MONITORING RESULTS FROM THE FIELD PILOT STUDY OF IN SITU CAPPING OF PALOS VERDES SHELF CONTAMINATED SEDIMENTS (Part 1 of 2)

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LIST OF ACRONYMS

ABAB	acoustic backscatter above background (from underway ADCP)
ADCP	Acoustic Doppler Current Profiler
ADISS	Automated Disposal Surveillance System
ADISSPlay	ADISS Display (helmsman display)
ADISSPro	ADISS data processing software
AF	accumulation factor
AMS	Applied Marine Science, Inc.
ARESS	Automated Resuspension Surveillance System
ASTM	American Society of Testing and Materials
BBADCP	Broad Band Acoustic Doppler Current Profiler
BEQ	Benthic Effect Quotient
BRI	Benthic Response Index
BSAF	biota-sediment accumulation factor
CAD	Contained Aquatic Disposal
CBO	community-based organization
CDF	Confined disposal facility
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CHL	Coastal and Hydraulics Laboratory
cm	centimeter
cm/sec	centimeter per second
cm/yr	centimeter per year
cm^2/yr	square centimeters per year
COC	chain of custody
COC	chemicals of concern
COPCs	chemical of potential concern
CRZ	contamination reduction zone
CT	central tendency
CTD	Conductivity-Temperature-Depth
CZMA	Coastal Zone Management Act
DAMOS	Disposal Area Monitoring System
DAN-LA	Disposal Analysis Network - Los Angeles
DDD	1,1-dichloro-2,2-bis(p-chlorophenyl)ethane
DDE	2,2-bis(p-chlorophenyl) 1,1-dihloroethylene
DDMU	1-chloro-2,2-bis(p-chlorophenyl)ethylene
DDT	1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane
DGPS	Differential Global Positioning System
DQOs	Data Quality Objectives
EA	Effluent-Affected
EC&HS	Environmental Compliance and Health and Safety
EE/CA	Engineering Evaluation and Cost Analysis
EIS	Environmental Impact Statement
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ERDC	Engineer Research and Development Center
ERL	effects range – low
ERM	effects range – median

FDA	Food and Drug Administration
FR	Federal Register
FSP	Field Sampling Plan
FTU	Formazin Turbidity Unit
g/day	grams per day
GIS	geographic information system
GMT	Greenwich Mean Time
GPS	Global Positioning System
HCB	hexachlorobenzene
HCH	hexachlorocyclohexane
HDPE	high density polyethylene
HHRE	human health risk evaluation
HML	Hazard Materials Laboratory
HQ	hazard quotient
HSP	Health and Safety Plan
ICV	Initial Calibration Verification
IE	infusorial earth
IRIS	Integrated Risk Information System
ITI	Infaunal Trophic Index
JWPCP	Joint Water Pollution Control Plant
kg	kilogram
kg/yr	kilograms per year
km	kilometer
km^2	square kilometers
kPa	kilopascal (unit of measurement for shear strength)
LACSD	Los Angeles County Sanitation Districts
LADD	lifetime average daily dose
LCS	laboratory control standard
LTFATE	Long Term FATE numerical model
LC	Landward-Center
LD	Landward-Downcurrent
LU	Landward-Upcurrent
m	meter
m/yr	meter per year
m^2	square meter
MDFATE	Multiple Dump FATE of Dredged Material
MDL	method detection limit
mg/kg	milligram per kilogram
mg/kg-day	milligram per kilogram per day
mg/L	milligram per liter
$mg/m^2/yr$	milligram per square meter
MPRSA	Marine Protection, Research and Sanctuaries Act
MS/MSD	matrix spike and matrix spike duplicates
MSDS	Material Safety Data Sheets
MT	metric ton
NAD 83	North American Datum 1983
NAS	National Academy of Sciences
NATCO	North American Trailing Company
NCP	National Oil & Hazardous Substances Pollution Contingency Plan
ng/L	nanogram per liter
NIEHS	National Institute of Environmental Health Sciences

NIST	National Institute of Standards and Technology
NOAEL	no-observed-adverse-effect level
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
NRDA	Natural Resources Damage Assessment
NTUs	Nephelometric turbidity units
OBS	Optical Backscatter Sensors
OC	organic carbon
OEHHA	Office of Environmental Health Hazard Assessment
OSHA	Occupational Safety and Health Administration
OSI	Organism-Sediment Index
PAHs	polycyclic aromatic hydrocarbons
PAI	Pacific Analytical Incorporated
PCB	polychlorinated biphenyl
PDFs	probability density functions
PEL	Probable effects level
PPE	personal protective equipment
ppm	parts per million
ppt	parts per trillion
PRSC	Post-Removal Site Control
PV	Palos Verdes
PVC	Plan View Camera
PVI	Plan View Image
PV-Web	Palos Verdes Monitoring Project Website
PWP	Project Work Plan
QA	quality assurance
QAO	QA/QC Officer
QAPP	Quality Assurance Project Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RDI	RD Instruments
REMOTS®	Remote Ecological Monitoring of the Seafloor
RfD	reference dose
RME	reasonable maximum exposure
RPD	Redox Potential Discontinuity
RPD	relative percent differences
RRM	Regional Reference Material
RSD	relative standard deviation
SAIC	Science Applications International Corporation
SC	Sample Custodian
SCBPP	Southern California Bight Pilot Project
SCCWRP	Southern California Coastal Water Research Project
SCMI	Southern California Marine Institute
SDCDHS	San Diego County Department of Health Services
SEC	sediment effects concentration
SFs	slope factors
SHSO	(no description)
SIF	summary intake factor
SL#	standard log number
SMBRP	Santa Monica Bay Restoration Project
SOP	Standard Operating Procedure

SPC	Sediment Profile Camera
SPI	sediment-profile imaging
SRMs	Standard Reference Materials
STFATE	Short Term FATE of Dredged Material
SU	Seaward-Upcurrent
SVPS	sediment vertical profile sampling
TBC	to be considered
TCMX	tetrachloro-meta-xylene
tDDT	1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane and its metabolites
TEL	threshold effects level
TOC	total organic carbon
TRBM	Trawl Resistant Bottom Mount (containing ADCP instrument)
TSS	Total Suspended Solids
µg/day	micrograms per day
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
$\mu g/m^3$	microgram per cubic meter
µm	micrometer
UCL95	95 percent upper confidence limit
USACE	U.S. Army Corps of Engineers
USC	United States Code
USCG	United States Coast Guard
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
USFDA	United States Food and Drug Administration
USGS	United States Geological Survey
WHG	Woods Hole Group Environmental Laboratories
WoE	weight of evidence
WQB	water quality benchmark]SA-saltwater acute; SC-saltwater chronic]
WQC-A	Water Quality Criteria-Acute

EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) is evaluating the effectiveness of in situ capping as an option for managing chemically contaminated sediments on the Palos Verdes Shelf off Los Angeles, California (Figure ES-1). The U.S. Army Corps of Engineers (USACE) is supporting EPA with design and implementation of a pilot capping project, as well as monitoring and modeling tasks. Science Applications International Corporation (SAIC) is, in turn, providing technical support to USACE with monitoring during and following cap placement operations.

A pilot capping program, conducted during July through September, 2000, provided an opportunity to evaluate cap constructability using a variety of placement methods under varying environmental conditions, such as bottom depth and slope. The project involved placement of clean cap material, obtained primarily from maintenance dredging operations in Queen's Gate Channel, within four 300 by 600 meter (m) cells on the Palos Verdes Shelf (Figure ES-2). The four cells were designated Landward-Upcurrent (LU), Landward-Downcurrent (LD), Seaward-Upcurrent (SU), and Landward-Center (LC). A fifth cell, designated Seaward-Downcurrent (SD), was evaluated during baseline monitoring, but not used for the subsequent pilot capping program.

Sediments dredged from the Queen's Gate Channel were placed with a hopper dredge using conventional (point) placement methods at pre-defined locations in Cells LU and SU. A total of 69,800 m^3 were placed in Cell LU during 71 placement events, and 22,800 m^3 were placed in Cell SU during 21 placement events. A spreading method was used during nine placement events in Cell LD to place 10,300 m^3 of sand-sized sediment dredged from the A-III Borrow Area; and 300 m^3 of sediments from Queen's Gate Channel were placed in Cell LC using a pump-out method. In general, initial placement events occurred in the center of each cell. Subsequent cap loads were placed at locations that overlapped with previous placements to minimize potential impacts to existing, effluent-affected (EA), bottom sediments.

The pilot cap monitoring program was designed to answer the following general questions:

- Can a uniform cap be constructed?
- Can disturbance to in-place sediments be kept within tolerable limits?
- Does the cap remain clean?
- Does the cap remain stable during placement?
- Does placement occur as modeled?

Monitoring tasks associated with the pilot capping program occurred in three phases: pre-capping (baseline), during cap placement, and postcapping. Baseline monitoring occurred from May through September 2000, and cap placement monitoring was conducted from July through September 2000. As part of the postcap monitoring, a supplemental survey was performed during February and March 2001. Results of baseline, cap placement, and postcap monitoring, including the supplemental survey, are presented in this report. Specific monitoring and data quality objectives for the baseline and cap placement phases were defined in phase-specific project work plans. Each project work plan included: data quality objectives; field sampling plan; quality assurance project plan; and health and safety plan.

