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Your network success story.

Boston Gateway Expansion
CoreSite BO1
70 Inner Belt Road

October 16, 2019

Why the new expansion?

Recent growth demands a bigger gateway hub in the region

- Unforeseen growth in TWDX fiber builds this year:
  - ✓ Fiber 10G/100G to commercial buildings, interconnection ecosystem to large enterprises and small-cell backhaul for wireless carriers: all this activity is overloading our current facilities
- We needed new location for a major network hub that would offer us improved diversity:
  - ✓ Boston suffers from "too many eggs in one basket" problem:
    - Excessive network concentration in very limited sites
    - We saw this movie before in NYC: Hurricane Sandy, 111 8th Avenue, etc..
  - ✓ Both NYC and N. Virginia regions are becoming much more competitive and diversified, this is a good thing:
    - Virginia Beach, QTS, 165 Halsey, 1025 Connect, NJFX, DE-CIX NY, etc
  - ✓ Boston is now a fast growing city, with growth outpacing existing network investments
    - To ensure resiliency of the internet architecture, networks must plan for diversity today to prepare for tomorrow

Why did we choose CoreSite at 70 Inner Belt for our new Boston hub?

- Optimal balance between geographical diversity vs. cost:
  - ✓ We wanted a location which is right next to downtown while being sited away from existing hubs: Being too far away from the city increases network costs by requiring more backhauls
- Inner Belt district offers easy access to long-haul fibers, making it ideal for new network developments
  - ✓ Shortest route to GTT sub-sea landing station and Maine Fiber Company (now FirstLight)
  - ✓ Near from Cambridge Ma Bell row (Bent St./Fulkerson St.) and straight path to westbound long-haul routes
  - ✓ Industrial area makes it easier to construct underground utilities, compared to very busy downtown areas

Joint Network Facilities BSN 04

- New expanded gateway hub at CoreSite is called Joint Network Facilities BSN 04

  It's called "Joint Facilities" because the premises are jointly built and maintained for TWDX IP (AS27552), Packetsurge, TWDX Optical (TOC) and MASS IX.

BSN04 Construction Project Key Objectives

1. **Build diverse fiber entrance facilities and network points of presence in CoreSite BO1:**
   - New TWDX designed and constructed diverse fiber entrance facilities
   - Maintain two separate redundant POPs inside the data center
     - ✓ Existing legacy POP already at CoreSite will be called "BSN 05"
     - ✓ New facility under construction is "BSN 04." Both legacy and new facilities will be operated together under a diverse infrastructure design.

2. **Contribute to our mission of maintaining assured access to fiber assets**

   While challenges in accessing dark fiber at scale is a fact of life for competitive network operators, for critical connectivity between our gateways, we can no longer afford to remain over-leveraged by incumbent players. We need to start owning some of the underlying infrastructure that we rely so heavily on, for our backbone:

   - Construct new underground utility infrastructure to accommodate TWDX communications facilities feeding our backbone gateways
   - TWDX owned system of duct banks and underground facilities will secure right-of-way for our own fibers and facilitate utility interconnection agreements

Joint Network Facilities BSN 04

- BSN 04 Colocation Space Specifications:
  - New 560 sq ft cage at CoreSite BO1 data center in 70 Inner Belt Road
  - Initial fit out for 20 telecom racks
  - Low density power (100 kW) for network loads
  - 10-year colocation license from CoreSite commenced in 2019, with option to renew for 3 years
  - TOC Class-B Optical Facility for termination of long-haul fibers (OTS segments ≥150km):
    Site is rated for high powered amplifier operations (≥0.5 W pump laser output)

- Project work is divided into two contract packages:

  - **C19E1: Outside Plant Construction at Third Avenue**
    - Underground duct bank, manhole construction and trenching from CoreSite property line facing 3rd Avenue to TWDX underground utilities
    - 864-count fibers from TWDX manhole to CoreSite North Fiber Room

  - **C20E3: Inside Plant Activities**
    - Colocation facility fit out and distribution frames installation
    - Optical Cable Entrance Facility (OCEF) interfacing at North & South Fiber Rooms
    - Diverse 192-count fibers to both first floor and second floor Meet-Me Rooms

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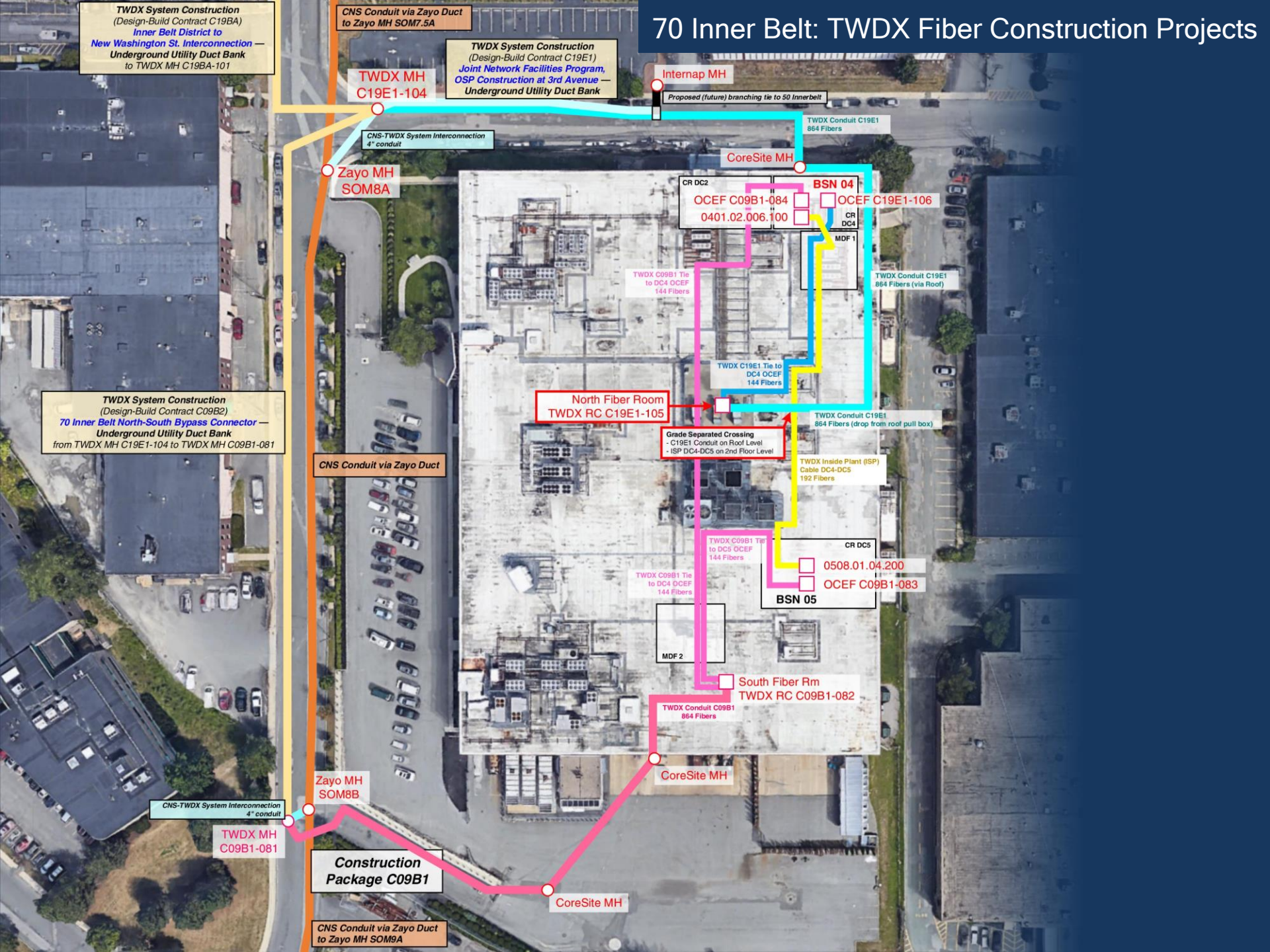
Outside Plant Construction Overview

Joint Network Facilities BSN 04

70 Inner Belt Road

October 2019

70 Inner Belt: TWDX Fiber Construction Projects



C19E1: Outside Plant Construction at Third Avenue

Design-Build Contract Package:

General Contractor:	CNS LLC
Project Engineer:	Gill Engineering Associates, Inc.
Construction and Suppliers:	JBC Utility LLC, Waveguide Inc, CommScope, Century Fiber Optics

