TECHNICAL MEMO:

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

S-NB-1 Contract Area
Survey # 2

Prepared for

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

June 2009

1.0 Introduction

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, a far field WQ/TSS survey was conducted during the week of 17 November 2008 in the main navigation channel of Newark Bay. The objective of the far field survey was to assess the spatial extent and temporal dynamics of suspended sediment plumes associated with mechanical dredging of fine-grained sediment. These mobile and fixed-array surveys were consistent with previous far field sampling events conducted by USACE-NYD within Newark Bay (USACE 2007a & USACE 2008). Mobile surveys were conducted using a vessel-mounted Acoustic Doppler Current Profiler (ADCP) and consisted of predetermined parallel transects run perpendicular to the axis of the suspended sediment plume. Transects were conducted adjacent to and down-current of the active dredge operation and were run such that the entire spatial extent of the plume's acoustic signature (i.e., the detectable signature above ambient backscatter) was recorded.

In addition to the mobile ADCP surveys, turbidity measurements were recorded at multiple fixed locations and at various water depths using optical backscatter sensors (OBS) hung in the water column using an anchor and buoy array. During each survey, a total of three fixed arrays were deployed (one ambient and two down-current of the plume). Each of the fixed arrays were located within the vicinity of the active dredge operation (no more than 250 meters away to start) and positioned on the channel side slope in approximately four to six meters of water. The objective of this deployment was to determine the spatial extent of the plume beyond the channel boundaries, if any.

1.1 Study Area & Dredge Plant

The far field surveys during the week of 17 November 2008 were conducted in the vicinity of a dredge operating within the B-1 Acceptance Area of the Newark Bay S-NB-1 Harbor Deepening Project (HDP) Contract Area (Figure 1). For all surveys, the dredge plant was situated on the eastern edge of the main channel (roughly between the Red "12" and Red "14" Navigation Buoys) across from Port Elizabeth Marine Terminal and just south and east of the Port Elizabeth Channel. The Newark Bay Channel at this location is approximately 500 meters wide with water depths approximately 15 meters (50 feet) at mean lower low water (MLLW). This is a high volume vessel traffic area frequented by tugs and barges as well as large deep draft commercial vessels including container ships and car carriers. The channel is flanked on the eastern side by extensive flats with prevailing depths of 3 meters (9 feet) or less at MLLW.

The dredge contractor for this study was Great Lakes Dredge & Dock Company (GLDD), operating the Dredge #55 configured with a New Jersey Department of Environmental Protection (NJDEP) permitted twenty–six (26) cubic-yard capacity Cable Arm bucket. The Cable Arm bucket is a variation of an environmental “closed” clamshell bucket designed to minimize release of sediment to the water column. During routine operation, flaps covering vents arrayed in rows on both sides of the bucket serve to maximize retention of cohesive sediments and minimize spillage of sediment/water slurries. In contrast to conventional “grab” buckets, the Cable Arm bucket can produce a relatively level cut when removing bottom sediment, thereby enhancing vertical as well as horizontal control. In addition to the use of a Cable Arm bucket, operational measures including restriction of hoist speed to no more than two feet/second and the use of dredging instrumentation ensuring full bucket closure were used as Best Management Practices (BMPs) to reduce overall sediment re-suspension. These BMPs are documented in the Phased Consistency Determination and Water Quality Certification (PCD/WQC) issued by NJDEP.

2.0 Methods

2.1 Hydrodynamic Survey

Prior to initiation of the far field surveys, hydrodynamic conditions were assessed using a vessel-mounted Teledyne RD Instruments 1200-kHz Workhorse Monitor Series Acoustic Doppler Current Profiler (ADCP). The ambient survey was conducted during a period of non-dredging and incorporated the area of the main Newark Bay navigational channel from South Elizabeth Channel northeast to approximately 500 meters beyond the Port Elizabeth Channel (Figure 2). Mobile transects were conducted with an east to west and west to east orientation from the Green “7” buoy at the entrance to South Elizabeth Channel to the Green “15A” buoy north of Port Elizabeth Channel. Transect lines were spaced approximately 50 meters apart and were towed at a boat speed of between 2.0 and 2.5 meters/second (m/s).

ADCP data provided a characterization of prevailing hydrodynamics conditions within the area of the Newark Bay main navigation channel. Raw data for all ambient and later suspended sediment plume transects were processed and examined for evidence of stratified flows, tidal eddies, and other patterns that could influence plume dispersion.

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 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.). The relative frequency and intensity of the reflected pulses can then be analyzed and an estimate of current velocity, and if water samples are collected concurrently, suspended sediment concentration can be determined. Navigation data and dredge positional data (i.e. GPS data of barge location) were collected concurrently by GLDD and integrated during post-processing of data. To cover a range of tidal conditions, backscatter data were collected during both an early and late flood tide stage on 18 November 2008 and during an ebb tide on 19 November 2008.

Mobile ADCP survey transects were oriented in a direction perpendicular to the channel and extended down-current until plume acoustic signatures could no longer be detected against background conditions. Background conditions on the days of the survey were determined by conducting ambient transects up-current of the plume and outside the 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 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. All other sources of potential backscatter, such as passing container ships or tugs, prop wash from the survey vessel, or air entrainment caused by the bucket entering and exiting the water, were noted on the field datasheets and when applicable described in the report.

2.3 Design of Fixed Station Turbidity Survey

In addition to the mobile ADCP surveys described above, 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 locations using a fixed anchor and buoy array. Optical backscatter sensors (OBS) project a beam of near-infrared light into a known volume of water and measure the amount of light scattered from suspended particles. The OBS units used in this survey were pre-calibrated by the manufacturer against known turbidity standards and were 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 (mean + standard deviation, in meters), turbidity (mean + standard deviation, in 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.

During the 19 November 2008 survey, a total of three fixed arrays were deployed (one ambient and two down-current of the plume). The ambient array consisted of one OBS unit tethered at mid-depth while each of the down-current arrays consisted of two OBS units each tethered at near surface and near bottom depths. Each of the fixed arrays (both ambient and down-current) were located within the vicinity of the active dredge operation (no more than 250 meters away to start) and positioned on the channel side slope in approximately four to six meters of water. The objective of this deployment was to determine the spatial extent of the plume beyond the channel boundaries, if any.

2.4 Water Sample Collection

During the far field survey, water samples were collected to directly measure TSS concentrations (mg/L) and turbidity (NTU) throughout the water column. The water samples were collected using an onboard winch system and 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 laptop. The OBS unit provided real-time depth, temperature, salinity and turbidity values of the entire water profile. The Carousel Sampler was also hardwired to an onboard laptop and features a magnetically-actuated lanyard release system used to remotely “fire” the sample bottles using a custom application that recorded the exact time that each bottle fired to the nearest second.

Each of the water samples collected in the field was 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 further described below.

2.5 Sediview 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 proportional to the strength 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.

During the far field surveys, a total of 60 discrete water samples (16 ambient and 44 within the plume) were collected and analyzed gravimetrically to create the calibration data set. 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. Because air is injected into the water column as the 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.

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. During the present study, current flows were relatively slow to moderate, consistent with flows observed in the Providence River where a closed bucket was monitored during maintenance dredging operations (Reine et al. 2006). Experiments during the Providence River monitoring, in which the bucket was intentionally plunged through the air-water interface without removing sediment from the bottom, determined that the “bubble signature” pattern dissipated within approximately 50 meters of the source. Beyond 50 meters estimates of TSS concentration for the calibrated ADCP should be accurate.

Following the Sediview calibration, the results were then applied to all of the ADCP files recorded during each of the two far-field surveys, resulting in an ADCP-derived estimate of TSS concentration for each recorded ADCP bin.

2.6 Sediment Sample Collection

When possible, *in situ* sediment samples were collected once per day from the dredge scow and the sediment bed using a ponar grab sampler. These samples were analyzed in the laboratory by Test America Laboratories, Inc. for sediment grain size distribution (ASTM D-422 Method), bulk density (ASTM D-2937 Method) and Atterberg Limits (ASTM D-4318 Method).

3.0 Results

3.1 Hydrodynamic Survey

Figure 2 presents the results of the hydrodynamic survey conducted on 17 November 2008. Mobile ADCP transects were conducted during a period of non-dredging and encompassed the area of the Main Newark Bay Channel from the Green “7” buoy at the entrance to South Elizabeth Channel to the Green “15A” buoy north of Port Elizabeth Channel. Transects were conducted from approximately 1130 to 1420 hours during the period from high slack water, predicted to occur at 1143 at South Reach, Newark Bay, into an ebb tide which was predicted to peak at 1443. Survey conditions were generally favorable with a west wind at 15-20 mph and seas at 1-2 feet.

The depth-averaged current vectors presented in Figure 2 show a generally uniform flow pattern orientated in a southern direction parallel to the Main Channel during an ebb tide. Maximum velocities up to 0.50 m/s were recorded in the northern portion of the survey area north of and adjacent to the Port Elizabeth Channel. Although a pattern of generally increasing current velocities was observed as the survey vessel advanced north up the channel, this was likely a function of increasing tidal flow as the survey moved from high slack conditions at the beginning to almost peak ebb conditions at the end. Importantly, the survey ended in the immediate area of the proposed dredge location and showed the maximum expected current velocities to be in the range of 0.50 m/s with no unusual directional patterns, or eddies, that could influence plume dispersion.

3.2 Mobile ADCP Surveys

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

- Vertical Profile Plots – Vertical cross-section profiles representing each individual transect are examined in detail for TSS concentration gradient structure of the plume at known 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 – Representative transects are plotted three dimensionally in X and Y coordinates with an exaggerated Z (depth) axis and then superimposed on the existing bathymetry to show the spatial extent of the plume within the channel. Channel bathymetry was obtained during the S-NB-1 pre-dredge survey and, when unavailable, from ADCP data collected during the far field survey. Transects were selected for best visual display of the general plume characteristics in three dimensions.

For all figures, unless otherwise noted, estimates of TSS concentrations above ambient are assumed to be associated with dredging activities. In addition, several of the vertical profile plots, such as Figures 3a – 3m and 6m – 6r, have noted the presence of "sidelobe" interference along the channel side slopes. This interference of the data signal results from the fact that even though the majority of the ADCP acoustic beam is focused within a narrow beam, some of this power is emitted at far greater angles. The reflections of these sidelobes can contaminate the data signal returned from the near-bed area and is magnified when moving rapidly between deep water and shallow areas (DRL 2003).

3.2.1 Ambient Conditions

It is important to consider that no single TSS measurement adequately represents ambient conditions; instead a range of samples variable with regard to depth and tidal conditions is a better representation of the dynamic nature of suspended sediment concentration. On 17 November 2008, a total of 16 ambient water samples were collected at various depths and later analyzed in the laboratory for TSS and turbidity (Table 1). Ambient turbidity values ranged from 5.88 to 8.32 NTU with TSS values ranging between 12.0 and 21.7 mg/L. The average gravimetric estimate of TSS concentration based on the 16 ambient water samples was 17.9 mg/L. For graphical purposes, in this study, all acoustically estimated TSS concentrations greater than 22 mg/L (the highest measured ambient value) are herein considered above background and attributable to the dredging-induced plume unless otherwise noted, e.g., clearly attributable to air entrainment or other sources such as survey vessel prop wash or tug and ship plumes.

3.2.2 November 18, 2008 (Early Flood Tide Survey)

A mobile ADCP plume characterization survey was completed during the first half of a flooding tide from approximately 0810 to 0850 hours on 18 November 2008. Peak flooding conditions that morning were predicted at 0850 at the South Reach, Newark Bay. The entire ADCP survey consisted of a total of 13 transects. Vertical profile plots representing successive transects at increasing distance from the dredge source are given in Figures 3a – 3m. Four ambient transects (Figures 3a – 3d) were conducted on the up-current side of the dredging operation, beginning approximately 45 meters off the stern of the dredge platform, and out to approximately 260 meters up-current. A total of nine transects (Figures 3e – 3m) were conducted down-current from the dredge in the direction of plume movement. The first down current transect was located immediately off of the bow of the dredge platform and approximately 130 meters from the stern of the dredge platform[1]. Subsequent transects were conducted north of this position at progressive increments of approximately 25 to 75 meters (Table 2). The outermost down-current transect was a distance of approximately 615 meters from the dredge platform. Transects were orientated perpendicular to the channel and the axis of the dredge plant and were run back and forth in a general east-west direction. Transect length ranged from approximately 205 to 365 meters (Table 2).

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[1] Dredge positional data for the entire survey was provided by GLDD. According to GLDD correspondence, their GPS antenna for this survey mounted on the aft part of the dredge platform atop the house and approximately 170 feet away from the average bucket position in front of the dredge.

To examine the spatial extent of the plume, a series of plan-view layouts of the ADCP transects depicting estimates of TSS concentrations in two meter depth averaged increments are given in Figures 4a – 4h while Figure 5 provides a three-dimensional depiction of average TSS values for selected representative transects superimposed on existing channel bathymetry. A summary of each of the graphically represented transects is presented in Table 2.

Estimated TSS concentrations above ambient (22 mg/L) associated with the dredging operation on 18 November 2008 during the early flood stage were exclusively limited to within the first 130 meters down-current from the stern of the dredge platform (Figure 3e). Maximum TSS concentrations were observed near the surface and approached 300 mg/L with the core signature ranging between 100 and 150 mg/L. Although some lateral spreading of the plume was observed near the surface, the main stem of the plume was typically no more than 40 meters in width and was confined entirely within the channel side slopes (Figure 3e). Successive vertical profiles (Figures 3f – 3m) conducted between 200 and 615 meters down current of the dredge platform show almost no evidence of the dredge plume signature which may be indicative of the early state of the dredging operation and a lack of time for the suspended sediment plume to build given that dredging operations had begun only approximately 30 minutes earlier. In addition, previous investigations have noted the “pulsating” nature of some dredge plumes which result from intermittent sediment releases caused when dredging operations are non-continuous with frequent starts and stops due to a variety of circumstances including vessel passage, routine periodic maintenance, and equipment repairs (USACE 2007a). Because of this, a second flood tide survey was conducted immediately afterwards to incorporate the second half of the morning’s flood tide with the results presented below in section 3.2.3 (Late Flood Tide Survey).

Although no evidence of the dredge plume was observed in the transects conducted 200 meters down current and beyond, a second source of acoustic backscatter is clearly seen developing near the bottom and reaching a peak between 360 and 525 meters from the dredge platform (Figures 3i – 3l). Given the early state of the dredging operation that morning and the fact that the estimated TSS concentration appears to be increasing at transects that are farther away from the GLDD platform (for example, see Figure 4e), it appears unlikely that the GLDD dredging operation was the source of this acoustic backscatter. Although no container ship activity was noted that morning, a possible explanation for the backscatter was that it was a remnant signature induced by vessel traffic transiting the Port Elizabeth Channel. As discussed in previous investigations, the

Port Elizabeth Channel where it drains into Newark Bay is an area frequented by the passage of deep-draft container ships, a likely source for repeated sediment re-suspension in Newark Bay (USACE 2007b).

3.2.3 November 18, 2008 (Late Flood Tide Survey)

A second mobile ADCP plume characterization survey was completed during the second half of a flooding tide from approximately 0855 to 0932 hours on 18 November 2008. Peak flooding conditions that morning were predicted at 0850 at the South Reach, Newark Bay. The entire ADCP survey consisted of 14 transects conducted down-current from the dredge in the direction of plume movement (Figures 6e – 6r). For reference, the four ambient transects conducted earlier in the morning for the early flood tide survey are shown in Figures 6a-6d. The first down current transect was located immediately off of the bow of the dredge platform, approximately 100 meters from the stern of the dredge platform. Subsequent transects were conducted north of this position at progressive increments of approximately 25 to 75 meters (Table 3). The outermost down-current transect was a distance of approximately 700 meters from the dredge platform. Transects were orientated perpendicular to the channel and the axis of the dredge plant and were run back and forth in a general east-west direction. Transect length ranged from approximately 165 to 350 meters (Table 3).

To examine the spatial extent of the plume, a series of plan-view layouts of the ADCP transects depicting TSS concentrations in two meter depth averaged increments are given in Figures 7a – 7h while Figure 8 provides a three-dimensional depiction of average TSS values for selected representative transects superimposed on existing channel bathymetry. A summary of each of the graphically represented transects is presented in Table 3.

Estimated TSS concentrations above ambient (22 mg/L) associated with the dredging operation on 18 November 2008 during the late flood stage were primarily limited to within the first 150 meters down-current from the stern of the dredge platform (Figures 6e – 6g). Maximum TSS concentrations were observed near the surface and exceeded 300 mg/L (433 mg/L maximum value) with the core signature ranging between 150 and 300 mg/L in the upper half of the water column and between 100 and 150 mg/L in the lower half at 100 meters down-current (Figure 6e). The plume was initially no more than 40 meters in width at 100 meters down-current (Figure 6e), although subsequent transects showed some lateral spreading of the plume up to 80 meters, it remained confined entirely within the channel side slopes (Figures 6f & 6g). Beyond 150 meters down-current, the core signature of the plume quickly dissipated to concentrations below 70 mg/L with some remnants observed near the bottom (Figures 6h & 6j).

Of note, and as observed during the Early Flood Tide Survey (Section 3.2.2), a second source of acoustic backscatter is seen developing near the bottom at the base of the channel side slope at distances between 325 and 430 meters down-current from the dredge platform (Figures 6k – 6o). Again, as noted in the field and as plotted graphically (Figures 7f & 7g), the areas of high estimated TSS concentrations generally corresponded to the area where Newark Bay Channel intersects Port Elizabeth Channel and is most likely attributable to the repeated disturbance caused by vessel traffic and/or the tidal disturbance created by the confluence of these two bodies of water. Figures 6p – 6r show areas of estimated TSS concentrations less than 80 mg/L.

3.2.4 November 19, 2008 (Ebb Tide Survey)

A third mobile ADCP plume characterization survey was completed during the first half of an ebbing tide from approximately 1515 to 1610 hours on 19 November 2008. Peak ebbing conditions that afternoon were predicted at 1715 at the South Reach, Newark Bay. The entire ADCP survey consisted of three ambient transects (Figures 9a – 9c) and 11 transects conducted down-current from the dredge in the direction of plume movement (Figures 9d – 9n). The ambient transects were conducted off the bow of the dredge platform beginning at approximately 110 meters distance from the stern to approximately 232 meters up-current. The first down current transect was located approximately 30 meters off of the stern of the dredge platform. Subsequent down-current transects were conducted south of this position at progressive increments of approximately 50 to 75 meters until the final two transects which were conducted approximately 120 and 160 meters apart, respectively (Table 4). The outermost down-current transect was a distance of approximately 765 meters from the dredge platform in the vicinity of the Red "10" Buoy. Transects were orientated perpendicular to the channel and the axis of the dredge plant and were run back and forth in a general east-west direction. Transect length ranged from approximately 250 to 470 meters (Table 4).

To examine the spatial extent of the plume, a series of plan-view layouts of the ADCP transects depicting TSS concentrations in two meter depth averaged increments are given in Figures 10a – 10h while Figure 11 provides a three-dimensional depictions of average TSS values for selected representative transects superimposed on existing channel bathymetry. A summary of each of the graphically represented transects is presented in Table 4.

Estimated TSS concentrations above ambient (22 mg/L) associated with the dredging operation on 19 November 2008 during the ebb tidal stage was primarily limited to within the first 145 meters down-current from the stern of the dredge platform (Figures 9d – 9f). Maximum TSS concentrations exceeded 300 mg/L near the surface at 30 meters from the source with the core of the signature ranging between 100 and 150 mg/L for the entire depth of the water column (Figure 9d). Successive vertical profiles, however, show a rapid and steady decay in the signal strength of the plume, although a faint signature may still be present as far as 600 meters down-current (Figure 9m). Beyond 145 meters, estimated TSS concentrations typically did not exceed 70 mg/L (Figure 9g – 9n). The initial plume measured no more than 100 meters across at 30 meters down-current (Figure 9d), although subsequent transects showed some lateral spreading of the plume to as much as 200 meters it was always confined entirely within the channel side slopes (Figures 9d – 9n).

3.3 Fixed Station Turbidity Survey

Campbell Scientific, Inc.'s OBS-3A units were deployed at various water depths at fixed station locations during both a flood and ebb tide on 19 November 2008.

3.3.1 Flood Survey

Figure 12 presents the locations and times of deployment of the fixed arrays as well as the dredge position during the flood tide sampling. Flood tide conditions on 19 November 2008 were predicted for South Reach, Newark Bay from approximately 0816 to 1346 with peak flooding expected at 1010. Figure 13 plots the recorded turbidity values (NTU) from the surface (black line) and bottom (red line) OBS units at approximately 150 and 250 meters down-current from the dredge (Figures 13a & 13b, respectively). Ambient turbidity as measured from the up-current OBS at mid-depth is plotted as a blue line and superimposed on both of the down-current plots.

Sampling at the fixed station arrays during the flood tide occurred from approximately 0930 to 1320. A majority of both the ambient and down-current turbidity measurements fell into a narrow range of values between approximately 8 and 20 NTU (Figure 13). No evidence of suspended sediment plume excursion onto the flats was recorded by the fixed station arrays which were positioned over the channel side slopes in approximately six meters of water depth. In general, for both the 150 and 250 meter down-current deployments, turbidity at the bottom tracked slightly lower than the surface, which in turn tracked slightly lower than ambient (blue line). As discussed earlier in Section 3.2.1, true ambient conditions typically represent a dynamic range of turbidity concentrations and this apparent incongruity (i.e. higher ambient values) may simply reflect underlying variability in ambient conditions with regards to spatial differences in the location of the sensors both within the water column and/or on the channel side slope.

The dredge platform was repositioned beginning at approximately 0930 to 1030, resulting in an approximate move of 200 meters to the south and west (Figure 12), and each of the fixed station arrays were repositioned accordingly. A temporary spike in turbidity to levels above 200 NTU was observed for the both the bottom and surface sensors at 150 meters down-current from approximately 1045 to 1050. This temporary spike was most likely the result of sediment sampling activity from the survey vessel as noted on the field datasheets.

3.3.1 Ebb Survey

Figure 14 presents the locations and times of deployment of the fixed arrays as well as the dredge position during the ebb tide sampling. Ebb tide conditions on 19 November 2008 were predicted for South Reach, Newark Bay from approximately 1346 to 2117 with peak ebbing expected at 1715. Figure 15 plots the recorded turbidity values (NTU) from the surface (black line) and bottom (red line) OBS units at both 100 and 200 meters down-current from the dredge (Figures 15a & 15b, respectively). Ambient turbidity as measured from the up-current OBS tethered at mid-depth is plotted as a blue line and superimposed on both of the down-current plots.

Sampling at the fixed station arrays during the ebb tide occurred from approximately 1445 to 1620. A majority of both the ambient and down-current turbidity measurements fell into a narrow range of values between approximately 6 and 20 NTU (Figure 15). No evidence of suspended sediment plume excursion onto the flats was recorded by the fixed station arrays which were positioned over the channel side slopes in approximately six meters of water depth. In general, for both the 100 and 200 meter down-current deployments, turbidity at the bottom tracked slightly lower than the surface, which in turn tracked slightly lower than ambient (blue line). As discussed earlier in Section 3.2.1, true ambient conditions typically represent a dynamic range of turbidity concentrations and this apparent incongruity (i.e. higher ambient values) may simply reflect underlining variability in ambient conditions with regards to spatial differences in the location of the sensors both within the water column and/or on the channel side slope.

3.4 Laboratory Analysis of Water Samples

A total of 60 water samples were collected in the Newark Bay project area over the course of three sampling days of the far field surveys (17 November 2008 through 19 November 2008). The laboratory results of the optical turbidity and the gravimetric analysis of TSS concentration of those 60 samples are presented in Table 1. To accommodate the requirement for calibration of the ADCP backscatter, samples were taken from locations to represent the broadest possible concentration gradient from ambient to as close to the source as possible. Logistical and safety constraints of working in the area of an active dredging operation imposed a constraint on collecting the highest range of TSS concentration samples.

In this study, the TSS concentrations of the 60 water samples ranged from 12.0 to 234.0 mg/L. (Table 1). Figure 16a plots both the gravimetric measurements and acoustic estimates derived by the Sediview calibration, arranged in concentration versus time order. Note that not all of the 60 samples collected were used in the Sediview calibration; some samples were excluded if they exhibited clear signs of either air bubble contamination or interference with the water sampler apparatus. Overall, there was a very strong agreement (R^2 = 0.96) between the acoustic estimates of TSS concentration and the gravimetric measurements (Figure 16b).

3.5 Sediment Samples

During the far field surveys a total of four sediment samples were collected including two from the dredge scow and two from the sediment bed within the dredge field. The laboratory results of these sediment collections for grain size distribution, bulk density and Atterberg Limits are presented in Table 5. All of the sediments collected from the study area were predominantly composed of silt (62% to 66%) and clay (31% to 35%) with fine and medium sand typically composing the rest of the samples. The two samples collected from the dredge scow had slightly higher silt content (66% and 63%) as compared to the dredge field samples (62% and 62.5%) as well as generally lower moisture content (121% and 138% as compared to 138% and 175%).

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.

The acoustic backscatter patterns and dimensions observed during the far-field surveys conducted in November 2008 in the B-1 Acceptance Area of the HDP S-NB-1 Contract Area were consistent with the results of previous mechanical dredge plume monitoring efforts conducted within the Newark Bay (USACE 2007a and USACE 2008). Although exact comparisons between studies is impossible due to varying hydrodynamic conditions as well as varying sediment types within the various study areas, some consistent patterns have emerged. During previous surveys in the Arthur Kill, maximum TSS concentrations measured acoustically by the ADCP approached 300 mg/L near the surface and within 10 meters of the dredge but decreased to less than 50 mg/L at a distance of approximately 150 meters and to 20 mg/L at 350 meters, although faint plume signatures with concentrations less than 10 mg/L above background did persist as far as 620 meters from the source (USACE 2007a).

Maximum TSS concentrations measured acoustically during previous far field surveys in Newark Bay also approached 300 mg/L near the surface, although air entrainment likely affected these measurements to some degree (USACE 2008). The core of the plumes measured previously in Newark Bay typically ranged between 80 and 200 mg/L within the first 75 meters down current from the source, although a consistent pattern was observed of relatively rapid decay and settlement within the water column in which TSS concentrations 150 meters down current from the source generally did not exceed 100 mg/L (USACE 2008). During the mobile ADCP surveys of November 2008, peak estimated TSS concentrations were again found to approach, and in small pockets near the surface, exceed 300 mg/L. The main core of the plume within the first 150 meters down-current from the dredge typically ranged between 100 and 200 mg/L but as in previous investigations showed a pattern of rapid decay with estimated concentrations of TSS not expected to exceed 70 mg/L beyond 150 meters.

One of the unique physical features of Newark Bay is the extensive area of shallow water flats located along the eastern perimeter of the Bay across from the Port Elizabeth and Port Newark Marine Terminals (Figure 1). The location of the dredging operation adjacent to these flats during the November 2008 sampling provided an opportunity to assess the extent, if any, of suspended sediment plume excursion beyond the channel and channel side slopes. Mobile ADCP surveys were designed to encompass the entire spatial extent of the plume and, as in previous investigations, clearly showed that the suspended sediment plumes typically exhibit minimal lateral diffusion with distance traveled down current, and seldom measure more than 75 to 100 meters across at substantial concentrations above background. Figure 5 (early flood survey), Figure 8 (late flood survey) and Figure 11 (ebb survey) show selected ADCP transects superimposed over existing channel bathymetry and provide further evidence that the spatial extent of dredge induced plumes are almost inconsequential in the context of the larger channel and that, as in previous studies, the movements of plumes are generally confined to the bottom of the navigation channel with no evidence of plume excursion beyond the channel side slopes.

In addition to the mobile ADCP surveys, the November 2008 sampling included a fixed station turbidity component in which an array of OBS units were tethered to an anchor and buoy system and placed above the channel side slopes in approximately six meters of water. The fixed station OBS arrays were deployed in both ambient and down-current conditions within 250 meters of the active dredging operation during both an ebb and a flood tide and clearly showed no evidence of increased turbidity above observed ambient conditions.

5.0 Literature Cited:

Dredging Research Limited (DRL). 2003. The Sediview Method: Sediview Procedure Manual. Draft 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.

Reine, K. J., Clarke, D. G. and C. Dickerson. 2006. Suspended sediment plumes associated with maintenance dredging in the Providence River, Rhode Island. Report prepared by the U.S. Army Engineer Research and Development Center for the U.S. Army Engineer New England District. Concord, MA, 34pp.

Science Applications International Corporation (SAIC). 2002. Water quality monitoring results during excavator dredging in the Kill Van Kull Channel. SAIC Report Number 577, for the Port Authority of New York and New Jersey, SAIC, Newport, RI.

United States Army Corps of Engineers (USACE) – New York District (NYD). 2007a. 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). 2007b. Ship-Induced Suspended Sediment Plumes In Newark Bay, New Jersey**:** Preliminary Assessment. Appendix 3-2 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.

