06 / 08/ 2020

ORDINANCE NO. M-4295

AN ORDINANCE declaring an emergency and adopting a six-month temporary moratorium prohibiting the establishment of new, or expansion of existing, large-scale fossil fuel facilities; directing staff to formulate recommendations addressing the circumstances necessitating the moratorium; and establishing an immediate effective date.

WHEREAS, the City of Vancouver is a Charter City of the First Class and has the authority to adopt temporary moratoria pursuant to the City's constitutional police powers, home rule authority, RCW 36.70A.390, and 35.63.200; and

WHEREAS, "Goal 1" of the City of Vancouver's 2016-2021 Strategic Plan is to "[e]nsure our built urban environment is one of the safest, most environmentally responsible and well maintained in the Pacific Northwest;" and

WHEREAS, local governments have a core responsibility for upholding the public health, safety, and welfare, mitigating and preparing for disasters, protecting and preserving natural systems and supporting economic development; and

WHEREAS, the City of Vancouver and the greater Pacific Northwest are vulnerable to powerful subduction zone earthquakes that occur with periodic frequency along the Juan de Fuqua and North American plates; and

WHEREAS, geologic research has shown that subduction zone earthquakes have occurred along the Pacific Northwest with relative regularity over the last 10,000 years, and if averages from past events are predictive, the region could be overdue for another powerful subduction zone earthquake; and

WHEREAS, many of the city's buildings and critical infrastructure were built before the city's seismic exposure was widely understood; and

WHEREAS, the Clark Regional Emergency Services Agency has identified Critical Facilities and Infrastructure (including Hazardous Materials, Energy Facilities, Transportation Systems, and Water and Sanitation Systems) to be co-located within areas of the City with a "Moderate to High" liquefaction susceptibility (see Exhibits A-1, A-2: Clark Regional Natural Hazard Mitigation Plan, Vol. 2 – Planning Partner Annexes, Aug. 2017, pp. 156-157); and

WHEREAS, the City of Vancouver's drinking water (almost 26 million gallons per day) is supplied entirely from groundwater resources; and

WHEREAS, the vast majority of Vancouver's drinking water (approximately 90%) is supplied from the Troutdale, Upper Orchards and Lower Orchards Aquifers, the boundaries of which are often blurred (the Orchards Aquifer is likely an alluviated portion of the Troutdale with little or no silica cementing), and historical water monitoring indicates that water moves vertically through the hydrogeologic layers of these aquifers; and

WHEREAS, facilities that store or process hazardous materials have been recognized to present an increased risk of spills or leaks (see Exhibit B), and a greater concentration of such facilities renders the City's water supply at an increased susceptibility to contamination, particularly in the event of a powerful earthquake; and

WHEREAS, prior Vancouver city councils have endeavored to protect City water resources by establishing development regulations and minimum standards to reduce the risks of contaminants entering water resources by enacting local ground and surface water regulations in the form of a Water Resource Protection Ordinance, Title 14.26 VMC; and

WHEREAS, recognizing the risks posed by transportation of one particular fossil fuel (petroleum), prior Vancouver city councils have encouraged agencies to deny permits for facilities that increase the transportation of Bakken crude oil through Clark County (June 2014, Resolution M-3821), restricted the expansion of crude petroleum facilities by way of a moratorium (Sept. 2014, Resolution M-4090), and made corresponding revisions to the City land use code (Title 20.150 VMC); and

WHEREAS, this City Council recognizes that the storage, transfer, processing and handling of other fossil fuels within the City pose risks to safety, health, and livability, including mobility of people, other freight, and other commercial vehicles which are potentially catastrophic in magnitude; and

WHEREAS, this City Council finds that it is appropriate to conduct review and analysis of its current vulnerabilities to determine whether, and if so how, the purposes of Title 20 and Title 14.26 VMC may continue to be fulfilled while accommodating the establishment of new, or expansion of existing, large-scale fossil fuel facilities; and

WHEREAS, in addition to the foregoing, on January 17, 2020, the Ninth Circuit Court of Appeals found that "Copious expert evidence" establishes that an unprecedented rise in the Earth's carbon concentration levels stems from fossil fuel combustion, and if left unchecked, such levels will wreak havoc on the Earth's climate; stating further: "The problem is approaching 'the point of no return.' Absent some action, the destabilizing climate will bury cities, spawn life-threatening natural disasters, and jeopardize critical food and water supplies." (Hon.

Andrew D. Hurwitz, Circuit Judge authoring the majority opinion of Juliana v. United States, No. 18-36082, p.13 (9th Cir., Jan. 17, 2020); and

WHEREAS, studies conducted by the University of Oregon have found that the effects of climate change on water supplies, public health, coastal and storm damage, wildfires, and other impacts, will cost Washington almost $10 billion per year after 2020, unless we take additional actions to mitigate these effects (Washington State Executive Order No. 14-04); and

WHEREAS, the University of Washington has found that Washington State has experienced long-term warming, a lengthening of the frost-free season, more frequent nighttime heat waves, rising sea levels along most of Washington's coast, increased coastal ocean acidity, declining glacial area and spring snowpack, and changes in the peak streamflows in many rivers to earlier in the year; such that three key areas of risk, specifically changes in the natural timing of water availability, sea level rise and ocean acidity, and increased forest mortality, will likely bring significant consequences for the economy, infrastructure, natural systems, and human health of the region (Washington State Executive Order No. 14-04; University of Washington summary of existing knowledge regarding the causes, impacts, and effects of climate change on Washington State); and

WHEREAS, the scientifically projected increase of forest mortality poses a unique, and heightened threat to the quality of life enjoyed by residents of the City of Vancouver, which has been annually recognized as "Tree City USA" since 1989; and

WHEREAS, the scientifically projected changes to streamflows pose a unique, and heightened threat to the life, health, safety, and economic vitality enjoyed by residents of the City of Vancouver, as it has been long-recognized that "one of the greatest assets of Vancouver is its shoreline along the Columbia River" (August 1991, Resolution M-2739); and the City has made significant financial investments to complete capital improvements such as the Waterfront Development Project and Columbia River Renaissance Trail, in order to "draw walkers and bikers to the water's edge" and "reinforce recognition of the [Columbia River] waterfront as a place of community-wide enjoyment" (June 1993, Resolution M-2836); and

WHEREAS, large-scale fossil fuel facilities create significant public health risks, including air pollution resulting in impaired respiratory functions from fine particulates, noise pollution affecting hearing loss and psychological health, and exposure to heavy metals and contaminated drinking sources resulting in cancers, premature death and lung and heart diseases; and

WHEREAS, fossil fuels including petroleum, coal and natural gas, are a major source of carbon dioxide, heavy metals, nitrogen oxide and sulfur dioxide, and each has a demonstrated nexus to climate change and environmental pollution; the Vancouver City Council has grave concerns regarding the safety of Vancouver City residents and the environment, and the strain on public services and existing infrastructure resulting from the siting and operation of new, or expansion of existing, large-scale fossil fuel facilities; and

WHEREAS, the City of Vancouver is preparing to update the City Strategic Plan, the Vancouver City Center Vision ("VCCV"), and make annual updates to Title 20 VMC; and it is appropriate to facilitate citizen engagement, and undertake appropriate review of large-scale fossil fuel zoning and siting considerations in order to mitigate avoidable risks of catastrophic harm and ensure that any resiliency goals the City Council may adopt as part of the City Strategic Plan are capable of being fully realized; and

WHEREAS, the City Council finds that in order to preserve the ability to develop the Strategic Plan, VCCV, and Title 20 updates, with the widest range of choices and alternatives for future development, it is necessary to temporarily restrict the establishment of new, or expansion of existing, large-scale fossil fuel facilities until the strategy and corresponding code updates are completed; and

WHEREAS, a temporary moratorium will enable the City to hold public hearings and maximize public input in the siting of new, or expansion of existing, large-scale fossil fuel facilities without jeopardizing any possible land use options that may be precluded by unrestricted development; and

WHEREAS, a temporary moratorium as proposed herein will allow City staff additional time to research and develop appropriate strategies to mitigate risks associated with the establishment of new, or expansion of existing, large-scale fossil fuel facilities in the future, through amendments to existing zoning ordinances if necessary; and

WHEREAS, the City Council believes that a temporary moratorium promotes the public health, safety, and general welfare of the people of Vancouver, and will encourage the most desirable and productive use of land and community resources; and

WHEREAS, a public hearing on this ordinance establishing a temporary moratorium will be held within 60 days of the adoption of this ordinance; and

WHEREAS, it is necessary that this ordinance go into effect immediately in order to avoid a rush of applications for new or expanded development of large-scale fossil fuel facilities.

NOW, THEREFORE,

BE IT ORDAINED BY THE CITY OF VANCOUVER:

Section 1. The recitals to this ordinance are hereby incorporated by this reference. City staff is directed to formulate recommendations addressing the circumstances necessitating this moratorium.

Section 2. Definitions. For the purposes of this ordinance:

A. "Fossil fuels" means petroleum and petroleum products, coal, and natural gasses, including without limitation methane, propane and butane, derived from prehistoric organic matter and used to generate energy. Fossil fuels do not include by-products such as asphalt, plastics, fertilizers, paints, or denatured ethanol.

