Design and Construction of NEORSD's Doan Valley Storage Tunnel

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ABSTRACT

The Doan Valley Storage Tunnel Project in Cleveland Ohio was constructed to control Combined Sewer Overflows (CSOs). It is a complex system of three tunnels ranging from 8.5 to 18 feet in diameter with a total length of about 2.3 miles that was put into operation in mid-2021. The project lies within and below the cultural, educational, and medical hub of Cleveland, which presented unique design and construction challenges. This paper provides a case history of the design and construction, with particular attention given to lessons learned in devising a large tunnel system that can carry both dry and wet weather flows constructed in rock with limited cover, within a flood plain area and vibrant urban center.

INTRODUCTION

The Northeast Ohio Regional Sewer District (NEORSD or District) was established on July 15, 1972, by Court Order. The District is a political subdivision of the state of Ohio and a regional authority in northeast Ohio servicing over one million customers in its 62 member communities, including the City of Cleveland, as shown in Figure 1. The District is charged with the responsibility for planning, financing, constructing, operating, and controlling three wastewater treatment and disposal facilities, the major interceptor sewers and other water pollution control features within its 355 square mile service area comprised of the Easterly, Southerly and Westerly Districts.

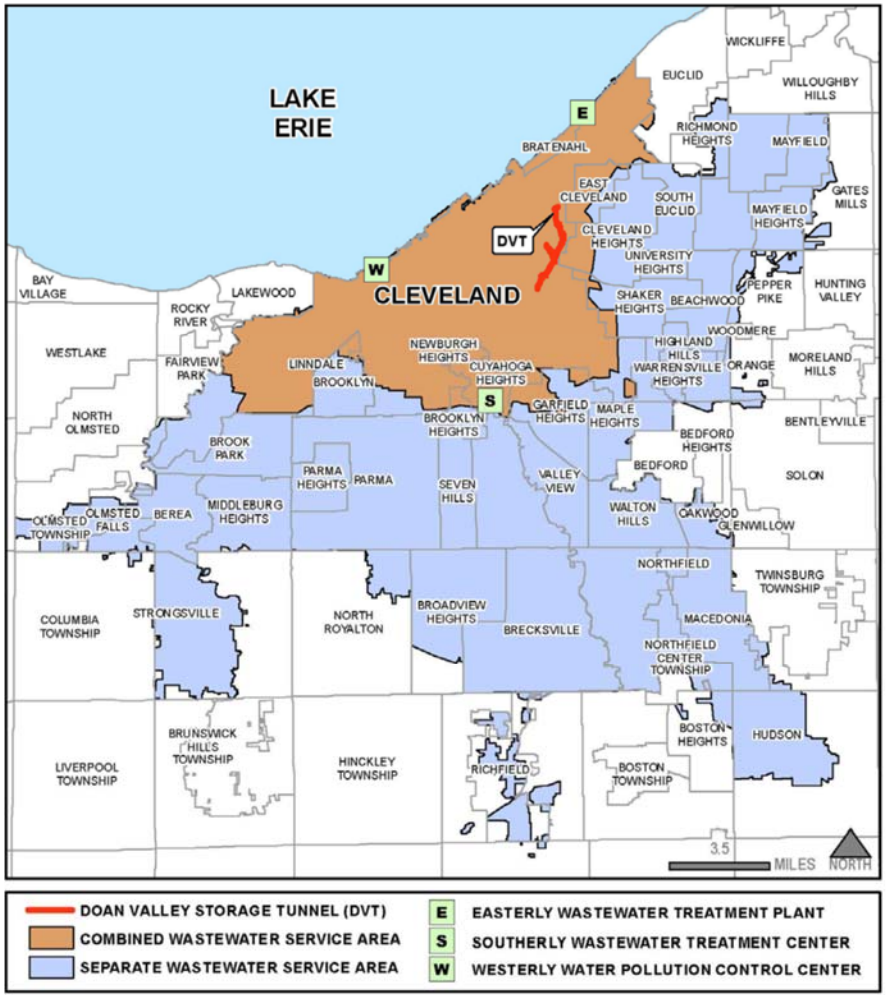

Figure 1. Northeast Ohio Regional Sewer District service area

The District's interceptors include several combined sewer systems that convey both sewage and stormwater during wet weather events up to their carrying capacities for treatment at all three wastewater plants. When the combined sewer capacities are exceeded, they are relieved via 112 CSO outfalls to Lake Erie and its tributary waterways. The District entered a Consent Decree with the Ohio and United States Environmental Protection Agencies (OEPA/USEPA) and the United States Department of Justice (USDOJ) in 2011 to implement, within a 25-year time limit, a $3B long-term control plan (LTCP) to control these CSO outfalls. The plan is comprised of a network of seven CSO storage tunnels complemented with numerous collection system improvements, remote storage tanks, green infrastructure facilities and wet weather treatment upgrades at each treatment plant. The District refers to this plan as Project Clean Lake. This paper provides a case history of one of the seven CSO tunnel systems, the Doan Valley Storage Tunnel (DVT), located in the Easterly District.

BACKGROUND

DVT Overview

DVT was the third tunnel system designed and constructed under Project Clean Lake. The DVT is located east of downtown Cleveland in an area near and around the University Circle, a cultural, educational, and medical center. The 18-foot internal diameter main tunnel leg, referred to as the DVT, originates in an urban recreational area called Ambler Park and extends through the University Circle area approximately 2.3 miles to its terminus at Superior Avenue and E. 115th Street where it discharges by gravity to the Dugway Interceptor system via the newly constructed Dugway South Relief and Consolidation Sewer.

