Health Impact Assessment Technical Report

Multnomah County | Earthquake Ready Burnside Bridge Project

Portland, OR

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Earthquake Ready Burnside Bridge Health Impact Assessment Technical Report

Prepared for

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Executive Summary

Health Impact Assessment (HIA) provides decision-makers with information about a policy, program, or project's potential health effects and the distribution of those health effects on people. The process identifies health consequences, documents health disparities, and recommends appropriate actions before a decision is made. HIA considers the social, physical, and economic environments where a person spends time as important influences on overall health. HIA brings short-term and long-term health outcomes to the forefront of decision-making.

Earthquake Ready Burnside Bridge Project

The current Burnside Bridge, owned by Multnomah County and built in 1926, along with all other aging bridges across the Willamette River, is expected to fail during the next major Cascadia Subduction Zone earthquake. As part of the County's process to evaluate replacement and retrofit options for the Burnside Bridge, the County's Transportation Division partnered with Environmental Health Services in the County's Public Health Division to develop a HIA. The Earthquake Ready Burnside Bridge HIA helps decision-makers choose a Preferred Alternative and inform decisions about local impacts during construction. Five alternatives are considered in the HIA:

- No-Build Alternative
- Enhanced Seismic Retrofit (replace certain elements of the existing bridge)
- Replacement Alternative with Short-span Approach (remove current bridge and replace with a similar bridge)
- Replacement Alternative with Long-span Approach (remove current bridge and replace with a bridge with a superstructure and fewer columns)
- Replacement Alternative with Couch Extension (remove current bridge and replace with a forked span to approach the bridge from NE Couch Street)

The HIA also considers three different scenarios during construction:

- Temporary Bridge
- Temporary Bridge open only to bikes, pedestrians, and transit
- Full closure

For each Alternative and construction scenario, the HIA considers the following topics as they relate to health: transportation; climate change; parks and recreation; toxic exposures; noise; displacement; air quality; land use; social environment; and environmental justice. The HIA reviews scientific evidence, uses modeling tools, and analyzes quantitative and qualitative data to determine health impacts of the different alternatives and construction options.

Summary of Findings

The HIA finds that all Build Alternatives would lead to fewer negative health impacts after a major earthquake. Evidence does not suggest a disproportionate health burden or benefit from this Project to people of color. Because walking, biking, and transit use are all expected to increase, all Build Alternatives would result in health benefits in 2040, avoiding $32 million in medical costs annually.

When looking at construction, the health impacts are similar across construction scenarios. Noise and air pollution from all construction scenarios would impact nearby residents and workers the most. Long closures of the Vera Katz Eastbank Esplanade could negatively affect health by disrupting physical activity from active transportation and recreational exercise (walking, biking, skating, etc.). Compared to construction strategies that use a temporary bridge, those that do not use one result in lower amounts of walking but higher amounts of biking. Health benefits from physical activity are similar regardless of the construction strategy. An earthquake ready bridge would minimize injuries and increase economic stability in the aftermath of an earthquake.

Recommendations

To reduce negative health impacts of a major earthquake, the HIA recommends decision-makers select an alternative that minimizes the risk of bridge collapse. Transportation projects can affect physical activity, air pollution, access to green spaces, crash injuries, noise levels, and urban heat. These changes affect the leading causes of death such as cancer, heart disease, stroke, diabetes, chronic obstructive pulmonary disease, and unintentional injury. To minimize health harms and maximize health benefits, the HIA recommends:

Reduce negative health impacts of a major earthquake

- Select one of the Build Alternatives that minimizes the risk of bridge collapse.

Maximize long-term physical activity

- Prioritize direct, low-stress routes for people walking, cycling, and taking transit.
- Leverage transportation demand management strategies to promote long-term adoption of mode changes adopted during construction.

Minimize short-term disruptions to physical activity

- Establish and publicize alternate routes for recreation.
- Select a construction approach that maximizes physical activity during the construction phase.
- Minimize closure of the Vera Katz Eastbank Esplanade. The Long-span Alternative with no Temporary Bridge would result in the least displacement of physical activity on the Vera Katz Eastbank Esplanade.
- Collaborate with researchers to monitor changes to physical activity from recreation during closures.
- Minimize the duration of Burnside Skatepark closure. Promote alternate venues for skating and related cultural events during the closure, consulting with users on preferences prior to finalizing a plan. Replacement Alternatives with no Temporary Bridge would result in the shortest closure of the Burnside skatepark.

Eliminate serious and fatal traffic crash deaths in the Project Area

- Develop an action plan to address safety concerns that arise during construction
- Select an alternative with maximum crash injury reduction. The Short-span and Long-span Alternatives result in the greatest reduction in all crashes.
- Design for speeds of 25 mph.

Minimize impacts of urban heat

- Minimize large expanses of pavement, and coordinate with the City of Portland to add trees or other shade structures where feasible.
- Minimize removal of existing trees and vegetation.

Minimize short-term health risks from air pollution during construction

- Adhere to clean diesel contracting rules, and use electric equipment or other pollution controls when possible.
- Adopt dust control measures for demolition of buildings and the bridge.
- Offer indoor air filtration and air conditioning to affected residents and small businesses.
- Establish plans for pollution reductions on days with wildfire smoke infiltration, high ozone, or wintertime inversions.

Minimize long-term health risks from air pollution during operation

- Select an alternative that maximizes separation between vehicle pollution and people walking and cycling.

Protect social cohesion

- Acknowledge native peoples and lands.
- Mitigate impacts to Governor Tom McCall Waterfront Park, including impacts to special events, Portland Saturday Market, Bill Naito Legacy Fountain, and the Japanese American Historical Plaza.

Mitigate noise impacts

- Communicate with residents about the nature and duration of noise impacts.

Prevent harm and create health benefits for the unhoused population

- Conduct outreach regarding construction impacts including air pollution exposure, noise, and access to social services.
- Mitigate short-term displacement of facilities used by the unhoused population.
- Work with partner agencies to identify opportunities to provide long-term benefits from the Project, such as restrooms or storage facilities.
- If there is no Temporary Bridge, provide assistance such as transit passes to people accessing social services near the western bridgehead.

Generate economic benefits in local communities

- Coordinate with nonprofits to support recruiting and job-training efforts, prioritizing low-income residents and people of color.

1 Introduction

As a part of the preparation of the Environmental Impact Statement (EIS) for the Earthquake Ready Burnside Bridge (EQRB) Project, this technical report has been prepared to identify and evaluate health impacts from the proposed project.

1.1 Project Location

The Project Area is located within the central city of Portland. The Burnside Bridge crosses the Willamette River connecting the west and east sides of the city. The Project Area encompasses a one-block radius around the existing Burnside Bridge and W/E Burnside Street, from NW/SW 3rd Avenue on the west side of the river and NE/SE Grand Avenue on the east side. Several neighborhoods surround the area including Old Town/Chinatown, Downtown, Kerns, and Buckman. Map 1 shows the Project Area.

1.2 Project Purpose

The primary purpose of the Project is to build a seismically resilient Burnside Street lifeline crossing over the Willamette River that will remain fully operational and accessible for vehicles and other modes of transportation following a major Cascadia Subduction Zone (CSZ) earthquake. The Burnside Bridge will provide a reliable crossing for emergency response, evacuation, and economic recovery after an earthquake. Additionally, the bridge will provide a long-term safe crossing with low-maintenance needs.

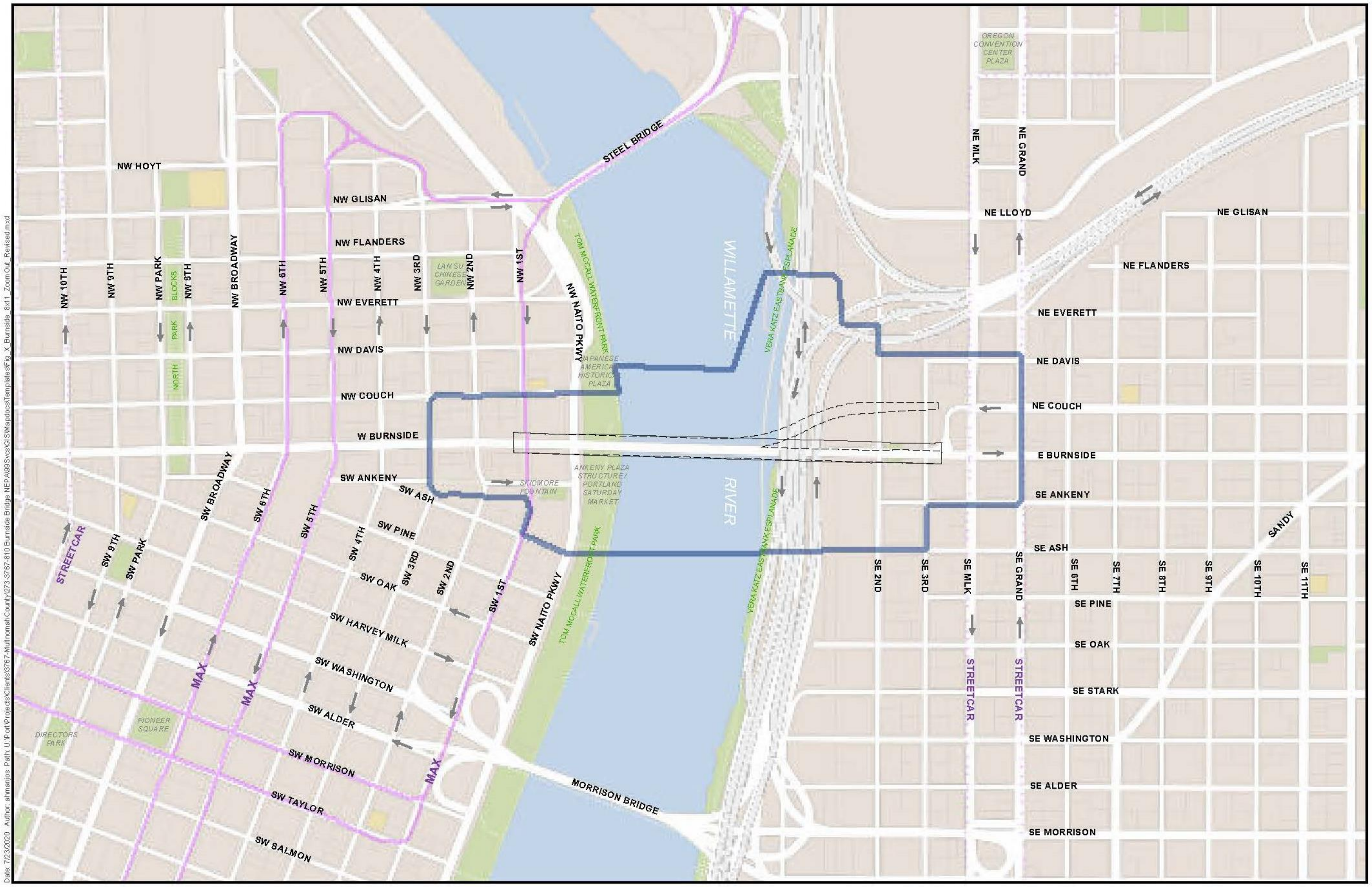
2 Health Impact Assessment

As part of the County's process to evaluate replacement and retrofit options, this Health Impact Assessment (HIA) was undertaken in coordination with environmental review of Project Alternatives under the National Environmental Policy Act. As with other technical reports from the environmental review, the HIA provides decision support, transparency about impacts, and suggestions for mitigation.

The HIA is intended to help planners and decision-makers:

- Understand potential health impacts of a bridge project, including the construction phase.
- Document existing health disparities and estimate how they may be affected by the bridge project.
- Develop recommendations to mitigate potential harms and maximize potential benefits.

Map 1. Project Area



Project Area
Retrofit
Short-span Alterative
Long-span Alternative
Couch Extension

Source:
City of Portland, Oregon
HDR, Parametrix

0 250 500 1,000 Feet

Map 1.
Project Area

Earthquake Ready Burnside

An HIA is warranted for this project because of the influence that transportation decisions have on leading causes of death in Multnomah County. [1] In 2011, the County conducted an HIA for a similar project, the Sellwood Bridge replacement. [2] The most direct health impacts from transportation projects affect health through the pathways of physical activity, air pollution, crash injuries, and noise. These affect leading causes of death such as cancer, heart disease, stroke, diabetes, chronic obstructive pulmonary disease, and unintentional injury. For many of these conditions, there are documented unfair and systematic differences between race groups. For example, the death rate from diabetes among Black residents in Multnomah County is nearly three times the rate of non-Hispanic whites. [3] The effect of urban transportation on health is large and well-documented. A 2017 study by a European research team estimated that up to 20 percent of all premature death could be prevented by changes to urban transportation. [4] There are many additional, less direct pathways through which any large construction project could impact health, including disruptions to social and recreation opportunities, economic activity, social services, climate resilience, and emergency response.

This HIA informs the decision on the selection of a Preferred Alternative, as well as secondary decisions about managing construction impacts. This decision will be made by the Board of County Commissioners and the Federal Highway Administration with input from an executive-level policy group, a community task force, a team of agency staff and consultants, community members, and other stakeholders. The alternatives considered are described in the following section.

A major earthquake could impact population health in profound ways. Immediate effects could include injury, death, and exposure to toxics. During recovery, people may be exposed to continued high risk of injury, infectious diseases, and ongoing impacts to mental and physical health associated with loss of property, livelihood, and social connections. Throughout this HIA, resilient infrastructure is presumed to lessen these potential impacts, and the impacts of seismic events are discussed as part of evaluation of a No-Build Alternative.

In addition to differences between alternatives, differences between potential construction management strategies could influence health impacts. All Build Alternatives under consideration propose a crossing of the Willamette River that is very similar to the current bridge in size and capacity, but without specifying design characteristics such as bridge type. Given the similarity between alternatives, the health impacts of each are expected to be similar. However, with a lengthy construction period of up to 6 years, differences between construction management strategies could affect health. This HIA devotes special attention to health impacts of the construction phase and offers mitigation suggestions for both the temporary and permanent conditions.

Health impact assessment generally follows five steps: screening, scoping, assessment, reporting, and evaluation. This document represents the assessment step of the HIA and adheres as closely as possible to the Minimum Elements and Practice Standards version 3.0 used by the Society of Practitioners of Health Impact

Assessment. [5] Assessment results are organized by topic areas that roughly correspond to other technical reports developed as part of environmental review. This document contains only the Project information most relevant to interpreting findings of the assessment; readers are advised to consult technical reports and other Project materials for a full description of the Project purpose, areas of potential impact, and other specific project information. Detailed methods and descriptions of activities undertaken for each of the steps of HIA are available in the Appendix B.

3 Project Alternatives

The project alternatives are described in detail with text and graphics in the *EQRB Description of Alternatives Report*. That report describes the alternatives' current design as well as operations and construction assumptions.

Briefly, the DEIS evaluates the No-Build Alternative and four Build Alternatives. Among the Build Alternatives there is an Enhanced Seismic Retrofit Alternative that would replace certain elements of the existing bridge and retrofit other elements. There are three Replacement Alternatives that would completely remove and replace the existing bridge. In addition, the DEIS considers options for managing traffic during construction. Nomenclature for the alternatives/options are:

- No-Build Alternative
- Build Alternatives:
  - Enhanced Seismic Retrofit (Retrofit Alternative)
  - Replacement Alternative with Short-span Approach (Short-span Alternative)
  - Replacement Alternative with Long-span Approach (Long-span Alternative)
  - Replacement Alternative with Couch Extension (Couch Extension Alternative)
- Construction Traffic Management Options
  - Temporary Detour Bridge Option (Temporary Bridge) includes three modal options:
    - Temporary Bridge: All modes
    - Temporary Bridge: Transit, Bicycles and Pedestrians only
    - Temporary Bridge: Bicycles and Pedestrians only
  - Without Temporary Detour Bridge Option (No Temporary Bridge)

4 Definitions

Causal pathway – A chain of mechanisms, risk and protective factors, and events that lead to an outcome. For example, the release of air pollution from a vehicle affects people who are exposed to it in different amounts at different times, leading to a range of health impacts such as asthma exacerbation.

Health outcome – The endpoint of a causal pathway, such as illness (e.g., diabetes), injury (e.g., traffic crash injury) or premature death (e.g., death from cancer).

Cancer risk – The probability of contracting cancer over the course of a lifetime. For estimates from the US EPA National Air Toxics Assessment, this risk is based on the assumption of continuous exposure over a 70-year lifetime and is expressed in cases per million population.

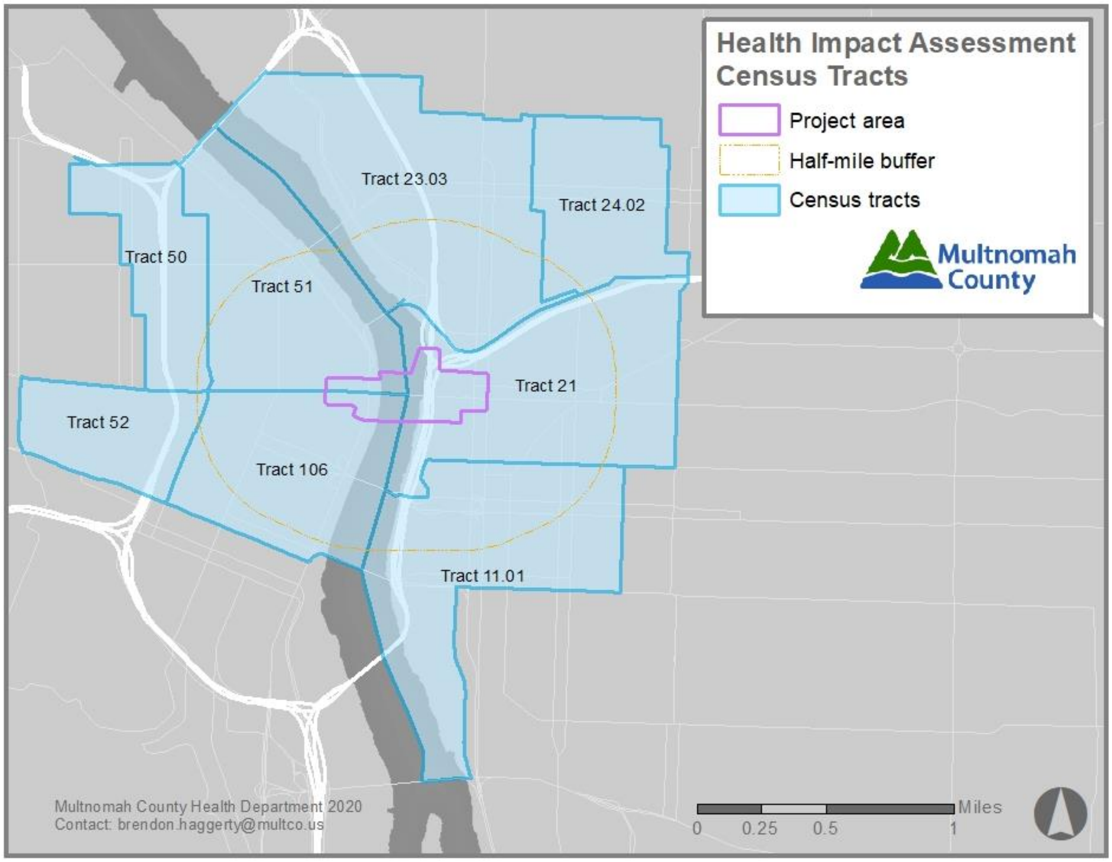
Health impacts are characterized using the concepts of likelihood (whether the impact will happen), magnitude (how widespread impacts are), severity (whether the impacts are reversible, life changing, or long lasting), and distribution (groups of people who are most likely to be affected). Beneficial impacts are described in terms of their protective effects, used here as the inverse of severity.

