Figure 3.8-8. Evidence of epifaunal activity. This image from Cell LU Station I08, taken during the Post 1 survey, shows evidence of recent epifaunal activity on the cap material surface in the form of tracks.

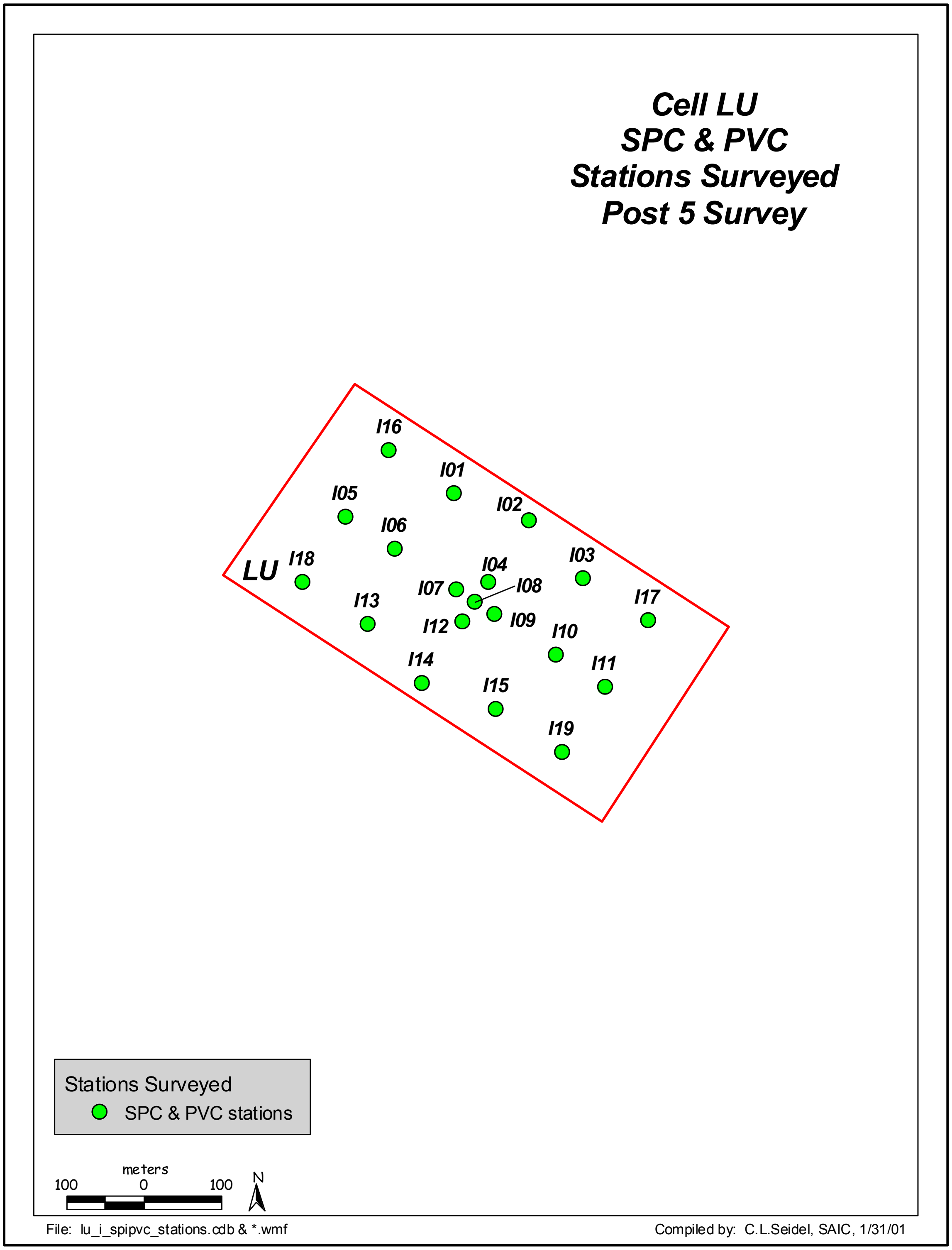


Figure 3.8-9. Cell LU SPI and PVC stations surveyed during the Post 5 survey.

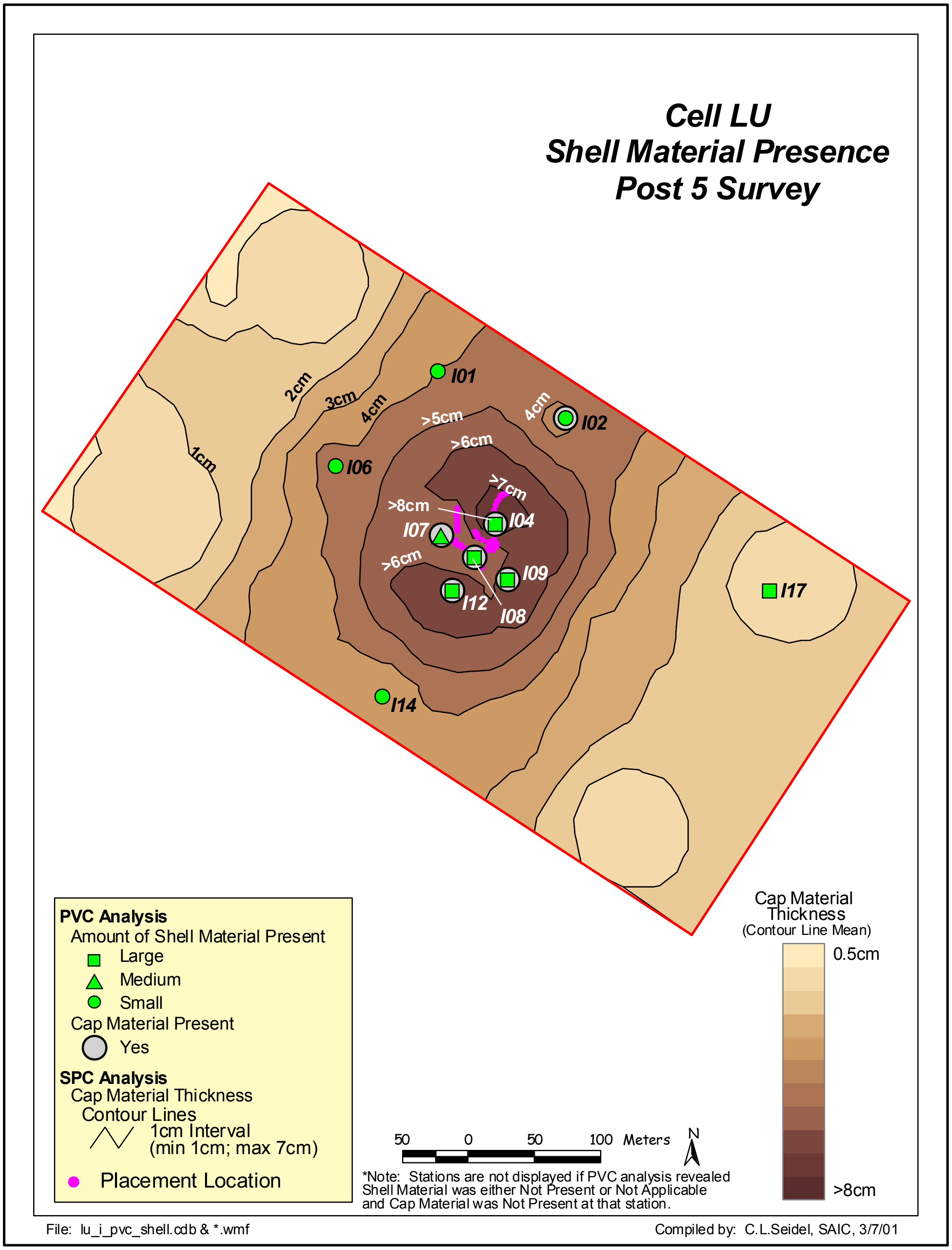


Figure 3.8-10. Lateral extent of cap material based on plan view image (PMI) analysis, Post 5 survey. The plan view image data are overlain on the SPI cap material footprint.

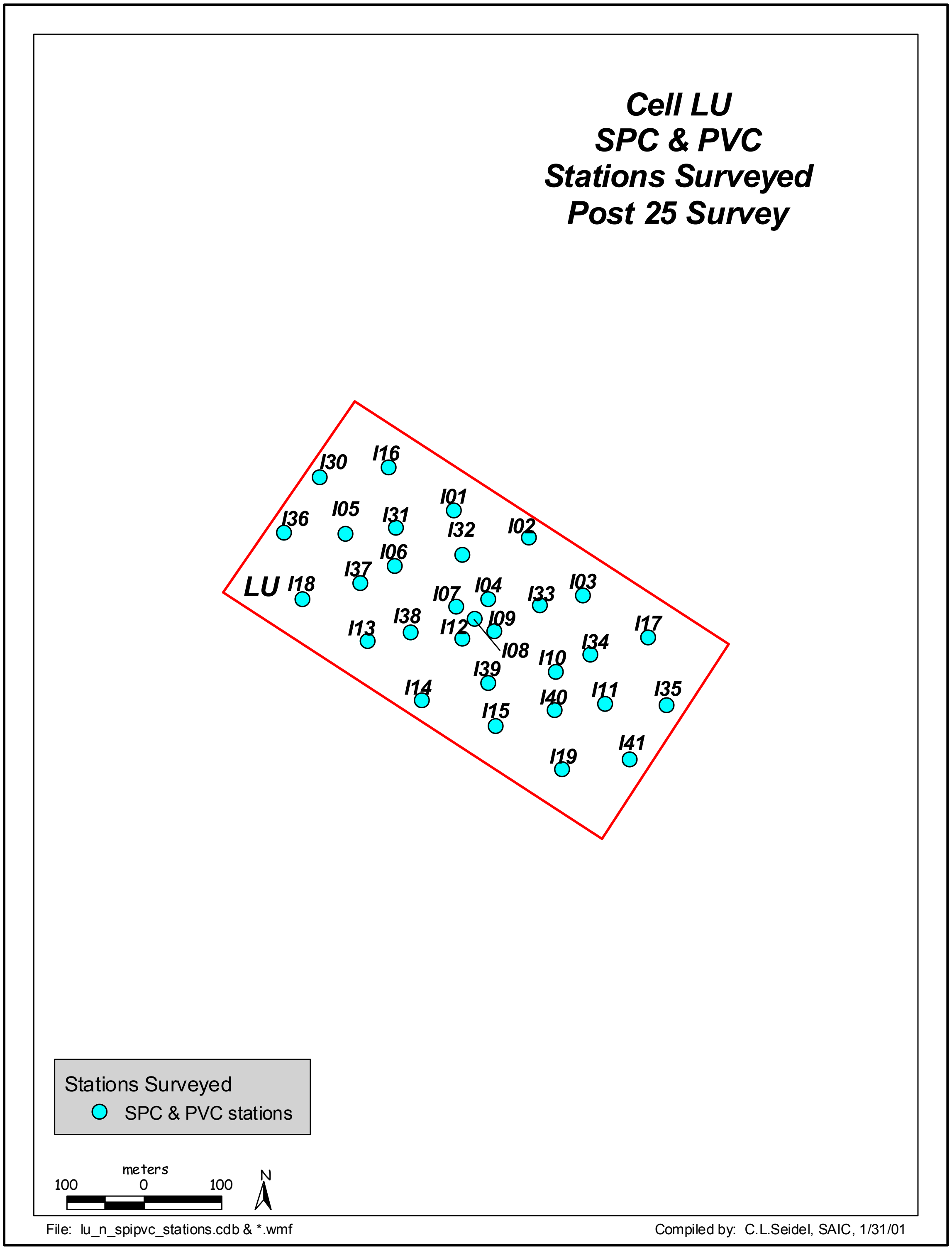


Figure 3.8-11. Cell LU SPI and PVC stations surveyed during the Post 25 survey.

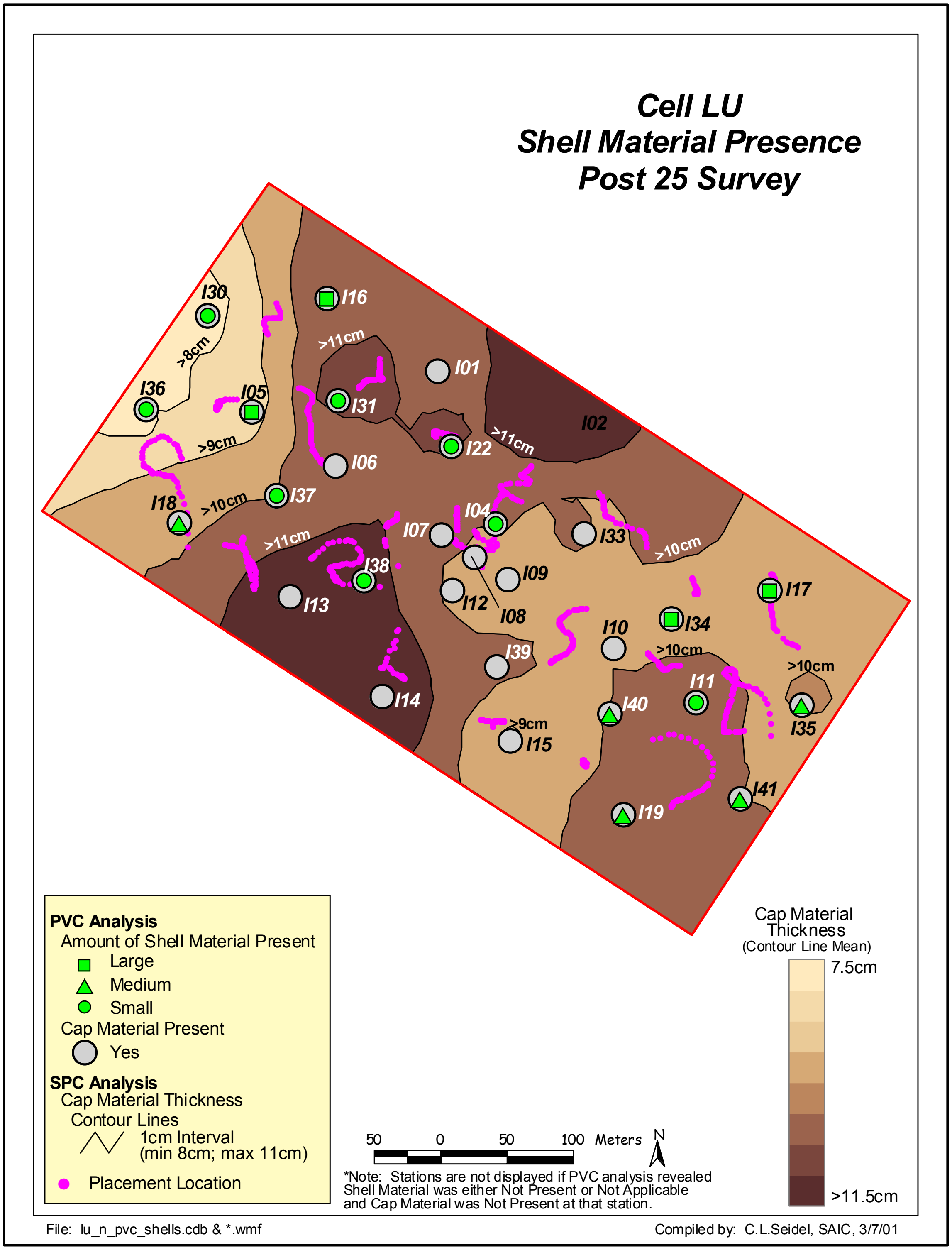


Figure 3.8-12. Lateral extent of cap material based on plan view image (PMI) analysis, Post 25 survey. The plan view image data are overlain on the SPI cap material footprint.

Figure 3.8-13. Physical processes. The uniform sand waves in these images from Station I11 and I30, taken during the Cell LU Post 25 survey, suggest a slight re-working of the cap material surface due to physical processes such as currents.

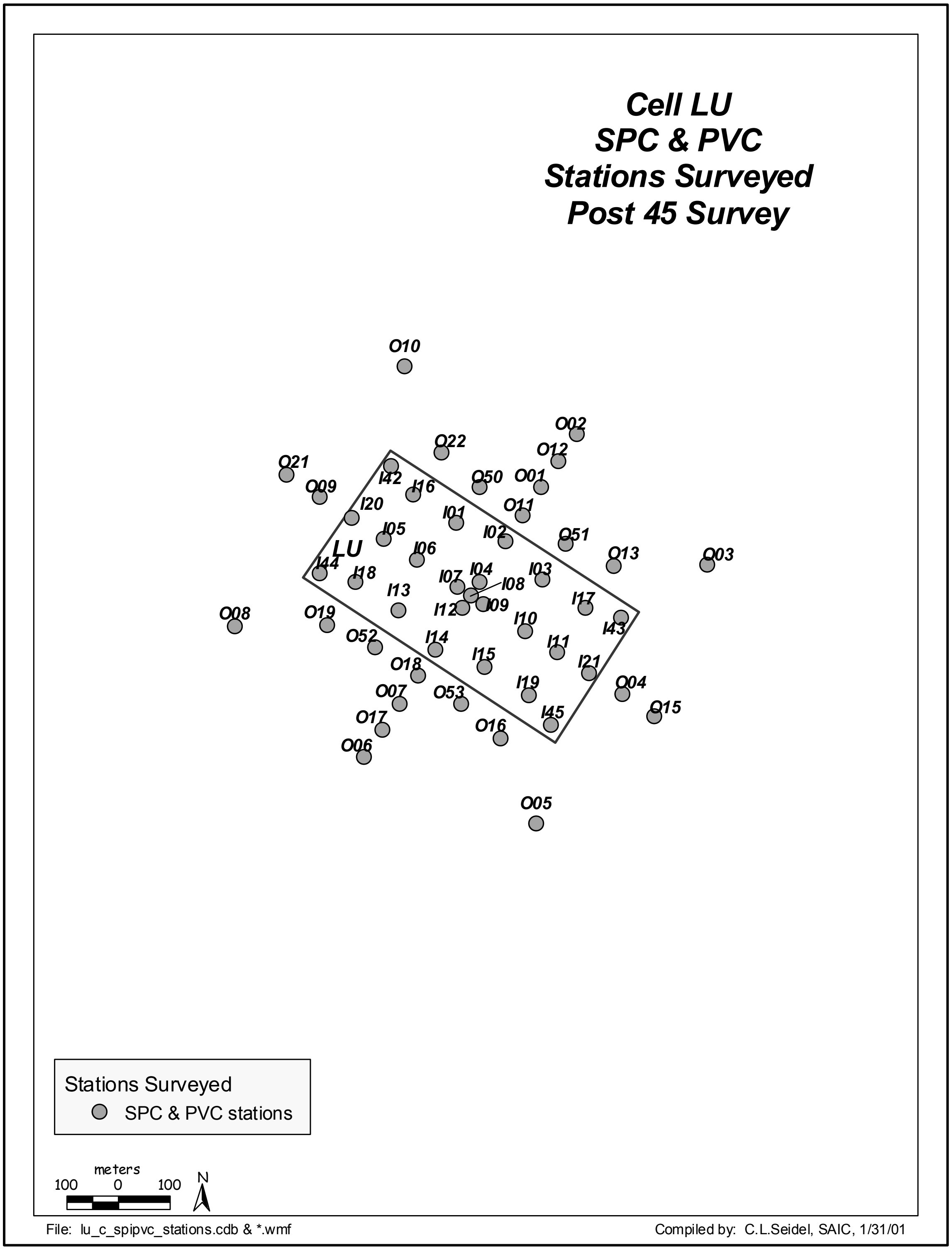


Figure 3.8-14. Cell LU SPI and PVC stations surveyed during the Post 45 survey.

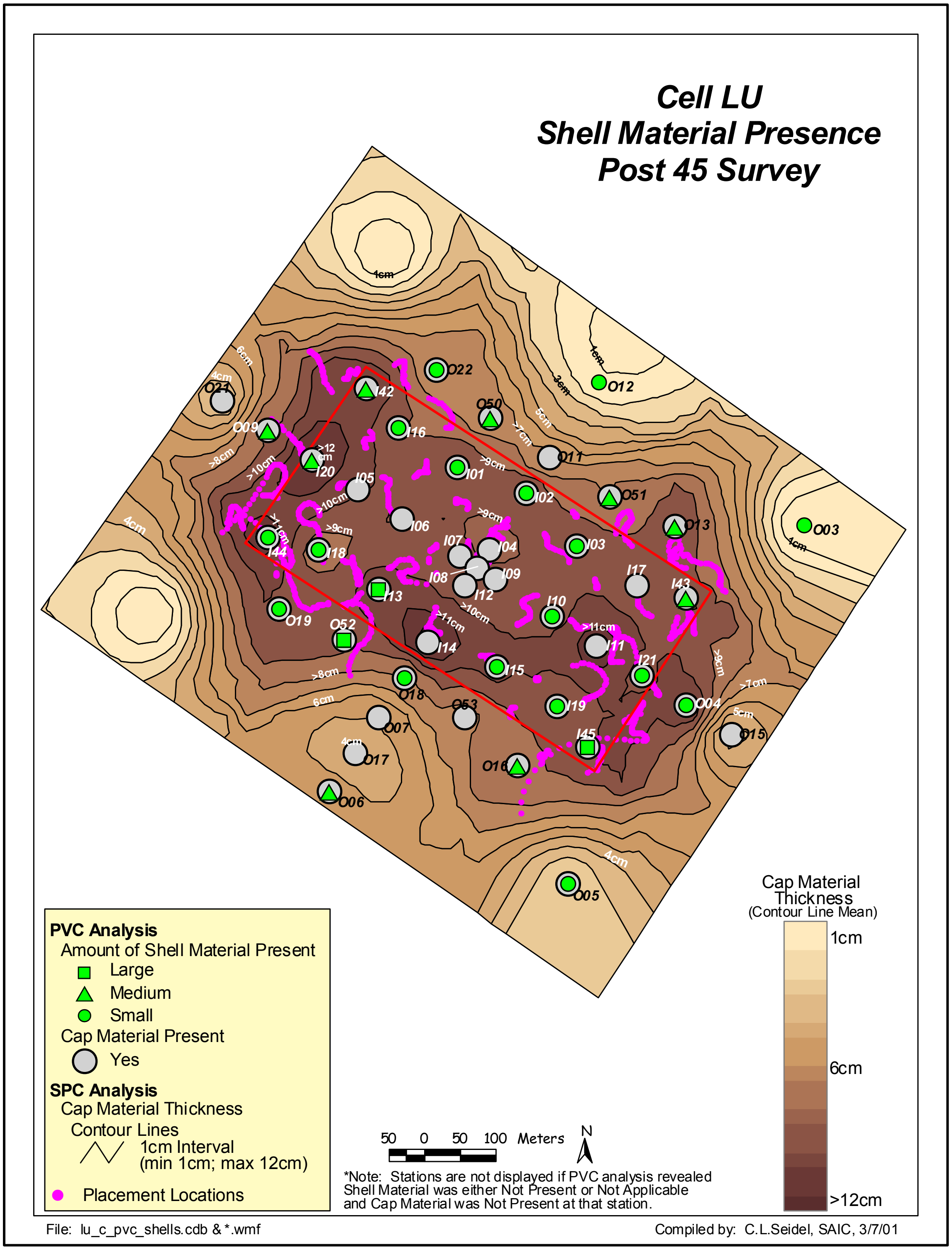


Figure 3.8-15. Lateral extent of cap material based on plan view image (PVI) analysis, Post 45 survey. The plan view image data are overlain on the SPI cap material footprint.

Figure 3.8-16. Epifaunal activity. The track leading to this recently re-excavated burrow at Cell LU, Station I14, provides insight into the foraging activities of this fish. The image was acquired during the Post 45 PVC survey.

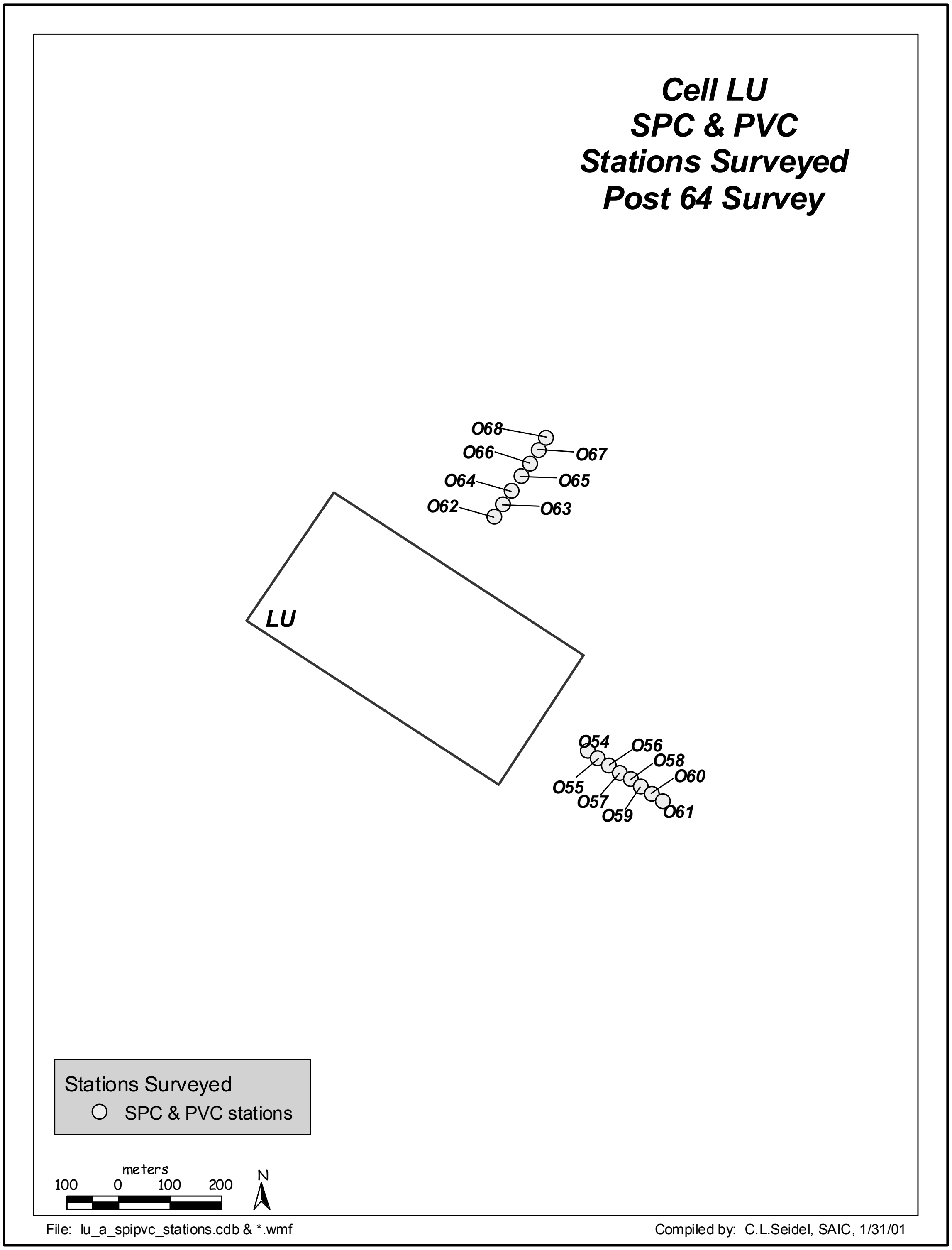


Figure 3.8-17. Cell LU SPI and PVC stations surveyed during the Post 64 survey.

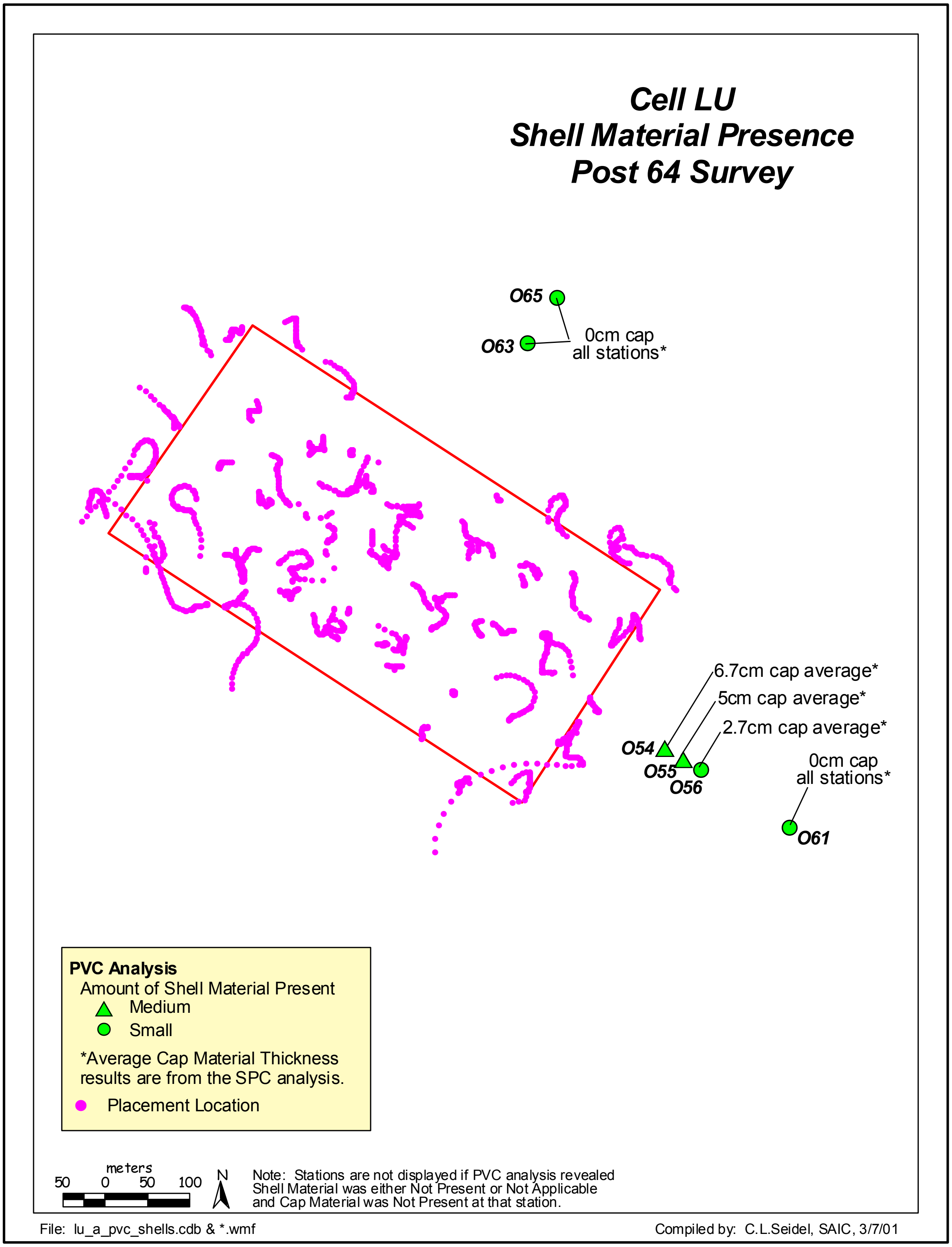


Figure 3.8-18. Lateral extent of cap material based on plan view image (PVI) analysis, Post 64 survey.

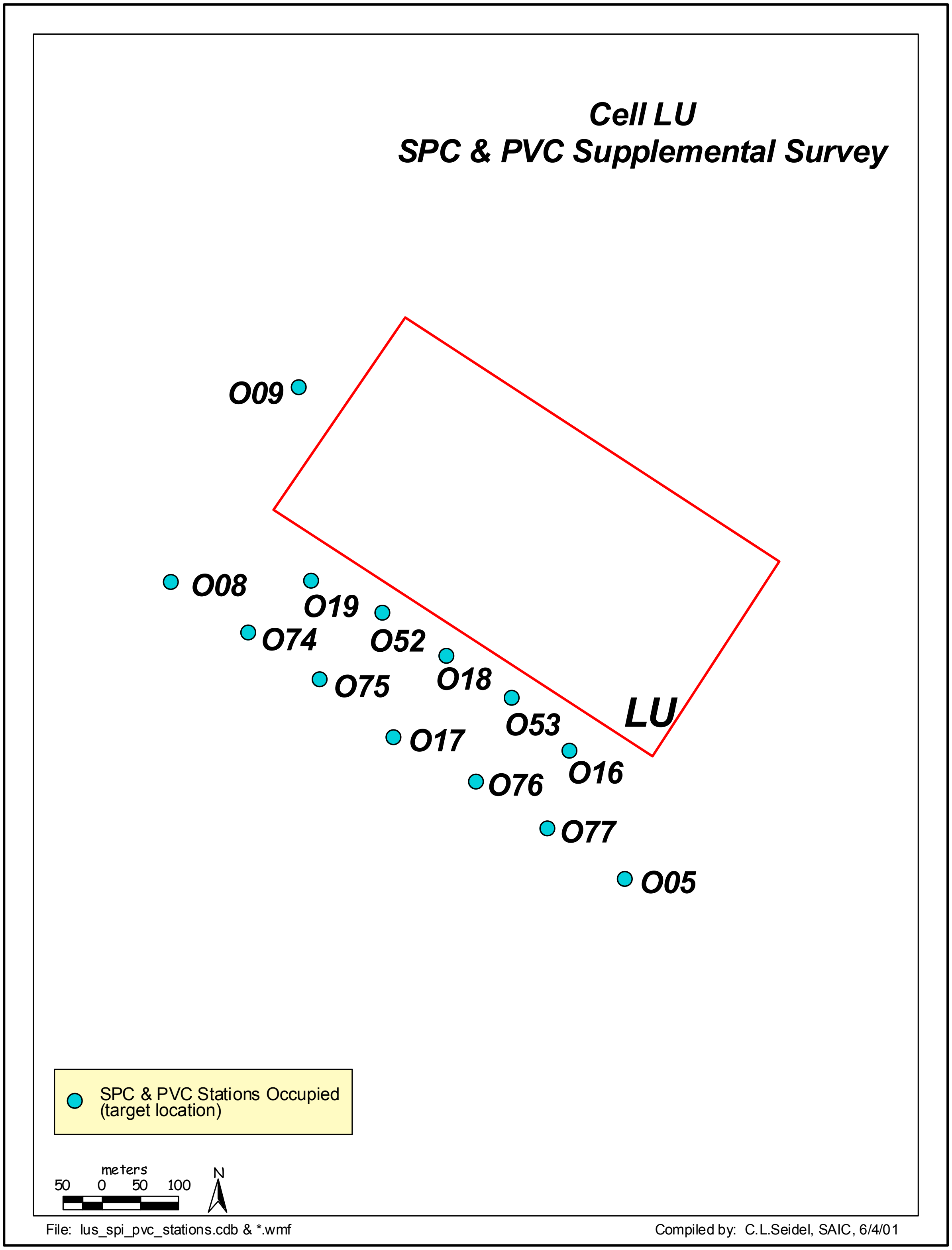


Figure 3.8-19. Cell LU SPI and PVC stations surveyed during the supplemental survey.

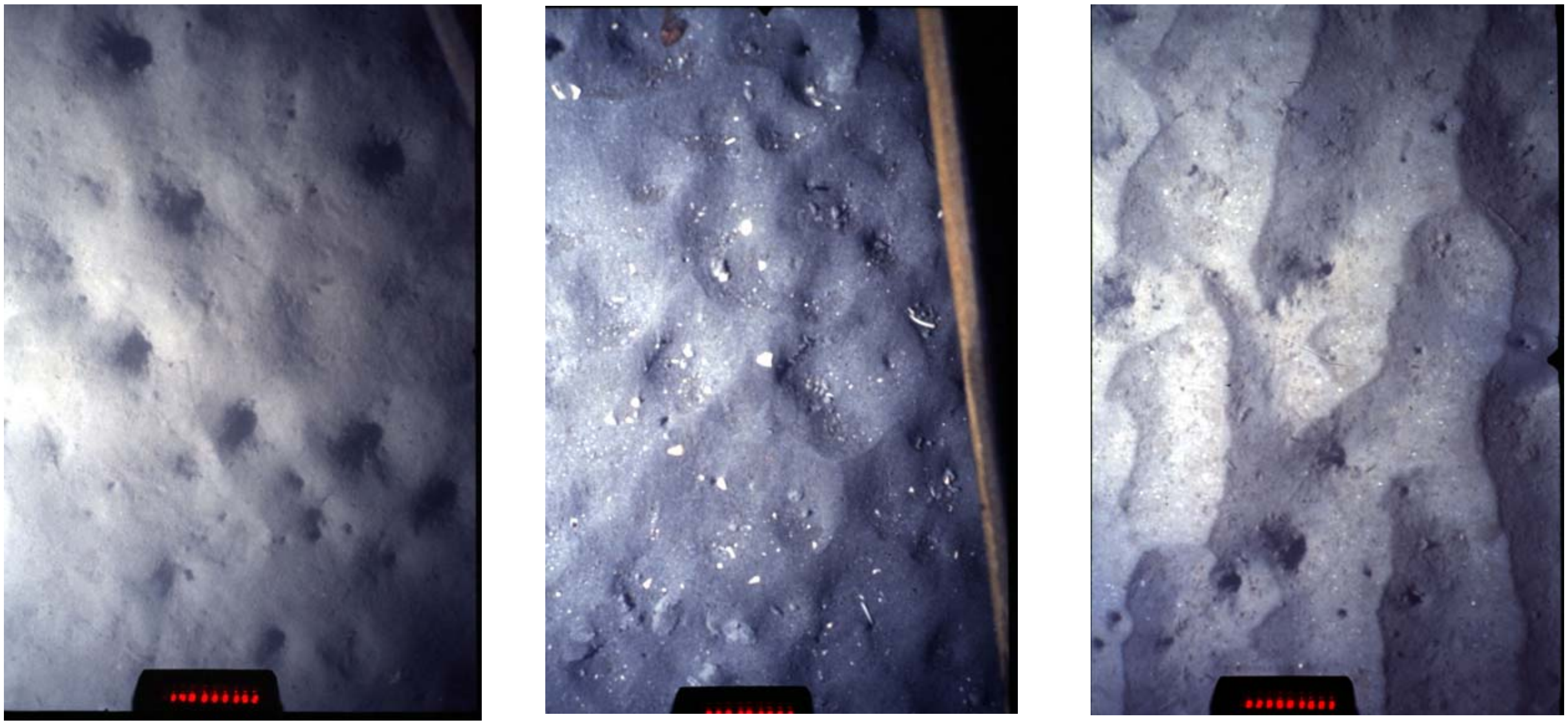


Figure 3.8-20. Temporal comparison between Cell LU Station O09 plan view images acquired during the baseline, Post 45 and Supplemental surveys. The image taken during the Post 45 survey indicates that cap material exists as the biological burrows that can be seen in the Background image are filled. The re-excavation of this material is evident in the image taken during the Supplemental survey based on the re-appearance of these burrows. Also note the sand ripples that can be seen in the Supplemental survey image, suggesting that the sediment surface is being re-worked by physical processes such as bottom currents.

3.9 Seafloor Video Results from Cell LU

3.9.1 Overview of Field Sampling Plan

The field sampling plan for the seafloor video surveys in Cell LU followed the methods described in the Field Sampling Plan (FSP) of the Interim/Postcap PWP (SAIC 2001). Table 3.9-1 summarizes the video activities that were conducted in Cell LU for the Pilot Capping Project. The table presents the actual video surveys that were conducted during the Interim/Postcap project, as deviations from the planned FSP were made throughout each of the placement events. As described below in Section 3.9.2, the primary objective of the video surveys was to document plume surge at varying distances from the point of sediment release. Due to unexpected difficulty in deploying, retrieving, and maneuvering the camera system quickly, the majority of the surveys were conducted at one fixed point or while drifting during or after placement events. A total of four (4) video surveys were conducted in Cell LU. This exceeded the stated requirement in the FSP of performing a minimum of three (3) video surveys in Cell LU. A detailed description of each of these survey events can be found in the Cruise Report (SAIC 2000b).

3.9.2 Review of Data Quality Objectives

Table 3.9-2 presents a summary of the Data Quality Objectives (DQOs) for the seafloor video surveys. A more detailed description of the DQO's can be found in the PWP (SAIC 2001). The purpose of this section is to provide a brief assessment as to whether these DQOs were met. It should be noted that these DQOs were not established for the individual pilot cells, but rather for the video survey monitoring in general. Therefore, the DQO assessment presented in this section is applicable not only to Cell LU, but to all of the interim/postcap video monitoring.

The primary objective of the seafloor video surveys was to record visual evidence for the characteristics (speed and thickness) of near-bottom surge with increasing distance from the point of cap material release to a point where surge is minimal. This objective was only partially met and deviations from the planned FSP were made throughout the video surveys. These deviations were made in response to a number of unforeseen problems including difficulties in deploying and retrieving the camera system quickly enough to move ahead of the plume at each 25 meter-spaced station, coupled with periodic difficulties in vessel positioning and maneuvering. Typically, video was collected at only one stationary position for each placement event or while drifting, and not at a number of stations at varying distances from the point of disposal as planned.

3.9.3 Technical Considerations

A number of problems were encountered during the video surveys that affected the amount and type of video footage that was obtained. These problems included insufficient operational capabilities (e.g., winch capacity) of the survey vessel R/V *Bottom Scratcher* coupled with a relatively in-experienced R/V *Bottom Scratcher* field crew. These problems made real-time data acquisition difficult, as the platform was not mobile enough to quickly move to multiple stations during the video surveys. Another problem encountered during the video surveys was the anchoring of the boat in order to maintain station. As with the insufficient winch capacity, the inability to retrieve the anchor and the video equipment in a timely manner created a trade-off for mobility to effectively track the plume. A third problem that was identified as affecting data quality was the fact that the video system was tethered to the vessel by the winch wire and video cable. This caused the system to bob up and down in the water column due to boat heave and at times slam into the seafloor.

3.9.4 Monitoring Results

Placement 1 Survey

The Cell LU Placement 1 video survey was conducted on August 2, 2000. A total of 4 stationary sites and one drift were surveyed (Figure 3.9-1). Approximately 19 minutes of footage was acquired during the survey. At the first stationary site the vessel was positioned to be approximately 50 meters from the planned location of disposal, the center of Cell LU (Station I08). The vessel was not anchored. The other stations were spaced at approximately 150, 225 and 350 meters from the center of Cell LU and were occupied after placement in an attempt to get ahead of the leading edge of the plume after disposal. Due to unexpected maneuvering by the dredge during placement, the video survey vessel was required to abruptly move away from the dredge during the initial placement to avoid collision. This resulted in somewhat erroneous data, as the video system was in motion (pulling away) as cap placement was taking place. The plume was clearly visible and appeared to be surging from the west, which was not possible and was the result of the video vessel maneuvering to avoid the dredge. The estimated velocity of the plume at this point was approximately 2.08 meters per second. The sediments that were visible in the surge appeared to be very fine-grained sediments. A number of downcasts, where the video camera was raised and lowered, were conducted at the outlying stations to try to determine plume thickness. The survey vessel was not able to get ahead of the plume surge at these stations, and therefore plume surge and velocity could not be calculated.

Post 5 Survey

The video survey conducted in Cell LU on August 15th was not associated with any disposal event in that cell. The survey was performed after the planned video survey was conducted in Cell LD. The most recent placement event at this time was the Post 5 disposal that was conducted on August 13, 2000. The survey in Cell LU was conducted while drifting. The vessel drifted SW to NE across the center of the cell to help establish the boundaries of the most recent placement events in that cell (Figure 3.9-2). The speed of the drift was approximately 0.25 to 0.5 knots.

Approximately 30 minutes of video footage was taken during the drift. The drift began at 20:44:26 GMT. Approximately two and a half minutes later (20:47:04) cap material was visible within the cell. The material was initially distinguishable by the presence of a large amount of shell material and clay clasts. At approximately 20:58:00 biological burrows filled with cap material were visible. Approximately 21 minutes later (21:19:00) a clear transition from cap material to ambient sediments can be seen as the amount of shell fragments begin to decrease and the number of open biological burrows begins to increase.

An additional video survey was attempted near Cell LU on August 15, 2000, with the intent of towing the system lengthwise through the cell to identify cap material. However, the video system became tangled in the video cable due to the speed of the vessel and no data were obtained.

Placement 8 and 9 Surveys

The video survey conducted on August 22, 2000, in Cell LU was to monitor the plume of Placements 8 and 9 in Cell LU. The purpose of the surveys was to collect video data from the beginning of the disposal until the plume was no longer visible. Eight down casts were taken through the plume associated with Placement 8 (Figure 3.9-3). A total of 21 down casts were taken during Placement 9.

Narrative Placement 8

"At approximately 16:54:22 GMT the dredge begins to deposit cap material taken from the Queen's Gate site near the eastern edge of Cell LU. The dredge is placing material on a stationary point. The distance between the two vessels at this point is approximately 150 meters. This time and distance represents the starting time and point that are used to measure the plume surge and velocity associated with the placement of the cap material. Approximately four minutes after placement (16:58:49) the leading edge of the plume becomes visible beneath the video camera. The plume arrives from the northeast and was moving to the southwest at an estimated velocity of 0.56 meters per second. The surge maintained this velocity for at least one minute (16:59:59) and a number of downcasts, where the video camera was raised and lowered, are performed to determine the thickness of the plume layer. These downcasts indicate that the plume is approximately three to five meters thick approximately 14 minutes (17:12:42) after cap material placement. The depth of the water at this site is approximately 45 meters deep. The bottom of the plume appears to lie directly on the seafloor. After repeating a number of additional downcasts, the video camera system is retrieved aboard the survey vessel at 17:13:58, approximately 15 minutes after cap material placement."

Narrative Placement 9

"At approximately 20:15:34 GMT the dredge begins to deposit cap material taken from the Queen's Gate site near the eastern edge of Cell LU. The dredge is placing material on a stationary point. The distance between the two vessels at this point is approximately 150 meters. This time and distance represents the starting time and point that are used to measure the plume surge and velocity associated with the placement of the cap material. Approximately three and a half minutes after placement (20:19:09) the leading edge of the plume becomes visible beneath the video camera. The plume arrives from the northeast and is moving to the southwest at an estimated velocity of 0.71 meters per second. The surge maintains this velocity for at least two minutes (20:21:28) and a number of downcasts, where the video camera is raised and lowered, are performed to determine the thickness of the plume layer. These downcasts indicate that the plume is approximately four to eight meters thick approximately 24 minutes (20:39:09) after cap material placement. The plume thins to 1 to 2 meters in depth approximately 34 minutes after placement (20:49:51). The depth of the water at this site is approximately 46 meters deep. The bottom of the plume appears to lie directly on the seafloor. After repeating a number of additional downcasts, the video camera system is retrieved aboard the survey vessel at 20:56:09, approximately 40 minutes after cap material placement."

Table 3.9-1. Summary of Seafloor Video Field Sampling Effort

Stationary/Drift	3.75	5	Y	14	42
Drift	0.5	----	Y	----	30
Drift		----	N	0	----

Table 3.9-2. Monitoring Objectives and Approach for Surge Video Documentation

Monitoring Objective	Data Requirements	Monitoring Approach	Field Decision Criteria/Performance Specifications
Record visual evidence for and characteristics (speed and thickness) of near-bottom surge with increasing distance from the point of release to a point where surge is minimal	Edited video record of surge (as indicated by visual changes in particle concentrations, particle velocities, and erosion, resuspension, or mass movement of bottom sediments) at specific distances from point of release	Deploy video camera at locations in cell LU, SU, and two other events at 50 m, 75 m, 100 m, and 200 m from disposal point and collect video records immediately following placement events	Navigational accuracy for both the camera location and cap placement location; Acceptable video quality record (adequate light, depth of field, directional orientation)

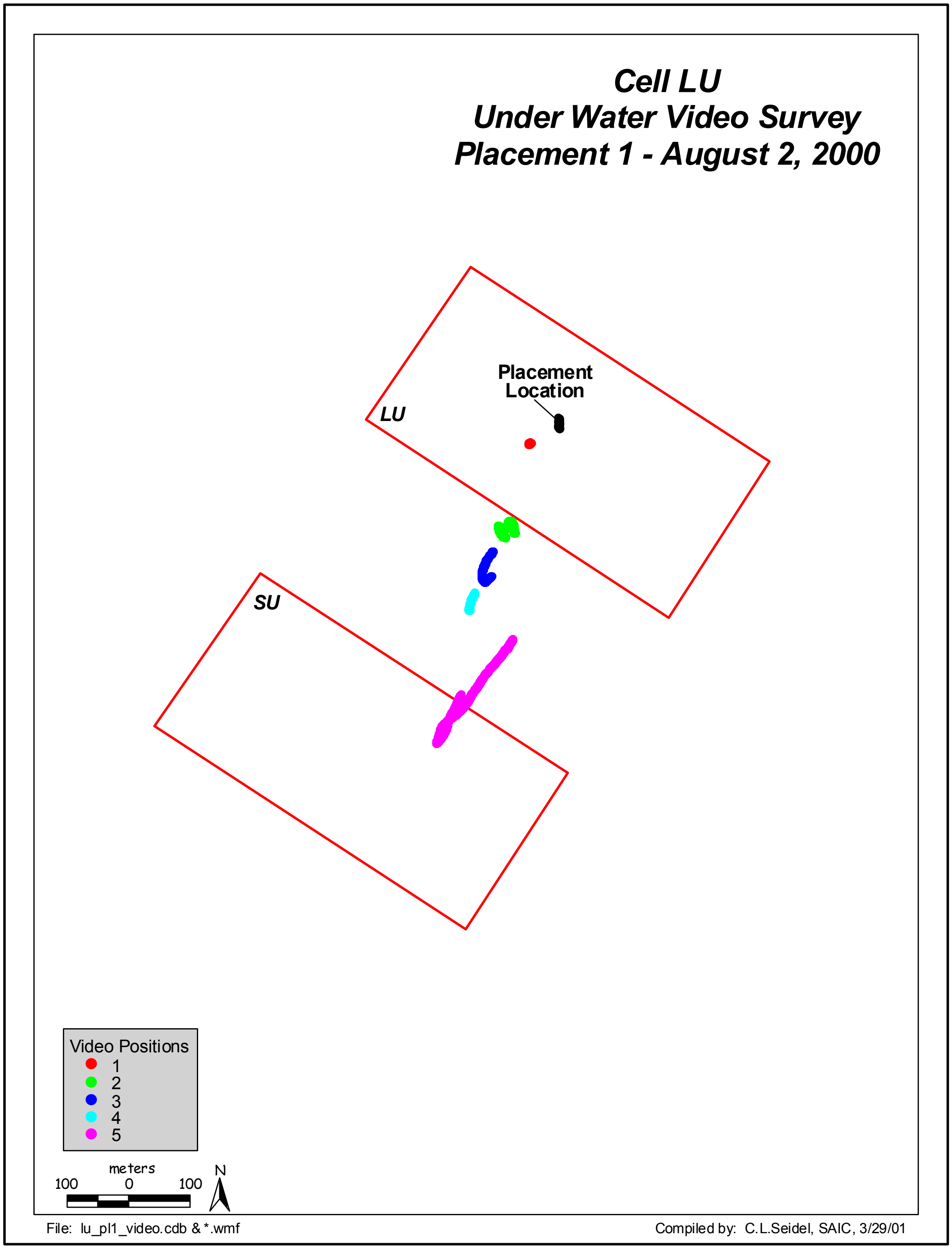


Figure 3.9-1. Cell LU placement 1 video survey.

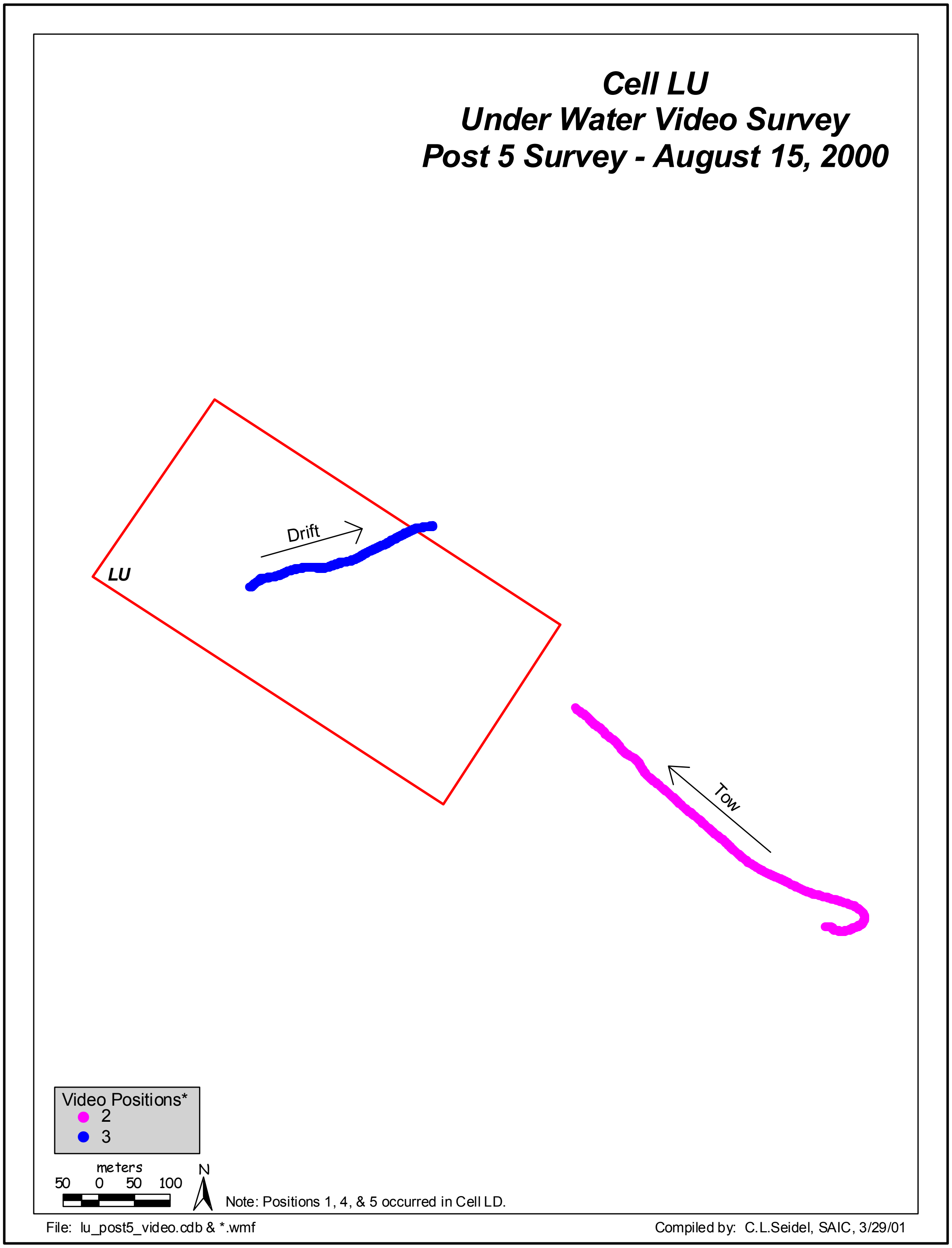


Figure 3.9-2. Cell LU Post 5 video survey.

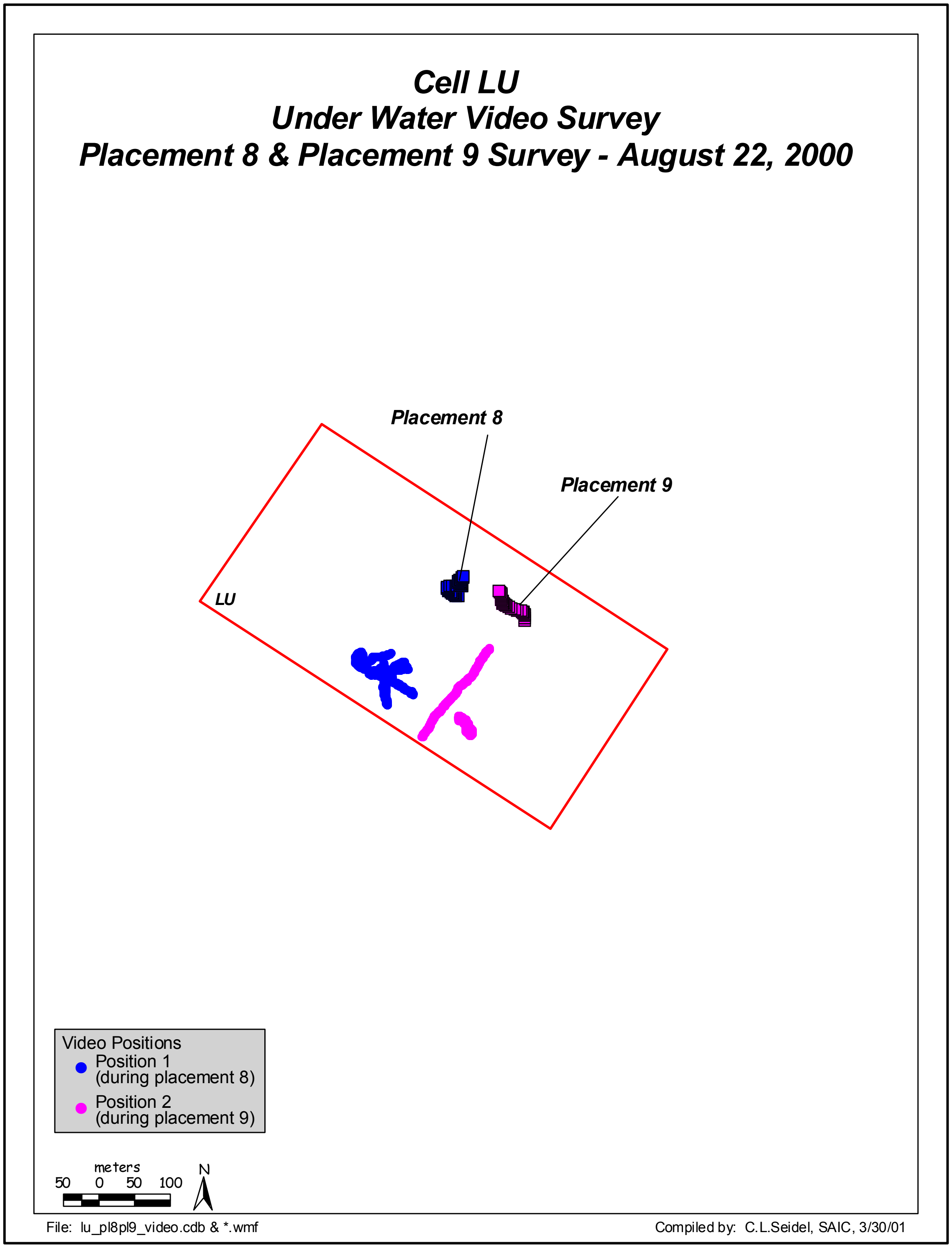


Figure 3.9-3. Cell LU placement 8 and 9 video survey.

3.10 Side-scan Sonar Results

3.10.1 Overview of Field Sampling Plan

An initial side-scan survey of Cell LU was conducted for baseline monitoring, and five follow-up surveys were conducted periodically during active cap placement within Cell LU. Two of the five follow-on side-scan surveys were originally planned, and three were added as flex operations. Side-scan monitoring activities conducted in Cell LU are summarized in Table 3.10-1, along with an overview of ADISS and SPI monitoring activities. Both ADISS and SPI monitoring data were very useful for analysis and interpretation of side-scan sonar imagery.

3.10.2 Review of Data Quality Objectives

The primary monitoring objectives for side-scan data analysis were the ability to determine distributions of cap sediments, bottom disturbance features, and topography after both a single placement event and final cap placement. Monitoring objectives for side-scan operations were presented in the PWP and are summarized in Table 3.10-2. All side-scan data acquisition efforts within Cell LU were successful, and full-bottom coverage imagery was obtained from each of the monitoring surveys. Except for occasional loss of the differential signal, navigational accuracy met or exceeded the ±3 m data quality objective for all side-scan operations. Thus, data quality objectives for side-scan sonar were achieved.

3.10.3 Technical Considerations

Initially, side-scan survey lines were planned to run both parallel and perpendicular to the existing bottom contours, to provide 200% bottom coverage. Although survey lines parallel to bottom contours generally provide the most efficient scheme for side-scan data acquisition, changes in the towfish aspect can produce a different acoustic image of a seafloor feature. This difference tends to be more pronounced in smaller and irregularly-shaped features (e.g., small, man-made debris) that may not be well ensonified along a particular track. For instance, a narrow feature (e.g., a small wreck) oriented perpendicular to the survey track would not be well defined because only a few acoustic pulses would reflect off the feature. If the survey line had instead been oriented along the main axis of the feature, then it would have been well reflected (and defined) by numerous acoustic pulses.

A point cap material placement event generally appears as a large, round, and symmetrical bottom feature. Consequently, towing aspect would not have a major impact on acoustic images observed within the PV capping cells. This was evident in comparisons between two acoustic images of the same point placement feature from side-scan data acquired along perpendicular trackline headings during the same time period (Figure 3.10-1). Because water depth changes rapidly within the placement site, it was difficult to track and maintain the proper towfish altitude on the survey lines that were aligned perpendicular to the steep sloping bottom. Although at least 200% bottom coverage was obtained during each of the side-scan operations, most of the higher quality coverage data came from track lines run parallel to the shore. After the Post-5 survey, all subsequent side-scan operations used only survey lines that were aligned parallel to bottom contours.

During all but the baseline survey, the presence of large schools of fish throughout the water-column impacted the quality of the side-scan records. In image mosaics, schools of fish generally appeared as small, dark, and irregularly-shaped patches scattered randomly throughout the records. The actual intensity of the acoustic return from a fish school was dependent on the density and location (depth) in the water column. Schools located nearer to the surface appeared dark and well defined, whereas those lower in the water column appeared lighter and less defined. Although fish may appear in the records as hard bottom features, their acoustic signature is somewhat different and generally can be distinguished from true bottom features. Schools of fish were present during most side-scan operations; however, they did not significantly obscure any bottom features. Figure 3.10-1 has been annotated to indicate several different views of fish schools.

The only other non-placement related feature of interest was the sewer outfall pipe in the southern portion of the survey area, well below Cell SU. As shown in Figure 3.10-1, this feature accurately overlays the charted sewer outfall (as depicted on NOS Chart 18476). During the periodic side-scan operations, numerous survey lines were run over this feature to provide a check on data quality for the navigation and side-scan sonar systems.

Immediately after data acquisition, side-scan data were analyzed and edited as necessary using Triton-Elics ISIS® software. After initial quality control and data processing, a full-bottom coverage image mosaic was created using Triton-Elics Delph-Map® software. Mosaics were then saved as a geo-referenced TIFF file and imported into Arcview® for additional analysis. Within Arcview®, any features of interest could be examined more closely at much larger scales, and mosaic images could be overlaid on top of one another to view differences or similarities in the imagery. In addition, side-scan mosaics could be viewed in conjunction with other relevant data sets acquired within the same area during a similar time period. Of particular interest, were the ADISS placement and cap thickness contour data from sediment profile imagery (see Section 3.7). Because the initial evaluation of side-scan data was based on subjective interpretation of the imagery, the additional data sets were invaluable for verifying the validity of this interpretation. Results from each of the side-scan monitoring surveys, listed in Table 3.10-1, are addressed in the following sections.

3.10.4 Monitoring Results

3.10.4.1 Baseline Survey

The image mosaic created for the baseline side-scan survey data is shown in Figure 3.10-2. This mosaic shows a relatively uniform and undisturbed seafloor with no prominent differences and few distinguishing features. The sewer outfall discussed above was evident in the southern portion of the survey area and a small, rectangular feature (11 m long) was detected in the inshore portion of the southern cross-slope survey lane. As noted earlier, the baseline survey was somewhat unique in comparison with subsequent monitoring surveys because no schools of fish were evident.

3.10.4.2 Post 1 Survey

The Post-1 side-scan survey was conducted eight days after a single placement event in the center of Cell LU. As depicted in Figure 3.10-3, this placement event can be clearly identified in the side-scan mosaic, and the image correlates well with the ADISS position for this event. It is likely that this initial placement created a slight impact depression as it struck the seafloor, and a mix of displaced sediment and cap material surged laterally outward from the main impact area. This disturbed area exhibits a much stronger acoustic signature than the ambient bottom material and, therefore, shows up clearly on the side-scan mosaic. The SPI cap contours corresponding to the thicker portions of the cap (Section 3.7) match the darker portions of the image mosaic, and represent areas where the cap layer thickness is greater than 4 cm. The outer extent of the lateral surge pattern seen in the imagery appears to correspond well with the 2 to 4 cm SPI cap contour. The thin layer of cap material (<2 cm) indicated in the outer portions of the SPI cap contours, cannot be differentiated from ambient material in the side-scan imagery.

3.10.4.3 Post 5 Survey

The Post 5 side-scan survey was conducted six days after the fifth placement event. Placement events two through five were all directed near the center of Cell LU, within the footprint of the first placement event. As depicted in Figure 3.10-4, the general placement area can be identified in the side-scan mosaic, and the image correlates well with the ADISS positions for the five prior placement events. It is not possible to identify each individual placement event, because each later placement essentially covered-up the remnants of the previous placement. This placement strategy of targeting within the prior cap impact area was used so that each subsequent placement event impacted already placed cap material instead of ambient material. Although the lateral surge from the first placement event probably comprised both cap material and some displaced ambient material, the lateral surge from the subsequent placement events was probably due solely to cap material.

As the cap layer was built-out from the center, ambient material displaced during the first placement was covered with additional cap material surging outward from each subsequent placement event. Since the bottom disturbance from these events occurred on recently placed cap material and already disturbed bottom, the apparent cap footprint depicted in this mosaic is actually less pronounced than the footprint indicated from the Post 1 survey. These results illustrate that because of differences in the extent of bottom disturbance, the acoustic footprint of a placement event is more pronounced when it has impacted ambient material than recently placed cap material. Essentially, the side-scan image is providing a measure of the disturbance footprint, and not a true cap footprint. The SPI cap contours indicate that the cap area was enlarged considerably during the five placement events, primarily outward from the center of the cell (Figure 3.10-4). Because the image mosaic essentially shows the seafloor impact from only the most recent placement event, it is not possible to correlate the SPI cap thickness from five events with apparent cap footprint depicted on the mosaic.

3.10.4.4 Post 25 Survey

The Post 25 survey was conducted one day after the 25th placement event. Placement events 6 through 25 were directed throughout Cell LU, beginning near the center and then working outward towards the cell boundaries. This strategy was employed so that each placement event was primarily impacting already placed cap material and not ambient sediment. As the cap layer was built out, potential placement target areas also expanded outward. As depicted in Figure 3.10-5, general placement areas can be identified in the side-scan mosaic, and the image correlates well with ADISS positions for these events. Several individual placement disturbance areas near the center of the cell are not evident because the disturbance footprint from nearby later placement events had covered them. Because the placement events during this period were more evenly spread, the apparent cap footprint images for the outer placement events closely resemble the single cap footprint images obtained during the prior surveys. Although most of the placement events can still be identified in the mosaic, some of the records are obscured or blurred by fish interference low in the water column.

3.10.4.5 Post 45 Survey

The Post 45 survey was conducted four days after the 45th placement event. Placement events 26 thru 45 were directed along the outer edges of Cell LU. As depicted in Figure 3.10-6, many of the specific placement events can be identified in the side-scan mosaic along the edges of the placement cell, and the image correlates well with ADISS positions for these events. This mosaic included several narrow and linear bottom features that were not detected on any of the earlier side-scan surveys. A close examination of these features revealed that each of these features originated from the site of a recent point placement event. Because the placement event images on the mosaic corresponded so well with actual ADISS placement data, these linear features may represent a cap material trail left by the dredge as it departed the placement site with its hull still open and pumps still operating. Although ADISS plots typically present the dredge approach to the site and the main placement location, position data are also recorded as the dredge departs the placement site. By overlaying dredge departure data on the side-scan mosaic, it was clear that these features represent a narrow cap material trail. Although the departure trail from Placement Event 45 shows up most prominently as it runs the entire length of the cell, numerous other trails are also evident in the mosaic. Several of these features have been highlighted in Figure 3.10-6.

3.10.4.6 Post 68 Survey

The Post 68 survey was conducted one day after the 68th placement event. Placement events 46 thru 68 were located around the center portions of Cell LU, with anywhere from two to four placement events directed to the same target location. Because many of these placement events were directed to the same location, only the most recent events are evident in the side-scan mosaic. As depicted in Figure 3.10-7, many of the specific placement events can be identified in the side-scan mosaic near the center of the placement cell, and the image correlates well with ADISS positions for these events. As with the Post 45 survey mosaic, several narrow and linear bottom features were detected, and though they were more clustered and uniform in appearance, these features probably represented cap material trails from the dredge as it departed the cell. Because most placement activity during this period was concentrated near the center of the cell, these departure trails originate from the same general area and were oriented consistently in a southeasterly direction (back towards the dredge site). Again, by overlaying the ADISS dredge departure data on the side-scan mosaic, it was clear that these features represented cap material trails created by the dredge. These areas are highlighted in Figure 3.10-7.

3.10.5 Discussion

Monitoring operations conducted in Cell LU verified that side-scan imagery could be used to identify distribution of cap sediments and bottom disturbance features (the first and second parts of the first monitoring objective) following a single placement event. However, because the seafloor topographic changes are so small, side-scan imagery cannot determine topographic changes following a single placement event (the third part of the first monitoring objective). Because of grain-size similarities between cap and ambient bottom material, it was likely that the ability to distinguish cap material was primarily a function of bottom disturbance rather than significant differences in acoustic properties. It also appears as if the acoustic footprint of a cap placement event was somewhat more pronounced when it occurs over ambient bottom rather than recently placed cap material.

During all Cell LU side-scan operations, a single point placement event produced a consistent acoustic signature, consisting of a high-reflectance circular area with a diameter of approximately 125 m, and then a lighter-return, scattering pattern radiating outward another 15 to 25 m from this strong-return area. This high-reflectance area represents the main disturbance area created as cap material impacted the seafloor, while the lighter-return, scattering pattern represents the lateral surge of material away from the main impact point.

The Post 1 survey was the only iteration that allowed a direct correlation between SPI cap thickness contours and the acoustic cap footprint. All subsequent placement events contributed to the cumulative cap thickness while simultaneously covering up the seafloor surface effects of any prior placement within its acoustic footprint. Because the side-scan imagery only provides an acoustic return of the seafloor surface, it cannot be expected to reflect the cap build-up resulting from numerous placement events conducted over the same general area. Comparisons between the Post 1 side-scan image and the SPI cap thickness contours (Figure 3.10-3) showed that the inner high-reflectance circular area correlated well with the 4 cm SPI cap contour, while the lighter radial spreading pattern correlated well with the 2 cm cap contour. Beyond the 2 cm contour, no definitive differences between the cap and ambient sediment could be detected on the side-scan image.

The second monitoring objective addressed the ability of side-scan imagery to determine distribution of cap sediments, bottom disturbance features, and topography following final cap placement. As illustrated in the Cell LU Post 68 side-scan image (Figure 3.10-7), the most recent side-scan image will only reflect those placement events that have not been obscured by more recent events. Although 68 placement events were conducted in Cell LU prior to the final side-scan operations, only a fraction of these events can be clearly identified in the imagery. Because side-scan imagery only reflects the surface seafloor conditions resulting from the most recent placement events, it can only be expected to determine distribution of cap sediments and bottom disturbance features associated with these same recent placement events.

No major topographic changes were detected during side-scan operations within Cell LU. The ability to detect any topographic changes would tend to be more of a long-term monitoring objective associated with the final cap placement, not individual placement events. Although single-beam or multibeam hydrographic surveying is the primary technique for measuring seafloor topographic changes, side-scan imagery can provide indications of major topographic features and changes. For instance, any significant slumping or movement of material within Cell LU would have been detected with the side-scan imagery. Similarly, if all of the cap material was placed in one location, creating a more prominent topographic mound relative to the surrounding seafloor, this feature would have been reflected within the imagery also. However, because cap material was spread throughout the cell, and the resulting topographic changes were minor, side-scan imagery did not reflect any topographic changes.

As discussed above, side-scan imagery provides a useful tool for identifying the location and the approximate footprint of individual placement events. This is particularly true when cap material has been placed over ambient bottom material and the resulting bottom disturbance is more pronounced. Even within a few weeks of the placement event, the approximate footprint of the placement activity could still be clearly seen in the side-scan records, provided the areas had not been covered by subsequent placement events. However, over time it appears as if the disturbed area had weathered enough so that these older placement events could no longer be clearly identified in the side-scan imagery. Had side-scan data been acquired several weeks after the placement operations were completed, it is unlikely that any of the individual placement events could still be identified. This is probably true within the PV site because the cap material had grain size characteristics very similar to ambient bottom material. In other areas, like the New York Historic Area Remediation Site (HARS) where cap material is sometimes significantly different than ambient bottom material, cap material is clearly discernable in side-scan imagery for years following placement.

While the first monitoring objective addressed the ability of side-scan imagery to determine distribution of cap sediments, bottom disturbance features, and topography following a single placement event, the second objective addressed these same characteristics following final cap placement. The side-scan operations in Cell LU demonstrate that the ability to determine distribution of cap sediments and bottom disturbance features is primarily a short-term monitoring objective that is mainly applicable to individual placement events. If cap material was dramatically different from ambient material, then side-scan imagery may provide a longer-term ability to differentiate cap material from ambient bottom material. Although it has not really been demonstrated within Cell LU (or any of the other PV cells), the ability to determine topographic changes from side-scan imagery is primarily a long-term monitoring objective that would only be effective after major topographic change has occurred; subtle or small-scale topographic change would not be detected by side-scan imagery.

By viewing side-scan mosaics for Cell LU in conjunction with other relevant data sets within Arcview®, it was possible to evaluate and consider many different side-scan record interpretations. By viewing the relevant ADISS data overlaid on top of each side-scan mosaic, numerous individual placement events could be clearly identified. Additionally, some unexpected features, such as the wash-out trails left by the dredge departing the placement site, could also be clearly confirmed from the ADISS data. Similarly, the SPI cap contour information was useful for evaluating the accuracy of side-scan imagery for defining the extent of the cap footprint for individual placement events. The extent and variety of different data sets acquired during this project provided a unique opportunity to verify many of the conclusions from side-scan image interpretations.

Table 3.10-1. Side-Scan Sonar Surveys Conducted

Cell	Survey Sequence	Description	ADISS Event Date	Survey Type	SS Survey Date	SPI Survey Dates
LU	Post 1	After 1 placement	8/2/00	Planned	8/10/00	8/3/00 & 8/9/00
LU	Post 5	After 5 placements	8/13/00	Flex	8/19/00	8/17/00 & 8/18/00
LU	Post 25	After 25 placements	8/25/00	Flex	8/26/00	8/25/00
LU	Post 45	After 45 placements	9/2/00	Planned	9/6/00	9/5/00 & 9/7/00
LU	Post 68	After 68 placements	9/14/00	Flex	9/14/00	9/13/00
SU	Post 1	After 1 placement	8/8/00	Planned	8/10/00	8/9/00 & 8/17/00
SU	Post 5	After 5 placements	8/19/00	Flex	8/19/00	8/22 & 8/24 & 8/25
SU	Post 21	After 21 placements	8/27/00	Planned	9/6/00	8/31/00 & 9/1/00
LD	Post 1	After 1 placement	8/15/00	Planned	8/19/00	8/18/00 & 8/24/00
LD	Post 9	After 9 placements	8/30/00	Planned	8/30/00	8/30/00

Table 3.10-2. Monitoring Objectives and Approach for Side-Scan Sonar

Monitoring Objective	Data Requirements	Monitoring Approach	Field Decision Criteria/Performance Specifications
Determine distributions of cap sediments, bottom disturbance features, and topography following single placement event.	Delineate cap footprint and provide information regarding spatial coverage that can be used by USACE to verify model predictions; Describe broad-scale features of the sediment surface, including: Sediment type (e.g., sand, mud) Small-scale boundary roughness (e.g., ripples, bedforms).	Collect high resolution, dual frequency side-scan sonar records following a single placement event for both conventional and spreading placement methods.	Navigational accuracy should be ±3 m. Completeness goal is 100% (obtain continuous records from all survey lines).
Determine distributions of cap sediments, bottom disturbance features, and topography following cap placement.	Delineate cap footprint and broad-scale features of the sediment surface.	Collect high resolution, dual frequency side-scan sonar records postcapping for both conventional and spreading placement methods.	Navigational accuracy should be ±3 m. Completeness goal is 100% (obtain continuous records from all survey lines).

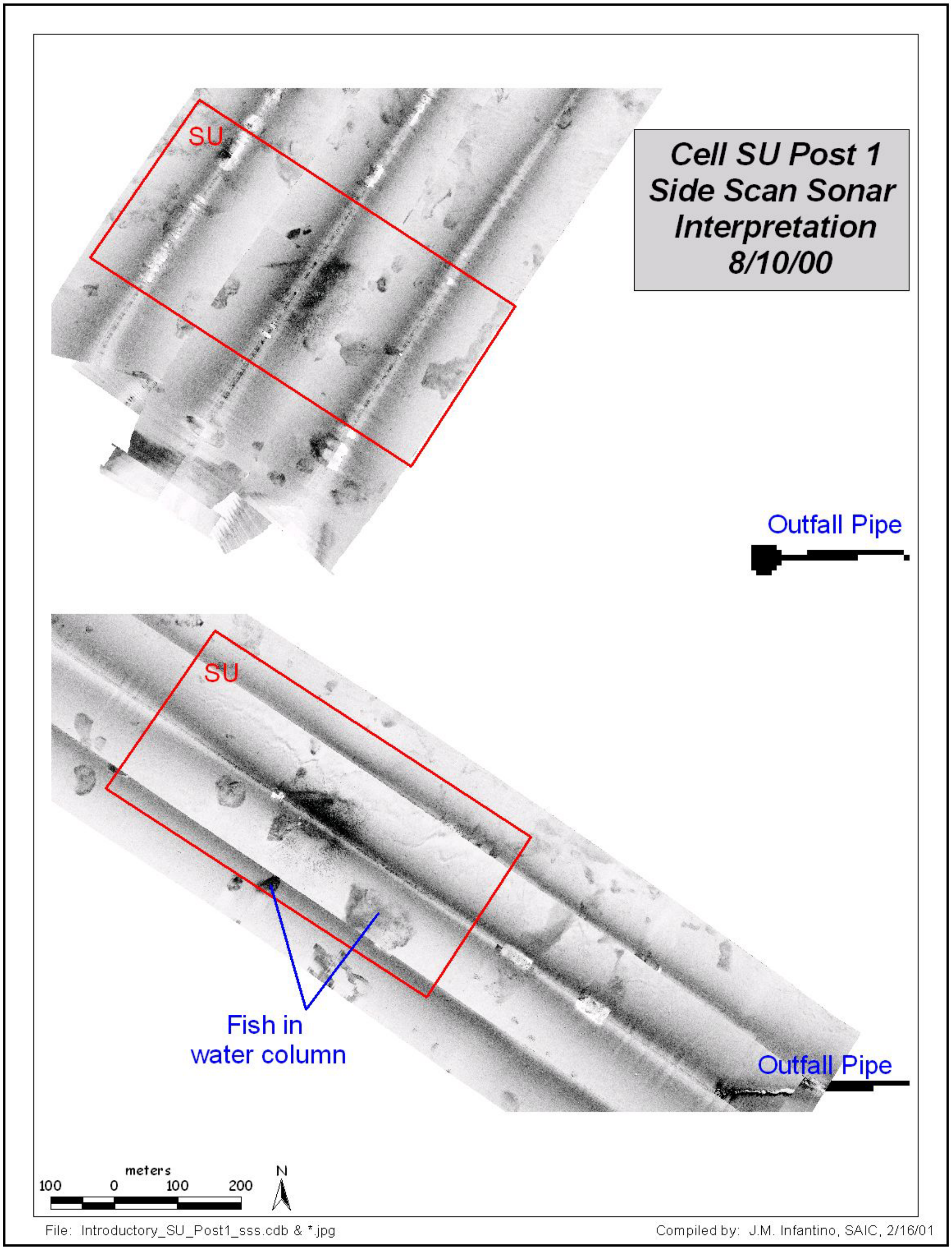


Figure 3.10-1. Side-scan record interpretation

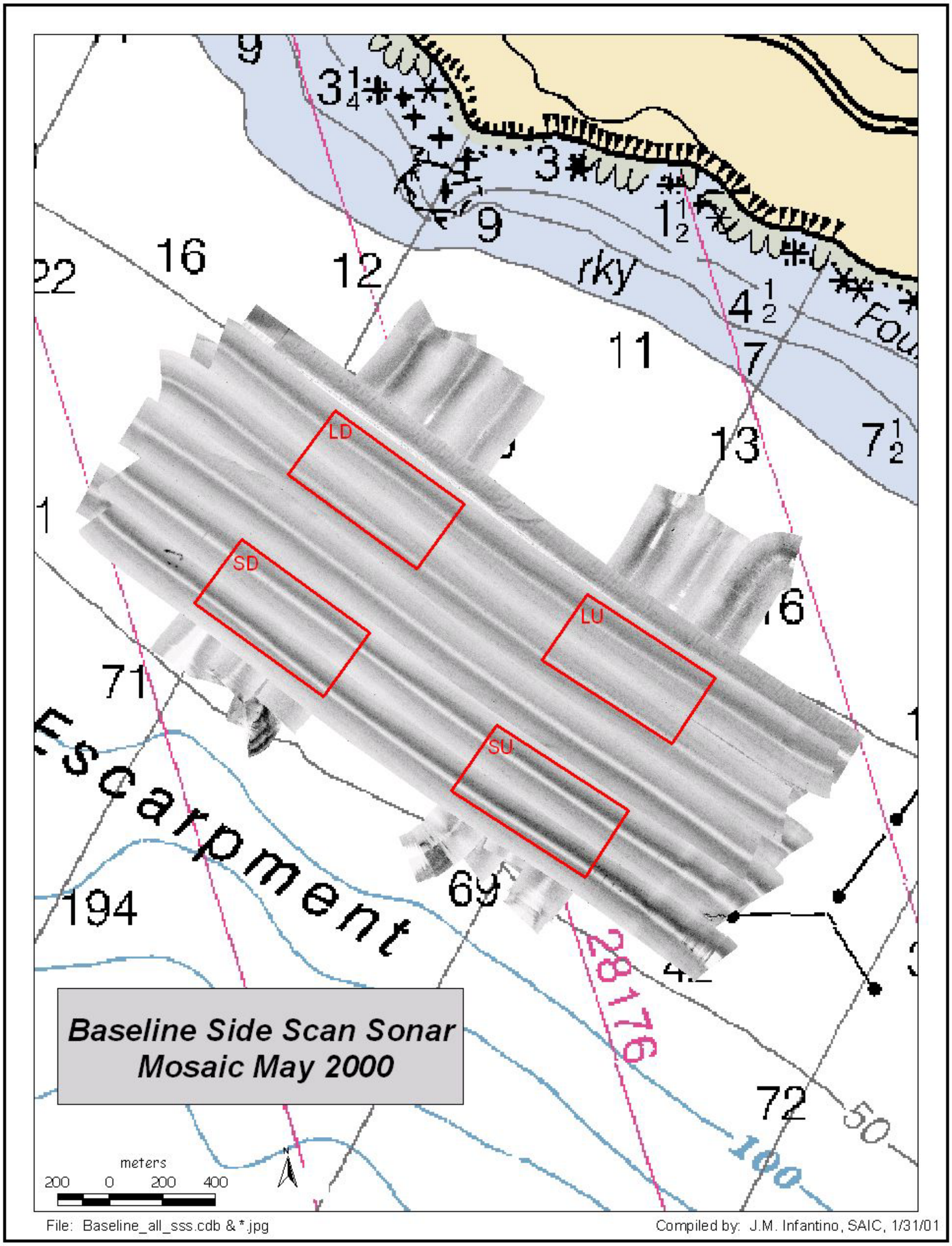


Figure 3.10-2. Side-scan mosaic baseline.

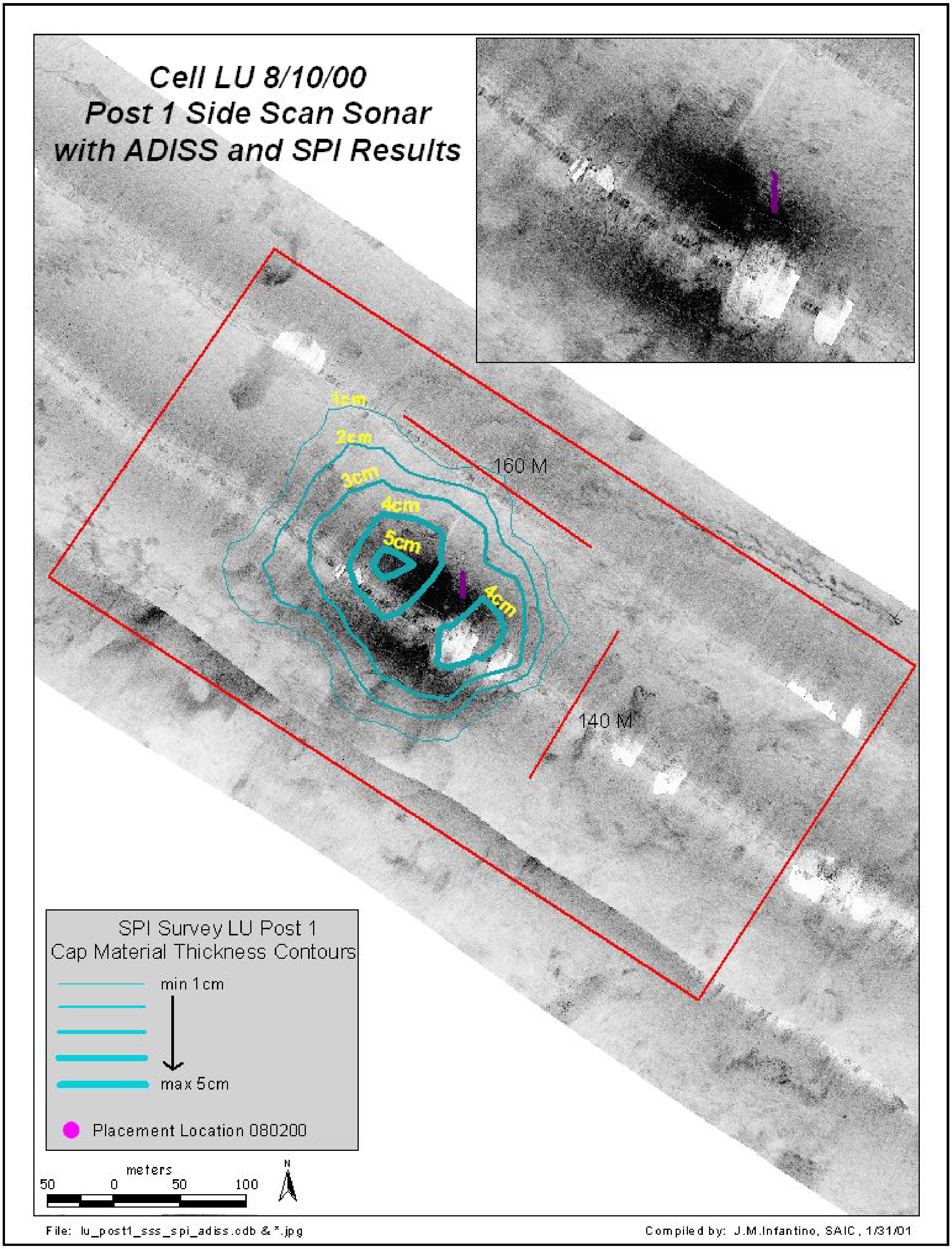


Figure 3.10-3. Side-scan mosaic w/SPI cap contours – LU Post 1.

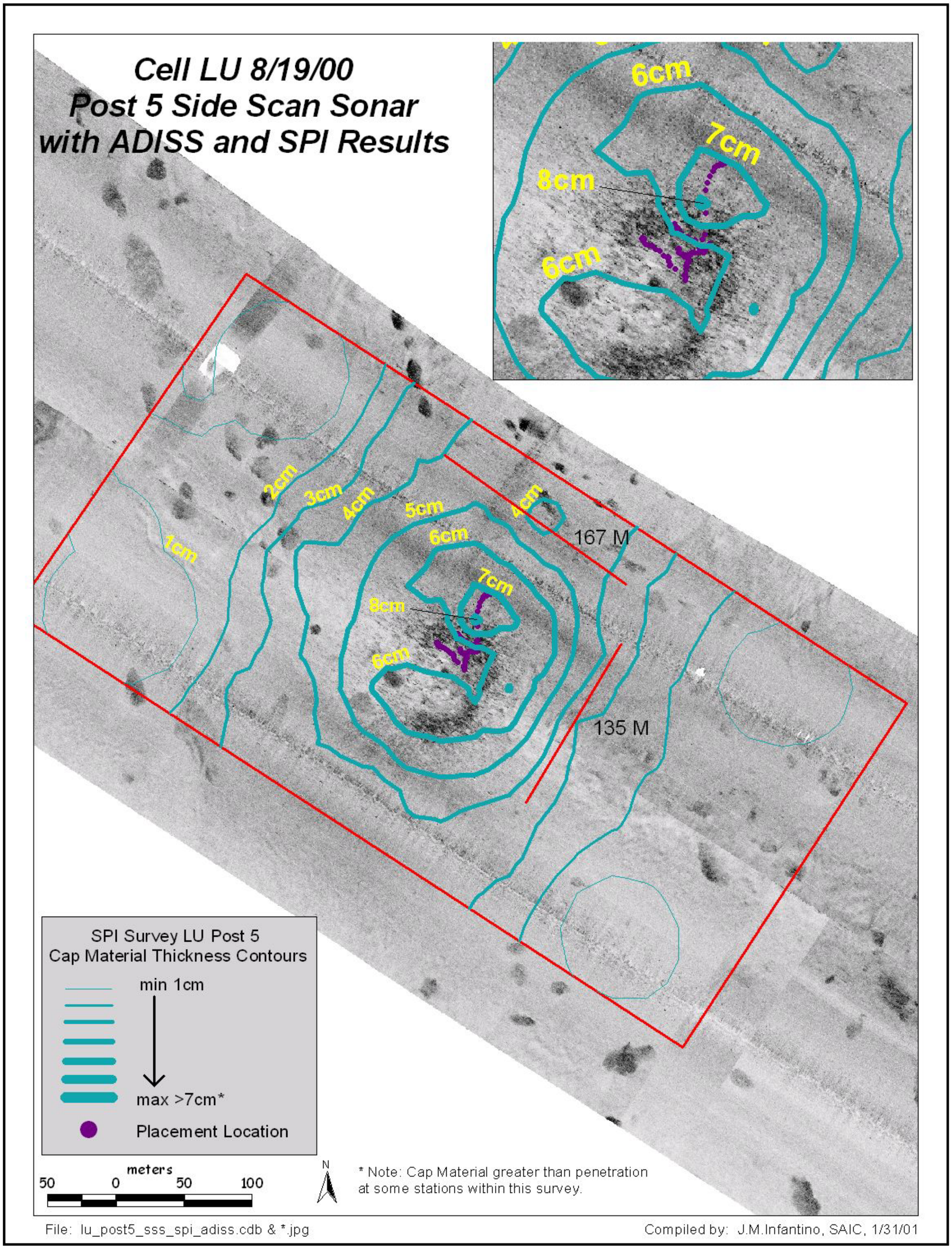


Figure 3.10-4. Side-scan mosaic w/SPI cap contours.

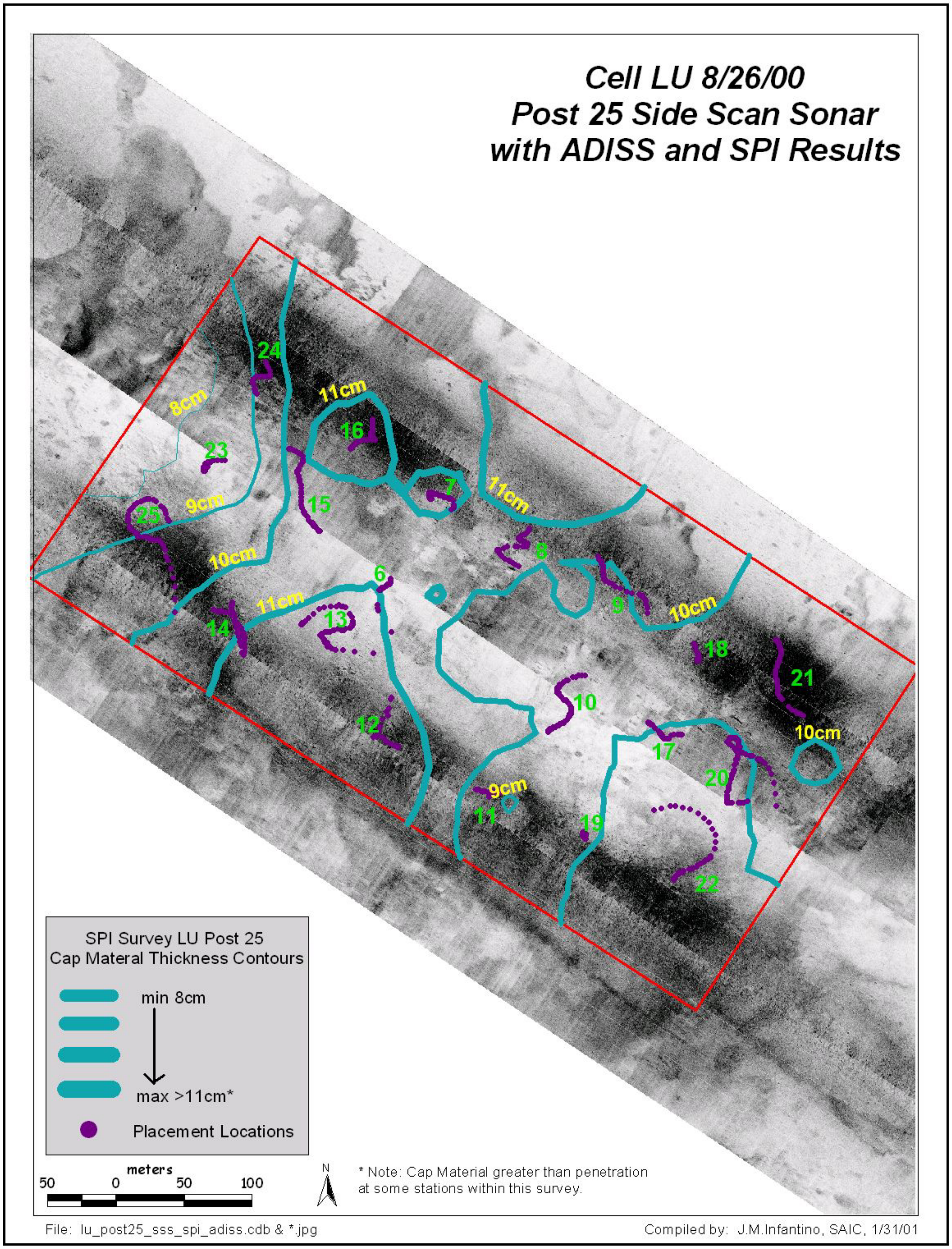


Figure 3.10-5. Side-scan mosaic w/SPI cap contours – LU Post 25.

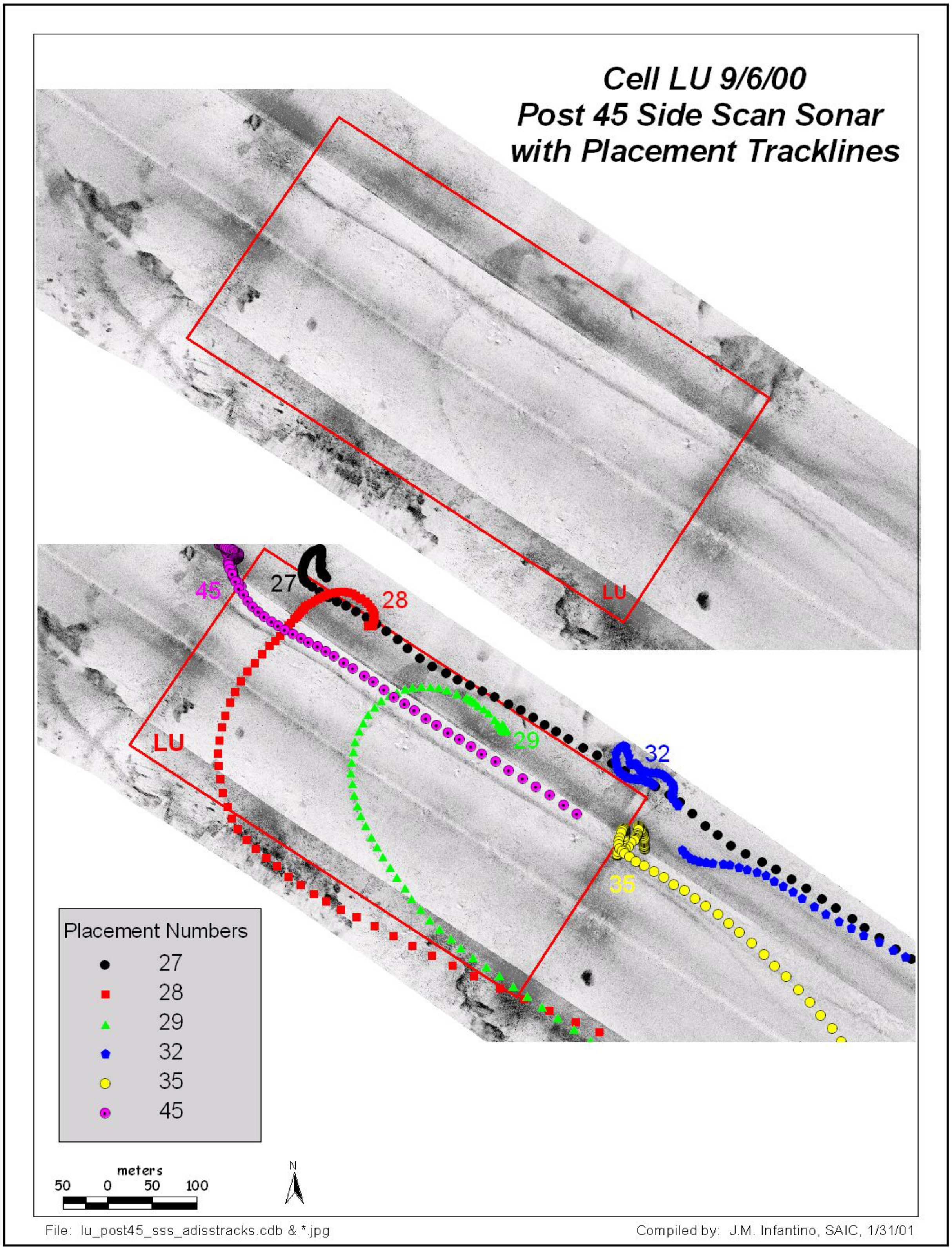


Figure 3.10-6. Side-scan mosaic w/ADISS departure trails – LU Post 45.

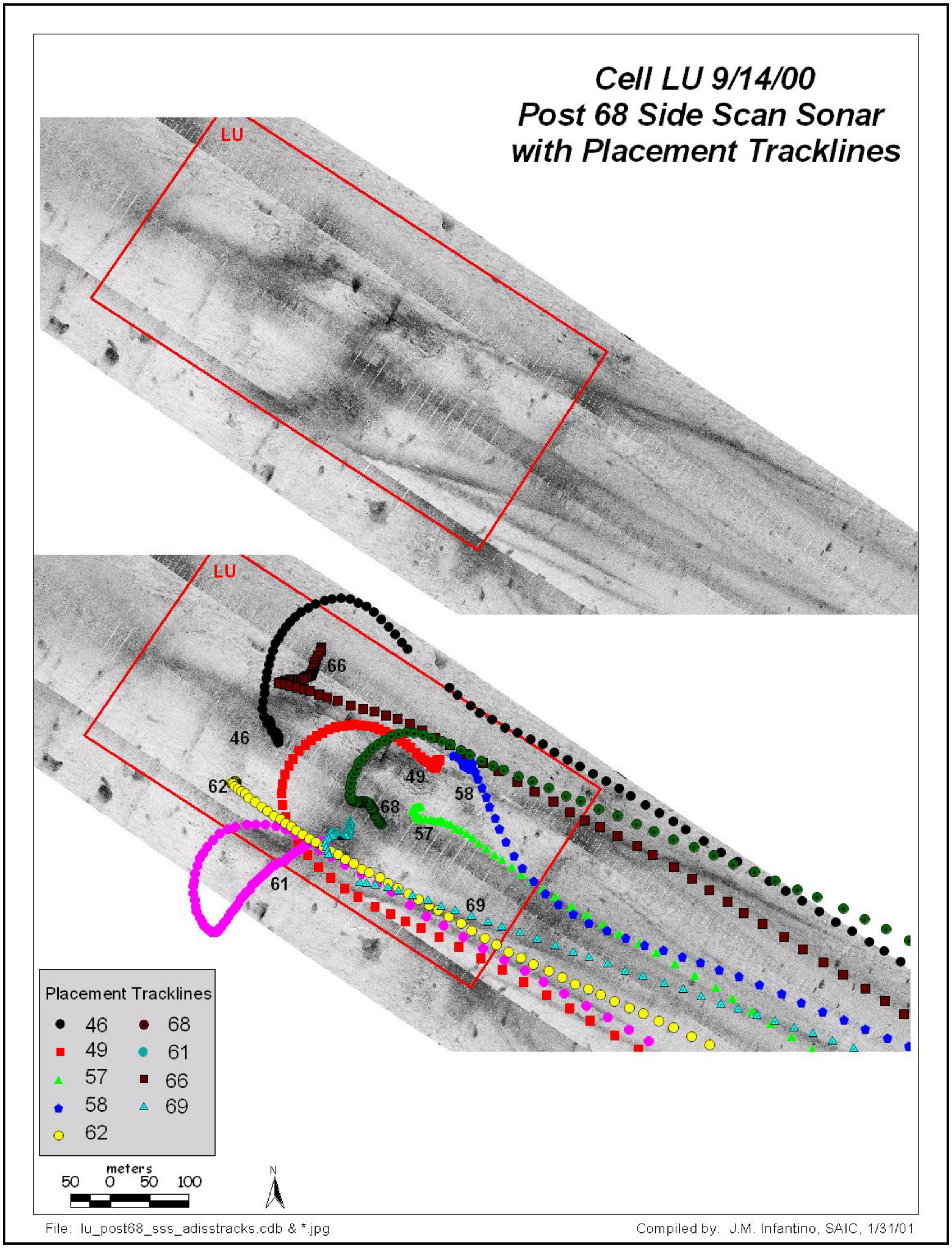


Figure 3.10-7. Side-scan mosaic w/ADISS departure trails – LU Post 68.

3.11 Sediment Core Results

3.11.1 Overview of Field Sampling Plan

Brief descriptions of the field sampling plans for baseline, interim, and postcapping phases of sediment coring tasks in Cell LU are provided below, along with a summary of methods and significant deviations from sampling plans defined in the respective PWPs (SAIC 2000a, 2001).

3.11.1.1 Field Sampling Plans

Baseline Survey

Sediment cores were collected at nine stations within Cell LU during the baseline survey (Figure 3.11-1a). Core locations corresponded to intersection points of the sub-bottom profile lines (see Section 3.12). Each core was photographed and visually described. Cores were subsampled from the core surface to a depth of 20 cm at discrete 4-cm intervals (Figure 3.11-2), and sediments from each layer were analyzed for bulk density, grain size, Atterberg limits, shear strength, and concentrations of DDE. Bulk density and shear strength samples were collected from the center of each horizon (i.e., at 2, 6, 10, 14, and 18 cm). Two additional cores were collected (at stations C1 and C6) to provide sufficient sample volume for Atterberg limit analysis.

Post 1 Survey

Following the first placement of cap material, a coring survey collected four cores within the Cell LU and one from outside the cell boundary (Figure 3.11-1b). Each core was photographed and visually described (DAN-LA). One core, LUH03A, was subsampled from 0 to 13 cm and analyzed for grain size and bulk density.

Post 5 Survey

After five cap placement events in Cell LU, six cores from five stations were collected during the Post 5 survey (Figure 3.11-1c). Each core was photographed and visually described, and the 0 to 8 cm horizon of Core LUI11B was analyzed for both grain size and bulk density.

Post 25 Survey

Following the 25 cap placement events, Post 25 survey collected 10 cores from Cell LU; nine from within the cell and one from outside the cell boundary (Figure 3.11-1d). Each core was photographed and visually described; however, no discrete geotechnical or chemical analyses were preformed.

Post 45 Survey

Sediment cores were collected at nine locations in Cell LU following 45 cap placement events (Figure 3.11-1e). Each core was photographed and visually described. Four of the nine cores (LUC52, LUC55, LUC56, and LUC57) were subsampled at specific core horizons for geotechnical and DDE analyses. Cores were subsampled from 4-cm horizons corresponding to the surface (A1), approximately 7 cm above the cap/EA sediment interface (A2), 3 cm above the interface (A3), 4 cm below the interface (A4), and 8 cm below the interface (A5) (Figure 3.11-2). In each case, the position of the cap/EA interface was determined visually, and actual sampling depths varied slightly among individual cores depending on the accumulated cap, sediment composition, and minimum sample volume required for the analytical protocol (defined in the QAPP). When adequate sample volume was present, samples were collected from the A2 and A5 horizons and archived in accordance with the FSP.

