# WASTEWATER SYSTEM ANALYSIS

C16-110-S

Final Report

December 20, 2019

Seattle Public Utilities

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# Abbreviations

| Term | Definition |
|---|---|
| AACE | American Academy of Cost Engineers |
| CBO | Community-based organization |
| CIP | Capital Improvement Program |
| City | City of Seattle (organization) |
| city | city of Seattle (place) |
| CMOM | Capacity Management Operations and Maintenance |
| CSO | combined sewer overflow |
| Diff. | difference |
| DSA | Drainage System Analysis |
| DWF | dry weather flow |
| DWW | Drainage and Wastewater |
| EJSE | Environmental Justice and Service Equity Division |
| EPA | U.S. Environmental Protection Agency |
| ft | feet |
| GIS | geographic information system |
| gpad | gallons per acre per day |
| GW | groundwater |
| H&H | hydrologic and hydraulic |
| HGL | hydraulic grade line |
| hr | hour |
| I/I | infiltration and inflow |
| IDF | intensity-duration-frequency |
| IE | invert elevation |
| in | inch |
| ISP | Integrated System Plan |
| IW | InfoWorks |
| KC | King County |
| LOS | level of service |
| LTCP | Long Term Control Plan |

| | |
|---|---|
| Metro | Municipality of Metropolitan Seattle |
| MG | million gallon(s) |
| MGD | million gallons per day |
| MH(s) | maintenance hole(s) |
| MHHW | mean higher high water |
| Min | minutes |
| MU | MIKE URBAN |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollutant Discharge Elimination System |
| OPCD | Office of Planning and Community Development |
| Obs. | observed |
| PDEB | Project Delivery and Engineering Branch |
| PS | pump station |
| QA/QC | quality assurance and quality control |
| RS | regulator station |
| SCADA | supervisory control and data acquisition |
| Sim. | simulated |
| SDOT | Seattle Department of Transportation |
| SPU | Seattle Public Utilities |
| SSO | sanitary sewer overflow |
| SWMM5 | Storm Water Management Model, Version 5 |
| USACE | U.S. Army Corps of Engineers |
| WW | wastewater |
| WPTP | West Point Treatment Plant |
| WSDOT | Washington State Department of Transportation |
| WWSA | Wastewater System Analysis |

# Executive Summary

Seattle Public Utilities (SPU) is currently undertaking an ambitious effort to integrate planning for its drainage and wastewater systems. The goal of this integrated planning effort is to identify the best investment strategy to achieve the greatest environmental and community benefits for Seattle at the lowest cost to our customers. The Wastewater System Analysis (WWSA) provides a technical analysis of Seattle's wastewater system to support the development of the Integrated System Plan (ISP), which will be prepared by SPU's Drainage and Wastewater (DWW) Line of Business (LOB).

The WWSA is a citywide technical analysis of wastewater system capacity that includes an accompanying community outreach effort. The technical component of the WWSA builds from previously developed hydraulic and hydrologic (H&H) models to conduct a citywide modeling analysis that identifies areas at risk from limited wastewater capacity. Lack of wastewater system capacity causes sewer overflows through maintenance holes (MHs) in the street or backups into residents' and customers' homes or businesses. The outreach effort expands SPU's understanding of wastewater capacity challenges and focuses on communities of color, who historically under report system issues. Connecting with SPU's communities provides an opportunity to learn about current capacity issues from customers and residents and provide information to the community about how to report issues.

The WWSA focuses on the following challenges:

- Public Health and Safety
- Growth
- Climate Change

## Goals and Objectives:

The goal of the WWSA is to provide the technical analysis of the wastewater system needed to develop the ISP.

The project objectives to meet the goal are as follows:

- Identify and understand wastewater system capacity needs
- Set a transparent and consistent method to prioritize wastewater system needs
- Provide analysis of the wastewater system that aligns with the Drainage System Analysis (DSA) and provides technical foundation for the ISP

In addition, SPU developed and implemented the Equity Strategy for System Analysis Projects to ensure that considerations of racial equity were embedded in the WWSA. The goals of the equity strategy are to:

- Incorporate analysis of equity impacts into the WWSA in a meaningful way
- Build shared understanding among the project team members and project leadership that considering equity early in the integrated system planning process is valuable
- Reinforce that equity is an important factor every time DWW makes a decision or selects a preferred option
- Lay groundwork for the ISP equity framework

# Wastewater Capacity Performance Goals and Thresholds

A primary objective of the WWSA is to identify and understand wastewater capacity needs. To meet this objective, SPU selected wastewater system Performance Thresholds to achieve performance goals, for private property and public rights-of-way (ROW), that are consistent with SPU risk tolerance.

## Performance Goals

Performance goals for wastewater system capacity were developed based on previous work. For the WWSA, the wastewater system performance goals are:

- Provide adequate capacity in the public wastewater system to minimize the risk of sewer backups into private property
- Provide adequate capacity in the public wastewater system to minimize the risk of sewer backups into the public ROW

## Performance Thresholds

For the WWSA, a Performance Threshold defines adequate capacity; it was used for the citywide modeling analyses to identify areas at risk from limited capacity. Performance Thresholds are made up of two components: a performance parameter and a design storm.

***Performance Parameters:***

A performance parameter is a set hydraulic grade line (HGL) that defines when simulated surcharging or flooding represents a potential impact. The following three performance parameters were selected to conduct the analysis:

- Surcharged pipes: Greater than or equal to 1-foot of surcharge above the crown of the pipe
- MH flooding: Peak HGL > MH rim elevation leaving no freeboard
- Capacity limited pipes: $Q_{peak}/Q_{capacity} > 1.0$, where Q is flow. 100% of existing pipe capacity is utilized, when all restrictions are removed.

***Design Storm:***

A design storm is a specified amount of rainfall distributed over time and space. The selected performance parameters were evaluated in the following three design storms:

- 1-year, 24-hour design storm (1.4 inches of rain in 24 hours)
- 2-year, 24-hour design storm (2.0 inches of rain in 24 hours)
- 5-year, 24-hour design storm (2.7 inches of rain in 24 hours)

## Performance Threshold Selection

Prior to selecting the Performance Thresholds, a comprehensive methodology was developed to analyze and characterize the wastewater system. Citywide hydrologic and hydraulic (H&H) models were run to analyze system performance under the 1-, 2-, and 5-year, 24-hour design storms. A summary of the citywide analysis is presented in Table ES-1.

| Table ES-1. Citywide Performance Threshold Results | | | | | | |
|---|---|---|---|---|---|---|
| **Design Storm** | **Surcharged Pipes (miles)** | **Surcharged Pipes (% of System)** | **Capacity Limited Pipes (miles)** | **Capacity Limited Pipes (% of System)** | **Flooded MHs (count)** | **Flooded MHs (% of system)** |
| 1-year, 24-hour | 86 | 6% | 57 | 4% | 179 | < 1% |
| 2-year, 24-hour | 240 | 17% | 150 | 11% | 839 | 2% |
| 5-year, 24-hour | 419 | 30% | 264 | 19% | 2,073 | 6% |

*Note: Total length of SPU wastewater system pipe analyzed is approximately 1,400 miles*

American Academy of Cost Engineers (AACE) Class 5 cost estimates were developed to compare the cost to upsize capacity limited pipes under each design storm. Total cost projections for the three design storms ranged from $0.862 billion for the 1-year design storm with -30% uncertainty to $8.685 billion for the 5-year design storm with +50% uncertainty. Citywide pipe upsizing costs were used to inform the selection of Performance Thresholds, along with other non-technical metrics.

To help understand how Performance Thresholds may impact the community, the WWSA project team completed a racial equity toolkit that was developed by DWW and Environmental Justice and Service Equity (EJSE) staff for this analysis. The toolkit contained questions to help the project team compare and identify possible inequitable impacts of the potential Performance Thresholds.

The 5-year, 24-hour design storm that delivers 2.7 inches of rain in 24-hours was selected for the Performance Threshold storm event. The following considerations supported selection of 5-year, 24-hour design storm:

- It is robust; it incorporates the most up to date understanding of precipitation in Seattle
- It is protective of customers. High upfront costs to address sewer capacity issues on private property, e.g. installing backflow preventors, are a considerable burden for people of color and low-income customers. More customers will benefit from the 5-year, 24-hour storm because relative to the 1- or 2-year, 24-hour storms, a larger number of capacity issues will be addressed over time by SPU programs or projects
- It is a good measure of what DWW should be planning for long-term. The ISP will identify projects and programs to address wastewater capacity issues over a 50-year period, and planning for a 1- or 2-year, 24-hour storm did not seem appropriate for the 50-year planning horizon

The performance goals and thresholds shown in Table ES-2 were approved and accepted by the Planning Management Team.

| Table ES-2. Wastewater System Performance Goals and Thresholds | |
|---|---|
| **Performance Goal** | **Performance Threshold** |
| Provide adequate capacity in the public wastewater system to minimize the risk of sewer backups into private property. | Adequate capacity is defined as surcharging less than one foot above the crown of the wastewater pipe for the storm event that delivers 2.7 inches of rain in 24 hours. |
| Provide adequate capacity in the public wastewater system to minimize the risk of sewer backups into the public ROW. | Adequate capacity is defined as no flooding at the wastewater maintenance hole rim for the storm event that delivers 2.7 inches of rain in 24 hours. |

Additionally, future conditions modeling was completed accounting for climate change impacts (changes in precipitation and sea level rise) and growth and redevelopment across the city. Results of the future conditions modeling were used as a comparison to the existing conditions modeling to forecast potential future impacts to the wastewater system.

## Community Outreach

The WWSA included community outreach to supplement the technical analysis. Feedback from residents and business owners helped SPU determine whether modeled wastewater system capacity issues such as backups on private property or sewer overflows in the ROW have occurred. Data gathered through community outreach was incorporated into risk area prioritization.

### Outreach Goals

Outreach goals for the WWSA were:

- Use strategic citywide outreach and targeted priority area outreach to confirm WWSA findings and to identify potential new wastewater capacity risk areas
- Educate SPU system users about Seattle's wastewater and drainage systems and issues, customer service and response tools, and the Integrated System Planning effort
- Use various outreach strategies to engage communities of color to ensure their needs are represented in outreach findings

### Outreach Strategy

SPU determined that a qualitative survey sent to parcel owners and occupants would best meet the outreach goal to confirm WWSA model results. Three primary groups were targeted for outreach:

1. SPU customers who live in specific areas
2. Communities of color though partnership with SPU's Community Connection program
3. SPU customers citywide to identify potential gaps in results from the targeted outreach

SPU prioritized potential outreach areas. The prioritization process yielded 13 final priority areas for targeted mailings and door-to-door outreach. An additional 30 priority areas received targeted mailings only.

SPU tailored outreach tactics based on the specific character and needs of each neighborhood. These tactics included post card mailings (and targeted follow-up mailings), door-to-door canvassing, targeted social media advertising, outreach to business and industrial groups, and coordination with community-based organizations. Priority outreach areas and strategies are shown in Figure ES-1.

SPU worked to engage communities of color by partnering with community-based organizations that are contracted through its Community Connections program consisting of Chinese Information Service Center (CISC), Horn of Africa Services (HOAS), and ECOSS.

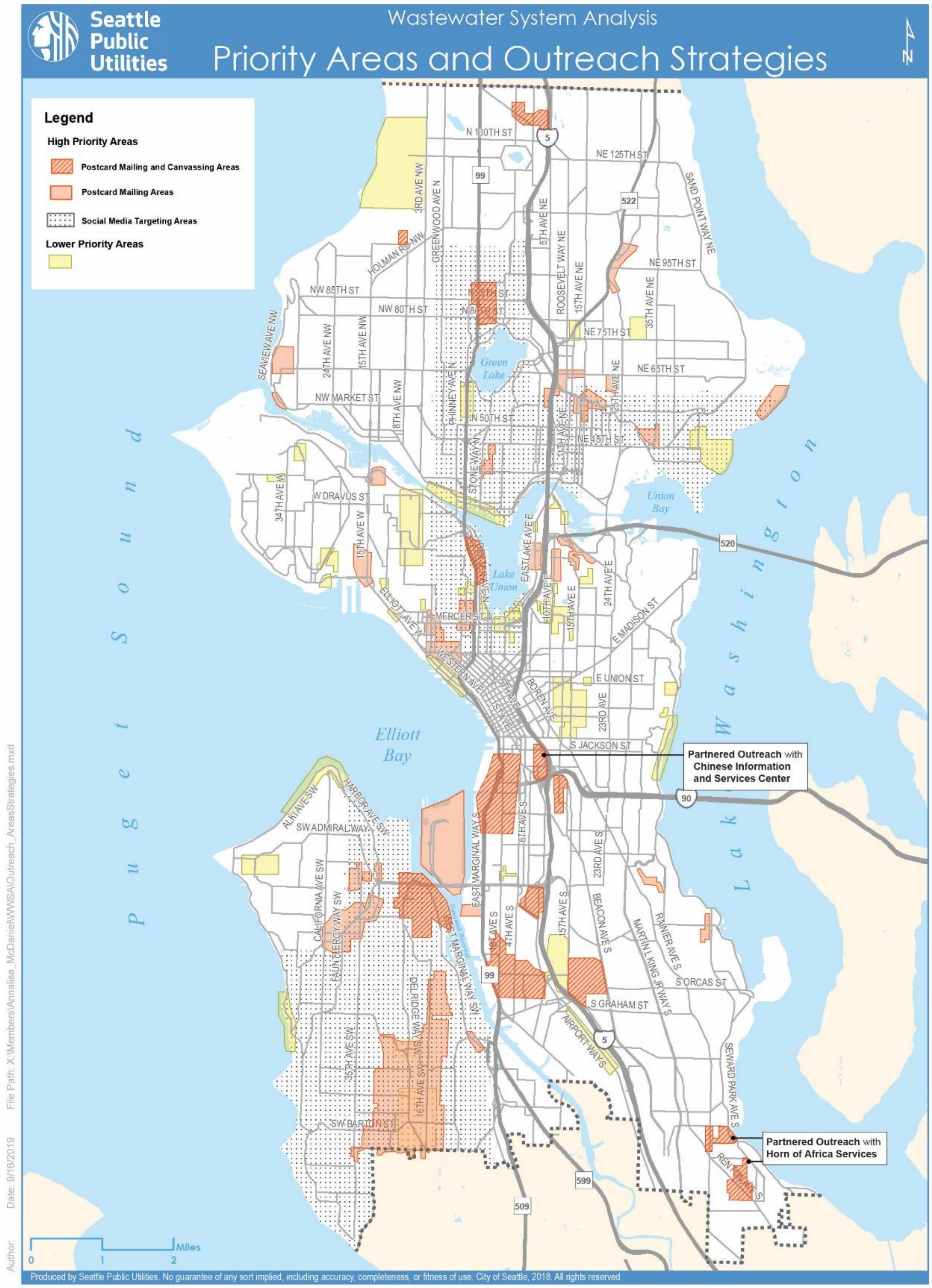


**Figure ES-1. Priority Areas and Outreach Strategies**

## Outreach Results

WWSA outreach efforts included over 19,000 mailers with links to surveys distributed to 43 outreach priority areas. Additionally, over 2,400 homes and businesses in 13 priority areas were visited by door-to-door outreach teams as a follow up to the mailer. The density of survey responses throughout the City is shown in Figure ES-2. SPU received 468 completed surveys from outreach in priority areas. Ninety-two reports of sewer overflows received through survey responses were reviewed by SPU and incorporated into risk area prioritization.

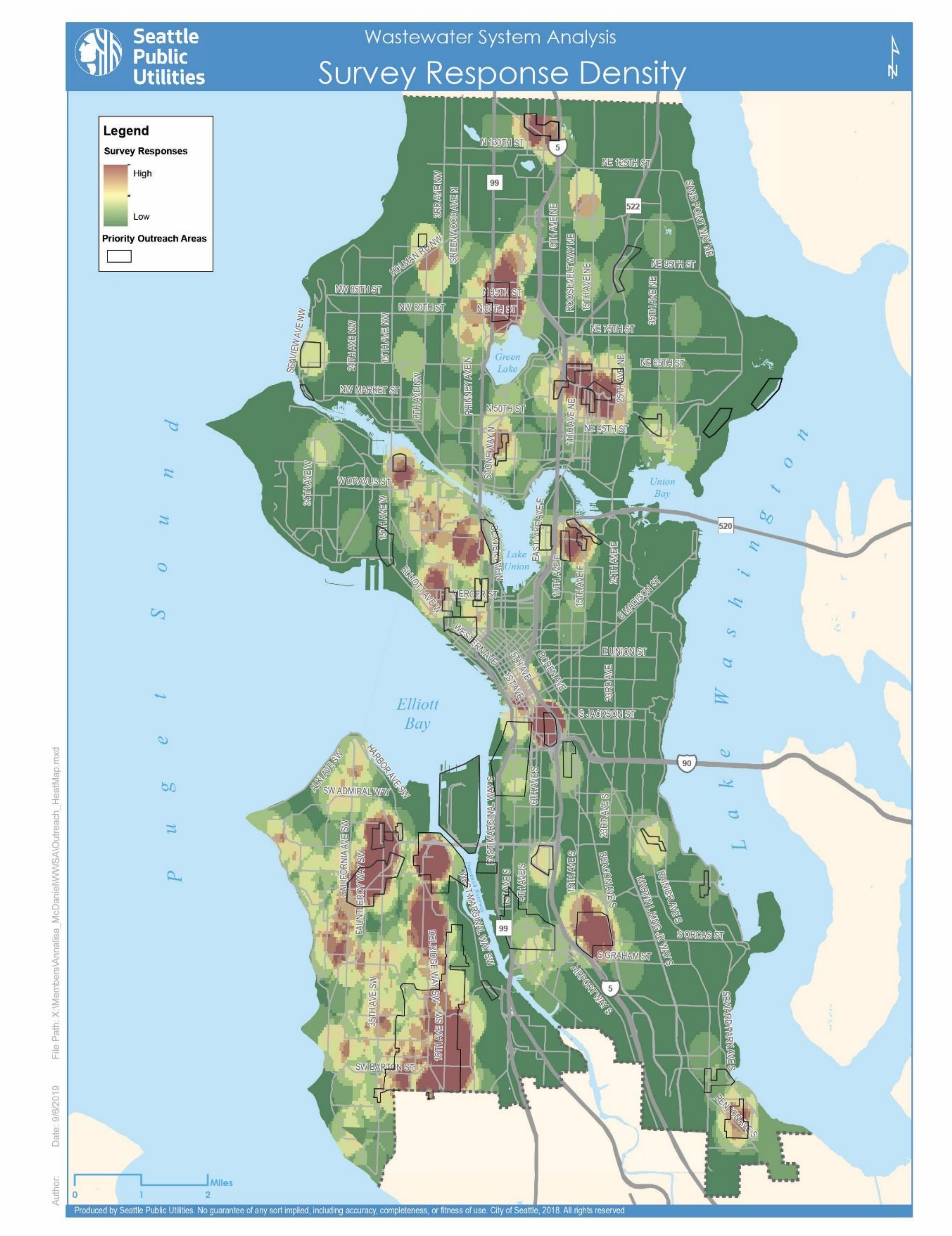


**Figure ES-2. Survey Response Density**

# Risk Area Identification and Prioritization

Risk areas were delineated and prioritized to understand areas in the city at risk of not meeting the WWSA Performance Thresholds. The following steps were completed to identify and understand the areas at risk of not meeting the WWSA Performance Thresholds:

- Delineate risk areas
- Develop risk-based prioritization criteria
- Develop a prioritization tool
- Use the tool to score and prioritize risk areas

## Risk Areas

A risk area is an area, including parcels and ROW, served by hydraulically connected wastewater pipes that exceed Performance Thresholds. Three hundred eighty-four risk areas were delineated, and risk-based criteria were used to prioritize the risk areas.

## Risk-Based Prioritization Criteria

SPU developed risk-based criteria to prioritize the wastewater capacity risk areas.

Risk was assessed based on the consequence of a sewer overflow or backup and simulated likelihood of that backup or overflow, with consideration that vulnerable communities are disproportionately impacted by sewer overflows. To calculate risk, the consequence score is multiplied by the likelihood score, which each have a maximum value of five points. An equity score of up to five points is added to the product of consequence and likelihood for a final maximum risk score of 30 points.

The equation to calculate the risk score is shown in Figure ES-3. The higher the risk score, the higher the risk associated with a potential sewer backup or overflow.

$$\underset{2-30}{\text{Risk}} = \left( \underset{1-5}{\text{Consequence}} \times \underset{1-5}{\text{Likelihood}} \right) + \underset{1-5}{\text{Equity Score}}$$

*Points Possible*

**Figure ES-3. Risk Score Equation**

## Consequence Criteria

Consequence, also referred to as impact, is the potential consequence of the wastewater system being under capacity. The consequence score is the sum of the following five criteria:

- Existing conditions model results
- Future conditions model results
- Confidence in model results
- Presence of critical facilities
- Presence of high use areas

## Likelihood Criteria

Likelihood is the second component of the risk score. A likelihood score is determined by storm recurrence, which is based on the probability that a storm will be equaled or exceeded in a given year. Likelihood categories included:

- Annual or more frequent storm recurrence (simulated flooding in 1-year, 24-hour design storm)
- Storm recurrence between 1 and 2 years (simulated flooding in 2-year, 24-hour design storm)
- Storm recurrence between 2 and 5 years (simulated flooding in 5-year, 24-hour design storm)
- Storm recurrence between 5 and 10 years (not simulated for the WWSA)
- Storm recurrence of more than 10 years (not simulated for the WWSA)

## Equity Criteria

The equity score is used to acknowledge that areas of racial and socioeconomic disparity are at a relative disadvantage to recover from a sewer overflow. This score is based on the Racial and Social Equity Index developed by the Office of Community Planning and Development (OPCD). The composite index includes measures of race, English speaking ability, national origin, socioeconomic disadvantage, and health disadvantage. The index is mapped by census tract and includes five categories that range from low to high racial and social equity disadvantage and priority.

## Risk Area Prioritization

A prioritization tool was developed using the Microsoft Excel platform to prioritize risk areas and house the inventory of wastewater capacity risk areas. The tool includes the consequence, likelihood, equity, and total risk scores for all risk areas.

The prioritization tool was used to prioritize the 384 risk areas into critical, high, medium, medium low, and low categories using the risk-based prioritization criteria. Citywide prioritization results are shown in Figures ES-4 through ES-7.

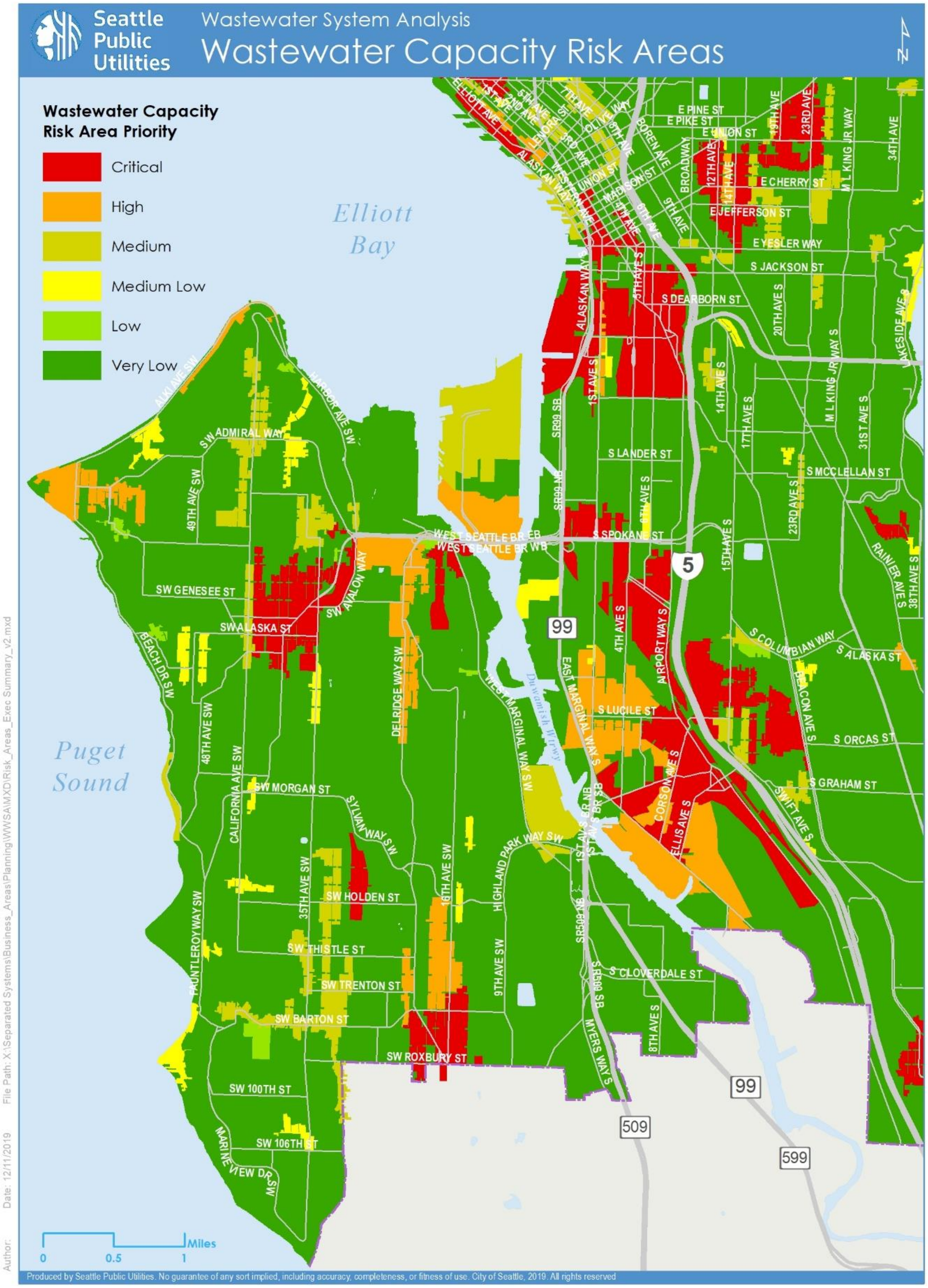


**Figure ES-4: Wastewater Capacity Risk Areas - Southwest**

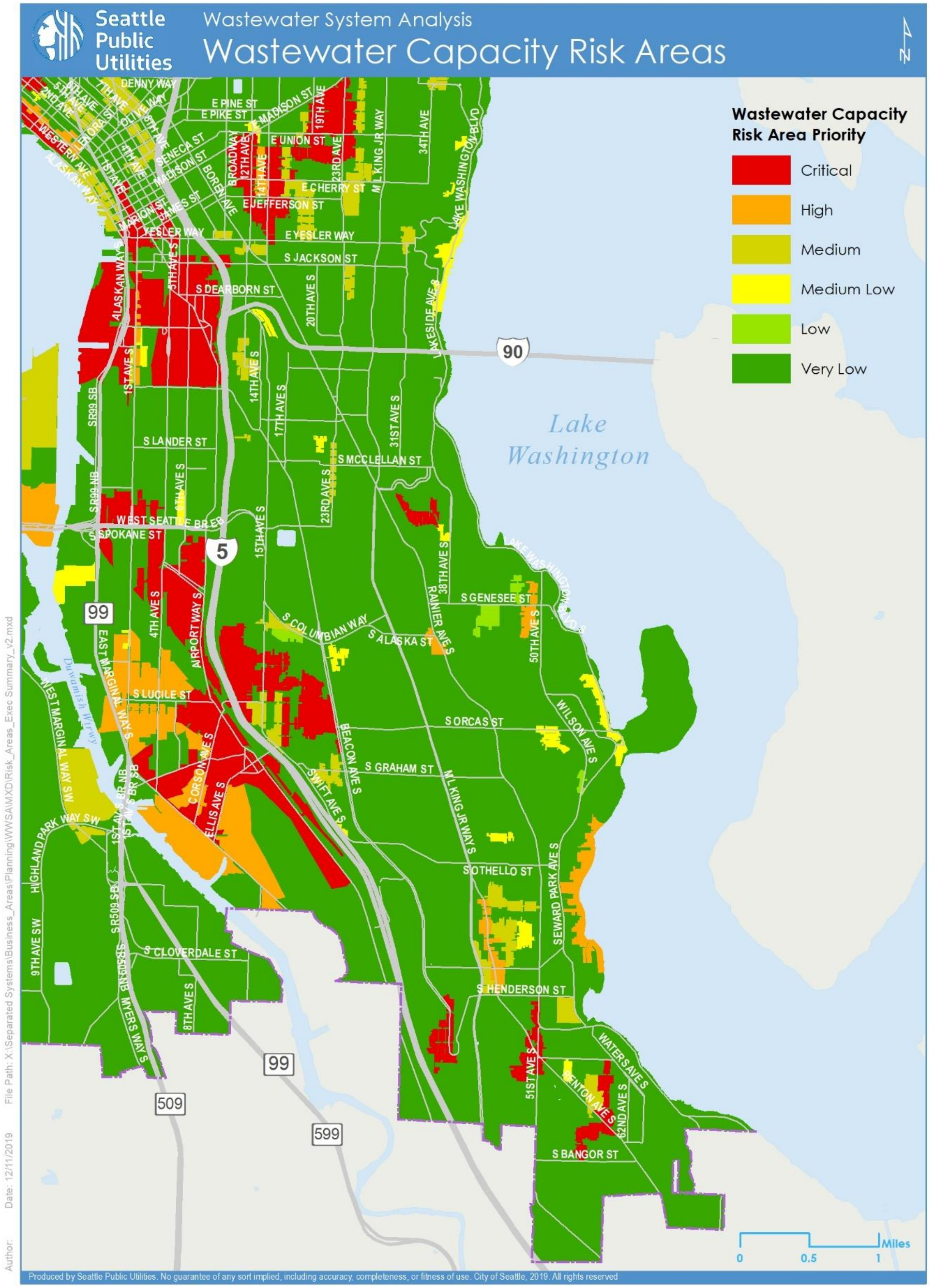


**Figure ES-5: Wastewater Capacity Risk Areas - Southeast**

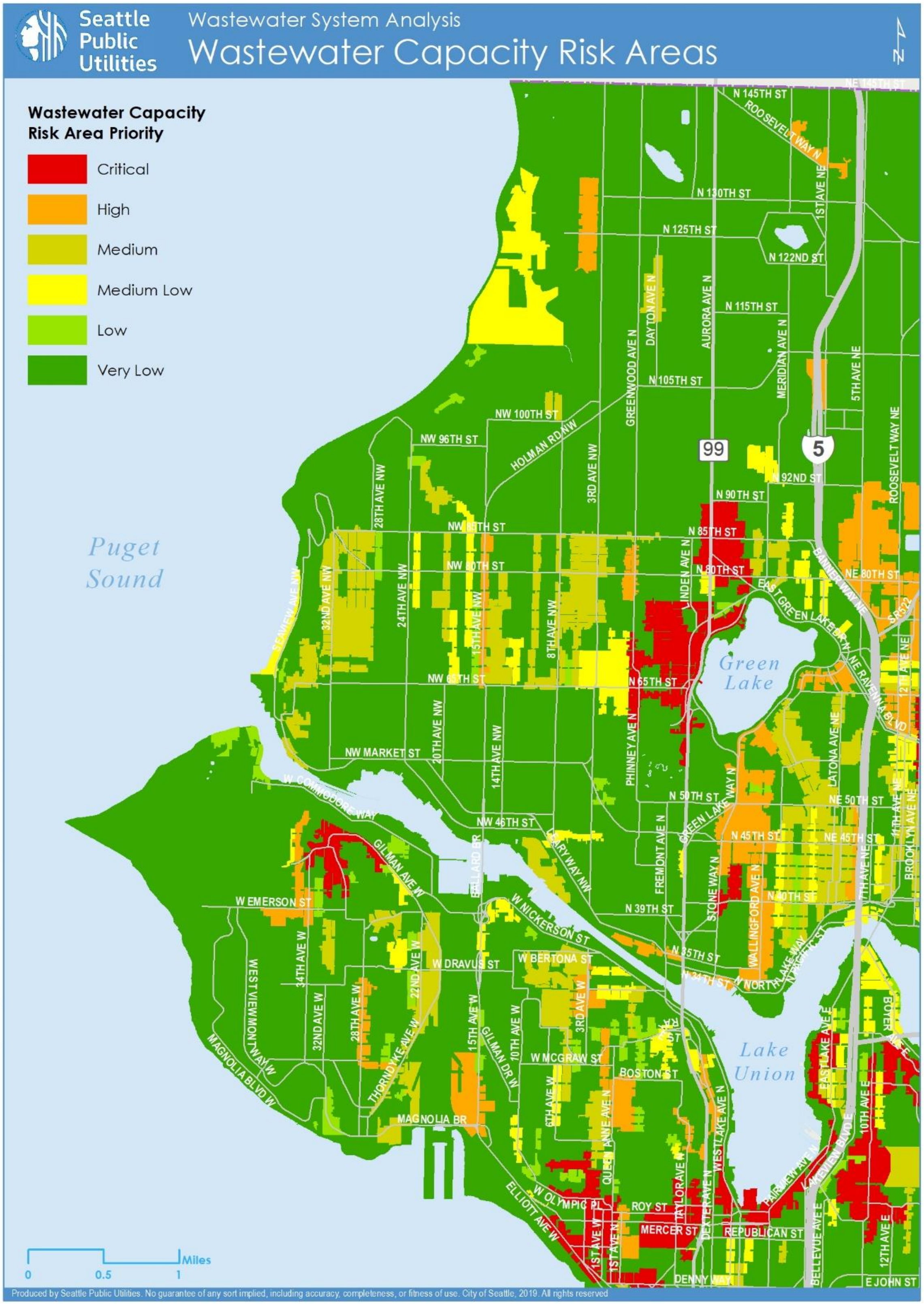


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**Figure ES-6: Wastewater Capacity Risk Areas - Northwest**