5 Existing Conditions

5.1 Existing Burden of Morbidity and Mortality

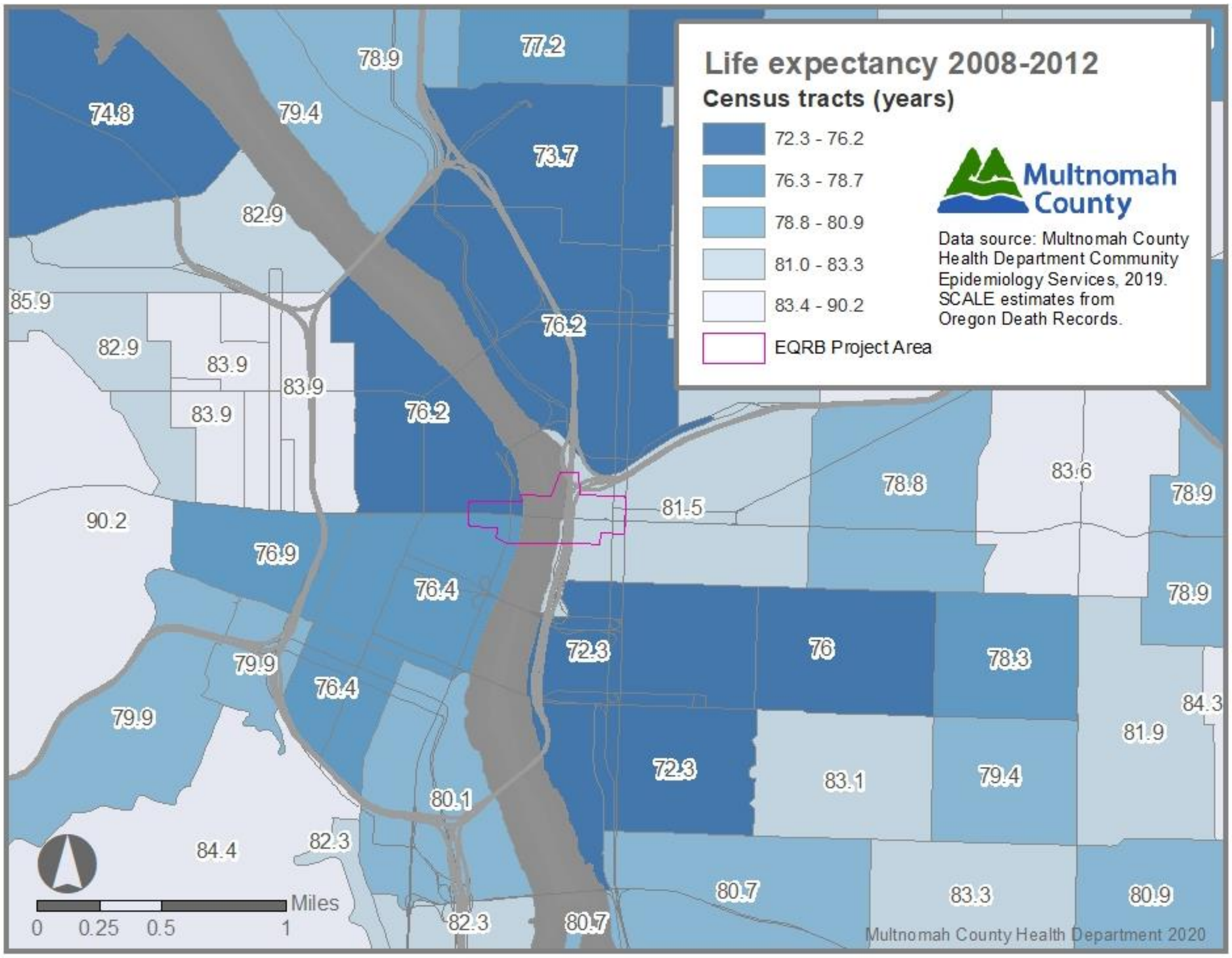
Data on morbidity (disease) and mortality (death) in Multnomah County are presented below, with a breakdown of disparities among populations of concern detailed in the following section. For most conditions, data are available only at the county level, but in some cases data are available at the census tract level. When available, data are summarized for the eight census tracts intersecting a half-mile buffer of the Project Area. As shown in Map 2, these include tracts 11.01, 21, 23.03, 24.02, 50, 51, 52, and 106. Data are presented for the most recent years available, in most cases combining 5 years of data to produce more reliable estimates.

Map 2. Health Impact Assessment Census Tracts



Life expectancy is a basic measure of overall health. Map 3 displays estimated life expectancy by census tract for the period of 2008 through 2012. Estimated life expectancy in census tracts near the Project Area is mostly in the middle range among all tracts in the county. However, the census tract to the south of East Burnside is tied for the lowest life expectancy in the county, 72.3 years. This is 18 years less than tracts with the highest life expectancy, those bordering Burnside to the west of NW 23rd Avenue.

Map 3. Estimated Life Expectancy by Census Tract 2008–2012



The 10 leading causes of death in Multnomah County are displayed in Table 1. [6] Most of these are associated with issues that could be affected by the EQRB Project and with all transportation projects. For example, physical activity prevents some cancers, heart disease, stroke, Alzheimer's, diabetes, depression, and hypertension. [7] Air pollution from vehicles causes or exacerbates some cancers, heart disease, stroke, chronic lower respiratory disease, and diabetes. [8] Traffic noise is associated with heart disease, [9] and traffic crashes contribute to unintentional injuries. [10]

Table 1. Leading Causes of Death in Multnomah County, 2014–2018

Cause		Crude rate per 100,00 population (95% confidence interval)
1	Cancer	156.3 (152.4–160.2)
2	Heart disease	137.2 (133.5–140.8)
3	Unintentional injuries	45.4 (43.3–47.5)
4	Stroke	40.8 (38.8–42.7)
5	Chronic lower respiratory disease	36.2 (34.4–38.1)
6	Alzheimer's disease	32.3 (30.5–34.1)
7	Diabetes	24.1 (22.5–25.6)
8	Suicide	17.1 (15.8–18.4)
9	Chronic liver disease	12.8 (11.7–14)
10	Essential hypertension	10.9 (9.8–11.9)

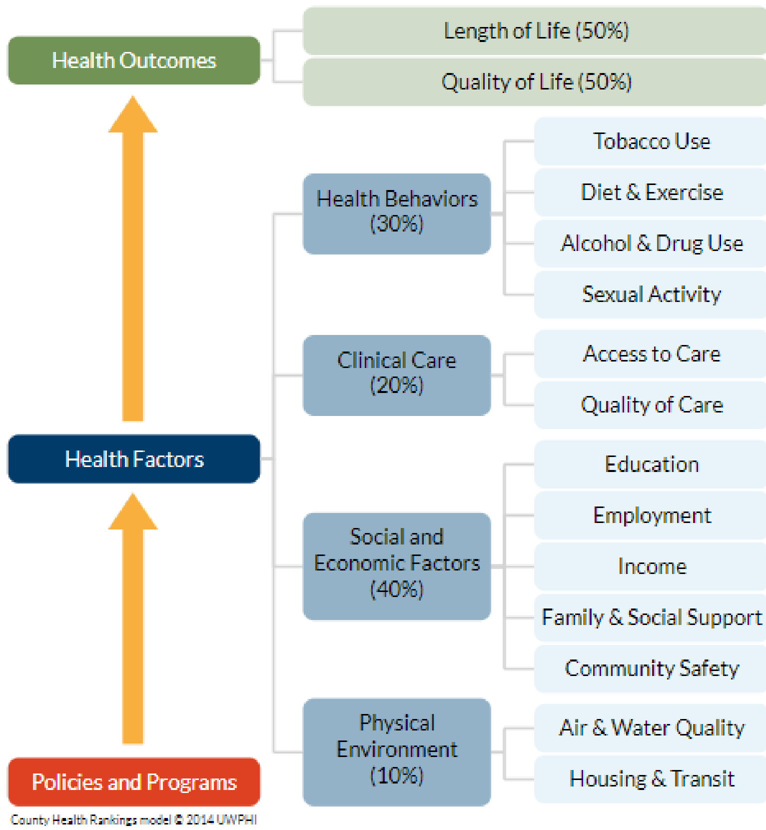
The existing burden of illness in Multnomah County for common conditions is detailed in Table 2. [11] These conditions could be affected by elements of the EQRB Project and all transportation projects. For example, physical activity from active transportation prevents diabetes, some cancers, heart attacks, hypertension and stroke, [7] and is an effective treatment for arthritis and depression. [12, 13]

Table 2. Morbidity in Multnomah County, 2014–2017

Condition	Crude prevalence (95% confidence interval)
Depression	26.5% (25.2–27.9)
Hypertension	25.1% (23.1–27.3)
Arthritis	20.9% (19.8–22.1)
Self-reported health is fair/poor	16% (14.9–17.2)
Asthma	10.0% (9.1–10.9)
Diabetes	7.8% (7.1–8.6)
Cancer	6.6% (5.9–7.3)
Heart attack	3.3% (2.8–3.8)
Stroke	2.6% (2.1–3.1)

According to commonly used models of population health, the broad categories of determinants of health are the physical environment, social and economic factors, access to clinical care, and behaviors (Figure 1). This HIA focuses primarily on built and social environment determinants of health, but these interact with behaviors to produce health outcomes. Behaviors are thought to explain about 30 percent of overall health, and can prevent chronic diseases that comprise many of the leading causes of premature death. [14]

Figure 1. Model of Determinants of Health



Some of these behaviors help explain the existing burden of disease and death described above. Among these are tobacco use, alcohol use, physical activity, and commute behavior. Some of these behaviors (physical activity, commute behavior) could be directly influenced by the EQRB Project, while others (tobacco use, alcohol use) contribute to health outcomes that are also linked to the Project, such as respiratory illness from pollution and injuries from traffic crashes. Data on these behaviors in Multnomah County are provided in Table 3. [11] In addition to these estimates from the Oregon Behavioral Risk Factor Surveillance Survey, the U.S. Census Bureau American Community Survey provides estimates of commute behavior. Five-year estimates for 2014 to 2018 suggest that 60.4 percent of commuters in Multnomah County drive alone to work. [15]

Table 3. Selected Behavioral Risk and Protective Factors in Multnomah County, 2014–2017

Behavior	Prevalence (95% confidence interval)
Tobacco use*	22.6% (20.3–25.2)
Meets physical activity recommendations	22.5% (20.2–25.0)
Heavy drinking**	9.4% (8.5–10.5)

*Includes cigarettes, cigars, hookah, electronic cigarettes, and smokeless tobacco
** More than two drinks per day for men or more than one drink per day for women in the past 30 days

5.2 Populations of Concern

HIA scoping exercises identified many potential populations of concern to be evaluated for disproportionate impacts. The full list of populations includes some groups for which health data are not readily available, but disparities are reported when possible. Populations of concern identified in the scoping phase include low-income residents, people of color, tribal communities, area residents and employees, all Project users, vulnerable road users, people with disabilities, older adults, youth, people fishing on the Willamette river, non-English speakers, construction workers, and Minority-owned, Women-owned, and Emerging Small Business (MWESB) enterprises. The data presented below are not comprehensive for each of these groups.

The study of environmental justice and its links to health arose from activism regarding extreme disparities in environmental exposures based on race. [16] This led to the establishment of principles of fair treatment and meaningful involvement for all people in environmental decision-making. Consistent with this history, environmental justice principles, and Multnomah County practices, we recognize the intersectionality of race with other markers of marginalization and therefore describe racial and ethnic disparities in greatest depth. Additional discussion of the intersection of racism and planning is provided in the section on environmental justice and in the *EQRB Environmental Justice Technical Report.* A summary of key disparities for priority groups is provided in Table 4.

Table 4. Summary of Health Disparities for Selected Populations of Concern

Group	Current population	Relevant health disparities
People of color	7,055 residents in the area (23%) identify as a race or ethnicity other than non-Hispanic white.[a]	The death rate is higher among Black residents than white residents for diabetes (2.7 times), cancer (1.4 times), stroke (1.5 times), and traffic crash deaths (1.8 times).[b]
Low income	6,329 residents in the area (22%) live below the Federal Poverty Level.[a]	1.3 times more likely to report a chronic health condition, 1.8 times more likely to report a disability or health condition limiting daily activities.[c]

Group	Current population	Relevant health disparities
Tribal communities	924 residents in the area (3%) identify as American Indian or Alaska Native.[a]	Life expectancy 5 years less than the population as a whole, higher death rates from Alzheimer's and from traffic crashes.[b]
People with chronic conditions	52% of residents in Multnomah County report at least one common chronic condition.[c]	Chronic diseases are 8 of the 10 leading causes of death in Multnomah County.[b] Downtown Portland census tracts have high estimated prevalence of multiple chronic diseases.[d]
Area residents and employees	30,155 residents live near the project area.[a]	Census tract 106 has a high estimated burden of key chronic diseases.[d] Census tract 11.01 has the lowest estimated life expectancy among Multnomah County census tracts.[e]

Sources: a. US Census Bureau American Community Survey 5-year estimates 2014-2018; b. Oregon Death Certificates 2012-2016; c. Oregon Behavioral Risk Factor Surveillance System, 2014-2017; d. Centers for Disease Control and Prevention 500 Cities Data project, 2020; e. Multnomah County Health Department 2019

In the eight census tracts near the Project Area, there is a total estimated population of 30,155 residents. Of these, 7,055, or 23 percent identify as a race or ethnicity other than non-Hispanic white. The largest communities of color are Black (7 percent), Asian (7 percent), and Hispanic or Latinx (6 percent). The estimated racial and ethnic breakdown of the area is provided in Table 5. The race categories used here are "[race] alone or in combination with any other race" and therefore overlap. These estimates are from the U.S. Census Bureau American Community Survey for 2014–2018. [15]

Table 5. Race and Ethnicity in Project Area Census Tracts, 2014–2018

Racial or Ethnic Group	Population (percentage)
Black	2,194 (7%)
American Indian or Alaska Native	924 (3%)
Asian	2,192 (7%)
Native Hawaiian or other Pacific Islander	316 (1%)
Hispanic or Latinx	1,741 (6%)
non-Hispanic white	21,300 (77%)

For leading causes of death related to transportation such as cancer, heart disease, stroke, and diabetes, there are large disparities by race and ethnicity in Multnomah County, especially among the Black population and American Indian/Alaska Native population. Death rates are detailed below in Table 6. Black residents in Multnomah County experienced a death rate from diabetes that was nearly three times that of the non-Hispanic white population in 2012–2016, with death rates from cancer and stroke also significantly higher. The death rate from Alzheimer's disease among the American Indian/Alaska Native population was 2.4 times the rate of the non-Hispanic white population. These two race groups had a lower life expectancy in 2013–2017, as shown in Table 7. The estimated life expectancy for American Indians/Alaska Natives and for the Black population was at least 4.5 years less than for other race and ethnic groups in Multnomah County. [17]

Table 6. Age-Adjusted Death Rates from Leading Causes of Death by Race and Ethnicity in Multnomah County, 2012-2016

Race/ Ethnicity	Age-Adjusted Death Rate per 100,000 (95% Confidence Interval)					
	Cancer	Heart disease	Stroke	Alzheimer's	Diabetes	Suicide
Total population	163.0 (158.8-167.1)	141.4 (137.5-145.3)	39.7 (37.6-41.7)	31.4 (29.6-33.3)	24.3 (22.6-25.9)	15.8 (14.6-17.1)
American Indian or Alaska Native	146.5 (102.1-203.8)	140.3 (90.8-207.2)	46.0 (21.0-87.3)	79.3 (39.6-142.0)	40.9 (18.7-77.6)	21.6 (9.9-41.0)
Asian or Pacific Islander	117.5 (104.1-130.8)	77.6 (66.5-88.6)	42.1 (33.9-50.3)	14.9 (10.3-20.9)	23.6 (17.9-30.6)	9.8 (6.8-13.6)
Black or African American	225.0 (202.6-247.5)	160.5 (141.0-179.9)	58.6 (47-72.1)	23.7 (16.3-33.3)	58.7 (47.2-70.3)	8.6 (5.2-13.2)
Hispanic or Latinx	115.8 (94.5-137.1)	98.1 (77.0-119.3)	26.8 (17.2-39.9)	19.2 (10.5-32.3)	27.8 (18.2-40.8)	9.5 (6.5-13.5)
Non-Hispanic white	163.9 (159.3-168.5)	144.7 (140.4-148.9)	38.1 (35.9-40.3)	32.9 (30.9-35)	22.1 (20.5-23.8)	17.1 (15.6-18.5)

Source: Oregon Death Certificates 2012-2016. Race categories are single non-Hispanic race and Hispanic ethnicity.

Table 7. Life Expectancy by Race and Ethnicity in Multnomah County, 2013–2017

Group	Life expectancy in years (95% confidence interval)
Total population	79.4 (79.3-79.6)
American Indian/Alaska Native	74.4 (72.7-76.2)
Asian/Pacific Islander	85.5 (84.9-86.0)
Black	74.9 (74.3-75.6)
Hispanic or Latinx	83.5 (82.7-84.3)
Non-Hispanic White	79.5 (79.4-79.7)

In the eight census tracts within 0.5 mile of the Project Area, there are 29,391 people for whom poverty status has been determined. Of these residents, 6,329 (21.5

percent) live below the Federal Poverty Level, and 11,084 (38 percent) live below 200 percent of the Federal Poverty Level. [15] In Multnomah County, people living below the Federal Poverty Level are more likely to report living with a chronic disease. Data from the Oregon Behavioral Risk Factor Surveillance System (2014–2017) illustrate socioeconomic disparities in the burden of disease. [11] Among those living below the poverty level, 64 percent report at least one of the following conditions: arthritis, diabetes, asthma, heart disease/stroke, cancer, depression, or chronic obstructive pulmonary disease. This compares to 49 percent of the population above the Federal Poverty Line. Similarly, 42 percent of adults in poverty report that poor physical or mental health limits their daily activities or requires the use of special equipment, compared to 23 percent of those not in poverty.

Data from 2014 to 2017 show that more than half of Multnomah County residents (52 percent) have at least one of the following chronic diseases: arthritis, diabetes, asthma, heart disease/stroke, cancer, depression, or chronic obstructive pulmonary disease. [11] Assuming this proportion applies to the population near the Project Area, an estimated 15,681 people with a chronic disease live near the Project. The Centers for Disease Control and Prevention provides modeled disease prevalence data for census tracts. [18] These data reveal basic spatial patterns in chronic disease prevalence. Census tract 106, which spans most of the area south of Burnside in downtown Portland, has a high estimated prevalence of several chronic diseases compared to the rest of Portland, including arthritis, cancer, chronic obstructive pulmonary disease, diabetes, high blood pressure, and stroke.

Area residents and workers are a population of concern. As noted above, the eight census tracts near the Project Area are home to an estimated 30,155 residents. In addition, these tracts have the highest density of employment in Multnomah County. The Census Bureau estimated that 126,378 jobs were located in these tracts as of 2017. [19] Not included in these estimates are the unhoused population, many of whom spend time in the Project Area and access services on both sides of the river. As noted above, census tracts near the eastern end of the bridge have an estimated life expectancy among the lowest in the county, 18 years less than the tracts with the highest estimated life expectancy (Map 3).