The DVT receives flows from two 8.5-foot internal diameter conveyance tunnels at the DVT-2 Shaft in Ambler Park; the 6,300 lineal feet Woodhill Conveyance Tunnel (WCT) running adjacent to Cleveland Water Department's Baldwin Water Treatment Plant and Woodhill Avenue within commercial, industrial areas and the 3,000 lineal foot MLK Conveyance Tunnel (MLKCT) running along MLK Avenue, within educational, medical, and residential areas. The DVT carries dry weather flows and stores and conveys wet weather flows (effective storage volume approximately 18 Million Gallons) provides control of CSO to the Doan Brook and enhances the existing Doan Valley Interceptor conveyance capacities and level of service. Figure 2 illustrates the DVT alignment and component profiles.

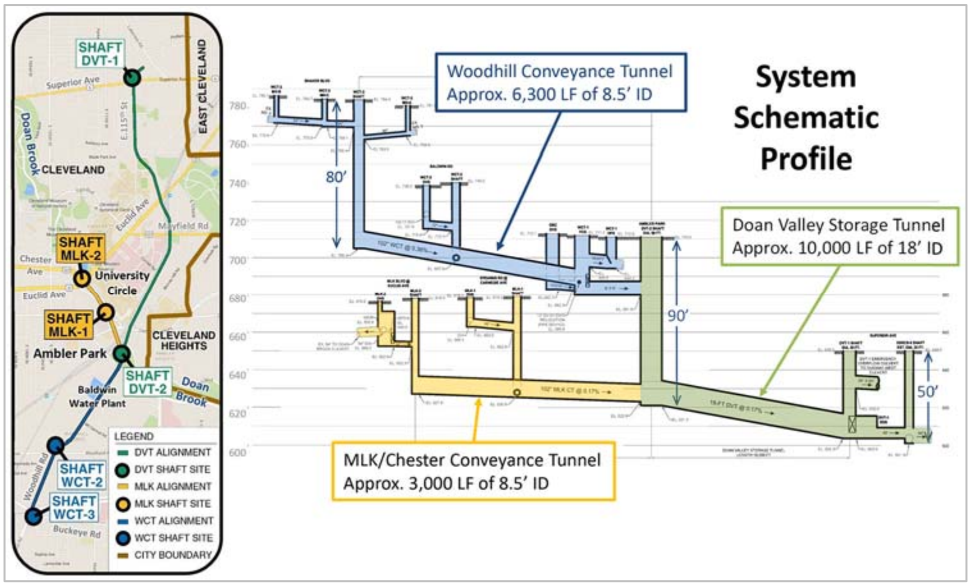

Figure 2. DVT alignment and component profiles

DESIGN CONSIDERATIONS

Performance Objectives

The performance objectives for the DVT system were to provide control of CSO from its outfalls to no more than 2 or 3 overflows in a typical year of rainfall and to provide additional conveyance to ensure a collection system level of service up to the 5-year design storm level. The typical year was developed with consideration of historical rain data collected at Hopkins International Airport for over 50 years and included over 120 annual rain events spread over the entire District service area. An additional performance objective was that the tunnel system drain by gravity into the existing interceptor system to avoid pumping thus allowing both dry weather and wet weather flows to be cost-effectively conveyed and stored to provide both CSO capture and additional conveyance. The flows were captured at key locations along the WCT and MLKCT, delivered to the DVT and carried approximately two miles downstream to the deeper Dugway Interceptor system via a gravity discharge shaft DVT-1 as shown in Figure 3.

Figure 3. DVT system

Hydraulic Design and Challenges

Since the DVT system functions as both a deep interceptor conveyance sewer and a CSO storage facility, it operates continuously and controls varying amounts of flow using control gates at Shaft DVT-1. The tunnel systems' additional conveyance capacities provide relief for the capacity constrained existing Doan Valley Interceptor (DVI) sewer system to improve its level of service. During wet weather, the tunnel system also reduces CSO to its stipulated Consent Decree frequencies through conveyance and storage of increased flows. These wet weather flows (WWF) are conveyed and discharged at a maximum rate of 50 million gallons per day (MGD) to the downstream Dugway Interceptor system based on its available excess WWF capacity. This maximum discharge rate is regulated by control gates within the DVT-1 shaft to a 48-inch dewatering sewer.

The gates were required to restrict flows to 50 MGD considering upstream high head conditions as the tunnel fills up to its maximum capacity. However, these higher head conditions result in extreme discharge velocities through the restricted gate openings, so a subsurface energy dissipation chamber at the DVT-1 shaft was also required to mitigate these velocities prior to entering the dewatering sewer. Flows beyond this discharged rate back-up and are stored within the DVT up to its 18-million-gallon (MG) storage capacity. For storms beyond the systems control level, the DVT inflows from the WCT and MLKCT are cutoff by inflow control gates at the DVT-2 and MLK-2 shafts to manage surge and tunnel filling conditions and the system overflows at these locations to the existing permitted outfalls CSO-073 and CSO223/224, respectively. If one of the inflow control gates fails in the open position, an emergency overflow at downstream DVT-1 Shaft will relieve the system to the Dugway culverted stream. DVT's gravity discharge configuration allows the tunnel system to dewater without pumping in less than a day to the existing interceptor system for treatment at the Easterly Wastewater Treatment Plant. Figure 4 illustrates the DVT-2 inflow, baffled drop shaft, and gravity discharge orientation.

