TECHNICAL MEMO:

FAR-FIELD SURVEYS OF SUSPENDED SEDIMENT PLUMES ASSOCIATED WITH HARBOR DEEPENING DREDGING IN NEWARK BAY

S-NB-2/S-AK-1 Contract Area
(South Elizabeth Channel)
Surveys #1 & #2

U.S. Army Corps of Engineers - New York District

January 2013

Table of Contents

1.0 Introduction 1
1.1 Study Area and Dredge Operational Setup 2
2.0 Methods 3
2.1 Hydrodynamic Survey 3
2.2 Survey Design of Mobile ADCP Transects 3
2.3 Design of Fixed Station Turbidity Surveys 5
2.4 Water Sample Collection 6
2.5 ADCP Calibration 6
2.6 Sediment Sample Collection 8
3.0 Results 8
3.1 S-NB-2/S-AK-1 Far Field Survey #1 (Week of 25 July 2011) 8
3.1.1 Hydrodynamic Surveys 8
3.1.1.1 26 July 2011 (Flood Tide Hydrodynamic Survey) 8
3.1.1.2 27 July 2011 (Ebb Tide Hydrodynamic Survey) 9
3.1.1.3 28 July 2011 (Ebb Tide Hydrodynamic Survey) 9
3.1.2 Ambient Conditions 10
3.1.3 Mobile ADCP Surveys 11
3.1.3.1 25 July 2011 (Flood Tide) 11
3.1.3.2 26 July 2011 (Flood Tide) 12
3.1.3.3 27 July 2011 (Ebb Tide) 13
3.1.3.4 29 July 2011 (Ebb Tide) 14
3.1.4 Fixed Station Turbidity Surveys 15
3.1.4.1 Flood Tide (26 July 2011) 15
3.1.4.2 Ebb Tide (29 July 2011) 16
3.1.5 Laboratory Analysis of Water Samples 17
3.1.6 Sediment Samples 18
3.1.7 Dredging Operations — Bucket Cycles 18

3.2 S-NB-2/S-AK-1 Far Field Survey #2 (Week of 03 October 2011) 19
3.2.1 Hydrodynamic Surveys 19
3.2.1.1 03 October 2011 (Ebb Tide Hydrodynamic Survey) 19
3.2.1.2 05 October 2011 (Flood Tide Hydrodynamic Survey) 20
3.2.2 Ambient Conditions 20
3.2.3 Mobile ADCP Surveys 20
3.2.3.1 04 October 2011 (Flood Tide) 20
3.2.3.2 06 October 2011 (Ebb Tide) 22
3.2.3.3 07 October 2011 (Ebb Tide) 23
3.2.4 Fixed Station Turbidity Surveys 24
3.2.4.1 Flood Tide (05 October 2011) 25
3.2.4.2 Ebb Tide (06 October 2011) 25
3.2.5 Laboratory Analysis of Water Samples 26
3.2.6 Sediment Samples 27
3.2.7 Dredging Operations — Bucket Cycles 27
4.0 Discussion 27
5.0 Literature Cited 30

List of Tables

Table 1: Laboratory Results of Water Samples, S-NB-2/S-AK-1 Far Field Survey #1 (25-29 July 2011)

Table 2: 25 July 2011 Far Field Flood Tide Survey Transect Summary Table

Table 3: 26 July 2011 Far Field Flood Tide Survey Transect Summary Table

Table 4: 27 July 2011 Far Field Ebb Tide Survey Transect Summary Table

Table 5: 29 July 2011 Far Field Ebb Tide Survey Transect Summary Table

Table 6: Sediment Collection and Analysis Summary Table, S-NB-2/S-AK-1 Far Field Survey #1 (25-29 July 2011)

Table 7: Laboratory Results of Water Samples, S-NB-2/S-AK-1 Far Field Survey #2 (03-07 October 2011)

Table 8: 04 October 2011 Far Field Flood Tide Survey Transect Summary Table

Table 9: 06 October 2011 Far Field Ebb Tide Survey Transect Summary Table

Table 10: 07 October 2011 Far Field Ebb Tide Survey Transect Summary Table

Table 11: Sediment Collection and Analysis Summary Table, S-NB-2/S-AK-1 Far Field Survey #2 (03-07 October 2011)

List of Figures

Figure 1: Newark Bay - South Elizabeth Channel S-NB-2/S-AK-1 Far Field Survey Area
Figure 2: Depth Averaged Velocities, 26 July 2011, Flood Tide Hydrodynamic Survey
Figure 3: Depth Averaged Velocities, 27 July 2011, Ebb Tide Hydrodynamic Survey
Figure 4: Depth Averaged Velocities, 28 July 2011, Ebb Tide Hydrodynamic Survey

Figure 5a-o: Vertical Profiles of ADCP Average TSS, 25 July 2011, Flood Tide
Figure 6a-h: ADCP Average TSS by Depth Interval, 25 July 2011, Flood Tide
Figure 7: ADCP Average TSS Values, 3D View of Selected Transects, 25 July 2011, Flood Tide
Figure 8: Depth Averaged Velocities, 25 July 2011, Flood Tide TSS Survey

Figure 9a-k: Vertical Profiles of ADCP Average TSS, 26 July 2011, Flood Tide
Figure 10a-h: ADCP Average TSS by Depth Interval, 26 July 2011, Flood Tide
Figure 11: ADCP Average Values, 3-D View of Selected Transects, 26 July 2011, Flood Tide
Figure 12: Depth Averaged Velocities, 26 July 2011, Flood Tide TSS Survey

Figure 13a-l: Vertical Profiles of ADCP Average TSS, 27 July 2011, Ebb Tide
Figure 14a-h: ADCP Average TSS by Depth Interval, 27 July 2011, Ebb Tide
Figure 15: ADCP Average TSS Values, 3-D View of Selected Transects, 27 July 2011, Ebb Tide
Figure 16: Depth Averaged Velocities, 27 July 2011, Ebb Tide TSS Survey

Figure 17a-p: Vertical Profiles of ADCP Average TSS, 29 July 2011, Ebb Tide
Figure 18a-h: ADCP Average TSS by Depth Interval, 29 July 2011, Ebb Tide
Figure 19: ADCP Average TSS Values, 3-D View of Selected Transects, 29 July 2011, Ebb Tide
Figure 20: Depth Averaged Velocities, 29 July 2011, Ebb Tide TSS Survey

Figure 21: Location of OBS Vertical Arrays and Dredge Position, 26 July 2011, Flood Tide
Figure 22: Surface and Bottom OBS Array Turbidities, 26 July 2011, Flood Tide
Figure 23: Location of OBS Vertical Arrays and Dredge Position, 29 July 2011, Ebb Tide
Figure 24: Surface and Bottom OBS Array Turbidities, 29 July 2011, Ebb Tide

Figure 25a-b: Comparison of Gravimetric and ADCP Estimates of TSS Concentration
a) Concentration vs. Time b) ADCP Concentration vs. Gravimetric Concentration
Figure 26: Elapsed Time of Six Separate Components of Dredge Cable Arm Bucket Cycles, 29 July 2011, Ebb Tide
Figure 27: Depth Averaged Velocities, 03 October 2011, Ebb Tide Hydrodynamic Survey
Figure 28: Depth Averaged Velocities, 05 October 2011, Flood Tide Hydrodynamic Survey

Figure 29a-n: Vertical Profiles of ADCP Average TSS, 04 October 2011, Flood Tide
Figure 30a-g: ADCP Average TSS by Depth Interval, 04 October 2011, Flood Tide
Figure 31: ADCP Average TSS Values, 3-D View of Selected Transects, 04 October 2011, Flood Tide
Figure 32: Depth Averaged Velocities, 4 October 2011, Flood Tide TSS Survey

Figure 33a-o: Vertical Profiles of ADCP Average TSS, 06 October 2011, Ebb Tide
Figure 34a-g: ADCP Average TSS by Depth Interval, 06 October 2011, Ebb Tide
Figure 35: ADCP Average TSS Values, 3-D View of Selected Transects, 06 October 2011, Ebb Tide
Figure 36: Depth Averaged Velocities, 06 October 2011 Ebb Tide TSS Survey

Figure 37a-i: Vertical Profiles of ADCP Average TSS, 07 October 2011, Ebb Tide
Figure 38a-g: ADCP Average TSS by Depth Interval, 07 October 2011, Ebb Tide
Figure 39: ADCP Average TSS Values, 3-D View of Selected Transects, 07 October 2011, Ebb Tide
Figure 40: Depth Averaged Velocities, 07 October 2011, Ebb Tide TSS Survey

Figure 41: Location of OBS Vertical Arrays and Dredge Position, 05 October 2011, Flood Tide
Figure 42: Surface and Bottom OBS Turbidities, 05 October 2011, Flood Tide
Figure 43: Location of OBS Vertical Arrays and Dredge Position, 06 October 2011, Ebb Tide
Figure 44: Surface and Bottom OBS Turbidities, 06 October 2011, Ebb Tide

Figure 45a-b: Comparison of Gravimetric and ADCP Estimates of TSS Concentration a) Concentration vs. Time b) ADCP Concentration vs. Gravimetric Concentration, 04 October 2011 TSS Survey, Flood Tide

Figure 46a-b: Comparison of Gravimetric and ADCP Estimates of TSS Concentration a) Concentration vs. Time b) ADCP Concentration vs. Gravimetric Concentration, 06 October 2011 TSS Survey, Ebb Tide

Figure 47a-b: Comparison of Gravimetric and ADCP Estimates of TSS Concentration a) Concentration vs. Time b) ADCP Concentration vs. Gravimetric Concentration, 07 October 2011 TSS Survey, Ebb Tide

Figure 48: Elapsed Time of Six Separate Components of Dredge Cable Arm Bucket Cycles, 06 October 2011, Flood Tide

1.0 INTRODUCTION

The resuspension of bottom sediments within aquatic habitats may be induced by a variety of events both natural and anthropogenic. Naturally occurring storms or tidal flows, for example, will influence suspended sediment concentrations within the water column although the timing, duration and intensity of the resuspension may differ from that caused by human activities (Wilber & Clarke 2001). Information on the extent and nature of suspended sediment plumes generated by dredge activities, therefore, is critical to enhance the understanding of sediment transport processes and associated environmental concerns (Puckette 1998).

As part of U.S. Army Corps of Engineers New York District's (USACE-NYD) Harbor-wide Water Quality/Total Suspended Solids (WQ/TSS) Monitoring Program, two far-field WQ/TSS surveys were conducted within the S-NB-2 portion of the S-NB-2/S-AK-1 contract area of the Harbor Deepening Project (HDP) in the South Elizabeth Channel of Newark Bay, New Jersey (Figure 1). The first of the studies (S-NB-2/S-AK-1 Survey #1) was conducted between 25 and 29 July, 2011, and the second study (S-NB-2/S-AK-1 Survey #2) was conducted between 03 and 07 October, 2011. The objective of these far-field surveys was to assess the spatial extent and temporal dynamics of suspended sediment plumes associated with mechanical dredging of fine-grained sediment. The methodologies employed for this survey were similar to those used previously to survey environmental or "closed" (i.e. with seals and flaps, as per contract specifications) clamshell bucket dredging of fine-grained sediment within the Arthur Kill (USACE 2007), Newark Bay (USACE 2008 and USACE 2009) and Port Elizabeth Channel (USACE 2010), and course-grained sand in Anchorage Channel (USACE 2011); as well as cutterhead dredging of sediments in the Kill Van Kull (USACE 2012a and USACE 2012b).

Mobile surveys were conducted using a vessel-mounted Acoustic Doppler Current Profiler (ADCP) and consisted of parallel transects running perpendicular to the longitudinal axis of the suspended sediment plume. Transects were conducted adjacent to and down-current of the active dredging operation and were run such that the entire spatial extent of the plume's acoustic signature (i.e. the detectable signature above ambient conditions) was recorded. To calibrate ADCP backscatter with suspended sediment concentrations, water samples were collected concurrently with ADCP data to directly measure TSS concentration (via gravimetric analysis) and turbidity across the broadest possible range of tidal and concentration gradients.

In addition to the mobile ADCP surveys, turbidity measurements were recorded during a variety of tidal conditions at fixed locations and at various water depths using OBS-3A optical turbidity sensors attached to an anchor and buoy array.

1.1 Study Area and Dredge Operational Setup

The dredge contractor for this study was Northeast Dredging Equipment Company, LLC (Northeast Dredging), a joint venture between Donjon Marine Company, Inc. (Donjon) and Cashman Dredging, operating Donjon's dredge the *Delaware Bay,* configured with an eight (8) cubic-yard capacity Cable Arm Environmental Bucket (S/N: 05406). This bucket features an over-square design with greater width than length to reduce sediment loss during bucket closing. In contrast to conventional "grab" buckets, the Cable Arm environmental bucket produces a relatively level cut when removing bottom sediment, thereby enhancing vertical as well as horizontal control. In addition, overlapping steel side plates with rubber seals reduce sediment squeezing out of the side (known as windrowing). Rubber flaps on the face of the bucket allow air to escape during descent while sealing the top during ascent, thereby slowing the inflow of water and reducing the loss of material due to washout. In addition to the use of an environmental bucket, best management practices (BMPs) were employed by the dredge contractor to reduce overall sediment resuspension. BMPs included restriction of bucket hoist speed to no more than two feet per second and the use of dredging instrumentation and software to ensure full bucket closure.

Far-field WQ/TSS surveys were conducted between 25 and 29 July, 2011 (S-NB-2/S-AK-1 Survey #1), and 03 and 07 October, 2011 (S-NB-2/S-AK-1 Survey #2) in the vicinity of this dredging operation in the S-NB-2/S-AK-1 Contract Area. Figure 1 shows the S-NB-2 Contract Area, the area of WQ/TSS surveys conducted within the Contract Area, and the approximate position of the dredge *Delaware Bay* during each survey. During Survey #1 (July 2011) the *Delaware Bay* was located within the South Elizabeth Channel, close to the midpoint of the channel between the shoreline to the west and the Green "#1" navigation buoy located at the mouth of the channel, and close to the bulkhead of Port Elizabeth Marine Terminal. Water depths at this location were approximately 15 meters. During Survey #2 (October 2011), the *Delaware Bay* was located further to the southwest, on the flats adjacent to the South Elizabeth Channel. In this position, water depths were as shallow as approximately three to five meters on the south side of the dredge but sloped from approximately 5 to 10 meters on the channel edge to the north of the dredge. Overall, the survey area has a relatively low amount of vessel traffic, with some large deep draft container ships berthing at the Port Elizabeth Marine Terminal, as well as attendant tug and barge traffic.

2.0 METHODS

2.1 Hydrodynamic Survey

Hydrodynamic conditions within the South Elizabeth Channel were assessed during both ebb and flood tides using a vessel-mounted Teledyne RD Instruments 1200-kHz Workhorse Monitor Series ADCP. The mobile transects were conducted perpendicular to the South Elizabeth Channel. ADCP data provided a characterization of prevailing hydrodynamic conditions within the Study Area. Raw data from the hydrodynamic surveys were processed and examined for evidence of stratified flows, tidal eddies, and other patterns that could influence plume dispersion.

The observed hydrodynamic conditions were then cross-referenced against predicted currents generated from NobleTec Tides & Currents™ software for the South Reach of Newark Bay, to place the survey within the context of the daily tidal cycle.

2.2 Survey Design of Mobile ADCP Transects

Suspended sediment plumes were also characterized using the ADCP. In the field, RD Instruments WinRiver software was used for the display of plume acoustic signatures and data recording. The ADCP operates by emitting acoustic pulses into the water column at set time intervals. Each group of pulses, referred to as an "ensemble," is vertically stratified into discrete, fixed-depth increments, or "bins." The number of bins and size of each bin is a configurable operation parameter of the instrument. In this study, 40 bins of 0.5-meter depth were used, for a maximum profile range of 20 meters. After the instrument emits a pulse, the ADCP then "listens" for the return of any sound (i.e. backscatter) that has been reflected from particles in the water column (in this case, a "particle" is any acoustic reflector, including sediment, plankton, fish, air bubbles etc.). Once the instrument receives the reflected signals, the WinRiver software calculates the three-dimensional movement of particles in the water column and thus determines water velocity in each bin. When water samples are collected concurrently, suspended sediment concentration can be determined using additional software and analyses (see *Section 2.5 - ADCP Calibration* below). Dredge positional data (i.e. GPS positions) were collected by the dredge contractor throughout the monitoring period and were integrated during post-processing of the ADCP data to determine the distance each transect was from the dredge. To cover a range of tidal conditions, ADCP backscatter data were collected during various stages of ebb and flood tides during the survey periods.

It is important to note that the ADCP cannot simultaneously receive and emit an acoustic pulse. Thus, when emitting a pulse, the ADCP cannot obtain data from immediately in front of its transducers (in addition to the water above the immersion depth of the instrument itself). This "blanking distance" is a user-defined parameter with limitations imposed by the operating frequency of the ADCP. For the 1200-kHz ADCP used in this survey, the blanking distance is approximately 0.5 meters (i.e. one bin depth).

In addition, acoustic "echoes" reflected from the seabed may interfere with the ADCP signal. The ADCP emits most of its acoustic energy in a very narrowly confined beam (main lobe); however, a small amount of energy is emitted at angles far greater than that of the main lobe. These "side lobes", despite their low power, can contaminate the echo from the main lobe, typically in the area directly above the seabed. The net effect of this side lobe interference is to show erroneously high backscatter from the near-seabed areas. This effect can be exacerbated in vessel-mounted surveys when the seabed elevation changes rapidly (e.g. during the transition from the shallows to the channel areas or vice-versa). In general, the side lobe distance above the seafloor is equal to approximately 6% of the water depth at that point.

Prior to initiating the mobile plume surveys, circular transects using the ADCP were conducted around the actively operating dredge to assess the location and acoustic strength of the plume. Subsequent ADCP transects were generally oriented in a direction perpendicular to the channel and extended down-current until the plume's acoustic signatures could no longer be detected against background conditions. Background conditions on the days of the surveys were determined by conducting ambient transects up-current of the plume and outside the active dredging area. Individual transect length was generally determined by bathymetry at the site, but always with the objective of extending beyond the detectable boundaries of the plume. The number, and consequently the spacing, of cross-plume transects were maximized within each designated tidal phase in order to provide complete spatial coverage of the detectable plumes and optimal resolution of internal plume structure.

Results for the mobile ADCP plume transects are presented graphically in three ways:

- **Vertical Profile Plots** – Vertical cross-section profiles representing individual transects are examined in detail for TSS concentration gradient structure of the plume at fixed distances from the source.

- **Plan-View Plots** – TSS concentrations are presented as composite horizontal "slices" through the plume signature at two meter depth increments.

- **Three-dimensional Plot Depiction** – Selected transects are plotted three dimensionally to show the spatial extent of the plume within the channel (note: the depth (Z) axis is exaggerated to show detail better since the X,Y spatial extents are much larger than the Z extents).

For all figures, unless otherwise noted, estimates of TSS concentrations above ambient concentration are assumed to be associated with dredging activities.

2.3 Design of Fixed Station Turbidity Surveys

In addition to the mobile ADCP surveys, turbidity measurements were recorded at fixed locations and at various water depths using Campbell Scientific, Inc.'s (formerly D&A Instrument Company) OBS-3A turbidity sensors tethered to a taut line and anchored at predetermined depths using a fixed anchor and buoy array. Optical backscatter sensors (OBS) project a beam of near-infrared light into the water, and measure the amount of light reflected back from suspended particles. The OBS units used in this survey were pre-calibrated by the manufacturer and programmed to measure turbidities in the 0-1,000 Nephelometric Turbidity Unit (NTU) range. The OBS units deployed during the fixed station survey were configured to output depth (meters), turbidity (NTU), temperature (°C), salinity (ppt), conductivity (mS/cm) and battery level (V). Readings were logged internally every 10 seconds at a rate of 25 samples per second for duration of 5 seconds. That is, every 10 seconds the OBS recorded 125 samples (25 samples/sec x 5 sec). All internally recorded data were retrieved from the units at the end of the survey.

2.4 Water Sample Collection

During the far-field surveys, water samples were collected to measure TSS concentrations (mg/L) and turbidity (NTU) throughout the water column, and to calibrate ADCP backscatter data to suspended sediment conditions. The water samples were collected from the survey vessel using a Sea-Bird Electronics SBE32C Compact Carousel Water Sampler equipped with six 1.7L Nisken sample bottles. A Campbell Scientific, Inc. OBS-3A optical backscatter sensor was also mounted to the Carousel Sampler and hardwired directly to an onboard computer. The OBS unit provided depth, temperature, salinity, and turbidity values of the entire water profile. The Carousel Sampler was also hardwired to an onboard computer and featured a magnetically-actuated lanyard release system used to remotely "fire" the sample bottles. A custom application recorded the exact time that each bottle fired to the nearest second.

All the water samples collected in the field were processed in the laboratory by Test America Laboratories, Inc. for optical turbidity (Method SM 2130-B) and for the gravimetric analysis of TSS concentration (Method SM 2540-D). The laboratory results were then used to provide a robust calibration data set to convert the raw ADCP backscatter measurements to estimates of TSS concentration using the Sediview methodology and software as described below.

2.5 ADCP Calibration

Following the field data collection effort, the raw acoustic backscatter measurements collected by the ADCP were converted to estimates of suspended sediment concentration using Sediview Software provided by Dredging Research, Ltd. The Sediview Method (Land and Bray 2000) derives estimates of suspended solids concentration in each ADCP data bin by converting relative backscatter intensity to TSS concentration. This process requires collecting a calibration data set consisting of discrete water samples and concurrently recorded ADCP acoustic backscatter data. The degree of confidence that can be placed in the estimates of TSS is directly proportional to the quality of the calibration data set. The quality of the calibration is in turn dependent on the collection of adequate water samples to represent sediments in suspension at all depths in the water column and across the entire gradient of concentrations occurring in ambient as well as plume conditions.

Samples were collected at known locations within the water column, so that individual gravimetric samples could be directly compared with acoustic estimates of TSS concentration for a "bin" of water as close to the water sample as possible. Following the Sediview calibration, the results were then applied to all of the ADCP files recorded during the far-field survey, resulting in an ADCP-derived estimate of TSS concentration for each recorded ADCP bin. Note, because of the continuously changing conditions present in estuaries, it is important to collect water samples frequently, and it may be necessary to perform multiple calibrations specific to the time period where the ADCP data were collected (DRL 2003). This was the case for S-NB-2/S-AK-1 Far Field Survey #2 (week of 03 October 2011). It is also important to collect enough samples to constitute a robust sample size which results in a statistically better calibration. The samples should be collected across the broadest possible range of depths and TSS concentrations as it is occasionally necessary for some outlier samples to be excluded. This is due to the dynamic nature of the sampling environment where it is often difficult to achieve perfect spatial and temporal synchronization of the water samples and ADCP data. For example, outlier samples may exhibit erroneously high TSS based on the disturbance of bottom sediments by the Carousel Sampler (i.e. the Carousel apparatus impacts on the sea floor resulting in localized elevated TSS concentrations), or if the ADCP backscatter exhibited signs of air bubble contamination (e.g. air bubbles will show as extremely high backscatter/TSS estimates but the corresponding water sample for that time/position has relatively low TSS concentration) or interference (e.g. the ADCP beam(s) reflect off the carousel sampler apparatus itself, causing an erroneously high reading) or if the water sample apparatus is out of the area being measured by the ADCP (e.g. spatial de-synchronization due to high current velocities).

Because air is injected into the water column as the dredge bucket breaks the air-water interface, and air bubbles are acoustic reflectors, care was exercised in converting acoustic data derived very close to the operating bucket. Air bubbles dissipate by rising to the surface with time. The distance down-current of bubble interference of the signal is therefore influenced by current velocities. Previous surveys were conducted during the monitoring of a closed bucket during maintenance dredging operations in the Providence River, in which the bucket was intentionally plunged through the air-water interface without removing sediment from the bottom (Reine *et al*. 2006). These surveys were conducted under slow to moderate current flow conditions, and determined that the "bubble signature" pattern dissipated within approximately 50 meters of the source. Therefore, estimates of TSS concentration collected more than 50 meters from the dredge using the calibrated ADCP for this survey were typically assumed to be free of air bubble interference from the bucket unless otherwise noted.

2.6 Sediment Sample Collection

Sediment samples were collected once per day from both the sediment bed in the vicinity of the dredge using a ponar grab, and from the dredge scow during down periods of active dredging operations. Additional ponar grab samples were collected from the sediment bed on 28 July and 03 October during the hydrodynamic surveys. All of the sediment samples were analyzed in the laboratory by Test America Laboratories, Inc. for sediment grain size distribution (ASTM D-422 Method), density (ASTM D-2937 Method) and Atterberg Limits (ASTM D-4318 Method).

3.0 RESULTS

3.1 S-NB-2/S-AK-1 Far Field Survey #1 (Week of 25 July 2011)

3.1.1 Hydrodynamic Surveys

General hydrodynamic conditions within South Elizabeth Channel and its immediate vicinity were assessed during both ebb (27 and 28 July), and flood tides (26 July). Transects were conducted approximately perpendicular to the South Elizabeth Channel. Additionally, the specific hydrodynamic conditions during each mobile ADCP TSS survey (see below) were also recorded to aid in the interpretation, and place the corresponding TSS data in a hydrodynamic context. These results are discussed along with each TSS survey in Section 3.1.3. The results of the hydrodynamic surveys are discussed below and presented in Figures 2, 3, and 4. For comparison purposes, the predicted currents in the South Reach of Newark Bay for the respective survey day are shown on Figures 2 through 4. Current predictions were generated using NobleTec Tides & Currents™ software. The predicted currents data show the water speed (in m/s; blue bars) and direction (negative values for ebb, positive for flood) and are useful to place a particular survey within the daily tide cycle.

3.1.1.1 26 July 2011 (Flood Tide Hydrodynamic Survey)

Figure 2 presents the results of the hydrodynamic survey conducted on 26 July 2011 during the beginning portion of a flood tide from approximately 12:18 to 13:12. During the survey depth-averaged current velocities within the area ranged between 0 m/s and approximately 0.25 m/s. Within the South Elizabeth Channel currents generally flowed in a south-easterly direction, however direction of flow throughout the channel was variable, flowing to the south or southwest in some locations. The hydrodynamic survey area extended out from South Elizabeth Channel to the Newark Bay Main Channel, and in this area, currents changed to flow in a northeasterly direction. The greatest current velocities (approximately 0.20 – 0.25 m/s) were also recorded in this area, with velocities observed within the South Elizabeth Channel remaining below approximately 0.15 m/s.

3.1.1.2 27 July 2011 (Ebb Tide Hydrodynamic Survey)

Figure 3 presents the results of the hydrodynamic survey conducted on 27 July 2011 during the first half of an ebb tide from approximately 08:06 to 09:38. During the survey, depth averaged current velocities within the area ranged between 0 and approximately 0.5 m/s. Current direction within the South Elizabeth Channel was highly variable. At the western end of the channel currents flowed mostly in a southwesterly direction, changing gradually towards the southeast in the eastern end of the channel and then swinging back around to a southerly or southwesterly direction near the mouth of the channel. Along the south edge of the channel near the flats, the current direction was more uniformly to the southeast. As was observed previously, the highest current velocities (above 0.25 m/s) were over the flats and in the southeast end of the channel, with current velocities within the majority of the channel less than approximately 0.25 m/s.

3.1.1.3 28 July 2011 (Ebb Tide Hydrodynamic Survey)

Figure 4 presents the results of the hydrodynamic survey conducted on 28 July 2011 during the first half of an ebb tide from approximately 09:16 to 10:37. During the survey, depth averaged current velocities within the area ranged between close to 0 and approximately 0.45 m/s. Similar to the previous two surveys, current direction within the South Elizabeth Channel was highly variable. At the western end of the channel currents flowed mostly in a south-southwesterly direction at low speed (generally less than 0.2 m/s). Moving east down the length of the channel towards the Main Channel of Newark Bay, the currents gradually changed to a more uniform southeasterly direction with increasing speeds. The current speeds in the Main Channel of Newark Bay ranged from approximately 0.25 to 0.30 m/s. The highest current velocities observed during this survey (approximately 0.35 to 0.45 m/s) were seen in an area over the corner of the flats to the southeast of South Elizabeth Channel.

Results of the hydrodynamic surveys show that the current directions in the South Elizabeth Channel during both flood and ebb tides were generally similar to each other. Moreover, there did not appear to be any distinct bi-directional flow pattern as seen in the Main Channel of Newark Bay. During both tides, current speed in South Elizabeth Channel proper was generally low (less than 0.2 m/s) compared to current speeds in the Main Channel of Newark Bay. These results are not surprising given the relatively sheltered "backwater" location of South Elizabeth Channel.

3.1.2 Ambient Conditions

It is important to consider that no single TSS measurement adequately represents ambient conditions; instead a range of samples, collected across multiple depth and tidal conditions, is a better representation of the dynamic nature of suspended sediment concentrations in a tidal estuary. Similarly, as noted above, if multiple calibrations are required due to changing conditions, it is important that corresponding ambient samples are collected that can be associated with each condition. During this survey, a total of 70 ambient water samples were collected at various depths and tidal conditions on 26 through 29 July 2011, and later analyzed in the laboratory for TSS and turbidity (Table 1). Ambient turbidity values ranged from 3.3 to 31.8 NTU, and the corresponding TSS values ranged between 21.2 to 80.8 mg/L.

For the purposes of delineating the margins of a sediment plume, it is necessary to determine a single critical TSS concentration, below which are ambient conditions and above which are plume conditions. Because of the naturally heterogeneous distribution of suspended sediment, ambient conditions are often associated with a large range of TSS concentrations and the distribution of these values is rarely symmetric. As a result, the average ambient TSS measured will often underestimate the ambient condition and thus using a percentile approach as a measure of central tendency is more applicable. Choice of which percentile to use is largely a matter of which one most clearly demarcates the plume from the background condition (i.e. removes the natural "noise" of the ambient condition), but typically it ranges from the 50th percentile (median) to 95th percentile. For this study, the 37th percentile of 40 mg/L was used as the TSS critical value which would best provide a clearly visible demarcation of the plume against background conditions. Hence, all acoustically estimated TSS concentrations greater than 40 mg/L are herein considered above background and attributable to the dredge-induced plume unless otherwise noted, e.g., clearly attributable to air entrainment, vessel prop wash, or from other sources of resuspension such as tug and ship plumes, or from side-lobe interference (see ADCP calibration methods, Section 2.5, for further information).

3.1.3 Mobile ADCP Surveys

3.1.3.1 25 July 2011 (Flood Tide)

The 25 July 2011 mobile ADCP plume characterization was completed during the beginning of a flood tide from approximately 11:42 to 13:27 (Figures 5a-o). The survey consisted of three ambient transects (Figures 5c through 5e), three circle transects (Figures 5a, 5b, and 5f), and nine down-current transects (Figures 5g through 5o). The dredge *Delaware Bay* changed location after the first two circle transects were completed. The third circle transect (C03) encompasses the location of the dredge when the up-current and down-current transects were recorded. A summary of each of the graphically represented transects is presented in Table 2.

To examine the spatial extent of the plume, a series of plan-view layouts are given in Figures 6a through 6h. During this survey, the dredge *Delaware Bay* was located approximately 330 meters northwest of the of the green “1” navigation buoy. Ambient transects were conducted northwest of the dredge while down-current transects were southeast of the dredge and oriented perpendicular to the channel. Figure 7 provides a three-dimensional depiction of average TSS values for selected representative transects.

Figures 5c through 5e show up-current TSS concentrations between 0 and 40 mg/L throughout most of the water column. Estimated TSS concentration signatures above ambient (40 mg/L) associated with the dredge operation were limited to within the first 344 meters down-current of the dredge (Transects T01 – T07). In these transects, a clearly defined plume was detectable within the lower half of the water column (depths >7 meters), with peak concentrations of 200-250 mg/L at a depth of around 12-14 meters within 90 meters of the source (Transect T01). Plume width varied from approximately 50-120 meters at various locations, expanding laterally to a maximum width at 126 meters down-current and then narrowing as the plume began to dissipate as the distance from the dredge increased. Because many of the transects extended into shallower water, some side-lobe reflectivity was observed on the slopes.

Figure 8 presents the hydrodynamic conditions recorded during the 25 July 2011 mobile ADCP survey discussed above. During the survey, depth-averaged current velocities within the area ranged between 0 m/s and approximately 0.25 m/s. Within the South

Elizabeth Channel currents generally flowed in a south-easterly direction, but towards the southeast edge of the channel and onto the adjacent flats, currents flowed more to the south to southwest. These observations are consistent with observations of the sediment plume gathered in this survey, where the plume was seen directly to the southeast (down-current) of the dredge locations. The highest current velocities (>0.10 m/s) were observed in a very small area along the south edge of the channel, current velocities in the vast majority of the survey area were under 0.10 m/s. These velocities were relatively low, and are consistent with the relatively short distance (197 m from the dredge) within which the plume was observed during this survey.

3.1.3.2 26 July 2011 (Flood Tide)

The 26 July 2011 mobile ADCP plume characterization was completed during the peak of a flood tide from approximately 14:16 to 14:45 (Figures 9a-k). The survey consisted of one circle transect (Figure 9a), three ambient transects (Figures 9b through 9d), and seven down-current transects (Figures 9e through 9k). A summary of each of the graphically represented transects is presented in Table 3.

To examine the spatial extent of the plume, a series of plan-view layouts are given in Figures 10a through 10h. For this survey, the dredge *Delaware Bay* was located approximately 400 meters northwest of the green “1” navigation buoy. Ambient transects were conducted northwest of the dredge while down-current transects were southeast of the dredge and oriented perpendicular to the channel. Figure 11 provides a three-dimensional depiction of average TSS values for selected representative transects.

Figures 9b through 9d show up-current TSS concentrations below 70 mg/L throughout most of the water column, with slightly higher concentrations (70-120 mg/L) observed along the bottom (approximately 12 m depth and below). Estimated TSS concentration signatures above ambient (40 mg/L) associated with the dredge operation were limited to within the first 476 meters down-current of the dredge (Transects T01 – T07). In these transects, a clearly defined plume was detectable in the bottom quarter of the water column (depth greater than approximately 12 meters), with peak concentrations of approximately 250 mg/L at a depth of around 14 meters within 102 meters of the source (Transect T01). Plume width remained approximately 100 meters for the extent of the plume, spreading out to cover the entire width of the channel, but not extending beyond the sides of the channel. At Transect T07, 476 meters down-current, the TSS concentrations and distribution pattern were similar to the ambient transects. Since many of the transects extended into shallower water, some side-lobe reflectivity was observed on the slopes. An anomalous region of high backscatter was detected in Transect T07, however this was likely due to some interference (e.g. physical object) in the ADCP data as evidenced by the loss of bottom tracking (which accounts for the large spike in the seabed elevation).

Figure 12 presents the hydrodynamic conditions recorded during the above 26 July, 2011 mobile ADCP survey. During the survey, depth-averaged current velocities within the area ranged between 0 m/s and approximately 0.35 m/s. Within the South Elizabeth Channel currents generally flowed in a south-easterly direction, but in the western portion of the survey area, currents swept around from a southerly to a southeasterly direction, moving from the west to east. In the eastern half of the channel area, the currents flowed more uniformly to the southeast, this was also where the highest current velocities, from approximately 0.20 up to 0.35 m/s, were observed. In the western portion of the channel, current velocities were below approximately 0.25 m/s.

3.1.3.3 27 July 2011 (Ebb Tide)

The 27 July 2011 mobile ADCP plume characterization was completed during the peak of an ebb tide from approximately 09:44 to 10:42 (Figures 13a to 13l). The survey consisted of two circle transects (Figures 13a and 13b), four ambient transects (Figures 13c through 13f), and six down-current transects (Figures 13g through 13l). A summary of each of the graphically represented transects is presented in Table 4.

To examine the spatial extent of the plume, a series of plan-view layouts are given in Figures 14a through 14h. For this survey, the dredge *Delaware Bay* was located approximately 450 meters northwest of the green “1” navigation buoy. Ambient transects were conducted northwest of the dredge while down-current transects were southeast of the dredge and oriented perpendicular to the channel. Figure 15 provides a three-dimensional depiction of average TSS values for selected representative transects.

Figures 13c through 13f show up-current TSS concentrations between 0 and 40 mg/L throughout most of the water column, with some smaller areas of slightly higher concentrations (40-70 mg/L) close to the bottom (approximately 12 m depth and below). Estimated TSS concentration signatures above ambient (40 mg/L) associated with the dredge operation were limited to within the first 247 meters down-current of the dredge (Transects T01 – T04). In these transects, a clearly defined plume was detected in the bottom third of the water column (depth >10 meters), with peak concentrations of 300 mg/L at a depth of around 14 meters within 113 meters of the source (Transect T01). The plume varied from approximately 70-90 meters in width, decreasing in both width and height as the distance from the dredge increased. Since many of the transects extended into shallower water, some side-lobe reflectivity was observed on the channel side slopes.

Figure 16 presents the hydrodynamic conditions recorded during the above 27 July 2011 mobile ADCP survey. During the survey, depth-averaged current velocities within the South Elizabeth Channel were approximately 0.10 m/s or less. Current direction was generally southeast throughout the length of the survey area, but was closer to south-southeast or south towards the western part of the survey area.

3.1.3.4 29 July 2011 (Ebb Tide)

The 29 July 2011 mobile ADCP plume characterization was completed during the beginning of an ebb tide from approximately 11:22 to 13:22 (Figures 17a to 17p). The survey consisted of four circle transects (Figures 17a-d), four ambient transects (Figures 17e-h), and six plume transects (Figures 17i-p). A summary of each of the graphically represented transects is presented in Table 5.

To examine the spatial extent of the plume, a series of plan-view layouts are given in Figures 18a through 18h. For this survey, the dredge *Delaware Bay* was located approximately 170 meters northwest of the green "1" navigation buoy. Ambient transects were conducted up-current (northwest) of the dredge while down-current transects were southeast of the dredge and oriented perpendicular to the channel. Figure 19 provides a three-dimensional depiction of average TSS values for selected representative transects.

Figures 17e-17h show up-current TSS concentrations between 0 and 40 mg/L throughout most of the water column. Estimated TSS concentration signatures above ambient (40 mg/L) associated with the dredge operation were limited to within the first 196 meters down-current (east) of the dredge (Transects T01 – T08). In these transects, a small well-defined plume was detected in the bottom quarter of the water column (depths greater than approximately 11 meters), with peak concentrations of up to approximately 160 mg/L from 81-93 meters from the source (Transects T01 and T02). Plume width varied from approximately 15-35 meters but was largely concentrated to the channel side slopes and did not extend onto the adjacent flats. Because the plume was concentrated at the toe of the side slope, some of the plume signature was masked by side lobe interference and the two distinct signatures can be seen superimposed on each other (e.g Transect T02). Furthermore, these same side lobe patterns also were recorded on transects without plume (e.g. Transect T06), as well as on up-current transects (e.g. Transects A01-A04), and thus were not part of the dredge-induced plume.

Figure 20 presents the hydrodynamic conditions recorded during the above 29 July 2011 mobile ADCP survey. During the survey, depth-averaged current velocities within the area ranged between close to 0 m/s to approximately 0.30 m/s. The greatest current velocities (approximately 0.15 to 0.30 m/s) were observed in an area along the southeastern edge of the survey area adjacent to and over the flats. Current velocities in the majority of the rest of South Elizabeth Channel were approximately 0.15 m/s or less. Current direction in the western half of the survey area was generally to the southeast, but towards the mouth of the South Elizabeth Channel the currents were more south-southwest. This variation from the prevailing current direction of the area may account for the small amount of plume observed on the ambient transects conducted within 73 meters of the dredge (Figures 17e and 17f).

3.1.4 Fixed Station Turbidity Surveys

Two fixed station turbidity surveys were conducted, one on 26 July during a flood tide, and one on 29 July during an ebb tide. A total of three fixed arrays were deployed during each survey (one ambient up-current of the dredge, and two down-current of the dredge with the objective to examine turbidity structure within the plume at varying distances from the dredge). The ambient array consisted of one OBS unit tethered at mid-depth while each of the down-current arrays consisted of two OBS units, one tethered at mid-depth and the other at near bottom based on water depth.

3.1.4.1 Flood Tide (26 July 2011)

A fixed station turbidity survey was conducted on 26 July during a flood tide. Figure 21 shows the location of the two down-current arrays and the one up-current array with respect to the dredge position. The down-current arrays were located 150 and 255 meters southeast of the dredge, respectively. The up-current array was located 300 meters to the northwest of the dredge near the end of the channel. The fixed OBS arrays were placed closer to the shoal on the south side of the channel so as to avoid any potential hazards to navigation and to better define any potential plume moving towards the shallow water flats. Figure 22 plots the recorded turbidity values (NTU) from the mid-depth (red line), and bottom (black line) OBS units. Ambient turbidity is plotted as a blue line and superimposed on both of the down-current plots for comparison.

Overall, mid-water and bottom turbidity readings from both down-current OBS arrays were similar, both between depths and between the near and far arrays. These readings were also similar overall to ambient conditions recorded by the up-current array. Turbidity averaged 8.0 NTU for all down-current arrays, across all depths and the entire length of the survey, compared to an average of 8.5 NTU at the up-current array across the survey.

At one point, the turbidity values for the ambient array rose above those recorded at any depth by both of the down-current arrays. This occurred during a period beginning around 13:33 when turbidities rose rapidly from approximately 10 NTU to around 40 NTU. Up-current turbidity values reached a peak of 41.6 NTU at 13:39 before gradually returning to around 10 NTU by 14:07. A corresponding rise in turbidities was not seen at any of the down-current arrays during this time period. The mobile ADCP survey conducted during the same tide cycle detected the plume down-current (southeast) from the dredge and confined to the bottom half of the water column, at its greatest extent only present at a depth of 8 meters or below. The average depth of the OBS unit on the up-current array was 5.2 meters, so while the exact source of the rise in turbidity recorded by this array is unknown, it is unlikely that it was associated with dredging operations.

Turbidity values recorded by the down-current arrays showed only a few small deviations from ambient levels during this survey. In the largest of these, the bottom turbidity at the closer down-current array, and both bottom and mid-depth turbidity at the far down-current array all showed a brief increase at around 13:21 to 13:24, this was most pronounced at the close array, where turbidity values reached a maximum of 44.1 NTU.

3.1.4.2 Ebb Tide (29 July 2011)

A fixed station turbidity survey was conducted on 29 July during an ebb tide. Figure 23 shows the location of the two down-current arrays and the one up-current array with respect to the dredge position. The down-current arrays were located 200 and 270 meters northwest of the dredge, respectively. The up-current array was first located 100 meters to the southeast of the dredge, but then drifted too close to the dredge *Delaware Bay*, and was redeployed at 152 meters southeast of the dredge approximately two hours into the survey. Both positions are shown on Figure 23. The fixed OBS arrays were placed closer to the shoal on the south side of the channel so as to avoid any potential hazards to navigation and to better define any potential plume moving towards the shallow water flats. Figure 24 plots the recorded turbidity values (NTU) from the mid-depth (red line), and bottom (black line) OBS units. Ambient turbidity values from the first deployment (blue line), and second deployment (purple line) of the up-current array are superimposed on both of the down-current plots for comparison.

Bottom turbidity values recorded at both of the down-current arrays were very similar to each other, with average values of 7.7 and 9.1 NTU for the duration of the deployment for the near and far array, respectively. Both of these arrays also showed no large changes in bottom turbidity at any time during the deployment. At the array farther down-current (270 meters) from the dredge, mid-depth turbidities were slightly lower than those at the bottom, with an average value of 4.8 NTU. All of these readings were consistent with turbidity levels that would fall within the ambient range for this survey, and were similar to the turbidity values recorded during both deployments of the ambient, up-current array, which averaged 4.5 NTU. The mobile ADCP survey conducted during this survey shows a plume with a very limited spatial extent and largely confined to the toe of the channel side slope. Therefore, the OBS array data are consistent with the ADCP data with no evidence of the suspended sediment plume extending beyond 150 meters from the dredge.

The OBS unit set at mid-depth in the down-current array located 200 meters from the dredge malfunctioned during deployment and recorded erroneous values when the sensor shifted and was obscured by a solid object, likely either the tether line or the shackles used to attach the instrument. The data collected by this particular OBS unit during this survey is therefore considered invalid.

3.1.5 Laboratory Analysis of Water Samples

A total of 120 water samples were collected in the project area during the week of 25 July 2011. The laboratory results of the optical turbidity and the gravimetric analysis of TSS concentration of those 120 samples are presented in Table 1. To provide a robust data set for calibration of the ADCP backscatter, samples were taken from locations to represent the broadest possible concentration gradient, from ambient to the highest TSS concentrations that could be safely collected in the area of the active dredging operation.

In this study, the TSS concentrations of the 120 water samples ranged from 21.2 to 139 mg/L and turbidity concentrations ranged from 3.3 to 67.6 NTU. Figure 25a plots the paired gravimetric measurements and ADCP acoustic estimates of TSS arranged in concentration versus time order for the 81 water samples used in the Sediview calibration. Note that some of the 120 water samples collected were excluded if they exhibited clear signs of air bubble contamination, interference with the water sampler apparatus, or contact with the sea bottom (see ADCP calibration methods described in section 2.5). Overall, there was a strong agreement (R^2 = 0.84) between the acoustic estimates of TSS concentration and the gravimetric measurements (Figure 25b).

3.1.6 Sediment Samples

A total of nine sediment samples were collected (four from the dredge scow and five from the dredge area) during the week of 25 July 2011. The laboratory results of these sediment collections for grain size distribution, density and Atterberg Limits are presented in Table 6. Sediment samples collected during the S-NB-2/S-AK-1 Far-field Survey #1 were comprised mostly fine sand, silt, and clay, with silt comprising between 23% and 78% of each sample collected. Each of the samples collected also consisted of 14% to 35% clay and 3% to 46% fine sand. Across all nine samples, the average grain size distribution was: Gravel (6%), Coarse Sand (1%), Medium Sand (4%), Fine Sand (20%), Silt (48%), and Clay (21%). None of the samples collected contained more than 20% of medium sand or coarser material, with the exception of the dredge area samples taken on 26 and 27 July, which each contained 21% gravel. The in-place density of the sediment samples ranged between 0.459 and 1.120 g/cc (Table 6).

3.1.7 Dredging Operations — Bucket Cycles

To examine the bucket cycle sequence, a video record was obtained of 10 complete cycles during an ebb tide on 29 July, 2011. The video was then analyzed for time increments for each component of the cycle (Figure 26). The average total elapsed time per cycle was 102 seconds. A certain degree of variability in cycle component elapsed times can be seen across the 10 cycles in Figure 26. The shortest cycle was 72 seconds, whereas the longest cycle was 165 seconds. These results were consistent with the variability seen in mechanical bucket dredging operations observed during previous harbor deepening monitoring surveys (USACE 2007 and USACE 2011).

Average time for each component of the dredge cycle was: Descent (22 seconds), Grab (7 seconds), Raise (21 seconds), Slew Over (29 seconds), Dump (10 seconds), and Slew Back (12 seconds).

3.2 S-NB-2/S-AK-1 Far Field Survey #2 (Week of 03 October 2011)

3.2.1 Hydrodynamic Surveys

General hydrodynamic conditions within South Elizabeth Channel and its immediate vicinity were assessed during both ebb (03 October) and flood tides (05 October). Transects were conducted approximately perpendicular to the South Elizabeth Channel. Additionally, the specific hydrodynamic conditions during each mobile ADCP TSS survey (see below) were also recorded to aid in the interpretation, and place the corresponding TSS data in a hydrodynamic context. These results are discussed along with each TSS survey in Section 3.2.3. The results of the hydrodynamic surveys are discussed below and presented in Figures 27 and 28.

For comparison purposes, the predicted currents in the South Reach of Newark Bay for the respective survey day are shown on Figures 27 and 28. Current predictions were generated using NobleTec Tides & Currents™ software. The predicted currents data show the water speed (in m/s; blue bars) and direction (negative values for ebb, positive for flood) and is useful to place a particular survey within the daily tide cycle.

3.2.1.1 03 October 2011 (Ebb Tide Hydrodynamic Survey)

Figure 27 presents the results of the hydrodynamic survey conducted on 03 October 2011 during the first half of an ebb tide from approximately 14:58 to 15:54. During the survey, depth averaged current velocities within the area ranged from 0 to approximately 0.50 m/s. The highest current velocities (approximately 0.35 to 0.50 m/s) were observed in a narrow area along the corner of the flats to the south of South Elizabeth Channel. Current velocities within the South Elizabeth Channel were observed to be less than 0.20 m/s, and velocities in the area of the Main Channel of Newark Bay which was covered by this survey were generally observed to be between approximately 0.20 and 0.30 m/s. Current direction observed during this survey varied with location. In the Main Channel of Newark Bay and along the corner of the flats to the south of the South Elizabeth Channel the direction was generally to the south and west. Within the South Elizabeth Channel the current direction varied from west-southwest closer to the bulkhead at the north side of the channel to south-southeast closer to the flats at the south side of the channel.

3.2.1.2 05 October 2011 (Flood Tide Hydrodynamic Survey)

Figure 28 presents the results of the hydrodynamic survey conducted on 05 October 2011 during the first half of a flood tide from approximately 12:16 to 14:43. During the survey, depth-averaged current velocities within the area ranged from near 0 m/s up to approximately 0.50 m/s. The greatest current velocities (above 0.20 m/s) were observed along the flats to the south of the South Elizabeth Channel. The very highest velocities (approximately 0.35 to 0.50 m/s) were observed in a small area at the corner of these flats to the southeast of the channel. Current directions observed in the South Elizabeth Channel and over nearby flats during this survey were generally eastward. At the eastern end of the survey area, towards the Newark Bay Main Channel, current direction turned more towards the northeast.

3.2.2 Ambient Conditions

A total of 41 ambient water samples were collected at various depths on 03-07 October 2011, and later analyzed in the laboratory for TSS and turbidity (Table 7). Ambient turbidity values ranged from 5.2 to 18.4 NTU, and the corresponding TSS values ranged between 8.0 to 49.2 mg/L. However, for the purposes of delineating the margins of a sediment plume, it is necessary to determine a single critical TSS concentration, below which are ambient conditions and above which are plume conditions. For this study, the 58th percentile of 40 mg/L was used as the TSS critical value which would best provide a clearly visible demarcation of the plume against background conditions. Hence, all acoustically estimated TSS concentrations greater than 40 mg/L are herein considered above background and attributable to the dredge-induced plume unless otherwise noted, e.g., clearly attributable to air entrainment, vessel prop wash, or from other sources of resuspension such as tug and ship plumes, or from side-lobe interference (see ADCP calibration methods, Section 2.5, for further information).

3.2.3 Mobile ADCP Surveys

3.2.3.1 04 October 2011 (Flood Tide)

The 04 October 2011 mobile ADCP plume characterization was completed during the beginning portion of a flood tide from approximately 13:12 to 15:21 (Figures 29a-n). The survey consisted of one circle transect (Figure 29a), three ambient transects (Figures 29l through 29n), and ten down-current transects (Figures 29b through 29k). A summary of each of the graphically represented transects is presented in Table 8.

To examine the spatial extent of the plume, a series of plan-view layouts are given in Figures 30a through 30g. During this survey, the dredge *Delaware Bay* was located approximately 325 meters west-northwest of the green “1” navigation buoy. Ambient transects were conducted northwest of the dredge and oriented perpendicular to the channel, while down-current transects were southeast of the dredge and oblique to the channel. Figure 31 provides a three-dimensional depiction of average TSS values for selected representative.

Figures 29l through 29n show up-current TSS concentrations between 0 and 40 mg/L throughout most of the water column. In this survey, the dredge was situated outside of the channel in the shallow water flats to the south. Circle transect C01 recorded some backscatter activity at the 8-10 meter depth interval along the channel side slopes just to the north and east of the dredge (Figure 30d), although some of this backscatter could be attributed to side-lobe reflectivity. Estimated TSS concentration signatures above ambient (40 mg/L) associated with the dredge operation within the South Elizabeth Channel were primarily limited to within the first 434 meters down-current of the dredge (Transects T01 – T09). In these transects, a light plume was detected within the bottom quarter (depths greater than approximately 11 meters) of the water column, with peak concentrations of approximately 90 mg/L close to the bottom and within 174 meters of the source (Transect T01). Plume width varied from approximately 50-150 meters at various locations. Because many of the transects extended into shallower water, some side-lobe reflectivity was observed on the slopes.

Figure 32 presents the hydrodynamic conditions recorded during the above 4 October 2011 mobile ADCP survey. During the survey, depth-averaged current velocities within the area ranged between close to 0 to approximately 1.30 m/s. However, the very high current velocities (approximately 0.50-1.30 m/s) observed in a small area over the flats to the south of South Elizabeth Channel were likely artifacts of the ADCP surveying in very shallow water (~1.5 m deep at the time of the survey). Current velocities in the surrounding area were between approximately 0.20 and 0.30 m/s, which were more typical of the hydrodynamic conditions. In the remaining areas of South Elizabeth Channel, current velocities were approximately 0.20 m/s or less. At both the western and eastern ends of the channel, current directions were observed to range from southeast to southwest, and in an area between this and along the Port Elizabeth bulkhead, current direction was variable and current velocity very low.

3.2.3.2 06 October 2011 (Ebb Tide)

The 06 October 2011 mobile ADCP plume characterization was completed during the beginning portion of an ebb tide from approximately 08:42 to 09:43 (Figures 33a-o). The survey consisted of one circle transect (Figure 34a), three ambient transects (Figures 33m through 33o), and eleven down-current transects (Figures 33b through 33l). A summary of each of the graphically represented transects is presented in Table 9.

To examine the spatial extent of the plume, a series of plan-view layouts are given in Figures 34a through 34g. For this survey, the dredge *Delaware Bay* was located approximately 400 meters west-northwest of the green “1” navigation buoy. Ambient transects were conducted northwest of the dredge and oriented perpendicular to the channel, while down-current transects were conducted both north of the dredge (parallel to the channel), and southeast of the dredge (perpendicular to the channel). This was due to the position of the dredge in very shallow water and the extent and direction of the plume (Figures 34a-g, Table 9). Figure 35 provides a three-dimensional depiction of average TSS values for selected representative transects.

Figures 33m through 33o show up-current TSS concentrations between 0 and 40 mg/L throughout most of the water column. Estimated TSS concentration signatures above ambient (40 mg/L) associated with the dredge operation were limited to within the first approximately 164 meters down-current of the dredge (Transects T02 – T05, T07 - T08). In these transects, a clearly defined plume was detected extending from the top to the bottom of the water column (Transects T02, T03). As the plume began to dissipate, it remained only in the top third (approximately 5 meters depth and above) of the water column (Transect T04, T07-T08) as a result of the prevailing current pattern and physical components of the water column (i.e., temperature, salinity and water density). Peak TSS concentrations within the plume reached approximately 200 mg/L close to the bottom and within 46 meters of the source (Transect T02). Plume width varied from approximately 50-185 meters at various locations, in general being more spread out closer to the source and becoming narrower as the distance from the dredge increased. Since many of the transects extended into shallower water, side-lobe reflectivity was observed on the slopes. Heavy side-lobe reflectivity was recorded along the bottom of Transect T08. This transect was recorded along the bank (i.e. parallel to the channel slope), causing side-lobe reflectivity with no apparent depth change.

Figure 36 presents the hydrodynamic conditions recorded during the above 06 October 2011 mobile ADCP survey. During the survey, depth-averaged current velocities within the area ranged from close to 0 m/s to approximately 0.25 m/s. The highest current velocities (approximately 0.15-0.25 m/s) were observed in areas over the flats to the south of South Elizabeth Channel. In the remaining areas of South Elizabeth Channel, current velocities were approximately 0.10 m/s or less. Current directions observed during this survey were overall oriented towards the east-southeast and out of the channel. The plume observed during this survey was generally to the northeast of the dredge and remained relatively close to the dredge, which was consistent with the relatively slow current velocities observed, and the northeasterly to southeasterly current direction.

3.2.3.3 07 October 2011 (Ebb Tide)

The 07 October 2011 mobile ADCP plume characterization was completed during an ebb tide from approximately 09:09 to 10:54 (Figures 37a through 37i). The survey consisted of three ambient transects (Figures 37g through 37i), and six down-current transects (Figures 37a through 37f). A summary of each of the graphically represented transects is presented in Table 10.

To examine the spatial extent of the plume, a series of plan-view layouts are given in Figures 38a through 38g. For this survey, the dredge *Delaware Bay* was located approximately 550 meters west-northwest of the green "1" buoy. Ambient transects were conducted northwest of the dredge and oriented perpendicular to the channel, while down-current transects were conducted north of the dredge and parallel to the channel. This was due to the position of the dredge in very shallow water and the extent and direction of the plume (Figures 38a-g, Table 10). Figure 39 provides a three-dimensional depiction of average TSS values for selected representative transects.

Figures 37g through 37i show up-current TSS concentrations between 0 and 40 mg/L through the top half to two-thirds (top 7-10 meters) of the water column. The up-current transects (transects A01-A03) showed a layer of ambient resuspension between approximately 50-80 mg/L in the lower half (below approximately 7 meters) of the water column. The highest up-current concentrations were seen at 109 meters from the dredge, in the transect farthest up-current (transect A03, Figure 37i), and were potentially due to a naturally occurring resuspension of sediments (caused by tidal flows and shallow water depths) or a residual plume from the preceding tidal phase. The latter could be due to the lack of current flow to diffuse the plume and the shallow water depths. Estimated TSS concentration signatures above ambient (40 mg/L) associated with the dredge operation were limited to within the first approximately 151 meters down-current of the dredge (Transects T01 – T05). In these transects, a clearly defined plume was detected extending from the top to the bottom of the water column, with peak concentrations of approximately 200 mg/L within the bottom 1-2 meters of the water column and within 48 meters of the source (Transect T01). Plume width varied from approximately 100-200 meters at various locations, spreading out further closer to the source and becoming less extensive as the distance from the dredge increases. Since many of the transects extend into shallower water, some side-lobe reflectivity was observed on the slopes and bottom.

Figure 40 presents the hydrodynamic conditions recorded during the above 07 October 2011 mobile ADCP survey. During the survey, depth-averaged current velocities within the area ranged from close to 0 m/s to approximately 0.20 m/s. The highest current velocities (approximately 0.15-0.20 m/s) were confined to a small area at the edge the flats to the south of South Elizabeth Channel. In the remaining areas of South Elizabeth Channel, current velocities were approximately 0.10 m/s or less. Current directions observed during this survey were generally towards the east and south.

3.2.4 Fixed Station Turbidity Surveys

Two fixed station turbidity surveys were conducted, one on 05 October during a flood tide, and one on 06 October during an ebb tide. A total of three fixed arrays were deployed during each survey (one ambient up-current of the dredge, and two down-current of the dredge with the objective to examine turbidity structure within the plume at varying distances from the dredge). The ambient array consisted of two OBS units, one tethered at one-quarter of the total water column depth (near surface) and one at mid-depth. Each of the down-current arrays consisted of two OBS units, one tethered at one-quarter of the total water column depth (near surface), and one at three-quarters of total water depth (near bottom). Each of the fixed arrays (both ambient and down-current) was located within the vicinity of the active dredging operation.

3.2.4.1 Flood Tide (05 October 2011)

A fixed station turbidity survey was conducted on 05 October during a flood tide. Figure 41 shows the location of the two down-current arrays and the one up-current array with respect to the dredge position. The down-current arrays were located 85 and 300 meters southeast of the dredge, respectively. The up-current array was located 370 meters northwest of the dredge. The fixed OBS arrays were placed close to or on top of the shoal on the south side of the channel so as to avoid any potential hazards to navigation and to better define any potential plume moving onto the shallow water flats. Figure 42 plots the recorded down-current turbidity values (NTU) from the mid-depth (red line), and bottom (black line) OBS units. Ambient turbidity is plotted from the near-surface (blue line) and near-bottom (purple line) up-current OBS units and superimposed on both of the down-current plots for comparison.

Throughout the duration of the survey, down-current arrays recorded very similar surface and bottom turbidity values to the surface and mid-depth turbidity values recorded by the up-current ambient array. Average surface and bottom turbidities from the near down-current array were 3.6 and 3.4 NTU respectively, from the far down-current array 6.2 and 5.8 NTU respectively, while average ambient surface and bottom turbidities from the up-current array were 4.0 and 5.4, respectively. None of the turbidity readings from any of the OBS units in this survey showed any large variations above ambient levels, and no readings above 9.1 NTU were recorded at any array. According to the daily field report for this date, active dredging was occurring throughout the deployment period of the arrays.

3.2.4.2 Ebb Tide (06 October 2011)

A fixed station turbidity survey was conducted on 06 October during an ebb tide. Figure 43 shows the location of the two down-current arrays and the one up-current array with respect to the dredge position. The down-current arrays were located 120 and 405 meters southeast of the dredge, respectively. The up-current array was located 320 meters northwest of the dredge. The fixed OBS arrays were placed close to or on top of the shoal on the south side of the channel so as to avoid any potential hazards to navigation and to better define any potential plume moving onto the shallow water flats. Figure 44 plots the recorded turbidity values (NTU) from the mid-depth (red line), and bottom (black line) OBS units. Ambient turbidity is plotted from the near-surface (blue line) and near-bottom (purple line) up-current OBS units and superimposed on both of the down-current plots for comparison.

Overall, turbidity values recorded at the down-current arrays during this survey did not differ greatly from those recorded at the up-current ambient array (Figure 44). Average surface and bottom turbidities from the near down-current array were 7.4 and 6.0 NTU respectively, from the far down-current array 5.8 and 3.6 NTU respectively, while average ambient surface and bottom turbidities from the up-current array were 4.2 and 5.0, respectively. At the closer (120 meters from the dredge) down-current array, near-surface, and to a lesser extent near-bottom turbidities did climb somewhat above ambient values for a period of time. This occurred between approximately 09:53 and 10:25, when near-surface turbidities rose from around 6 NTU to a peak of 20.9 NTU. Near-bottom turbidities during the same span of time peaked at 13.7 NTU.

3.2.5 Laboratory Analysis of Water Samples

A total of 94 water samples were collected in the project area during the week of 03 October, 2011. The laboratory results of the optical turbidity and the gravimetric analysis of TSS concentration of those 94 samples are presented in Table 7. To provide a robust data set for calibration of the ADCP backscatter, samples were taken from locations to represent the broadest possible concentration gradient from ambient to the highest TSS concentrations that could be safely collected in the area of the active dredging operation.

In this study, the TSS concentrations of the 94 water samples ranged from 8 to 103 mg/L and turbidity concentrations ranged from 3.9 to 53.2 NTU. Figures 45a, 46a, and 47a plot the paired gravimetric measurements and ADCP acoustic estimates of TSS arranged in concentration versus time order for the 64 water samples used in the Sediview calibrations. Note that some of the 94 water samples collected were excluded if they exhibited clear signs of air bubble contamination, interference with the water sampler apparatus, or contact with the sea bottom (see ADCP calibration methods described in section 2.5). Also note that a Sediview calibration was performed for each mobile ADCP survey rather than for the entire survey week. This is due to the fact that water conditions changed enough between each survey day that a single calibration spanning the entire survey could not be achieved. Overall, there was a strong agreement (R^2 = 0.91, 0.85, and 0.76) between the acoustic estimates of TSS concentration and the gravimetric measurements (Figures 45b, 46b, 47b) for each calibration period.

3.2.6 Sediment Samples

A total of nine sediment samples were collected (four from the dredge scow and five from the dredge area) during the week of 03 October, 2011. The laboratory results of these sediment collections for grain size distribution, density and Atterberg Limits are presented in Table 11. Sediment samples collected during the S-NB-2/S-AK-1 Far-Field Survey #2 were comprised mostly of silt, fine sand, and clay, with silt comprising between 20% and 65% of each sample collected. Each of the samples collected also consisted of 4% to 52% fine sand and 6% to 32% clay. Each sample contained only 0.2% to 20% medium sand and coarser material. The in-place density of the sediment samples ranged between 0.461 and 1.32 g/cc (Table 11).

3.2.7 Dredging Operations — Bucket Cycles

To examine the bucket cycle sequence, a video record was obtained of 13 complete cycles during a flood tide on 06 October, 2011. The video was then analyzed for time increments for each component of the cycle (Figure 48). The average total elapsed time per cycle was 87 seconds. A certain degree of variability in cycle component elapsed times can be seen across the 13 cycles in Figure 48. The shortest cycle was 67 seconds, whereas the longest cycle was 109 seconds.

Average time for each component of the dredge cycle was: Descent (21 seconds), Grab (9 seconds), Raise (13 seconds), Slew Over (22 seconds), Dump (9 seconds), and Slew Back (10 seconds).

4.0 DISCUSSION

During the course of normal dredging operations, some sediment is resuspended into the water column. In many cases, this suspended sediment is evident as a visible turbidity plume within the immediate vicinity of the dredge operation. Because suspended sediment plumes are dynamic rather than static phenomena and because they vary over large areas in short periods of time, particularly when driven by tidal forces, characterizing plumes can present a difficult challenge. Data collected at arbitrarily determined points in time at fixed locations are inadequate to assess dredge plume structure. However, advanced acoustic technologies offer advantages in capturing data at appropriate spatial and temporal scales to allow more accurate interpretation of plume dynamics (Tubman & Corson 2000).

As part of USACE-NYD's Harbor-wide WQ/TSS Monitoring Program, two far-field WQ/TSS surveys were conducted during the weeks of 25 July 2011 and 03 October 2011 within the S-NB-2/S-AK-1 contract area of the South Elizabeth Channel in Newark Bay, New Jersey. The objective of the far-field survey was to assess the spatial extent and temporal dynamics of suspended sediment plumes associated with environmental or "closed" clamshell bucket dredging of fine-grained sediment. The methodologies employed for this survey were similar to those used previously to survey WQ/TSS within the Arthur Kill (USACE 2007), Newark Bay (USACE 2008 and USACE 2009), and Port Elizabeth Channel (USACE 2010), and course-grained sand in Anchorage Channel (USACE 2011); as well as cutterhead dredging of sediments in the Kill Van Kull (USACE 2012a and USACE 2012b). However, direct comparisons between studies are inexact due to the varying hydrodynamic conditions and sediment types within the different study areas. Sediment conditions in the S-NB-2/S-AK-1 contract area were predominantly fine sand, silt, and clay (Tables 6 and 11). Fine grained sediments such as these can remain in suspension for longer than coarser sediments might.

The acoustic backscatter patterns and dimensions observed during the far-field surveys conducted within the S-NB-2/S-AK-1 contract area were varied depending on the tide and the location of the dredge operating within South Elizabeth Channel. In nearly all mobile ADCP surveys conducted, however, the suspended sediment plume was confined to the lower half of the water column and did not extend outside of the navigation channel. Exceptions to this were the two surveys conducted on an ebb tide during the week of 03 October 2011, when the plume was observed throughout the water column close to the dredge. In these cases, the dredge was positioned partially over the channel side slopes and over the flats adjacent to South Elizabeth Channel and the total water column was shallower than in previous surveys. However, even during these surveys the plume descended to the bottom half of the water column within 100 meters of the dredge. Peak suspended sediment concentrations were typically 300 mg/L or less within approximately 100 meters of the dredge platform and dissipated to background conditions within approximately 300 meters of the dredge. Even at its greatest observed distance from the dredge, the plume remained confined either entirely within the South Elizabeth Channel, or just along the edge and slopes of the adjacent flats.

Prevailing currents in the South Elizabeth Channel were highly variable, sometimes exhibiting a more or less uniform direction and sometimes exhibiting eddying characteristics with different current directions observed within a small area. As noted, current characteristics in South Elizabeth Channel differed from those observed previously in larger channels such as the main channel of Newark Bay or the Anchorage Chanel of the Upper Bay (USACE 2008, 2009, 2011). Likely because of its position directly to the south of the Port Elizabeth bulkhead and to the north of a large area of flats, the hydrodynamics of South Elizabeth Channel are more complex. As described previously in Section 3.2.1, during an ebb tide, water heading south and west out of the Newark Bay Main Channel appears to be pulled around the bulkhead and turned westward into the South Elizabeth Channel before turning south and eastward and funneling out of the channel and over the flats. By comparison, during a flood tide, water pulled over the flats and entering the South Elizabeth Channel is then funneled eastward out of the channel before turning north and east into the Newark Bay Main Channel.

Because of these current patterns, and depending on the position of the dredge, the plume was often observed to collect within the channel boundaries on the same side of the dredge (eastern side) during both an ebb and flood tide as was the case during the 25 July and 26 July flood surveys (plume primarily to the east and north of dredge) and 27 July ebb survey (primarily to the east and south of dredge). Mobile ADCP surveys conducted during the week of 03 October 2011 were affected by the position of the dredge *Delaware Bay.* During this survey, the dredge was positioned over the channel side slopes and over the flats to the south of South Elizabeth Channel such that ADCP transects were recorded not only perpendicular to the channel both up-current and down-current, but also parallel to the channel, in order to give the most complete picture of the suspended sediment plume possible. In these surveys, the plume was shown to quickly dissipate within 300 meters of the dredge which was confirmed by the deployment of the OBS arrays in which down-current (between 85 and 405 meters from the dredge) turbidity over the flats was largely similar to ambient turbidity within the channel.

5.0 LITERATURE CITED

Dredging Research Ltd. (DRL). 2003. The Sediview Method. Sediview Procedure Manual. July 2003.

Land, J.M. and R.N. Bray. 2000. Acoustic measurement of suspended solids for monitoring of dredging and dredged material disposal. Journal of Dredging Engineering 2 (3):1-17.

Puckette, T.P. 1998. Evaluation of dredged material plumes: Physical monitoring techniques. DOER Technical Notes Collection (TN-DOER-E5). U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Tubman, M.W. and W.D. Corson. 2000. Acoustic monitoring of dredging-related suspended-sediment plumes. DOER Technical Notes Collection (ERDC TN-DOER-E7). U.S. Army Engineer Research and Development Center, Vicksburg, MS.

United States Army Corps of Engineers (USACE) – New York District (NYD). 2007. Suspended Sediment Plumes Associated With Navigation Dredging In The Arthur Kill Waterway, New Jersey**.** Appendix 3-1 of the Final Environmental Assessment: Effects of the NY/NJ Harbor Deepening Project on the Remedial Investigation/Feasibility Study of the Newark Bay Study Area. June 2007.

United States Army Corps of Engineers (USACE) – New York District (NYD). 2008. Far-field Surveys of Suspended Sediment Plumes Associated With Harbor Deepening Dredging In Newark Bay. September 2008.

United States Army Corps of Engineers (USACE) – New York District (NYD). 2009. Far-field Surveys of Suspended Sediment Plumes Associated With Harbor Deepening Dredging In Newark Bay. S-NB-1 Contract Area. S-NB-1 Contract Area Survey #2. June 2009.

