MONITORING RESULTS FROM THE FIELD PILOT STUDY OF IN SITU CAPPING OF PALOS VERDES SHELF CONTAMINATED SEDIMENTS (Part 2 of 2)

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5.0 MONITORING RESULTS FROM CELL LD (SPREADING PLACEMENTS)

5.1 Schedule of Operations

The following provides an overview of monitoring activities within Cell LD. 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 and post-1 pump-out. Cap placement events in Cell LD are summarized in Table 5.1-1. All cap placements were made using a spreading placement technique. Placement positions are described in Section 5.2.

Table 5.1-1. Summary of Cap Placement Events in Cell LD

Placement Event #	Dates	Cumulative Volume (m^3)	Positions	Hopper Sample No.
1	8/15/00	967	A	LD-HOP 1
2-9	8/28-30/00	10,324		LD-HOP 2-3

Baseline Monitoring

Baseline monitoring in Cell LD was conducted in May and August 2000. Dates associated with individual sampling tasks are listed in Table 5.1-2. Results from each of the baseline sampling tasks in Cell LD are presented in Sections 5.2 through 5.12.

Table 5.1-2. Summary of Sampling Dates for Baseline and Cap Placement Monitoring Activities in Cell LD

	SPI/PV	Core	SS	SB	CM	WQ	Video	ADCP
Baseline	8/14	5/18	5/15, 5/16, 5/17	5/15, 5/16, 5/17	none	none	none	none
Post 1	8/18, 8/24	8/17	8/19	none	8/14-8/16	8/15	8/15	8/15
Post Pump-Out	9/9	9/15	none	none	none	none	none	none
Post Cap	8/30	none	8/30	none	none	none	8/22	none
Supple-mental	2/24/01	2/27/01 2/28/01 3/1/01	none	none	none	none	none	none

SPI/PVC-sediment profile image/plan view camera; 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 LD was conducted from August through September, 2000. Supplemental coring and sediment profile/plan view sampling in Cell LD were conducted in February/March, 2001. Primary monitoring activities coincided with specific sequences of placement events listed in Table 5.1-1. A timeline of activities associated with cap placement monitoring is shown

schematically in Figure 5.1-1. Specific dates for individual sampling tasks are listed in Table 5.1-2. Results from each of the cap placement monitoring tasks in Cell LD are presented in Sections 5.2 through 5.12.

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 5.2). Also, a moored current meter/optical backscatter array was deployed near Cell LD on August 4, and retrieved on August 16 (see Section 5.3).

Supplemental Coring

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

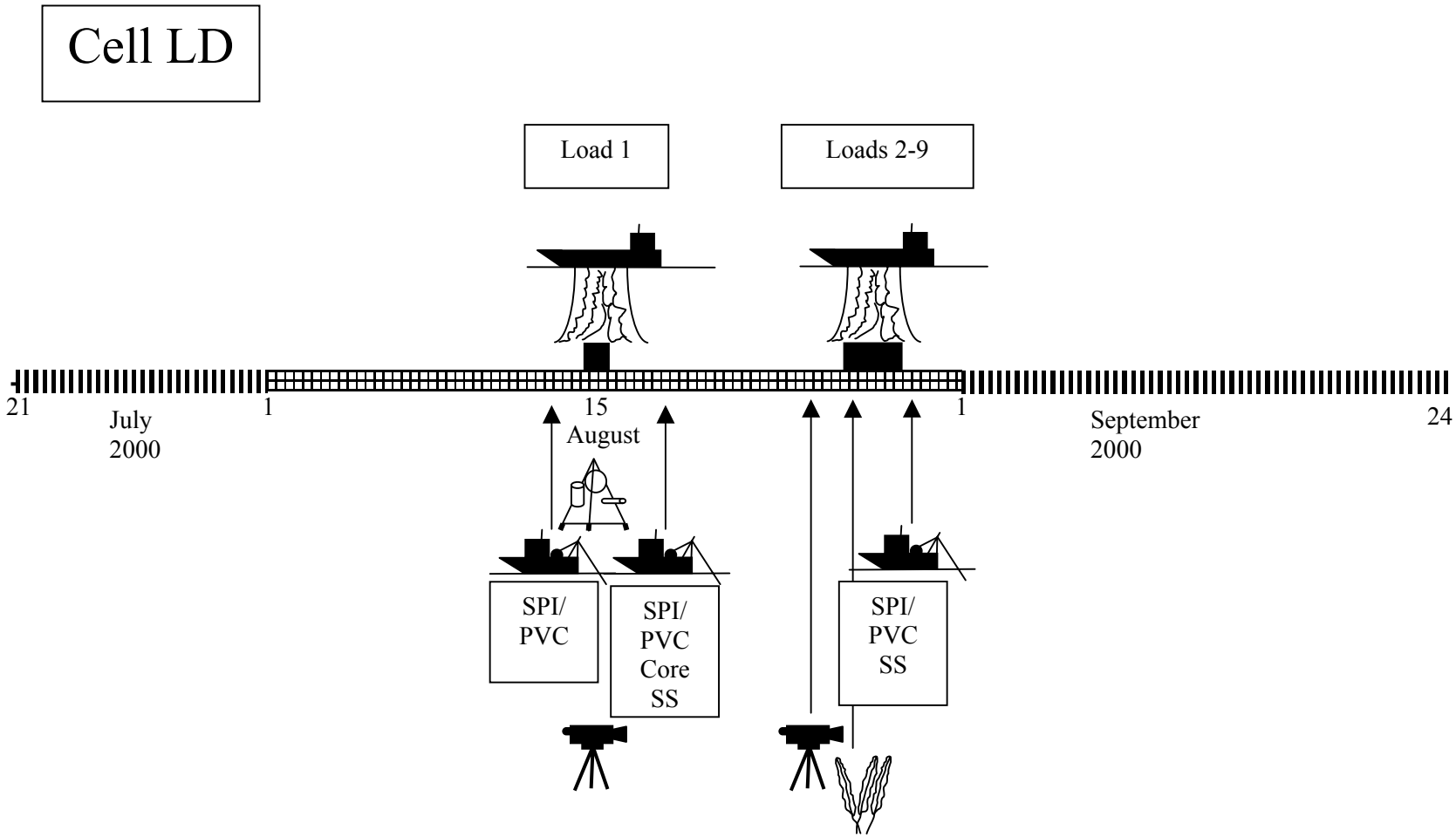

Figure 5.1-1. Activities timeline for Cell LD 21 July 2000-24 September 2000. Cap placement activities are indicated by the dredge symbol and solid bar. Monitoring activities are shown by the research vessel, current meter tripod, video camera, and kelp symbols. Monitoring activity codes associated with the research vessel symbol are SPI-Sediment Profile Imaging, PVC-Plan View Camera, Core-Coring survey, and SS-Side Scan.

5.2 Hopper Dredge Monitoring during Cap Placement

5.2.1 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 that was outlined in the FSP (SAIC 2001).

All cap material used for placements in Cell LD was dredged from the A-III Borrow Area located southwest of the Queen's Gate Channel. Placements of material in Cell LD were conducted using a spreading technique where material was released relatively slowly as the hopper dredge traveled at a speed of a few knots along a pre-determined line down the long axis of the cell. Upon initiation of spreading, the dredge's hull was "cracked" open a small amount to restrict the rate at which material was released from the hopper. The operational objective was to release the entire hopper load of cap material at a relatively constant rate along the axis of the cell.

5.2.2 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 nine placement events in Cell LD.

5.2.3 Technical Considerations

No technical problems were associated with dredge operational monitoring in Cell LD, except for unsuccessful attempts to incorporate a digital compass into the ADISS data acquisition system.

5.2.4 Monitoring Results

For cap placement operations in Cell LD, ADISS recorded the dredge position and draft during the loading of dredged material from the A-III Borrow Area, during transit from the dredging site to the cell, and during placement of dredged material in the cell. Figure 5.2-1 presents an example ADISS dredge position data acquired during spreading Event 1 in Cell LD on August 15, 2000, with data points representing individual positions of the dredge acquired at 6-sec intervals as the dredge moved from southeast to northwest along the axis of the cell. Figure 5.2-2 presents a companion plot of hopper dredge draft versus time during one entire operation leading up to the placement in Cell LD. Starting at the left side of the plot, dredge positions were recorded at 6-sec intervals while the dredge was being loaded (see period of rapidly increasing draft). After the hopper was full and the dredge started to leave the vicinity of the A-III Borrow Area, the ADISSPlay software automatically shifted to a 5-min recording rate during the transit operation (see widely spaced data points in Figure 5.2-2). As the dredge approached Cell LD,

the ADISS software automatically returned to a 6-sec sampling period during the final stages of the transit and throughout the cap placement (spreading) operation. Figure 5.2-2 illustrates ADISS dredge position data acquired during material loading in the Borrow Area. As seen in the figure, the material originated from near the center of the Borrow Area. In Figure 5.2-3, 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 (6-sec sampling) until the placement operation began at 1915 GMT. When the dredge "cracked" its hull to release the cap material, the draft decreased fairly fast then slowed until a minimum draft of roughly 16 ft was achieved at the end of the 10 min spreading event. Note that the rate of release during spreading in Cell LD was considerably slower than the rate of conventional release in Cells LU and SU.

As compiled in Table 5.2-1, nine spreading events were conducted in Cell LD during the period from August 15 through 30, 2000. These placements were grouped into two cap placement (time) phases (Event 1 as Phase 1 and Events 2 through 9 as Phase 2) with a 13-day gap between the phases during which monitoring activities were conducted (Figure 5.1-1) within Cell LD. Figure 5.2-4 presents ADISS dredge position data collected during spreading Event 1 in Cell LD, as well as information that shows where the majority of the cap material was released during this event. For example, the figure shows the time and location when 25% of the load had been released from the hopper (in the figure this is indicated as 75% of load remaining within the hopper). Similarly, positions where 50%, 75% and 100% of the load had been released also are indicated in the figure. From this information (derived from draft, time and position) we can readily see that 75% of the hopper load had been released in the first half of the cell as the dredge moved slowly toward the northwest during Event 1.

Figure 5.2-5 presents ADISS information from Event 9 where 75% of the hopper load was released in the first one-third of the trackline as the dredge moved northwestward along the axis of Cell LD. For this event, the spreading began at the southeastern boundary of the cell as planned, but the rate of spreading was again too fast, resulting in the entire load of A-III material having been released by the time the dredge had reached the center of the cell. To summarize the distribution of cap material spread in Cell LD during the nine placement events, Figure 5.2-6 indicates the location where 75% of the load from each event had been released along the axis of the cell, based upon the ADISS data acquired during discharge of material which always commenced at the southeastern boundary of the cell. The point of 75% release was achieved very early along the track for Events 3, 7 and 9; near the center of the cell for Events 1 and 4; and in the northwestern segment of the cell for the four remaining events. Thus, spreading was much too fast for one-third of the loads, somewhat fast for two additional loads and exactly as planned for nearly half of the loads. It is also noteworthy that the dredge was able to accurately follow the predetermined trackline down the axis of the cell; as expected, maneuverability of the dredge was much greater during spreading at a slow but constant vessel speed, as compared to the conventional placement technique when the dredge was required to stop at the target placement location and remain stationary for a period of 3 to 5 min during release of the material.

The total volume of cap material placed during the nine events in Cell LD was 10,324 m^3 (Table 4.2-1). The average volume per event was 1,147 m^3 and the average duration of each event was 7 min, 25 sec. In approximate terms, the average rate of cap material release during 71 conventional placements in Cell LU (983 m^3 in 4.65 minutes) was 1.4 times the rate experienced during the nine spreading events in Cell LD (1,147 m^3 in 7.42 minutes).

The asymmetry of A-III placements within Cell LD is best realized when the cell is divided into three segments: southeast, center and northwest (Table 5.2-2). The volume of cap material placed within the center and northwest segments was essentially identical, whereas the volume placed in the southeast segment was 3.7 times that placed within either of the other two segments. In other words, 65% of the A-III material was released in the first one-third of the spreading trackline along the axis of Cell LD.

Table 5.2-1. Volume and Times of Cap Placement Events in Cell LD

Date	Placement Event	Placement Position	Volume (m^3)	Start (GMT)	End (GMT)	Duration (hh:mm:ss)
08/15/00	1	Axis	967	19:15:23	19:25:30	0:10:07
08/28/00	2	Axis	1451	17:45:40	17:51:36	0:05:56
08/28/00	3	Axis	1070	22:03:10	22:07:55	0:04:45
08/29/00	4	Axis	1216	00:43:47	00:51:06	0:07:19
08/29/00	5	Axis	1146	03:14:12	03:22:30	0:08:18
08/29/00	6	Axis	1174	05:38:36	05:46:53	0:08:17
08/29/00	7	Axis	1119	08:09:20	08:15:06	0:05:46
08/29/00	8	Axis	1160	10:44:55	10:52:44	0:07:49
08/30/00	9	Axis	1022	10:28:49	10:37:18	0:08:29

Table 5.2-2. Summary of Cap Volume Placed Within Three Geographic Segments of Cell LD

Placement Event	Southeast (m^3)	Center (m^3)	Northwest (m^3)
1	457	390	121
2	759	101	590
3	826	245	0
4	908	205	103
5	674	135	337
6	614	205	355
7	870	249	0
8	711	137	312
9	874	148	0
Totals	**6693**	**1815**	**1818**

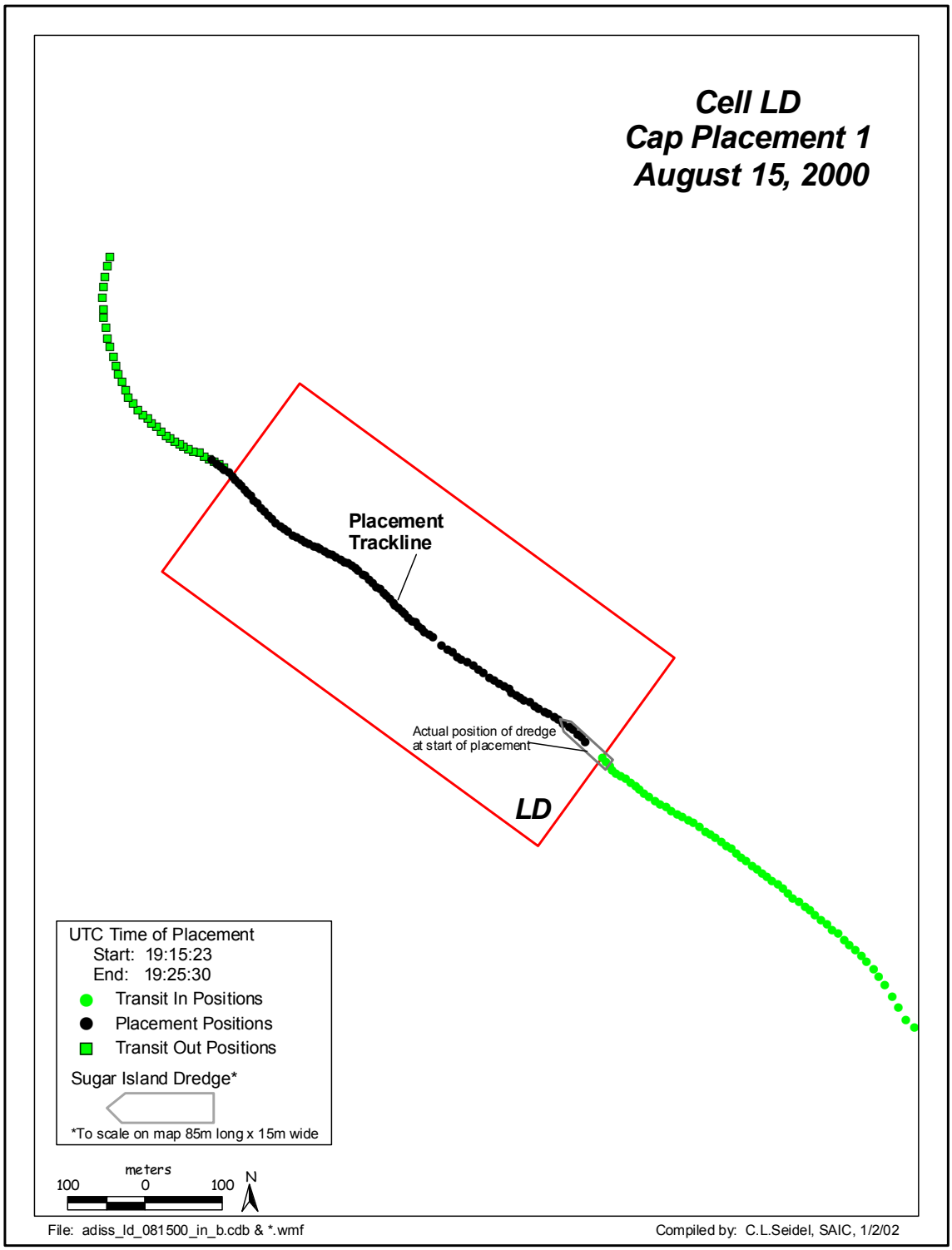

Figure 5.2-1. Map illustrating Cell LD on the Palos Verdes Shelf and the trackline of the hopper dredge *Sugar Island* as it traveled northwestward along the axis of the cell during spreading Event 1 on August 15, 2000. Dredge position data were acquired by ADISS.

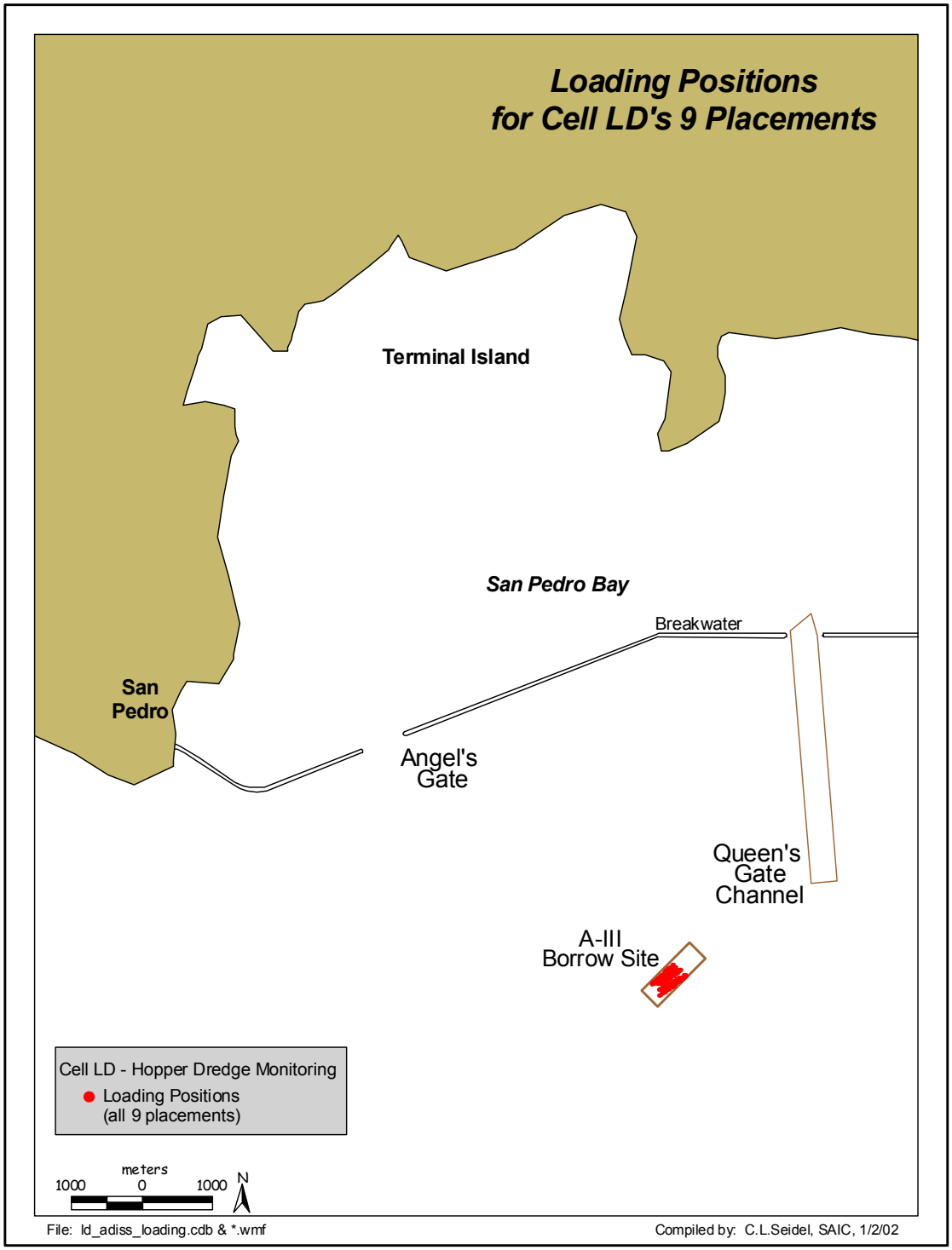

Figure 5.2-2. Map of Los Angeles/Long Beach Harbor region indicating the locations of the dredging within the A-III Borrow Area for material that was used for capping during Events 1 to 9 in Cell LD. Dredge position data were acquired by ADISS.

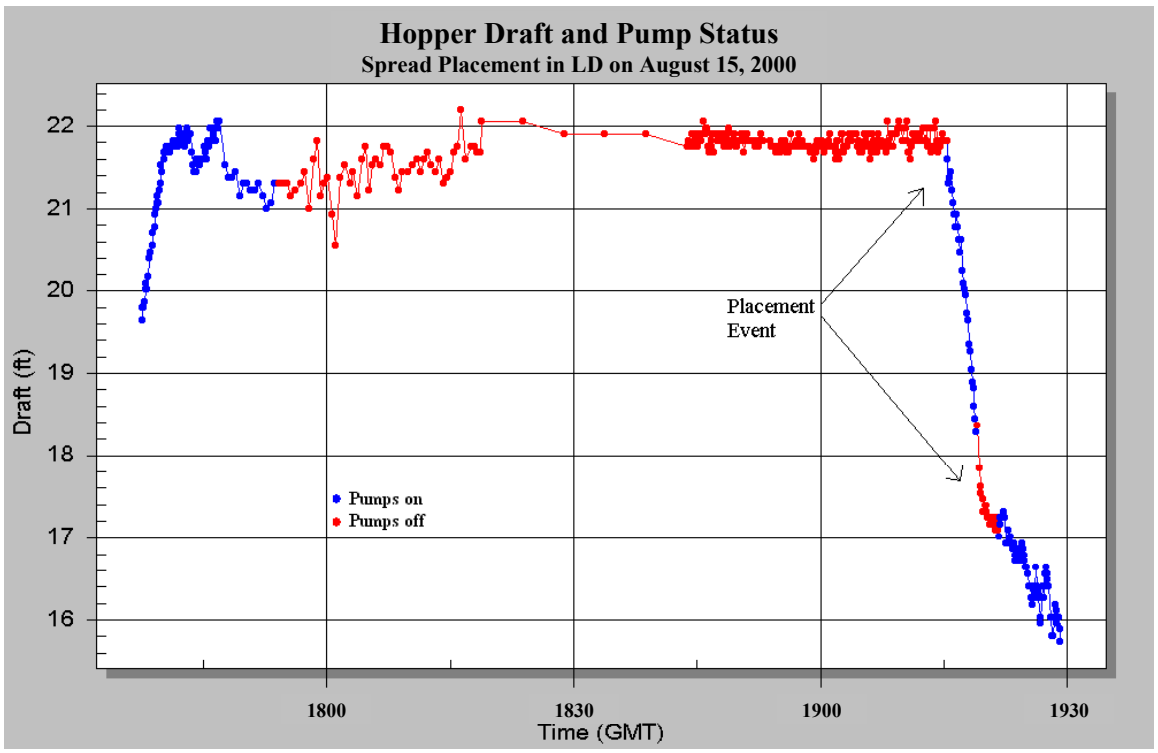

Figure 5.2-3. Time series plot of the draft of the hopper dredge *Sugar Island* during loading, transit and spreading of cap material in Cell LD during Event 1 on August 15, 2000. Dredge draft data were acquired by ADISS.

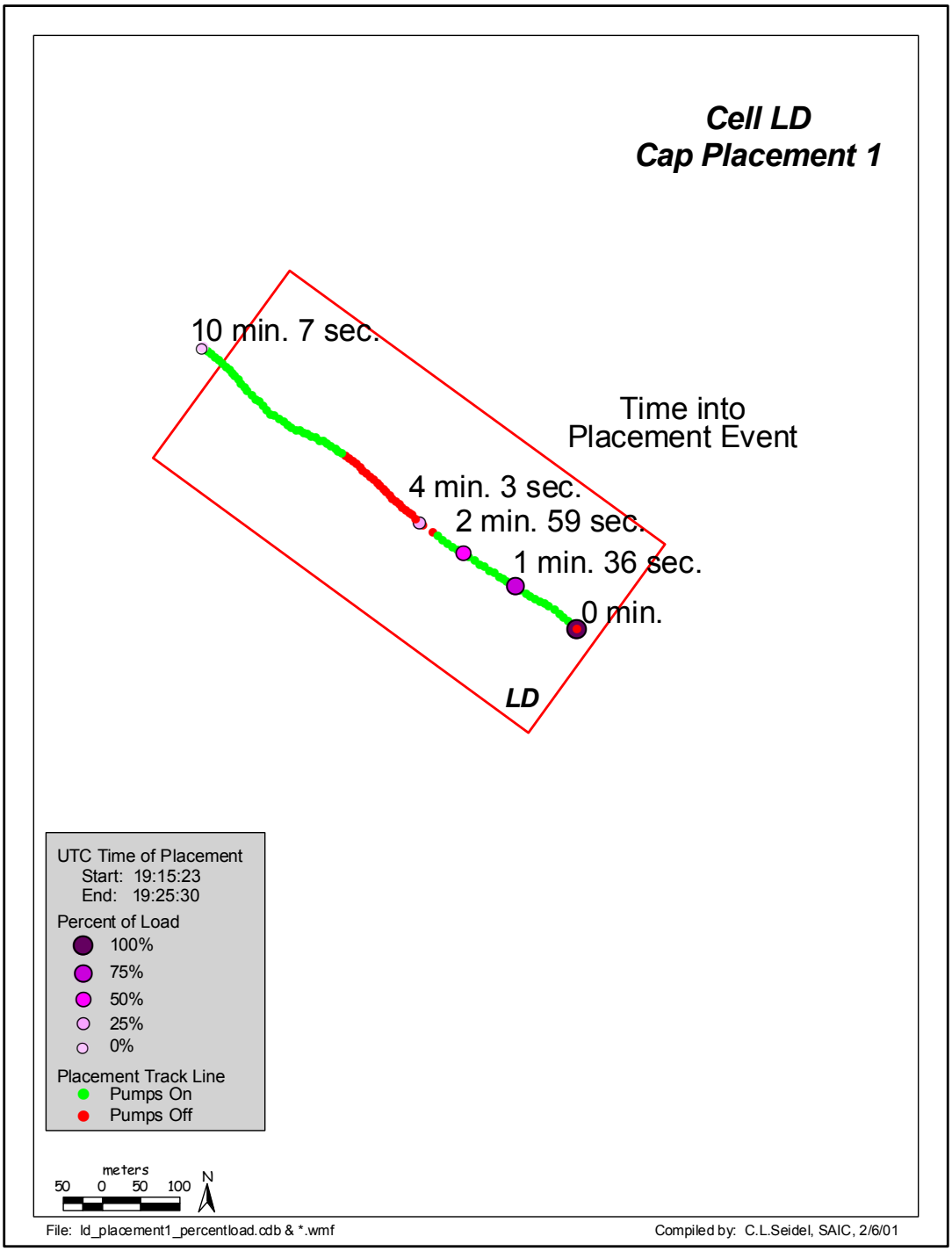

Figure 5.2-4. Map illustrating Cell LD on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* as it moved northwestward during spreading of cap material during Event 1 on August 15, 2000. Dredge position data were acquired by ADISS. Also shown are the elapsed times that correspond with the percent of material (i.e., 100%, 75%, etc.) remaining within the hopper.

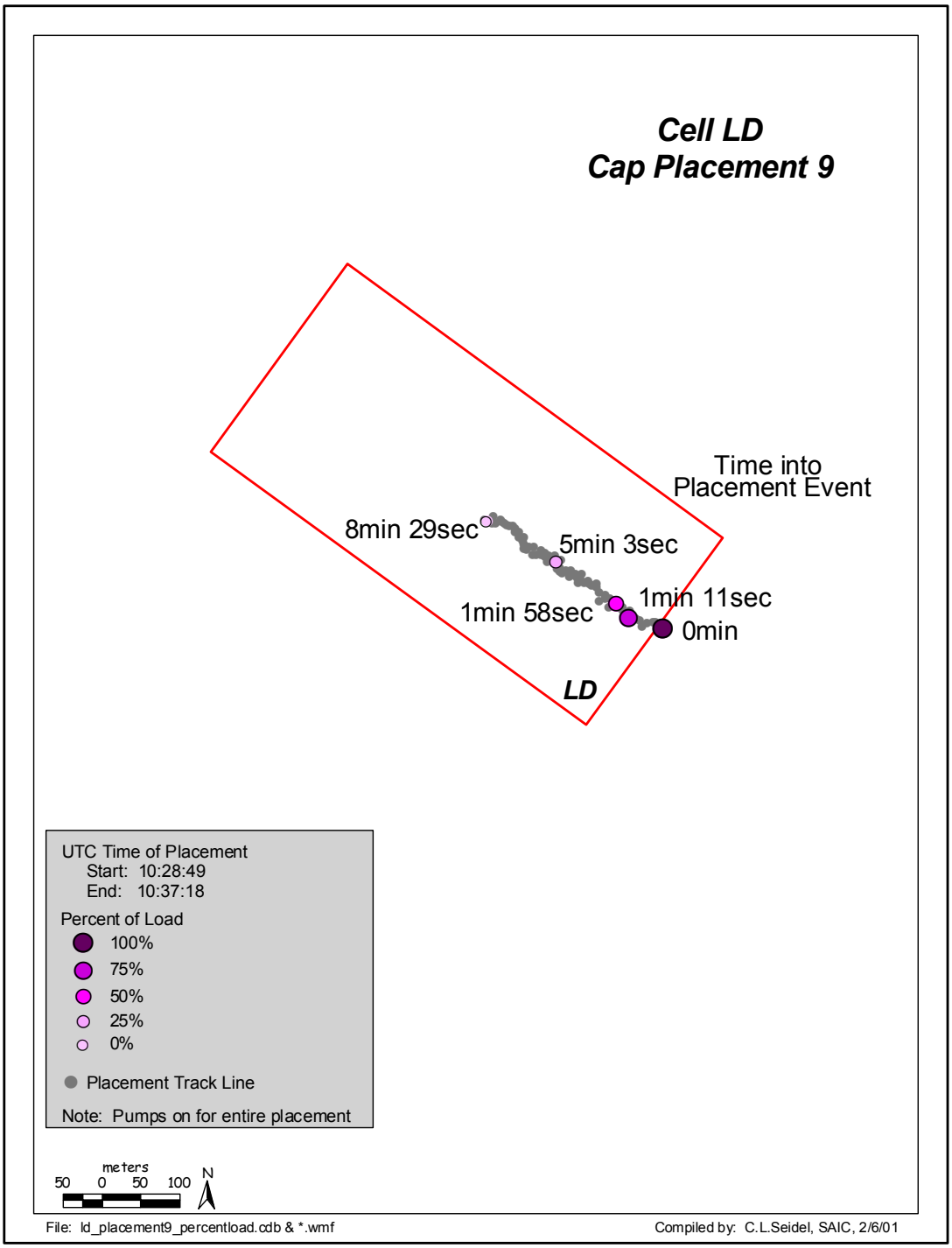

Figure 5.2-5. Map illustrating Cell LD on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* as it moved northwestward during spreading of cap material during Event 9 on August 30, 2000. Dredge position data were acquired by ADISS. Also shown are the elapsed times that correspond with the percent of material (i.e., 100%, 75%, etc.) remaining within the hopper.

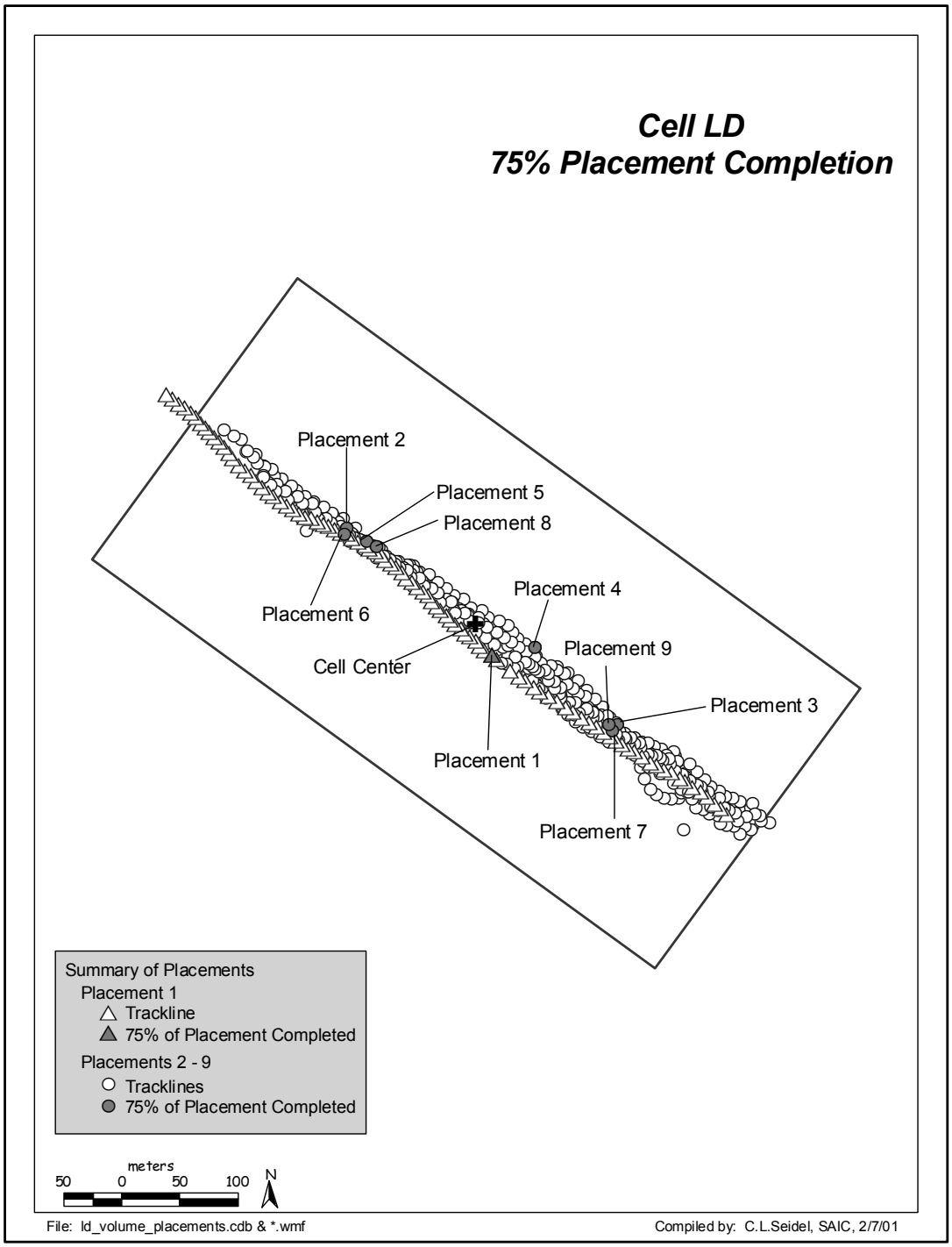

Figure 5.2-6. Map illustrating Cell LD on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* as it moved northwestward during spreading of cap material during Events 1 to 9 in August 2000. Dredge position data were acquired by ADISS. Also shown are the positions where 75% of the hopper volume had been released during each spreading event.

5.3 Moored Measurements of Currents and Turbidity during Cap Placement in Cell LD

5.3.1 Overview of Field Sampling Plan

The scientific objectives for the in situ measurements of near-bottom currents and water clarity (turbidity) in Cell LD were identical to those for Cells LU and SU (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 cap material placement along a line down the center of Cell LD. 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.

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

5.3.1.1 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 deployment in Cell LD spanned the time period of cap placement Event 1 during which 967 m^3 of material was placed within Cell LD during a 10-min 7-sec release period on August 15 using a spreading technique with the hull of the hopper dredge kept partially open as the dredge moved along the cell at a speed of a few knots.

Four moored arrays were deployed (at 75 m upslope and 75 m, 150 m and 250 m downslope) in the afternoon of August 14 and recovered in the morning of August 16. Deployment of a fifth array at the 150 m upslope location was not possible due to the temporary loss of one array at the 150 m upslope location in Cell SU. Following recovery of the four arrays from Cell LD on August 16, data records were retrieved from the internally recording instruments and the equipment was demobilized as this was the last deployment of the pilot cap study. (see Cruise Report (SAIC 2000b) for details on deployment times and field operations).

Figure 5.3-1 illustrates the location of the four moored arrays that were deployed within and adjacent to Cell LD 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 42 to 49 m. A summary of the instrumentation deployed during Event 1 in Cell LD is presented in Table 3.3-2.

Also shown in Figure 5.3-1 are the heading (315° T) and trackline of the hopper dredge during the cap material spreading operation. A more detailed discussion of the rate of material spreading in Cell LD is provided in Section 5.2. As planned, this resulted in a line source of sand from the A-III Borrow Area that was spread down the long axis of Cell LD midway between the upslope and downslope arrays.

Percent data return from the four moored arrays that were recovered following cap placement Event 1 in Cell LD is presented in Table 3.3-3. Complete data records were acquired by the Aquadopp current meter at the 75 m upslope location, by the ARESS current sensors at the 75 m, 150 m and 250 m downslope locations, and by the ADCP at the 75 m downslope location.

Results from the moored current and turbidity records acquired during placement Event 1 are presented in Section 5.3.4.

5.3.2 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 Cells LU and SU, this objective was achieved via high-resolution current measurements at various locations and water depths during a single cap placement event in Cell LD as described in Section 5.3.1. Data return from the moored current meters is summarized in Table 3.3-3. Monitoring highlights and data deficiencies for Cell LD are discussed in Section 3.3.2.

- As planned, one cap placement event was monitored.
- Four moored arrays were deployed in and adjacent to this cell.
- 100% return of near-bottom current data was achieved at all four measurement locations.
- 100% return of ADCP data also was achieved at one of the ARESS locations.

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 LD. Turbidity data return from the moored instrumentation is summarized in Table 3.3-3. Monitoring highlights and data deficiencies for Cell LD are discussed in Section 3.3.2.

- As planned, one cap placement event was monitored.
- 100% return of near-bottom turbidity data was achieved at all four measurement locations.

5.3.3 Technical Considerations

No losses of data or equipment were encountered during monitoring in Cell LD.

5.3.4 Monitoring Results

5.3.4.1 Observations during Cap Placement Event 1

<u>Near-Bottom Currents and Turbidity at the 75 m and 250 m Downslope Locations</u>

Cap placement Event 1 in Cell LD began at 1915 GMT on August 15, 2000 while instrumentation was moored at the four 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 event, as had been seen for multiple events in Cells LU and SU. To illustrate the surge effects in Cell LD, Figure 5.3-2 presents near-bottom current speed, current direction, and turbidity data acquired at the 75 m and 250 m downslope locations beginning at 1900 GMT on August 15 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 75 m and 250 m downslope locations were very weak (5 to 10 cm/s) and directed toward the west (250° to 300° T; Figure 5.3-2). Near-bottom turbidities also were consistently low (<10 FTU) prior to the event. Within seven minutes of commencement of cap placement operations, current speeds at the 75 m location increased sharply to a maximum of 35 cm/s then decreased to background levels within 10 minutes of the onset of the surge. The surge current was oriented to the south, such that a brief deflection of the current at the 75 m array location was observed for a period of approximately four minutes corresponding with the time of maximum surge current (Figure 5.3-2).

Near-bottom turbidities during the surge of Event 1 rose sharply above background levels, but the maximum turbidity achieved a value of only 108 FTU (Figure 5.3-2) during the event at the 75 m downslope location, compared with much higher turbidity levels observed during all other events within Cells LU and SU. Furthermore, turbidities at the 75 m location returned to low background levels within 2.5 min of the onset of the surge, which was much quicker than observed for all other surge events monitored (Table 3.3-9).

The surge at the 250 m downslope location was barely distinguishable above the background conditions, with a maximum speed of 20 cm/s, corresponding with the time of a small but recognizable increase in turbidity (Figure 5.3-2). The leading edge of the surge at the 250 m location arrived 10 minutes after it had arrived at the 75 m location, which corresponds with an average speed of 29 cm/s as the surge moved the 175 m distance between the two array locations. The current direction record at the time of the surge at the 250 m location exhibited a slight deflection toward the south-southwest in association with the southward surge current that was observed at the 75 m location.

Near-bottom turbidity during the surge event at the 250 m location rose only slightly to a maximum of 25 FTU (Figure 5.3-2) then dissipated relatively quickly, as had been seen at the 75 m location. Note that the spike having a maximum turbidity of approximately 190 FTU, observed 3 min after the arrival of the surge, was probably associated with an erroneous 1-sec measurement that was used in the 20-sec average and consequently, this data point should not be viewed as representative of the surge event.

Near-Bottom Currents and Turbidity at the 150 m Downslope Location

The surge event was clearly recognizable in the current and turbidity records at the 150 m downslope array location (Figure 5.3-3). A maximum current speed of 33 cm/s was measured above the weak background currents and current vectors veered toward the south-southwest for a period of 7 min during the passage of the surge. The surge current at this 150 m downslope location had maximum speeds only slightly less than those observed at the 75 m downslope location, but the duration of the elevated current at the 150 m location was roughly half that at the other location.

Also shown in Figure 5.3-3 are the turbidity records acquired at 0.5 and 1.25 m above the bottom at the 150 m downslope location. Both records exhibited a significant increase in turbidity upon arrival of the surge current. The maximum turbidity of 42 FTU (disregarding the presumably erroneous data spike of 100 FTU) at the 150 m location was midway between the maximum turbidity observed at the 75 m and 250 m locations (i.e., 108 and 25 FTU, respectively).

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

Near-bottom current and turbidity data also were acquired from a fourth array situated 75 m upslope of the placement site during Event 1 in Cell LD. The time series results from this array are presented in Figure 5.3-4, along with data previously presented from the array moored at the 75 m downslope location. In this figure we can see that the maximum current speed of 35 cm/s at the upslope

location was equal to that observed at the downslope location, but the elevated currents at the upslope location persisted for a shorter time than was observed at the downslope location.

With regard to the current direction at the 75 m upslope location, background currents were directed toward the west-northwest prior to the placement event, but veered to the north-northeast during the surge (Figure 5.3-4). This again illustrates that, at the 75 m upslope location, the surge momentum was oriented upslope and directed away from the placement location along the centerline of Cell LD.

As had been seen at the upslope locations in Cells LU and SU, the turbidity associated with the surge at the 75 m upslope location in Cell LD (a maximum of 44 FTU) was considerably less than the turbidity at the 75 m downslope location: 108 FTU (Figure 5.3-4).

Radial Spreading and Dissipation of the Surge Current

One of the primary objectives of the surge monitoring effort was to determine whether surge current velocities and turbidity levels decrease with distance from the placement location in Cell LD. Figure 5.3-5 presents a plot of the maximum near-bottom current speed observed at the three downslope and one upslope array locations in Cell LD during placement Event 1 versus the horizontal distance from the moored array location to the actual cap placement location. This figure illustrates that maximum current speeds in the surge were comparable at the 75 m upslope, 75 m downslope and 150 m downslope locations, but the maximum current speeds dissipated somewhat at the 250 m location. What is most noticeable about these surge currents in Cell LD is that they are much less than those observed during all other events monitored in Cells LU and SU (see Figure 4.3-6 and Table 3.3-6 that present a composite of maximum speeds for all cells).

Before we compare results from the various cells, it is important to point out that the water depths and bottom slope (1.2°) within Cell LD were comparable to those within Cell LU and considerably less than those of Cell SU. We suspect that any differences between surge monitoring results from Cells LU and LD can be attributed to the different cap placement techniques that were used: spreading along the axis of Cell LD versus conventional (bottom-dump) placement at a single location for each event within Cell LU. As indicated in Table 3.3-1, it is estimated that 967 m^3 of cap material was released during Event 1 in Cell LD as the dredge traveled along the 600 m length of the cell. If we divide the length of the cell by the length of the hopper (85 m), it follows that the placement in Cell LD was made within seven hopper lengths rather than having all of the load released within one length of the hopper as was the case for the conventional placements in Cells LU and SU. Therefore, if we were to assume that the load of cap material was released at a constant rate along the length of Cell LD, we would estimate that 138 m^3 (one seventh of 967 m^3) of material was released within each 85-m segment of the spreading trackline. And since the average load of cap material released in Cell LU was 989 m^3, it follows that about seven times as much cap material (989 m^3 divided by 138 m^3) was released in a dredge length in Cell LU compared to that released in a dredge length during spreading within Cell LD. In simple terms, there was much less cap material descending through the water column at a specific location along the axis of Cell LD during the spreading operation. For this reason, it is not surprising that the current velocities and turbidity levels within the surge monitored in Cell LD were much less than those monitored during six events in Cells LU and SU. (see Figure 4.3-7 and Table 3.3-9 for a comparison of turbidity results from events monitored in Cells LU, SU and LD.)

Persistence of Surge Currents

As another method to compare the surge results from the spreading event in Cell LD with those of conventional placement events in Cells LU and SU, 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 50 cm/s

at any of the four measurement sites for Event 1 in Cell LD, but speeds exceeding 25 cm/s were observed (for durations of 1.0 to 2.5 min) at all but the 250 m downslope location. The time duration of speeds exceeding 25 cm/s decreased in the downslope direction, from 2.5 min at the 75 m downslope location to 0 min at the 250 m location. Additionally, speeds exceeding 25 cm/s persisted for more than twice as long at the 75 m downslope location compared to the 75 m upslope location, in agreement with the concept of enhanced upslope dissipation of surge energy. Overall, the persistence of surge currents during the spreading event in Cell LD was substantially less than observed during conventional placement events in Cell LU (Table 3.3-6) and Cell SU (Table 4.3-1).

Vertical Profiles of Horizontal Currents during Placement Event 1

The ADCP mounted on the ARESS array located 75 m downslope of the placement site in Cell LD acquired current velocity data for approximately 40 hrs from the afternoon of August 14 to August 16, 2000. This deployment period spanned placement Event 1 that occurred on August 15. The velocity data acquired by the ADCP at this cell consisted of individual time series records (averaged over 1-min time intervals) from each of 36 one-meter thick depth layers starting 3 m above the bottom. Figure 5.3-6 presents a composite of current speed records from seven depth layers starting at 40 m and continuing upward to 5 m depth; Figure 5.3-7 presents a companion plot of current direction at the seven 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 40-m measurement level (lowest tier in Figure 5.3-6) illustrates weak bottom currents that ranged from 2 to 18 cm/s, with minor fluctuations that occurred at roughly 6-hr intervals. Current speeds did not increase significantly with distance off the bottom up to the 14-m depth level, nor were they much higher at the 5-m level. There was, however, a brief (~1/2 hr) period of relatively high ambient currents observed between the 37-m and 39-m levels at roughly 1300 GMT on August 15. This pulse had very limited vertical extent because it was barely recognizable at the 29-m depth level.

Current directions in Cell LD were variable but more vertically coherent than were observed during other measurement periods in Cells LU and SU (Figure 5.3-7). Flow was generally westward throughout the water column following high water and eastward on the rising tide. Currents rotated clockwise at the 14-m depth level, but were more bi-directional at lower layers.

Also shown in Figures 5.3-6 and 5.3-7 is the time of cap placement Event 1 in Cell LD. At the 40-m ADCP depth level, a brief 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 44 cm/sec for the 1-min average at 40 m compared to the background currents which were below 20 cm/s. This brief period of intensified current was evident at the 37-m level, but above that level, there was no intensification of currents at the time of the placement event.

The ADCP current direction record (Figure 5.3-7) illustrates that ambient currents were directed toward the west-northwest throughout the water column around the time of cap placement Event 1 in Cell LD. During the very brief surge event currents between 38 and 40 m veered to the south-southwest but returned west-northwestward shortly after. Above that level current directions at the 75 m downslope location did not vary from their background directions.

The near-bottom water temperature record from the ADCP (top tier in Figures 5.3-6 and 5.3-7) exhibited temperature fluctuations of approximately 1.0°C at 12-hr periods, with temperature increases occurring during ebb tidal cycles. A small (0.2°C) temperature increase was associated with cap placement Event 1, which was substantially less than temperature increases that had been observed during events in

Cells LU and SU. This smaller temperature change may potentially have been due to the smaller volume of material released per unit of track length during the spreading event in Cell LD.

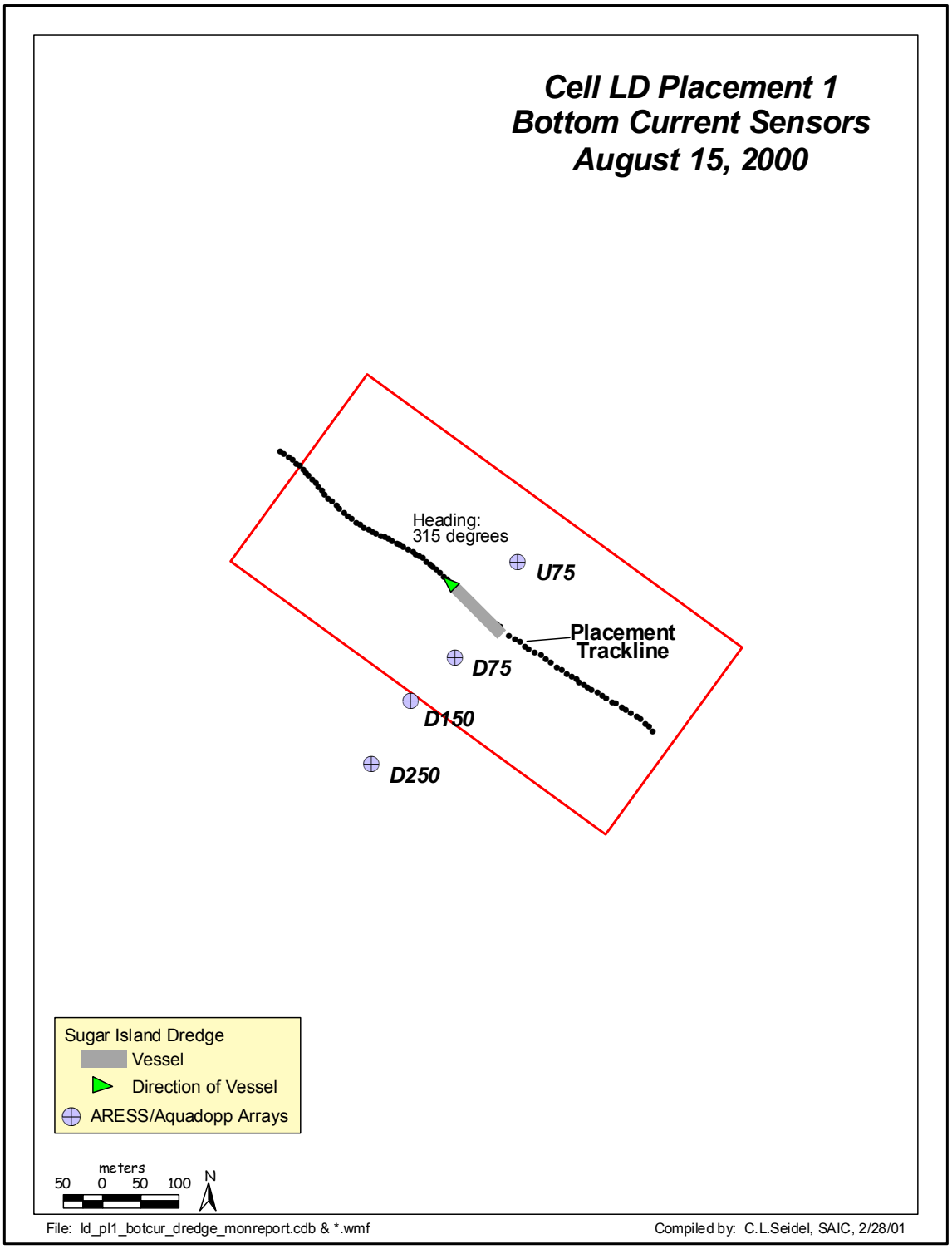

Figure 5.3-1. Map illustrating location of moored instrumentation during placement Event 1 in Cell LD, as well as the trackline of the hopper dredge during the spreading of cap material.

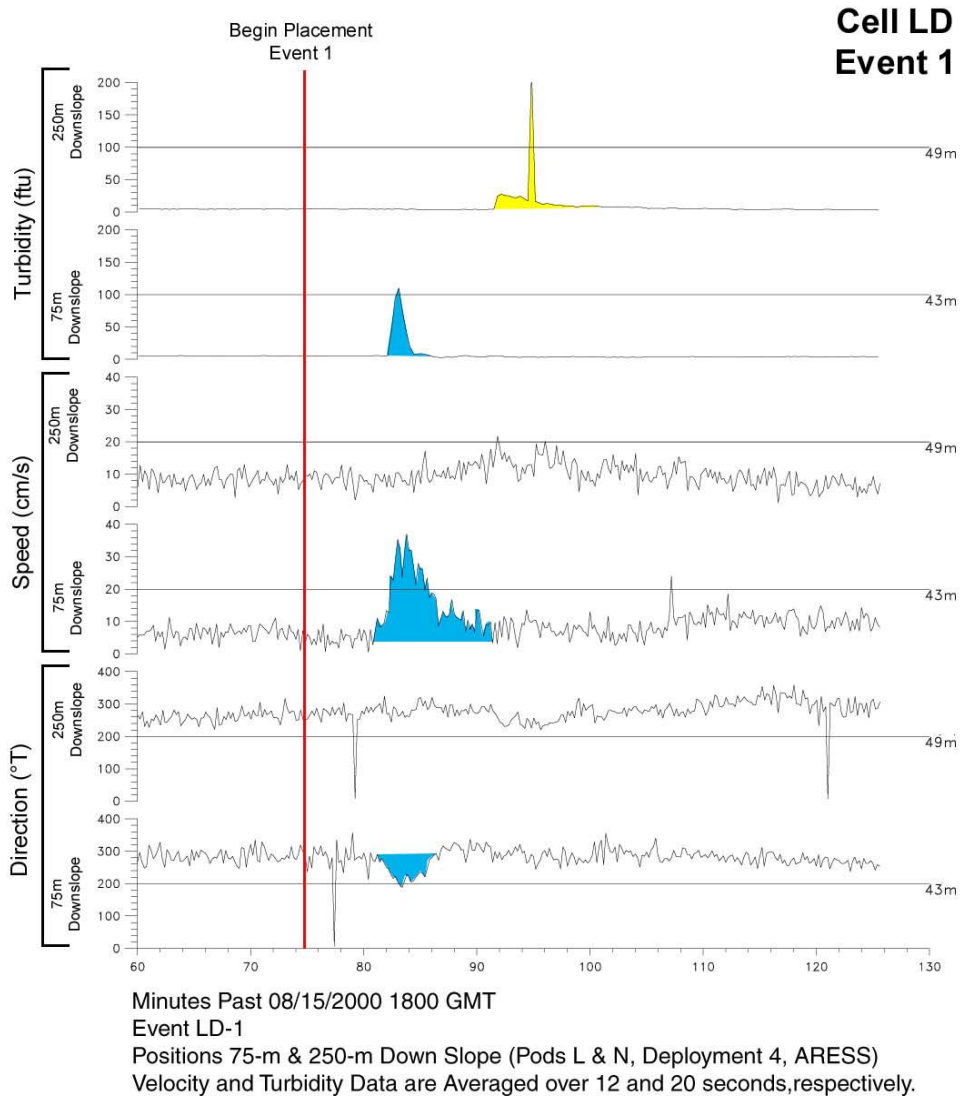

Figure 5.3-2. Time series plot of near-bottom data from the 75 m and 250 m downslope locations in Cell LD during cap placement Event 1 on August 15, 2000. Turbidity from the two locations (upper two tiers); current speed from the two locations (middle two tiers); and current direction from the two locations (lower two tiers).

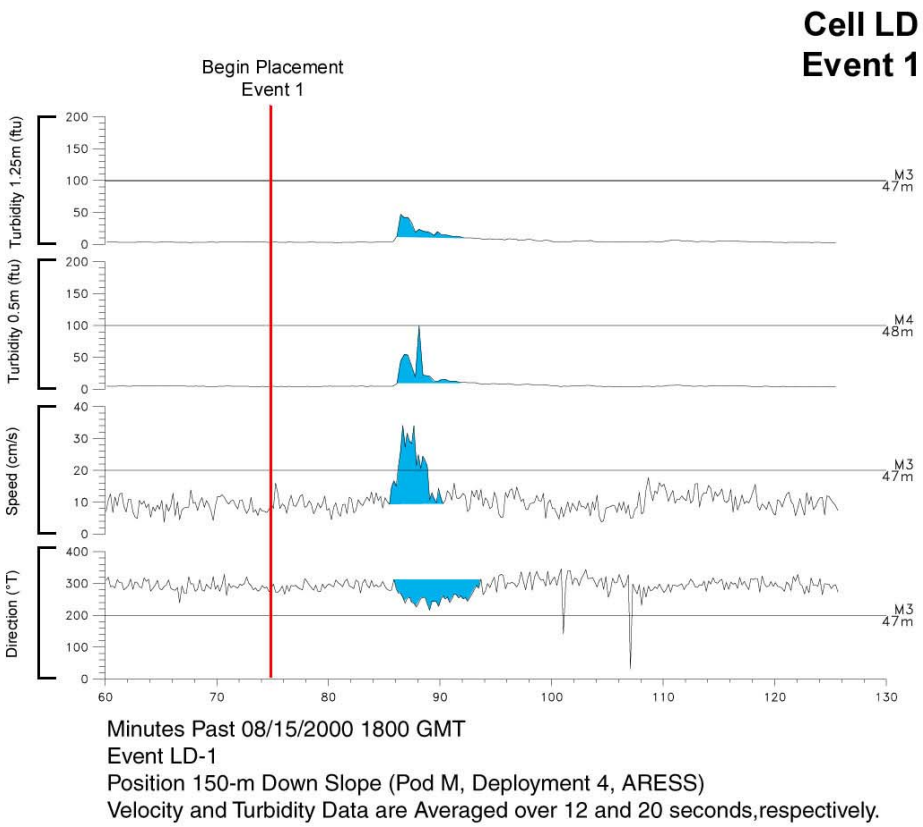

Figure 5.3-3. Time series plot of near-bottom data from the 150 m downslope location in Cell LD during cap placement Event 1 on August 15, 2000. Turbidity from the two sensor locations (upper two tiers); current speed and direction from 1.25 m (lower two tiers).

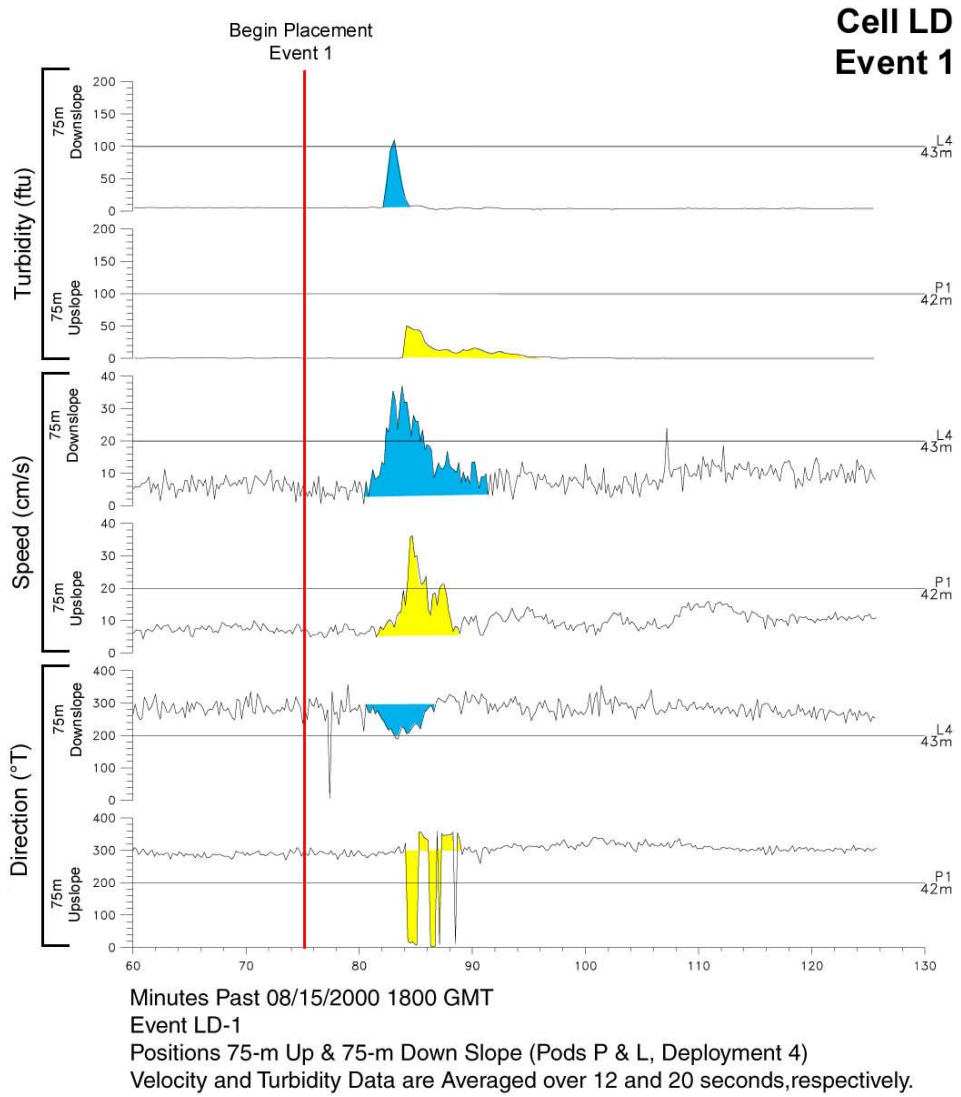

Figure 5.3-4. Time series plot of near-bottom data from the 75 m upslope and 75 m downslope locations in Cell LD during cap placement Event 1 on August 15, 2000. Turbidity from the two locations (upper two tiers); current speed from the two locations (middle two tiers); and current direction from the two locations (lower two tiers).

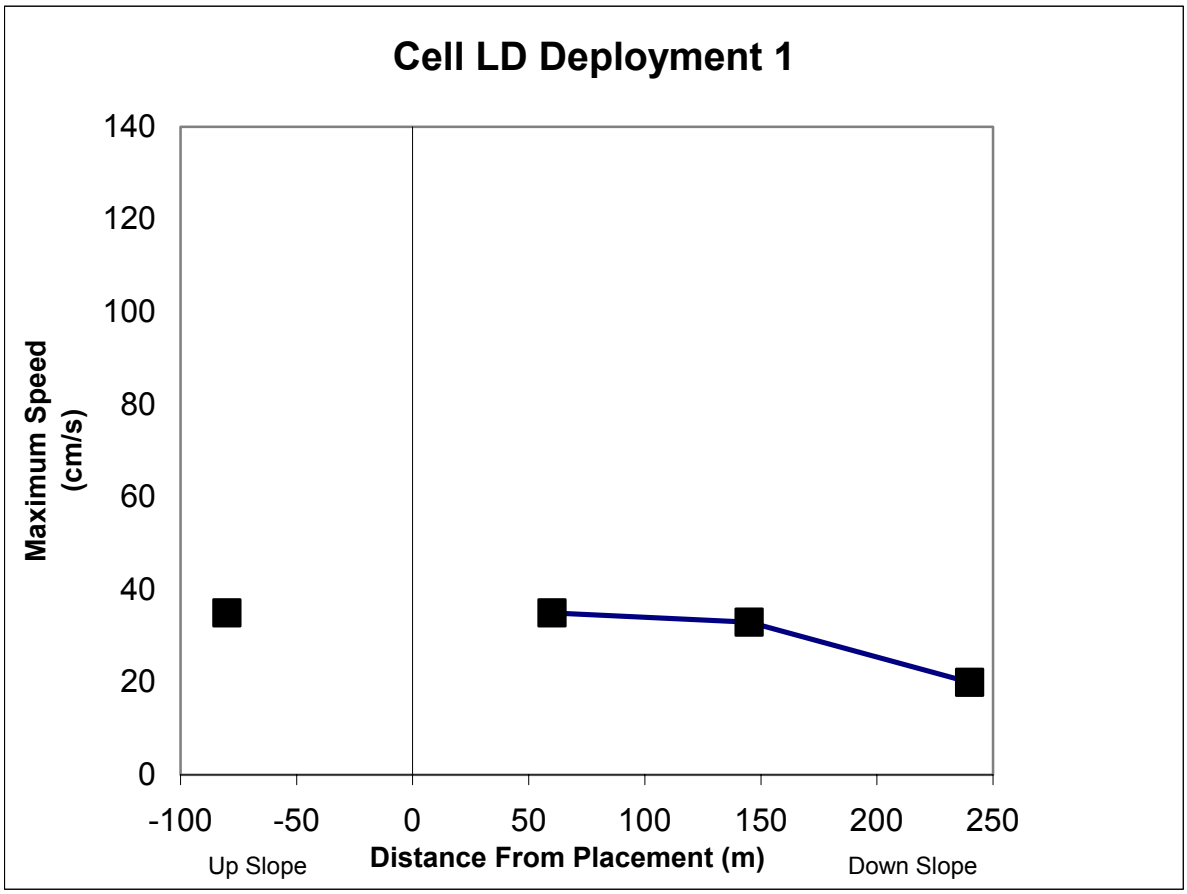

Figure 5.3-5. Plot of the maximum near-bottom current speed (y-axis) observed during cap placement Event 1 at multiple array locations within Cell LD versus the horizontal distance (x-axis) from the moored array locations to the actual cap placement locations (dredge positions).

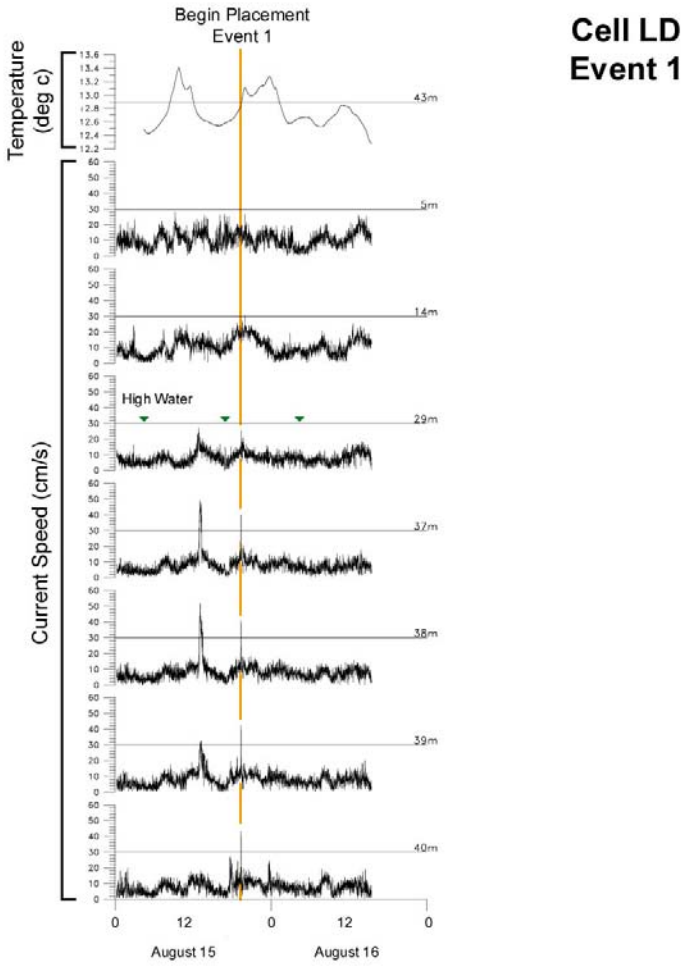

Figure 5.3-6. Time series plot of ADCP data from the 75 m downslope location in Cell LD bracketing cap placement Event 1 from August 15-16, 2000. Water temperature from 1-m above the bottom (top tier). Lower tiers present current speed data from seven 1-m thick depth levels extending from 5 m to 40 m (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.

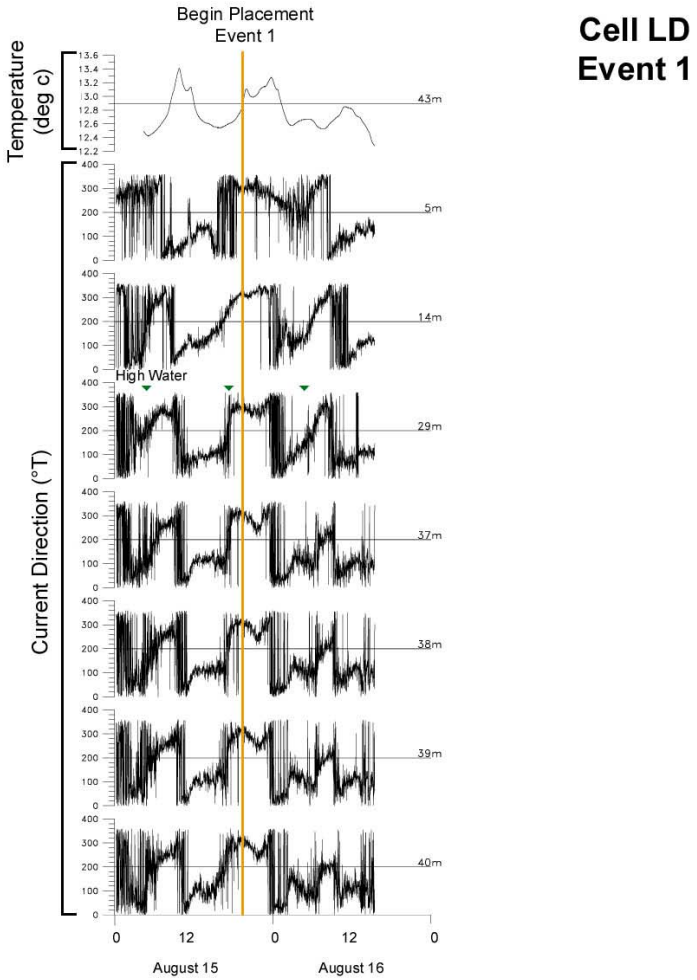

Figure 5.3-7. Time series plot of ADCP data from the 75 m downslope location in Cell LD bracketing cap placement Event 1 from August 15-16, 2000. Water temperature from 1-m above the bottom (top tier). Lower tiers present current direction data from seven 1-m thick depth levels extending from 5 m to 40 m (which was 3 m above the bottom). Data are 1-min averages

5.4 Drogue Trajectory Results

5.4.1 Overview of Field Sampling Plan

The monitoring objectives for water quality measurements in Cell LD (Section 5.5) focus on sampling within the near-bottom plume of suspended sediments associated with the spreading of cap material in Cell LD. 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.

5.4.2 Review of Data Quality Objectives

The Data Quality Objectives for water quality monitoring (see 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.

5.4.3 Technical Considerations

Drogue Configuration

Two water-following "holey-sock" drogues were deployed and visually tracked during monitoring of cap placement operations in Cell LD 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 LD was 42 m. Depths increase gradually to the south of Cell LD and decrease toward shore, as had been observed in the vicinity of Cell LU. The strategy for drogue deployment in Cell LD was identical to that for Cell LU, with drogues tethered at 15- and 30-m depths and marker flags uniquely assigned for deep and shallow drogues.

5.4.4 Monitoring Results

Placement Event 1

Two drogues were deployed at 1923 GMT on August 15, 2000, corresponding with the commencement of cap placement operations during Event 1 in Cell LD. As demonstrated in Figure 5.4-1, both drogues initially moved toward the northwest, then the drogues began to diverge, with the deeper drogue taking a more westerly heading. Table 3.4-1 (see Subsection 3.4) indicates that the 15-m drogue traveled a distance of 1,431 m (greater than the length of two pilot cells) during the 2 hr, 13 min period the drogue was tracked by the survey vessel. The average horizontal speed of this shallow drogue was 17.8 cm/s on a heading of 310°T. The deeper, 30-m drogue exhibited an average speed of 11.2 cm/s on a heading of 285°T during its 2 hr, 4 min drift period.

Because high water on the PV Shelf occurred at 1748 GMT (and low water occurred at 2300 GMT), the drogue tracks corresponded with ebb tide in the study area. These northwesterly trajectories at both the 15- and 30-m drogue depths agreed well with the current meter data acquired by the moored, upward-looking ADCP in Cell LD (see Figures 5.3-6 and 5.3-7), which indicated moderate (10 to 20 cm/s) westward or northwestward flow throughout the water column.

Data acquired by the near-bottom current meters at the time of Event 1 in Cell LD (see Figure 5.3-2) showed that near-bottom currents were weak (less than 10 cm/s) and directed toward the west, which agrees with the ADCP data from 40-m depth. Therefore, both of the moored instrument systems indicated that background, near-bottom currents at the time of this event were weak (near 10 cm/s) and directed toward the west. Given these data, the drogue track from 30-m depth (Figure 5.4-1) was representative of the northwestward flow near 40-m depth.

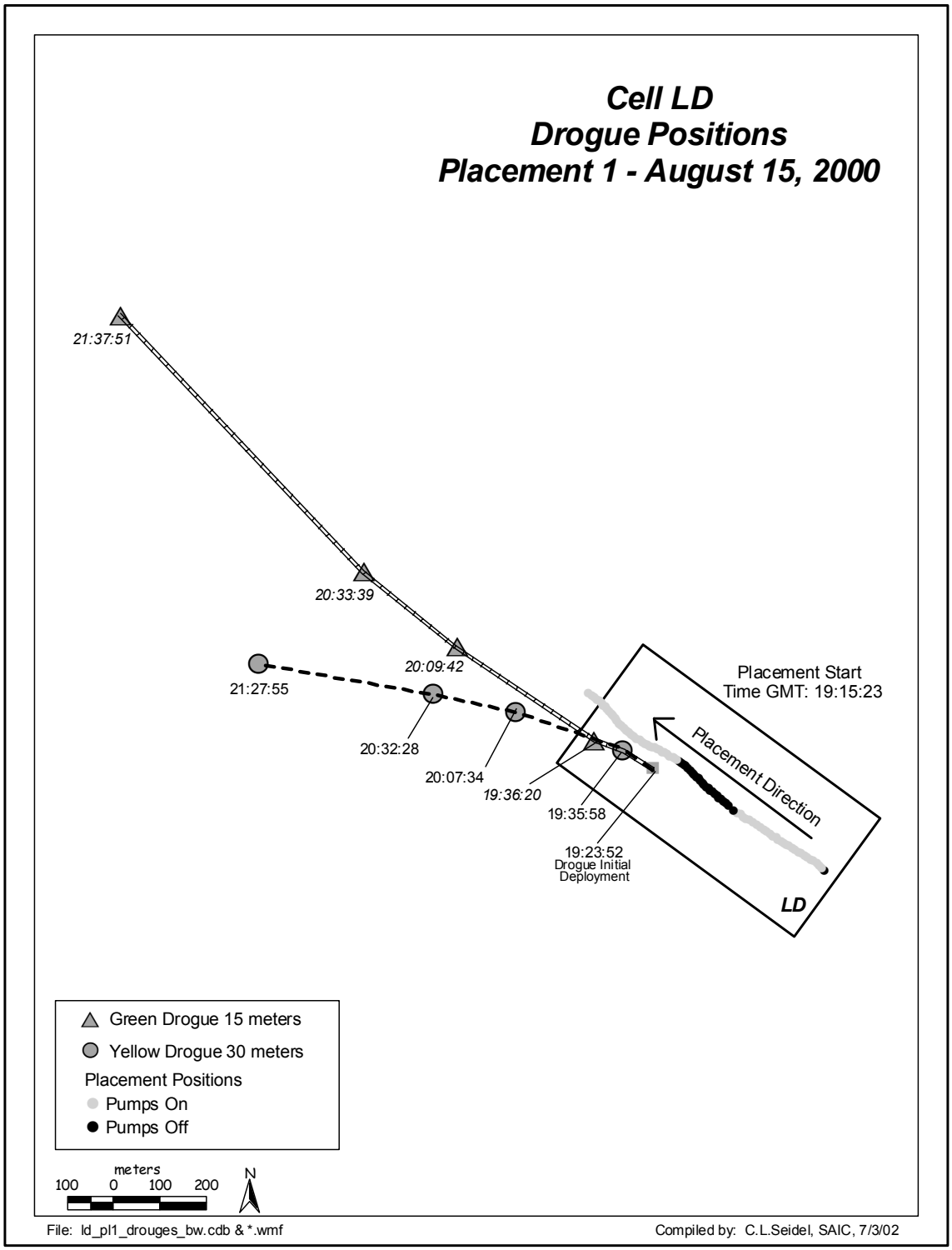

Figure 5.4-1. Map of Cell LD indicating trajectories of two drogues during water quality monitoring of placement Event 1 in Cell LD on August 15, 2000.

5.5 Water Column Monitoring Results

5.5.1 Overview of Field Sampling Plan

Water column monitoring during cap placement operations in Cell LD followed the same field procedures as implemented for Cells LU and SU (see 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 (spreading) event.

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

As discussed in Section 5.4, 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 throughout the water column using a vessel-mounted ADCP (see Section 5.6). 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. Nevertheless, the in situ sampling capabilities of the CTD system, coupled with the spatial mapping capability of the more mobile ADCP system complimented each other and yielded a good representation of the spatial and temporal characteristics of the plume surveyed.

5.5.2 Review of Data Quality Objectives

5.5.2.1 Water Quality Objectives

The monitoring objectives and approach for water quality measurements in Cell LD were consistent with those presented in Table 3.5-1 for Cell LU. Note however, that the initial water samples in Cell LD were collected 8 min after commencement of the placement event (as opposed to 5 min) because no bottom plume was encountered earlier than 8 min. In fact, the leading edge of the plume did not arrive at the CTD until 10 min after the start of cap placement operations in Cell LD.

Water quality monitoring objectives were met with one exception. During the single water quality survey in Cell LD, the mechanical components of the rosette water sampling device became clogged by descending cap material at approximately 12 min after the beginning of a cap placement operation. Consequently, water samples were not acquired at 20 min after the placement operation. The problem with the rosette sampling device was rectified quickly such that 40-min water samples were collected for this sampling event.

5.5.2.2 Plume Mapping Objectives

The monitoring objectives and approach for plume mapping operations in Cell LD 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 a single placement event. 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, the water following drogues proved to be an excellent, real-time tool for predicting the location of the near-bottom plume (see Section 5.4).

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.

5.5.3 Technical Considerations

As described in Section 5.2, capping operations in Cell LD differed from those in Cells LU and SU with regard to cap material characteristics and placement technique:

Cap Material

The dredged material used for capping in Cell LD originated from the A-III Borrow Area rather than from the Queen's Gate Channel. This borrow area material had significantly larger grain size than did the material originating in the channel. Consequently, the bulk of the cap material released in Cell LD was expected to settle more rapidly than the finer-grained material placed in Cells LU and SU. And because there was less fine grained material released in Cell LD, the turbid plume of suspended cap material was not expected to persist as long as those monitored in Cells LU and SU.

Placement Technique

Cap placement in Cell LD was implemented using the spreading technique, whereby material was released from the bottom of the hopper as the dredge moved slowly along a line down the axis of Cell LD. As indicated in Section 5.2, this spreading technique resulted in much less material being placed at a specific location compared to the conventional technique of "point disposal" from a stationary vessel. For this reason, the plume of suspended cap material resulting from the spreading process was expected to be much less turbid than plumes generated from cap material release during the conventional capping process.

As described in Section 5.4, the water quality monitoring studies were conducted in conjunction with tracking of water-following drogues. For the single cap placement event monitored in Cell LD, holey-sock drogues were situated at 15-m and 30-m depths as during monitoring activities in Cell LU. This approach was implemented because the water depth at Cell LD was essentially the same as that within Cell LU (roughly 43 m).

5.5.4 Monitoring Results

Water quality monitoring studies using the CTD, transmissometer, and Niskin bottles with rosette sampler were conducted at Cell LD during cap spreading Event 1 on August 15, 2000. The sampling methodology followed the Field Sampling Plan as summarized in Section 3.5.1.

5.5.4.1 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 5.5-1. Specific details regarding the sampling operations can be found in the Cruise Report (SAIC 2000b).

Prior to commencement of cap placement operations for Event 1, three CTD profiles were made within Cell LD 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 5.5-1 provides the minimum percent light transmittance (equivalent to maximum turbidity) for each of the three background CTD stations made prior to Event 1 in Cell LD. The minimum transmittance values were similar for all stations, and ranged from 68 to 74%.

Cap placement Event 1 in Cell LD began at 1915 GMT on August 15, 2000. Upon initiation of material release from the hopper dredge, the CTD survey vessel was positioned near the seaward boundary of Cell LD awaiting passage of the dredge as it moved slowly toward the northwest, along the axis of the cell (Figure 5.5-1). At the time the dredge passed the survey vessel, 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 8% as the surge passed the CTD sensors. Shortly after the surge arrived, the CTD was raised and lowered over the depth range from roughly 25 to 40 m in order to determine the thickness of and PLT in the near-bottom plume. During this CTD station (designated as LD-1D-CTD1 in Table 5.5-1) two near-bottom profiles were acquired and five water samples were collected within 18 min of the initiation of cap placement. Unfortunately, the firing mechanism of the rosette sampler became clogged with cap material after the fifth water sample was collected such that the CTD system had to be brought aboard the vessel for cleaning. The next CTD profile began 32 min after initiation of the cap placement.