Limitations on physical, cognitive, and emotional functions occur in the context of health and wellbeing. People with a disability are likely to also experience a chronic disease and are less likely to report good health. The Oregon Health Authority analyzes disability as indicated by the presence of any of the following: deafness, blindness, cognitive function problems, mobility problems, or difficulty taking care of personal care or errands without assistance. In Multnomah County from 2014 to 2017, people with one of these conditions were twice as likely (83 percent) to report at least one common chronic disease compared to those without a disability (41 percent). The same data show that 45 percent of people with one of the above disabilities reported fair or poor general health status, compared to just 8 percent of people without. [11]

An unknown number of people fish on the Willamette River, but they are considered a population of concern because of potential exposure to toxic substances. Outreach conducted as part of the Portland Harbor Superfund Site cleanup effort suggests that people fish on the Willamette both for recreation and for subsistence. People fishing for subsistence on the Willamette are more likely to be exposed to toxic substances through fish consumption. The Oregon Health Authority has issued a fish advisory for the Lower Willamette River from the Sellwood Bridge to the confluence with the Columbia River. [20] Polychlorinated biphenyls (PCBs), mercury, and pesticides contaminate some fish in the Willamette River, especially resident fish. Exposure to these toxics can result in damage to the brain, central nervous system, and other biological systems. PCB exposure can also increase cancer risk. [21] Anecdotal evidence from outreach suggests that recent immigrants may be more likely to consume fish caught in the Willamette River.

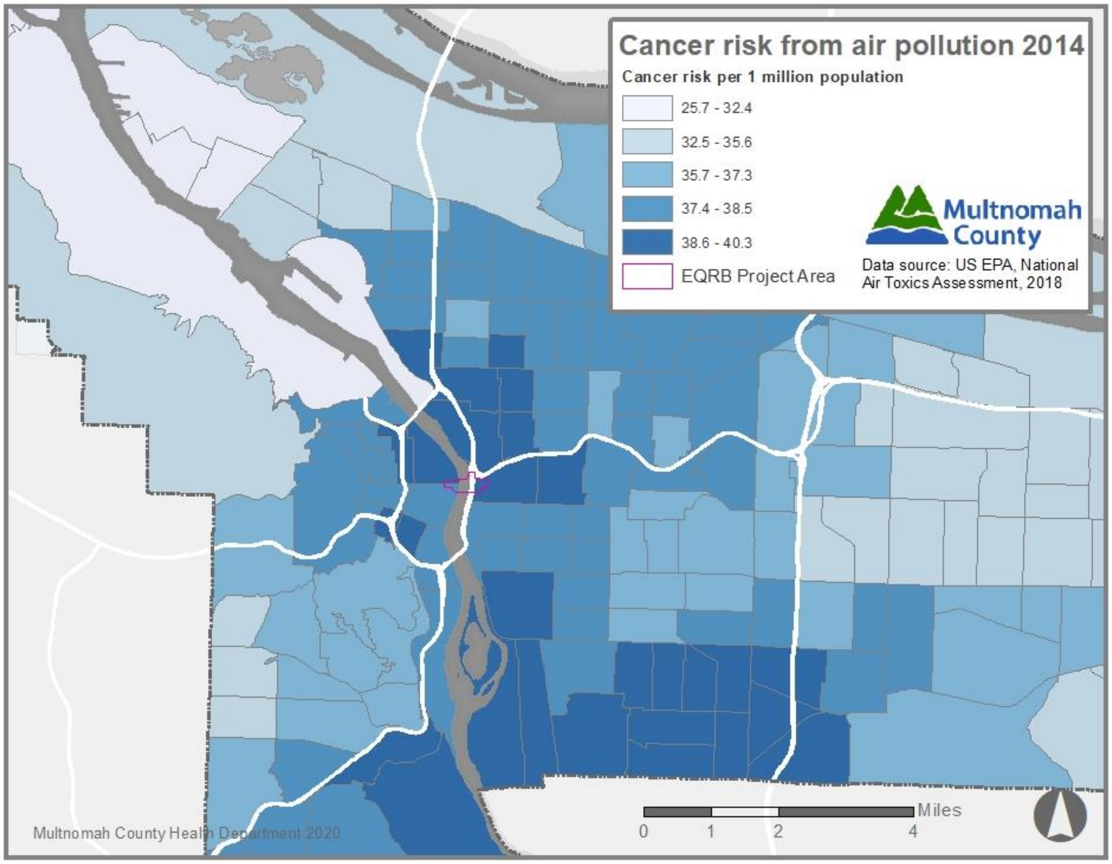
5.3 Affected Environment

The built environment in the Project Area contains risk and protective factors that influence the health of people living, working, and passing through the area. Evidence supports at least five aspects of the built environment that influence health and have a strong connection to transportation planning projects: opportunities for physical activity, access to green spaces, and exposure to air pollution, noise, and heat. [4] There is also evidence that land use characteristics such as the density of jobs, residences, and destinations is associated with health. [22] Existing conditions for most of these topics are described in detail in corresponding technical reports, so they are treated briefly below with additional health-specific information.

5.3.1 Air Pollution

The Project is in an area with high exposure to mobile sources of air pollution from on-road and nonroad sources. [23] In addition to pollution from traffic on Burnside Street, other sources include the junction of Interstates 5 and 84, a freight rail line, and nearby arterials such as Grand Avenue, Martin Luther King Jr. Boulevard, and Naito Parkway. This combination of sources contributes to high exposure and health risk from air toxics near the Project Area as compared to other parts of the county. Map 4 displays modeled cancer risk from air toxics by census tract. Tracts on the east side of the Project Area are among the five tracts in Multnomah County with the highest estimated risk. As discussed in more depth in the section on air impacts, these estimates do not fully take into account the effects of diesel particulate matter.

Map 4. Cancer Risk from Air Toxics by Census Tract, 2014

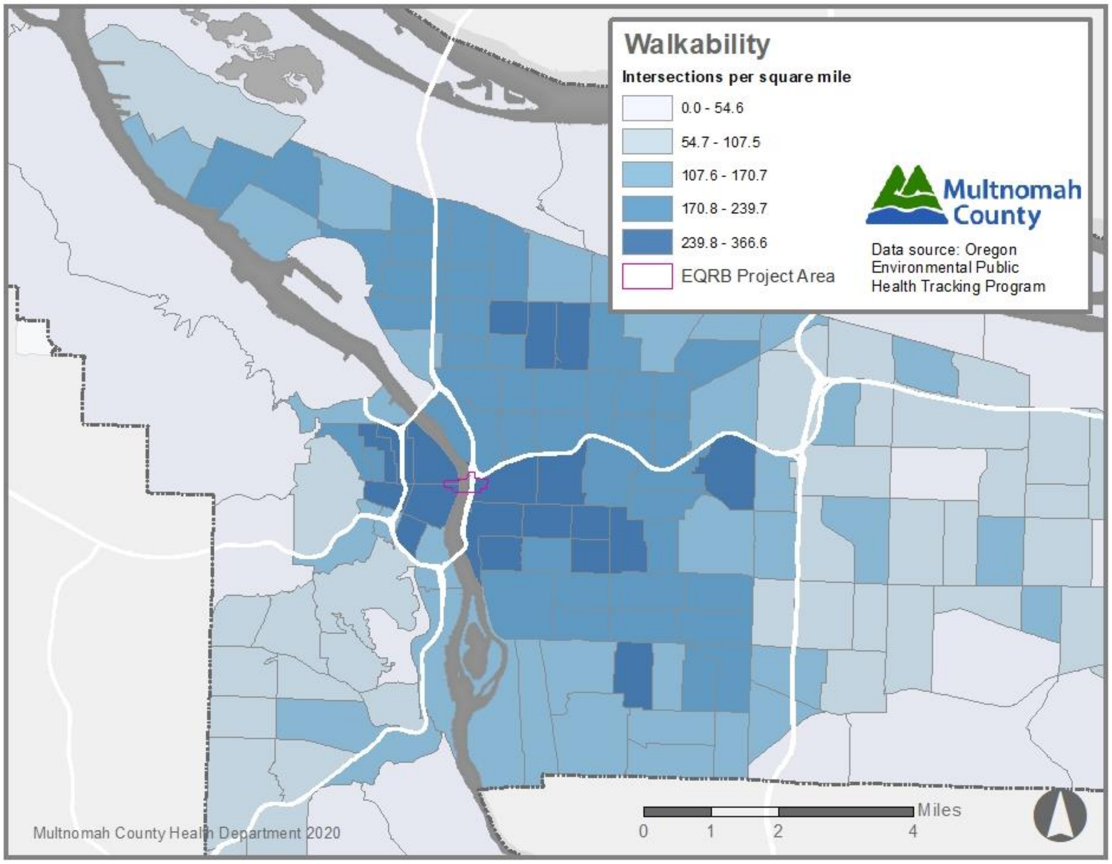


5.3.2 Physical Activity

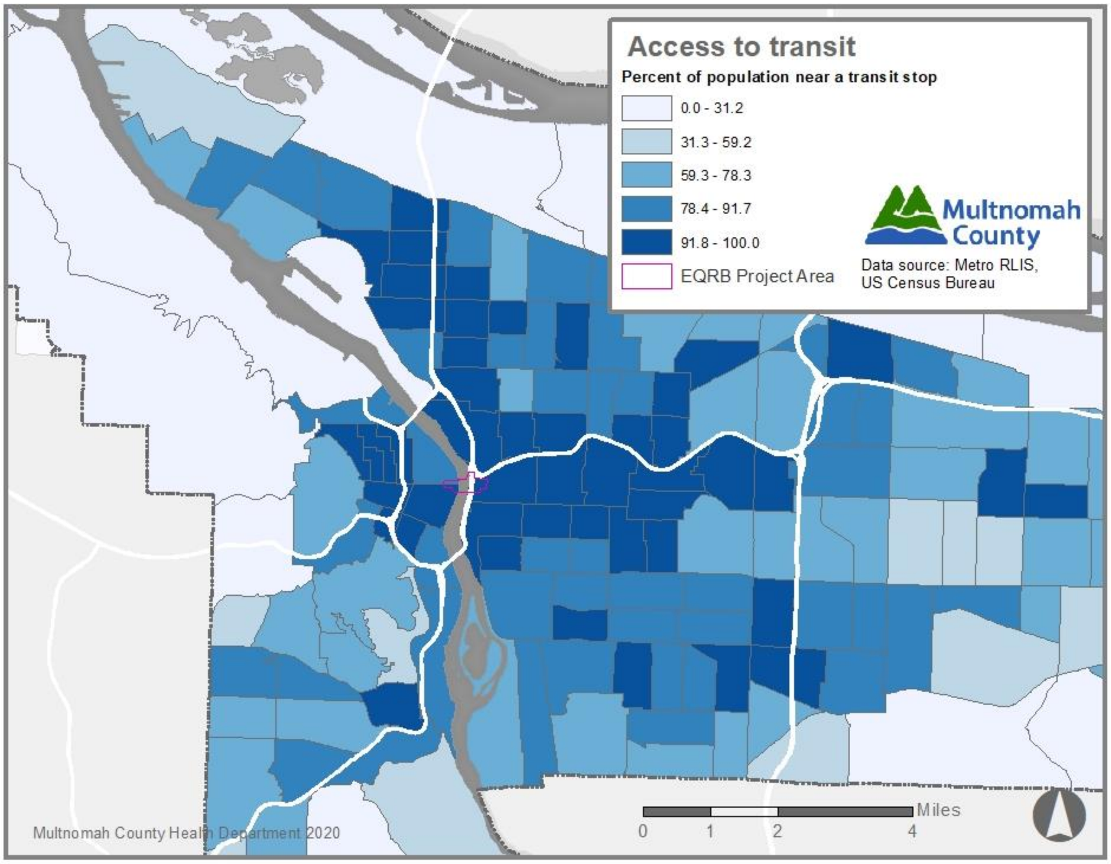
Connected street patterns are consistently and strongly associated with active travel. [24, 25, 26] Greater connectivity is associated with higher levels of active travel to an extent that some researchers weight it most heavily among measures of walkability. [27] High connectivity creates multiple routes and shorter block lengths, enabling more direct travel and a lower likelihood of sharing space with motorized traffic. Street patterns with high connectivity increase transit ridership both because transit stops are easier to access and because transit trips are more direct. [24] Transit use itself is associated with a higher likelihood of meeting physical activity recommendations. [28] The Community Preventive Services Task Force recommends policies that increase street connectivity as an approach to increasing active travel. [22]

Map 5 shows the existing street network connectivity in the Project Area by census tract. It shows that the area has some of the highest street connectivity in the county and is highly walkable compared to other places. Similarly, Map 6 displays the percent of census tract population living near a transit stop, indicating very high transit access near the Project Area.

Map 5. Walkability by Census Tract



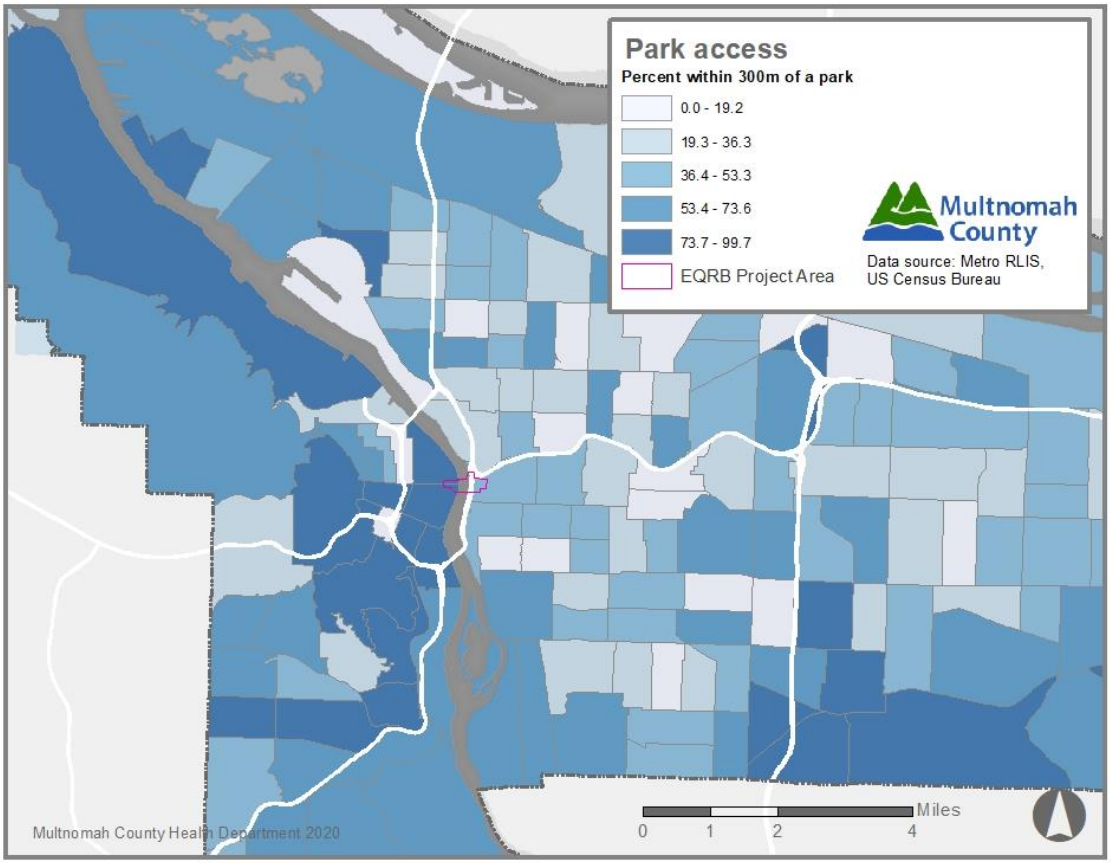
Map 6. Access to Transit by Census Tract



5.3.3 Green Space

Parks and green space benefit health by providing opportunities for physical activity, social cohesion, and contact with nature. [26, 29, 30] Practitioners and researchers use various definitions of the appropriate access to park space. Map 7 applies the World Health Organization's benchmark of 0.5 hectares (1.25 acres) within 300 meters (984 feet) of all residences. [4] This benchmark is more specific and more protective than the City of Portland's strategic goal and performance metric of 100 percent of households within a half mile of a park (81 percent as of 2016). [31] Parks in the area include Tom McCall Waterfront Park, the Vera Katz Eastbank Esplanade, Ankeny Plaza, and the Burnside Skatepark. Census tracts in the Project Area have high parks access compared to other parts of the county.

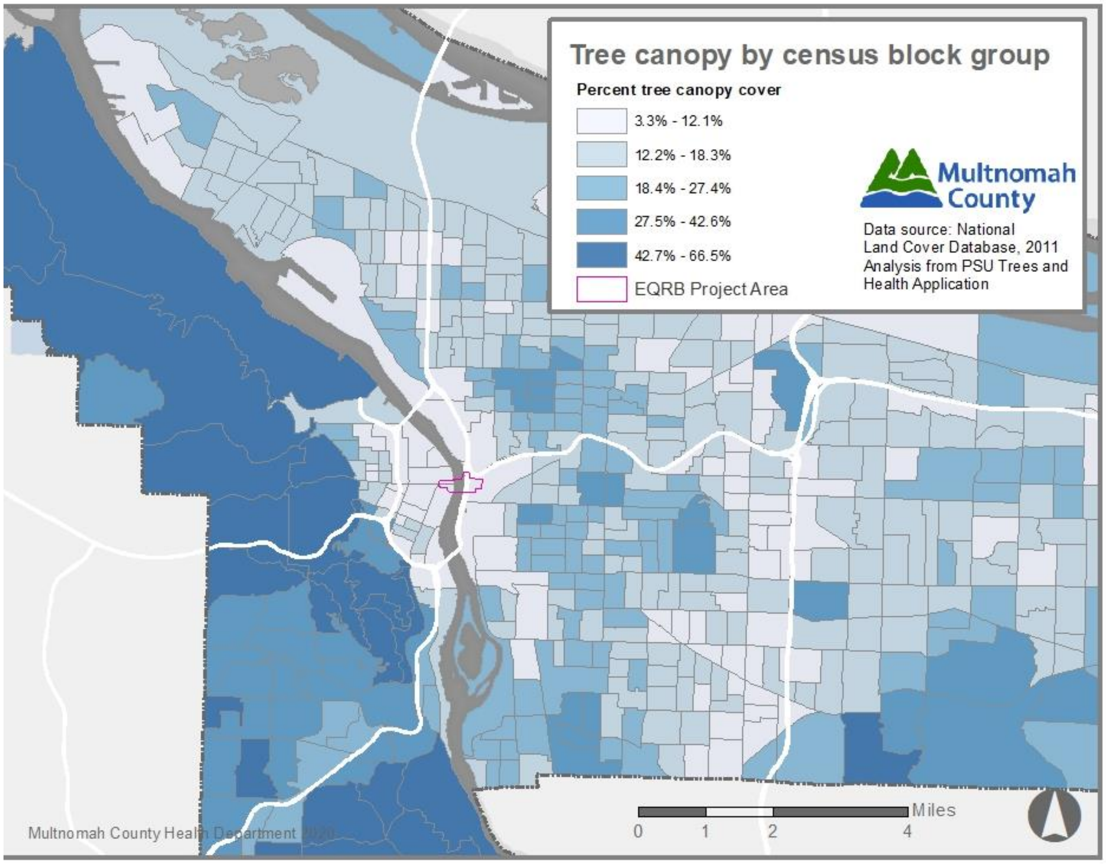
Map 7. Park Access by Census Tract



5.3.4 Heat

Urban areas are susceptible to higher temperatures on hot days compared to surrounding areas, an effect expected to worsen with climate change if not mitigated. This leads to health effects such as heat stroke and premature death. [32] In Portland, the Burnside Bridge bridgehead on the east side has been found to have relatively high temperatures compared to other areas of the city. [33] Generally, green spaces and tree canopy are effective at reducing the effects of urban heat. Map 8 displays tree canopy by census tract in Multnomah County. The area near the Project has less tree canopy compared to other parts of the county.