B.1. "Large-scale fossil fuel facilities" means:

a. Facilities engaged in the wholesale distribution, extraction, refinement or processing of fossil fuels;

b. Terminals engaged in the bulk movement of fossil fuels (excluding railyards, fuel storage for airports, and fuel storage for marine servicing facilities);

c. Bulk coal storage: any structure, group of structures, equipment, or device that stores or transfers coal for use in the production of electricity or power.

d. Coal power plant: a thermal power station which burns coal to generate electricity or other usable power.

e. Natural gas processing: any facility which (i) separates natural gas components to recover usable natural gas liquids (*i.e.*, liquefied petroleum or natural gas), or (ii) produces natural gas suitable for transport (*i.e.*, pipeline quality dry natural gas), or (iii) processes natural gas to create methanol or other chemical products.

f. Natural gas storage and handling: any structure, group of structures, equipment, or devices that stores or transfers natural gas for use in the production of electricity or power, or for further processing (excluding facilities that create energy from landfill gas).

g. Bulk storage of one type of fossil fuel, or a combination of multiple types of fossil fuels, in excess of two million gallons.

2. "Large-scale fossil fuel facilities" do not include facilities that solely provide direct sales or distribution to consumers (*e.g.*, gas stations are not large-scale fossil fuel facilities).

Section 3. Temporary Moratorium. As authorized by the City's constitutional police powers, home rule authority, RCW 36.70A.390 and RCW 35.63.200, the City Council hereby adopts a temporary moratorium on the acceptance, processing, and granting of applications for permits for establishment of new, or expansion of existing, large-scale fossil fuel facilities.

Section 4. Exemptions. The moratorium established in Section 2 of this ordinance shall not apply to permits required for upkeep, repair, or maintenance of existing buildings or properties, or work mandated by the City to maintain public health and safety.

Section 5. Duration. This moratorium shall be in effect for six months following the effective date of this ordinance.

Section 6. Vested Rights. The moratorium created by this ordinance does not apply to properties with vested rights existing on the date of adoption of this moratorium ordinance. "Vested Rights" shall be defined in accordance with VMC 20.210.110.

Section 7. Severability. If any provision of this ordinance or its application to any person or circumstance is held invalid, or should any portion of this ordinance be preempted by state or federal law or regulation, the remainder of the ordinance or the application of the provision to other persons or circumstances shall survive and be unaffected.

Section 8. Effective date. The City Council hereby finds and declares that an emergency exists which necessitates that this ordinance become effective immediately in order to preserve the public health, safety and welfare. This ordinance shall become effective immediately upon passage. The City Clerk is directed to publish a summary hereof including the title at the earliest possible publication date.

Ayes:	Councilmembers	Fox, Paulsen, Lebowsky, Glover, Stober, Hansen, Mayor McEnerny-Ogle
Nays:	Councilmembers	None
Absent:	Councilmembers	None

SIGNED this 8th day of June, 2020.

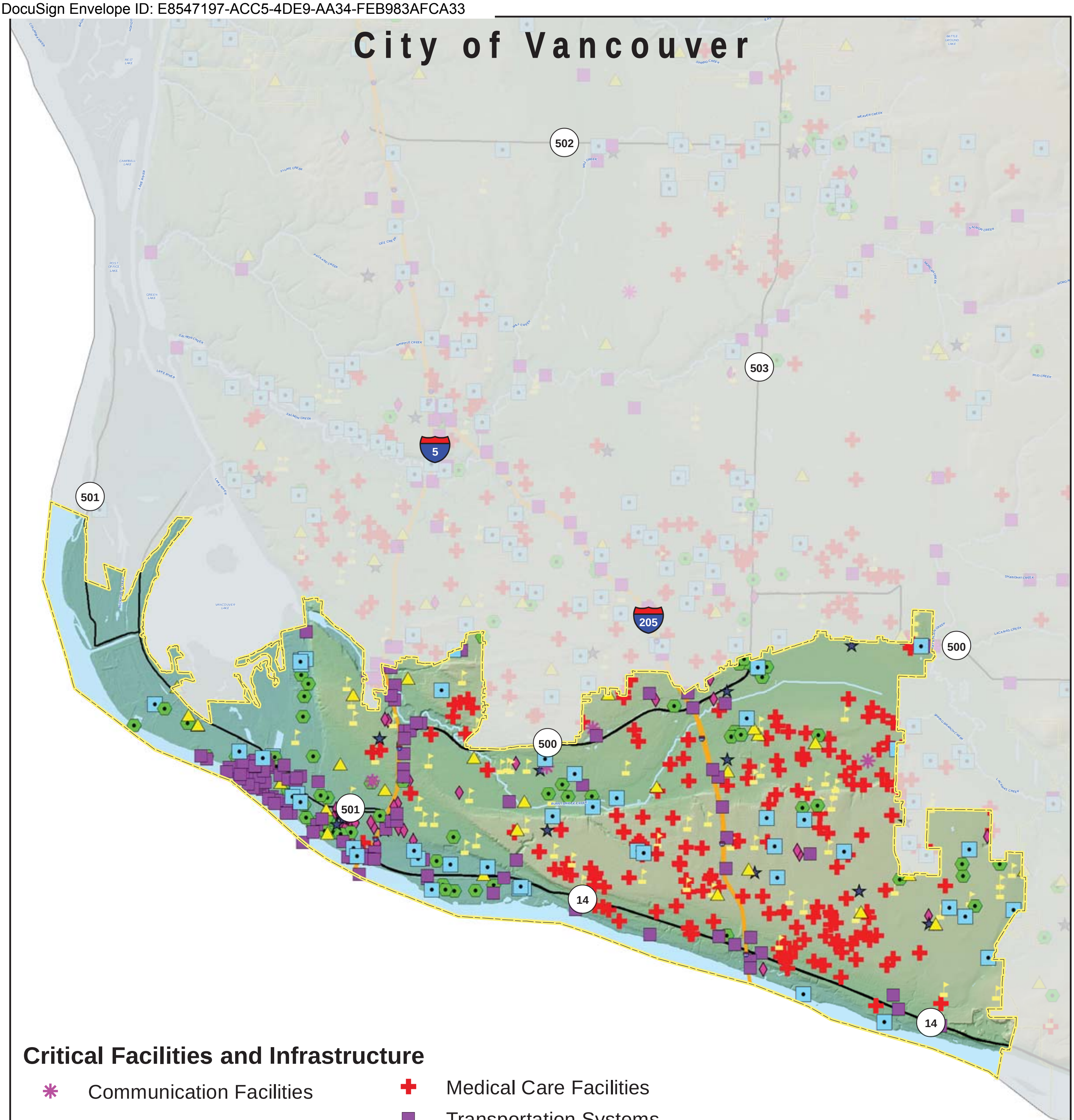
DocuSigned by:
Anne McEnerny-Ogle
58CB15C0632F403...
Anne McEnerny-Ogle, Mayor

Attest:

DocuSigned by:
Natasha Ramras
BCF6734E40E94AE...
Natasha Ramras, City Clerk

Approved as to form:

DocuSigned by:
9A7DC2E31F694A2...
Jonathan Young, City Attorney



Critical Facilities and Infrastructure

- Communication Facilities
- Dams
- Emergency Services
- Energy Facilities
- Hazardous Materials
- Medical Care Facilities
- Transportation Systems
- Schools
- Water and Sanitation Systems
- Other Facilities

CRESA 9-1-1

TETRA TECH

0 1.25 2.5 5 Miles

N W E S

Base Map Data Sources: Clark County, U.S. Geological Survey

Clark County does not warrant the accuracy, reliability or timeliness of any information on this map, and shall not be held liable for losses caused by using this information.

