SPLICE VAULT PLACEMENT DETERMINATION FOR LOCATIONS WITHIN ConnDOT TRAVELWAY

ROUTE 1, FAIRFIELD, CT
&
ROUTE 130, BRIDGEPORT, CT

MIDDLETOWN TO NORWALK 345-kV TRANSMISSION PROJECT

NORTHEAST UTILITIES SERVICE COMPANY
&
CONNECTICUT DEPARTMENT OF TRANSPORTATION

PREPARED BY
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Rev. 08

Executive Summary

The current routing along the underground transmission section of the Middletown-Norwalk 345 kV Transmission Project, Docket No. 272, minimizes the number of vaults in state roadways. The vaults can not be shifted more than 75' longitudinally without shifting other vault locations potentially from off-street to in-street or an intersection. The location of vaults is constrained by several factors including:

1. Available cable length on standard reels,
2. Fixed or "hard coded" vault locations,
3. Maximizing system reliability,
4. Minimizing impacts (condemnation) to existing structures,
5. Maximizing the number of off-street vault locations,
6. Avoidance of existing utilities,
7. Avoidance of intersections,
8. Water and railroad crossings,
9. and Wetlands.

Initially, available cable length on standard reels was determined and confirmed to conform with physical logistical constraints. Second, locations were identified as fixed and absolutely necessary due to constraining surficial features and construction methods such as Horizontal Directional Drills at river crossings, intersections, wetlands, railroad crossings, etc. Concurrently, the distances between fixed locations were analyzed to minimize the number of splices thus maximizing the system reliability.

Extensive field investigations were performed at all possible locations on both sides of the route falling within a several hundred feet range of idealized incrementally spaced distances. Existing features such as shear ledge faces, existing structures and environmentally sensitive areas were avoided further narrowing the potential locations.

Initial iterations using ideal off-street vault locations such as large parking lots induced roughly 50% of the vaults to be located with roadways. Smaller, less ideal, off-street vault locations were further investigated and subsequently utilized until the number of in-street vault locations was minimized with the current design.

The current design with minimal in-street vault locations would require condemnation and demolition of structures to move the current in-street vaults to off-street locations. Prudence standards enforced by Connecticut Light and Power's regulators and customers preclude the unnecessary and impractical expenditures associated with such activity.

1.0 Purpose and Project Overview:

This document serves to explain the logic for placement of splicing vault locations within ConnDOT travel way along Route 130 in Bridgeport and Route 1 in Fairfield (Segment 4a) of the 345-kV Middletown to Norwalk transmission project (the Project). The Development and Management plan (D&M) submission of the underground portion of the overall project is divided into three segments consisting of approximately 24 miles of double circuit 345-kV XLPE underground transmission line. The first segment titled Segment 3 in the Connecticut Siting Council (CSC) application Docket No. 272 is an 8-mile joint effort between Connecticut Light & Power Company (CL&P) and The United Illuminating Company (UI) beginning at the new East Devon Substation in Milford, traversing across Stratford, and terminating at the new Singer Substation in Bridgeport. The second segment titled Segment 4 in the CSC application Docket No. 272 is owned and managed by CL&P. Segment 4 is a 16-mile segment beginning at Singer Substation in Bridgeport, passing through Fairfield and Westport before terminating at the existing Norwalk Substation in Norwalk. This 16-mile segment was split in two sections for D&M submissions. Bridgeport and Fairfield are located within Segment 4a, while Segment 4b consists of Norwalk and Westport. Burns & McDonnell and Northeast Utilities completed extensive investigations and analysis to minimize the number of vaults within ConnDOT travel way. Four sets of vaults (8 vaults total) out of 22 sets (44 vaults) within Bridgeport and Fairfield are located within ConnDOT travel way. One of the four sets (2 vaults total) in Bridgeport extends only 3 feet into the roadway occupying space reserved for on-street parking.

The Connecticut Siting Council (CSC) issued a decision and order for Docket No. 272 on April 7, 2005. Docket No. 272 is a joint application between CL&P and UI for a Certificate of Environmental Compatibility and Public Need for the Construction of the 345-kV Middletown-Norwalk transmission lines and associated facilities. In addition to the underground Segments 3 and 4 are Segments 1 and 2 consisting of approximately 45 miles of new overhead 345-kV transmission lines and reconstruction of portions of existing 115-kV overhead transmission lines. Among other items, the CSC decision and order approved the proposed underground route. The distance between successive splice vaults was estimated to be approximately 1800 ft. based on information provided in the application and Findings of Fact (FOF).