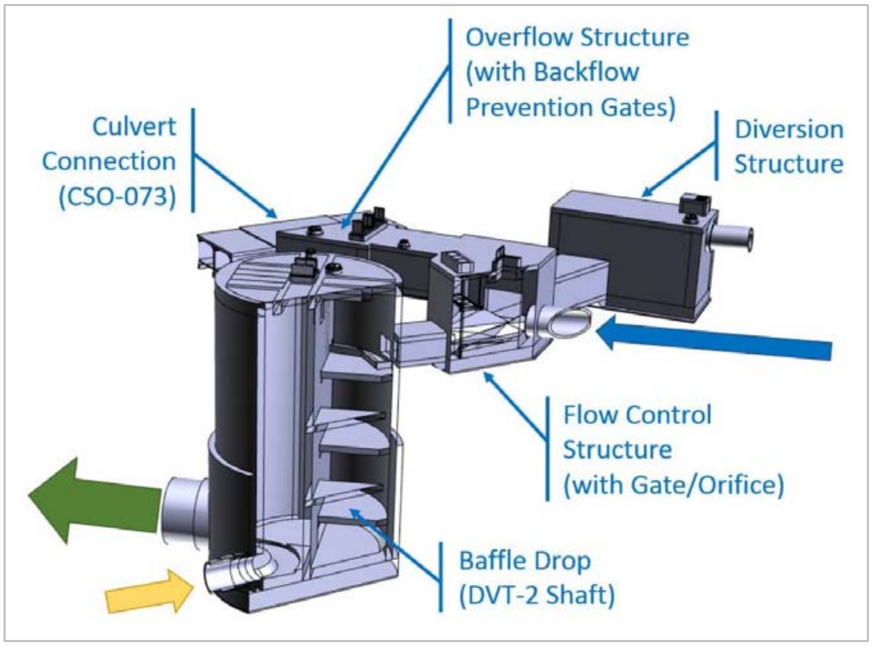

Figure 4. DVT-2 Baffle drop shaft and associated near surface structures

By controlling overflows at 11 locations, the DVT system advances Project Clean Lake's overall goal of capturing 98% of all CSOs for treatment. The CSO control system is designed to protect public health and Lake Erie as a key freshwater resource in the Great Lakes System for the next 100 years.

Ground Conditions

The DVT project is in the Erie Lake Plain Section of the Central Lowland Physiographic Province in northeast Ohio and lies immediately adjacent to the Portage Escarpment of the Appalachian Plateau. The project area consists of a gently sloping land surface, incised by river erosion. Historic tributary valleys and streams have been used as dumping sites or backfilled for development.

The Doan Brook stream has cut steep-walled valleys into bedrock along the escarpment and flow across the lower plain to the northwest of the escarpment in narrow to broad valleys. Doan Brook and other streams in the area have been placed in culverts.

Surficial deposits in the project area vary in thickness from about 1 to 46 feet and consist of fill material and discontinuous occurrences of alluvium underlain by Pleistocene-age glacial sediments. The bedrock underlying the glacial sediments consists of Late Devonian-age Ohio Shale. The Ohio Shale in the project site is subdivided into three members in ascending vertical order: Chagrin Shale, Cleveland Shale and Bedford Shale. The Chagrin Shale is the primary bedrock member encountered in the various shaft and tunnel excavations. The Cleveland Shale and Bedford Shale, including a thin layer of Euclid Lentil, were encountered in the southern portion of the WCT alignment. Within the horizon of the tunnels, the average unconfined compressive strength of the shale is about 2,800 psi and with a few exceptions, the rock mass is of relatively higher quality with RQDs generally classified as good to very good rock (RQD greater than 75 percent).

Horizontal and Vertical Alignment

The DVT, MLKCT, and WCT horizontal alignments are roughly north-south in orientation and traverse below the Woodland Hills, University, Little Italy, or Glenville neighborhoods located east of downtown Cleveland. These heavily developed urban neighborhoods include parks, schools, Case Western University and other college campuses, the medical care facilities of the Cleveland Clinic and University Hospital, and cultural destinations such as the Cleveland Museum of Art and Cleveland Orchestra. The WCT and DVT alignments roughly parallel a railroad corridor that includes freight and commuter rail service. As much as feasible, the MLKCT and DVT alignments were set to minimize the length of the tunnel below the railroad tracks at crossings. The WCT does not cross the railroad, but the alignment was shifted to the west of its originally planned location to minimize risks to twin 60-inch water supply lines in Ambler Park and other critical, 100+ year old water infrastructure in areas of extremely low rock cover associated with the Baldwin Water Treatment Plant.

The desired minimum radius curve for tunnels was 1,000 feet, but to reduce the number of easements, the minimum radius curve for the WCT was 750 feet.

The downstream ends of the MLKCT and WCT alignments converge with the upstream end of the DVT at Ambler Park served as the mining site for all three tunnels. The layout of the mining shafts, near surface hydraulic structures, and the relatively shallow WCT had to accommodate the large Doan Brook Culvert and Giddings Brook Culvert that are located at Ambler Park.

The elevation of the downstream end of the tunnel system was fixed due to the requirement that the system drain by gravity into the existing interceptor system. The design slopes of the tunnels were relatively flat and ranged from 0.17% for the DVT and MLKCT and 0.36% for the WCT and were controlled by hydraulic considerations. For the WCT there were additional hydraulic considerations in that it was desirable to keep this tunnel as shallow as possible to minimize impacts of hydraulic transients. These hydraulic considerations had to be balanced with the geotechnical consideration of keeping the entire tunnel system in rock to avoid mixed face tunneling. These constraints lead to the vertical alignment of the DVT illustrated on Figure 5 and MLKCT and WCT illustrated on Figure 6. Total cover for the DVT ranged from about 27 to 90 feet with minimum rock cover at the downstream end of about 14 feet. For the MLKCT total cover ranged from 36 to 83 feet with minimum rock cover of 11 feet. For the WCT total cover ranged from 20 to 70 feet with minimum rock cover of 6 feet.