EXHIBIT A-1

CITY OF VANCOUVER

Critical Facilities and Infrastructure

- Communication Facilities
- Dams
- Emergency Services
- Energy Facilities
- Hazardous Materials
- Medical Care Facilities
- Transportation Systems
- Schools
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- Other Facilities

CRESA 9-1-1 TETRA TECH

0 1.25 2.5 5 Miles

N W E S

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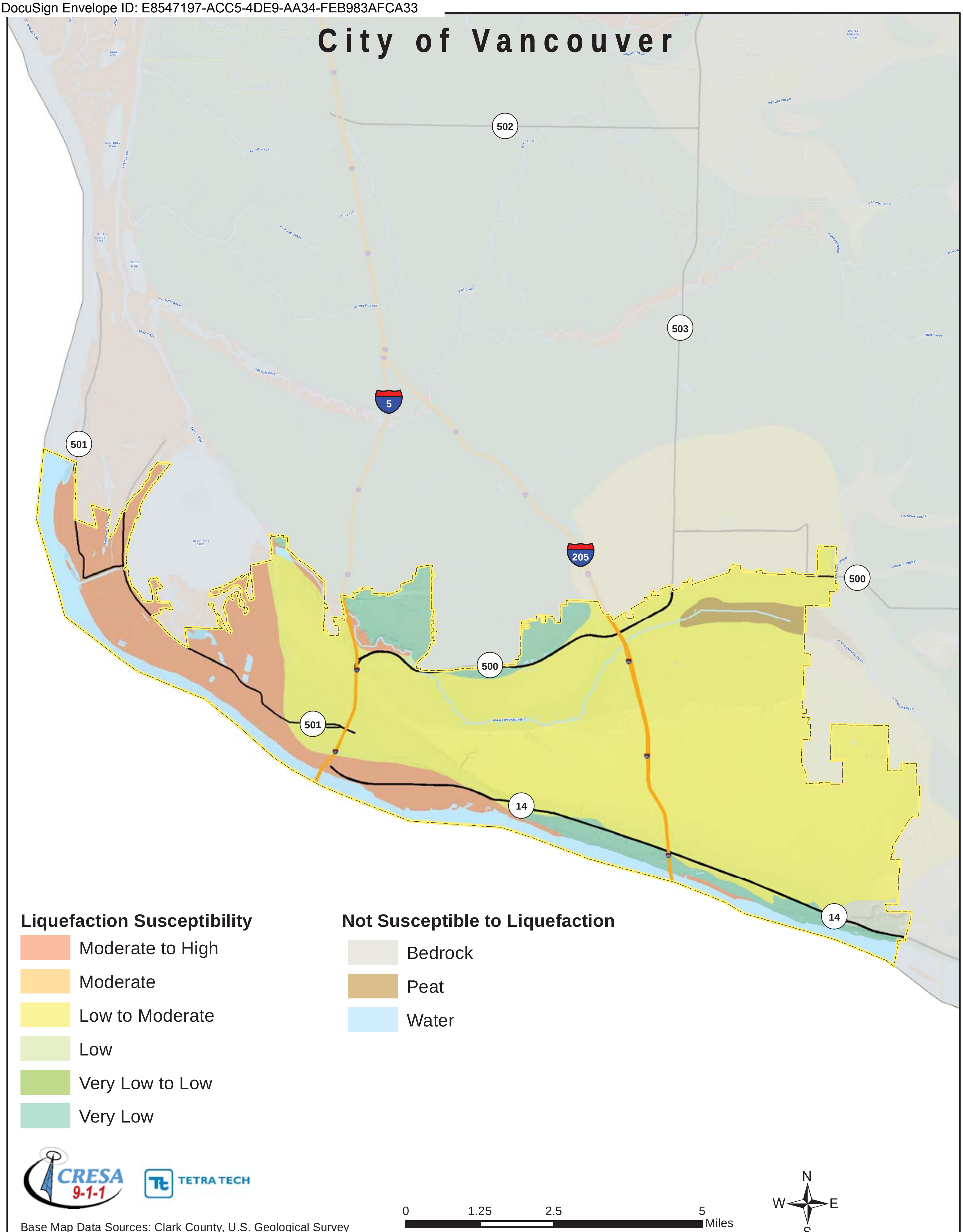
Exhibit A-2



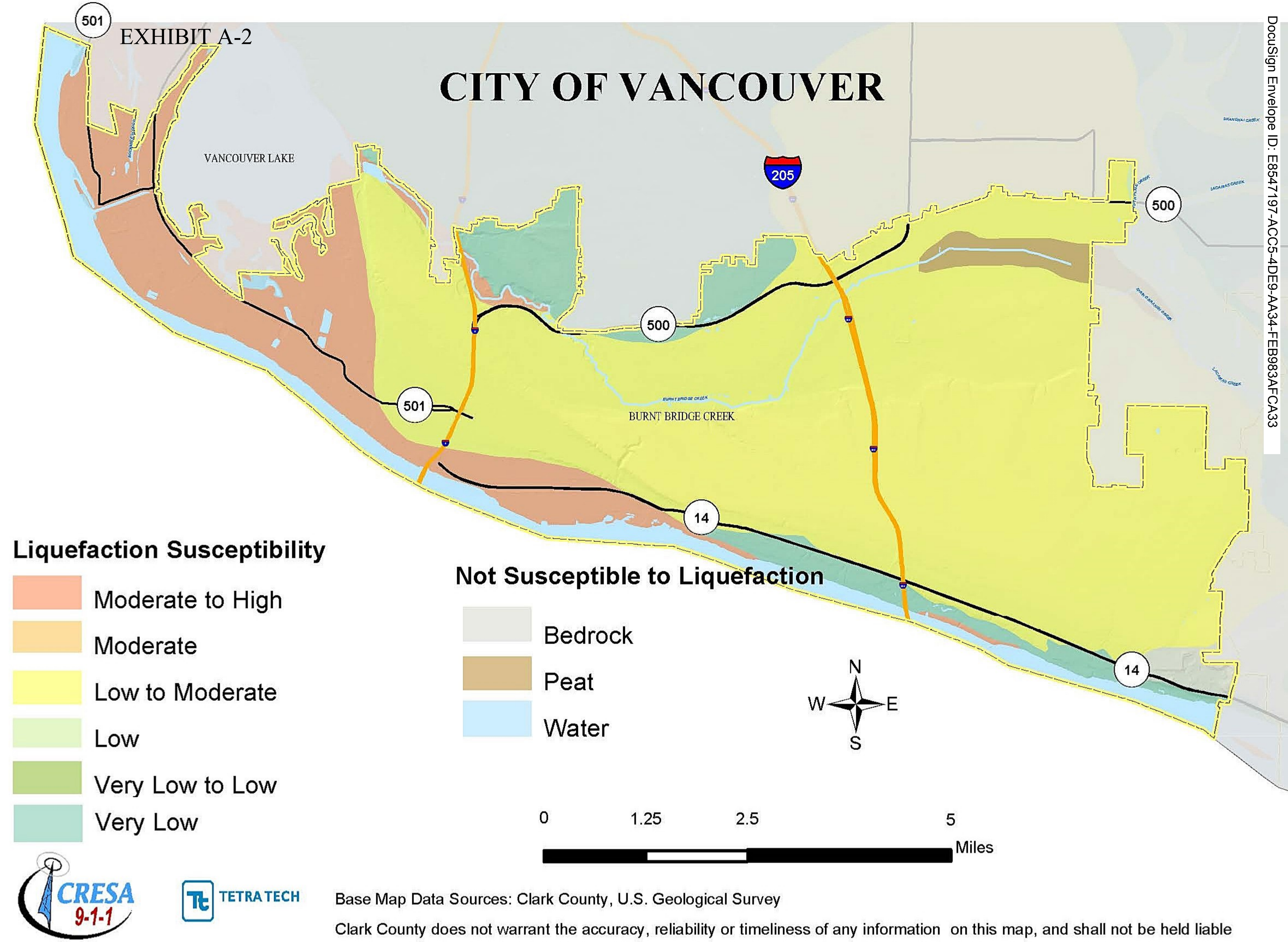
CRESA 9-1-1

TETRA TECH

Base Map Data Sources: Clark County, U.S. Geological Survey

EXHIBIT A-2

CITY OF VANCOUVER



Base Map Data Sources: Clark County, U.S. Geological Survey

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Exhibit B

Vulnerability Assessment of Groundwater in an Urban Environment – Vancouver, WA

Richard Hoiland and Douglas Wise, City of Vancouver Water Resources Protection

The goal of this vulnerability assessment is to identify relative risks of aquifer contamination in the Vancouver urban area. Contaminants of concern are primarily anthropogenic (introduced by human activity) and are most often present in significant quantities at commercial facilities and industries.

In 2003 Vancouver adopted a Water Resources Protection ordinance and a city-wide site inspection program to identify compliance issues. Since then program inspectors have visited almost every facility in the city that stores and manages hazardous materials, currently numbering over 200 sites.

By assigning relative risk values to areas based on vulnerability factors, program inspectors can utilize limited resources more effectively and, in the process, better protect valuable groundwater and surface water resources. There are limitations to a vulnerability mapping approach, however. A groundwater vulnerability publication from the Committee on Geosciences, Environment, and Resources (National Resource Council, 1993) lists the following three **"Laws of Ground Water Vulnerability"**:

1. *All ground water is vulnerable.*
2. *Uncertainty is inherent in all vulnerability assessments.*
3. *The obvious may be obscured and the subtle indistinguishable.*

This NRC study makes a strong point: uncertainty, which is pervasive in individual risk-factor maps, leads to uncertainty in resulting composite vulnerability maps. This does not mean that the exercise is not valuable, but it is a caution on the overall accuracy of vulnerability assessments.

Laws 2 and 3 also provide an endorsement to the acronym formed by the title of this study. Conveniently, ***V****ulnerability* ***A****ssessment of* ***G****roundwater in an* ***U****rban* ***E****nvironment* forms the abbreviation VAGUE, which works appropriately as a reminder of the non-exact nature of results.

For Vancouver's purposes, this VAGUE study effectively highlights areas which warrant further visits and monitoring by our inspector. Information displayed on these vulnerability maps can be somewhat vague but the exercise is still valuable for indicating which areas of the city present higher relative threats to the aquifer. Maps and data developed for this study are also helpful additions to various city reports including Sole Source Aquifer evaluations required by the EPA and Environmental Impact Statements for local projects.