The decision and order also requests CL&P and UI use a previous ConnDOT encroachment permit process developed for Docket No. 217 (Bethel-Norwalk transmission project). Wording in this agreement states ConnDOT will allow splice vaults within the paved roadway when conditions outside the state highway limit placement off the paved road. Specifically, the encroachment agreement reads:

> "The Encroachment Permits issued hereunder shall expressly allow…location of cross-link polyethylene cable vaults within the paved roadway where physical

conditions within, along or outside the state highway right of way limit or preclude location off the paved roadway…"

This document will explain the technologies and methodologies employed in decisions regarding placement of the Project underground splicing vaults.

2.0 Available Cable Technology:

2.1 Available cable length

Information gathered from various manufacturers of 345-kV XLPE cable indicate limitations in the length of a single cable. These limitations make it necessary to have splice vaults located along the alignment at predetermined intervals. Eight cable manufacturers were sent questionnaires to determine the feasible cable length which can be shipped on a standard reel. Responses suggest 1800 ft. of cable is the maximum length for standard cable reels. Allowing for overlap of splices, construction contingency and vertical curves actual vault spacing becomes less than 1800 feet. Oversized reels would require special handling equipment and shipping requirements, therefore only standard sized reels are currently being considered.

2.2 Transportation Limitations

The deck height of a typical step down low boy trailer is 20" unloaded. The height of a typical standard reel on its steel holding pallet ranges from 12' to 14', loaded on the truck the total height would range from 13' 8" to 15' 8". Most states limit non-permitted highway transportation vehicles to a height of 14' 6" and require special markings on overpasses with less vertical clearance. The ConnDOT maximum height is limited to the physical restraints of the route and excess dimensions require an engineering review of the route. An investigation is currently underway to identify specific hauling routes within the project vicinity as well as potential ports of entry for the case of water transport.

The maximum weight limit allowed on Connecticut roadways without a permit is 80,000 lbs. The weight of each loaded reel ranges from 45,000 to 50,000 lbs. With allowances for the truck and trailer self-weight it is possible to only ship one standard sized reel per trailer.

3.0 Preliminary Vault Spacing Determination:

Some of the selected splice vault locations fall between sites that are "hard coded" or physically locked to a specific location. A good example of a hard coded location would be both sides of the Saugatuck River crossing. The length of the Horizontal Directional Drill (HDD) underneath the river approaches the available reel length of cable. Therefore, it is imperative that a splice vault be located immediately before and

after the river crossing due to the obvious limitations of placing a splice vault within the waterway.

When splice vaults fall between two "hard coded" locations the approximate distance between successive vaults is determined first by calculating the total alignment length available and subdividing into segments of nearly equal spacing until a minimum number of total splice vault locations was found. For example the distance between the new East Devon Substation in Milford to the "hard coded" eastern side of the Housatonic River crossing is 10,775 ft. Dividing this number into 6 equal length increments results in an average vault spacing of 1,800 ft., considering vertical and horizontal allowances, this is beyond the available cable length. Now, dividing the alignment into 7 equal length increments results in successive average vault spacing of 1,540 ft., a length used as the starting point for preliminary vault locating. Adding an additional vault to get 8 spacings of equal length produces an unacceptable average length of 1,350 ft. as well as reducing the system reliability. This issue is addressed later along with the potential necessity of balancing cable lengths between successive locations.

Another example of preliminary locating between two "hard coded" locations is between the Norwalk River south crossing (Byington Place) in the City of Norwalk and the Saugatuck River crossing in the Town of Westport. The distance between these two locations is 16,800 ft. Dividing this distance into 10 equal increments results in an average vault spacing of 1,680 ft. An acceptable distance based on 1,800 ft. of available cable. Attempting to eliminate a vault results in spacing of 1,867 ft., beyond standard reel capacity. Conversely, adding an additional vault resulting in 11 equal increments produces an average spacing of 1,530 ft., reducing system reliability.

The "hard coded" location governing Segment 4a occurs on the eastern side of the Saugatuck River in the Town of Westport. The distance between this location and the Singer Substation in Bridgeport is approximately 57,000 ft. Applying the same logic as the previous examples 34 segments with an average spacing of 1675 ft. were chosen over the less reliable 35 segments with an average spacing of 1630 ft. Thirty-three segments results in an average spacing of 1730 feet, maxing out available cable length and not allowing for construction contingencies.

4.0 Electrical Issues Concerning Vault Spacing:

System reliability is inversely related to the number of splices along an alignment. In other words, reliability decreases as the number of splices increases. Therefore, from a reliability standpoint minimizing the number of splices along a given alignment is critical. This point is brought out in the Tutorial of Underground Electric Power Transmission Cable Systems produced by Cable Consulting International (CCI) and included in the application to the CSC in Volume 6 of 12. CCI says joints (splices) are recognized as the weakest links in reference to system reliability. Referencing the

previous Milford example, this supports the reasoning for choosing 7 equal increments of 1,540 ft. rather than the less reliable 8 increments of 1,350 ft.