Post 71/Flex Survey

Following placement of an additional 26 hopper loads of cap material in Cell LU (i.e., a total of 71 placement events), five sediment cores were collected from five stations as part of the flex surveys (Figure 3.11-1f). Three of the cores were subsampled at the A1, A3, and A4 horizons (no A2 horizons were sampled, due to insufficient cap thickness) and analyzed for geotechnical parameters and DDE. No shear strength analyses were performed on these cores.

Supplemental Coring

A supplemental coring survey, conducted in February/March, 2001 collected vibracores at 15 stations (Figure 3.11-3a). Cores were subsampled at 4-cm intervals to a core depth of 20 cm, and sediments from each interval (cores I01, I03, I12A, I13) or from every other interval (I17, I21) were analyzed for grain size, bulk density, water content, specific gravity, and DDE. Atterberg limits in two cores were analyzed. All cores were photographed and visually described. Detailed core descriptions and digital core images are included in the DAN-LA project database.

A series of box cores were also collected during the supplemental survey from Cell LU (Figure 3.11-3b). The objective was to determine whether an alternate coring method (e.g., box coring) could provide representative sediment cores, including both surface cap materials and subsurface EA sediments, with a minimum penetration depth of 25 cm that were not affected by sampling artifacts. Sediments collected with the box core were visually described and photographed, but were not subsampled for geotechnical or chemical analyses.

Vibracore subsamples were collected from 4-cm intervals at up to 12 horizons per core (Figure 3.11-2). If the cap/EA interface was discernable based on visual examination of the cores, samples were collected from the sediment surface to two horizons below this detected interface. The majority of cores from Cell LU had a visually discernable cap/EA interface and were sampled to horizon 6 (20 to 24 cm). Six of the 15 stations were subsampled for geotechnical and chemical analysis. Primary geotechnical analyses included grain size, bulk density, water content, specific gravity, and shear strength. The original sample plan analyzed only the odd numbered horizons and archived the even numbered horizons. However, a few cores were analyzed for grain size and DDE at horizons 2 and 4. Atterberg limits were also analyzed on three cores at two horizons and 1 horizon in core I07. All 21 cores (box cores and vibracores) were visually described and photographed. Detailed descriptions of the supplemental cores collected in Cell LU, including depth intervals at which samples were analyzed and digital images of the core, are included in the DAN-LA project database

Hopper Sampling

Cap material samples from the Queen's Gate Channel were collected from 19 of the 71 hopper loads placed in Cell LU. Hopper sediments were analyzed for grain size, bulk density, specific gravity, and water content. Atterberg limits for cap material were not tested due to the high sand content, which would yield unreliable results. Queen's Gate sediments were not analyzed for DDE during this study because suitable data were available from previous testing (Sea Surveyor 1994).

3.11.1.2 Methods

Specific methods used for collection and processing of sediment cores, and geotechnical and chemical analysis of core samples, are described in detail in the PWPs for the baseline and cap placement monitoring phases of the program (SAIC 2000a, 2001). The general approach used is summarized below. These methods apply to all sediment cores collected during both monitoring phases within each of the placement cells.

Cores were collected during the baseline, interim, and postcap monitoring using a gravity corer with a 8.9 cm bore diameter and butyrate core liners. Each liner was used only once and then discarded as investigation-derived waste (IDW). Cores (in liners) were removed from the corer on the survey vessel, labeled, and then stored upright, on wet ice at approximately 4°C, and transported to the shore-based laboratory at the end of each survey day. All liquid and sediments collected during equipment decontamination were containerized and transported to the laboratory for disposal. All excess sediments remained at the laboratory for disposal.

Cores were collected during the supplemental survey using an electric vibracore, consisting of a 6-in. diameter, 20-ft. long aluminum barrel attached to a core head powered by a 10 kW generator. A stainless steel core catcher was attached to the base on the barrel, and an acrylic core liner was inserted into the barrel, to retain sediments. After cores were collected, the core liner with sediment was removed from the barrel and the ends of the core liner were capped and secured with tape. The sealed core samples were stored upright on wet ice in a clean polyethylene container and covered with an opaque bag. Core samples were transported to the laboratory for processing at the end of each survey day.

Box cores were collected at selected stations using a 0.06 square meter, Grey-O'Hara box corer. Weights were added to the box core frame to maximize penetration through the cap sediment layer. Box cores were carefully subsampled by pushing a 6-inch diameter section of core liner through the cores, removing the subcore, and capping both ends. These subcores were stored and processed using procedures similar to those used for vibracores.

Navigation equipment and procedures used to locate and document specific geographical coordinates associated with each core, and protocols used to clean sediment coring equipment, are described in detail in the PWPs.

Shore-Based Processing of Cores

Sediment cores were stored in the dark on wet ice (approximately 4°C) at SCMI until processed. Core processing included splitting, photography, visual descriptions, and subsampling. Cores were split by scoring the external surface of the core liner using a hand-held router. The remaining core liner was cut using a utility knife, and the core split horizontally into two halves using a taut wire. The least disturbed core half was photographed, visually described, and subsampled for sediment chemistry, while the other core half was tested for geotechnical parameters. Discrete samples were removed from specified core horizons for chemical (DDE) and geotechnical analysis. Vane shear measurements were performed on selected cores.

Equipment used to section the sediment cores and subsample the sediment intervals was scrubbed with laboratory-grade detergent, rinsed with ASTM or equivalent reagent-grade water, pesticide-grade methanol, and pesticide-grade hexane, in that order. Equipment rinsate blanks were prepared with each sample batch. All liquids and sediments collected during the equipment decontamination were containerized and stored onsite with other IDW.

Hopper Dredge Sampling

Cap material samples were collected from the hopper dredge using the procedure described in the SOP ([SOP] Volume II PWP) for hopper sampling. Single grab samples were collected at the bow, center, and stern of the hopper. Equal volumes of each of the three samples were later homogenized into a composite sample in the shore-based laboratory.

Laboratory Analysis of Sediment Samples for Geotechnical Properties

Sediment and hopper dredge samples were analyzed by Applied Marine Sciences (AMS) located in League City, Texas, for geotechnical properties according the following protocols:

- Particle Size Distribution (Phi Size Classification) in Sediment Samples according to Plumb (1981; SOP: AMS-PGS93).
- Bulk Density of Soil Samples according to USACE EM 1110-2-1906 (SOP: AMS-9504).
- Atterberg Limits: Liquid Limit, Plastic Limit, and Plasticity Index of Soils according to ASTM-D4318 wet multi-point procedure (SOP: AMS-D4318).
- Moisture (Water) Content according to ASTM D2216 (SOP: AMS-D2216).
- Specific Gravity of Soil Samples according to ASTM D854-83 (1984; SOP: AMS-D854).

Grain size analyses were conducted using the Plumb (1981) method, which classifies grain size in phi intervals according to the Wentworth Classification System. Due to the engineering nature of the project, a conversion table is provided in Appendix B to cross-reference the Wentworth Classification and the ASTM Unified Classification systems. The Wentworth Classification system classifies –1 phi as gravel, whereas this classification corresponds to 2 mm or coarse sand in the ASTM Unified Classification. The Wentworth Classification system assigns a different classification name to each phi size, and this naming convention has been used in the following sections to describe sediment characteristics.

Laboratory Analysis of Sediment Samples for Chemical (DDE) Concentrations

Selected sediment samples were analyzed by Woods Hole Group Environmental Laboratories (WHG) located in Raynham, Massachusetts for concentrations of DDE. The analytical protocol was based on Solid Waste (SW) Methods 8081A and 8000B, described in *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition, Final Update III, December 1996 (USEPA Office of Solid Waste and Emergency Response, Washington, D.C.). Samples were first screened by gas chromatography/mass spectrometry (GC/MS), using procedures in WHG SOP for EPA Method 8270C, to determine the surrogate spike amounts for extraction. Up to 20 field samples were extracted with the following batch quality control (QC) samples: one method blank, one spiked method blank, one matrix spike/matrix spike duplicate pair, and one regional reference material (RRM PV7C). Extracts were cleaned with activated copper following procedures described in WHG SOP *Method 3660B Sulfur Cleanup (Revision 1.0)* and, if necessary, further extract cleanup through amino-propyl gel following procedures described in WHG SOP *Amino-Propyl Cleanup of Tissues and Sediments (Revision 0)* and/or gel permeation chromatography following automated high-performance liquid chromatography procedures described in WHG SOP *Gel Permeation Chromatography (Revision 0)*. Sample extracts were analyzed by dual column gas chromatograph-electron capture detector (GC-ECD) following procedures in WHG SOP *Determination of Polychlorinated Biphenyls (PCBs) as Congeners and Organochlorine Pesticides by Gas Chromatography/ Electron Capture Detection (Revision 1.1)*. For 10% of the samples, identification and quantification of DDE was confirmed by GC/MS-selected ion monitoring (GC/MS-SIM) following instrumental procedures in WHG SOP *Analysis of Polynuclear Aromatic Hydrocarbons by Gas Chromatography/Mass Spectrometry with Selected Ion Monitoring (Revision 1.0)*.

Quality assurance procedures and QC checks were conducted according to specifications described in the Baseline and Post Cap Monitoring PWPs (SAIC 2000a 2001). All analytical data were validated according to the specifications described in the PWPs (SAIC 2000a, 2001). The data validation reports are presented in Appendix B.

3.11.1.3 Deviations from Field Sampling Plan

Core sampling at Cell LU during baseline and cap placement monitoring did not deviate significantly from the approach described in the respective Field Sampling Plan sections of the PWPs (SAIC 2000a, 2001). However, post placement cores could not be consistently subsampled at the specified depth intervals due to insufficient material and/or the absence of a distinct cap material/EA sediment interface. In many cases, decisions concerning core subsampling were made in consultation with USACE personnel (T. Fredette). For some sampling events, fewer samples than planned were collected and analyzed. Additionally, analyses of Atterberg limits, particularly of hopper samples, were limited due to the presence of high proportions of sand.

3.11.2 Review of Data Quality Objectives

General monitoring objectives for the monitoring program are discussed in Section 2. Specific DQOs for baseline and cap placement monitoring are presented in the following sections. Data quality objectives for hopper sampling are discussed in Section 3.2.

Baseline Monitoring

Specific monitoring objectives for sediment coring conducted during baseline monitoring are summarized in Table 3.11-1. These objectives apply to sediment coring within Cell LU, as well as baseline sampling within the other placement cells.

3.11.2.1 Summary of Results for Baseline Survey Relative to Data Quality Objectives

Specific monitoring objectives for sediment coring in Cell LU during the baseline survey were achieved. In particular, all of the sediment cores specified in the PWP were collected, along with the defined numbers of field quality control samples. A total of 51 grain size, 54 bulk density and shear strength, and 49 sediment DDE samples were analyzed (field samples plus QC analyses) and 4 Atterberg limit measurements were performed. Cores provided sufficient sample volume for all required chemical and geotechnical analyses, including analytical QC samples specified in the QAPP. Results of the sediment DDE QC analyses are presented in Appendix B.

3.11.2.2 Interim and Postcapping Monitoring

Specific monitoring objectives for sediment coring conducted during the interim and postcap placement monitoring phases are summarized in Table 3.11-2. These objectives apply to sediment coring within Cell LU, as well as sampling within the other placement cells.

Sediment coring using a vibracorer was performed during the supplemental monitoring to provide data on cap thickness as well as the vertical distributions of physical and chemical characteristics for assessments of mixing between cap material and EA sediments. Specifically, cores were visually inspected and photographed to distinguish patterns indicative of different sediment types (e.g., EA sediments and cap material), and individual core strata were sampled to determine vertical patterns in physical and chemical characteristics as a function of distance below the sediment surface or distance above the EA sediment/cap layer boundary. These data are important because the gravity coring approach used during the August and September 2000 surveys on the Palos Verdes Shelf pilot capping cells appears to have resulted in disturbance to the samples to a larger degree than was anticipated.

A vibracore was expected to provide cores of sufficient length to penetrate through the cap (up to 45 cm cap thickness) and into EA sediment at all stations with minimal disturbance of the core. Monitoring objectives and approach for the supplemental coring are summarized in Table 3.11-3.

3.11.2.3 Summary of Results for Cap Placement Surveys Relative to Data Quality Objectives

Sediment cores specified in the PWP were collected, along with the defined numbers of field QC samples. Adequate core penetration was achieved (core lengths exceeded 20 cm), and most cores provided adequate sample volume for all specified chemical and geotechnical analyses. However, for some cores, one or more specific core horizons were not sampled due to limited cap material or the absence of an obvious cap material/EA sediment interface. This resulted in fewer than planned numbers of samples for some geotechnical and chemical analyses. The Post-45 survey collected a total of 20 grain size, 21 bulk density, 12 specific gravity and water content, 6 Atterberg limits, 13 shear strength, and 16 DDE analyses were performed (Table 3.11-4) compared with 16 analyses of each parameter described in the FSP. Additionally, six Atterberg limit analyses were performed. For the Post 71/flex survey, a total of nine grain size, five bulk density, nine specific gravity and water content, nine DDE, and two Atterberg limit analyses were performed compared to nine analyses specified in the FSP.

All sediment cores for the supplemental coring survey were collected, processed, and analyzed as specified in the PWP. Specific monitoring objectives for the supplemental coring survey in Cell LU were achieved. Cores provided adequate sample mass for all required chemical and geotechnical analyses, including analytical quality control samples specified in the QAPP.

3.11.3 Technical Considerations

Several technical considerations affected the interpretability of the sediment coring results. These considerations were primarily associated with sampling artifacts related to the gravity corer and vibracorer.

Some of the cores collected during interim and postcap surveys exhibited evidence for non-uniform mixing of cap material with EA sediments. This non-uniform mixing was characterized by the presence of sandy material along the inside surface of the core liner but absent from the center of the core. This pattern may be attributable to drag down, which is a coring artifact that can occur when surface material sticks to the core liner upon corer penetration instead of sliding to the surface of the core. Drag down may also occur as an artifact of the core malfunctioning upon penetration and affecting the manner in which sediments enter the core liner. The specific reason(s) for drag down of cap material is unknown. Regardless, the amount of drag down was appreciable in some cores.

The effects of drag down resulted in the apparent presence of cap material in core layers below the cap material/EA interface. These conditions were noted in the core descriptions. Results from analyses of DDE concentrations in duplicate samples obtained during the Post 45 survey were in good agreement (RPD <10%). This indicated that sediment chemistry samples were not appreciably affected by drag down or other sampling artifacts that artificially mixed cap material with EA sediments. The absence of greater variability in the duplicate DDE results may be due to the fact that aliquots for sediment chemistry analyses were obtained from the central portion of the cores, which were not affected by drag down effects.

In addition to drag down effects, there was evidence for loss of surface sediments from the gravity corer due to a bow wake effect or failure of the corer to retain surface materials. Similar observations were made by Lee (1994) during the USGS mapping of EA sediment on the PV Shelf. According to Lee (1994), gravity corers incompletely sample the surface layer because the presence of a "fingers" type core catcher that only opens when the sediment strength exceeds a threshold value. In the presence of soft, non-cohesive sediment, the corer may not retain the surface sediment layer. To match core profiles obtained separately from the same location using gravity and box corers, Lee (1994) shifted downward the gravity core profiles by distances of 6 to 18 cm. For the present monitoring program, the effects of sampling disturbances to surface sediment layers were most apparent at sites within the seaward cells (e.g., Cell SU). Regardless, the extent to which the gravity corer used for this program affected surface sediment layers during sampling for the baseline and postcap monitoring in Cell LU could not be determined quantitatively.

The sampling plan required visual distinctions of the cap material/EA sediment interface as a basis for sampling similar core horizons over multiple cores, regardless of the core-specific thickness of the cap layer. However, EA and Queen's Gate sediments were visually similar. For example, EA sediment in Cell LU was greenish black, moist, firm silty SAND; whereas, cap material (i.e., Queen's Gate sediment) was dark grey, moist, firm silty SAND with scattered shell fragments. Based on ASTM D2499-93 (Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)), both the cap and the ambient EA material fall into the same sediment classification. Grain size distributions for cap and EA sediment, illustrated in Figure 3.11-4, demonstrate similarities in sediment characteristics. Consequently, identification of the interface between the cap and ambient EA material was challenging. Regardless, the geotechnical and chemical data for interim and postcap cores indicated that the interface was identified with reasonable accuracy, and portions of cores associated with cap and EA material were sampled appropriately.

Due to technical considerations associated with possible sampling artifacts, sediment cores were collected using different coring methods (vibracore and box core) during the supplemental coring survey in February/March, 2001. Although coring methods were expected to provide undisturbed cores that could be used to further assess cap thickness and existing chemical profiles in portions of the cell covered by cap material, geotechnical and chemical results (presented below) suggest that the vibracoring procedure did not provide representative cores. Further, the extent of disturbance from the coring procedure may have varied among sites due to spatial differences in the physical/chemical properties of the EA sediments.

3.11.4 Monitoring Results

Results of geotechnical and chemical analyses of hopper sediments and sediment cores collected during baseline, interim, and postcapping surveys are described in the following sections.

3.11.4.1 Geotechnical Characteristics

Hopper Sediments

Geotechnical results for sediment samples from hopper loads placed in Cell LU are available in DAN-LA. Table 3.11-5 summarizes grain size and geotechnical properties of hopper samples placed in each of the capping cells. Cap materials placed in Cell LU contained 79% sand (0.0625 to 2 mm); of which 35% was fine sand (0.125 mm) and 33% was very fine sand (0.0625 mm). Distinctions between fine and very fine sand were important for determining cap thickness and potential mixing of the cap and ambient EA sediments. The average silt and clay fractions in the cap material were 16% and slightly less than 4%, respectively. Gravel (>4 mm) primarily contained shell hash and, although it represented only 0.38% of the sample, shell hash was used as an indicator of cap material in the postcapping cores. Grain size distributions for hopper sediments placed in Cell LU were similar to those for Queen's Gate sediments placed in the other capping cells (Figure 3.11-5).

The average wet weight bulk density was 1.95 g/cc, while the dry weight bulk density was 1.49 g/cc (Table 3.11-5). Specific gravity was consistently 2.7, and the average water content was 32%. These results were consistent with those for other Queen's Gate samples placed in Cells SU and LC.

Baseline Survey

Detailed descriptions of baseline cores collected in Cell LU, including depth intervals at which samples were analyzed, and digital images are included in DAN-LA.

The majority of baseline sediments in Cell LU were greenish black, moist, and soft to firm in consistency, with an apparent grain size of clayey SILT. Sediment grain size distribution was dominated by sand-sized material (0.0625 to 2 mm), of which approximately 50% was very fine sand (0.0625 mm). Silt (0.0312 to 0.0039 mm) contributed slightly more than 25%, and clay (<0.00195 mm) comprised roughly 13% of the grain size composition (Table 3.11-6; Figure 3.11-4). No gravel-size (>4 mm) particles were present in EA sediment from Cell LU. Appreciable differences between core horizons in sediment composition were not apparent.

The average wet weight bulk density for Cell LU was 1.76 g/cc, and the average dry weight bulk density was 1.19 g/cc. Bulk density results were very uniform throughout each core. Shear strength values for Cell LU sediments ranged from 0.94 to 23.53 kPa, and these results were characterized by high variability with random spikes attributable to the high sand content of the sediment. Correlations between depth and apparent shear strength were not evident. Reliable shear strength results typically are difficult to obtain from sandy material, and sediments from Cell LU were predominantly sand. Consequently, it is not surprising that no patterns or trends in the shear strength data were evident.

Atterberg limits separate the silt and clay fraction via the plasticity index (PI) based on the difference between the liquid limit (LL) and plasticity limit (PL). The two cores analyzed for Atterberg limits were tested at two horizons, 0 to 10 cm and 10 to 20 cm, to determine whether the characteristics of fines changed with depth. In cores LUBC1 and LUBC6, the average liquid limit was 37% with a plastic limit of 32%, indicating an average plasticity index of 5. In general, the plasticity index did not vary significantly with depth in Cell LU sediment cores. Summary results are included in Appendix B.

Post 1 Survey

Four cores were collected from inside Cell LU in conjunction with the Post 1 Survey. All of the cores contained a surface layer ranging from 2 to 8 cm that was considerably softer and appeared to contain a higher water content than deeper sediment in the cores. This surface layer was consistently described as a clayey SILT. The deeper sediment was described as a clayey sandy SILT. Core LUH 03 was analyzed for geotechnical properties. The sediments from the 0 to 7 cm horizon of Post 1 core 3 were greenish black, homogeneous, wet, and very soft clayey SILT. Some worms and tube mats were present at the core surface. Sediment from the 2 to 7 cm horizon was sandy SILT, and appeared to contain cap material mixed with worm tubes. However, the grain size distribution did not appear to be appreciably different from the baseline sediment (Figure 3.11-6). The major (51%) component of Post 1 core 3 was very fine sand (0.0625 mm), while coarse silt (0.0312 mm) contributed 20% of the core sediment. Fine to very coarse sand contents were comparable to those in baseline cores. Silt (32%) and clay (12%) contents were similar to the baseline conditions. No gravel or shell hash was detected in the surface material of cores collected near the disposal event.

Wet weight and dry weight bulk densities at the 3-cm interval of Post 1 core 3 were 1.77 g/cc and 1.18 g/cc, respectively. Compared with values for the baseline cores, no changes in bulk density following the single placement event were evident.

<u>Post 5 Survey</u>

The Post 5 survey core 11B consisted of two visually different sediment types, neither of which was present during the baseline survey. The surface (0 to 4 cm) horizon contained a pocket of dark gray, moist, firm CLAY. The second sediment type present in the 0 to 10 cm horizon, was dark gray, moist, firm clayey sandy SILT with shell fragments. Shell fragments or gravel (>4 mm) made up 6% of the sediment composition and indicated the presence of cap material in the upper 10 cm of the core. In contrast, gravel was not detected in samples collected during any of the previous surveys in Cell LU. Compared with grain size distributions for baseline sediments, the sand component in the Post 5 survey core 11B was 15% greater, while the silt fraction was 14% less. No change in the amount of clay (11%) was indicated (Figure 3.11-7).

Wet weight bulk density was 2.07 g/cc, 0.31g/cc higher then the average baseline value. Dry weight bulk density changed from 1.19 g/cc in the baseline to 1.58 g/cc in Post 5 core 11B. Bulk density and grain size results both reflected a change in the geotechnical characteristics of surface sediment relative to baseline conditions.

<u>Post 25 Survey</u>

Following 25 placement events at Cell LU, some cap material was visually evident at the surface of the nine cores collected within the cell boundary; however, clear transitions between EA and the cap layer were not apparent. Mixing of cap material with EA sediments may have contributed to the absence of a distinct interface. The extent of mixing could not be determined because grain size was not analyzed. Drag down and other coring artifacts also may have affected the amount of cap material visible at the core surface. A tenth core was collected outside of the cell boundary and did not contain visible cap material.

<u>Post 45 Survey</u>

Visual evidence of gravel, and interpretations of geotechnical parameters, for cores collected after 45 placement events at Cell LU indicated that cap material was present from the surface to a maximum depth of 24 cm. Four cores were analyzed for grain size and bulk density, and the following summaries are based on cores LUC52, LUC55, LUC56 and LUC57. The surface horizon (A1) most clearly reflected characteristics of the cap material. The A3 horizon appeared to be primarily cap material. The A4 horizon contained gravel, indicative of cap material, regardless, the silt and clay contents of the A4 horizon were more similar to EA sediment than cap material.

A1: surface material

Surface sediment from three of four cores (LUC52, LUC55, LUC56) contained gravel (>4 mm), representing shell hash from Queen's Gate sediment, which were not present in baseline sediment cores (Figure 3.11-8). In addition to the presence of gravel in the surface material, the sand content was more coarse. Fine sand (0.125 mm) at 44%, and medium sand (0.25 mm) composed approximately 25% of the sediment (Table 3.11-7). This is a significant change from the very fine sand (0.0625 mm) that dominated the baseline cores at 53%. Of the three cores containing gravel the average very fine sand component was only18%. The average silt and clay contents were 6% and 4%, respectively, versus 30% and 12% in baseline sediments. By contrast, the surface horizon of the fourth core, LUC57, did not contain gravel.

A3: 3 cm above apparent EA/Cap interface

Core LUC57 was not analyzed for an A3 horizon due to insufficient cap thickness. Cores LUC52, LUC55 and LUC56 all contained significant volumes of gravel at this horizon, indicating that cap material was present to a depth of 12 cm (LUC52), 16 cm (LUC55), and 11cm (LUC56). As with surface materials, the sand fraction was coarser than that of the baseline sediments (Figure 3.11-8). The average A3 sample contained 27% fine sand (0.125 mm), 21% medium sand (0.25 mm), 19% very fine sand (0.06250), 11%

silt, and 5% clay (Table 3.11-8). The relatively coarser sand fraction, as well as the composition of the silt and clay fractions, also reflected the presence of cap material. Core LUC56 had a slightly finer sand fraction and a slightly greater silt fraction. This core was from the center of the cell, where the hopper most frequently released its load. The finer sediment in this core may be due to relatively greater mixing of cap material with EA sediments.

The 0 to 13 cm horizon of five additional cores were analyzed for Atterberg limits and grain size. These samples represented a composite of the A1, A2, and potentially A3 horizons. Cores LUC53, LUC54 and LUC58 contained a gravel component, whereas Cores LUC51 and LUC59 did not. The cores that did not contain gravel were primarily from the perimeter of the cell. The latter two cores also contained slightly higher proportions of sands in the 0.125 to 2 mm size class, with characteristics of both the cap material and EA sediment.

A4: 4 cm below apparent EA/Cap interface

Grain size characteristics of horizon A4 sediments were similar to those of EA sediment (Tables 3.11-6 and 3.11-9, Figure 3.11-8).

For example, samples from the 16 to 20 cm horizon of Core LUC52, which from visual inspection was subsampled below the cap material/EA sediment interface, contained very fine sand (42%) without measurable gravel. Grain size data supports the visual description that core LUC52 contained 12 cm of cap material.

The A4 horizon of core LUC55 contained negligible amounts of gravel and coarser grained (0.125 to 2 mm) sand that were characteristic of cap material. The majority of the sample (52%) was very fine sand (0.0625 mm), which was a dominant component of baseline sediment. The silt and clay fractions were also similar to baseline levels. However, distinct characteristics of cap material were also evident, suggesting that the 19 to 24 cm horizon might have contained both EA and cap material as a result of mixing or as an artifact of drag down. This core indicates that at station LUC55 at least 16 cm of cap material is present.

Core LUC56 had an estimated cap thickness of 11 cm, and the grain size distribution was very similar to core LUC55. Gravel and coarser grained sand were detected in the LUC56 core; however, the very fine sand, silt, and clay fractions indicated characteristics more similar to EA material than cap material. The small portion of sediments with similarities to cap material may have been from drag down or mixing of cap and EA sediments.

Core LUC57 contained sand, silt, and clay proportions that were consistent with the grain size characteristics of baseline sediments. Grain size distributions provided some evidence for mixing of cap material and EA sediment, although very little shell hash (i.e., cap material) was present. The small amount of gravel at depth may be due to drag down, or indicate the upper 12 cm horizon was primarily baseline sediment with some cap material. Similar patterns were indicated for cores LUC53, LUC54, and LUC58.

Bulk density results (1.8 and 1.27 g/cc for wet and dry weight, respectively) for these cores indicated slight changes relative to baseline values. The average specific gravity was 2.68. Specific gravity was not analyzed for the baseline cores; thus pre-capping values were not available for comparison. Water content averaged 36% during this survey, and appeared to be higher at lower horizons, where slightly higher silt and clay fractions occurred.

Atterberg limit analyses were performed on six cores. Four of the analysis results were 'NP' or non-plastic, indicating that the test could not be conducted due to high sand content. Results for the other two samples indicated an increase in liquid limit to 39% with a plastic limit of 31%, resulting in a plasticity index of 7.5 compared to a PI value of 5 for baseline samples. Shear strength ranged from 0.94 to 39.76 kPa with an average of 10.57 kPa. The shear strength analyses frequently failed due to high sand contents. Lower shear strength values were associated with the softer sediments near the surface of the core, whereas sediments from greater core depths had relatively higher shear strengths. In general, the apparent strength of the postcap cores increased slightly relative to baseline conditions. A summary table of all geotechnical analyses conducted in post placement cores is included in the Appendix C.

Post 71/Flex Survey

Following 71 placement events in Cell LU, cores LUA60A, LUA61A and LUA64A contained cap material at the surface. However, the depth of the cap material/EA interface was different for each core. Although the extent of mixing between cap and EA material was difficult to determine visually, all sediments from core depths greater than roughly 18 cm were more similar to EA sediment than to cap material.

A1: surface material

Grain size distributions for surface sediments were similar in each of the three cores. In cores LUA60 and LUA64, surface sediments were dark grey, moist, hard SAND. The gravel constituent consisted of shell fragments, and was the most significant change in sediment grain size in the Post 71 cores (Figure 3.11-9). The sand fraction of two of the Post 71 cores was 10 to 30% greater than that of baseline sediments. The coarseness of the sand component within the 0.125 to 2 mm particle size range changed dramatically. In baseline cores, coarser sands comprised less then 5% of the total sand, whereas the surface horizons in the Post 71 survey cores contained roughly 56% of the larger sand grains. The third core, LUA61, had a clay clast at the surface. This core contained a remarkably high (48%) amount of silt, compared to 10 to 20% in the other cores for this survey and 30% in baseline sediments. The clay content of this core (30%) was also higher compared to the 12% clay content of EA sediments. Some of the Queen's Gate material contained similarly high levels of silt and clay, whereas baseline sediments did not contain high proportions of clay. SPI images also showed distinct clay clasts in the cap material that were not detected in appreciable amounts in the hopper samples. Thus, these characteristics may reflect the presence of some of the finer particles derived from cap material.

A3: 3 cm above apparent EA/Cap interface

The A3 horizon occurred at depths of 6 to 16 cm in the postcap cores, and was dark gray, moist, silty sandy CLAY. This description was not supported by the grain size analysis, which identified this region as a clayey silty SAND. The visual description indicates an apparent cap/EA sediment interface at 13 cm for core LUA60 and 8 cm in core LUA64. The visual description of LUA61 did not indicate an apparent cap/ EA interface, however the grain size sample collected from 10 to 15 cm indicates a sediment type similar to cap material. As with the surface horizon, presence of relatively higher (1.5% on average) gravel fraction was the primary evidence for cap material (Figure 3.11-10). The overall sand fraction was 20% higher, while the very fine sand component was approximately 30% lower, in the Post 71 survey A3 core samples than in baseline sediments. Based on grain size the major sediment mode of the A3 horizon indicates sediment dominated by cap material.

A4: 4 cm below apparent EA/Cap interface

In all three cores analyzed, the A4 samples appeared to be more similar to EA sediment than to cap material (Figure 3.11-11). Two of the cores contained less than 0.5% gravel, while the third core did not contain any measurable gravel. The sand contents of the A4 horizons of Post 71 survey cores were similar to those of baseline sediment, where the majority (51%) of the total sand content consisted of very fine sand (0.0625 mm). The proportion of larger grained sands (0.125 to 2 mm) was significantly lower than those in the A3 horizon, and silt and clay fractions of the postcap cores were comparable to baseline levels at this horizon. Results for all three cores indicated that the A4 samples were primarily EA sediment with only a slightly higher proportion of fine sand than ambient EA levels.

Average wet and dry weight bulk densities of the Post 71 survey cores were 1.74 g/cc and 1.16 g/cc, respectively. These values were higher than corresponding baseline values, but slightly lower than the bulk densities of cap material (Appendix B). The average specific gravity for the Post 71 survey cores was 2.7, which is consistent with values measured in the cores collected after 45 placement events in Cell LU. The average water content was 34%. Relatively higher water contents occurred in lower horizons and in direct proportion to the fines content of the lower horizons. Atterberg limit and shear strength analyses were not conducted on any of these samples. A summary table of all geotechnical analyses conducted in post placement cores is included in Appendix C.

3.11.4.2 Supplemental Survey

Following analyses of the post cap coring survey results, it was determined that additional core data were needed to further understand cap accumulation at the survey site. Sediment cores were collected using a vibracorer and box corer during the supplemental survey.

<u>Comparison of Box Core and Vibracore Results</u>

In late February and early March 2001, 16 vibracores and 5 box cores were collected from 15 stations in Cell LU (Figure 3.11-3a). The initial vibracores met the criteria set forth in the Supplemental SOW (Fredette, 2001; Table 3.11-10) and therefore vibracoring was selected as the primary core collection method. Five box cores were collected from Cell LU (Figure 3.11-3b). Four of the cores consisted entirely of cap material, indicating that the box corer did not penetrate deeply enough to sample the cap/EA interface and, therefore, providing only a minimal estimate of the actual cap thickness. Penetration in these four box cores ranged from 9.5 to 12 cm, resulting in a calculated average cap thickness of >11 cm (Table 3.11-10).

The box core from station O09 (collected northeast of the survey cell) contained a distinct cap material/EA sediment interface. In this sample, the total penetration was 11 cm, with the surface cap material layer measuring 7 cm and the underlying EA sediment layer measuring 4 cm. Box core O09 contained 11 cm of sediment; the surface 2 cm were dark brown gray silt and sand, from 2 to 7 cm was greenish black sand, and from 7 to 11 cm was greenish black clayey silt with sand.

No chemical or geotechnical analyses of the box core material were preformed. The cap thickness estimates from the box cores were compared to those from the co-located vibracores (Table 3.11-10). Cap thickness obtained from the box cores was consistently and, at several stations, significantly greater than that in the vibracores.

<u>Vibracoring Artifacts</u>

During shore-based processing of the vibracores, drag down or wash down of cap material along the inside wall of the plastic core liner was observed in the majority (12 of 16) of the cores (Figure 3.11-12). It is believed that the unconsolidated sandy surface of the cores was disrupted and washed down between the core sediment and the liner, either while the vibracore was penetrating the sediment or during post collection handling, or some combination of both. The thickness of the dragged down cap material was highly variable, from a thin line of sand along the liner to a band 1 to 2.5 cm thick across the entire liner extending into the center of the core sediment. The cap material appeared to have a tendency to stick to the core liner. When dragged down cap material was present, samples collected from the corresponding horizons were carefully extruded to avoid including material associated with the drag down artifact in the sample.

In an attempt to determine if the core liner was causing the drag down artifact, vibracores with and without a liner were collected from station I12. No distinct cap material/EA sediment interface was observed in the core collected without a liner (Core LUSV4 I12). The sample appeared to be highly disturbed, with sand (cap material) distributed to a depth of 42.5 cm. Cap material thickness in the core was estimated to be 12 cm, with significant cap material present to a depth of 20 cm. The core collected with a core liner from station I12 (LUSV2 I12) also contained cap material to a depth of 20 cm, with an estimated thickness of 12 cm. Neither vibracoring method produced cores with undisturbed surface material. Core I12 will refer to core LUSV2 I12, collected with a core liner.

Vibracore Results

The results of the cap thickness measurements presented in the following section should be viewed as minimum estimates of the actual cap thickness, due to the drag down artifact noted in the majority of cores.

The cap material was light gray in color and contained both gray clay clasts and shell fragments mixed with the sand. The color of the EA was a greenish black to black, indicating that differentiation between the sediments should be possible. The similarity in grain size between the two sediments made mixed areas difficult to distinguish visually without laboratory analysis for grain size. In most cores the interface between EA and cap material was identified. The average cap thickness based on the visual interface ranged from 0.5 cm (LUSV2I16) to 18 cm (LUSV2I13). Grain size data indicated cap material present to a depth of 28 cm. The ratio of cap to EA decreased with depth and distinct (apparently unmixed) cap material was present to a depth of 16 cm or horizon 4. Horizons 5 and 7 (16 to 28 cm) had both cap and EA sediment present and were considered mixed. Because a distinct interface was identified in most of the Cell LU cores, samples were not collected below horizon 6.

Horizon 1: surface material, 0 to 4 cm

The surface sediment from five of six vibracores, sampled for grain size, contained gravel (>4 mm) representing shell hash from the Queen's Gate sediment, which was not present in the baseline sediment cores. The percent frequency of medium (0.25 mm), fine (0.125 mm) and very fine sand (0.0625 mm) all increased from baseline values. Overall, horizon 1 indicated a distinct change in sediment characteristics and was classified as cap material (Table 3.11-11; Figures 3.11-13 through 3.11-18). Core I17, collected from the north-eastern corner of the cell, contained surface sediments that were neither distinctly cap or EA sediment and was classified as mixed (Figure 3.11-17). Finer grained silts and clays were more variable from sample to sample and difficult to discriminate distinct trends in the fine fraction.

Horizon 2: 4 to 8 cm

The sediment from four vibracores (I01, I03, I12 and I13) was analyzed from 4 to 8 cm for grain size (Table 3.11-12). The grain size results indicate that the percent frequency of medium (0.25 mm), fine (0.125 mm) and very fine (0.0625 mm) sand is characteristic of cap material (Figures 3.11-13 through 3.11-16). The cores analyzed at this horizon were collected from the center region of the cell and indicate that cap material is present at a depth of 8 cm.

Horizon 3: 8 to 12 cm

Cores I01, I03, I12 and I13 all continue to indicate cap material at the 8 to 12 cm horizon (Figures 3.11-13 through 3.11-16; Table 3.11-13). The percent frequency of medium (0.25 mm), fine (0.125 mm) and very fine (0.0625 mm) sand is characteristic of cap material. Cores I17 and I21 were also analyzed for grain size at this horizon and indicated a sediment type characteristic of both cap material and EA sediment. Therefore, both cores (collected from the north-eastern side of the cell) were classified as 'mixed' (Figures 3.11-17 and 3.11-18). The center region of the cell, where the remainder of the analyzed cores were collected, was considered to have cap material present to a depth of 12 cm.

Horizon 4: 12 to 16 cm

Horizon 4 grain size analysis indicated variability in cap thickness at a depth of 12 to 16 cm. Cores I03 and I13 both indicated sediment at this horizon dominated by cap material (Figures 3.11-14 and 3.11-16). Core I01 indicated a mixed geotechnical signature for this horizon, while Core I12 contained EA sediments (Figures 3.11-13 and 3.11-15). Core I12, located in the center of the cell, did not contain the thickest cap detected in the cell. This horizon indicates the strong presence of cap material, while frequencies of finer-grained sediments (silts and clays) are similar to those observed in the EA sediment (Table 3.11-14).

Horizon 5: 16 to 20 cm

Horizon 5 was analyzed for grain size (Table 3.11-15). This horizon indicated the strong presence EA material with a negligible amount of cap material. All the cores analyzed at this depth interval indicated the presence of EA sediments with minimal proportions of medium sand (Figures 3.11-13 through 3.11-18). Negligible cap material was present at this horizon, thus the 16 to 20 cm horizon is considered EA sediment.

Horizon 6: (20 to 24 cm)

Samples were collected from the 20 to 24 cm horizon and archived. This was the average depth to which supplemental cores from Cell LU were sampled. These samples were not analyzed.

Horizon 7: (24 to 28 cm)

Two vibracores (I12 and I13) were sampled and analyzed at the 24 to 28 cm horizon (Table 3.11-16). Both cores displayed a disturbed interface. The cap/EA interface in Core I12 was at approximately 16 cm, however, shell fragments were present the entire length of the core (Figure 3.11-15). Core I13 contained apparent cap material including crushed shells to a depth of 18 cm (Figure 3.11-16). Horizon 7 was analyzed to ensure that the interface was appropriately identified in both of these cores. The grain size results indicated that the sediment horizon was EA sediment.

Horizon 8: (28 to 32 cm)

Only two vibracores (I12 and I13) were sampled at Horizon 8. In both cases the material was archived. With the exception of vibracore LUSV4 I12, collected without a core liner, this was the deepest horizon sampled from the Cell LU vibracores.

Horizon 9: (32 to 36 cm) and Horizon 11 (40 to 44 cm)

These horizons were analyzed for vibracore LUSV4 I12, collected without a core liner. The results of the analysis can be found in Table 3.11-17. The results do not indicate cap material present at either horizon.

A summary table including the wet and dry weight, water content, specific gravity, liquid limit, plastic limit, plasticity index as well as shear strength measurements is included in Appendix B.

Bulk density was analyzed for both wet and dry weight. Both measurements were consistent from core to core. There was no noticeable variability with depth. The average wet weight ranged from 1.7-2.1 g/cm^3 (1.8 g/cm^3 average). Dry weight was even more consistent ranging from 1.1-1.7 g/cm^3 with an average of 1.3 g/cm^3. Water content was more variable ranging from 24-57%. Higher water content was frequently found in either horizon 1 (0 to 4 cm) or below horizon 3 (8 to 12 cm). The highest water content (57%) was detected at Station I01 at a depth of 16 to 20 cm. Specific gravity ranged from 2.6 to

2.7. There was no consistent relationship between specific gravity and the other geotechnical parameters analyzed.

Atterberg limits were analyzed on 4 vibracores at 2 horizons in each core. Vibracore LUSV 2 I07B was too sandy in the surface for analysis and resulted in a nonplastic result in the lower horizon. Indicating that the core contained sand to a depth of 20 cm. Core I15 had a LL of 33, PL or 20 and PI of 13 in the surface and the lower horizon was nonplastic to a depth of 16 cm. I18 contained nonplastic surface material and the lower horizon had LL of 45, PL of 29 and PI of 16. Core I20 was the only core that could be tested for AL in both the upper and lower horizons. 0 to 8 cm: LL of 33, PL of 22 and PI of 11, 8 to 16 cm LL of 40, PL of 28 and PI of 12. Shear strength analysis was also conducted on 7 of the cores collected in cell LU. In most of the cores the surface material to 12 cm was too sandy to conduct an accurate test. The shear strength results were highly variable ranging from 3-104 kPa. No significant trends were noted within the shear strength results.

3.11.4.3 Chemical (DDE) Characteristics

Results of chemical analyses of sediment cores collected during the baseline and postcapping surveys are presented in the following sections. Tabular listings of sediment DDE results are presented in DAN-LA.

Baseline Survey

Concentrations of DDE in sediment core horizons (surface to 20 cm measured at 4-cm intervals) from within Cell LU ranged from 0.75 to 3.5 parts per million (ppm), and averaged approximately 1.5 ppm with no consistent trends with core depth (Figure 3.11-19). In general, sediments from seaward locations (cores C3, C4, C7, and C8) within Cell LU contained slightly higher concentrations than those from the central and shoreward stations (C1, C2, C5, C6, and C9). A plot of DDE concentrations in surface sediments (Figure 3.11-20) illustrates the horizontal trends within Cell LU. These spatial patterns were generally consistent with the presence of relatively higher proportions of fine-grained sediments in the seaward portions of the cell than in the landward portions of the cell. However, DDE concentrations were not significantly correlated with percentages of the silt plus clay fraction (correlation coefficient [r^2] =0.05) in baseline surface sediments from Cells LU and LD combined. Measured DDE concentrations in baseline cores were generally consistent with historical values and trends reported for this portion of the PV Shelf (Lee 1994), although the vertical distributions of DDE observed during the baseline survey were relatively less variable than those reported historically (Figure 3.11-19).

Post 45 Survey

Following 45 placement events, surface sediments corresponding approximately to the upper 10 cm of cores from three of the four Cell LU stations (52, 55, and 56) contained DDE concentrations from 0.017 to 0.14 ppm. These levels were up to two orders of magnitude lower than concentrations in surface layers of baseline cores from Cell LU. These results were generally consistent with those obtained from the corresponding Post 45 SPI survey which indicated a minimum cap layer thickness at the four coring stations was 7 cm and, in all cases, exceeded the penetration depth of the SPC (see Section 3.7). In contrast, the core from one station (57) near the northwestern boundary of the cell, contained DDE concentrations of 0.94 and 1.3 ppm for the 0 to 6 cm and 6 12 cm horizons, respectively, which were comparable to levels in baseline cores from Cell LU.

Differences in the apparent pre- and postcap sediment stratigraphies indicated by DDE concentrations are illustrated in Figure 3.11-21. The sediment core DDE results for stations 52, 55, and 56 reflected the presence of a relatively clean, 10 to 15 cm thick, surface cap layer. Similarly, the SPI results indicated the presence of cap materials at these stations. Although the SPI results for station 57 indicated the presence of a 10.3 cm cap layer after 45 placement events, the DDE results suggested that cap material was absent from this site. The description of core LUC 57 also noted that the appearance of the core was entirely homogeneous. Furthermore, grain size results indicated a negligible gravel component, which was consistent with the absence of cap material and correspondingly higher DDE values. This discrepancy between the SPI and core chemistry results could reflect spatial patchiness in the cap layer and/or loss of cap material from the core during sampling.

The extent of mixing between cap material and EA sediments was estimated based on comparisons of DDE concentrations in the postcapping cores to those in the cap material and in baseline sediments. Based on previous sampling and analyses performed by Sea Surveyor (1994), DDE concentrations in Queen's Gate sediments, comprising Cell LU cap material, typically (>70%) were below 0.02 ppm (the method detection limit), with maximum concentrations of 0.1 ppm. Estimates of the contribution of cap material to individual core samples discussed below assume a uniform DDE concentration in cap material of 0.02 ppm (higher DDE concentrations were associated with surface layers and not used for capping). The estimated proportions of cap material within specific horizons of the sediment cores are listed in Table 3.11-18. For all but core LUC57, which was mostly or all EA sediments, and the A3 layer of core LUC55 (10 to 15 cm below the core surface), cap material comprised more than 90% of the surface horizons. These values could overestimate the proportions of cap sediments present if the actual DDE concentrations in EA sediments were lower than the assumed average value. Regardless, the DDE results indicated minimal mixing of EA sediments in the cap layer.

<u>Post 71/Flex Survey</u>

Three of the Post 71 survey cores were subsampled and analyzed for DDE (Figure 3.11-1f). No SPI images were collected within the cell following 71 placement events; nevertheless, SPI results following the 45 placement events indicated a cap layer thickness >9 cm. Therefore, cap layer thickness at the coring locations following 71 placements was expected to be 9 cm or greater.

In general, DDE concentrations in the surface 0 to 4 cm layers of cores from all three stations were low (0.0034 to 0.048 ppm), consistent with levels in the Queen's Gate cap material. These levels represent a reduction, by up to two orders of magnitude, in DDE concentrations in surface sediments within Cell LU. Relatively higher DDE concentrations (0.05 to 0.67 ppm) occurred at core depths of about 4 to 22 cm (stations 60 and 64), indicating some mixing of cap material and EA sediments, while concentrations at core depths from 22 to 27 cm at station 61 were 1.9 ppm and comparable to concentrations in baseline cores (Figure 3.11-22). These vertical patterns in DDE concentrations were generally consistent with the core geotechnical and SPI survey results. Estimated proportions of cap material in core horizons above the cap/EA interface were >90%; whereas sediments below the interface comprised approximately 30-100 % EA sediment (Table 3.11-18). The depth of the cap/EA sediment interface could not be determined from these results.

<u>Supplemental Survey</u>

DDE concentrations in the surface 0 to 4 cm and 4 to 8 cm layers of cores from six stations within Cell LU ranged from 0.095 to 0.87 ppm (Table 3.11-19). In three cores, DDE concentrations in the 0 to 4 cm layers were relatively higher than those in the corresponding 4 to 8 cm layers, which may reflect the presence of a recently deposited layer (observed in SPI data) consisting of EA sediments from adjacent areas. Sediment DDE concentrations in surface layers (0 to 8 cm) generally were up to one order of magnitude lower than pre-capping concentrations, but also severalfold higher than concentrations in Post-71 core surface layers. The 8 to 12 cm layers contained a wider range of DDE concentrations (0.07 to 2.0 ppm), reflecting spatial differences in the depth of the cap/EA sediment interface. DDE concentrations in deeper core layers generally were comparable to baseline concentrations, indicating an absence of appreciable cap material below 12 cm. As discussed in previous sections, the core geotechnical results indicated a cap thickness of 16 cm. Differences in cap layer thickness estimates may reflect relatively greater effects from drag down on sediment grain size than on DDE results.

Although a cap layer was still evident in the supplemental cores from Cell LU, the DDE concentrations were relatively higher than those in the cap layer during the Post-71 survey. Higher concentrations probably reflect the contributions from recently deposited EA sediments transported onto the cap by bottom currents. Further, the apparent thickness of the cap layer, as indicated by the differences between successive core layers in the magnitude of DDE concentrations (e.g., differences between the 8 to 12 cm and 12 to 16 cm layers of cores I01 and I03), was reduced compared to the cap layer thickness following 71 placement events. For example, the Post-71 core data indicated cap thickness up to approximately 15 cm (Figures 3.11-21 and 3.11-22), whereas the supplemental core data suggested a maximum cap thickness of 12 cm. The extent to which these differences were an artifact of the two coring devices used for the Post-71 and supplemental surveys could not be determined. Furthermore, comparisons with SPI data suggest that both coring methods may under-represent cap thickness.

Table 3.11-1. Monitoring Objectives for Sediment Coring During Baseline Monitoring

Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Determine physical characteristics of sediments in the placement cells.	**Testing** Grain size Bulk density **Visual** Grain size Texture Color Visible stratification or lenses Debris Sheen or presence of oil Organic material **Odor**	Collect 9 gravity cores in each of the 4 cells. Section each core into 4-cm sections for testing. Visual inspection of cores. Description of core using core log.	Navigational accuracy to ± 3 m. Minimum core penetration: 20 cm based on the study design requirement for sampling the upper 20 cm layer. Fingers at bottom of corer closed. Overlying water is present and clear. No significant disturbance of sediment surface. Unified Soil Classification System used for visual description. Identifiable strata, changes in appearance, notable features measured from core surface to nearest 1 cm. If compaction, smearing, or mixing between strata precludes meeting this specification, qualify data accordingly or resample.
Determine physical characteristics of sediments in the placement cells with sufficient accuracy to permit distinctions between ambient EA sediments and cap material (dependent also on characteristics of the cap materials).	Same as above. Sufficient accuracy is defined as being able to discern a difference between the ambient EA sediments and cap material for the above "visual" parameters and quantifying a significant difference between the layers based on the above testing parameters.	Same as above.	Same as above.
Confirm that the thickness of EA sediments (defined as DDE exceeding 1 part-per-million [ppm]) exceeds 10 cm in the placement cells.	Concentration of DDE in ppm dry weight (dw).	Same as above for core sampling and testing.	Same as above for core penetration and recovery. Adequate sediment volume for testing. Decontamination of sampling tools between samples to prevent cross contamination and use of clean subsampling techniques. Determine core sections with DDE concentrations exceeding 1 ppm dw.
Determine DDE concentrations in surface sediments.	Concentration of DDE.	Same as above for core sampling and testing.	Same as above for core penetration and recovery, and clean sampling techniques.

Table 3.11-2. Monitoring Objectives and Approach for Sediment Coring During Cap Placement Monitoring.

Monitoring Objectives	**Data Requirements**	**Monitoring Approach**	**Field Decision Criteria/ Performance Specifications**
Determine cap layer thickness.	Provide data on a cap layer thickness for validation/-ground truthing USACE model predictions.	Collect gravity cores following a single placement event, after a 10-cm cap layer has accumulated, and after a 15-cm cap layer has accumulated. Visually inspect and photograph whole cores. Prepare core log. Analyze grain size and density from the cap layer portion of one core or a core composite.	Samples collected within the 5 m radius watch circle and navigational accuracy ±3 m. Fingers at bottom of corer closed. Overlying water is present and clear. No significant disturbance of sediment surface. Use Unified Soil Classification System for visual description. Identifiable strata, changes in appearance, notable features to be measured from core surface to nearest 1 cm. If smearing or mixing between strata precludes meeting this specification, note vertical layering characteristics in core log and qualify data.
Determine lateral extent of cap materials.	Same as above.	Same as above.	Same as above. Sufficient accuracy for distinguishing sediment layers is defined as being able to discern a difference between the EA sediments and cap material for the "visual" parameters.
Determine the postcapping extent of mixing between the cap and EA sediment layers.	Vertical distributions of physical/ chemical parameters that can be used to distinguish EA sediments and cap materials (e.g., DDE and grain size).	Collect postcapping cores and analyze for sediment grain size, bulk density, specific gravity, vane shear, water content, Atterberg limits and DDE concentrations in selected core horizons.	For postcap monitoring, corer must penetrate at least 20 cm into EA layer. Adequate sediment volume for testing must be obtained for each core strata sampled. Decontamination of sampling tools between samples to prevent cross contamination and use of clean subsampling techniques.

Table 3.11-3. Monitoring Objectives and Approach for Supplemental Sediment Coring.

Monitoring Objectives	Data Requirements	Monitoring Approach	Field Decision Criteria/ Performance Specifications
Evaluate and document the ability of the vibracore to take relatively undisturbed samples.	Provide sediment core data that can be compared directly with sediment profile imaging (SPI) results.	Collect vibracores at locations where sediment stratigraphy has been well documented. Visually inspect and photograph cores. Prepare core log. Analyze grain size and density. Adjust sampling procedure as needed to improve performance.	The following factors will be used to assess the success of coring: (1) core recoveries of at least 50 cm (caps are less than 20 cm thick at these stations, so this will result in the EA penetration need of 20 cm) and (2) cores that provide visual descriptions comparable to previously collected SPI photos from the selected stations.
Evaluate chemical and physical characteristics of cap material to assess cap success and provide data (e.g., bulk density of cap) for ongoing model refinement efforts by USACE.	Measure and map cap thickness in cells LU, SU, and LD using the most effective means available.	Collect cores at 22 sites in cells LU, LD, and SU. Split, photograph, and visually describe all cores. Particular attention will be given to the condition of the transition between the EA and cap sediments. Samples from two cores from Cell LD, six cores from Cell LU, and four cores from Cell SU for sediment grain size, bulk density, vane shear, specific gravity, water content, and chemistry (DDE).	Core recoveries of at least 70 cm (the cap is expected to be less than 50 cm thick at these stations), so this will result in minimum penetration of 20 cm into the EA layer.
Compare the effectiveness with which samples are taken with both a vibracore and box core to assess potential coring artifacts.	Undisturbed box cores from cells LD and LU for comparison to vibracores collected at the same locations.	Box cores will be sub-sampled with a hand-pushed core tube. All cores will be split, photographed, and visually described.	The box corer should have a minimum penetration capability of 25 cm.

Table 3.11-4. Summary of Sediment Cores and Core Analyses Performed During Baseline and Cap Monitoring in Cell LU

Cell LU Core Summary	DDE	Grain Size	Bulk Density	Specific Gravity	Water Content	Atterberg Limits	Shear Strength
Baseline Survey							
11 cores	49	51	54	na	na	4	54
Post 1 Survey							
9 cores	na	1	1	na	na	na	na
Post 5 Survey							
6 cores	na	1	1	na	na	na	na
Post 25 Survey							
12 cores	na	na	na	na	na	na	na
Post 45 Survey							
9 cores	16	20	21	12	12	6	13
archive samples	5A	2A	-	1A	1A	-	na
Post 71 Survey							
5 cores	9	9	5	9	9	0	0
archive samples	1A	-	-	3A	3A	5A	na
Summer Capping	25	31	28	21	21	8	13
archive samples	6A	2A	-	4A	4A	3A	na
Supplemental Survey	38	37	31	30	37	7	43
archive samples	14A	14A	-	14A	14A	na	na
Total Palos Verdes Project	112	119	113	51	58	17	110
archive samples	20A	16A	-	18A	18A	5A	na

Visual Descriptions of 78 cores from Cell LU

Table 3.11-5. Summary of Grain Size and Geotechnical Characteristics of Hopper Sediments Placed in Cells LU, SU, LD, and LC

Palos Verdes Pilot Capping Project
Hopper Composite Samples
Geotechnical Summary Table
Hopper Samples Composite of Bow, Center and Stern Grab Samples

HOPPER ID		Bulk Density		Specific Gravity	Water Content	Atterberg Limits	Gravel (>4mm)	Sand (0.0625-2mm)	Silt (0.0312-0.0039mm)	Clay (<0.00195mm)
		wet (g/cc)	dry (g/cc)	(T_x/20°C)	(%)		(%)	(%)	(%)	(%)
LU HOP Summary	Min	1.73	1.37	2.63	21	NA	0.00	52.73	3.43	1.05
19 Samples	Max	2.05	1.63	2.75	43	NA	2.86	91.92	33.02	18.74
2 Blind Duplicates	Median	1.96	1.45	2.73	33	NA	0.00	79.56	15.48	2.38
	StDev	0.07	0.08	0.03	5.53		0.73	10.06	8.66	3.83
	Average	1.95	1.49	2.72	32	NA	0.38	79.42	16.58	3.63
SU HOP Summary	Min	1.71	1.37	2.67	25	NA	0.00	70.65	6.34	1.24
7 Samples	Max	2	1.57	2.74	35	NA	1.58	92.42	25.72	9.40
	Median	1.95	1.47	2.73	29	NA	0.00	88.39	9.83	1.77
	StDev	0.11	0.06	0.02	3.95		0.59	8.83	6.77	2.92
	Average	1.90	1.47	2.72	30	NA	0.25	83.49	13.43	2.82
LD HOP Summary	Min	1.74	1.37	2.67	24	NA	0.00	94.25	0.08	0.64
4 Samples	Max	1.94	1.51	2.69	37	NA	0.00	99.29	2.78	2.97
	Median	1.83	1.39	2.68	29	NA	0.00	98.72	0.25	1.03
	StDev	0.09	0.06	0.01	5					
	Average	1.84	1.42	2.68	30	NA	0.00	97.74	0.84	1.42
LC HOP Summary										
1 Sample										
1 Blind Duplicate	Average	1.95	1.47	2.74	35	NA	0.00	84.83	13.27	1.90

Grain Size results based on % Frequency Weight
Gravel in this sample set represents shell fragments

Table 3.11-6. Summary of Grain Size Characteristics of Cell LU Sediments During Baseline Survey

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	A Average LUB (0-4cm)	B Average LUB (4-8cm)	C Average LUB (8-12cm)	D Average LUB (12-16cm)	E Average LUB (16-20cm)	All Horizons Standard Deviation LUB	All Horizons Average LUB
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	Small Pebble	-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coarse Sand	2	Gravel	-1	0.02	0.00	0.01	0.04	0.22	0.09	0.06
Medium Sand	1	V. Coarse Sand	0	0.20	0.10	0.21	0.30	0.36	0.10	0.23
	0.5	Coarse Sand	1	0.20	0.13	0.37	0.52	0.65	0.22	0.38
Fine Sand	0.25	Medium Sand	2	0.73	0.70	1.14	1.40	1.63	0.41	1.12
	0.125	Fine Sand	3	3.43	3.94	4.98	5.19	5.18	0.81	4.54
	0.0625	V. Fine Sand	4	53.41	54.49	54.46	52.14	48.74	2.39	52.65
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	18.58	18.63	17.29	16.63	16.99	0.93	17.63
	0.0156	Medium Silt	6	5.79	5.56	5.43	5.93	6.51	0.42	5.85
	0.0078	Fine Silt	7	3.87	3.59	3.45	3.63	4.06	0.24	3.72
	0.0039	V. Fine Silt	8	1.40	1.32	1.23	1.48	1.59	0.14	1.40
	0.00195	Clay	9	2.67	2.44	2.64	3.03	3.53	0.43	2.86
	<0.00195	Clay	>9	9.70	9.10	8.78	9.71	10.54	0.67	9.56

Horizon	Average LUB (0-4cm)	Average LUB (4-8cm)	Average LUB (8-12cm)	Average LUB (12-16cm)	Average LUB (16-20cm)	Standard Deviation LUB	Average LUB
Gravel (>4mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand (0.0625-2mm)	57.99	59.36	61.17	59.60	56.78	1.67	58.98
Silt (0.0312-0.0039mm)	29.64	29.10	27.41	27.67	29.15	0.99	28.59
Clay (<0.00195mm)	12.37	11.54	11.42	12.74	14.06	1.07	12.42

Grain Size results based on % Frequency Weight

Table 3.11-7. Summary of Grain Size Characteristics of Surface (A1) Layer of Sediment Cores from Cell LU During Post 45 Survey

Palos Verdes Post45 Survey Core Grain Size Data
Cell LU
A1=0-6cm or surface material

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LUC52 (0-4cm)	LUC55 (0-6cm)	LUC56 (0-4cm)	LUC57 (0-6cm)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	2.54	0.00	1.35	0.00
	4	Small Pebble	-2	2.11	0.08	2.29	0.00
Coarse Sand	2	Gravel	-1	2.45	0.21	1.92	0.00
Medium Sand	1	V. Coarse Sand	0	1.44	0.16	0.76	0.25
	0.5	Coarse Sand	1	3.02	0.51	1.96	0.19
Fine Sand	0.25	Medium Sand	2	26.39	16.99	21.31	0.65
	0.125	Fine Sand	3	41.05	48.91	41.03	3.81
	0.0625	V. Fine Sand	4	10.77	23.40	19.42	51.43
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	2.13	4.81	3.76	19.76
	0.0156	Medium Silt	6	1.38	1.56	1.45	6.44
	0.0078	Fine Silt	7	1.37	0.86	1.15	3.69
	0.0039	V. Fine Silt	8	1.22	0.48	0.77	2.56
	0.00195	Clay	9	0.81	0.41	0.50	1.67
	<0.00195	Clay	>9	3.32	1.64	2.32	9.55

Horizon	LUC52 (0-4cm)	LUC55 (0-6cm)	LUC56 (0-4cm)	LUC57 (0-6cm)
Gravel (>4mm)	4.66	0.08	3.64	0.00
Sand (0.0625-2mm)	85.11	90.17	86.40	56.33
Silt (0.0312-0.0039mm)	6.10	7.71	7.14	32.45
Clay (<0.00195mm)	4.13	2.04	2.82	11.22

Grain Size results based on % Frequency Weight

Table 3.11-8. Summary of Grain Size Characteristics of A3 Layer of Sediment Cores from Cell LU During Post 45 Survey

Palos Verdes Post 45 Survey Core Grain Size Data
Cell LU
A3= 3cm Above apparent EA/Cap interface; depth of sample is dependent on core

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LUC52 (6-9cm)	LUC55 (10-16cm)	LUC56 (6-10cm)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	1.49
	16	Large Pebble	-4	0.00	0.00	1.68
Fine Gravel	8	Medium Pebble	-3	1.38	17.64	2.14
	4	Small Pebble	-2	0.51	3.87	1.15
Coarse Sand	2	Gravel	-1	1.20	4.46	3.36
Medium Sand	1	V. Coarse Sand	0	0.53	3.19	1.23
	0.5	Coarse Sand	1	1.32	4.40	2.47
Fine Sand	0.25	Medium Sand	2	14.65	30.26	18.00
	0.125	Fine Sand	3	34.05	27.11	20.06
	0.0625	V. Fine Sand	4	28.96	4.02	24.49
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	7.67	0.53	7.89
	0.0156	Medium Silt	6	2.37	0.67	4.99
	0.0078	Fine Silt	7	1.38	0.82	1.29
	0.0039	V. Fine Silt	8	1.03	0.77	2.06
	0.00195	Clay	9	0.83	0.53	1.47
	<0.00195	Clay	>9	4.12	1.73	6.21

Horizon	LUC52 (6-9cm)	LUC55 (10-16cm)	LUC56 (6-10cm)
Gravel (>4mm)	1.89	21.51	6.47
Sand (0.0625-2mm)	80.70	73.44	69.62
Silt (0.0312-0.0039mm)	12.46	2.79	16.23
Clay (<0.00195mm)	4.95	2.26	7.68

Grain Size results based on % Frequency Weight

Table 3.11-9. Summary of Grain Size Characteristics of A4 Layer of Sediment Cores from Cell LU During Post 45 Survey

Palos Verdes Post 45 Survey Core Grain Size Data
Cell LU
A4= 4cm Below apparent EA/Cap interface; different depths are due to individual core characteristics

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LUC52 (16-20cm)	LUC55 (20-24cm)	LUC56 (13-17cm)	LUC57 (6-12cm)	LUC57 (6-12cm) DUPLICATE
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.00	0.37	3.03	0.00
	4	Small Pebble	-2	0.00	0.07	1.26	0.64	0.00
Coarse Sand	2	Gravel	-1	0.28	0.22	0.68	0.57	1.14
Medium Sand	1	V. Coarse Sand	0	0.08	0.06	0.37	0.38	0.25
	0.5	Coarse Sand	1	0.53	0.41	0.71	0.42	0.57
Fine Sand	0.25	Medium Sand	2	2.12	4.19	2.68	0.98	1.05
	0.125	Fine Sand	3	5.01	7.53	5.29	4.39	3.57
	0.0625	V. Fine Sand	4	41.48	52.14	48.76	48.81	51.89
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	18.64	17.76	16.81	17.52	18.36
	0.0156	Medium Silt	6	8.35	4.50	5.88	5.97	5.72
	0.0078	Fine Silt	7	4.68	2.65	3.58	3.73	3.67
	0.0039	V. Fine Silt	8	3.52	1.80	2.40	2.58	2.45
	0.00195	Clay	9	2.82	1.41	1.65	1.69	1.63
	<0.00195	Clay	>9	12.49	7.26	9.56	9.29	9.70

Horizon	LUC52 (16-20cm)	LUC55 (20-24cm)	LUC56 (13-17cm)	LUC57 (6-12cm)	LUC57 (6-12cm) DUPLICATE
Gravel (>4mm)	0.00	0.07	1.62	3.67	0.00
Sand (0.0625-2mm)	49.49	64.55	58.50	55.55	58.47
Silt (0.0312-0.0039mm)	35.19	26.71	28.66	29.80	30.20
Clay (<0.00195mm)	15.32	8.67	11.21	10.98	11.33

Note LUC56 A4 was described as having drag down
Grain Size results based on % Frequency Weight

Table 3.11-10. Supplemental Core Summary

Boxcores			Vibracores		
Replicate ID Box Cores	Total Box Core Length (cm)	Depth of Cap/EA Sediment Interface (cm)	Replicate ID Vibracores	Total Core Length (cm)	Depth of Cap/EA Sediment Interface (cm)
-	-	-	LUSV1 I10A	117	12
-	-	-	LUSV1 I06A	108.5	14
-	-	-	LUSV2 I01A	84	13
-	-	-	LUSV2 I03A	73	14
-	-	-	LUSV2 I07B	77	8
-	-	-	LUSV2 I12A	69	12
-	-	-	LUSV2 I13A	72.5	18
LUSB4 I16A	10.5	>10.5	LUSV2 I16A	61	0.5
LUSB4 I17B	12	>12	LUSV2 I17A	79	3
LUSB4 I19B	12	>12	LUSV2 I19A	64.5	10
-	-	-	LUSV2 I21A	69	7
LUSB4 O09A	11	7	LUSV3 O09A	69	4
-	-	-	LUSV3 I15A	79	8
LUSB4 I18B	9.5	>9.5	LUSV3 I18A	72	8
-	-	-	LUSV3 I20A	75.5	8
-	-	-	LUSV4 I12A	93	12

Table 3.11-11. Grain Size distribution in Horizon 1 (0 to 4 cm) of the Supplemental Vibracores from Cell LU.

Palos Verdes Pilot Capping Project
LUS; Post 71 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
0-4cm of core
Sample Horizon 1

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LUSV 2 I01 A (0-4cm)	LUSV 2 I03 A (0-4cm)	LUSV 2 I12 A (0-4cm)	LUSV 4 I12 A (0-4cm)	LUSV 2 I13 A (0-4cm)	LUSV 2 I17 A (0-4cm)	LUSV 2 I21 A (0-4cm)	LUSV 2 I21 A Duplicate (0-4cm)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	5.54	0.00	0.00	0.00	0.23	0.00	0.00	0.00
	4	Small Pebble	-2	0.39	2.93	0.43	0.00	0.53	0.00	0.00	0.21
Coarse Sand	2	Gravel	-1	0.91	0.65	0.14	0.54	0.43	0.16	0.41	0.25
Medium Sand	1	V. Coarse Sand	0	0.86	1.64	0.18	0.31	0.20	0.23	0.08	0.20
	0.5	Coarse Sand	1	1.17	0.89	0.45	0.65	0.76	0.41	0.55	0.44
Fine Sand	0.25	Medium Sand	2	12.61	9.26	9.10	10.88	7.38	4.00	7.87	7.57
	0.125	Fine Sand	3	38.62	20.36	44.95	43.75	17.01	24.27	30.12	27.48
	0.0625	V. Fine Sand	4	19.71	29.93	31.31	27.15	23.83	44.22	38.18	39.72
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	6.61	11.32	7.27	7.88	11.92	12.53	11.62	12.33
	0.0156	Medium Silt	6	3.66	5.72	2.45	2.80	7.93	4.02	3.45	3.82
	0.0078	Fine Silt	7	2.65	5.33	1.41	1.59	7.14	2.36	2.04	2.01
	0.0039	V. Fine Silt	8	1.92	3.33	0.86	0.90	5.89	1.56	1.27	1.39
	0.00195	Clay	9	1.37	2.39	0.53	0.59	4.05	1.11	0.89	0.86
	<0.00195	Clay	>9	3.99	6.27	0.92	2.98	12.70	5.12	3.53	3.72

Summary of LUSV 0-4cm Grain Size Data	LUSV 2 I01 A (0-4cm)	LUSV 2 I03 A (0-4cm)	LUSV 2 I12 A (0-4cm)	LUSV 4 I12 A (0-4cm)	LUSV 2 I13 A (0-4cm)	LUSV 2 I17 A (0-4cm)	LUSV 2 I21 A (0-4cm)	LUSV 2 I21 A Duplicate (0-4cm)
Horizon								
Gravel (>4mm)	5.92	2.93	0.43	0.00	0.75	0.00	0.00	0.21
Sand (0.0625-2mm)	73.88	62.72	86.13	83.26	49.61	73.29	77.21	75.66
Silt (0.0312-0.0039mm)	14.84	25.70	11.99	13.17	32.89	20.47	18.36	19.55
Clay (<0.00195mm)	5.36	8.66	1.45	3.57	16.75	6.24	4.42	4.58

Grain Size results based on % Frequency Weight

Table 3.11-12. Grain Size distribution in Horizon 2 (4 to 8 cm) of the Supplemental Vibracores from Cell LU.

Palos Verdes Pilot Capping Project
LUS; Post 71 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
4-8cm of core
Sample Horizon 2

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LUSV 2 I01 A (4-8cm)	LUSV 2 I03 A (4-8cm)	LUSV 2 I12 A (4-8cm)	LUSV 2 I13 A (4-8cm)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	3.46	0.68	0.00	0.53
	4	Small Pebble	-2	0.76	0.60	1.19	0.36
Coarse Sand	2	Gravel	-1	1.38	1.42	1.63	1.01
Medium Sand	1	V. Coarse Sand	0	0.79	0.57	0.73	0.48
	0.5	Coarse Sand	1	1.42	1.30	1.56	1.18
Fine Sand	0.25	Medium Sand	2	12.85	10.10	18.30	10.28
	0.125	Fine Sand	3	32.35	16.66	33.03	23.88
	0.0625	V. Fine Sand	4	18.34	14.16	24.95	18.30
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	6.26	7.51	7.82	7.53
	0.0156	Medium Silt	6	4.28	6.36	2.91	5.56
	0.0078	Fine Silt	7	4.13	8.31	1.69	6.72
	0.0039	V. Fine Silt	8	3.46	7.82	1.49	5.79
	0.00195	Clay	9	2.57	6.18	1.08	4.43
	<0.00195	Clay	>9	7.94	18.35	3.62	13.95

Summary of LUSV (4-8cm) Grain Size Data	LUSV 2 I01 A (4-8cm)	LUSV 2 I03 A (4-8cm)	LUSV 2 I12 A (4-8cm)	LUSV 2 I13 A (4-8cm)
Horizon				
Gravel (>4mm)	4.23	1.28	1.19	0.88
Sand (0.0625-2mm)	67.13	44.20	80.20	55.14
Silt (0.0312-0.0039mm)	18.14	30.00	13.91	25.59
Clay (<0.00195mm)	10.50	24.52	4.70	18.39

Grain Size results based on % Frequency Weight

Table 3.11-13. Grain Size distribution in Horizon 3 (8 to 12 cm) of the Supplemental Vibracores from Cell LU.

Palos Verdes Pilot Capping Project
LUS; Post 71 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
8-12 cm of core
Sample Horizon 3

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LUSV 2 I01 A (8-12cm)	LUSV 2 I03 A (8-12cm)	LUSV 2 I12 A (8-12cm)	LUSV 2 I12A Duplicate (8-12cm)	LUSV 4 I12 A (8-12cm)	LUSV 2 I13 A (8-12cm)	LUSV 2 I13A Duplicate (8-12cm)	LUSV 2 I17 A (8-12cm)	LUSV 2 I17A Duplicate (8-12cm)	LUSV 2 I21 A (8-12cm)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	5.38	4.10	0.80	1.28	0.00	0.98	0.67	0.00	0.00	0.00
	4	Small Pebble	-2	0.38	2.05	0.34	0.20	0.08	0.98	1.14	0.31	0.00	0.00
Coarse Sand	2	Gravel	-1	0.88	3.34	0.51	0.43	0.11	2.34	2.41	0.65	0.54	0.29
Medium Sand	1	V. Coarse Sand	0	0.83	1.27	0.30	0.33	0.14	0.99	0.78	0.29	0.26	0.26
	0.5	Coarse Sand	1	1.14	1.76	0.74	0.79	0.28	1.54	1.46	0.79	0.66	0.79
Fine Sand	0.25	Medium Sand	2	12.25	15.71	9.86	10.64	2.01	16.71	16.38	5.59	4.75	5.94
	0.125	Fine Sand	3	37.52	29.49	23.77	21.85	7.10	33.63	37.28	12.50	12.71	14.32
	0.0625	V. Fine Sand	4	19.15	12.72	36.88	38.46	50.54	16.25	17.79	46.08	48.23	41.73
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	6.03	4.92	12.37	12.80	18.09	5.11	5.36	13.82	14.41	14.84
	0.0156	Medium Silt	6	4.06	4.72	4.46	4.33	5.91	3.96	3.34	5.31	5.20	6.15
	0.0078	Fine Silt	7	3.38	4.86	2.57	2.54	3.35	4.16	3.10	3.31	3.31	3.90
	0.0039	V. Fine Silt	8	2.61	4.18	1.81	1.90	2.35	3.39	2.50	2.23	2.32	2.48
	0.00195	Clay	9	1.73	3.18	1.32	1.36	1.66	2.32	1.81	1.72	1.86	1.94
	<0.00195	Clay	>9	4.68	7.71	4.27	3.08	8.39	7.65	5.96	7.41	5.75	7.35

Summary of LUSV 8-12cm Grain Size Data	LUSV 2 I01 A (8-12cm)	LUSV 2 I03 A (8-12cm)	LUSV 2 I12 A (8-12cm)	LUSV 2 I12A Duplicate (8-12cm)	LUSV 4 I12 A (8-12cm)	LUSV 2 I13 A (8-12cm)	LUSV 2 I13A Duplicate (8-12cm)	LUSV 2 I17 A (8-12cm)	LUSV 2 I17A Duplicate (8-12cm)	LUSV 2 I21 A (8-12cm)
Horizon										
Gravel (>4mm)	5.8	6.2	1.1	1.5	0.1	2.0	1.8	0.3	0.0	0.0
Sand (0.0625-2mm)	71.8	64.3	72.1	72.5	60.2	71.5	76.1	65.9	67.1	63.3
Silt (0.0312-0.0039mm)	16.1	18.7	21.2	21.6	29.7	16.6	14.3	24.7	25.2	27.4
Clay (<0.00195mm)	6.4	10.9	5.6	4.4	10.1	10.0	7.8	9.1	7.6	9.3

Grain Size results based on % Frequency Weight

Table 3.11-14. Grain Size distribution in Horizon 4 (12 to 16 cm) of the Supplemental Vibracores from Cell LU.

Palos Verdes Pilot Capping Project
LUS; Post 71 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
(12-16cm) of core
Sample Horizon 4

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LUSV 2 101 A (12-16cm)	LUSV 2 103 A (12-16cm)	LUSV 2 112 A (12-16cm)	LUSV 2 113 A (12-16cm)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.81	0.00	0.86
	4	Small Pebble	-2	0.00	0.73	0.00	0.15
Coarse Sand	2	Gravel	-1	0.11	1.13	0.18	1.18
Medium Sand	1	V. Coarse Sand	0	0.27	0.57	0.14	0.50
	0.5	Coarse Sand	1	0.69	1.21	0.27	1.10
Fine Sand	0.25	Medium Sand	2	5.58	13.73	1.59	13.74
	0.125	Fine Sand	3	13.20	35.73	5.71	32.84
	0.0625	V. Fine Sand	4	45.60	25.37	47.71	26.92
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	13.49	6.47	18.15	8.66
	0.0156	Medium Silt	6	5.30	3.08	6.89	3.49
	0.0078	Fine Silt	7	2.81	2.60	3.72	2.57
	0.0039	V. Fine Silt	8	2.47	1.86	2.98	1.55
	0.00195	Clay	9	1.80	1.27	2.11	1.07
	<0.00195	Clay	>9	8.70	5.44	10.54	5.36

Summary of LUSV (12-16cm) Grain Size Data	LUSV 2 101 A (12-16cm)	LUSV 2 103 A (12-16cm)	LUSV 2 112 A (12-16cm)	LUSV 2 113 A (12-16cm)
Horizon				
Gravel (>4mm)	0.00	1.54	0.00	1.01
Sand (0.0625-2mm)	65.44	77.75	55.61	76.29
Silt (0.0312-0.0039mm)	24.06	14.00	31.74	16.27
Clay (<0.00195mm)	10.50	6.71	12.65	6.43

Grain Size results based on % Frequency Weight

Table 3.11-15. Grain Size distribution in Horizon 5 (16 to 20 cm) of the Supplemental Vibracores from Cell LU.

Palos Verdes Pilot Capping Project
LUS; Post 71 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
16-20cm of core
Sample Horizon 5

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LUSV 2 I01 A (16-20cm)	LUSV 2 I03 A (16-20cm)	LUSV 2 I12 A (16-20cm)	LUSV 4 I12 A (16-20cm)	LUSV 2 I13 A (16-20cm)	LUSV 2 I17 A (16-20cm)	LUSV 2 I21 A (16-20cm)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	Small Pebble	-2	0.09	0.21	0.18	0.00	0.03	0.21	0.02
Coarse Sand	2	Gravel	-1	0.24	1.44	0.52	0.08	0.44	0.17	0.48
Medium Sand	1	V. Coarse Sand	0	0.32	0.44	0.12	0.08	0.24	0.11	0.27
	0.5	Coarse Sand	1	0.75	0.43	0.35	0.25	0.48	0.33	0.65
Fine Sand	0.25	Medium Sand	2	2.54	2.43	3.18	1.16	4.76	1.56	2.05
	0.125	Fine Sand	3	7.51	8.07	10.09	5.26	13.10	7.27	5.37
	0.0625	V. Fine Sand	4	43.21	52.10	45.15	49.44	38.65	44.19	51.23
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	15.25	15.61	17.04	18.35	17.25	15.86	20.75
	0.0156	Medium Silt	6	7.78	6.01	6.70	6.52	6.45	7.18	5.92
	0.0078	Fine Silt	7	5.26	3.72	4.08	4.26	4.02	5.20	3.05
	0.0039	V. Fine Silt	8	4.17	2.30	2.85	2.64	2.98	3.78	1.96
	0.00195	Clay	9	3.22	1.65	2.09	2.04	2.19	2.86	1.52
	<0.00195	Clay	>9	9.65	5.58	7.66	9.93	9.40	11.30	6.72

Summary of LUSV 16-20cm Grain Size Data	LUSV 2 I01 A (16-20cm)	LUSV 2 I03 A (16-20cm)	LUSV 2 I12 A (16-20cm)	LUSV 4 I12 A (16-20cm)	LUSV 2 I13 A (16-20cm)	LUSV 2 I17 A (16-20cm)	LUSV 2 I21 A (16-20cm)
Horizon							
Gravel (>4mm)	0.09	0.21	0.18	0.00	0.03	0.21	0.02
Sand (0.0625-2mm)	54.57	64.91	59.40	56.26	57.68	53.62	60.05
Silt (0.0312-0.0039mm)	32.47	27.65	30.66	31.77	30.70	32.01	31.69
Clay (<0.00195mm)	12.88	7.23	9.76	11.97	11.59	14.16	8.25

Grain Size results based on % Frequency Weight

Table 3.11-16. Grain Size distribution in Horizon 7 (24 to 28 cm) of the Supplemental Vibracores from Cell LU.

Palos Verdes Pilot Capping Project
LUS; Post 71 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
24-28 cm of core
Sample Horizon 7

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LUSV 2 I12 A (24-28cm)	LUSV 4 I12 A (24-28cm)	LUSV 2 I13 A (24-28cm)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.30	0.00	0.00
	4	Small Pebble	-2	0.00	0.00	0.08
Coarse Sand	2	Gravel	-1	0.19	0.00	0.17
Medium Sand	1	V. Coarse Sand	0	0.15	0.13	0.17
	0.5	Coarse Sand	1	0.33	0.42	0.19
Fine Sand	0.25	Medium Sand	2	1.42	1.14	0.56
	0.125	Fine Sand	3	6.95	4.31	3.32
	0.0625	V. Fine Sand	4	47.47	48.45	48.99
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	18.03	17.60	25.61
	0.0156	Medium Silt	6	7.50	6.71	6.95
	0.0078	Fine Silt	7	4.39	4.24	1.94
	0.0039	V. Fine Silt	8	3.14	3.18	3.32
	0.00195	Clay	9	2.36	2.41	1.44
	<0.00195	Clay	>9	7.78	11.41	7.24

Summary of LUSV (24-28cm) Grain Size Data	LUSV 2 I12 A (24-28cm)	LUSV 4 I12 A (24-28cm)	LUSV 2 I13 A (24-28cm)
Horizon			
Gravel (>4mm)	0.30	0.00	0.08
Sand (0.0625-2mm)	56.50	54.45	53.41
Silt (0.0312-0.0039mm)	33.06	31.73	37.83
Clay (<0.00195mm)	10.14	13.82	8.68

Grain Size results based on % Frequency Weight

Table 3.11-17. Grain Size distribution in Horizon 9 (32 to 36 cm) and Horizon 11 (40 to 44 cm) of the Supplemental Vibracores from Cell LU.

Palos Verdes Pilot Capping Project
LUS; Post 71 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
32-36cm and 40-44cm
Sample Horizon 9 and 11; core collected without liner

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LUSV 4 I12 A (32-36cm)	LUSV 4 I12 A (40-44cm)
			(f)	(%)	(%)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00
	16	Large Pebble	-4	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.00
	4	Small Pebble	-2	0.00	0.00
Coarse Sand	2	Gravel	-1	0.52	0.17
Medium Sand	1	V. Coarse Sand	0	0.20	0.22
	0.5	Coarse Sand	1	0.58	0.59
Fine Sand	0.25	Medium Sand	2	1.31	1.28
	0.125	Fine Sand	3	5.56	4.48
	0.0625	V. Fine Sand	4	46.42	44.87
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	17.07	17.98
	0.0156	Medium Silt	6	7.18	7.63
	0.0078	Fine Silt	7	4.55	4.98
	0.0039	V. Fine Silt	8	3.43	3.59
	0.00195	Clay	9	2.40	3.01
	<0.00195	Clay	>9	10.78	16.03

Summary of LUSV (32-36cm) and (40-44cm) Grain Size Data	LUSV 4 I12 A (32-36cm)	LUSV 4 I12 A (40-44cm)
Horizon		
Gravel (>4mm)	0.00	0.00
Sand (0.0625-2mm)	54.59	51.62
Silt (0.0312-0.0039mm)	32.23	34.18
Clay (<0.00195mm)	13.18	19.04

Grain Size results based on % Frequency Weight

Table 3.11-18. DDE Concentration (ppm dry weight) and Estimated Proportions (%) of Cap Material (Queen's Gate Sediment) in Post 45 and Post 71 Sediment Cores from Cell LU. Proportions were calculated from DDE concentrations in postcapping sediment cores and assuming a uniform DDE concentration of 0.02 ppm DDE concentration in cap material and 1.5 ppm DDE concentration in EA sediments.

	Post 45 Survey				Post 71 Survey		
Core	**LUC52**	**LUC55**	**LUC56**	**LUC57**	**LUA60**	**LUA61**	**LUA64**
A1	0.044 (99)	0.139 (92)	0.082 (96)	0.94 (38)	0.011 (>99)	0.0034 (>99)	0.048 (98)
A2	0.028 (>99)	0.017 (>99)	0.066 (97)	-	-	-	-
A3	0.019 (>99)	0.43 (73)	0.14 (92)	-	0.052 (98)	0. 12 (94)	0. 15 (91)
A4	0.0 (0)	1.0 (34)	1.6 (0)	1.3 (14)	0.67 (56)	1.9 (0)	0.43 (73)

- = not sampled; A1=surface; A2=7 cm above interface; A3=3 cm above interface; A4=4 cm below interface.

Table 3.11-19. DDE Concentrations (ppm dry weight) in Sediment Cores from the Supplemental Survey.

Supplemental Survey						
Core Depth (cm)	**I01**	**I03**	**I12**	**I13**	**I17**	**I21**
0-4	0.66	0.30	0.12	0.31	0.70	0.35
4-8	0.50	0.095	0.87	0.10	-	-
8-12	0.14	0.070	1.3	0.20	1.2	2.0
12-16	1.4	0.97	1.8	1.4	-	-
16-20	1.9	0.71	1.5	1.5	3.1	0.98
24-28	-	-	1.6	0.09	-	-
36-40	-	-	1.6	-	-	-

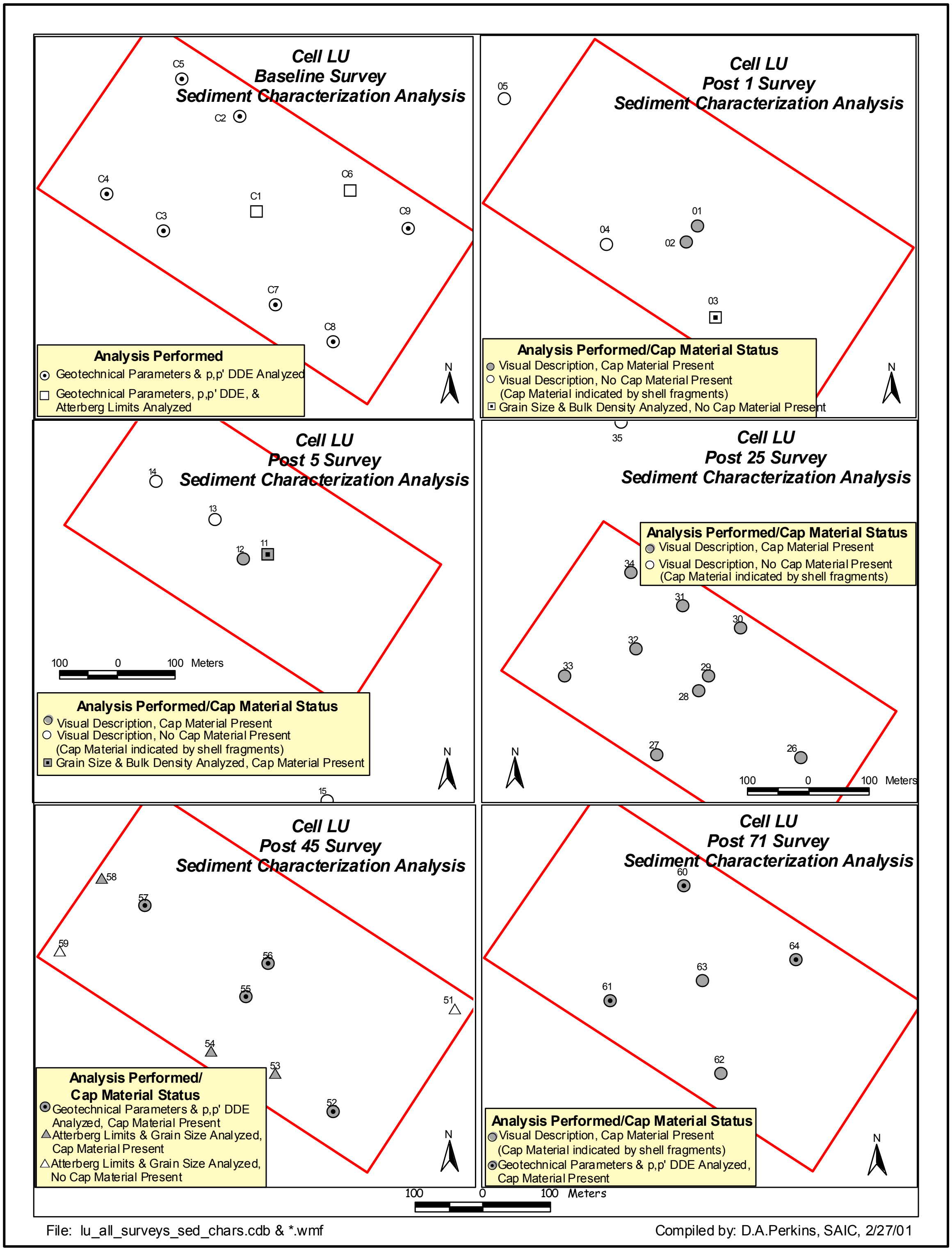


Figure 3.11-1. Coring locations in Cell LU during (a) Baseline, (b) Post 1, (c) Post 5, (d) Post 25, (e) Post 45, and (f) Post 71 surveys.

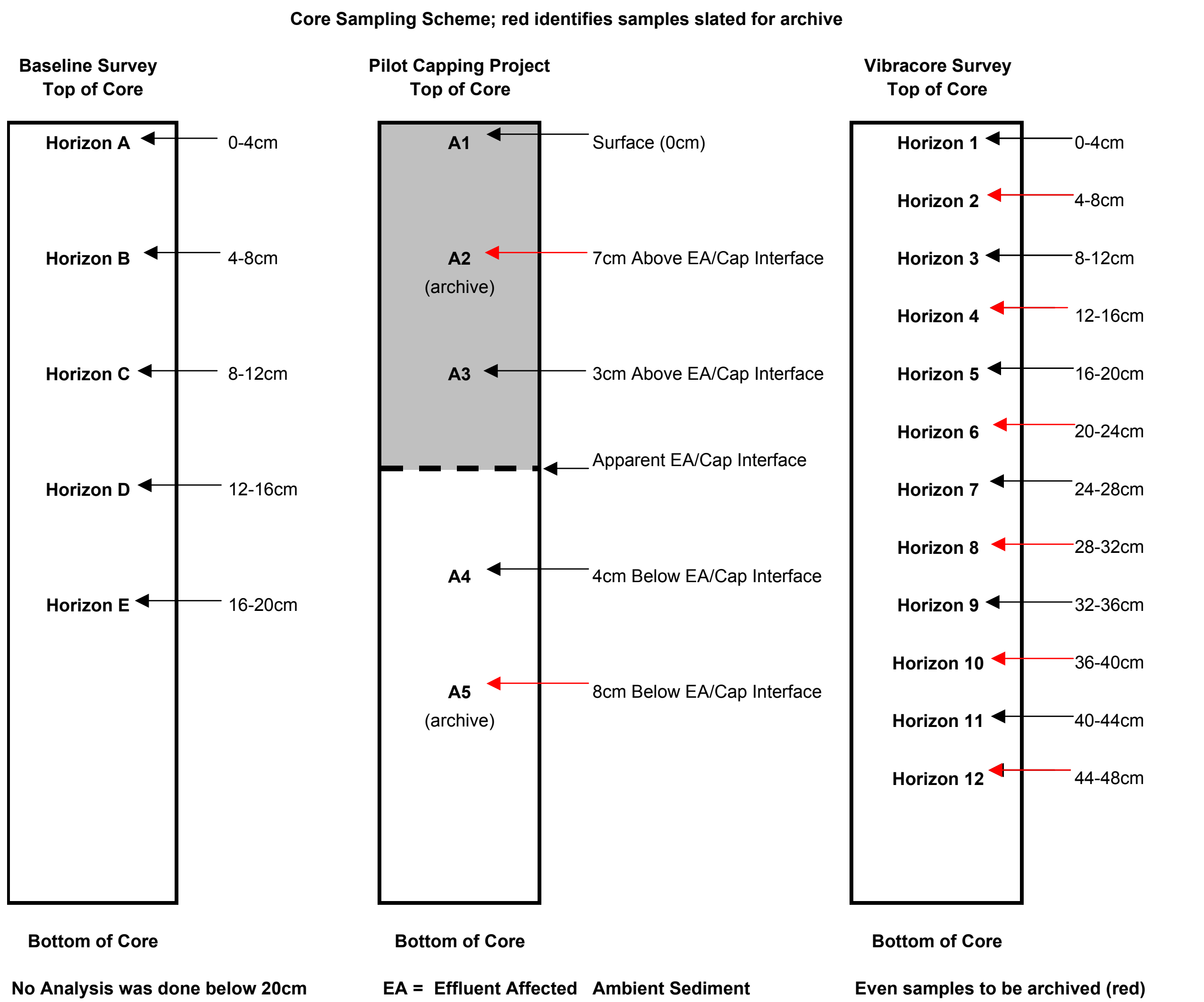


Figure 3.11-2. Core subsampling scheme for baseline and postcapping surveys.

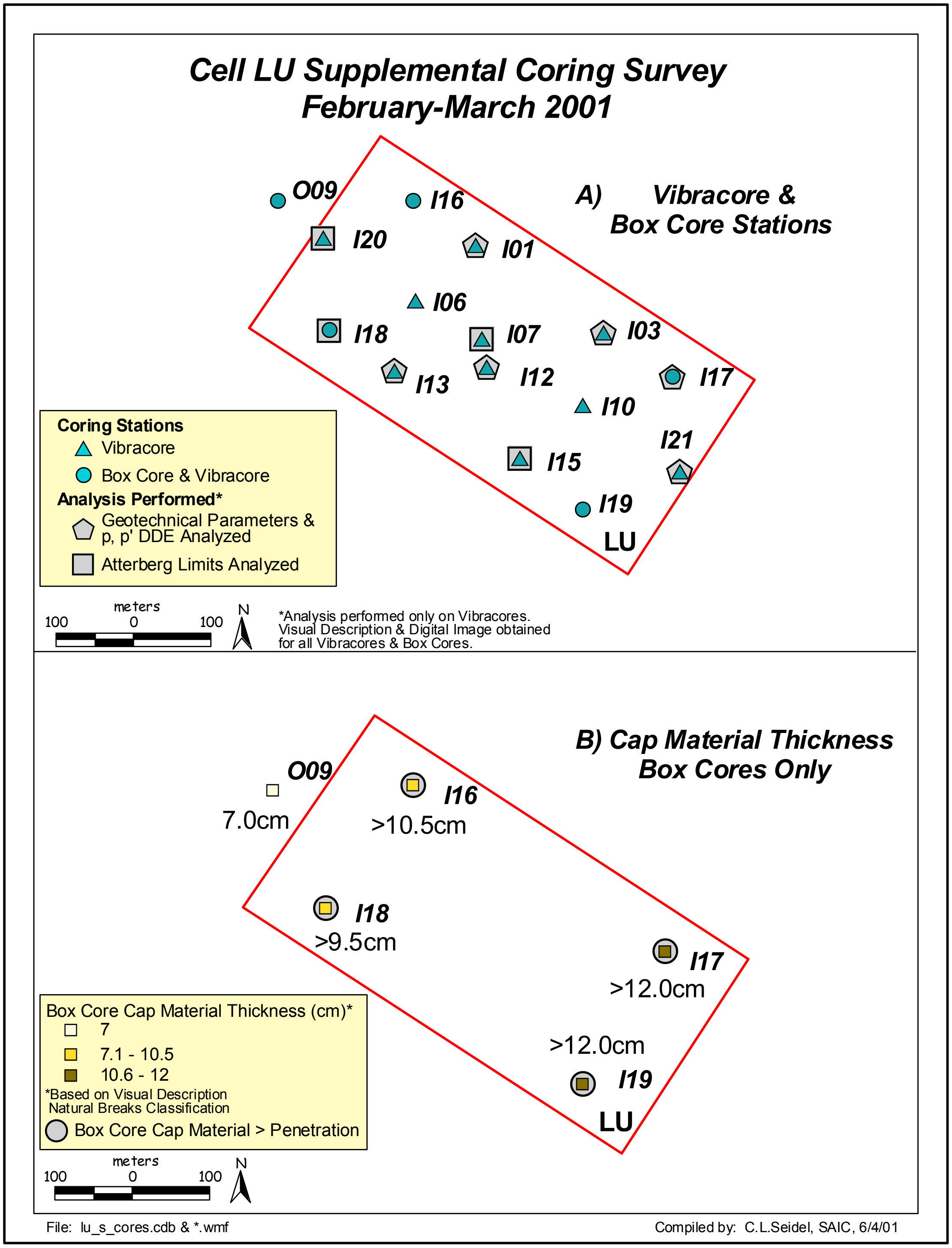


Figure 3.11-3. Vibracore (a) and box (b) core locations for Cell LU supplemental survey.

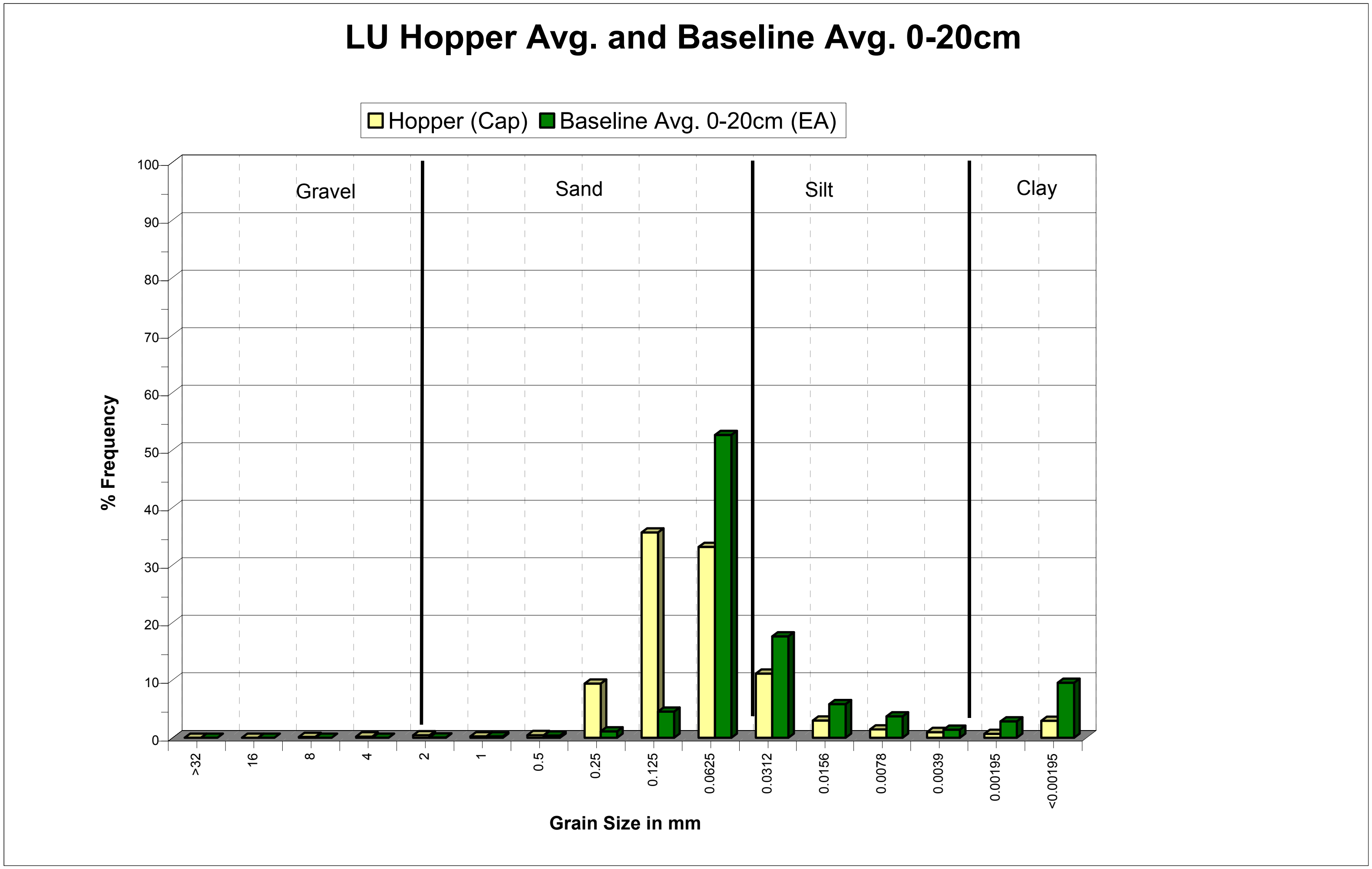


Figure 3.11-4. Comparisons of grain size distributions for hopper and baseline (EA) sediments from Cell LU. Baseline sediment values represent an average of 0 to 20 cm of core.

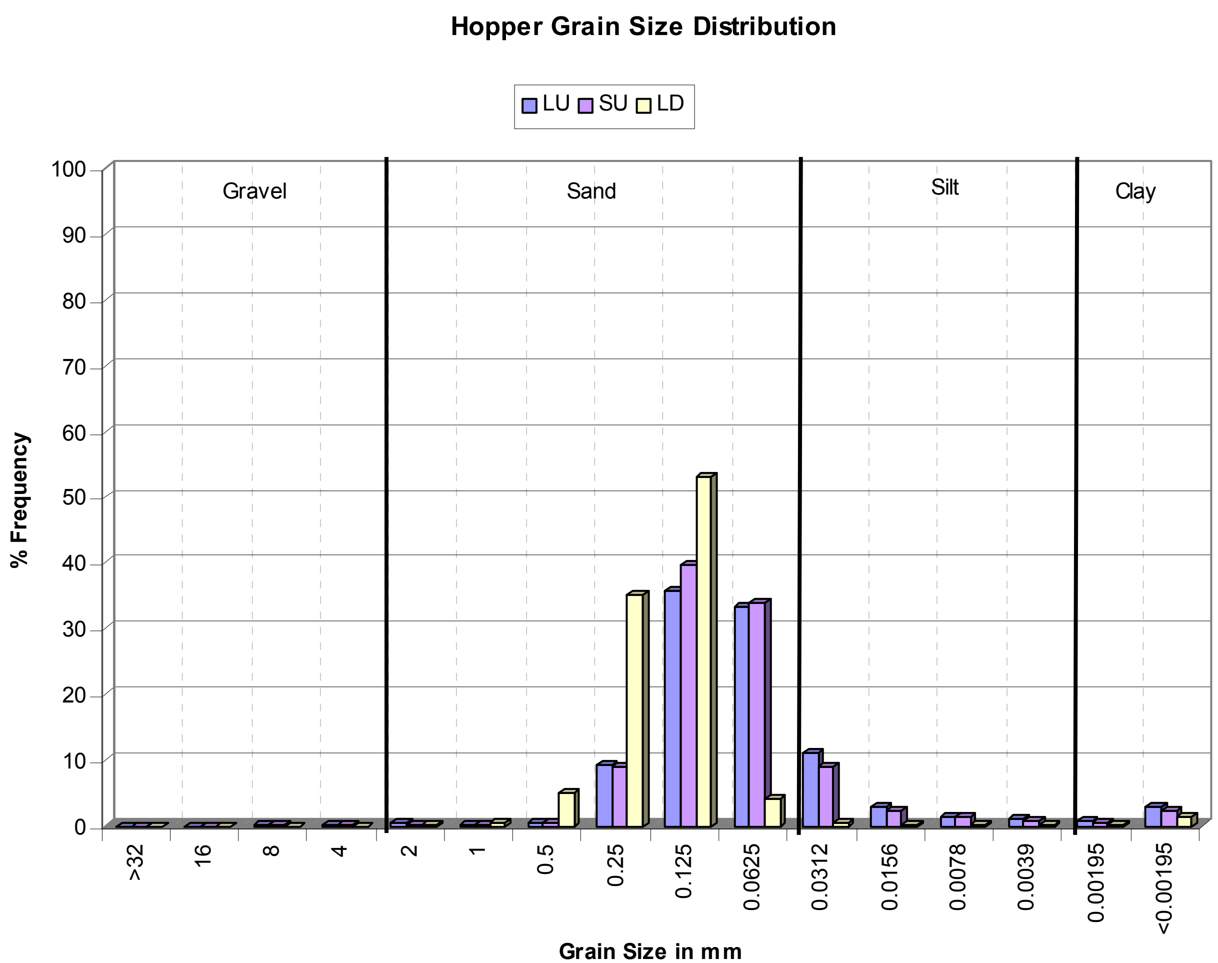


Figure 3.11-5. Sediment grain size distributions for hopper sediments placed in Cells LU, SU, and LD.