During the first 3 hrs following cap placement Event 1, a total of seven CTD profile stations were occupied. Table 5.5-1 indicates that 13 near-bottom profiles were acquired at these seven stations and a total of 33 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 8% for CTD 1 to 68% for CTD 2, which demonstrates that turbidity within the near-bottom plume was decreasing rapidly within the first 49 min following passage of the dredge.

To illustrate the characteristics of the near-bottom plume observed at approximately 10 min after the placement event, Figure 5.5-2 presents a 3-min segment of the time series of PLT and CTD sensor depth acquired during CTD 1. This station was located approximately 130 m seaward of the track of the hopper dredge where the water depth was approximately 45 m (Figure 5.5-1). During this 3-min time segment, the CTD/transmissometer encountered a minimum PLT of 8% when held 2 m above the bottom, but the PLT dropped to approximately 40% within 20 sec. Shortly after, the CTD was raised and the upper boundary of the plume was seen at roughly 32 m depth, above which low-turbidity background

waters were encountered. Therefore, the near-bottom plume at this location was 13 m thick shortly after the placement event.

Another descent of the CTD/transmissometer through the plume 2 min later (Figure 5.5-2) showed that the minimum PLT had already increased to about 50%. This observation illustrates that the turbid plume resulting from spreading of borrow area material in Cell LD was dissipating much quicker than had been observed for plumes resulting from conventional cap placements of finer-grained Queen's Gate material in Cells LU and SU.

During the first 90 min of water quality monitoring operations (CTD stations 1 through 4), the survey vessel remained in close proximity to the 30-m drogue location in an attempt to follow the near-bottom flow, as represented by the drogue (Figure 5.5-1). Because the near-bottom PLT values were close to background levels shortly after CTD 1, there was concern aboard the CTD survey vessel whether contact with the plume had been lost. Radio communication from the survey vessel conducting the ADCP measurements suggested that the near-bottom plume was located seaward of the cell rather than to the west-northwest as suggested by the drogue trajectory. Consequently, the CTD vessel departed from the deep drogue to conduct CTD stations 5 and 6 closer to, but seaward of Cell LD. The near-bottom plume was not, however, more turbid at these two locations.

The temporal evolution of turbidity within the near-bottom plume resulting from Event 1 in Cell LD is illustrated in Figure 5.5-3. This figure presents the minimum PLT observed during the seven CTD stations, versus time since the cap placement event. The rapid increase in PLT during the first 30 min was followed by a period of very slow dilution of turbidity. Although we cannot be sure that CTD stations 4, 5 and 6 were taken within the centroid of the near-bottom plume, these results suggest that a relatively broad region west of Cell LD (see Figure 5.5-1) possessed a near-bottom plume that was slightly more turbid than the background waters.

The final CTD (station 7) was made in the center of Cell LD nearly 3 hrs after the spreading event. The turbidity data acquired at this station indicated that the near-bottom plume was no longer present at this station. This absence of suspended material was most likely a result of westward plume advection and/or particle settling.

A total of 33 water samples were collected within the near-bottom plume during the first 3 hrs following cap placement in Cell LD. Table 5.5-2 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 0.007 μg/L.

To graphically illustrate the temporal characteristics of TSS and DDE from within the near-bottom plume for placement Event 1, Figures 5.5-4 and 5.5-5 present the laboratory results (Table 5.5-2) plotted versus the actual sample collection time following initiation of the cap placement operation. As illustrated in Figure 5.5-4, TSS concentrations were highest within two samples collected during CTD 1: the highest value (350 mg/L) was measured within 2 m of the bottom 11 min after the dredge passed the survey vessel. Light transmission values concurrently measured by the CTD profiler were in the range from 9% to 15%, confirming that the discrete water samples were collected from within the plume. All subsequent TSS samples ranged from 13 mg/L to background levels (2 mg/L).

As illustrated in Figure 5.5-5, the temporal evolution of DDE was similar to the observed temporal characteristics of TSS within the near-bottom. The highest concentration of DDE (0.1 μg/L) was measured 11 min after the placement event, within the same water sample that possessed the maximum TSS concentration during this event. Within 30 min of the event, DDE concentrations had nearly returned to background levels; thereafter, concentrations remained close to background levels regardless of sampling location.

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

- The near-bottom plume could be tracked using the CTD/transmissometer and water-following drogues.
- Water samples could be collected from within the most concentrated portion of the turbid, near-bottom plume.
- At a measurement location roughly 100 m from the placement site, the near-bottom plume was 10 to 15 m thick shortly after the placement event and highest turbidity concentrations were observed close to the bottom. Turbidities decreased rapidly within the first 30 min following the spreading event and remained slightly above background levels for at least 2 hrs.
- The highest TSS concentration of discrete water samples from the plume (350 mg/L) was measured 11 min after the placement event. Concentrations decreased rapidly within the first 30 min as had been observed by the transmissometer.
- The highest DDE concentration from water samples within the plume (0.1 μg/L) was measured 11 min after the placement event, at the time of the maximum observed TSS concentration. DDE concentrations decreased to near-background levels within 30 min after the placement.

5.5.5 Discussion

Water column profiling was conducted during cap spreading Event 1 in Cell LD 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 effective for indicating the trajectory of the near-bottom flow such that CTD profiles made in close proximity to the deepest (30-m) drogue appeared to remain with the plume. Additionally, real-time results from the ADCP current and turbidity profile data being acquired simultaneously by a separate survey vessel aided plume location during CTD profiling operations.

Turbidity Profile Observations

Percent light transmittance data measured in Cell LD by the CTD/transmissometer revealed that turbidity within the near-bottom plume was high within the first 11 min after release of cap material from the dredge. As illustrated in Figure 4.5-6 (see Section 4.5 on water quality results from Cell SU), the minimum percent light transmittance within the plume increased rapidly after the cap spreading operation in Cell LD, and approached background levels within 30 min. These results from the spreading operation (using borrow area material) were very different from the results obtained during conventional cap placement events in Cells LU and SU, which showed that conventional placements using Queen's Gate material resulted in near-bottom plumes that retained higher-than-background turbidity characteristics for more than 2 hrs.

TSS Observations from Discrete Samples

Water samples collected prior to the cap spreading operation in Cell LD 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 measured during three events in Cell LU (Figure 4.5-7). We suspect that the lower TSS concentration in the plume associated with cap material spreading in Cell LD was due to: 1) less material released at a specific location because the dredge was moving along the axis of the cell; 2) greater settling rates of the borrow area material released in Cell LD compared to settling rates of the Queen's Gate material (released in Cells LU and SU) which contained a higher percentage of fine-grained material, and 3) less resuspension of EA material. The relatively low TSS concentration in the leading edge of the near-bottom plume (surge) in Cell LD could also have been partly due to the fact that the CTD survey vessel was located farther from the actual placement location within Cell LD than the vessel's relative position during conventional placements in Cells LU and SU. The leading edge of the near-bottom plume in Cell LD took 11 min to reach the CTD survey vessel and during this time period, a significant fraction of the suspended material may have settled to the seafloor.

The comparison of TSS results from the various placement events in Cells LU, SU and LD (Figure 4.5-7) also illustrates that TSS concentrations approached background levels much quicker for the spreading event in Cell LD than for the conventional events in Cells LU and SU. Again, this was most likely due to the larger percentage of fine-grained particles in the Queen's Gate material (placed in Cells LU and SU) compared to the borrow area material placed in Cell LD.

We must remember, however, that the near-bottom plumes from these capping events may contain EA sediments that were resuspended during the material spread and impact phase of the capping operations. Consequently, it is quite possible that the spreading event in Cell LD resuspended significantly less EA sediment than did the conventional placement operations in Cells LU and SU. As discussed below, TSS data alone are insufficient for distinguishing whether the near-bottom turbid plumes contained cap material, EA sediment, or a combination of the two materials.

DDE Observations from Discrete Samples

Fourteen of the near-bottom water samples collected within Cell LD 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 very low, ranging from 0.0057 to 0.0074 μg/L. Following the cap placement operation, the highest observed DDE concentration (0.10 μg/L) was obtained from a sample collected 11 min after the cap placement. This sample from the near-bottom plume apparently contained contaminated EA sediment that had been resuspended by the descending cap material. This maximum concentration was comparable to observations during other placement events in Cell LU (Figure 4.5-8), but less than the maximum concentration observed in Cell SU. This suggests that resuspension of EA sediments in Cells LU and LD may have been comparable and independent of cap placement technique, assuming that: 1) the DDE concentration of the background sediments at the sediment-water interface was the same in both cells, and 2) the individual water samples analyzed were representative of water property characteristics in the near-bottom plume, and the results were not affected by spatial and/or temporal limitations of the water sampling program.

Another interesting result that is evident from the time series of DDE concentrations in the near-bottom plume (Figure 4.5-8) is that concentrations in Cell LD decreased at roughly the same rate as observed for plumes in Cell LU. Within approximately 30 min of each placement event, DDE concentrations in the near-bottom plume had decreased substantially, achieving concentrations that were comparable to pre-placement background levels. DDE concentrations within water samples from the spreading event in Cell LD exhibited low values for all subsequent samples acquired within 3 hrs after the placement event.

Table 5.5-1. Summary of CTD profiles acquired and water samples collected during cap placement Event 1 in Cell LD on August 15, 2000. Also given is the maximum turbidity (minimum percent light transmission) observed by the transmissometer interfaced to the CTD system during each profile.

Start Time After Placement (hr:min:sec)	Background	Background	Background	0:09:04	0:32:53	1:02:37	1:26:07	2:02:37	2:32:20	2:49:07
File/Cast End Time	Background	Background	Background	0:18:37	0:49:40	1:14:52	1:37:55	2:07:11	2:40:37	2:55:37
Elapsed Time of Cast	0:17:23	0:07:57	0:12:35	0:09:33	0:16:47	0:12:15	0:11:48	0:04:34	0:08:17	0:06:30
CTD File Name	LD-1B-CTD1	LD-1B-CTD2	LD-1B-CTD3	LD-1D-CTD1	LD-1D-CTD2	LD-1D-CTD3	LD-1D-CTD4	LD-1D-CTD5	LD-1D-CTD6	LD-1D-CTD7
Total Water Column Profiles	1	1	1	1	1	1	1	1	1	1
Near Bottom Profiles	1	1	2	2	4	2	2	1	1	1
Water Samples Collected	3	0	0	5	13	8	4	2	1	0
Minimum % Light Transmittance (PLT)	68	71	74	8	68	65	69	66	67	72
Depth of Minimum Turbidity	B-11m	B-10m	B-9m	B-0m	B-0m	B-2m	B-1m	B-2m	B-3m	B-1m

Table 5.5-2. Total suspended solids and DDE concentrations from discrete water samples collected during CTD profiling operations during cap placement Event 1 in Cell LD on August 15, 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	LD1BCTD1	LD1BBOT1	41.1	73.9	2	0.0057	B-1	no
Background	LD1BCTD1	LD1BBOT2	43.0	73.8	2	0.0066	B-2	no
Background	LD1BCTD1	LD1BBOT3	41.2	72.3	2	0.0074	B-3	no
8	LD1DCTD1	LD1DBTA2	44.0	72.2	2		1	no
9	LD1DCTD1	LD1DBTA3	43.3	72.6	2		2	no
10	LD1DCTD1	LD1DBTA4	44.2	62.7	3		3	no
10	LD1DCTD1	LD1DBTA5	43.6	8.6	92		4	yes
11	LD1DCTD1	LD1DBTA6	43.8	15.2	350	0.10	5	yes
30	LD1DCTD2	LD1DBTB1	44.2	72.8	9		6	yes
35	LD1DCTD2	LD1DBTB2	44.6	69.9	10	0.013	7	yes
35	LD1DCTD2	LD1DBTB2	44.6	69.9	10	0.0098	8	yes
40	LD1DCTD2	LD1DBTB4	44.8	76.6	5		9	yes
41	LD1DCTD2	LD1DBTB5	45.6	74.8	12		10	yes
43	LD1DCTD2	LD1DBTB6	33.3	76.5	3		11	no
43	LD1DCTD2	LD1DBTB16	33.3	76.5	3		12	no
45	LD1DCTD2	LD1DBTB7	43.8	72.3	9		13	yes
46	LD1DCTD2	LD1DBTB8	46.2	69.0	8		14	yes
46	LD1DCTD2	LD1DBTB9	44.7	68.8	7	0.012	15	yes
47	LD1DCTD2	LD1DBTB19	44.7	68.8	10		16	yes
47	LD1DCTD2	LD1DBTB10	44.7	69.0	10		17	yes
48	LD1DCTD2	LD1DBTB11	45.3	68.1	13		18	yes
63	LD1DCTD3	LD1DBTC1	43.1	75.8	8		19	yes
64	LD1DCTD3	LD1DBTC2	43.4	76.2	7		20	yes
65	LD1DCTD3	LD1DBTC3	45.9	77.1	5		21	yes
66	LD1DCTD3	LD1DBTC4	47.1	71.2	6	0.0094	22	yes
66	LD1DCTD3	LD1DBTC14	47.1	71.2	6	0.0089	23	yes
67	LD1DCTD3	LD1DBTC5	47.4	65.2	6		24	yes
67	LD1DCTD3	LD1DBTC15	47.4	65.2	4		25	yes
70	LD1DCTD3	LD1DBTC7	45.4	76.8	4		26	yes
90	LD1DCTD4	LD1DBTD3	49.0	70.2	2		27	yes
97	LD1DCTD4	LD1DBTD5	50.2	70.8	3		28	yes
97	LD1DCTD4	LD1DBTD6	51.3	69.3	4	0.0090	29	yes
127	LD1DCTD4	LD1DBTD9	53.5	73.8	3	0.0085	30	yes
157	LD1DCTD5	LD1DBTE2	52.6	70.1	4	0.012	31	yes
157	LD1DCTD5	LD1DBTE4	38.5	66.8	4	0.0093	32	yes
171	LD1DCTD6	LD1DBTF1	47.9	67.1	4	0.012	33	no

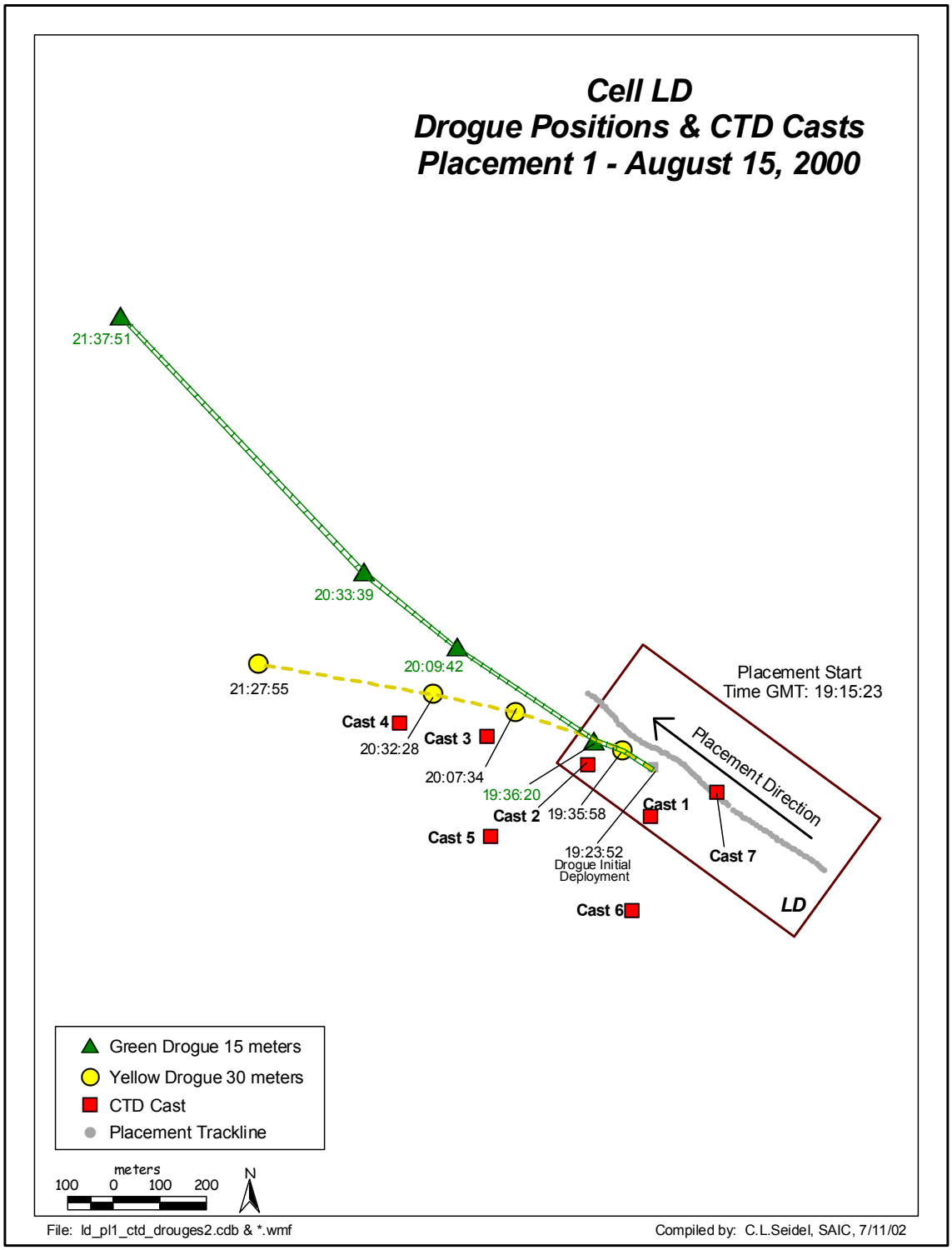

Figure 5.5-1. Map of Cell LD indicating drogue trajectories and CTD stations during cap placement Event 1 on August 15, 2000.

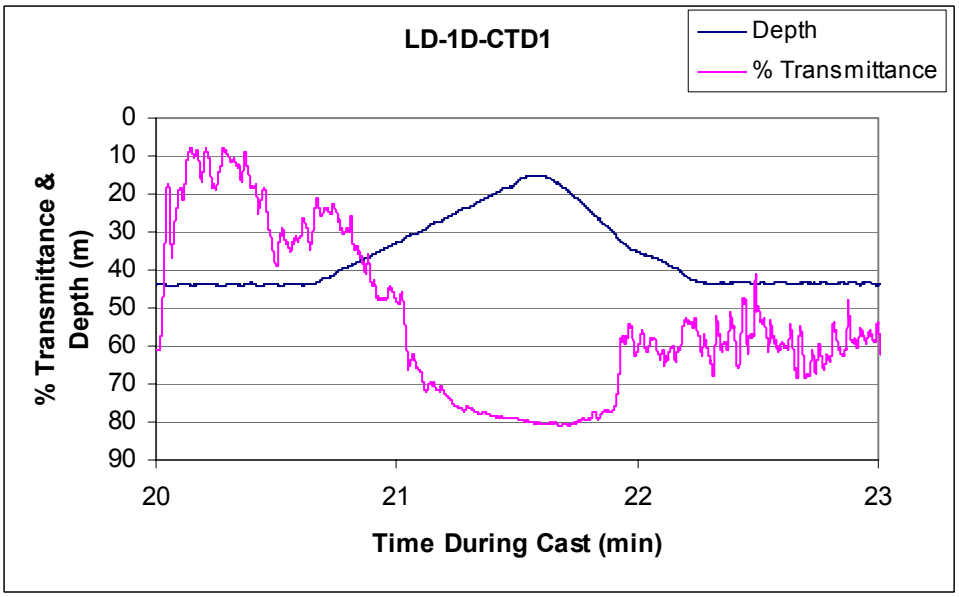

Figure 5.5-2. Time series plot of percent light transmission and sensor depth acquired during CTD Station 1 during cap placement Event 1 in Cell LD on August 15, 2000. See Table 5.5-1 for CTD profile information.

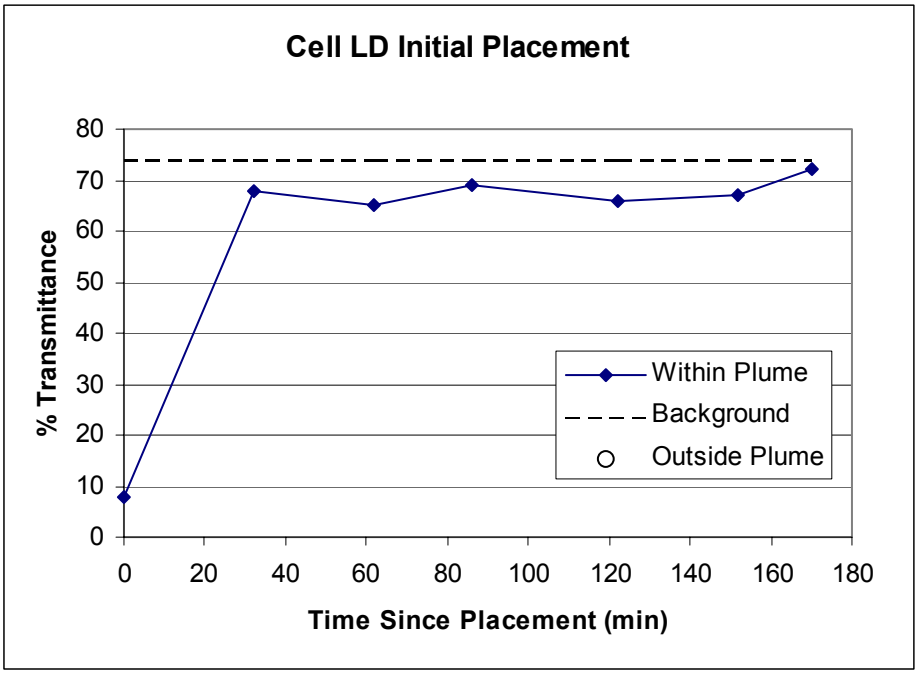

Figure 5.5-3. Time series plot of the minimum value of percent light transmission acquired during each CTD profile conducted during cap placement Event 1 in Cell LD on August 15, 2000. See Table 5.5-1 for CTD profile information.

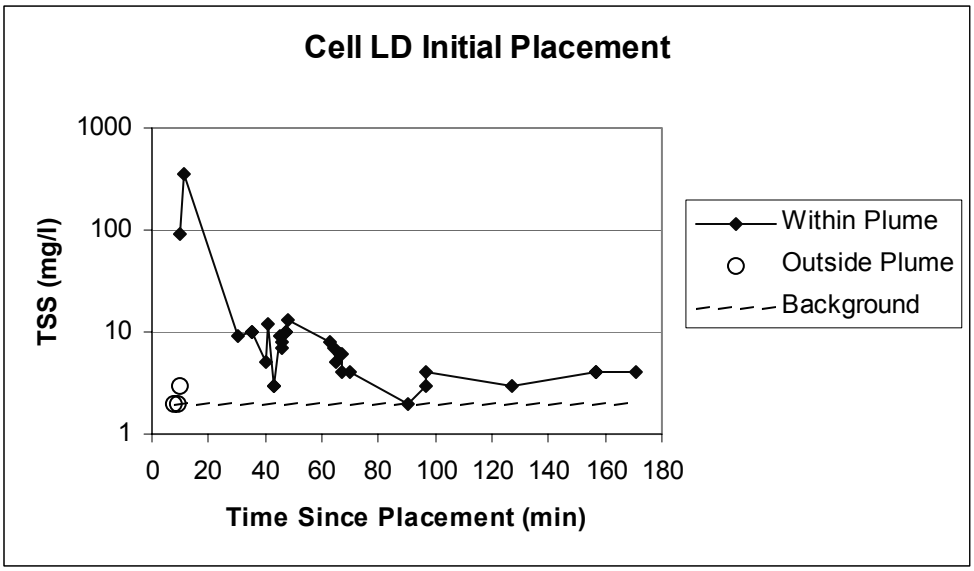

Figure 5.5-4. Plot of total suspended solids concentration versus time since cap placement event for discrete water samples collected during CTD profiling operations of cap placement Event 1 in Cell LD on August 15, 2000.

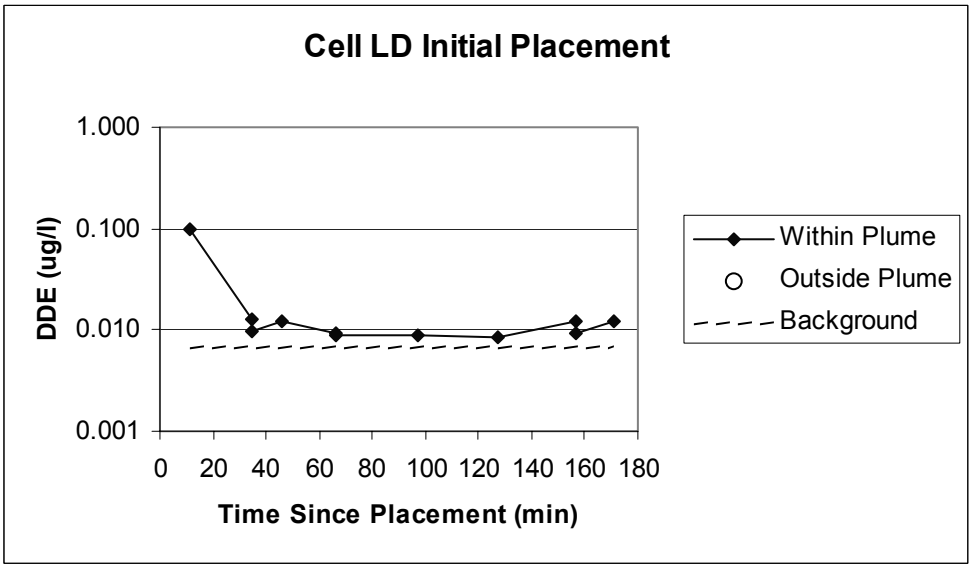

Figure 5.5-5. Plot of DDE concentration versus time since cap placement event for discrete water samples collected during CTD profiling operations of cap placement Event 1 in Cell LD on August 15, 2000.

5.6 Underway Measurements of Acoustic Backscatter

5.6.1 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 LD. The measurements were conducted in the same manner as those for Cell LU (Section 3.6). Details of the system and methodology can be found in the PWP (SAIC 2001). The objectives of the sampling plan for Cell LD were the same as those for Cell LU (Section 3.6). All phases of the sampling plan were accomplished. Details of the sampling plan can be found in the PWP.

5.6.2 Review of Data Quality Objectives

The BBADCP performed to specification, and all data objectives were achieved. Monitoring was conducted for 1 hr and 27 min but there was little indication of a residual plume after about 47 min.

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° from the vertical. For the surveys in Cell LD, the system was able to track bottom, and tow speed and tow stability were well within the limits required to achieve the highest quality data. The PWP stated that a BBADCP with velocity-measuring beams set at 20° from the vertical would be used for the surveys. The system had the beams set at 30° from the vertical. The data quality objectives were not compromised by this change.

5.6.3 Technical Considerations

The technical considerations for Cell LD were the same as for Cell LU (Section 3.6.3).

5.6.4 Monitoring Results

5.6.4.1 Current Profiles

Figure 5.6-1 shows the first current profile obtained on August 15, 2000, in Cell LD. It is the result of a 15-min average of current speed and direction ending at 18:48 GMT, 27 min before the placement operation began. It was taken at 33° 42.852’ N and 118° 20.424’W, which is close to the center of the cell

Figure 5.6-2 shows the current profile obtained after the placement operation. It is the result of a 15-min average of current speed and direction beginning at 22:08 GMT, 1 hr and 43 min after the placement operation ended. It was taken at 33° 42.852’ N and 118° 20.424’W, which is close to the center of the cell.

5.6.4.2 Acoustic Backscatter Monitoring

Figure 5.6-3 shows the survey lines run to monitor the acoustic backscatter from the suspended sediment resulting from the placement operation in Cell LD on August 15, 2000 (Table 5.6-1). Plots of the ABAB along these lines are shown in Figures 5.6-4 through 5.6-11.

5.6.5 Discussion

The current profile shown in Figure 5.6-1 were from data taken about 45 minutes before the placement operation began. It shows an indication of current shear in the upper 5 m, and northwest currents from 10 to 18 cm/s from 5 to 35 m. Figure 5.6-2 shows the current profile from measurements made 1 hr and 43 min after the placement operation ended. At this time, the near-surface shear had deepened and apparently increased in speed; the northwestward flow below this has changed its direction more toward the north.

The placement operation in Cell LD differed from the other operations monitored by underway measurements of acoustic backscatter. For this operation, placement material was slowly released as the dredge traversed the main axis of the cell. It was expected that this would reduce the strength of the bottom surge. Figure 5.6-4 shows that it did so. There was no indication of a bottom surge from the ABAB. Table 5.6-2 summarizes the information on the acoustic backscatter measurements

Table 5.6-1. Start and End Times for ADCP Lines during placement Event 1 in Cell LD on August 15, 2000

Towed ADCP Lines		
Line Number	Start Time GMT	End Time GMT
1	19:21:24	19:27:52
2	19:31:17	19:37:44
3	19:40:41	19:46:40
4	19:49:51	19:56:01
5	19:59:28	20:05:21
6	20:12:42	20:19:44
7	20:22:23	20:28:59
8	20:33:05	20:40:18

Table 5.6-2. Summary of Results of Acoustic Monitoring of Suspended Sediment on August 15, 2000

Survey Line	Elapsed Time[1] (min:sec)	Location[2] Distance (m)	Bearing (°T)	Speed[3] (cm/s)	Characteristics
1	2:27	0	0	0	Suspended sediment plume was narrow. No bottom surge was apparent.
2	12:32	35	40	5	Plume becoming patchy below 30 m.
3	21:40	72	294	6	Plume starting to not be visible below 30 m.
4	31:21	39	228	2	An apparent second plume to the northeast along the line was visible from 20 m down to the bottom. May be biologically induced backscatter.
5	39:40	92	226	4	Possible biologically-induced plume still visible.
6	52:34	NA	NA	NA	Possible biologically-induced plume the only one visible.
7	64:39	NA	NA	NA	Possible biologically-induced plume the only one visible.
8	73:02	NA	NA	NA	Possible biologically-induced plume the only one visible.

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 the dredge crossed survey Line 1 during the placement operation.
2. Location is the distance and bearing from the location of the dredge when it crossed survey Line 1 during 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.

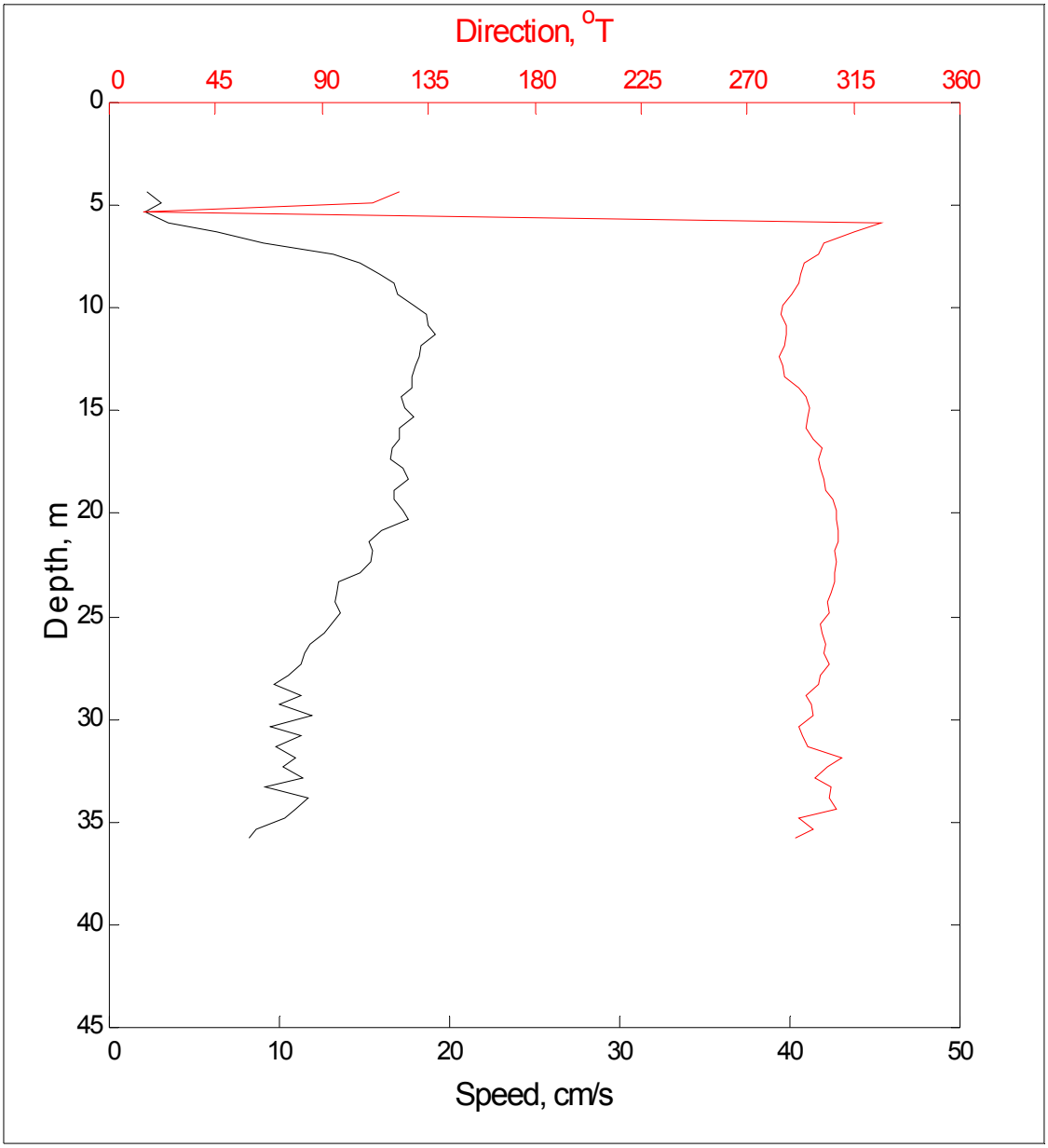

Figure 5.6-1. Vertical current profile on August 15, 2000, at 1830 GMT.

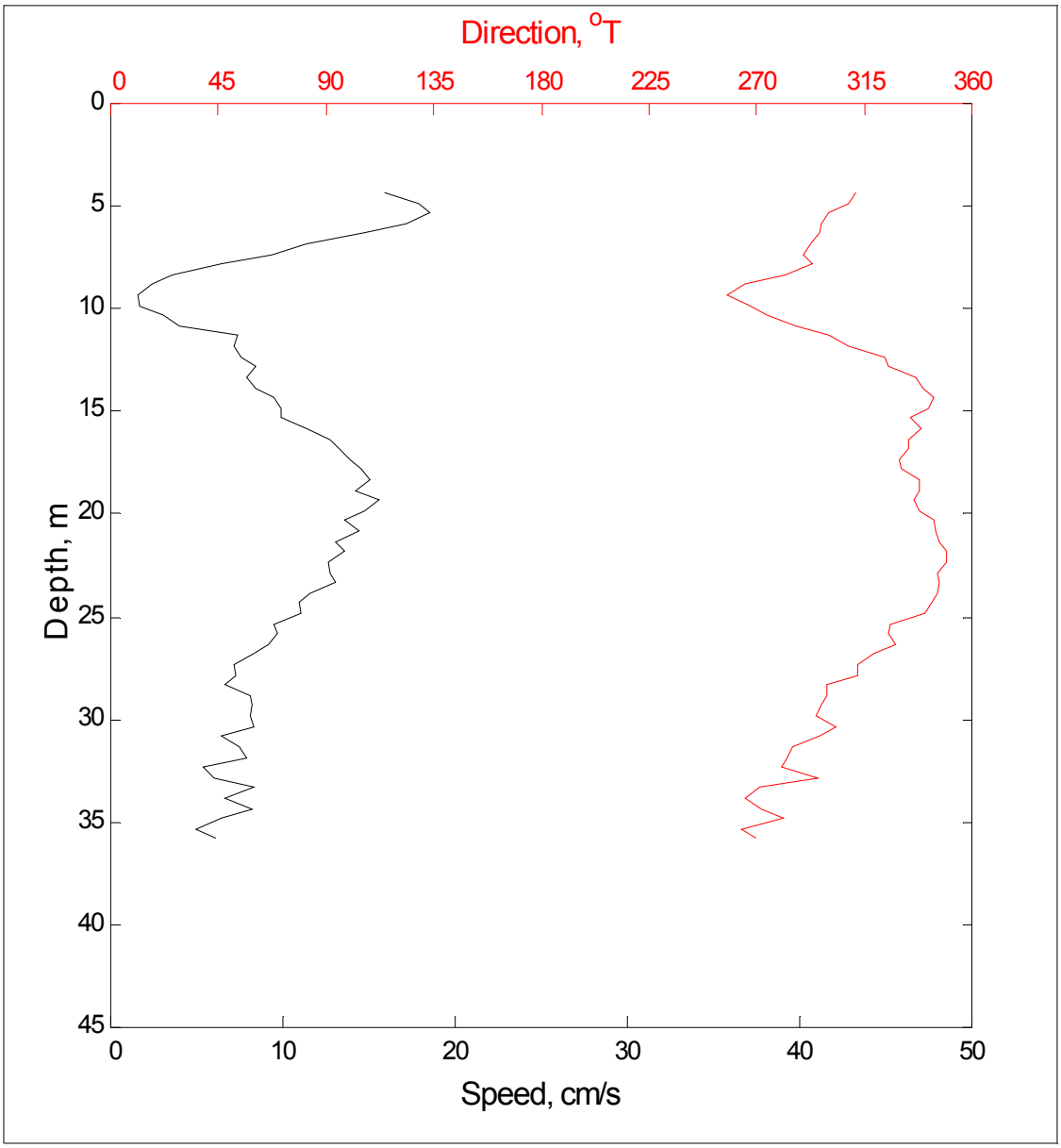

Figure 5.6-2. Vertical current profile on August 15, 2000 at 2208 GMT.

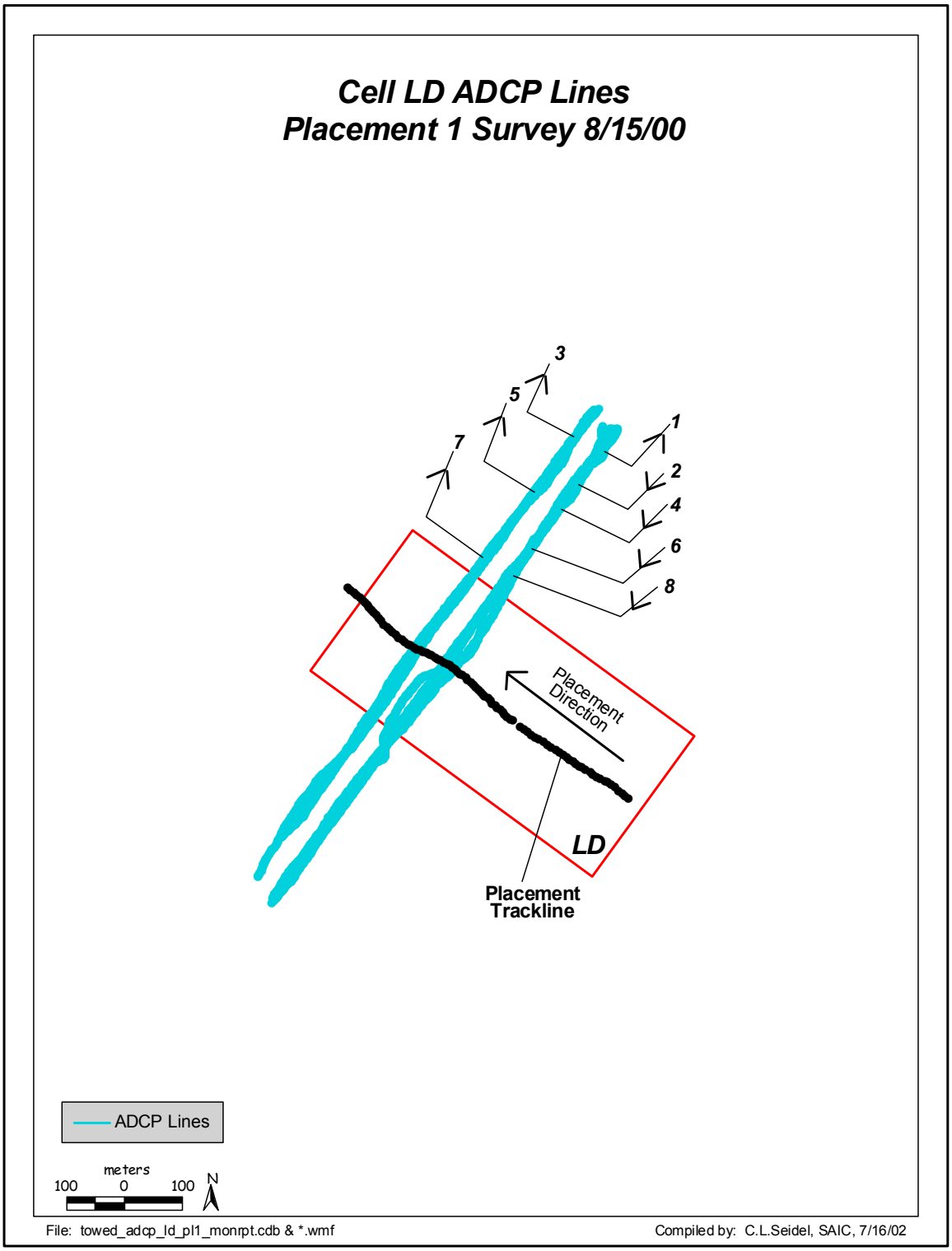

Figure 5.6-3. Survey tracklines for acoustic monitoring of suspended sediment on August 15, 2000.

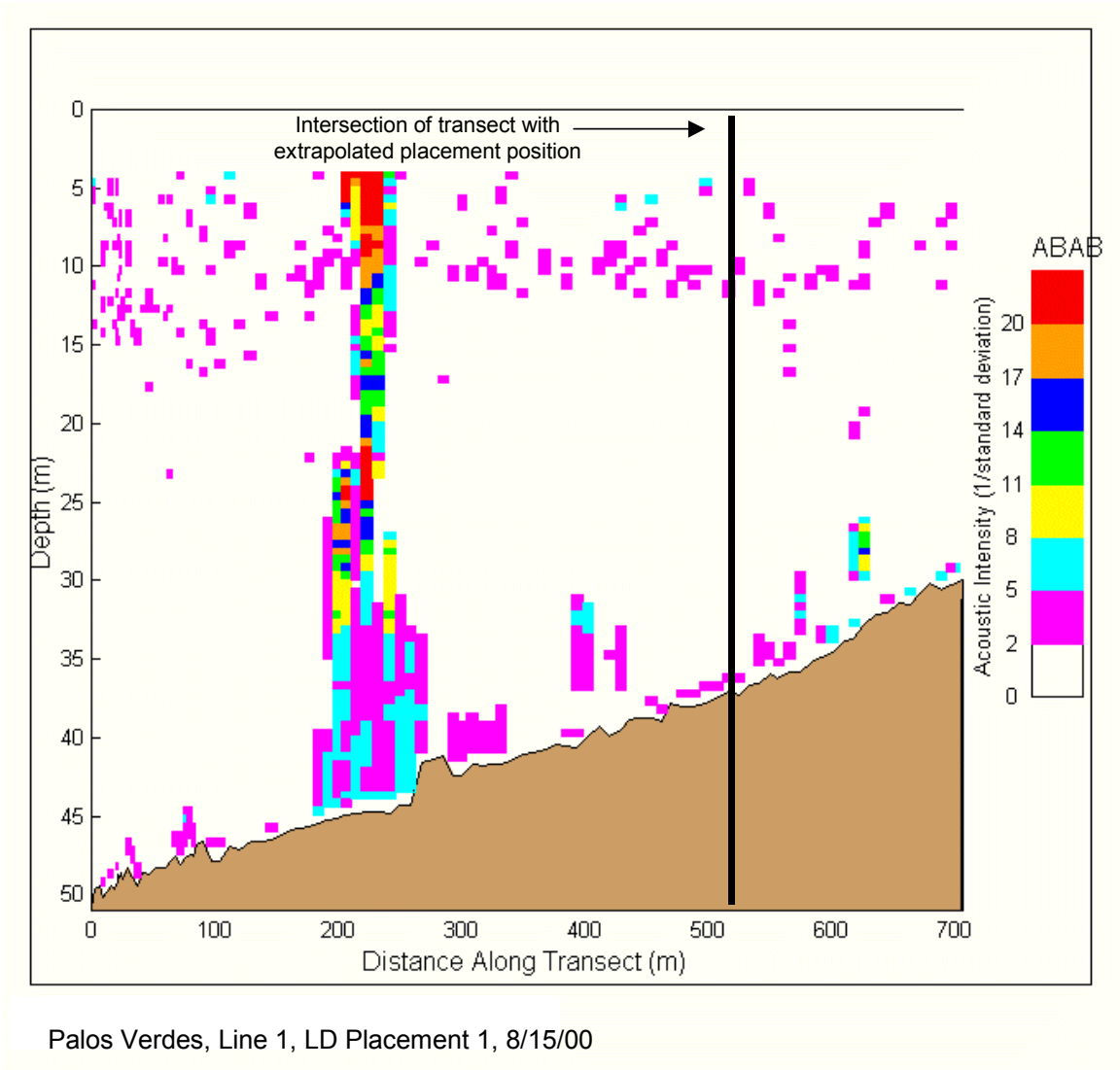

Figure 5.6-4. ABAB along Survey Line 1, run from southwest to northeast 6 min after the placement started and 4 min before the placement ended.

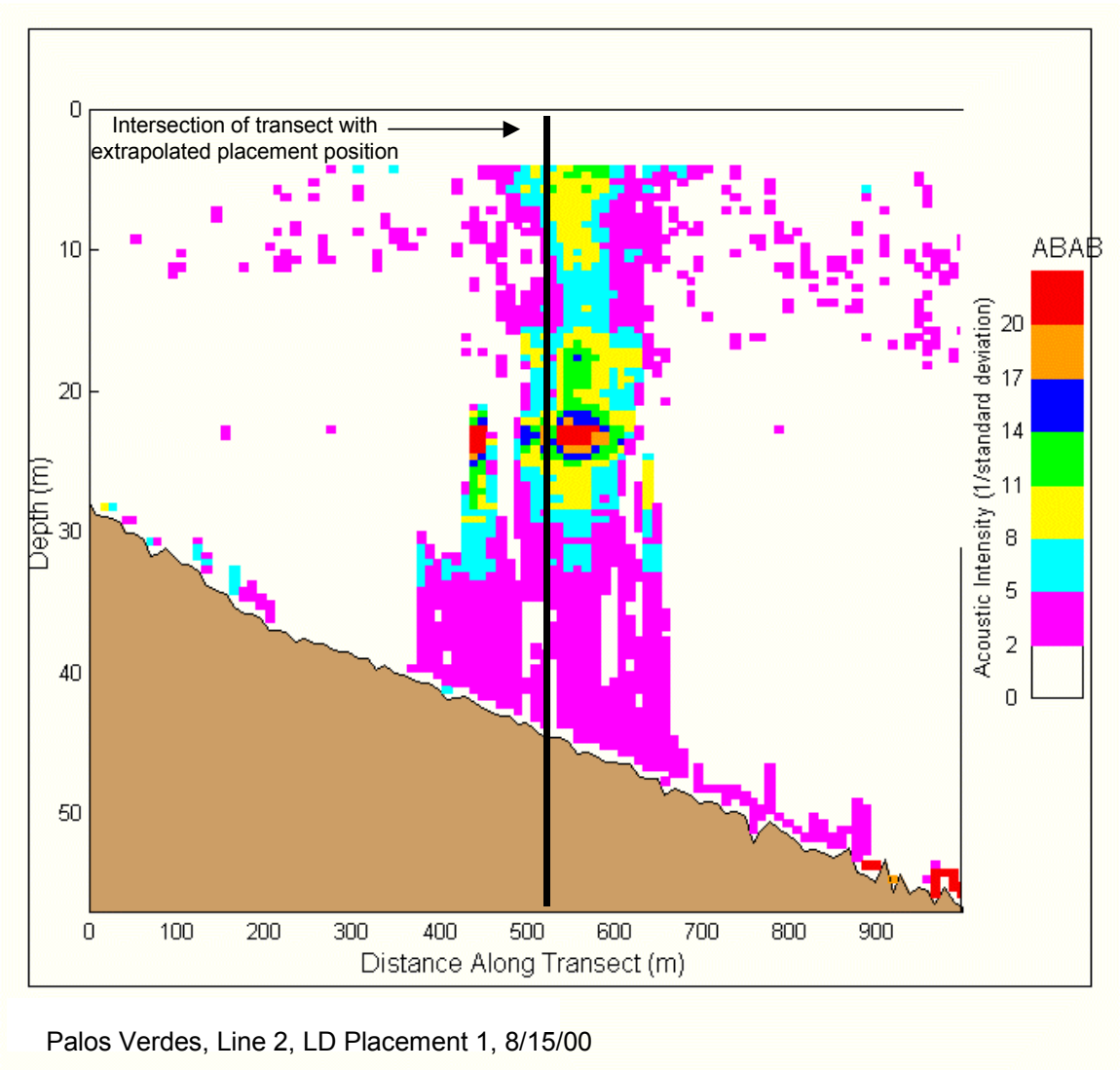

Figure 5.6-5. ABAB along Survey Line 2, run from northeast to southwest 6 min after the placement ended.

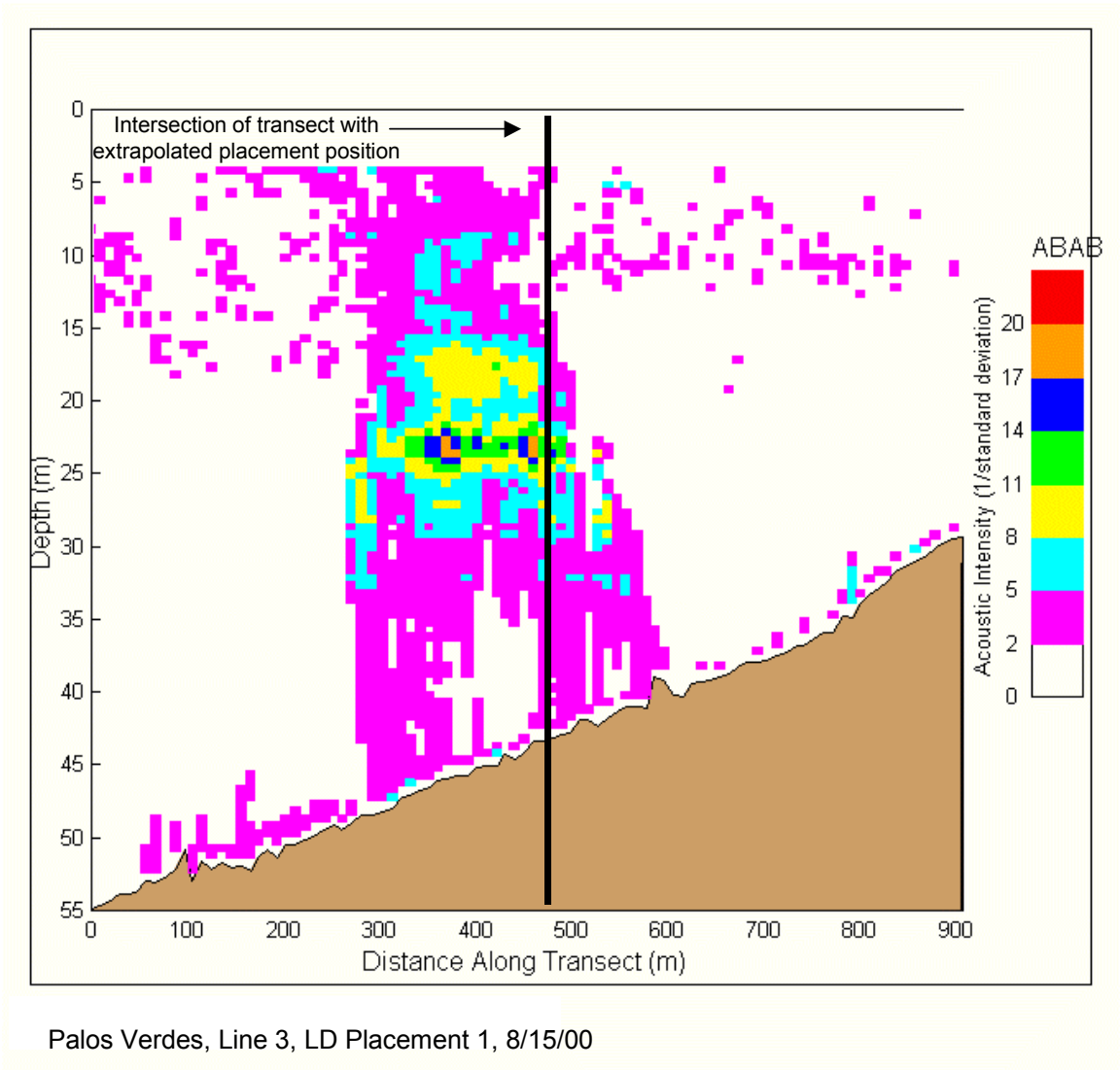

Figure 5.6-6. ABAB along Survey Line 3, run from southwest to northeast 15 min after the placement ended.

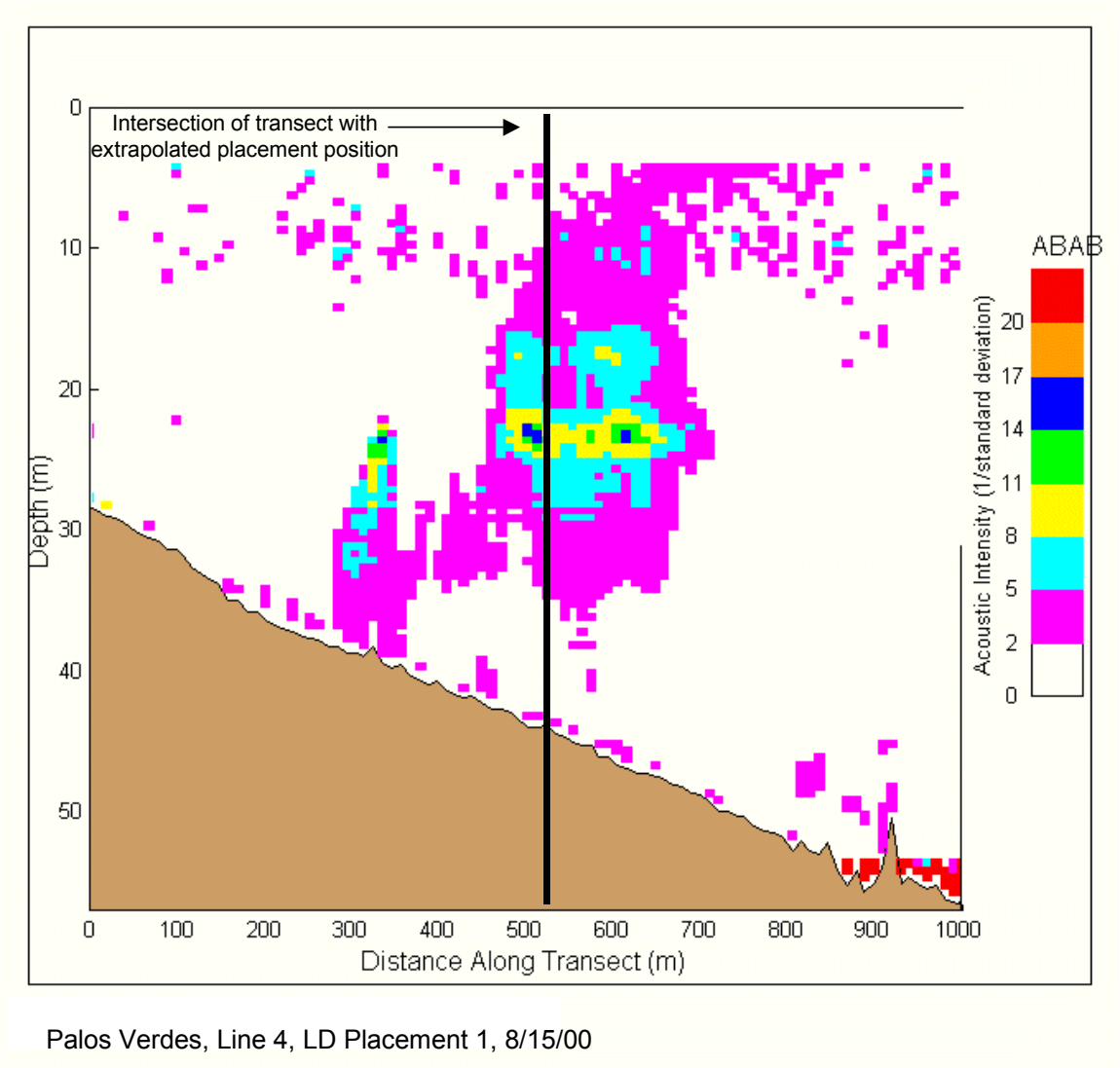

Figure 5.6-7. ABAB along Survey Line 4, run from northeast to southwest 24 min after the placement ended.

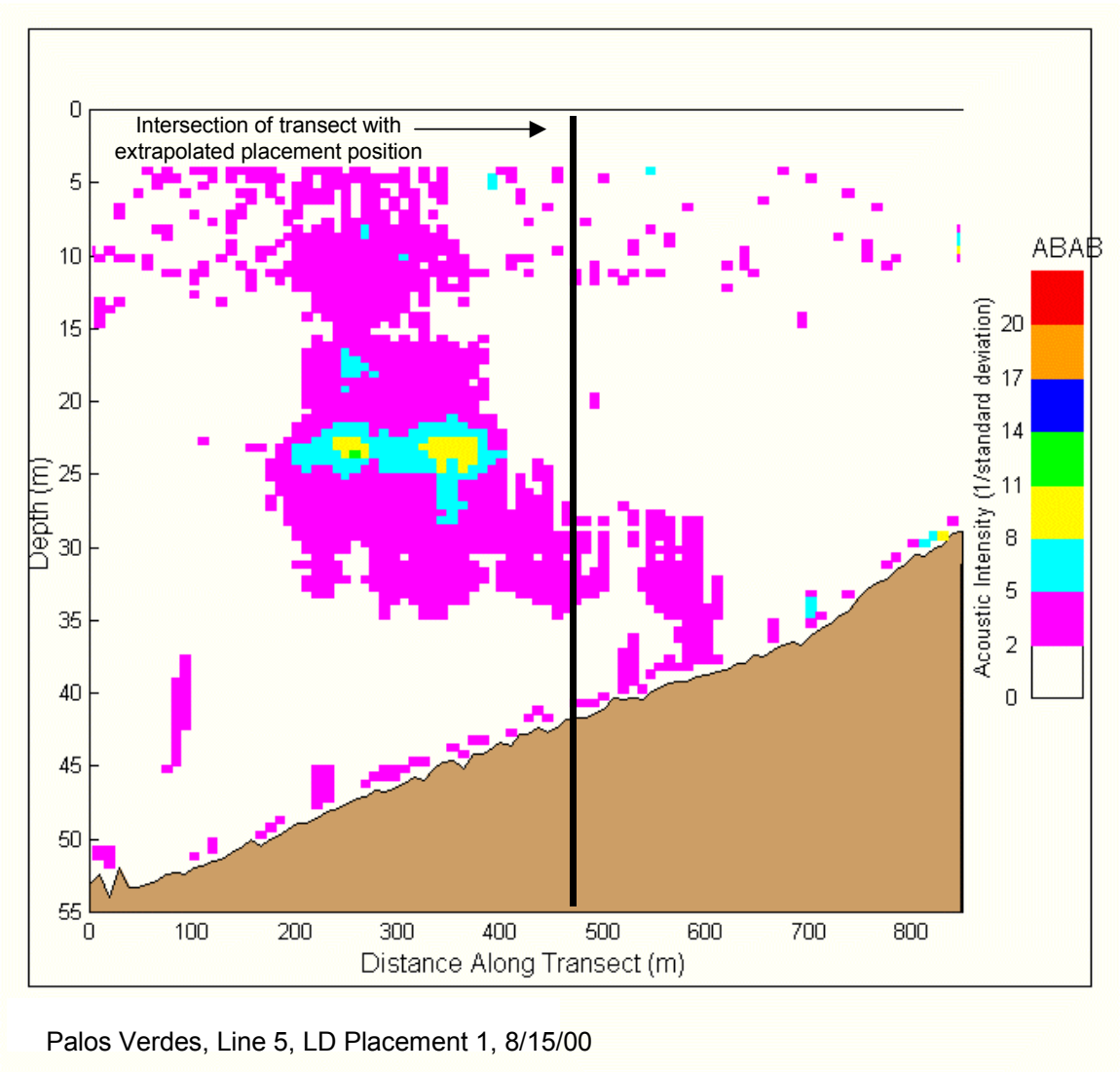

Figure 5.6-8. ABAB along Survey Line 5, run from southwest to northeast 34 min after the placement ended.

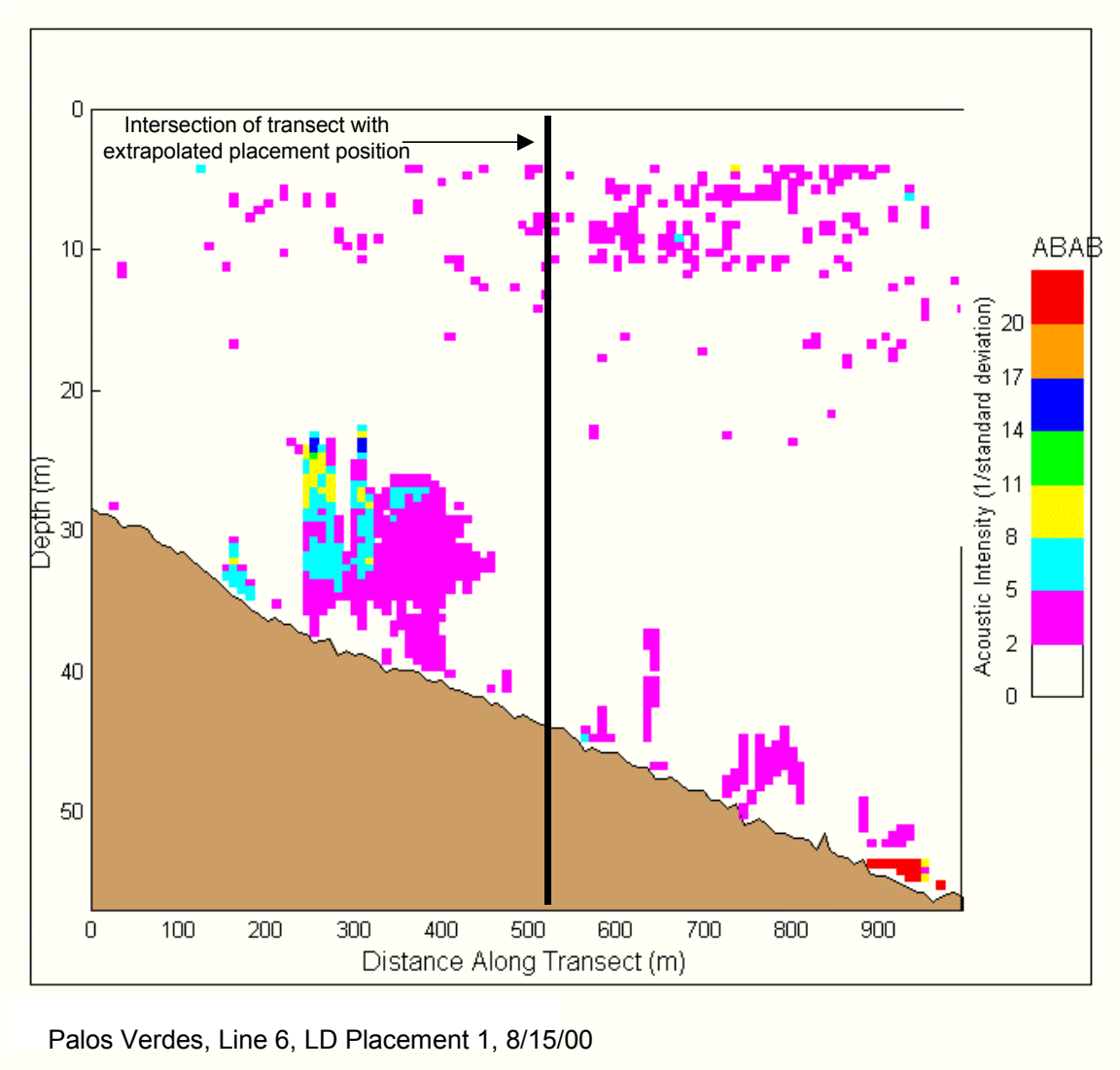

Figure 5.6-9. ABAB along Survey Line 6, run from northeast to southwest 47 min after the placement ended.

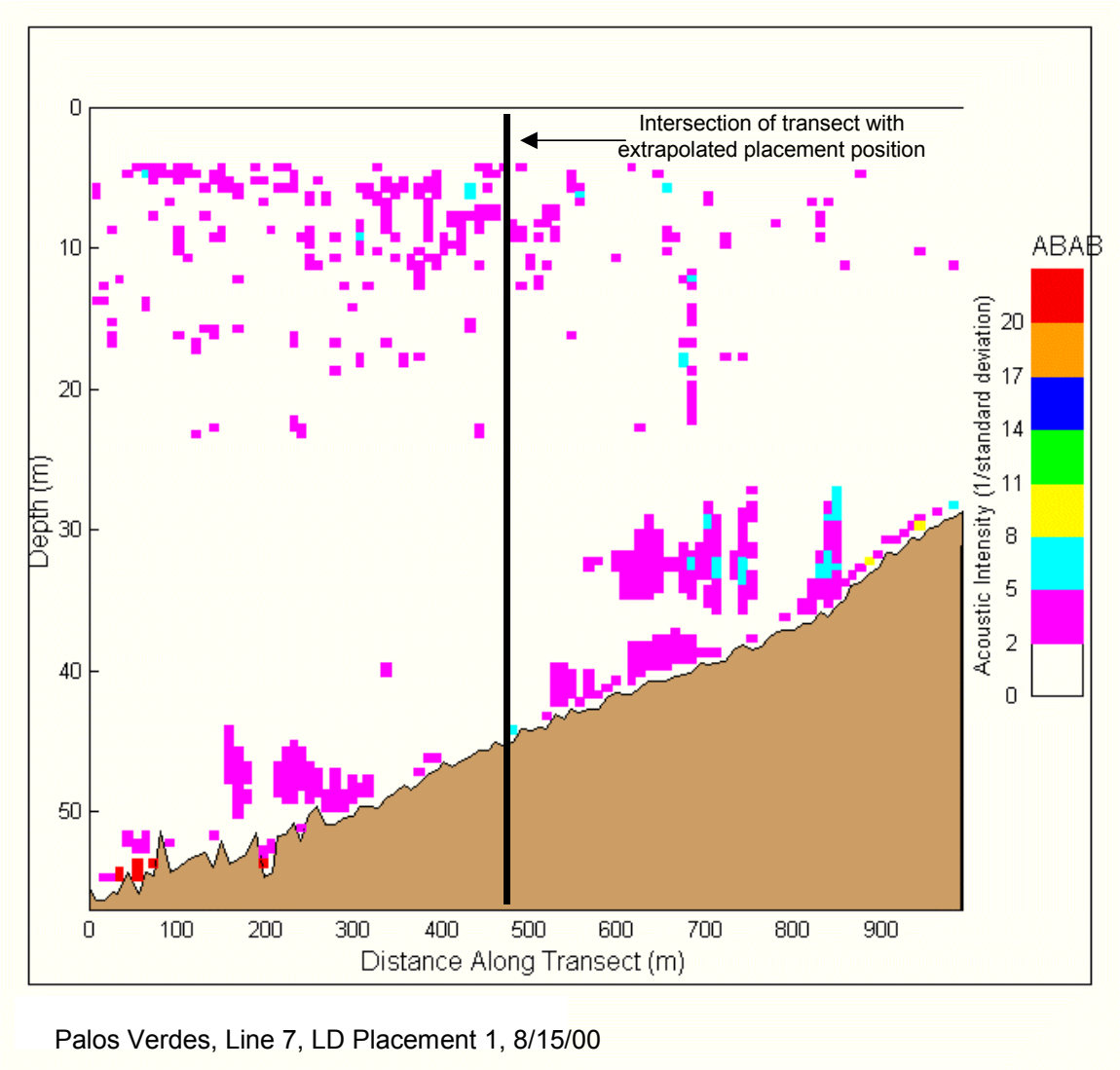

Figure 5.6-10. ABAB along Survey Line 7, run from southwest to northeast 57 min after the placement ended.

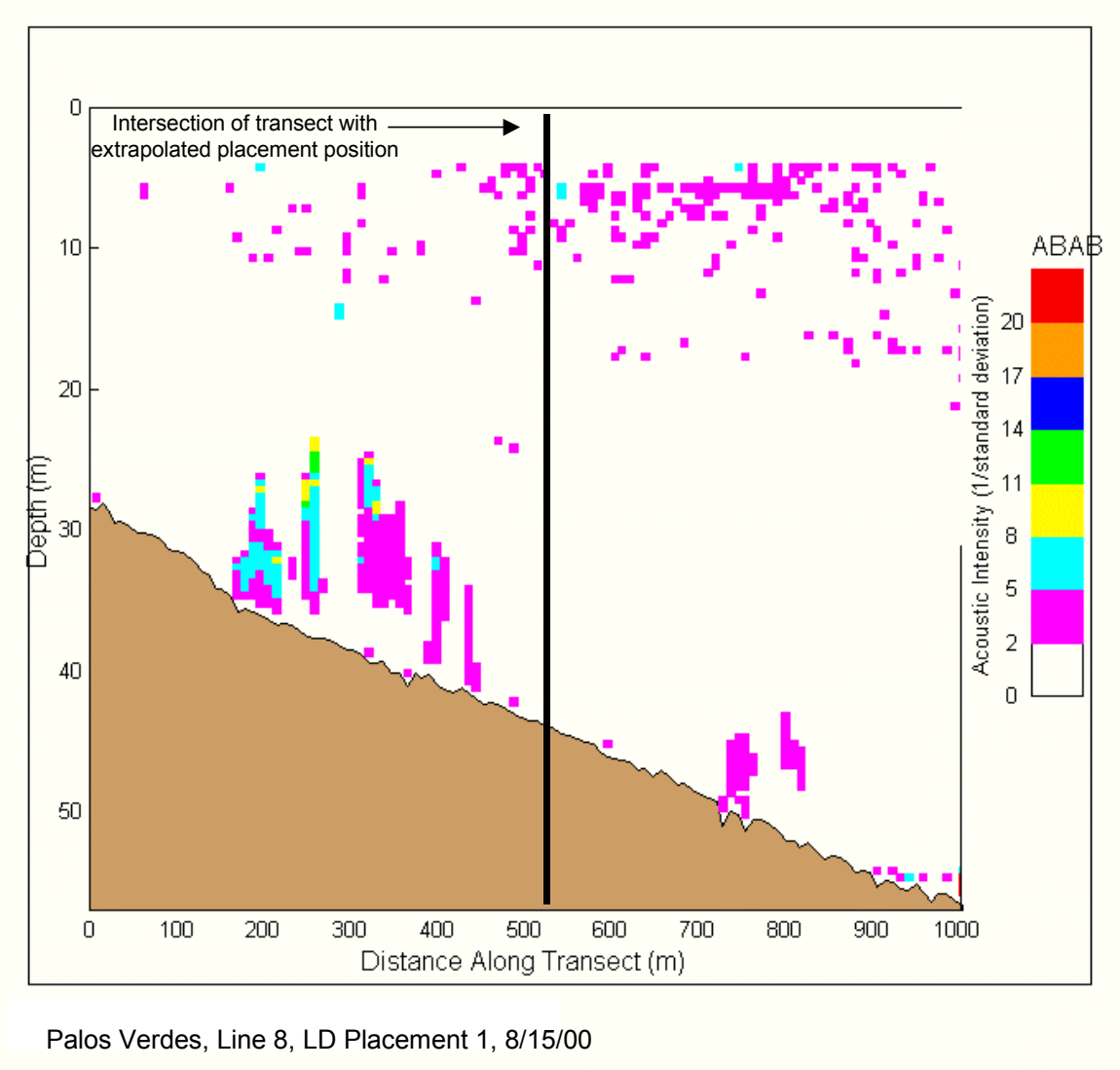

Figure 5.6-11. ABAB along Survey Line 8, run from southwest to northeast 1 hr and 7 min after the placement ended.

5.7 Sediment Profile Imagery Results

5.7.1 Overview of Field Sampling Plan

Field sampling activities for sediment profile camera (SPC) surveys in Cell LD 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 background (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 and Post 9), and a survey performed following pump-out placement of Queen's Gate material (Post 1 Pump Out). Images obtained with a plan view camera (PVC) were collected simultaneously with the sediment profile images at each station.

Two SPC surveys in Cell LD involved sampling at more stations than originally planned to provide better delineation of the cap material footprint. Table 5.7-1 provides a summary of SPC field sampling activities in Cell LD 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 Section 5.7.4 below.

Table 5.7-1. Summary of SPC Field Sampling Activities in Cell LD

Survey Name	Number of Survey Stations		Completeness
	Required	Sampled	
Background	25	25	100%
Post 1	37	44	119%
Post 9	37	44	119%
Post 1 Pump-Out (Flex Survey)	19	19	100%
Supplemental Survey	3	3	100%

5.7.2 Review of Data Quality Objectives

The DQOs identified in Section 3.7.2 are applicable to SPC monitoring in all pilot capping cells. As described in that section, all DQOs were met for SPC monitoring in each cell.

5.7.3 Technical Considerations

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

5.7.4 Monitoring Results

5.7.4.1 Baseline Survey

The SPC survey to evaluate background (i.e., pre-cap) seafloor conditions in and around Cell LD was conducted on August 14, 2000. Similar to baseline surveys in the other pilot cells, three replicate

sediment profile images were obtained at each of 25 stations both inside and outside the cell boundary (inside stations I-01 through I-15 and outside stations O-01 through O-10; Figure 5.7-1).

A complete set of image analysis results for the background SPC survey in Cell LD is provided in the DAN-LA database and summarized in Table 5.7-2. Surface sediments at all stations in and around Cell LD appeared to be fine-grained, consisting predominantly of silt-clay having a grain size major mode of >4 phi (Table 5.7-2). Similar to the other two pilot cells, 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 5.7-2). These results are confirmed by the grain size analysis of the core samples, which showed that the surface sediments in Cell LD consisted of roughly equal proportions of very fine sand and silt-clay (see Section 5.11).

Boundary roughness values ranged from 0.8 to 2.6 cm at the baseline stations; the overall mean of 1.5 cm was comparable to mean values for the other two pilot capping cells and is indicative of a moderate amount of small-scale surface relief across Cell LD (Table 5.7-2). Apparent RPD depths at Cell LD baseline stations ranged from 1.7 to 3.6 cm, with an overall average of 2.6 cm (Table 5.7-2). This value is also comparable to average values for the other two cells and is considered indicative of moderately deep sediment aeration.

Of the 75 total replicate sediment profile images obtained for the Cell LD baseline survey, 74 (99%) showed an infaunal successional stage of either Stage III or Stage I on Stage III (I on III), while 1 (1%) had an infaunal successional stage designation of Stage I only (Table 5.7-2). Many images from the Cell LD baseline survey had multiple feeding voids, burrows, and organisms visible at depth, suggesting a relatively high abundance of Stage III infauna (Figure 5.7-2). The apparent widespread distribution of both Stage I and Stage III taxa in and around Cell LD suggests an abundant and diverse benthic community. As in the other two cells, benthic production in Cell LD may be stimulated by the addition of organic matter discharged from the LACSD outfall.

Mean OSI values at Cell LD stations ranged from +6.7 to +10, with an overall average of +8.8 (Table 5.7-2). The mean OSI value at each station was greater than or equal to +6. These relatively high OSI values reflect the widespread presence of an abundant and diverse benthic community and moderately deep RPD depths of between 2 and 4 cm in and around this pilot capping cell.

5.7.4.2 Post 1 Survey

The Post 1 SPC survey in Cell LD was conducted on August 18 and 24, 2000, following the first cap material placement event (spreading placement of a single hopper load of sand from A-III Borrow Area). The survey involved sampling at all 25 primary baseline stations (stations I01 through I15 and O01 through O10), as well as at 19 additional stations located both inside and outside the cell boundaries (stations I20 and I21, O-11 to O-13, O-15 to O-19, O-21 and O-22, O43 to O49; Figure 5.7-3). Several outside stations were added northwest of the cell boundary because a preliminary review of SPC data suggested that cap material continued in this direction. Therefore, a total of 44 stations were sampled for the Post 1 survey in Cell LD. Each of the three replicate images obtained at each station was analyzed for: 1) cap material presence/absence, 2) cap thickness, and 3) estimated depth of disturbance of existing EA sediment. A complete set of the analysis results is presented in DAN-LA database.

Cap material was detected at 18 stations (Figure 5.7-4). The cap material deposit on the seafloor was elliptical, with the long axis in the northwest-southeast direction corresponding to the hopper dredge track line across the center of Cell LD (Figure 5.7-4). No cap material was detected at stations outside the cell boundary to the southeast, while cap material was present at stations up to 300 m northwest of the cell boundary.

Cap material from A-III Borrow Area was visible in the sediment profile images as a distinct, well-defined, surface layer of homogenous, golden fine sand (Figure 5.7-5). The golden color and homogenous texture of the sand were clearly distinguishable from the underlying, brown, fine-grained sediment. Average thickness of the cap layer, as depicted by contours in Figure 5.7-4, ranged from 3 cm along the centerline of the hopper dredge track to less than 1 cm near the outer edge of the deposit. Likewise, cap material thickness in individual replicate images ranged from patchy, "sprinkle" layers of less than 1 cm to continuous, distinct layers of 3 cm (e.g., Figure 5.7-5).

At the majority of stations, the maximum difference in the measured cap thickness among the three replicate images was 1 cm or less (Figure 5.7-6). The thickest cap layers (2 to 3 cm) were found at station I10 on the southeast side of the cell (roughly 150 m from the beginning of the spreading placement track line) and station O09, located 50 m outside the cell boundary to the northwest (at the very end of the spreading placement track line; Figure 5.7-4). The estimated depth of disturbance of EA sediment also was greatest at these two stations (greater than about 2 cm; Figure 5.7-7). At other stations where a depositional layer of cap material was noted, the estimated depth of EA sediment disturbance generally was less than about 2 cm (Figure 5.7-7). At stations outside the cap material footprint, no disturbance of EA sediment was apparent (i.e., the RPD layer remained intact; Figure 5.7-7).

5.7.4.3 Post 9 Survey

The Post 9 survey was conducted on August 3, 2000, following spreading placement of a cumulative total of 9 hopper loads of cap material from A-III Borrow Area in Cell LD. During each placement event, the hopper dredge moved from southeast to northwest across the center of the cell, always following roughly the same track line. Sediment profile images were obtained at the same 44 stations that had been sampled in the Post 1 survey (Figure 5.7-3).

A layer of cap material was observed in images at all stations inside the cell boundary and at a few stations immediately outside the cell boundary (Figure 5.7-8). Average thickness of the cap layer ranged from >11.5 cm along the hopper dredge track line to less than 1 cm at a distance of 200 to 300 m on either side of the track line (Figure 5.7-8). The average thickness of the cap layer decreased uniformly with increasing distance on either side of the center track line (i.e., moving either upslope or downslope).

The thickest cap layer observed in the survey (>12 cm) was recorded for one of the replicate images at station I21. Cap layer thickness exceeded the camera penetration depth in all three replicate images at stations I11 and I21 and in one of three replicate images at stations I06, I09 and I10 (Figures 5.7-8 and 5.7-9a). In all other replicate images where cap material was present, it occurred in a discrete, measurable layer (Figure 5.7-9b). At the majority of these stations, the maximum difference in the measured cap thickness among the three replicate images was 1 cm or less (Figure 5.7-10). The estimated depth of EA sediment disturbance ranged from 0 to > 2.5 cm at stations within the cap material footprint (Figure 5.7-11). At the majority of stations, the estimated depth of EA sediment disturbance was minimal (less than about 2 cm).

5.7.4.4 Post 1 Pump Out Survey

The Post 1 Pump Out SPC survey in Cell LD occurred on September 9, 2000, following the pump-out placement of a single hopper load of Queen's Gate cap material over both Cell LC and LD. Three replicate sediment profile images were obtained at each of 19 stations inside and outside the cell boundary (Figure 5.7-12).

Cap material was pumped out at a steady rate as the dredge traveled slowly from southeast to northwest across Cells LC and LD. Cap material subsequently was visible in sediment profile images at 15 of the 19 stations, all located inside the cell boundary (Figure 5.7-13). With the exception of a single replicate image at station I21, cap material was visible in all replicate images at each station as a very thin, discontinuous "sprinkle" layer. The gray, sandy material from Queen's Gate was detected easily in the images because the color contrasted with that of underlying clean, golden sand (i.e., A-III Borrow Area cap material) that had been placed in Cell LD (Figure 5.7-14). The thickness of the patchy, sprinkle layer was estimated to be less than 1 cm (Figures 5.7-13 and 5.7-14).