United States Army Corps of Engineers (USACE) – New York District (NYD). 2010. Far Field Surveys of Suspended Sediment Plumes Associated With Harbor Deepening

Dredging In Newark Bay. S-E-1 Contract Area. S-NB-1 Contract Area (Port Elizabeth Channel Survey #1 & #2. February 2010.

United States Army Corps of Engineers (USACE) – New York District (NYD). 2011. Far Field Surveys of Suspended Sediment Plumes Associated With Harbor Deepening Dredging In Upper Bay. S-AN-2 Contract Area (Anchorage Channel). June 2011.

United States Army Corps of Engineers (USACE) – New York District (NYD). 2012a. Far Field Surveys of Suspended Sediment Plumes Associated With Cutterhead Dredging In Upper Bay. S-KVK-1 Contract Area (Kill Van Kull). April 2012.

United States Army Corps of Engineers (USACE) – New York District (NYD). 2012b. Far Field Surveys of Suspended Sediment Plumes Associated With Harbor Deepening Dredging In Upper Bay. S-KVK-1 Contract Area (Kill Van Kull). September 2012.

Wilber, D.A. and D.G. Clarke. 2001. Biological effects of suspended sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. North American Journal of Fisheries Management 21: 855-875.

Table 1. Laboratory Results of Water Samples, S-NB-2/S-AK-1 Far Field Survey #1 (25-29 July 2011)

Sample	Sample Date	Sample Time	Location	Total Suspended Solids (mg/L)	Turbidity (NTU)
1	7/25/2011	1:46:37 PM	Plume	80.8	22.8
2	7/25/2011	1:46:52 PM	Plume	84.0	26.8
3	7/25/2011	1:47:07 PM	Plume	78.8	20.4
4	7/25/2011	1:47:18 PM	Plume	73.6	24.3
5	7/25/2011	1:47:29 PM	Plume	71.2	25.2
6	7/25/2011	1:49:22 PM	Plume	73.6	23.5
7	7/25/2011	1:49:33 PM	Plume	92.8	24.1
8	7/25/2011	1:49:42 PM	Plume	67.2	19.4
9	7/25/2011	1:49:52 PM	Plume	54.0	14.5
10	7/25/2011	1:50:04 PM	Plume	47.2	10.2
11	7/25/2011	1:51:21 PM	Plume	56.4	10.0
12	7/25/2011	1:51:32 PM	Plume	53.6	10.5
13	7/25/2011	1:51:42 PM	Plume	58.8	9.1
14	7/25/2011	1:51:55 PM	Plume	45.2	10.0
15	7/25/2011	1:52:06 PM	Plume	53.6	9.6
16	7/25/2011	1:54:11 PM	Plume	77.2	20.0
17	7/25/2011	1:54:21 PM	Plume	51.2	18.6
18	7/25/2011	1:54:32 PM	Plume	48.4	20.2
19	7/25/2011	1:54:43 PM	Plume	63.6	20.2
20	7/25/2011	1:54:54 PM	Plume	72.0	25.0
21	7/25/2011	2:10:07 PM	Ambient	38.0	6.2
22	7/25/2011	2:10:20 PM	Ambient	40.0	5.7
23	7/25/2011	2:10:31 PM	Ambient	42.4	6.4
24	7/25/2011	2:10:41 PM	Ambient	48.4	7.2
25	7/25/2011	2:10:52 PM	Ambient	33.2	6.4
26	7/25/2011	2:11:44 PM	Ambient	35.6	5.9
27	7/25/2011	2:12:01 PM	Ambient	40.8	6.1
28	7/25/2011	2:12:10 PM	Ambient	31.2	6.7
29	7/25/2011	2:12:20 PM	Ambient	37.2	6.3
30	7/25/2011	2:12:31 PM	Ambient	42.4	6.6
31	7/25/2011	2:13:30 PM	Ambient	30.8	5.1
32	7/25/2011	2:13:41 PM	Ambient	34.4	5.7
33	7/25/2011	2:13:53 PM	Ambient	35.6	5.0
34	7/25/2011	2:15:09 PM	Ambient	44.0	8.0
35	7/25/2011	2:15:19 PM	Ambient	47.2	6.5
36	7/25/2011	2:15:30 PM	Ambient	48.0	4.9
37	7/25/2011	2:15:40 PM	Ambient	36.8	4.5

Table 1. Laboratory Results of Water Samples, S-NB-2/S-AK-1 Far Field Survey #1 (25-29 July 2011)

Sample	Sample Date	Sample Time	Location	Total Suspended Solids (mg/L)	Turbidity (NTU)
38	7/25/2011	2:15:50 PM	Ambient	40.8	4.6
39	7/26/2011	1:35:45 PM	Ambient	62.4	25.9
40	7/26/2011	1:35:54 PM	Ambient	60.0	20.8
41	7/26/2011	1:35:57 PM	Ambient	61.6	19.5
42	7/26/2011	1:36:27 PM	Ambient	46.0	10.6
43	7/26/2011	1:36:29 PM	Ambient	43.2	13.8
44	7/26/2011	2:02:55 PM	Ambient	36.0	8.1
45	7/26/2011	2:02:57 PM	Ambient	31.2	7.7
46	7/26/2011	2:03:14 PM	Ambient	36.8	6.5
47	7/26/2011	2:03:26 PM	Ambient	23.2	7.5
48	7/26/2011	2:30:11 PM	Ambient	41.6	7.6
49	7/26/2011	3:29:57 PM	Plume	42.8	16.4
50	7/26/2011	3:29:58 PM	Plume	42.8	15.6
51	7/26/2011	3:30:01 PM	Plume	46.0	14.0
52	7/26/2011	3:30:41 PM	Plume	42.8	12.1
53	7/26/2011	3:30:51 PM	Plume	41.6	12.0
54	7/26/2011	3:30:54 PM	Plume	47.6	13.8
55	7/26/2011	3:38:45 PM	Plume	55.6	15.4
56	7/26/2011	3:38:46 PM	Plume	48.8	18.1
57	7/26/2011	3:39:32 PM	Plume	43.6	15.6
58	7/26/2011	3:39:38 PM	Plume	53.2	16.4
59	7/26/2011	3:39:52 PM	Plume	41.2	13.3
60	7/26/2011	3:39:57 PM	Plume	51.6	17.3
61	7/27/2011	9:56:43 AM	Ambient	80.8	31.8
62	7/27/2011	9:56:45 AM	Ambient	58.0	14.2
63	7/27/2011	9:57:15 AM	Ambient	43.2	6.4
64	7/27/2011	9:57:17 AM	Ambient	32.0	5.8
65	7/27/2011	9:57:37 AM	Ambient	32.0	5.5
66	7/27/2011	9:57:40 AM	Ambient	35.6	5.9
67	7/27/2011	10:05:50 AM	Ambient	34.4	6.4
68	7/27/2011	10:05:52 AM	Ambient	22.8	6.8
69	7/27/2011	10:06:13 AM	Ambient	29.6	4.4
70	7/27/2011	10:06:15 AM	Ambient	22.4	4.4
71	7/27/2011	10:06:32 AM	Ambient	33.2	7.8
72	7/27/2011	10:06:35 AM	Ambient	48.8	9.4
73	7/27/2011	10:48:13 AM	Ambient	50.8	5.7
74	7/27/2011	10:48:14 AM	Ambient	30.0	7.3

Table 1. Laboratory Results of Water Samples, S-NB-2/S-AK-1 Far Field Survey #1 (25-29 July 2011)

Sample	Sample Date	Sample Time	Location	Total Suspended Solids (mg/L)	Turbidity (NTU)
75	7/27/2011	10:48:16 AM	Ambient	29.2	8.7
76	7/27/2011	10:48:34 AM	Ambient	38.4	8.5
77	7/27/2011	10:48:35 AM	Ambient	36.8	8.4
78	7/27/2011	10:48:36 AM	Ambient	38.0	6.7
79	7/27/2011	10:55:20 AM	Ambient	71.2	34.6
80	7/27/2011	10:55:22 AM	Ambient	81.2	33.0
81	7/27/2011	10:55:24 AM	Ambient	84.4	32.9
82	7/27/2011	10:55:39 AM	Ambient	70.4	29.0
83	7/27/2011	10:55:40 AM	Ambient	64.0	29.1
84	7/27/2011	10:55:43 AM	Ambient	60.4	28.2
85	7/28/2011	9:40:39 AM	Ambient	44.8	3.9
86	7/28/2011	9:40:55 AM	Ambient	44.8	4.1
87	7/28/2011	9:41:03 AM	Ambient	32.0	4.2
88	7/28/2011	9:41:11 AM	Ambient	22.4	3.4
89	7/28/2011	9:41:22 AM	Ambient	26.4	3.4
90	7/28/2011	9:41:29 AM	Ambient	37.6	3.3
91	7/28/2011	10:05:54 AM	Ambient	32.8	4.3
92	7/28/2011	10:06:13 AM	Ambient	36.8	4.5
93	7/28/2011	10:06:47 AM	Ambient	32.8	4.2
94	7/28/2011	10:06:56 AM	Ambient	30.0	3.7
95	7/28/2011	10:07:01 AM	Ambient	21.2	3.6
96	7/28/2011	10:07:11 AM	Ambient	33.6	3.7
97	7/29/2011	12:15:44 PM	Ambient	50.4	18.4
98	7/29/2011	12:15:55 PM	Ambient	38.4	6.8
99	7/29/2011	12:16:00 PM	Ambient	44.8	7.2
100	7/29/2011	12:16:06 PM	Ambient	35.2	4.7
101	7/29/2011	12:16:09 PM	Ambient	30.4	4.6
102	7/29/2011	12:16:14 PM	Ambient	33.6	4.6
103	7/29/2011	12:20:34 PM	Ambient	31.6	4.4
104	7/29/2011	12:20:51 PM	Ambient	37.6	3.3
105	7/29/2011	12:20:56 PM	Ambient	39.6	6.0
106	7/29/2011	12:21:01 PM	Ambient	21.6	5.5
107	7/29/2011	12:21:04 PM	Ambient	45.6	5.7
108	7/29/2011	12:21:20 PM	Ambient	42.0	4.8
109	7/29/2011	1:39:34 PM	Plume	69.6	21.5
110	7/29/2011	1:39:37 PM	Plume	87.2	30.3
111	7/29/2011	1:39:41 PM	Plume	94.8	34.1

Table 1. Laboratory Results of Water Samples, S-NB-2/S-AK-1 Far Field Survey #1 (25-29 July 2011)

Sample	Sample Date	Sample Time	Location	Total Suspended Solids (mg/L)	Turbidity (NTU)
112	7/29/2011	1:39:44 PM	Plume	82.8	26.9
113	7/29/2011	1:39:47 PM	Plume	78.4	28.1
114	7/29/2011	1:39:49 PM	Plume	70.4	36.4
115	7/29/2011	1:45:03 PM	Plume	72.8	26.1
116	7/29/2011	1:45:05 PM	Plume	118.0	38.0
117	7/29/2011	1:45:08 PM	Plume	90.4	23.9
118	7/29/2011	1:45:12 PM	Plume	107.0	18.2
119	7/29/2011	1:45:21 PM	Plume	116.0	61.0
120	7/29/2011	1:45:24 PM	Plume	139.0	67.6

Table 2. 25 July 2011 Far Field Flood Tide Survey - Transect Summary Table

Transect Number	Figure Number	Time	Transect Length (m)	Distance From Dredge (m)	Plume Description	Additional Field Remarks
C01	5a	11:42:31	680	90	Circle Transects to locate plume	Start of Ebb
C02	5b	11:49:06	551	82		Tug Mary Alice at 1150
A01	5c	12:52:04	128	74	Ambient Transects	
A02	5d	12:54:07	116	137		Surface Chop
A03	5e	12:56:49	92	240		
C03	5f	13:00:26	498	82	Circle Transect to locate plume	Plume SE of dredge
T01	5g	13:10:56	123	90	Plume is wide and low near bottom, concentrations up to 250 mg/l	Propwash on surface at start: tug Brian Nicholas
T02	5h	13:13:47	112	126	Plume begins to dissipate	Propwash on surface at end: tug Brian Nicholas
T03	5i	13:15:15	116	141		Propwash on surface at start: tug Brian Nicholas
T04	5j	13:17:22	122	197		Propwash near bulkhead: tug Brian Nicholas
T05	5k	13:19:17	112	233		Propwash near bulkhead
T06	5l	13:21:15	107	298		
T07	5m	13:23:06	121	344	Plume is almost entirely dissipated	
T08	5n	13:25:13	112	426	No visible Plume	
T09	5o	13:27:08	116	476		

Table 3. 26 July Far Field Flood Tide Survey - Transect Summary Table

Transect Number	Figure Number	Time	Transect Length (m)	Distance From Dredge (m)	Plume Description	Additional Field Remarks
C01	9a	14:16:54	580	107	Circle Transect to Locate Plume	
A01	9b	14:25:07	154	85	Ambient Transects	
A02	9c	14:27:31	124	105		
A03	9d	14:29:20	119	174		
T01	9e	14:32:56	147	102	Plume mostly along the bottom, concentrations up to 250 mg/l	
T02	9f	14:34:43	131	150	Plume begins to dissipate, concentrations drop to 160 mg/l	
T03	9g	14:36:44	143	206	Plume continues to dissipate	
T04	9h	14:38:39	143	246		Propwash at 1550, Ens 1529
T05	9i	14:40:47	160	313		
T06	9j	14:42:59	139	384		
T07	9k	14:45:13	137	476	Plume has dissipated	At ens 1855 possible object on bottom

Table 4. 27 July 2011 Far Field Ebb Tide Survey - Transect Summary Table

Transect Number	Figure Number	Time	Transect Length (m)	Distance From Dredge (m)	Plume Description	Additional Field Remarks
C01	13a	9:44:48	358	82	Circle transects to locate plume	
C02	13b	10:13:22	553	77		Propwash from Matthew Scott
A01	13c	10:21:25	118	66	Ambient Transects	
A02	13d	10:23:44	144	90		
A03	13e	10:26:02	141	124		
A04	13f	10:28:10	137	148		
T01	13g	10:31:55	145	113	Narrow Plume along bottom, concentrations reaching 300 mg/l	
T02	13h	10:34:46	136	150	Plume dissipates, remaining on the bottom	
T03	13i	10:36:59	126	213		
T04	13j	10:38:40	115	247		
T05	13k	10:40:20	128	302	Plume has dissipated	
T06	13l	10:42:03	117	326		

Table 5. 29 July 2011 Far Field Ebb Tide Survey - Transect Summary Table

Transect Number	Figure Number	Time	Transect Length (m)	Distance From Dredge (m)	Plume Description	Additional Field Remarks
C01	17a	11:22:32	475	45	Circle Transects to locate plume	
C02	17b	11:49:34	460	41		Prop Wash ens 224
C03	17c	12:58:13	475	40		Circle to located plume
C04	17d	13:04:53	252	43		Half Circle
A01	17e	13:16:22	105	34	Ambient Transects	
A02	17f	13:18:07	117	73		
A03	17g	13:20:16	122	117		
A04	17h	13:22:27	119	166		
T01	17i	11:54:54	127	81	Plume present on toe of side slope at concentrations up to 160 mg/L. Overlaps with side lobe interference	Prop Wash ens 397
T02	17j	11:57:30	125	93		
T03	17k	13:08:57	83	106	Plume begins to dissipate, present in bottom of water column	
T04	17l	12:00:03	145	118		
T05	17m	13:10:36	98	134		
T06	17n	12:02:44	155	151		
T07	17o	13:12:16	179	170		
T08	17p	12:24:23	137	196	Very little visible plume, with low concentrations, is present on bottom	

Table 6. Sediment Collection and Analysis Summary Table.
S-NB-2/S-AK-1 Far Field Survey #1 (25-29 July 2011)

			Grain Size Distribution[1]						Density[2]	Atterberg Limits[3]		
Sample Location	Date Sampled	Time Sampled	Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	In Place Density	Liquid Limit	Plastic Limit	Plasticity Index
			(%)	(%)	(%)	(%)	(%)	(%)	(g/cc)	--	--	--
Dredge Field	7/25/2011	11:39	0.0	0.0	5.3	42.2	37.0	15.5	0.739	50	23	27
Dredge Scow	7/25/2011	11:10	2.2	1.0	11.9	46.8	22.8	15.3	1.120	26	20	6
Dredge Field	7/26/2011	10:54	20.5	0.3	3.9	14.5	37.6	23.2	0.717	69	28	41
Dredge Scow	7/26/2011	12:02	12.8	2.4	4.1	7.0	39.1	34.6	0.589	88	34	54
Dredge Field	7/27/2011	10:54	20.5	0.3	3.9	14.5	37.6	23.2	0.717	69	28	41
Dredge Scow	7/27/2011	8:45	0.0	0.5	1.1	4.7	76.8	16.9	0.541	92	36	57
Dredge Field	7/28/2011	10:52	0.0	0.0	0.2	3.3	65.8	30.7	0.488	102	37	65
Dredge Field	7/29/2011	10:23	0.0	0.3	0.3	3.5	77.9	18.0	0.459	99	36	62
Dredge Scow	7/29/2011	11:37	0.0	0.6	4.4	41.0	39.6	14.4	0.893	42	20	22

[1]ASTM D-422 Method

[2]ASTM D-2937 Method

[3]ASTM D-4318 Method

Table 7. Laboratory Results of Water Samples, S-NB-2/S-AK-1 Far Field Survey #2 (03-07 October 2011)

Sample	Sample Date	Sample Time	Location	Total Suspended Solids (mg/L)	Turbidity (NTU)
1	10/3/2011	13:55:28	Ambient	20.8	8.4
2	10/3/2011	13:55:29	Ambient	18.8	8.8
3	10/3/2011	13:56:15	Ambient	22.0	7.8
4	10/3/2011	13:56:17	Ambient	22.8	7.1
5	10/3/2011	13:56:40	Ambient	24.4	7.7
6	10/3/2011	13:56:44	Ambient	25.6	7.2
7	10/3/2011	14:11:30	Ambient	34.8	13.1
8	10/3/2011	14:11:33	Ambient	37.6	14.2
9	10/3/2011	14:12:07	Ambient	28.4	9.3
10	10/3/2011	14:12:10	Ambient	26.4	9.3
11	10/3/2011	14:12:40	Ambient	23.6	8.0
12	10/3/2011	14:12:43	Ambient	26.0	8.6
13	10/4/2011	10:32:36	Ambient	17.2	5.6
14	10/4/2011	10:32:55	Ambient	13.2	5.8
15	10/4/2011	10:33:04	Ambient	12.4	6.1
16	10/4/2011	10:33:09	Ambient	40.0	5.5
17	10/4/2011	10:33:30	Ambient	8.0	7.6
18	10/4/2011	10:33:36	Ambient	22.0	6.1
19	10/4/2011	14:34:32	Plume	14.4	9.9
20	10/4/2011	14:34:58	Plume	46.0	10.2
21	10/4/2011	14:35:14	Plume	32.8	10.5
22	10/4/2011	14:35:17	Plume	34.0	10.9
23	10/4/2011	14:35:32	Plume	25.2	8.6
24	10/4/2011	14:35:49	Plume	29.2	9.6
25	10/4/2011	14:45:10	Plume	79.6	37.8
26	10/4/2011	14:45:15	Plume	72.4	38.1
27	10/4/2011	14:45:22	Plume	89.2	52.4
28	10/4/2011	14:45:24	Plume	103.0	53.2
29	10/4/2011	14:45:28	Plume	42.0	21.3
30	10/4/2011	14:45:34	Plume	14.0	6.2
31	10/4/2011	14:54:08	Plume	36.8	14.7
32	10/4/2011	14:54:19	Plume	30.4	13.1
33	10/4/2011	14:54:25	Plume	57.2	24.9
34	10/4/2011	14:54:29	Plume	56.8	21.1
35	10/4/2011	14:54:42	Plume	76.4	40.6
36	10/4/2011	14:54:52	Plume	25.2	6.8
37	10/5/2011	2:56:53 PM	Ambient	38.0	9.6

Table 7. Laboratory Results of Water Samples, S-NB-2/S-AK-1 Far Field Survey #2 (03-07 October 2011)

Sample	Sample Date	Sample Time	Location	Total Suspended Solids (mg/L)	Turbidity (NTU)
38	10/5/2011	2:56:57 PM	Ambient	40.8	9.7
39	10/5/2011	2:57:15 PM	Ambient	20.4	5.2
40	10/5/2011	2:57:20 PM	Ambient	26.8	5.4
41	10/5/2011	2:57:52 PM	Ambient	20.4	6.3
42	10/5/2011	2:57:56 PM	Ambient	20.0	6.1
43	10/5/2011	3:07:19 PM	Ambient	31.2	5.2
44	10/5/2011	3:07:22 PM	Ambient	28.4	5.4
45	10/5/2011	3:07:45 PM	Ambient	25.2	5.4
46	10/5/2011	3:07:49 PM	Ambient	26.4	6.0
47	10/5/2011	3:08:06 PM	Ambient	22.8	6.2
48	10/6/2011	9:48:26	Plume	66.5	39.4
49	10/6/2011	9:48:30	Plume	75.5	37.5
50	10/6/2011	9:48:43	Plume	62.5	31.9
51	10/6/2011	9:48:45	Plume	67.0	36.3
52	10/6/2011	9:48:59	Plume	66.5	35.4
53	10/6/2011	9:49:01	Plume	62.5	30.7
54	10/6/2011	10:11:19	Plume	43.5	19.9
55	10/6/2011	10:11:29	Plume	47.0	19.2
56	10/6/2011	10:11:57	Plume	47.5	20.7
57	10/6/2011	10:12:03	Plume	55.0	24.5
58	10/6/2011	10:12:21	Plume	72.0	22.3
59	10/6/2011	10:12:26	Plume	53.5	27.2
60	10/6/2011	10:25:27	Plume	20.0	4.9
61	10/6/2011	10:25:44	Plume	25.5	4.3
62	10/6/2011	10:25:55	Plume	14.0	4.5
63	10/6/2011	10:26:04	Plume	16.0	5.0
64	10/6/2011	10:26:32	Plume	17.3	6.6
65	10/6/2011	10:26:34	Plume	17.7	7.3
66	10/6/2011	10:37:19	Plume	14.8	4.0
67	10/6/2011	10:37:34	Plume	13.3	3.9
68	10/6/2011	10:37:54	Plume	17.0	4.8
69	10/6/2011	10:38:29	Plume	15.5	5.2
70	10/6/2011	10:38:45	Plume	16.0	6.1
71	10/6/2011	10:39:07	Plume	20.0	7.2
72	10/7/2011	9:47:19	Plume	85.0	48.2
73	10/7/2011	9:47:20	Plume	84.5	44.2
74	10/7/2011	9:47:22	Plume	78.5	42.2

Table 7. Laboratory Results of Water Samples, S-NB-2/S-AK-1 Far Field Survey #2 (03-07 October 2011)

Sample	Sample Date	Sample Time	Location	Total Suspended Solids (mg/L)	Turbidity (NTU)
75	10/7/2011	9:47:41	Plume	73.5	34.5
76	10/7/2011	9:48:04	Plume	92.5	45.2
77	10/7/2011	9:58:17	Plume	96.0	51.2
78	10/7/2011	9:58:18	Plume	93.5	46.0
79	10/7/2011	9:58:37	Plume	93.5	47.6
80	10/7/2011	9:58:38	Plume	97.0	50.2
81	10/7/2011	9:58:58	Plume	59.0	33.0
82	10/7/2011	9:59:00	Plume	61.0	33.4
83	10/7/2011	10:05:26	Plume	30.5	11.0
84	10/7/2011	10:05:27	Plume	39.5	18.0
85	10/7/2011	10:05:39	Plume	44.0	24.1
86	10/7/2011	10:05:43	Plume	56.5	27.5
87	10/7/2011	10:05:49	Plume	57.5	36.2
88	10/7/2011	10:06:02	Plume	71.6	39.7
89	10/7/2011	10:12:05	Plume	39.2	7.4
90	10/7/2011	10:12:06	Plume	28.0	5.6
91	10/7/2011	10:12:22	Plume	34.0	7.7
92	10/7/2011	10:12:49	Plume	30.8	12.7
93	10/7/2011	10:13:04	Plume	35.2	10.8
94	10/7/2011	10:13:07	Plume	39.2	11.3
95	10/7/2011	10:21:25	Ambient	43.6	9.5
96	10/7/2011	10:21:27	Ambient	37.2	10.0
97	10/7/2011	10:21:50	Ambient	35.2	8.9
98	10/7/2011	10:21:53	Ambient	38.8	9.2
99	10/7/2011	10:22:12	Ambient	24.8	6.9
100	10/7/2011	10:22:18	Ambient	23.2	5.9
101	10/7/2011	10:29:44	Ambient	44.8	17.0
102	10/7/2011	10:29:46	Ambient	49.2	15.0
103	10/7/2011	10:30:01	Ambient	48.0	18.4
104	10/7/2011	10:30:21	Ambient	46.8	14.4
105	10/7/2011	10:30:30	Ambient	45.2	13.1
106	10/7/2011	10:30:44	Ambient	41.2	14.9

Table 8. 04 October 2011 Far Field Flood Tide - Survey Transect Summary Table

Transect Number	Figure Number	Time	Transect Length (m)	Distance From Dredge (m)	Plume Description	Additional Field Remarks
C01	29a	13:12:07		67	No Plume - side lobe present	Dredging stopped 5 mins ago
T01	29b	13:31:04	312	174	Light plume along bottom - side lobe present	Downcurrent, dredge on other side of barge
T02	29c	13:38:53	230	102		Dredging and plume occuring on channel slope
T03	29d	13:43:18	349	165		Standing plume along bottom of channel
T04	29e	13:53:23	345	217		
T05	29f	13:57:51	429	245		Tug wake in middle, plume extends to bulkhead
T06	29g	14:03:36	334	259		
T07	29h	14:07:31	328	352	Light plume along bottom	
T08	29i	14:12:19		355	Light plume along bottom - beginning to dissipate	
T09	29j	14:14:47	194	434	No visible plume	
T10	29k	14:19:06	313	396	No visible plume - side lobe present	Tug wake at surface
A01	29l	15:13:32	295	139	Possible lingering plume near bottom - side lobe present	Some plume may be visible
A02	29m	15:17:43	344	195	No visible plume - side lobe present	
A03	29n	15:21:53	244	338		

Table 9. 06 October 2011 Far Field Ebb Tide Survey - Transect Summary Table

Transect Number	Figure Number	Time	Transect Length (m)	Distance From Dredge (m)	Plume Description	Additional Field Remarks
C01	33a	8:42:43	293	60	Plume present in shallow, near surface water - heavy side lobe	
T01	33b	8:48:17	154	220	No plume - possible sidelobe from bulkhead	Along Bulkhead to check for Plume
T02	33c	8:51:05	156	46	Plume present throughout water column	
T03	33d	8:53:26	166	83	Plume beginning to dissipate - side lobe present	
T04	33e	8:55:52	212	127	Plume nearly completely dissipated, in top of water column	
T05	33f	8:58:49	188	164	No visible plume - possible fish/debris	
T06	33g	9:01:30	205	194		
T07	33h	9:04:33	212	140	Possible plume in top of water column	Filling in Gaps
T08	33i	9:07:45	256	96	Plume present, primarily near surface, exending to bottom - heavy side lobe present	
T09	33j	9:12:51	210	281	No plume, possible fish/debris - side lobe present	Perpendicular to other transects
T10	33k	9:16:28	226	217		
T11	33l	9:19:58	220	164		
A01	33m	9:25:53	187	75		
A02	33n	9:29:05	218	147		
A03	33o	9:33:20	177	208		Possible surface propwash

Table 10. 07 October Far Field Ebb Tide Survey - Transect Summary Table

Transect Number	Figure Number	Time	Transect Length (m)	Distance From Dredge (m)	Plume Description	Additional Field Remarks
T01	37a	9:09:26	197	48	Plume throughout entire water column	
T02	37b	9:12:08	247	54		
T03	37c	9:15:26	248	90	Plume throughout entire water column, starting to dissipate - side lobe present	
T04	37d	9:19:12	340	114	Plume throughout water column, almost entirely dissipated	
T05	37e	9:23:52	318	151	No plume present - possible fish/debris	
T06	37f	9:28:23	251	167		Unable to get closer to bulkhead due to ships
A01	37g	10:48:06	141	27	Higher ambient concentration (40-70 mg/L) visible in bottom of water column bottom, sidelobe present	Perpendicular to Downcurrent Transects - Water was too shallow on the opposite side of the barge
A02	37h	10:51:08	177	74		
A03	37i	10:54:23	163	109	Higher ambient concentration (40-80 mg/L) visible along bottom, sidelobe present	

Table 11. Sediment Collection and Analysis Summary Table.
S-NB-2/S-AK-1 Far Field Survey #2 (03-07 October 2011)

			Grain Size Distribution[1]						Density[2]	Atterberg Limits[3]		
Sample Location	**Date Sampled**	**Time Sampled**	**Gravel**	**Coarse Sand**	**Medium Sand**	**Fine Sand**	**Silt**	**Clay**	**In Place Density**	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**
			(%)	(%)	(%)	(%)	(%)	(%)	(g/cc)	--	--	--
Dredge Field	10/3/2012	14:25	2.1	0.8	2.0	5.6	57.5	32.0	0.502	87	31	56
Dredge Field	10/4/2012	10:15	0.0	0.0	0.2	4.2	74.6	21.0	0.461	94	34	60
Dredge Scow	10/4/2012	15:10	1.5	1.2	3.2	33.1	35.2	25.8	1.120	46	18	28
Dredge Field	10/5/2012	14:35	1.2	0.7	8.9	35.2	47.8	6.2	0.752	61	21	39
Dredge Scow	10/5/2012	16:05	0.6	0.6	3.2	35.6	52.1	7.9	0.857	49	21	28
Dredge Field	10/6/2012	10:50	2.4	2.9	7.3	35.9	43.5	8.1	0.761	53	22	31
Dredge Scow	10/6/2012	10:00	8.9	2.7	8.3	51.9	19.6	8.6	1.320	NA	NP	NA
Dredge Field	10/7/2012	11:05	0.0	0.0	4.0	38.3	46.0	11.7	0.763	54	21	32
Dredge Scow	10/7/2012	9:45	2.8	0.9	5.0	24.0	41.4	25.9	1.010	48	20	28

[1]ASTM D-422 Method
[2]ASTM D-2937 Method
[3]ASTM D-4318 Method

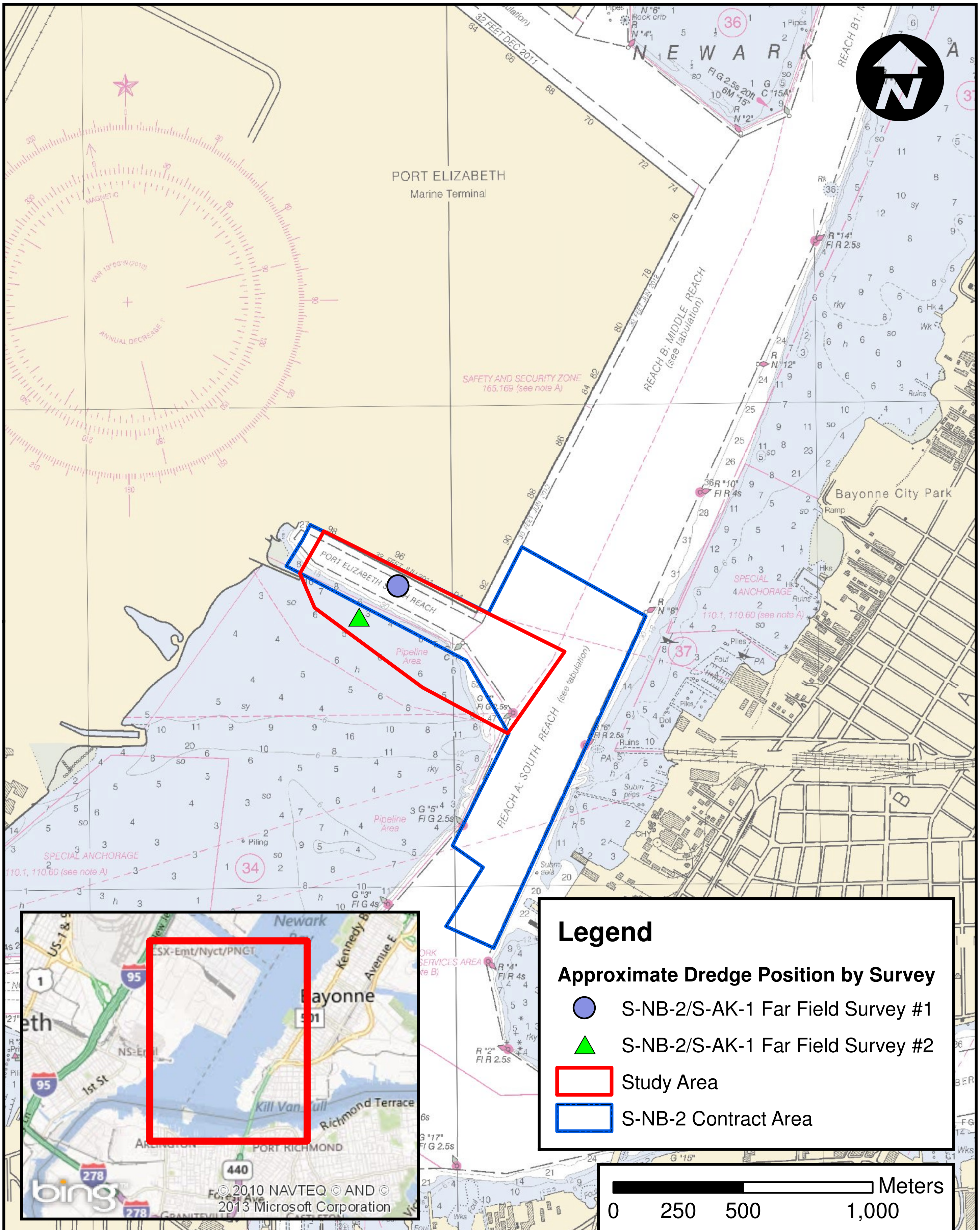


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2/S-AK-1	Newark Bay - South Elizabeth Channel S-NB-2/S-AK-1 Far Field Survey Area	Tide
1			N/A

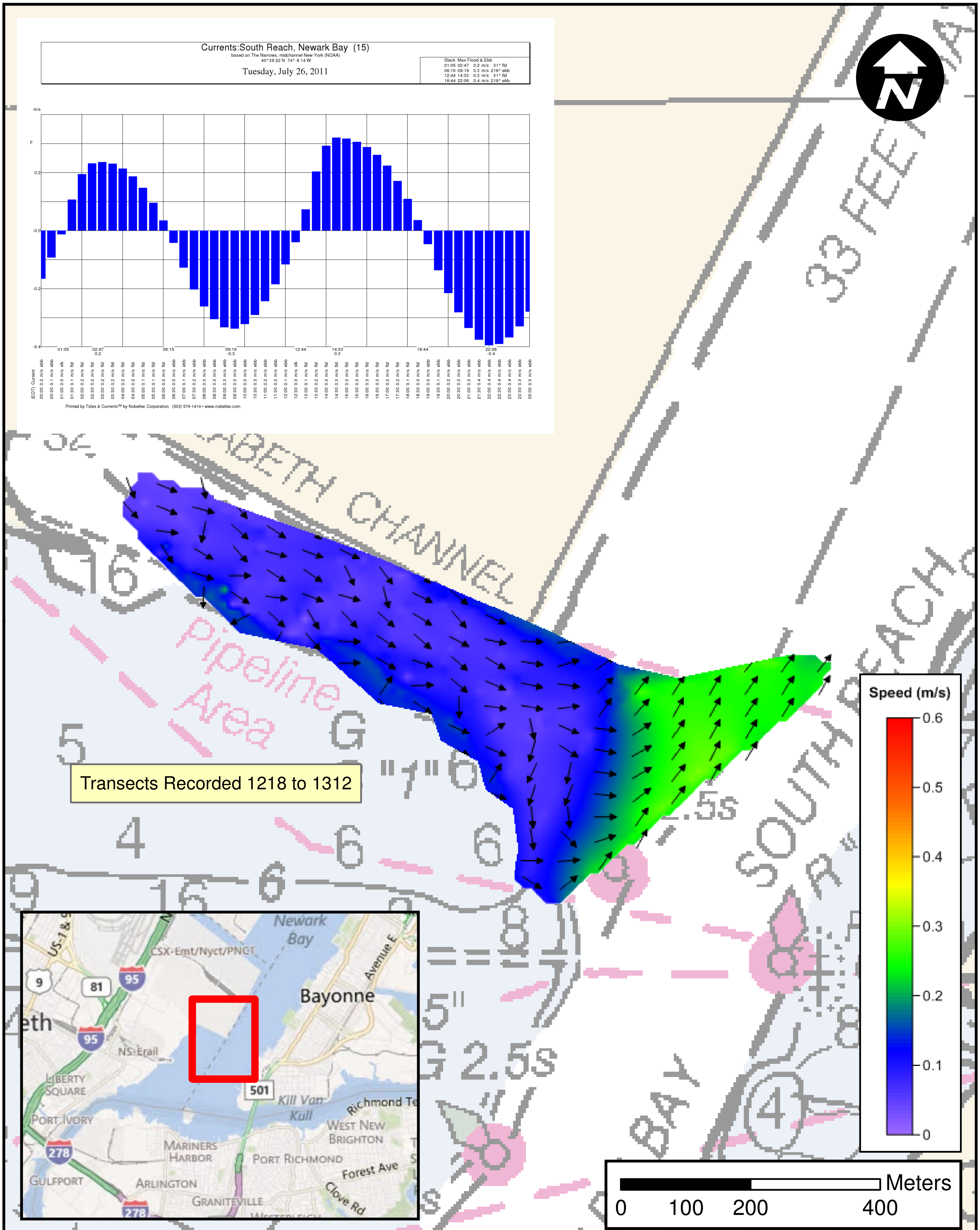


Figure	USACE Harborwide TSS *Far Field Survey* *HDP Contract Area: S-NB-2*	**Depth Averaged Velocities** **26 July 2011 - Flood Tide Hydrodynamic Survey**	Tide
2			Flood

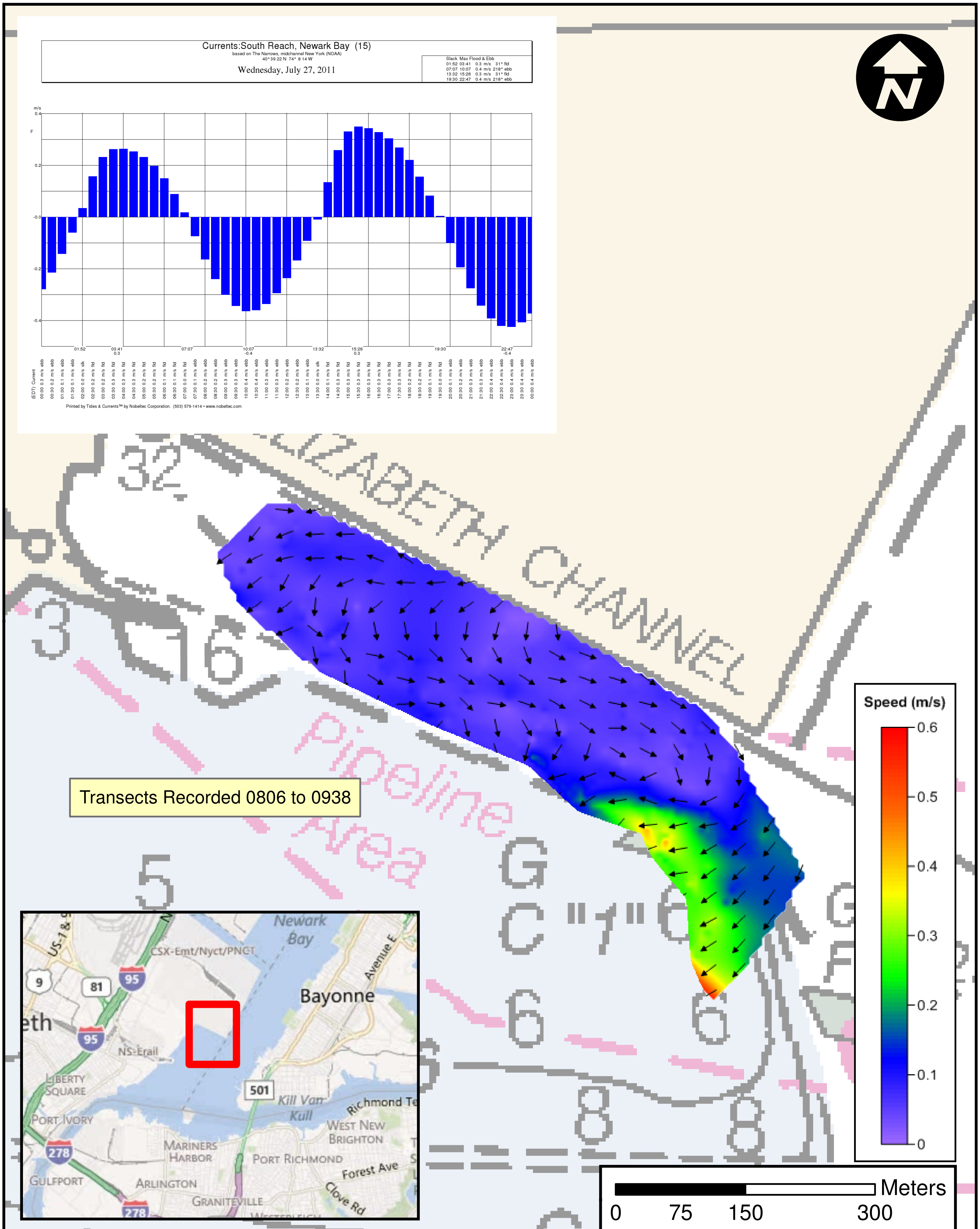


Figure	USACE Harborwide TSS *Far Field Survey* *HDP Contract Area: S-NB-2*	Depth Averaged Velocites 27 July 2011 - Ebb Tide Hydrodynamic Survey	Tide
3			Ebb

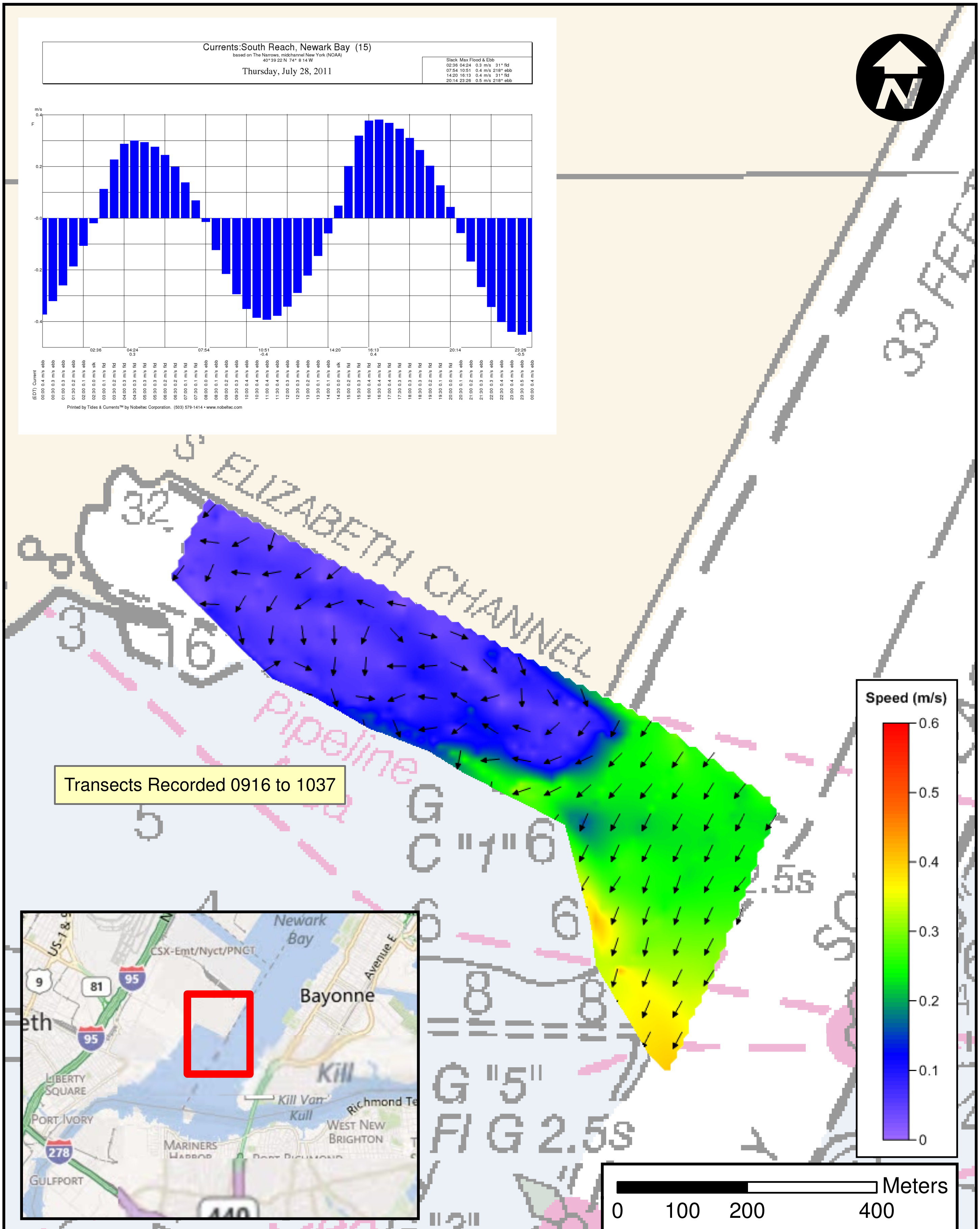


Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2*	**Depth Averaged Velocities** **28 July 2011 - Ebb Tide Hydrodynamic Survey**	**Tide**
4			**Ebb**

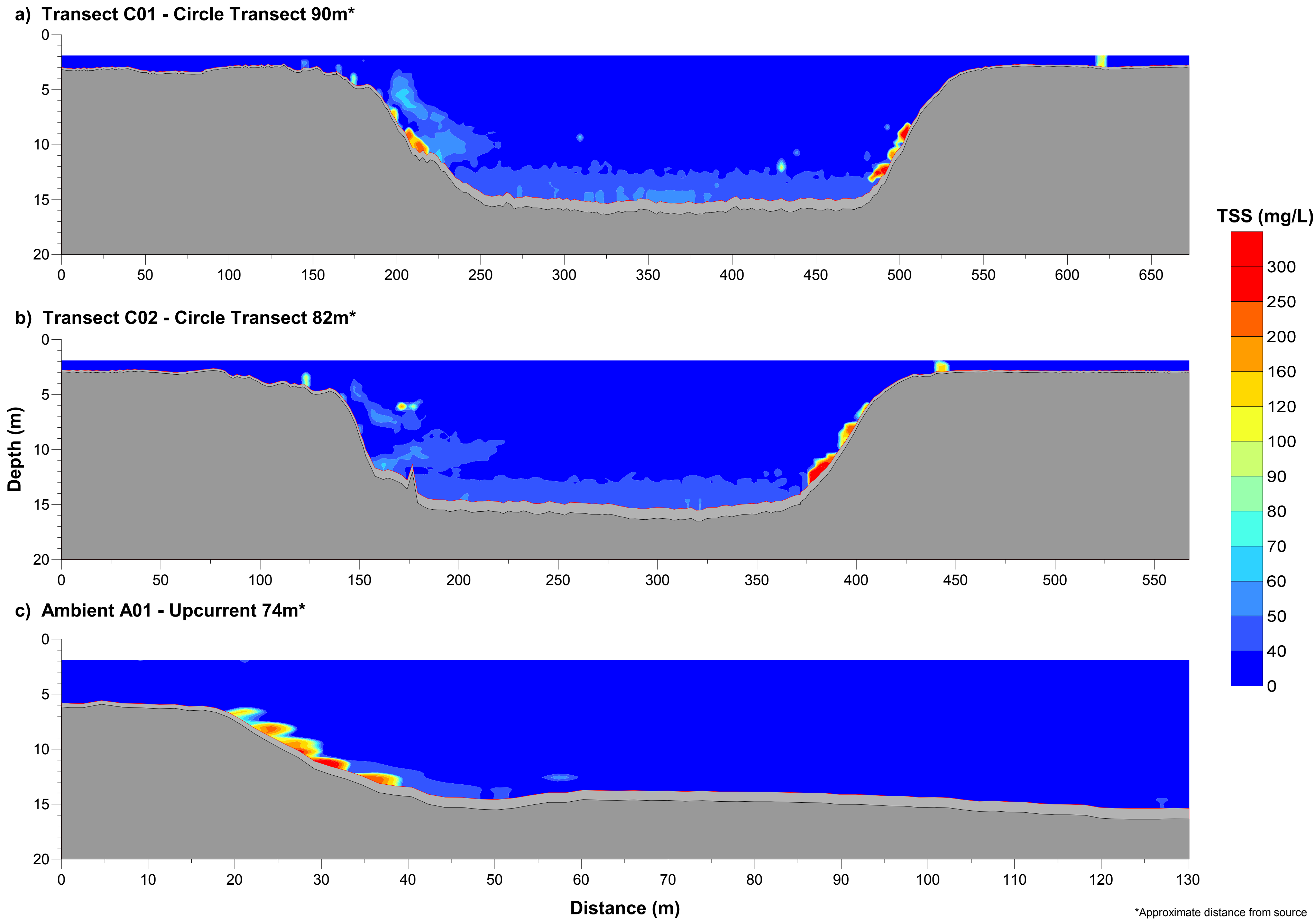


FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 25 July 2011 - Flood Tide**	TIDE
5a-c			**Flood**

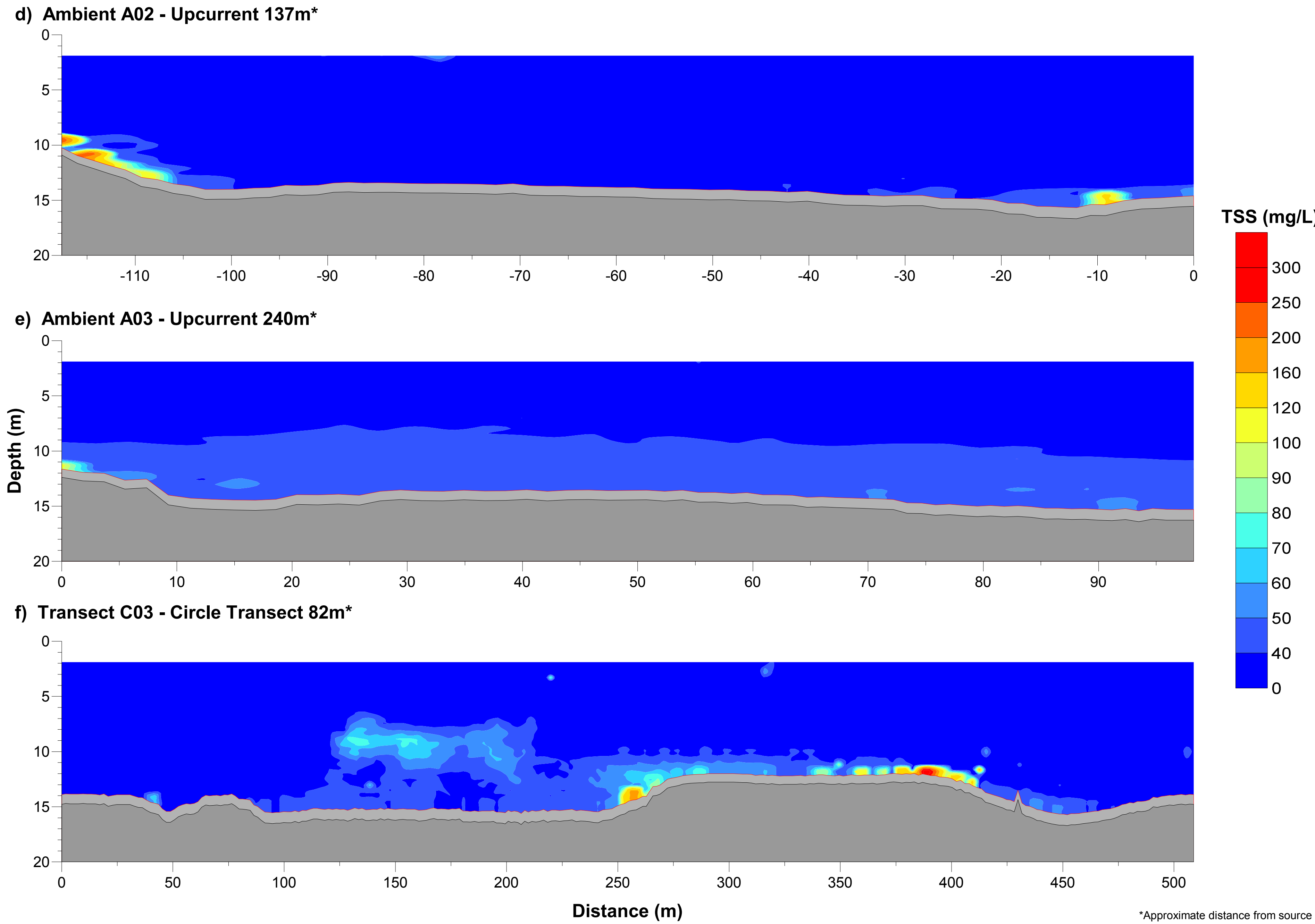


FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	Vertical Profiles of ADCP Average TSS 25 July 2011 - Flood Tide	TIDE
5d-f			Flood

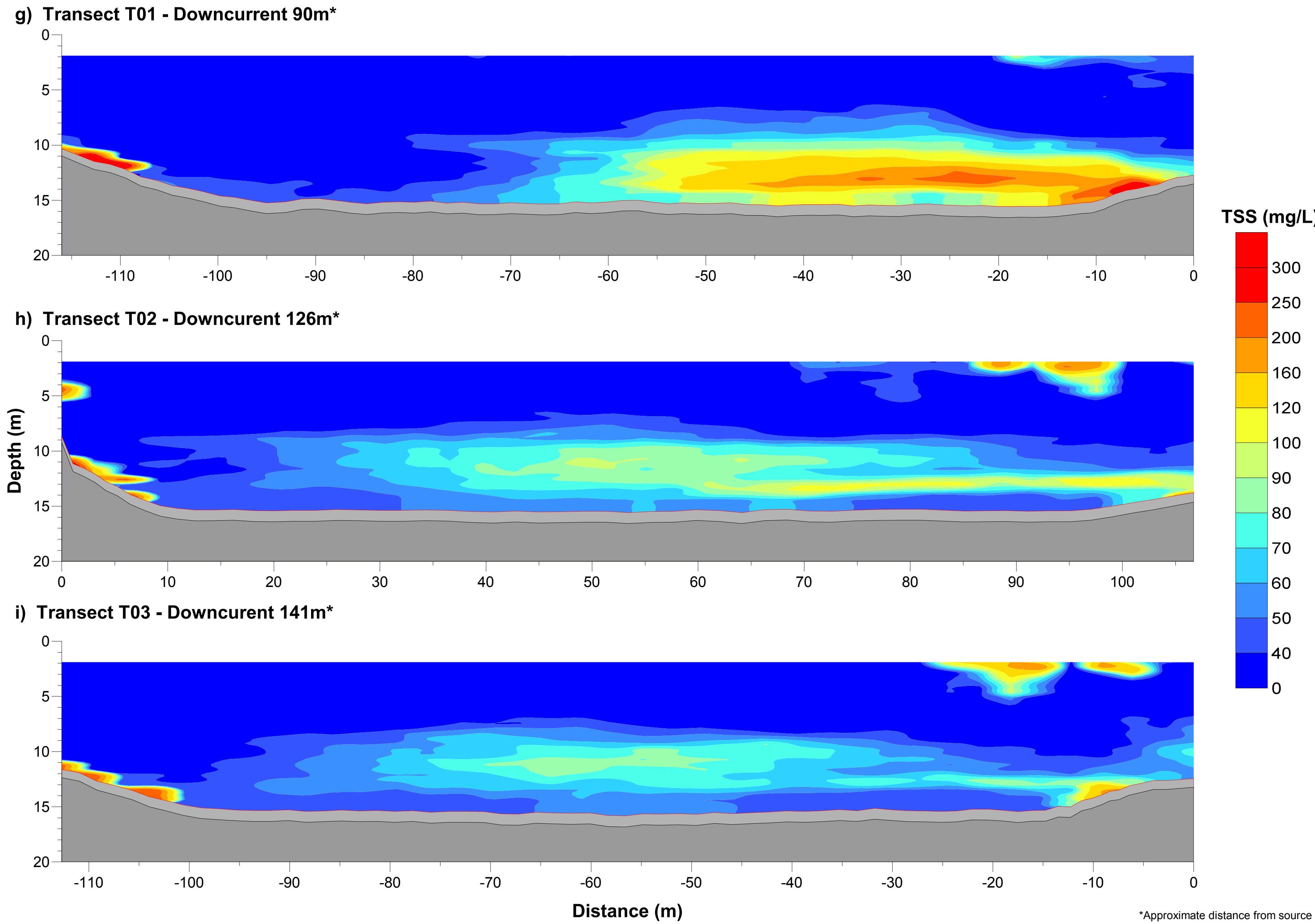


FIGURE			TIDE
5g-i	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS** **25 July 2011 - Flood Tide**	**Flood**

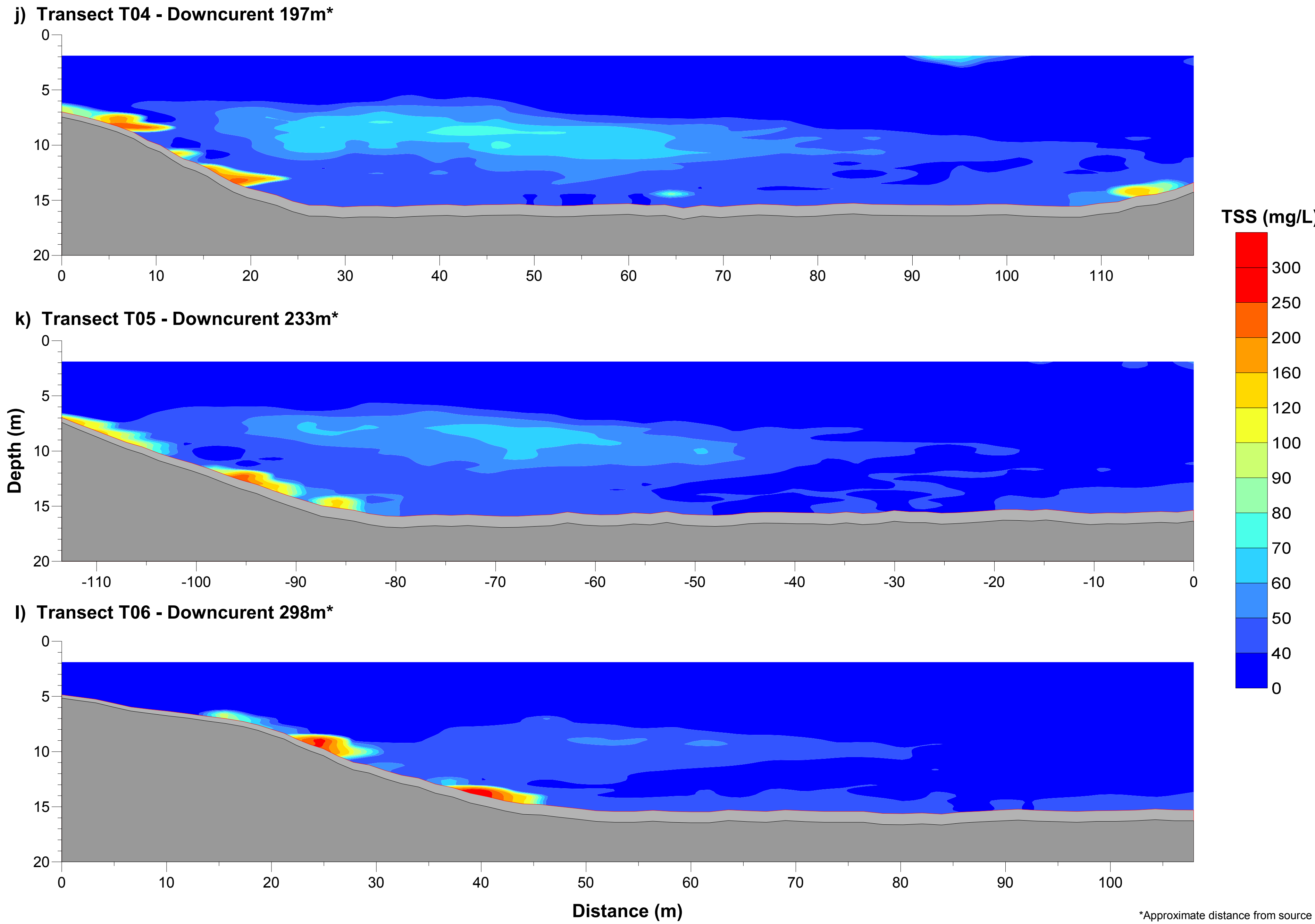


FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 25 July 2011 - Flood Tide	TIDE
5j-l			Flood

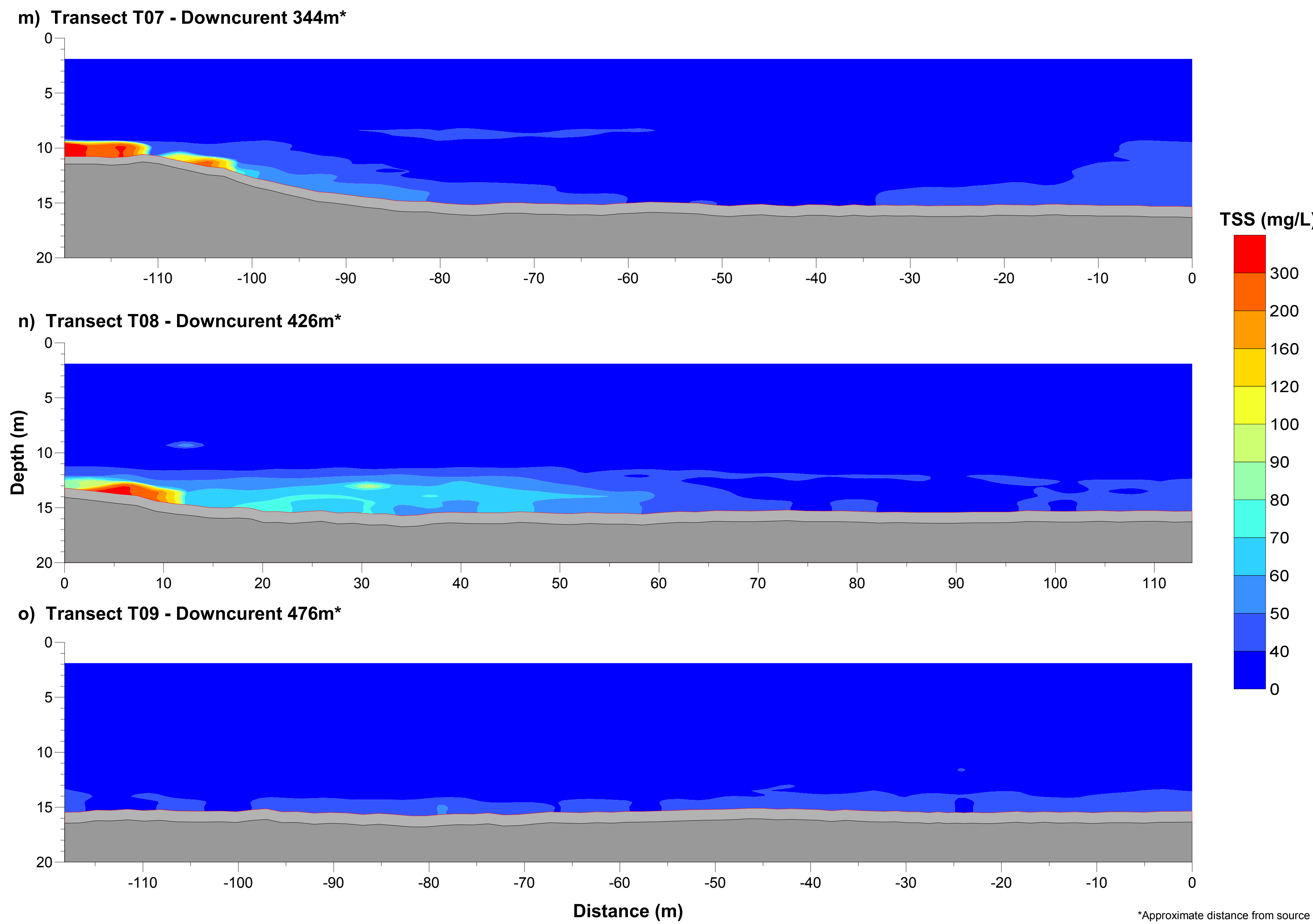


FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 25 July 2011 - Flood Tide	TIDE
5m-o			Flood

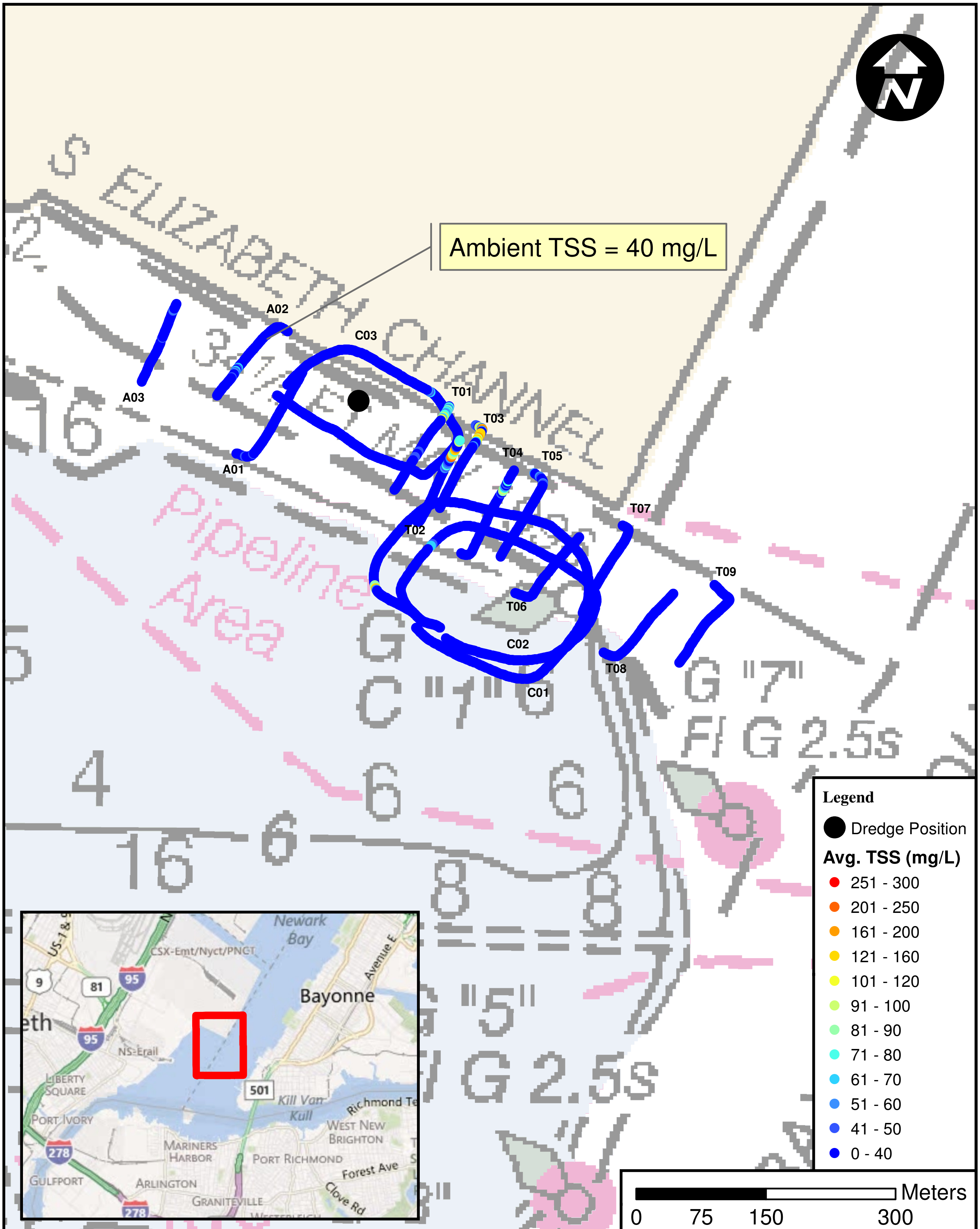


Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2*	**ADCP Average TSS - 25 July 2011 0-2 Meter Depth Interval**	Tide
6a			Flood

