CHALLENGING DREDGE OPERATION OVER ACTIVE UTILITIES IN NEW YORK HARBOR

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ABSTRACT

Channel deepening is occurring at ports throughout the United States (US) due to the ever-increasing size of vessels calling at these ports. Specifically, completion of the new Panama Canal has resulted in a wave of dredging projects along the east coast of the US, where ports are racing to complete their capital projects to capture the additional trade volumes expected from the larger ships capable of passing through the new Panama Canal. In addition to impacts on existing port structures due to berth deepening, water mains, electric lines, gas and fuel lines in subsea utility corridors crossing navigation channels where dredging is performed may result in major challenges when these utilities are active and in close proximity to the dredged mudline. To add to the complexity, most of these utilities were generally constructed long ago when subsea construction controls were less accurate and as-built conditions were not recorded with high precision.

This paper discusses the navigation channel deepening operations undertaken over the active utility corridors crossing the main navigation channel in New York Harbor. Prior to the deepening project, the limiting water depth at the New York Harbor navigation channel was 13.7 meters (45 feet), severely constricting the new generation of container ships, which requires a minimum of 15.2 meters (50 feet) navigable water depth. The main challenges encountered during the dredging project were precisely locating the utilities in the channel, both their horizontal and vertical coordinates; locating the dredging plant and the dredge bucket in the channel where currents are strong; and cutting hard native material while using a special flat dredge bucket to minimize the risk of damage to the utilities. The importance of redundancy in sensor methods for locating the exact coordinates of the utility lines and the actual depth of digging for the dredge equipment, anomalies in utility corridor dredging where presumed controls do not seem to be functioning as expected, and the risks this imposes on the dredging project are discussed in the paper with examples.

Keywords: Subsea utility lines, navigation channel deepening, horizontal position control, depth control, environmental dredge bucket

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INTRODUCTION

Construction of the new Panama Canal locks and dams resulted in a new wave of dredging projects at east-coast US ports, racing to finish these projects earlier than the completion to capture additional trade volumes expected from the larger ships now capable of passing the newly expanded Panama Canal. One such dredging project has recently been completed at the Port of New York and New Jersey (PONYNJ), which is the largest port on the east coast of the US and the third largest in the country in terms of cargo volume. The port is strategically located, with over 100 million people living in the surrounding region. However, the majority of the PONYNJ marine terminals serving this area are located 6.5 to 15.5km from the harbor entrance, known as "The Narrows."

Prior to the dredging project, controlling water depth at the navigation channel leading to PONYNJ terminals was 13.7m (45ft) at Mean Low Water (MLW). The US Army Corps of Engineers (USACE), the Federal organization tasked with maintaining the navigable waterways of the country, started the channel deepening project in 2004 to increase the navigable water depth to 15.2m (50ft). The project, referred to as the "Harbor Deepening Program", included 21 individual dredging contracts and several additional contracts for the beneficial use of approximately 40 million cubic meters (52 million cubic yards) of dredged material in marshland restoration projects (USACE, 2016). The last and final dredging contract in the Harbor Deepening Program was completed in 2016 and required dredging over three utility corridors close to the navigation channel entrance, as marked on the National Oceanic and Atmospheric Administration (NOAA) chart in Figure 1 (NOAA, 2017a). Two cast iron water mains, electric cables, gas pipelines, and oil pipelines are currently active in these utility corridors. Millions of customers rely on these utilities for their basic everyday needs, and any damage to them would result in extended periods of service interruption and put millions of people in jeopardy.