Single-conductor XLPE cables induce a current in the cable's metallic sheath. The sheath current generates ohmic losses within the system. In lay terms this means the system experiences losses and thus delivers less power to the final destination. To counteract these losses a technique called cross bonding can be used to connect sheaths of each phase to each other and ground. The cross-bonding requires that every three lengths of cable (distance between successive splice vaults) are within 10% of each other. Returning to the aforementioned 1800 ft. spacing, any three successive vault spacings would have to be within 10% of each other or between 1890 ft. and 1710 ft. to avoid losses in system ampacity. Specific information concerning sheath cross bonding was presented in a report evaluating potential cable systems by Power Delivery Consultants (PDC) and included in Volume 6 of 12 in the application to the CSC. The Project is not currently planned for cross bonding however the technique may be employed in the future.

5.0 Splicing Vault Characteristics:

As previously described, splicing vaults serve to connect successive lengths of cable. The splicing vaults are generally constructed of pre-cast segments; however conditions do arise that require cast in place construction. Splicing vaults' walls, roofs and floors measure approximately 12 in. in thickness and have outer dimensions of 10 ft. by 30 ft. by 10 ft high. The vaults will be buried to a minimum cover of 2.5 ft. Since the Project is a double circuit two vaults will be required at each location, bringing the typical excavation footprint for each location (two vaults) to approximately 45 ft. by 95 ft.

After initial vault installation, the locations will have to be revisited a minimum of two additional times prior to energizing the system. First, the cable reels on a reel trailer will be positioned over vaults during the process of pulling in the cables. Second, a splicing trailer, necessary for conditioning the environment, will be stationed over the vaults during the splicing process. Periodic maintenance and inspection will require later visits unassociated with initial system construction efforts.

6.0 Preliminary Vault Siting Efforts:

Existing underground utilities as well as various overhead obstructions will interfere with vault placement and construction. Efforts have been made to minimize these interferences and minor adjustments in splice vault locations have been made to accommodate existing conditions. Efforts were made to not place vault locations in major intersections and traffic control plans will be produced for each site individually. The site specific maintenance and protection of traffic plans (MPT) as prescribed by the CSC will be issued for ConnDOT and municipal review prior to construction.

Off-street vault locations will require cooperation with businesses and land owners. Efforts have been made to utilize off-street locations that would produce minimal social impacts. Large parking lots and business lawn and open spaces were areas typically chosen so social impacts would be minimized. Land acquisition efforts are underway impacted property owners identified. In a worst case scenario, land condemnation would be required when owner cooperation and acceptance of terms and conditions of easement documents is withheld.

7.0 In-Street Vault Locations:

As previously stated only four sets of vaults (8 vaults total) out of 22 sets (44 vaults) within Bridgeport and Fairfield are located within ConnDOT travel way. The Fairfield location, vaults 6435 and 7535 (formerly MN-F-35a and MN-F-35b), is located in Route 1 just west of the intersection with Round Hill Rd. The first location along Route 130 in Bridgeport, vaults 6440 and 7540 (formerly MN-B-40a and MN-B-40b) is located just west of the intersection with Gilman St. The second location along Route 130 in Bridgeport, vaults 6441 and 7541 (formerly MN-B-41a and MN-B-41b) is located just west of the intersection with Melrose St. The final Bridgeport location, vaults 6443 and 7543 (formerly MN-B-43a and MN-B-43b), is located in Route 130 just east of the intersection of Burr Rd. Moving any of these vault locations will cause a shift in other vault locations, thus increasing the probability of occupying ConnDOT travel way elsewhere. Each vault location is addressed individually below.

7.1 Route 1, Fairfield, Vaults 6435 and 7535

The current in-street vault location including existing underground utilities in Fairfield is supplied as Figure 1. The figure shows the vault location in the westbound lanes leaving the intersection of Route 1 and Round Hill Rd. Route 1 at this location has a left turning lane in each direction; as seen in Photo 8, therefore the additional width could be used to allow traffic flow in both the westbound and eastbound directions. The eastbound lanes of Route 1 at this location have on street parking as seen in the foreground of Photo 5.

The properties to both the north and south of Route 1 were investigated however both have limited areas of available workspace as well as underground storage tanks and were thus ruled out (Photos 5 and 6). Attempts were made to locate the vaults in open spaces outside the ROW and across the Round Hill Road intersection to the northeast (Photo 7); however doing so caused vaults at other locations to shift to in-street occupancy due to similar constraints. Additional information regarding this vault location is presented below.

6435 and 7535 (Formerly MN-F-35a and MN-F-35b)

Town:	Fairfield
Street or Road:	Post Rd. (US Rt. 1)
Preliminary Stationing:	580+75
Placement:	In Street
Photographs:	5,6,7,8
Approaching Vault Spacing:	1,426 ft.
Successive Vault Spacing:	1,700 ft.