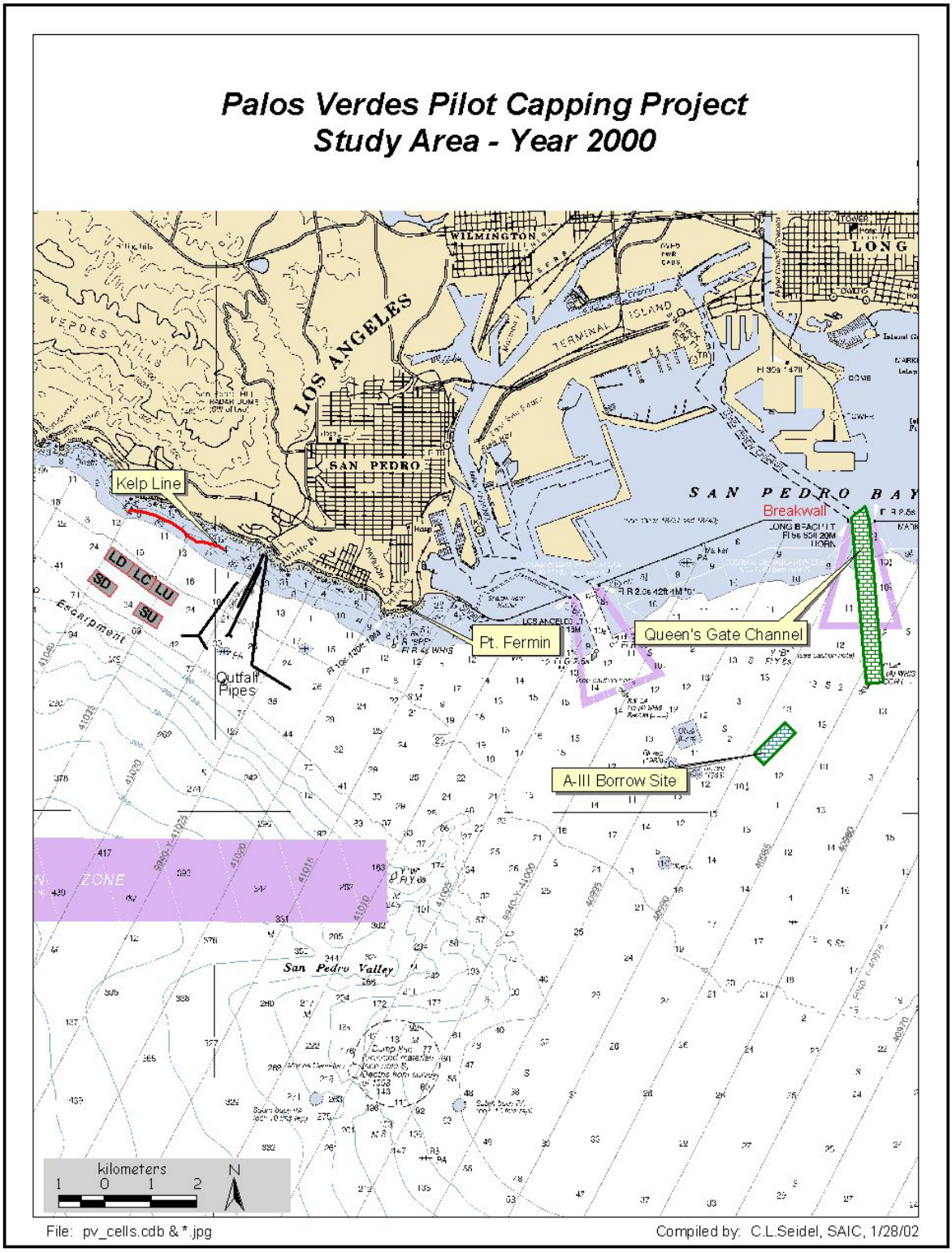

Figure ES-1. Palos Verdes Shelf pilot capping cells in relation to the LACSD wastewater outfalls, kelp line, and cap material source areas (Queen's Gate Channel and A-III Borrow Area).

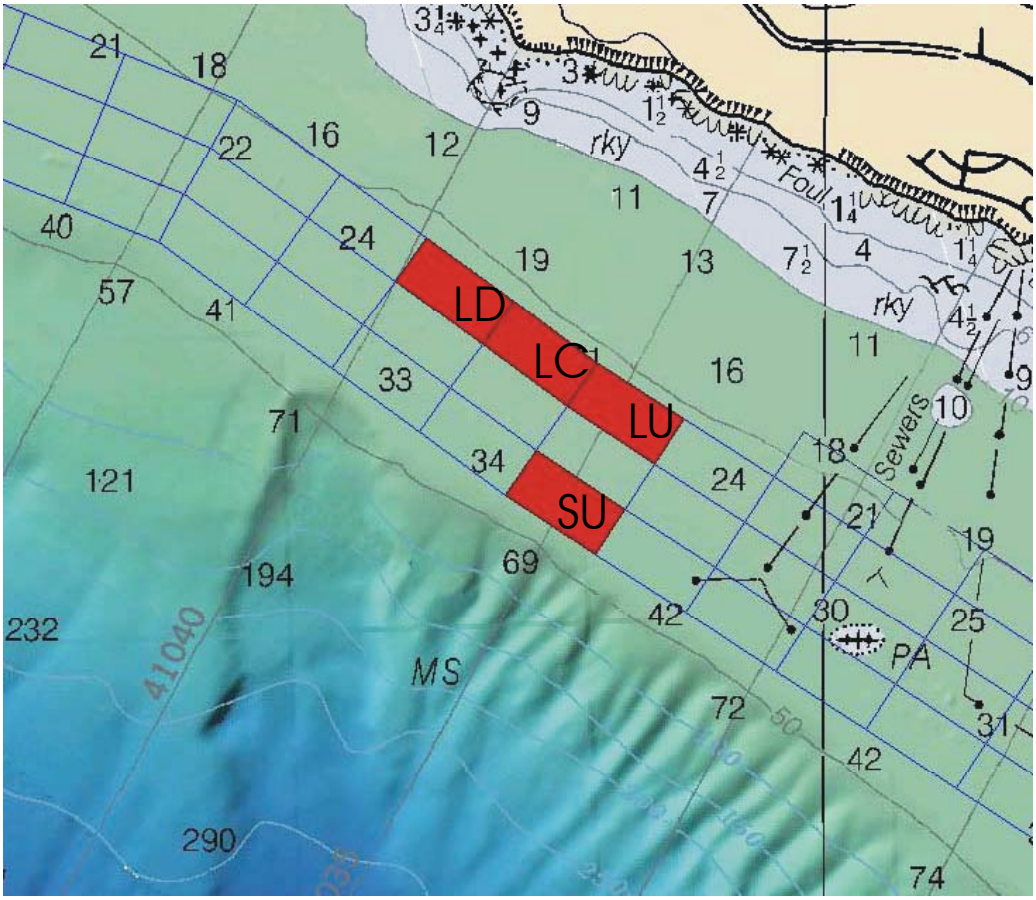

Figure ES-2. Location of pilot cells monitored on the Palos Verdes Shelf. Water Depths are given in Fathoms

Baseline and cap placement monitoring involved a number of measurement techniques, including in situ and remote sensing methods, as well as discrete sample collection. Specific techniques included: sediment profile image/plan view camera; side-scan sonar; sub-bottom profiling; sediment coring; water current/bottom surge using moored instruments; water quality profiling; and plume tracking. In addition to these sampling and measurement techniques, the volumes and locations of individual placement events were monitored throughout construction of the pilot cap. Also, samples of dredged sediments were collected periodically from the hopper dredge and analyzed to provide information on geotechnical characteristics of cap material that are important for modeling cap construction. All monitoring tasks were performed by SAIC, with the exception of plume tracking using an acoustic doppler current profiler, which was performed by USACE. With a few exceptions, all planned measurements were performed and specified samples were collected and analyzed in accordance with defined objectives.

Important results from baseline, cap placement, and supplemental monitoring are summarized by placement method in the following sections.

Conventional Placement in Cells LU and SU

Prior to cap placement, bottom conditions within Cell LU were characterized by a relatively uniform and undisturbed seafloor. Bottom sediments consisted primarily of fine sands and silts. Redox potential discontinuity (RPD) depths ranged from 1.1 to 5.0 cm, with average RPD depths of 2 to 3 cm, indicative of moderately deep aeration of surface sediment layers. Sediments were inhabited by a mix of small, tube-dwelling organisms in the surface layers and larger, deeper-dwelling organisms, characteristic of environments with high organic inputs. Average surface sediment DDE concentrations were approximately 1.5 parts per million (ppm), and concentrations did not vary substantially depth within the core.

Background bottom conditions within Cell SU were characterized by a relatively uniform and undisturbed seafloor. Bottom sediments were primarily silt with substantial clay and sand components, although proportions of sand decreased and clay increased with core depths. Redox potential discontinuity depths ranged from 0.5 to 4.5 cm, with an average value of 2.5 cm, indicating moderately deep aeration of surface sediment layers. Infaunal communities were similar to those in Cell LU, and included high abundances of deep burrowing organisms. Surface sediment DDE concentrations ranged from 4.3 to 10 ppm. Concentrations increased significantly with core depth, reaching maximum levels of 110 ppm at depths of 12 to 16 cm, which were considerably higher than those observed in the landward cells.

During cap placement in Cells LU and SU, monitoring activities occurred at specified intervals coinciding with a pre-defined sequence of placement events. The hopper dredge tracks and individual placement locations were documented using the Automated Disposal Surveillance System (ADISS).

Measurements of bottom surge and near-bottom water quality were conducted during three of the initial five placement events in Cell LU. Current and turbidity measurements provided evidence of bottom surge in the immediate vicinity of the placement location. Surge currents had sufficient velocities to erode bottom sediments. However, the magnitude of bottom currents, and potential for sediment scour, dissipated rapidly with distance, and generally were undetectable at distances of 250 m from the placement location. Similar conditions were observed during the initial placement event at Cell SU, but the bottom surge persisted farther from the placement location. The steeper bottom slope in and seaward of Cell SU is suspected as the cause for the less rapid attention of bottom surge at Cell SU versus Cell LU.

Resuspended bottom sediments, associated with surge currents, caused localized and temporary increases in turbidity levels and suspended solids and DDE concentrations in near-bottom waters. The highest DDE concentration (0.29 µg/L) in Cell LU occurred after the initial placement event. During subsequent placement events, peak total suspended solids (TSS) levels were generally comparable, whereas maximum DDE concentrations were relatively lower than those observed during the initial placement event. Because cap materials placed during Events 2 through 71 were released on top of the existing cap layer, the lower DDE concentrations during the Post-1 placement events were likely due to the progressively smaller amounts of existing bottom sediments affected by cap construction. Assessments of the magnitude of TSS and DDE concentrations following cap placement, compared with respective background levels, indicated that considerable portions of the suspended sediments in near-bottom plumes comprised cap materials settling to the bottom, whereas a significantly smaller portion was associated with resuspended bottom sediments. Impacts to water quality dissipated rapidly, and background conditions typically were reached within two hours following each placement event.

Within Cell SU, increases in turbidity levels in near-bottom waters immediately following cap placement were similar to those observed in Cell LU. Maximum TSS and DDE concentrations were 1100 mg/L and 1.2 µg/L, respectively. The peak water column DDE concentrations were relatively higher than those in Cell LU, and these were consistent with the severalfold higher DDE concentrations in surface EA sediments within Cell SU than in Cell LU.

Following the initial placement event in Cell LU, side-scan sonar data showed slight impact depressions and mixtures of displaced sediments and cap materials up to 150 m from the placement site. The outer extent of the surge pattern corresponded roughly to the 2 to 4 cm cap thickness contour determined from sediment profile image (SPI) data. The lateral surge associated with the initial placement event scoured approximately 0.1 to 2.4 cm of surface sediments within this area, whereas no disturbance was evident in areas beyond the portions of the cell covered by the cap layer. Lateral surge from subsequent placement events appeared to be due solely to displaced cap material. The side-scan sonar data also indicated that no major topographic feature changes, which could be indicative of mass sediment movement or slumping, occurred as a result of cap placement.

After five placements (cumulative total of 4,980 m^3) in Cell LU, cap material was evident from the higher proportion of 0.125 to 2 mm sand and the presence of a distinct gravel component (shell hash) in the surface layers of sediment cores. Following 45 placement events, average cap material thickness was at least 9 to 11 cm throughout the cell, with relatively minor (< 2 cm) small-scale variability. The presence of a distinct cap layer also was evident in most sediment cores collected following 45 and 71 placement events.

Analyses of the geotechnical and chemical profiles for three postcap cores indicated a cap thickness in Cell LU between 8 and 18 cm. However, this estimate is probably inaccurate (low bias) due to sampling artifacts associated with drag down and wash out from the gravity corer. Additionally, one of the cores collected after 45 placement events contained only minor amounts of cap material. Thus, in contrast with the SPI results, some sediment coring results suggested that cap material was spatially discontinuous within Cell LU.