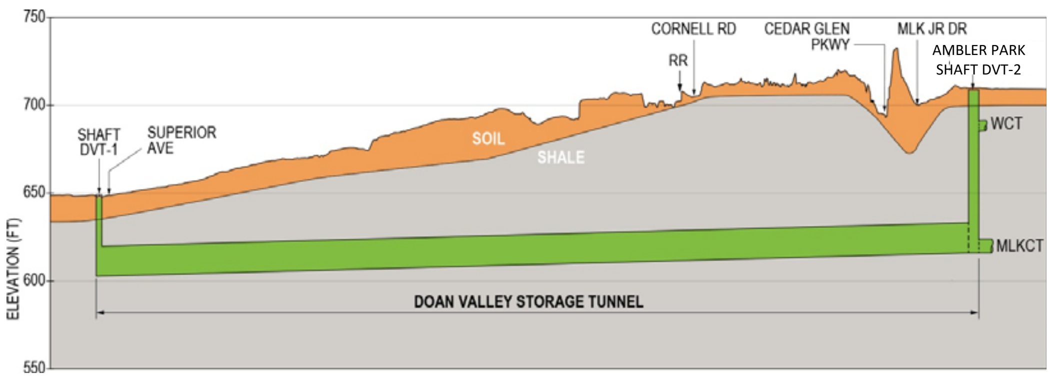

Figure 5. DVT profile

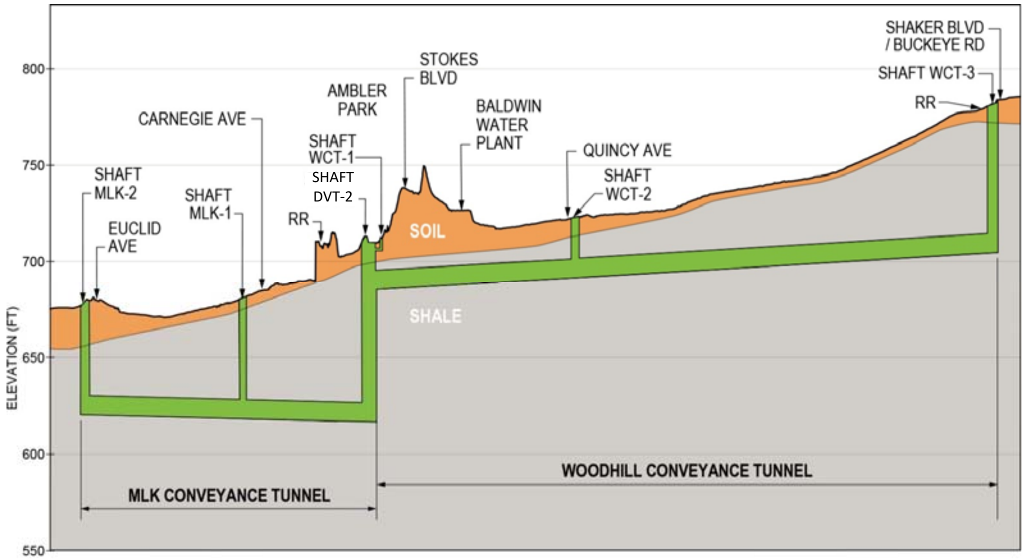

Figure 6. MLKCT and WCT profiles

Shaft and Tunnel Excavation and Lining

The excavated diameters of the shafts ranged from 12 to 59 feet. The 12-foot diameter MLK-1 Shaft was drilled and the other larger diameter shafts were excavated using conventional bucket excavators in the soil overburden and hydraulic hammers in bedrock. Although not prohibited for shaft excavation, drilling and blasting was not used on the project to reduce construction impacts on the community. The design contemplated steel ribs and liner plate initial support for the shafts in the overburden and pattern rock dowels and shotcrete within bedrock. The contractor, McNally/Kiewit DVT JV (MK), proposed some variances such as a steel casing for the MLK-1 drilled shaft for the overburden and installing Tensar mining geogrid in lieu of shotcrete after gaining some project experience and observing the overall stability of the shale bedrock.

Groundwater inflow was anticipated to be relatively low during shaft excavation due to relatively shallow top of bedrock, except at the MLK-2 Shaft which had approximately 30 vertical feet of granular alluvial soil and weathered rock. Based on past historic tunneling experience in these soils, it was anticipated that vertical dewatering wells would be needed to provide adequate ground stability during the shaft excavation.

The DVT was excavated with a new Herrenknecht single shield TBM using 17-inch disc cutters, creating a 20.75-foot diameter bore. The tunnel was lined with a one-pass precast concrete bolted and gasketed segmental lining to mitigate the risk of encountering gassy conditions based on past tunneling challenges in Cleveland.

The design contemplated the MLKCT and WCT being excavated with single shield TBM and steel ribs and timber lagging for initial support. The design for the final lining allowed for reinforced concrete pipe (RCP) or a fiberglass reinforced mortar pipe (FRP). RCP was selected by McNally/Kiewit DVT JV for the two-pass MLKCT and WCT tunnels. The contract requirement for the single shield TBM was based on the concern for encountering weathered, weak shale that might not be competent enough to support the side grippers of a main beam TBM. McNally/Kiewit DVT JV proposed to use a 12-foot diameter main beam TBM and provided contingency plans to address the concerns of the District and design team. They completed the excavations in the weathered rock without incident.

Offline shafts at the MLK-1 and WCT-2 were connected to the main tunnels via adits constructed in rock. Also, a consolidation sewer was tunneled in rock from the WCT-2 Shaft to a new diversion structure below sensitive water lines and required careful sequential excavation to minimize the impact to existing water lines (Rogoff, et al. 2020). The adits and the WCT-2 consolidation sewer were excavated with a

Brokk remote-controlled demolition machine with a hammer and supported with steel ribs. The final lining was 6-foot diameter RCP with cast-in-place concrete connection collars to the offline shafts and main tunnels.