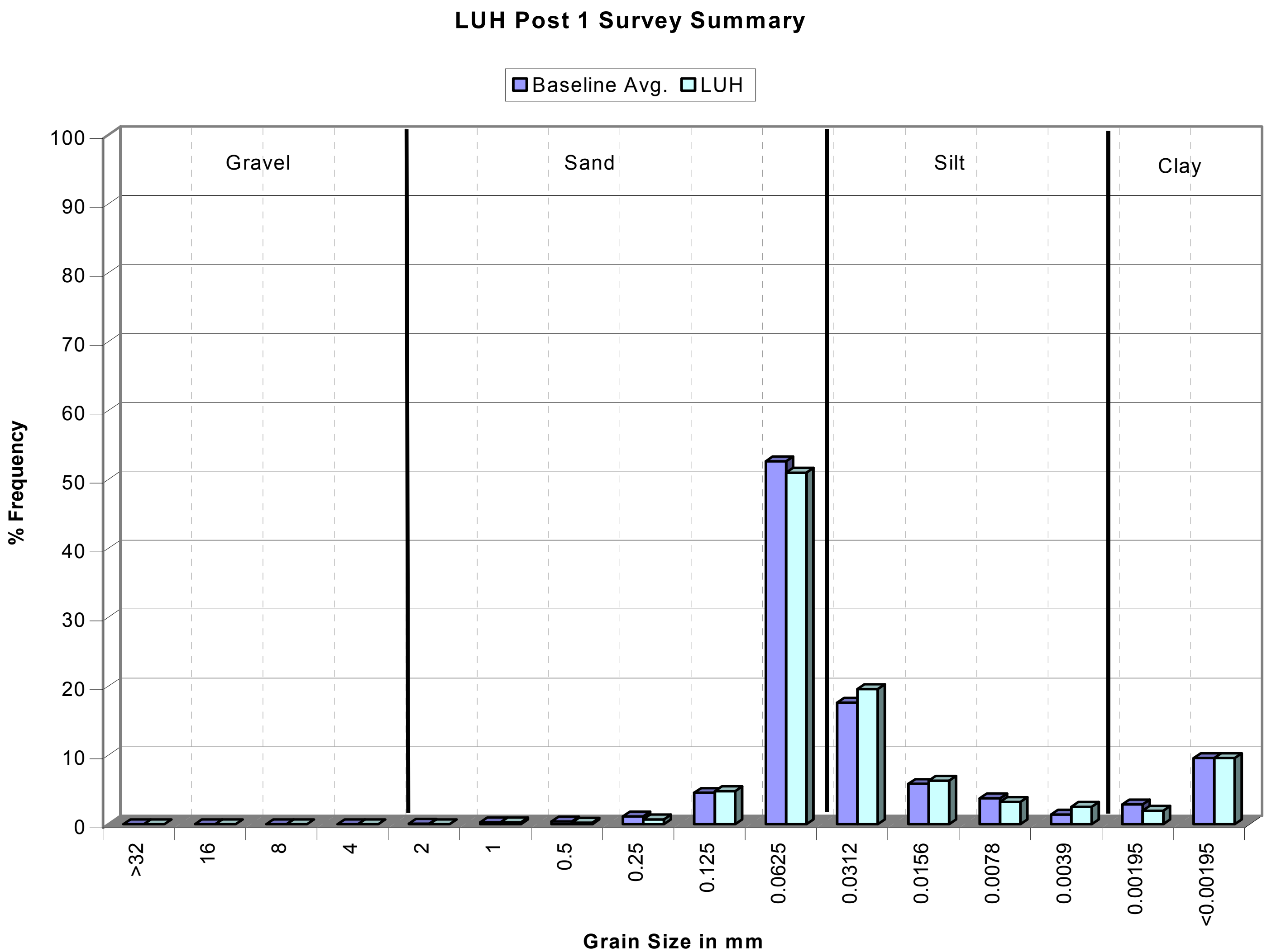


Figure 3.11-6. Grain size distributions of Cell LU sediments for the baseline survey and following one placement event (LUH).

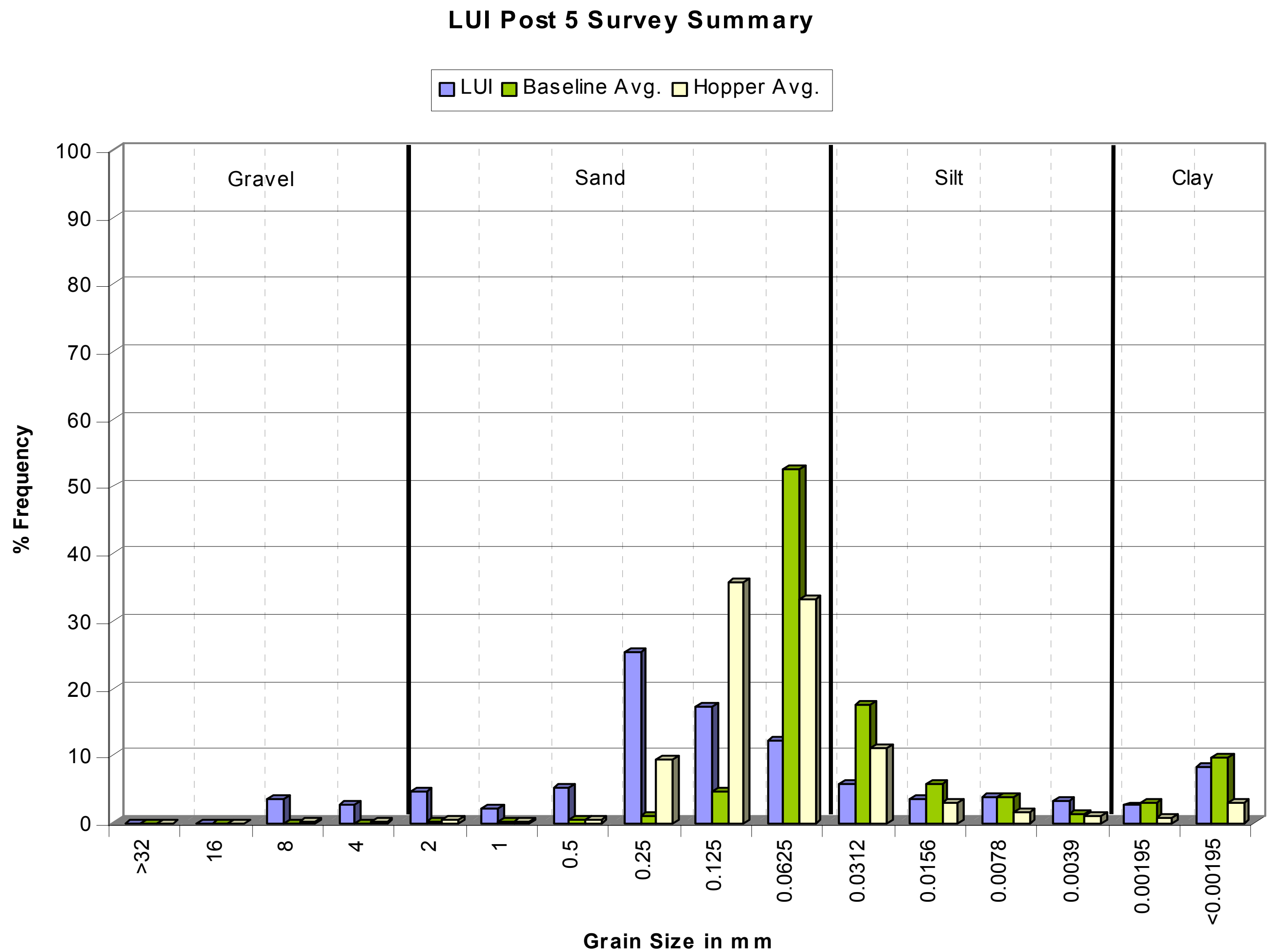


Figure 3.11-7. Grain size distributions of Cell LU sediments for the baseline survey and following five placement events (LUH).

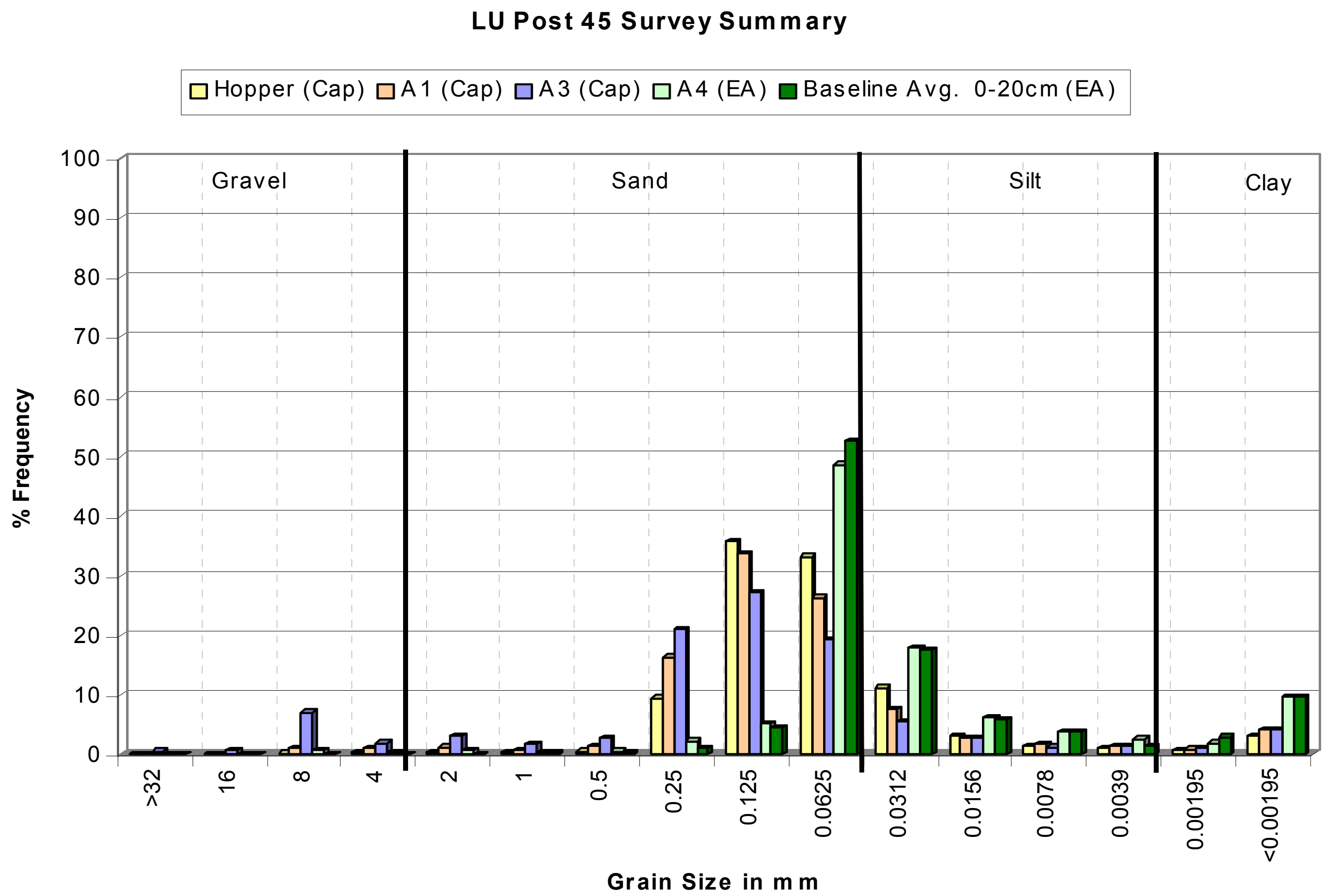


Figure 3.11-8. Grain size distributions in Post 45 survey sediments from Cell LU. Data from baseline cores and hopper samples are provided for comparisons with postcap

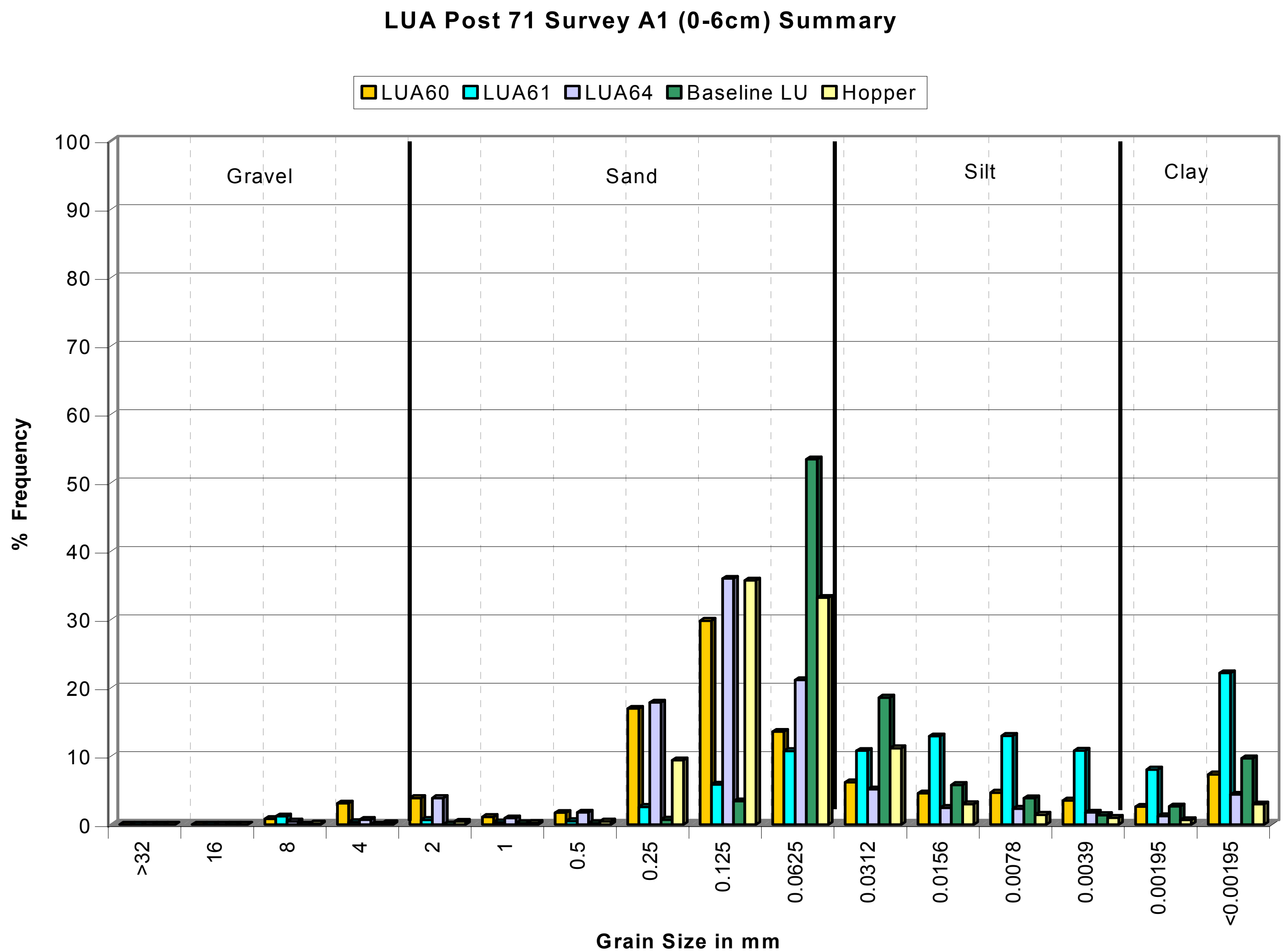


Figure 3.11-9. Grain size distributions in surface (A1) horizon of Post 71 survey sediment cores from Cell LU. Data from baseline cores and hopper samples are provided for comparison.

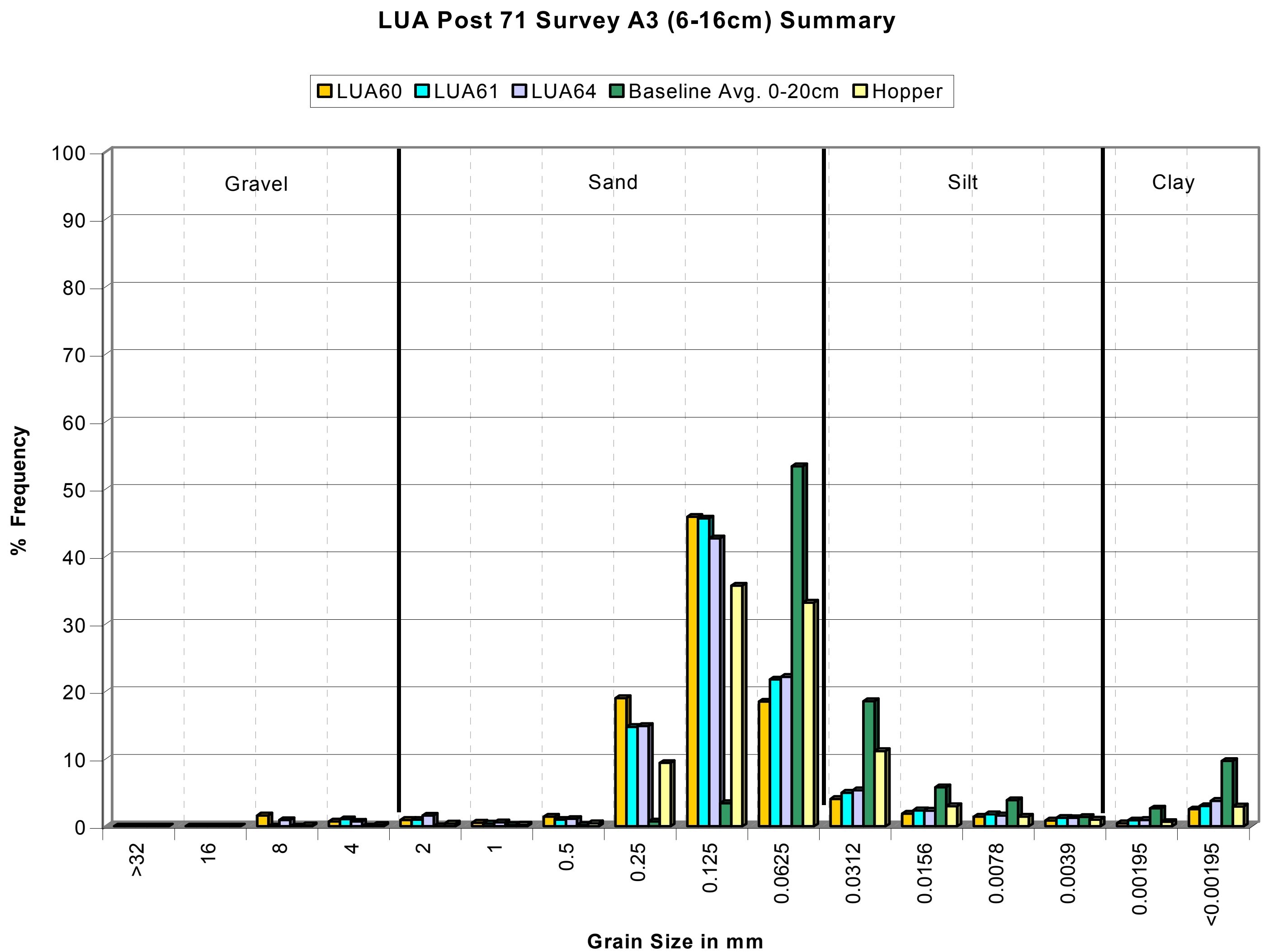


Figure 3.11-10. Grain size distributions in A3 horizons of Post 71 survey sediments from Cell LU. Data from baseline cores and hopper samples are provided for comparisons with postcap.

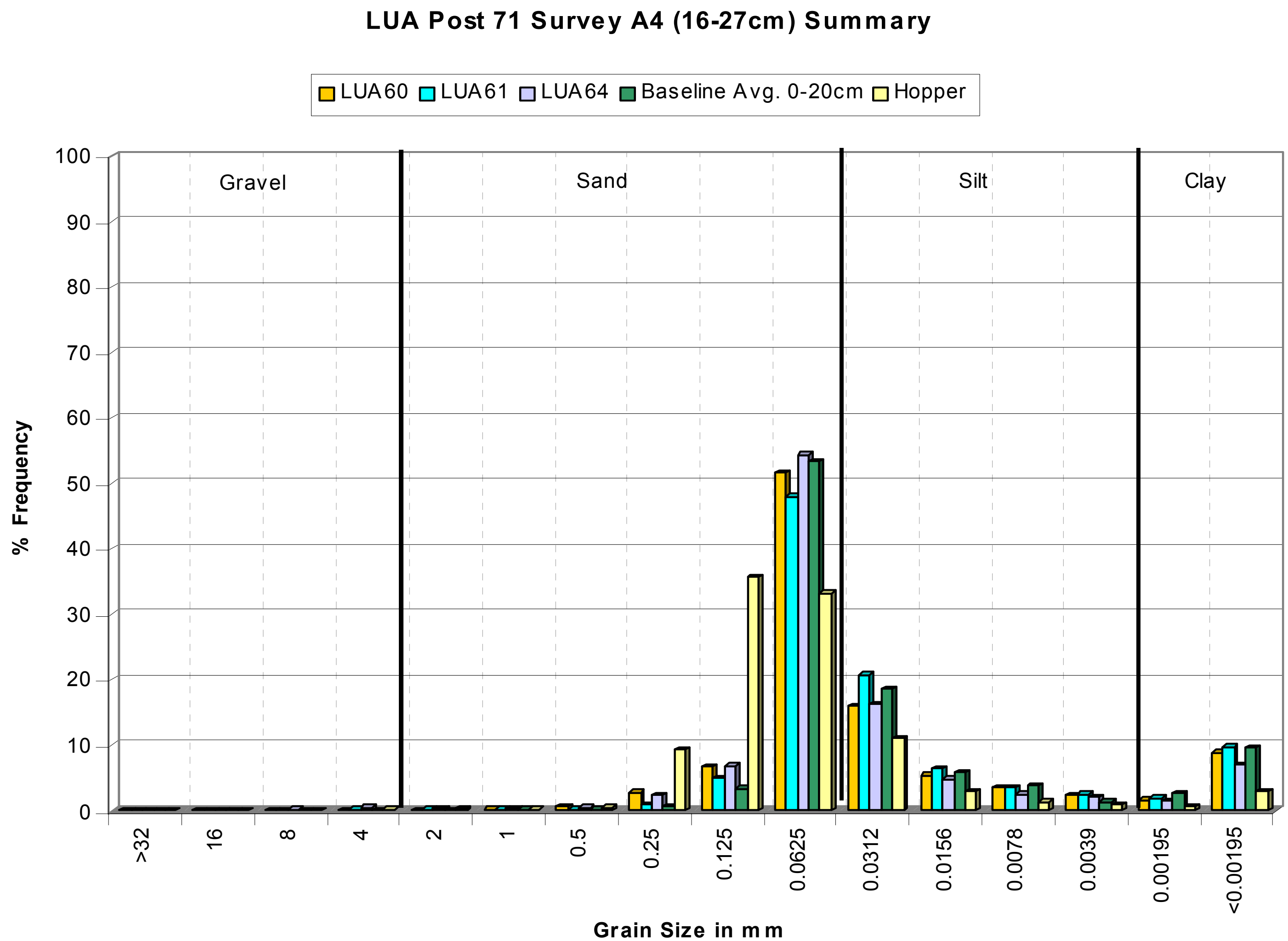


Figure 3.11-11. Grain size distributions in A4 horizons of Post 71 survey sediments from Cell LU. Data from baseline cores and hopper samples are provided for comparisons with postcap.

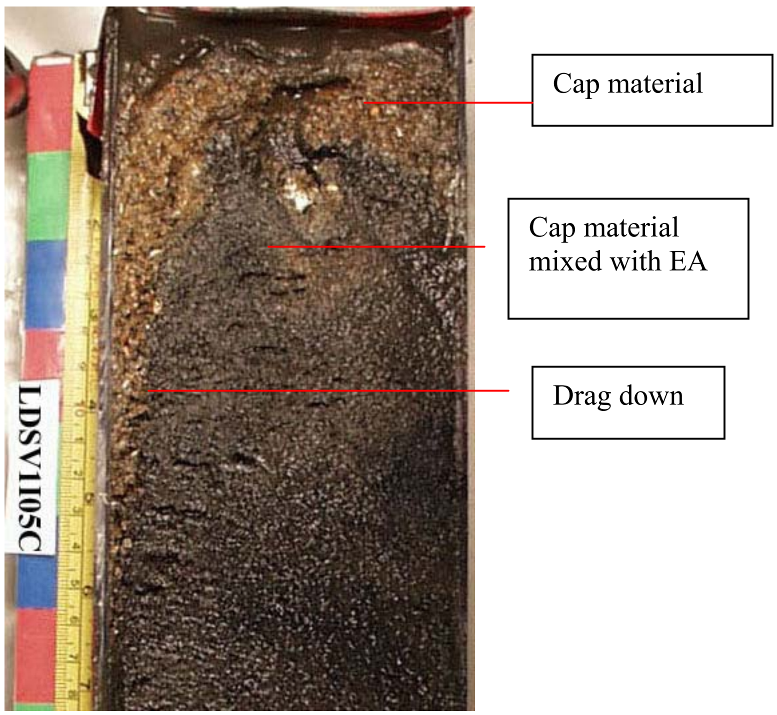


Figure 3.11-12. Core LDSV1 I05 C, illustration of coring artifact referred to as 'drag down'.

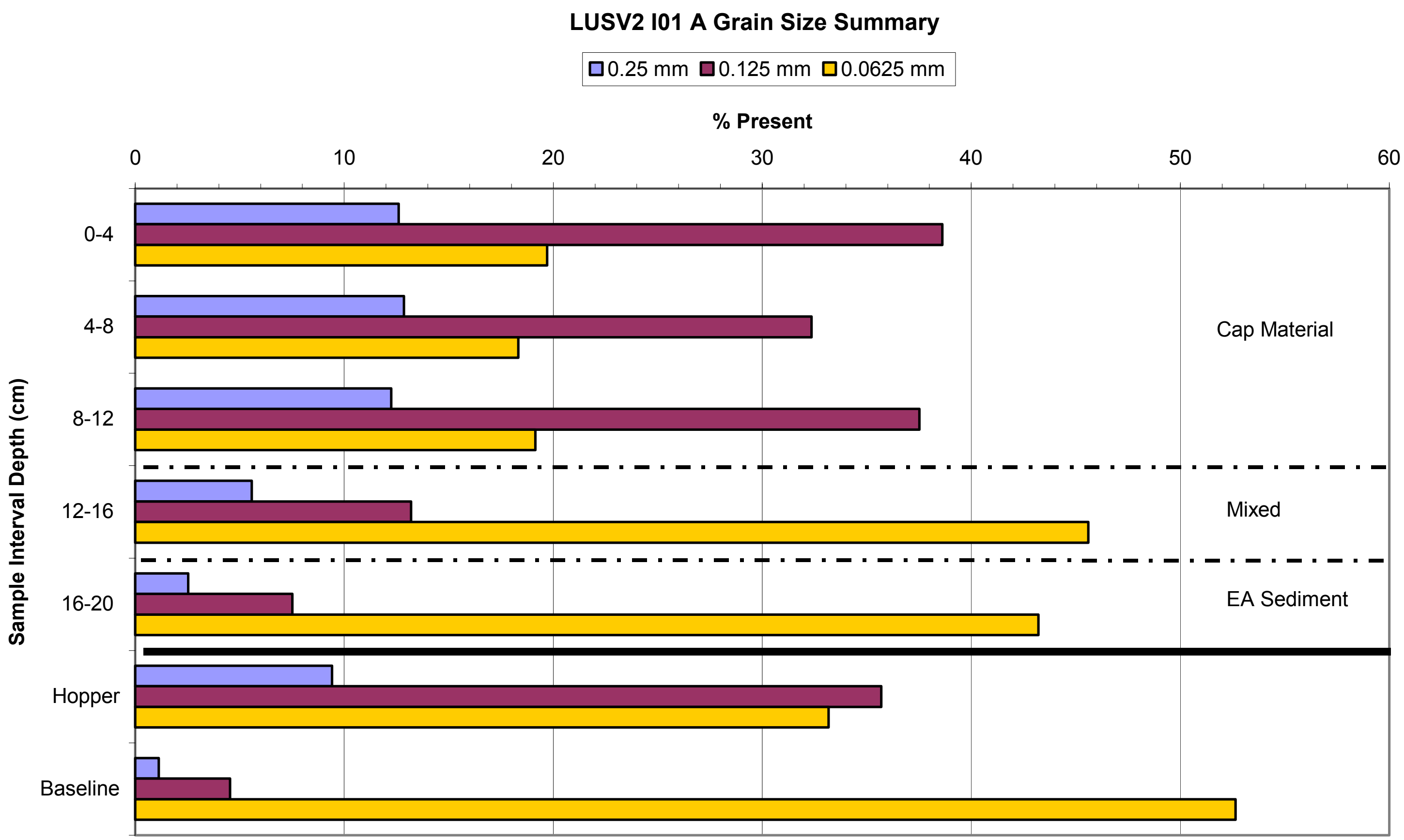


Figure 3.11-13. Grain Size distribution in Core LUSV2 I01 A of the Supplemental Vibracores from Cell LU. Hopper sample and baseline averages are provided for comparison.

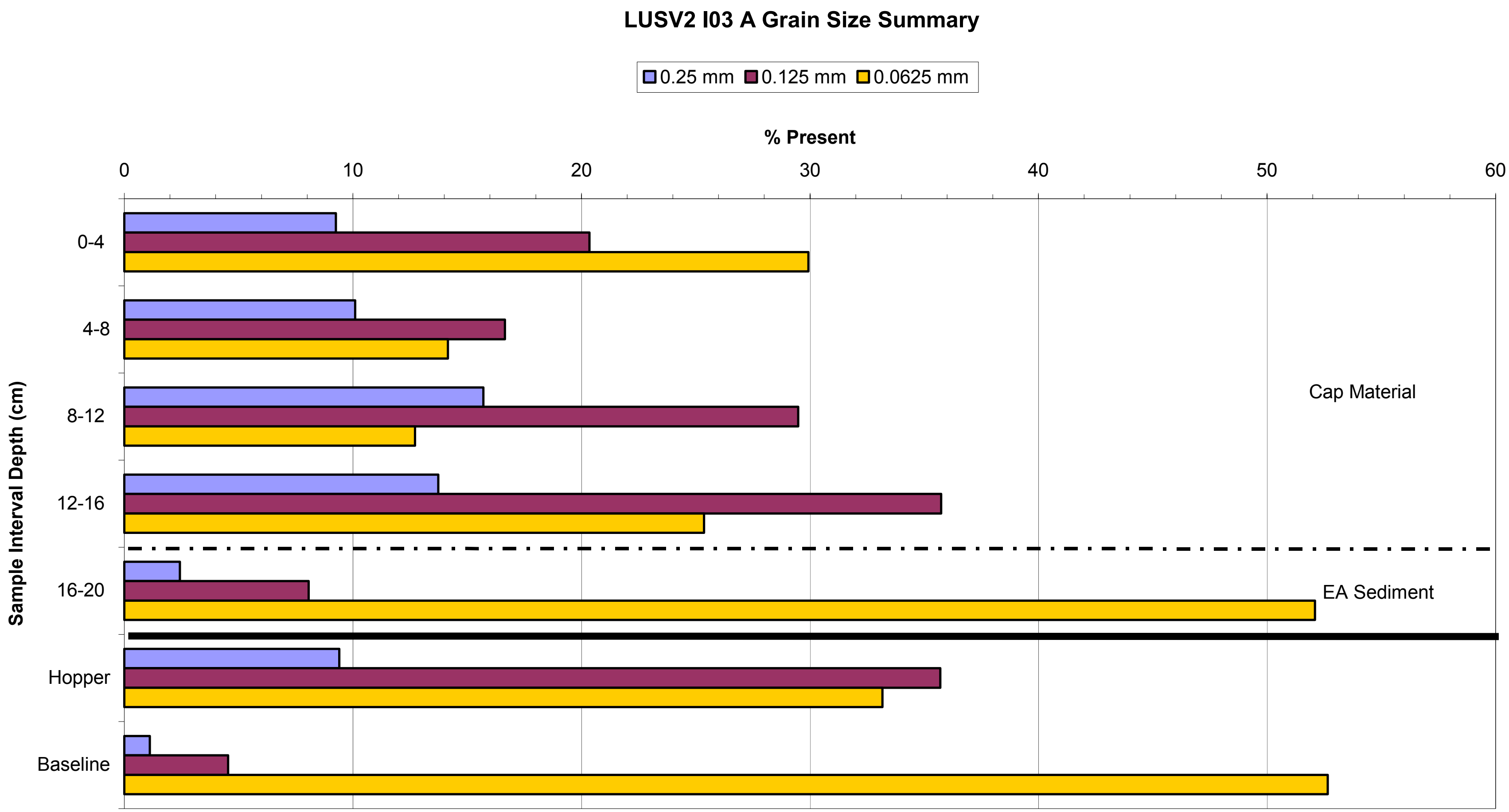


Figure 3.11-14. Grain Size distribution in Core LUSV2 I03 A of the Supplemental Vibracores from Cell LU. Hopper sample and baseline averages are provided for comparison.

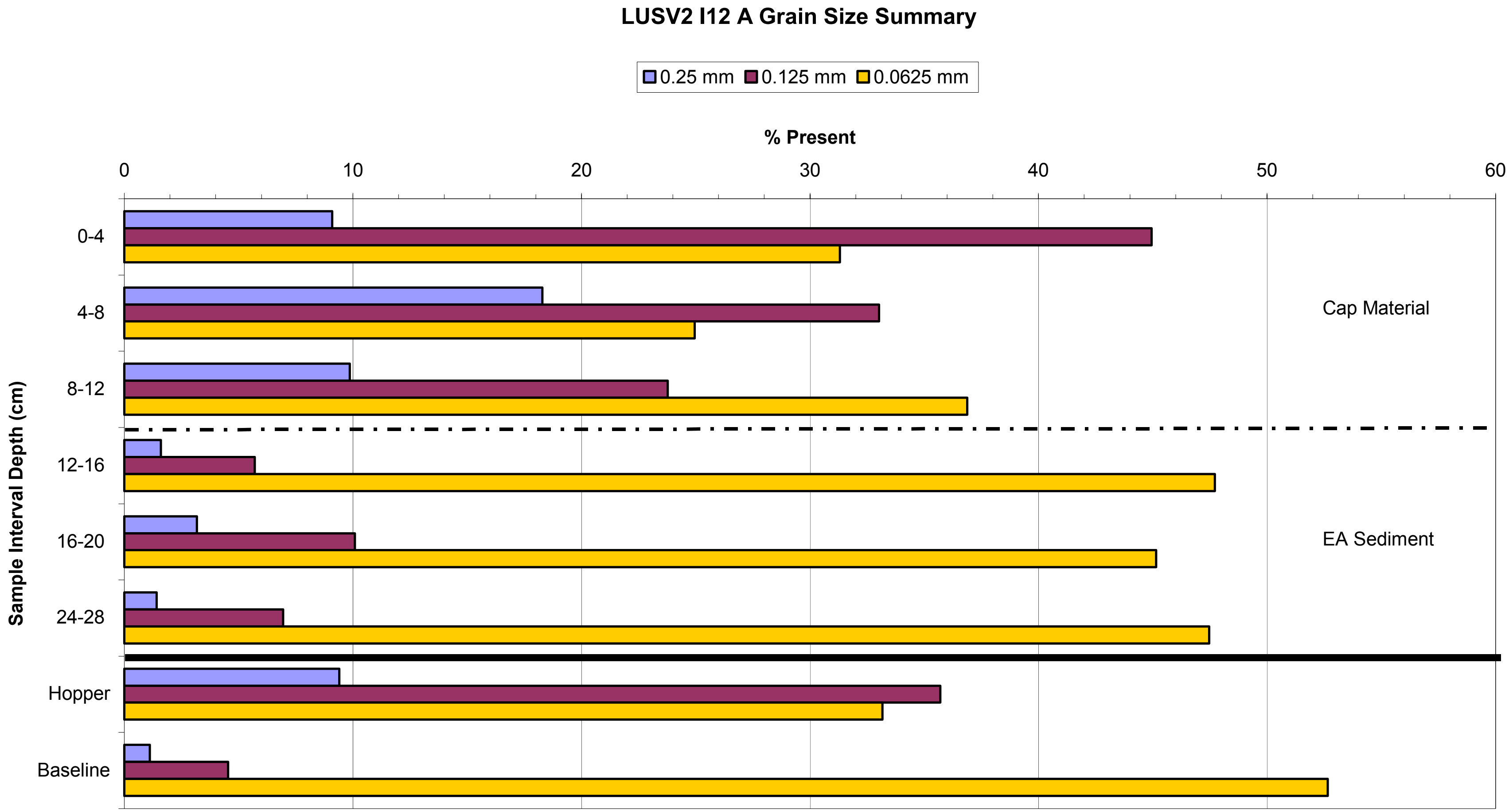


Figure 3.11-15. Grain Size distribution Core LUSV2 I12 A of the Supplemental Vibracores from Cell LU. Hopper sample and baseline averages are provided for comparison.

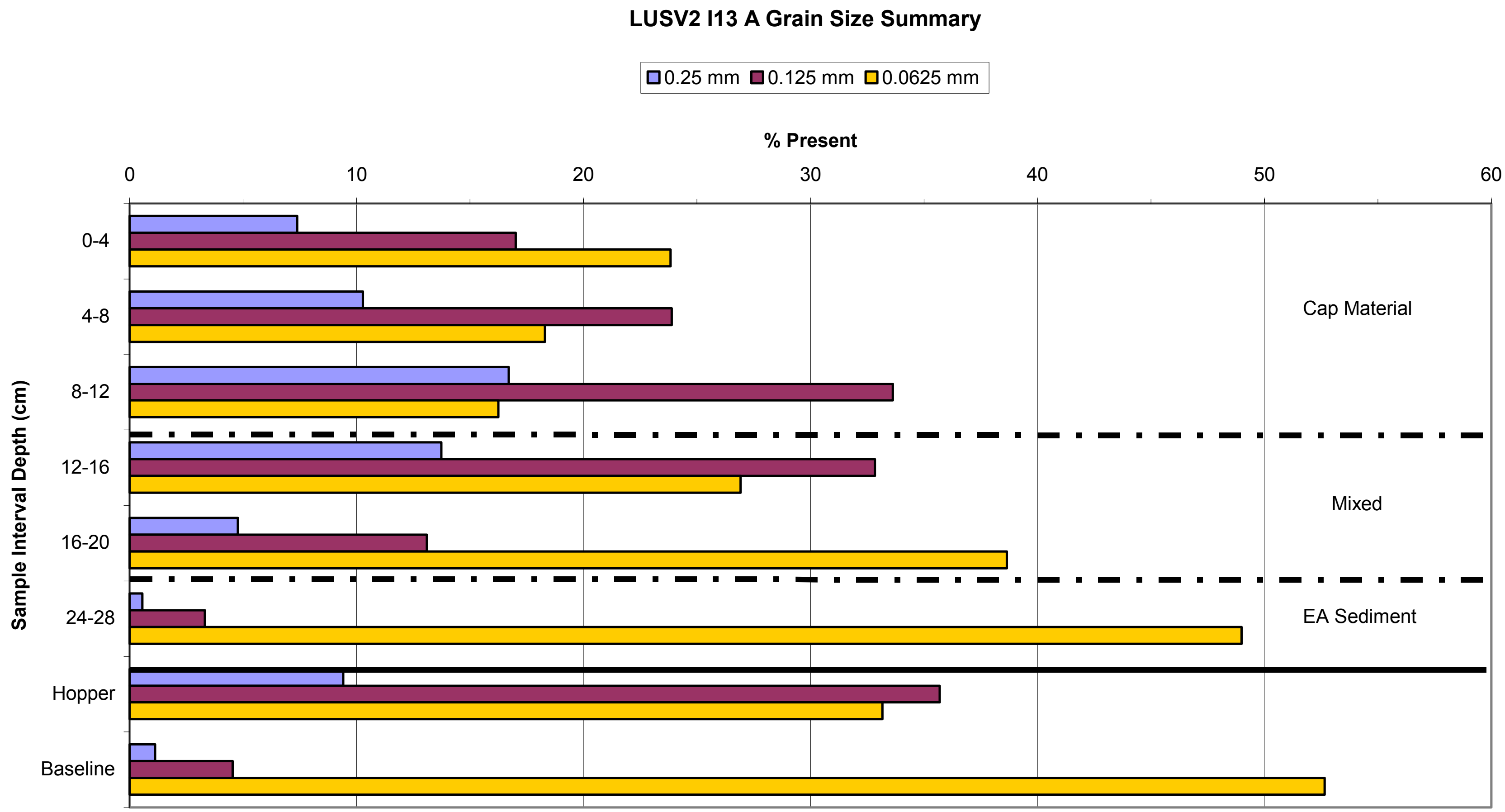


Figure 3.11-16. Grain Size distribution in Core LUSV2 I13 A of the Supplemental Vibracores from Cell LU. Hopper sample and baseline averages are provided for comparison.

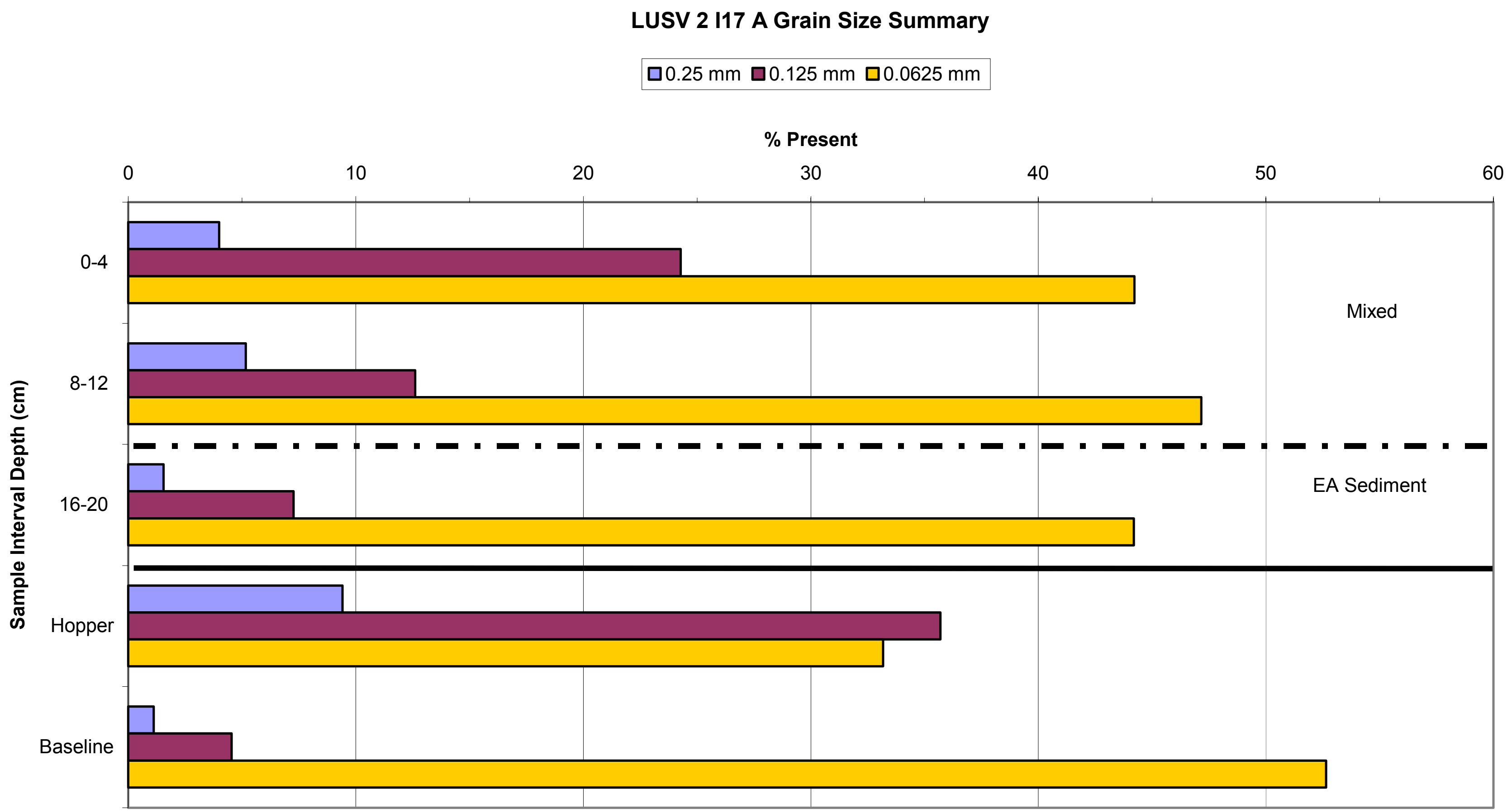


Figure 3.11-17. Grain Size distribution Core LUSV2 I17 A of the Supplemental Vibracores from Cell LU. Hopper sample average and baseline are provided for comparison.

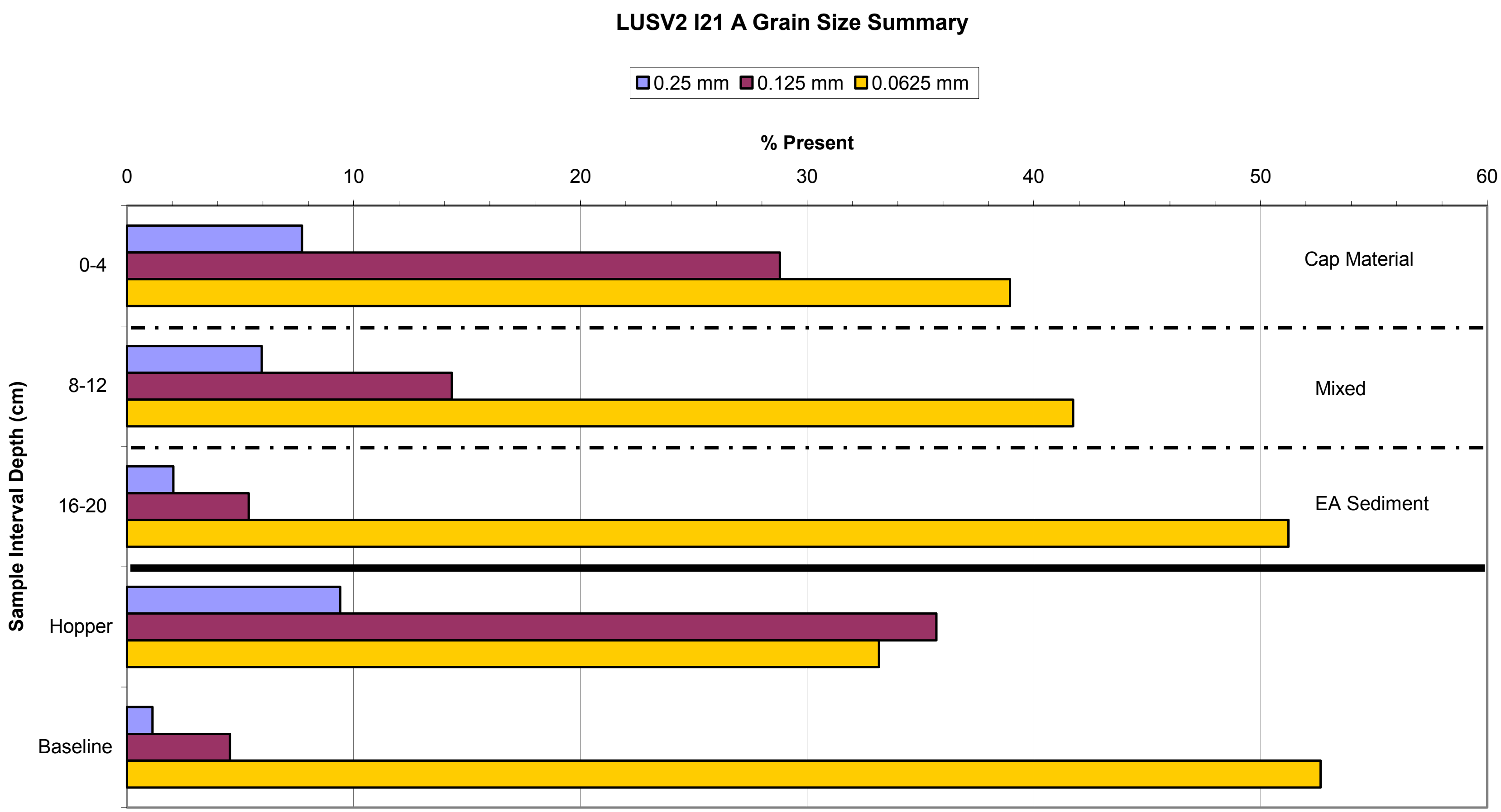


Figure 3.11-18. Grain Size distribution in Core LUSV2 I21 A of the Supplemental Vibracores from Cell LU. Hopper sample and baseline averages are provided for comparison.

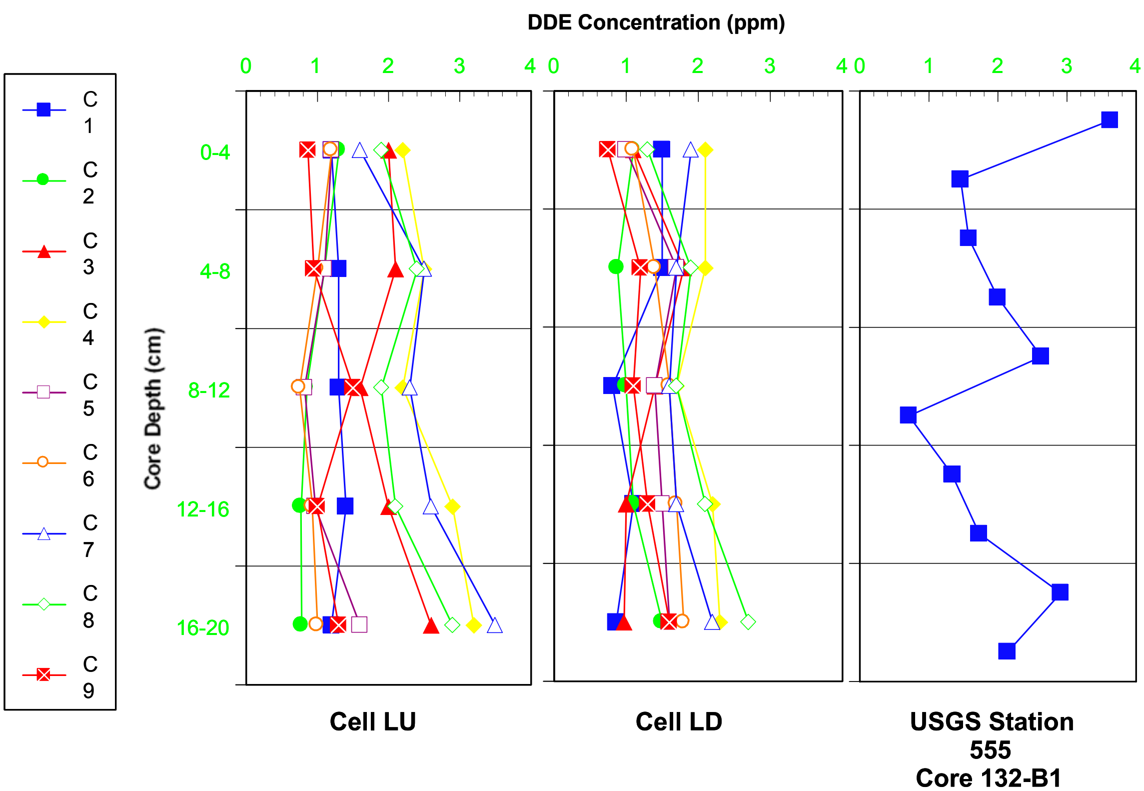


Figure 3.11-19. Sediment DDE concentrations (ppm) in Cell LU and comparisons with historical (USGS) data.

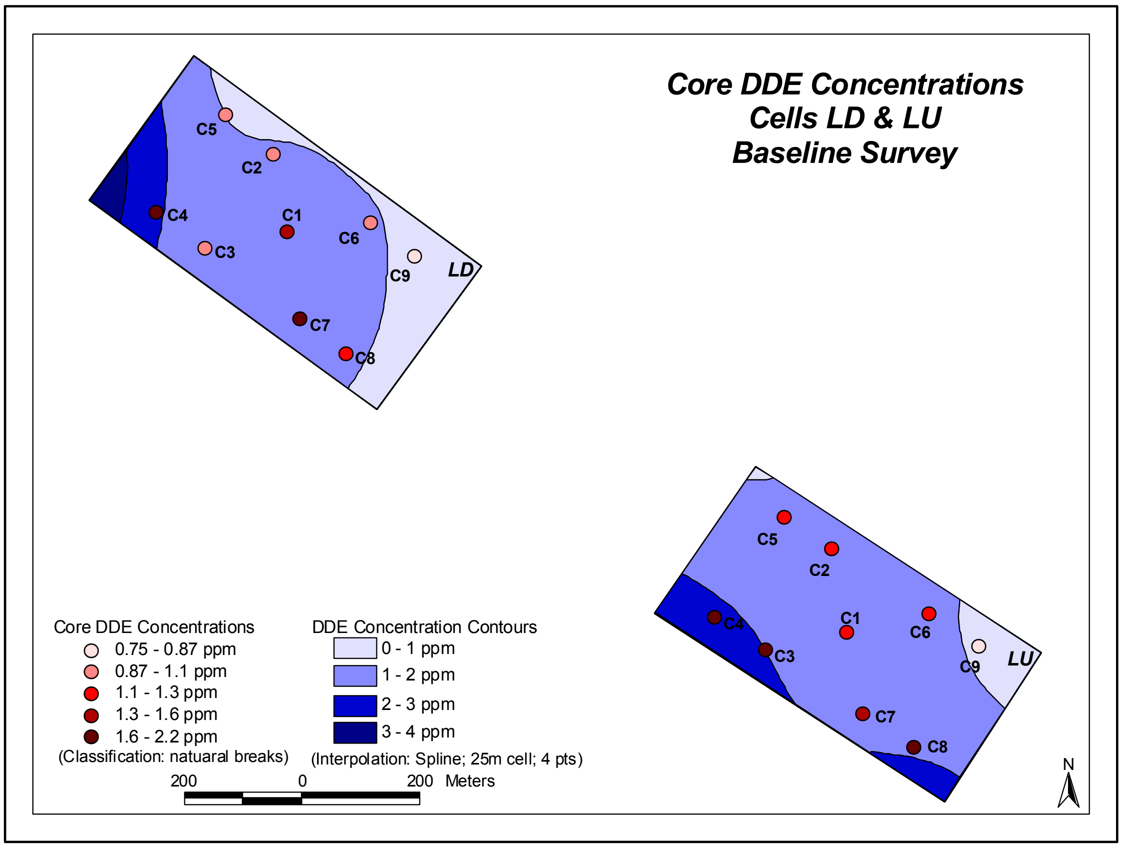


Figure 3.11-20. Sediment DDE concentrations (ppm) in Cell LU baseline cores.

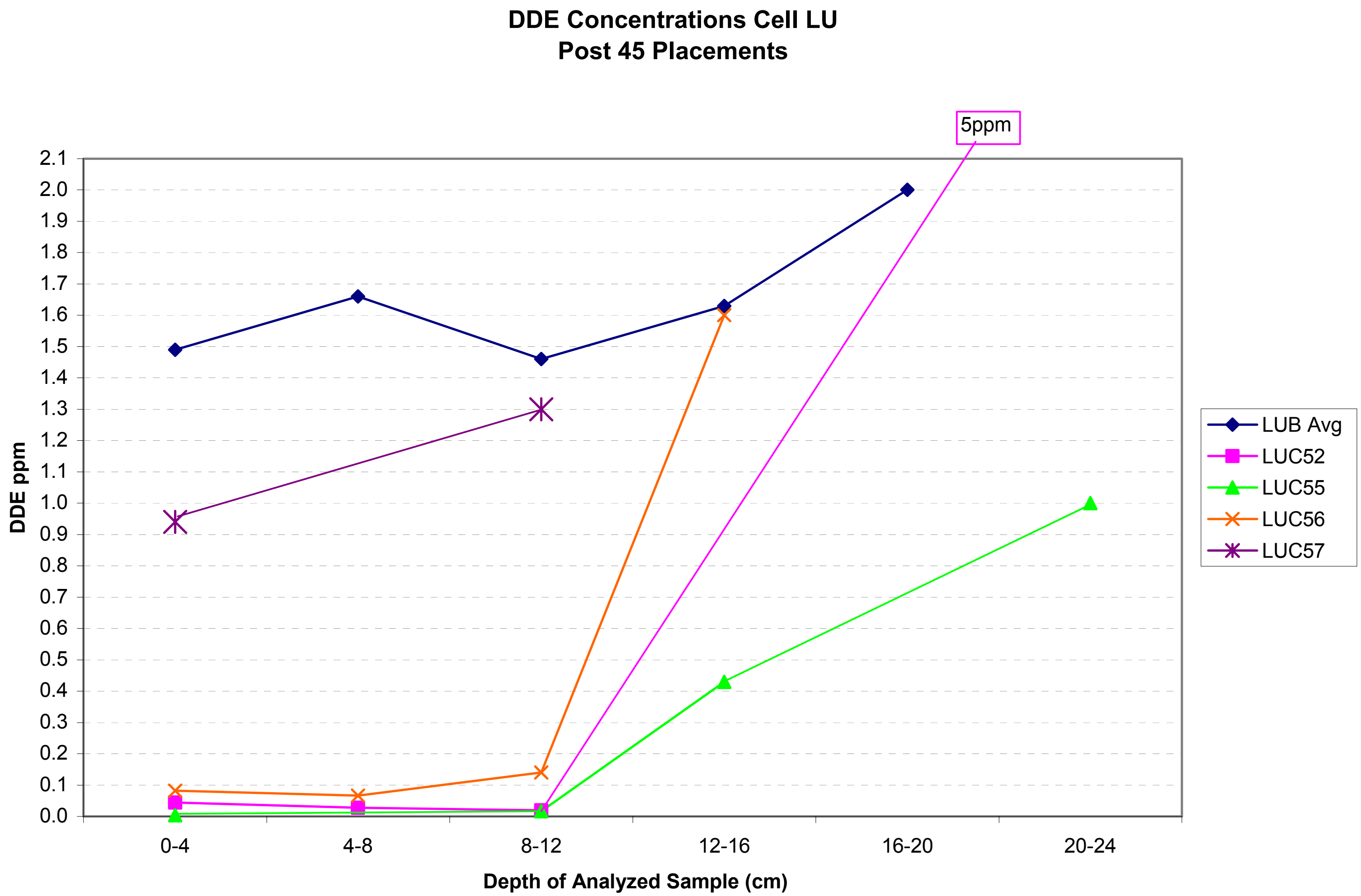


Figure 3.11-21. DDE versus Depth – Cell LU Cores: Post 45 survey and average baseline.

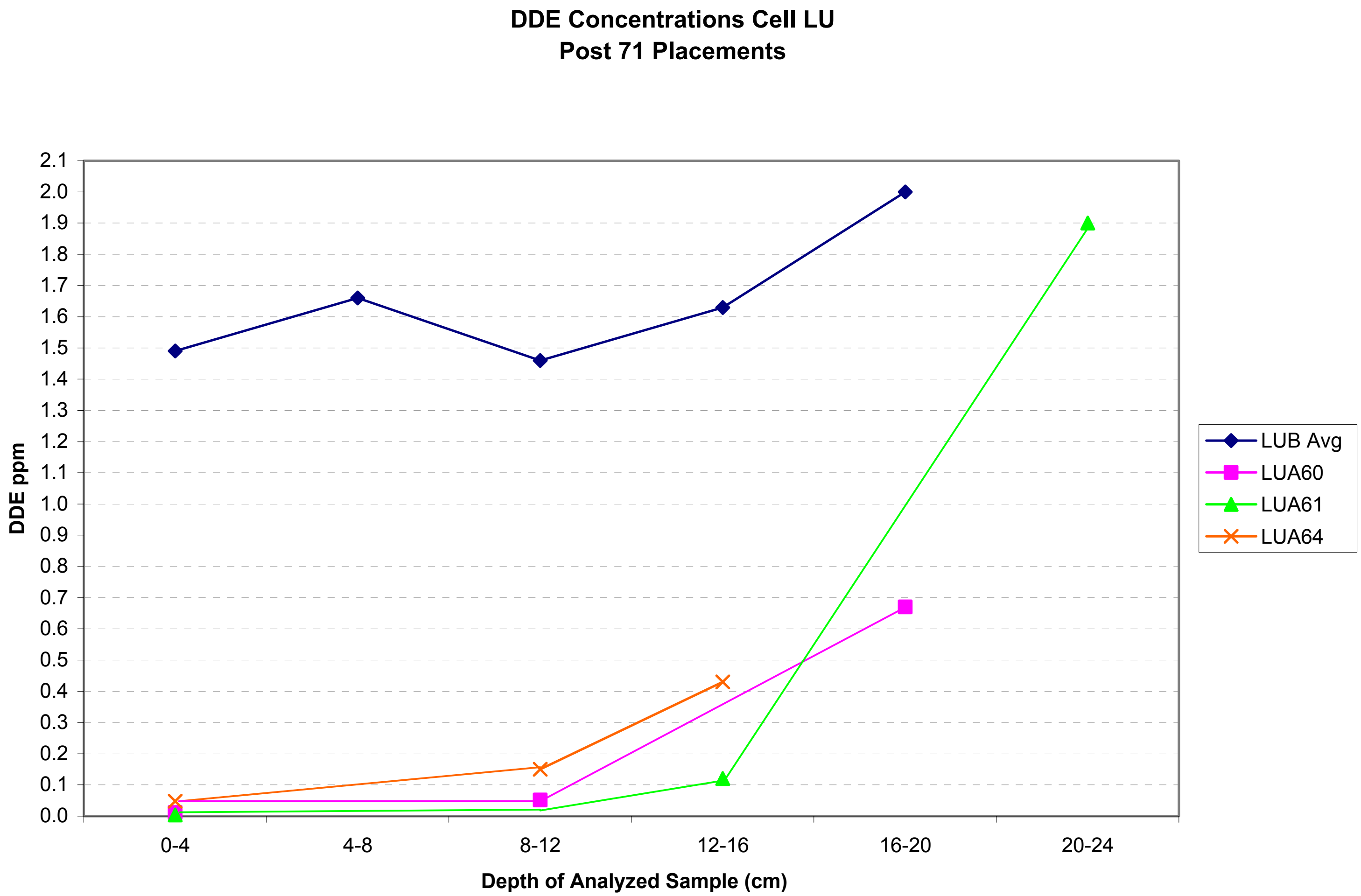


Figure 3.11-22. DDE versus Depth – Cell LU Cores: Post 71 survey and average baseline.

3.12 Sub-bottom Results

3.12.1 Overview of Field Sampling Plan

In addition to an initial baseline sub-bottom survey conducted in the spring, two follow-up sub-bottom surveys were conducted during the active placement periods of the capping project within Cell LU. One of these sub-bottom surveys was originally planned and the other was added as a flex operation. The sub-bottom monitoring activities that were conducted in Cell LU are summarized in Table 3.12-1. In addition to summarizing the sub-bottom survey monitoring activities, this table also provides an overview of the ADISS and SPI monitoring activities that were conducted in Cell LU.

3.12.2 Review of Data Quality Objectives

The primary monitoring objective that was to be evaluated through the sub-bottom data analysis was the ability to determine cap thickness following final cap placement. The monitoring objectives for the sub-bottom operations were presented in the PWP and are summarized in Table 3.12-2. All of the sub-bottom data acquisition efforts were completed as planned within Cell LU and the navigational accuracy met or exceeded the ±3 m data quality objective. However, because no distinct sub-bottom layers could be detected in the immediate seafloor surface areas after cap placement, no measure of cap material thickness could be obtained from these data.

3.12.3 Technical Considerations

Sub-bottom profiling is a standard technique used for distinguishing and measuring various sediment layers that exist below the sediment/water interface. Sub-bottom systems are able to distinguish these sediment layers by measuring differences in acoustic impedance between the layers. Acoustic impedance is a function of the density of a layer and speed of sound within that layer and is affected by differences in grain size, roughness, and porosity. Sound energy transmitted to the seafloor is reflected off the boundaries between sediment layers of different acoustic impedance. A sub-bottom system uses the energy reflected from these boundary layers to build the image.

The sub-bottom system used for this survey was a Benthos/Datasonics Chirp II Profiling System that consisted of a dual frequency towfish configured with two operating swept frequency ranges of 2-7 kHz and 8-20 kHz. The depth of penetration and the degree of resolution of a sub-bottom system depends on the frequency and pulse width of the acoustic signal and the characteristics of the various layers encountered. The vertical resolution of an acoustic sub-bottom profiler refers to the minimum distance between adjacent layer interfaces that can be visually distinguished in the image produced by the system. A sonar system with a 10 cm resolution will resolve layers that are at least 10 cm apart. Layers that are spaced closer than 10 cm will be resolved by the system as one layer. In a swept-frequency system, such as the Chirp II profiler used for this survey, it is the bandwidth that sets the system's theoretical resolution. Although the Chirp II has a theoretical resolution of 10 cm, the actual resolution is usually less than that and is impacted by many factors including water depth, observed signal to noise ratios, and the composition of the sediment layers being measured.

Immediately after data acquisition, the sub-bottom data were analyzed and edited as necessary using the Triton-Elics ISIS® software. ISIS® enables automatic or manual detection, tracking, and digitizing of any sub-bottom layers that are present in the data and also allows the data to be re-displayed under a variety of different configurations. The results from the baseline sub-bottom survey were compared to the results from the USGS acoustic survey conducted in 1994 (Hampton 1994). Because the cap material layer could not be distinguished on any of the monitoring sub-bottom data, only limited additional post-processing was performed on this data . Because the records were similar for both monitoring sub-bottom surveys, the brief discussion for these two surveys has been combined into a single section below.

3.12.4 Monitoring Results

3.12.4.1 Baseline

The baseline sub-bottom operation for Cell LU was conducted in mid-May 2000. The initial review of the sub-bottom data for this survey showed a distinct and well-defined surface layer with indications of a probable bedrock layer well below the main seafloor surface layer. In addition, sub-bottom lines N and O clearly showed the sewer diffuser pipe as it rises above the seafloor surface. Figures 3.12-1 and 3.12-2 show some sample sub-bottom cross-sections that include examples of the possible bedrock layer and also the sewer diffuser pipe. In addition, a relatively fine surficial layer of sediment can also be distinguished upon a close examination of the seafloor interface layer. This thin, surficial layer is thought to represent a basal reflector from the effluent-affected sediment that lies above the ambient sediment (Hampton 1994).

3.12.4.2 Post 45 and Post 68 Surveys

The Post 45 sub-bottom survey was conducted on 9/6/00, four days after the 45th placement event. The Post 68 sub-bottom survey was conducted on 9/14/00, one day after the 68th placement event. Because the purpose of these follow-up surveys was to attempt to measure the thickness of the cap layer, this analysis focused primarily on a close review of the immediate seafloor surface layer. The same sub-bottom features addressed in the baseline survey discussion above were also detected during the monitoring surveys. As depicted in Figures 3.12-3 and 3.12-4, no discernable sub-bottom layers were evident in this upper portion of the seafloor interface. Although these records represent only a small sampling of all of the sub-bottom data that was acquired during these surveys, the entire dataset was very consistent with little or no difference detected between the survey lines.

As shown in Figure 3.12-3, the primary difference noted between the baseline survey and Post 68 survey was in the strength and definition of the first return from the seafloor. In the baseline survey, the seafloor exhibited a dark and well-defined return that was indicative of the uniform, well-consolidated bottom that existed within the PV cells prior to cap placement. In addition, a relatively fine surficial layer, thought to represent a basal reflector from the effluent-affected sediment, could also be distinguished upon a close examination of the seafloor interface layer. In the Post 68 survey, the seafloor within the placement areas exhibited a less-distinct and thicker return that was indicative of the bottom disturbance caused by the capping operations and the generally unconsolidated nature of the seafloor at the time of the survey. Because of the condition of the seafloor after the capping operations were completed, more acoustic energy was absorbed by the seafloor and the amplitude of the first return was not as consistent or as strong as during the baseline survey. In addition, the thin surficial layer of EA sediment could no longer be clearly distinguished in the sub-bottom data.

3.12.5 Discussion

The sub-bottom surveys conducted in Cell LU showed that the techniques employed during this operation were not sufficient to allow the determination of cap thickness following cap placement. Although the techniques and equipment used should have provided sufficient resolution to detect any sub-bottom layers greater than 10 cm thick, this would only have been possible under near ideal conditions. Although the water depth was one factor that impacted the ultimate resolution of the sub-bottom survey following cap placement, the primary reason for the inability of the sub-bottom system to detect the cap layer was most likely the very similar grain size characteristics for both the cap and ambient bottom material. (The ambient bottom material was primarily soft and fine-grained silt, mixed with a fair amount of fine-grained sand at the surface, while the cap material was primarily fine-grained sand.)

Sub-bottom systems rely on being able to detect differences in acoustic impedance between sediment layers below the water/seafloor interface. Acoustic impedance is a function of the density of a layer and speed of sound within that layer, and is affected by differences in grain size, roughness, and porosity. If there is not a distinct difference in the acoustic impedance between seafloor layers, then the layers will not be differentiated, no matter what the theoretical resolution of the sub-bottom system may be. Within Cell LU, the sediment characteristic differences between the ambient bottom material and the placed cap material were minor, and at their interface there was a certain amount of mixing of the materials. Because there was no distinct boundary layer that separated the ambient material from the cap material, the sub-bottom system was unable to distinguish these two similar material layers.

Although the sub-bottom system could not provide a measure of cap thickness, some inferences about the presence of cap material could be made based upon the hardness or strength of the first return measured by the sub-bottom system. Generally, the bottom hardness values measured by the sub-bottom system within the placement cells were lower than the hardness values measured outside of the placement areas. Similarly, the amplitudes of the first return observed within the placement areas were lower than the first return amplitudes measured outside of the placement areas. The lower hardness values and first return amplitudes observed within the placement areas are primarily a function of the recent bottom disturbance and the unconsolidated nature of the material within those areas, rather than any major differences between the acoustic properties of the cap material and the ambient material outside of the placement areas.

Table 3.12-1. Sub-bottom Profiling Surveys Conducted

Cell	Survey Sequence	Description	ADISS Event Date	Survey Type	SS Survey Date	SPI Survey Dates
LU	Post Forty Five	After 45 Placements	9/2/00	Planned	9/6/00	9/5/00 & 9/7/00
LU	Post Sixty Eight	After 68 placements	9/14/00	Flex	9/14/00	9/13/00
SU	Post Twenty One	After 25 placements	8/27/00	Planned	9/6/00	8/31/00 & 9/1/00

Table 3.12-2. Monitoring Objectives and Approach for Sub-bottom Profiling

Monitoring Objective	Data Requirements	Monitoring Approach	Field Decision Criteria/Performance Specifications
Determine cap thickness following placement.	Provide information regarding cap layer thickness that can be used by USACE to verify model predictions.	Collect continuous sub-bottom profiling data along a series of transects in three pilot placement cells following cap placement for both conventional and spreading placement methods.	Navigational accuracy should be ±3 m. Completeness goal is 100% (obtain continuous sub-bottom records from all survey lines).

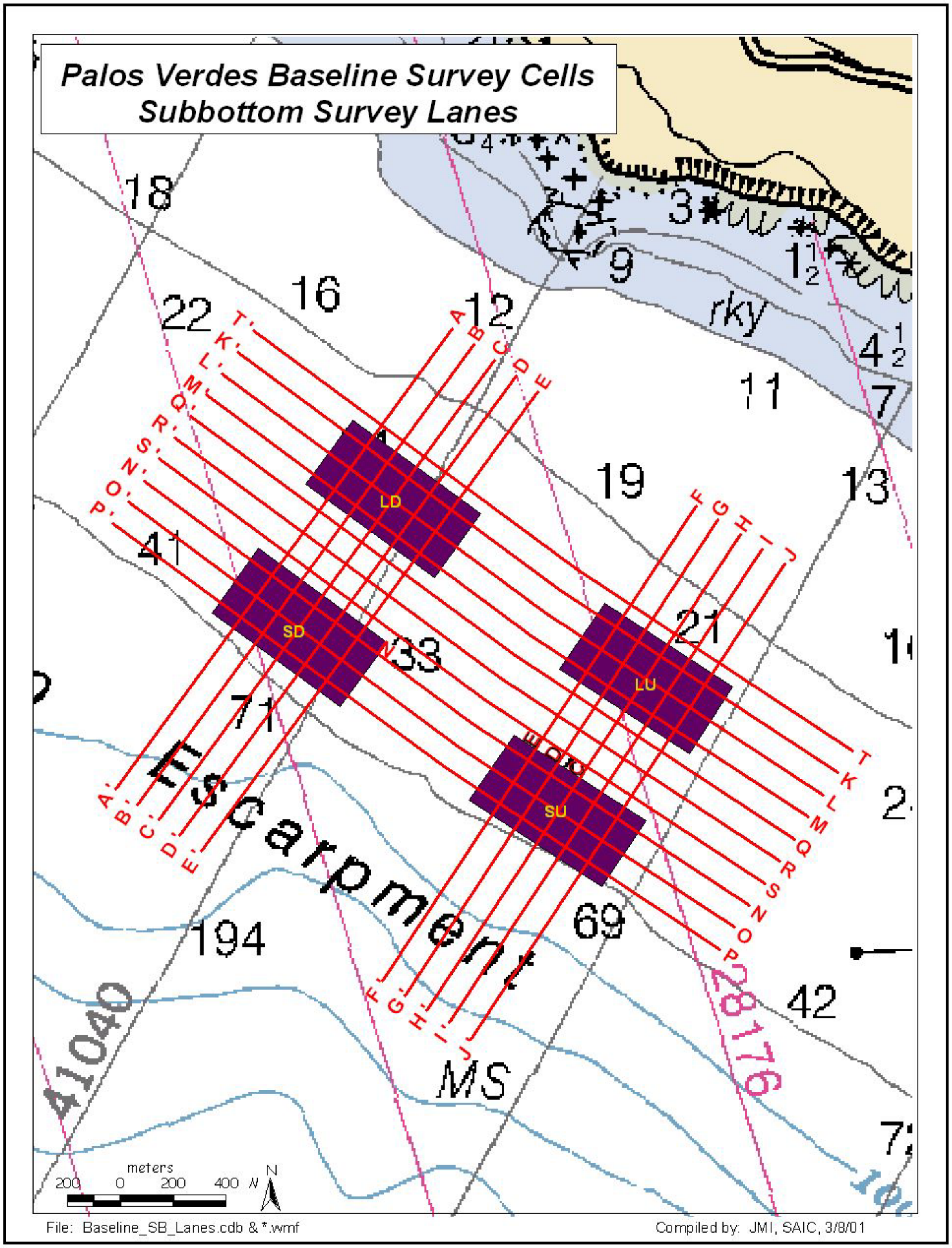


Figure 3.12-1. Sub-bottom survey line scheme.

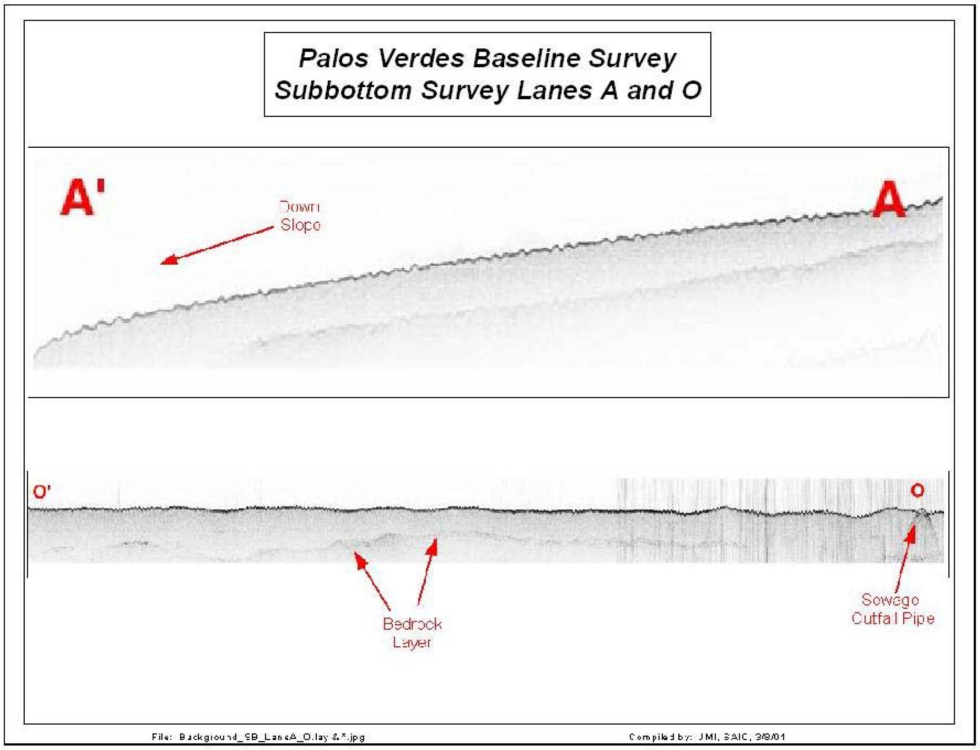


Figure 3.12-2. Sample sub-bottom transects - baseline survey.

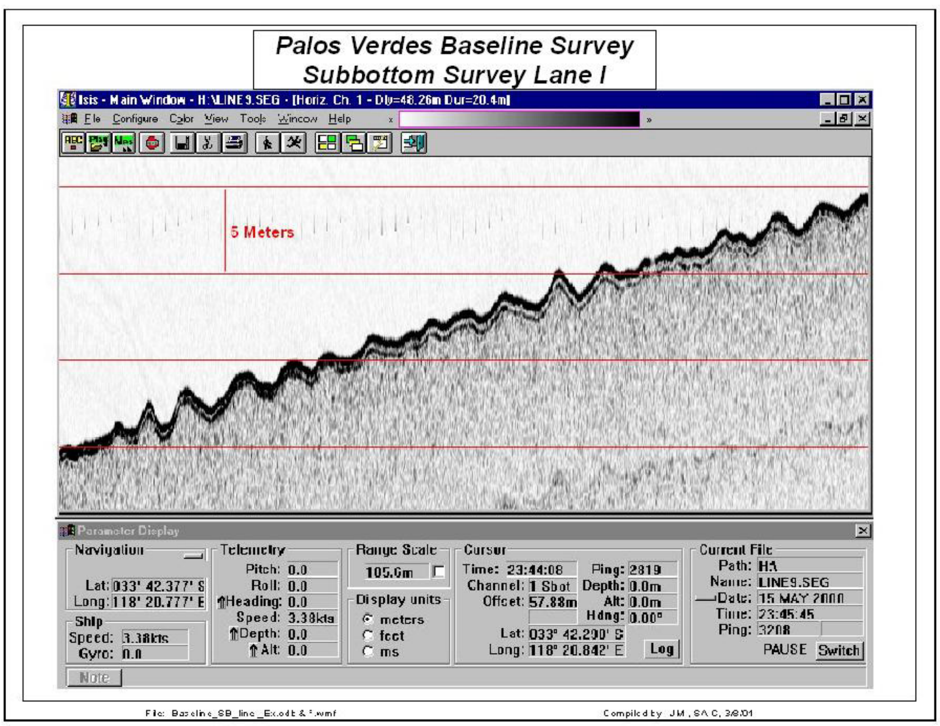


Figure 3.12-3. Sample sub-bottom transect showing EA Layer - baseline survey.

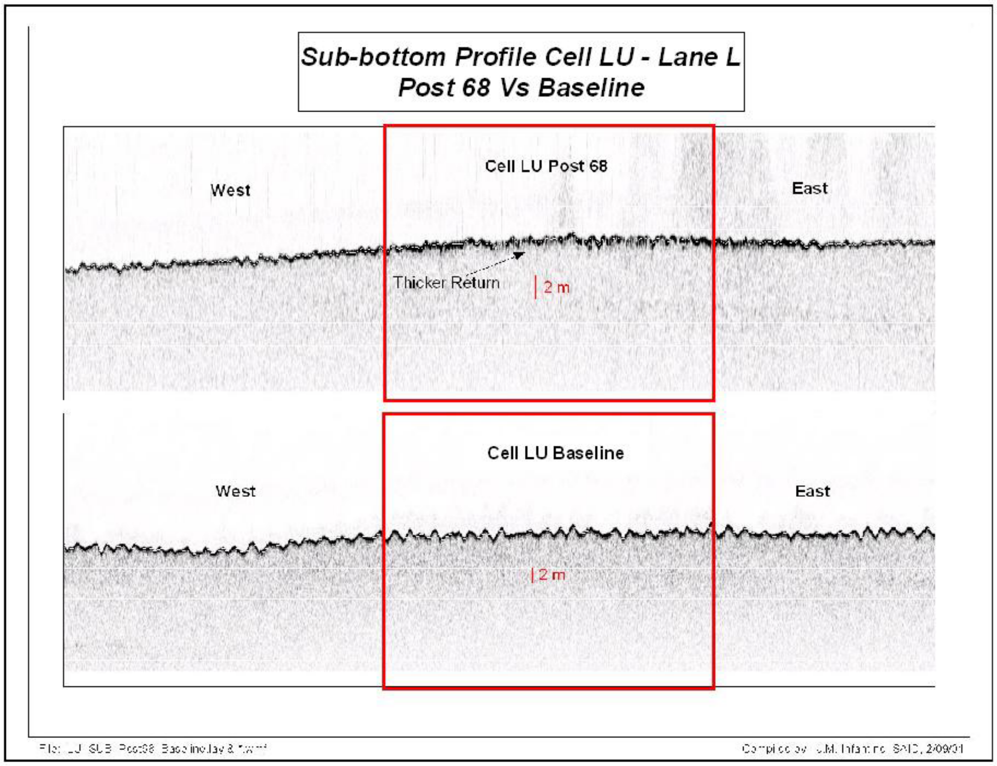


Figure 3.12-4. Sample sub-bottom transect – LU Post 68 and baseline survey.

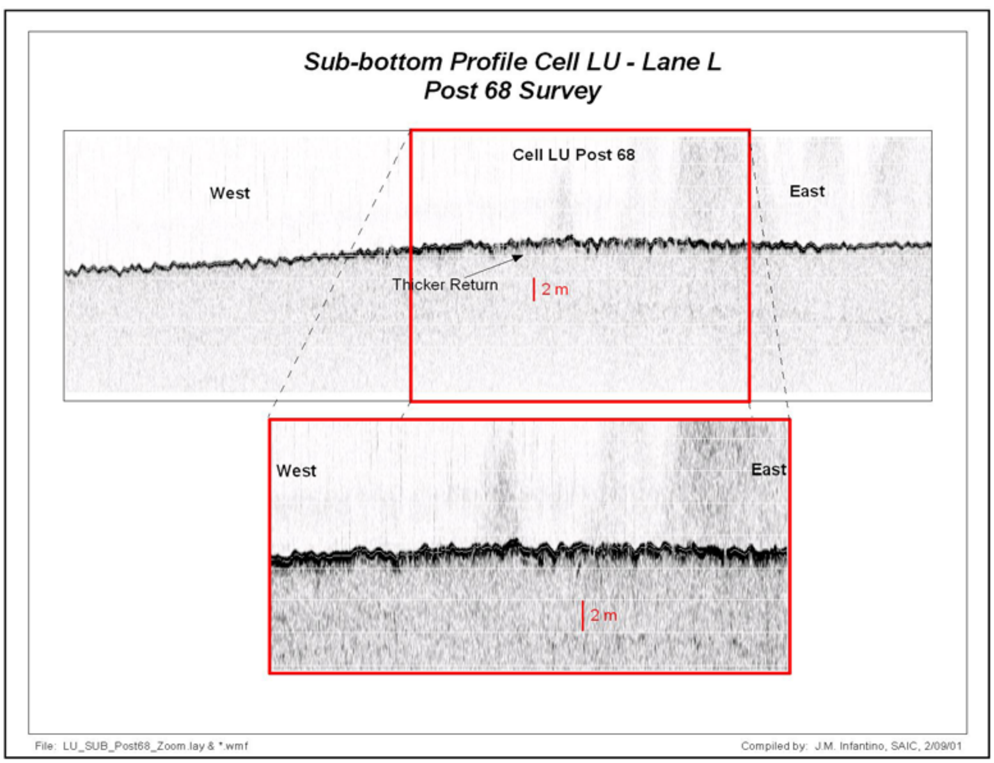


Figure 3.12-5. Sub-bottom transect with enlargement – LU Post 68 survey.

4.0 MONITORING RESULTS FROM CELL SU (CONVENTIONAL PLACEMENTS)

4.1 Schedule of Operations

The following provides an overview of monitoring activities within Cell SU. In general, monitoring occurred in two phases, baseline and cap placement. Baseline monitoring occurred prior to the first cap placement event to characterize existing conditions with the capping cell. For cap placement monitoring, individual surveys coincided with placement events 1, 2-5, and Post-21. Cap placement events in Cell SU are summarized in Table 4.1-1. All cap placements were made using a point placement technique. Placement positions are described in Section 4.2.

Table 4.1-1. Summary of Cap Placement Events in Cell SU

Placement Event #	Dates	Cumulative Volume (m^3)	Positions	Hopper Sample Nos.
1	8/8/00	1,077	A	SU-HOP 1
2-5	8/18-19/00	5,470	A	SU-HOP 2-3
6-21	8/25-27/00	21,749	B-BE (non-consecutive)	SU-HOP 4-7

Baseline Monitoring

Baseline monitoring in Cell SU was conducted in May, July, and August 2000. Dates associated with individual sampling tasks are listed in Table 4.1-2. Results from each of the baseline sampling tasks in Cell SU are presented in Sections 4.2 through 4.12.

Table 4.1-2. Summary of Sampling Dates for Baseline and Cap Placement Monitoring Activities in Cell SU

	SPI/PV	Core	SS	SB	CM	WQ	Video	Kelp	ADCP
Baseline	7/28, 8/3	5/21	5/15, 5/16, 5/17	5/15, 5/16, 5/17	none	none	none	none	none
Post 1	8/9, 8/17	8/10	8/10	none	8/7-8/9	8/8	8/8	none	8/8
Post 5	8/22, 8/24, 8/25	8/22	8/19	none	8/11-8/14	none	none	none	none
Post 21	8/31, 9/1, 9/13	8/29, 9/7	9/6	9/6	none	none	none	none	none
Supple-mental	2/24/01	2/27/01 3/1/01	none	none	none	none	none	none	none

SPI/PVC-sediment profile image/plan view; Core-sediment gravity coring; SS-side-scan sonar; SB-sub-bottom profiling; CM-current meters/ARESS/Aquadopp; WQ-water quality; Video-video; Kelp-kelp bed surveys; ADCP-towed ADCP

Cap Placement Monitoring

Cap placement monitoring in Cell SU was conducted from August through September, 2000. Supplemental coring and sediment profile image/plan view sampling also were conducted during February/March, 2001. Primary monitoring activities coincided with specific sequences of placement events listed in Table 4.1-1. A timeline of activities associated with cap placement monitoring is shown schematically in Figure 4.1-1. Specific dates for individual sampling tasks are listed in Table 4.1-2. Results from each of the cap placement monitoring tasks in Cell SU are presented in Sections 4.2 through 4.12.

The ADISS system was installed on the hopper dredge (*Sugar Island*) on July 28, and data were recorded and retrieved each day of cap placement operations (see Section 3.2). Also, a moored current meter/optical backscatter array was deployed near Cell SU on August 7 and retrieved on August 9 (see Section 4.3).

Supplemental Coring

Additional SPI/PVC data and sediment cores were collected in Cell SU during February and March 2001.

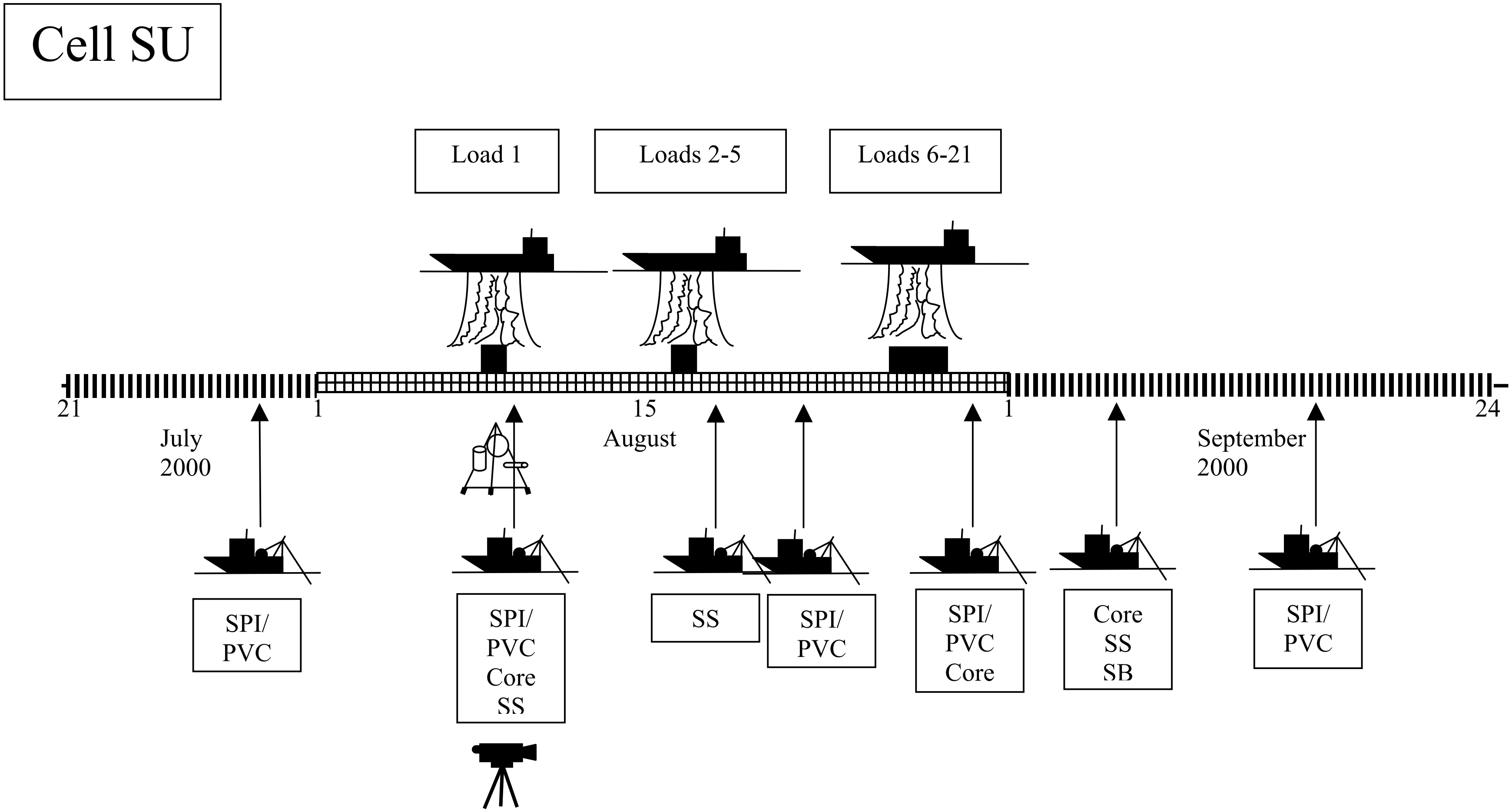


Figure 4.1-1. Activities time-line for Cell SU 21 July 2000-24 September 2000. Cap placement activities are indicated by the dredge symbol and solid bar. Monitoring activities are shown by the research vessel, current meter tripod, and video camera symbols. Monitoring activity codes associated with the research vessel symbol are SPI-Sediment Profile Imaging, PVC-Plan View Camera, Core-Coring survey, SS-Side Scan, SB-Sub-bottom profiling. Supplemental coring and SPI/PV surveys conducted in February/March 2001 are not shown.

4.2 Hopper Dredge Monitoring during Cap Placement

4.2.1 Overview of Field Sampling Plan

SAIC's dredged material disposal monitoring system, the Automated Disposal Surveillance System (ADISS), was temporarily installed on the hopper dredge *Sugar Island* to monitor cap material placement operations in the pilot cells on the Palos Verdes Shelf. During each placement event, ADISS recorded the dredge position, draft, and pump status during the dredged material loading, transit to the Palos Verdes Shelf, and placement operations within the predetermined pilot cells. Other than attempts to acquire a digital record of the dredge heading using a digital compass temporarily interfaced to ADISS, there were no significant deviations from the monitoring approach outlined in the FSP (SAIC 2001).

All cap material used for placements in Cell SU was dredged from the Queen's Gate Channel outside of the Long Beach Harbor breakwater. Placements of material in Cell SU were conducted using conventional, bottom-dump operations where the hopper dredge hull is hydraulically opened to release the entire hopper load rapidly at a specific geographic location while remaining stationary at the target location.

4.2.2 Review of Data Quality Objectives

As required by the DQOs for hopper dredge monitoring (see Table 3.2-1), ADISS and its real-time data display software (ADISSPlay) successfully recorded the loading, transit and cap placement operations, including all data necessary to determine the cap material discharge rate and time of release for each placement event. ADISS acquired accurate DGPS dredge position data and a pressure sensor temporarily installed beneath the water level in the dredge recorded the draft of the dredge versus time. Overall data recovery with ADISS was 100%; all critical dredge operational data were recorded during each of 21 placement events in Cell SU.

4.2.3 Technical Considerations

No technical problems were associated with dredge operational monitoring in Cell SU, except for unsuccessful attempts to incorporate a digital compass into the ADISS data acquisition system. It was concluded that the digital compass could not obtain accurate dredge headings due to the magnetic interference associated with the steel superstructure of the dredge's bridge where ADISS was installed.

4.2.4 Monitoring Results

For cap placement operations in Cell SU, ADISS recorded the dredge position and draft during the loading, transit from the dredging site to the cell, and placement of dredged material in the cell. Figure 4.2-1 presents an example ADISS dredge position data acquired during placement Event 1 on August 8, 2000, with points representing individual positions of the dredge during: 1) loading within Queen's Gate Channel, 2) transit to the Palos Verdes Shelf, and 3) placement operations within Cell SU. As discussed in more detail below, dredge positions were acquired more frequently during loading and placement phases than during the transit phase, thus the widely separated data points during the transit phase in Figure 4.2-1.

Figure 4.2-2 presents a closer view of placement Cell SU, with closely spaced data points representing the position of the dredge during the time that cap material was being released from the dredge in Cell SU. Figure 4.2-3 presents a companion plot of hopper dredge draft versus time during one entire operation leading up to the placement in Cell SU. Starting at the left side of the plot, dredge positions were recorded at 6-sec intervals while the dredge was being loaded (increasing draft). After the hopper was full and the dredge started to leave the vicinity of the Queen's Gate Channel, the ADISSPlay software automatically shifted to a 5-min recording rate during the transit operation; see widely spaced data points in Figure 4.2-1. As the dredge approached Cell SU, the ADISS software automatically returned to a 6-sec sampling period during the final stages of the transit and throughout the cap placement operation. Figure 4.2-3 illustrates ADISS dredge position data acquired during material loading in the channel. As seen in the figure, the material originated near the west side of the channel. In Figure 4.2-4, the transit phase is easily recognizable due to the separation of data points at 5-min intervals. Approaching the target cell, data points are closer together along the time line until the placement operation begins at 1834 GMT. When the dredge opened its hull to release the cap material, the draft decreased rapidly then slowed until a minimum draft of roughly 16.5 ft was achieved at the end of the 3 min, 10 sec placement event. Material continued to be released for the next 10 min until the draft decreased to about 14.5 ft.

Dredge position and draft data continued to be recorded at 6-sec intervals as the dredge returned to the Queen's Gate Channel, but at approximately 1850 GMT the ADISS unit automatically stopped recording data to conserve data memory space. Note that the ADISS unit shut off automatically when the vessel had reached a preset longitude during its transit eastward.

As compiled in Table 4.2-1, 21 cap placement events were conducted in Cell SU during the period from August 8 to 27, 2000. These placements were grouped into two cap placement (time) phases with a 6-day gap between the phases during which monitoring activities were conducted (Figure 4.1-1) within Cell SU. Figure 4.2-5 presents ADISS dredge position data collected during each of cap placement Events 1 through 5 constituting Phase 1. Each of these events was targeted for a common point at the center of the cell, designated as target position "A."

Under direction from the USACE technical representatives, the hopper dredge was directed to place material at other locations within Cell SU. ADISS dredge positions during cap placement Events 6 through 21 of Phase 2 are presented in Figure 4.2-6. During this phase, the dredge was directed to place material at 16 specific locations within the cell. All material was placed around the center of the cell (position A) during Phase 2 in order to construct an even thickness of cap material over the majority of the cell (Figure 4.2-6).

As described in Section 3.2.4, each placement event occurred during different environmental conditions and under different engineering controls. For this reason, some of the placement events were accomplished very close to the designated target location while others were conducted as the dredge drifted slowly away from its predetermined target position. Overall, the conventional cap placement operations in Cell SU were conducted accurately and successfully, and that the majority of cap material was placed within a short distance from the target position. Table 4.2-2 presents an estimate of the average distance from the actual geographic position of the center of the hopper to the target placement location for each of the 21 events in Cell SU. This hopper position (actual center of the placement location) was computed from the average of hopper positions during the entire event. For all 21 placement events conducted in Cell SU, the average distance from the hopper center to the target placement location was only 18 m, which was comparable to the width of the dredge. Note also that this average distance from the target location is identical to that determined from placement operations in Cell LU.

The total volume of cap material placed during the 21 events in Cell SU was 22,814 m^3 (Table 4.2-3). The average volume per event was 1, 087 m^3 and the average duration of each event was 3 min, 30 sec. Approximately 72% of the material was placed near the center of the cell, with the remainder going to either side of the cell. The symmetry of placements within the cell is best illustrated when the cell is divided into three segments: southeast, center and northwest (Tables 4.2-3). The difference in placed volume between the southeast and northwest segments was only 110 m^3. Figure 4.2-7 provides a summary of cap volume placed at each of 17 locations within Cell SU.

Table 4.2-1. Volume and Times of Cap Placement Events in Cell SU

Phase	Date	Placement Event	Placement Position	Volume m^3	Start Time (GMT)	End Time (GMT)	Duration (hh:mm:ss)
1	08/08/00	1	A	1077	18:34:29	18:37:39	0:03:10
	08/18/00	2	A	926	18:17:43	18:23:00	0:05:17
	08/18/00	3	A	926	22:26:01	22:32:29	0:06:28
	08/19/00	4	A	1188	2:06:01	2:10:17	0:04:16
	08/19/00	5	A	1353	5:43:48	5:48:27	0:04:39
2	08/25/00	6	B	1146	16:41:24	16:42:29	0:01:05
	08/25/00	7	D	1105	20:11:05	20:12:24	0:01:19
	08/25/00	8	F	1201	23:42:29	23:45:18	0:02:49
	08/26/00	9	H	1064	3:01:41	3:03:44	0:02:03
	08/26/00	10	I	1119	6:22:14	6:25:43	0:03:29
	08/26/00	11	C	1239	9:48:42	9:52:02	0:03:20
	08/26/00	12	E	1132	13:15:07	13:17:50	0:02:43
	08/26/00	13	G	1009	16:45:07	16:47:55	0:02:48
	08/26/00	14	K	1036	20:14:59	20:17:21	0:02:22
	08/26/00	15	AE	1009	23:37:12	23:41:15	0:04:03
	08/27/00	16	N	1036	3:11:40	3:15:03	0:03:23
	08/27/00	17	BE	995	6:34:15	6:38:10	0:03:55
	08/27/00	18	J	1064	9:56:46	10:01:22	0:04:36
	08/27/00	19	L	1050	13:08:47	13:12:06	0:03:19
	08/27/00	20	M	1050	16:32:13	16:36:17	0:04:04
	08/27/00	21	O	1022	19:57:26	20:03:41	0:06:15

Table 4.2-2. Distance from Center of Hopper to Target Placement Position

Placement Position	Placement Number	Distance (m) From Hopper to Placement Position
A	3	84
A	5	42
O	21	25
D	7	19
G	13	18
E	12	17
A	2	16
AE	15	16
BE	17	15
H	9	14
K	14	14
L	19	14
I	10	13
J	18	13
C	11	12
M	20	12
B	6	11
F	8	8
A	4	6
A	1	4
N	16	1

Table 4.2-3. Summary of Cap Volume Placed Within Three Geographic Segments of Cell SU

Cell	Segment	Average Volume (m^3)	Total Volume (m^3)	Total Trips
SU	SE	1,036	4,065	3
SU	CENTER	1,101	16,488	15
SU	NW	1,073	3,218	3
		Totals:	**22,814**	**21**

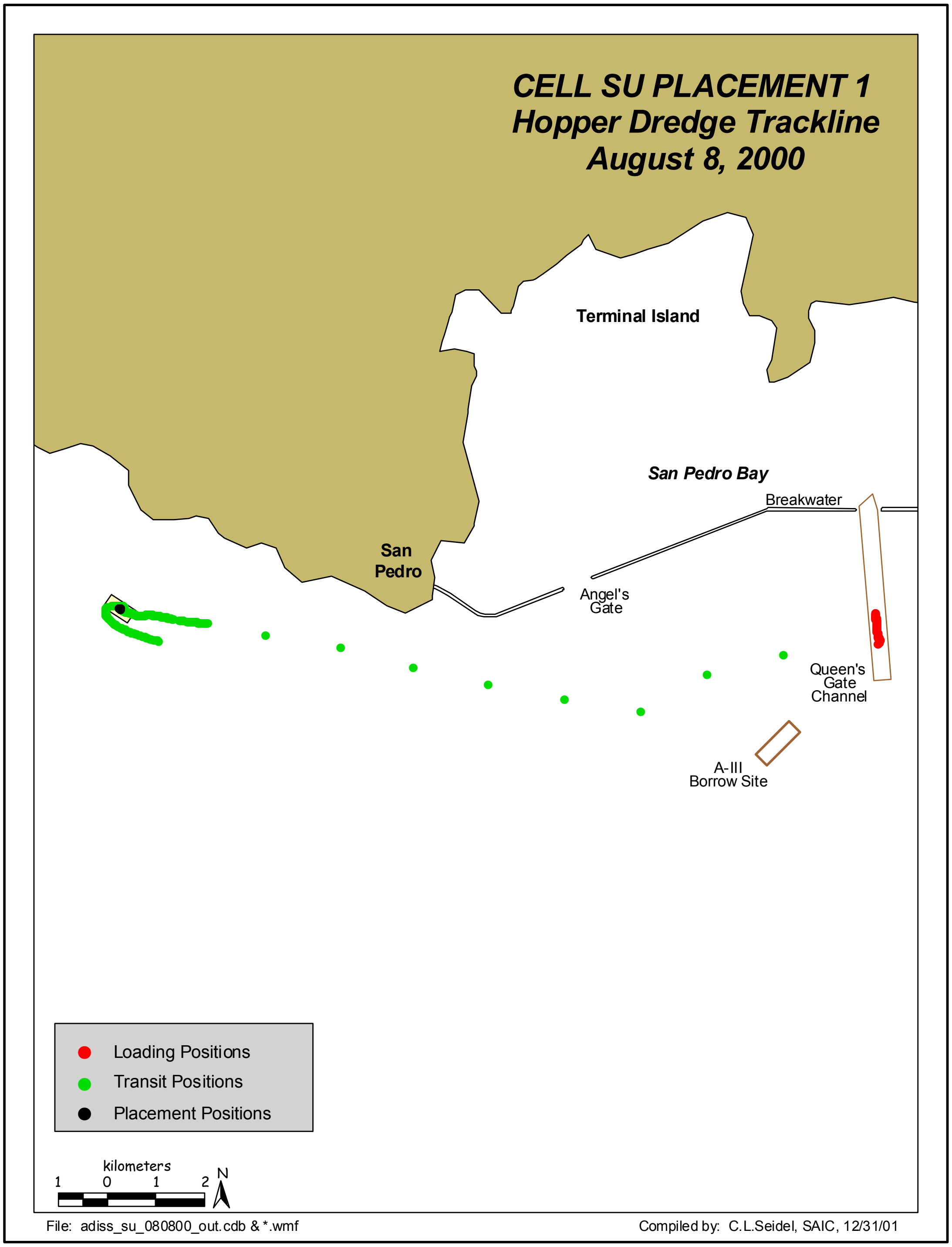


Figure 4.2-1. Map of Los Angeles/Long Beach Harbor region indicating the location of the dredging site within Queen's Gate Channel and the track of the hopper dredge *Sugar Island* during transit to Cell SU and placement of cap material during Event 1. Dredge position data were acquired by ADISS.