Urban Aquifers

Vulnerability concerns in aquifers underlying urban areas differ from those in a regional aquifer assessment. The urban environment usually encompasses a much smaller area, in this case only the Vancouver municipal water service area. Groundwater movement differences and geological heterogeneities are not easily mapped at such a small scale. Risks of contamination in an urban area do, however, increase with the greater concentrations of businesses and industries and with the wide array of infiltration facilities.

Several risk factors were considered in establishing Vancouver's aquifer vulnerability. These factors have been divided into *aquifer susceptibility* and *infiltration risks.* Aquifer susceptibility refers to hydrogeologic characteristics that dictate how quickly a contaminant can move to a point of withdrawal in the aquifer. The two main susceptibility characteristics considered here are "depth to aquifer", which is measured from surface to the top of well screens, and "time of travel" which refers to the time, typically in years, that it would take a "particle" of groundwater to move horizontally through to a City water station. Infiltration risks are identified by discreet discharge points such as infiltration drywells and septic tanks that can allow a contaminant to enter the vadose zone (below the soil surface). Risks associated with contaminant infiltration also increase at commercial or industrial facilities that manage hazardous materials.

Hydrogeology

Vancouver's drinking water is supplied entirely from groundwater resources. An average of 26 million gallons is pumped every day out of 40 wells that take water from four different aquifer horizons: the Troutdale, the Upper and Lower Orchards, and the Sand and Gravel.

The Upper and Lower Orchards Aquifers were formed from the catastrophic floods of the Pleistocene period and are composed of sands and gravels. Both Orchards aquifers are unconfined. Beneath the Orchards lies the Troutdale aquifer. The Upper Orchards aquifer does not develop in central and western Vancouver. In these parts of the city the Lower Orchards and the Upper Troutdale are found near or at the surface. The Troutdale is composed of semi-consolidated sand and gravel with some interbedded fine-grained material. Below the Troutdale formation lies the Sand and Gravel aquifer, also known as the Sandy River Mudstone, composed mostly of fine-grained material. All of these aquifers overlie a bedrock of basalt.

The following map from a study by HDR Engineering (2007) depicts a west to east cross-section of the aquifers underlying Vancouver.

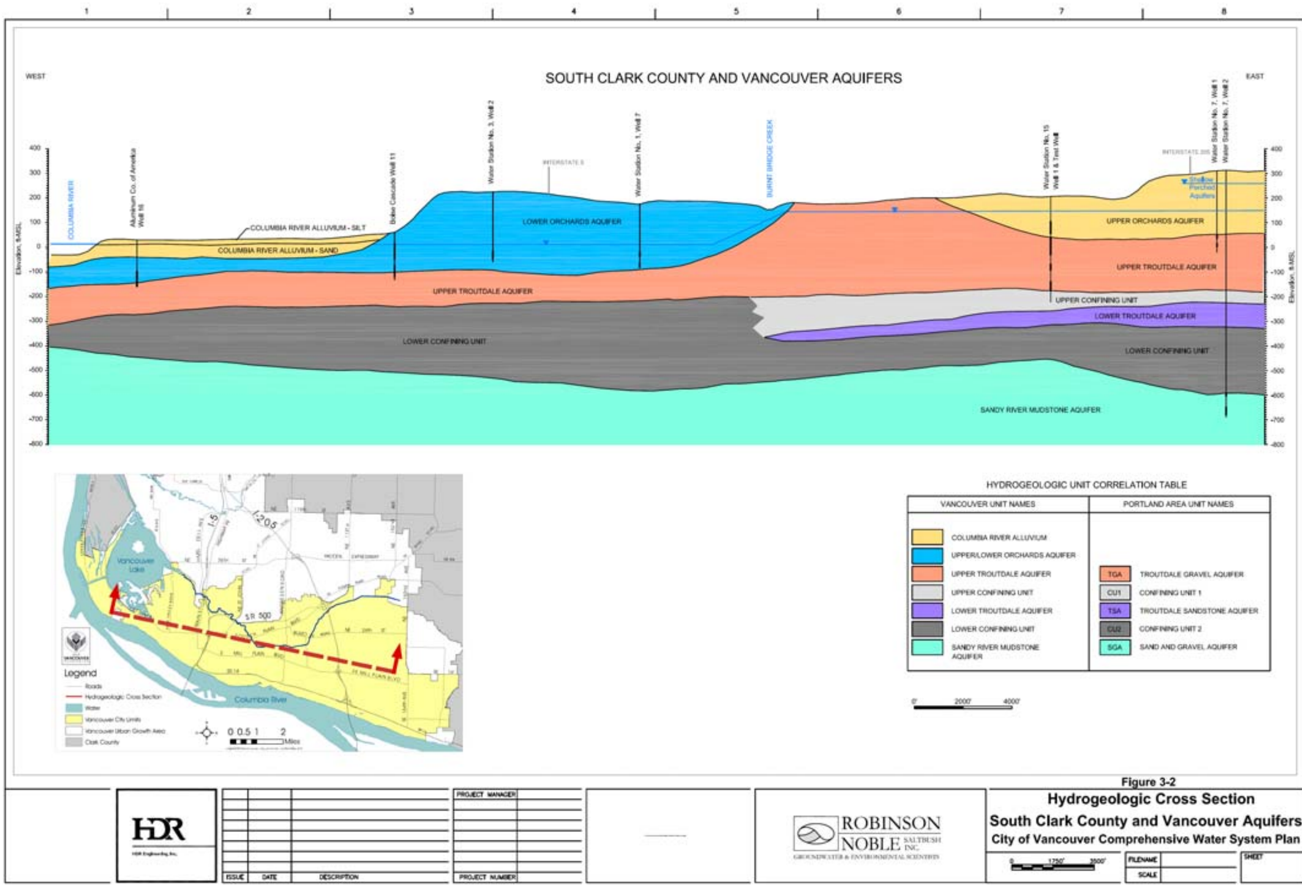

Figure 1: Vancouver area aquifer cross-section

The Troutdale/Orchards lithology throughout the Vancouver subsurface is primarily interbedded sedimentary material mixed with drainage-basin derived pebbles and cobbles. There are occurrences of clay and other flow barriers but these are scattered and difficult to map throughout the region.

Although the map in Figure 1 shows distinct separations between the differing geologic units, these layer boundaries are often blurred. The Orchards Aquifer, also called the Unconsolidated Sedimentary Aquifer, is likely an alluviated portion of the Troutdale with little or no silica cementing. Historical water monitoring by the City indicates that water moves vertically through the hydrogeologic layers making it difficult to assign a specific aquifer sequence to the produced water.

Hydrogeologist Chandler Ellis alluded to the challenge of identifying the source horizon in a 2008 email saying: *"Many wells in Clark County are "Troutdale" wells and they are truly completed in a cemented sand and gravel that is typical of the Troutdale geologic formation, BUT most of the water from the well comes from the Orchards aquifer above it."*

Aquifer Susceptibility

Two aquifer susceptibility parameters have been selected for this study as strong indicators of susceptibility of Vancouver's urban aquifer system to contaminants. These parameters are 1) the time groundwater takes to reach the City's pumping wells, known as "time-of-travel" or TOT and 2) the depth from surface to the drinking water aquifer.

Time of Travel Modeling: In the early 1990s a groundwater flow and particle tracking model developed for the Portland Basin was used by the U.S. Geological Survey to simulate groundwater movement in Clark County aquifers (Morgan and McFarland, 1994). Based on the analytical model, time of travel maps (also known as "zones of contribution" maps) were developed for Vancouver and Clark County water stations. The 1, 5 and 10 year time of travel depictions in Figure 2 represent the time it takes groundwater to flow horizontally through porous aquifer media until it discharges into a public water supply wellbore.

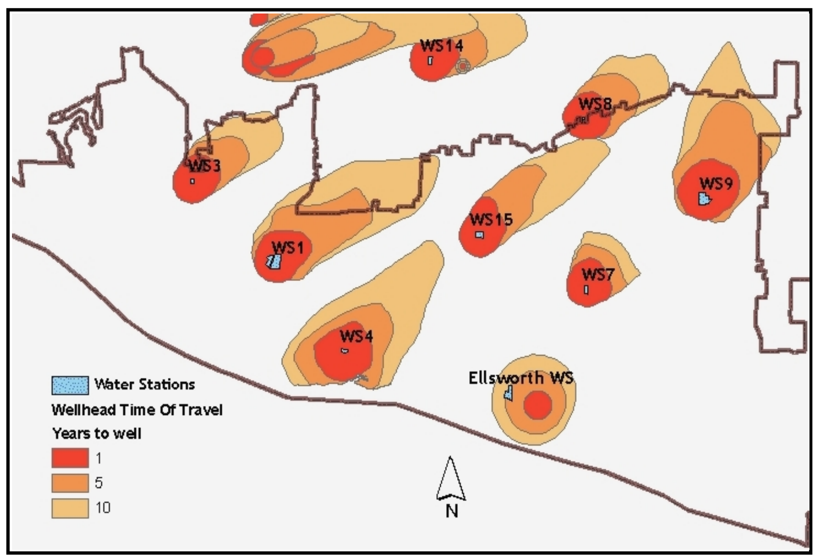

Figure 2: Groundwater travel time vulnerability map

Although flow and tracking models such as these can provide high quality simulations of complex groundwater dynamics, this analysis of Vancouver's urban aquifer system has some limitations. In the Portland Basin model each cell was 3000 feet by 3000 feet, or about 200 acres per cell. Flow delineations near wellheads are, therefore, broad approximations. Analytical results out beyond the 1 and 5 year times of travel tend to be better indicators of flow direction and extent.