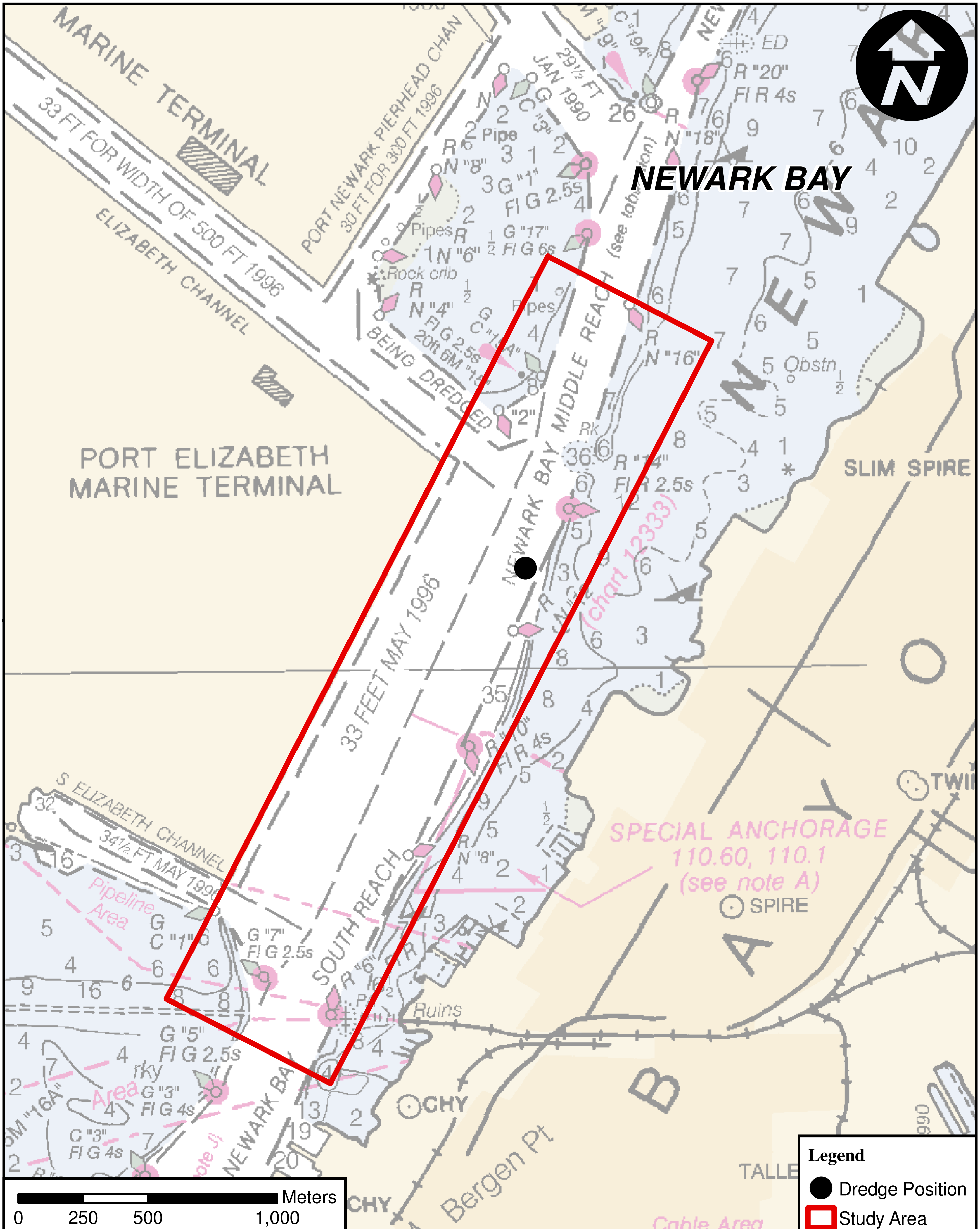


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	Newark Bay S-NB-1: B1 Far-Field Study Area 17-19 November 2008	Tide
1			N/A

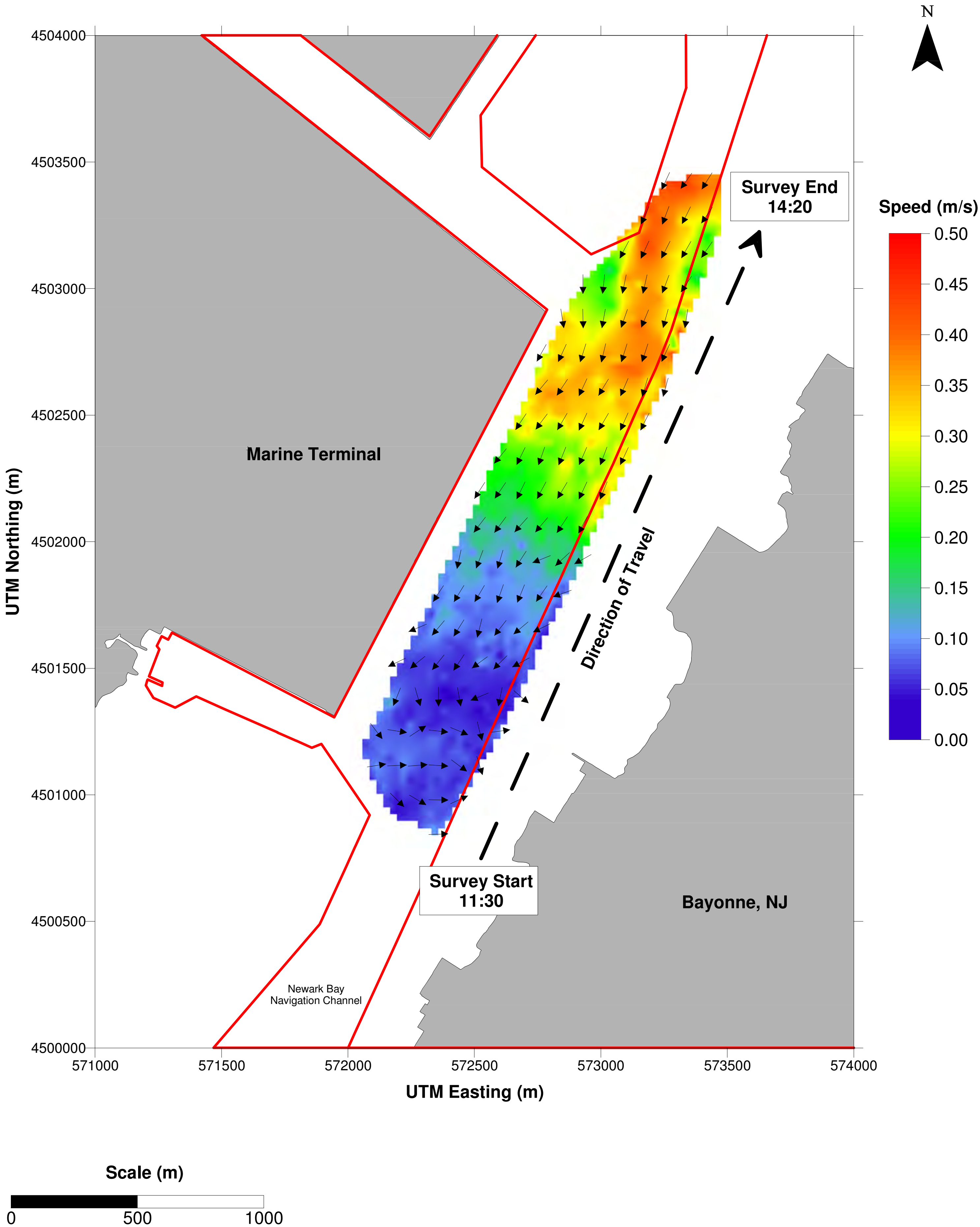
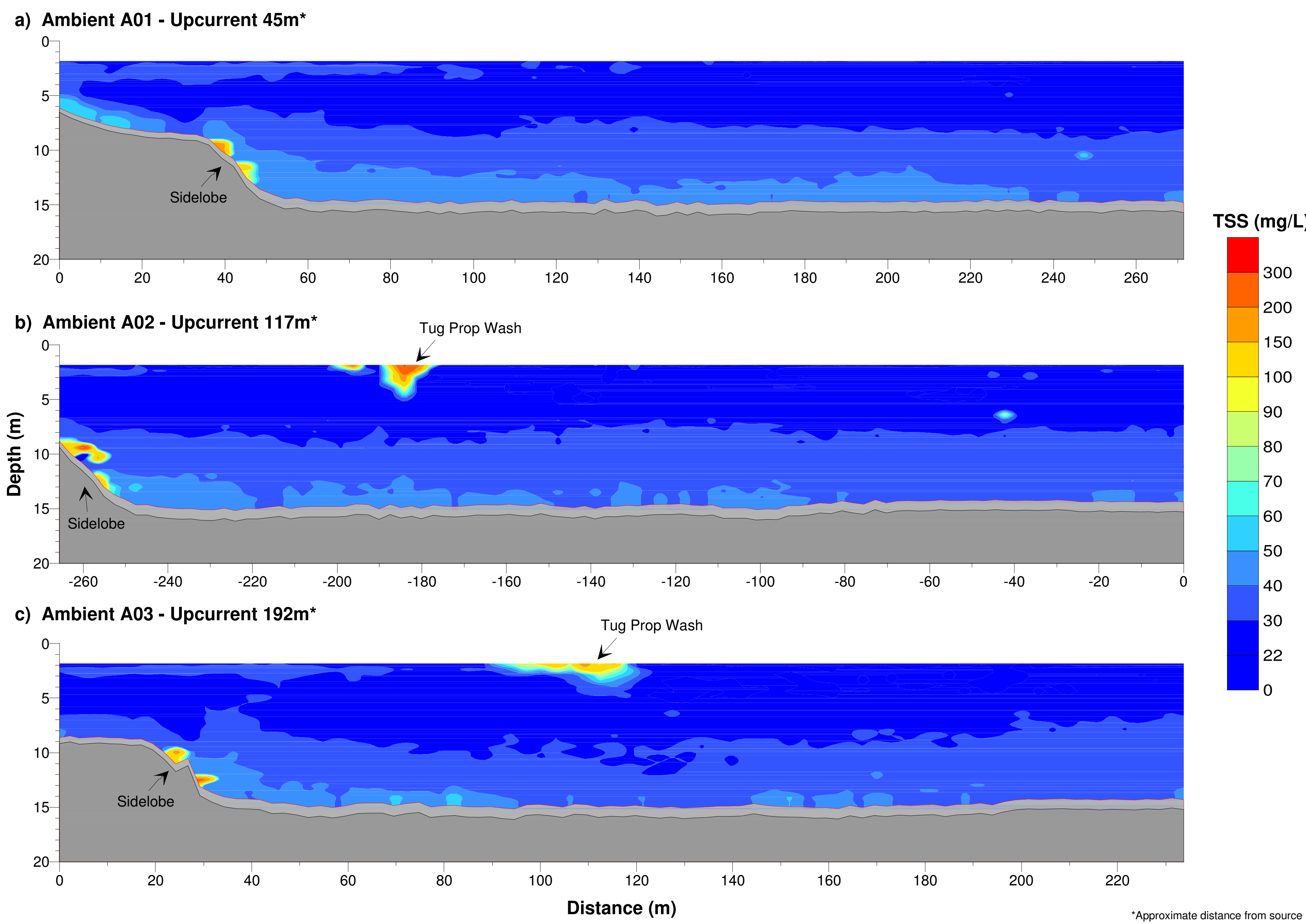


Figure	*USACE Harborwide TSS*	**Depth Averaged Velocities**	Tide
2	*Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**17 November 2008 - End of Slack to Ebb Tide**	**Ebb**



*Approximate distance from source

FIGURE	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1*	**Vertical Profiles of ADCP Average TSS 18 November 2008**	TIDE
3a-c			**Early Flood**

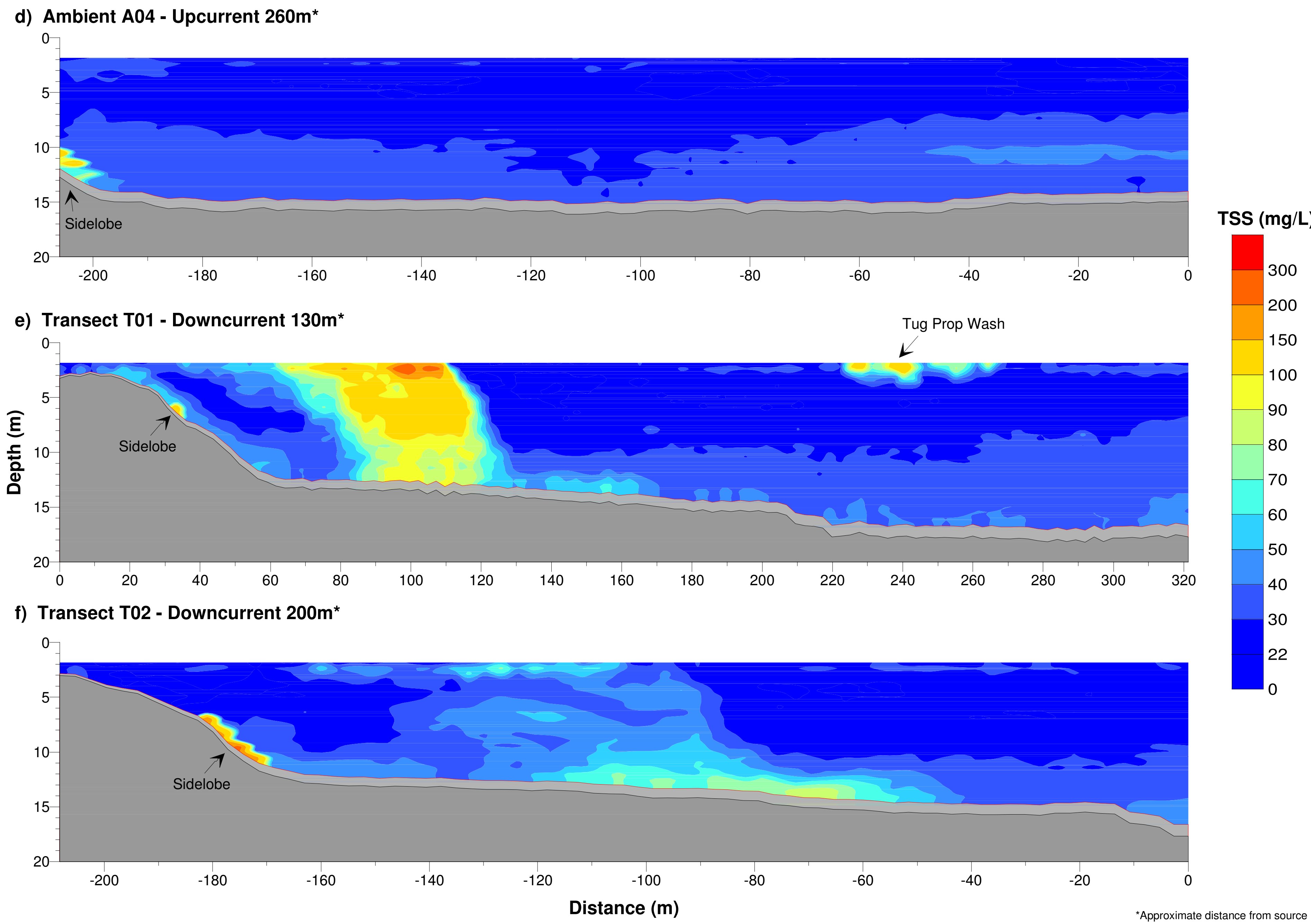


FIGURE	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**Vertical Profiles of ADCP Average TSS** **18 November 2008**	TIDE
3d-f			Early Flood

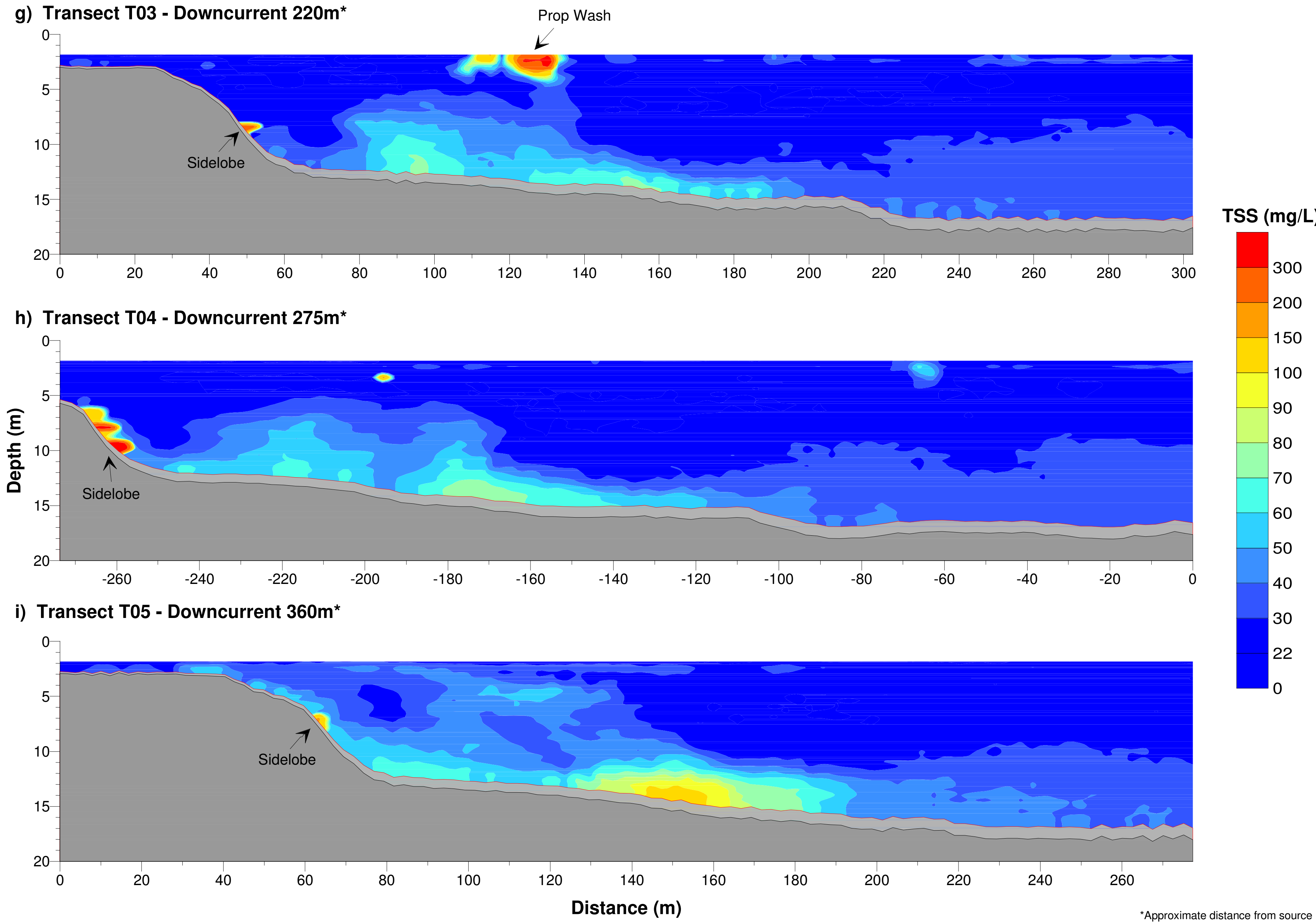


FIGURE	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	Vertical Profiles of ADCP Average TSS 18 November 2008	TIDE
3g-i			Early Flood

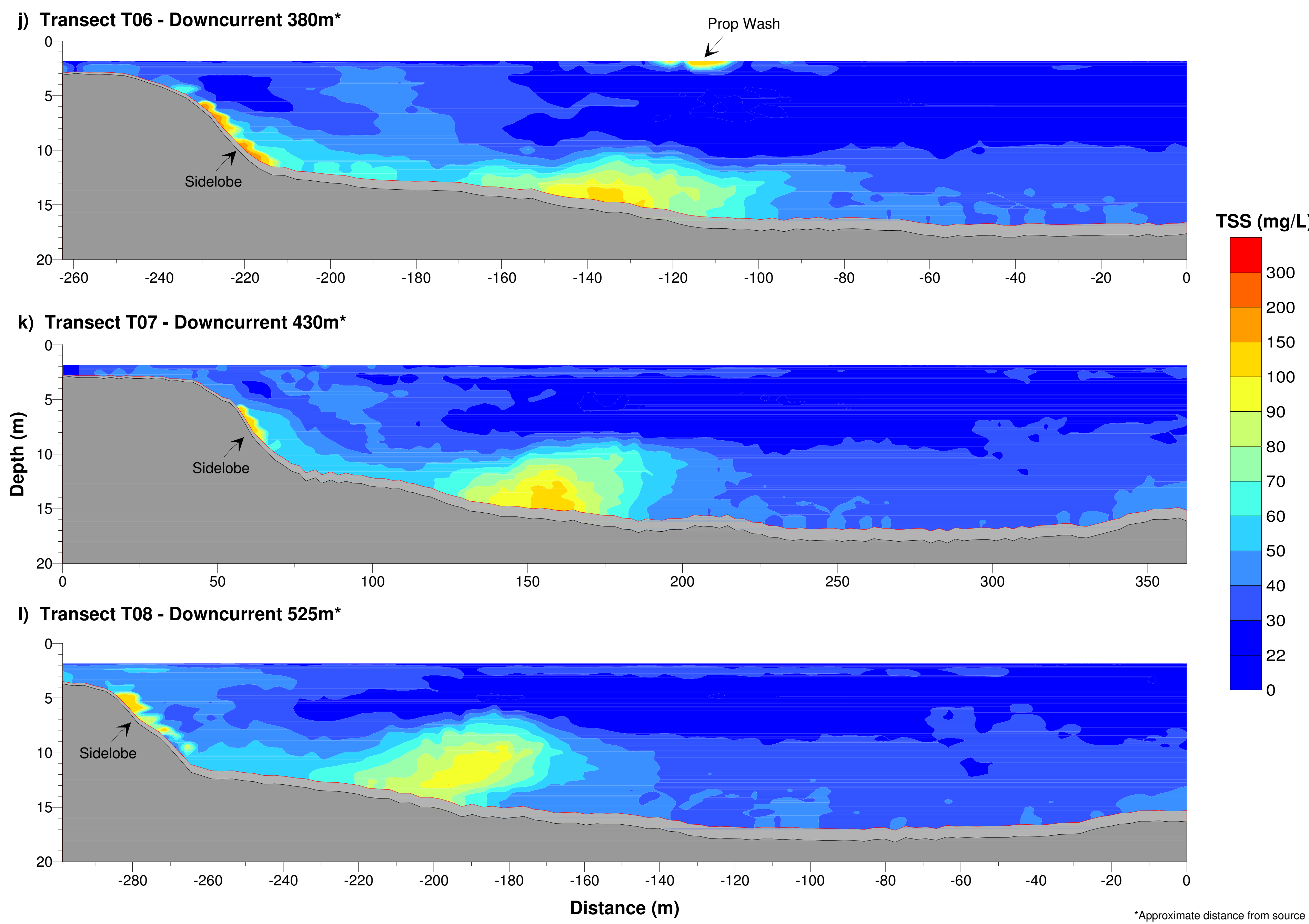
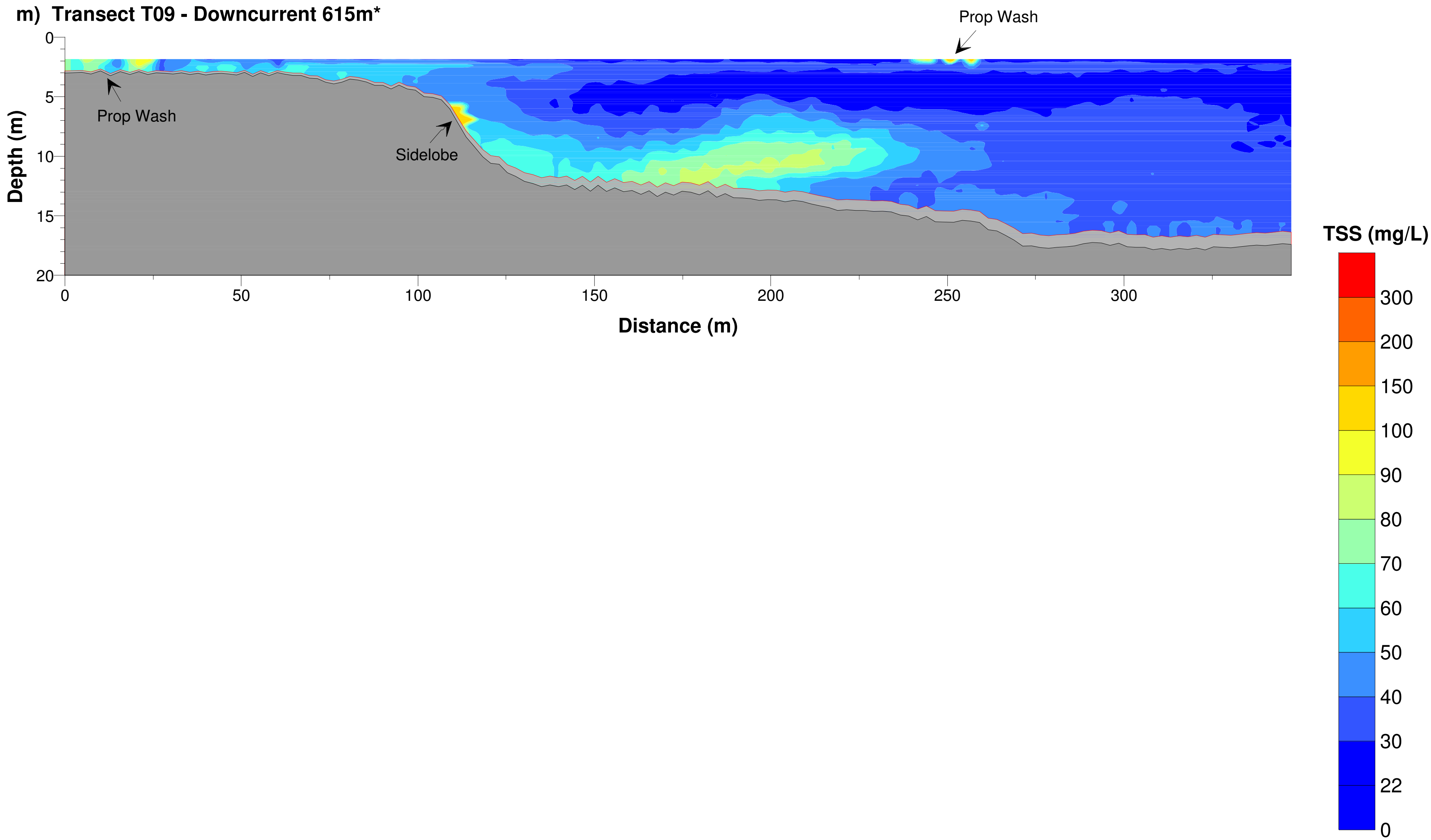


FIGURE	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	Vertical Profiles of ADCP Average TSS 18 November 2008	TIDE
3j-l			Early Flood



*Approximate distance from source

FIGURE	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**Vertical Profiles of ADCP Average TSS** **18 November 2008**	TIDE
3m			Early Flood

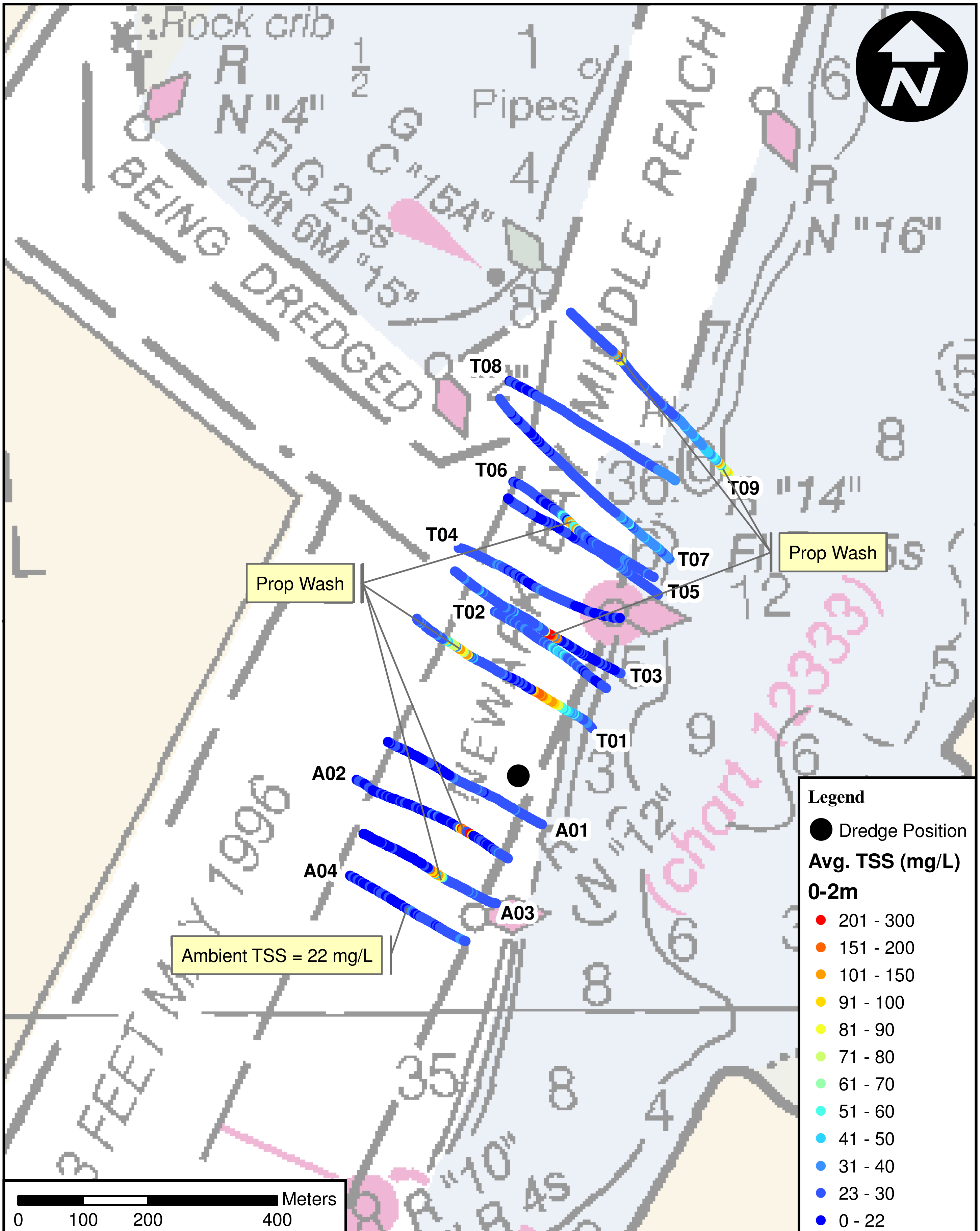


Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS -18 November 2008 0-2 Meter Depth Interval**	**Tide**
4a			**Early Flood**