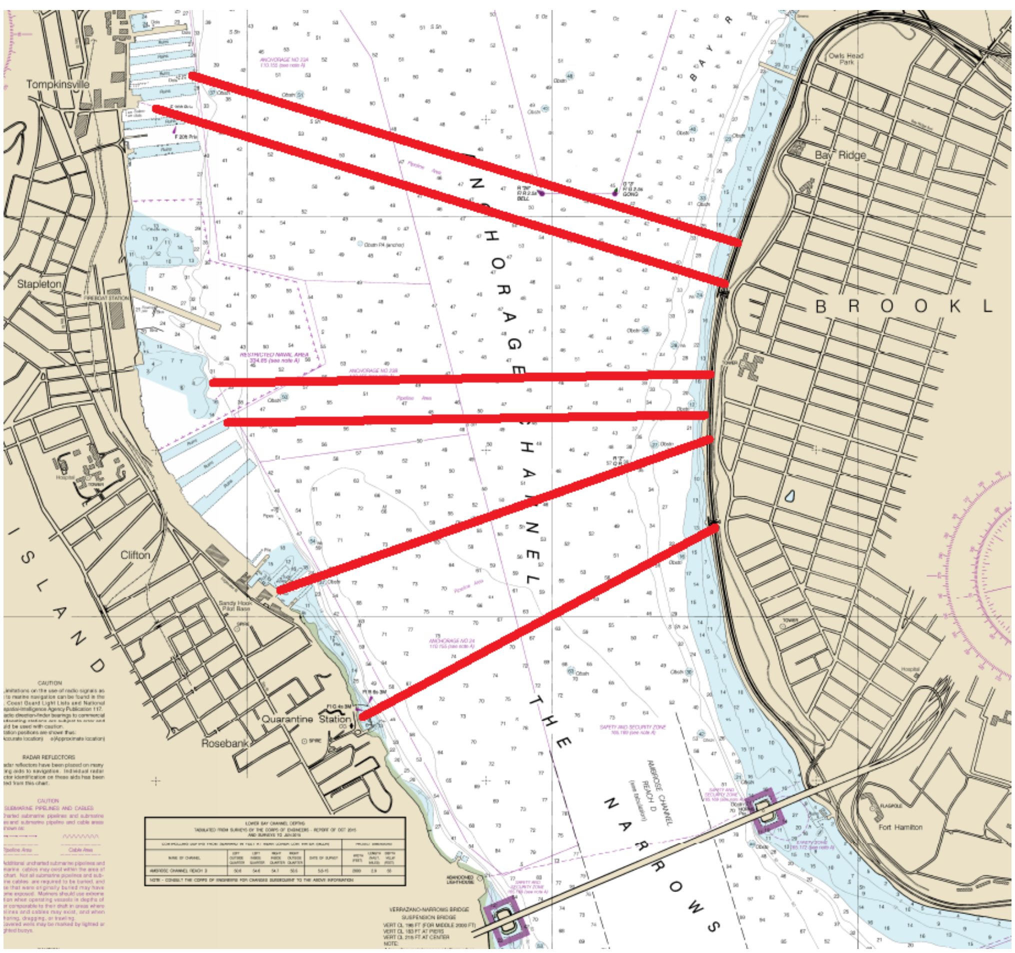

Figure 1. Some of the Designated Utility Crossings (red lines) at New York Harbor Navigation Channel

The dredging operation over one of these utility corridors, containing oil and gas pipelines, is the subject of this paper. Special precautions taken before, during, and after the dredging operations are described in the following sections.

EXISTING CONDITIONS AND ASSOCIATED RISKS

The utility corridor passing through the dredging area, where the oil and gas pipelines are located, was constructed in the 1960s by traditional trench-and-cover methods (Figure 2). A trench was excavated at the seabed to a minimum depth of 6.1m (20ft) below the existing mudline, with side slopes sufficient for temporary stability during construction based upon the in-situ sediment natural angle of repose. After the pipelines were placed in the trench, they were covered with a minimum cover thickness of 5.5m (18ft) backfill. The limited available construction drawings do not provide the specification of the backfill material. However, it was observed later during the dredging that the backfill material was actually different in color than the native material. This color difference was used as a telltale sign of cutting in to the trench.