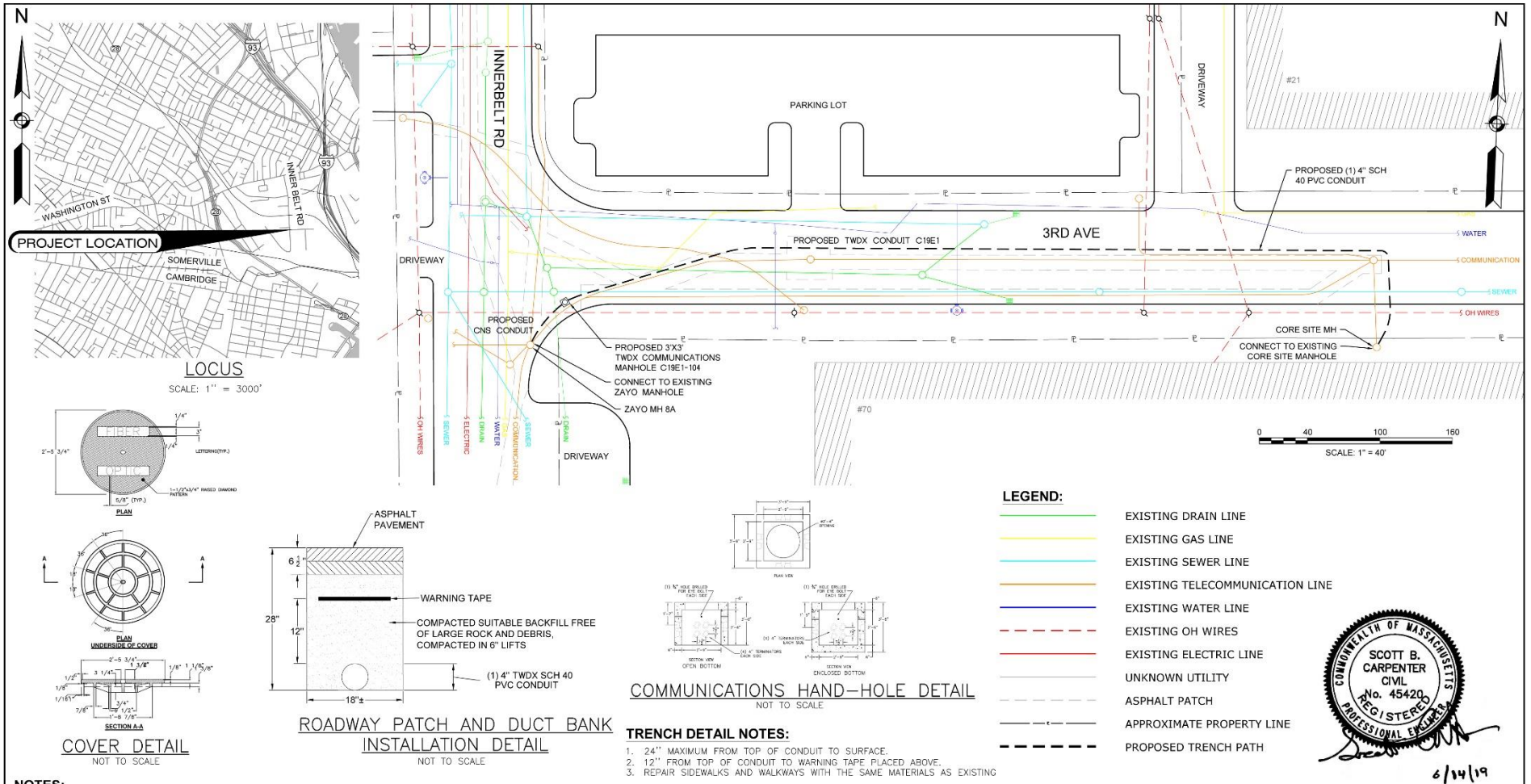
Description:

Trench approximately 400’ and construct underground utility duct bank & conduit facilities, starting at the intersection of 3rd Ave & Innerbelt Rd and running easterly down 3rd Ave. Trench 4 inch pipe into CoreSite manhole located in the grass on the north side of the building at 70 Inner Belt Rd; cap & terminate a spare 4 inch pipe in front of 50 Inner Belt, aligned near from Internap manhole for future branching expansion.

C19E1 Project Timeline

- May 7, 2019: Design-Build Contract awarded to CNS; Notice to Proceed issued
- June 6, 2019: Draft civil engineering and traffic control plan completed by Gill Engineering
- June 13, 2019 Petition for Grant of Location submitted to City of Somerville for construction upon the public right of way.
- June 18, 2019 Street Opening & Excavation Permit procedure with City of Somerville Department of Public Works
- July 11, 2019: City Council Meeting: Advisement that Third Avenue is not a city managed street; CNS-TWDX must follow notification procedure for affected abutters. Construction Package RFP issued to Waveguide Inc, Phoenix Communications Inc and JBC Utility LLC for bids.
- July 23, 2019: Approval from CoreSite Facilities for utility ingress onto CoreSite private property
- July 26, 2019: Owner's Meeting: C19E1 Construction Package awarded to JBC Utility LLC for heavy construction
- August 2, 2019: Dig Safe called to summon all utilities to mark their underground facilities; police escort detail & traffic plan
- August 13, 2019: Crews commence saw cutting and excavation on 3rd Avenue
- August 20, 2019: TWDX conduit entry into CoreSite manhole past property demarcation; Underground trenching complete.
- August 22, 2019: Excavation on Inner Belt Road for manhole and approach duct bank construction
- August 28, 2019: Construction of TWDX manhole C19E1-104 and 3rd Avenue utility duct bank completed.
- August 29, 2019: Re-pavement of 3rd Avenue completed with 4" base/binder and 2" topcoat per MassDOT Standard Specification
- Sept. 4, 2019: Dig Safe System membership and marking of new TWDX underground utilities on Inner Belt Road & Third Ave; work commences on C09B2 & C20E3 project interfaces
- Sept. 16, 2019: C19E1 Construction Package closeout: project turn-over to Waveguide, Inc. for fiber optic cable plant design and installation

C19E1: Third Avenue Initial Trench Alignment Proposal



COVER DETAIL
NOT TO SCALE

ROADWAY PATCH AND DUCT BANK INSTALLATION DETAIL
NOT TO SCALE

COMMUNICATIONS HAND-HOLE DETAIL
NOT TO SCALE

LEGEND:

- EXISTING DRAIN LINE
- EXISTING GAS LINE
- EXISTING SEWER LINE
- EXISTING TELECOMMUNICATION LINE
- EXISTING WATER LINE
- EXISTING OH WIRES
- EXISTING ELECTRIC LINE
- UNKNOWN UTILITY
- ASPHALT PATCH
- APPROXIMATE PROPERTY LINE
- PROPOSED TRENCH PATH

TRENCH DETAIL NOTES:

1. 24" MAXIMUM FROM TOP OF CONDUIT TO SURFACE.
2. 12" FROM TOP OF CONDUIT TO WARNING TAPE PLACED ABOVE.
3. REPAIR SIDEWALKS AND WALKWAYS WITH THE SAME MATERIALS AS EXISTING

COMMONWEALTH OF MASSACHUSETTS
SCOTT B. CARPENTER
CIVIL
No. 45420
REGISTERED PROFESSIONAL ENGINEER
6/14/19

NOTES:

1. ALL UTILITY LOCATIONS ARE APPROXIMATE AND MAY NOT MATCH FIELD CONDITIONS. EXISTING UTILITY INFORMATION SHOWN ON THIS DRAWING HAS BEEN COMPILED FROM EXISTING CITY DRAWINGS AND/OR FIELD INSPECTION. VERIFICATION BY THE SUBCONTRACTOR SHALL BE REQUIRED.
2. THE EXACT LOCATION OF ALL UNDERGROUND STRUCTURES MUST BE VERIFIED. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO LOCATE AND AVOID EXISTING SUBSTRUCTURES. BEFORE EXCAVATING, CALL: 1-888-DIGSAFE.
3. MAINTAIN A MINIMUM CLEARANCE OF 12 INCHES WHEN CROSSING FOREIGN SUBSTRUCTURES.
4. ALL CONDUIT, MANHOLES AND POLES SHALL BE LOCATED IN PUBLIC PROPERTY UNLESS OTHERWISE SPECIFIED.
5. ALL WORK PERFORMED ACCORDING TO THIS DRAWING SHALL BE DONE AS TO COMPLY WITH ALL THE CONDITIONS, RESTRICTIONS, CONSTRUCTION METHODS, AND SAFETY REQUIREMENTS IMPOSED BY THE THE EXCAVATION PERMIT ISSUED AND THOSE REQUIREMENTS IMPOSED BY OSHA. BEFORE EXCAVATING, CALL: 1-888-DIGSAFE.
6. THE LOCATIONS AND SAFE CROSSINGS OF ALL FOREIGN UTILITIES IS THE SUBCONTRACTOR'S RESPONSIBILITY. HAND DIG WHERE REQUIRED.
7. THE SUBCONTRACTOR WILL BE RESPONSIBLE FOR RESTORING THE CONSTRUCTION TO ORIGINAL OR BETTER THAN ORIGINAL CONDITION.
8. IT WILL BE THE RESPONSIBILITY OF THE SUBCONTRACTOR TO MAINTAIN CONSTRUCTION AS BUILT DRAWINGS AND PRESENT A COMPLETE SET OF DRAWINGS UPON SUBMITTAL OF FINAL INVOICE.
9. TRENCH WORK WILL BE COMPLETED BY CAMBRIDGE NETWORK SOLUTIONS.