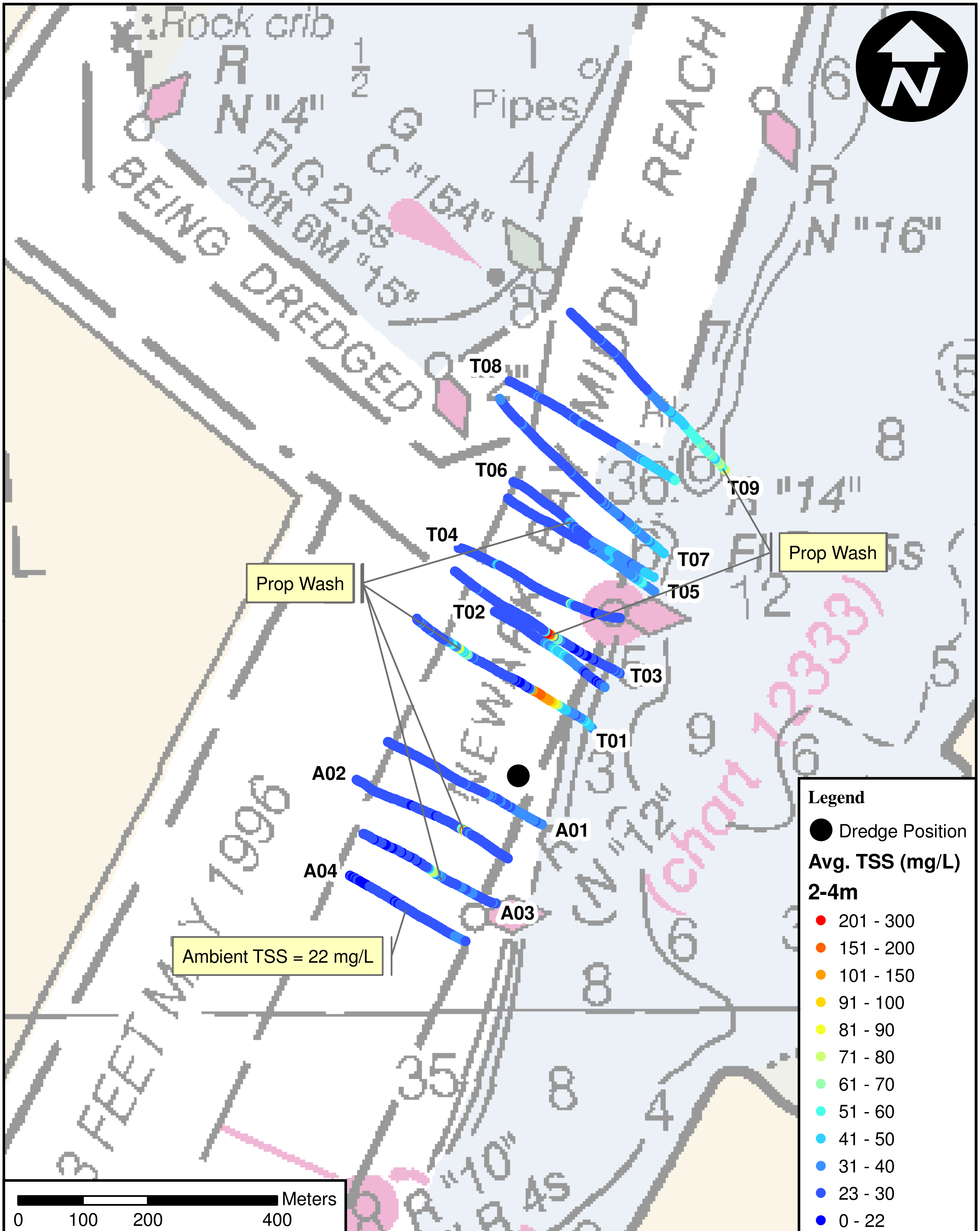


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	ADCP Average TSS - 18 November 2008 2-4 Meter Depth Interval	Tide
4b			Early Flood

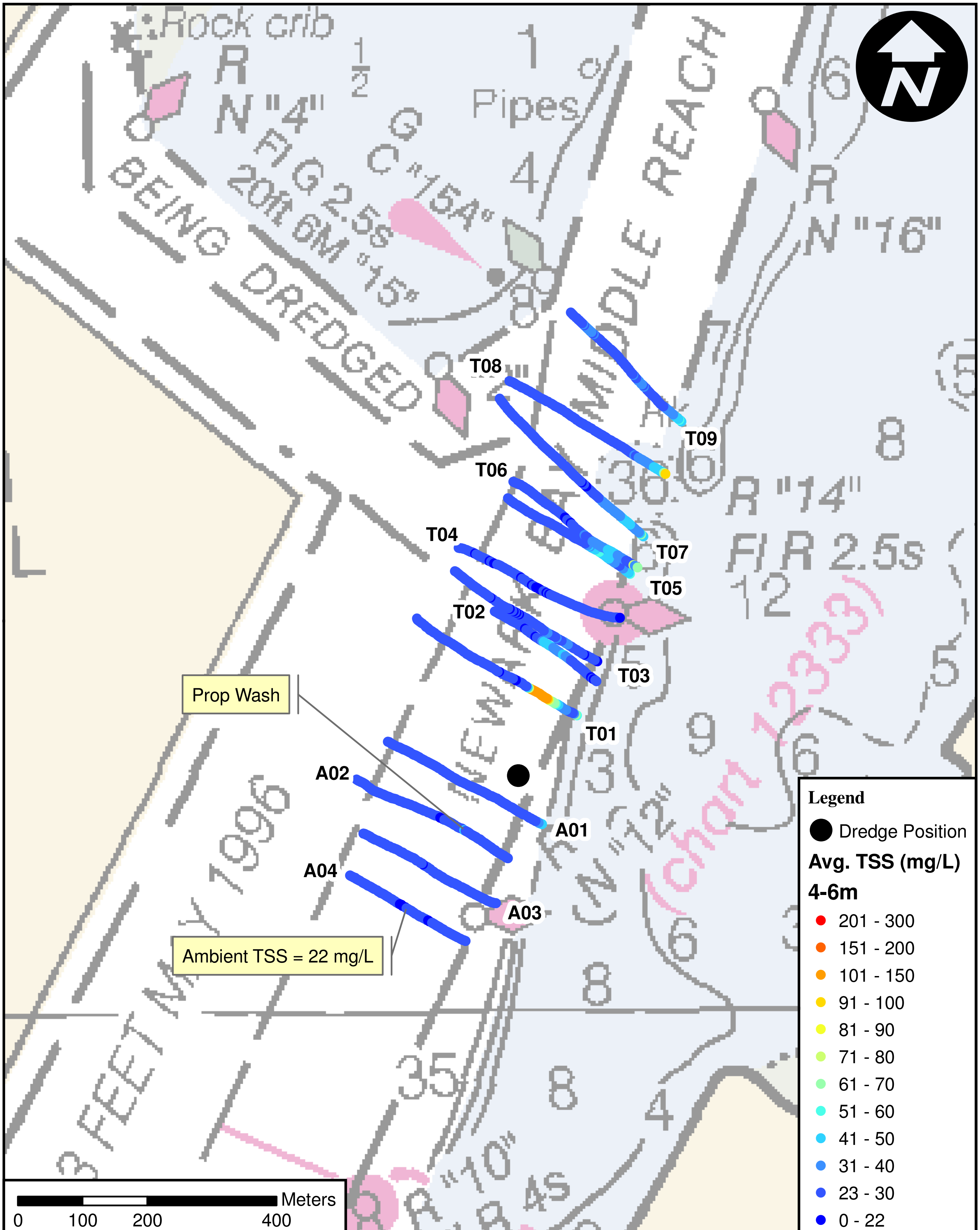


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 18 November 2008** **4-6 Meter Depth Interval**	**Tide**
4c			**Early Flood**

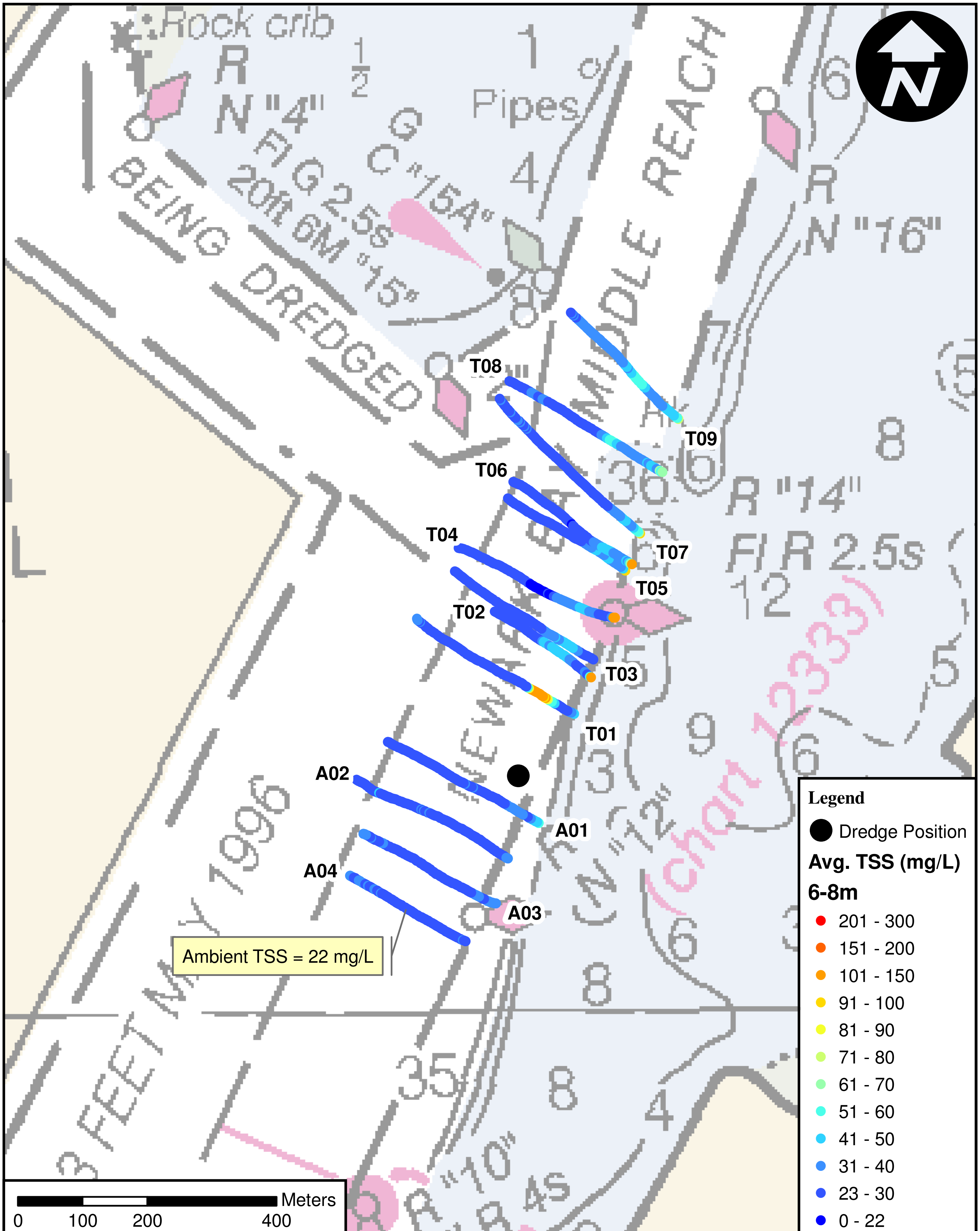


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	ADCP Average TSS - 18 November 2008 6-8 Meter Depth Interval	Tide
4d			Early Flood

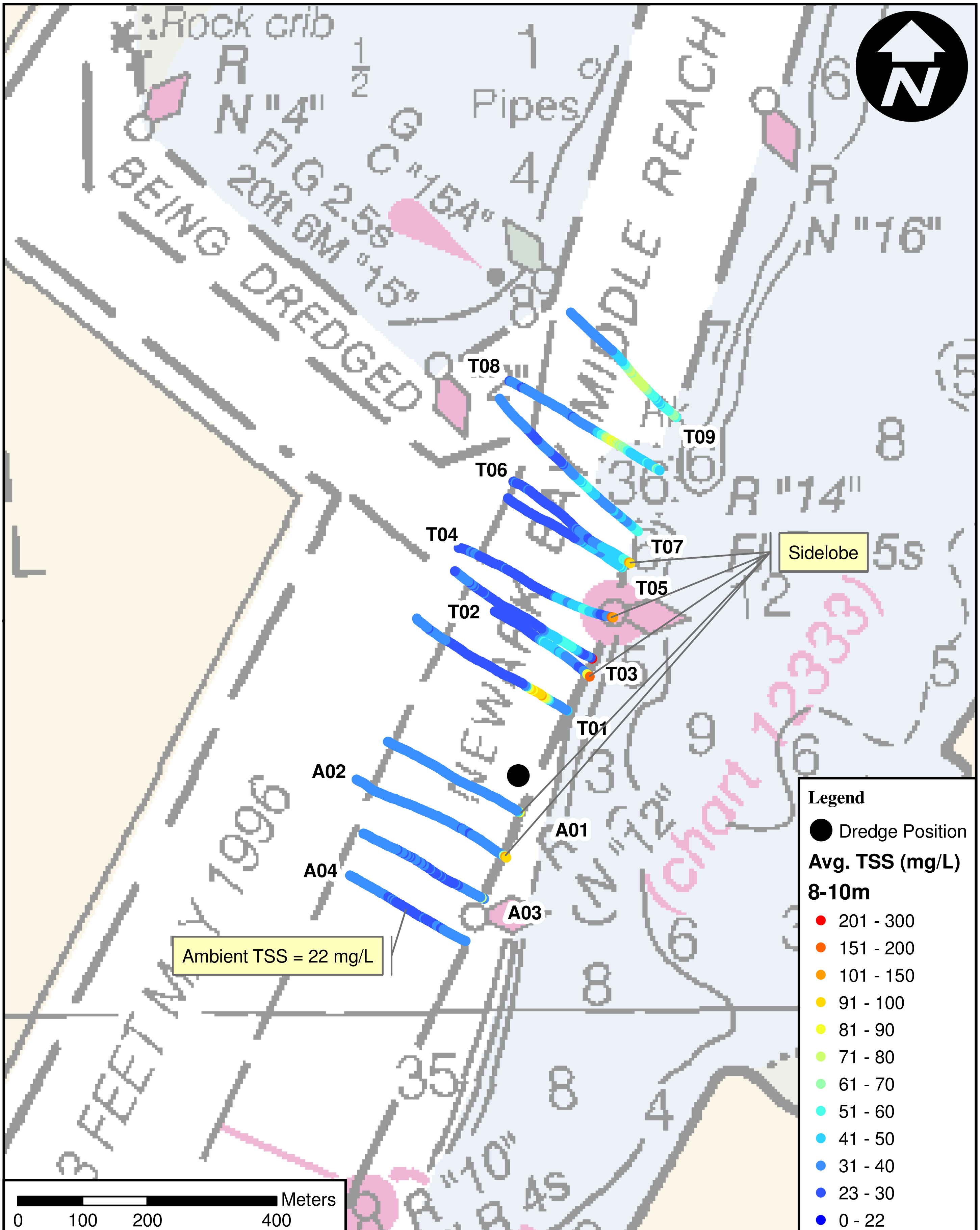


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 18 November 2008** **8-10 Meter Depth Interval**	**Tide**
4e			**Early Flood**

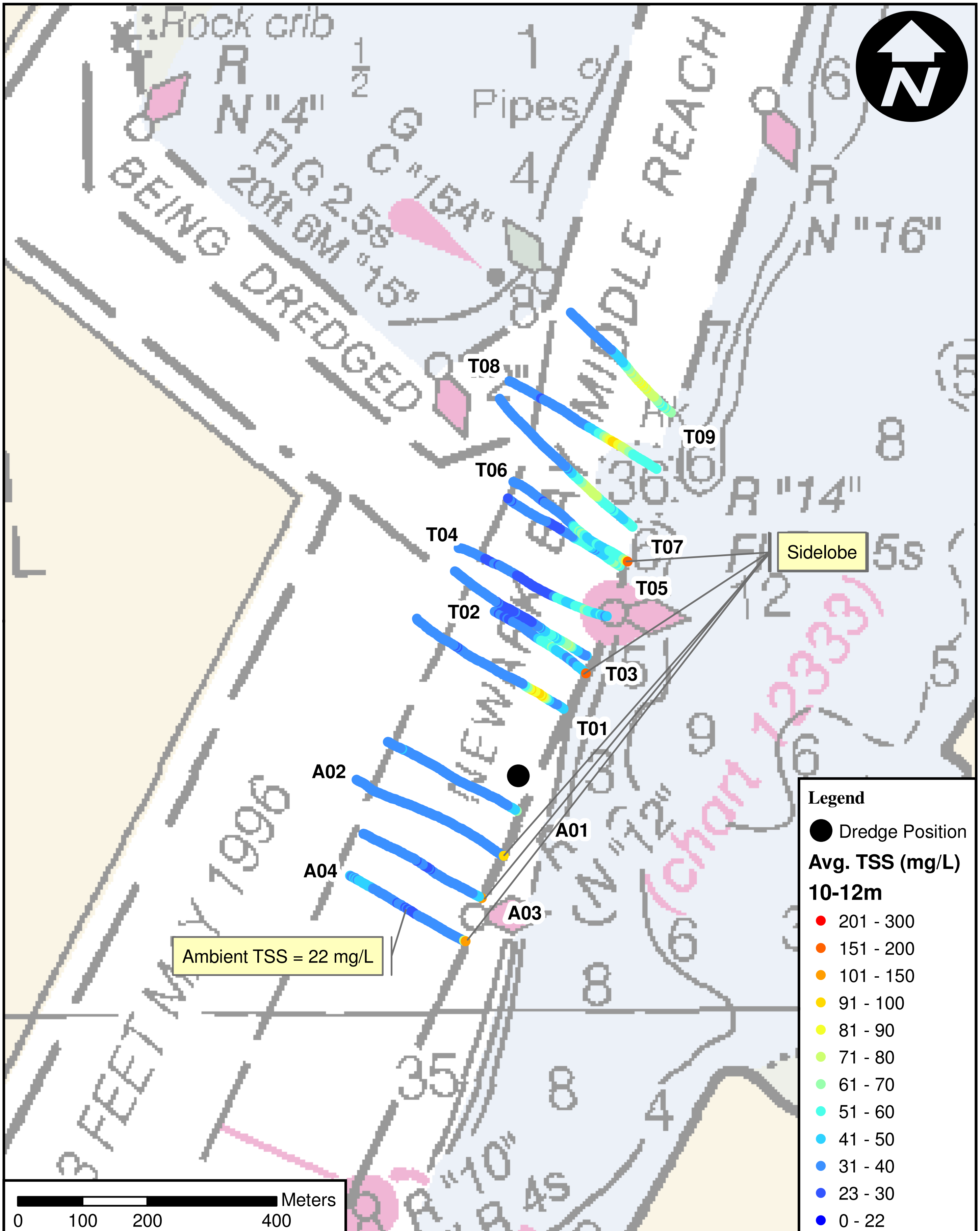


Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1*	ADCP Average TSS - 18 November 2008 10-12 Meter Depth Interval	Tide
4f			Early Flood

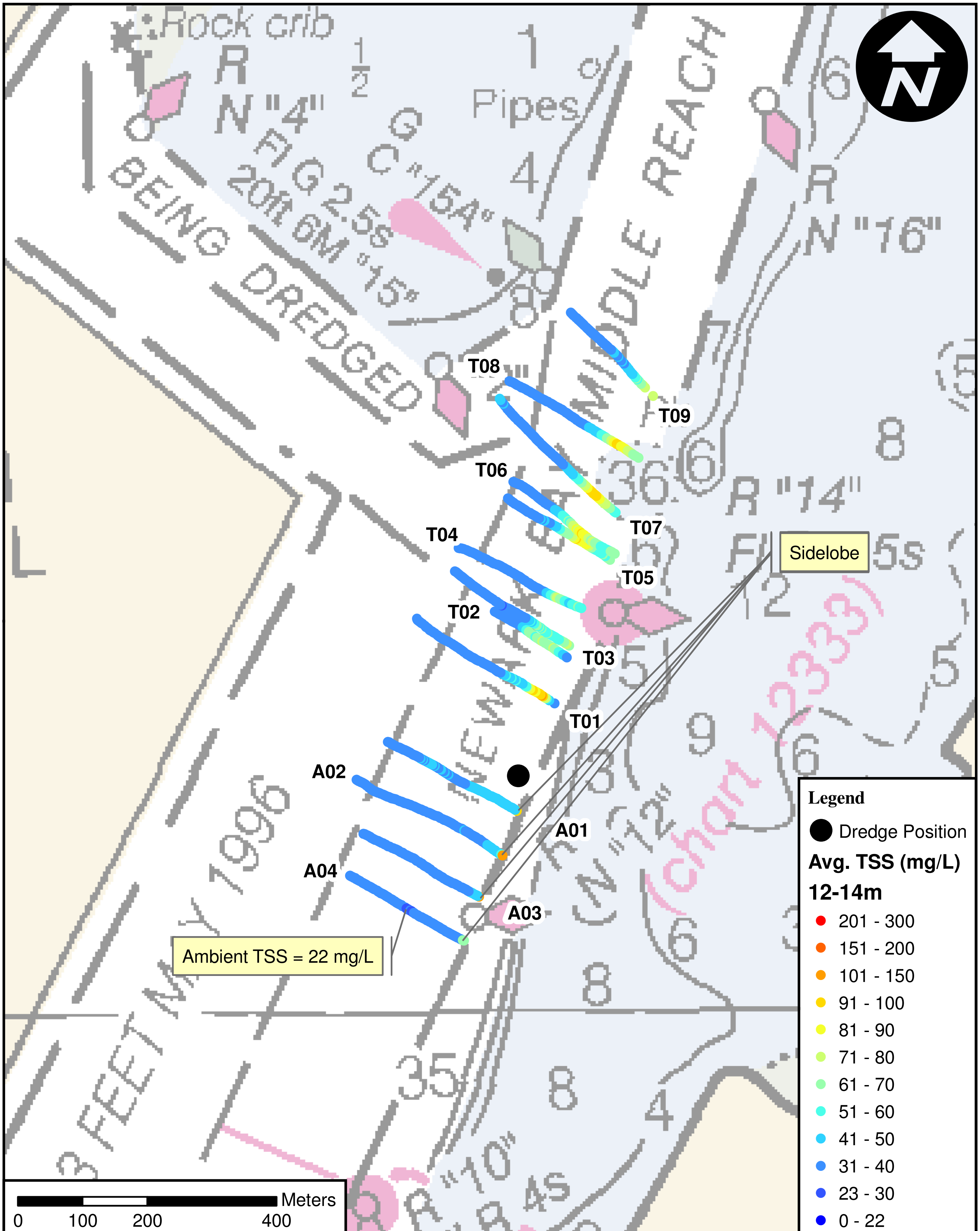


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	ADCP Average TSS - 18 November 2008 12-14 Meter Depth Interval	Tide
4g			Early Flood

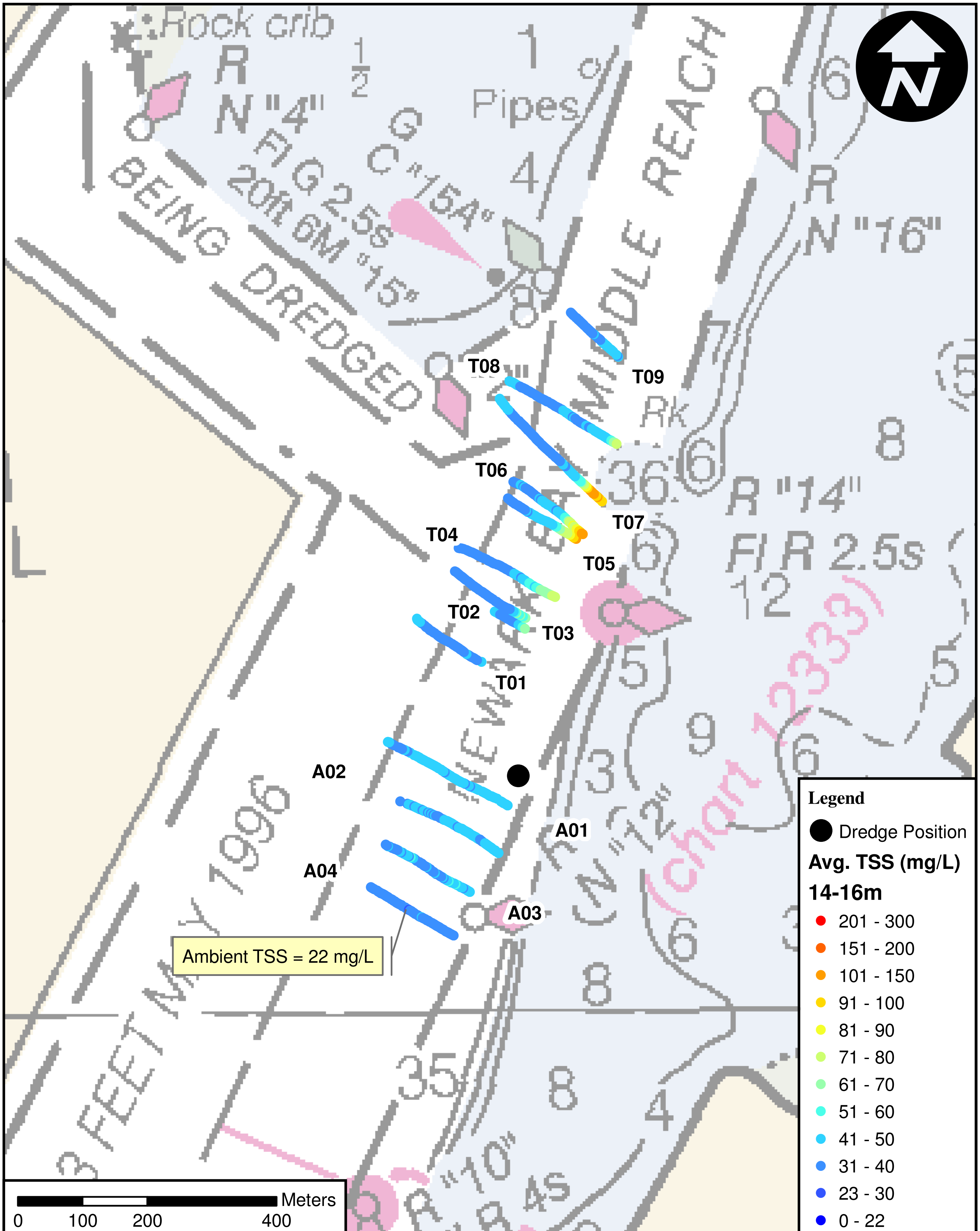
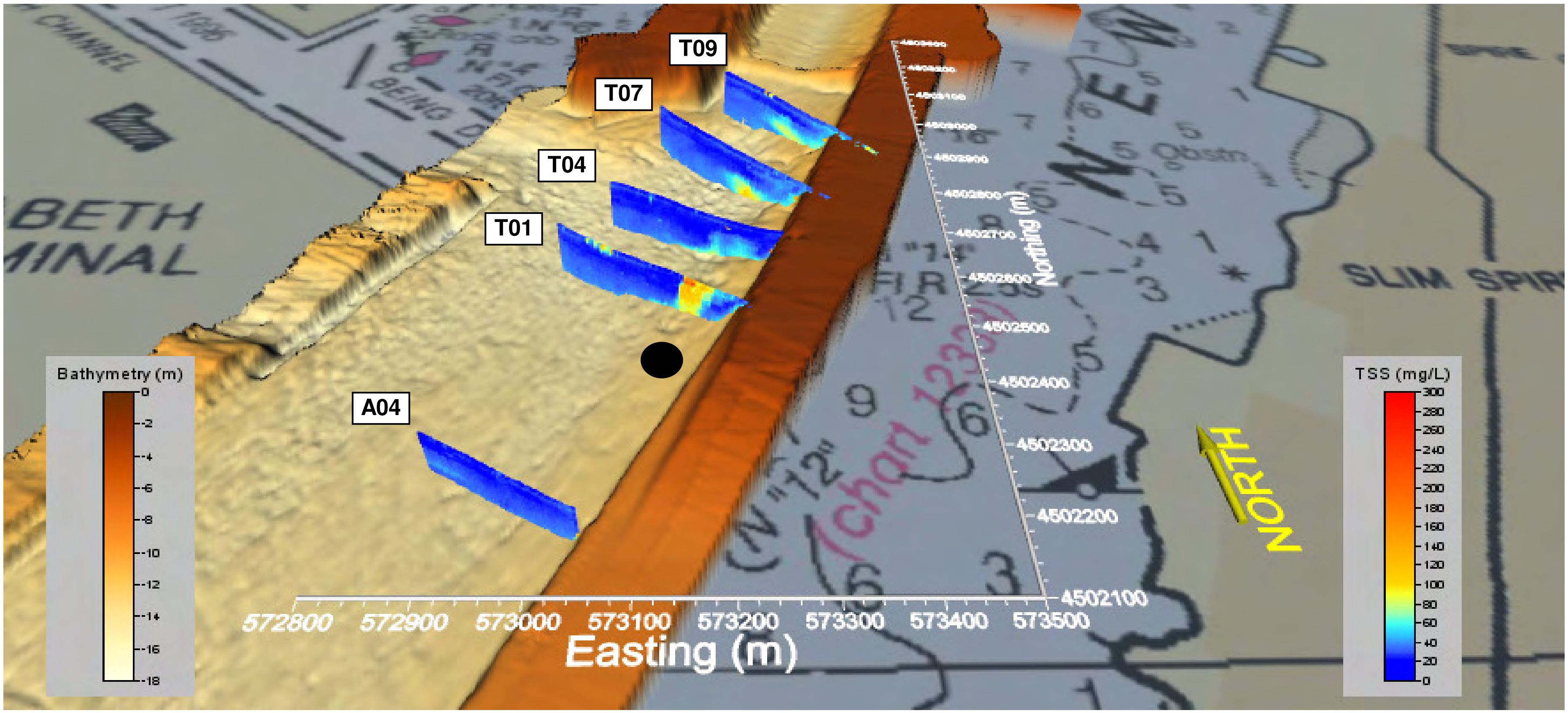