Map 8. Tree Canopy by Census Block Group



5.3.5 Noise

The *EQRB Noise and Vibration Technical Report* provides detailed information on existing conditions. The report found 133 residences, 10 outdoor community destinations, and 1 outdoor restaurant seating area in the Project Area with noise levels above state or federal guidelines, primarily due to traffic noise on Interstate 5. While occupants of buildings can be protected from existing noise while indoors with windows closed, the unhoused population is likely to be chronically exposed to traffic noise, a risk factor for cardiovascular disease.

5.3.6 Land Use

The *EQRB Land Use Technical Report* provides detailed information on existing conditions. Existing land uses in the area are generally supportive of health compared to other parts of Multnomah County, offering a diverse mix of uses and a density that can support beneficial resources such as transit service. The area is notably lacking in access to full-service grocery stores, and some surface parking detracts from the walkable nature of nearby neighborhoods. Surface parking has been associated with lower physical activity. [27]

6 Impact Assessment Methodology and Data Sources

6.1 Methods Overview

Review of scientific evidence establishing a link with health outcomes is the core approach to analysis, and a summary of relevant studies is provided for each topic. For most topics, we interpret findings from the corresponding technical reports and apply causal relationships drawn from research literature. We analyze impacts identified in technical reports and apply an evaluation matrix to determine health impacts, describing the likelihood of impacts, direction of impacts (benefit/harm), the magnitude of impacts, the severity of impacts, and the distribution of impacts among populations of concern. For transportation impacts, changes in the burden of disease for several scenarios were quantified using the modeling tools described below. For chronic disease related to physical inactivity, we estimate the change in medical treatment costs associated with changes in the burden of disease using cost of illness methods commonly used in health economics and applied in similar studies, such as Nicholas et al. 2019. [34]

Table 8 provides detail on the likelihood, magnitude, and severity of impacts. A summary table of impacts can be found in Appendix A.

Table 8. Health Impact Evaluation Matrix

	Likelihood	Magnitude	Benefit	Harm
Low	Mixed or unsupported evidence, unclear whether a mechanism exists in the scenario/alternative	Affects few people who directly interact with the project area or project elements	Some evidence of protective effect or small effect size, short term	Reversible, treatable, short term
Medium	Emerging, some or moderate evidence of a causal link, scenario/alternative includes a possible mechanism	Affects many people who may or may not interact directly with the project area or project elements	Well established protective effect, possibly short term	Chronic, possibly long-term, mostly treatable
High	Strong evidence of causal link, mechanism is a necessary part of the scenario/alternative	Affects many people over a wide area who don't need to interact with the project to be affected	Evidence of a large protective effect size, benefits accrue over a long period	Acute, irreversible, life-altering or long-lasting

6.2 Modeling Tool

Changes in outcomes related to physical activity and air quality are quantified using the Integrated Transport and Health Impacts Model (ITHIM). [35] ITHIM is an application of comparative risk assessment approach consistent with World Health

Organization practices. There are several iterations of ITHIM; this HIA adapts Cal-ITHIM[1] for the EQRB Project. Health outcomes modeled include breast cancer, colon cancer, lung cancer, heart disease, stroke, dementia, diabetes, depression, and acute respiratory infections.

There are three types of input data required by ITHIM:

Input	Source
Population size, age, and sex distribution	U.S. Census
Burden of disease (deaths, YLL, YLD, DALY)	Oregon Health Authority
Transportation behavior	Metro

YLL = years of life lost; YLD = years lost due to disability; DALY = disability-adjusted life years

6.3 Evidence Standards

As articulated in guidance documents for HIA practice, a broad range of evidence from multiple disciplines and sources is commonly used in the assessment phase. This is paired with a commitment to transparency about the strength of evidence cited and a discussion of how ways of knowing interact in public decision-making. We use data from credible sources such as the U.S. Census and local government agencies. Generalized conclusions about causal relationships are based on peer-reviewed published studies as described in Table 9. We weight systematic reviews and meta-analyses most heavily, and we avoid making statements about causality unless we are confident that moderate or strong evidence exists. Systematic reviews attempt to capture the state of knowledge by summarizing findings of multiple studies meeting a set of inclusion criteria. Meta analyses extract data from multiple studies and combine it into a single quantitative analysis.

Table 9 describes categories of evidence for the Project. For any category, a single recent publication from an authoritative body such as the Centers for Disease Control and Prevention, American Public Health Association, or a branch of the National Academies is a sufficient amount and type.

Qualitative aspects of the assessment, including existing conditions reports, draw from an array of sources including perspectives gathered in current and past outreach efforts. Personal accounts of lived experience and statements from groups representing historically marginalized groups are weighted most heavily in these aspects of the report.

[1] http://cal-ithim.org/ithim/#Health

Table 9. Standards of Evidence for Determining Causal Relationships

	Amount and Type	Quality	Characterization
Strong evidence	1 systematic review or meta-analysis, 3 experimental studies, or a combination of 8+ experimental and observational studies	High-integrity design, consistent findings, statistically significant effect sizes	Further research or study review is unlikely to change our confidence in the estimate of effects or causal relationships.
Moderate evidence	1 systematic review, 2 experimental studies, or a combination of 4+ experimental and observational studies	Consistent findings, statistically significant effect sizes, less rigorous design or weaker effect sizes than 'strong', fewer studies available for review	Further research is likely to have an important impact on our confidence and may influence interpretation of results.
Some evidence	At least 2 peer-reviewed experimental, observational, or qualitative studies	Statistically significant findings, consistent results	Further research is necessary to improve our confidence in effects or causal relationships.
Emerging evidence	2 or more citable expert opinions, anecdotal evidence from community sources, case studies, conference proceedings, gray literature, or unpublished/reviewed studies	Theoretically sound, low study quality or data availability, study findings vary	Low certainty. Further research is necessary to improve our basic understanding of potential effects and causal relationships.
Mixed evidence	1 systematic review, 2 experimental studies, or a combination of 4+ experimental and observational studies	Inconsistent findings (especially contradicting directional effects), statistically significant findings, body of evidence inconclusive as a whole	Further research or more rigorous research could shift the balance of findings and lead to a different conclusion than previously held.
Unsupported	Indicated primarily by lack of published evidence, also by studies that are too few or too small to support a conclusion about whether data are suggestive of a causal relationship	Findings not statistically significant, inconclusive, unfavorable discrepancy between more rigorous and less rigorous studies	Any additional research could lead to different conclusions about the effect or causal relationship.

6.4 Parameters of Analysis

Alternatives and Time Horizon

Assessment findings are presented for alternatives described above:

- No-Build Alternative
- Enhanced Seismic Retrofit (Retrofit Alternative)
- Replacement Alternative with Short-span Approach (Short-span Alternative)
- Replacement Alternative with Long-span Approach (Long-span Alternative)
- Replacement Alternative with Couch Extension

Results describe permanent operating conditions in 2015 and 2040 using Metro travel model outputs. Three construction scenarios are described using the 2015 model year:

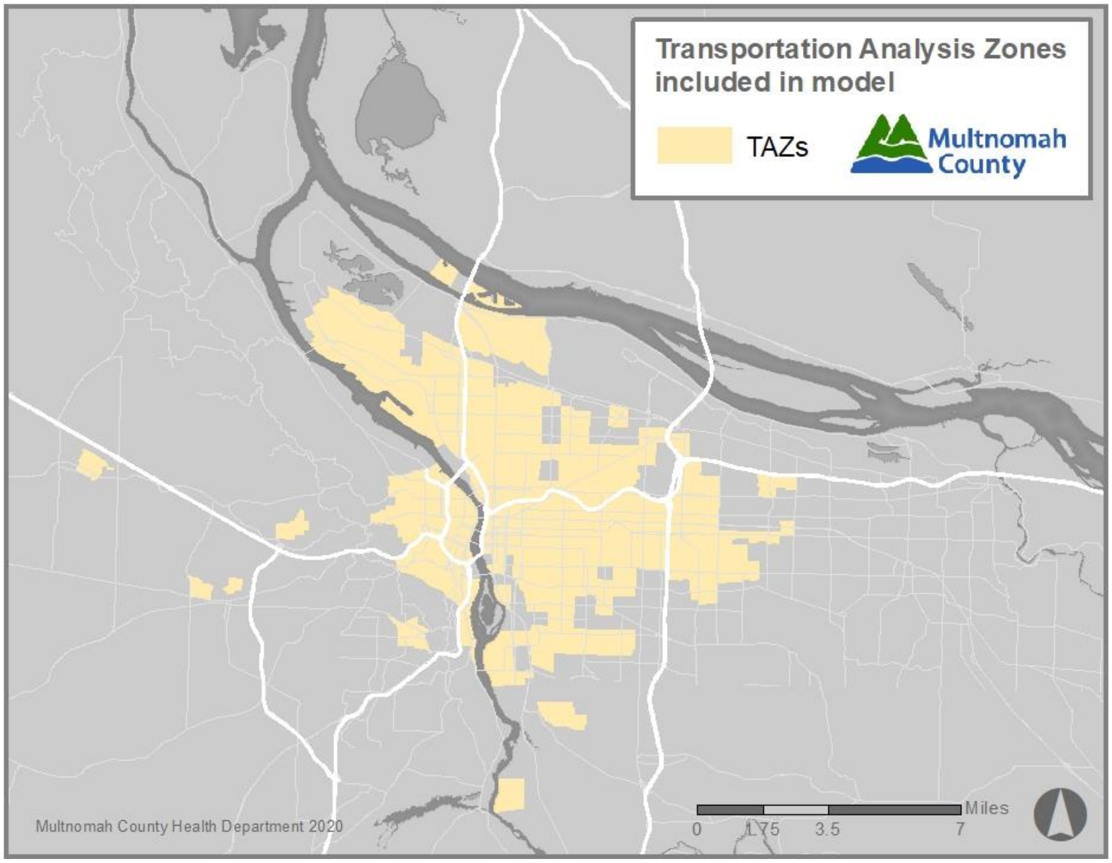
- Temporary Bridge open to all modes
- Temporary Bridge open only to bikes, pedestrians, and transit
- Full closure

Other technical reports describe additional scenarios relating to construction coinciding with closures of Interstate 5 (I-5) related to the I-5 Rose Quarter project. If I-5 is closed for construction, such closures would be partial, relatively short duration, and sporadic (e.g., northbound lanes closed for 12 separate weekends over a 4-year period). Scenarios that include these closures do not represent conditions that would last for a long period of time and are therefore not well suited for health modeling tools, which assume that changes in travel behavior persist for a year or more.

6.5 Spatial Extent

To reflect the population most likely to change travel behavior during construction, we constrained the study population using outputs from Metro's travel demand model. We considered only transportation analysis zones that showed variation in biking, walking, and transit behavior between modeled scenarios. We used 2015 data from the U.S. Census Bureau American Community Survey to approximate the size of this population, as well as the age and sex distribution. The resulting study population is drawn from inner Portland and a few outlying areas, displayed in Map 9. The estimated 2015 population of this area is 501,180. One census tract in Clark County, WA is excluded from this the modeled population because baseline health data were not available.

Map 9. Transportation Analysis Zones Included in Health Modeling



6.6 Populations of Concern

As described in the existing conditions section of this document, populations of concern identified in scoping exercises include low-income residents, people of color, tribal communities, people with chronic conditions, residents and employees in the Project area, users of the temporary or permanent bridge, vulnerable road users, people with disabilities, older adults, youth, people fishing on the Willamette, non-English speakers, construction workers, and Minority and Women-owned Emerging Small Businesses.

6.7 Limitations

Methodological limitations inform the interpretation of quantitative portions of this HIA. ITHIM underestimates the total burden of diseases related to physical activity, as it does not include all diseases and causes of death, especially those without a well-established exposure-response function. Because ITHIM uses inputs from Metro’s travel demand model, it is also subject to all embedded assumptions and limitations. Among the pertinent limitations of the travel demand model is a lack of accounting for the quality of bicycle or pedestrian experience as an incentive that induces trips. Most importantly, the model does not account for changes to recreational physical activity (exercise) that would result from this Project; it focuses solely on active transportation, i.e., biking and walking for the purpose of reaching a destination. ITHIM does not offer tools to illustrate whether specific groups are being harmed or benefited disproportionately. The Cal ITHIM implementation uses a cost of illness approach to estimate the economic value of avoided treatment costs. This approach is considered among the best available, but its flaws include a lack of accounting for fixed costs, variations in healthcare costs across cities and states, and the assumption that savings are not applied to treatment of other subsequent illnesses. These limitations may result in underestimating changes in disease or overestimating associated costs. In the absence of these limitations, available evidence suggests that the modeled differences between scenarios would remain the same and conclusions would be similar.

Qualitative portions of this HIA rely on research literature, data on existing conditions, and expert judgment. Categories of low, medium, and high are not clearly demarcated and thresholds between them are necessarily somewhat arbitrary. Evaluation criteria were applied based on available evidence, with an emphasis on assuring the greatest amount of certainty with regard to direction of impacts (harm/benefit). Other characteristics of impacts are based on a reasonable interpretation of available evidence, but in some cases our conclusions about the likelihood, magnitude, and severity of impacts could change if presented with additional information. Uncertainty stems primarily from methodological limitations rather than unresolved design decisions. For example, limited information about recreational physical activity and crash injury influence the ability to draw conclusions about related impacts.

6.8 COVID-19 Impacts

The global coronavirus pandemic began during the late stages of this study, and its influence on potential impacts is undetermined. The Project could affect underlying conditions that are risk factors for COVID-19, including respiratory and cardiovascular disease. With an unknown duration of impact, any effects from the pandemic on the Project are highly uncertain and no additional analysis is included in this report.

7 Health Impacts

7.1 Seismic Resilience

The foremost goal of the EQRB Project is seismic resilience. The sections below generally include discussions of health impacts from a major earthquake as part of the impact of the No-Build Alternative. Additional detail about the nature and extent of health impacts expected during a large-magnitude Cascadia Subduction Zone (CSZ) earthquake is provided here as context for all other topic areas.

Traumatic injuries are the most immediate health impact of a major earthquake and are often fatal. In a review of epidemiologic evidence on injuries from earthquakes, Ramirez and Peek-Asa [36] documented thousands of fatal injuries, even in high-income countries and from events of lower magnitude than the anticipated CSZ earthquake. Perhaps their most relevant finding was the fact that 81 percent of deaths during the 1989 Loma Prieta earthquake in California were the result of the collapse of roadway structures. The same review found that females, older adults, and people with disabilities are consistently and disproportionately injured during earthquakes.

In addition to the intuitive and widely documented health impact of earthquake injuries, the recovery from major disasters can lead to disease outbreaks in the near term and lasting health impacts that occur over a timespan of years. In higher income countries, the combination of stress from loss of homes, livelihoods, and social networks leads to long-term health effects. These include higher risk of all-cause mortality, and a roughly 35 percent increase in the risk of heart attacks and stroke. [37]

This evidence supports a finding that infrastructure that improves emergency response and facilitates long-term recovery has a high likelihood of health benefits that are of high magnitude and are highly protective.

7.2 Transportation

7.2.1 Causal Pathways and Health Outcomes

Transportation influences leading causes of death by affecting physical activity, exposure to air pollution, and risk of injury. It also affects noise exposure and access to health-supportive resources such as jobs, education, and healthy food. This section evaluates impacts from the topics covered by the *EQRB Transportation Technical Report*: physical activity and injury. Exposure to noise and air pollution are discussed separately in response to their respective technical reports.

Transportation has a strong influence on health outcomes. Some researchers estimate that 20 percent of premature deaths can be prevented by changing urban transportation. [4] Physical activity from active transportation is especially effective at preventing disease and premature death from chronic disease; the World Health Organization estimates a 22 percent reduction in the risk of all-cause mortality for every 29 minutes of walking per day, and a 28 percent reduction for every 3 hours of cycling per week. [38] For some conditions, such as depression and osteoarthritis, physical activity is as effective as medication in reducing symptoms. [12, 13]

In addition to physical activity from active transportation, the transportation technical report also presents data on a second health impact: safety. Being in or near fast-moving vehicles increases traffic crash injury risk, the leading cause of death among younger age groups in the U.S. Researchers describe proximity to moving vehicles as the "fundamental cause of road traffic deaths and injuries." [39] Stated differently, the risk of physical impact from a heavy, fast-moving object is the basic exposure that leads to injury. A 2016 review of best practices calls attention to the fundamental cause of traffic injuries as follows:

> *It is the kinetic energy that kills and injures the road user - not the collision. The level of physical force the human body can tolerate thus forms the basic parameter in the design of the transportation system, the core around which all safety interventions are to be based. [10]*

The amount of vehicle travel in an area is a key determinant of exposure to injury risk. Researchers use Vehicle Miles Traveled (VMT) as a way to measure this. [40, 35]

7.2.2 Impacts

7.2.2.1 No-Build Alternative

For all alternatives in 2045, including the No-Build, active transportation is projected to increase. On average, residents in the area are estimated to engage in 15 percent more minutes of walking and 16 percent more minutes of cycling. This translates into a 1.3 percent decrease in the burden of chronic disease associated with physical inactivity, avoiding an estimated $32 million (2020 dollars) in medical treatment costs annually. These estimates do not account for increases in bicycle or pedestrian travel that could be induced by higher quality facilities, greater separation from auto traffic, or new connections to parks on both sides of the river. These health benefits have a high likelihood, medium magnitude, and a high protective effect.

The *EQRB Transportation Technical Report* includes an analysis of changes to crash risk for all alternatives. The report finds that there would be minimal changes to safety from current conditions, but that a 2.8 percent decrease in traffic volumes in 2045 would result in similar or slightly improved conditions. The technical report notes that in the seven-year period of 2011 to 2017, there were 3 deaths and 16 serious injuries in the Project Area. If conditions stayed the same and injuries continued at the same rate, the area would see one traffic death every 2.3 years and one serious injury about every 6 months. The Portland Bureau of Transportation has designated Burnside Street as a high injury corridor, marking this as an unacceptably high number of injuries.

The technical report documents 425 property damage only crashes out of 818 total crashes in the same seven-year period and includes these crashes in the safety analysis. These crashes do not result in a reported injury, and, therefore, there is no health outcome directly associated with the crash. While property damage only crashes may be an indicator of injury risk, their inclusion in a safety analysis adds uncertainty about whether injuries would increase or decrease. Additional analysis of injury crashes could change the conclusions, but there is a medium likelihood that crash injuries would decrease for vulnerable road users, an impact of low magnitude and high severity.

The impacts of the No-Build Alternative during and after an earthquake are discussed in the *EQRB Transportation Technical Report*. The report describes the likely outcomes of structure failure, gridlock in the immediate aftermath of an earthquake, and blockage of other routes such as the Blue and Red MAX lines and Union Pacific Railroad rail line. The report authors estimate that without a retrofit or replacement, Central Portland would be functionally cut off from the east side for a period of months, and that during this time biking and walking could become a dominant mode of transportation. While this would have health benefits from physical activity, such benefits may be outweighed by harms caused by injuries, illness, and stress that accompany disasters. [41] Therefore the No-Build Alternative would have long-term negative health impacts associated with disrupted transportation following a major earthquake. These impacts have a medium likelihood, a high magnitude, and a medium severity.