Results from analyses of DDE concentrations in interim and postcapping cores in Cell LU were largely consistent with trends in sediment grain size and other geotechnical characteristics. Specifically, relatively low DDE concentrations in surface layers of most cores from postcapping surveys indicated the presence of cap material, with corresponding reductions

in contaminant levels up to two orders of magnitude, and little mixing between cap and EA sediments. However, one core, collected from a location with a 10.3-cm thick cap, as indicated by SPI, contained DDE concentrations comparable to levels in EA sediments. This discrepancy between SPI and core chemistry results could reflect spatial patchiness in the cap layer and/or loss of cap materials from the core during sampling.

Results from SPI images and geotechnical and chemical analyses of vibracore samples collected during the February/March 2001 supplemental survey, approximately five months after the final placement event in Cell LU, demonstrated the presence of a distinct cap layer. At locations sampled using SPI during both the Post-45 and supplemental coring surveys, measured cap thickness values were comparable and did not indicate any detectable decreases in cap layer thickness. SPI images for the supplemental survey also indicated the presence of a surface layer of recently-deposited sediments that were visually distinct from the underlying cap layer. This surface layer varied in thickness from 2 to 8 cm, and comprised sediments that were finer grained than cap material. Thus, it is likely that this layer consisted of EA sediments from adjacent areas outside the cell that were resuspended, transported into the cell, and re-deposited on top of the Cell LU cap layer.

Vibracores collected from Cell LU during the supplemental survey also contained evidence of the cap layer. In general, the grain size characteristics of the surface 16 cm portions of cores were consistent with cap material, with the exception that the surface 0 to 4 cm layer contained slightly smaller proportions of the coarse sand fractions than surface layers of cores collected during the Post 71 survey. This change may reflect the contributions from the recently-deposited layer of fine-grained EA sediments. Similarly, contaminant (DDE) concentrations in surface layers (0 to 8 cm) were generally lower by up to one order of magnitude than pre-capping concentrations, but also higher than concentrations in Post 71 core surface layers. The 8 to 12 cm layers contained a wider range of DDE concentrations (0.07 to 1.7 parts-per-million [ppm]), reflecting spatial differences in the depth of the cap/EA sediment interface, while DDE concentrations in sediments 12 cm and deeper were comparable to background concentrations, indicating an absence of appreciable cap material. In three cores, DDE concentrations in the 0 to 4 cm layers were relatively higher than those in the corresponding 4 to 8 cm layers, which may reflect the presence of the recently deposited layer of EA sediments observed in the SPI images. Cap layer thickness indicated by geotechnical properties was relatively greater than that suggested by the contaminant concentration profiles. This difference likely is the result of sampling artifacts associated with the vibracore procedure. Indications of these sampling artifacts further suggest that the results of the supplemental coring survey did not provide an accurate measurement of cap layer thickness in Cell LU.

The initial placement event in Cell SU produced an acoustic signature, discernible by side-scan sonar, that extended approximately 125 m from the placment site. An outer strip of approximately 15 to 25 m was also observed that may correspond to lateral surge of a mixture of EA sediment and cap material. The SPI data indicated a cap layer within a circular area with a diameter of 275 to 325 m, whereas cap material was not evident outside the cell. Cap layer thickness ranged from 8 cm at the center of the cell to less than 1 cm near the outer edge of the cap. Side-scan sonar and SPI data indicated that bottom surge from the initial placement event caused scouring of bottom sediments near the placement location. Sediment scour from the initial placement removed the surface layer near the center of the cell to depths below the RPD. At locations away from the center, depths of sediment disturbance ranged from 0.1 to 2.4 cm, while sediment scour was not evident in areas beyond the boundary of the cap layer.

Following five placement events in Cell SU, the diameter of the cap layer exceeded 350 m. Cap thickness was greater than 10 cm in the center of the cell, and from 4 to 8 cm in areas beyond the center of the cell, following 21 placement events. In general, relatively small variations in cap thickness occurred over short distances, which reflected a uniform cap layer. Evidence of material surge was less apparent following the five placement events than the initial placement event.

Sediment cores collected near the center of Cell SU following 21 placement events all contained cap material as indicated by the presence of gravel and the size frequency distribution of sand in the upper core layers. Subsurface layers, 3 cm above the apparent EA/cap interface, reflected some mixing of the fines (silt and clay) with sands from the cap material.

DDE concentrations in the surface (0 to 4 cm) layers of two cores collected near the center of Cell SU were low (0.042 and 0.030 ppm, respectively), consistent with the presence of clean, cap material. Sediments from depths of 4 to 8 cm below the core surface consisted of a mix of cap material and EA sediments, as indicated by higher DDE concentrations (2.2 to 5.8 ppm). The 10 to 14 cm core layers from these sites consisted of EA sediment only, with DDE concentrations up to 32 ppm. Thus, cap thickness at these sites, as suggested by the core chemistry results, was less than that indicated from the SPI results. Regardless, DDE concentrations in surface sediments at these two sites were more than two orders of magnitude lower than corresponding levels in baseline sediments. Consistent with the grain size data, the DDE concentration in the 10 to 14 cm horizon (32 ppm) of one core was comparable to levels measured in the 16 to 20 cm layer of the corresponding baseline core, suggesting that some of the surface EA sediment may have been displaced during cap placement. Surface layers of cores from two other sites near the southeastern boundary and in the northeastern corner of the cell contained DDE concentrations (5.7 and 9.6 ppm, respectively) comparable to those measured in surface layers of baseline cores from the same general location. Furthermore, the magnitude of DDE concentrations associated with the 6 to 12 cm layer of the postcapping core from one site (29 ppm) was comparable only to concentrations occurring at depths of 12 to 20 cm in the corresponding baseline core. These results suggested that any cap material present at this site during postcap coring was lost, probably as a result of bow wave effect from the gravity corer.

During the supplemental survey in February/March, 2001, SPI sampling in the vicinity of Cell SU occurred primarily outside (upslope) of the cell boundary. Cap layer thickness values (2.3 to 8.5 cm) obtained at these sites were slightly less than those obtained immediately following (Post-21) cap placement (3 to 9.3 cm), with the exception of one site that had a 3-cm thick cap layer during Post-21 but no detectable cap during the supplemental survey. These differences between surveys in cap layer thickness could be due to loss of small amounts of cap material by erosion, compaction of the initial cap layer, and/or spatial variability in cap thickness. However, the presence of a layer of newly-deposited, fine-grained sediment, with thicknesses ranging from 1 to 4.7 cm, suggests that erosion effects in the vicinity of Cell SU were negligible during the time between the Post-21 and supplemental surveys.

Evidence of cap material in the vibracore samples collected during the supplemental survey was equivocal. Visual observations of shell hash, as well as apparent changes in sediment texture characterized by higher proportions of coarser sediments, in the Cell SU cores indicated the possible presence of cap material to core depths of approximately 16 cm or greater. The cap/EA interface occurred at depths from 6 to 8 cm in two cores, and a mixed boundary was centered at 9 cm in one core, whereas no distinct cap/EA interface was evident in the four remaining cores from Cell SU. The core with a cap/EA boundary at 6 cm was consistent with co-located SPI data that showed the presence with a cap layer thickness of 8.5 cm, whereas other

cores containing apparent evidence of cap material to depths of 16 cm were inconsistent with maximum cap layer thicknesses in the vicinity of Cell SU indicated by SPI results. Overall, the core grain size results indicated the presence of measurable amounts of cap material to core depths of 8 cm. However, compared with results from cores collected from Cell SU during the Post-21 survey, relatively lower proportions of cap materials were present in surface layers during the supplemental survey. In contrast with the core geotechnical and SPI results, core chemistry data showed high DDE concentrations, with a high water/low solids content, in surface layers of cores that were inconsistent with the presence of a cap layer. In particular, the surface layer of the core from the center of the site (I09) contained DDE concentrations that were several orders of magnitude higher than corresponding concentrations in cores collected from the same location immediately following completion of cap placement in this cell.

The most plausible explanation for these results is that the Cell SU cores reflected coring artifacts that resulted in loss of both cap material and up to 14 cm of underlying EA sediment from the surface layers of the cores. The subsurface distribution of coarser sediments in the supplemental cores from Cell SU suggest that cap material was present at the site at the time the cores were collected, but the coring process did not accurately preserve the sediment stratigraphy. Instead, cap material was dragged down the length of the cores along the sides of the core liner, resulting in anomalous geotechnical and chemistry results. For example, drag-down along the sides of the cores may have displaced sediments in the central portion of the cores upwards towards the core surface. This effect would explain the apparent loss of up to several centimeters of surface EA sediments from cores. Cores from Cell SU may be relatively more susceptible to these coring artifacts because the underlying EA sediments have a high water content/high porosity and, therefore, may be more readily displaced compared with cores from the landward cells with sediments characterized by lower water content and lower porosity. As a result of this postulated displacement effect, the geotechnical and chemistry samples removed from individual 4-cm thick layers may have originated from different strata in the unaffected core stratigraphy. In total, while these results suggest that a cap layer was present at the time of the supplemental survey, the core chemistry and geotechnical results did not accurately reflect the actual thickness of the cap layer.

Spreading Placement in Cell LD

Prior to cap construction, bottom conditions in Cell LD were characterized as relatively uniform and undisturbed with few distinguishing features. Baseline sediments in Cell LD consisted primarily of very fine sands and silt. Apparent RPD depths ranged from 1.7 to 3.5 cm, with an average value of 2.6 cm, similar to that of Cells LU and SU. SPI data indicated the presence of a diverse and abundant infaunal community, including numerous deep-burrowing organisms. Concentrations of DDE in Cell LD sediments ranged from 0.75 to 2.7 ppm, and averaged approximately 1.5 ppm with no apparent trends with core depth.

Cap placement monitoring coincided with placement Events 1 and 9 and Post-1 pump-out. All cap placements were made using a spreading placement technique, and cap material consisted of sandy sediments from the A-III Borrow Area.

Compared to conventional placement methods used for cap construction in Cells LU and SU, the extent of sediment disturbance associated with the spreading placement method was expected to be relatively smaller. 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 surge currents was relatively lower than those observed in Cells LU and SU, probably because the impact of cap material on the bottom was spread horizontally over a relatively larger area.

Water quality measurements in the vicinity of Cell LD during the two hours following initial cap placement revealed a 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.

Following the initial placement event, an elliptical cap layer, consistent with the hopper dredge track line, was evident from SPI data. The average cap thickness ranged from 3 cm along the cap centerline to less than 1 cm near the outer edge, and cap coverage ranged from a continuous, distinct layer to a patchy, "sprinkle" layer near the cap boundary. Surge associated with cap placement disturbed the surface sediment layer to depths greater than 2 cm in areas along the trackline. In areas of the cap away from the trackline, the depth of sediment disturbance was less than 2 cm, whereas no sediment disturbance was evident in areas with no cap layer.

The grain size of the core sample collected during the Post 1 survey was characteristic of EA sediment, and did not demonstrate any discernable increase in proportions of fine sands typical of the presence of cap material. No postcapping cores were collected from Cell LD for DDE analyses.