7.2 Route 130, Bridgeport, Vaults 6440 and 7540

The current in-street vault location including existing underground utilities in Fairfield is supplied as Figure 2. The figure shows the vault location on the south side of Route 130 just west of the intersection with Gilman St. The vaults are primarily located on the sidewalk in front of a U-Haul self storage facility (see Photo 9), The business front abuts the sidewalk (see Photo 10). Allowing room for available workspace and clearance to prevent undermining the building foundation the vaults encroach approximately three feet into the paved parking lane of the travel way. Route 130 has on street parking in this vicinity therefore minimal traffic disruption should occur.

All properties in this area of Bridgeport have structures with limited setback. The self storage parking lot to the west of the current vault location was investigated but is too small for vault placement.

6440 and 7540 (Formerly MN-B-40a and MN-B-40b)

Town:	Bridgeport
Street or Road:	Fairfield Avenue (St. Rt. 130)
Preliminary Stationing:	664+00
Placement:	Partial In Street/On sidewalk
Photographs:	9, 10
Approaching Vault Spacing:	1,505 ft.
Successive Vault Spacing:	1,675 ft.

7.3 Route 130, Bridgeport, Vaults 6441 and 7541

The current in-street vault location including existing underground utilities in Bridgeport is supplied as Figure 3. The figure shows the vault location on the south side of Route 130 just west of the intersection with Melrose St. The vaults occupy the full width of the parking lane and extend into the eastbound slow lane.

All properties in this area of Bridgeport have structures with limited setback as evidenced in Photos 11 and 12. There are no vacant areas outside of the roadway within 150 feet in either direction of the vault location.

6441 and 7541 (Formerly MN-B-41a and MN-B-41b)

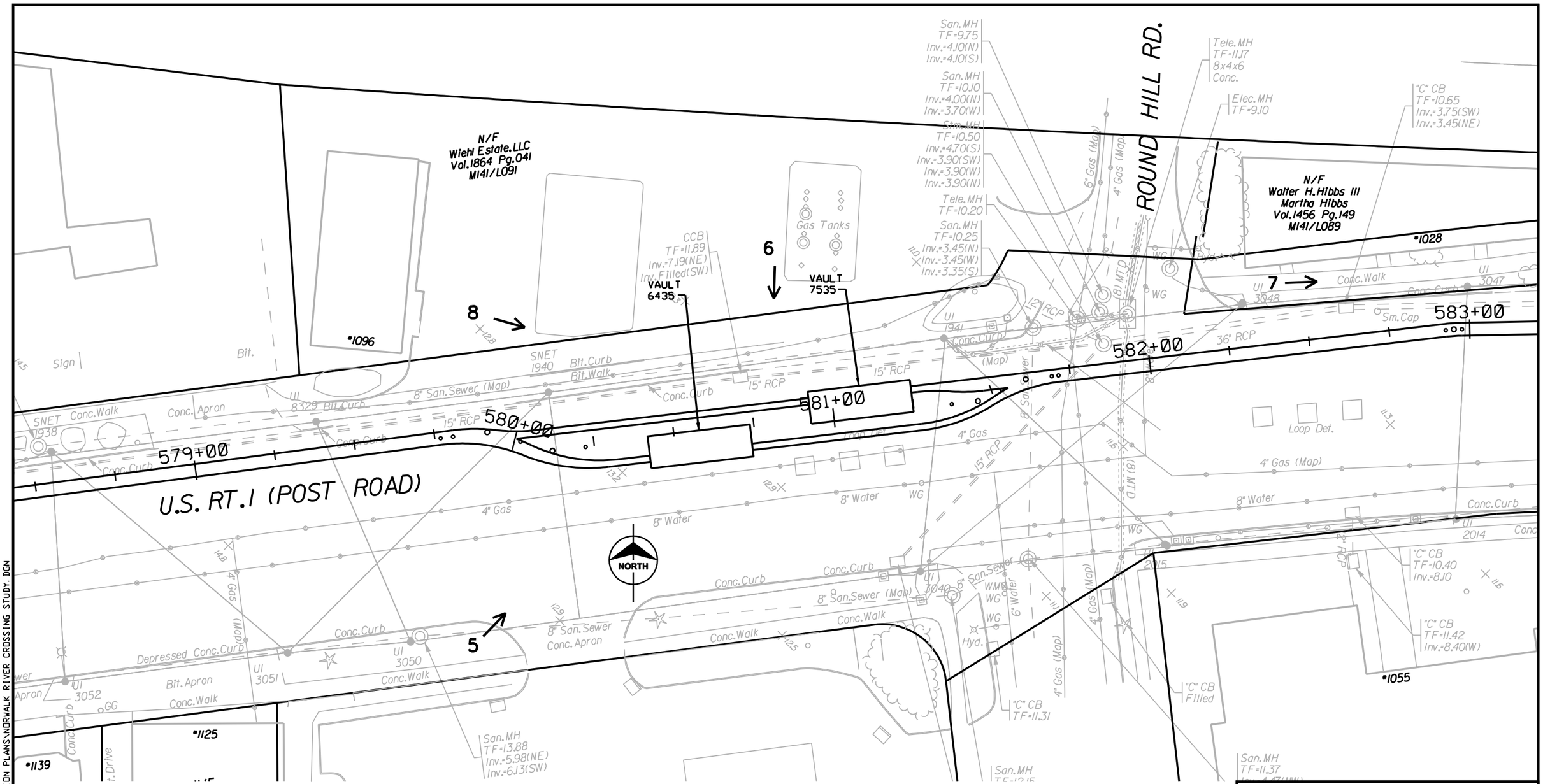
Town:	Bridgeport
Street or Road:	Fairfield Avenue (St. Rt. 130)
Preliminary Stationing:	680+50
Placement:	In Street
Photographs:	11, 12
Approaching Vault Spacing:	1,650 ft.
Successive Vault Spacing:	1,585 ft.