Minimizing Impacts

Located within a wide range of urban contexts, the DVT Project focused on minimizing and managing community impacts during construction and operation of the project. The vibrant University Circle area with its park-like settings and busy pedestrian and vehicular traffic is at one end of the spectrum with stakeholders such as Case Western Reserve University, several hospitals, schools, museums, and public parks. Areas with abandoned buildings that may be ripe for urban development are at the other end. Minimizing impacts to stakeholders was a major consideration when siting shafts. In addition, the horizontal alignments for the tunnels were established to maximize the use of public rights-of-way and further reduce stakeholder impacts.

In addition, all three tunnels were designed to be mined from the same main construction site, and two of the three tunnels were mined from the same shaft. The DVT-2 Shaft was configured to capture flows from the MLKCT and WCT, ultimately directing flows downstream into the DVT. The MLKCT alignment was revised to improve hydraulic performance of the tunnel system during surge conditions while maintaining minimum offsets from an existing railroad bridge foundation. The MLKCT invert is only 1.4 feet higher than the DVT outlet invert, allowing both tunnels to be constructed from a single shaft. This shared construction site allowed for a quicker, more efficient construction timeline.

Multiple constraints at and near the MLK-1 Drop Shaft, including a new, Cleveland Metropolitan School District high school (the Cleveland School of the Arts), a sculpture park and Stearns Road, a heavily used transportation corridor, required a very compact site design. As shown in figure 7, the site accommodates a diversion Structure (MLK-1 DVS), consolidation sewer and drop shaft. Due to the limited space available both for construction and future operation and maintenance (O&M) activities, a 52-foot deep stainless steel helicoidal ramp drop shaft was employed to transfer flows from the shallower interceptor sewer to the deeper MLKCT. This less frequently used, innovative method of transferring flows via a relatively small diameter (6.0 foot) conduit significantly reduced the footprint required for both construction and maintenance access. Additionally, since the stainless-steel structure was prefabricated, installation was straightforward and rapid.

Figure 7. The MLK-1 shaft site required a compact design

CONSTRUCTION

Staging at Ambler Park – Constrained Site

Staging at the main mining site at Ambler Park (DVT-2) was challenging. Not only is the location in the middle of the City of Cleveland Cultural Center of University Circle it is also a hub point for several utilities. What appears on the surface is an open park area with the Lake-to Lake bike trail, a City centennial memorial tree and the open channel of the Doan Brook. What lies beneath is the challenge. With the location being so close to several major institutions, the need to maintain service is critical.

Ambler Park has several major utility lines. On the east side of the site there are twin 60-inch raw water service lines that bring water from Lake Erie to the Baldwin Water Treatment Plant for processing prior to distribution for drinking water. There are 16-inch and 24-inch-high pressure water distribution lines to the west of the site that are the primary service for the nearby hospitals and other east side of Cleveland. A 6-inch gas line bisects the site from the southeast to the northwest. Ambler Park is also where the Doan Brook transitions from an open channel to an underground 10-foot by 7-foot double barrel brick box culvert located on the northwest side of the site as well as the 84-inch diameter Giddings Brook culvert tie-in to the Doan Brook culvert from the southeast. Further, unknown at the time of bid was a 13.8kV underground electrical conduct in 6-bay duct bank, again bisecting the site from the southeast to the northwest.

Protecting and keeping these vital utilities in service was paramount to the success of the DVT operations. As such, the project team came up with several varied methods for protection. The twin 60-inch raw water supply lines were not touched; MK reduced the site limits to allow for the smaller MLKCT crossing to be the only potential for disturbance to these vital supply lines. The Lake-to Lake bike trail was relocated for the duration of the project and the City of Cleveland's centennial memorial tree was stacked off with a ring of cleared area for the tree's protection. The 16-inch and 24-inch water mains were covered on the surface with buried crane mats to allow for H-20 loading and construction traffic. MK installed an internal bracing system within the construction limits in both the 10-foot by 7-foot double barrel box culvert of the Doan Brook and the 84-inch Giddings Brook culvert. The 6-inch gas line, at the direction of the utility owner, had an "air bridge" system installed over it to allow for construction traffic to cross and facilitate laydown areas. Finally, the 13.8kV underground electrical line was relocated to overhead lines surrounding the perimeter of the site, and a small portion of the duct bank needed to be removed and replaced to allow for the installation of the project items.

Figure 8. Aerial view of Ambler Park site

Coordination with Stakeholders, Commuting Public in General

The DVT-2 site is in the heart of the Cleveland cultural center University Circle. This area is home to the City's Art and Natural History Museums, Severance Hall (Cleveland Orchestra Home), two major hospitals (Cleveland Clinic and University Hospital), John Hayes High School, Cleveland School of the Arts and Case Western University with several other lesser institutions. The primary mining Site of DVT-2 Shaft and two of the shaft locations, MLK-2 and MLK-1, were in the middle of this sensitive area. Discussion started early in the design process on what impacts the construction activities would have on the area with the City of Cleveland and other key stakeholders such as the University Circle Development Group, Case Western University and museum officials. These discussions lead to an improved understanding of the maintenance of traffic needs and the peak times of travel and how to best address those needs while maintaining efficient mining operations. The active lines of communication established in the design phase were carried through the construction with weekly calls to affected parties as construction sites were established and mining activities were underway. During this time the NEORSD sent out several mass mailings to alert residents in the surrounding areas of the upcoming and ongoing work that was being completed. The NEORSD even took the opportunity to place informational banners (screen covering along construction site fences) along these three highly trafficked locations to inform the public of the planned activities and how the DVT project would ultimately improve the local water quality issues.