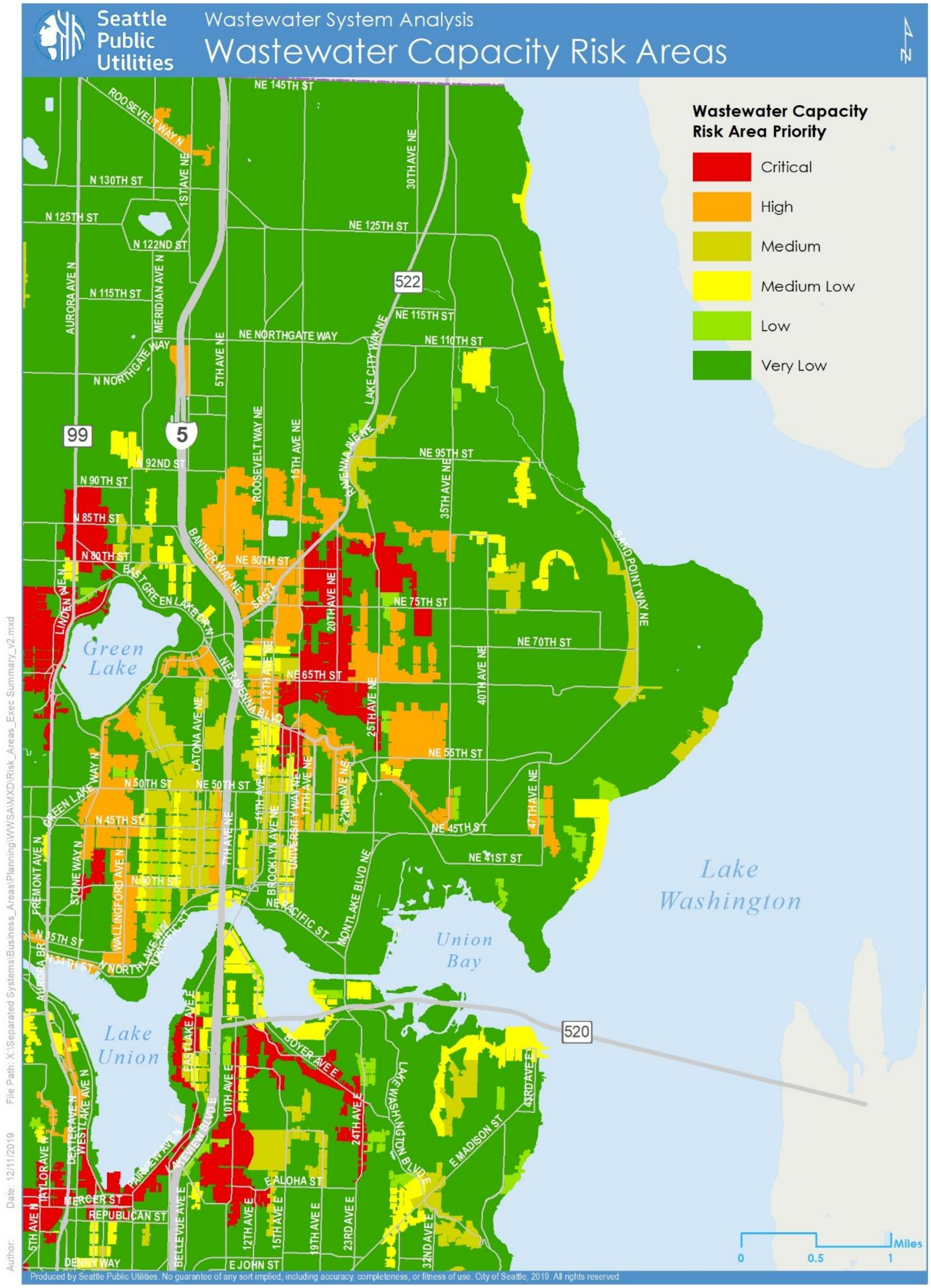


**Figure ES-7: Wastewater Capacity Risk Areas - Southeast**

In summary, 45 (12%) risk areas were categorized as critical, 51 (13%) were categorized as high, 104 (27%) were categorized as medium, 106 (28%) were categorized as medium low, and 79 (20%) were categorized as low priority. The distribution of risk area scores is shown in Figure ES-8.

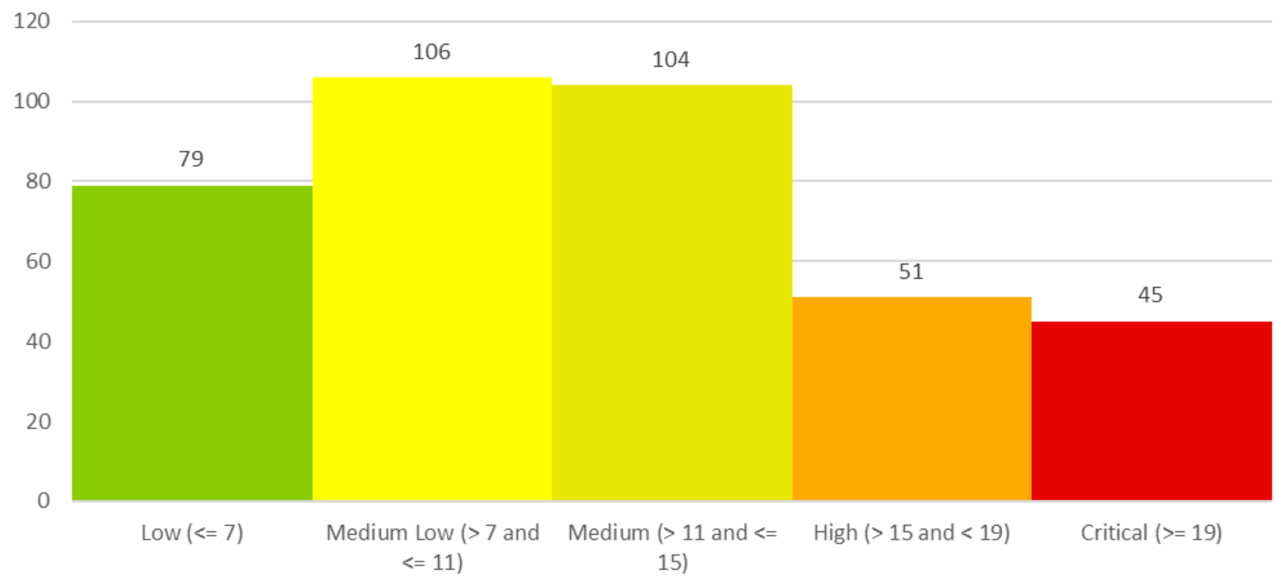


**Figure ES-8: Risk Area Priority and Numeric Score**

Suspected causes that contribute to limited wastewater capacity were identified for critical and high priority risk areas. Contributing causes include the following:

- Simulated flow exceeds pipe capacity causing surcharge or MH flooding (most cases)
- Low pipe slopes reduce capacity below simulated flow
- SPU operational controls cause upstream backups
- King County system is backing up into the SPU system
- Pump station capacity is too low to convey simulated flow, or
- Any combination of the above

# Additional Analyses

Two additional analyses were completed through the WWSA to develop informational GIS layers for use in the ISP:

- Identification of drainage connections to the combined system
- Inflow and infiltration (I/I) contribution estimates in separated sewer areas

## Identification of Drainage Connections to the Combined System

Understanding the source of inflow to a wastewater capacity risk area provides valuable information for determining the appropriate method to improve the conveyance capacity. SPU mapped drainage connections to the combined system to identify stormwater inputs that contribute to limited conveyance capacity in risk areas.

### I/I Contribution Estimates

SPU's Infiltration and Inflow Mitigation in Separated Sewer Areas Policy states, if hydrologic modeling indicates I/I contributions are greater than 3,500 gallons per acre per day (gpad) for a 20-year peak event storm, an I/I reduction project is a potential solution to capacity issues (Seattle Public Utilities, 2018). Hydrologic modeling was run for the 20-year storm event to identify separated sewer areas with I/I contributions greater than the 3,500 gpad.

## Recommendations for Future Use

### How information could be used for the ISP

The WWSA provides critical data and analysis required to complete the ISP. Results of the WWSA can or will be used in the ISP to:

- Be synthesized into representative maps or graphics that demonstrate how DWW systems, social, and environmental conditions are connected or related to each other
- Populate a cross-issue inventory that will include both wastewater and drainage risk areas and issues identified in Asset Management Plans (AMPs) and the Long-Term Control Plan (LTCP), including the Integrated Plan
- Develop focus areas that include multiple issue types and opportunities
- Perform a cross-issue, risk-based prioritization of focus areas for directing solution development and evaluation
- Identify a suite of solutions to address capacity issues in wastewater risk areas

### How information could be used outside of the ISP

The results of the WWSA could be used in a number of ways. The results could be used to inform existing SPU programs including combined sewer overflow (CSO), sewer capacity, pump station rehabilitation, and Capacity, Management, Operation and Maintenance (CMOM) programs. The results could be used to support evaluation of partnership opportunity projects led by transportation agencies or private development. The results could be used to direct flow monitoring and model calibration resources to model basins within critical or high priority risk areas that are either uncalibrated or of poor calibration quality. Finally, the results could be used to provide information on wastewater system performance to other City departments to support their planning processes and outreach efforts.

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# 1. Introduction

The Wastewater System Analysis (WWSA) provides a technical analysis of Seattle's wastewater system to support the development of the future Integrated System Plan (ISP), which will be prepared by Seattle Public Utilities' (SPU) Drainage and Wastewater (DWW) Line of Business (LOB).

The WWSA focuses on the following challenges:

- Public Health and Safety: The need to supplement our complaint-based knowledge of wastewater issues related to the capacity of Seattle's wastewater system
- Growth: The need to quantitatively evaluate impacts of growth on Seattle's wastewater system
- Climate Change: The need to assess potential impacts of changing precipitation patterns on Seattle's wastewater system

This report is organized to walk the reader through the steps involved in developing the WWSA. The report is organized into six sections as follows:

1. **Introduction:** Provides a history of the wastewater system, a description of integrated system planning, and the project background, goals, and objectives
2. **Wastewater Capacity Performance Goals and Thresholds:** Summarizes the method and process to select Performance Thresholds
3. **Community Outreach:** Provides an overview of outreach goals, strategy, and results
4. **Risk Area Identification and Prioritization:** Describes process to delineate and prioritize risk areas
5. **Additional Analyses:** Describes additional analyses including drainage connections to the combined system and infiltration and inflow (I/I) contribution estimates
6. **Products and Recommendations for Future Use:** Lists products created as part of the WWSA, provides recommendations on how results can be used to support the ISP and recommendations on how results may be used for purposes beyond the ISP

## 1.1 History of Wastewater System

Seattle's wastewater system has rich a history that has been shaped by the physical landscape of the city as well as by political and cultural influences. Seattle's current wastewater system has been shaped by the following events and eras:

- 1853 - 1880: White settlement and the need to control disease caused by growth and lack of proper methods to dispose of sewage
- 1880s – 1890s: population booms associated with Northern Pacific Railway expansion and Klondike Gold Rush
- 1889: Great Fire and reconstruction
- 1900s – 1930s: substantial modification of natural topography through regrades and land reclamation efforts
- 1940s – 1960s: post WWII economic expansion and population growth

- 1960s: changing values toward environmental protection
- 1968 – 1970: voter-approved measures known as Forward Thrust
- 1972: amendments to the Federal Water Pollution Control Act (Clean Water Act)
- 1996: creation of Seattle Public Utilities

To understand Seattle's wastewater system, one must first understand the growth and development of the city.

The Puget Sound area has been home to Coast Salish tribes for over 10,000 years, and Seattle is the home of the Duwamish people. White settlers arrived in the region in 1851, and the town of Seattle was platted shortly after in 1853 (Crowley, 1998). The town developed without an adequate plan for conveying wastewater and maintaining the quality of the streams, river, lakes, and Puget Sound that form its landscape. Settlers utilized surrounding waterbodies as sources of drinking water as well as locations to dispose of raw sewage. By 1865, when the population was approximately 300, primitive open sewers discharged to Elliott Bay and Lake Union, contaminating drinking water sources.

In 1875 when Seattle's population was approximately 1,500, the first effort to plan and construct sewers began. Puget Sound, Lake Union, Lake Washington, the Duwamish River, and other waterbodies were used to receive and convey domestic and industrial wastewater away from the city. Impacts from this approach quickly caused public health problems, including outbreaks of Typhoid fever and diphtheria as soon as 1885.

Seattle's population boomed from 3,500 in 1880 to over 40,000 by 1890 as a result of the extension of the Northern Pacific Railway from Tacoma to Seattle in 1883 (City of Seattle, n.d.). Commerce and population followed the railroad. Additionally, population increased to over 80,000 by 1900 as a result of the Klondike Gold Rush in the late 1890s.

After the Great Fire of 1889, to address the urgent need to provide sewer service and improve drainage, the City commissioned plans for a comprehensive sewer system. In 1890, based on recommendations from the report, the City began constructing combined sewers to convey wastewater and stormwater in the same pipe (Brown and Caldwell, 1958). Combined sewers were installed despite anticipated limitations, such as overflows during storm events and water quality impacts to waterbodies from those overflows (Brown and Caldwell, 1958). Cost and the need for formal stormwater conveyance were primary drivers for installing combined wastewater and sewer pipes. By the turn of the century over 30 miles of combined pipe had been constructed within the original city limits, much of which is still in use today. The merits of combined sewers have been questioned since the first pipes were installed.

Many of the City's current challenges with wastewater capacity can be traced back to the legacy of rapid growth and reliance on combined sewers to convey wastewater and stormwater. As early as 1910, trunk sewers did not have adequate capacity to convey wastewater flow due to growth and connections from smaller tributary areas (Brown and Caldwell, 1958). In 1928 the City Engineer recommended constructing separate stormwater sewers. A 1948 report to City Council recommended discontinuing construction of combined sewers completely, predicting financial problems if construction continued.

In the 1950s, the City and voters took action to address deteriorating water quality and lack of adequate wastewater infrastructure. Seattle City Ordinance No. 84390 established the City's Sewer Utility in 1955. The Sewer Utility was tasked with financing, maintaining, and operating the existing sewerage system and improvements. A $1 per month sewer service charge for single-family homes was established and approved by voters in 1956 (City of Seattle, n.d.). The City completed construction of its first modern primary sewage treatment plant, the Alki Wastewater Treatment Plant, in 1957.

In 1954, the unincorporated area of King County between North 85$^{th}$ Street and North 145$^{th}$ Street became part of Seattle, as approved by voters in 1953 (Wilma, 2005). The properties in this 10-square mile area developed under King County regulations and were served by smaller sewer districts prior to annexation. Under King County development regulations, sewer pipes were fully separated, and formal drainage systems were not required for all suburban residential developments.

In 1958, Seattle and King County voters approved the creation of the Municipality of Metropolitan Seattle (Metro), a new regional entity tasked with conveying and treating wastewater from the region and leading the effort to clean up Lake Washington and Puget Sound (Oldham, 2006). The City transferred ownership of wastewater infrastructure within city boundaries that conveyed wastewater from basins larger than 1,000 acres to Metro. As a result, SPU's wastewater collection infrastructure is characterized by relatively small service areas, which typically do not exceed 1,000 acres in size.

The *Metropolitan Sewerage and Drainage Survey* was developed in 1958. It was the first regional comprehensive sewer plan to address population growth, raw sewage discharges and overflows, Lake Washington and Duwamish River pollution, suburban sewerage problems, and combined sewer problems.

In 1968 and 1970, voters approved "Forward Thrust" ballot initiatives to fund sewer separation projects as well as other public projects such as parks, youth service centers, fire stations, and the Kingdome. The City Engineering Department completed partial separation projects in combined sewer basins. Fully combined systems were separated such that only rooftop stormwater runoff and raw sewage continued to enter the wastewater collection system. Street stormwater runoff was directed to newly constructed separated stormwater pipes. As a result, SPU's wastewater collection system includes sanitary, fully combined wastewater and stormwater, and partially separated wastewater pipes. Approximately 27 percent of the City's wastewater collection system is sanitary (mostly in the north end in areas that developed under King County regulations), 33 percent is fully combined (mostly in the central core), and 40 percent is partially separated (throughout the southern parts of the city but also in several northern basins) (see Figure 1-1).

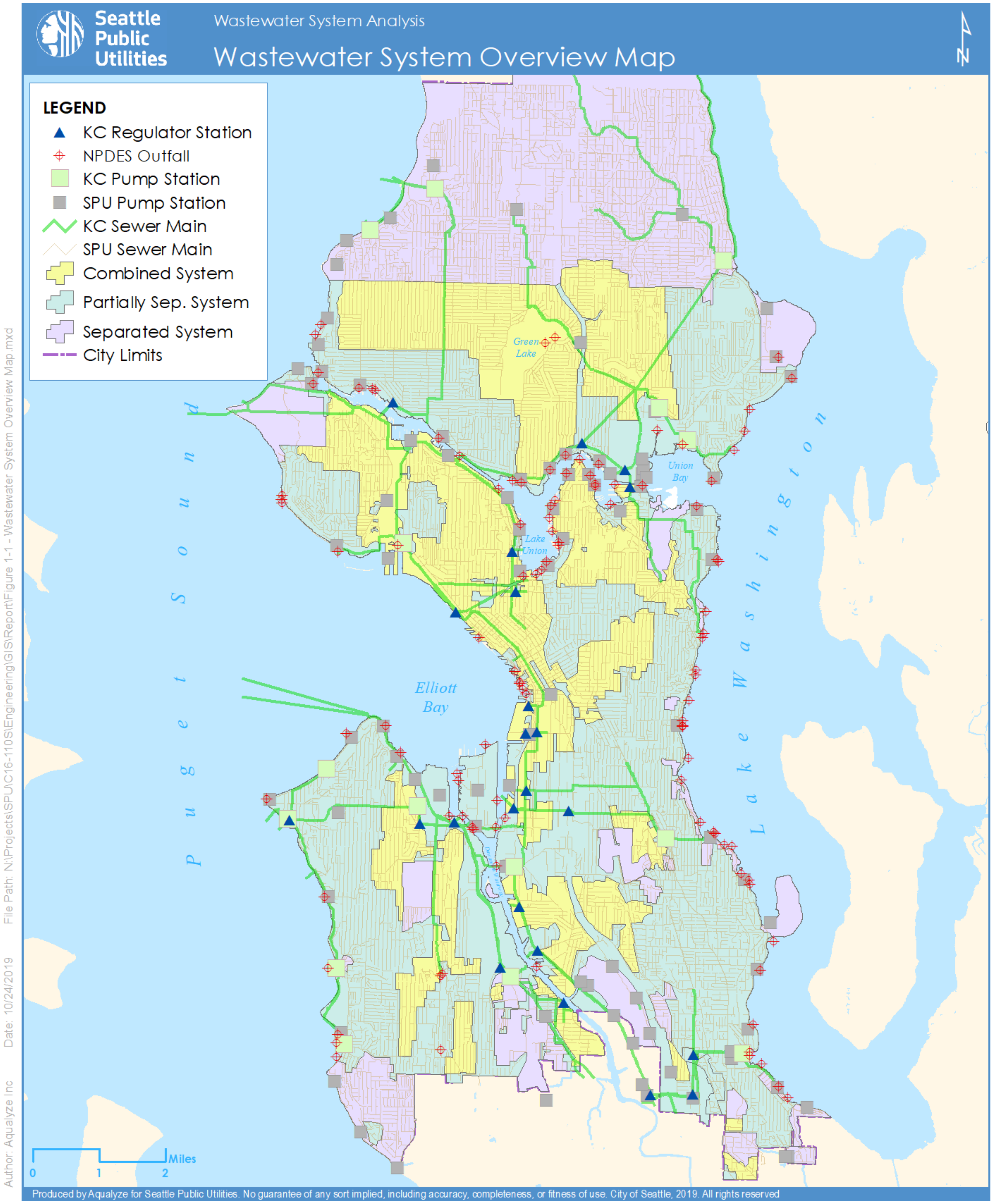



**Figure 1-1. Wastewater System Overview Map**

National policy has also shaped Seattle's wastewater system. The Federal Water Pollution Control Act, as amended (also referred to as the CWA), was significantly amended in 1972. The CWA establishes a broad goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. Some of the ways the CWA has most influenced wastewater operation, maintenance, and capital improvement projects are:

- Requiring permitting of point source discharges of pollutants into waters of the United States under the NPDES program (Section 402)
- Guiding the development of effluent limitations to regulate such wastewater treatment and management
- Mandating that states set water quality standards (WQS) to protect beneficial uses and requires periodic listing of water bodies that do not meet WQS (Section 303(d) list)
- Prohibiting oil and hazardous material discharges to waters

In 1990, the structure of Metro was deemed unconstitutional, violating the "one person, one vote" principle clarified by Board of Estimate of City of New York v. Morris, 489 U.S. 688 (1989). As a result, Metro joined King County in 1994 (Oldham, 2006). Today the county's Wastewater Treatment Division (WTD) serves about 1.7 million people within a 424-square-mile service area, which includes most urban areas of King County and parts of south Snohomish County and northeast Pierce County (King County, n.d.).

In 1996, the City established Seattle Public Utilities. Operation and management of the wastewater system formerly housed in the Seattle Engineering Department were merged with the Water Department, along with the Customer Service Call Center and Construction Engineering Sections of City Light. Today the DWW LOB in SPU manages Seattle's drainage and wastewater reliably and affordably to protect public health, safety, and the environment.

SPU's DWW LOB serves a population of approximately 747,300 spread over 84 square miles. SPU operates a complex wastewater collection system network comprised of 1,423 miles of separated and combined sewer pipes and maintenance holes (MH), 68 pump stations (PS), and 86 permitted combined sewer overflow (CSO) outfalls in Puget Sound, Lake Washington, and the Duwamish Waterway. Seattle's wastewater system is complex for a number of reasons. As previously stated, there are three types of systems: combined, partially separated, and separated, each with unique challenges. Split ownership of the system, where smaller collection pipes are owned and managed by SPU and large trunk sewers and wastewater treatment plants are owned and managed by King County, adds further complexity to providing adequate capacity in the wastewater system.

Continual growth and development have made providing adequate sewer capacity a challenge throughout Seattle's history. We have made incredible progress as a city and a region given that much of the wastewater system was designed and installed when primary wastewater treatment technology was not available and values surrounding environmental protection were markedly different. Irrespective of regional progress, individual residents and customers continue to be impacted by lack of adequate wastewater capacity at a localized scale. Providing adequate capacity in the wastewater system requires constant effort, and it is a challenge we continue to face. Now, and in the future, we must address this challenge within an aging system, growing population, and a changing climate. While the need to provide adequate capacity remains constant, methods to meet this challenge need to evolve over time.

## 1.2 Integrated System Planning

SPU is currently undertaking an ambitious effort to integrate planning for its drainage and wastewater systems. The WWSA is a critical component of integrated planning for SPU's drainage and wastewater systems. The goal of this integrated planning effort is to identify the best investment strategy to achieve the greatest environmental and community benefits for Seattle at the lowest cost to our customers. The effort will integrate planning across drainage and wastewater systems, emphasize engagement, and focus on leveraging effective partnerships to meet Seattle's infrastructure challenges.

The integrated system planning effort is broken into four stages: Analysis, Visioning, Planning, and Implementation. Figure 1-2provides a description of each stage and summaries of some of the key outcomes from each stage.

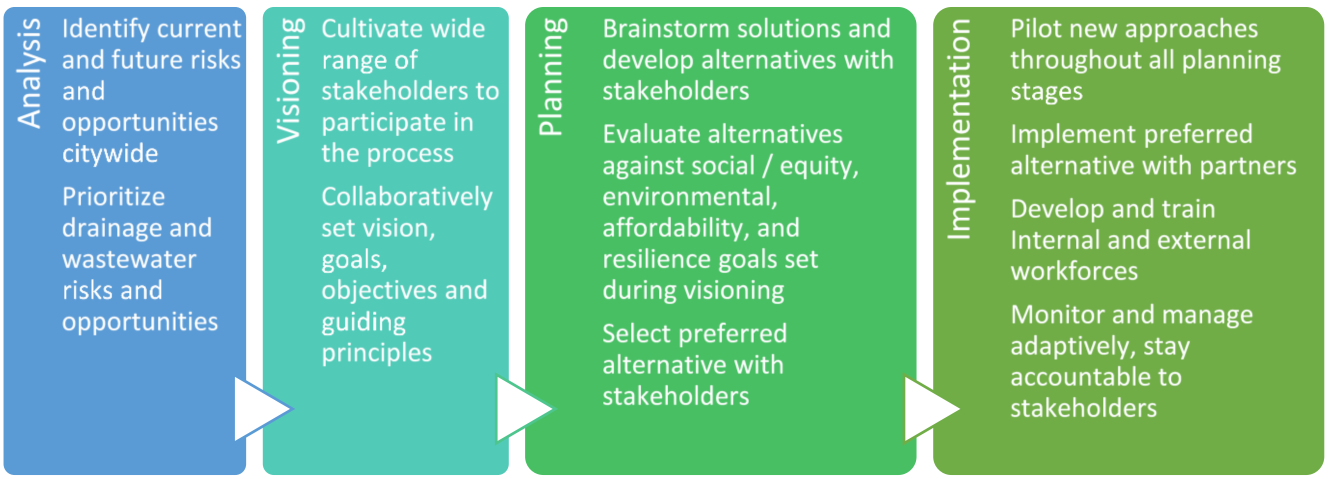



**Figure 1-2. Integrated System Planning Stages**

The Analysis stage is focused on identifying and prioritizing current and future risks and opportunities citywide. The Analysis stage includes both technical analysis and community outreach. The WWSA is one of the major analysis projects that has been initiated as part of this stage of planning.

The Visioning stage consists of engagement and collaboration with our community, other city departments, and partners. In this stage we will develop goals, objectives, guiding principles, and measures of success for the drainage and wastewater system to guide long-range planning and investment.

The Planning stage will build from the knowledge acquired through the Analysis stage and will be guided by the goals, objectives and principles set through the Visioning stage. The Planning stage will culminate in the completion of an Integrated System Plan (ISP). The ISP will include both a long-term (50-year) vision for drainage and wastewater services in Seattle and a short-term (6-year) implementation plan that sequences actions for the City of Seattle, SPU, and our partners. In addition, the plan will include an adaptive management approach to implementation, including procedures for revisiting and refining the planned actions over time.

## 1.3 Project Background

The Wastewater System Analysis is a technical, citywide analysis that incorporates equity to improves on our complaint-based knowledge of wastewater capacity issues and identifies priorities for future investment. The WWSA was initiated to meet the need for a citywide analysis of the wastewater system to better understand current and potential future wastewater capacity issues.

Lack of wastewater system capacity causes sewer overflows through MHs in the street or backups into residents' and customers' homes or businesses. A sewer overflow is defined as any overflow, spill, diversion, or release of wastewater from or caused by the Sanitary Sewer System or the Combined Sewer System, not including CSOs or Dry Weather Overflows (DWOs) discharged from the CSO outfalls regulated by SPU's wastewater NPDES permit. SPU uses the acronym SSO for all sewer overflows, including sewer overflows from combined sewers as well as those from sanitary sewers.

There are numerous plans and technical documents that preceded the WWSA, including the Wastewater Systems Plan (Brown and Caldwell, 2006), the Sanitary Sewer Wastewater Capacity Improvement Programmatic Business Case (Seattle Public Utilities, 2010), and CMOM Phase II Task 3 - Sewer Capacity Analysis Design Rainfall Time Series Development (Aqualyze, 2016).

In the past, SPU relied heavily on customer complaints or field reports to identify locations with wastewater capacity issues. This approach has many drawbacks: it favors neighborhoods or business districts that communicate more frequently with City government, it provides an incomplete picture of how the wastewater system functions, and it does not provide insight on how the wastewater system may be impacted by growth and climate change.

The technical component of the WWSA builds from previously developed hydraulic and hydrologic (H&H) models to conduct a citywide modeling analysis (Appendix A). The outreach effort expands SPU's understanding of wastewater capacity challenges and focuses on communities of color where under reporting is likely in order to learn about current capacity issues from customers and residents and provide information to the community about how to report issues. Underreporting of capacity issues may occur for a number of reasons including lack of action by the City when issues were reported in the past, language barriers, or lack of awareness of how to report issues.

## 1.4 Goals and Objectives

The goal of the WWSA is to provide the technical analysis of the wastewater system needed to develop the ISP.