7.2.2.2 Build Alternatives

The Build Alternatives would have the same health impacts from physical activity as the No-Build Alternative, but the Replacement Alternatives would result in a substantially greater reduction in injury risk compared to the Retrofit Alternative because of greater separation between modes. Differences between alternatives are summarized in Table 10. Replacement Alternatives would all provide shoulders and a mixed use path 18 feet wide with physical separation from the travel lane. The *EQRB Transportation Technical Report* estimates a 63 percent reduction in bicycle crashes, and though changes were not quantified for pedestrian crashes, it is likely that the same reduction or better could be accomplished. This is notable because two of the three deaths documented in the existing conditions report could have been prevented by the presence of a physical barrier. The technical report also anticipates that improved facilities would attract cyclists and pedestrians and potentially reduce vehicle traffic volumes. This would have the combined effect of reducing exposure to injury risk and reducing the injury rate among cyclists and pedestrians, which tends to decrease as pedestrian and cyclist volumes increase. [42] This supports a finding of a medium likelihood of reduced injury, with medium magnitude, and high severity.

All Build Alternatives would improve ADA access in the Project Area, including ramps or elevators connecting the bridge to the Vera Katz Eastbank Esplanade and the Skidmore Fountain MAX station. These new or improved connections would promote physical activity and improve access to services on the west side, especially for people with physical disabilities. Associated improvements in chronic disease have a high likelihood, medium magnitude, and low protective effect.

7.2.2.3 Replacement Alternative with Couch Extension

The Couch Extension would permanently close the existing bicycle and pedestrian street connecting NE Couch and NE 3rd Avenue. This would require a 0.15 mile detour around the block for trips that access the bridge from NE 3rd Avenue. This detour could deter bicycle and pedestrian trips for some users, especially those who travel more slowly, such as a person with a mobility assistance device. This would negatively impact health outcomes related to physical activity, but the likelihood is uncertain and impacts would be low in both magnitude and severity. The Couch Extension Alternative would result in slightly less reduction in traffic crashes compared to the Short-span and Long-span Alternatives (Table 10). This small difference does not change the likelihood, magnitude, or severity of changes in risk of traffic crash injury compared to the Long-span and Short-span Alternatives.

Table 10. Summary of Long-term Health Impacts from Transportation

Alternative	Physical Activity	Safety
No-Build	15% increase in walking and 16% increase in cycling in 2045, 1.3% decrease in chronic disease, $32m annually in avoided treatment cost	2.8% reduction in vehicle volumes would result in similar or slightly improved conditions compared to baseline
Retrofit	Same as No-Build	Changes to bike lanes and parking result in 6% reduction in all crashes, 24% reduction in bike crashes (change in injury unknown)
Replacement, Short-span	Same as No-Build	Greater separation between modes and changes to parking result in 8% reduction in all crashes, 63% reduction in bike crashes (change in injury unknown)
Replacement, Long-Span	Same as No-Build	Same as Short-span
Replacement with Couch Extension	Same as No-Build; Removes existing bike/ped connection at NE 3rd and Couch	Greater separation between modes and changes to parking result in 5% reduction in all crashes, 63% reduction in bike crashes (change in injury unknown)

7.2.3 Construction Impacts

All construction scenarios show a decrease in the burden of diseases related to physical activity of approximately 0.6 percent. Health impacts from changes to physical activity do not vary substantially depending on whether a temporary bridge is in place. Model results for scenarios with and without a temporary bridge are discussed below. These results reflect transit disruptions discussed in the *EQRB Transportation Technical Report*, as the modeling approach incorporates walking and cycling trips to transit.

7.2.3.1 With a Temporary Bridge

Model results show that scenarios with Temporary Bridges result in increases in biking and walking. In aggregate across the modeled population, a temporary bridge increases biking between 4,000 (with autos) and 7,500 (without autos) minutes daily. Similarly, aggregate walking increases between 6,000 (with autos) and 11,000 (without autos) minutes per day compared to baseline. Distributed across the study population, these changes are relatively small and result in similar levels of health benefits.. Model results are summarized in Table 11.

7.2.3.2 Without a Temporary Bridge

The estimated effects of full closure options cause a decrease in walking and an increase in cycling. For full closure scenarios, estimated decreases in walking are partly attributable to decreased bus trips on lines that use the Burnside Bridge because walk time to access transit is included in the model. Cycling at a moderate pace burns roughly twice as much energy as walking at a brisk pace, [43] and accordingly the health benefits of physical activity can accrue over a shorter period of time. As model results confirm, the increase in biking during full closures more than offsets decreases in walking in terms of health benefits. Consequently, estimated health benefits from physical activity *without* a temporary bridge are comparable to those estimated for scenarios *with* a temporary bridge. Without a temporary bridge, detours for cycling and walking routes would be a shorter duration and potentially a shorter distance.

For all construction scenarios, estimates do not account for long-term effects from habit formation that could occur, for example, if travel behavior adopted during the construction phase continues after the Project is completed. Similarly, with a lengthy construction period, households or firms could respond by permanently moving, a potential effect not captured in these estimates. Additionally, none of these estimates includes changes to recreational physical activity. No data on existing conditions were found, and published research on the effect of trail closures on physical activity is scarce. Experts were consulted [44] and provided consensus that while some of the existing recreation/exercise on the bridge and on the Vera Katz Eastbank Esplanade would be displaced to other forms and locations, a portion of existing recreational physical activity would not take place during an esplanade closure. The lack of similar-quality venues (i.e., off-street paths with views and proximity to major destinations) means that direct substitution of recreational opportunities is unlikely. Given the lack of estimates of changes in recreation, monitoring changes to recreational physical activity in the project area could enable the County and City to adaptively manage or mitigate impacts. Physical activity for recreation would likely decrease during construction, which would have a negative impact on chronic diseases associated with sedentary behavior. Among the Build Alternatives, the Long-span Alternative with no Temporary Bridge results in the shortest closure and fewest impacts.

There is uncertainty about the extent to which a decrease in recreational activity would offset an increase in active transportation. The projected increase in active transportation is relatively small, meaning that a large decrease in recreation could more than offset it. Therefore there is a low likelihood of health benefits from changes to physical activity during the construction period. Given the temporary nature of this impact, the benefits would likely have a small effect size (low severity), but could reach a large population of users (medium magnitude).

Table 11. Health Model Results by Construction Scenario

	Temporary Bridge	Temporary Bridge with No Autos	Full Closure
Change in total daily walk minutes	6,068	11,108	-38,180
Change in total daily bike minutes	4,020	7,556	10,527
Treatment costs avoided annually	$22m	$22.1m	$21.6m

7.2.4 Distribution of Impacts

Whereas there are few differences in health impacts between construction scenarios, the health benefits of additional physical activity during full closure scenarios would largely accrue to populations that are able and willing to travel by bicycle. Observed data show that working-age men are much more likely to cycle for transportation. [45]

The *EQRB Transportation Technical Report* notes that vulnerable road users are disproportionately impacted by existing and future traffic crash injury risk. All three documented deaths in the Project Area were pedestrians, and 75 percent of serious injuries were people walking or cycling.

7.3 Sustainability and Climate Change

7.3.1 Causal Pathways and Outcomes

Climate change threatens the building blocks of population health: clean air, clean water, healthy food, and a stable economy. [32] In the Northwest, climate-related health impacts include an increasing number of hot days, poor air quality from wildfire smoke, and exposure to infectious disease. [46] Vulnerable populations such as people with existing health conditions and low-income households are especially at risk. As discussed in Section 5 - Existing Conditions, urban heat is a climate-related environmental health hazard linked to the built environment, and therefore has a nexus with this project. As climate change continues, the number of extreme heat days in Multnomah County is projected to increase, which is likely to intensify effects of urban heat. Models under a high emissions scenario indicate an increase in annual days with a maximum temperature above 90°F, rising from about 14 days in 2020 to 41 days in 2080. [47] Exposure to extreme heat results in illnesses and deaths, including those from heat stroke.

7.3.2 Impacts

7.3.2.1 All Alternatives

The *EQRB Climate Change Technical Report* found reductions in greenhouse gas emissions for all scenarios in 2045 attributable to improved vehicle fuel efficiency, and that none of the alternatives would alter the risks from global climate change. While climate change continues to be a major public health challenge, technical reports do not suggest evidence of health impacts from this Project related to climate change.

The Project may influence adaptive capacity through exposure to urban heat. On both ends of the bridge and in mid-span, there may be opportunities for increasing tree canopy in the permanent conditions, and opportunities to minimize impacts to existing canopy during construction. In addition to natural shading and cooling, structures may provide shading at the bridgeheads and/or mid-span. Additional shading would reduce exposure to extreme heat among users of the project, minimize contributions of the project to the Urban Heat Island effect, and thereby reduce the likelihood of heat illness such as heat stroke.

7.3.3 Distribution of Impacts

Evidence clearly indicates that climate change affects low-income people and people of color first and worst, as a result of disproportionate exposure to health risks from climate change. Urban heat disproportionately affects older adults, young children, people with chronic disease, and people who work outside. [32] A 2018 study of the Urban Heat Island effect in Portland found that Black and Pacific Islander households are more likely to experience higher heat exposure due to variations in temperature across the urban area. [48] A similar study found that racist housing policies have contributed to inequitable exposure to urban heat and unequal access to cooling. [49]

7.4 Parks and Recreation

7.4.1 Causal Pathways and Health Outcomes

Parks are associated with physical activity [26, 29], which prevents the leading causes of death including cancer and heart disease. Parks also provide urban green space, which has been associated with decreased mortality, violence, and heart rate, as well as with improved attention and mood. [50] These spaces promote various health benefits through improved social cohesion. [51] Similarly, many health benefits are documented from contact with nature, including decreased mortality, violence, and heart rate, as well as improved attention and mood. [30] The World Health Organization has recommended access to a green space of 0.5 hectare (1.25 acres) within 300 meters (984 feet) of all residences. [4]

7.4.2 Impacts

7.4.2.1 No-Build Alternative

The *EQRB Parks and Recreation Technical Report* notes that the No-Build Alternative would result in periodic disruptions to recreation spaces due to greater maintenance needs as compared to the Build Alternatives. Associated closures would have a negative impact on physical activity and contact with nature, increasing the likelihood of chronic diseases and mental health impacts. The likelihood of this impact is high, but of small magnitude and mild severity.

The No-Build Alternative would also result in bridge failure during an earthquake, damaging and blocking access to parks and recreation resources for a period of weeks or months. Collapse of the structures over the Burnside Skatepark, Vera Katz Eastbank Esplanade, and Tom McCall Waterfront Park could result in severe injury or death during an earthquake, and would sever important routes used to minimize health impacts during recovery. These impacts have a medium likelihood, low magnitude, and high severity.

7.4.2.2 Enhanced Seismic Retrofit Alternative

For all Build Alternatives, the Burnside Skatepark would be temporarily closed for a period of months, but the Enhanced Retrofit Alternative would entail complete demolition. The skatepark would not be rebuilt after construction in its current location. See the *EQRB Historic and Cultural Resources Technical Report* and *EQRB Parks and Recreation Technical Report* for additional discussion. There is no evidence on behavior during a similar closure, and findings are mixed in studies of physical activity following the completion of trails. [52, 53] We cannot confidently conclude that users would find other places to skate, whether they would substitute a different activity, or whether such activities and locations would likely be safer or more dangerous than the current skatepark. If skating were not substituted with other locations or activities, the closure could negatively impact health by diminishing physical activity and disrupting social and cultural ties. This would increase the potential for chronic diseases. These impacts have a low likelihood, a low magnitude, and low severity.

All Build Alternatives include improved access from Burnside Street to the Vera Katz Eastbank Esplanade in the form of a ramp, stairway, or elevator. This could promote active transportation and increase the likelihood of separation for biking and walking, thereby reducing exposure to air pollution and injury risk.

7.4.2.3 Replacement Alternatives

Replacement Alternatives would result in fewer sets of columns in Tom McCall Waterfront Park compared to the Retrofit Alternative, creating more space that could be used for recreation activities. This could support a greater range of activities, including physical activity and contact with nature, also potentially offering improved perception of safety due to fewer visual obstructions. Also, under both the Short-span and Long-span Alternatives, the Burnside Skatepark would not be demolished, only closed during construction. In comparison with other alternatives, these distinctions could offer more opportunity for physical activity and social cohesion, supporting healthy behaviors. This impact is low likelihood, low magnitude, and low severity.

7.4.2.4 Replacement Alternative with Couch Extension

Health impacts from changes to park access resulting from the Couch Extension would be similar to the impacts of the Short-span and Long-span Alternatives.

7.4.3 Construction Impacts

As detailed in Table 12, construction would affect parks resources for a period of years. During this time, opportunities for physical activity and contact with nature would be diminished, reducing their protective effect against chronic diseases and mental health morbidity. Detours readily available for off-street paths in Tom McCall Waterfront Park, but that is not the case for the Vera Katz Eastbank Esplanade. Detour routes on both sides of the river could result in increased travel time and diminished travel experience. As explained in the transportation section above, an unknown amount of recreational physical activity is likely to cease as a result of this closure, which would negatively impact chronic disease rates.

Construction approaches using a temporary bridge would result in greater constraints on existing opportunities for cultural events, physical activity, and contact with nature. These constraints result from a lengthy closure of portions of Tom McCall Waterfront Park, including Bill Naito Legacy Fountain and the Japanese American Historical Plaza. Compared to approaches without a temporary bridge, the use of a temporary bridge would entail removal of more trees from Tom McCall Waterfront Park. Removal of large ornamental trees would diminish opportunities for contact with nature, and also risk damaging social cohesion attached to the plaza. Depending on the extent of mitigation provided, for example mature trees versus juvenile ones, these impacts could continue for a period of years following construction.

Table 12. Construction Timing Impacts on Parks

	Retrofit	Replacement, Short-Span	Replacement, Long-Span	Replacement, Couch Extension
Overall Construction – No Temporary Bridge	3.5 years	4.5 years		4.5 years
Overall Construction – with a Temporary Bridge	5 years	6.5 years		6.5 years
Tom McCall Waterfront Park Restrictions – No Temporary Bridge	3.5 years	4.5 years		4.5 years
Tom McCall Waterfront Park Restrictions – Temporary Bridge	5 years	6.5 years		6.5 years

	Retrofit	Replacement, Short-Span	Replacement, Long-Span	Replacement, Couch Extension
Willamette River Passage Under Bridge – No Temporary Bridge	6 – 10 weeks (intermittent)			
Willamette River Passage Under Bridge – Temporary Bridge	8 – 12 weeks (intermittent)			
Vera Katz Eastbank Esplanade Detour – No Temporary Bridge	26 months	30 months	18 months	30 months
Vera Katz Eastbank Esplanade Detour– Temporary Bridge	30 months	34 months	22 months	34 months
Burnside Skatepark Closure – No Temporary Bridge	Permanent	4 months		4 months
Burnside Skatepark Closure – Temporary Bridge	Permanent	8 months		8 months

7.4.4 Distribution of Impacts

Closure of park areas offering free or low-cost recreational opportunities disproportionately impacts lower income people, potentially affecting their risk of chronic disease related to physical activity. Removal of large trees and/or closure of the park could alter local temperature and reduce available cooling opportunities for people seeking relief from extreme heat. Users for whom the Japanese American Memorial Plaza holds special significance would be impacted by both the disruption to access and the construction/reconstruction of the memorial. The same applies to Bill Naito Legacy Fountain. As noted in the *EQRB Parks and Recreation Technical Report*, there is also potential for some cultural events to permanently relocate from Tom McCall Waterfront Park as a result of the lengthy construction period. These disruptions could have mental health impacts associated with barriers to social cohesion.

7.5 Toxic Exposures

7.5.1 Causal Pathways and Health Outcomes

In its 2011 Public Health Assessment, the Oregon Health Authority (OHA) determined that four exposure pathways were completed in the Portland Harbor Superfund site, and that consumption of resident fish is an exposure pathway of concern. OHA issued a fish consumption advisory in 2004, and expanded it in 2018 to include the area between the Sellwood Bridge and Sauvie Island. [20]

Toxins assessed for human health impact by the OHA due to contamination of the lower Willamette River sediment and water include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), dioxins/furans, pesticides, mercury, and arsenic. Health effects of these chemicals include cancer, skin conditions, developmental harms, and damage to the nervous system. [54] These are in part attributable to runoff and stormwater, which also increase the risk of bacterial illness. [55] Among these, those that dominate risk to human health are PCBs, mercury, and dioxins/furans, which persist in the environment and accumulate in fish tissue. PCBs are classified as a probable human carcinogen. [21] [56]

In addition to exposure pathways related to the river, the *EQRB Hazardous Materials Technical Report* describes multiple additional pathways, including disturbance of potentially contaminated sites near the Project Area. The hazardous materials technical report documents the results of extensive research into historical land uses and potential sources of contamination. The potentially impacted sites have documented soil or groundwater contamination with one or more of the following: petroleum hydrocarbons, PAHs, volatile organic chemicals, trimethylbenzenes, metals, cyanide, and PCBs.

7.5.2 Impacts

7.5.2.1 No-Build Alternative

The *EQRB Hazardous Materials Technical Report* finds that failure during an earthquake could result in contamination of air, water, and soil by lead-based paint, asbestos, or other hazardous materials currently contained by the bridge. For those exposed, this could result in lead poisoning, adverse birth outcomes, or cancer. The technical report does not document with certainty the nature or quantity of the materials contained on the current bridge, making it difficult to determine the most likely way for an exposure pathway to be completed. The clearest exposure pathway is by inhalation, which would be a risk in the immediate aftermath of an earthquake or during debris cleanup. We conclude that this impact has a medium likelihood, a medium magnitude, and high severity.

7.5.2.2 Build Alternatives

The *EQRB Hazardous Materials Technical Report* finds no known hazardous materials sites that would be directly impacted by construction, but does identify nearby legacy sites that could potentially be impacted by all Build Alternatives, especially Replacement Alternatives. The Towne Storage and Portland Gas Works Gas Holder Tank Site are near temporary construction easements and could be impacted. Both sites have undergone some cleanup, but there is possible residual contamination from the following: petroleum hydrocarbons, PAHs, volatile organic chemicals, trimethylbenzenes, metals, cyanide, and PCBs. Among the potential health impacts of exposure to these chemicals are cancer, fatal poisoning, and damage to the nervous system. [21] The technical report notes that the extent of contamination at these sites is not fully characterized, and no study has been conducted on the potential exposure pathways or associated doses. This impact has a low likelihood, a medium magnitude, and high severity.

Contaminants in existing sediment could be disturbed and re-deposited downstream, and changes to river flow following construction could result in scouring that further disturbs existing contaminants. This would contribute to the existing health risks from consumption of fish and contact with sediment in the Lower Willamette. This potential impact could be mitigated as proposed in the *EQRB Hazardous Materials Technical Report*, which lists a contaminated media management plan and sediment evaluation framework as potential mitigations. If mitigated, this health impact would have a low likelihood, low magnitude, and low severity.

7.5.2.3 Replacement Alternative with Couch Extension

The Couch Extension would include the largest number of property acquisitions, and removal of building material from acquired sites could involve uncontrolled release of dust containing lead or asbestos. Unmitigated dust release could result in inhalation of lead or asbestos, leading to neurological damage and increased risk of cancer. If removal occurs, these impacts could be readily mitigated. Assuming mitigation measures are taken, there would be a low likelihood of adverse health impacts, a low magnitude of impact, and high severity.

All construction activities increase the probability of release from a previously unknown source or an accidental spill. This includes areas used for construction staging, some of which could be outside of the immediate Project Area. The *EQRB Hazardous Materials Technical Report* finds that while the degree of potential impacts increases with more construction activity, there are no significant differences between Build Alternatives.

