FIBER NETWORK COMPREHENSIVE PLAN

2025-2035

CITY OF BELLINGHAM
WASHINGTON

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10-year Fiber Network Comprehensive Plan

Executive Summary

This Fiber Network Comprehensive Plan outlines a strategic approach to enhancing the City of Bellingham's existing fiber network. The plan focuses on improving redundancy, reliability, and future-proofing the network to better support critical City operations, such as public safety, emergency response, and essential services.

Key findings from the network assessment indicate that while the existing network adequately serves current needs, it has limitations in redundancy and capacity for expansion. The analysis also determined that providing commercial or residential broadband services through the municipal network is financially infeasible due to significant capital investment requirements and the lack of eligibility for federal funding.

Based on the direction provided in City Council Resolution 2024-23, this plan prioritizes network enhancements that directly benefit City operations and public safety. It recommends the implementation of network rings for critical sites, upgrades to infrastructure (handholes, conduits, fiber augmentation), and ongoing maintenance and updates to the City's Long-Term Fiber Needs Map.

Introduction

This Fiber Network Comprehensive Plan was developed in response to City Council Resolution 2024-23 that built upon the recommendations of the Broadband Advisory Workgroup (BAW), which were adopted by City Council resolution 2023-05, and the comprehensive network assessment of the existing fiber network completed in 2024.

The City of Bellingham's municipal fiber network, spanning 71 route miles, currently supports various critical City services, including fire, police, water, wastewater, streetlights, traffic signals, and information technology. However, the network was developed primarily to serve existing operational needs, and as a result, lacks the "carrier-class" capabilities necessary for supporting commercial or residential broadband services.

The network assessment revealed key limitations, including insufficient redundancy and capacity for significant expansion. Furthermore, the analysis determined that providing commercial or residential broadband services through the municipal network is not financially feasible due to the substantial capital investment required to upgrade the network to carrier-class standards and the City's ineligibility for federal funding programs designed to support broadband expansion in underserved areas.

Therefore, this plan focuses on strategically enhancing the network to optimize its performance for the City's operational needs, ensuring its long-term reliability and resilience. This approach aligns with the BAW recommendations, which include increasing redundancy and reliability in the existing system and exploring opportunities to expand the use of the system within the context of the City's operational requirements.

This plan addresses these recommendations by focusing on enhancing the network's capacity and resilience to support the City's evolving operational needs while acknowledging the financial limitations of expanding into commercial or residential broadband services.

Guiding Principles

This Fiber Network Comprehensive Plan is guided by the following key principles:

- **Prioritize City Operational Needs:** The primary focus of the plan is to ensure the fiber network reliably and effectively supports current and future City operations.
- **Financial Responsibility:** Given the significant capital investment required to upgrade the network for broader uses and the lack of access to federal funding, the plan prioritizes cost-effective solutions that maximize the value of existing infrastructure.
- **Long-Term Resiliency:** The plan aims to create a resilient network capable of withstanding disruptions, adapting to evolving technology, and meeting the City's needs for years to come.

Network Assessment

A comprehensive assessment of the existing fiber network was conducted, including a detailed inventory of infrastructure components such as vaults, splice cases, conduits, and fiber strands.

- **Data Collection and Organization:** The inventory involved collecting and organizing GIS data, developing walkout maps for field inspections, and collecting data from OSP Insight, the City's fiber network management software. Field inspections were conducted at key splice locations, cabinets, and patch panels to assess conditions and document findings.

- **Key Findings (see table 1):**
    - **Vaults:** 40 vaults were found to be suitable, while 15 require replacement and 5 need significant rework.
    - **Splice Cases:** Predominantly legacy models, these splice cases require replacement with smaller, more modern options to improve efficiency and cable management.

- **Conduits:** Many conduits, originally installed for streetlight and traffic loops, are nearing or at full capacity, limiting future expansion.
- **Fiber Availability:** 166 cable segments with at least 2 available fibers (2,198 strand miles) were identified, providing potential for enhanced network redundancy.
- **OSP Characteristics:** 57.1 miles of fiber are installed underground, while 14.4 miles are aerial. Underground installations generally offer better security and reliability but are typically more expensive.