Following nine placement events in Cell LD, a cap layer was present throughout the cell, with an average thicknesses greater than 11.5 cm along the centerline to less than 1 cm at distances 200 to 300 m on either side of the centerline. At the majority of sampling sites, the maximum difference between replicate images in cap layer thickness was 1 cm or less, indicating minimal spatial variability in cap thickness, and the magnitude of sediment disturbance was small.

The supplemental survey results collected approximately five months after the final placement event provided equivocal evidence for the presence of a distinct cap layer in Cell LD. SPI results indicated the presence of a visually distinct cap material layer having thicknesses (5.3 to >8.5 cm) consistent with those measured during the Post-9 survey. SPI images for the supplemental survey also indicated the presence of a surface layer of recently-deposited, fine-grained sediment, with an average thickness of 6 cm, that likely consisted of EA sediments transported from adjacent areas outside the cell and re-deposited on top of the Cell LD cap layer.

Visual inspections of two vibracores collected from Cell LD during the supplemental survey noted the presence of distinct cap/EA layer interface at core depths of 4 and 11 cm. Results from grain size analyses of 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 Cell LD cores were comparable to baseline concentrations, indicating either an absence of appreciable cap material or contamination of the cap surface layers by the recently-deposited, fine-grained EA sediment observed in the SPI images. Cap layer thickness indicated by geotechnical properties was relatively greater than that suggested by the contaminant concentration profiles. This inconsistency between the core chemistry data and the geotechnical and SPI results for Cell LD likely was the result of sampling artifacts associated with the vibracoring procedure. Indications of these sampling artifacts further suggest that the

results of the supplemental coring survey did not provide an accurate measurement of cap layer thickness for Cell LD.

Pump-Out Placement in 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. Monitoring occurred during a single placement event, and consisted of SPI and plan view camera sampling, sediment coring, and water quality measurements. With the exception of SPI and plan view camera sampling, no baseline monitoring was performed in Cell LC. However, background conditions were expected to be similar to those in Cells LU and LD, which are immediately adjacent to Cell LC and having equivalent water depths.

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 vertical 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, and results were consistent with the expectation that the pump-out method would result in less disturbance to bottom sediments. Based on evaluations of measured water column DDE concentrations, TSS loads in the near-bottom plume largely comprised sinking cap materials. Measurements in Cell LC demonstrated that water column properties returned rapidly to background conditions following each 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 indicates that particles remaining in the plume following the initial settlement period (i.e., 30 minutes) consisted primarily of suspended cap materials.

A single core collected in Cell LC did not contain any visual evidence of cap material.

Baseline Conditions in Cell SD

Cell SD was sampled during the baseline survey only. Because cap material was not placed in Cell SD, no interim or postcap monitoring was performed. Additionally, baseline characteristics were based on sediment core results only because no SPI data were collected within Cell SD.

Overall, sediment grain size within Cell SD was similar to that of Cell SU. Bottom sediments were primarily fine sands and silts. The sand content decreased, and the clay fraction increased, with core depth.

Concentrations of DDE in surface sediment within Cell SD ranged from 3.2 to 93 ppm. In general, concentrations increased with core depth, and the highest measured concentrations occurred in the 12 to 16 or 16 to 20 cm horizons.

Monitoring of Surface Plumes of Cap Material

Drogue tracking studies conducted on two occasions of conventional cap placements in Cell LU during the incoming tide indicated surface 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 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.

Similar studies of surface plumes during a cap spreading evnet in Cell LD during the incoming tide indicated near-surface transport to the southeast over a distance of 0.94 km, and transport to the northwest at 10 m depths over a distance of 0.48 km in 1.5 hours. The surface plume was not 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.

Although 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.

Sampling Protocol Assessment – Comparisons of Vibracoring and Box Coring Methods

Analyses of geotechnical and chemical data obtained from vibracores collected during the supplemental survey, as well as comparisons with co-located SPI results and historical coring data, suggested that the vibracoring procedure strongly biased (underestimated) determinations of cap thickness. The suitability of alternate coring methods was evaluated during the supplemental survey by collecting replicate box cores (Gray – O'Hara) at selected coring locations in Cells LU and LD, visually inspecting the cores, and comparing estimates of the depths of the cap/EA sediment interface obtained with the box core to those obtained using a vibracore.

In several cases, the box corer did not penetrate completely through the cap layer and into the underlying EA sediment. Consequently, the depth of the interface could not be determined in all box cores. Regardless, comparisons of interface depths in the co-located box cores and vibracores show that in all cases the box core retained a greater proportion of cap layer than the vibracorer. The difference between the two methods in apparent cap layer thickness ranged from 0.5 to greater than 10 cm at individual sampling stations, with an average greater than 5 cm. These comparisons provide further evidence that the vibracorer did not retain all of the cap material, and also point out the limitations in the Gray-O'Hara box corer to penetrate consistently through the cap layer and into the EA sediment layer.

Key Monitoring Questions

In general, the primary monitoring questions encompassed a number of key issues and concerns that could be assessed directly by monitoring results; therefore, the general monitoring issues identified above are rephrased as specific questions and addressed below.

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

Accurate and consistent placement of multiple loads of cap material depends largely on the dredge operator. However, the ADISS has proven to be a useful tool both for assisting the operator in navigating to the target location and monitoring all placement operations. All of the conventional placement operations 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 and 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.

The accuracy and consistency of cap placement using a spreading placement method were acceptable but somewhat less accurate and precise than conventional 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. 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.

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

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. 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. Confirming the ability to create a relatively symmetrical deposit of material on the seafloor through point placment on the Palos Verdes Shelf is a significant study outcome.

As the number of placement events increased, the cap layer expanded laterally. Repeated placement of individual hopper loads in the center of each cell acted to increase both the thickness and spread of the cap material in concentric rings around a central point of impact. Once this “base” deposit was in place, subsequent placement occurred at increasing distances away from the cell center, and the cap material continued to spread laterally.

In general, cap materials did not spread beyond a few hundred meters of the initial placement location. However, subsequent placement events may have caused some lateral displacement of previously placed cap materials. Following 71 placement events in Cell LU, the outer edge of the cap layer extended as far as 200 m beyond the cell boundary in the alongshelf direction, but less than 150 m beyond the cell boundary in the upslope direction. 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-shelf). Somewhat greater lateral spread in the downslope direction compared to the along-shelf/upslope directions is consistent with expectations and will need to be accounted for in any future modeling efforts. Additionally, the result of greater downslope spread of cap material in Cell SU than observed in Cell LU can be attributed to the significantly greater bottom slope in and seaward of Cell SU.

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

This question addresses whether multiple loads of cap material can be placed within an acceptable range of cap layer thickness. SPI data showed relatively minor, small-scale variability in cap thickness (e.g., less than a few centimeters) in Cells LU and SU. Following 45 placement events in Cell LU, cap layer thickness exceeded 9 cm at all sites sampled using SPI. Results from sediment coring were generally consistent with these patterns. However, in some cases, cores collected in Cells LU and SU contained no evidence of cap material, which could reflect spatial patchiness in the cap and/or sampling artifacts.

At the majority of stations within the capping cells sampled using both SPI and cores (gravity core and vibracore), estimates of cap thickness associated with SPI generally were greater than those provided by visual, geotechnical, or chemical analyses of cores. Based on these comparisons, as well as other indications of coring artifacts, it appears that SPI provided the most accurate approach for estimating cap thickness. However, this only applies to areas where cap layer thickness was less than the penetration depth of the sediment-profile 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 using a box corer appeared to have fewer artifacts, and more representative stratigraphies, than those collected by gravity or vibracores. However, small box cores, similar to those used during the supplemental survey, can not consistently penetrate the cap/EA sediment interface. Use of larger, heavier box cores may be needed to provide consistent, high quality sediment cores that retain the entire cap layer as well as the underlying EA sediment.

- *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 entrance channel, so it was not possible to evaluate the potential effects of different cap material types in these two cells. Cell SU was both deeper (60 to 70 m) and had greater slope (3.2°) than Cell LU (depth = 40 to 45 m; slope = 0.9°). The Post-1 results indicated that the initial cap material footprint was considerably 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 to spread more as it fell through the water column, and 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, particularly Cell SU, which might be expected if the difference in slope was a factor.

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. 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 show a greater distribution of the lateral surge material moving in the downslope direction, whereas Cell LU had a uniform surge pattern around the entire placement area.

The Post-45 SPI monitoring in Cell LU generally indicated an even distribution of cap material, although slightly thicker cap layers observed at the distant downslope stations compared to those upslope again suggested a minor effect of slope. In contrast, the Post-21 SPI results from Cell SU failed to show a strong influence of slope, as cap layer thickness at the distal upslope stations was greater than those downslope. These somewhat confounding results lead to the conclusion that depth and slope have a relatively insignificant role in the creation of a uniform cap material deposit in Cells LU and SU.

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

Following placement of the pilot cap, bottom topography was not substantially greater than baseline conditions.

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

Monitoring results showed that some disturbance of EA sediments occurred during cap placement, particularly during the initial placement event. Sediment disturbance resulted from localized scouring and lateral displacement of surface sediments, as well as temporary increases in turbidity levels and TSS and DDE concentrations in near-bottom waters. However, monitoring results also showed that the magnitude of EA sediment disturbance was lower during subsequent placement events, which largely impacted existing cap layers rather than EA sediments.

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, and the higher energy levels would be expected to cause greater disturbance to the in-place sediments. It is important to note that the interpretation of the SPI results is limited in that it does not address what happened to the in-place sediments when they were disturbed. It is reasonable to assume that some of this disturbed sediment mixed with the cap material and became part of the cap deposit, and some was displaced into the water column to become part of the near-bottom plume and lateral surge.

Scour and lateral displacement of EA sediments was inferred from measurements of near-bottom currents and turbidity following immediately cap placement events. Some, albeit minor, mixing of cap and EA sediments was observed in sediment cores. In Cell SU, where DDE concentrations in EA sediments increased substantially with core depth, surface scouring resulted in apparent upward displacement of the subsurface DDE peaks. However, these peaks were still well below the sediment-water interface, and actual core profiles may have been affected to an unknown degree by sampling artifacts.

- *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 initial cap placement in Cells LU and SU, using conventional methods, maximum TSS and DDE concentrations in the center of the suspended sediment plumes were up to two orders of magnitude higher than respective background levels. Impacts to water quality were relatively localized and elevated turbidity was typically not detectable beyond one kilometer from the placement site. The magnitude of DDE concentrations in near-bottom plumes measured in Cells LD and LC were relatively lower, reflecting the reduced disturbance to bottom sediments associated with spreading and pump-out placement methods. Monitoring results also suggested

that a substantial portion of suspended solids, responsible for elevated TSS concentrations and turbidity levels, was due to settling cap material and not resuspended sediment.

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

Measurements at both Cells LU and SU demonstrated that water column properties return 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 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?*

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 contaminated sediments. As a result, impacts to water quality associated with the initial placement were 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 did not exhibit any clear temporal trends. In contrast, peak DDE concentrations in the water column following events 4 and 5 were considerably lower than those associated with the initial placement event, suggesting that 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 be effective at minimizing disturbances of existing sediments.

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

Plume tracking studies demonstrated that suspended, near-surface sediment plumes, associated with cap placement operations in the landward cells, did not pose a risk to near shore kelp beds. Only three events were monitored but each was conducted the incoming tide to assess worst-case transport conditions associated with tides.