7.5.3 Distribution of Impacts

Current disproportionate exposures may be exacerbated by the Project if hazards are not mitigated. Anecdotal evidence suggests that immigrant and refugee populations may be more likely to consume fish from the Willamette River under current conditions. These groups have barriers to health care that can exacerbate effects. Exposure pathways of drinking, swimming, or bathing in the Willamette River may disproportionately affect people experiencing homelessness. [55] Children are especially at risk from all toxics, especially PCBs. This is in part due to their lower weight, which increases the dose of toxic substances ingested or inhaled, and also is based on differences in diet and behavior. [21]

7.6 Noise and Vibration

7.6.1 Causal Pathways and Health Outcomes

Noise and vibration result in multiple health effects that can be divided between temporary (construction) noise and ongoing (traffic) noise. Traffic noise is associated with heart disease and likely associated with other health outcomes. Scientific understanding of the links between environmental noise and health has steadily advanced in recent years, but it remains an emerging area of research. In 2018 the World Health Organization published a review of studies confirming previous findings [57] that road traffic noise is associated with heart disease. [9] The same report series found emerging evidence of an association with stroke, diabetes, low birthweight, and cognition, but not enough research has been done to characterize these relationships with confidence. [58, 59]

The *EQRB Noise and Vibration Technical Report* assesses existing and future conditions applying the ODOT Noise Approach Abatement Criteria (NAAC). The NAAC standards are in turn based on Federal Highway Administration standards, which are designed based on potential to interfere with speech communication outdoors. [60] These values differ in some respects from recommended noise levels considered protective of health. The World Health Organization's recommendations for traffic noise are expressed in terms of dB L_{den}, which weights noise based on the time of day it is experienced. Strong evidence associating road noise with heart disease suggests an 8 percent increase in the incidence of ischemic heart disease per 10 dB L_{den} increase in noise. [61]

7.6.2 Impacts

For all alternatives, there is minimal difference between existing and future conditions, or between alternatives. The *EQRB Noise and Vibration Technical Report* found that locations near the Project would experience changes ranging from a decrease of 5 dB to an increase of 5 dB, concluding that traffic noise would be similar to existing conditions for all alternatives. The report focuses on peak vehicular hour and peak truck hour noise, which are not directly comparable to the 24-hour noise levels recommended by the World Health Organization. This divergence makes it unclear whether future noise levels exceed World Health Organization recommendations, but it is likely that the alternatives would not change current health risks from traffic noise exposures. Current noise levels during the peak vehicular traffic hour at most receptors in the technical report range from 40 to 77 dBA Leq(h). This compares to projections of 40 to 75 dBA in 2045. The difference between outdoor and indoor noise levels is considered to be about 25 dBA with closed windows. [62] Based on this difference, and considering that 24-hour values are likely to be lower than peak values, it is assumed that indoor noise levels from traffic are likely below the World Health Organization recommended level of 53 dB L_{den}. Based on available evidence, long-term health impacts from traffic noise associated with the Project are unlikely.

Short-term impacts from construction would be perceptible across a wide area, and for some activities could reach annoyance thresholds for up to 500 feet. Longer construction periods result in more exposure to noise. Construction periods range from 3.5 years to 6.5 years depending on the alternative and whether a temporary bridge is used. Table 13 summarizes the differences in construction time.

Table 13. Estimated Construction Duration (years)

Alternative	Without Temporary Bridge	With Temporary Bridge
Retrofit	3.5	5
Short-span	4.5	6.5
Long-span	4.5	6.5
Couch Extension	4.5	6.5

Pile driving and bridge demolition are identified in the technical report as the activities most likely to result in elevated noise levels. The amount and duration of pile driving required would vary by construction approach. In some locations modeled in the *EQRB Noise and Vibration Technical Report*, peak-hour construction noise is anticipated to reach levels up to 106 dBA $L_{eq(h)}$ including at some residential receptors. As the *EQRB Noise and Vibration Technical Report* notes, a noise variance would be required from the City of Portland. The construction contractor also would be required to adhere to a noise control plan for mitigation. It is likely that the loudest construction activities would be confined to limited hours, but these noise levels could have negative health impacts if they are disruptive to sleep among those who work at night and sleep during the day. Sleep disrupted by noise can lead to strain on the cardiovascular system, and increased levels of stress hormones. [63] These impacts would be temporary, have a low likelihood, low magnitude, and low severity.

7.6.3 Distribution of Impacts

While occupants of buildings could be protected from noise, people experiencing homelessness would likely be chronically exposed to traffic noise, a risk factor for cardiovascular disease. Similarly, people who work at night and sleep during the daytime would likely experience sleep disruption due to daytime construction activities. Noise and vibration impacts of construction would likely burden nearby residents and businesses, but benefits of construction would be shared across the region.

7.7 Displacement and Relocation

7.7.1 Causal Pathways and Health Outcomes

Displacement could potentially take place as a consequence of the Project. Business displacement could lead to unemployment, which has unequivocally negative health impacts including a much higher risk of mortality and cardiovascular disease. [64] Residential displacement is associated with housing stressors and economic insecurity, including chronic diseases, depression, and anxiety. [65] Residential displacement and accompanying social disruption following disasters is connected to mental health morbidity and chronic disease. [66, 67] Homelessness presents a set of risks apart from housing quality and affordability. Among homeless populations, researchers observe premature death, accelerated aging, and higher rates of a variety of infectious and non-communicable diseases. [68]

7.7.2 Impacts

7.7.2.1 No-Build Alternative

No displacements of any kind would occur under the No-Build Alternative. However, following a major earthquake, severe damage to surrounding properties and lack of access attributable to bridge collapse would have long-term consequences. This could cause physical displacement from damaged structures, economic displacement from disrupted commerce and traffic flows, and social displacement from the long-term loss of important sites such as social services, Portland Saturday Market, and park spaces. As researchers have documented, these impacts have a high likelihood in the event of an earthquake, and they would be widespread and long-lasting. [67] Negative health impacts include mental health morbidity such as stress disorders and anxiety, chronic diseases such as cardiovascular disease and diabetes, and premature death. These impacts have a high likelihood, high magnitude, and high severity.

7.7.2.2 Build Alternatives

In all Build Alternatives, six businesses would be displaced through full or partial acquisitions: The Portland Saturday Market, the University of Oregon, Diamond Parking Services, Pacific Coast Fruit Company, Rose City Transportation, and American Medical Response (AMR). Together, these permanent and temporary displacements would affect fewer than 10 employees at the west bridgehead, and as many as 680 employees at the east bridgehead. Zero residential displacements would be required (for further detail on displacements and mitigation, see the *EQRB Acquisitions and Displacements Technical Report*). Research literature on job displacement focuses primarily on unemployment, and it is unclear whether these business displacements would result in any job losses. At least one study suggests that job displacements under similar conditions do not have adverse health effects. [69] With substantial uncertainty about employment impacts and no apparent residential impacts, there is a low likelihood of adverse health impacts from displacement, with low magnitude and medium severity.

Notably, the AMR location that would be displaced during construction could potentially result in greater resilience if the company relocates to a place less vulnerable to damage from a major earthquake.

All Build Alternatives could use off-site staging areas. These have not been finalized, but four potential sites are identified in the *EQRB Acquisitions and Displacements Technical Report*. No permanent business or residential displacements are anticipated from the use of these sites; they would return to their current use following completion of the Project.

7.7.3 Distribution of Impacts

Health impacts from a No-Build Alternative following an earthquake would be highly localized to residences and businesses adjacent to the bridge. These include social service and shelter facilities on the west end of the bridge, especially those housed in unreinforced masonry buildings described in the *EQRB Acquisitions and Displacement Technical Report*. The report identifies 10 buildings likely to be impacted by bridge collapse and 6 that could be damaged from bridge sway. These include buildings that provide safety-net social services and housing, such as Central City Concern, the Salvation Army, Portland Rescue Mission, and Mercy Corps.

The technical report also notes that construction would displace people experiencing homelessness who shelter on both sides of the bridge for 3.5 to 6 years. Any such displacements are likely to exacerbate the multitude of health challenges facing people experiencing homelessness. Whereas no displacements of housing units is anticipated, these impacts could be viewed as residential displacements with the combined negative health impacts of residential displacement and homelessness.

7.8 Air

7.8.1 Causal Pathways and Health Outcomes

In the U.S., on-road transportation sources represent the largest contributor to health impacts from particulate matter (PM) and nitrogen oxides (NOx). [70] Transportation-related air pollution, often referred to as TRAP, is associated with many negative health outcomes, especially among people living within 500 meters of a major roadway, among low-income communities, and communities of color. [8] The risk of cardiovascular disease, heart attack, and stroke increases with higher levels of TRAP. [71, 72] Based on a review of epidemiological studies, the U.S. EPA estimates that a 1 percent decrease in all-cause mortality (total number of deaths) results from a 1 microgram per cubic meter (µg/m3) reduction in PM2.5[2] concentrations. For NO2, a common marker of TRAP, an increased 24-hour concentration of 10 µg/m3 results in an estimated 1 percent increase in all-cause, cardiovascular, and respiratory mortality. [73] Risk of heart disease is increased even from short-term exposure. [74] Components of TRAP are also associated with Type 2 Diabetes, dementia and cognitive function, childhood leukemia, lung cancer, preterm birth, and low birth weight. [75, 76, 77, 78, 79] Modeling studies consistently find that TRAP accounts for a large fraction of air pollution in North America, as well as a large portion of the considerable burden of premature death associated with exposure. [70, 80] Caiazzo et al. (2013) estimated that TRAP accounts for approximately 58,000 premature deaths in the U.S. annually. [70] Health risks from on-road and non-road mobile sources are exacerbated by poor air quality events. These include inversion/stagnation events, high ozone days, and wildfire smoke inundation. Construction produces harmful air pollution. Heavy-duty non-road equipment and on-road vehicles emit diesel exhaust pollution—a mix of particles and

[2] Atmospheric particulate matter (PM) that has a diameter of less than 2.5 micrometers.

gases including nitrogen oxides and Diesel Particulate Matter (DPM or soot). DPM has been identified by the World Health Organization as a human carcinogen. [81] The California Air Resources Board estimates that 70 percent of cancer risk from airborne toxics is attributable to diesel exhaust. [82] Adverse health effects are well-documented for both chronic and acute (short-term) exposure to air pollutants from vehicle fuel combustion, including all-cause mortality, cardiovascular disease, and respiratory disease. [83]

7.8.2 Impacts

As no changes to vehicle capacity are proposed, the total emissions from traffic are identical across all alternatives in the permanent operating condition. There are slight variations in exposure patterns among alternatives that could produce differences in health risk. Variations in the duration of construction may result in different amounts of exposure between alternatives. These differences are discussed below and summarized in Table 14.

Table 14. Changes in exposure to air pollution

Alternative	Long term	Short term
No-Build	Decreased traffic pollution compared to baseline	None
Retrofit	Same as No-Build	Increased air pollution from construction for 3.5-5 years
Short-span	Decreased traffic pollution compared to baseline Greater protection from traffic pollution for pedestrians and cyclists compared to other alternatives	Increased air pollution from construction for 4.5-6.5 years
Long-span	Same as Short-span	Same as Short-span
Couch Extension	Decreased traffic compared to baseline Potential shift in air pollution to Couch and to higher elevation	Same as Short-span

Current levels of air pollution are harmful to health and would continue to affect health even as they decline under all alternatives. The *EQRB Air Quality Technical Report* affirms that the region is currently in attainment with National Ambient Air Quality Standards (NAAQS), and that attainment status would not change as a result of this Project. However, NAAQS are not sufficiently protective, and existing levels of pollution from vehicles are harmful to health. Recent reports from the Oregon Department of Environmental Quality suggest that the region is close to being out of attainment for the NAAQS for ozone, with nine exceedances in 2017 and four in 2018. [84] Ground-level ozone forms as a result of combustion, mostly of fossil fuels, mixed with sunlight. Even at levels below the NAAQS, ozone is associated with premature death and exacerbates respiratory illnesses such as asthma and bronchitis. [85] As noted in the existing conditions description in this document, the area near the Project Area already experiences a relatively high estimated cancer risk from air toxics (about 40 cases in 1 million), and on-road pollution accounts for approximately 25 percent of risk (about 10 cases in 1 million).[3] [23]

7.8.2.1 No-Build Alternative

Long-term reductions in TRAP are likely for all alternatives due to improvements in fleet fuel efficiency. Health risks from TRAP in the Project Area will decrease by 2045, though this change is not attributable to the Project or to any specific alternative. The *EQRB Air Quality Technical Report* notes that EPA models suggest a 90 percent combined reduction in mobile source air toxics from 2010 to 2050, which would lead to a sharp decrease in risk from on-road pollution. Other studies find that while air toxics may be reduced as a result of cleaner vehicles, criteria pollutants may not decline as much. This is especially true for particulate pollution, which is thought to be dominated by re-suspension and tire and brake wear rather than tailpipe emissions. [86] The permanent operating condition in 2045 for the Build Alternatives would be very similar to the No-Build Alternative, as no changes to vehicle capacity are proposed. .

Total TRAP emissions are identical for all alternatives, but there may be slight variations in exposure. The No-Build and Retrofit Alternatives would result in the same exposure, but additional separation of travel modes could somewhat reduce or modify exposure for Replacement Alternatives. These differences are discussed below; there are otherwise no specific long-term health impacts from changes to air quality from the No-Build Alterative. Under the No-Build Alternative, no construction would take place and no additional air pollution from equipment or demolition would occur, thus there are no short-term health impacts from air pollution from the No-Build Alternative.

7.8.2.2 Enhanced Seismic Retrofit Alternative

In 2045, total TRAP emissions from the Retrofit Alternative would be the same as for all other alternatives. Compared to Replacement Alternatives, the Retrofit Alternative would result in closer proximity between TRAP-emitting vehicles and people walking and biking, potentially producing greater long-term exposure for these users compared to Replacement Alternatives. This is documented as a protective health impact of the Short-span and Long-span Alternatives with medium likelihood, medium magnitude, and low severity.

Compared to the No-Build Alternative, there would be more short-term impacts from construction. The *EQRB Air Quality Technical Report* notes that higher levels of carbon monoxide (CO) and PM_{10}[4] would result from construction. It does not document an estimated amount of pollutants, nor an estimated concentration during

[3] Estimates from the National Air Toxics Assessment underestimate risk because they do not include cancer risk from diesel exhaust.
[4] Atmospheric particulate matter (PM) that has a diameter of less than 10 micrometers.

construction. Other products of combustion of fuel from heavy equipment would also increase in the project area during construction, including DPM, NO_x, and fine particulate matter $PM_{2.5}$. With clean diesel contracting requirements in place, we anticipate large reductions in construction-related pollution compared to previous projects. Construction is currently planned to begin in 2024, by which time County contracting regulations will require the following:

- Five-minute limit on idling equipment
- Non-road Tier 4 diesel engines
- On-road diesel engines (cement mixers and dump trucks) manufactured after 2007

As of 2017, the estimated DPM in census block groups in the Project Area ranges from 11 to 12 times greater than the state Ambient Benchmark Concentration of 0.1 µg/m3. The Oregon Department of Environmental Quality estimates that non-road sources contribute to 65 percent of DPM in the region and on-road sources comprise an additional 15 percent. [87] Tier 4 diesel equipment engines reduce emissions of DPM and NOx by more than 90 percent compared to engines manufactured under previous regulations. [88] On-road engines from 2007 or later emit 90 percent less particulate matter compared to models manufactured from 2004 to 2006. [89] Short-term, temporary increases in air pollution from construction could have negative health impacts, including cardiovascular and respiratory disease. For the Retrofit Alternative, these would last between 3.5 and 5 years. Some of the increase could take place at off-site staging areas in industrial areas downstream along the Willamette River. Four potential sites are identified in the EQRB Acquisitions and Displacements Technical Report, but locations have not been finalized. Due to uncertainty about the amount of construction pollution, these impacts have a medium likelihood, low magnitude, and low severity.

7.8.2.3 Replacement Alternatives

Long-term impacts from reduced total TRAP would be identical to other alternatives. The Short-span and Long-span Alternatives offer an additional benefit of greater vertical and horizontal separation from vehicle pollution for people on foot and on bicycle compared to other alternatives. Evidence shows that TRAP exposure among road users cycling and walking is reduced when they are separated from vehicle traffic by low barrier walls or by greater horizontal distance. [90] The separation of modes through low barrier walls and horizontal distance in the Short-span and Long-span Alternatives provides a greater degree of protection from air pollution than the No-Build or Retrofit Alternatives. This could result in less illness from TRAP, especially cardiovascular and respiratory illness, compared to other alternatives. This protective effect has a medium likelihood, a medium magnitude, and a low severity.

Short-term construction impacts are the same as the Retrofit Alternative, but would last longer, between 4.5 and 6.5 years.

7.8.2.4 Replacement Alternative with Couch Extension

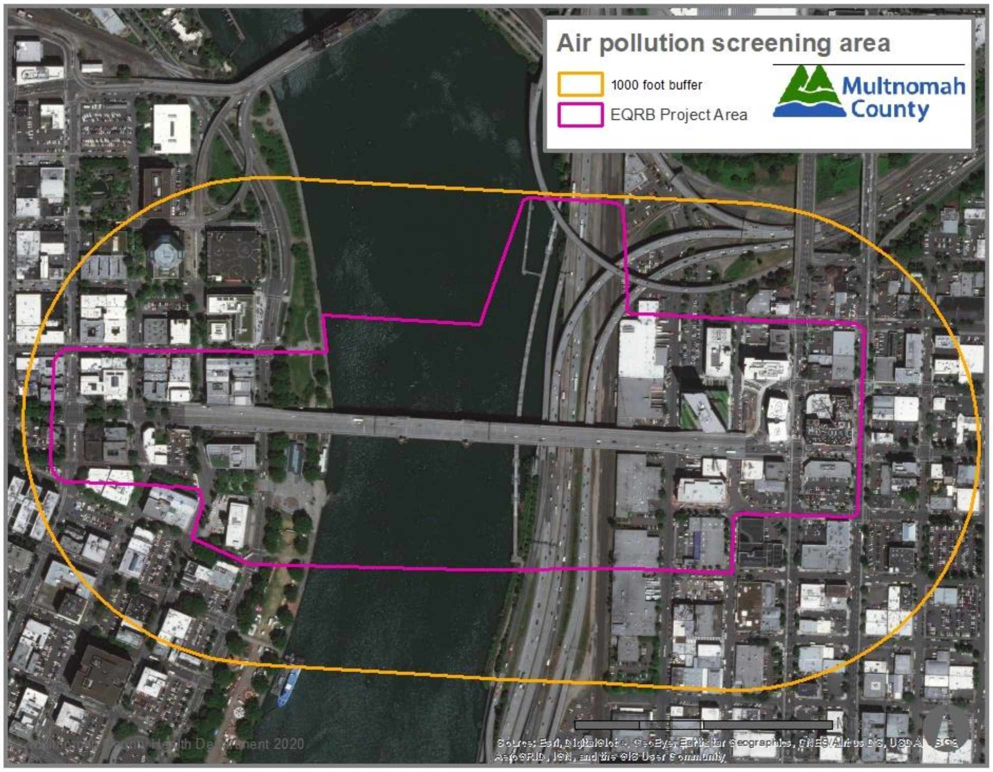
Long-term impacts from reduced total TRAP would be identical to other alternatives. The Couch Extension would move the source of TRAP northward and upward, creating somewhat different exposure than currently exists. While this is unlikely to change the total amount of air pollution from traffic, it would redistribute it slightly, potentially impacting homes and businesses with elevated outdoor spaces such as balconies. Neither this HIA nor the technical report includes quantitative dispersion modeling of these effects, or characterizes the use patterns of such spaces. While health impacts are possible from this change in exposure pattern, available information is insufficient for conclusions about the direction, magnitude, likelihood, and severity of these impacts. Long-term health impacts are otherwise similar to the Short-span and Long-span Alternatives.