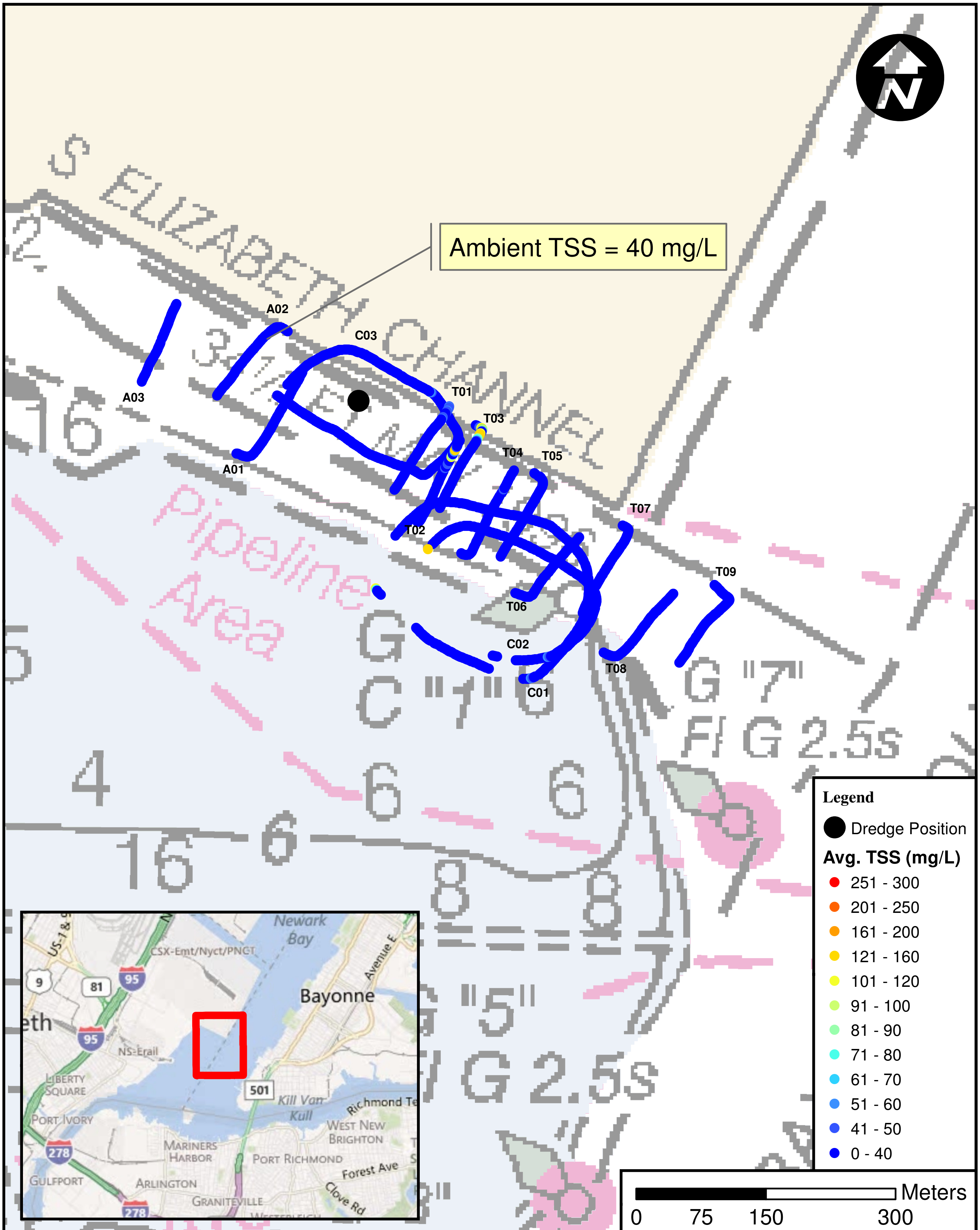


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 25 July 2011 2-4 Meter Depth Interval	Tide
6b			Flood

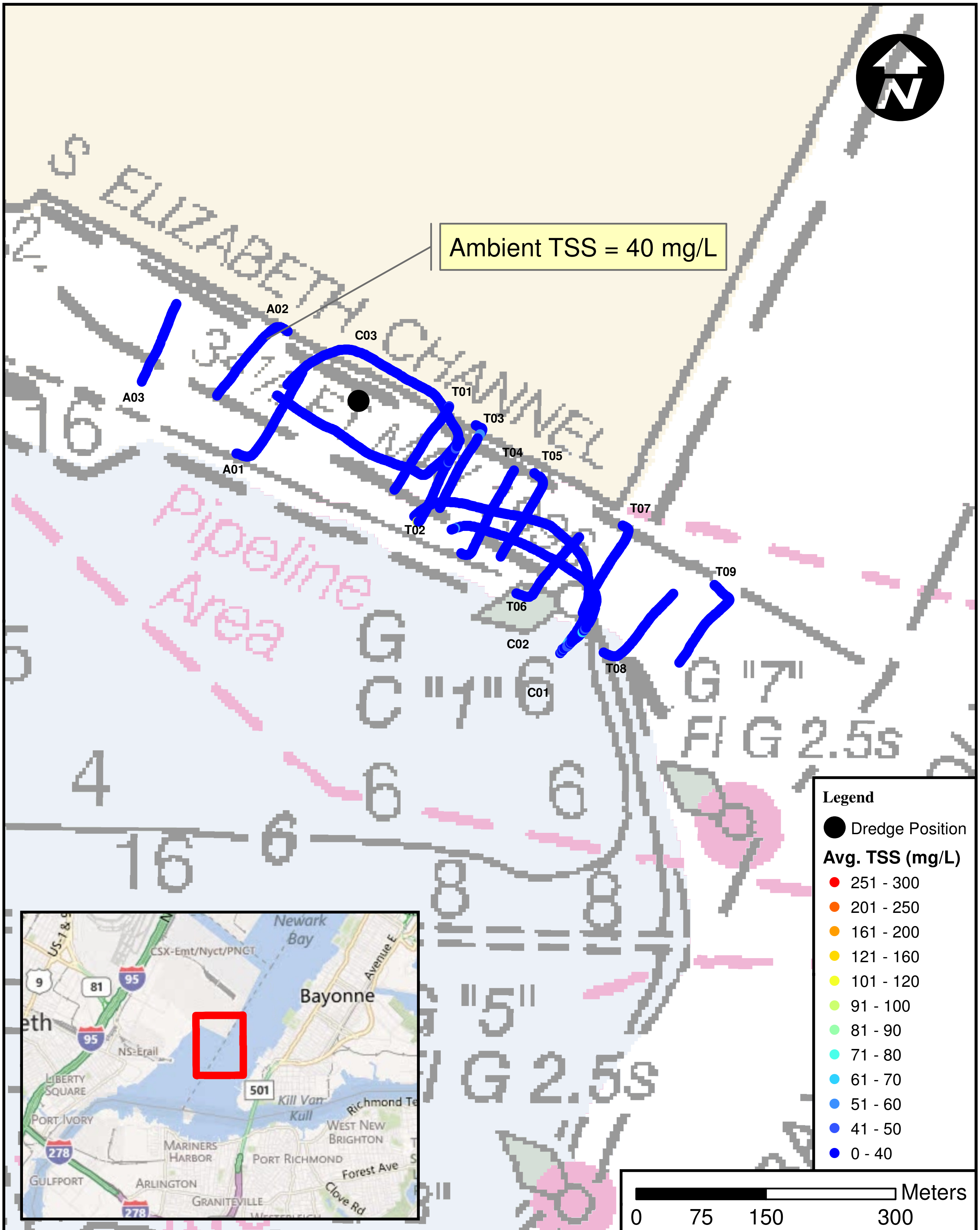


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 25 July 2011 4-6 Meter Depth Interval	Tide
6c			Flood

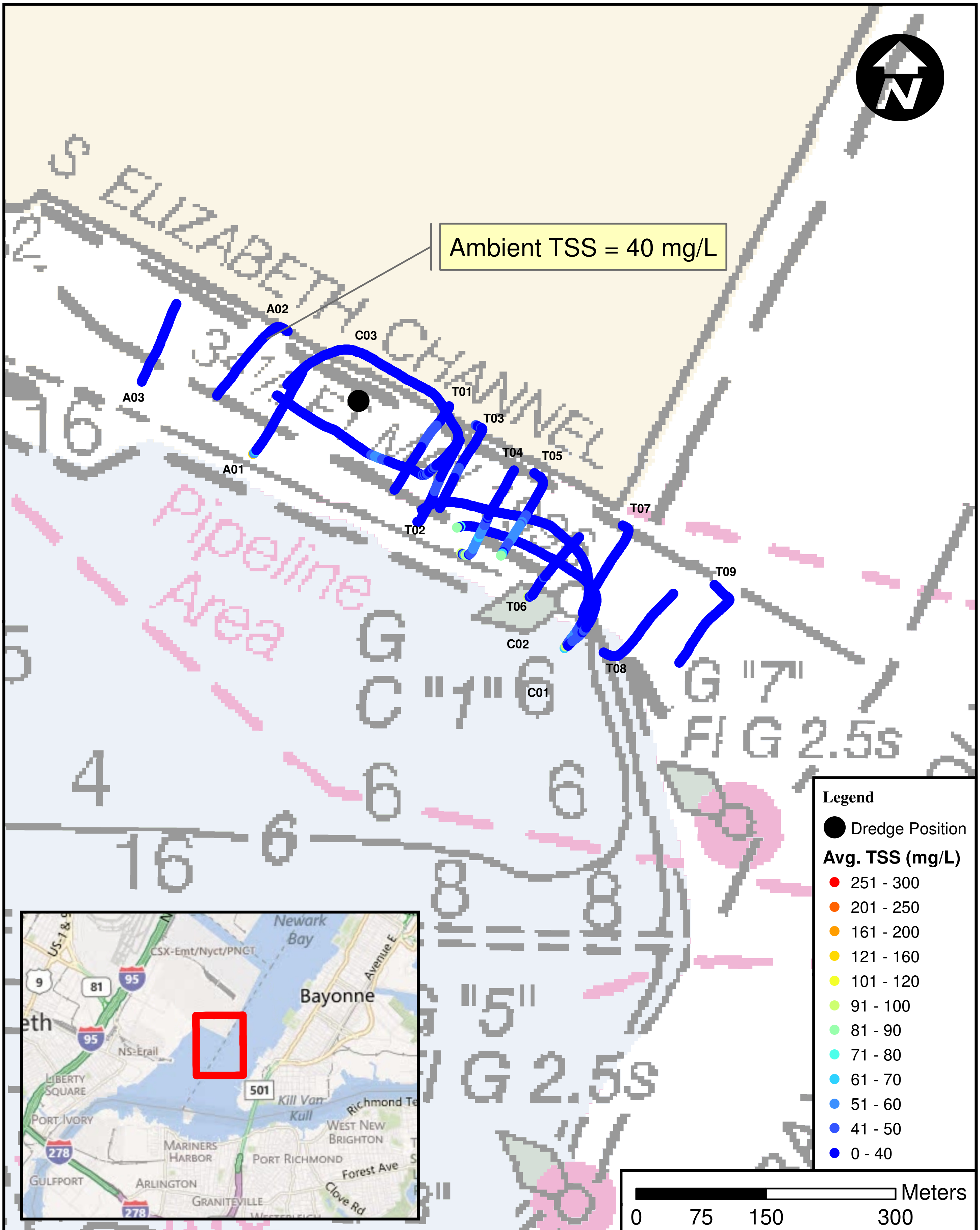


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 25 July 2011 6-8 Meter Depth Interval	Tide
6d			Flood

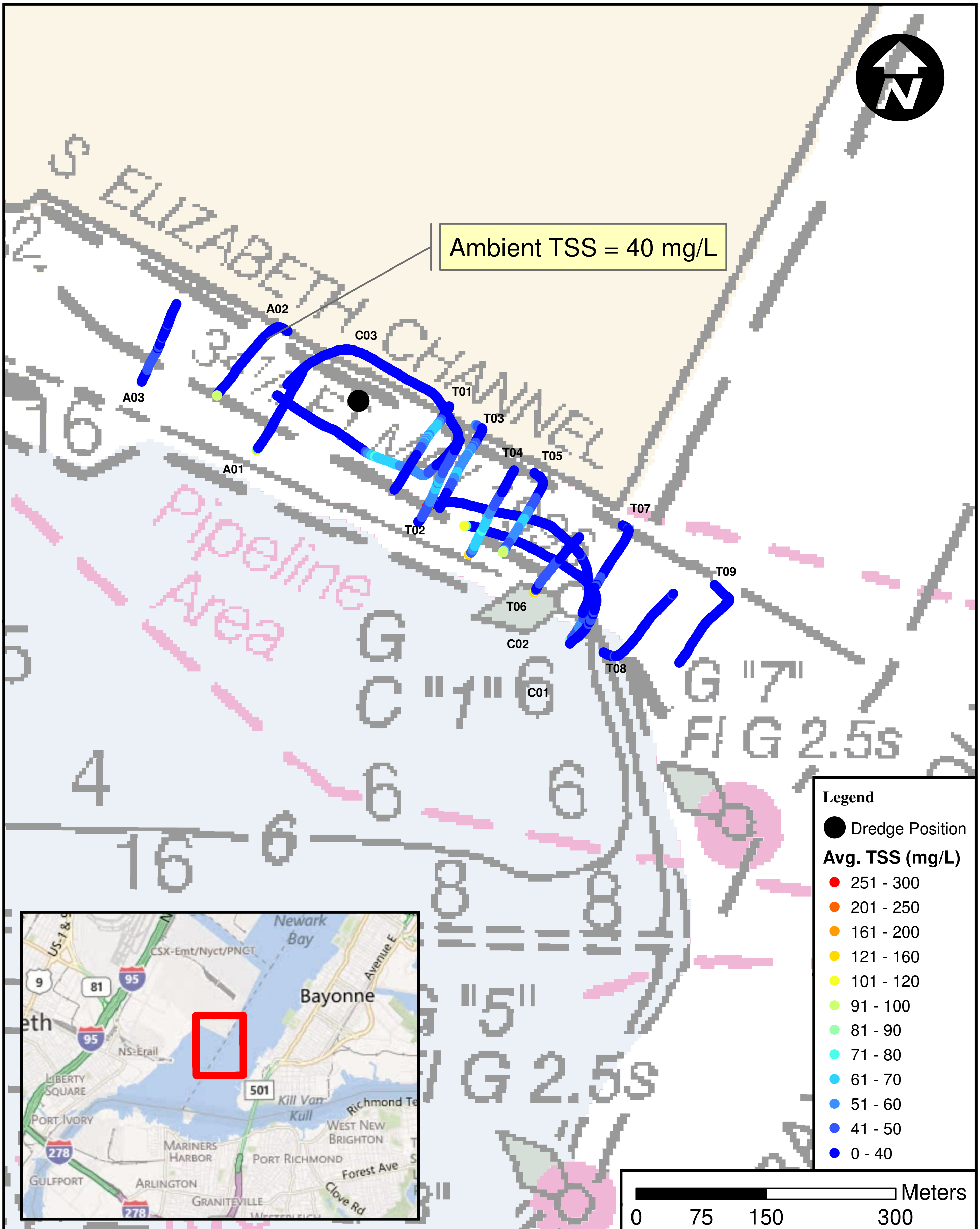


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 25 July 2011 8-10 Meter Depth Interval	Tide
6e			Flood

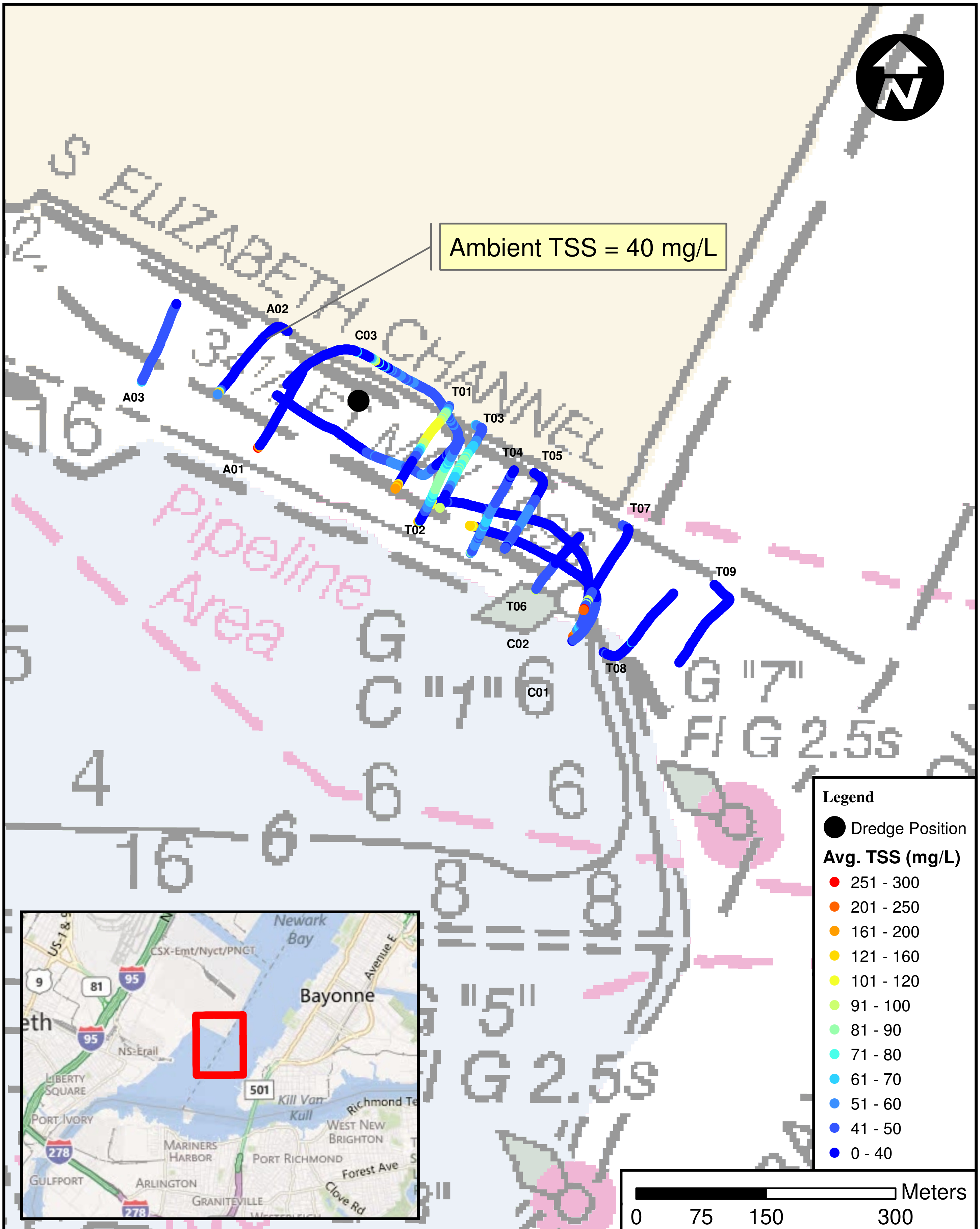


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 25 July 2011 10-12 Meter Depth Interval	Tide
6f			Flood

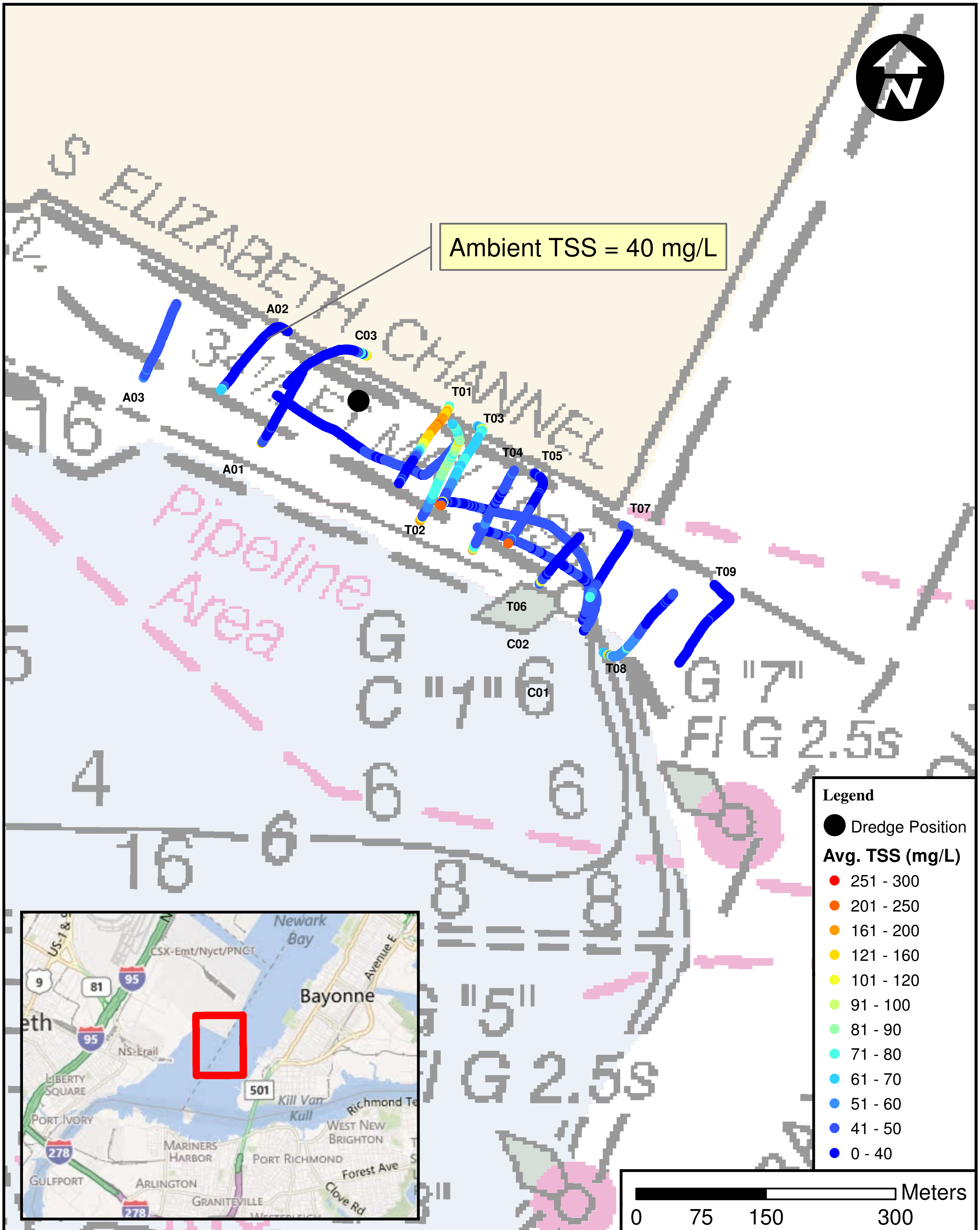


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-2*	**ADCP Average TSS - 25 July 2011** **12-14 Meter Depth Interval**	**Tide**
6g			**Flood**

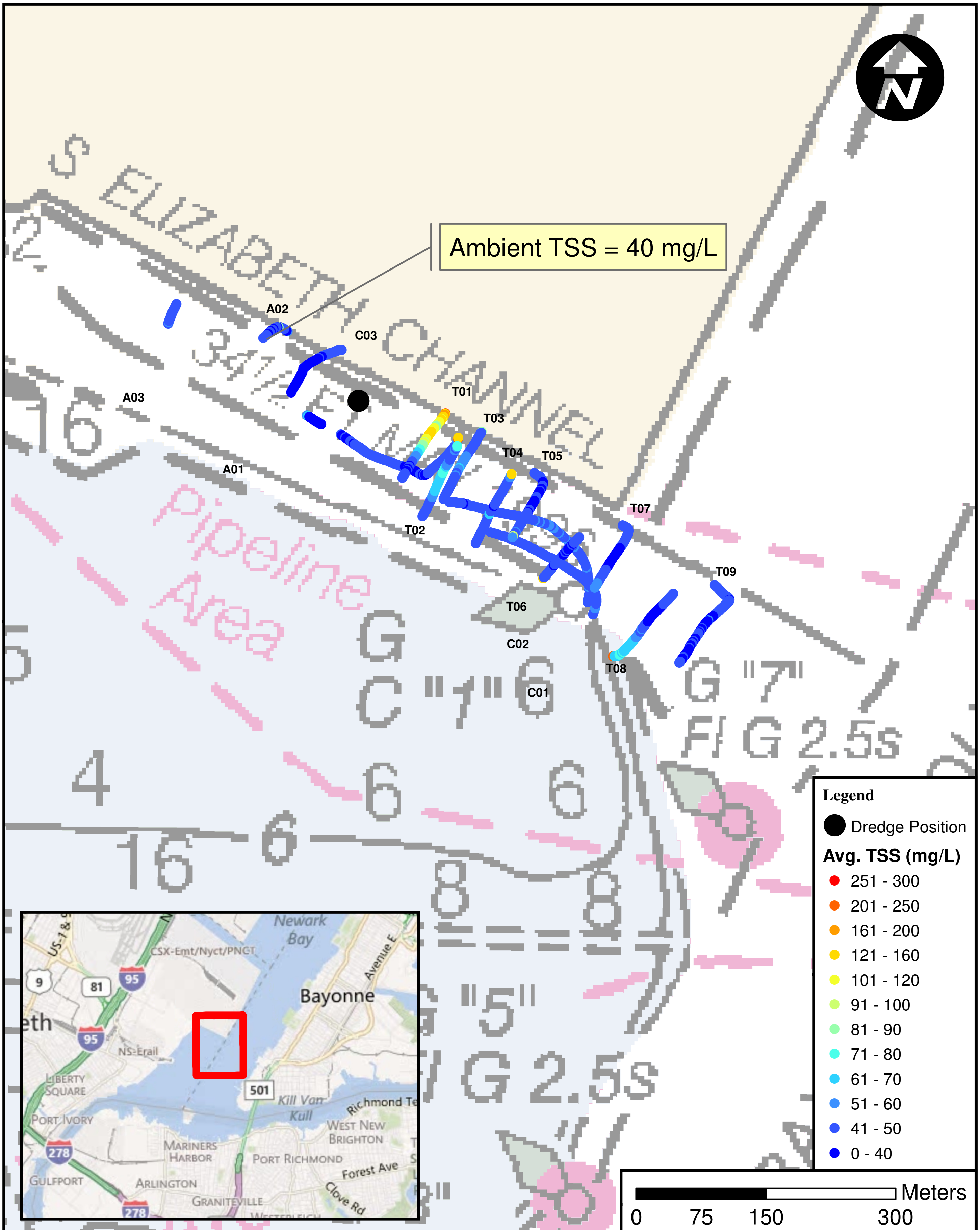
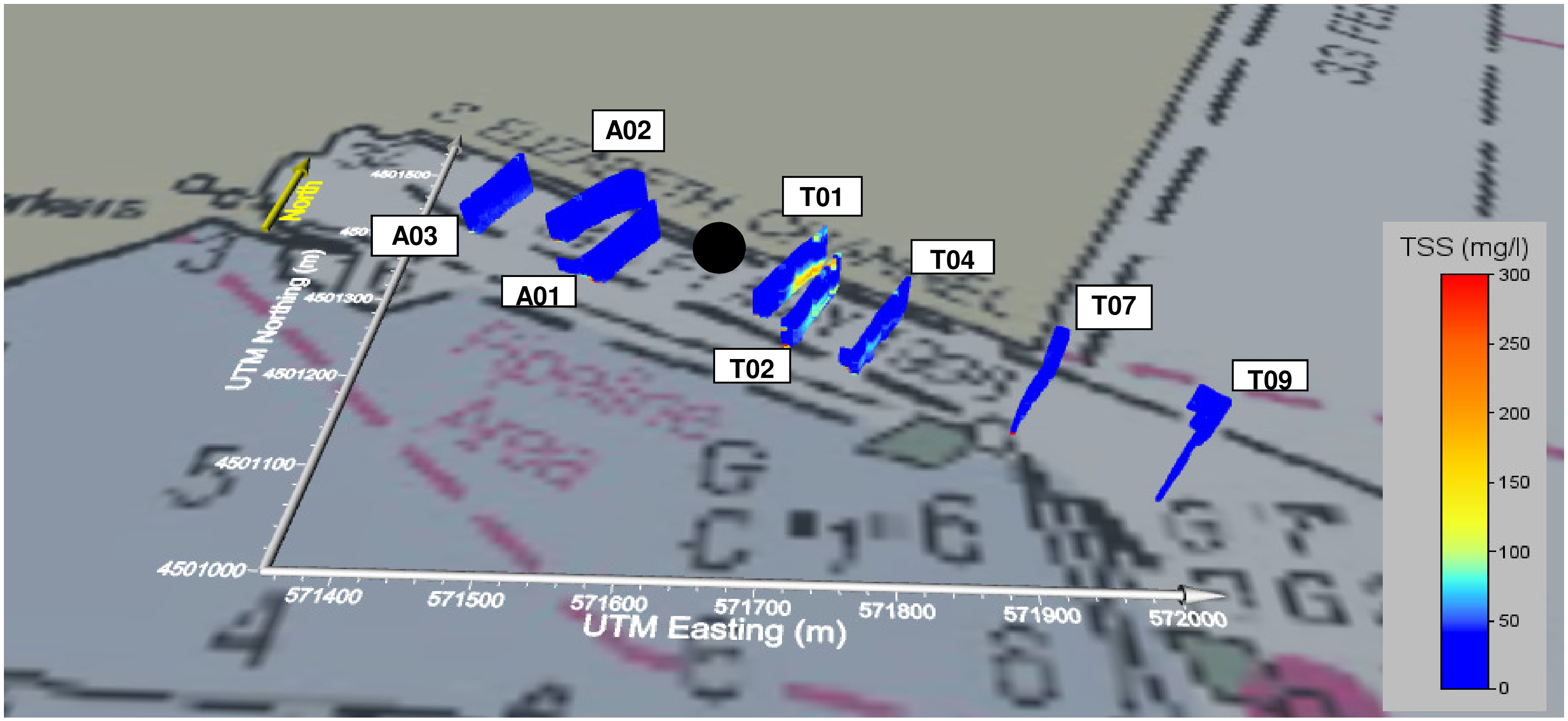


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 25 July 2011 14-16 Meter Depth Interval	Tide
6h			Flood



= Dredge Location

Z scale exaggerated 6X

Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area S-NB-2*	ADCP Average TSS Values, 3D View of Selected Transects 25 July 2011	Tide
7			Flood

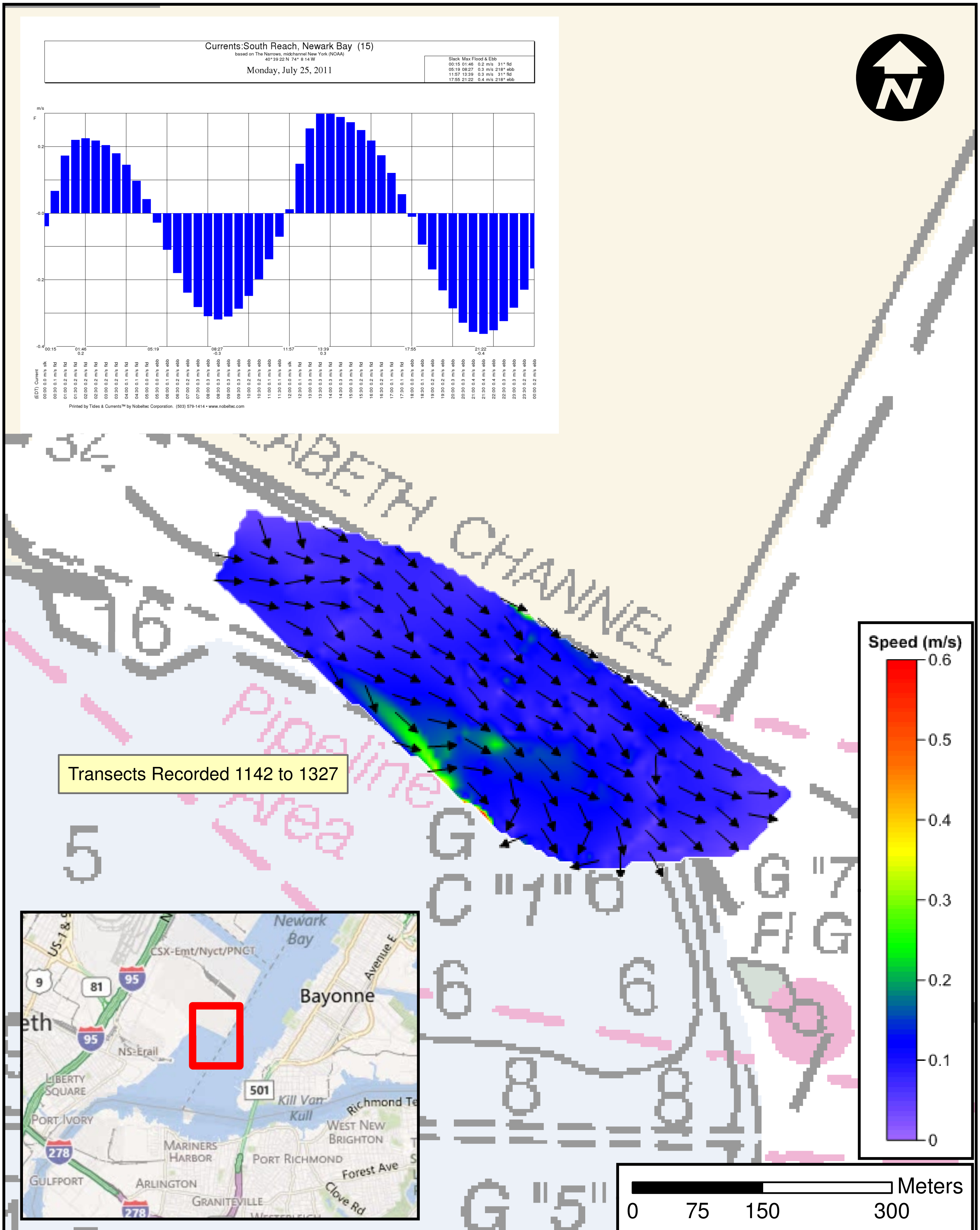


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	Depth Averaged Velocities 25 July 2011 - Flood Tide TSS Survey	Tide
8			Flood

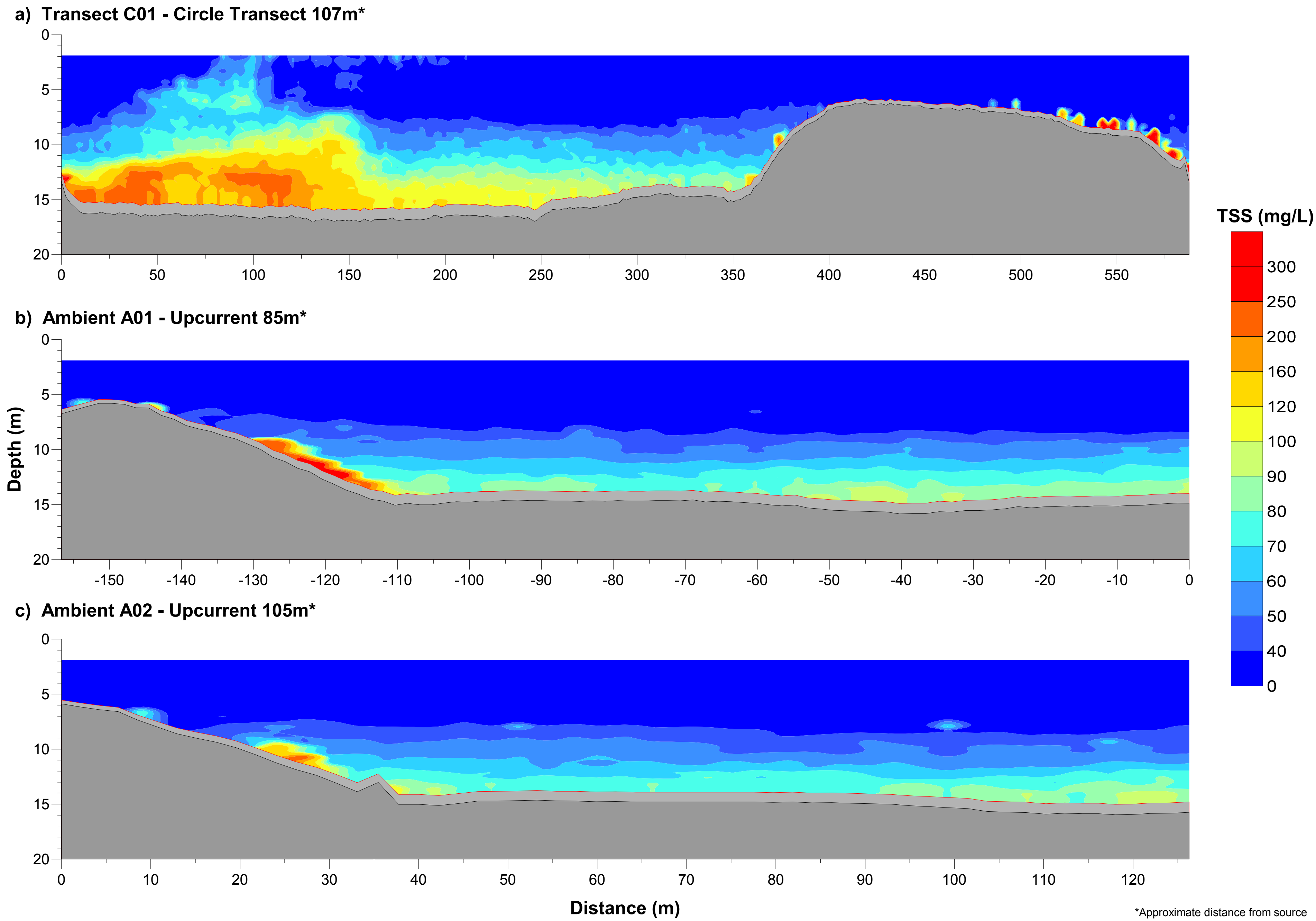


FIGURE			TIDE
9a-c	*USACE Harborwide TSS* *Far Field Survey* *S-NB-2*	**Vertical Profiles of ADCP Average TSS** **26 July 2011 - Flood Tide**	**Flood**

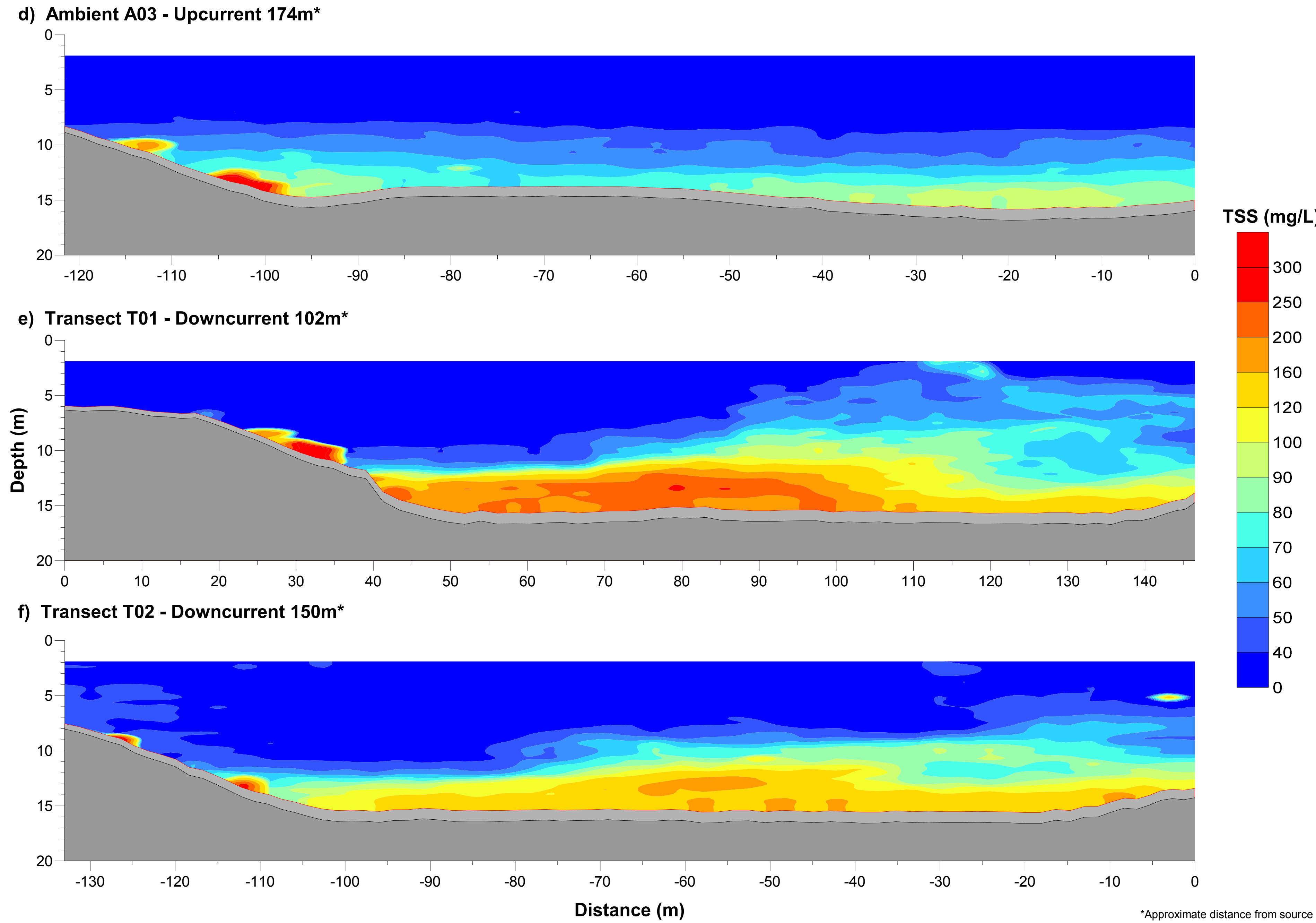


FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 26 July 2011 - Flood Tide**	TIDE
9d-f			Flood

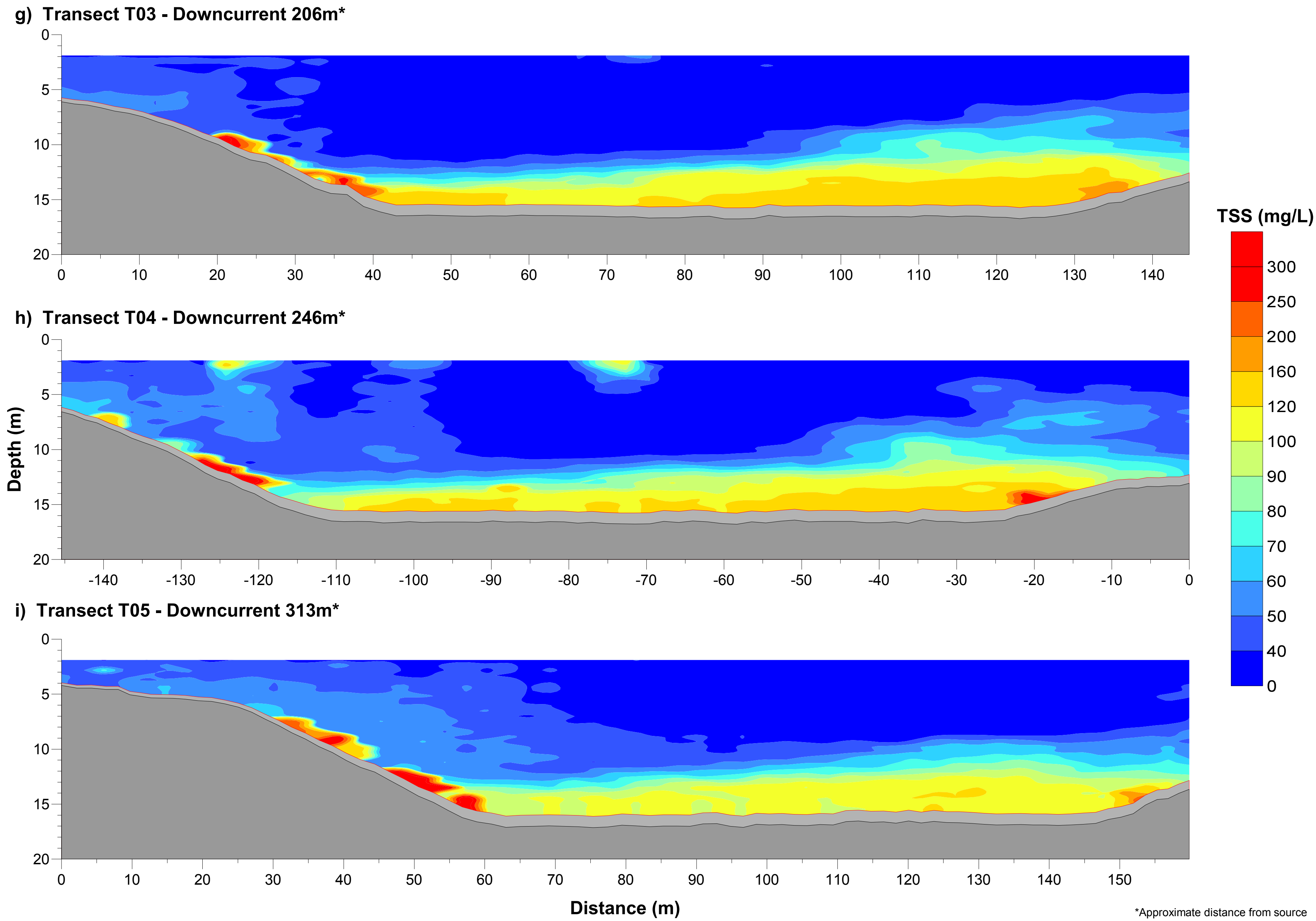
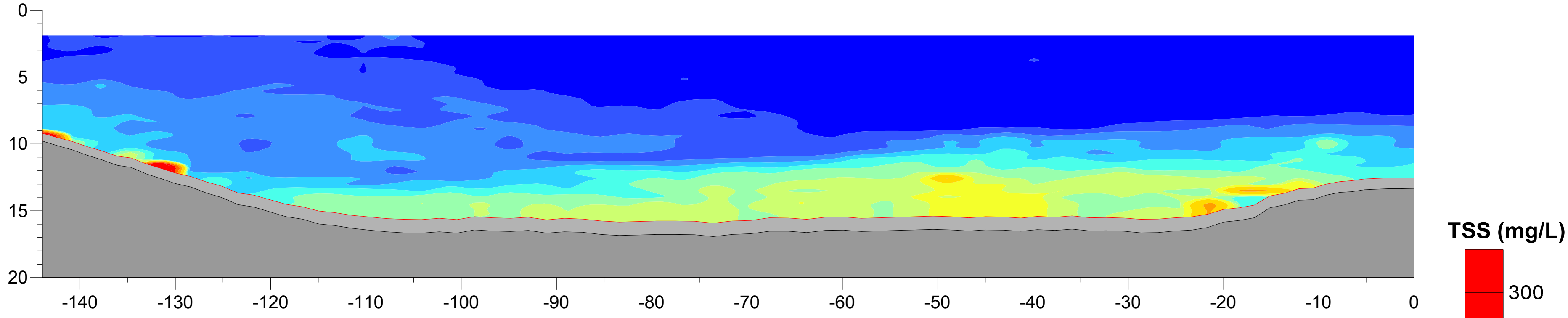
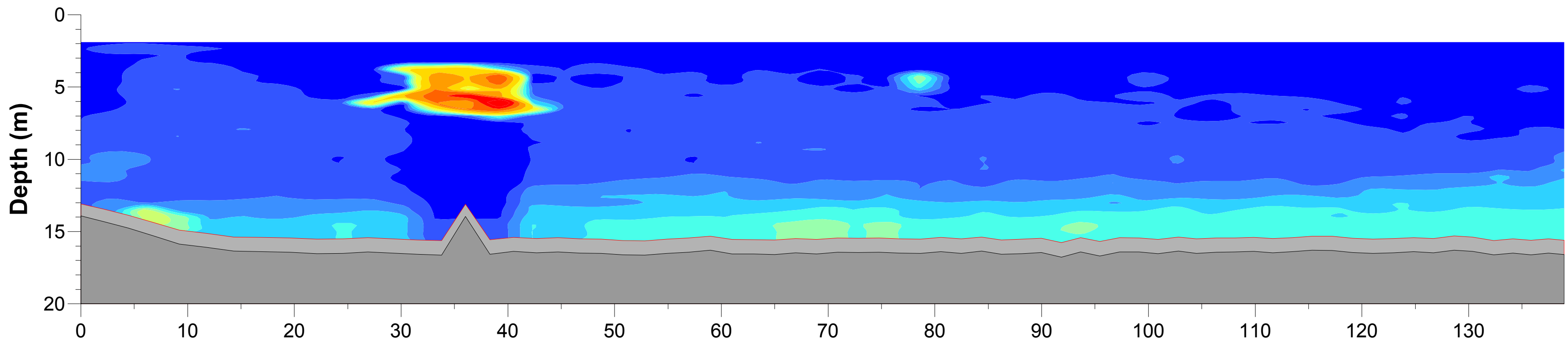


FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 26 July 2011 - Flood Tide**	TIDE
9g-i			**Flood**

j) Transect T06 - Downcurrent 384m*



k) Transect T07 - Downcurrent 476m*



*Approximate distance from source

FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	Vertical Profiles of ADCP Average TSS 26 July 2011 - Flood Tide	TIDE
9j-k			Flood

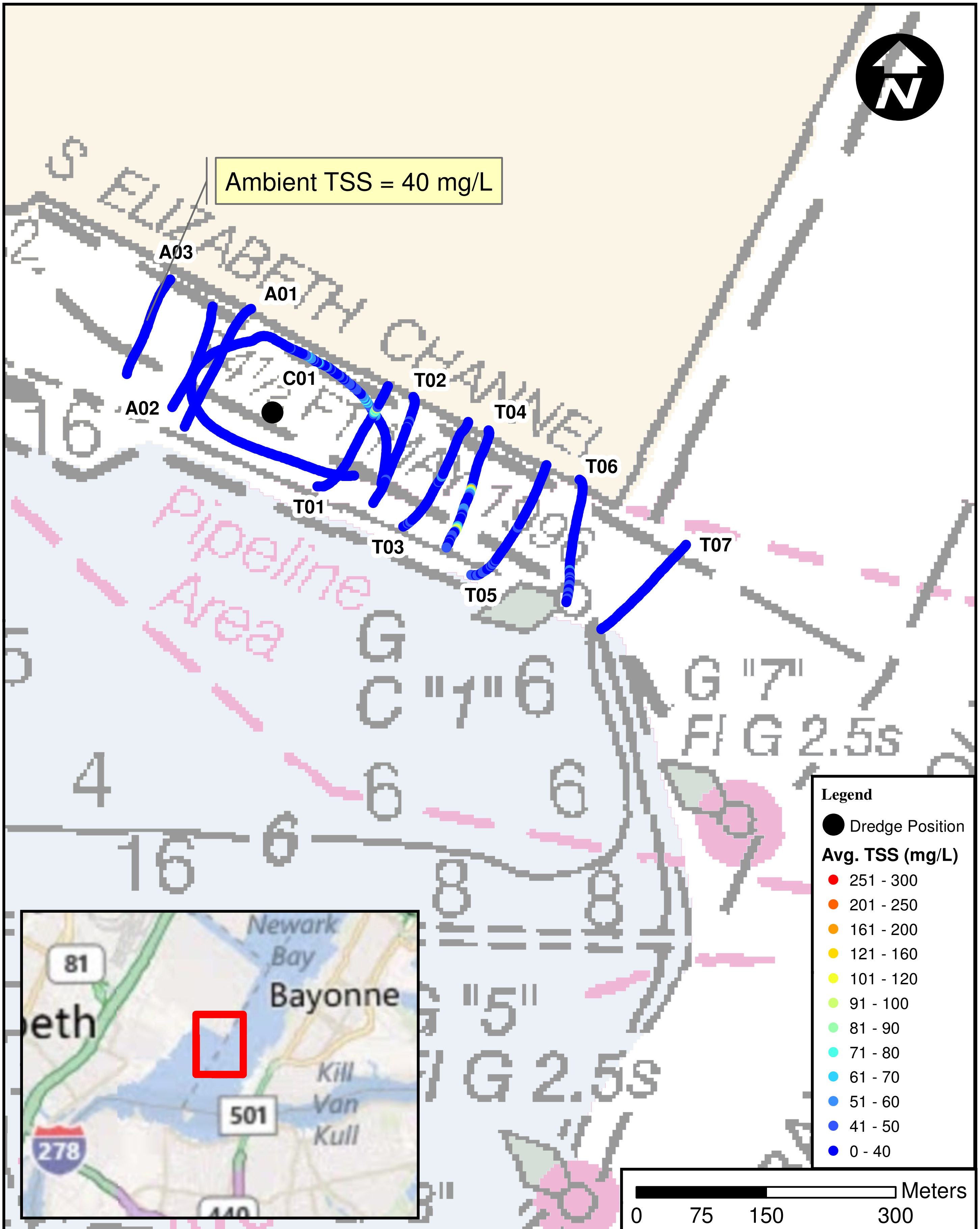


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 26 July 2011 0-2 Meter Depth Interval	Tide
10a			Flood

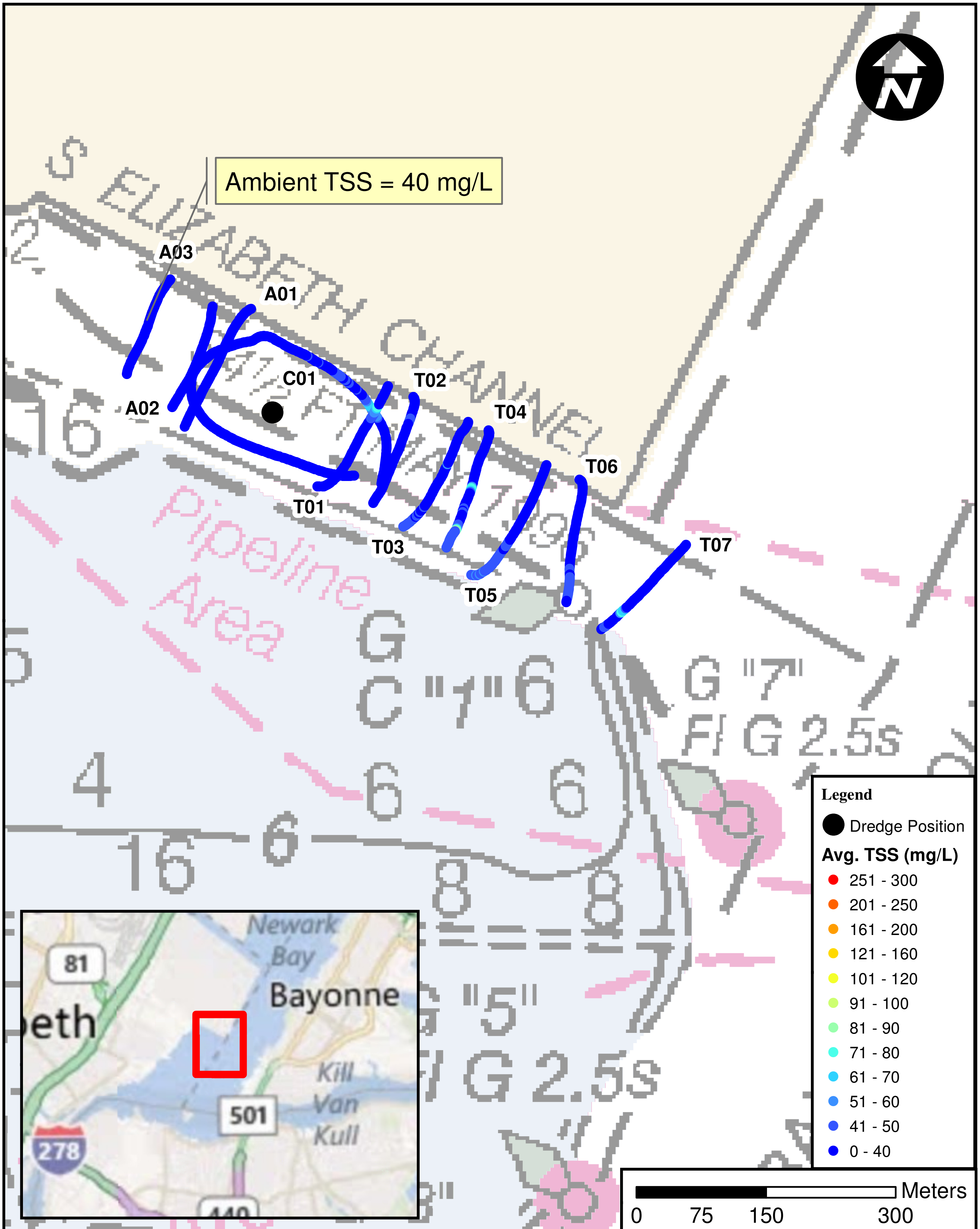


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-2*	**ADCP Average TSS - 26 July 2011** **2-4 Meter Depth Interval**	Tide
10b			Flood

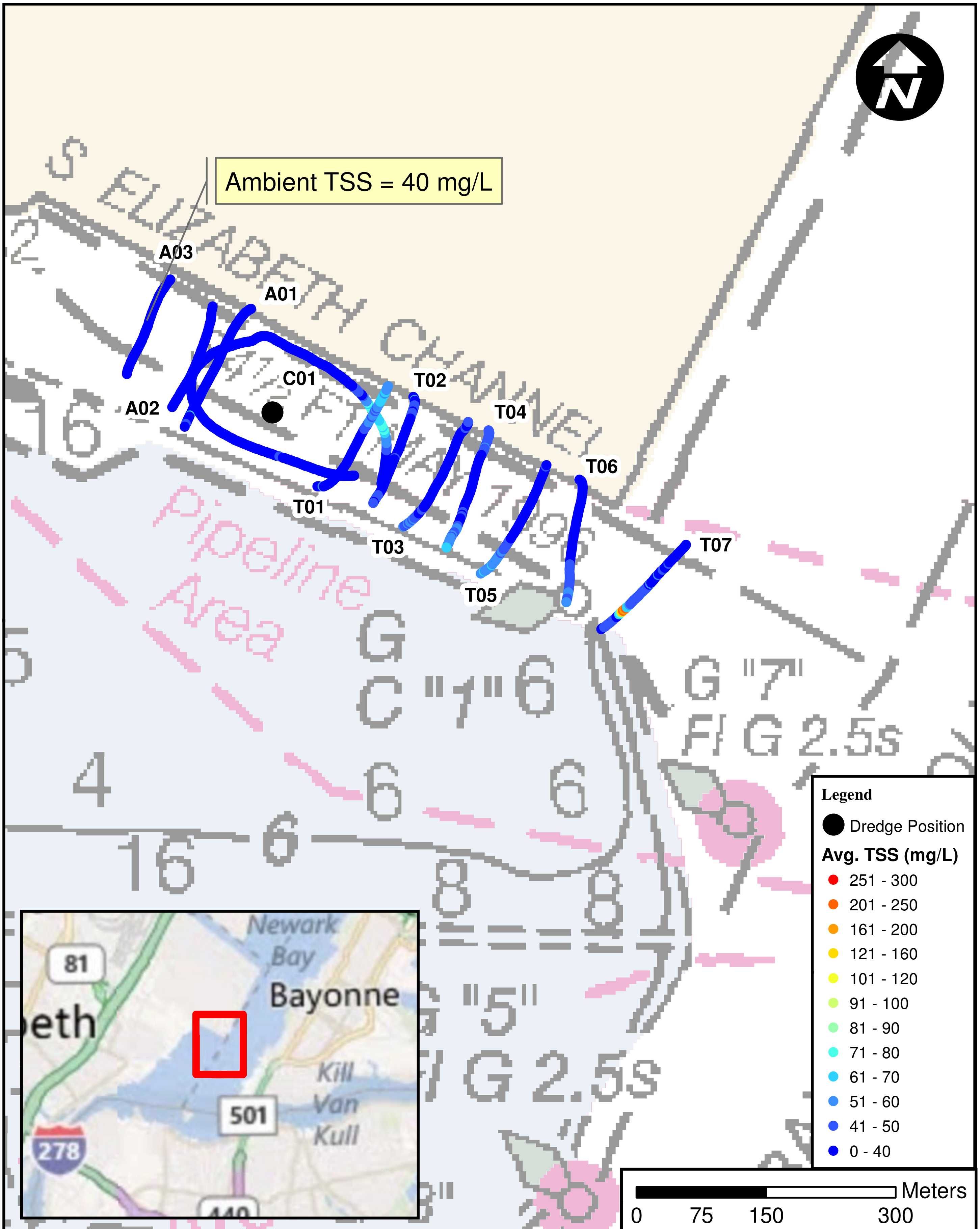


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-2*	**ADCP Average TSS - 26 July 2011** **4-6 Meter Depth Interval**	**Tide**
10c			**Flood**

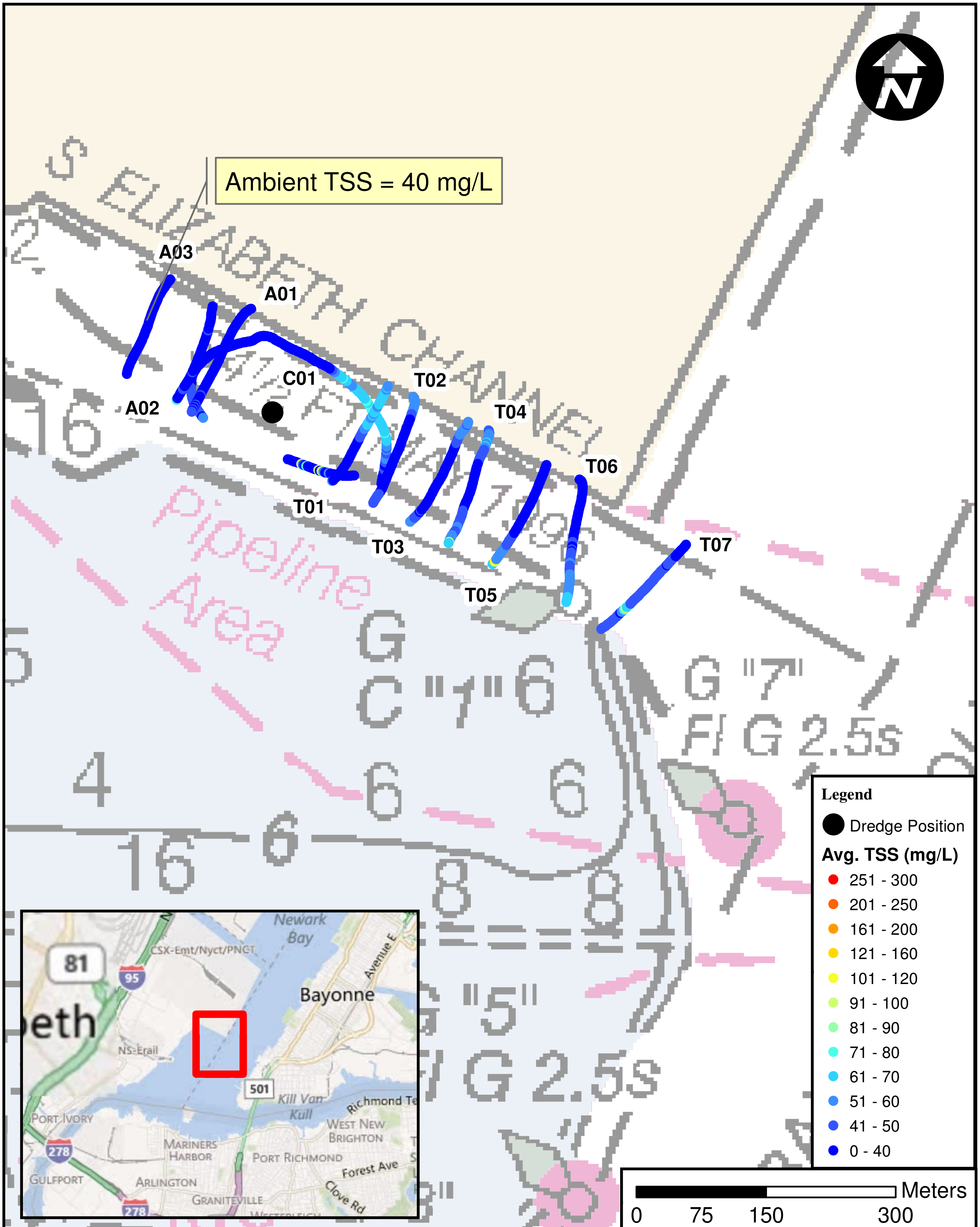


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-2*	**ADCP Average TSS - 26 July 2011** **6-8 Meter Depth Interval**	**Tide**
10d			**Flood**

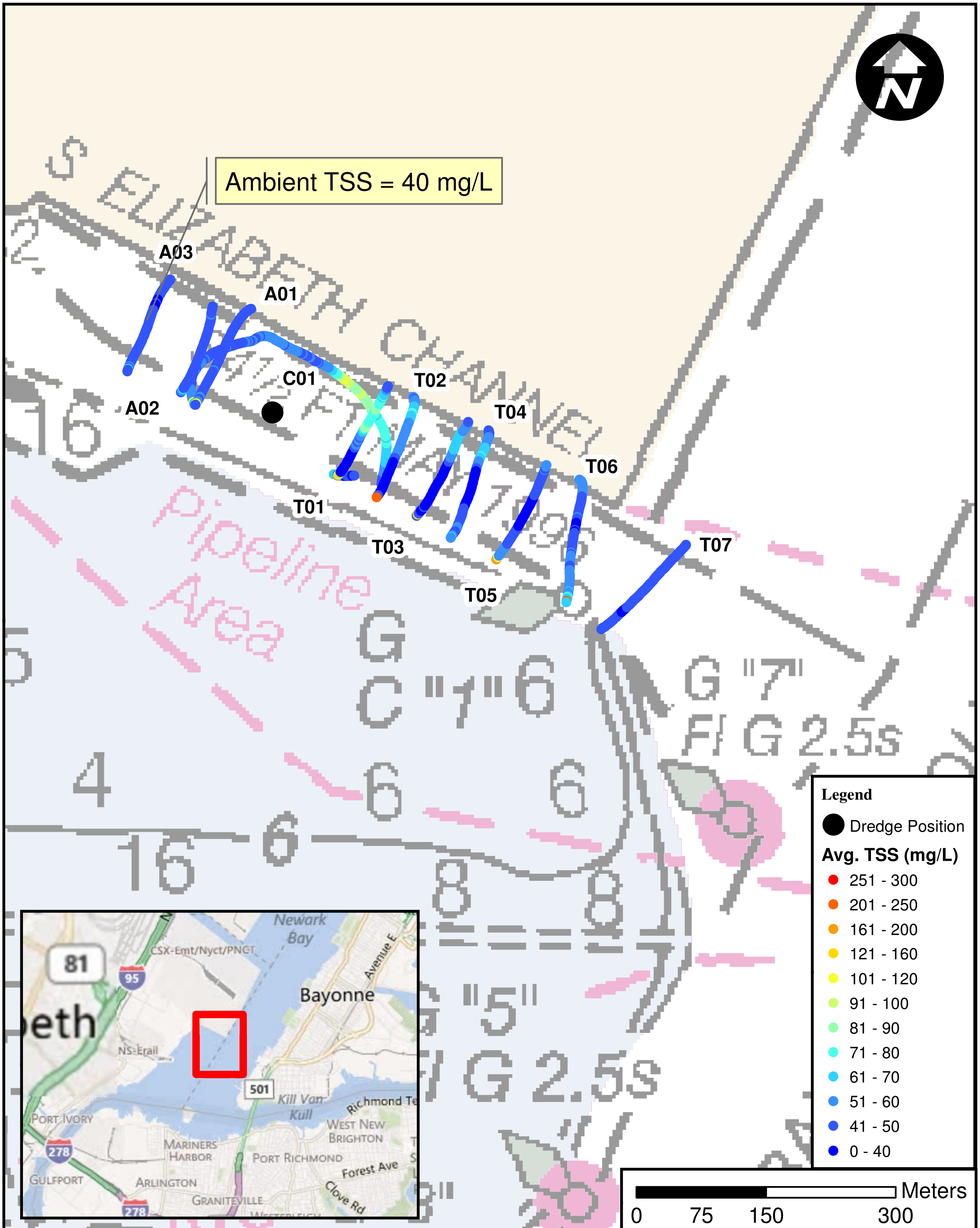


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 26 July 2011 8-10 Meter Depth Interval	Tide
10e			Flood

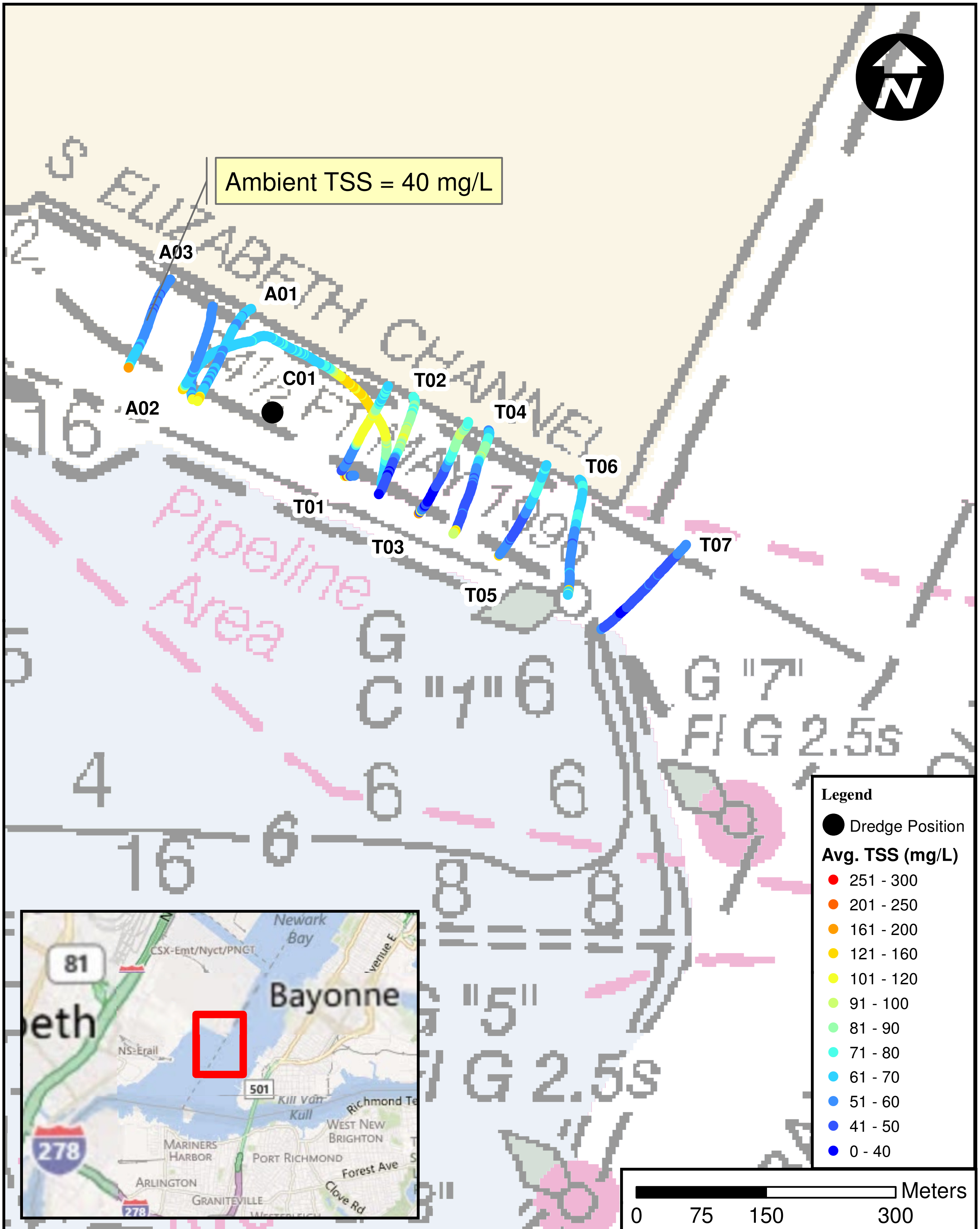


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 26 July 2011 10-12 Meter Depth Interval	Tide
10f			Flood