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JEFF HARRINGTON
CAMBRIDGE NETWORK SOLUTIONS

6/14/2019

GILL ENGINEERING

TRENCH INSTALLATION
CAMBRIDGE NETWORK SOLUTIONS

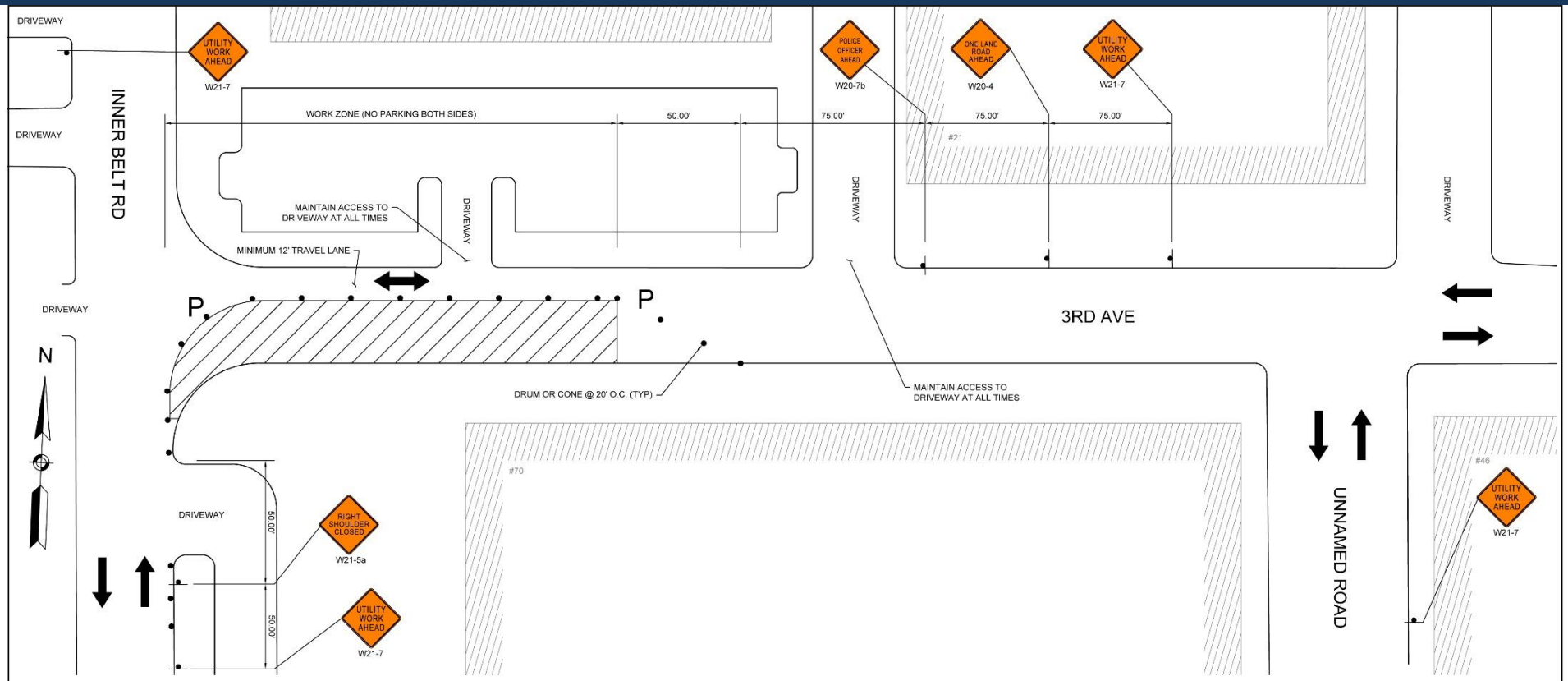
70 INNER BELT ROAD
SOMERVILLE, MA

GENERAL PLAN

SHEET 1 OF 01

Gill Engineering Associates, Inc. 63 Kendrick Street Needham, MA 02494 781-355-7100 www.gill-eng.com

C19E1: Construction Traffic Management Plan



NOTES:

1. ALL TEMPORARY TRAFFIC CONTROL WORK SHALL CONFORM TO THE LATEST EDITION OF THE "MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES" (MUTCD) AND ALL REVISIONS, UNLESS SUPERCEDED BY THESE PLANS.
2. ALL SIGN LEGENDS, BORDERS, AND MOUNTING SHALL BE IN ACCORDANCE WITH THE MUTCD.
3. TEMPORARY CONSTRUCTION SIGNING AND ALL OTHER TRAFFIC CONTROL DEVICES SHALL BE IN PLACE PRIOR TO THE START OF ANY WORK.
4. TEMPORARY CONSTRUCTION SIGNING, BARRICADES, AND ALL OTHER NECESSARY WORK ZONE TRAFFIC CONTROL DEVICES SHALL BE REMOVED FROM THE HIGHWAY OR COVERED WHEN THEY ARE NOT REQUIRED FOR CONTROL OF TRAFFIC.
5. SIGNS AND SIGN SUPPORTS LOCATED ON OR NEAR THE TRAVELED WAY, CHANNELIZING DEVICES, BARRIERS, AND CRASH ATTENUATORS MUST PASS THE CRITERIA SET FORTH IN NCHRP REPORT 350, "RECOMMENDED PROCEDURES FOR THE SAFETY PERFORMANCE EVALUATION OF HIGHWAY FEATURES" AND/OR "MANUAL FOR ASSESSING SAFETY HARDWARE" (MASH).
6. CONTRACTORS SHALL NOTIFY EACH ABUTTER AT LEAST 24 HOURS IN ADVANCE OF THE START OF ANY WORK THAT WILL REQUIRE THE TEMPORARY CLOSURE OF ACCESS, SUCH AS CONDUIT INSTALLATION, EXISTING PAVEMENT EXCAVATION, TEMPORARY DRIVEWAY PAVEMENT PLACEMENT, AND SIMILAR OPERATIONS.
7. THE ADVISORY SPEED LIMIT, IF REQUIRED, SHALL BE DETERMINED BY THE ENGINEER.
8. DISTANCES ARE A GUIDE AND MAY BE ADJUSTED IN THE FIELD BY THE ENGINEER.
9. MAXIMUM SPACING OF TRAFFIC DEVICES IN A TAPER (DRUMS OR CONES) IS EQUAL IN FEET TO THE SPEED LIMIT IN MPH.
10. MINIMUM LANE WIDTH IS TO BE 11 FEET UNLESS OTHERWISE SHOWN. MINIMUM LANE WIDTH TO BE MEASURED FROM THE EDGE OF DRUMS OR MEDIAN BARRIER.
11. ALL SIGNS SHALL BE MOUNTED ON THEIR OWN STANDARD SIGN SUPPORTS.

INNER BELT ROAD AT 3RD AVE TTCP STAGE 1

APPROXIMATE SCALE: 1" = 40'

0 40 100 160

SCALE: 1" = 40'

LEGEND:

- DIRECTION OF TRAFFIC
- SIGN
- DRUM OR CONE @ 20' O.C (TYP)
- P POLICE DETAIL
- TYPE III BARRICADE

COMMONWEALTH OF MASSACHUSETTS
SCOTT B. CARPENTER
CIVIL
No. 45420
REGISTERED PROFESSIONAL ENGINEER
6/14/19

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CAMBRIDGE NETWORK SOLUTIONS

6/14/2019

GILL ENGINEERING

TRENCH INSTALLATION
CAMBRIDGE NETWORK SOLUTIONS

INNER BELT ROAD AT 3RD AVE
SOMERVILLE, MA

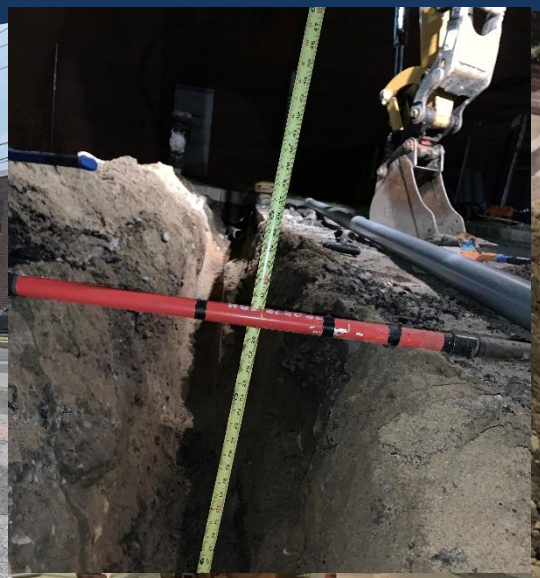
TEMPORARY TRAFFIC CONTROL PLAN

SHEET 1 OF 02

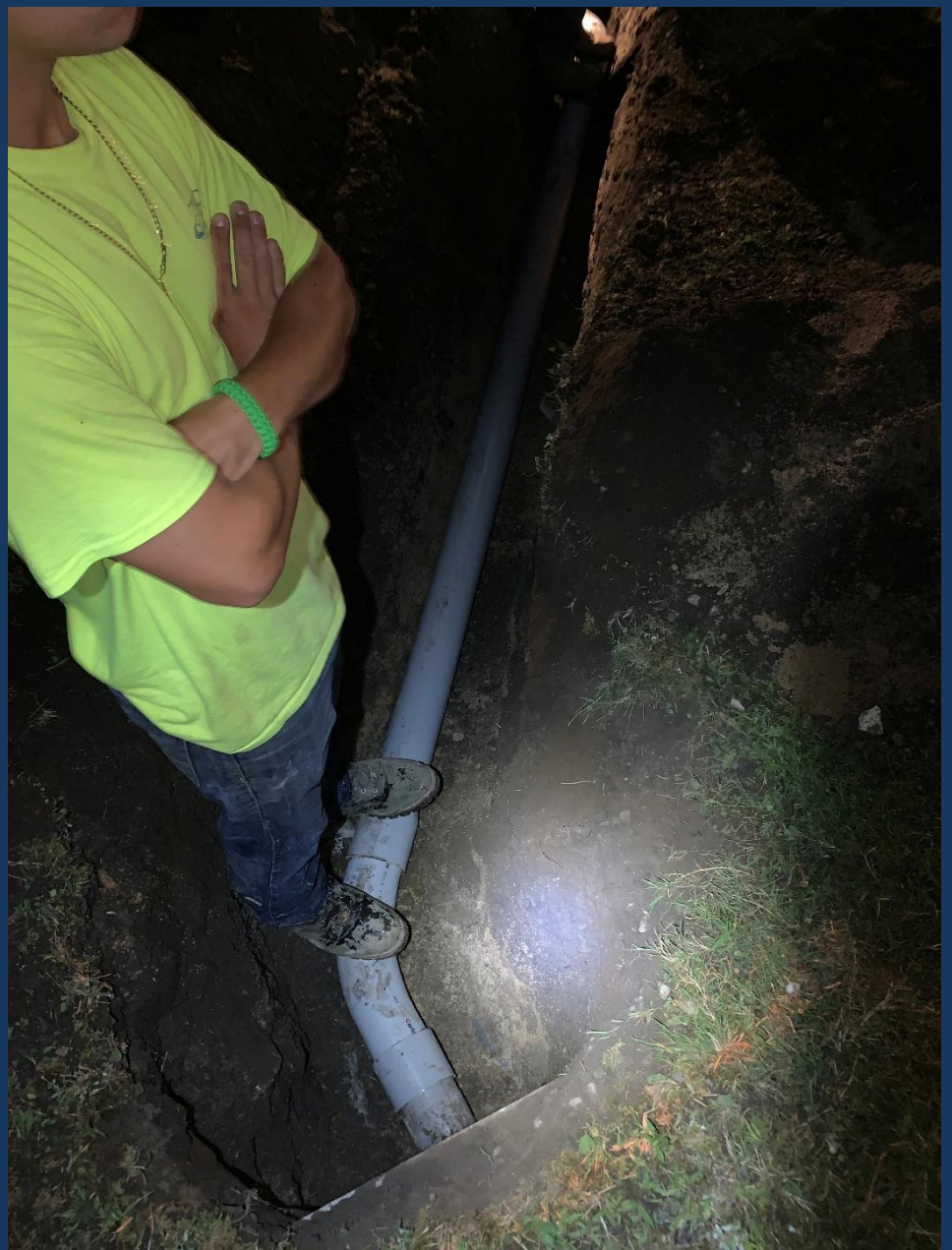
Gill Engineering Associates, Inc. 63 Kendrick Street Needham, MA 02494 781-355-7100 www.gill-eng.com

8/8/2019 – Excavation and Trenching

8/13/2019 - Trenching Continues..

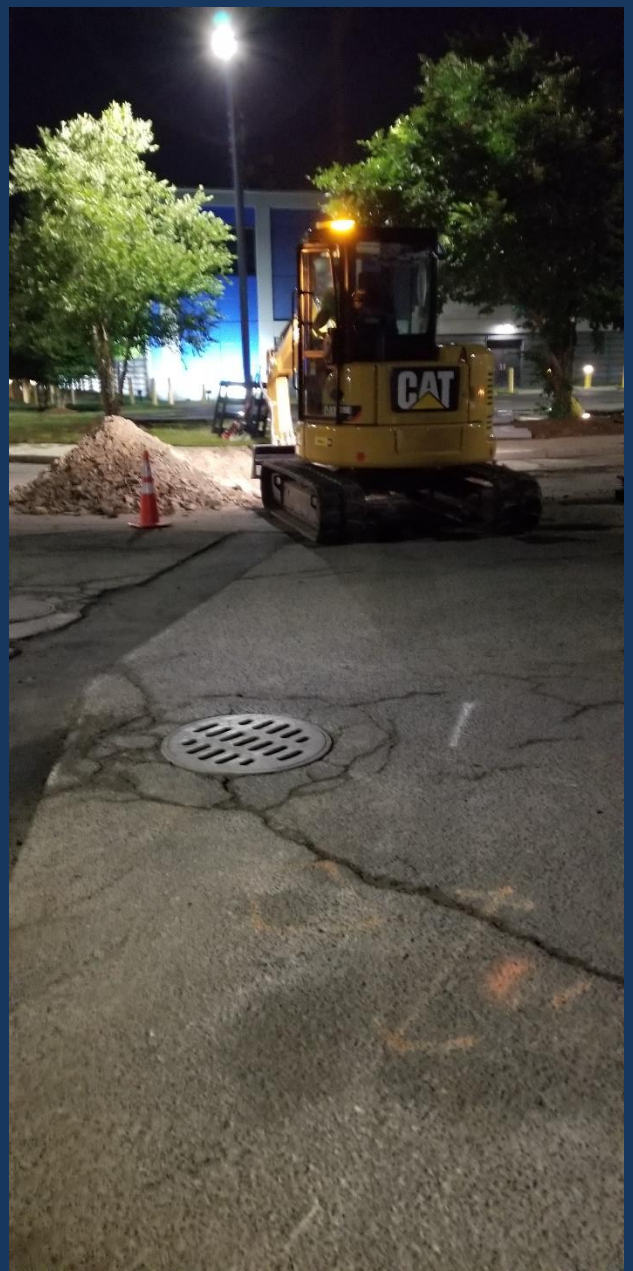


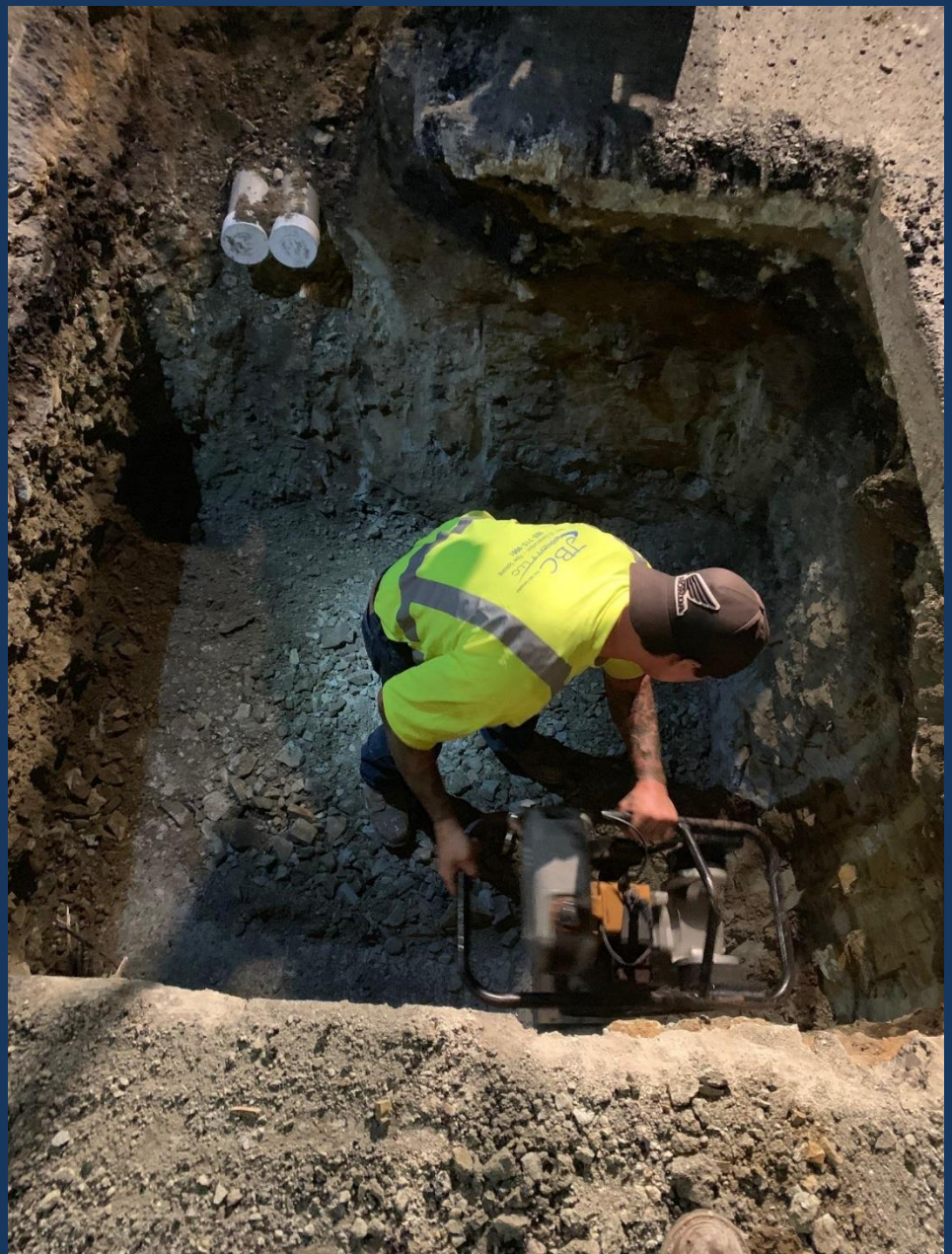
8/20/2019 - C19E1 CoreSite Manhole Interface