- **Limitations:** Inaccuracies and limitations were identified in existing GIS data and OSP Insight, hindering a complete understanding of the network's current state. Limited access to third-party fiber network data restricted a complete understanding of overall network connectivity.

- **Needs Analysis:** The assessment determined the current and projected bandwidth requirements for critical City operations, considering factors such as increasing data demands for public safety, emergency response, and other essential services. The impact of emerging technologies on future network demands was evaluated. Potential threats and vulnerabilities to the network, including cyberattacks, natural disasters, and human error, were identified and assessed.

Table 1: Existing Fiber Infrastructure Inventory Summary

Component	Condition	Notes
Vaults	40 suitable as is 15 require replacement 5 need significant rework	
Splice Cases	Predominantly legacy PLP Coyote Require replacement with smaller models Cable strain observed	Consider vault installation as an alternative in some cases.
Conduits	Originally installed for streetlight/traffic loops 58 conduits <= 50% fill 12 conduits 75% fill 45 conduits completely full	Identify conduits with available capacity for future expansion.
Fiber Cabinets	Well-maintained, but require improved documentation.	
Fiber Availability	224 total cable segments 166 segments with at least 2 available fibers (2,198 strand miles) 58 segments with no available fibers	
Outside Plant (OSP)	57.1 miles underground 14.4 miles aerial	Underground generally preferred for security and reliability.

Network Design and Architecture

Ring Architecture

The proposed network architecture will employ a combination of core rings, subrings, and collapsed segments to enhance redundancy and reliability. A core ring will connect critical hub sites such as City Hall, Public Works Operations, and the Emergency Operations Center. Subrings will connect to the core ring and encompass key facilities like fire stations, police stations, libraries, and hospitals. Tertiary rings will connect to subrings and other critical sites, with some segments potentially operating as collapsed rings (non-diverse) due to existing infrastructure constraints identified in the inventory. (See Appendix A for the ring maps.)

The ring architecture provides multiple paths for data transmission, enhancing redundancy and minimizing the impact of potential outages. By connecting critical sites to the core ring and subrings, the network ensures continued operation of essential services even in the event of a disruption on a single segment. This approach addresses the limitations of the existing network, which lacks sufficient redundancy in many areas. The ring architecture is flexible so that sites can be added or removed, and ring can be split as bandwidth needs change over time.

Critical sites for inclusion in the ring architecture include:

- Fire stations
- Police stations
- Hospitals
- Emergency Operations Center
- City Hall
- Public Works Operations
- Libraries
- Data centers
- Carrier interconnection points

Redundancy and Diversity

Strategies for Achieving Network Redundancy:

- **Fiber Strand Utilization:** Utilize available spare fiber strands identified in the inventory to create redundant paths between critical sites.

- **Diverse Routing:** Explore opportunities for diverse routing, such as utilizing aerial routes as backup for underground cables where feasible. This will mitigate the impact of potential outages due to excavation, construction, or other ground-based disruptions.

- **Equipment Redundancy:** Implement redundant equipment at critical locations, such as routers, switches, and power supplies, to minimize the impact of equipment failures.

- **Mitigation of Single Points of Failure:** Based on the inventory findings, identify and address critical single points of failure, such as congested conduits, vulnerable splice points, and inadequate vaulting. Implement bypass mechanisms or alternative routes to minimize the impact of potential outages at these locations.

Scalability and Future Growth

The network design will be adaptable to accommodate future growth in bandwidth demand and the integration of new technologies such as 5G and advanced data applications. The plan prioritizes conduit upgrades with available capacity to facilitate future fiber additions and accommodate the increasing demands of City operations. Modularity in the network design will be considered to allow for incremental expansion and upgrades as needed.

Certain aerial routes will be considered for new fiber installations where feasible and cost-effective, particularly in areas where underground construction is challenging or prohibitively expensive. Aerial routes will be evaluated to provide diverse paths and enhance network resilience.