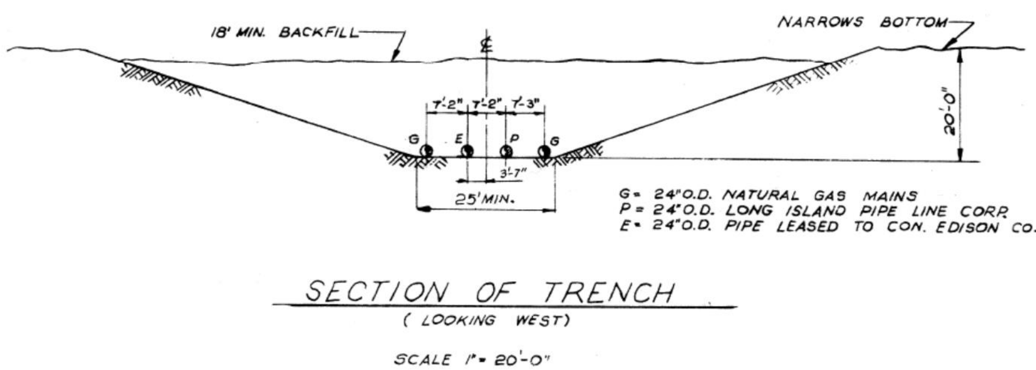

Figure 2. Typical Cross-section of Utilities

Although the existing utility trench construction drawings provided some information about the cross-section of the trench, they were far from adequate in providing precise elevations of the pipelines along the trench. Thus, additional surveys were needed to approximately locate the vertical positions (i.e. depth) of the pipelines within the dredging prism. Existing historical design drawings indicated that the utility pipelines rise in elevation on the eastern boundary of the navigation channel to tie in to pipelines on the shore.

Several subsea profiler surveys had previously been conducted at the project site to locate the pipelines. Unfortunately, subsea profiler surveys are not precise by their nature and the results are highly operator-dependent. Figure 3 shows a subsea cross-section profile obtained from such a survey, where green lines indicate the approximate trench boundaries interpreted from the subsea profiler data and the blue lines indicate mudline elevations obtained from multi-beam bathymetric survey. As can be seen in the figure, only a trained individual can distinguish the trench boundaries by interpretation of the data.

Based on the subsea profile obtained from magnetometer surveys, the mudline profile obtained from multi-beam bathymetry surveys, the navigation channel profile from official navigation charts, and a target dredge depth of 15.2m (50ft), Figure 4 was developed for locations where the proximity of dredging to existing pipes was being investigated. It can be seen in the figure that, with an over-dredge tolerance of 0.6m (2ft), a common tolerance benchmark for dredging projects, the dredged seabed profile comes within 2.1m (7ft) of the pipelines, making the dredging operation over the utilities a high-risk operation by industry standards.