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	ADCP Average TSS - 18 November 2008 14-16 Meter Depth Interval	Tide
4h			Early Flood

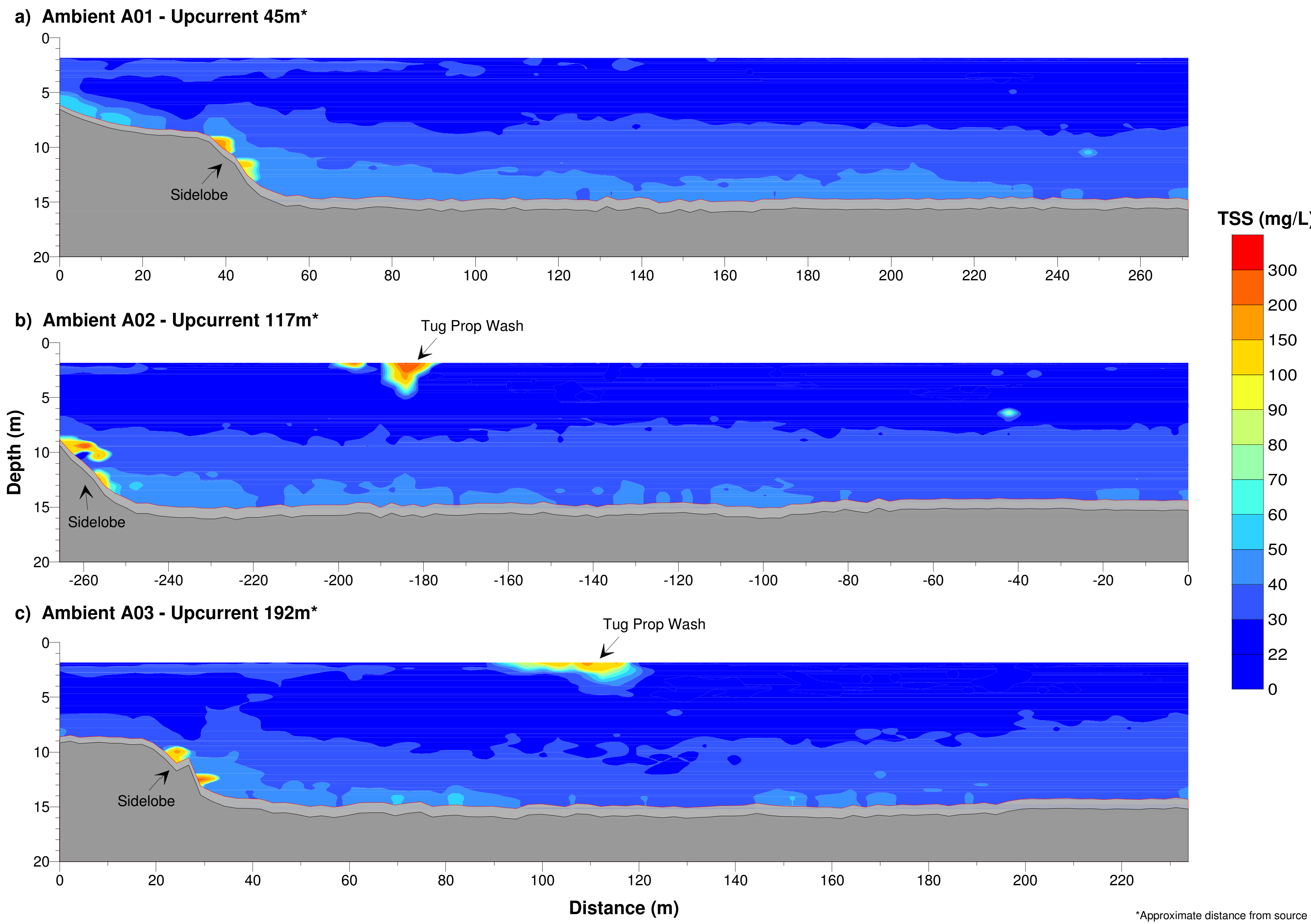


Bathymetry provided by: US Army Corps of Engineers, NY District

Z Scale Exaggerated 6x

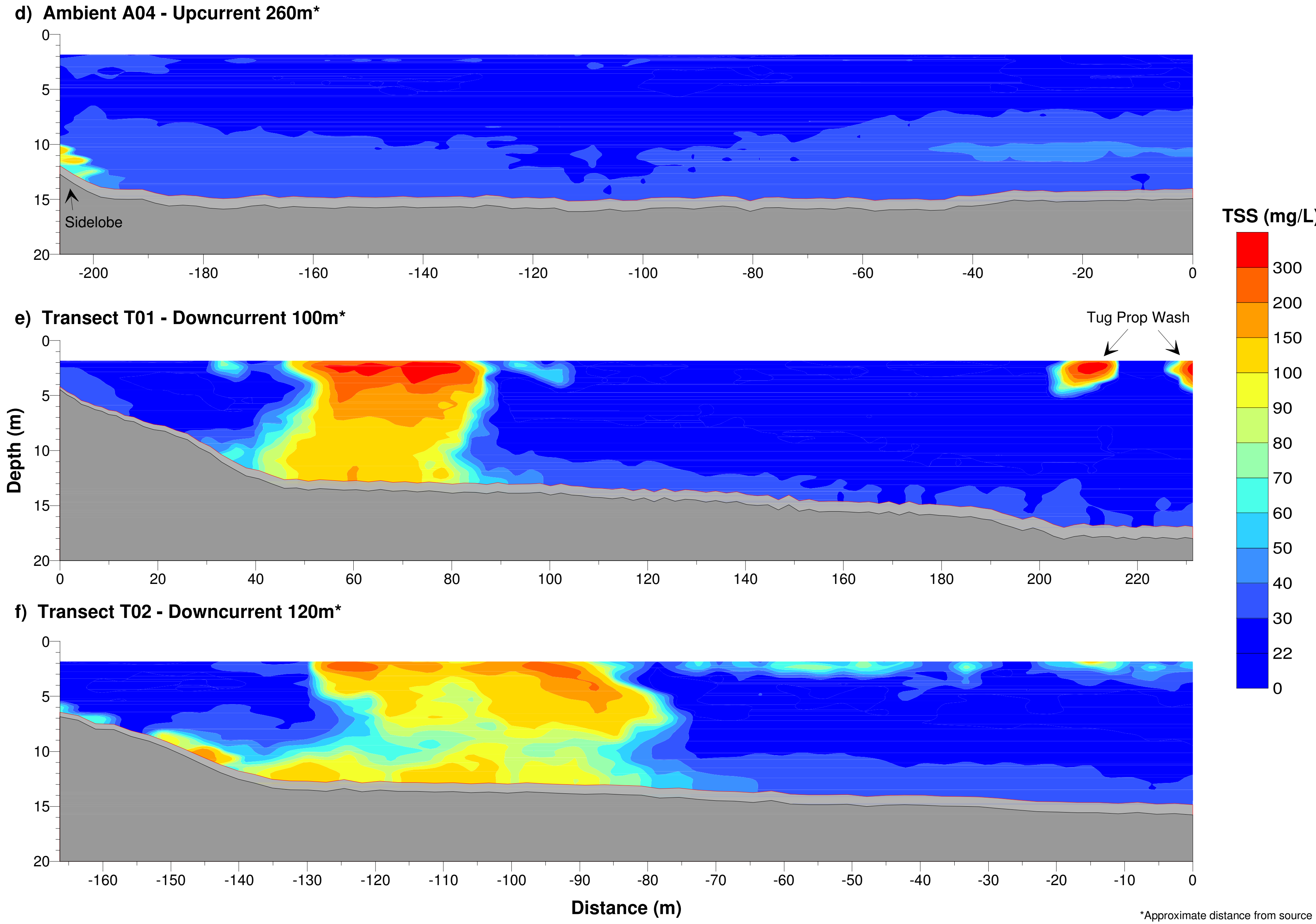
● = Dredge Location

Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS Values with Respect to their x, y, and z Coordinates** **Superimposed on Channel Bathymetry** **18 November 2008**	Tide
5			Early Flood



*Approximate distance from source

FIGURE	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	Vertical Profiles of ADCP Average TSS 18 November 2008	TIDE
6a-c			Late Flood



*Approximate distance from source

FIGURE	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	Vertical Profiles of ADCP Average TSS 18 November 2008	TIDE
6d-f			Late Flood

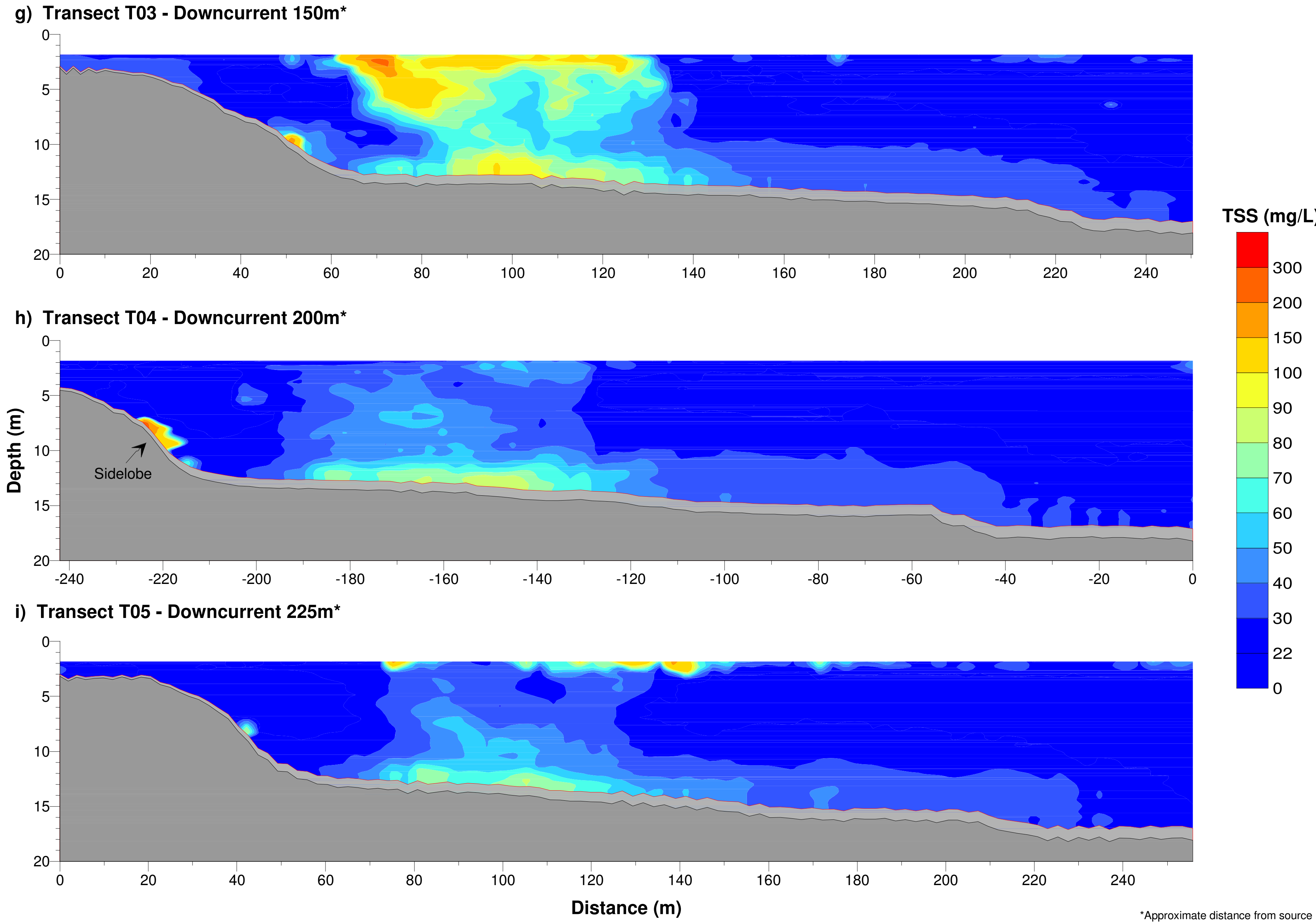


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FIGURE	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	Vertical Profiles of ADCP Average TSS 18 November 2008	TIDE
6g-i			Late Flood

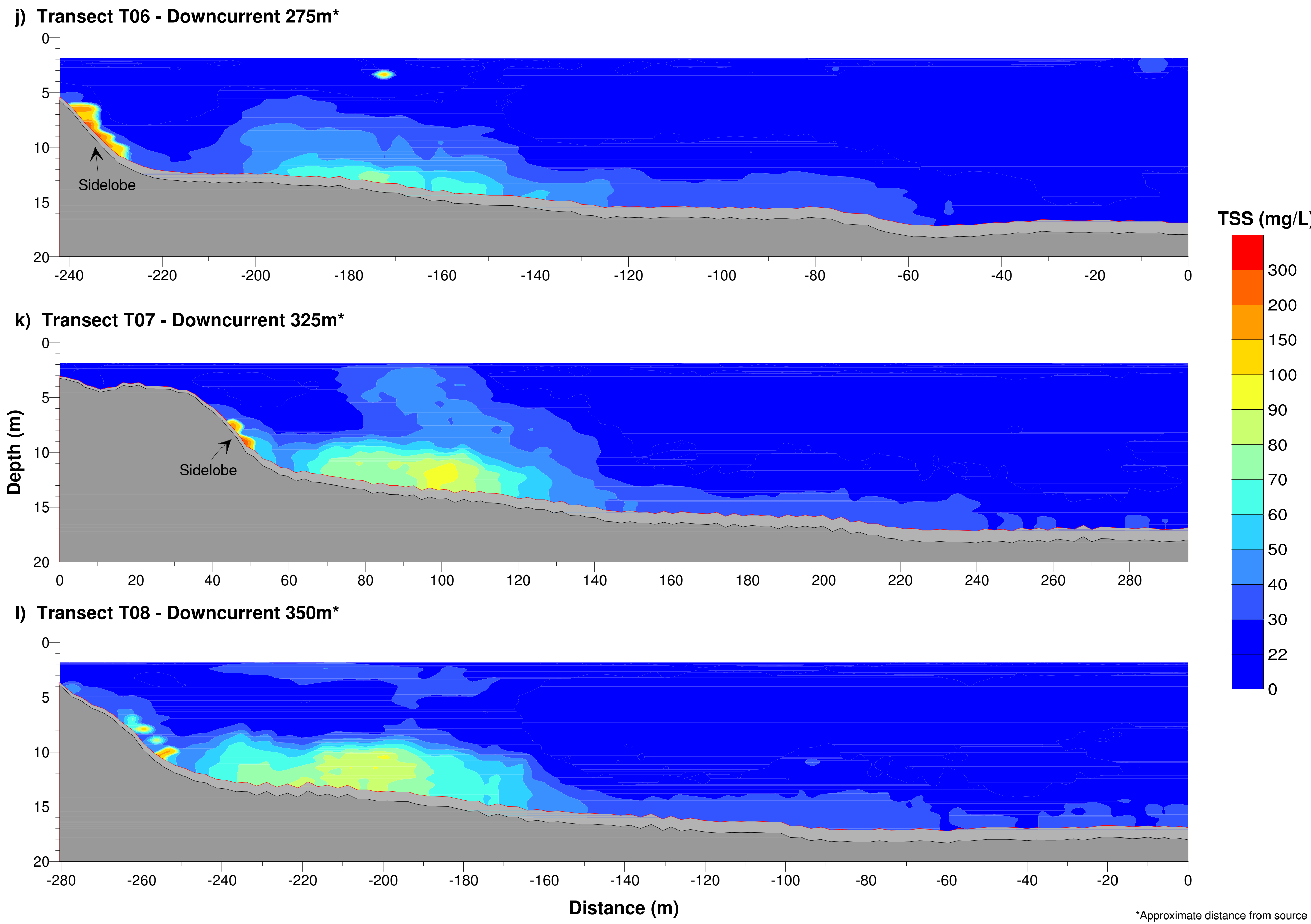


FIGURE	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**Vertical Profiles of ADCP Average TSS** **18 November 2008**	TIDE
6j-l			Late Flood

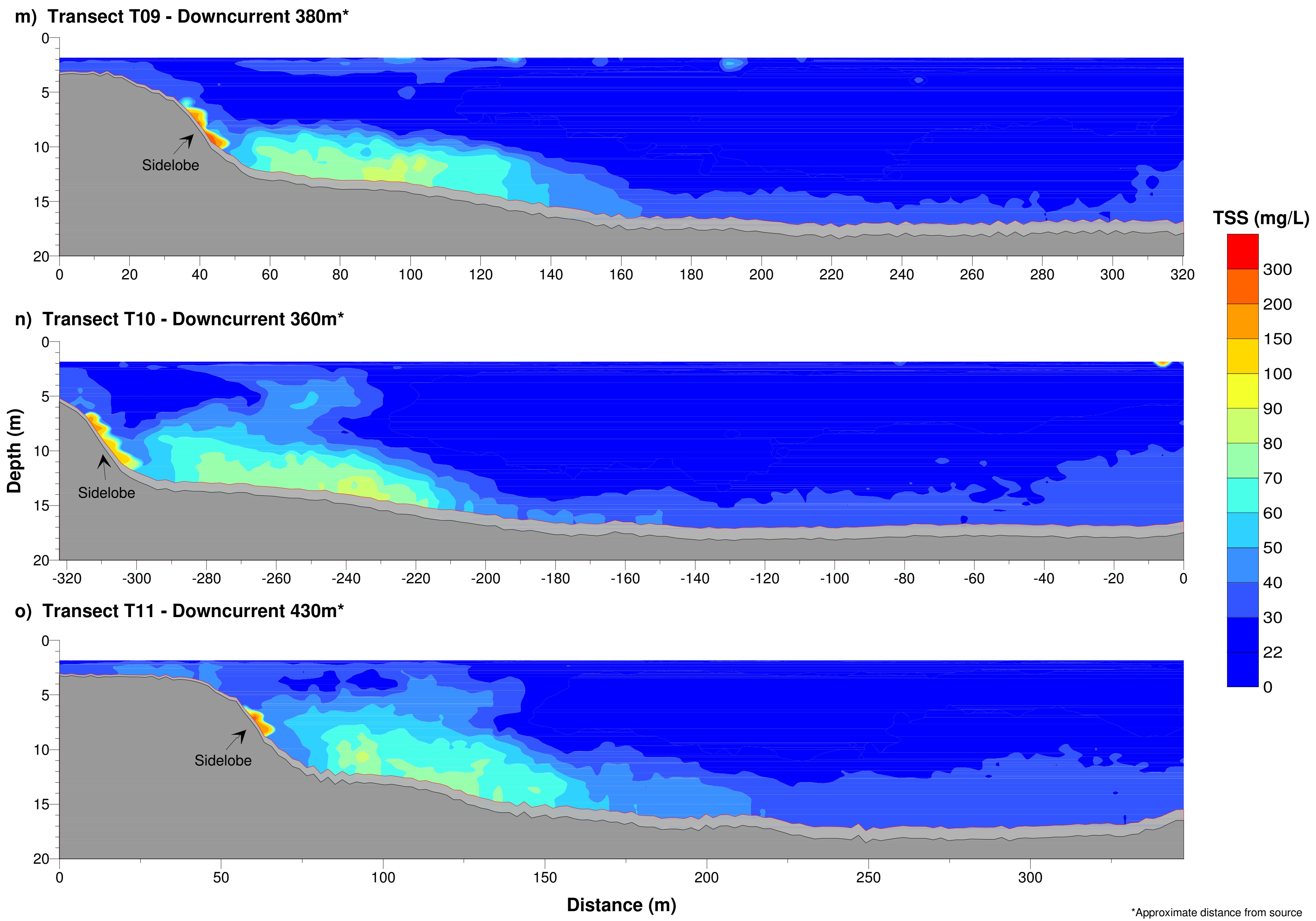


FIGURE	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1*	**Vertical Profiles of ADCP Average TSS 18 November 2008**	TIDE
6m-o			**Late Flood**

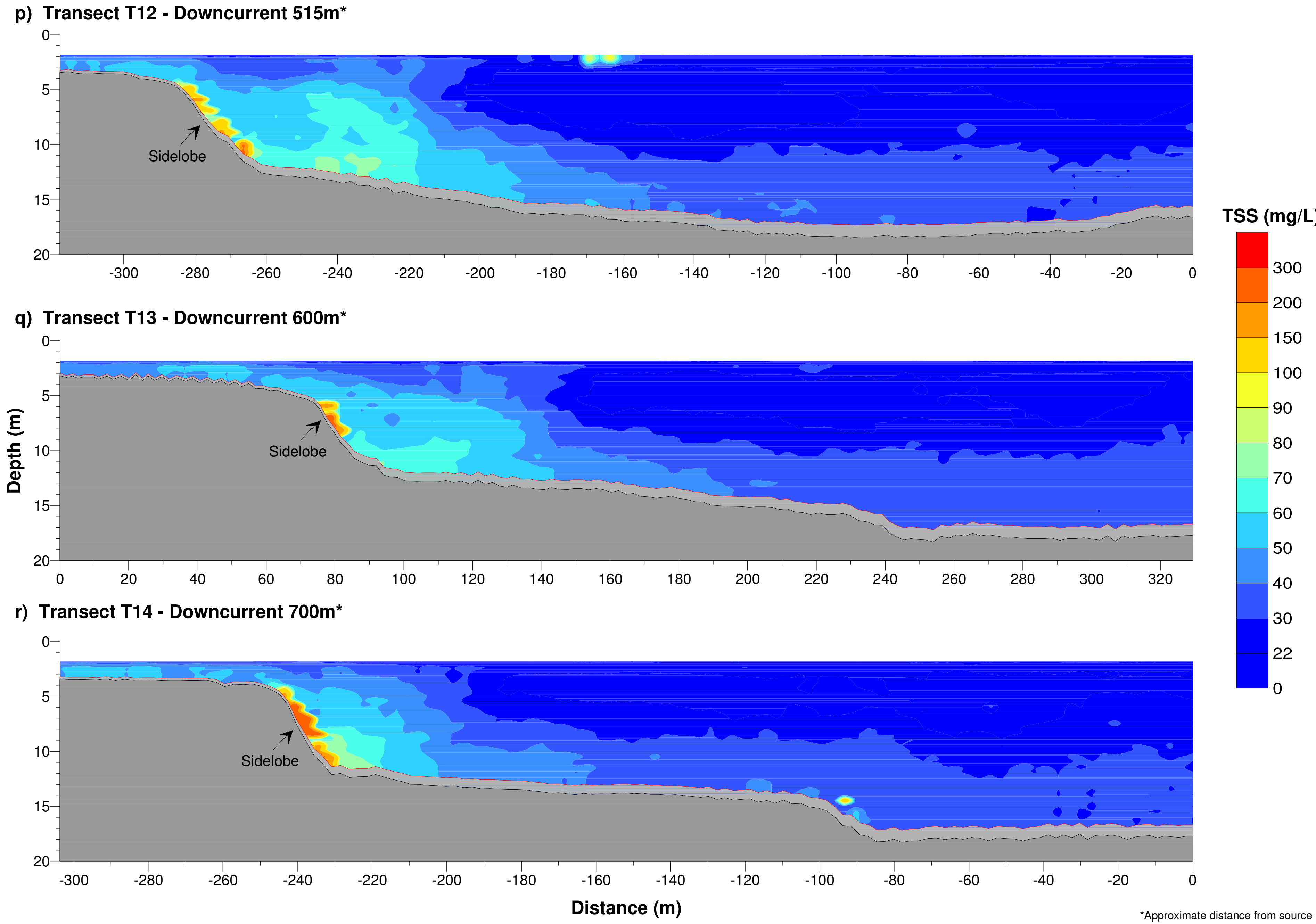


FIGURE	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	Vertical Profiles of ADCP Average TSS 18 November 2008	TIDE
6p-r			Late Flood

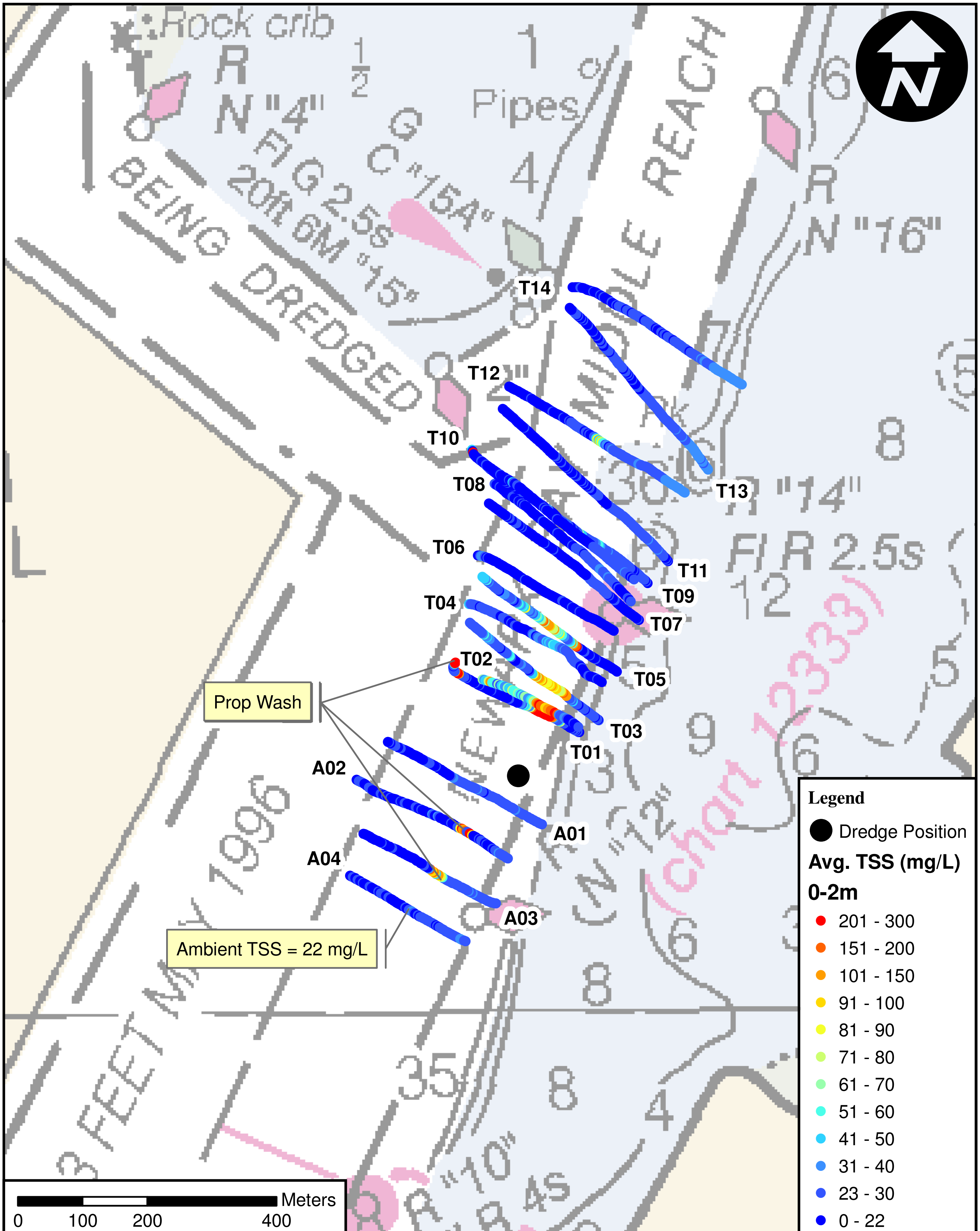


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	ADCP Average TSS - 18 November 2008 0-2 Meter Depth Interval	Tide
7a			Late Flood