The project objectives to meet the goal are as follows:

- Identify and understand wastewater system capacity needs
  - Set wastewater system Performance Thresholds
  - Incorporate appropriate projections for growth and climate change
  - Improve the wastewater system H&H models, by making them predict observed data better, prior to completing capacity analysis
  - Use citywide H&H models as a tool to assess capacity citywide and to counter bias in complaint-based approaches to understanding capacity issues

   - Further our knowledge of the contribution of infiltration and inflow (I/I) to locations that exceed system Performance Thresholds
   - Incorporate current knowledge of the operations, maintenance, criticality and condition of the wastewater system in higher priority locations that exceed system Performance Thresholds
   - Improve knowledge of our system needs through equitable community engagement
- Set a transparent and consistent method to prioritize wastewater system needs
   - Apply appropriate criteria to prioritize wastewater system capacity issues
   - Incorporate equity into those criteria
   - Link those criteria back to the SPU priorities
- Provide analysis of the wastewater system that aligns with the Drainage System Analysis (DSA) and provides technical foundation for the ISP
   - Coordinate with the team completing the DSA to ensure that deliverables are consistent and compatible so that they are useful for the ISP
   - Coordinate with the team developing the Vision Plan for the ISP to ensure that the WWSA meets the vision
   - Adaptively align the WWSA with the DSA and ISP

In addition, SPU developed and implemented the Equity Strategy for System Analysis Projects to ensure that considerations of racial equity were embedded in the WWSA (Appendix B). The goals of the equity strategy are to:

- Incorporate analysis of equity impacts into the WWSA in a meaningful way
- Build shared understanding among the project team members and project leadership that considering equity early in the integrated system planning process is valuable
- Reinforce that equity is an important factor every time DWW makes a decision or selects a preferred option
- Lay groundwork for DWW Vision and ISP equity framework

# 2. Wastewater Capacity Performance Goals and Thresholds

A primary objective of the WWSA is to identify and understand wastewater capacity needs. One strategy to meet this objective is to select wastewater system Performance Thresholds to achieve performance goals, for private property and public rights-of-way (ROW), that are consistent with SPU risk tolerance. This section summarizes the method used in the WWSA to select the Performance Thresholds for the wastewater system. For detailed information refer to Appendix C: Wastewater System Performance Thresholds.

## 2.1 Performance Goals

Performance goals for wastewater system capacity were developed based on assessment of service levels outlined in the 2006 Wastewater Systems Plan, the SPU Strategic Business Plan (2015), the DWW Level of Service (LOS) Framework (2016) and review of similar work conducted by other utilities. LOS Framework provided recommendations for DWW Service Goals and the future development of technical Performance Targets. The LOS Framework recognized the need to further develop the Performance Targets, especially where technical studies were needed to support the development of specific and measurable targets or thresholds for DWW system performance.

Wastewater system capacity performance goals were established from the DWW Service Goals proposed in the LOS Framework.

For the WWSA, the wastewater system performance goals are:

- Provide adequate capacity in the public wastewater system to minimize the risk of sewer backups into private property
- Provide adequate capacity in the public wastewater system to minimize the risk of sewer backups into the public ROW

## 2.2 Performance Thresholds

Since developing the LOS Framework, SPU decided to use the term "Performance Threshold," rather than "Performance Target." For the WWSA, a Performance Threshold defines adequate capacity; it was used for the citywide modeling analyses to identify risk areas. Performance Thresholds are made up of two components: a performance parameter and design storm.

***Performance Parameters:***

A performance parameter is a set hydraulic grade line (HGL) that defines when simulated surcharging or flooding represents a potential impact. Performance parameters were defined to conduct the analysis. Through a series of workshops and discussions with the project team the following three performance parameters were selected:

1. Surcharged pipes: Greater than or equal to 1-ft of surcharge above the crown of the pipe
2. MH flooding: Peak HGL > MH rim elevation leaving no freeboard
3. Capacity limited pipes: $Q_{peak}/Q_{capacity} > 1.0$, where Q is flow. 100% of existing pipe capacity is utilized, when all restrictions are removed

***Design Storm:***

A design storm is a specified amount of rainfall distributed over time and space. The selected performance parameters were evaluated in the following three design storms:

1. 1-year, 24-hour design storm
2. 2-year, 24-hour design storm
3. 5-year, 24-hour design storm

These design storms were selected because they were thought to be the most helpful for selecting Performance Thresholds for the wastewater system, based on the design of the majority of the combined system (Brown and Caldwell, 1958) and review of preliminary modeling results from these events.

A set of three synthetic rainfall hyetographs, based on current intensity-duration-frequency (IDF) curves (Tetra Tech, 2017), for a 1-, 2- and 5-year return period and a 24-hour duration were developed (see Appendix D: Design Rainfall Time Series Development and Capacity Analysis Methodology). These rainfall hyetographs were developed by applying the alternating block methodology, which ensures that the peak precipitation occurs at the midpoint of the storm and the falling limbs of the hyetograph successively decrease in depth. A 24-hour duration was used as rainfall response varies from short term to longer durations across the city. The design storms were embedded in a 24-month rainfall time series that was developed for this project. Using the rainfall time series in the system-wide models provided a way to analyze the system performance under a suite of storms of varying return periods, with typical antecedent conditions. Figure 2-1. shows the 24-hour duration hyetographs of the three design storms used.

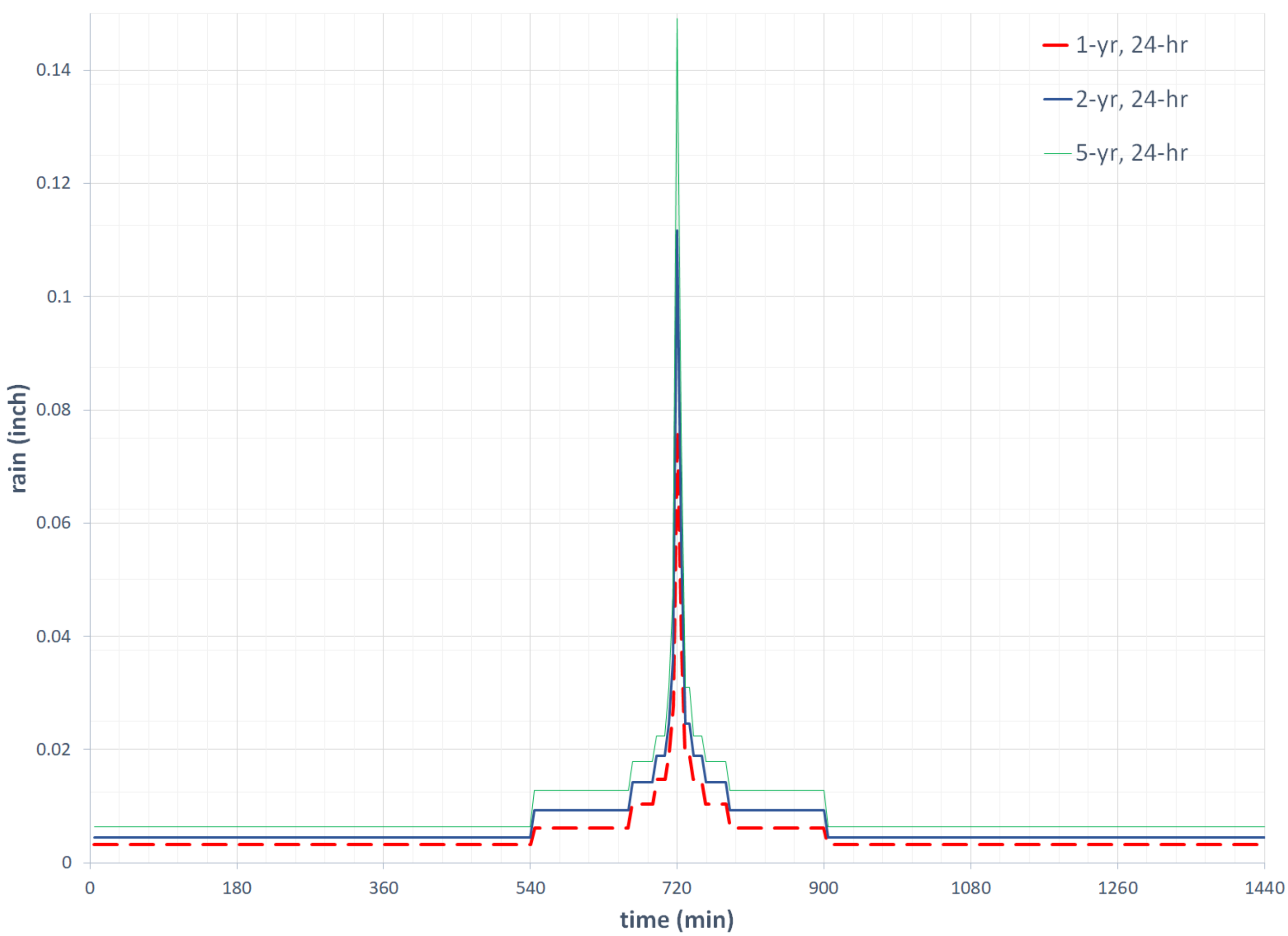



**Figure 2-1. Synthetic Design Rainfall Hyetographs**

### 2.2.1 Modeling Methodology

Prior to selecting the Performance Thresholds, a comprehensive methodology was developed to analyze and characterize the wastewater system. Modeling was completed to evaluate the wastewater system response to the selected rainfall storm events for the existing system. Boundary conditions in regional models were set at 26 discharge locations to the KC system to account for possible backwater impacts from the KC system. The boundary conditions were generated by running a system-wide model (built from the regional models) for the 24-month rainfall time series and exporting the flow and head time series data at the 26 locations. A flow boundary condition was used as upstream input while a head boundary condition was used if the system terminated at a key structure (typically PSs and regulator stations (RS)).

Modeling was also completed for an idealized system. An idealized system is defined as a system with no hydraulic constraints, and it was used to calculate $Q_{peak}$ for the capacity limited performance parameter.

Model output was processed to extract peak HGL at each MH and peak flow at each pipe for the three design storms. The processing of results included the following data and calculations:

- System inventory data (e.g., pipe diameter, length, invert elevations, and connecting MH information such as invert and rim elevations)
- For performance parameters:
  - Feet of surcharged pipe
  - MH freeboard
  - Feet of capacity limited pipe ($Q_{peak}/Q_{capacity}$), where $Q_{capacity}$ was calculated using Manning's equation for a full-flow circular pipe

$$Q_{capacity} = \frac{1.49}{n} S^{1/2} R_h^{2/3} \frac{\pi}{4} D^2, \text{ where } R_h = \frac{D}{4}$$

See Appendix A for additional details on modeling methodology.

### 2.2.2 System Performance Under Simulated Existing Conditions

Using the modeling methodology described in Section 2.2.1, citywide H&H models were run to analyze system performance under the selected design storms. Parameters to interpret modeling results, as summarized in Section 2.2 were used to generate tables and maps for the citywide analysis. System wide pipe upsizing costs were computed based on pipe capacity limitations as identified from modeling. System performance under existing conditions and associated costs required to upsize the system are discussed and presented in this section.

Existing system performance was analyzed for the 1-, 2-, and 5-year, 24-hour design storms described in Section 2.2. A summary of the citywide analysis is presented in Table 2-1. Pipe surcharging ranged from 86 miles during the 1-year, 24-hour design storm event to 419 miles under the 5-year, 24-hour event, and 179 flooded MHs to 2,073 MHs respectively under the 1-year, 24-hour and 5-year, 24-hour events. It is important to note that the capacity limited pipes statistics show a lesser degree of problem indicating that not all pipes surcharged are capacity limited, but surcharge is likely caused due to system bottleneck downstream.

| Table 2-1. Citywide Performance Threshold Results | | | | | | |
|---|---|---|---|---|---|---|
| **Design Storm Event** | **Surcharged Pipes (miles)** | **Surcharged Pipes (% of System)** | **Capacity Limited Pipes (miles)** | **Capacity Limited Pipes (% of System)** | **Flooded MHs** | **Flooded MHs (% of system)** |
| 1-year, 24-hour | 86 | 6% | 57 | 4% | 179 | < 1% |
| 2-year, 24-hour | 240 | 17% | 150 | 11% | 839 | 2% |
| 5-year, 24-hour | 419 | 30% | 264 | 19% | 2,073 | 6% |

*Note: Total length of SPU wastewater system pipe analyzed is approximately 1,400 miles*

Table 2-2 distinguishes pipe surcharging and MH flooding by system type categorized as combined, partially separated and separated. A stark difference in system performance can be seen in both pipe surcharging (7%) and MH flooding (5%) between the separated system and the other two system types. This is likely a direct result of inflow connected to the combined and partially separated systems.

| Table 2-2. Citywide Performance Threshold Results for 5-yr, 24-hr Design Storm by System Type | | | | |
|---|---|---|---|---|
| **Performance Threshold** | **Simulated surcharge 1 ft or greater** | | **Simulated MH Flooding** | |
| | **Length (miles)** | **% of all surcharged pipes** | **Flooded MHs** | **% of all flooded MHs** |
| **System Type** | | | | |
| Combined | 248 | 59% | 1,481 | 71% |
| Partially Separated | 143 | 34% | 489 | 24% |
| Separated | 28 | 7% | 103 | 5% |
| **Total** | **419** | **100%** | **2,073** | **100%** |

Maps showing the distribution of simulated surcharge across the city for each design storm are presented in Figure 2-2 through Figure 2-5 and maps of capacity limited pipes for each design storm are presented in Figure 2-6 through Figure 2-9. These results were presented to SPU in a series of workshops held between May and October of 2018. Finer resolution details at a sub-basin level can be found in Appendix E: Sub-basin Summary Sheets.