Coordination at Downstream End (DSRCS and DVRCS shafts)

Physical Interface and Contractual Interface

DVT-1 Shaft site was the home to two shafts, DVT-1 and DSRCS-6 as shown in figure 9. DVT-1 was excavated as the retrieval shaft for the DVT TBM, and DSRCS-6 shaft excavated by McNally Tunneling on a previously completed project, Dugway South Relief and Consolidation Sewer (DSRCS). MK connected these two shafts with an energy dissipation chamber and auger bore tunnel drive. DSRCS-6 shaft was also the terminus point of the Doan Valley Relief and Consolidation Sewer (DVRCS) tunnel performed by a third, separate contractor. Thorough scheduling efforts, cooperation with DVRCS contractor and MK, along with coordination efforts and oversight by NEORSD project team allowed little to no interference between the three contracts and two contractors. Coordination efforts between all parties allowed both contractors to work simultaneously on the same small site with little to no impact on each other's operations.

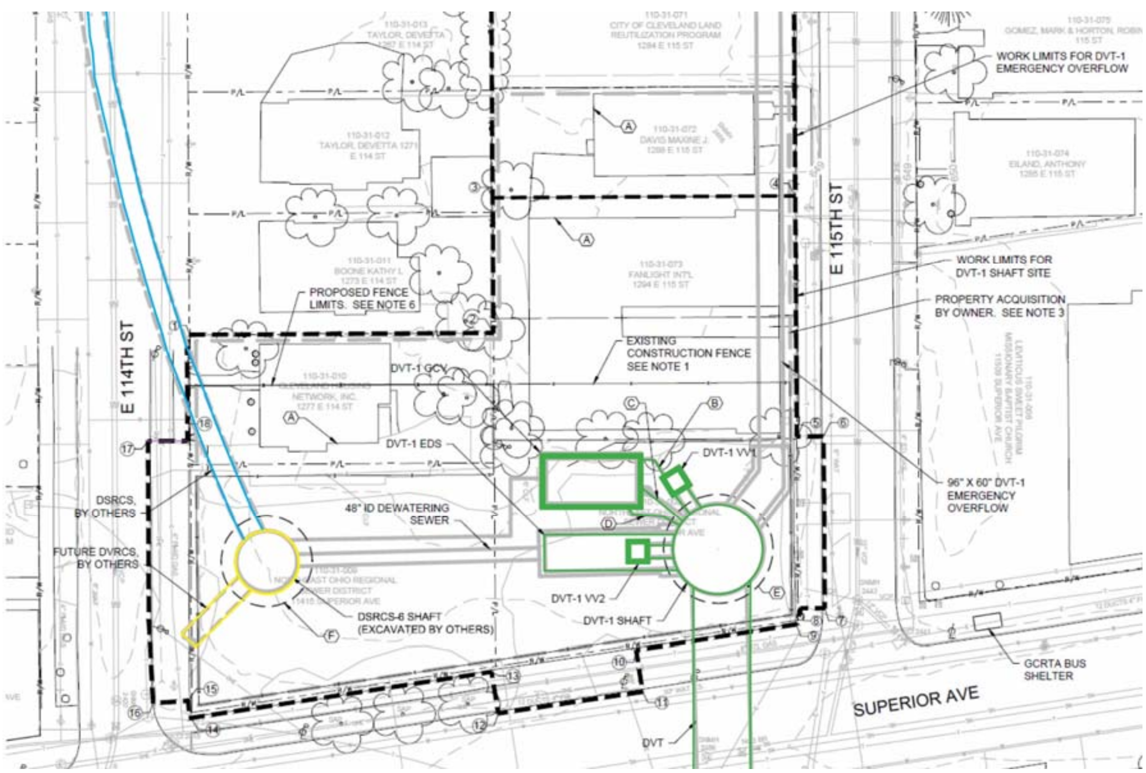

Figure 9. DVT-1 Shaft site was home to two shafts and three construction contracts