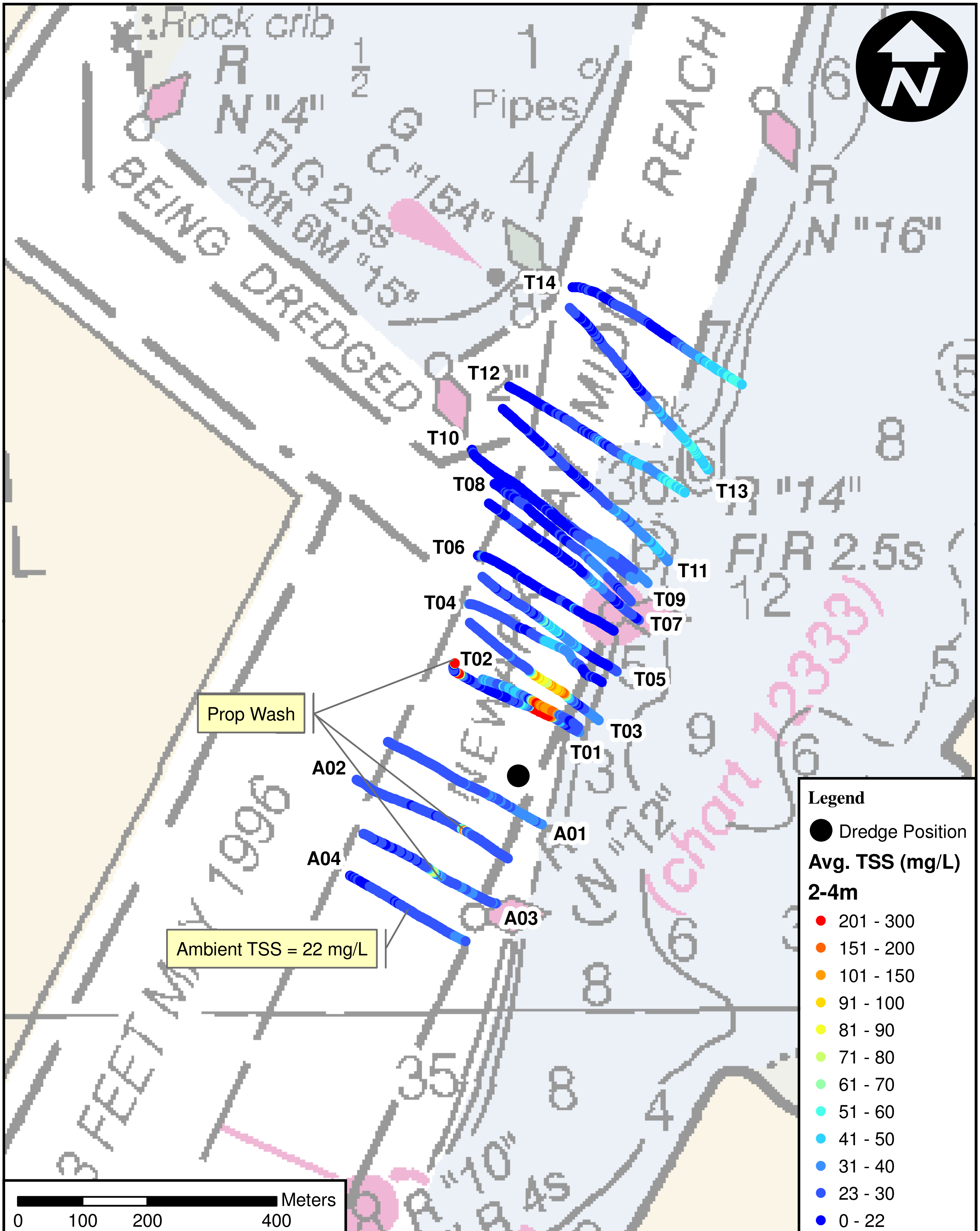


Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 18 November 2008 2-4 Meter Depth Interval**	Tide
7b			Late Flood

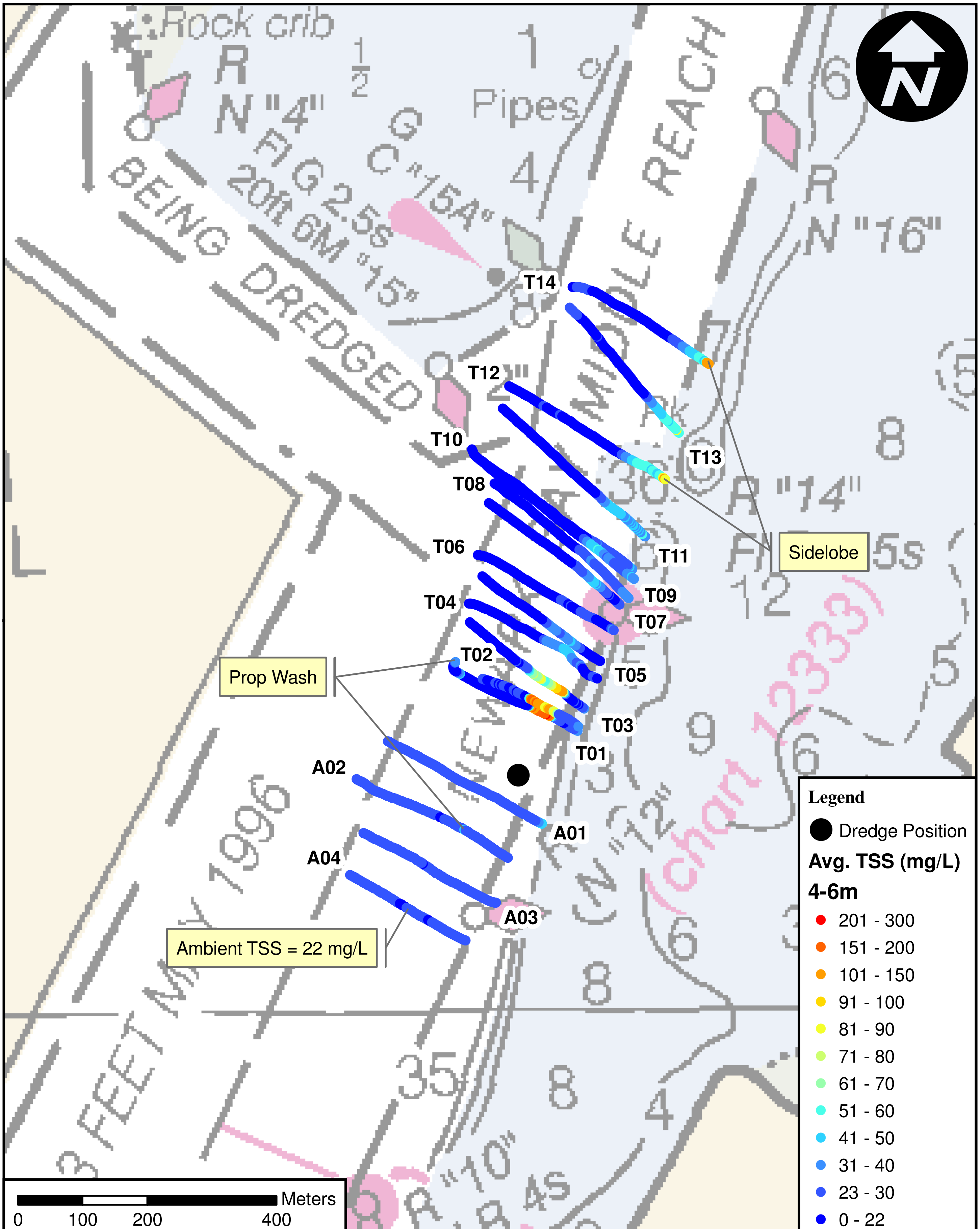


Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 18 November 2008 4-6 Meter Depth Interval**	Tide
7c			Late Flood

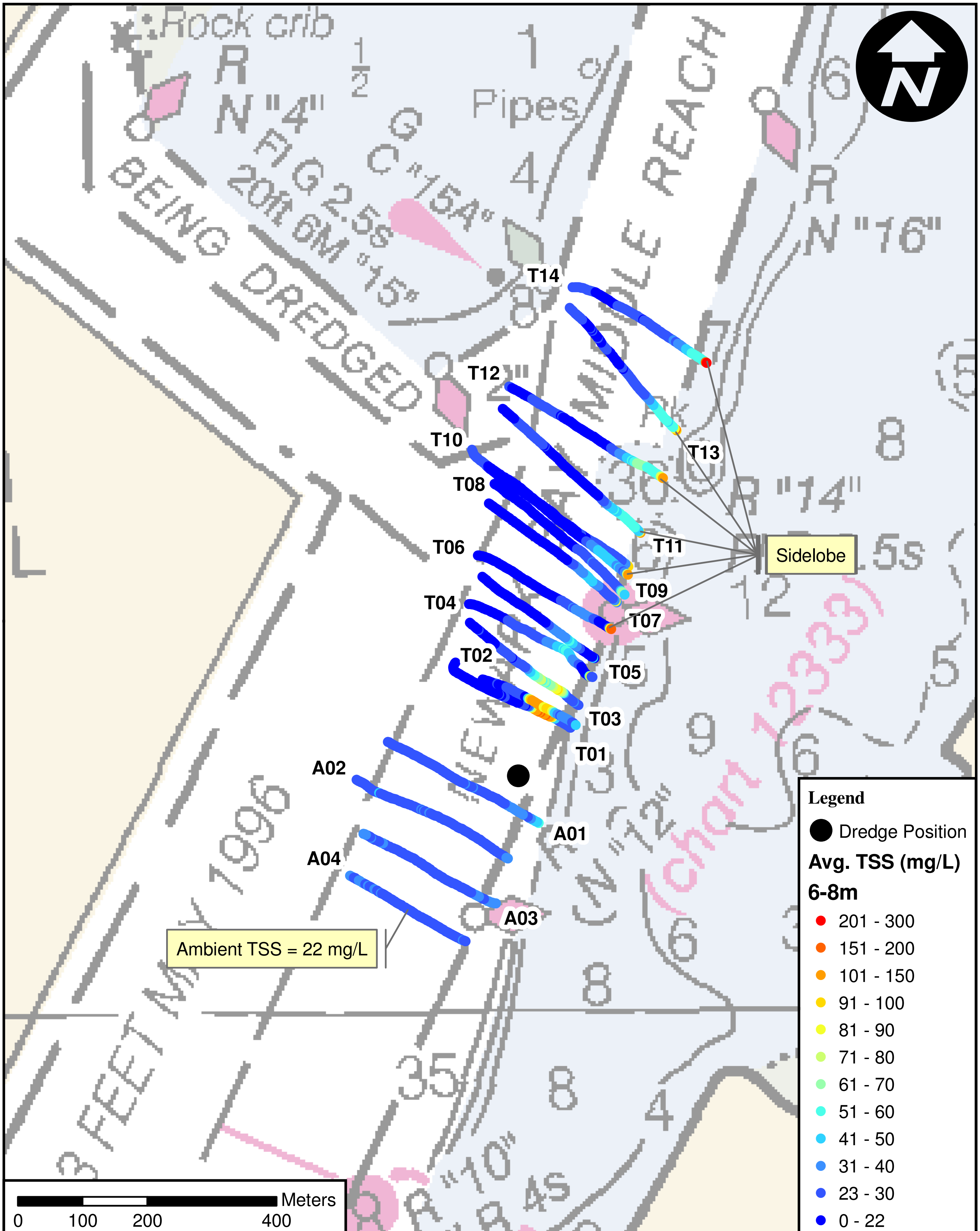


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	ADCP Average TSS - 18 November 2008 6-8 Meter Depth Interval	Tide
7d			Late Flood

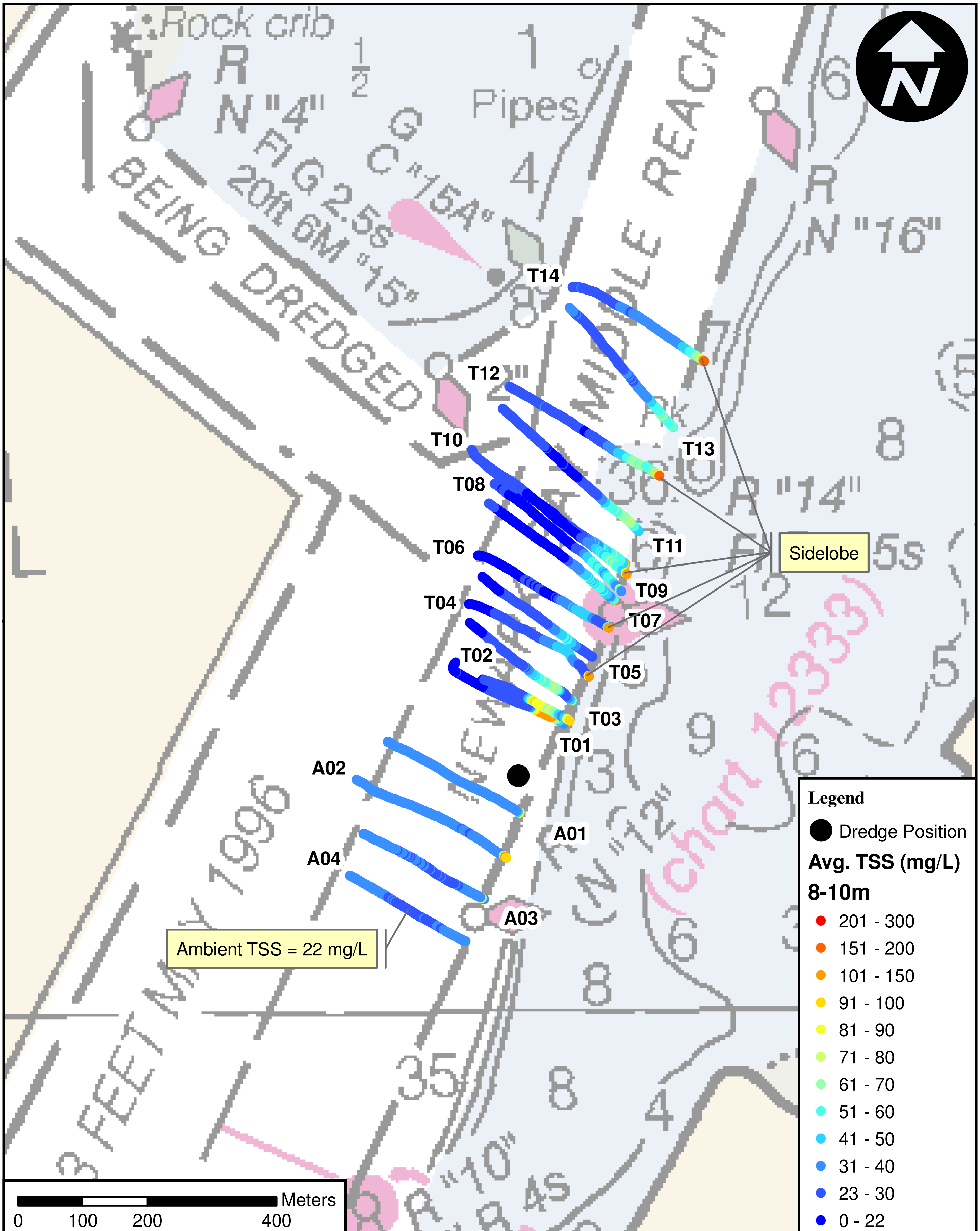


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 18 November 2008** **8-10 Meter Depth Interval**	**Tide**
7e			**Late Flood**

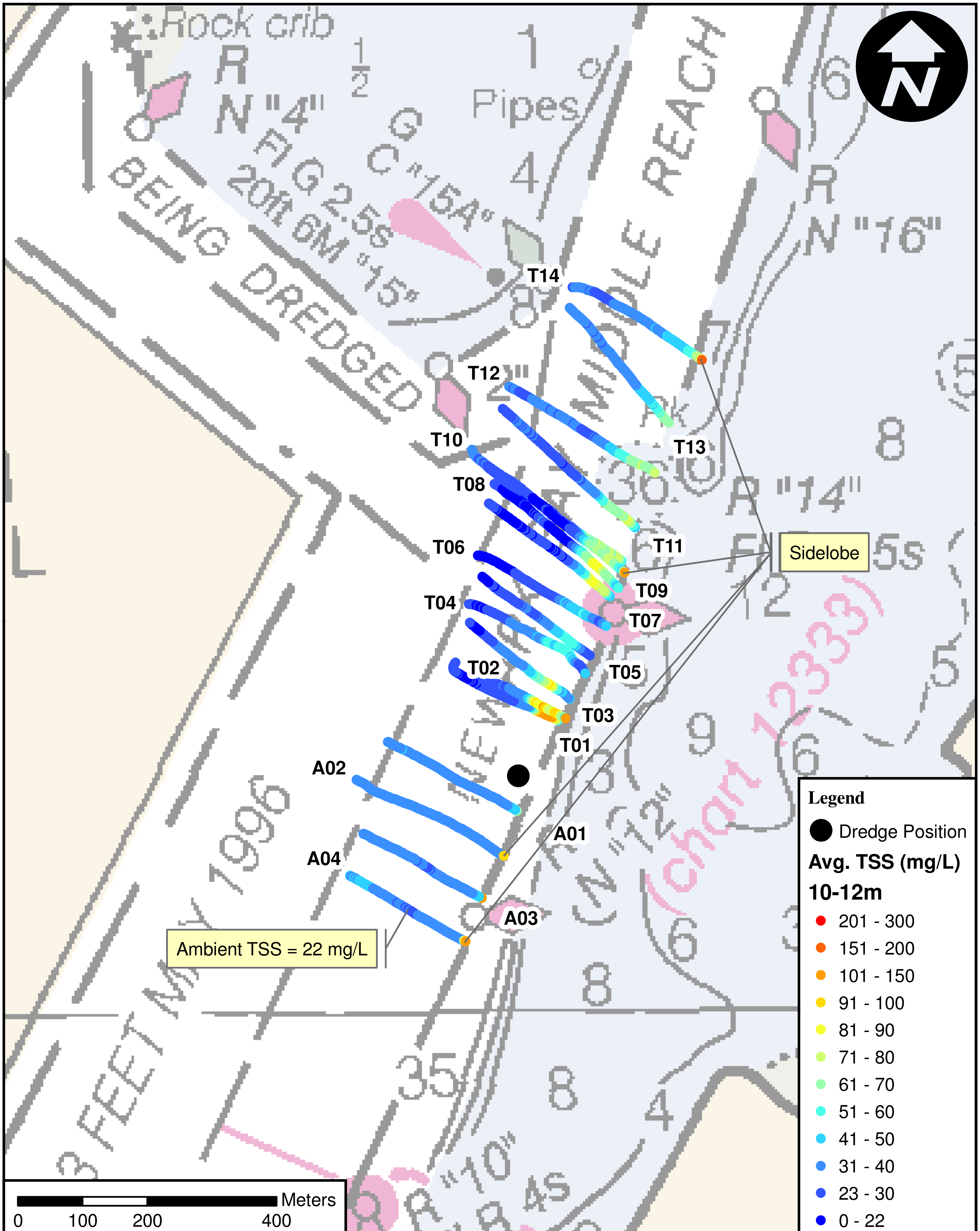


Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1*	ADCP Average TSS - 18 November 2008 10-12 Meter Depth Interval	Tide
7f			Late Flood

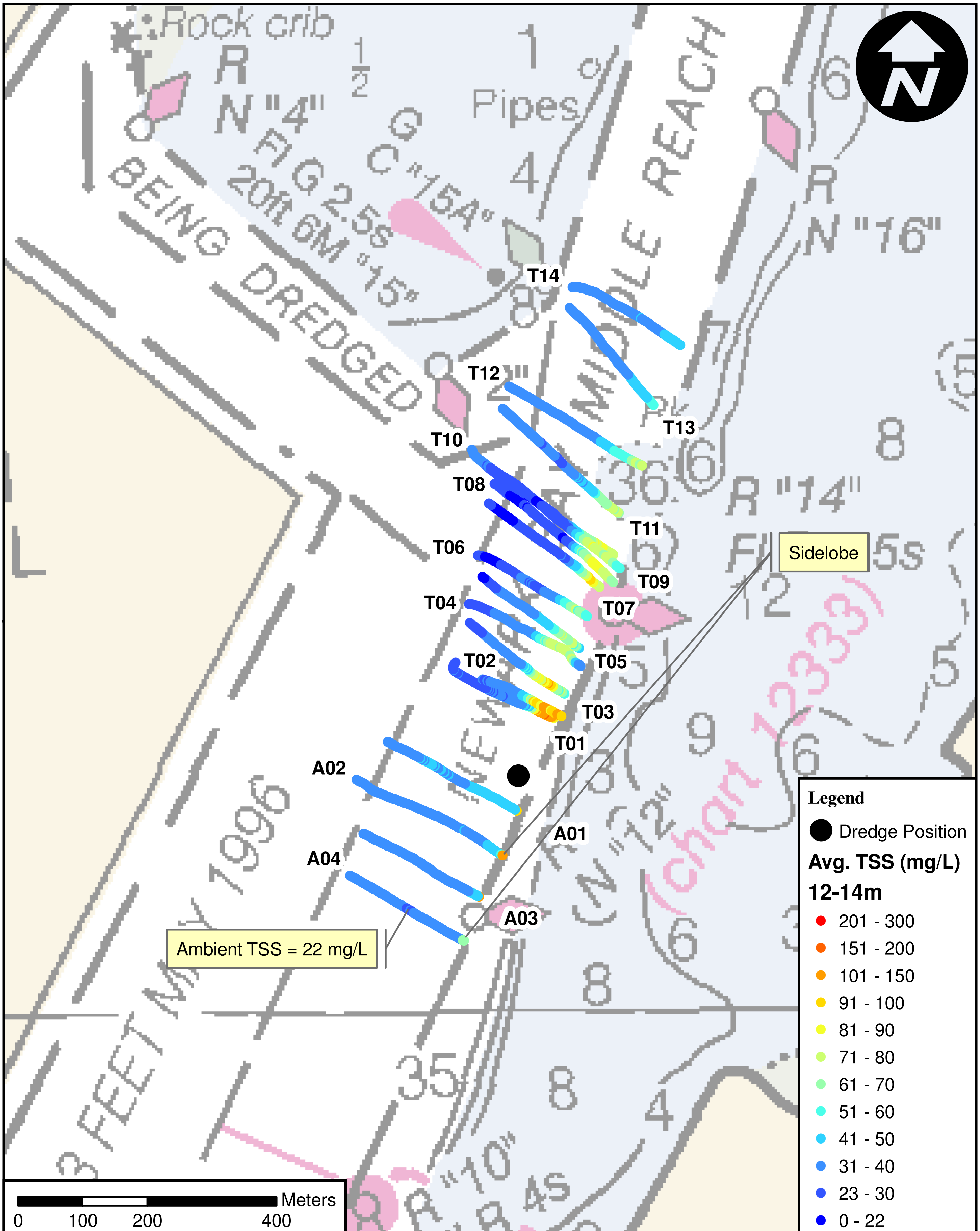


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	ADCP Average TSS - 18 November 2008 12-14 Meter Depth Interval	Tide
7g			Late Flood

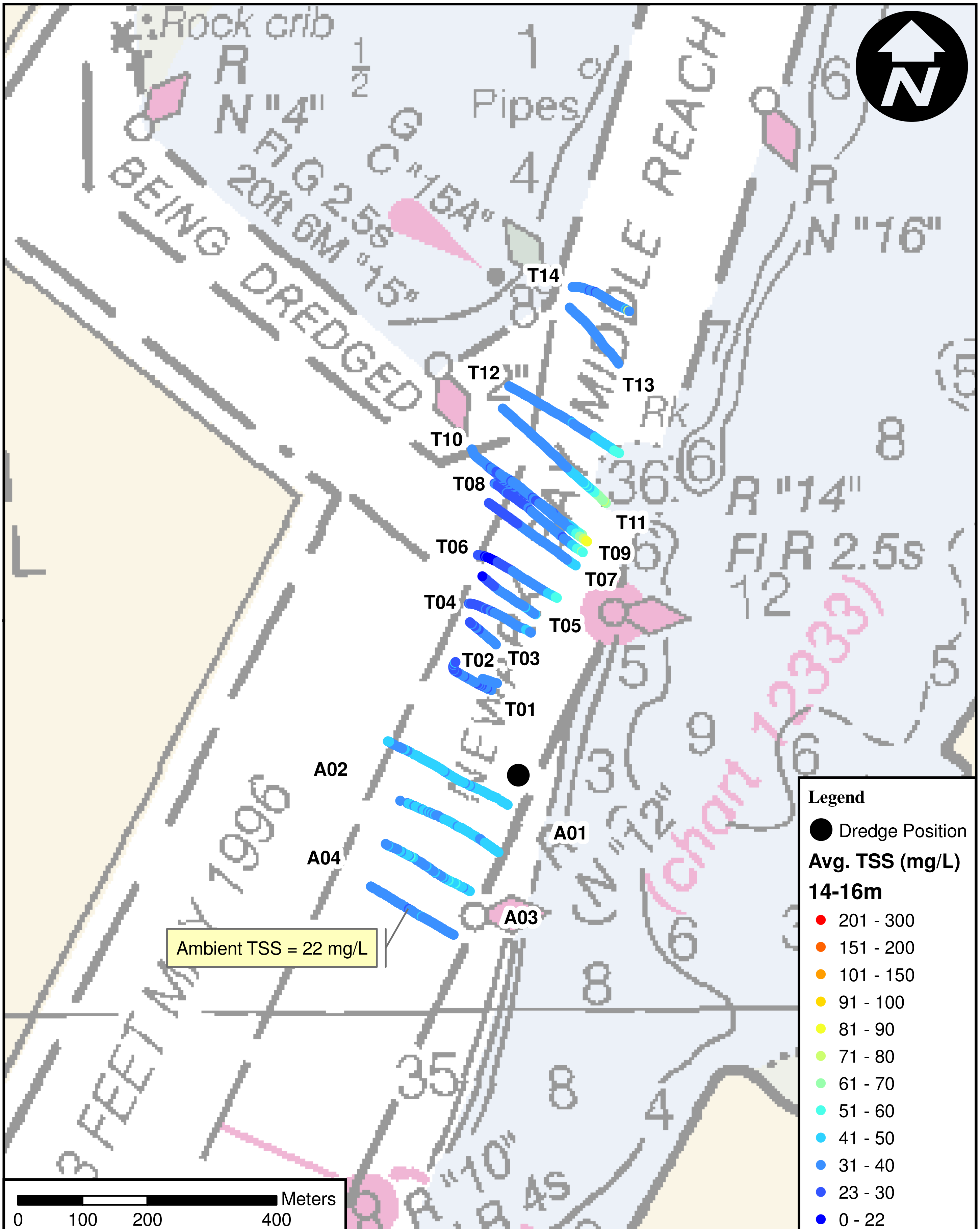
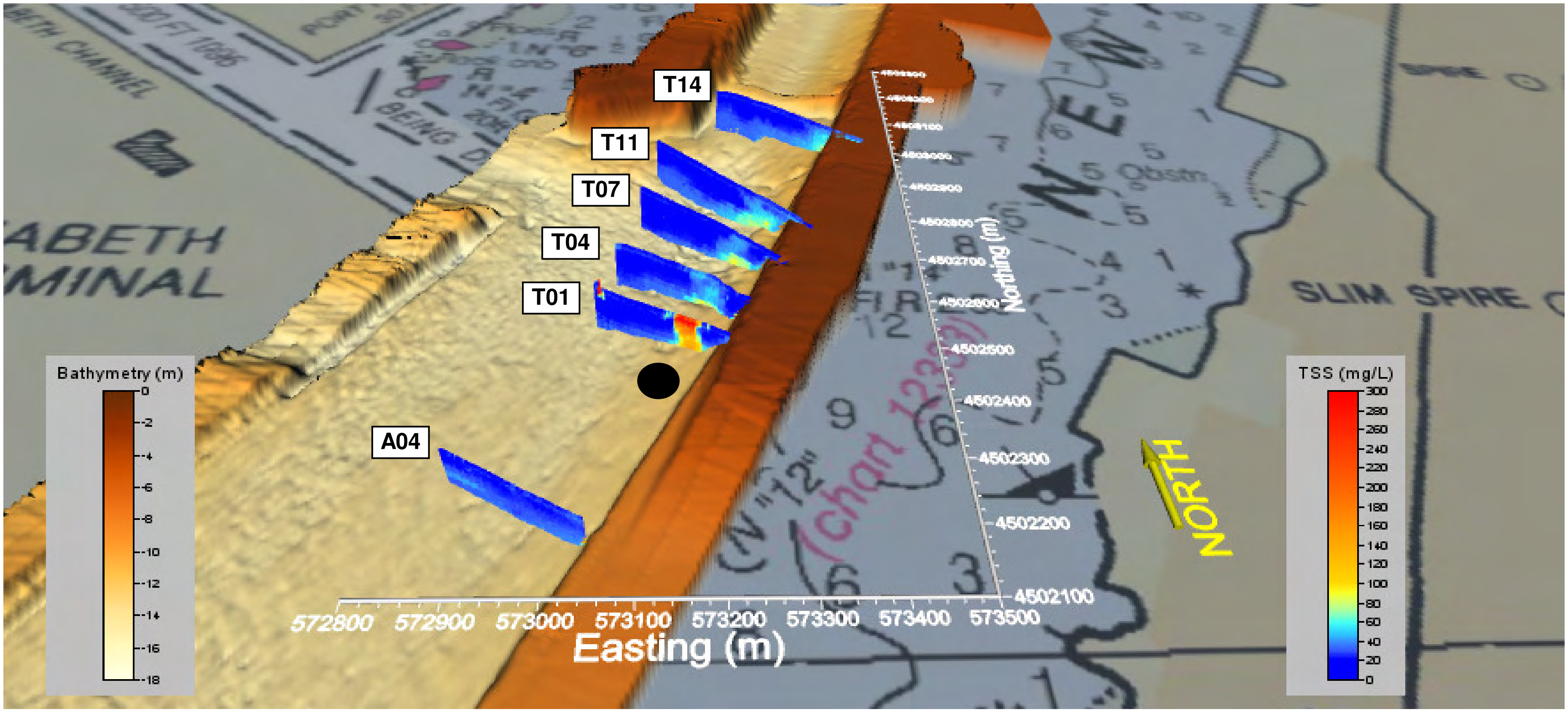