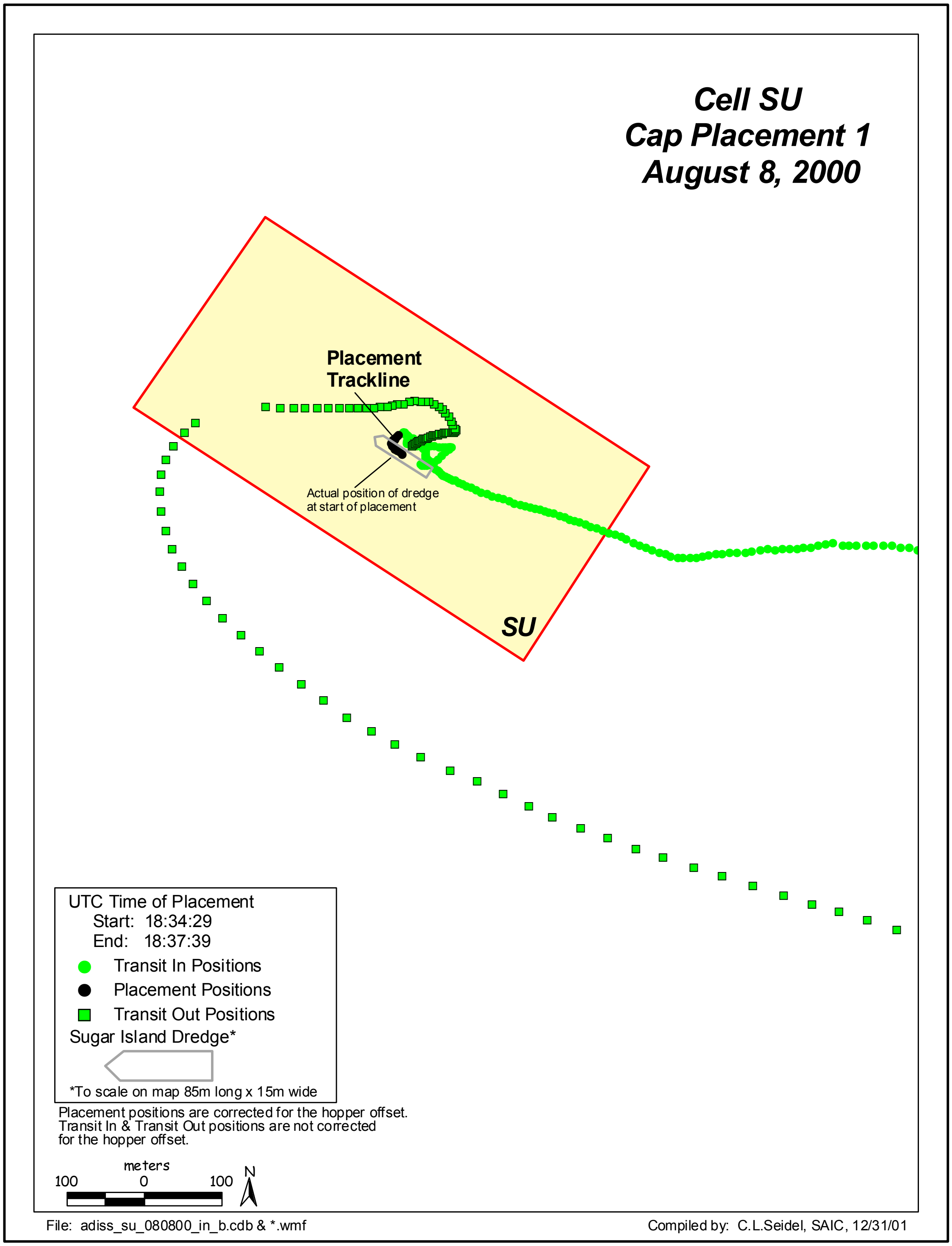


Figure 4.2-2. Map illustrating Cell SU on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* during placement of cap material during Event 1 on August 8, 2000. Dredge position data were acquired by ADISS.

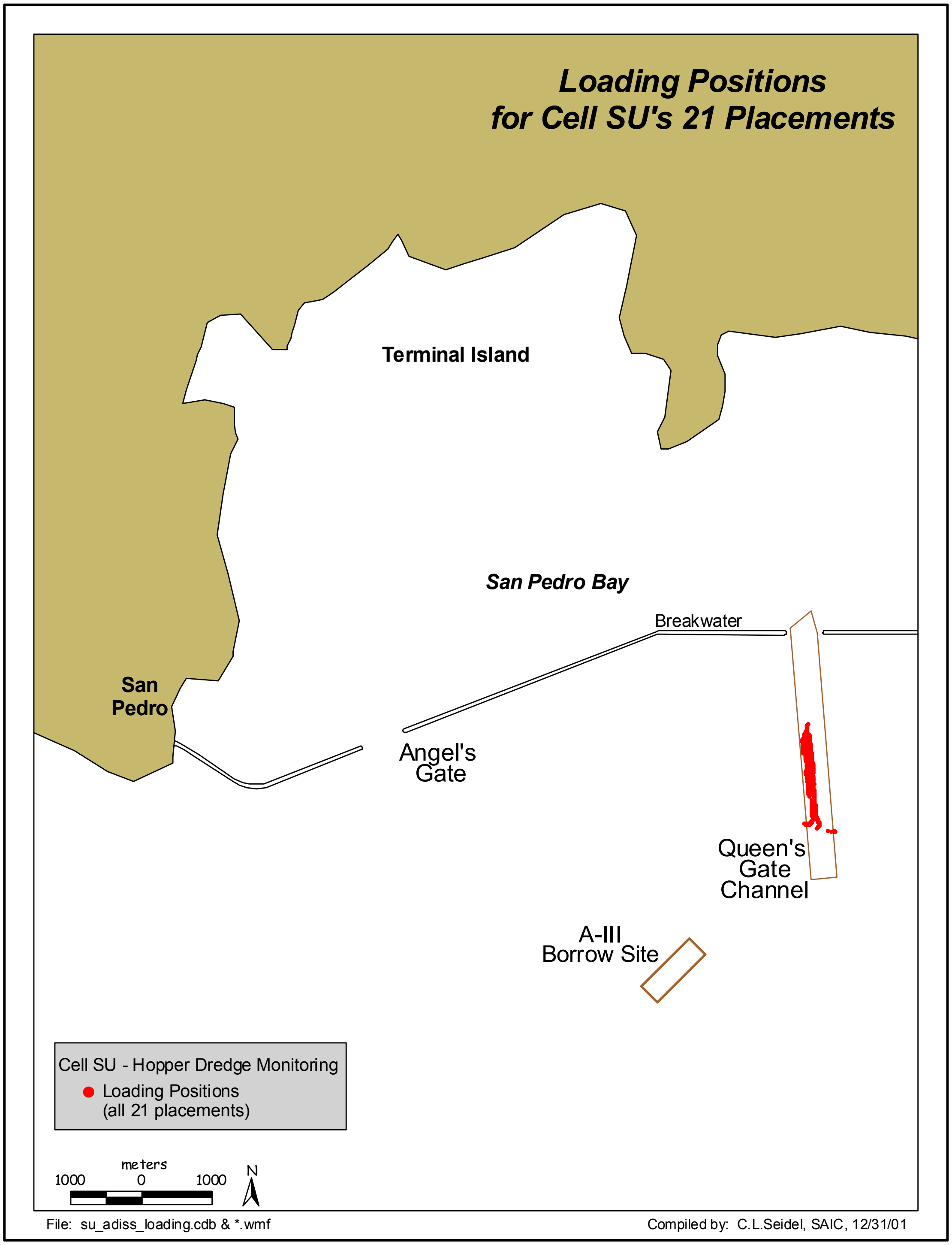


Figure 4.2-3. Map of Los Angeles/Long Beach Harbor region indicating the locations of the dredging within Queen's Gate Channel for material that was used for capping during Events 1-21 in Cell SU. Dredge position data were acquired by ADISS.

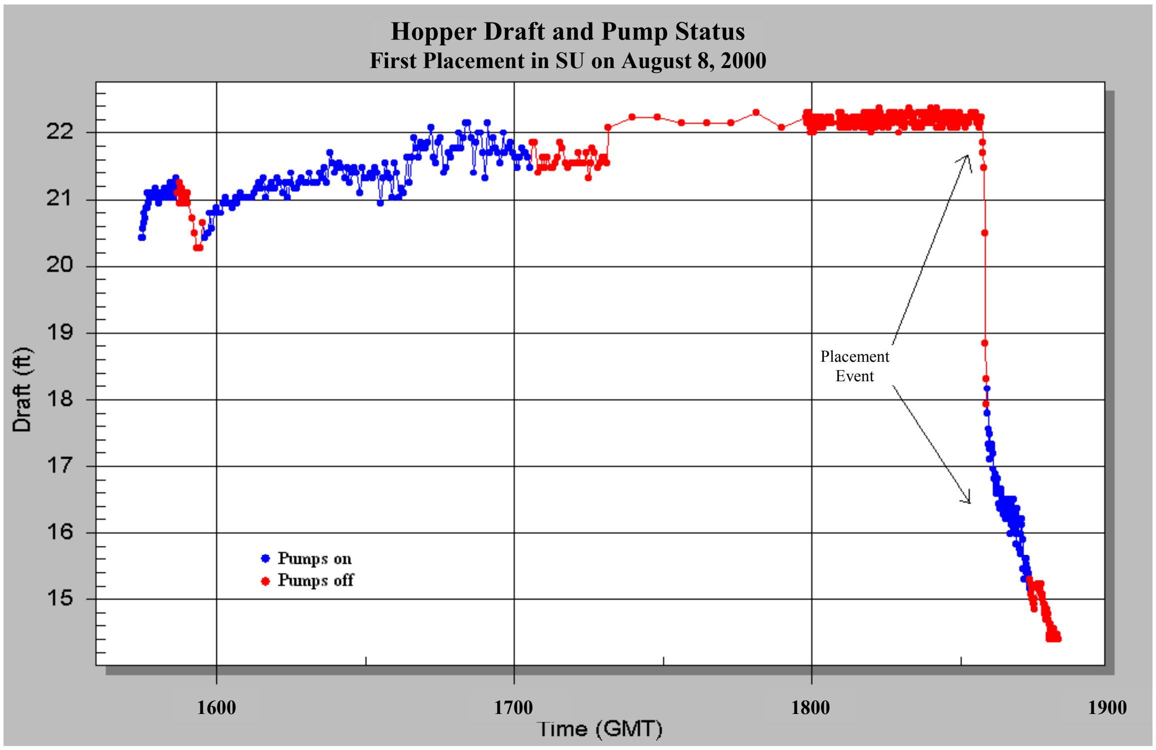


Figure 4.2-4. Time series plot of the draft of the hopper dredge *Sugar Island* during loading, transit, and placement of cap material in Cell SU during Event 1 on August 8, 2000. Dredge draft data were acquired by ADISS.

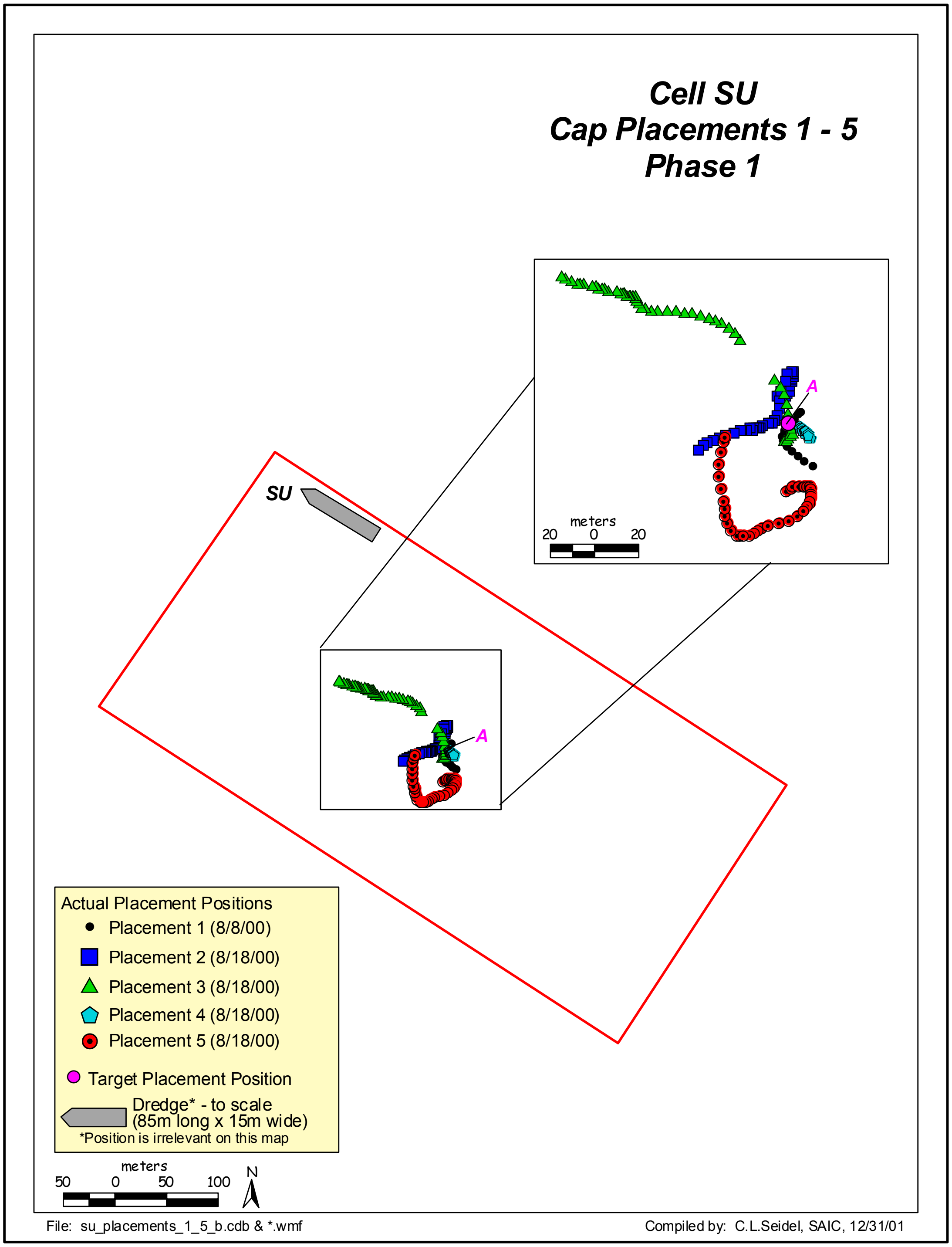


Figure 4.2-5. Map illustrating Cell SU on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* during placement of cap material during Events 1-5 in August 2000. Dredge position data were acquired by ADISS.

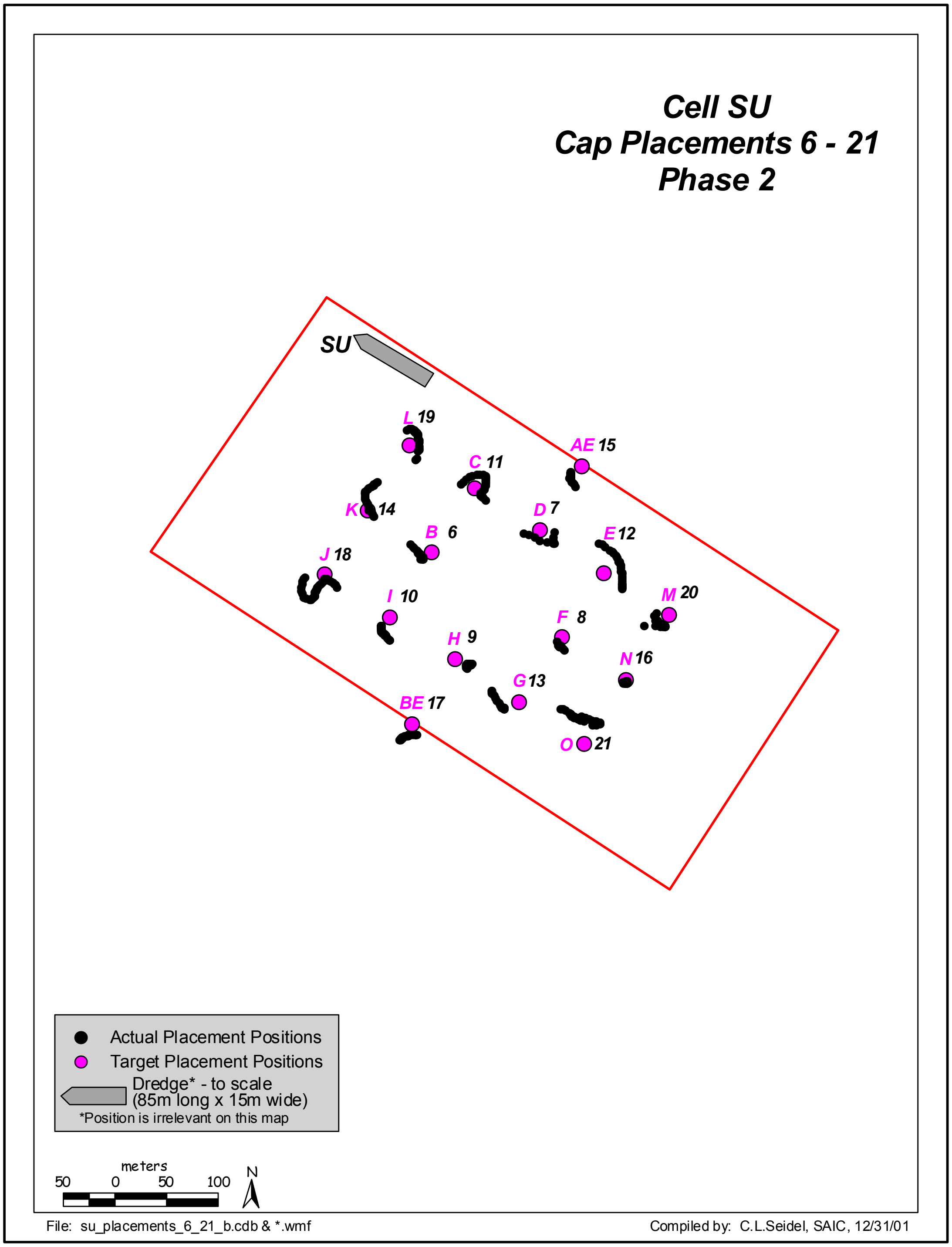


Figure 4.2-6. Map illustrating Cell SU on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* during placement of cap material during Events 6-21 in August 2000. Dredge position data were acquired by ADISS.

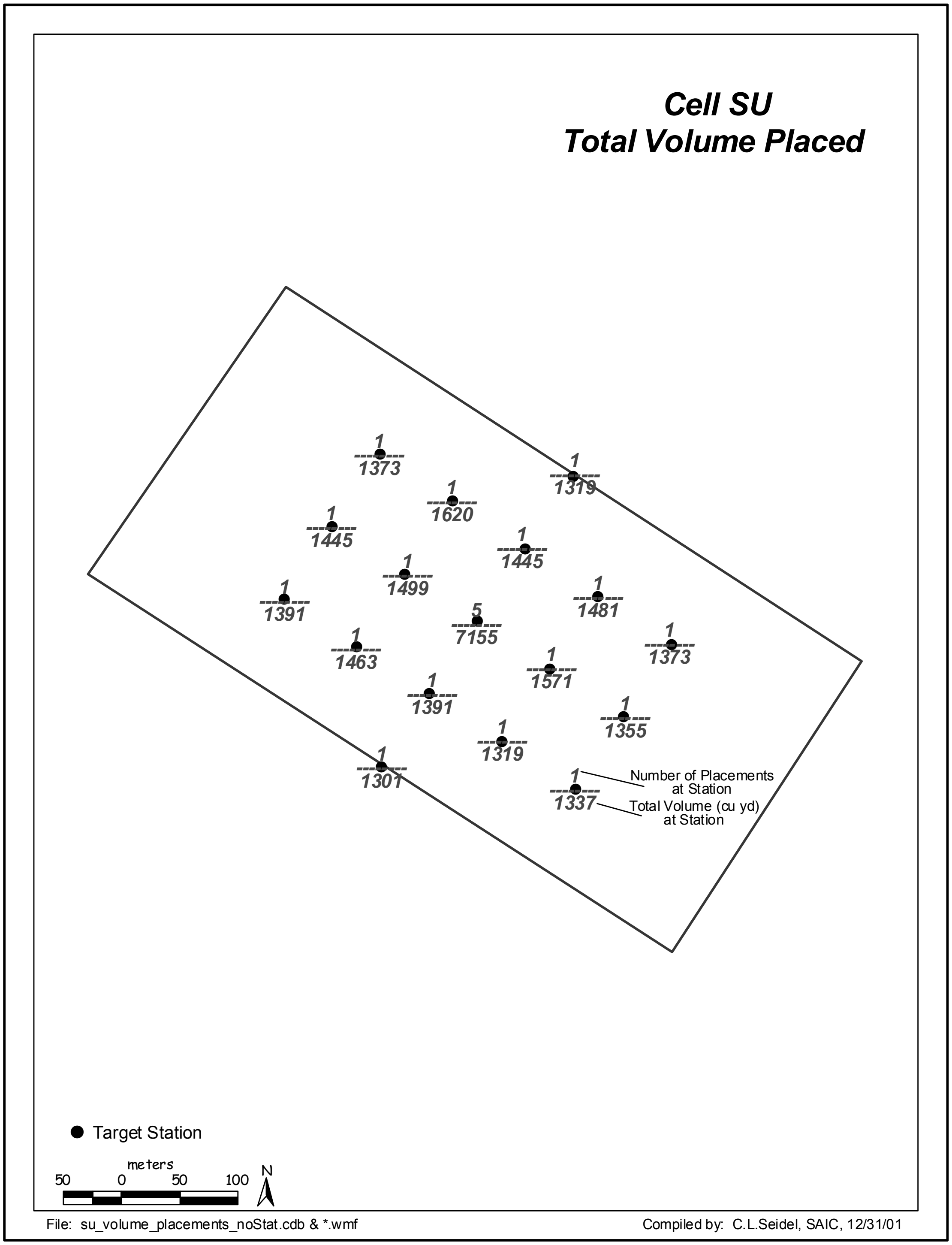


Figure 4.2-7. Map illustrating Cell SU on the Palos Verdes Shelf and the volume of cap material placed at the various target positions for all 21 events during August 2000. Cap placement data were acquired by ADISS.

4.3 Moored Measurements of Currents and Turbidity during Cap Placement in Cell SU

4.3.1 Overview of Field Sampling Plan

The scientific objectives for the in situ measurements of near-bottom currents and water clarity (turbidity) in Cell SU were identical to those for Cell LU (i.e., to determine whether a detectable surge in bottom currents was caused by the downward momentum of cap material as it impacted the seafloor during cap placement operations).

The Field Sampling Plan of the PWP (SAIC 2001) specified that near-bottom current velocities and turbidity were to be measured at five locations during placement events (i.e., at 75 m, 150 m and 250 m downslope, as well as 75 m and 150 m upslope). These locations were based on the cap material placement site at the center of Cell SU during the first placement event in August 2000. In addition to the near-bottom measurements from each moored array, an upward-looking current profiler was installed on one of the arrays to acquire data on horizontal currents throughout the water column.

Because the ARESS data logging units had limited pressure (depth) capabilities, these units could not be deployed in water depth greater than approximately 85 m. Consequently, the southernmost ARESS array was deployed at a distance of 170 m from the cap placement site and the next array was deployed at 115 m from the placement site (approximately equidistant between the 75 m and 170 m arrays).

The Cruise Report (SAIC 2000b) provides details on the field activities conducted during each day of deployment/recovery operations for the moored measurements.

4.3.1.1 Moored Array Deployment during Cap Placement Event 1

Table 3.3-1 provides a summary of moored-array deployments within Cells LU, SU and LD during the period from August 2-15, 2000. As indicated in the table, the first deployment in Cell SU spanned the time period of cap placement Event 1 during which 1,077 $m^3$of material was placed within Cell SU during a 3-min 10-sec release period on August 8 using the conventional (bottom dump) placement technique. The five moored arrays were deployed in the afternoon of August 7; only four could be recovered in the morning of August 9. Data records were retrieved from the internally recording instruments and the equipment was prepared for redeployment in Cell LU four days later. (see Cruise Report SAIC 2000b) for details on deployment times and field operations).

Temporary Loss of Moored Array in Cell SU

In April 2002, the Aquadopp array that had been deployed at the 150 m upslope location in Cell SU on August 7, 2000, was recovered by the F/V Vantuna during bottom fish trawling operations on the Palos Verdes Shelf and adjacent slope. The instrumented array was returned to the SCMI facility in San Pedro in relatively good physical condition with all instruments attached. The pressure case of the Aquadopp current meter was intact and contained a good-quality data record of 4.2 days length, which began at the time of deployment on August 7, 2000 (21 months before array recovery). Analysis of the data record indicates that the array was snagged by a passing vessel at 1504 GMT on August 8, about 3 hrs before the placement event in Cell SU.

A review of the other survey operations conducted on August 8, 2000 (Cruise Report; SAIC 2000b) confirmed that the R/V Tuna was conducting underway measurements in and adjacent to Cell SU for acquisition of spatial data on acoustic backscatter characteristics throughout the water column prior to and during placement Event 1 (see Section 4.6). The navigation record from the R/V Tuna indicated that near 1500 GMT the vessel was conducting reciprocal transects along a cross-shelf line adjacent (and very close) to the line of moored arrays already positioned in Cell SU. Apparently, the submerged ADCP profiler being towed by the R/V Tuna snagged the vertical line connecting the moored Aquadopp array to its small surface marker float. The crew of the R/V Tuna may have been unaware of this snagging as they continued to run reciprocal ADCP transect lines for acquisition of data adjacent to the line of moored arrays.

Inspection of the time series record from the recovered Aquadopp current meter revealed that the array was released from its tow at a location southwest of Cell SU in relatively deep water when the R/V Tuna apparently turned 180° to a reciprocal course heading shoreward along the line of moored arrays. Because the Aquadopp array was temporarily tethered to the ADCP towfish of the R/V Tuna and because the array's vertical line to its surface float was relatively short, the instrument array was well above the bottom as it was towed offshore into deeper water.

When the array's marker float line was freed (below the surface, without the R/V Tuna knowing it), the array sank to the bottom in an upright orientation with assistance from the flotation trailing above. The array settled on the seafloor with a final tilt that was approximately 20° from the vertical, as confirmed by tilt sensors within the Aquadopp instrument. Because of the 70-m length of the tether line, the small marker float was not visible at the sea surface when the array was moored at its new resting place.

Good quality current and turbidity data were recorded during this entire "relocation" operation and thereafter, until the instrument's memory was full. The time series data clearly showed the passage of the surge from placement Event 1 in Cell SU, which occurred approximately 3 hrs after the array had settled at its new location offshore of Cell SU. The pressure record from the Aquadopp indicated that the water depth at this location was approximately 174 m, which translates to a horizontal distance of approximately 475 m offshore/downslope from the center of Cell SU based upon analysis of the bathymetric data from the PV Shelf made available by USGS.

Data Return From Moored Arrays

Figure 4.3-1 illustrates the location of the five moored arrays that were deployed within and adjacent to Cell SU during Event 1. In this figure, array locations are labeled according to their position relative to the center of the cell (e.g., D75 refers to "downslope 75 m"). Water depth along the transect of arrays ranged from 59 m at the U150 location, to 74 m at the D170 location, and 174 m at the D475 location.

Also shown in Figure 4.3-1 are the position and heading (302° T) of the hopper dredge during the placement operation. The dredge was stationary at the center of the cell upon commencement of cap material release, and drifted only slightly toward the north during the 3-min release period. As planned, this resulted in a "point release" of Queen's Gate material at the center of the cell, nearly midway between the 75 m upslope and downslope arrays. Instrumentation deployed during Event 1 in Cell SU is summarized in Table 3.3-2.

Percent data return from the five moored arrays deployed during Event 1 in Cell SU is presented in Table 3.3-3. Complete data records were acquired by the Aquadopp current meters at the 75 m upslope and 475 m downslope locations, by the ARESS current sensors at the 115 m and 170 m downslope locations, and by the ADCP at the 75 m downslope location. No data were acquired by the ARESS sensor at the 75 m downslope location due to an electronic problem with the Aanderaa current sensor.

Results from the moored current and turbidity records acquired during placement Event 1 are presented in Section 4.3.4.

4.3.2 Review of Data Quality Objectives

The general monitoring objectives, data requirements, and technical approach for the moored current and turbidity measurement program are listed in Table 3.3-4.

A. Determine the physical extent and current velocities of the near-bottom current surge

As for Cell LU, this objective was achieved via high-resolution current measurements at various locations and water depths during a single cap placement event in Cell SU as described in Section 4.3.1. Data return from the moored current meters is summarized in Table 3.3-3. Monitoring highlights and data deficiencies for Cell SU are identified below:

Cell SU

- As planned, one cap placement event was monitored.
- Five moored arrays were deployed in this cell, but one array was inadvertanly moved from the U150 location to a D475 location.
- 100% return of near-bottom current data was achieved at four of five measurement locations.
- 100% return of ADCP data throughout the water column was achieved at one location. Concurrent, near-bottom current data were not acquired at the site of the ADCP because of an electronic problem with the circuitry of one of the Aanderaa (ARESS) current sensors.

B. Determine suspended particulate levels in the near-bottom current surge

This objective was achieved via high-resolution measurements of near-bottom turbidity at various locations during a single cap placement event in Cell SU. Turbidity data return from the moored instrumentation is summarized in Table 3.3-3. Monitoring highlights and data deficiencies for Cell SU are identified below:

Cell SU

- As planned, one cap placement event was monitored.
- 100% return of near-bottom turbidity data was achieved at four of five measurement locations.
- Near-bottom turbidity data were not acquired at one site because of an electronic problem with the circuitry of one of the Aanderaa current sensors on the ARESS array.

4.3.3 Technical Considerations

The only significant problem that was encountered during monitoring in Cell SU was the temporary loss of the moored array at the 150 m upslope location. The relocation of this array to the 475 m downslope location was discussed in Section 4.3.1.1. Ironically, the results acquired at this distant downslope location proved very valuable for analysis of bottom slope effects on the momentum dissipation within the horizontal surge current.

4.3.4 Monitoring Results

4.3.4.1 Observations during Cap Placement Event 1

Near-Bottom Currents and Turbidity at the 115 m and 170 m Downslope Locations

Cap placement Event 1 in Cell SU began at 1834 GMT on August 8, 2000 while instrumentation was moored at the five positions described above. Inspection of time series records from the moored instruments revealed that near-bottom current velocities and turbidity increased sharply during passage of the horizontal surge, as had been seen for multiple events in Cell LU. To illustrate the surge effects in Cell SU, Figure 4.3-2 presents near-bottom current speed, current direction, and turbidity data acquired at the 115 m and 170 m downslope locations beginning at 1810 GMT on August 8 and extending for roughly 1 hr. This figure presents data from ARESS current and OBS sensors at heights of 1.25 m above the seafloor.

Immediately prior to Event 1, near-bottom currents at both the 115 m and 170 m downslope locations were very weak (<10 cm/s) and directed toward the southeast or south (140° to 200°T; Figure 4.3-2). Near-bottom turbidities also were consistently low (<10 FTU). Within four minutes of commencement of cap placement operations, currents at the 115-m location increased sharply and demonstrated more directional stability (between 220° and 240°T) for the next 12 min. Maximum current speeds of 72 cm/s were encountered briefly at the 115-m location. Current speeds associated with this surge event dissipated gradually, such that speeds returned to background (pre-placement) levels within 13 min of the placement event. Coincidentally, current vectors shifted toward the north after the surge event had dissipated.

Near-bottom turbidities during the surge of Event 1 also rose sharply above background levels, achieving a maximum of approximately 510 FTU at the 115 m downslope location (Figure 4.3-2). These time series data suggest that the maximum turbidity associated with the surge occurred about 2 min before the maximum current speed, but the intensified currents persisted longer than did the elevated turbidity. Turbidity levels returned to their pre-placement background levels within about 8 min.

The surge at the 170 m downslope location occurred 2 min after it had arrived at the 115 m downslope location. A maximum current speed of 63 cm/s was encountered at the 170-m location and the surge was directed toward the southwest (toward 240°T; Figure 4.3-2). Current speeds associated with this surge dissipated as quickly as had been observed at the shallower location, returning to background levels within 10 min of the placement event. Current vectors at the 170-m location gradually shifted toward the east then northeast after the surge had dissipated. Near-bottom turbidities during the surge event at the 170-m location rose sharply then dissipated relatively quickly, as had been seen at the 115-m location. The maximum turbidity was comparable at these two measurement locations (Figure 4.3-2).

Near-Bottom Currents and Turbidity at the 75 m Upslope Location

Near-bottom current and turbidity data also were acquired from an array situated 75 m upslope of the placement site during Event 1 in Cell SU. The time series results from this array are presented in Figure 4.3-3, along with data previously presented from the array moored at the 115 m downslope location. In this figure we can see that the maximum current speed of 55 cm/s at the upslope location was considerably weaker than the maximum speed at the downslope location. And with regard to persistence of currents, speeds at the upslope location were only briefly above 30 cm/s, compared to about 6 min at the downslope location when speeds exceeded this value.

With regard to the current direction at the 75 m upslope location, background currents were directed toward the west prior to the placement event, but swung to the north-northeast during the surge

(Figure 4.3-3). This again illustrates that the surge momentum was oriented radially away from the placement site at the center of Cell SU.

As had been seen at the upslope locations in Cell LU, the turbidity (maximum of 360 FTU) associated with the surge at the upslope location in Cell SU was considerably lower than the turbidity at both of the downslope measurement locations in Cell SU (Figure 4.3-3, Table 3.3-9).

Near-Bottom Currents and Turbidity at the 475 m Downslope Location

The Aquadopp array that was inadvertently moved from the 150 m upslope location to a position situated 475 m downslope of the center of Cell SU provided an excellent data set for assessing the effect of bottom slope on the dissipation of downslope momentum within the horizontal surge current. Before presenting the observations of currents and turbidity within the surge of Event 1, it is important to point out that the bottom slope within and seaward of Cell SU is much greater than that within Cell LU (~1°). For example, between the 75 m upslope and 115 m downslope array locations in Cell SU, the bottom slope was only 1.5°, but slightly farther offshore, bottom slopes increased substantially. Between the 115 m and 170 m downslope locations, the slope increased to 9°, whereas between the 170 m and 475 m downslope locations, the slope achieved 18.5° (based upon the local USGS multibeam bathymetric data, the approximate position of this deep array, and the water depth measured by the instrumented array). Cell SU was, therefore, situated at the seaward edge of the flat PV Shelf, which abutted the relatively steep continental slope in this region. The effect of this bottom slope is discussed further in sections that follow.

Near-bottom current and turbidity data acquired by the array moored at the 475 m downslope location seaward of Cell SU are presented in Figure 4.3-4, along with data from the 170 m downslope array. The leading edge of the surge current arrived at the farthest downslope location at 1851 GMT, which was 17 min after the beginning of the placement in the center of the cell. Prior to the arrival of the surge, ambient bottom currents were on the order of 3 to 8 cm/s and currents were directed to the southwest. When the surge arrived, near-bottom current speeds increased abruptly, attaining a (12-sec averaged) maximum of 29 cm/s, then decreased gradually to the low background levels after 10 min. Current directions during this surge event were primarily southward in the direction of the local bottom slope as well as generally directed away from the cap placement site.

The near-bottom turbidity record from the 475 m downslope array exhibited a sharp increase that coincided with the time of the maximum surge current (Figure 4.3-4). The maximum observed turbidity during this event was 270 FTU which was approximately half the value observed at both the 115 m and 170 m downslope arrays (Figure 4.3-4; Table 3.3-9).

Radial Spreading and Dissipation of the Surge Current

One of the primary objectives of the surge monitoring effort was to determine the rate at which surge current velocities and turbidity levels decrease with distance from the placement location in Cell SU. Secondarily, it was important to determine whether the greater bottom slope at Cell SU would result in less downslope dissipation in surge momentum. Figure 4.3-5 presents a plot of the maximum near-bottom current speed observed at the four array locations in Cell SU during placement Event 1 versus the horizontal distance from the moored array location to the actual cap placement location. The slope of the line connecting data from the three downslope measurement sites illustrates that the surge current decreased gradually with distance from its point of origin. The three downslope data points in this figure illustrate that the rate of dissipation in maximum current speed was generally consistent over distances from 115 to 475 m from the placement location. Over this distance of 360 m, the maximum observed speed of the surge current decreased by 60%, corresponding to a 12 cm/s speed reduction per 100 m of horizontal distance.

When the maximum speed results from surge Event 1 in Cell SU are compared with the results from Events 1 to 5 in Cell LU (Figure 4.3-6, Table 3.3-6), we see that the SU results acquired from arrays situated 115 to 170 m from the placement site generally agree with those from Cell LU, but the slope of the speed-dissipation line is steeper for observations in Cell LU. Over the range from 80 to 250 m from the placement site in Cell LU, speeds decreased at the rate of 50 cm/s per 100 m which was about four times faster than observed for Cell SU.

For distances greater than 170 m from the placement site, the maximum speed in the surge at Cell SU was greater than observed for all events in Cell LU (Figure 4.3-6). It is likely that these differences were associated with differences in bottom slope within and offshore of the two cells. For example, the bottom slope along the line of moored arrays in Cell LU was 0.9° (1:65 slope) compared to a slope of 3.2° (1:18 slope) between the 75 m upslope and 170 m downslope arrays in Cell SU. This 3.5-fold greater slope in Cell SU may have resulted in greater damping of the horizontal momentum propagating upslope in Cell SU, as well as less damping of the momentum propagating downslope, relative to that within Cell LU. As discussed above, the bottom slope between the 115 and 170 m array locations at Cell SU was 9° while the bottom slope between the 170 and 475 m array locations increased to 18.5°. In oceanographic terms, this is a steep slope that may impart minimal drag to a horizontally propagating surge current. The current data from the surge at the 475 m location do, however, provide evidence that the surge was decelerating, even on this relatively steep bottom slope offshore of Cell SU. These potential effects of bottom slope may later be evaluated by numerical models of cap material descent and lateral transport of momentum in a surge current.

Another observation that can be drawn from Figure 4.3-6 is that the slope of the line connecting data from SU arrays situated between 170 and 475 m is very similar to the slope of the line for LU Events 2 and 4 for arrays at distances beyond 150 m (and for Event 1 in Cell LD, as discussed in Section 5.3). Closer to the placement site during all LU events, surge currents dissipated much quicker per unit distance from the placement, but at a distance of approximately 150 m from the placement site the dynamics of the surge current may have changed, with more gradual dissipation beyond. Note that this reduced rate of dissipation was similar to the rate of dissipation observed in Cells SU and LD at these distances from the placement site. If the surge dynamics were as described above, then it suggests that the behavior of the surge current, at significant (greater than 150 m) distances from the placement site, may be independent of bottom slope and cap material placement technique. Further data analysis, field measurements, and/or numerical modeling would be necessary to prove or disprove this concept of surge dynamics, but we believe this scenario is unlikely because it does not explain why surge speeds far from the placement site in Cell SU are much greater than those observed during the other placement events.

Another factor that may have an effect on the dynamics of the surge current is the water depth at the various pilot cells. The water depth at the center of Cell SU (62 m) is 44% greater than that within Cell LU (43 m), which may have a significant effect on the cross-sectional area of the cap material "column" as it descends through the water column upon release from the hopper dredge. Numerical modeling could shed light on this process, but intuition suggests that a descending plume would be somewhat broader (having a larger initial footprint looking downward through the water column) in a deep cell compared to a relatively shallow cell. And if the total downward momentum (a function of material mass and terminal velocity) in the descending plume were equal for plumes released in shallow and deep cells, then the vertical momentum per unit area of the seafloor may be less in the deeper cell where the impact footprint would be greater. Taking this argument further, it may result that the initial horizontal momentum of the surge current in the deeper cell would be less than that within a relatively shallow cell due to the broader impact footprint. This may require testing by numerical models, but in order to assess the significance of this process, the models would have to be run with similar bottom slopes in the two cells so that potential slope effects can be separated from potential water depth effects.

To assess the rate at which the turbidity of the surge current is dissipated with distance away from the cap placement site in Cell SU, Figure 4.3-7 presents a plot of the maximum near-bottom turbidity observed at the four array locations in Cell SU during placement Event 1 versus the horizontal distance from the moored array location to the actual cap placement location. When these turbidity results from Cell SU are compared with the results from Events 1 to 5 in Cell LU (Figure 4.3-7; Table 3.3-9), we see that the SU observations agree well with those from multiple events in Cell LU in the range from 115 m to 170 m from the placement site but farther seaward turbidities decrease much more rapidly for the LU events. The reduced slope of the line connecting the three downslope measurement sites in Cell SU indicate that turbidities at these locations offshore of Cell SU dissipate at a much slower spatial rate than the observed turbidities within Cell LU, which had less bottom slope. We suspect that although the current speeds in the surge current at the 475 m array were considerably less than those observed farther upslope, they may have been sufficient to induce resuspension of local, ambient bottom sediments. This hypothesis is indirectly supported by the unlikely scenario that cap material and/or material resuspended from the actual cap placement site could remain in suspension during its entire horizontal excursion from the placement site to the 475 m array location.

Note that the maximum turbidity at the 75 m upslope location in Cell SU was practically identical to that observed at the same relative location during four placement events in Cell LU (Figure 4.3-7), suggesting that the minor differences in bottom slope upslope within the two cells had minimal effect on concentrations of suspended material in the upslope direction. It is also interesting to note that the observations of maximum turbidity in the surge during five separate events in Cells LU and SU at upslope measurement locations were much lower than those at equivalent distances downslope from the placement site (Figure 4.3-7). This may have been a result of weaker horizontal velocities propagating in the upslope direction, and a corresponding reduced ability to erode the ambient, in-place sediment as the surge moved upslope. It is expected that the surge current would contain suspended cap material that had not had a chance to deposit on the seafloor, but the surge current may also contain suspended sediment that had been eroded from the ambient seafloor in close proximity to the placement site ("ground zero") where the initial horizontal velocities may have been very strong. Consequently, the stronger the horizontal surge current, the greater potential for resuspension of in-place sediments and the higher the turbidity within the surge. And if the surge currents were greater in the downslope direction, then the horizontal pattern (plan view map) of the quantity of resuspended in-place sediments may be asymmetrically distributed, with more resuspension on the downslope side of a placement cell.

These results illustrate there was asymmetry in both current speeds and turbidity on the upslope and downslope sides of the placement sites in Cells LU and SU. Because upslope surge currents dissipated more quickly with horizontal distance, it is likely that cap material was deposited sooner and closer to the placement site on the upslope side. Similarly, resuspension of ambient sediment would have been less on the upslope side of the placement sites.

Persistence of Surge Currents

As another method to compare the surge results from Event 1 of Cell SU with those of Events 1 to 5 in Cell LU, the persistence of near-bottom current speed within the individual surge events was analyzed. Table 4.3-1 presents the persistence (time duration) that currents exceeded specific speed levels for each placement event. Current speeds did not exceed 75 cm/s at any of the four measurement sites for Event 1 in Cell SU, but speeds exceeding 50 cm/s were observed (for durations of 0.25 to 1.50 min) at all but the 475 m downslope location. The time duration of speeds exceeding 25 cm/s decreased from 7.25 to 2.25 min over the downslope distance from 115 to 475 m.

Persistence results from Events 1 to 5 in Cell LU (Table 3.3-7) showed that near-bottom speeds exceeding 75 cm/s were relatively infrequent (observed during less than half of the events) and brief (never exceeding 1 min). In Cell LU, speeds exceeding 50 cm/s generally persisted for longer than 1 min at the 75 m upslope and 75 m downslope locations but typically not at locations farther downslope. The time duration of speeds exceeding 25 cm/s decreased substantially between the 75 m downslope location and the 150 m downslope location for LU events, and was near zero at the 250 m downslope location. For the single event monitored in Cell SU, speeds exceeded 25 cm/s for similar time durations at the 170 m location as observed at the 150 m downslope location for Cell LU.

The largest difference in persistence results from Cells LU and SU was the relatively long duration (2.25 min) of current speeds exceeding 25 cm/s at the 475 m location in Cell SU compared to less than 0.25 min at the 250 m location in Cell LU. This supports the observation that the surge was more energetic at greater distances downslope for Cell SU (on the steeper bottom slope) than for Cell LU.

Vertical Profiles of Horizontal Currents during Placement Event 1

The ADCP mounted on the ARESS array nominally located 75 m downslope of the placement site in Cell SU acquired current velocity data throughout the water column for approximately 44 hrs from August 7-9, 2000. This deployment period spanned placement Event 1 that occurred on August 8. Water depth at this mooring location was 64 m. The velocity data acquired by the ADCP at this cell consists of individual time series records (averaged over 1-min time intervals) from each of 57 1-m thick depth layers starting 3 m above the bottom. Figure 4.3-8 presents a composite of current speed records from eight depth layers starting at 61 m (3 m above the bottom) and continuing upward to 5 m depth; Figure 4.3-9 presents a companion plot of current direction at the eight depth layers. A time series record of water temperature acquired by a sensor situated 1 m above the bottom also is presented at the top of the two figures.

The time series of current speed at the 61-m measurement level (lowest tier in Figure 4.3-8) illustrates very weak and steady bottom currents that generally ranged from 2 to 10 cm/s, with brief periods when speeds approached 20 cm/s. Current speeds were somewhat higher at the shallower 19-m depth, with maximum speeds approaching 30 cm/s. At 5-m depth, speeds were much higher than at the lower levels, with speeds frequently in the range of 20 to 60 cm/s and maximum speeds near 110 cm/s. Current speeds in the lower water column were much less variable than in the upper layers. And there were no events of intensified currents following times of high water, as had been observed in the lower layers at Cell LU (Figure 3.3-19).

Current directions were generally eastward or southeastward (80° to 150°T) for the 2-day current record at the 5-m depth level (Figure 4.3-9). Directions were much more variable in the lower half of the water column where currents were weaker. Initiation of eastward flow preceded the time of low water at near-bottom levels, and occurred progressively later with height off the bottom up to the 34-m depth level (see the shift to eastward flow at 61-m depth at 0300 GMT on August 8).

Also shown in Figures 4.3-8 and 4.3-9 is the time of cap placement Event 1 in Cell SU. At the 61-m ADCP depth level, a brief (10-min) high-speed event was evident at the time of the placement. The current speed from the ADCP record clearly stood out above the weak background currents near the bottom. This maximum speed was 70 cm/s for the 1-min average at 61 m, compared to the background currents which were below 20 cm/s. This brief period of intensified current also could be seen up to the 58 m depth level (6 m above the bottom). Above that level, there was a suggestion of intensified currents at the time of the placement event, but the intensification was not significantly higher than the ambient variability.

The near-bottom water temperature record from the ADCP (top tier in Figures 4.3-8 and 4.3-9) illustrates that temperatures varied gradually over a range of 1.5°C during the 2-day record. Temperatures fluctuations were not correlated with changes in ambient current speed nor direction. At the time of cap placement in Cell SU, a relatively large and sudden temperature increase of 0.7°C was, however, evident in the records corresponding with the surge current. Even at this depth in the water column, the water and suspended particulates contained within the surge had a noticeable effect on bottom temperature.

4.3.4.2 Conceptual Model of Surge as Radially Spreading Annulus

The in-situ observations of near-bottom currents within the horizontal surge of Event 1 in Cell SU have been used to develop a conceptual model of this radially spreading feature. Using the same methodology as described in Section 3.3.4.6, the observations of surge speed and persistence can be used to estimate the radial width of the annulus and its spatial variability. For example, when the annulus passed the D115 array location in Cell SU during Event 1, the surge persisted for 15 min. Using the average speed of the surge during its passage at the D75 location (25.8 cm/s), the radial dimension of the annulus was approximately 232 m (900 s times 25.8 cm/s). Figure 4.3-10 illustrates this annulus width at Time 2 when the surge had ended at the D75 location. Time 1 and Time 3 correspond with the end of the surge at the U75 and D170 locations, respectively.

The surge during Event 1 at the U75 location had significantly shorter duration (11 min) than at the D115 location and the average speed at the U75 location (15.8 cm/s) was 39% less than at the D115 location. As the annulus propagated past the U75 location its width was 104 m, which was 45% of that observed at the D115 location on the downslope side of the placement site. This observation indicates that the annulus was decaying at a significantly greater rate in the upslope direction, most likely due to the bottom slope in Cell SU which was greater than that within Cell LU.

When the surge passed the D170 array, the radially directed currents persisted for 11 min and the average speed was slightly lower (22.9 cm/sec) than observed nearer the placement site at the D115 location. The surge characteristics at D170 correspond with an annulus width of 151 m (at Time 3 in Figure 4.3-10) compared with 232 m when the annulus passed the D115 location. Thus, both the annulus propagation speed and the width of the annulus were decreasing with distance from the placement site, as had been observed for Event 4 in Cell LU (Section 3.3.4.6). These results demonstrate that, even on the steeper bottom slope at Cell SU, the horizontal momentum of the surge was continually decreasing as it spread from the placement site and therefore, was becoming continually less effective at: 1) transporting suspended sediment originating from the placement site, and 2) eroding in-place bottom sediments in the path of the surge.

Table 4.3-1. Persistence of Bottom Surge Current Within Speed Ranges for Placement Event 1 in Cells SU and LD

	CELL SU Event 1					CELL LD Event 1			
Speed (cm/s)	75 m Upslope	115 m Downslope	170 m Downslope	475 m Downslope		75 m Upslope	75 m Downslope	150 m Downslope	250 m Downslope
	time*	time*	time*	time*		time*	time*	time*	time*
>75	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
>50	0.25	1.50	1.00	0.00		0.00	0.00	0.00	0.00
>25	1.50	7.25	3.00	2.25		1.00	2.50	1.75	0.00

*Persistence time reported in minutes

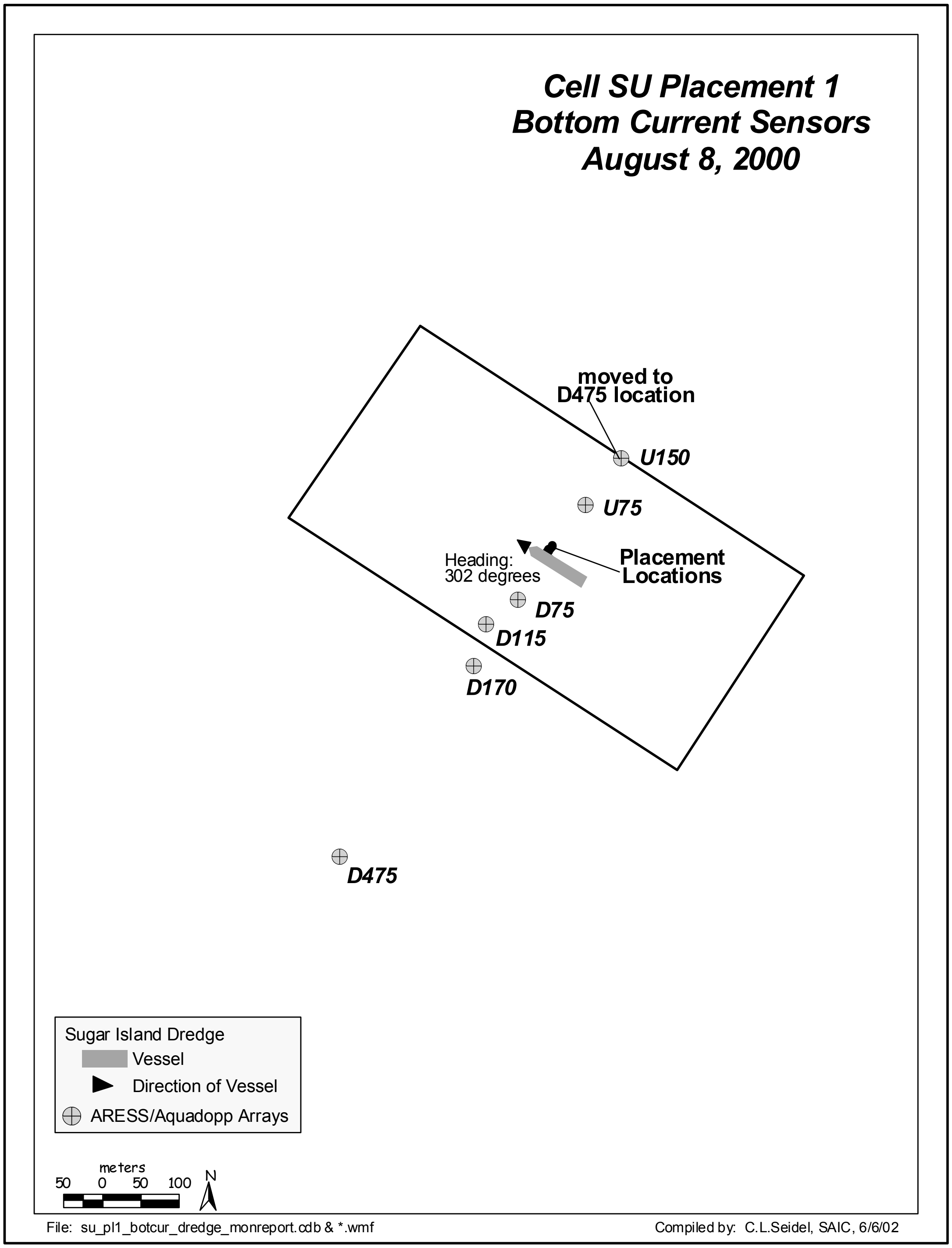


Figure 4.3-1. Map illustrating location of moored instrumentation during placement Event 1 in Cell SU, as well as the position and heading of the hopper dredge during the placement operation. The dredge drifted slightly to the north as shown in black.

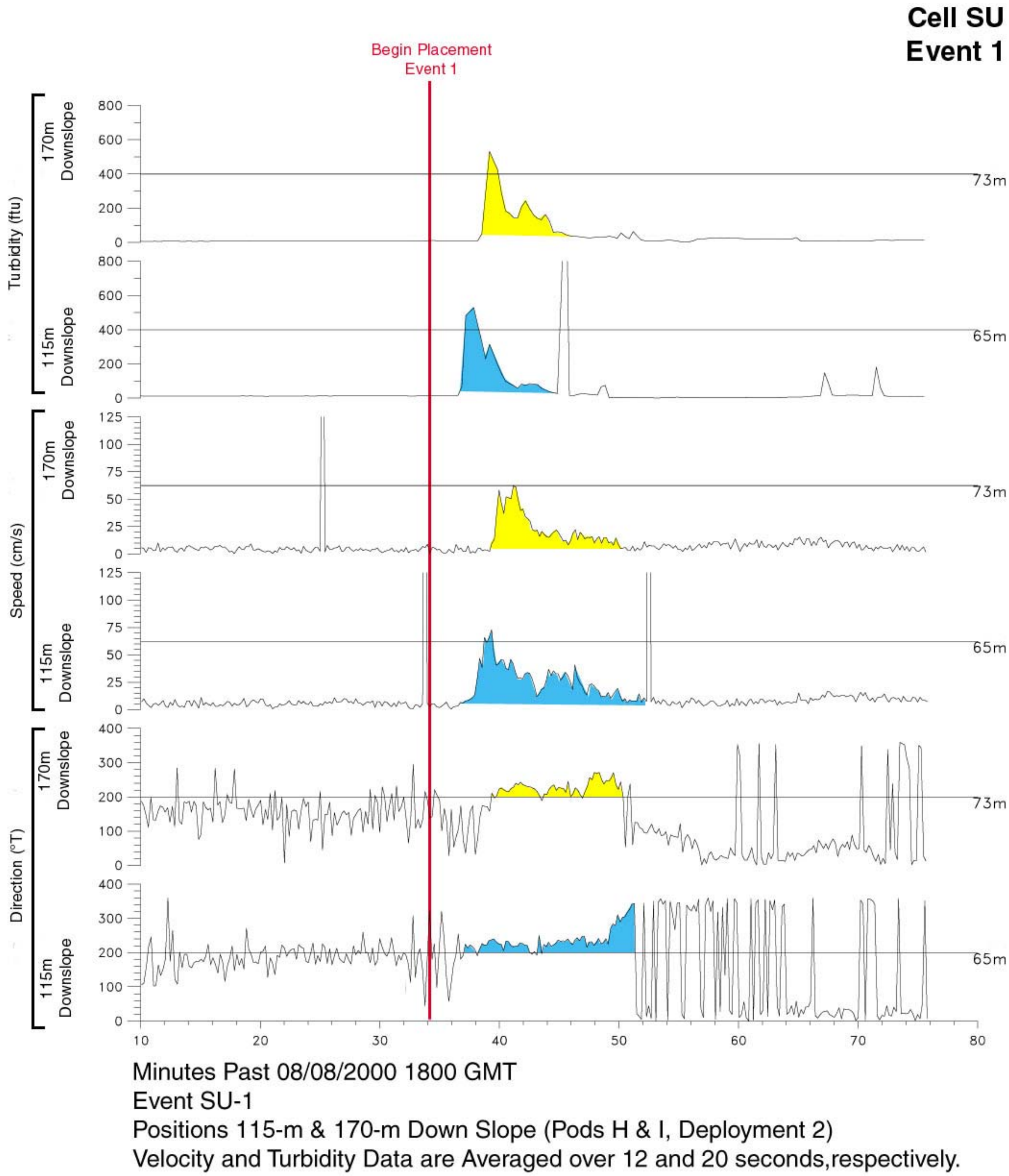


Figure 4.3-2. Time series plot of near-bottom data from the 115 m and 170 m downslope locations in Cell SU during cap placement Event 1 on August 8, 2000. Turbidity from the two locations (upper two tiers); current speed from the two locations (middle two tiers); and current direction from the two locations (lower two tiers).

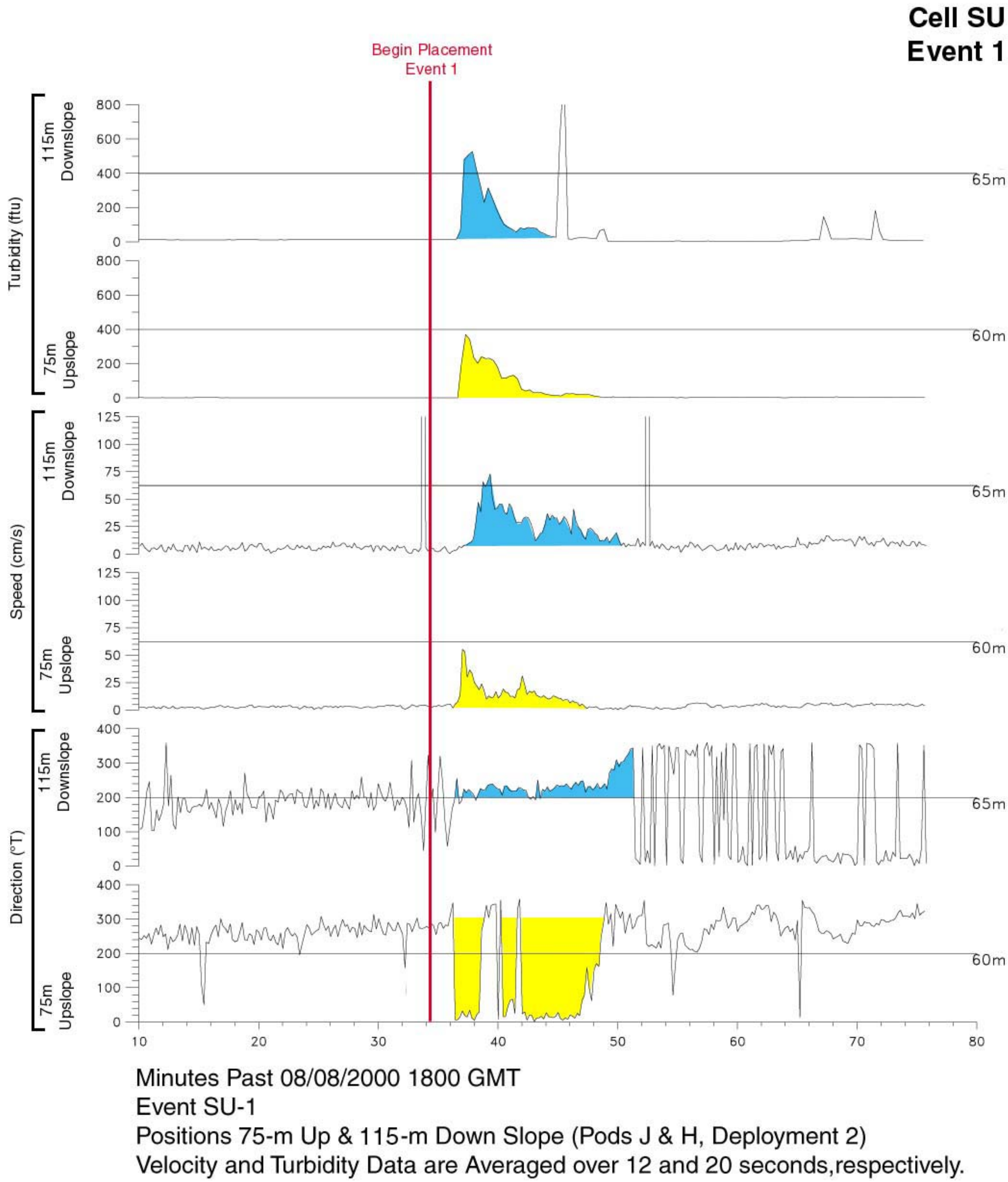


Figure 4.3-3. Time series plot of near-bottom data from the 75 m upslope and 115 m downslope locations in Cell SU during cap placement Event 1 on August 8, 2000. Turbidity from the two locations (upper two tiers); current speed from the two locations (middle two tiers); and current direction from the two locations (lower two tiers).

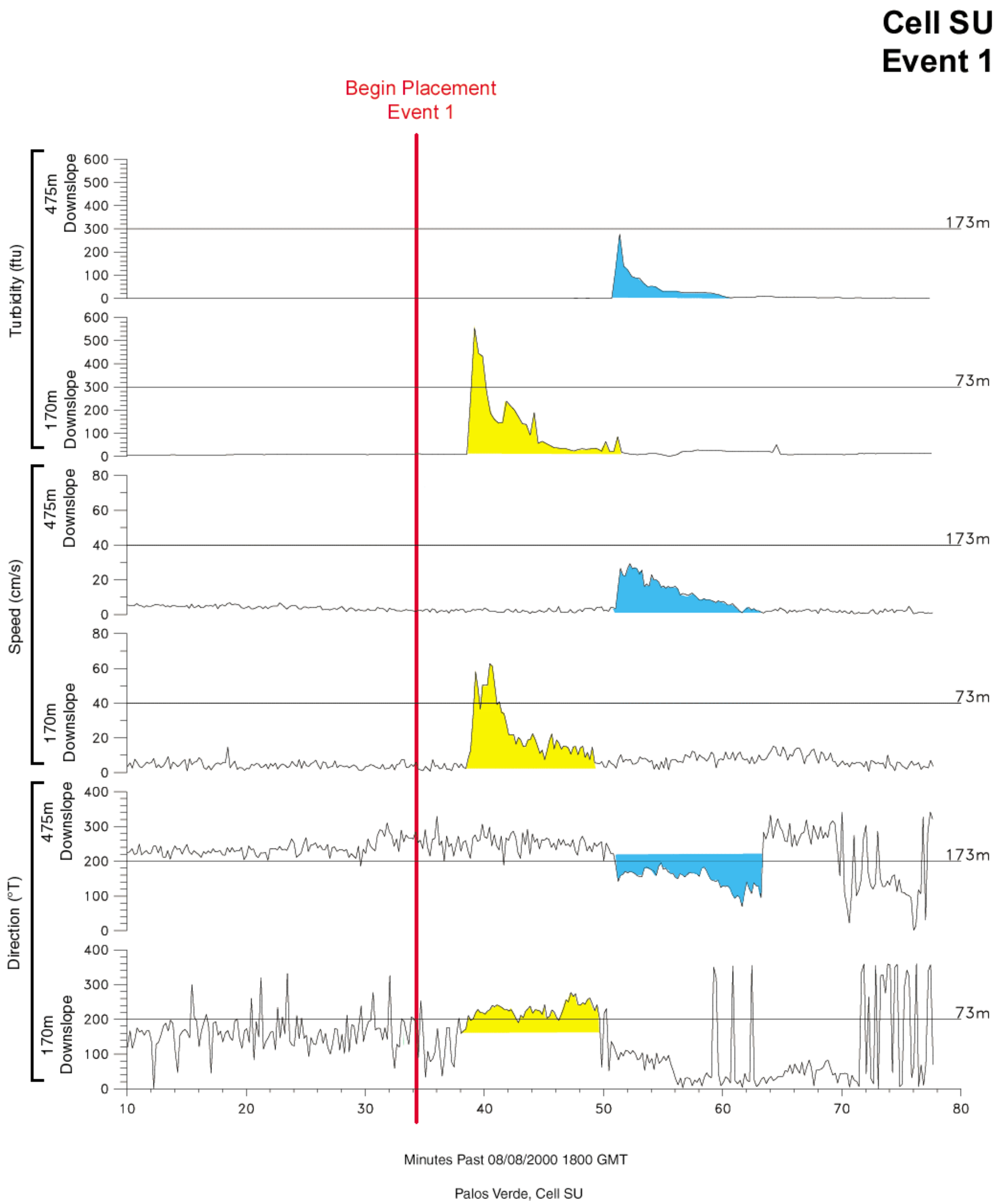


Figure 4.3-4. Time series plot of near-bottom data from the 170 m and 475 m downslope locations in Cell SU during cap placement Event 1 on August 8, 2000. Turbidity from the two locations (upper two tiers); current speed from the two locations (middle two tiers); and current direction from the two locations (lower two tiers).

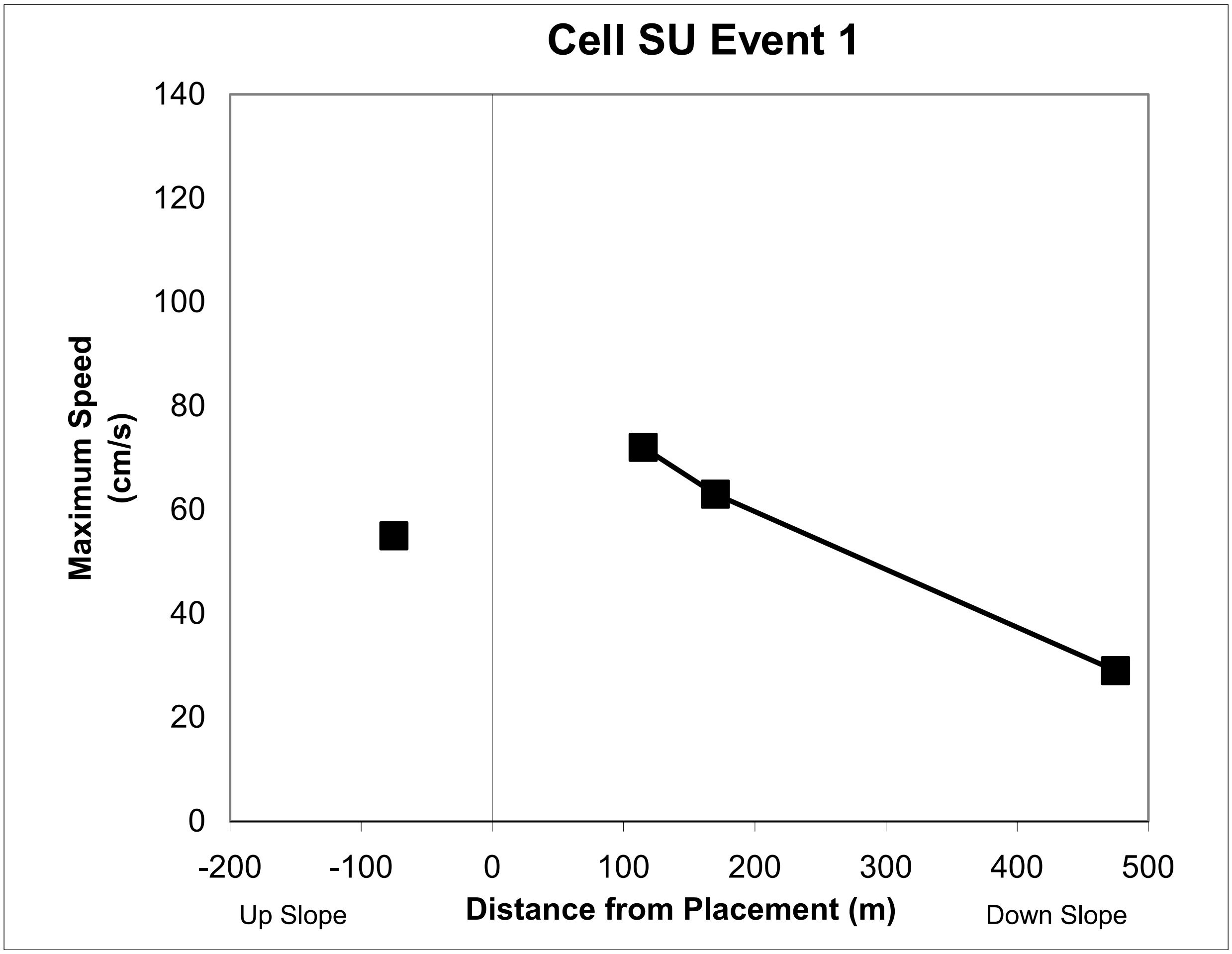


Figure 4.3-5. Plot of the maximum near-bottom current speed (y-axis) observed during cap placement Event 1 at multiple array locations within Cell SU versus the horizontal distance (x-axis) from the moored array locations to the actual cap placement locations (dredge positions).

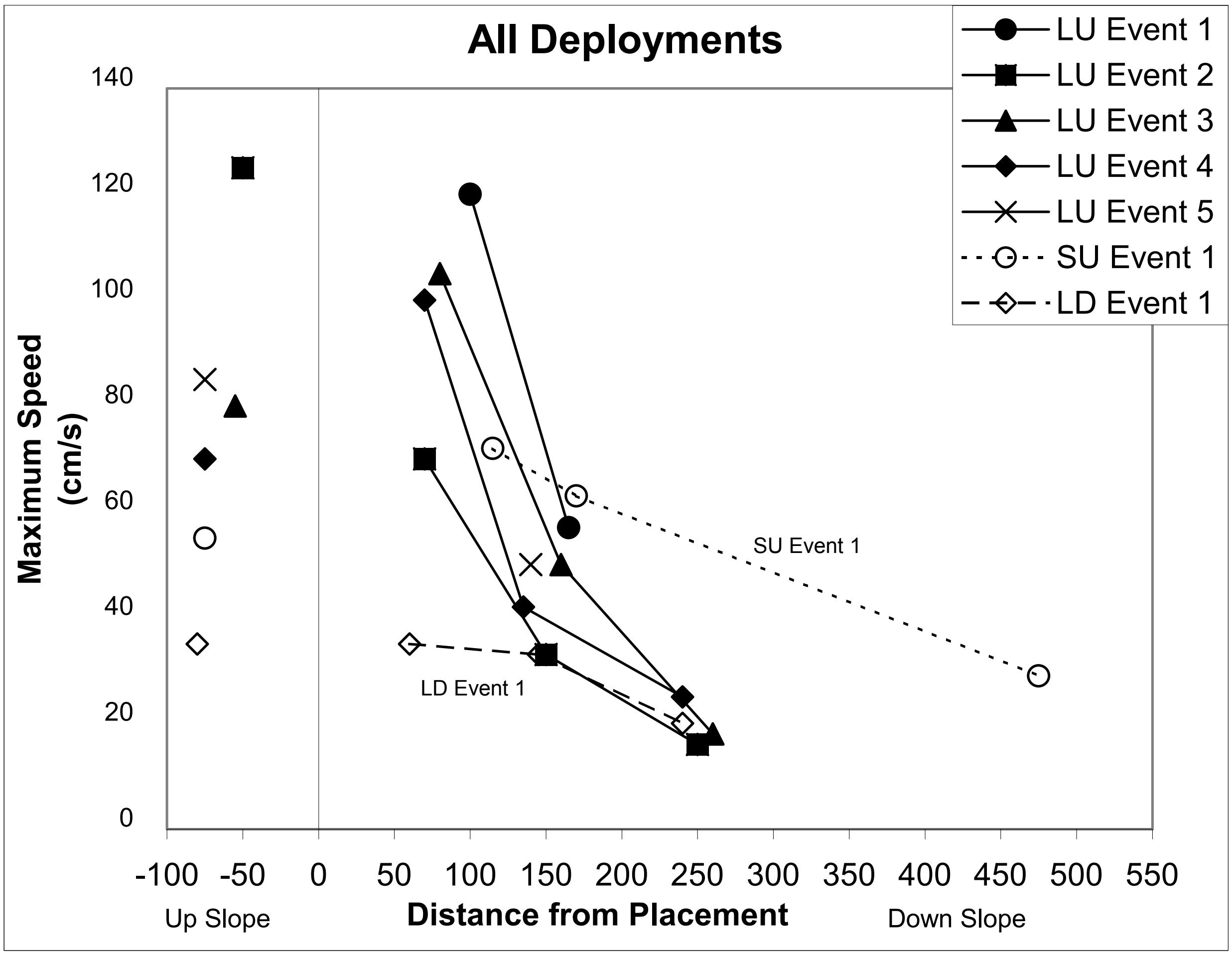


Figure 4.3-6. Plot of the maximum near-bottom current speed (y-axis) observed at multiple array locations during cap placement Event 1 in Cell SU, Events 1 to 5 in Cell LU, and Event 1 in Cell LD versus the horizontal distance (x-axis) from the moored array locations to the actual cap placement locations (dredge positions).

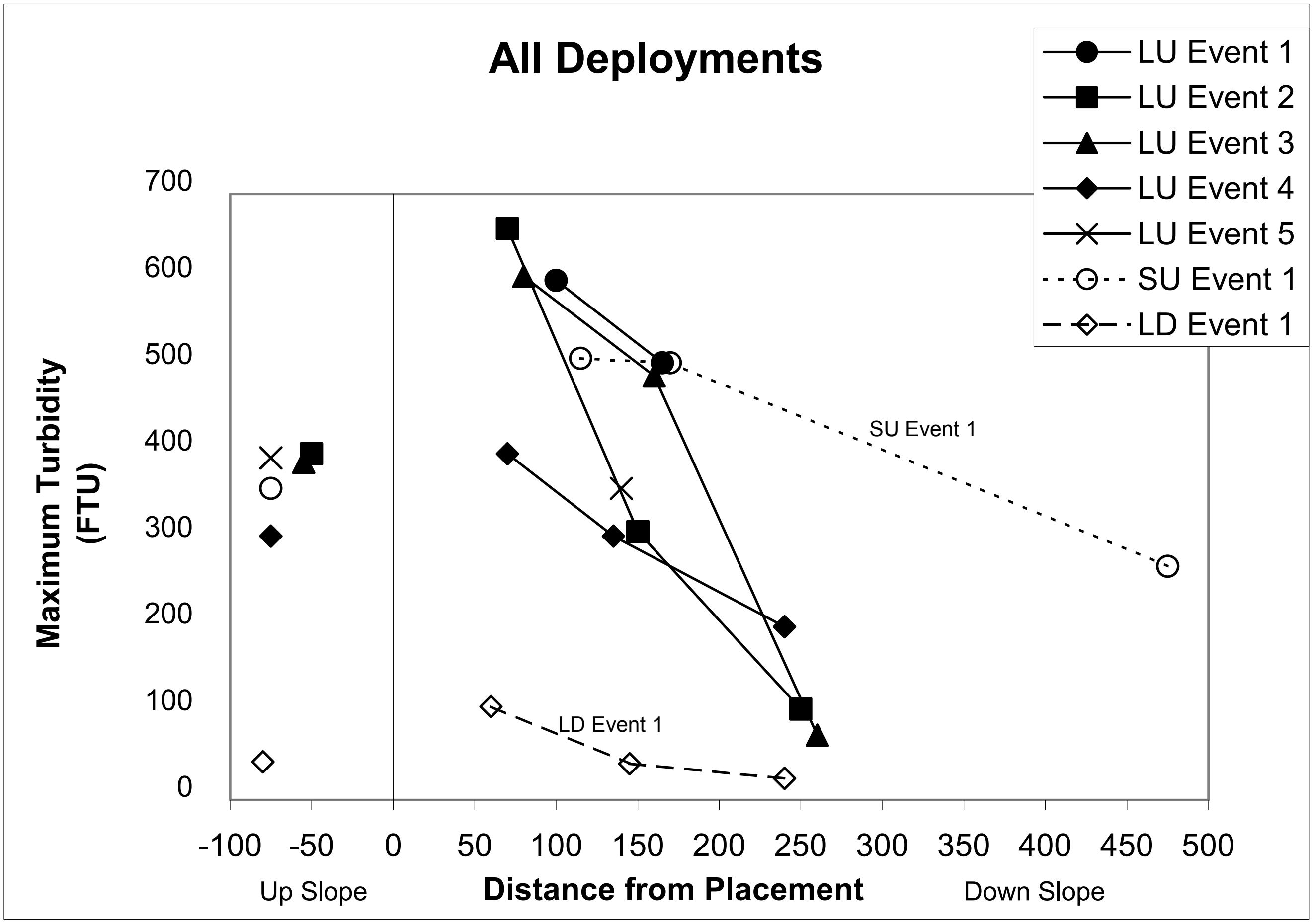


Figure 4.3-7. Plot of the maximum near-bottom turbidity (y-axis) at the time of maximum current speed observed at multiple array locations during placement Event 1 in Cell SU, Events 1 to 5 in Cell LU, and Event 1 in Cell LD versus the horizontal distance (x-axis) from the moored array locations to the actual cap placement locations (dredge positions).

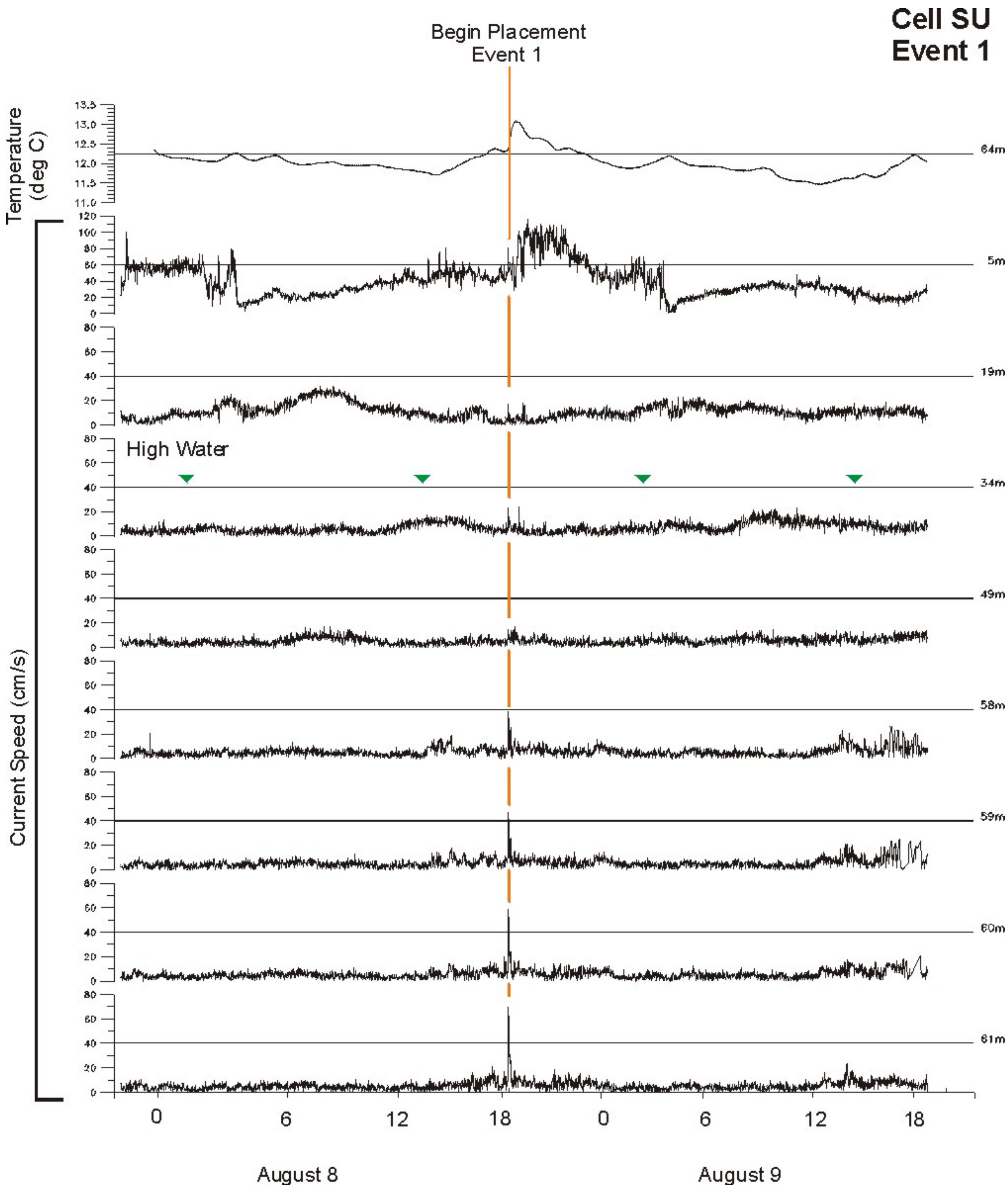


Figure 4.3-8. Time series plot of ADCP data from the 75 m downslope location in Cell SU bracketing cap placement Event 1 from August 7-9, 2000. Water temperature from 1-m above the bottom (top tier). Lower tiers present current speed data from eight 1-m thick depth levels extending from 5 m to 61 m (which was 3 m above the bottom). Data are 1-min averages. The times of high water at the NOAA tide station in Outer Los Angeles Harbor are also shown.

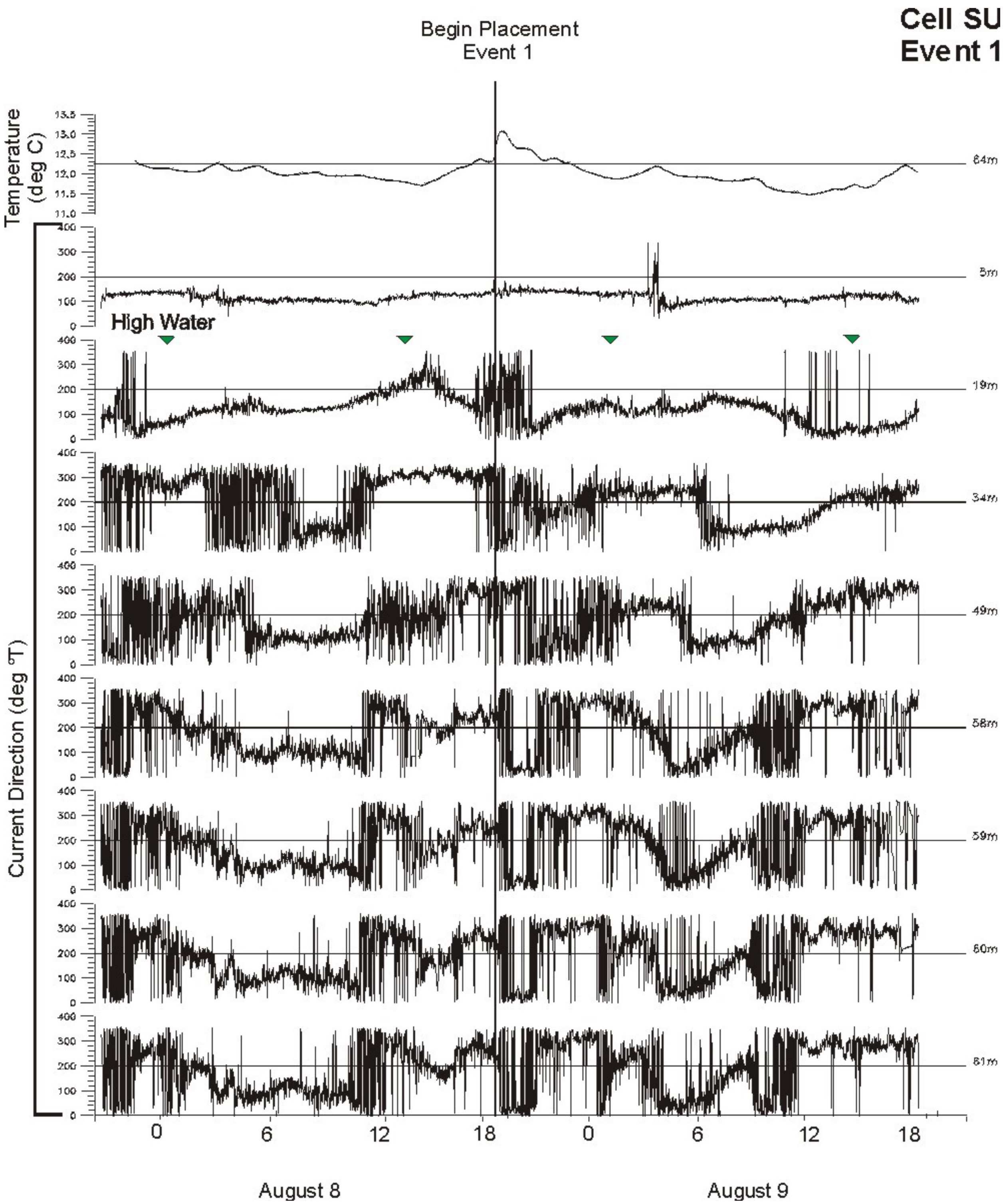


Figure 4.3-9. Time series plot of ADCP data from the 75 m downslope location in Cell SU bracketing cap placement Event 1 from August 7-9, 2000. Water temperature from 1-m above the bottom (top tier). Lower tiers present current direction data from eight 1-m thick depth levels extending from 5 m to 61 m (which was 3 m above the bottom). Data are 1-min averages.

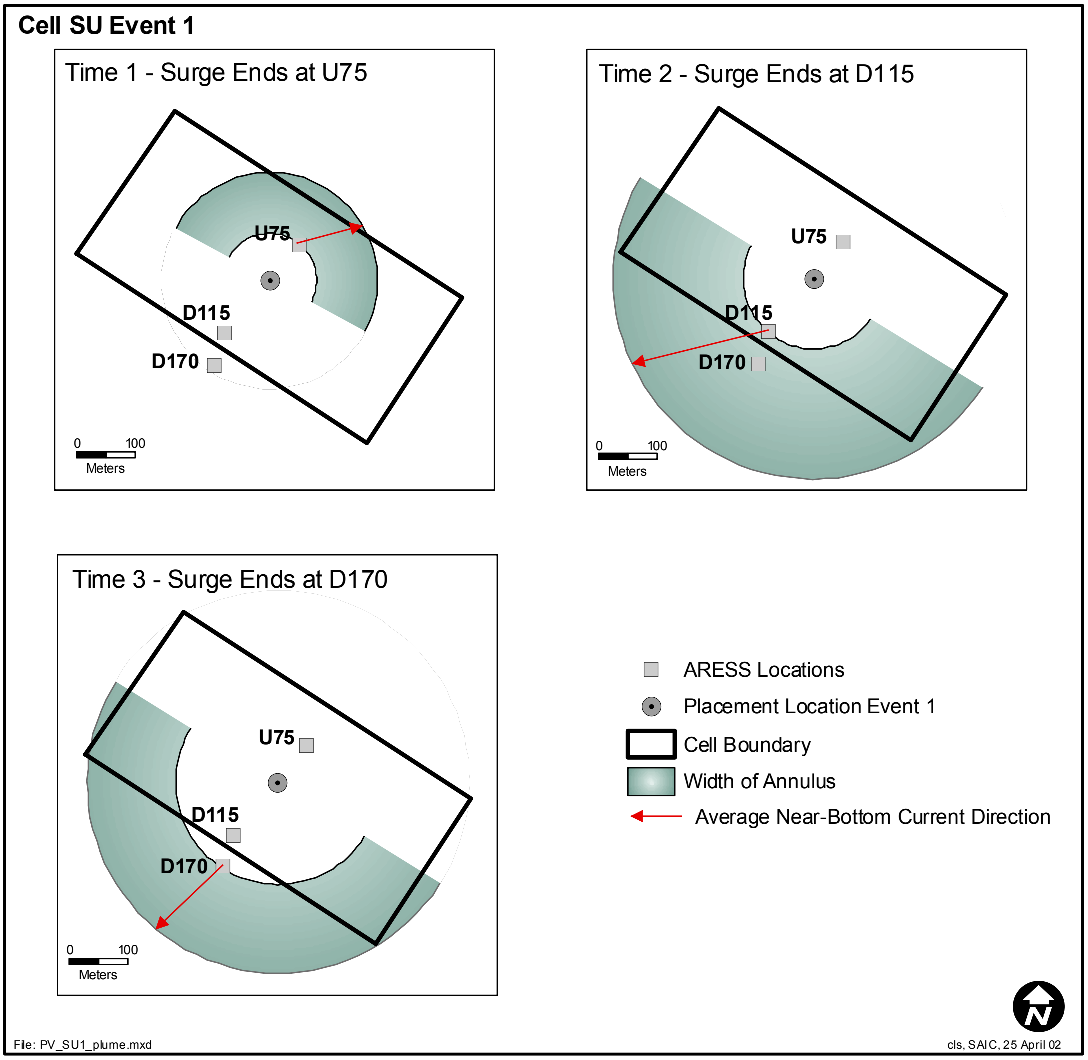


Figure 4.3-10. Diagram of the near-bottom surge process in Cell SU that spreads radially as an annulus. Time 1: surge had completely passed the U75 array. Time 3: surge had passed the D170 array.

4.4 Drogue Trajectory Results

4.4.1 Overview of Field Sampling Plan

The monitoring objectives for water quality measurements in Cell SU (Section 4.5) focus on sampling within the near-bottom plume of suspended sediments associated with the conventional (bottom-dump) placement of cap material in Cell SU. A key element of this sampling plan entailed positioning of the survey vessel at the optimum geographic location directly above the near-bottom suspended sediment plume. Because the water sampling survey vessel was not equipped with a vessel-mounted Acoustic Doppler Current Profiler (ADCP) for vertical profiling of horizontal currents throughout the water column, water-following drogues were used to determine, in real-time, the approximate speed and direction of the near-bottom flow.

4.4.2 Review of Data Quality Objectives

The Data Quality Objectives for water quality monitoring (Table 3.5-2) required collection of water samples from near-bottom plumes at varying times following cap placement events. As stated, coordination between the cap placement vessel and the two survey vessels supporting water quality measurements and plume mapping (ADCP) operations was critical for acquisition of data that could be used to achieve the water quality monitoring objectives. Water-following drogues proved useful for aiding vessel positioning during plume tracking operations, especially since two survey vessels were used rather than the original plan of one survey vessel for both ADCP and water quality measurements.

4.4.3 Technical Considerations

Drogue Configuration

Two water-following “holey-sock” drogues were deployed and visually tracked during monitoring of cap placement operations in Cell SU to obtain real-time information on horizontal currents at various depths in the water column. The physical design of these drogues is described in Subsection 3.4.3.

Depths of Drogues

The water depth at the center of Cell SU was 62 m. Depths increase rapidly to the south of Cell SU, corresponding with the edge of the continental shelf. Toward shore, depths decrease more gradually, as had been observed in the vicinity of Cell LU. The optimum plan for following the near-bottom suspended sediment plumes as they were advected out of Cell SU would have been to tether a drogue such that it was situated 2 m above the seafloor as it moved with the horizontal currents. But because the tidal and low-frequency currents could possibly transport the near-bottom plumes toward shore and into shallower water, one drogue was tethered at a depth of 40 m below the surface. It was anticipated that this drogue would characterize the near-bottom flow regime in the vicinity of Cell SU, but more importantly, it would not be “grounded” if the flow carried the near-bottom plume (and associated drogue) toward shore a distance of up to 0.5 km. During survey operations, this 40-m drogue was tracked visually by locating the yellow flag that was attached to the drogue’s surface marker buoy.

As during survey operations in Cell LU, a second drogue was tethered 15 m below the surface to provide an independent measurement of real-time currents in the upper quarter of the water column. The surface buoy of this shallow drogue contained a green flag to aid relocation.

4.4.4 Monitoring Results

Placement Event 1

Two drogues were deployed at 1836 GMT on August 8, 2000, corresponding with the commencement of cap placement operations during Event 1 in Cell SU. As demonstrated in Figure 4.4-1, the shallow (15-m) drogue moved toward the southeast while the deeper (40-m) drogue moved toward the east-northeast over the two-hour monitoring period. Table 3.4-1 (Subsection 3.4) indicates that the 15-m drogue traveled a distance of 1,401 m (greater than the length of two pilot cells) during the 2 hr, 21 min period the drogue was tracked by the survey vessel. The average horizontal speed of this shallow drogue was 16.5 cm/s on a heading of 126°T. The deeper, 40-m drogue exhibited an average speed of 5.9 cm/s on a heading of 77°T during its 2 hr, 10 min drift period.

Because low water on the PV Shelf occurred at 1800 GMT, the drogue tracks corresponded with a rising tide in the study area. This easterly flow at the 15-m drogue depth generally agreed with the current meter data acquired by the moored, upward-looking ADCP in Cell SU (Figures 4.3-8 and 4.3-9) which indicated relatively strong (50 cm/s) eastward flow at the 5-m depth level. The ADCP data also showed that current vectors rotated counterclockwise with increasing depth such that flow at 19 m was oriented northward and near-bottom currents were directed toward the west. The ADCP data indicated that current speeds below the 19-m depth level were very weak (less than 10 cm/s).

Data acquired by the near-bottom current meters at the time of Event 1 in Cell SU (Figure 4.3-2) also showed that near-bottom currents were directed toward the south-southwest. Therefore, both of the moored instrument systems indicated that background, near-bottom currents at the time of this event were very (less than 10 cm/s) and directed toward the west or southwest. Returning to the drogue track from 40-m depth (Figure 4.4-1), which was from 20 m above the bottom in Cell SU, it appears that this trajectory is not representative of the northwestward flow near 40-m depth that was observed by the ADCP during the time of the placement event. Because we have more confidence in the accuracy and representativeness of the current velocity data acquired by the moored instruments, we suspect that the northeastward drift of the 40-m drogue was due to eastward forces on the long (40-m) tether above the drogue, which were applied by the eastward currents in the upper one-third of the water column. And because the eastward, near-surface currents were much stronger than the northwestward currents near 40-m depth, the resultant drag on the drogue-tether system was northeastward as seen in Figure 4.4-1. Consequently, the 40-m drogue may not have been a true indicator of the speed and direction of the near-bottom ambient flow. These contradictory data are discussed further in Section 4.5.

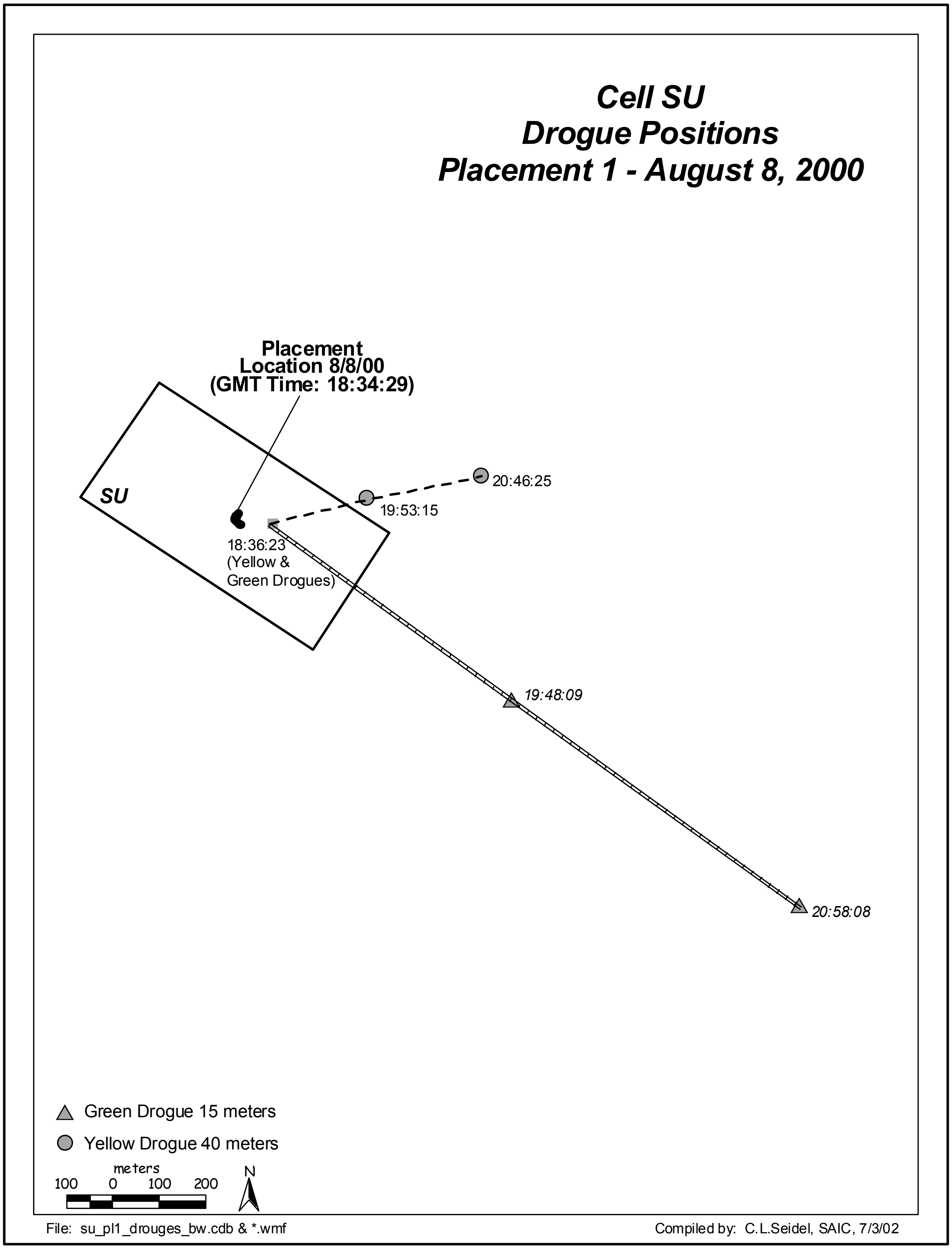


Figure 4.4-1. Map of Cell SU indicating trajectories of two drogues during water quality monitoring of placement Event 1 in Cell SU on August 8, 2000.

4.5 Water Column Monitoring Results

4.5.1 Overview of Field Sampling Plan

Water column monitoring during cap placement operations in Cell SU followed the same field procedures as implemented for Cell LU (Section 3.5.1). A description of the methodology and sampling approach for the CTD/transmissometer and the rosette sampler is provided in the Field Sampling Plan of the PWP (SAIC 2001).

The primary monitoring objectives were to:

1. Determine whether a near-bottom plume of suspended sediment is detectable following the placement of cap material. If so, use the monitoring equipment and survey techniques to identify the centroid of the plume such that water samples could be collected to address monitoring objectives 2 and 3.

2. Determine the suspended sediment concentrations in the near-bottom plume during the first two hours following a single cap placement event.

3. Determine the EA-derived contaminant concentrations in the near-bottom plume during the first two hours following a single cap placement event.

As discussed in Section 4.4, water-following drogues were used to determine in real-time, the speed and direction of the local currents and thus aid tracking of the suspended sediment plumes. Additionally, underway in situ measurements of acoustic backscatter (relative turbidity) were acquired in the lower 30 m of the water column using a vessel-mounted ADCP but these data were marginally useful (Section 4.6). Note that these ADCP measurements were acquired using a separate survey vessel, such that the CTD and ADCP profile data were not co-located at a given time.

4.5.2 Data Quality Objectives

4.5.2.1 Water Quality Objectives

The monitoring objectives and approach for water quality measurements in Cell SU were consistent with those presented in Table 3.5-1 for Cell LU. All water quality monitoring objectives were met with one exception. During the single water quality survey in Cell SU, the mechanical components of the rosette water sampling device became clogged by descending cap material near the beginning of the cap placement operation when the survey vessel was very close to the dredge. Consequently, water samples were not acquired at 40 min after the placement operation. The problem with the rosette sampling device was rectified quickly such that 60-min water samples were collected for this sampling event.

4.5.2.2 Plume Mapping Objectives

The monitoring objectives and approach for plume mapping operations in Cell SU were consistent with those presented in Table 3.5-2 for Cell LU. These objectives were similar in scope to the data quality objectives for water quality monitoring. Plume mapping techniques were used to determine the spatial extent, direction of transport, and temporal variability in suspended sediment concentrations during the first two hours following placement of cap material during individual placement events.

Real-time coordination between the two sampling vessels (for CTD and ADCP measurements) and the cap placement vessel (hopper dredge), the positioning accuracy for all vessels, and the accurate recording of sampling times were all critical activities for ensuring that all measurement data could later be merged and properly interpreted. Additionally, water-following drogues were marginally useful for real-time monitoring of the location of the near-bottom plume (see Section 4.4).

Data quality objectives for plume mapping using the transmissometer were met in full. A complete data set, consisting of multiple vertical profiles during each monitoring event, was acquired using the CTD/transmissometer profiling system.

4.5.3 Technical Considerations

The technical considerations described in Section 3.5.3 for monitoring in Cell LU also applied for monitoring in Cell SU. Cap material for both cells originated in the Queen's Gate Channel and conventional placement operations were utilized in both cells. Therefore, the only difference between capping/monitoring operations at the two cells was the average water depth at each location (i.e., 43 m at Cell LU and 63 m at Cell SU). In practice, the cap material placed in Cell SU descended through a water column approximately 50% deeper than Cell LU.

As described in Section 4.4, the water quality studies were conducted in conjunction with tracking of water following drogues. For the single cap placement event monitored in Cell SU, holey-sock drogues were situated at 15-m and 40-m depths, as compared to 15-m and 30-m depths during monitoring in Cell LU. Had the deeper drogue been tethered at 50-m depth (roughly 10 m above the bottom as for Cell LU), there would have been concern that the drogue would become "grounded" during movement toward shore. Consequently, the deepest drogue was tethered roughly 20 m above the bottom upon deployment in Cell SU. The disadvantage of this strategy was that the deep drogue was not an accurate, real-time indicator of near-bottom currents during monitoring operations in Cell SU.

4.5.4 Monitoring Results

Water quality studies using the CTD, transmissometer, and Niskin bottles with rosette sampler were conducted at Cell SU during cap placement Event 1 on August 8, 2000. The sampling methodology followed the Field Sampling Plan as summarized in Section 3.5.1.

4.5.4.1 Plume Survey during Cap Placement Event 1

A summary of all CTD profile measurements and water samples collected during Event 1 is provided in Table 4.5-1. Specific details regarding the sampling operations can be found in the Cruise Report (SAIC 2000b).

During a 2-hr period prior to commencement of cap placement operations for Event 1, five CTD profiles were made within and adjacent to Cell SU to assess background water properties in the vicinity of the planned capping operation. Background turbidity characteristics were generally similar at all station locations, and vertical profiles exhibited only minor turbidity variations with depth from the surface to the bottom. Table 4.5-1 provides the minimum percent light transmittance (equivalent to maximum turbidity) for each of the five background CTD stations made prior to Event 1 in Cell SU. The minimum transmittance values were very similar for all stations and ranged from 70 to 75%.

Cap placement Event 1 in Cell SU began at 1834 GMT on August 8, 2000. Upon initiation of material release from the hopper dredge, the CTD survey vessel was positioned in close proximity to the dredge as the cap material was released (Figure 4.5-1), and the CTD profiler was situated 2 m above the bottom in order to detect the leading edge of the turbid plume associated with the radially spreading surge current. This feature was readily apparent, as percent light transmittance (PLT) decreased to zero as the surge passed the CTD sensors. Shortly after the surge arrived, the CTD was raised and lowered repeatedly, over the depth range from roughly 30 to 60 m in order to determine the thickness of and PLT in the near-bottom plume. During this CTD station (designated as SU-1D-CTD2 in Table 4.5-1) three near-bottom profiles were acquired and three water samples were collected within 3 min of the initiation of cap placement. Unfortunately, the firing mechanism of the rosette sampler became clogged with cap material after this third sample and the CTD had to be brought aboard the vessel for cleaning. The next CTD profile began at 21 min after initiation of the cap placement.

During the first 3 hrs following cap placement Event 1, a total of seven CTD profile stations (2 through 8) were occupied. Table 4.5-1 indicates that 20 near-bottom profiles were acquired at these seven stations and a total of 31 water samples were collected using the rosette sampler and Niskin bottles. Also shown in this table are: 1) the minimum PLT values observed at each station, and 2) the depth at which this minimum value was observed, expressed as the height above the bottom (i.e., B-2 equals 2 m above the bottom). As seen in this table, the minimum PLT rose from 0% for CTD 2 to 52% for CTD 8, which demonstrates that turbidity within the plume was decreasing gradually over the 3-hr monitoring period. The depth at which the minimum value of PLT was encountered gradually decreased with time after the placement event. The minimum PLT was initially observed within 2 m of the bottom but by CTD 8, which was made roughly 3 hrs after the placement event, the minimum PLT within the plume was situated 6 m above the bottom.

To illustrate the characteristics of the near-bottom plume observed approximately 1 hr after the placement event, Figure 4.5-2 presents an 8-min segment of the time series of PLT and CTD sensor depth data acquired during CTD 4. This station was located at the inshore boundary of the cell where the water depth was approximately 60 m (Figure 4.5-1). During this 8-min time segment, the CTD/transmissometer passed vertically through the near-bottom plume on three occasions and minimum PLT values were 0% for each excursion. These data illustrate the near-bottom plume was highly turbid but was contained within the lower 5 m of the water column; turbidities above 55-m depth were representative of low background levels, ranging from 75% to 78%.