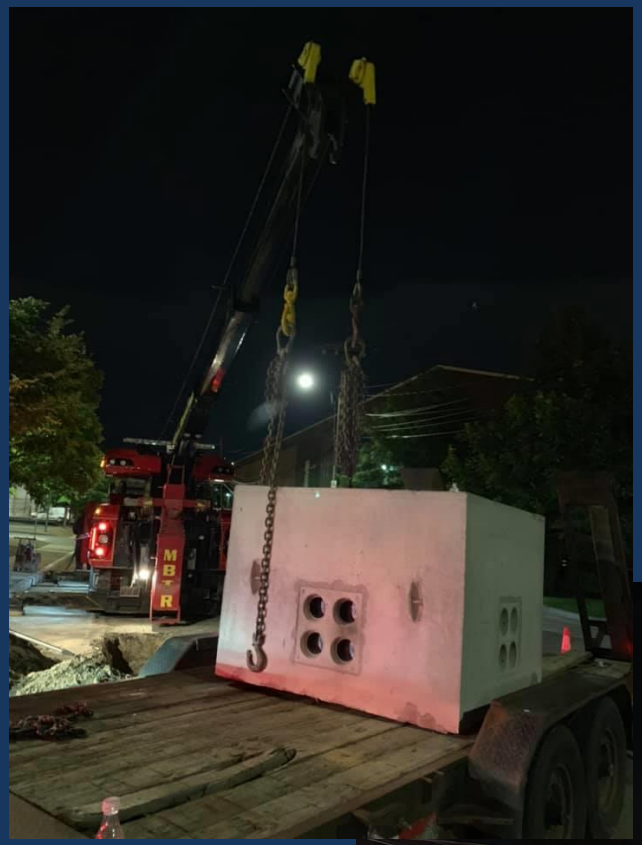
8/22/2019 - C19E1 Duct Bank Construction