Another limitation with the analytical model is that each layer of cells generally represents the entire thickness of an aquifer which can be from 30 feet to several hundred feet. Also, all aquifer properties and pumping rates are assumed to be equal for the cell area. These assumptions again indicate that this regional type of analysis is more reliable at greater distances from the water stations. The model was calibrated at steady-state conditions for 1988 well pumping and recharge rates. Historical data indicates that these rates haven't changed significantly since then.

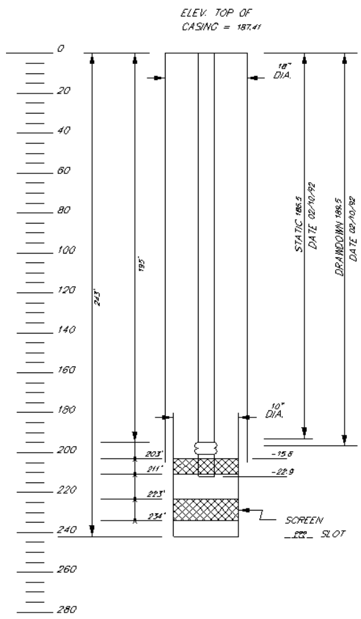

Figure 3: *Example wellbore diagram*

Water level measurements evaluated in the lower Troutdale aquifer found that groundwater flows vertically from shallow to deeper in all areas of Vancouver except in some limited discharge areas near the Columbia River where there are upward flows.

Depth to Drinking Water Aquifer: There are many depth measurements used in aquifer analyses. One, termed "seasonal depth to high groundwater", takes into account the depth the water table rises due to seasonal storms. Another, called "depth to groundwater" may describe shallow and perched water tables influenced by surface water levels of nearby water bodies. In Vancouver these include the Columbia River and Burnt Bridge Creek. The City also tracks "static" fluid levels in water wells which indicate how high a column of water will naturally rise in a wellbore due to hydraulic pressure in the aquifer before it is drawn down from pumping.

In this aquifer vulnerability study we chose to map the depth where water is actually drawn from the aquifer into the pipe. Any contaminant descending from the surface would have to reach this depth to enter the municipal water source. This depth is lower than the static level and is recorded in well data as the "top of screen", which indicates where the pipe is actually screened for inflow. At a depth corresponding with the screened opening in the pipe, a contaminant can enter the city's water system even if it does not disperse throughout deeper regions of the aquifer. The following table lists details on aquifers accessed for municipal water in Vancouver:

Table 1 – Vancouver Aquifers

Vancouver Water Station	Producing Aquifer	Aquifer Inflow (highest screen top, feet below surface)	Surface Water Features Nearby	Direction of G/W Flow
WS 1	Lower Orchards	191	Burnt Bridge Cr.	NE to SW
WS 3	Lower Orchards	231	Burnt Bridge Cr. Vancouver Lake	NE to SW
WS 4	Lower Orchards	85	Columbia River	NE to SW
WS 7	Upper Troutdale Sand and Gravel	268 859		NE to SW
WS 8	Upper Orchards	131	Burnt Bridge Cr.	NE to SW
WS 9	Upper Orchards	130		N to S
WS 14	Upper Orchards	147		NE to SW
WS 15	Upper Orchards	68	Burnt Bridge Cr.	NE to SW
Ellsworth WS	Sand and Gravel	799	Columbia River	Radial
CPU – South Lake		411	Vancouver Lake	NE to SW

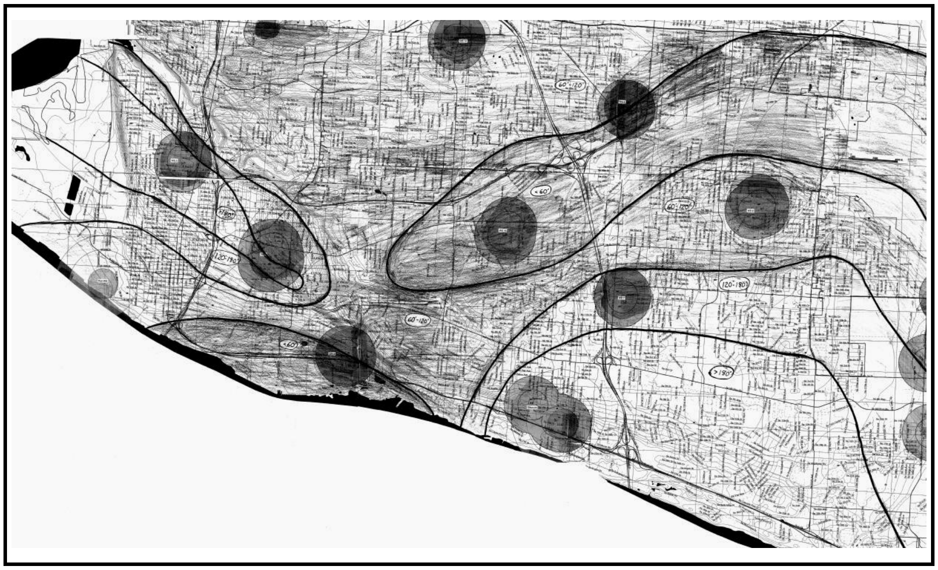

Figure 4: Initial hand-drawn depth map based on static water levels

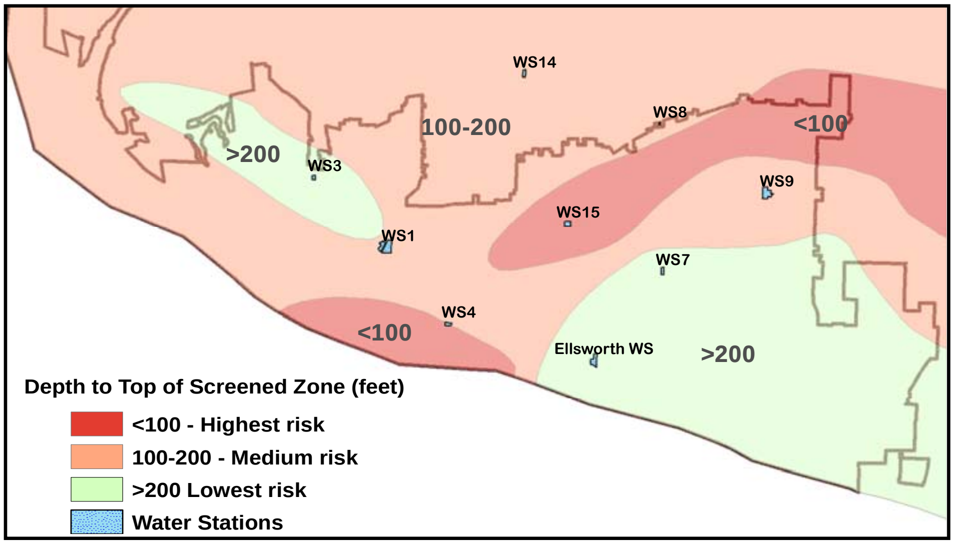

Figure 5: Depth to groundwater vulnerability map based on top of screen

Developing the Depth Map: To develop the depth-to-aquifer map, contours were initially hand-drawn on a large city map using static water level data, time of travel delineations, and topographical information (Figure 4). The map was then scanned as a TIFF image and depth range boundaries were traced into a polygon layer for editing and display in ArcMap. This map was later redrawn to reflect depth to top of well screen instead of static fluid level. Figure 5 depicts depth ranges of less than 100 ft., 100-200 ft., and greater than 200 ft. representing high, medium, and low relative risks, respectively.

Recently developed CPU Water Station: In 2010 Clark Public Utilities drilled water wells and constructed a water station southeast of Vancouver Lake (near Fruit Valley Road). They produce approximately 2600 gpm from the Sand and Gravel Aquifer at a screened depth of approximately 420 feet below ground. The City's Ellsworth Water Station wells, producing from the same aquifer at higher rates, have relatively small time-of-travel patterns (Figure 2). The CPU time-of-travel zones have not been included in vulnerability calculations because their depths and rates do not present a significant susceptibility risk compared to City wells producing higher volumes from shallower aquifers.

Infiltration Risks
In addition to the aquifer susceptibility factors described previously, infiltration risks were also identified and mapped to provide a better composite determination of aquifer vulnerability. Potentially threatening infiltration sources in Vancouver include drywells, septic tanks, underground storage tanks, older sanitary pipe installations and perforated drainage pipe.