Long-Term City Fiber Needs Map Integration

The Long-Term City Fiber Needs Map, developed as part of this planning process, plays a crucial role in guiding future network expansion. This map identifies critical routes and areas for future fiber infrastructure development, considering factors such as growth areas, system needs, and potential for future connectivity. By incorporating the Long-Term City Fiber Needs Map into future capital projects and construction plans, the City can strategically plan for the installation of conduit and fiber infrastructure, ensuring that the network is prepared to meet future demands and accommodate evolving technologies. This proactive approach will help to ensure the long-term sustainability and resilience of the City's fiber network. (See Appendix B for map.)

Infrastructure Upgrades

The network assessment findings have informed the development of a prioritized framework for infrastructure upgrades. High-priority upgrades focus on addressing critical issues identified in the inventory, such as:

- **Vault Replacements:** Replacing 15 vaults deemed unsuitable for current fiber infrastructure requirements with larger, deeper vaults to accommodate future needs and improve safety.

- **Splice Case Upgrades:** Replacing existing legacy splice cases with smaller, more modern models to improve cable management, reduce strain, and enhance overall network performance.

- **Conduit Upgrades:** Prioritizing upgrades for conduits with limited capacity (58 conduits with <= 50% fill rate and 12 conduits with 75% fill rate) to accommodate future fiber expansion and ensure sufficient capacity for City operations.

Medium-priority upgrades will address areas with moderate risk and potential for future expansion, focusing on preventative maintenance and improving the overall network's resilience.

Specific upgrade projects include (see Appendix C for map):

- **Fiber Testing:**
    - Comprehensive testing of all terminated fiber strands owned by the City will be conducted, including Optical Time Domain Reflectometry (OTDR) testing to identify potential trouble spots such as kinks or bends in the fiber.
    - This testing will provide valuable data for prioritizing upgrades and identifying areas for improvement.
    - **Budget:** $144,000 (estimated)
    - **Level of Effort:** Three to six months of work.
- **Fiber Augmentation:**
    - Augment the existing fiber capacity in the Southwest route, which is currently exhausted, by installing new 96-fiber cable after vault upgrades are completed.
    - **Budget:** $127,500 (estimated)
    - **Level of Effort:** One to three months of work.
- **Handhole and Conduit Upgrades:**
    - Upgrade 845 handhole locations to fiber standards, ensuring they can safely accommodate both streetlight and fiber infrastructure.
    - Prioritize upgrades associated with the Southwest Route Fiber Augmentation and based on the findings of the fiber testing and risk assessment, focusing on locations with critical vulnerabilities or high potential for future expansion.
    - **Budget:** $8 million (estimated)
    - **Level of Effort:** Pending budget availability, two to four years of work.

Network Operations and Maintenance

Ongoing network operations and maintenance (O&M) are essential for ensuring the long-term reliability, performance, and resilience of the City's fiber network. The City is committed to a proactive and scalable O&M strategy that will adapt to both current needs and future growth,

as well as incorporate ongoing improvements to the network. This strategy will include routine preventative maintenance, as well as reactionary maintenance as needed to address unplanned issues, and will be crucial to supporting the City's operational priorities.

Ongoing and Upcoming O&M Responsibilities

The City's existing O&M operations will continue to cover monitoring, troubleshooting, and basic maintenance of the fiber network, ensuring its readiness to support critical City operations, including public safety, emergency response, and essential services.

As the network evolves through the proposed upgrades, expanded responsibilities will be introduced, such as maintaining new infrastructure (e.g., upgraded vaults, splice cases, and handholes) and ensuring the network can scale to meet growing bandwidth demands.

Maintenance Scheduling and Resource Allocation

Preventative Maintenance: Scheduled inspections will be conducted to identify and address potential issues before they result in service disruptions. This will include periodic fiber testing, splice case inspections, and maintenance of critical components like vaults and conduits.

Reactionary Maintenance: In addition to preventative efforts, the network will be maintained reactively, with dedicated teams available to resolve urgent issues such as fiber cuts, equipment failures, or other disruptions to the service.