5.7.4.5 Supplemental Survey

The Supplemental SPC survey was conducted on February 24, 2001, five months following the last cap placement event in Cell LD. Sediment profile images were obtained at 3 stations located along the track line of the hopper dredge; each station had been sampled in the August 2000 Post-9 survey (Figure 5.7-15). A layer of cap material (golden sand from A-III Borrow Area) was observed at each station in the Post-9 survey, and a cap material layer similarly was observed at each station in the supplemental survey. The average thickness of the cap material layer in the supplemental survey was similar to that measured five months earlier in the Post-9 survey (Figure 5.7-16). The average cap material thickness in the supplemental survey ranged from 5.3 to >8.7 cm at the three stations (Figure 5.7-16).

Similar to Cells LU and SU, a surface depositional layer of fine-grained sediment was visible on top of the cap material layer at each of the three stations (Figure 5.7-17). This surface layer was of relatively recent origin, having been deposited since the August 2000 Post-9 survey. The average thickness of this new surface depositional layer ranged from 4 to 6 cm at the three stations (Figure 5.7-18). The origin of this layer is unknown, but it may be due to natural deposition of resuspended sediment and organic matter on the PV Shelf.

Table 5.7-2. Summary of Image Analysis Results for the Background SPC Survey in Cell LD. Values for RPD depth, boundary roughness and Organism-Sediment Index are averages for 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						
LDBI01	>4	11.5	2.6	2.0	I on III (3)	8.3
LDBI02	>4	11.3	1.3	2.8	III (1), I on III (2)	9.3
LDBI03	>4	9.9	1.8	2.9	III (1), I on III (2)	9.7
LDBI04	>4	11.6	1.6	2.6	I on III (3)	9.0
LDBI05	>4	11.8	0.8	3.1	III (2), I on III (1)	9.7
LDBI06	>4	10.7	2.0	2.1	I on III (3)	8.3
LDBI07	>4	12.3	1.3	2.2	I on III (3)	8.7
LDBI08	>4	12.0	2.2	2.8	I on III (3)	9.0
LDBI09	>4	11.8	1.3	2.0	I on III (3)	8.0
LDBI10	>4	11.3	2.0	2.5	III (1), I on III (2)	8.7
LDBI11	>4	12.3	1.4	2.3	III (1), I on III (2)	8.3
LDBI12	>4	11.3	1.1	2.8	I on III (3)	9.0
LDBI13	>4	10.0	1.6	1.7	III (2), I on III (1)	7.7
LDBI14	>4	11.4	1.0	2.2	III (1), I on III (2)	8.7
LDBI15	>4	11.4	1.2	1.8	I on III (3)	8.0
OUTSIDE STATIONS						
LDBO01	>4	12.5	0.9	3.5	III (1), I on III (2)	10.0
LDBO02	>4	12.6	1.3	3.2	I on III (3)	9.7
LDBO03	>4	12.5	1.5	3.6	III (1), I on III (2)	10.0
LDBO04	>4	12.8	1.2	2.0	I (1), I on III (2)	6.7
LDBO05	>4	13.1	2.2	2.6	I on III (3)	9.3
LDBO06	>4	11.7	1.3	2.5	I on III (3)	8.7
LDBO07	>4	10.7	2.2	2.6	III (1), I on III (2)	9.0
LDBO08	>4	12.0	1.6	2.5	I on III (3)	9.0
LDBO09	>4	11.2	1.1	2.3	III (1), I on III (2)	8.3
LDBO10	>4	11.2	1.0	3.1	III (1), I on III (2)	9.3
MIN	>4	9.9	0.8	1.7	ST I	6.7
MAX	>4	13.1	2.6	3.6	ST I on III	10.0
MEAN		11.6	1.5	2.6		8.8

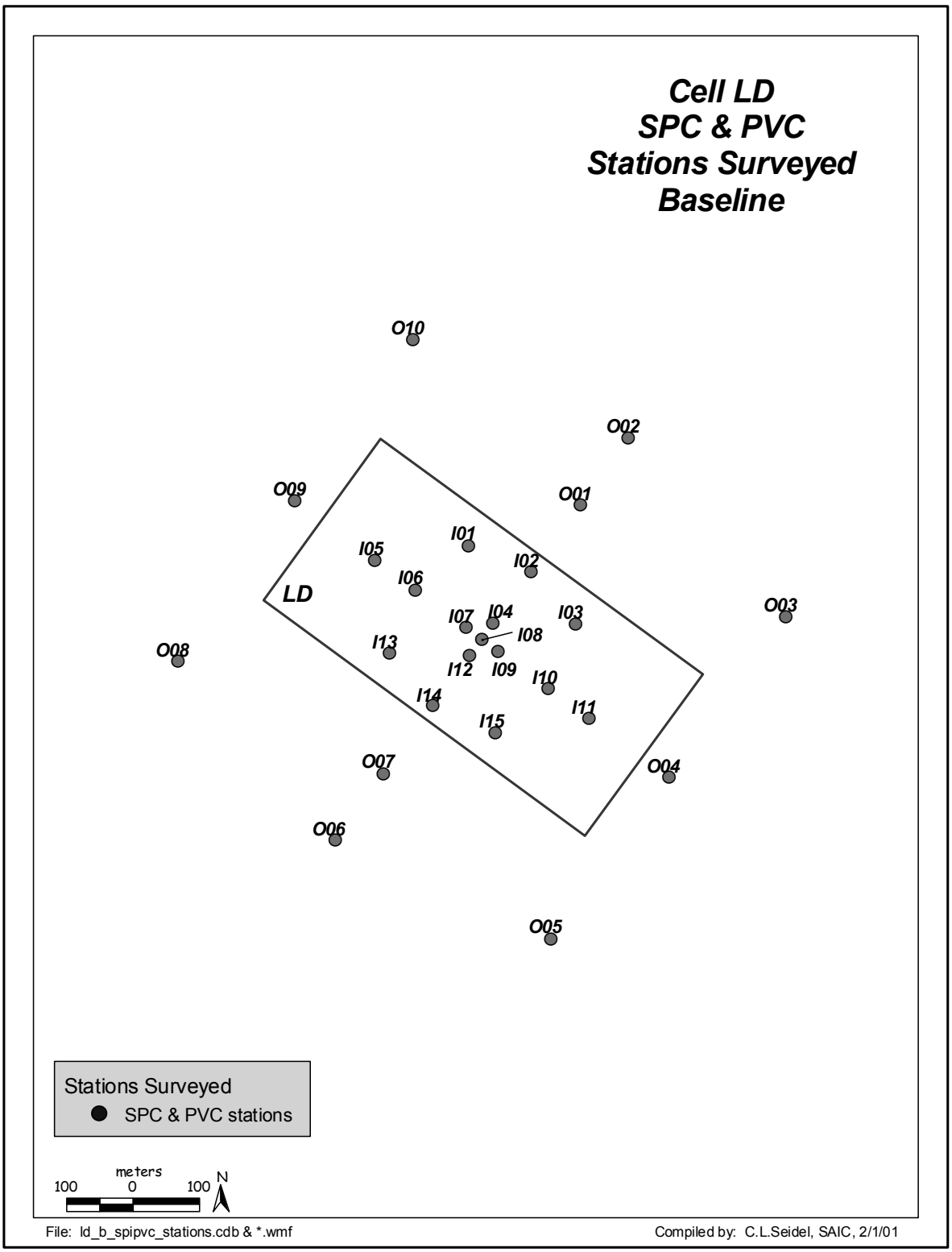

Figure 5.7-1. Station locations for the baseline SPC survey in Cell LD.

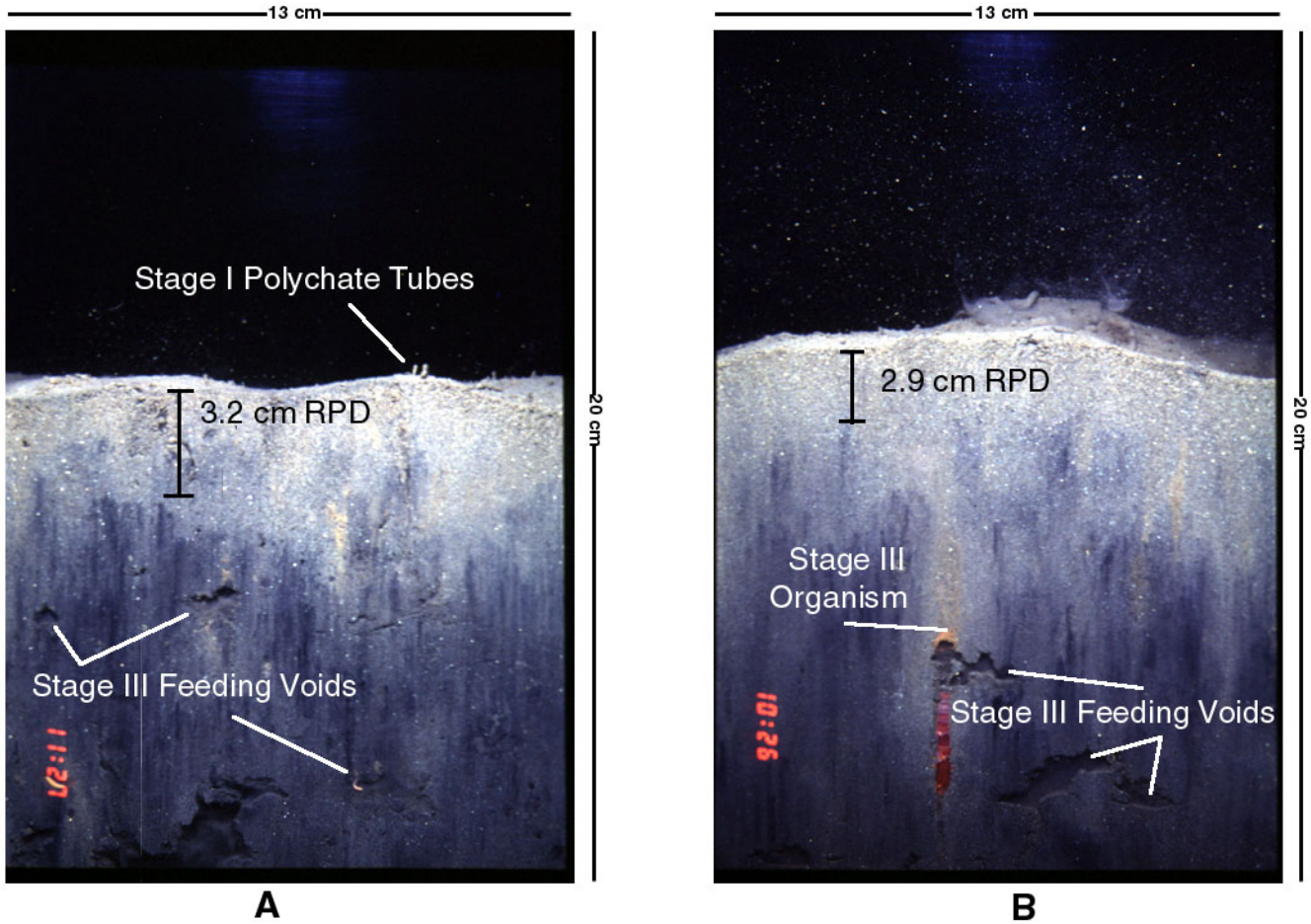

Figure 5.7-2. Sediment-profile images from Stations I05 (Image A) and I11 (Image B) illustrating typical background seafloor conditions in and around Cell LD. The sediment in both images is predominantly fine-grained (silt-clay), and its texture appears slightly coarser near the sediment surface due to an increased proportion of fine sand. Image A shows an RPD depth of 3.2 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 2.9 cm; Stage III feeding voids and a larger-bodied Stage III organism are visible at depth in this image.

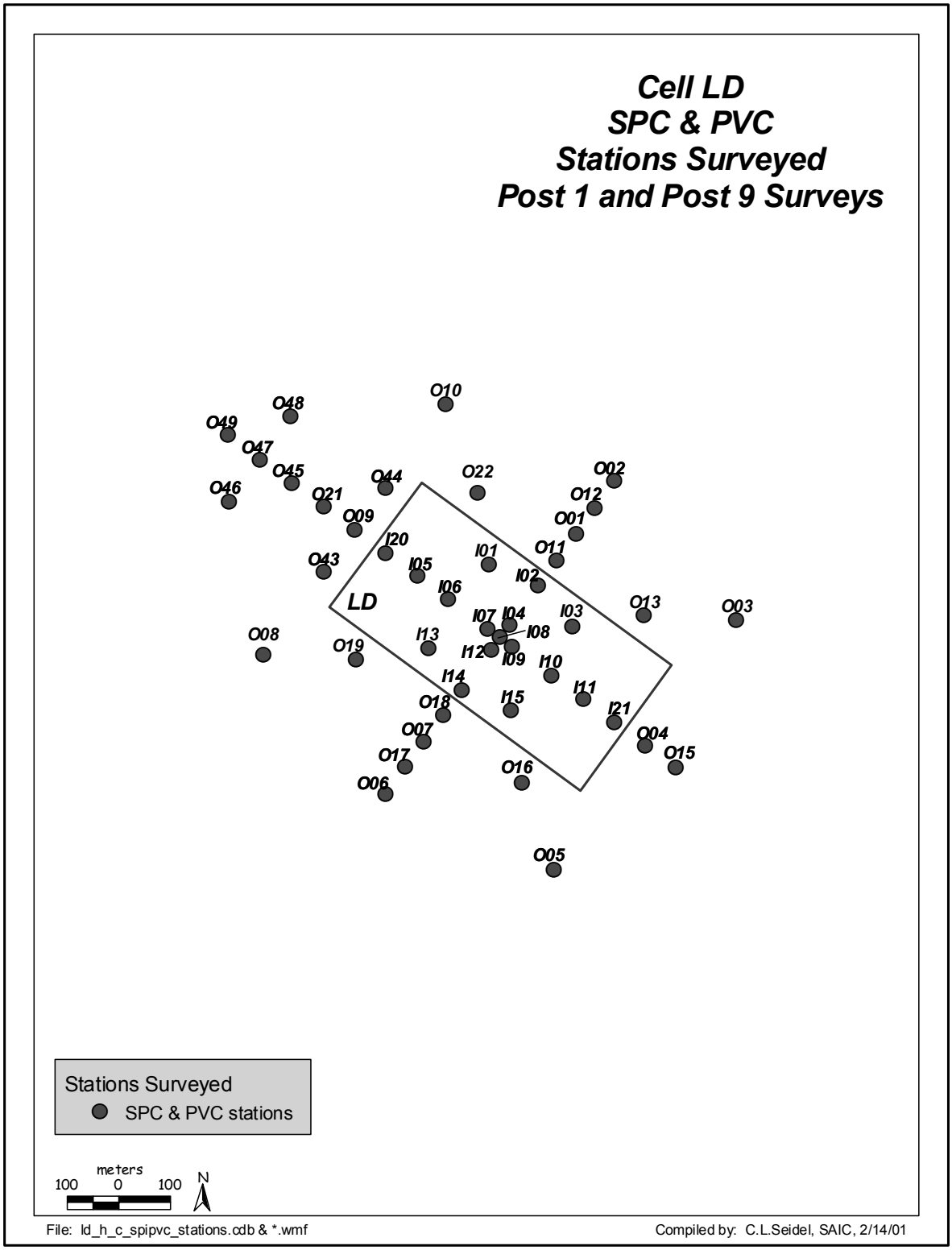

Figure 5.7-3. Station locations for the Post 1 and Post 9 SPC surveys in Cell LD.

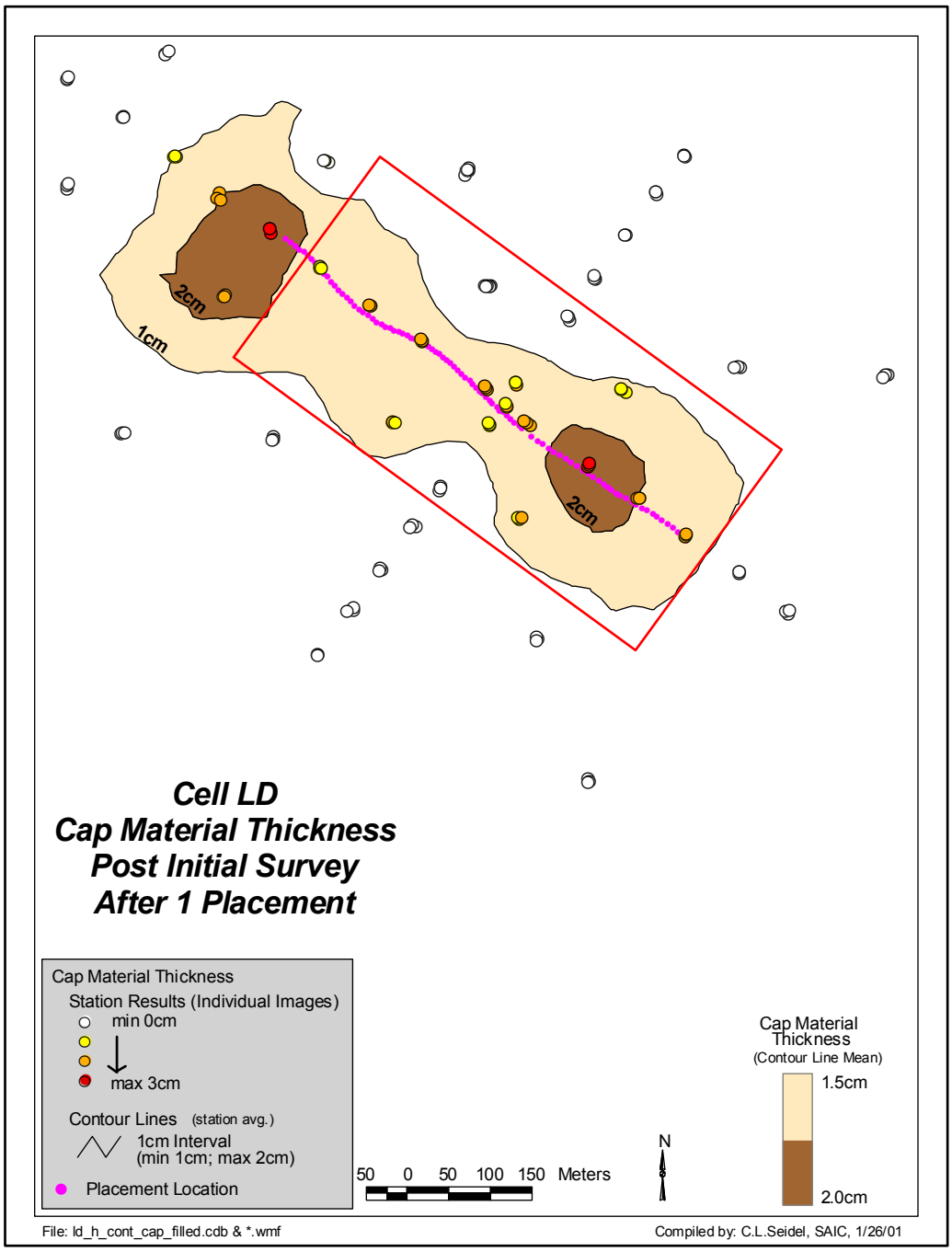

Figure 5.7-4. Track line of the hopper dredge during the first spreading placement event in Cell LD, and thickness of the resultant cap deposit on the seafloor as detected in the Post 1 SPC survey. Contour lines are based on the average measured thickness of the cap material layer at each station (mean of n = 3 replicate sediment profile images), while each plotted circle depicts the cap material thickness measurement for an individual replicate image.

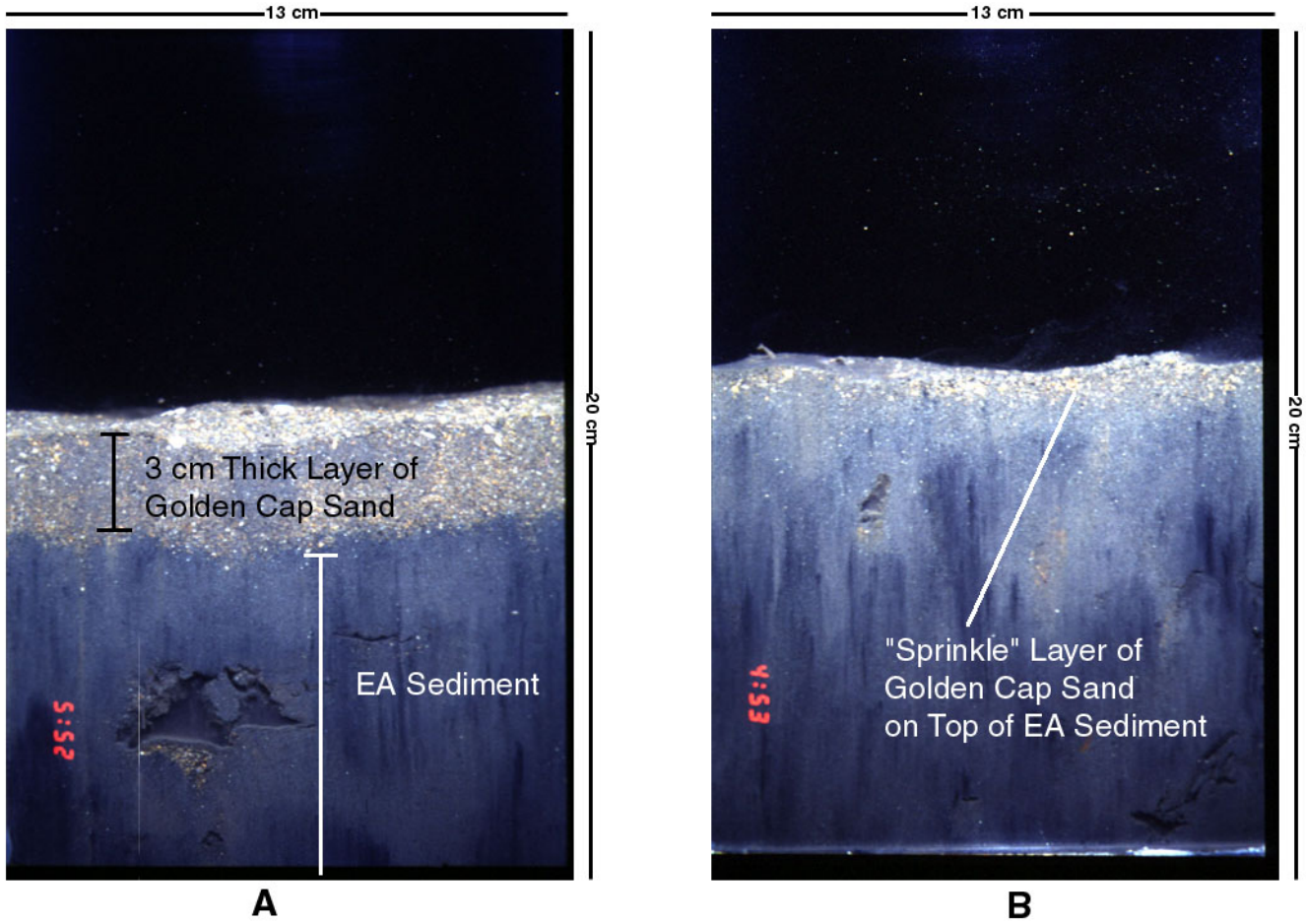

Figure 5.7-5. Sediment profile images from the Post-1 survey in Cell LD illustrating variations in the thickness of the cap material layer. Image A from station O09 shows a continuous, 3-cm thick depositional layer of the homogenous, golden fine sand cap sand from A-III Borrow Area overlying the fine-grained EA sediment at depth. Image B from station I08 provides an example of a thin and patchy "sprinkle" layer of cap material deposited at the surface of the EA sediment. The measured thickness of such sprinkle layers was generally less than 1 cm.

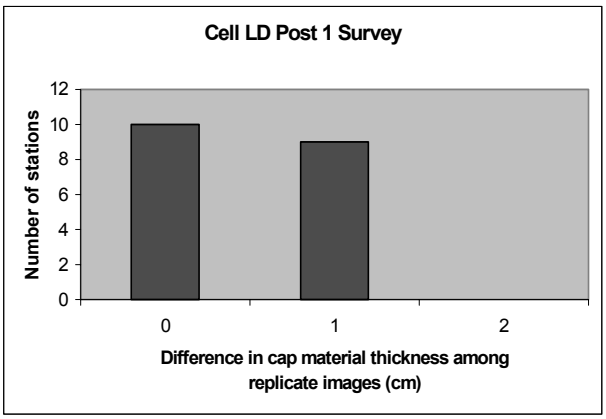

Figure 5.7-6. Frequency distribution of stations with a given maximum difference in cap material thickness among three replicate images.

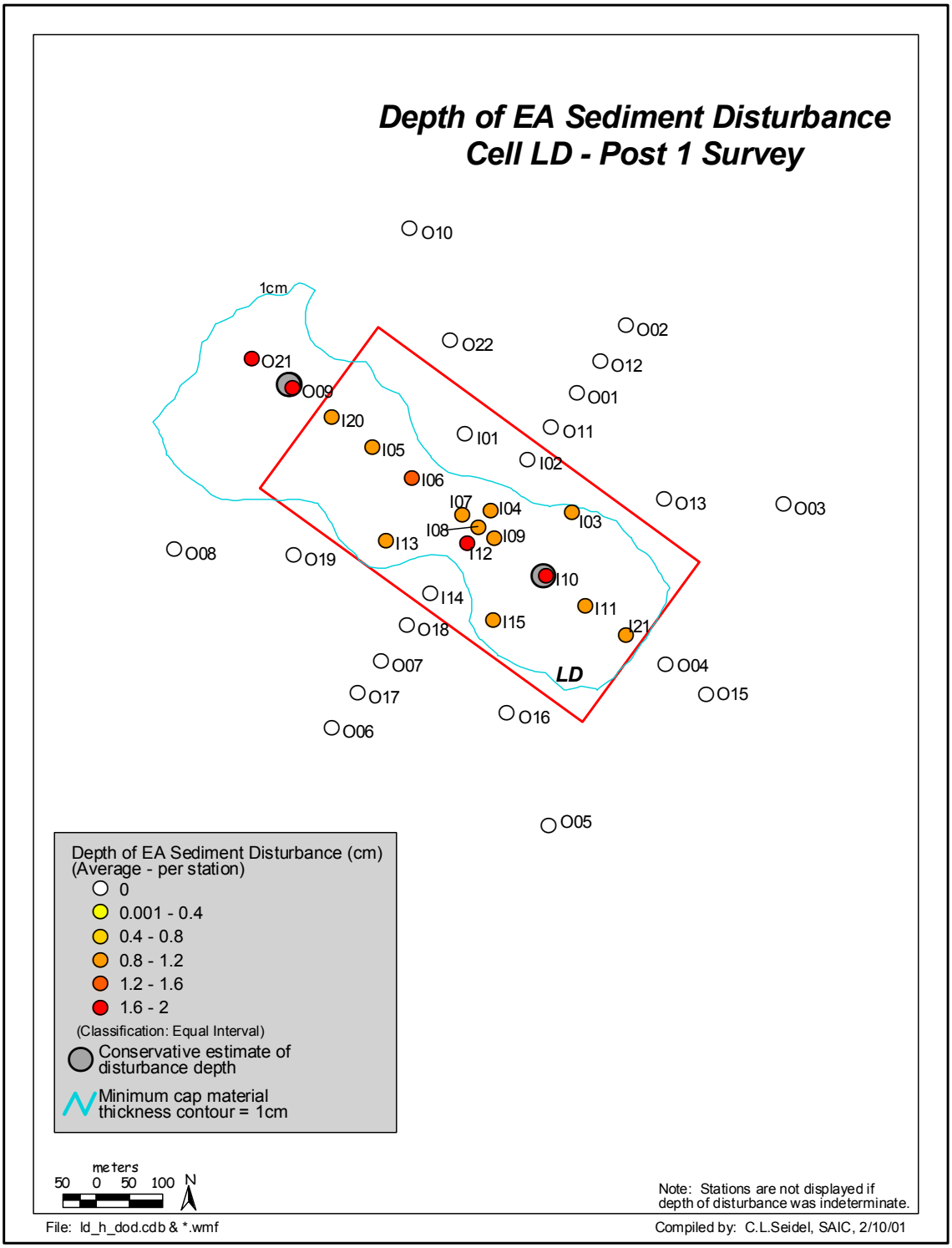

Figure 5.7-7. Estimated depth of disturbance of EA sediment for the Post 1 SPC survey in Cell LD.

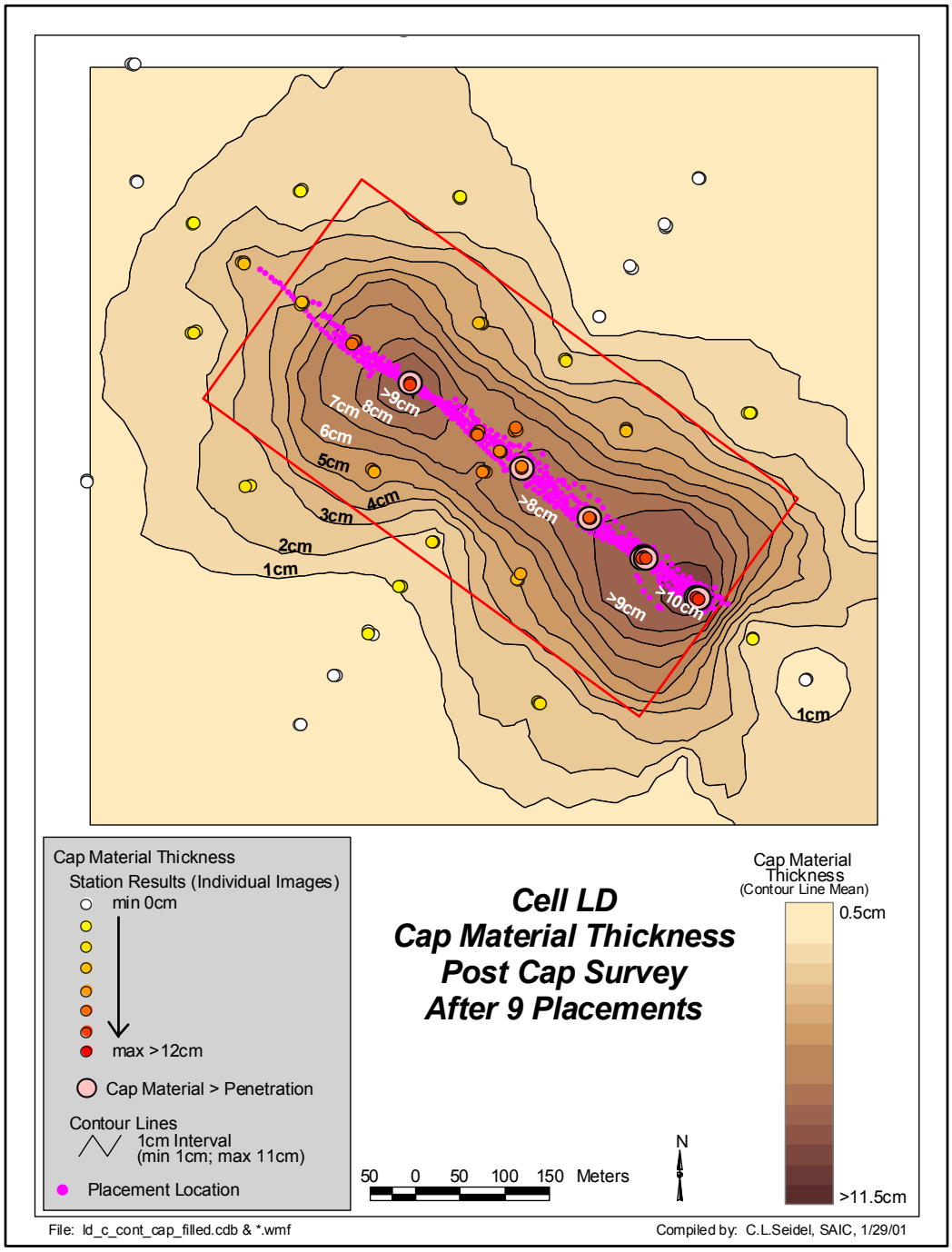

Figure 5.7-8. Placement locations and thickness of cap material on the seafloor in Cell LD for the Post 9 SPC survey. Contour lines are based on average measured thickness of the cap layer at each station (mean of n = 3 replicate sediment profile images), while each plotted circle depicts the cap material thickness measurement for an individual replicate image. Note that cap layer thickness exceeded the penetration depth of the sediment profile camera in a number of images along the hopper dredge track line (cap material > penetration).

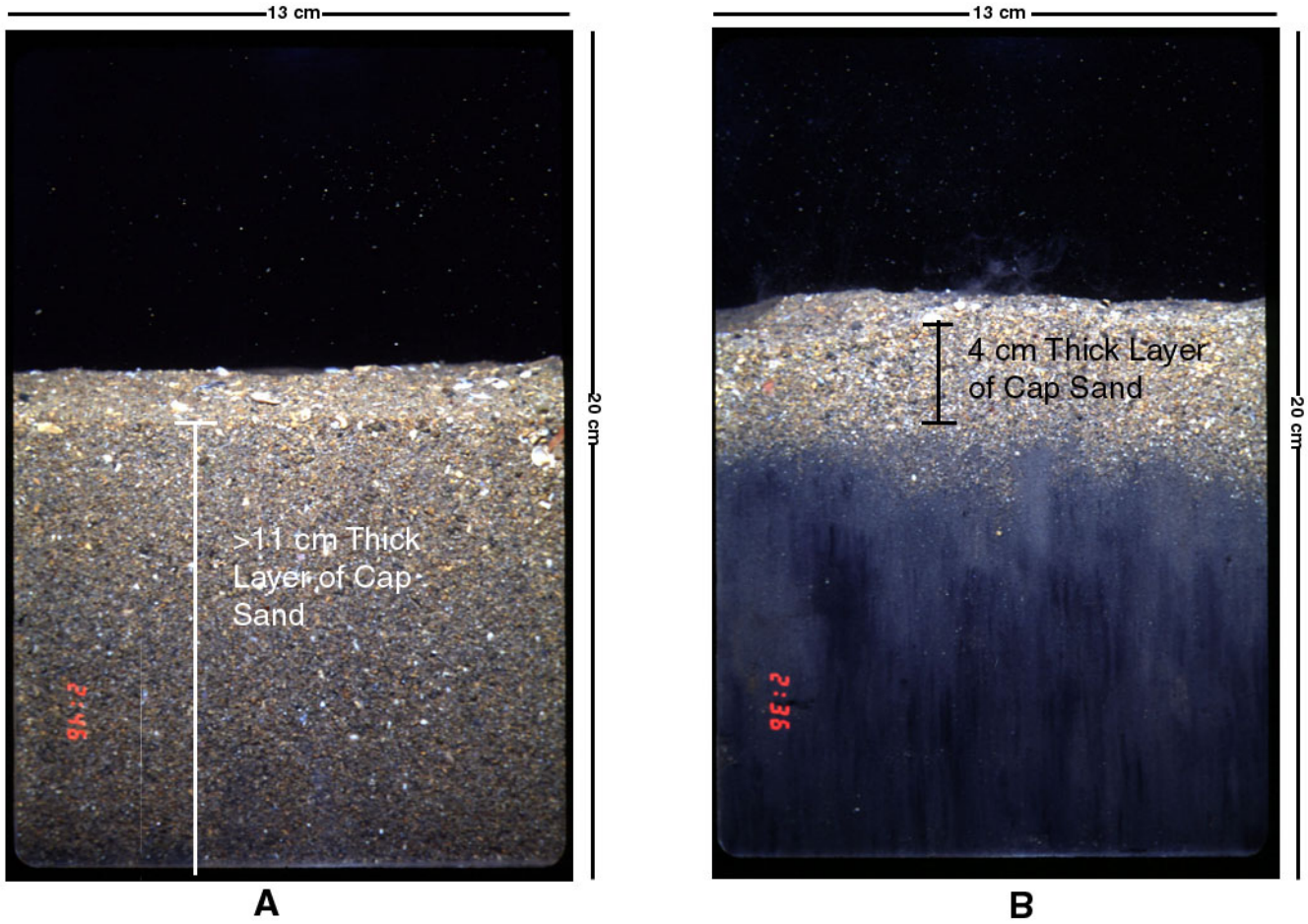

Figure 5.7-9. Representative sediment profile images from the Post-9 survey in Cell LD. Image A from station I06 shows the cap material from A-III Borrow Area (homogenous, golden sand) extending from the sediment surface to below the imaging depth (cap material thickness greater than the penetration depth of 11 cm). Image B from station I20 shows a discrete layer of the golden cap sand measuring 4 cm thick.

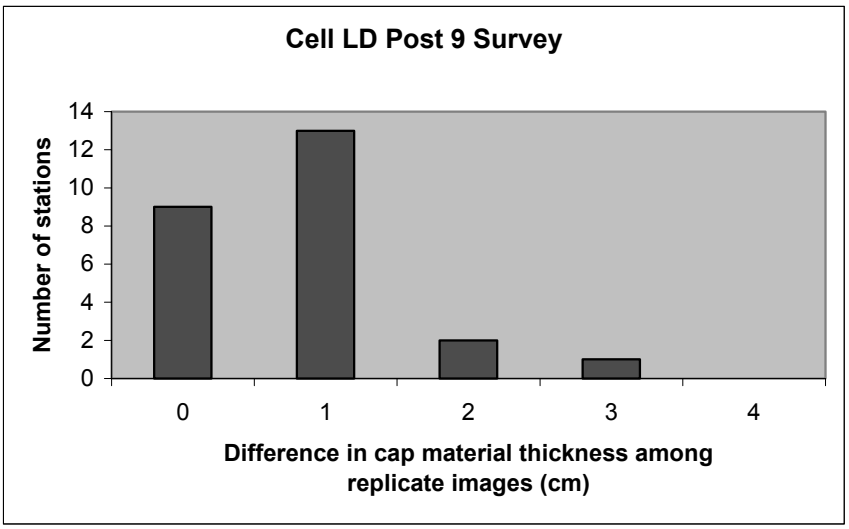

Figure 5.7-10. Frequency distribution of stations with a given maximum difference in cap material thickness among three replicate images.

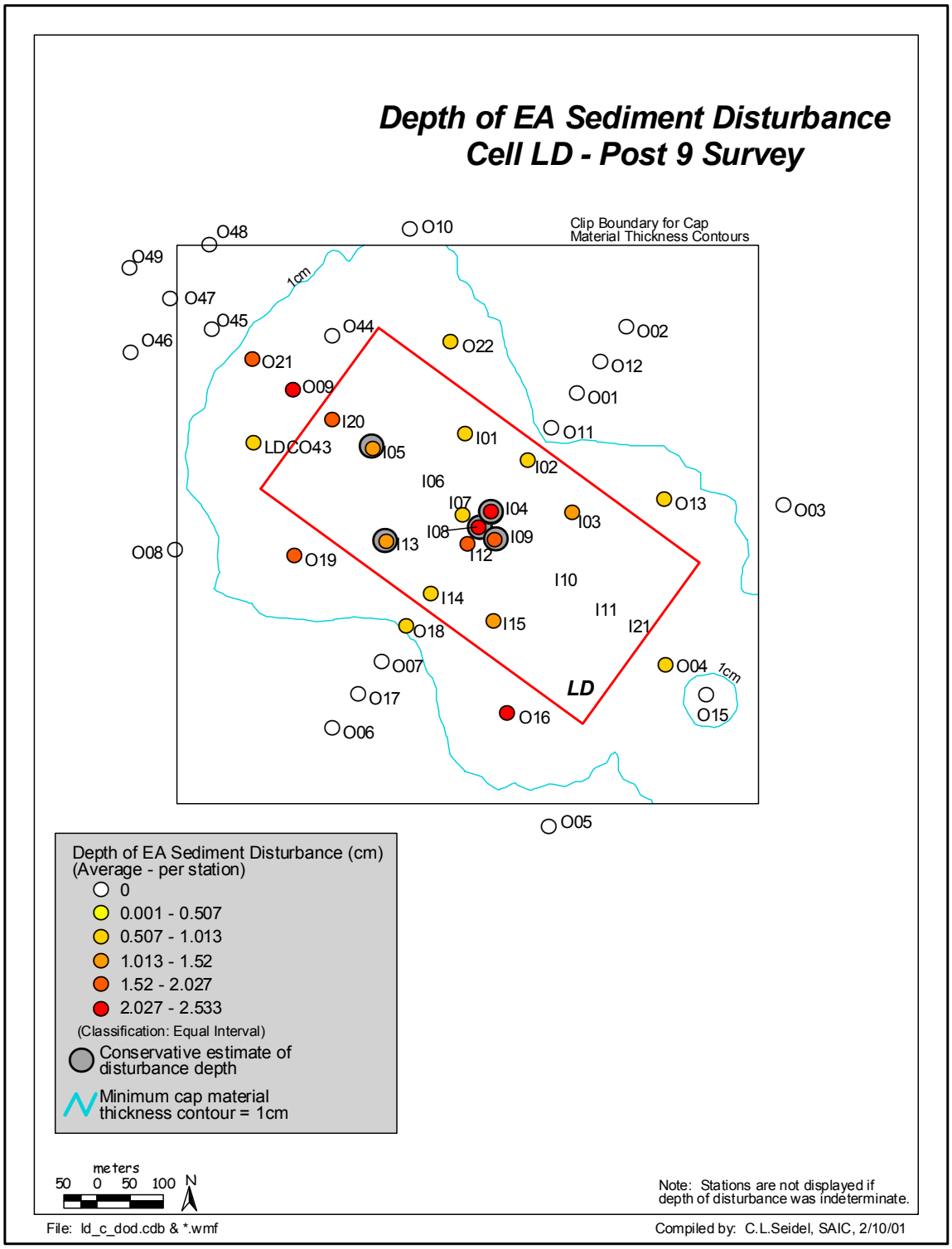

Figure 5.7-11. Estimated depth of disturbance of EA sediment for the Post 9 SPC survey in Cell LD.

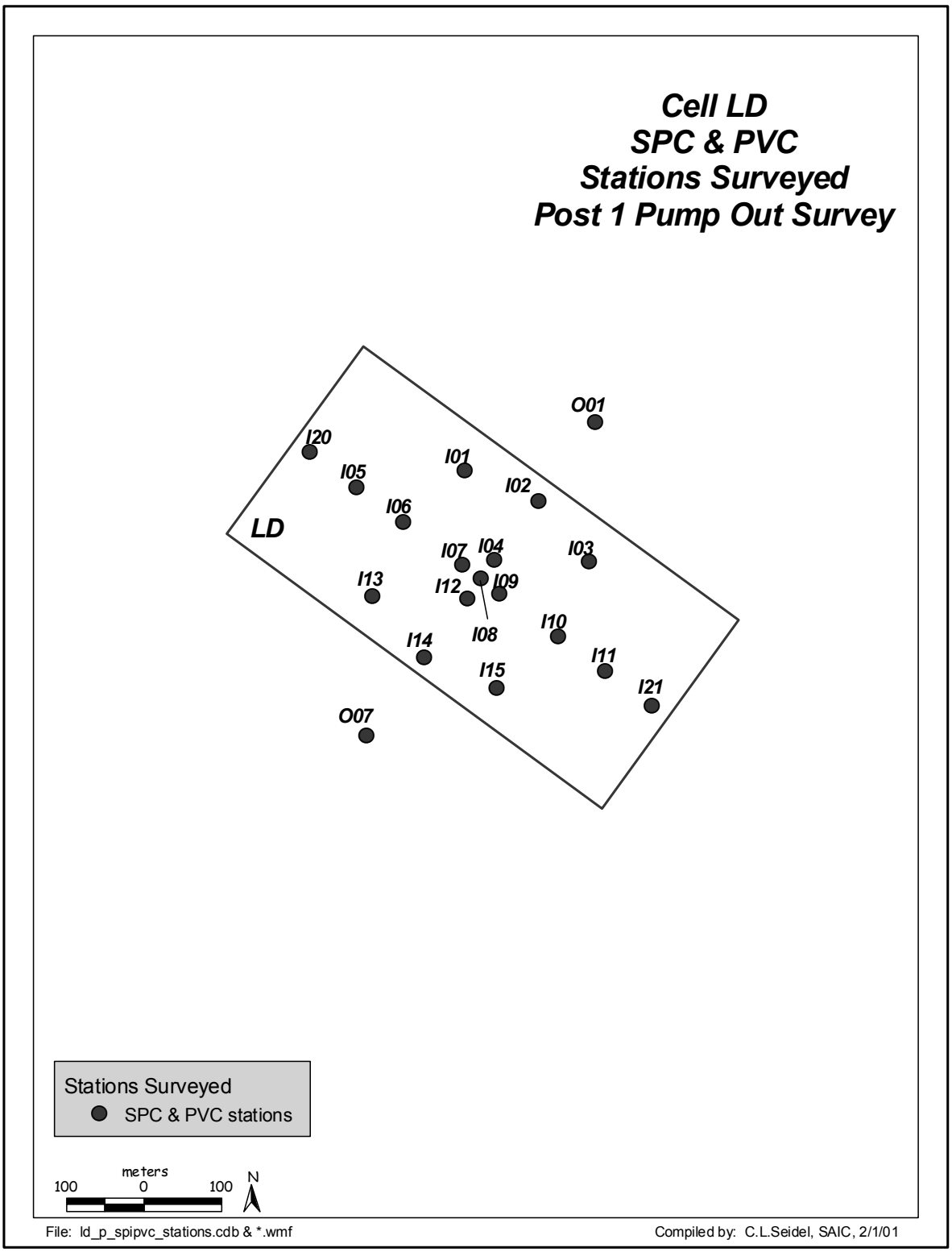

Figure 5.7-12. Station locations for the Post 1 Pump Out SPC survey in Cell LD.

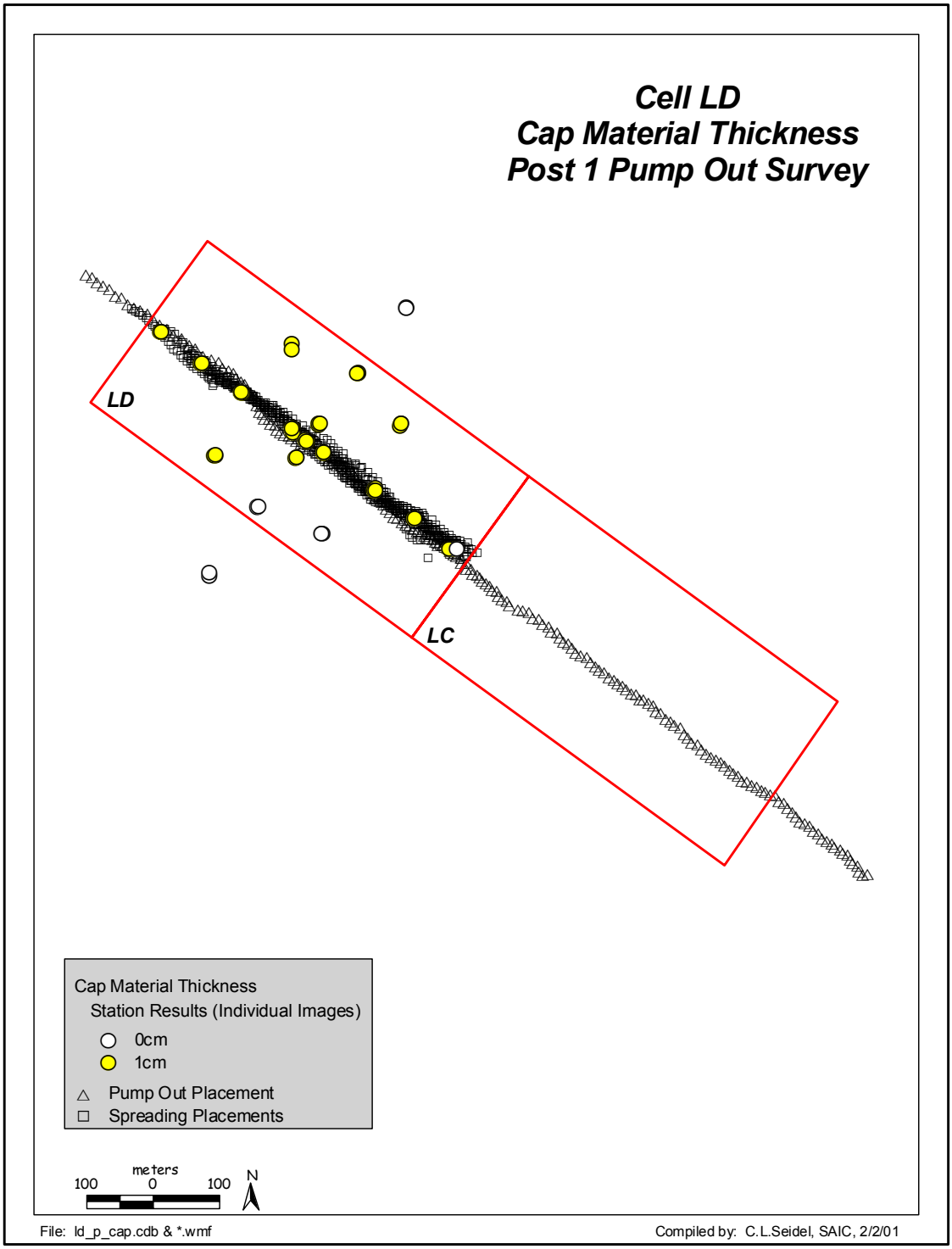

Figure 5.7-13. Track line of the hopper dredge during pump-out placement in Cell LD, and thickness of the resultant cap layer in replicate images obtained at each station.

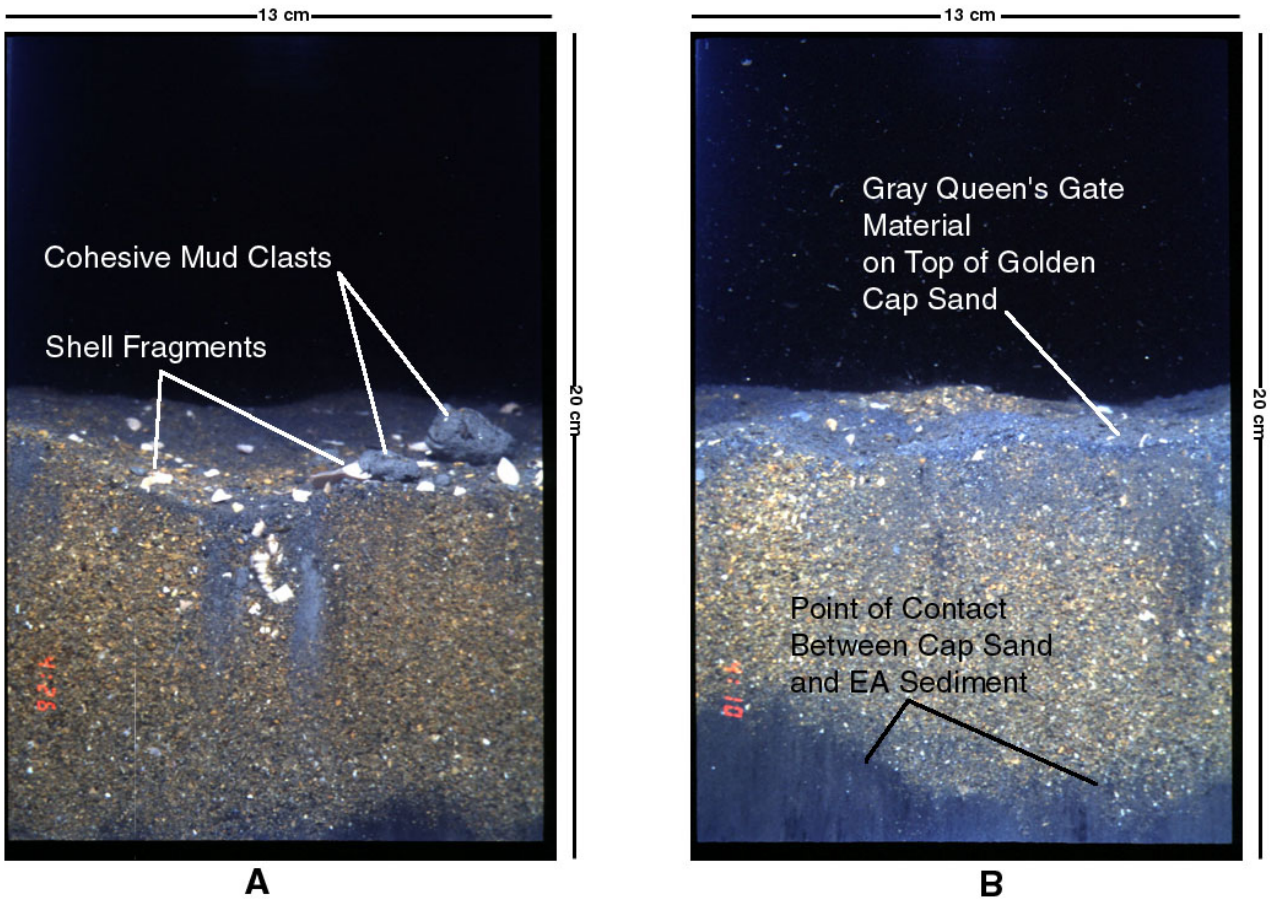

Figure 5.7-14. Two representative sediment profile images from the post pump-out survey in Cell LD. Image A from station I06 shows a very thin and patchy "sprinkle" layer of gray-colored Queen's Gate cap material on top of the golden cap sand from A-III Borrow Area. Note that the gray Queen's Gate material includes numerous shell fragments and cohesive mud clasts in this image. Image B from station I09 likewise shows a thin and patchy depositional layer of gray Queen's Gate material at the surface of the golden cap sand. The point of contact between the layer of golden cap sand and the underlying EA sediment also is visible in this image. In both images, the thickness of the surface depositional layer of gray Queen's Gate cap material was estimated to be less than 1 cm.

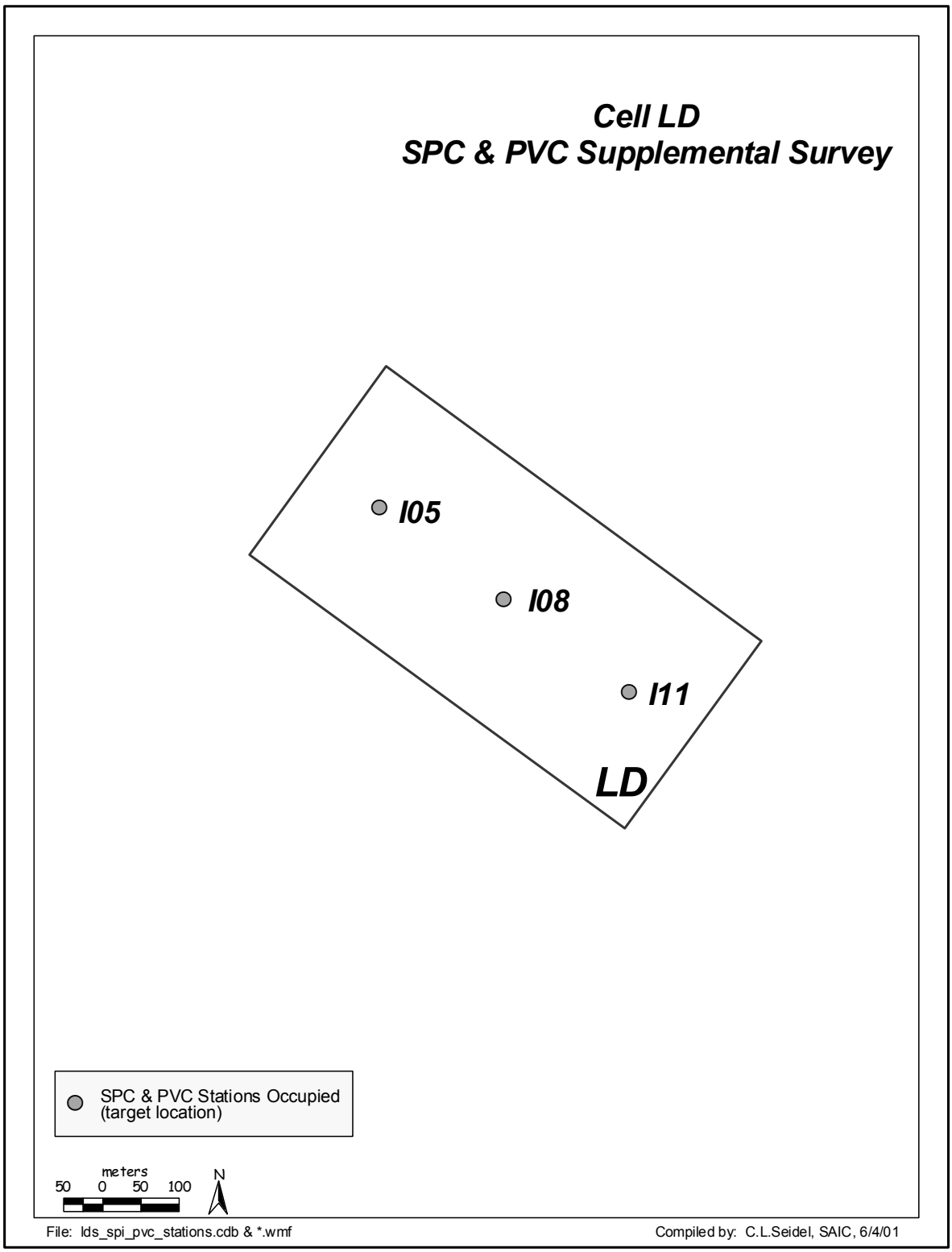

Figure 5.7-15. Station locations for the February 2001 Supplemental SPC survey in Cell LD.

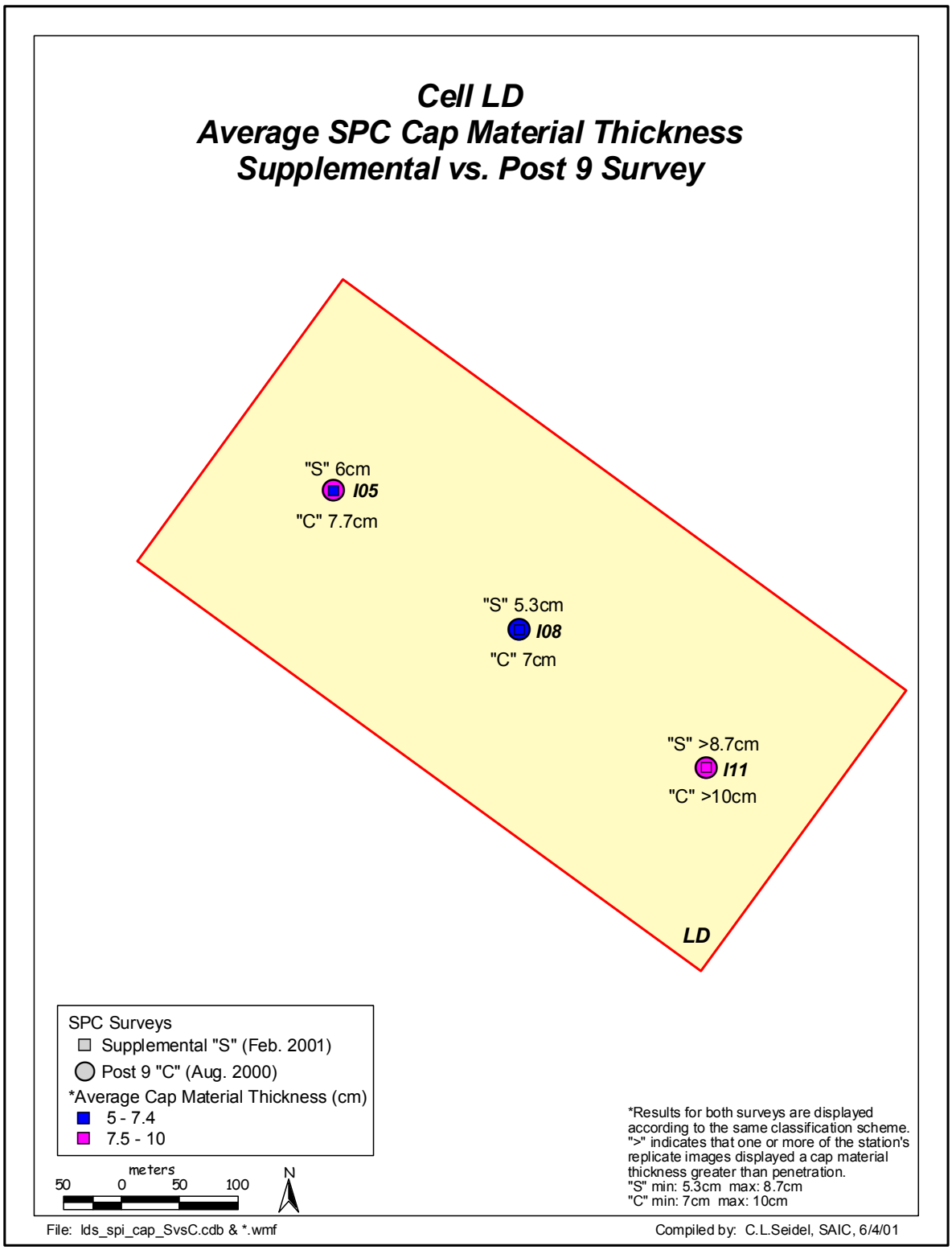

Figure 5.7-16. Average thickness of the cap material layer observed at each station in the August 2000 Post-9 survey and the February 2001 supplemental survey.

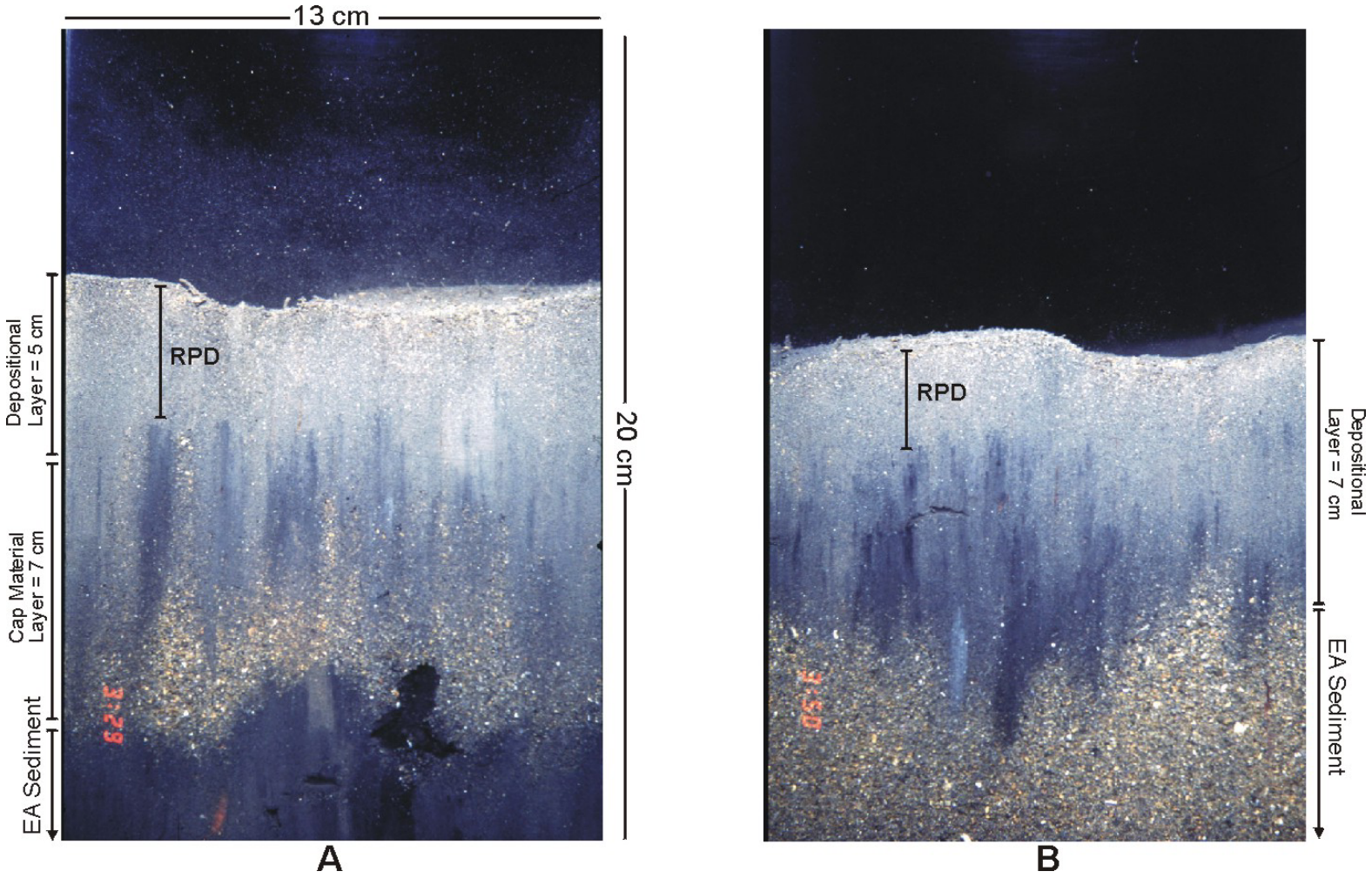

Figure 5.7-17. Sediment profile images obtained in the supplemental survey at Cell LD stations I05 (image A) and I11 (image B). Image A shows a 5-cm surface depositional layer of fine-grained sediment overlying a 7-cm layer of golden sand (cap material from A-III Borrow Area). The golden sand cap material layer in turn overlies EA sediment at depth. In image B, a 7-cm surface depositional layer of fine-grained sediment overlies a cap material layer (golden sand) that extends below the imaging depth of the sediment profile camera (>6 cm thickness). In both images, the new surface depositional layer of fine-grained sediment is beginning to develop an RPD.

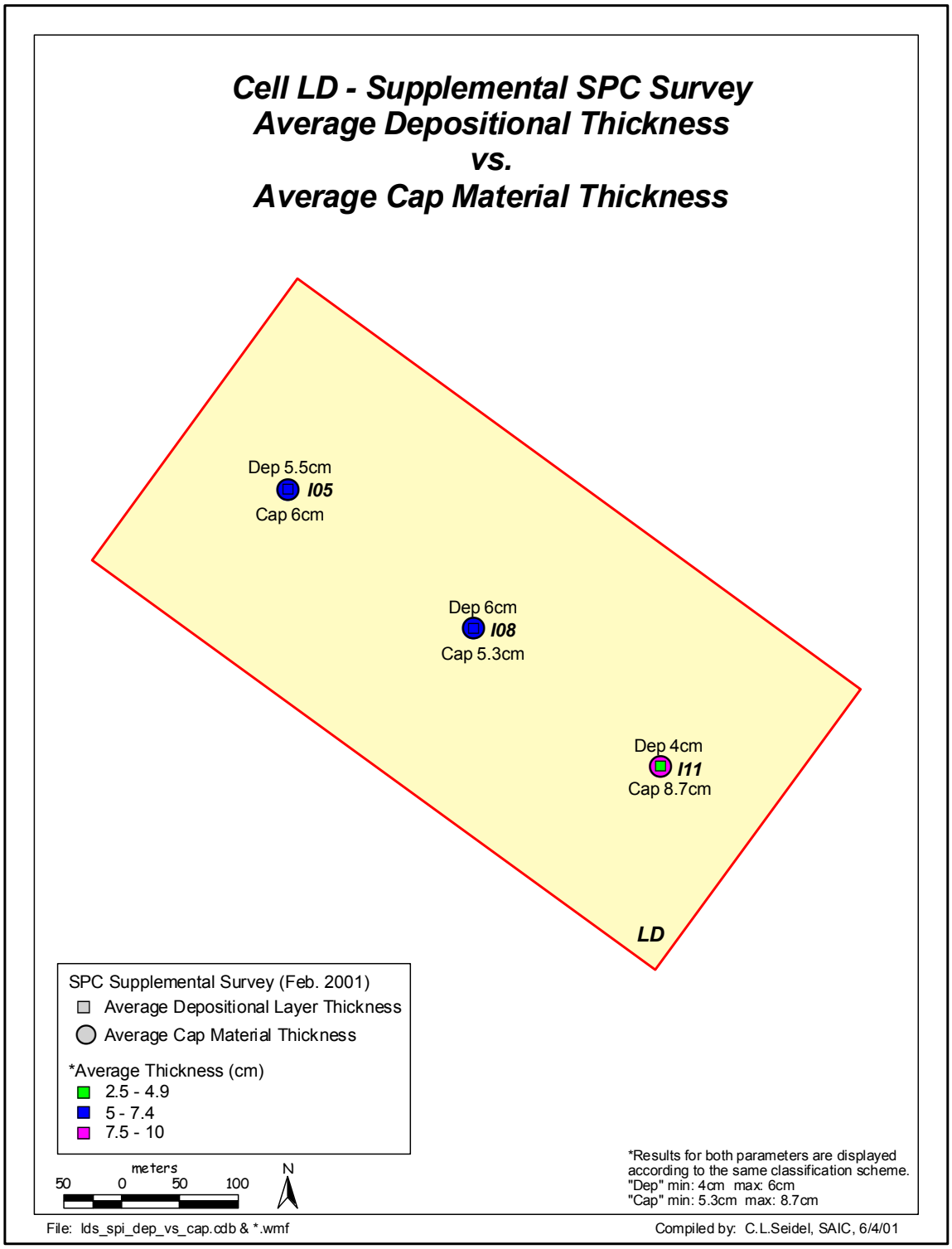

Figure 5.7-18. Map showing the average thickness of both the surface depositional layer of fine-grained sediment and the underlying cap material layer at each station in the February 2001 supplemental survey.

5.8 Cell LD Plan View Image Results

5.8.1 Overview of the Plan View Field Sampling Plan

The field sampling plan for the SPC/PVC surveys in Cell LD followed the methods described in the FSP (SAIC 2000a and 2001). All SPC/PVC surveys 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 LD 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 5.8-1 summarizes the PVC field sampling activities that were conducted in Cell LD for the Pilot Capping Project. The table presents both the number of planned stations, 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 5.8.4 Monitoring Results below.

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

Table 5.8-1. Summary of Field Sampling Activities in Cell LD

SURVEY	NUMBER OF STATIONS		PERCENT COMPLETENESS
	REQUIRED	SAMPLED	
Baseline	25	25	100%
Post-1	37	44	119%
Post-9	37	44	119%
Post-1 Pumpout	19	19	100%
Supplemental Survey	3	3	100%

5.8.2 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 mentioned in that section.

5.8.3 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.

5.8.4 Monitoring Results

5.8.4.1 Baseline Survey

The Cell LD background plan view image (PVI) survey was conducted on August 14, 2000. A total of twenty-five stations located inside and outside the cell boundaries were occupied (Figure 5.8-1). The purpose of the survey was to evaluate the ambient physical and biological characteristics of the surface sediments in and around the cell prior to the disposal of the initial load of borrow area cap material.

The results of the Cell LD baseline PVI survey indicate that the bottom topography throughout the cell was relatively smooth. The EA sediments throughout the cell appeared to be homogenous in both texture and color and consisted of very fine sandy-gray mud.

The biological activity in Cell LD appeared to be quite active in both the number of burrows that were present as well as the degree to which the burrows were established (e.g., size and construction). Numerous burrows with large crater-like structures, due most likely to the presence of epifaunal organisms, were found at the majority of the station replicates. Many of these burrows had burrow channel openings approximately 0.3 cm to 3.5 cm in size (Figure 5.8-2).

Epifauna observed included small fish, snails and organism tracks. Evidence of infauna included small worm tubes in a number of the images.

5.8.4.2 Post-1 Survey

The Post 1 plan view survey was conducted on August 18, 2000, following the initial spreading placement of the A-III Borrow Area material in Cell LD. A total of thirty-five stations were occupied in and around Cell LD (Figure 5.8-3). The purpose of the survey was to determine the spatial distribution of the cap material after placement.

<u>Cap Material Footprint</u>

The A-III Borrow Area material was easily identified in the plan view images due to the contrast in colors between the cap material (golden) and the gray ambient seafloor (Figures 5.8-4 and 5.8-5). This material is easily identified even in areas where the cap material coverage was classified as a trace amount of cap material.

The presence of shell fragments was found at all inside stations extending along the center transect of Cell LD (Figure 5.8-4). The amount of shell material at these stations was primarily classified as small, except at Stations I04 and I21, which were classified as showing a medium amount of shell materials. Cap material shell fragments were not observed at any stations outside of the cell boundaries.

<u>Biological Activity</u>

The epifauna observed in the images included mainly small snails. Infaunal evidence included a sea pen worm extending from the surface. The cell also contains many biological burrows and organism tracks.

5.8.4.3 Post-9 Survey

The Cell LD Post 9 survey was conducted on August 30, 2000, following the placement of nine loads of the A-III Borrow Area material (Figure 5.8-3).

Plan view results suggest the presence of cap material at all inside stations within Cell LD (Figure 5.8-6). Cap material could also be seen at many outside stations including O04, 07, 09, 16, 18, 21 and 43. The degree of cap material coverage for all of these stations was complete. The spatial extent of cap material based on the presence of shell fragments was primarily located along the center transect of the cell. Shell materials were also present at inside Stations I01, 13 and 15 as well as at outlying Stations O02, 13 and 19.

The re-working of the cap material was evident in a number of images from Cell LD. Images from I11 indicated that physical processes such as currents were affecting the sediments (as can be seen in the form of small uniform sand ripples). Due to the location of this station, however, the currents that were affecting these sediments may be generated by the placement of additional cap material in and around I11, and not ambient natural oceanographic currents.

The re-working of cap material could also be seen in the form of re-excavated biological burrows at a number of stations throughout the cell. These re-excavated burrows were easily discernable due to the color contrasts of the gray EA sediments and the golden colored cap material. Re-excavated burrows existed as circular gray spots on top of the golden cap material. A number of images also showed clearly defined channel openings (holes) in the middle of these sediments. Re-excavated burrows that did not have clearly defined channel openings could most likely be attributed to the collapse of the burrow channels in the loose sand (Figure 5.8-7).

Epifaunal evidence in the images for this survey consisted of a small fish and numerous organism tracks. Infauna included a sea pen worm extending up from EA sediments and a worm tube mat and individual worm tubes in a number of replicate images.

5.8.4.4 Post-1 Pump Out Survey

The Post 1 Pump Out SPC survey in Cell LD occurred on September 9, 2000, following the pump-out placement of a single hopper load of Queen's Gate cap material. Plan view images were obtained at each of 19 stations inside and outside the cell boundary (Figure 5.8-8). Cap material was pumped out at a steady rate as the dredge traveled slowly from southeast to northwest across Cells LC and LD.

Cap Material Footprint

Queen's Gate material overlying the A-III Borrow Area material could be seen at all inside stations throughout Cell LD (Figure 5.8-9). The degree of cap material coverage throughout the cell was generally partially covered. Trace amounts of Queen's Gate materials could be seen in a small number of images. Complete coverage of Queen's Gate material was not observed in any replicate images. Outside Station O01 showed the presence of the newly placed Queen's Gate material. The identification of the Queen's Gate material in these images is difficult to determine as to whether or not it is patches of Queen's Gate material over borrow area material that is seen, or patches of borrow area material on top of EA sediments.

Shell fragments can be seen in all images, except I03, I12 and I13 and O01. The majority of these stations were classified as a having a medium amount of shell material present.

Biological Activity

There was no direct evidence of epifauna in the station replicates. Evidence of infauna included worm tubes on the surface of the seafloor and a sea pen worm extending from the sediments.

5.8.4.5 Supplemental Survey

The Cell LD supplemental survey was conducted on February 24, 2001, approximately five and one-half months after the Post-1 Pump Out Survey (conducted on September 9, 2000). A total of three primary SPC/PVC stations were occupied during the supplemental survey (Figure 5.8-10). The purpose of the PVC survey was to identify the presence or absence of cap material (borrow area material) at these stations as well as to assess the status of the benthic habitat for comparison to the 2000 baseline and postcap surveys.

Cap Material Footprint

No direct evidence of a large amount of borrow cap material (golden sand) could be seen in any of the replicate images. The surface sediments appeared to be very similar to background conditions biologically and were gray in color (Figure 5.8-11). This suggested that EA sediments that were adjacent to the cap material were moving laterally and covering the borrow material or biological organisms at depth were transporting underlying EA sediments vertically to the surface. The presence of the gray sediments overlying golden sand was verified from the SPC images. A very small amount of shell material fragments could be seen in each replicate image, however, these fragments were most likely ambient shell material and not directly associated with the presence of cap material.

In addition, each replicate image showed the presence of small sand ripples that were most likely associated with physical processes (i.e., currents) that were affecting the sediments within the cell (Figure 5.8-11).

Biological Activity

A number of biological burrows could be seen in each image. Some of these burrows appeared to have a very small amount of golden colored sand near the openings, suggesting that the re-excavation of the burrows by underlying organisms (Figure 5.8-12). No direct evidence of epifaunal or infaunal activity could be seen in the images.

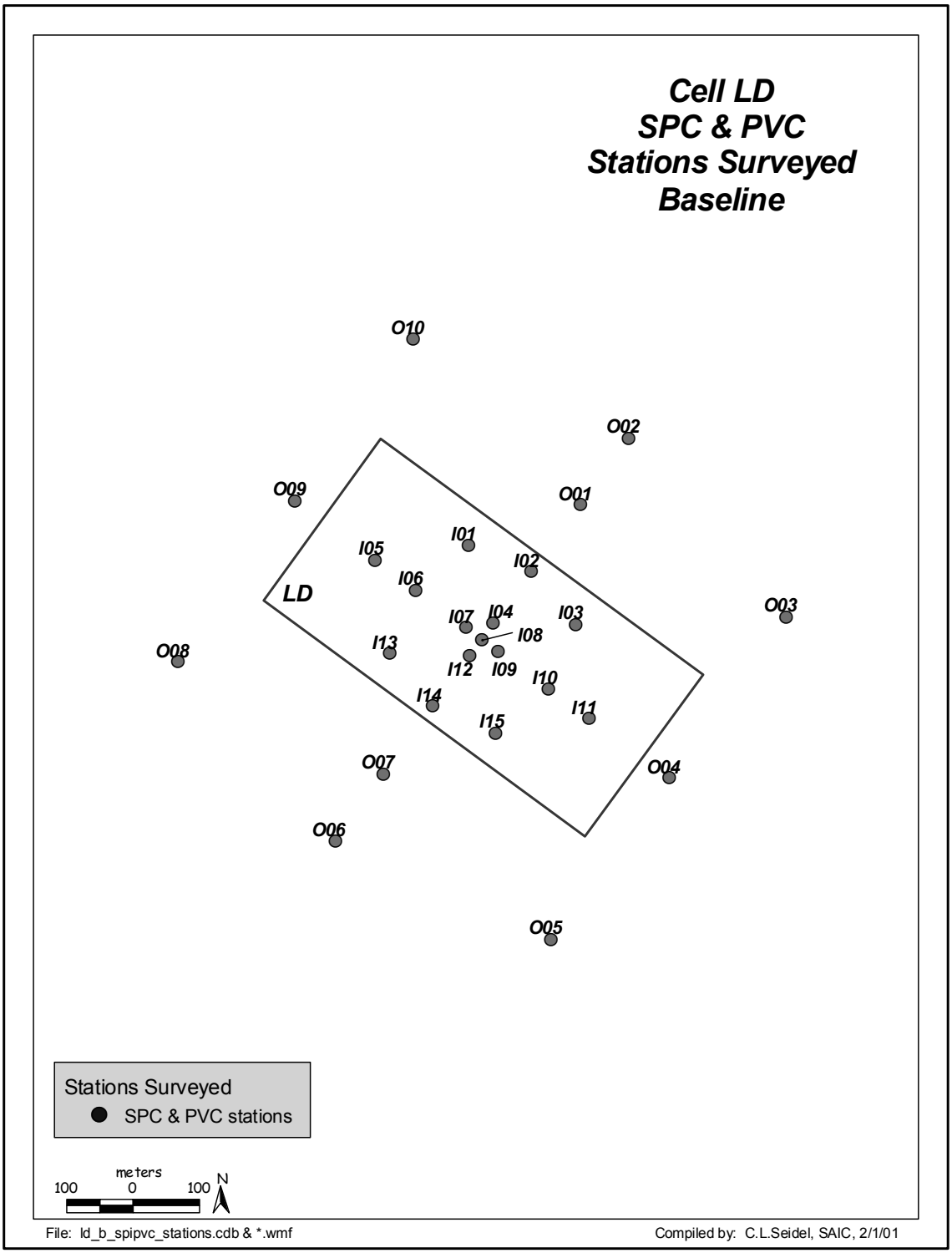

Figure 5.8-1. Cell LD SPI and PVC Stations surveyed – baseline survey.

Figure 5.8-2. Biological burrows. These images taken during the baseline survey in Cell LD Stations I07 and I09 typifies the type and amounts of biological burrows found on the Palos Verdes Shelf prior to cap placement.