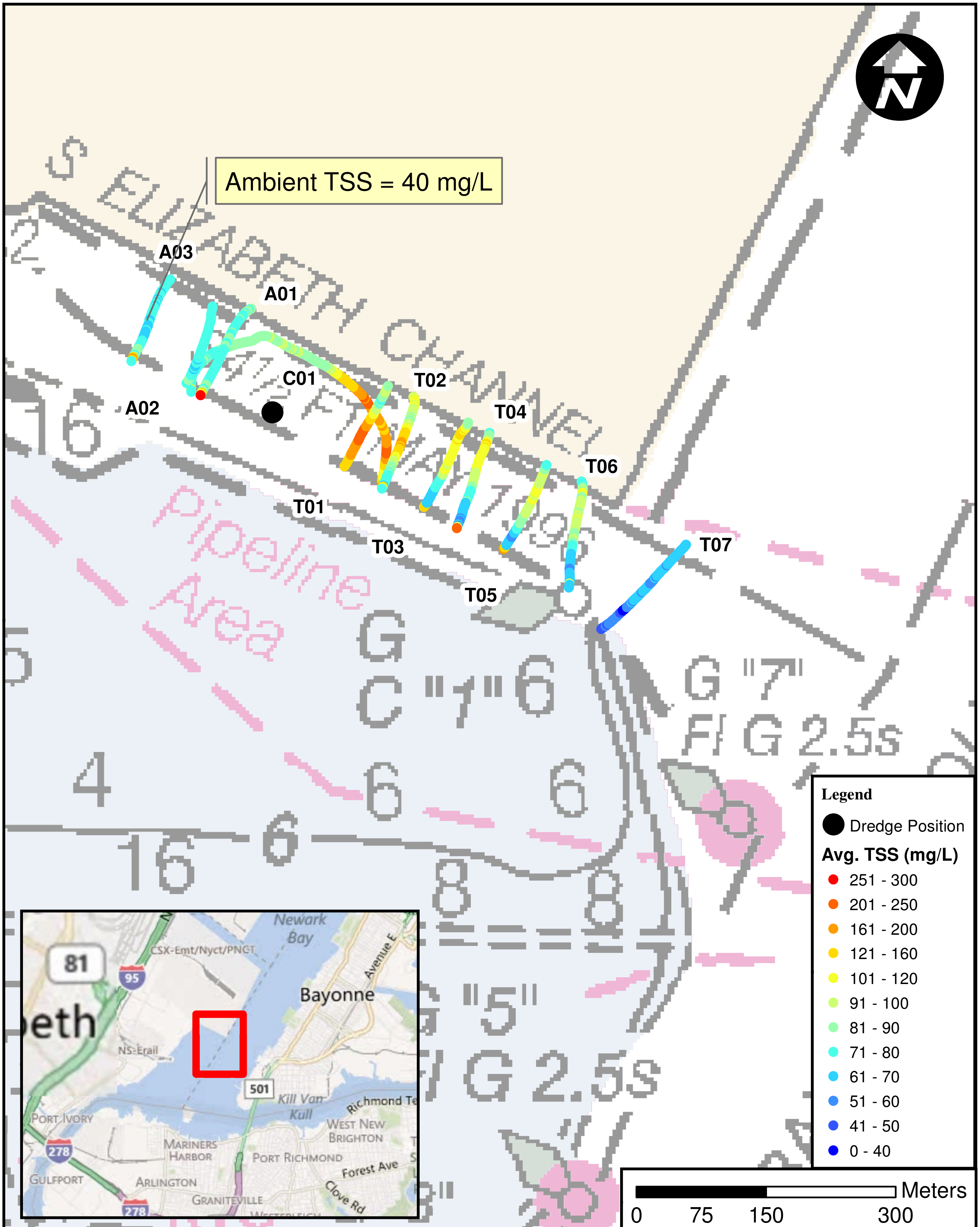


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 26 July 2011 12-14 Meter Depth Interval	Tide
10g			Flood

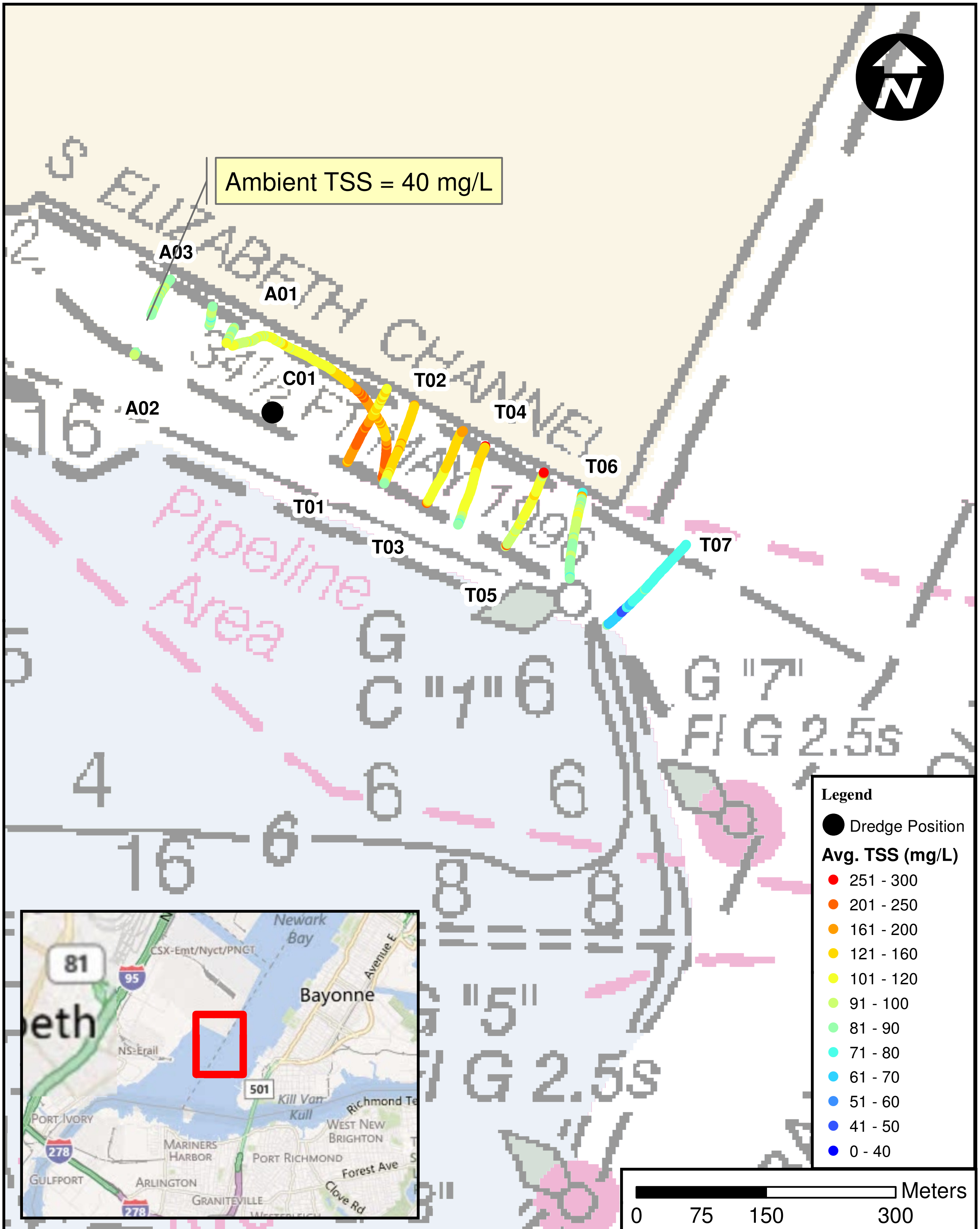
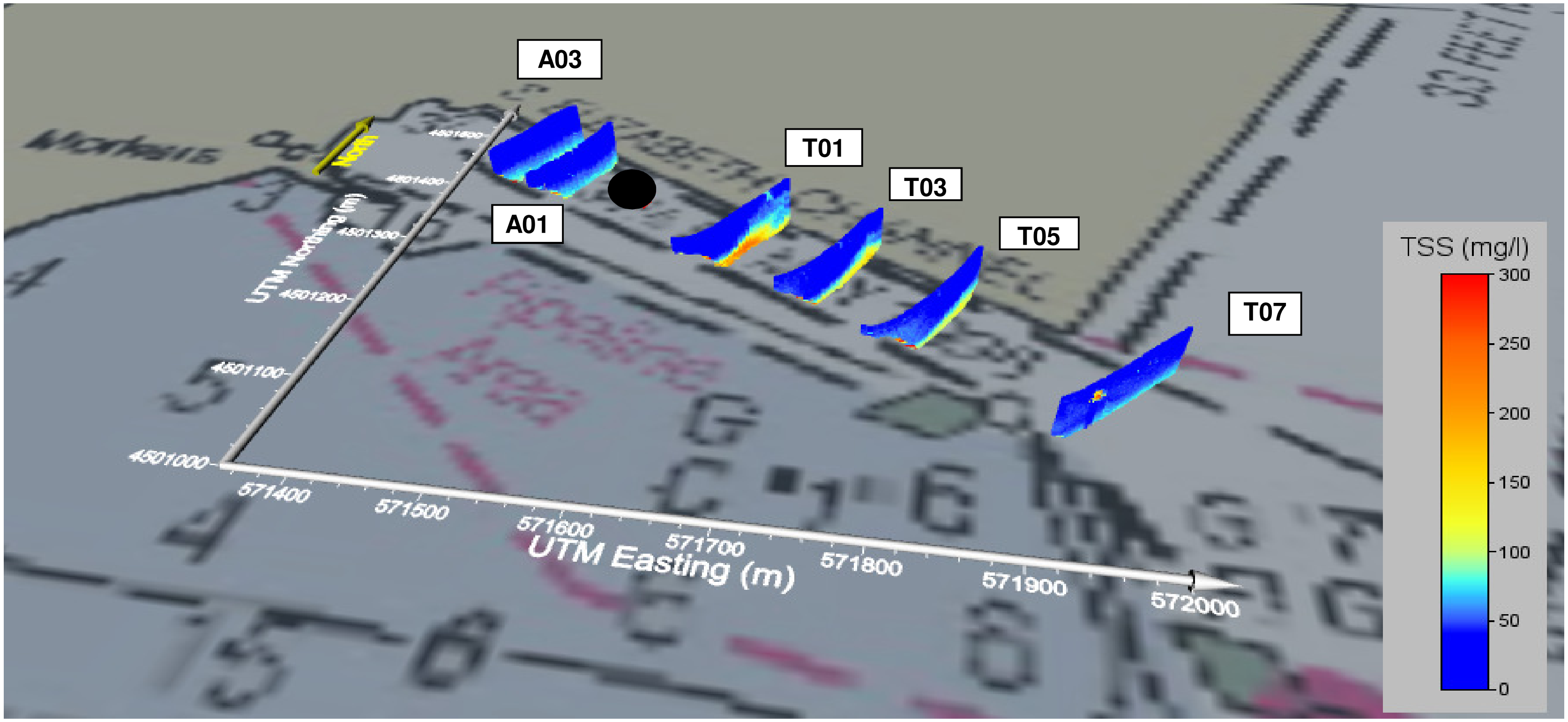


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 26 July 2011 14-16 Meter Depth Interval	Tide
10h			Flood



● = Dredge Location

Z scale exaggerated 6X

Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area S-NB-2*	ADCP Average TSS Values, 3D View of Selected Transects 26 July 2011	Tide
11			Flood

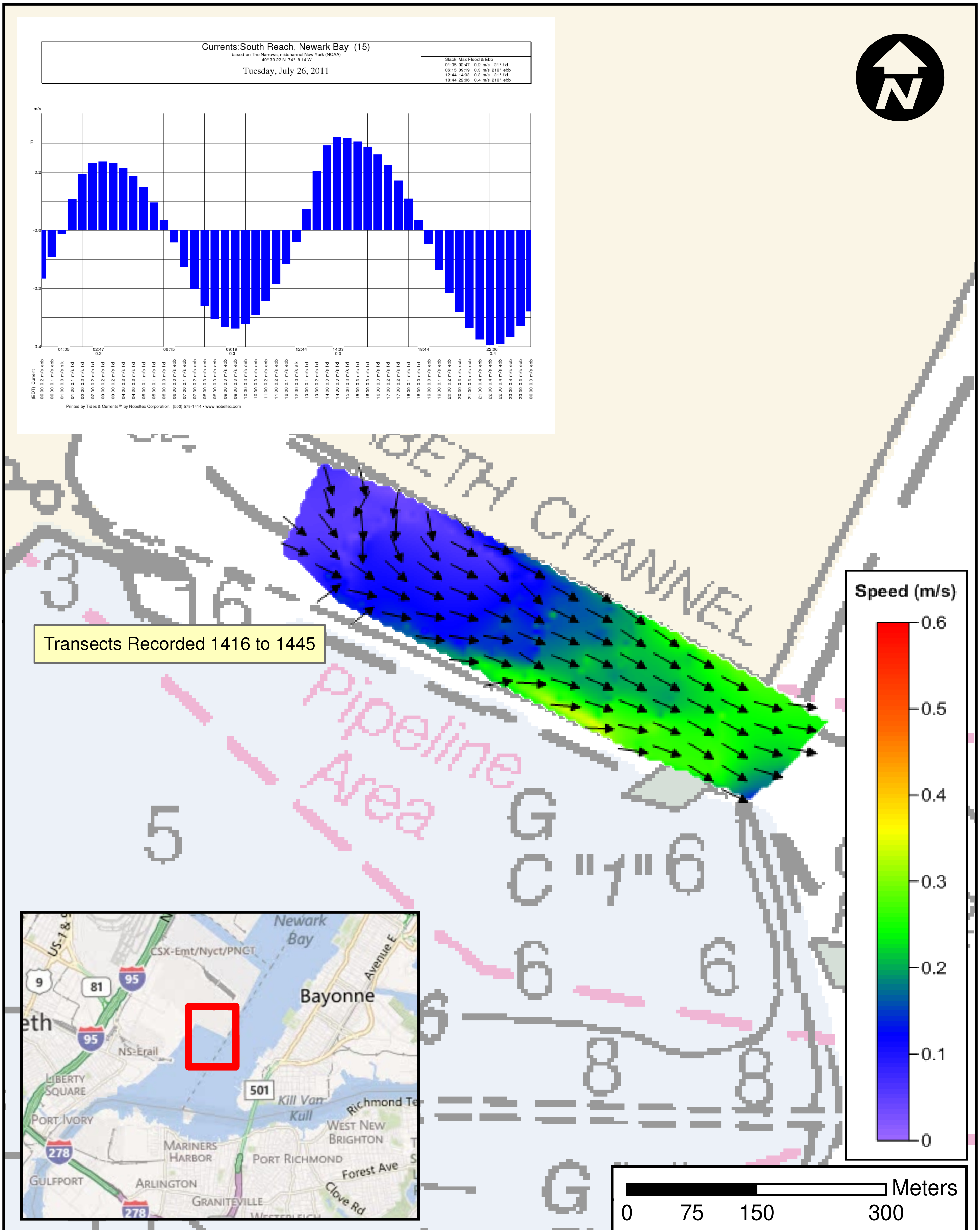
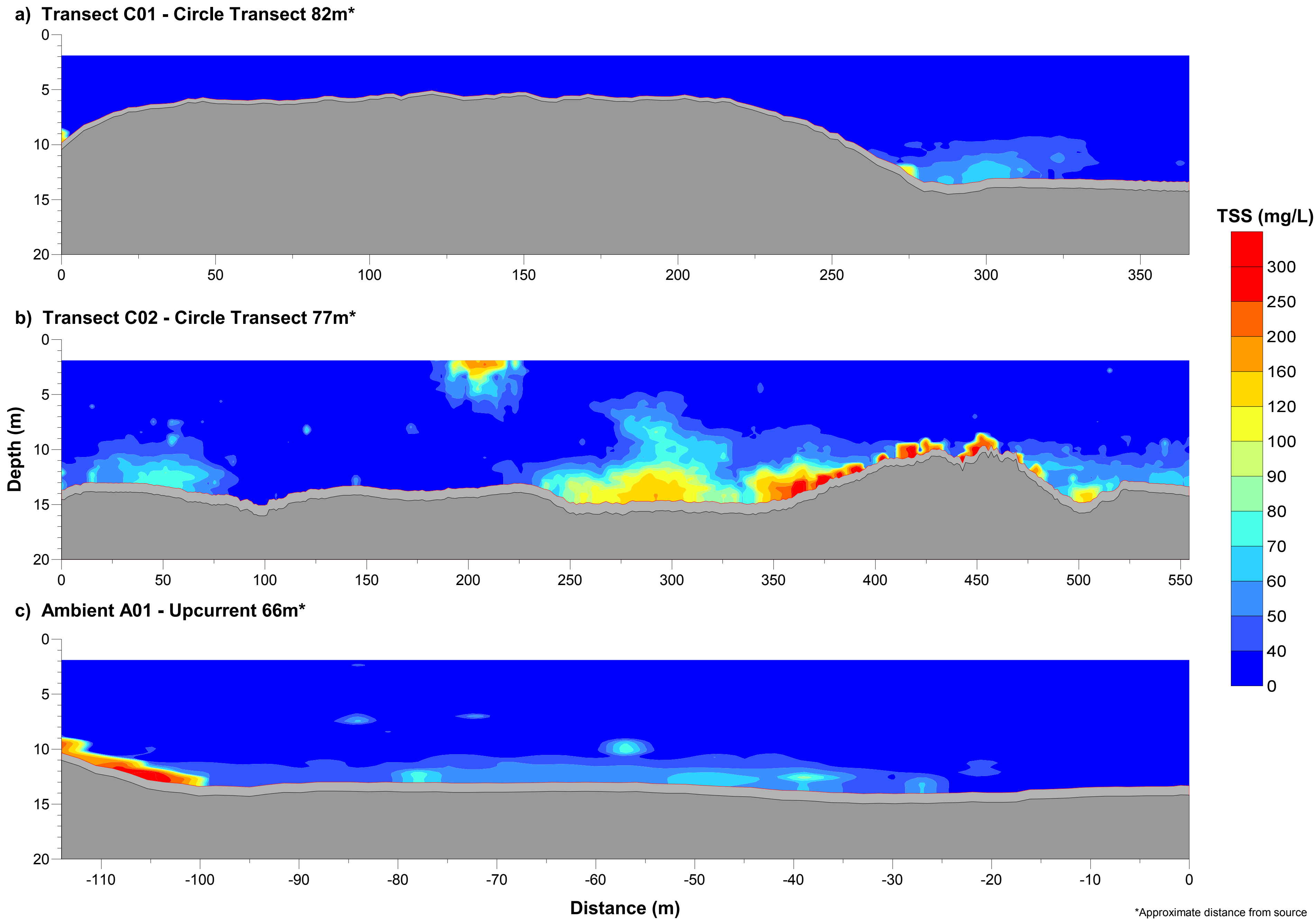
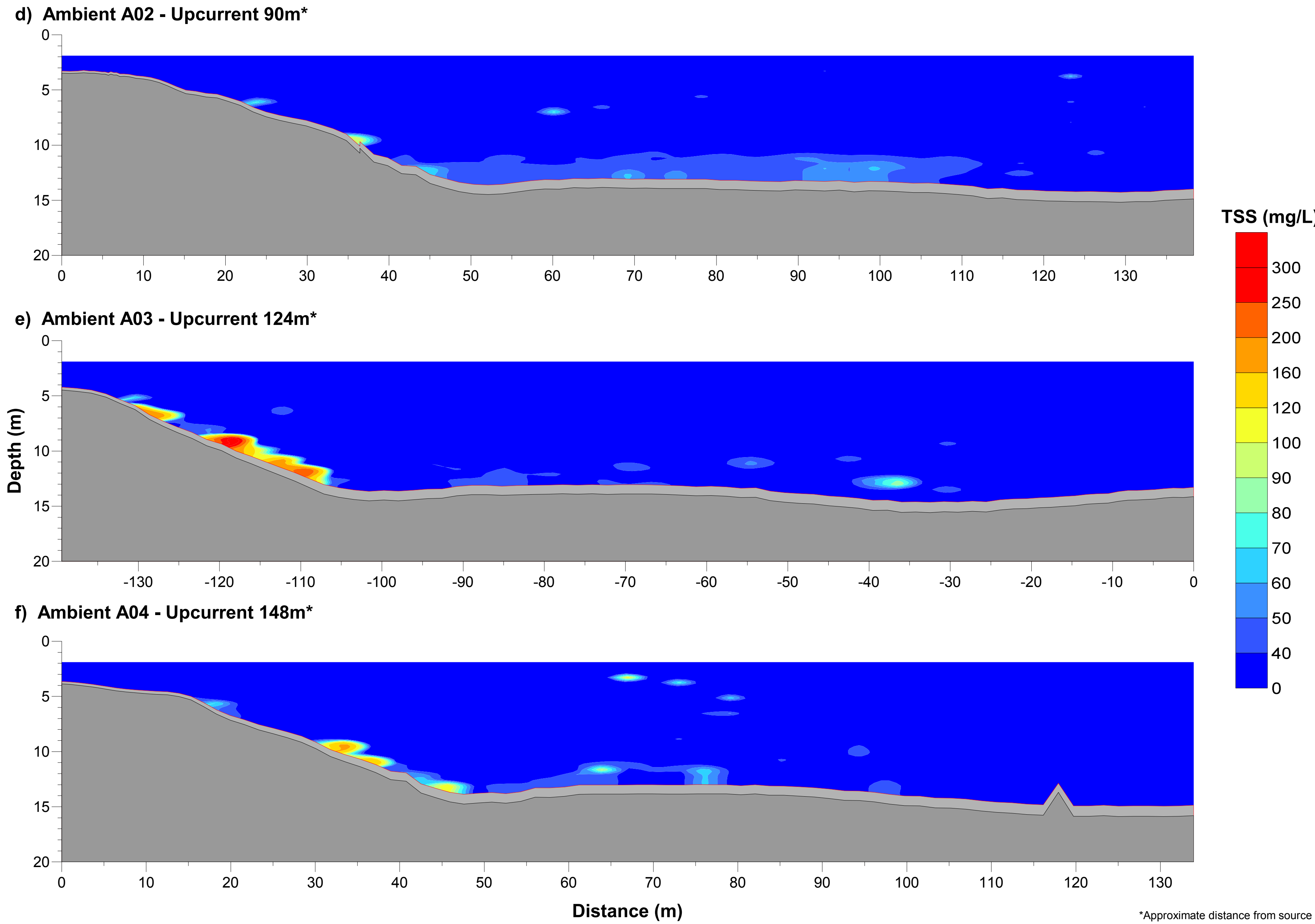


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	Depth Averaged Velocites 26 July 2011 - Flood Tide TSS Survey	Tide
12			Flood



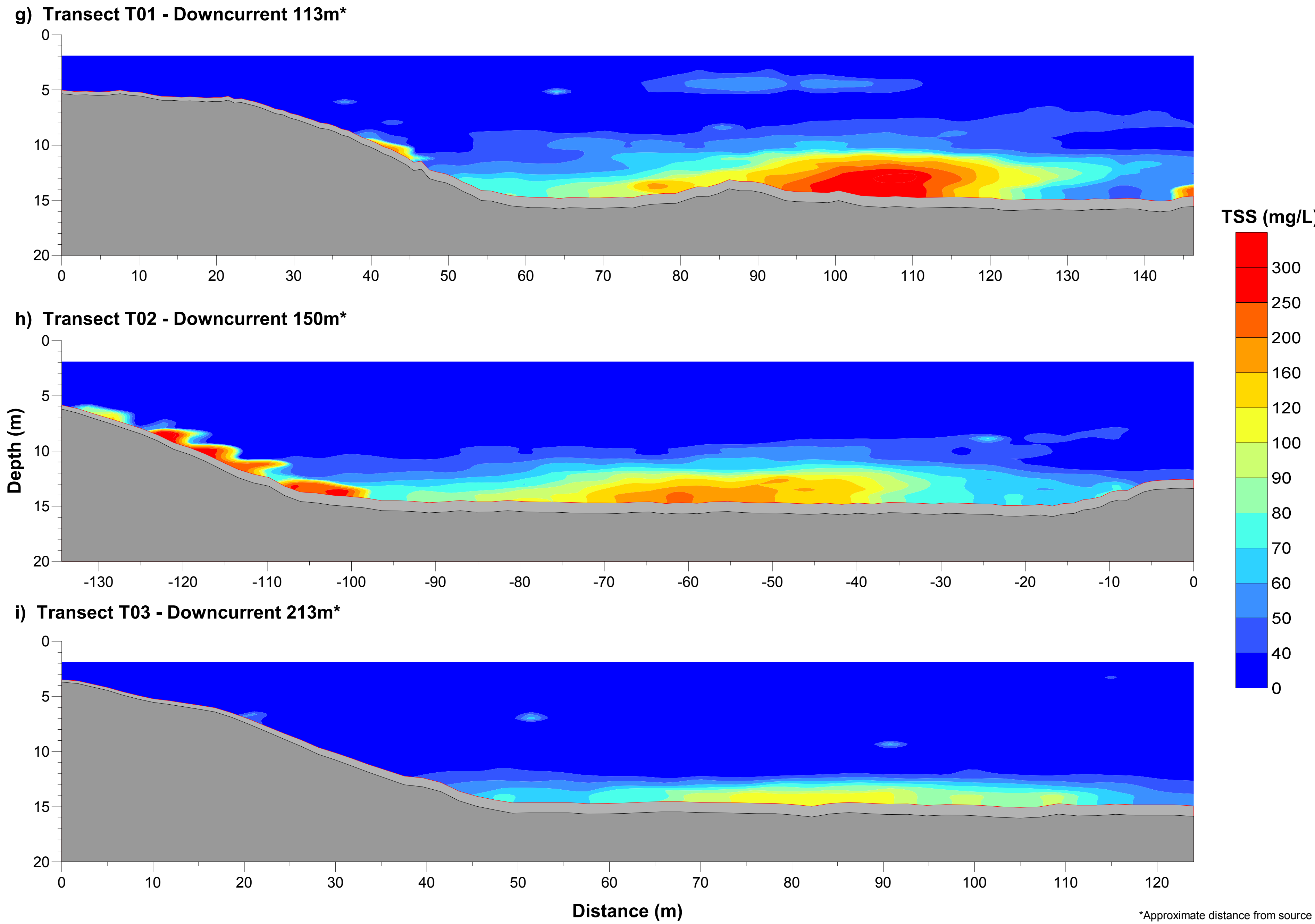
*Approximate distance from source

FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 27 July 2011 - Ebb Tide	TIDE
13a-c			Ebb



*Approximate distance from source

FIGURE	*USACE Harborwide TSS*	**Vertical Profiles of ADCP Average TSS**	TIDE
13d-f	*Far Field Survey* *S-NB-2*	**27 July 2011 - Ebb Tide**	**Ebb**



*Approximate distance from source

FIGURE	USACE Harborwide TSS	Vertical Profiles of ADCP Average TSS	TIDE
13g-i	*Far Field Survey* *S-NB-2*	27 July 2011 - Ebb Tide	Ebb

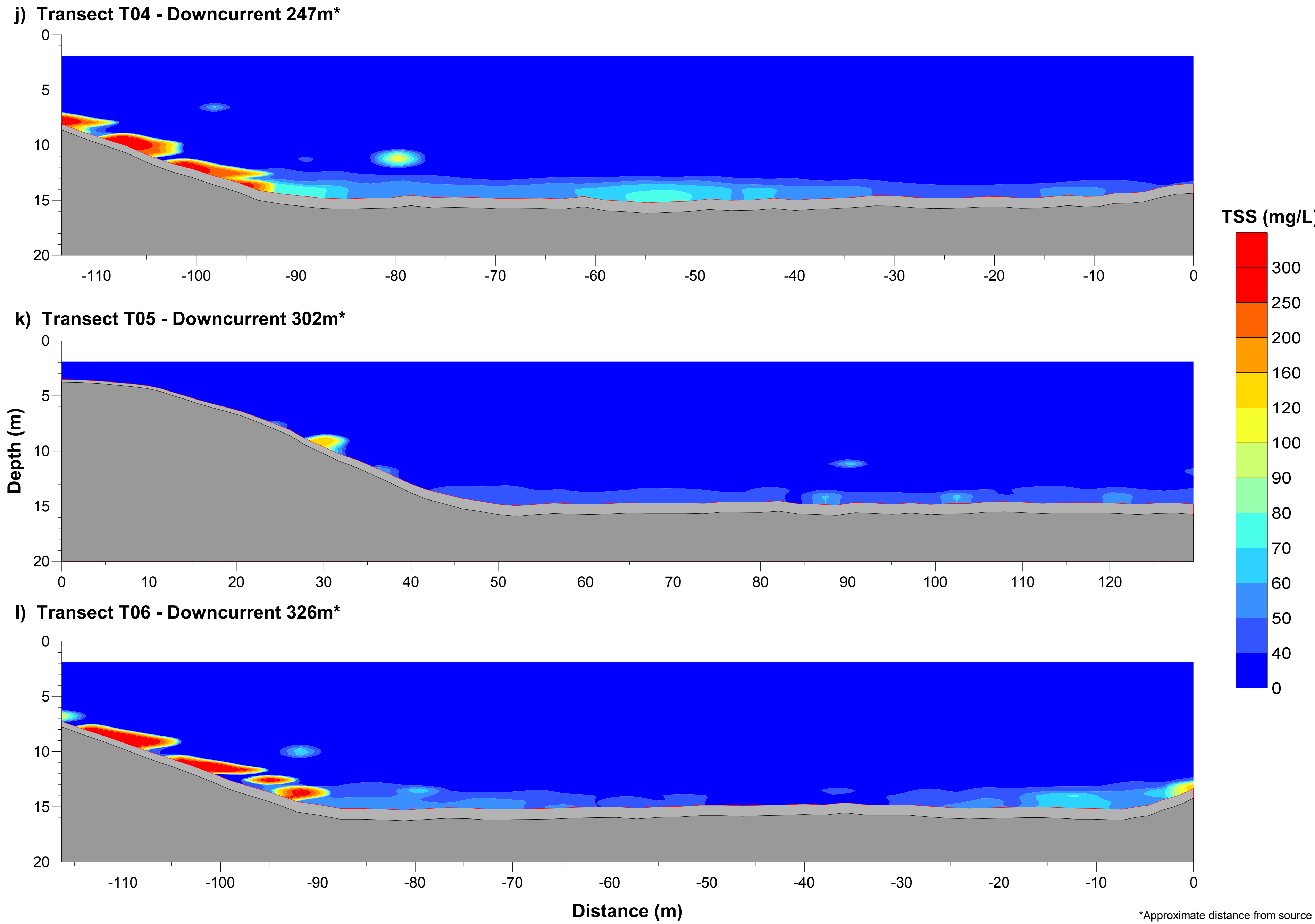


FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 27 July 2011 - Ebb Tide	TIDE
13j-l			Ebb

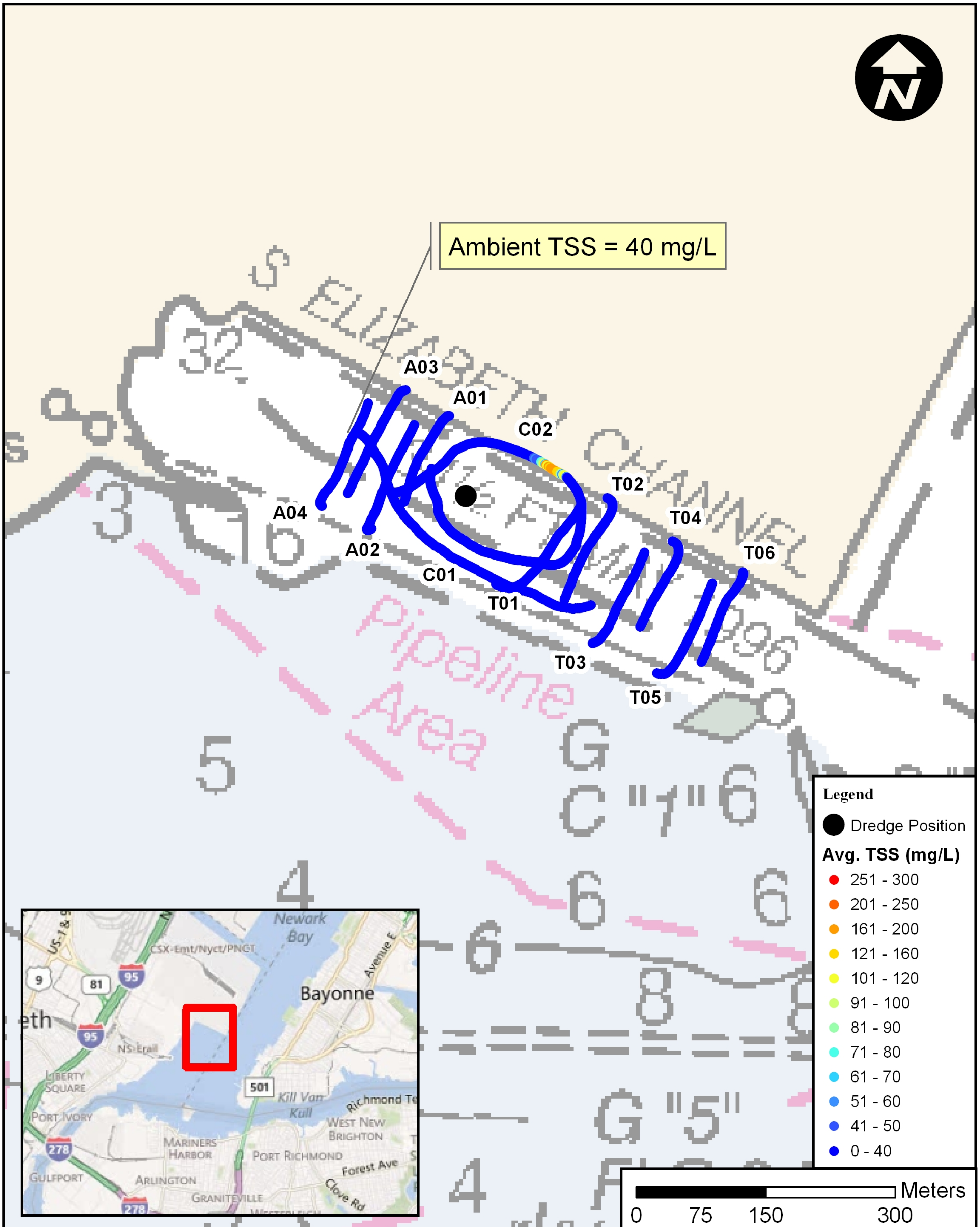


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 27 July 2011 0-2 Meter Depth Interval	Tide
14a			Ebb

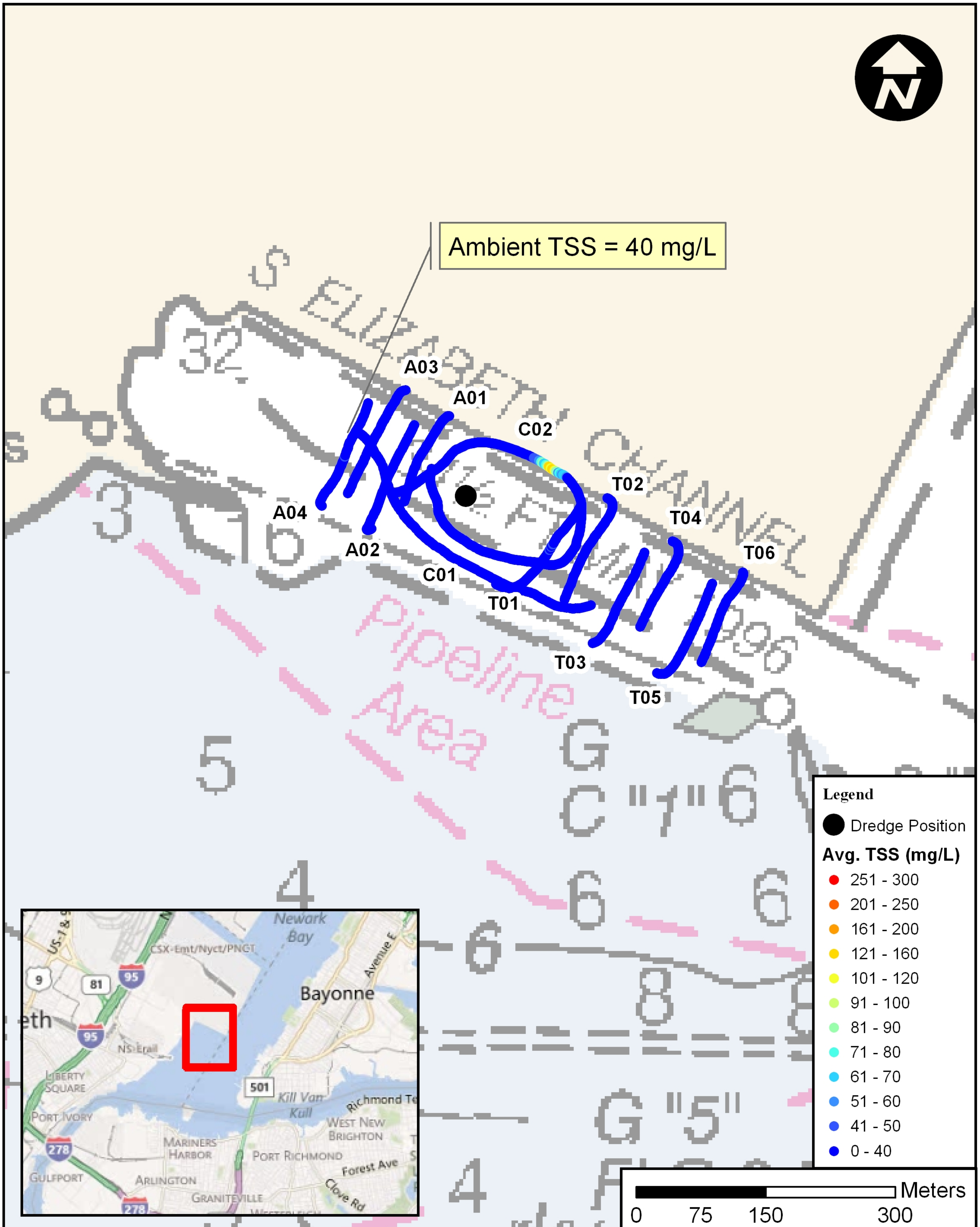


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 27 July 2011 2-4 Meter Depth Interval	Tide
14b			Ebb

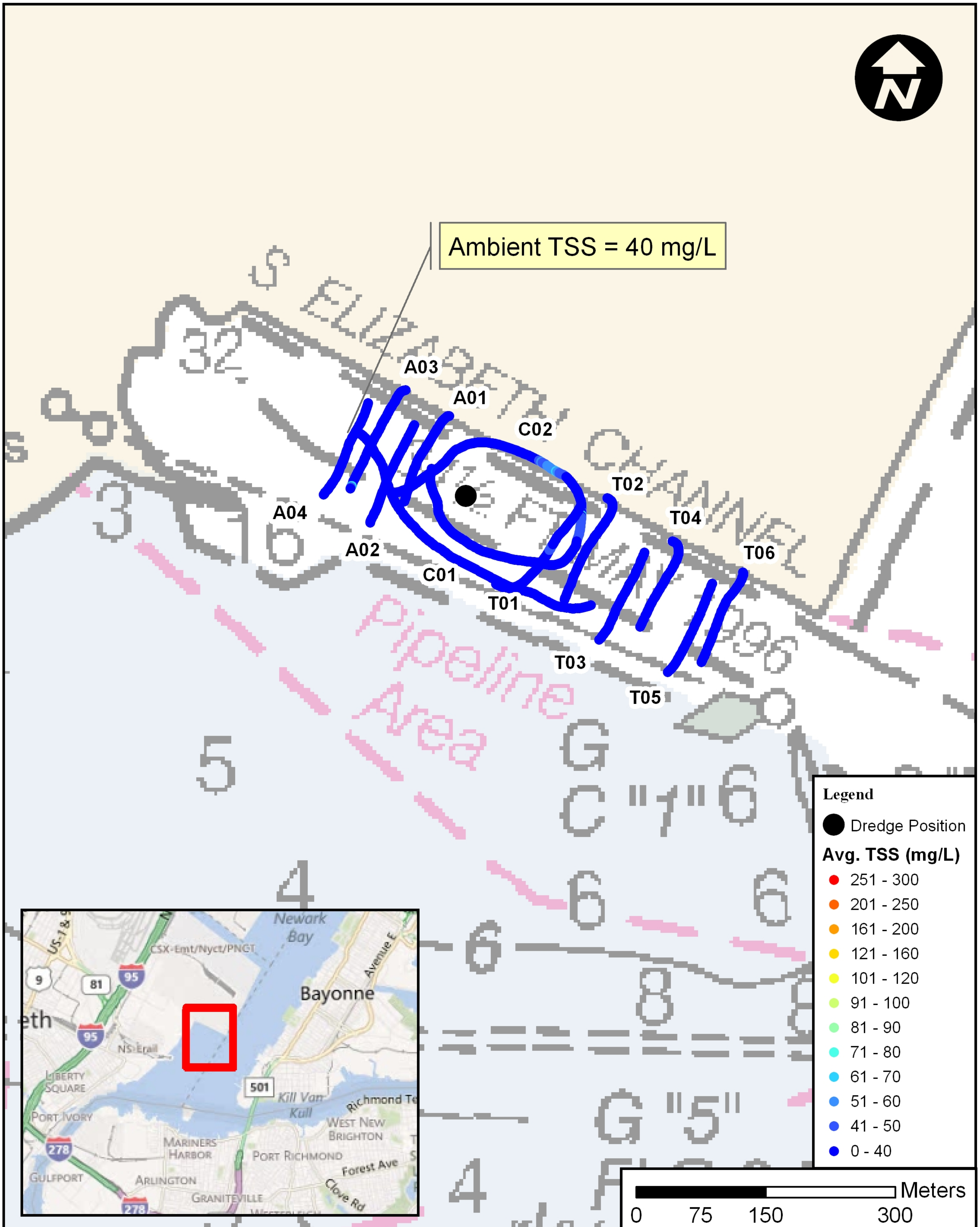


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 27 July 2011 4-6 Meter Depth Interval	Tide
14c			Ebb

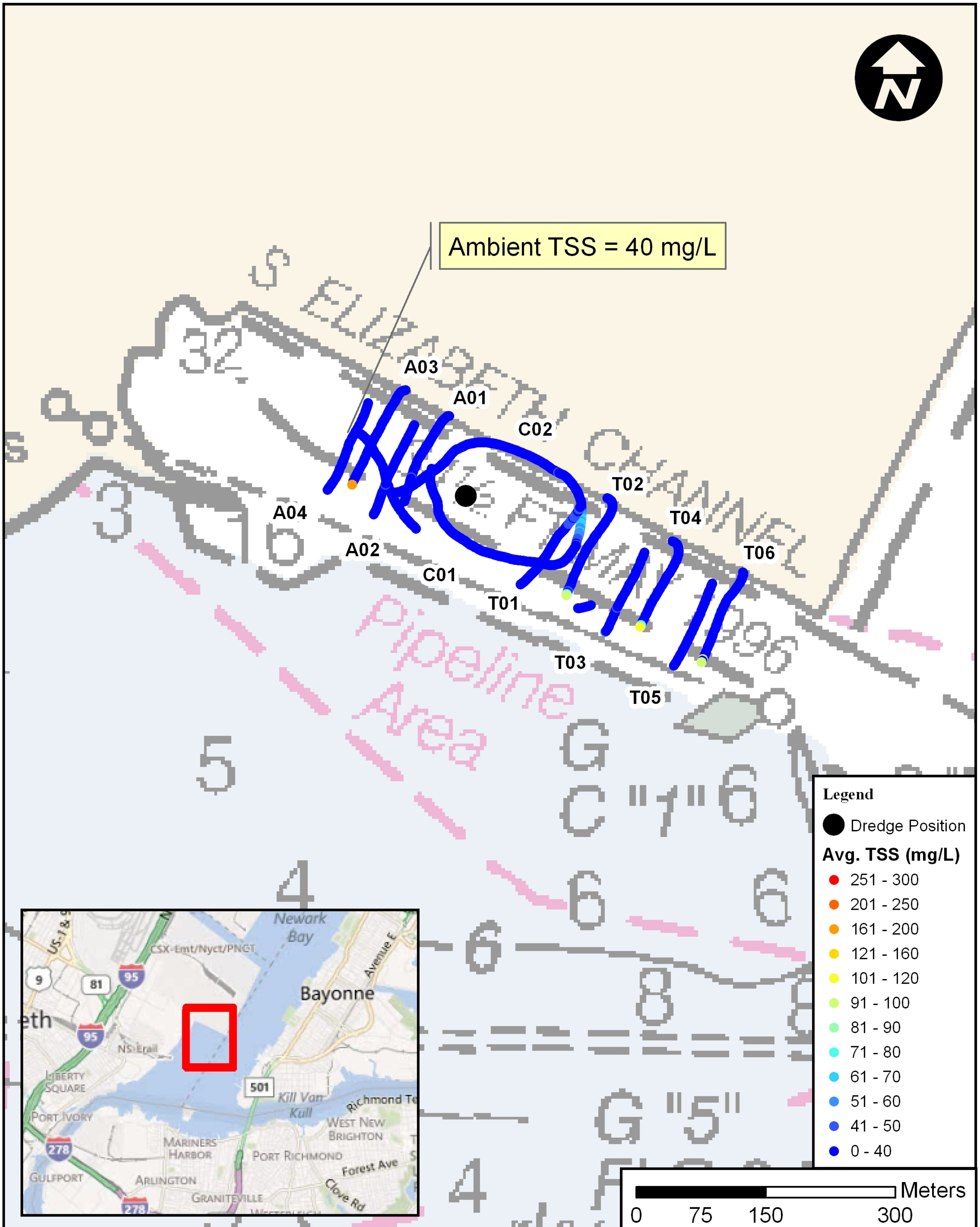


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 27 July 2011 6-8 Meter Depth Interval	Tide
14d			Ebb

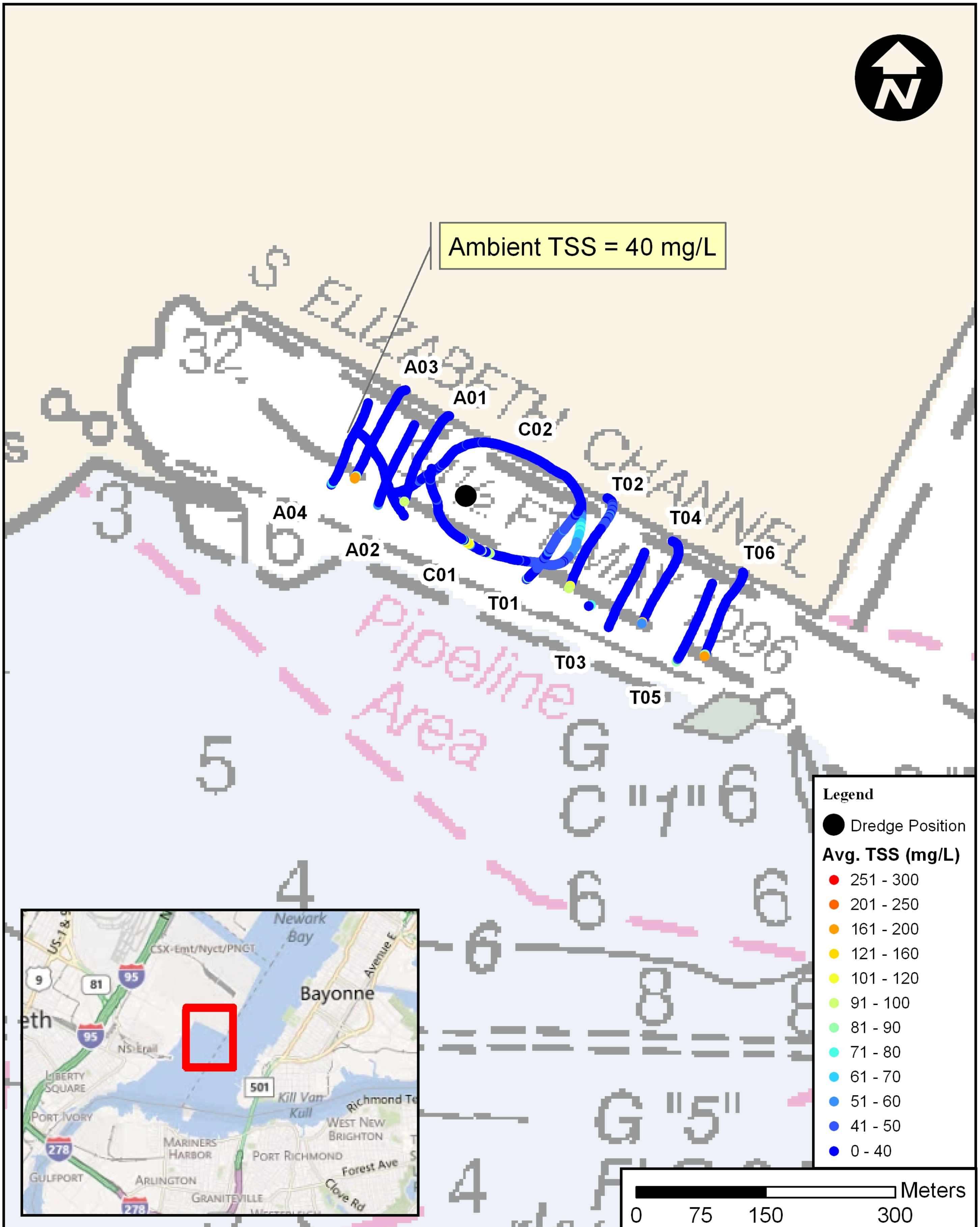


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 27 July 2011 8-10 Meter Depth Interval	Tide
14e			Ebb

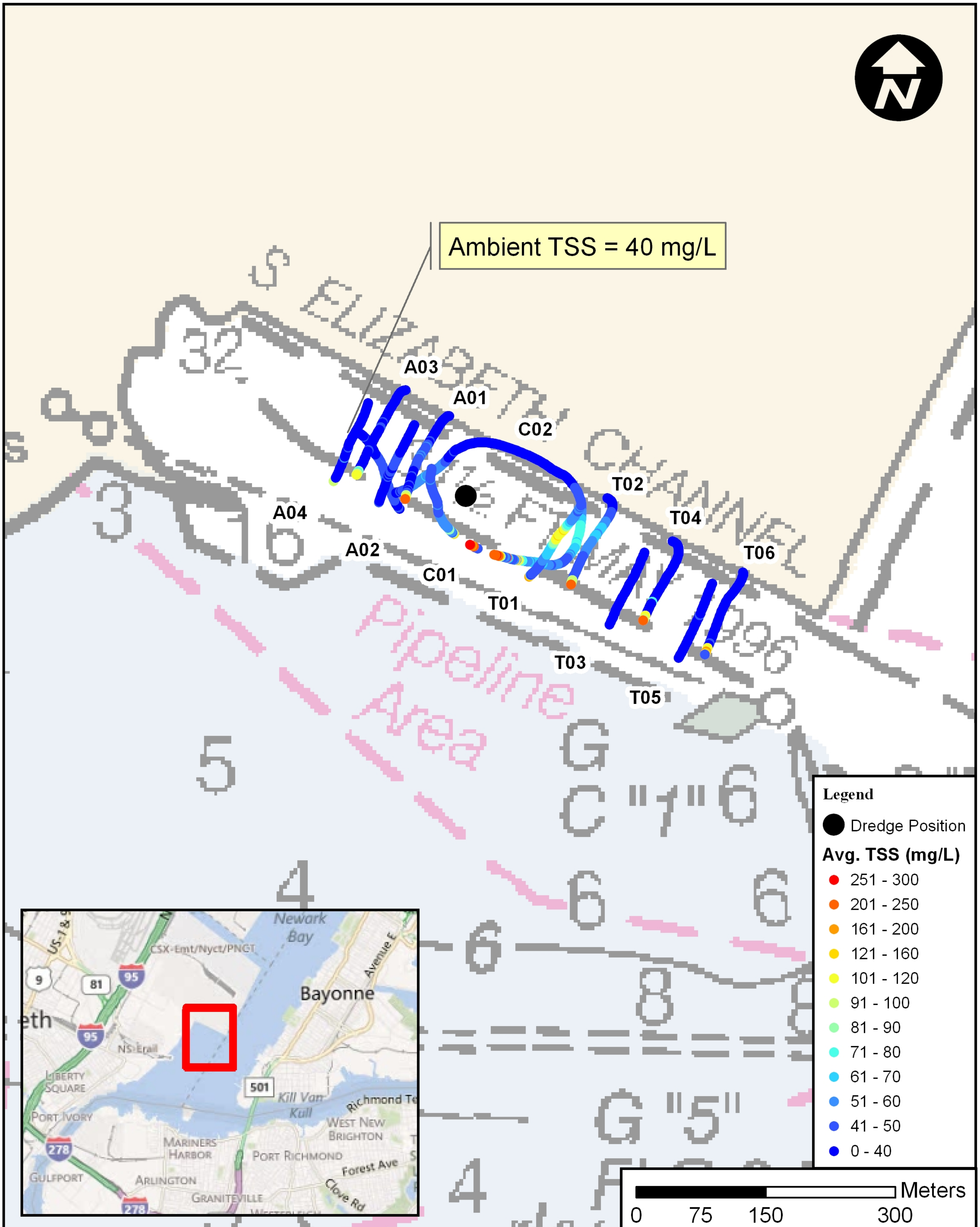


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 27 July 2011 10-12 Meter Depth Interval	Tide
14f			Ebb

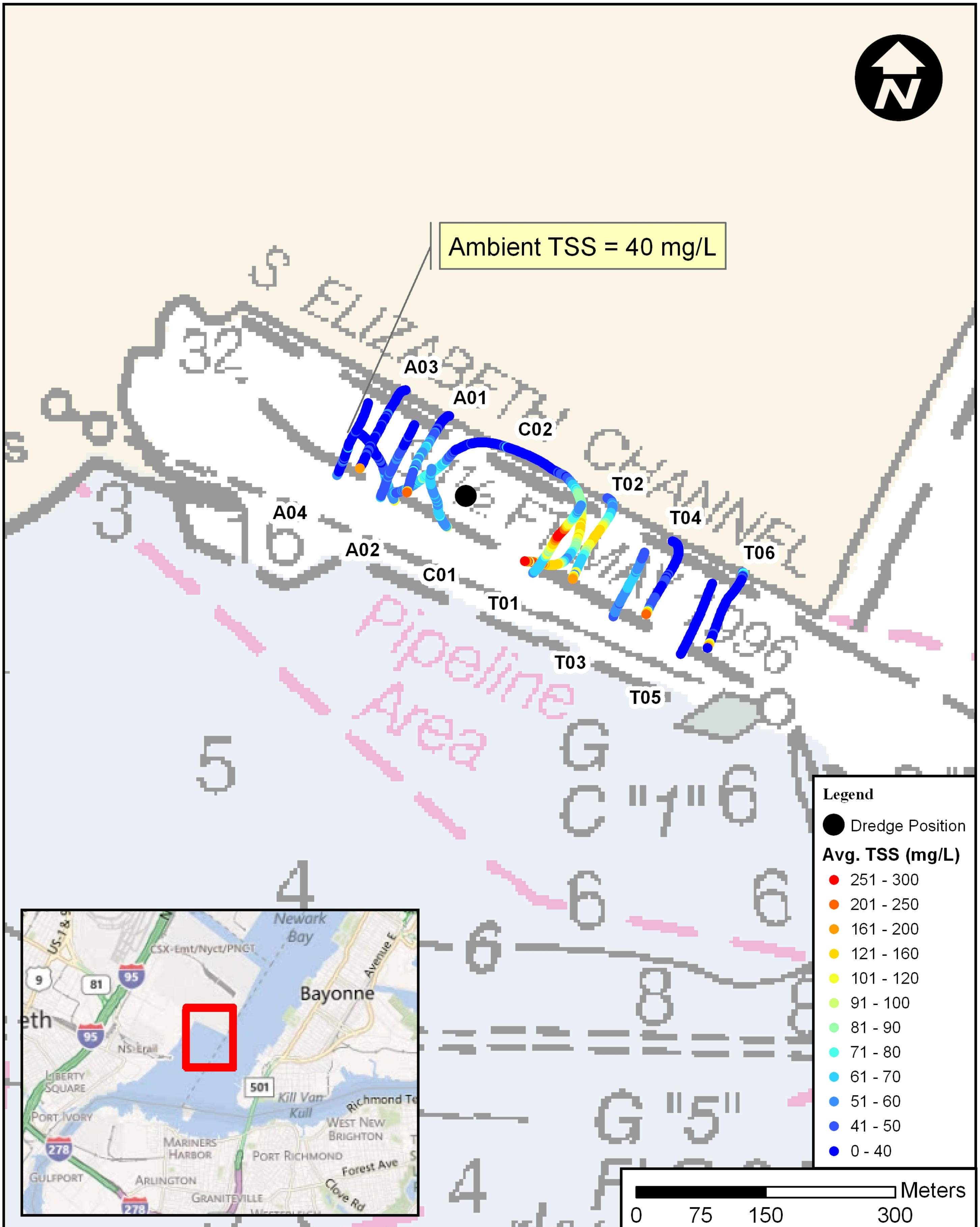


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 27 July 2011 12-14 Meter Depth Interval	Tide
14g			Ebb

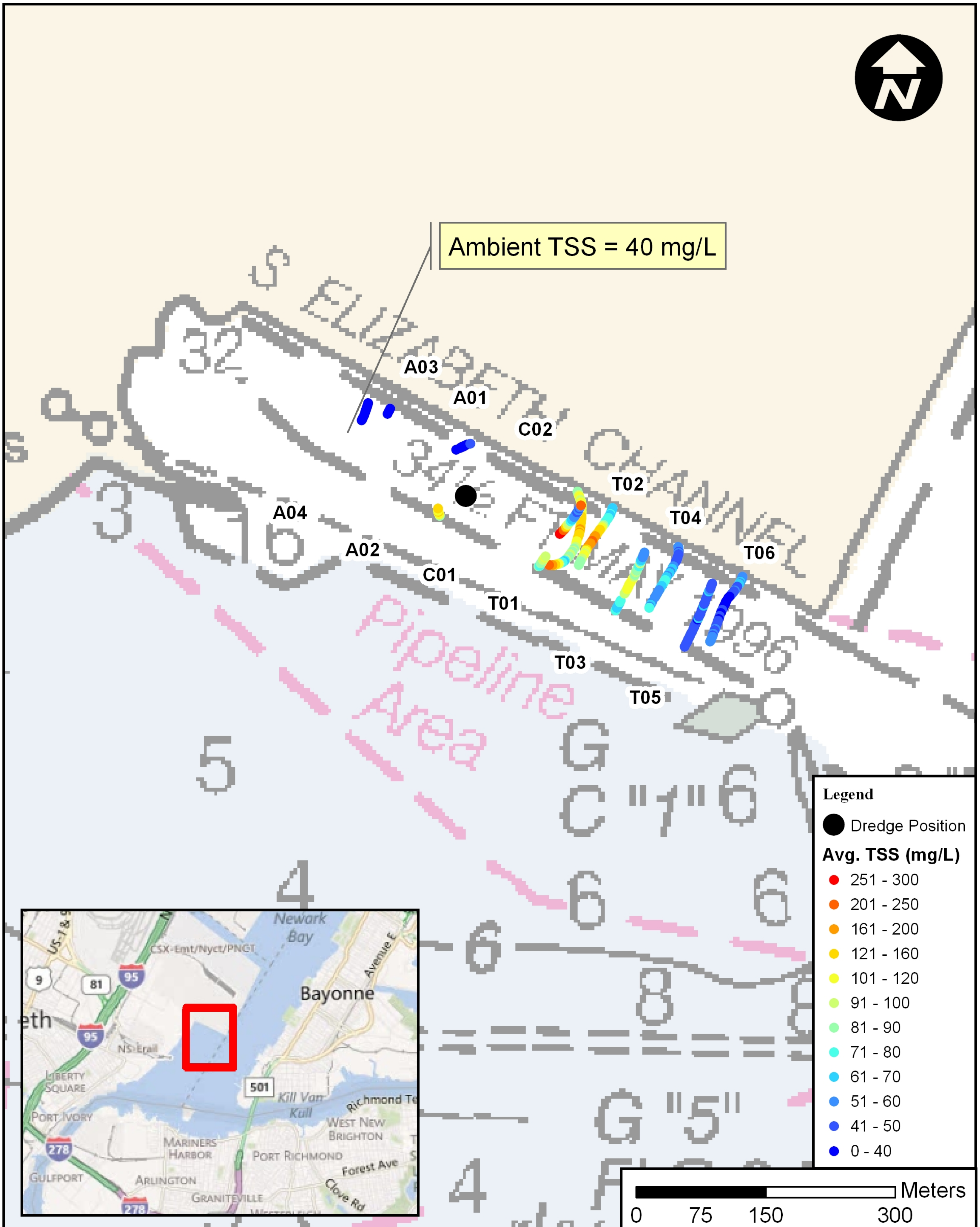
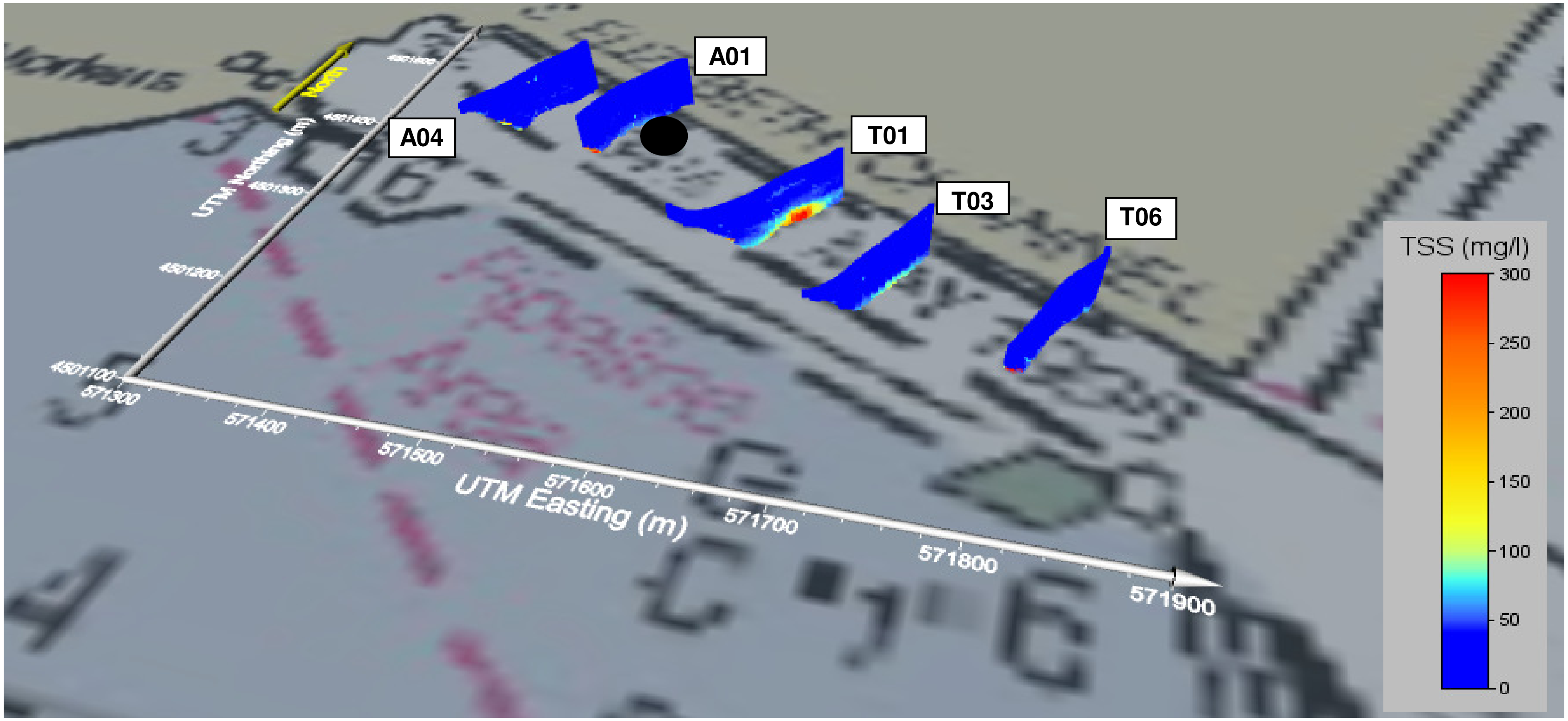


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 27 July 2011 14-16 Meter Depth Interval	Tide
14h			Ebb



● = Dredge Location

Z scale exaggerated 6X

Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area S-NB-2*	ADCP Average TSS Values, 3D View of Selected Transects 27 July 2011	Tide
15			Ebb

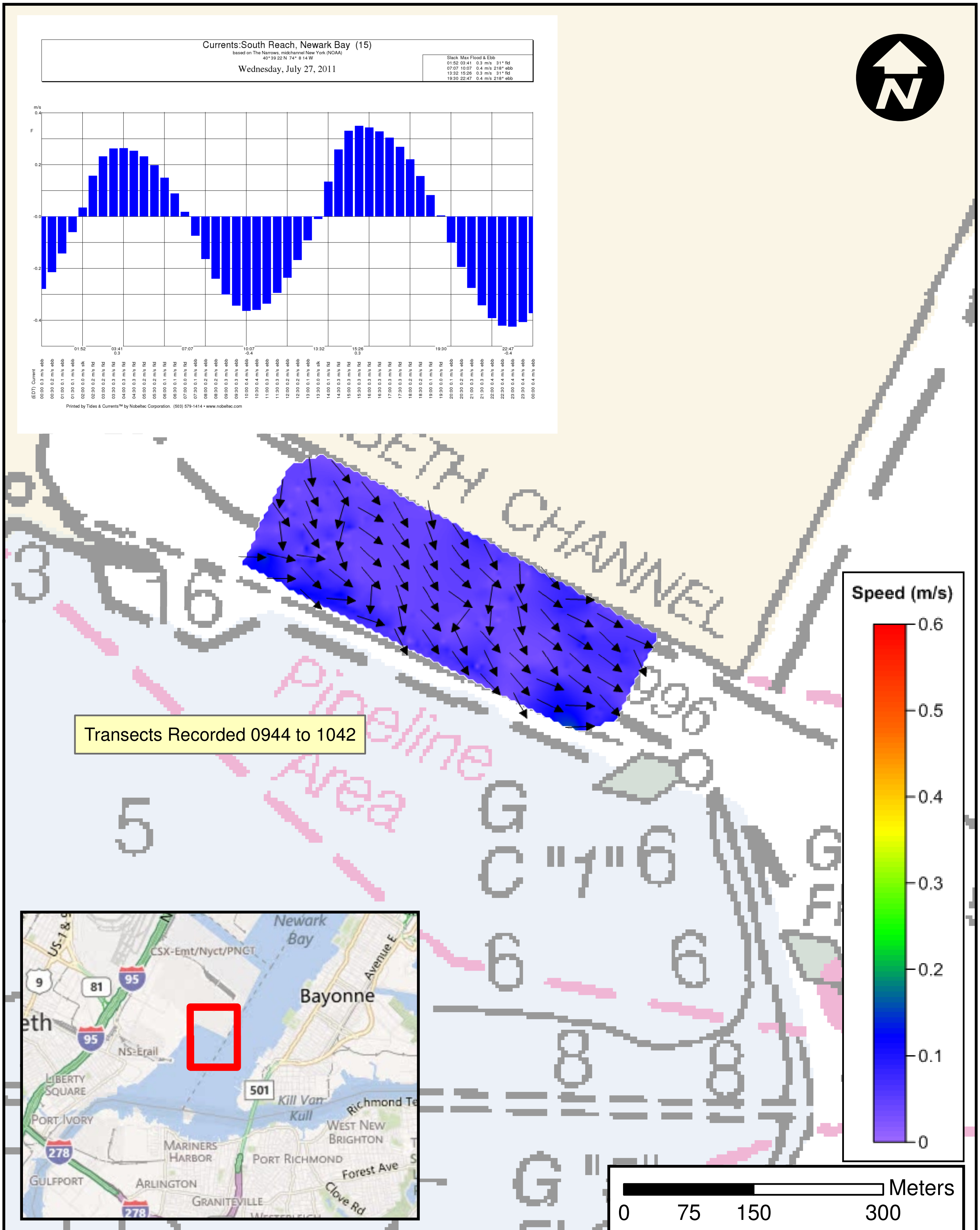


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	Depth Averaged Velocites 27 July 2011 - Ebb Tide TSS Survey	Tide
16			Ebb