8/23/2019 - C19E1-104 Manhole Foundation





8/23/2019 - C19E1-104 Manhole Installation

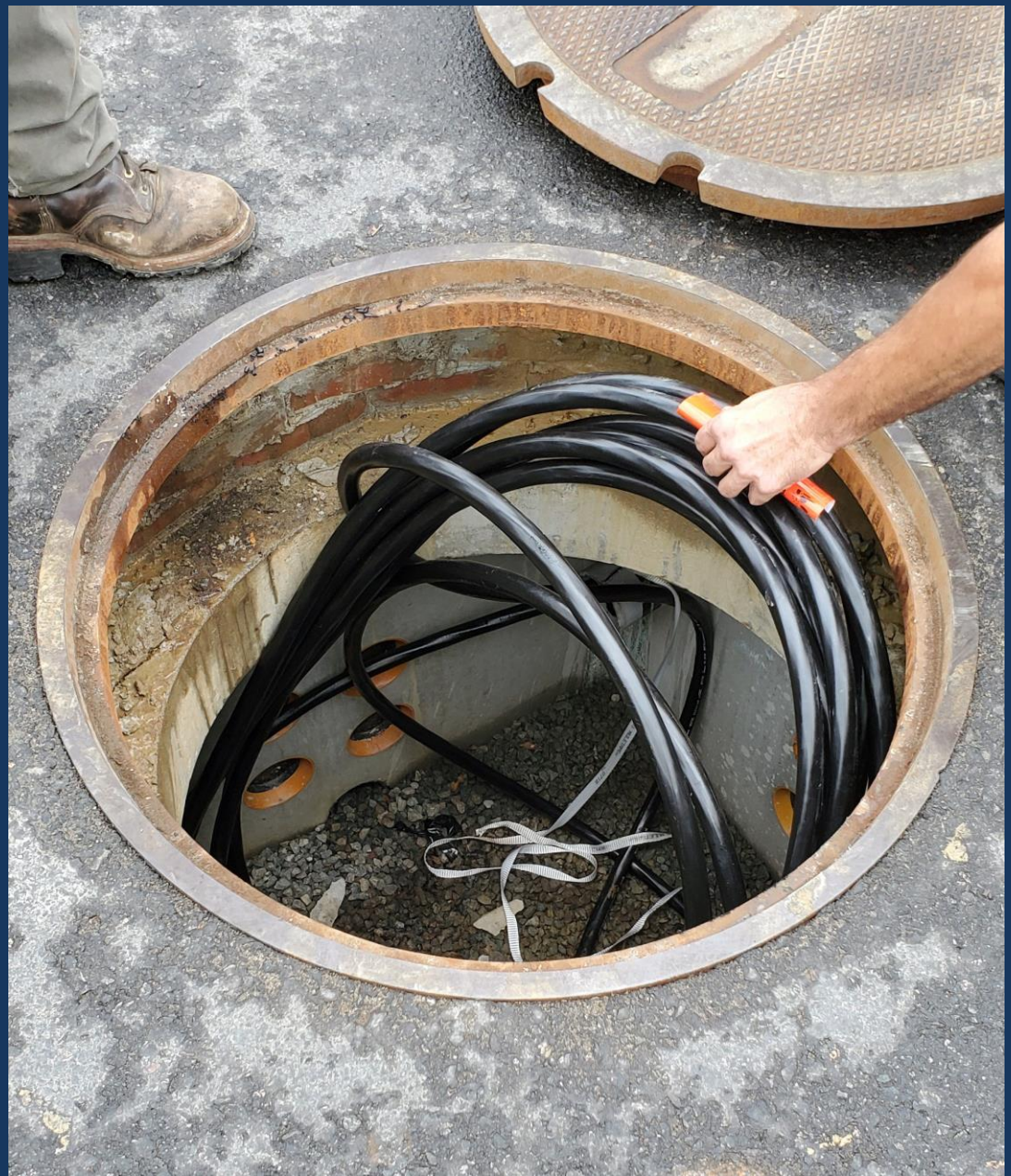


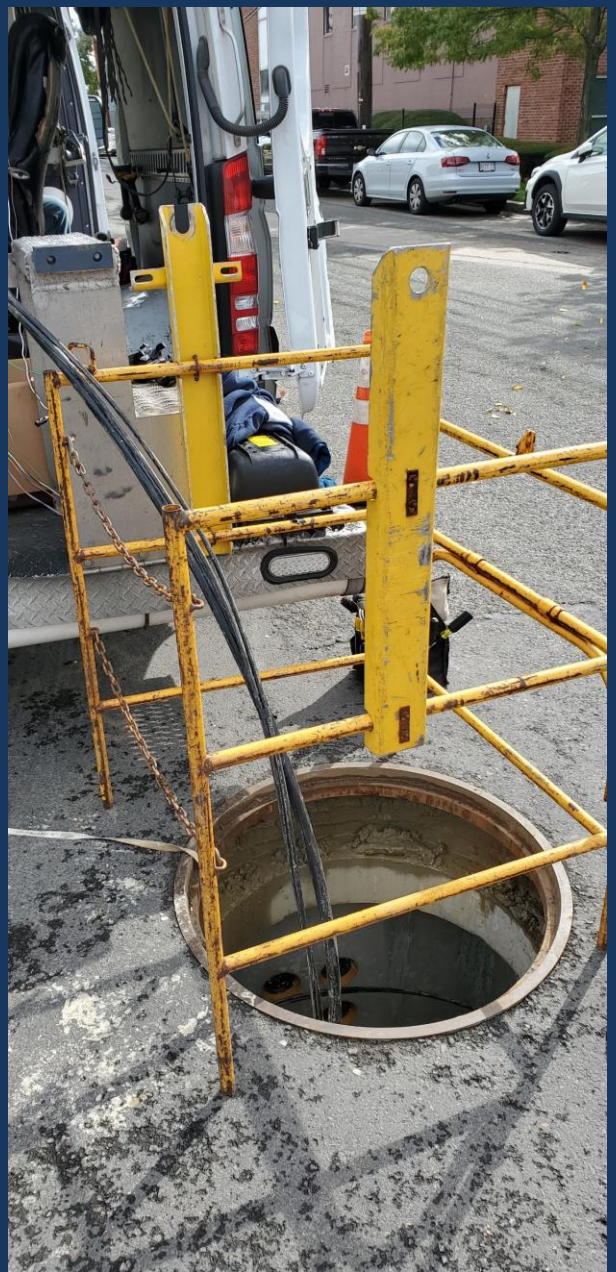
8/28/2019 - 3rd Avenue Re-pavement

8/28/2019 - Completed TWDX MH C19E1-104

9/10/2019 – Dig Safe marking of completed utilities

10/1/2019 – Terminating 864F cable at TWDX MH C19E1-104





10/3/2019 – Entrance Facility installation at CoreSite North Fiber Room

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Inside Plant Activities Overview

Joint Network Facilities BSN 04

70 Inner Belt Road

October 2019

C20E3: Inside Plant Activities

Design-Bid-Build Contract Package:

Project Engineer: In-house engineering

Installation Suppliers: McLean Telecom LLC, Comnet Telecom Supply, CommScope, Amphenol-Telect, Newton Instrument Company

Description:

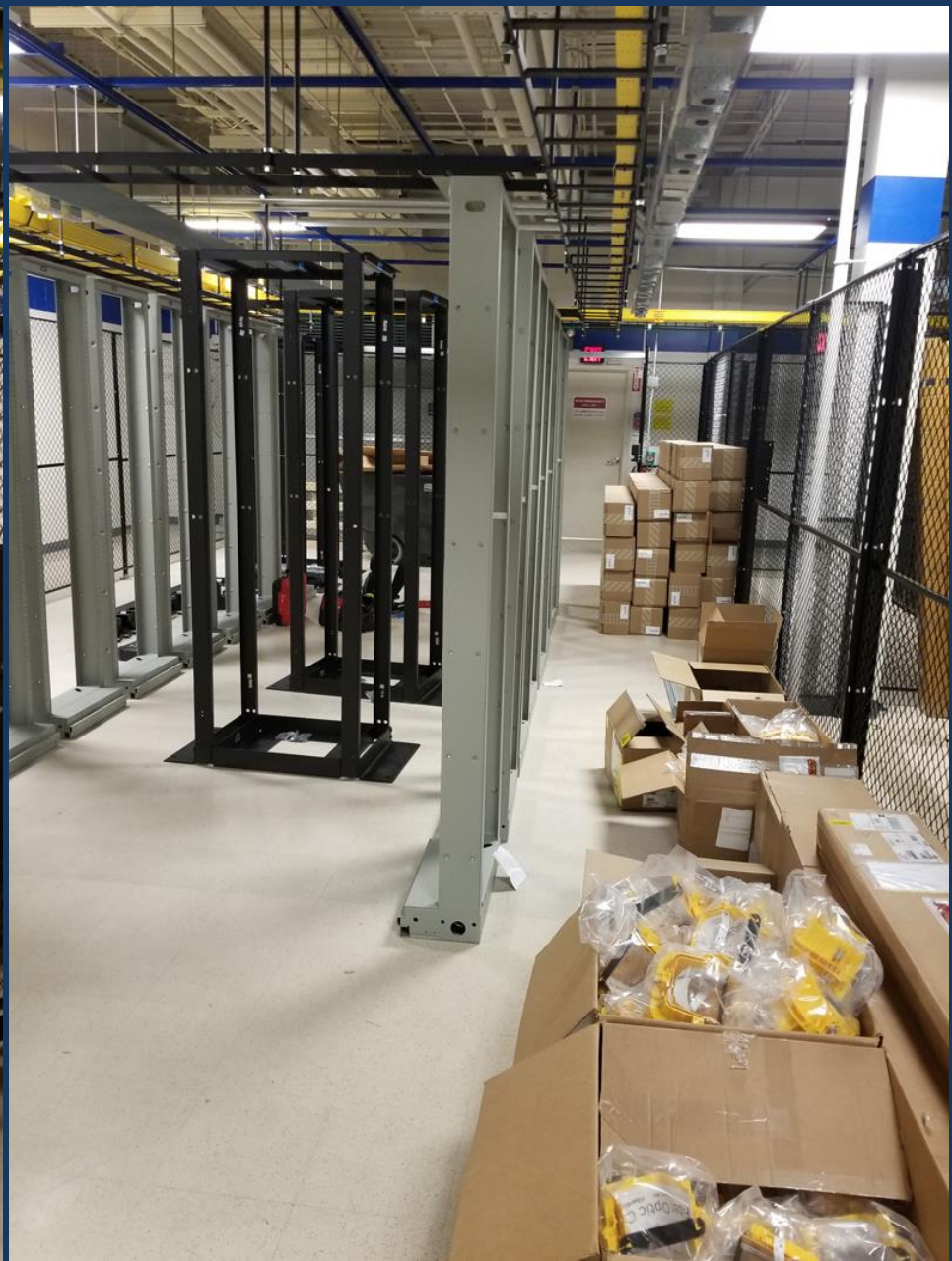
Fit out and install a 150kW rated telecommunications facility for TWDX IP, in accordance with Telcordia GR-63-CORE, ANSI/TIA 942-A and NFPA 76 standards.

Project Timeline:

- 3/22/2019: Space released for occupancy by CoreSite
- 3/25/2019: Notice to Proceed and physical access issued to all vendors working on-site
- 5/17/2019: Premises completed and delivered to TWDX by McLean Telecom
- 5/23/2019: Project inspection for TIA-942
- 6/30/2019: Begin installation of CommScope Quareo cross-connection system
- 7/15/2019: Install 192 fibers to C0508 (BSN 05) space and CoreSite MDF
- 8/5/2019: Design review and premise inspection for NFPA 76
- 9/2/2019: Site ready for occupancy
- 9/19/2019: Commence equipment fit out and begin optical network installation
- 10/15/2019: Waveguide, Inc. Project Interface with C19E1: fusion-splice and test 144 fibers to outside plant
- 11/11/2019: Commence DC plant installation (rectifiers, breaker/fuse panels, etc) for row 2 optical racks

3/22/2019 - New space turn-over from CoreSite

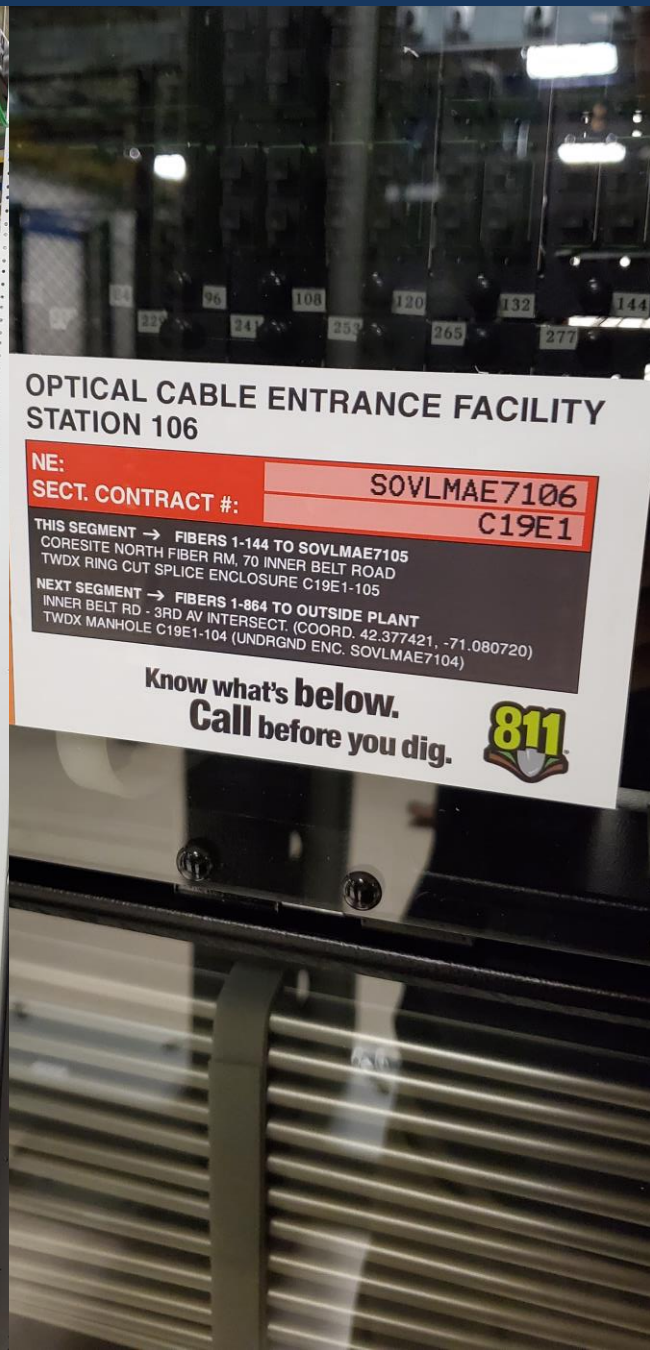
5/2/2019 - McLean Telecom building the new facility



