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MUNICIPAL BROADBAND FEASIBILITY AND BUSINESS MODEL OPTIONS

Cambridge City Council Roundtable Discussion

March 13, 2023

KEY STUDY FINDINGS

FTTP in Cambridge will likely require a City contribution to be financially feasible

- The full capital cost is estimated at **~$194 million**, incorporating a 30% contingency and inflation over a 5-year construction period, assuming a 40% take-rate.
- A City contribution of **~$150 million** is required to establish a sustainable FTTP business from scratch, applying reasonable assumptions under a “base case”. This contribution is the investment the City would need to make for which there would likely be no return. The remaining capex can be supported from net revenues after operating costs.
- Entering into a partnership with one or more entities to lease fiber and run the business would reduce the City’s risks and potentially reduce costs. A partner could potentially leverage existing operations and assets, achieving economies of scale.

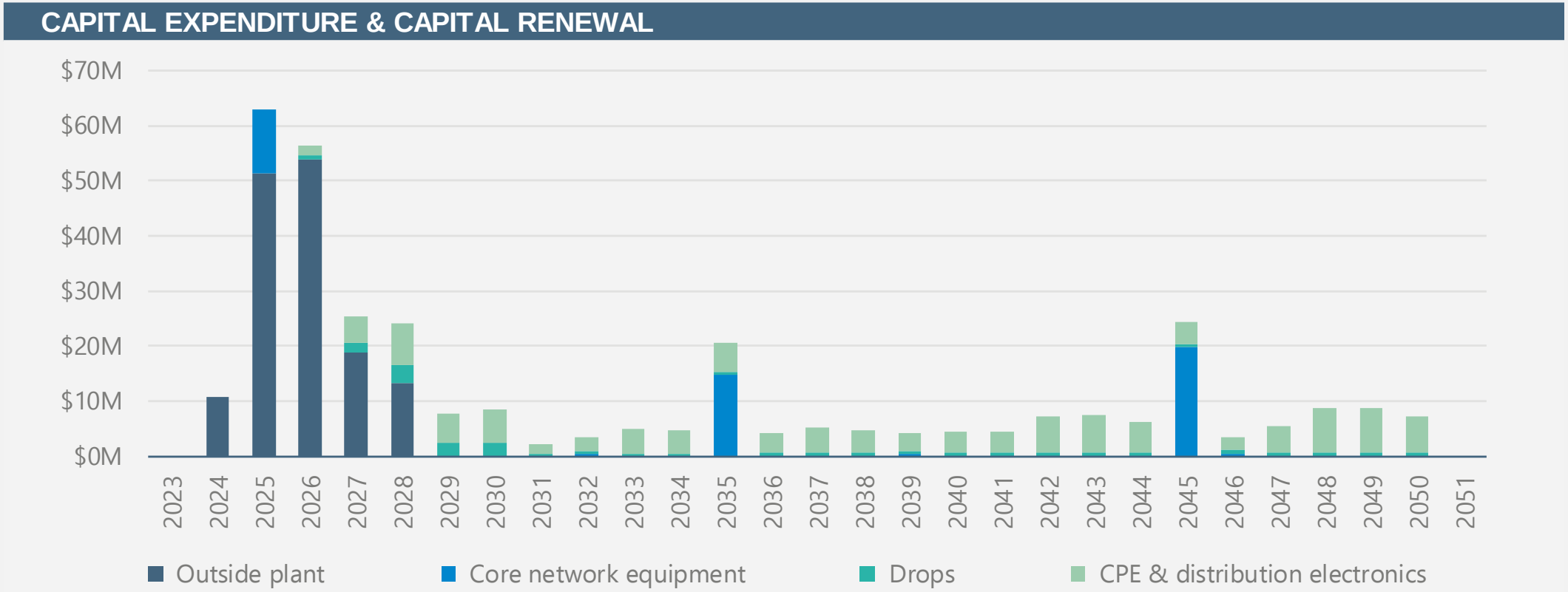
CAPITAL COST SUMMARY

Cost Component	Costs*
Project management & engineering	$18.4M
Utility pole make-ready	$4.8M
Distribution network construction *(aerial & underground, labor & materials)*	$63.3M
MDU fiber laterals and indoor cabling	$27.4M
Core network electronics	$8.8M
Total fixed cost	$122.6M
Fixed cost per passing	$2,345
Distribution electronics cost	$5.6M
Customer activation cost *(includes drops & CPE)*	$20.6M
Total cost (*without contingency*)	$148.9M
Total cost per customer	$7,117
Contingency (*30%*)	$44.7M
Total cost (*with contingency*)	**$194M**
Total cost per drop (*with contingency*)	$9,252

*Assumes drops are built to 40% of passings

BASE CASE: CAPITAL CONSTRUCTION AND RENEWAL COSTS

Initial construction is over five years; figures assume 40% take-rate



OPERATING EXPENSES SUMMARY

Cost categories considered to create full retail operations from scratch

Labor O&M

- Fiber technicians
- Customer service representatives
- Integrity Manager
- GIS analysts
- IT Specialists
- Account representatives

Parametric non-labor O&M

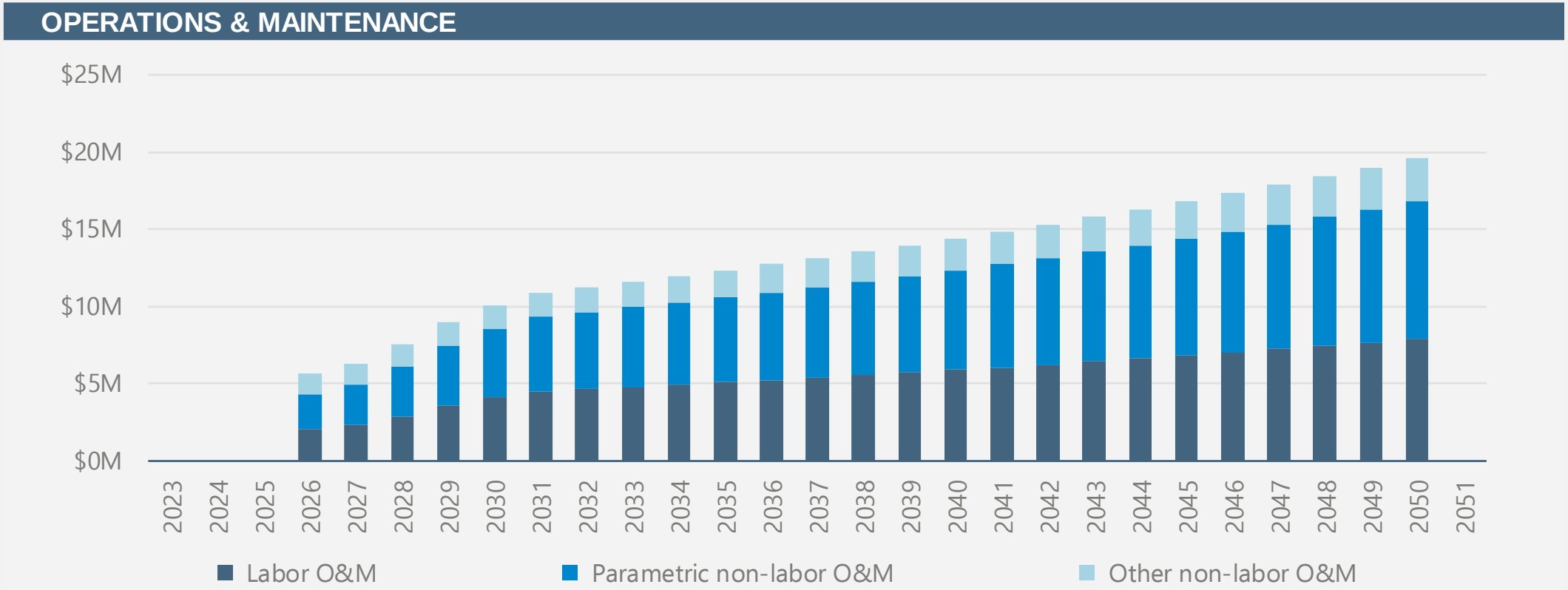
- Underground fiber locates and repairs
- Fiber maintenance and relocations
- Core network electronics maintenance
- CPE maintenance
- Education and training
- Customer billing
- Bad debt allowance
- Commodity internet capacity
- Pole attachment lease fees

Other non-labor O&M

- Insurance
- Utilities
- Office expenses
- Legal expenses
- Marketing

BASE CASE: OPERATIONS AND MAINTENANCE EXPENSES

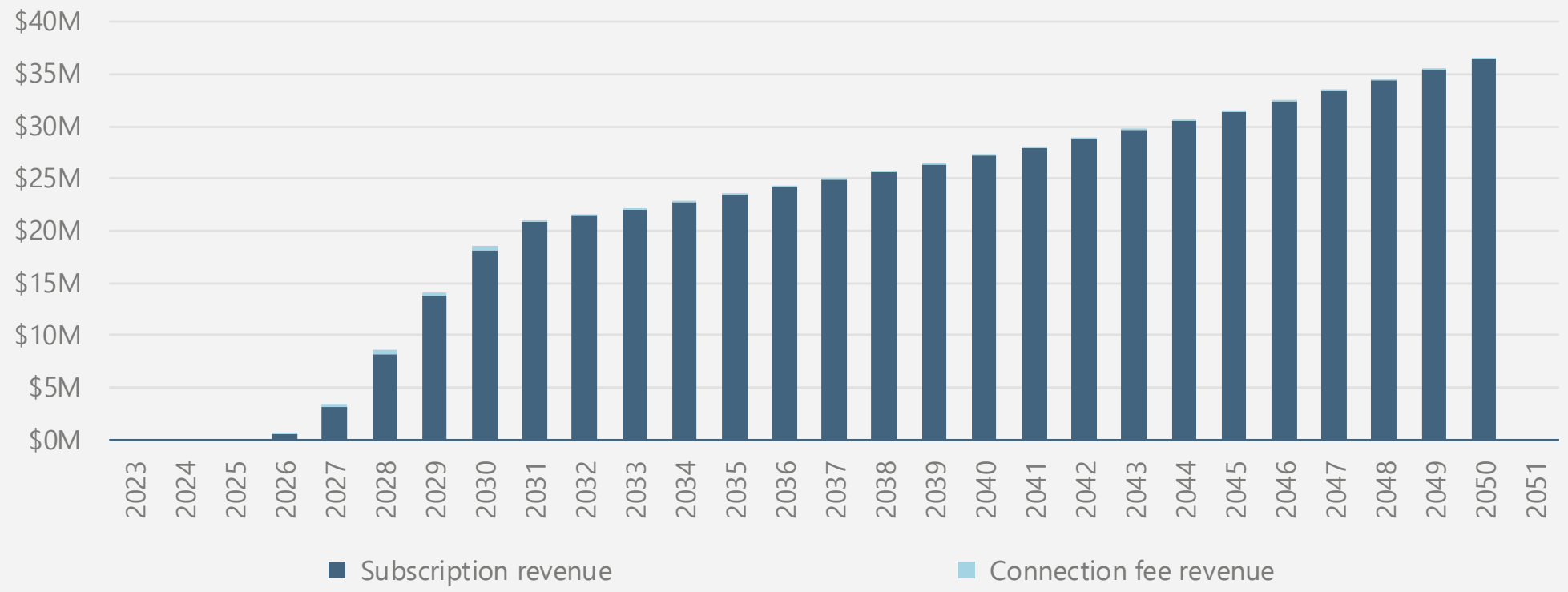
Annual operating expenses rise over time with inflation and labor rates



BASE CASE: PROJECTED REVENUES AT 40% TAKE-RATE

Assumes average of $70/mo., rising 3% per year ($30/mo. for low-income residents)

REVENUE



FINANCIAL MODEL

A custom financial model was developed to understand the project's business case and key sensitivities with the following key inputs:

- **Capital expenses:** Outside plant, network equipment, drops, CPE, buildout schedule, etc.
- **Pricing:** Target pricing based on market, mix of full paying vs. low-income
- **Take-rate / adoption curve:** Steady state take-rate, take-rate ramp up, churn
- **Operating expenditures:**
  - Labor costs
  - Non-labor parametric operating costs (e.g., $x per pole times n poles)
  - Other non-labor operating costs (e.g., $x per month for insurance)
- **Inflation adjustment (capex, opex, revenue)**
- **Capital grant funding:** City subsidy to reduce initial capital expenses
- **Financing conditions:** Interest rate, expected return on equity, debt-to-equity ratio, term, etc.