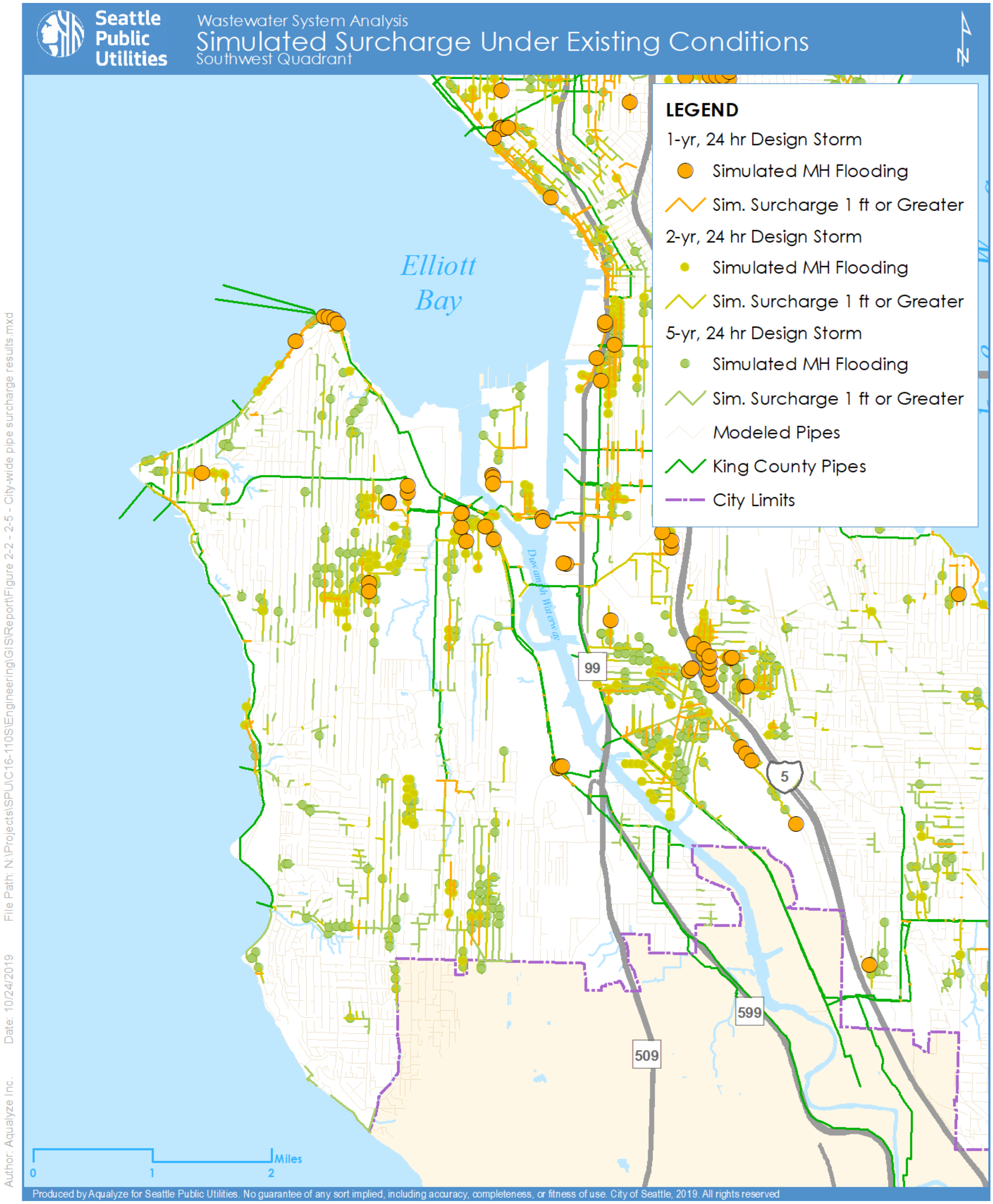



**Figure 2-2. Simulated Surcharge Under Existing Conditions – Southwest Quadrant**

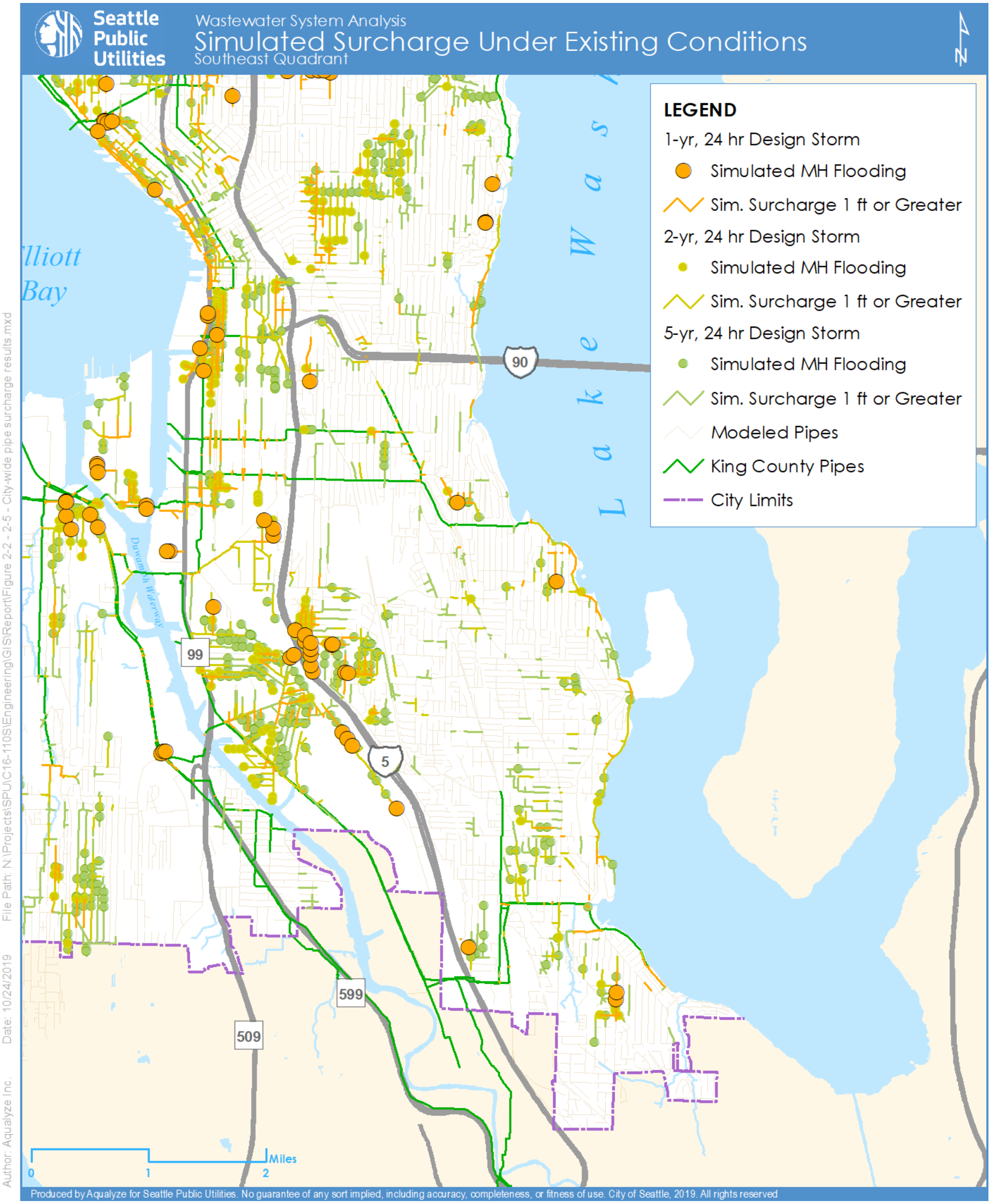



**Figure 2-3. Simulated Surcharge Under Existing Conditions – Southeast Quadrant**

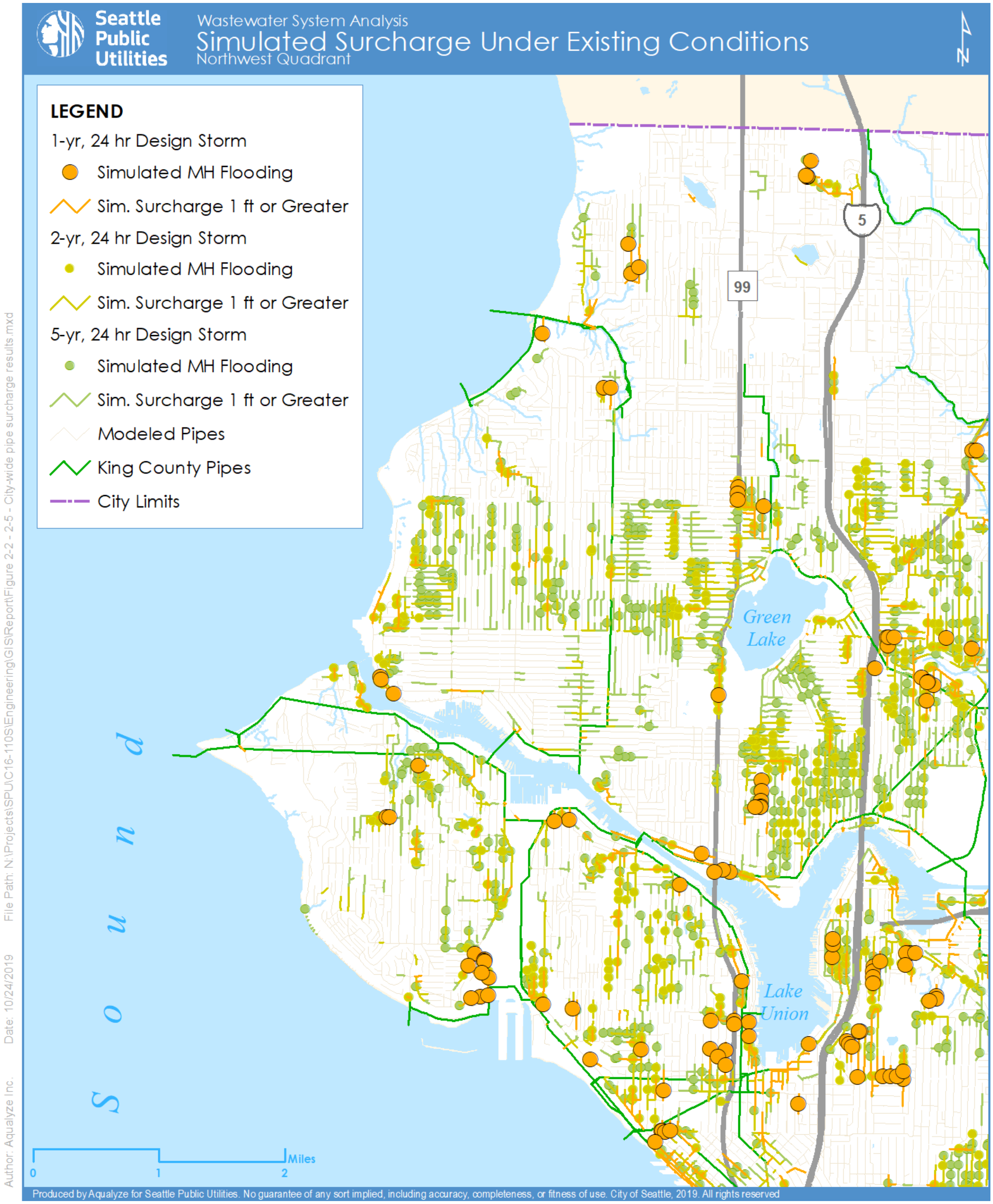



**Figure 2-4. Simulated Surcharge Under Existing Conditions – Northwest Quadrant**

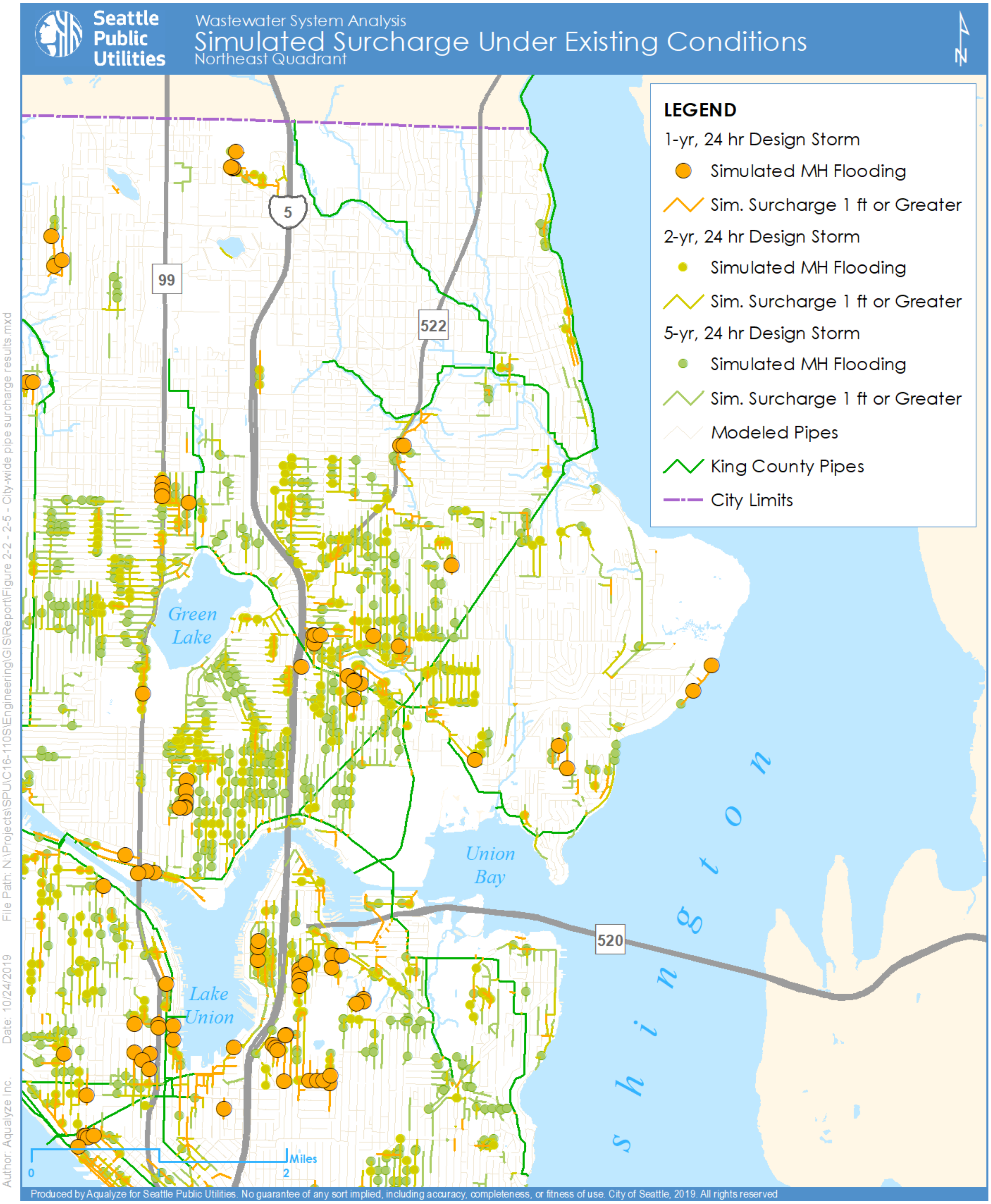



**Figure 2-5. Simulated Surcharge Under Existing Conditions – Northeast Quadrant**

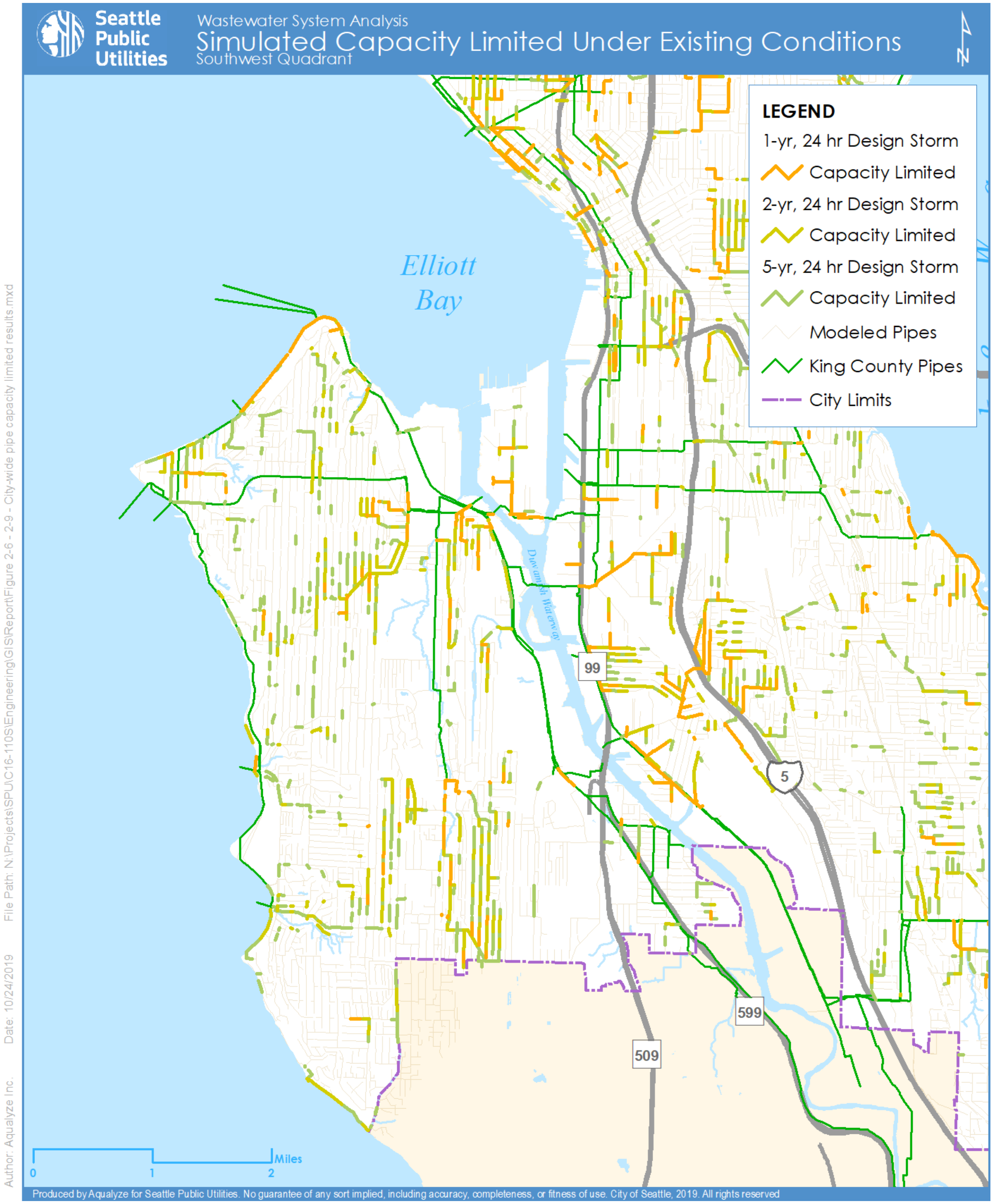



**Figure 2-6. Simulated Capacity Limited Under Existing Conditions – Southwest Quadrant**

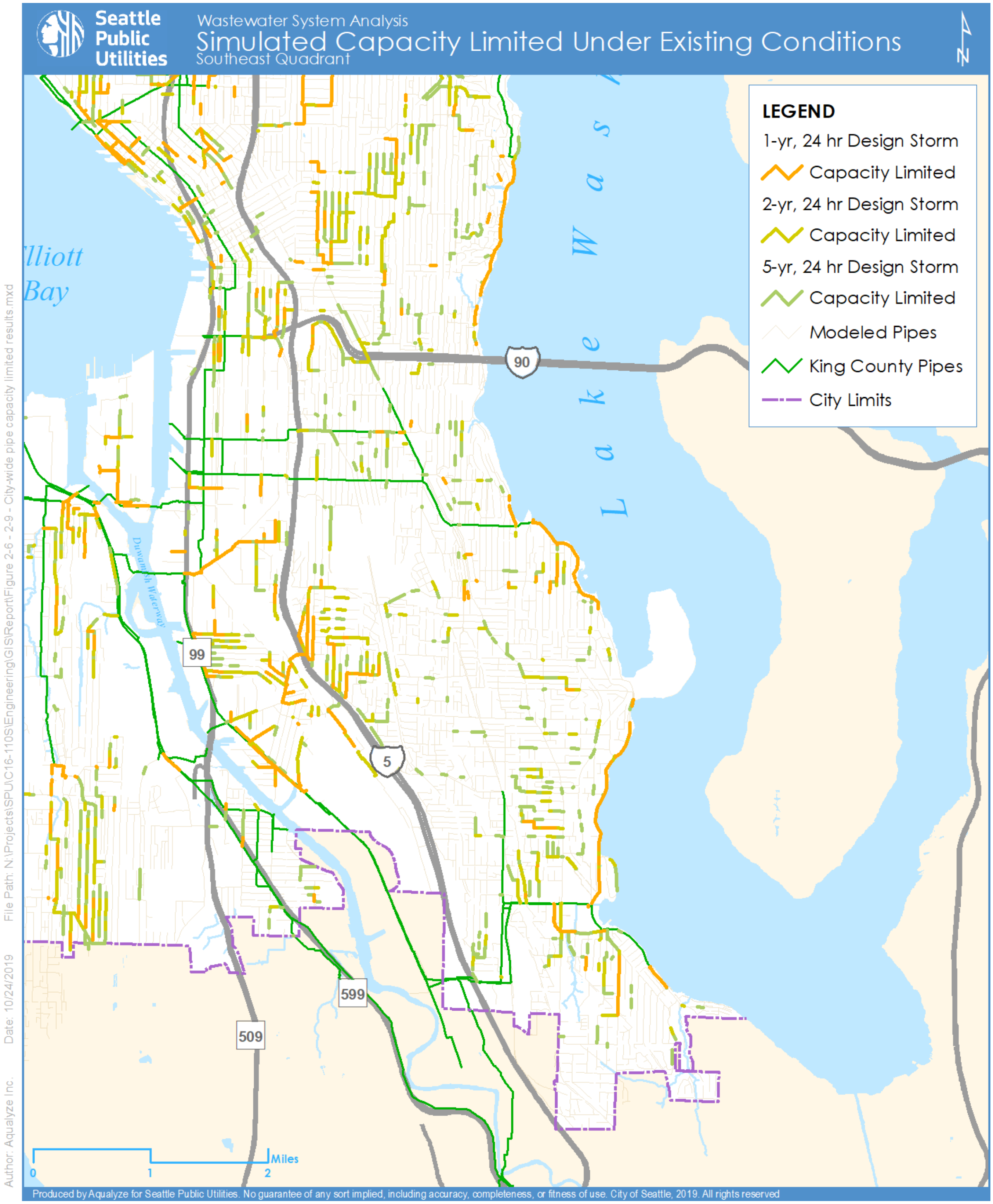



**Figure 2-7. Simulated Capacity Limited Under Existing Conditions – Southeast Quadrant**

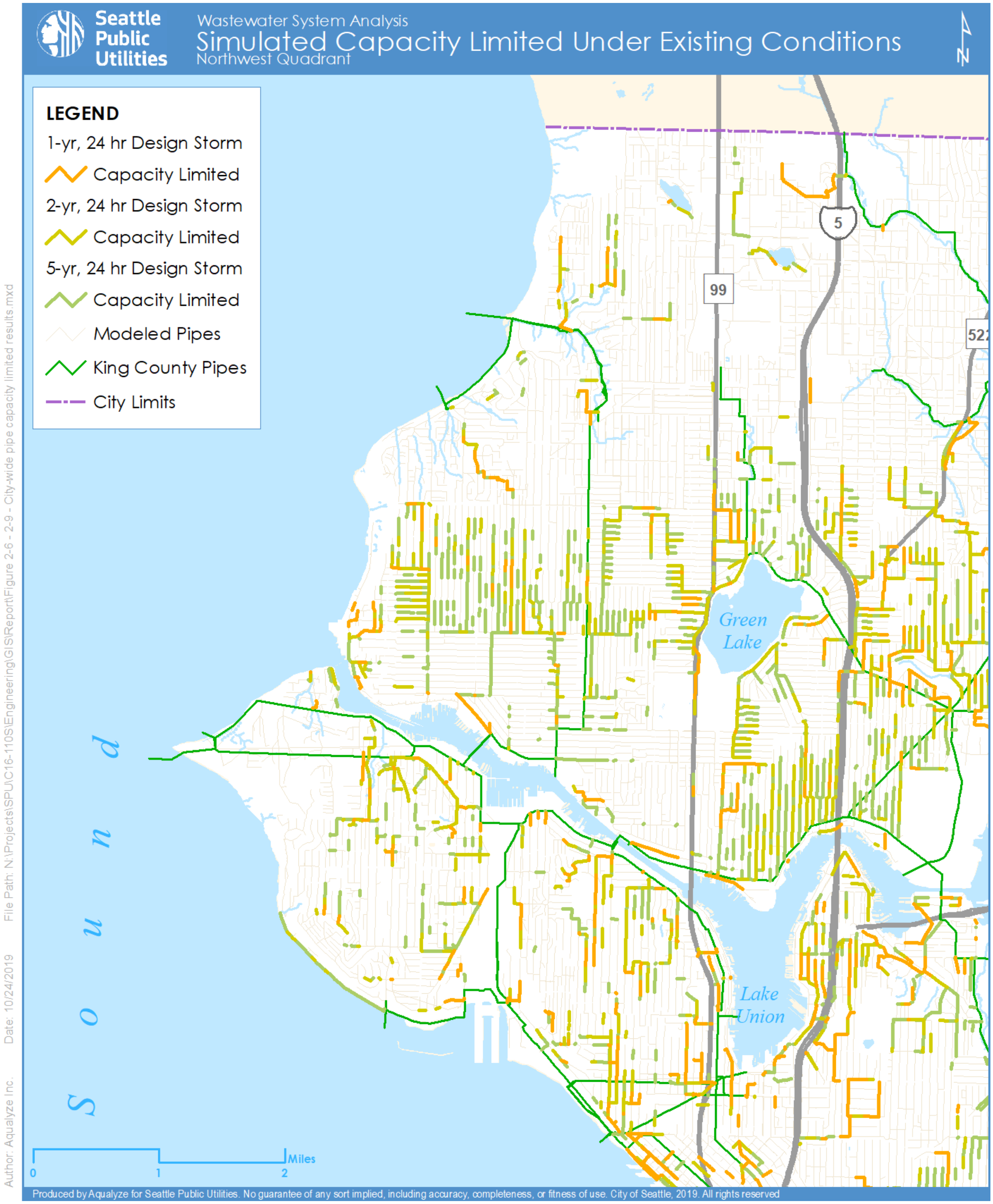



**Figure 2-8. Simulated Capacity Limited Under Existing Conditions – Northwest Quadrant**

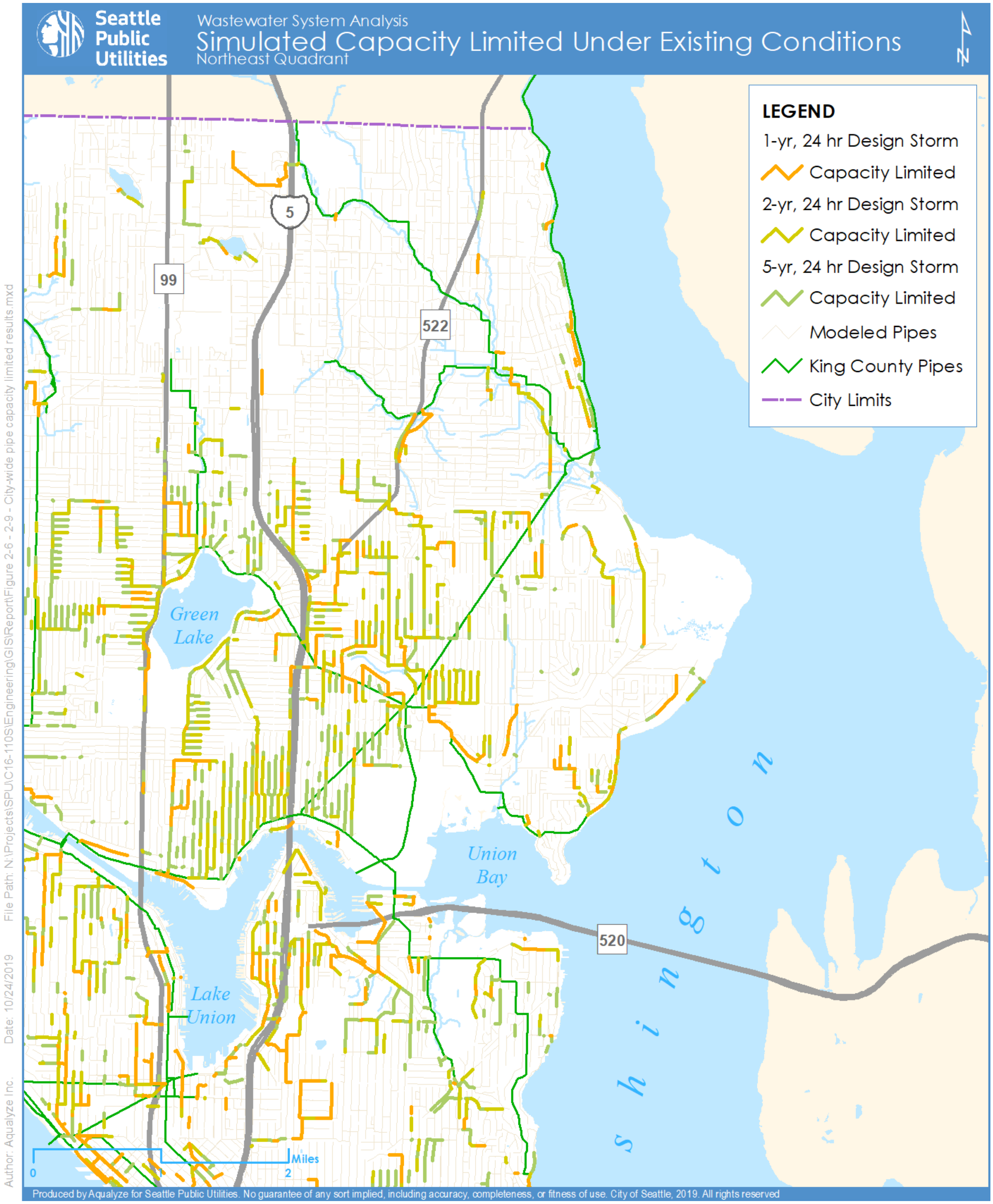



**Figure 2-9. Simulated Capacity Limited Under Existing Conditions – Northeast Quadrant**

Model results were reviewed in further detail at the sub-basin level for the three design storms. Sixty-five sub-basins were delineated for the WWSA; they vary in size and hydraulic complexity. See Appendix F: Basin Delineation Methodology and WWSA Sub-basin Definition for more details. Performance parameter summaries were normalized by unitizing over the sub-basin area to facilitate comparisons between sub-basins. It was noted that sub-basins with a relatively high rate of flooded MHs also had a high rate of capacity limited pipes per area for the same design storm event and vice versa. Some sub-basins saw significant increases in flooded MHs or capacity limited pipes from one design storm event to another (e.g., Wallingford sub-basin), while others responded more moderately to changes in the design storm event (e.g. Duwamish PS sub-basin). Figure 2-10 and Figure 2-11 present results for simulated MH flooding and pipe surcharging.

Figure 2-12 presents the results of capacity limited pipes. It should be noted that the number of pipes showing capacity limitations are less than the pipes surcharged within the same sub-basin when compared with Figure 2-11. This indicates that many pipes that surcharge do not have a hydraulic capacity limitation but are surcharged due to possible downstream capacity limitations. This is evident by comparing the statistics of surcharged versus capacity limited pipes statistics in Table 2-1 where 419 miles or 30% of the system was surcharged under the 5-year, 24-hour design storm as compared to 264 miles or 19% of the system with limited capacity. This has a direct impact in computing the system wide costs of upsizing or improving the infrastructure. Costs presented in Section 2.2.3 are based on capacity limited pipes.

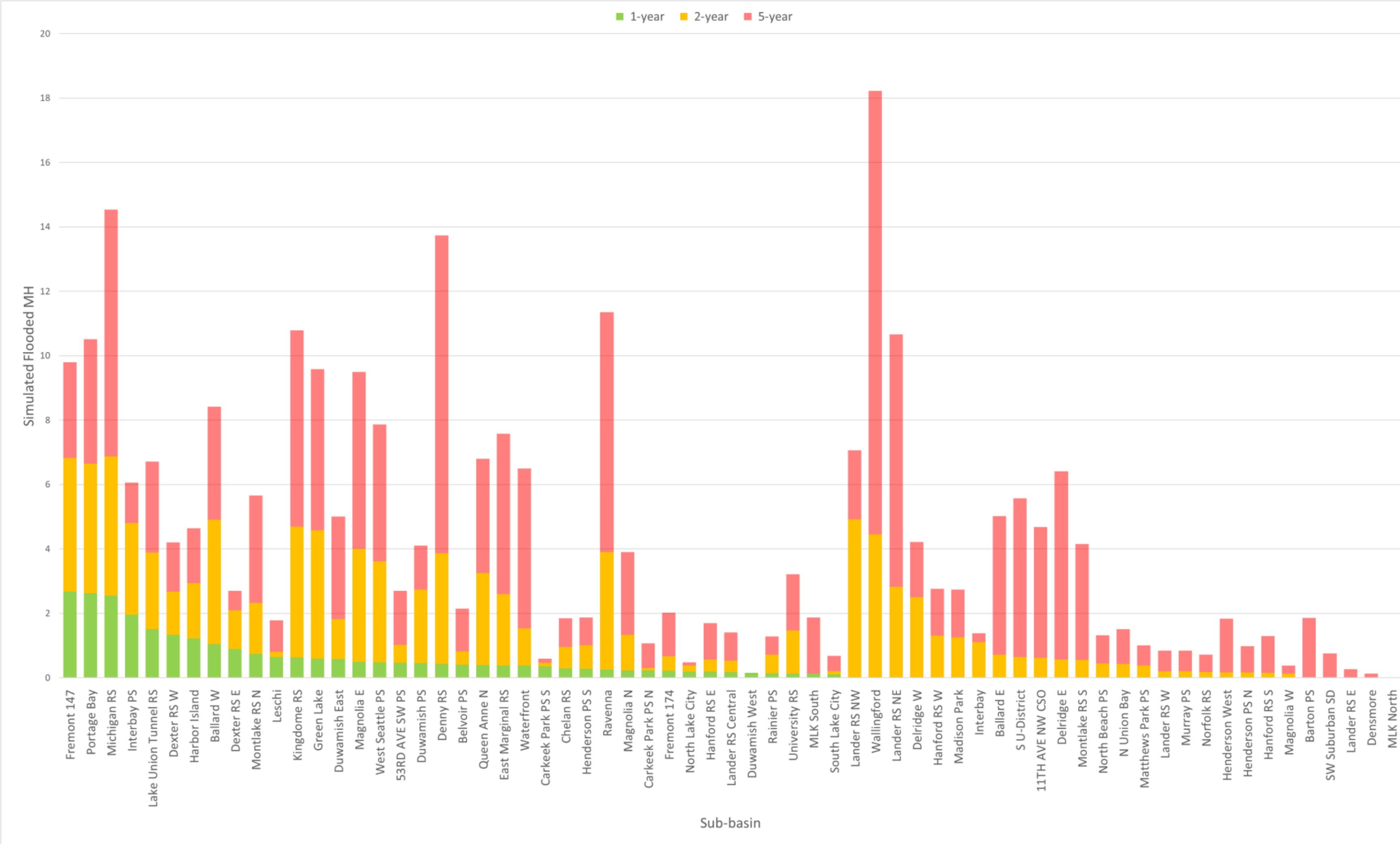



**Figure 2-10. Simulated MHs Flooding by Sub-basin Normalized by Area**

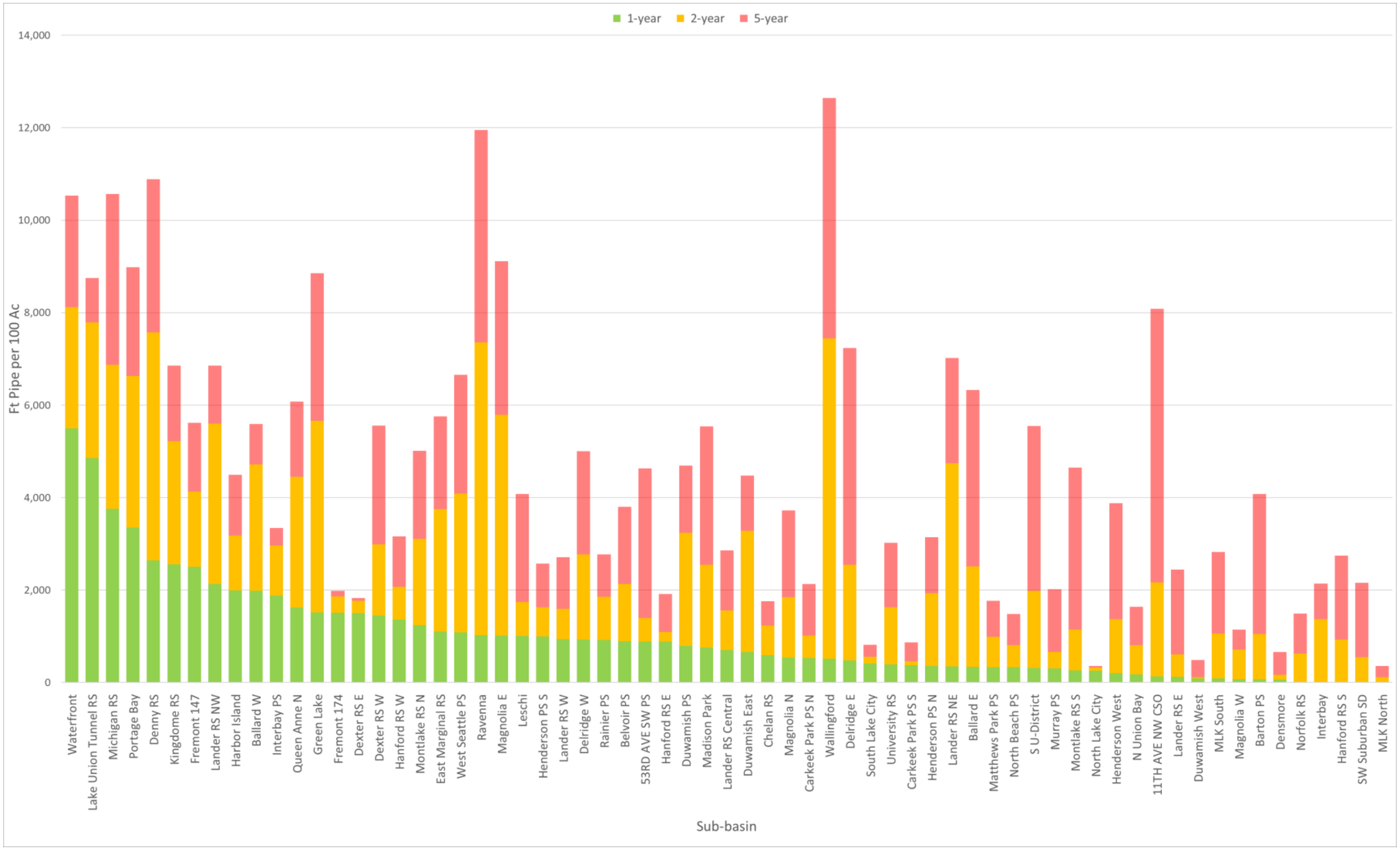



**Figure 2-11. Surcharged Pipe Length by Sub-basin Normalized by Area**

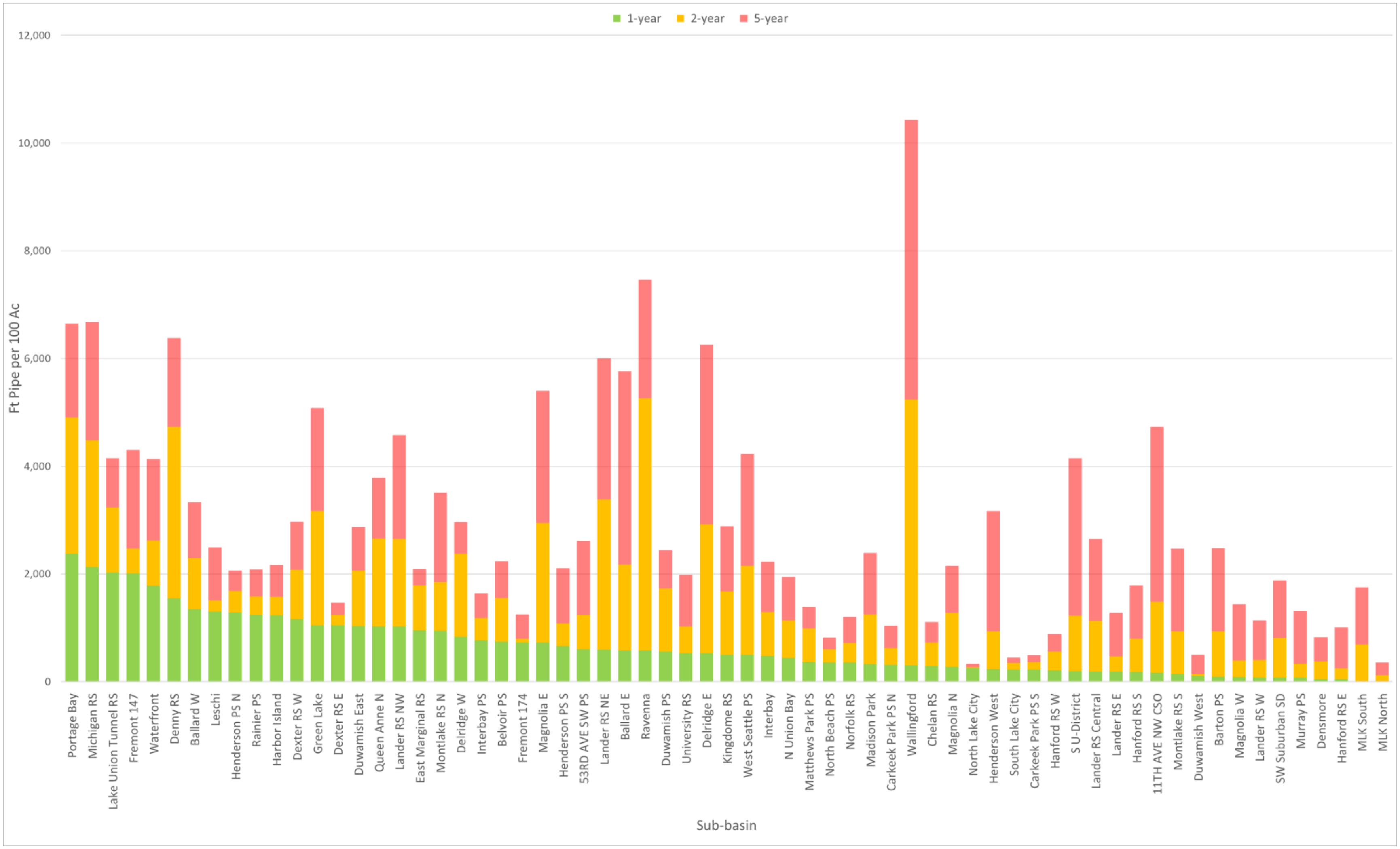



**Figure 2-12. Capacity Limited Pipe Length by Sub-basin Normalized by Area**

For each of the performance parameters evaluated – pipe surcharge, hydraulic capacity limitations ($Q_{peak}/Q_{capacity}$), and flooded MHs – system performance decreased as design storm event severity (1-year, 2-year, and 5-year 24-hour events) increased, as expected.

Citywide modeling analysis using consistent standards provided a sound approach to compare and evaluate the hydraulic capacity of the wastewater system. The approach to include peak flow to pipe capacity ratio in the analysis resulted in not only analyzing the system for existing conditions but also provided insight into future impacts on downstream systems if the bottlenecks in existing locations were alleviated.

### 2.2.3 Pipe Replacement Cost Estimates

American Academy of Cost Engineers (AACE) Class 5 cost estimates were developed to compare the cost to upsize capacity limited pipes under each design storm. Standard pipe sizes, ranging from 10 inches to 72 inches, were used in the cost estimate. Unit cost for pipe construction, per lineal foot, was based on the 2017 SPU Cost Estimating Guide and Cost Model. To compute total capital pipe replacement costs, additional costs and uncertainties per SPU's Class 5 cost estimate guidelines were included as summarized in Appendix C.

Total cost projections for the three design storms, as presented in Table 2-3, ranged from $0.862 billion to $8.685 billion. Total cost projection range is $0.862 billion for the 1-year design storm event with -30% uncertainty to $8.685 billion for the 5-year design storm event with +50% uncertainty.

**Table 2-3. Citywide AACE Class 5 Cost Estimate (in billions)**

| Cost Item [a] | Design Storm | | |
|---|---|---|---|
| | 1-Year, 24-hr | 2-Year, 24-hr | 5-Year, 24-hr |
| Construction Cost ($)<br>*(including 10.1% sales tax)* | $0.501 | $1.323 | $2.355 |
| Total Cost Projection ($)<br>*(including soft cost, contingency and management reserve)* | $1.232 | $3.253 | $5.790 |
| Opinion of Cost – Low<br>*(-30% uncertainty)* | $0.862 | $2.277 | $4.053 |
| Opinion of Cost – High<br>*(+50% uncertainty)* | $1.848 | $4.880 | $8.685 |

*a. All costs are in 2018 dollars*

For all three design storms, nearly 75% of all costs were for pipe diameters ranging from 10 to 24 inches. Roughly 20% of the costs were for pipe diameters ranging from 30 to 48 inches, and the remaining 5% of costs were for pipe diameters between 54 and 72 inches.

Citywide pipe upsizing costs were used to inform the selection of Performance Thresholds, along with other non-technical metrics. These are discussed in the following section.

### 2.2.4 Performance Threshold Selection

Selecting Performance Thresholds for private property and public ROW involved SPU staff input from multiple SPU Divisions including DWW, Project Delivery and Engineering Branch (PDEB), and Environmental Justice and Service Equity Division (EJSE). The merits of each design storm event were identified and discussed during three workshops and communicated with key stakeholders at SPU.

The WWSA project team followed the recommendation of the Equity Strategy for System Analysis Projects (Appendix B) to embed equity into the selection of Performance Thresholds by completing a racial equity toolkit. A modified racial equity toolkit was developed by DWW and EJSE staff that contained questions to help the project team compare and identify possible inequitable impacts of the potential Performance Thresholds. The project team completed the modified toolkit together during a meeting, where customer experience and affordability were the main topics that were discussed in detail. Refer to Appendix G for the completed toolkit.

It was determined as part of the racial equity toolkit that while the cost to meet each Performance Threshold was important, the higher cost of the 5-year, 24-hour design storm was not the most important factor. The project team assumed that over time individual customers who experience basement backups would incur higher out-of-pocket costs if the 1-year, 24-hour design storm was selected for the Performance Threshold storm event compared to the 5-year, 24-hour design storm. A 1-year, 24-hour design storm event would potentially impact lower-income customers disproportionately. In Seattle, lower median household income is correlated with race, where people of color have lower median household incomes than white, non-Latino residents (U.S. Census Bureau, 2017).

The 5-year, 24-hour design storm that delivers 2.7 inches of rain in 24-hours was selected for the Performance Threshold storm event. The following considerations supported this recommendation:

- While affordability to meet each Performance Threshold was an important topic of discussion, it was determined that the higher cost of the 5-year, 24-hour design storm was not the most important factor. Other considerations were valid, such as the fact that a larger number of customers would have to pay high upfront costs if the 1-year, 24-hour design storm was selected given that fewer wastewater capacity issues would be addressed by SPU
- The 5-year, 24-hour event is robust, in that it includes rainfall intensities for several durations, which are based on IDF curves developed based on historical data from 1977-2017 from all of SPU's rain gages. It incorporates the most up to date understanding of precipitation in Seattle
- The ISP will identify projects and programs to address wastewater capacity issues over a 50-year period. The team felt that the 5-year, 24-hour storm was a good measure of what DWW should be planning for long-term and that 1- and 2-year, 24-hour storms were too insignificant for the 50-year planning horizon

The performance goals and thresholds shown in Table 2-4 were approved and accepted by the Planning Management Team.

| **Table 2-4. Wastewater System Performance Goals and Thresholds** | |
|---|---|
| **Performance Goal** | **Performance Threshold** |
| Provide adequate capacity in the public wastewater system to minimize the risk of sewer backups into private property. | Adequate capacity is defined as surcharging less than one foot above the crown of the wastewater pipe for the storm event that delivers 2.7 inches of rain in 24 hours. |
| Provide adequate capacity in the public wastewater system to minimize the risk of sewer backups into the public ROW. | Adequate capacity is defined as no flooding at the wastewater maintenance hole rim for the storm event that delivers 2.7 inches of rain in 24 hours. |

## 2.3 System Performance Under Simulated Future Conditions

Future system performance was evaluated to understand how the wastewater system's performance may change in the future due to several factors. A modeling methodology was developed for SPU to estimate future wastewater flows accounting for redevelopment, population growth, and climate change – both sea level rise and changes to precipitation patterns (Osborn Consulting, Inc., 2018). These factors are anticipated to impact future wastewater flows in the following ways:

- Redevelopment can result in additional impervious areas which can increase peak flows and affect conveyance capacity. Due to the City's stormwater code requirements, new or replaced impervious areas associated with development may require flow control, which mitigate the increased flows and sometimes decrease existing flows
- Population growth increases dry weather flow into the wastewater system.
- While sea level rise will not increase flows, it will increase the HGL at outfalls to Puget Sound. A higher HGL could result in backups upstream of the CSO outfalls
- Changing precipitation patterns can result in increased precipitation, increasing peak flows in the conveyance system

The future flows methodology recommended estimating population growth and redevelopment based on Puget Sound Regional Council's predicted population changes for the year 2035. These were the latest data available and set the future conditions to year 2035 for all the data used.