The highest infiltration risks identified are those that result in discharges below soil. A contaminant spilled onto surface soil does not usually present the same risk to groundwater as an accidental or intentional discharge to a below-ground facility. Soils slow or even stop infiltration and soil organic matter often effectively filters out contaminants. Also, in most cases a significant surface spill will be noticed by someone and a timely cleanup will follow. Aquifer contamination risks are, therefore, substantially higher for discharges happening below the soil, and soil types were not considered in this vulnerability assessment.

Drywells are installed frequently in Vancouver to handle stormwater discharge. Due to high infiltration rates, the city has more drywells and other infiltration devices than any other municipality in western Washington, handling approximately 60% of the city's stormwater. Drywells can serve as fast pathways for contaminants in storm runoff, such as metals, petroleum products, pesticides, and animal wastes, which can be discharged below the soil into permeable zones above aquifers. The prevalence of below-soil stormwater infiltration facilities can, therefore, be linked to groundwater quality. An illustration of the number drywell installations in the city is shown in Figure 6 along with other infiltration devices at their points of discharge ("point sources").

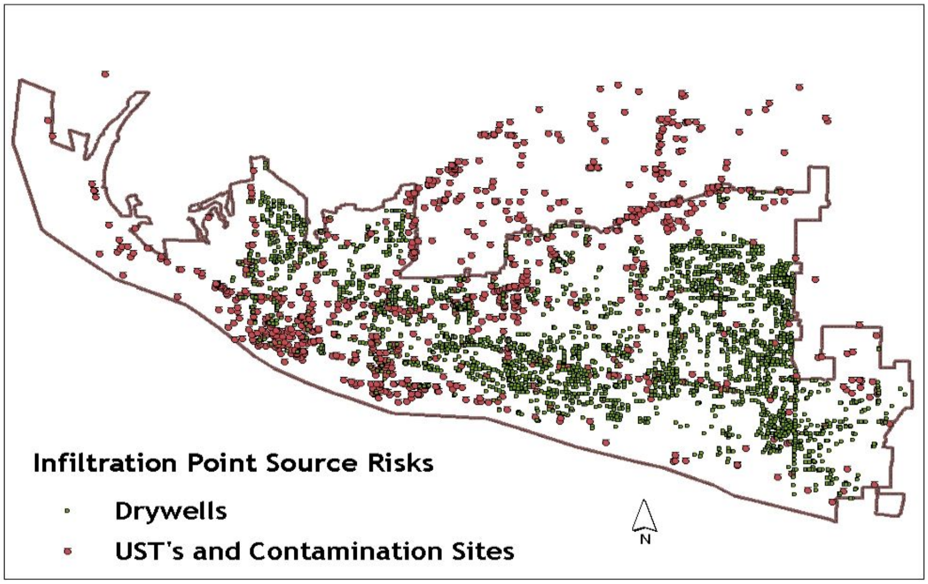

Figure 6: Drywells, underground storage tanks and contamination sites

Underground storage tanks (UST's), like septic tanks, provide a potential avenue for spills or other discharges to infiltrate below the soil and possibly reach groundwater. There are many types of UST's present in an urban environment including home heating oil tanks, fuel tanks and large below-ground industrial material storage tanks. Because they are not visible at the surface, underground tanks have elevated environmental risks. State and federal agencies now regulate UST's more closely than they did in the past. This means underground tanks have new requirements for double wall containment, leak detection, alarms, and periodic assessments.

A concern specific to leaking fuel tanks has been the gasoline additive, MTBE, which tends to migrate quickly and does not biodegrade in the ground. Also of concern are the standard gasoline components of benzene, toluene, ethylene and xylene (BTEX). Many states have implemented MTBE bans but there are still risks from past contaminated sites and in areas where its usage as a gasoline oxygenate is allowed.

Contaminated sites represent another type of risk to groundwater. Typically ground and water analyses have been performed at these sites which indicate to what extent soil and near-surface groundwater has been contaminated by past practices. Data shown above in Figure 6 comes from WA Dept. of Ecology maps which depict occurrences of known or suspected contamination sites with state-registered underground storage tanks. In the Vancouver area there are over 1200 combined UST's and suspected, confirmed and remediated (no further action) contamination sites.

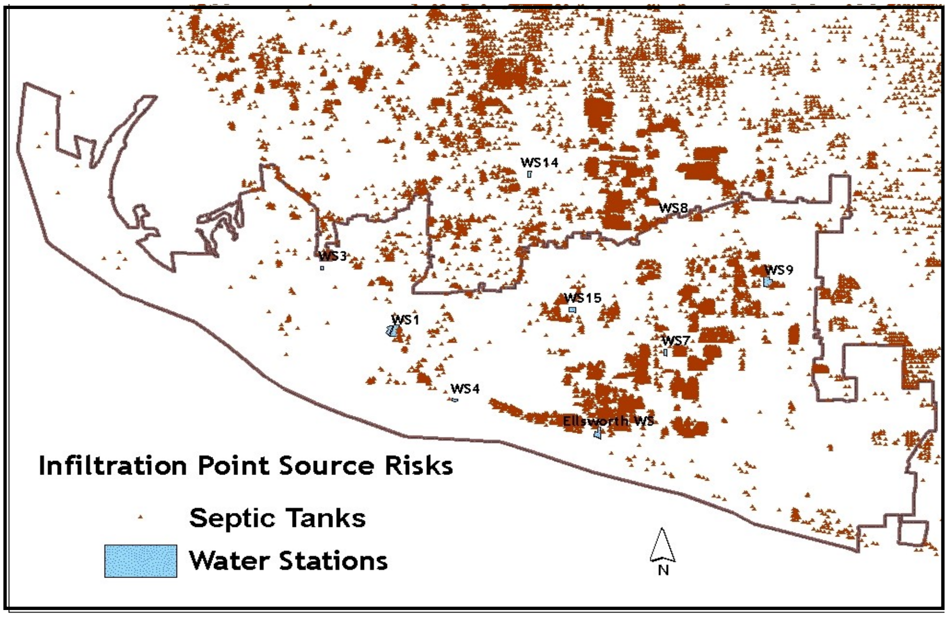

Figure 7: Septic tanks in Vancouver

Septic tanks in Vancouver are regulated and permitted by SW Washington Health District. Contaminants associated with septic effluent at commercial sites can include pathogens, toxic chemicals and nitrogen compounds. The City initiated a septic tank removal program which has effectively decommissioned over 1500 tanks and made connections to sanitary sewer. Figure 7 illustrates the locations of residential and commercial septic tanks.

Perforated storm drainage pipe can also present a risk to the aquifer. Like drywells or septic systems, perforated pipe can allow inadvertent spills and discharges to enter the ground. Unlike drywells, these are usually located near the surface which allows for some contaminant capture in the soil horizon.

Age of sanitary sewer pipe installations can also increase the risk of infiltration. In Vancouver, sanitary pipes that were installed

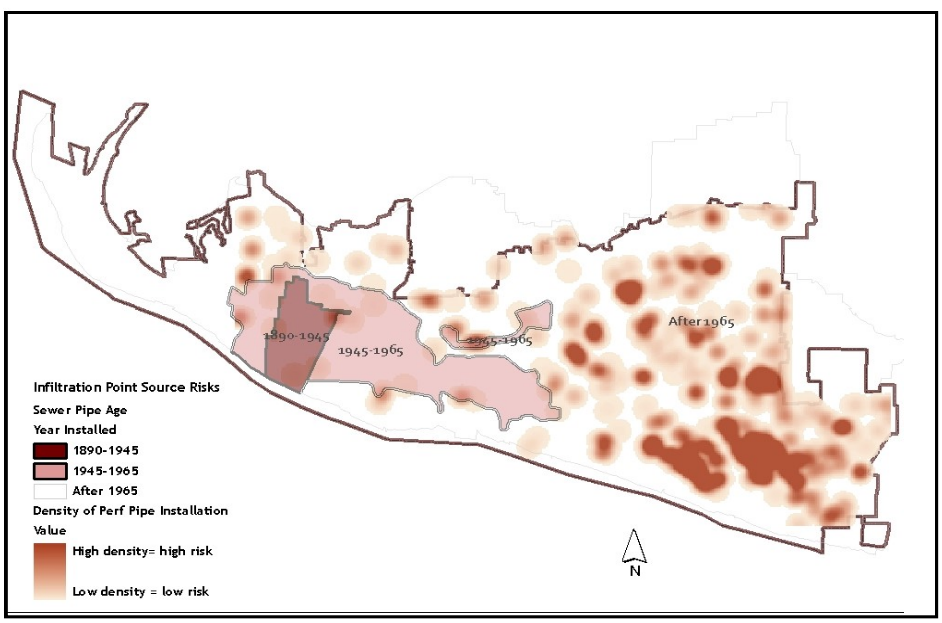

Figure 8: Sewer pipe age and concentration of perforated storm drainage pipe

in the late 1800's are considered to have greater potential for leaks than those installed after 1965 when the materials used were standardized and relatively reliable.