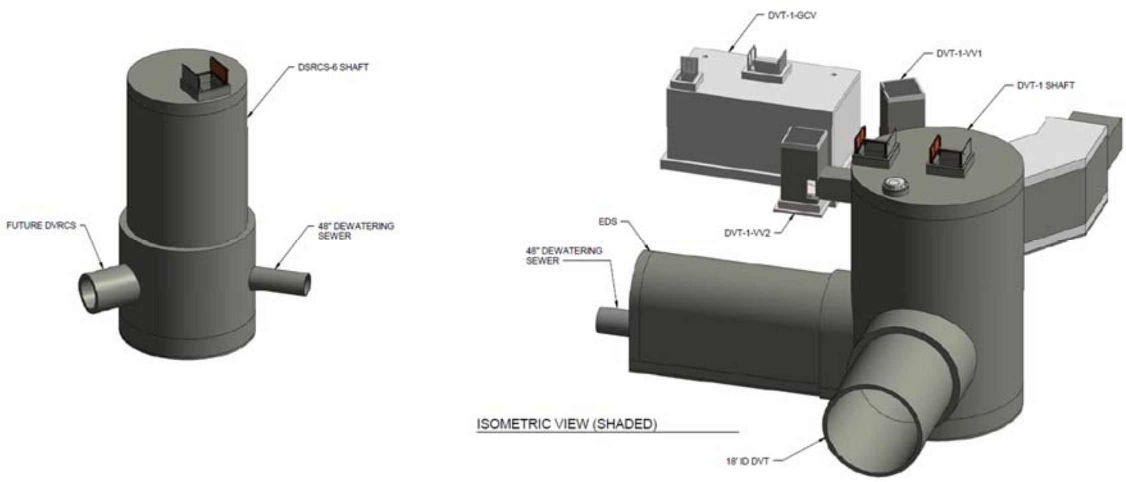

Figure 10. DVT-1 Shaft and DSRCS-6 shaft ISO views

Site Issues and Challenges

Floodplain and Flooding

Overall, the DVT project was successful for all parties involved but it was not without its challenges. Following a flooding event of the Doan Brook, which impacted the WCT tunnel drive due to its launch shaft located in a 100-year floodplain, MK focused on expediting the schedule as much as possible. This could not have been possible without an outstanding local craft workforce. Through the past decade the Cleveland area, primarily due to NEORSD, has had numerous tunnel projects and through these projects has developed a local experienced labor force. Capitalizing on this experienced and talented workforce allowed MK to ramp up operations and number of crews, which allowed MK to work two tunnel drives simultaneously, installing pipe in the two-pass WCT tunnel drive while mining the DVT tunnel on three shifts, all while having a shaft / near surface works excavation crew. Later MK worked two tunnel drives simultaneously, DVT and MLKCT, out of the DVT-2 Shaft. Within the DVT, MK performed tunnel patching, cleaning, and starter tunnel cast-in-place concrete work, and within the MLKCT they installed and grouted the pipe annulus. This experienced and dedicated workforce along with a lot of planning, and some construction optimization opportunities, allowed MK to recover a lot of time lost due to this flood event.

Construction Optimization and Value Engineering Opportunities

MLK-2 GCV

At the DVT MLK-2 Site, the design envisioned separate excavations for the diversion structure (MLK-2 DVS) and gate control vault (MLK-2 GCV). However, during the planning of the support of excavation (SOE), MK collaborated with the NEORSD to realign these structures to combine the excavations and create one large SOE structure. This saved both material and labor cost for MK and reduced the overall time to install and excavate these two structures. MK also eliminated a soldier pile and lagging SOE for the conveyance sewer between the MLK-2 DVS and MLK-2 Shaft by electing to install this section of 54-inch ID pipe by opencut methods with trench box support prior to excavating the MLK-2 DVS and MLK-2 shaft. MK coordinated with NEORSD and their Engineer of Record to accomplish this scheme and had to slightly tweak the alignment of the MLK-2 DVS and GCV to accomplish the combined SOE system. Cooperation and coordination efforts between the project team along with good working relationships between all parties allowed this vision to come to fruition and expedited the overall project schedule.