FINANCIAL FEASIBILITY ANALYSIS

The baseline feasibility analysis examines the overall attractiveness of the project from a commercial perspective

- The financial feasibility analysis does not include assumptions around how the citywide FTTP network is funded or financed, but assesses whether the project requires external funding for it to be financially feasible based on the fundamentals of the operational cash flows (revenue, capex, and opex)
- The financial model calculates the internal rate of return of the project (project IRR) using the operational cash flows over the construction period and 25 years of operations
- To evaluate financial feasibility, the analysis determines what combination of take-rates and public funding, if any, would be necessary to achieve a sufficient project IRR (assumed to be 10%), given certain assumptions about average revenue per user (ARPU)
- The report includes sensitivity analysis on the baseline feasibility assessment for the following key variables: Capex, opex, ARPU, and project term

FINANCIAL FEASIBILITY ANALYSIS OUTPUTS

Our baseline financial feasibility analysis shows that a ~**$150 million** upfront contribution combined with a **40% take rate** would achieve a **project IRR of ~10%.** The sensitivity analysis shows how changes in pricing and capex amounts affect the required upfront capital contribution.

Scenario / sensitivity	Required upfront capital contribution at different take rates		
	30%	40%	50%
Baseline analysis (30% capex contingency)	$178M	$151M	$126M
Baseline analysis with $10 lower pricing	$206M*	$185M	$165M
Baseline analysis with $10 higher pricing	$152M	$121M	$91M
Baseline analysis with 20% capex contingency	$158M	$130M	$172M
Baseline analysis with 40% capex contingency	$199M*	$172M	$148M

*Required upfront capital contribution amount exceeds overall capex

PARTNERSHIP OPTIONS

Partnership could offer significant advantages while the City could meet key goals

What City could gain…

- De-risking business model through market validation
- Operational and marketing expertise in a highly competitive and fast-changing business
- Potential private capital investment to reduce upfront costs

…what City could give up…

- Upside revenue potential
- Control over day-to-day business operations and market rate setting

…what City could retain

- Fiber service to all City premises
- City long-term ownership of fiber infrastructure
- Affordable options and pricing control for low-income households
- Key policy goals around data privacy and net neutrality

INTEREST IN A PARTNERSHIP IS LIKELY STRONG

A range of companies may be interested in partnering with the City

- Given the attractive Cambridge market, a number of ISPs and infrastructure companies would likely look at a City RFP seriously
- P3 investors are very comfortable with City owning the asset and the P3 investor having a long-term commercialization opportunity
- Some ISPs also might be willing to lease City fiber, but others would want fiber ownership
- Some ISPs require a larger footprint (now or in near future) than Cambridge, but they would explore this themselves

PARTNERSHIPS: ELEMENTS OF THE BROADBAND NETWORK

Business models are distinguished largely by defining the role of parties at each scope element of the network

Passive Infrastructure	Active Infrastructure	Service Provision
		
Building and maintaining dark fiber network	Setting up and operating active electronics on network	Delivering broadband services to subscribers

SUMMARY OF BUSINESS MODELS

The business models differ regarding how the three scope elements are combined into one or several contracts, and how competition is structured in the marketplace

Model #	Passive Infrastructure	Active Infrastructure	Service Provision
1	City funded/financed and maintained	Muni ISP (Broadband department or outsourced)	
2	City funded/financed and maintained	ISP (one or multiple)	
3	City funded/financed and maintained	Active Infra contractor	Multiple ISPs / open market
4	(Largely) privately funded/financed, privately maintained and operated		

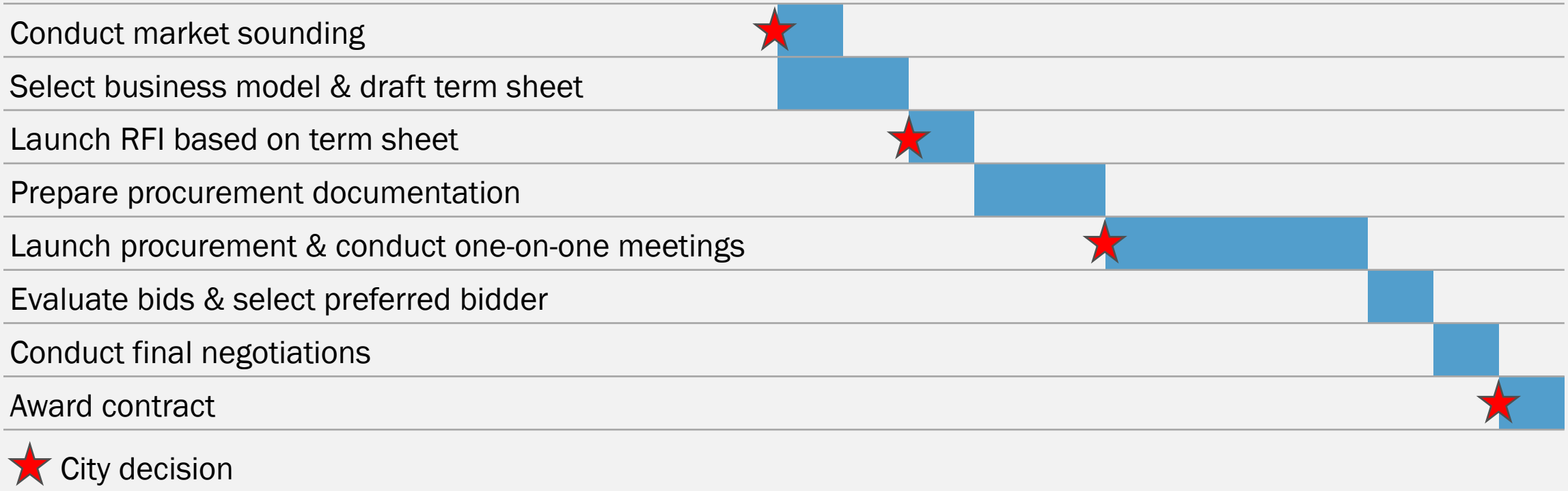
BUSINESS MODEL TAKEAWAYS

Models 2 and 4 are likely to attract strong market interest, with Model 4 transferring most responsibilities, risk, and control to a private party

- The City lacks the operational experience and expertise to successfully implement a citywide network as required under Business Model 1, making this model less feasible and attractive to the City
- Business Model 2 is a viable and attractive business model for the City which leverages the City's access to relatively cheap capital to develop the Passive Infrastructure while transferring most of the operational and commercial risks to a private partner
- Business Model 3 is the least proven model, which builds on Business Model 2 to potentially enable more competition but creates additional contractual layers which adds significant complexity and is less familiar to the market
- Business Model 4 increases private sector involvement across all project scope elements to also include developing and financing Passive Infrastructure
- Regardless of the business model selected, the project will likely require an upfront capital contribution from the City. But partners may also bring economies of scale and existing assets to the table, potentially reducing the magnitude of the contribution

TIMELINE AND POTENTIAL NEXT STEPS

Below is an indicative 18 to 24 months roadmap that would occur once the City makes its initial “go-forward” decision



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QUESTIONS AND DISCUSSION

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APPENDIX

SENSITIVITY ANALYSIS: CAPEX

To meet 10 percent project IRR, the upfront capital contribution could be higher or lower than if capital costs or take-rates are higher or lower than in the base case

Capex sensitivity	Required upfront capital contribution at different take rates				
	30%	35%	40%	45%	50%
20% capex contingency	$158M	$143M	$130M	$117M	$105M
30% capex contingency (base case)	$178M	$164M	$151M	$138M	$126M
40% capex contingency	$199M*	$184M	$172M	$159M	$148M

*Required upfront capital contribution amount exceeds overall capex

SENSITIVITY ANALYSIS: OPEX

To meet 10 percent project IRR, the upfront capital contribution could be higher or lower if opex is higher or lower than in the base case

Opex assumption relative to baseline	Required upfront capital contribution at different take rates				
	30%	35%	40%	45%	50%
10% decrease in opex	$165M	$151M	$139M	$126M	$114M
Base case	$178M	$164M	$151M	$138M	$126M
10% increase in opex	$191M*	$177M	$164M	$151M	$139M
20% increase in opex	$205M*	$190M	$178M	$164M	$153M

*Required upfront capital contribution amount exceeds overall capex

SENSITIVITY ANALYSIS: AVERAGE REVENUE PER USER

Changes in pricing dramatically affect the required upfront capital contribution required to meet 10 percent project IRR

Pricing assumption relative to baseline	Required upfront capital contribution at different take rates				
	30%	35%	40%	45%	50%
Low income/full paying: $20/$50	$230M*	$223M*	$217M*	$210M*	$203M*
Low income/full paying: $20/$60	$206M*	$195M*	$185M	$174M	$165M
Low income/full paying: $30/$60	$202M*	$190M	$180M	$169M	$159M
Low income/full paying: $30/$70	$178M	$164M	$151M	$138M	$126M
Low income/full paying: $30/$80	$156M	$140M	$125M	$110M	$96M
Low income/full paying: $40/$80	$152M	$136M	$121M	$105M	$91M
Low income/full paying: $40/$90	$133M	$114M	$96M	$79M	$62M

*Required upfront capital contribution amount exceeds overall capex

SENSITIVITY ANALYSIS: OPERATING PERIOD

Upfront capital contribution required to meet 10 percent project IRR with varying operating periods, at different take rates

Operating period duration	Required upfront capital contribution at different take rates				
	30%	35%	40%	45%	50%
20-year operations period	$182M*	$169M	$158M	$146M	$136M
25-year operations period (base case)	$178M	$164M	$151M	$138M	$126M
30-year operations Period	$178M	$162M	$148M	$134M	$121M