- *Does the cap remain clean?*

This question refers to the extent that cap materials and EA sediments are mixed during placement, potentially resulting in higher than intended contaminant concentrations in the cap layer. The extent of cap and EA sediment mixing was evaluated from sediment core data collected for Cells LU and SU.

Results from analyses of DDE concentrations in postcapping cores indicated that surface (0 to 4 cm) cap layers typically comprised cap material with negligible proportions of EA sediment. Proportions of EA sediments in subsurface horizons above the apparent cap/EA interface exhibited slightly greater variability, but still consisted primarily of cap material. Further, some core horizons below the cap/EA interface contained variable proportions of cap material. Consequently, some mixing between cap material and EA sediments was evident, but mixing was generally confined to subsurface horizons near the cap/EA sediment interface. One Post-45 core from Cell LU and two Post-21 cores from Cell SU contained variable proportions of cap and EA sediments, which may reflect a combination of cap layer patchiness and sampling artifacts.

During the supplemental survey, SPI images demonstrated the presence of a visually-distinct layer, up to several centimeters thick, of recently-deposited, fine-grained sediment on top of the intact cap layer. This recent layer was interpreted as EA sediment from adjacent uncapped areas which had been transported horizontally from adjacent shelf regions 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 contains appreciably higher contaminant (DDE) concentrations than cap material, any physical or biological mixing of recent EA sediments with cap material would increase the contaminant concentrations in the cap layer. In fact, DDE concentrations in surface layers of some cores collected 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 EA sediment 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 EA sediment layer may be mixed over time into the surface of the cap layer.

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

This topic pertains to the momentum of the cap material immediately after release 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 near-bottom current data illustrated that, upon impact with the bottom, 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, beneath the hopper dredge. The surge events were very brief, with current velocities returning to ambient levels at all measurement sites within approximately twenty minutes.

The initial surge current was sufficient to resuspend bottom sediments (ambient and/or cap material) only within about 100 m of the placement site, because the surge momentum decreased 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. This mechanism for horizontal transport of suspended sediment was primarily confined within 250 m of the placement site. This result was based on measurement data that demonstrated weak surge velocities, as well as turbidity levels that were greatly reduced from their initial values, at greater distances from the placement site.

- *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, or in Cell SU after Event 1. Although surge data are not available from these events, we expect that the surge momentum, horizontal currents, and near-bottom turbidity levels for these subsequent placement events would be similar to those observed during Events 1-5 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 volumes 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 then the horizontal momentum of the radially spreading surge.

Prior to placement Event 1, the seafloor consisted of EA sediment, whereas after all 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 approximately 15 to 20 cm. At the center of the cell, the majority of the in-place cap would have been deposited during placement Events 1-5, as all of the placements were co-located. Subsequent placement events (6-71) may have contributed additional cap thickness near the center of the cell due to horizontal transport of surge-transported cap material during placements at adjacent locations within the cell.

The near-bottom turbidity data acquired during placement Events 1-5 in Cell LU showed that maximum turbidity levels were comparable, although cap thickness was certainly increasing at this location in the center of the cell. This suggests that the major contributor to the high turbidity levels in the surge must have been suspended cap material, with lesser contributions from resuspended EA sediment.

The side-scan sonar results also suggested that minimal ambient sediment was displaced during Post-1 placement events because the existing layer of cap material essentially shielded the ambient 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, EA sediment that had been displaced during the first placement event presumably became covered by additional cap material from subsequent placement events. Sidescan 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 seen during the pre-capping baseline survey.

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

Larger-scale topographic features or other indications of mass sediment movement on the Palos Verdes Shelf did not occur as a result of cap placement. As mentioned, bottom surge dissipated rapidly (within a few hundred meters) from the point of impact.

1.0 INTRODUCTION

1.1 Program Background

The U.S. Environmental Protection Agency (EPA), Region IX is evaluating alternatives for remediation of contaminated sediments on the Palos Verdes (PV) Shelf off the coast of Los Angeles, California (Figure 1.1-1). One possible remediation alternative, in situ capping, involves placement of a covering or cap of clean material over contaminated sediment, thereby isolating the contaminated material. EPA is collaborating with the U.S. Army Corps of Engineers (USACE) to conduct a Pre-Design Data Collection and Studies related to the capping alternative. As part of this study, EPA recently entered into an interagency agreement with the USACE, Los Angeles District to provide technical support for implementation of a pilot study for cap placement. Science Applications International Corporation (SAIC), in turn, is assisting USACE Los Angeles District with monitoring cap placement operations.

Previously, USACE (Palermo et al. 1999) evaluated in situ capping alternatives at the Palos Verdes site for EPA. The evaluation included prioritizing areas of the PV Shelf to be capped, determining appropriate cap designs, developing an equipment selection and operations plan for placement of the cap, developing a monitoring plan to ensure successful cap placement and long term cap effectiveness, and developing preliminary cost estimates.

USACE (Palermo et al. 1999) considered two primary capping alternatives: (1) a thin cap design (thickness of 15 cm) that would reduce potentials for biological remobilization of sediment contaminants by shallow-burrowing benthic organisms, as well as reduce contaminant concentrations in surficial sediments and contaminant flux into overlying waters; and (2) an isolation cap design (thickness of 45 cm) which would provide sufficient thickness to effectively isolate contaminated sediments from the majority of benthic organisms, reduce contaminant bioaccumulation, and effectively prevent contaminant flux within those areas of the site covered by a cap. The area considered for capping lies on the Shelf between the 40 and 70 m depth contours. Cap placement on the slope was considered infeasible due toincreased potential for flow failure under seismic loading. Capping operations would be undertaken in an incremental fashion, until the total selected area was capped. Since the area that could be capped is large (on the order of several square kilometers), cap placement cells measuring 300 by 600 m were defined for purposes of managing the placement of material and monitoring.

The purpose of the pilot study was to provide information for evaluating key operational aspects of an in situ capping alternative for remediation of the PV Shelf. Operational aspects for the pilot study included selection of appropriate placement areas, capping materials, and placement techniques, as well as pre-design data collection and studies. The pilot study consisted of controlled operations for placement of capping material within three pilot capping cells on the PV Shelf and associated monitoring prior to, during, and following the placements. The locations of the pilot capping cells in relation to the shoreline, wastewater outfalls, offshore boundary of kelp beds, and dredging sites (i.e., sources of capping materials) are shown in Figure 1.1-2. The monitoring program for the pilot study was designed to evaluate the following: areal extent and thickness of the cap; mixing of cap and contaminated sediments; resuspension of contaminated sediments during cap placement; short term biological recolonization of the cap; and short term physical and chemical characteristics of the cap and underlying sediments immediately after capping and following initial sediment consolidation.

1.2 Relevant Program Documents

Several documents related to the remediation alternatives, feasibility studies, and pilot study designs have been prepared. Relevant program documents are summarized in Table 1.2-1. Complete reference citations are listed in Section 11 of this report.

The Palermo (2000) and Fredette (2000) documents present a technical approach/design that was developed by EPA and USACE Los Angeles District, following the work of Palermo et al. (1999). These documents present justification for the sampling design and analytical techniques used in the cap monitoring program. Separate Project Work Plans (PWPs) were prepared by SAIC (2000a, 2001) for the Baseline and Cap Placement phases of the monitoring program. Each PWP provides a general overview of the project, specific data quality objectives (DQOs), a field sampling plan (FSP), quality assurance project plan (QAPP), and health and safety plan (HSP). These components of the PWPs are consistent with the overall study designs developed by Palermo (2000) and Fredette (2000).

This report presents the results and key findings of monitoring and data collection tasks performed by SAIC for the baseline and cap placement phases of the Pilot Cap Monitoring Program. The results of independent USACE evaluations of modeling efforts and monitoring results are presented in a separate report that is being prepared by USACE.

1.3 Organization of Report

This report presents the primary findings and conclusions from the baseline and cap placement monitoring. As such, only selected data are included; complete listings of data from the baseline and cap placement monitoring are contained in the DAN-LA database (see Section 2.9).

A program overview is presented in Section 2. Monitoring results for baseline, interim, and postcapping surveys in Cells LU, SU, LD, LC, and SD are presented in Sections 3 through 7, respectively. Each of these five sections includes the major results and findings for individual sampling tasks. Monitoring near-surface plume transport is described in Section 8. A discussion of significant findings and conclusions for the baseline and cap placement monitoring surveys that integrates and synthesizes the results of multiple sampling tasks is presented in Section 9. Recommendations related to site monitoring are presented in Section 10. References are listed in Section 11. Appendix A provides chronological summaries of cap placement and associated monitoring activities. Data validation reports are provided in Appendix B. Data summaries for individual monitoring tasks are included in Appendix C.

Detailed descriptions of methods, including quality assurance/quality control protocols used for the baseline and cap placement monitoring, are provided in the respective PWPs (SAIC 2000a, 2001). Specific methods used in the collection and analyses of monitoring samples are described only briefly in this report.

Table 1.2-1. Summary of Relevant Program Documents

Title	Date	Reference	Comment (Abstract)
Feasibility Study of Sediment Restoration Alternatives for Southern California Natural Resources Damage Assessment	1994	Palermo 1994	Presents a feasibility study that evaluated several remediation alternatives for treating and/or managing contaminated PV sediments.
Queen's Gate Dredging Geotechnical and Chemical Investigation	December 1994	Sea Surveyor et al. 1994	Presents results from geotechnical and chemical analyses of sediment cores collected within Queen's Gate Channel.
Options for In Situ Capping of Palos Verdes Shelf Contaminated Sediments	1999	Palermo et al. 1999	Presents results from analyses and evaluations by USACE of capping as a remedial alternative, including modeling and engineering issues.
Potential Borrow Areas A-II and A-III, Sediment Evaluation, Palos Verdes Shelf Superfund Project	June 2000	Geomatrix Consultants, Inc.	Presents findings of a study that characterized the suitability of sediments from the A-II and A-III Borrow Areas for in situ capping.
Field Pilot Study of In Situ Capping of the Palos Verdes Shelf Contaminated Sediments – Operations and Monitoring Plan	February 2000	Palermo 2000	Operations and Monitoring Plan for the Pilot Capping Project; includes the rationale and justification for the study design of cap placement monitoring program.
Palos Verdes Shelf Pilot Project Monitoring Scope of Work	July 2000	Fredette 2000	Companion document to Palermo (2000) that specifies the scope of work for monitoring portion of the Pilot Capping Project.
Project Work Plan for Palos Verdes Pilot Capping Project: Baseline Monitoring	December 2000	SAIC 2000a	PWP containing Data Quality Objectives, Field Sampling Plan, Quality Assurance Project Plan, and Health and Safety Plan for the baseline monitoring program.
Palos Verdes Pilot Capping Monitoring Project, Cruise Report:	December 2000	SAIC 2000b	Provides summaries of all monitoring surveys conducted for the baseline, interim, and postcap phases.
Project Work Plan for Palos Verdes Pilot Capping Project: Interim and Postcap Monitoring	January 2001	SAIC 2001	PWP for interim and postcap monitoring.
Supplemental Palos Verdes Shelf Pilot Project Monitoring Scope of Work	January 2001	Fredette 2001	Specifies the scope of work for supplemental coring/sediment profile camera survey phase of the Pilot Cap Monitoring Program.