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 18 November 2008** **14-16 Meter Depth Interval**	**Tide**
7h			Late Flood



Bathymetry provided by: US Army Corps of Engineers, NY District

Z Scale Exaggerated 6x

● **= Dredge Location**

Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS Values with Respect to their x, y, and z Coordinates** **Superimposed on Channel Bathymetry** **18 November 2008**	**Tide**
8			**Late Flood**

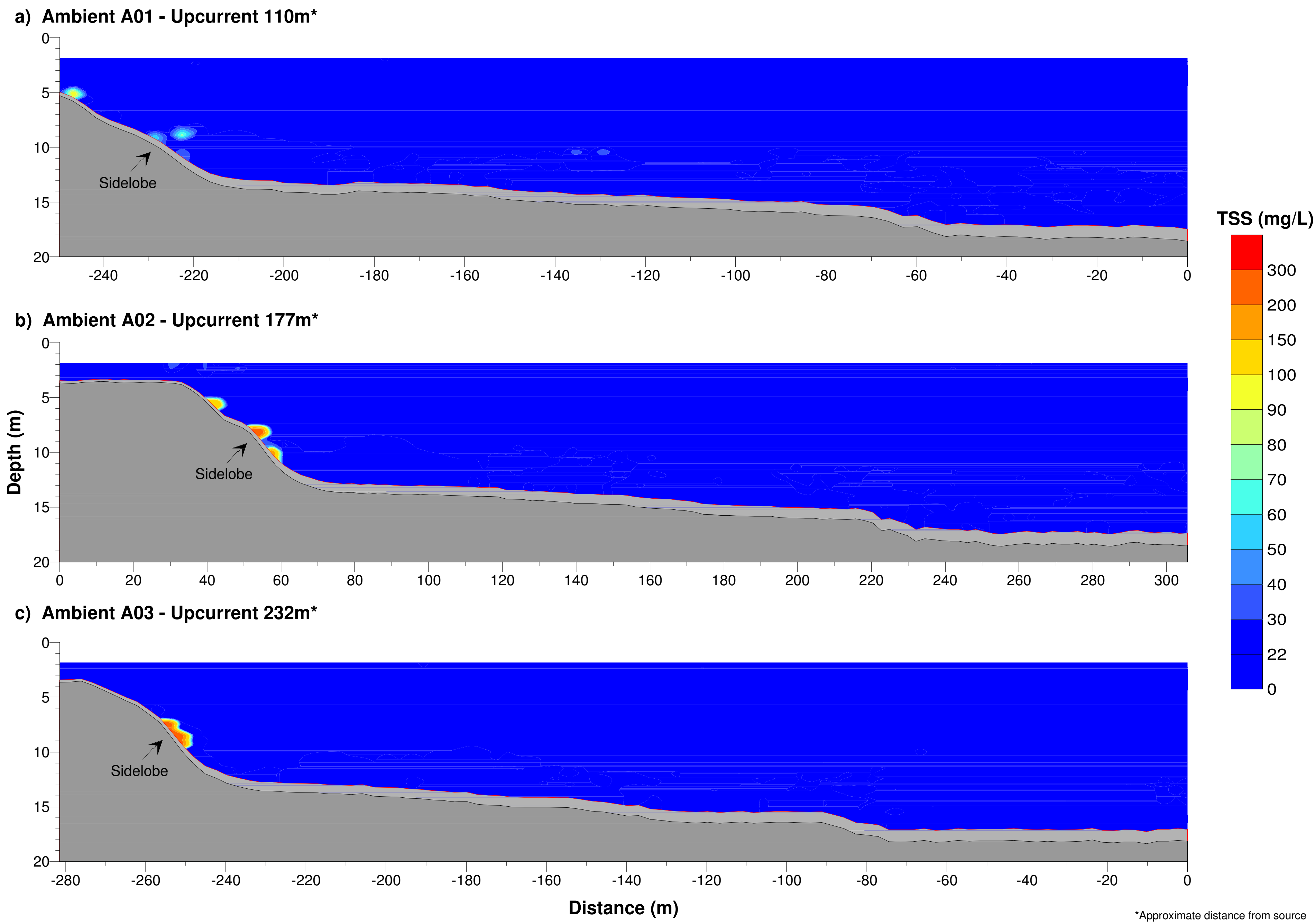
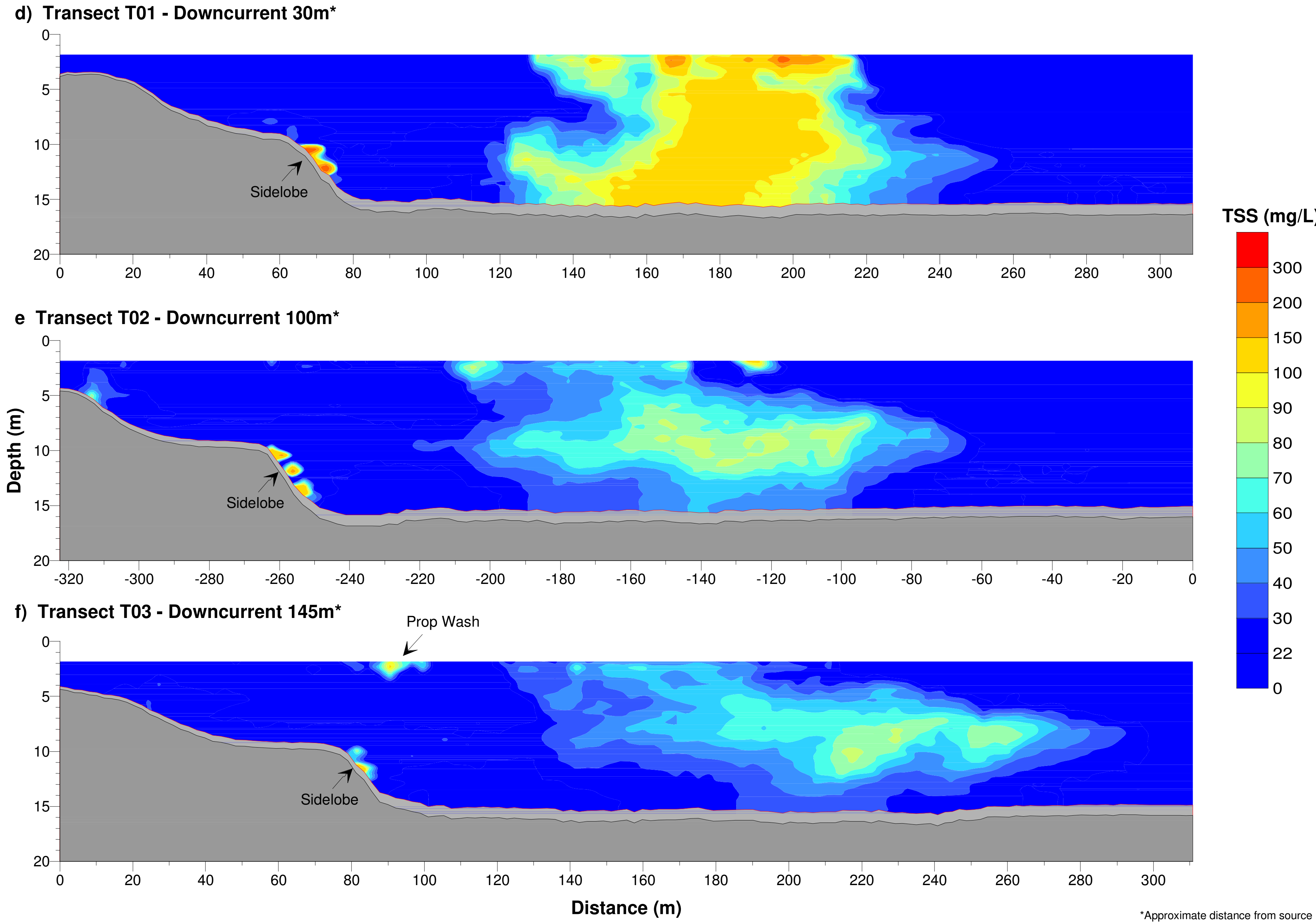
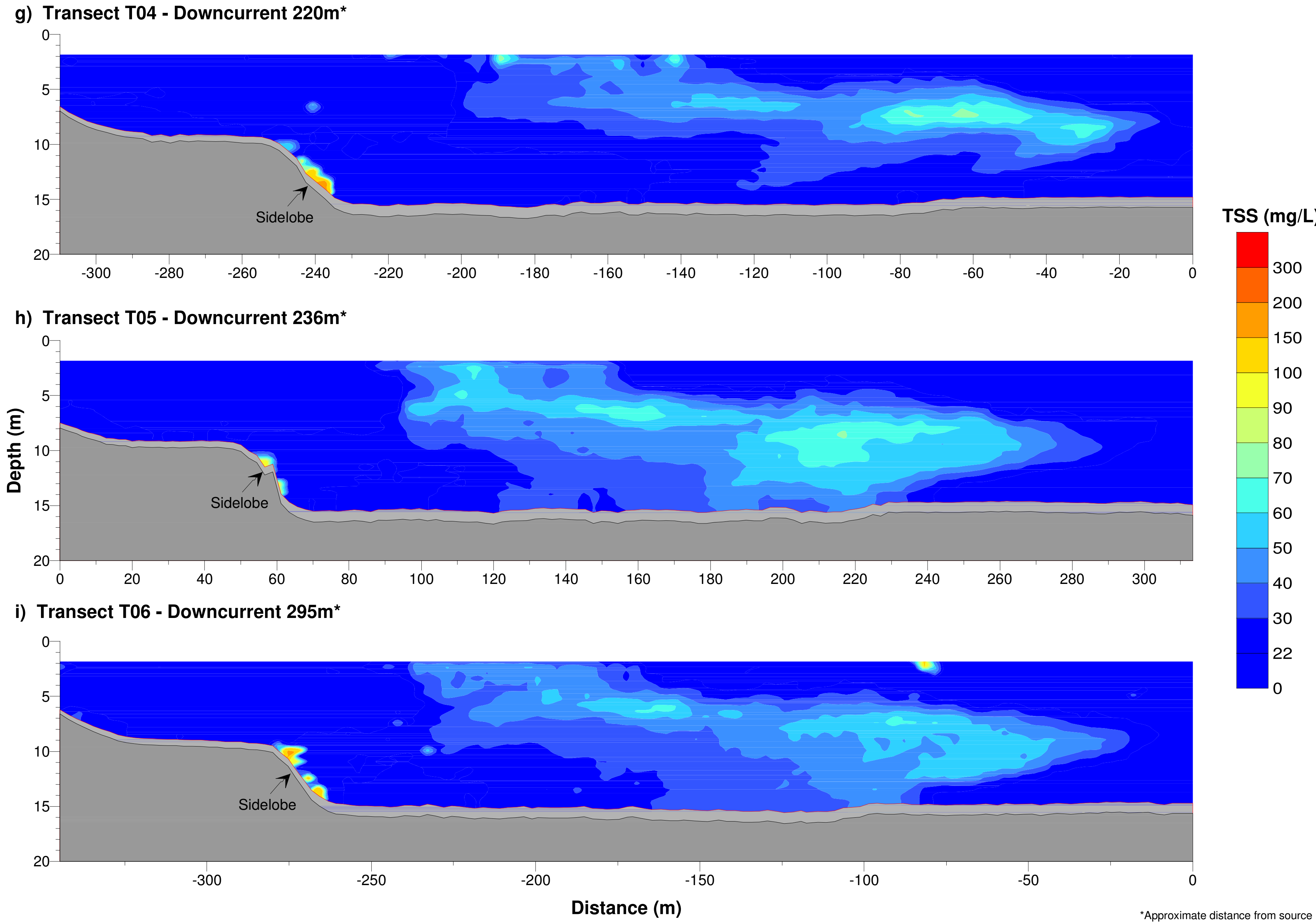


FIGURE	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**Vertical Profiles of ADCP Average TSS** **19 November 2008**	TIDE
9a-c			Ebb



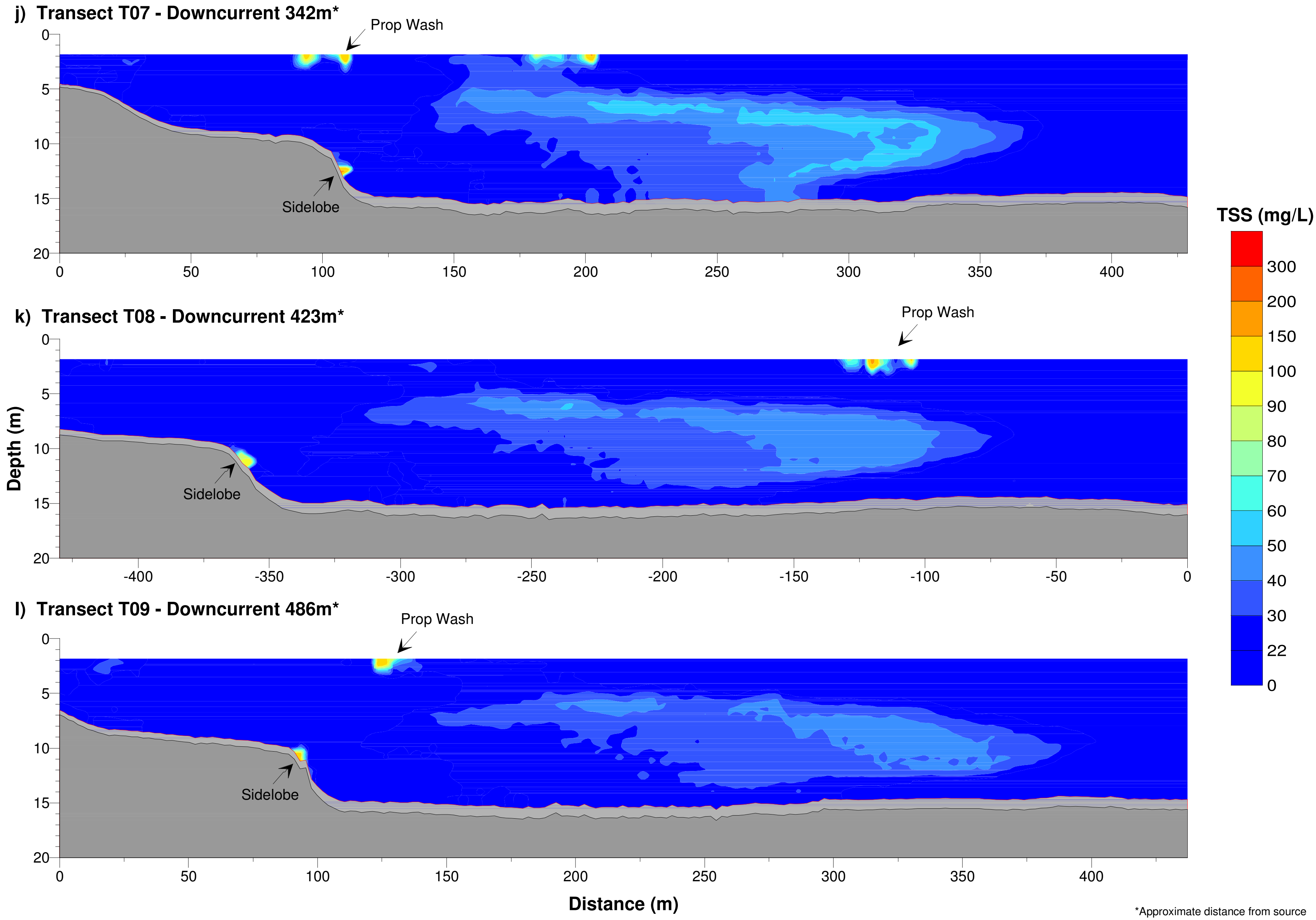
*Approximate distance from source

FIGURE	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	Vertical Profiles of ADCP Average TSS 19 November 2008	TIDE
9d-f			Ebb



*Approximate distance from source

FIGURE	*USACE Harborwide TSS*	**Vertical Profiles of ADCP Average TSS**	TIDE
9g-i	*Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**19 November 2008**	**Ebb**



*Approximate distance from source

FIGURE	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1*	**Vertical Profiles of ADCP Average TSS 19 November 2008**	TIDE
9j-l			Ebb

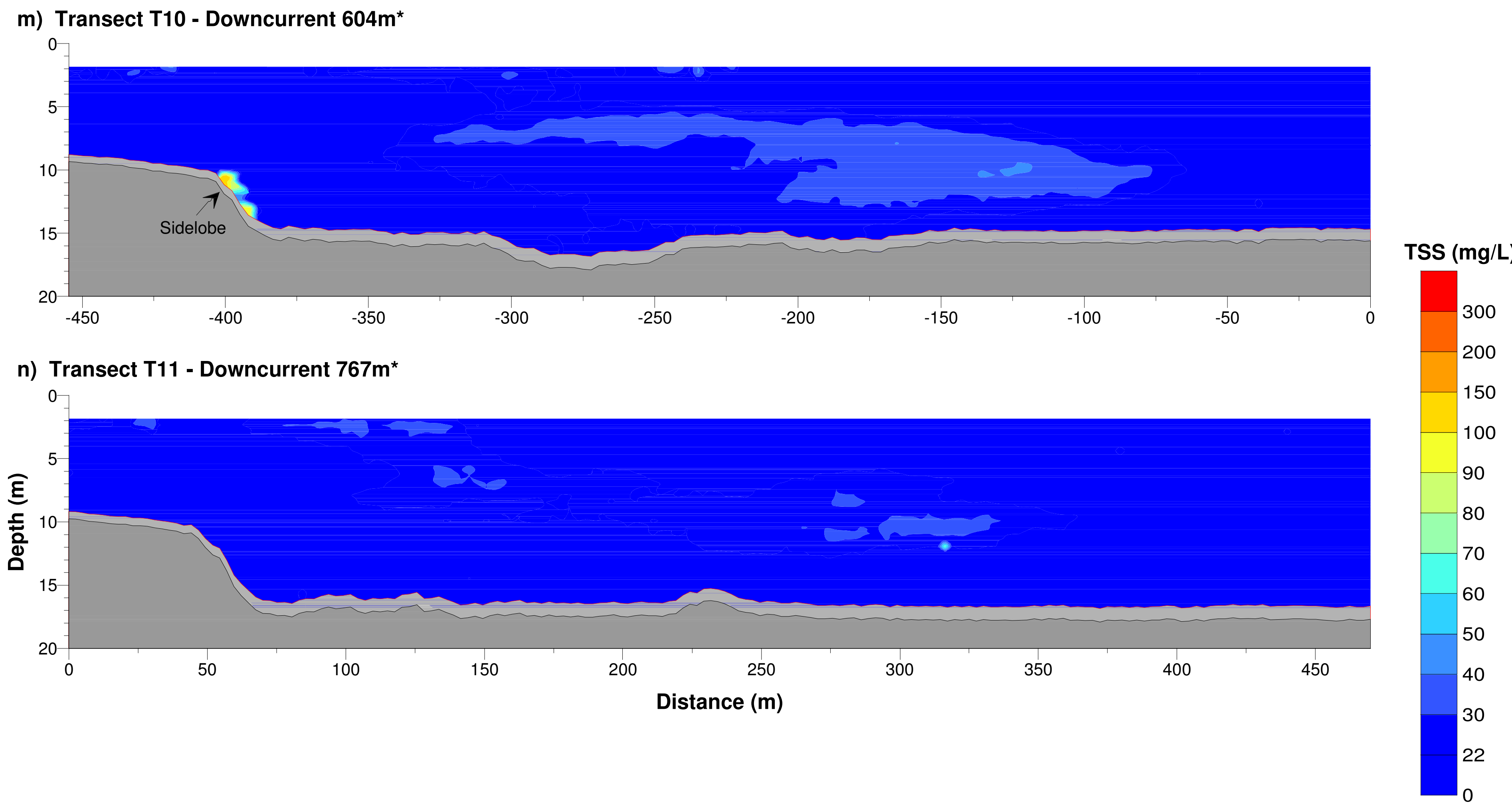


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FIGURE	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	Vertical Profiles of ADCP Average TSS 19 November 2008	TIDE
9m-n			Ebb

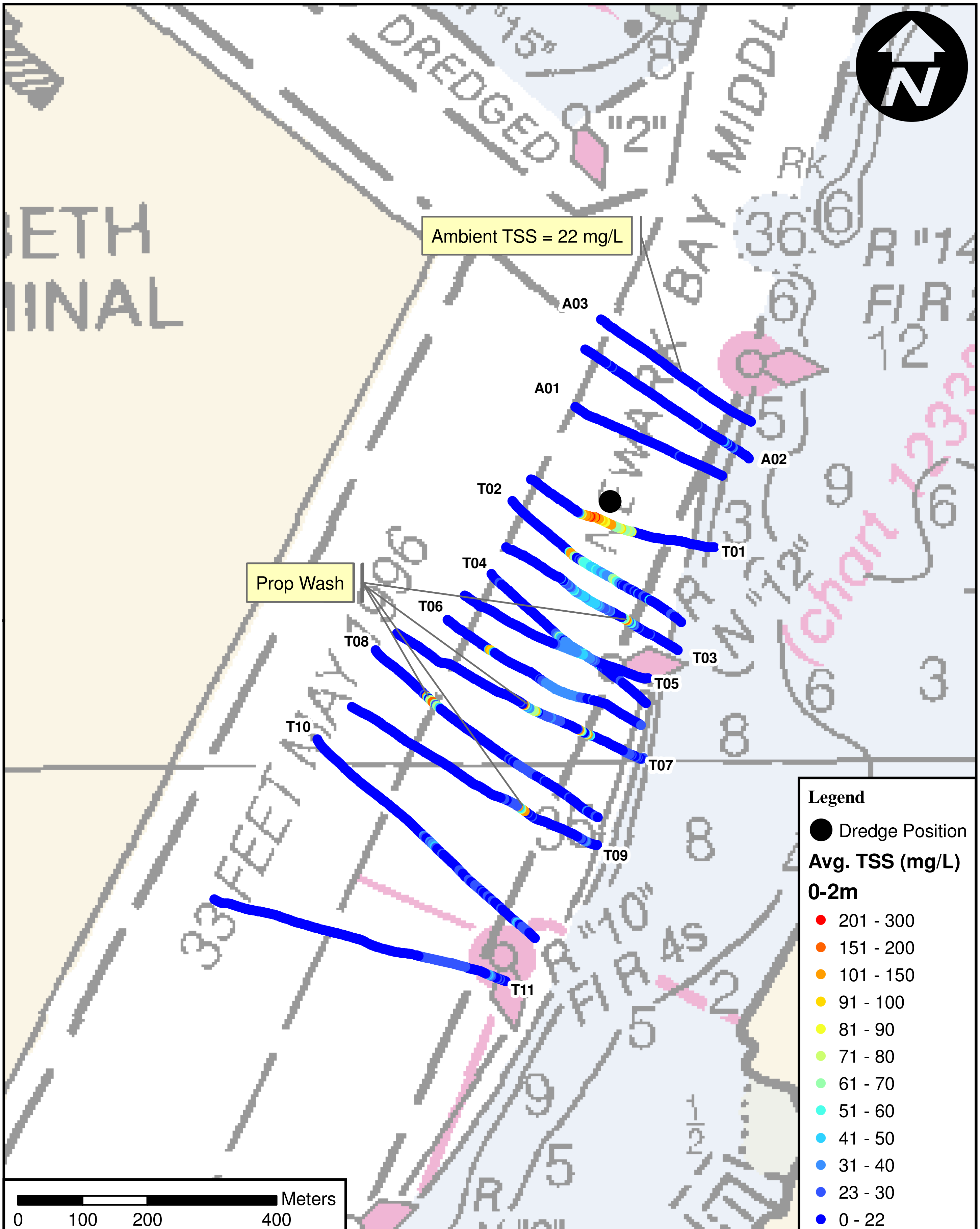


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 19 November 2008** **0-2 Meter Depth Interval**	**Tide**
10a			**Ebb**

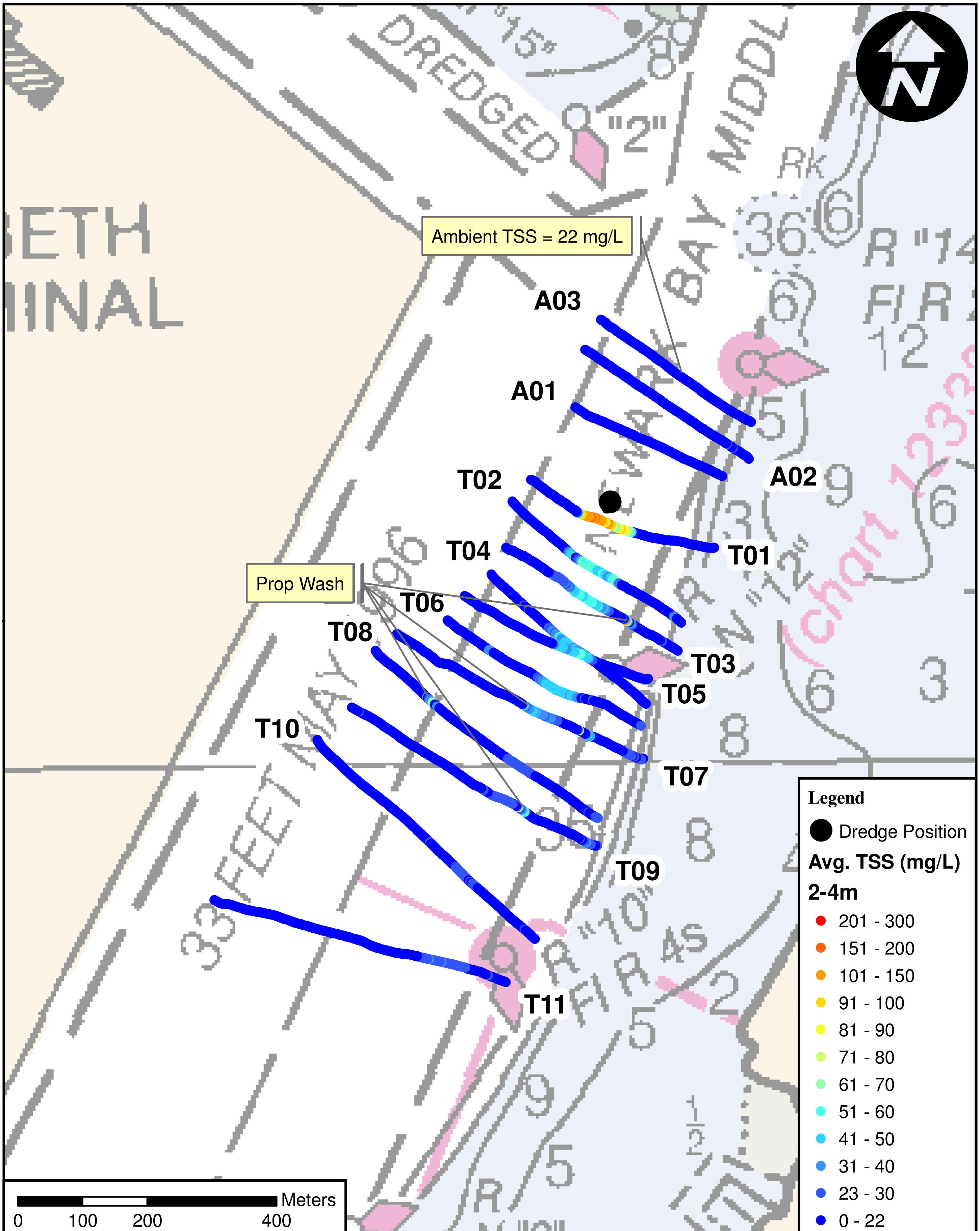


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 19 November 2008** **2-4 Meter Depth Interval**	**Tide**
10b			**Ebb**