7/15/2019 - CommScope Quareo cross connect system installation

9/2/2019 – Site ready for occupancy

10/14/2019 – Splice & termination box for C19E1 cable landing



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Site Commissioning

Joint Network Facilities BSN 04

70 Inner Belt Road

October 2019

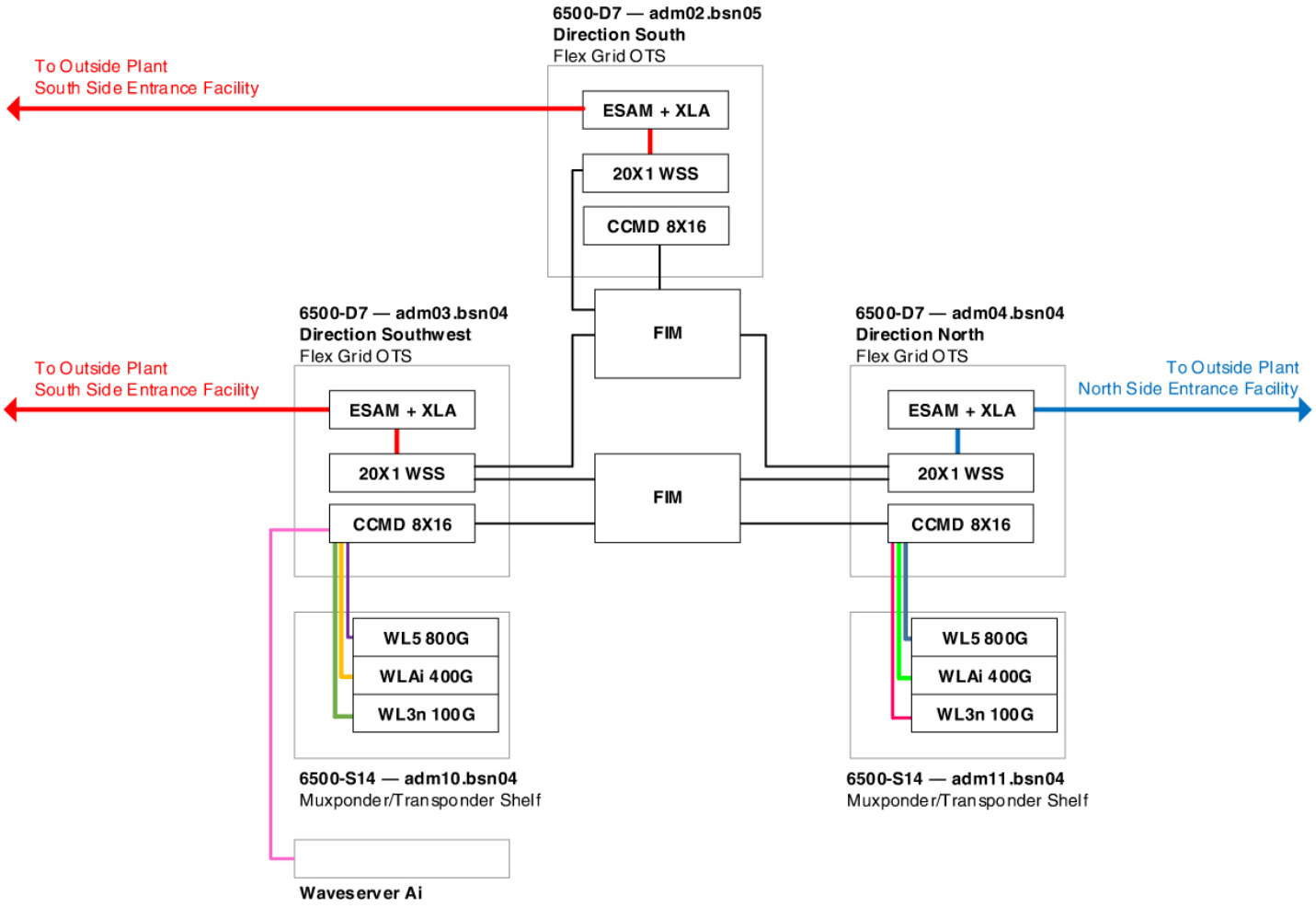
9/20/2019 - Equipment fit out commenced

Optical transport infrastructure for BSN 04

- Joint Facilities BSN 04 is planned to commence full operations in H1CY2020.
- BSN 04 will connect to Cambridge, MA gateway (BOS 01) to form a fully diverse fiber ring
- Optical Transport Architecture:
  - We've tapped Ciena to build a state-of-the-art Flex Grid (CDC ROADM) network that will tie our backbone gateways and outlying interconnection facilities together.
    - ✓ Conventional colored-directional WSS to connect smaller facilities, where gridless operation is not required at such sites.
    - ✓ Disaggregation model: Native support for alien wavelengths from the get go. *"Bring your own light / modems"* operational philosophy increases flexibility at the photonic layer
  - Ciena 6500 nodes are being installed throughout TWDX network facilities in the Boston metro. BluePlanet MCP deployment is under way to provide orchestration for the optical infrastructure.
  - BSN 04 will also function as a high-powered terminal amplification facility for long-haul fiber segments.

    Counter-propagating RAMAN amplifiers are used to terminate long distance optical segments (≥150km) arriving at BSN 04
  - WaveLogic AI and WaveLogic 5 transponders to provide 400G and 800G coherent transmissions (using 56 and 95 Gigabaud sized channels)

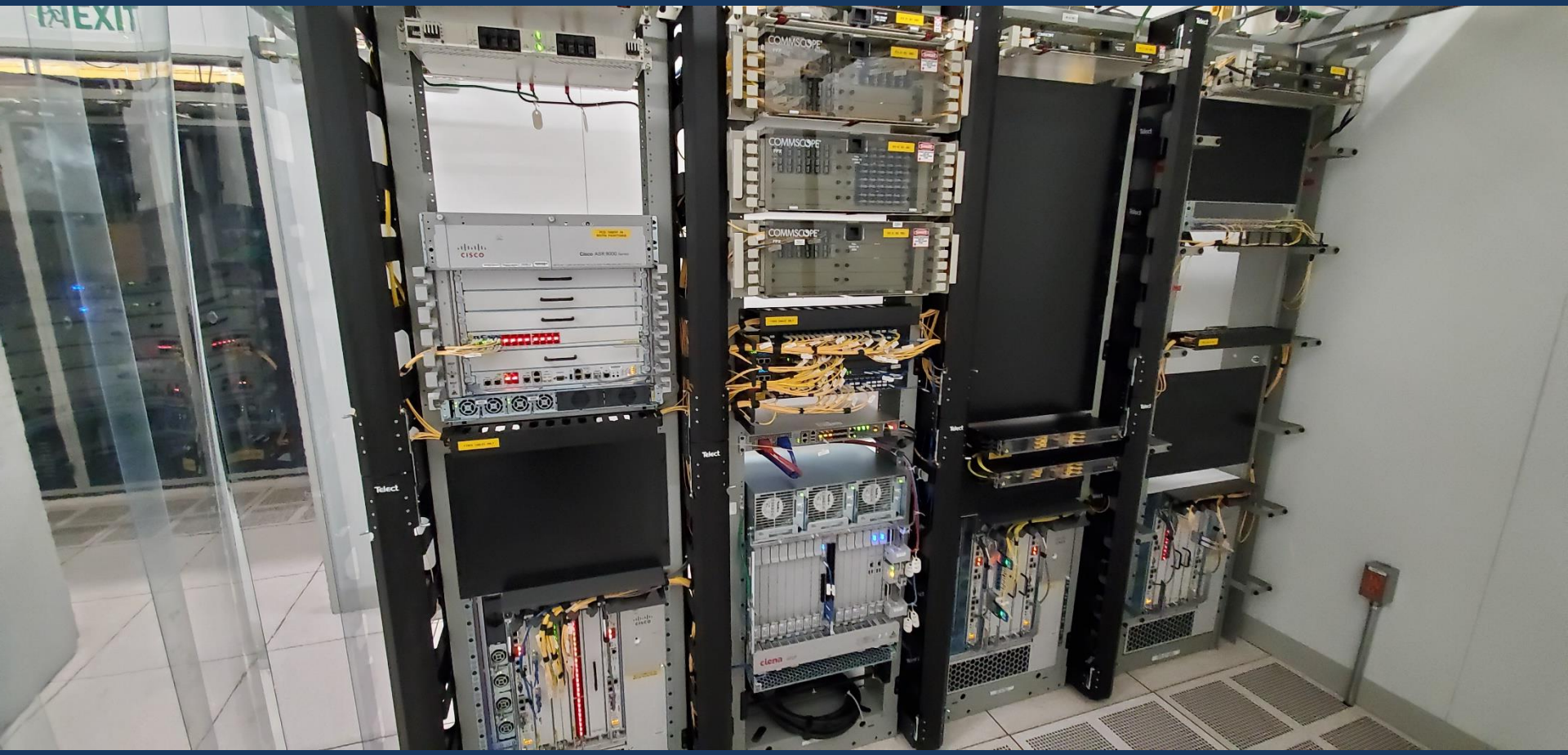
9/26/19 – 70 Inner Belt ROADM Engineering Plan