During the first hour of water quality monitoring operations, the survey vessel remained in close proximity to the 40-m drogue location in an attempt to follow the near-bottom flow, as represented by the drogue (Figure 4.5-1). Radio communication from the survey vessel conducting the ADCP measurements suggested, however, that the centroid of the near-bottom plume was located to the west of the 40-m drogue. For this reason, the CTD survey vessel moved approximately 210 m west of CTD 4 to begin CTD 5 near the center of the cell. Minimum PLT values of 32% at this location (Table 4.5-1) suggested that the plume was less concentrated at this location than had been encountered at CTD 4. The next station (CTD 6) was positioned farther to the west but minimum PLT values were comparable to those at CTD 5. Additional CTD stations made at the landward boundary of the cell (CTD 7) and near the center of the cell (CTD 8; Figure 4.5-1) illustrated that the near-bottom plume still possessed turbidity levels that were significantly above background levels at 3 hrs after the placement event.

To illustrate the temporal evolution of turbidity within the near-bottom plume resulting from placement Event 1 in Cell SU, Figure 4.5-3 presents a plot of the minimum PLT observed during the seven CTD stations (2 through 8), versus time since the cap placement event. The gradual increase in PLT to 52% at CTD 8 illustrates that the turbid, near-bottom plume persisted for well over 3 hrs following the placement operation, and its horizontal scale was sufficiently large that all stations made within Cell SU were situated within its appreciable diameter. These transmittance data alone cannot, however, be used to estimate suspended sediment concentrations nor the mass of suspended sediment contained within the three-dimensional plume.

A total of 31 water samples were collected within the near-bottom plume during the first 3 hrs following cap placement in Cell SU. Table 4.5-2 presents the depth and PLT value measured by the CTD at the time discrete water samples were collected. The values of TSS and DDE concentration were derived from post-survey laboratory analysis of the discrete water samples collected by the Niskin bottles. The farthest right column in the table indicates whether the discrete water samples were collected from within the plume, based upon the analytical results. The three background (pre-placement) samples indicated that ambient TSS concentrations were 2 mg/L and ambient DDE concentrations averaged 0.017 μg/L.

To graphically illustrate the temporal characteristics of TSS and DDE from within the near-bottom plume for placement Event 1, Figures 4.5-4 and 4.5-5 present the laboratory results (Table 4.5-2) plotted versus the actual sample collection time following initiation of the cap placement operation. As illustrated in Figure 4.5-4, TSS concentrations were highest within two samples collected during CTD 4: the highest value (1,100 mg/L) was measured within 2 m of the bottom at 52 min after the placement event. Light transmission values concurrently measured by the CTD profiler were near zero, as within the plume during CTD 2, but the TSS concentration of the samples from CTD 4 were much higher than those from CTD 2 presumably due to spatial and temporal variations in TSS concentration within the plume. Many more TSS samples would have been needed from multiple locations during the first hour following cap placement in order to differentiate between spatial and temporal effects of plume dilution, but this was beyond the scope of the present sampling program.

As illustrated in Figure 4.5-5, the temporal evolution of DDE was considerably different from the temporal characteristics of TSS within the near-bottom layer. The highest concentration of DDE (1.2 μg/L) was measured 2 min after the placement event, although the corresponding TSS concentration was only 14 mg/L. Thereafter, DDE concentrations for all samples acquired within 2 hrs of cap placement (CTD 2 through 6) were less than 0.1 μg/L (Table 4.5-2). As had been observed for turbidity and TSS concentrations, the DDE concentrations from plume samples acquired during CTD 4 possessed higher values than those from CTD 3 taken earlier and closer to the cap placement location. DDE concentrations within samples from CTD 5 and 6 were comparable to background concentrations although they were collected from within the near-bottom plume.

The primary results from this plume survey during cap placement Event 1 in Cell SU can be summarized as follows:

- The vertical structure of the near-bottom plume could be tracked using the CTD/transmissometer. The water-following drogues were less useful for tracking the horizontal movement of the near-bottom plume than at Cell LU which was substantially shallower.
- Water samples could be collected from within the most concentrated portion of the turbid, near-bottom plume.
- The near-bottom plume was 5-10 m thick shortly after the placement event and highest turbidity concentrations were observed close to the bottom. Turbidities decreased gradually, but were significantly above background levels 3 hrs after the cap placement operation.
- The highest TSS concentration from discrete water samples within the plume (1,100 mg/L) was measured 52 min after the placement event, rather than within the first 5 min after the placement as had been observed during events in Cell LU. This may have been a result of the survey vessel's position not being close to the most concentrated portion of the near-bottom plume during CTD 2 and 3. TSS concentrations within the plume were above background levels for all samples collected within the first 2 hrs following the placement.

- The highest DDE concentration from water samples within the plume (1.2 µg/L) was measured 2 min after the placement event. Concentrations were at background levels within 90 min after the placement.
- Water samples collected 20 min after the placement may not have been representative of the centroid of the plume. Consequently, temporal characteristics of TSS and DDE concentrations within the near-bottom plume were not adequately sampled between 5 and 60 min after the placement. We believe this was mostly due to difficulties in real-time assessment of the speed and direction that the plume was moving.

4.5.5 Discussion

Water column profiling was conducted during cap placement Event 1 in Cell SU to: 1) monitor the temporal evolution of the near-bottom disposal plume and 2) measure suspended solids and contaminant concentrations of the plume within 2 hrs of the cap placement event. During this survey, water-following drogues proved less effective for indicating the trajectory of the near-bottom plume than during surveys in shallower Cell LU. Additionally, real-time results from the ADCP current and backscatter profile data acquired simultaneously by a separate survey vessel were not useful for indicating plume location during CTD profiling operations.

Turbidity Profile Observations

Percent light transmittance data measured in Cell SU by the CTD/transmissometer revealed that turbidity within the near-bottom plume was high within the first 5 min after release of cap material from the dredge. As illustrated in Figure 4.5-6, the minimum percent light transmittance within the plume increased after the placement operation, and results from Event 1 in Cell SU were similar to those from three events monitored in Cell LU. Turbidity values were significantly above background levels 2 and 3 hrs after the placement event in Cell SU, confirming that water sampling operations were still being conducted with the plume associated within the cap placement activity.

The observed turbidity was presumably comprised of fine-grained particles (e.g., fine silts and clays) from the descending Queen's Gate cap material, with a smaller mass contribution from EA sediments that had been resuspended during the capping operation.

TSS Observations from Discrete Samples

Water samples collected prior to the cap placement operation in Cell SU demonstrated that background TSS concentrations near the seafloor were very low (2 mg/L). As the leading edge of the near-bottom surge (turbidity plume) passed the stationary CTD/transmissometer, TSS concentrations rose but did not achieve the high concentrations (i.e., greater than 1,000 mg/L) measured at the beginning of the three events in Cell LU (Figure 4.5-7). For CTD 2 in Cell SU, both the transmissometer measurement and the DDE concentration from the discrete water sample confirmed that an intense plume resided near the bottom, but the low TSS values from the same discrete water sample raises questions about the accuracy of the TSS data from this sample. It would have been more conceivable for TSS concentrations within the near-bottom plume to exceed 1,000 mg/L as observed 50 min later at CTD 4. Interestingly, the highest TSS concentration measured during Event 1 in Cell SU occurred during CTD 4. This result may have partially been attributed to cap material that had taken more time to descend through the water column at Cell SU, which was roughly 50% deeper than Cell LU. Spatial heterogeneity in the three-dimensional plume also may have contributed to this variability in TSS concentrations that have been interpreted in this section as purely temporal variability due to insufficient spatial sampling on short time scales.

Nevertheless, TSS concentrations measured within the near-bottom plume of Cell SU remained above local background levels for at least 2 hrs after the placement event, as had been observed for all events Cell LU.

DDE Observations from Discrete Samples

Ten of the near-bottom water samples collected within Cell SU and analyzed for TSS concentration were analyzed for DDE concentration. Water samples collected prior to the cap placement operation demonstrated that background DDE concentrations were low, ranging from 0.012 to 0.02 µg/L. Following the cap placement operation, the highest observed DDE concentration (1.2 µg/L) was obtained from a sample collected immediately after the cap placement when descending cap material had apparently resuspended contaminated EA sediment. This maximum concentration was higher than the maximum concentration observed during the three placement events in Cell LU (Figure 4.5-8). DDE concentrations in the near-bottom plume from Cell SU decreased slower than those measured within plumes resulting from three separate cap placement events in Cell LU.

One possible explanation for the relatively high, post-placement, DDE concentrations in Cell SU is that: 1) the EA sediments in this cell were more easily resuspended than those at the sediment-water interface within Cell LU, prior to the first placement event in each cell; and 2) the surficial EA sediments in Cell SU had higher DDE concentrations than those of Cell LU. Under this scenario, the EA sediments from Cell SU would have contributed more dissolved and particulate DDE to the water column than would result from EA sediment resuspension in Cell LU, and the resuspended EA sediment from Cell SU may have remained in the water column longer than resuspended material from Cell LU. The baseline sediment studies conducted prior to capping operations revealed that surficial EA sediments in Cell SU were in fact, comprised of more fine-grained material than within Cell LU (i.e., Cell SU had 22% sand whereas Cell LU had 57% sand, on average). The baseline studies also revealed that DDE concentrations of the surficial EA sediments in Cell SU were four times higher than surficial EA sediments in Cell LU (i.e., 6.0 ppm versus 1.5 ppm, respectively). Consequently, the EA sediments in Cell SU were more easily resuspended and contained higher DDE concentrations than surface sediments in Cell LU.

Background DDE concentrations of the near-bottom water in Cell SU prior to cap placement Event 1 were 31 to 180% higher than those observed prior to the three placement events monitored in Cell LU. Although the DDE concentrations measured at 90 and 130 min after the cap placement event in Cell SU were significantly higher than those measured at roughly the same times in Cell LU (Figure 4.5-8), one must remember that these late samples from the plume of Cell SU were comparable to local background values prior to the cap placement operation. From the data acquired during Event 1 in Cell SU we can, therefore, conclude that DDE concentrations within the near-bottom plume decreased to background concentrations within roughly 1 hr of the placement event, as compared to roughly 0.5 hr for the placement events in Cell LU.

Table 4.5-1. Summary of CTD profiles acquired and water samples collected during cap placement Event 1 in Cell SU on August 8, 2000. Also given is the maximum turbidity (minimum percent light transmission) observed by the transmissometer interfaced to the CTD system during each profile.

Station Type	Background	Background	Background	Background	Background
Elapsed Time of Cast (h:min:sec)	0:05:38	0:04:21	0:08:57	0:12:42	0:03:16
CTD File Name	SU-1B-CTD1	SU-1B-CTD2	SU-1B-CTD3	SU-1B-CTD4	SU-1B-CTD5
Total Water Column Profiles	1	1	1	1	1
Near Bottom Profiles	1	1	1	2	1
Water Samples Collected	0	0	2	1	0
Minimum % Light Transmittance (PLT)	75	70	72	71	70
Depth of Minimum PLT (m)	B-5 m	B-5 m	B-13 m	B-11 m	B-13 m

Table 4.5-1 (continued)

Start Time After Placement (hr:min:sec)	-0:43:35	-0:25:48	0:21:21	0:49:49	1:27:20	1:45:19	2:08:01	2:49:54
File/Cast End Time	-0:26:35	0:09:13	0:28:06	1:09:18	1:35:42	2:04:32	2:40:05	3:01:35
Elapsed Time of Cast	0:17:00	0:34:50	0:06:45	0:19:29	0:08:22	0:19:13	0:32:04	0:11:41
CTD File Name	SU-1D-CTD1	SU-1D-CTD2	SU-1D-CTD3	SU-1D-CTD4	SU-1D-CTD5	SU-1D-CTD6	SU-1D-CTD7	SU-1D-CTD8
Total Water Column Profiles	1	1	1	1	1	1	1	1
Near Bottom Profiles	1	3	2	4	2	3	4	2
Water Samples Collected	0	3	2	13	3	8	1	1
Minimum % Light Transmittance (PLT)	76	0	12	0	32	36	45	52
Depth of Minimum PLT (m)	B-18 m	B-2 m	B-6 m	B-2 m	B-2 m	B-3 m	B-5 m	B-6 m

Table 4.5-2. Total suspended solids and DDE concentrations from discrete water samples collected during CTD profiling operations during cap placement Event 1 in Cell SU on August 8, 2000. CTD profile number, transmissometer data, and sampling depth of discrete water samples are also given.

			Data from CTD/transmissometer		Analysis of discrete water samples			
Time after placement (min)	**CTD Station**	**Sample bottle ID**	**Sample depth (m)**	**Percent light transmittance**	**TSS (mg/L)**	**DDE (ug/l)**	**Sample number**	**Sample from near-bottom plume?**
Background	SU-1B-CTD3	SU-1B-BOT-01	59.5	61.8	2	0.02	B-1	no
Background	SU-1B-CTD3	SU-1B-BOT-02	59.7	64.6	2	0.019	B-2	no
Background	SU-1B-CTD4	SU-1B-BOT-03	57.9	74.5	2	0.012	B-3	no
2	SU-1D-CTD2	SU-1D-BTA-01	61.7	70.0	41		1	yes
2	SU-1D-CTD2	SU-1D-BTA-02	60.4	0.0	14	1.2	2	yes
3	SU-1D-CTD2	SU-1D-BTA-03	60.9	0.0	27		3	yes
22	SU-1D-CTD3	SU-1D-BTB-01	60.7	48.0	10	0.032	4	yes
22	SU-1D-CTD3	SU-1D-BTB-11	60.7	48.0	10	0.018	5	yes
51	SU-1D-CTD4	SU-1D-BTC-01	58.3	0.0	3		6	yes
52	SU-1D-CTD4	SU-1D-BTC-02	58.6	1.0	1,100		7	yes
55	SU-1D-CTD4	SU-1D-BTC-03	58.7	0.0	620		8	yes
57	SU-1D-CTD4	SU-1D-BTC-04	57.5	0.0	82	0.051	9	yes
60	SU-1D-CTD4	SU-1D-BTC-05	56.3	39.0	17		10	yes
61	SU-1D-CTD4	SU-1D-BTC-06	57.3	15.0	12		11	yes
61	SU-1D-CTD4	SU-1D-BTC-16	57.3	15.0	8		12	yes
61	SU-1D-CTD4	SU-1D-BTC-07	57.3	0.0	31	0.082	13	yes
61	SU-1D-CTD4	SU-1D-BTC-17	57.3	0.0	24		14	yes
64	SU-1D-CTD4	SU-1D-BTC-08	56.2	51.0	5		15	yes
65	SU-1D-CTD4	SU-1D-BTC-09	56.3	0.0	4		16	yes
65	SU-1D-CTD4	SU-1D-BTC-19	56.3	0.0	4		17	yes
65	SU-1D-CTD4	SU-1D-BTC-10	56.1	2.0	13		18	yes
89	SU-1D-CTD5	SU-1D-BTD-01	60.4	34.0	16	0.019	19	yes
95	SU-1D-CTD5	SU-1D-BTD-03	58.5	42.0	13		21	yes
115	SU-1D-CTD6	SU-1D-BTD-04	59.5	51.0	13		22	yes
117	SU-1D-CTD6	SU-1D-BTD-05	55.2	42.0	12		23	yes
120	SU-1D-CTD6	SU-1D-BTD-06	55.2	41.0	12		24	yes
122	SU-1D-CTD6	SU-1D-BTD-07	58.9	45.0	13		25	yes
126	SU-1D-CTD6	SU-1D-BTD-08	56.6	44*	16		26	yes
127	SU-1D-CTD6	SU-1D-BTD-09	55.3	45*	16		27	yes
130	SU-1D-CTD6	SU-1D-BTD-10	55.6	45*	15	0.017	28	yes
132	SU-1D-CTD6	SU-1D-BTD-11	59.0	47*	14		29	yes
138	SU-1D-CTD7	SU-1D-BTD-12	55.9	53.0	10		30	yes
178	SU-1D-CTD8	SU-1D-BTE-1	51.0	67.0	2		31	no

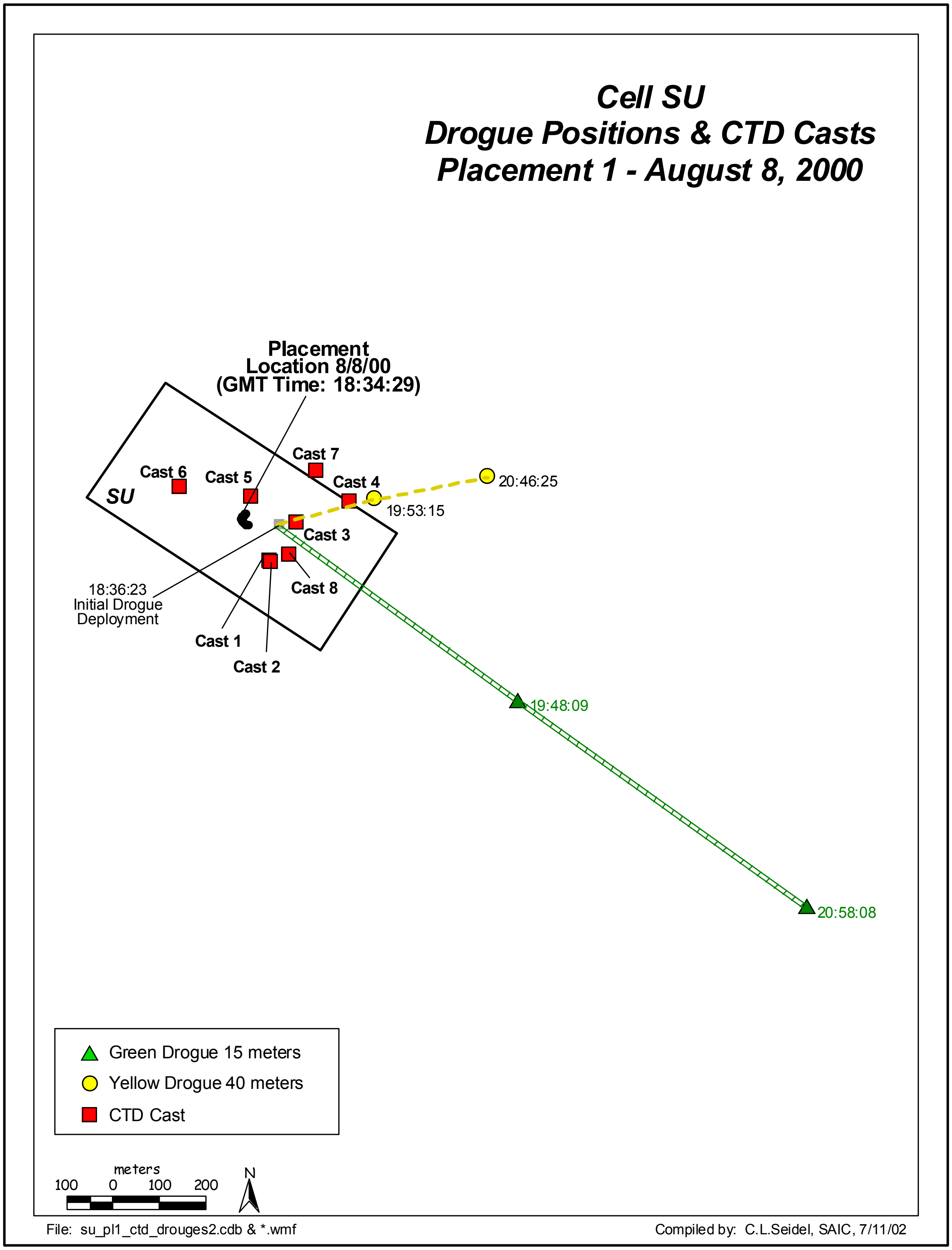


Figure 4.5-1. Map of Cell SU indicating drogue trajectories and CTD stations during cap placement Event 1 on August 8, 2000.

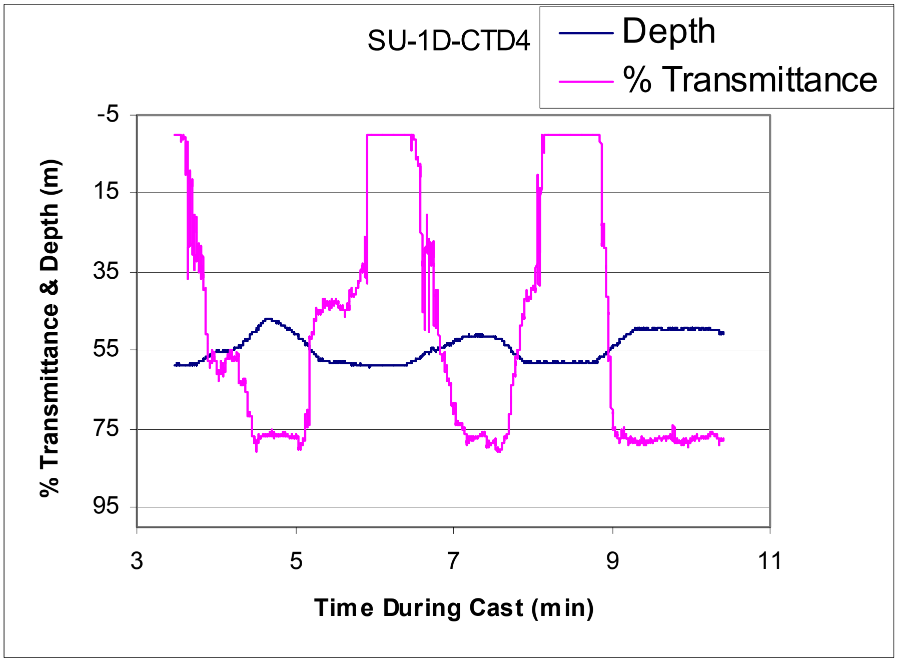


Figure 4.5-2. Time series plot of percent light transmission and sensor depth acquired during CTD Station 4 during cap placement Event 1 in Cell SU on August 8, 2000. See Table 4.5-1 for CTD profile information.

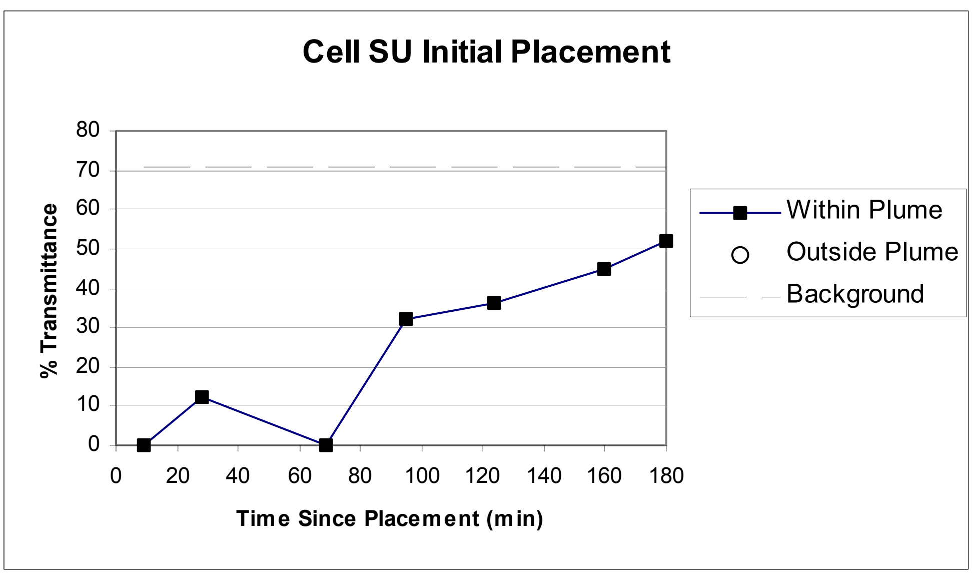


Figure 4.5-3. Time series plot of the minimum value of percent light transmission acquired during each CTD profile conducted during cap placement Event 1 in Cell SU on August 8, 2000. See Table 4.5-1 for CTD profile information.

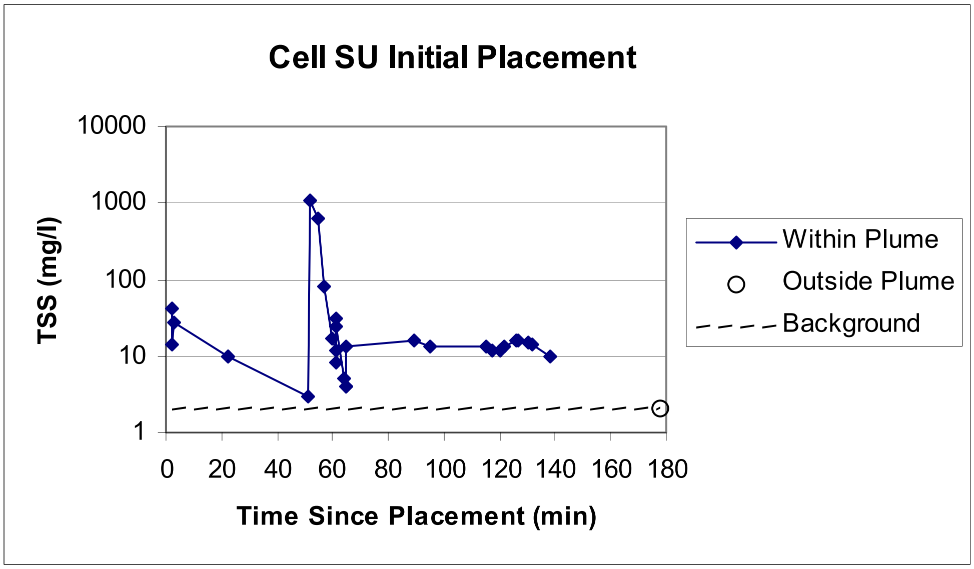


Figure 4.5-4. Plot of total suspended solids concentration versus time since cap placement event for discrete water samples collected during CTD profiling operations of cap placement Event 1 in Cell SU on August 8, 2000.

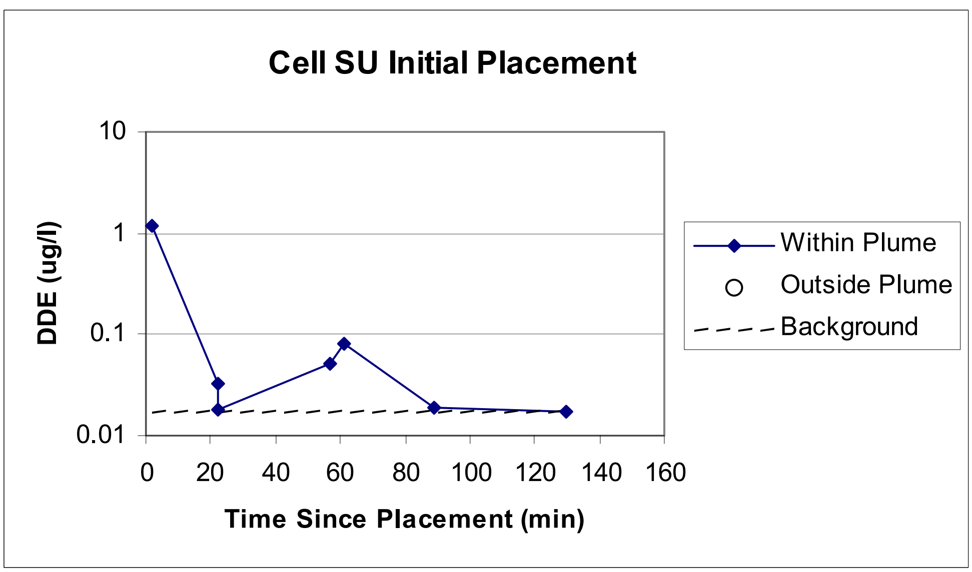


Figure 4.5-5. Plot of DDE concentration versus time since cap placement event for discrete water samples collected during CTD profiling operations of cap placement Event 1 in Cell SU on August 8, 2000.

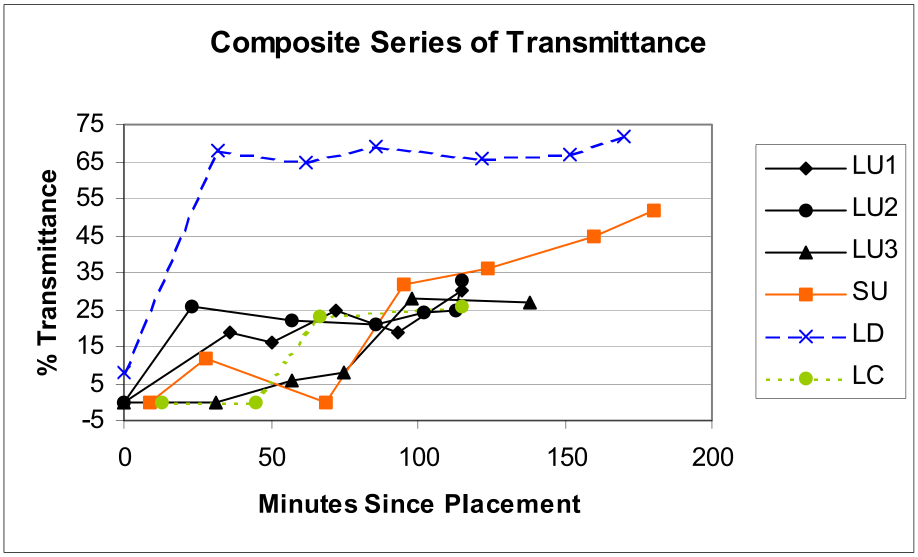


Figure 4.5-6. Composite time series plot of the minimum value of percent light transmission acquired during CTD profiles conducted during cap placement events in Cells LU, SU, LD and LC.

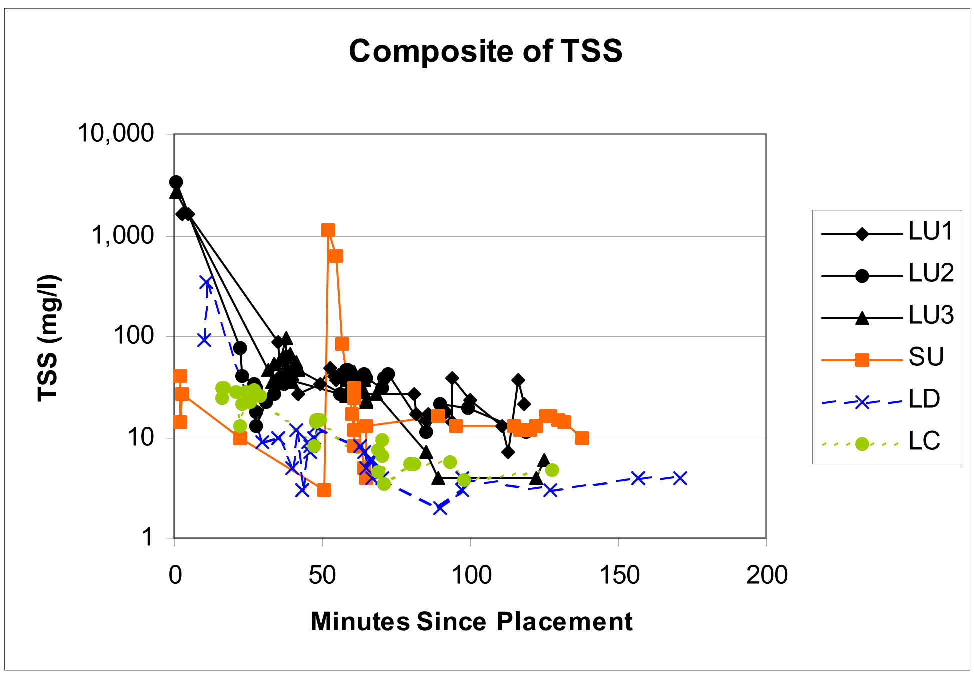


Figure 4.5-7. Composite plot of total suspended solids concentration versus time of sample collection (after initiation of cap placement) for discrete water samples collected during CTD profiling operations of cap placement events in Cells LU, SU, LD and LC.

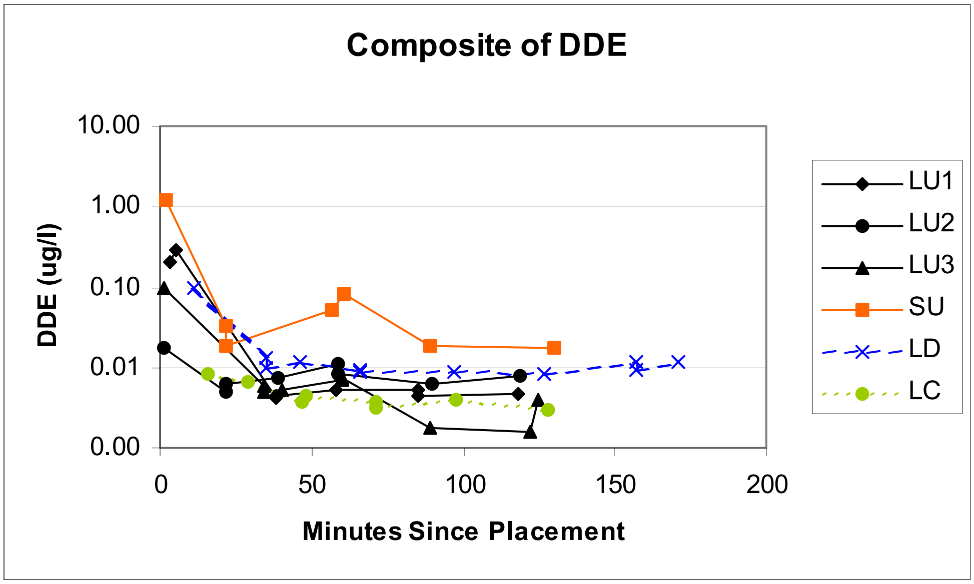


Figure 4.5-8. Composite plot of DDE concentration versus time of sample collection (after initiation of cap placement) for discrete water samples collected during CTD profiling operations of cap placement events in Cells LU, SU, LD and LC.

4.6 Underway Measurements of Acoustic Backscatter

4.6.1 Overview of Field Sampling Plan

A towed Broad Band Acoustic Doppler Current Profiler (BBADCP) was used to measure acoustic backscatter prior to, during, and after the placement operation in Cell SU. The measurements were conducted in the same manner as those for Cell LU (Section 3.6), with one exception. Due to the fact that the seaward portion of Cell SU had water depths greater than the range of the BBADCP system, the BBADCP was towed at a depth of approximately 30 m during monitoring to obtain near-bottom results. Due to this range limitation, it was necessary to profile currents in two steps to get a full-depth profile. Details of the system and methodology can be found in the PWP (SAIC 2001). The objectives of the sampling plan for Cell SU were the same as those for Cell LU (see Section 3.6). All phases of the sampling plan were accomplished. Details of the sampling plan can be found in the PWP.

4.6.2 Review of Data Quality Objectives

The BBADCP performed to specification, and all data objectives were achieved. The plume was monitored for 2 hr and 20 min, for the placement operation in Cell SU.

The PWP discusses the importance of being able to track bottom, the need to have survey vessel speeds less than 2 m/s, and to have the instrument point straight down within +/-20^{o} from the vertical. For the survey in Cell SU, the system was able to track bottom when towed at a depth of 30 m, and tow speed and tow stability were within the limits required to achieve the highest quality data. The PWP stated that a BBADCP with velocity-measuring beams set at 20^{o} from the vertical would be used for the surveys. The system had the beams set at 30^{o} from the vertical. The data quality objectives were not compromised by this change.

4.6.3 Technical Considerations

The technical considerations for Cell SU were the same as for Cell LU (Section 3.6.3) with the exception of needing to measure the current profiles in two parts. The BBADCP system was first placed at a depth of approximately 3 m to get the near-surface currents. At this depth the system could not track bottom, and it was necessary to remove the vessel motion from the measurements using navigation data. The system was then lowered to where it could track bottom, and current measurements down to near-bottom were made. The two sections of the profile were put together to get a single full-depth profile. The details of this procedure are given in the PWP. Biologically induced acoustic backscatter seems to have been a significant problem in Cell SU. It is discussed in Section 4.6-5.

4.6.4 Monitoring Results

4.6.4.1 Current Profiles

The current profile data obtained in Cell SU are presented in this section. Consistent with the recommendations of the manufacturer of the BBADCP, the last 15% of the depth below the instrument when the instrument was at 30 m depth is not presented because of possible contamination of the data from acoustic side lobes.

Figure 4.6-1 shows the current profile obtained on August 8, 2000 in Cell SU. It is the result of a 12-min average (starting at 1719 GMT) of current speed and direction from 30 m to within 15% of the depth below the instrument, and a 5-min average of near-surface currents starting at 1737 GMT and ending at 1742 GMT. It was taken at 33° 42.259' N and 118° 20.912'W, which was close to the location of the cap material placement.

4.6.4.2 Acoustic Backscatter Monitoring

Figure 4.6-2 shows the survey lines run to monitor the acoustic backscatter from the suspended sediment resulting from the placement operation in Cell SU on August 8, 2000 (Table 4.6-1). Plots of the acoustic backscatter for lines 2 through 14 are shown in Figures 4.6-3 through 4.6-15.

Table 4.6-1. Start and End Times for ADCP Lines during placement Event 1 in Cell SU on August 8, 2000

Towed ADCP Lines		
Line Number	Start Time GMT	End Time GMT
1	18:42:44	18:46:35
2	18:50:14	18:54:14
3	18:56:53	19:05:09
4	19:09:18	19:13:14
5	19:16:41	19:23:50
6	19:30:03	19:35:49
7	19:38:12	19:44:05
8	19:48:20	19:56:54
9	20:01:02	20:06:13
10	20:17:58	20:19:58
11	20:22:11	20:26:57
12	20:30:15	20:34:30
13	20:36:18	20:42:11
14	20:53:14	20:58:28

4.6.5 Discussion

The results of the acoustic backscatter monitoring in Cell LU are the most complicated and least illuminating in regards to the characteristics of the bottom surge and residual plume from the placement operation. The first of three major complications was the existence of a highly sheared current profile. The current profile shown in Figure 4.6-1 had two distinctly different layers. In the upper 30 m, the currents were toward the east with a measured maximum speed of 31 cm/s. Below 30 m they were toward the northwest at less than 10 cm/s. The second complication was our requirement to tow the instrument at 30 m. This made it difficult to compare the results from SU with those from Cells LU and LD. However, the most serious complication was the very high variability of background acoustic variability below 53 m.

As discussed in Section 3.6.3 and the PWP, the calculation of ABAB involves dividing by the standard deviation of the naturally occurring background acoustic backscatter measured just before the placement operation begins. In Cell SU, the standard deviation of the background backscatter from 53 to 64 m, and from 68 m to the bottom, was much greater than it was from 30 to 53 m (because the tow depth was 30 m there are no measurements of acoustic backscatter above 30 m). At 56 m the standard deviation was about 5.8 times greater than what was observed from 30 to 53 m, and at 70 m it was about 7.0 times greater. From 64 to 68 m, it was about the same as what it was from 30 to 53 m. The most likely reason for this high variability in acoustic backscatter was the presence of biological backscatterers. Regardless of the reason for the high standard deviations of background backscatter, the result was that suspended sediment from the placement operation could not be detected above background from 53 to 64 m, and from 68 m to the bottom. This means that very little or nothing can be said about the bottom surge on the basis of the underway measurements of acoustic backscatter. Table 4.6-2 summarizes the information derived from acoustic backscatter measurements.

When the locations of the boundaries of the plume near the end of the monitoring effort are compared between lines, it appears that residual suspended sediment from the placement operation was located to the northwest and north of the placement site, and was being transported back to the east.

Table 4.6-2. Summary of Results of Acoustic Monitoring of Suspended Sediment on August 8, 2000

Survey Line	Elapsed Time[1] (min:sec)	Location[2] Distance (m)	Bearing (°T)	Speed[3] (cm/s)	Characteristics
1	5:30	NA	NA	NA	No visible plume.
2	17:02	73	342	7	Suspended sediment plume was spread along survey line above 53 m depth, and, with the exception of between 63.5 and 68 m, not visible from ABAB below 53 m.
3	26:03	72	330	5	Suspended sediment plume was spread along survey line above 53 m depth, and, with the exception of between 63.5 and 68 m, not visible from ABAB below 53 m.
4	36:14	65	343	3	Suspended sediment plume was spread along survey line above 53 m depth, and, with the exception of between 63.5 and 68 m, not visible from ABAB below 53 m.
5	44:13	50	332	2	Suspended sediment plume was spread along survey line above 53 m depth, and, with the exception of below 63.5 m, not visible from ABAB below 53 m.
6	56:28	93	307	3	
7	66:07	96	308	2	
8	78:47	97	318	2	Plume not visible above 41 m.
9	87:48	104	311	2	Plume not visible above 36.5 m.
10	104:24	182	331	3	
11	107:18	231	352	4	Plume not visible above 35.5 m.
12	117:33	283	357	4	Plume not visible above 39.5 m.
13	122:59	287	340	4	Plume not visible above 39 m.
14	139:00	283	302	3	Small remnant of plume between 39 and 50.9 m.

1. Elapsed time is the difference between the time the approximate center of the plume believed to be from the initial placement was measured along the survey line, and the approximate time at the mid-point of the placement operation.
2. Location is the distance and bearing from the location of the dredge at the approximate time of the mid-point of the placement operation, to the location of the approximate center of the plume believed to be from the initial placement operation along the survey line.
3. Speed is the location distance divided by the elapsed time.

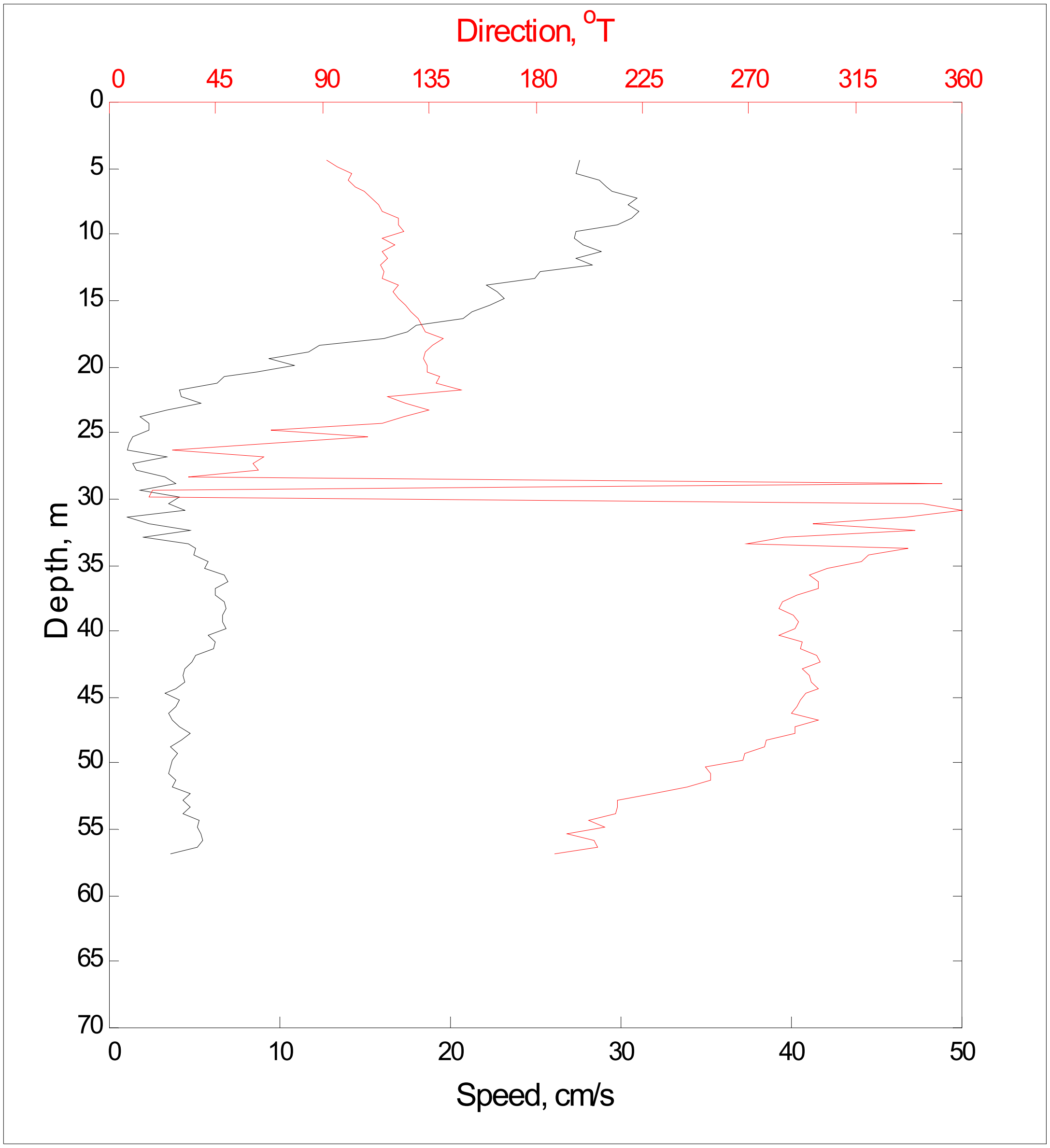


Figure 4.6-1. Vertical current profile on August 8, 2000, at 1719 GMT.

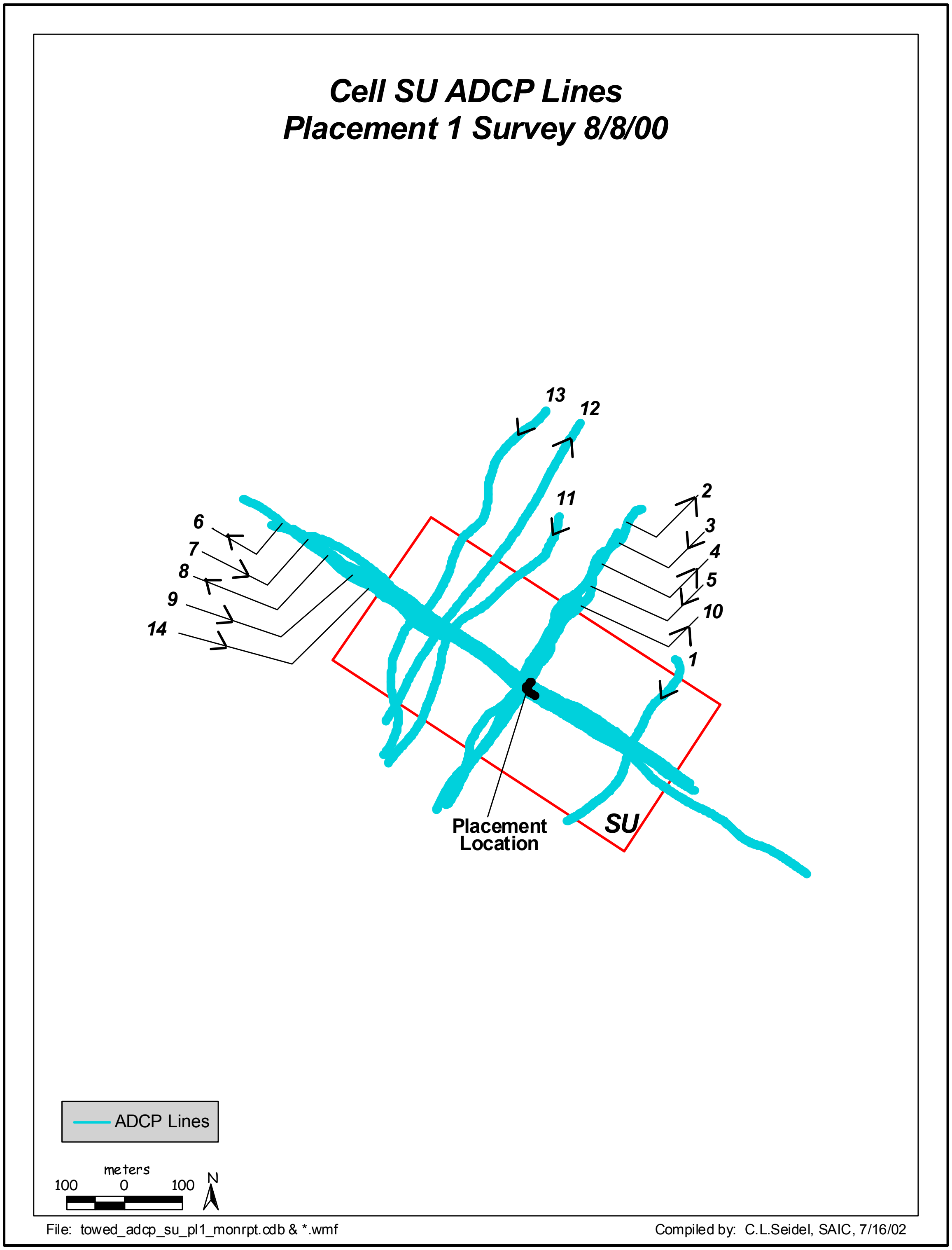


Figure 4.6-2. Survey tracklines for acoustic monitoring of suspended sediment on August 8, 2000.

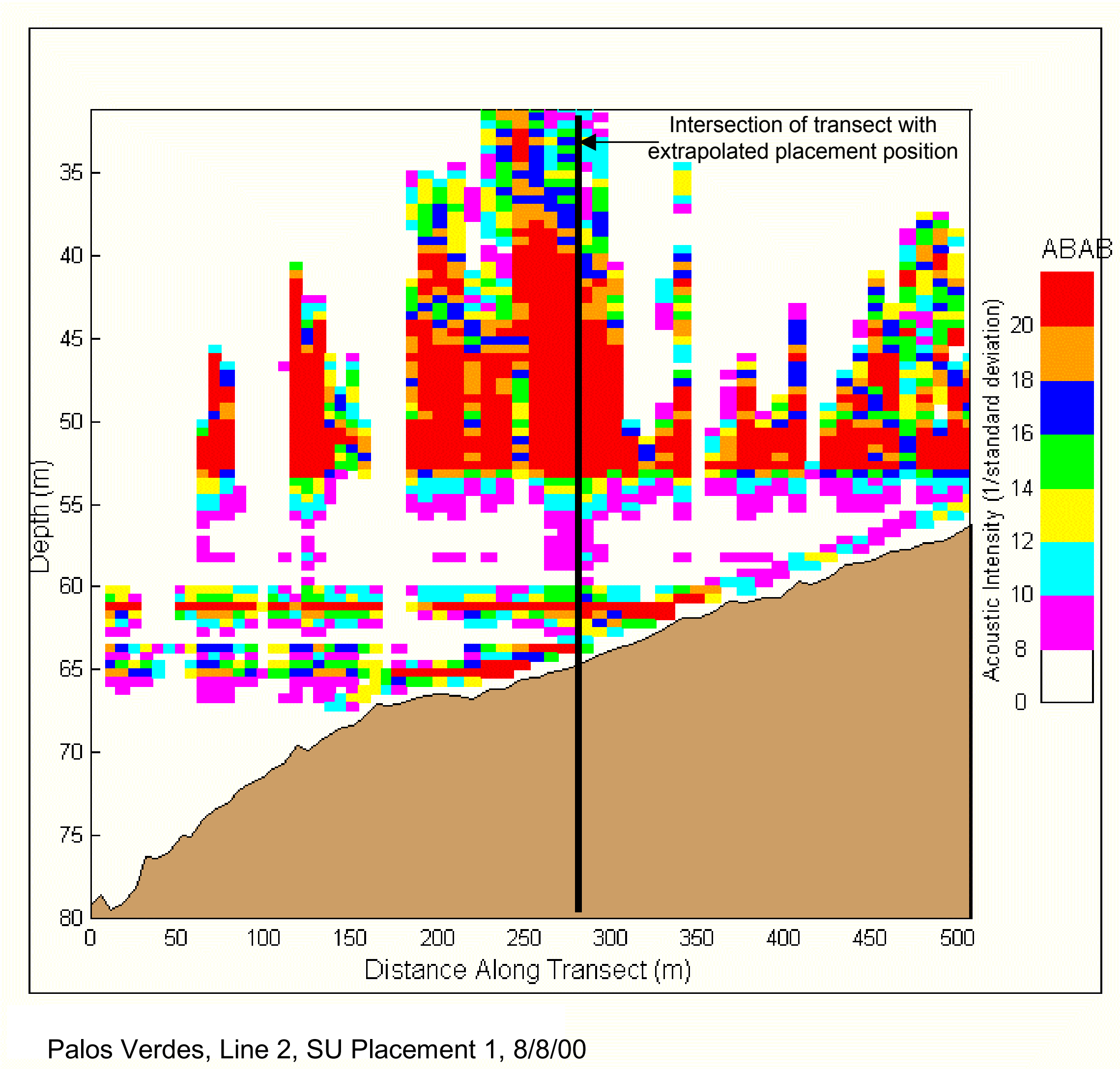


Figure 4.6-3. ABAB along Survey Line 2, run from southwest to northeast 12 min after the placement operation ended.

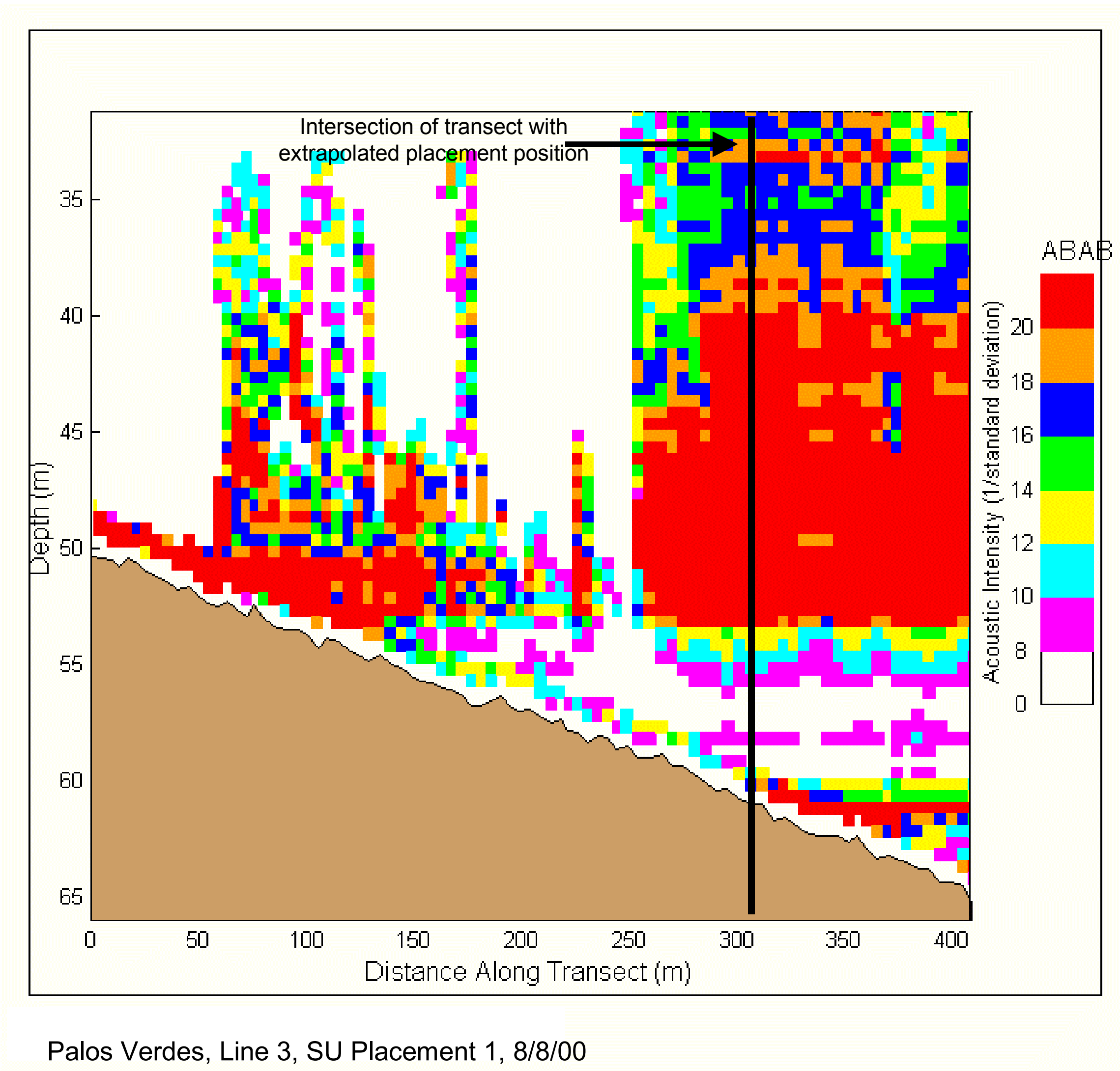


Figure 4.6-4. ABAB along Survey Line 3, run from northeast to southwest 19 min after the placement operation ended.

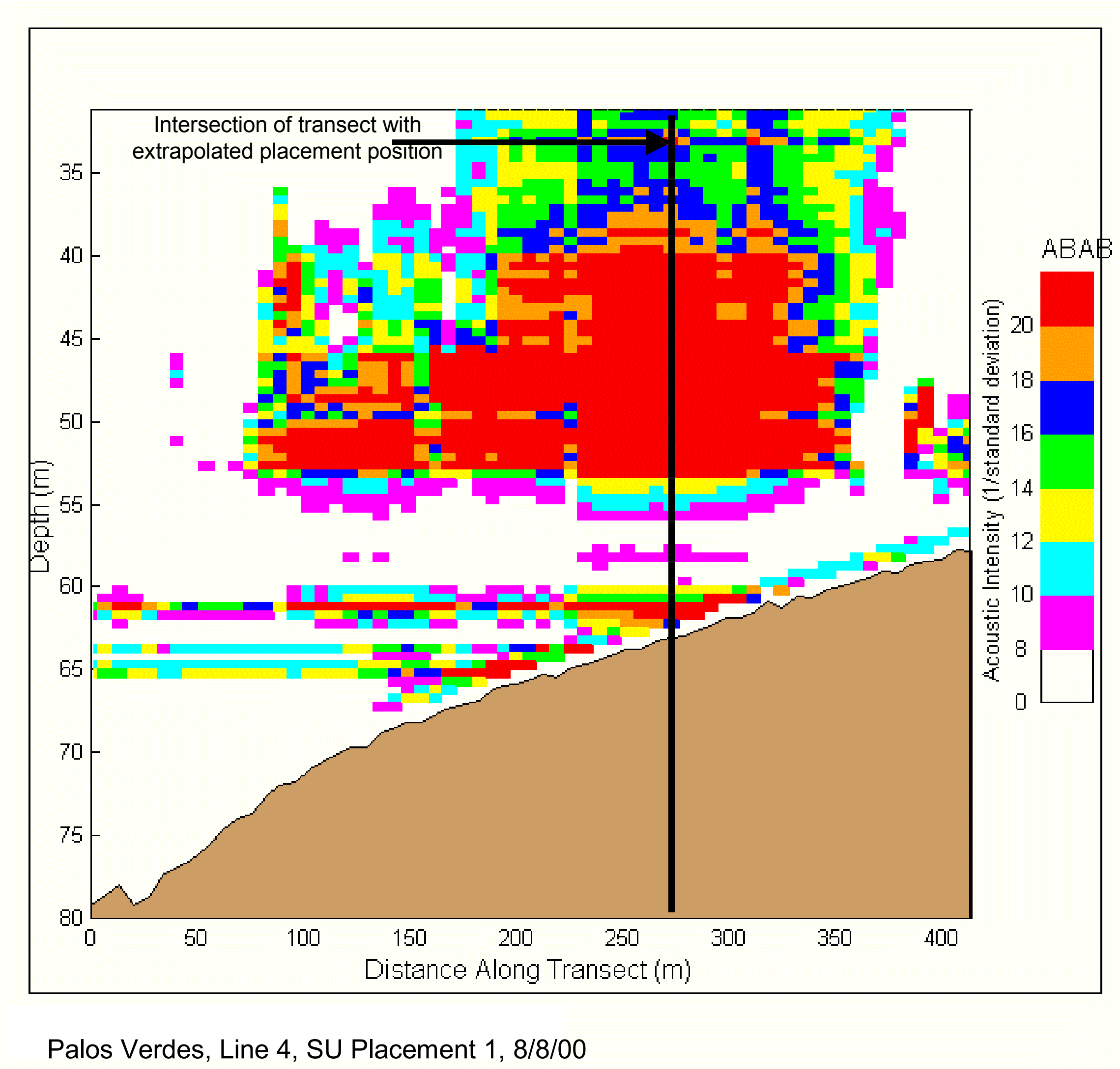


Figure 4.6-5. ABAB along Survey Line 4, run from southwest to northeast 31 min after the placement operation ended.

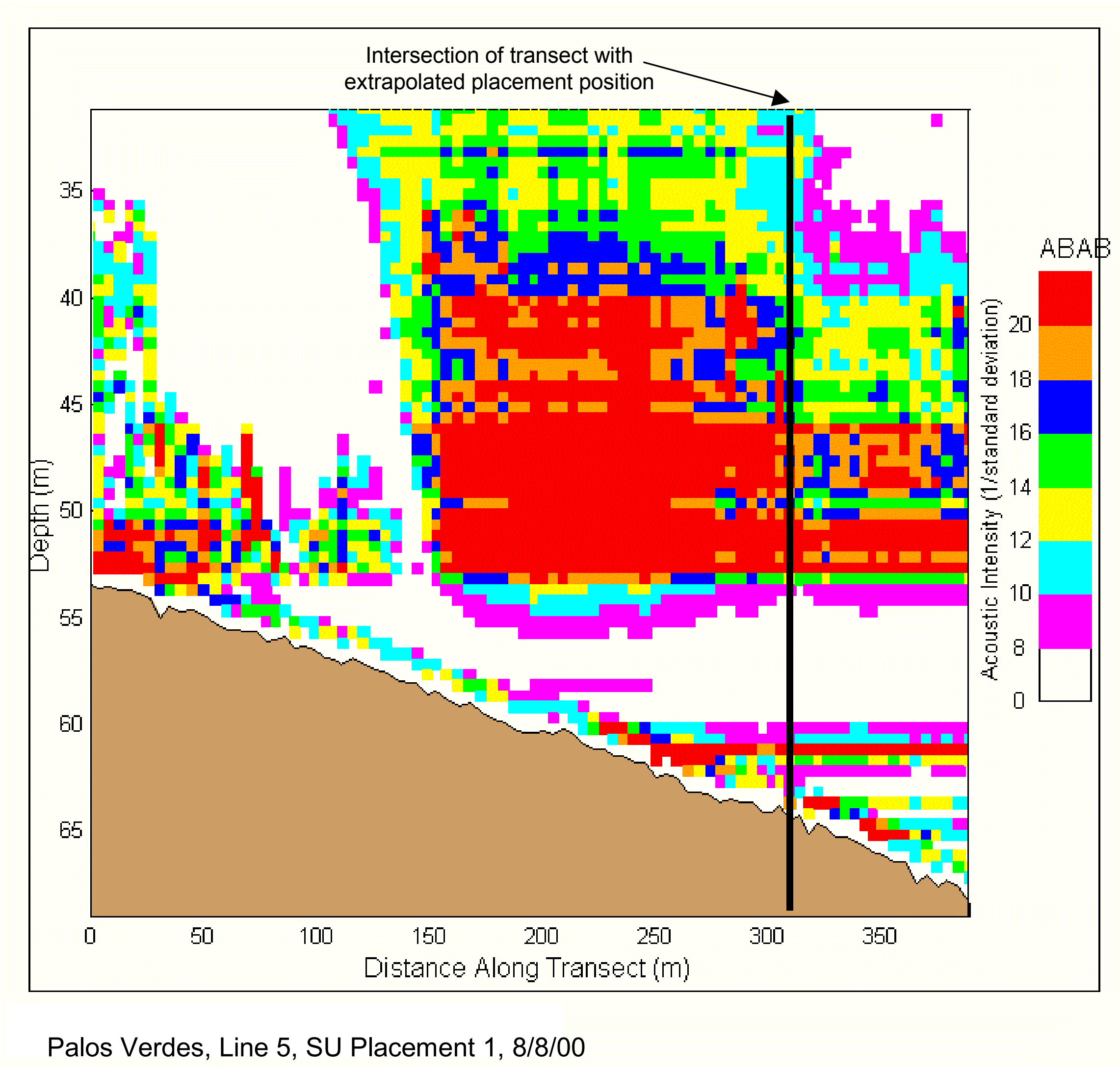
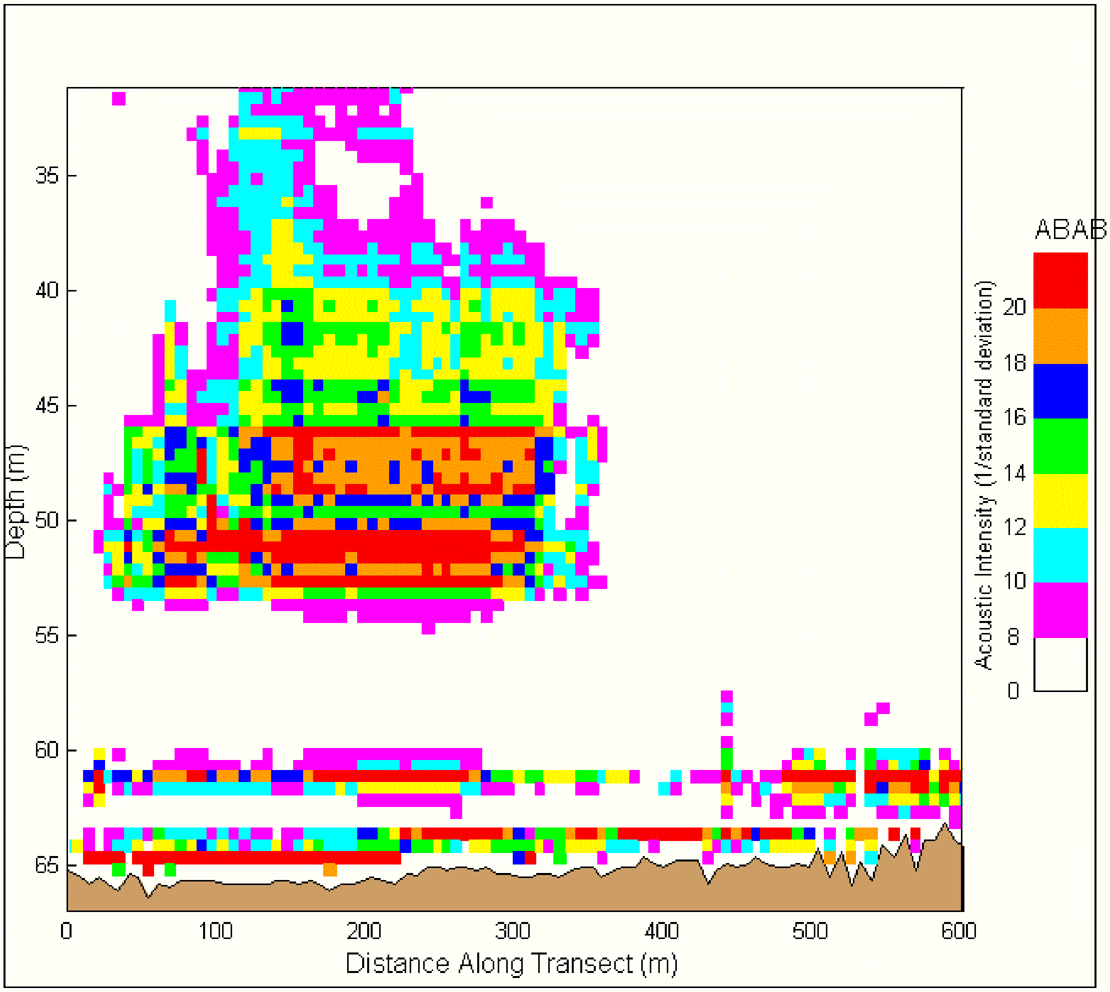


Figure 4.6-6. ABAB along Survey Line 5, run from northeast to southwest 39 min after the placement operation ended.



Palos Verdes, Line 6, SU Placement 1, 8/8/00

Figure 4.6-7. ABAB along Survey Line 6, run from southeast to northwest 52 min after the placement operation ended.

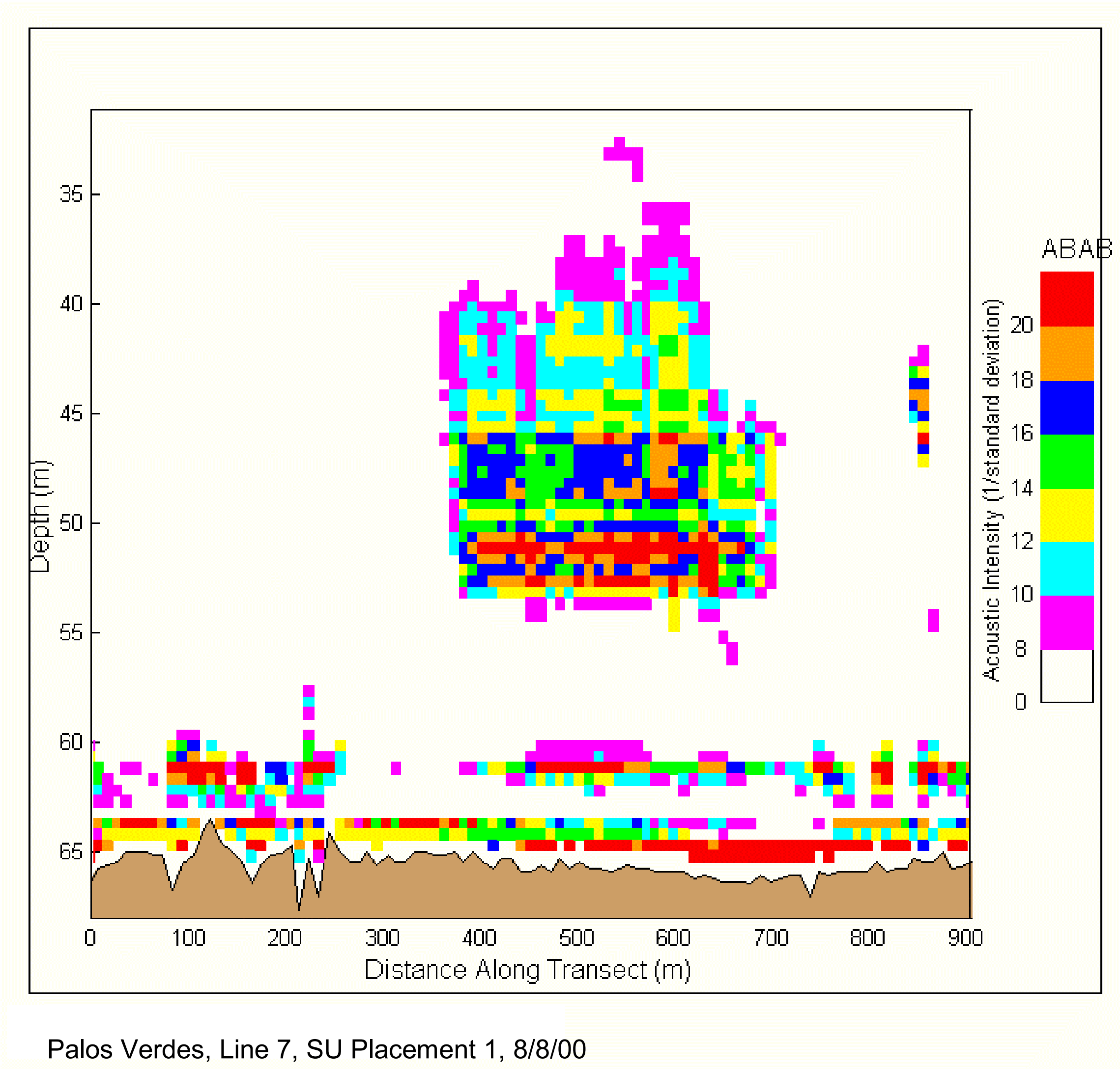


Figure 4.6-8. ABAB along Survey Line 7, run from northwest to southeast 1hr after the placement operation ended.

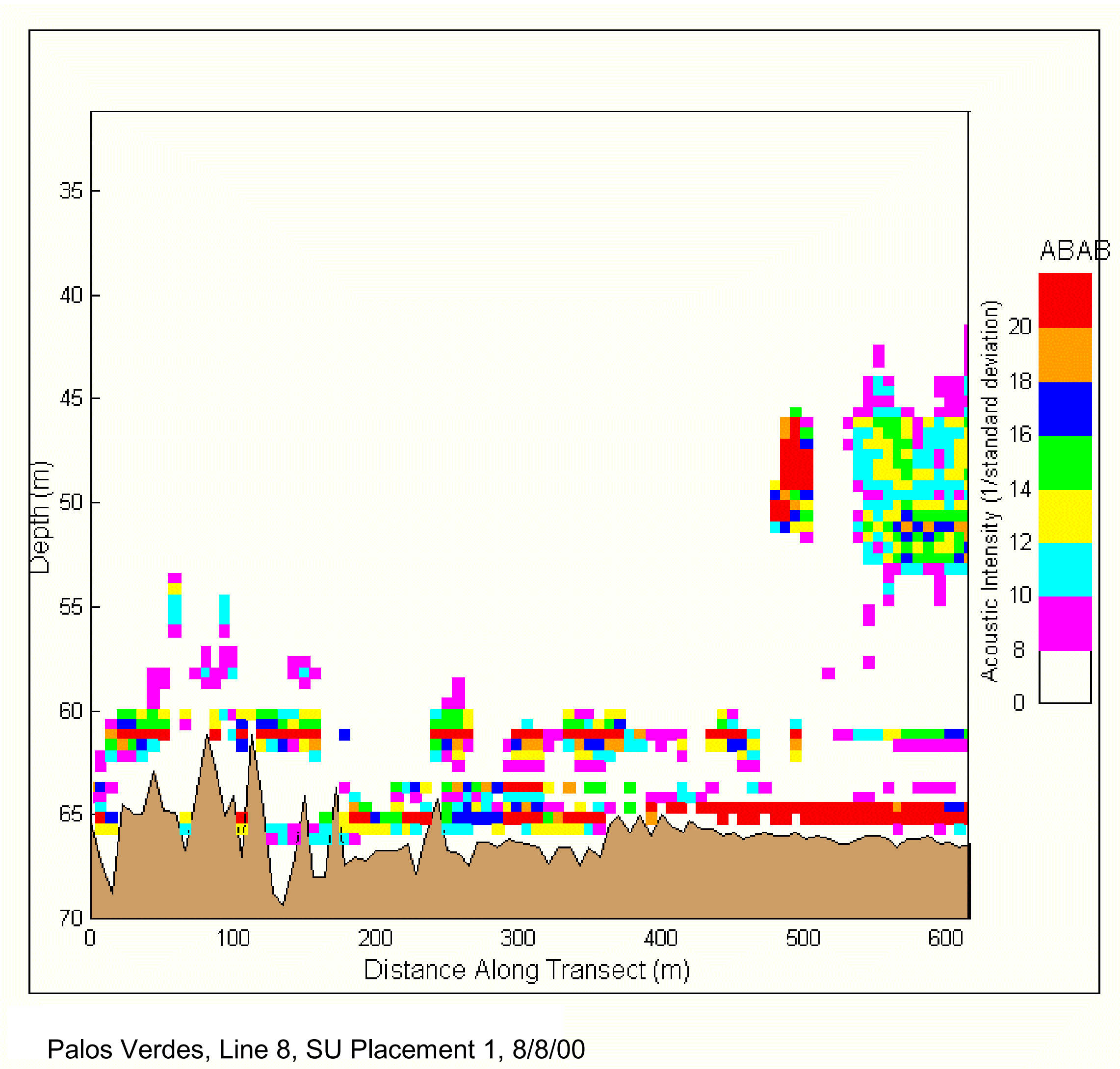


Figure 4.6-9. ABAB along Survey Line 8, run from southeast to northwest 1 hr and 10 min after the placement operation ended.

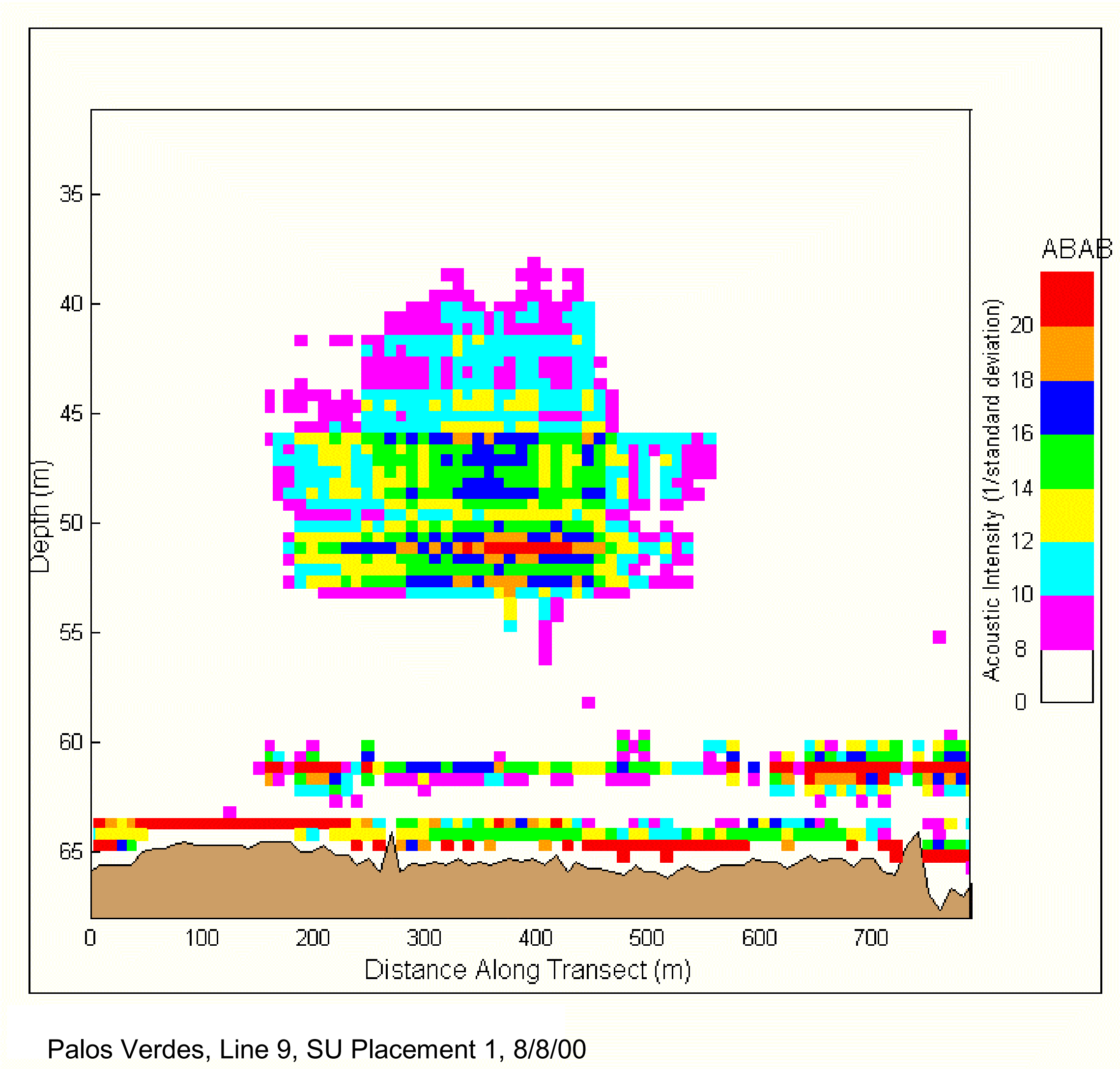


Figure 4.6-10. ABAB along Survey Line 9, run from northwest to southeast 1 hr and 23 min after the placement operation ended.

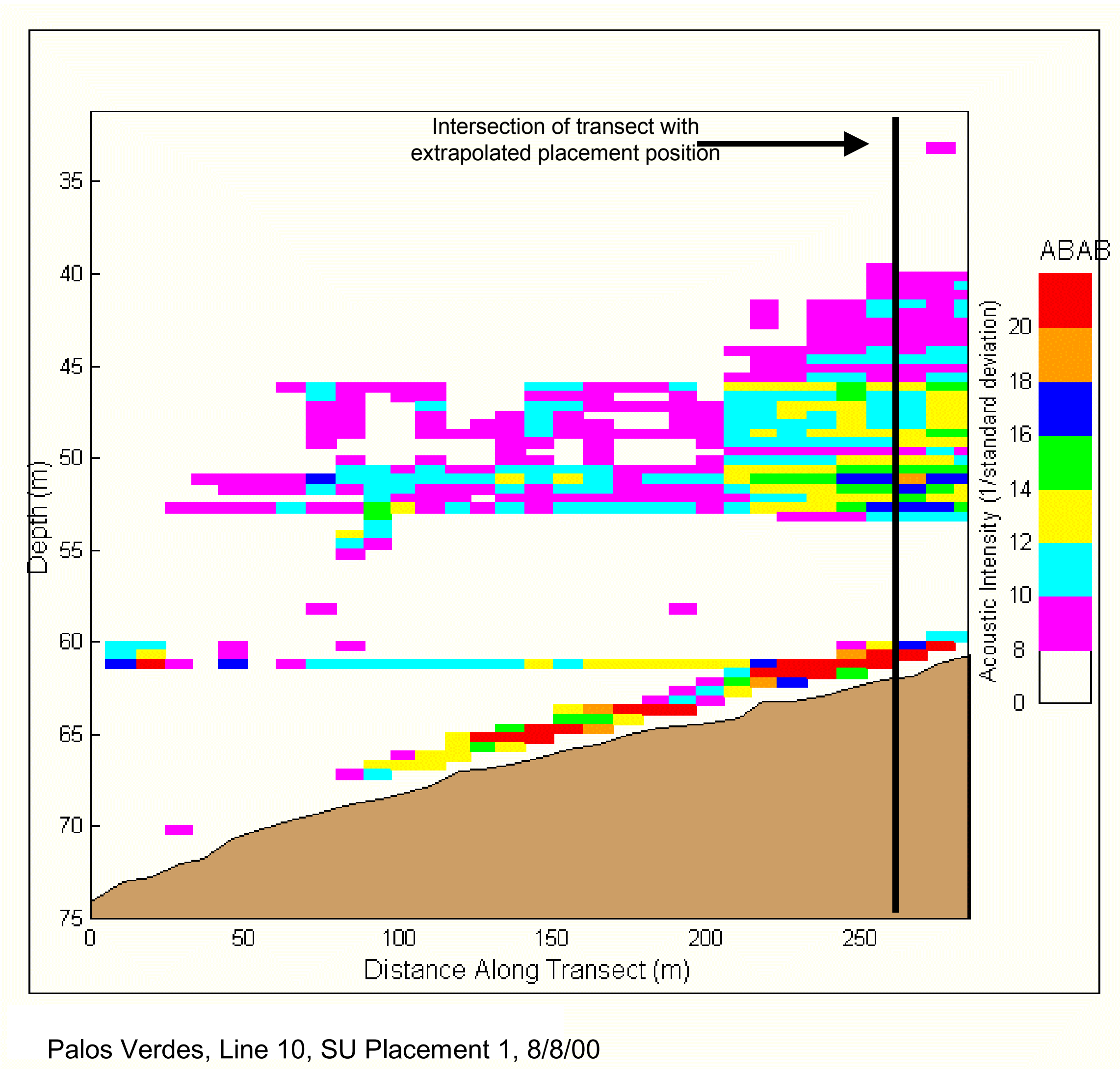


Figure 4.6-11. ABAB along Survey Line 10, run from southwest to northeast 1 hr and 40 min after the placement operation ended.

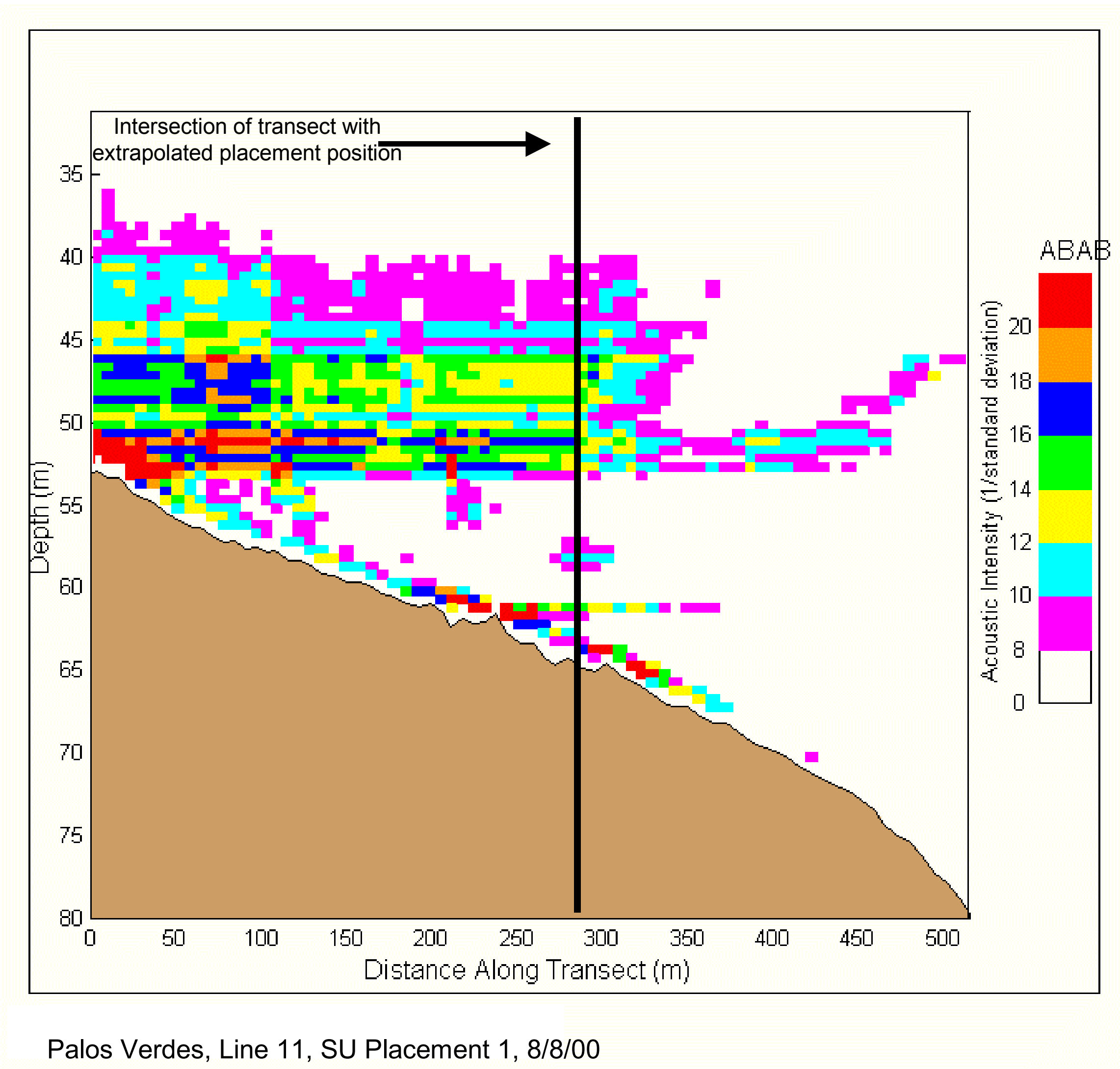
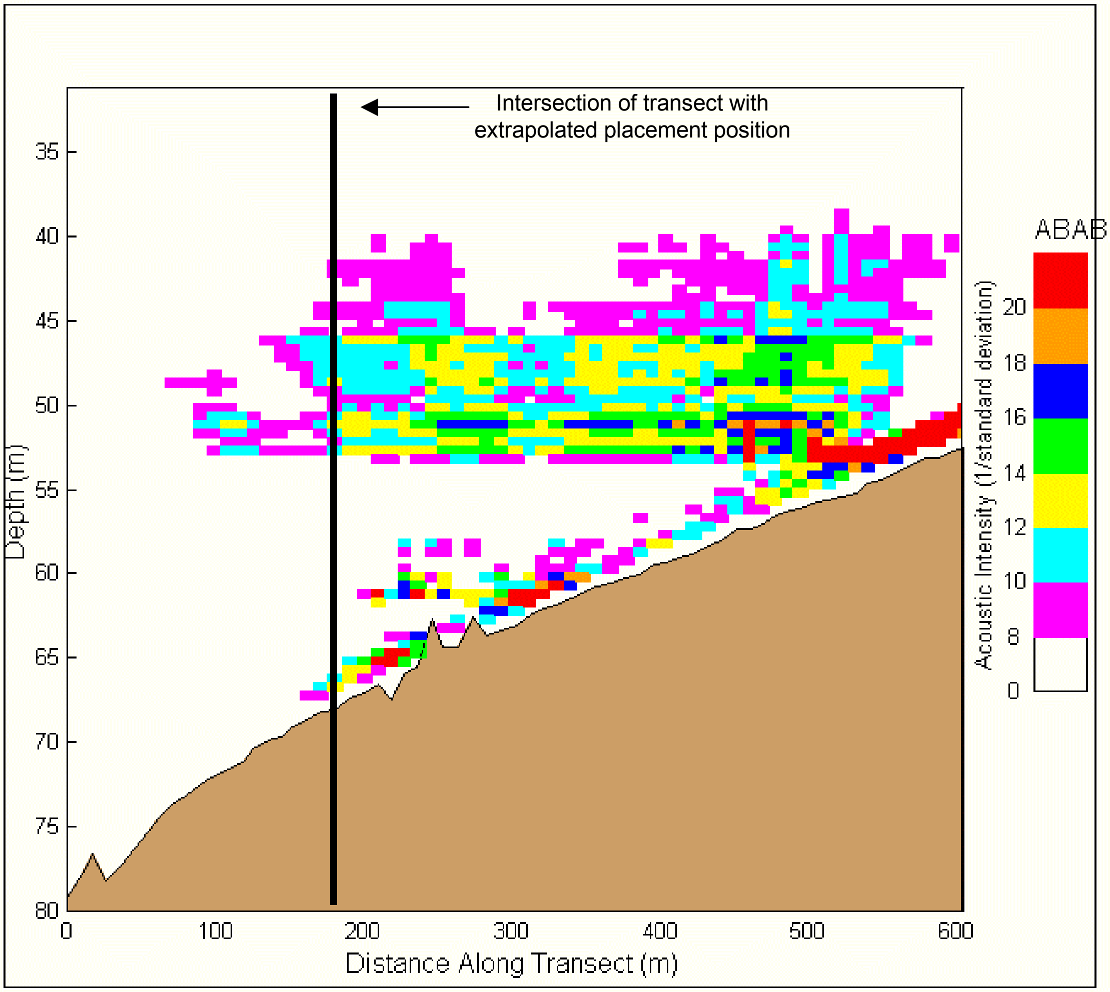
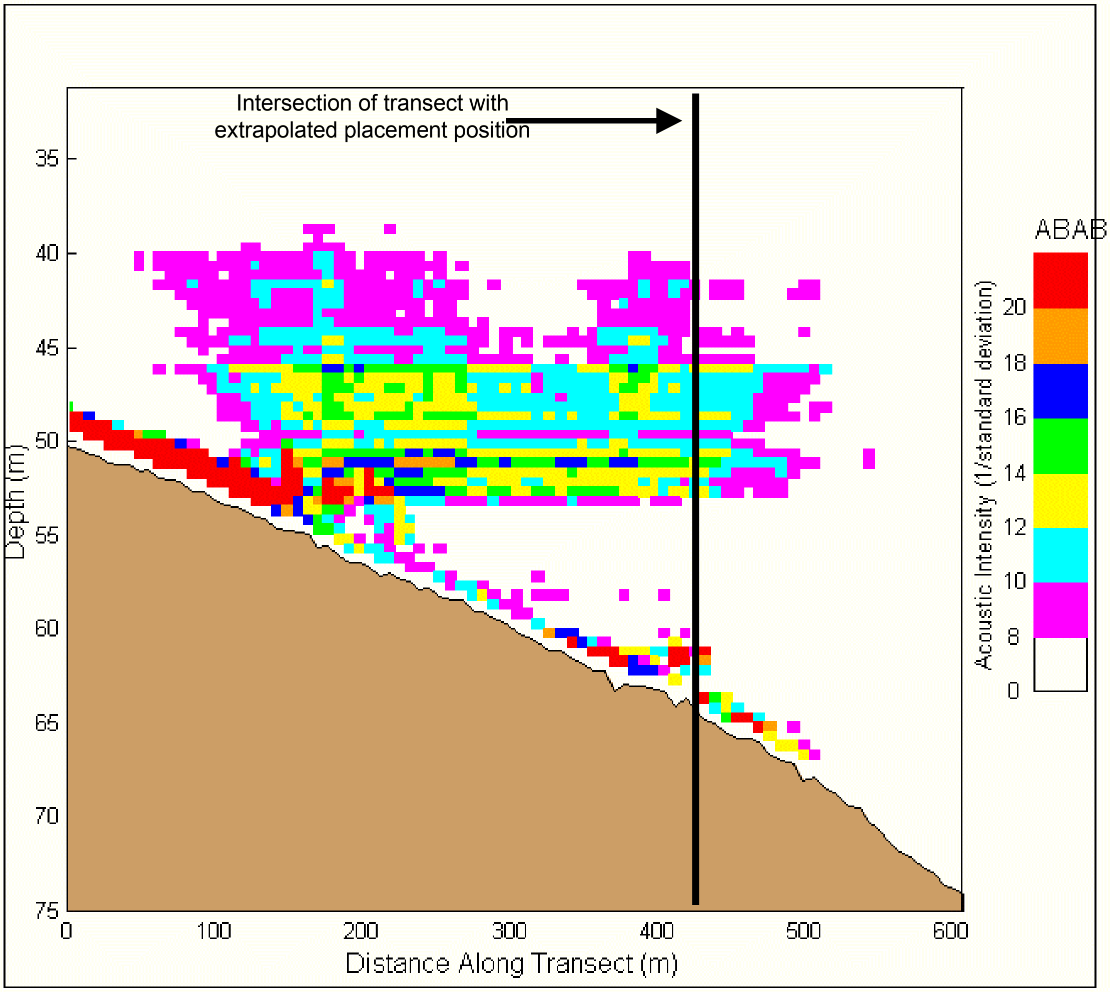


Figure 4.6-12. ABAB along Survey Line 11, run from northeast to southwest 1 hr and 44 min after the placement operation ended.



Palos Verdes, Line 12, SU Placement 1, 8/8/00

Figure 4.6-13. ABAB along Survey Line 12, run from southwest to northeast 1 hr and 52 min after the placement operation ended.



Palos Verdes, Line 13, SU Placement 1, 8/8/00

Figure 4.6-14. ABAB along Survey Line 13, run from northeast to southwest 1 hr and 58 min after the placement operation ended.

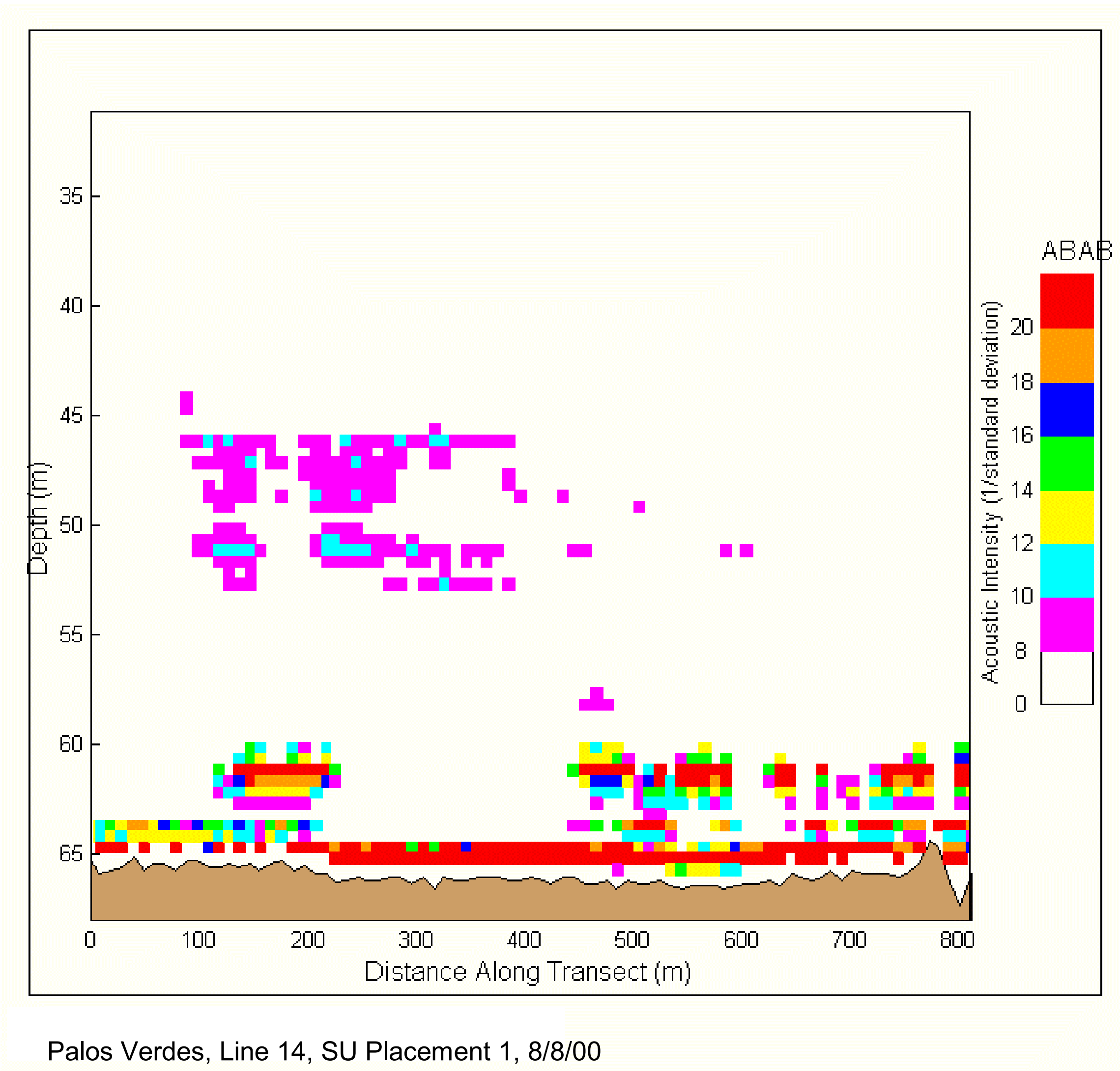


Figure 4.6-15. ABAB along Survey Line 14, run from northwest to southeast 2 hr and 15 min after the placement operation ended.

4.7 Sediment Profile Imagery Results

4.7.1 Overview of Field Sampling Plan

Field sampling activities for SPC surveys in Cell SU followed the methods described in the Baseline and Interim/Postcap PWPs (SAIC 2000a, 2001). All SPC surveys specified in the PWPs were completed, including a baseline survey to characterize seafloor conditions immediately before commencement of capping operations, surveys scheduled to follow a specific number of cap placement events (e.g., Post 1, Post 5, and Post 21), and one flex survey (Post 21 Far Field). Plan view images (PVI) were obtained simultaneously with sediment profile images at each station.

Several SPC surveys in Cell SU involved sampling at more stations than originally planned; this provided improved coverage of the seafloor and better delineation of the cap material footprint. Table 4.7-1 provides a summary of SPC field sampling activities in Cell SU and indicates the number of stations planned (required) versus those actually sampled. Additional details regarding the number and location of stations for each survey are presented in the "monitoring results" section below.

4.7.2 Review of Data Quality Objectives

The review of DQOs provided in Section 3.7.2 is applicable to SPC monitoring in all pilot capping cells. As described in that section, all DQOs were met for the SPC monitoring in each cell.

4.7.3 Technical Considerations

Technical considerations presented and discussed in Section 3.7.3 are applicable to SPC monitoring in all cells and, therefore, not repeated here.

4.7.4 Monitoring Results

4.7.4.1 Baseline Survey

The baseline sediment-profile camera (SPC) survey to evaluate the pre-cap physical and biological seafloor conditions in Cell SU was conducted on July 28, 2000. Similar to the baseline survey in Cell LU, three replicate sediment profile images were obtained at each of 25 primary baseline stations both inside and outside cell boundaries (inside stations I-01 through I-15 and outside stations O-01 through O-10; Figure 4.7-1). Sampling also was conducted at 16 additional stations comprising two long transects to the northwest of Cell SU (stations O-23 through O-35 and O-40 through O-42; Figure 4.7-1) to permit mapping of the cap material footprint in the event the footprint extended into this far field area.

A complete set of image analysis results for the baseline SPC survey in Cell SU is provided in DAN-LA database and summarized in Table 4.7-2. Surface sediments at all stations in and around Cell SU appeared to be fine-grained, consisting predominantly of silt-clay having a grain size major mode of >4 phi (Table 4.7-2). Similar to Cell LU, there appeared to be a significant component of very fine sand (major mode of 4 to 3 phi) mixed with the silt-clay, particularly at and near the sediment surface (upper 5 cm of the sediment column; Figure 4.7-2). These grain size results based on SPC are consistent with the actual grain size analyses preformed as part of the baseline coring survey in cell SU. The core samples showed that silt-clay was predominant in the sediment surface layers, along with a minor component of very fine sand (see Section 4.11).

Boundary roughness values ranged from 0.6 to 2.9 cm at the baseline stations, with an overall mean value of 1.2 cm, indicating a moderate amount of small-scale surface relief across the area (Table 4.7-2). Apparent RPD depths at Cell SU baseline stations ranged from 0.5 to 4.5 cm, with an overall average of 2.5 cm (Table 4.7-2). In many of the replicate images, the RPD was partially obscured by cohesive black mud adhering to the cutting edge of the sediment profile camera (e.g., image B in Figure 4.7-2). The RPD depth typically could be estimated from an unobstructed portion of each image (i.e., an area of the RPD without mud smears), thereby eliminating the effects of the smearing artifact. Similar to Cell LU, RPD depths of about 2 or 3 cm were observed at most Cell SU stations, indicating moderately deep sediment aeration.

Of the 123 replicate sediment profile images obtained during the baseline survey, 116 (94%) showed an infaunal successional stage of either Stage III or Stage I on Stage III (I on III), while 7 (6%) had an infaunal successional stage designation of Stage I only (Table 4.7-2). Many images from the Cell SU baseline survey had multiple feeding voids, burrows, and organisms visible at depth, suggesting a relatively high abundance of Stage III infauna (Figure 4.7-2). The PV Shelf area in and around the pilot capping cells presumably experiences deposition of organic matter discharged from the LACSD outfall. Organic enrichment of shelf sediments can stimulate benthic production and apparently has resulted in an abundant, mature benthic community comprised of both Stage I and Stage III taxa at Cell SU.

The OSI values at Cell SU stations ranged from +4.3 to +10.3, with an overall average of +8.5 (Table 4.7-2). The mean OSI value at all but two stations was greater than or equal to +6. These relatively high OSI values reflect the widespread presence of an abundant and diverse benthic community comprised of both Stage I and Stage III taxa, and RPD depths generally exceeding 2 cm in and around this pilot cell.

4.7.4.2 Post 1 Survey

The Post 1 SPC survey was conducted on August 9 and 17, 2000, following the first cap material placement event in Cell SU (conventional placement of a single hopper load of Queen's Gate dredged material). The survey involved sampling at all 25 of the primary baseline stations (inside stations I-01 through I-15 and outside stations O-01 through O-10), as well as at 20 additional stations located both inside and outside the cell boundaries (I-20 through I-29, O-11 to O-13, O-15 to O-19, and O-21 to O-22; Figure 4.7-3). Therefore, a total of 45 stations were sampled in the Post 1 survey in Cell SU.

A complete set of the image analysis results for the Post 1 survey is presented in DAN-LA database. Cap material was detected in sediment-profile images at 21 stations, in and around the center of Cell SU (Figure 4.7-4). No cap material was detected at any stations outside the cell boundary. Similar to survey results from Cell LU, cap material was visible in the majority of sediment profile images as a distinct, continuous, well-defined, surface layer comprised mainly of gray-colored fine sand, with variable amounts of both white shell fragments and white or gray cohesive clay clasts (Figure 4.7-5). At stations toward the outer edge of the deposit, very thin and discontinuous "sprinkle" layers of cap material were observed at the sediment surface (Figure 4.7-6).

The measured thickness of the cap layer ranged from a maximum of 8 cm in replicate image A at station I09 near the center of the deposit to less than 1 cm (sprinkle layer) at several stations near the outer edge of the deposit (see DAN-LA database). At the majority of stations, the maximum difference in measured cap thickness among the three replicate images was 2 cm or less (Figure 4.7-7).

Contours in Figure 4.7-4 indicate that the cap material deposit on the seafloor was roughly circular, with a diameter ranging between 275 and 325 meters. The average cap material thickness ranged from 6 cm at the center of the deposit to less than 1 cm at the outer edge, with the center of the deposit coinciding exactly with the placement location at the sea surface (Figure 4.7-4).