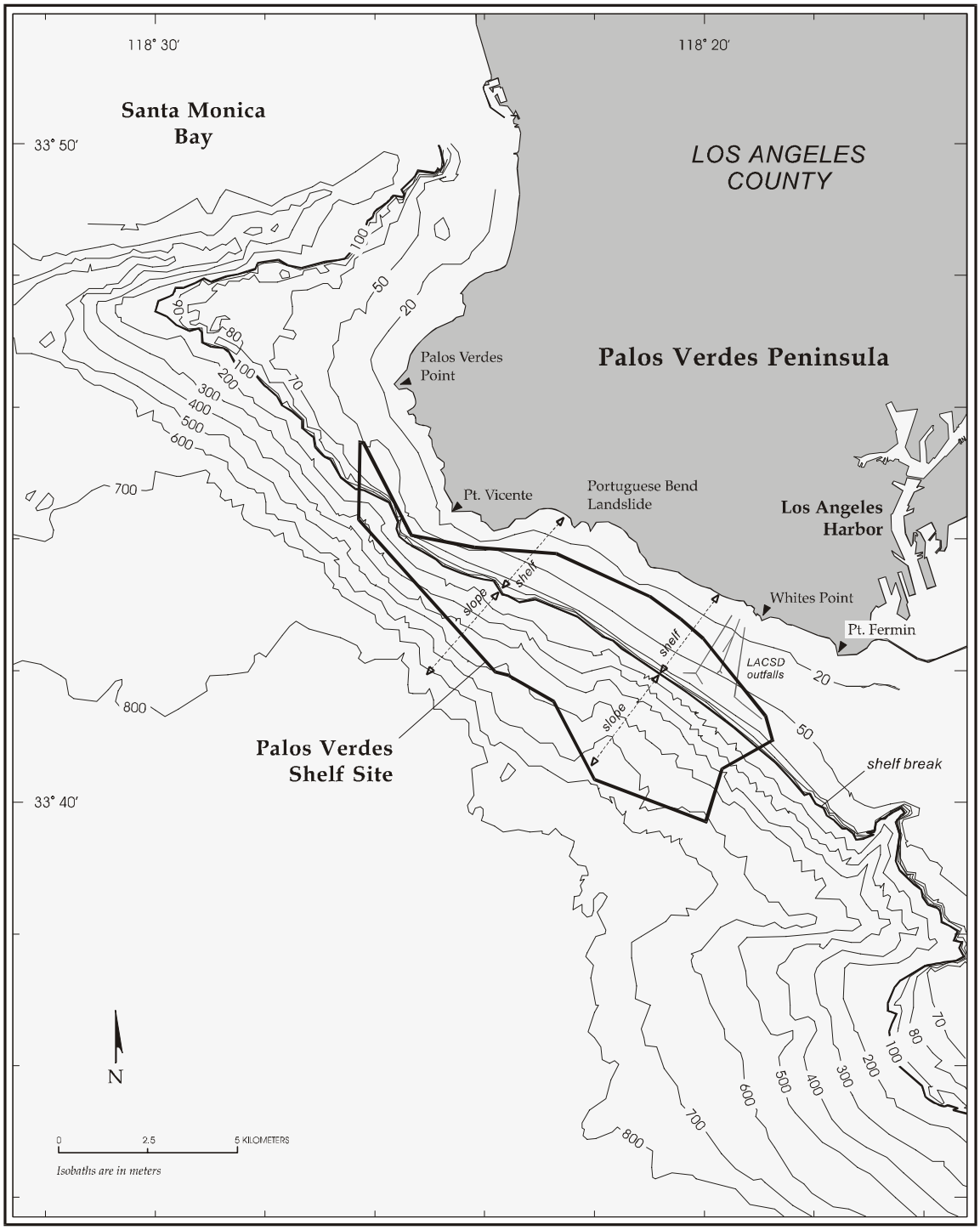

Figure 1.1-1. Palos Verdes Shelf Site Map. The bold line delineates the boundary of contaminated sediments

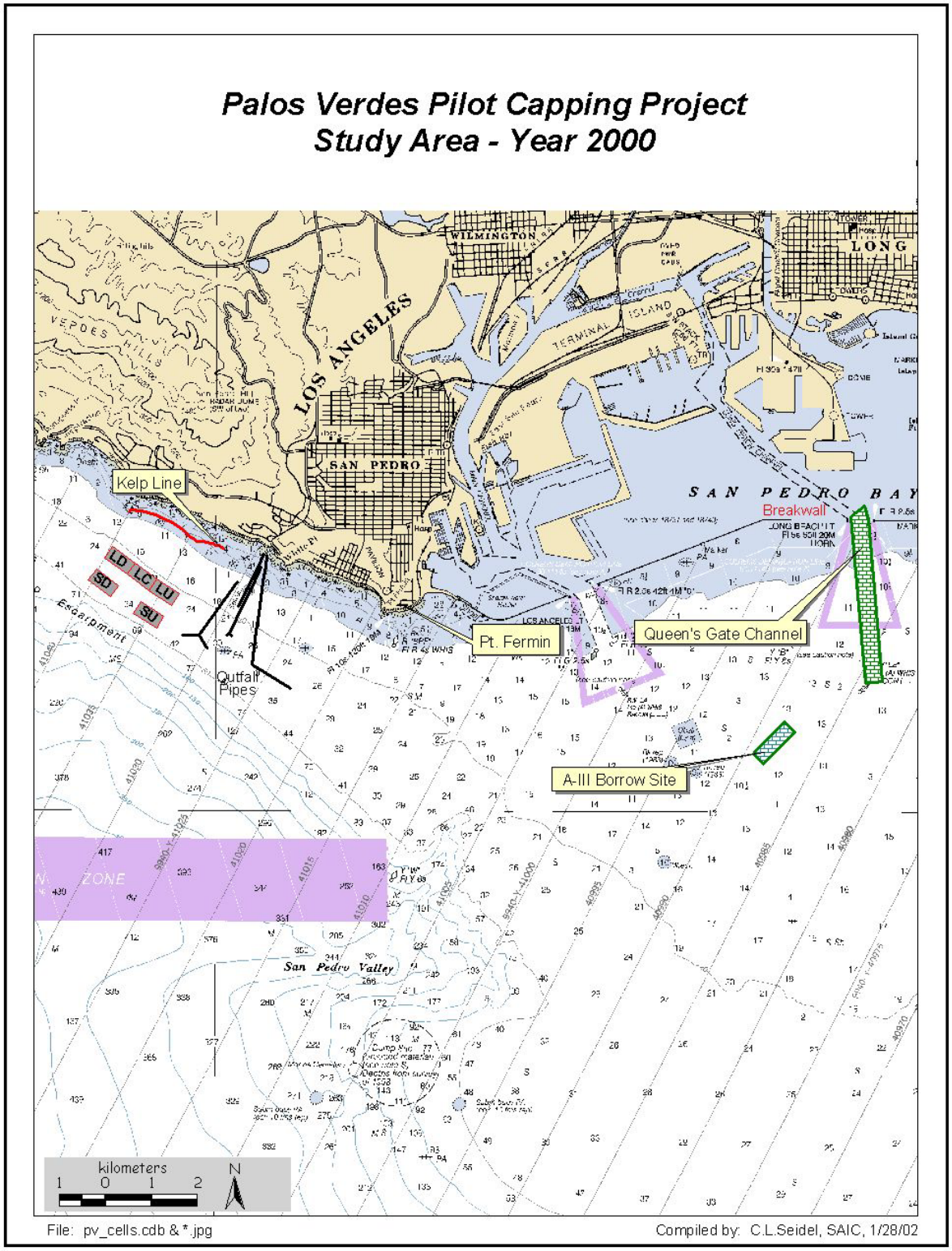

Figure 1.1-2. Palos Verdes Shelf pilot capping cells in relation to the LACSD wastewater outfalls, kelp line, and cap material source areas (Queen's Gate Channel and A-III Borrow Area).

2.0 PROGRAM OVERVIEW

2.1 Monitoring Program Objectives

The overall objectives of the pilot study are to demonstrate that a cap can be placed on the PV Shelf as intended by the design, and to obtain field data on short-term processes and the behavior of the cap as placed. Specific objectives addressed by the pilot capping project (Palermo 2000) include:

- Demonstrate that an appropriate cap thickness can be placed with an acceptable level of variability in cap thickness.
- Demonstrate that excessive resuspension of existing sediments and excessive mixing of cap and contaminated sediments can be avoided.
- Demonstrate that excessive losses of cap materials can be avoided.
- Determine, to the degree possible, the effect of variable cap material type, bottom slope, water depth, and placement method (e.g., conventional versus spreading) on cap thickness and sediment displacement and resuspension.
- Demonstrate the effectiveness of the cap with respect to short-term isolation of contaminants during the initial phase of sediment consolidation.
- Demonstrate the ability to monitor cap placement operations.
- Evaluate and modify, where needed, all operational and monitoring approaches.
- Improve the knowledge-base contributing to decisions on implementation of a full-scale cap.

An initial phase of the monitoring program consisted of sampling and analyses to characterize baseline (pre-capping conditions) within four cells considered by USACE as sites for cap construction (one of the four cells, SD, was subsequently eliminated from further study during the interim and postcapping phases of the Pilot Project). The general objectives of the baseline monitoring task are described in the PWP for the baseline monitoring (SAIC 2000a). The study design developed by USACE (Palermo 2000) expected that information obtained during baseline monitoring would be appropriate and sufficient to use as a basis for comparisons to physical and chemical conditions within the proposed pilot capping cells during and following cap construction.

Placement of the pilot cap was anticipated to occur over a period of several weeks to months. The associated monitoring effort was designed to address short-term processes (i.e., events and conditions occurring during and shortly after cap placement). Site monitoring involved characterizing the cap material and evaluating conditions on the seafloor and in the water column prior to, during, and following cap placement operations (defined as baseline, interim, and post cap monitoring, respectively). The pilot cap monitoring program was not designed to evaluate longer term processes or conditions. A plan for long-term monitoring currently is being developed. Instead, a full-scale monitoring program, which may be conducted during construction of a full-scale cap on the PV Shelf and in the years to follow, would address long-term processes not easily observed during the relatively short time period available for the pilot study. This could include, for example, erosion during storm events or migration of contaminants due to diffusive processes.

2.2 Program Organization, Participants and Responsibilities

As mentioned, SAIC's role was to provide technical support to USACE and EPA on specific tasks as requested by USACE. Overall program management was performed by USACE, and final decisions regarding study design, program objectives, and analyses and interpretations of the data collected for the monitoring program were performed by USACE. Additionally, QA oversight, including document review

and approval, external audits of contractors, and reviews and assessments of project data, data quality, and data usability were performed by USACE.

The USACE Los Angeles District was responsible for overall management of the Palos Verdes Pilot Cap Monitoring Program. Ms. Ellie Nevarez, the USACE Los Angeles District's Project Manager, was responsible for: providing monitoring objectives via definitive Statements of Work; leading the inter-agency technical review committee for the Palos Verdes Monitoring Program; and review/approval of all deliverables produced by SAIC.