7.4 Route 130, Bridgeport, Vaults 6443 and 7543

The current in-street vault location including existing underground utilities in Bridgeport is supplied as Figure 4. The vaults are located within Route 130 east of the intersection of Burr Rd. Storefronts abut the ROW on the south side of Route 130 eliminating this as a potential site (left side of Photo 13). The business to the north is an active gas station with underground storage tanks, and thus ruled out from a potential relocation (Photos 14 and 15). Any shift of this vault will cause approaching and successive off-street vault locations to move to in-street locations. The I-95 overpass to the east and current construction on the southwest quadrant of its interchange with Route 130 inhibit shifts to the east. The intersection located to the west (Orland St., Burr Rd., Albion St., and Fairfield Ave) also prevents a shift in that direction (Photo 14). Additional information regarding this vault location is presented below.

6443 and 7543 (Formerly MN-B-43a and MN-B-43b)

Town:	Bridgeport
Street or Road:	Fairfield Ave. (St. Rt. 130)
Preliminary Stationing:	712+85
Placement:	In Street
Photographs:	13, 14, 15
Approaching Vault Spacing:	1,650 ft.
Successive Vault Spacing:	1,555 ft.



NOT FOR CONSTRUCTION

LEGEND

— · · — · · — ROW/PROPERTY LINE

ARROWS AND NUMBERS REPRESENT LOCATION AND DIRECTION OF PHOTOGRAPHS

DRAWING NOT TO SCALE

MIDDLETOWN TO NORWALK
345–kV TRANSMISSION PROJECT
VAULTS 7535, AND 6435 (ROUTE 1)