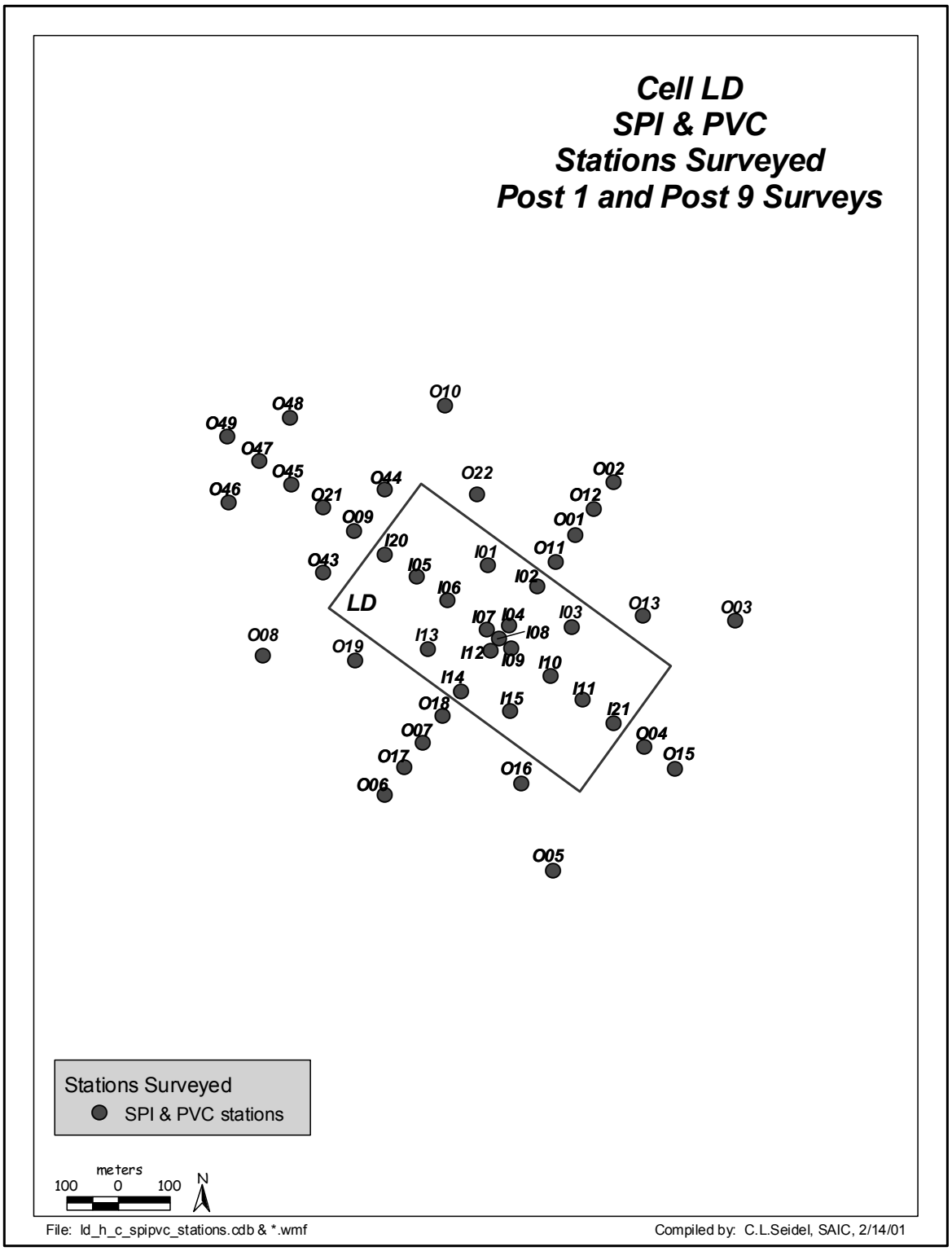

Figure 5.8-3. Cell LD SPI and PVC Stations surveyed – Post 1 survey.

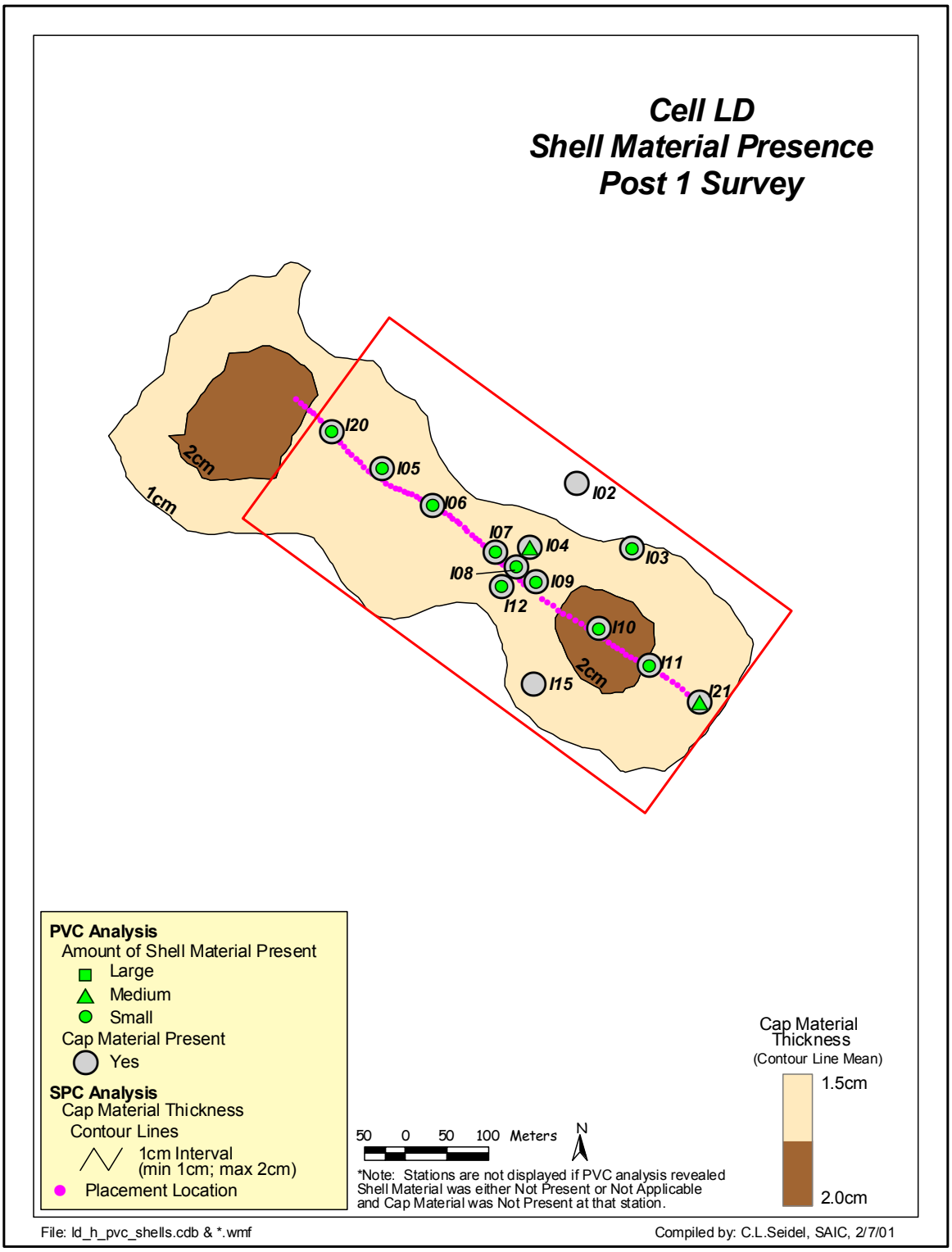

Figure 5.8-4. Lateral extent of cap material based on planview image (PVI) analysis – Post 1 survey. The plan view image data are overlain on the SPI cap material footprint.

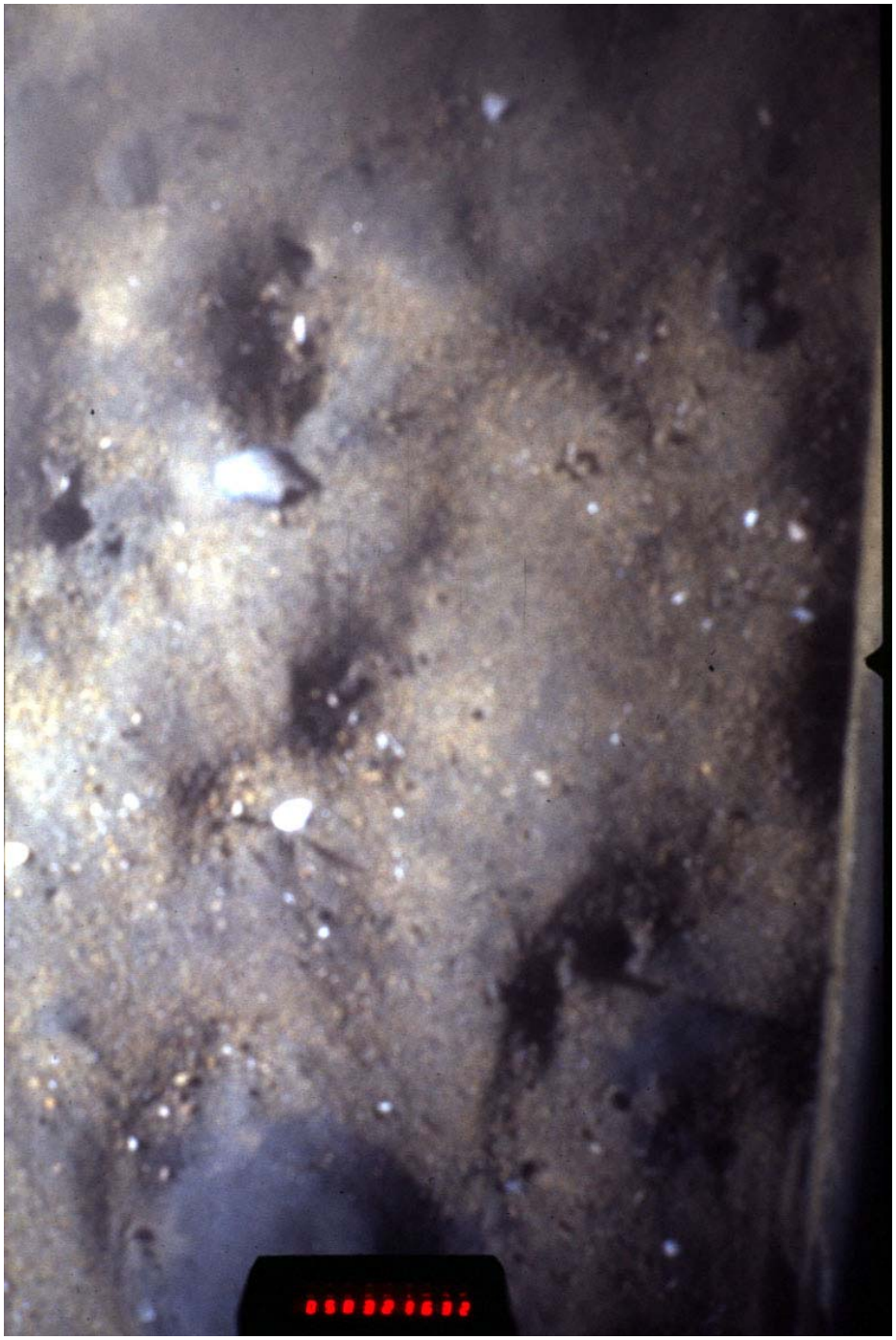

Figure 5.8-5. Color Contrast of Cap Material and EA Sediments. This plan view image acquired at inside station I10 in Cell LD provides an example of the color differences between the golden borrow cap material and the gray ambient sediments. This color difference aided in the identification of the presence or absence of cap material during analysis, even in areas were cap material was present in only trace (patchy) amounts.

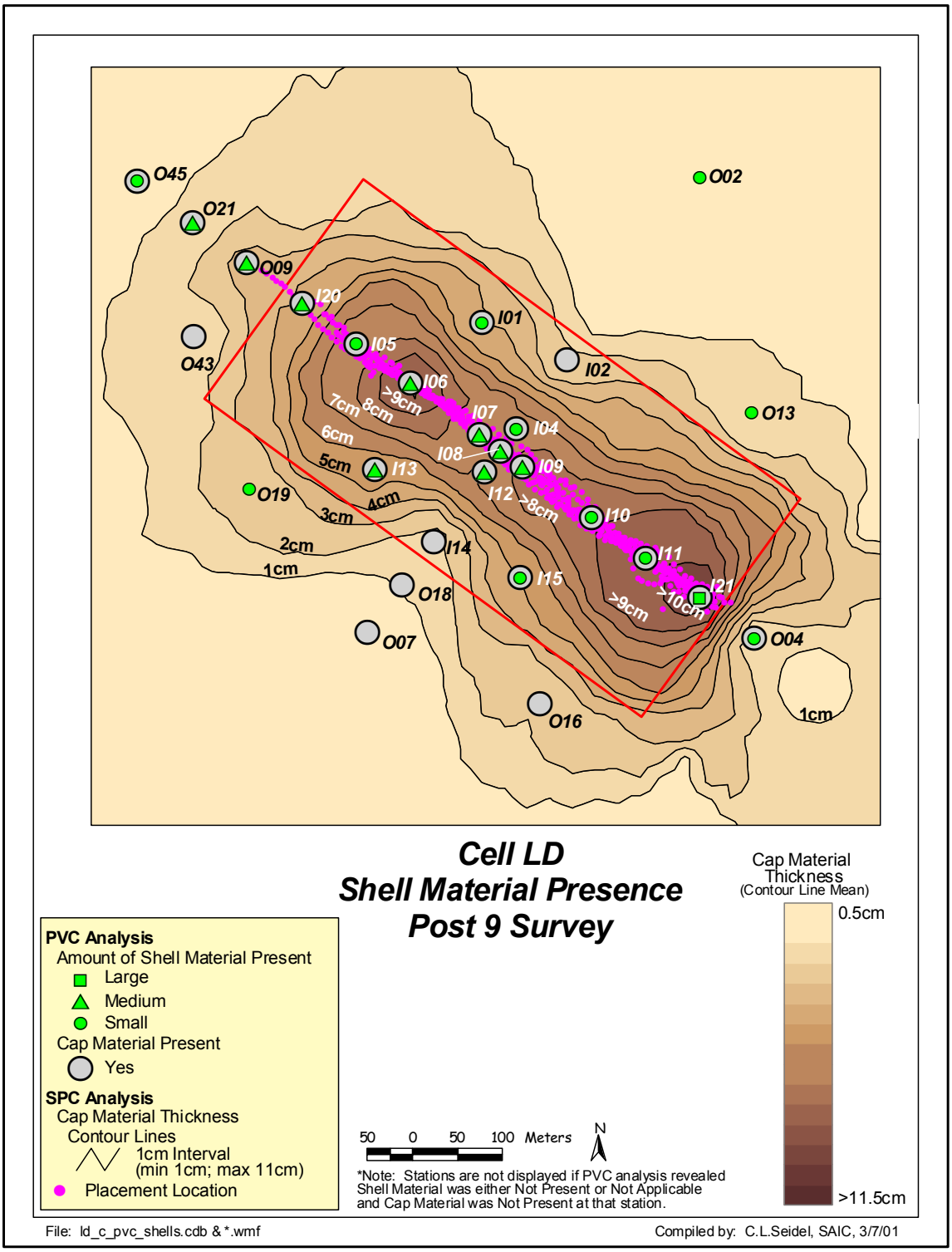

Figure 5.8-6. Lateral extent of cap material based on plan view image (PVI) analysis – Post 9 survey. The plan view image data are overlain on the SPI cap material footprint.

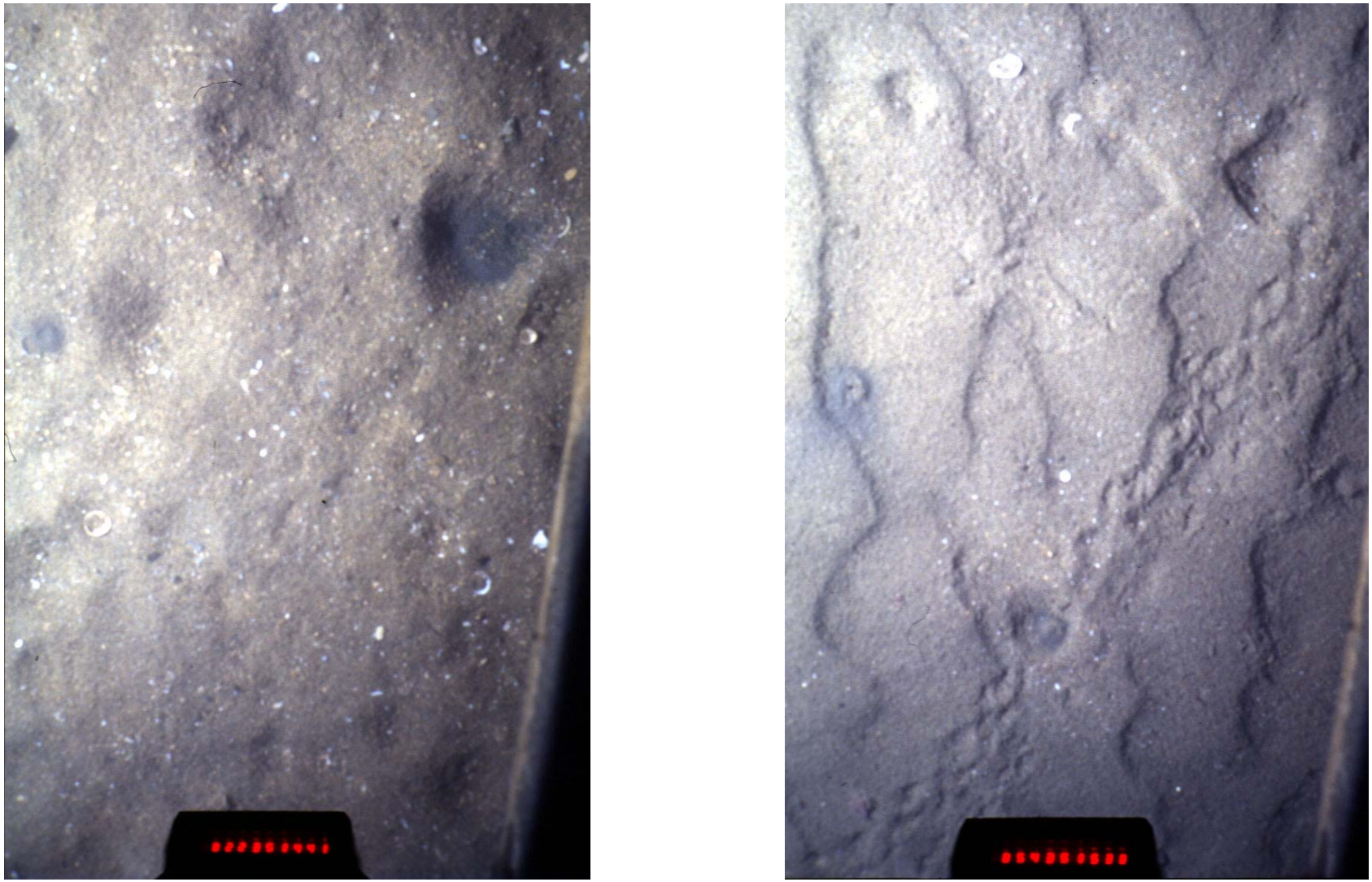

Figure 5.8-7. Re-excavated burrows. These images taken at Stations I05 and I11D during the Post 9 survey shows the re-excavation of biological burrows, denoted by patches of gray EA sediments overlying golden sand cap material.

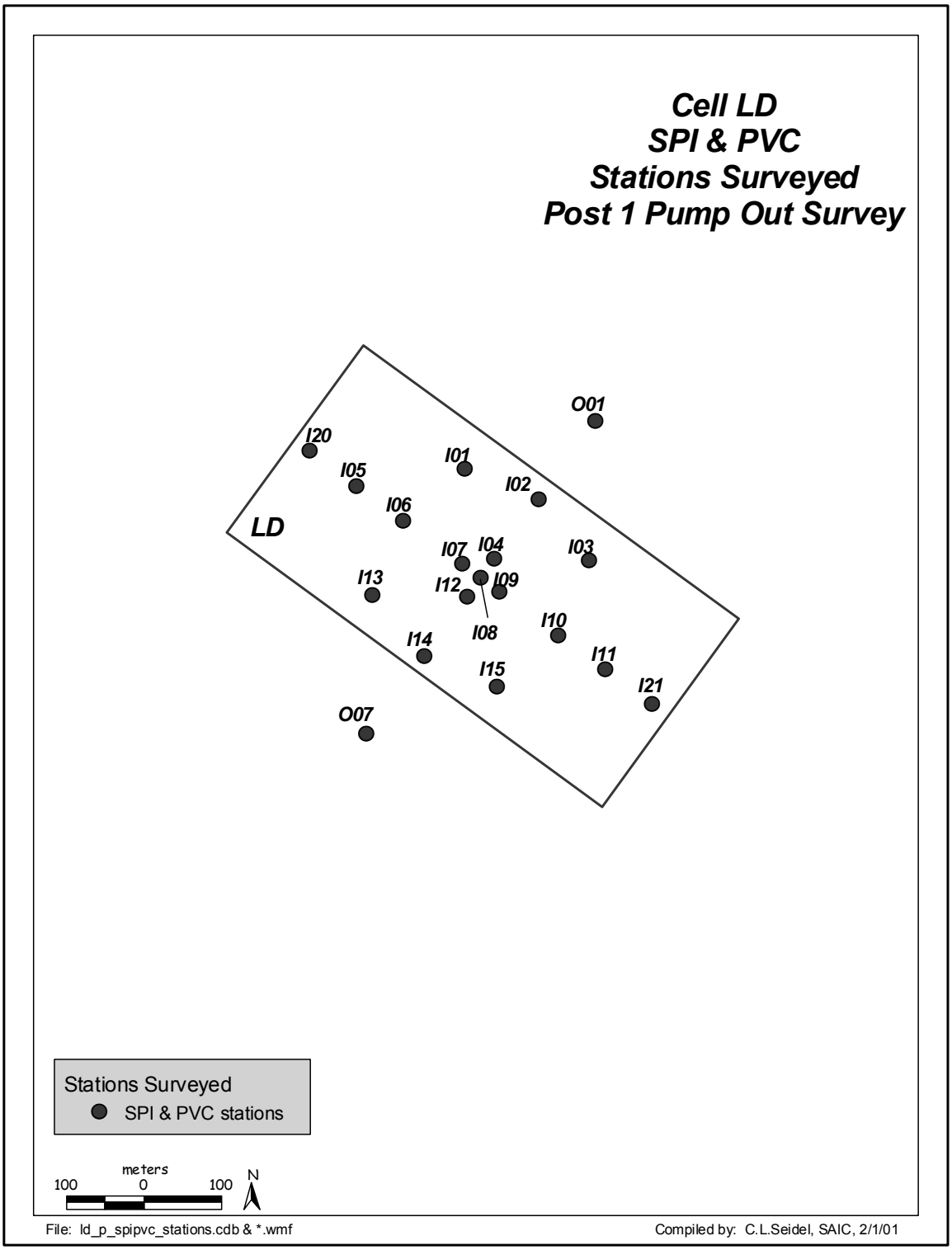

Figure 5.8-8. Cell LD SPI and PVC Stations surveyed – Post 1 Pump Out survey.

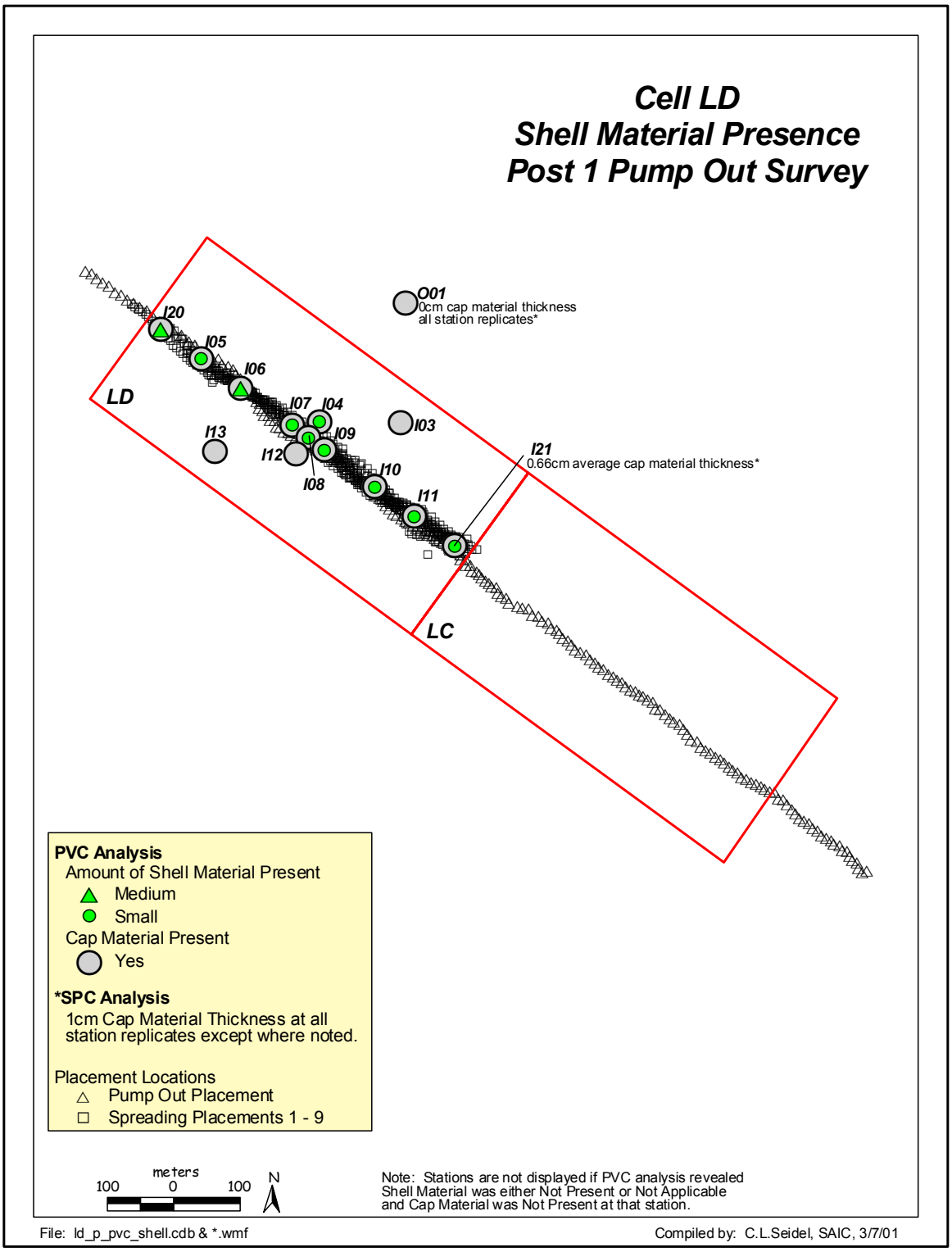

Figure 5.8-9. Lateral extent of cap material based on plan view image (PVI) analysis – Post 1 supplemental survey.

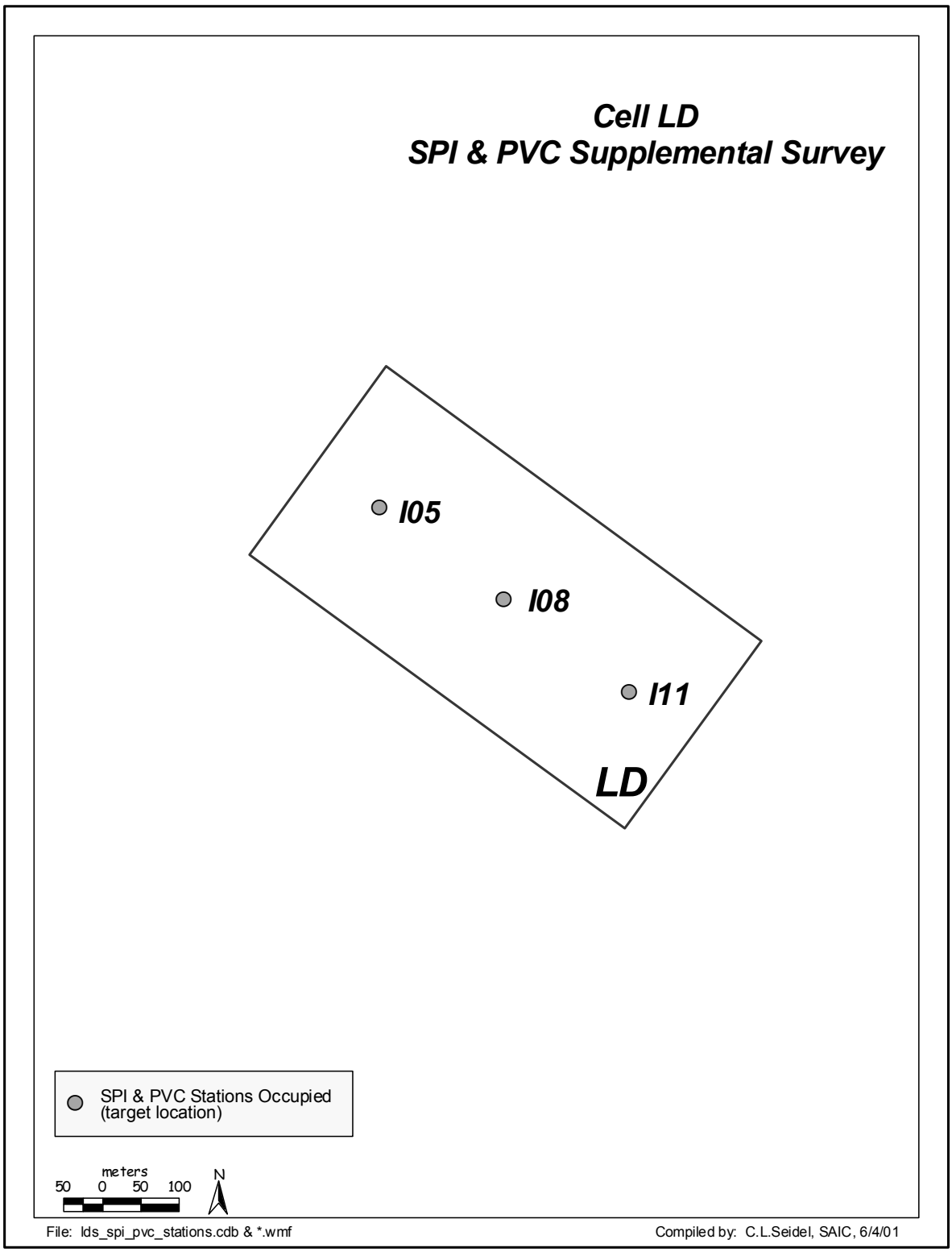

Figure 5.8-10. Cell LD SPI and PVC stations surveyed during the supplemental survey.

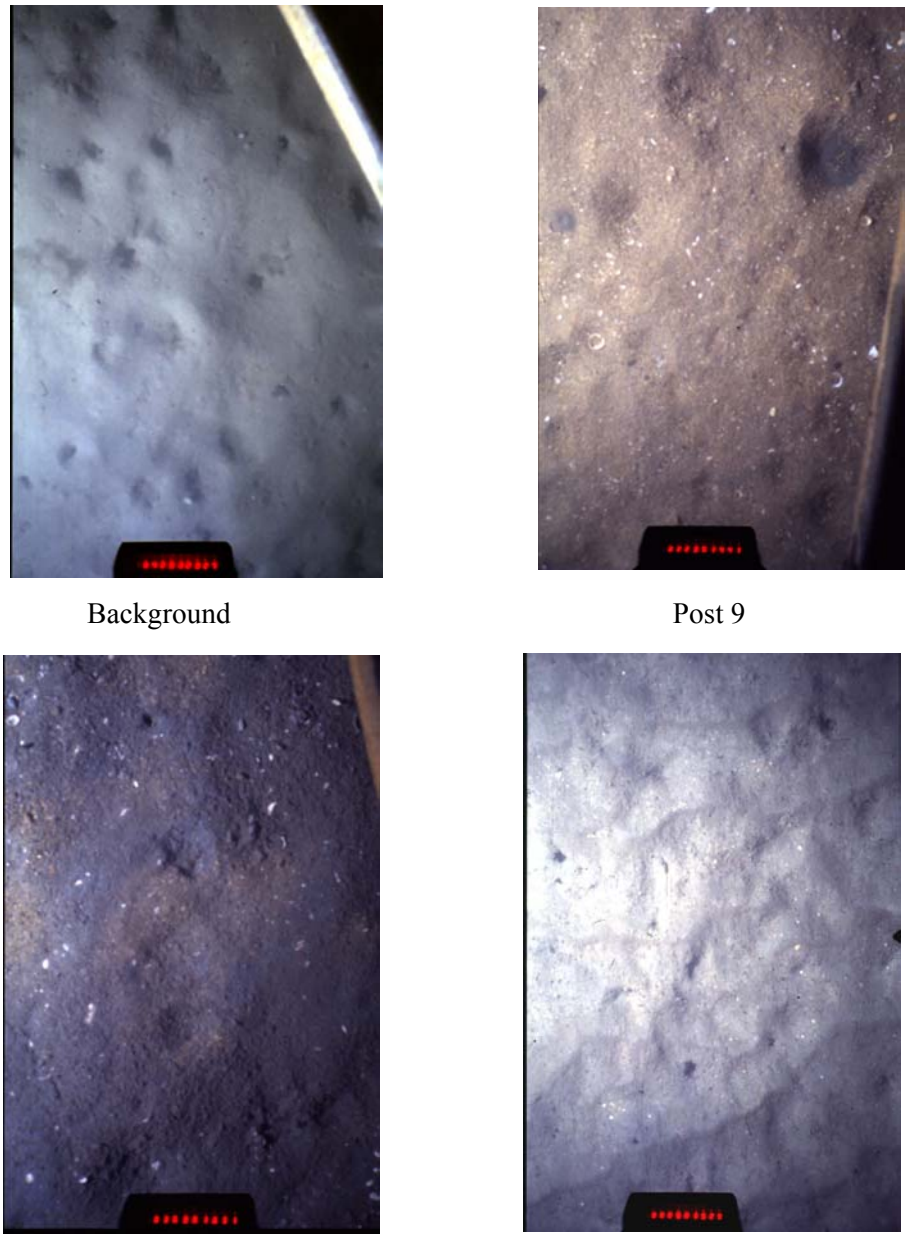

Figure 5.8-11. Temporal comparison between Cell LD Station I05 plan view images acquired during the Background, Post 9, Post 1 Pump Out and Supplemental surveys. In the images the transition between background conditions (gray sand with biological burrows), capped conditions (golden sand and golden sand mixed with Queen's Gate material) and the apparent reversion back to conditions similar to background (Supplemental Survey) can be seen. This transition may be attributed to the lateral movement of adjacent EA sediments over the top of the cap material. Also note the re-excavated burrows and sand ripples that can be seen in the Supplemental survey image, suggesting that the sediment surface is being re-worked by biological organisms as well as physical processes such as bottom currents.

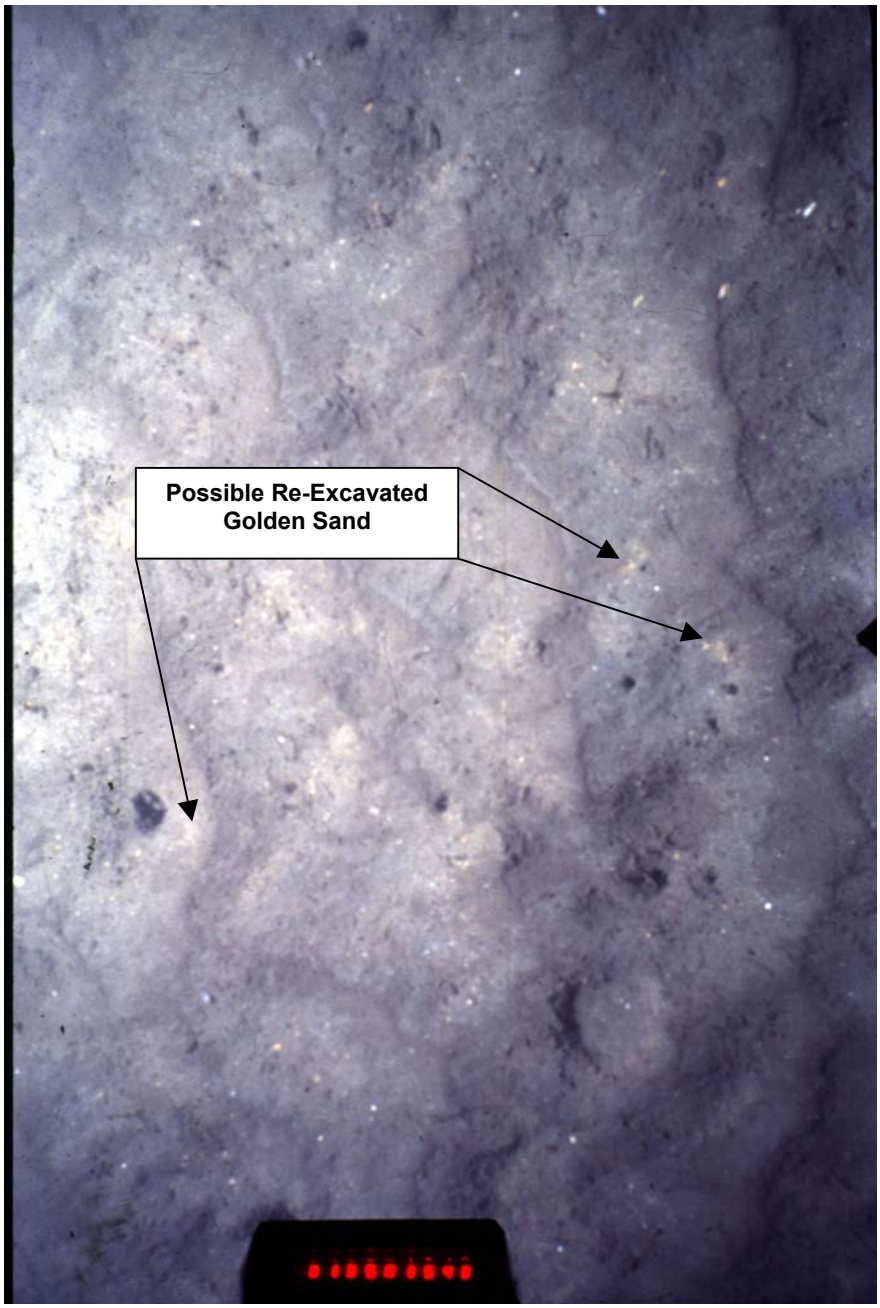

Figure 5.8-12. Plan view image acquired at Cell LD Station I08 showing a trace amount of golden sand (cap material) near the entrances of some of the biological burrows. This evidence suggests that the burrows are being re-excavated by the organisms below.

5.9 Seafloor Video Results from Cell LD

5.9.1 Overview of Field Sampling Plan

The seafloor video surveys in Cell LD followed the methods described in the FSP (SAIC 2001). In accordance to the FSP, one (1) video survey was conducted in Cell LD during the initial placement of cap material. A summary of the survey can be found in Table 3.8-1. 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 and while drifting after the placement event. In addition to the August 15, 2000 survey, a drift survey was also conducted in Cell LD on August 22, 2000. There was no placement event associated with this survey. The survey was conducted after the planned survey in Cell LU. The results of these surveys are described in the Monitoring Results (Section 5.9.4) below. A detailed description of this survey event can also be found in the Cruise Report (SAIC 2000b).

5.9.2 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.

5.9.3 Technical Considerations

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

5.9.4 Monitoring Results

Placement 1 Survey

The Placement 1 Cell LD underwater video survey was conducted on August 15, 2000. Video was collected at a stationary position (during the spreading placement of cap material) and by drifting over the cell two times after the placement was complete (Figure 5.9-1).

Stationary Survey

Approximately 14 minutes of video footage was obtained during the stationary survey. Prior to cap placement, the survey vessel anchored near the southern corner of the cell approximately 150 meters from where the dredge was to begin placement (Figure 5.9-1). The plume was clearly visible approximately five minutes after the placement of cap material began. Plume surge velocity was estimated at 0.5 meters per second. The plume was visible for nearly 21 minutes after cap placement and measured between 10 to 15 meters in thickness. The plume appeared to hover approximately one to two meters above the seafloor.

Narrative Placement 1 Survey

At approximately 19:15:31 GMT the dredge begins to spread cap material taken from the borrow areas on the southeastern edge of Cell LD. The dredge is heading in a northwesterly direction down a track line that bisects the cell lengthwise. Approximately three minutes later (19:18:37), the dredge is directly abeam of the video survey vessel and is continuing to spread cap material down the center of the cell. The distance between the two vessels at this point is approximately 150 meters. This time and position 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 five minutes after placement (19:23:36) the leading edge of the plume becomes visible. The plume arrives from the northeast and is moving to the southwest at an estimated velocity of one-half meter per second. The surge maintains this velocity for approximately two minutes and 15 seconds (19:25:48) until the velocity of the plume dissipates. Although no longer in constant motion, a more static plume remains at the site where 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 10 to 15 meters thick approximately five minutes (19:28:34) after cap material placement. The depth of the water at this site is approximately 50 meters. The bottom of the plume appears to be one to two meters above the seafloor. A significant increase in water clarity can be seen approximately thirteen minutes (19:36:34) after cap placement. After repeating a number of additional downcasts, nearly all visible elements of the plume have diminished, and the video camera system is retrieved aboard the survey vessel at 19:44:33 approximately 21 minutes after cap material placement.

Drift Surveys

Approximately 42 minutes of video was obtained in Cell LD while drifting on August 15, 2000. Two drifts were performed through the cell (Figure 5.9-1). The first drift acquired approximately 13 minutes of video footage. The second drift acquired approximately 29 minutes of bottom video. The purpose of the drifts was to try to distinguish newly placed cap material from the ambient sediments.

Drift Number 1

The first drift began approximately 75 meters southwest of the center of the cell at 21:57:03 GMT (Figure 5.9-1). The vessel was drifting in an east to northeasterly direction. Upon contact of the video camera with the seafloor (21:59:07), cap material was evident in the form of shell fragments, golden sand and the appearance of mottled sediments consisting of EA sediments (gray in color) and cap material (golden sand). The transition between cap material and EA sediments was clearly evident and could be seen approximately ten minutes (22:06:51) after the beginning of the drift.

Drift Number 2

A second drift survey was conducted in Cell LD on August 15, 2000 to further identify the placement of cap material. The duration of this survey was approximately 29 minutes. The vessel was positioned near the southwest corner of the cell and drifted in a north to northeasterly direction. The drift was completed where the start point of cap material deposit began (Figure 5.9-1).

Approximately eighteen minutes after the drift began (22:40:23) shell fragments, signifying cap material, became evident. The contrast between the colors of ambient sediment (gray) and the capping material (golden sand with shell fragments) was also evident. Cap material (shell fragments) was seen for an additional four minutes (22:44:35) until the vessel drifted outside of the cell boundaries.

Post 1 Survey (August 22, 2000)

The video survey conducted in Cell LD on August 22 was not associated with any disposal event in that cell. The survey was performed after the planned video survey was conducted in Cell LU to establish the boundaries of the most recent placement events in that cell (Figure 5.9-2). The most recent placement event at this time was the Placement 1 disposal that was conducted on August 15, 2000. The survey in Cell LD was conducted while drifting.

Approximately 50 minutes of video footage were taken during the drift. The drift began at 28:06:01 GMT near the southwest corner of the cell. The vessel drifted to the northeast (Figure 5.9-2). Cap material was easily distinguishable within the cell. The material was identifiable by the presence of a large amount of shell material and clay clasts. Biological burrows filled with cap material were visible. A transition from cap material to ambient sediments was seen as the amount of shell fragments began to decrease and the number of open biological burrows began to increase.

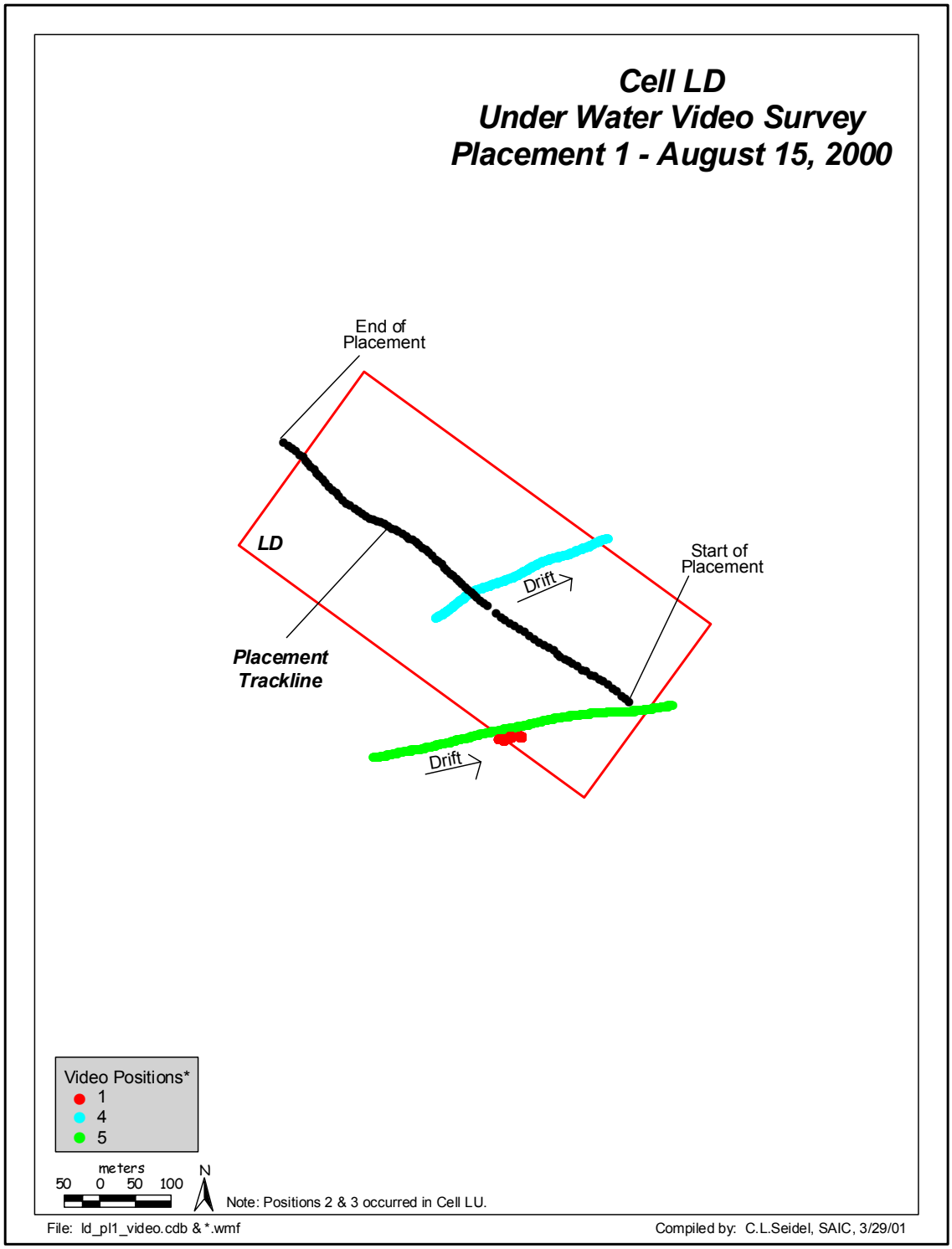

Figure 5.9-1. Cell LD Placement 1 Video Survey.

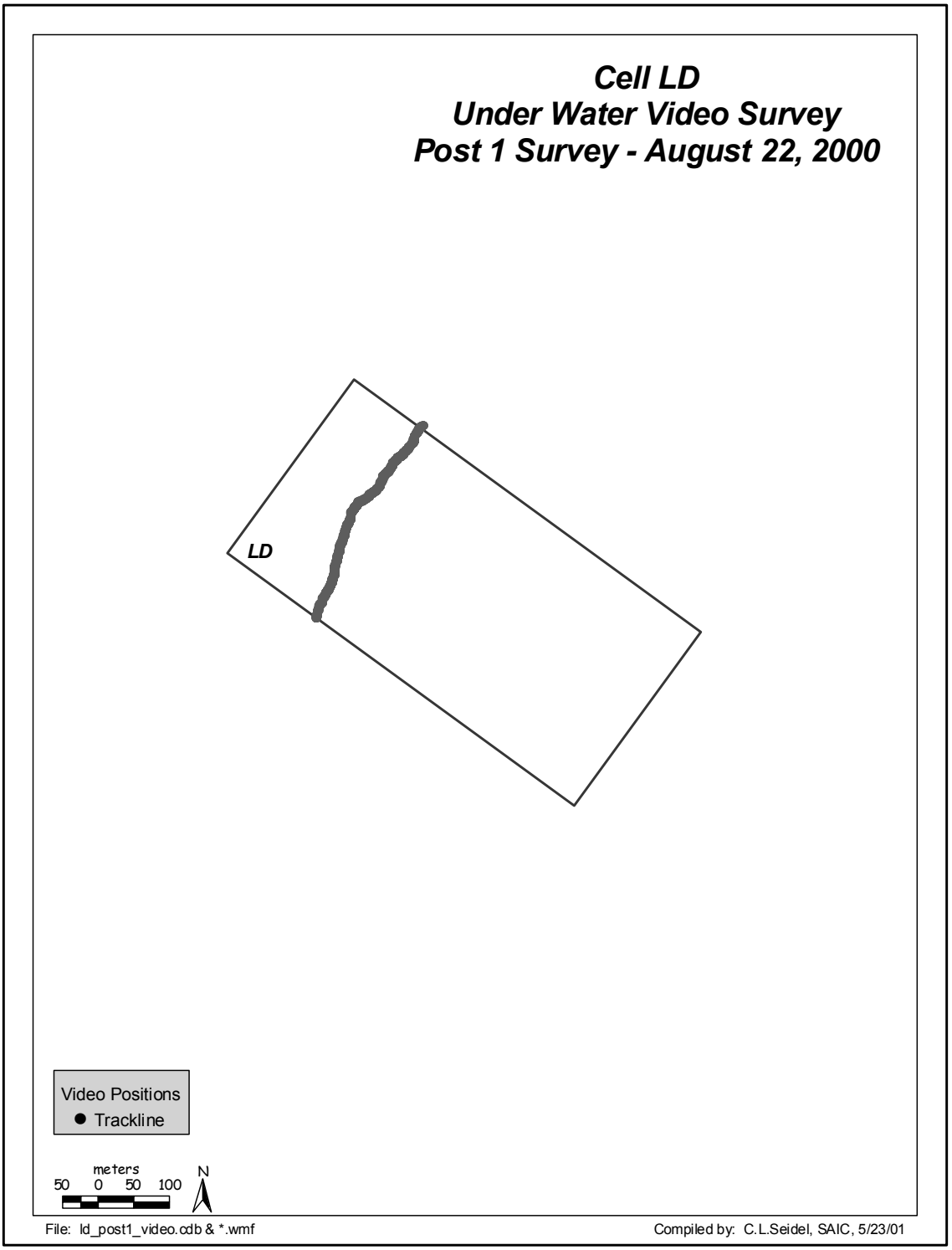

Figure 5.9-2. Cell LD Post 1 Video Survey.

5.10 Side-scan Sonar Results

5.10.1 Overview of Field Sampling Plan

In addition to an initial background side-scan survey conducted in the spring, two follow-up side-scan surveys were conducted through the summer during the active placement periods of the capping project within Cell LD. Both of these follow-on side-scan surveys were originally planned within the PWP. The side-scan monitoring activities that were conducted in Cell LD 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 LD. Both the ADISS and SPI monitoring data proved very useful in the analysis and interpretation of the side-scan sonar imagery.

5.10.2 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 LD 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.

5.10.3 Technical Considerations

In all but the baseline survey conducted in the spring, the presence of large schools of fish throughout 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.

5.10.4 Monitoring Results

5.10.4.1 Baseline Survey

The background side-scan survey for Cell LD 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 line. 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.

5.10.4.2 Post 1 Survey

The Post 1 side-scan survey was conducted on 8/19/00, four days after a single spreading placement event directed along the lengthwise centerline of Cell LD. As depicted in Figure 5.10-1, this event can be identified in the side-scan mosaic, and the image correlates well with the ADISS position tracks for the dredge as it conducted the spreading placement. Unlike a point placement event which exhibits a high acoustic-reflectance area associated with the main disturbance footprint, a spreading placement event causes far less seafloor disturbance and creates a more subtle acoustic signature. In this mosaic, a light-return material trail can be detected that aligns well with the ADISS track that runs through the center of the cell.

In addition, on each end of this material trail there are two circular, light return features that are reflective of the lateral surge pattern associated with a larger quantity of cap material being released at the start and end of this placement event. (The second of these surge features actually lies outside the northern end of the cell and corresponds with the end of the ADISS track for this event.) Although the acoustic return associated with these circular features is still light, their shape and symmetry are similar to those exhibited by a point placement event. Because smaller amounts of cap material (relative to a point placement event) are impacting the seafloor in these instances, there is far less bottom disturbance and a much lighter acoustic return. The diameter of these circular features is approximately 100 m and seems to reflect the full extent of the lateral surge away from the center of the circle. When the SPI cap contours are compared against the mosaic, they show that the only two areas with a cap thickness greater than 2 cm correspond well with these circular side-scan features.

5.10.4.3 Post 9 Survey

The Post 9 side-scan survey was conducted on 8/30/00, four days after the ninth spreading placement event; placement events two thru nine were all directed along the same line through the center of the cell as the initial placement. As depicted in Figure 5.10-2, the general placement area can be identified in the side-scan mosaic and the image correlates well with the ADISS positions for the nine prior placement events. (For improved viewing of the mosaic, Figure 5.10-3 also provides the same image without the ADISS tracks.) It is not possible to identify each individual placement event, because each event was directed along the same line and each later placement partially covered-up the remnants of the previous placement. Because a spreading placement event causes less seafloor disturbance than a point placement event, a later spreading event may not completely obscure a previous placement return.

As with the Post 1 survey, it is possible to detect some light return material trails through the center of the cell and also some prominent circular surge patterns that are reflective of releases of larger quantities of cap material from the dredge. Because the image mosaic primarily reflects the seafloor impacts from only the most recent placement events, it is not possible to correlate the SPI cap thickness from nine events with apparent cap footprint depicted on the mosaic. However, the SPI cap contours do show that the areas of greatest cap thickness correspond well with the three most prominent surge areas indicated on the mosaic. All three of these prominent surge areas originate from the later placement events.

5.10.5 Discussion

The monitoring operations conducted in Cell LD 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.

During the Cell LD side-scan operations, a single spreading placement event produced a relatively consistent acoustic signature, though the signature was somewhat dependent on the operation of the dredge. During the spreading placement events it appears as if there was a consistent slow release of cap material from the dredge, punctuated by occasional much larger releases of cap material. For the first placement event, there were two larger releases of cap material, one near the beginning and the other near the end of the release cycle. The SPI cap contours indicate that the greatest cap thickness occurs near the start and end of the ADISS tracks, so it appears as if this release pattern is consistent for all of the spreading events. Because each spreading event was directed along the same line and each later placement partially covered-up the remnants of the previous placement, it was only possible to make definitive statements about the initial placement event.

During the slow material release periods from the dredge, there was generally a light return trail that could be distinguished on the seafloor. Although the acoustic return during the slow release periods was light, the ADISS track data helped to confirm this interpretation. During the faster material release periods that occurred near the start and end of each spreading event the acoustic signature was more similar to that seen during a point placement event. Although there were no prominent high-reflectance areas indicative of major bottom disturbance associated with these faster release periods, there were noticeable circular surge patterns that radiated outward from a central point. The measured diameter on a

few of these circular surge features was approximately 100 m, though that measurement is likely dependent on the amount of cap material that was released from the dredge.

The Cell LD 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 much of the seafloor surface effects from the prior placement events. 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 5.10-3) showed that the two circular surge areas associated with the faster release of material correlated well with the 2 cm SPI cap contour. The lighter material trail associated with the slower release of cap material fell within the 1 cm SPI cap contour, though no definitive correlation could be made between the 1 cm contour and the image mosaic.

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 LD Post-9 side-scan image (Figure 5.10-2,3), the most recent side-scan image will only reflect those placement events that have not been obscured by more recent events. Although 9 placement events were conducted in Cell LD prior to the final side-scan operations, it is not clear how many of these events can be 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 LD. 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 LD 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 LD 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 LD (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 LD 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, individual placement events could be clearly identified. Additionally, some unexpected features, such as the circular surge features associated with a faster release of cap material from the dredge, 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.

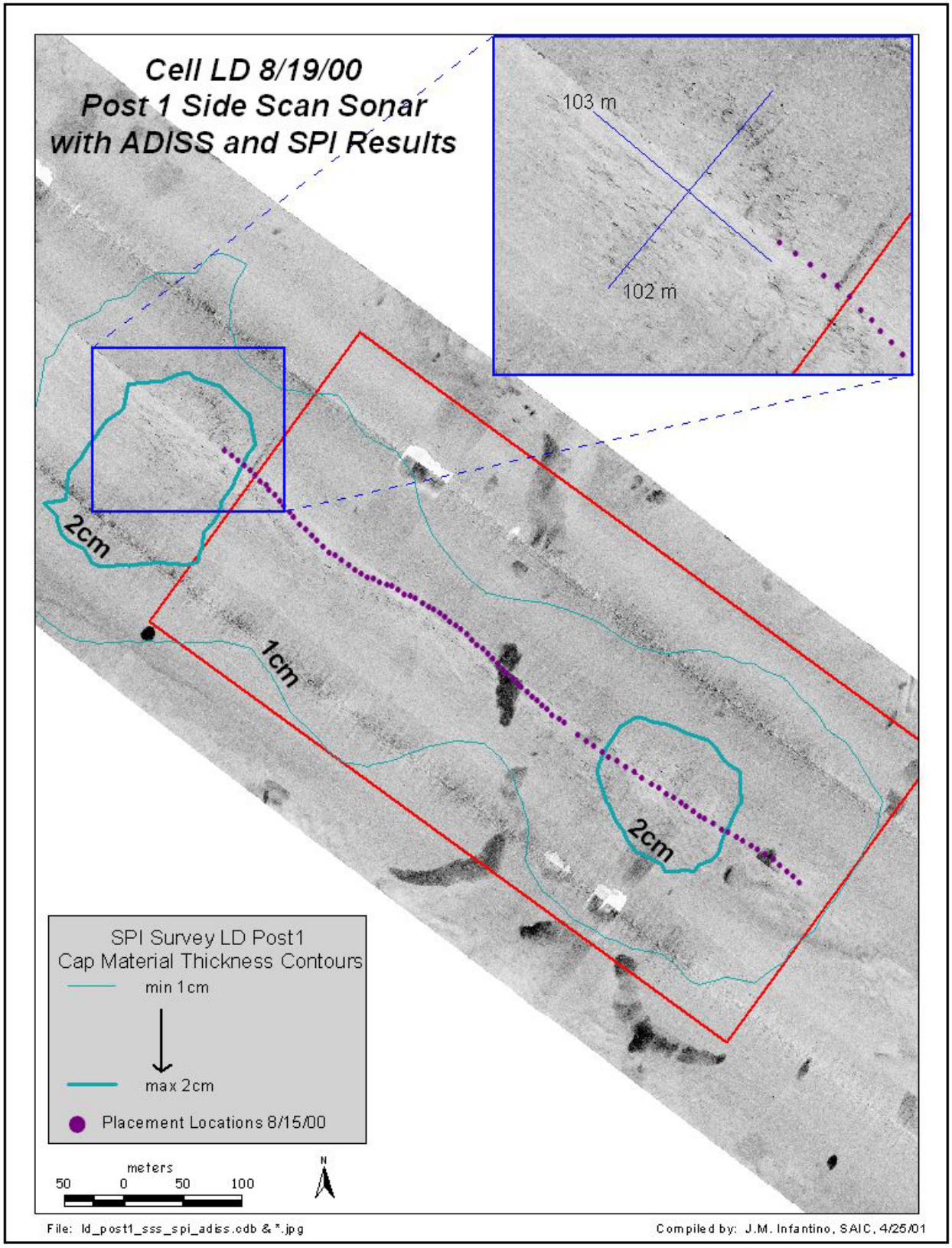

Figure 5.10-1. Side-Scan Mosaic with SPI Cap Contours and ADISS track - LD Post 1.

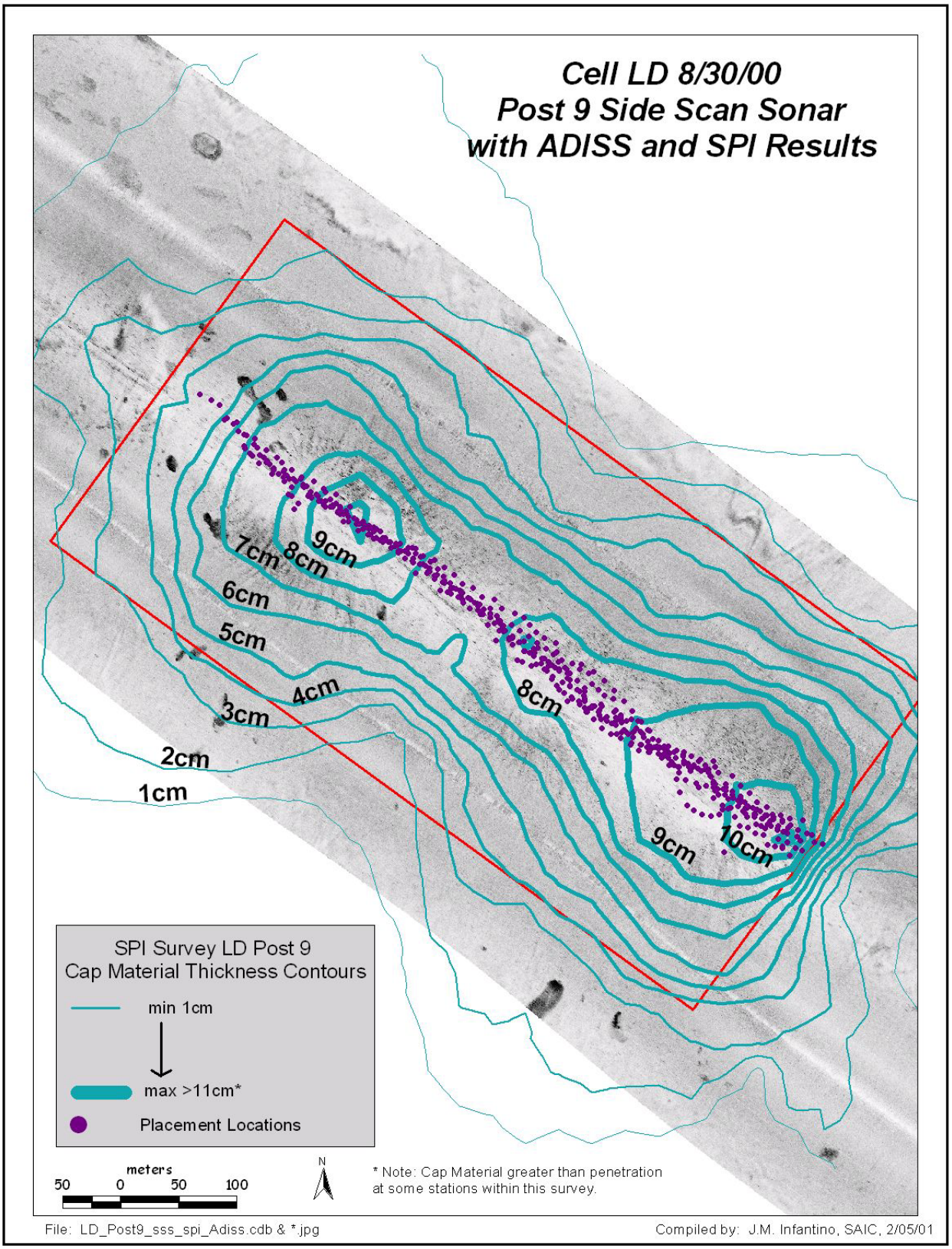

Figure 5.10-2. Side-Scan Mosaic with SPI Cap Contours and ADISS track - LD Post 9.

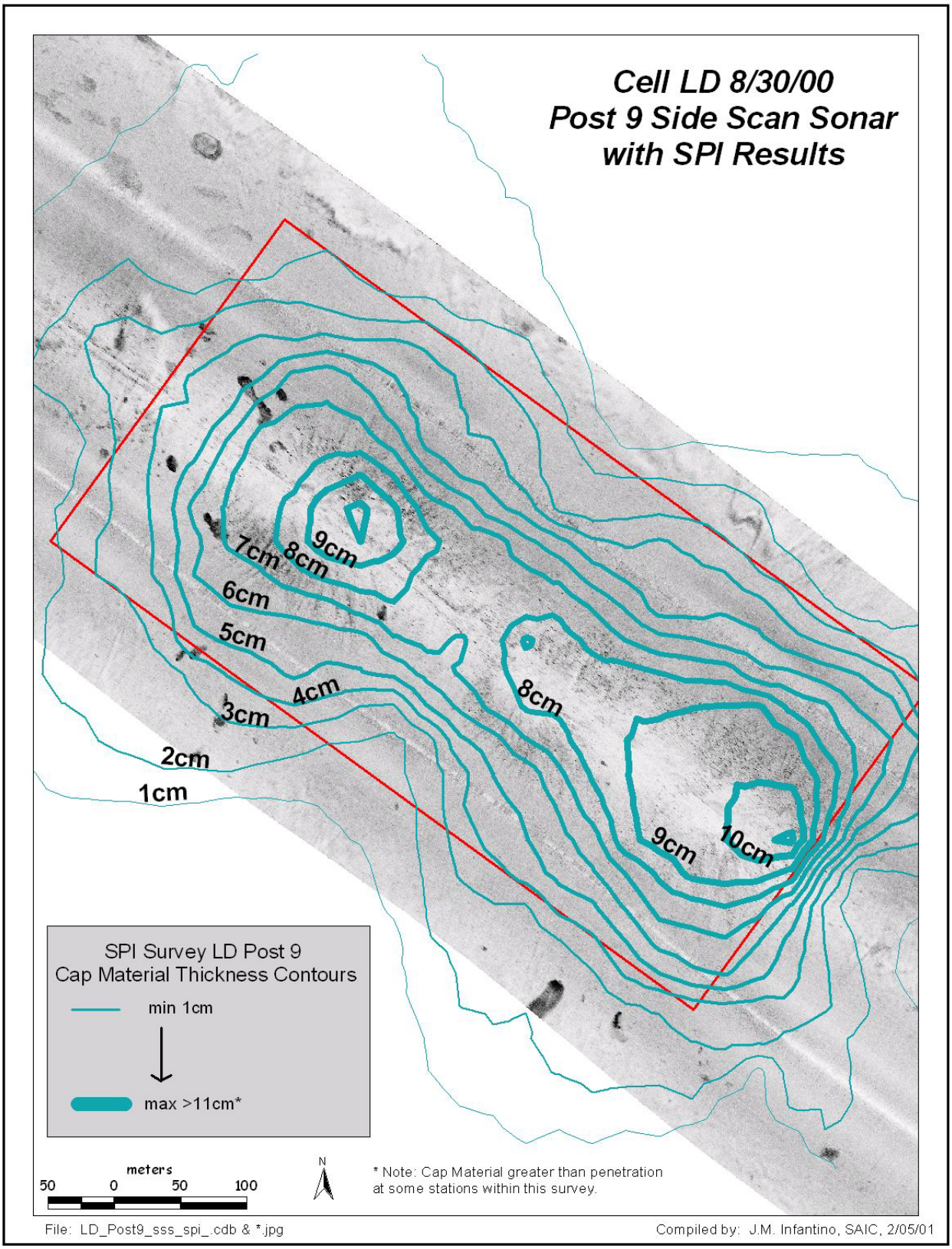

Figure 5.10-3. Side-Scan Mosaic w/SPI Cap Contours - LD Post 9.

5.11 Sediment Core Results

5.11.1 Overview of Field Sampling Plan

Brief descriptions of field sampling plans for baseline phase of the monitoring program are provided below, along with a summary of methods and significant deviations from the sampling plans defined in the PWP.

5.11.1.1 Field Sampling Plans

Baseline Survey

Sediment cores were collected at nine stations within Cell LD during the baseline survey as presented in Figure 5.11-1a. Station locations corresponded to intersection points of the sub-bottom profile lines. Each of the nine cores was subsampled at discrete 4-cm intervals, and sediments from each interval were analyzed for DDE, grain size, and bulk density. Two additional cores were collected (at stations C1 and C6) to provide adequate sediment for Atterberg limit analyses.

Post 1 Survey

Cores were collected at five stations during the Post 1 survey following the single-hopper placement event (Figure 5.11-1b). Four of the sampling stations were selected randomly from among the SPC stations within the cell and one station was selected randomly as a reference from SPC stations immediately outside the cell. Each cores was photographed, visually described, and subsampled for grain size and bulk density.

Post 1 Pump-Out Survey

A post pump-out survey was added to the monitoring program to determine the effects of slowing pumping sediment out of the drag arm while the hopper moved slowly across the cell. Cap material used for this event came from the Queen's Gate Channel. Initially, no cores were to be collected for this survey because it was presumed that very little accumulation of cap material would occur. However, a single core (LDP66) was collected from the center of the cell (Figure 5.11-1c) after nine placements of A-III Borrow Area material and the pump out event. The digital image of core LDP66 and visual description are included in DAN-LA.

Postcapping Survey

No further postcapping surveys were conducted at Cell LD.

Supplemental Survey

A supplemental coring survey, conducted in February/March, 2001, collected a total of nine vibracores and three box cores at four stations within Cell LD (Figure 5.11-2). Multiple cores were collected at some stations to ensure that at least one representative core (i.e., unaffected by sampling artifacts) would be available for subsampling. A single core from each of two stations (I05 and I08) was subsampled at 4-cm intervals to a depth of 20 cm, and sediments from each interval were analyzed for grain size, bulk density, water content, specific gravity and DDE. Core I11 was analyzed for Atterberg limits.

The objective of the box coring was to determine whether this sampling method could provide representative sediment cores, which included both surface cap materials and subsurface EA sediments that were not affected by sampling artifacts, with a minimum penetration depth of 25 cm. Sediments

collected with the box core were inspected visually and photographed, but were not subsampled for geotechnical or chemical analyses.

All cores were photographed and visually described. Detailed descriptions, including the depth intervals subsampled for geotechnical and chemical analyses, and core photographs are included in the DAN-LA database.

5.11.1.2 Methods

The methods used for collection and processing of sediment cores, and geotechnical and chemical analysis of core samples are described in the baseline and cap placement monitoring FSPs and summarized in Section 3.11.2.

5.11.1.3 Deviations from Field Sampling Plan

Core sampling at Cell LD during baseline, Post 1, and supplemental coring surveys did not deviate significantly from the approach described in the FSPs. Atterberg limit analyses of hopper samples were not performed due to a significant sand fraction, which thereby hindered analyses.

5.11.2 Review of Data Quality Objectives

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

5.11.2.1 Baseline Monitoring

Specific DQOsfor sediment coring conducted during baseline monitoring at Cell LD are the same as those described for Cell LU (Table 3.11-1).

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

Specific monitoring objectives for sediment coring during the baseline survey were achieved. In particular, all sediment cores specified in the PWP were collected, along with the defined numbers of field quality control samples. Cores provided adequate sample volume for all required chemical and geotechnical analyses, including analytical quality control samples specified in the QAPP. A total of 48 grain size, 53 bulk density, 4 Atterberg limits, and 54 shear strength analyses were completed. Samples from the baseline survey were not analyzed for water content or specific gravity. In addition to geotechnical samples, 47 sediment samples were analyzed for DDE (Table 5.11-1). Results of QC analyses are presented in Appendix B.

5.11.2.3 Supplemental Coring Survey

Specific data quality objectives for sediment coring during the supplemental coring survey in Cell LD were the same as those described for Cell LU (Table 3.11-3).

5.11.2.3.1 Summary of Results for Supplemental Coring Survey Relative to Data Quality Objectives

Specific monitoring objectives for the supplemental coring survey in Cell LD were achieved. All cores specified in the PWP were collected, along with the defined numbers of field QC samples. A total

of 12 grain size, 8 bulk density, 6 specific gravity, 8 water content, 2 Atterberg limits, and 9 shear strength analyses were completed. Samples from the baseline survey were not analyzed for water content or specific gravity. In addition to geotechnical samples, 11 sediment samples were analyzed for DDE (Table 5.11-1). Cores provided adequate sample volume for all required chemical and geotechnical analyses, including analytical QC samples specified in the QAPP.

5.11.3 Technical Considerations

Technical considerations relevant to sediment core and hopper samples collected in Cell LD are identical to those discussed for Cell LU (Section 3.11.3).

5.11.4 Results

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

5.11.4.1 Geotechnical Characteristics

Hopper Samples

Detailed grain size results for the four hopper loads are presented in DAN-LA. The major component (98%) of A-III Borrow Area material was sand (0.0625-2 mm), of which 53% was classified as fine sand (0.125 mm) and 35% was medium sand (0.25 mm) (Figure 3.11-5). On average, samples contained less than 1% silt and 1.5% clay. Proportions of both silt and clay were considerably lower in A-III Borrow Area material than the Queen's Gate material. Gravel (>4 mm) was not present in the A-III Borrow Area material.

Wet and dry weight bulk densities were 1.84 g/cm^3 ±0.09 and 1.42 g/cm^3 ±0.06 respectively. Specific gravity averaged 2.68, while the average water content ranged from 24 to 37% with an average of 30%. Results for these geotechnical parameters are listed in comparison with additional hopper data in Table 3.11-5.

Baseline Survey

Detailed visual descriptions and core images are included in DAN-LA. Baseline sediments from Cell LD were greenish gray, wet, soft SILT and SAND. Samples from different core horizons contained similar grain size distributions, and no distinct stratification with depth was evident as Figure 5.11-3 suggests. Sand (0.0625 to 2 mm) was the dominant component of the EA sediment. Proportions of very fine sand (0.0625 mm) dominated the sand fraction ranging from 43 to 48%. Silt (0.0312 to 0.0039 mm) was the second largest component, comprising an average 35% of the sediment type. Coarser material including gravel (>4 mm) was not detected in the baseline sediment (Table 5.11.2).

The average wet weight bulk density was 1.72 g/cc, while the average dry weight bulk density was 1.11 g/cc. Atterberg limits were conducted at two horizons in cores from stations C1 and C6. The average liquid limit was 42%, with a plastic limit of 30% and an average plasticity index of 12. Specific gravity and water content were not analyzed during the baseline survey. Core-specific data are summarized in Appendix C.

Shear strength results for Cell LD sediments exhibited a general increase in strength with depth (Figure 5.11-4). Two data points (LDBC3D1 at 30.22 kPa and LDBC4D1 at 50.61 kPa) were considered outliers and removed from the data set. The high sand content of the sediment hindered the ability to

collect shear strength results and frequently skewed the data. Shear strength measurements cannot be collected accurately within highly sandy sediments. With the exceptions noted, values were within the expected range and followed a trend of increasing strength with depth. A summary of geotechnical results is included in Appendix C.

Post 1 Survey

Five cores were collected in association with the Post 1 survey. These five cores were photographed and visually described; the results are presented in DAN-LA. Four of the five cores were collected inside the cell while one core (LDH16) was collected outside of the cell (Figure 5.11-1b). Sediment cores collected during the Post 1 survey were generally greenish black or black in color, moist, firm clayey SILT or silty CLAY with shell fragments at depth. Shell fragments were also noted in the deeper cores collected during the baseline survey, and therefore did not indicate the presence of cap material. A composite sample (0 to 4 cm) from cores LDH17 and LDH18 was analyzed (Table 5.11-3). There was no clear visual indication of cap material and EA sediment separation in the cores. Overall, the grain size data for the composite sample were characteristic of EA sediment and did not indicate any discernable increase in proportions of fine sand (0.125 mm) characteristic of cap material (Figure 5.11-5).

Bulk density for the composite sample indicated no significant change relative to baseline values. The wet weight bulk density was 1.88 g/cc, compared to the baseline value of 1.76 g/cc; dry weight bulk density for the composite sample was 1.24 g/cc as compared to 1.11 g/cc for baseline sediment. No additional geotechnical analyses were performed on Post 1 cores.

Post 1 Pump-Out Survey

The core collected during the post pump-out survey was 64 cm in length and did not contain a cap material/ EA interface as expected. The upper 40 cm of the core was greenish black and appeared to be silty CLAY. Core sediment in the 40-64 cm interval appeared to be very hard clayey SILT. Apparent cap material was located along the core liner as 'drag down'; however, no cap material or sand was evident in the center of the core. No further analysis was conducted on this core. The complete core description and digital image is included in DAN-LA.

Supplemental Survey

A comparison survey of vibracoring and box coring was conducted in Cell LD (Figure 5.11-2).

Comparison of Box Core and Vibracore Cap Thickness Measurements

Three box cores were collected from two stations in Cell LD (Figure 5.11-2b). All three samples contained a surface layer of cap material and an underlying layer of EA sediment, with a visually distinct interface between the two sediment types. Based on the visual observations, cap thickness measurements of 11.5 and 12 cm were recorded for two box cores obtained at station I05 (Table 5.11-4). These cap thickness measurements were somewhat greater than the estimated average cap thickness of 6 cm measured in the sediment-profile images obtained at station I05 in the supplemental survey (see Section 5.7). A 3 cm thick layer of brownish silty clay was noted on the surface of the I05 box cores. The presence of this surface depositional layer in the box core samples is consistent with the SPI results for this station (see Section 5.7 and Figure 5.7-17). Cap thickness was 10 cm in the box core obtained at station I08; no depositional layer was present. This cap thickness value was greater than the average thickness of 5 cm measured in the supplemental survey sediment profile images at this station.

Cap thickness measured in each of the Cell LD box cores was greater than that measured in the co-located vibracores (Table 5.11-4). However, the cap thickness measurements in the vibracores were generally consistent with those obtained from the sediment-profile images at each station. Coring artifacts drastically reduced the apparent cap thickness of the vibracores. Of the nine vibracores

collected, eight contained dragged down cap material along the sides of the core liner. One core did not appear to be affected by drag down but contained negligible amounts of cap material. Drag down, an artifact noted in the cores, reduced the thickness of the cap layer and explains the difference between the vibracore and box core results.

Vibracore Results

Cap material was a yellow-brown to tan-colored, coarse-grained sand, whereas the color of the EA sediment was a greenish-black to black. The interface between the EA sediment and cap material was easily identified in all of the vibracores. The cap thickness at station I05, based on the depth of the visual interface, ranged from 4 to 11 cm.

Two of the nine vibracores were analyzed for grain size, water content, specific gravity, and shear strength. Grain size data indicated the presence of cap material to a depth of 16 cm. The ratio of cap material to EA sediment decreased with depth. Distinct cap material was present only to a depth of 8 cm in Core I08 (Figure 5.11-6).

Horizon 1: surface material, 0-4 cm

The surface sediment, from the two cores analyzed, both contained sand (>0.25 mm), representing A-III Borrow Area material, and not detected in the baseline sediment cores. Course sand (0.5mm) was detected in the LD hopper samples at 35% frequency and at 9% in the supplemental cores. While the coarse sand (5%) detected in the LD hopper samples was found to be very similar at 4.3%. The increase in the sand fraction was the most significant change in grain size for Cell LD material (Table 5.11-5). The percent frequency of coarse silt and very fine sand (0.0625 to 0.0312 mm) changed very little over baseline values. The finer grained silts and clays had no noticeable changes in frequency. Core I08 contained distinct cap material in Horizon 1 (Figure 5.11-6). Core I05 indicated minimal accumulation of cap material (Figure 5.11-7).

Horizon 2: 4-8 cm

The sediment from both cores (I05 and I08) was analyzed from 4-8 cm for grain size (Table 5.11-5). The grain size results indicated that coarse (0.5 mm) and medium (0.25 mm) sand was present at a higher frequency than in baseline samples (Figures 5.11-6 and 5.11-7). The percent frequency of very fine sand and finer-grained sediments did not change significantly from baseline values and remain at baseline frequencies.

Horizon 3: 8-12 cm

The 8-12 cm horizon illustrated a slightly coarser variation of dominantly EA sediment and appeared to be the transitional horizon between cap material and EA sediment in Core I08. Finer-grained sediments continue to reflect EA concentrations while only minor changes in the medium and coarse sand are present (Table 5.11-6). Fine sand (0.125 mm) continued to be slightly elevated at 4% compared to 2% frequency in baseline. Coarse (1.3%) and medium (2%) sand remain slightly higher than EA frequencies of 0.1% and 0.2% respectively (Figures 5.11-6 and 5.11-7). Core I05 continues to indicate a minimal volume of cap material and was similar to Core I08 at this horizon. Overall, there is only a slight indication that cap material is present in this horizon.

Horizon 4: 12-16 cm

Both cores were analyzed from 12-16 cm. Horizon 4 continues the trends noted in horizon 3, as all grain sizes are similar to EA frequencies (Figures 5.11-6 and 5.11-7). Fine sand and finer grains are all at EA concentrations. While fine and medium sand concentrations remain 2% greater in frequency than in the EA. Coarse sand concentrations are similar to EA (0.8% and 0.1% respectively). There was a trace amount of cap material present at this horizon in Core I08, though only in negligible quantities (Table 5.11-6).

Horizon 5: 16-20 cm

Horizon 5 was the deepest horizon analyzed from Cell LD and consisted entirely of EA sediment. The distribution of sediment grain size fractions from this interval most similar to that found in the baseline survey. There was no geotechnical indication that cap material or the capping procedure affected this horizon (Figures 5.11-6 and 5.11-7, Table 5.11-7).

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

Bulk density was calculated for both wet and dry weight. The bulk density was consistent from core to core as well as with depth. Wet weight ranged from 1.7-2.1 g/cm^3 (1.8 g/cm^3 average). The dry weight ranged from 1.1-1.7 g/cm^3 w/ an average of 1.3 g/cm^3. Water content was more variable and ranged from 36% to 53%. Higher water contents were common in the upper 12 cm of sediment. Specific gravity was consistently 2.7 in every core and at all depths.