Cost Allocation and Financial Considerations

The financial responsibility for O&M will be shared between the City and its designated partners. Operating costs, including staffing and equipment, will be covered by the City's annual operating budget. Any major repairs or upgrades (such as replacing legacy splice cases or augmenting fiber capacity) will require capital funds, which may be sourced from a combination of City budgets, grants, and reserves.

- **Upgrades and Reduced Maintenance Needs**: As the network undergoes planned upgrades, certain areas will see a reduction in maintenance requirements. For example, replacing legacy splice cases with modern versions or upgrading conduits with larger capacities will reduce the frequency of maintenance interventions, while improving the overall reliability of the network.
- **Usage Rates**: A plan will be developed to establish usage rates for key public entities that use the City's system. In some cases, external contractors or vendors may be engaged for specialized tasks or during high-demand periods. The terms of these engagements will specify payment schedules based on milestones or completion dates, and financial oversight will ensure that these costs remain within the budgetary constraints of the City's fiber program.

Staffing and Training

The City will assess its staffing needs to ensure that it has adequate personnel to support network operations and maintenance. This may include adding new staff or offering specialized training to current employees, particularly as the fiber network grows in complexity and scale. Emphasis will be placed on training for troubleshooting new technologies and the advanced infrastructure resulting from the planned upgrades.

Integration with Network Upgrades

As the network expands and upgrades are implemented, O&M protocols will be reviewed and adjusted to reflect changes in network configuration and technology. This includes creating new standard operating procedures (SOPs) to accommodate upgraded infrastructure and to ensure that staff can manage these changes effectively.

Upgrades that enhance the network's scalability, such as expanded conduit capacity and redundant fiber strands, will streamline future O&M needs, allowing for easier expansion and fewer disruptions during regular maintenance activities.

By focusing on a combination of proactive maintenance, timely reactionary efforts, and a structured financial and staffing plan, the City can ensure that its fiber network remains reliable and resilient for the next decade and beyond.

Financial Considerations

Budget needs must be identified for network upgrades, operations, and maintenance, considering the costs associated with the prioritized projects. Potential funding sources will be explored, including City budgets, grants, and reserves as funds are available.

The phased approach to infrastructure upgrades is outlined below, with estimated funding needed.

Phase 1	
Fiber Testing Comprehensive testing of all terminated fiber strands will be conducted, including OTDR testing to identify potential trouble spots.	$144,000
Fiber augmentation – Southwest route	$127,500
Infrastructure Upgrades – Handholes and conduits – Southwest route	$150,000
Anticipated Funding Source	Street Fund
Total	**$421,500**

Phase 2	
Infrastructure Upgrades – Handholes and conduits – Core	**$1,750,000**

Phase 3	
Infrastructure Upgrades – Handholes and conduits – East	$1,375,000
Infrastructure Upgrades – Handholes and conduits – South	$825,000
Total	**$2,200,000**

Phase 4	
Infrastructure Upgrades – Handholes and conduits – Northeast	$1,590,000
Infrastructure Upgrades – Handholes and conduits – Northcentral	$810,000
Total	**$2,400,000**

Phase 5	
Infrastructure Upgrades – Handholes and conduits – Northwest	$1,149,000
Infrastructure Upgrades – Handholes and conduits – West	$351,000
Total	**$1,500,000**

Totals (as outlined in City Council Resolution 2024-23)	
Fiber Testing	$144,000
Fiber Augmentation – Southwest Route	$127,500
Infrastructure Upgrades	$8,000,000
Grand Total	**$8,271,500**

This phased approach allows for a systematic and manageable implementation of the infrastructure upgrades, addressing critical areas and minimizing disruption to City operations.