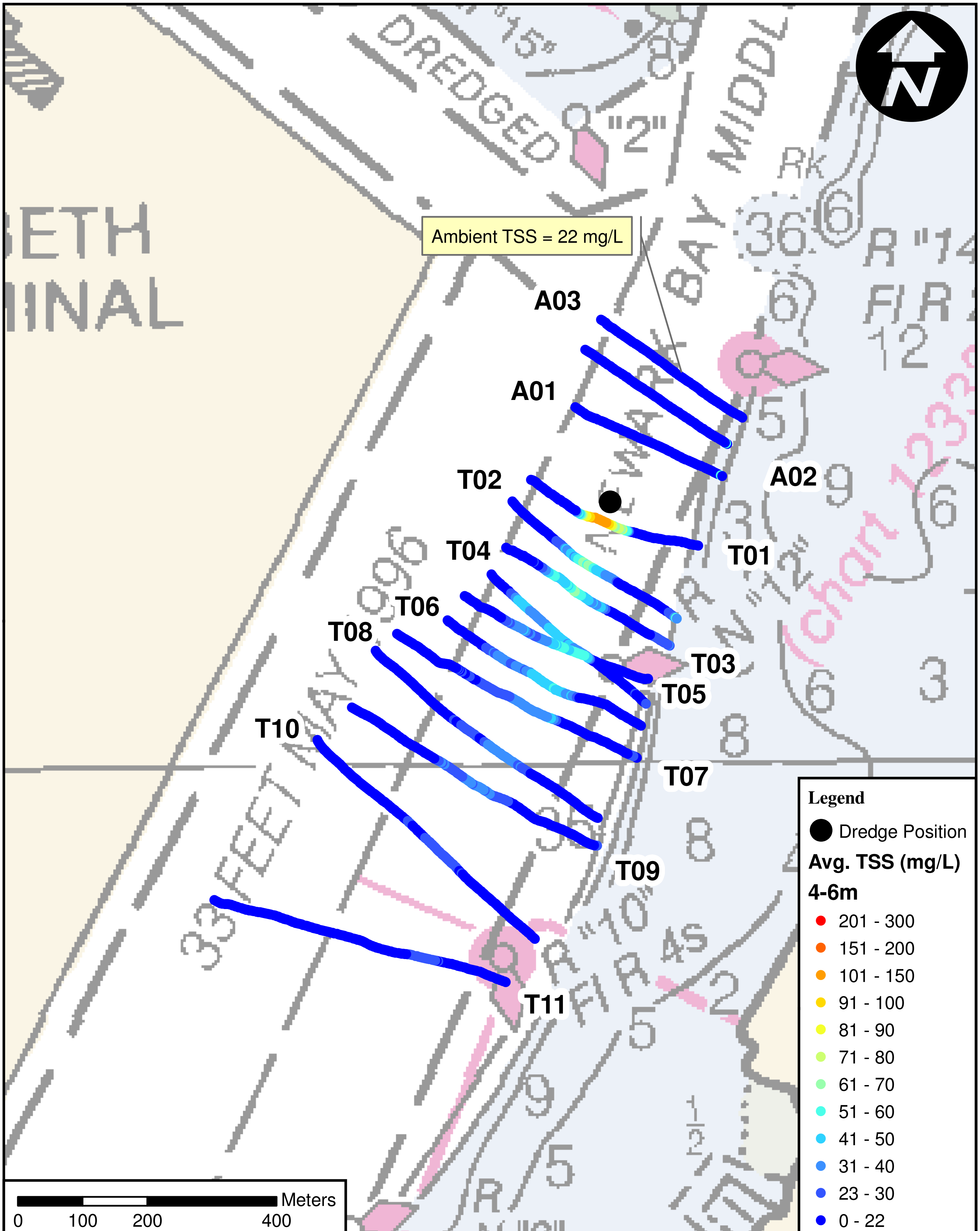


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 19 November 2008** **4-6 Meter Depth Interval**	**Tide**
10c			**Ebb**

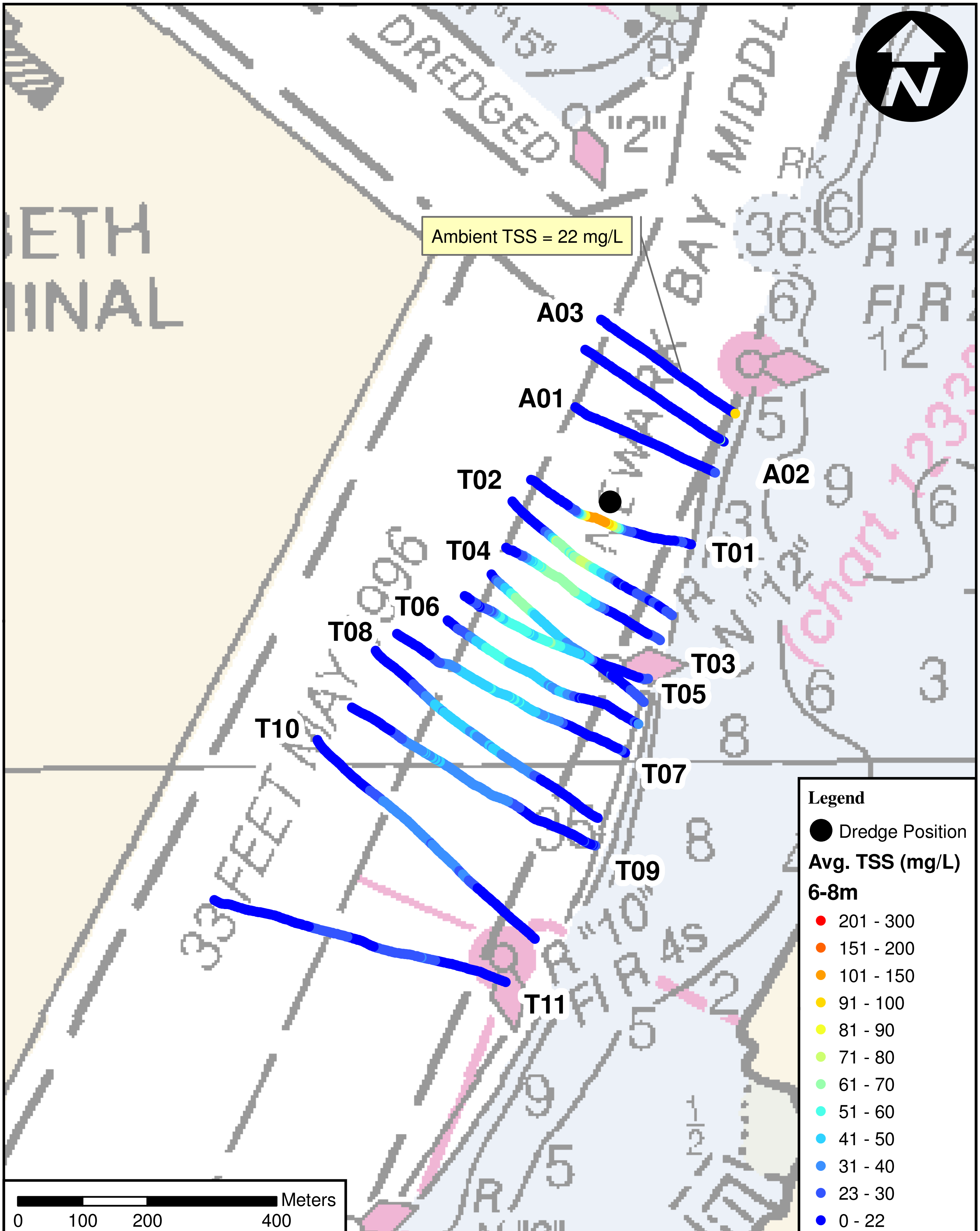


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	ADCP Average TSS - 19 November 2008 6-8 Meter Depth Interval	Tide
10d			Ebb

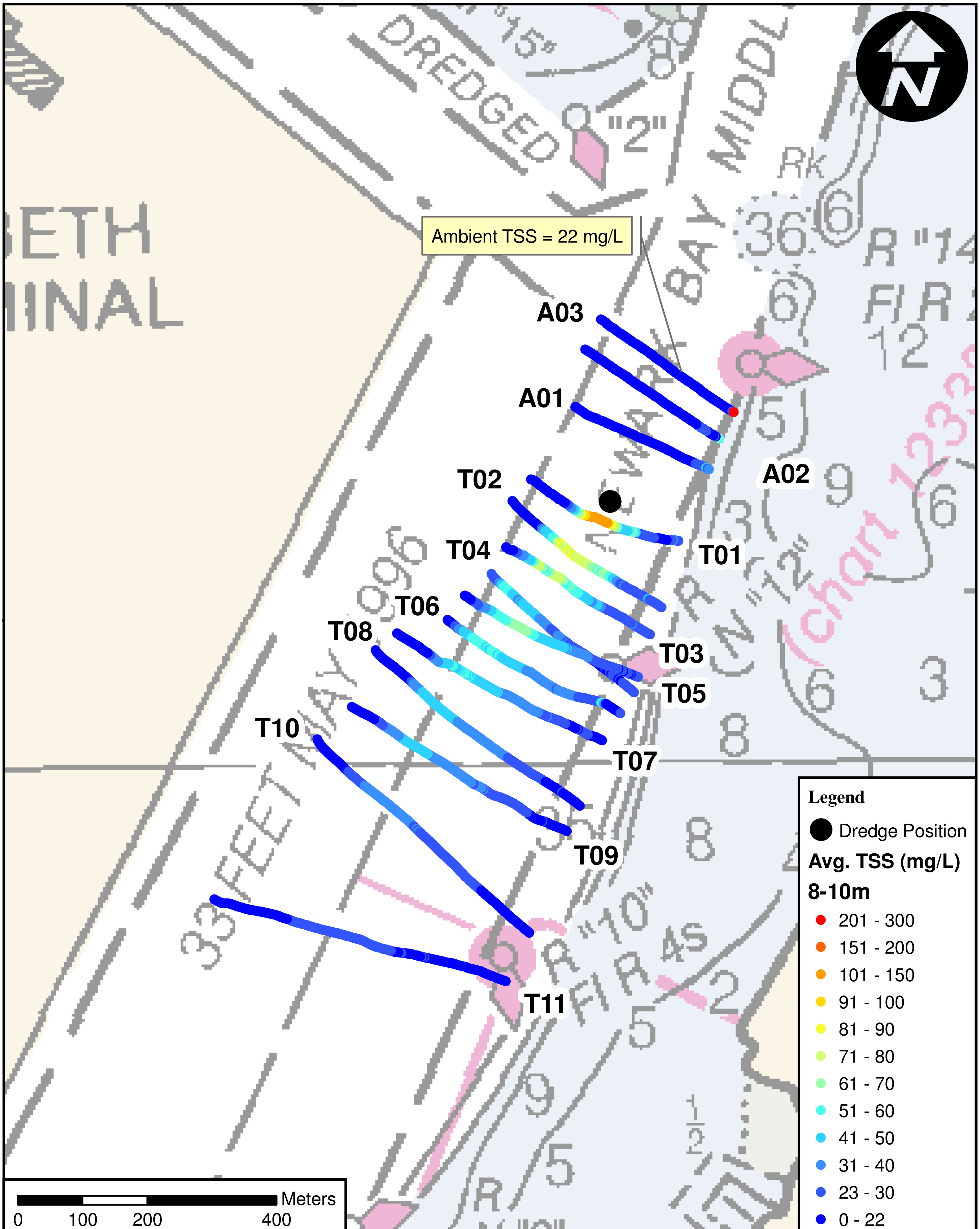


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 19 November 2008** **8-10 Meter Depth Interval**	Tide
10e			Ebb

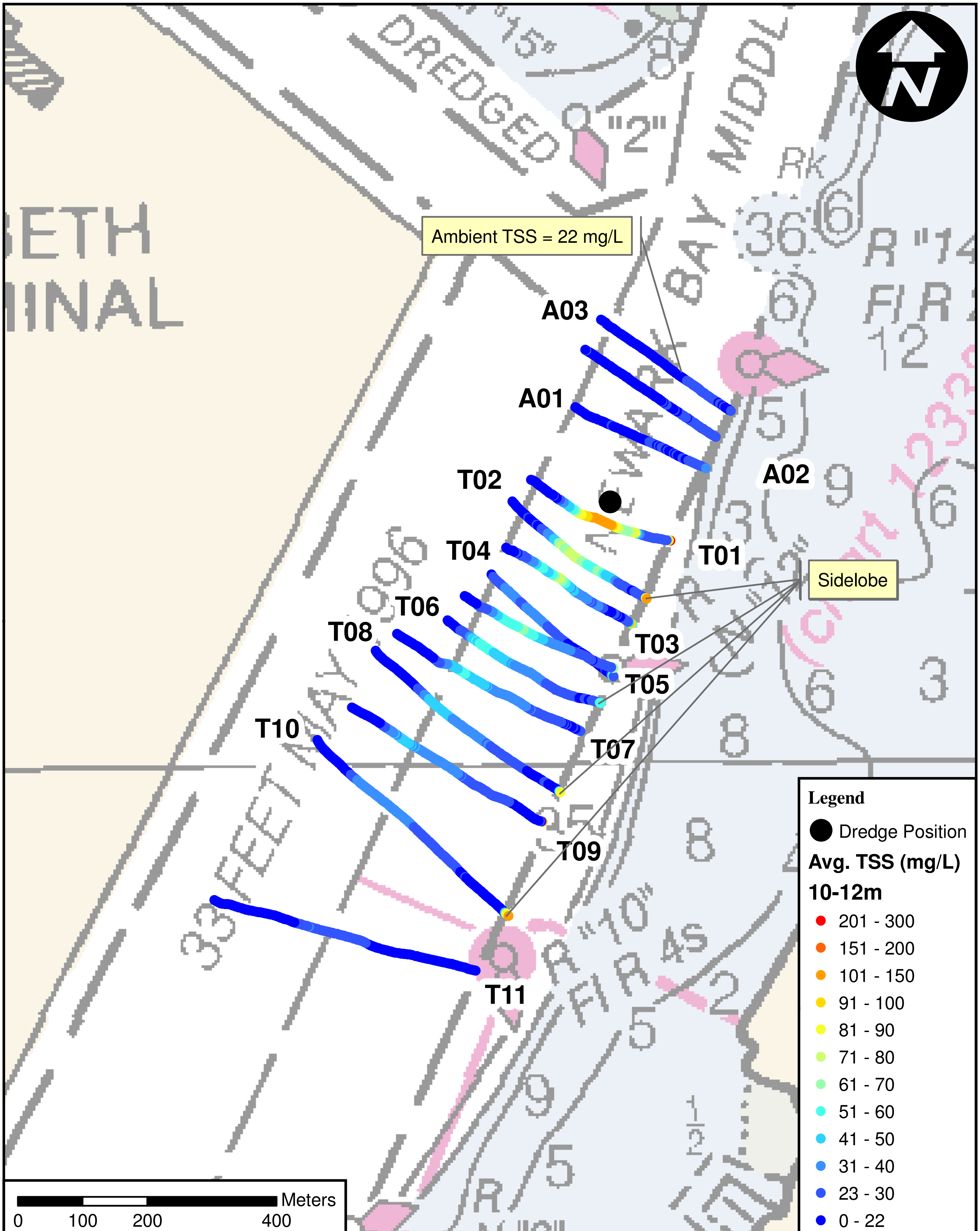


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 19 November 2008** **10-12 Meter Depth Interval**	**Tide**
10f			**Ebb**

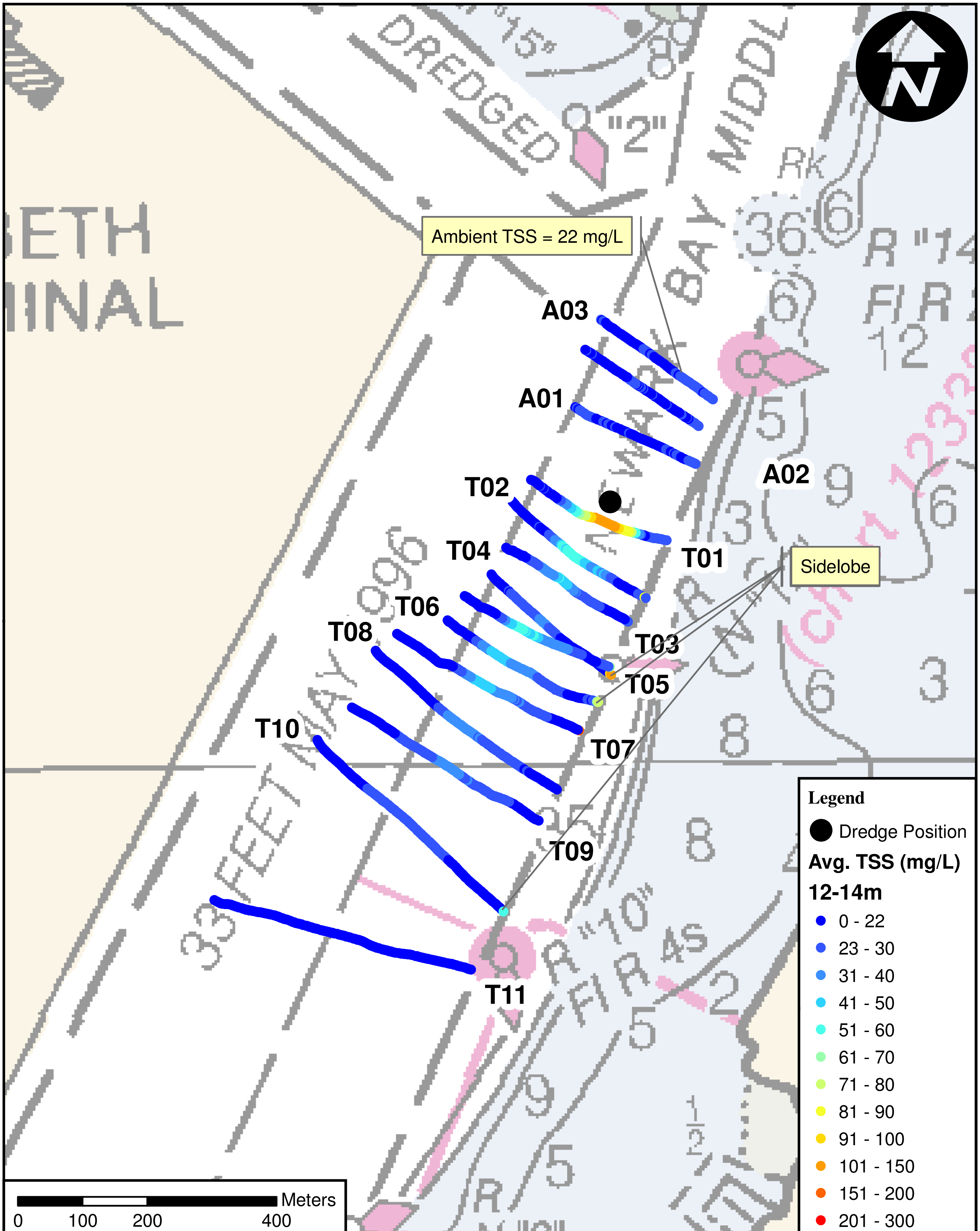


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	ADCP Average TSS - 19 November 2008 12-14 Meter Depth Interval	Tide
10g			Ebb

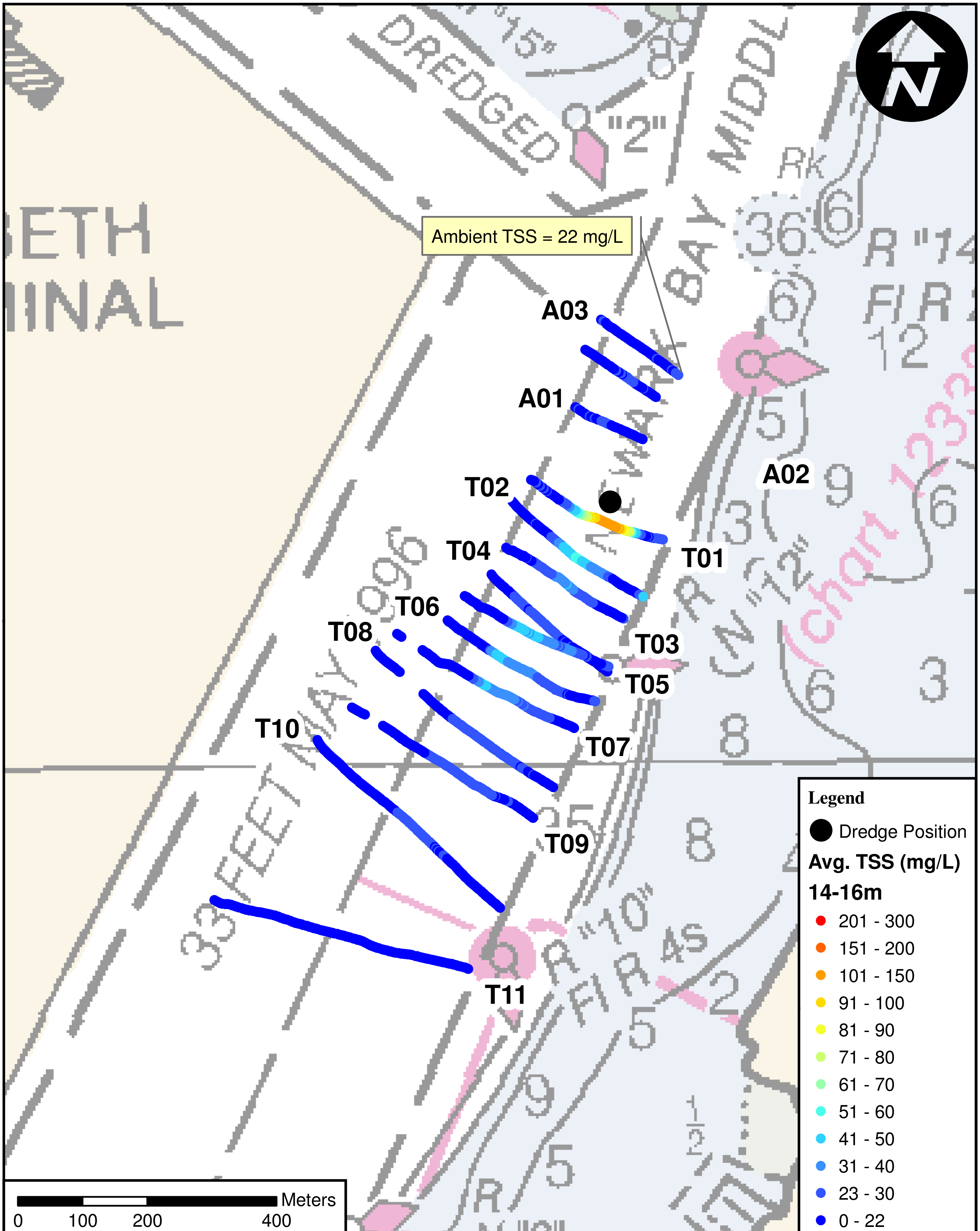
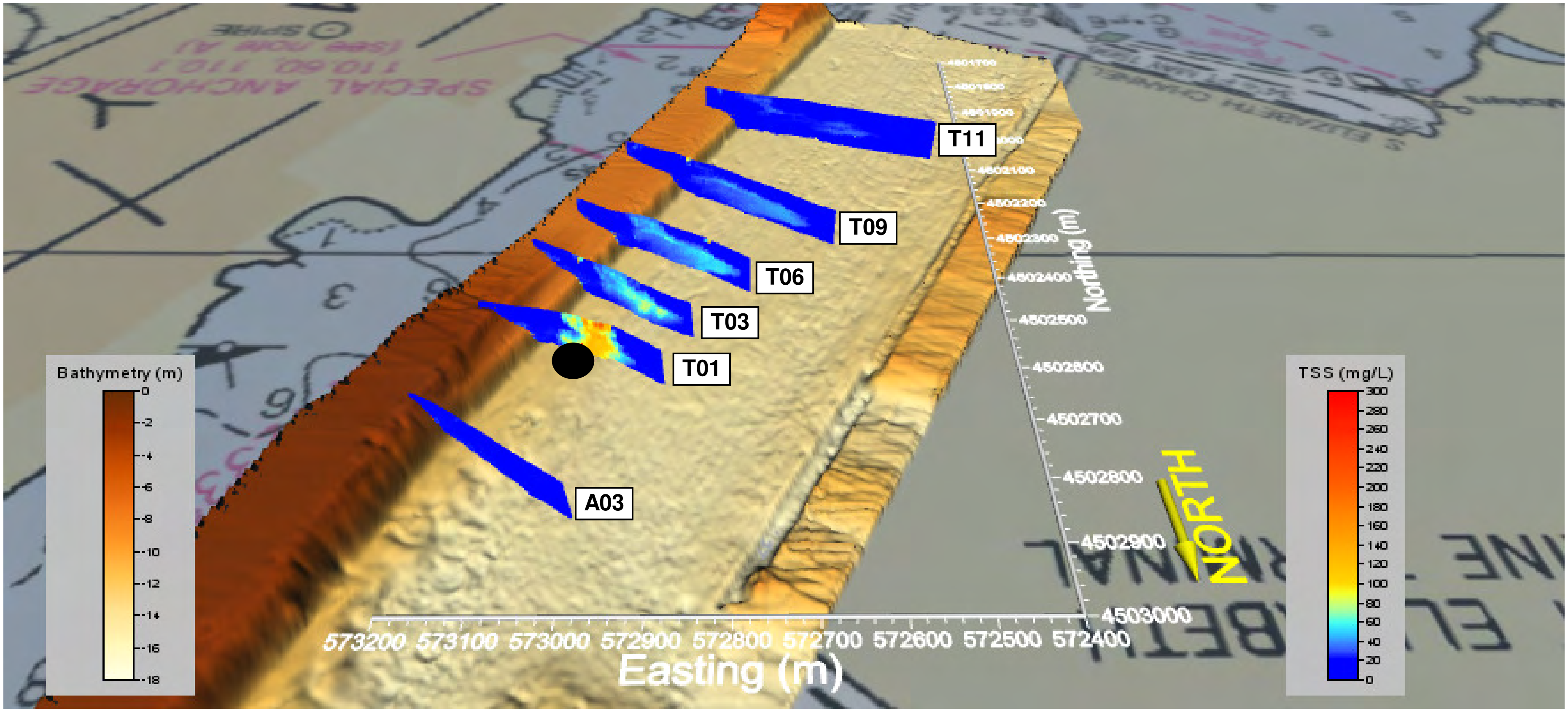


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**ADCP Average TSS - 19 November 2008** **14-16 Meter Depth Interval**	Tide
10h			Ebb



Bathymetry provided by: US Army Corps of Engineers, NY District

Z Scale Exaggerated 6x

● = Dredge Location

Figure	*USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1*	ADCP Average TSS Values with Respect to their x, y, and z Coordinates Superimposed on Channel Bathymetry 19 November 2008	Tide
11			Ebb

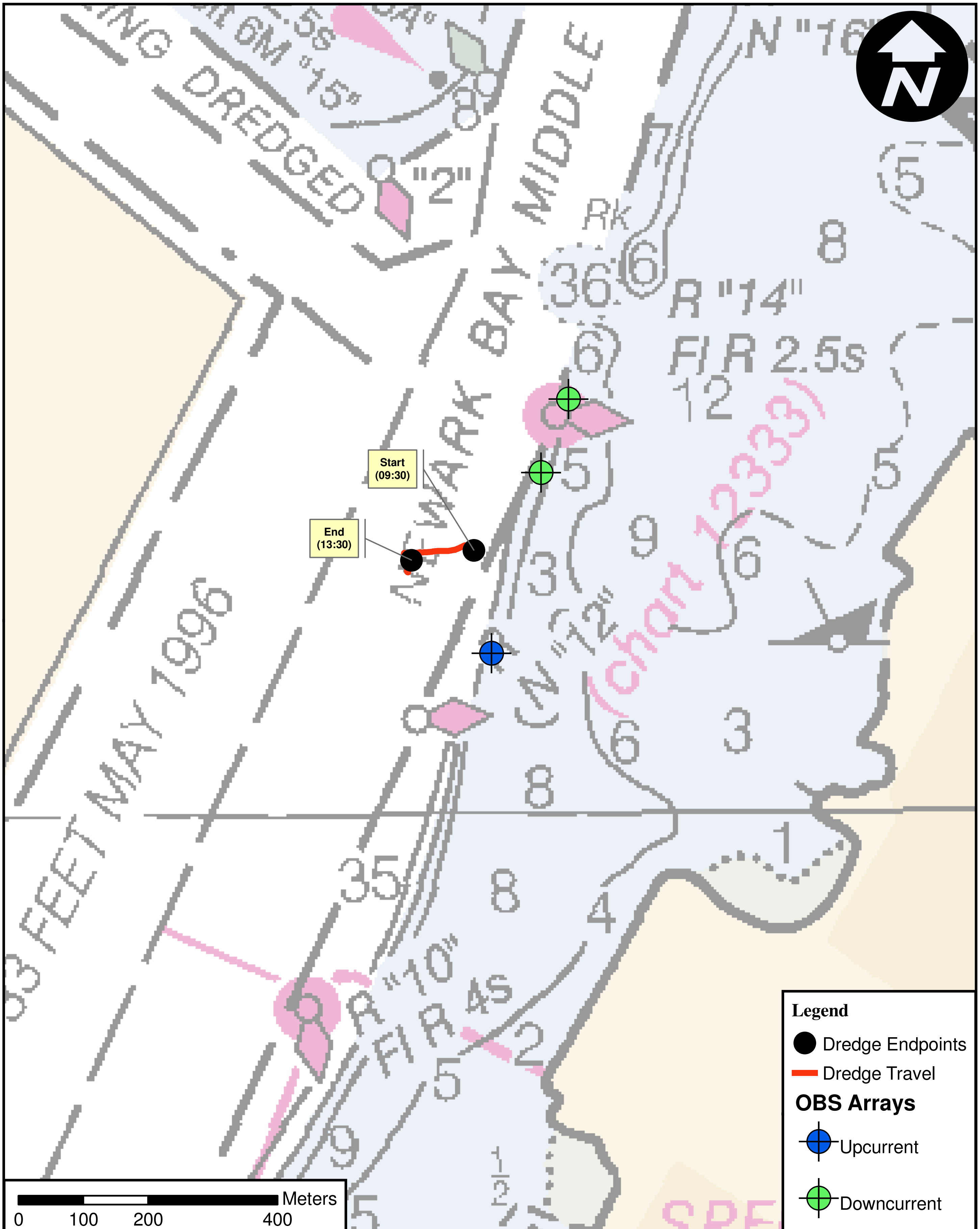
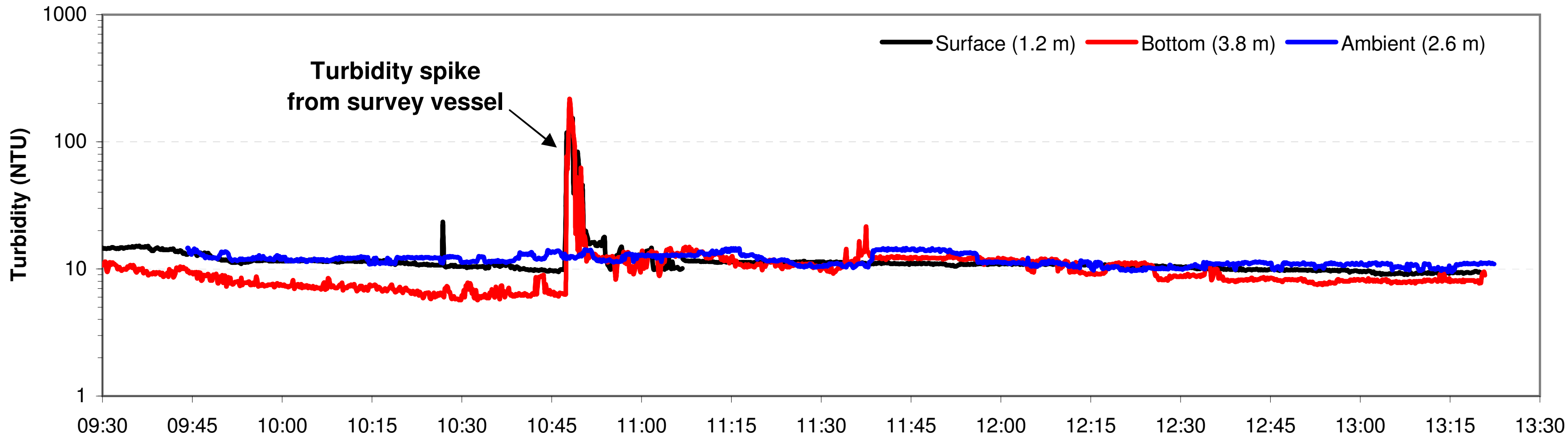