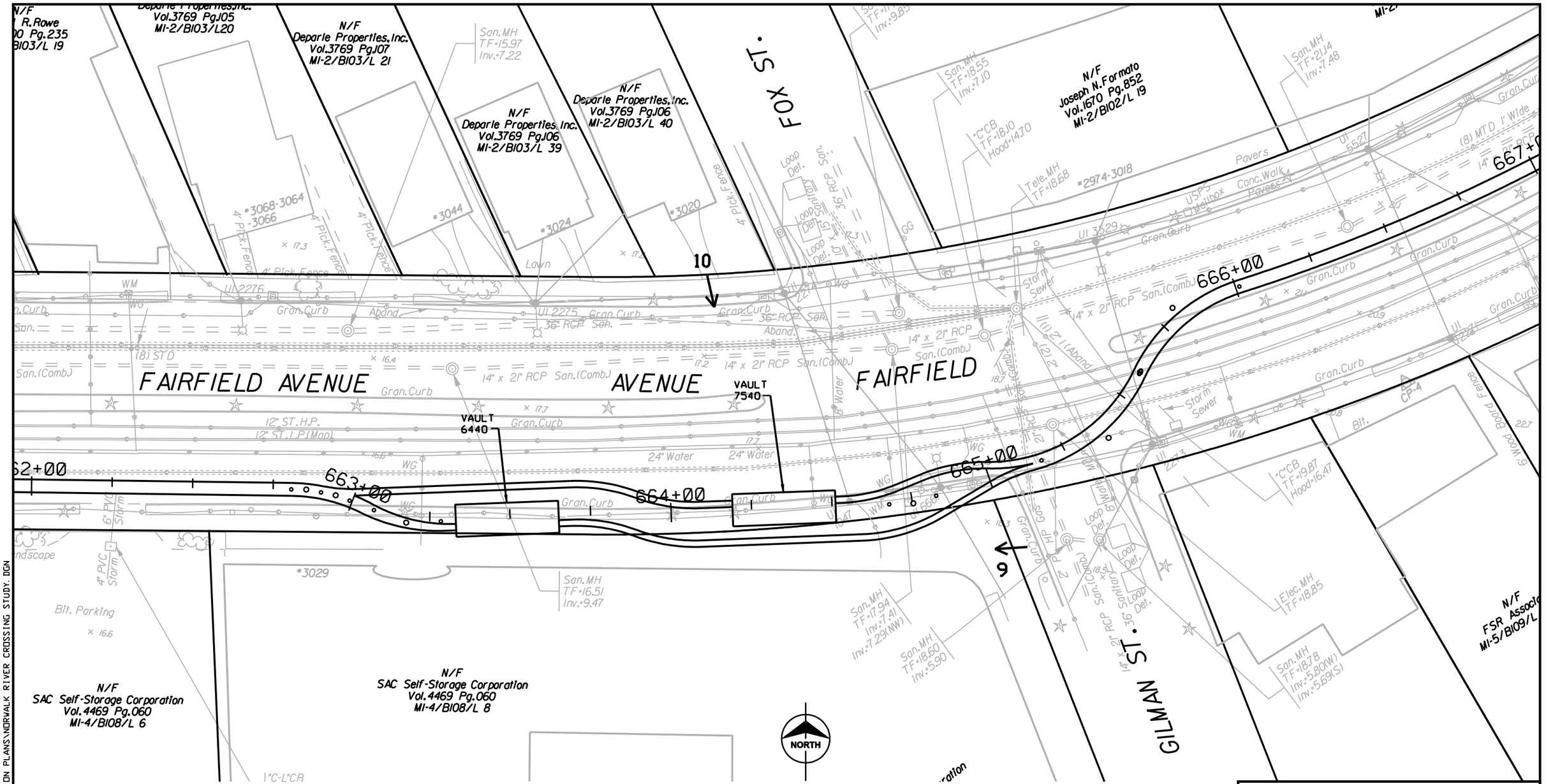
LOCATION: TOWN OF FAIRFIELD
COUNTY: FAIRFIELD STATE: CT

Connecticut Light & Power
The Northeast Utilities System

Burns & McDonnell

DATE: 12/21/05 FIGURE 1

N:\NUSCO\38565\CADD\UG\PRODUCTION PLANS\NORWALK RIVER CROSSING STUDY.DGN



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LEGEND

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ARROWS AND NUMBERS REPRESENT LOCATION AND DIRECTION OF PHOTOGRAPHS

DRAWING NOT TO SCALE

MIDDLETOWN TO NORWALK
345-kV TRANSMISSION PROJECT
VAULTS 7540, AND 6440 (ROUTE 130)