The estimated depth of EA sediment disturbance was greatest at stations near the center of the cap material deposit (Figure 4.7-8). At these stations, it appeared that the entire layer of light-colored EA sediment comprising the RPD had been removed as a result of cap material placement (e.g., see Figure 3.7-3), and the depth of disturbance was mapped as a conservative estimate (i.e., greater than the former RPD, which ranged from about 1 to 2.5 cm at each station; Figure 4.7-8). At stations with cap material but located away from the center of the deposit (e.g., Station I10), the estimated depth of EA sediment disturbance ranged from 0.1 to 2.4 cm (Figure 4.7-8). At the remaining stations outside the cap material footprint, disturbances of EA sediment were not evident (i.e., depth of disturbance = 0 cm, because the RPD was still present at these stations at roughly the same depth as before cap placement; Figure 4.7-8).

4.7.4.3 Post 5 Survey

Sampling for the Post 5 SPC survey occurred on August 22, 24, and 25, 2000, following conventional placement of a cumulative total of five hopper loads of Queen's Gate cap material in the center of Cell SU. Sediment profile images were obtained at 19 stations within the cell, including the original 15 inside stations from the baseline survey and 4 additional stations located near the four corners of the cell (Figure 4.7-9).

A surface layer of cap material was observed in the images from all 19 stations (Figure 4.7-10). Cap material thickness ranged from >14 cm in replicate image B at station I-09 near the center of the cell to less than 1 cm at stations on the outer edge of the deposit (DAN-LA database). The five stations at the very center of the cell (I04, I07, I08, I09 and I12) all had average cap material layers thicker than the penetration depth of the sediment profile camera (ranging from >8.6 to >12.0 cm). The maximum average cap material thickness (as indicated by the contours in Figure 4.7-10) was >11 cm at the center of the cell. The diameter of the cap material deposit, measured lengthwise across the cell, was >350 m following the five placement events. Contouring in Figure 4.7-10 is constrained by the number and location of stations; it appears likely that the cap material deposit extended beyond the cell boundary in both the landward (upslope) and seaward (downslope) directions.

At stations having a discrete cap layer (i.e., cap thickness did not exceed the camera penetration), the maximum difference in measured thickness among replicate images was predominantly less than 2 cm (Figure 4.7-11). At these same stations, the depth of disturbance of EA sediment in general was estimated conservatively to be greater than about 2 cm (i.e., the images suggest that the former RPD was completely removed at these stations; Figure 4.7-12).

4.7.4.4 Post 21 Survey

The Post 21 SPC survey was conducted on August 31 and September 1, 2000, following conventional placement of a cumulative total of 21 hopper loads of Queen's Gate material in Cell SU. Sediment profile images were obtained at a total of 49 stations, which are located both inside and outside the cell boundary (Figure 4.7-13).

Cap material placement locations were distributed within a radius of about 200 m of the cell center, and cap material was observed in sediment profile images at 48 of the 49 stations (Figure 4.7-14). The average thickness of the cap layer varied among stations, both within and outside the cell boundary. Inside the cell boundary, average cap thickness ranged from >9 to >11 cm at 10 stations located within a radius of about 150 m of the cell center (Figure 4.7-14). At the remaining stations inside the cell boundary, the average cap thickness ranged from 4 to 8 cm, while average cap thickness at stations outside the cell boundary ranged from 2 to 8 cm. The coverage of cap material was patchy and thin (i.e., a "sprinkle" layer less than 1 cm thick) at several of the outermost outside stations (stations O06, O08, O09, O15, O21, and O04; see DAN-LA database). No cap material was observed at outermost outside station O05.

At 36 of the 38 stations where a discrete cap layer was measured (i.e., not greater than penetration), the maximum difference in cap thickness among replicate images was ≤2 cm (Figure 4.7-15). Cap thickness among replicate images at stations O07 and O17 varied by 3 and 4 cm, respectively. These results suggest there was little variation in cap thickness across relatively short horizontal distances (i.e., on the order of a few meters between replicate images) at most stations.

At stations where the remnants of the RPD occurred below the cap layer, the depth of EA sediment disturbance generally was estimated to be greater than about 2 or 3 cm (Figure 4.7-16). The estimated depth of EA sediment disturbance generally decreased with distance from the placement locations within the cell boundary. There was no apparent disturbance of EA sediment at distal stations O05, O15 and O21, and the estimated depth of disturbance was limited to less than about 2 cm at stations O03, O06 and O08 (Figure 4.7-16).

At station I02, a discrete cap material layer measuring 3 cm thick was observed in all three replicate images from the Post 21 SPC survey. This result was considered curious, because this station coincided with one of the placement locations, and cap thickness was considerably greater at each of the four neighboring stations (ranging from 8 to >10 cm at stations I01, I03, I04 and O11; Figure 4.7-14).

4.7.4.5 Post 21 Far Field Survey

The Post 21 Far Field SPC survey in Cell SU was conducted on September 13, 2000. Sediment profile images were obtained at 10 stations within the cell boundary and 20 stations outside the cell. The 10 stations inside the cell comprised two cross-shaped sampling grids: one grid had station I02 at its center (I02C) and the other was centered on station I19, where less variability had been observed among the triplicate images in the Post-21 survey (Figure 4.7-17). The surrounding stations in each grid were located 25 meters away in each of the four primary compass directions (e.g., I02N, I02E, I02S and I02W). The objective of sampling at each of the two grids was to evaluate variability in cap material thickness over relatively small horizontal scales.

Variability in cap material thickness for each cross-shaped grid is illustrated in Figure 4.7-18 and summarized in Table 4.7-3. For the grid around station I02, within-station variability (i.e., among the three replicate images for each station) was minimal (less than or equal to 1 cm at four of the five stations and 3 cm at the fifth station). The among-station variability was more significant: discrete layers of cap material measuring an average of 3.3 cm and 4.7 cm were observed at stations I02C and I02N, respectively, while average cap material thickness at the other three stations ranged from >8 to >10 cm. If individual replicate images are considered, measured cap thickness ranged from a minimum of 3 cm at station I02C to >10 cm at stations I02W, I02S, and I02E (Figure 4.7-19). These results indicate that the cap thickness varied by at least 7 cm within a 25 m radius of station I02 and that the area with cap of only 3-4 cm was quite localized.

Relatively less variability in cap material thickness occurred around station I19. A discrete layer of cap material was observed and measured in replicate images at all five of the stations (i.e., cap material thickness did not exceed the penetration depth). Maximum within-station variability in cap thickness was 3 cm at two of the stations (I19N and I19W), and zero at the other three stations (Table 4.7-3). Average cap thickness ranged only from 5 to 7 cm at the five stations, while measured cap thickness in the individual replicate images ranged from 5 to 8 cm across the five stations. Average cap thickness decreased with distance from the nearest placement point, consistent with expectations (Figure 4.7-18).

The 20 stations located outside the Cell SU boundary comprised two transects; one beginning 100 m southeast of the cell boundary (i.e., along slope) and the other beginning 200 m southwest of the cell boundary (i.e., downslope; Figure 4.7-17). The objective of sampling along each transect was to determine the location of the outer edge of the cap material.

No cap material was detected at any of the southeast transect stations (Figure 4.7-18). A 2-cm thick, patchy cap material layer was observed only at the first station on the southwest transect (station O62); whereas, no cap material was observed at the remaining stations on this transect. These results indicate that the outer edge of the cap deposit in Cell SU occurred roughly 200 m southwest of the cell boundary in the downslope direction, but less than 100 m in the along-slope direction.

With the exception of station O62, all of the remaining stations on the southwest transect showed ambient EA sediment to be present, with the RPD remaining intact. The intact RPD layers at the southwest transect stations located up to 500 m downslope of the cell boundary indicate an absence of any current scour in this direction following 21 placement events in Cell SU.

4.7.4.6 Supplemental Survey

The Supplemental SPC survey was conducted on February 24, 2001, roughly six months following the last cap placement event in Cell SU. Sediment profile images were obtained at a total of 6 stations: 5 located outside the cell boundary to the northeast (upslope) and one located inside the boundary, southwest of the cell center (Figure 4.7-20). All six of the stations had been sampled in the September 2000 Post-21 survey in Cell SU.

Figure 4.7-21 shows the average cap material thickness measured at each station in both the supplemental survey and the previous Post-21 survey. In the supplemental survey, a cap material layer was observed at five of the six stations, and the average thickness of this layer ranged from 2.3 to 8.5 cm (Figure 4.7-21). In general, the average cap thickness measured at each station in the supplemental survey was consistent with, but slightly less than, the average thickness measured in the Post-21 survey (Figure 4.7-21). At station O13, a cap layer with an average thickness of 3 cm was observed in the Post-21 survey, but no cap material was detected in the images from the supplemental survey.

Similar to Cells LU and LD, a new surface depositional layer of fine-grained sediment was visible on top of the cap material layer at each of the five stations where cap material was detected in the supplemental survey (Figures 4.7-22 and 4.7-23). The average thickness of this new surface depositional layer ranged from 1 to 4.7 cm at the five stations (Figure 4.7-24).

Table 4.7-1. Summary of SPC Field Sampling Activities in Cell SU

Survey Name	Number of Survey Stations		Completeness
	Required	Sampled	
Baseline	25	42	168%
Post 1	37	45	122%
Post 5	14	19	136%
Post 21	37	49	132%
Post 21 Far Field (Flex Survey)	30	30	100%

Table 4.7-2. Summary of Image Analysis Results for the baseline SPC Survey in Cell SU. Values for RPD depth, boundary roughness, and Organism-Sediment Index are averages for the three replicate images obtained and analyzed at each station.

STATION	GRAIN SIZE MAJOR MODE (phi)	CAMERA PENETRATION MEAN (cm)	BOUNDARY ROUGHNESS MEAN (cm)	APPARENT RPD THICKNESS MEAN (cm)	SUCCESSIONAL STAGES PRESENT (# of replicates)	OSI MEAN
INSIDE STATIONS						
SUBI01	>4	14.5	0.9	3.1	ST_I_ON_III (3)	9.7
SUBI02	>4	13.9	1.2	0.5	ST_III (2), ST_I_ON_III (1)	5.7
SUBI03	>4	15.0	0.7	2.2	ST_III (1), ST_I_ON_III (2)	8.3
SUBI04	>4	13.5	1.0	1.7	ST_III (1), ST_I_ON_III (2)	7.7
SUBI05	>4	13.6	1.3	3.2	ST_I_ON_III (3)	9.7
SUBI06	>4	14.2	1.0	2.8	ST_I_ON_III (3)	9.3
SUBI07	>4	14.6	1.0	2.5	ST_I_ON_III (3)	8.7
SUBI08	>4	15.0	1.2	1.6	ST_III (1), ST_I_ON_III (2)	7.3
SUBI09	>4	15.2	1.8	0.9	ST_I_ON_III (3)	6.3
SUBI10	>4	13.8	1.0	2.3	ST_I_ON_III (3)	8.3
SUBI11	>4	14.0	0.6	2.0	ST_I_ON_III (3)	8.0
SUBI12	>4	14.3	0.9	2.4	ST_III (2), ST_I_ON_III (1)	8.7
SUBI13	>4	14.7	0.8	3.2	ST_I (1), ST_I_ON_III (2)	8.7
SUBI14	>4	14.1	1.2	1.8	ST_I_ON_III (3)	7.7
SUBI15	>4	14.8	0.7	1.8	ST_III (1), ST_I_ON_III (2)	8.0
OUTSIDE STATIONS						
SUBO01	>4	13.2	1.2	2.9	ST_I_ON_III (3)	9.3
SUBO02	>4	12.9	1.3	2.0	ST_III (1), ST_I_ON_III (2)	8.0
SUBO03	>4	13.3	0.7	2.4	ST_I_ON_III (3)	8.7
SUBO04	>4	13.6	1.1	1.9	ST_I_ON_III (3)	8.0
SUBO05	>4	13.0	0.6	3.7	ST_III (1), ST_I_ON_III (2)	10.3
SUBO06	>4	17.6	2.3	2.4	ST_I (3)	4.3
SUBO07	>4	15.1	1.9	3.3	ST_I (1), ST_I_ON_III (2)	8.7
SUBO08	>4	15.4	0.6	4.5	ST_I (1), ST_I_ON_III (2)	9.7
SUBO09	>4	14.4	0.7	2.9	ST_I_ON_III (3)	9.3
SUBO10	>4	14.1	1.4	2.9	ST_I_ON_III (3)	9.0
SUBX23	>4	14.9	1.3	2.3	ST_I_ON_III (3)	8.3
SUBX24	>4	14.8	0.7	2.5	ST_I_ON_III (3)	9.0
SUBX25	>4	14.3	1.8	2.3	ST_I_ON_III (3)	8.7
SUBX26	>4	15.1	0.7	2.4	ST_I_ON_III (3)	8.7
SUBX27	>4	16.0	1.7	2.9	ST_III (1), ST_I_ON_III (2)	9.3
SUBX28	>4	13.8	2.1	2.6	ST_III (1), ST_I_ON_III (2)	9.5
SUBX29	>4	15.6	0.9	2.9	ST_III (1), ST_I_ON_III (2)	9.0
SUBX30	>4	15.4	1.4	3.0	ST_I_ON_III (3)	9.0
SUBX31	>4	13.9	1.2	3.7	ST_I_ON_III (3)	10.3
SUBX32	>4	14.4	0.8	2.4	ST_I_ON_III (3)	8.7
SUBX33	>4	14.8	1.3	3.4	ST_I_ON_III (3)	10.0
SUBX34	>4	14.3	1.2	2.8	ST_I (1), ST_I_ON_III (2)	7.7
SUBX35	>4	15.3	2.9	2.3	ST_I_ON_III (3)	8.7
SUBX40	>4	14.4	1.2	2.6	ST_I_ON_III (3)	8.7
SUBX41	>4	14.5	1.5	3.0	ST_I_ON_III (3)	9.3
SUBX42	>4	13.2	2.8	1.6	ST_III (1), ST_I_ON_III (2)	7.3

MIN	>4	12.9	0.6	0.5	ST_I	4.3
MAX	>4	17.6	2.9	4.5	ST_I_on_III	10.3
MEAN		14.5	1.2	2.5		8.5

Table 4.7-3. Variability in Cap Thickness at and around Stations I02 and I19 in the Post 21 Far Field SPC survey

Station	Replicate	Cap Thickness of Replicate	Average Cap Thickness for Station	Maximum Difference Among Replicates	Range of Cap Thickness for all Station Replicates (within 25 m of center)
I02 Center	A	4 cm	3.3 cm	1 cm	3 to > 10 cm
I02 Center	B	3 cm			
I02 Center	C	3 cm			
I02 North	A	4 cm	4.7 cm	1 cm	
I02 North	B	5 cm			
I02 North	C	5 cm			
I02 East	A	> 8 cm	> 8.3 cm	3 cm	
I02 East	B	> 7 cm			
I02 East	C	> 10 cm			
I02 South	A	> 10 cm	> 9.7 cm	1 cm	
I02 South	B	> 9 cm			
I02 South	C	> 10 cm			
I02 West	A	> 10 cm	> 10 cm	0 cm	
I02 West	B	> 10 cm			
I02 West	C	> 10 cm			
I19 Center	A	5 cm	5 cm	0 cm	5 to 8 cm
I19 Center	B	5 cm			
I19 Center	C	5 cm			
I19 North	A	8 cm	7 cm	3 cm	
I19 North	B	8 cm			
I19 North	C	5 cm			
I19 East	A	5 cm	5 cm	0 cm	
I19 East	B	5 cm			
I19 East	C	5 cm			
I19 South	A	5 cm	5 cm	0 cm	
I19 South	B	5 cm			
I19 South	C	5 cm			
I19 West	A	8 cm	7 cm	3 cm	
I19 West	B	8 cm			
I19 West	C	5 cm			

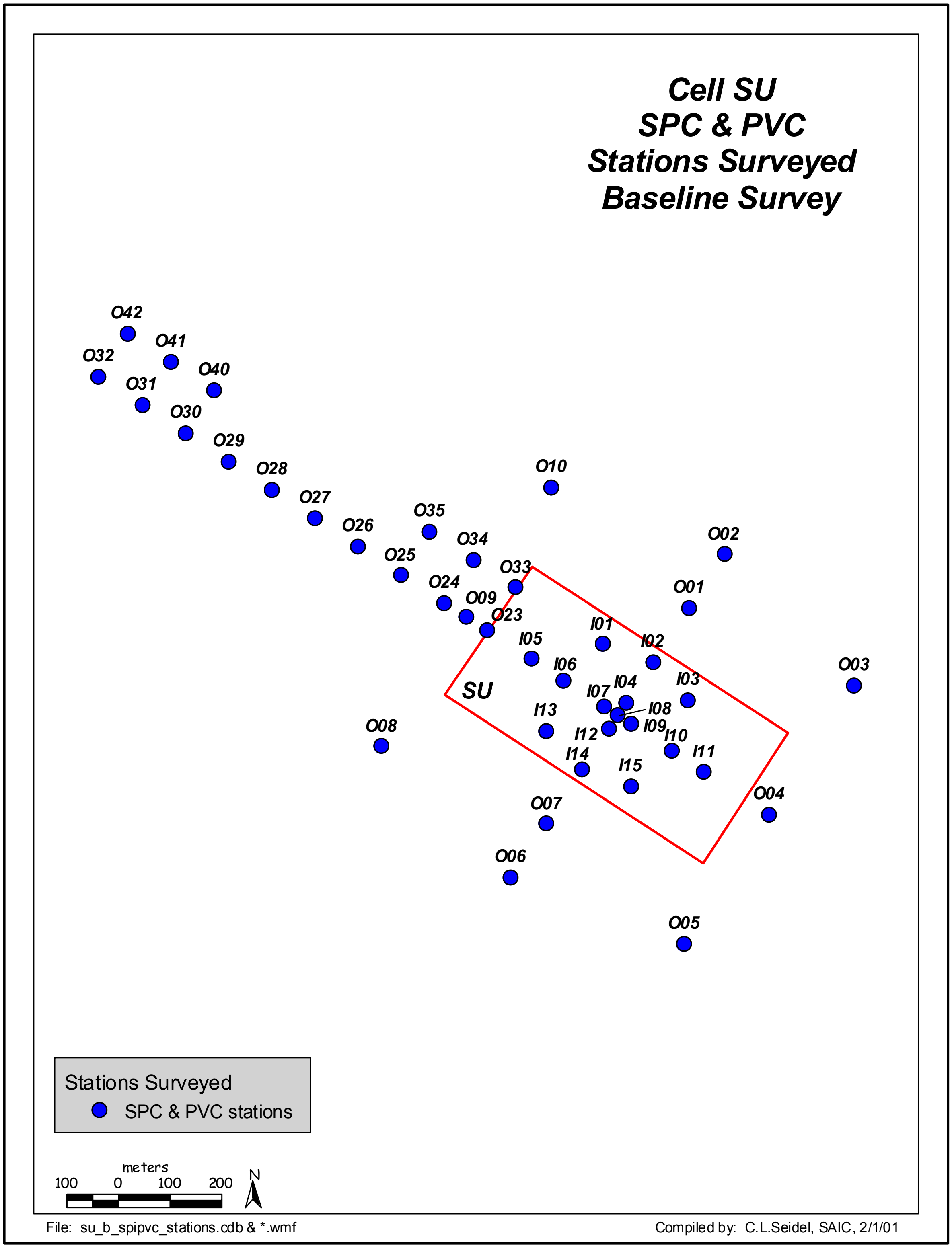


Figure 4.7-1. Station locations for the baseline SPC survey in Cell SU.

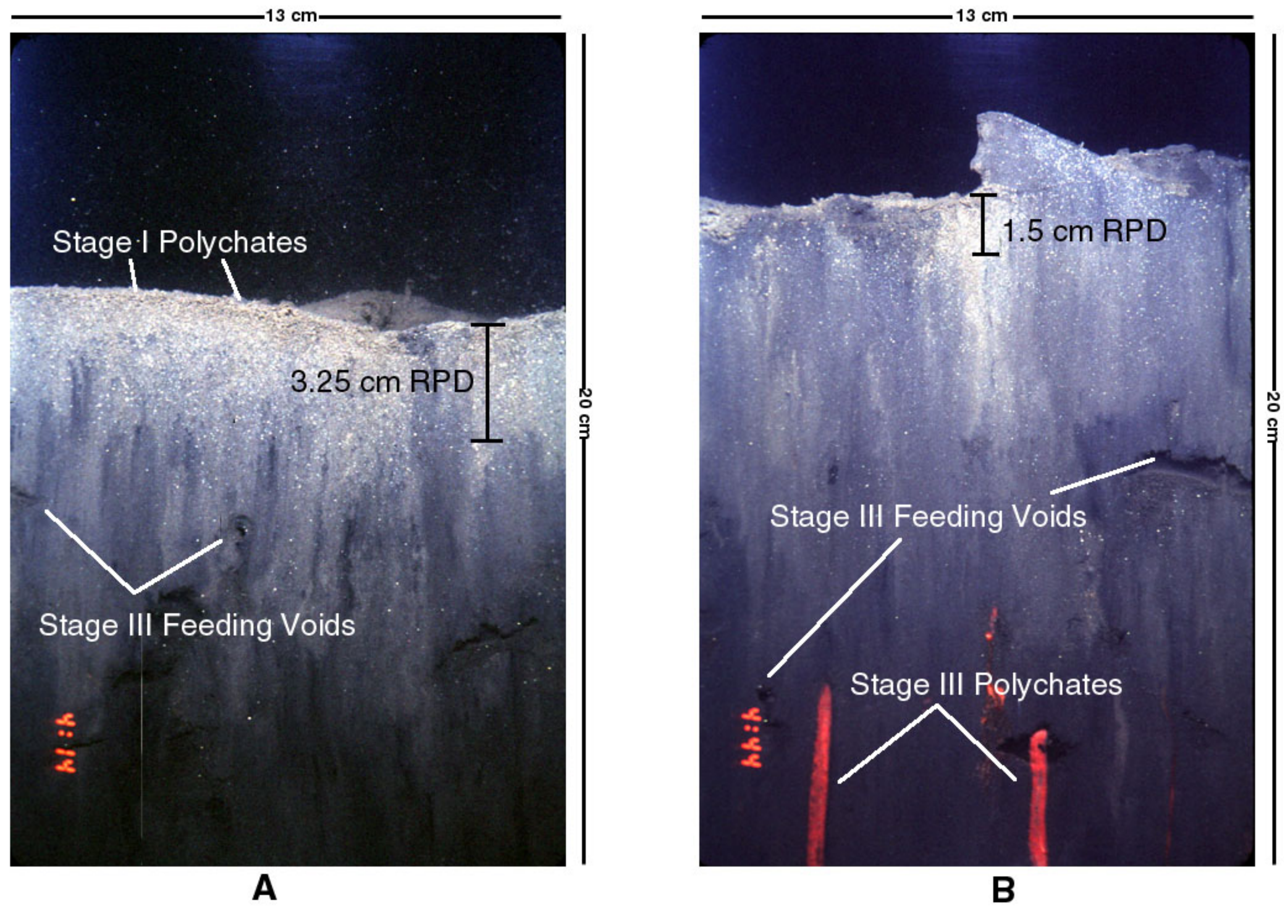


Figure 4.7-2. Sediment-profile images from Stations O01 (Image A) and I09 (Image B) illustrating typical baseline seafloor conditions in and around Cell SU. The sediment in both images is predominantly fine-grained (silt-clay), and its texture appears slightly coarser near the sediment surface due to an increased proportion of fine sand. Image A shows an RPD depth of 3.25 cm, Stage I polychaete tubes at the sediment surface, and Stage III feeding voids at depth (Stage I on III). The RPD depth in image B measures 1.5 cm and is somewhat obscured by smeared black mud from the sediment-profile camera; Stage III feeding voids and several larger-bodied Stage III organisms are visible at depth in this image.

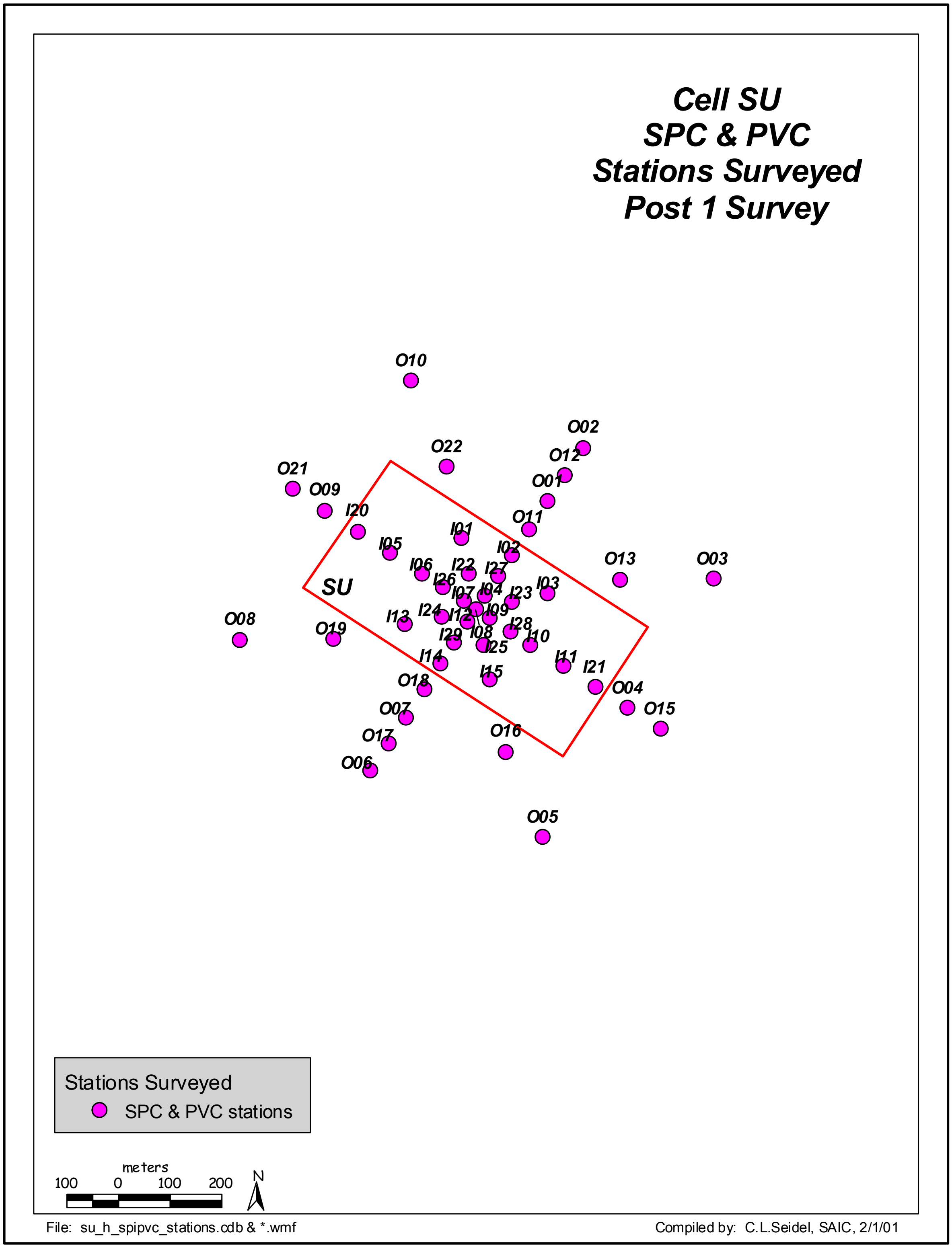


Figure 4.7-3. Station locations for the Post 1 SPC survey in Cell SU.

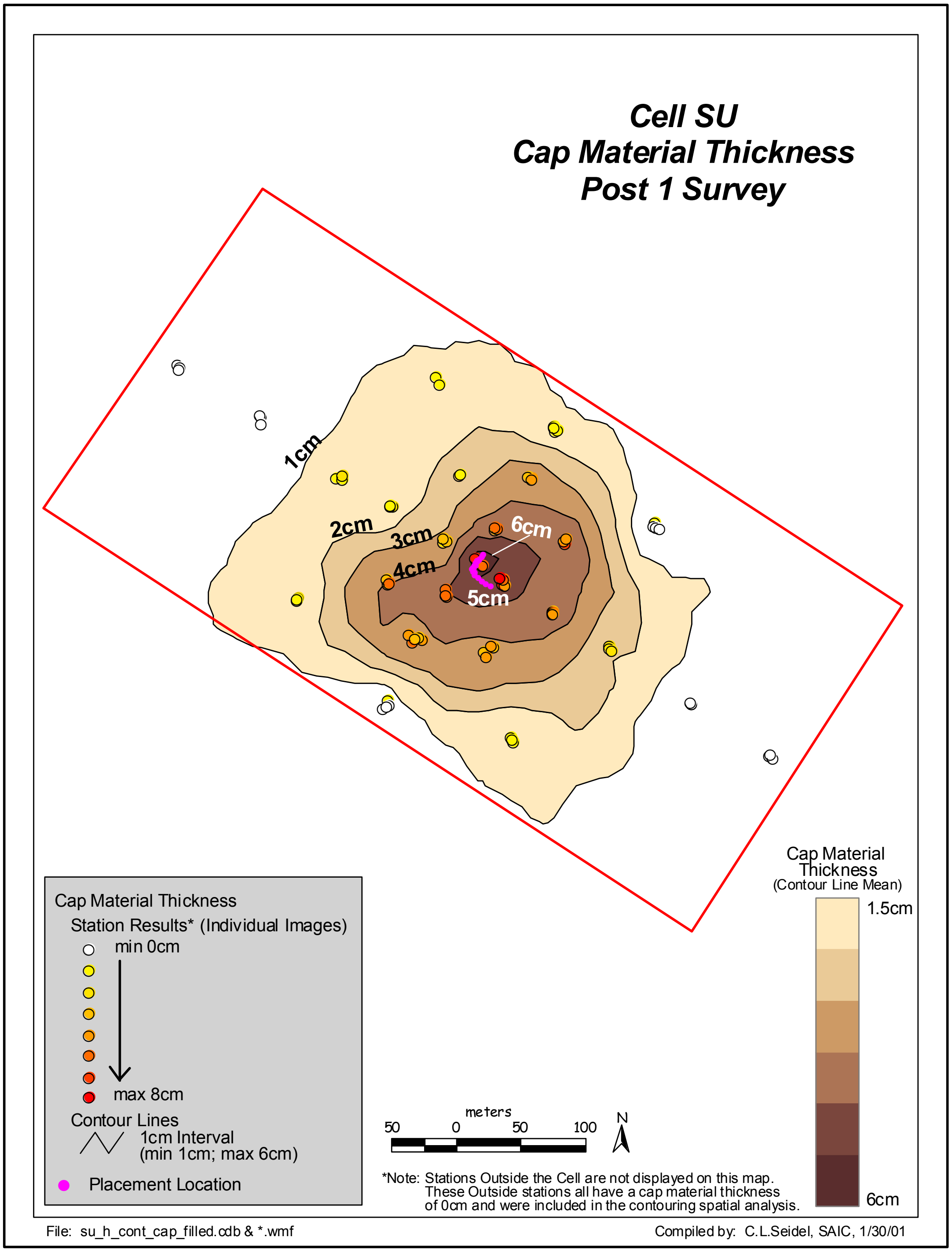


Figure 4.7-4. Placement location and thickness of cap material on the seafloor for the Post 1 SPC survey in Cell SU. Contour lines are based on the average measured thickness of the cap material layer at each station (mean of n = 3 replicate sediment profile images), while each plotted circle depicts the cap material thickness measurement for an individual replicate image.

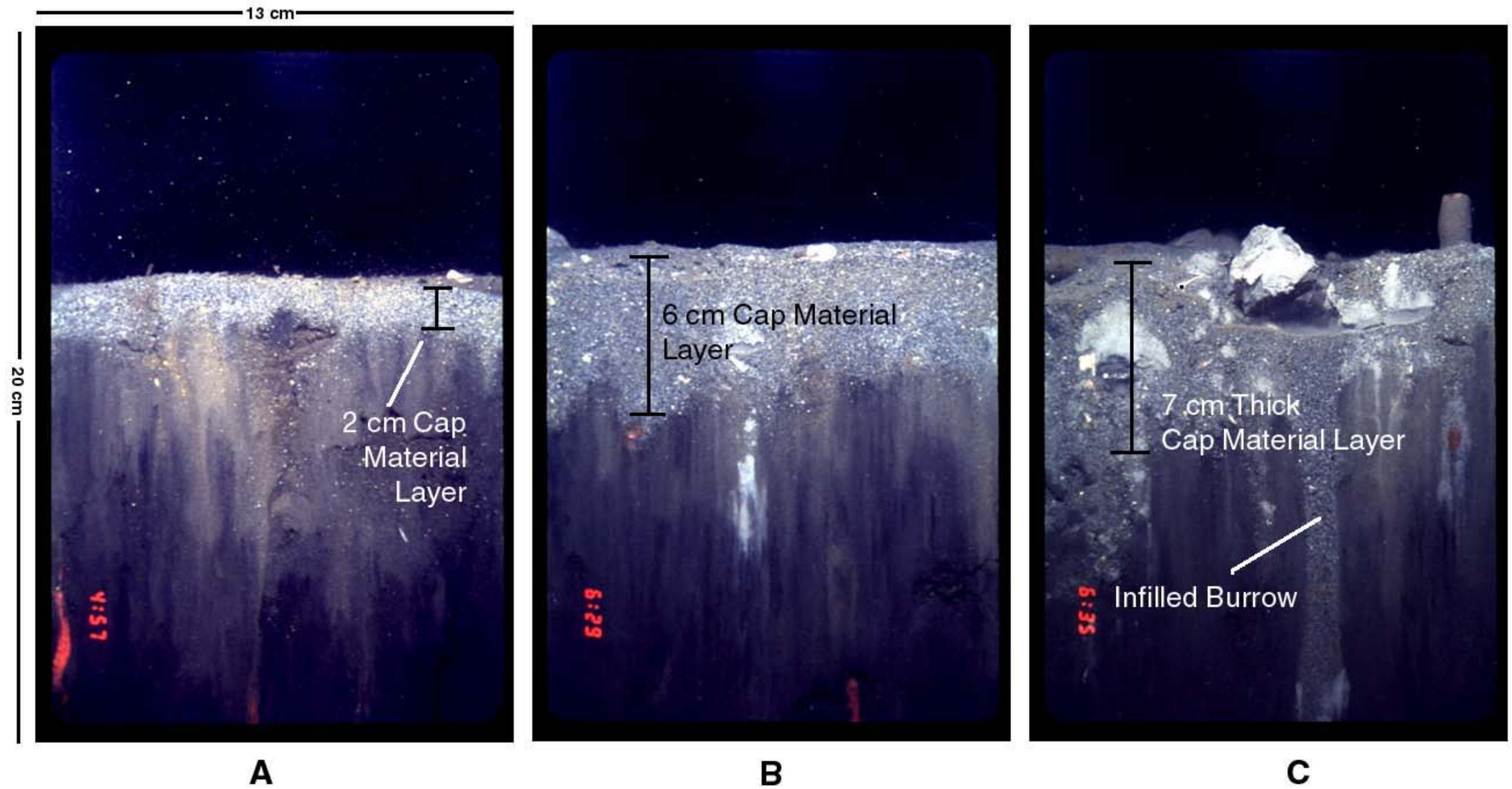


Figure 4.7-5. Sediment profile images from the Post-1 survey in Cell SU illustrating variations in the appearance and thickness of the cap material layer. Image A from station I07 shows a 2-cm thick depositional layer of gray cap sand with only a few small white shell fragments. Image B from station I23 shows a 6-cm thick depositional layer of gray cap sand with shells and smaller cohesive gray clay clasts, while the 7-cm thick cap layer in image C from station I08 shows the gray sand mixed with larger cohesive clay clasts. Note in image C that the cap material layer has an uneven thickness across the field of view, and some of this material has filled in a vertical burrow opening.

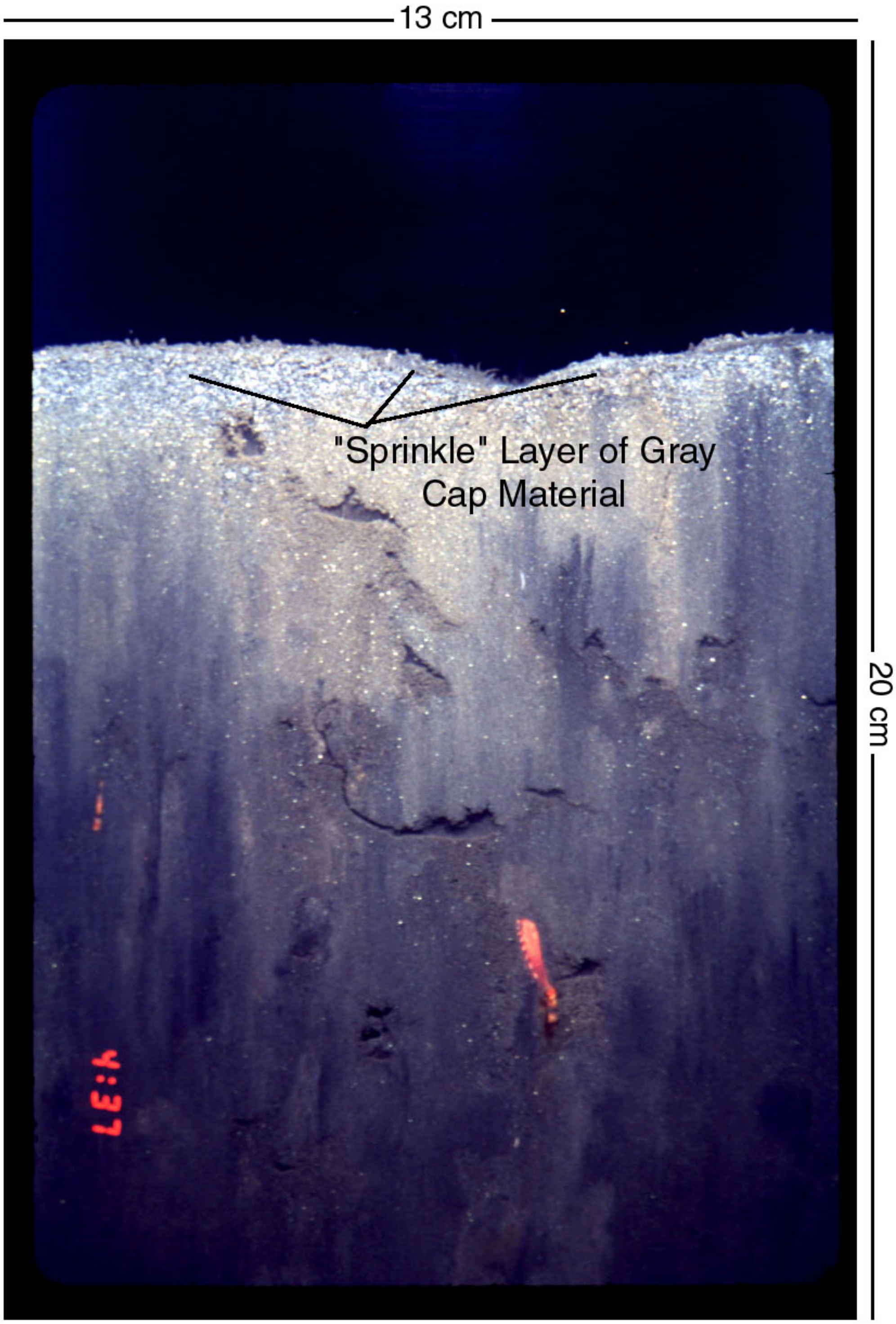


Figure 4.7-6. Sediment profile image from station I06 providing an example of a very thin and patchy "sprinkle" layer of cap material at the surface of the EA sediment. Such thin layers of cap material were observed at several stations near the outer edge of the cap material deposit.

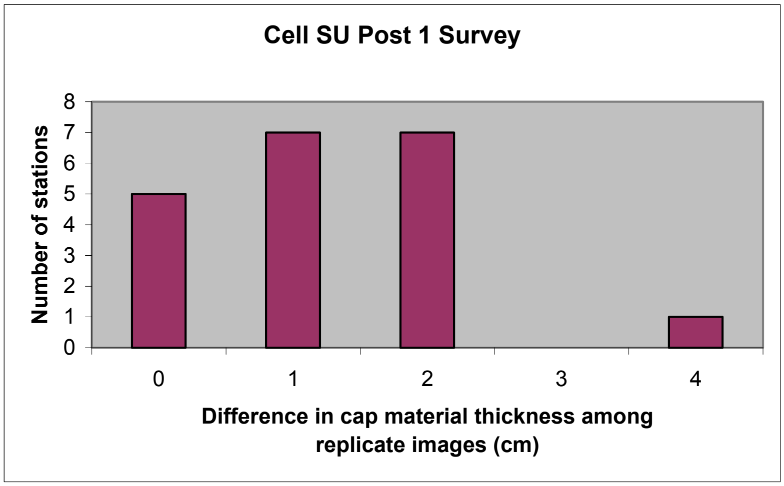


Figure 4.7-7. Frequency distribution of stations with a given maximum difference in cap material thickness among the triplicate images, Cell SU Post 1 survey.

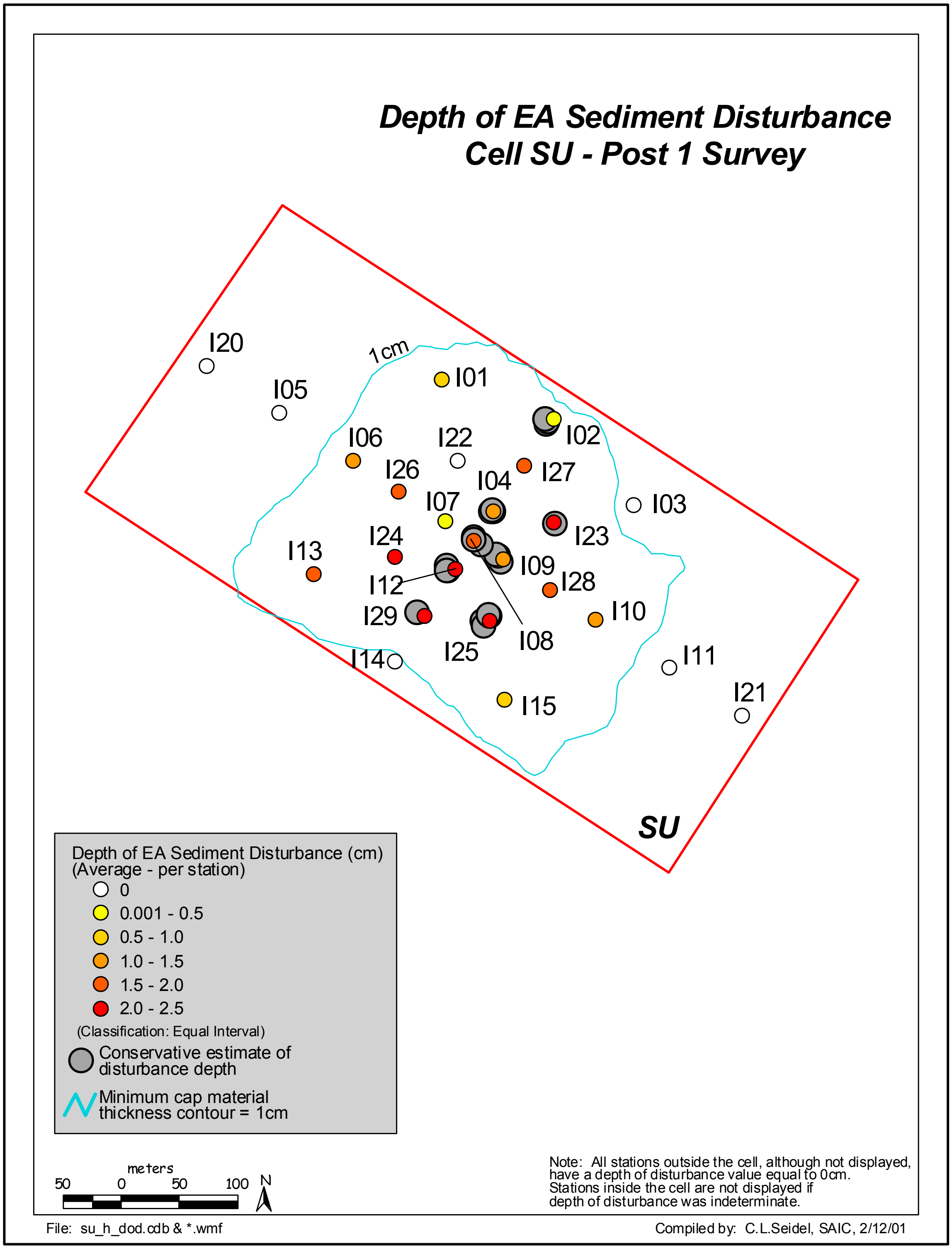


Figure 4.7-8. Estimated depth of disturbance of EA sediment (in cm) as a result of cap material placement, Cell SU Post 1 survey.

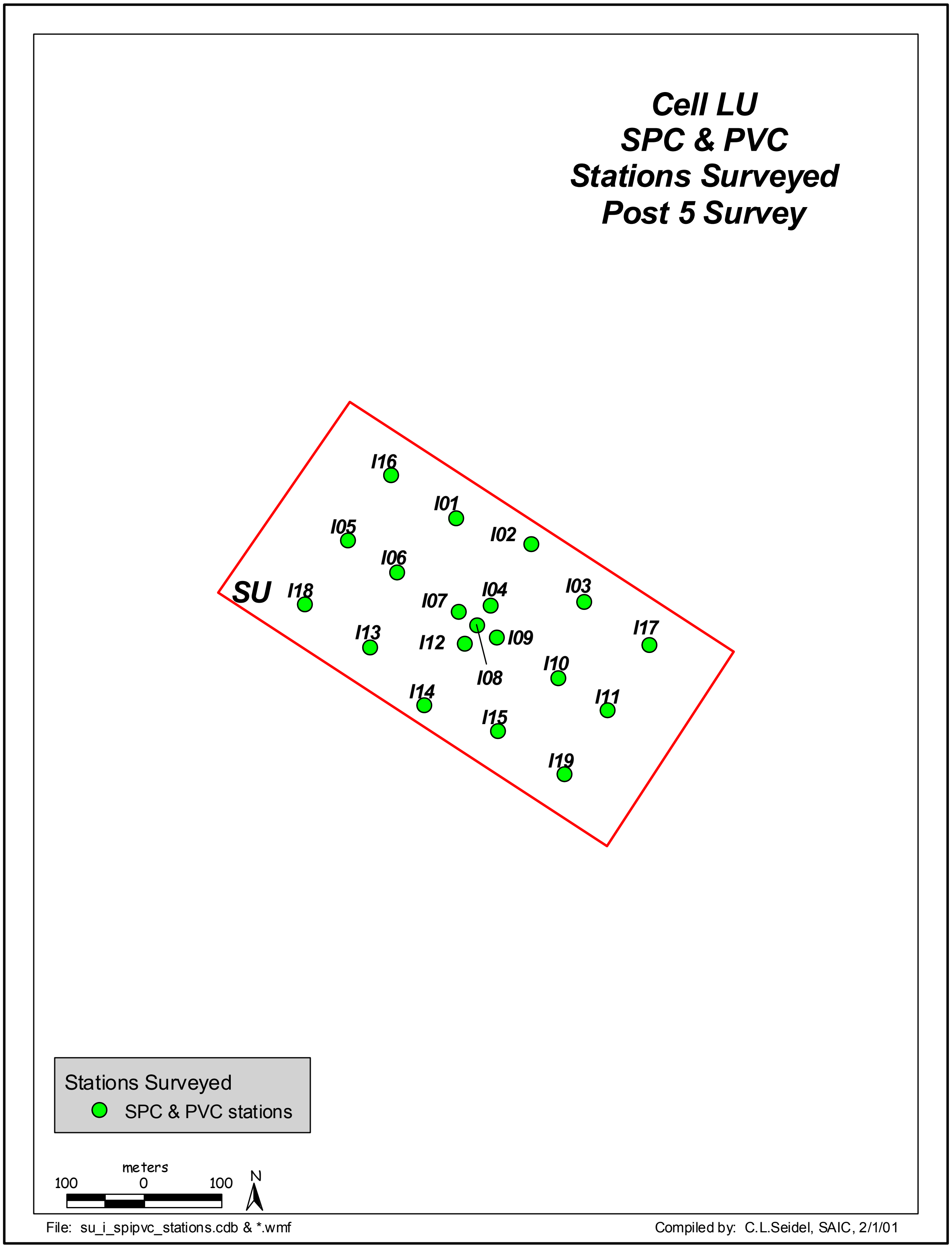


Figure 4.7-9. Station locations for the Post 5 SPC survey in Cell SU.

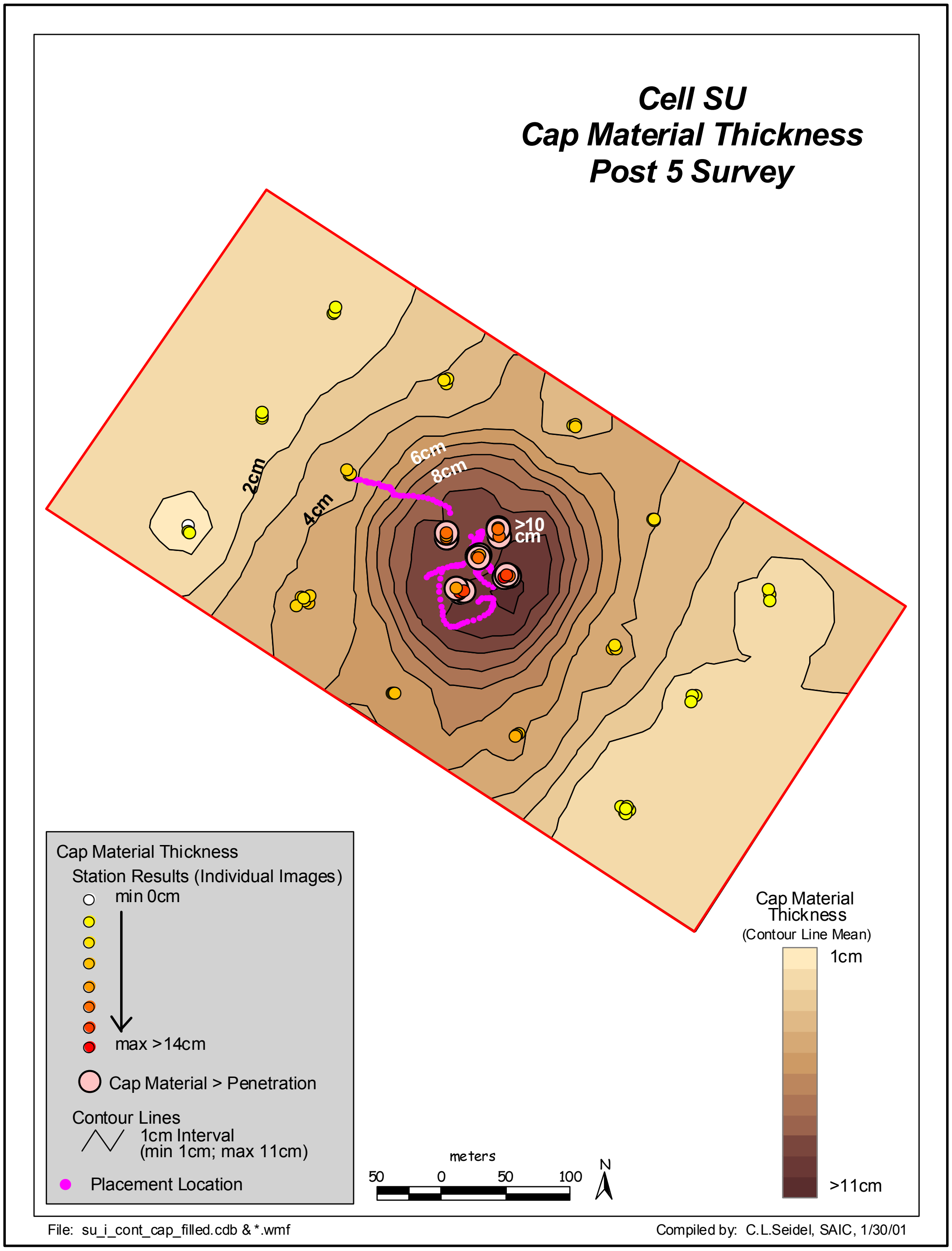


Figure 4.7-10. Placement locations and thickness of cap material on the seafloor in Cell SU for the Post 5 SPC survey. Contour lines are based on the average measured thickness of the cap material layer at each station (mean of n = 3 replicate sediment profile images), while each plotted circle depicts the cap material thickness measurement for an individual replicate image. Note that the cap material layer thickness exceeded the penetration depth of the sediment profile camera in a number of images near the center of the cell (cap material > penetration).

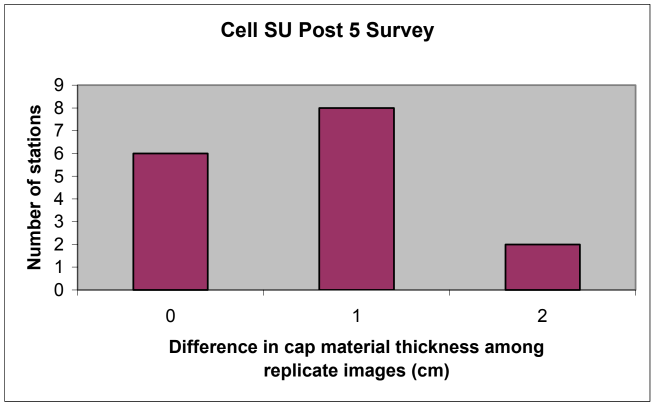


Figure 4.7-11. Frequency distribution of stations with a given maximum difference in cap material thickness among triplicate images, Cell SU Post 5 survey.

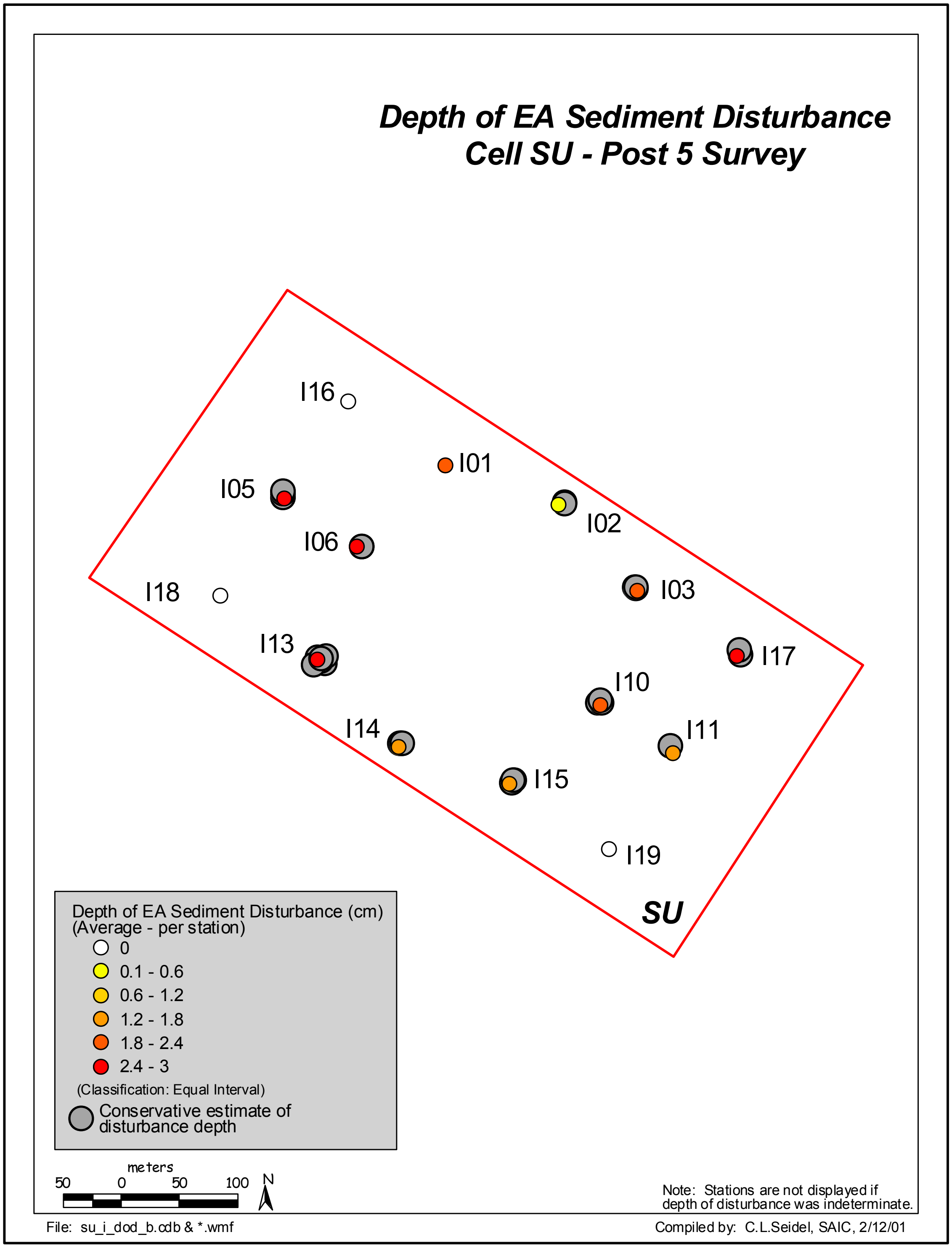


Figure 4.7-12. Estimated depth of disturbance of EA sediment for the Post 5 SPC survey in Cell SU.

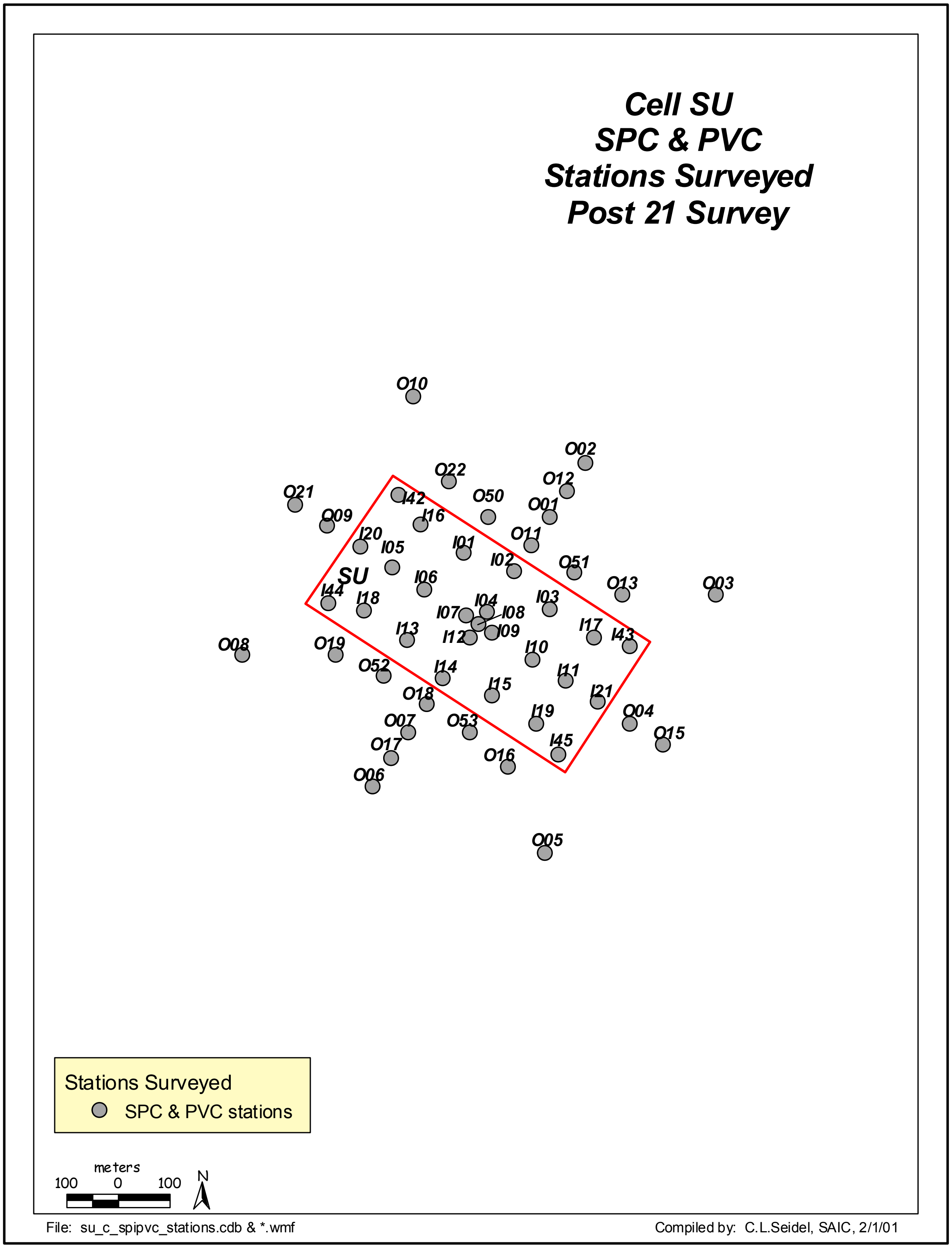


Figure 4.7-13. Station locations for the Post 21 SPC survey in Cell SU.

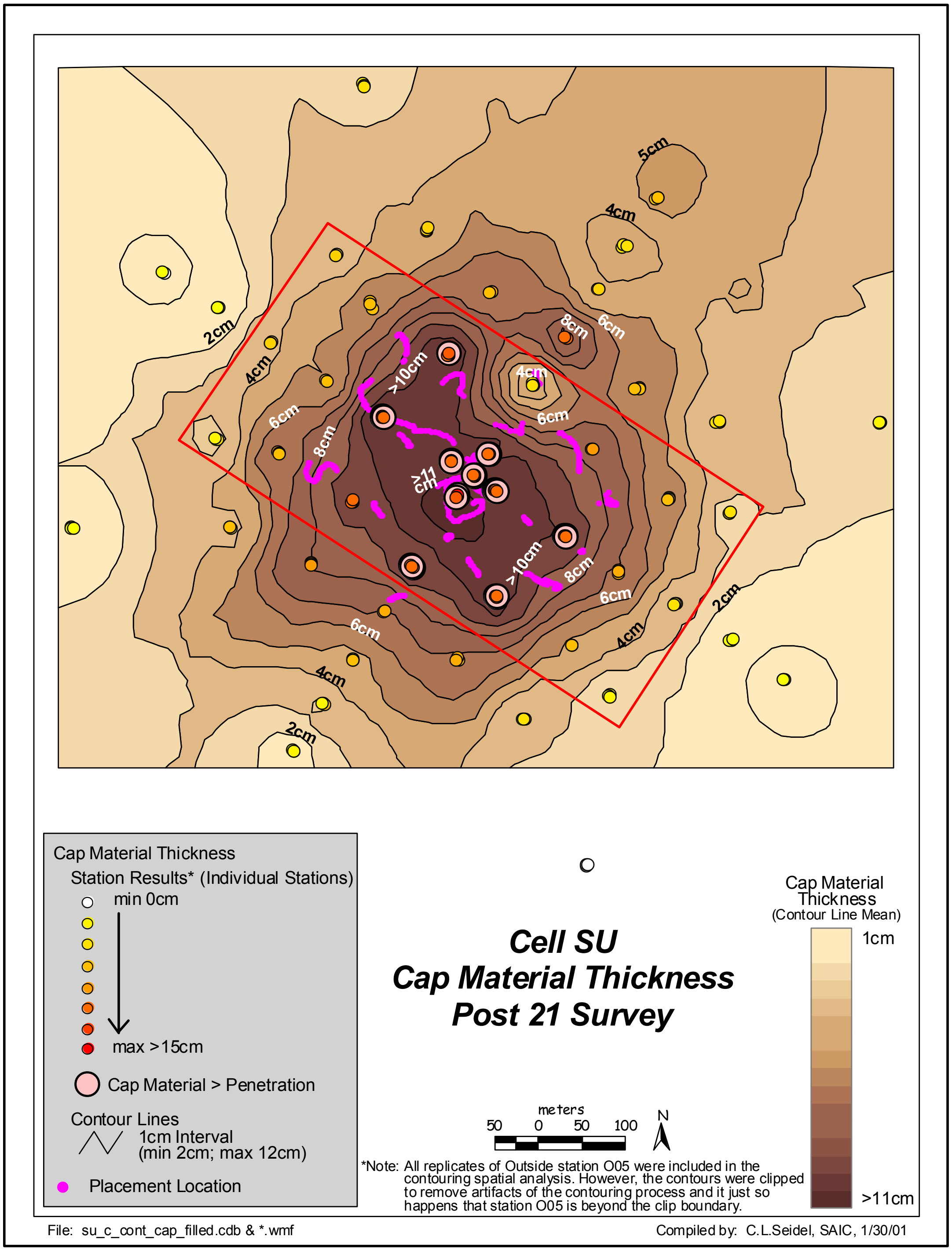


Figure 4.7-14. Placement locations and thickness of cap material on the seafloor in Cell SU for the Post 21 SPC survey. Contour lines are based on the average measured thickness of the cap material layer at each station (mean of n = 3 replicate sediment profile images), while each plotted circle depicts the cap material thickness measurement for an individual replicate image. Note that the average cap material layer thickness exceeded the penetration depth of the sediment profile camera at 10 stations inside the cell boundary (cap material > penetration).

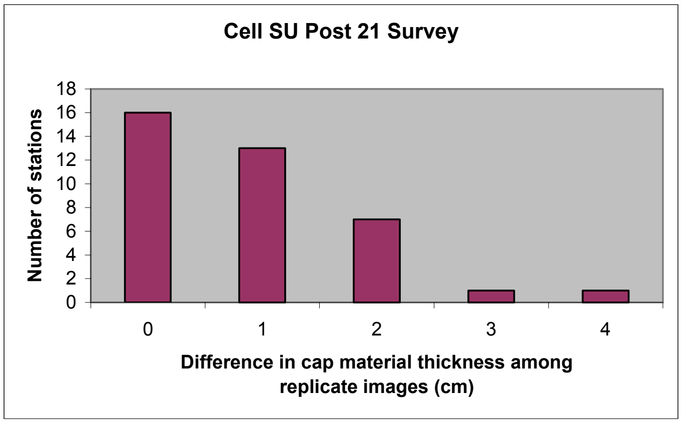


Figure 4.7-15. Frequency distribution of stations with a given maximum difference in cap material thickness among three replicate images, Cell SU Post 21 survey.

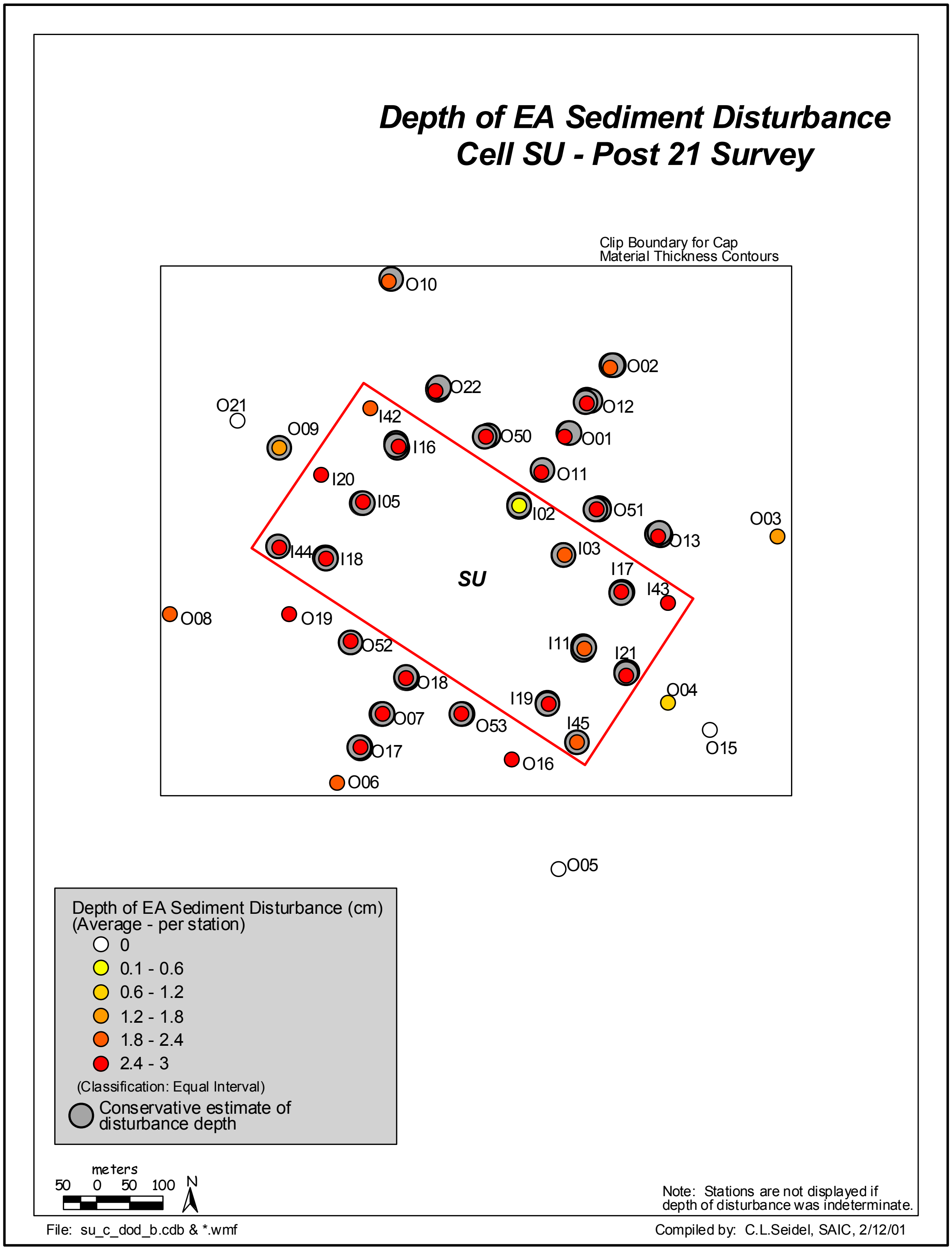


Figure 4.7-16. Estimated depth of disturbance of EA sediment for the Post 21 SPC survey in Cell SU.

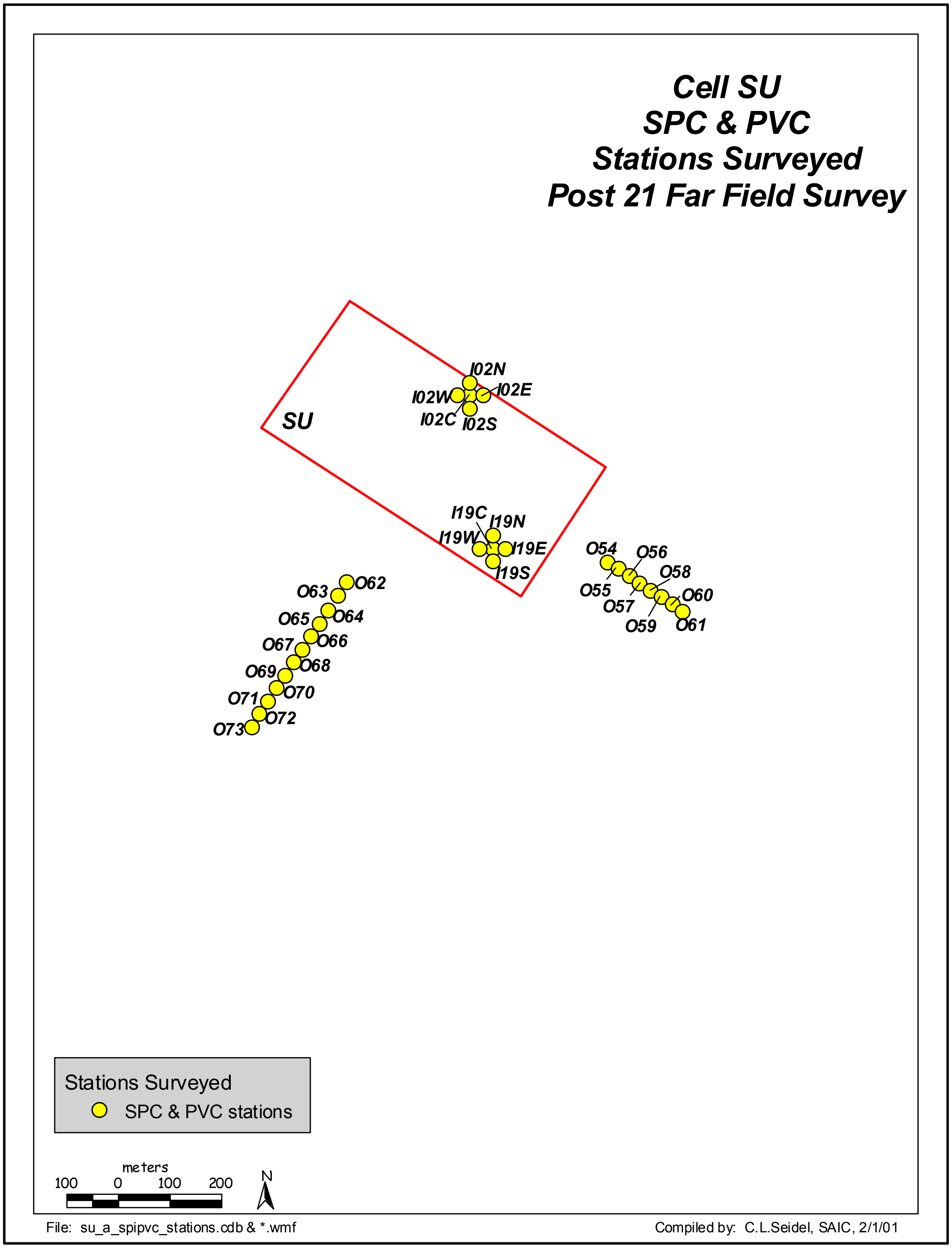


Figure 4.7-17. Station locations for the Post 21 Far Field SPC survey in Cell SU.

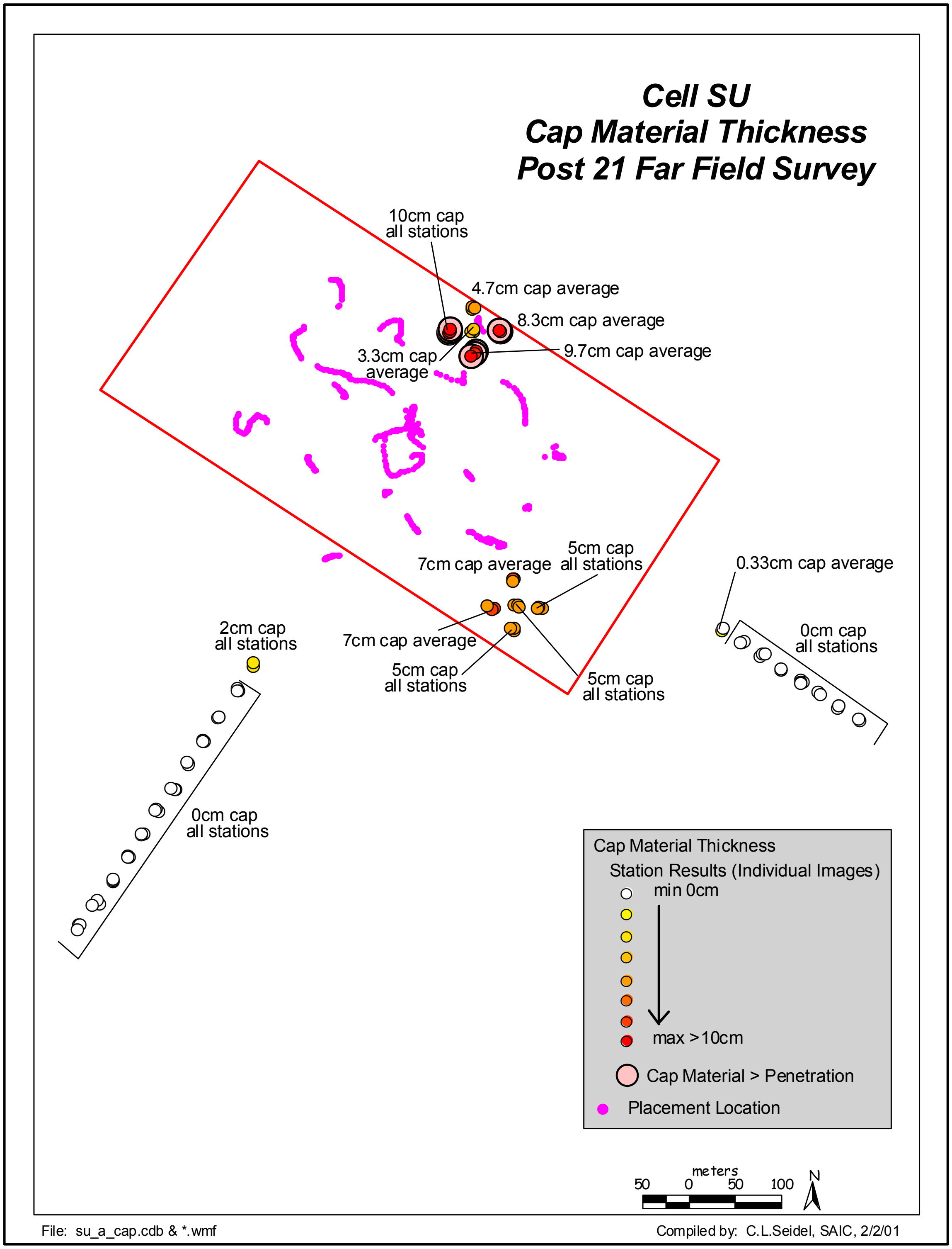


Figure 4.7-18. Placement locations and cap material thickness for the Post 21 Far Field SPC survey in Cell SU.

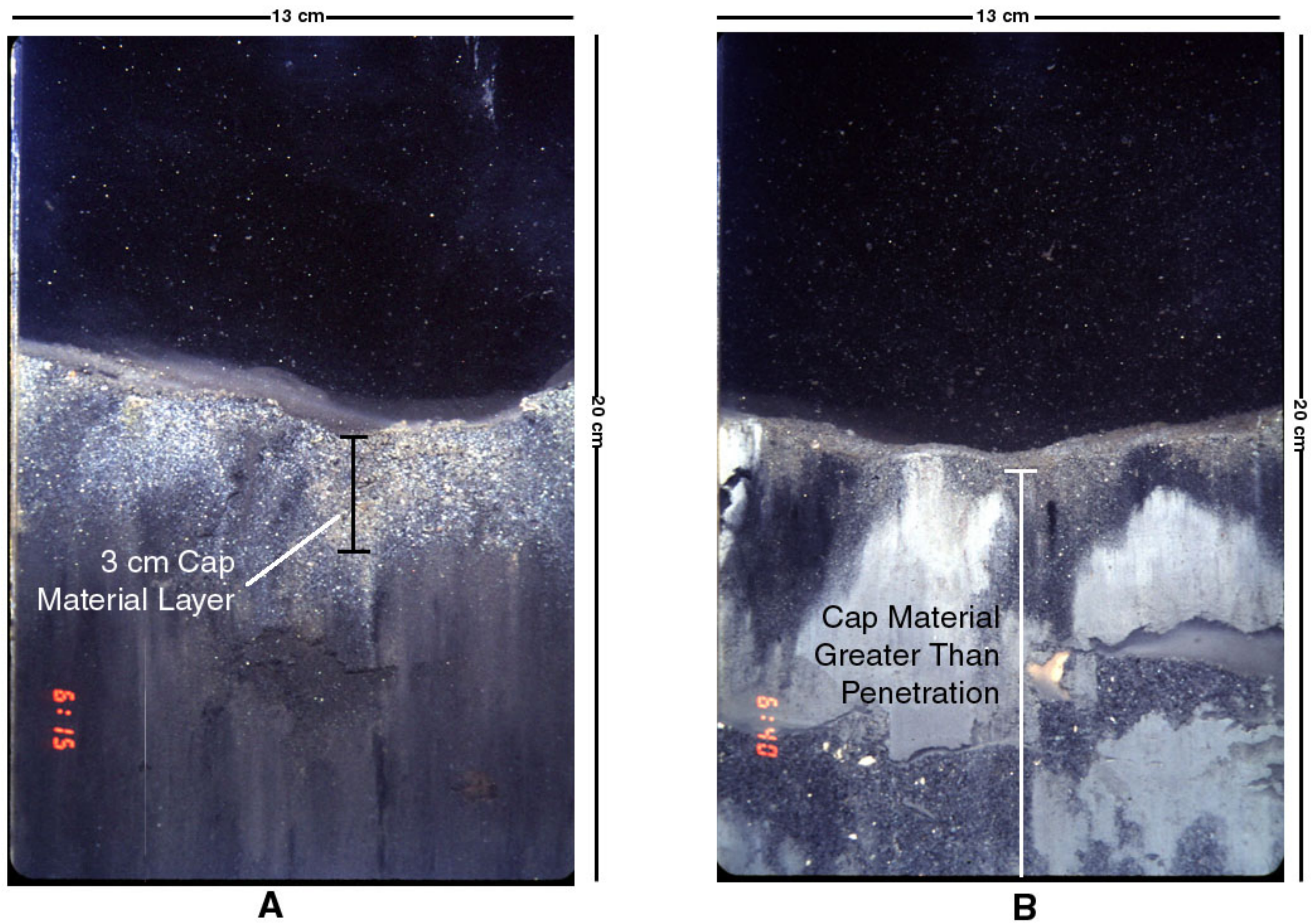


Figure 4.7-19. Two sediment profile images depicting variation in cap material thickness around station I02 in the Post-21 supplemental survey in Cell SU. Image A from station I02 Center shows a discrete cap material layer of gray sand measuring 3 cm thick, while image B from station I02 South shows cap material consisting of gray sand and gray cohesive clay extending below the penetration depth of the sediment profile camera.

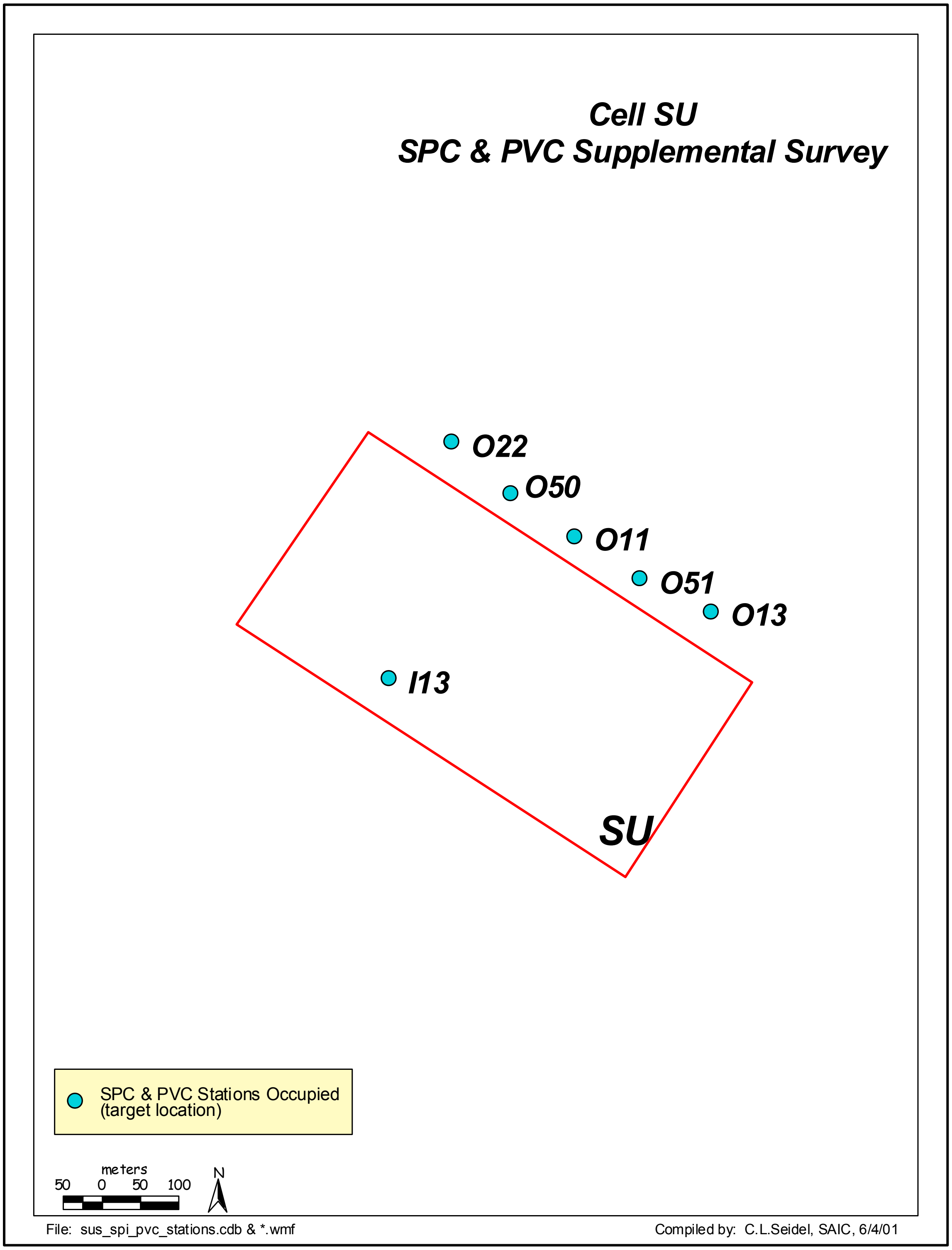


Figure 4.7-20. Station locations for the February 2001 Supplemental SPC survey in Cell SU.

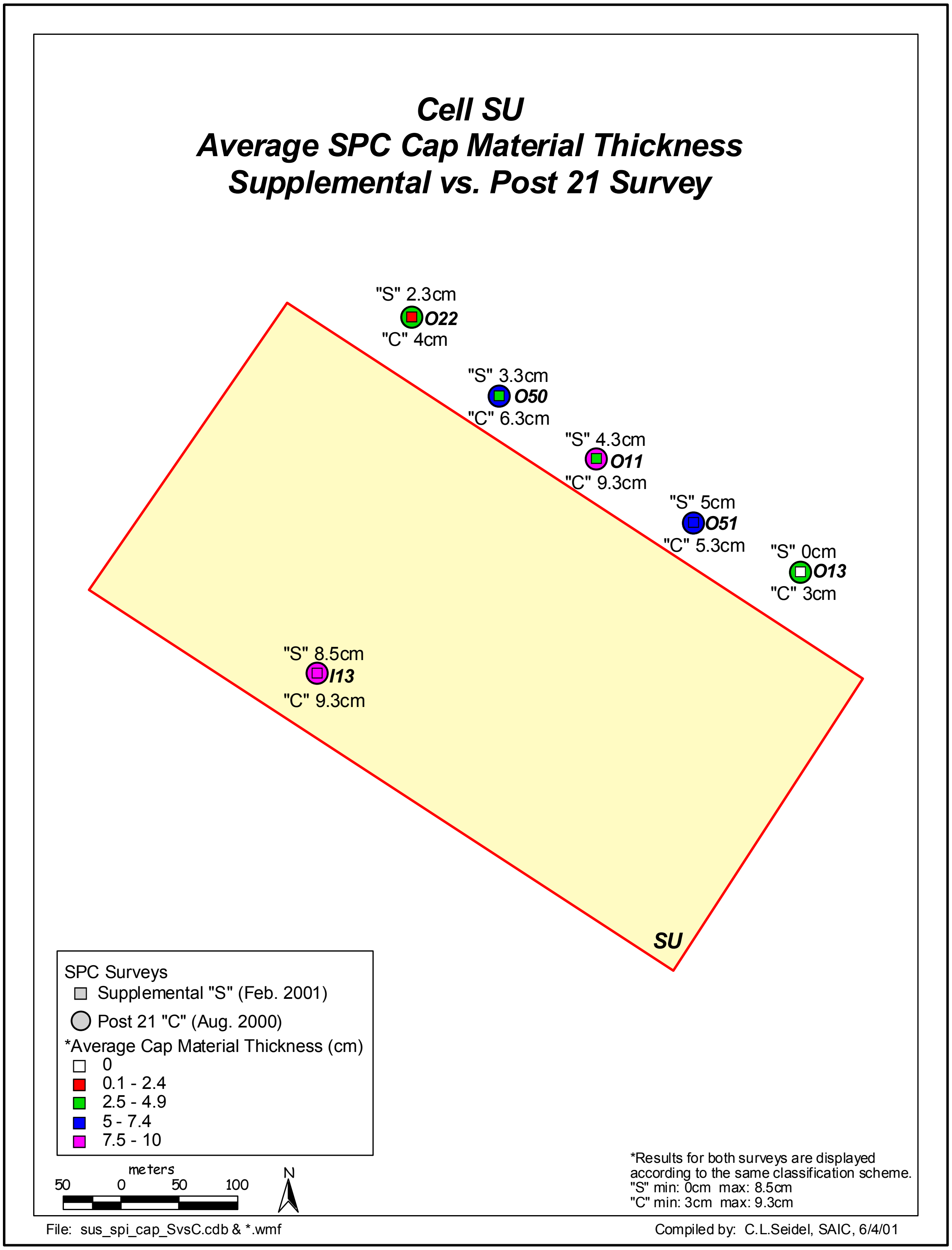


Figure 4.7-21. Average thickness of the cap material layer observed at each station in the September 2000 Post-21 survey and the February 2001 supplemental survey.

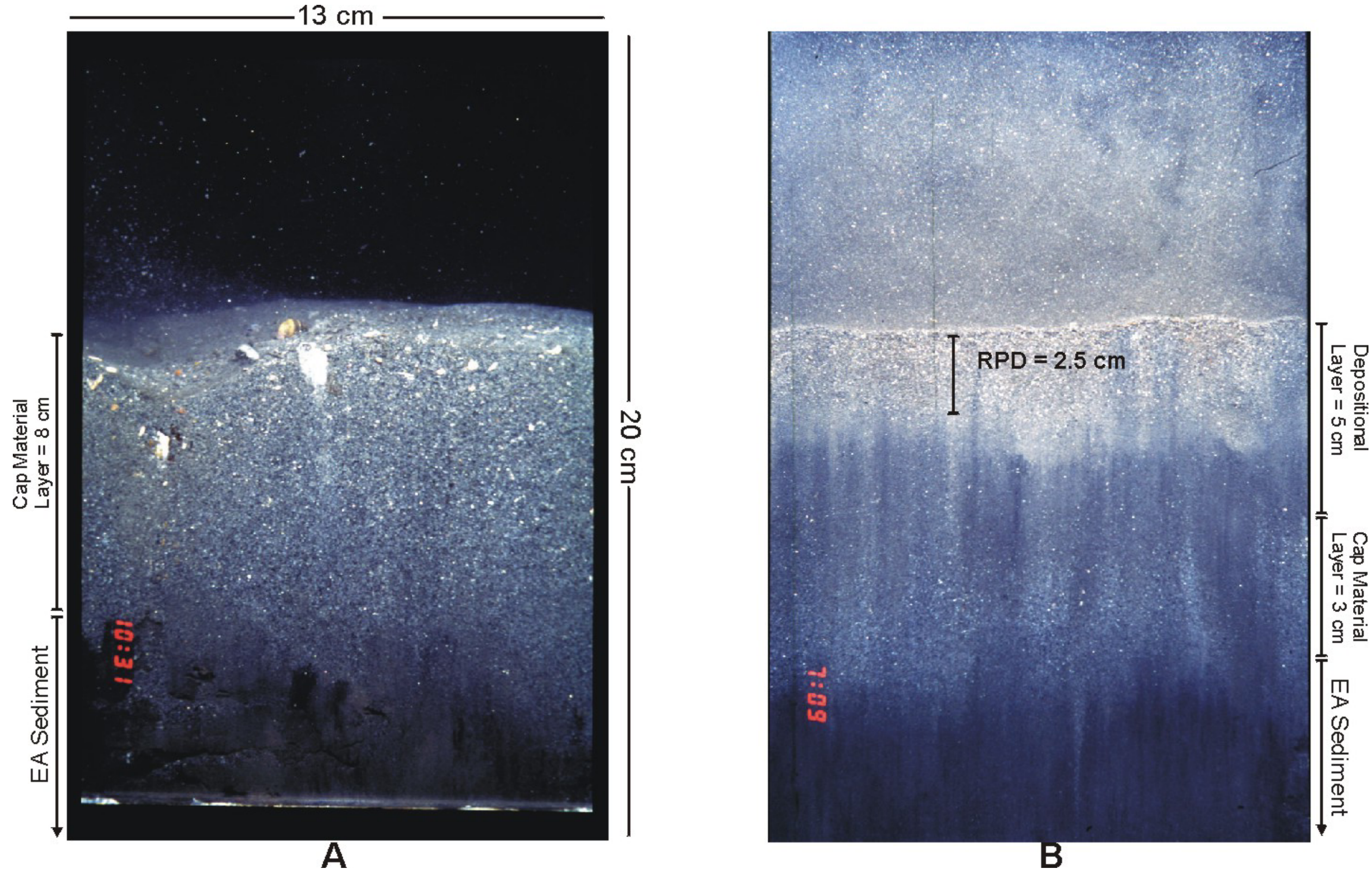


Figure 4.7-22. Sediment profile images obtained at Cell SU station O11 in the Post-21 survey of September 2000 (image A) and the supplemental survey of February 2001 (image B). Image A shows an 8-cm surface layer of grey sand (cap material from Queen's Gate channel) overlying EA sediment at depth. In image B, the cap material layer is still visible as a faint horizon of grey sand at depth, with an overlying surface layer of brown, fine-grained sediment. The thickness of the buried cap material layer in image B is 3 cm, while the new surface depositional layer is 5 cm thick. An RPD depth of 2.5 cm has developed in the new surface depositional layer.

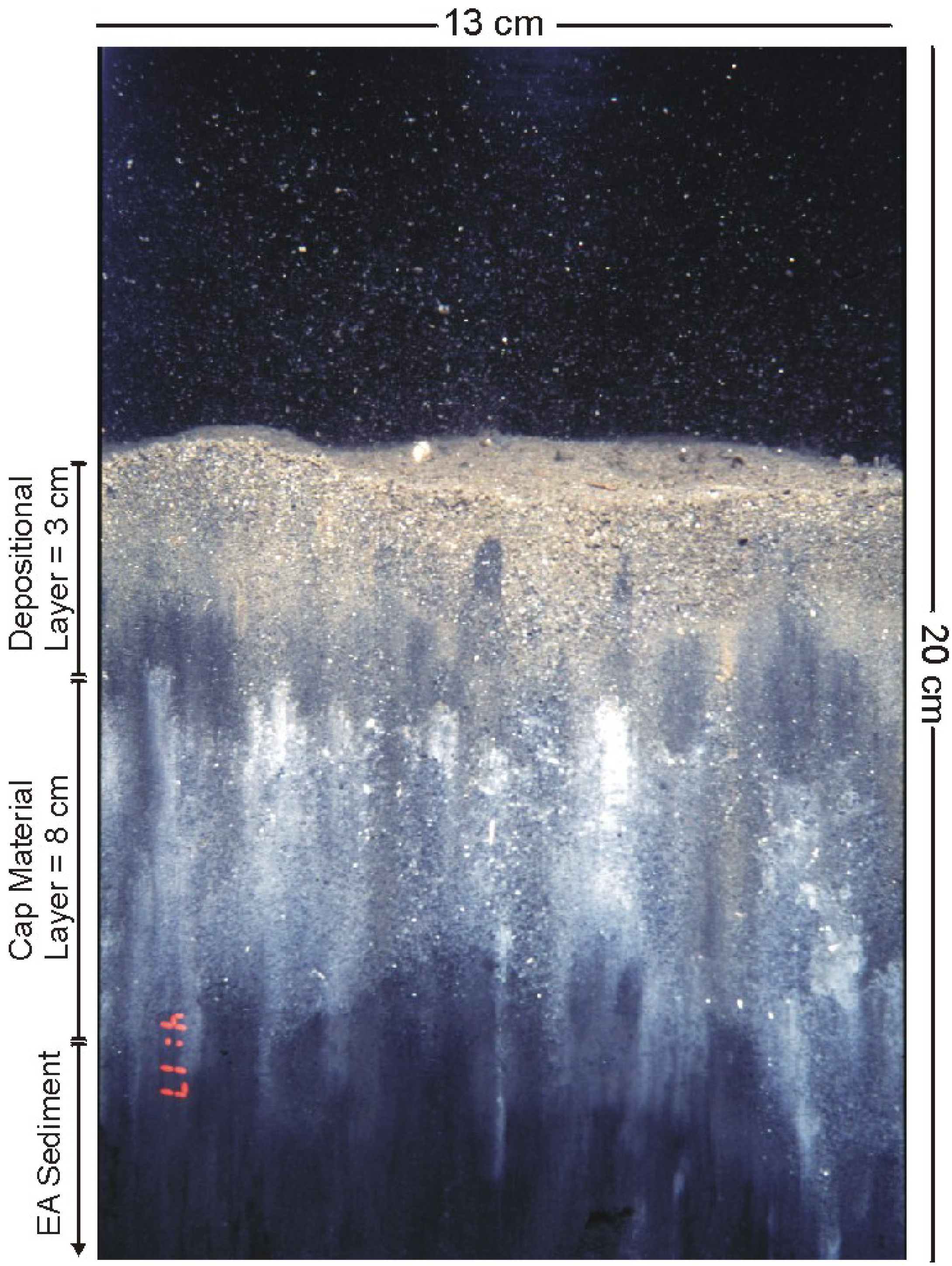


Figure 4.7-23. Sediment profile image obtained in the supplemental survey at Cell SU station I13. The image shows a 3-cm surface depositional layer of brown, fine-grained sediment overlying an 8-cm layer of grey cap material. The EA sediment that has been capped is also visible at depth.

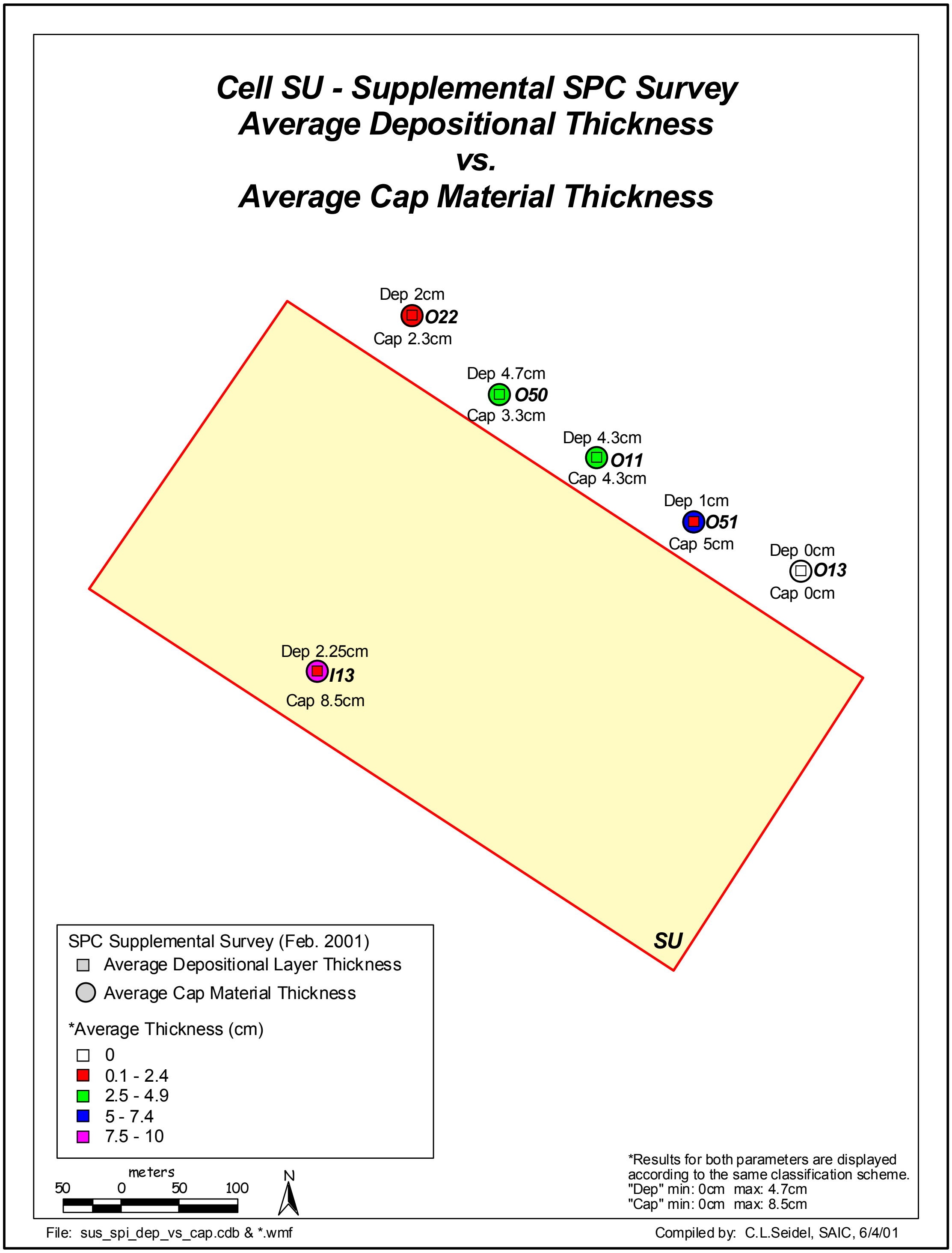


Figure 4.7-24. Map showing the average thickness of both the surface depositional layer of fine-grained sediment and the underlying cap material layer at each station in the February 2001 supplemental survey.

4.8 Cell SU Plan View Image Results

4.8.1 Overview of Field Sampling Plan

The field sampling plan for the SPC/PVC surveys in Cell SU followed the methods described in the FSP (SAIC 2000a and 2001). All SPC/PVC surveys that were specified in the FSP were completed. In many cases, additional stations for a number of surveys beyond those specified in the FSP were occupied to provide additional survey data. In addition, a supplemental SPC/PVC survey was performed in conjunction with a supplemental vibracoring survey in Cell SU in February 2001 to evaluate the presence of cap material and assess biological activity of the sediments approximately five and one half months after the completion of the pilot cap placement activities. Table 4.8-1 summarizes the PVC field sampling activities that were conducted in Cell SU for the Pilot Capping Project. The table presents both the number of planned stations to be surveyed as stated in the FSP as well as the actual number that was surveyed during each event. The percent completeness of the survey efforts is derived from these numbers. Additional details regarding the number and location of stations for each survey are presented in Section 4.8.4 Monitoring Results below.

The PVC and SPC surveys were conducted concurrently throughout the Summer 2000 project. However, for purposes of clarity and organization, the results for the sediment profile images (SPI) can be found separately in Section 3.7.

Table 4.8-1. Summary of Field Sampling Activities in Cell SU

SURVEY	NUMBER OF STATIONS		PERCENT COMPLETENESS
	REQUIRED	SAMPLED	
Baseline	25	42	168%
Post-1	37	44	119%
Post-5	14	19	136%
Post-21	37	49	132%
Post-21 (Flex Survey)	30	30	100%
Supplemental Survey	6	6	100%

4.8.2 Review of Data Quality Objectives

The reviews of the DQOs provided in Section 3.8.2 is applicable to PVC Monitoring in all pilot-capping cells. A review to how well the PVC DQOs were met are described in that section.

4.8.3 Technical Considerations

Technical considerations presented and discussed in Section 3.8.3 are applicable to PVC monitoring in all cells and, therefore, not repeated here.

4.8.4 Monitoring Results

4.8.4.1 Baseline Survey

The baseline plan view image survey for Cell SU was conducted on July 28, 2000. The purpose of the survey was to provide additional physical and biological information on ambient seafloor conditions to support the results of the SPC survey (Section 4.7). The Cell SU PVC and SPC surveys were conducted concurrently. The analyses of the plan view images generated during the Cell SU survey are consistent to those described in the Cell LU baseline survey (Section 3.8.3).

Plan view images were generated at each of 25 primary baseline stations located both inside and outside the cell boundaries (inside Stations I-01 through I-15 and outside Stations O-01 through O-10; Figure 4.8-1). Sampling also was conducted at 16 stations that formed two long transects to the northwest of Cell SU (Stations O-23 through O-35 and O-40 through O-42) to assess the spatial extent of capping material that may have extended into areas outside of the boundaries of Cell SU.

The topography of Cell SU was smooth and showed little evidence that physical processes (e.g., currents) were affecting the surface sediments. The sediments in SU were homogenous in both color and texture and were comprised of very-fine sandy-gray mud. Cell SU also appeared to have a visible flocculent layer on the surface sediments in a number of replicate images.

A small amount of biological burrows existed within Cell SU. These burrows were characterized by entrances that were flush with the surface sediments. The diameters of these burrows appeared to range between 0.3 and 2.5 cm in diameter.

Evidence of epifaunal activity in Cell SU included small fish, numerous organism tracks, small snails and hard-shelled spiraled organisms on the surface sediments (Figure 4.8-2).