Atterberg limits were analyzed on 1 core at two horizons; 0-5 cm and 5-10 cm. The surface horizon was nonplastic, indicating that there were not enough fine-grained sediments to perform the analysis. The 5-12 cm sample had a LL of 40, a PL of 29 resulting in a PI of 11. The PI of the sediment in Cell LD continues to be within the range established during the baseline survey (9-14). Shear strength analysis was also conducted on 2 of the cores. The cores surface material up to about 8 cm was too sandy to conduct an accurate test. The shear strength results appeared to increase with depth; however, some variation was noted.

5.11.4.2 Chemical (DDE) Characteristics

Hopper Samples

The first three hopper loads from the A-III Borrow Area area were sampled for DDE in addition to geotechnical properties. DDE concentrations in the three hopper samples were 0.0025, 0.0013, and 0.0017 ppm. These values were consistent with DDE concentrations measured previously in Borrow Area sediment by EPA and USACE. Although DDE occurs at measurable levels in sediments throughout the Southern California Bight (Schiff and Gossett 1998), concentrations in Borrow Area sediment are one order of magnitude less than baseline levels for the Bight and several orders of magnitude less than values in baseline sediment within the pilot capping cells on the PV Shelf.

Baseline Survey

Concentrations of DDE in sediment core horizons (surface to 20 cm measured at 4-cm intervals) from within Cell LD ranged from 0.75 to 2.7 parts per million (ppm), and averaged approximately 1.5 ppm with no apparent trends with core depth (Figure 3.11-19). Similar to Cell LU, sediments from the seaward stations within Cell LD generally contained slightly higher concentrations than those from the landward stations. A plot of DDE concentrations in surface sediments (Figure 3.11-20) illustrates the general trends within Cell LD. 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. These results are 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 previously (Figure 3.11-19).

Postcapping Survey

As mentioned, no cores were collected immediately following cap placement in Cell LD. However, cores were collected at two stations during the supplemental coring survey for DDE analyses.

Supplemental Survey

Sediment DDE concentrations in cores collected from two stations in Cell LD during the supplemental coring survey ranged from 0.63 to 2.7 ppm, with the exception of an anomalously high concentration (10 ppm) in the 12 to 16 cm horizon of Core I08 (Table 5.11-8). The source of this high concentration, which was approximately four times greater than the maximum level measured in the baseline cores, is not apparent. Other than this one value, the DDE concentrations in the surface layers of the supplemental cores were not substantially different from those in the baseline cores and did not indicate the presence of any cap material. This finding was inconsistent with results from the supplemental SPI/PVC survey, which identified a cap layer ranging in thickness from 5.3 to >8.7 cm, and the core geotechnical results which indicated the presence of minor amounts of cap material along the core length. Similar to results from Cells LU and SU, this inconsistency appears to be attributable to coring artifacts. The results suggest that cap materials were present at the Cell LD sampling locations, but these were dragged down along the sides of the cores during sample collection. Cap materials likely contributed to grain size subsamples from the outer portions of the core, but did not contribute substantially to the chemistry subsamples.

Table 5.11-1. Summary of Sediment Cores and Core Analyses Performed During Baseline and Cap Monitoring in Cell LD

Cell LD Core Summary	DDE	Grain Size	Bulk Density	Specific Gravity	Water Content	Atterberg Limits	Shear Strength
Baseline							
11 cores	47	48	53	na	na	4	54
Post 1 Survey							
5 cores	na	1	1	na	na	na	na
Post Pump Out							
1 core	na	na	na	na	na	na	na
Supplemental Survey	11	12	8	6	8	2	9
Total Palos Verdes Project	58	61	62	6	8	6	63

Visual Descriptions of 29 cores from Cell LD

Table 5.11-2. Summary of Grain Size Characteristics of Cell LD Sediments During Baseline Survey

Palos Verdes Baseline Core Grain Size Data
Cell LD
LD Baseline Summary All Horizons

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	A Average LDB (0-4cm)	B Average LDB (4-8cm)	C Average LDB (8-12cm)	D Average LDB (12-16cm)	E Average LDB (16-20cm)	Standard Deviation LDB
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	0.06	0.08	0.00	0.02	0.11	0.04
Medium Sand	1	V. Coarse Sand	0	0.06	0.05	0.09	0.10	0.11	0.03
	0.5	Coarse Sand	1	0.13	0.10	0.16	0.15	0.21	0.04
Fine Sand	0.25	Medium Sand	2	0.22	0.22	0.26	0.32	0.40	0.08
	0.125	Fine Sand	3	2.00	2.04	2.05	2.12	2.38	0.15
	0.0625	V. Fine Sand	4	46.60	47.81	44.86	43.41	44.90	1.71
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	20.43	20.16	19.81	18.91	18.76	0.75
	0.0156	Medium Silt	6	8.41	8.22	8.49	9.55	8.30	0.54
	0.0078	Fine Silt	7	5.00	4.76	5.65	5.93	5.63	0.49
	0.0039	V. Fine Silt	8	1.80	1.74	1.87	1.93	1.98	0.10
	0.00195	Clay	9	3.66	3.63	4.11	4.36	4.23	0.33
	<0.00195	Clay	>9	11.64	11.19	12.63	13.21	13.00	0.88

Horizon	Average LDB (0-4cm)	Average LDB (4-8cm)	Average LDB (8-12cm)	Average LDB (12-16cm)	Average LDB (16-20cm)	Standard Deviation LDB
Gravel (>4mm)	0.00	0.00	0.00	0.00	0.00	0.00
Sand (0.0625-2mm)	49.07	50.29	47.43	46.12	48.10	1.58
Silt (0.0312-0.0039mm)	35.64	34.88	35.83	36.31	34.67	0.68
Clay (<0.00195mm)	15.29	14.82	16.74	17.56	17.23	1.21

Grain Size results based on % Frequency Weight

Table 5.11-3. Sediment Grain Size and Bulk Density in Post 1 Survey Cores from Cell LD

Palos Verdes Pilot Capping Project
LDH Composite Sample; Post 1 Survey
0-4 cm; cores LDH17A & LDH18A

Bulk Density (g/cc)	
Wet Unit Weight	1.88
Dry Unit Weight	1.24

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LDH Composite
Coarse Gravel	>32	V. Large Pebble	<-5	0.00
	16	Large Pebble	-4	0.00
Fine Gravel	8	Medium Pebble	-3	0.00
	4	Small Pebble	-2	0.00
Coarse Sand	2	Gravel	-1	0.00
Medium Sand	1	V. Coarse Sand	0	0.02
	0.5	Coarse Sand	1	0.11
Fine Sand	0.25	Medium Sand	2	0.63
	0.125	Fine Sand	3	3.77
	0.0625	V. Fine Sand	4	47.85
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	19.70
	0.0156	Medium Silt	6	7.63
	0.0078	Fine Silt	7	4.45
	0.0039	V. Fine Silt	8	2.90
	0.00195	Clay	9	2.10
	<0.00195	Clay	>9	10.85

Total % LDH Composite	
Gravel (>4mm)	0.00
Sand (0.0625-2mm)	52.38
Silt (0.0312-0.0039mm)	34.68
Clay (<0.00195mm)	12.94

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

Table 5.11-4. Supplemental Core Summary

Replicate ID Box Cores	Total Box Core Length (cm)	Interface EA Cap (cm)	Replicate ID Cores	Total Core Length (cm)	Interface EA Cap (cm)
LDSB2 I05A	14	11.5	LDSV1 I05A	121.5	11
LDSB4 I05A	21	12	LDSV1 I05B	55	rejected
-	-	-	LDSV1 I05C	120	4
-	-	-	LDSV3 I05A	72.5	rejected
-	-	-	LDSV4 I05A	86	6
-	-	-	LDSV1 I08A	82	rejected
LDSB4 I08A	17.5	10	LDSV1 I08B	86.5	8
-	-	-	LDSV4 I08A	92	5
-	-	-	LDSV4 I11A	62	5

Table 5.11-5. Grain Size distribution in Horizon 1 (0-4 cm) and Horizon 2 (4-8 cm) of the Supplemental Vibracores from Cell LD.

Palos Verdes Pilot Capping Project
LDS; Post 71 Placements, Supplemental Survey
Sediment Grain Size Summary Table:

				Sample Horizon 1 0-4 cm		Sample Horizon 2 4-8 cm	
ASTM (Unified) Classification	**Size in mm**	**Wentworth Classification**	**Phi Size**	**LDSV 4 105 A 0-4cm**	**LDSV 4 108 A 0-4cm**	**LDSV 4 105 A 4-8cm**	**LDSV 4 108 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	0.00	0.00	0.00
	4	Small Pebble	-2	0.00	0.00	0.00	0.00
Coarse Sand	2	Gravel	-1	0.14	0.38	0.05	0.35
Medium Sand	1	V. Coarse Sand	0	0.43	1.52	0.51	0.74
	0.5	Coarse Sand	1	1.93	6.71	1.38	4.69
Fine Sand	0.25	Medium Sand	2	3.62	13.72	2.49	9.09
	0.125	Fine Sand	3	2.98	7.49	3.88	6.81
	0.0625	V. Fine Sand	4	38.83	31.27	39.58	33.25
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	20.50	15.91	20.34	17.79
	0.0156	Medium Silt	6	8.17	6.91	8.40	7.52
	0.0078	Fine Silt	7	5.20	4.02	4.96	4.51
	0.0039	V. Fine Silt	8	3.70	2.56	3.42	3.08
	0.00195	Clay	9	2.47	1.98	2.41	1.89
	<0.00195	Clay	>9	12.03	7.53	12.57	10.29

Summary of LDSV 0-4cm Grain Size Data	**LDSV 4105A 0–4cm**	**LDSV 4108A 0–4cm**	**LDSV 4 105 A 4–8cm**	**LDSV 4 108 A 4–8cm**
Gravel (>4mm)	0.00	0.00	0.00	0.00
Sand (0.0625-2mm)	47.92	61.09	47.89	54.92
Silt (0.0312-0.0039mm)	37.58	29.40	37.13	32.90

Table 5.11-6. Grain Size distribution in Horizon 3 (8-12 cm) and Horizon 4 (12-16 cm) of the Supplemental Vibracores from Cell LD.

Palos Verdes Pilot Capping Project
LDS; Post 71 Placements, Supplemental Survey
Sediment Grain Size Summary Table:

				Sample Horizon 3 8-12 cm		Sample Horizon 4 12-16 cm	
ASTM (Unified) Classification	**Size in mm**	**Wentworth Classification**	**Phi Size**	**LDSV 4 I05 A 8-12cm**	**LDSV 4 I08 A 8-12cm**	**LDSV 4 I05 A 12-16cm**	**LDSV 4 I08 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	0.00	0.00	0.00	0.02
Coarse Sand	2	Gravel	-1	0.09	0.10	0.17	0.25
Medium Sand	1	V. Coarse Sand	0	0.32	0.49	0.26	0.29
	0.5	Coarse Sand	1	0.99	1.69	0.91	0.70
Fine Sand	0.25	Medium Sand	2	1.97	2.59	2.30	2.25
	0.125	Fine Sand	3	3.47	4.33	3.29	4.73
	0.0625	V. Fine Sand	4	40.83	42.40	40.69	42.40
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	20.68	17.08	21.46	18.89
	0.0156	Medium Silt	6	8.47	10.89	8.81	7.95
	0.0078	Fine Silt	7	5.29	4.78	5.19	4.93
	0.0039	V. Fine Silt	8	3.51	3.19	3.49	3.51
	0.00195	Clay	9	2.55	2.52	2.46	2.55
	<0.00195	Clay	>9	11.83	9.94	10.95	11.54

Summary of LDSV 8-12cm Grain Size Data	**LDSV 4 I05 A 8-12cm**	**LDSV 4 I08 A 8-12cm**	**LDSV 4 I05 A 12-16cm**	**LDSV 4 I08 A 12-16cm**
Gravel (>4mm)	0.00	0.00	0.00	0.02
Sand (0.0625-2mm)	47.67	51.60	47.63	50.61
Silt (0.0312-0.0039mm)	37.95	35.94	38.96	35.28
Clay (<0.00195mm)	14.38	12.47	13.42	14.09

Table 5.11-7. Grain Size distribution in Horizon 5 (16-20 cm) of the Supplemental Vibracores from Cell LD.

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

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	LDSV 4I05A 16-20 cm	LDSV 4I08A 16-20 cm
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	0.29	0.63
Medium Sand	1	V. Coarse Sand	0	0.29	0.34
	0.5	Coarse Sand	1	0.60	0.40
Fine Sand	0.25	Medium Sand	2	1.66	0.56
	0.125	Fine Sand	3	3.14	2.83
	0.0625	V. Fine Sand	4	49.18	45.28
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	22.18	20.36
	0.0156	Medium Silt	6	6.71	8.88
	0.0078	Fine Silt	7	3.73	5.21
	0.0039	V. Fine Silt	8	2.14	3.22
	0.00195	Clay	9	1.51	2.58
	<0.00195	Clay	>9	8.59	9.71

Summary of LDSV 16-20cm Grain Size Data	LDSV 4 I05 A 16-20 cm	LDSV 4 I08A 16-20 cm
Gravel (>4mm)	0.00	0.00
Sand (0.0625-2mm)	55.15	50.04
Silt (0.0312-0.0039mm)	34.75	37.67
Clay (<0.00195mm)	10.10	12.29

Table 5.11-8. DDE Concentrations (ppm dry weight) in Baseline and Supplemental Cores from Cell LD. Baseline core concentrations represent the average per core horizon from all nine sites.

	Baseline	**Supplemental Survey**	
Core Depth (cm)	Average – All Cores	I05	I08
0-4	1.3	1.3	1.1
4-8	1.6	2.3	2.1
8-12	1.4	1.1	2.7
12-16	1.5	0.73	10
16-20	1.7	0.63	1.5

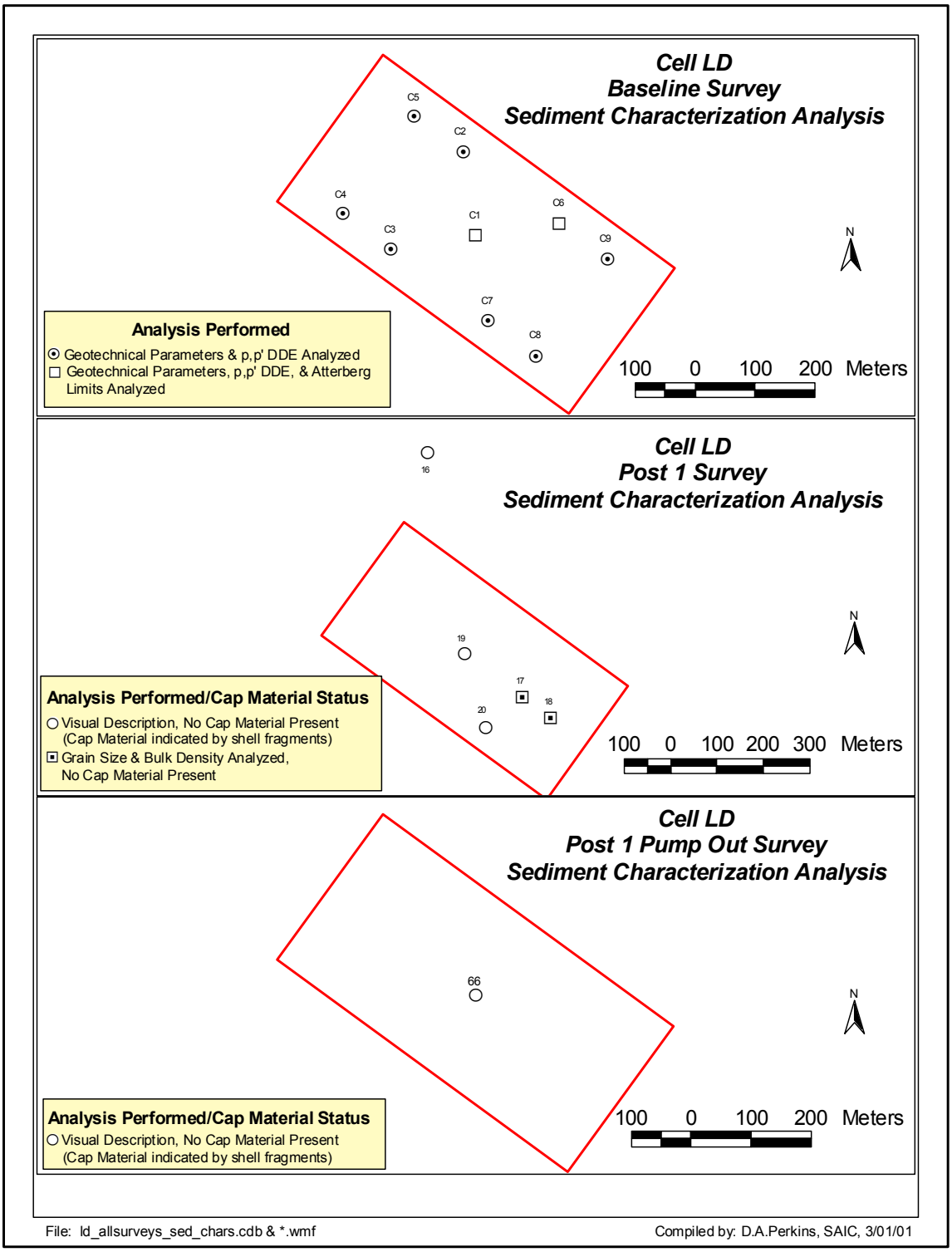

Figure 5.11-1. Coring locations in Cell LD during (a) Baseline, (b) Post 1, (c) Post 1 Pump-Out.

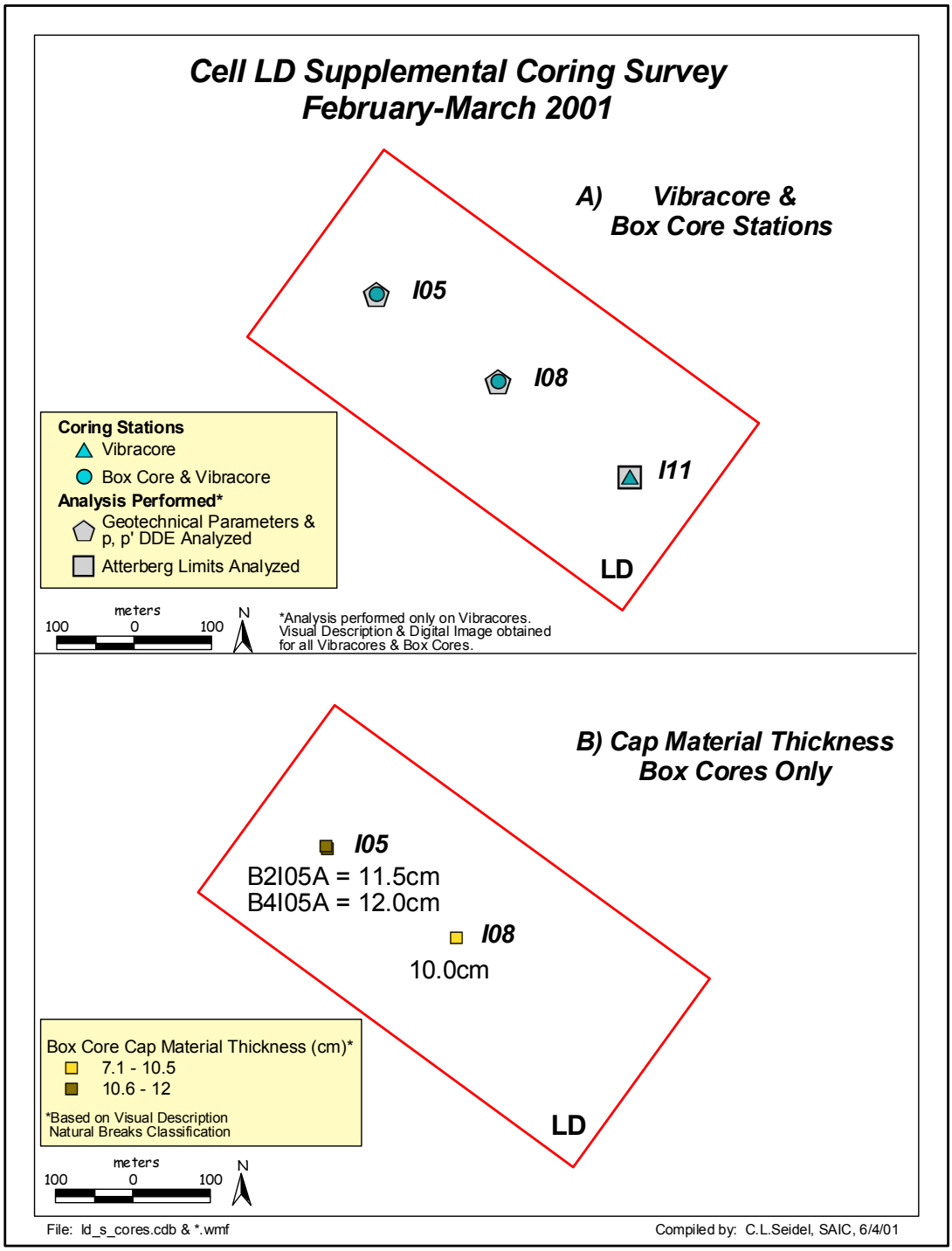

Figure 5.11-2. Vibracore (a) and Box Core (b) locations for Cell LU Supplemental Survey

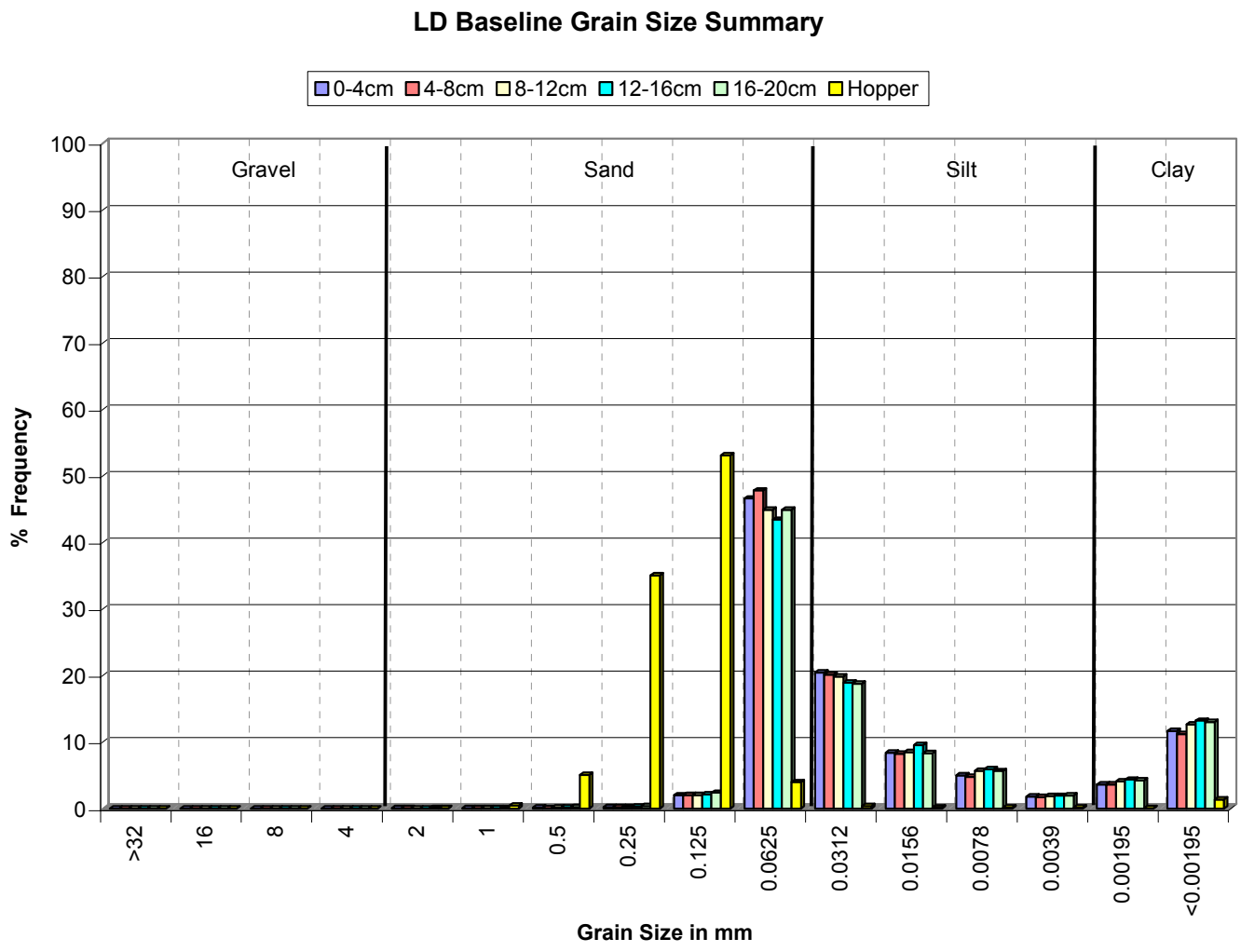

Figure 5.11-3. Grain size distributions of Cell LD baseline sediments.

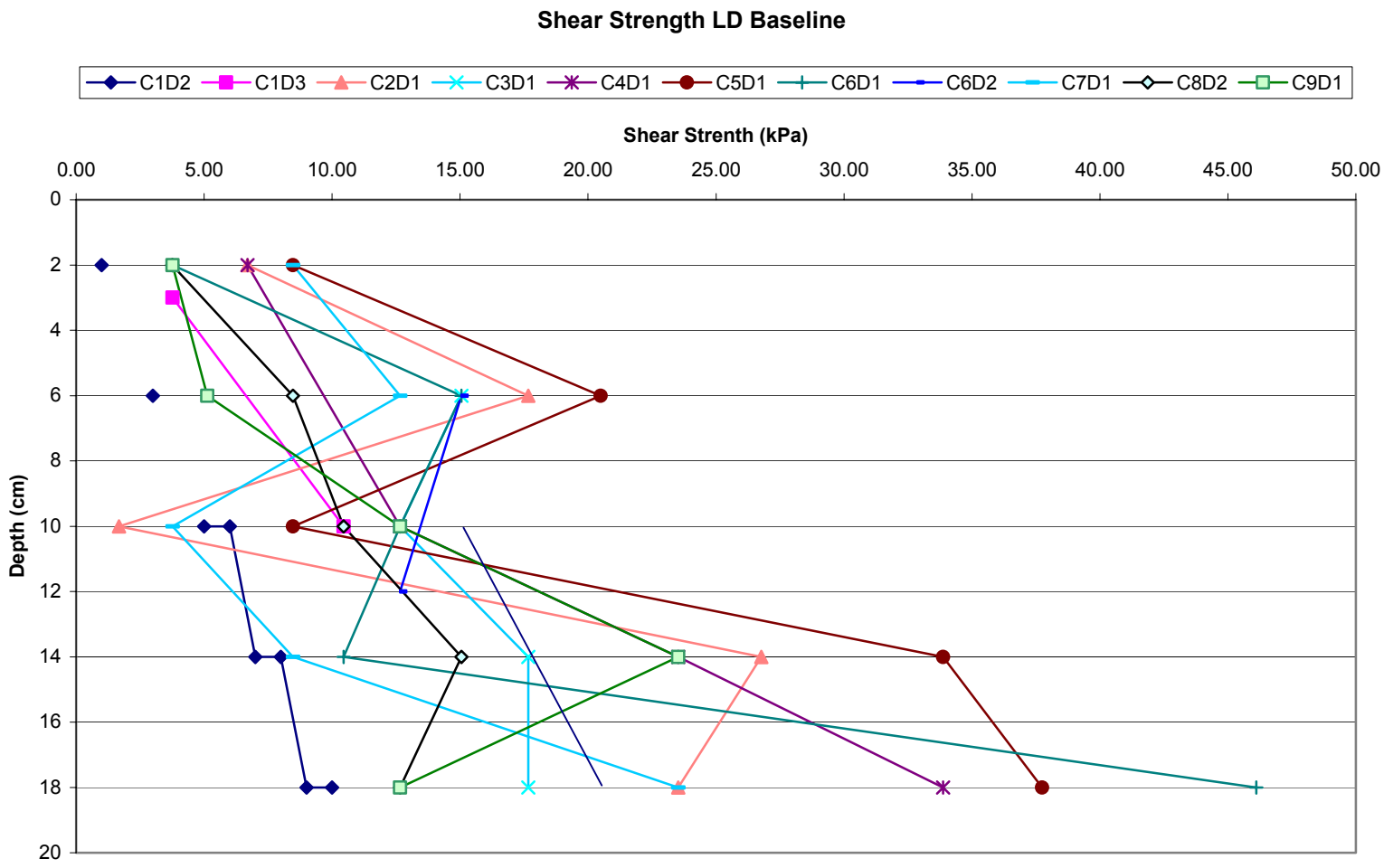

Figure 5.11-4. Profiles of shear strength values in baseline cores from Cell LD.

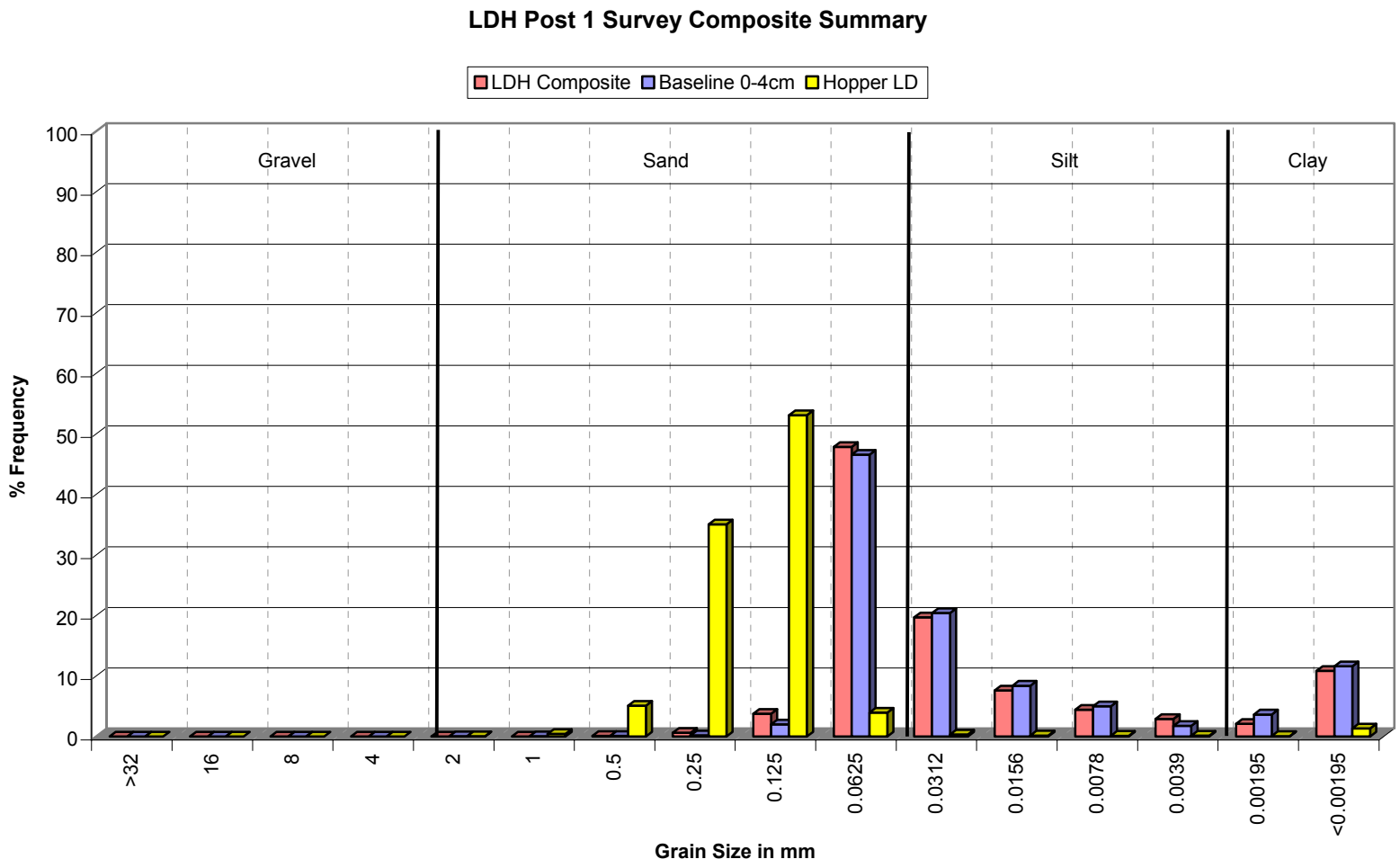

Figure 5.11-5. Grain size distributions of Cell LD Post 1 Composite Sediments.

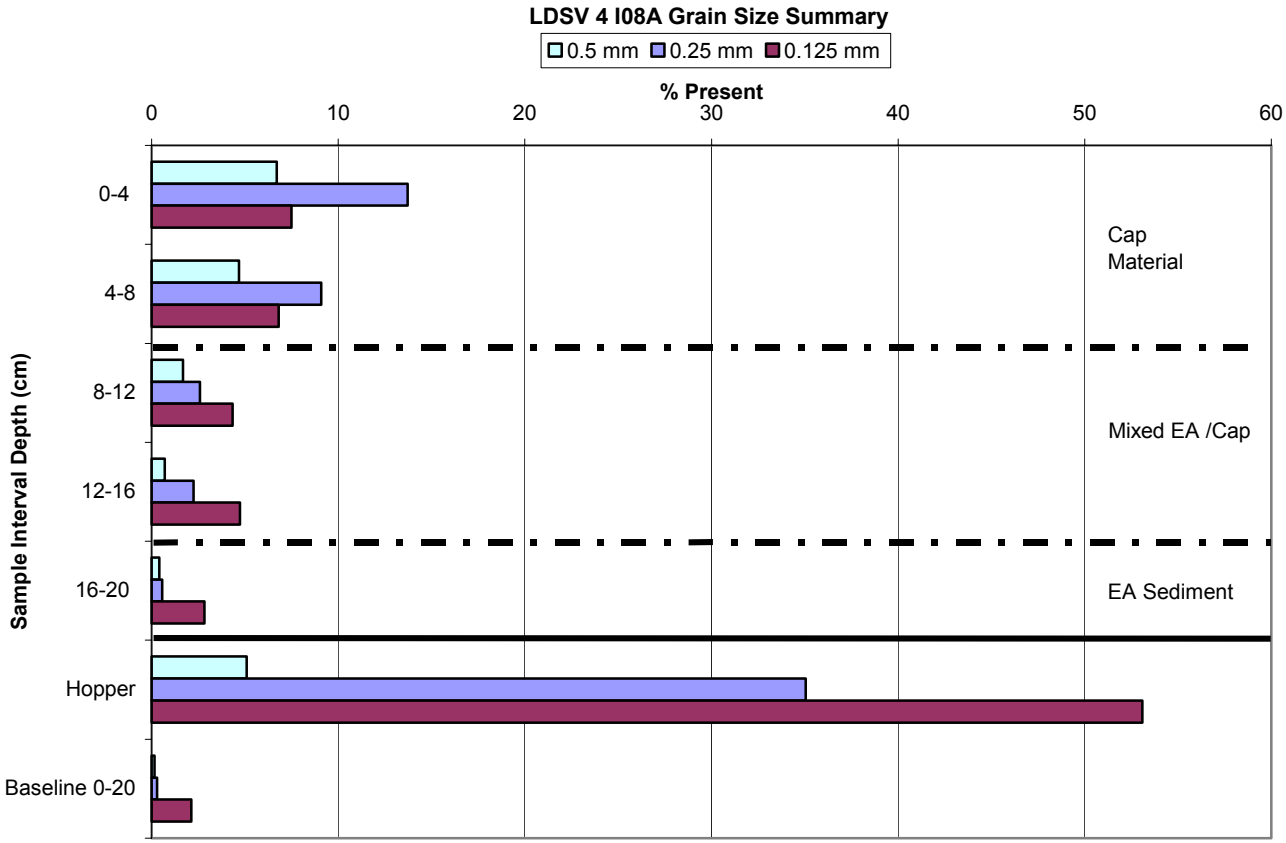

Figure 5.11-6. Grain Size distribution in Core I08 of the Supplemental Vibracore Survey from Cell LD for all Sampled Horizons. Hopper and Baseline averages are provided for comparison.

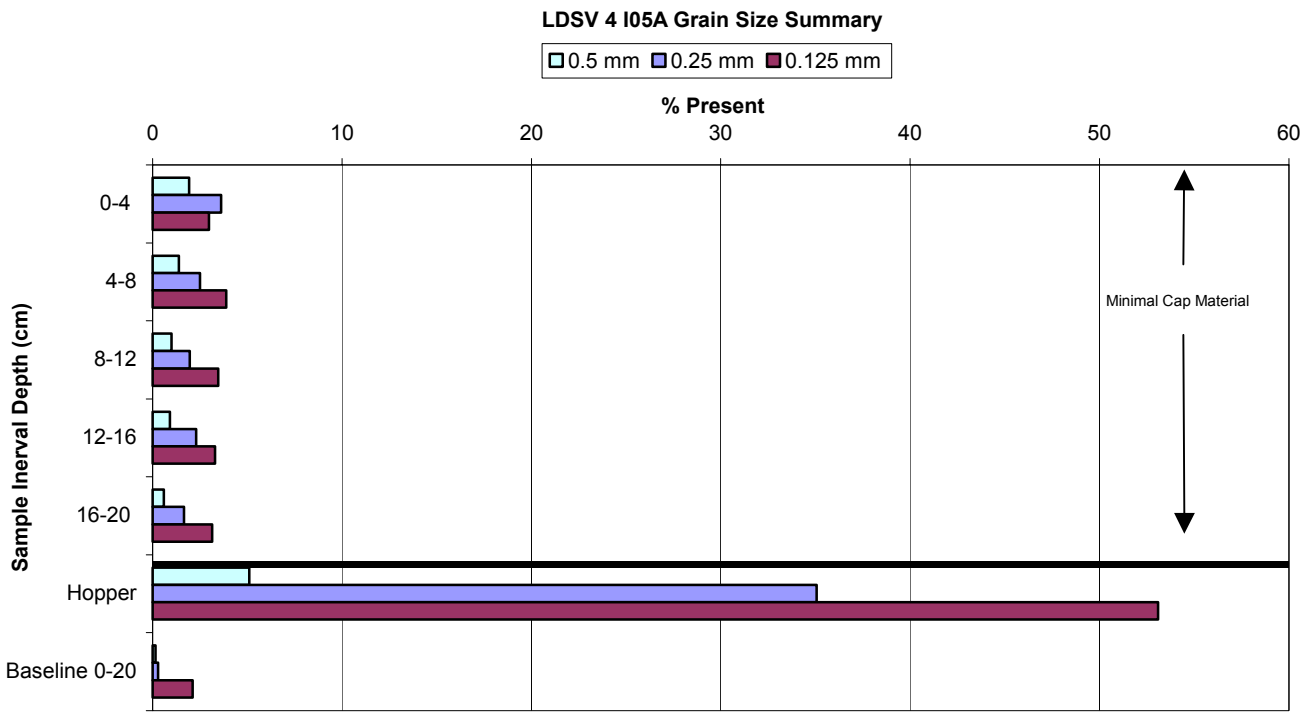

Figure 5.11-7. Grain Size distribution in Core I05 of the Supplemental Vibracore Survey from Cell LD. Hopper sample and Baseline averages are provided for comparison.

6.0 MONITORING RESULTS FROM CELL LC (PUMP-OUT PLACEMENT)

6.1 Schedule of Operations

The following provides an overview of monitoring activities within Cell LC. In contrast to monitoring within the other capping cells, no baseline monitoring was performed at Cell LC. Monitoring within Cell LC was added to the survey plan by USACE for the purpose of evaluating cap placement using a pump-out technique. A single cap placement event in Cell LC occurred on September 9, as summarized in Table 6.1-1. Placement positions are described in Section 6.2. The sampling event at Cell LC was not part of the original monitoring SOW (Fredette 2000), but was added to the survey plan by USACE during the cap placement program to evaluate the effectiveness of the placement method.

Table 6.1-1. Summary of Cap Placement Events in Cell LC

Placement Event #	Date	Cumulative Volume (m^3)	Positions	Hopper Sample No.
1	9/8/00	298	Center Line	LC-HOP 1

6.1.1 Baseline monitoring

With the exception of SPI/PVC sampling on September 6, no baseline monitoring was conducted in Cell LC.

6.1.2 Cap Placement Monitoring

Cap placement monitoring in Cell LC was conducted from September 8-9, 2000. Dates associated with individual sampling tasks are listed in Table 6.1-2, and a timeline of activities associated with cap placement monitoring is shown schematically in Figure 6.1-1. Results from each of the cap placement monitoring tasks in Cell SU are presented in Sections 6.2 through 5.11.

Table 6.1-2. Summary of Sampling Dates for Cap Placement Monitoring Activities in Cell LC

	SPI/PVC	Core	WQ
			none
Baseline	9/6	none	NA
Post Pump-Out	9/8	9/8	9/8

SPI/PV-sediment profile image/plan view camera; core-sediment coring; WQ-water quality

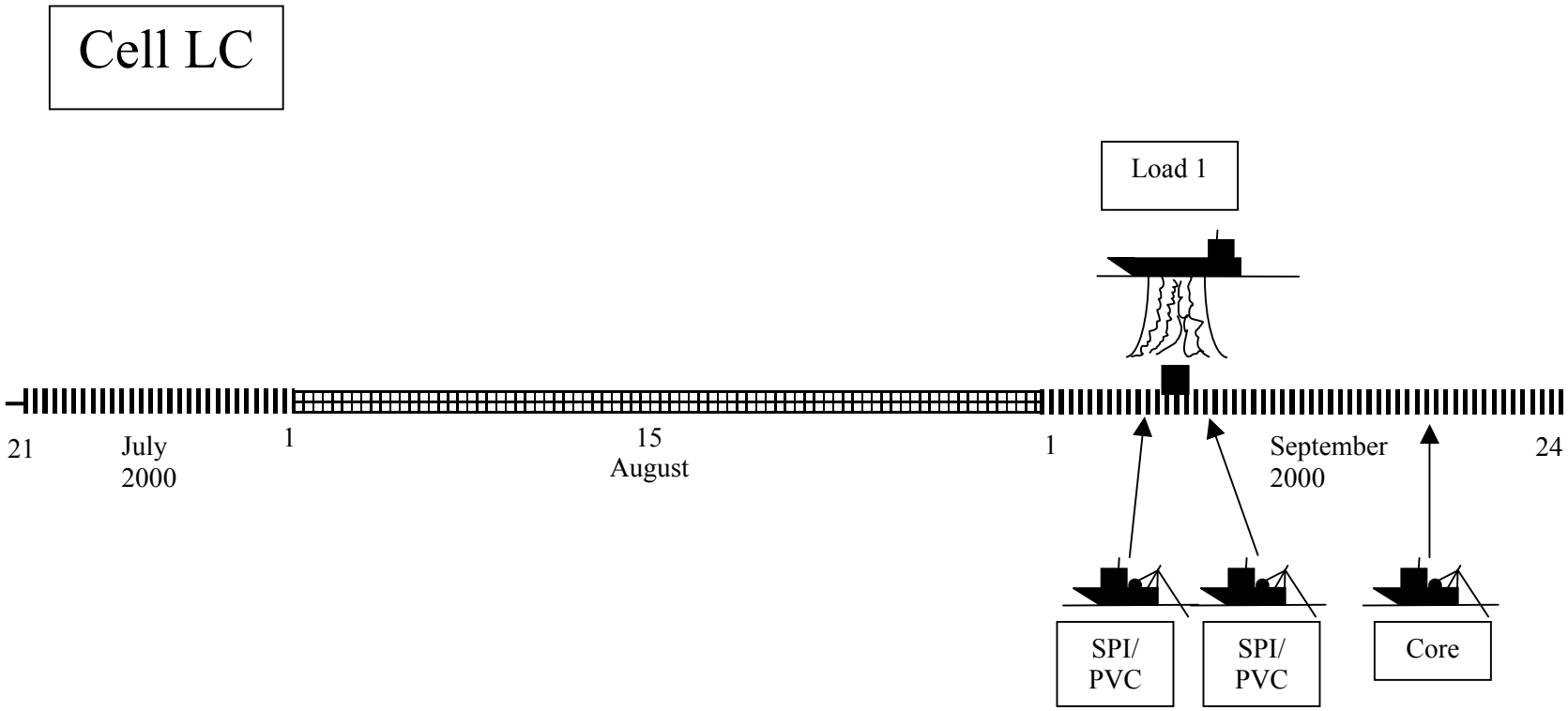

Figure 6.1-1. Activities timeline for Cell LC 21 July 2000-24 September 2000. Cap placement activity is indicated by the dredge symbol and solid bar. Monitoring activities are shown by the research vessel. Monitoring activity codes associated with the research vessel symbol are SPI-Sediment Profile Imaging, PVC-Plan View Camera, Core-Coring survey.

6.2 Hopper Dredge Monitoring during Cap Placement

6.2.1 Overview of the 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).

For the single cap material placement in Cell LC, material was dredged from the Queen's Gate Channel. Material placement in Cell LC was conducted using a "pump-out" technique where the dredged material was pumped out of the dredge through its starboard drag arm, which was locked in a downward orientation such that the drag head was situated at a depth of approximately 24 m below the surface. Consequently, the cap material was released at a constant depth of 24 m as the dredge moved slowly along the predetermined trackline through Cell LC.

6.2.2 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 during the 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 the single placement event in Cell LC.

6.2.3 Technical Considerations

For cap material monitoring in cells LU, SU and LD, the ADISS GPS antenna was installed along the centerline of the hopper dredge because material was released from the hopper during both the conventional (cells LU and SU) and spreading (Cell LD) procedures. This antenna was relocated to the starboard side of the dredge's flying bridge for the pump-out operations in Cell LC, and a measurement was made from the antenna to the top of the starboard drag arm in order that the ADISS position data would accurately represent the location of cap material release during the pump-out operations.

No technical problems were associated with dredge operational monitoring in Cell LC, except for unsuccessful attempts to incorporate a digital compass into the ADISS data acquisition system.

6.2.4 Monitoring Results

For cap placement operations in Cell LC, ADISS recorded the dredge's position and draft during the loading, transit from the dredging site to the cell, and during pump-out operations in the cell. Figure 6.2-1 presents the ADISS dredge position data acquired during spreading Event 1 in Cell LC on September 9, 2000, with data points representing individual positions of the dredge acquired at 6-sec intervals as the dredge moved northwestward along the axis of cells LU, LC and LD at an average speed

of 2.2 knots. Cap material was pumped out for a period of 21 min, 23 sec while the dredge traveled a distance of 1530 m along the trackline shown in Figure 6.2-1.

Figure 6.2-2 presents a plot of hopper dredge draft versus time during the entire operation leading up to the placement in Cell LC. Dredge positions were recorded at 6-sec intervals while the dredge was being loaded (see period of rapidly increasing draft near 2300 GMT on September 8). 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 beginning at 2345 GMT on September 8 in Figure 6.2-2). As the dredge approached the target cell on the Palos Verdes Shelf, the ADISS software automatically returned to a 6-sec sampling period during the final stages of the transit and throughout the cap placement (pump-out) operation.

At 0024 GMT on September 9, the pump-out operation began as the dredge moved along the centerline of Cell LU, approaching Cell LC. As evident in Figure 6.2-2, the rate of change in draft was very constant due to the constant rate which cap material was pumped out of the starboard drag arm. A total of 298 m^3 of material was released during the 21-min pump-out period along the trackline from Cell LU, through Cell LC and continuing past the northwest boundary of Cell LD (Figure 6.2-1). This 14 m^3/min discharge rate was 11 times less than the average spreading rate for the nine events in Cell LD (155 m^3/min), and 15 times less than the average conventional release rate for the 71 events in Cell LU (212 m^3/min).

In terms of the cap material volume released within an 85-m dredge vessel length along the trackline shown in Figure 6.2-1, the pump-out operation released 298 m^3 of material in 18 dredge lengths (1530 m) which translates to only 17 m^3 of material per dredge length. This volume per dredge length was 10 times less than the average volume-per-length during spreading events in Cell LD (164 m^3/85 m), and 59 times less than the volume-per-length during individual conventional placements in Cell LU (983 m^3/85 m). Consequently, we should expect that the amount of cap material placed on the seafloor per unit length of track during the pump-out operation in Cell LC would be much less than placed during either the spreading or conventional placement operations.

As a final comment on the pump-out operation, it should be recognized that pumping requires continuous addition of significant volumes of water, such that the slurry discharged from the drag head at 24 m depth probably had low solids content at the point of release. And because the drag head was pointed forward (in the direction the dredge was moving), dispersion of the slurry would be enhanced by conventional bulk-mixing processes. Consequently, we should expect the 17 m^3 of material released per 85-m length of trackline would be highly mixed at its point of release from the drag arm, and settling of the particulates would be much slower than encountered during conventional releases when a large fraction of the material may "clump" and settle at greater speeds than would individual particles (e.g., Stokes settling). Results of water column monitoring within sediment plumes generated from the conventional, spreading, and pump-out operations should illustrate any differences between suspended particulate concentrations resulting from the different placement operations.

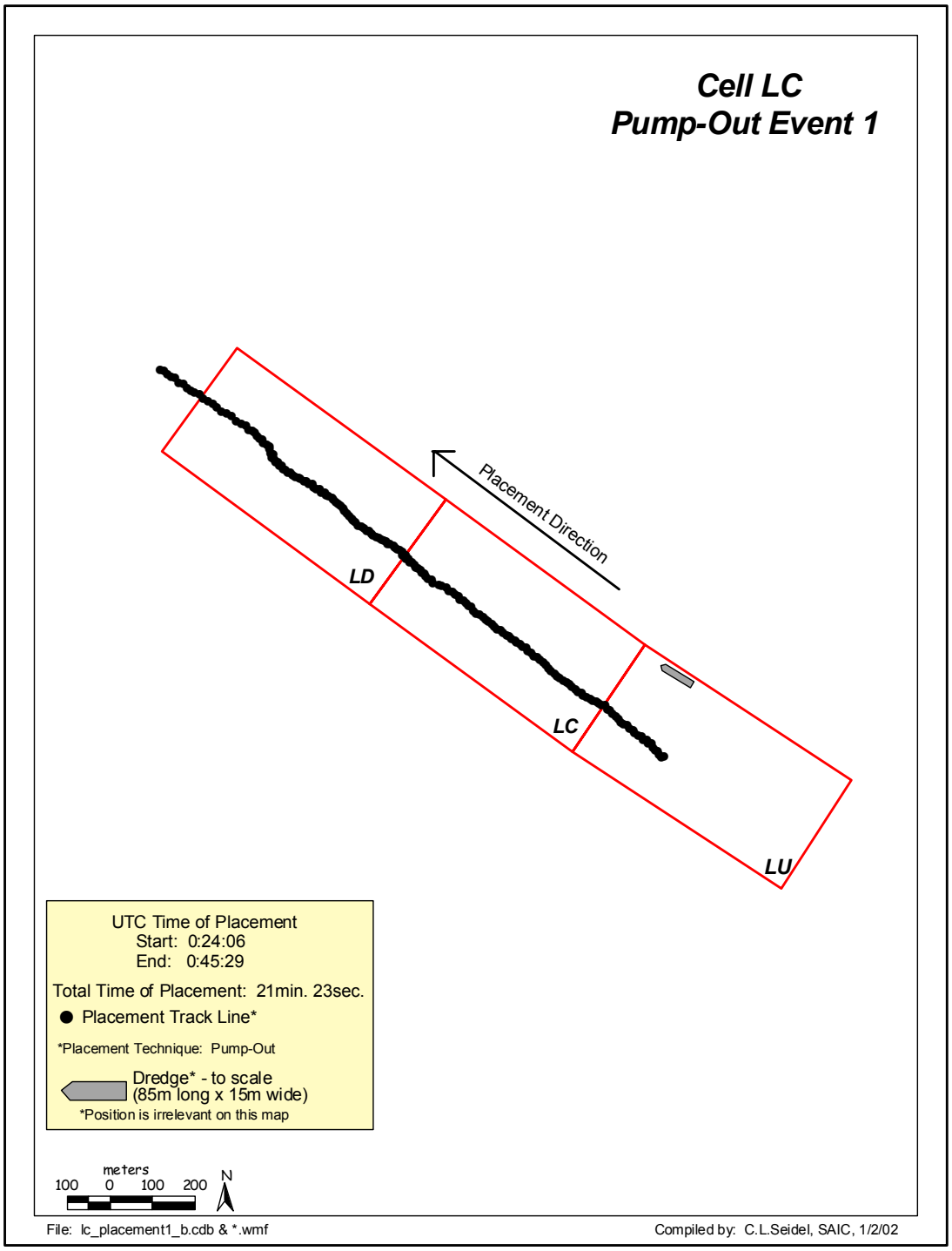

Figure 6.2-1. Map illustrating cells LU, LC and LD on the Palos Verdes Shelf and the trackline of the hopper dredge *Sugar Island* as it traveled northwestward along the axis of the cells during pump-out Event 1 on September 9, 2000. Dredge position data were acquired by ADISS.

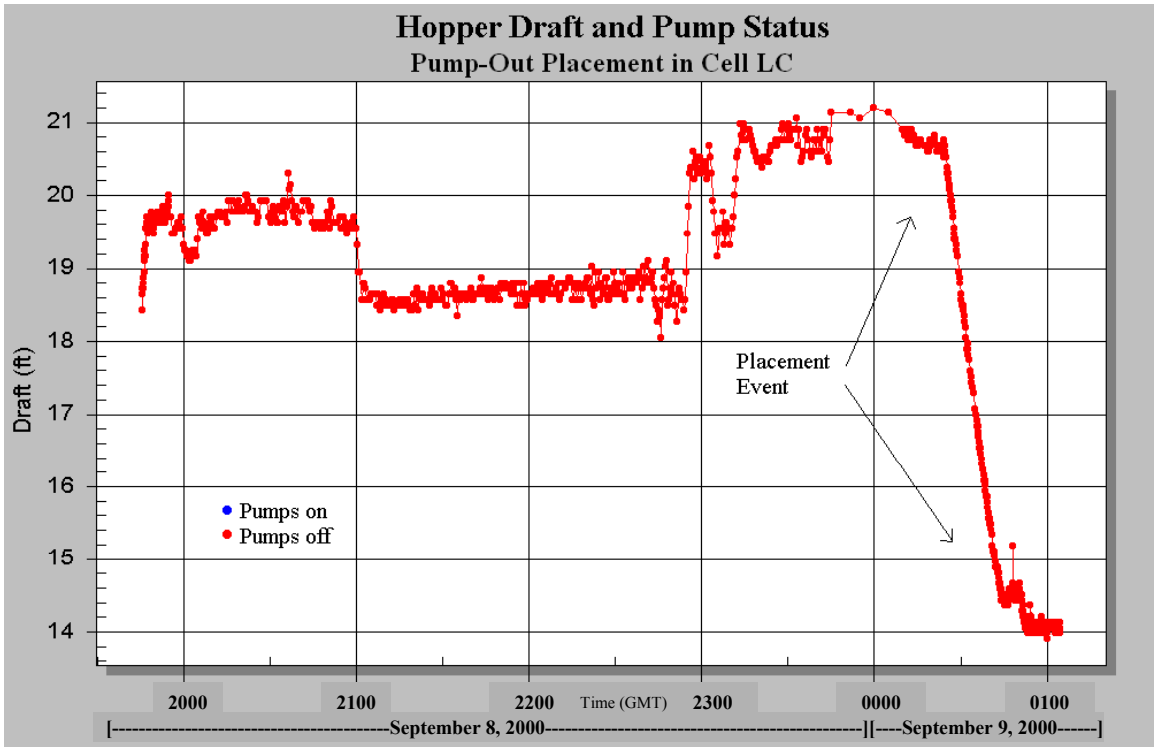

Figure 6.2-2. Time series plot of the draft of the hopper dredge *Sugar Island* during loading, transit and pump-out of cap material in Cells LU, LC and LD during Event 1 on September 9, 2000. Dredge draft data were acquired by ADISS.

6.3 Drogue Trajectory Results

6.3.1 Overview of Field Sampling Plan

The monitoring objectives for water quality measurements in Cell LC (Section 6.4) focus on sampling within the near-bottom plume of suspended sediments associated with the pump-out operation of cap material placement in Cell LC. 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.

6.3.2 Review of Data Quality Objectives

There were no Data Quality Objectives for water quality monitoring (see Table 3.5-2) during the pump-out operation in Cell LC because this placement operation (and associated monitoring) was not planned. Nevertheless, monitoring was conducted during this single pump-out event using the procedures established for water quality monitoring in Cells LU, SU and LD and with the goal of collecting water samples from near-bottom plumes at varying times following the cap placement event. As stated, coordination between the cap placement vessel and the survey vessel supporting the water quality measurements was critical for acquisition of data that could be used to achieve the water quality monitoring objectives established for the events in other cells. Although the use of water-following drogues had not been included in the PWP (SAIC 2001), this ancillary technique was critical for aiding vessel positioning during plume tracking operations in Cell LC, especially since there was no ADCP monitoring being conducted during this placement operation.

6.3.3 Technical Considerations

Drogue Configuration

Two water-following "holey-sock" drogues were deployed and visually tracked during monitoring of cap placement operations in Cell LC 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 LC was 42 m, identical to that of Cell LU. Depths increase gradually to the south of Cell LC and decrease toward shore, as had been observed in the vicinity of Cell LU. The strategy for drogue deployment in Cell LC was identical to that for Cell LU, with drogues tethered at 15- and 30-m depths and marker flags uniquely assigned for deep and shallow drogues.

6.3.4 Monitoring Results

Placement Event 1

Two drogues were deployed at 0033 GMT on September 8, 2000, corresponding with the commencement of cap placement (pump-out) operations during Event 1 in Cell LC. As demonstrated in Figure 6.3-1, the shallow (15-m) drogue moved eastward a distance of only 216 m during the 1 hr, 39 min drift period. The average horizontal speed of this drogue was 3.6 cm/s on a heading of 95°T (see Table

3.4-1). The deeper (30-m) drogue moved north-northeastward a distance of 296 m, with an average speed of 4.0 cm/s toward 32°T.

Because high water on the PV Shelf occurred at 0112 GMT, the drogue tracks corresponded with the end of the flood tide and the beginning of the ebb tide in the study area. These eastward trajectories at both the 15- and 30-m drogue depths are consistent with the notion of a weak onshore component to the flow during the flood tide in this region. Comparison with simultaneous current measurements from moored instrumentation is not feasible because the instrument arrays were not deployed during placement Event 1 in Cell LC.

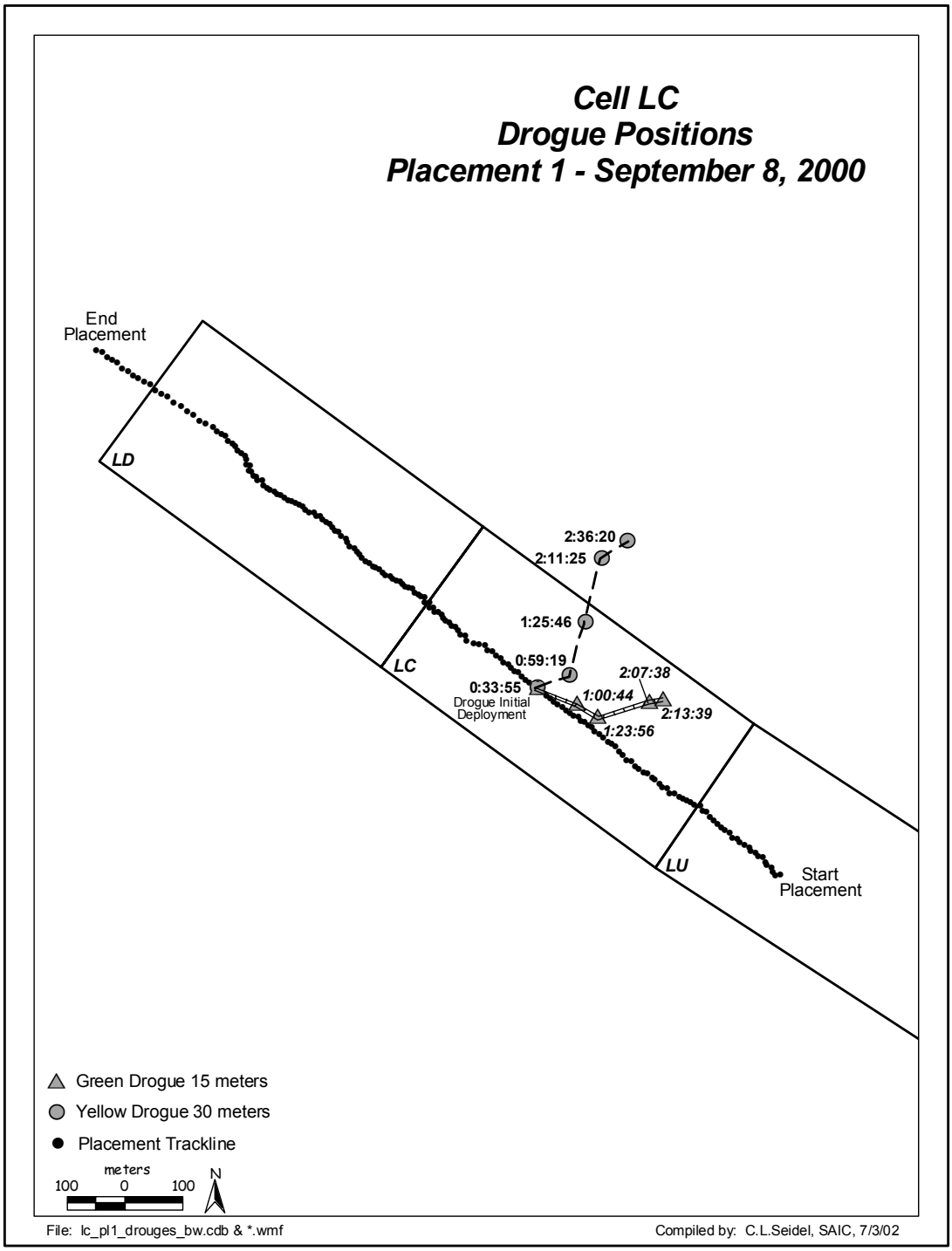

Figure 6.3-1. Map of Cell LC indicating trajectories of two drogues during water quality monitoring of placement Event 1 in Cell LC on September 8, 2000.

6.4 Water Column Monitoring Results

6.4.1 Overview of Field Sampling Plan

Water column monitoring during cap placement operations in Cell LC followed the same field procedures as implemented for Cells LU and SU (see 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 pump-out placement event.

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

As discussed in Section 6.3, 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 plume. The ADCP system, which had been employed from a separate survey vessel during the other water quality surveys, was neither planned nor available for current velocity and turbidity profile measurements during the monitoring event in Cell LC.

6.4.2 Review of Data Quality Objectives

6.4.2.1 Water Quality Objectives

The monitoring objectives and approach for water quality measurements in Cell LC were consistent with those presented in Table 3.5-1 for Cell LU. Note that the initial water samples in Cell LC were collected 15 min after commencement of the pump-out event, but within 5 min of when the hopper dredge passed the stationary CTD survey vessel as it was situated near the center of Cell LC. The pump-out operation started as the dredge was moving northwestward from Cell LU, into and along the axis of Cell LC, then through Cell LD (see Section 6.2 for further description of the pump-out operation).

All water quality monitoring objectives were met during monitoring of the pump-out event in Cell LC and no problems were encountered with the mechanical components of the rosette water sampling device.

6.4.2.2 Plume Mapping Objectives

The monitoring objectives and approach for plume mapping operations in Cell LC 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 a single placement event. Water-following drogues proved to be useful as real-time indicators of the movement of the near-bottom plume (see Section 6.3).

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.

6.4.3 Technical Considerations

The dredged material used for capping operations in Cell LC originated from the Queen's Gate Channel, as for capping operations in Cells LU and SU. Cap placement in Cell LC was implemented using the pump-out technique, whereby material was pumped out of the hopper dredge's starboard drag arm as the dredged moved at a constant speed of roughly 3 kts. The capping material was released from the drag arm situated at a depth of 80 ft (24 m) below the sea surface. As discussed in Section 6.2, only 298 m^3 of cap material was released along the entire track of the pump-out event; consequently, the volume of cap material released per unit of track length through Cell LC was one-tenth of the volume released during the spreading operation in Cell LD. For this reason, the plume of suspended cap material resulting from the pump-out operation was expected to be much less turbid than plumes generated from cap material release during conventional and spreading operations.

As described in Section 6.3, the water quality monitoring studies were conducted in conjunction with tracking of water-following drogues. For the single cap placement event monitored in Cell LC, holey-sock drogues were situated at 15-m and 30-m depths as during monitoring activities in Cells LU and LD. These drogue depths were selected because the average water depth at Cell LC (roughly 43 m) was essentially the same as that within the two adjacent cells (LU and LD).

6.4.4 Monitoring Results

Water quality monitoring studies using the CTD, transmissometer, and Niskin bottles with rosette sampler were conducted at Cell LC during pump-out Event 1 on September 8, 2000. The sampling methodology followed the Field Sampling Plan as summarized in Section 3.5.1.

6.4.4.1 Plume Survey during Pump-Out Event 1

A summary of all CTD profile measurements and water samples collected during Event 1 in Cell LC is provided in Table 6.4-1. Specific details regarding the sampling operations can be found in the Cruise Report (SAIC 2000b).

Prior to commencement of pump-out Event 1, one CTD profile was made within Cell LC to assess background water properties in the vicinity of the planned capping operation. Background turbidity characteristics were generally similar to background conditions observed on other survey days, and vertical profiles exhibited only minor turbidity variations with depth from the surface to the bottom. Table 6.4-1 provides the minimum percent light transmittance (equivalent to maximum turbidity) for the background CTD station made prior to Event 1 in Cell LC; as during other events, the minimum percent light transmittance within the water column was 72%.

Pump-out Event 1 in Cell LC began at 0024 GMT on September 8, 2000. Upon initiation of the pump-out operation from the hopper dredge, the CTD survey vessel was positioned seaward of the long axis of Cell LC, awaiting passage of the dredge as it moved slowly toward the northwest, along the axis

of the cell (Figure 6.4-1). At the time the dredge passed the survey vessel, the CTD profiler was situated 2 m above the bottom in order to detect the leading edge of the turbid plume associated with the spreading surge current. This feature was readily apparent, as percent light transmittance (PLT) decreased to 0% as the surge passed the CTD/transmissometer sensors. Shortly after the surge arrived, the CTD was raised and lowered over the depth range from roughly 20 to 40 m in order to determine the thickness and PLT within the near-bottom plume. During this CTD station (designated as LC-1D-CTD1 in Table 6.4-1) two near-bottom profiles were acquired and 13 water samples were collected within 29 min of the initiation of cap placement. The next CTD profile began 45 min after initiation of the pump-out operation.

During the first 2 hrs following pump-out Event 1, a total of four CTD profile stations were occupied. Table 6.4-1 indicates that 13 near-bottom profiles were acquired at these four 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. As seen in this table, the minimum PLT was 0% during both CTD 1 and 2, the latter station being occupied approximately 50 min after initiation of the pump-out operation.

To illustrate the characteristics of the near-bottom plume observed at approximately 90 min after initiation of the pump-out event, Figure 6.4-2 presents a 15-min segment of the time series of PLT and CTD sensor depth acquired during CTD 3. This station was located approximately 110 m landward of the track of the hopper dredge, where the water depth was approximately 42 m (Figure 6.4-1). During this 15-min time segment, the CTD/transmissometer was raised and lowered three times, and the near-bottom plume was observed to reside between 30 m depth and the bottom; the minimum PLT of 23% was encountered 5 m above the bottom.

For each of the four CTD stations, the survey vessel remained in close proximity to the 30-m drogue location in an attempt to follow the near-bottom flow. These drogue tracks showed that currents were directed northward and were very weak, such that the drogue was only 250 m north of the dredge trackline two hours after the pump-out event (Figure 6.4-1).

The temporal evolution of turbidity within the near-bottom plume resulting from pump-out Event 1 in Cell LC is illustrated in Figure 6.4-3. This figure illustrates that the minimum PLT during the first hour after the pump-out event was very low, followed by gradual increases over the next hour. The fact that this plume of suspended cap material was easily detected two hours after pump-out from the dredge was surprising, considering the relatively small amount of material that was pumped into the receiving water at a depth of 80 ft (24 m), which corresponded with a height of 19 m above the seafloor.

A total of 31 water samples were collected within the near-bottom plume during the first 2 hrs following the pump-out operation in Cell LC. Table 6.4-2 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 two background (pre-placement) samples indicated that ambient TSS concentrations were approximately 2 mg/L and ambient DDE concentrations averaged 0.0048 μg/L.

To graphically illustrate the temporal characteristics of TSS and DDE from within the near-bottom plume for pump-out Event 1, Figures 6.4-4 and 6.4-5 present the laboratory results (Table 6.4-2) plotted versus the actual sample collection time following initiation of the cap placement operation. As illustrated in Figure 6.4-4, TSS concentrations were highest within samples collected during the first 30 min (CTD 1). The highest value (30 mg/L) was measured within 1 m of the bottom 16 min after initiation

of the pump-out operation. Light transmission values concurrently measured by the CTD profiler were 0%, confirming that the discrete water samples were collected from within the plume. Samples acquired during CTD stations 2 through 4 (from roughly 45 min to 2 hrs after initiation of pump-out) had TSS concentrations that generally decreased with time, approaching background levels near the end of the sampling operations. During water sampling for each CTD station, some of the samples were collected outside of (e.g., above) the near-bottom plume; this was evident from the TSS concentrations which were close or equal to background concentrations.

An interesting result from this survey is that the transmissometer (PLT) data suggested that the near-bottom plume was very turbid, especially during the first hour after initiation of the pump-out operation, but the TSS data revealed that suspended solids concentrations were actually quite low compared with the near-bottom plumes surveyed during conventional placement operations in Cells LU and SU, and cap spreading operations in Cell LD. We suspect that the pump-out operation was very effective at homogenizing the discharge that contained a relatively small volume of Queen's Gate cap material. And because there would be little, if any, clumping of cap material during the pump-out operation, the settling rate of the cap material would be governed by Stokes law for individual particles, which is substantially less than the settling rate for clumps of material.

The time series of DDE concentrations in samples from the near-bottom plume associated with pump-out Event 1 (Figure 6.4-5) illustrated that concentrations were not significantly above background levels during CTD 1 nor within any of the samples acquired within the first two hours after initiation of the pump-out event. These data represent evidence that the pump-out operation in Cell LC did not resuspend significant volumes of EA sediment.

The primary results from this plume survey during pump-out Event 1 in Cell LC can be summarized as follows:

- The near-bottom plume could easily be tracked using the CTD/transmissometer and water following drogues.
- Water samples could be collected from within the most concentrated portion of the turbid, near-bottom plume.
- The near-bottom plume was 10 to 15 m thick shortly after the placement event and highest turbidity concentrations were observed close to the bottom. Turbidities remained high within the first hour following the pump-out event and increased very slowly thereafter, such that turbidities were well above background levels for at least 2 hrs after the pump-out event.
- The highest TSS concentration of discrete water samples from the plume (30 mg/L) was measured 16 min after initiation of the pump-out event (shortly after the dredge passed the stationary survey vessel). TSS concentrations within the near-bottom plume decreased gradually over the next two hours. The turbidity and TSS results suggest that the pump-out operation resulted in a homogenized plume that was easy to track with the transmissometer, but contained much lower TSS concentrations than had been encountered during conventional placements and spreading events in other cells.
- The highest DDE concentration from water samples within the plume (0.0082 μg/L) was measured 16 min after initiation of the pump-out event, within the same water sample as the maximum observed TSS concentration (30 mg/L). This maximum DDE concentration was only a factor of two higher than background concentrations. DDE concentrations within the plume were close to background levels for all subsequent samples collected within the 2-hr sampling period.

6.4.5 Discussion

Water column profiling was conducted during pump-out of Queen's Gate material during Event 1 in Cell LC 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 effective for indicating the trajectory of the near-bottom flow such that CTD profiles made in close proximity to the deepest (30-m) drogue were definitely within the plume. ADCP current and acoustic backscatter data were not acquired during the pump-out event.

Turbidity Profile Observations

Percent light transmittance data measured in Cell LC by the CTD/transmissometer revealed that turbidity within the near-bottom plume was high within the first 50 min following initiation of pump-out from the dredge. As illustrated in Figure 4.5-6 (see Section 4.5 on water quality results from Cell SU), these persistently high turbidities were equal to or greater than turbidities measured in plumes associated with conventional placement of Queen's Gate material in Cells LU and SU, despite much less material being released at a given location during the pump-out event in Cell LC (see Section 6.2).

During the period from 1 to 2 hrs following the pump-out event, turbidities in the near-bottom plume within Cell LC were very similar to those measured during the conventional placements in other cells. Most noticeable in Figure 4.5-6 is that turbidities resulting from the spreading event in Cell LD were much lower than turbidities resulting from the pump-out method in Cell LC, despite 10 times more material being released (per unit of track length) during the spreading event. This lower turbidity was presumably due to the coarser borrow area material being spread in Cell LD and its greater settling rate compared to the Queen's Gate material pumped in Cell LC, which contained a greater percentage of fine-grained material that could remain suspended in the water column for longer periods of time.

TSS Observations from Discrete Samples

Water samples collected prior to the pump-out operation in Cell LC 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 measured during three conventional placements in Cell LU nor during the spreading event in Cell LD (Figure 4.5-7). We suspect that the lower TSS concentration in the plume associated with the pump-out event in Cell LC was due to less cap material being released at a specific location within the cell compared with both the conventional (point) placements and the spreading event that discharged 10 times more material along the hopper dredge's track line than was released during the pump-out event.

The comparison of TSS results from the various placement events in Cells LU, SU, LD and LC (Figure 4.5-7) also illustrates that TSS concentrations in the plume associated with the pump-out operation were significantly lower than concentrations resulting from the majority of conventional placements in Cells LU and SU for the time period from 1 to 2 hrs after each placement operation. (Note that all placements in Cells LU, SU and LC used Queen's Gate material.) The TSS concentration in the plume resulting from the spreading event in Cell LD was slightly lower, presumably because it contained borrow area material that settled quicker due to its larger grain size.

DDE Observations from Discrete Samples

Ten of the near-bottom water samples collected within Cell LC and analyzed for TSS concentration were analyzed for DDE concentration. Water samples collected prior to the pump-out operation demonstrated that background DDE concentrations were very low, ranging from 0.0047 to 0.0049 μg/L. Following the cap placement operation, the highest observed DDE concentration (0.0082 μg/L) was obtained from a sample collected 16 min after initiation of the pump-out operation. This sample from the near-bottom plume suggests that significant volumes of contaminated EA sediment were not resuspended by the descending cap material during the pump-out event. This maximum observed

concentration was relatively low and only a factor of two higher than background concentrations observed immediately prior to the pump-out operation. All subsequent water samples collected from the near-bottom plume had DDE concentrations that were comparable to or below background levels.

Table 6.4-1. Summary of CTD profiles acquired and water samples collected during pump-out Event 1 in Cell LC on September 8, 2000. Also given is the maximum turbidity (minimum percent light transmission) observed by the transmissometer interfaced to the CTD system during each profile.

Start Time After Placement (hr:min:sec)	Background	0:13:53	0:45:21	1:07:15	1:55:40
File/Cast End Time	Background	0:29:01	0:51:53	1:38:47	2:08:05
Elapsed Time of Cast	0:07:56	0:15:48	0:06:32	0:31:32	0:13:15
CTD File Name	LC-1B-CTD1	LC-1D-CTD1	LC-1D-CTD2	LC-1D-CTD3	LC-1D-CTD4
Total Water Column Profiles	1	1	1	1	1
Near Bottom Profiles	2	2	2	6	3
Water Samples Collected	2	13	5	11	2
Minimum % Light Transmittance (PLT)	72	0	0	23	26
Depth of Minimum Turbidity	B-11m	B-1m	B-1m	B-5m	B-3m

Table 6.4-2. Total suspended solids and DDE concentrations from discrete water samples collected during CTD profiling operations during pump-out Event 1 in Cell LC on September 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	LC-1B-CTD-01	LC-1B-BOT-01	39.1	77.3	2.2	0.0049	B-1	no
Background	LC-1B-CTD-01	LC-1B-BOT-02	39.6	76.6	2.0	0.0047	B-2	no
15	LC-1D-CTD-01	LC-1D-BTA-01	43.5	63.2	4.4		1	no
16	LC-1D-CTD-01	LC-1D-BTA-02	43.8	0.0	30	0.0082	2	yes
16	LC-1D-CTD-01	LC-1D-BTA-03	43.7	4.1	24		3	yes
17	LC-1D-CTD-01	LC-1D-BTA-04	43.4	1.1	30		4	yes
20	LC-1D-CTD-01	LC-1D-BTA-05	40.6	75.5	2.9		5	no
20	LC-1D-CTD-01	LC-1D-BTA-05	40.6	75.5	2.5		6	no
21	LC-1D-CTD-01	LC-1D-BTA-06	41.8	7.0	28		7	yes
22	LC-1D-CTD-01	LC-1D-BTA-07	43.7	18.2	13		8	yes
23	LC-1D-CTD-01	LC-1D-BTA-08	43.4	16.6	21		9	yes
24	LC-1D-CTD-01	LC-1D-BTA-09	43.1	18.7	28		10	yes
26	LC-1D-CTD-01	LC-1D-BTA-10	43.1	13.1	22		11	yes
27	LC-1D-CTD-01	LC-1D-BTA-11	43.7	8.7	29		12	yes
29	LC-1D-CTD-01	LC-1D-BTA-12	44.2	0.7	26	0.0067	13	yes
47	LC-1D-CTD-02	LC-1D-BTB-01	39.9	64.1	2.6		14	no
47	LC-1D-CTD-02	LC-1D-BTB-02	39.9	19.9	8.2	0.0037	15	yes
48	LC-1D-CTD-02	LC-1D-BTB-03	40.9	14.2	15	0.0044	16	yes
48	LC-1D-CTD-02	LC-1D-BTB-03	40.9	14.2	14		17	yes
49	LC-1D-CTD-02	LC-1D-BTB-04	41.8	53.0	15		18	yes
69	LC-1D-CTD-03	LC-1D-BTC-01	37.0	58.6	4.5		19	yes
69	LC-1D-CTD-03	LC-1D-BTC-02	38.9	45.6	7.3		20	yes
70	LC-1D-CTD-03	LC-1D-BTC-03	39.7	64.5	9.5		21	yes
70	LC-1D-CTD-03	LC-1D-BTC-03	39.7	64.5	6.4		22	yes
71	LC-1D-CTD-03	LC-1D-BTC-04	37.1	47.6	3.4	0.0038	23	yes
71	LC-1D-CTD-03	LC-1D-BTC-04	37.1	47.6	3.4	0.0031	24	yes
80	LC-1D-CTD-03	LC-1D-BTC-05	36.4	32.5	5.4		25	yes
81	LC-1D-CTD-03	LC-1D-BTC-06	39.4	60.8	5.5		26	yes
87	LC-1D-CTD-03	LC-1D-BTC-07	36.6	58.7	2.4		27	no
93	LC-1D-CTD-03	LC-1D-BTC-08	35.2	26.4	5.6		28	yes
98	LC-1D-CTD-03	LC-1D-BTC-09	37.1	51.4	3.7	0.0039	29	yes
117	LC-1D-CTD-04	LC-1D-BTD-01	33.1	39.7	2.3		30	no
128	LC-1D-CTD-04	LC-1D-BTD-04	33.3	36.9	4.8	0.0029	31	yes

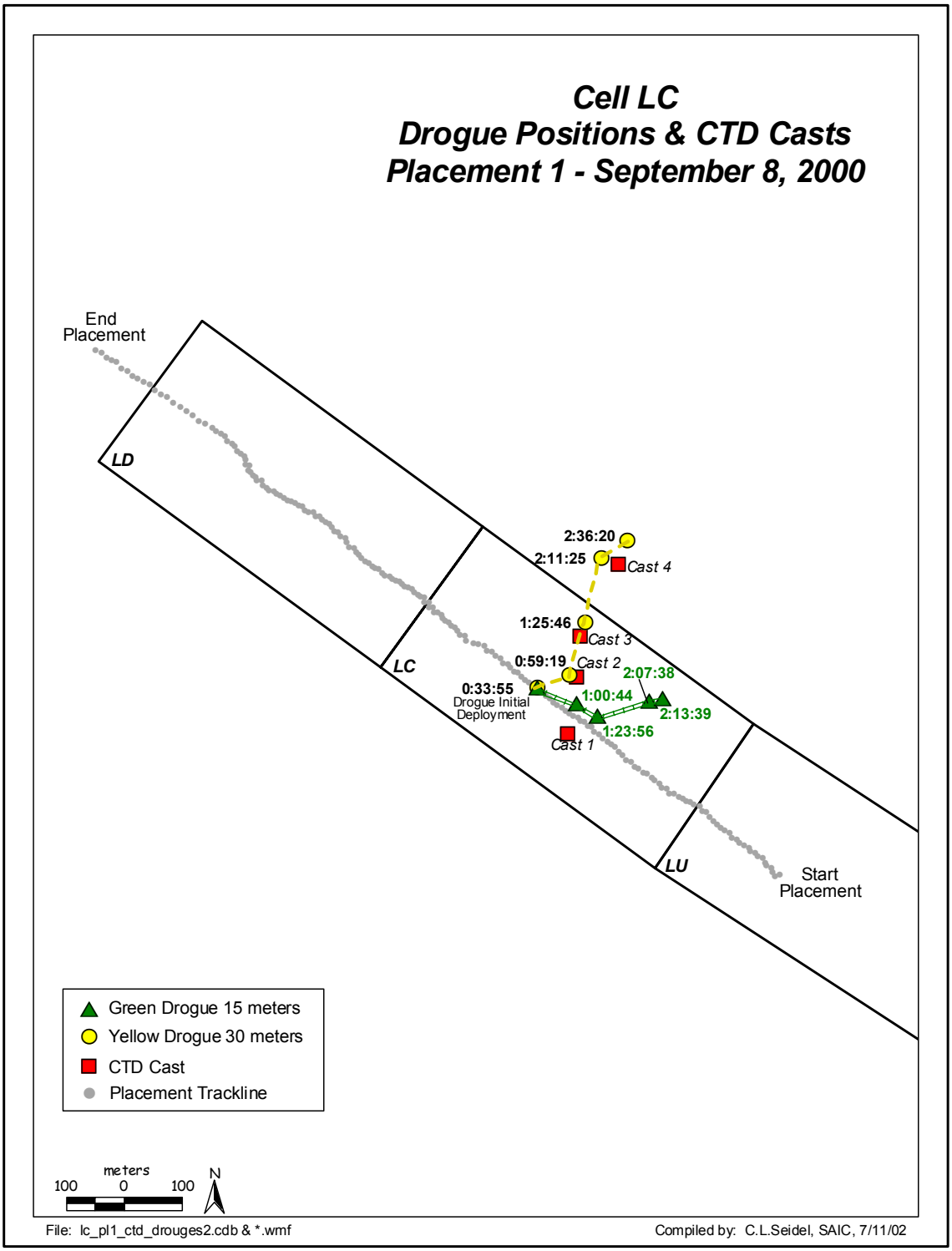

Figure 6.4-1. Map of Cell LC indicating drogue trajectories and CTD stations during pump-out Event 1 on September 8, 2000.