This methodology was applied for the WWSA to evaluate future wastewater system performance.

The first step was to modify the existing conditions models to develop future conditions models. Key steps included the following:

- Adjusting DWF average values to account for changes in population
- Adjusting model subcatchment percent imperviousness to reflect redevelopment and compliance with the City's Stormwater Code. This value could increase or decrease depending on redevelopment patterns and the Stormwater Code requirement
- Updating tidal boundary conditions to reflect a higher projection of sea level rise for the year 2035. Mean Higher-High Water (MHHW) was adjusted up 11.3 inches from the existing conditions value of 9.02 feet
- Using modified design rainfall time series with increased rainfall peak intensities and magnitudes to account for climate change. Each analysis design storm was multiplied by a scaling factor based on the

scaling factors in *Combined Sewer Overflow Sizing Approach Implementation: Perturbing Precipitation Time Series to Future Climate Conditions* (CH2M, 2017). The storms with 1-year and 2-year return periods were increase by 5.6 percent and the storms with higher return periods were increased by 5.5 percent

In addition to the existing conditions models, the models used to identify capacity limited pipes were updated to reflect future conditions. Additional modifications were required for these models to ensure no flow restrictions.

Once the models were updated to represent future conditions, model runs were performed, and results were processed for the same Performance Thresholds as the existing conditions models. Table 2-5 shows the results for the 5-yr 24-hr design storm broken out by system type.

**Table 2-5. Citywide Performance Threshold Results for Future Conditions 5-yr, 24-hr Design Storm by System Type**

| Performance Threshold | Simulated surcharge 1 ft or greater | | Simulated MH Flooding | |
|---|---|---|---|---|
| | Length (miles) | % of all surcharged pipes | Flooded MHs | % of all flooded MHs |
| **System Type** | | | | |
| Combined | 269 | 58% | 1,712 | 71% |
| Partially Separated | 164 | 35% | 584 | 24% |
| Separated | 31 | 7% | 117 | 5% |
| **Total** | **464** | **100%** | **2,413** | **100%** |

*Note: Total length of SPU wastewater system pipe analyzed is approximately 1,400 miles*

In general, future conditions results showed a higher degree of surcharging in all sub-basins except for one where the existing and future conditions surcharge results were the same. Table 2-6 shows the comparison between existing and future conditions. Citywide, the percent of surcharged pipe length increased slightly from 30% under existing conditions to 33% under future conditions for the 5-yr, 24-hour storm. Simulated MH flooding increased to a lesser degree from 6% under existing conditions to 7% under future conditions. Maps showing change in system performance across the city for the 5-yr 24 hour design storm are presented in Figure 2-13 through Figure 2-16. Finer resolution details at a sub-basin level can be found in Appendix E: Sub-basin Summary Sheets.

**Table 2-6. Existing Vs. Future Citywide Performance Threshold Results**

| Design Storm Event | Surcharged Pipes (miles) | Surcharged Pipes (% of System) | Capacity Limited Pipes (miles) | Capacity Limited Pipes (% of System) | Flooded MHs | Flooded MHs (% of system) |
|---|---|---|---|---|---|---|
| Existing 5-year, 24-hour | 419 | 30% | 264 | 19% | 2,073 | 6% |
| Future 5-year, 24-hour | 464 | 33% | 288 | 21% | 2,143 | 7% |
| Difference | +45 | +3% | +24 | +2% | +70 | +1% |

*Note: Total length of SPU wastewater system pipe analyzed is approximately 1,400 miles*

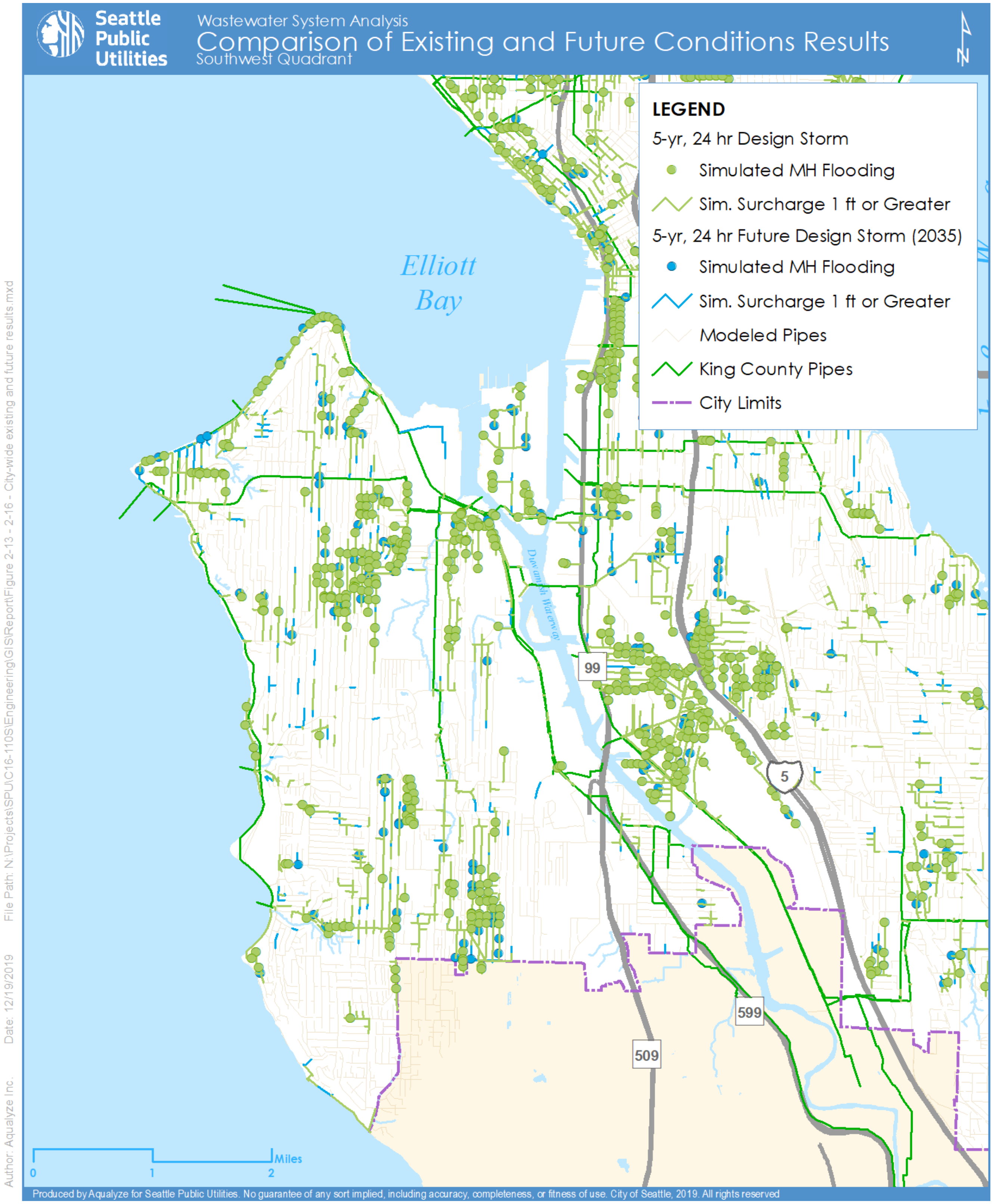



**Figure 2-13. Comparison of Existing and Future Conditions Results – Southwest Quadrant**

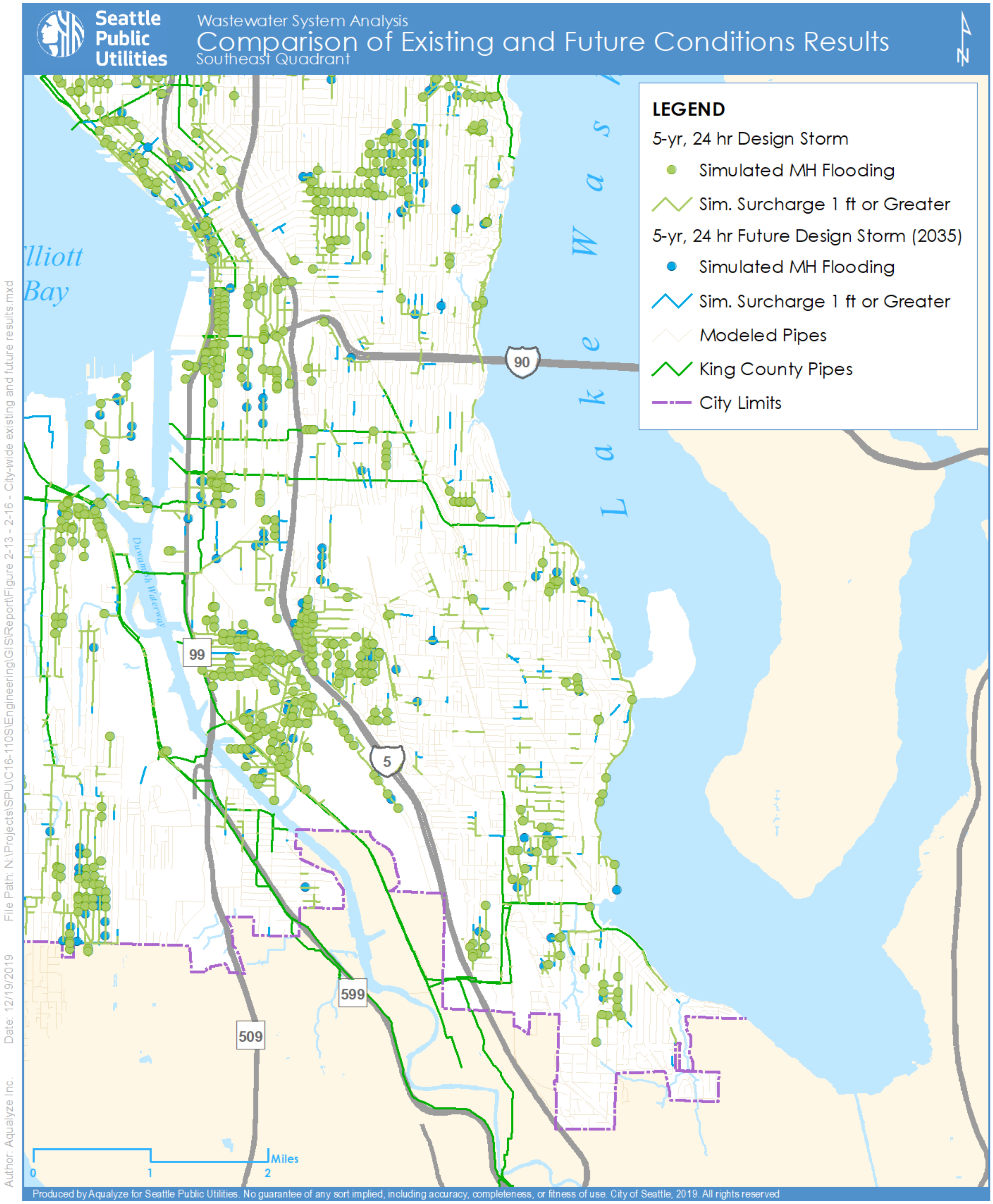



**Figure 2-14. Comparison of Existing and Future Conditions Results – Southeast Quadrant**

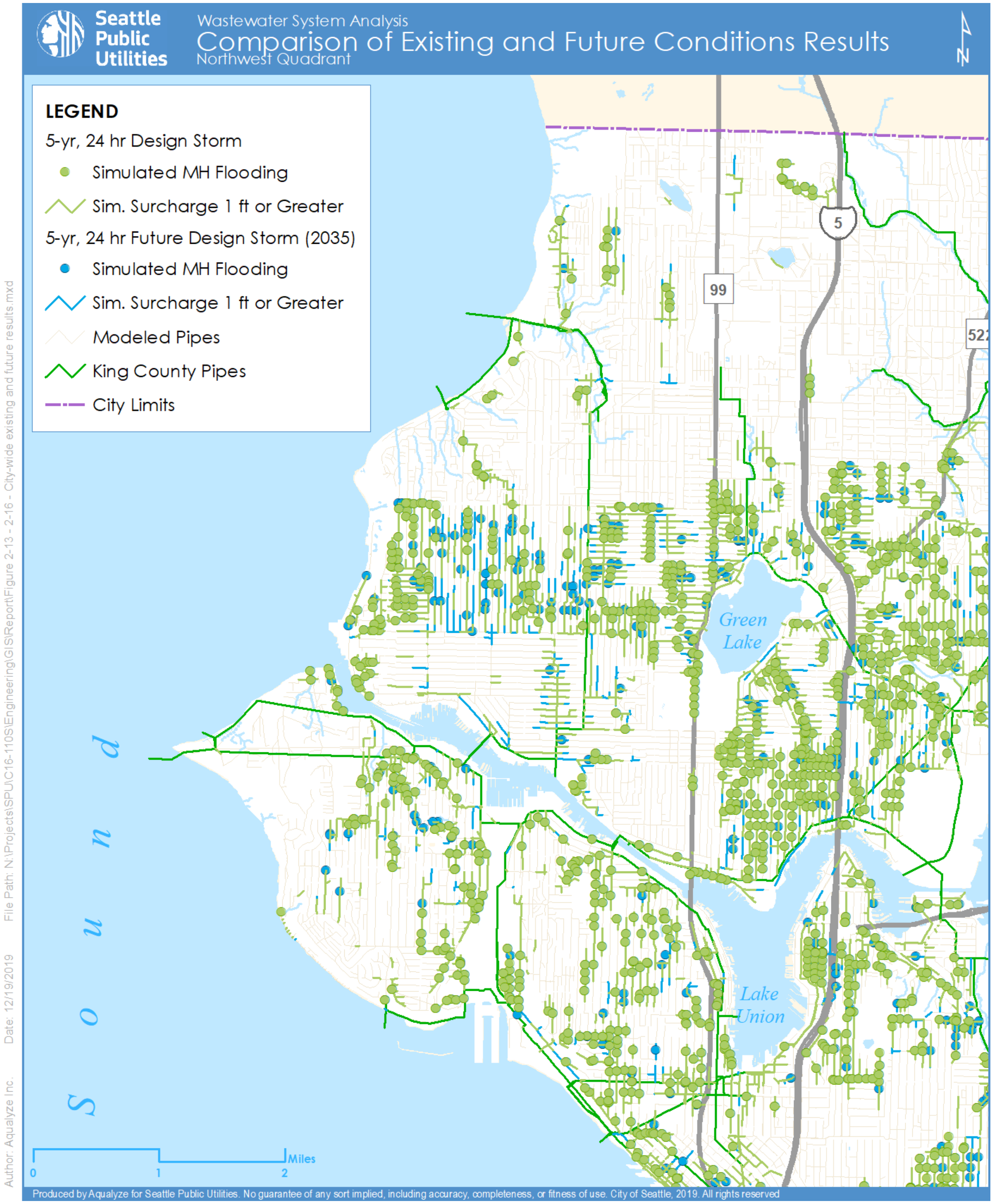



**Figure 2-15. Comparison of Existing and Future Conditions Results – Northwest Quadrant**

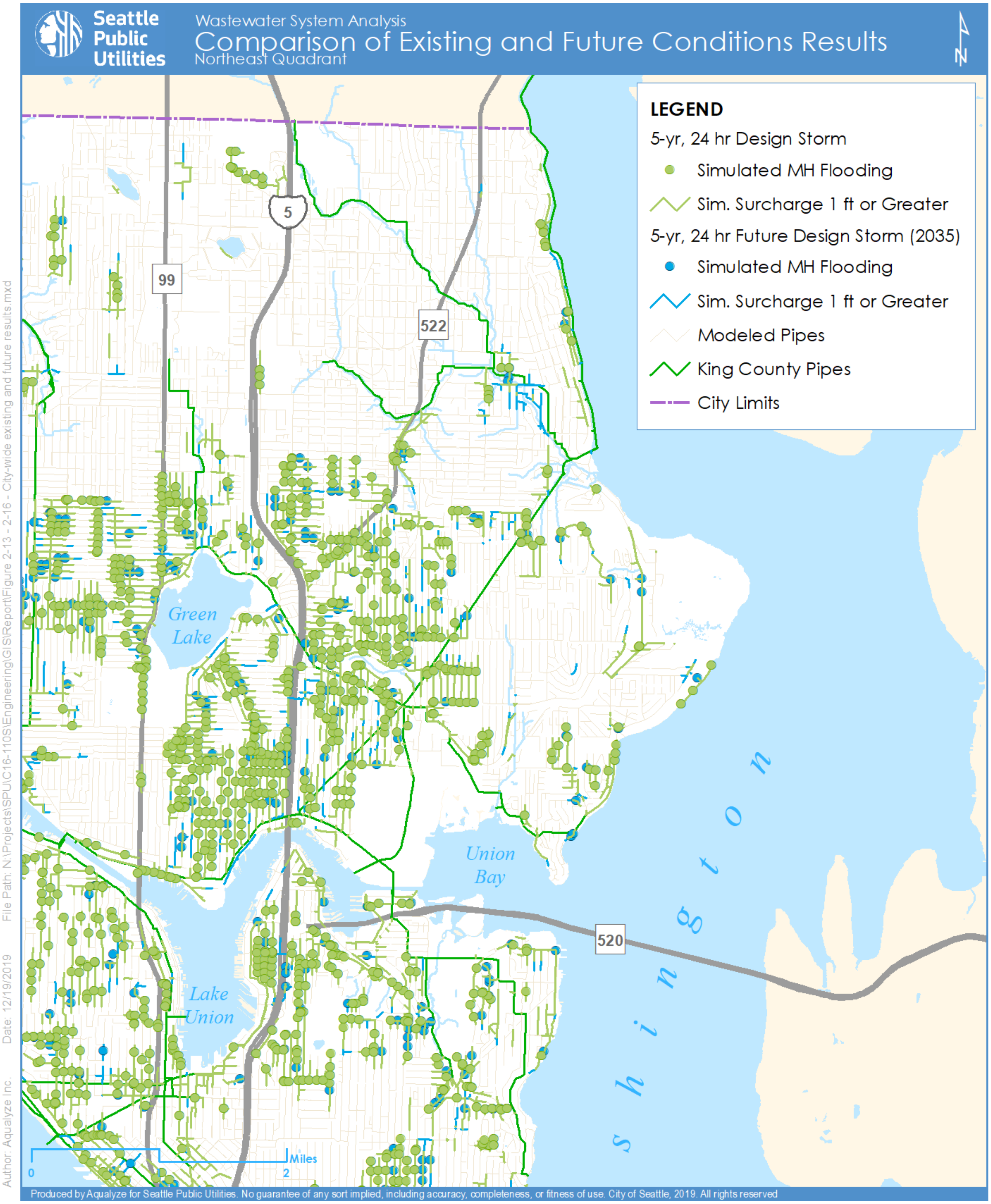



**Figure 2-16. Comparison of Existing and Future Conditions Results – Northeast Quadrant**

## 2.4 Sub-Basin Summary Sheets

Presentation of wastewater system analysis results citywide required a mechanism to synthesize results of the analysis in a meaningful way. Summary sheets containing system capacity analysis results, along with other relevant information, were developed in units of sub-basins to cover the complete SPU service area including King County facilities serving SPU.  The City was divided into 65 sub-basins to support a high-level planning analysis of wastewater system performance. These sub-basins were named using recognizable neighborhood terms such as Fremont, Ballard, Duwamish, etc.

The sub-basin summary sheets were designed to support a holistic appraisal of wastewater system performance integrating racial and socioeconomic data based on the recommendation of the Equity Strategy, SPU assets data, and hydraulic capacity modeling results. Background information that provides essential context for interpreting model results was combined with a base map, a map of the existing conditions model results and a map of the future conditions model results.

Information from many different sources was compiled to be included in the sub-basin summary sheets. This includes current land use population estimates, sub-basin system type (separated, partially separated, combined), DWF, inflow and infiltration (I/I) where applicable, intersecting CMOM Management Areas, overview of the wastewater system, and tabular summaries of capacity modeling results for both existing and future conditions.

A base map was prepared for each sub-basin, providing background and context for understanding the sub-basin. Capacity modeling results are displayed on two maps: one showing the existing conditions results for the 5-year 24-hour design storm and one showing the existing conditions results superimposed on the future conditions results for the 5-year 24-hour design storm, to facilitate assessment of areas where performance is predicted to worsen under future conditions.

Additional details on the development of summary sheets, along with the 65 sub-basin summary sheets, can be found in Appendix E.

# 3. Community Outreach

The WWSA included community outreach to supplement the technical analysis. SPU simultaneously planned outreach for the WWSA and the DSA, however, outreach for the WWSA was implemented based on the unique needs of the project.

Feedback from residents and business owners helped SPU determine whether they experienced wastewater system capacity issues such as backups on private property or sewer overflows in the ROW caused by the public wastewater system. Data gathered through community outreach was incorporated into risk area prioritization (Section 4.4)

This section provides an overview of the outreach goals, strategy and results.

## 3.1 Outreach Goals

Outreach goals for the WWSA were:

- Use strategic citywide outreach and targeted priority area outreach to confirm WWSA findings and to identify potential new wastewater capacity risk areas
- Educate SPU system users about Seattle's wastewater and drainage systems and issues, customer service and response tools, and the overall Integrated System Planning effort
- Use various outreach strategies to engage communities of color to ensure their needs are represented in outreach findings

## 3.2 Outreach Strategy

The WWSA outreach strategy was developed to meet the outreach goals and was informed by the outreach-specific recommendations of the Equity Strategy for System Analysis Projects (Appendix B), including:

- Set clear expectations about implementation of equity-focused communications and outreach best-practices, including:
  - Dedicate outreach funding specifically for low-income communities and communities of color
  - When resources are limited, prioritize outreach resources for outreach to low-income communities and communities of color
  - When time is limited, prioritize outreach to low-income communities and communities of color in the schedule
- Ensure demographic information is gathered as part of public outreach to determine if our efforts are successfully targeting a diverse range of community members
- Provide information about SPU generally, in addition to gathering information on risk areas
- Ensure coordination between WWSA and DSA outreach and other overlapping SPU outreach efforts to ensure that communities of color are not overburdened by SPU outreach efforts
- Build a partnership with SPU's Community Connections Program that works on outreach strategy, planning, materials and implementation

The SPU outreach team examined a variety of outreach strategies that ranged from citywide surveying to geographically relevant information and stories. The outreach team decided to send surveys to parcel owners and occupants. The decision to gather qualitative information from parcel occupants and owners within identified geographies was influenced by a higher than expected number of priority areas and a desire to do a deeper dive to collect feedback in these specific locations.

The team determined that a qualitative, survey-based strategy would best meet identified outreach goals to confirm WWSA model results. We targeted three primary groups:

1. SPU customers who live in specific areas were prioritized for outreach (Section 3.2.1 Priority Area Outreach)
2. Communities of color through partnership with SPU's Community Connection program (Section 3.2.2 Community Connections Outreach)
3. SPU customers citywide to identify potential gaps in results from the targeting outreach (Section 3.2.3 Citywide Outreach)

SPU provided information and links to the survey in an online format to SPU customers in specific areas identified in (1.) above. Refer to Appendix H for a copy of the survey and informational materials. Paper surveys were also available upon request. Survey questions were translated into Spanish, Vietnamese, Korean, Simplified Chinese, Traditional Chinese, Tagalog, and Somali. The survey included questions about wastewater and drainage issues and side sewers in order to be efficient with resources, limit engagement fatigue, and because drainage and wastewater issues are often indistinguishable to community members.

Outreach efforts were planned for the rainy season (early 2019) so that rain and neighborhood flooding or other indications of sewer capacity issues would be visible and on people's minds.

### 3.2.1 Priority Area Outreach

SPU identified a list of initial priority areas across the city based on the results of the modeling analysis. Model results identified 92 initial areas where residents and customers may have a higher likelihood of experiencing sewer overflows or observing maintenance hole flooding in the ROW during a 1-year, 24-hour design storm.

The consultant outreach team and SPU went through two rounds of prioritization to strategically focus outreach resources. The team prioritized areas:

- **Where SPU did not have reports of sewer overflows:** SPU compared model results with the location of reported sewer overflows. Many of the initial priority areas were identified in locations where SPU did not already have reports of sewer overflows. The lack of information in these areas made it more important to learn about customer experiences.
- **Not part of active SPU wastewater capacity capital projects:** Some initial priority areas were identified in locations where SPU has capital projects in progress (such as the Pearl Street project area in Beacon Hill and sewer and drainage improvements in the Broadview neighborhood). Areas that did not have active capital projects addressing wastewater capacity issues were assigned a greater priority.
- **Where customers were potentially less likely to report problems:** Some initial priority areas were identified in parts of the City where customers may be less likely to report wastewater issues due to lack of action by the City when issues were reported in the past, language barriers, or lack of awareness of how to report issues. These communities may also be in traditionally underserved areas of

the city and include people of color, immigrants, refugees, and low-income SPU customers. WWSA outreach in these areas provided customers with SPU contact information in-language, as needed.

The prioritization process yielded 13 final priority areas for targeted mailings and door-to-door outreach. An additional 30 priority areas received targeted mailings only. The final priority areas where door to door outreach occurred were in the following neighborhoods (see Figure 3-1):

- Beacon Hill (2)
- Crown Hill (1)
- Georgetown (1)
- Haller Lake (1)
- International District/Chinatown (1)
- Licton Springs (1)
- Rainier Beach (2)
- SODO (2)
- Queen Anne (1)
- West Seattle (1)

SPU's targeted outreach in these priority areas sought to corroborate model results, including information on the presence or absence, severity, recurrence and duration of wastewater system issues experienced by residents and customers. SPU tailored outreach tactics for each of the selected neighborhoods, based on its specific character and needs. These tactics included post card mailings (and targeted follow-up mailings), door-to-door canvassing, targeted social media advertising, outreach to business and industrial groups, and coordination with community-based organizations (see Section 3.2.2 Community Connections Outreach).

The project team partnered with the Longfellow Creek Water Quality Improvement Project in the Delridge 168 and 169 combined sewer basins in West Seattle. In order to collect information that may be useful for that project, post cards were also sent to addresses within the Longfellow Creek project area.

Interpreters conducted in-person outreach to non-English speaking households and businesses in Cantonese, Mandarin, and Vietnamese. In addition, translated fact sheets and surveys were available in Simplified Chinese, Traditional Chinese, Korean, Somali, Spanish, Tagalog, and Vietnamese.

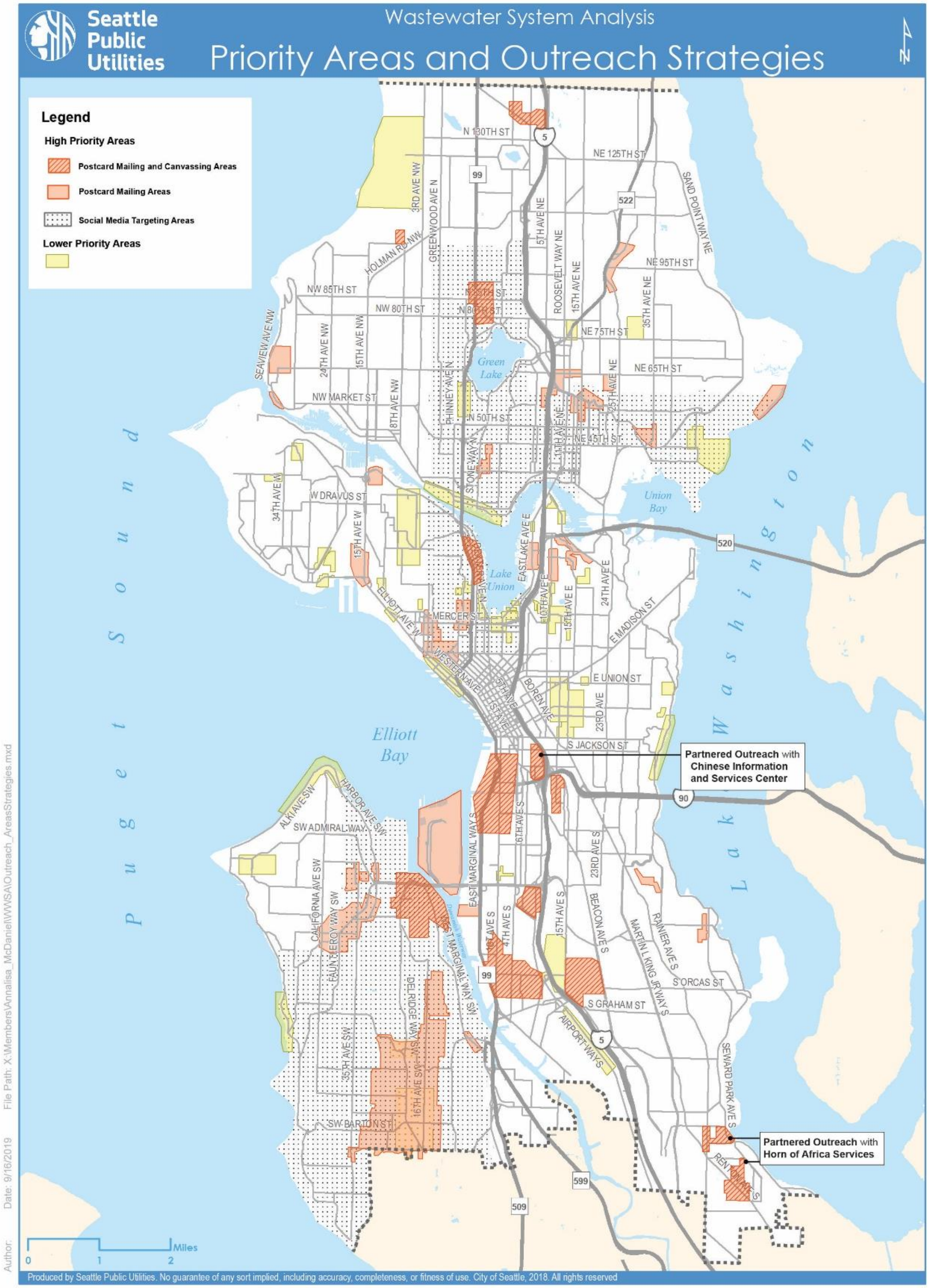



**Figure 3-1. Priority Areas and Outreach Strategies**

### 3.2.2 Community Connections Outreach

SPU worked to engage communities of color by partnering with community-based organizations that are contracted through its Community Connections program. To better support people of color, immigrant, refugee and low-income customers SPU funds multi-year partnerships with trusted organizations and leaders that serve a variety of ethnic and language groups. These organizations included Chinese Information Service Center (CISC), Horn of Africa Services (HOAS), and ECOSS. CISC and HOAS organizations conducted direct door-to-door outreach in the International District/Chinatown and Rainer Beach wastewater priority areas respectively, which are communities where they provide services and have existing relationships. CISC integrated questions about the sewer and drainage systems into their existing community events and meetings. HOAS conducted 380 survey-focused interviews with community members about their experiences with the drainage and wastewater system. Additionally, Cascadia, the lead consultant for DSA outreach, and ECOSS collaborated on outreach in DSA priority areas including Puget Ridge and Rainier Ave communities where information was gathered on flooding and wastewater issues.