4.8.4.2 Post-1 Survey

The Post-1 plan view survey was conducted on August 9 and 17, 2000, following the first cap material placement event in Cell SU (conventional placement of a single hopper load of Queen's Gate dredged material). A total of 45 stations were sampled in the Post-1 survey in Cell SU. The survey involved sampling at all 25 of the primary baseline stations (inside Stations I-01 through I-15 and outside Stations O-01 through O-10), as well as at 20 additional stations located both inside and outside the cell boundaries (I-20 through I-29, O-11 to O-13, O-15 to O-19, and O-21 to O-22; Figure 4.8-3). The analyses of the plan view images generated during the Cell SU Post-1 survey (and all additional Cell SU post-disposal surveys) was consistent with those described in the Cell LU surveys (see Section 3.8.3).

<u>Cap Material Footprint</u>

Cap material sediments were seen at 17 of the 25 inside Stations of SU (Figure 4.8-4). The cap material was distinguishable primarily by the presence of filled burrows, shell materials and clay clasts and was circular in shape. The degree of cap material coverage at these stations was primarily complete coverage, with the exception of Stations I02, 03, 10, 14 and 27, which were classified as having only partial coverage. An apparent color differentiation between the EA sediments and the cap material (darker gray) was seen in a number of the replicate images. No cap material was evident in any of the stations outside of the cell.

The clay clasts visible in many of the images differed in both the number present and the size of the clasts. The size of the clasts ranged from approximately 3 to 10 cm in diameter.

Shell material fragments were found at many of the inside stations that were located nearest the center of the cell, resulting in a shell fragment footprint that was essentially circular in shape (Figure 4.8-4). The majority of these stations were classified as having small or medium amount of shell material present. Stations I04, 09 and 26, which were classified as having a large amount of shell material. No shell material was seen at the stations outside the cell.

Biological Activity

The appearance of re-excavated burrows was minimal throughout the stations that had received cap material.

The presence of epifauna included a number of small fish and organism tracks. Infauna included many different types of visible worms and worm tubes of various sizes that were dispersed throughout the cell. (See Figures 3.8-16 and 4.8-2).

4.8.4.3 Post-5 Survey

Sampling for the Post-5 PVC survey occurred on August 22, 24 and 25, 2000, following the conventional placement of five hopper loads of Queen's Gate cap material in the center of Cell SU. Plan view images were obtained at 19 stations located within the cell, including the original 15 inside stations from the baseline survey and four additional stations located near the four corners of the cell (Figure 4.8-5).

Cap Material Footprint

Evidence of cap material was seen at 11 of the 19 stations that are located primarily within the center of the cell (Figure 4.8-6). Due to the small number of burrows that were seen in the baseline survey and the lack of extensive burrow walls, the identification of cap material based on filled burrows was difficult for a number of the stations for the Cell SU Post-5 analysis. The primary evidence of cap material was the presence of shell fragment material and clay clasts at the majority of the 11 stations where cap material was identified. The clay clasts varied in number and size (approximately 3 to 10 cm in diameter) at each of the stations.

Shell material fragments were observed at 13 of the 19 stations (Figure 4.8-6). The five stations nearest the center of the cell (I04, 07 to 09 and 12) were classified as having a medium amount of shell material. The ring of inside stations immediately surrounding these center stations showed primarily a small amount of shell material present.

Biological Activity

The re-excavation of burrows was evident in only a few of the station replicates. Epifauna that were observed in the images included a sediment-covered bottom-dwelling fish. Infauna that was observed included a sea pen worm extending from what appeared to be a re-excavated burrow.

4.8.4.4 Post-21 Survey

The Post-21 plan view survey was conducted on August 31 and September 1, 2000, following the conventional placement of a cumulative total of 21 hopper loads of Queen's Gate material in Cell SU. Images were obtained at a total of 49 stations, located both inside and outside the cell boundary (Figure 4.8-7).

Cap Material Footprint

The cap material footprint following the Post-21 survey indicated that 35 of the 49 stations showed evidence of cap material sediment (Figure 4.8-8). Eight of the stations (Stations I42 and 43 and outside Stations O05, 08, 09, 13, 21 and 22) did not appear to have cap material present. Three of the stations (Stations I44 I45 and Station O07) were classified as indeterminate as there were indications that cap material may or may not exist when replicate images were compared from each station. These indeterminate stations had replicate images that showed atypical EA or cap material sediments in the form of a blacker mud with clasts (Figure 4.8-9).

Shell material fragments were observed at 29 of the 49 stations located within and surrounding the cell (Figure 4.8-8). Four stations (Stations O01, 04, 11 and 12) were not analyzed as no replicate image existed for these stations. The degree of cap material coverage varied from small amounts to large amounts throughout the stations. The inside stations generally contained a small to medium amount of shells. The majority of the outside stations where shell material was observed generally contained small amounts of shell material. Two exceptions were Stations O06 and 10, where a medium and large amount of shell material was seen, respectively. Shell material (three of these stations were not analyzed) was not observed at the outside stations located to the northeast of the cell (landward).

Biological Activity

A number of biological burrows, including re-excavated burrows, were seen at many of the stations. These burrows predominately existed at the outside stations where the layer of cap material was thinner (based on SPI results), although a number of them can be seen at the inside stations as well.

Epifaunal evidence included bottom dwelling fish and many organism tracks. Infauna include a number of worms and worm tubes lying on, and extending from, the surface sediments (Figure 4.8-10.

4.8.4.5 Post-21 Supplemental Survey

The Post-21 supplemental plan view survey in Cell SU was conducted on September 13, 2000. Images were obtained at 10 stations in the cell boundary and 20 stations outside the cell (Figure 4.8-10). The 10 stations inside the cell comprised two cross-shaped sampling grids: one grid had Station I02 at its center (I02C) and the other was centered on Station I19. The surrounding stations in each grid were located 25 meters away in each of the four primary compass directions (e.g., I02N, I02E, I02S and I02W).

Cap Material Footprint

The cap material footprint following the Post-21 Supplemental Survey was confined to the two cross shaped sampling grids centered at Stations I02 and 09 (Figure 4.8-12). Many of the outside stations had the appearance of cap material sediments, but were classified as having no material present since the surface had little indication of the recent deposition of cap material. The sediment surface had extensive biological organism tracks, many burrows, numerous worm tubes and a homogenous flocculent layer on the sediment surface.

Sediment color changes and conditions were seen in the images generated along the Stations O62-73 transect. Sediment color at Stations O62-64, 66 and 70-73 were predominately light gray/brown. Stations O65 and 67-69 were a much darker gray and appeared to lack the flocculent layer that was present at the other stations. The sediment surfaces at these stations were uniform and very flat. Biological organism tracks and burrows were also more prevalent in the images from Stations O67-73.

Shell material was seen at all but three of the 30 stations sampled during this survey (Figure 4.8-12). A homogenous amount of very small shell fragments was observed at twelve Stations (O62-O73) located seaward of the cell.

Biological Activity

Epifauna observed in the images for this survey included a lobster and a large fish. Evidence of infaunal activity was quite extensive in a number of the replicate images including many different types of worm tubes, a number of sea pen worms extending from the surface and an image of a number of worms lying on the seafloor sediments. An extensive amount of biological organism tracks were seen in many of the outside station images, especially at the stations in deeper water (Stations O67-73). Burrow construction appeared to be more extensive at these stations as well exhibited more pronounced burrow walls (Figure 4.8-13).

4.8.4.6 Supplemental Survey

The Cell SU Supplemental Survey was conducted on February 24, 2001, approximately five and one-half months after the Post 21 Survey (conducted on September 13, 2000). One primary and 5 secondary SPC/PVC stations were occupied in cell SU during the supplemental survey (Figure 4.8-14). The purpose of the PVC survey was to identify the presence or absence of Queen's Gate cap material at these stations as well as to assess the status of the benthic habitat for comparison to the summer 2000 baseline and postcap surveys.

Cap Material Footprint

The presence or absence of Queen's Gate material for the Cell SU Supplemental Survey was inconclusive, as the sediments appear to be very similar to background conditions both biologically (small number of burrows) and in terms of sediment color. All replicate images show the presence of gray colored sediments, but whether or not these sediments are comprised of Queen's Gate material can not be determined. With the exception of one replicate image from station I13, the parameters typically used to determine the presence of cap material (i.e., filled biological burrows and/or shell material, etc.) are not directly evident in the images. A small amount of shell material and what appears to be filled burrows can be seen in one replicate image from station I13 and would tend indicate the presence of cap material (Figure 4.8-15). However, the results from the SPC survey show that a depositional layer of fine-grained materials overlies the cap material at all stations within SU.

Biological Activity

A small number of biological burrows can be seen in the plan view images (Figure 4.8-15). The size of the burrow channel openings range from approximately 0.5 to 1.25 cm. No direct evidence of epifaunal or infaunal activity (e.g., organism tracks, worm tubes) can be seen in the images.

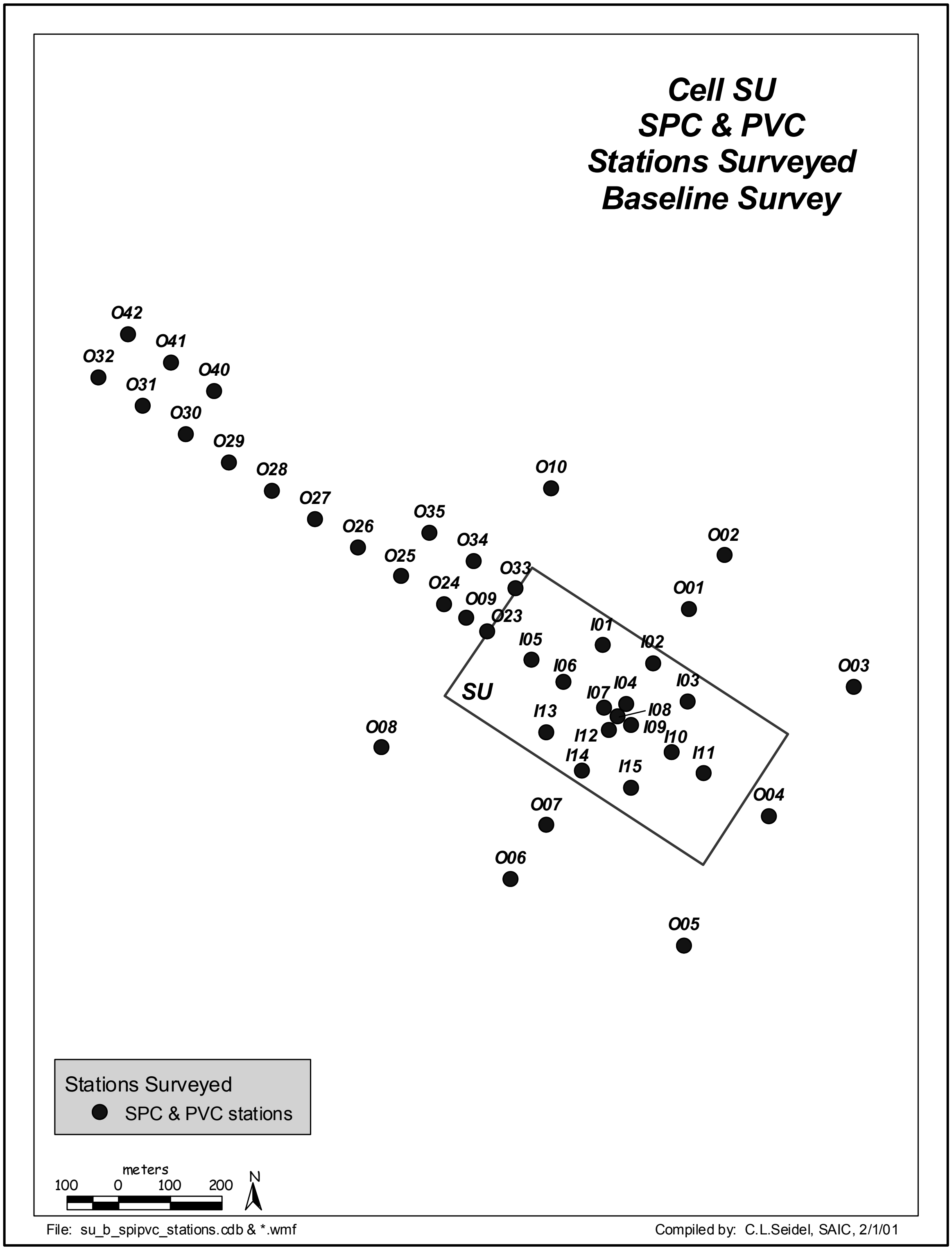


Figure 4.8-1. Cell SU SPI and PVC Stations surveyed - baseline survey.

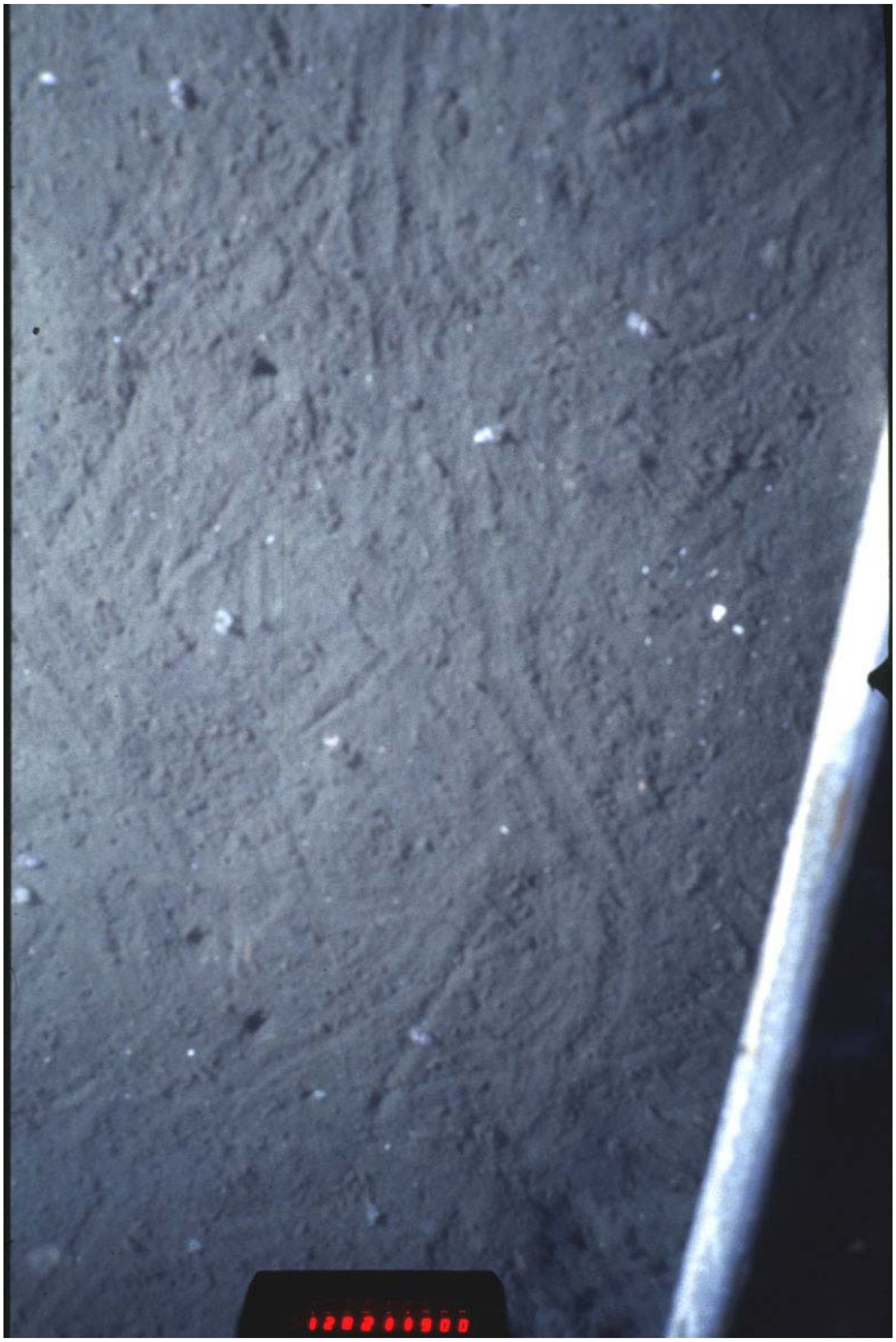


Figure 4.8-2. Evidence of Biological Activity in Cell SU. This plan view image acquired during the baseline survey in Cell SU at outside station O05 provides direct evidence of epifaunal and infaunal activity. The image shows numerous epifaunal organism tracks coupled with white spiraled organisms dotted across the surface. The image also shows small biological burrows. These burrows are estimated to measure approximately 0.5 to 1.5 cm in diameter.

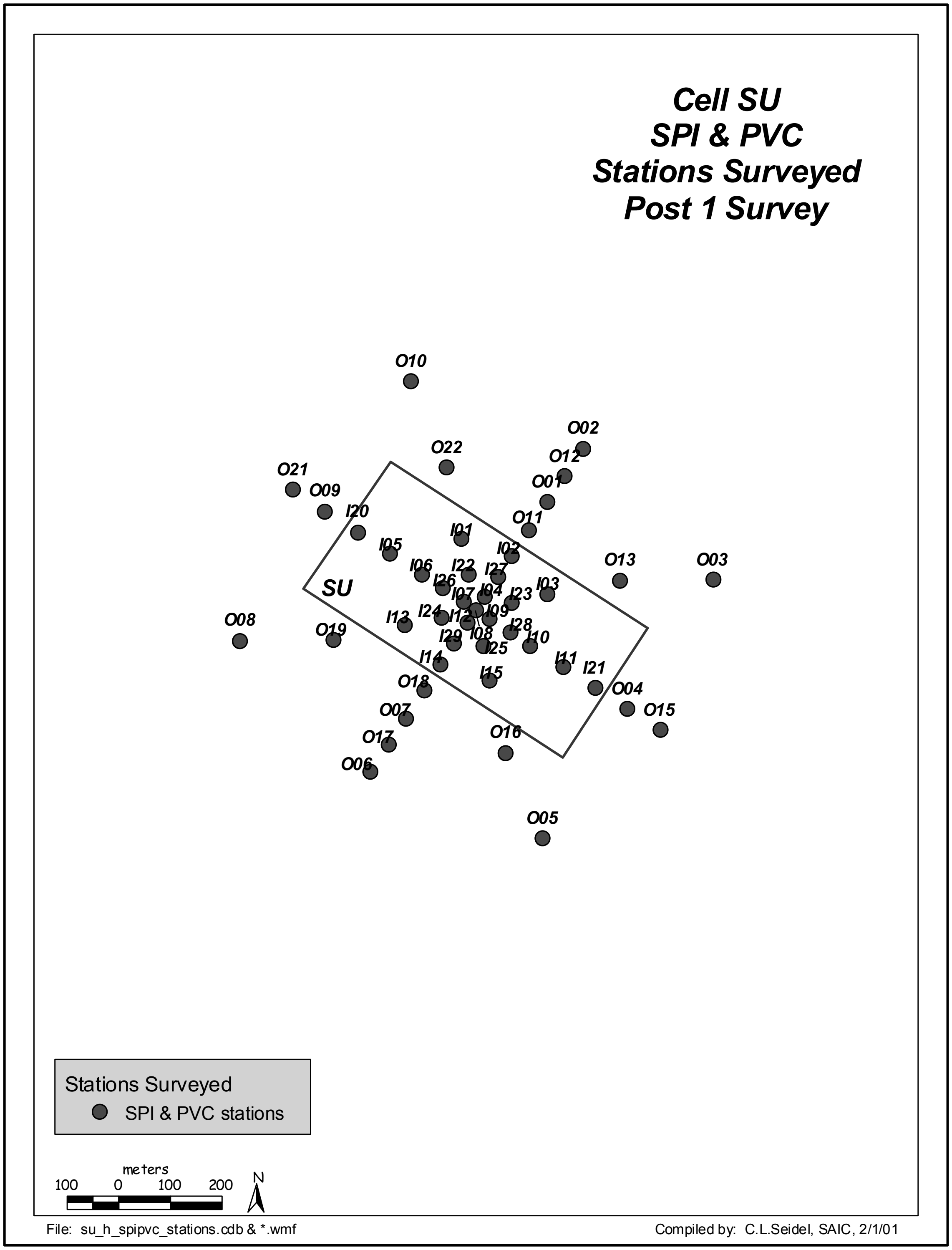


Figure 4.8-3. Cell SU SPI and PVC Stations surveyed – Post 1 survey.

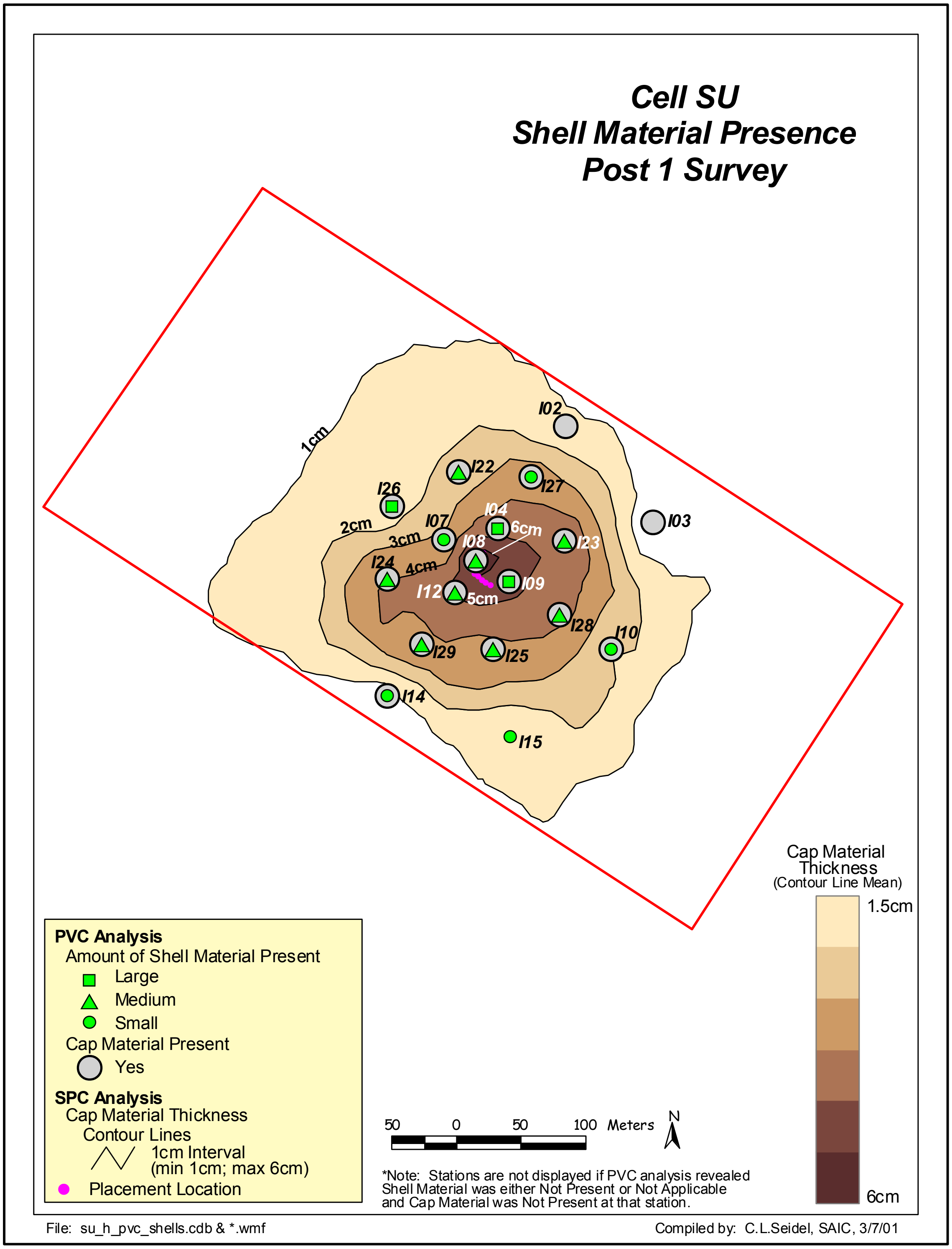


Figure 4.8-4. Lateral extent of cap material based on plan view image (PVI) analysis – Post 1 survey. The plan view image data are overlain on the SPI cap material footprint.

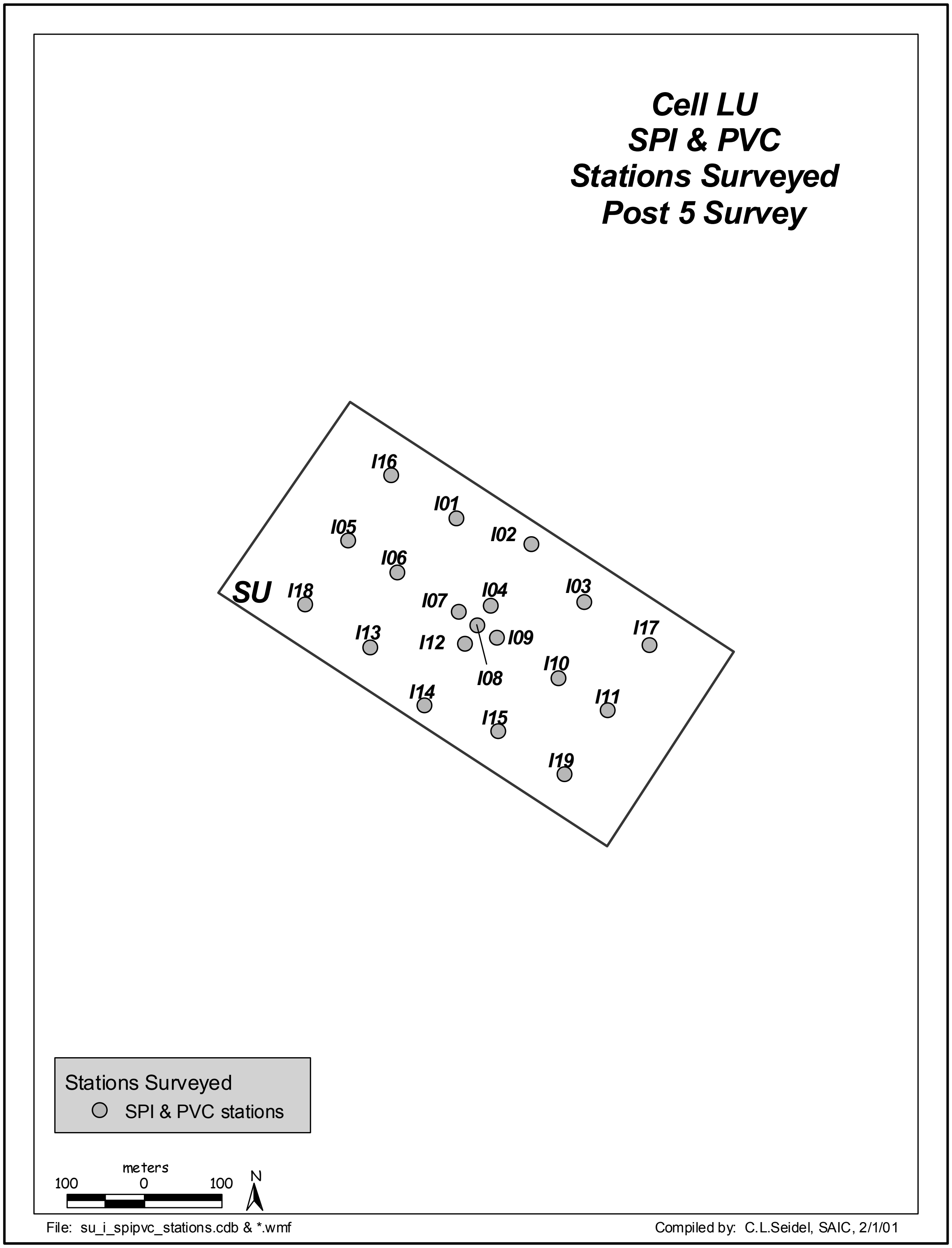


Figure 4.8-5. Cell SU SPI and PVC Stations surveyed – Post 5 survey.

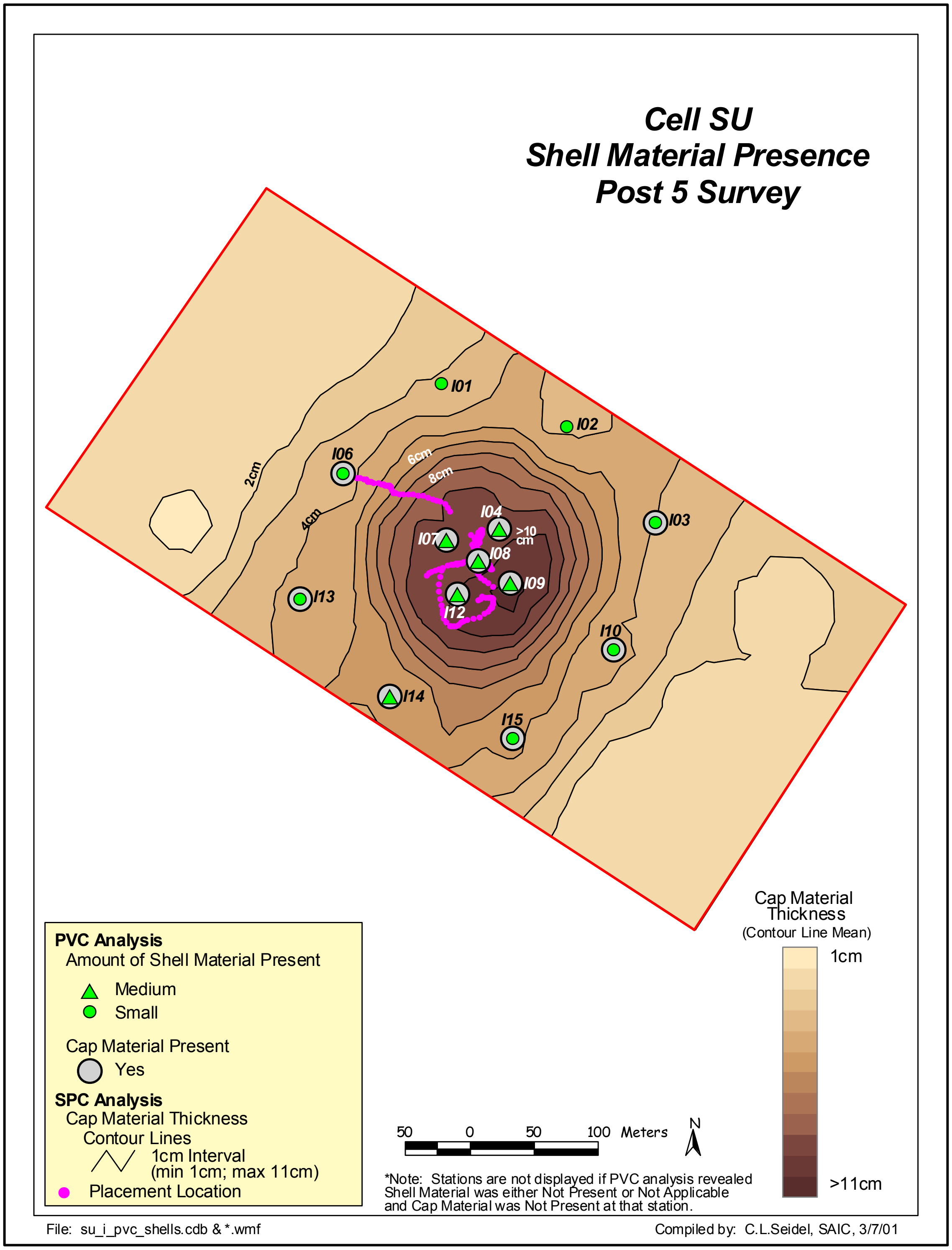


Figure 4.8-6. Lateral extent of cap material based on plan view image (PVI) analysis – Post 5 survey. The plan view image data are overlain on the SPI cap material footprint.

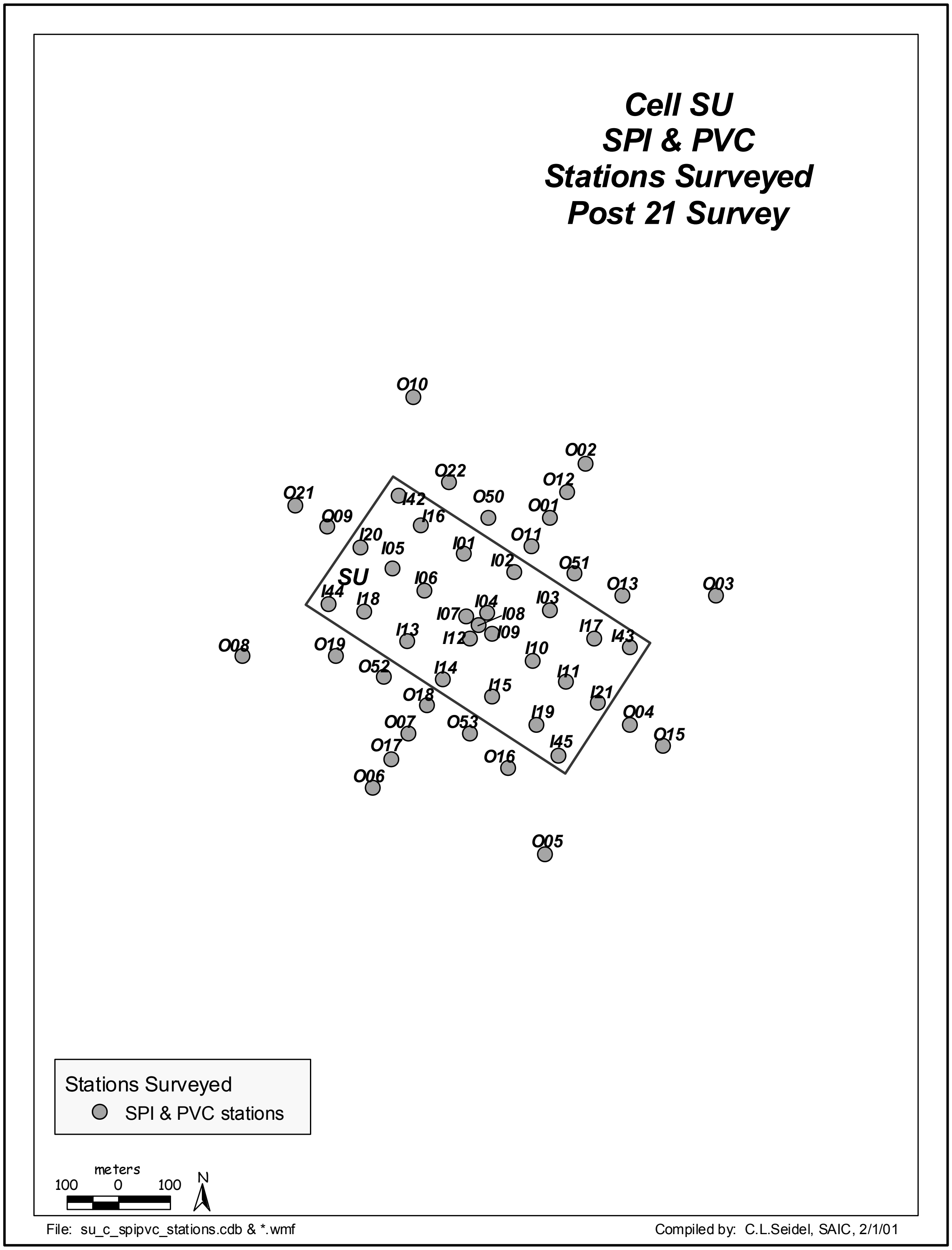


Figure 4.8-7. Cell SU SPI and PVC Stations surveyed – Post 21 survey.

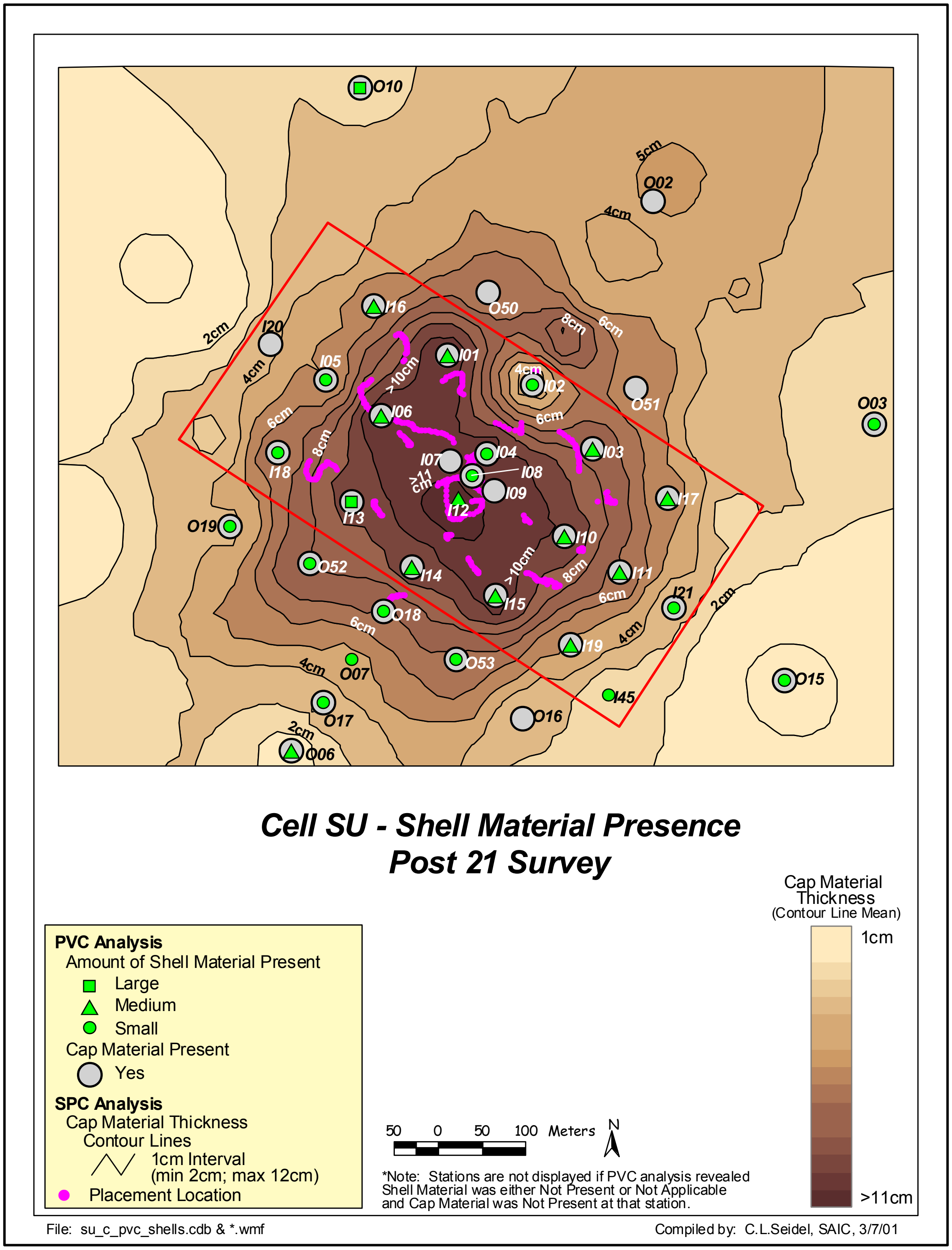


Figure 4.8-8. Lateral extent of cap material based on plan view image (PVI) analysis – Post 21 survey. The plan view image data are overlain on the SPI cap material footprint.

Figure 4.8-9. Atypical sediments in Cell SU. This plan view image acquired at Cell SU outside Station O07 shows atypical surface sediments compared to the fine-grained gray sediments that characterize the cell. Sediments similar to that shown here were also seen at inside Stations I44 and 45.

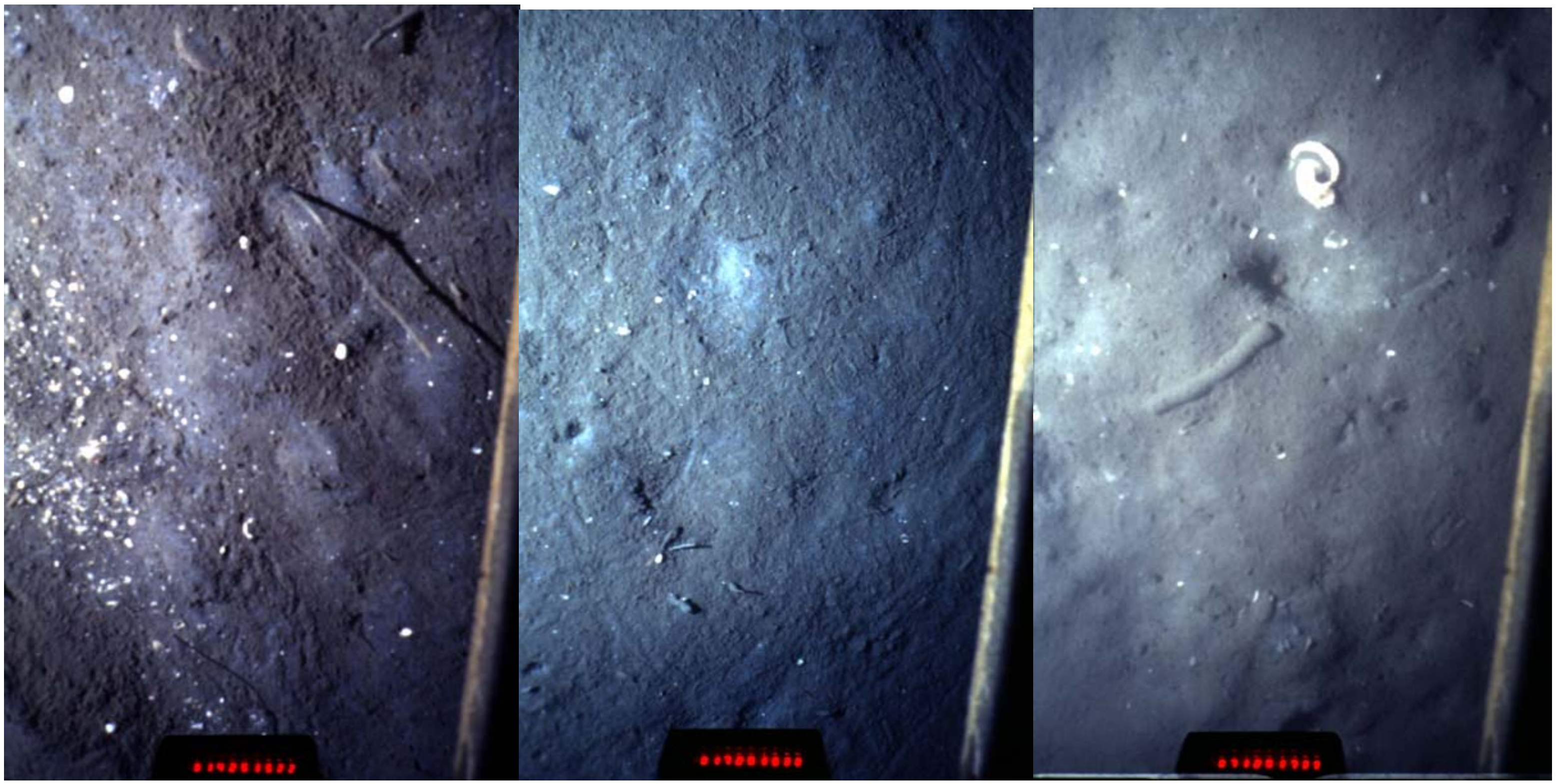


Figure 4.8-10. Evidence of biological activity in Cell SU. These plan view images acquired during the Post 21 survey in Cell SU at outside stations O06, O15, and O17 provides evidence of epifaunal and infaunal activity. The image shows numerous epifaunal organism tracks and a number of worm tubes lying on, and extending from, the surface sediments.

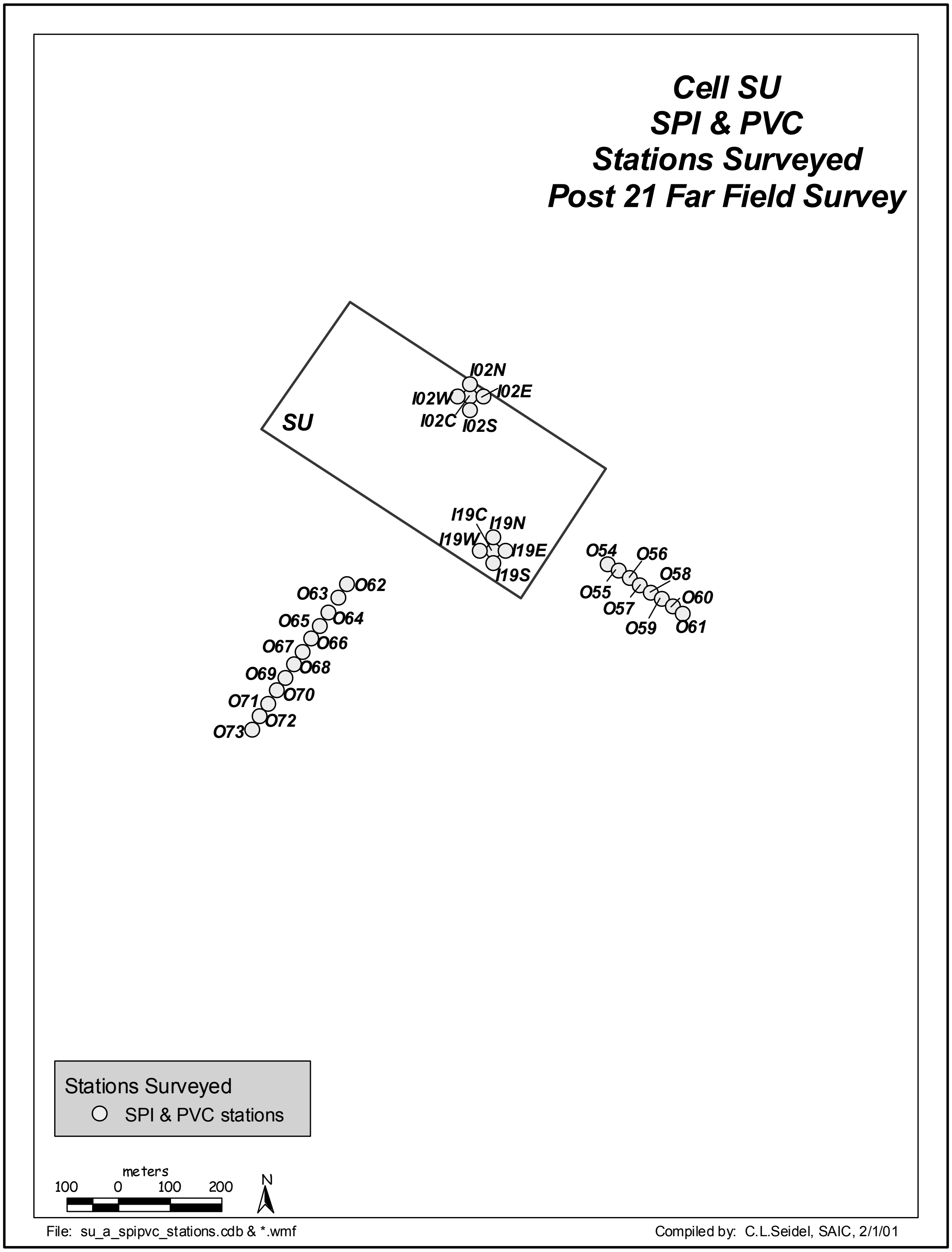


Figure 4.8-11. Cell SU SPI and PVC Stations surveyed – Post 21 Far Field survey.

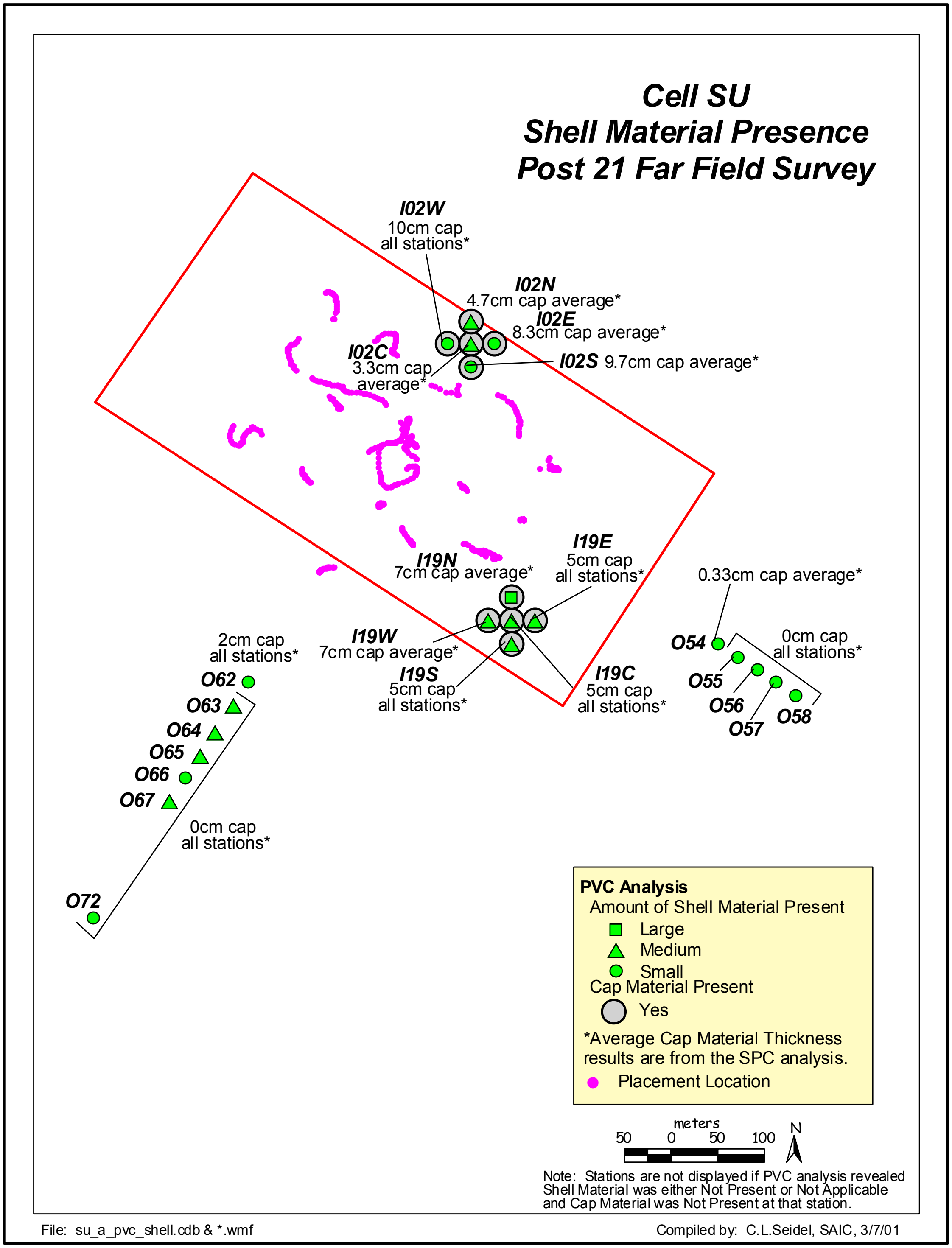


Figure 4.8-12. Lateral extent of cap material based on plan view image (PVI) analysis – Post 21 Far Field survey. The plan view image data are overlain on the SPI cap material footprint.

Figure 4.8-13. Re-excavated burrows. The image taken outside Station O71 during the Post 21 survey shows the re-excavation of biological burrows. Denoted by the well-constructed and more pronounced burrow walls.

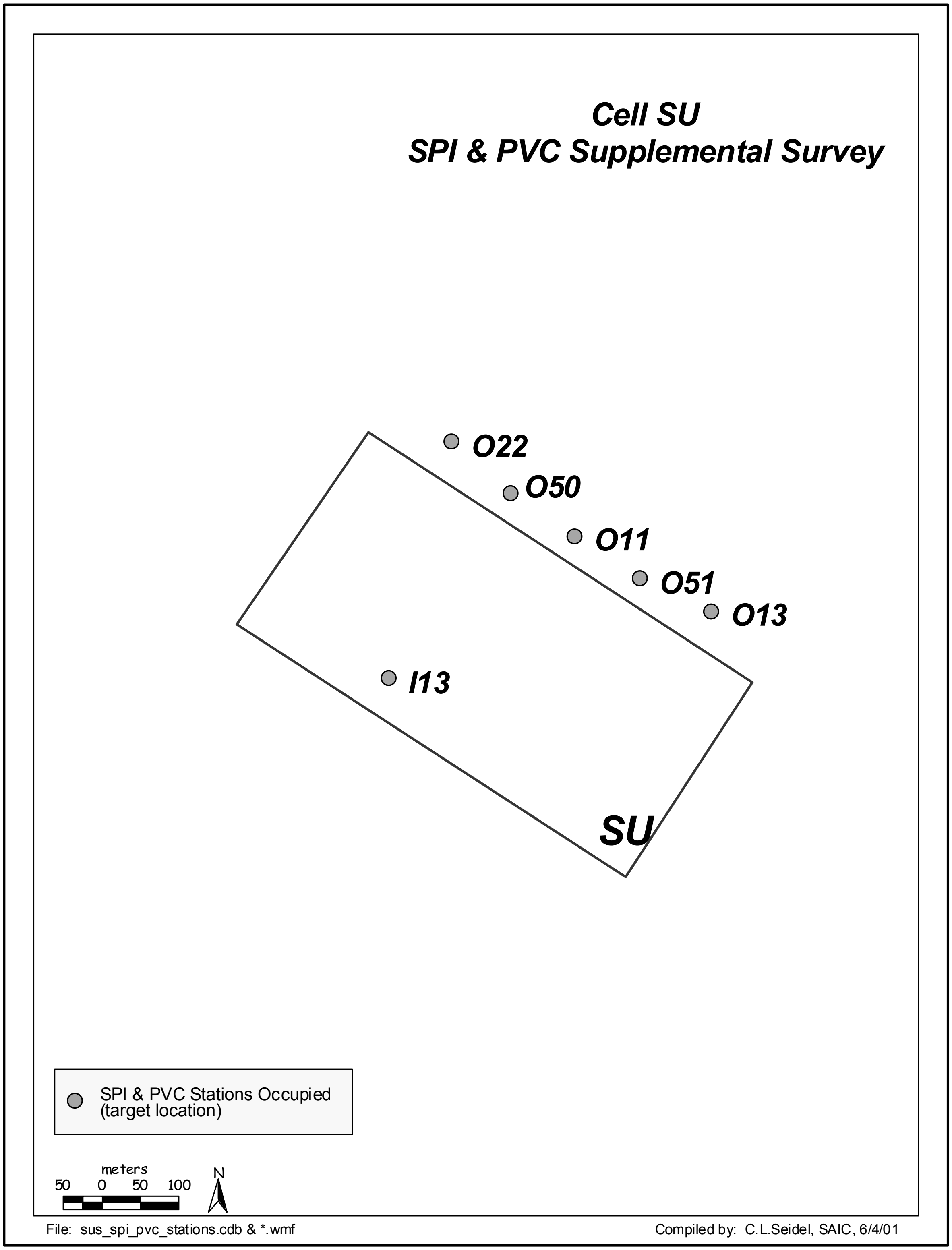


Figure 4.8-14. Cell SU SPI and PVC stations surveyed during the supplemental survey.

Figure 4.8-15. Plan view image acquired at Cell SU Station I13 showing a small amount of shell material and the appearance of filled burrows on the sediment surface which may indicate the presence of Queen's Gate cap material. The remaining replicate images from Cell SU looked similar to background conditions.

4.9 Seafloor Video Results from Cell SU

4.9.1 Overview of Field Sampling Plan

The field sampling plan for the seafloor video surveys in Cell SU followed the methods described in the FSP (SAIC 2001). In accordance to the FSP, one (1) video survey was conducted in Cell SU during the initial placement of cap material. A summary of the survey can be found in Table 3.9-1. The primary objective of the survey was to document plume surge at varying distances from the point of sediment release. Due to unexpected difficulty in deploying, retrieving, and maneuvering the camera system quickly, the majority of the surveys were conducted at one fixed point or while drifting for each placement event. The results of this survey are described in Section 4.9.4. A detailed description of this survey event can also be found in the Cruise Report (SAIC 2000b).

4.9.2 Review of Data Quality Objectives

The review of DQOs provided in Section 3.9.2 is applicable to the video monitoring surveys conducted in all pilot capping cells and, therefore, not repeated here.

4.9.3 Technical Considerations

The technical considerations presented and discussed in Section 3.9.3 are applicable to the video monitoring in Cell SU and, therefore, not repeated here.

4.9.4 Monitoring Results

<u>Placement 1 Survey</u>

The Cell SU Placement 1 video survey was conducted on August 8, 2000, during the placement of the initial load of Queen's Gate capping material. The purpose of the survey was to document plume surge and velocity associated with the placement of the cap material on the seafloor. The survey was conducted between 18:17:06 and 19:13:00 GMT. The initial stationary position of the vessel was located to the southwest of the center of the cell, where the placement of cap material was to take place (Figure 4.9-1). The vessel was not anchored and therefore began drifting in an easterly direction away from the cell.

The placement of the cap material occurred at approximately 18:34:29 GMT, but no plume was visible during the survey. Several macrofauna, including lobsters, were seen in the video footage.

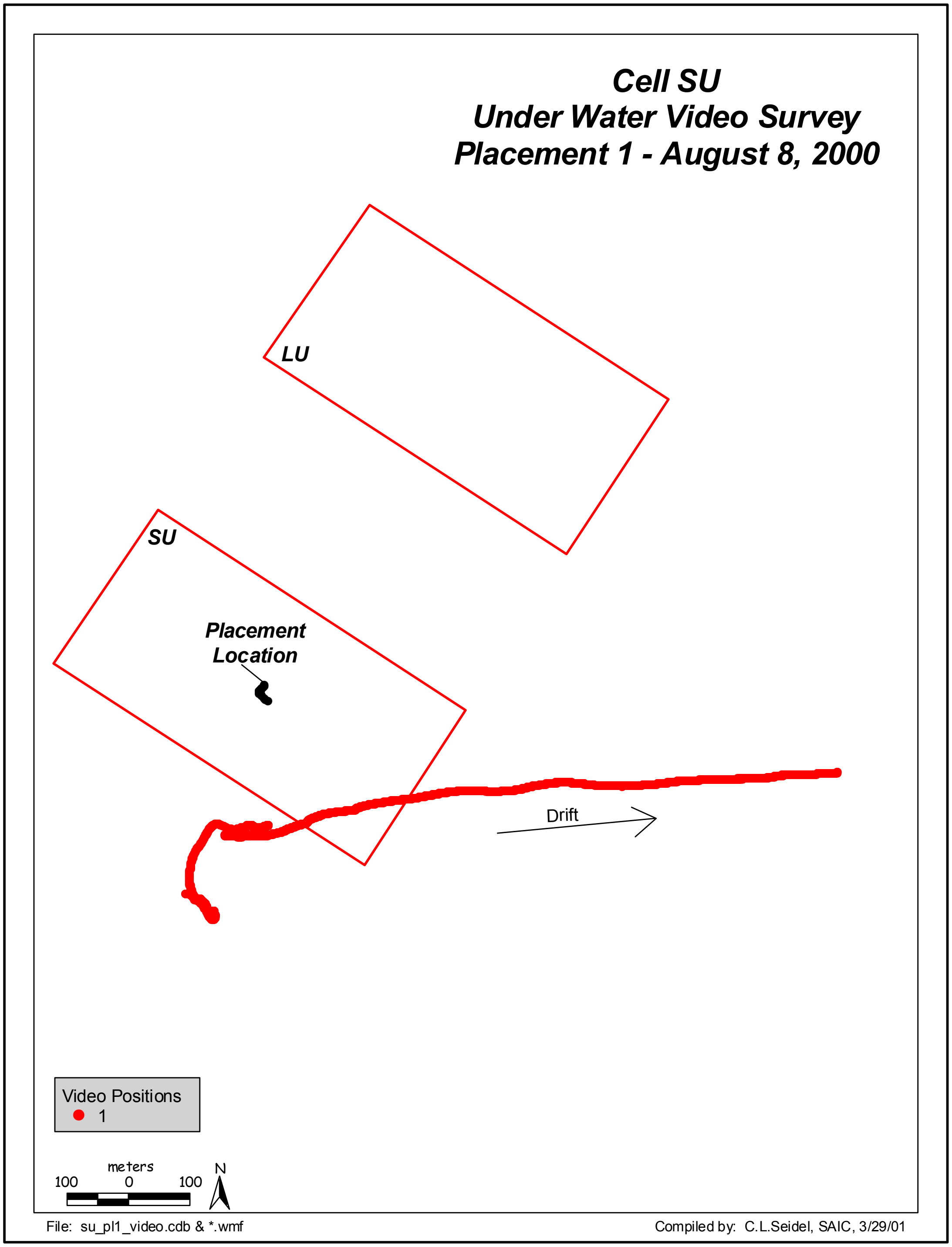


Figure 4.9-1. Cell SU Placement 1 Video Survey.

4.10 Side-scan Sonar Results

4.10.1 Overview of Field Sampling Plan

In addition to an initial baseline side-scan survey conducted in the spring, three follow-up side-scan surveys were conducted periodically through the summer during the active placement periods of the capping project within Cell SU. Of these three follow-on side-scan surveys, two were originally planned and one was added as a flex operation. The side-scan monitoring activities that were conducted in Cell SU are summarized in Table 3.10-1. In addition to summarizing the side-scan survey monitoring activities, this table also provides an overview of the ADISS and SPI monitoring activities that were conducted in Cell SU. Both the ADISS and SPI monitoring data proved very useful in the analysis and interpretation of the side-scan sonar imagery.

4.10.2 Review of Data Quality Objectives

The primary monitoring objectives that were to be evaluated through the side-scan data analysis was the ability to determine distributions of cap sediments, bottom disturbance features, and topography after both a single placement event and final cap placement. The monitoring objectives for the side-scan operations were presented in the PWP and are summarized in Table 3.10-2. All of the side-scan data acquisition efforts within Cell SU were successful, and full-bottom coverage imagery was obtained from each of the monitoring surveys. Except for the occasional loss of the differential signal, navigational accuracy met or exceeded the ±3 m data quality objective for all of the side-scan operations. Although at least 200% bottom coverage was obtained during each of the side-scan operations, most of the higher quality coverage data came from the lines run parallel to the bottom contours. The discussion addressing the difficulties associated with running the side-scan lines perpendicular to the steeply sloping bottom is presented in detail in Section 3.10.2.

4.10.3 Technical Considerations

In all but the baseline survey conducted in the spring, the presence of large schools of fish throughout the water-column had some impact on the quality of the side-scan records. In the image mosaics, the schools of fish generally show-up as small, dark, and irregularly-shaped patches scattered randomly throughout the records. The actual intensity of the acoustic return from the fish is dependent on the density of the school and also where in the water column the school is located. Schools located nearer to the surface will appear dark and well defined, whereas those located lower in the water column will be lighter and less defined. Although the fish may appear in the records as hard bottom features, their acoustic signature is somewhat different and can generally be distinguished from true bottom features. Although these schools of fish were present during most side-scan operations, they did not significantly obscure any bottom features. Figure 3.10-1 has been annotated to indicate several different views of these fish schools.

The only other non-placement related feature of interest was the sewer outfall pipe located in the southern portion of the survey area, well below the SU placement cell. As shown in Figure 3.10-1, this feature overlays very well on top of the charted sewer outfall as depicted on Chart 18476. During the course of the periodic side-scan operations, numerous survey lines were run over this feature to provide a data quality check on both the navigation and the side-scan sonar systems.

Immediately after data acquisition, the side-scan data was analyzed and edited as necessary using the Triton-Elics ISIS® software. After this initial quality control and data processing effort, a full-bottom coverage image mosaic was created using the Triton-Elics Delph-Map® software. These mosaics were then saved as a geo-referenced TIFF file and imported into Arcview® for additional analysis. Within Arcview®, any features of interest could be more closely examined at much larger scales, and mosaic images could be overlaid on top of one another to view any differences or similarities in the imagery. In addition, the side-scan mosaics could also be viewed in conjunction with other relevant data sets that were acquired within the same area during a similar time period. Of particular interest during the side-scan analysis, were the ADISS placement data and the sediment profiling cap contour data. Because the initial evaluation of the side-scan data was based on a subjective interpretation of the imagery, the additional data sets were an invaluable tool for verifying the validity of this interpretation. The interpretation and results from each of the side-scan monitoring surveys listed in Table 3.10-1 will be addressed in the sections below.

4.10.4 Monitoring Results

4.10.4.1 Baseline Survey

The baseline side-scan operation for Cell SU was conducted in mid-May 2000. The image mosaic created for this data is shown in Figure 3.10-2. This mosaic shows a relatively uniform and undisturbed seafloor with no prominent differences and only a few distinguishing features. The sewer outfall discussed above was evident in the southern portion of the survey area and a small, rectangular feature (11 m long) was detected in the inshore portion of the southern cross-slope survey lane. As noted earlier, the baseline survey was somewhat unique in comparison with the subsequent monitoring surveys because no schools of fish were present in the water column. The presence of fish is a seasonal occurrence that is dependent on a variety of environmental factors.

4.10.4.2 Post 1 Survey

The Post 1 side-scan survey was conducted on 8/10/00, eight days after a single placement event in the center of Cell SU. As depicted in Figure 4.10-1, this placement event can be clearly identified in the side-scan mosaic, and the image correlates well with the ADISS position for this event. It is likely that this initial placement created a slight impact depression as it struck the seafloor, and that a mix of the displaced ambient material and cap material surged laterally outward from the main impact area. This disturbed area exhibits a much stronger acoustic signature than the natural ambient bottom material, and shows up clearly on the side-scan mosaic. On the up-slope side of the main impact area there is a high reflectance edge on the image and not much indication of any surge beyond this edge. On the down-slope side of the impact area, there is more indication of the lateral surge away from the center.

When the SPI cap contours are compared against the mosaic, they show that the thicker portions of the cap correspond well with the darker portions of the image mosaic. Based on the comparison with the SPI contours, the darker areas depicted in the image mosaic represent the areas where the cap layer from this single point placement is greater than four centimeters. The outer extent of the lateral surge pattern seen in the imagery appears to correspond well with the 3 cm SPI cap contour. The thin layer of cap material (<3 cm) indicated in the outer portions of the SPI cap contours cannot be differentiated from ambient material in the side-scan imagery.

4.10.4.3 Post 5 Survey

The Post 5 side-scan survey was conducted on 8/19/00, six days after the fifth placement event; placement events two thru five were all directed near the center of Cell SU within the footprint of the first placement event. As depicted in Figure 4.10-2, the general placement area can be identified in the side-scan mosaic and the image correlates well with the ADISS positions for the five prior placement events. It is not possible to identify each individual placement event, because each later placement essentially covered-up the remnants of the previous placement. This placement strategy of targeting within the prior cap impact area was used so that each of the subsequent placement events impacted already placed cap material instead of ambient material. Although the lateral surge from the first placement event was probably comprised of both cap material and some displaced ambient material, the lateral surge from the subsequent placement events was comprised almost solely of cap material.

As the cap layer was built-out from the center, any ambient material displaced during the first placement was covered over with additional cap material surging outward from each subsequent placement. Since the bottom disturbance from these events occurred on recently placed cap material and already disturbed bottom, the apparent cap footprint depicted in this mosaic is actually less pronounced than the footprint indicated from the Post 1 survey. These events illustrate that because of the differences in the extent of the bottom disturbance, that the acoustic footprint of a placement event is more pronounced when it has impacted ambient material as opposed to recently placed cap material. Essentially, the side-scan image is providing a measure of the disturbance footprint, and not a true cap footprint. The SPI cap contours indicate that the cap area was enlarged considerably by these events primarily outward from the center of the cell (Figure 4.10-2). Because the image mosaic essentially shows the seafloor impact from only the most recent placement event, it is not possible to correlate the SPI cap thickness from five events with apparent cap footprint depicted on the mosaic.

The down-slope side of the Post 5 image mosaic shows evidence of the lateral surge pattern extending well beyond the cell limits and as far as 175 m from the primary placement area. On the up-slope side, the lateral surge pattern is far less pronounced and extends less than 100 m from the primary placement area. This more extensive surging of material on the down-slope side is also reflected in the SPI cap contours. Both the four and five cm SPI cap contours show far more extensive cap build-up on the down-slope side of the placement area. Also, it appears as if the extent of the lateral surge pattern observed on the image mosaic is closely aligned with the four cm SPI cap contour.

4.10.4.4 Post 21 Survey

The Post 21 side-scan survey was conducted on 8/26/00, one day after the 21st placement event; placement events six thru 21 were directed throughout the extent of Cell SU, beginning near the center of the cell and then working outward towards the cell boundaries. This strategy was employed so that each placement event was primarily impacting already placed cap material and not ambient sediment. As the cap layer was built out, the potential placement target areas could also be expanded outward. As depicted in Figure 4.10-3, the general placement areas can be identified in the side-scan mosaic and the image correlates well with the ADISS positions for these events. For this survey, several of the individual placement disturbance areas near the center of the cell are not evident because the disturbance footprint from nearby later placement events has covered them over. Because the placement events during this period were more evenly spread around the extent of the cell, the apparent cap footprint images for the outer placement events closely resemble the single cap footprint images obtained during the prior surveys. This was a day where the schools of small fish in the water column had the greatest impact on data quality. Although most of the placement events can still be identified in the mosaic, some of the records are obscured or blurred by fish interference low in the water column.

This mosaic included a few narrow and linear bottom features that were not detected on any of the earlier side-scan surveys in Cell SU. A close examination of these features revealed that each of these features originated from the site of a recent point placement event. Because the placement event images on the mosaic corresponded so well with actual ADISS placement data, it was thought that these linear features represented a cap material trail that was left by the dredge as it departed the placement site with its pumps still operating. Although the ADISS plots typically present the dredge approach to the site and the main placement location, position data is also recorded as the dredge departs the placement site. By overlaying this dredge departure data on the side-scan mosaic, it was clear that these features did represent a narrow cap material trail that was created as the dredge left the main placement site. Although the curved departure trails from Placement Events 19 and 20 show up most prominently, a few other probable trails are also evident in the mosaic. Several of these features have been highlighted in Figure 4.10-3.

4.10.5 Discussion

The monitoring operations conducted in Cell SU verified that side-scan imagery could be used to identify distribution of cap sediments and bottom disturbance features (the first and second parts of the first monitoring objective) following a single placement event. However, because the seafloor topographic changes associated with a single placement event are so small, side-scan imagery cannot determine topographic changes following a single placement event (the third part of the first monitoring objective). Because of the grain-size similarities between the cap and ambient bottom material, it is likely that the ability to identify the distribution of cap material is primarily a function of the bottom disturbance rather than significant differences in the acoustic properties between the cap and ambient material. It also appears as if the acoustic cap footprint of a placement event is somewhat more pronounced when it has been made over ambient bottom rather than recently placed cap material.

During all of the Cell SU side-scan operations, a single point placement event produced a consistent acoustic signature. There was generally a high-reflectance circular area with a diameter of approximately 125 m, and then a lighter-return, scattering pattern radiating outward another 15 to 25 m from this strong-return area. It is thought that this high-reflectance area represents the main disturbance area created as the cap material impacted the seafloor while the lighter-return, scattering pattern represents the lateral surge of material away from the main impact point.

The Cell SU Post 1 survey was the only iteration that allowed a direct correlation between the SPI cap contours and the acoustic cap footprint. All subsequent placement events after the first one contributed to the cumulative cap build-up while simultaneously covering up the seafloor surface effects of any prior placement that fell within its acoustic footprint. Because the side-scan imagery only provides an acoustic return of the seafloor surface, it cannot be expected to reflect the cap build-up resulting from numerous placement events conducted over the same general area. The comparison between the Post 1 side-scan image and the SPI cap contours (Figure 4.10-1) showed that the inner high-reflectance circular area correlated well with the 4 cm SPI cap contour, while the lighter radial spreading pattern correlated well with the 3 cm cap contour. Beyond the 3 cm contour, no definitive differences between the cap and ambient sediment could be detected on the side-scan image.

The second monitoring objective addressed the ability of side-scan imagery to determine distribution of cap sediments, bottom disturbance features, and topography following final cap placement. As illustrated in the Cell SU Post 21 side-scan image (Figure 4.10-3), the most recent side-scan image will only reflect those placement events that have not been obscured by more recent events. Although 21 placement events were conducted in Cell SU prior to the final side-scan operations, only a few of these events can still be clearly identified in the imagery. Because the side-scan imagery only reflects the surface seafloor conditions resulting from the most recent placement events, it can only be expected to determine distribution of cap sediments and bottom disturbance features associated with these same recent placement events.

There were no major topographic changes detected during the side-scan operations within Cell SU. The ability to detect any topographic changes would tend to be more of a long-term monitoring objective associated with the final cap placement, not individual placement events. Although single-beam or multibeam hydrographic surveying is the primary technique for measuring seafloor topographic changes, side-scan imagery can provide indications of major topographic features and changes. For instance, any significant slumping or movement of material that had occurred within Cell SU would have been reflected within the side-scan imagery. Similarly, if all of the cap material had been placed in one location creating a more prominent topographic mound relative to the surrounding seafloor, then this feature would have been reflected within the imagery also. However, because the cap material was spread around the cell and the resulting topographic changes were minor, the side-scan imagery did not reflect any topographic changes.

As discussed above, side-scan imagery can provide a useful tool for identifying the location and the approximate footprint of individual placement events. This is particularly true when the cap material has been placed over ambient bottom material and the resulting bottom disturbance is more pronounced. Even within a few weeks of the placement event, the approximate footprint of the placement activity could still be clearly seen in the side-scan records, provided the areas had not been covered by subsequent placement events. However, over time it appears as if the disturbed area had weathered enough so that these older placement events could no longer be clearly identified in the side-scan imagery. Had side-scan data been acquired several weeks after the placement operations were completed, it seems unlikely that any of the individual placement events could still be identified. This is probably true within the PV site because the cap material had very similar grain size characteristics to the ambient bottom material. (The ambient bottom material was primarily soft and fine-grained silt, mixed with a fair amount of fine-grained sand, while the cap material was primarily fine-grained sand.) In other areas, like the New York Historic Area Remediation Site (HARS) where cap material is sometimes significantly different than ambient bottom material, the cap material is clearly discernable in the side-scan imagery for years after the placement event.

While the first monitoring objective addressed the ability of side-scan imagery to determine distribution of cap sediments, bottom disturbance features, and topography following a single placement event, the second objective addressed these same characteristics following final cap placement. The side-scan operations in Cell SU have shown that the ability to determine distribution of cap sediments and bottom disturbance features is primarily a short-term monitoring objective within PV that is mainly applicable to individual placement events. If the cap material was dramatically different than the ambient material, then the side-scan imagery may provide a longer-term ability to differentiate cap material from ambient bottom material. Although it has not really been demonstrated within Cell SU (or any of the other PV cells), the ability to determine topographic changes from side-scan imagery is primarily a long-term monitoring objective that would only be applicable after major topographic change has occurred; subtle or small-scale topographic change would not be detected by side-scan imagery.

By viewing the SU side-scan mosaics in conjunction with other relevant data sets within Arcview®, it was possible to evaluate and consider many different side-scan record interpretations. By viewing the relevant ADISS data overlaid on top of each side-scan mosaic, numerous individual placement events could be clearly identified. Additionally, some unexpected features, such as the wash-out trails left behind as the dredge departed the placement site, could also be clearly confirmed from the ADISS data. Similarly, the SPI cap contour information was useful in trying to evaluate how well the side-scan imagery could be used to define the extent of the cap footprint for individual placement events. The great extent and variety of different data sets that were acquired during this project provided a unique opportunity to verify many of the conclusions that could be drawn from the side-scan image interpretations.

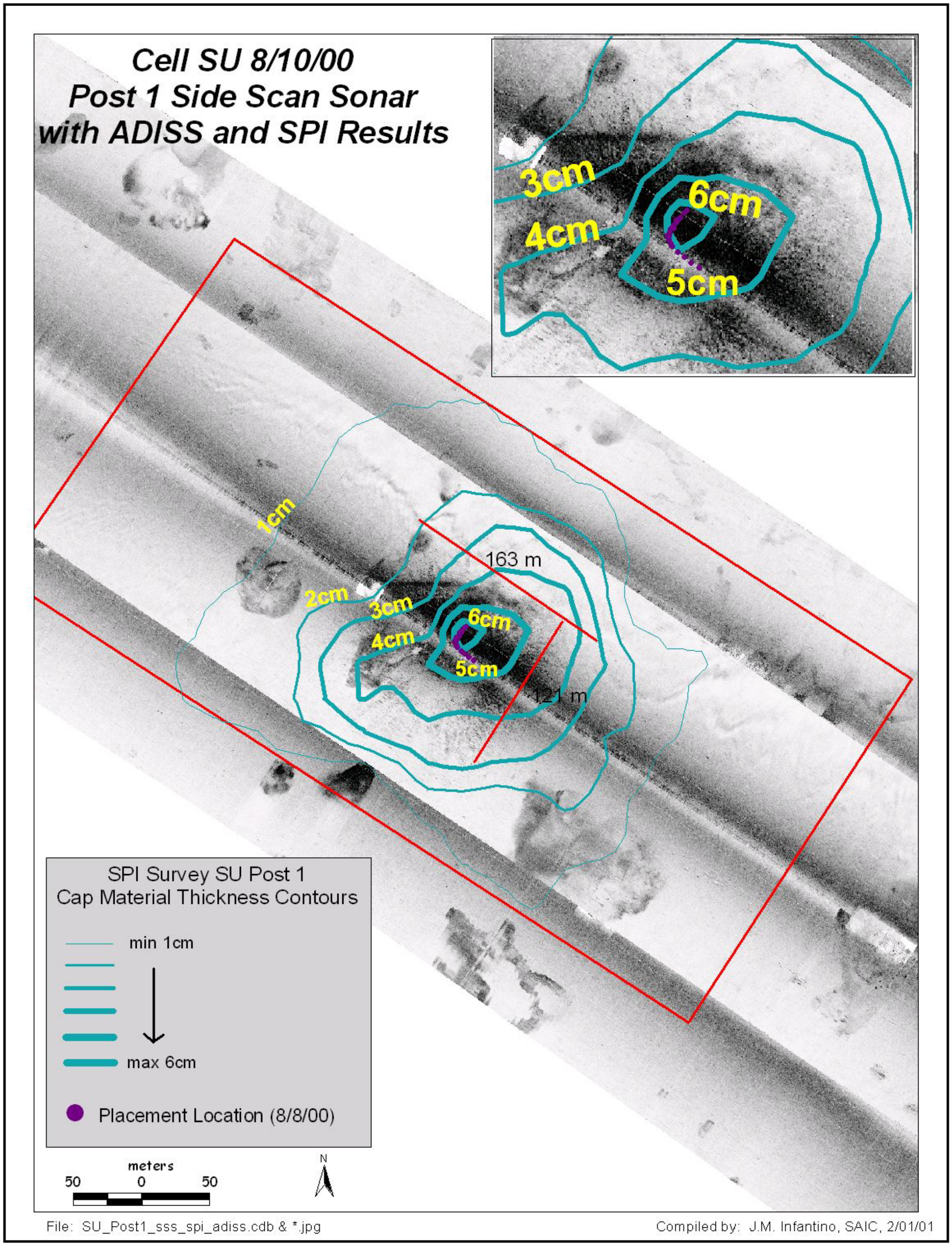


Figure 4.10-1. Side-scan mosaic with SPI cap contours – SU Post 1.

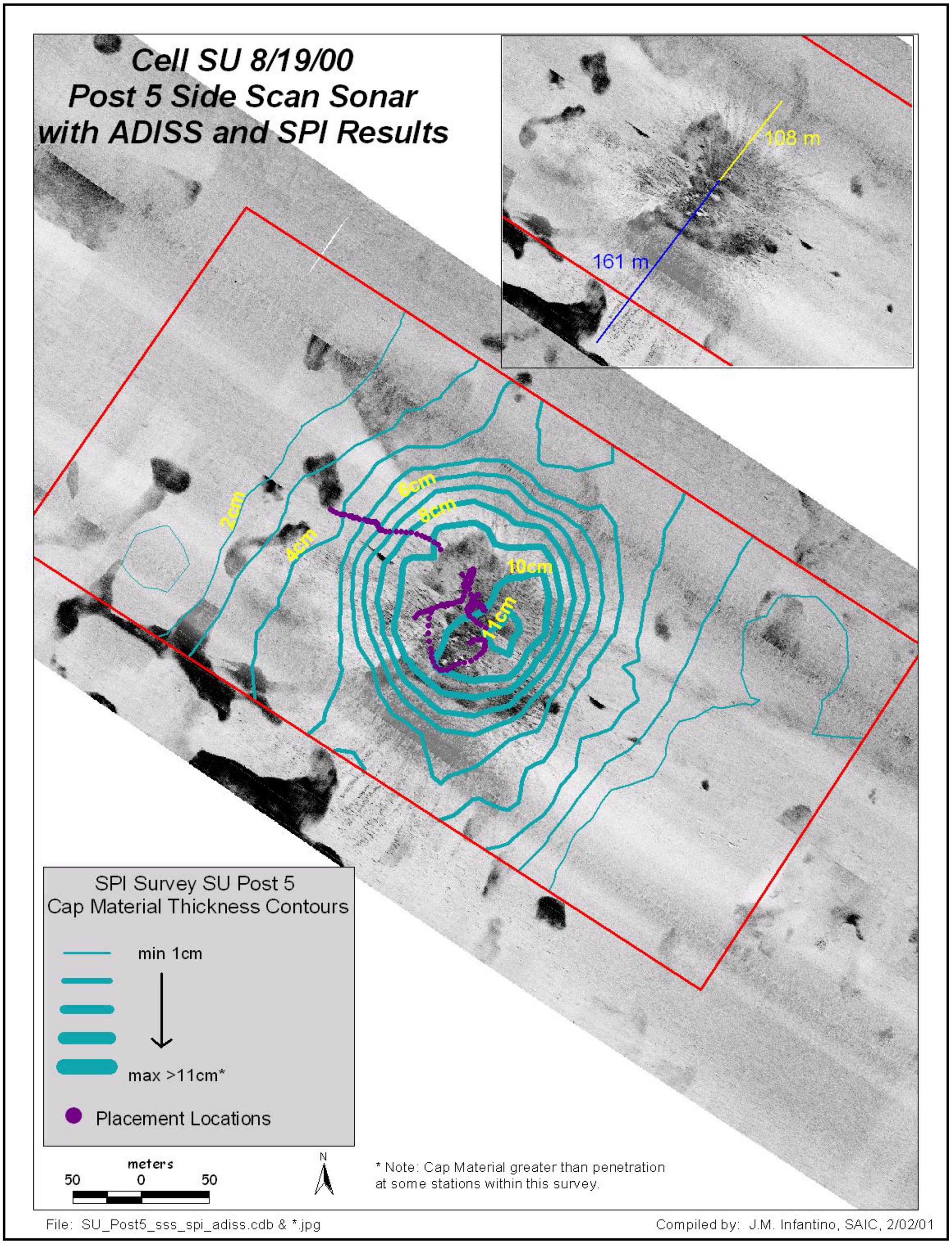


Figure 4.10-2. Side-scan mosaic with SPI cap contours – SU Post 5.

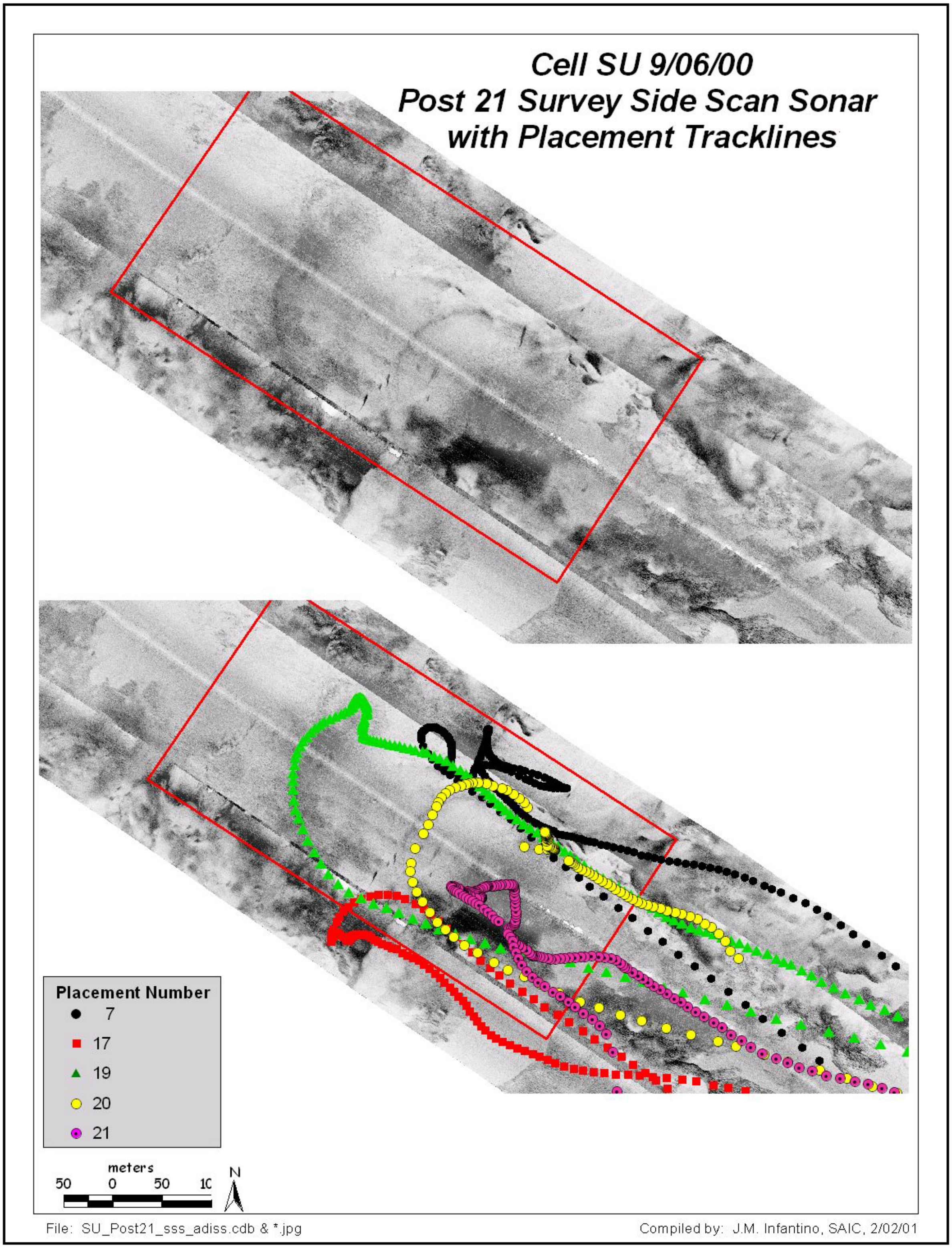


Figure 4.10-3. Side-scan mosaic with SPI cap contours – SU Post 21.

4.11 Sediment Core Results

4.11.1 Overview of Field Sampling Plan

Brief descriptions of the field sampling plans for baseline and postcapping phases of sediment core monitoring in Cell SU are provided below, along with a summary of significant deviations from the sampling plans defined in the respective PWPs.

4.11.1.1 Field Sampling Plans

Baseline Survey

Sediment cores were collected at nine stations within Cell SU during the baseline survey (Figure 4.11-1a). Station locations corresponded to the intersection points of the sub-bottom profile lines. Each of the nine cores was subsampled at discrete 4-cm intervals, and sediments from each layer were analyzed for DDE, grain size, bulk density, and shear strength. Two additional cores were collected at core stations C1 and C3 to provide sufficient material for Atterberg limit analyses.

Post 1 Survey

The Post 1 survey occurred after one placement event in Cell SU. Five cores were collected, photographed and visually described (Figure 4.11-1b). The top 3-cm horizons of four cores (SUH06, SUH07, SUH08 and SUH09) were homogenized and analyzed for grain size and bulk density.

Post 5 Survey

Five cores from Cell SU were collected, photographed and visually described as part of the Post 5 survey (Figure 4.11-1c). The top 4-cm horizons from two cores (SUI22 and SUI24) were homogenized and analyzed for grain size and bulk density.

Post 21Survey

A total of 16 cores were collected in Cell SU after 21 placement events. Seven cores were collected at six stations (36-41) in Cell SU as part of a flex survey in late August 2000. Cores SUC36 through SUC40 were located within the central portions of the cell and SUC41 was collected outside of the cell. These cores were visually described but were not tested for geotechnical or chemical parameters. In early September, nine cores were collected from within the cell, photographed, and visually described. Four of the nine cores (SUC45, SUC46, SUC47, and SUC49) were subsampled at specific core horizons for grain size, bulk density, specific gravity, water content, and DDE analyses (Figure 4.11-1d). Cores were subsampled at horizons corresponding to the surface (A1), approximately 7 cm above the cap/EA sediment interface (A2), 3 cm above the interface (A3), 4 cm below the apparent cap/EA interface (A4), and 8 cm below the apparent cap/EA interface (A5). In each case, the position of the interface was determined visually. The actual sampling depth varied slightly among individual cores depending on the composition of the core and minimum sample volume required for the analytical protocol (defined in the QAPP).

Supplemental Survey

The supplemental coring survey of February/March, 2001 collected one vibracore at each of seven stations in Cell SU (Figure 4.11-2). No box cores were collected from Cell SU during the supplemental survey. The cores were subsampled at 4-cm intervals to a core depth of 44 cm. Sediments from each 4-cm interval between 0 and 20 cm, and every other interval between 20 and 44 cm, were analyzed for grain size, bulk density, water content, specific gravity, and DDE. Atterberg limits in two cores were analyzed. All cores were photographed and visually described. Core descriptions and photographs are included in the DAN-LA database.

Hopper Sediments

Hopper sediment samples were collected from the first three hopper loads of cap material placed in Cell SU. Samples from seven of the 21 loads placed in Cell SU were analyzed for geotechnical parameters. Samples were collected in accordance with the SOP's (SAIC 2001) for hopper sampling, and consisted of a composite of single grab samples collected at the bow, center, and stern of the hopper. Equal volumes from each of the three samples were combined and homogenized in the shore-based laboratory. Hopper samples were subsequently analyzed for grain size, bulk density, specific gravity, and water content. Although specified in the Monitoring SOW (Fredette 2000), Atterberg limits were not analyzed due to the high sand content of the material.

4.11.1.2 Methods

Methods used for collection and processing of sediment cores and hopper samples, and geotechnical and chemical analysis of sediments, are described in detail in the PWPs for the baseline and cap placement monitoring phases (SAIC 2000a, 2001), and summarized in Section 3.11.2.

4.11.1.3 Deviations from Field Sampling Plan

Core sampling at Cell SU during baseline and cap placement monitoring did not deviate significantly from the approach described in the FSP (SAIC 2000a, 2001).

4.11.2 Review of Data Quality Objectives

General monitoring and DQOs for the monitoring program are discussed in Section 2.

4.11.2.1 Baseline Monitoring

Specific monitoring objectives for sediment coring in Cell SU conducted during the baseline survey are summarized in Table 3.11-1.

4.11.2.2 Summary of Results for Baseline Survey Relative to Data Quality Objectives

Specific objectives for sediment coring in Cell SU during the baseline survey were achieved. In particular, all of the sediment cores specified in the PWP were collected, along with the defined numbers of field quality control samples. A total of 48 grain size, 53 bulk density, 55 shear strength, and four Atterberg limit analyses were completed (Table 4.11-1). In addition, 49 sediment samples were analyzed for DDE. Results of QC analyses are presented in Appendix B.

4.11.2.3 Interim and Postcapping Monitoring

Specific monitoring objectives for sediment coring in Cell SU conducted during the interim and postcap placement monitoring phases are summarized in Table 3.11-2.

Sediment coring using a vibracorer was performed during supplemental monitoring to provide data on cap thickness as well as the vertical distributions of physical and chemical characteristics for assessments of mixing between cap material and EA sediments. A vibracore was expected to provide cores of sufficient length to penetrate through the cap (up to 45 cm) and into EA sediment at all stations with minimal disturbance of the core. Monitoring objectives and approach for the supplemental coring are summarized in Table 3.11-3.

4.11.2.4 Summary of Results for Cap Placement Surveys Relative to Data Quality Objectives

All of the sediment cores specified in the PWP for interim and postcap monitoring were collected, along with the defined numbers of field QC samples. A total of 22 grain size, 17 bulk density, 12 specific gravity and water content, 9 Atterberg limit and 10 shear strength, and 11 sediment DDE analyses were conducted (Table 4.11-1).

Adequate core penetration was achieved (core lengths exceeded 20 cm), and most cores provided adequate samples volume for all of the specified chemical and geotechnical analyses. However, for some cores, one or more of the specific horizons were not sampled due to limited cap thickness or the absence of an obvious cap material/EA sediment interface.

Specific monitoring objectives for the supplemental coring survey in Cell SU were achieved. All cores specified in the PWP were collected, along with the defined numbers of field quality control samples. A total of 37 grain size, 26 bulk density, 25 specific gravity, 29 water content, 4 Atterberg limits, 29 shear strength, and 34 sediment DDE analyses were conducted (Table 4.11-1). Cores provided adequate sample volume for all required chemical and geotechnical analyses, including QC samples specified in the QAPP. Analytical QC results are presented in Appendix B.

4.11.3 Technical Considerations

Technical considerations relevant to sediment core and hopper samples from Cell SU are consistent with those discussed for Cell LU (Section 3.11.3).

4.11.4 Results

Results from analyses of hopper sediments and sediment cores from Cell SU for physical and chemical characteristics are discussed separately in the following sections.

4.11.4.1 Geotechnical Characteristics

<u>Hopper Sediments</u>

Grain size results for hopper sediment samples are summarized in Table 3.11-5. Hopper sediments placed in Cell SU consisted primarily (84%) of sand (0.0625-2 mm), of which 40% was classified as fine sand (0.125 mm) and 34% was very fine sand (0.0625 mm). The average proportions of silt and clay components were 14% and 3%, respectively. Gravel (>4 mm) contributed 0.25%, and consisted primarily of shell hash. The grain size distribution for Cell SU hopper sediments is illustrated in Figure 3.11-5.

Average wet and dry weight bulk density values measured were 1.90 g/cc and 1.47 g/cc, respectively. The average specific gravity for the hopper samples was 2.72, and the water content ranged from 25 to 35% and averaged 30%. Results for these geotechnical parameters are summarized in Table 3.11-5.

Baseline Survey

Digital images and visual descriptions of cores are presented in DAN-LA.

Baseline cores in Cell SU were greenish black, moist, firm clayey SILT or silty CLAY, depending upon the horizon described. Ratios of sand, silt, and clay changed with depth. No gravel (>4 mm) was detected in baseline sediments (Figure 4.11-3). In all horizons sampled, silt (0.0039-0.0312 mm) was the dominant component, contributing from 48 to 52% of the sediment composition. Sand (0.0625-2 mm) occurred in greater proportions (22%) at the surface and decreased to 10% at core depths of 16-20 cm (Table 4.11-2). Clay (<0.00195 mm) was inversely proportional to sand, comprising 26% of the surface sediment and 41% of the 16-20 cm horizon.

The average wet weight bulk density for all horizons was 1.39 g/cc, and the average dry weight bulk density was 0.63 g/cc. Specific gravity and water content were not analyzed for the baseline survey.

Results for Atterberg limit analyses of cores from stations C1 and C3 indicated an average liquid limit of 107%, a plastic limit of 62%, and an average plasticity index (PI) of 62. The higher liquid limit in Cell SU is characteristic of predominantly clayey sediment. Ambient EA sediments existed as sandy lean clay with a high PI due to the clay content.

Shear strength values ranged from 0.94-41.82 kPa. Even though Cell SU sediments contained significant proportions of silt and clay, the shear strength data did not indicate any trends with core depth. Surface sediment (0-4 cm) values ranged from 0.94-23.53 kPa. The large range can be attributed to variability in the sand fraction. Values for the 16-20 cm core horizon ranged from 1.67-41.82 kPa and no clear pattern or trend in relation to the strength of the overlying material was observed. Overall, the shear strength data were inconclusive. A summary of geotechnical parameters analyzed is included in the Appendix C.

Post 1 Survey

Sediments from the five Post 1 survey cores were greenish black, homogeneous, moist, soft to firm, and either clayey SILT or silty CLAY, and visually similar to ambient EA material. Cap material and EA sediments had very similar grain size characteristics; therefore, visual distinctions between EA sediment and cap material were difficult. Regardless, there was no visual evidence of cap material in any of the Post 1 cores.

Because the four Post 1 cores collected within the cell, as well as core SUH10 collected outside the cell, did not contain evidence of cap material, a composite sample was analyzed. The upper 3 cm of the cores were homogenized, labeled SUH Composite, and analyzed for grain size and bulk density (Table 4.11-3). Results from grain size analysis of this composite sample indicated no increase relative to baseline sediments in the gravel or sand components. However, the grain size data indicated a change in proportions of silt and clay sized particles. Specifically, the composite sample contained 51.9% silt, 36.4% clay, and 11.7% sand. When plotted with the hopper and baseline grain size data, the composite sample shows characteristics most similar to the baseline cores, and is distinctly different from the hopper samples (Figure 4.11-4).

The wet weight bulk density of the composite sample was 1.40 g/cc, while the dry weight bulk density was 0.55 g/cc. These values are comparable to those for baseline sediments.

Post 5 Survey

Shell fragments were present in two of the cores from the Post 5 survey; otherwise, cap materials were not visually distinguishable from EA sediments. Sediment cores were primarily greenish-black, moist, firm, sandy clayey SILT, while surface layers of cores SUI22 and SUI24 were dark gray, wet, soft, clayey sandy SILT with shells. Results from grain size analyses (SUI composite) of the surface layers from cores SUI22 and SUI24 indicated the presence of cap material (Table 4.11-3). Surface grain size changed dramatically compared with baseline conditions. In particular, the SUI composite sample contained 14% gravel (>4 mm), and 31% sand (0.0625 to 2 mm) a change of 11% over baseline. The coarse fraction (0.125 to 2 mm) contained the most significant change within the overall sand component. Plots of grain size distribution for SUI Composite, hopper sediment, and selected baseline sediment samples illustrate distinct attributes of the Queen's Gate cap material in the Post 5 composite sample (Figure 4.11-5).

The wet weight bulk density was 1.56 g/cc, while the dry weight bulk density was 0.87 g/cc. A slight increase in both the wet and dry weight bulk densities over baseline values were apparent. Both Post 5 sediment values were comparable to those of Queen's Gate material.

<u>Post 21 Survey</u>

Detailed descriptions and digital images of Post 21 survey cores are included in DAN-LA.

All cores collected near the center of Cell SU as part of the flex survey contained shell fragments or apparent cap material; whereas, the core collected at station SUC41, outside the cell, did not contain any evidence of cap material. Of the nine cores collected during the Post 21 survey, only three contained visual evidence of shell fragments. Unlike the flex survey, the Post 21 cores were not collected from the center of the survey cell, where cap placement was focused. Thus, the post 21 cores analyzed for geotechnical parameters originated from areas within the cell where cap placement was minimal.

A1: surface material

The surface (0 to 6 cm) horizon of cores SUC46 and SUC49 contained gravel (>4 mm), whereas gravel did not occur in the surface layers of cores SUC45 or SUC47 (Table 4.11-4, Figure 4.11-6). Core SUC46, collected from the center of the cell, contained 6% gravel, 87% sand, 4.4% silt, and 2% clay, which reflected the presence of cap material in the surface horizon. Core SUC46 contained the greatest sand and gravel component of any of the A1 samples (Figure 4.11-6). SUC47 surface sediment was proportionately 36% silt and sand with 27% clay. Core SUC49 contained a small (1.28%) gravel component however, the majority of the sediment was silt (53%). Overall the A1 samples indicated sediment dominated by silts and clays.

A3: 3 cm above apparent EA/Cap interface

The A3 horizon (4 to 8 cm) of cores SUC46 and SUC47 both contained gravel-size sediments (Table 4.11-4). Core SUC46 contained 15% gravel (>4 mm), 60% sand (0.0625-2 mm), 15% silt (0.0312-0.0039 mm), and 8.75% clay (<0.00195 mm), which was clearly indicative of Queen's Gate material. While Core SUC47 did not contain any geotechnical evidence of cap material in the surface (A1) layer, grain size characteristics in the A3 horizon indicated a mixture of EA sediment and cap material. The presence of cap material was reflected in the distinctly higher gravel (+1.56%), sand (+4.81%) and silt (+3.25%) proportions and a smaller clay (-9.62%) fraction compared to the A1 sample. However, the finer grained characteristics of the EA sediments were also evident in the A3 samples (Figure 4.11-7). Cores SUC45 and SUC49 did not contain sufficient material to subsample the A3 horizon.

A4: 4 cm below apparent EA/Cap interface

The depth of the A4 horizon samples in the four Post 21 cores ranged from 6 to 12 cm to 10 to 14 cm, depending on the amount of cap material present. Duplicate samples from cores SUC45 and SUC46 had grain size characteristics generally similar to those of the 'parent sample'. However, only one of the samples from core SUC45 contained gravel (6%), while the other did not (Table 4.11-5). The absence of gravel in the duplicate sample reflects the spatial variation within the cell. Despite the presence of cap material at a maximum depth of 14 cm, the sand (13-20%), silt (45-53%) and clay (31-36%) contents of A4 samples were characteristic of EA sediment than cap material (Figure 4.11-8).

Additional Geotechnical Analyses

Five additional cores (SUC42, SUC43, SUC44, SUC48 and SUC50) were collected around the perimeter of the cell for Atterberg limit and grain size analyses. The cores were subsampled from roughly the 0-15 cm and 30-45 cm. Surface (0 to 15 cm) sediments were dominated by silt (0.0312 to 0.0039 mm). The sand fraction was consistently less then 20%, clay averaged 30%, and the gravel component was miniscule. These results did not indicate significant changes in the geotechnical properties of sediments along the perimeter of Cell SU, and suggested that cap material was not present at these locations.

The lower horizon was expected to consist of EA sediment. However, the grain size distribution for sediments from 30-45 cm differed from any of the EA material analyzed during the baseline survey. At this depth, sediments consisted of 26% sand, 55.77% silt, and 17.54% clay, and were more similar to baseline surface than subsurface sediments in Cell SU. The lower liquid limit associated with the 30 to 45 cm sample was also consistent with the higher sand fraction at depth.

The additional grain size and Atterberg limit data did not indicate that cap material was present in detectable volumes along the perimeter of the cell. This is consistent with the small gravel proportions in cores SUC45, SUC47 and SUC49.

Average wet weight bulk density of the postcap cores was 1.5 g/cc, while dry weight bulk density was 0.8 g/cc. The dry weight bulk density value was lower than that measured in the baseline and hopper sediments. Specific gravity averaged 2.5, which was lower than the average value for hopper samples (2.72). Specific gravity was not measured in the baseline sediments.

The average liquid limit for Cell SU Post 21 survey cores was 75.5%, with a plastic limit of 38% and a plasticity index (PI) of 36. This was lower than baseline values, indicating changes in the plasticity of the sediment. Hopper material was not analyzed for Atterberg limits because it did not contain sufficient fines. Shear strength results exhibited high variability. Consequently, no patterns in shear strength with core depth were observed. A summary table including all analyzed geotechnical parameters is included in the Appendix C.

4.11.4.2 Vibracore Results

No box cores were collected from Cell SU for comparison with the vibracores. Four cores were analyzed for grain size, bulk density, water content, specific gravity, shear strength and chemistry while two additional cores were analyzed for Atterberg limits (Figure 4.11-2). The cap material observed visually in the vibracores was primarily light to dark gray in color and contained both gray clay clasts and shell fragments mixed with the sand. The color of the EA sediment was a greenish black to black. The similarity in grain size between the cap material and EA sediment, and mixing between the two, made it visually difficult to distinguish the exact location of the cap material/EA sediment interface in many of the cores.

None of the cores collected for grain size analysis contained a distinct cap/EA interface. Therefore, grain size samples were collected from the 4 cores at 12 horizons to a depth of 48 cm. A summary of total vibracore length and the depth at which the cap material/EA interface was visually detected is included in Table 4.11-6. In many of the cores no distinct interface was detected.

At station I13, the cap thickness of 6 cm detected in the vibracore sample is somewhat less than the thickness measurement of 8.5 cm obtained from the co-located sediment-profile images. Sediment profile images were not obtained at any of the other vibracore stations, thereby precluding direct comparisons of cap thickness measurements.

Horizon 1: surface material, 0-4 cm

The surface sediment from one of the four samples analyzed contained gravel (>4 mm), representing shell hash from the Queen's Gate sediment, which was not present in the baseline sediment cores. The core (I14) was collected seaward of the cell center and contained the most significant cap signal of all the SU supplemental vibracores (Table 4.11-7). In addition to the presence of gravel the fine fraction of sand was 18% compared to 2.4% average of the other 3 cores. The percent frequency of sand and silt was highly variable among the cores. The very fine sand and coarse silt component of core SUSV3 I14A was the only core in the supplemental survey of Cell SU to display grain size characteristics similar to cap material (Figure 4.11-9). The 0-4 cm horizon contained elevated levels of fine sand (0.125 mm; 18%) and medium sand (0.25 mm; 5%). The other 3 cores analyzed at this horizon did not indicate this change in grain size distribution (see Figures 4.11-10 through 4.11-12).