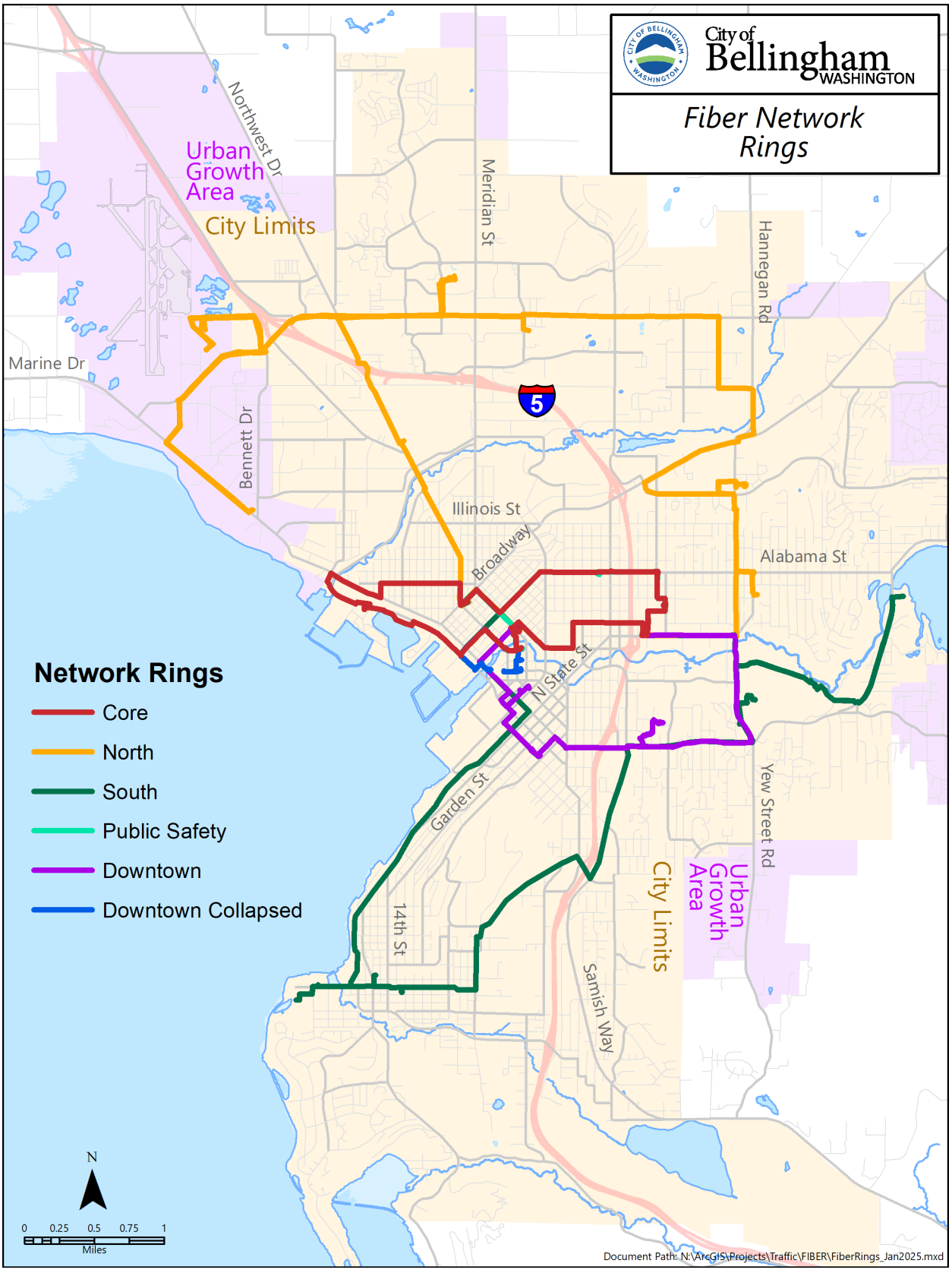
Conclusion

This Fiber Network Comprehensive Plan outlines a strategic approach to enhancing the City of Bellingham's fiber network, prioritizing improvements in redundancy, reliability, and future-proofing for critical City operations. By implementing the recommended upgrades and maintaining a proactive approach to network management, the City can ensure that its fiber network remains a valuable asset for years to come, supporting essential services and contributing to the overall well-being of the community.