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	Location of OBS Vertical Arrays with Respect to Dredge Position 19 Novemeber 2008	Tide
12			Flood

a) 150 meters Downcurrent from Dredge



b) 250 meters Downcurrent from Dredge

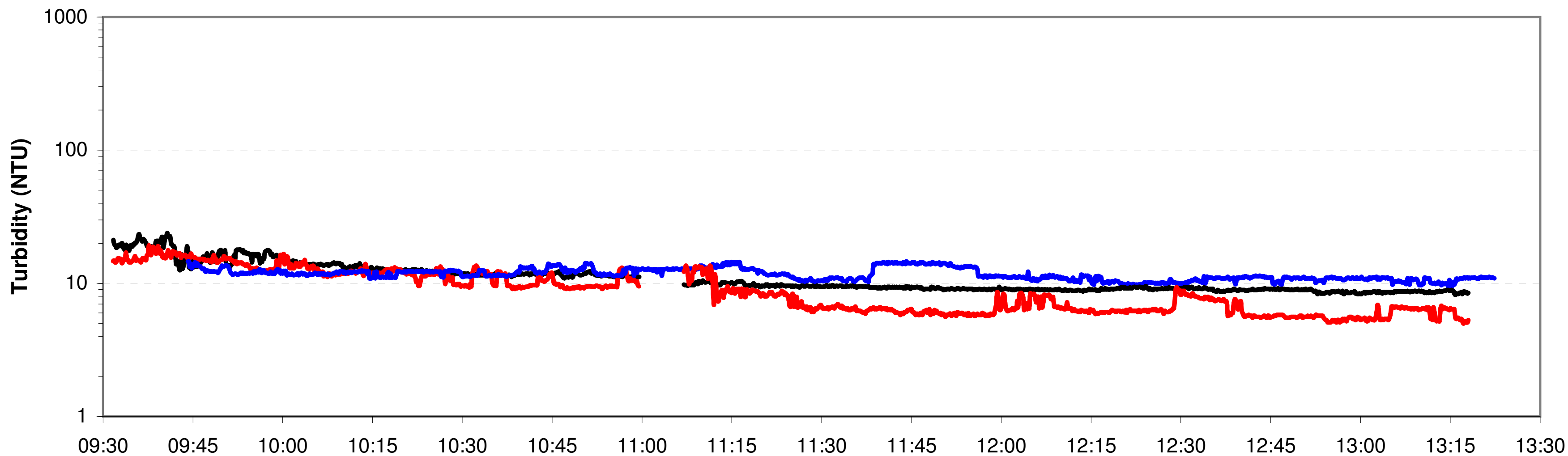


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**Surface and Bottom OBS Turbidities at a) 150 m and b) 250 m Downcurrent of Dredge.** **Ambient Station Located Upcurrent of Dredge** **19 November 2008 TSS Survey**	**Tide**
13			**Flood**

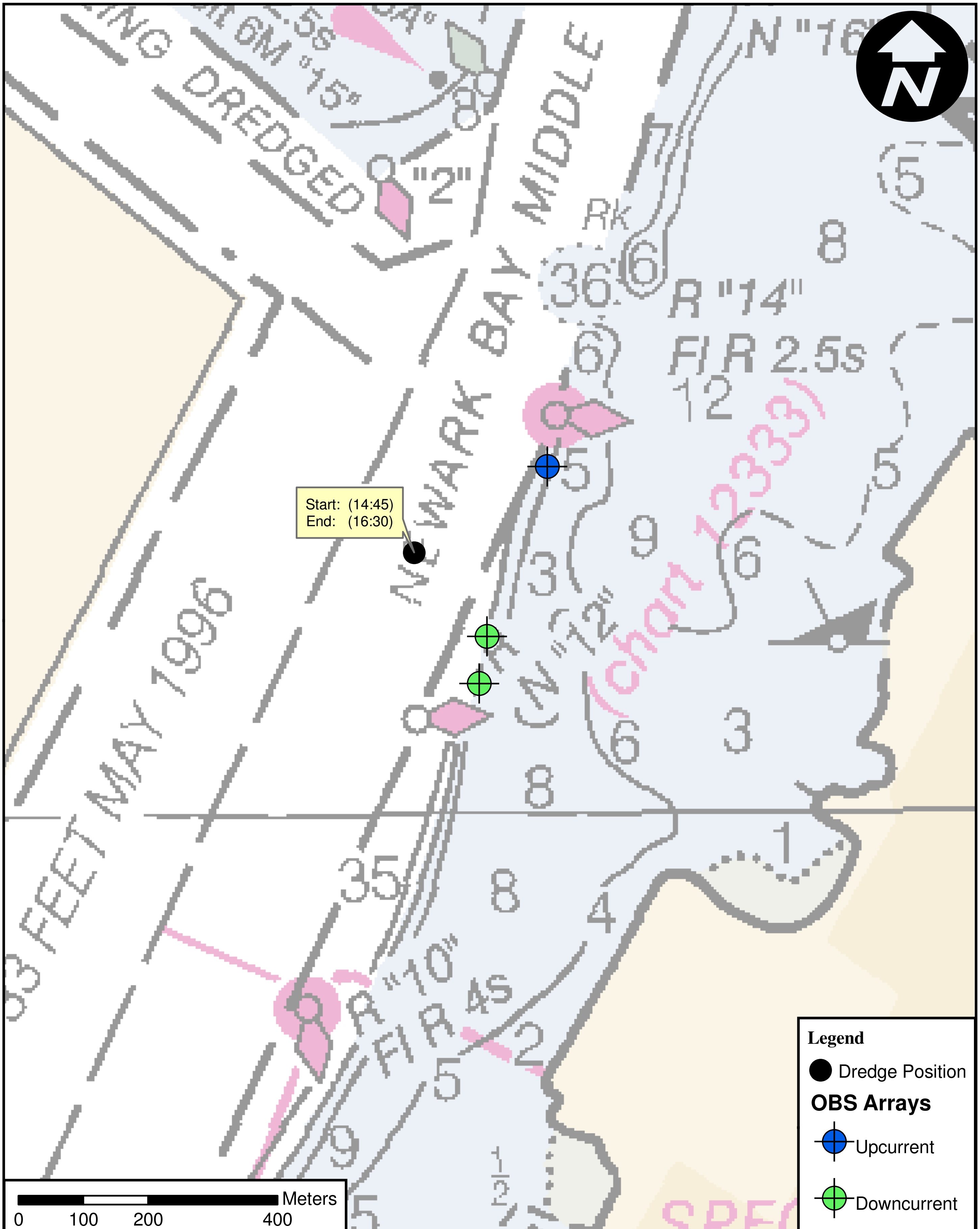
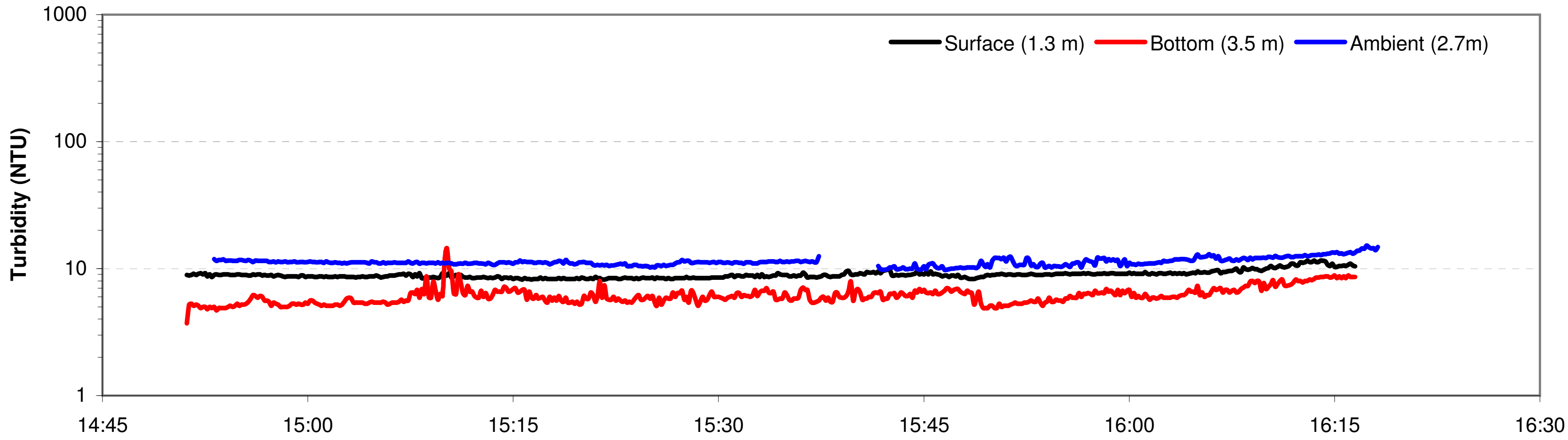


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**Location of OBS Vertical Arrays with Respect to Dredge Position** **19 Novemeber 2008**	**Tide**
14			**Ebb**

a) 100 meters Down Current from Dredge



b) 200 meters Down Current from Dredge

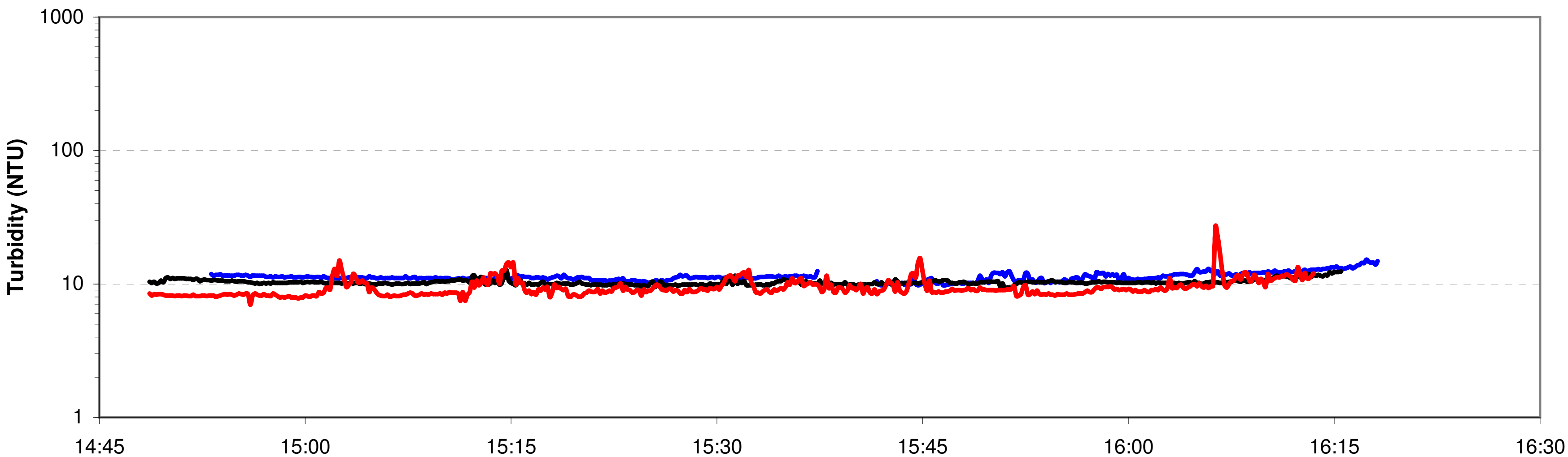
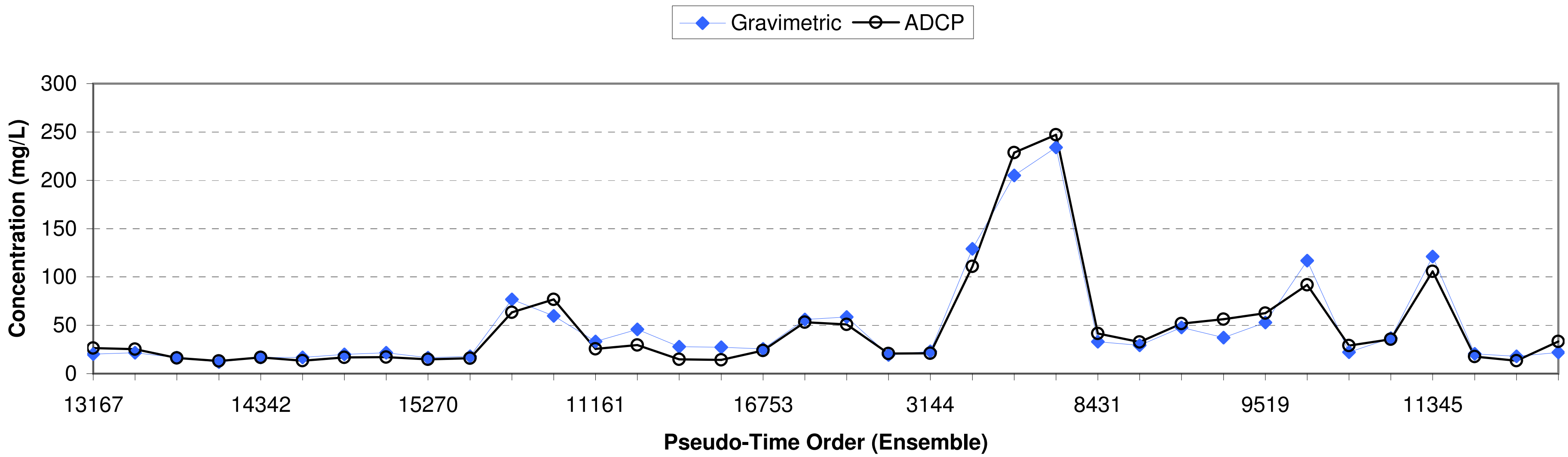


Figure	USACE Harborwide TSS Far Field Survey HDP Contract Area: S-NB-1: B1	Surface and Bottom OBS Turbidities at a) 100 m and b) 200 m Downcurrent of Dredge. Ambient Station Located Upcurrent of Dredge 19 November 2008 TSS Survey	Tide
15			Ebb

a) Concentration vs. Time Order



b) ADCP Concentration vs. Gravimetric Concentration

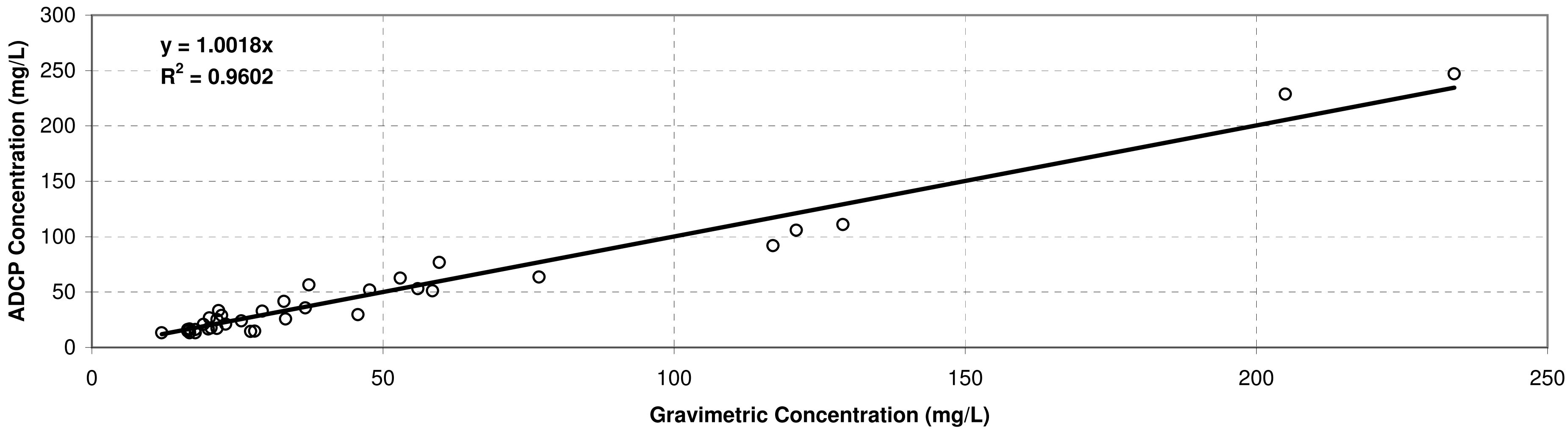


Figure	*USACE Harborwide TSS* *Far Field Survey* *HDP Contract Area: S-NB-1: B1*	**Comparison of gravimetric and ADCP estimates of TSS concentration** **a) Concentration vs. Time b) ADCP Concentration vs. Gravimetric Concentration** **17-19 November 2008 TSS Survey**	Tide
16			N/A

Table 1. Laboratory Results of Water Samples

Sample Date	Sample Time	Location	Turbidity (NTU)	TSS (mg/l)
11/17/2008	15:27:05	Ambient	8.15	21.7
11/17/2008	15:27:09	Ambient	8.06	16.2
11/17/2008	15:28:57	Ambient	8.08	20.2
11/17/2008	15:30:10	Ambient	8.32	18.8
11/17/2008	15:30:20	Ambient	7.92	21.5
11/17/2008	15:48:56	Ambient	7.48	16.0
11/17/2008	15:49:05	Ambient	6.75	15.5
11/17/2008	15:49:34	Ambient	7.26	16.5
11/17/2008	15:50:23	Ambient	6.58	12.0
11/17/2008	15:50:33	Ambient	6.23	16.8
11/17/2008	16:05:16	Ambient	6.45	19.3
11/17/2008	16:05:25	Ambient	6.53	16.8
11/17/2008	16:06:58	Ambient	7.39	20.0
11/17/2008	16:07:06	Ambient	6.86	21.5
11/17/2008	16:07:36	Ambient	6.14	16.5
11/17/2008	16:07:44	Ambient	5.88	17.8
11/18/2008	11:05:40	Plume	44.40	76.8
11/18/2008	11:06:24	Plume	62.60	103.0
11/18/2008	11:06:47	Plume	25.30	45.0
11/18/2008	11:07:02	Plume	33.70	59.7
11/18/2008	11:07:49	Plume	7.11	16.5
11/18/2008	11:30:25	Plume	14.10	33.3
11/18/2008	11:30:39	Plume	22.10	45.7
11/18/2008	11:31:05	Plume	10.50	28.0
11/18/2008	11:31:20	Plume	7.61	27.3
11/18/2008	11:31:46	Plume	7.58	22.7
11/18/2008	11:31:56	Plume	7.36	16.3
11/18/2008	13:13:09	Plume	6.90	25.7
11/18/2008	13:18:30	Plume	11.90	29.0
11/18/2008	13:18:48	Plume	14.70	29.7
11/18/2008	13:19:06	Plume	11.50	24.0
11/18/2008	13:19:25	Plume	28.20	56.0
11/18/2008	13:19:30	Plume	27.60	58.5
11/19/2008	10:05:04	Plume	67.60	163.0
11/19/2008	10:05:30	Plume	9.86	19.2
11/19/2008	10:05:45	Plume	9.70	23.0
11/19/2008	10:23:11	Plume	20.50	46.0
11/19/2008	10:23:36	Plume	58.00	129.0
11/19/2008	10:23:45	Plume	85.20	205.0
11/19/2008	10:23:53	Plume	112.00	234.0
11/19/2008	10:23:58	Plume	104.00	187.0
11/19/2008	10:24:13	Plume	86.00	133.0
11/19/2008	11:41:53	Plume	6.08	23.0
11/19/2008	11:42:53	Plume	11.80	33.0
11/19/2008	11:43:17	Plume	8.85	29.3
11/19/2008	12:02:12	Plume	20.80	47.7
11/19/2008	12:02:31	Plume	14.70	37.3
11/19/2008	12:02:52	Plume	23.50	53.0
11/19/2008	12:03:10	Plume	54.40	132.0
11/19/2008	12:03:21	Plume	9.30	25.3
11/19/2008	12:03:52	Plume	58.40	117.0

Table 1. Laboratory Results of Water Samples

Sample Date	Sample Time	Location	Turbidity (NTU)	TSS (mg/l)
11/19/2008	12:34:50	Plume	6.51	22.3
11/19/2008	12:35:56	Plume	10.30	36.7
11/19/2008	12:36:25	Plume	49.60	121.0
11/19/2008	12:36:42	Plume	50.00	154.0
11/19/2008	12:36:55	Plume	9.30	20.5
11/19/2008	12:36:57	Plume	6.87	17.8
11/19/2008	12:56:46	Plume	7.24	21.8
11/19/2008	12:57:18	Plume	7.27	19.8
11/19/2008	12:57:39	Plume	7.60	22.8

Table 2. 18 November 2008 Far Field Early Flood Tide Survey Transect Summary Table

Transect Number	Figure Number	Time	Approximate Distance to Dredge (m)	Transect Length (m)	Plume Description	Additional Field Remarks
A01	3a	8:11:55	45	271	Ambient	Ambient off stern
A02	3b	8:14:36	117	266	Ambient	Ambient off stern
A03	3c	8:17:20	192	234	Ambient	Tug Prop wash at surface
A04	3d	8:19:49	260	206	Ambient	End at Red "12" Buoy
T01	3e	8:24:50	130	321	Plume approx. 50 m wide at surface with max TSS at surface 200-300 mg/L with core signature between 90-150 mg/L	Downcurrent off Bow/Prop wash at end
T02	3f	8:28:08	200	208	Core signature approx. 70 m wide with max TSS near bottom at < 100 mg/L	
T03	3g	8:29:57	220	302	Core signature at bottom approx. 100 m wide with max TSS typically < 80 mg/L	Prop wash at surface
T04	3h	8:32:38	275	274	Core signature at bottom approx. 100 m wide with max TSS typically < 80 mg/L	End at Red "14"
T05	3i	8:35:04	360	277	Evidence of independent backscatter (see report) near bottom with a core TSS signature 50 m wide at 80-150 mg/L	
T06	3j	8:37:28	380	263	Evidence of independent backscatter (see report) near bottom with a core TSS signature 50 m wide at 80-150 mg/L	
T07	3k	8:39:55	430	363	Evidence of independent backscatter (see report) near bottom with a core TSS signature 50 m wide at 80-150 mg/L	
T08	3l	8:43:00	525	299	Evidence of independent backscatter (see report) near bottom with a core TSS signature 50 m wide at < 100 mg/L	
T09	3m	8:47:32	615	347	Evidence of independent backscatter (see report) near bottom with a core TSS signature 50 m wide at < 100 mg/L	End at Green "15A"

Table 3. 18 November 2008 Far Field Late Flood Tide Survey Transect Summary Table

Transect Number	Figure Number	Time	Approximate Distance to Dredge (m)	Transect Length (m)	Plume Description	Additional Field Remarks
A01	6a	8:11:55	45	271	Ambient	Ambient off stern
A02	6b	8:14:36	117	266	Ambient	Ambient off stern
A03	6c	8:17:20	192	234	Ambient	Prop wash at surface
A04	6d	8:19:49	260	206	Ambient	End at Red "12" Buoy
T01	6e	8:55:22	100	231	Plume approx. 40 m wide with max TSS at surface > 300 mg/L with core signature 150-300 mg/L in the upper half of the water column and 100-150 mg/L in the lower half	Tug prop wash at end
T02	6f	8:59:20	120	166	Plume approx. 50 m wide with max TSS at surface 200-300 mg/L with a core signature 80-150 mg/L	
T03	6g	9:00:55	150	250	Plume approx. 60 m wide with max TSS at surface 200-300 mg/L with a stratified core signature between the surface at 80-150 mg/L and the bottom at 70-100 mg/L	
T04	6h	9:03:19	200	242	Highly diffused plume with a core width of 70 m and max TSS <100 mg/L at the bottom	
T05	6i	9:05:48	225	256	Plume with a core width of 70 m and max TSS <100 mg/L at the bottom	End at Red "14" Buoy
T06	6j	9:08:22	275	242	Highly diffused plume with a core width of 70 m and max TSS <80 mg/L at the bottom	
T07	6k	9:10:49	325	295	Development of a second backscatter signature independent of dredge source (see report) with a core width of 70 m and max TSS <100 mg/L	Bottom scatter may be enhanced by Elizabeth flow/Don John or traffic
T08	6l	9:13:49	350	280	Development of a second backscatter signature independent of dredge source (see report) with a core width of 80 m and max TSS <100 mg/L	
T09	6m	9:16:30	380	320	Development of a second backscatter signature independent of dredge source (see report) with a core width of 80 m and max TSS <100 mg/L	Bottom scatter from Elizabeth channel
T10	6n	9:19:56	360	322	Development of a second backscatter signature independent of dredge source (see report) with a core width of 80 m and max TSS <100 mg/L	
T11	6o	9:23:11	430	347	Development of a second backscatter signature independent of dredge source (see report) with a core width of 80 m and max TSS <90 mg/L	
T12	6p	9:26:37	515	318	Development of a second backscatter signature independent of dredge source (see report) with a core width of 100 m and max TSS <80 mg/L; signature extending to the sideslopes	
T13	6q	9:30:07	600	329	Development of a second backscatter signature independent of dredge source (see report) with a core width of 80 m and max TSS <70 mg/L; signature extending to the sideslopes	
T14	6r	9:32:23	700	304	Development of a second backscatter signature independent of dredge source (see report) with a core width of 60 m and max TSS <80 mg/L; signature extending to the sideslopes	

Table 4. 19 November 2008 Far Field Ebb Tide Survey Transect Summary Table

Transect Number	Figure Number	Time	Approximate Distance to Dredge (m)	Transect Length (m)	Plume Description	Additional Field Remarks
A01	9a	15:15:29	110	250	Ambient	
A02	9b	15:17:34	177	306	Ambient	
A03	9c	15:20:43	232	281	Ambient	
T01	9d	15:24:07	30	309	Max TSS at the surface primarily at 200-300 mg/L with core plume at 100 m width and 100-150 mg/L	Plume: 13-15 m off stern of dredge
T02	9e	15:27:16	100	323	Core of the plume centered in middle water column with 100 m width and max TSS <100 mg/L	
T03	9f	15:30:16	145	311	Core of the plume centered in middle water column with 120 m width and max TSS <90 mg/L	Noticed OBS Array # 3 drifting; prop wash from survey vessel leaving dredge
T04	9g	15:33:38	220	310	Core of the plume dispersed over 180 m width with max TSS <80 mg/L	
T05	9h	15:45:50	236	313	Core of the plume dispersed over 180 m width with max TSS <80 mg/L	Restarted approx. near where previous transect
T06	9i	15:49:12	295	345	Core of the plume dispersed over 200 m width with max TSS <70 mg/L	
T07	9j	15:52:29	342	429	Core of the plume dispersed over 200 m width with max TSS <70 mg/L	Prop wash from survey vessel at surf
T08	9k	15:56:37	423	430	Core of the plume dispersed over 200 m width with max TSS <60 mg/L	
T09	9l	16:00:16	486	437	Core of the plume dispersed over 200 m width with max TSS <60 mg/L	Prop wash from survey vessel at surf
T10	9m	16:04:35	604	455	Core of the plume dispersed over 200 m width with max TSS <50 mg/L	
T11	9n	16:08:20	767	470	Plume dissipated	Dredge washing scow

Table 5. Sediment Collection and Analyses Summary Table.

			Grain Size Distribution[1]						Bulk Density[2]			Atterberg Limits[3]			
Area	Date Sampled	Time Sampled	Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Wet Bulk Density	Moisture Content	Dry Bulk Density	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
			(%)	(%)	(%)	(%)	(%)	(%)	(lb/ft3)	(%)	(lb/ft3)				
Dredge Field	11/18/2008	1145	0.0	0.0	1.0	2.5	62.5	34.0	81.2	138	34.1	80	29	51	2
Dredge Scow	11/18/2008	1200	0.0	0.0	1.0	2.0	66.0	31.0	82.7	121	37.5	86	31	55	2
Dredge Field	11/19/2008	1055	0.0	0.5	0.5	2.0	62.0	35.0	79.5	175	28.9	83	30	53	3
Dredge Scow	11/19/2008	1115	0.0	0.0	1.0	1.0	63.0	35.0	80.3	138	33.7	86	30	56	2

[1] ASTM D-422 Method

[2] ASTM D-2937 Method

[3] ASTM D-4318 Method