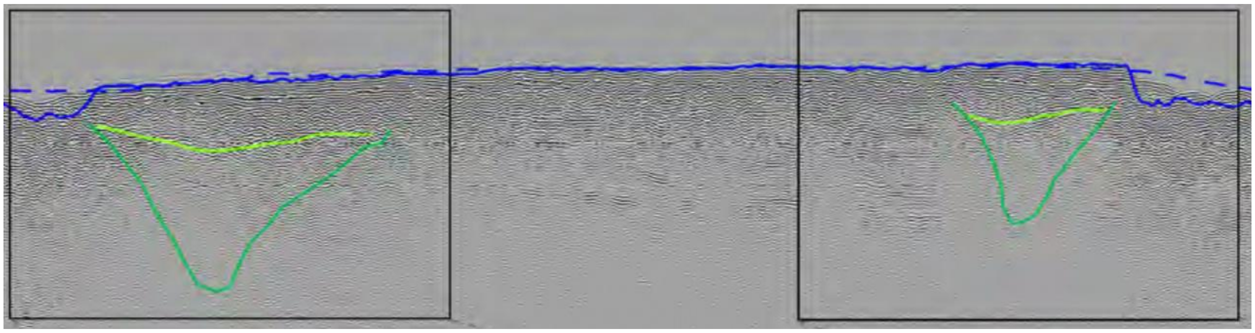

Figure 3. Imagery Indicating Utility Trench Location

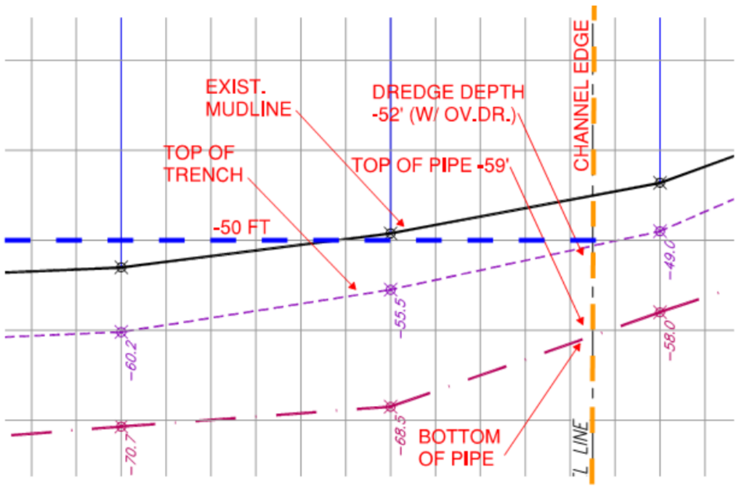

Figure 4. Assessed Location of Utility

As mentioned earlier, the pipelines in the subject utility corridor provide gas and oil to millions of customers in the New York region. Thus, it was crucial to avoid any damage to any of the pipelines, no matter how minor, during dredging. Any potential damage would trigger comprehensive inspection requirements and shutting down the utilities until such inspections are completed, according to Department of Transportation regulations. It was obvious that such a scenario would leave millions of customers without oil and gas.

To add to the complexity of the project, the dredge site was located near the exit point of New York Harbor, where currents, especially ebb currents, are known to be very strong. Ebb currents at the project site routinely reach 2 knots (1 m/s), as depicted in Figure 5 (NOAA, 2017b). Once the dredge bucket is in the water, it will be subject to lateral forces from the currents acting on it. For a water depth of 15.2m (50ft), even a small bucket inclination angle of 5 degrees would result in an offset of 1.3m (4.3ft).

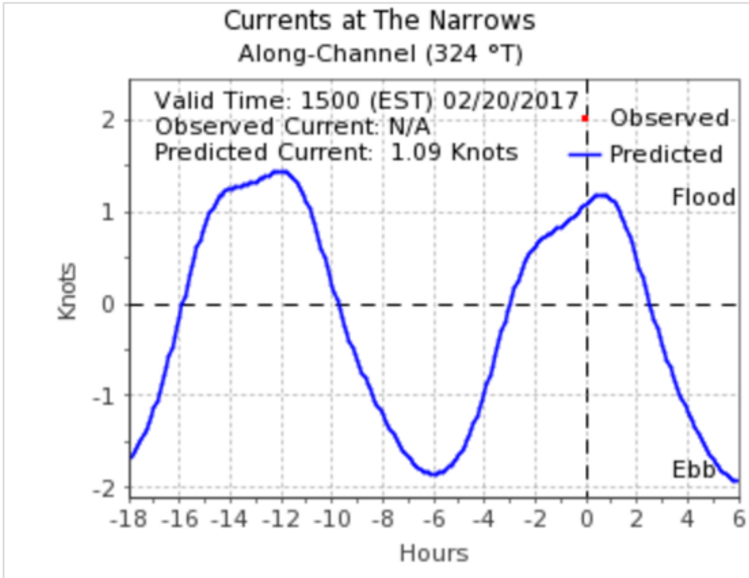

Figure 5. Typical Current Speeds at Project Site

PREPARATION FOR DREDGING OPERATIONS

A systematic risk-reduction approach was employed for the project. The first step in minimizing the risks associated with the dredging over the active pipelines was determining the risk factors and preparing for them. A step by step process was discussed and agreed between all parties involved. The dredging contractor, pipeline owners and operators, end users, government agencies, and other significant stakeholders had regular coordination meetings to fine tune the details of operation, and are described in the following sections.

Initial Planning and Contingency Plans

One of the main risks associated with dredging over the active oil and gas pipelines was damaging the pipelines, which would take the pipelines out of service for a considerable duration of time while inspections, remediation, and repairs were performed. During stakeholder coordination meetings, several preparatory protocols were discussed and agreed upon, which included:

- Procedures to shut-down and re-open pipelines (valve closure and opening sequence, pressure monitoring and maintenance, etc.);
- Timing and duration of shutdown window tolerable by the end users;
- End-user preparations for pipeline shutdown (i.e. storing enough product in the tanks to continue serving customers while the pipeline is closed);
- Points of contact and communications protocols between the parties involved during the dredging;
- Details of dredge equipment and procedures (horizontal and vertical location of dredge, bucket type and equipment details, etc.).