### 3.2.3 Citywide Outreach

A citywide outreach campaign shared information about the WWSA and created opportunities for customers to learn about the City's wastewater system and share their stories about system issues in areas of the city not included in the 15 final priority areas. A website, ("Raincheck") provided context for the analysis effort and included an online mapping tool that allowed users to submit locations where they have experienced wastewater or drainage problems in the public right of way. An abbreviated online version of the priority area survey was coupled with the mapping tool, allowing users to share information on system challenges they have observed.

Residents and SPU customers outside priority areas were also directed to the Raincheck website and associated survey through neighborhood news outlets (such as the West Seattle Blog and Seattle Greenlaker), as well as social media. Links to the survey were also provided to all SPU customers who receive the @ Your Service newsletter, a monthly information source provided through paper and electronic billing services.

## 3.3 Outreach Results

Results from WWSA outreach efforts included:

- Over 19,000 mailers with links to surveys were distributed to the final 15 outreach priority areas. Additionally, over 2,400 homes and businesses were visited by the outreach team as a follow-up to the mailer. Survey response density is shown in Figure 3-2
- SPU reviewed the outreach data and made informed decisions about whether the reported issues were about the drainage or the wastewater system. Survey results were reviewed by SPU and incorporated into risk area prioritization (See Section 4.4). Drainage problems were referred for inclusion into the DSA

- SPU received 468 completed surveys from outreach in priority areas. Ninety-two reports of sewer overflows received through survey responses were incorporated into risk area prioritization (See Section 4.4).
- Of the 92 responses incorporated into risk area prioritization:
  - Sixty-six responses (72%) were located within the 38 model-identified risk areas and 26 responses (28%) were located outside of model-identified risk areas
  - Thirty-eight responses (41%) reported ROW flooding in areas of the city that are served by a combined and partially separated wastewater system. (ROW flooding reported in areas served by a separated wastewater system were considered a drainage issue as opposed to a wastewater issue)
  - Fifty-four responses (59%) reported backups or flooding into private property that may have contained sewage. Of these, 31 (34%) reported that the backup or flooding had caused property damage
- Of the 468 completed WWSA surveys from outreach priority areas, 355 respondents (76%) provided optional, self-identified demographic information. These responses identified:
  - **Race:** 235 respondents (66%) identified as white, 13 respondents (4%) identified as Chinese, 5 respondents (1%) identified as Filipino, 2 respondents (<1%) identified as black or African American, 2 respondents (<1%) identified as Vietnamese, 27 respondents (8%) identified as "other," and 5 respondents (1%) identified as "I don't know," 66 respondents (19%) declined to answer
  - **Hispanic, Latino, or Spanish Origin:** 11 respondents (3%) identified as being of Hispanic, Latino, or Spanish origin
  - **Annual Household Income:** 11 respondents (3%) identified an income below $25,000, 26 respondents (7%) identified an income of $25,000 - $49,999, 40 respondents (11%) identified an income of $50,000 - $74,999, 39 respondents (11%) identified an income of $75,000 - $99,999, 87 respondents (25%) identified an income of $100,000 – $149,999, 74 respondents (21%) identified an income of $150,000 or over, 5 respondents (>1%) did not know, and 72 respondents (20%) declined to answer
  - **Gender:** 172 respondents (48%) identified as female, 155 respondents (44%) identified as male, 2 respondents (<1%) identified as other, and 26 respondents (7%) declined to answer
  - **Property Owners:** 300 respondents (85%) identified that they own the property, 55 respondents (15%) did not own the property or declined to answer
  - **Age:** 38 respondents (11%) identified as 18-34, 177 respondents (50%) identified as 35 – 54, 71 respondents (20%) identified as 55 – 64, 53 respondents (15%) identified as 65 or older, and 16 respondents (<5%) declined to answer
- Twelve WWSA surveys were completed in-language (10 in traditional Chinese, 1 in simplified Chinese, and 1 in Vietnamese)
- In addition to the 468 completed surveys from the outreach priority areas, 380 surveys were completed through the outreach conducted by SPU's Community Connections partners. These survey results were also reviewed by the WWSA team and responses that indicated potential sewer overflows were also

incorporated into risk area prioritization. Those survey response results are presented in the Horn of Africa Services "Drainage and Wastewater, and Side Sewer Survey Report" dated March 22, 2019

- Seventy-seven entries were provided through the online Raincheck website; however, all responses highlighted drainage issues in the public right of way and were therefore not incorporated into risk area prioritization
- All information collected through outreach that indicated a drainage system related issue was referred on to the DSA team for incorporation into that project

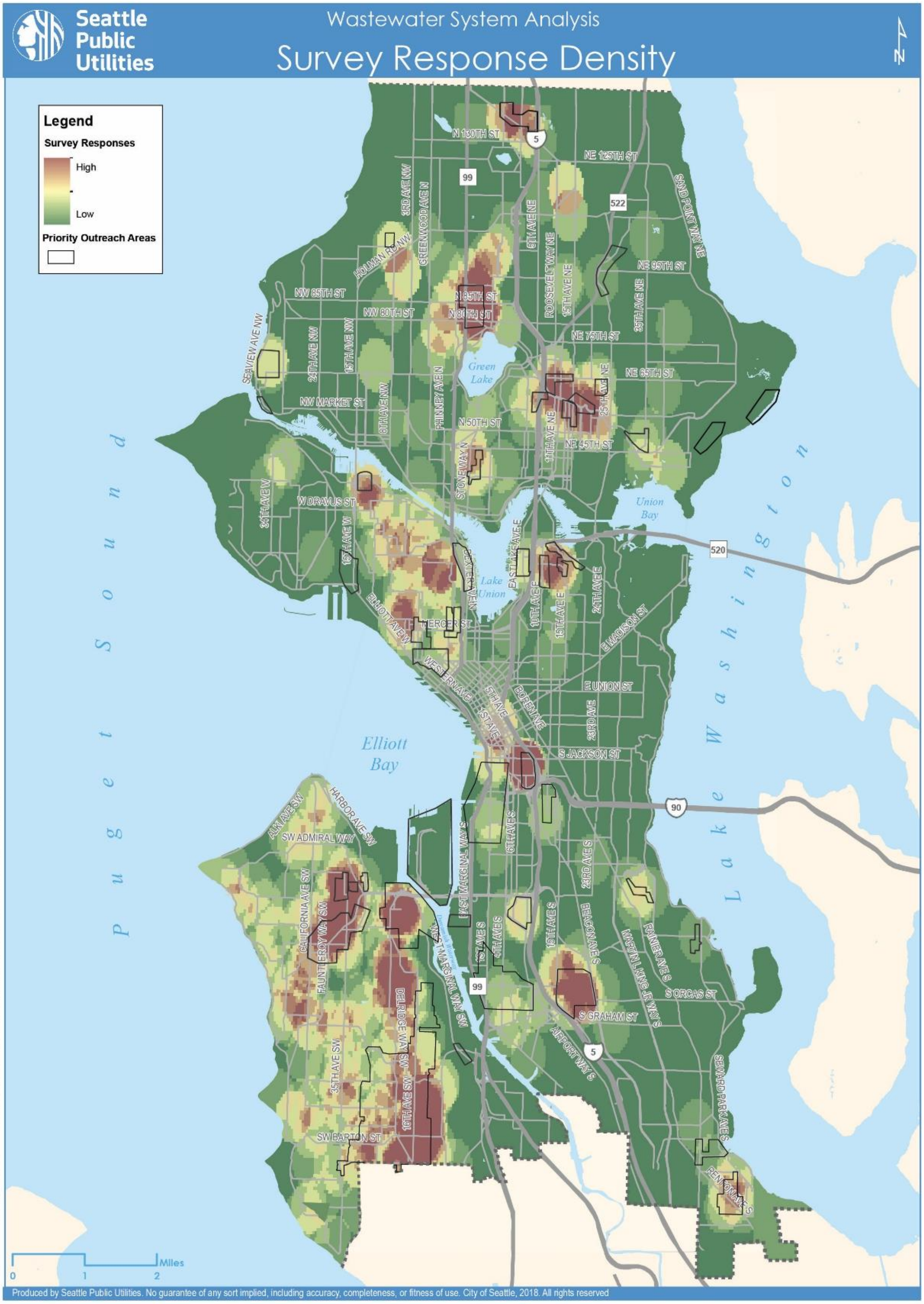



**Figure 3-2. Survey Response Density**

### 3.3.1 Discussion

Below is a discussion of some of the key findings, limitations, and lessons learned from the WWSA outreach.

- **Key Findings:**
  - Generally, survey responses corroborated the results of the modeling analysis.
  - Door to door outreach confirmed that the low survey response rate is at least partially an indication that many people within the modeled risk areas have not experienced significant sewer backups or observed MH flooding. Conversations identified that customers who did not experience backups or observe MH flooding were less likely to participate in the survey.
- **Limitations:**
  - Outreach was conducted during a relatively dry winter and early spring season (2019), which may have resulted in lower survey participation rates. In addition, there were responses that spoke to snowmelt-related flooding due to significant snow events in February 2019.
  - The complexity of the drainage and wastewater system makes it difficult to determine whether survey respondents were reporting a wastewater or a drainage issue. For example, when respondents reported ROW flooding, the information they provided did not always clearly demonstrate whether flooding included wastewater. The presence of wastewater in ROW floodwater is a possibility in the combined or partially separated areas of the city; however, ROW flooding in these areas could be caused by several issues in addition to pipe capacity, including improper road grading, pavement and parking lane quality, etc. The survey attempted to guide responses to gather clear information on the cause of flooding, but it was not always successful in doing so.
  - The results demonstrated that the distinction between public and private infrastructure was not clear to survey respondents. As SPU analyzed survey information, backup events that occurred during dry weather were considered to be private infrastructure problems (e.g., issues with a home's side sewer). Other storm-related reports were clearly related to failures of private infrastructure, such as sump pumps. SPU reviewed the outreach data and made informed decisions about whether the reported issues were about private or public infrastructure. Wastewater problems reported about private infrastructure were not included in risk area prioritization.
- **Lesson Learned:**
  - Different outreach methods were effective in different ways. Priority areas engaged through mailings and in-person canvassing efforts had lower response rates; however, these surveys had a high rate of completion (approximately 80%). Social media and digital media advertisements yielded high numbers of survey responses in advertised areas; however, survey completion rates were not as high as responses to more targeted mailing and canvassing. While partial surveys did yield some useful data, more complete responses generally yielded more data useful to the risk area prioritization.

# 4. Risk Area Identification and Prioritization

Risk areas were delineated and prioritized to understand areas in the city at risk of not meeting the WWSA Performance Thresholds. The following steps were completed to identify and understand the areas at risk of not meeting the WWSA Performance Thresholds:

- Delineate risk areas (Section 4.1)
- Develop risk-based prioritization criteria (Section 4.2)
- Develop a prioritization tool (Section 4.3)
- Use the tool to score and prioritize risk areas (Section 4.4)
- Develop Risk Area Fact Sheets for the highest priority areas (Section 4.5).

## 4.1 Risk Area Delineation

A risk area is an area, including parcels and ROW, served by hydraulically connected wastewater pipes that exceed Performance Thresholds. Risk areas were delineated manually in GIS. All pipes predicted to not meet the pipe surcharge performance parameter (> 1 foot above pipe crown) in the 5-year, 24-hour design storm, and all MHs predicted to flood in the 5-year, 24-hour design storm were displayed in GIS along with parcel and side-sewer GIS data from SPU (parcel data supplied Jan 2018, side-sewer data supplied July 2017). Risk area polygons were drawn around all parcels served by hydraulically connected pipes based on the following guidelines:

- Risk areas should include at least one simulated flooded MH during the 5-year, 24-hour design storm
- Risk areas should be distinct and include one problem, and not multiple problems in close proximity
- Risk areas should include (1) parcels served by the mainlines simulated as not meeting the Performance Threshold and (2) clipped ROW polygons
- Each risk area should be represented by a single, topologically correct polygon. Risk area polygons should not overlap. There should not be any multi-part polygons or slivers

SPU's wastewater collection system is complex and has evolved over a century. There are many parts of the city where the network does not conform to expectations; for example, where there are multiple mainlines in a single ROW or a mainline running under private properties with those properties not connected to it, or one property on a block that connects to a different mainline than the rest. As each exception was encountered by the Consultant team, it was communicated with SPU via e-mail, a decision was made about how to treat it, and that decision disseminated to the rest of the Consultant team so that all other cases could be handled similarly.

Three hundred eighty-four risk areas were delineated. They were numbered from south to north, with areas west of the Duwamish Waterway numbered first. Then risk-based criteria (see Section 4.3) were used to prioritize the risk areas (see Section 4.4).

## 4.2 Risk-Based Prioritization Criteria

SPU developed a set of risk-based criteria to prioritize the wastewater capacity risk areas. The prioritization criteria were developed based on SPU's Risk Assessment Framework, staff subject matter expertise, and a review of past prioritization criteria developed and applied by SPU (Seattle Public Utilities, 2007).

Risk is assessed based on the consequence of a sewer overflow or backup and simulated likelihood of that backup or overflow, with consideration that vulnerable communities are disproportionately impacted by sewer overflows. To calculate Risk the consequence score is multiplied by the likelihood score, which each have a maximum value of five points. An equity score of up to five points is added to the product of consequence and likelihood for a final maximum risk score of 30 points. The equation to calculate the risk score is shown in Figure 4-1. The higher the risk score, the higher the risk associated with a potential sewer backup or overflow.

$$\underset{\text{2 - 30}}{\text{Risk}} = \left( \underset{\text{1 - 5}}{\text{Consequence}} \times \underset{\text{1 - 5}}{\text{Likelihood}} \right) + \underset{\text{1 - 5}}{\text{Equity Score}}$$

*Points Possible*: Risk 2 - 30; Consequence 1 - 5; Likelihood 1 - 5; Equity Score 1 - 5

**Figure 4-1. Risk Score Equation**

### 4.2.1 Consequence Criteria

Consequence, also referred to as "impact," is the potential consequence of the wastewater system being under capacity. The consequence score is the sum of the five criteria shown in Table 4-1and described in detail in this section. The five criteria are:

- Existing conditions model results
- Future conditions model results
- Confidence in model results
- Presence of critical facilities
- High use areas

Weights were not assigned to the consequence criteria, rather the number of points assigned to each criterion represents its relative importance.

Three of the criteria, existing conditions, future conditions, and confidence in model results capture our current understanding of the extent of backups and overflows within a given risk area. Current and future conditions results account for 3.0 points, or 60% of the consequence score.

Confidence in model results criterion is included to assign higher points to risk areas where we have more confidence in the model results. The confidence criterion accounts for 0.5 points, or 10% of the consequence score.

Two of the criteria, critical facilities and high use areas are included because the presence of either a critical facility or high use area has the potential to increase the impact of a backup or overflow. Combined, these criteria account for 1.5 points, or 30% of the consequence score.

| **Table 4-1. Consequence Criteria and Scoring** | |
|---|---|
| **Criteria** | **Score** |
| **1. Existing Conditions** | |
| Existing Conditions Model Results, Private Property | |
| Simulated surcharge < 1' above crown | 0.00 |
| Simulated surcharge > 1' above crown for <1,500 ft of mainline | 0.48 |
| Simulated surcharge > 1' above crown for 1,500 - 4,000 ft of mainline | 0.97 |
| Simulated surcharge > 1' above crown for >4,000 ft of mainline | 1.45 |
| Existing Conditions Model Results, ROW | |
| No simulated MH overflow | 0.00 |
| Simulated flooding from 1 - 2 MHs | 0.48 |
| Simulated flooding from 3 - 5 MHs | 0.97 |
| Simulated flooding from >5 MHs | 1.45 |
| **Existing Conditions Total** | **2.90** |
| | |
| **2. Future Conditions** | |
| Future Conditions Model Results | |
| Increase in number of simulated flooded MHs | 0.10 |
| Unchanged number of simulated flooded MHs | 0.00 |
| **Future Conditions Total** | **0.10** |
| | |
| **3. Confidence in Model Results** | |
| Corroborated Sewer Overflow | |
| Corroborated sewer overflow in risk area | 0.25 |
| No corroborated sewer overflow in risk area | 0.00 |
| Model Calibration Quality | |
| Model calibration quality is fair | 0.25 |
| Model is uncalibrated or poor calibration quality | 0.00 |
| **Confidence in Model Results Total** | **0.50** |
| | |
| **4. Critical Facilities** | |
| Critical facility in risk area | 0.75 |
| No critical facility in risk area | 0.00 |
| **Critical Facilities Total** | **0.75** |
| | |
| **5. High Use Area** | |
| > 50% of risk area is within high use area | 0.75 |
| 0 - 50% of risk area is within high use area | 0.75 x ratio |
| Risk area is not within high use area | 0.00 |
| **High Use Area Total** | **0.75** |
| | |
| **Maximum Consequence Score** | **5.00** |

**Existing Conditions Criterion.** The existing conditions criterion is separated into two sub-criteria: impacts to private property and impacts to ROW. Model results that simulate surcharge are used to score impacts to private property; model results that simulate MH flooding are used to score impacts to the ROW (see Figure 2-2 through Figure 2-5 and Figure 2-13 through Figure 2-16). For each sub-criterion, the length of pipe or number of MHs exceeding the Performance Threshold determines the score. Points are assigned on scale ranging from 0 to 2.90 based on the length of pipe and number of MHs.

Existing conditions GIS data used for prioritization was created by the Consultant Team for the WWSA (See Section 2) and finalized in February 2019.

**Future Conditions Criterion.** The future condition criterion is based on model results that simulate wastewater system performance under future conditions. The score is determined based on the increase in number of MHs predicted to exceed the Performance Threshold in future conditions. If the number of MHs exceeding the Performance Threshold is predicted to increase by 1 or more relative to existing conditions, 0.10 points are assigned. If the number of simulated flooded MHs remained constant or decreased, no points are assigned.

Future conditions GIS data used for prioritization was created by the Consultant Team for the WWSA (See Section 2.3) and finalized in September 2019.

**Confidence in Model Results.** Because models may over predict or under predict the impacts of a storm event, a criterion that identifies SPU's confidence in the model results was included. The confidence in model results criterion has two sub-criteria: corroborated sewer overflows and model calibration quality.

A corroborating sewer overflow can either be an SPU-confirmed sewer overflow that is recorded in Maximo or a sewer overflow reported through the WWSA outreach. A risk area receives 0.25 points for the corroborated sewer overflows criterion if SPU has record of a sewer overflows within the risk area.

SPU-confirmed sewer overflows are displayed in the "Sanitary Sewer Overflow (SSO) Locations" GIS data provided by SPU July 2017. For the purposes of assessing confidence in model results, all SSOs with a primary cause listed in Maximo of "Capacity – Gravity Main", "Capacity – King Co", "Extreme Wet Weather" or "Pump Station – Capacity" were counted as corroborating sewer overflows. SSOs caused by "Extreme Wet Weather" were included as these show where the wastewater system backs up during heavy rains.

Sewer overflow GIS data displaying overflows or backups reported through outreach were created by SPU and provided in April 2019. Ninety-two sewer overflows reported through outreach were incorporated into prioritization (See Section 3).

All metersheds in the wastewater system H&H models were assigned a calibration quality rating of fair, poor, or uncalibrated.

- Fair indicates that the metershed was calibrated as part of the WWSA and met SPU's calibration targets specified in Chapter 7 of the Design Standards and Guidelines (Seattle Public Utilities, 2017) and described in Appendix A
- Poor indicates that the metershed was:
  - Calibrated as part of WWSA but the calibration targets were not met for various reasons including meter data quality as discussed in detail in Appendix A (3% of the service area).
  - Calibrated as part of WWSA to King County SCADA data, which is lower quality than SPU

monitoring data (45% of the service area). Previously calibrated by others, where the project focus was not conveyance capacity (11% of the service area). Model areas developed and calibrated as part of the Long-Term Control Plan (LTCP) used different protocols than those used under current standards (and WWSA calibrated areas). Work through the WWSA has maintained the LTCP models' hydrology and sub-basin delineation.

- Uncalibrated indicates that the area has not been calibrated

A risk area receives 0.25 points if it falls in a metershed rated "fair." A risk area receives a score of 0 if it falls in a metershed rated "poor" or "uncalibrated." If a risk area crosses metersheds, it is scored based on the metershed of largest overlap.

Model calibration quality GIS data was created by SPU for the WWSA and finalized in January 2019 (Figure 4-2).

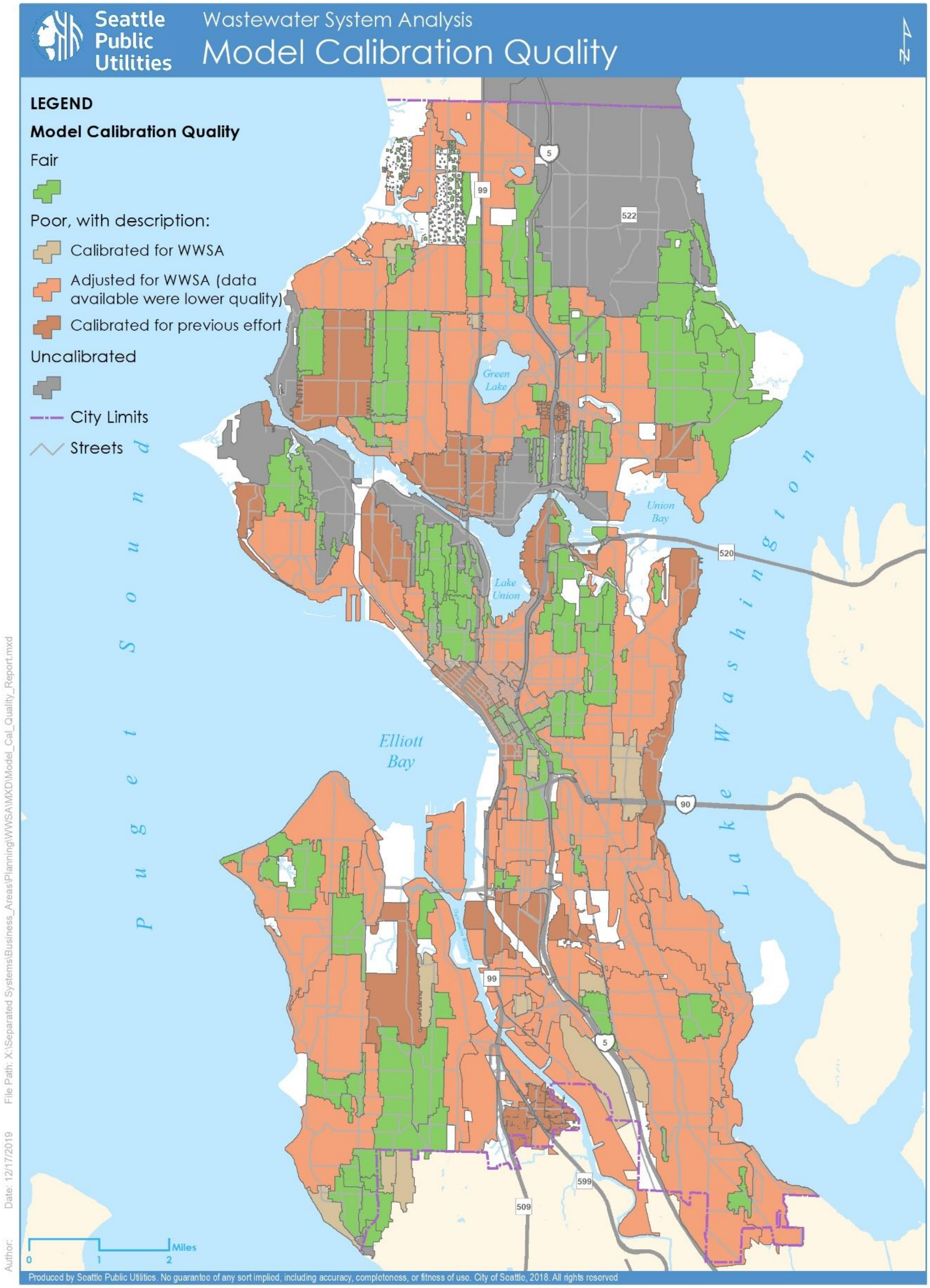



**Figure 4-2. Model Calibration Quality**

**Critical Facilities**. The critical facilities criterion is based on whether a critical facility is located within a risk area. Critical facility locations were derived from the list of critical facilities maintained by the Office of Emergency Management. The project team reviewed the list and included (1) facilities where sewer backups or overflows would cause negative impacts to operations; and (2) facilities that provide services to vulnerable populations that would be negatively and disproportionately impacted by sewer backups or overflows. A risk area receives 0.75 points if a critical facility is located within the risk area boundary.

Critical Facilities GIS data was created by SPU utilizing data from the Office of Emergency Management and finalized in December 2018 (Figure 4-3).

**High Use Area.** The high use area criterion is based on whether an area impacted by a sewer overflow or backup is likely to have a large number of pedestrians traveling in or through it relative to other areas of the city. A risk area receives up to 0.75 point if it is located completely or partially within a high use area.

High use areas include the following land uses and ROW buffers (data sources are provided in parentheses):

- Residential and Hub Urban Villages, including a 50-foot ROW buffer (Office of Community Planning and Development (OPCD))
- Urban Center, including a 50-foot ROW buffer (OPCD)
- Hospital campuses, including a 50-foot ROW buffer (City of Seattle)
- Colleges and universities, including a 50-foot ROW buffer (City of Seattle)
- Public and private schools, including a 50-foot ROW buffer (City of Seattle)
- Link light rail stops, including a quarter mile ROW buffer (Sound Transit)
- High frequency bus stops, including a 50-foot ROW buffer (King County Metro)
- Neighborhood greenways (Seattle Department of Transportation (SDOT))

High Use Area GIS data was created by SPU utilizing data listed above and finalized in September 2018 (Figure 4-4).

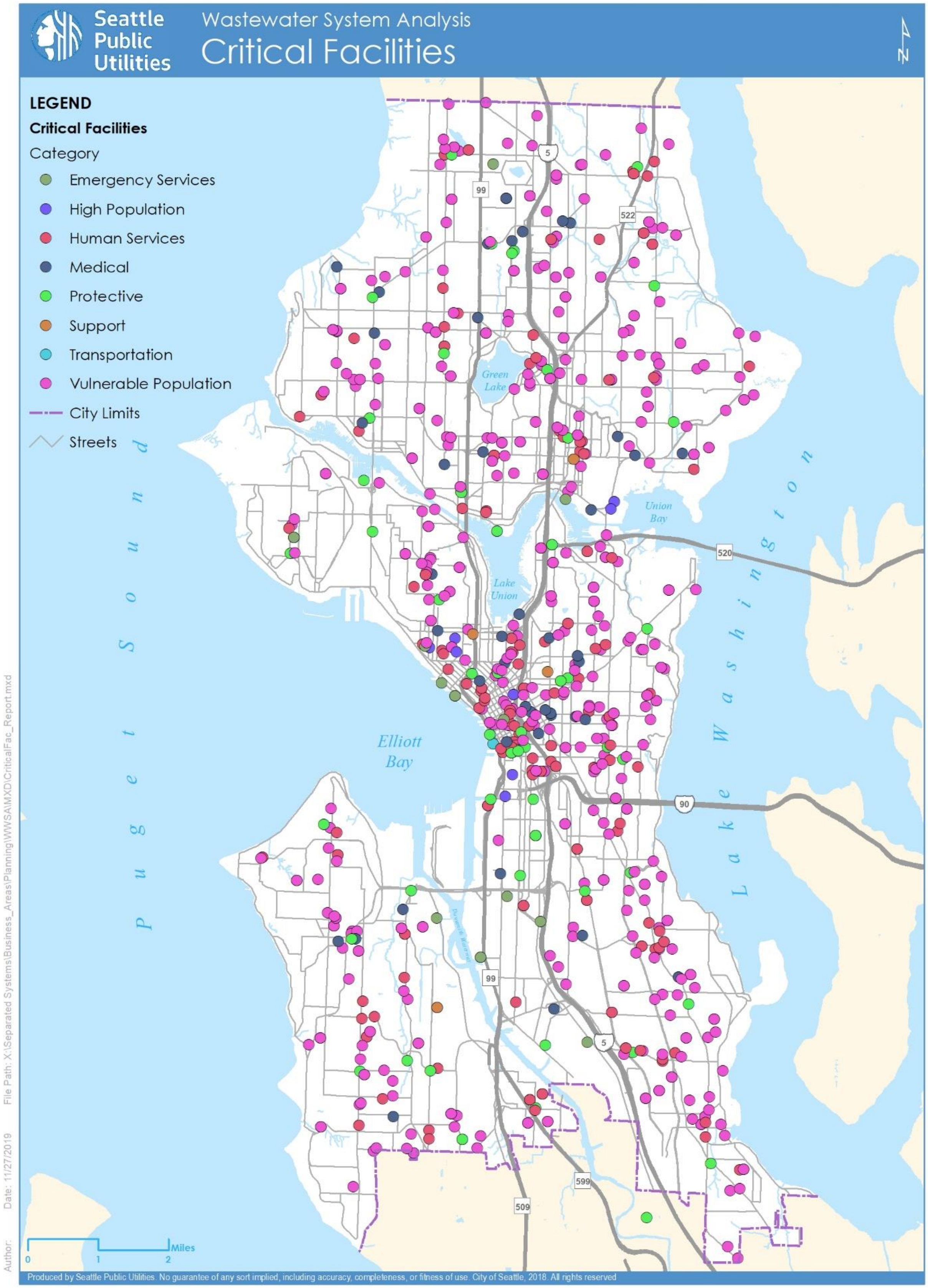



**Figure 4-3. Critical Facilities**

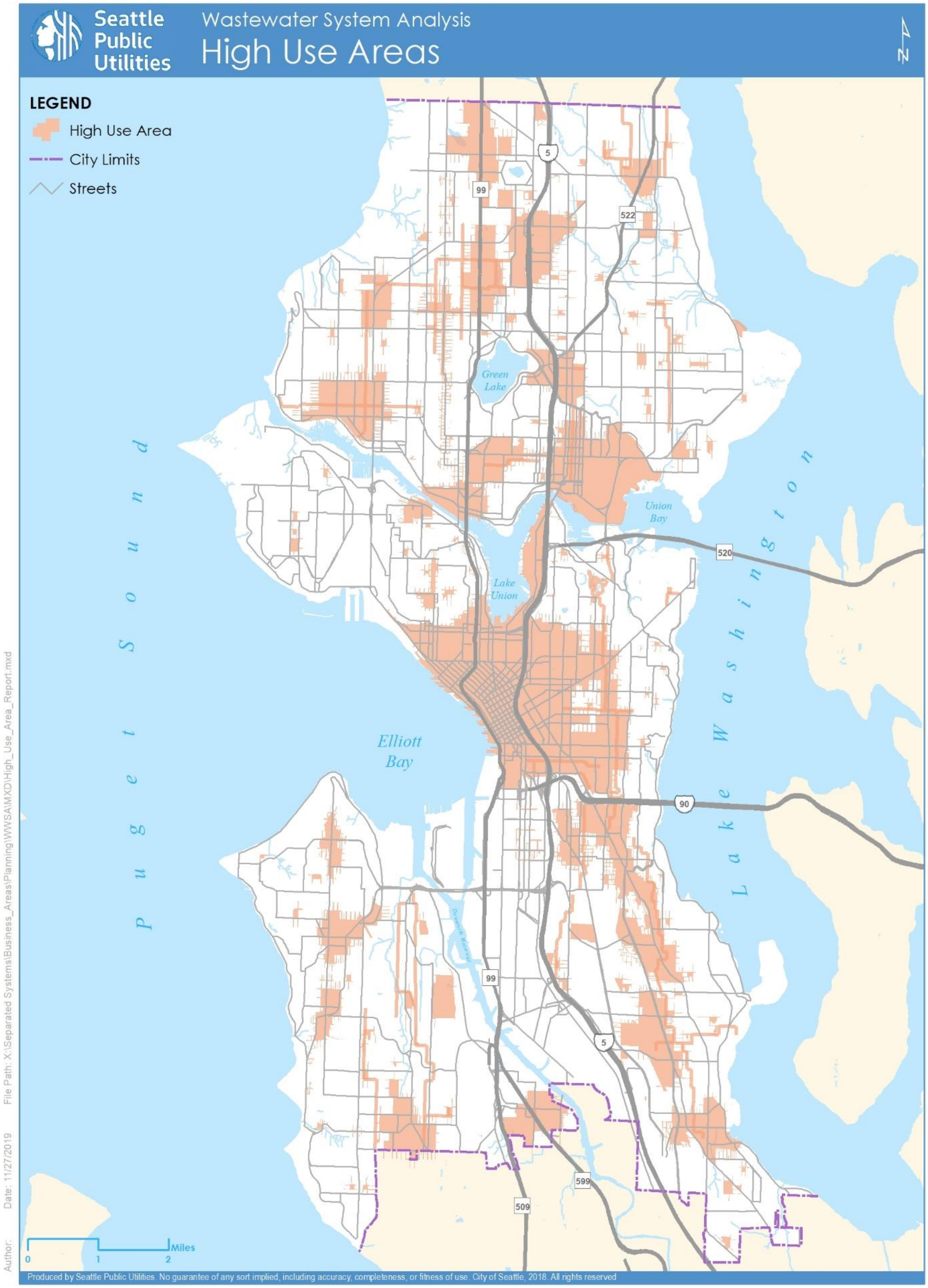



**Figure 4-4. High Use Area**

### 4.2.2 Likelihood Criteria

Likelihood is the second component of the risk score. A likelihood score is determined by storm recurrence, which is based on the probability that a storm will be equaled or exceeded in a given year.