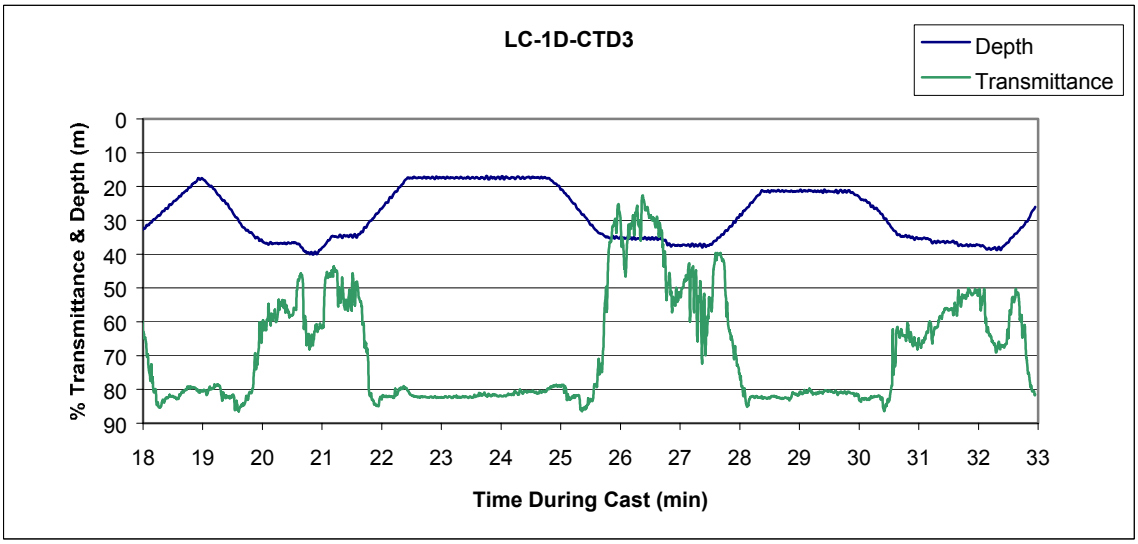

Figure 6.4-2. Time series plot of percent light transmission and sensor depth acquired during CTD Station 3 during pump-out Event 1 in Cell LC on September 8, 2000. See Table 6.4-1 for CTD profile information.

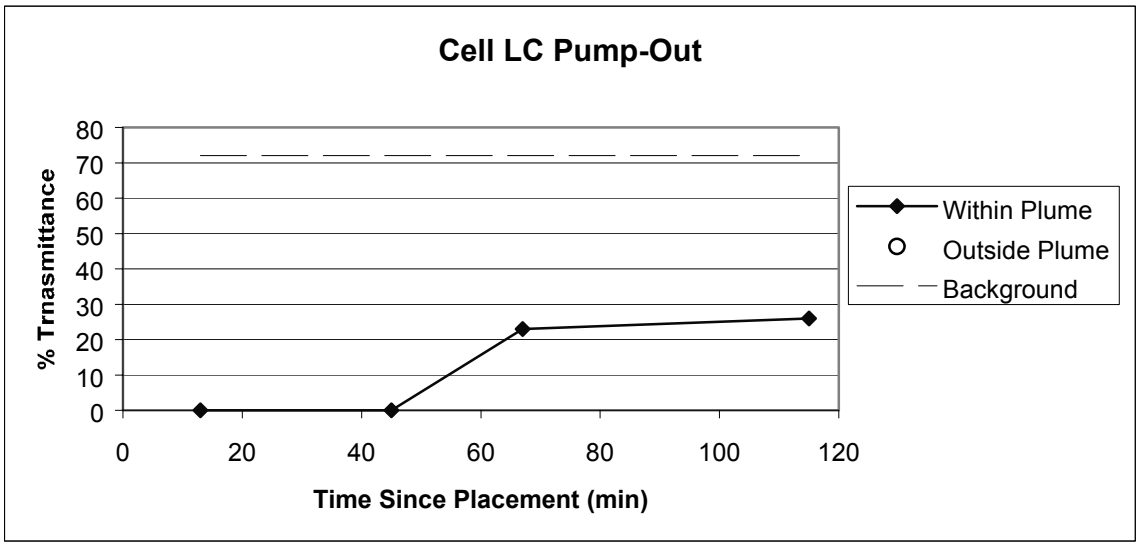

Figure 6.4-3. Time series plot of the minimum value of percent light transmission acquired during each CTD profile conducted during pump-out Event 1 in Cell LC on September 8, 2000. See Table 6.4-1 for CTD profile information.

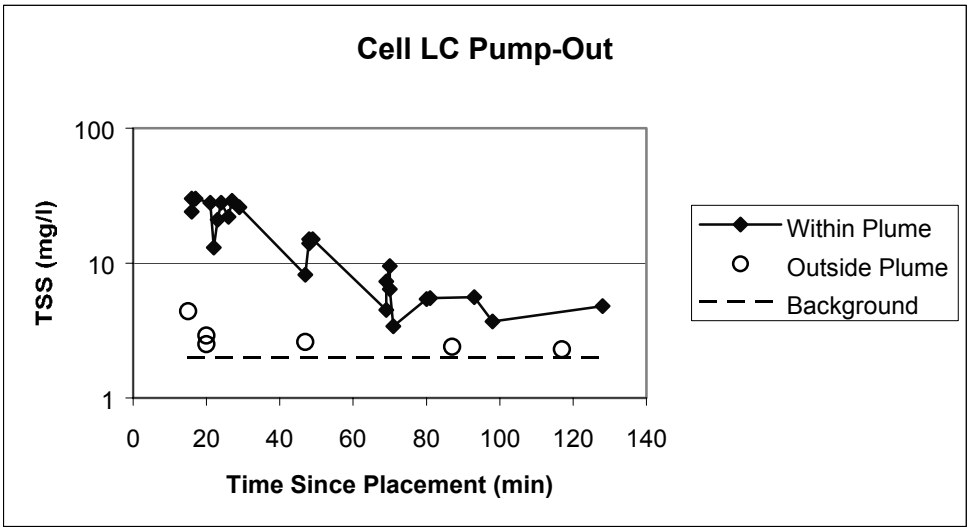

Figure 6.4-4. Plot of total suspended solids concentration versus time since initiation of pump-out for discrete water samples collected during CTD profiling operations of pump-out Event 1 in Cell LC on September 8, 2000.

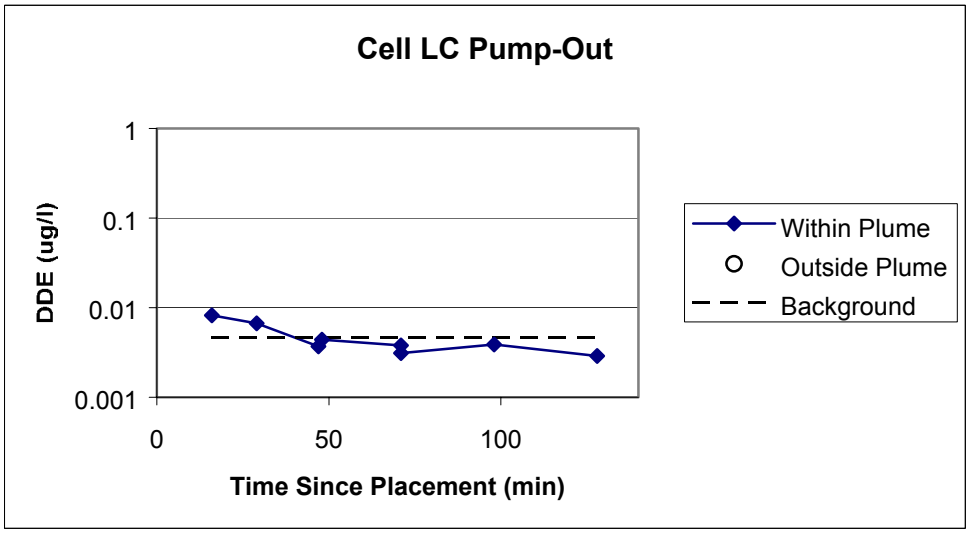

Figure 6.4-5. Plot of DDE concentration versus time since initiation of pump-out for discrete water samples collected during CTD profiling operations of pump-out Event 1 in Cell LC on September 8, 2000.

6.5 Sediment Profile Results

6.5.1 Overview of Field Sampling Plan

For the pump out placement event, the plan was for the hopper dredge to begin placing the material in Cell LU and continue in a northwesterly direction across the center of Cells LC and LD. Background SPC sampling was required in Cell LC (located between Cells LU and LD) to characterize seafloor conditions prior to pump out placement of Queen's Gate cap material. A grid of baseline stations was established in the northwestern half of Cell LC. Sampling was limited to this half of the cell because monitoring in Cell LU suggested that a layer of Queen's Gate cap material already occurred in the eastern half of Cell LC.

The baseline survey in Cell LC was conducted on September 7, 2000. Three replicate images were obtained at each of 18 planned sampling stations: stations I46 to I51 were aligned along the planned track line of the hopper dredge, and stations I52 to I63 were arranged in two perpendicular transects to detect the lateral spread of cap material on either side of the track line (Figure 6.5-1). The post 1 pump out SPC survey in Cell LC was conducted on September 9, 2000, immediately following the placement operation. Three replicate images were again obtained, as planned, at each of the 18 stations that had been sampled in the baseline survey (Figure 6.5-1). Table 6.5-1 provides a summary of the field sampling activities in Cell LC.

6.5.2 Review of Data Quality Objectives

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

6.5.3 Technical Considerations

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

6.5.4 Monitoring Results

6.5.4.1 Baseline Survey

Unlike the baseline surveys in Cells LD, LU and SU, analyses of images from Cell LC for the complete set of measurement parameters was not required. Rather, the objective of background sampling was simply to provide a visual basis for comparison with the post pump-out images and thus facilitate detection of any changes. In general, background physical and biological characteristics of surface sediments in Cell LC appeared similar to those in Cell LD. Surface sediments at all stations appeared to be predominantly fine-grained (i.e., silt-clay), with 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). The RPD depth in most images was well-developed, appearing to range from about 2 to 4 cm in depth. The infaunal successional stage appeared to be predominantly Stage I on Stage III, with evidence of larger-bodied infauna (e.g., feeding voids, burrows, organisms) in most images.

6.5.4.2 Post Pump-Out Survey

In the post pump-out SPC survey in Cell LC, there was limited evidence of a thin layer of cap material at 5 of the 18 stations (Figure 6.5-3). All stations were aligned along the track line of the hopper dredge, and the presence of a thin and patchy depositional layer of Queen's Gate cap material was inferred from the presence of shell fragments and gray clay clasts at the sediment surface (Figure 6.5-4). In sediment profile images from the post pump-out survey in Cell LD, the gray, sandy Queen's Gate material was clearly visible as a thin layer on top of the underlying golden sand. Because the existing sediment surface in Cell LC consisted of light-colored, sandy mud, it was much more difficult to distinguish and measure thin "sprinkle" layers of Queen's Gate material against this similar "background." Therefore, the map in Figure 6.5-3 denotes the presence of these presumed thin layers of cap material as patchy. At most stations in Cell LC, no visible differences in the appearance of sediment between the baseline and post 1 pump out surveys were evident (Figure 6.5-4).

Table 6.5-1. Summary of SPC Field Sampling Activities in Cell LC

Survey Name	Number of Survey Stations		Completeness
	Required	Sampled	
Background (Flex Survey)	18	18	100%
Post 1 Pump Out (Flex Survey)	18	18	100%

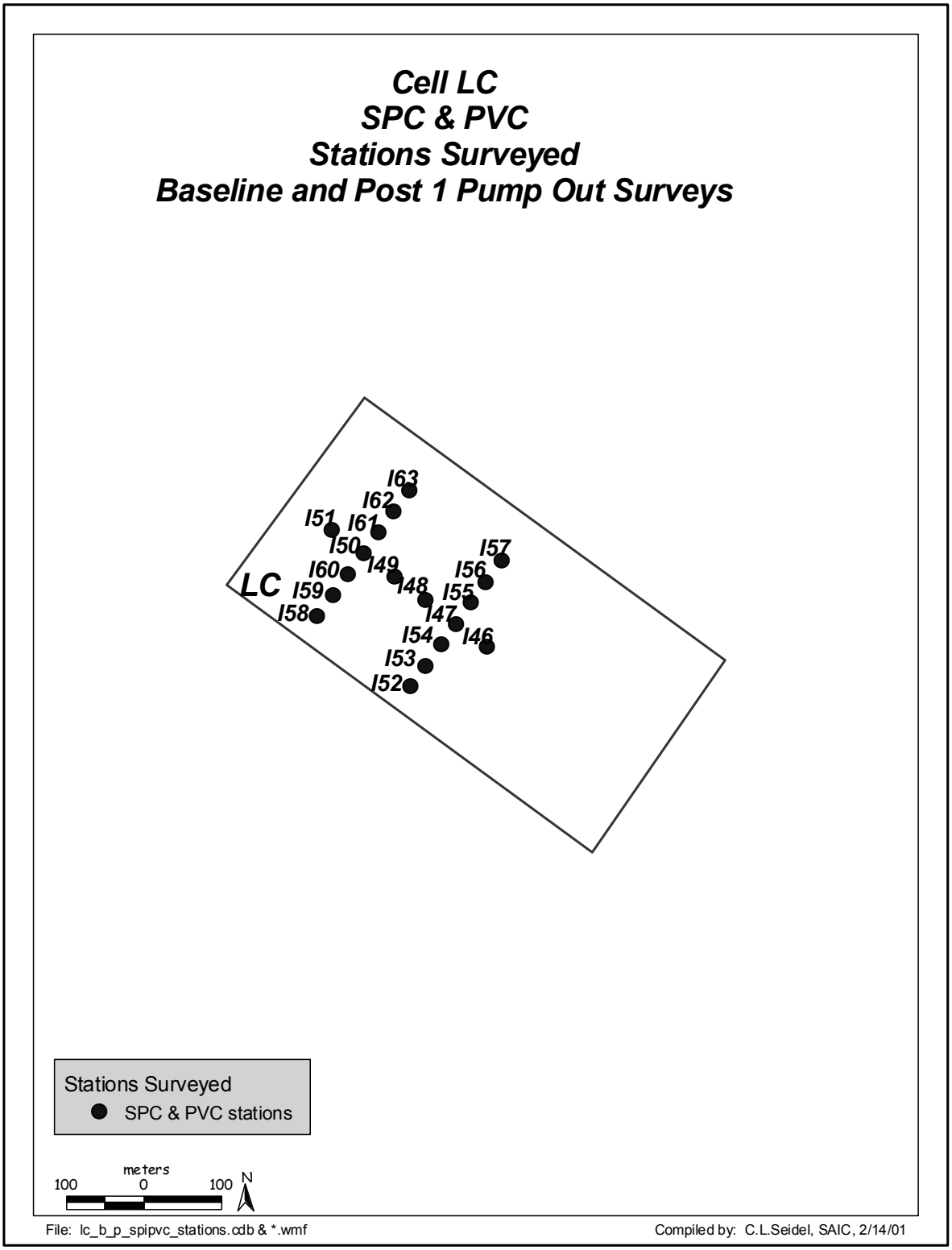

Figure 6.5-1. Station locations for the baseline and Post 1 pump out SPC surveys in Cell LC.

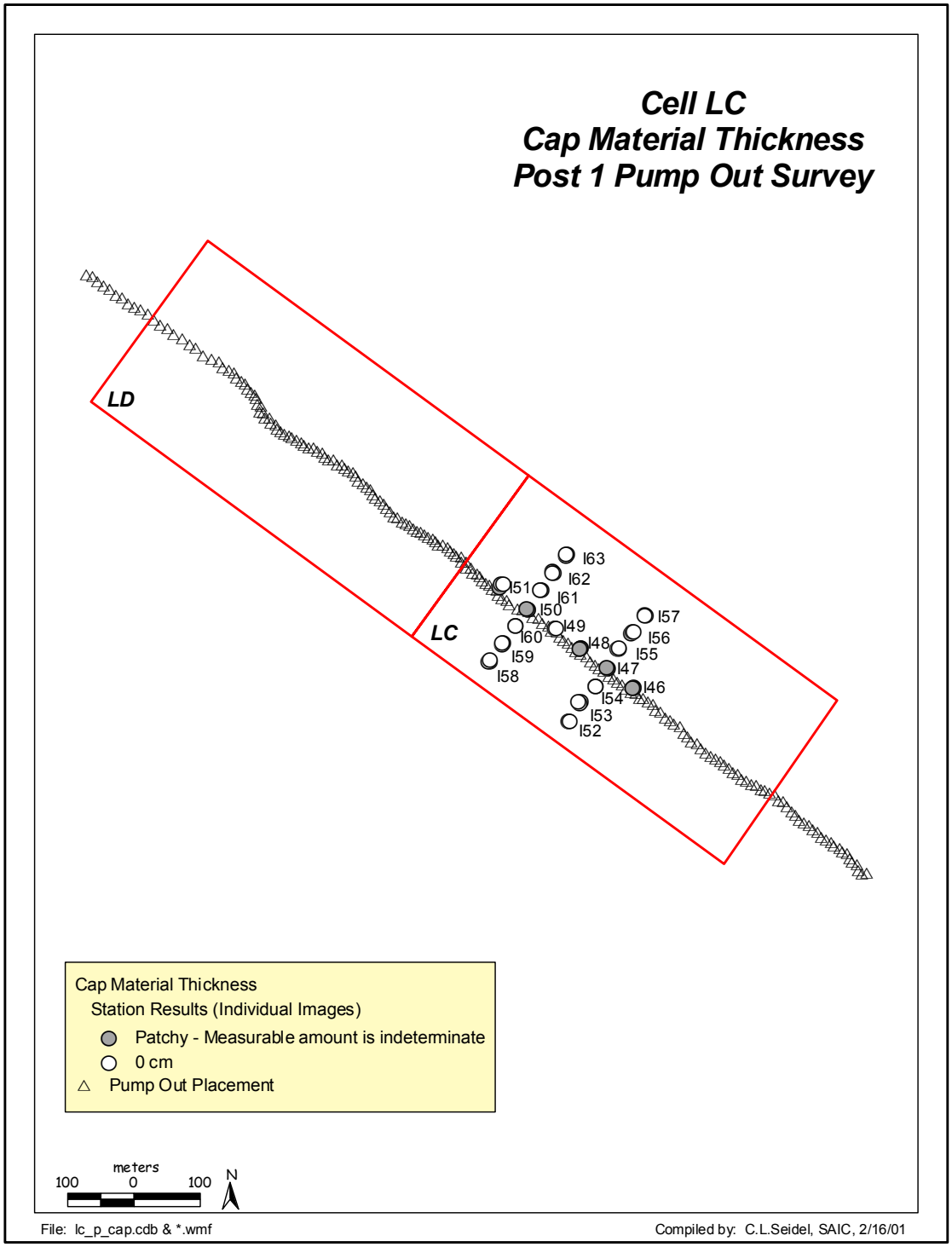

Figure 6.5-2. Track line of the hopper dredge during the pump-out placement event in Cell LC, and thickness of the resultant cap layer in replicate images obtained at each station.

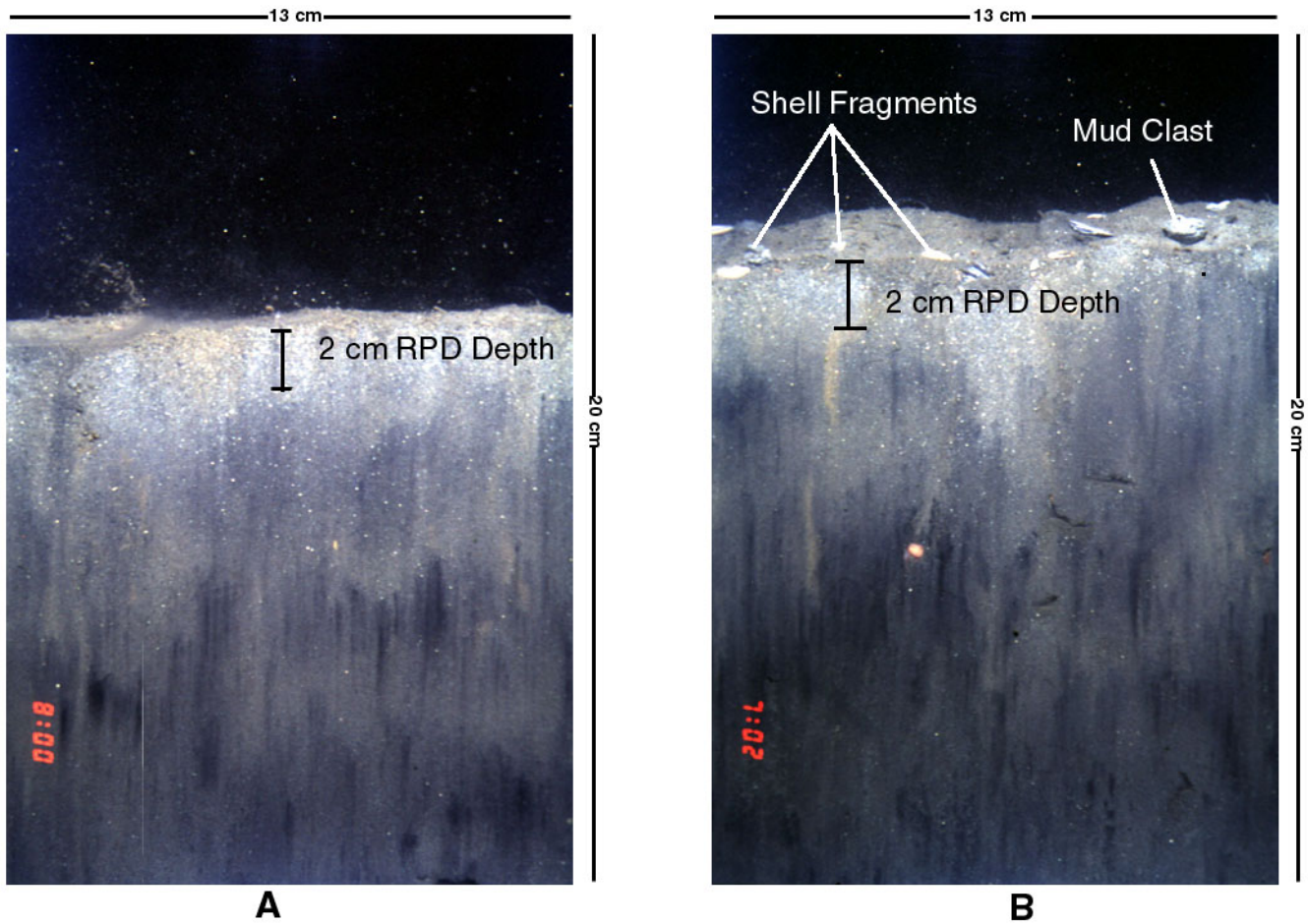

Figure 6.5-3. Two sediment profile images from Cell LC station I47. Image A from the baseline survey shows existing EA sediment consisting of sandy mud, with an RPD depth of 2.0 cm. Image B from the post 1 pump out survey shows the same EA sediment, with several shell fragments and gray mud clasts at the surface, providing evidence of the presence of Queen's Gate cap material.

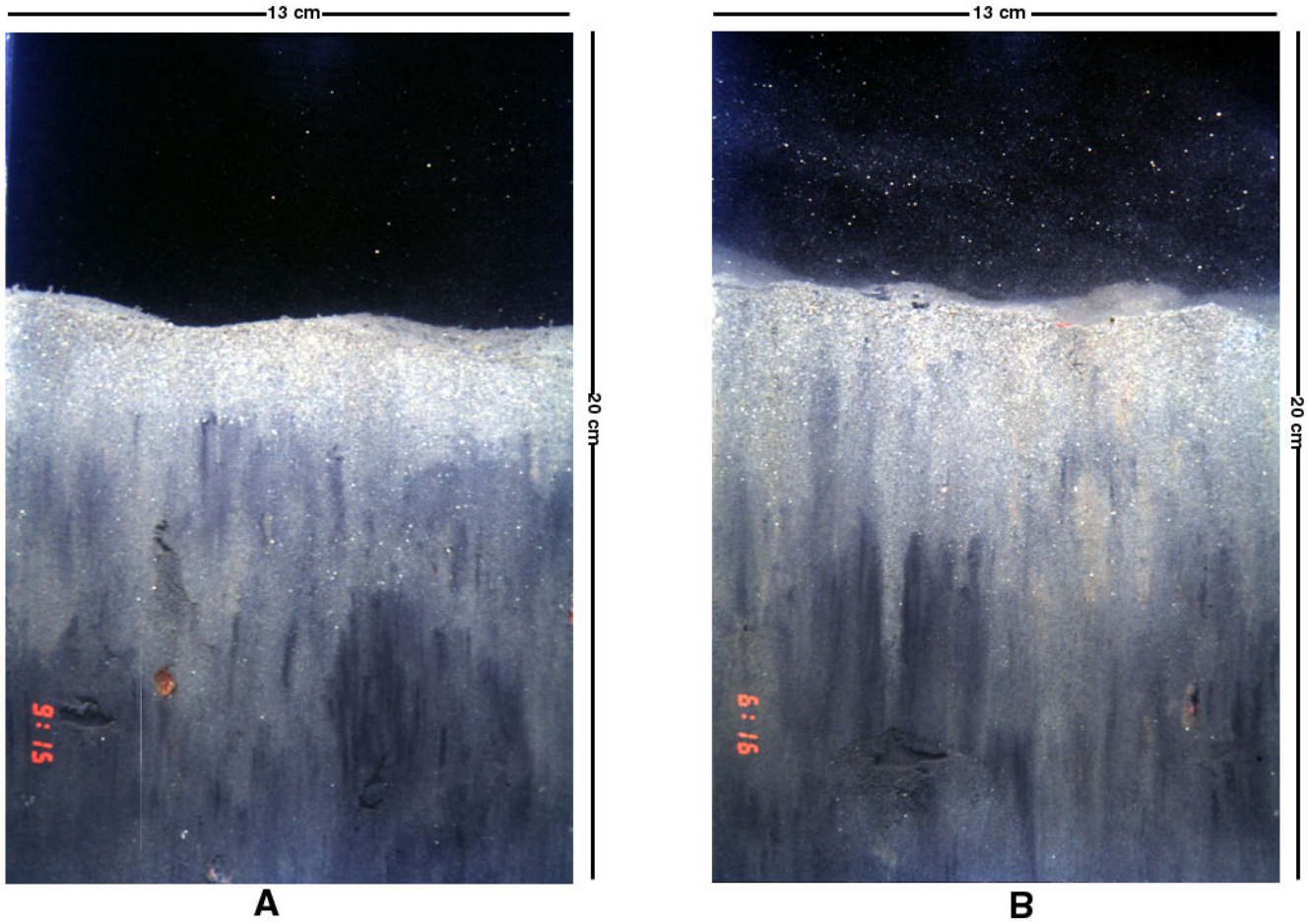

Figure 6.5-4. Two sediment profile images from Cell LC station I61 showing the similarity in sediment conditions before (Image A) and after (Image B) the Post 1 pump out placement event. In both images, surface sediment consists of sandy mud with a well-developed RPD. Note the absence of any distinct surface depositional layers of cap material in image B.

6.6 Cell LC Plan View Image Results

6.6.1 Overview of the Plan View Field Sampling Plan

The field sampling plan for the SPC/PVC surveys in Cell LC was derived as part of a flex survey for the cell. For the pump out placement event, the plan was for the hopper dredge to begin placing material in Cell LU and continue in a northwesterly direction across the center of Cells LC and LD. A baseline survey was required in Cell LC to characterize seafloor conditions prior to the pump out placement of Queen's Gate material. A grid of stations was established in the northwestern half of Cell LC. The sampling was limited to this half of the cell because the monitoring activity in Cell LU suggested a depositional layer of Queen's Gate material already occurred in the eastern half of Cell LC. Table 6.6-1 summarizes the PVC field sampling activities that were conducted in Cell LC 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 6.6.4 Monitoring Results below.

The PVC and SPC surveys were conducted simultaneously 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 6.6-1. Summary of Field Sampling Activities – Cell LC

Survey Name	Number of Survey Stations		Completeness
	Required	Sampled	
Baseline	18	18	100%
Post 1 Pump-Out	18	18	100%

6.6.2 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 mentioned in that section.

6.6.3 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.

6.6.4 Monitoring Results

6.6.4.1 Baseline Survey

The baseline survey in Cell LC was conducted on September 7, 2000. A total of 18 stations were occupied (Figure 6.6-1).

The PVC results for the baseline survey indicated that the bottom topography throughout the cell was relatively smooth. The EA sediments throughout the cell appeared to be homogenous in both texture and color and consisted of very-fine sandy-gray mud.

The biological activity in Cell LC appeared to be quite active in both the number of burrows that were present as well as the degree to which the burrows were established (e.g., size and construction). Numerous burrows with large crater-like structures, due most likely to the presence of epifaunal organisms, were found at the majority of the station replicates. Many of these burrows had burrow channel openings approximately 0.3 cm to 3.5 cm in size.

6.6.4.2 Post 1 Pump Out Survey.

The Post 1 Pump Out Survey in Cell LC was conducted on September 9, 2000, immediately following the placement operation. A total of 18 stations were occupied for this survey (Figure 6.6-1).

Cap Material

Stations that appeared to have cap material present include Stations I48-51 (Figure 6.6-2). Station I50 appeared to be completely covered. These results are based on what appeared to be cap filled burrows.

Shell material could be seen in Stations I48-51 as well (Figure 6.6-3). The amount of shell material was primarily a small to medium amount.

Biological Activity

Epifaunal activity included a small bottom dwelling fish, a small starfish and a number of organism tracks. Infaunal evidence included worm tubes in a number of replicates.

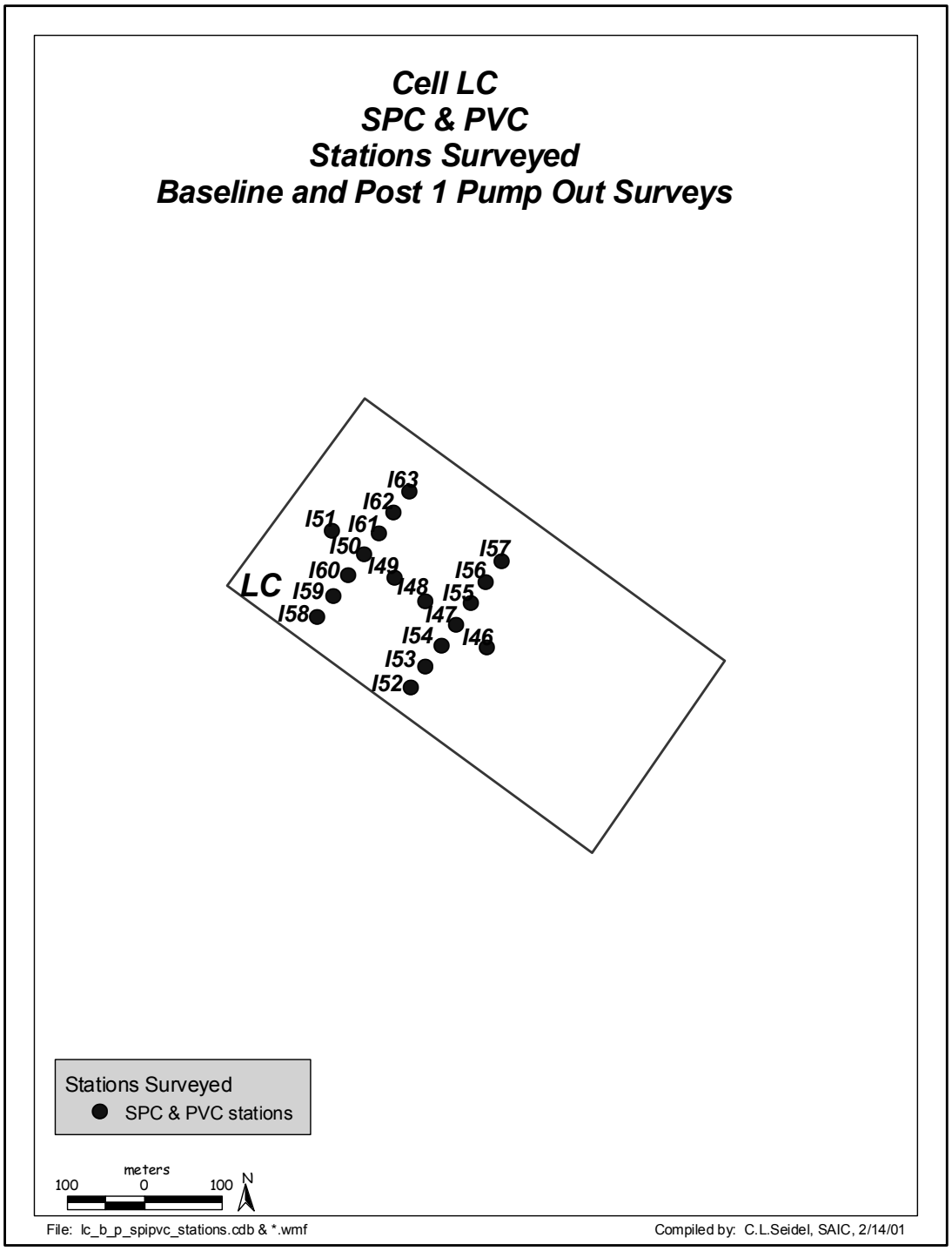

Figure 6.6-1. Cell LC SPI and PVC Stations surveyed – baseline and Post 1 pump out surveys.

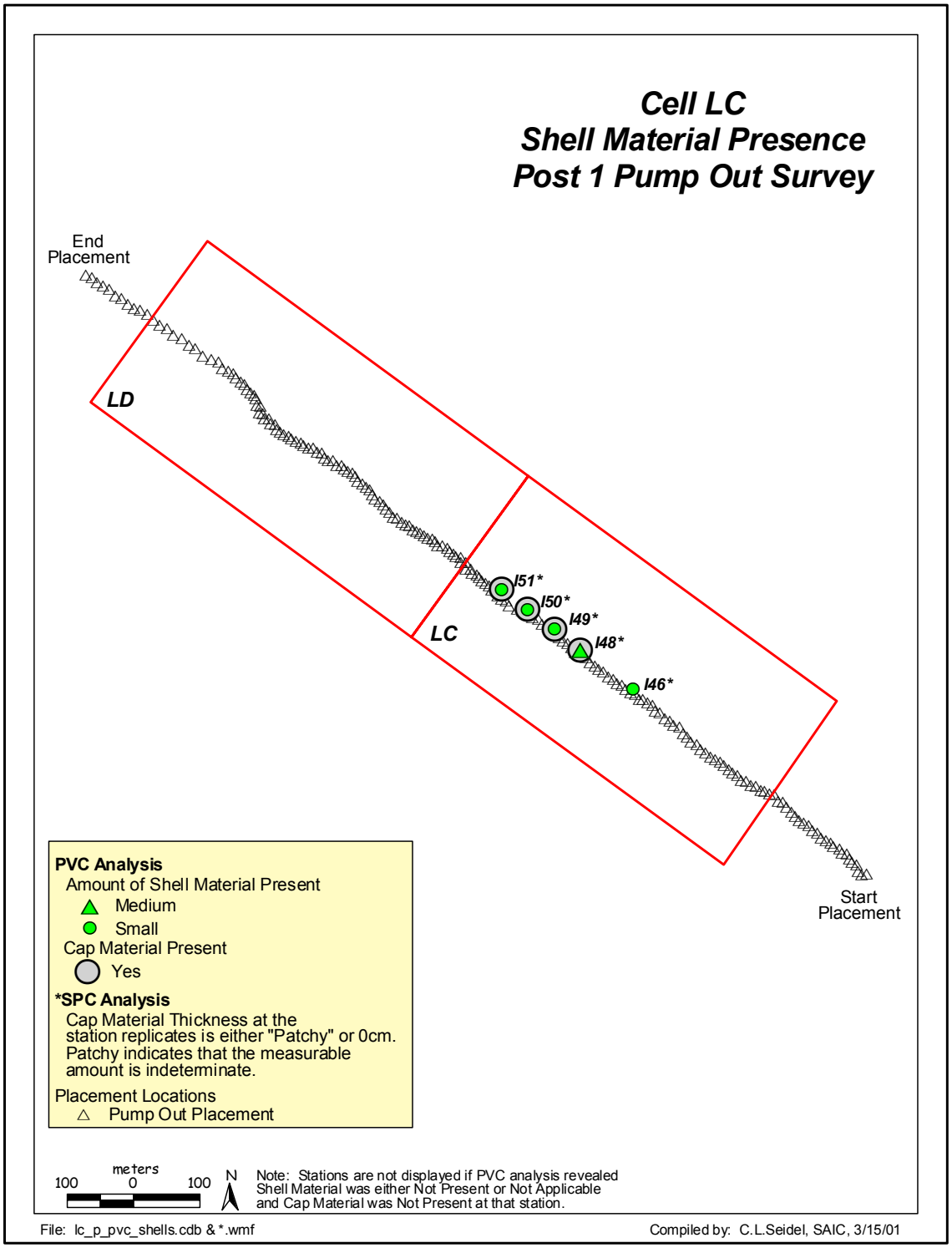

Figure 6.6-2. Lateral extent of cap material based on plan view image (PVI) analysis – Post 1 supplemental survey.

Figure 6.6-3. Cap Material Presence in Cell LC. This image acquired at inside station I48 during the Post 1 Pump Out plan view survey provides evidence of the presence of cap material within the cell in terms of the color contrast between sediments and through the presence of shell material. The image appears to contain patches of lighter gray material and darker gray material, suggesting that this station received a trace amount of cap material coverage. Shell material, the apparent presence of filled burrows and small clay clasts throughout the image also support the presence of cap material.

6.7 Sediment Core Results

6.7.1 Overview of Field Sampling Plan

Brief descriptions of field sampling plans are provided in section 6.11.1, along with a summary of methods and significant deviations from the sampling plans.

6.7.1.1 Field Sampling Plans

Postcapping Survey

Sediment coring within Cell LC was conducted following a single placement event using a pump-out method. This sampling event was not part of the original monitoring SOW (Fredette 2000), but was added to the survey plan by USACE during the cap placement monitoring program to evaluate the effectiveness of this placement method. One coring survey was conducted in Cell LC, and a single core was collected from the center of the cell and visually described. No laboratory analyses were conducted on this core.

Hopper Dredge Sampling

No hopper dredge sampling was performed for Cell LC.

6.7.1.2 Methods

Methods used for collection and processing of the sediment core are described in the PWP for the cap placement monitoring phase of the program, and summarized in Section 3.11.2.

6.7.1.3 Deviations from Field Sampling Plan

Core sampling at Cell LC did not deviate significantly from the general approach described in the Field Sampling Plans of the PWP.

6.7.2 Review of Data Quality Objectives

General monitoring and data quality objectives for the pilot monitoring program are discussed in Section 2.

6.7.2.1 Postcap Monitoring

Data quality objectives for sediment coring conducted at Cell LC were generally the same as those described for Cell LU (Table 3.11-2), although visual analyses only were performed to determine the presence of an obvious cap layer. Therefore, DQOs related to geotechnical and contaminant patterns were not applicable to results for the core from Cell LC.

6.7.2.2 Summary of Results for Postcap Monitoring Relative to Data Quality Objectives

The sediment core collected within Cell LC met the performance specifications defined for coring tasks.

6.7.3 Technical Considerations

Technical considerations relevant to visual descriptions of the sediment core sample from Cell LC are identical to those discussed for Cell LU in Section 3.11.3.

6.7.4 Results

Results from visual description of the sediment core from Cell LC are discussed in the following section. The digital image and core description can be found in DAN-LA.

Core 65 was collected from the center of Cell LC after the pump-out event (Figure 6.7-1). The core was 45 cm in length and fairly homogeneous, greenish black to black, moist, soft to firm in consistency, and appeared to consist of silty clay. Similarities in grain size between cap material and existing sediment made visual distinctions of even trace amounts of cap material impossible. No evidence of mixing surface sediments and the underlying, softer material was present in the upper 31 cm. Due to the minimal volume of cap material placed in the cell, the absence of cap material in the core was not unexpected.

The core from Cell LC was not analyzed for grain size, geotechnical properties, or DDE; therefore, no postcapping data are available.

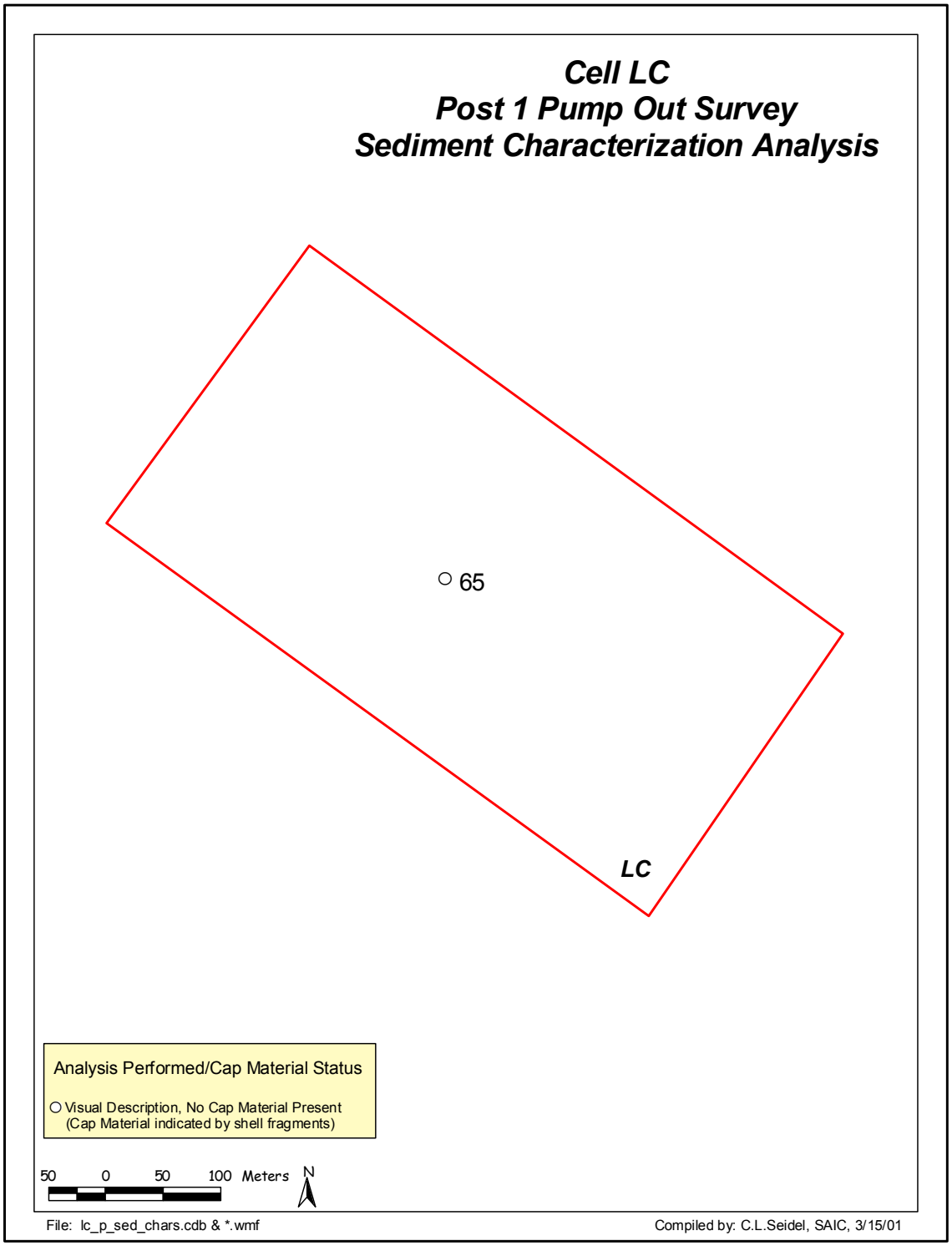

Figure 6.7-1. Core location in Cell LC during Post 1 Pump-Out survey.

7.0 MONITORING RESULTS FROM CELL SD (BASELINE MONITORING ONLY)

7.1 Schedule of Operations

The following provides an overview of baseline monitoring activities within Cell SD. No capping operations were conducted at Cell SD. Therefore, the following schedule of operations covers only baseline monitoring within this cell.

Baseline monitoring in Cell SD was conducted in May, 2000. Dates associated with individual sampling tasks are listed in Table 7.1-1. Results from each of the baseline sampling tasks in Cell SD are presented in Sections 7.2 through 7.4.

Table 7.1-1. Summary of Sampling Dates for Baseline Monitoring Activities in Cell SD

	Core	SS	SB
Baseline	5/19	5/15 & 5/17	5/15 & 5/17

Core-sediment coring; SS-side-scan sonar; SB-sub-bottom profiling

7.2 Sediment Core Results

7.2.1 Overview of Field Sampling Plan

Brief descriptions of the field sampling plan for baseline monitoring are provided below, along with a summary of methods and significant deviations from the sampling plan.

7.2.1.1 Field Sampling Plan

Baseline Survey

Sediment cores were collected at nine stations within Cell SD during the baseline survey (Figure 7.2-1). Station locations corresponded to intersection points of the sub-bottom profile lines. Each of the nine cores was subsampled at discrete 4-cm intervals, and sediments from each horizon were analyzed for DDE, bulk density, and grain size. Two additional cores were collected (at stations C1 and C6) to provide adequate material for Atterberg limit analyses. A summary of the geotechnical and chemical analyses of sediment cores from Cell SD is included in Table 7.2-1.

Postcapping Survey

No capping occurred in Cell SD; therefore, no postcapping cores were collected.

Hopper Dredge Sampling

No hopper dredge sampling was performed because cap materials were not placed in Cell SD.

7.2.1.2 Methods

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 phase of the monitoring program, and these are summarized in Section 3.11.2.2.

7.2.1.3 Deviations from Field Sampling Plan

Core sampling in Cell SD during the baseline survey did not deviate significantly from the approach described in the Field Sampling Plan of the PWP.

7.2.2 Review of Data Quality Objectives

General monitoring and data quality objectives for the monitoring program are discussed in Section 2.

7.2.2.1 Baseline Monitoring

Specific data quality objectives for sediment coring conducted during baseline monitoring in Cell SD are the same as those described for Cell LU (Table 3.11-1).

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

Specific monitoring objectives for sediment coring during the baseline survey were achieved. In particular, all sediment cores specified in the PWP were collected, along with the defined numbers of field QC samples. Cores provided adequate sample volume for all required chemical and geotechnical analyses, including analytical QC samples specified in the QAPP. A total of 50 grain size, 55 bulk density, 4 Atterberg limits, and 55 shear strength analyses were completed. No samples from the baseline survey were analyzed for water content or specific gravity. In addition to geotechnical samples, 53 sediment samples were analyzed for DDE (Table 7.2-1). Results of QC analyses are presented in Appendix B.

7.2.3 Technical Considerations

Technical considerations relevant to sediment core samples from Cell SD were identical to those discussed for Cell LU (Section 3.11.3).

7.2.4 Results

Results from analyses of sediment cores from Cell SD for geotechnical and chemical characteristics are discussed in the following sections.

7.2.4.1 Geotechnical Characteristics

<u>Baseline Survey</u>

Digital images and detailed visual descriptions are available in DAN-LA. Cores collected in Cell SD were described as greenish black to black color, moist, and soft in consistency. The ambient sediment appeared to be clayey sandy SILT at the surface, and sandy clayey SILT below 8 cm.

The grain size data supported these visual descriptions, as the sand content decreased, and the clay fraction increased with core depth (Figure 7.2-2). The major (53%) component of the cores was silt (0.0312 to 0.0039 mm). Coarse silt (0.0312 mm) represented 25% of the sediment in the upper 8 cm and 16% of the sediment below 8 cm in the core. The clay fraction of the sample increased from 23% at the surface to 36% at the 16-20 cm horizon, while the sand component decreased from 25% in the surface material to 10% at 16-20 cm (Table 7.2-2).

Additional geotechnical parameters analyzed included bulk density, Atterberg limits and a shear strength summary data table is included in Appendix C. Sediment bulk density did not vary appreciably with core depth. The average wet weight bulk density was 1.4 g/cc, while the average dry weight density was 0.7 g/cc. Atterberg limit analyses were preformed at two horizons in two cores. The average liquid limit was 88% with a plastic limit of 37% indicating an average plasticity index of 51. Fifty-five shear strength analyses were preformed. Although the shear strength data were characterized by random spikes, the results generally indicated that shear strength either increased or was relatively consistent with depth. One exception was Core C4D1, in which shear strength decreased with core depth. Shear strength values above 8 cm may be inaccurate due to the sand content of this horizon. The average shear strength was 14.82 kPa, with a standard deviation of 9.75, which is consistent with expectations for Cell SD sediment. Specific gravity and water content were not analyzed during the baseline coring survey.

Postcapping Survey

No postcapping cores were collected from Cell SD for geotechnical analyses.

7.2.4.2 Chemical (DDE) Characteristics

Baseline Survey

Concentrations of DDE in sediment core horizons (surface to 20 cm measured at 4-cm intervals) from within Cell SD ranged from 3.2 to 93 ppm. In general, concentrations increased with core depth (Figure 4.11-14), and the highest measured concentrations occurred in the 12-16 or 16-20 cm horizons. Similar to patterns observed in Cell SU, sediments from seaward locations within Cell SD contained slightly higher concentrations than those from the landward stations. A map of DDE concentrations in surface sediments (Figure 4.11-13) illustrates the general trends for surface sediments within Cell SD. 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. These results are also consistent with historical values and trends reported for this portion of the PV Shelf (Lee 1994; Figure 4.11-14).

Postcapping Survey

No postcapping cores were collected from Cell SD for DDE analyses.

Table 7.2-1. Summary of Geotechnical and Chemical Samples Collected in Cell SD during Baseline Survey

Cell SD Core Summary	DDE	Grain Size	Bulk Density	Specific Gravity	Water Content	Atterberg Limits	Shear Strength
Baseline							
11 cores	53	50	55	na	na	4	55

Visual Descriptions of core from Cell SD

Table 7.2-2. Summary of Sediment Grain Size in Cell SD Cores during Baseline Survey

ASTM (Unified) Classification	Size in mm	Wentworth Classification	Phi Size	A Average SDB (0-4cm)	B Average SDB (4-8cm)	C Average SDB (8-12cm)	D Average SDB (12-16cm)	E Average SDB (16-20cm)	Standard Deviation SDB
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	0.07	0.05	0.05	0.03	0.05	0.02
Medium Sand	1	V. Coarse Sand	0	0.49	0.41	0.14	0.39	0.25	0.14
	0.5	Coarse Sand	1	0.36	0.45	0.15	0.35	0.17	0.13
Fine Sand	0.25	Medium Sand	2	0.73	0.52	0.26	0.47	0.38	0.18
	0.125	Fine Sand	3	1.75	1.50	1.53	0.94	0.73	0.43
	0.0625	V. Fine Sand	4	20.94	16.77	13.61	8.96	8.06	5.39
Fine Grained Soil (silt/clay variation determined by plasticity Index and "A" line)	0.0312	Coarse Silt	5	27.80	24.88	19.91	16.00	15.47	5.43
	0.0156	Medium Silt	6	13.56	14.03	14.46	17.14	15.92	1.48
	0.0078	Fine Silt	7	8.14	9.55	13.05	14.69	16.46	3.48
	0.0039	V. Fine Silt	8	2.89	3.73	5.00	5.72	6.17	1.37
	0.00195	Clay	9	5.93	7.38	9.18	10.90	11.17	2.26
	<0.00195	Clay	>9	17.34	20.73	22.65	24.40	25.17	3.15

Horizon	Average SDB (0-4cm)	Average SDB (4-8cm)	Average SDB (8-12cm)	Average SDB (12-16cm)	Average SDB (16-20cm)	Standard Deviation SDB
Gravel (>4mm)	0.00	0.00	0.00	0.00	0.00	0.00
Sand (0.0625-2mm)	25.03	20.53	17.40	12.24	10.29	6.02
Silt (0.0312-0.0039mm)	52.40	52.19	52.42	53.56	54.02	0.82
Clay (<0.00195mm)	23.26	28.11	31.83	35.30	36.34	5.38

Grain Size results based on % Frequency Weight

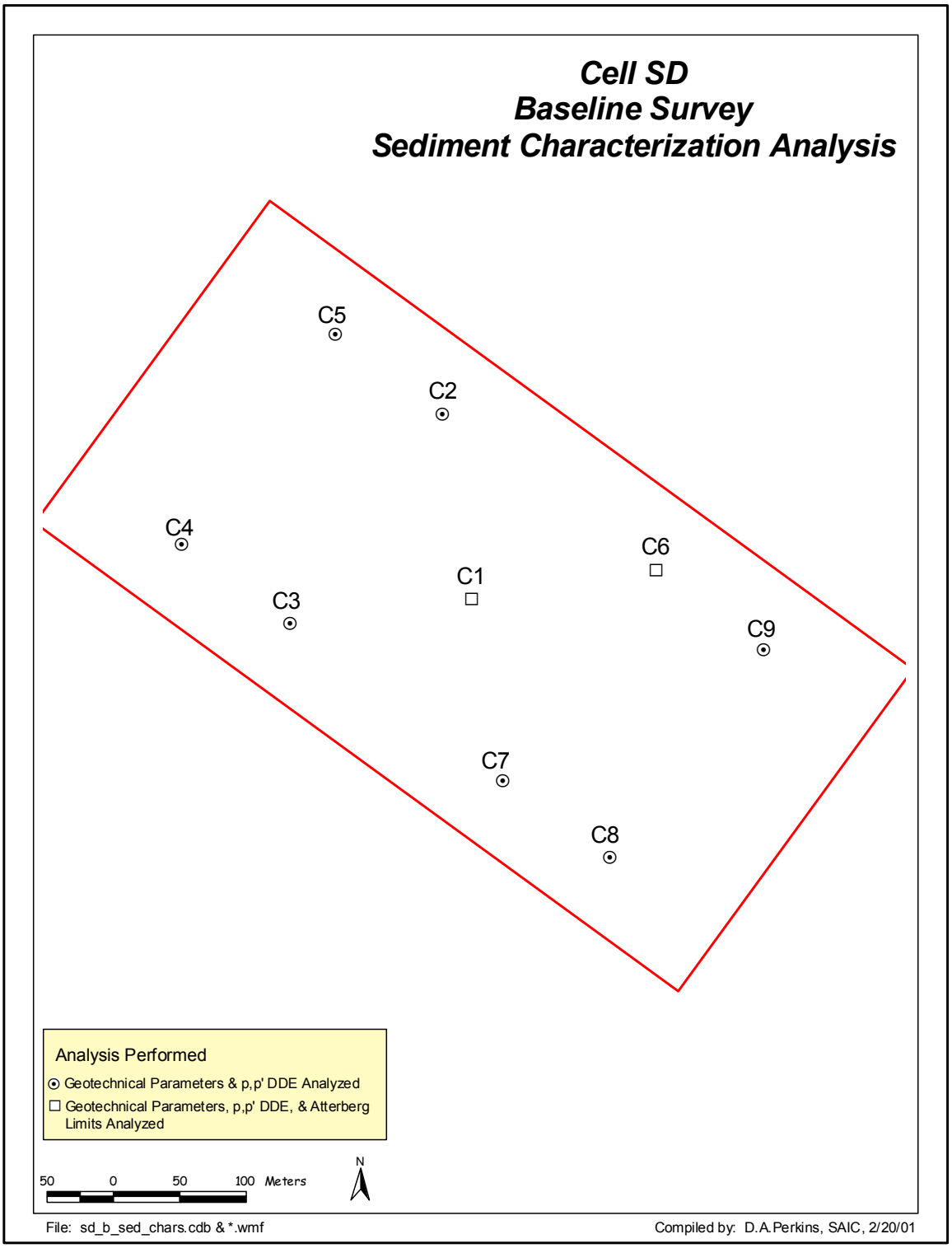

Figure 7.2-1. Coring locations in Cell SD during baseline survey.

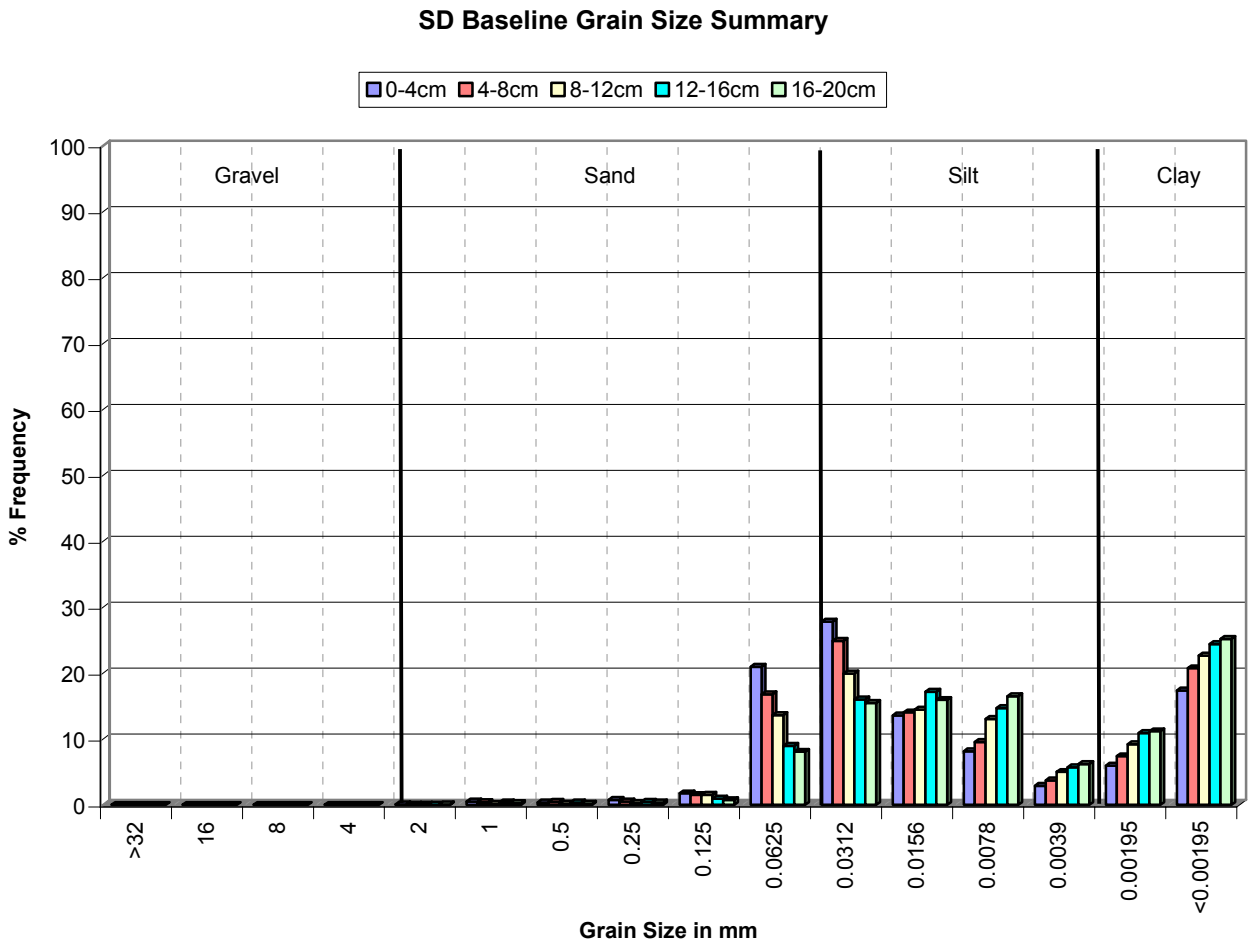

Figure 7.2-2. Grain size distributions of Cell SD baseline sediments.

8.0 MONITORING OF NEAR-SURFACE PLUME TRANSPORT (INVESTIGATIONS OF KELP IMPINGEMENT)

8.1 Schedule of Operations

The following provides a schedule of near-surface plume transport monitoring near Cells LD and LU. No baseline monitoring was performed.

Near-surface plume monitoring in Cell LD coincided with Placement Event 3 on August 28, and surveys at Cell LU coincided with Placement Events 47 and 59 on September 10 and September 12, respectively. Results from monitoring tasks are presented in Sections 8.2 through 8.3.

Table 8.1-1. Summary of Sampling Dates for Plume Transport Monitoring

	Kelp
Post Cap	8/28 (LD; Placement 3) 9/10 (LU; Placement 47) 9/12 (LU; Placement 59)

Kelp-kelp bed surveys

8.2 Drogue Trajectory Results

8.2.1 Overview of Field Sampling Plan

The third monitoring objective for mapping of suspended sediment plumes associated with cap material placement operations addressed the potential for onshore transport of suspended cap material and elevated turbidity in the vicinity of existing, nearshore kelp beds (forests). The primary requirement was to obtain in situ data on the spatial distribution of suspended sediment plumes in the upper water column immediately following release of cap material at the inshore/Landward cells (i.e., LU and LD).

The water depth in these cells ranged from 41 to 45 m, whereas the inshore kelp forests were generally confined to depths less than 15 m. Consequently, if plumes of suspended cap material were to be advected horizontally to the vicinity of the kelp forests, they would have to remain in the upper 10 to 15 m of the water column, assuming that the water parcels and suspended particulates would move primarily along surfaces of constant water depth (very likely based upon hydrostatic principles and local water column stratification). Therefore, the monitoring approach for this program element entailed tracking of any near-surface plumes associated with the cap placement operations.

Although we have limited data on the near-surface flow regime on the PV Shelf, we expect that in the absence of strong winds, onshore flow would be most likely to occur during the incoming tide. For this reason, this element of the monitoring program was designed such that cap placement events in the landward cells would correspond with the time of low water and hence, the beginning of the incoming tide.

Near-surface plume monitoring was conducted during two conventional placement events in Cell LU and during one spreading placement event in Cell LD. A key element of the field sampling plan entailed positioning of the survey vessel at the optimum geographic location, within or directly above the near-surface plume of suspended cap material. During each placement event the survey vessel was positioned within the wake of the dredge and within the visible surface plume of suspended material. As the near-surface plume was advected away from the placement site by the ambient currents, it was critical to know the speed and direction at which the plume was moving so that the survey vessel could remain within or above the plume to monitor any temporal changes in water properties (e.g., decrease in suspended solids concentrations) within the plume. Because the survey vessel was not equipped with a vessel-mounted Acoustic Doppler Current Profiler (ADCP) for vertical profiling of horizontal currents throughout the water column, nor was a second vessel available for ADCP measurements, water-following drogues were used to determine, in real-time, the approximate speed and direction of the near-surface flow.

8.2.2 Review of Data Quality Objectives

The Data Quality Objectives for near-surface plume mapping are addressed in subsection 8.3.2. As stated, coordination (timing and geographical positioning) between the hopper dredge and the survey vessel supporting the water quality measurements was critical for acquisition of data that could be used to achieve the water quality monitoring objectives. Although the use of water-following drogues had not been included in the PWP (SAIC 2001), this ancillary technique proved useful for aiding vessel positioning during plume tracking operations because no ADCP current profile measurements were made during the three near-surface plume studies.

8.2.3 Technical Considerations

Mid-Depth Drogue Configuration

As for the near-bottom plume studies, water-following "holey-sock" drogues were deployed and visually tracked during monitoring of three cap placement operations to obtain real-time information on horizontal currents in the upper water column. The design of these mid-depth drogues is described in subsection 3.4.3 (see Figure 3.4-1).

To obtain drogue positions, the survey vessel passed closely alongside the surface buoy of the drogue and the DGPS position of the vessel was recorded by the navigation system used for the water quality monitoring operations. The drogue number, time, and DGPS positions were recorded by the onboard SAIC navigator.

Surface Drogue Configuration

Modified "Davis drifters" were used for the surface drifters due to their small size, low cost, and proven design for accurately presenting currents in the presence of winds and surface waves. This drifter design was developed at Scripps Institution of Oceanography and used successfully on many Lagrangian current measurement programs during the past decade. Figure 8.2-1 presents a drawing of the surface drifter used for the present study. The central, vertical element of the drifters was constructed of 7-cm diameter PVC pipe. Fiberglass rods passed through the PVC pipe, arranged in a cruciform configuration to support sails that were fabricated of 50-cm by 90-cm sheets of lightweight nylon. Lobster pot toggle buoys were attached to the four corners of the drifter sails to provide buoyancy. A 100-cm fiberglass whip and 30-cm by 30-cm nylon flag were used to aid visual sightings.

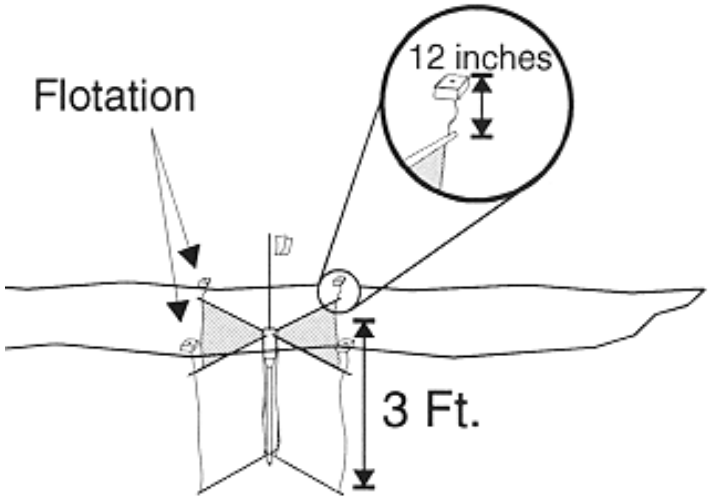

Figure 8.2-1. Sketch of surface drifter used for plume tracking during water quality monitoring.

Depths of Drogues

The surface drogue was designed to remain at the sea surface. The holey-sock drogues were tethered at a depth of 10 m below the surface for these near-surface plume studies. During survey operations, this 10-m drogue was tracked visually by locating the yellow flag that was attached to the drogue's surface marker buoy.

8.2.4 Monitoring Results

Near-Surface Plume Transport Study during Placement Event 3 in Cell LD

At 2203 GMT on August 28, 2000, cap placement operations for Event 3 began in Cell LD using the spreading technique. This time was purposely selected for initiation of the placement operation because it corresponded with the time of low water (2212 GMT) at the National Oceanic and Atmospheric Administration (NOAA) tide station at Los Angeles Outer Harbor. During the cap spreading operation, the hopper dredge entered Cell LD on a northwestward heading down the long axis of the cell. As indicated in Figure 8.2-2, cap material was spread along a line extending from the southeastern boundary of the cell to a point near the center of the cell, with 1070 m^3 of material being released from the dredge during a period of approximately 5 min. At 2207 GMT the survey vessel entered closely behind the moving dredge and two drogues (one surface and one tethered at 10-m depth) were deployed in the wake of the dredge. The 10-m drogue moved northwestward at an average speed of 8.4 cm/s, traveling a distance of 481 m in the 1 hr, 35 min drift period (Table 8.2-1) The surface drogue moved in the opposite direction, traveling a net distance of 935 m to the east-southeast at an average speed of 14.9 cm/s. These two drogue trajectories demonstrate the considerable vertical shear in horizontal currents at the study area. More importantly in terms of the study objective, these drogues illustrated that currents (and presumably any near surface plume of suspended sediments) were not directed shoreward during the first two hours following cap placement at the onset of the rising tide.

Near-Surface Plume Transport Study during Placement Event 47 in Cell LU

At 2111 GMT on September 10, 2000, cap placement operations for Event 47 began in Cell LU using the conventional placement technique. This time was selected for initiation of the placement operation because it corresponded with the time of low water (2112 GMT) at the NOAA tide station at Los Angeles Outer Harbor. During the cap placement operation, the hopper dredge released its load of

material at a single position slightly north of the center of Cell LU (Figure 8.2-3). At 2114 GMT the survey vessel moved very close to the dredge to deploy two drogues (one surface and one tethered at 10-m depth). The 10-m drogue moved continually northwestward at an average speed of 10.1 cm/s, traveling a distance of 725 m in the 1 hr, 59 min drift period (Table 8.2-1). The surface drogue initially moved toward the west, then turned toward the east-southeast, with speeds of roughly 6 cm/s during both drift segments. As had been observed by the drogues during Event 3 in Cell LD, the two drogue trajectories demonstrated considerable vertical shear in horizontal currents at the study area. In terms of the study objective, these drogue tracks from Cell LU illustrated that currents (and presumably any near surface plume of suspended sediments) were not directed shoreward during the first two hours following cap placement at the onset of the rising tide.

Near-Surface Plume Transport Study during Placement Event 59 in Cell LU

At 2224 GMT on September 12, 2000, cap placement operations for Event 59 began in Cell LU using the conventional placement technique. This time was selected for initiation of the placement operation because it corresponded with the approximate time of low water (2212 GMT) at the NOAA tide station at Los Angeles Outer Harbor. During the cap placement operation, the hopper dredge released its load of material at a position slightly north of the center of Cell LU (Figure 8.2-4). Note that because the dredge was maneuvering at the site of the cap placement for over 10 min, the survey could not deploy the drogues at the exact time of the placement operation. At 2237 GMT the survey vessel moved close to the dredge to deploy two drogues (one surface and one tethered at 10-m depth). Unfortunately, the dredge turned sharply and reversed course shortly after the drogues were deployed. The consequence of this action was that the 10-m drogue was run over by the dredge and the tether line extending from the surface buoy to the drogue was cut. Consequently, no drogue data were obtained from the 10-m level.

The surface drogue moved continually westward after release, at an average speed of 11.5 cm/s and traveling a distance of 766 m in the 1 hr, 50 min drift period (Table 8.2-1). In terms of the study objective, this drogue track from Cell LU illustrated that currents (and presumably any near-surface plume of suspended sediments) were not directed shoreward during the first two hours following cap placement at the onset of the rising tide.

8.2.5 Discussion

In August 2000, the offshore boundary of the kelp forest was approximately 1 km inshore of the boundary of Cells LU, LC and LD (see Figure 8.2-2). During monitoring of three cap placement events that commenced at the beginning of the incoming tide, neither the surface drogues nor the 10-m drogues moved toward shore; trajectories demonstrated flow that was either alongshore (northwestward or southeastward) or offshore (westward). Both of the drogue trajectories from 10-m depth moved toward the northwest, whereas the trajectories from the three surface drogues were more variable (eastward or westward). These data represent strong evidence that if a plume of suspended sediment had remained in the upper 10 m of the water column for the first two hours following one of these cap placement events, the material would not have been transported toward shore and in the vicinity of the existing kelp forests.

It is important to acknowledge that this data set, representing three separate cap placement events during summer conditions with minimal winds, is not a statistical representation of the variability in surface currents that could be expected on the Palos Verdes Shelf. Additional cap placement (plume) events and concurrent monitoring studies would be required for development of a statistically significant prediction of the likelihood that suspended cap material could reach nearshore kelp forests within a few hours after release of material from a hopper dredge. However, it is evident from these and other drogue-tracking surveys (Sections 3.4, 4.4, 5.4, and 6.3) that onshore transport was not observed to be prevalent.

Table 8.2-1. Summary of drift statistics for drogues deployed during three cap placement events in Cells LD and LU during August and September 2000

Cell / Event	Date	Drogue (Depth)	Time Period	Start Time (GMT)	End Time (GMT)	Duration (hh:mm:ss)	Distance (m)	Direction (deg T)	Speed (cm/s)	Tide Phase
LD-3	8/28/2000	Blue (Surface)	Total Deployment	22:07:21	23:52:14	1:44:53	935	116	14.9	Flood
		Yellow (10m)	Total Deployment	22:07:21	23:43:11	1:35:50	481	316	8.4	Flood
LU-47	9/10/2000	Blue (Surface)*	First 1hr27min.	21:14:32	22:41:54	1:27:22	285	275	5.4	Flood
			Last 45min.	22:41:54	23:27:18	0:45:24	187	113	6.9	Flood
		Yellow (10m)	Total Deployment	21:14:32	23:14:14	1:59:42	725	302	10.1	Flood
LU-59	9/12/2000	Blue (Surface)	Total Deployment	22:37:49	0:28:25	1:50:36	766	261	11.5	Flood
			First 45min.	22:37:49	23:23:33	0:45:44	325	280	11.8	Flood
			Last 1hr4min.	23:23:33	0:28:25	1:04:52	472	248	12.1	Flood
		Yellow (10m)**		22:37:49						

Notes:
* Time, distance, trajectory, and speed for two segments are presented due to a significant change in trajectory during deployment.
Total time deployed equals the sum of both segments (2:12:46)
** Yellow drogue was lost under hopper dredge.

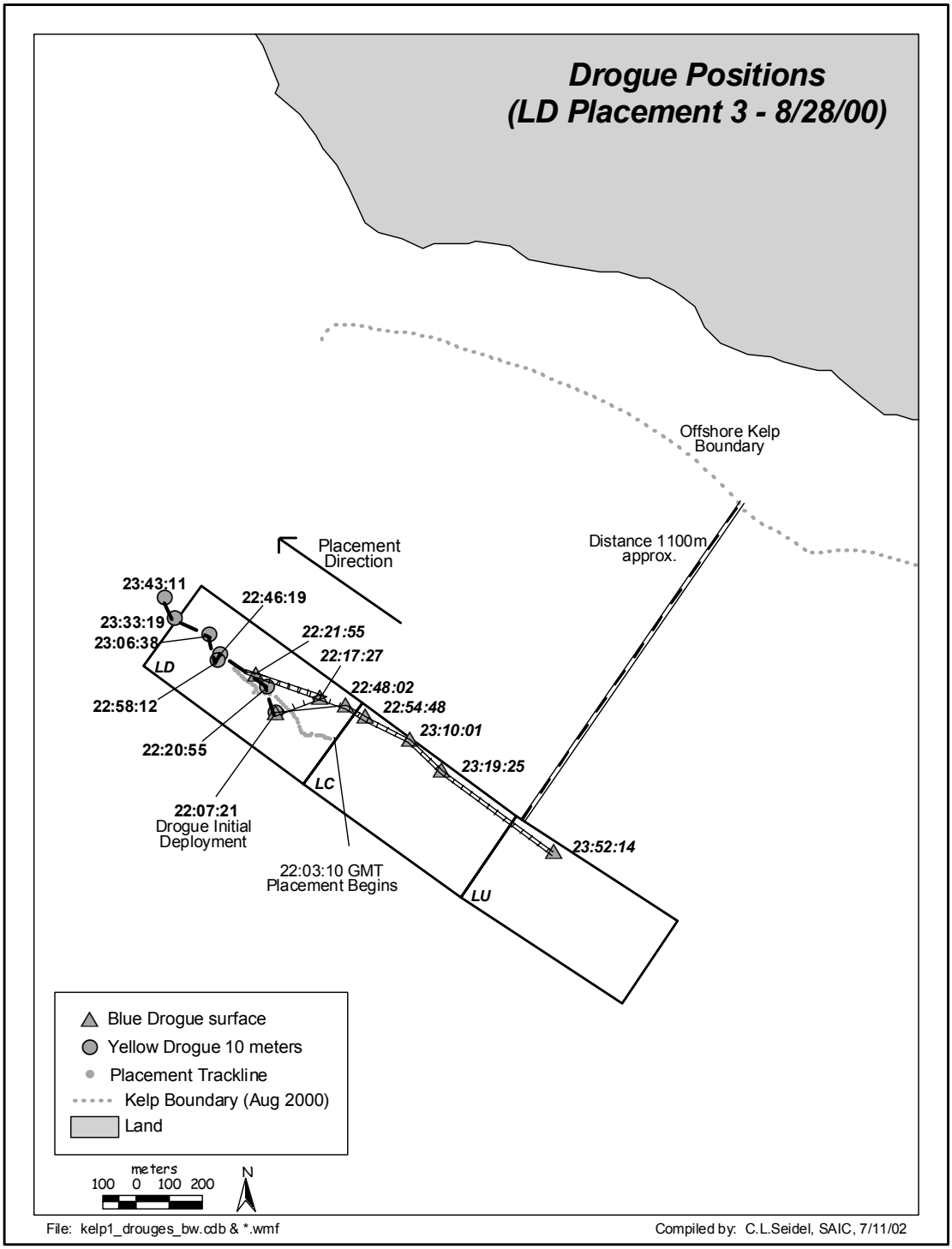

Figure 8.2-2. Map of Cells LD, LC and LU indicating trajectories of two drogues during water quality monitoring of near-surface plumes during spreading placement Event 3 in Cell LD on August 28, 2000.

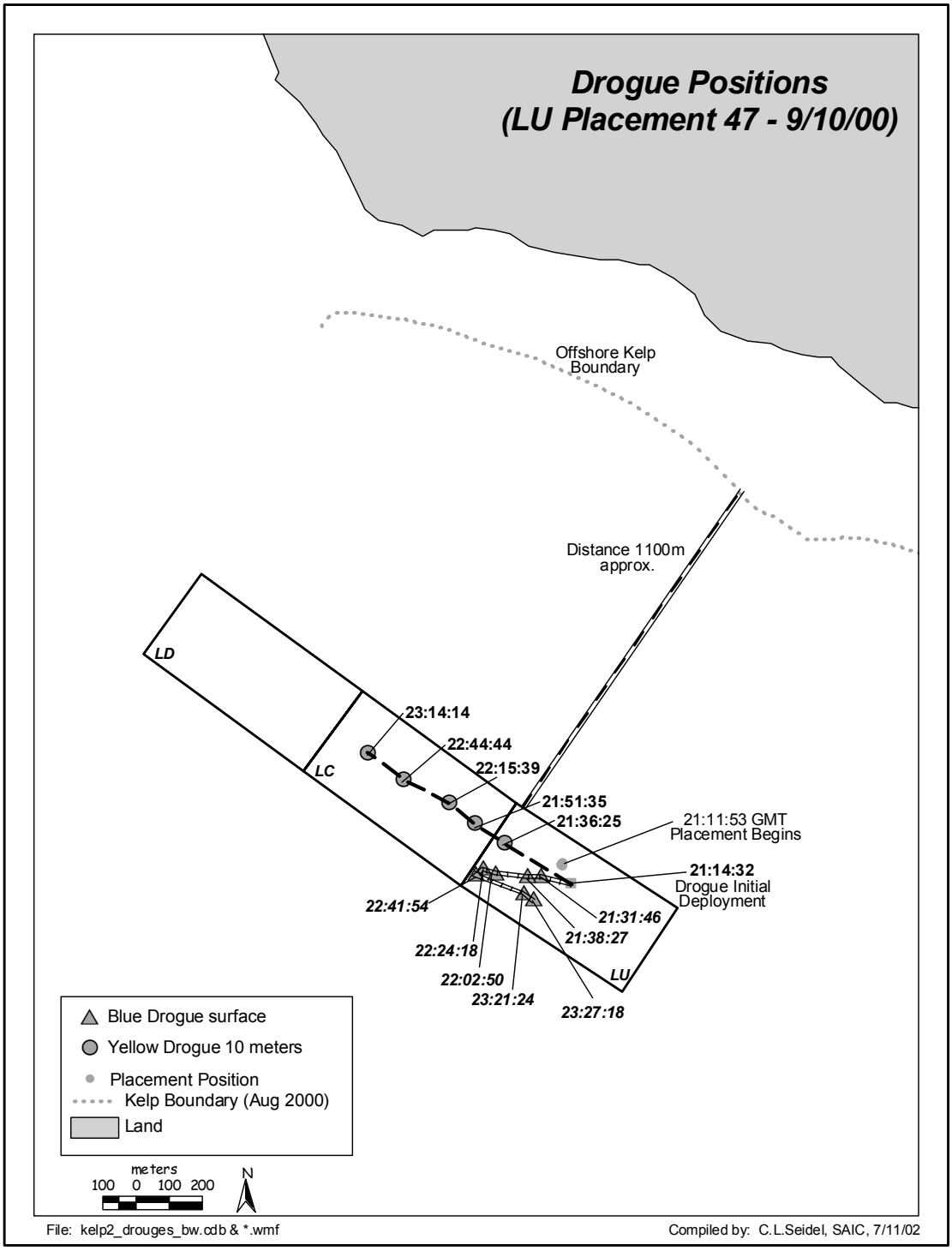

Figure 8.2-3. Map of Cells LD, LC and LU indicating trajectories of two drogues during water quality monitoring of near-surface plumes during conventional placement Event 47 in Cell LU on September 10, 2000.