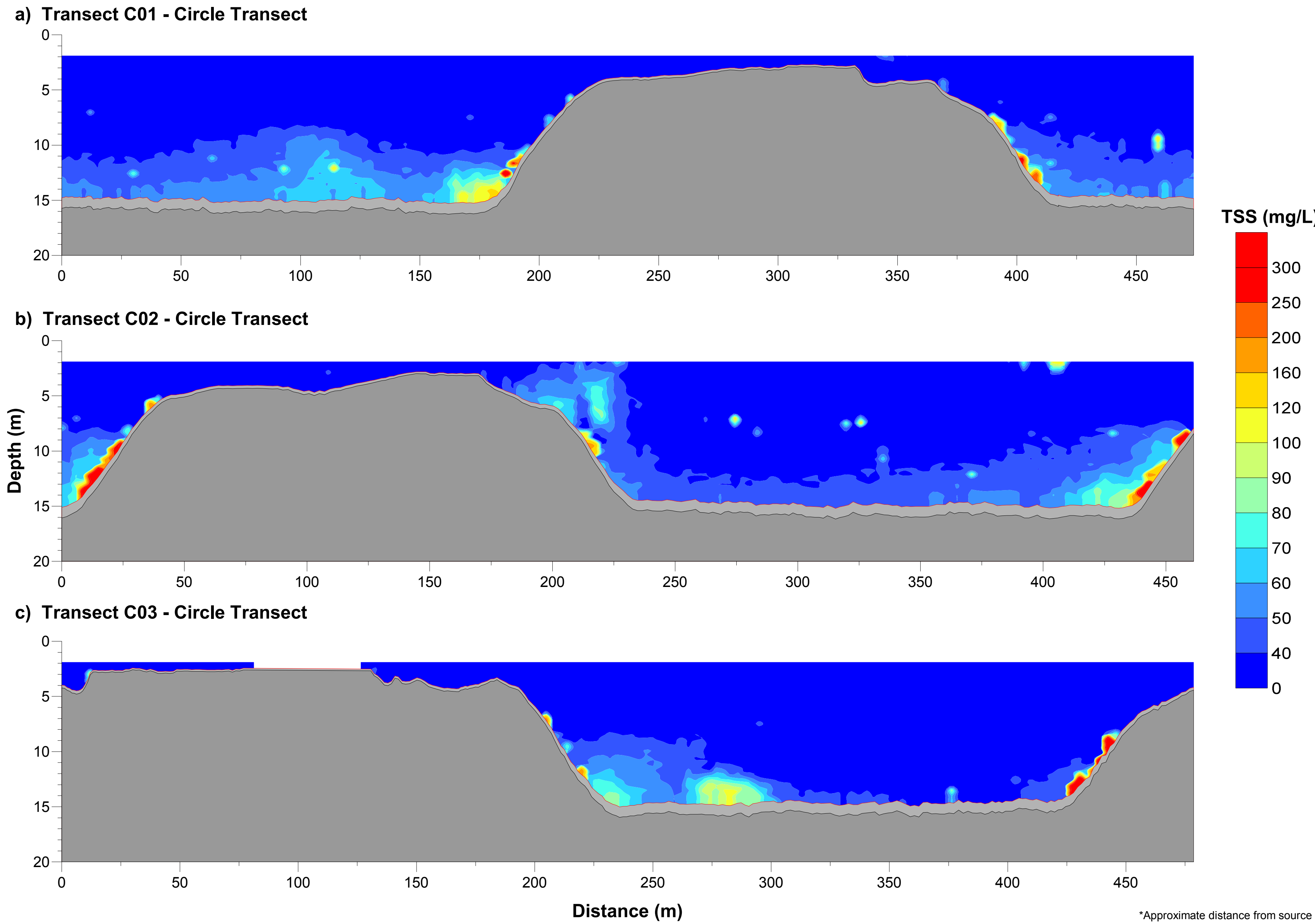
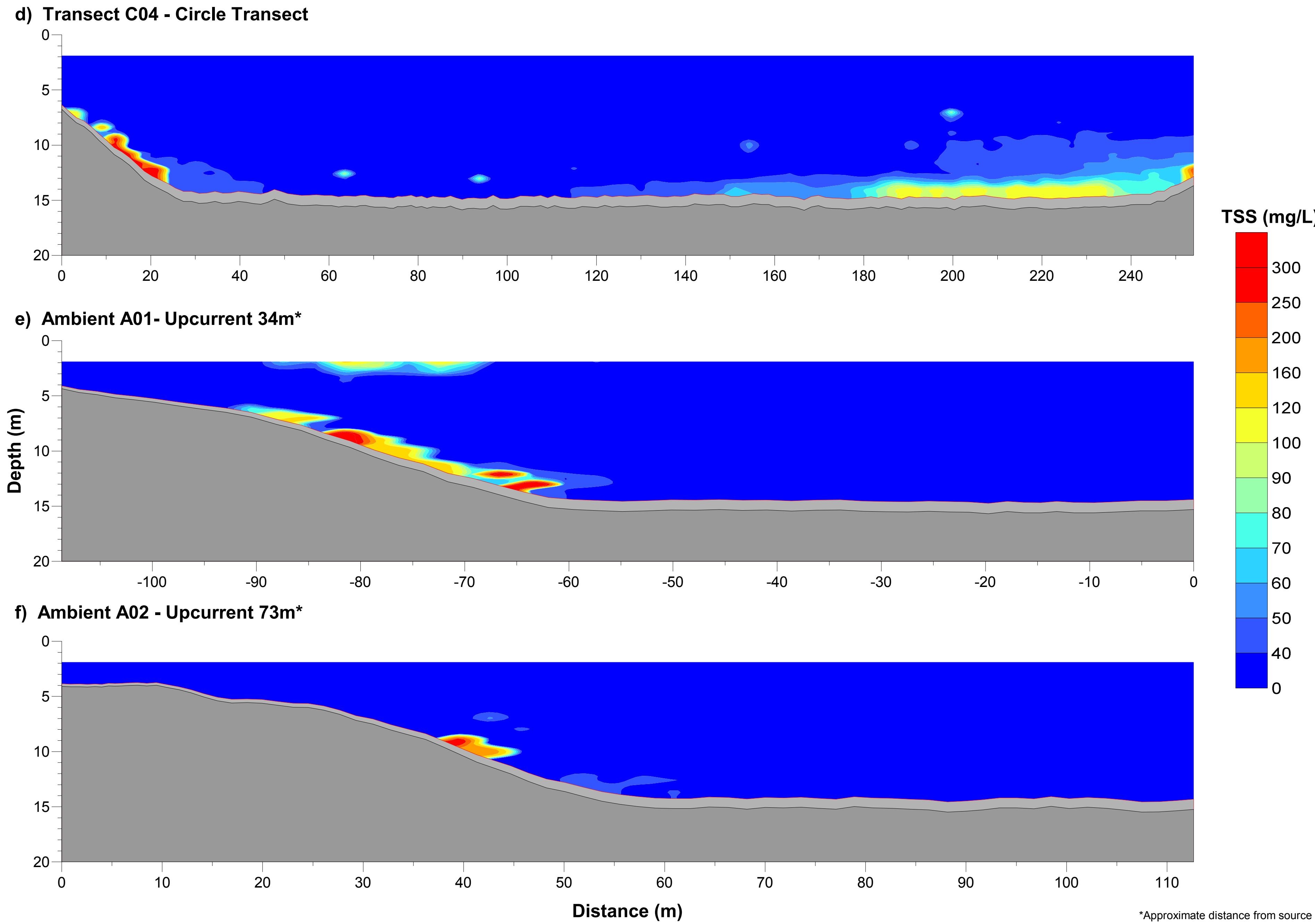


FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 29 July 2011 - Ebb Tide**	TIDE
17a-c			**Ebb**



*Approximate distance from source

FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 29 July 2011 - Ebb Tide**	TIDE
17d-f			Ebb

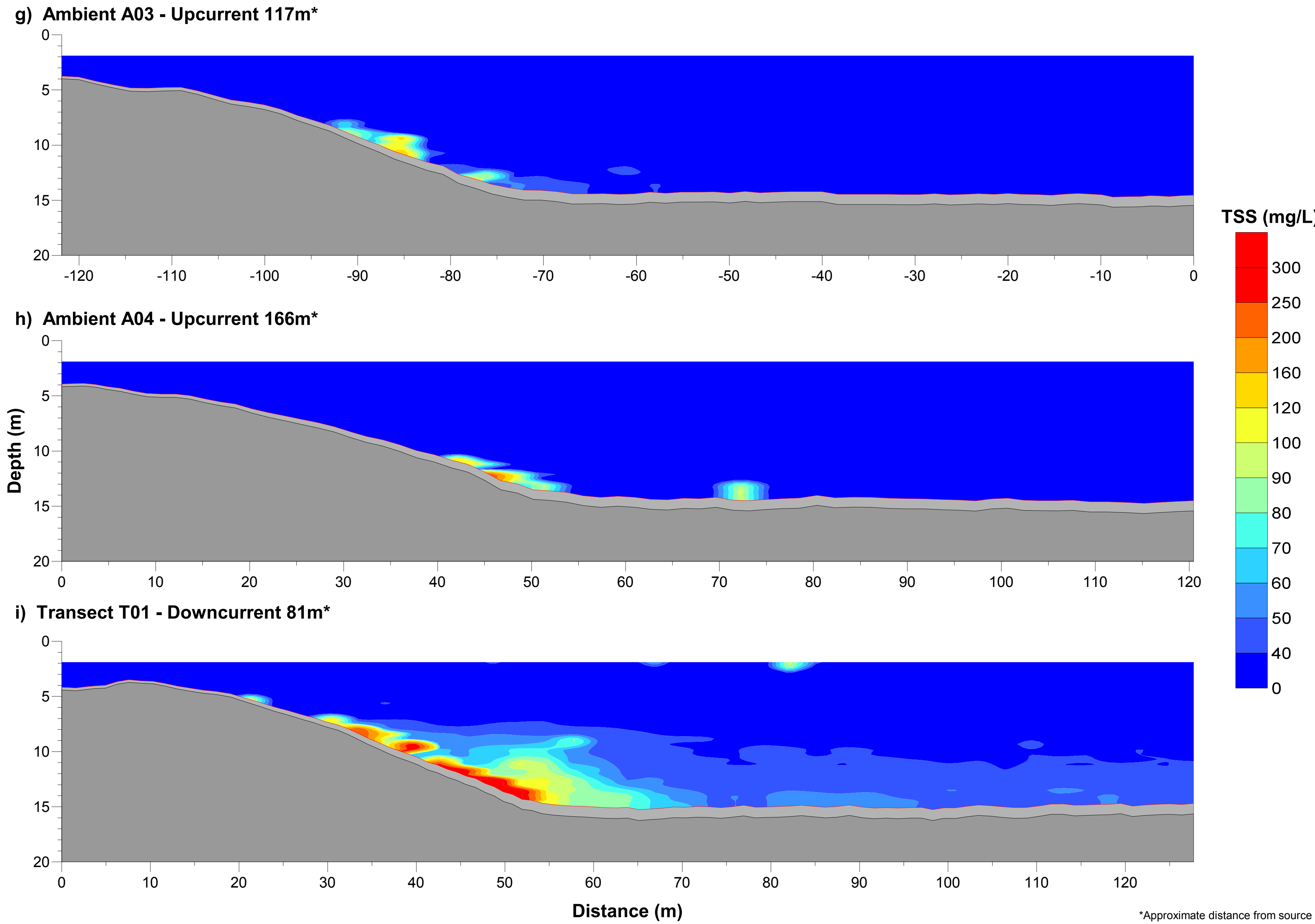


FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 29 July 2011 - Ebb Tide	TIDE
17g-i			Ebb

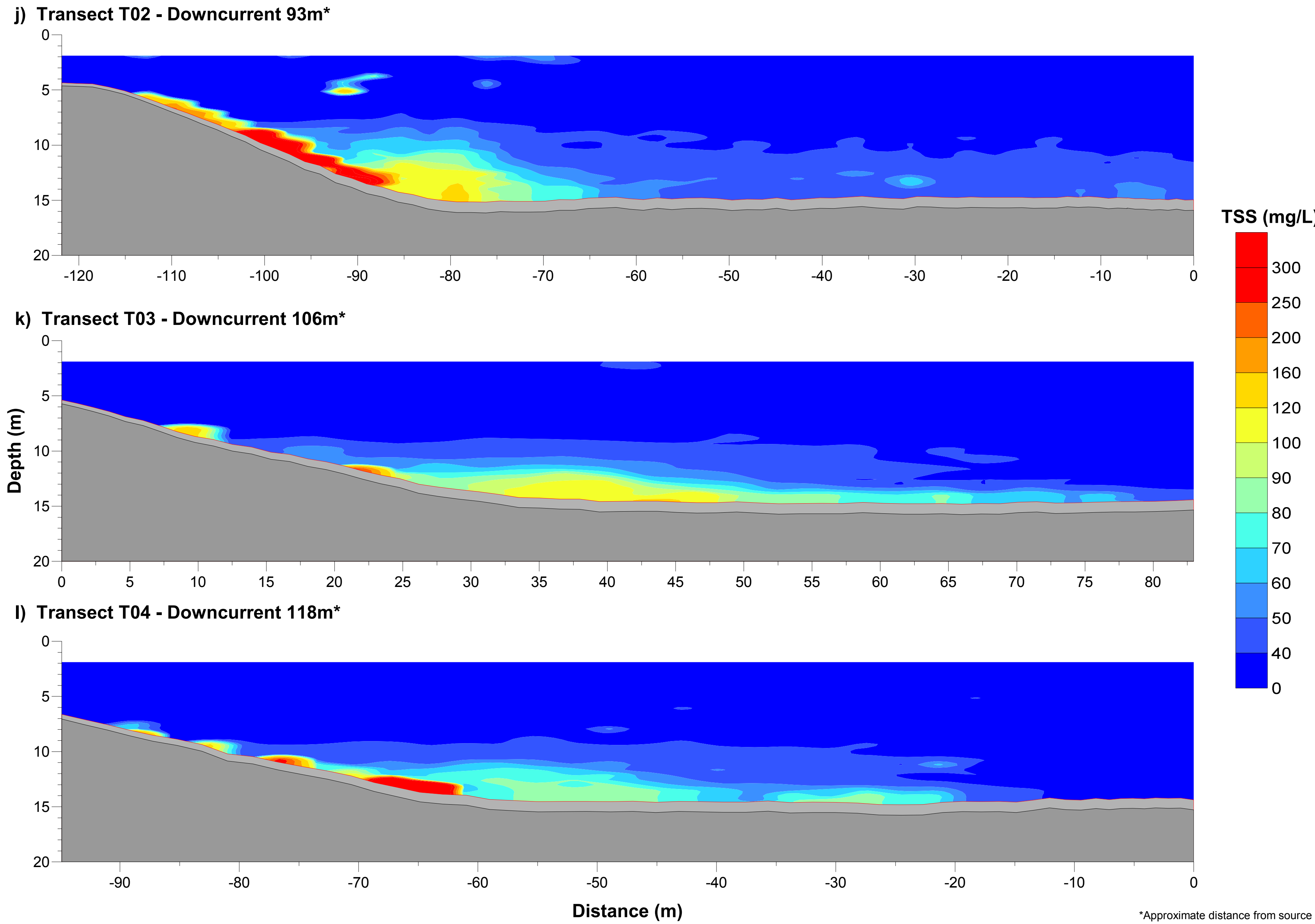
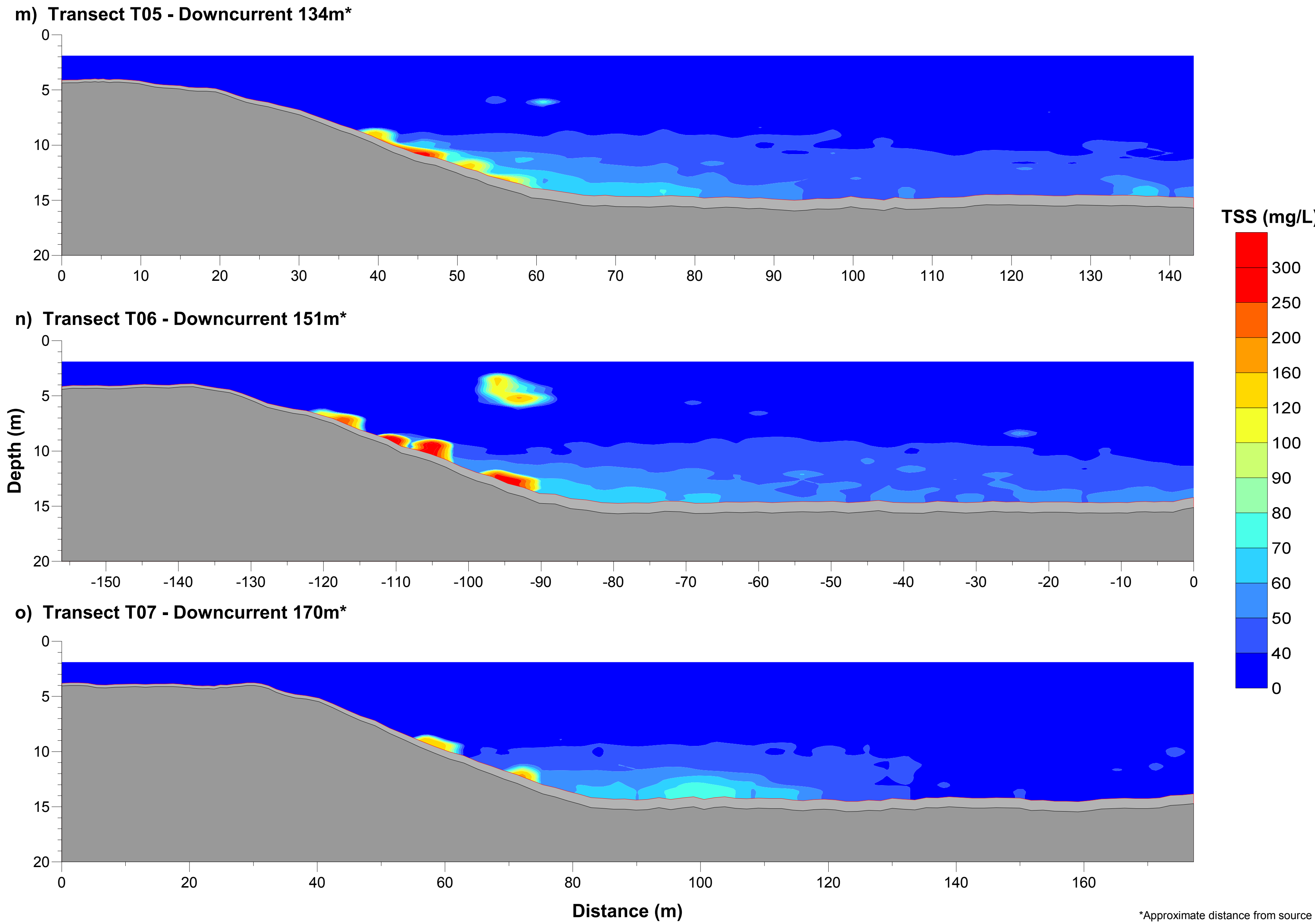


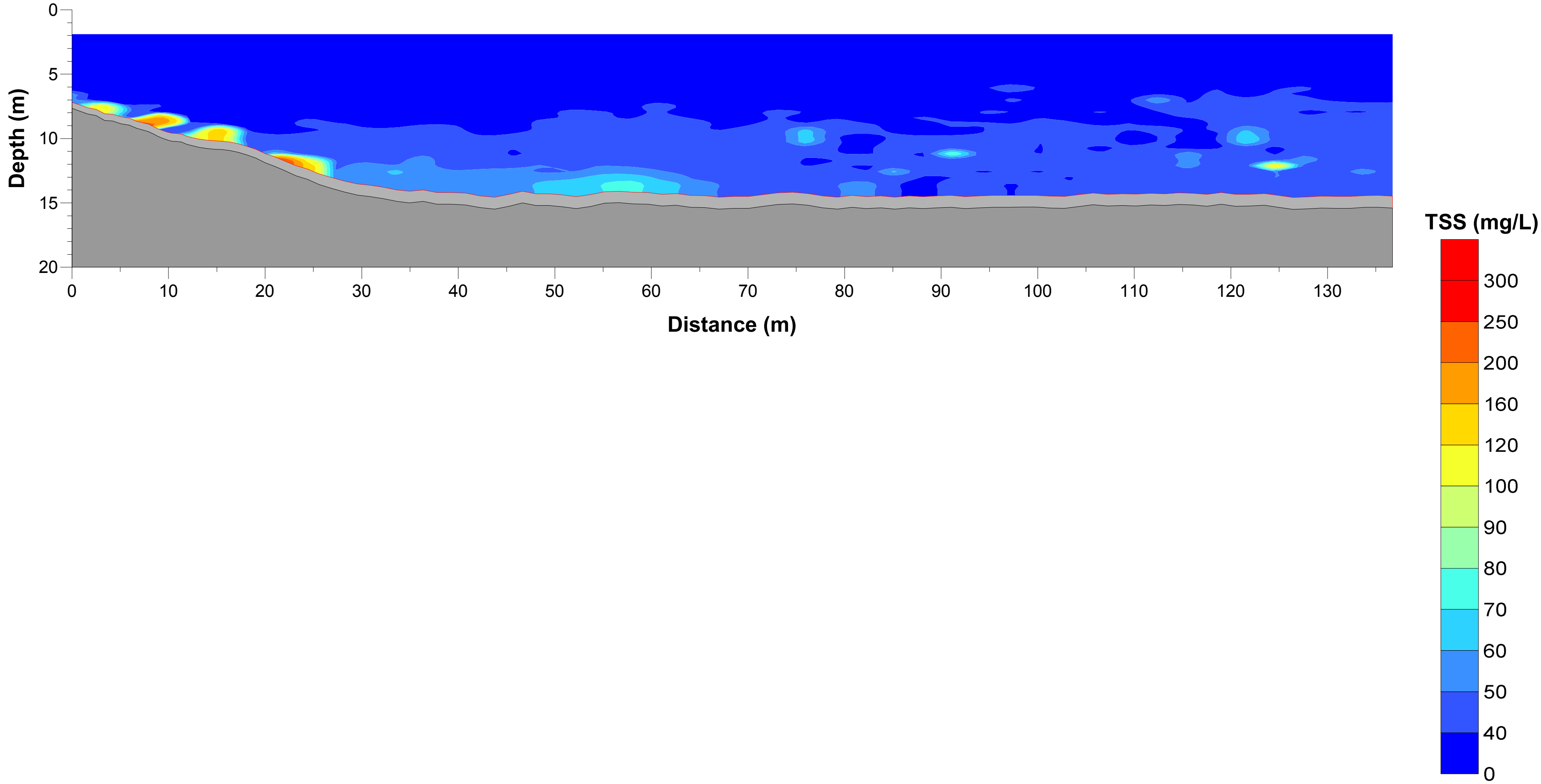
FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 29 July 2011 - Ebb Tide**	TIDE
17j-l			**Ebb**



*Approximate distance from source

FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 29 July 2011 - Ebb Tide**	TIDE
17m-o			**Ebb**

p) Transect T08 - Downcurrent 196m*



*Approximate distance from source

FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 29 July 2011 - Ebb Tide	TIDE
17p			Ebb

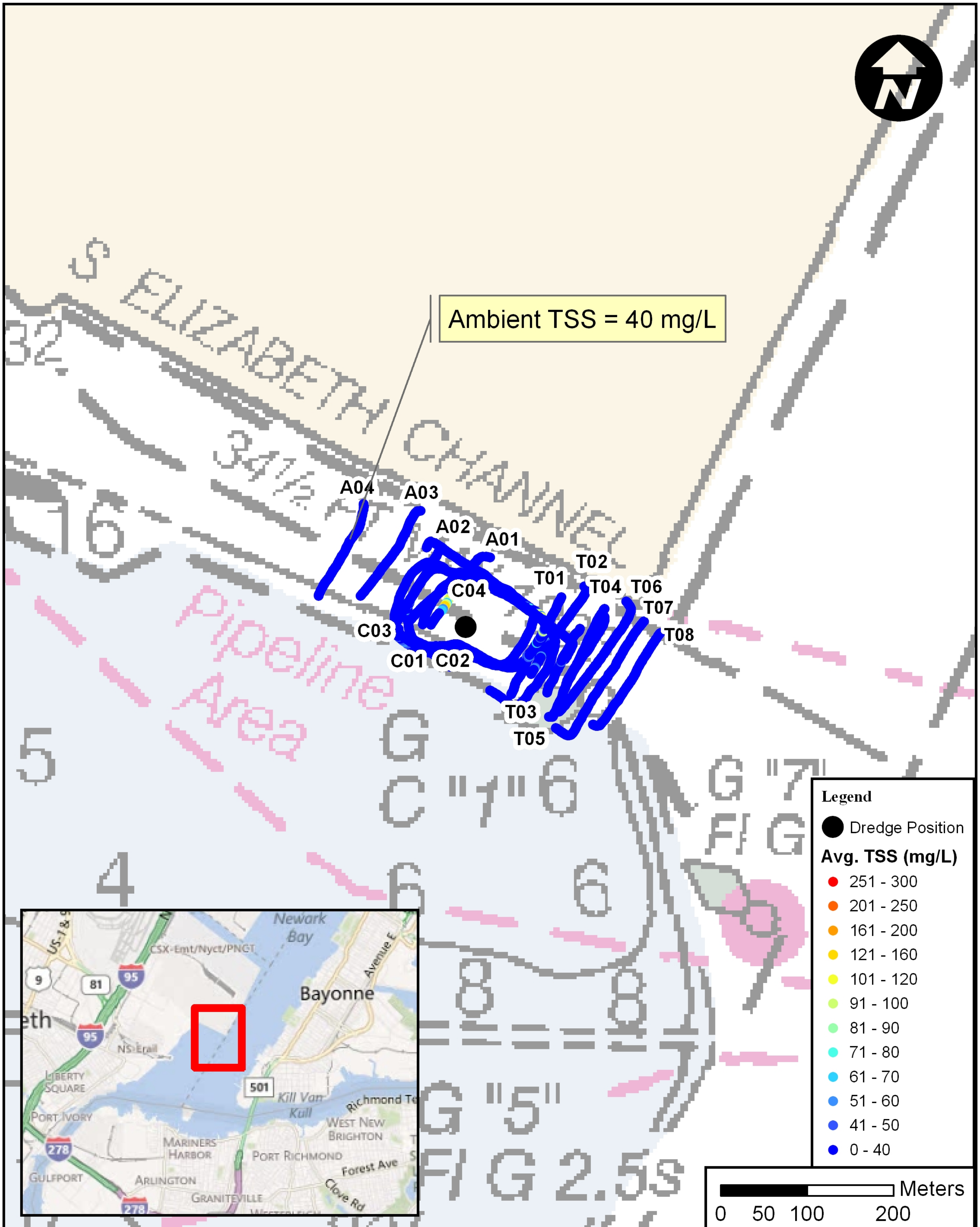


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 29 July 2011 0-2 Meter Depth Interval	Tide
18a			Ebb

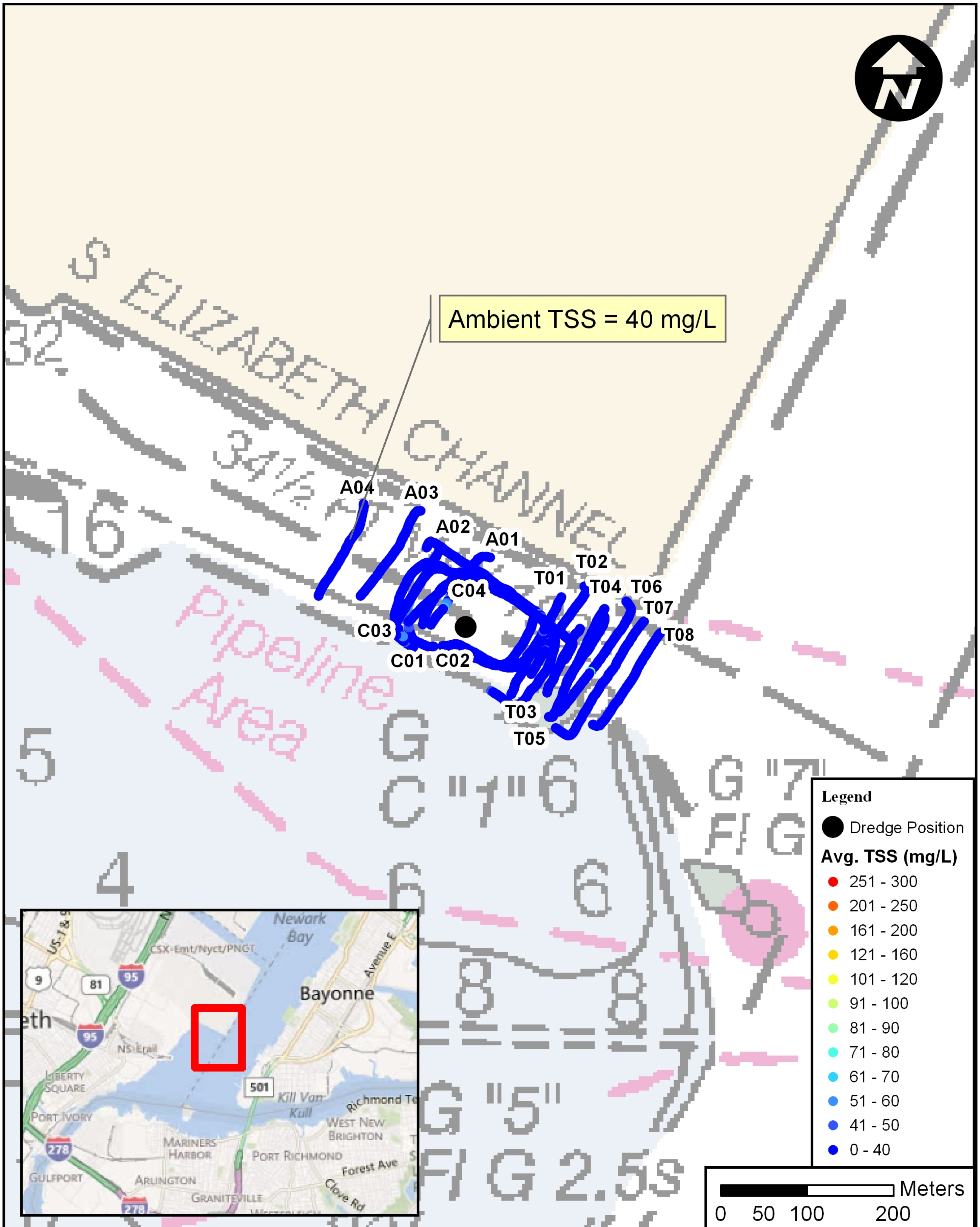


Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2*	**ADCP Average TSS - 29 July 2011** **2-4 Meter Depth Interval**	**Tide**
18b			**Ebb**

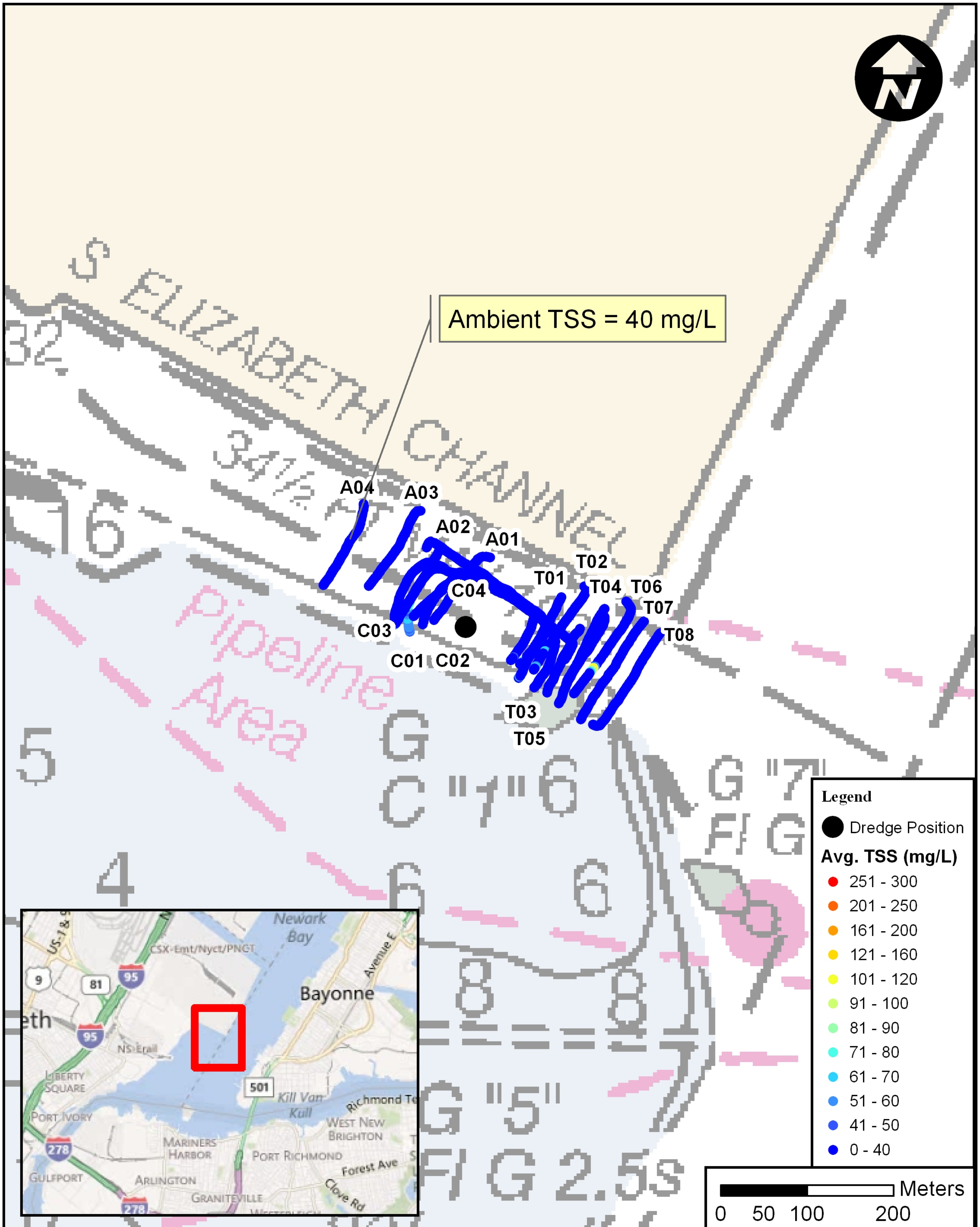


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 29 July 2011 4-6 Meter Depth Interval	Tide
18c			Ebb

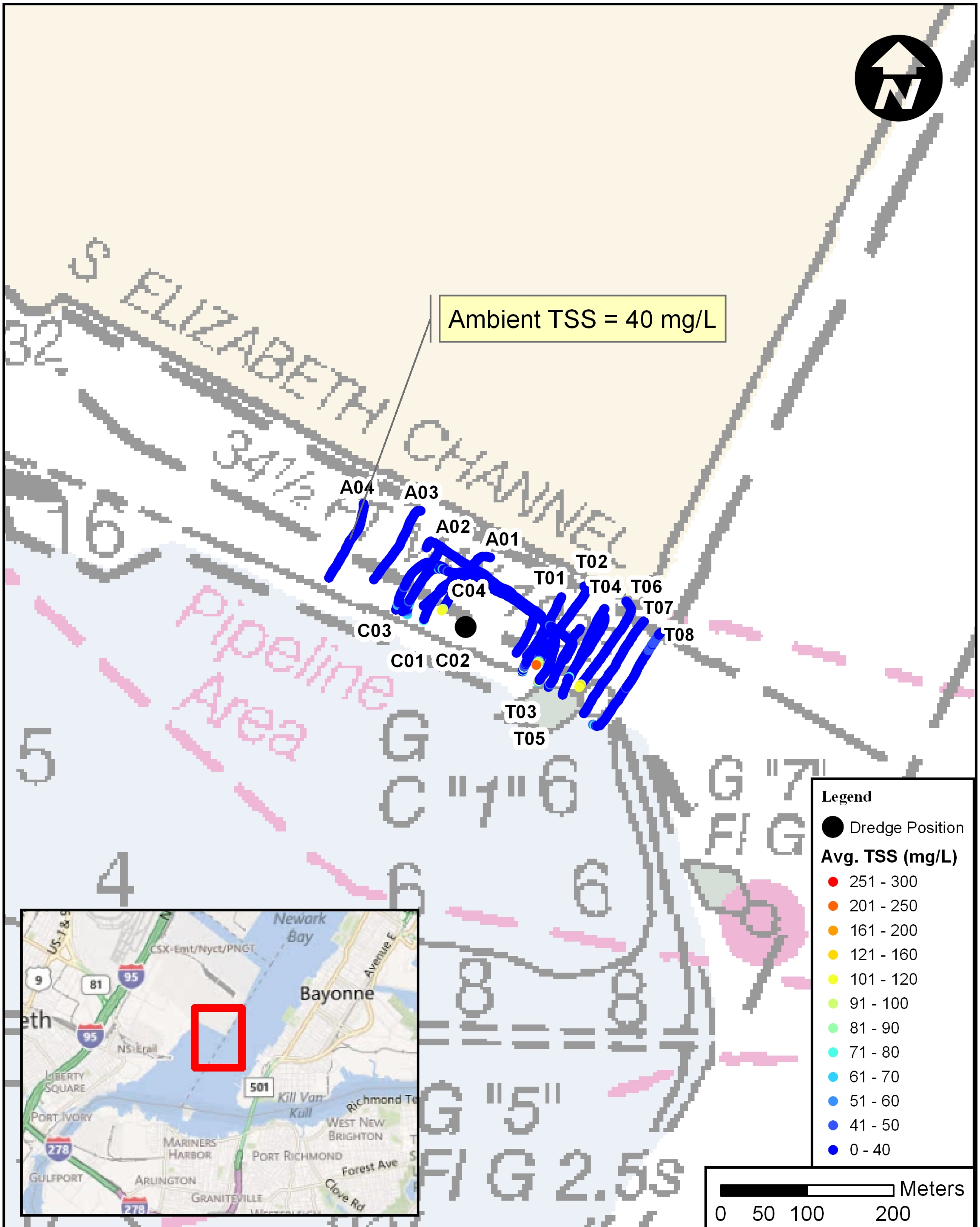


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 29 July 2011 6-8 Meter Depth Interval	Tide
18d			Ebb

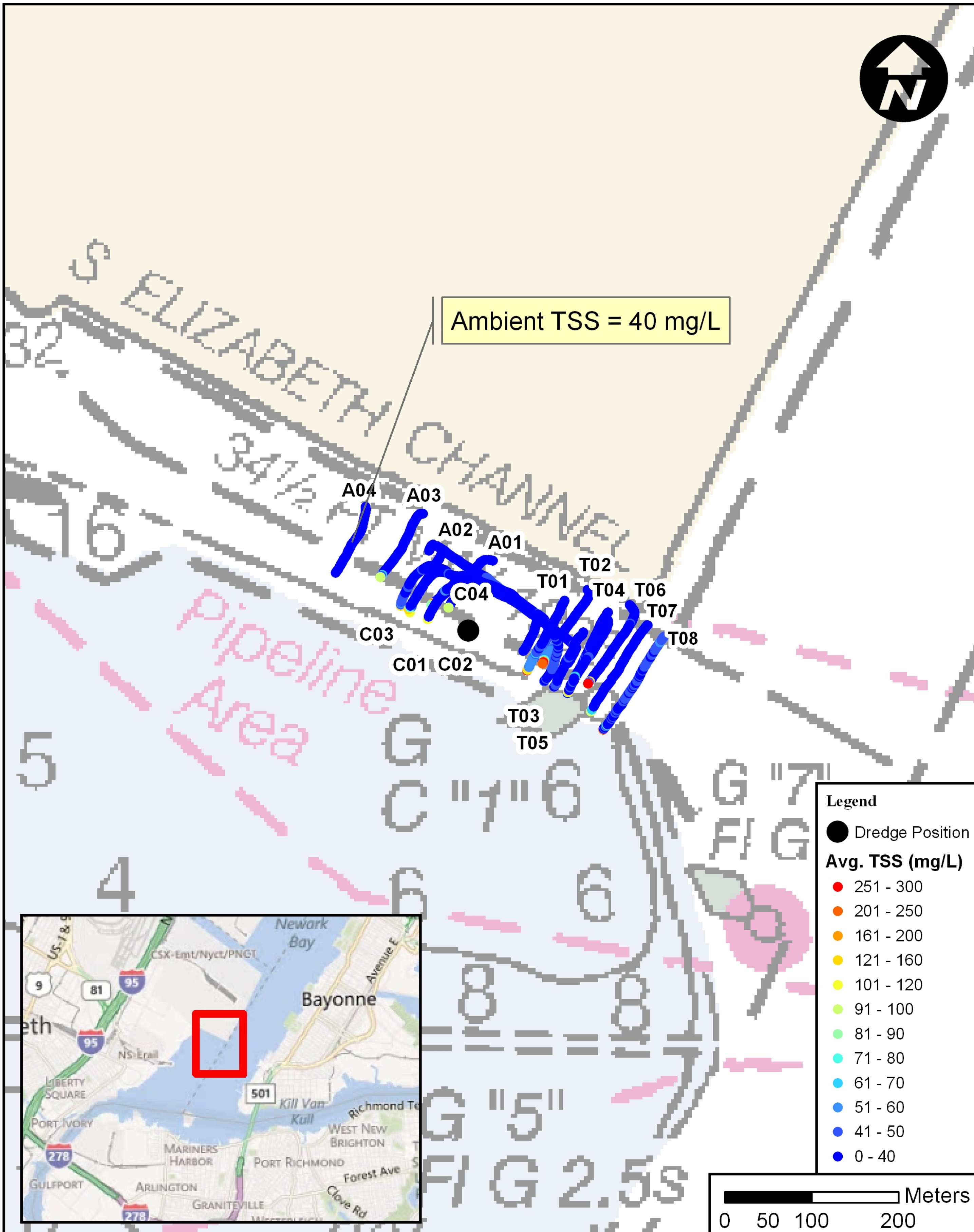


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 29 July 2011 8-10 Meter Depth Interval	Tide
18e			Ebb

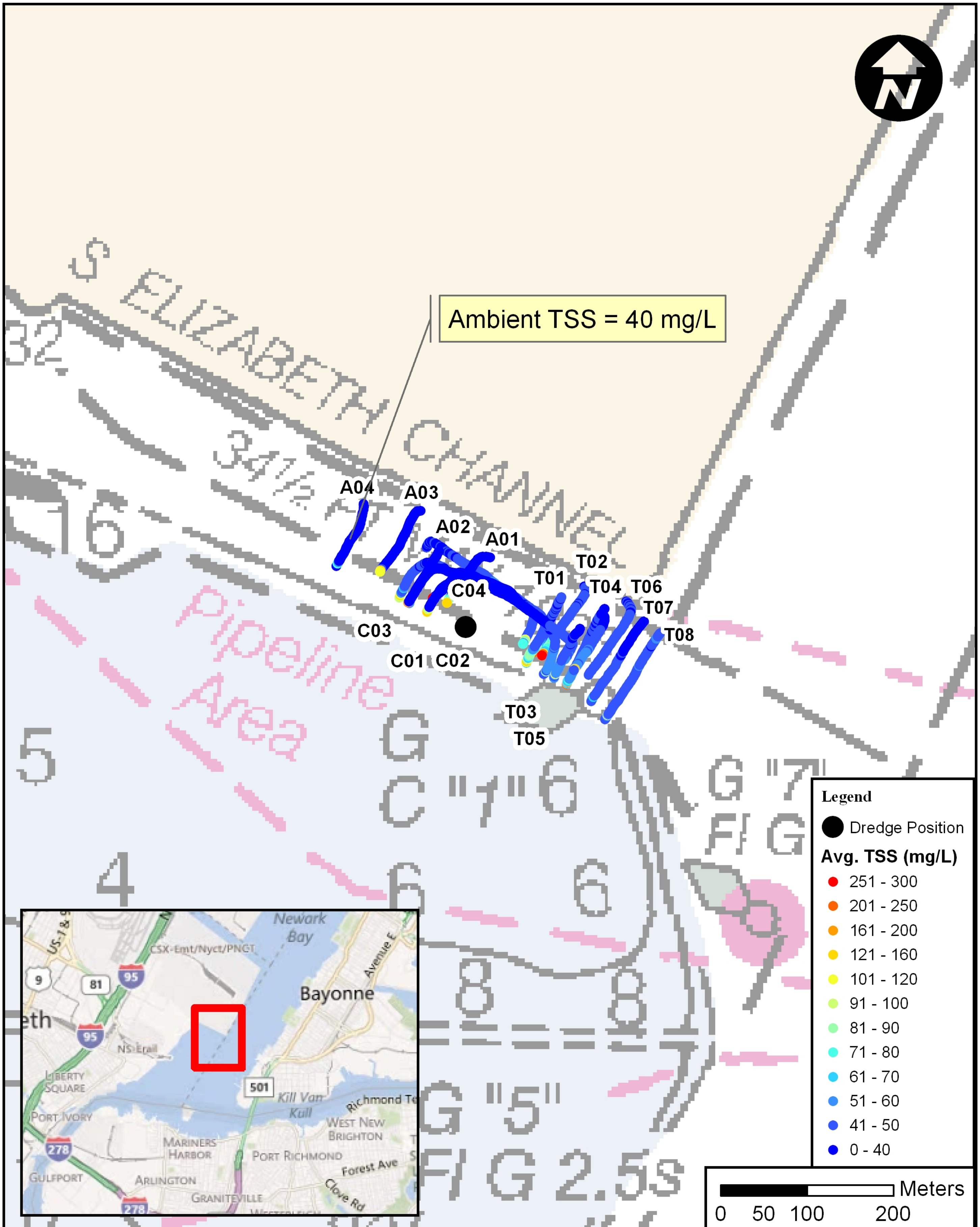


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 29 July 2011 10-12 Meter Depth Interval	Tide
18f			Ebb

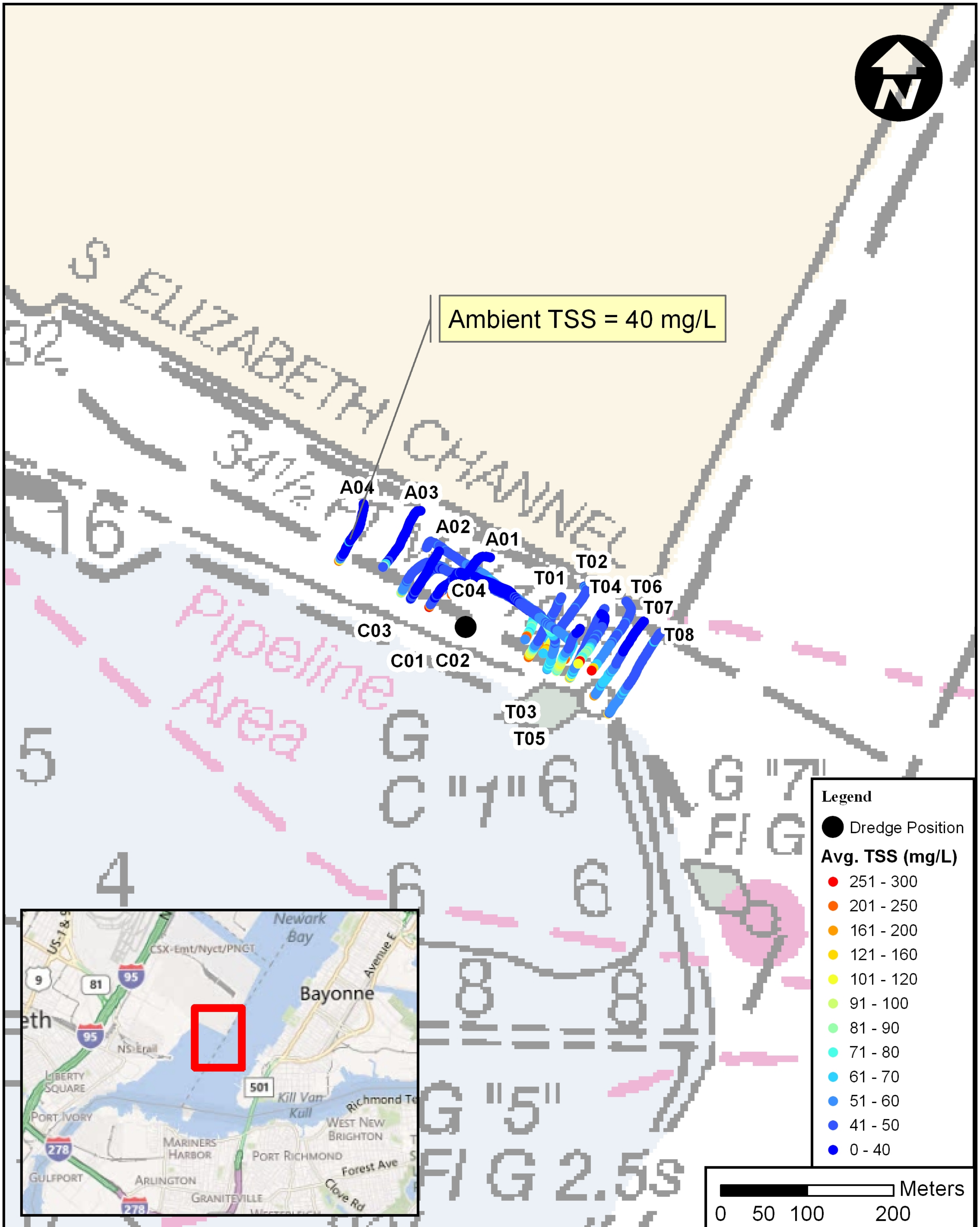


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 29 July 2011 12-14 Meter Depth Interval	Tide
18g			Ebb

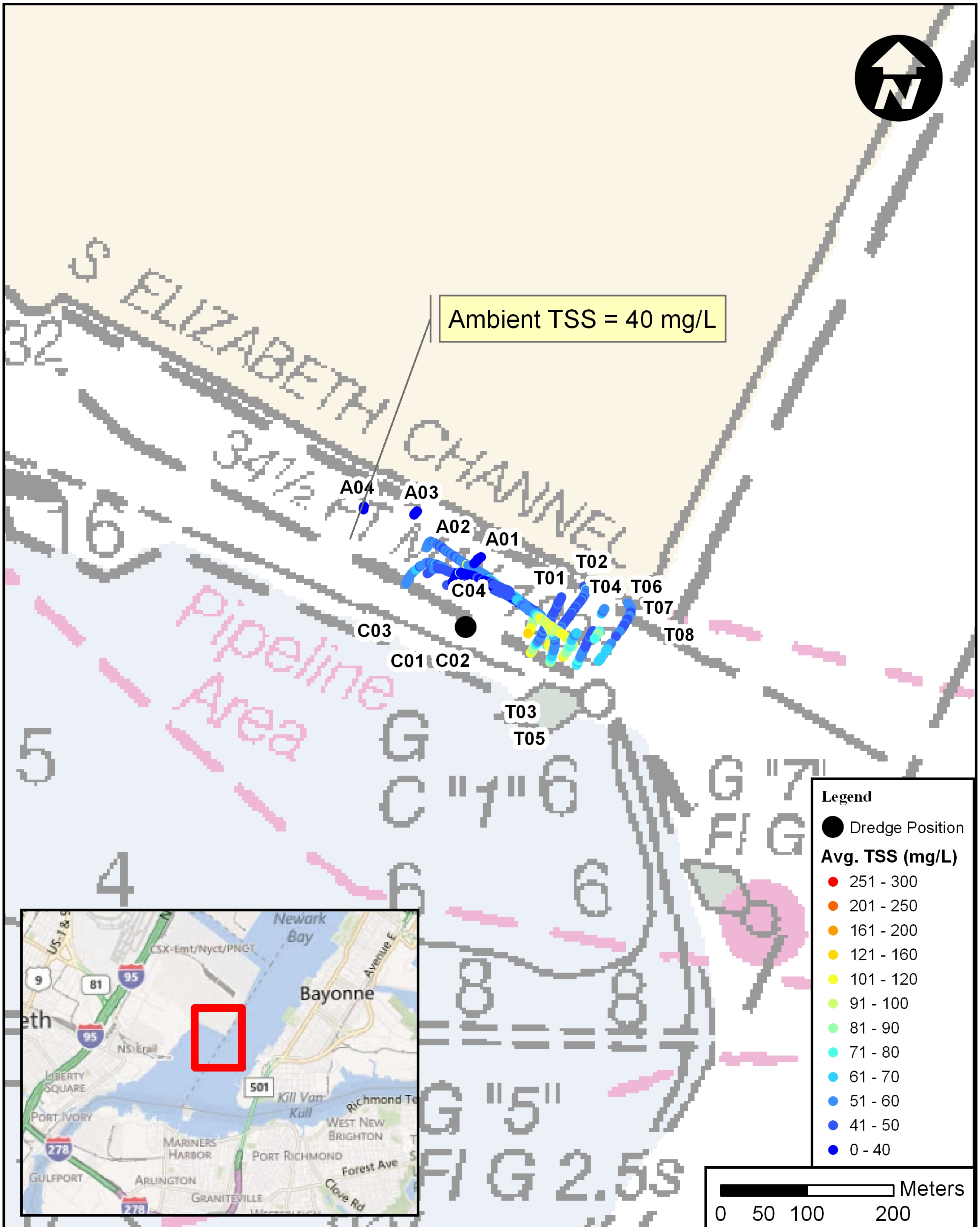
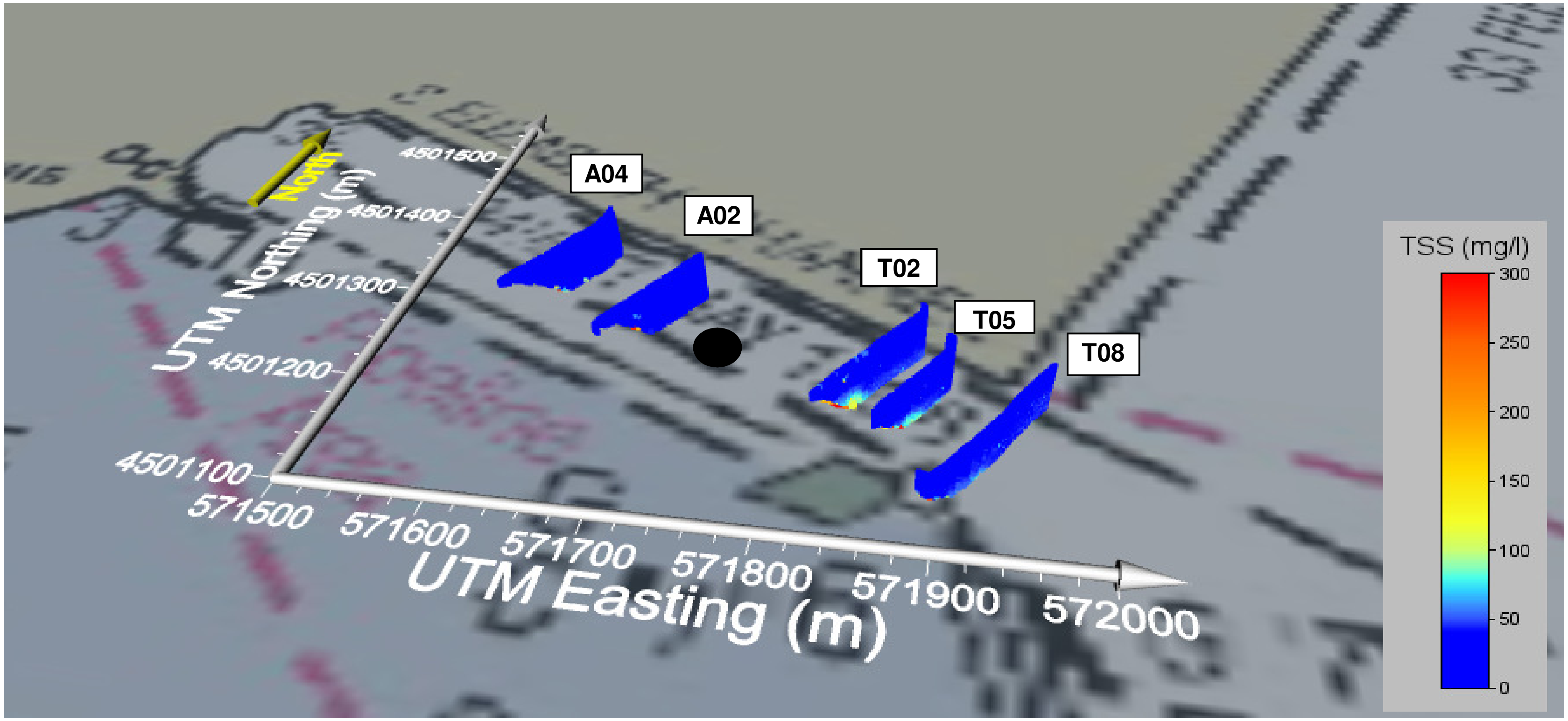


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 29 July 2011 14-16 Meter Depth Interval	Tide
18h			Ebb



= Dredge Location

Z scale exaggerated 6X

Figure	*USACE Harborwide TSS*	ADCP Average TSS Values, 3D View of Selected Transects	Tide
19	*Far Field Survey* *HDP Contract Area S-NB-2*	29 July 2011	Ebb

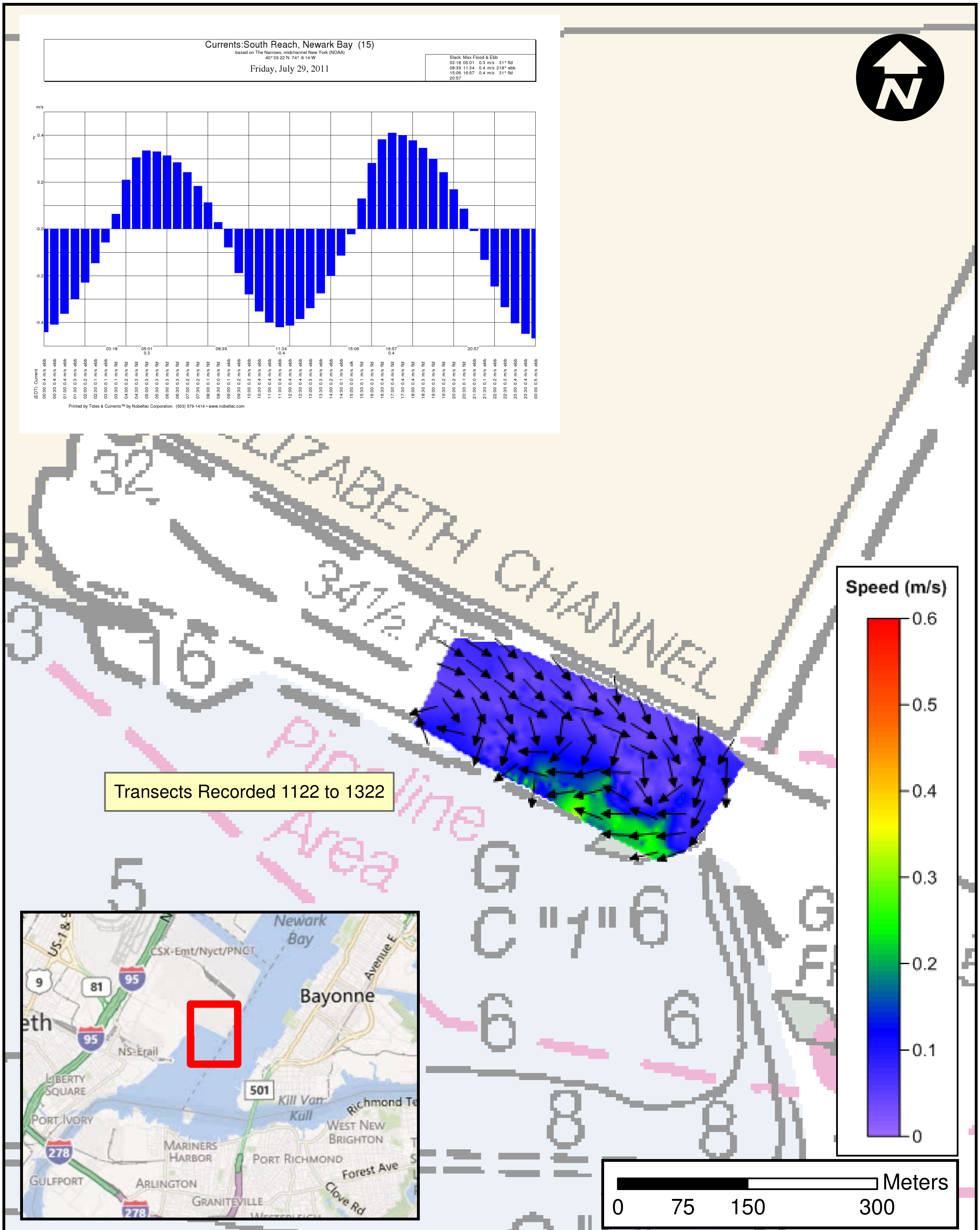


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	Depth Averaged Velocites 29 July 2011 - Ebb Tide TSS Survey	Tide
20			Ebb

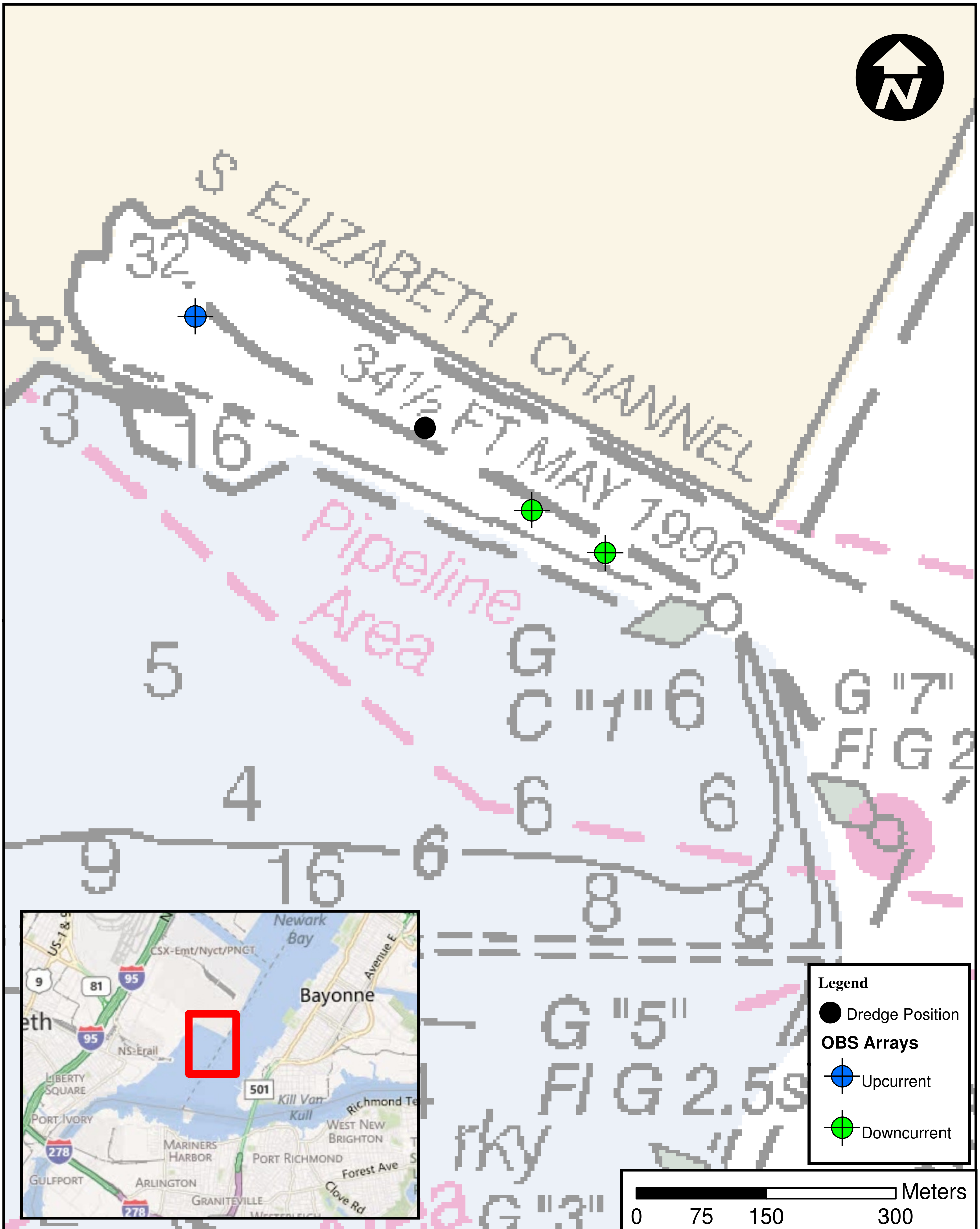
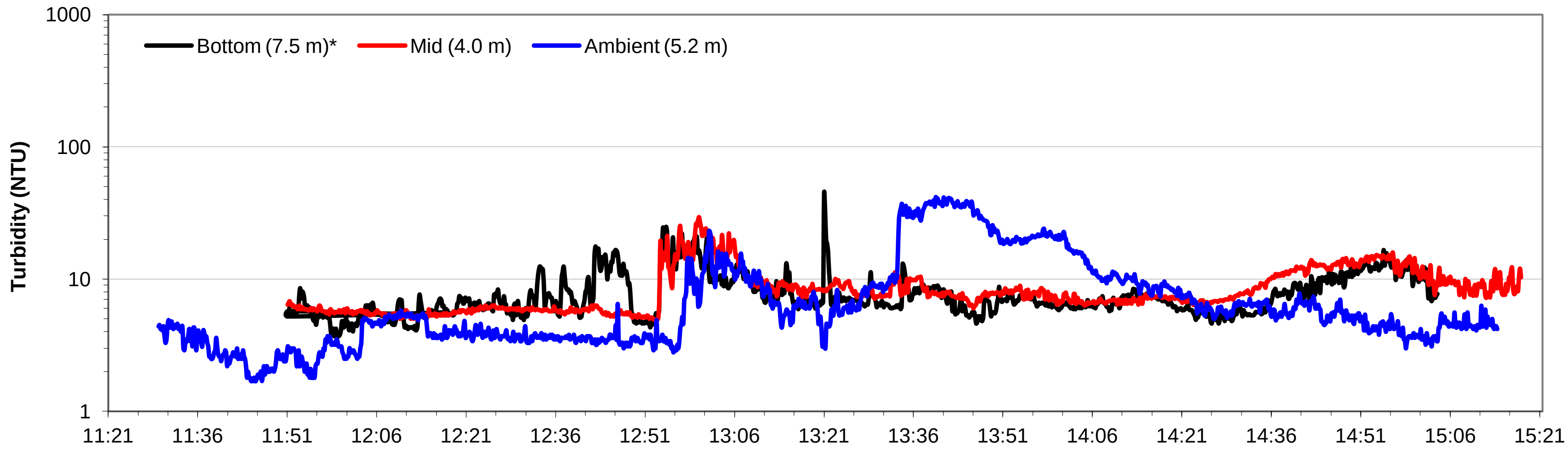
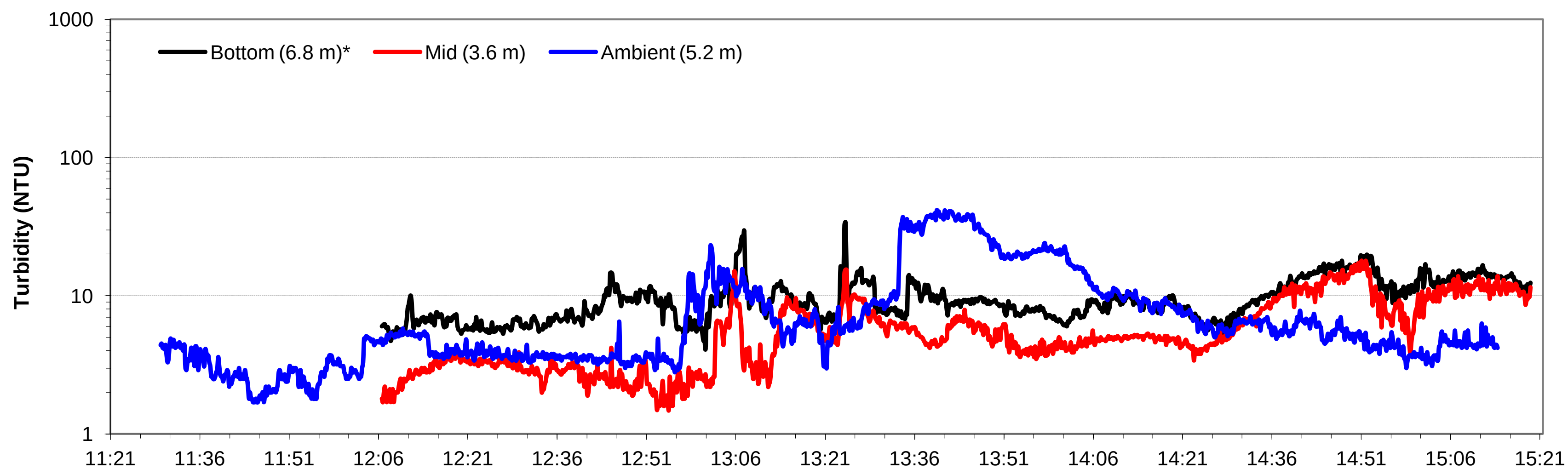


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-2*	**Location of OBS Vertical Arrays and Dredge Position** **26 July 2011**	**Tide**
21			**Flood**

a) 150 meters Down Current from Dredge



b) 255 meters Down Current from Dredge



*Number in parentheses is average depth of instrument over period recorded

Figure	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Surface and Bottom OBS Turbidities at a) 150 m and b) 255 m Downcurrent of Dredge. Ambient Station Located 300 m Upcurrent of Dredge 26 July 2011 TSS Survey**	Tide
22			Flood