As part of the contingency planning, a dive team was contracted to stand-by throughout the entire duration of the dredging and provide emergency diving inspection services if needed. Additionally, an emergency pipeline repair contractor was put on stand-by to immediately mobilize and start the repair of the pipelines in the event they were damaged.

Horizontal Positioning of Dredge Plant

The dredge plant was equipped with a high-precision differential global positioning system (DGPS) receiver constantly updating the plant coordinates and tide levels. Knowing the precise location of the GPS antenna on the plant, overall dimensions of the barge, coordinates of the center of rotation of crane ringer on the barge, crane boom length and angle, and bucket size (open and closed footprints and height of the bucket) enabled the operator to precisely locate the dredge plant over the utility corridors and the dredge bucket over the pipelines. Once positioned at the desired location, the dredge plant was held in place by three spud piles lowered into the mudline. To avoid damage to the pipelines, spudding was not permitted inside the utility corridor. Coordinates of the spud pile locations were measured relative to the DGPS antenna location. This information was entered in to the dredge contractor’s propriety software and displayed on dual screens, one in the operator’s cabin and one in the engineer’s room (Figure 6 and 7). All readings were refreshed in-real time, approximately once per second.

The pipeline utility corridor easement was wider (approximately 200ft, or 61m) than the safe reach of the dredge plant at its lowest boom angle from one side only. Thus, once finished dredging from one side, the dredge plant had to be re-positioned to the other side of the easement with the help of a standby tug boat.