Short-term construction impacts are the same as the Retrofit Alternative, but would last longer, between 4.5 and 6.5 years.

7.8.3 Distribution of Impacts

As with other construction impacts, the burdens affect adjacent residents and workers, while benefits are generalized across the region. Consistent with other health impact analysis practices [91, 2], we apply a 1,000-foot buffer around the Project to screen for potential air pollution impacts (Map 10). Within this buffer, there are sensitive receptors where consistent exposure to air pollution could occur. The buffer includes more than 600 residential units in the immediate vicinity of the east end of the bridge. On the west end, the buffer includes employers such as the University of Oregon, Mercy Corps, AirBnB, and also shelter services such as Portland Rescue Mission and Central City Concern.

Map 10. 1,000-Foot Buffer Screening Area



Occupants of buildings with modern air-handling equipment and a sealed building envelope are the most protected. Such buildings typically have HVAC systems with filters rated at MERV 8[5] or higher, which protect against particulate matter pollution. Based on age, nearly all of the residential buildings on the east side of the bridge are believed to be equipped with such systems. Older buildings, primarily on the west side, may have no mechanical movement or filtration of air at all, relying instead on radiant heat for heating and open windows or fans for cooling. These buildings provide some protection from outdoor air pollution with closed windows and doors, but lack the capacity to remove pollutants from the air or provide cooling without additional mechanical equipment. People living or working in such buildings, especially shelters and short-term housing in the Project Area, are especially vulnerable to exposure from construction-related air pollution if they have underlying respiratory or cardiovascular conditions. Particulate pollution is associated with adverse birth outcomes including low birthweight and preterm birth; construction pollution could elevate this risk for families in the immediate area.

[5] Minimum Efficiency Reporting Value

7.9 Land Use and Economics

7.9.1 Causal Pathways and Health Outcomes

Researchers conclude that population density, distance to destinations, and land use mix are key environmental predictors of travel mode choice. [24, 40, 26] The Centers for Disease Control and Prevention Community Preventive Services Task Force, a respected clearinghouse for effective prevention strategies, recommends mixed land uses that increase the diversity and density of destinations to increase active travel. [22]

7.9.2 Impacts

7.9.2.1 No-Build Alternative

The No-Build Alternative would result in no changes to land use and transportation variables that influence health. The density and diversity of destinations would not be affected, and therefore no changes to physical activity or other exposures would be expected. There are no pre-earthquake health impacts from this alternative.

In the event of a major earthquake, the bridge and many buildings in the area are likely to collapse, leading to a period of low economic activity that could last during months or years of recovery. Land uses, institutions, and social services that withstand the earthquake would experience severe challenges with access and supply networks for the duration of recovery. The *EQRB Land Use Technical Report* estimates that reduced demand could lead to long-term vacancies in the Project Area. These impacts would reduce the density and diversity of destinations in the Project Area, reducing the existing health-supportive features of the neighborhood. This would likely contribute to reduced physical activity and disrupted livelihoods, resulting in an increased burden of chronic diseases, mental health morbidity, and premature death. These impacts have a high likelihood, medium magnitude, and medium severity.

7.9.2.2 Build Alternatives

Very few long-term changes to land use are proposed as part of the Project. Of the anticipated property acquisitions for construction of a bridge or access to a temporary bridge, approximately 4 acres are expected to be available for redevelopment upon completion of the Project. These include 1.1 acres of surface parking near the west bridgehead and 2.9 acres in the eastern part of the Project Area, currently a mix of uses including vacant land, parking, right of way, and office. An additional change in land use is the conversion of a currently vacant lot to an ADA ramp connecting SW 1st Avenue to West Burnside Street. No specific plan for redevelopment is proposed, but adopted plans call for a highly diverse and dense mix of land uses in the Old Town/Chinatown neighborhood, including affordable housing, commercial use, cultural attractions, and institutions. On the east side of the river, some of the parcels with redevelopment potential are restricted to industrial uses. Taken together, these land use changes are likely to benefit health by reducing land uses that inhibit healthy behaviors and increasing the density and diversity of destinations. These changes can be expected to promote physical activity and social cohesion, reducing the burden of chronic diseases and mental health morbidity—impacts with a low likelihood, low magnitude, and low severity.

7.9.3 Construction Impacts

Considering only temporary land use changes for construction (staging, etc.), there is no evidence of long-term health effects.

The *EQRB Economic Impacts Technical Repor*t estimates the number of jobs and total value of economic activity associated with construction, summarized as approximately 400 jobs and $170 million in business output annually. To the extent that this activity would not otherwise occur, these jobs contribute to stable or improving socioeconomic status, one of the most powerful predictors of overall health. This is especially the case for living-wage jobs that offer benefits and some degree of worker control over work hours. The impact of these jobs is medium likelihood, low magnitude, and highly protective.

7.9.4 Distribution of Impacts

Long-term land use changes resulting from the Project and from redevelopment are likely to benefit people with physical disabilities, as improvements to ADA facilities are planned or required as part of construction and redevelopment.

The *EQRB Economic Impacts Technical Report* finds that there is not sufficient information to determine whether employment and contracting opportunities are likely to benefit nearby residents or other populations of concern. These resources present an opportunity for just distribution that could contribute to correcting historical injustices and existing inequality that drives health disparities.

7.10 Neighborhoods and Social Environment

7.10.1 Causal Pathways and Health Outcomes

Social cohesion and social capital are associated with life expectancy and a range of measures of overall health. [92] There is emerging evidence that neighborhood-level social capital is beneficial to health, but interventions to influence social capital or related measures of social cohesion are not well understood. [93]

7.10.2 Impacts

7.10.2.1 No-Build Alternative

As reflected in the *EQRB Social/Neighborhoods Technical Report*, the No-Build Alternative would not result in any of the neighborhood disruption associated with construction. However, occasional disruption would continue as maintenance needs increase. After a major earthquake, the collapse of the bridge, damage to nearby buildings, and debris would cause devastation in the neighborhood, hindering the immediate emergency response as well as long-term recovery. Health impacts from this would be similar to those described in the displacement section of this report and in the discussion of seismic resilience; injuries, mental health morbidity, and chronic disease are negative health impacts with a high likelihood, high magnitude, and high severity.

7.10.2.2 Enhanced Seismic Retrofit Alternative

The *EQRB Social/Neighborhoods Technical Report* finds that investment in a retrofit or replacement bridge could make redevelopment in the Project Area more attractive. Gentrification that leads to economic displacement or damage to social networks could have health impacts similar to those described in the displacement and relocation section of this document, namely mental health morbidity and chronic disease. They include mental health morbidity such as stress disorders and anxiety, chronic diseases such as cardiovascular disease and diabetes, and premature death.

Construction of any of the Build Alternatives would disrupt events and locations that contribute to social cohesion in the neighborhood. These include a closure or relocation of the Portland Saturday Market, displacement of Rose Festival activities, closure of the Burnside Skatepark, and both noise and access impacts in Tom McCall Waterfront Park. There is potential for impacts to health indicators associated with social cohesion, namely overall health and life expectancy. However, these disruptions would be temporary and it is unclear from research literature what, if any health impacts would result. There is a low likelihood of a negative impact, with low magnitude and low severity.

The Retrofit Alternative is anticipated to take about 1 year less to construct compared to the Replacement Alternatives, meaning that any health impacts from construction would result in less disruption and exposure. Similarly, the addition of a temporary bridge is expected to add 18 months of construction time. Construction approaches that do not include a temporary bridge would minimize health impacts from social disruption and exposure.

7.10.2.3 Replacement Alternatives

The Long-span Option would have fewer physical impacts than other alternatives and would not require a permanent easement from the Japanese American Historical Plaza. As reflected in the *EQRB Social/Neighborhoods Technical Report*, the Long-span Option presents the least risk of disrupting the neighborhood, as it is least dependent on soils that are vulnerable to lateral spread. However, construction would carry on for an additional year compared to the Retrofit Alternative. Health impacts related to social and neighborhood dynamics are otherwise the same as those described for the Retrofit Alternative.

7.10.2.4 Replacement Alternative with Couch Extension

Health impacts related to social and neighborhood dynamics are nearly the same for the Couch Extension as described for the Long-span and Short-span Alternatives.

The main difference results from permanent closure of the connection from NE Couch Street to NE 3rd Avenue, described as follows in the *EQRB Social/Neighborhood Technical Report*:

> *The resulting out-of-distance travel for pedestrians could have a potential impact on low-income, minority, and/or unhoused individuals living or working in the area, especially those with disabilities, who may be disproportionately burdened by transit fares or are less likely to have access to a personal vehicle or bicycle. This would make it more difficult for these individuals to access the services provided by the social and community service providers in the API.*

To the extent that this change makes access to clinical care more difficult or dis-incentivizes physical activity, it could have negative health impacts. There is uncertainty about the current and future demand for trips that would be affected, especially among populations of concern. There is a high likelihood of impact, with a low magnitude and low severity.

7.10.3 Distribution of Impacts

As discussed in the *EQRB Social/Neighborhood Technical Report*, people accessing social services are the primary population of concern regarding health impacts from changes to social and neighborhood dynamics.

7.11 Environmental Justice

7.11.1 Causal Pathways and Health Outcomes

The concept of environmental justice arises from a history of disproportionate exposure to environmental hazards such as air pollution and toxic sites, combined with a lack of involvement in decision-making about these sites. [16] These exposures stem from the cumulative effects of harmful policies and systemic racism spanning generations. The same policies and systems that cause disproportionate harm also result in barriers to accessing health-promoting opportunities. Together, these effects have contributed to major disparities in health outcomes by race and by socioeconomic status. For example, Chetty et al. documented a disparity in life expectancy of 14.6 years between the wealthiest and poorest Americans. [94] Local studies in Multnomah County have found severe disparities between race groups in birth outcomes, diabetes, and exposure to air pollution. [3]

Oregon and Portland have a history of discriminatory policies and practices that continue to produce inequitable conditions and uneven exposure to health risks in neighborhoods. This history is documented in reports from the City of Portland, the Oregon Historical Society, and the Coalition of Communities of Color. [95, 96, 97] In summary, from 1844 through 1926, African Americans were excluded from Oregon by law. While Oregon is the only state to have had such a law, many other racist policies and practices are similar to those found elsewhere in the U.S. As African Americans moved to Oregon to staff factories during World War II, the combination of sundown laws, restrictive zoning, racist real estate covenants, and unfair lending practices forced black and African American residents into certain neighborhoods. [95] From the mid-twentieth century onward, these neighborhoods were targeted for urban renewal, freeway construction, and upzoning that continues to result in displacement. As a consequence, the Black population has decreased in inner neighborhoods and increased in neighborhoods farther from the central city. Many of these areas were developed before being incorporated into Portland and have infrastructure that has yet to be brought up to urban standards. One can trace the chain of events from exclusion laws of the past century through current displacement issues, and the result is that people of color and low income households are pushed into neighborhoods where the built environment presents more health risks and offers fewer protections from risk factors for injuries and chronic disease.

7.11.2 Impacts

The *EQRB Environmental Justice Technical Report* identifies impacts to environmental justice populations (defined as low income people and people of color) and other equity populations (defined as other historically marginalized groups such as people with disabilities).

7.11.2.1 No-Build Alternative

The *EQRB Environmental Justice Technical Report* found no disproportionate impacts from the No-Build Alternative in pre-earthquake conditions. Existing conditions would essentially continue, with periodic maintenance. However, following a major earthquake, the report anticipates “disproportionate and devastating” effects on environmental justice populations. These impacts would be due to damage to buildings under or adjacent to the bridge, which employ low-income workers and people of color, and house services for low-income residents. Environmental justice populations would be negatively impacted by the elimination of a primary cross-river route to social services, emergency response, and community services. These populations could also be affected by a longer economic recovery following an earthquake. Health harms to these populations would be similar to those for the population at large, but potentially occurring with higher incidence or greater severity due to higher existing burdens of underlying conditions. They include injury, death, mental health morbidity, and chronic diseases. These impacts have a medium likelihood, high magnitude, and high severity.

7.11.2.2 Build Alternatives

For all Build Alternatives, the negative impacts of a bridge collapse during a major earthquake and attendant health outcomes would be largely averted. Environmental justice populations would benefit from a faster economic recovery and improved access to social and healthcare services in the aftermath of an earthquake. Importantly, businesses displaced from under the bridge would avoid injury to workers and disruption to operations, which is especially relevant to the first responder service AMR. Reducing the negative health impacts of an earthquake has a high likelihood, high magnitude, and is highly protective.

The Replacement Alternatives would result in safety improvements for people walking, biking, and using transit. The *EQRB Environmental Justice Technical Report* notes that this is likely to disproportionately benefit lower income travelers and people of color, who are more likely to rely on these modes. For the same reason, the report finds that under the Couch Extension, out-of-direction travel necessitated by the closure of existing access between NE 3rd Avenue and NE Couch Street would disproportionately affect people with less access to vehicles or who are burdened by the cost of transit fare. Health benefits from safety improvements have a high likelihood, low magnitude, and high severity. Health harms from out-of-direction travel have a low likelihood, low magnitude, and low severity.

Displacements would affect workers at Pacific Fruit and AMR. The *EQRB Environmental Justice Technical Report* finds that workers at Pacific Fruit may be lower income or people of color, and that AMR provides frequent care to low-income people seeking services on the west side of the bridge. Relocation plans remain uncertain and long-term impacts are therefore also uncertain. If loss of livelihood occurs as a result, it could lead to health impacts including chronic disease, mental health morbidity, and premature death. These impacts could be mitigated as suggested in the report. They are therefore characterized as low likelihood, low magnitude, and medium severity.

Social service providers in the Project Area include Portland Rescue Mission, Central City Concern, and Salvation Army. The *EQRB Environmental Justice Technical Report* finds no long-term impacts to these providers associated with the Build Alternatives. It also notes that the Long-span Option would have no footings in Tom McCall Waterfront Park, a change that would have uncertain impacts on use as a sheltering space, but is viewed by stakeholders as a safety improvement due to improved visibility. Evidence is lacking to conclude that any health impacts would result.

7.11.3 Construction Impacts

The *EQRB Environmental Justice Technical Report* describes impacts with potential health effects resulting from impacts to transportation, impacts to social service providers, and impacts to culturally important sites.

The report describes how some groups are more likely to be affected by delays from out-of-direction travel or congestion due to a bridge closure. People more dependent on walking, biking, and taking transit could be disproportionately delayed. Conversely, they may benefit disproportionately from a temporary bridge depending on the travel modes permitted. If delays are long enough to shift trips from active modes to sedentary ones, it would contribute to chronic disease among residents and workers most likely to rely on these modes. Additionally, if the delays create a barrier so great that trips are not taken at all, it could result in health care delayed or forgone, exacerbating existing health conditions. There are potential health benefits for environmental justice and equity populations if a temporary bridge is used, stemming from continued physical activity and access to essential services. Behavior changes among specific populations (e.g., people accessing social services) were not modeled and are uncertain. Health benefits for environmental justice populations have a low likelihood, low magnitude, and low severity.

Culturally significant sites affected by construction include the Burnside Skatepark and the Japanese American Historical Plaza. The *EQRB Environmental Justice Technical Report* identifies the skatepark as potentially important to youth and people of color, and the plaza as culturally important to Japanese Americans. The plaza commemorates the internment of Japanese Americans during World War II, as well as their service in the armed forces. Disconnection from these important sites could erode social cohesion and reduce opportunities for recreational physical activity, negatively impacting mental health and risk factors for chronic disease. Although these impacts would be temporary, they represent a relatively large amount of time for youth who could see closure of the skatepark for the majority of their high school years. These impacts have a high likelihood, low magnitude, and low severity.

Temporary construction easements would affect access to Portland Rescue Mission, Central City Concern, Mercy Corps, and the Salvation Army, all of which serve environmental justice and equity populations. Construction of the Retrofit Alternative would entail a 3-month interruption to pedestrian access from Burnside Street to the Portland Rescue Mission; no interruption would be needed for the Replacement Alternatives. Mitigation options for this interruption are described in the *EQRB Social/Neighborhoods Technical Report*. Disruption of critical services for people in unstable housing or experiencing homelessness could exacerbate existing health conditions and risk factors. These impacts have a high likelihood, low magnitude, and medium severity.

Distribution

The findings of the *EQRB Environmental Justice Technical Report* are inherently focused on the distribution of impacts, therefore minimal additional discussion is included here. The preceding analysis emphasizes disproportionate burdens and benefits that may affect low-income populations and people of color, identifying potential health impacts.

The burdens of construction are likely to affect a smaller population living, working or accessing services near the Project Area. Among those burdened are low-income residents accessing social services and low-income workers at displaced businesses. In contrast, the benefits of the completed Project, especially those stemming from improved recovery after an earthquake, are spread across the entire region. This creates potential environmental justice issues and should be mitigated to the extent possible with tools such as Community Benefit Agreements, as suggested in the *EQRB Environmental Justice Technical Report*.

8 Recommendations

Reduce negative health impacts of a major earthquake

- Select one of the Build Alternatives that minimizes the risk of bridge collapse.

Maximize long-term physical activity

- Prioritize direct, low-stress routes for people walking, cycling, and taking transit.
- Leverage transportation demand management strategies to promote long-term adoption of mode changes adopted during construction.

Minimize short-term disruptions to physical activity

- Establish and publicize alternate routes for recreation.
- Select a construction approach that maximizes physical activity during the construction phase.
- Minimize closure of the Vera Katz Eastbank Esplanade. The Long-span Alternative with no Temporary Bridge would result in the least displacement of physical activity on the esplanade.
- Collaborate with researchers to monitor changes to physical activity from recreation during closures.
- Minimize the duration of Burnside Skatepark closure. Promote alternate venues for skating and related cultural events during the closure, consulting with users on preferences prior to finalizing a plan. Replacement Alternatives with no Temporary Bridge would result in the shortest closure of the skatepark.

Eliminate serious and fatal traffic crash deaths in the Project Area

- Develop an action plan to address safety concerns that arise during construction
- Select an alternative with maximum crash injury reduction. The Short-span and Long-span Alternatives result in the greatest reduction in all crashes.
- Design for speeds of 25 mph.
- Minimize impacts of urban heat
- Minimize large expanses of pavement, and coordinate with the City of Portland to add trees or other shade structures where feasible.
- Minimize removal of existing trees and vegetation.

Minimize short-term health risks from air pollution during construction

- Adhere to clean diesel contracting rules, and use electric equipment or other pollution controls when possible.
- Adopt dust control measures for demolition of buildings and the bridge.

- Offer indoor air filtration and air conditioning to affected residents and small businesses.
- Establish plans for pollution reductions on days with wildfire smoke infiltration, high ozone, or wintertime inversions.

Minimize long-term health risks from air pollution during operation

- Select an alternative that maximizes separation between vehicle pollution and people walking and cycling.

Protect social cohesion

- Acknowledge native peoples and lands.
- Mitigate impacts to Tom McCall Waterfront Park, including impacts to special events, Portland Saturday Market, Bill Naito Legacy Fountain, and the Japanese American Historical Plaza.

Mitigate noise impacts

- Communicate with residents about the nature and duration of noise impacts.