SAIC was contracted by USACE Los Angeles District and EPA to:

- Prepare a Project Work Plan (PWP) for the baseline monitoring portion of the pilot capping project;
- Implement the baseline portion of the pilot capping project;
- Prepare an Addendum to the PWP addressing all elements of monitoring associated with the cap placement phase of the pilot capping project;
- Implement the Pilot Cap Monitoring Project;
- Revise the PWP to include a supplemental coring survey;
- Conduce a supplemental coring survey; and
- Compile, analyze, and report data collected during the baseline and cap placement phases of the study.

Dr. Scott McDowell served as SAIC's Project Manager. SAIC's QA/QC Officer and Project Safety Officer were Mr. Ray Valente and Mr. John Nakayama, respectively. SAIC's project organization also identified Team Leaders for each of the major logistical/technical areas, including data management. Each of these technical areas was further broken down into the logical components of field sampling, sample/data analysis, and reporting.

Field monitoring activities were conducted by a large team of SAIC scientists, engineers, technicians, and data specialists, the majority of whom temporarily relocated from their home offices in Newport, Rhode Island, San Diego, California, Bothell, Washington, and Raleigh, North Carolina, to the project site for the duration of the field activities. With the exception of Mr. Michael Tubman of the USACE Engineer Research and Development Center who was responsible for the underway acoustic doppler current profile (ADCP) measurements, the conductivity, temperature, depth (CTD) technicians from Southern California Marine Institute (SCMI), and the survey vessel operators, all other project staff were SAIC employees.

The monitoring program utilized subcontractor laboratories for geotechnical and chemical analyses of sediment samples extracted from sediment cores and sediment samples collected from hopper dredges. Chemical analyses of sediment core and seawater samples were performed by Woods Hole Group Environmental Laboratories (Falmouth, Massachusetts). Geotechnical analyses of sediment core samples were performed by Applied Marine Sciences (League City, Texas).

2.3 Field Logistics and Survey Vessels

For baseline monitoring activities, SAIC established a subcontract agreement with the SCMI for use of survey vessels, shore-based facilities, oceanographic equipment (CTD profiling system and gravity corer), and support services. A 56 m^2 garage area within SCMI's research facility on Terminal Island (San Pedro), CA, was leased for use during the baseline field program. This space and an adjacent 23 m^2 area also were leased for the summer monitoring program (mid-July through September 2000), and used for project coordination, data control, and mobilization of equipment throughout the program. This close

proximity of the project office(s) to the SCMI piers and research vessels allowed efficient mobilization of vessels and survey personnel. Dockside crane services and occasional welding and machine shop services also were provided by SCMI.

Under subcontract to SAIC, SCMI provided two research vessels, the R/V *YELLOWFIN* and the R/V *SEA WATCH*, on an as-needed basis. Additionally, SAIC chartered three other survey vessels during the monitoring program: the R/V *TUNA*, the R/V *SEAWORLD*, and the M/V *BOTTOM SCRATCHER*. These vessels were used at various times during the monitoring program depending on availability and monitoring capabilities.

SAIC conducted all mobilization, operation, and demobilization of navigation equipment aboard the survey vessels, as well as operated and maintained all survey equipment for each cruise (with exception of the CTD profiling system that was operated by SCMI personnel). A brief description of each survey vessel utilized during the monitoring program is given below:

R/V *Sea Watch*

Operator:	Southern California Marine Institute
Home Port:	Terminal Island, CA
Dimensions:	65-ft length overall (LOA), 24-ft beam, 5-ft draft

R/V *Yellowfin*

Operator:	Southern California Marine Institute
Home Port:	Terminal Island, California
Dimensions:	76-ft LOA, 24-ft beam, 8.6-ft draft

R/V *Tuna*

Operator:	Pacific Tugboat Service
Home Port:	San Diego, California
Dimensions:	40-ft LOA, 16-ft beam, 3.5-ft draft

R/V *Sea World*

Operator:	UCLA Marine Science Center
Home Port:	Marina Del Rey, California
Dimensions:	64-ft LOA, 18-ft beam, 8-ft draft

R/V *Bottom Scratcher*

Operator:	Greg Elliot
Home Port:	Long Beach, California
Dimensions:	63-ft LOA, 18-ft beam, 4-ft draft

2.4 Project Communications Plan

A communications plan was prepared and disseminated to the PV team that: (1) identified lead contacts for USACE Los Angeles District, EPA, USACE technical review team, SAIC, Great Lakes Dredge and Dock Company/North American Trailing Company (NATCO), and U.S. Coast Guard for individual activities; (2) provided telephone numbers for key contacts; and (3) specified a schedule for required communication (e.g., conduct readiness and review meetings and identify observers for specific monitoring tasks). The objective of the project communication plan was to ensure adequate coordination within the PV team.

2.5 Baseline Monitoring Program

One basic objective of baseline monitoring was to characterize existing conditions in selected areas of the PV Shelf in order to evaluate future changes resulting from cap placement. Although the existing shelf and slope sediments (i.e., EA deposit) had been characterized previously through extensive sampling (e.g., Lee 1994), the baseline monitoring effort was necessary to establish site-specific conditions in four proposed cap placement cells immediately prior to the pilot capping operation (Palermo et al. 1999). Problem statements, and associated monitoring objectives and techniques of the baseline monitoring program are summarized in Table 2.5-1.

It is important to note that the objectives of the baseline monitoring are largely qualitative in nature, involving physical, chemical, and biological characterization of surface and subsurface sediments in the four placement cells prior to pilot capping activities. For the baseline and subsequent monitoring phases, DDE was selected as the chemical marker for EA sediments, although DDE is only one of several chemical contaminants at the site. Deviations from the Field Sampling Plan (FSP) and summaries of results relative to data quality objectives (DQOs) for the baseline survey are discussed for each of the sampling tasks in Sections 3 through 7.

2.6 Cap Placement Operations

Cap placement operations occurred from August 2 to September 15, 2000. During that time, 102,185 cubic meters of sediments dredged from the Queen's Gate Channel were placed by 102 separate events with the hopper dredge *SUGAR ISLAND*. NATCO dredging company was responsible for all dredging and placement operations during the pilot capping program.

A summary of placement operations, with time, date, and volume for each event, is provided in Appendix A. Additionally, target placement positions within each cell are given, as well as identification numbers of sediment samples collected from the hopper dredge.

The Pilot Capping Program was conducted using two types of cap material: (1) "relatively fine" material (i.e., predominantly small diameter sand particles) that was being dredged from the Queen's Gate channel (at the entrance to Los Angeles/Long Beach Harbor) during the final phase of an ongoing navigational dredging contract, and (2) relatively coarse material (sand) that was dredged from the A-III Borrow Area located offshore and southwest of the Queen's Gate channel.

The pilot study consisted of controlled operations for placement of cap material within selected areas (cells) on the PV Shelf (Figure 1.1-2), and associated monitoring prior to, during, and following the placements. The placement cells were designated according to their relative geographic location, Cell LU (Landward Upstream), Cell LD (Landward Downstream), Cell SU (Seaward Upstream), and Cell LC (Landward Center), where "downstream" referred to the northwest direction, in the direction of the prevailing bottom current in this region. Capping operations within Cells LU, SU and LC utilized the relatively fine material dredged from Queen's Gate channel, whereas Cell LD was capped with sand dredged from the A-III Borrow Area.

Note, that baseline monitoring activities were conducted in Cells LU, LD, SU, and SD (Seaward Downstream), but cap placement and monitoring operations in this latter cell were not conducted during the summer program due to funding limitations.

Cap placement operations were conducted as follows:

Cell	Placement Events	Material Type	Source Location	Placement Technique
LU	71	Relatively fine	Queen's Gate	Conventional
SU	21	Relatively fine	Queen's Gate	Conventional
LD	9	Relatively Coarse	Borrow Area	Spreading
LC/LD	1	Relatively fine	Queen's Gate	Pump Out

Therefore, the engineering objective of the pilot study was to test the operational feasibility and effectiveness of capping operations with two types of capping material (coarse and fine) placed within cells in different water depths (landward cells in 40 to 45 m depth and seaward cells in 60 to 70 m depth).

The Pilot Capping Program also evaluated cap placement by three discharge techniques: (1) conventional (bottom dump) release from a stationary dredge, (2) "spreading" conducted by "cracking" the hull to gradually release material as the dredge moved slowly (approximately two to three knots) along a predetermined trackline, and (3) "pump out" of material through a single (starboard) drag arm that released material at a water depth of approximately 23 m as the dredge moved slowly along a predetermined trackline.

Schedule of Field Monitoring Operations

The monitoring program was implemented as a near-continuous, 8-week field project that began in late-July 2000 and continued through mid-September 2000; field operations were suspended only during a 3-day period over the Labor Day weekend in September. Schedules for cap placement and monitoring activities within Cells LU, SU, and LD are summarized in Sections 3.1, 4.1, and 5.1, respectively.

Primary factors that dictated the schedule of capping operations and field monitoring activities were:

1. The requirement to place a specific number of loads of Queen's Gate material in the pilot cell area before NATCO completed dredging of this material as part of their maintenance dredging project, and
2. Optimal usage of chartered survey vessels, when they were available to the project.

The daily schedule of field operations, from initial mobilization of the project office at the SCMI facility on July 22, 2000, to the final recovery of current meter equipment on September 24, is presented in Appendix A. Daily monitoring activities are presented chronologically for each monitoring cell (LU, SU, LD and LC).

A chronological summary of monitoring surveys, organized to indicate surveys conducted within each cell and phased according to the placement operations (e.g., baseline, interim-placement, post placement, etc.), is also presented in Appendix A. All survey entries are given according to their designation in Fredette (2000); additionally, "flex" surveys were conducted with the following measurement objectives:

- Additional monitoring in Cells LU and SU associated with the primary placement operations;
- Additional monitoring in Cell LU associated with placements 46 to 71 (supplemental);
- Far field monitoring of the material footprint surrounding Cells LU and SU following completion of placements in those cells; and
- Monitoring associated with pump-out events in Cells LC and LD.

2.7 Interim and Postcap Monitoring Program

Monitoring objectives and associated techniques for the cap placement monitoring phase are summarized in Table 2.7-1.

The relationships between individual measurement techniques and monitoring tasks are described in the Palos Verdes Shelf Pilot Project Monitoring Scope of Work (Fredette 2000). The sampling design and associated QA procedures are described in the PWP, and are consistent with the overall sampling design described by Fredette (2000) and Palermo (2000). In some cases, specific decisions regarding sampling protocols, such as the location and timing of water quality sampling and plume tracking activities, were left to the discretion of the Chief Scientist/Task Leader. Additionally, the monitoring program described by Fredette (2000) anticipated that it may not be possible to delineate the footprint of cap materials on the seafloor based on the defined station array (i.e., the cap boundary may extend beyond the presently defined sampling area), and, therefore, incorporated some flexibility into the study design to accommodate additional sampling needed to achieve the monitoring objectives. Consequently, some deviations from the sampling plan occurred at the request of, and in consultation with, the USACE Program Manager to maximize potential for achieving DQOs for this monitoring program.

The Monitoring Plan (Fredette 2000) described specific sampling tasks for the interim and postcap phases of the monitoring program. Each task consisted of one or more of the monitoring approaches described in the following sections. Specific monitoring techniques required for individual tasks are summarized in Table 2.7-2.