A new dedicated fiber ring between 300 Bent and 70 Inner Belt is provided to support engineering-development topology for Flex Grid using 20X1 WSS and coherent transponders. 95 Gbaud transponders (800 Gbps) will be driven entirely from the Flex Grid architecture.

To support staff familiarity with the new technology and reduce shared risk, a conventional colored-directional ROADM ring (4X1 WSS → fixed filters) is also being built on parallel fibers. The conventional ROADM ring will accommodate lambdas with ≤ 56 Gbaud bandwidth requirements (400 Gbps coherent and below).

Cambridge, MA (BOS 01) Gateway Retrofit – September 2019



Pictured above is the existing Cambridge, MA gateway in 300 Bent Street, which has a much smaller footprint than the new BSN 04 gateway under construction at the CoreSite data center. This site commenced full operations in August, 2018.

This site is being modified and retrofitted with DC power to support Flex Grid deployment along with the new BSN 04 gateway.

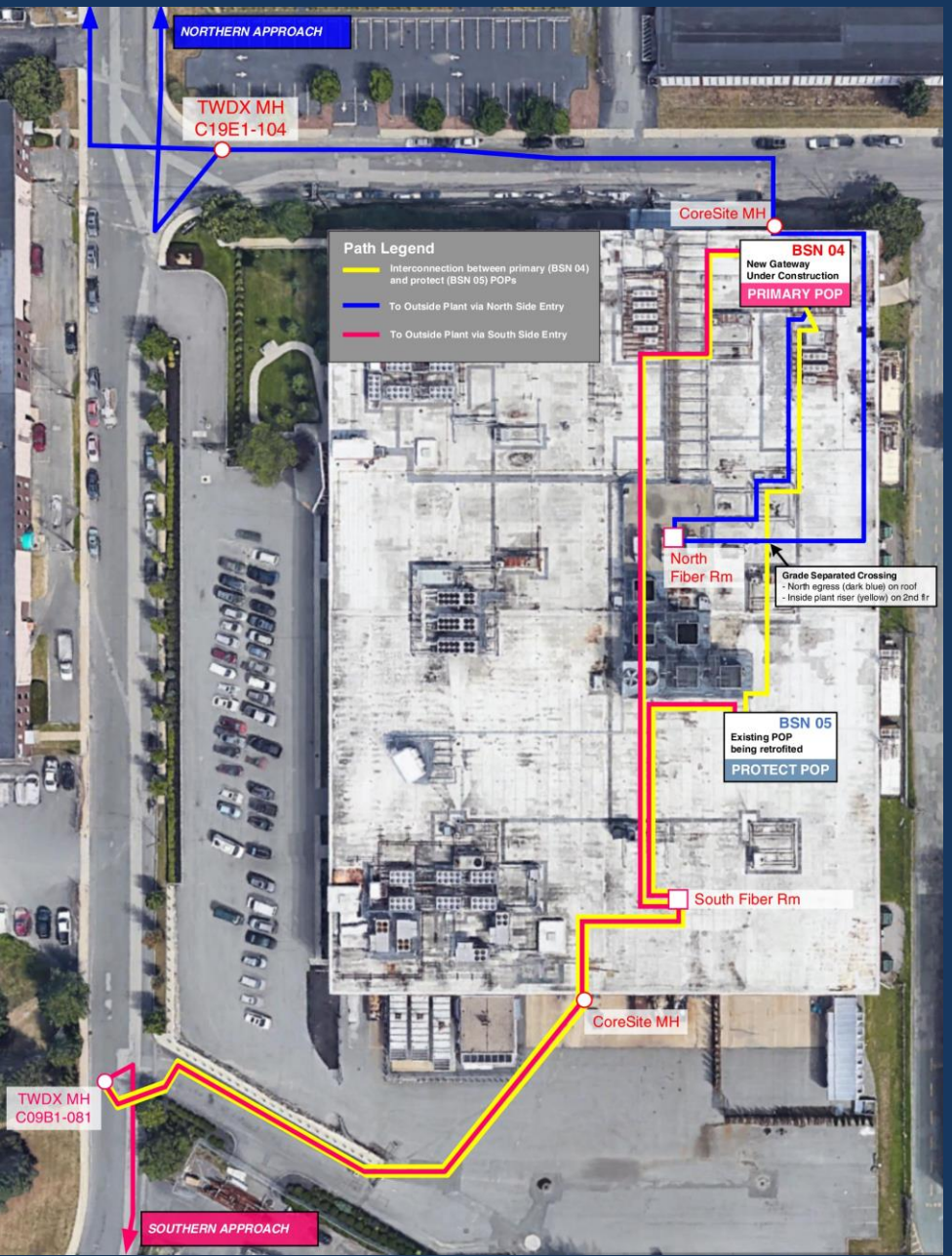
Packetsurge and TWDX IP deployments at BSN 04

- Packetsurge will deploy new core router (AR) at BSN 04
- TWDX IP will also deploy new edge router (dcr03.bsn04) for IP transit customers
  - ✓ The new DCR will replace the existing ASR 9010 (dcr01.bsn05) residing in legacy BSN 05 space.

- Discussions with Cisco in Oct-2019:
  - ASR 9922 (Megatron) selected for both new Packetsurge AR and TWDX IP dcr03.bsn04:
    - ✓ Greenfield considerations: Time to consider 400GBASE deployment is now. Some 100G links are now running above 50% loads, requiring LAG
    - ✓ Cisco plans First Customer Ship (FCS) of new 400GBASE capable ASR9K line cards in 2020
  - Timeline issues: TWDX IP needs to start deploying new DCR as soon as possible to phase out the existing ASR9010 in the legacy POP; can't wait until the new 400G cards ship
    - ✓ A proposed interim option is to deploy dcr03.bsn04 for TWDX IP first, using current generation Tomahawk 100G line cards, and push back Packetsurge AR deployment to second half of 2020, once new 400G cards begin shipping.

- TWDX IP: bbr01.bsn05 (MPLS label switching core router) replacement
  - bbr01.bsn05 will need to be upgraded or replaced to support 400G backbone interfaces at 70 Inner Belt
  - NCS 5504/5508 proposed by Cisco for bbr01.bsn05 replacement:
    - Merchant silicon: substantially lower port cost for 100G/400G compared to ASR9K Perfectly ideal for "dumb" MPLS core router
    - 400G cards and fabric are shipping *today* for NCS 5508
    - Free LSR license for core MPLS forwarding - no additional licensing requirements for TWDX

Redundancy Options for CoreSite Tenants



Two ships approach in CoreSite data center

- ✓ Legacy DC5 POP (BSN 05) is being retrofitted to function as standby/protect side POP
- ✓ New BSN 04 gateway (in DC4) is now the new primary hub

Unmatched redundancy for a network provider deployment amongst any data center in Boston

- Close partnership with CoreSite to carefully plan for diversity with TWDX outside plant facilities.
- Each POP is fed by diverse cooling & power infrastructure.
- Both primary and protect side POPs are tied together not only by using in-building fiber, but also by going outside of the building and coming back, using TWDX constructed dark fiber – return loop splice at manhole C09B1-081

We're not kidding: two ships in parallel.

- Both primary and protect side POPs are being tied to second floor MMR and the new first floor MMR. Customers can order cross connects to TWDX facilities through CoreSite Meet-Me Room located on either floor.
- IP transit and dedicated internet access customers: *Network provider caused SPOF in data centers? No more.*
  - Primary connection goes to the new IP gateway at BSN 04 primary POP
  - Secondary connection goes to 300 Bent Street IP gateway (Cambridge, MA), via L2 transport from BSN 05 protect-side POP
  - ✓ Use BGP with BFD for rapid (≤ 1.5 sec) convergence between TWDX POPs. Substantially superior failover performance to VRRP/HSRP setups.

Questions?

Contact us at ip-admin@twdx.net