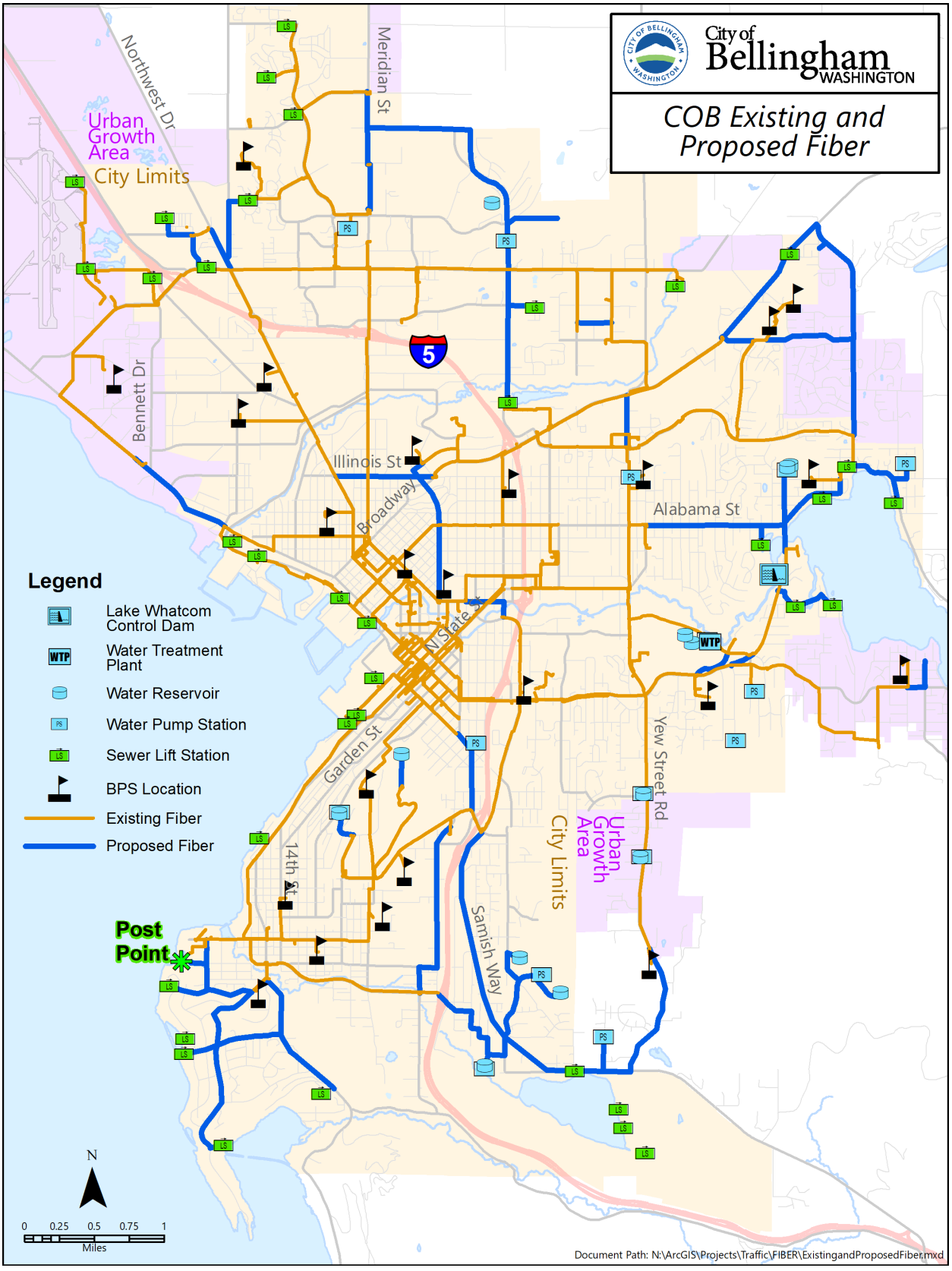
Appendix

A. Network Rings Map
B. Long-Term City Fiber Needs Map
C. Fiber Upgrades Map

Appendix A: Network Rings Map



Appendix B: Long-Term City Fiber Needs Map



Appendix C: Fiber Upgrades Map