In Figure 8 above aquifer vulnerability is depicted based on risks associated with concentrations of perforated stormwater pipe applications throughout the city and the age periods that sanitary sewer pipes were installed.

Sites storing hazardous materials also present an increased risk of spills or leaking tanks. In 2003 the City of Vancouver's City Council enacted local ground and surface water protection regulations in the form of a Water Resources Protection Ordinance, VMC 14.26. As a part of the water protection program commercial sites are inspected and if a site stores certain defined volumes of specified hazardous materials then they are considered Class I or II sites.

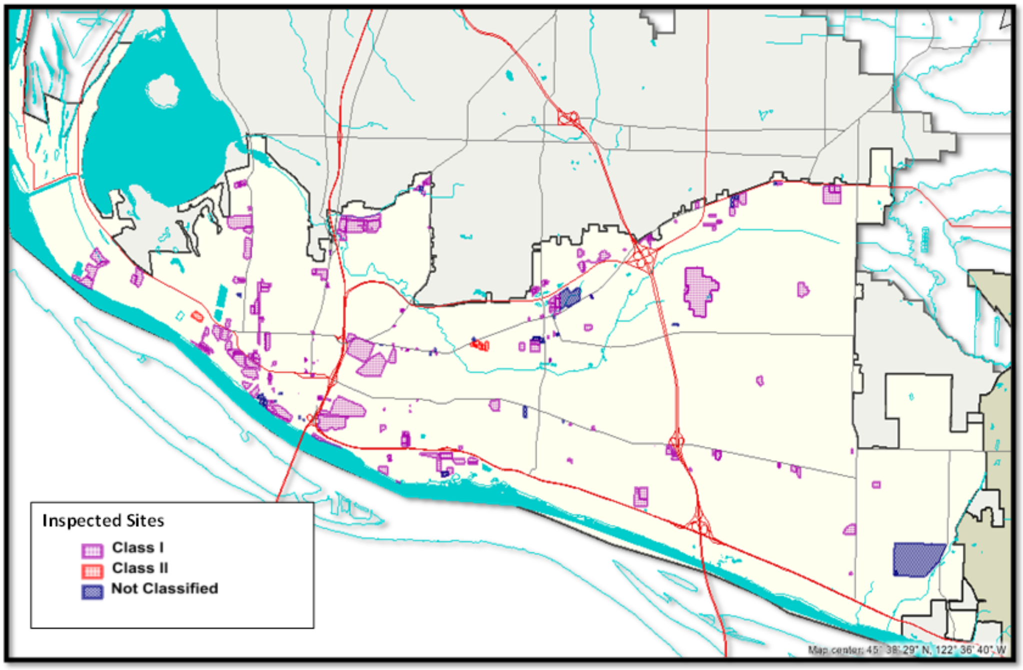

Figure 9: Facilities storing hazardous materials, classified by ordinance

Class I operations manage over 220 pounds of any mixture of hazardous materials containing constituents referenced in the U.S. Code of Federal Regulations, 40 CFR 302.4 (over 700 CERCLA designated chemicals). Class II operations are defined as those that manage over 2,200 pounds in total of the hazardous materials containing chemicals from 1) the Washington Administrative Code's Toxicity Characteristics listing of 40 metals and toxic chemicals (WAC 173-303-090), or 2) containing any of 47 designated halogenated solvents, such as TCE and PCE, which have had a history of negatively impacting groundwater. Based on these classifications, City inspection staff has identified over 200 higher risk "classified" businesses and industries located within the city limits. A map of these facilities is shown in Figure 9. Program inspectors also visit sites which store lower volumes of hazardous material. These are labeled "not classified" facilities on the map.

Vulnerability Calculations

As discussed previously, two factors are considered significant in determining source water vulnerability in the Vancouver area. These are ***aquifer susceptibility*** parameters including depth to aquifer and distance to municipal water wells, and ***infiltration risks*** such as drywells, septic tanks; and facilities that store hazardous materials. The combination of hydrogeologic susceptibility factors and pollutant risk factors form a ***composite vulnerability***.

Risk Factors and Weights

A table of the susceptibility and risk factors selected for the evaluation of aquifer vulnerability in Vancouver's urban setting is shown below:

Table 2 - Vancouver Aquifer Vulnerability Parameters		
Vulnerability Factors	**Weighting**	**Map Raster Formats**
Aquifer Susceptibility		**Susceptibility Maps**
Wellhead time of travel - (Vtrvl)	**4**	Polygons
Depth to drinking water aquifer - (Vaqdp)	**4**	Polygons
Infiltration Risk Sources		**Infiltration Risk Maps**
Class I,II Facilities – parcels (Vclss)	**4**	Parcel polygon centers converted to density
Drywells – (Vdrwl)	**4**	Points converted to density
Septic tanks – (Vsptc)	**4**	Points converted to density
Known/suspected contamination sites - (Vcont)	**3**	Points converted to density
Underground storage tanks - (Vust)	**3**	Points converted to density
Perforated storm drainage pipe - (Vperf)	**2**	Lines converted to density
Age sanitary sewer pipes installed – (Vsanp)	**2**	Polygons

The vulnerability parameters chosen had to meet three criteria: 1) they clearly represent a susceptibility or infiltration risk, 2) they have been identified through research or experience, and 3) they are measurable and therefore "mappable".

Vulnerability parameters were weighted based on the potential risk each represents to the aquifers. The following describes the reasoning behind assignments of parameter weights:

Wellhead time of travel (4): Since the main goal here is to map the risk that a contaminant could reach a municipal water well, the horizontal time of travel to a water station is considered one of the most significant risk factors.

Depth to drinking water aquifer (4): Like time of travel, the depth to which a contaminant must vertically move to reach the inflow point in a water well is one of the most important factors.

Class I, II facilities (4): Since they store and manage significant volumes of hazardous materials, Vancouver classified facilities present a fairly high risk to source waters. Many of these sites are also recognized by state and federal agencies as designated Tier II facilities and as permittees in the Industrial Pretreatment or Industrial General Stormwater programs.

Drywells (4): The presence of drywells represents a higher risk in that they provide an avenue for contaminants to enter the sand and gravel lithology below the soil surface.

Septic tanks (4): Septic tanks in commercial areas can present a high risk of flushing of contaminants below the soil's surface. Mapped septic occurrences include both commercial and residential locations.

Contaminated sites (3): Although sites with a history of contamination can present a risk to an aquifer, these sites have already been identified by the state and in most cases are in remediation, so the risks to groundwater are moderate.

Underground storage tanks (3): In the past UST's presented a greater risk but state and federal regulations now stipulate more protective design features such as double-walls and alarm systems which reduce the risks of leaks and groundwater contamination.

Perforated storm drainage pipe (2): These types of pipes present a lower risk in that they are usually placed fairly shallow allowing for some contaminant capture in the soil horizon.

Age of sanitary sewer pipe (2): A fairly minor risk for leaks to groundwater but still a concern because some sanitary pipes in Vancouver have been in the ground since the late 1800's.

Creating Vulnerability Maps in ArcGIS

Three specific data formats were used to develop the composite vulnerability maps. Input data were available as polygons (time of travel, depth to aquifer, and age of sanitary pipe), discrete points (classified facilities, drywells, septic tanks, contamination sites, and UST's), and lines (perforated storm pipe). These formats are listed above in Table 2. All input data were converted to raster format with gridded cells of 50 feet x 50 feet.

The point data were converted to densities to allow for raster calculations. These conversions resulted in a risk range of 1-10 with 10 representing the highest risk. The polygon map ratings, on the other hand, ranged from 1 to 3 with 3 representing the highest risk. Because polygon shapes were not converted to densities it was necessary to increase the polygon risk ranges to match the 1-10 ranges used in the other data. Depth to aquifer and age of sanitary pipe ranges were modified to three risk values of 2, 5 and 10. Time of travel polygon ranges were bumped to 4, 7, and 10 recognizing that a 10-year time of travel still represents a moderate aquifer risk.

Because the City has defined by ordinance that the entire city limits is a "critical aquifer recharge area", all of the underlying aquifer is considered vulnerable and areas outside of defined time of travel polygons (areas of "no data") were given a rating value of 2.