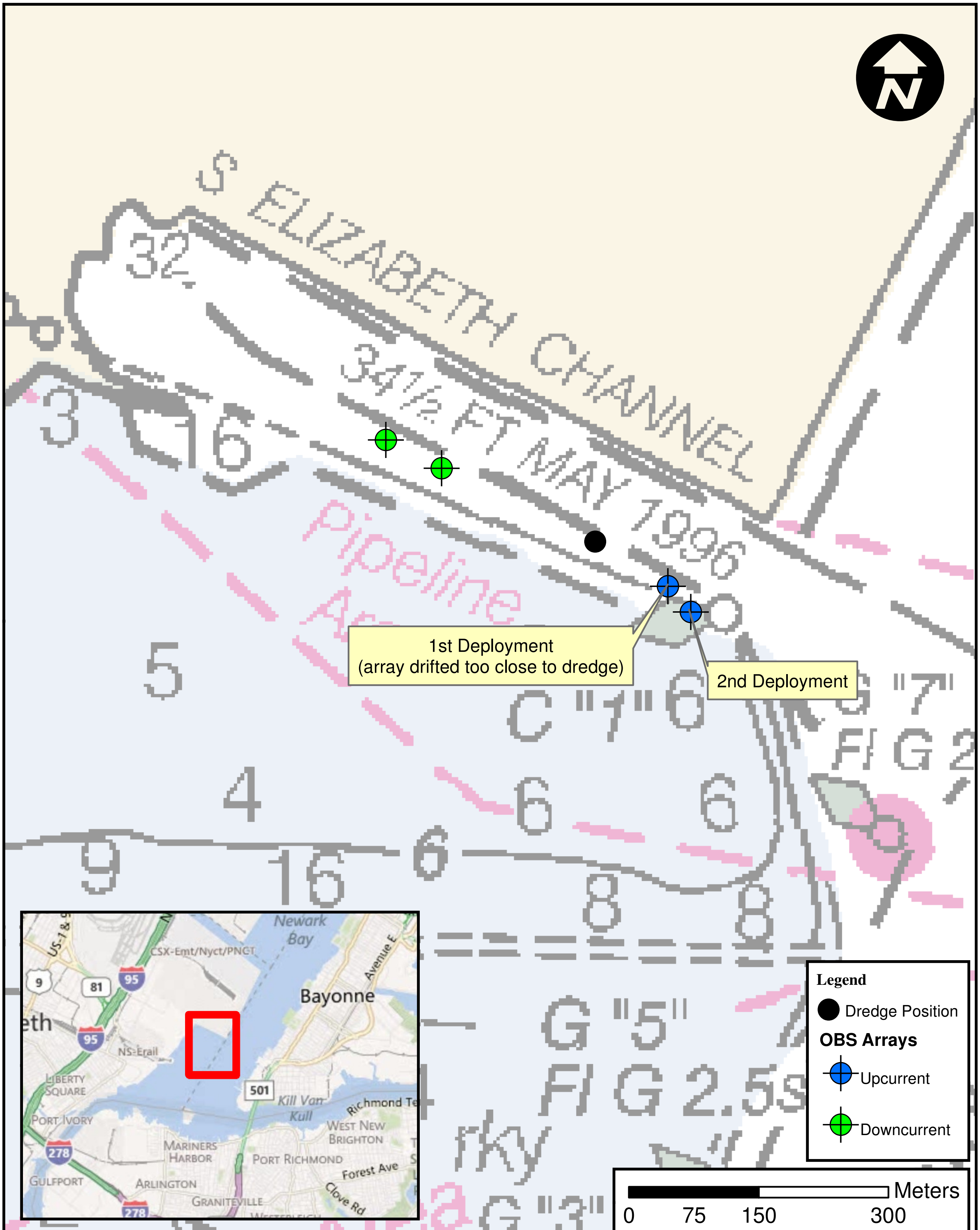
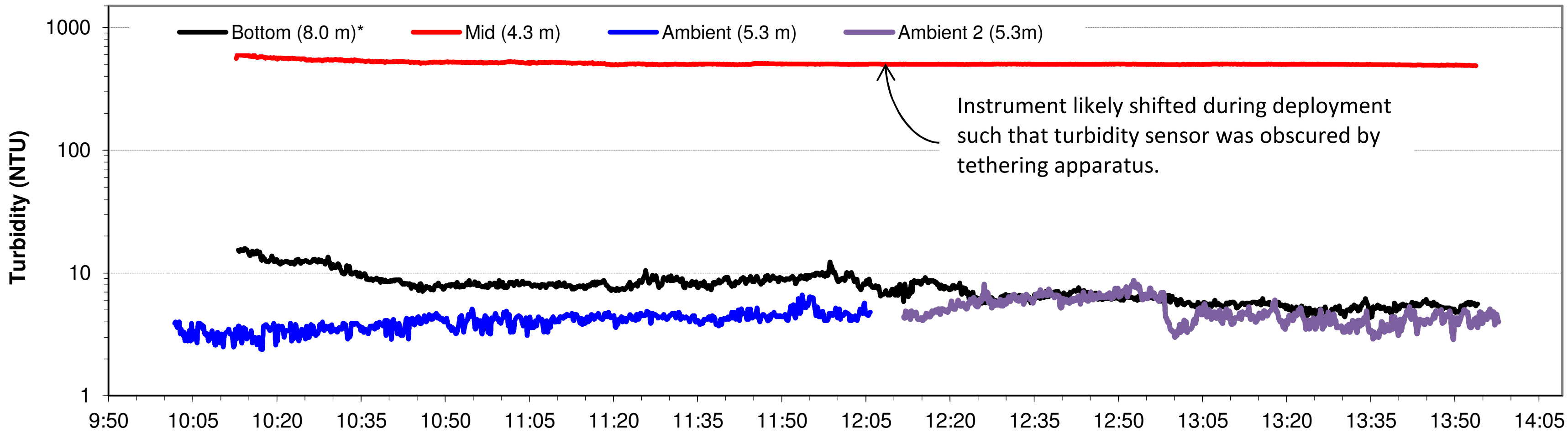
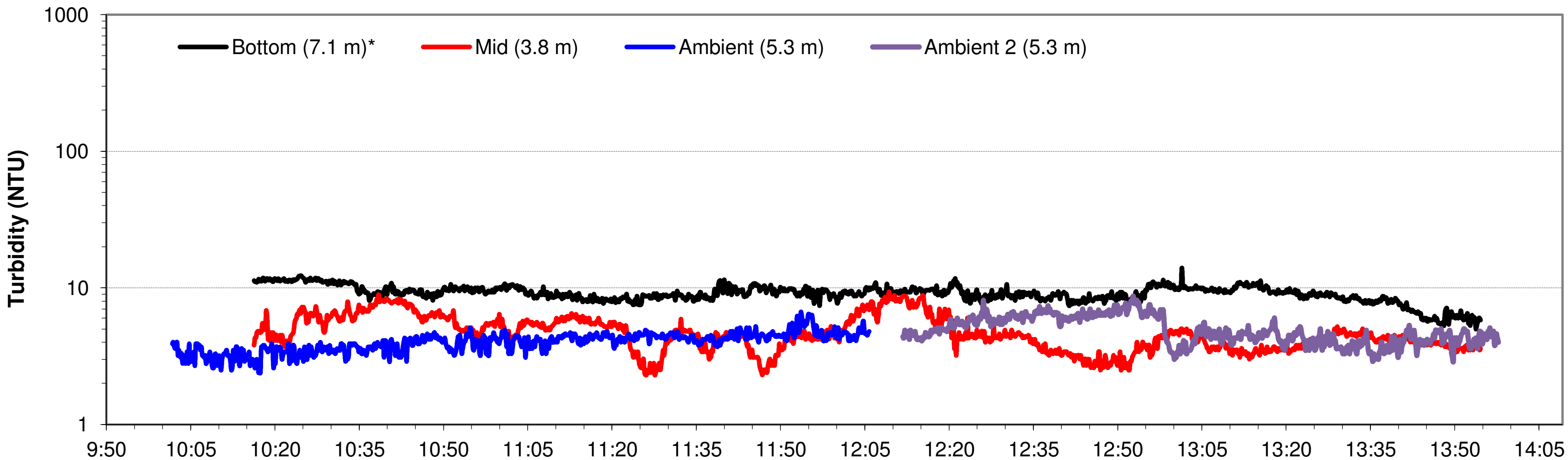


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	Location of OBS Vertical Arrays and Dredge Position 29 July 2011	Tide
23			Ebb

a) 200 meters Downcurrent from Dredge



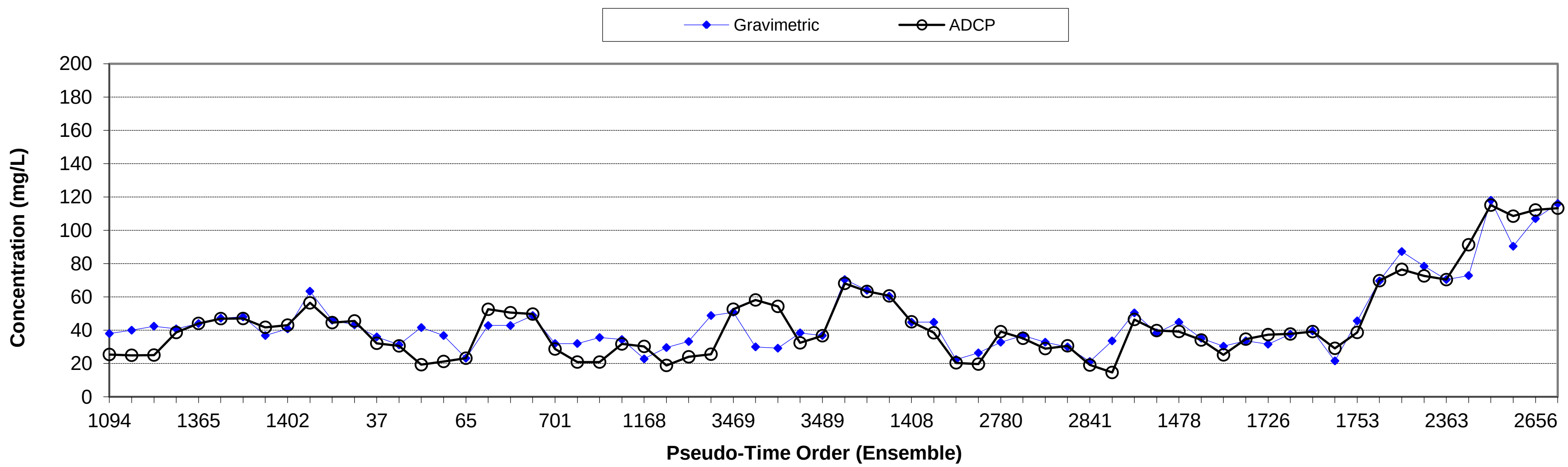
b) 270 meters Downcurrent from Dredge



*Number in parentheses is average depth of instrument over period recorded

Figure	USACE Harborwide TSS Far Field Survey S-NB-2	Surface and Bottom OBS Turbidities at a) 200 m and b) 270 m Downcurrent of Dredge Ambient Station Located 100 m Upcurrent of Dredge. Ambient 2 Located 152 m Upcurrent 29 July 2011 TSS Survey	Tide
24			Ebb

a)



b)

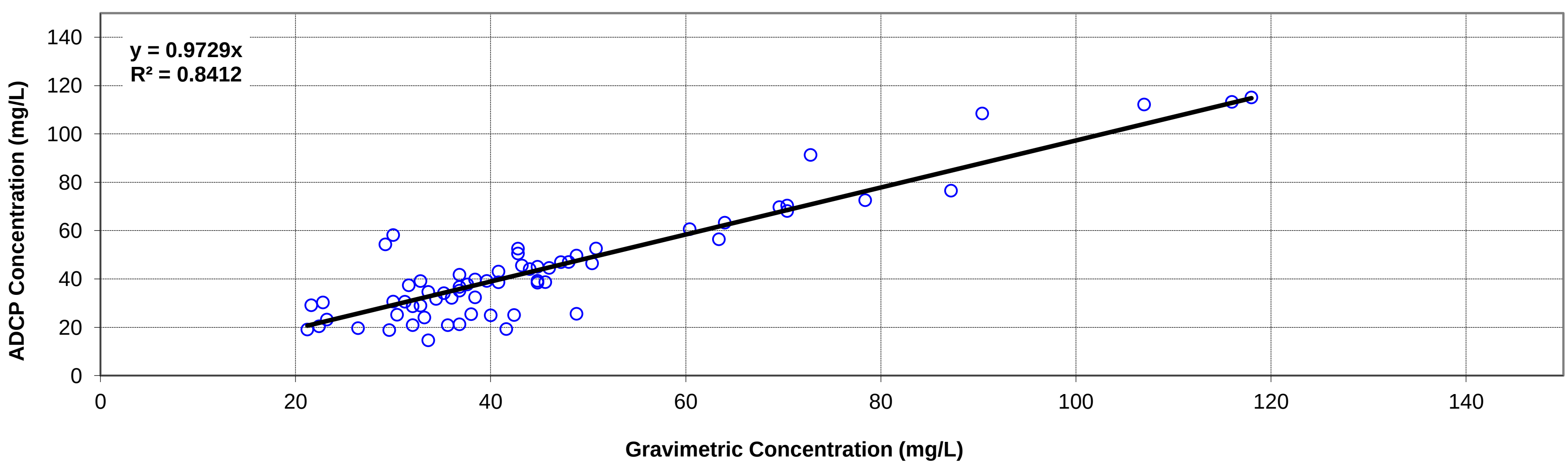


Figure	*USACE Harborwide TSS* *Far Field Survey* *S-NB-2*	**Comparison of Gravimetric and ADCP Estimates of TSS Concentration** **a) Concentration vs. Time b) ADCP Concentration vs. Gravimetric Concentration** **S-NB-2/S-AK-1 Far Field Survey #1 (25 July - 29 July 2011)**
25a-b		

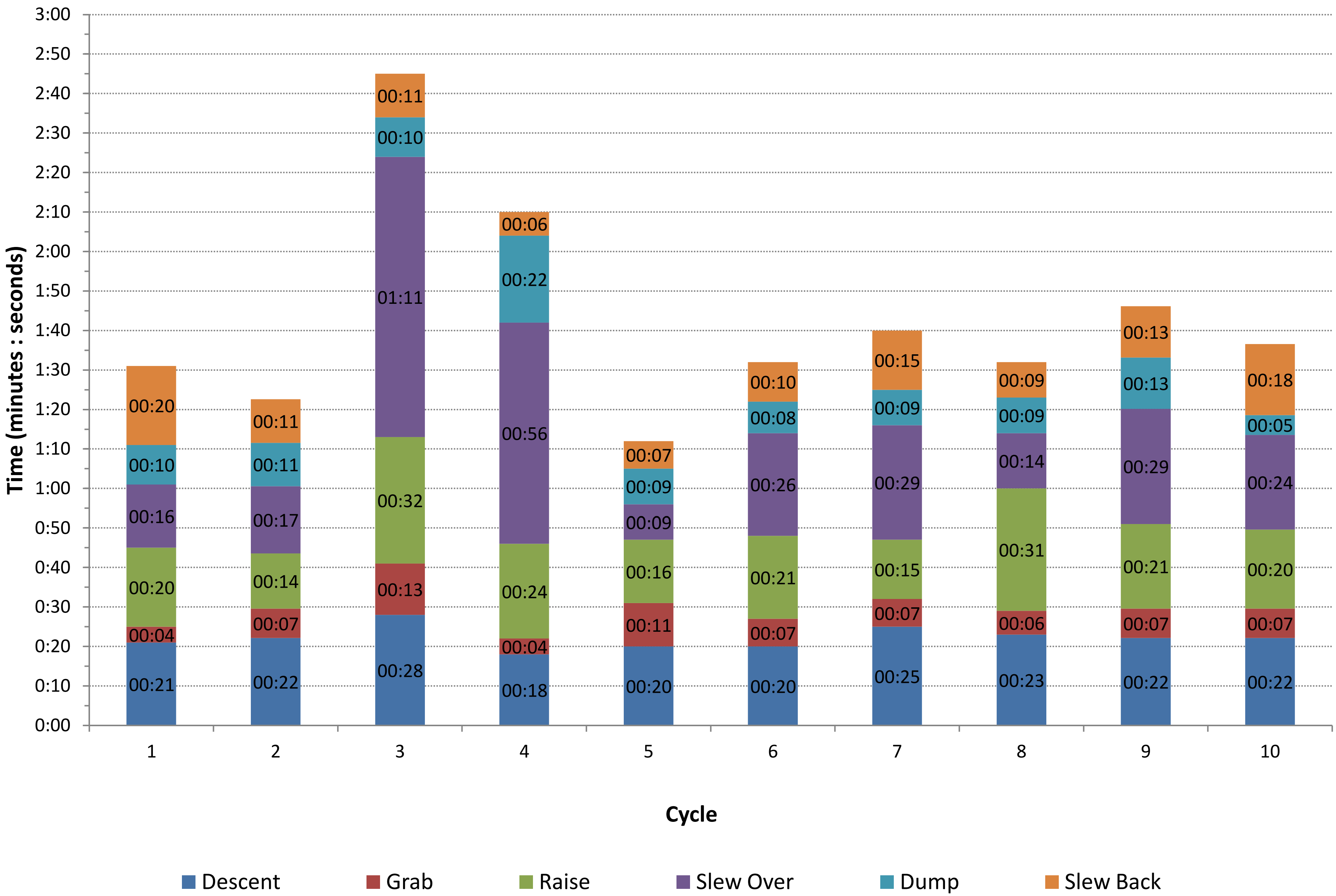


Figure	*USACE Harborwide TSS*	**Elapsed Time of Six Separate Components of Dredge Cable Arm Bucket Cycles**	Tide
26	*Far Field Survey* *HDP Contract Area: S-NB-2*	**29 July 2011**	**Ebb**

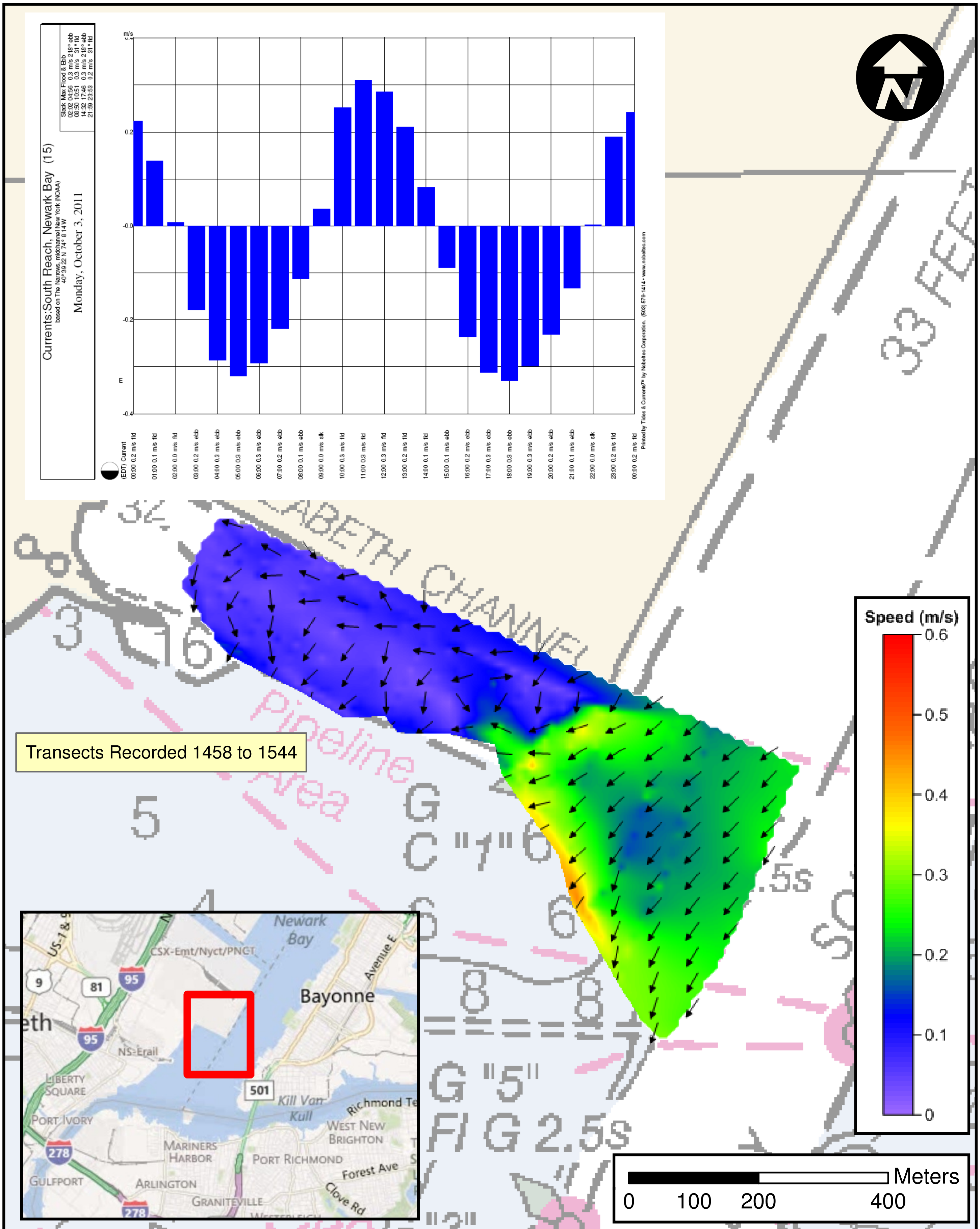


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-2*	**Depth Averaged Velocities** **03 October 2011 - Ebb Tide Hydrodynamic Survey**	**Tide**
27			**Ebb**

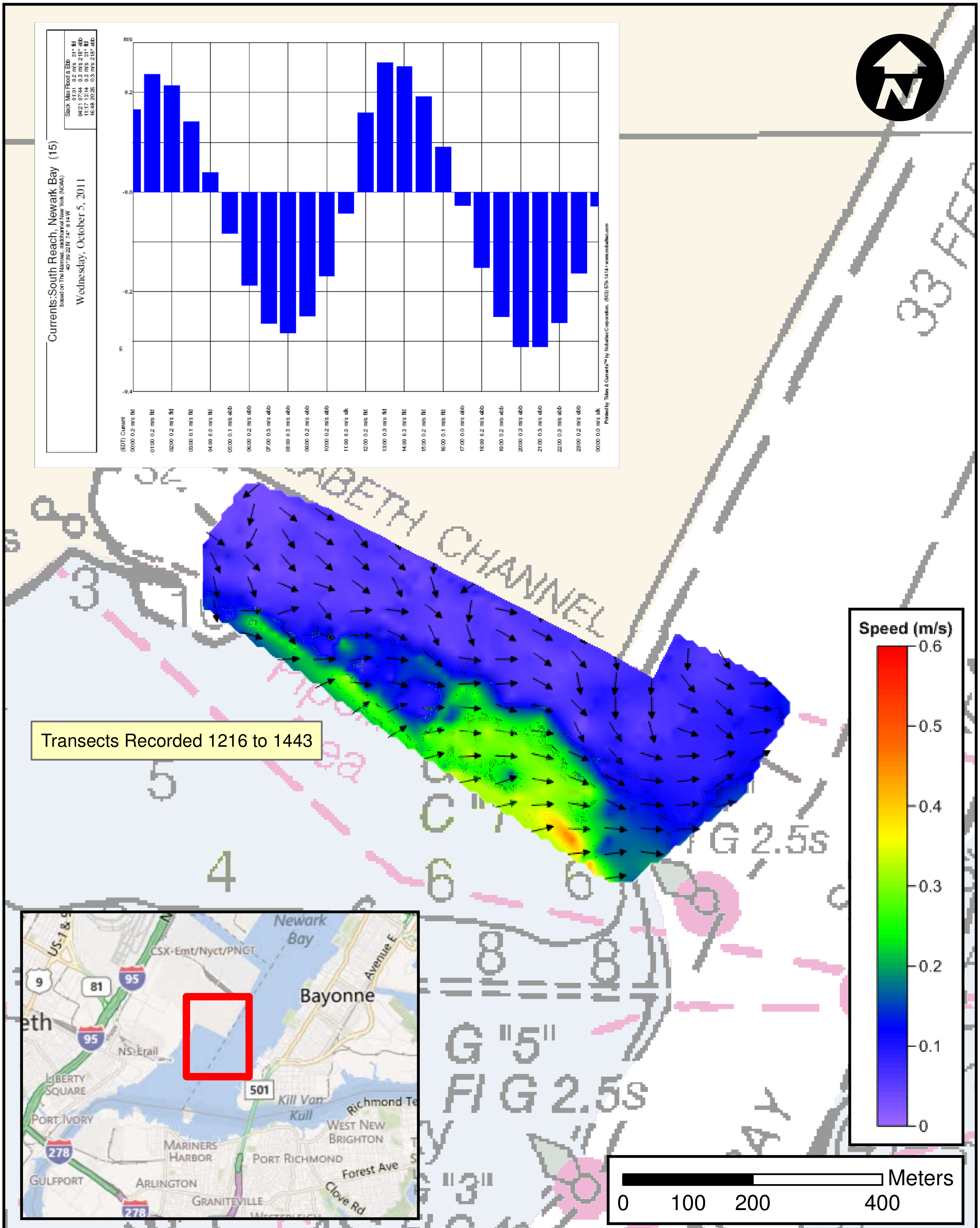


Figure	USACE Harborwide TSS *Far Field Survey* *HDP Contract Area: S-NB-2*	**Depth Averaged Velocities** **05 October 2011 - Flood Tide Hydrodynamic Survey**	**Tide**
28			**Flood**

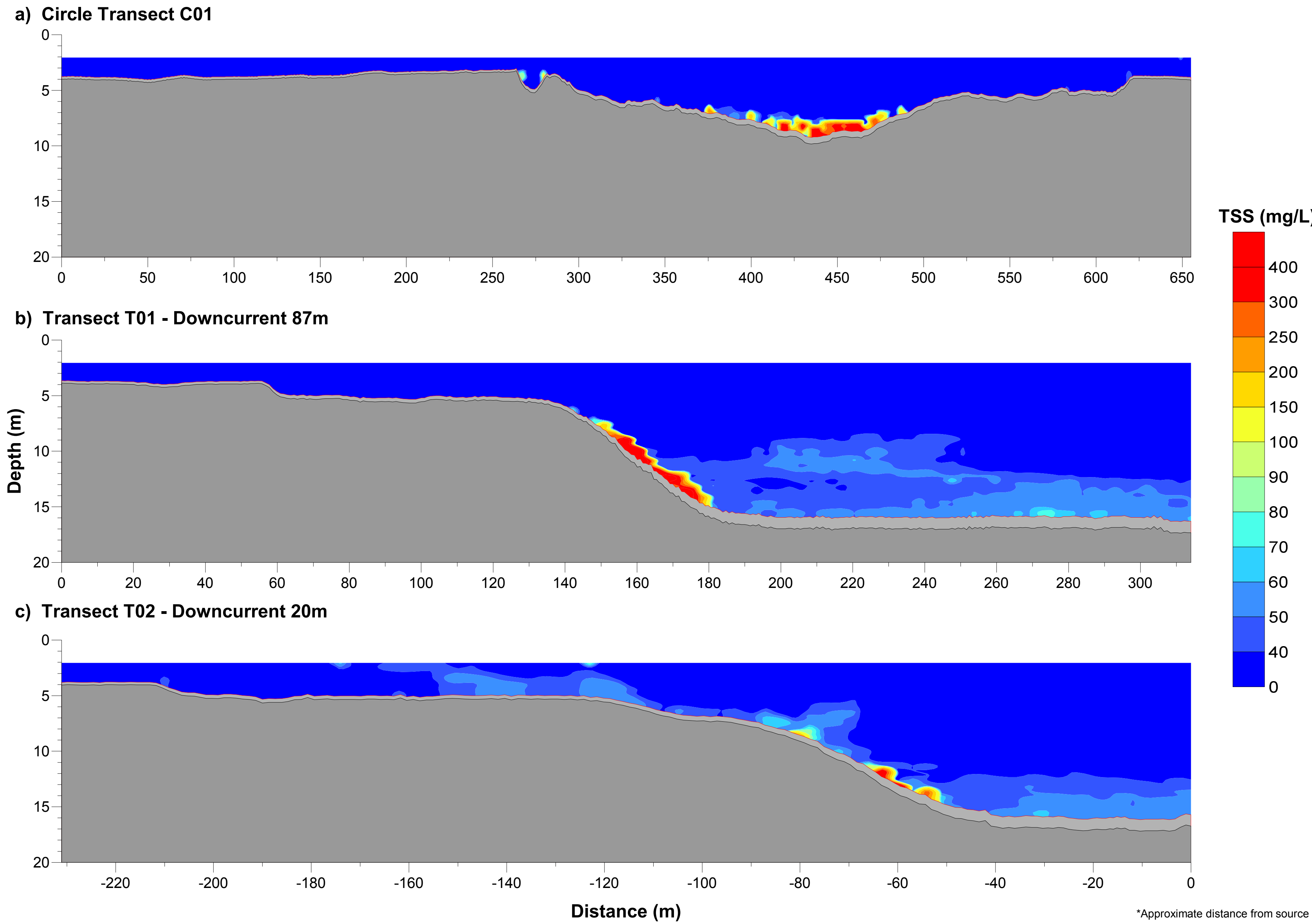


FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 04 October 2011 - Flood Tide**	TIDE
29a-c			**Flood**

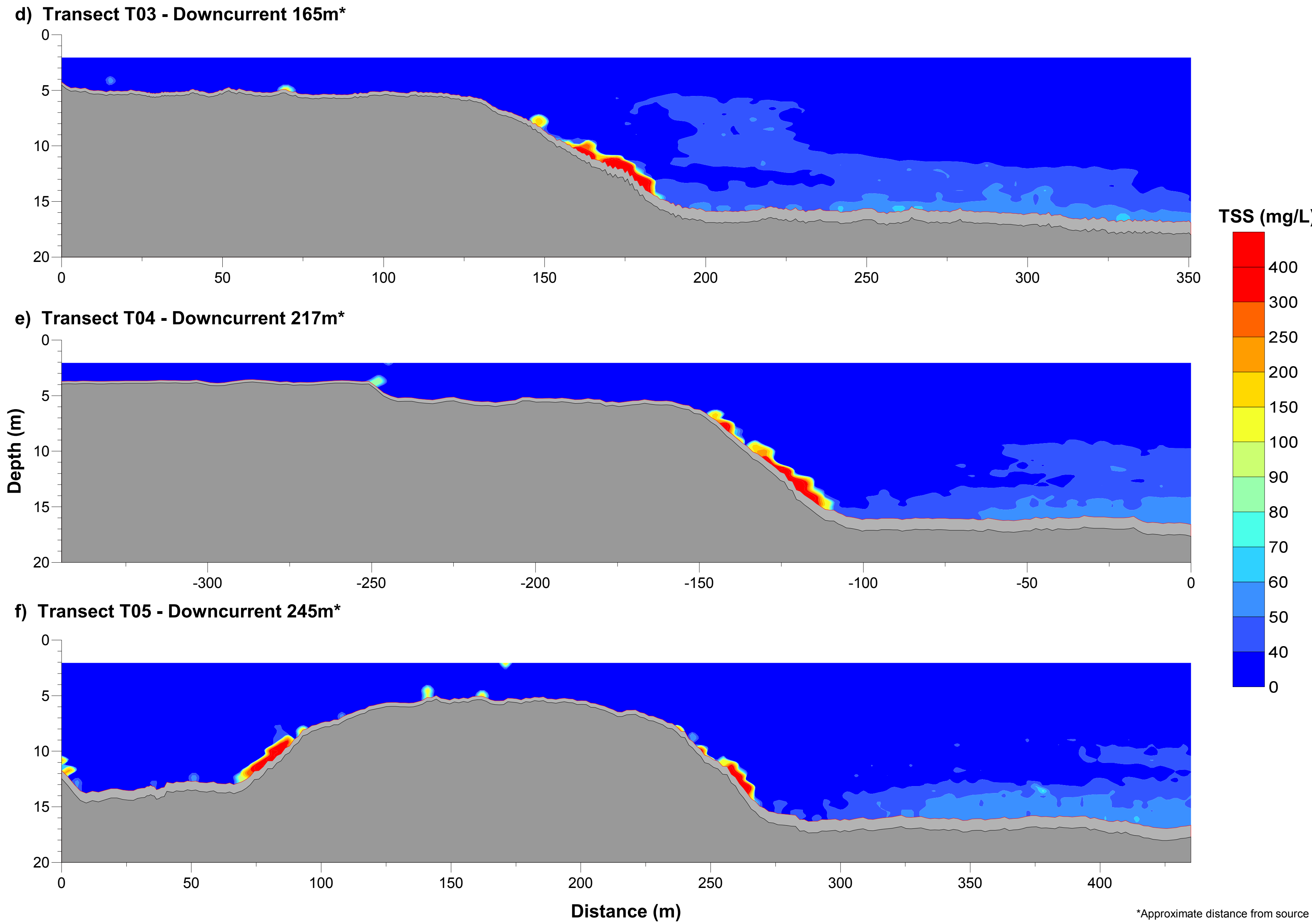
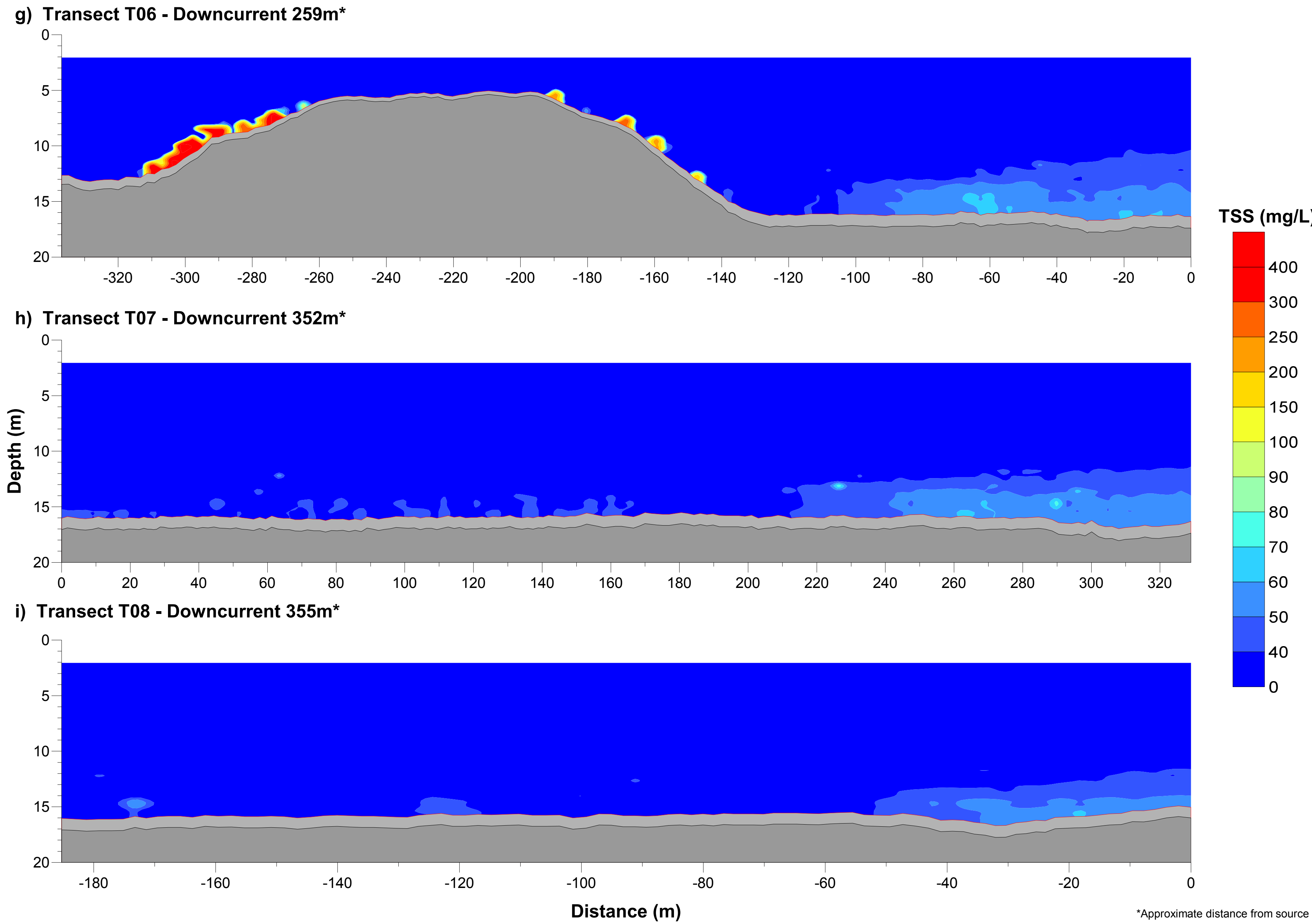


FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 04 October 2011 - Flood Tide	TIDE
29d-f			Flood



*Approximate distance from source

FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 04 October 2011 - Flood Tide	TIDE
29g-i			Flood

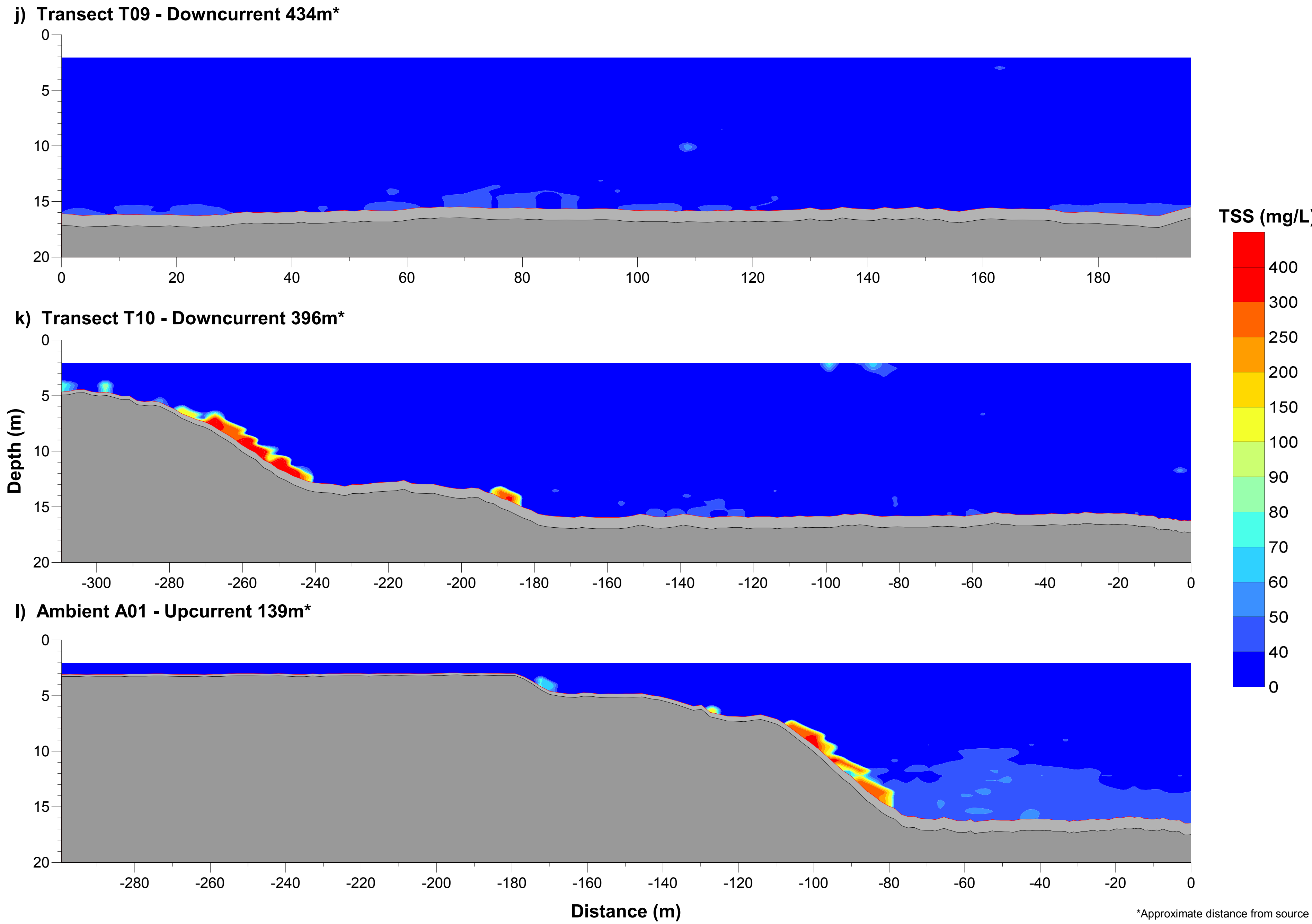
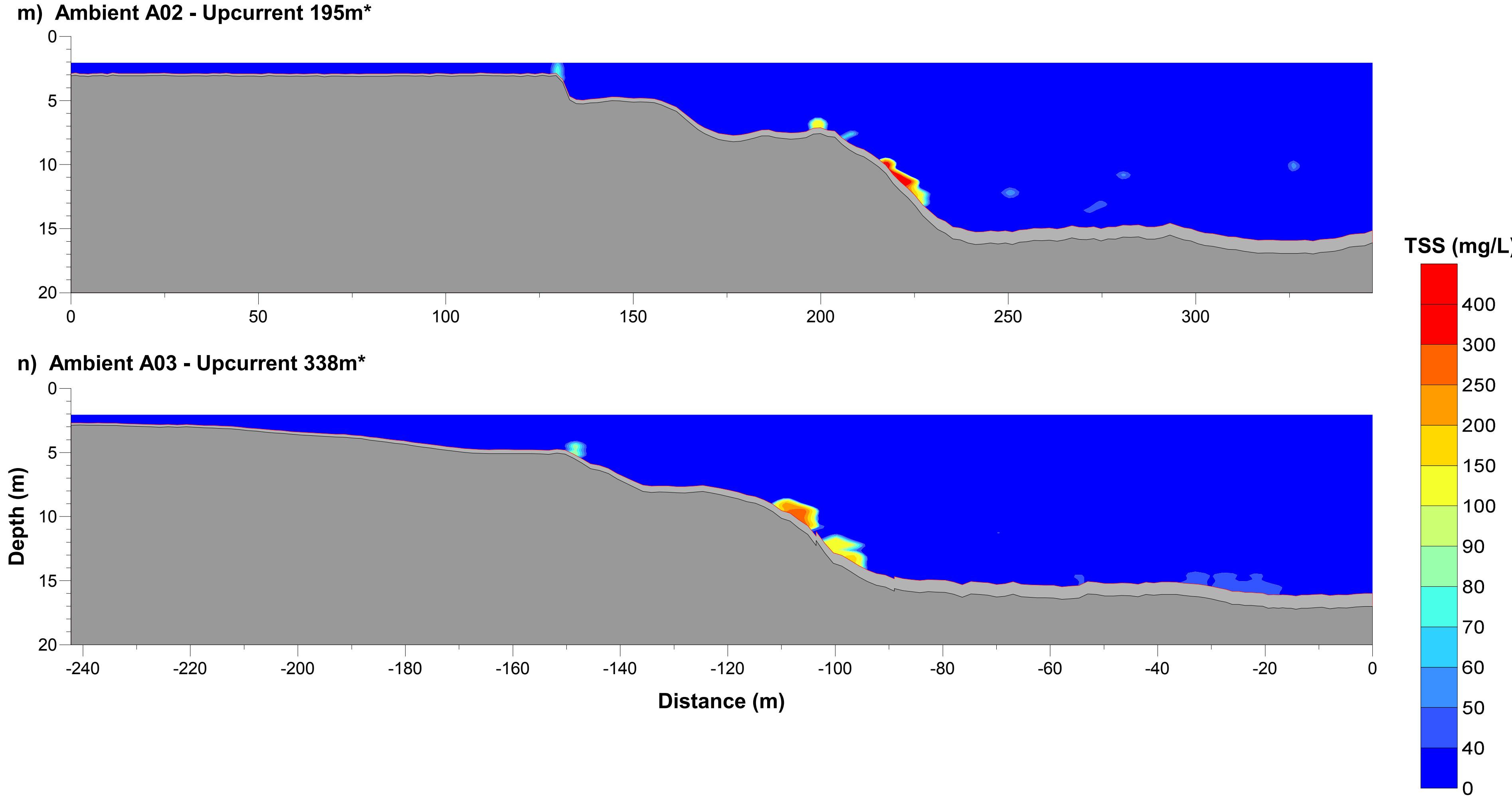


FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 04 October 2011 - Flood Tide**	TIDE
29j-l			**Flood**



*Approximate distance from source

FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 04 October 2011 - Flood Tide	TIDE
29m-n			Flood

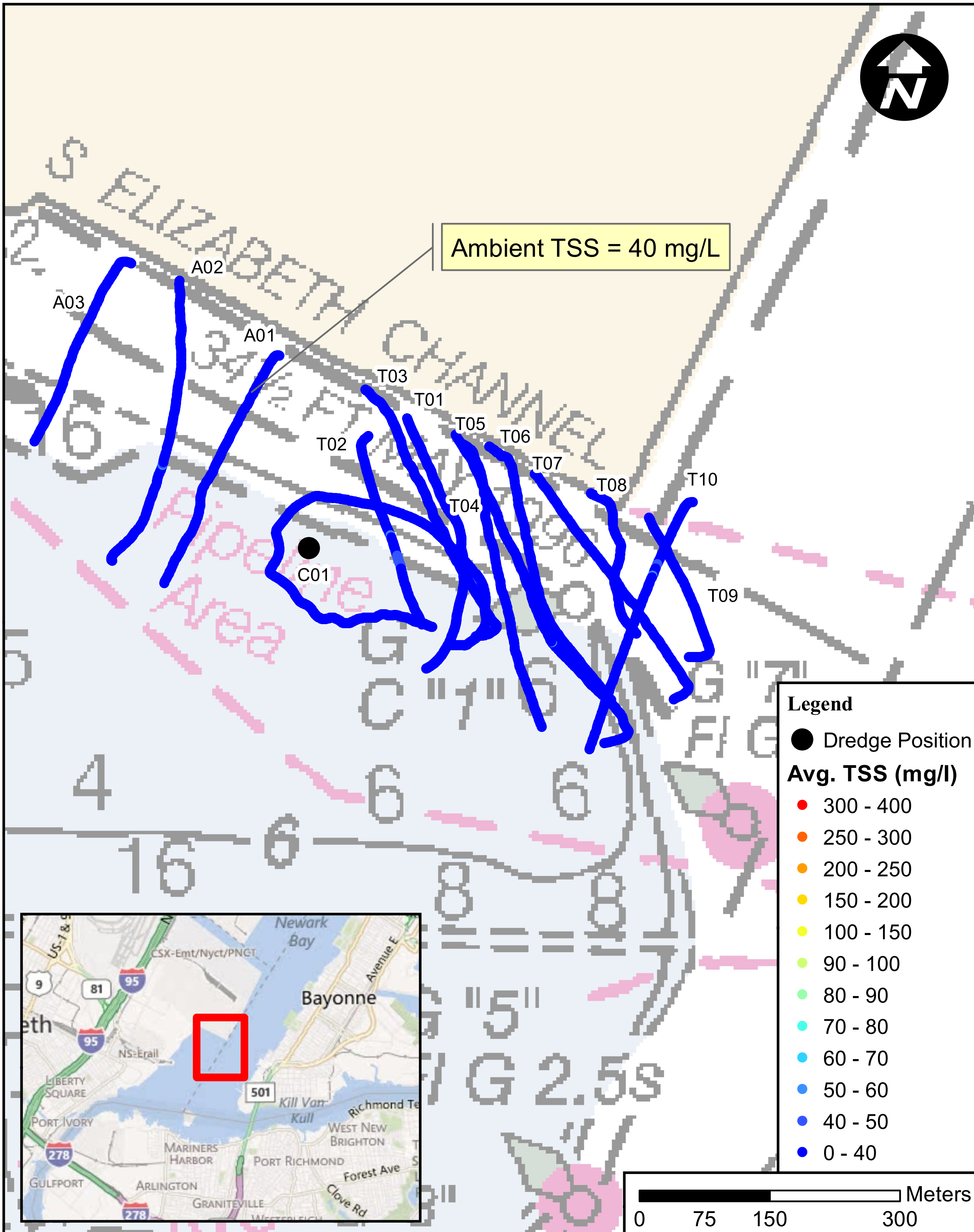


Figure	USACE Harborwide TSS *Far Field Survey* *HDP Contract Area: S-NB-2*	ADCP Average TSS - 04 October 2011 2-4 Meter Depth Interval	Tide
30a			Flood

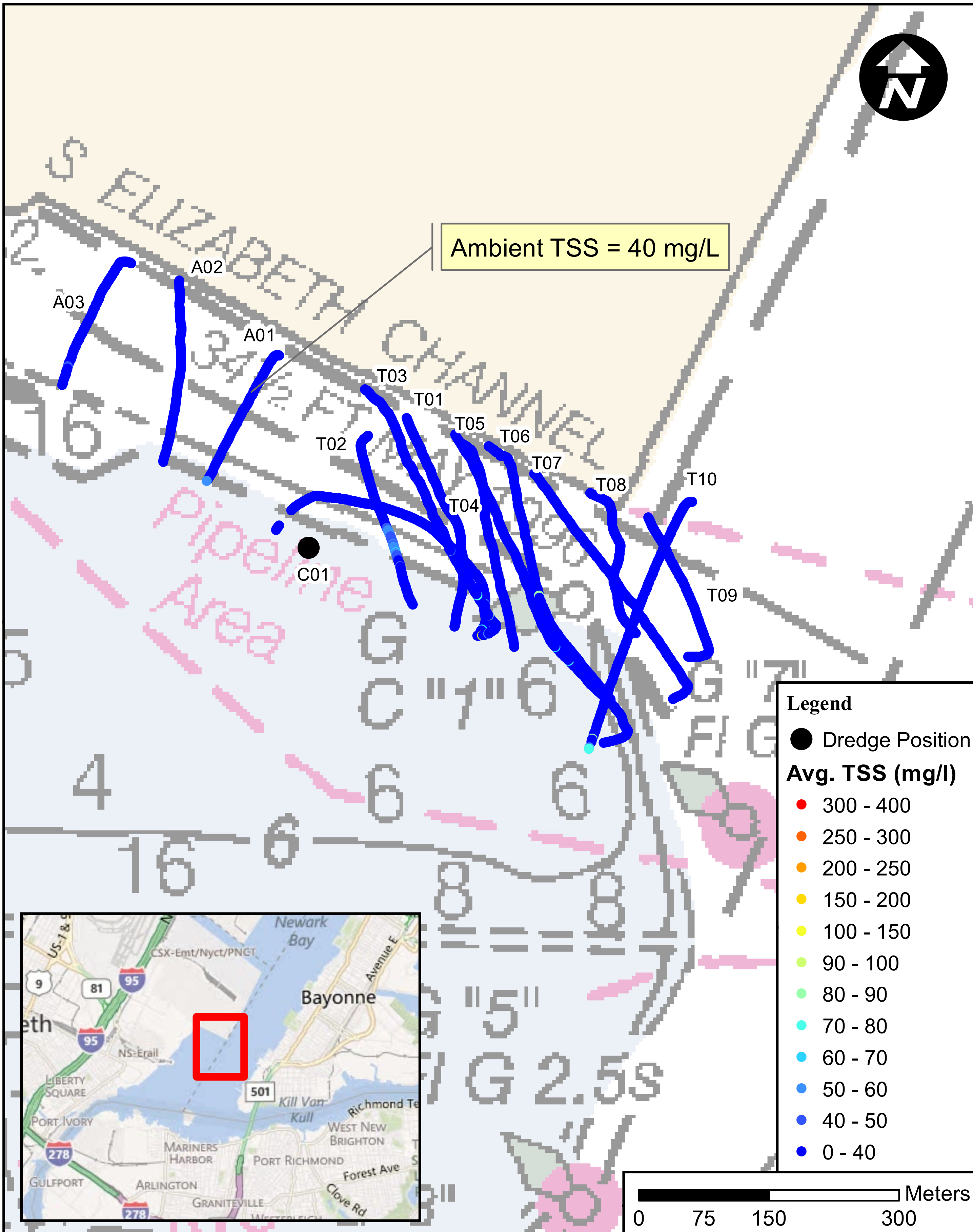


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 04 October 2011 4-6 Meter Depth Interval	Tide
30b			Flood

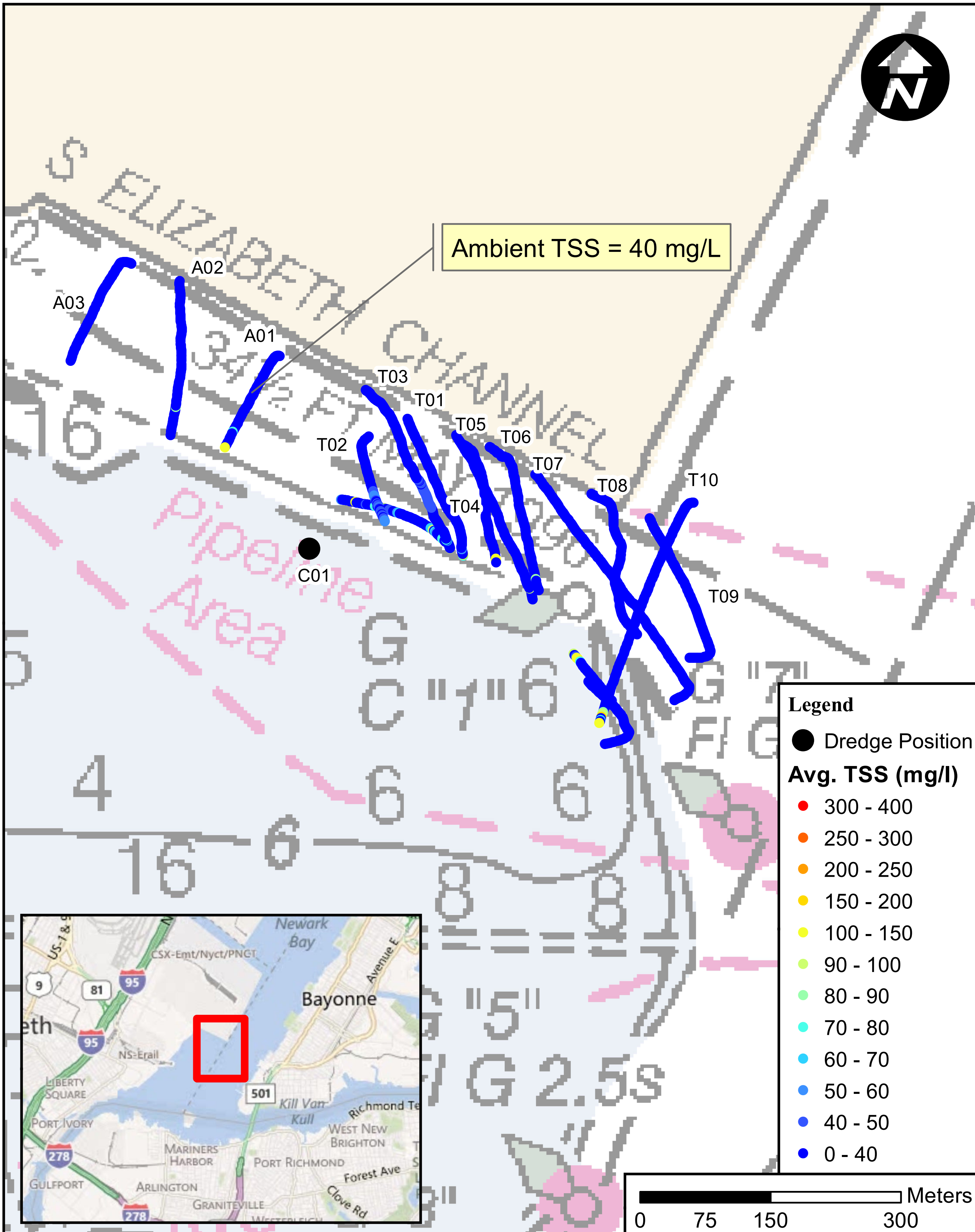


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 04 October 2011 6-8 Meter Depth Interval	Tide
30c			Flood

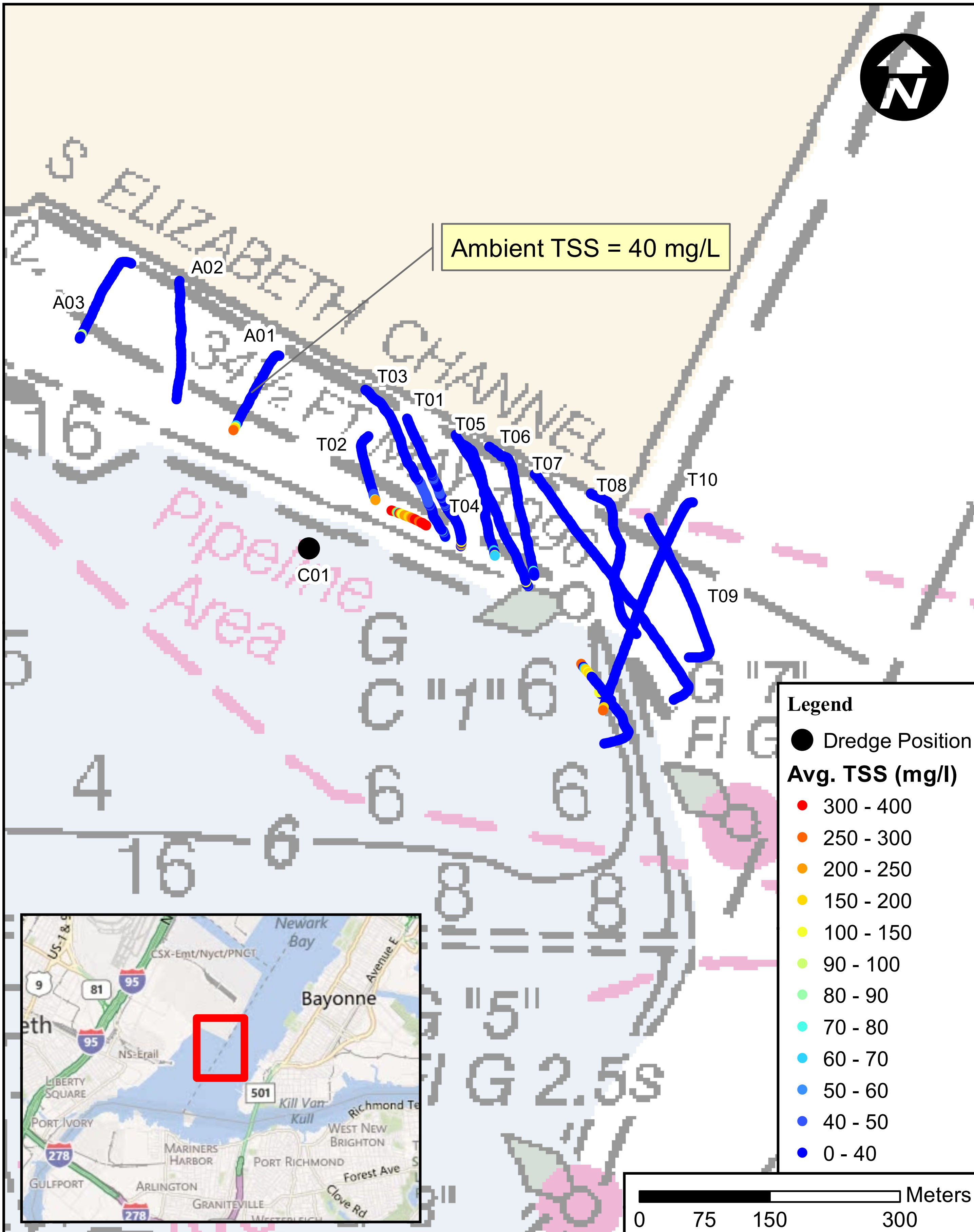


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 04 October 2011 8-10 Meter Depth Interval	Tide
30d			Flood

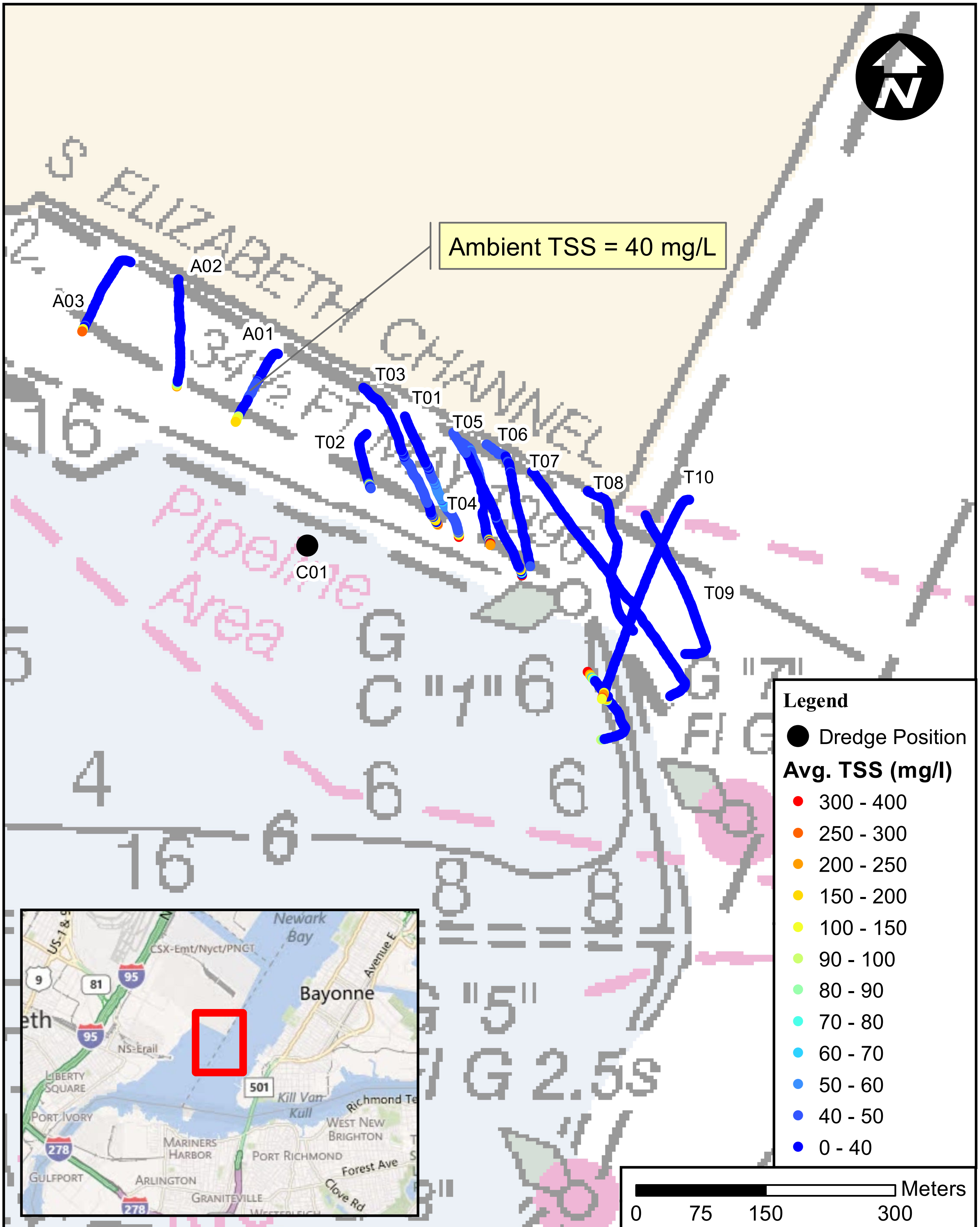


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 04 October 2011 10-12 Meter Depth Interval	Tide
30e			Flood

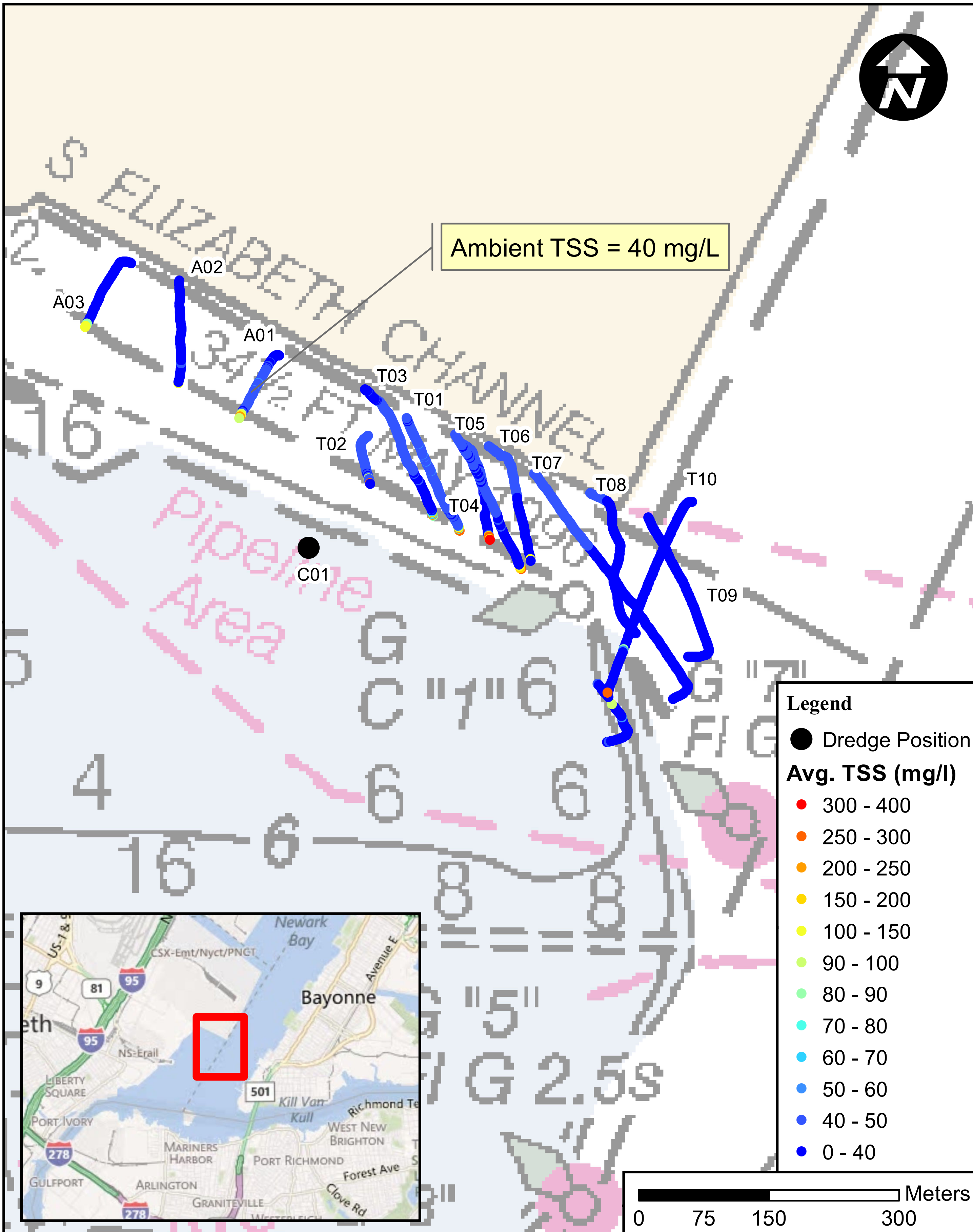


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 04 October 2011 12-14 Meter Depth Interval	Tide
30f			Flood

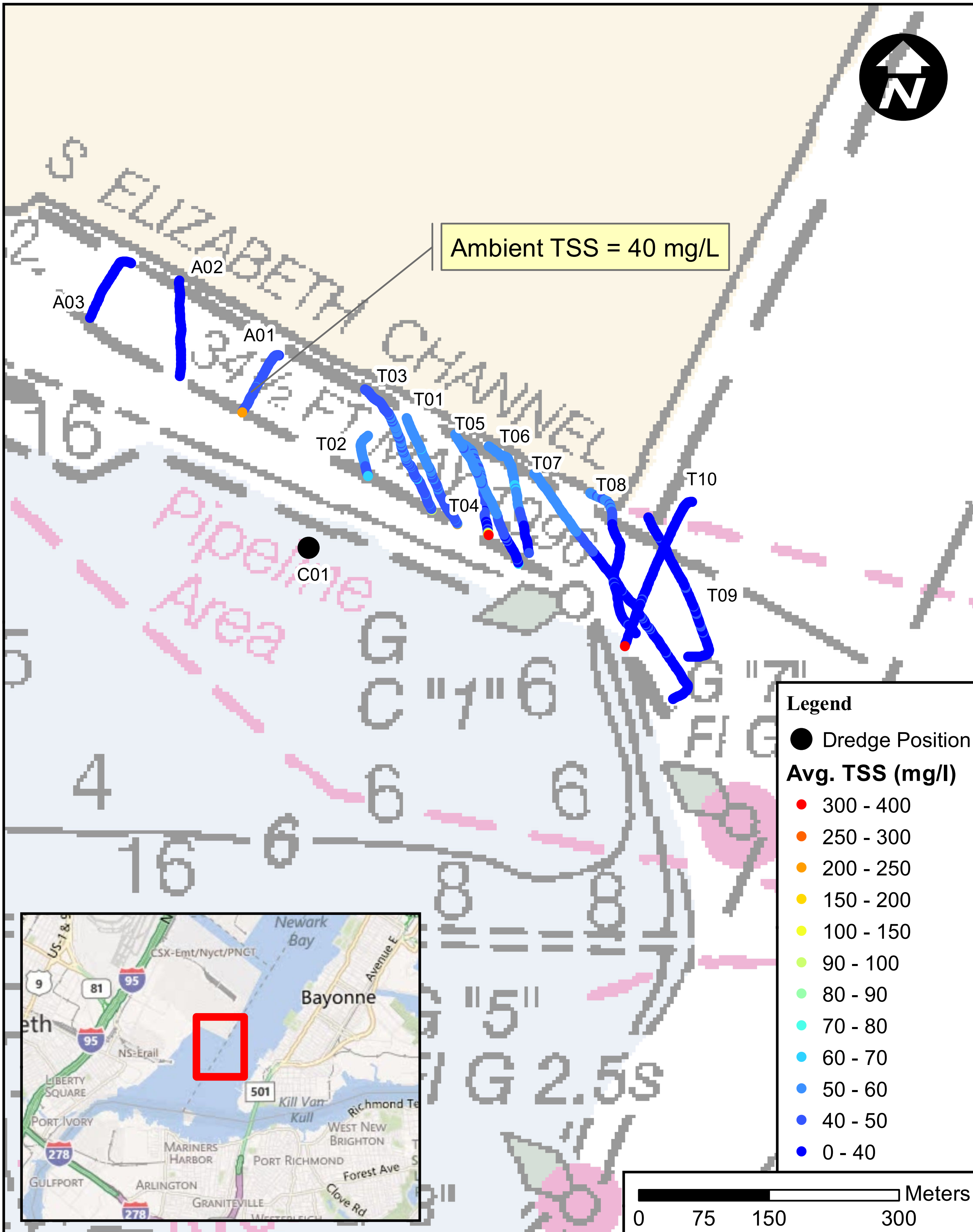
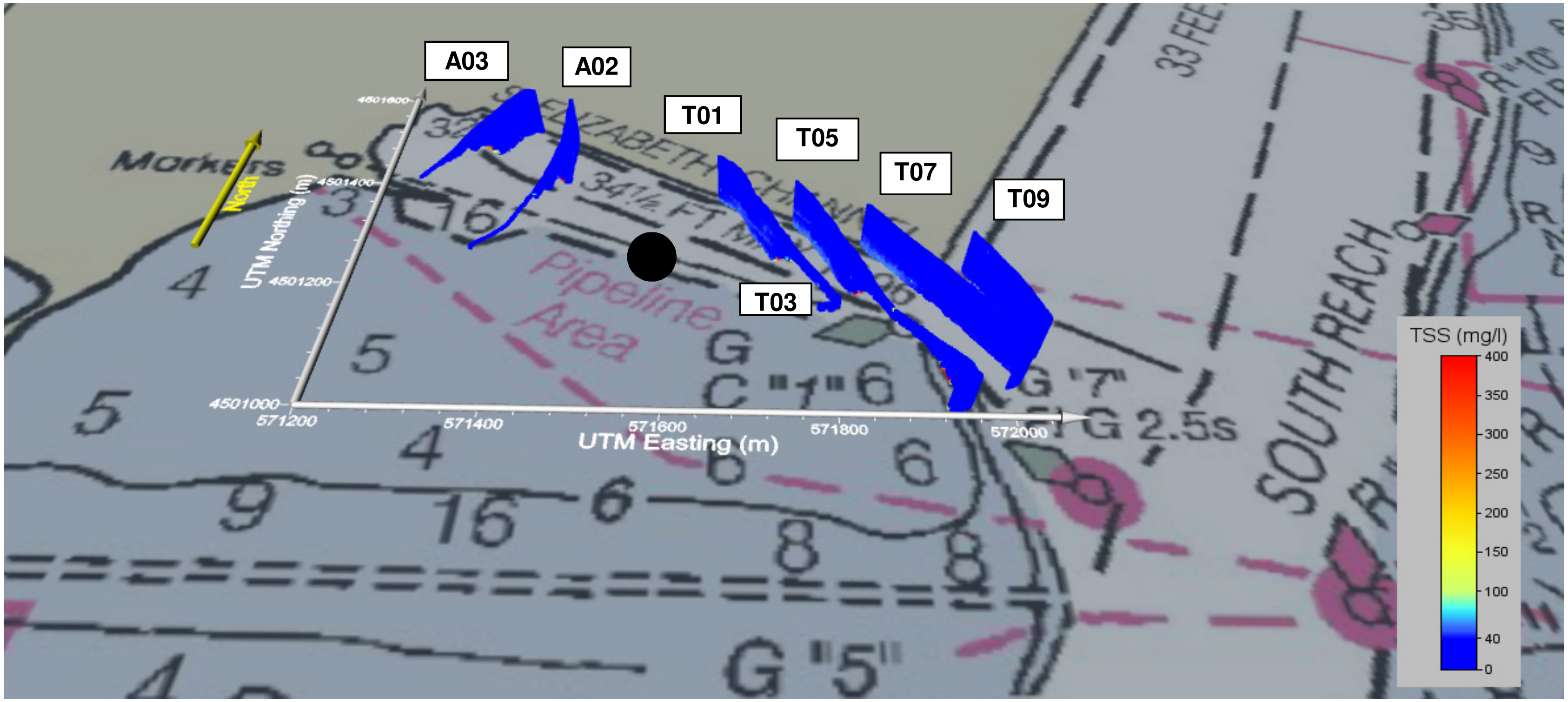