*Required upfront capital contribution amount exceeds overall capex

SURVEY METHODOLOGY

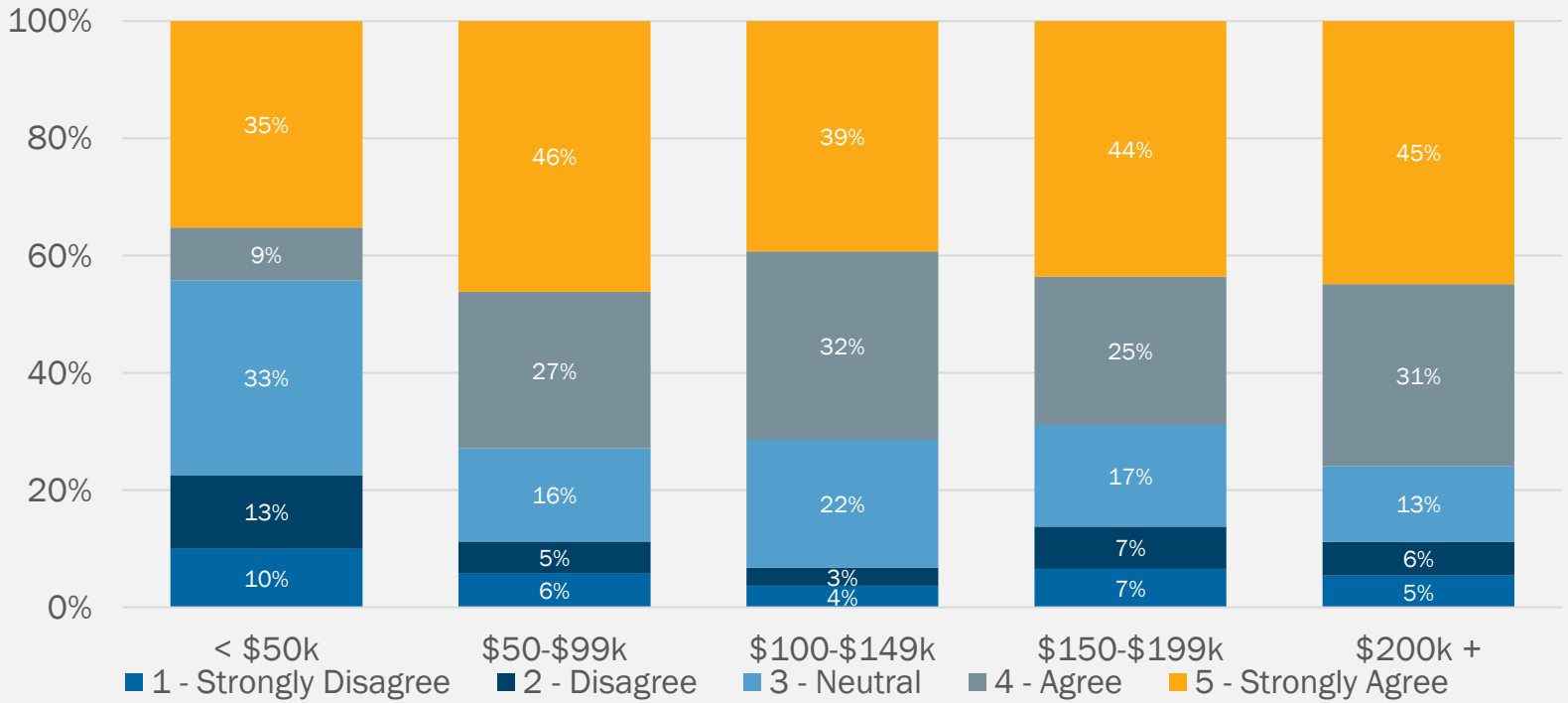
Mailed survey was met with a strong response and has high degree of statistical validity

- 5,000 survey packets mailed to a random set of Cambridge residential addresses
- Of these, 3,000 went to low-income households (to plan for typically lower response)
- Goal was 450 responses; results exceeded goal, with 604 responses
- Results developed data on relevant topics including
  - Current providers used and prices paid
  - Willingness to switch to a new FTTP provider at various price points
  - Level of support for City taking on a role or subsidizing

MARKET OVERVIEW

Statistically valid survey shows community support for a municipal fiber network, even if a tax subsidy is required

Agreement with Statement: "The City Should Facilitate a Fiber Broadband Network, Even If This Requires a Tax Subsidy"



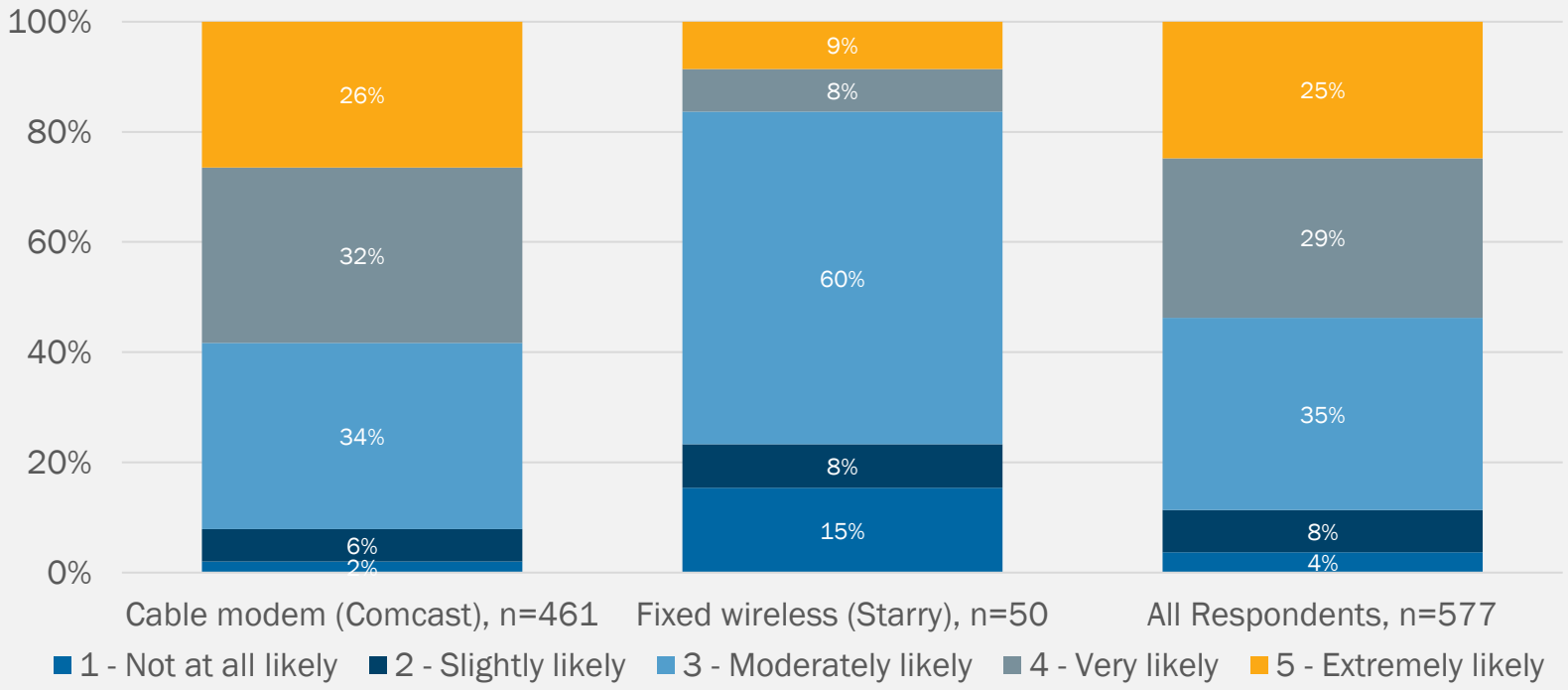
- 66% agreed or strongly agreed that City should facilitate building a fiber broadband network, even if this requires tax subsidy
- Modest differences in such support between owners and renters (61% vs. 68%)

Notes: Citywide mail survey conducted to a random sample of 5,000 households in summer of 2022, with 604 responses exceeding target and providing 95% confidence that the results are within 4% of the population as a whole

MARKET OVERVIEW

Survey also shows baseline interest in switching to new internet options, particularly among Comcast subscribers

Likelihood of Acquiring New Internet Service



- 87% believe there is need for an additional ISP
- Interest in switching strong among Comcast subscribers (58% likely or very likely)
- Interest in switching weaker for Starry subscribers (17% likely or very likely)

Notes: Citywide mail survey conducted to a random sample of 5,000 households in summer of 2022, with 604 responses exceeding target and providing 95% confidence that the results are within 4% of the population as a whole

MARKET OVERVIEW

Comparison can be challenging because of differences in speed, bundled services, customer experience, and promotional pricing, but the market generally prices FTTP products close to cable offerings, around $70/month

Cambridge provider	Gigabit internet-only service	Monthly price
Comcast (Internet/phone/cable – range of prices based on services and promotions chosen)	1 Gbps download, 35 Mbps upload (company says symmetrical gig speeds are in development)	$70* (promotional price; rises to $102 after 24 months)
Starry (fixed wireless internet)	1 Gbps download/500 Mbps upload (in optimal conditions)	$80
FTTP competitor in other markets		
Google Fiber (internet)	1 Gbps symmetrical	$70
Ting Internet (internet)	1 Gbps symmetrical	$89

Notes: FTTP = Fiber To The Premises, which references deployments where fibers extends all the way to the end-user and offers higher speed and reliability

*Prices reflect $10 discount for enrolling in auto-pay. Offer includes free 12 months of HBO Max with ads.

MARKET OVERVIEW

Municipal FTTP would primarily compete on a strong local brand with similar pricing to existing cable offerings, while achieving key public policy goals

- **Pricing:** The service would offer symmetrical gigabit service with indicative price points of $70 gigabit ($30 for low-income households, aligned with Affordable Connectivity Program) – but would likely face promotional pricing pressure from existing providers
- **Product:** While a fiber product would initially provide a stronger product, Comcast is focused on infrastructure improvements that could achieve gig symmetry
- **Brand:** A key competitive advantage would be brand with marketing focused on local pride and values (data privacy, net neutrality, digital equity, strong local customer service) to drive adoption and win loyalty
- **Public Policy Goals:** A municipal offering could ensure policy goals that aren't being met in the market, including increased competition, digital equity, data privacy, and net neutrality