LOCATION: CITY OF BRIDGEPORT
COUNTY: FAIRFIELD STATE: CT

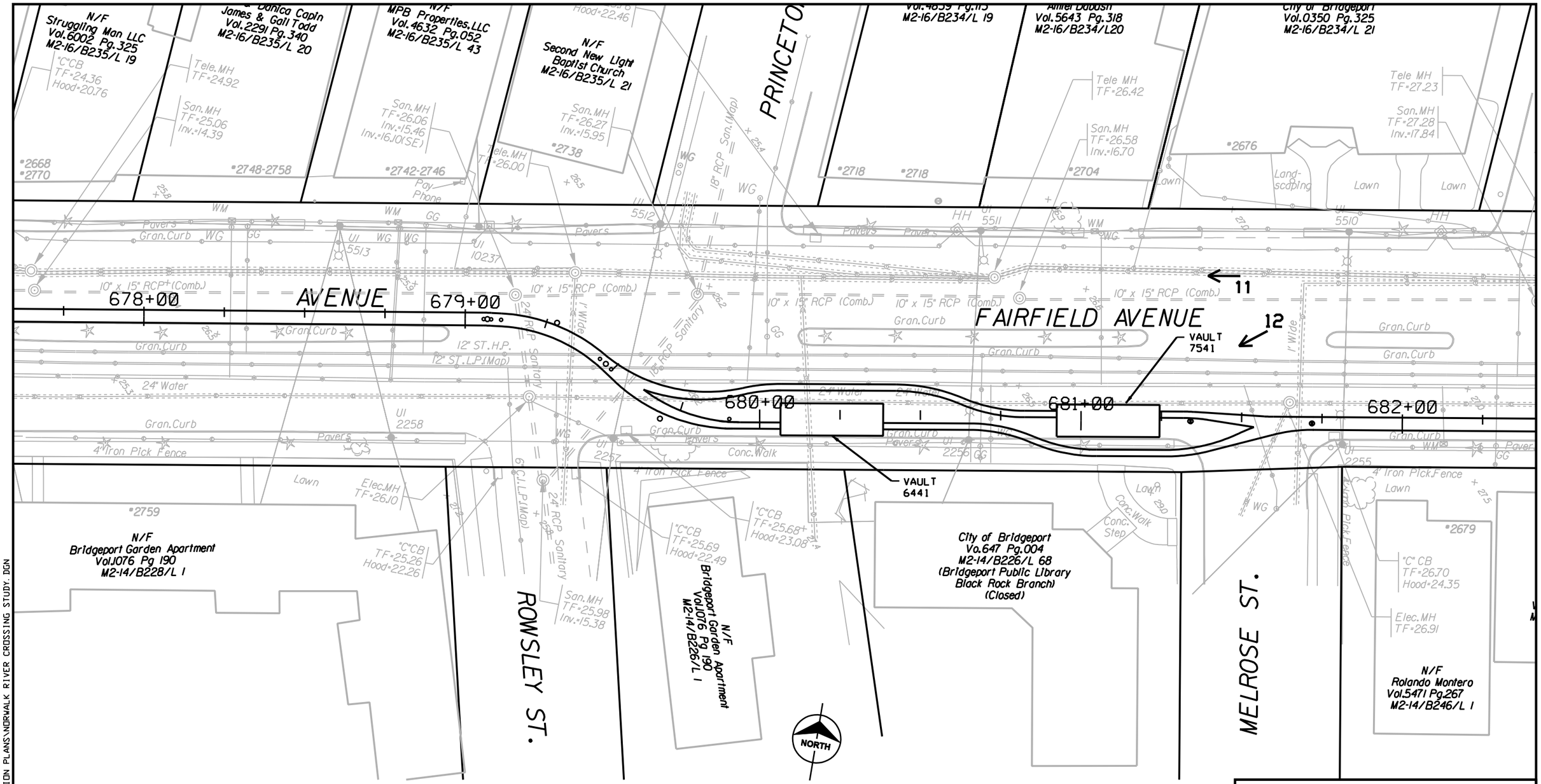
Connecticut Light & Power
The Northeast Utilities System

Burns & McDonnell

DATE: 12/21/05

FIGURE 2

N:\NUSCO\38565\CADD\UG\PRODUCTION PLANS\NORWALK RIVER CROSSING STUDY.DGN



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LEGEND

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ARROWS AND NUMBERS REPRESENT LOCATION AND DIRECTION OF PHOTOGRAPHS

DRAWING NOT TO SCALE

MIDDLETOWN TO NORWALK
345-kV TRANSMISSION PROJECT
VAULTS 7541, AND 6441 (ROUTE 130)