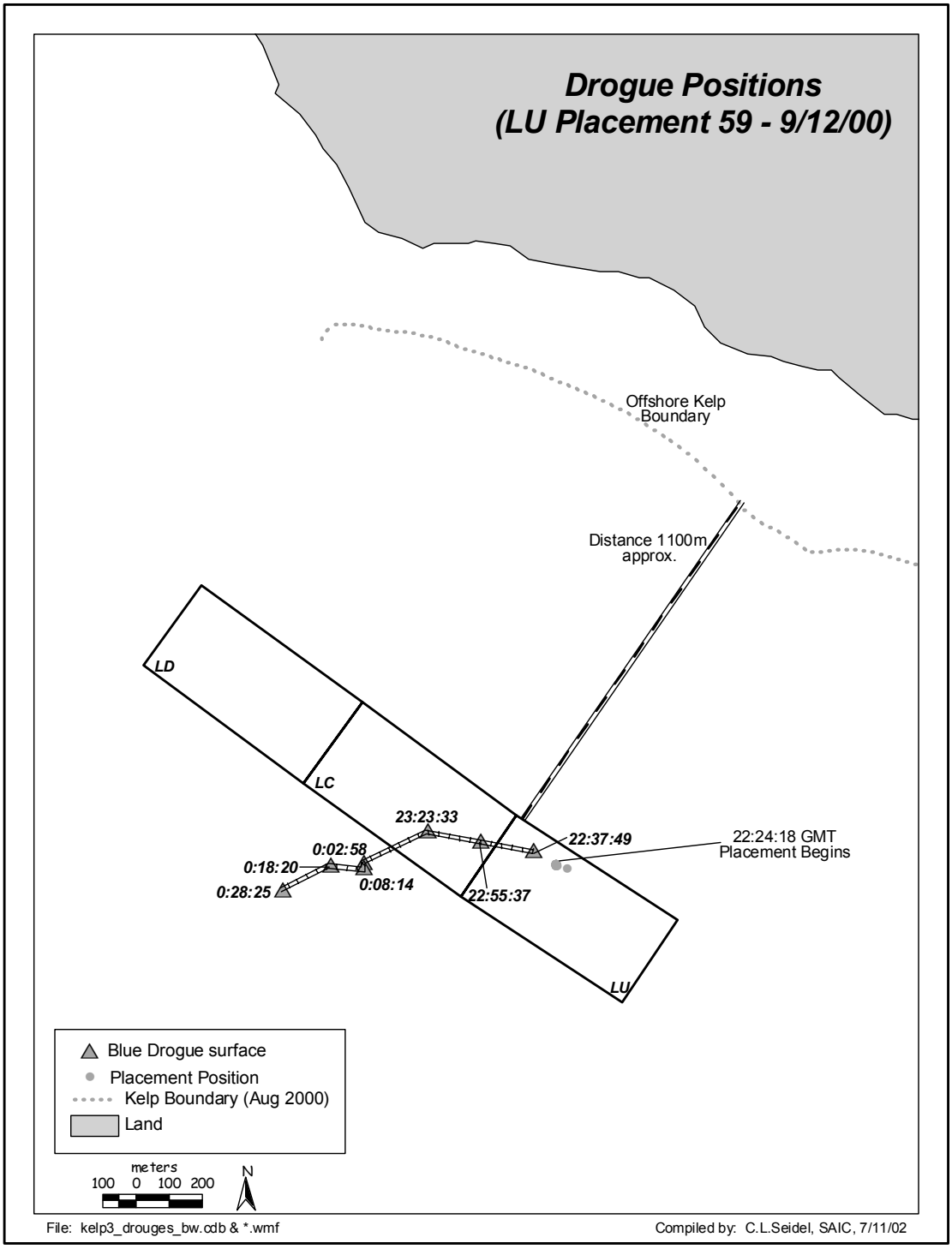

Figure 8.2-4. Map of Cells LD, LC and LU indicating the trajectory of the surface drogue during water quality monitoring of near-surface plumes during conventional placement Event 59 in Cell LU on September 12, 2000.

8.3 Water Column Monitoring Results

8.3.1 Overview of Field Sampling Plan

Cap placement operations have the potential of creating plumes of suspended fine-grained cap material that remain in the water column for varying lengths of time depending upon particle settling rates and other environmental factors. This could result in elevated suspended sediment concentrations in the surface waters that could migrate to nearshore kelp forests. Monitoring of near-surface plume transport was conducted to determine the potential for onshore transport of cap materials. This monitoring followed similar field procedures as implemented for monitoring of near-bottom plumes (see 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-surface 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-surface plume during the first two hours following each of three cap placement events in landward Cells LD and LU.

3. Determine whether plumes of suspended sediment (cap material) are transported toward and into existing nearshore kelp forests by ambient currents.

As discussed in Section 8.2, water-following drogues were used to determine, in real-time, the speed and direction of the near-surface currents and thus aid tracking of the near-surface suspended sediment plumes. The ADCP system, which had been employed from a separate survey vessel during the near-bottom plume surveys, was neither planned nor available for current velocity and acoustic backscatter measurements during the monitoring of near-surface plumes.

8.3.2 Data Quality Objectives

8.3.2.1 Water Quality Objectives

The monitoring objectives and approach for near-surface plume measurements were generally similar to those presented in Table 3.5-1 for monitoring of near-bottom plumes resulting from capping operations. Sampling operations during the spreading event in Cell LD followed those procedures discussed in Section 5.5.2, whereas the sampling operations during the conventional placement events in Cell LU followed those discussed in Section 3.5.2. All water quality objectives were met during monitoring of the three events.

8.3.2.2 Plume Mapping Objectives

The monitoring objectives and approach for near-surface plume measurements were similar to those presented in Table 3.5-2 for monitoring of near-bottom plumes. 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. Water-following drogues proved to be useful as real-time indicators of the movement of the near-surface plume (see Section 8.2).

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.

8.3.3 Technical Considerations

As described in Section 8.2, the water quality studies were conducted in conjunction with tracking of water-following drogues. For the three cap placement events monitored, a surface drogue and a 10-m drogue were deployed to represent, in real-time, the near-surface flow.

Also note that water samples were not collected for post-survey analysis of DDE concentration because: 1) near-surface plumes were the focus of these studies, and 2) it is highly unlikely that ambient EA sediments would have been resuspended and carried upward from 40 m depth and into a near-surface plume. Consequently, near-surface water samples were analyzed for TSS concentration only.

8.3.4 Monitoring Results

Near-surface water quality studies using the CTD, transmissometer, and Niskin bottles with rosette sampler were conducted during the following cap placement operations:

- Spreading Event 3 in Cell LD on August 28, 2000. Material from the A-III Borrow Area was used for capping.
- Conventional placement Event 47 in Cell LU on September 10, 2000. Material from the Queen's Gate Channel was used for capping.
- Conventional placement Event 59 in Cell LU on September 12, 2000. Material from the Queen's Gate Channel was used for capping.

The sampling methodology followed the Field Sampling Plan as summarized in Section 3.5.1, with minor modifications that are discussed in Section 8.3.3.

8.3.4.1 Plume Survey during Cap Spreading Event 3 in Cell LD

A summary of all CTD profile measurements and water samples collected during spreading Event 3 in Cell LD is provided in Table 8.3-1. Specific details regarding the sampling operations can be found in the Cruise Report (SAIC 2000b).

Prior to commencement of spreading Event 3, five CTD profiles were made to assess the background water properties in the vicinity of the planned cap spreading operation in Cell LD. Baseline stations were situated along a line extending from the seaward boundary of the existing kelp forest to the center of Cell LD. (See Figure 8.3-1, which indicates the offshore boundary of the kelp forest as determined on August 13, 2000.) Background turbidity characteristics were generally similar to conditions observed on other water quality survey days, and vertical profiles exhibited only minor turbidity variations with depth from the surface to the bottom. Table 8.3-1 provides the minimum percent light transmittance (PLT, equivalent to maximum turbidity) observed in the upper 15 m of the water column at each background CTD station made prior to Event 3. As during other surveying events, the upper water column had low natural turbidity, with minimum PLT values ranging from 76% to 79%.

Spreading Event 3 in Cell LD began at 2203 GMT on August 28, 2000. Upon initiation of the spreading operation from the hopper dredge, the CTD survey vessel was positioned near the center of Cell LD, awaiting passage of the dredge as it moved slowly toward the northwest along the axis of the cell (Figure 8.3-1). Immediately after the dredge passed, the survey vessel moved into the wake of the moving dredge for deployment of the surface and 10-m drogues, and lowering of the CTD/transmissometer. The turbidity profile data acquired during CTD 1 revealed that there was no plume of suspended cap material within the upper 15 m of the water column; the near-surface minimum PLT value of 77% demonstrated that turbidities were comparable to background levels immediately after the dredge passed (Table 8.3-1).

Light transmission data acquired during CTD 2 located close to the two drogues and within 0.5 hr of dredge passage, also demonstrated that a surface plume did not exist in the wake of the dredge. Approximately 15 min later, CTD 3 was made adjacent to the surface drogue which was beginning to move southeastward and in the opposite direction of the 10-m drogue (Figure 8.3-1). Again, there was no evidence of a suspended sediment plume in the upper water column.

Four additional CTD stations (4 through 7) were made in close proximity to either the surface or the 10-m drogue, with the result that near-surface turbidity (PLT) values were equivalent to background conditions at all stations. As indicated in Table 8.3-1, the minimum PLT in the upper 15 m of the water column at CTD stations 1 through 7 ranged from 77% to 78%.

The temporal evolution of turbidity within the near-surface plume resulting from the spreading event in Cell LD is illustrated in Figure 8.3-2. This figure shows that the minimum PLT in the near-surface waters was not significantly different from the background water properties for any of the CTD stations occupied within 90 min following the spreading event. During this sampling period, a total of 17 water samples were collected using the rosette sampler and Niskin bottles. Table 8.3-2 presents the depth and PLT value measured by the CTD at the time discrete water samples were collected. The values of TSS concentration were derived from post-survey laboratory analysis of the discrete water samples collected by the Niskin bottles. During the 90-min sampling period (Figure 8.3-3), we see that the highest TSS concentration of all samples was only 5.3 mg/L. All other samples had values of 2 mg/L, but note that this concentration was the detection threshold of the laboratory TSS analysis for this batch of water samples. Consequently, the laboratory reported 2 mg/L for any sample having a TSS concentration less than or equal to this detection limit. No background (pre-placement) water samples were analyzed for this survey, but recall that background TSS concentrations were comparable to or less than 2 mg/L for all other survey days.

The primary results from this near-surface plume survey during cap spreading Event 3 in Cell LD can be summarized as follows:

- Drogues situated at the surface and at 10-m depth demonstrated along-shore movement, but no transport toward shore during their 90-min drift period corresponding with the beginning of the incoming tide.
- The CTD/transmissometer data confirmed that there was no near-surface plume associated with the spreading of A-III Borrow Area material.
- Water samples collected within the upper 15 m of the water column immediately behind the dredge had TSS concentrations of 5 mg/L or less, confirming that suspended cap material was nearly absent.

8.3.4.2 Plume Survey during Conventional Cap Placement Event 47 in Cell LU

A summary of all CTD profile measurements and water samples collected during conventional cap placement Event 47 in Cell LU is provided in Table 8.3-3. Specific details regarding the sampling operations can be found in the Cruise Report (SAIC 2000b).

Prior to cap placement Event 47, three CTD profiles were made to assess the background water properties in the vicinity of the cap placement operation in Cell LU. Background turbidity characteristics were generally similar to conditions observed on other water quality survey days, and vertical profiles exhibited only minor turbidity variations with depth from the surface to the bottom. Table 8.3-3 provides the minimum PLT (equivalent to maximum turbidity) observed in the upper 15 m of the water column at each background CTD station made prior to Event 47 in Cell LU. As during other surveying events, the upper water column had low natural turbidity, with minimum PLT values ranging from 71% to 72%.

Cap placement Event 47 began at 2111 GMT on September 10, 2000. Upon initiation of the conventional placement operation, the CTD survey vessel was positioned within 75 m of the dredge. As soon as the placement operation was complete and the dredge began to move away (at 2114 GMT), the survey vessel slowly moved into the visible surface plume of suspended sediments to deploy the two drogues and conduct CTD/transmissometer profiling at the location of CTD 1, as shown in Figure 8.3-4. The turbidity profile data acquired during CTD 1 revealed a near-surface plume that was highly turbid and possessed a minimum PLT value of 4% (Table 8.3-3). Eight water samples were collected during this 16-min CTD station.

To illustrate the characteristics of the near-surface plume observed within the first 20 min following the placement operation, Figure 8.3-5 presents an 8-min segment of the time series of PLT and CTD sensor depth acquired during CTD 1. During this time segment, the CTD/transmissometer was raised and lowered three times, and the near-surface plume was observed to reside between the surface and a depth of 10 m; the minimum PLT of 25% was encountered at a depth of 4 m.

Turbidity profile data acquired during CTD 2, located within 15 m of the westward-moving surface drogue, demonstrated a less turbid near-surface plume, having a minimum PLT value of 58%. To determine whether the near-surface plume was moving more in the direction of the 10-m drogue than in the direction of the surface drogue, CTD 3 was located adjacent to the 10-m drogue (Figure 8.3-4) and begun 41 min after the placement operation. Here, the near-surface plume was more turbid than at CTD 2 with a minimum PLT value of 32%. Subsequently, CTD stations 5 and 7 were located at the 10-m drogue, whereas CTD stations 4, 6 and 8 were located at the surface drogue. This survey strategy was established in real-time because the flow at the surface and 10-m levels diverged during this 2-hr sampling period.

The temporal evolution of turbidity within the near-surface plume resulting from the conventional placement event in Cell LU is illustrated in Figure 8.3-6. This figure shows that turbidities in the near-surface plume generally decreased with time and approached low-turbidity background conditions within approximately 2 hr of the placement event. The shallowest portion of the plume (represented by sampling at CTD stations 1, 2, 4, 6 and 8) appeared to have diluted quicker than the portion of the plume situated near 10-m depth (represented by sampling at CTD stations 1, 3, 5 and 7). As time progressed, the vertical shear in horizontal currents apparently contributed to increased dilution of the near-surface plume.

During monitoring of placement Event 47, a total of 30 water samples were collected using the rosette sampler and Niskin bottles. Table 8.3-4 presents the depth and PLT value measured by the CTD at the time discrete water samples were collected. The values of TSS concentration were derived from post-survey laboratory analysis of the discrete water samples collected by the Niskin bottles. The first

water sample, collected at a depth of 2 m and 8 min after the placement event, had a TSS concentration of 240 mg/L. Subsequent water samples collected within 21 min of the placement had concentrations that decreased to approximately 20 mg/L. Over the entire 2-hr sampling period, TSS concentrations within the near-surface plume generally decreased with time, achieving concentrations near 10 mg/L within approximately 30 min of the placement operation (Figure 8.3-7). After that time, TSS concentrations within the most concentrated portions of the plume remained near 10 mg/L but the plume was continually dispersing such that many of the subsequent water samples were apparently collected outside of the plume. No background (pre-placement) water samples were analyzed for this survey, but recall that background TSS concentrations were comparable to or less than 2 mg/L for all other survey days.

The primary results from this near-surface plume survey during conventional cap placement Event 47 in Cell LU can be summarized as follows:

- Drogues situated at the surface and at 10-m depth demonstrated along-shore movement, but no transport toward shore during their 2-hr drift period corresponding with the beginning of the incoming tide.
- The CTD/transmissometer data confirmed that there was a turbid near-surface plume associated with the conventional placement of Queen's Gate material in Cell LU. Turbidity decreased with time, achieving low background levels approximately 2 hr after the placement operation.
- Water samples collected within the upper 15 m of the water column immediately following the placement operation had maximum TSS concentrations of 240 mg/L; concentrations decreased to approximately 10 mg/L within roughly 30 min and remained slightly above background concentrations during the 2-hr monitoring period.

8.3.4.3 Plume Survey during Conventional Cap Placement Event 59 in Cell LU

A summary of all CTD profile measurements and water samples collected during conventional cap placement Event 59 in Cell LU is provided in Table 8.3-5. Specific details regarding the sampling operations can be found in the Cruise Report (SAIC 2000b).

Prior to cap placement Event 59, three CTD profiles were made to assess the background water properties in the vicinity of the cap placement operation in Cell LU. Background turbidity characteristics were generally similar to conditions observed on other water quality survey days, and vertical profiles exhibited only minor turbidity variations with depth from the surface to the bottom. Table 8.3-5 provides the minimum percent light transmittance (PLT, equivalent to maximum turbidity) observed in the upper 15 m of the water column at each background CTD station made prior to Event 59 in Cell LU. As during other surveying events, the upper water column had relatively low natural turbidity, with minimum PLT values ranging from 69% to 72%.

Cap placement Event 59 began at 2224 GMT on September 12, 2000. Upon initiation of the conventional placement operation, the CTD survey vessel was positioned within 50 m of the dredge. Following this placement operation the dredge did not move quickly away; rather, it turned and remained within its visible surface plume for nearly 10 min. The surface and 10-m drogues were deployed in the plume (see Section 8.2), but the dredge ran over the buoy and tether of the 10-m drogue causing loss of the holey-sock drogue. Consequently, the surface drogue was the only tool available for indicating the direction of the near-surface flow and plume transport (Figure 8.3-8).

The light transmission data acquired during CTD 1 within the visible plume of suspended cap material revealed moderate near-surface turbidities and a minimum PLT value of 53% (Table 8.3-5). PLT data acquired during CTD 2, located adjacent to the westward-moving surface drogue (Figure 8.3-8), exhibited somewhat higher turbidity approximately 30 min after the placement operation and a minimum

PLT of 30%. It appears that CTD 2 was situated in a more concentrated portion of the plume than CTD 1. Additional CTD stations (3 through 6) also were situated near the surface drogue during the 2-hr sampling period. At these stations, maximum turbidities in the near-surface plume decreased with time and approached background conditions within approximately 2 hr of the placement event (Figure 8.3-9).

During monitoring of placement Event 59, a total of 21 water samples were collected using the rosette sampler and Niskin bottles. Table 8.3-6 presents the depth and PLT value measured by the CTD at the time discrete water samples were collected. The values of TSS concentration were derived from post-survey laboratory analysis of the discrete water samples collected by the Niskin bottles. The first water sample, collected at a depth of 2.9 m and 7 min after the placement event, had a TSS concentration of only 2.3 mg/L which indicates that it was not collected from within the relatively turbid near-surface plume. After the survey vessel was repositioned, eight water samples were collected at CTD 2 and moderate (22 to 96 mg/L) turbidity levels indicated that samples contained suspended cap material.

Subsequent water samples collected within the near-surface plume during CTD 3 (within 36 to 53 min of the placement operation) had TSS concentrations that decreased to approximately 5 mg/L (Figure 8.3-10). After that time, TSS concentrations within the most concentrated portions of the plume remained near 5 mg/L until water sample collection ended at approximately 80 min after the placement operation.

The primary results from this near-surface plume survey during conventional cap placement Event 59 in Cell LU can be summarized as follows:

- The drogue situated at the sea surface demonstrated westward movement and no transport toward shore during the nearly 2-hr drift period corresponding with the beginning of the incoming tide.
- The CTD/transmissometer data confirmed that there was a moderately turbid near-surface plume associated with the conventional placement of Queen's Gate material in Cell LU. Turbidities decreased with time, achieving low levels approximately 1 hr after the placement operation.
- Water samples collected within the upper 15 m of the water column at 21 min after the placement operation had maximum TSS concentrations of 96 mg/L; concentrations decreased to approximately 5 mg/L within roughly 1 hr of the placement event and remained slightly above background concentrations during the 80-min water sampling period.

8.3.5 Discussion

The objective of the near-surface plume study was to determine the potential for onshore transport of suspended cap material following placement in landward cells (e.g., Cells LD and LU). The concern was whether fine-grained cap material could remain within the upper portion of the water column and be advected into existing, nearshore kelp forests. Critical data requirements to address this objective included: 1) monitoring of the location and temporal evolution of the near-surface plume and 2) measurements of suspended solids concentration of the plume within 2 hrs of the cap placement event. During this near-surface study, water-following drogues proved effective for indicating the trajectory of the near-surface flow such that CTD profiles made in close proximity to the drogues were situated within the plumes.

Turbidity Profile Observations

PLT data measured in the upper portion of the water column at multiple station locations revealed a moderately turbid, near-surface plume during each of two conventional placements of Queen's Gate cap material monitored in Cell LU. In contrast, a near-surface plume did not result from spreading of A-III Borrow Area material in Cell LD. As illustrated in Figure 8.3-11, which presents a composite of

minimum observed PLT values (comparable to maximum turbidity) versus time since placement operation for the three events monitored, turbidity results from the two events in Cell LU were very similar, whereas the data from the spreading event in Cell LD were representative of low-turbidity background conditions. The absence of a near-surface plume during the spreading event was presumably due to the coarser borrow area material being spread in Cell LD and settling more rapidly than the Queen's Gate material, which contained a greater percentage of fine-grained material that could potentially remain suspended in the water column for longer periods of time.

TSS Observations from Discrete Water Samples

A comparison of TSS results from the three near-surface plume studies (Figure 8.3-12) further illustrates that TSS concentrations in the plumes associated with the conventional placement of Queen's Gate material possessed much higher TSS concentrations than were observed during the spreading of A-III Borrow Area material in Cell LD. Results from the two conventional placement events are remarkably similar considering the variety of environmental, operational, and material differences that may have occurred between the two survey events. The main result was that relatively dilute, near-surface plumes of suspended, fine-grained Queen's Gate material persisted for at least two hours after the placement event, but the TSS concentration within these plumes was only slightly above background conditions.

Drogue Results during Incoming Tides

All three of the near-surface plume studies were initiated at the beginning of the incoming tide, when the local flow was expected to have an onshore velocity component. This strategy was intended to maximize the possibility of onshore transport of any near-surface plumes of suspended cap material that may have existed immediately following cap placement operations. Tracking of surface and 10-m drogues for a period of 2 hrs during each of the three studies resulted in data that represented near-surface currents during the time of the water quality measurements. Figure 8.3-13 presents a composite of drogues tracks for the three studies, illustrating that none of the five drogue tracks demonstrated onshore flow during this tidal phase. Furthermore, the results illustrate the complexity of the near-surface flow regime, which appears to be dominated by alongshore (northwest-southeast) flow. In summary, the water column profiling results combined with the alongshore drogue trajectory data suggest that capping operations at the landward cells will not result in turbid, near-surface plumes of suspended cap material, nor would the plumes be transported shoreward to existing kelp forests under normal tidal conditions and weak winds.

Table 8.3-1. Summary of CTD profiles acquired and water samples collected during cap spreading Event 3 in Cell LD on August 28, 2000. Also given is the maximum turbidity (minimum percent light transmission) observed in the upper 15 m of the water column during each profile.

Station Type	Background	Background	Background	Background	Background
Elapsed Time of Cast	0:05:49	0:03:48	0:06:23	0:06:20	0:05:59
CTD File Name	K1-1B-CTD1	K1-1B-CTD2	K1-1B-CTD3	K1-1B-CTD4	K1-1B-CTD5
Total Water Column Profiles	1	1	1	1	1
Water Samples Collected	0	0	0	0	0
Minimum % Light Transmittance (PLT)	76	79	77	78	77

Start Time After Placement (hr:min:sec)	0:09:01	0:20:28	0:46:45	0:56:42	1:09:15	1:22:51	1:32:17
File/Cast End Time	0:12:55	0:31:28	0:51:43	1:00:55	1:20:55	1:27:55	1:37:55
Elapsed Time of Cast	0:03:54	0:11:00	0:04:58	0:04:13	0:11:40	0:05:04	0:05:38
CTD File Name	K1-1D-CTD1	K1-1D-CTD2	K1-1D-CTD3	K1-1D-CTD4	K1-1D-CTD5	K1-1D-CTD6	K1-1D-CTD7
Total Water Column Profiles	1	1	1	1	1	1	1
Water Samples Collected	2	5	2	2	2	2	2
Minimum % Light Transmittance (PLT)	77	77	78	78	78	78	78

Table 8.3-2. Total suspended solids concentrations from discrete water samples collected during CTD profiling operations during cap spreading Event 3 in Cell LD on August 28, 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)	Sample number
9	K1-1D-CTD1	K1-1D-BTA-01	9.9	78.3	2.0	1
12	K1-1D-CTD1	K1-1D-BTA-02	5.2	80.8	2.0	2
19	K1-1D-CTD2	K1-1D-BTB-01	9.9	78.2	5.3	3
20	K1-1D-CTD2	K1-1D-BTB-02	5.0	78.2	2.0	4
25	K1-1D-CTD2	K1-1D-BTB-03	31.5	81.0	2.0	5
25	K1-1D-CTD2	K1-1D-BTB-03	31.5	81.0	2.0	6
26	K1-1D-CTD2	K1-1D-BTB-04	9.0	78.8	2.0	7
45	K1-1D-CTD3	K1-1D-BTC-01	8.3	78.8	2.0	8
46	K1-1D-CTD3	K1-1D-BTC-02	5.1	79.1	2.0	9
55	K1-1D-CTD4	K1-1D-BTD-01	11.0	78.8	2.0	10
56	K1-1D-CTD4	K1-1D-BTD-02	4.9	78.5	2.0	11
67	K1-1D-CTD5	K1-1D-BTE-01	10.3	79.2	2.0	12
68	K1-1D-CTD5	K1-1D-BTE-02	5.0	79.8	2.0	13
81	K1-1D-CTD6	K1-1D-BTF-01	9.7	77.9	2.0	14
82	K1-1D-CTD6	K1-1D-BTF-02	6.0	79.1	2.0	15
90	K1-1D-CTD7	K1-1D-BTG-01	10.7	78.3	2.0	16
92	K1-1D-CTD7	K1-1D-BTG-02	5.4	79.5	2.0	17

Table 8.3-3. Summary of CTD profiles acquired and water samples collected during conventional cap placement Event 47 in Cell LU on September 10, 2000. Also given is the maximum turbidity (minimum percent light transmission) observed in the upper 15 m of the water column during each profile.

Start Time After Placement (hr:min:sec)	Background	Background	Background	0:04:35	0:30:57	0:41:24	0:55:04	1:05:34	1:17:18	1:35:40	2:11:11
File/Cast End Time	Background	Background	Background	0:20:49	0:35:36	0:45:55	1:04:08	1:12:47	1:30:23	1:59:34	2:14:27
Elapsed Time of Cast	0:17:23	0:07:57	0:12:35	0:16:14	0:04:39	0:04:31	0:09:04	0:07:13	0:13:05	0:23:54	0:03:16
CTD File Name	K2-1B-CTD1	K2-1B-CTD2	K2-1B-CTD3	K2-1D-CTD1	K2-1D-CTD2	K2-1D-CTD3	K2-1D-CTD4	K2-1D-CTD5	K2-1D-CTD6	K2-1D-CTD7	K2-1D-CTD8
Total Water Column Profiles	1	1	1	1	1	1	1	1	1	1	1
Water Samples Collected	0	0	0	8	5	4	5	3	2	2	1
Minimum % Light Transmittance (PLT)	72	71	71	4	58	32	65	45	57	60	70

Table 8.3-4. Total suspended solids concentrations from discrete water samples collected during CTD profiling operations during conventional cap placement Event 47 in Cell LU on September 10, 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)	Sample number
8	K2-1D-CTD1	K2-1D-BTA-01	2.4	14.0	240	1
9	K2-1D-CTD1	K2-1D-BTA-02	9.7	71.7	62	2
11	K2-1D-CTD1	K2-1D-BTA-03	2.8	50.8	31	3
11	K2-1D-CTD1	K2-1D-BTA-03	2.8	50.8	18	4
13	K2-1D-CTD1	K2-1D-BTA-04	2.2	33.6	58	5
14	K2-1D-CTD1	K2-1D-BTA-05	2.2	37.8	43	6
17	K2-1D-CTD1	K2-1D-BTA-06	2.2	55.1	19	7
21	K2-1D-CTD1	K2-1D-BTA-07	4.0	56.5	27	8
31	K2-1D-CTD2	K2-1D-BTB-01	3.3	69.4	20	9
32	K2-1D-CTD2	K2-1D-BTB-02	15.5	73.5	8.4	10
34	K2-1D-CTD2	K2-1D-BTB-03	2.2	68.0	12	11
36	K2-1D-CTD2	K2-1D-BTB-04	27.6	80.7	2.0	12
36	K2-1D-CTD2	K2-1D-BTB-04	27.6	80.7	2.0	13
41	K2-1D-CTD3	K2-1D-BTB-05	2.2	42.4	13	14
44	K2-1D-CTD3	K2-1D-BTB-06	20.2	79.0	15	15
45	K2-1D-CTD3	K2-1D-BTB-07	2.3	58.3	8.2	16
46	K2-1D-CTD3	K2-1D-BTB-08	8.1	35.8	7.3	17
55	K2-1D-CTD4	K2-1D-BTC-01	3.6	70.8	6.6	18
56	K2-1D-CTD4	K2-1D-BTC-02	13.4	72.6	2.3	19
57	K2-1D-CTD4	K2-1D-BTC-03	23.8	82.8	2.0	20
59	K2-1D-CTD4	K2-1D-BTC-04	3.4	70.1	3.1	21
59	K2-1D-CTD4	K2-1D-BTC-04	3.4	70.1	2.9	22
66	K2-1D-CTD5	K2-1D-BTC-05	3.9	60.5	4.2	23
68	K2-1D-CTD5	K2-1D-BTC-06	10.7	44.0	10	24
70	K2-1D-CTD5	K2-1D-BTC-07	4.0	57.7	9.7	25
77	K2-1D-CTD6	K2-1D-BTD-01	3.0	69.8	2.9	26
87	K2-1D-CTD6	K2-1D-BTD-02	2.5	68.4	3.5	27
90	K2-1D-CTD7	K2-1D-BTE-01	3.2	69.6	8.0	28
119	K2-1D-CTD7	K2-1D-BTE-02	10.1	72.0	3.3	29
134	K2-1D-CTD8	K2-1D-BTF-01	3.8	71.6	2.7	30

Table 8.3-5. Summary of CTD profiles acquired and water samples collected during conventional cap placement Event 59 in Cell LU on September 12, 2000. Also given is the maximum turbidity (minimum percent light transmission) observed in the upper 15 m of the water column during each profile.

Start Time After Placement (hr:min:sec)	Background	Background	Background	0:07:52	0:18:12	0:37:33	1:03:08	1:20:27	2:08:48
File/Cast End Time	Background	Background	Background	0:14:35	0:31:04	0:53:51	1:14:36	1:36:51	2:16:49
Elapsed Time of Cast	0:08:56	0:07:45	0:08:02	0:06:43	0:12:52	0:16:18	0:11:28	0:16:24	0:08:01
CTD File Name	K3-1B-CTD1	K3-1B-CTD2	K3-1B-CTD3	K3-1D-CTD1	K3-1D-CTD2	K3-1D-CTD3	K3-1D-CTD4	K3-1D-CTD5	K3-1D-CTD6
Total Water Column Profiles	1	1	1	1	1	1	1	1	1
Water Samples Collected	0	0	0	1	8	7	5	0	0
Minimum % Light Transmittance (PLT)	70	69	72	53	30	42	51	61	67

Table 8.3-6. Total suspended solids concentrations from discrete water samples collected during CTD profiling operations during conventional cap placement Event 59 in Cell LU on September 12, 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)	Sample number
7	K3-1D-CTD-01	K3-1D-BTA-01	2.9	73.4	2.3	1
14	K3-1D-CTD-02	K3-1D-BTA-02	2.9	35.9	53	2
17	K3-1D-CTD-02	K3-1D-BTA-03	4.2	45.8	64	3
18	K3-1D-CTD-02	K3-1D-BTA-04	12.8	45.1	61	4
18	K3-1D-CTD-02	K3-1D-BTA-04	12.8	45.1	22	5
21	K3-1D-CTD-02	K3-1D-BTA-05	1.9	52.3	96	6
22	K3-1D-CTD-02	K3-1D-BTA-06	16.7	23.6	53	7
22	K3-1D-CTD-02	K3-1D-BTA-06	16.7	23.6	25	8
24	K3-1D-CTD-02	K3-1D-BTA-07	2.8	46.3	40	9
36	K3-1D-CTD-03	K3-1D-BTB-01	2.9	55.8	20	10
39	K3-1D-CTD-03	K3-1D-BTB-02	8.8	46.9	26	11
44	K3-1D-CTD-03	K3-1D-BTB-03	2.7	60.0	14	12
44	K3-1D-CTD-03	K3-1D-BTB-03	2.7	60.0	9.7	13
47	K3-1D-CTD-03	K3-1D-BTB-04	19.6	46.0	5.4	14
51	K3-1D-CTD-03	K3-1D-BTB-05	21.9	49.7	5.2	15
53	K3-1D-CTD-03	K3-1D-BTB-06	4.3	71.5	2.8	16
62	K3-1D-CTD-04	K3-1D-BTC-01	2.6	65.4	6.8	17
64	K3-1D-CTD-04	K3-1D-BTC-02	22.7	49.7	6.2	18
71	K3-1D-CTD-04	K3-1D-BTC-03	2.2	67.1	5.6	19
73	K3-1D-CTD-04	K3-1D-BTC-04	22.5	51.4	6.1	20
79	K3-1D-CTD-04	K3-1D-BTC-05	3.8	69.9	4.6	21

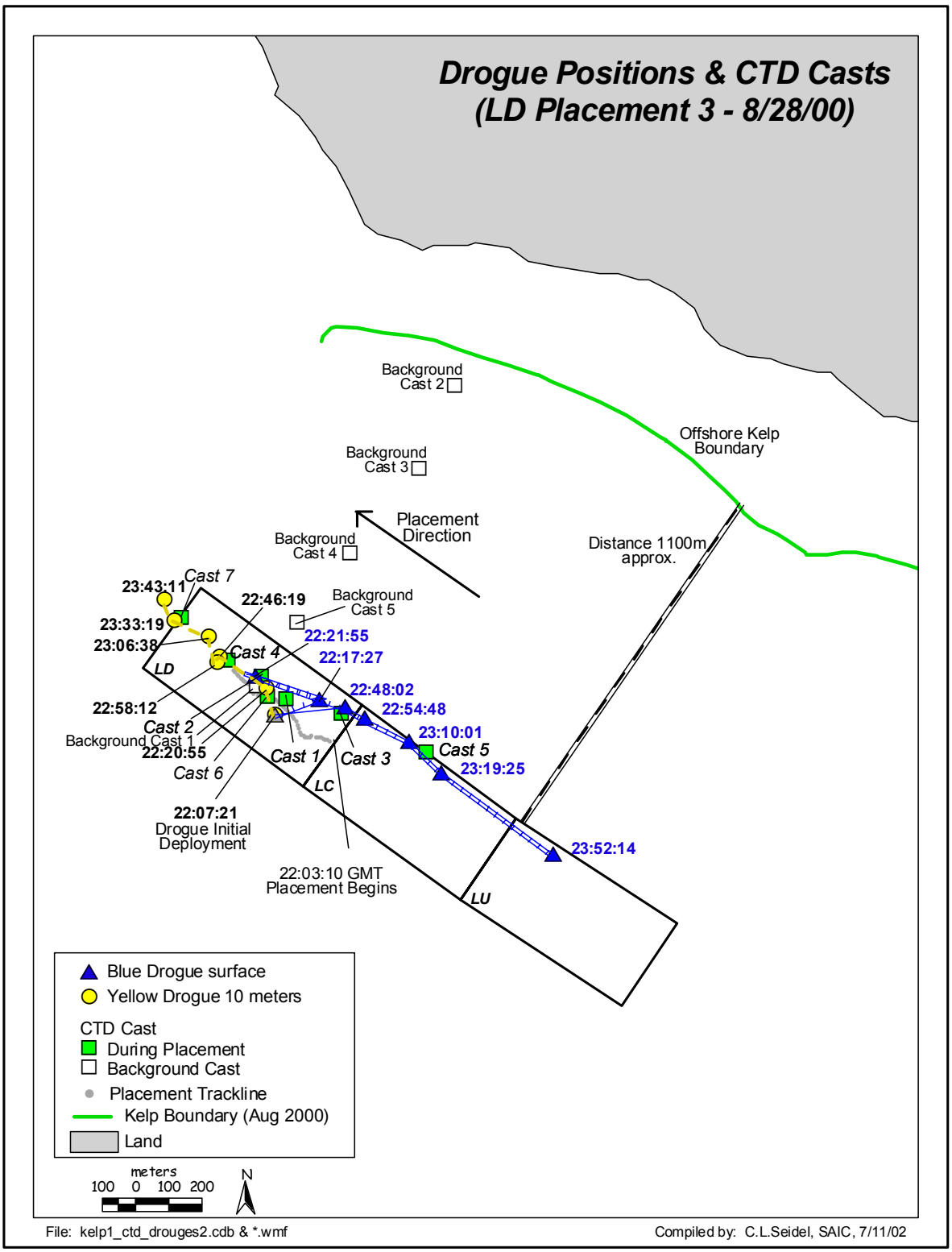

Figure 8.3-1. Map of Cell LD indicating drogue trajectories and CTD stations during cap spreading Event 3 on August 28, 2000.

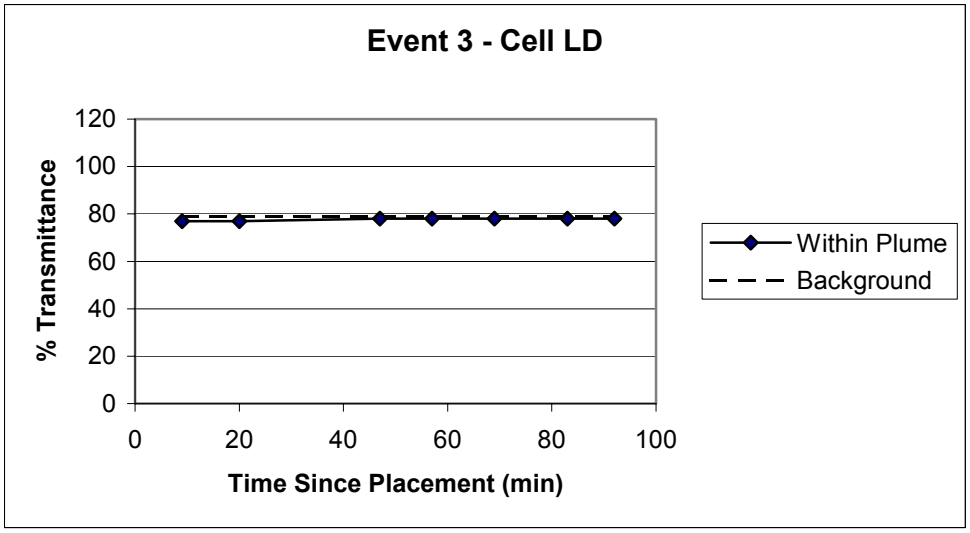

Figure 8.3-2. Time series plot of the minimum value of percent light transmission acquired during each near-surface CTD profile conducted during cap spreading Event 3 in Cell LD on August 28, 2000. See Table 8.3-1 for CTD profile information.

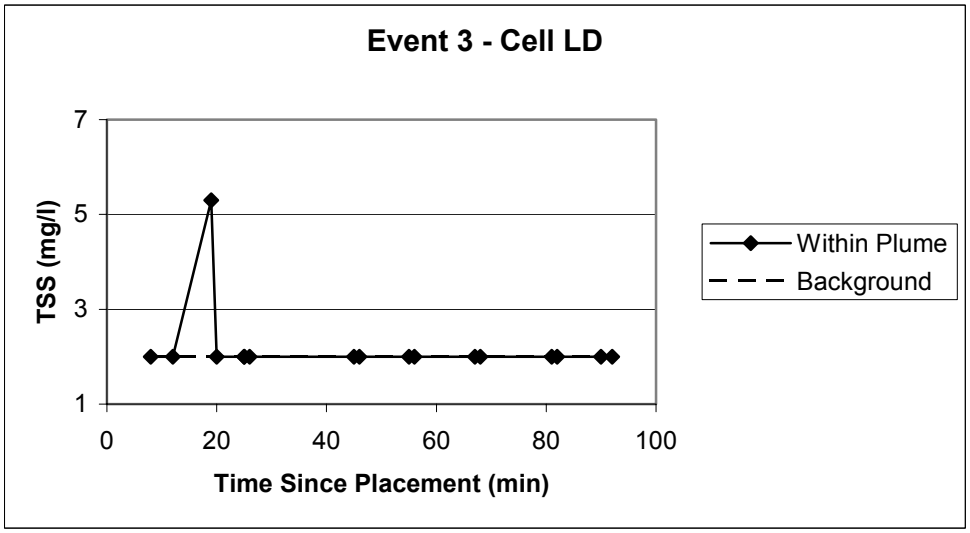

Figure 8.3-3. Plot of total suspended solids concentration versus time since initiation of spreading for discrete water samples collected during CTD profiling operations of cap spreading Event 3 in Cell LD on August 28, 2000.

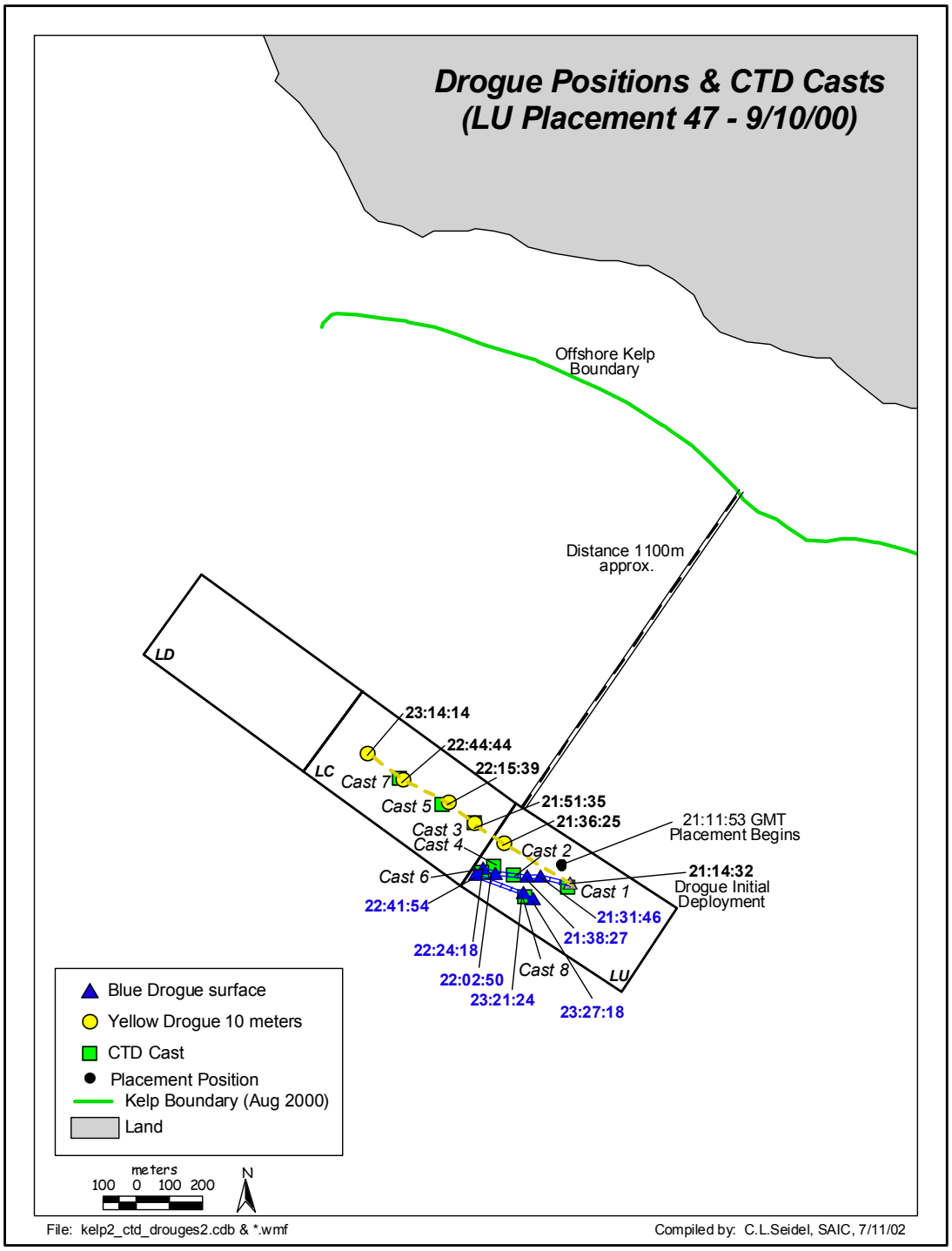

Figure 8.3-4. Map of Cell LU indicating drogue trajectories and CTD stations during conventional cap placement Event 47 on September 10, 2000.

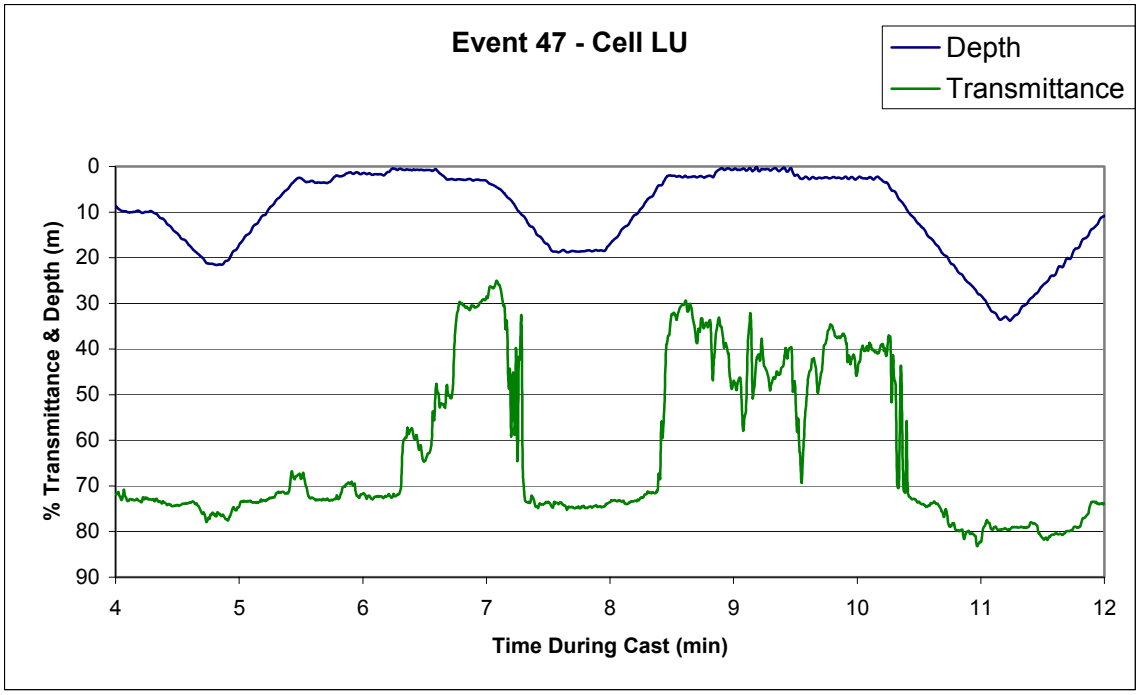

Figure 8.3-5. Time series plot of percent light transmission and sensor depth acquired near the surface during CTD Station 1 during conventional cap placement Event 47 in Cell LU on September 10, 2000. See Table 8.3-3 for CTD profile information.

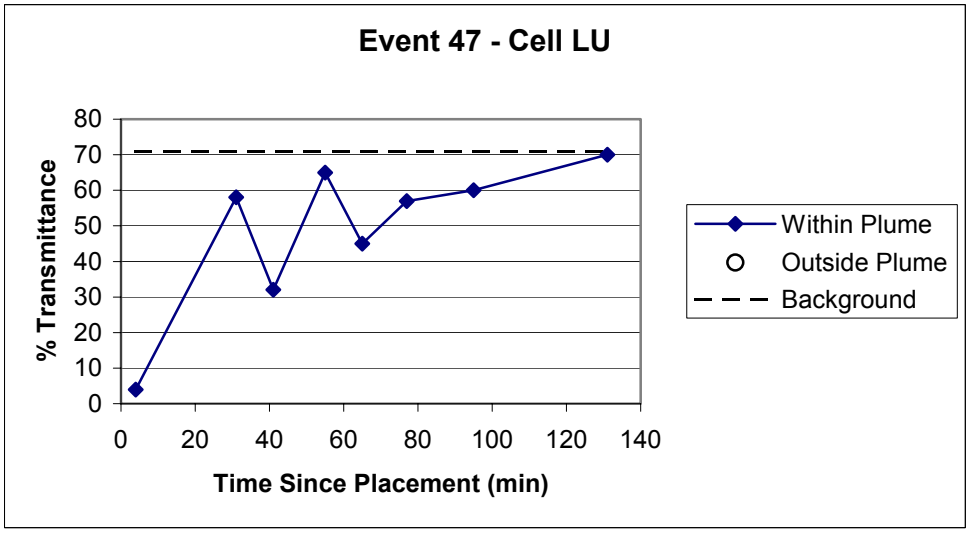

Figure 8.3-6. Time series plot of the minimum value of percent light transmission acquired during each near-surface CTD profile conducted during conventional cap placement Event 47 in Cell LU on September 10, 2000. See Table 8.3-3 for CTD profile information.

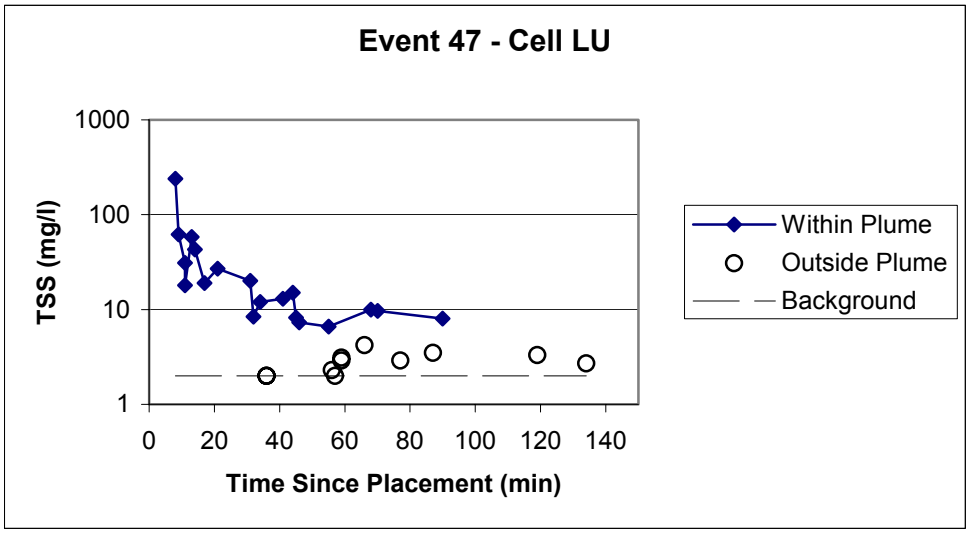

Figure 8.3-7. Plot of total suspended solids concentration versus time since initiation of cap placement for discrete water samples collected during CTD profiling operations of conventional cap placement Event 47 in Cell LU on September 10, 2000.

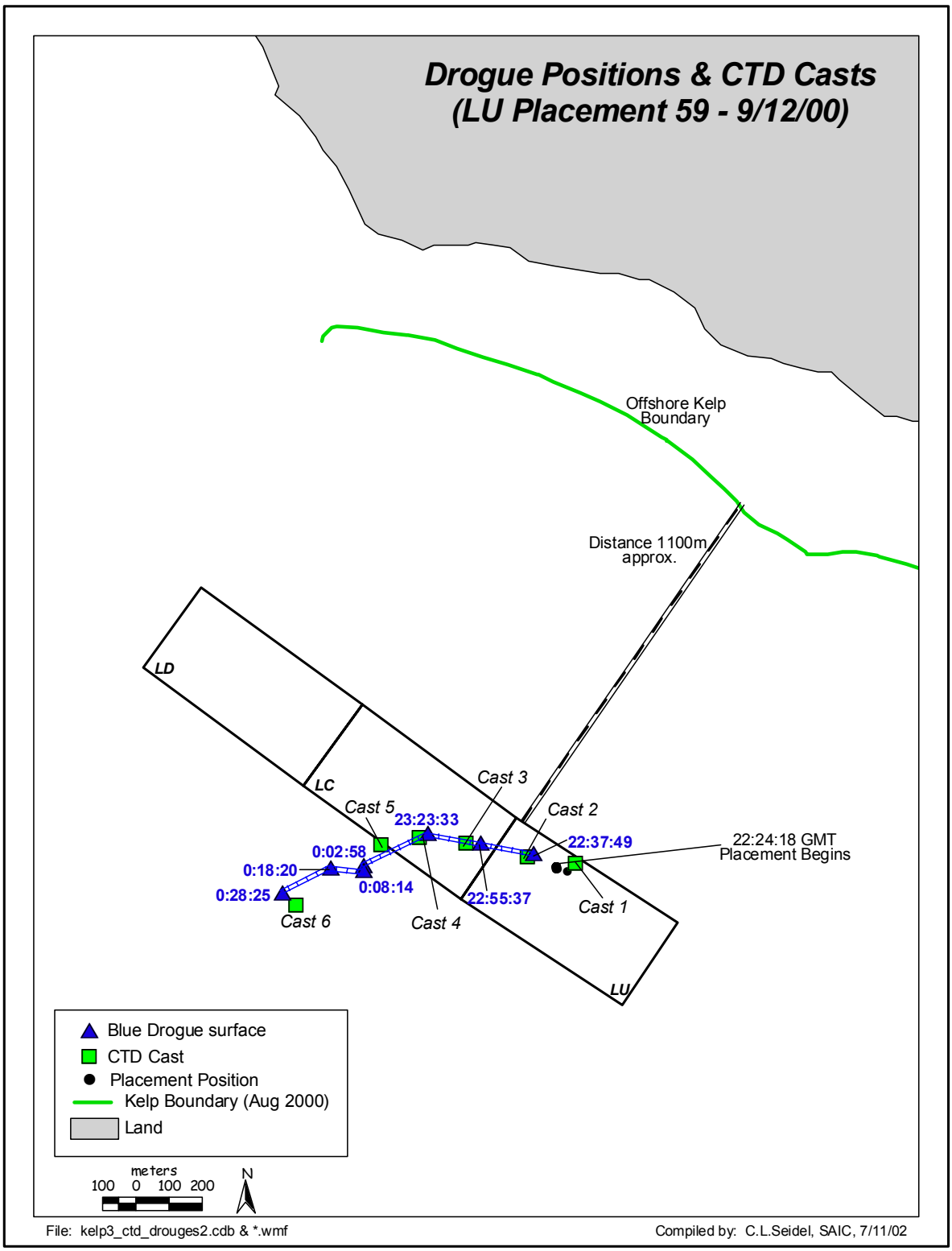

Figure 8.3-8. Map of Cell LU indicating drogue trajectories and CTD stations during conventional cap placement Event 59 on September 12, 2000.

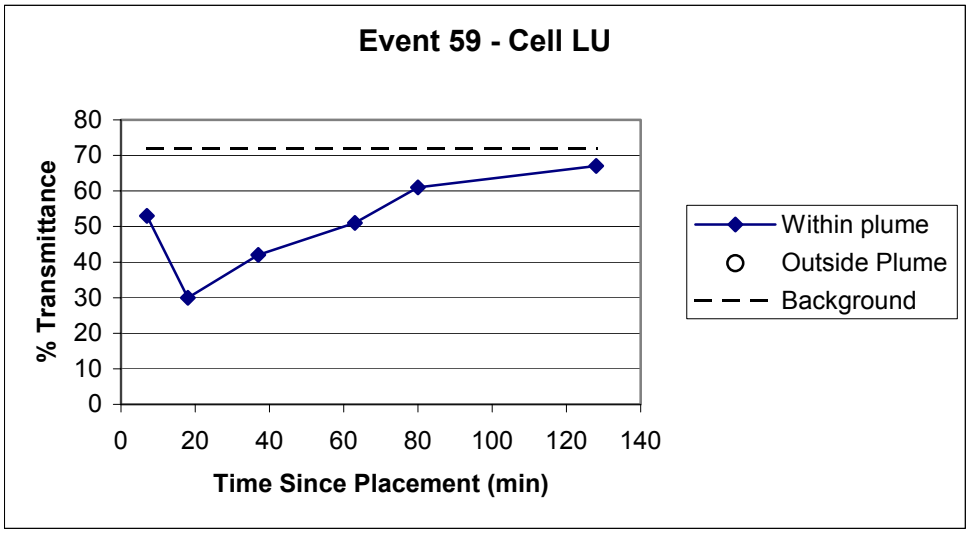

Figure 8.3-9. Time series plot of the minimum value of percent light transmission acquired during each near-surface CTD profile conducted during conventional cap placement Event 59 in Cell LU on September 12, 2000. See Table 8.3-5 for CTD profile information.

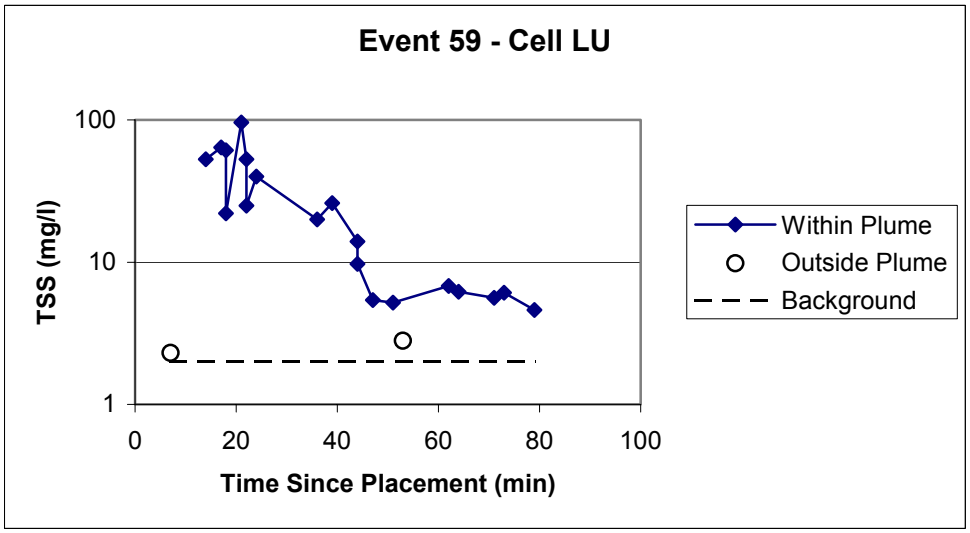

Figure 8.3-10. Plot of total suspended solids concentration versus time since initiation of cap placement for discrete water samples collected during CTD profiling operations of conventional cap placement Event 59 in Cell LU on September 12, 2000.

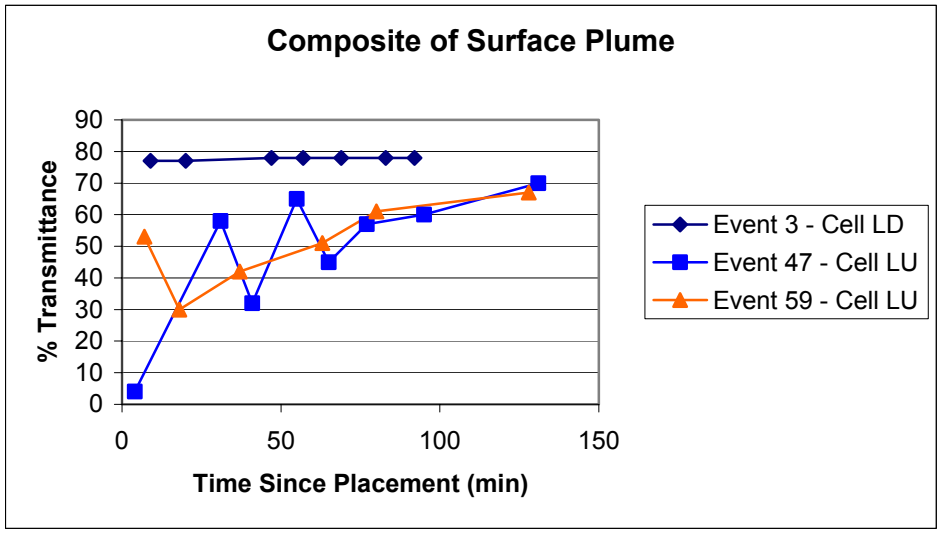

Figure 8.3-11. Composite time series plot of the minimum value of percent light transmission acquired during each near-surface CTD profile conducted during three cap placement events in Cells LD and LU.

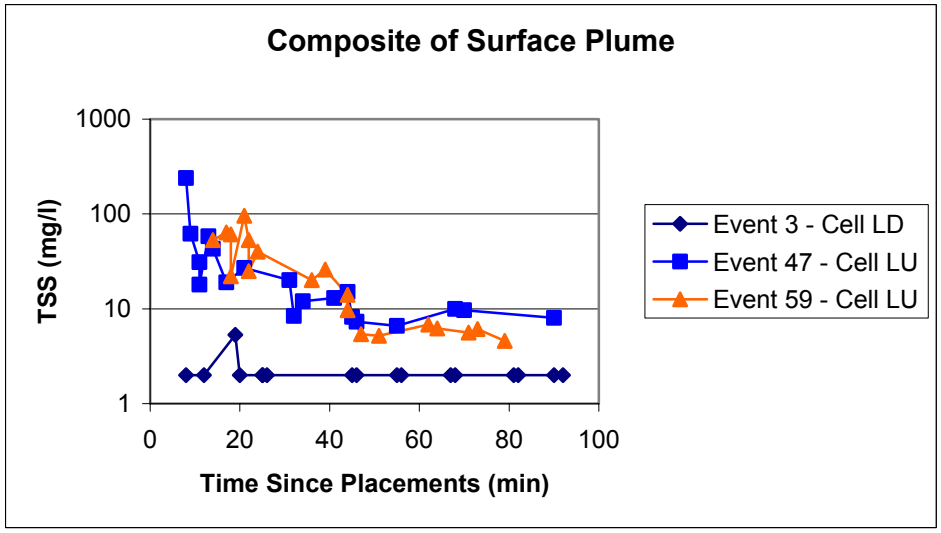

Figure 8.3-12. Composite plot of total suspended solids concentration versus time since initiation of cap placement for discrete water samples collected during CTD profiling operations of three cap placement events in Cells LD and LU.

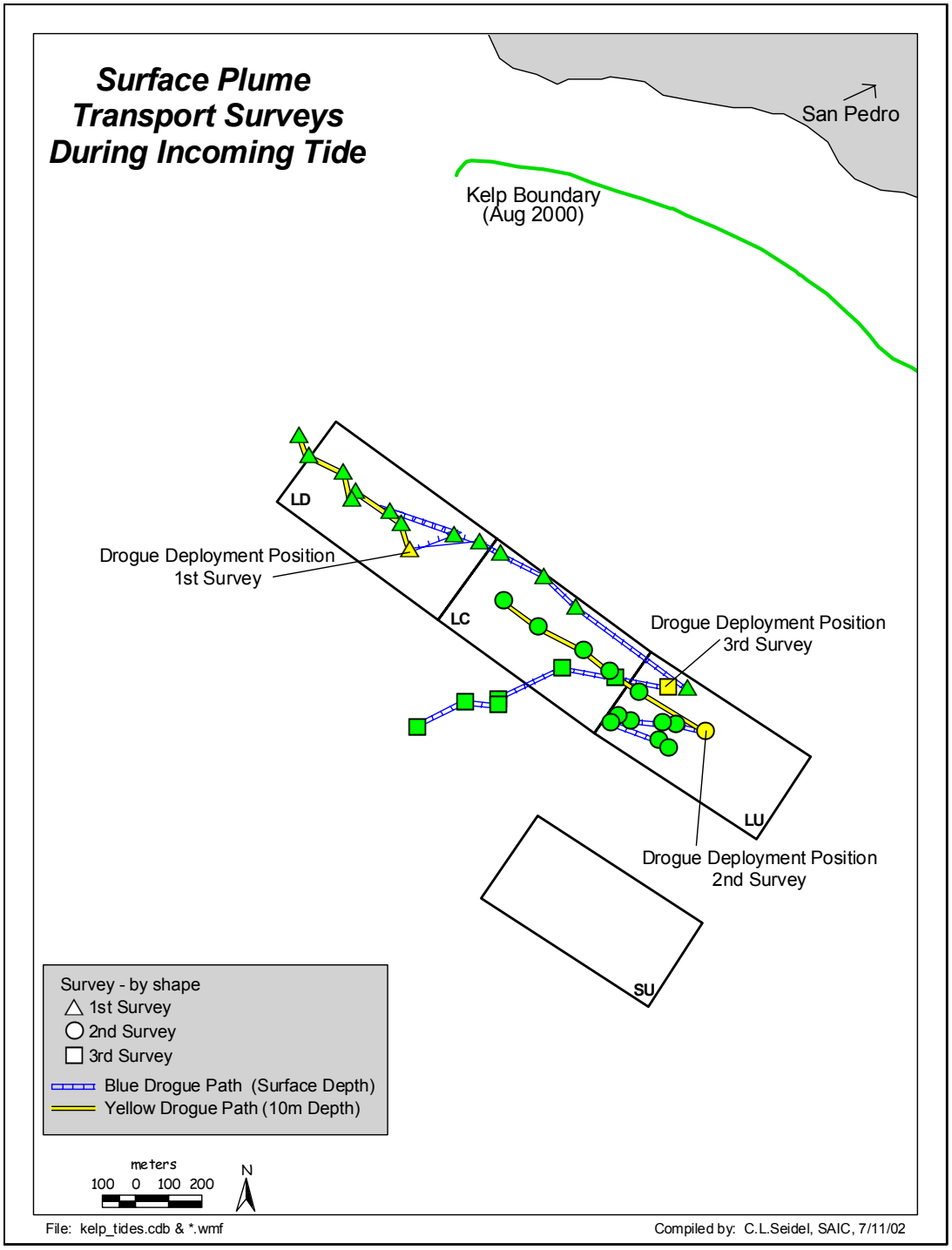

Figure 8.3-13. Map of Cells LD and LU indicating trajectories of drogues deployed during monitoring of near-surface plumes during three cap placement events. For each study, drogues were deployed within 30 min of the time of local high water to correspond with the beginning of the incoming tide.

9.0 DISCUSSION AND CONCLUSIONS

The pilot project was designed to address several key questions relative to capping on the Palos Verdes Shelf:

- **Can a cap with uniform thickness be constructed?**
- **Can disturbance to in-place sediments be kept within tolerable limits?**
- **Does the cap remain clean (i.e., free of contaminants)?**
- **Does the cap remain stable during placements?**

The following discussion is organized around providing answers to these questions for each of the three different placement methods employed in the pilot project (conventional, spreading and pump out). In most cases, the primary questions above encompass a number of ancillary issues or questions, which are identified and answered. Ultimately, the answers provided by the intensive monitoring program will be used by the USACE and USEPA to evaluate the feasibility of capping as a remediation option on the Palos Verdes Shelf.

9.1 Conventional Placements in Cells LU and SU

Can a cap with uniform thickness be constructed?

This question encompasses several secondary questions/issues related to the ability to place multiple loads of cap material accurately, the lateral spread and thickness of the resulting deposit on the seafloor, the potential effects of water depth, bottom slope, or material type, and possible changes to the existing bottom topography:

- ***Can multiple loads of cap material be placed accurately and consistently based upon a pre-determined cap placement plan?***

The ability to place multiple loads of cap material accurately and consistently, in accordance with a pre-determined cap placement plan, ultimately rests with the dredge operator. However, the Automated Disposal Surveillance System (ADISS) has proven to be a useful tool both for assisting the operator in navigating to the target location and for monitoring the results of all placement operations. As was discussed in Sections 3.2 and 4.2, all of the conventional placement operations that were conducted in Cells LU and SU were completed accurately and successfully, and a large percentage of the cap material was placed within a short distance of the pre-defined target position. Although each placement event occurred during varying environmental conditions (e.g., surface currents; wind speed and direction) and under different engineering controls (e.g., different dredge captains; slightly different rates of discharge, etc.), the ADISS monitoring results showed that a large hopper dredge could be operated to consistently meet a pre-determined cap placement plan. In addition, the side-scan sonar and SPI monitoring results showed good spatial correlation between the hopper location at the sea surface during placement and the subsequent deposit of material on the seafloor (i.e., the cap material experienced little lateral displacement as it fell through the water column).

♦ ***How far did the cap material spread on the seafloor following placement?***

The four monitoring techniques used to address this question were SPI, gravity coring, side-scan sonar, and sub-bottom profiling. However, these techniques showed varying degrees of effectiveness in determining cap material spread. For the single hopper placement technique employed in Cells LU and SU, the cap material spread out laterally in a concentric pattern upon impact with the bottom, as expected based on extensive past experience and model predictions. This resulted in a deposit of cap material on the seafloor that was thickest near the point of impact and increasingly thinner toward its outer edges. The ability of the various monitoring techniques to determine the lateral extent of material spread was dependent on being able to detect the relatively thin layers at the outermost edge.

Sub-bottom profiling was not able to detect the thickness, and thus the spread, of the cap material on the seafloor primarily due to the similar grain size characteristics of cap material and the underlying EA sediment, and the relatively thin layer of cap sediments being placed. Likewise, while the side-scan sonar imagery proved useful for discerning the general footprint of the cap material during the early stages of capping (e.g., Post-1 and Post-5), placement during later stages tended to obscure the acoustic signature of the deposit. In general, side-scan sonar has limited ability to detect subtle changes in seafloor topography resulting from placement of relatively thin sedimentary layers. Finally, gravity coring was conducted at a limited subset of the SPI stations, but it was not intended for use in mapping the lateral spread of material. One of the primary objectives of coring was to determine cap material thickness as a supplement to the SPI monitoring, particularly during stages when cap thickness exceeded the SPI penetration depth. Unfortunately, sampling artifacts associated with the gravity coring method (e.g., bow wave disturbance and drag down of cap material) hindered its effectiveness for this purpose.

Because of its ability to image surface depositional layers of sediment as thin as 1 cm, SPI proved to be the most effective tool for determining the complete spread or "footprint" of cap material on the seafloor at specified operational milestones in Cells LU and SU. The Post-1 SPI contour maps were particularly important to USACE efforts to verify and refine the MDFATE disposal model for capping operations on the PV Shelf. Accurate model predictions of the horizontal spread of material on the seafloor will be a vital aspect of any future efforts to create a cap of uniform thickness.

As described in Sections 3.7 and 4.7, the Post-1 SPI results showed the initial cap material deposit in Cell LU had a diameter of 200 to 250 m, while the deposit in Cell SU had a diameter of 275 to 325 m. In both cells, the positioning of the SPI sampling stations within the cell, relative to the hopper's location at the sea surface during placement, proved adequate for constructing contour maps illustrating the spread of material. Despite differences in depth and bottom slope, the initial deposit on the seafloor was roughly circular in both cells, and the contours formed concentric rings of decreasing cap material thickness toward the outer edges. These results were generally consistent with model predictions and served to illustrate an overall "evenness" in the lateral spread of material around the central point of impact. Confirming the ability to create a relatively symmetrical deposit of material on the seafloor through point disposal on the PV Shelf was a significant study outcome. Given the results of the initial single hopper point disposal events, it is reasonable to assume that multiple, sequential point disposals ultimately can be combined to construct a cap having uniform thickness based on the assumption of hopper dredging and material similar to that from the Queen's Gate Channel.

The SPI results from subsequent monitoring events in Cells LU and SU (e.g., Post-5, Post-21, etc.) illustrated the expanding lateral spread of the cap material as the number of placement events increased. The Post-5 monitoring showed how repeated placement of individual hopper loads in the center of each cell increased both the thickness and to a lesser degree, the spread of the cap material on the seafloor in concentric rings around a central point of impact. Once this "base" deposit was in place on

the seafloor, placement occurred at increasing distances away from the cell center, and the cap material continued to spread laterally.

The Post-71 SPI sampling in Cell LU showed that the outer edge of the cap material deposit extended as far as 200 m beyond the cell boundary to the southeast (along slope), but less than about 100 m beyond the boundary to the northeast (upslope). In the Post-21 far field survey in Cell SU, the outer edge of the cap material deposit extended roughly 200 m beyond the cell boundary to the southwest (downslope), but less than 100 m beyond the boundary to the southeast (along-slope). Somewhat greater lateral spread in the downslope direction compared to the along-slope/upslope directions was consistent with expectations and will need to be accounted for in any future modeling efforts.

The results of the supplemental SPI sampling in Cells LU and SU, performed roughly six months following the creation of the cap material deposits, generally showed cap material layers at approximately the same thickness as observed in the immediate postcap monitoring. For locations where postcapping and supplemental SPI data could be compared, the results suggest there was no significant change in the lateral spread of material on the seafloor at six months postcapping.

♦ ***How much variability was there in cap thickness?***

As previously indicated, neither side-scan sonar nor sub-bottom profiling proved to be effective for determining cap material thickness under the conditions of the 2000 summer monitoring program. In addition, cap material thickness measured in many of the gravity cores was significantly less than that detected in situ through SPI. Drag down of cap material along the inner wall of the core liner was noted in a number of these cores, and the measured cap material thickness may also have been reduced as a result of disturbance upon penetration by the gravity corer (bow wave effect). Such sampling artifacts help explain why the core thickness measurements of cap layer thickness were often less than the corresponding SPI measurements.

During the supplemental survey, estimates of cap thickness based on SPI generally were greater than those provided by visual, geotechnical, or chemical analyses of cores, similar to results obtained during earlier postcapping surveys. Based on these comparisons, as well as other indications of coring artifacts, the SPI provided the most accurate information for estimating cap thickness. However, this only applied to areas where cap layer thickness was less than the penetration depth of the camera. In areas where cap thickness exceeded the camera penetration depth, cap thickness could not be determined accurately from SPI. By comparison, estimates based on visual or analytical assessments of the cap/EA sediment interface in cores underestimated cap thickness due to coring artifacts. Sediment cores collected during the supplemental survey using a box core appeared to have fewer artifacts, and more representative stratigraphies, than those collected by gravity or vibracores. However, the small box core used during the supplemental survey could not consistently penetrate the cap/EA sediment interface. In total, the chemistry and geotechnical results obtained from sediment cores could not be used to accurately determine the actual thickness of the cap layer or spatial variability in cap thickness.

The series of frequency distributions presented in Sections 3.7 and 4.7 indicated that cap thickness measurements varied by less than about 2 cm among the three replicate SPI images obtained at each station in Cells LU and SU. Thus, across relatively short horizontal distances on the seafloor (i.e., a few meters between replicate images), there was very little variability in cap material thickness. Likewise, the SPI cap thickness contour maps for the early surveys (i.e., Post-1 and Post-5) clearly demonstrated that the seafloor deposits resulting from release of individual hopper loads of cap material consisted of a series of concentric rings having uniform thickness. These maps showed how the individual placement events resulted in relatively flat, uniform, “pancake-like” deposits that were thicker

near the center and tapered gradually and evenly toward the outer edge, as expected based on model predictions. There was little variability in cap thickness within each concentric ring.

The monitoring results showing general confirmation of model predictions for individual placement events are important, but so is the question of cap thickness variability across the larger spatial scale of a cell. At issue is the ability to construct a uniform cap by combining multiple placement events in a predetermined sequence at selected locations throughout each cell. The Post-25 and Post-45 SPI surveys in Cell LU and the Post-21 survey in Cell SU provided some confirmation, albeit limited, of the ability to construct a uniform cap across each cell. In Cell LU, the SPI results for both surveys showed that cap thickness was consistently greater than 8 to 12 cm across the entire cell. This was partial evidence of uniformity, in the sense that all of the individual station results were consistent in showing cap material thickness exceeding the penetration depth of the SPI camera. However, the assessment was limited by the lack of reliable measurements of the actual cap thickness from the coring surveys, making it difficult to quantify the actual variation across the cell.

The results of the Post-21 and Post-21 far field SPI surveys in Cell SU were somewhat different from those in Cell LU, in that cap thickness was not uniform across the entire cell following placement of 21 hopper loads. The cap material deposit was centered within the cell and roughly circular, consisting of concentric rings of increasingly thinner layers moving outward from the placement locations. Compared to the Post-25 results in Cell LU, the lack of a uniform cap thickness across the entire length of Cell SU in the Post-21 survey probably reflected the intentional placement of material along the centerline, as well as the lower number of placement events.

Cap thickness within each of the Post-21 concentric rings in Cell SU was relatively uniform, with the exception of the anomalous results from station I02, where thickness varied significantly from the surrounding stations. Additional SPI sampling in the Post-21 far field survey confirmed that cap thickness varied by up to 7 cm within a 25-m radius of this station, despite the fact that it coincided with a placement location. The results were considered anomalous because this was the only instance in multiple surveys where this kind of variation from the uniform, concentric ring pattern was observed.

In the supplemental survey performed approximately six months following the creation of the cap material deposit in Cell SU, the average cap thickness measured at selected stations was consistent with, but slightly less than, the average thickness measured in the Post-21 survey. These results may have reflected minor consolidation of the cap layer, minor loss of material due to erosion, or minor small scale variability in cap thickness at the sampled locations. In general, the supplemental SPI results suggested little change in cap thickness at the sampled locations after six months.

Overall, the SPI results in Cells LU and SU indicated a fairly consistent pattern in the construction of relatively uniform layers of cap material. The initial deposits in both cells were roughly circular, with little variability in thickness within the concentric rings that formed around the placement point. As this pattern was repeated in multiple subsequent placement events, cap thickness increased uniformly near the placement locations, and the overall footprint of the deposit spread outward in a fairly symmetrical pattern. The deposits in both cells eventually extended beyond the cell boundaries.

♦ ***What is the effect of water depth, bottom slope, and cap material type on a point placement?***

Cells LU and SU both received sediments dredged from the Queen's Gate Channel, so it was not possible to evaluate the effects of different cap material types in these two cells. Cell SU was both deeper (60 to 70 m) and steeper (3.2°) than Cell LU (depth = 40 to 45 m; slope = 0.9°). The Post-1 SPI results indicated that the initial cap material footprint was wider in Cell SU compared to LU (Post-1 SU diameter

= 275 to 325 m; Post-1 LU diameter = 200 to 250 m). The greater depth of Cell SU presumably allowed the descending jet of cap material to entrain additional water, increasing its size, which caused the cap material both to spread out more widely as it fell through the water column, resulting in greater lateral spread on the bottom.

The Post-1 SPI monitoring did not show any preferential spread of material in the downslope direction in either cell, which might be expected if the difference in slope was a factor. Likewise, the Post-1 side-scan images from both cells generally showed the cap material deposit as a round, symmetrical feature with an inner high-reflectance disturbance area that correlated well with the 4 cm SPI cap contour, and a lighter radial spreading pattern that correlated well with the 2 cm SPI cap thickness contour. Beyond the 2 cm contour, no definitive differences between the cap material and EA sediment could be detected on the side-scan images. These general characteristics were very similar in both Cells LU and SU.

The Post-5 SPI monitoring indicated that the cap material deposits in the two cells were largely similar in thickness and distribution, although the measured thickness at the upslope stations in Cell SU was somewhat less than that in Cell LU (e.g., Stations I01, I02 and I03). This suggests that the steeper slope in this cell may have resulted in some preferential accumulation of cap material in the downslope direction compared to Cell LU, as might be expected. Likewise, the Post-5 side-scan records from Cell SU showed a greater distribution of the lateral surge material moving in the down-slope direction, whereas the side-scan records from Cell LU showed a more uniform surge pattern around the entire placement area. Differences between cells in cap thickness at Station O16 may have been related to variations in hopper loads, vessel orientation and velocities, rates of release, and composition of loads.

The Post-45 SPI monitoring in Cell LU generally indicated an even distribution of cap material within and outside the cell, although slightly thicker cap layers observed at the distal downslope stations compared to those upslope again suggested a minor influence of bottomslope. In contrast, the Post-21 SPI results from Cell SU did not show a strong influence of slope, as cap layer thickness at the distal upslope stations was greater than that downslope. These somewhat confounding results lead to the conclusion that the difference in depth and slope appeared to have played a relatively insignificant role in the creation of uniform cap material deposits in Cells LU and SU.

- ***Following placement of the pilot cap, was there considerably more seafloor topography than observed during baseline surveys?***

Based on comparisons between the postcap and baseline side-scan sonar data, there appeared to be no major changes in bottom topography after the capping operations were completed in either Cell LU or 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 rather than individual placement events. Although single-beam or multibeam hydrographic surveying would be recommended as 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 would have been reflected within the side-scan imagery. Similarly, if all of the cap material had been placed in only a few locations, creating more prominent topographic mounds relative to the surrounding seafloor, then these features would have been reflected in the imagery also. However, because the cap material was spread evenly around the cell and the resulting topographic changes were minor, the side-scan imagery did not reflect any topographic changes. Likewise, the sediment plan view images did not indicate any significant, consistent increases in small-scale surface roughness following the cap placement events. The cap surface in the majority of plan view images appeared relatively flat or with small ripples, similar to those observed in the baseline monitoring.