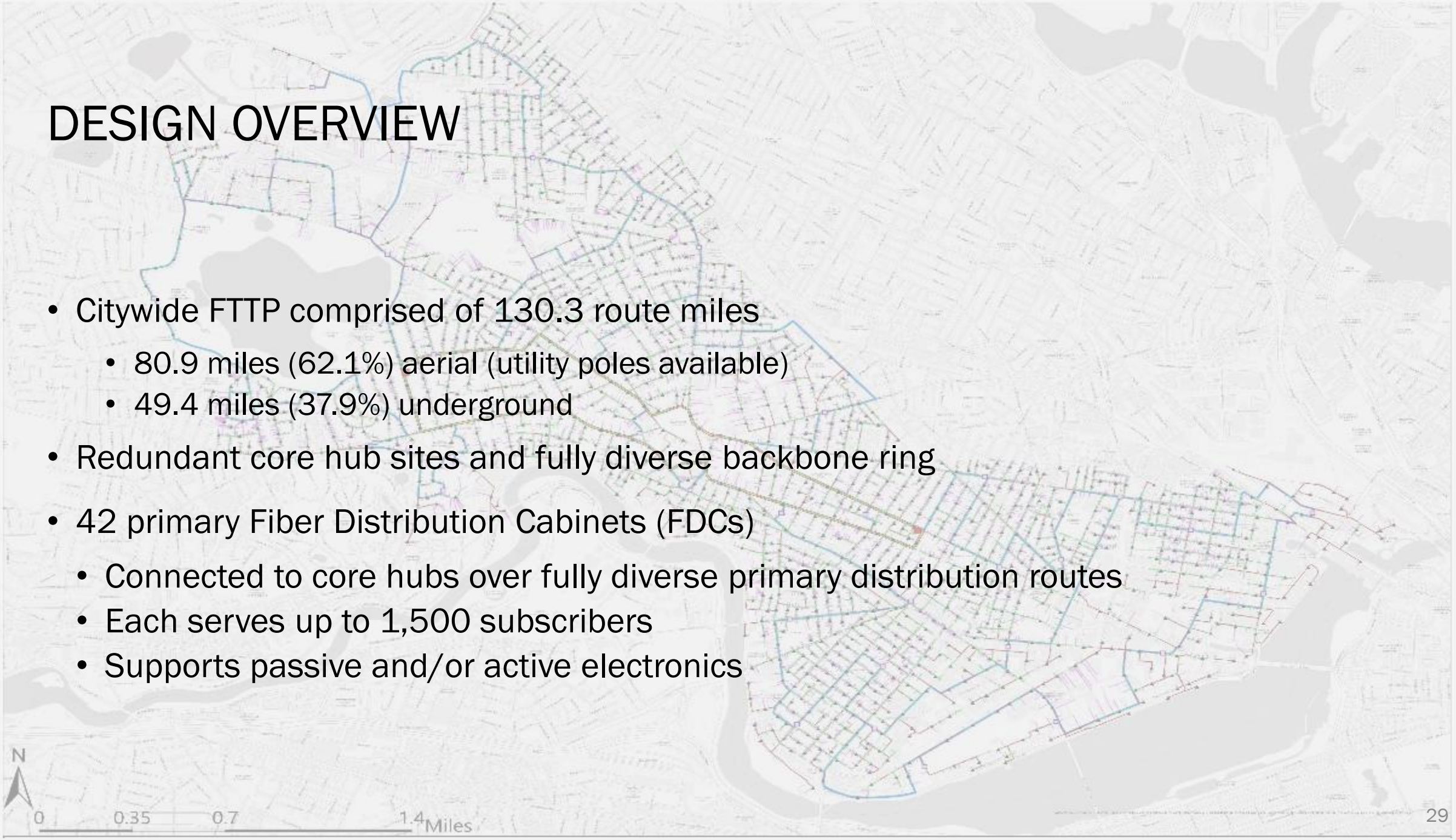
MARKET OVERVIEW

Based on national benchmarks, a target take-rate of 30-40% seems feasible in Cambridge with strong operational and marketing execution

- Successful publicly traded telcos with FTTP operations focus on achieving 35-40% market penetration
- Higher market penetration above 40% is possible in markets with weak or no cable competitor; successful case examples with municipal FTTP networks are mostly run by municipal electric companies with an existing customer base
- Municipal FTTP networks that are ending up lower than 30% exhibit poor execution, competition from both cable and telco FTTP (i.e., Verizon FiOS), and are mostly suburban markets

Wired competitors	Take rate range for new competitor
Weak DSL	High ‘40s & above
Weak DSL and cable (Cambridge market)	35-40%
Partial fiber or fast DSL and cable	30-40%
Extensive fiber and cable	12-30%

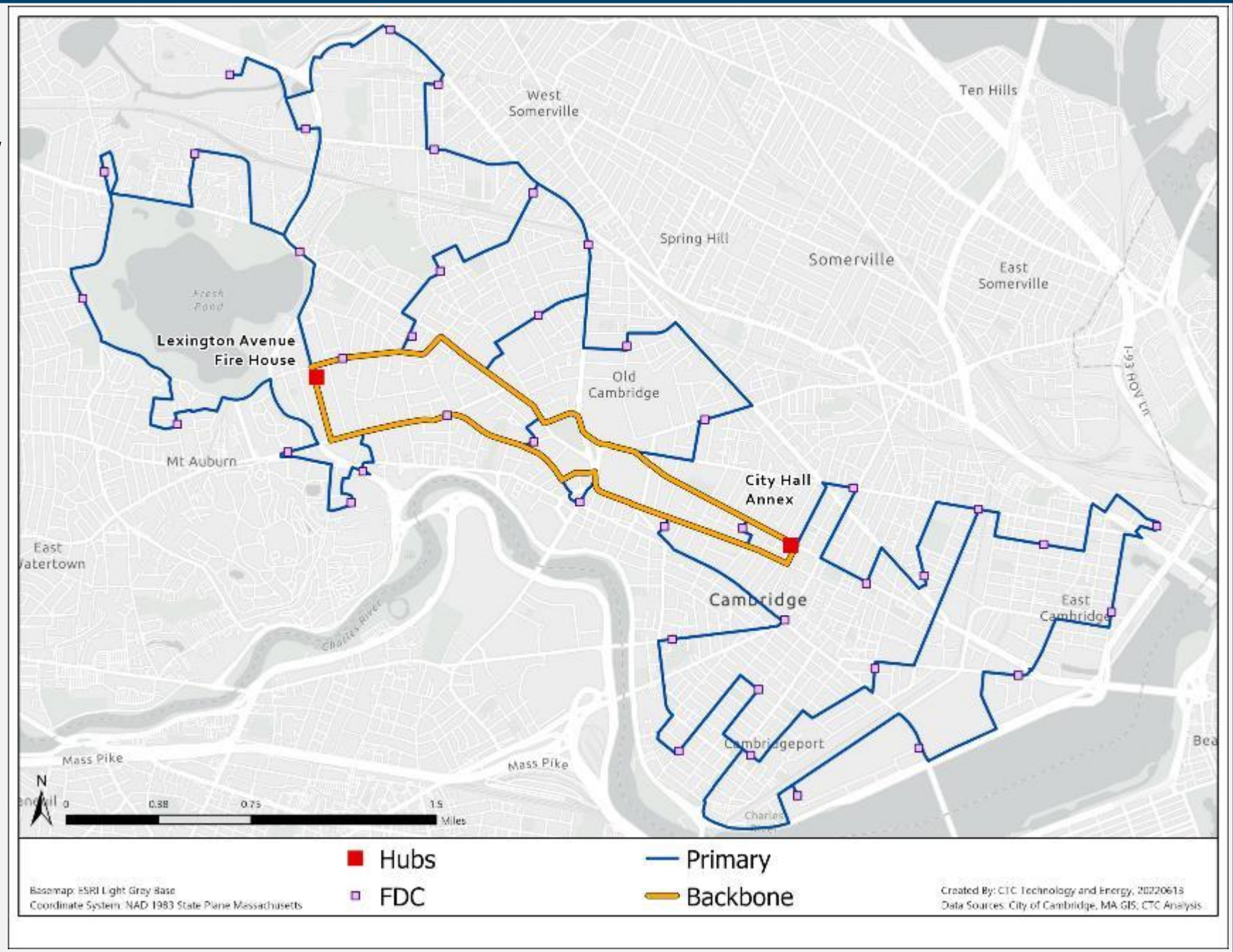
DESIGN OVERVIEW



- Citywide FTTP comprised of 130.3 route miles
  - 80.9 miles (62.1%) aerial (utility poles available)
  - 49.4 miles (37.9%) underground
- Redundant core hub sites and fully diverse backbone ring
- 42 primary Fiber Distribution Cabinets (FDCs)
  - Connected to core hubs over fully diverse primary distribution routes
  - Each serves up to 1,500 subscribers
  - Supports passive and/or active electronics

