their character.

Utilities

Water, sewer, electrical, communication and natural gas utilities are at risk.

- ***Water/sewer:*** Vulnerable to significant damage from major ground shaking, particularly where surface rupture or lateral spreading would occur. Pump stations, tanks and other equipment could also be seriously damaged. Sewage discharges to local water bodies could occur.
- ***Electricity:*** Could experience damage to transmission and distribution lines and substations. Potential collapse of the Alaskan Way Viaduct would cause significant damage or impairment to adjacent electrical systems. Approximately half of the electrical system would suffer outages, with service likely restorable within a few days.
- ***Communications:*** Could experience damage and service challenges.
- ***Natural Gas:*** Facilities in poor soils will experience some damage, even though Puget Sound Energy has replaced much of its iron pipe with PVC pipe.

Transportation Systems

Road, transit, rail, ferry, air and water port systems are integral to the regional economy. "*A major disruption to any one of these components…will overload the other systems, reducing their efficiency, potentially bringing them to a halt, with devastating effect on the region's economy."* (EERI, 2005). Some roads and bridges could be severely damaged or collapse, particularly vulnerable structures such as the Alaskan Way Viaduct and Fourth Avenue South bridge structure.

Marine Ports and Related Infrastructure

The Ports of Seattle and Tacoma are each multi-billion dollar contributors to the region's economy, providing movement of goods to and from other countries. Connections to rail and highway networks are important conduits for the flow of goods. Various port facilities, such as piers, wharves, seawalls, container storage yards, and upland equipment are at risk of damage. Most of the ground in these facilities is moderately or highly susceptible to seismic movement and damage. The 1995 Kobe, Japan quake caused great damage to port facilities, leading to major losses of shipping business. The same could occur in this region. Damage to railroad lines would compound the problems with the flow of goods.

Economic and Business Impacts

As suggested by the preceding discussion, potentially catastrophic damage would have tremendous regional economic impacts. Kobe, Japan incurred losses of roughly $200 billion, in a city of comparable size and geography to the Seattle area. Many small businesses would fail in the wake of a major earthquake, and impaired roads and utilities would create lasting effects on commerce and industry.

A consultant’s study for DPD used a Federal Emergency Management Agency model known as “HAZUS” to estimate potential earthquake losses in the study area. The model estimates potential losses of building inventory, transportation and utility infrastructure, economic losses due to impaired conditions, social impacts (shelter and casualties) and debris generation. It estimates damages to the existing inventory of buildings, facilities and infrastructure per the soil conditions and possible kinds of earthquakes. Because this study represents only an initial review of potential losses, it may underestimate some losses that could be better estimated if additional in-depth examination of potential infrastructure damage and economic losses occurred.

Table 3-34 illustrates the model results for earthquakes at different magnitudes. For example, the aftermath of an 8.5 magnitude earthquake could generate almost $10 billion in damages to buildings and infrastructure: around $1.7 billion in building-related capital and economic losses, almost $8 billion in transportation system capital losses and economic losses, and around $300 million in other utility infrastructure capital and economic losses, just in the study area. The presence of transportation and port facilities that are critical to the region's economy heighten the potential for losses and the interests in seismic damage prevention.

Table 3-34
Estimated Capital and Economic Losses in South Downtown During Major Earthquake Events

Earthquake Magnitude	Building-Related		Transportation System		Other Utility Infrastructure		Totals
	Capital (000,000)	Economic (000,000)	Capital (000,000)	Economic (000,000)	Capital (000,000)	Economic (000,000)	(000,000)
7.0	$568	$108	$6,486	$747	$199	$45	$8,153
8.0	$1,322	$224	$6,486	$1,189	$199	$66	$9,486
8.5	$1,447	$277	$6,486	$1,478	$199	$84	$9,971

Source: Ince, 2006

ENVIRONMENTAL IMPACTS

IMPACTS WITH FUTURE GROWTH

All Alternatives

This EIS makes does not identify significant adverse seismic hazard impacts directly related to the EIS zoning alternatives. However, under any zoning alternative, future development is likely to occur across the study area in vicinities that have elevated risk of seismic damage, due to presence of fill soils in former tidelands in the southern half of the study area, and proximity to the Seattle Fault zone.

Alternatives 1, 2 and 3 are similar in their overall relationship to potential seismic impacts. Each would accommodate large developments on the west side of 1st Avenue S., in the north parking lot of Qwest Field, possibly over the railroad tracks near 4th Avenue S. and in the south-of-Dearborn vicinity. These are all areas at least partially within fill soils.

New structures would be subject to the protective requirements of Seattle's building code, which requires increased structural strength that would limit seismic damage potential. This means that residents of future newly developed buildings would meet required levels of protection against seismic damage to their building. However, due to the potential damages to its utility and road infrastructure and older building inventory, the study area could be subject to delay in restoring habitable living conditions. This risk might be reduced if strategic investments are made to reduce worst-case potential for seismic damages to the infrastructure networks and building stock. For example, the installation of isolation valves between Downtown and the study area could reduce the risk and extent of damage to the water system.

Under any alternative, the southern portion of the study area would be subject to risks of interrupted transportation networks, damage to port facilities and other impairments to port-related economic activity. There are no meaningful differences in potential adverse impacts among these zoning alternatives.

If an earthquake occurred under Elliott Bay, a tsunami could be generated that could flood portions of the study area, to a depth of approximately five feet. This might occur in the lower elevations that were previously tidelands. This risk provides some support for continued discouragement of residential uses at ground floor level in Pioneer Square, Chinatown core, and the south-of-Dearborn area.

MITIGATION STRATEGIES

POSSIBLE MITIGATION STRATEGIES

South Downtown's seismic vulnerabilities mean it is at risk for loss of life and major damage of its existing historic buildings, infrastructure and economy. The following is a brief list of possible strategies for improving protection against damage and losses from a major earthquake:

- Prioritize investments in utility system safeguards and retrofits, such as water system isolation valves, that would help reduce disruption of service and utility system damage
- Encourage retrofit of high-risk unreinforced masonry buildings
- Prioritize protection of transportation and port infrastructure, to reduce economic impacts and disruption of vehicle movement
- Replace the vulnerable Alaskan Way Viaduct and seawall
- Expand public earthquake awareness and education programs
- Expand funding for emergency management and preparedness
- Develop an earthquake recovery strategy that would identify cost-effective preventive measures to speed recovery after a major earthquake.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

The study area and its infrastructure are subject to seismic damage risks. However, no significant unavoidable adverse impacts specific to the zoning alternatives are identified.