For illustration purposes, the processes used to achieve a final composite sum of weighted cell values for 4 of the 9 raster source data are shown in the following partial flowchart:

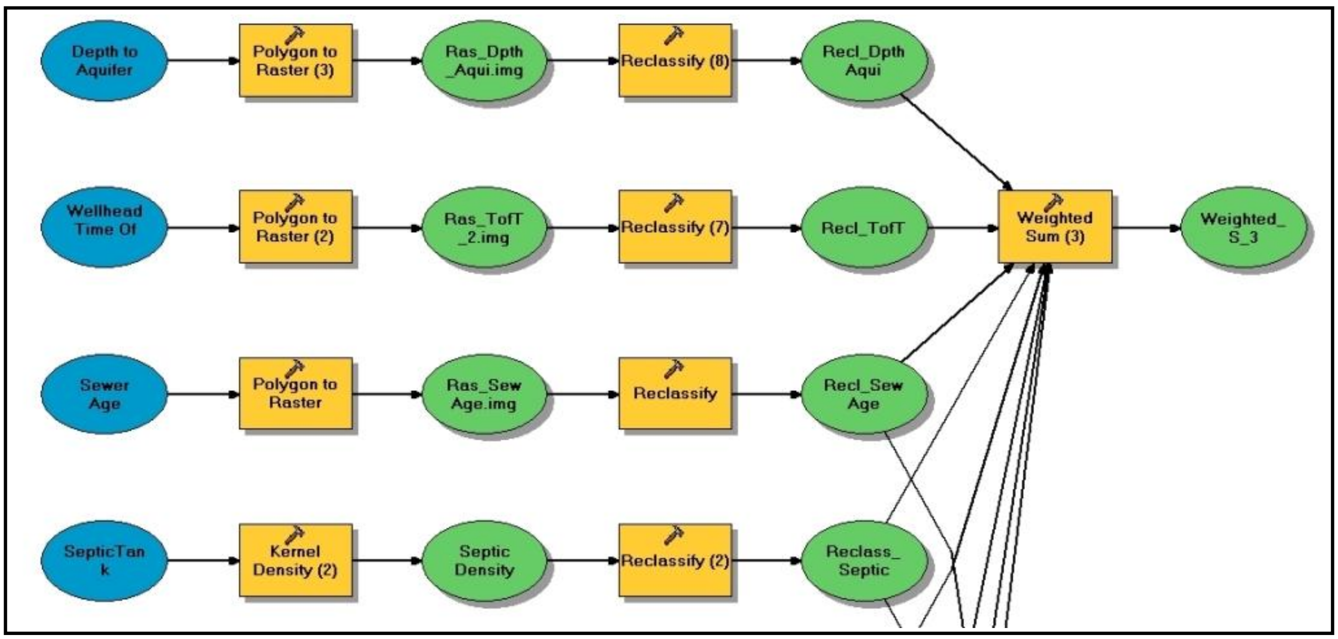

Figure 10: Segment of flowchart showing composite weighting calculation process

Creating density and normalized polygon maps made it possible to use the ArcMap© raster calculator to perform a weighted sum on layers with different map formats. A sum of combined weighted infiltration risks was developed based on the following calculation:

$$V_{INFL} = Vclss(Wclss) + Vdrwl(Wdrwl) + Vsptc(Wsptc) + Vcont(Wcont) + Vust(Wust) + Vperf(Wperf) + Vsanp(Wsanp)$$

Final composite vulnerability was calculated using the total weighted infiltration factors combined with a sum of weighted susceptibility factors consisting of depth to aquifer plus time of travel:

$$V_{SUSC} = Vaqdp(Waqdp) + Vtot(Wtot)$$

Composite Aquifer Vulnerability = $V_{INFL} + V_{SUSC}$

Objectives of the Aquifer Vulnerability Study

The main objective of this project was to determine areas in Vancouver where the aquifer is most susceptible to contamination due to physical aquifer properties, such as depth of and distance to water wells, and risk factors related to below-soil infiltration of contaminants. An urban aquifer system is at an increased risk for contamination because there are greater numbers of commercial and industrial operations located in a more populated area. The vulnerability factors that present the most significant aquifer threats in Vancouver were individually mapped, risk-rated, and then used to calculate and map the composite vulnerability.

The final vulnerability map allows the City's Water Protection program to target inspections, focus outreach campaigns, and provide guidance on where to apply more concentrated technical oversight in the field to maximize the effectiveness of limited staffing and budget. The susceptibility maps are also useful when evaluating a proposal for development. New facilities that are to be developed in the highest risk areas of the city will need to incorporate appropriate protective measures and be designed to minimize the risk of groundwater contamination.

The map in Figure 11 depicts the final composite risk tally representing weighted sums of the selected urban aquifer vulnerability parameters. This map can be overlain with useful layers showing city streets, tax lots, storm and sanitary lines, and aerial photos to provide a valuable overview of areas in the city in which to focus staff time for monitoring and inspections.

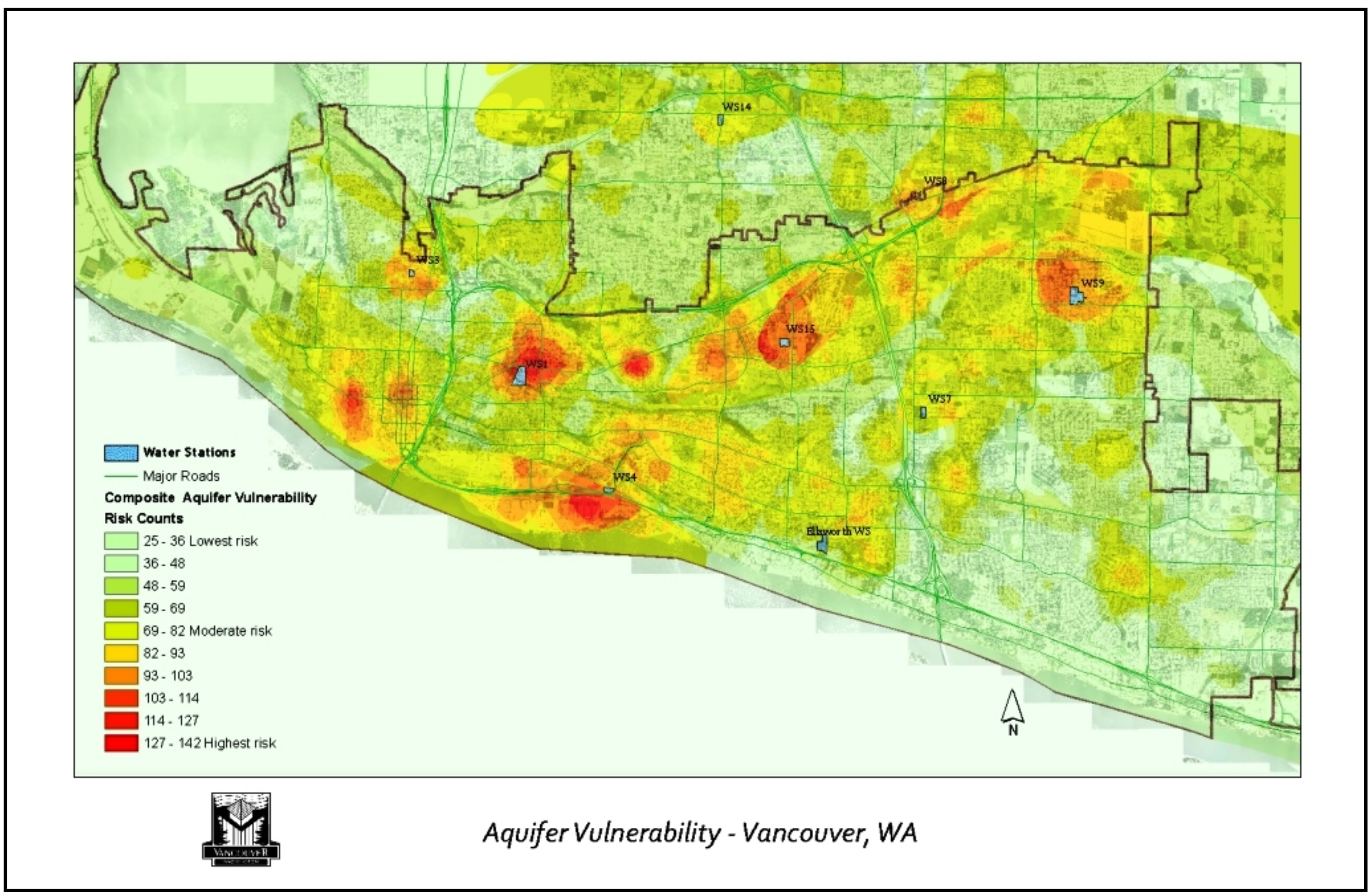

Figure 11: Composite aquifer vulnerability map

Conclusion

Aquifer vulnerabilities for an urban drinking water source have been assessed and mapped using local ***aquifer susceptibility attributes*** which include depth to drinking water aquifer and time-of-travel to municipal water wells, and ***infiltration risk sources*** which include industrial and commercial sites managing hazardous materials, known or suspected contamination sites, drywells, septic tanks, underground storage tanks, perforated drain pipes and aging sanitary pipes.

Vulnerability factors were mapped, weighted, and combined to form a composite vulnerability map. The resulting composite map has become a valuable tool for identifying areas that should be closely monitored by the City's Water Protection program in order to verify that the facilities in those areas implement practices that are protective of water quality and the environment.

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SUMMARY

ORDINANCE NO. __________

AN ORDINANCE declaring an emergency and adopting a six-month temporary moratorium prohibiting the establishment of new, or expansion of existing, large-scale fossil fuel facilities; directing staff to formulate recommendations addressing the circumstances necessitating the moratorium; and establishing an immediate effective date.

The full text of this ordinance will be mailed upon request. Contact Raelyn McJilton, Records Officer at (360) 487-8711, or via www.cityofvancouver.us (Go to City Government and Public Records).