Storm recurrence is based on the magnitude and duration of a storm event. The three design storms analyzed for the WWSA were:

- 1-year event delivering 1.4 inches of rain in 24 hours
- 2-year event delivering 2.0 inches of rain in 24 hours
- 5-year event delivering 2.7 inches of rain in 24 hours

The likelihood criteria and corresponding points are shown in Table 4-2. For example, a sewer overflow or backup was predicted to occur every year would receive a likelihood score of 5 while a sewer overflow predicted to occur approximately every seven years would receive a likelihood score of 2. The likelihood criteria focus on the frequency of system failures, not their impact or severity. Therefore, risk areas are scored based on the most frequent event that causes MH flooding; a risk area with one simulated flooded MH during the 1-yr, 24-hr event and two simulated flooded MHs during the 5-yr, 24-hr event would get a score of 5, and a risk area with no simulated flooded MHs in the 1-yr, 24-hr event and 10 simulated flooded MHs during the 5-yr, 24-hr event would get a score of 3. Only risk areas with a likelihood of 3 or higher (at least one simulated flooded MH during the 5-year, 24-hour design storm) were delineated for the WWSA.

**Table 4-2. Likelihood Criteria and Scoring**

| Likelihood Criteria | Score |
|---|---|
| Annual or more frequent storm recurrence (Sim. flooding in 1-yr, 24-hr event) | 5 |
| Storm recurrence between 1 and 2 years (Sim. flooding in 2-yr, 24-hr event) | 4 |
| Storm recurrence between 2 and 5 years (Sim. flooding in 5-yr, 24-hr event) | 3 |
| Storm recurrence between 5 and 10 years (Sim. flooding in 10-yr, 24-hr event) | 2 |
| Storm recurrence of more than 10 years | 1 |

### 4.2.3 Equity Criteria

One of the recommendations of the Equity Strategy for System Analysis Projects (Appendix B) was to incorporate equity into the prioritization criteria and tasks in a meaningful way. The equity score is used to acknowledge that areas of racial and socioeconomic disparity are at a relative disadvantage to recover from a sewer overflow. This element could have been incorporated into the consequence criteria instead since the impact of the sewer overflow is greater in these areas. However, SPU decided to separate the equity criteria out so that it would have greater influence on the final score. This score is based on the Racial and Social Equity Index developed by OPCD. The composite index includes measures of race, English speaking ability, national origin, socioeconomic disadvantage, and health disadvantage. It was derived from data from the U.S. Census Bureau, Centers for Disease Control and Prevention, Washington State Department of Health, and Public Health – Seattle & King County. The index is mapped by census tract and ranges from 1 (low) to 5 (high) racial and social equity disadvantage and priority. The final index scores were supplied by SPU as a GIS layer on 2/25/2019 (Figure 4-5).

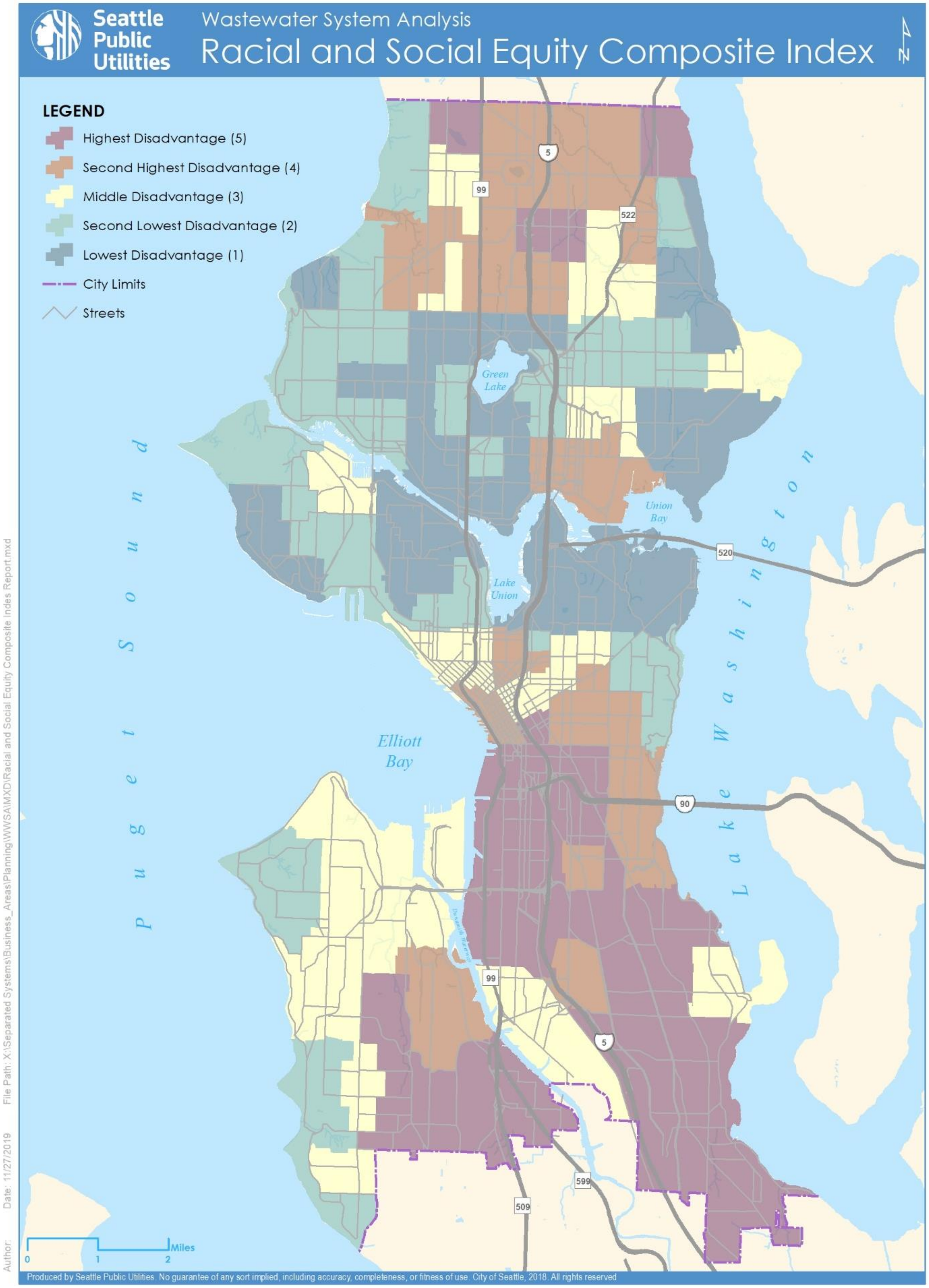



**Figure 4-5. Racial and Social Equity Composite Index**

The equity index includes the following measures:

- Race and ethnicity
  - Percentage of population who are persons of color
  - Percentage of population who are English language learners
  - Percentage of population who are foreign born
- Socioeconomics
  - Percentage of the population whose income is below 200 percent of poverty level
  - Percentage of the population age 25 and older with less than a bachelor's degree
- Health
  - Percentage of adults age 18 and older engaging in no leisure-time physical activity
  - Percentage of adults age 18 and older with diagnosed diabetes
  - Percentage of adults age 18 and older who are obese
  - Percentage of adults age 18 and older indicating mental health is not good for 14 or more days out of a month
  - Percentage of adults age 18 and older who currently have asthma
  - Life expectancy at birth
  - Percentage of the noninstitutionalized population 18 and older who have one or more disabilities

The equity criteria and corresponding points are shown in Table 4-3.

**Table 4-3. Equity Criteria and Scoring**

| Equity Criteria | Score |
|---|---|
| Lowest priority / least disadvantaged | 1 |
| Second lowest | 2 |
| Middle | 3 |
| Second highest | 4 |
| Highest priority / most disadvantaged | 5 |

## 4.3 Prioritization Tool

Once the prioritization criteria were finalized (Section 4.2), a prioritization tool (tool) was developed using the Microsoft Excel platform to prioritize risk areas and house the inventory of wastewater capacity risk areas. The tool is comprised of worksheets containing the input information, prioritization criteria, computations and results summary. The user can update the parameters for each criterion, adjust criterion weighting, and add newly delineated risk areas. As new information becomes available, input information can be revised, and scores will update automatically. The tool also contains graphs showing overall risk score and sub-component distributions so the user can review the impact of parameter choices on prioritization.

One concern with using numeric prioritization methods is the potential for a risk area to receive a score that seems misleading. For example, a risk area in an area that is generally affluent and therefore has a low equity score, but the simulated overflows or backups are adjacent to the one low-income apartment building in the census block. Therefore, to accommodate the potential need to adjust the risk score to correct unexpected outcomes, while still maintaining a robust and objective prioritization process, there are three 'Manual Adjustment' columns and a Manual Adjustment Documentation' column. If either the Consequence, Likelihood or Equity Score is determined by the user to misrepresent the risk area, the score can be adjusted in a transparent and documented way so that subsequent users can revisit that judgment call.

Once the prototype tool was developed, values for each prioritization criterion were computed for each of the 384 risk areas and combined with the results of the targeted outreach efforts (see Section 3). Blank rows were left for new risk areas to be entered. A total of 24 new risk areas were entered by SPU after reviewing the outreach data and SPU-investigated sewer overflows to identify areas where performance issues have been reported but for which the capacity modeling did not predict MH flooding in the 5-year, 24-hour design storm.

The protype tool was tested by SPU and suggested revisions were implemented, resulting in the final tool. Although the ability to adjust criterion weightings and enter manual score adjustments were important design objectives, these features were not used for the final risk area scores that are presented in this report.

## 4.4 Risk Area Prioritization

Risk areas were prioritized using the prioritization criteria described in Section 4.2. The prioritization method achieved a good distribution of scores for each of the three components of the risk score, allowing fine-scale discrimination among risk areas with broadly similar characteristics. The risk scores were divided into five priority categories: Critical, High, Medium, Medium Low and Low. The Jenks natural breaks classification method in ArcGIS was used to make the initial division between categories. This data clustering method calculates the best way to group values into classes where like areas are grouped together. It minimizes variation within each group so that values within each group are as close as possible to one another and it maximizes differences between categories. After natural breaks were determined, division boundaries were then adjusted to fall on whole numbers.

Overall distribution of scores for Consequence, Likelihood, Equity and Total Risk are summarized in Figure 4-6. In summary:

- Less than 9% of the risk areas had a consequence score greater than 4
- 21% of the risk areas had a Likelihood score of 5 signifying annual or more frequent storm recurrence (Simulated flooding in 1-yr, 24-hr event)
- 12% of the risk areas fell in the highest priority/most disadvantaged category of the Equity score
- 45 risk areas were categorized as critical and received a combined risk score greater than or equal to 19
- While critical risk areas (45 of 384) represent 12% of the total number of risk areas, these 45 areas comprise approximately 32% of the risk areas acreage
- Critical risk areas tend to impact a large hydraulically connected area
- Areas hydraulically connected to critical risk areas should be investigated regardless of their priority. This is important because hydraulically connected areas may share the same root cause as the critical risk area and a solution may exist that would mitigate more than one risk area. Additionally, removal of

capacity constraints upstream could increase capacity limitations downstream, so projects need to be sequenced so that all anticipated flows can be accommodated.

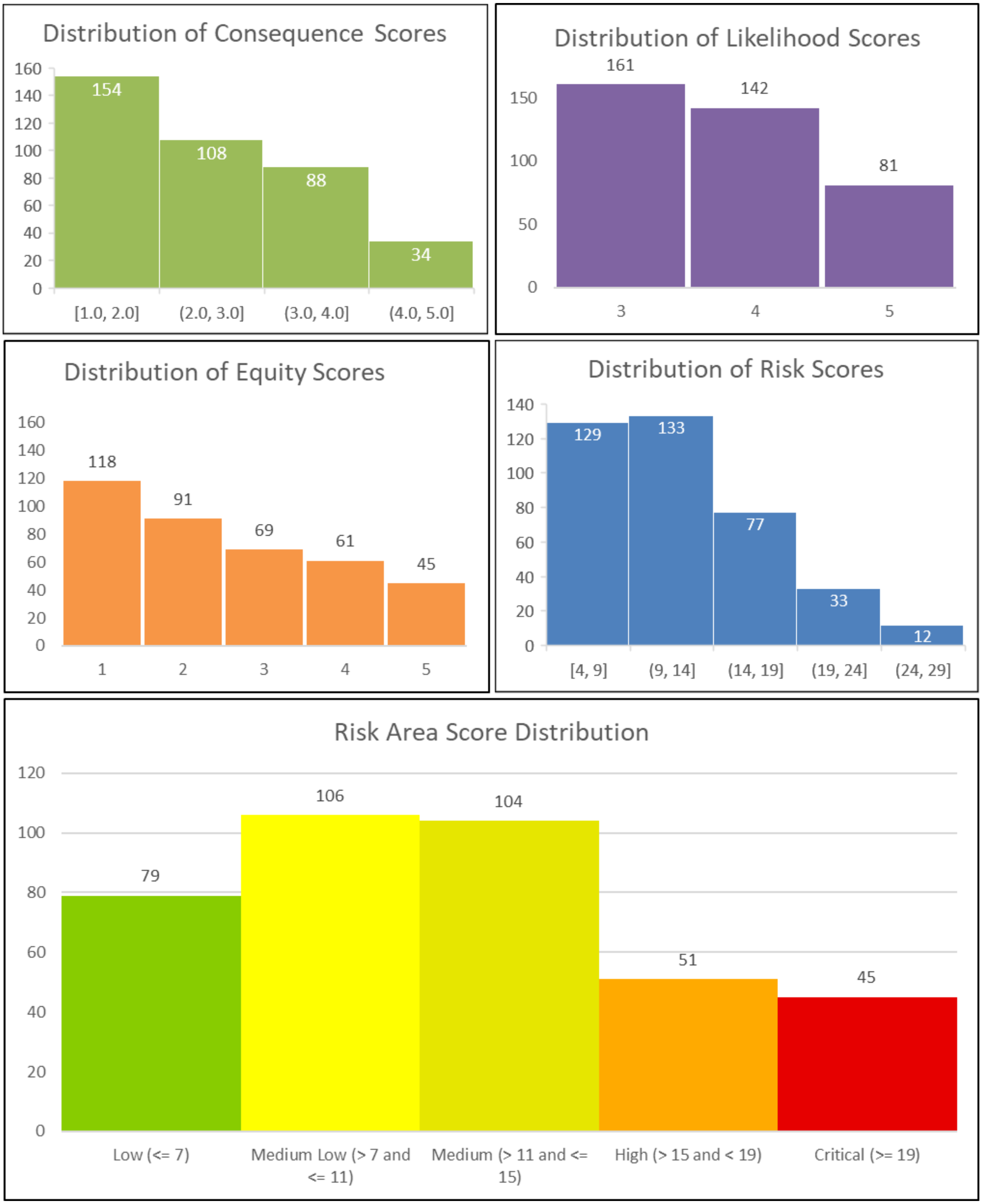



**Figure 4-6. Distribution of Consequence, Likelihood, Equity and Total Risk Score**

The 45 critical priority and 52 high priority risk areas were evaluated to determine the factors that cause the risk areas to exceed the Performance Thresholds. Contributing causes include the following:

- simulated flow exceeds pipe capacity causing surcharge or MH flooding (the vast majority of cases)
- low pipe slopes reduce capacity below simulated flow
- SPU operational controls cause upstream backups
- King County system is backing up into the SPU system,
- PS capacity is too low to convey simulated flow, or
- any combination of the above

A table of contributing causes for all critical and high priority areas and reference maps can be found in Appendix I.

The 45 critical risk areas are well distributed throughout the city as shown (red) in Figure 4-7 through Figure 4-710. The critical risk areas were located in the following neighborhoods: Ravenna, Phinney Ridge, Green Lake, Wallingford, Haller Lake Union, Lower Queen Anne, Belltown, Broadway, Minor, Pioneer Square, Industrial District, Lawton Park, South Delridge, Highland Park, Genesee/Fairmount Park, High Point/Roxhill, North Delridge, Mid Beacon Hill, Georgetown, Mount Baker, South Beacon Hill, Rainier Beach and Dunlap.

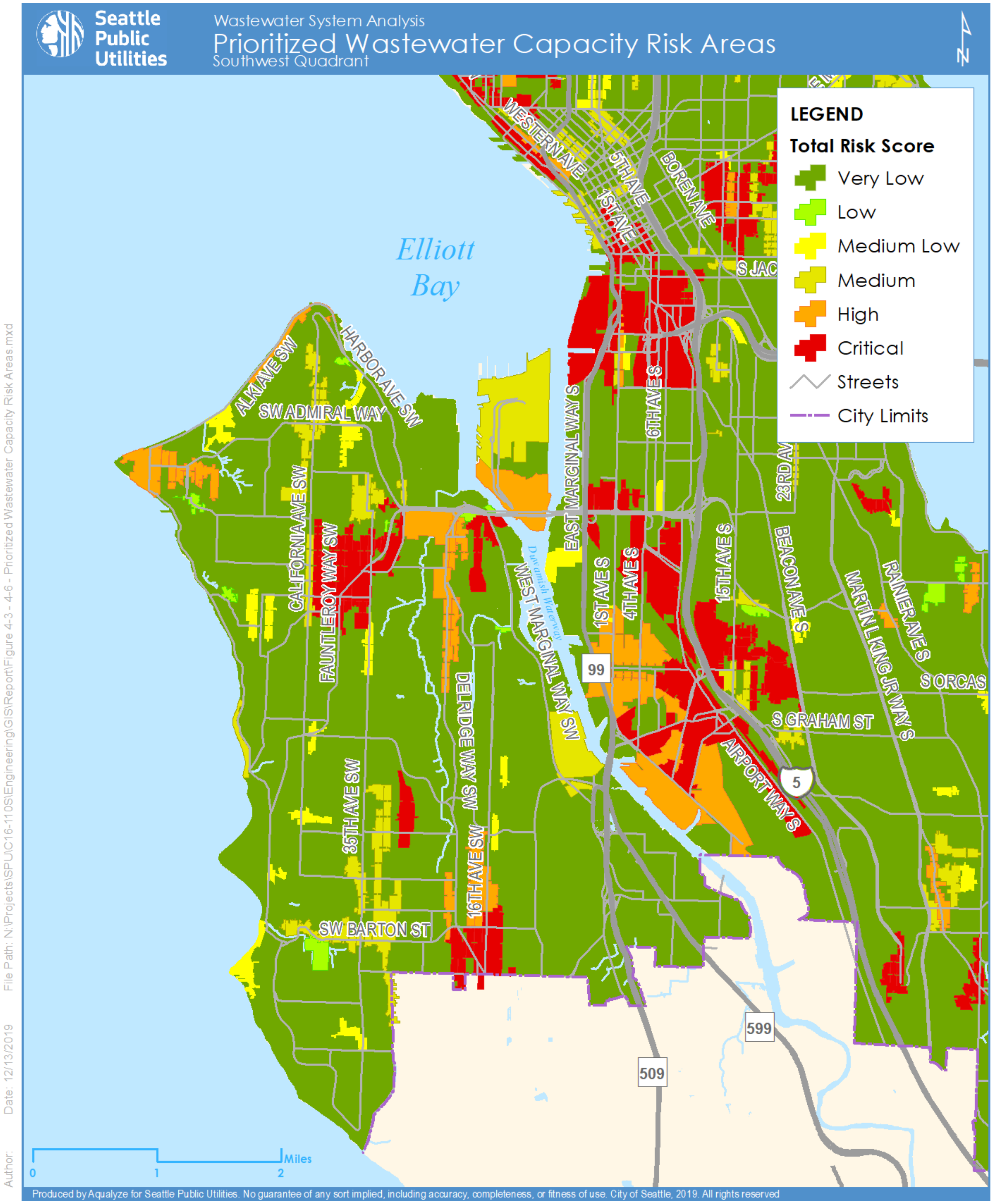



**Figure 4-7. Prioritized Wastewater Capacity Risk Areas – Southwest Quadrant**

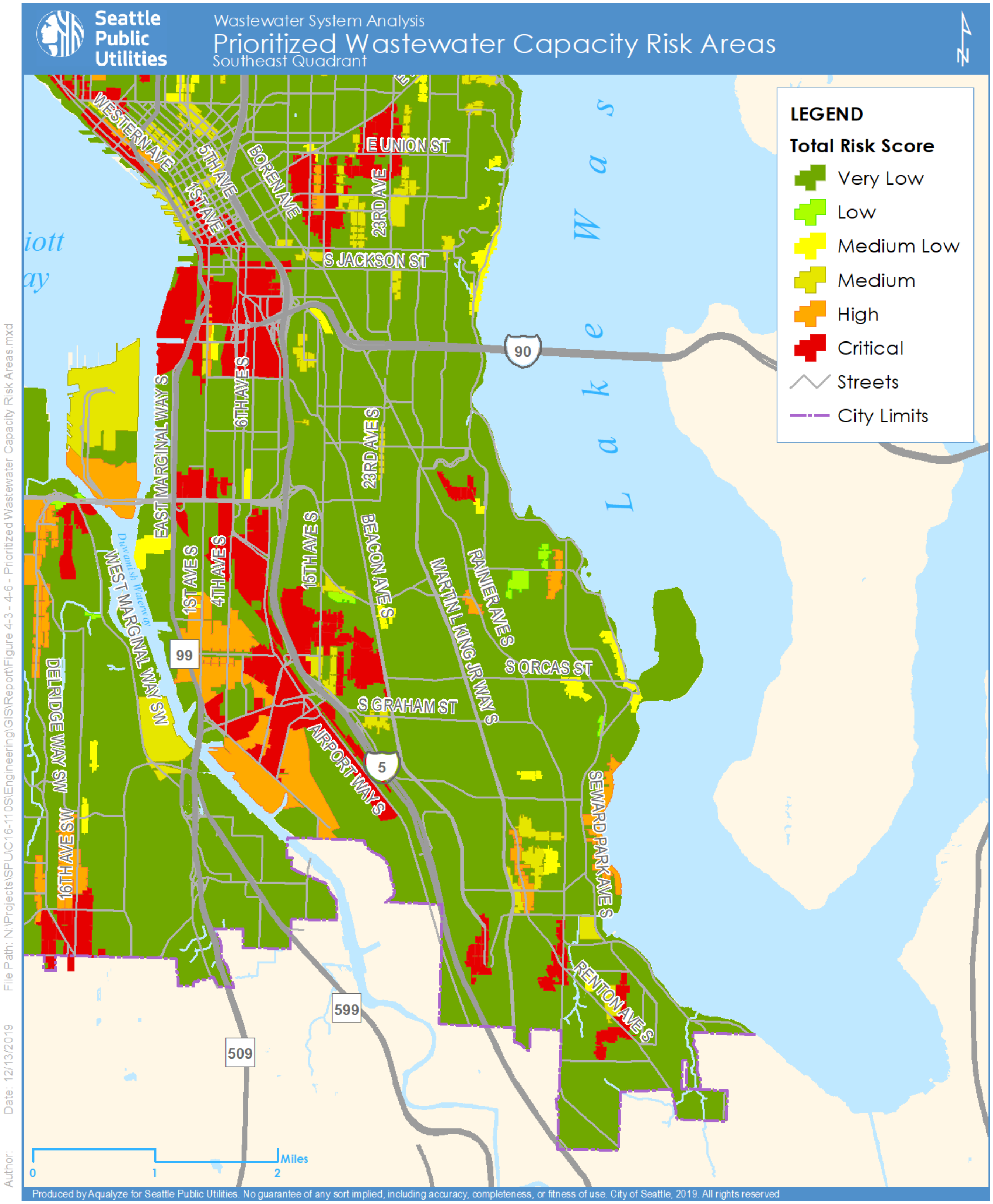
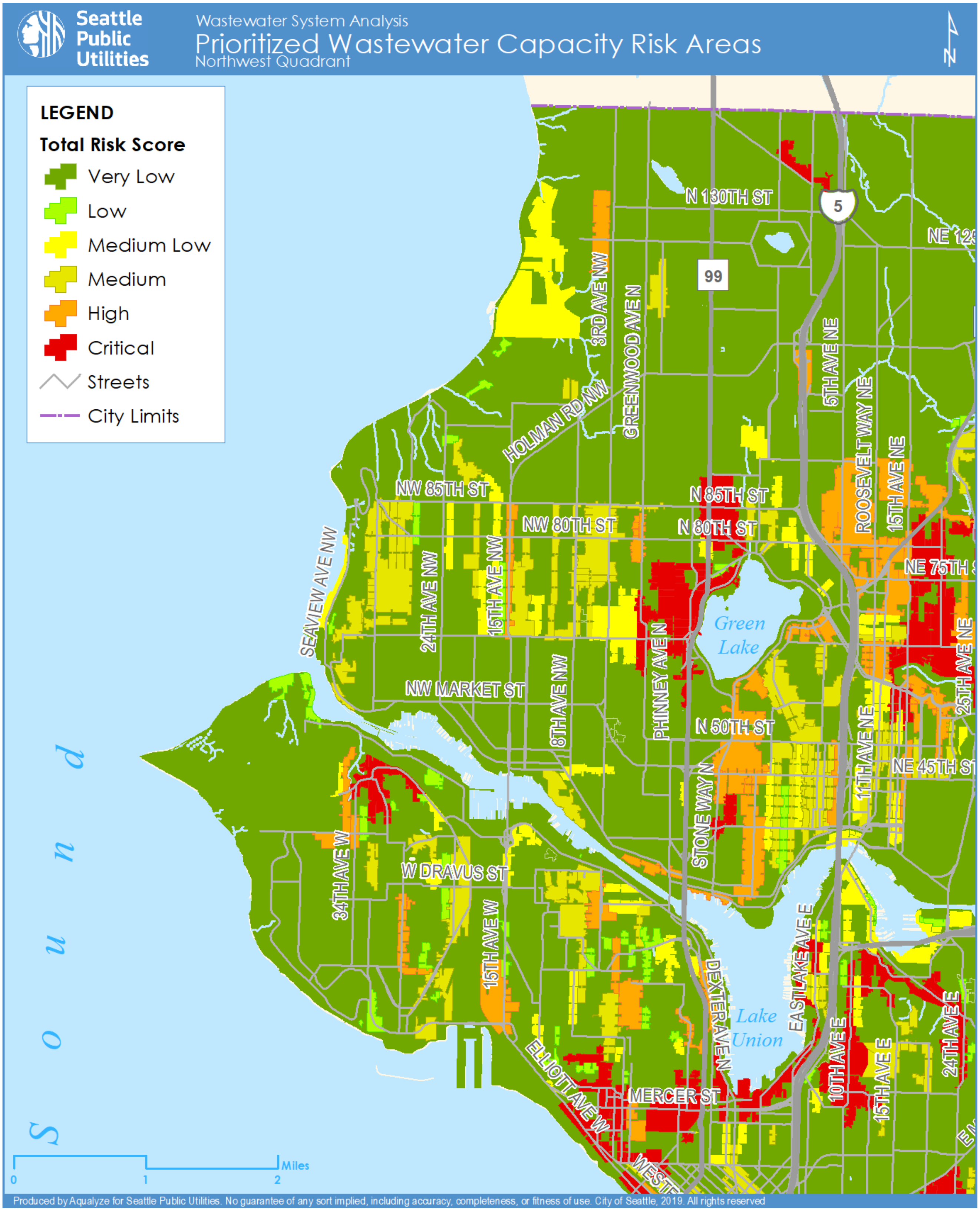



**Figure 4-8. Prioritized Wastewater Capacity Risk Areas – Southeast Quadrant**




Author: Date: 12/13/2019 File Path: N:\Projects\SPU\C16-110S\Engineering\GIS\Report\Figure 4-3 - 4-6 - Prioritized Wastewater Capacity Risk Areas.mxd

**Figure 4-9. Prioritized Wastewater Capacity Risk Areas – Northwest Quadrant**

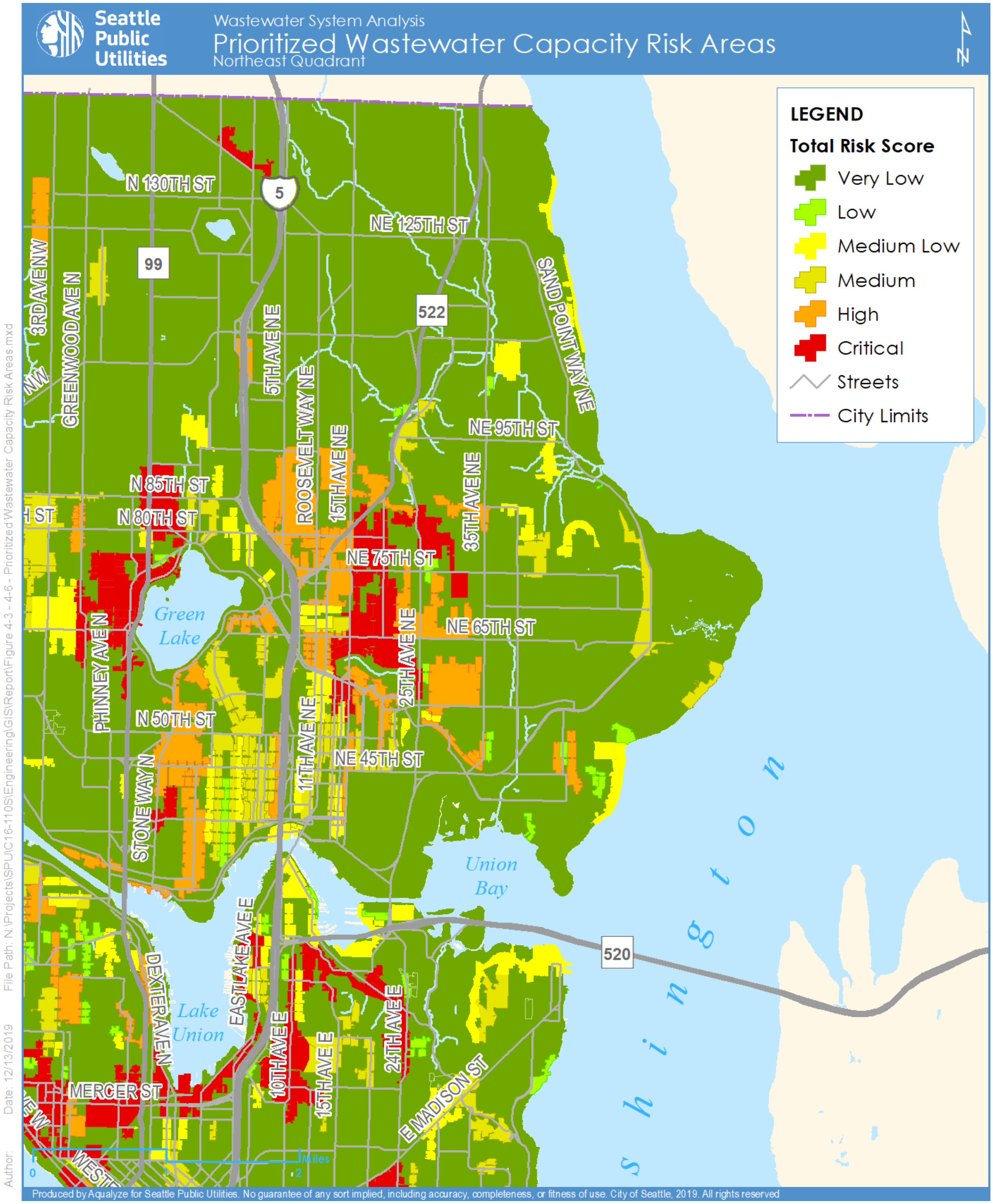



**Figure 4-10. Prioritized Wastewater Capacity Risk Areas – Northeast Quadrant**

## 4.5 Risk Area Fact Sheets

Following risk area prioritization (Section 4.4), a set of fact sheets were developed for the 45 critical risk areas (Appendix J). The fact sheets were designed to support a holistic appraisal of these risk areas. The fact sheets combine summary data for the sub-basin within which the risk area lies with descriptions of the risk area, model results and prioritization scores.