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 04 October 2011 14-16 Meter Depth Interval	Tide
30g			Flood



= Dredge Location

Z scale exaggerated 6X

Figure	*USACE Harborwide TSS*	ADCP Average TSS Values, 3D View of Selected Transects	Tide
31	*Far Field Survey* *HDP Contract Area S-NB-2*	04 October 2011	Flood

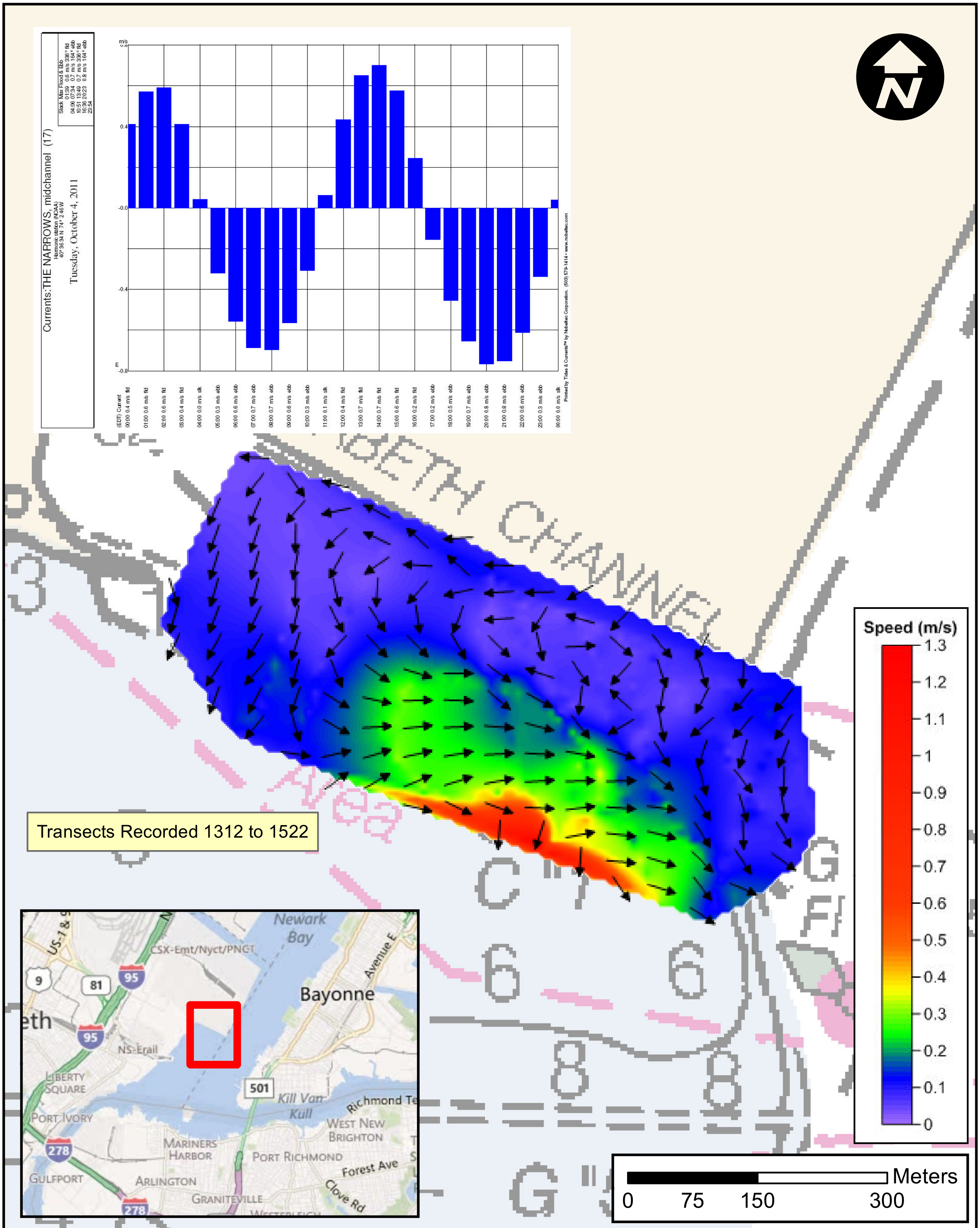


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	Depth Averaged Velocities 04 October 2011 - Flood Tide TSS Survey	Tide
32			Flood

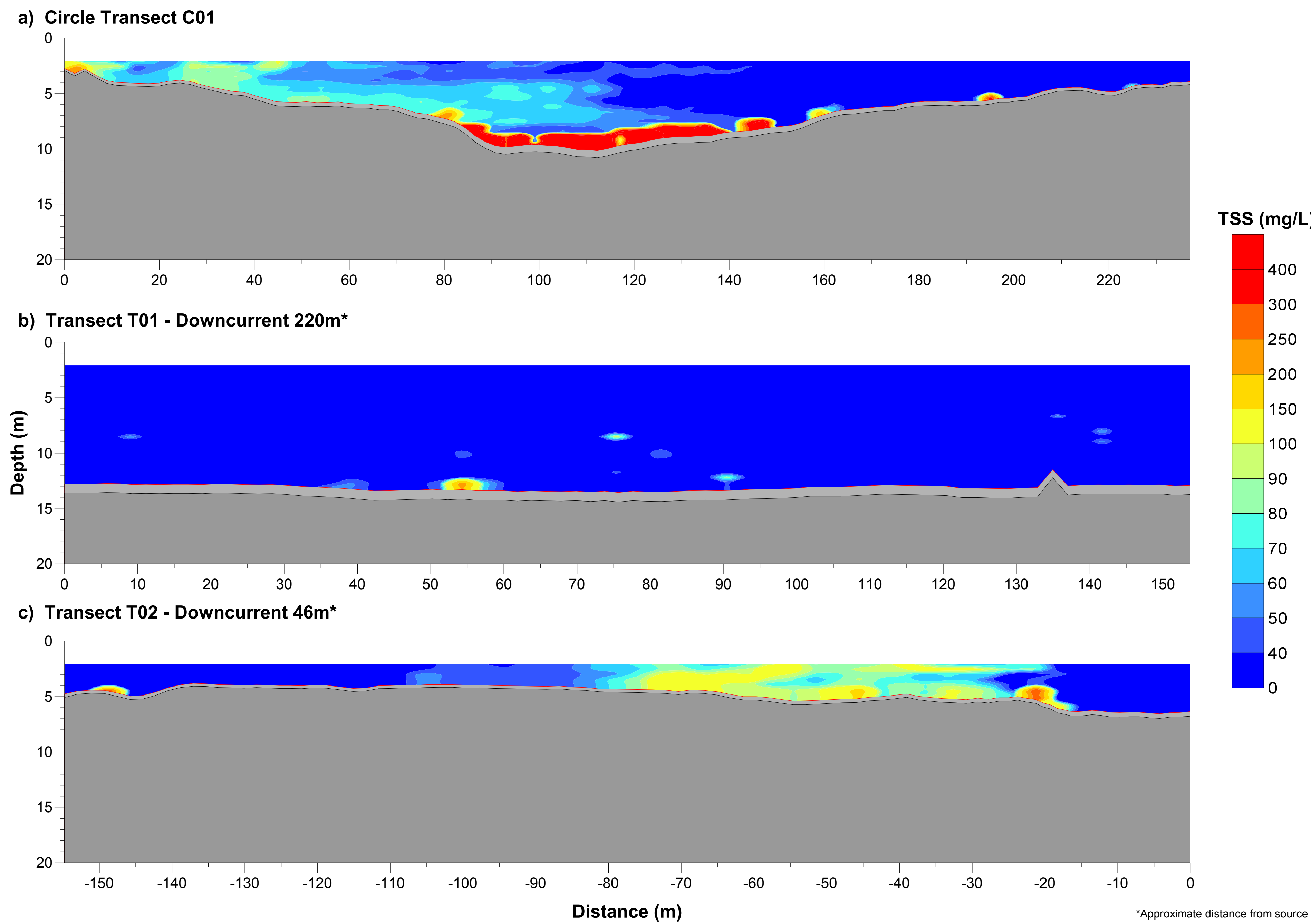
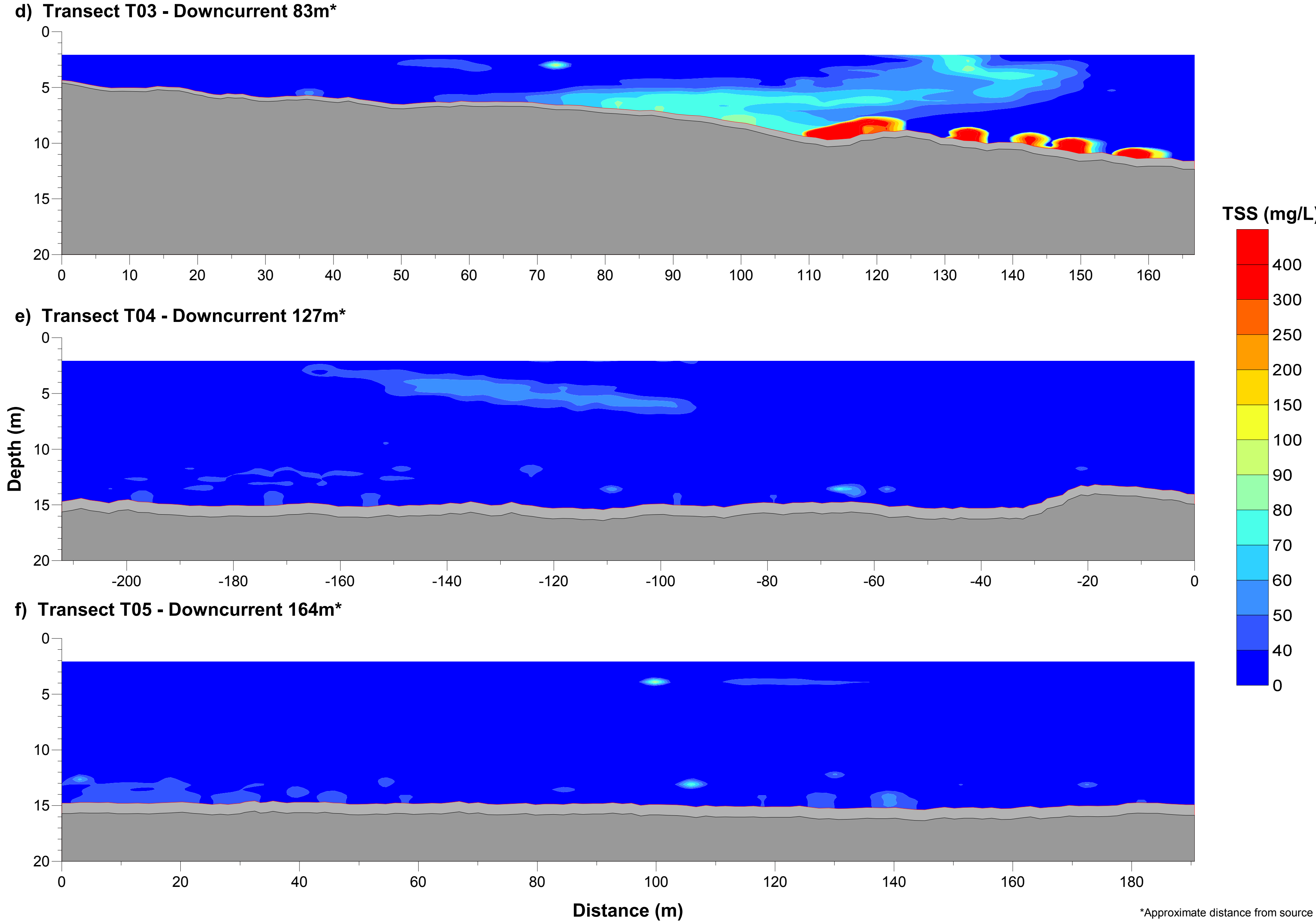


FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 06 October 2011 - Ebb Tide	TIDE
33a-c			Ebb



*Approximate distance from source

FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 06 October 2011 - Ebb Tide	TIDE
33d-f			Ebb

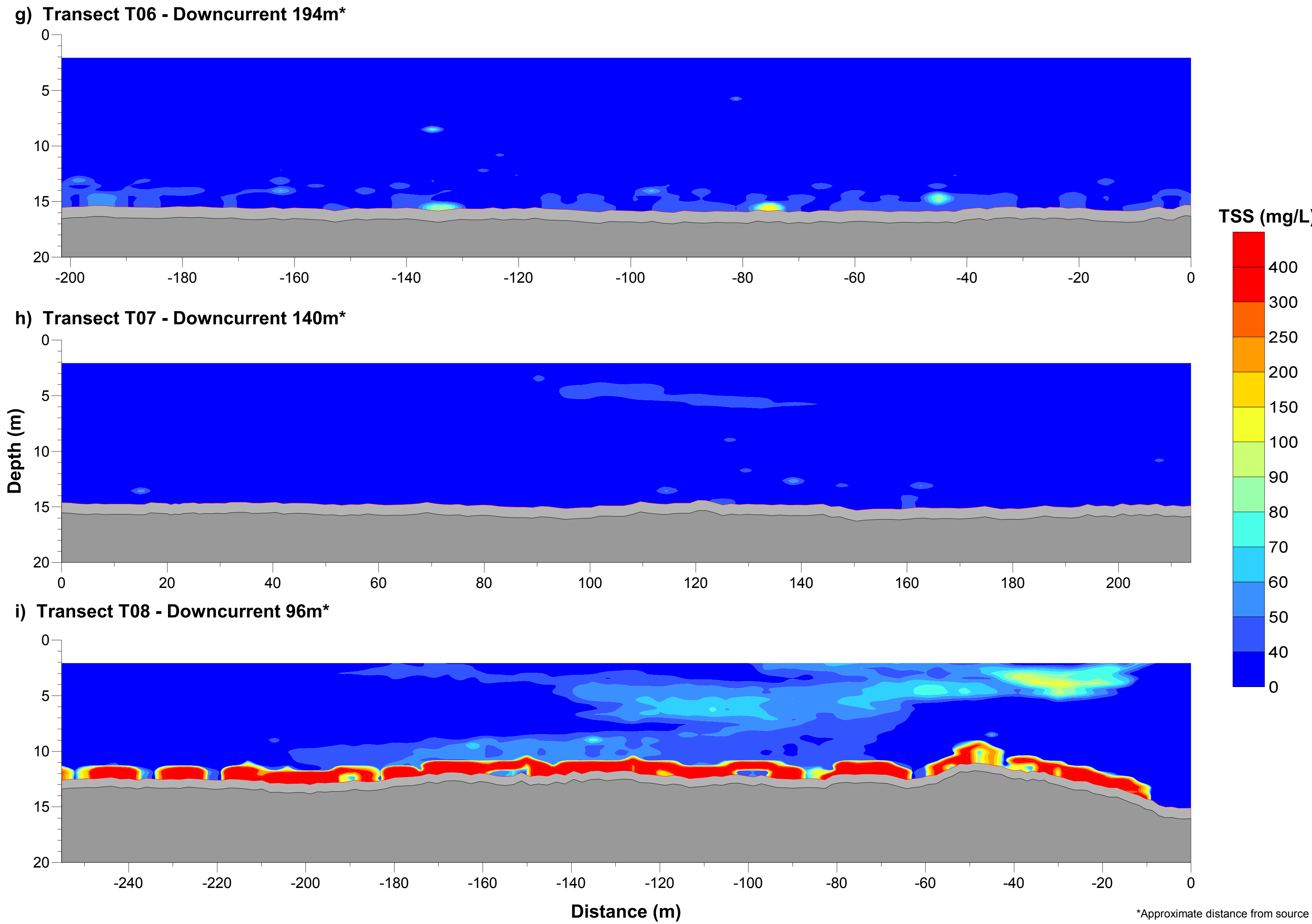
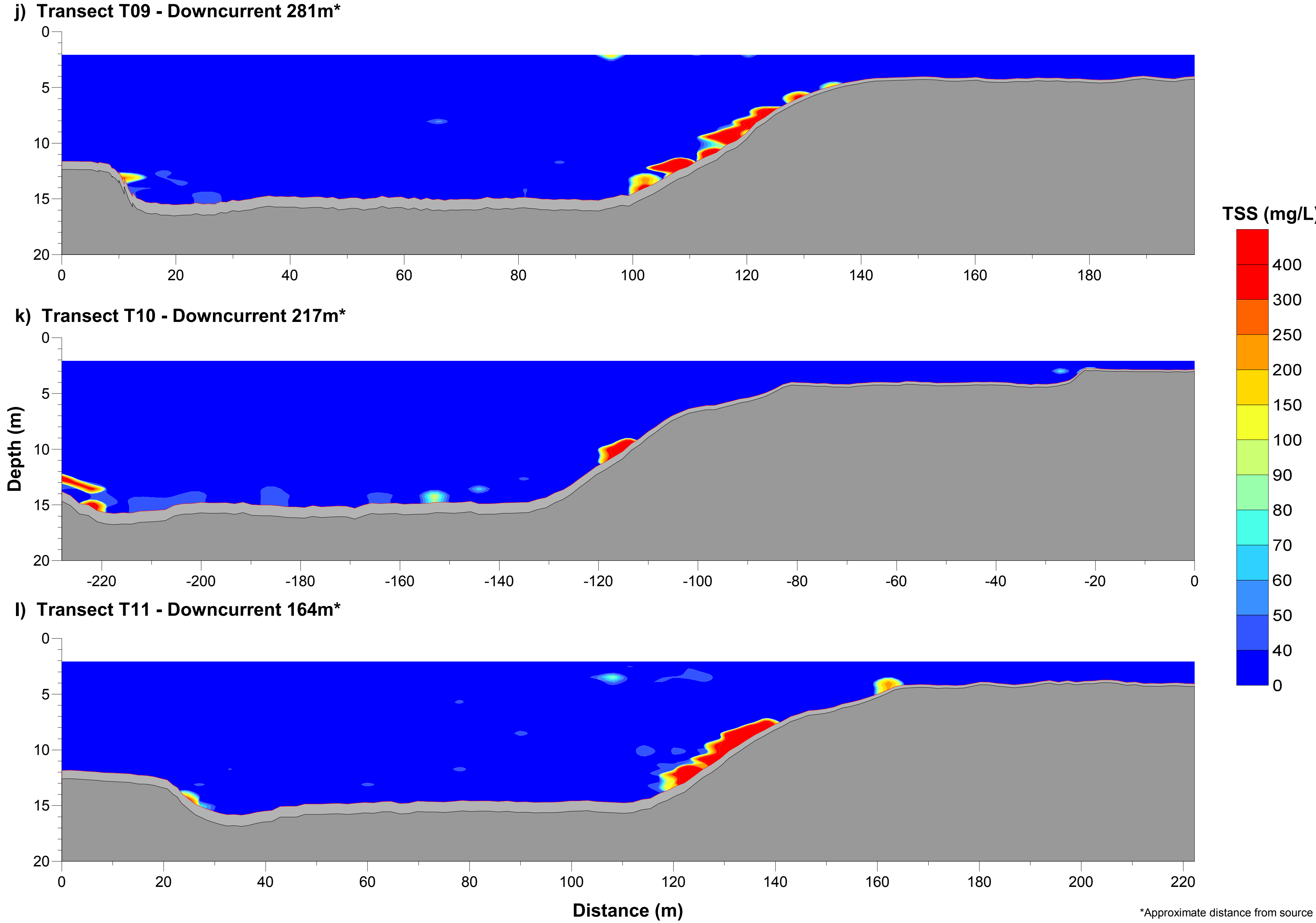


FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 06 October 2011 - Ebb Tide	TIDE
33g-i			Ebb



*Approximate distance from source

FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 06 October 2011 - Ebb Tide	TIDE
33j-l			Ebb

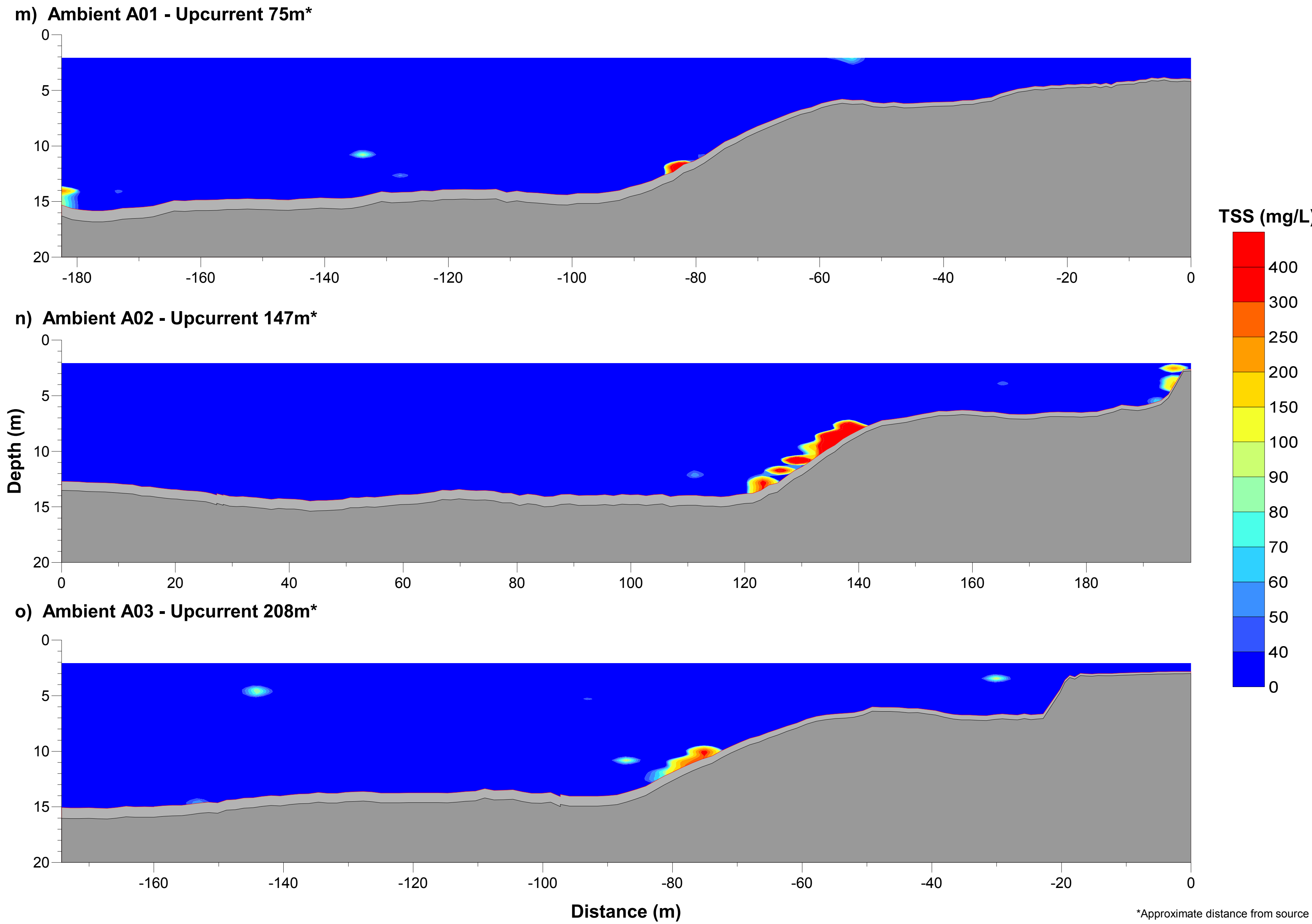


FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 06 October 2011 - Ebb Tide**	TIDE
33m-o			Ebb

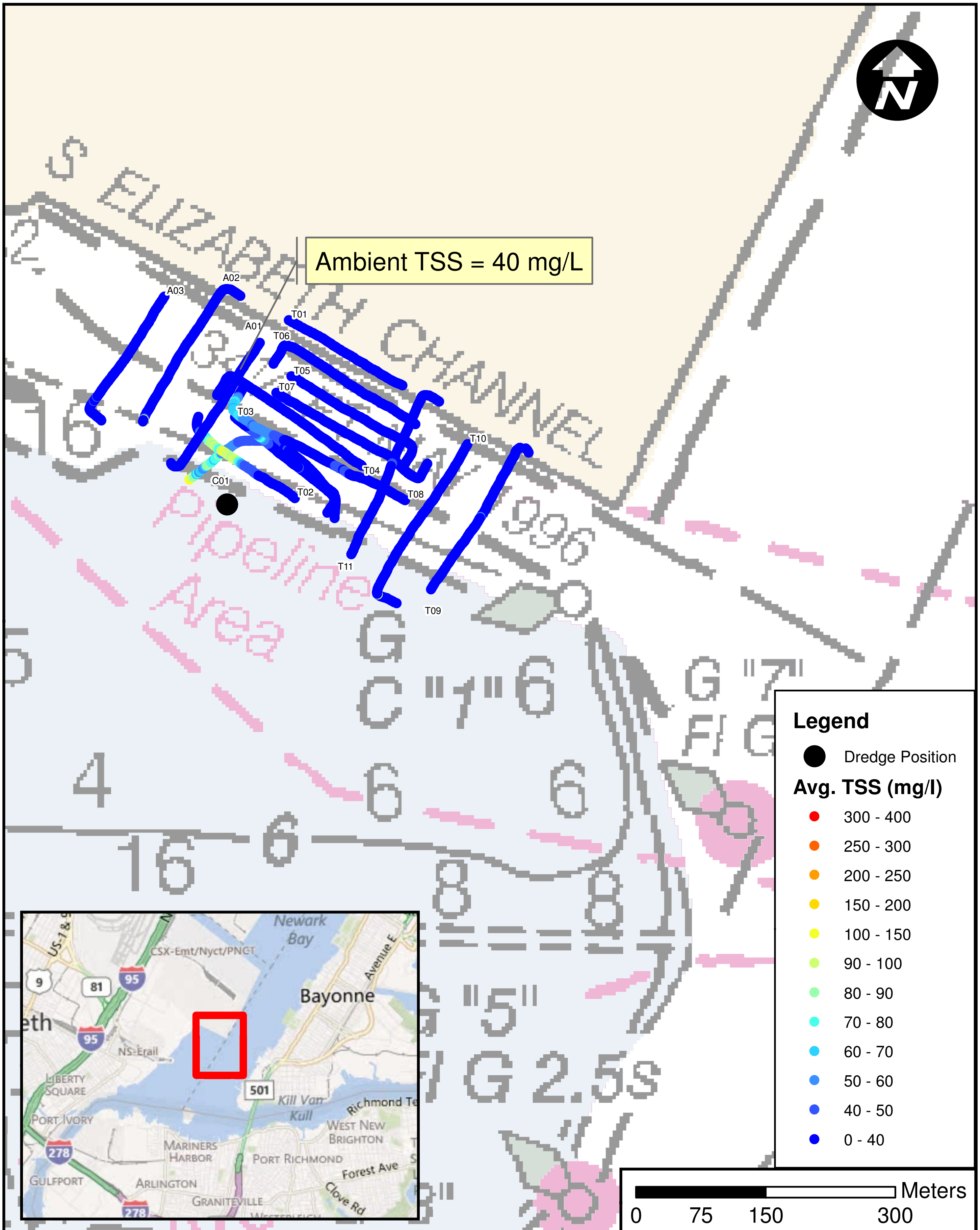


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-2*	**ADCP Average TSS - 06 October 2011** **2-4 Meter Depth Interval**	Tide
34a			**Ebb**

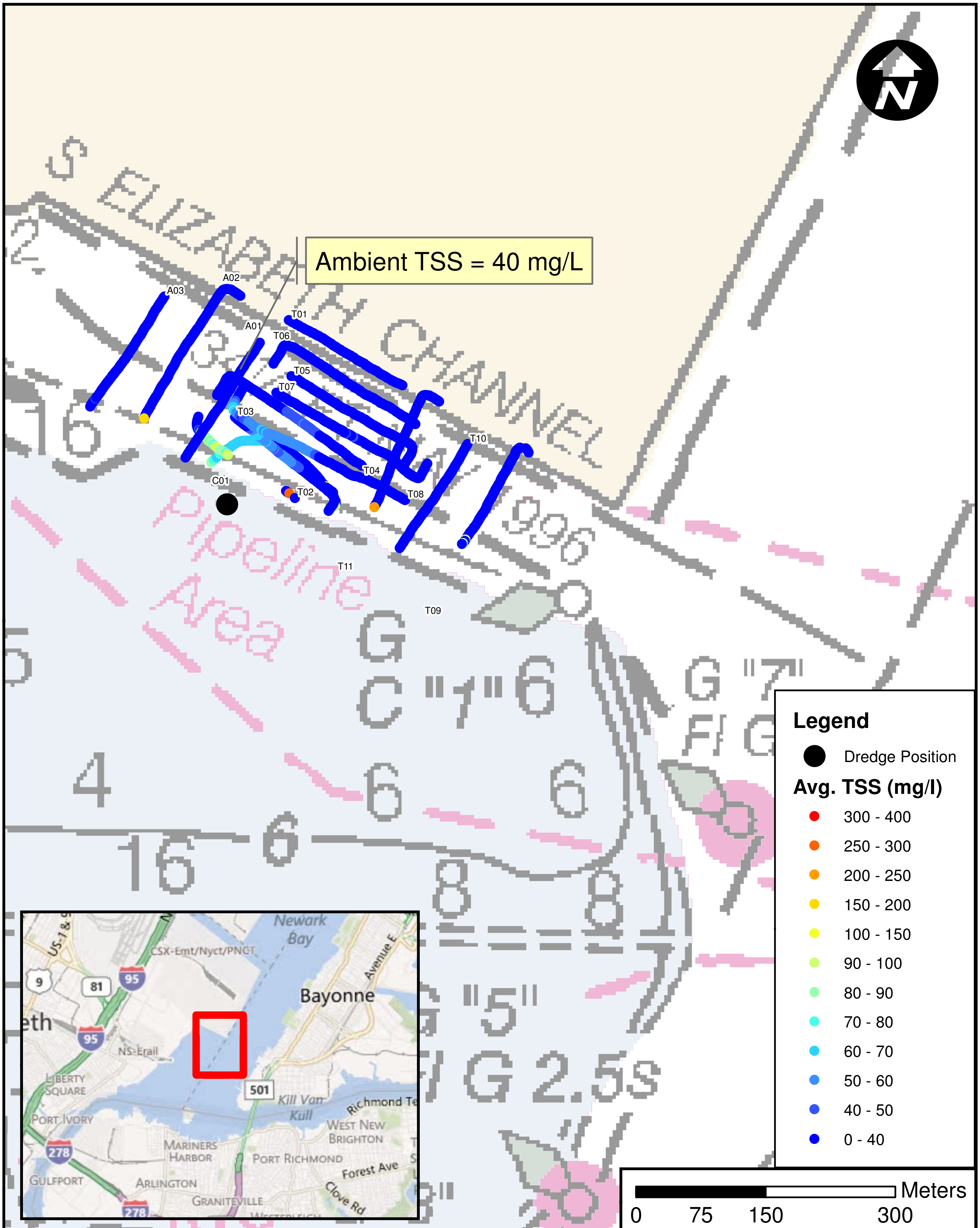


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 06 October 2011 4-6 Meter Depth Interval	Tide
34b			Ebb

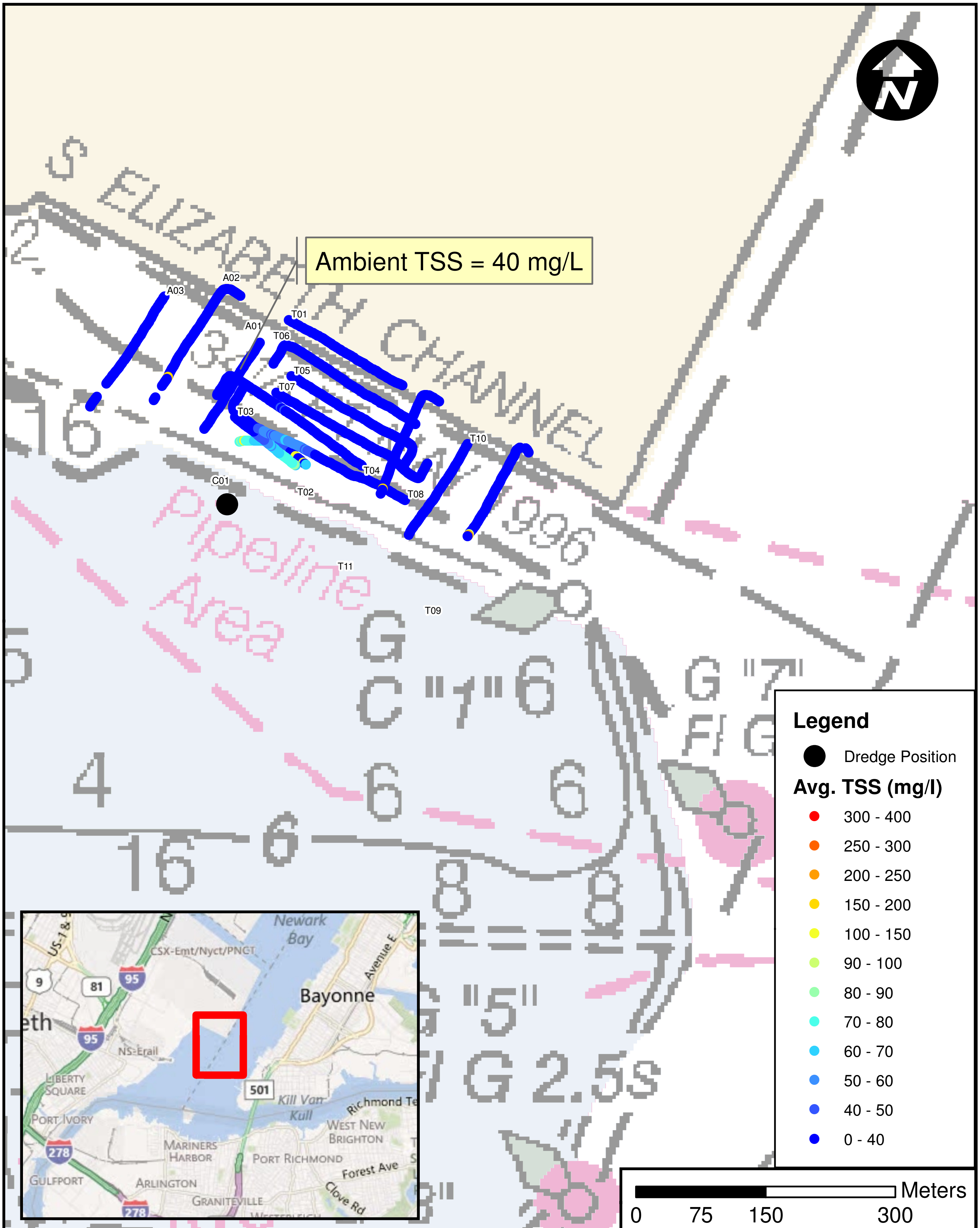


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 06 October 2011 6-8 Meter Depth Interval	Tide
34c			Ebb

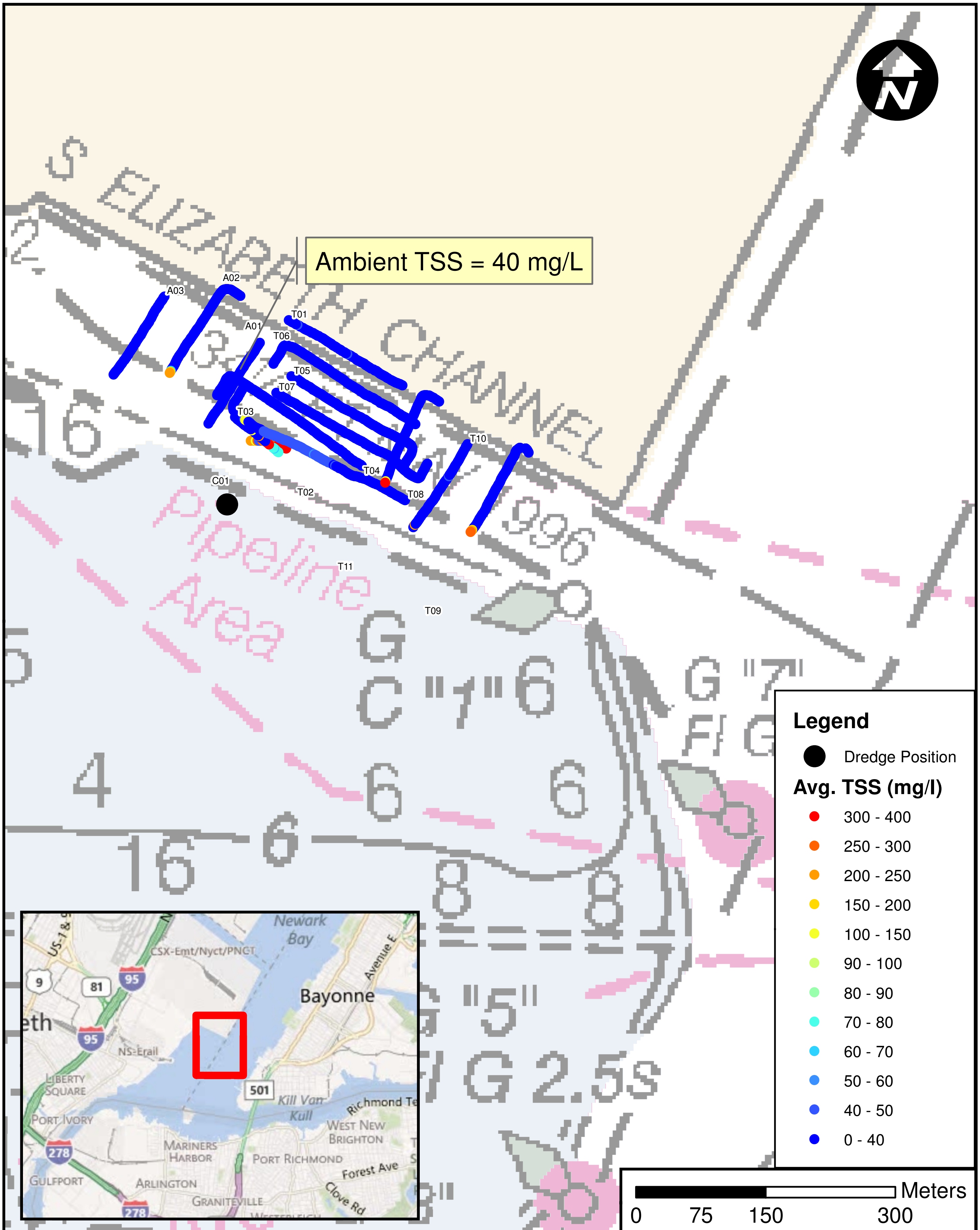


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 06 October 2011 8-10 Meter Depth Interval	Tide
34d			Ebb

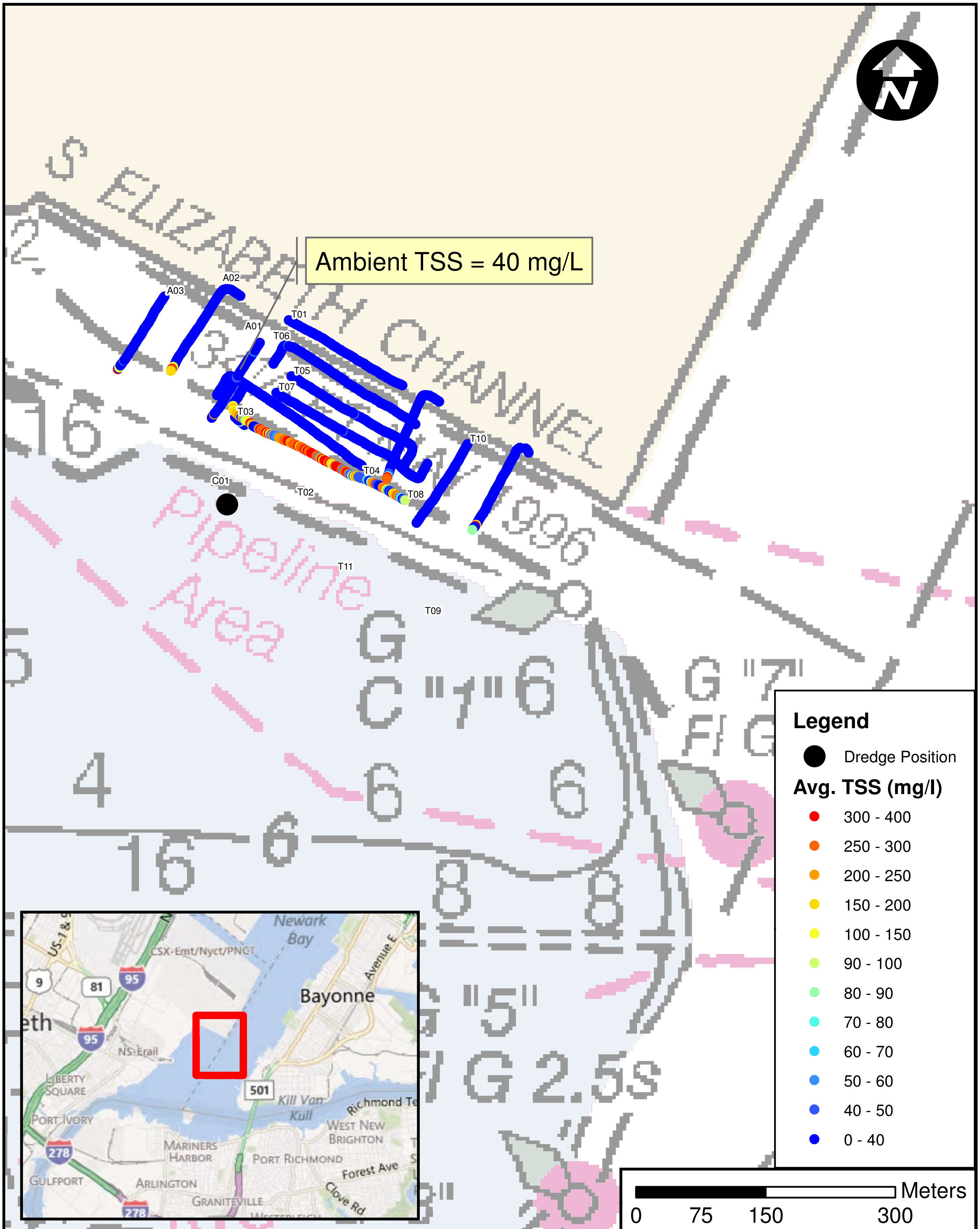


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 06 October 2011 10-12 Meter Depth Interval	Tide
34e			Ebb

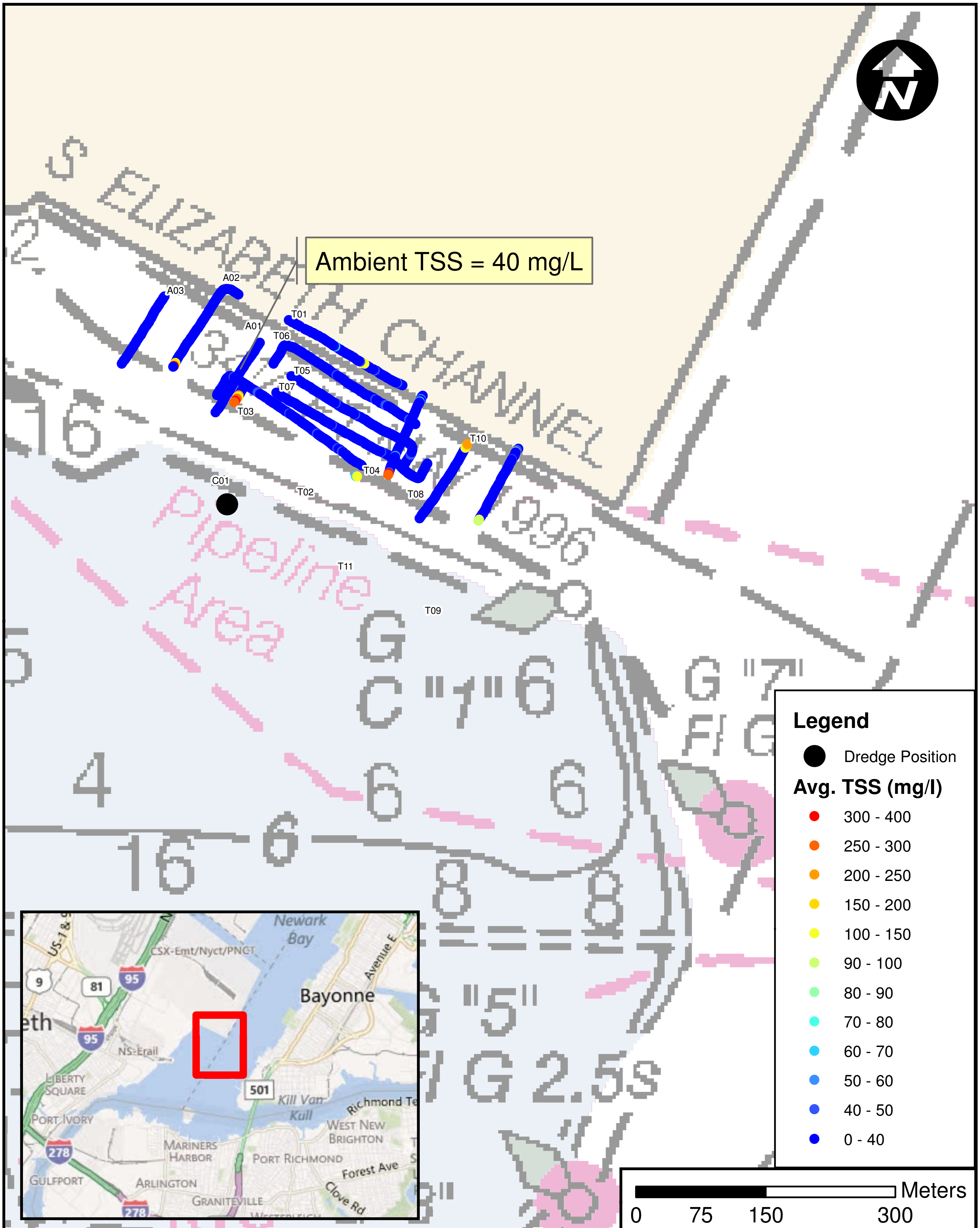


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-2*	**ADCP Average TSS - 06 October 2011** **12-14 Meter Depth Interval**	Tide
34f			Ebb

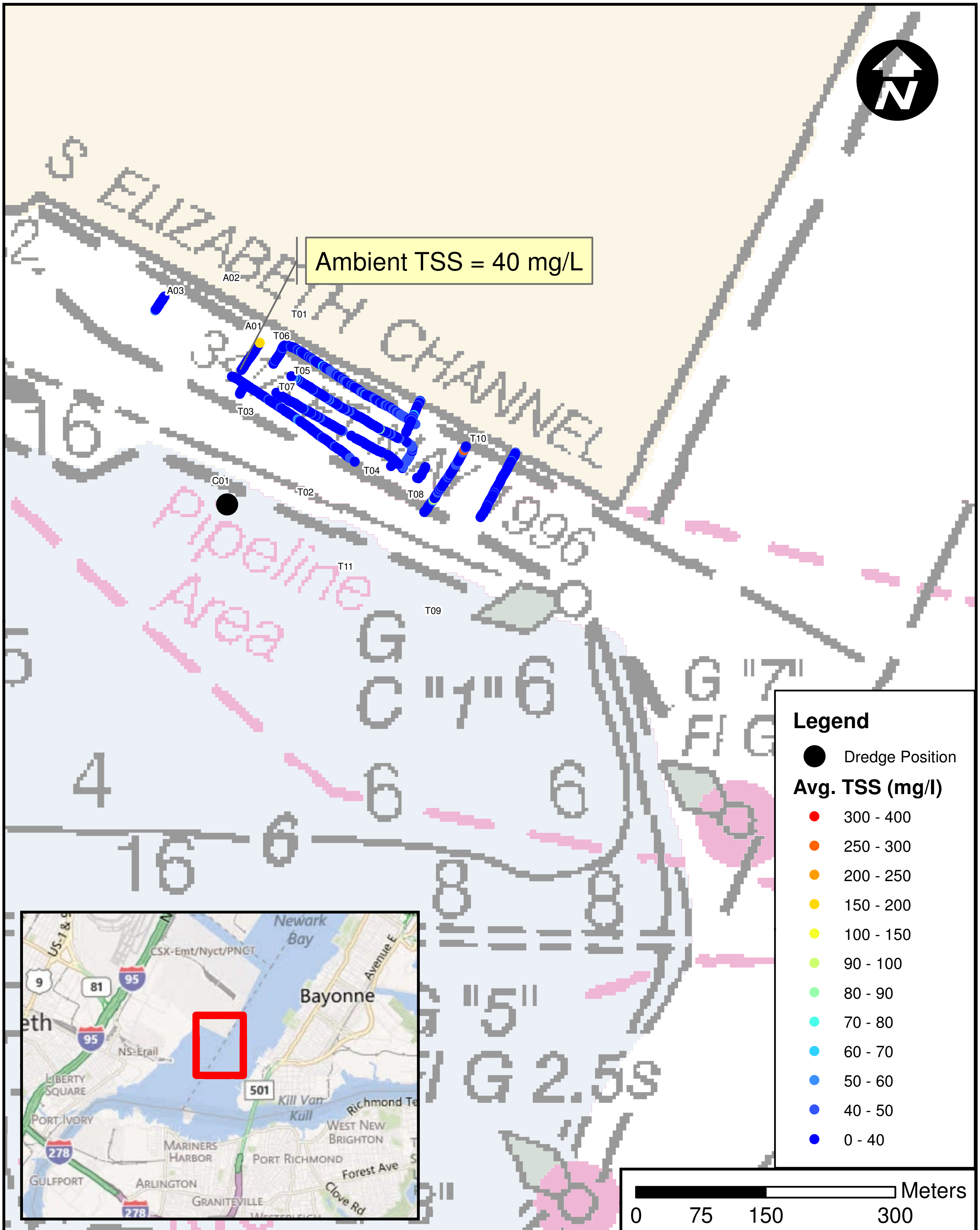
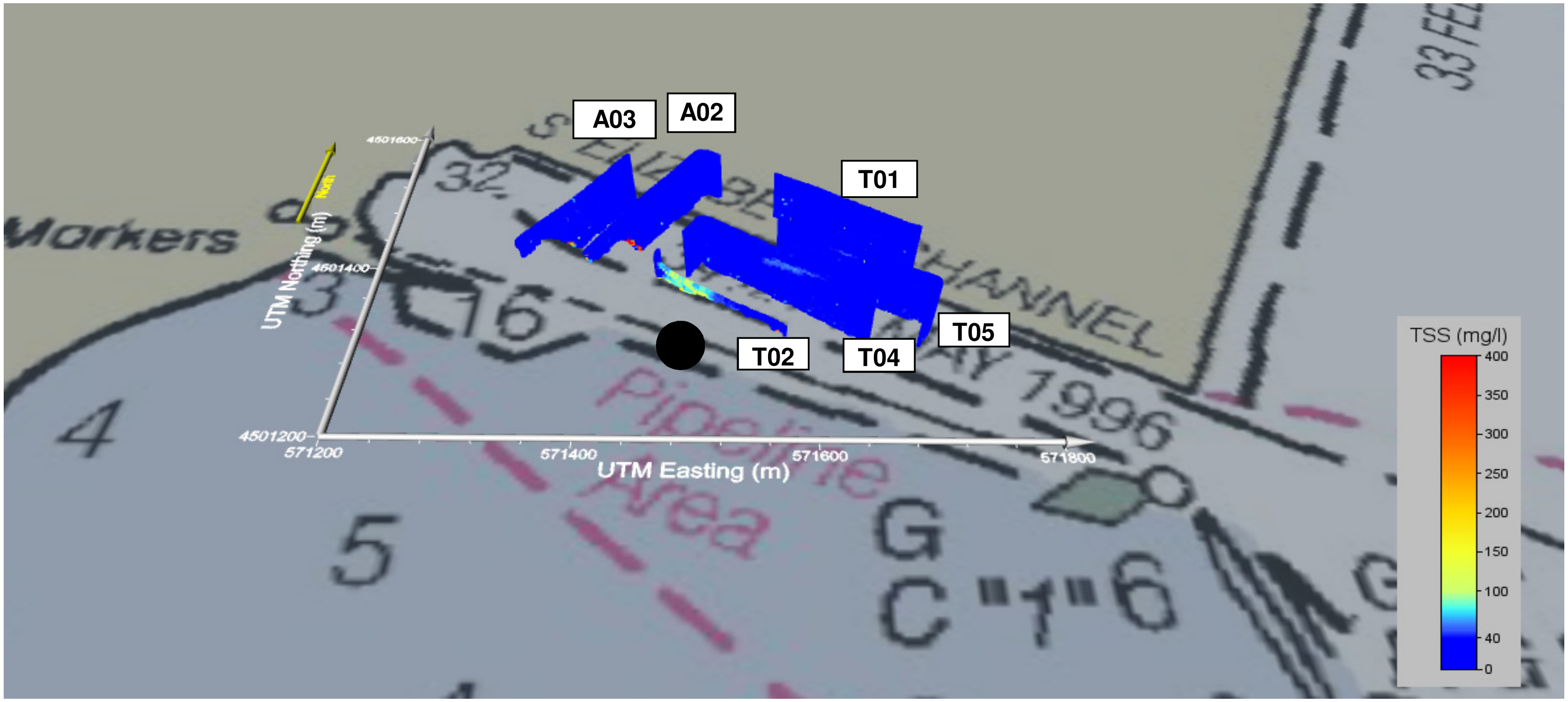


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 06 October 2011 14-16 Meter Depth Interval	Tide
34g			Ebb



● = Dredge Location

Z scale exaggerated 6X

Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area S-NB-2*	ADCP Average TSS Values, 3D View of Selected Transects 06 October 2011	Tide
35			Ebb

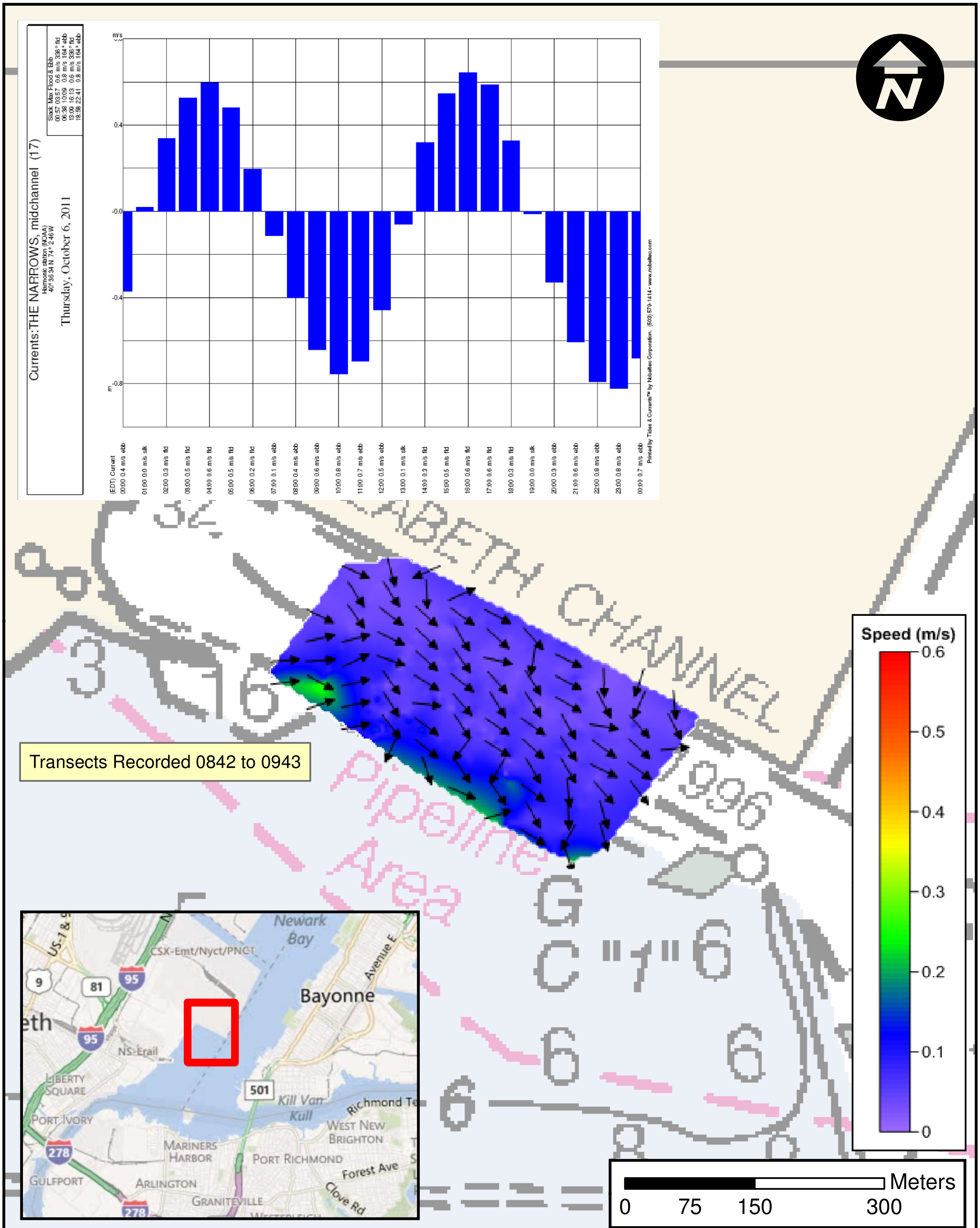


Figure	USACE Harborwide TSS	Depth Averaged Velocities	Tide
36	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2*	**Depth Averaged Velocities 06 October 2011 - Ebb Tide TSS Survey**	Ebb

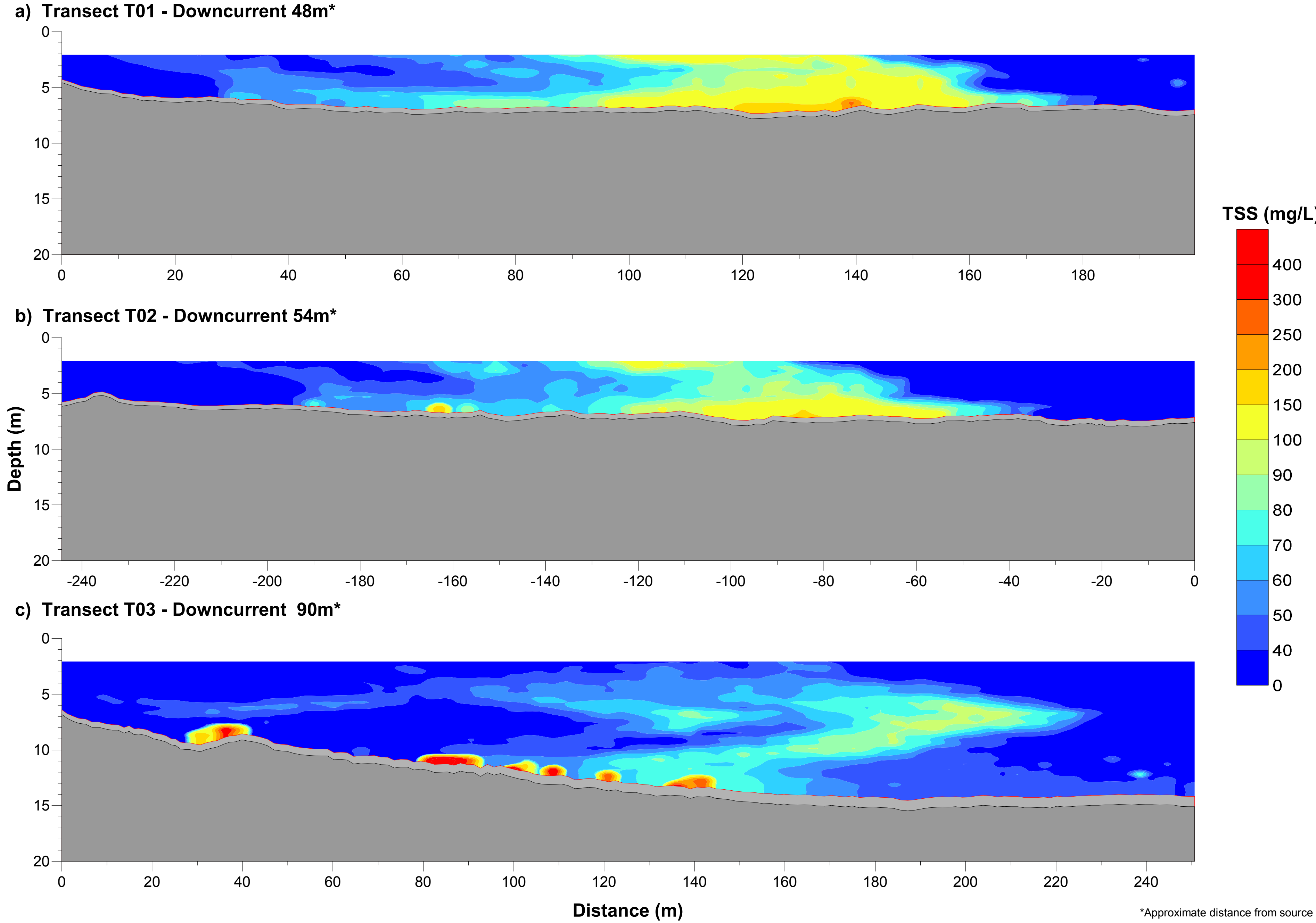


FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 07 October 2011 - Ebb Tide	TIDE
37a-c			Ebb

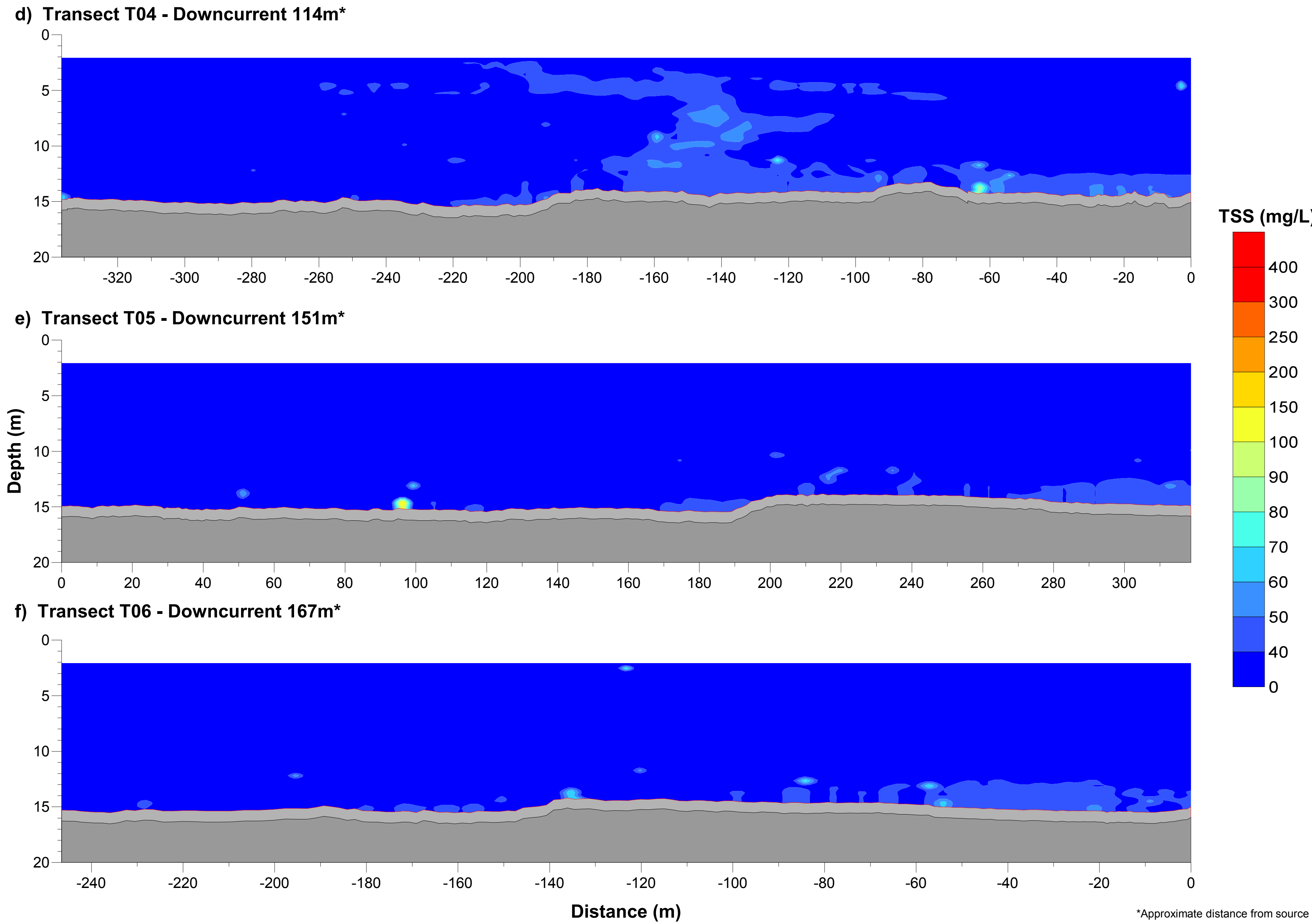
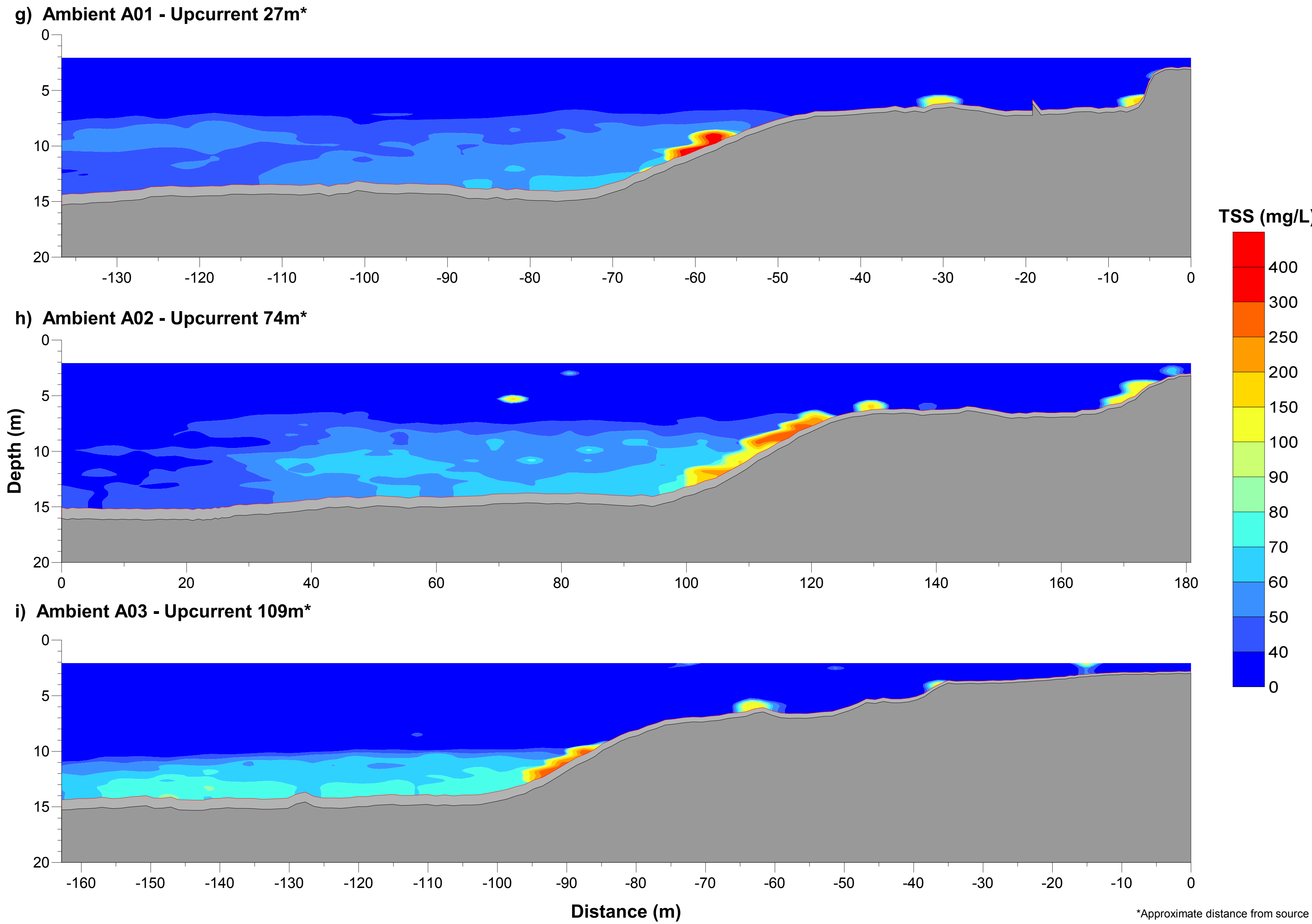


FIGURE	*USACE Harborwide TSS Far Field Survey S-NB-2*	**Vertical Profiles of ADCP Average TSS 07 October 2011 - Ebb Tide**	TIDE
37d-f			**Ebb**