LOCATION: CITY OF BRIDGEPORT
COUNTY: FAIRFIELD STATE: CT

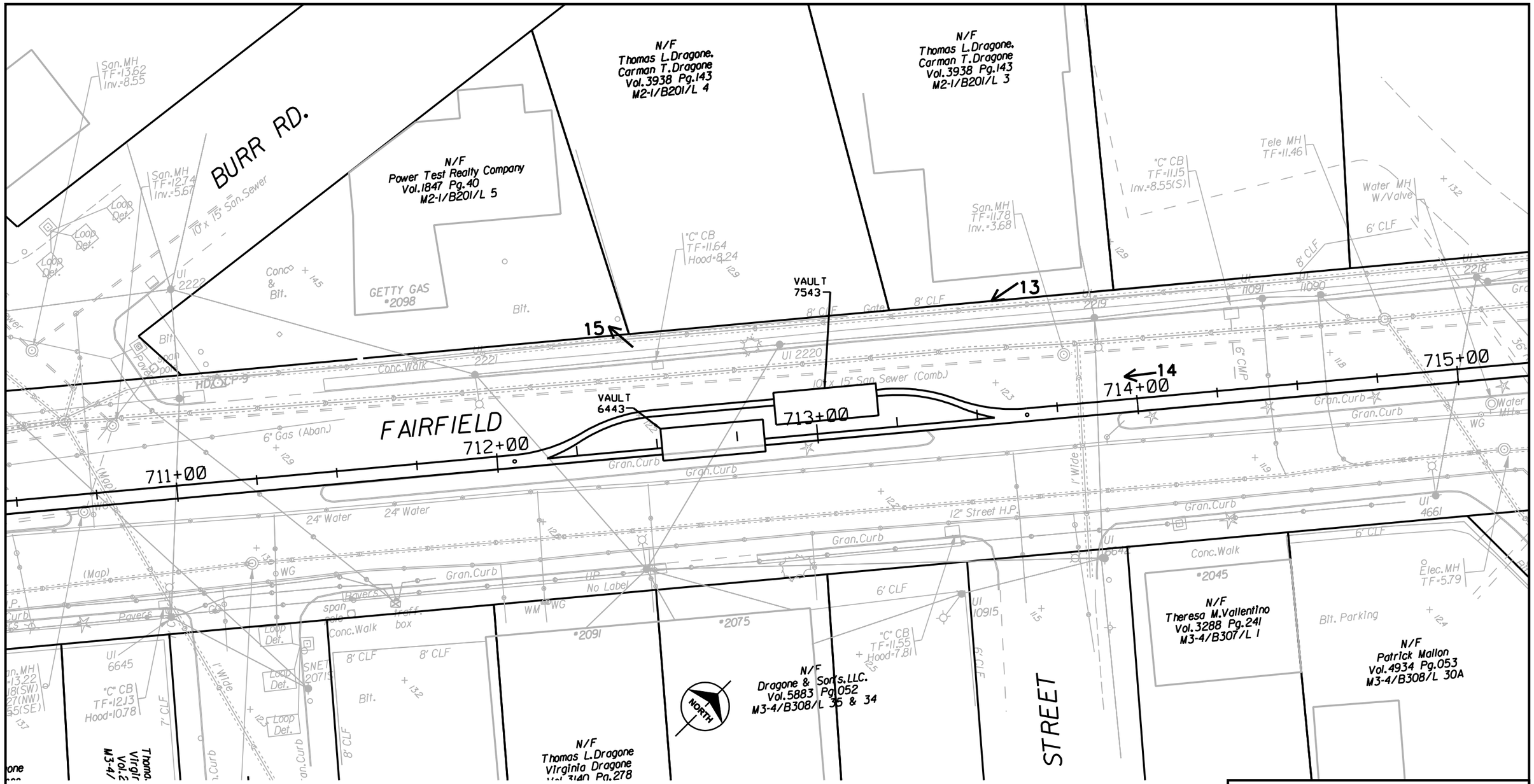
Connecticut Light & Power
The Northeast Utilities System

Burns & McDonnell

DATE: 12/21/05

FIGURE 3

N:\NUSCO\38565\CADD\GIS\PRODUCTION PLANS\NORWALK RIVER CROSSING STUDY.DGN



NOT FOR CONSTRUCTION

LEGEND

ROW/PROPERTY LINE

ARROWS AND NUMBERS REPRESENT LOCATION AND DIRECTION OF PHOTOGRAPHS

DRAWING NOT TO SCALE

MIDDLETOWN TO NORWALK
345-kV TRANSMISSION PROJECT
VAULTS 7543, AND 6443 (ROUTE 130)

LOCATION: CITY OF BRIDGEPORT
COUNTY: FAIRFIELD STATE: CT

Connecticut Light & Power
The Northeast Utilities System

Burns & McDonnell

DATE: 12/21/05

FIGURE 4

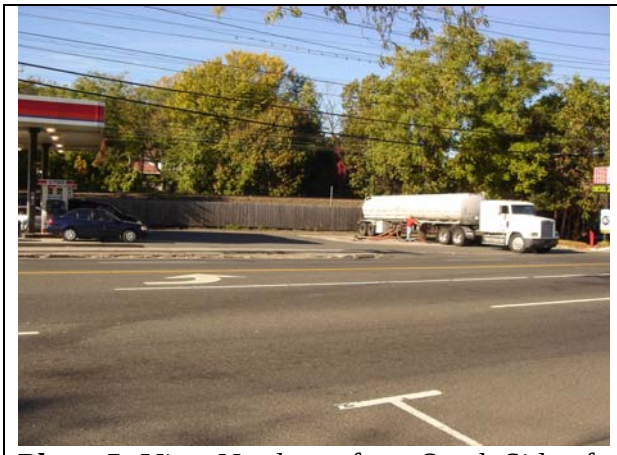


Photo 5: View Northeast from South Side of Route 1 (Vaults 6435 & 7535)

Photo 6: View South from North side of Route 1 (Vaults 6435 & 7535)

Photo 7: View Northeast from North side of Route 1 (Vaults 6435 & 7535)

Photo 8: View West from North side of Route 1 (Vaults 6435 & 7535)

Photo 9: View West from South side of Route 130 (Vaults 6440 & 7540)

Photo 10: View South from North side of Route 130 (Vaults 6440 & 7540

Photo 11: View West from North side of Route 130 (Vaults 6441 & 7541)

Photo 12: View Southwest from North side of Route 130. (Vaults 6441 & 7541)

Photo 13: View South from North side of Route 130 (Vaults 6443 & 7543)

Photo 14: View Southwest from middle of Route 130 (Vaults 6443 & 7543)

Photo 15: View West from North side of Route 130 (Vaults 6443 & 7543)