Prevent harm and create health benefits for the unhoused population

- Conduct outreach regarding construction impacts including air pollution exposure, noise, and access to social services.
- Mitigate short-term displacement of facilities used by the unhoused population.
- Work with partner agencies to identify opportunities to provide long-term benefits from the Project, such as restrooms or storage facilities.
- If there is no Temporary Bridge, provide assistance such as transit passes to people accessing social services near the western bridgehead.

Generate economic benefits in local communities

- Coordinate with nonprofits to support recruiting and job-training efforts, prioritizing low-income residents and people of color.

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Brendon Haggerty	Multnomah County Health Department	M.S. Urban and Regional Planning	10
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Andrea Hamberg	Multnomah County Health Department	B.A. Community Organizing	15

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Appendix A. Impacts Summary Table

Alternative	Topic	Impact	Outcomes	Direction	Likelihood	Magnitude	Severity	Distribution
All Build	Air pollution	Short term health impacts from construction pollution	Cancer, respiratory illness, cardiovascular disease, diabetes, birth outcomes	Negative	Medium	Low	Medium	People with existing chronic disease
Replacement	Air pollution	Separation of modes through low barrier walls and horizontal distance in the Replacement Alternatives provide a greater degree of protection from air pollution than the No-Build or Retrofit options.	Cancer, respiratory illness, cardiovascular disease, diabetes, birth outcomes	Positive	Medium	Medium	Low	Vulnerable road users
All Build	Displacement	Adverse health impacts from displacement	Chronic disease, mental health morbidity	Negative	Low	Low	Medium	Nearby workers, people experiencing homelessness
No-Build	Displacement	Negative health impacts in the event of an earthquake include mental health morbidity such as stress disorders and anxiety, chronic diseases such as cardiovascular disease and diabetes, and premature death.	Injury, premature death, cardiovascular disease, mental health morbidity	Negative	High	High	High	
All Build	Economics	Health benefits from living wage jobs	Life expectancy	Positive	Medium	Low	High	Construction workers
All Build	HazMat	Exposure to toxics from disturbed contamination	Cancer, nervous system damage	Negative	Low	Medium	High	Children, nearby residents and workers
All Build	HazMat	Increasing toxic loads for fish	Cancer, nervous system damage	Negative	Low	Low	Low	Children, people who fish on the Willamette

Alternative	Topic	Impact	Outcomes	Direction	Likelihood	Magnitude	Severity	Distribution
All Build	HazMat	Exposure to lead and asbestos during demolitions	Cancer, nervous system damage	Negative	Low	Low	High	Children, nearby residents and workers
No-Build	HazMat	Exposure to dust from collapse	Cancer, nervous system damage	Negative	Low	Medium	High	Children, nearby residents and workers
All Build	Land use	Land use changes can be expected to promote physical activity and social cohesion, reducing the burden of chronic diseases and mental health morbidity	Chronic diseases related to physical activity	Positive	Low	Low	Low	Nearby residents and workers
All Build	Noise	Noise levels could have negative health impacts if they are disruptive to sleep among those who work at night and sleep during the day.	Cardiovascular disease, stress	Negative	Low	Low	Low	People who work at night and sleep during the day
Short- and Long-span	Parks	More park space and not demolishing the skate parks could offer slightly more opportunity for physical activity and social cohesion, supporting healthy behaviors.	Chronic disease related to physical activity, mental health morbidity	Positive	Low	Low	Low	Youth, low income
No-Build	Parks	Severe injury or death during an earthquake, and would sever important routes used to minimize health impacts during recovery.	Injury, premature death, cardiovascular disease, mental health morbidity	Negative	Medium	Low	High	
Retrofit	Parks	Skatepark closure could increase the potential for chronic diseases.	Chronic diseases related to physical activity	Negative	Low	Low	Low	Youth

Alternative	Topic	Impact	Outcomes	Direction	Likelihood	Magnitude	Severity	Distribution
All Build	Seismic resilience	Infrastructure that improves emergency response and facilitates long-term recovery	Injury, premature death, cardiovascular disease, mental health morbidity	Positive	High	High	High	
All Build	Social/ Neighborhoods	Disruptions to parks and events are temporary and it is unclear from research literature what, if any health impacts would result.	Chronic diseases related to physical activity	Negative	Low	Low	Low	
Couch	Social/ Neighborhoods	Out of direction travel makes access to clinical care more difficult or disincentivizes physical activity, it could have negative health impacts.	Chronic diseases related to physical activity	Negative	Low	Low	Low	ADA
No-Build	Social/ Neighborhoods	Impacts from collapse include injuries, mental health morbidity, and chronic disease	Injury, premature death, cardiovascular disease, mental health morbidity	Negative	High	High	High	
All	Transportation	Long term health benefits from physical activity	Chronic disease related to physical activity	Positive	High	Medium	High	
All Build	Transportation	Short term health benefits from physical activity	Chronic disease related to physical activity	Positive	Low	Medium	Low	
All Build	Transportation	Improved ADA access to west side MAX stop and Vera Katz Eastbank Esplanade could promote physical activity	Chronic disease related to physical activity	Positive	High	Medium	Low	ADA
Couch	Transportation	Out of direction travel could have a negative impact on health outcomes related to physical activity	Chronic disease related to physical activity	Negative	Low	Low	Low	ADA

Alternative	Topic	Impact	Outcomes	Direction	Likelihood	Magnitude	Severity	Distribution
No-Build	Transportation	Crash injuries will decrease for vulnerable road users	Injury, premature death	Negative	Medium	Low	High	Vulnerable road users
No-Build	Transportation	Long term negative health impacts associated disrupted transportation following a major earthquake	Injury, premature death, cardiovascular disease, mental health morbidity	Negative	Medium	High	High	
Replacement	Transportation	Reduced traffic crash injury	Injury, premature death	Positive	Medium	Medium	High	Vulnerable road users
No-Build	EJ	Impacts of bridge collapse include injury, death, mental health morbidity, and chronic diseases. These impacts have a medium likelihood, high magnitude, and high severity.	Injury, premature death, cardiovascular disease, mental health morbidity	Negative	Medium	High	High	EJ and Equity populations
All Build	EJ	Reduced health impacts during and after an earthquake	Injury, premature death, cardiovascular disease, mental health morbidity	Positive	Medium	High	High	EJ and Equity populations
All Build	EJ	Improved safety	Injury	Positive	High	Low	High	People walking, biking, and taking transit
Couch	EJ	Out of direction travel	Chronic disease related to physical activity	Negative	Low	Low	Low	ADA
All Build	EJ	Displacement of workers	Chronic disease, mental health morbidity, premature death	Negative	Low	Low	Medium	EJ and Equity populations
Construction - temp bridge	EJ	Access & physical activity	Chronic disease related to physical activity	Positive	Low	Low	Low	EJ and Equity populations

Alternative	Topic	Impact	Outcomes	Direction	Likelihood	Magnitude	Severity	Distribution
All Build	EJ	Temporary closure of culturally important sites	Chronic diseases, mental health morbidity	Negative	High	Low	Low	Youth, people of color, Japanese Americans
Retrofit	EJ	3-month interruption of PRM	Chronic diseases, mental health morbidity	Negative	High	Low	Medium	People experiencing homelessness

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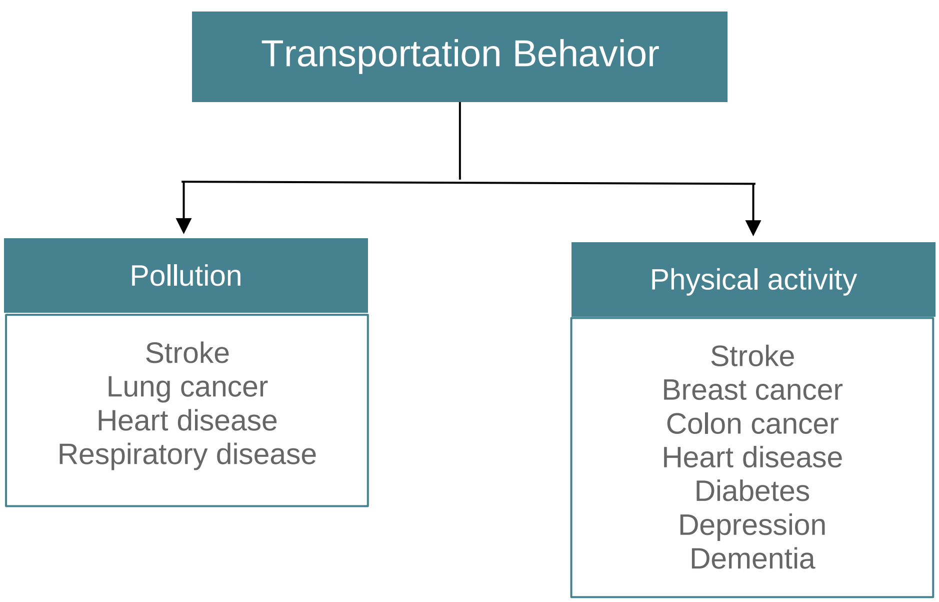
Appendix B. Methods

Overview of ITHIM
As described by Woodcock et al. (2009), ITHIM uses methods of Comparative Risk Assessment to estimate health effects of changes in transportation behavior. The foundation of this approach is a set of exposure-response functions extracted from systematic reviews and meta-analyses that describe the relationships between specific diseases and risk factors (e.g., cancer and pollution). Modeled diseases are listed in Figure B-1. For physical activity, ITHIM first converts time spent walking and biking into metabolic equivalent tasks (METs), a consistent unit of energy expenditure from exercise. The model uses average annual PM2.5 concentrations to estimate disease related to air pollution. As described in the limitations section, we were not able to use the injury module of ITHIM for this planning exercise.

The outputs of ITHIM are change in deaths and change in disability adjusted life years (DALYs). DALYs are a unit of disease burden that combine years of life lost with years of living with a disability. When summed across a population, changes in DALYs can be thought of as changes in the burden of disease within that population.

Figure B-1



Baseline death and burden of disease tables for each disease were compiled from Oregon Health Authority vital statistics. The number of deaths during the period of 2011-2015 were downloaded from the Oregon Public Health Assessment Tool (OPHAT) and averaged for the 5-year period. YLL are calculated inside the World Health Organization (WHO) DALY Template from number of deaths by age group, gender and life expectancy at the time of death. YLD are imputed for the Metropolitan Planning Area from WHO Global Burden of Disease 2010 data.

Costs

We used a cost-of-illness approach consistent with the method used for the Climate Smart Strategy HIAs (Iroz-Elardo et al. 2014) and the US EPA (US EPA, 2007). This method uses large-scale studies of the cost of treating specific illnesses in the US and estimates the regional share of that cost. In this case, the Cal-ITHIM cost module uses peer-reviewed studies that publish national-level estimates for direct (medical treatment) and indirect (absenteeism) costs of illness. These estimates are specific to each condition and in some cases draw from specialty societies such as the American Heart Association. Consistent with methods from previous studies, Cal-ITHIM applies the population attributable fraction (percent change in DALYs from baseline) to arrive at an estimated change in treatment cost.

References for Appendix B.

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Appendix C. Practitioners' Appendix

This appendix is intended to inform evaluators and others in the field of Health Impact Assessment. It describes details of this HIA process and how the HIA meets minimum practice standards.

Title
Earthquake Ready Burnside Bridge Health Impact Assessment

Timeline
HIA screened in October 2018, drafted March 2020

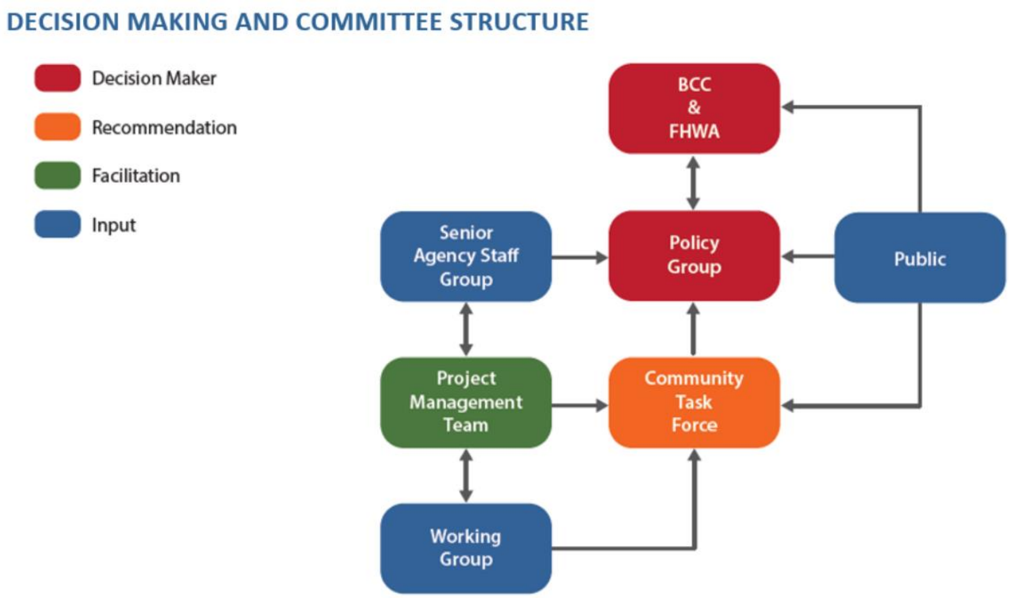
Location
Portland, Multnomah County, Oregon

Funding
Funded by Multnomah County

Sectors
Transportation

HIA Type
Decision support, comprehensive using existing advisory groups and outreach efforts

Decision Context
Excerpt from scoping documents:
This HIA will inform the Multnomah County Board of Commissioners and the Federal Highway Administration as they decide on a Preferred Alternative to repair or replace the Burnside Bridge. The alternatives advancing through the NEPA process include 1) an enhanced seismic retrofit, 2) a replacement movable bridge, 3) a replacement movable bridge with a connection to NE Couch, and, 4) a fixed bridge. In analyzing the end-product of each alternative, we will analyze impacts from the multi-year construction phase of each. Other decision making bodies influencing the development of a preferred alternative include a project management team of consultants and agency staff, an appointed community task force, and a policy group of elected officials. The diagram below illustrates the decision making structure.



Screening

The HIA was screened following a request from the Multnomah County Transportation Division very early in the project process.

Related Work

Both the Transportation Division and the Public Health Division had experience with a retrospective HIA on the Sellwood Bridge project in 2011.

This HIA is coupled with the environmental review phase of the project under the National Environmental Policy Act. It was prepared as one of many technical reports compiled for an environmental impact statement.

Scope and Goals

Goals of the HIA include:

- Understand potential health impacts of a bridge replacement, including the construction phase
- Document existing health disparities and project how they may be affected by the bridge replacement
- Develop recommendations to mitigate potential harms and maximize potential benefits

Parameters of analysis are adopted from the relevant technical reports. The HIA draws on modeling scenarios and outputs from Metro's Travel Demand Model using the model years of 2015 to represent current conditions and 2040 to represent future conditions. Populations of concern were identified in the scoping process and are listed in the report.

Health Pathways

Table C-1. Health pathways considered during the scoping step

Topic	Determinants	Outcomes
Construction	Noise, physical activity, injury risk, air pollution, socioeconomic status	Chronic diseases*, traffic crash injuries, stress and anxiety, heart attack
Transportation	Noise, physical activity, injury risk, air pollution, access to services	Chronic diseases*, traffic crash injuries, all-cause mortality, cognitive function
Sustainability and climate change	Climate change, extreme heat, extreme precipitation/flooding, air pollution	Heat related illness, waterborne disease, respiratory disease, cardiovascular disease
Parks and recreation	Social cohesion, contact with nature, physical activity	Chronic diseases*, mental health outcomes
Toxic exposures	Fish consumption, existing contamination, demolition & construction	Cancer, respiratory diseases, other acute non-cancer effects
Noise and vibration	Traffic noise, construction noise	Stress, heart attack, cardiovascular disease
Displacement and relocation	Social cohesion, housing	Chronic diseases*, mental health outcomes
Air	Air pollution	Cardiovascular disease, stroke, cancer, diabetes, dementia, cognitive function, birth outcomes
Land use and economics	Physical activity, socioeconomic status, segregation	Chronic diseases*, life expectancy
Neighborhoods and social environment	Social cohesion	Chronic diseases*, stress
Environmental justice	Social cohesion, socioeconomic status, air pollution, toxic exposures, physical activity, injury risk, noise, access to services, historical trauma	Chronic diseases*, injury, all-cause mortality, cognitive function, stress

*As used here, chronic diseases include cancer, diabetes, stroke, cardiovascular disease, depression, dementia, and respiratory disease.

Sources of evidence

Peer reviewed literature and qualitative analysis, quantitative model outputs, local data on built environment characteristics, data prepared for other technical reports that were part of the same environmental review process (e.g. safety data from the Transportation Technical Report)

Major data sources

Oregon Health Authority Vital Statistics, Behavioral Risk Factor Surveillance System, Metro Travel Demand Model, US EPA National Air Toxics Assessment, Metro Regional Land Information System, Community Modeling and Analysis System, Integrated Transportation and Health Impacts Model (Cal-ITHIM implementation)

Data gaps identified

Almost no information exists on the amount of recreational physical activity occurring on multi-use paths in the project area or on similar paths elsewhere. Specifically, we were unable to determine the proportion of trips occurring in Tom McCall Waterfront Park and the Vera Katz Eastbank Esplanade that are recreational in purpose as opposed to active travel to a destination. This has a bearing on the modeling aspects of this HIA, which estimate change to physical activity only from active transportation.

Stakeholder involvement

This HIA “piggy backs” on a robust stakeholder engagement process undertaken by the Transportation Division and consultant team. During the scoping phase, we also solicited involvement from experts in the fields of Health Impact Assessment, transportation and health, and others familiar with the project. Additional expertise was sought regarding recreational exercise and modeling guidance.

Communications plan

The HIA follows the same communication plans as other technical reports included in the environmental review phase. It also included participation in project management meetings, stakeholder meetings, and a special memorandum on weighting of decision making criteria which was delivered in early 2020.

Evaluation plan

Not completed as of March 2020

Monitoring plan

Not completed as of March 2020

Appendix D. Air Pollution Modeling Exercise

A modeling exercise was undertaken to understand a range of potential impacts to local air quality during construction. The team used C-LINE sketch modeling tools to estimate current concentrations of diesel particulate at sensitive receptor sites: the Yard apartments and the University of Oregon White Stag Building. With the current fleet of older diesel engines, the estimated concentration of diesel particulate matter at the Yard apartments is about 2.5 $\mu g/m^3$ and 1.9 $\mu g/m^3$ at the White Stag building (Map D-1). If heavy duty diesel traffic were to double on adjacent streets with the same vehicle age, we would expect to see concentrations of about 3.0 and 4.6 $\mu g/m^3$, respectively (Map D-2). Increases in long-term exposure of this size could increase the risk of cancer. [98] Doubling of heavy-duty diesel traffic is not intended to represent actual construction traffic, but is used here to illustrate how average annual concentrations are responsive to local activity. Three important considerations distinguish this illustrative example from likely conditions during construction. First, Multnomah County Clean Diesel purchasing rules would require post-2007 On-road vehicles, meaning that any construction-related traffic would be substantially cleaner than the current fleet modeled here. Second, the model does not include Non-road construction equipment, which would also contribute to localized emissions. Finally, the model does not reflect changes to the broader fleet that are likely to take place before construction commences, which will result in a lower background concentration. Given the uncertainty introduced by these three factors, we find a medium likelihood of short-term health impacts from construction pollution, with low magnitude and medium severity.

Map D-1. Modeled Diesel Particulate Matter Concentrations, Existing Conditions

Map D-2. Modeled Diesel Particulate Matter Concentrations with Doubling of Diesel Traffic