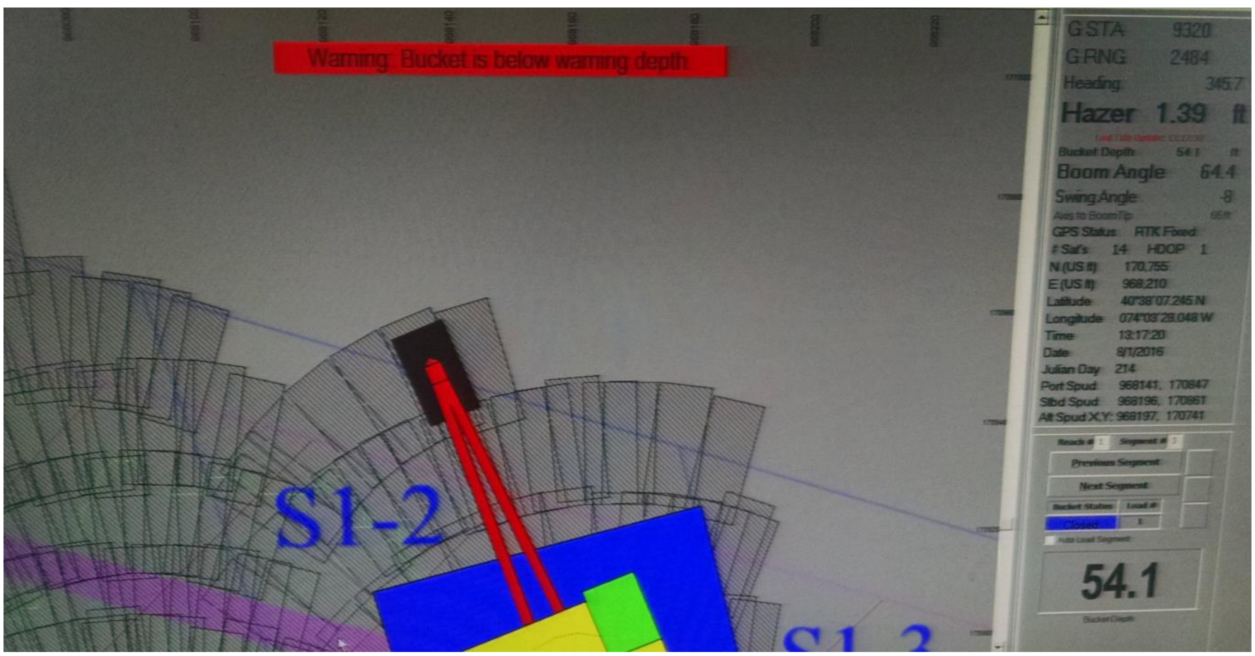

Figure 6. Screen Shot of Contractor’s Proprietary Dredge Control Software

Figure 7. Dredging Operation – View from Operator Cabin

Dredge Bucket Depth Control

Control of the bucket depth, and thus the dredge depth, was the most important aspect of the dredging operation, and required higher than normal precision. This, however, was challenging due to the swift currents at the project site. Both electronic and manual depth control measures were implemented. The control software providing the operator tide-adjusted bucket depth in the water was visually calibrated every time a new bucket was taken. This was done by closing the bucket in the air and checking the computer reading when the bucket was lowered just enough to touch the water surface, where the operator zeroed the depth reading. When the bucket was lowered to the mudline, depth readings on the computer screen were relative to the water surface at that specific time, taking tide level into account (Figure 8).

Visual redundancy was provided to the dredger operator by marking the steel cables holding the dredge bucket with white paint (refer to Figure 8). These markings indicated bucket open and closed position as well as mudline depth elevation. An electronic tide gage and a tide board were installed at a nearby dock to visually check the digital tide readings. Additionally, a Real Time Kinematic (RTK) tide gage was installed on the side of the dredge plant. The dredged area was surveyed by a survey boat immediately after the dredger moved out, to ensure the target depths were reached and over-dredge depth was within the target tolerance (Figure 9).

Figure 8. Dredging Operation in Progress (yellow arrows indicate cable markings for depth control and dredge bucket open/close check)