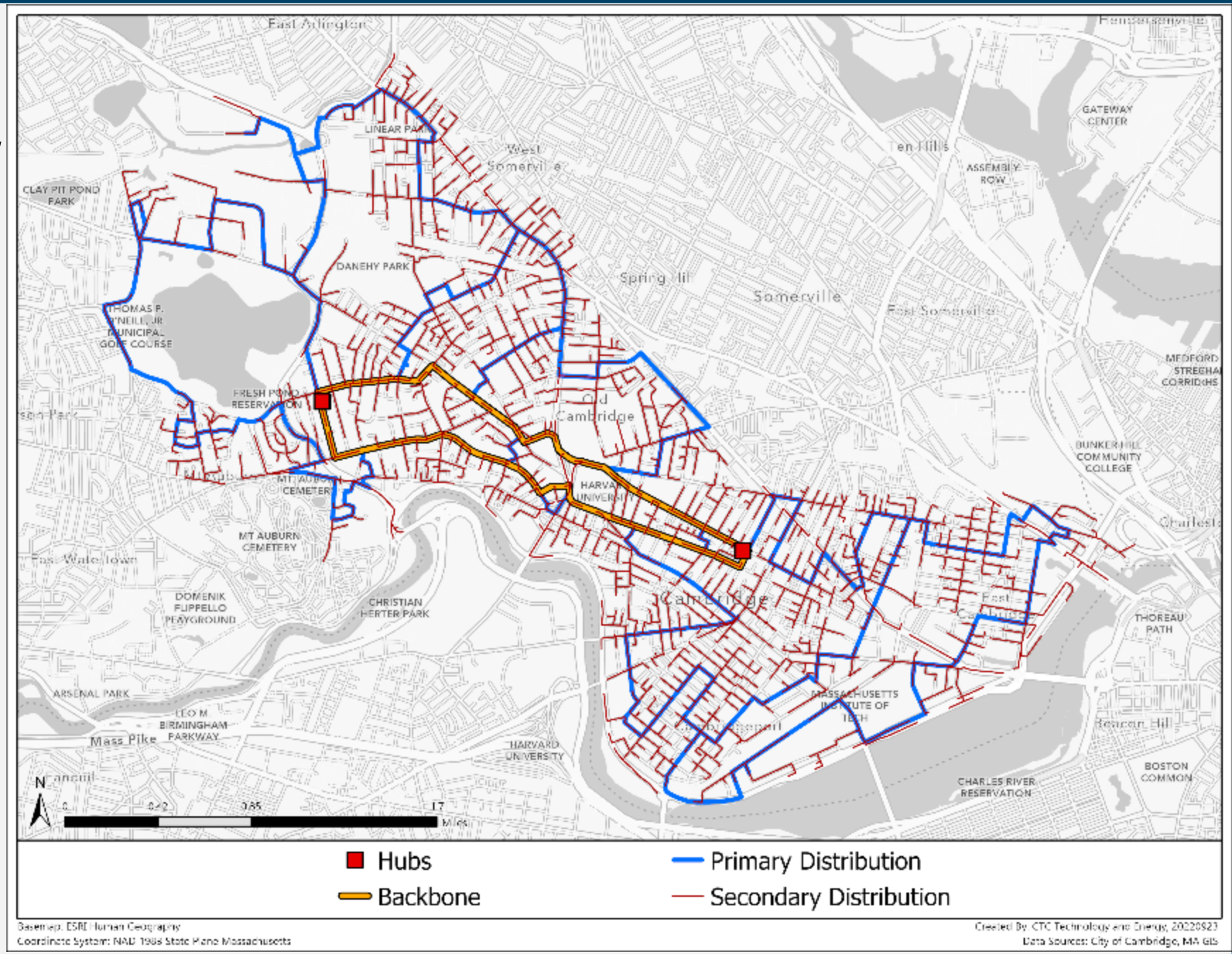
DESIGN OVERVIEW

Backbone and Primary Distribution

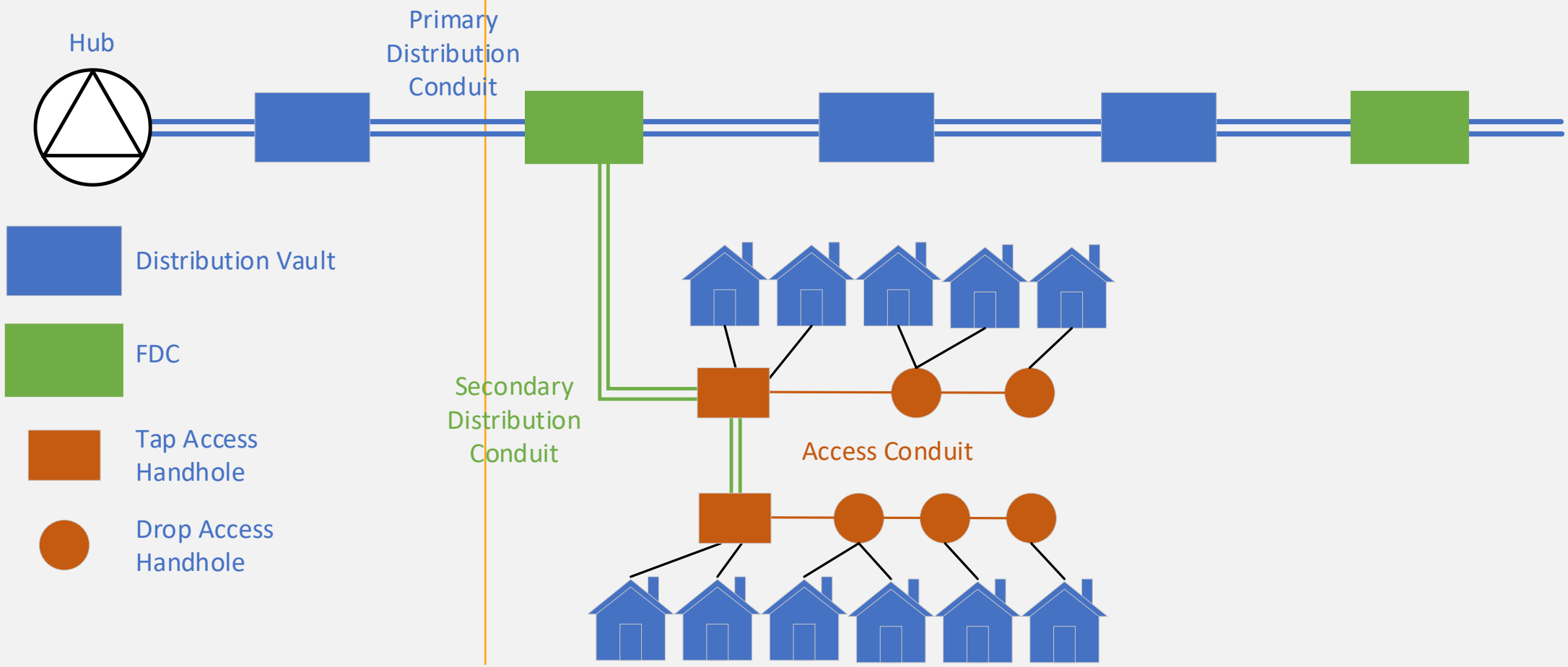


DESIGN OVERVIEW

Backbone, Primary Distribution, and Secondary Distribution



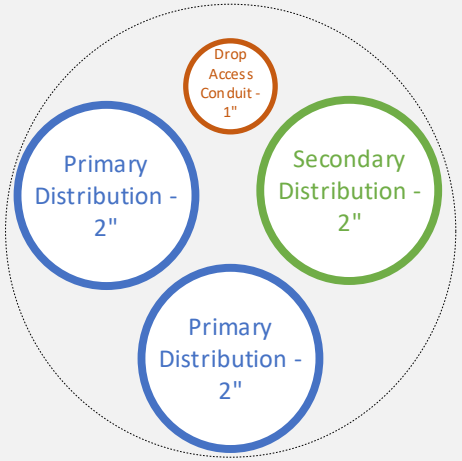
“LAYER 0” CONCEPTUAL DESIGN



PRIMARY CONDUIT CONFIGURATION TYPES AND UNIT COST ESTIMATES (COMPOSITE BORE / TRENCH)

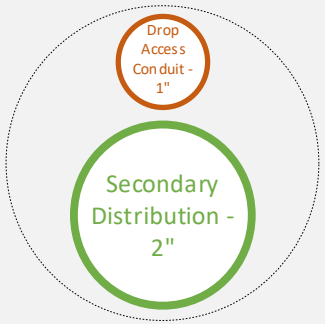
Scenario 1: *38% underground / 62% aerial*

Primary & Secondary Distribution, Drop Access



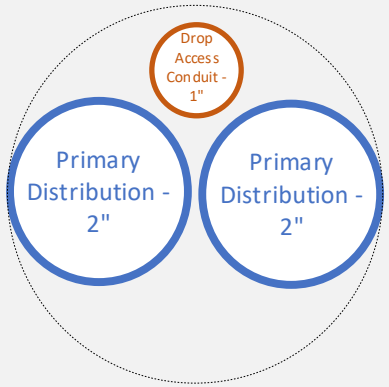
$71.20 per foot
~6.7 miles

Secondary Distribution and Drop Access



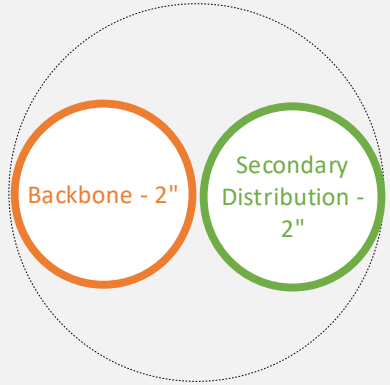
$58.2 per foot
~28.1 miles

Primary Distribution and Drop Access



$65.20 per foot
~2.3 miles

Backbone & Secondary Distribution



$64.20 per foot
~3.4 miles

Drop Access

$56.70 per foot
~10.9 miles

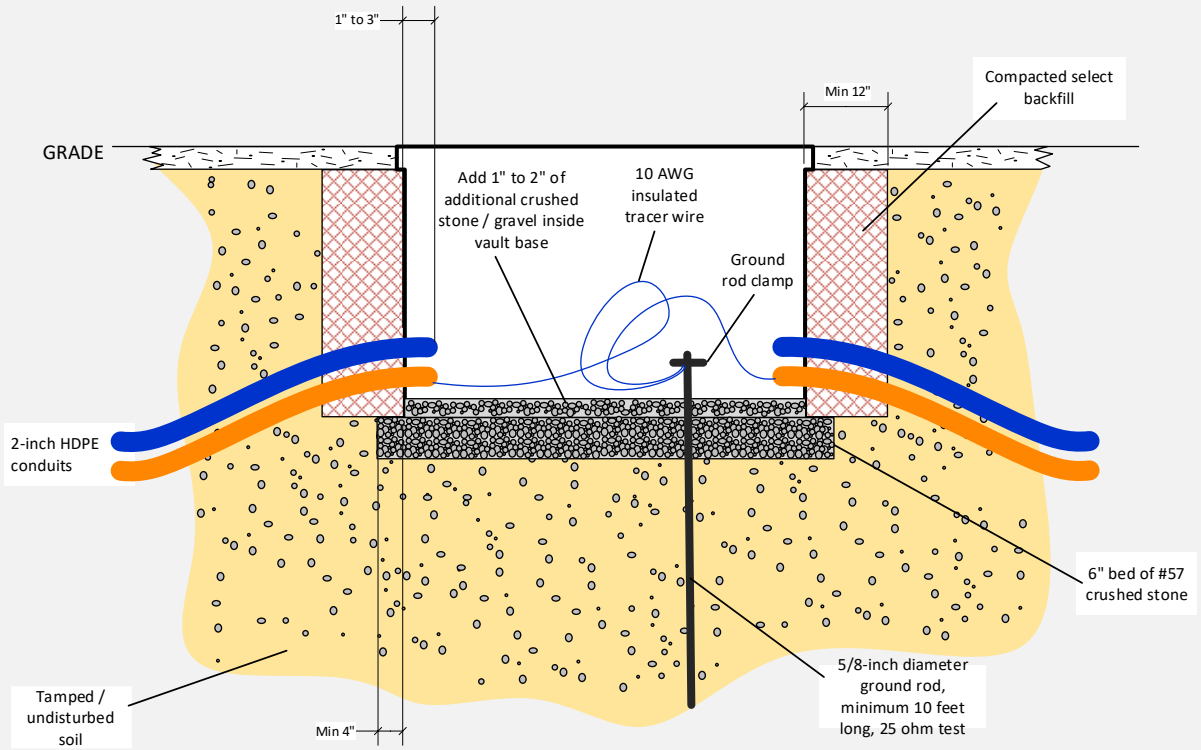
$56.70 per foot
~48.0 miles

Note: Pricing includes all labor and material costs for conduit installation, including tracer wire and hard rock contingency. Pricing does not include handholes or fiber-related labor and material.