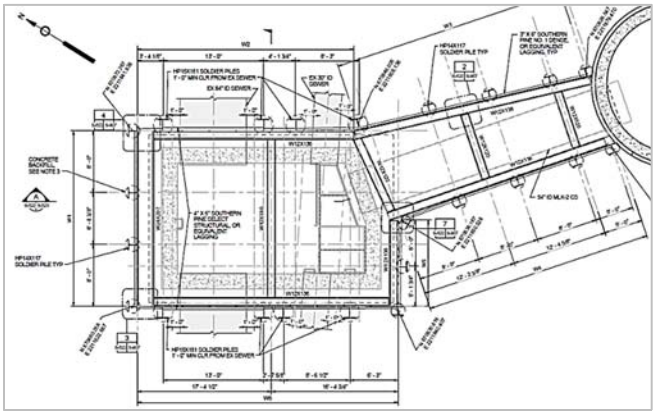

Figure 11. MLK-2 DVS, CS, and shaft original design

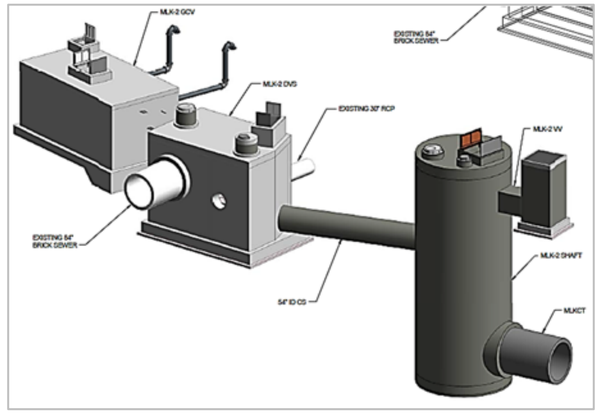

Figure 12. MLK-2 DVS, GCV, MLK-2 CS, and MLK-2 Shaft

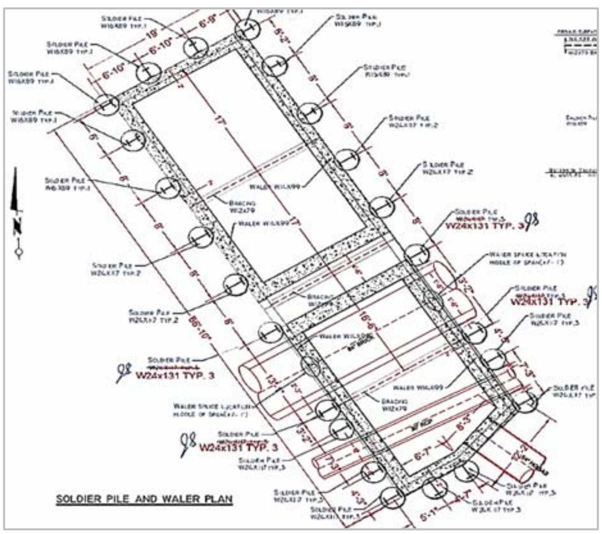

Figure 13. MLK-2 GCV and DVS SOE plan view re-design

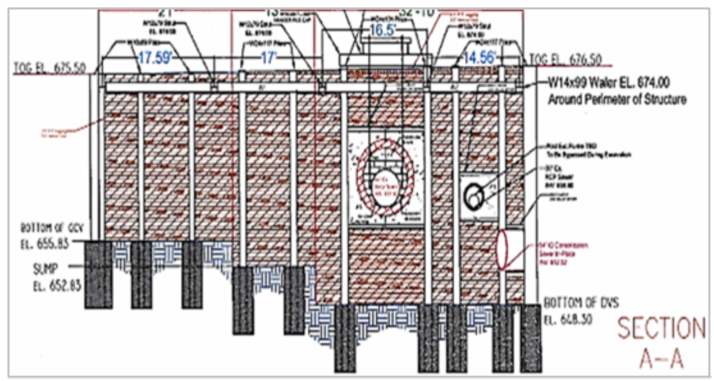

Figure 14. MLK-2 GCV and DVS profile view

DVT-2 GCV

At the DVT-2 Shaft site, MK also looked to take advantage of using one SOE system for multiple structures to save both time and cost. The DVT-2 site includes flow diversion and control structures along with the WCT mining shaft. The rectangular WCT mining shaft served to launch the main beam TBM and pipe was placed in the shaft after the WCT excavation to connect to the tunnel to the flow control structure. MK took the opportunity to place the WCT-1 GCV inside the WCT mining shaft SOE and overtop the backfilled WCT pipe. This was accomplished through several coordination and planning meetings between the project team. The success of this can be directly attributed to an owner and designer who are open to contractor modifications, optimizations and value engineering considerations.

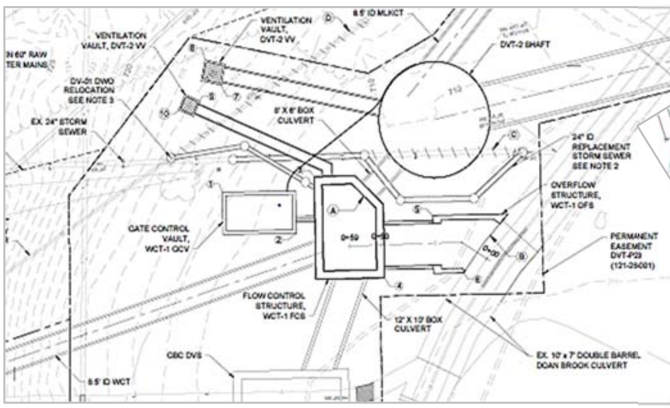

Figure 15. DVT-2 site SOE layout

Figure 16. DVT-2 structure layout

DVT-2 Shaft Top Slab Re-Design

Prior to constructing the final cast-in-place structure for the DVT-2 Shaft, MK along with subcontractor Northstar Contracting reached out to NEORSD and their Engineer of Record on the potential for redesigning the top slab of the main mining shaft from an entirely cast-in-place top slab to a composite of precast beams and panels and a cast-in-place top slab. Per this concept precast panels were used as formwork to support the cast-in-place portion of top slab. Large precast beams were cast on site, lifted into place and set in beam pockets located on shaft wall lining. Then, precast panels were placed as shown in Figures 17 and 18. After all precast panels were set, access hatches and precast removable planks were set, cast-in-place rebar was placed, and concrete poured as shown in Figure 18. MK, NEORSD, and Design Engineers worked together to accomplish this redesign, which provided a safer and more expeditious means to construct the shaft top slab. This change allowed MK to eliminate heavy formwork and shoring installation to support final cast-in-place concrete along with labor and time to install this shoring and formwork.

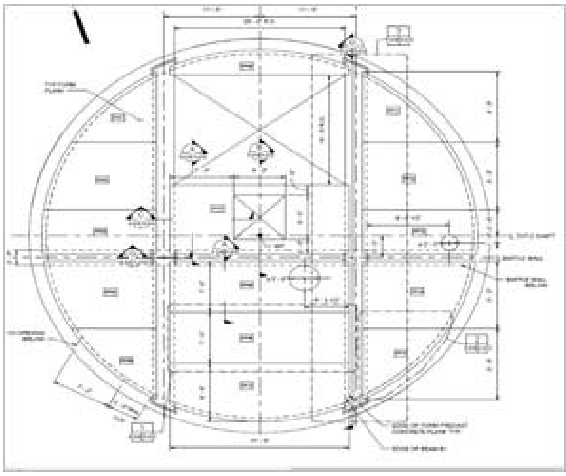

Figure 17. DVT-2 Shaft roof slab layout

Figure 18. DVT-2 top slab structure layout

Flow Management

MK and NEORSD have had success on previous projects and again on the DVT project maintaining existing sewer flows while excavating diversion structures by utilizing blockage plates and flume pipes designed for existing flow parameters included with the Contract Documents. These flume pipes and blockage plates would be installed during construction of the SOE and after the construction of cast-in-place concrete structures to prevent flows from entering shafts and ultimately tunnel prior to being able to accept flow. Typically, this would allow the complete construction of the final cast-in-place structures, minus the cast-in-place top slabs. Once the tunnel was able to accept flow, flume pipes were removed, and the top slabs of structures completed. This allowed diversion structures and more importantly gate structures to remain dry and allow for testing of gates prior to releasing flow.

Figure 2 GBC-DVS flume pipe

CONCLUSION

The DVT came online in July 26, 2021 and has been operating as planned since that time. Project features incorporated into the design of the project to address the hydraulic complexities and reduce impacts to the community during construction were successful. Design optimization and constructability enhancements initiated by MK during construction were implemented with close collaboration with the District and Designer leading to overall project improvements.