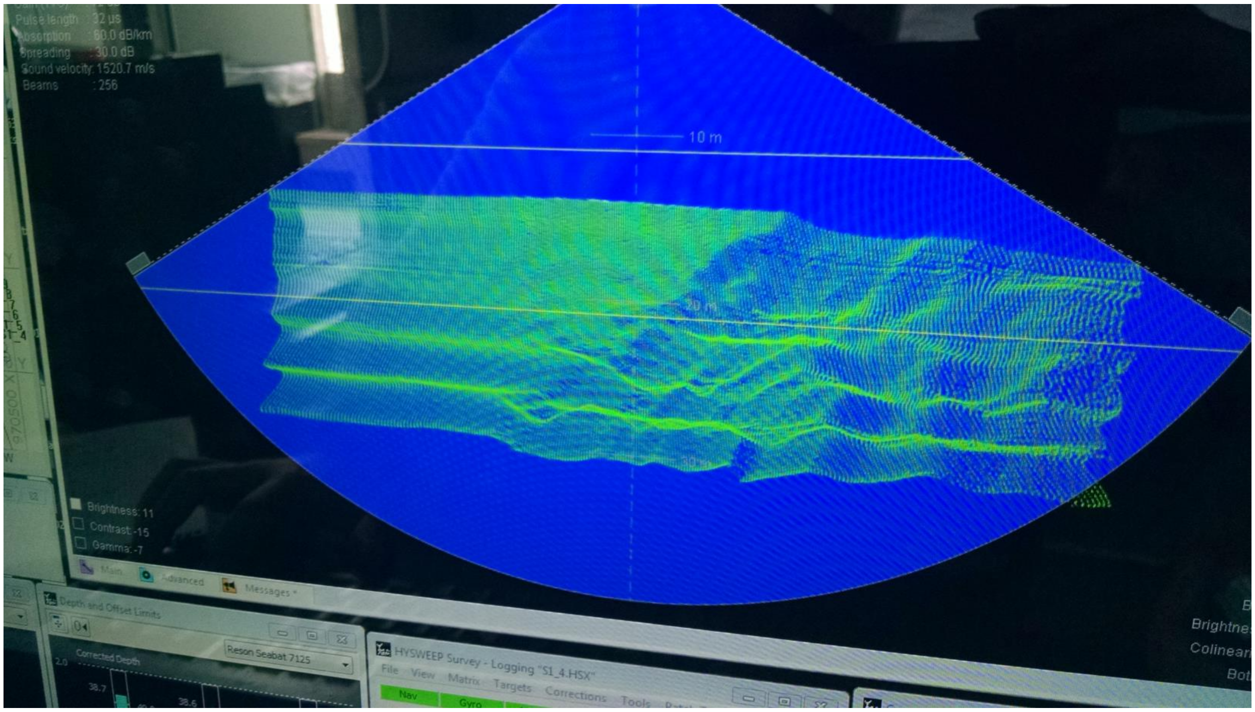

Figure 9. Bathymetry Survey at Site after Dredging

OBSERVATIONS

Dredging execution and associated contingency plans were carried out effectively. Pipeline shut-down and re-opening timing and procedures were followed by the operator’s field personnel. End users were informed before the shut-down so that they could store enough products in tanks for customers, so there was no shortage of products supplied by the utility pipeline if damage were to occur. However, unforeseen difficulties encountered during the dredging resulted in completion of the project in two separate phases instead of the desired one-phase completion.

Strong currents at the project site negatively affected the dredge bucket horizontal and vertical location control, resulting in over-dredging at certain locations and under-dredging at others relative to design dredge profile. The proprietary dredging computer control system used by the dredging contractor was effective in locating the dredge plant over the utility corridor. However, dredge bucket depth control in water under swift currents turned out to be more challenging and less accurate than initially anticipated. Following initial dredging work, progress bathymetric survey data revealed the unevenness of the dredged bottom (refer to Figure 9 for an example), which required the contractor to reposition the dredge plant back into previously dredged areas and re-dredge locations that were out of conformance with the design profile. Even so, follow-up progress bathymetric surveys often indicated many areas with bottom elevations higher than the design template elevation, requiring continued clean-up work in the areas that were still out of conformance. Relocating the dredge plant several times throughout the duration of dredging in order to clean up previously dredged areas was a time consuming process.

The environmental bucket used for dredging had difficulty in cutting into the native material (stiff Silt and Clay) on either side of the utility trench, which had never been dredged. This particular type of environmental bucket did not have cutting teeth in order to avoid damage to pipelines within the utility corridor. The disadvantage of this type of bucket was that the in-situ hard material was very difficult to cut through due to the lack of teeth, typical of most dredging buckets used for navigation channel dredging. Even though many buckets were taken from the same location, as indicated by the dredger’s overlapping bucket print data (refer to Figure 6), a bathymetric survey revealed many high spots were left behind and the dredging contractor had to go back on another day to clean these spots. Because these spots were still within the footprint of the utility corridor, the same pipeline shut-down and re-open protocols had to be followed and the diving team had to be kept on standby during the operation as a contingency measure.

CONCLUSIONS

Dredging over the active utility lines was completed successfully. The last few areas with water depths shallower than the design water depth left in the New York Harbor navigation channel were dredged and the access channel to New York and New Jersey terminals is now officially a 15.2m (50ft) depth navigation channel.

In the dredging of utility corridors, advance planning, contingency preparation, and close coordination between the stakeholders proved to work effectively. However, the dredging operation took longer than initially expected due to unforeseen factors associated with depth control in a swift current and the ineffectiveness of a toothless environmental dredge bucket on a hard sea bottom.

Although many technological advances have been achieved in the past decades to precisely locate dredge plants in the horizontal plane, provide automatic tide-adjusting for vertical control etc., the basic system for the bucket dredging operation remain mostly the same: a crane-operated cable controls where the bucket is in the water, an another cable opens and closes the bucket. For ordinary projects where normal dredging tolerances are acceptable, the cable control system works fine. However, for projects requiring higher precision and better bucket depth and location control in water where swift currents are present, the example discussed in this paper shows that the dredging industry is in need of improvement.

REFERENCES

United States Army Corps of Engineers (USACE) (2016). FACT SHEET – New York and New Jersey Harbor Deepening. Retrieved from http://www.nan.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/487407/fact-sheet-new-york-new-jersey-harbor-50-ft-deepening/

National Oceanic and Atmospheric Administration (NOAA) (2017a). New York Harbor Upper Bay and Narrows-Anchorage Chart (Chart No.12334). Retrieved from http://www.charts.noaa.gov/PDFs/12334.pdf.

National Oceanic and Atmospheric Administration (NOAA) (2017b). The Narrows (n03020) Predicted Current. Retrieved from https://tidesandcurrents.noaa.gov/ports/ports.html?id=n03020&mode=allcurrents.