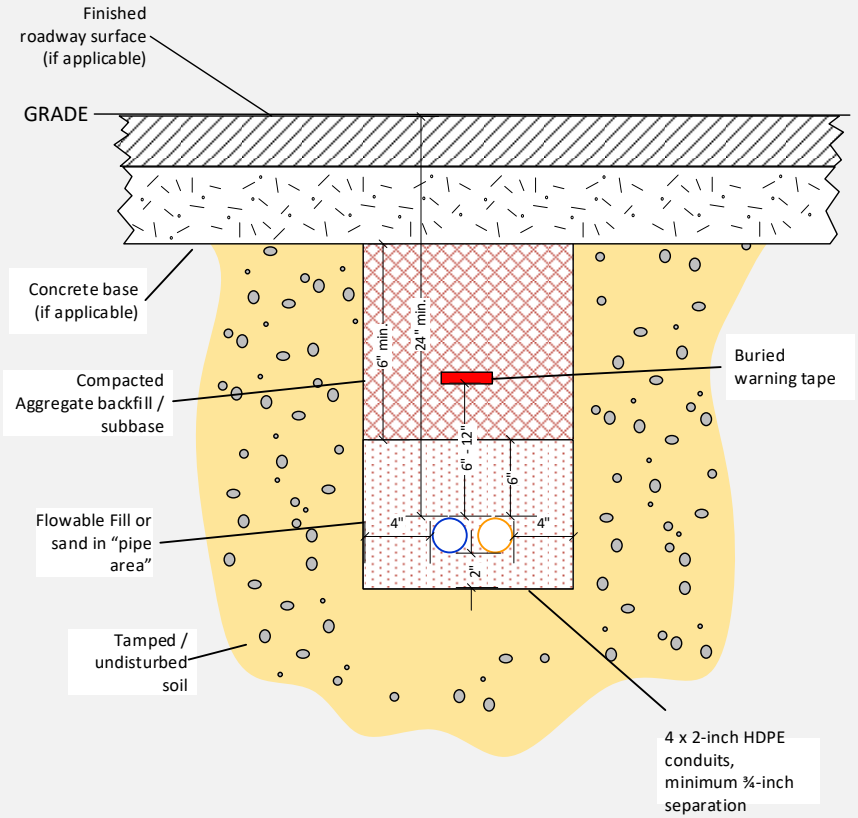
INSTALLATION TYPICALS

Vaults and Strand Trench Profiles

Typical Vault Installation

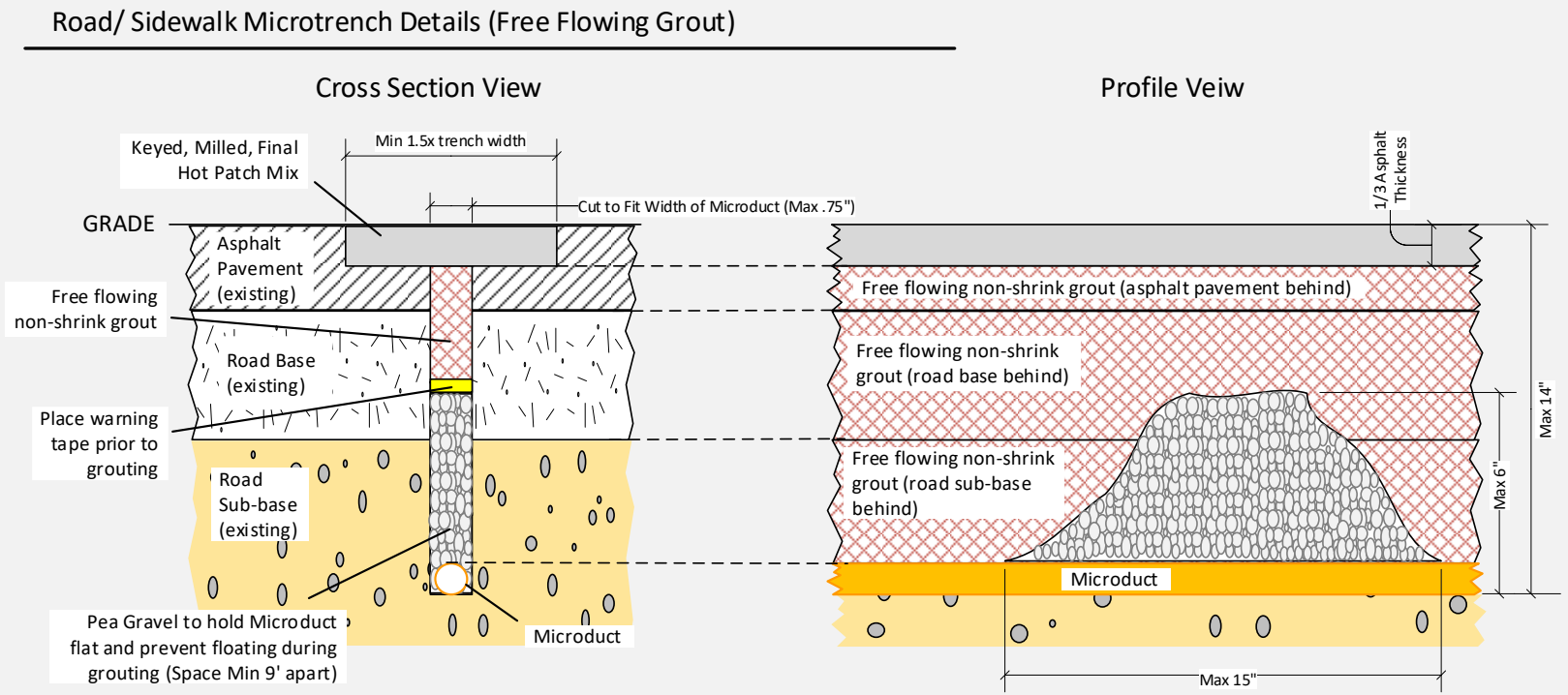


Trench Details



INSTALLATION TYPICALS

Microtrench



PRIMARY VAULT CONFIGURATION TYPES AND UNIT COST ESTIMATES

Scenario 1: *38% underground / 62% aerial*

Equipment Vault (30”x48”x36”)

$6,655 each
Qty. 16

Distribution Vault (24”x36”x36”)

$3,255 each
Qty. 58

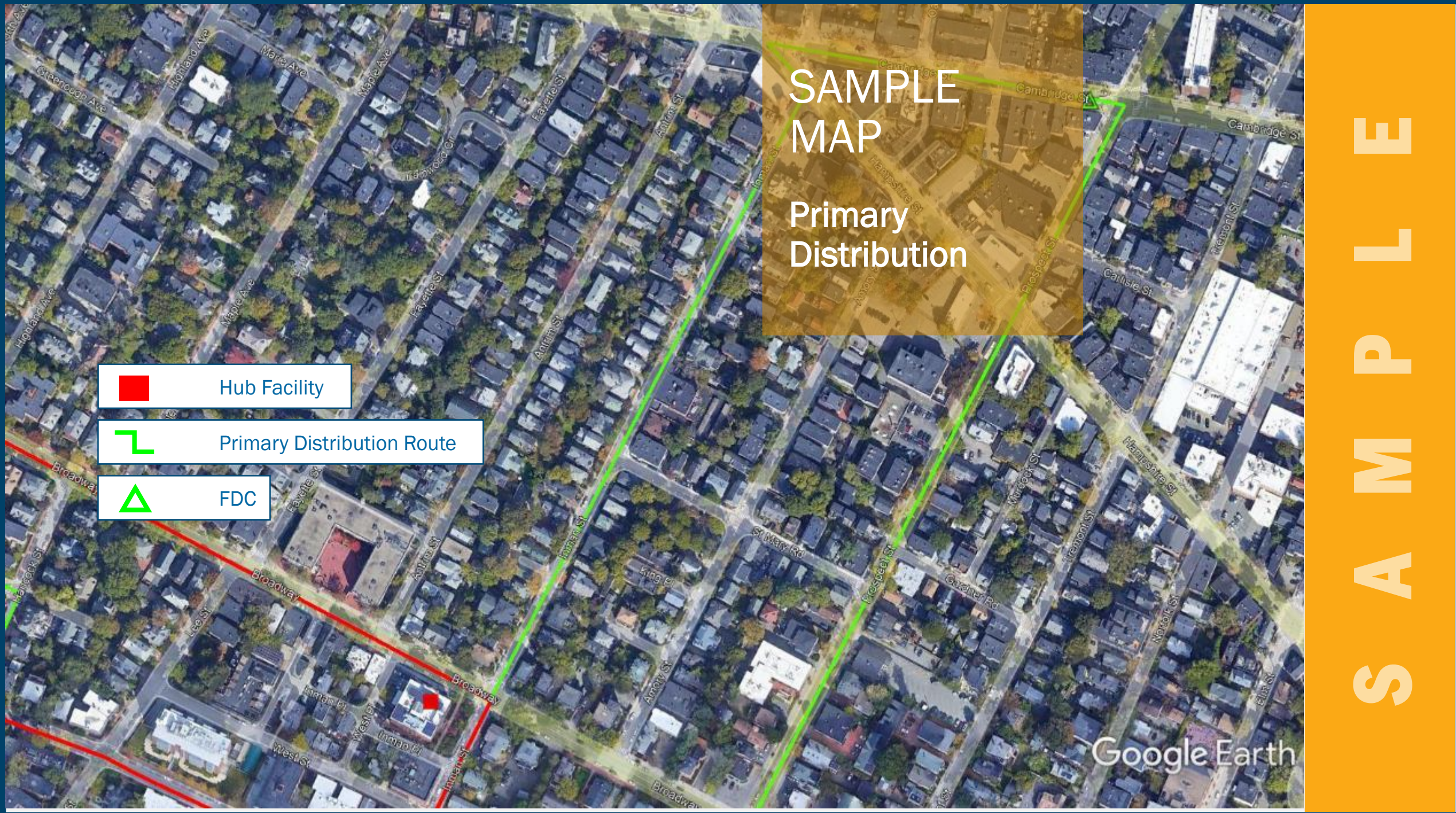
Tap Access Handhole (18”x30”x18”

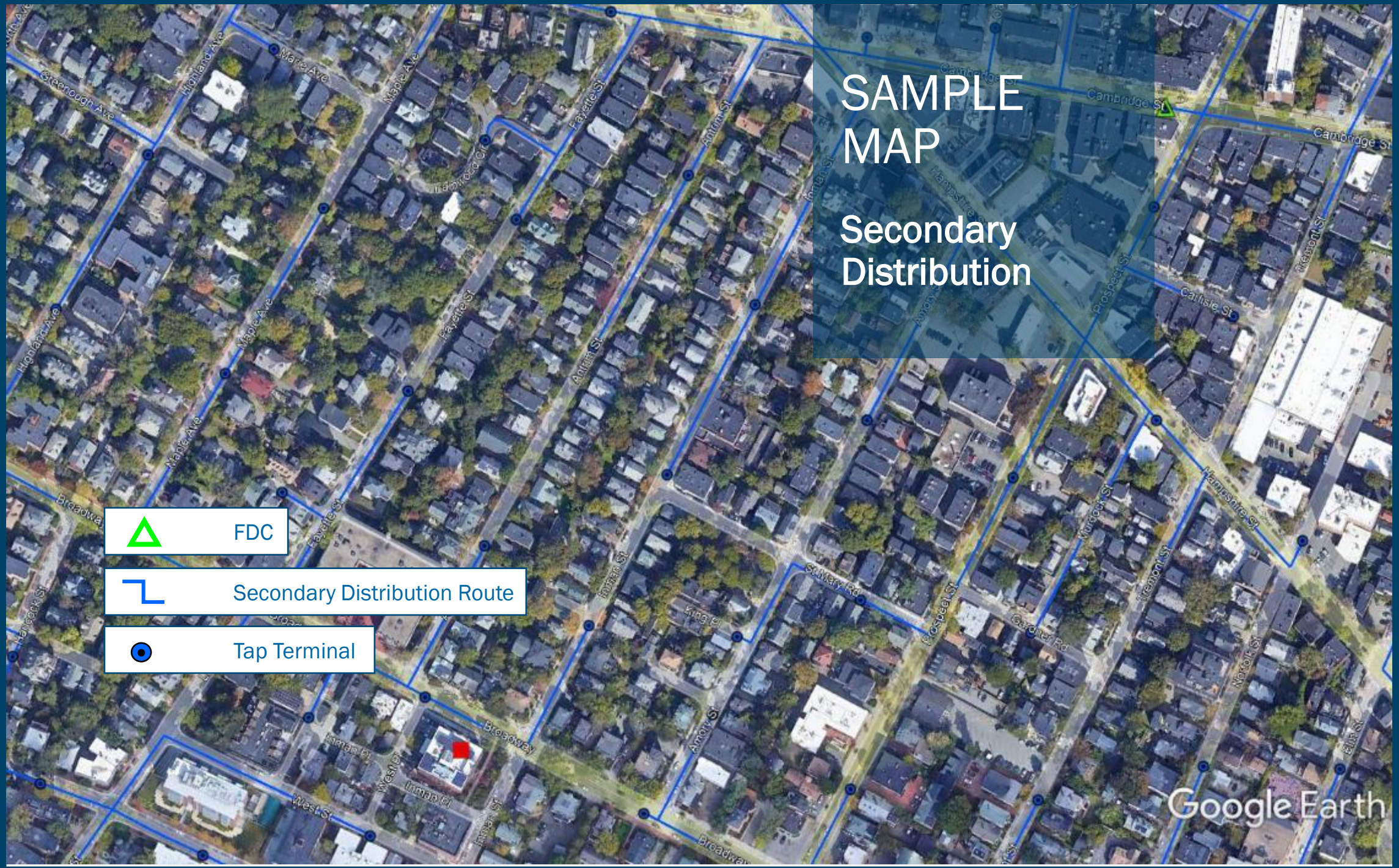
$1,455 each
Qty. 638

Drop Access Handhole (12”x12”x12”)