Each of the 45 critical risk areas were reviewed to determine the key reasons for being prioritized as critical. Short narratives were included in the fact sheets describing the location of the risk area and its key attributes. There is also a short description of the suspected causes of the capacity problem. Hydraulically connected risk areas that were also within the basin, regardless of their priority status, were also identified in the fact sheets for future planning considerations.

# 5. Additional Analyses

Two additional analyses were completed through the WWSA to develop informational GIS layers for use in the ISP:

- Identification of drainage connections to the combined system
- I/I contribution estimates in separated sewer areas

The following sections summarize the processes and results from these two analyses.

## 5.1 Drainage Connections to the Combined System

Understanding the source of inflow to a wastewater capacity risk area provides valuable information for determining the appropriate method to improve the conveyance capacity. SPU mapped drainage connections to the combined system to identify stormwater inputs that contribute to limited conveyance capacity in risk areas. SPU GIS data "Drainage_to Sanitary_Connection_Point" (March 2018) were the basis for this analysis. Drainage pipe upstream of the connection points were reviewed to estimate the length of drainage pipe discharging at the connection point to the combined system. For connection points with at least 300 feet of drainage pipe upstream, additional GIS data and record drawings were reviewed to confirm the connection. These connection points and the length of connected pipe were mapped (Figure 5-1.). Connections were mapped based on:

- Ownership (SPU or KC) of the system the drainage pipes are connected to
- Direct connections versus overflow connections

It is noted on Figure 5-1 if the connected pipes include some means of flow control as stormwater may not be a significant inflow at these connection points. During the analysis, one location was identified where a creek is connected to SPU's combined system. This location is also shown on Figure 5-1.

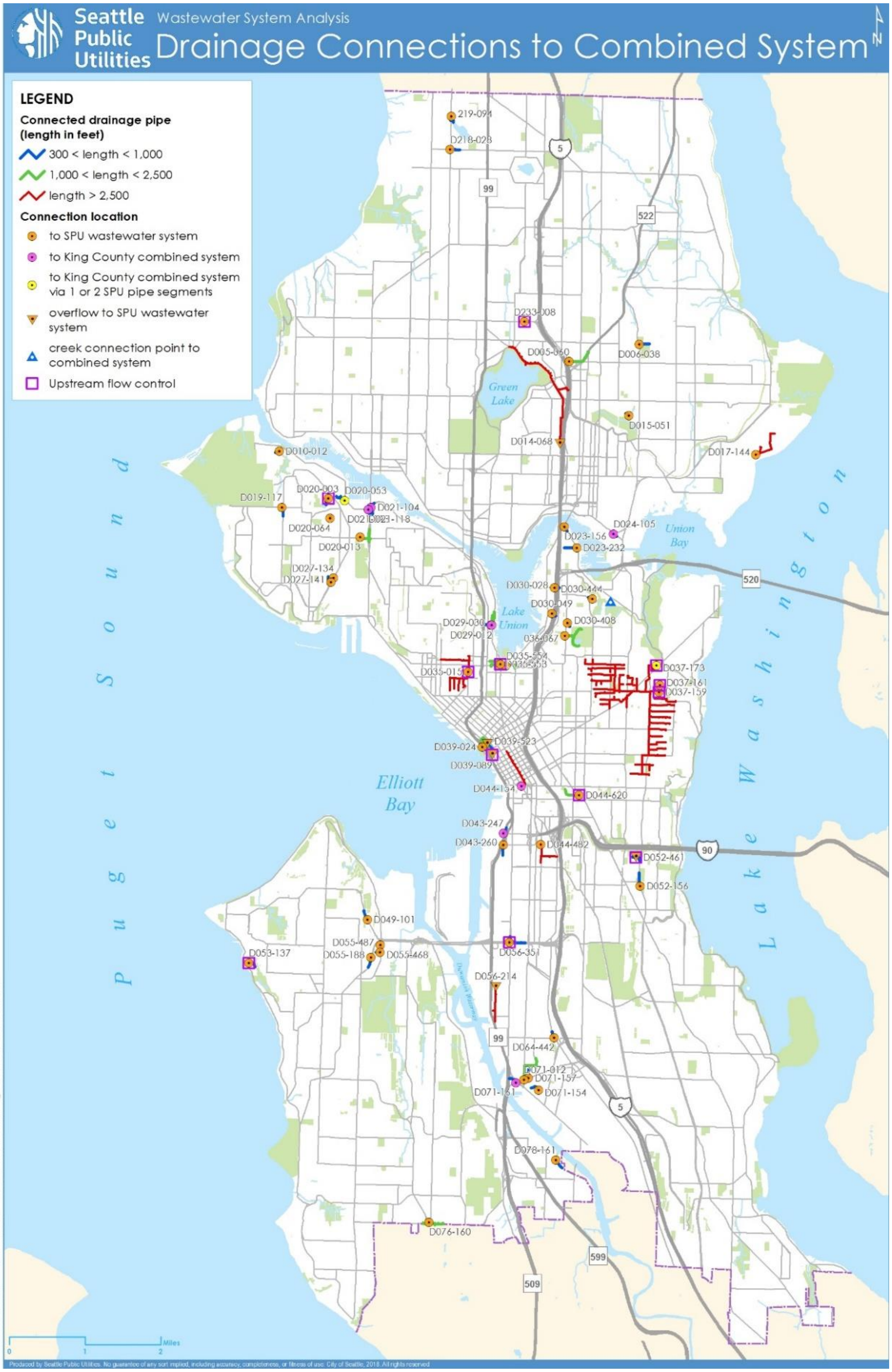



**Figure 5-1. Drainage Connections to the Combined System**

## 5.2 I/I Contribution Estimates

SPU's Infiltration and Inflow Mitigation in Separated Sewer Areas Policy states, if hydrologic modeling indicates I/I contributions are greater than 3,500 gallons per acre per day (gpad) for a 20-year peak event storm, an I/I reduction project is a potential solution to capacity issues (Seattle Public Utilities, 2018). Hydrologic modeling was completed to identify separated sewer areas with I/I contributions greater than the 3,500 gpad threshold.

I/I consists of both surface and subsurface response to rainfall. Surface response may be due to direct inflow via illicit connections or leaks in MH seals, while subsurface response may be from infiltration via cracks in pipes, MH chambers, and side sewers or leaky joints when the water table is elevated.

I/I areas were delineated based on areas tributary to meters used for calibration as part of WWSA and consultant knowledge from previous calibration efforts. The calibration resolution varied resulting in variable I/I area sizes. Each I/I area was given an ID based on the MH at the downstream end and was documented with the calibration source:

- WWSA, indicating a calibration metershed from this project
- Basin Project, indicating an area that was calibrated or refined during a previous calibration effort
- SCADA, indicating an area calibrated based on the downstream SCADA meter during previous modeling efforts

Simulated flow from the observed October 20, 2003 storm, at rain gauge 7, was categorized as a 20-year, 24-hour recurrence interval storm. SPU's existing conditions models were run for this event and used to estimate I/I rate, where:

**I/I = Total Flow – DWF**

The results of this analysis are presented on Figure 5-2 through Figure 5-5.

Typically, higher values indicate that there is more direct inflow possibly from directly connected impervious area or from side sewer pipes that are old or have defects, while lower values indicate a system that is newer in age and/or has less defects and direct inflow sources. For this analysis, lower values could also be due to an assumption of no direct inflow because the area is: (a) in an uncalibrated, separated area (information source set to Basin Project), (b) part of a larger, mostly combined area, where all inflow was assigned to the combined portion (information source set to SCADA). I/I rate estimates are highly dependent on the calibration quality and assumptions. Areas calibrated to SCADA data are considered to have a lower calibration quality as the areas are generally larger and the data are less reliable.

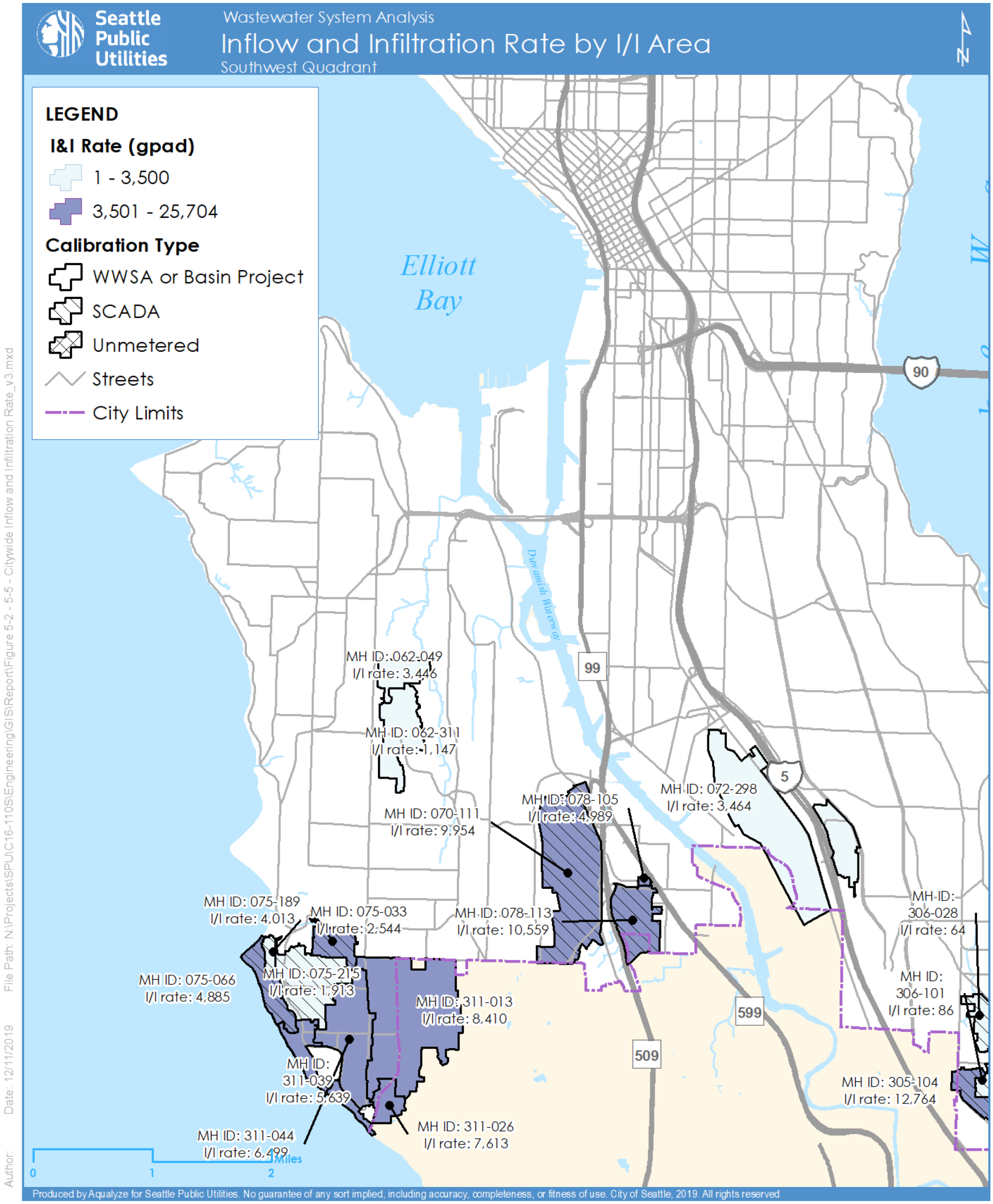



**Figure 5-2. Inflow and Infiltration Rate by I/I Areas – Southwest Quadrant**

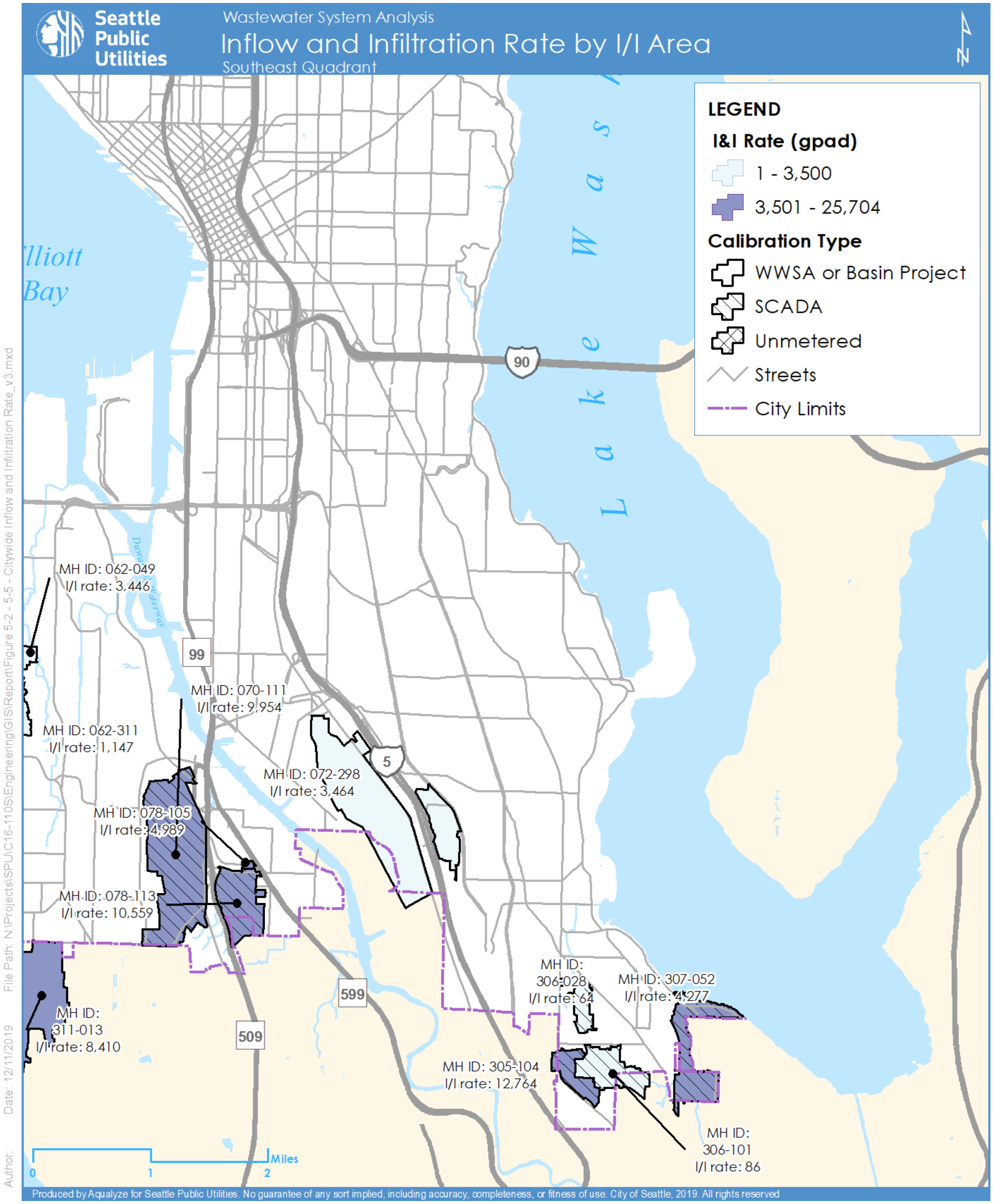



**Figure 5-3 Inflow and Infiltration Rate by I/I Areas – Southeast Quadrant**

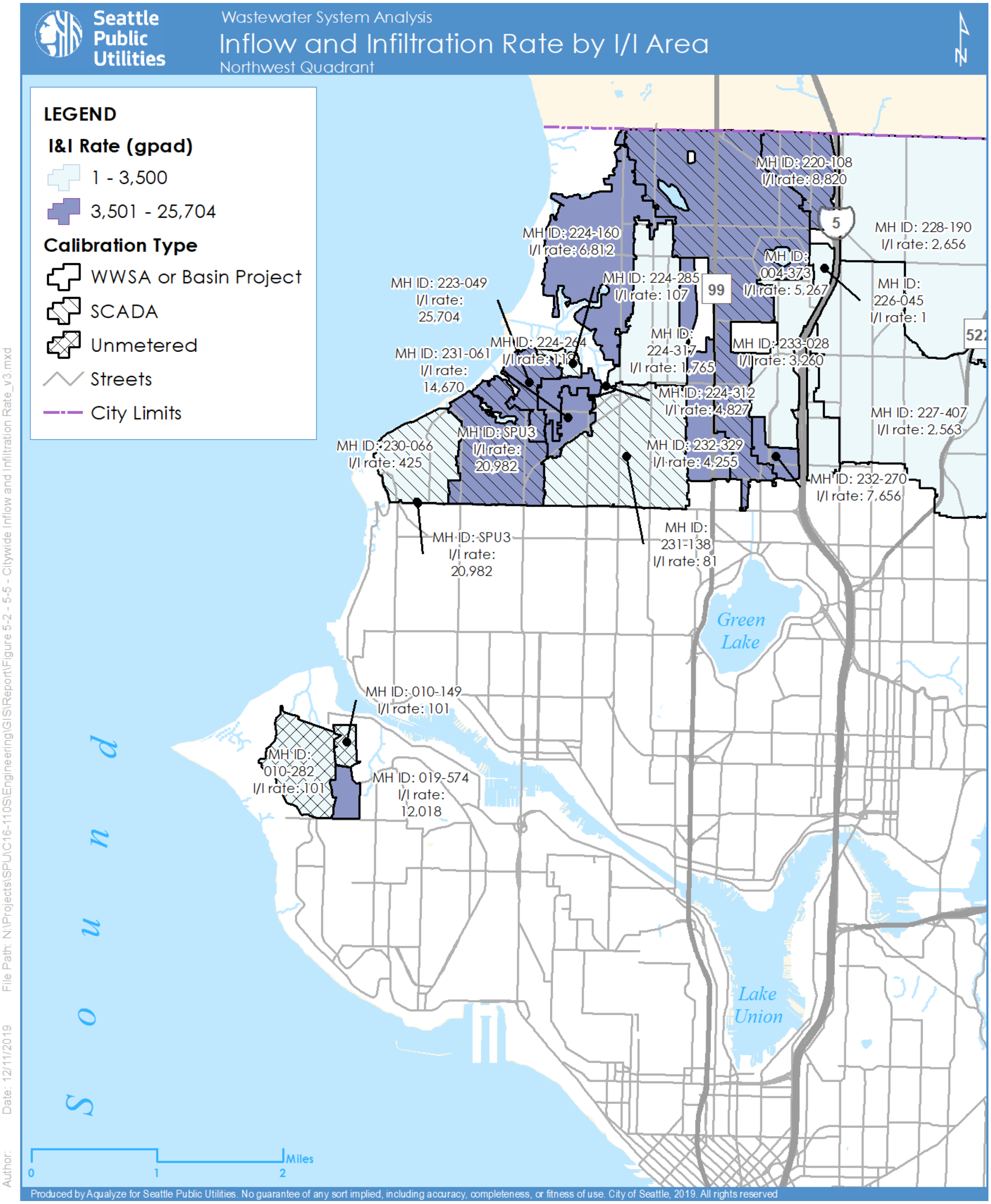



**Figure 5-4. Inflow and Infiltration Rate by I/I Areas – Northwest Quadrant**

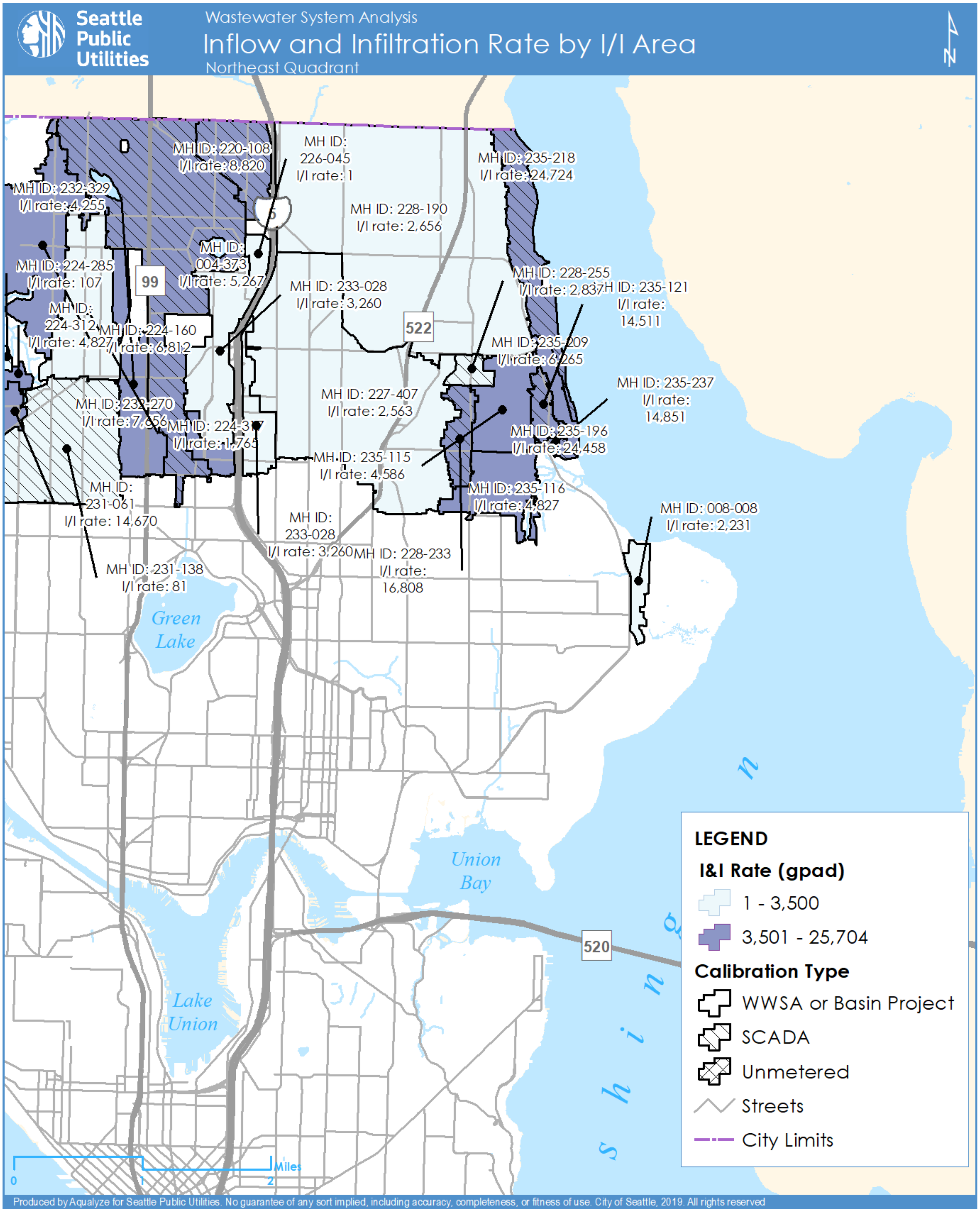



**Figure 5-5. Inflow and Infiltration Rate by I/I Areas – Northeast Quadrant**

I/I rate estimates are summarized in Table 5-1. These rates were aggregated over separated system sub-basins, using an area-weighted approach, for inclusion in the Sub-Basin Summary Sheets (Appendix E).

**Table 5-1. Estimated I/I Rates**

| I/I Area MH ID | I/I Rate (gpad) | I/I Area MH ID | I/I Rate (gpad) |
|---|---|---|---|
| 004-373 | 5,267 | 228-190 | 2,720 |
| 008-008 | 2,231 | 228-233 | 16,808 |
| 010-149 | 101 | 230-066 | 425 |
| 010-282 | 101 | 231-061 | 14,670 |
| 019-574 | 12,018 | 231-138 | 81 |
| 062-049 | 3,446 | 232-270 | 7,656 |
| 062-311 | 1,147 | 232-329 | 4,255 |
| 070-111 | 9,954 | 233-028 | 3,260 |
| 072-298 | 3,464 | 235-115 | 4,586 |
| 075-033 | 2,544 | 235-116 | 4,827 |
| 075-066 | 4,885 | 235-121 | 14,511 |
| 075-189 | 4,013 | 235-196 | 24,458 |
| 075-215 | 1,913 | 235-209 | 6,265 |
| 078-105 | 4,989 | 235-218 | 24,724 |
| 078-113 | 10,559 | 235-237 | 14,851 |
| 220-108 | 8,820 | 305-104 | 12,764 |
| 223-049 | 25,704 | 306-028 | 64 |
| 224-160 | 6,812 | 306-101 | 86 |
| 224-264 | 119 | 307-052 | 4,277 |
| 224-285 | 107 | 311-013 | 8,410 |
| 224-312 | 4,827 | 311-026 | 7,613 |
| 224-317 | 1,765 | 311-039 | 5,639 |
| 226-045 | 1 | 311-044 | 6,499 |
| 228-255 | 2,851 | SPU3 | 20,982 |
| 227-407 | 2,563 | - | - |

# 6. Products and Recommendations for Future Use

This section includes a list of the products created as part of the WWSA and recommendations on how the results of the analysis can be used to support the ISP and how they might also be used for purposes beyond the ISP.

## 6.1 Products

A simplified list of the products developed as part of the WWSA is as follows:

- Updated citywide wastewater H&H models (Appendix A)
- Equity Strategy for System Analysis Projects (Appendix B)
- Performance Thresholds for private property and the public ROW (Appendix C)
- Updated design rainfall time series and three synthetic design storms (Appendix D)
- WWSA sub-basins and summary sheets (Appendix E and Appendix F)
- WWSA racial equity toolkit (Appendix G)
- Outreach materials and survey (Appendix H)
- Risk area contributing cause table and reference maps (Appendix I)
- Risk area fact sheets (Appendix J)
- Risk-based prioritization criteria
- Risk area prioritization tool containing wastewater capacity risk area inventory
- Map displaying drainage connections to the wastewater system
- I/I contribution estimates for separated sewer areas
- Excel workbook containing outreach survey results
- GIS geodatabases containing:
  - Performance Threshold modeling results for 1-, 2-, and 5-year, 24-hour existing conditions design storms
  - Performance Threshold modeling results for 5-year, 24-hour future conditions design storm
  - Outreach survey response locations and data
  - Prioritized risk areas

## 6.2 How information could be used for ISP

The WWSA provides a critical component of the data and analysis required to complete the ISP. Results of the WWSA can or will be used in the ISP to:

- Be synthesized into representative maps or graphics, with accompanying narratives, that demonstrate how the DWW systems, social, and environmental conditions are connected or related to each other and how those relationships will inform the ISP
- Populate a cross-issue inventory that will include both wastewater and drainage risk areas and issues identified in Asset Management Plans (AMPs) and the LTCP, including the Integrated Plan

- Develop focus areas that include issues and opportunities identified in the WWSA, DSA, AMPs, and the LTCP
- Perform a cross-issue, risk-based prioritization of drainage and wastewater focus areas for directing solution development and evaluation
- Identify a suite of solutions to address capacity issues in wastewater risk areas, including:
  - Strategies to better partner with developers to improve wastewater system capacity incrementally over time
  - Strategies for capacity limited areas that are not likely to redevelop, such as industrial areas in SODO and Georgetown. These areas are often seen as lower priority for infrastructure investment, but experience wastewater system issues that are hard to fix due to topography, land development history (located in filled tidal flats), and lack of infrastructure
  - Strategies to remove stormwater from the fully combined portions of the wastewater system since the majority of risk areas are located in fully combined basins
- Build trust with stakeholders and describe the process SPU went through to implement a data-driven, equity focused approach to identify and prioritize issues citywide

## 6.3 How information could be used outside of ISP

The results of the WWSA could be used outside of the ISP by SPU to:

- Inform the CSO program, e.g. identify overlap in risk areas and King County uncontrolled basins as opportunity areas to partner and jointly develop solutions across SPU and King County combined sewer basins
- Inform near-term capital projects and near-term I/I program in SPU's Sewer Capacity program that may be initiated before the completion of the ISP
- Evaluate risks and potential solutions for ongoing projects, such as the Longfellow Creek Water Quality Project and GSI in Urban Villages projects
- Inform the Pump Station Rehab Program strategy
- Inform the CMOM pipe rehabilitation strategy
- Inform customer programs and/or to support identification of demand management actions that customers can take while a sewer capacity issue exists in the near term
- Understand impacts on downstream systems (SPU or King County) resulting from capital projects which increase upstream conveyance to relieve MH flooding and hydraulic capacity issues
- Support an analysis of the stormwater code that evaluates how SPU can more effectively leverage the code to alleviate capacity issues in the combined system
- Evaluate opportunities to partner on transportation projects with other agencies including SDOT, Washington State Department of Transportation (WSDOT), and Sound Transit
- Provide information on wastewater system performance to other City departments, such OPCD, to support their planning processes and outreach efforts
- Direct future flow monitoring and model calibration resources to model basins containing critical or high priority risk areas that are either uncalibrated or of poor calibration quality

- Direct flow monitoring and model calibration resources to separated areas with the goal of improving the confidence in I/I rate estimates

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