Horizon 2: 4-8 cm

The sediment from the four cores was analyzed from 4-8 cm for grain size (Table 4.11-8). Of the four cores analyzed, Core I14 displayed the strongest signal of cap material, with fine sand concentration of 6% (0.125 mm) and 2% (0.25 mm) (Figure 4.11-9). Core I06, collected north of the cell center also contained traces of gravel (2%). The proportions of medium, fine and very fine sand detected in Core I06 were slightly elevated over EA sediment values however; they did not carry a strong indication of cap material (Figure 4.11-10).

Horizon 3: 8-12 cm

Core I14 continued to contain coarser-grained sediments than the other vibracores sampled (Figure 4.11-9). Though slightly coarser in sediment grain size for horizon 3, Core I14 illustrates dominant characteristics of EA sediment (Table 4.11-9) in this horizon. All other cores contained grain size fractions reflecting EA distributions (see Figures 4.11-10 through 4.11-12).

Horizon 4: 12-16 cm

Core I09 contained 3% gravel (>4 mm) at this horizon, this is the first strong indication of cap material in this core (Table 4.11-10). However, fine and medium sand, other indicators of cap material, were at EA concentration in Core I09 (Figure 4.11-11). The finer-grained sediments (0.0156-<0.00195 mm) were detected at variable concentrations, however they reflect distribution trends most similar to EA sediment (Figures 4.11-9 through 4.11-12).

Horizon 5: 16-20 cm

Core I01 contains 1% gravel (>4 mm) at this horizon, and in horizon 4 this core also contained negligible (0.2%) amounts of gravel (Table 4.11-11). The fine sand frequency is 5.6%, similar to that detected in Core I14 (the core containing the most significant concentrations of cap material) (Figures 4.11-12 and 4.11-9). The grain size concentrations of horizon five indicated sediments with EA characteristics and slightly elevated very fine sand and coarse silt concentrations. This horizon is considered EA sediment.

Horizon 6: 20-24 cm

Samples were collected from the 20-24 cm and archived. These samples were not analyzed as part of the additional analysis preformed.

Horizon 7: 24-28 cm

The grain size results indicated that the sediment in horizon seven was most similar to EA sediments (Table 4.11-12). Baseline samples were not collected below 20 cm, therefore a comparison with baseline data at this horizon was not possible. The frequency of very fine sand (0.125 mm) and coarse silt (0.0625 mm) continued to be slightly elevated over EA concentrations (Figures 4.11-9 through 4.11-12).

Horizon 8: 28-32 cm

Samples were collected from the 28-32 cm and archived. These samples were not analyzed as part of the additional analysis preformed.

Horizon 9: 32-36 cm

The grain size results indicated that the sediment in horizon nine was most similar to EA sediments (Table 4.11-12). An exact comparison was not possible because baseline samples were not collected below 20 cm. The frequency of very fine sand (0.125 mm) and coarse silt (0.0625 mm) continued to be slightly greater than EA concentrations (see Figures 4.11-9 through 4.11-12).

Horizon 10: 36-40 cm

Samples were collected from the 36-40 cm and archived. These samples were not analyzed as part of the additional analysis preformed.

Horizon 11: 40-44 cm

The grain size results indicated that the sediment in horizon 11 was most similar to EA sediments (Table 4.11-12). Baseline samples were not collected below 20 cm, thus horizon specific comparisons of grain size data was not possible. The frequency of very fine sand (0.125 mm) and coarse silt (0.0625 mm) continued to be slightly greater than EA concentrations (see Figures 4.11-9 through 4.11-12).

Horizon 12: 44-48 cm

Samples were collected from the 44-48 cm and archived. These samples were not analyzed as part of the additional analysis preformed.

A summary table including the wet and dry weight, water content, specific gravity, liquid limit, plastic limit as well as shear strength measurements are included in Appendix B.

Bulk density was analyzed for both wet and dry weight. Both measurements were consistent from core to core. There was no noticeable variability with depth. The average wet weight ranged from 1.2-1.9 g/cm^3 (1.7 g/cm^3 average). Dry weight ranged from 0.4-1.4 g/cm^3 with an average of 1.1 g/cm^3. Water content was highly variable ranging from 35-196%. Higher water content was frequently found in horizons 1-3 (0-12 cm). Core I09 however, had a water content of 132% from 16-20 cm. The highest water content (196%) was detected at station I01B at a depth of 8-12 cm. Specific gravity ranged from 2.4 to 2.7. There was no consistent relationship between specific gravity and other geotechnical parameters analyzed.

Atterberg limits were analyzed on 2 cores at 2 horizons in each core. Core SUSV I15 was too sandy in the surface for analysis and resulted in a nonplastic result for both samples (0-8 cm and 8-16 cm). Indicating that the core contained a fair quantity of coarse sediment to a depth of 16 cm. Core I10 had a LL of 34, PL of 20 and PI of 14 in the surface (0-4 cm) and a LL of 41, PL of 30 and PI of 11 from 4-13 cm. Shear strength analysis was also conducted on 4 of the cores collected in Cell SU. In most of the cores the surface material to 12 cm failed to produce an accurate test. The shear strength results were highly variable ranging from 1.7 to 100 kPa. No significant trends were noted within the shear strength results for Cell SU.

4.11.4.3 Chemical (DDE) Characteristics

Results of chemical analyses of sediment cores collected during the baseline and postcapping surveys are presented in the following sections. Tabular listings of sediment DDE results are presented in DAN-LA.

Baseline Survey

Sediment cores from nine stations in Cell SU contained relatively higher DDE concentrations than cores from the adjacent landward cell (LU). In general, this pattern is consistent with the relatively higher proportions of fine-grained sediments within Cell SU compared to those from Cell LU and also to results from historical sediment analyses (e.g., Lee 1994). The cross-shelf patterns may reflect the relatively greater influence of wastewater discharges from JWPCP to areas within the 50-60 m isobaths upcoast from the outfall diffuser (Lee 1994).

Concentrations of DDE in surface (0-8 cm) layers ranged from 4.3 to 10 ppm, with relatively higher concentrations in the central landward portions of the cell. A map of DDE concentrations in surface sediments (Figure 4.11-13) illustrates the general trends within Cell SU. These spatial patterns are consistent with the presence of relatively higher proportions of fine-grained sediments in the seaward portions of the cell than in the landward portions of the cell. However, DDE concentrations were not significantly correlated with percentages of the silt plus clay fraction (correlation coefficient [r^2] =0.18) in baseline surface sediments from Cells SU and SD combined.

Sediment DDE concentrations increased significantly with core depth (Figure 4.11-14). Specifically, concentrations increased sharply, to maximum values of 110 ppm, at depths of 12 to 16 cm. Similar profiles were reported historically for sites in the general vicinity of Cell SU (Figure 4.11-14). However, an important difference is that the subsurface concentration peaks observed in the baseline cores were considerably shallower than those reported previously (Lee 1994). For example, sediment cores collected in 1992 at USGS Station 556 (east and slightly southwest of Cell SU) showed subsurface DDE peaks at core depths of 38 to 44 cm, or approximately 20 cm deeper than peaks observed in the baseline cores. These differences likely are due to loss of surface sediment layers from cores collected during the baseline survey due to a bow wave from the gravity corer. A similar issue was described by Lee (1994) and is discussed in Section 3.11.3.

Post 21 Survey

At two of the Cell SU stations (46 in the center of the cell and 47 on the northwestern portion of the centerline), DDE concentrations in the surface (0-4 cm; A1) horizon were low (0.042 and 0.030 ppm, respectively), consistent with the presence of clean cap material. Sediments from depths of 4-8 cm below the core surface (A3 layer) consisted of a mix of cap material and EA sediments, as indicated by higher DDE concentrations (2.2 to 5.8 ppm). The 10-14 cm (A4) core horizons from these stations consisted of EA sediment only, with DDE concentrations up to 32 ppm (Figure 4.11-15). For comparison, SPI data for Cell SU following 21 placement events indicated variable cap thickness. The cap layer thickness measured by SPI exceeded 10 cm at stations 46 and 47, whereas the apparent cap thickness at stations 45 and 49 ranged from 4 to 6 cm. Thus, cap thickness at these stations, as indicated by the core chemistry results, was less than that indicated from the SPI results. Regardless, DDE concentrations in surface sediments at these stations 46 and 49 were more than two orders of magnitude lower than corresponding levels in baseline sediments.

Surface layers of cores from the other two Cell SU stations (45 near the southeastern boundary and 49 in the northeastern corner of Cell SU) contained DDE concentrations of 5.7 and 9.6 ppm, respectively. These concentrations were comparable to levels measured in surface layers of baseline cores from the same general location. Furthermore, the magnitude of DDE concentrations associated with the 6-12 cm layer of the postcapping core from station 45 (29 ppm) was comparable only to concentrations occurring at depths of 12-20 cm in the closest baseline core (station C9). Further, any cap material present at this station during postcap coring was not retained by the gravity corer.

The extent of mixing between cap material and EA sediments was estimated based on comparisons of DDE concentrations in the postcapping cores to average concentrations in cap material (0.02 ppm) and in baseline sediments (6.8 ppm). The estimated proportions of EA sediments in the sediment cores are listed in Table 4.11-13. EA sediments contributed less than 10% to the surface layers of cores from stations 46 and 47, but more than 80% of the surface layers of cores from stations 45 and 49. Proportions of EA and cap sediments in the A3 horizons of cores from stations 46 and 47 were variable; whereas the A4 horizons of all four cores consisted exclusively of EA sediment. These values could overestimate the proportions of cap sediments present if the actual DDE concentrations in EA sediments were lower than the assumed average value.

These results for sediment chemistry were not entirely consistent with the geotechnical results for the Post 21 cores from Cell SU. Specifically, the grain size distributions for the surface (A1) horizon of core SU47 matched those of EA sediments, whereas the DDE results indicated negligible proportions of EA sediment. Also, grain size results for the A3 horizon of core SU46 reflected a strong cap material signature, whereas results for core SU47 suggested a mixture of cap and EA sediments. By comparison, the DDE results indicated that the A3 horizon of core SU47 contained a relatively higher proportion of cap material than core SU46. These differences between geotechnical and chemical results may reflect the effects of coring artifacts on sample homogeneity, as well as similarities in some of the Queen's Gate material to EA sediment.

Additionally, sediment profiles of DDE in postcap comes from stations 45 and 46 indicated that approximately 6 cm of the original surface layer were not well represented in the sediment cores. In contrast, postcapping cores from stations 47 and 49, in the northwest portion of Cell SU, did not exhibit any evidence of surface scouring. The reason(s) for their apparent differences in the extent of sediment distribution is not obvious from the sediment DDE results.

<u>Supplemental Survey</u>

The supplemental coring survey collected a single vibracore at each of four locations within Cell SU, including two locations (stations I06 and I09) that were close to sites sampled during the Post-21 survey (stations SUC47 and SUC46, respectively). Sediment DDE concentrations in the supplemental cores from Cell SU are listed in Table 4.11-14.

None of the cores from this cell contained chemical evidence of cap material; instead, DDE concentrations in the surface sediment layers were comparable to or higher than corresponding baseline values. In particular, the DDE concentration in the nominal surface (0-4 cm) horizon of the Core I09 (150 ppm) was more than 20 times higher than corresponding concentrations in baseline core (C1; 6.8 ppm), and more than three orders of magnitude higher than concentrations in the surface horizon of the Post-21 core from this station (0.042 ppm in core SUC46; see Figure 4.11-15). Concentrations in each of the successive horizons of Core I09 were progressively lower than the surface value, reaching 0.5 ppm at core depths of 40-44 cm. Core profiles at other Cell SU stations exhibited similar patterns, with peak DDE concentrations occurring between 0-4 cm (I09 and I14) to 12-16 cm (I06) core depths, with decreasing concentrations to levels at or below the detection limit (ca. 0.001 ppm) at 40 cm. DDE concentrations in the deeper core horizons (i.e., greater than 24 cm in cores I01, I06, and I14) were comparable to DDE levels in the Queen's Gate Channel sediments (approximately 0.02 ppm). However, as discussed in the previous sections, these deeper core horizons did not exhibit any of the geotechnical characteristics of cap material. Another characteristic of cores collected during the supplemental survey was that horizons with the highest DDE concentrations also contained relatively low solids content (or high moisture/water content). This latter trend is consistent with results obtained for cores collected by USGS (Lee, 1994).

Core profiles for the supplemental survey in Cell SU did not correspond well with the Post-21 cores. The reason(s) for the disparity in results from the Post-21 and supplemental coring surveys is not immediately apparent. Possible explanations include:

- Cores were accidentally inverted during processing and samples mislabeled;
- Results reflect coring artifacts that disturbed/removed up to 14 cm of surface sediment from the cores;
- Cap layers and underlying EA sediments were disturbed by fish trawl nets or storm-induced bottom turbulence that resorted sediment layers, resulting in previously-buried, highly contaminated sediments at the surface;
- Bioturbation resorted sediment layers;
- Lateral transport and redeposition of sediments inside the cell associated with cap placement in adjacent portions of the cell;
- Localized scouring and patchy cap distributions;
- Lateral transport and deposition of EA sediments originating from uncapped areas outside of the cell;
- Cap materials were significantly contaminated with DDE; and/or
- Deposition of recently discharged effluent particles.

Several of these possibilities appear implausible. Reviews of field notes and core logs indicate that accidental inversion of cores is an unlikely explanation. Similarly, random mislabeling of samples appears unlikely because duplicate samples showed good agreement and consistent depth-related trends in DDE concentrations observed in the cores are not indicative of random laboratory contamination. Lateral transport and deposition of EA sediments from adjacent uncapped areas and/or deposition of recently discharged effluent particles appears unlikely because of the magnitude of the DDE concentrations in the surface layers of Core I09 is much higher than concentrations of DDE in baseline cores or concentrations reported in JWPCP effluent. Scouring by fish trawls or storm turbulence can not be discounted, but appear to be unlikely explanations because (1) fish trawl effects would be localized whereas all of the Cell SU show apparent effects of scouring; (2) storm effects should also be evident in the Cell LU cores because of the wave-induced turbulence would be more severe in shallower areas of the PV Shelf. Scouring by cap placement in adjacent portions of the cell is not supported by evidence from the Post-21 survey of cap material in the center of the cell, unless the cap was discontinuous and all of the supplemental cores were collected by chance in areas of the cell which were not capped. Bioturbation appears unlikely because this process would promote greater homogenization of surface core horizons, whereas DDE profiles, particularly in Core I09, show no signs of vertical mixing. Results from extensive analyses of Queen's Gate Channel sediment indicated that DDE in materials used to construct the cap contained maximum DDE concentrations that were more than three orders of magnitude lower than peak DDE concentrations in the I09 core. Therefore, it is unlikely that the core profiles reflect high DDE concentrations in the cap layer sediments.

The high DDE concentration in the surface layer of supplemental Core I09 was comparable in magnitude only to concentrations occurring at sediment column depths between approximately 25 and

40 cm in cores collected by LACSD and USGS. Further, decreasing DDE concentrations in horizons below those containing the peak concentrations were also consistent with patterns observed historically in sediment cores from the PV Shelf. It is unlikely that deeper core horizons with relatively low DDE concentrations comprise recently-placed Queen's Gate Channel sediments. Instead, the low DDE concentrations (less than 0.01 ppm) in bottom layers of the cores may correspond to the native PV Shelf sediments deposited prior to initiation of wastewater discharges from the ocean outfall. Thus, the DDE profiles in the supplemental cores suggest that the cap layer, evident during the Post-21 survey and the supplemental SPI survey, plus a significant portion of the near-surface EA sediments were not captured or retained by the vibracore.

The most plausible explanation is that the Cell SU cores reflect coring artifacts that resulted in loss of both cap material and up to 14 cm of underlying EA sediment from the surface layers of the cores. Similar artifacts were postulated for the gravity cores collected during the baseline and postcapping surveys; however, the magnitude of the effect appears to be relatively greater for the vibracorer used during the supplemental coring. This effect appears to have been more severe in Cell SU than in Cells LU and LD. Some, albeit minor, amounts of cap material were observed visually in the supplemental cores from Cell SU (discussed in previous sections). This indicates that some cap materials were present at the time the cores were collected, but the coarser cap material may have been dragged down the sides of the core liner.

Artifacts associated with collections of cores comprising organic-rich sediments with high porosity (i.e., water content) from the PV Shelf are discussed by Santschi et al. (2001). Their studies focused on cores collected at LACSD station 6C, which is immediately north (inshore) from Cell SU. Sediments from this site were characterized by a high organic carbon content and high porosity, which provided lower resistance to mechanical disturbance. According to the authors, porous sediments with low resistance to disturbance are easily lost from sediment cores during sampling, resulting in cores that are unrepresentative of the actual sediment column. The same explanation could apply to cores collected from Cell SU during the supplemental survey, except that these cores exhibited preferential loss of surface layers, and the layers with high water content were preserved, rather than sediment loss along the entire length of the core, as described by Santschi et al. (2001).

Table 4.11-1. Summary of Sediment Cores and Core Analyses Performed During Baseline and Cap Monitoring in Cell SU

Cell SU Core Summary	DDE	Grain Size	Bulk Density	Specific Gravity	Water Content	Atterberg Limits	Shear Strength
Baseline							
11 cores	49	48	53	na	na	4	55
Post 1Survey							
5 cores	na	1	1	na	na	na	na
Post 5 Survey							
5 cores	na	1	1	na	na	na	na
Post 21 Survey and Flex							
7 flex	na	na	na	na	na	na	na
9 cores	11	20	15	12	12	9	10
archive samples	4A	5A	-	5A	5A	2A	na
Summer Capping	11	22	17	12	12	9	10
archive samples	4A	5A	-	5A	5A	2A	na
Supplemental Survey	34	37	26	25	29	4	29
archive samples	16A	16A	-	16A	16A	na	na
Total Palos Verdes Project	94	107	96	37	41	17	94
archive samples	20A	21A	-	21A	21A	2A	na

Visual Descriptions of 44 cores from Cell SU

Table 4.11-2. Summary of Sediment Grain Size in Baseline Cores in Cell SU

Palos Verdes Baseline Core Grain Size Data
Cell SU
SU Baseline Horizon Summary

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	A Average SUB (0-4cm)	B Average SUB (4-8cm)	C Average SUB (8-12cm)	D Average SUB (12-16cm)	E Average SUB (16-20cm)	Standard Deviation SUB
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.00	0.00	0.00	0.00	0.00
	4	Small Pebble	-2	0.00	0.00	0.00	0.00	0.00	0.00
Coarse Sand	2	Gravel	-1	0.85	0.07	0.00	0.00	0.01	0.37
Medium Sand	1	V. Coarse Sand	0	0.79	0.92	0.60	0.38	0.25	0.28
	0.5	Coarse Sand	1	0.55	0.50	0.43	0.38	0.20	0.13
Fine Sand	0.25	Medium Sand	2	0.70	1.10	0.54	0.48	0.27	0.31
	0.125	Fine Sand	3	2.16	2.33	0.85	0.83	0.70	0.80
	0.0625	V. Fine Sand	4	17.38	14.44	8.57	10.00	8.38	3.98
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	26.42	22.39	18.18	16.93	15.44	4.48
	0.0156	Medium Silt	6	14.06	14.04	13.94	13.69	13.73	0.17
	0.0078	Fine Silt	7	8.35	9.70	12.59	12.27	13.85	2.25
	0.0039	V. Fine Silt	8	3.19	3.97	5.05	5.45	6.02	1.14
	0.00195	Clay	9	6.44	8.13	10.05	9.93	11.40	1.93
	<0.00195	Clay	>9	19.09	22.43	29.20	29.64	29.74	4.95

Horizon	Average SUB (0-4cm)	Average SUB (4-8cm)	Average SUB (8-12cm)	Average SUB (12-16cm)	Average SUB (16-20cm)	Standard Deviation SUB
Gravel (>4mm)	0.00	0.00	0.00	0.00	0.00	0.00
Sand (0.0625-2mm)	22.45	19.35	10.99	12.09	9.82	5.88
Silt (0.0312-0.0039mm)	52.02	50.09	49.76	48.34	49.05	8.05
Clay (<0.00195mm)	25.53	30.56	39.25	39.57	41.14	6.88

Results based on % Frequency Weight
Gravel in this sample set represents shell fragments

Table 4.11-3 Summary of Grain Size Characteristics for the Post 1 Survey; SUH Composite sample and the Post 5 Survey; SUI Composite sample.

Palos Verdes Pilot Capping Project
SUH Composite Sample; Post 1 Survey
SU I Composite Sample; Post 5 Survey
Geotechnical Summary Table

POST 1; SUH Bulk Density (g/cc)	0-3 cm; cores SUH06A, SUH07A, SUH08A, SUH09A
Wet Unit Weight	1.40
Dry Unit Weight	0.55

POST 5; SUI Bulk Density (g/cc)	0-4 cm cores SUI 22A & SUI24A
Wet Unit Weight	1.56
Dry Unit Weight	0.87

Grain Size Analysis				0-3 cm; cores SUH06A, SUH07A, SUH08A, SUH09A	0-4 cm; cores SUI 22A & SUI24A
ASTM (Unified) Classification	**Size in mm**	**Wentworth Classification**	**Phi Size**	**POST 1; SUH Composite**	**POST 5; SUI Composite**
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00
	16	Large Pebble	-4	0.00	1.50
Fine Gravel	8	Medium Pebble	-3	0.00	10.83
	4	Small Pebble	-2	0.00	1.83
Coarse Sand	2	Gravel	-1	0.00	2.67
Medium Sand	1	V. Coarse Sand	0	0.96	0.95
	0.5	Coarse Sand	1	0.75	1.76
Fine Sand	0.25	Medium Sand	2	0.91	8.02
	0.125	Fine Sand	3	1.47	7.57
	0.0625	V. Fine Sand	4	7.66	10.35
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	13.06	11.97
	0.0156	Medium Silt	6	14.13	9.46
	0.0078	Fine Silt	7	15.65	12.84
	0.0039	V. Fine Silt	8	9.07	5.31
	0.00195	Clay	9	6.95	4.39
	<0.00195	Clay	>9	29.40	10.55

Total %	SUH Composite	SUI Composite
Gravel (>4mm)	0.00	14.16
Sand (0.0625-2mm)	11.74	31.32
Silt (0.0312-0.0039mm)	51.91	39.58
Clay (<0.00195mm)	36.35	14.94

Results based on % Frequency Weight
Gravel in this sample set represents shell fragments

Table 4.11-4 Summary of Grain Size Characteristics of (A1) Surface and (A3) 3 cm above the EA/Cap Interface Layer of Sediment Cores from Cell SU During Post 21 Survey

Palos Verdes Post 21 Survey Core Grain Size Data
Cell SU
A1= surface material
A3=3 cm above EA/Cap interface

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	A1 Horizon SUC45 (0-6cm)	A1 Horizon SUC46 (0-4cm)	A1 Horizon SUC47 (0-4cm)	A1 Horizon SUC49 (0-6cm)	A3 Horizon SUC46 (4-8cm)	A3 Horizon SUC47 (4-8cm)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	2.38	0.00	0.00	3.63	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	1.33	0.00	1.02	5.94	0.51
	4	Small Pebble	-2	0.00	1.87	0.00	0.26	5.38	1.04
Coarse Sand	2	Gravel	-1	0.06	3.61	0.68	0.37	8.55	1.31
Medium Sand	1	V. Coarse Sand	0	0.10	1.61	0.60	0.32	3.11	0.66
	0.5	Coarse Sand	1	0.86	2.83	1.18	0.19	5.63	1.01
Fine Sand	0.25	Medium Sand	2	1.39	23.25	8.66	0.74	21.83	6.68
	0.125	Fine Sand	3	2.45	42.91	16.87	3.04	15.45	15.06
	0.0625	V. Fine Sand	4	11.60	13.58	8.19	18.05	6.37	16.26
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	21.02	2.36	7.57	24.67	6.04	18.88
	0.0156	Medium Silt	6	14.78	0.92	8.90	13.62	3.88	10.66
	0.0078	Fine Silt	7	10.73	0.55	11.02	7.84	3.09	6.02
	0.0039	V. Fine Silt	8	7.24	0.59	9.30	6.48	2.35	4.49
	0.00195	Clay	9	5.53	0.34	7.27	3.81	1.67	3.07
	<0.00195	Clay	>9	24.24	1.88	19.77	19.56	7.08	14.34

Horizon	SUC45 (0-6cm)	SUC46 (0-4cm)	SUC47 (0-4cm)	SUC49 (0-6cm)	SUC46 (4-8cm)	SUC47 (4-8cm)
Gravel (>4mm)	0.00	5.58	0.00	1.28	14.95	1.56
Sand (0.0625-2mm)	16.47	87.79	36.18	22.73	60.94	40.99
Silt (0.0312-0.0039mm)	53.76	4.41	36.79	52.61	15.36	40.04
Clay (<0.00195mm)	29.77	2.22	27.03	23.37	8.75	17.41

Results based on % Frequency Weight
Gravel in this sample set represents shell fragments

Table 4.11-5 Summary of Grain Size Characteristics of (A4) Layer, 4 cm below the EA/Cap interface of Sediment Cores from Cell SU During Post 21 Survey

Palos Verdes Post 21 Survey Core Grain Size Data
Cell SU
A4= 4cm below the EA/Cap interface

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	SUC45 (6-12cm)	SUC45 (6-12cm) DUPLICATE	SUC46 (10-14cm)	SUC46 (10-14cm) DUPLICATE	SUC47 (10-14cm)	SUC49 (6-12cm)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	4.36	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.64	1.37	0.00	0.00	0.00
	4	Small Pebble	-2	0.00	1.05	1.02	1.12	0.00	0.39
Coarse Sand	2	Gravel	-1	2.84	1.17	1.97	1.91	0.00	0.54
Medium Sand	1	V. Coarse Sand	0	0.23	0.65	0.59	0.48	0.29	0.33
	0.5	Coarse Sand	1	0.49	0.84	0.62	0.83	0.26	0.20
Fine Sand	0.25	Medium Sand	2	1.48	2.65	2.45	2.44	0.73	0.76
	0.125	Fine Sand	3	2.54	4.45	3.82	3.48	1.64	1.60
	0.0625	V. Fine Sand	4	7.13	6.12	10.23	10.79	11.36	9.30
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	13.20	11.87	16.87	16.96	20.09	17.70
	0.0156	Medium Silt	6	13.62	11.65	12.35	12.99	13.96	14.37
	0.0078	Fine Silt	7	12.85	12.69	9.86	9.65	10.27	11.47
	0.0039	V. Fine Silt	8	9.63	8.80	7.68	8.18	8.74	9.04
	0.00195	Clay	9	6.67	6.61	5.68	5.73	5.29	5.97
	<0.00195	Clay	>9	29.31	26.46	25.50	25.45	27.35	28.33

Horizon	SUC45 (6-12cm)	SUC45 (6-12cm) DUPLICATE	SUC46 (10-14cm)	SUC46 (10-14cm) DUPLICATE	SUC47 (10-14cm)	SUC49 (6-12cm)
Gravel (>4mm)	0.00	6.05	2.39	1.12	0.00	0.39
Sand (0.0625-2mm)	14.72	15.88	19.67	19.93	14.28	12.73
Silt (0.0312-0.0039mm)	49.30	45.01	46.76	47.77	53.07	52.58
Clay (<0.00195mm)	35.98	33.07	31.18	31.18	32.65	34.30

Results based on % Frequency Weight
Gravel in this sample set represents shell fragments

Table 4.11-6. Vibracore Summary for Cell SU

Replicate ID CORES	Total Core Length (cm)	Cap material/EA sediment interface (cm)
SUSV1 I13A	106.5	6
SUSV3 I01B	77.5	None apparent
SUSV3 I14A	68	None apparent
SUSV3 I10A	46	9 (mixed)
SUSV3 I15A	63.5	8
SUSV4 I06A	82	None apparent
SUSV4 I09A	82	None apparent

Table 4.11-7. Grain Size distribution in Horizon 1 (0-4 cm) of the Supplemental Vibracores from Cell SU.

Palos Verdes Pilot Capping Project
SUS; Post 21 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
0-4cm of core
Sample Horizon 1

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	SUSV 3 I01B 0-4cm	SUSV 4 I06A 0-4cm	SUSV 4 I09A 0-4cm	SUSV 3 I14A 0-4cm
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.00	0.00	0.00
	4	Small Pebble	-2	0.00	0.00	0.00	0.22
Coarse Sand	2	Gravel	-1	0.00	0.26	0.23	0.21
Medium Sand	1	V. Coarse Sand	0	0.10	0.22	0.13	0.37
	0.5	Coarse Sand	1	0.24	0.53	0.20	0.30
Fine Sand	0.25	Medium Sand	2	1.06	1.56	0.44	4.78
	0.125	Fine Sand	3	3.02	3.10	1.07	18.02
	0.0625	V. Fine Sand	4	13.95	16.71	6.84	27.22
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	24.85	24.88	15.57	22.50
	0.0156	Medium Silt	6	14.34	14.71	31.05	8.93
	0.0078	Fine Silt	7	10.37	9.08	15.13	4.53
	0.0039	V. Fine Silt	8	6.58	6.71	4.23	2.88
	0.00195	Clay	9	5.22	5.09	5.57	2.00
	<0.00195	Clay	>9	20.27	17.13	19.53	8.04

Summary of SUSV 0-4cm Grain Size Data	SUSV 3 I01B 0-4cm	SUSV 4 I06A 0-4cm	SUSV 4 I09A 0-4cm	SUSV 3 I14A 0-4cm
Gravel (>4mm)	0.00	0.00	0.00	0.22
Sand (0.0625-2mm)	18.37	22.39	8.92	50.90
Silt (0.0312-0.0039mm)	56.14	55.38	65.98	38.84
Clay (<0.00195mm)	25.49	22.23	25.10	10.04

Results based on % Frequency Weight

Table 4.11-8. Grain Size distribution in Horizon 2 (4-8 cm) of the Supplemental Vibracores from Cell SU.

Palos Verdes Pilot Capping Project
SUS; Post 21 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
4-8cm of core
Sample Horizon 2

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	SUSV 3 I01 B 4-8cm	SUSV 4 I06 A 4-8cm	SUSV 4 I09 A 4-8cm	SUSV 3 I14 A 4-8cm
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	1.57	0.00	1.09
	4	Small Pebble	-2	0.00	0.23	0.00	0.00
Coarse Sand	2	Gravel	-1	0.00	0.57	0.00	0.03
Medium Sand	1	V. Coarse Sand	0	0.01	0.06	0.00	0.04
	0.5	Coarse Sand	1	0.15	0.40	0.01	0.17
Fine Sand	0.25	Medium Sand	2	0.45	2.44	0.06	2.12
	0.125	Fine Sand	3	1.26	4.44	1.14	6.22
	0.0625	V. Fine Sand	4	9.20	11.95	8.68	26.17
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	19.10	20.21	18.72	30.30
	0.0156	Medium Silt	6	15.06	13.31	16.29	12.75
	0.0078	Fine Silt	7	11.18	9.88	12.94	5.36
	0.0039	V. Fine Silt	8	9.14	8.00	10.44	3.43
	0.00195	Clay	9	7.66	6.12	8.19	2.18
	<0.00195	Clay	>9	26.79	20.82	23.53	10.15

Summary of SUSV 4-8cm Grain Size Data	SUSV 3 I01 B 4-8cm	SUSV 4 I06 A 4-8cm	SUSV 4 I09 A 4-8cm	SUSV 3 I14 A 4-8cm
Gravel (>4mm)	0.00	1.80	0.00	1.09
Sand (0.0625-2mm)	11.06	19.86	9.89	34.74
Silt (0.0312-0.0039mm)	54.48	51.39	58.39	51.84
Clay (<0.00195mm)	34.45	26.94	31.72	12.33

Results based on % Frequency Weight

Table 4.11-9 Grain Size distribution in Horizon 3 (8-12 cm) of the Supplemental Vibracores from Cell SU.

Palos Verdes Pilot Capping Project
SUS; Post 21 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
8-12cm of core
Sample Horizon 3

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	SUSV 3 I01B 8-12cm	SUSV 4 I06 A 8-12cm	SUSV 4 I06 A Duplicate 8-12cm	SUSV 4 I09 A 8-12cm	SUSV 3 I14 A 8-12cm
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.00	0.00	0.00	0.00
	4	Small Pebble	-2	0.46	0.00	0.00	0.00	0.29
Coarse Sand	2	Gravel	-1	0.25	0.00	0.48	0.13	0.27
Medium Sand	1	V. Coarse Sand	0	0.03	0.14	0.14	0.07	0.10
	0.5	Coarse Sand	1	0.17	0.27	0.29	0.15	0.19
Fine Sand	0.25	Medium Sand	2	0.71	0.64	0.81	0.57	2.19
	0.125	Fine Sand	3	1.48	1.59	2.89	1.81	5.79
	0.0625	V. Fine Sand	4	5.87	7.91	9.06	12.01	27.44
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	24.44	15.86	15.49	19.44	30.49
	0.0156	Medium Silt	6	14.04	15.86	15.56	16.17	12.55
	0.0078	Fine Silt	7	13.09	13.91	14.49	17.02	6.00
	0.0039	V. Fine Silt	8	8.21	10.25	9.49	6.36	3.49
	0.00195	Clay	9	6.42	7.80	7.11	5.82	2.23
	<0.00195	Clay	>9	24.83	25.77	24.20	20.46	8.96

Summary of SUSV 8-12cm Grain Size Data	SUSV 3 I01B 8-12cm	SUSV 4 I06 A 8-12cm	SUSV 4 I06 A Duplicate 8-12cm	SUSV 4 I09 A 8-12cm	SUSV 3 I14 A 8-12cm
Gravel (>4mm)	0.46	0.00	0.00	0.00	0.29
Sand (0.0625-2mm)	8.51	10.54	13.66	14.74	35.98
Silt (0.0312-0.0039mm)	59.77	55.89	55.03	58.99	52.53
Clay (<0.00195mm)	31.25	33.57	31.31	26.28	11.20

Results based on % Frequency Weight

Table 4.11-10. Grain Size distribution in Horizon 4 (12-16 cm) of the Supplemental Vibracores from Cell SU.

Palos Verdes Pilot Capping Project
SUS; Post 21 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
12-16cm of core
Sample Horizon 4

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	SUSV 3 I01 B 12-16cm	SUSV 4 I06 A 12-16cm	SUSV 4 I09 A 12-16cm	SUSV 3 I14 A 12-16cm
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.00	0.00	0.00
	4	Small Pebble	-2	0.14	0.00	2.79	0.00
Coarse Sand	2	Gravel	-1	0.15	0.02	0.08	0.11
Medium Sand	1	V. Coarse Sand	0	0.10	0.00	0.17	0.11
	0.5	Coarse Sand	1	0.07	0.08	0.21	0.12
Fine Sand	0.25	Medium Sand	2	0.57	0.72	0.55	1.40
	0.125	Fine Sand	3	1.75	2.23	1.50	3.72
	0.0625	V. Fine Sand	4	9.07	18.12	10.16	30.09
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	18.09	25.42	17.78	35.67
	0.0156	Medium Silt	6	15.18	13.82	14.47	11.02
	0.0078	Fine Silt	7	11.77	8.36	11.01	4.54
	0.0039	V. Fine Silt	8	8.30	6.69	8.80	2.60
	0.00195	Clay	9	8.36	4.50	6.87	1.53
	<0.00195	Clay	>9	26.45	20.03	25.60	9.09

Summary of SUSV 12-16cm Grain Size Data	SUSV 3 I01 B 12-16cm	SUSV 4 I06 A 12-16cm	SUSV 4 I09 A 12-16cm	SUSV 3 I14 A 12-16cm
Horizon				
Gravel (>4mm)	0.14	0.00	2.79	0.00
Sand (0.0625-2mm)	11.71	21.17	12.68	35.55
Silt (0.0312-0.0039mm)	53.34	54.30	52.05	53.83
Clay (<0.00195mm)	34.81	24.53	32.47	10.62

Results based on % Frequency Weight

Table 4.11-11. Grain Size distribution in Horizon 5 (16-20 cm) of the Supplemental Vibracores from Cell SU.

Palos Verdes Pilot Capping Project
SUS; Post 21 Placements, Supplemental Survey
Sediment Grain Size Summary Table:
16-20cm of core
Sample Horizon 5

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	SUSV 3 I01B 16-20cm	SUSV 4 I06A 16-20cm	SUSV 4 I09A 16-20cm	SUSV 3 I14A 16-20cm
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.83	0.00	0.00	0.00
	4	Small Pebble	-2	0.20	0.00	0.00	0.00
Coarse Sand	2	Gravel	-1	0.13	0.02	0.08	0.10
Medium Sand	1	V. Coarse Sand	0	0.08	0.01	0.05	0.06
	0.5	Coarse Sand	1	0.37	0.05	0.12	0.12
Fine Sand	0.25	Medium Sand	2	1.92	0.23	0.53	2.33
	0.125	Fine Sand	3	5.61	2.37	1.60	5.07
	0.0625	V. Fine Sand	4	20.37	27.31	12.09	31.41
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	25.61	31.96	19.50	34.85
	0.0156	Medium Silt	6	12.19	13.97	15.21	10.96
	0.0078	Fine Silt	7	7.80	6.62	12.35	4.28
	0.0039	V. Fine Silt	8	5.31	3.89	9.12	2.27
	0.00195	Clay	9	4.07	2.71	6.18	1.43
	<0.00195	Clay	>9	15.51	10.86	23.17	7.12

Summary of SUSV 16-20cm Grain Size Data	SUSV 3 I01B 16-20cm	SUSV 4 I06A 16-20cm	SUSV 4 I09A 16-20cm	SUSV 3 I14A 16-20cm
Horizon				
Gravel (>4mm)	1.03	0.00	0.00	0.00
Sand (0.0625-2mm)	28.48	29.99	14.47	39.09
Silt (0.0312-0.0039mm)	50.91	56.44	56.19	52.35
Clay (<0.00195mm)	19.58	13.57	29.34	8.56

Results based on % Frequency Weight

Table 4.11-12. Grain Size distribution in Horizon 7 (24-28 cm), Horizon 9 (32-36 cm) and Horizon 11 (44-48 cm) of the Supplemental Vibracores from Cell SU.

Palos Verdes Pilot Capping Project
SUS; Post 21 Placements, Supplemental Survey
Sediment Grain Size Summary Table: Sample Horizons 7, 9 and 11

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	Horizon 7				Horizon 9				Horizon 11			
				SUSV 3 101 B 24-28cm	SUSV 4 106 A 24-28cm	SUSV 4 109 A 24-28cm	SUSV 3 114 A 24-28cm	SUSV 3 101 B 32-36cm	SUSV 4 106 A 32-36cm	SUSV 4 109 A 32-36cm	SUSV 3 114 A 32-36cm	SUSV 3 101 B 40-44cm	SUSV 4 106 A 40-44cm	SUSV 4 109 A 40-44cm	SUSV 3 114 A 40-44cm
			(f)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Coarse Gravel	>32	V. Large Pebble	<-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	16	Large Pebble	-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fine Gravel	8	Medium Pebble	-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	Small Pebble	-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coarse Sand	2	Gravel	-1	0.18	0.00	0.03	0.14	0.22	0.02	0.00	0.50	0.09	0.01	0.00	0.04
Medium Sand	1	V. Coarse Sand	0	0.03	0.01	0.06	0.18	0.04	0.00	0.04	0.12	0.03	0.00	0.02	0.04
	0.5	Coarse Sand	1	0.18	0.03	0.10	0.22	0.09	0.04	0.03	0.27	0.13	0.02	0.05	0.08
Fine Sand	0.25	Medium Sand	2	1.09	0.26	1.14	2.51	0.96	0.38	0.57	1.12	1.06	0.26	0.11	0.60
	0.125	Fine Sand	3	3.45	2.52	6.00	4.85	2.28	1.89	2.27	2.20	1.99	1.61	1.27	1.60
	0.0625	V. Fine Sand	4	25.58	26.64	24.79	29.78	25.55	27.52	24.06	24.15	27.30	25.11	30.33	30.32
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	12.61	33.27	28.60	35.84	29.68	30.22	31.79	51.67	30.60	32.21	33.70	39.86
	0.0156	Medium Silt	6	24.82	13.99	13.57	11.41	15.93	14.68	16.06	8.55	15.86	14.58	14.21	11.26
	0.0078	Fine Silt	7	8.46	6.91	6.97	3.95	7.83	7.59	6.88	3.27	8.01	7.78	5.69	4.23
	0.0039	V. Fine Silt	8	5.38	3.63	4.29	2.14	4.05	4.19	3.79	1.59	3.92	4.37	3.00	2.27
	0.00195	Clay	9	3.47	2.30	2.57	0.74	2.38	2.72	2.66	1.04	2.24	2.81	2.08	1.48
	<0.00195	Clay	>9	3.49	2.08	2.04	2.18	10.99	10.75	11.85	5.52	8.78	11.25	9.53	8.21

Summary of SUSV 24-28cm Grain Size Data	Horizon 7				Horizon 9				Horizon 11			
	SUSV 3 101 B 24-28cm	SUSV 4 106 A 24-28cm	SUSV 4 109 A 24-28cm	SUSV 3 114 A 24-28cm	SUSV 3 101 B 32-36cm	SUSV 4 106 A 32-36cm	SUSV 4 109 A 32-36cm	SUSV 3 114 A 32-36cm	SUSV 3 101 B 40-44cm	SUSV 4 106 A 40-44cm	SUSV 4 109 A 40-44cm	SUSV 3 114 A 40-44cm
Horizon												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand (0.0625-2mm)	30.52	29.46	32.12	37.68	29.14	29.85	26.97	28.36	30.60	27.00	31.79	32.69
	51.28	57.80	53.44	53.34	57.49	56.68	58.52	65.09	58.39	58.94	56.61	57.62
Clay (<0.00195mm)	6.96	4.37	4.61	2.92	13.37	13.47	14.51	6.56	11.02	14.06	11.61	9.69

Table 4.11-13. DDE Concentrations (ppm dry weight) and Estimated Proportions (Percent) of Cap Material (Queen's Gate Sediment) in Post 21 Sediment Cores from Cell SU. Proportions were calculated from DDE concentrations in postcapping sediment cores and assuming a uniform DDE concentration of 0.02 ppm DDE concentration in cap material and 6.8 ppm DDE concentration in EA sediments**.**

	Post 21 Survey Cores			
Horizon	**SUC45**	**SUC46**	**SUC47**	**SUC49**
A1	9.6 (0)	0.042 (99)	0.030 (99)	5.7 (16)
A2	-	-	-	-
A3	-	5.8 (15)	2.2 (68)	-
A4	29 (0)	32 (0)	6.6 (0)	6.8 (3)

- = not sampled; A1=surface; A2=7 cm above interface; A3=3 cm above interface; A4=4 cm below interface.

Table 4.11-14. DDE Concentrations (ppm dry weight) in Supplemental Cores from Cell SU. Average concentrations in Cell SU baseline sediment cores are provided for comparison.

	Baseline	**Supplemental Survey**			
Core Depth (cm)	**Average – All Cores**	**I01**	**I06**	**I09**	**I14**
0-4	6.0	4.9	3.5	150	2.8
4-8	7.6	24	7.3	69	0.59
8-12	12	30	12	57	0.41
12-16	42	9.0	44	18	0.13
16-20	46	1.4	5.5	11	0.19
24-28	NA	0.056	0.067	3.0	0.004
32-36	NA	0.39	0.010	1.2	0.0069
40-44	NA	0.11	0.0074	0.50	<0.0014

NA = not analyzed

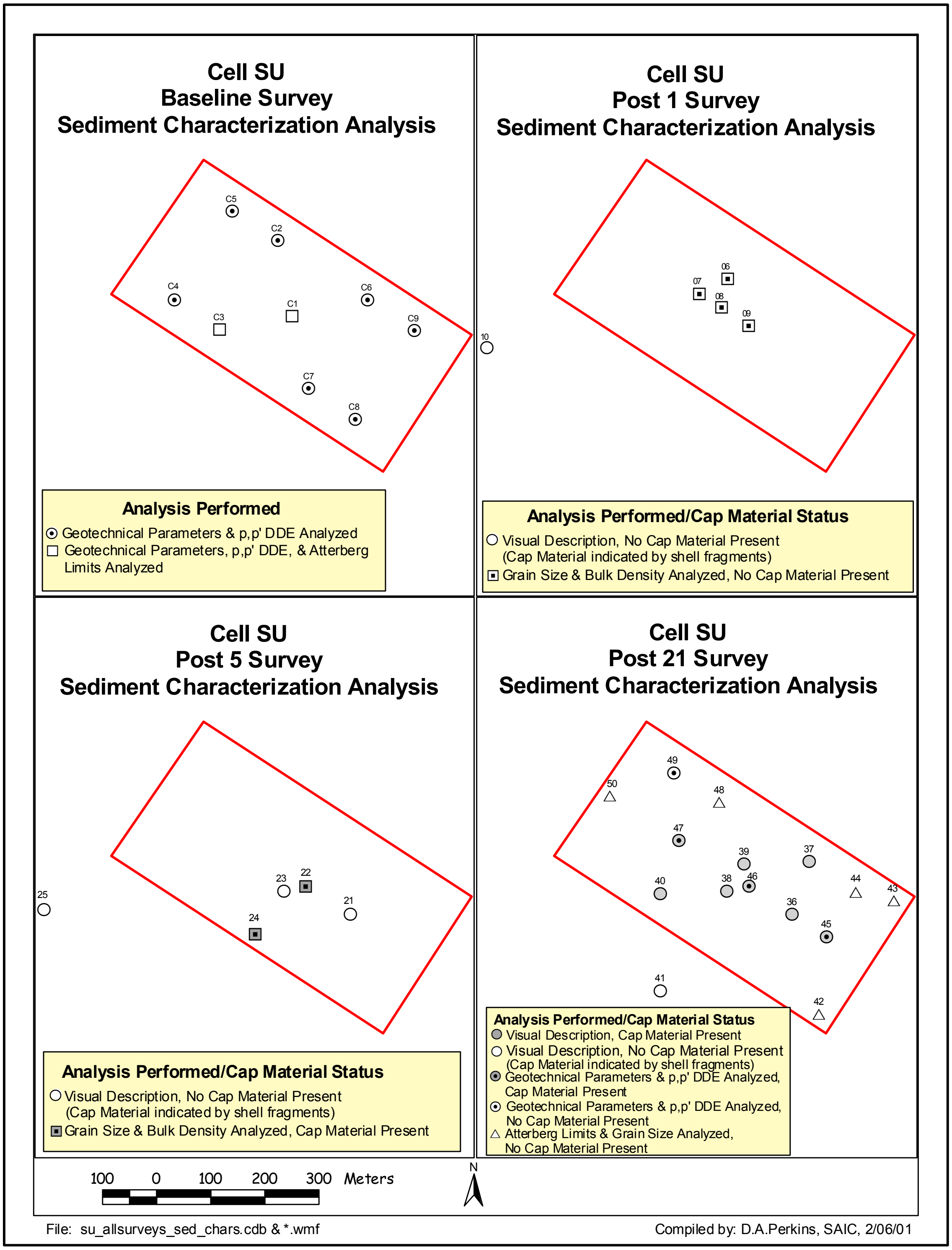


Figure 4.11-1. Coring locations in Cell SU during (a) Baseline, (b) Post 1, (c) Post 5 and (d) Post 21 surveys.

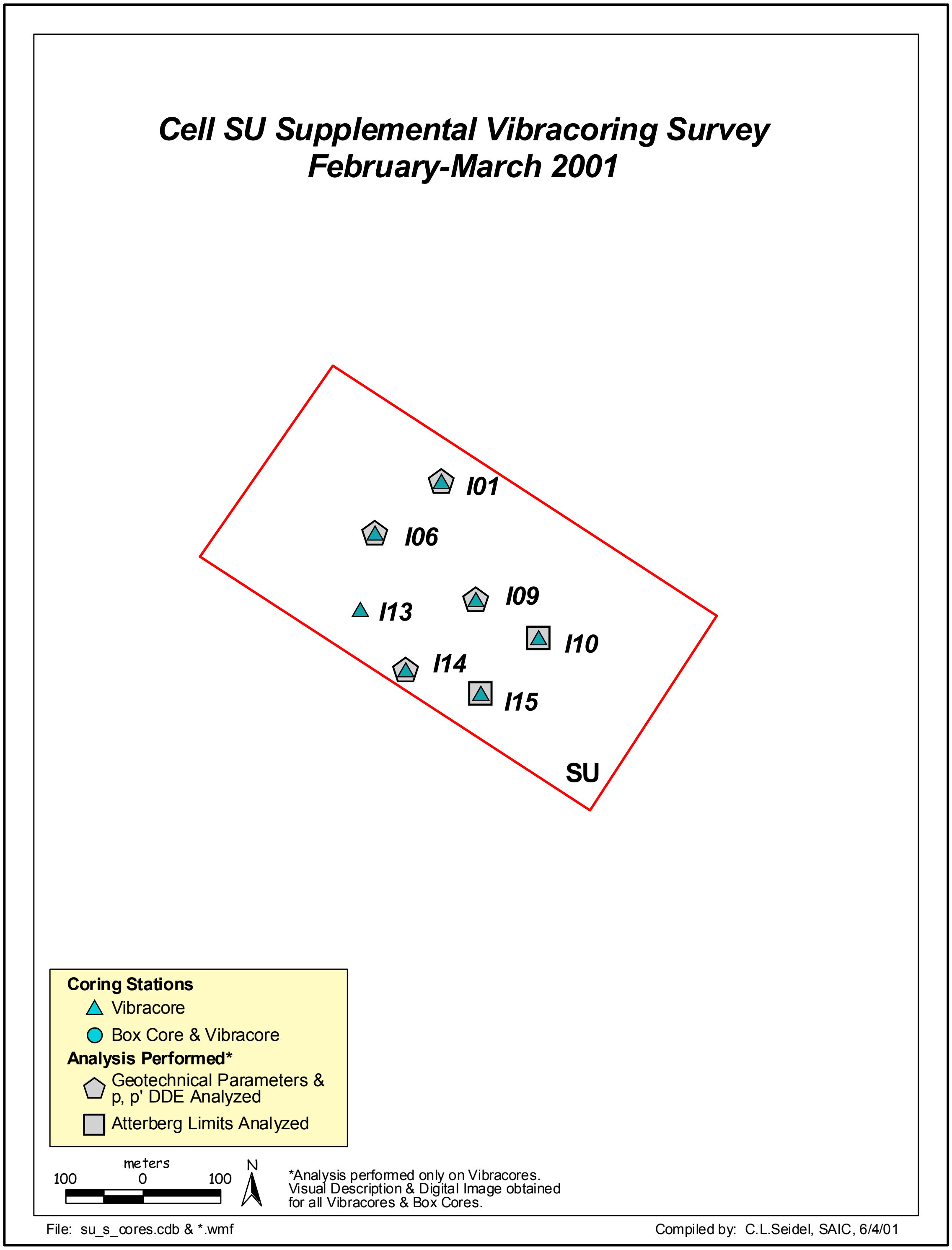


Figure 4.11-2. Vibracore locations for Cell SU supplemental survey.

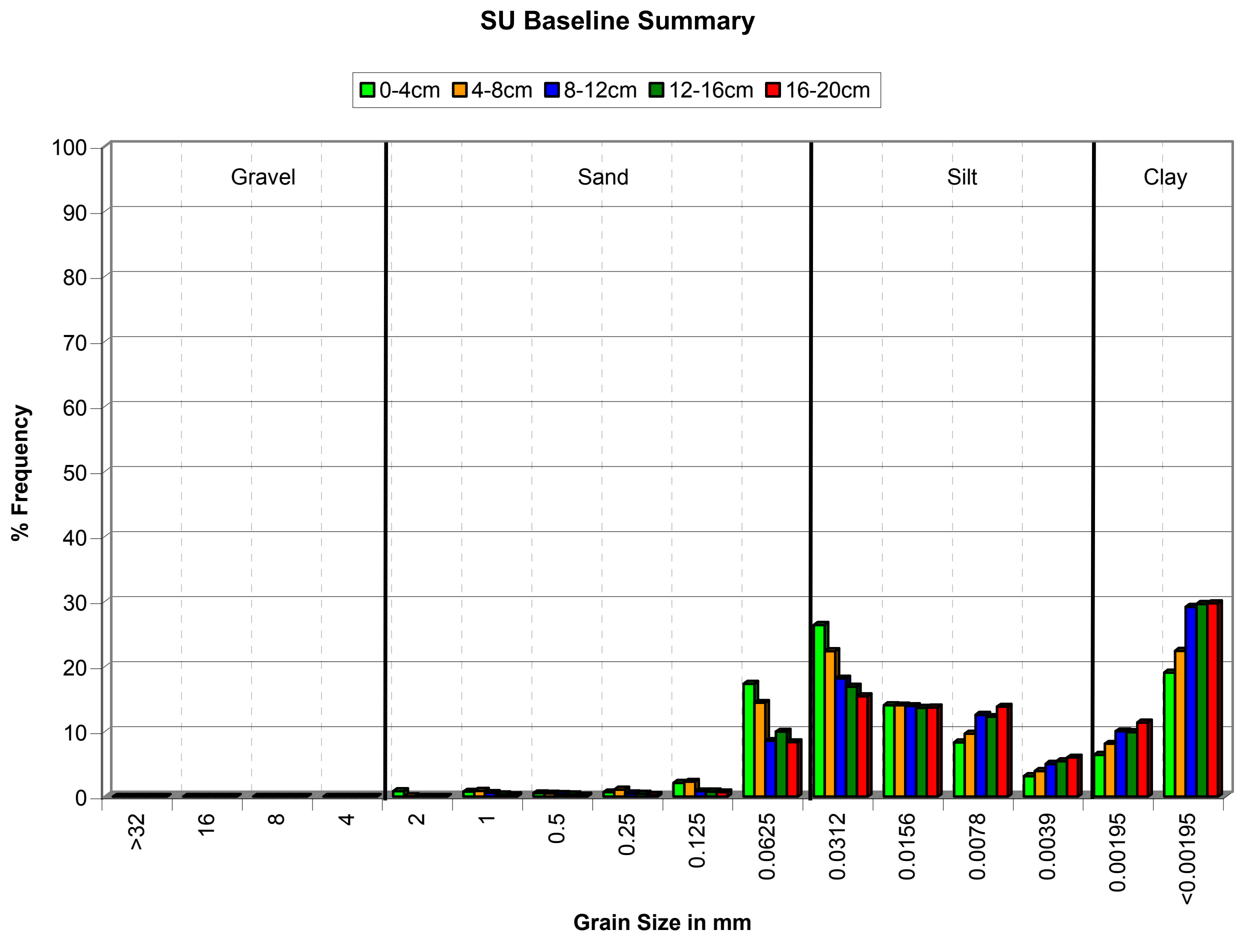


Figure 4.11-3. Baseline grain size distributions in Cell SU.

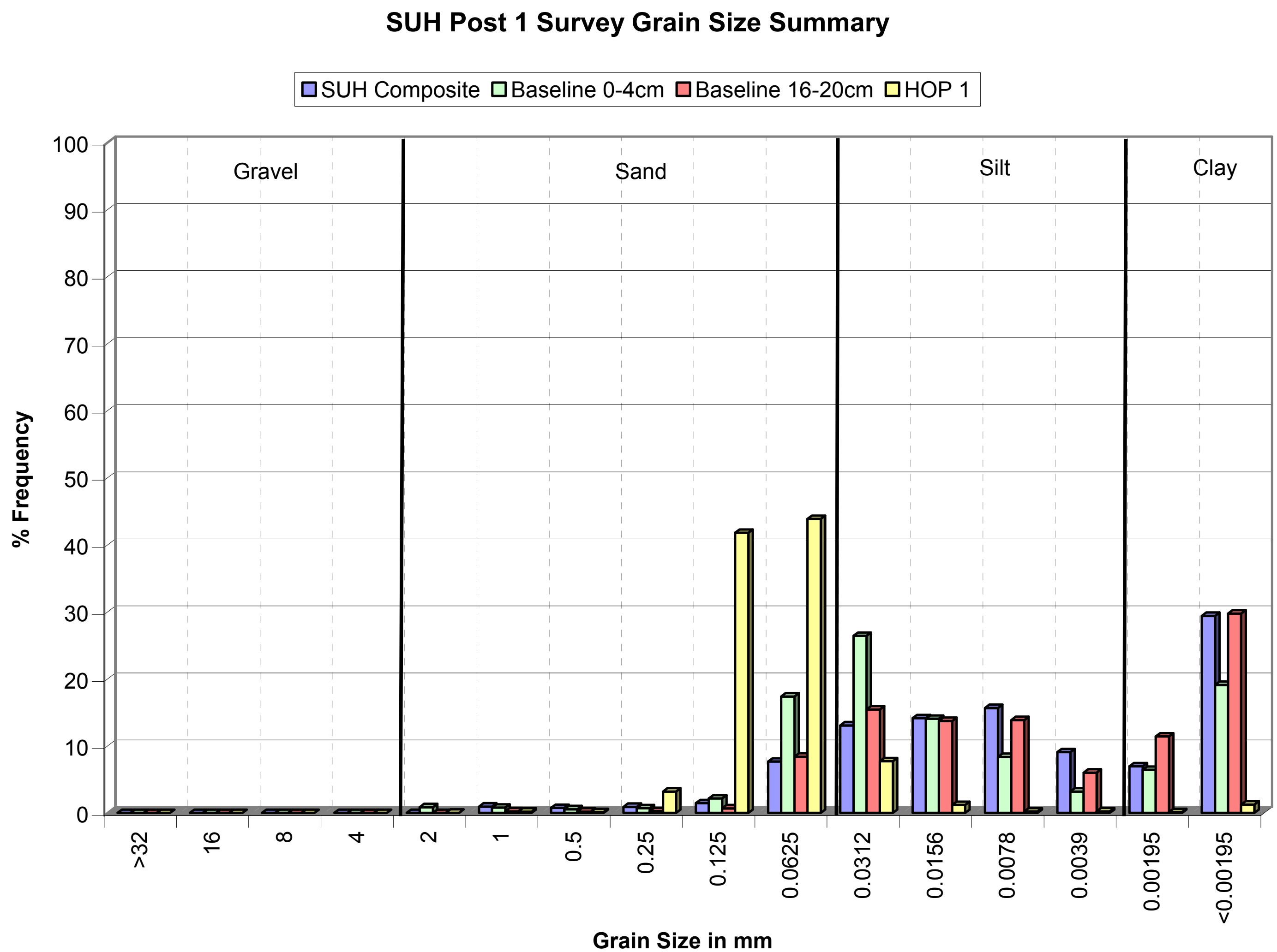


Figure 4.11-4. Grain size distributions of Cell SU sediments prior to (baseline) and following one placement event (SUH). Grain size data for hopper sediments (HOP 1) are provided for comparison.

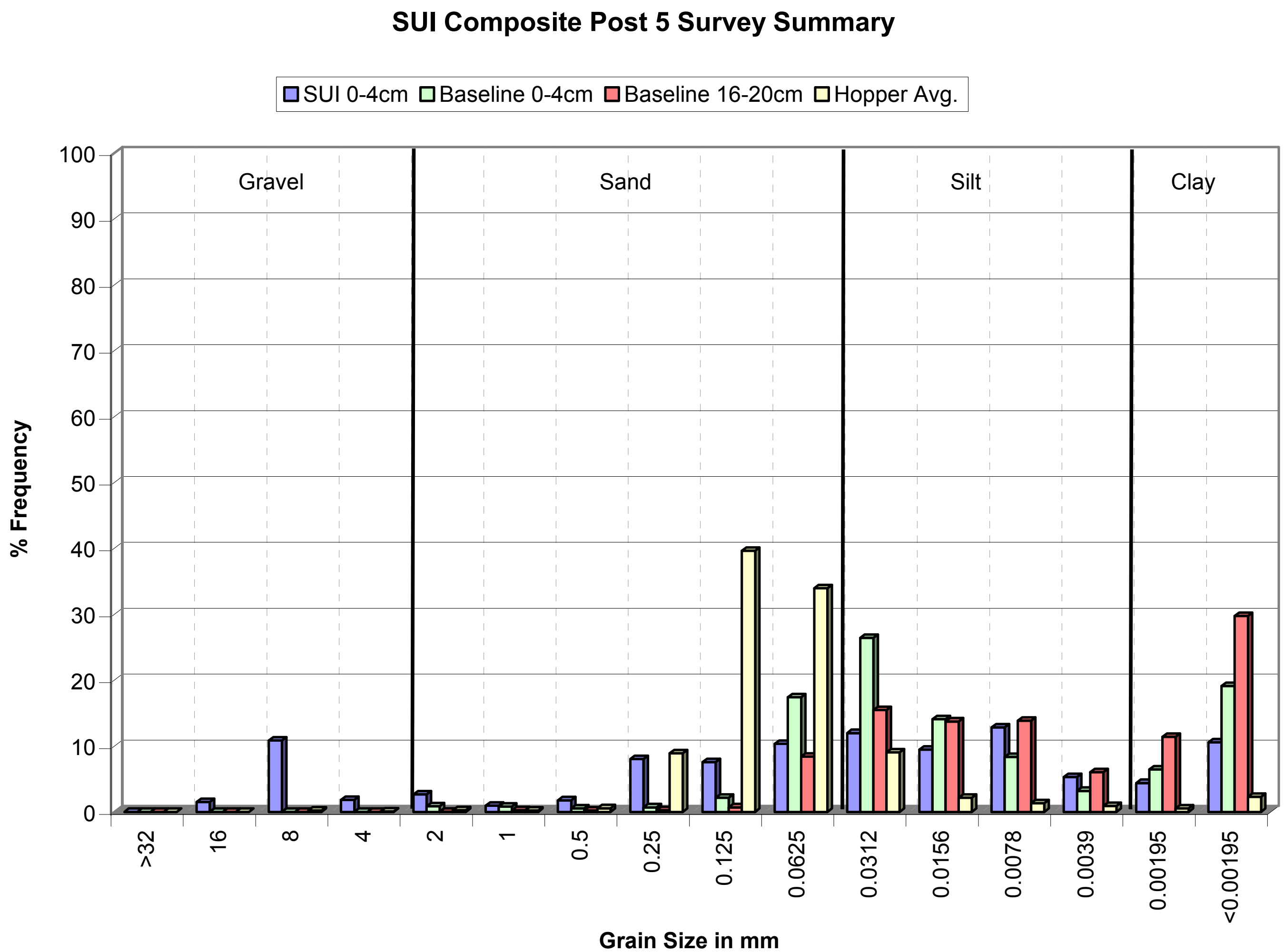


Figure 4.11-5. Grain size distributions of Cell SU sediments during baseline and following five placement events (SUI Composite). Average grain size distributions for hopper sediments (Hopper Avg.) are provided for comparison.

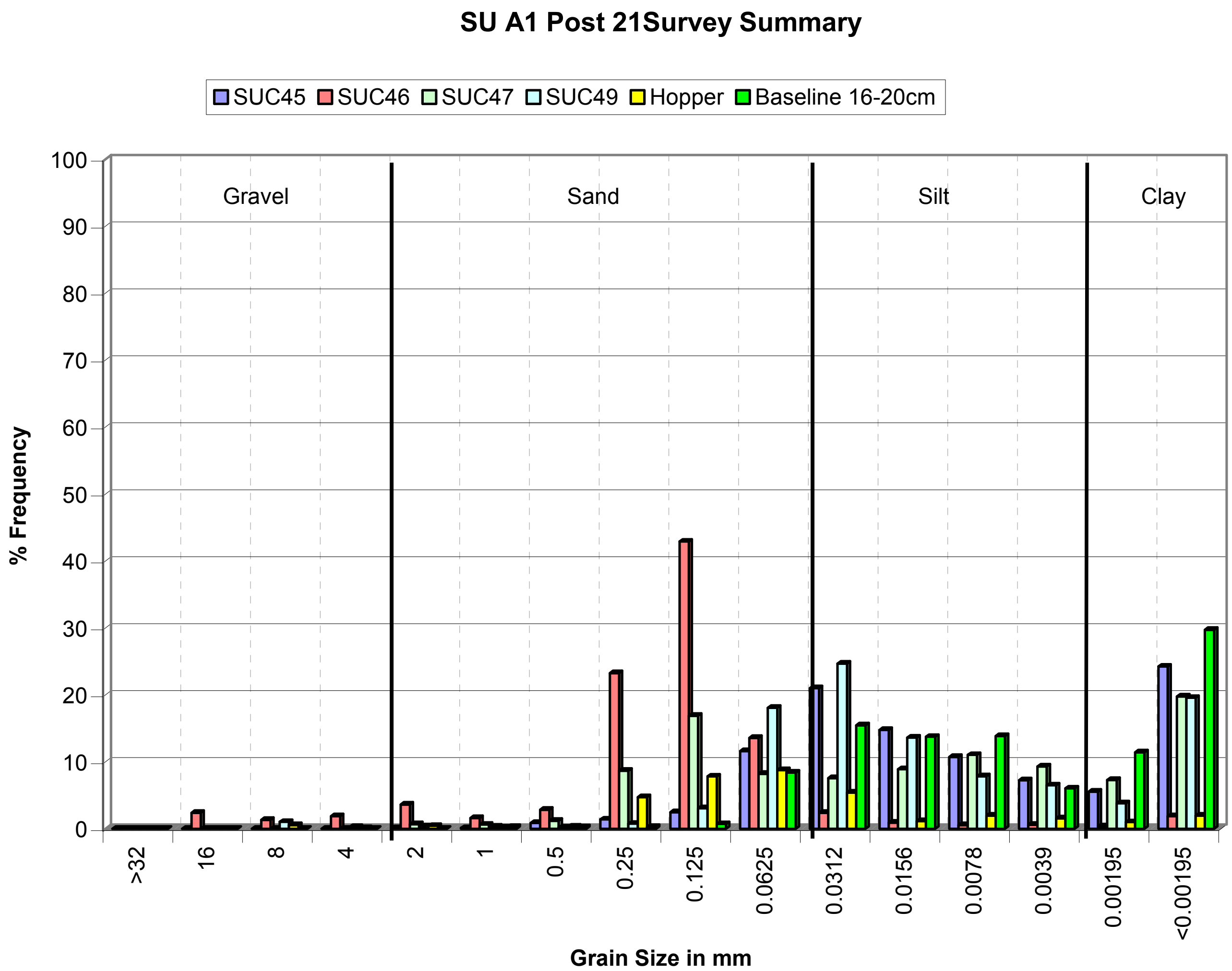


Figure 4.11-6. Grain size distributions in surface (A1) horizon of Post 21 survey sediment cores from Cell SU. Data from baseline cores and hopper samples are provided for comparisons with postcap sediments.

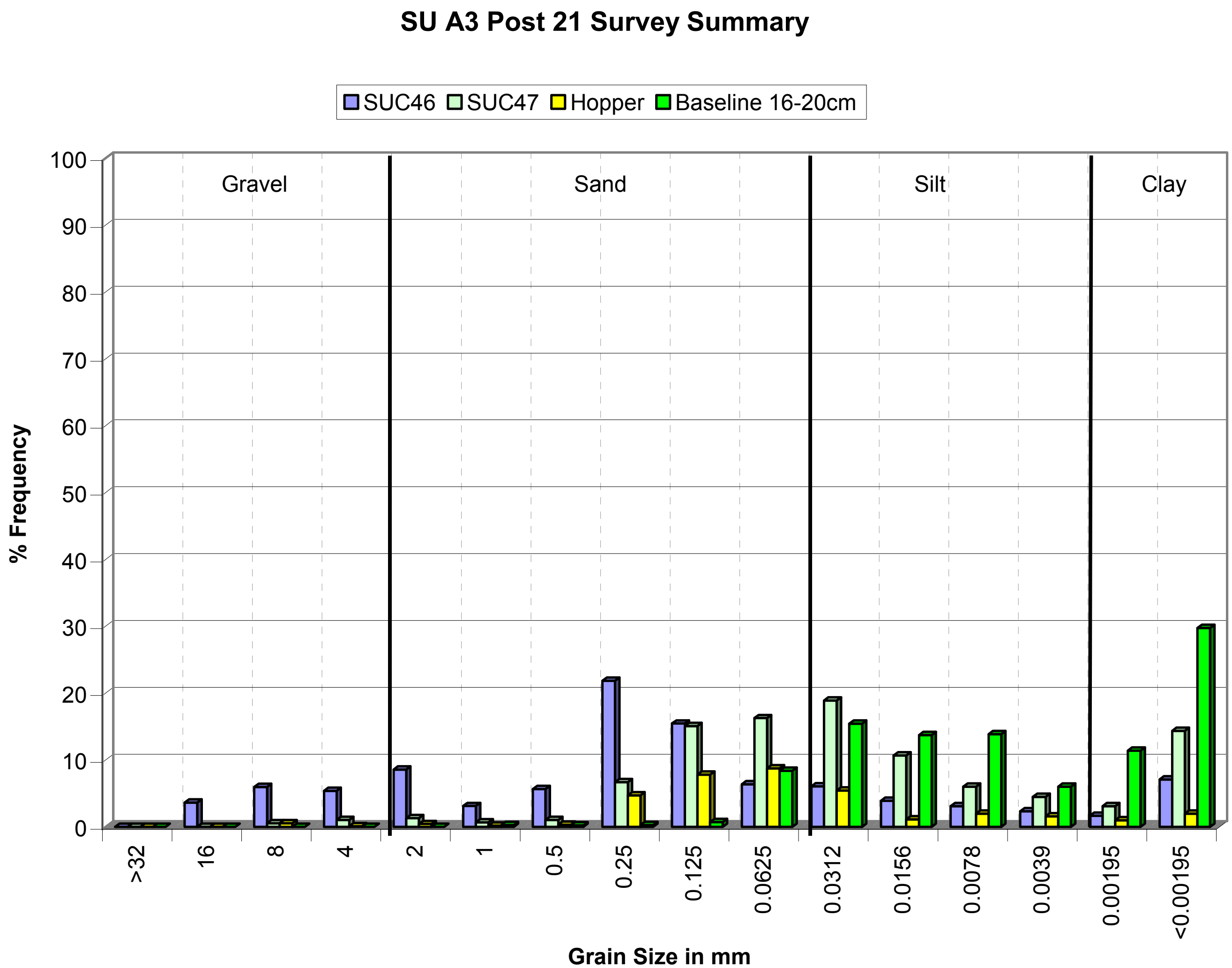


Figure 4.11-7. Grain size distributions in A3 horizon of Post 21 survey sediment cores from Cell SU. Data from baseline cores and hopper samples are provided for comparisons with postcap sediments.

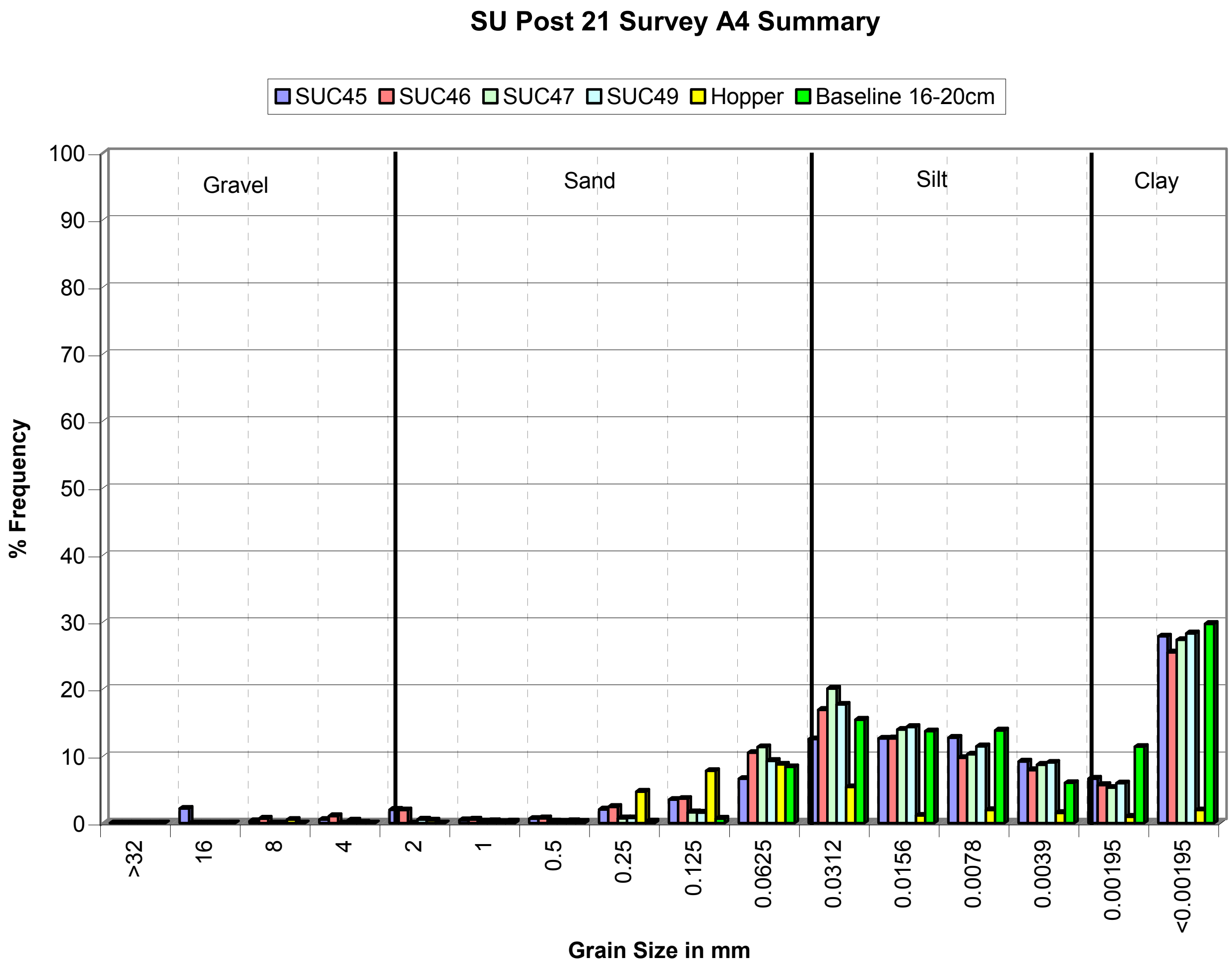


Figure 4.11-8. Grain size distributions in A4 horizon of Post 21 survey sediment cores from Cell SU. Data from baseline cores and hopper samples are provided for comparisons with postcap sediments.

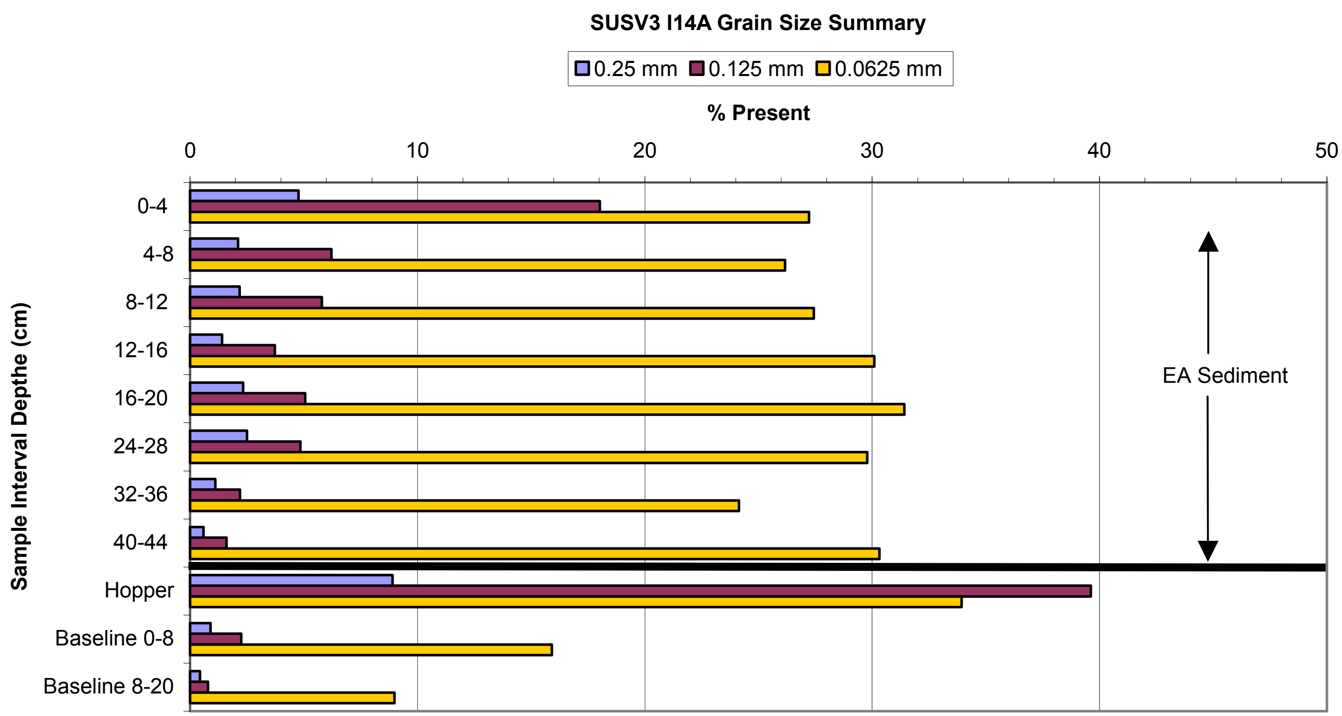


Figure 4.11-9. Grain Size distribution Core SUSV3 I14A of the Supplemental Vibracores from Cell SU. Hopper sample average and Baseline average 0-8 cm and 8-20 cm are provided for comparison.

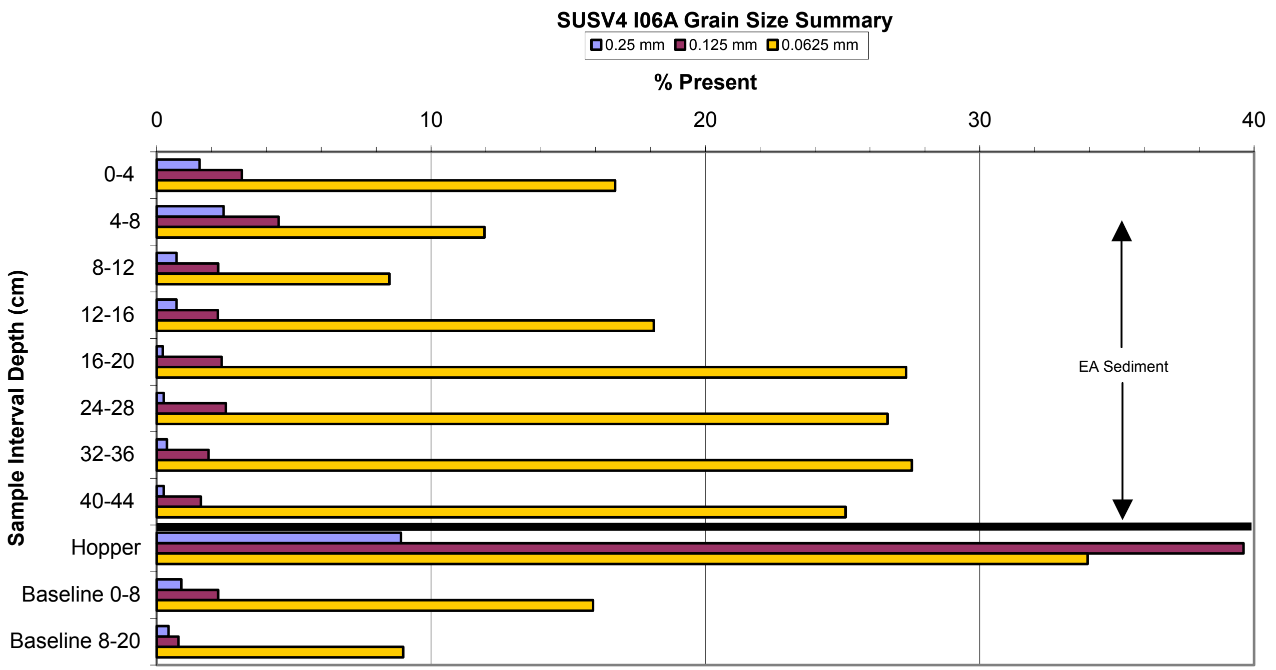


Figure 4.11-10. Grain Size distribution in Core SUSV4 I06A of the Supplemental Vibracores from Cell SU. Hopper sample average and Baseline average 0-8 cm and 8-20 cm are provided for comparison.

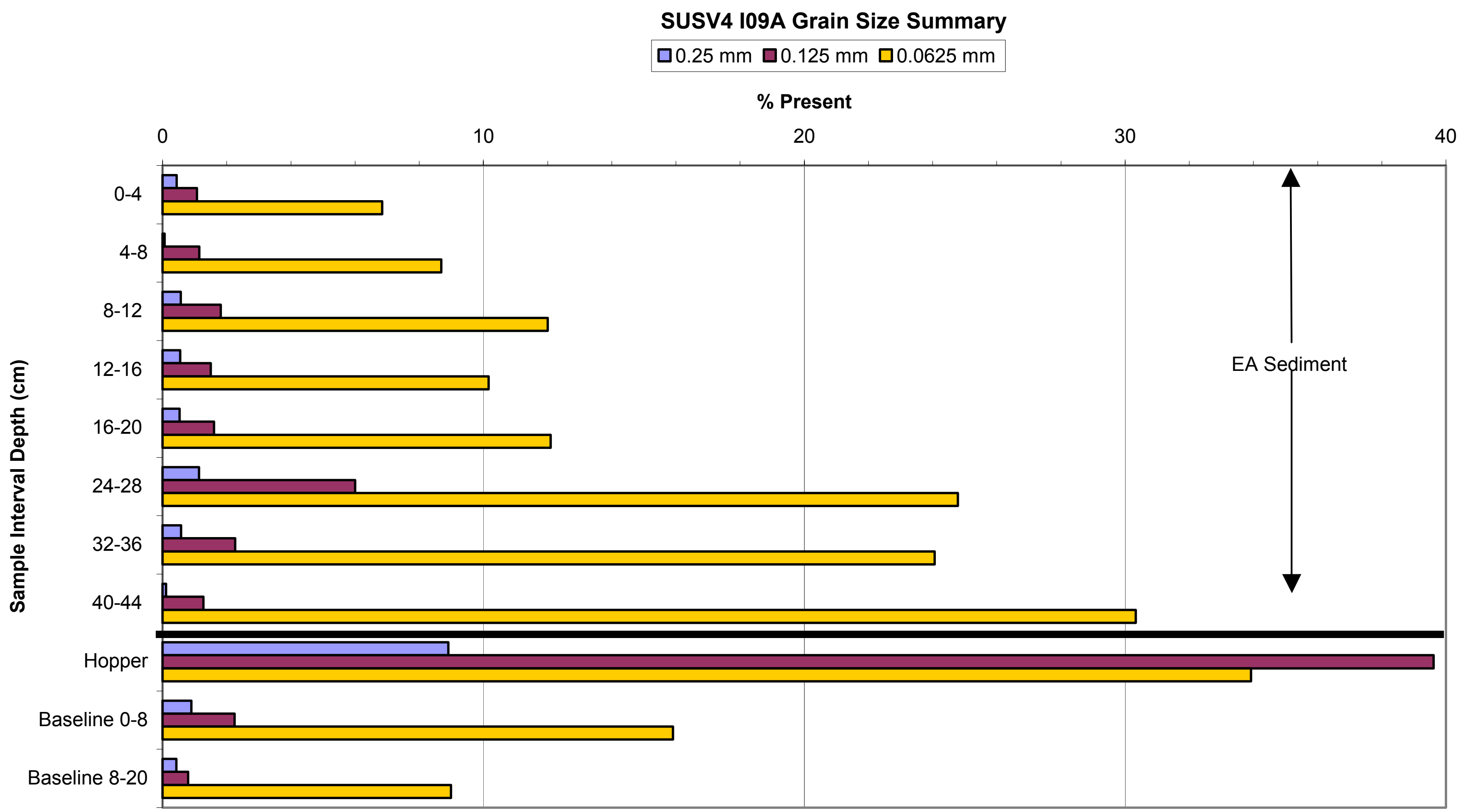


Figure 4.11-11. Grain Size distribution in Core SUSV4 I09A of the Supplemental Vibracores from Cell SU. Hopper sample average and Baseline average 0-8 cm and 8-20 cm are provided for comparison.

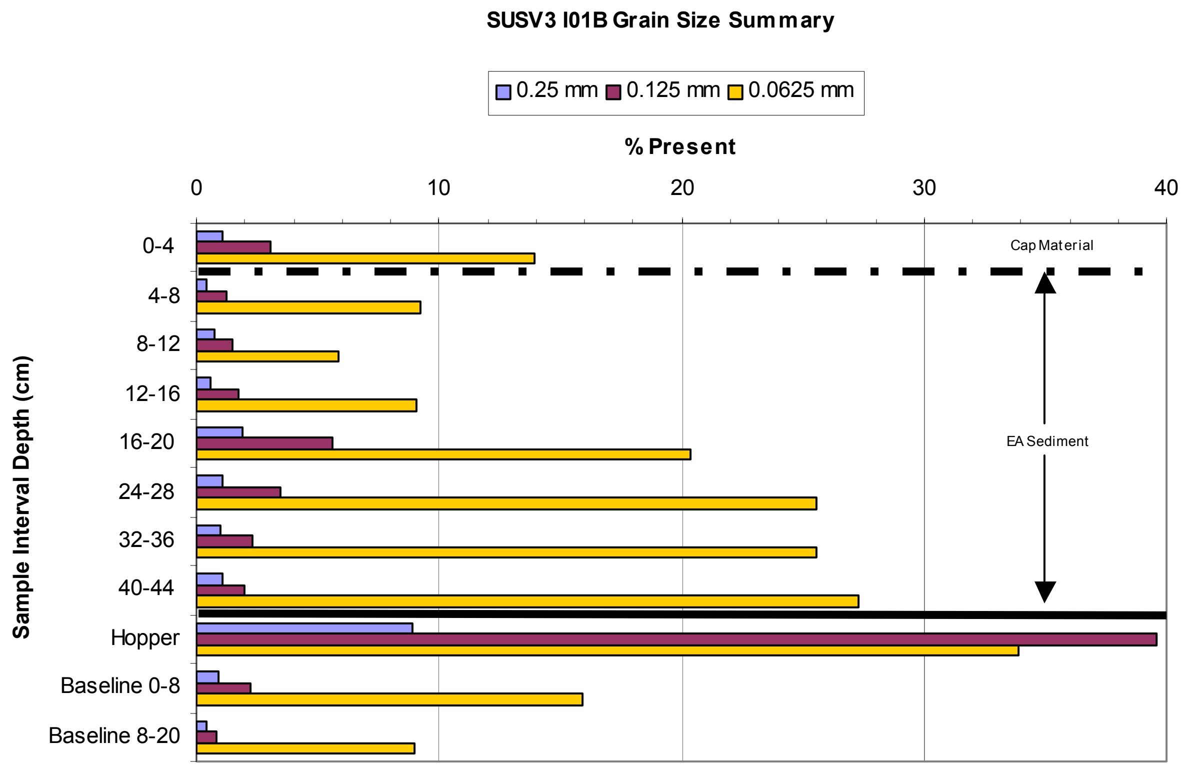


Figure 4.11-12. Grain Size distribution in Core SUSV3 I01B of the Supplemental Vibracores from Cell SU. Hopper sample average and Baseline average 0-8 cm and 8-20 cm are provided for comparison.

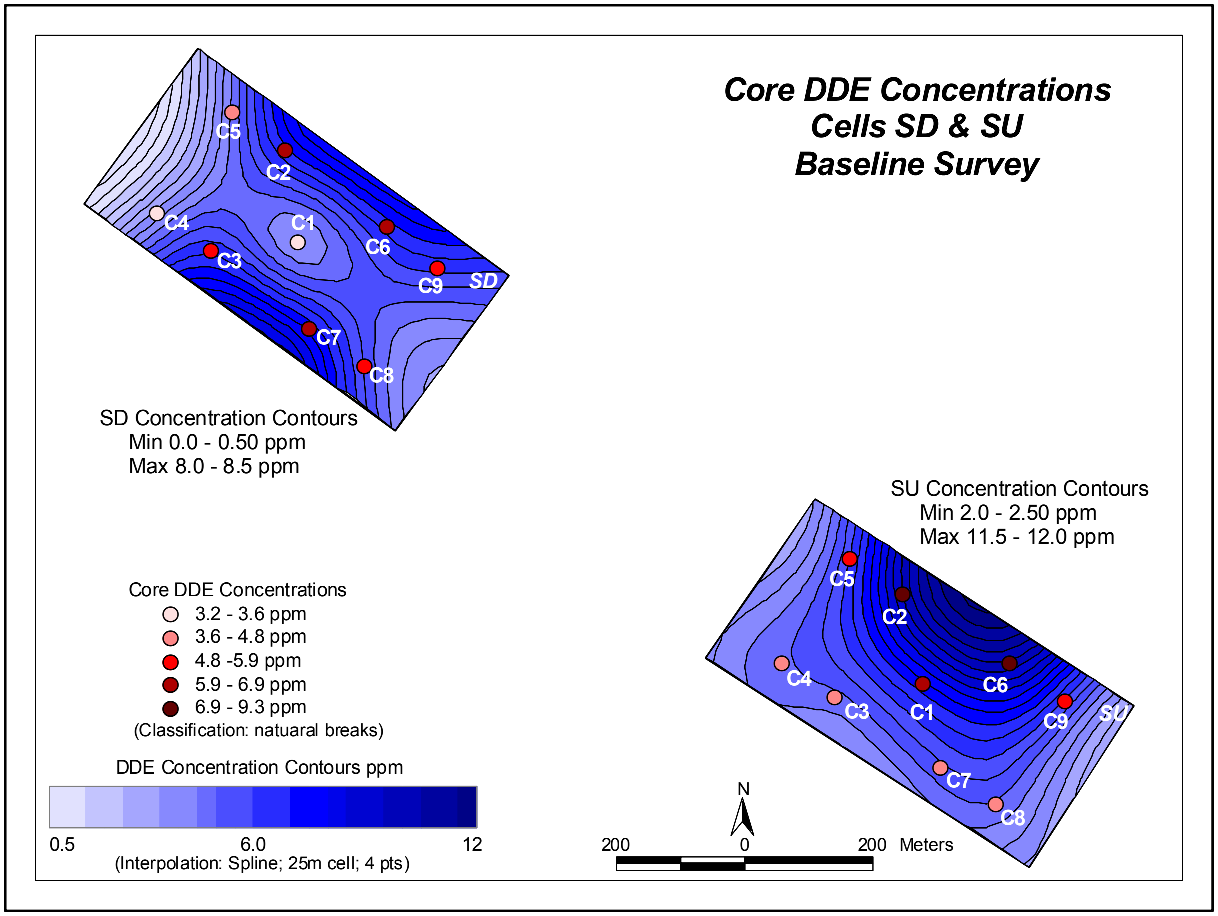


Figure 4.11-13 Sediment DDE concentrations (ppm) in Cell SU baseline cores.

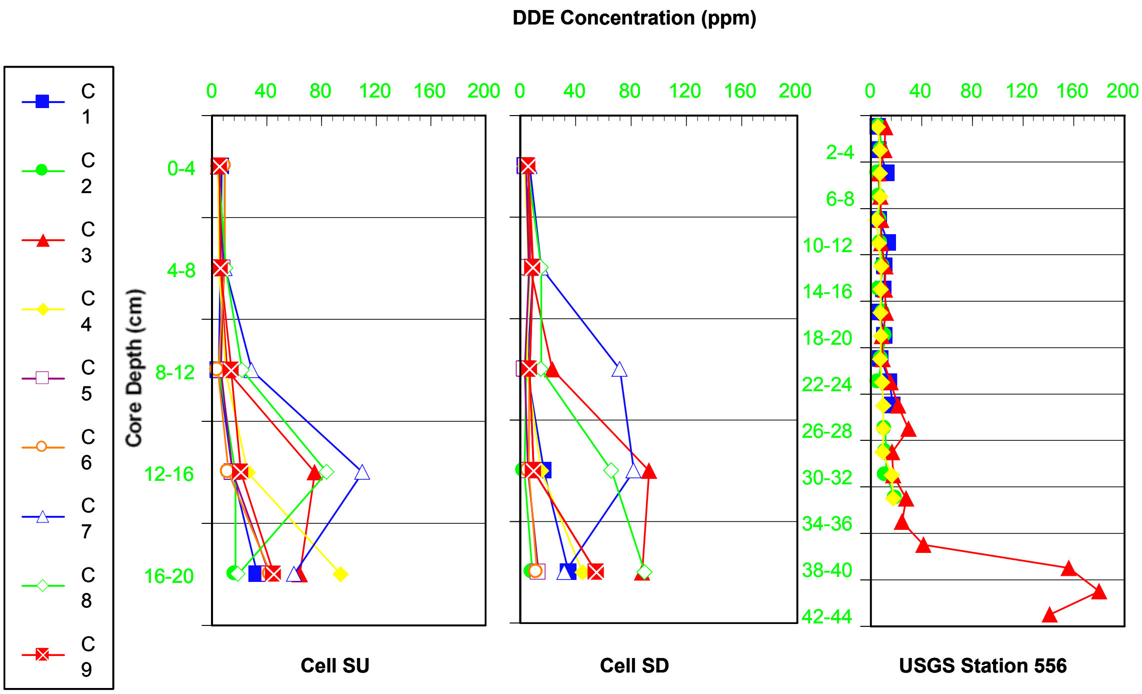


Figure 4.11-14 Surface sediment DDE concentrations (ppm) in Cell SU baseline cores and comparisons with historical (USGS) data.

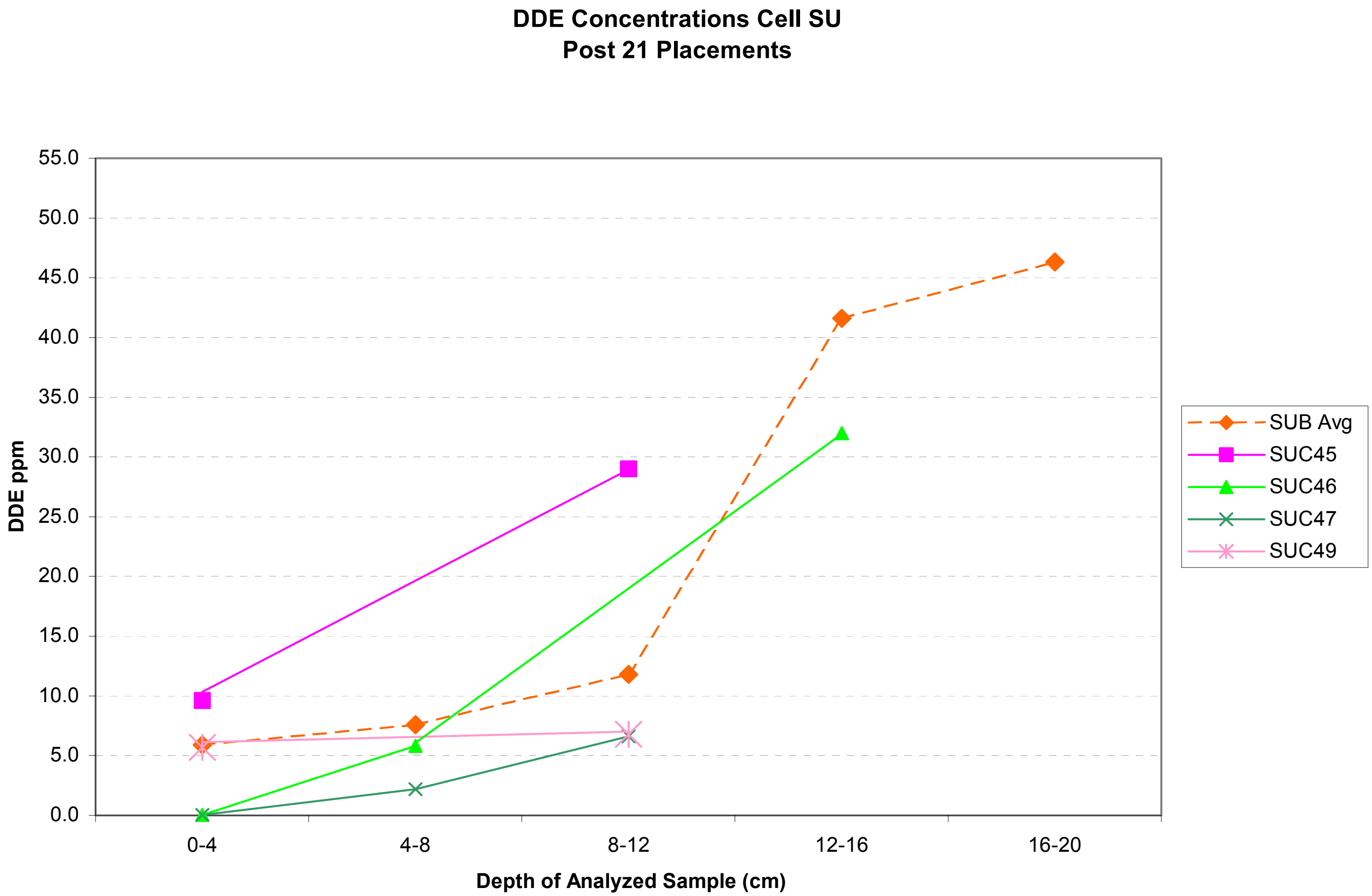


Figure 4.11-15. DDE versus Depth – Cell LU Cores: Post 21 survey and average background.

4.12 Sub-bottom Results

4.12.1 Overview of Field Sampling Plan

In addition to an initial baseline sub-bottom survey conducted in the spring, one follow-up sub-bottom survey was conducted following the completion of capping operations within Cell SU. The sub-bottom monitoring activities that were conducted in Cell SU are summarized in Table 3.12-1. In addition to summarizing the sub-bottom survey monitoring activities, this table also provides an overview of the ADISS and SPI monitoring activities that were conducted in Cell SU.

4.12.2 Review of Data Quality Objectives

The primary monitoring objective that was to be evaluated through the sub-bottom data analysis was the ability to determine cap thickness following final cap placement. The monitoring objectives for the sub-bottom operations were presented in the PWP and are summarized in Table 3.12-2. All of the sub-bottom data acquisition efforts were completed as planned within Cell SU and the navigational accuracy met or exceeded the ±3 m data quality objective. However, because no distinct sub-bottom layers could be detected in the immediate seafloor surface areas after cap placement, no measure of cap material thickness could be obtained from this data.

4.12.3 Technical Considerations

Sub-bottom profiling is a standard technique used for distinguishing and measuring various sediment layers that exist below the sediment/water interface. Sub-bottom systems are able to distinguish these sediment layers by measuring differences in acoustic impedance between the layers. Acoustic impedance is a function of the density of a layer and speed of sound within that layer and is affected by differences in grain size, roughness, and porosity. Sound energy transmitted to the seafloor is reflected off the boundaries between sediment layers of different acoustic impedance. A sub-bottom system uses the energy reflected from these boundary layers to build the image.

The sub-bottom system used for this survey was a Benthos/Datasonics Chirp II Profiling System that consisted of a dual frequency towfish configured with two operating swept frequency ranges of 2-7 kHz and 8-20 kHz. The depth of penetration and the degree of resolution of a sub-bottom system depends on the frequency and pulse width of the acoustic signal and the characteristics of the various layers encountered. The vertical resolution of an acoustic sub-bottom profiler refers to the minimum distance between adjacent layer interfaces that can be visually distinguished in the image produced by the system. A sonar system with a 10 cm resolution will resolve layers that are at least 10 cm apart. Layers that are spaced closer than 10 cm will be resolved by the system as one layer. In a swept-frequency system, such as the Chirp II profiler used for this survey, it is the bandwidth that sets the system's theoretical resolution. Although the Chirp II has a theoretical resolution of 10 cm, the actual resolution is usually less than that and is impacted by many factors including water depth, observed signal to noise ratios, and the composition of the sediment layers being measured.

Immediately after data acquisition, the sub-bottom data was analyzed and edited as necessary using the Triton-Elics ISIS® software. ISIS® enables automatic or manual detection, tracking, and digitizing of any subbotom layers that are present in the data and also allows the data to be re-displayed under a variety of different configurations. The results from the baseline sub-bottom survey were compared to the results from the USGS acoustic survey conducted in 1994 (Hampton 1994). Because the cap material layer could not be distinguished on any of the monitoring sub-bottom data, only limited additional post-processing was performed on this data. Because the records were similar for both monitoring sub-bottom surveys, the brief discussion for these two surveys has been combined into a single section below.

4.12.4 Monitoring Results

4.12.4.1 Baseline Survey

The baseline sub-bottom operation for Cell SU was conducted in mid-May 2000. The initial review of the sub-bottom data for this survey showed a distinct and well-defined surface layer with indications of a probable bedrock layer well below the main seafloor surface layer. In addition, subottom lines N and O clearly showed the sewer diffuser pipe as it rises above the seafloor surface. Figures 3.12-1 and 3.12-2 show some sample sub-bottom cross-sections that include examples of the possible bedrock layer and also the sewer diffuser pipe. In addition, a relatively fine surficial layer of sediment can also be distinguished upon a close examination of the seafloor interface layer. This thin, surficial layer is thought to represent a basal reflector from the effluent-affected sediment that lies above the ambient sediment (Hampton 1994).

4.12.4.2 Post 21 Survey

The Post 21 sub-bottom survey was conducted on 9/6/00, four days after the 45th placement event. Because the purpose of this follow-up survey was to attempt to measure the thickness of the cap layer, this analysis focused primarily on a close review of the area near the seafloor surface layer. The same sub-bottom features addressed in the baseline survey discussion above were also detected during the monitoring surveys. As depicted in Figures 3.12-1 and 3.12-2, no discernable sub-bottom layers were evident in this upper portion of the seafloor interface. Although these records represent only a small sampling of all of the sub-bottom data that was acquired during these surveys, the entire dataset was very consistent with little or no difference detected between the survey lines.

As shown in Figure 3.12-1, the primary difference noted between the baseline survey and Post 21 survey was in the strength and definition of the first return from the seafloor. In the baseline survey, the seafloor exhibited a dark and well-defined return that was indicative of the uniform, well-consolidated bottom that existed within the PV cells prior to cap placement. In addition, a relatively fine surficial layer, thought to represent a basal reflector from the effluent-affected sediment, could also be distinguished upon a close examination of the seafloor interface layer. In the Post 21 survey, the seafloor within the placement areas exhibited a less-distinct and thicker return that was indicative of the bottom disturbance caused by the capping operations and the generally unconsolidated nature of the seafloor at the time of the survey. Because of the condition of the seafloor after the capping operations were completed, more acoustic energy was absorbed by the seafloor and the amplitude of the first return was not as consistent or as strong as during the baseline survey. In addition, the thin surficial layer of EA sediment could no longer be clearly distinguished in the sub-bottom data.

4.12.5 Discussion

The sub-bottom surveys conducted in Cell SU showed that the techniques employed during this operation were not sufficient to allow the determination of cap thickness following cap placement. Although the techniques and equipment used should have provided sufficient resolution to detect any sub-bottom layers greater than 10 cm thick, this would only have been possible under near ideal conditions. Although the water depth was one factor that impacted the ultimate resolution of the sub-bottom survey following cap placement, the primary reason for the inability of the sub-bottom system to detect the cap layer was most likely the very similar grain size characteristics for both the cap and ambient bottom material. (The ambient bottom material was primarily soft and fine-grained silt, mixed with a fair amount of fine-grained sand at the surface, while the cap material was primarily fine-grained sand.)

Sub-bottom systems rely on being able to detect differences in acoustic impedance between sediment layers below the water/seafloor interface. Acoustic impedance is a function of the density of a layer and speed of sound within that layer, and is affected by differences in grain size, roughness, and porosity. If there is not a distinct difference in the acoustic impedance between seafloor layers, then the layers will not be differentiated, no matter what the theoretical resolution of the sub-bottom system may be. Within Cell SU, the sediment characteristic differences between the ambient bottom material and the placed cap material were minor, and at their interface there was a certain amount of mixing of the materials. Because there was no distinct boundary layer that separated the ambient material from the cap material, the sub-bottom system was unable to distinguish these two similar material layers.

Although the sub-bottom system could not provide a measure of cap thickness, some inferences about the presence of cap material could be made based upon the hardness or strength of the first return measured by the sub-bottom system. Generally, the bottom hardness values measured by the sub-bottom system within the placement cells were lower than the hardness values measured outside of the placement areas. Similarly, the amplitudes of the first return observed within the placement areas were lower than the first return amplitudes measured outside of the placement areas. The lower hardness values and first return amplitudes observed within the placement areas are primarily a function of the recent bottom disturbance and the unconsolidated nature of the material within those areas, rather than any major differences between the acoustic properties of the cap material and the ambient material outside of the placement areas.