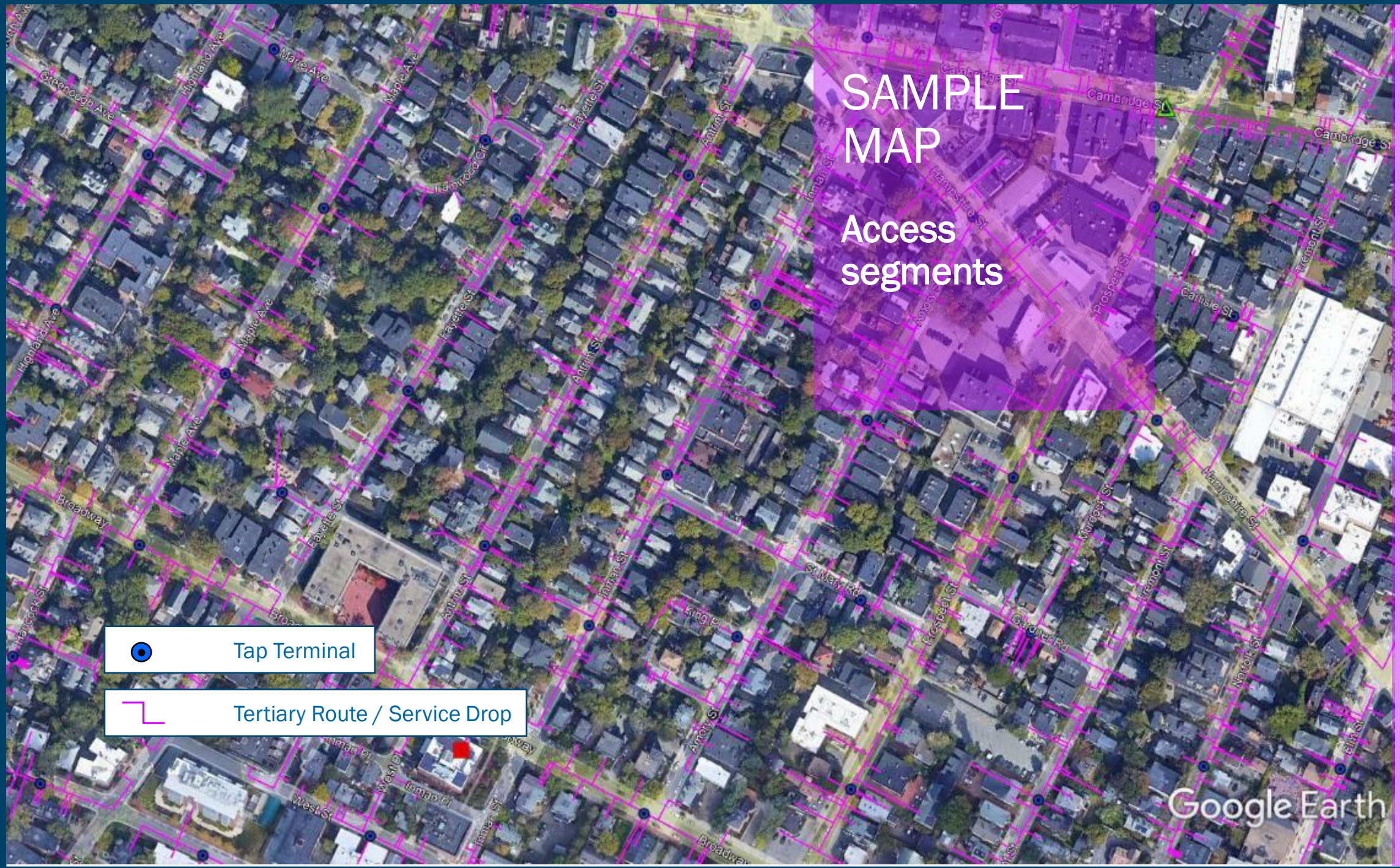
$1,105 each
Qty. 3,039

Note: Pricing includes all labor and material costs for vault / handhole installation, including ground rods. Pricing does not include conduit or fiber-related labor and material.


SAMPLE MAP
Primary Distribution
Hub Facility
Primary Distribution Route
FDC
Google Earth
SAMPLE


SAMPLE MAP
Secondary Distribution
FDC
Secondary Distribution Route
Tap Terminal
Google Earth

SAMPLE


SAMPLE MAP
Access segments
Tap Terminal
Tertiary Route / Service Drop
Google Earth

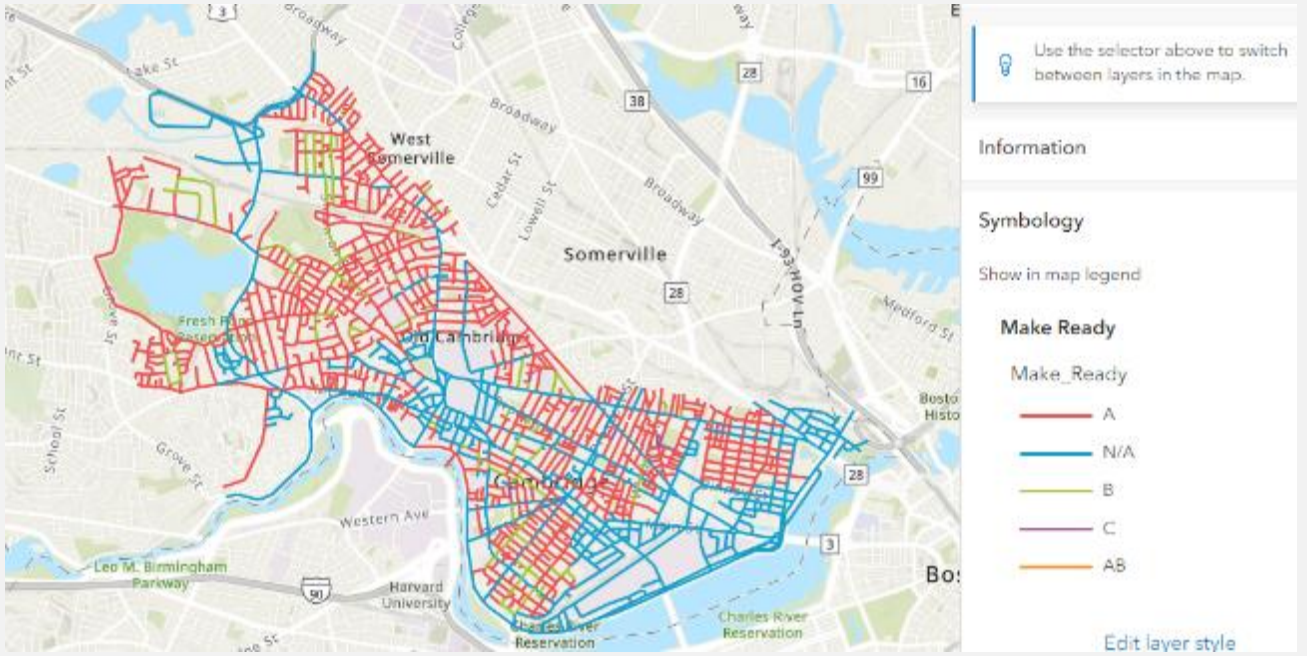
SAMPLE


SAMPLE MAP
Combined distribution & access segments
Hub Facility
Primary Distribution Route
FDC
Secondary Distribution Route
Tap Terminal
Tertiary Route / Service Drop
Google Earth

FIELD SURVEY RESULTS

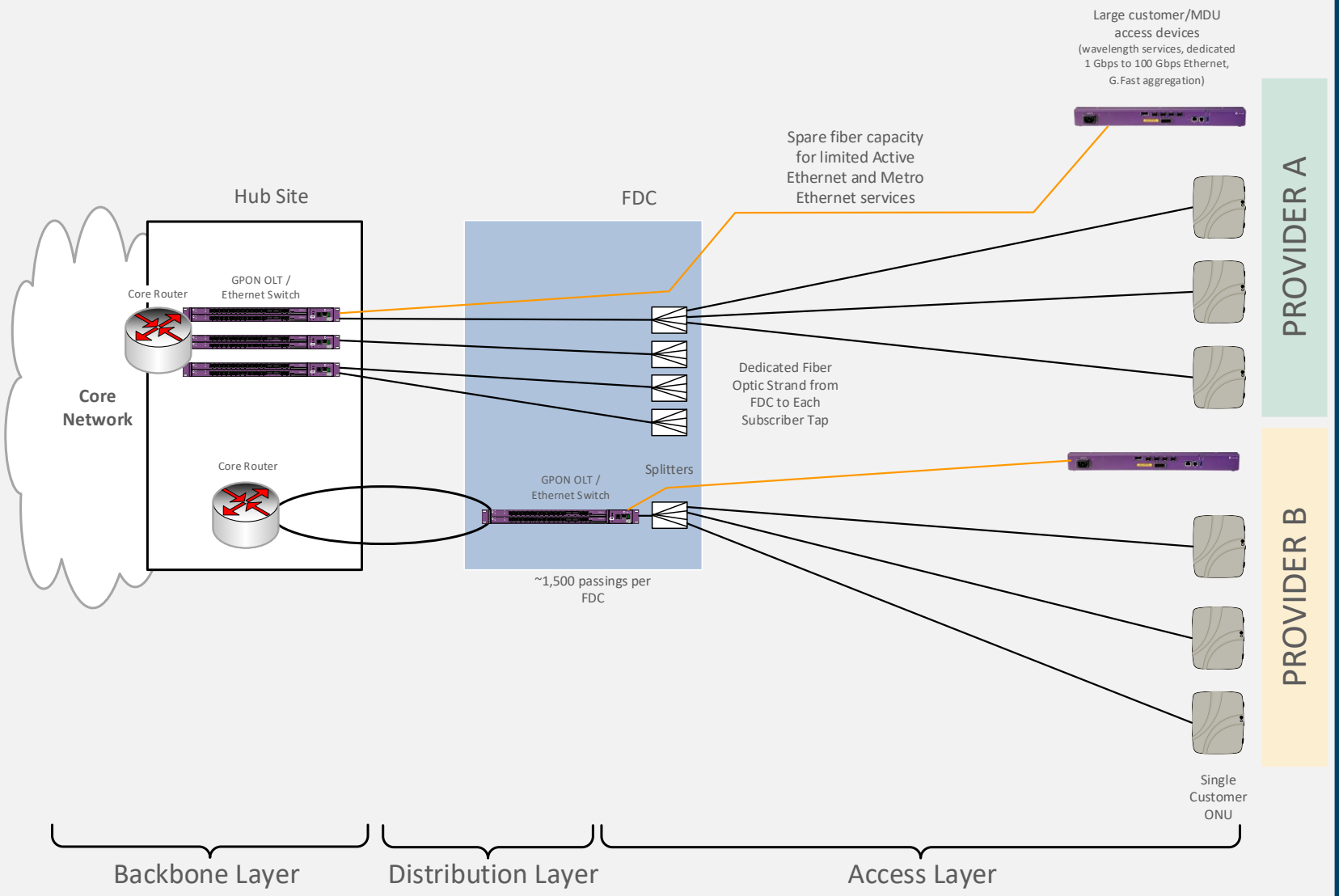
- Survey of all 156 miles of candidate public right-of-way
  - 62.1% aerial (utility poles available)
  - 37.9% underground
- Estimate utility pole make-ready costs to be $4.1 million based on design encompassing a total of 130.3 route miles (underground and aerial)