*Approximate distance from source

FIGURE	USACE Harborwide TSS Far Field Survey S-NB-2	Vertical Profiles of ADCP Average TSS 07 October 2011 - Ebb Tide	TIDE
37g-i			Ebb

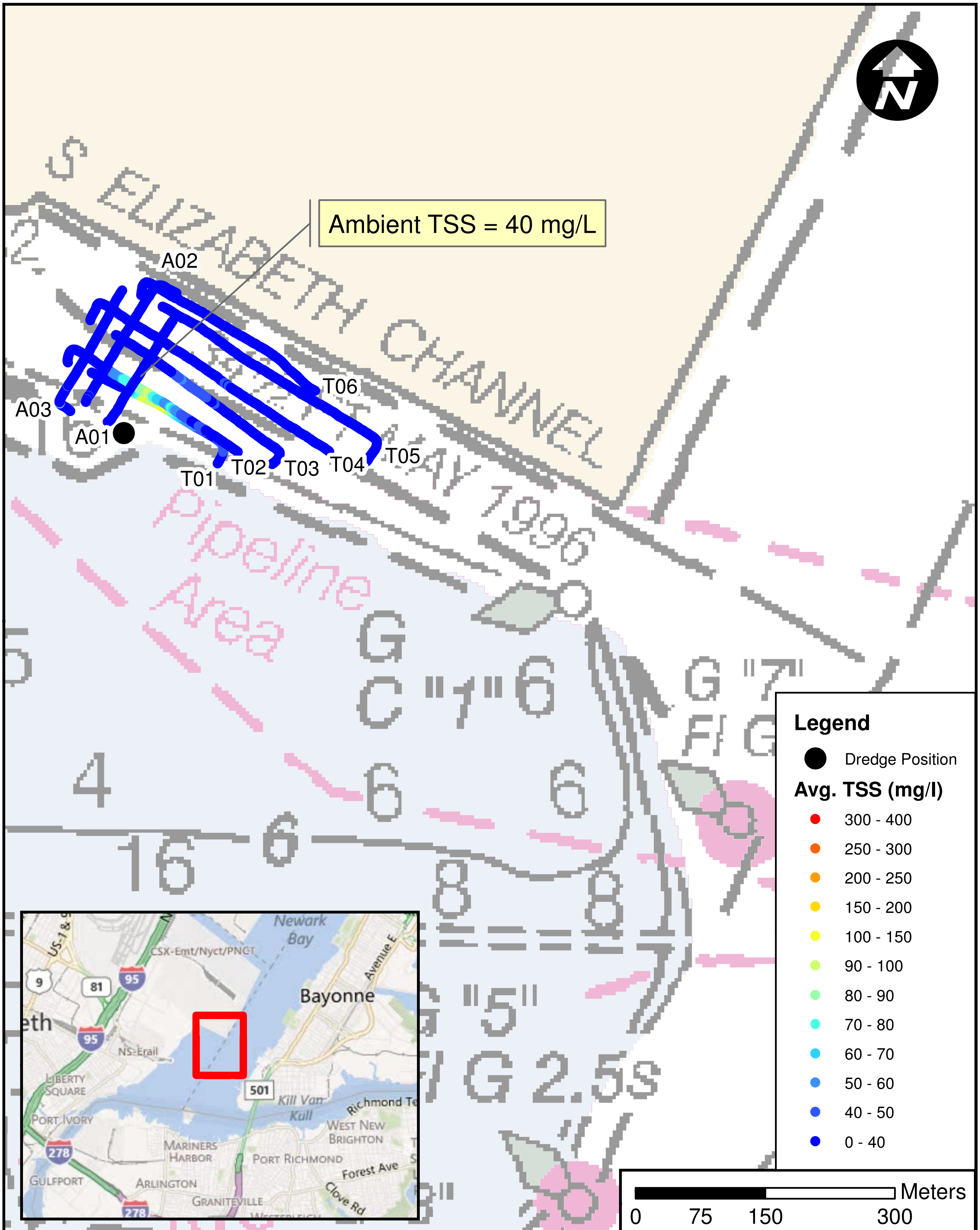


Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2*	ADCP Average TSS - 07 October 2011 2-4 Meter Depth Interval	Tide
38a			Ebb

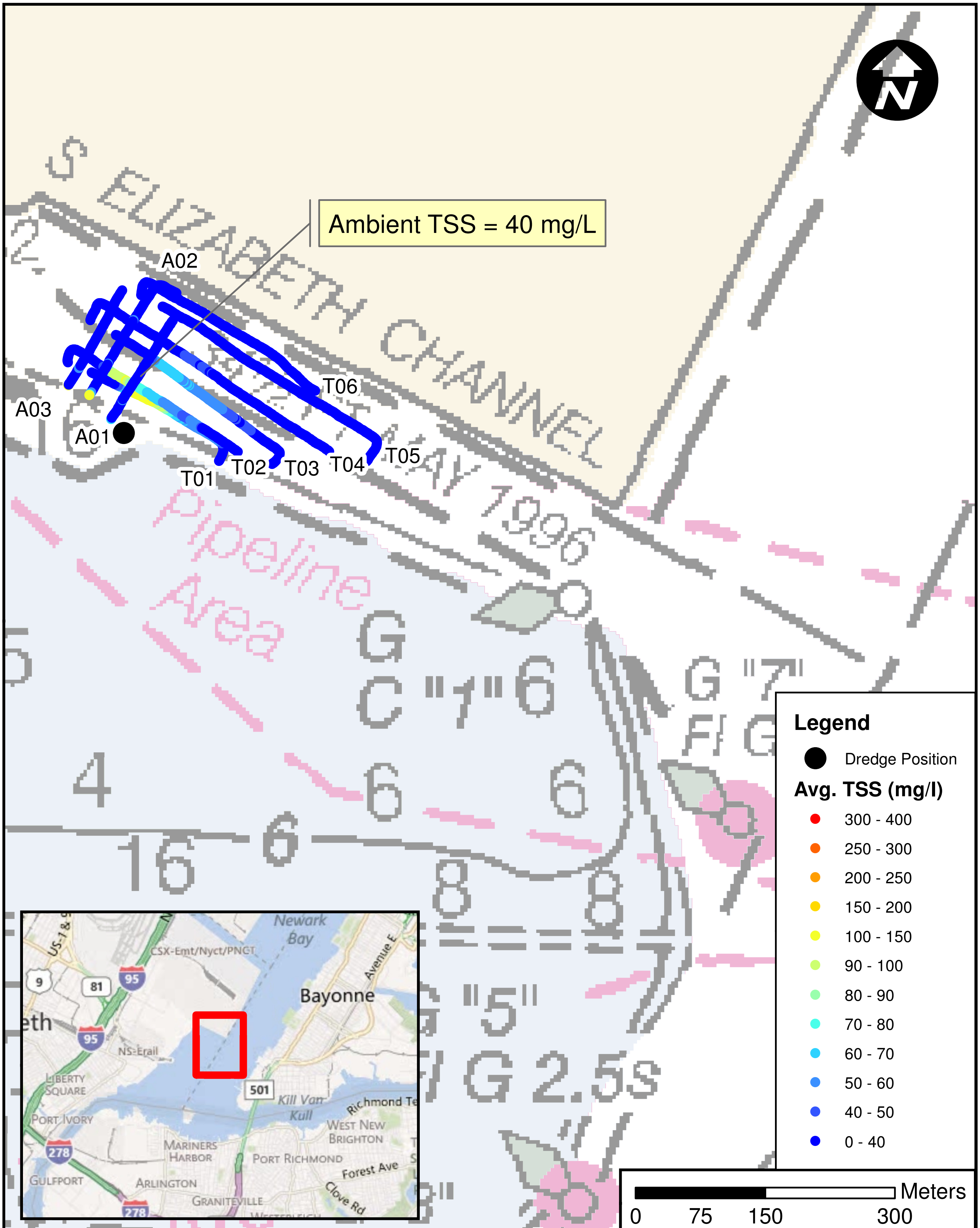


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 07 October 2011 4-6 Meter Depth Interval	Tide
38b			Ebb

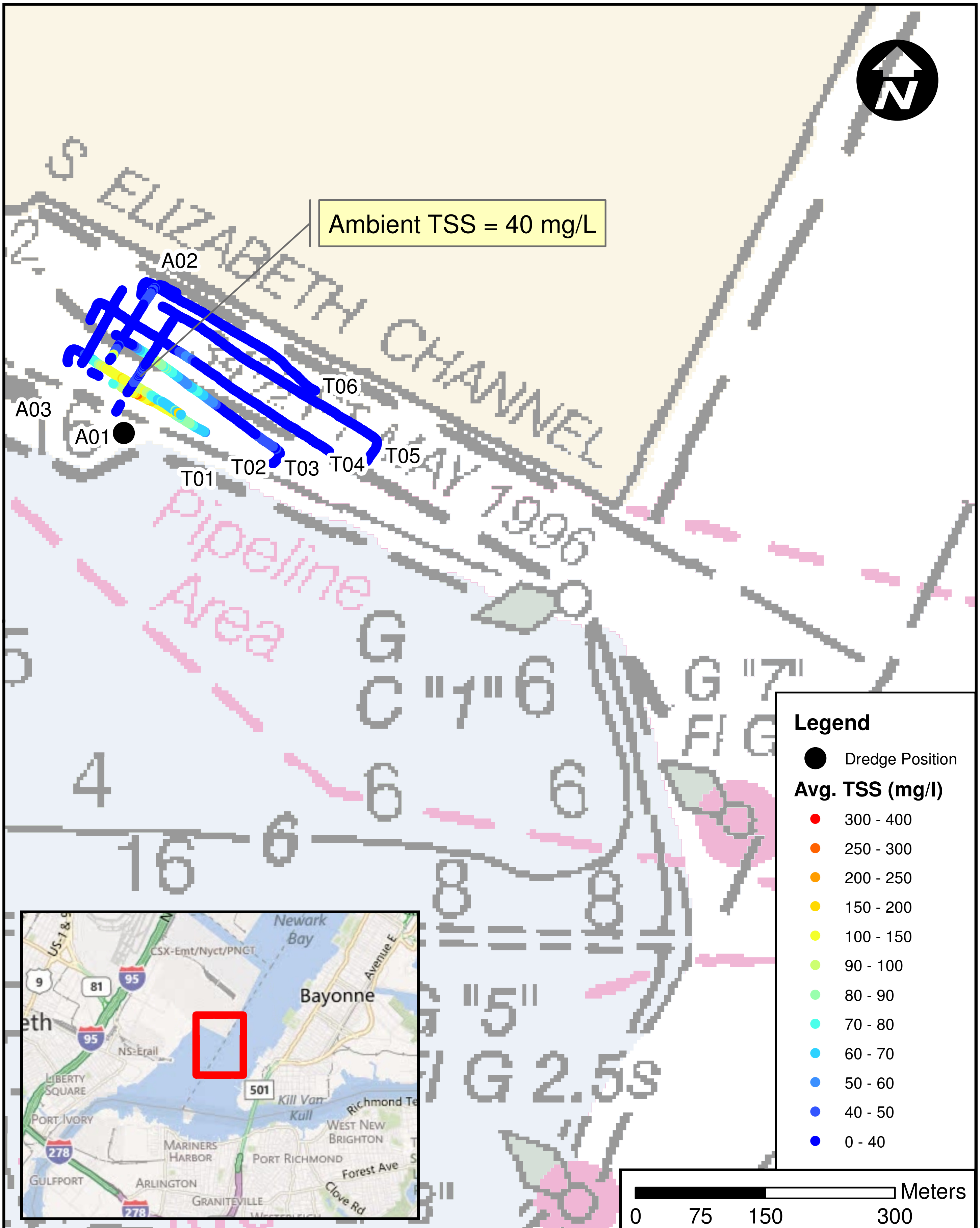


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 07 October 2011 6-8 Meter Depth Interval	Tide
38c			Ebb

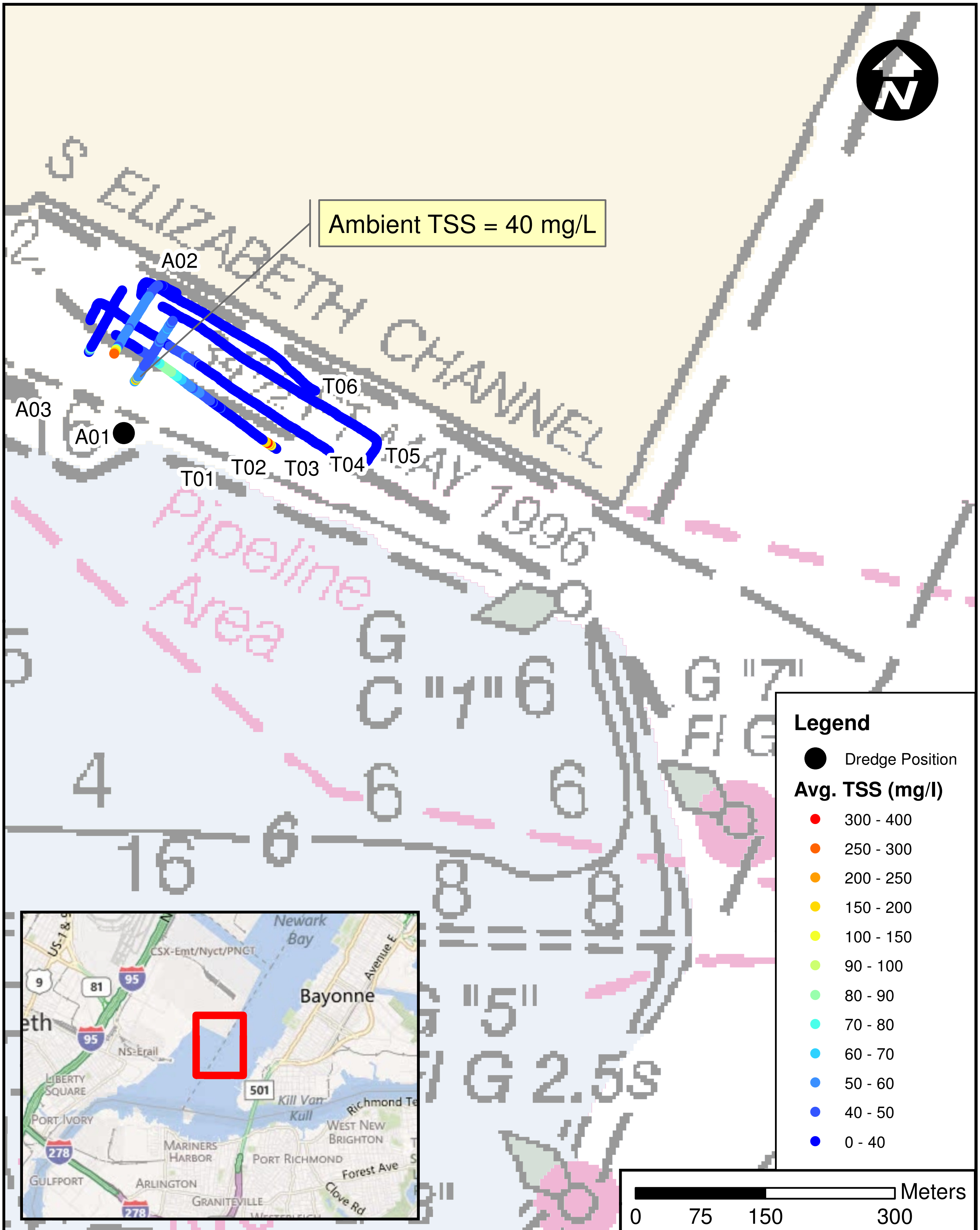


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 07 October 2011 8-10 Meter Depth Interval	Tide
38d			Ebb

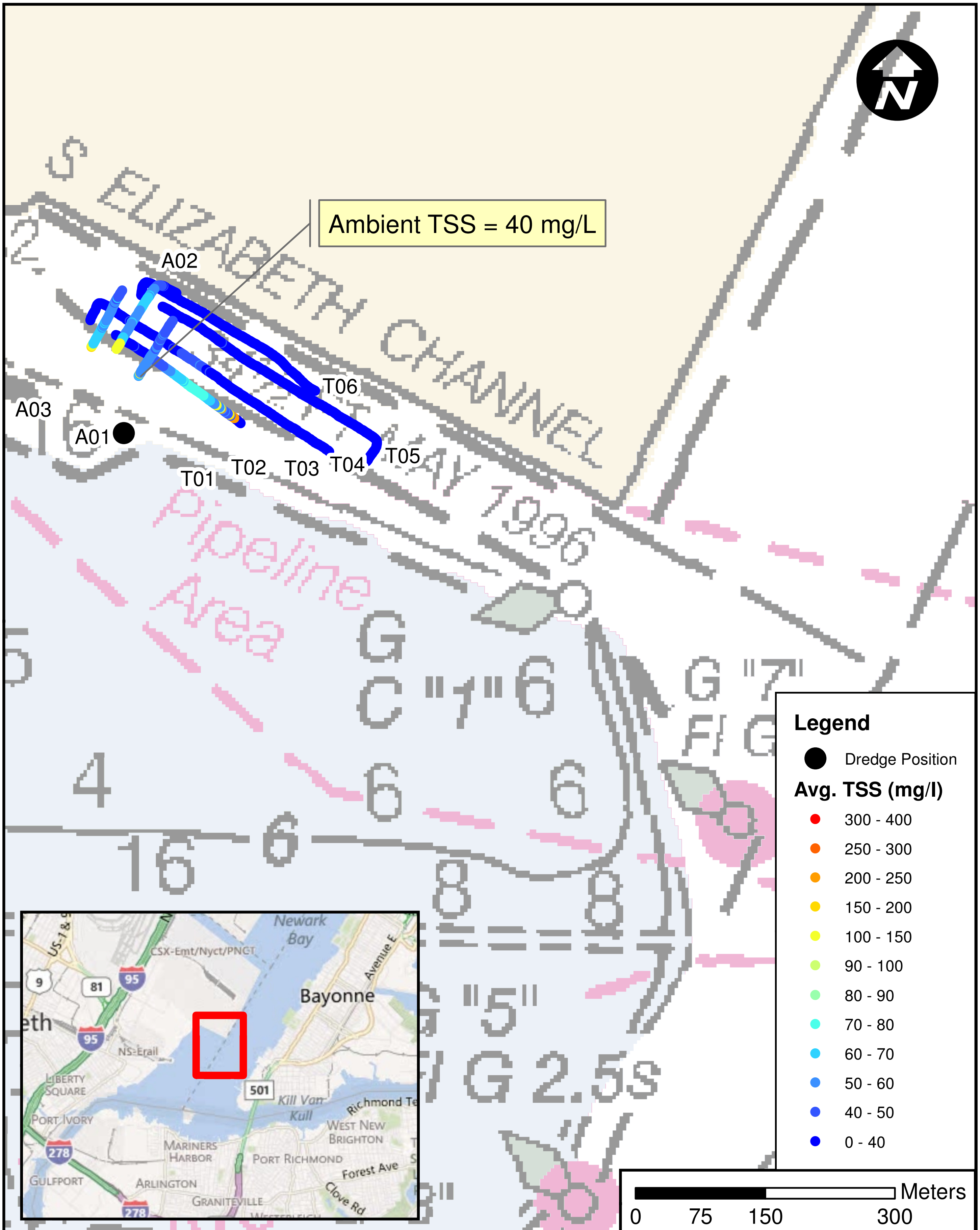


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 07 October 2011 10-12 Meter Depth Interval	Tide
38e			Ebb

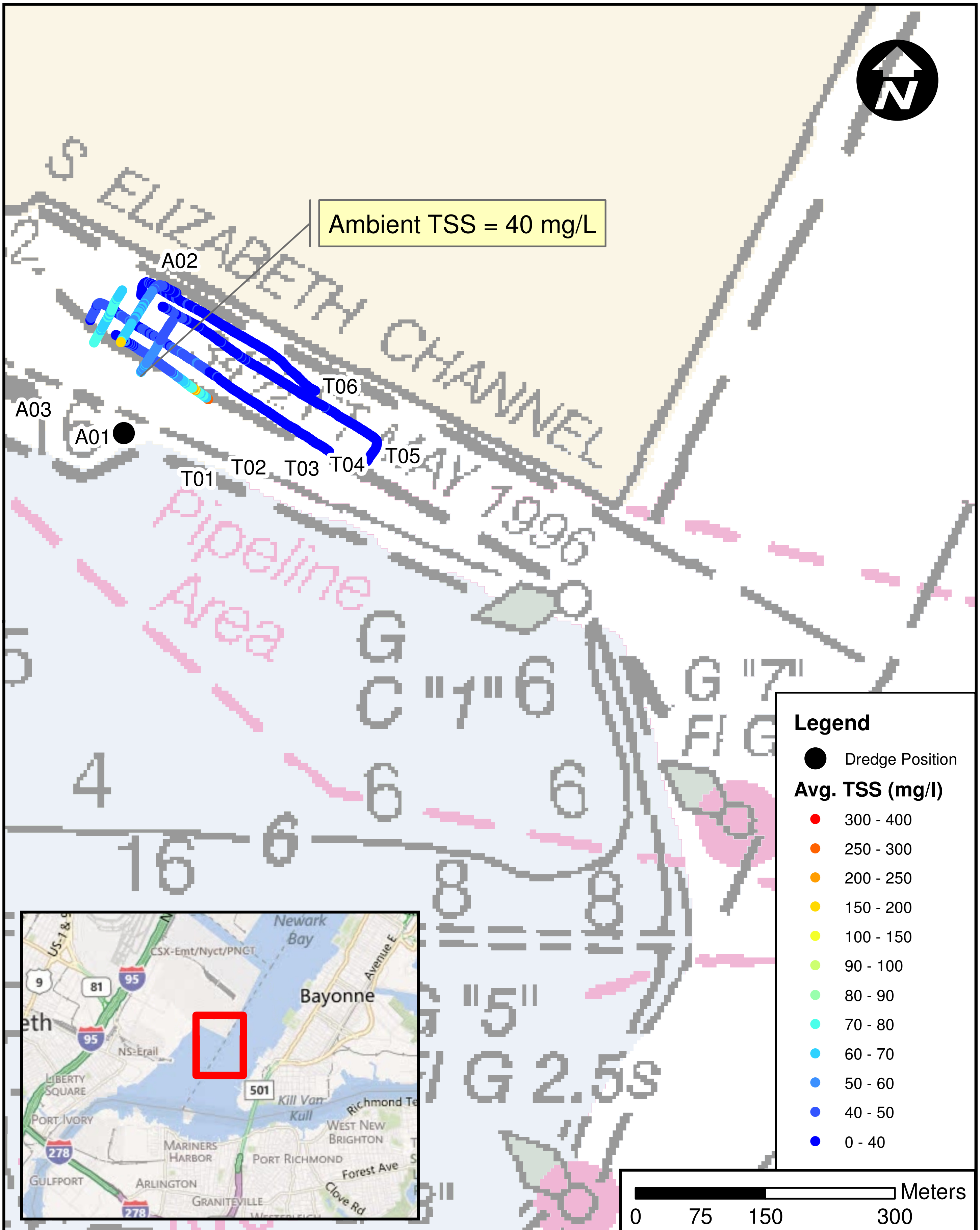


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 07 October 2011 12-14 Meter Depth Interval	Tide
38f			Ebb

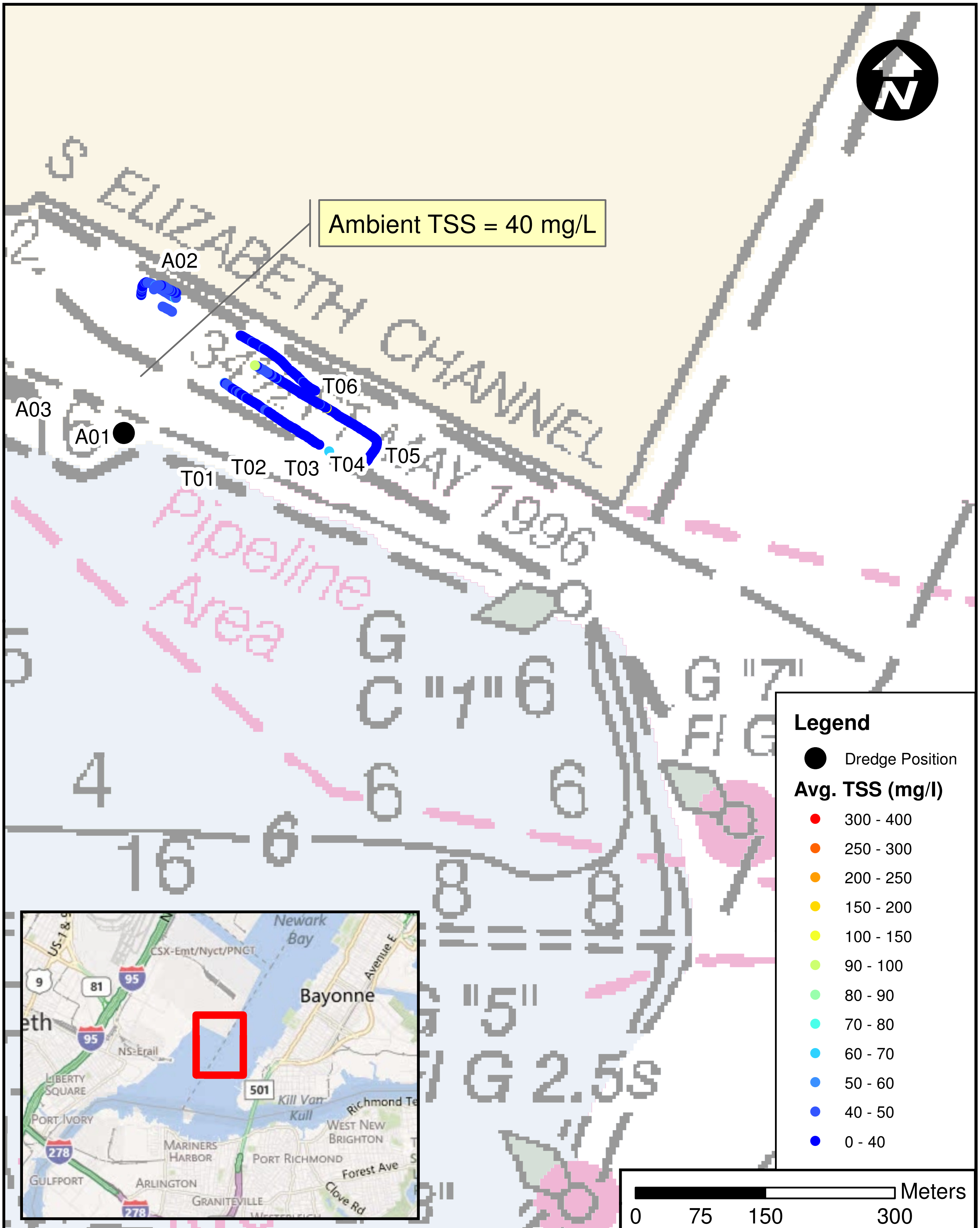
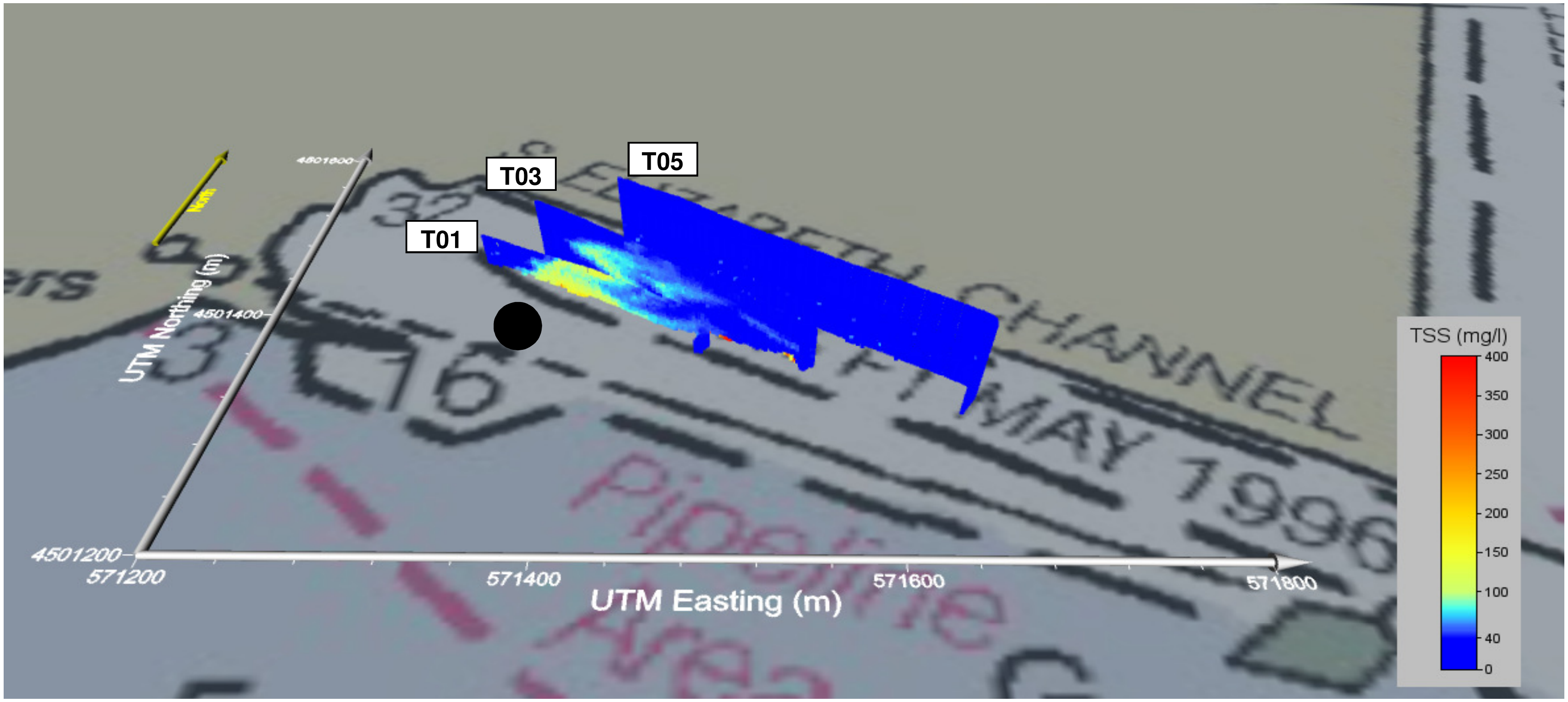


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	ADCP Average TSS - 07 October 2011 14-16 Meter Depth Interval	Tide
38g			Ebb



= Dredge Location

Z scale exaggerated 6X

Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area S-NB-2*	ADCP Average TSS Values, 3D View of Selected Transects 07 October 2011	Tide
39			Ebb

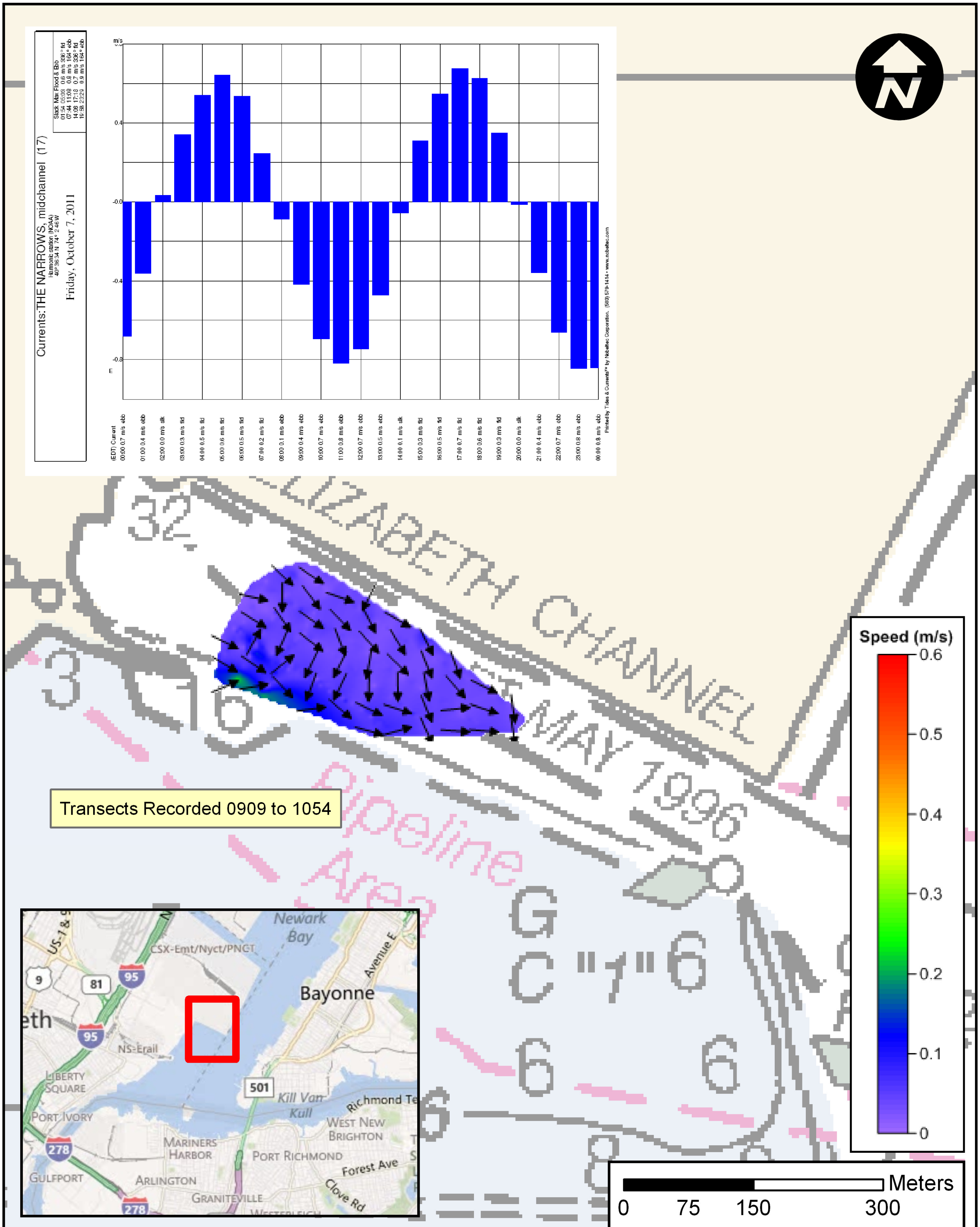


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	Depth Averaged Velocities 07 October 2011 - Ebb Tide TSS Survey	Tide
40			Ebb

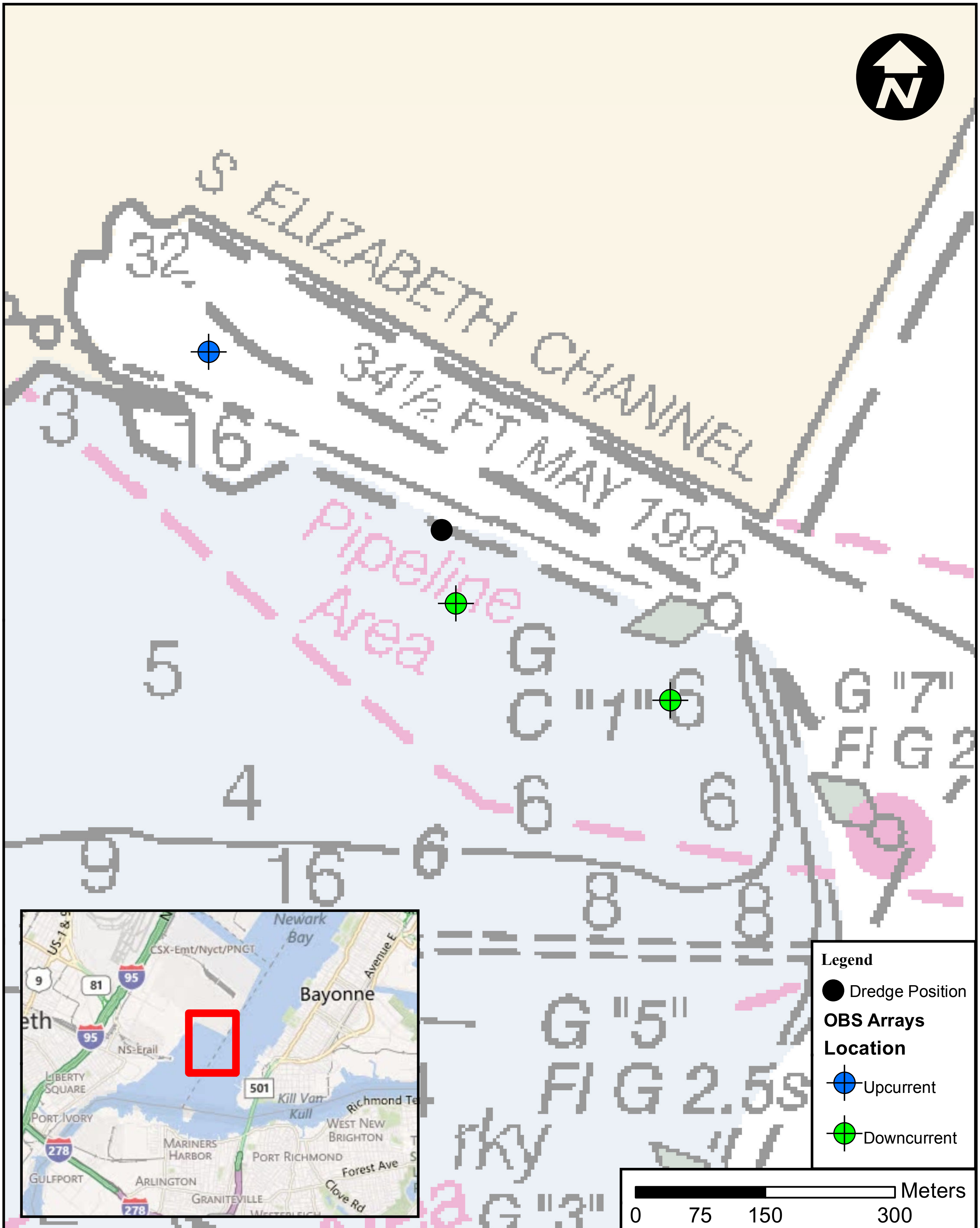
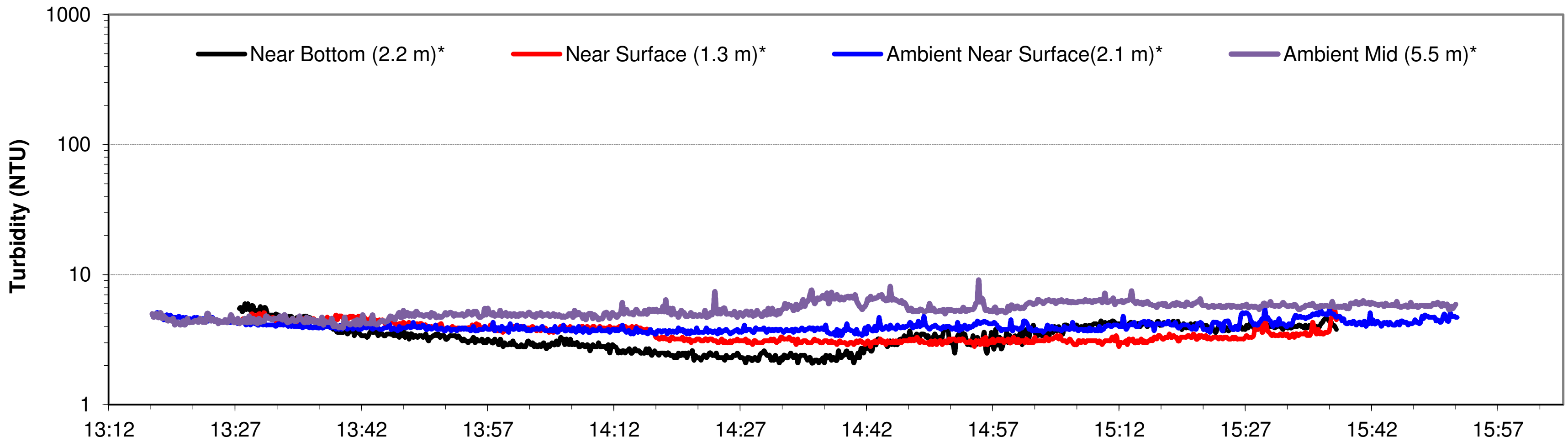
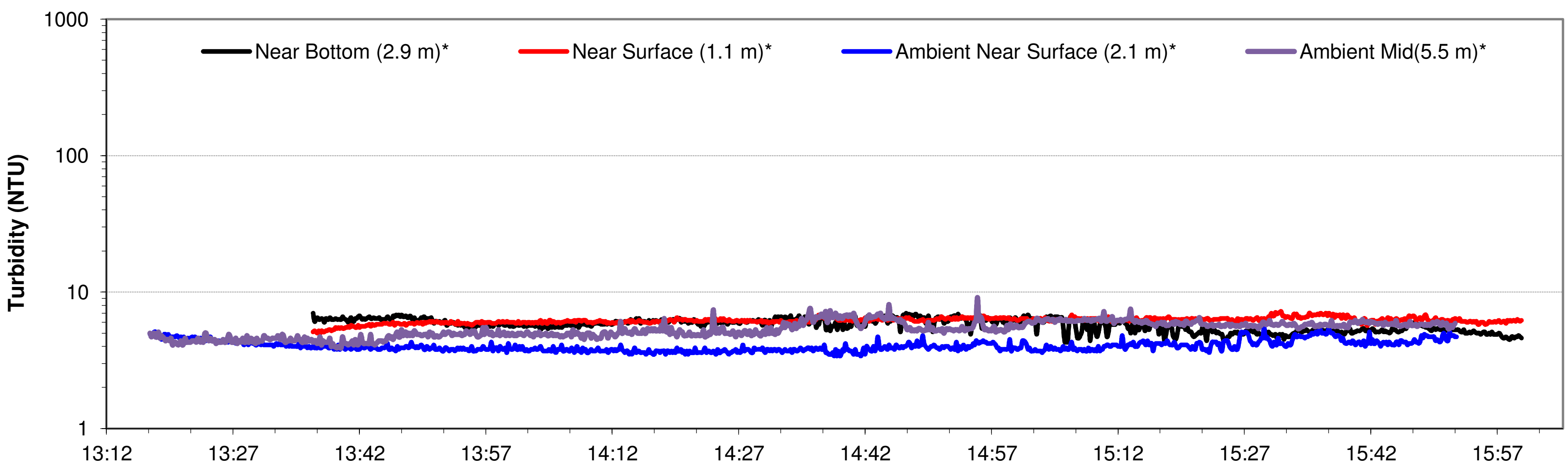


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	Location of OBS Vertical Arrays and Dredge Position 05 October 2011	Tide
41			Flood

a) 85 meters Down Current from Dredge



b) 300 meters Down Current from Dredge



*Number in parentheses is average depth of instrument over period recorded

Figure	*USACE Harborwide TSS* *Far Field Survey* *S-NB-2*	**Surface and Bottom OBS Turbidities at a) 85 m and b) 300 m Downcurrent of Dredge.** **Ambient Station Located 370m Upcurrent of Dredge** **05 October 2011 TSS Survey**	Tide
42			**Flood**

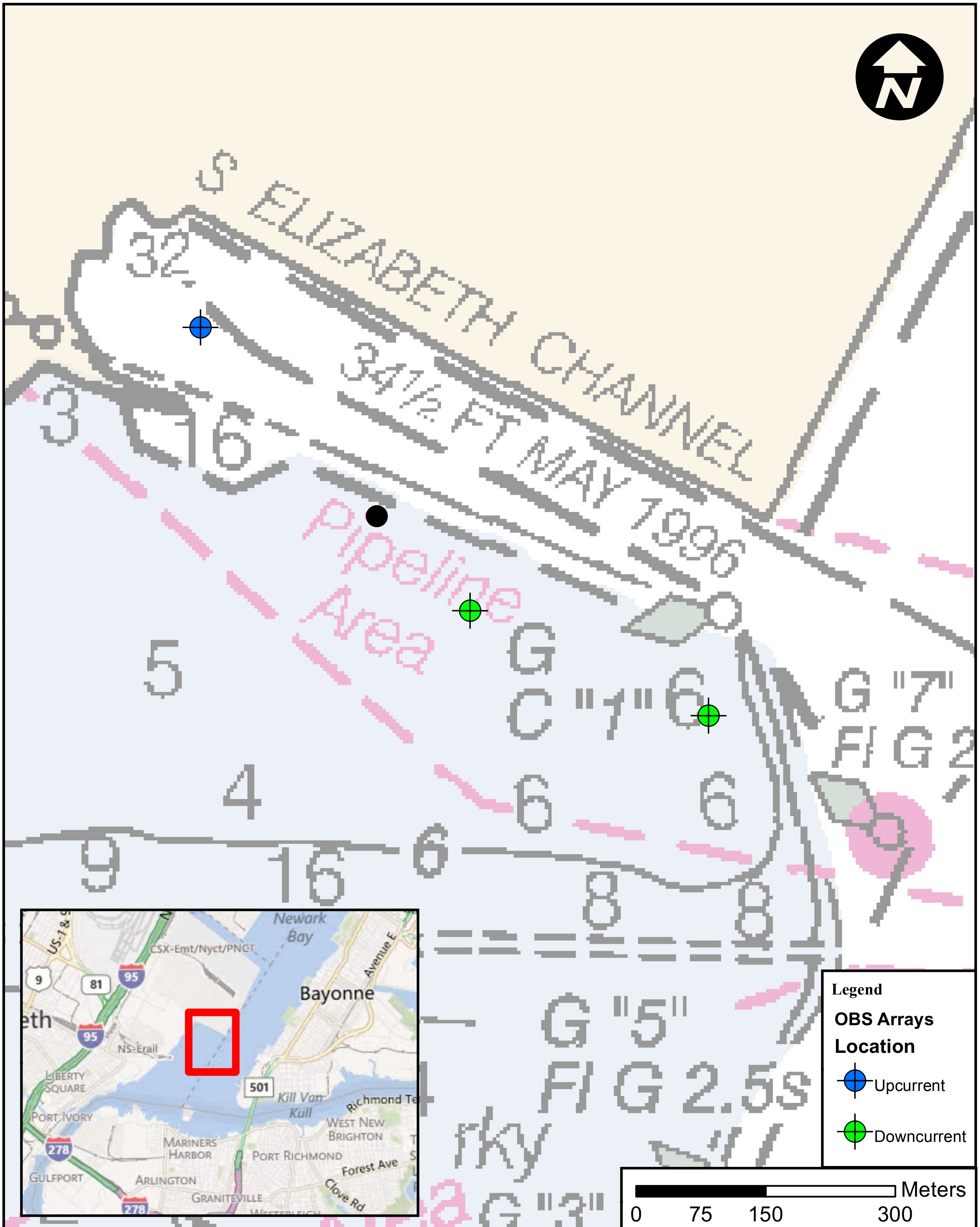
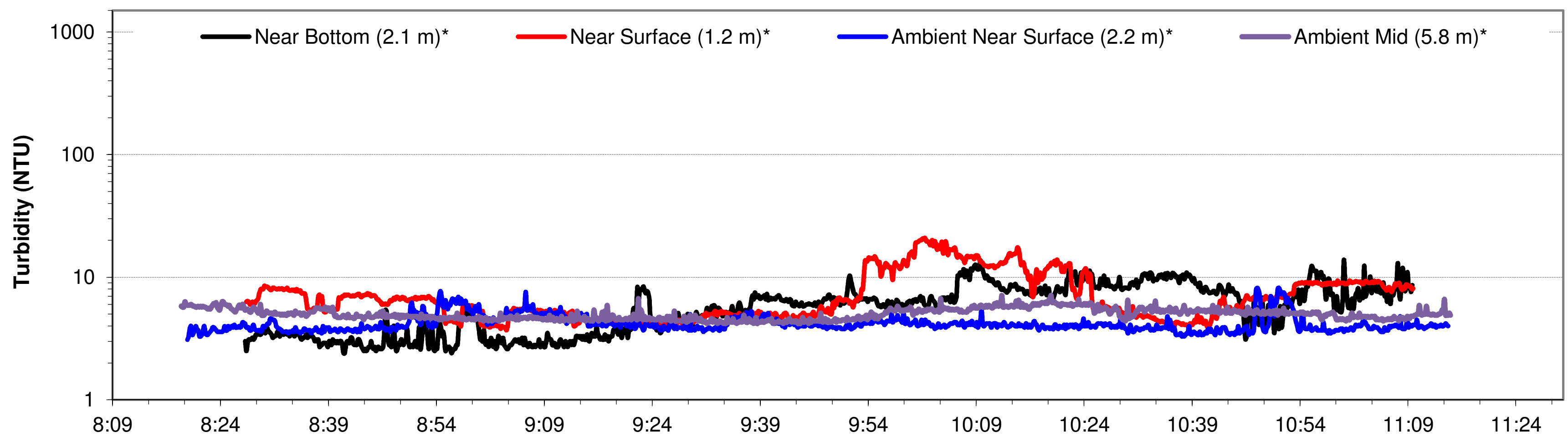
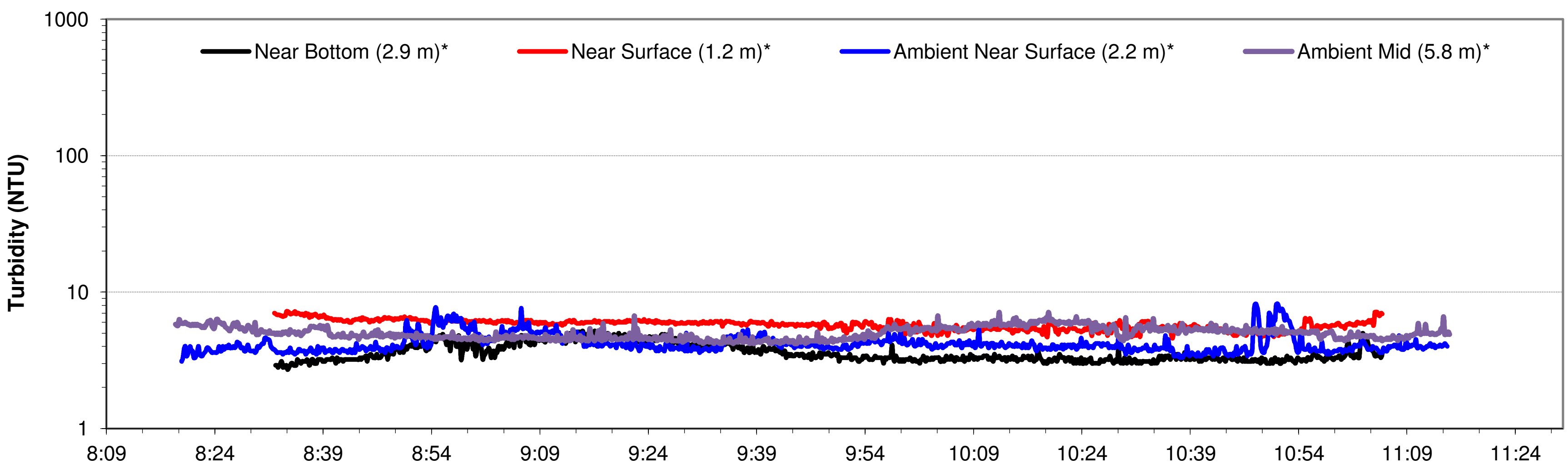


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-2	Location of OBS Vertical Arrays and Dredge Position 06 October 2011	Tide
43			Ebb

a) 120 meters Down Current from Dredge



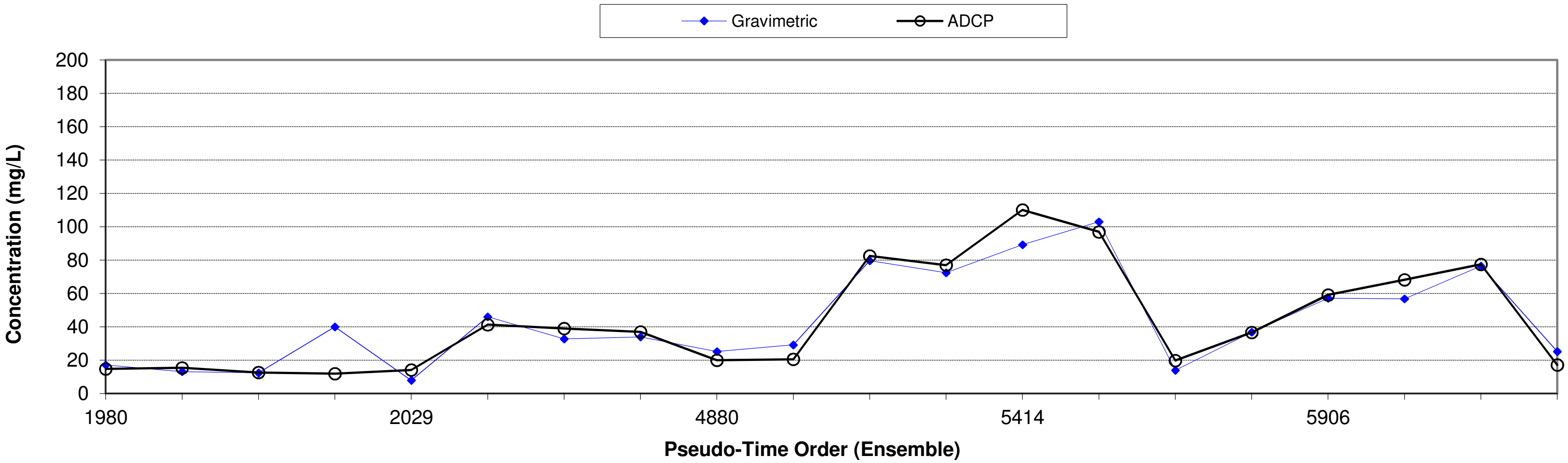
b) 405 meters Down Current from Dredge



*Number in parentheses is average depth of instrument over period recorded

Figure	USACE Harborwide TSS Far Field Survey S-NB-2	Surface and Bottom OBS Turbidities at a) 120 m and b) 405 m Downcurrent of Dredge. Ambient Station Located 320m Upcurrent of Dredge 06 October 2011 TSS Survey	Tide
44			Ebb

a)



b)

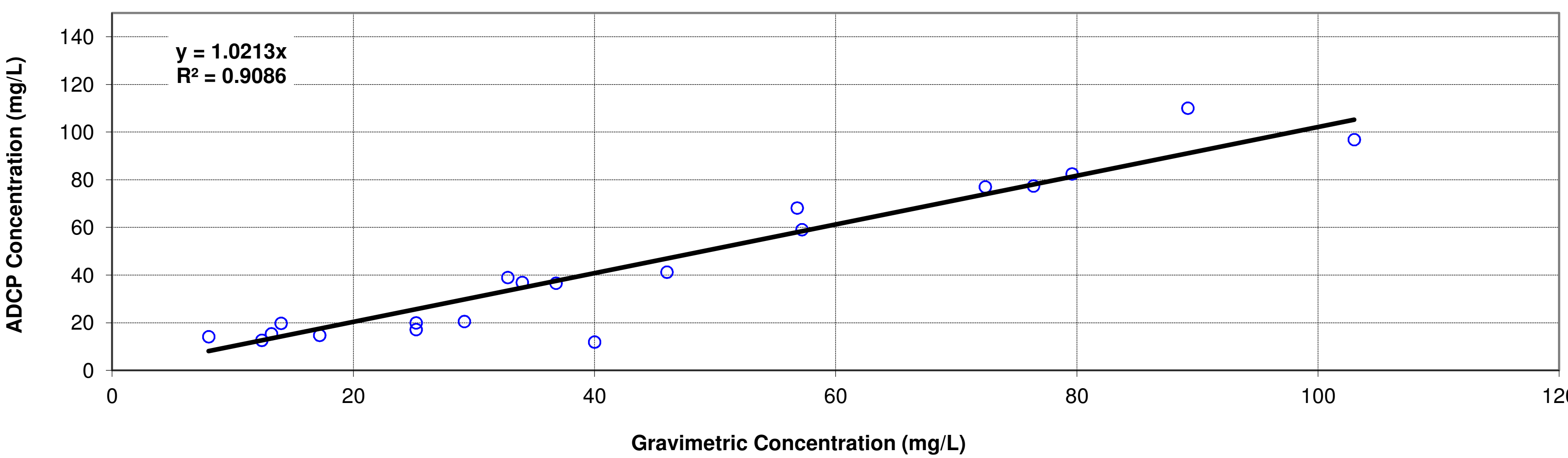
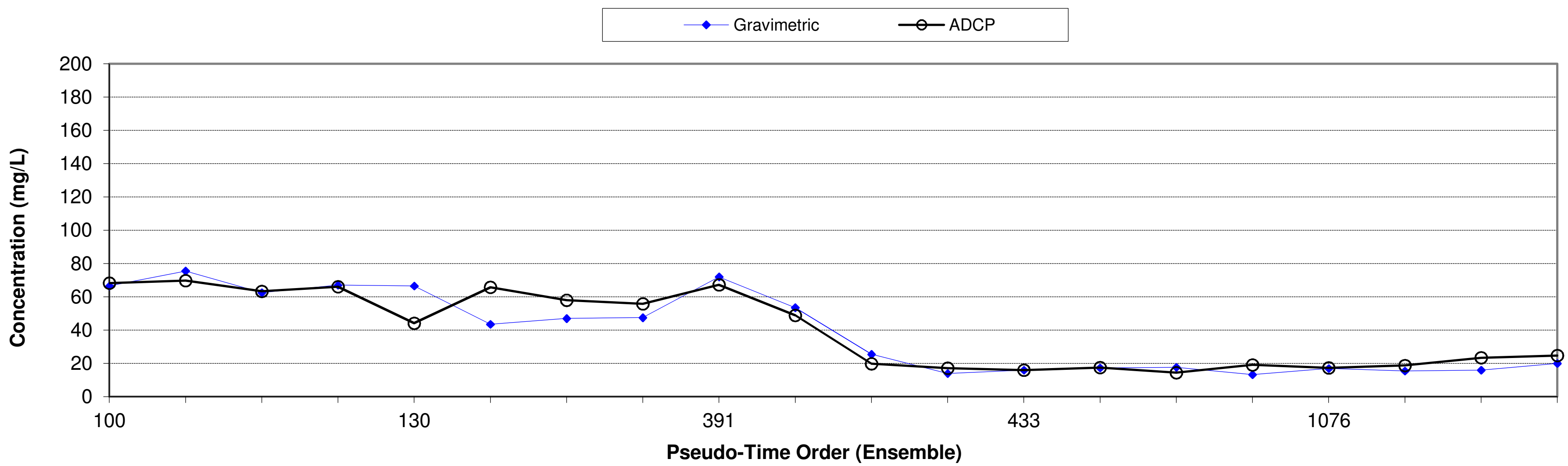


Figure	*USACE Harborwide TSS* *Far Field Survey* *S-NB-2*	**Comparison of gravimetric and ADCP estimates of TSS concentration** **a) Concentration vs. Time b) ADCP Concentration vs. Gravimetric Concentration** **04 October 2011 TSS Survey**	Tide
45a-b			**Flood**

a)



b)

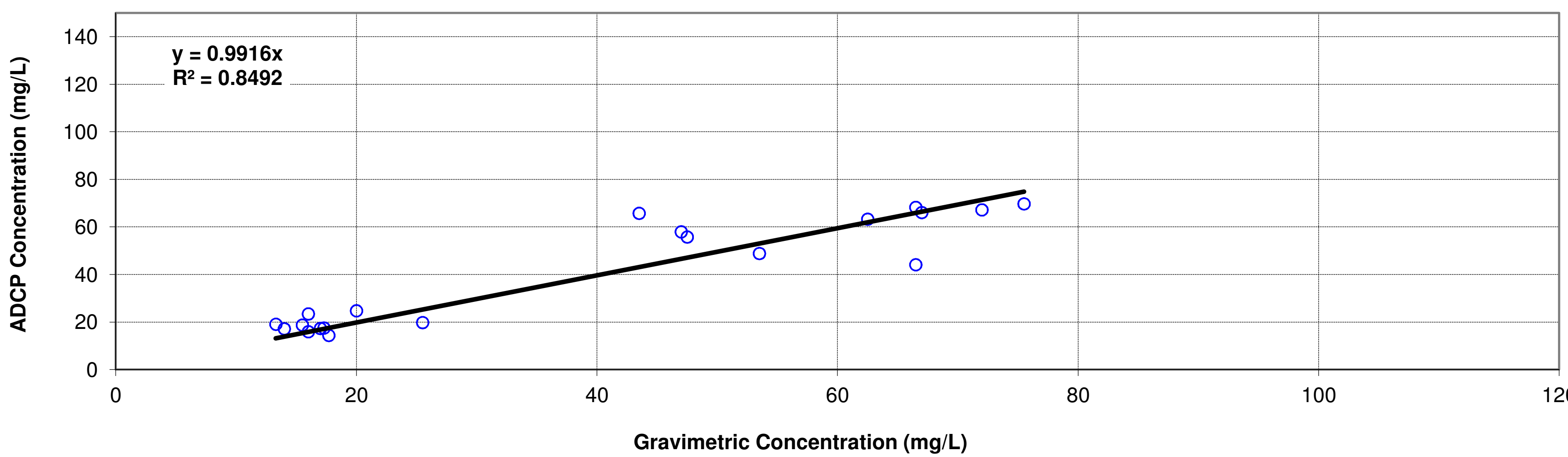
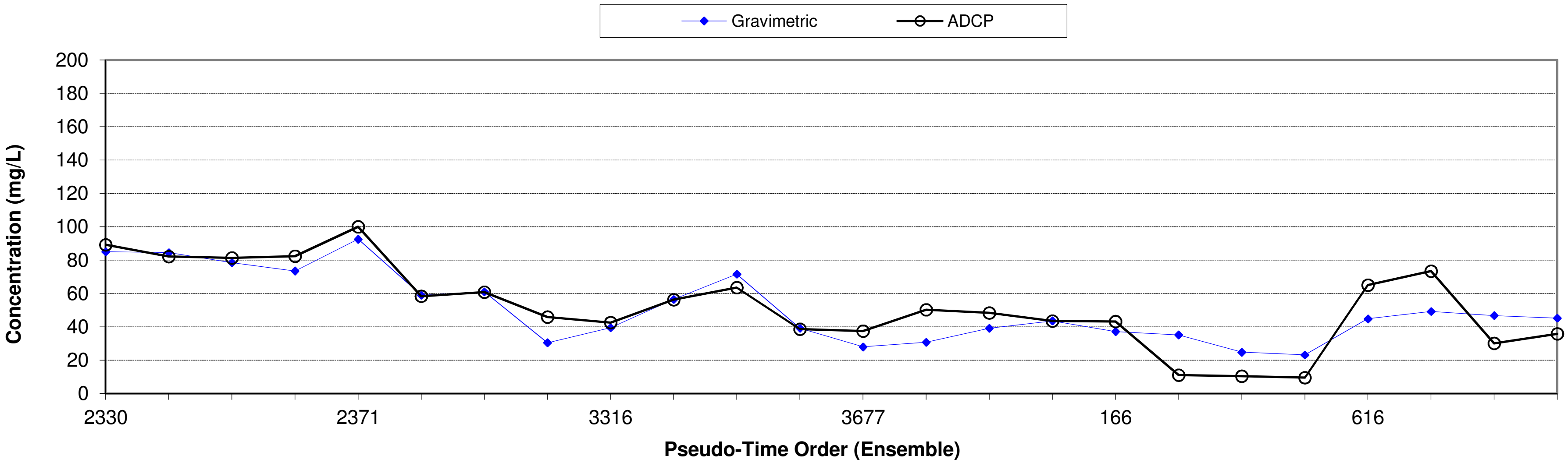


Figure			Tide
46a-b	*USACE Harborwide TSS* *Far Field Survey* *S-NB-2*	**Comparison of gravimetric and ADCP estimates of TSS concentration** **a) Concentration vs. Time b) ADCP Concentration vs. Gravimetric Concentration** **06 October 2011 TSS Survey**	Ebb

a)



b)

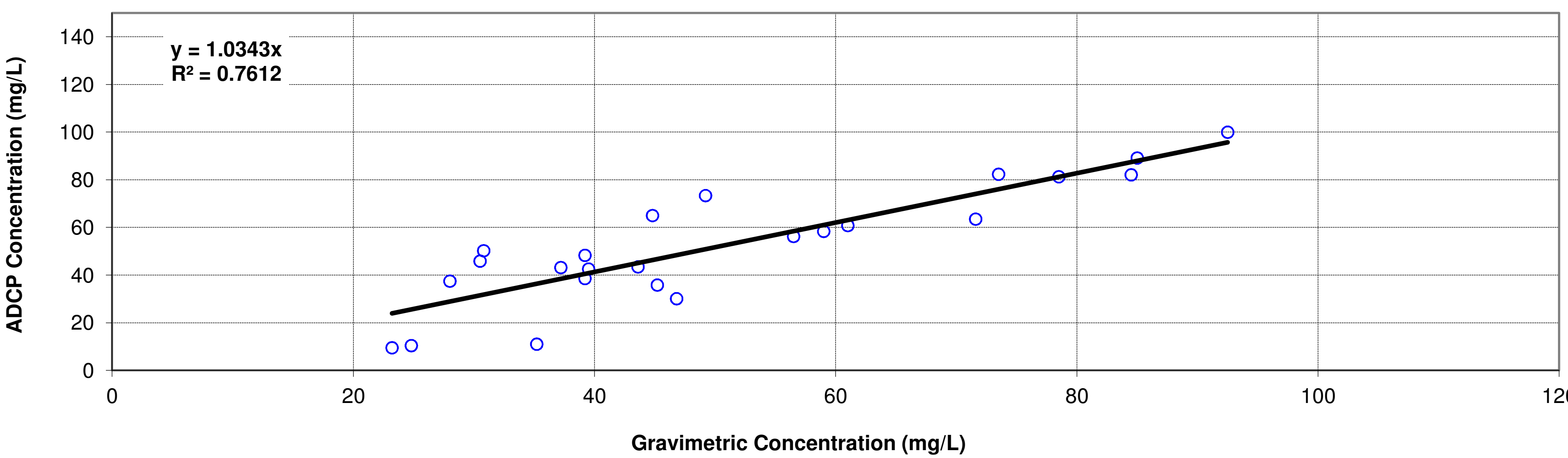


Figure	USACE Harborwide TSS Far Field Survey S-NB-2	Comparison of gravimetric and ADCP estimates of TSS concentration a) Concentration vs. Time b) ADCP Concentration vs. Gravimetric Concentration 07 October 2011 TSS Survey	Tide
47a-b			Ebb

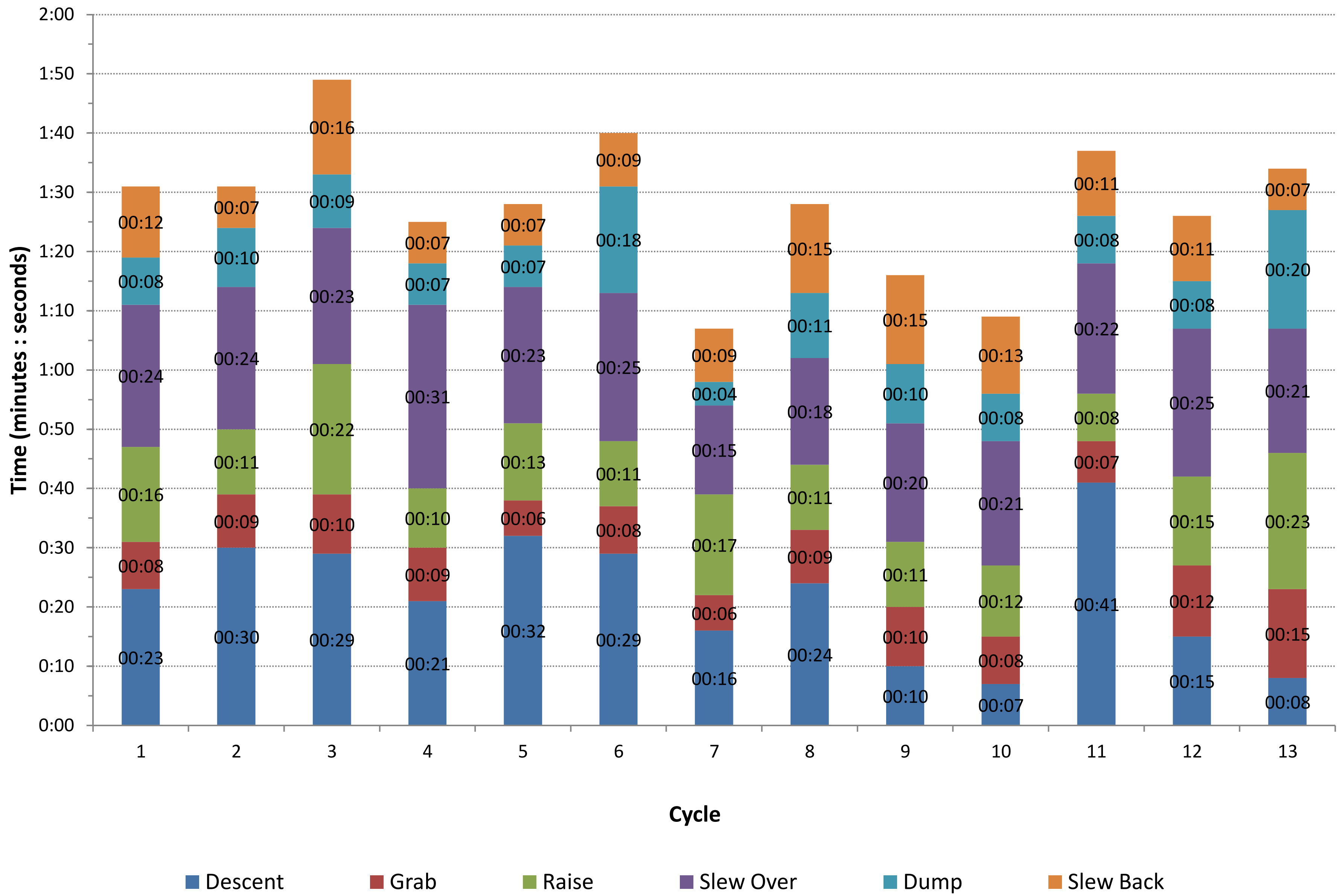


Figure	*USACE Harborwide TSS*	**Elapsed Time of Six Separate Components of Dredge Cable Arm Bucket Cycles**	Tide
48	*Far Field Survey* *HDP Contract Area: S-NB-2*	**06 October 2011**	**Flood**