Can disturbance to in-place sediments be kept within tolerable limits?

The following section primarily addresses potential disturbances to sediment and impacts to water quality, associated with resuspension of EA sediments following cap placement using conventional (point) placement methods. The magnitude and duration of water quality impacts were evaluated during cap placement monitoring using a combination in situ profiling instruments and discrete water samples for total suspended solids (TSS) and DDE concentrations, along with measurements from moored, instrumented arrays, and towed acoustic profiling instruments. Assessments of sediment disturbance, based on results from SPI, coring, and side-scan sonar methods, also considered potentials for contaminant remobilization associated with scouring the surface layers of bottom sediments. The concept of tolerable limits for in-place sediment disturbance has not been defined quantitatively for this pilot cap placement monitoring program. Consequently, the magnitude of sediment and water quality effects is described here in terms of constituent concentrations, persistence, and spatial extent of plumes, as well as potential impacts to nearshore kelp beds.

♦ ***To what degree were the in-place sediments disturbed as a result of cap material placement?***

The SPI monitoring for the conventional placement operations in Cells LU and SU provided estimates of the depth to which in-place sediments were disturbed based on direct visual observation of the remnant redox potential discontinuity (RPD) (or absence thereof). It is important to note that in sediment profile images where the layer of lighter colored surface sediment (i.e., former RPD) appeared to be completely missing, the estimated depth of disturbance represented a conservative or minimum estimate. In such instances, the actual depth to which the in-place sediments were removed may have been deeper than the depth of the former RPD, and the estimated depth of disturbance was denoted with a greater than symbol.

The initial monitoring results for Cells LU and SU (i.e., Post-1 and Post-5) were largely consistent in showing that the in-place sediments appeared to be disturbed to the highest degree near the center of the cap material deposits. This presumably represents the initial point of impact of the cap material with the bottom, where the higher energy levels were expected to cause greater disturbance to the in-place sediments. It is important to note that the interpretation of the SPI results was limited in that it did not address what happened to the in-place sediments when they were disturbed. It is reasonable to assume that some of this disturbed EA sediment mixed with the cap material and became part of the cap deposit, and some was displaced into the water column as part of the near-bottom plume.

At stations having cap material but located outside the initial point of impact, the depth of in-place sediment disturbance typically was limited to less than about 2 or 3 cm (i.e., less than the depth of the former RPD). Such stations presumably experienced the placement energy mainly in the form of a lateral surge of cap material, with less apparent disturbance to the in-place sediment than at the point of impact. Finally, a notable result of the SPI monitoring was the observation that the RPD generally remained intact at stations located immediately outside the footprint of the cap material deposits in Cells SU and LU. These results indicated that the instantaneous surge of water resulting from the cap placement had insufficient energy to resuspend the in-place sediments outside of a relatively limited area surrounding the point of impact.

- ***Does the cap placement operation cause high concentrations of contaminants in the water column immediately following placement, as a result of resuspension of ambient sediments?***

Following release from the hopper dredge, cap materials impacted the bottom with sufficient momentum to generate localized "surge" currents that spread radially from the point of impact (Sections 3.3 and 4.3). Measurements of the velocity and duration of surge currents (described below) indicated that currents had sufficient energy to resuspend bottom sediments into overlying waters and scour the surface of the EA sediment layer. However, surge current velocities were sufficient to resuspend bottom sediments (ambient and/or cap material) only within about 100 m of the placement site in Cell LU and somewhat farther in Cell SU.

Water quality measurements in Cell LU following each of cap placement Events 1, 4, and 5 revealed high, near-bottom turbidity levels in proximity to the placement site immediately after placement; light transmittance levels dropped to 0% immediately following the placement event. Maximum TSS and total (dissolved plus particulate) DDE concentrations measured at the centroid of the suspended particle plumes were 1600 mg/L and 0.29 µg/L, compared to background concentrations of 4 mg/L and 0.013 µg/L, respectively. Although the spatial extents of the resuspended sediment plumes were not accurately determined, turbidity levels and TSS and DDE concentrations in waters outside of the plume centroid were expected to be much lower than peak levels, immediately following the placement event.

Water quality measurements within Cell SU indicated similar increases in turbidity levels in near-bottom waters immediately following cap placement. Following placement Event 1, maximum TSS and DDE concentrations were 1100 mg/L and 1.2 µg/L, respectively. The peak DDE concentrations were relatively higher than those in Cell LU, consistent with the several-fold higher DDE concentrations in surface EA sediments measured during baseline surveys in Cell SU compared to Cell LU.

A large portion of the measured turbidity and elevated TSS concentrations likely were due to suspended cap material particles settling through the water column rather than resuspended bottom sediments. For example, maximum TSS concentrations in Cell LU bottom waters, following the initial placement event, were approximately 400 times higher than background, whereas maximum DDE concentrations were approximately 22 times above background. Thus, a substantial portion of the TSS load did not contribute to water column DDE concentrations and, therefore, probably represented cap sediments with very low DDE levels. The proportion of cap sediments contributing to TSS can be estimated by comparing the DDE concentrations measured in the water column samples with average DDE concentrations in cap material and surface EA sediments within the two cells, and assuming that all of the DDE in the water samples was associated with particles. With this approach, cap material contributed approximately 90% and 80% of the TSS following initial cap placement within Cells LU and SU, respectively.

- ***Do water quality impacts persist after individual placement events?***

Water quality measurements at both Cells LU and SU demonstrated that water column properties returned rapidly to background conditions following each cap placement event. In particular, turbidity levels and TSS concentrations declined from peak levels occurring immediately after release of cap material to near background levels within a period of approximately two hours. Further, DDE concentrations in the water column decreased to approximate background levels within a period of 30 minutes. This suggests that particles remaining in the plume following the initial settlement period (i.e., 30 minutes) consisted primarily of suspended cap materials.

- ***Do high concentrations of water column contaminants occur only following the first placement event in each cell (i.e., does potentials for water quality impacts decrease as proportionately greater portions of a cell are capped?)***

With the exception of the initial placement event in each cell, construction of the pilot cap involved placement of individual cap loads on top of existing cap material deposits. The purpose of this approach was to minimize disturbances to existing sediments. As a consequence, impacts to water quality associated with the initial placement was expected to be more extensive than those associated with subsequent placement events. This was evaluated by comparing water quality measurements performed in Cell LU following Events 1, 4, and 5.

Maximum TSS concentrations measured during Events 1, 4, and 5 were 1600 mg/L, 3400 mg/L, and 2700 mg/L, respectively, and did not exhibit any clear temporal trends. In contrast, maximum DDE concentrations measured during Events 1, 4, and 5 were 0.29 µg/L, 0.017 µg/L, and 0.10 µg/L, respectively. Therefore, peak DDE concentrations in the water column following Events 4 and 5 were considerably lower than those associated with the initial placement event, and proportions of TSS represented by resuspended bottom sediments during Events 4 and 5 were negligible (<1%).

Water quality sampling and near-bottom current and turbidity measurements were not made in Cell LU during Events 6 through 71. Although surge data were not available from these events, the surge momentum, horizontal currents, and near-bottom turbidity levels for these subsequent placement events were expected to have been similar to those observed during Events 1 to 5, especially since the placement technique (conventional, bottom-dump release from a stationary hopper dredge) and cap material volume were essentially the same for all 71 placements. In contrast, DDE concentrations likely decreased with successive placement events as the relative proportions of resuspended bottom sediments declined.

Similar assessments for Cell SU could not be performed because water quality sampling at this cell occurred only following the initial placement event. Nevertheless, the trend observed at Cell LU indicates that the approach used to place successive cap loads on top of existing cap material appeared to have been effective at minimizing disturbances of existing sediments.

- ***Are there differences among cells (i.e., Cells LU and SU) in the magnitude and duration of water quality impacts?***

As described above, maximum DDE concentrations following the initial placement event in Cell SU were higher than those following the initial placement event in Cell LU. Although the turbidity levels, TSS concentrations, and relative proportions of resuspended sediments and cap materials comprising TSS were generally comparable (discussed above), the higher DDE concentrations in the water column at Cell SU were attributable to the higher DDE concentrations in the surface EA sediments disturbed during initial cap placement.

- ***What is the likelihood that near-surface plumes of suspended cap material are transported inshore to existing, near-shore kelp forests?***

Kelp beds occur on the Palos Verdes Shelf directly inshore and approximately 1.1 km from the landward capping cells. During the monitoring program, some drogue tracking was conducted to assess whether and to what extent suspended sediment plumes generated by cap placement operations were transported towards the nearshore kelp beds. Concerns regarding potential impacts from turbidity plumes on water clarity in the vicinity of kelp beds were focused primarily on finer-grained particles in the upper water column with low settling rates and a high potential for longer range transport by near-surface

currents. Because sediments resuspended by the impact of cap materials on the bottom remained in the lower portions of the water column, and settled rapidly to the bottom, the near-surface plumes were expected to comprise cap materials only.

Drogue tracking studies conducted during the incoming tide on two occasions at Cell LU indicated plume transport distances of 0.72 km and 0.77 km over periods of 2 hours and 1.8 hours, respectively. Plumes were transported in northwesterly and westerly directions, but not directly shorewards towards the nearshore kelp beds. Maximum TSS concentrations (96 mg/L and 240 mg/L) occurred immediately after cap material release. Concentrations decreased to 20 to 60 mg/L within 30 minutes, and reached background levels (2 to 4 mg/L) within two hours. Turbidity levels followed similar patterns, and background levels were reached within 1.5 hours. Although the results from these plume tracking events may be considered representative of a relatively narrow range of conditions, the studies did not indicate any significant potential for the capping project to impact nearshore kelp beds.

Does the cap remain clean?

The answer to this question depends on the degree to which the clean cap material mixed with the contaminated EA sediment. No single monitoring technique utilized in the pilot capping project accurately assessed both the thickness of the accumulated cap and the contamination level of the surface material. Geotechnical and chemical analyses of core subsamples were used to provide insights on the degree of mixing and overall cap "cleanliness," but the coring effort was hindered by sampling artifacts. During the earlier stages of capping, it was assumed that there would be some degree of mixing between the EA sediments and cap material, but with repeated placement events, the surface of the cell would comprise increasingly higher proportions of cap material. As cap thickness increased during the later stages of capping, there was increasingly less mixing with in-place sediments and a simultaneous decrease in contamination levels in the surface of the cap. Following cap placement, the degree to which the cap layer remained clean depended on the extent of mixing between cap material and underlying EA sediments or between cap material and EA sediments (or other contaminated solids such as effluent particles) that were deposited on top of and subsequently mixed into the cap layer.

The following discussion of the degree to which the cap remained clean is organized around the following secondary questions:

- **What is considered clean?**
- **How was mixing between the EA sediment and cap material assessed?**
- **Is the mixing of cap material and EA sediments during the cap placement operation relatively minor such that contaminant concentrations in the cap layer immediately following placement are low**?
- **Following completion of the pilot capping operation, was the established cap free of contaminants originating from the EA sediments?**
- **What was the degree of mixing between the cap material and EA sediments?**

♦ ***What is considered clean?***

Previous testing of the Queen's Gate Channel sediment showed DDE concentrations below the analytical detection limit (0.02 ppm) in 70% of the samples (Section 3.11.4.2). For the purpose of this discussion and the presentation of chemistry data from the capping project, this concentration is considered representative of background DDE levels, and therefore, "clean" conditions.

- ***How was mixing between the EA sediment and cap material assessed?***

Cap material placement was monitored in a variety of ways, including side-scan sonar, SPI, and gravity coring. Each technique was limited in detecting and assessing the mixing of cap and EA sediment. These limitations are addressed below.

- ***Is the mixing of cap material and EA sediments during the cap placement operation relatively minor such that contaminant concentrations in the cap layer immediately following placement are low?***

SPI indicated the presence and thickness of cap material and provided an estimate of the depth to which the EA sediment was disturbed as a result of cap placement. In Cells LU and SU, the estimated depth of EA sediment disturbance was greatest near the center of the cap material deposits. At the center stations, it appeared that the entire layer of light-colored EA sediment comprising the RPD had been resuspended as a result of the initial cap material placement, and the depth of disturbance was mapped as a conservative estimate (i.e., greater than the former RPD of about 2 or 3 cm). While SPI was useful for determining the depth to which the EA sediment was disturbed or resuspended, it did not indicate how much of the EA sediment mixed with the overlying cap material.

The lack of visual evidence of thin cap material layers in the cores following the initial placement events (when the SPI sampling clearly demonstrated the existence of such layers) lead to the assumption that a bow wave effect was 'blowing off' surface layers of sediment upon impact of the corer with the bottom. In addition, a drag down artifact was noted in the cores, which affected the amount of cap material present at the surface of the core and artificially mixed the cap material inside the core to unrealistic depths. With the degree of disturbance noted in the cores, the extent of mixing between cap material and EA sediment could not be determined accurately based on the geotechnical and DDE results. Sampling stations that were evaluated by both SPI and gravity coring appeared to contain a reduced or a nonexistent cap layer in the cores. Overall, in areas where SPI indicated less than 6 cm of cap accumulation, the corresponding cores did not contain cap material. At sample stations where more than 6 cm of cap was estimated by SPI, the cap thickness estimates from coring results varied from approximately 4 to 10 cm. Therefore, the assumption that 6 cm of surface material was lost consistently upon gravity core penetration and core handling was a conservative estimate that will be utilized for this discussion.

- ***Following completion of the pilot capping operation, was the established cap free of contaminants originating from the EA sediments?***

Overall, the postcap coring results in Cells LU and SU demonstrated that the near surface layers of the cap material were clean. These surface layers covered deeper horizons of mixed EA and cap sediment.

- ***What was the degree of mixing between the cap material and EA sediments?***

SPI indicated that all gravity core stations in Cell LU contained greater than 8 cm of cap material based on camera penetration depths. Based on core descriptions, cap layer thicknesses varied from no apparent cap to 18 cm of cap over the same area (Table 9.1-1). Similarly, Cell SU SPI indicated 5.6 cm to greater than 11 cm of cap material, while an average of 8 cm of cap was evident in the cores (Table 9.1-1). In both cells, the SPI frequently indicated a thicker cap than was captured in the gravity core. Despite the apparent loss of the surface layer of cap material, both cells contained 'clean' surface material with less than 0.1 ppm DDE.

The amount of cap accumulation directly affected the concentration of DDE in the surface sediment. In Cell LU after 45 placement events, DDE concentration profiles indicated up to 8 cm of clean cap material, with mixed cap material and EA sediment in the 8 to 12 cm layer. After 71 placements, the 8-12 cm sample horizon reflected predominantly clean material, and the 12-16 cm horizon contained a mixture of cap material and EA sediment.

In Cell SU, the post placement cores illustrated a decrease in surface DDE concentrations and increasing concentrations with depth at core locations where significant cap material was present. Cores collected from the center of Cell SU, where SPI indicated >10 cm of cap material, contained a surface layer (0-4 cm) of clean material with a mixed layer starting at 4 cm. In Cell SU cores collected at locations of limited cap placement, the surface concentrations of DDE varied from baseline to slightly lower than baseline.

It was assumed that gravity coring artifacts disrupted at least the top 6 cm of sediment, thereby preventing accurate assessments of DDE concentrations at the surface of the cell. Assuming the surface material followed the concentration trends of the deeper sediments, the actual surface material displaced during sampling probably contained lower DDE concentrations than the surface horizon in the core sample. In both cells, the cap layer captured by the gravity corer was thinner than observed by SPI. Adding the missing 6 cm to the surface of each core reflected volumes closer to those observed for the volume of sand placed in each cell. In Cell LU, adding the 'missing' 6 cm of material increased the estimated cap thickness from 12 cm to 18 cm, with a mixed zone starting at 18 cm. Likewise, Cell SU contained an estimated 10 cm of clean cap, with mixing beginning between 10-14 cm.

During the supplemental survey, SPI images demonstrated the presence of a visually-distinct layer, up to several centimeters thick, of recently-deposited, fine-grained sediments on top of the intact cap layer. This recent layer was interpreted as EA sediment which had been transported horizontally from adjacent uncapped areas of the Shelf and then re-deposited on top of the cap layer during the period between completion of cap placement and the supplemental survey. Because the EA sediment was known to contain appreciably higher contaminant (DDE) concentrations than cap material, any physical or biological mixing of recent EA sediments with cap material would have increased contaminant concentrations in the cap layer. In fact, DDE concentrations in surface layers of some cores collected from Cell LU during the supplemental survey were more than one order of magnitude higher than concentrations in cores collected from the same area immediately following completion of cap placement. These differences could reflect contributions from the recently-deposited EA sediments to the measured contaminant concentrations. However, it is also likely that the surface layer is highly mobile, and subject to frequent resuspension and horizontal transport in response to storm- or wave-induced bottom turbulence. Consequently, only a portion of the mobile fraction of EA sediment may be mixed over time into the surface of the cap layer. Regardless, the rate at which existing shelf sediments are mixed into the cap layer, and resultant changes in contaminant levels, are important issues for long-term monitoring.

Table 9.1-1. Cap Thickness Estimates (cm) based on Core Descriptions, SPI Results, and DDE Concentrations

Core Station	Cap Thickness from Cores	Core Cap Thickness +6 cm	Cap Thickness from SPI	Cap Thickness from DDE Concentration
LUC51	0	6	>9.00	
LUC52	12	18	>9.33	>12
LUC53	3	9	>10.33	
LUC54	3	9	>12.66	
LUC55	16	25	>9.66	>12
LUC56	11	17	>8.00	>12
LUC57	0	6	>10.33	4
LUC58	0	6	>12.33	
LUC59	5	12	>11.33	
LUA60	13	19	NA	>12
LUA61	18	24	NA	>12
LUA64	8	14	NA	>12
SUC45	8 (noted interface)	14	7.00	0
SUC46	9	15	>10.66	4
SUC47	8	14	>11.00	4
SUC49	8 (noted interface)	14	5.66	0

The average baseline surface concentration for 0–4 cm in Cell LU was 1.5 ppm; station locations shown in Figure 3.11-1.
The average baseline concentration for 0-8 cm in Cell SU was 6.8 ppm; station locations shown in Figure 4.11-1.
NA = not analyzed

<u>Does the EA sediment and cap remain stable during placements?</u>

This topic pertains to the momentum of the cap material immediately after release from the hopper dredge, as it descends through the water column and hits the bottom. The concern is whether the bottom surge current associated with the descending material is capable of moving significant volumes of seafloor sediments (EA and/or cap materials). In order to focus this discussion, three more-specific questions are posed and results from prior sections of this report are referenced to support the conclusions.

- ***Did the initial cap placement event in Cells LU and SU cause a strong surge current at the seafloor that resulted in considerable lateral transport of EA sediment away from the placement location?***

The field monitoring program was optimally designed for acquisition of high-resolution data on near-bottom currents during conventional cap placement events in Cells LU and SU. Data were acquired during placement Events 1 through 5 in Cell LU (see Section 3.3), all of which were directed to the same location in the center of the cell where the water depth was 43 m and the ambient bottom was very flat and void of small-scale topographic features. Similarly, near-bottom current data were acquired during placement Event 1 in Cell SU (see Section 4.3), where the water depth was 62 m. The near-bottom current data illustrated that, upon impact with the bottom, a portion of the downward momentum of the descending cap material was transferred to horizontal momentum which manifested as a “surge” current that spread radially from the point of bottom impact, immediately beneath the hopper dredge.

Conclusions for Cell LU

The bottom-mounted current meter arrays were deployed twice in Cell LU, each for periods of 1-2 days, and positioned along a single cross-isobath line for acquisition of data at various distances from the point of cap placement; these deployment locations ranged from 75 to 250 m in the downslope direction, and from 50 to 75 m in the upslope direction. During each of the five placement events monitored in Cell LU, a distinct surge current was observed, having current speeds that were much greater than the weak ambient bottom currents at this location (Section 3.3). Within 100 m of the placement site, maximum bottom speeds ranged from 70 to 125 cm/s for all eight instrument records acquired during five placement events, and this surge current was always directed radially away from the point of the cap placement. The horizontal momentum of this surge current rapidly decreased with distance from the placement site, to the extent that maximum speeds had decreased to the range of 30 to 60 cm/s at a distance of 150 m downslope from the placement site, and to maximum speeds of only 20 cm/s (roughly comparable to the ambient currents) at a distance of 250 m in the downslope direction from the site. In terms of persistence, the surge events were brief, with current velocities returning to ambient levels at all measurement sites within approximately 10 to 15 min after passage of the surge. Overall, the observations of maximum near-bottom current velocities and persistence within the surge of the five separate placement events agreed closely, to the extent that these data can be viewed as statistically representative of the conventional cap placement process at Cell LU.

From these observations in Cell LU, we can formulate the following conclusions about the surge process:

- Although the initial horizontal surge current had sufficient magnitude (i.e., greater than 100 cm/s) to resuspend EA sediments and/or cap material at, and in close proximity to, the placement site, this resuspension was probably confined to a near-circular region within 100 m of the placement site because the surge momentum was seen to decrease considerably beyond that radial distance.

- The surge current initially contained a substantial load of suspended sediment (EA and/or cap material) while it spread radially from the placement site. This was evidenced by near-bottom turbidity measurements acquired concurrently with the velocity measurements. Turbidity levels at a specific measurement location rose sharply during the passage of the surge (maximum horizontal current), but returned to near-background levels within 10 to 15 minutes later. We believe this mechanism for horizontal transport of suspended sediment was primarily confined within 250 m of the placement site because the measurement data from this radial distance demonstrated weak surge velocities and turbidity levels that were greatly reduced from the initially high values measured during the surge at array locations close to the placement site. In summary, the leading edge of the surge carried a considerable load of suspended material, but its horizontal momentum dissipated within about 250 m of the placement site. Because the placement cells have a width of 300 m in the cross-isobath direction, these in situ observations of bottom surge velocities in Cell LU demonstrated that the majority of the horizontal momentum of the surge had essentially dissipated within the width of one cell.

- Limited measurement data were acquired at locations landward (upslope) of the placement site, but near-bottom current velocity measurements during three of four placements events demonstrated that maximum current speeds of the upslope surge (landward of the placement location) were somewhat less than the maximum speeds of the downslope-oriented surge measured at equivalent distances downslope from the placement site. Because the bottom slope at this location is very gradual (0.9°), it was not surprising that the local topography had minimal impact on the radial symmetry of the surge current.

- Water quality profile measurements (Section 3.5) and underway ADCP profiling operations (Section 3.6) in the vicinity of Cell LU during the two hours following cap placement Events 1, 4 & 5 revealed that suspended particulate levels were initially very high within the near-bottom plume associated with the surge. Within approximately 30 minutes after the placement event, turbidity levels within the plume had dropped substantially.

- Two side-scan sonar surveys conducted in Cell LU, after placement Events 1 and 5, revealed irregular characteristics in a near-circular pattern having a diameter of roughly 150 m and centered at the common placement site (Section 3.10). This seafloor pattern was clearly a result of the surge momentum that spread radially from the bottom impact (placement) location. Although the seafloor characteristics differed noticeably from the flat bottom that existed prior to the placement event(s), the minor topographic relief and/or variations in surface roughness created by the placement event had limited vertical scales (e.g., less than 0.3 meters). Although these side-scan data have insufficient vertical resolution to distinguish between small mounds of cap material and minor depressions, the spatial pattern of these seafloor features is very useful for delineating the areal extent of surge energy. Specifically, the 150-m diameter of the topographically affected area was consistent with the result from the moored current meter data that most of the horizontal momentum of the surge dissipated within a radial distance of roughly 150 m from the placement site. In fact, the side-scan results showed that seafloor topographic changes resulting from a single cap placement event did not extend as far from the placement location as the surge energy persisted.

Overall, these multidisciplinary survey results documented that bottom surges were generated during conventional placement operations in Cell LU, but their effects were generally confined within approximately 200 m of the placement location.

Conclusions for Cell SU

The bottom-mounted current meter arrays were deployed once in Cell SU, during conventional placement Event 1. The arrays were placed along a line and situated upslope and downslope of the cell's center point, similar to the deployment plan for Cell LU. Near-bottom current and turbidity data were acquired from four locations: 80 m upslope; as well as 115 m, 170 m, and 475 m downslope of the placement site at the center of Cell SU. The in situ observations revealed a distinct surge current having current speeds that were much greater than the weak ambient bottom currents, and this surge was similar to those observed during the five placement events monitored in Cell LU (see Section 4.3). From the observations in Cell SU, we can formulate the following conclusions about the surge process:

Maximum current speeds during the surge at the downslope array locations in Cell SU were comparable to those observed at similar distances from the placement locations in Cell LU (see Figure 4.3-6). The results from the three downslope locations in Cell SU indicated that current speeds in the surge did decrease with distance from the placement site, as had been observed in Cell LU, but these observations during a single placement event in Cell SU did not represent a statistically significant data set from which to draw conclusions about differences in surge characteristics between the two cells. Because the bottom slope in Cell SU (3.2°) was 3.5 times steeper than that within Cell LU (0.9°), it was possible that the momentum of the surge energy in Cell SU was dissipated at a slower rate (per unit of distance) than the surge within Cell LU. If this were the case, the surge at Cell SU could possibly transport suspended particulates farther from the cap placement site than would occur at Cell LU.

The turbidity records acquired in Cell SU (see Figure 4.3-7) demonstrated that turbidity levels within the surge for this event were similar to those observed at the same distances (both upslope and downslope) from the placement site for events in Cell LU. Maximum turbidity levels did not decrease significantly between measurements at the 115 m and 170 m downslope array locations in Cell SU. It

appeared that this surge retained a major fraction of its suspended particulate load as it propagated outward. At the 475 m downslope array, turbidity within the surge was substantially above background levels but below those measured closer to the placement site.

- Water quality profile measurements (Section 4.5) and underway ADCP profiling operations (Section 4.6) in the vicinity of Cell SU during the two hours following cap placement Event 1 revealed similar results as had been seen during conventional placements in Cell LU. Turbidity levels were initially very high within the near-bottom plume associated with the surge, but within approximately 30 minutes after the placement event, turbidity levels with the plume dropped substantially, even within the centroid of the plume.

- Two side-scan sonar surveys conducted in Cell SU, after placement Events 1 and 5, revealed small-scale topographic relief and/or variations in surface roughness in a near-circular pattern and centered at the common placement site (Section 4.10). This seafloor pattern was a result of the surge momentum that spread radially from the placement location, as had been observed for conventional placements in Cell LU. The side-scan image acquired after the initial placement illustrated that the surge effect was limited in the upslope direction, but free to travel farther in the downslope direction. The side-scan survey data following the fifth placement at the center of Cell LU showed a similar asymmetric pattern for the surge: the bottom pattern suggested that the upslope surge was limited to about 100 m from the placement site, whereas the downslope surge may have been significant up to a distance of 175 to 200 m from the placement site (just beyond the seaward boundary of Cell SU). These remotely sensed side-scan data also agreed well with SPI contours of cap thickness: the surge boundary from the side-scan images corresponded closely with the 3 cm cap thickness contour delineated by the SPI survey conducted after five placements in Cell SU.

Overall, these multidisciplinary survey results documented that bottom surges were generated during conventional placement operations in Cell SU. Because moored instrument arrays were not deployed at far field locations downslope of the placement site, we cannot predict the distance that the surge traveled following individual placements in this cell. We suspect, however, that because the bottom slope in Cell SU was greater than the slope in Cell LU, the surge may have propagated farther downslope during placements in this seaward cell.

♦ ***Would subsequent placements of cap material have sufficient surge energy to further erode EA sediments as well as cap material that was placed previously?***

In accordance with the design of the field sampling program, near-bottom current and turbidity measurements were not made in Cell LU during Events 6 through 71, nor in Cell SU after Event 1. Although surge data were not available from these events, we expected that the surge momentum, horizontal currents, and near-bottom turbidity levels for these subsequent placement events were similar to those observed during Events 1 to 5 in Cell LU and Event 1 in Cell SU, especially since the placement technique (conventional, bottom-dump release from a stationary hopper dredge), and cap material volume were essentially the same for all 71 placements in Cell LU and 21 placements in Cell SU. Assuming this surge energy was comparable for all placement events, the only variable that could affect bottom sediment resuspension was the geotechnical characteristics of the sediments which initially received the momentum of the descending cap material followed by the horizontal momentum of the radially spreading surge.

Prior to placement Event 1, the seafloor consisted of EA sediment, whereas after capping in Cell LU was complete, the seafloor near the center of the cell was covered with a layer of cap material ranging in thickness from 15 to at least 20 cm (see sediment coring results in Section 3.11). At the center of the

cell, the majority of the in-place cap would have been deposited during placement Events 1 to 5 as all of the placements were co-located. Subsequent placement events (6 to 71) may have contributed additional cap thickness near the center of the cell due to horizontal transport of suspended cap material during placements at adjacent locations within the cell.

The near-bottom turbidity data acquired by the moored arrays during placement Events 1 to 5 in Cell LU (see Section 3.3) showed that maximum turbidity levels during the surge of all five events were comparable, although cap thickness was certainly increasing at this location in the center of Cell LU. This suggested that the major contributor to the high turbidity levels in the surge must have been suspended cap material, with smaller contributions from resuspended EA sediment. Supporting this hypothesis was our belief that: 1) the volume of EA sediment that was eroded (resuspended) during each placement event decreased from Event 1 to Event 5 due to the continually increasing thickness of overlying cap material, and 2) the contribution of this resuspended EA sediment to the overall turbidity level was relatively small, or its decrease from Events 1 to 5 would have been noticeable. In other words, if the high turbidity of the surge consisted mainly of resuspended EA sediment, we should have seen a significant decrease in the turbidity from Events 1 to 5 due to armoring by the growing cap layer. Because the maximum turbidities were comparable for all five of the surge events monitored, the turbidity must have consisted primarily of cap material. Progressive decreases in water column DDE concentrations during successive placement event were consistent with this conclusion.

The side-scan sonar results (see Section 3.10) also suggested that EA sediments may have been resuspended during the first placement event in Cell LU. For subsequent placements at the same location, and for placements at adjacent locations, results indicated that minimal EA sediment was displaced during the surge events because of the in-place layer of cap material, which essentially shielded the EA sediment from the surge energy. Therefore, the overall capping strategy for conventional cap placements in Cell LU, whereby placements were targeted at locations that had already received cap material, was successful and effectively minimized the disturbance of EA sediments. As the cap layer grew spatially by sequential placements at increasing distances from the center of the cell, ambient material that had been displaced during the first placement event presumably became covered by additional cap material from subsequent placement events. Side-scan surveys following completion of 68 placement events in Cell LU and following 21 placement events in Cell SU illustrated that the capping plan of distributed locations for sequential cap placements resulted in a seafloor that was nearly as flat and void of small-scale topographic relief as had been seen during the pre-capping baseline survey.

♦ ***What is the potential for creation of turbidity flows and mudwaves?***

Turbidity Flows

One topic of concern about the capping operation on the Palos Verdes Shelf was whether the horizontal momentum of the bottom surge immediately following a placement event could gain momentum (accelerate) in the downslope direction and cause a "turbidity flow." If this were to occur, the momentum of this turbidity flow could carry suspended material considerable distances down the continental shelf and possibly the upper continental slope. If current velocities increased downslope, this could result in additional resuspension of bottom sediments along the path of the turbidity flow.

The moored current data acquired during cap placements in Cell LU (Section 3.3) demonstrated that horizontal velocities in the bottom surge decreased with distance from the placement location for all five events monitored. Because all conventional placement operations in Cell LU were conducted in the same manner, these surge data should have been representative of all placement events in Cell LU. Therefore, we concluded that turbidity flows were not generated during cap placement operations in Cell LU.

The near-bottom current data acquired at distances of 115 m and 170 m downslope of the placement location during Event 1 in Cell SU demonstrated that current velocities in Cell SU were comparable to those observed at similar relative positions within Cell LU during the five events monitored (Section 4.3). The results from the 475 m downslope measurement site in Cell SU did, however, demonstrate that surge currents persisted farther downslope than with Cell LU. Additional field measurements during cap placement operations and/or numerical modeling of the surge and turbidity flow processes would, however, be required to substantiate any conclusions about turbidity flows in the vicinity of Cell SU. Regardless, SPI, side-scan sonar, and sub-bottom profiling records collected after 21 placement events showed no evidence of downslope material flows.

Mudwaves

Another topic of concern about the capping operation was whether EA sediments underlying the newly formed cap would have sufficient gravitational potential that the underlying sediments could shift laterally under the weight of the cap and find a location to escape (breach) the cap layer. This process has been called a "mudwave" to associate it with potential horizontal transport of material ("mud" or underlying ambient sediment), versus the upwards process where underlying capped sediments breach an overlying cap by moving vertically, as within a chimney.

A "mudwave" developing under the pilot cap would require: 1) substantial overlying weight from a thick cap, and 2) relatively mobile, high water content sediments underlying the cap. Since these conditions were not met in the present study, mudwaves were not expected to occur following placement of the pilot cap. If however, they had occurred, spatial information acquired during the sequential side-scan sonar surveys may have been the only means of detecting this process. If the cap had been breached by a mudwave and a large volume of ambient sediment was lying on top of the cap material, the side-scan record may have revealed small-scale topographic relief at the location where the underlying material was ejected, and there may also have been a visible region of irregular side-scan signal strength due to the transition in return signal strength associated with the boundary from cap material to the mobile ambient material. Because no such topographic relief nor irregular signal strength patterns were detected during any of the side-scan surveys (Sections 3.10 and 4.10), results suggested that mudwaves had not occurred immediately following the capping operations in Cells LU or SU.

9.2 Spreading Placements in Cell LD

Can a cap with uniform thickness be constructed?

- ***Can multiple loads of cap material be placed accurately and consistently based upon a pre-determined cap placement plan?***

The ADISS monitoring results demonstrated that the hopper dredge achieved notable navigational accuracy and consistency in following the predetermined trackline across the center of Cell LD during nine separate placement events. The ADISS data also showed that there was somewhat less accuracy and precision in the rate of spreading placement. Variability in the rate of release among the nine placement events resulted in more cap material being placed in the first half of the cell than the second. It was determined that spreading was much too fast for one-third of the hopper loads, somewhat fast for two additional loads, and exactly as planned for nearly half of the loads. These results reflected some of the operational difficulties associated with trying to control the release rate from a moving hopper dredge, and the pilot program provided an opportunity to learn about and overcome some of these. Despite the variability in the rate of release, the spreading placement resulted in a relatively even accumulation of cap material on the seafloor in Cell LD (see below).

♦ ***How far did the cap material spread on the seafloor following placement?***

The Post-1 SPI results showed that the initial cap material deposit in Cell LD was elliptical, with the material spreading evenly on the seafloor on either side of the hopper's trackline. The precision of the contouring in Figure 5.7-4 was somewhat limited by the spacing of the SPI stations, but the contour map suggested that the cap material spread between about 75 to 150 meters on either side of the trackline in most of the cell. The spread of material was greatest near the beginning and again at the end of the trackline. The greater spread of material in the southeastern half of the cell, near the beginning of the trackeline, correlated well with the ADISS data showing that 75% of the load was placed in this location. The SPI results likewise agreed well with those from the Post-1 side-scan sonar survey, which showed a circular feature near the beginning of the trackline attributed to a larger quantity of cap material released in this location.

The ADISS data indicated the remaining 25% of the initial load was released between the center and northwestern boundary of Cell LD, but both the side-scan sonar and SPI results showed a significant accumulation of material outside the northwest boundary. This suggested that the cap material spread on the seafloor well beyond the point at which it had stopped being released at the sea surface. It is possible that most of the remaining 25% of the load was released at the end of the trackline rather than near the center of the cell, such that it accumulated predominantly outside the cell. The cap material also may have had some forward momentum imparted by the movement of the dredge towards the northwest. In general, the Post-1 SPI and side-scan sonar results generally indicated a relatively symmetrical lateral spread of material around the placement trackline.

The Post-9 SPI and side-scan sonar monitoring in Cell LD showed that the spreading placement continued to result in a relatively symmetrical lateral spread of material around the central tracklines. After nine spreading placements, SPI indicated the deposit was uniformly distributed on the seafloor at distances of 200 to 300 m on either side of the tracklines, in both the upslope and downslope directions. There was some evidence that the material had spread slightly farther in the downslope direction, as thin cap layers were observed at more of the downslope SPI stations located outside the cell boundary compared to the upslope. The Post-9 cap thickness contour map also showed slight "bulges," indicating wider spreading, near the center of the two halves of the cell compared to the cell center. The slightly wider spread of material on the seafloor at the two ends of the cell probably reflected somewhat higher volumes of material placed in these locations as a result of the variability in release rate from the hopper dredge. There was good agreement between these SPI results and the side-scan sonar records showing circular surge features around the locations where larger quantities of cap material were released. For Cell LD as a whole, both the SPI and side-scan sonar results indicated a fairly uniform lateral spread of cap material following the nine spreading placement events.

In the supplemental SPI survey conducted in Cell LD approximately six months after the last cap placement event, layers of cap material (golden sand from A-III Borrow Area) remained visible at each of three sampling stations. The average thickness of the cap material layer observed at each station in the supplemental survey was similar to that measured earlier in the Post-9 survey. The absence of appreciable change in cap thickness at the individual stations provided indirect evidence that there was no significant change in the lateral spread of material on the seafloor in Cell LD over the six month postcap period.

♦ *How much variability was there in cap thickness?*

Despite the somewhat greater contrast in texture and appearance between the A-III Borrow Area sand and the in-place EA sediment, sub-bottom profiling was not effective in Cell LD for determining the thickness of the relatively thin cap layer. In addition, the gravity coring effort in Cell LD was plagued by the same sampling artifacts (drag down and bow wave) experienced in Cells LU and SU, resulting in no reliable cap thickness measurements from this technique.

The series of frequency distributions presented in Section 5.7 indicated that cap thickness measurements generally varied by 1 cm or less among the three replicate SPI images obtained at each station in Cell LD. Similar to Cells LU and SU, it appeared that across relatively short horizontal distances on the seafloor (i.e., a few meters between replicate images), there was very little variability in cap material thickness as a result of spreading placement in Cell LD.

The SPI cap thickness contour map for the Post-1 survey showed that average cap thickness varied from about 3 cm at stations located along the center track line of the hopper dredge to less than 1 cm near the outer edge. Cap material thickness was generally uniform at the stations located along the track line, with the thickness tapering evenly on either side of this line. Station I10 in the center of the southeast half of the cell and station O09 located 50 m outside the northwest cell boundary had slightly thicker accumulations of cap material, reflecting an uneven rate of placement or momentum of the hopper dredge and transport during settling by northwesterly currents. Following nine spreading placement events, the cap material deposit continued to show uniform thickness on either side of the central track line (i.e., the thickness contours were symmetrical around the center of the cell), with some variation in thickness along the track line related to the variable rates of release.

The greatest thickness was observed most consistently at the SPI stations near the center of the southeast half of the cell, reflecting the higher rates of release near the beginning of the dredge's track line. Because the thickness of the cap material layer was greater than the penetration depth of the SPI camera at several of the Post-9 stations, a true assessment of cap variability across the cell was not possible. However, the Post-9 contour map suggested that cap thickness was relatively uniform across the center of the cell, ranging only between about 8 to >10 cm, with cap thickness decreasing evenly on either side of the trackline.

SPI results from the supplemental survey, conducted approximately six months after the final placement event in Cell LD, indicated the continued presence of a visually distinct cap material layer at each of three stations. The thickness of the layer at each station (5.3 to >8.5 cm) was consistent with that measured during the Post-9 survey, indicating little temporal variability in cap thickness in this cell over the six month postcap period.

♦ *What is the effect of water depth, bottom slope, and cap material type on a point placement?*

The depth (40 to 45 m) and slope (0.9°) of Cell LD were comparable to Cell LU and less than Cell SU (60 to 70 m and 3.2° slope). Both the Post-1 and Post-9 SPI results in Cell LD indicated that the cap material footprint on the seafloor was roughly symmetrical around the central placement trackline. There was some evidence in the Post-9 results that the material had spread slightly farther in the downslope direction near the middle of the cell compared to the upslope. In general, however, the very slight slope in Cell LD appeared to have a negligible effect on cap material distribution. The possible effects of different cap material types, increased water depths, or steeper slopes were not tested for the spreading placement method.

- ***Following placement of the pilot cap, was there considerably more seafloor topography than observed during baseline surveys?***

There were no major topographic changes observed during the side-scan sonar operations within Cell LD. Both the side-scan imagery and SPI suggested that the deposit of cap material was relatively flat and evenly spread across the seafloor. Neither SPI nor sediment plan view photography showed any evidence of an increase in small-scale surface roughness (i.e., roughness visible within the field of view of either the sediment-profile or plan view cameras).

Can disturbance to in-place sediments be kept within tolerable limits?

This section primarily addresses potential disturbances to sediment and water quality within Cell LD, including impacts to nearshore kelp beds, associated with resuspension of EA sediments following cap placement using spreading placement methods. The magnitude and duration of water quality impacts within Cell LD were evaluated during cap placement monitoring using a combination in situ profiling instruments and discrete water samples for TSS and DDE concentrations, along with measurements from moored, instrumented arrays, and towed acoustic profiling instruments. Assessments of sediment disturbance, based on results from SPI, coring, and side-scan sonar methods, also considered potential for contaminant remobilization associated with scouring surface layers of bottom sediments.

- ***To what degree were in-place sediments disturbed as a result of cap material placement?***

The depth of disturbance of EA sediments was estimated based on the degree to which the RPD was visible in the sediment profile images. For the spreading placement in Cell LD, the SPI monitoring generally showed that the greatest disturbance (roughly greater than about 2 or 3 cm) occurred at stations along the track line of the dredge, particularly where larger volumes of material were released and thicker layers of material subsequently accumulated on the bottom. Outside the immediate vicinity of the track line, the depth to which the in-place sediments appeared to be disturbed was generally limited to less than 2 cm. In general, the results suggested that the lateral surge of cap material resulting from spreading placement produced somewhat less disturbance of the in-place sediments than conventional placement. Similar to the results from Cells LU and SU, SPI monitoring in Cell LD showed no apparent disturbance to the in-place sediments at stations located outside the cap material footprint. At these stations, the 2-3 cm layer of light colored sediment comprising the RPD remained in place, despite the passage of a placement surge.

- ***Does the cap placement operation cause high concentrations of contaminants in the water column immediately following placement, as a result of resuspension of ambient sediments?***

Spreading/placement was expected to cause less sediment disturbance than conventional placement methods. Measurements of currents and turbidity levels from moored instruments indicated a near-bottom surge event following the initial placement event in Cell LD. However, the magnitude of the effects was lower than that observed in Cells LU and SU, probably because the impact of cap material on the bottom was spread horizontally over a relatively larger area for each placement event.

Water quality measurements in the vicinity of Cell LD during the two hours following initial cap placement revealed an initial spike of low light transmittance (0%) and correspondingly high near-bottom turbidity levels. Maximum TSS and total DDE concentrations measured at the centroid of the suspended particle plume were 350 mg/L and 0.1 µg/L, compared to background concentrations of 2 mg/L and 0.006 µg/L, respectively. As expected, these maximum TSS and DDE concentrations were lower than those associated with conventional placement methods used in Cells LU and SU. Although the spatial

extent of the resuspended sediment plumes was not determined, turbidity levels and TSS and DDE concentrations in waters outside of the plume centroid were expected to be relatively lower than peak levels.

Similar to Cells LU and SU, most of the measured turbidity and elevated TSS concentrations in Cell LD likely were attributable to suspended cap material settling through the water column rather than resuspended EA sediments.

- ***Do water quality impacts persist after individual placement events?***

Water quality measurements at Cell LD demonstrated that water column properties returned rapidly to background conditions following each placement event. In particular, turbidity levels and TSS concentrations declined from peak levels occurring immediately after release of cap material to background levels within a period of approximately 30 minutes. Thus, the duration of water quality impacts was shorter than those associated with placement in Cells LU and SU using conventional methods.

- ***Do high concentrations of water column contaminants occur only following the first placement event in each cell (i.e., do potentials for water quality impacts decrease as proportionately greater portions of a cell are capped?)***

Water quality sampling and near-bottom current and turbidity measurements were made in Cell LD following the initial placement event only. Thus, water quality conditions following the initial and subsequent placement events could not be directly compared. Regardless, based on observations made in Cell LU, the magnitude of potential disturbances of bottom sediments in Cell LD was expected to decrease as greater portions of the cell were covered with cap material.

- ***What is the likelihood that near-surface plumes of suspended cap material are transported inshore to existing, near-shore kelp forests?***

One drogue tracking study conducted during the incoming tide at Cell LD indicated near-surface transport to the southeast over a distance of 0.94 km, and transport at 10 meter depths to the northwest over a distance of 0.48 km in 1.5 hours. Neither drogue track was directed shoreward or directly towards the nearshore kelp beds. Small increases in TSS concentrations (to 5.3 mg/L) occurred during the first 30 minutes, but concentrations declined to background levels within two hours. No significant decreases in light transmittance levels were measured. Although the results from this plume tracking event may be considered representative of a relatively narrow range of conditions, the study did not indicate any significant potential for the capping project to impact nearshore kelp beds.

Does the cap remain clean?

- ***What is considered clean?***

Sediment from the A-III Borrow Area material was analyzed for DDE as part of the hopper sediment analysis. The average DDE concentration in material originating from the borrow pit area was 0.0018 ppm. This concentration is well below the value considered clean for material originating from the Queen's Gate Channel (Section 9.1).

- ***Is the mixing of cap material and EA sediments during the cap placement operation relatively minor such that contaminant concentrations in the cap layer immediately following placement are low?***

The limited amount of cap material placed in Cell LD and the introduction of coring artifacts hindered the detection of cap material in the cores collected from this cell. SPI Sections 5.7.4.3 and 5.7.4.4 indicated the accumulation of a layer of sand over the EA sediment. There was an indication that the depth of disturbance associated with the cap placement did not exceed 2 cm. The post 1 SPI survey indicated a 1-3 cm accumulation, while the post 9 placement survey indicated cap material greater than the camera penetration depth (>10 cm). Beyond the SPI assessment of the depth of disturbance, no quantitative data were collected from the cores to further determine the mixed zone or postcapping DDE concentrations in surface materials in Cell LD.

Visual inspections of two vibracores collected from Cell LD during the supplemental survey noted the presence of a distinct cap/EA layer interface at core depths of 4 cm and 11 cm. Results from grain size analyses of the cores suggested the presence of low but measurable proportions of cap material to core depths of 16 cm. In contrast, contaminant (DDE) concentrations in the surface layers of the Cell LD cores were comparable to background concentrations, indicating either the absence of appreciable cap material or contamination of any cap material that may have been present in the cores. The SPI images from the supplemental survey indicated the presence of a surface layer of recently-deposited sediment, with an average thickness of 6 cm, that likely consisted of EA sediment transported from adjacent areas outside the cell and re-deposited on top of the Cell LD cap layer. Due to sampling artifacts associated with the supplemental survey vibracoring (i.e., drag down or wash down of surface material along the inside of the core liner), the contributions of the recently deposited EA sediment to measured DDE concentrations could not be determined quantitatively. As a result, the supplemental survey data were considered of limited use for evaluating whether the cap layer in Cell LD cores remained clean.

Does the cap remain stable during placements?

As discussed in Section 9.1, this topic pertains to the momentum of the cap material immediately after release from the hopper dredge, as it descends through the water column and hits the bottom. The concern is whether the bottom surge current associated with the descending material is capable of moving significant volumes of seafloor sediments (EA and/or cap materials). The three sub-questions that had been posed in Section 9.1 are again addressed below as they pertain to results from monitoring cap material spreading operations in Cell LD.

Before we consider the effects of surge currents, turbidity flows, and other energy-driven processes in Cell LD, it is important to note that the cap spreading operations conducted in Cell LD were very different from the conventional capping operations in Cells LU and SU, such as:

- Only nine placement events were conducted in Cell LD (versus 21 and 71 in the other cells).
- Spreading along a single line resulted in a cap that was narrow, but extended the length of the cell.
- The spreading process in Cell LD resulted in much less material being discharged at a given location in the cell compared to an entire hopper load being discharged at a single location for conventional placement events. Thus, the volume of material descending through the water column at any given location was much lower for the spreading events.
- The material used for the spreading events originated from the A-III Borrow Area, whereas the cap material for conventional placements in Cells LU and SU originated in the Queen's Gate Channel, but differences in cap material characteristics (e.g., grain size) were not expected to have a significant impact on the surge current or other energy-related processes.

- ***Did the initial cap placement event in Cell LD cause a strong surge current at the seafloor that resulted in considerable lateral transport of ambient sediment away from the placement location?***

The field monitoring program was designed to acquire high-resolution data on near-bottom currents and turbidity during a single cap spreading event in Cell LD. Data were acquired during placement Event 1 when cap material was spread along the axis of Cell LD (see Section 5.2). The water depth within the cell was approximately 42 m and the ambient bottom was very flat and void of small-scale topographic features. As seen during cap placement events in Cells LU and SU, the near-bottom current data from Cell LD (see Section 5.3) illustrated that, upon impact with the bottom, a portion of the downward momentum of the descending cap material manifested as a "surge" current that spread radially from the point of bottom impact, immediately beneath the hopper dredge.

During Event 1 in Cell LD, the bottom-mounted current meter arrays were deployed along a line and situated upslope and downslope of the cell's center point. Near-bottom current and turbidity data were acquired from three locations: 80 m upslope; as well as 60 m, 145 m and 240 m downslope of the placement site at the center of Cell LD. During this placement event, the hopper dredge was moving slowly along the axis of the cell, and discharging material as the dredge passed between the 80 m upslope and 60 m downslope moored arrays.

From the observations in Cell LD, we formulated the following conclusions about the surge process:

- The in situ observations revealed a distinct surge current having current speeds that were greater than the weak ambient bottom currents, but this surge was much weaker than surge events monitored during six conventional placement events in Cells LU and SU. Maximum current speeds during the surge in Cell LD were 35 cm/s at both the 80 m upslope and 60 m downslope array locations compared to maximum speeds that exceeded 120 cm/s for some of the surge events during conventional placements in Cell LU (see Figure 4.3-6). The maximum current speed of 20 cm/s at the 240 m downslope array location at Cell LD revealed that current speeds in the surge decreased with distance from the placement site (spreading line) as had been observed in Cell LU which had a similar bottom slope as Cell LD.

- The turbidity records acquired for the surge event in Cell LD (Figure 4.3-7) demonstrated that turbidity levels were much lower than those observed at the same distances (both upslope and downslope) from the placement site for events in Cells LU and SU. Maximum turbidity levels at the upslope location were 8 to 10 times lower than those measured in Cells LU and SU. At the downslope array locations, turbidities were 4 to 10 times lower than those measured for the other cells. More importantly, the turbidity data from the spreading event in Cell LD showed that the load of suspended sediments within the surge was decreasing substantially with distance from the placement location, representing further evidence that turbidity flow was not generated.

- Water quality profile measurements (see Section 5.5) and underway ADCP profiling operations (see Section 5.6) in the vicinity of Cell LD during the two hours following spreading Event 1 revealed that suspended particulate levels in the near-bottom plume (surge) were significantly lower than those observed during the conventional placements in Cells LU and SU. These results agreed with the moored turbidity measurements discussed above.

Therefore, there was no evidence that a surge current or turbidity flow had carried large volumes of sediment away from the placement site in Cell LD.

- ***Would subsequent placements of cap material have sufficient surge energy to further erode EA sediments as well as cap material that was placed previously?***

In accordance with the design of the field sampling program, near-bottom current and turbidity measurements were not made in Cell LD after the first placement event. However, based upon the in situ current velocity and turbidity data acquired during Event 1, there was no reason to believe that the relatively weak surge associated with subsequent spreading events would be sufficient to erode EA sediments or in-place cap material.

- ***What is the potential for creation of turbidity flows and mudwaves?***

Turbidity Flows

The moored current data acquired during the spreading event in Cell LD demonstrated that horizontal velocities in the bottom surge decreased with distance from the placement location. Because all nine spreading operations in Cell LD were conducted in the same manner, these surge data should have been representative of all placement events in Cell LD. Further, SPI, side-scan sonar, and sub-bottom profiling records did not indicate that any turbidity flows occurred as a result of cap placement. Therefore, we concluded that turbidity flows were not generated during cap placement operations in Cell LD.

Mudwaves

Mudwaves were not expected to develop during the pilot cap program, especially for the minimal cap resulting from the nine spreading events in Cell LD, because this would have required: 1) substantial overlying weight from a thick cap, and 2) relatively mobile, high water content sediments underlying the cap. Because these conditions were not met in the present study, mudwaves were not expected to occur following placement of the thin cap in Cell LD. If however, they had occurred, spatial information acquired during the sequential side-scan sonar surveys would have been the only means of detecting this process. If the cap had been breached by a mudwave and a large volume of ambient sediment was lying on top of the cap material, the side-scan record may have revealed small-scale topographic relief at the location where the underlying material was ejected, and there may also have been a visible region of irregular side-scan signal strength due to the transition in return signal strength associated with the boundary from cap material to the mobile ambient material. Because no such topographic relief nor irregular signal strength patterns were detected during any of the side-scan surveys, we concluded that mudwaves had not occurred immediately following the cap spreading operations in Cell LD.

9.3 Pump-Out Placement in Cell LC

Can a cap with uniform thickness be constructed?

- ***Can multiple loads of cap material be placed accurately and consistently based upon a pre-determined cap placement plan?***

Because the pump-out in Cell LC was a one-time event during the summer pilot program, the question of placement consistency cannot be addressed. The ADISS monitoring results demonstrated that the hopper dredge achieved good navigational accuracy in following the predetermined track line across the center of Cells LU, LC, and LD during the single pump-out placement event. The ADISS results further confirmed that because the cap material was pumped out at a constant rate, the rate of change in

the draft of the hopper dredge (and thus the rate of release of cap material into the water column) was constant over the entire event.

- ***How far did the cap material spread on the seafloor following placement?***

The post pump-out SPI results in Cell LC were inconclusive with respect to determining the spread of the cap material on the seafloor, due to the inability to distinguish clearly between the very thin (i.e., less than 1 cm) "sprinkle" layers of this material and EA sediment. Such distinctions could only be made with confidence at several of the stations immediately along the central track line of the dredge in Cell LC. In Cell LD, the sprinkle layers of Queen's Gate cap material were clearly visible against the background consisting of golden sand from the A-III Borrow Area. The SPI results indicated that such layers were present at all of the stations along the track line, as well as at stations up to 100 m on either side of this line. Given the relatively small volume of cap material placed during the pump out event, compared to the spreading and conventional placements, the SPI results from LD suggested considerable lateral spreading of this material. As previously discussed (Section 6.2.4), the addition of significant volumes of water and greater mixing of the cap material during the pumping operation resulted in a lower solids content at the point of discharge and much slower settling rates through the water column. This allowed a smaller volume of material to spread in thinner layers over greater distances on the seafloor, consistent with the SPI observations.

- ***How much variability was there in cap thickness?***

As indicated above, the pump-out method resulted in very thin (less than 1 cm) depositional layers of the Queen's Gate cap material on the seafloor. These layers were consistently of the same thickness at the stations where they were observed, indicating a uniform spreading of the material on the seafloor. Based on the single pump-out event, this placement method appeared to offer the possibility of creating cap material layers of uniform thickness on the seafloor.

- ***What is the effect of water depth, bottom slope, and cap material type on a point placement?***

Because the pump-out was performed as a one-time event in a single cell, the potential effects of variables like water depth, bottom slope and cap material type were not assessed. Based on the results showing considerable lateral spread of a relatively small of volume of pumped out material, it was likely that increased water depths resulted in greater lateral spread than observed using other placement methods.

- ***Following placement of the pilot cap, was there considerably more seafloor topography than observed during baseline surveys?***

There were no major topographic changes observed during the side-scan sonar operations within Cell LD. Both the side-scan imagery and SPI suggested that the deposit of cap material was relatively flat and evenly spread across the seafloor. Neither SPI nor sediment plan view photography showed any evidence of an increase in small-scale surface roughness (i.e., roughness visible within the field of view of either the sediment-profile or plan view cameras).

Can disturbance to in-place sediments be kept within tolerable limits?

This section primarily addresses potential disturbances to sediment and water quality in Cell LC, including impacts to nearshore kelp beds, associated with resuspension of EA sediments following cap

placement using pump-out methods. The magnitude and duration of water quality impacts were evaluated during cap placement monitoring using a combination in situ profiling instruments and discrete water samples for total suspended solids and DDE concentrations. Assessments of sediment disturbance also considered potential for contaminant remobilization associated with scouring surface layers.

- ***To what degree were in-place sediments disturbed as a result of cap material placement?***

The SPI results from Cell LC suggested that the lighter-colored surface sediment comprising the RPD remained in place following the pump-out placement event, indicating no significant disturbance as a result of cap material deposition. Surface sediments in Cell LD consisted of clean, golden sand from the A-III Borrow Area. Unlike EA sediment, this material did not have an RPD serving as a visual marker to estimate the depth of disturbance. The pumped-out Queen's Gate cap material appeared as a very thin, sprinkle layer on top of the golden cap sand. Given the relatively small volume and significant spread of the Queen's Gate material, disturbance of in-place cap sand were considered unlikely.

- ***Does the cap placement operation cause high concentrations of contaminants in the water column immediately following placement, as a result of resuspension of ambient sediments?***

Similar to the spreading method, the pump-out placement method was intended to reduce possible disturbances to bottom sediments. Measurements of the velocity and duration of surge currents were not performed for cap placement within Cell LC. Nevertheless, the magnitude of bottom disturbances from cap placement using pump-out methods was expected to be considerably smaller than those associated with conventional methods because the material was released at a relatively lower rate and with less momentum.

Water quality measurements in the vicinity of Cell LC during the two hours following the initial placement event revealed low but variable TSS concentrations (3 to 30 mg/L) compared with background concentrations of 2 mg/L. Maximum total DDE concentrations were 0.008 µg/L, compared to background concentrations of 0.005 µg/L. These TSS and DDE concentrations were more than one order of magnitude lower than levels associated with both spreading and conventional placement methods. Based on evaluations of the measured water column DDE concentrations, TSS loads largely comprised cap materials.

- ***Do water quality impacts persist after individual placement events?***

Water quality measurements at Cell LC demonstrated that water column properties returned rapidly to background conditions following the placement event. In particular, TSS concentrations generally declined to background levels within a period of approximately two hours. Further, DDE concentrations in the water column decreased to approximate background levels within a period of 30 minutes. This indicated that particles remaining in the plume following the initial settlement period (i.e., 30 minutes) consisted primarily of suspended cap materials.

- ***Do high concentrations of water column contaminants occur only following the first placement event in each cell (i.e., do potentials for water quality impacts decrease as proportionately greater portions of a cell are capped?)***

Water quality sampling and near-bottom current and turbidity measurements were made in Cell LC following the initial placement event only. Thus, water quality conditions following the initial and subsequent placement events could not be directly compared. Regardless, the magnitude of potential disturbances of bottom sediments in Cell LC was expected to decrease as greater portions of the cell were covered with cap material.

- ***What is the likelihood that near-surface plumes of suspended cap material are transported inshore to existing, near-shore kelp forests?***

Drogue tracking studies were not conducted at Cell LC during cap placement. However, plume transport from Cell LC is expected to be similar to Cells LU and LD. Results from studies at these latter cells indicated that impacts from cap placement on nearshore kelp beds are unlikely.

Does the cap remain clean?

- ***What is considered clean?***

The material placed in Cell LC originated from the Queen's Gate Channel and would fall into the same classification of clean as stated in Section 9.1.

- ***Is the mixing of cap material and EA sediments during the cap placement operation relatively minor such that contaminant concentrations in the cap layer immediately following placement are low?***

The post pump-out coring survey failed to capture adequate surface sediment to distinguish additional cap accumulation from the pump-out event. In the post pump-out SPI survey in Cell LC, there was limited evidence of a presumed thin layer of cap material at 5 of the 18 stations (Figure 6.5-3). In sediment profile images from the post pump-out survey in Cell LD, the gray, sandy Queen's Gate material was clearly visible as a thin layer on top of the underlying golden sand. Because the existing sediment surface in Cell LC consisted of light-colored, sandy mud, it was much more difficult to distinguish and measure thin "sprinkle" layers of Queen's Gate material against this similar "background." At most stations in Cell LC, no visible differences in the appearance of sediment between the baseline and Post 1 pump-out surveys were evident (Figure 6.5-4). The undisturbed interface of A-III Borrow Area and Queen's Gate materials indicated that minor surface disturbance occurred during the pump-out event and that limited mixing occurred. No analysis of DDE was conducted for this placement technique. The lack of disturbance of the surface sediment in Cell LD indicated that initial placement events via pump-out reduced the extent of mixing between EA sediments and cap material.

Does the cap remain stable during placements?

As discussed in Section 9.1, this topic pertains to the momentum of the cap material immediately after release from the hopper dredge, as it descends through the water column and hits the bottom. The concern is whether the bottom surge current associated with the descending material is capable of moving significant volumes of seafloor sediments (ambient and/or cap materials). The three subquestions that had been posed in Section 9.1 are again addressed below as they pertain to results from monitoring cap material pump-out operations in Cell LC.

Before we consider the effects of surge currents, turbidity flows, and other energy-driven processes in Cell LC, it is important to note that the cap spreading operations conducted in Cell LC were very different from the capping operations in Cells LU, SU and LD, such as:

- Only one placement event was conducted in Cell LC (versus 21 and 71 in Cells LU and SU, respectively, and 9 in Cell LD).
- Pump-out operations along a single line resulted in a cap that was narrow, but extended the length of Cells LC and LD.

- During pump-out operations, the cap material was discharged from the drag-arm at a depth of 80 ft (24 m), whereas for the other placement techniques, material was released from the bottom of the hopper dredge.
- Only 298 m^3 of material was released during the 21-minutes pump-out operation. This discharge rate was 11 times lower than the average spreading rate for the nine events in Cell LD. Thus, the volume of material descending through the water column at any given location was much lower for the pump-out event than for any of the spreading or conventional events.
- During the pump-out operation, water was added to the material being pumped such that the slurry that was discharged from the drag arm was highly mixed and probably free of clumps.
- The material used for the pump-out event in Cell LC originated from the Queen's Gate Channel as for the conventional placements in Cells LU and SU.

♦ ***Did the initial cap placement event in Cell LC cause a strong surge current at the seafloor that resulted in considerable lateral transport of EA sediment away from the placement location?***

The field monitoring program did not include near-bottom current and turbidity measurements in Cell LC during the single pump-out event, nor were any vessel-mounted ADCP profile measurements conducted immediately following the event. Consequently, no in situ current data were available from which to draw conclusions about surge processes during pump-out operations. However, because the rate of cap material discharge was very low while the dredge traveled along the axis of the cell, the descending material would not have had a great deal of downward momentum, compared to the conventional placement operations when the entire load of material was released at one time. If a bottom surge had been generated by the pump-out operation, this surge would have had much less energy than the surge generated during both the spreading and conventional placement operations in Cells LD, LU and SU, respectively. Consequently, we conclude that the single pump-out operation in Cell LC did not generate a surge current that would result in considerable transport of bottom sediments away from the placement location.

Water quality profile measurements in the vicinity of Cell LC during the two hours following pump-out Event 1 revealed that suspended particulate levels in the near-bottom plume were well above the low background levels (Section 6.4). This plume was relatively easy to track using the transmissometer on the CTD profiling device because the pump-out operation through the drag arm had been very efficient at mixing the cap material as it was injected into the receiving water. Although the TSS concentration within this plume was considerably lower than that measured during the conventional placement operations, the plume resulting from the pump-out operation could be tracked for at least two hours due to its uniform characteristics and absence of material clumps that would accelerate particle settling. Therefore, because of the lower TSS concentrations within the plume from pump-out operations, this plume may have remained in the water column longer than plumes resulting from conventional placement operations. It is important to point out that the intensity of this plume from pump-out operations should not be interpreted as an indicator of bottom surge energy because the plume effects were totally unrelated to the process of bottom sediment resuspension caused by a surge.

Although the spreading operations in Cell LD had discharged more material per unit length of trackline than accomplished during the pump-out operation in Cell LC, the near-bottom plumes resulting from the spreading operation dissipated more rapidly than the plume from the pump-out operation. The more rapid dispersion of the plumes from spreading operations was mainly a result of the material type, as dredged material from the A-III Borrow Area was used for spreading operations versus Queen's Gate material for the pump-out operation. Because the borrow area material was primarily sand with only a small fraction of fines, the majority of this material settled quickly, leaving minimal quantities of fine material for plume effects. The higher percentage of fine material in the Queen's Gate sediment resulted

in plumes that were easier to track following pump-out and conventional placement operations, independent of surge energy.

The main result was that there was no evidence that a surge current or turbidity flow had carried large volumes of sediment away from the placement site during pump-out operations in Cell LD.

- ***Would subsequent placements of cap material have sufficient surge energy to further erode EA sediments as well as cap material that was placed previously?***

In accordance with the design of the capping program, there was only a single pump-out event in Cell LC. Consequently, concerns about surge effects from subsequent placements were negated.

- ***What is the potential for creation of turbidity flows and mudwaves?***

Turbidity Flows

Because there was substantially less cap material descending through the water column during the pump-out operation in Cell LC than during the conventional and spreading operations in Cells LU and LD, respectively, and because turbidity flows had not been generated at Cells LU and LD during capping operations, we concluded that turbidity flows were not generated during the pump-out operations in Cell LC.

Mudwaves

Mudwaves were not expected to develop during the pilot cap program, especially for the minimal cap resulting from the single pump-out event in Cell LC, because this would have required: 1) substantial overlying weight from a thick cap, and 2) relatively mobile, high water content sediments underlying the cap. Since neither of these conditions were met in the present study, mudwaves were not expected to occur following placement of the thin cap in Cell LC.

10.0 RECOMMENDATIONS

10.1 Vessels and Logistics

❖ **Recommendation:** Ensure that the survey vessels have adequate electrical systems to provide power to multiple survey equipment systems simultaneously (see Section 10.2 below).

10.2 Navigation and Vessel Positioning

❖ **Recommendation:** Ensure that the survey vessels have adequate electrical systems to provide power to multiple survey equipment systems simultaneously.

Navigation and vessel positioning were a success on the numerous surveys but there is always room for improvement. On some of the vessels that were used, specifically the R/V *SEAWATCH*, there was an electrical power conflict between the CTD winch operation and the navigation receivers, causing gaps in CTD positional data. This was a specific problem related to a necessary winch that was used to operate the CTD. This particular winch was electric and used a large portion of the available power that was supplied from the ship's generator; stealing power from the navigation receivers. This problem may happen on other vessels depending upon how the vessels' electrical systems are wired, but may be avoided by using a few different approaches. One suggestion would be to incorporate a back-up uninterrupted power supply (UPS) in between the ship's power and the navigation equipment. This would work in instances where the draw of power from the conflicting source was intermittent and not constant. If a survey requires the constant use of the conflicting device (winch), then the UPS will probably not work throughout the needed period. Mainly because UPS back-up units are designed to supply reserved power for only a short period of time before they need to be recharged again. The next option would be implementing a separate power supply from the ship, specifically a small generator that could sit outside on deck safely. This option would rule out any necessity for the use of ship's power to the navigation system.

10.3 Sediment Profile Imaging and Plan View Photography

❖ **Recommendation:** Position sediment profile and plan view photography stations closer together in the sampling grid to provide more data for cap thickness contouring.

The SPI station grids used within each cell to determine the horizontal spread and thickness of cap material on the seafloor proved adequate for this purpose. The DAN-LA Geographic Information System subsequently was used to produce a series of contour maps illustrating the SPI measurement results. The positioning and spacing of the stations sometimes hindered the accuracy of the contouring. In some of the early SPI monitoring, for example, contouring of cap material distribution would have been enhanced if there were fewer far field stations and a higher density of stations closer to the placement point. The results of the pilot monitoring program should be used in planning the layout of any future SPI sampling grids to optimize detection and contour mapping of cap material on the seafloor.

10.4 Sediment Coring

10.4.1 Sediment Coring Techniques

❖ **Recommendation:** Utilize a grab sampler rather than a gravity corer to determine surface sediment DDE concentrations.

Gravity coring appears to disrupt a minimum of 6 cm of surface material upon penetration. To get a more accurate assessment of surface sediment DDE concentrations and grain size the utilization of a grab sampler is recommended. Alternatively, a different coring device (e.g., box corer) should be considered.

10.4.2 Sediment Coring Analysis

❖ **Recommendation:** Utilize a different grain size analysis method to provide more detailed results.

Overall, few changes to the analysis performed are recommended. The ultimate project goal should be evaluated when selecting analysis methods to present data in the highest level of detail possible. For engineering projects and modeling, it is recommended that future projects utilize ASTM D422-63 for grain size analysis. Utilizing a precise, horizon specific sampling method that is consistent through all surveys is recommended for statistical references to data. The similarities between cap material and EA material made quick concise identification of cap difficult, making the laboratory results key in accumulation conclusions. If immediate assessment is needed it is recommended that more distinct material be utilized for capping. Coring artifacts associated with coring procedures generated many of the difficulties in core analysis. The grain size method utilized provided a breakdown of particle size based on phi and the contractor made a best fit to associate the phi results within the ASTM standards.

❖ **Recommendation:** Eliminate the Atterberg limits analysis and modify the shear strength analysis.

Atterberg limits (AL) analysis is not recommended for future surveys due to the inherent sand content of the EA and cap material. If AL are to be used in future analyses, it is recommended that grain size also be conducted instead of bulk density. Bulk density was a useful parameter, however when coupled with Atterberg limits it provided limited information and in those cases grain size analysis would be recommended in the future. Shear strength (SS) results also were distorted by sand content and consequently, it is recommended that in situ shear strength measurements be conducted on sites where coring artifacts and high sand content add to the variability in SS data.

❖ **Recommendation:** Use a top-down sampling method to better identify the cap/EA sediment interface.

The sampling method utilized during the baseline survey specified discrete horizons for analysis, making the core sampling clear-cut. The subsequent monitoring project focused on the cap/EA interface as the determinant in where down-core sub-sampling should occur. This sampling method created confusion when the interface was not apparent. The similarities in cap and EA material added to the challenges of detecting the interface, however the laboratory results indicate that the overall sampling occurred at the appropriate horizons. A set top-down sampling method is recommended for future surveys.

❖ **Recommendation:** Perform water content and specific gravity measurements on all sediment samples.

Water content and specific gravity were not conducted on the background samples, making the survey sample data difficult to interpret. It is recommended that in the future, these analyses be performed at all phases of capping.

❖ **Recommendation:** Collect cores at the same locations throughout the entire survey.

Core locations should be at set sites throughout the survey so that a comparison of sediment grain size and contaminant level can be effectively monitored over time. If located at designated SPI locations throughout the survey, a better comparison between SPI-derived cap thickness and core-derived cap thickness could be performed. This sampling plan would also be an effective technique to monitor changes at one site over different phases of cap construction.

10.5 Sub-bottom Profiling

❖ **Recommendation:** Supplement (or replace) the sub-bottom profiling system with a standard dual-frequency, survey quality echosounder.

The intent of the postcap sub-bottom surveys was to be able to detect the cap and to measure its thickness. Within the PV placement cells, the sediment characteristic differences between the ambient bottom material and the placed cap material were minor, and at their interface, there was apparent 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.

Because the primary area of interest for the postcap monitoring surveys was the top one-meter layer of the seafloor, the much greater sub-bottom penetration provided by the low frequency sub-bottom system was not needed. A standard dual frequency echosounder operating at a high frequency of 200 kHz and a low frequency of 10 to 20 kHz may have provided some differences in seafloor measurement immediately following the cap placement. Typically, the higher frequency will delineate the first seafloor layer encountered whether soft or hard, while the lower frequency may penetrate a soft or unconsolidated surface layer and delineate a lower, well-consolidated layer.

10.6 Surge (Bottom Current and Turbidity) Measurements

❖ **Recommendation:** Provide sufficient mobilization time for moored instruments to ensure more complete data collection.

The bottom-moored ARESS and Aquadopp instrumentation proved very effective for acquiring near-bottom current velocity and turbidity data at sufficiently rapid sampling rates to resolve the temporal variability within the bottom surge associated with cap placement operations. Because of the very limited time allotted for mobilization of equipment prior to the field measurement program, only a small number of instruments were available for the first deployment in Cell LU and consequently, arrays were deployed at only two sites for the initial placement event in Cell LU. For subsequent deployments, four to five arrays were deployed. The basic recommendation is to schedule at least two months for mobilization of moored instrumentation on such complex measurement programs.

❖ **Recommendation:** Acquire moored instruments that can be deployed at depths greater than 100 meters.

Another recommendation for surge measurements is to acquire a greater number of moored instruments that can operate in water depths of 100 m or greater. The existing pressure cases of the ARESS data logging units could not be deployed at depths greater than 75 m and consequently, this prevented ARESS deployments at distances greater than 170 m downslope from the center of Cell SU. Use of stronger pressure cases for the ARESS units and/or use of additional Aquadopp instruments are recommended for future near-bottom current velocity and turbidity measurement programs on the Palos Verdes Shelf.

❖ **Recommendation:** Acquire more reliable acoustic releases on moored equipment to ensure recovery of the equipment.

Operationally, the combined use of acoustic releases and marker buoys tethered to the sea surface from the moored arrays proved effective for recovery of moorings in the vicinity of the pilot cells. Fifteen separate deployments of instrumented arrays were conducted; arrays were recovered for all but one of the deployments in Cell LU. This array was inadvertently towed farther offshore and recovered in Spring 2002.

It is recommended that more expensive/capable acoustic releases be used on future measurement programs to facilitate acoustic interrogation from the surface vessel to aid search and recovery in the event that an array's surface buoy was missing and/or an array was moved some distance from its deployment location.

❖ **Recommendation:** Eliminate trawl resistant bottom mounts until a more effective deployment method is developed.

Trawl resistant bottom mounts should not be used for physical protection of bottom-moored equipment until a reliable deployment technique is developed to ensure proper orientation of equipment on the seafloor.

10.7 Hopper Dredge Operation Data

❖ **Recommendation:** Develop a modified ADISS system on the dredge to accurately record the vessels heading during placement activities.

It was necessary to obtain the dredge's heading during the placement of cap material within the cells. The heading was to be used to offset the DGPS position from the antenna to the center of the hopper. This was necessary because the distance between the stations in the cells was less than the overall length of the dredge's hopper. Therefore, knowing the position of the center of the hopper would provide the most accurate location of the placement of cap material.

The best method for obtaining the dredge's heading is to incorporate a compass into the ADISS system. However, incorporating a compass into the ADISS system was not accomplished after several methods were attempted. According to the FSP, the dredge's digital compass was going to be incorporated into the ADISS system. Unfortunately, the output of the compass was not compatible with the ADISS software. After several attempts and modifications, the dredge's digital compass method was abandoned and SAIC purchased a digital KVK compass. The KVK compass could not be calibrated properly aboard the dredge due to magnetic interface caused by the dredge's superstructure.

Because of project time constraints, the KVK method was abandoned and the dredge's mate logged the compass orientation manually.

For future surveys, it is recommended that two GPS antennae be placed on the dredge. There are two different methods that could be used to position these antennae. The first method requires one antenna on the fore of the fly bridge and one on the aft of the fly bridge. A vector can be created between the two antennae and extended to the center of the hopper. This method is logistically easier to implement because the fly bridge is directly above the bridge containing the ADISS equipment. However, there is less accuracy in calculating the center of the hopper because the distance between the calculated hopper center and true hopper center will be the cosine of the distance between the GPS drifts of the antennae.

The second method would require one antenna on the aft of the hopper compartment and the second antenna on the fore of the hopper compartment. The center of the hopper is the midpoint of the azimuth between the two antennas. This method is logistically more difficult to implement. It would require running the antenna's cable from the fore of the hopper to the computer on the bridge (approximately 250 feet) or using a radio transmitter and receiver to obtain the fore hopper's antenna position. However, the accuracy of calculating the center of the hopper is much greater using this technique.

❖ **Recommendation:** Provide real-time transmissions of ADISS data to the shore-based facility.

The ADISS used for monitoring the position and draft of the hopper dredge during loading, transit, and cap placement operations proved to be an accurate and reliable measurement system that met all project objectives and acquired data for all 102 placement events. One recommendation for future Palos Verdes capping projects would to provide real-time transmissions of all ADISS data to a shore-based project office via cell phone or radio link. Doing so would provide more timely access to data from the dredging and placement cycle. This would also reduce costs, as less ADISS manpower would be needed to visit the dredge. This technique would also allow for better monitoring of the system's performance.

10.8 Water Quality Sampling

❖ **Recommendation:** Use a CTD that does not rely upon an in situ pump for sensor preformance.

The Sea Bird Electronics CTD profiling system proved marginally useful for acquisition of water property data because the accuracy of its conductivity and temperature sensors was affected by the operation of an in-line seawater pump. Within the first 30 min following a cap placement event, this small, in situ pump often became clogged by cap material that was descending through the water column. During these periods, the conductivity (salinity), temperature, and density data from the CTD were erroneous due to this pump problem, but accurate data were, however, acquired by the optical backscatter (turbidity) sensor and the CTD's internal pressure sensor, which indicated the depth of the sensor package. Use of a different type of CTD that does not rely on an in situ pump for sensor time-lag processing is highly recommended for future plume tracking operations.

❖ **Recommendation:** Use a less automated water sampling system than the rosette water-sampling device in extremely turbid water conditions.

The mechanical triggering mechanism of the rosette water-sampling device that was used to collect discrete water samples within the suspended sediment plumes became clogged and inoperable during the period immediately following the cap placement operation, when suspended sediment concentrations were exceptionally high. This sampling device was very useful for collection of water samples in plumes of moderate and low sediment concentrations, but more basic sampling devices (e.g., Niskin bottles) are recommended for collection of water samples in highly turbid plumes.

10.9 Plume Mapping

❖ **Recommendation:** Deploy more than one water-following drogue during plume mapping to acquire statistical data for surface flow.

The water following drogues proved to be very useful for providing real-time information on the vertical shear of horizontal currents in the upper 20 m of the water on the Palos Verdes Shelf. It is, however, recommended that more than one surface drifter be deployed for each plume study to acquire better statistics on the temporal and spatial variability of the surface flow.

❖ **Recommendation:** Utilize a moored ADCP during plume mapping to better monitor mid-level and near bottom water currents.

Deployment (tethering) of drogues at depth levels greater than 20 m is not recommended because the accuracy of drogue trajectories from holey-sock drogues tethered at greater depths was adversely affected by the relatively strong currents that can occur in the upper water column on the Palos Verdes Shelf. The cumulative drag imparted on the surface buoy and long tether line in the presence of a strong surface current can overcome the drag on the holey-sock situated within a weak, near-bottom flow. Real-time data from a moored ADCP having capabilities for telemetering data to a survey vessel would be much more useful (and accurate) for plume surveying operations than reliance on drogues tethered at mid-depth or near-bottom levels. Alternatively, use of a downward-looking ADCP on the survey vessel would be beneficial.

10.10 Surge Video Documentation

❖ **Recommendation:** Utilize an ROV to obtain video footage.

The video system used on the project was marginally successful for documenting plume surge at stationary positions, plume thicknesses, and the presence or absence of cap material on the seafloor by drifting through the cells. One problem that was encountered during these surveys 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 vessel heave and at times, the video system slammed into the seafloor. Another problem with the system was that its depth gauge and compass were difficult to read during much of the footage, making plume thickness measurements and directional information difficult. And finally, the system did not allow any kind of a time stamp or positional information to be recorded on the videotape as the data were collected. If video surveys are to be used in future capping projects, it is recommended that a Remotely Operated Vehicle (ROV) be utilized. Doing so will allow the video camera to maintain a constant height off the bottom, will be independent of vessel heave as it is not directly tethered to the vessel, and will record time and depth directly onto the tape via a video overlay box. The mobility of the ROV system would also be more effective for accurate measurement of plume thickness.

10.11 In-Hopper Sediment Sampling

There are no recommendations for in-hopper sediment sampling techniques.

10.12 Data Management/GIS

❖ **Recommendation:** Design the PV website using ArcIMS.

For the next Palos Verdes capping effort there are two recommendations to improve the efficiency of data management: 1) design the web site using ArcIMS ; and 2) to maintain one Oracle/SDE database for all of the target and actual station locations and survey analysis results during the course of the capping project.

These two recommendations feed off of one another in that an ArcIMS web site is fueled by an Oracle/SDE database that exists behind the scenes. The web site for the Summer 2000 surveying effort was populated with hundreds of static maps. Whereas using ArcIMS, the user could choose which data they wish to see from an ArcView-like interface. That map would be created 'on the fly' by querying the database and displaying the results on the web site. The database behind this web site could be populated during the actual surveys and result in real time data dissemination that the client could view. Also, if a surveyor at sea needed access to information gathered on a previous survey, he/she could find these data by searching the project's web site instead of calling the office.

In contrast, the Summer 2000 data management consisted of archiving the survey log files and pulling the desired information into ArcView on an as-needed basis. Once in ArcView, the spatial data were stored as shape files. Given the volume of surveys conducted and data gathered, this type of GIS data management led to the creation of hundreds of shape files. By linking ArcView to one Oracle/SDE database that houses all of the survey station locations and analysis results, one would merely have to query that database for the desired information. One database would eliminate the need of keeping track of hundreds of shape files and also would eliminate the potential of having outdated files. Lastly, using Oracle/SDE and an ArcIMS web site would result in faster data dissemination via the web site and simplify the process of passing the information into the DAN-LA GIS project.

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