Make-Ready Attribute	Make-Ready Survey Classification		
	Type A	Type B	Type C
Total estimated utility poles along routes of each classification	3,603	412	28
Percent of poles requiring make ready	25.0%	50.0%	75.0%
Cost per existing attachment relocation	$500	$500	$500
Percent of poles requiring replacement	5.0%	10.0%	25.0%
Average attachments per pole	1.0	2.0	2.0
Average poles per mile	50	50	50
Cost per pole replacement	$10,000	$10,000	$10,000
Estimated make-ready cost per foot	$8.29	$18.94	$42.61
Total Strand (ft)	380,443	43,552	2,989
Total Strand (mi)	72.05	8.25	0.57
Total make-ready cost	$2,837,112	$742,371	$114,631



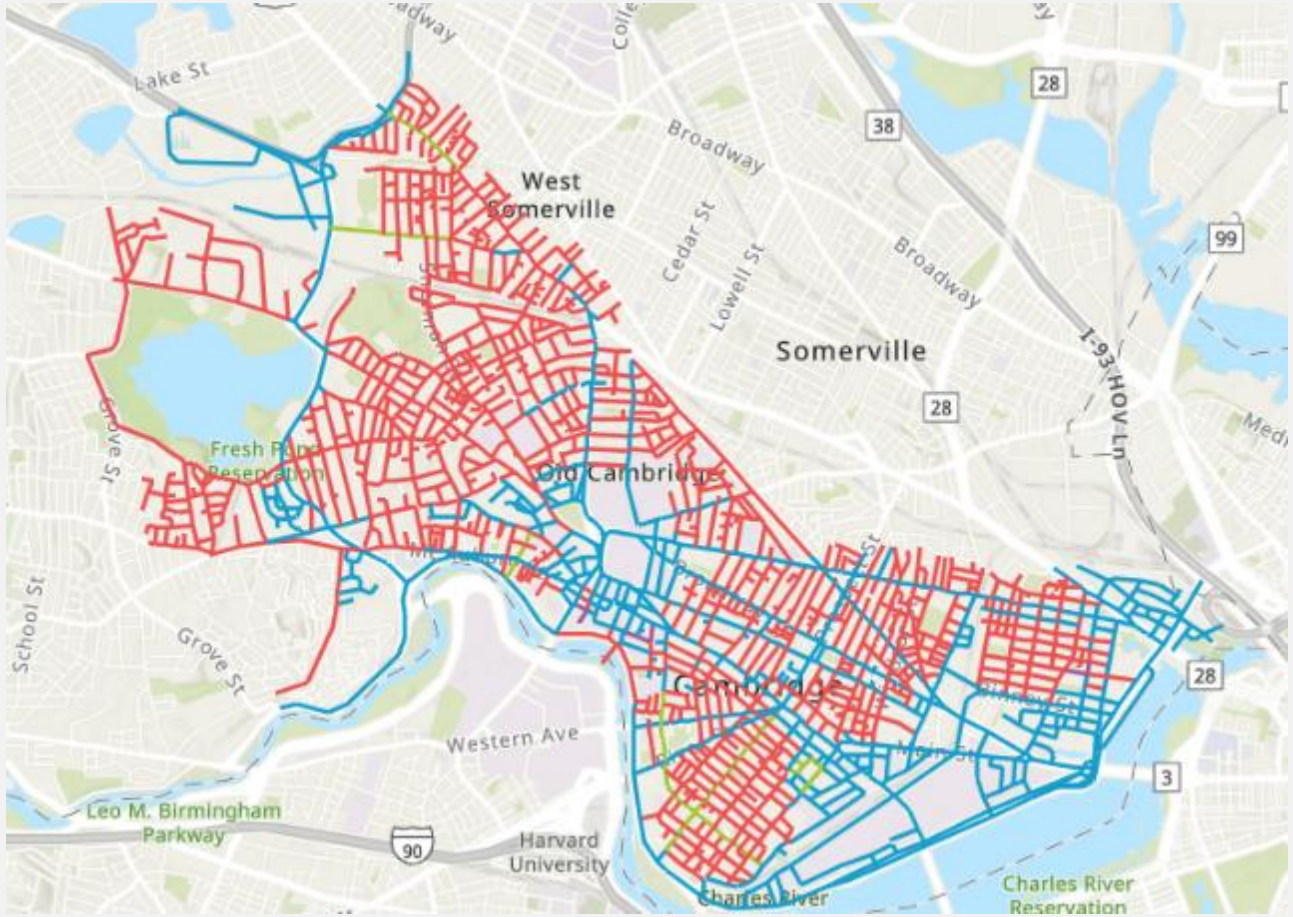
NETWORK ELECTRONICS & FIBER COMPONENT REFERENCE DESIGN

Flexible architecture capable of supporting multiple electronics architectures and/or multiple providers with differing approaches



INFRASTRUCTURE BUILDOUT

Extensive field survey work was conducted to develop preliminary design and inform capital expenditure estimate

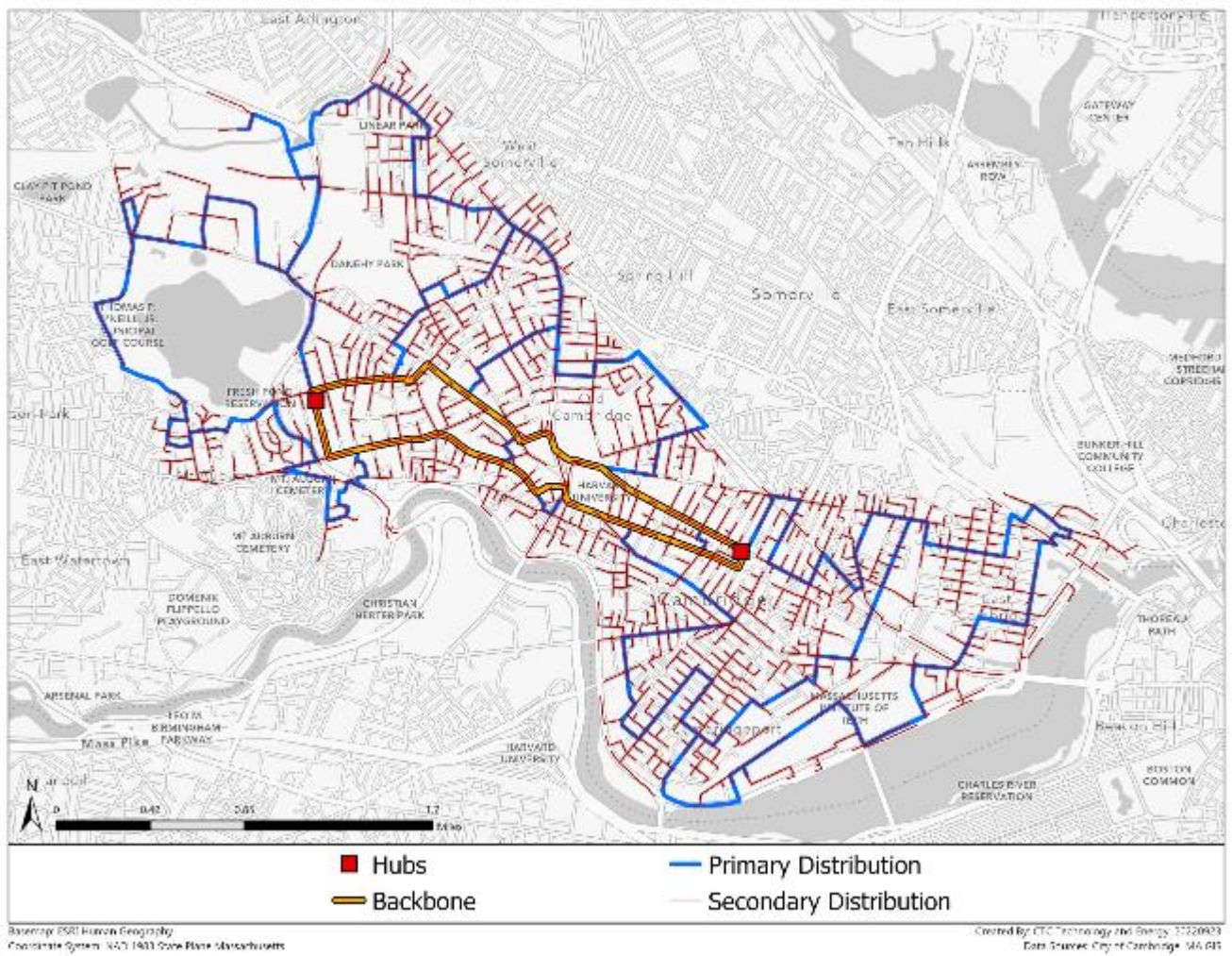


- Field survey conducted by a team of senior telecommunications outside plant (OSP) engineers
  - Physical walk-out or drive survey of 100% of 156 miles of candidate public right of way: 62.1% aerial (utility poles available) + 37.9% underground
  - Data collected in real-time using custom GPS/GIS tools to accurately record findings
- Generated GIS data to inform cost estimates and market conditions
  - Presence of existing utility poles
  - Make-ready assessment of utility poles
  - Presence of existing broadband infrastructure (cable, fiber, legacy telecom)

Notes: See Appendix for more detail

INFRASTRUCTURE BUILDOUT

Based on field survey, the proposed network design would create a robust infrastructure that could serve the city with leading edge technology for decades



- Citywide FTTP comprised of 130.3 route miles:
  - 80.9 miles (62.1%) aerial (utility poles available)
  - 49.4 miles (37.9%) underground
- Key elements would include redundant core hub sites, fully diverse backbone ring, and primary/secondary distribution
- 42 primary Fiber Distribution Cabinets (FDCs)
  - Connected to core hubs over fully diverse primary distribution routes
  - Each serves up to 1,500 subscribers
  - Supports passive and/or active electronics

MUNICIPAL LIGHT PLANT (MLP) STRUCTURE

MLPs are used by some Massachusetts municipalities that directly run broadband businesses in particular contexts

- An MLP is a Massachusetts legal entity that enables a municipality to directly run an electricity, gas or (more recently) communications business
  - Some longstanding MLPs that provide electricity (e.g., Braintree, Norwood) entered the cable broadband business about 20 years ago leveraging utility expertise and assets
  - Certain rural western Massachusetts towns created MLP structures solely to provide broadband service using one-shot state capital grants, but the context differs
- Creating a Cambridge MLP would be required if the City wishes to directly run a broadband business, but by itself does not affect business feasibility
- The City does not need an MLP to build a network that would be operated by a partner who would in turn provide broadband service

Note: Statements are general in nature and subject to updated legal guidance by qualified counsel. Neither CTC nor Rebel provide legal advice.

COST ESTIMATION OBJECTIVES

Purpose-built analysis to support strategic broadband planning

Understand the range of costs to deploy a state-of-the-art FTTP network under various scenarios for scope and construction methodologies

- Physical fiber plant construction and design – aerial vs underground, MDU connectivity and interior wiring
- Network hub facilities – redundancy and scale, use of existing facilities
- Network electronics at varying take-rates
- Customer activation costs (service drops and CPE) at varying take-rates

Inform financial modeling and negotiations with candidate private partners

- Generate breakdowns of component parts corresponding to division of capex contributions for most likely partnership scenarios and targeted populations
  - Active vs passive infrastructure
  - Wiring of MDUs containing affordable housing
- Collect field data and analysis that can be shared with candidate partners to support their own cost modeling
  - Determine availability of existing utility poles and ascertain pole make-ready cost factors
  - Characterize make-up of MDU structure types and related deployment cost