Deviations from the FSP and summaries of results relative to data quality objectives for the interim and postcap surveys are discussed for each of the sampling tasks in Sections 3 through 7.

2.8 Cruise Reports

Summaries of all cap placement cruise activities are presented in *Palos Verdes Pilot Capping Monitoring Project Cruise Report* (SAIC 2000b). This report addressed the following topics associated with the monitoring activities conducted by SAIC during July through September 2000: field logistics and vessel support; responsibilities of project staff; technical monitoring activities; and the schedule of field operations.

2.9 Project Data Archive within DAN-LA Project GIS

The Disposal Area Network for Los Angeles (DAN-LA) was developed by SAIC for USACE Los Angeles District as a geographic information system (GIS) providing direct and timely access to information and data collected during the pilot cap monitoring program. DAN-LA allows personal computer-based, desktop access to information by multiple users, and provides customized tools which support analyses of monitoring data, modeling, and near real-time management of capping operations.

2.10 Palos Verdes Internet Website

SAIC also developed and maintained a website to provide efficient access by the PV team to information relevant to the cap placement monitoring program. In particular, background documents (e.g., SOWs, PWPs, schedules, and communication plans) were posted. Data from the ADISS system were available on the website within days of collection, which could then be used by USACE for input to cap

placement modeling. Core photographs and core logs, and sediment profile and plan view camera images, also provided qualitative and quantitative data about cap thickness and horizontal coverages. Spatial data were GIS-based to provide geographical accuracy for all program elements. Access to the website was password-protected to maintain the security of the data.

Table 2.5-1. Baseline Monitoring Objectives and Techniques.

Problem Statement	Monitoring Objective	Monitoring Technique(s)
Placement locations should be representative of the overall range of conditions within the total potential capping prism for possible full-scale remediation.	Determine physical and biological characteristics of sediments in the placement cells.	1) Sediment profile imaging 2) Sub-bottom profiling 3) Side-scan sonar 4) Coring for sediment chemical and physical parameters
Physical characteristics of bottom material in the pilot placement areas should be clearly distinguishable from capping material.	Determine physical and biological characteristics of sediments in the placement cells with sufficient accuracy to permit distinctions between ambient sediments and capping material.	1) Sediment profile imaging 2) Sub-bottom profiling 3) Coring 4) Side-scan sonar
Thickness of EA sediment in the pilot placement areas should be sufficient (defined as ≥10 cm) to potentially measure the degree of mixing of cap and contaminated sediment and the effects of advection due to consolidation.	Confirm that the thickness of EA sediments, with concentrations of DDE greater than 1 mg/kg dry wt., exceeds 10 cm in the placement cells.	1) Sediment profile imaging 2) Sub-bottom profiling 3) Coring
The level of surficial EA sediment contamination by DDE (upper few cm) for the pilot placement areas should be sufficiently elevated (i.e., >10 mg/kg) that water column measurements of DDE would support evaluations of resuspension and transport.	Determine concentrations of DDE in sediments of the placement cells.	1) Coring

Table 2.7-1. Problem Statements, Monitoring Objectives, and Techniques for Interim and Postcap Monitoring.

Problem Statement	Monitoring Objectives	Monitoring Techniques
Does placement occur as modeled?	Measure the distribution and thickness of the cap during separate phases and under different cap placement scenarios; Provide information/data for comparisons with USACE model predictions of sediment accumulation/spreading within the capping areas.	1) Sediment profile imaging 2) Sub-bottom profiling 3) Side-scan sonar 4) Coring for sediment chemical and physical parameters 5) Hopper dredge sampling 6) ADCP water column current measurements
Can a cap with uniform thickness be constructed?	Determine the ability to control cap placement, spatial variability/uniformity of the cap thickness, and validate model predictions.	1) Sediment profile imaging 2) Sub-bottom profiling 3) Coring
Does resuspension of in-place sediments and water column dispersion of capping material occur as modeled?	Provide information/data for comparisons with model predictions of surge following cap placement, the lateral extent of disturbance, and evaluate effect of EA sediment resuspension on water column concentrations of TSS and contaminants relative to baseline levels.	1) Current and optical backscatter measurements to detect surge 2) Plume mapping and water column sampling for TSS and DDE 3) Video documentation
Does the cap remain clean?	Determine contaminant concentrations in the cap immediately following placement, and the extent of mixing of EA sediments and cap material.	1) Sediment profile imaging 2) Coring
Does the cap remain stable?	Determine the stability of the cap during and immediately after cap construction by assessing the cap distribution over the EA deposit and changes in lateral surge velocities during cap placement.	1) Sediment profile imaging 2) Coring 3) Side-scan sonar 4) Currents and optical backscatter measurements

Table 2.7-2. Summary of Monitoring Tasks and Associated Measurement Techniques for Cap Placement Operations (task numbers correspond to specific monitoring tasks identified in Fredette 2000).

Task	Single Placement Event	Interim Monitoring	Postcap Monitoring
1: Background Data	None	None	None
2: Placement Surge Video	Collect video records during initial placement events at Cell LU, SU, and two other events, at four distances from point of release.	None	None
3: Hopper Dredge Operation Data	Collect and record positioning and discharge data for all cap placement events.	Collect and record positioning and discharge data for all cap placement events.	None
4: In-Hopper Sediment Data	Collect and analyze representative samples from first three loads transported to each cell and first three loads from Borrow Areas.	Collect and analyze representative samples from 25 loads during continuous capping operations.	None
5: Flex Surveys	Collect 60 additional SPC/PVC images, 20 additional cores, 25 water samples to augment as needed planned sampling for Tasks 6-9 (for both single placement and interim phase).	Collect 60 additional SPC/PVC images, 20 additional cores, 25 water samples to augment as needed planned sampling for Tasks 6-9 (for both single placement and interim phase).	None
6: Monitoring of Cell LU	Bottom surge (current velocity and OBS) measurements at 5 sites; ADCP, light transmittance measurements, and water quality sampling up to 2 hours following placement, SPC/PVC at 37 stations, sediment coring at 5 locations, and side-scan sonar profiling over cell.	Bottom surge measurements at 5 sites; plume mapping using ADCP and light transmittance measurements up to 2 hours following second and third placement events; SPC/PVC at 14 stations each of two times, and sediment coring at 5 locations each of two times.	SPC/PVC at 37 stations, sediment coring at 9 locations, and side-scan sonar and sub-bottom profiling over cell.
7: Monitoring of Cell LD	Bottom surge measurements at 5 sites; ADCP, light transmittance measurements, and water quality sampling up to 2 hours following placement, SPC/PVC at 37 stations, sediment coring at 5 locations, and side-scan sonar profiling over cell.	None.	SPC/PVC at 37 stations, sediment coring at 9 locations, and side-scan sonar over cell.

Table 2.7-2. (continued)

8: Monitoring of Cell SU	Bottom surge measurements at 5 sites; ADCP, light transmittance measurements, and water quality sampling up to 2 hours following placement, SPC/PVC at 37 stations, sediment coring at 5 locations, and side-scan sonar profiling over cell.	SPC/PVC at 14 stations and sediment coring at 5 locations.	SPC/PVC at 37 stations, sediment coring at 9 locations, and side-scan sonar and sub-bottom profiling over cell.
9: Monitoring of Cell SD	Eliminated	Eliminated	Eliminated
10: Evaluation of Bathymetry	Eliminated	Eliminated	Eliminated
11: Disposal Plume Transport Study	Track plume using ADCP and light transmittance for 2 hours following three separate placement events.	Track plume using ADCP and light transmittance for 2 hours following three separate placement events.	None
12: Cap Erosion Analysis Samples	None	None	Collect and provide to USACE 120 liters of sediment and 3 sediment cores from both Cells LU and SU.
14: Water Current Monitoring	Current profile measurements for 30 days using a bottom-mounted ADCP.	Current profile measurements for 30 days using a bottom-mounted ADCP.	None

3.0 MONITORING RESULTS FROM CELL LU (CONVENTIONAL PLACEMENTS)

3.1 Schedule of Operations

The following provides an overview of monitoring activities within Cell LU. In general, monitoring occurred in two phases, baseline and cap placement. Baseline monitoring occurred prior to the first cap placement event to characterize existing conditions with the capping cell. For cap placement monitoring, individual surveys coincided with placement events 1, 2-5, Post-25, Post-45, and Post-64. Cap placement events in Cell LU are summarized in Table 3.1-1. All cap placements were made using a point placement technique. Placement positions are described in Section 3.2.

Table 3.1-1. Summary of Cap Placement Events in Cell LU

Placement Event #	Dates	Cumulative Volume (m^3)	Positions	Hopper Sample No.
1	8/2/00	1,022	A	LU-HOP 1
2-5	8/13/00	4,947	A	LU-HOP 2-3
6-25	8/22-25/00	27,037	B-S	LU-HOP 4-8
26-45	8/30-9/2/00	47,644	AA-AI; CA-CC; BA-BI; DA-DC	LU-HOP 9-14
46-71	9/10-15/00	69,814	B-N; B-I; L-M (non-consecutive)	LU-HOP 15-19

Baseline Monitoring

Baseline monitoring in Cell LU was conducted in May and July 2000. Dates associated with individual sampling tasks are listed in Table 3.1-2. Results from each of the baseline sampling tasks in Cell LU are presented in Sections 3.2 through 3.12.

Table 3.1-2. Summary of Sampling Dates for Baseline and Cap Placement Monitoring Activities in Cell LU

	SPI/PVC	Core	SS	SB	CM	WQ	Video	Kelp	ADCP
Base-line	7/27	5/21, 5/23	5/15, 5/16, 5/17	5/15, 5/16, 5/17	none	none	none	none	none
Post 1	8/3, 8/9	8/5, 8/10	8/10	none	8/1-8/3	8/2	8/2	none	8/2
Post 5	8/17-8/18	8/17	8/19	none	8/11-8/14	8/12, 8/13		none	8/13
Post 25	8/25	8/29	8/26	none	none	none	8/22	none	none
Post 45	9/5-9/7	9/7	9/6	9/6	none	none	none	none	none
Post 64	9/13	9/15	9/14	9/14	none	none	none	9/10, 9/12	none
Supple -mental	2/24/01	2/27/01 2/28/01 3/1/01	none	none	none	none	none	none	none

SPI/PVC-sediment profile image/plan view; Core-sediment 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 LU was conducted from August through September 2000. Supplemental coring and sediment profile image/plan view surveys were conducted in Cell LU during February/March, 2001. Primary monitoring activities coincided with specific sequences of placement events listed in Table 3.1-1. A timeline of activities associated with cap placement monitoring is shown schematically in Figure 3.1-1. Specific dates for individual sampling tasks are listed in Table 3.1-2. Results from each of the cap placement monitoring tasks in Cell LU are presented in Sections 3.2 through 3.12.

The ADISS system was installed on the hopper dredge (*Sugar Island*) on July 28, and data were recorded and retrieved each day of cap placement operations (see Section 3.2). Also, a moored current meter/optical backscatter array was deployed near Cell LU from August 1 to August 3 and from August 11 to August 14.

Supplemental Coring

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

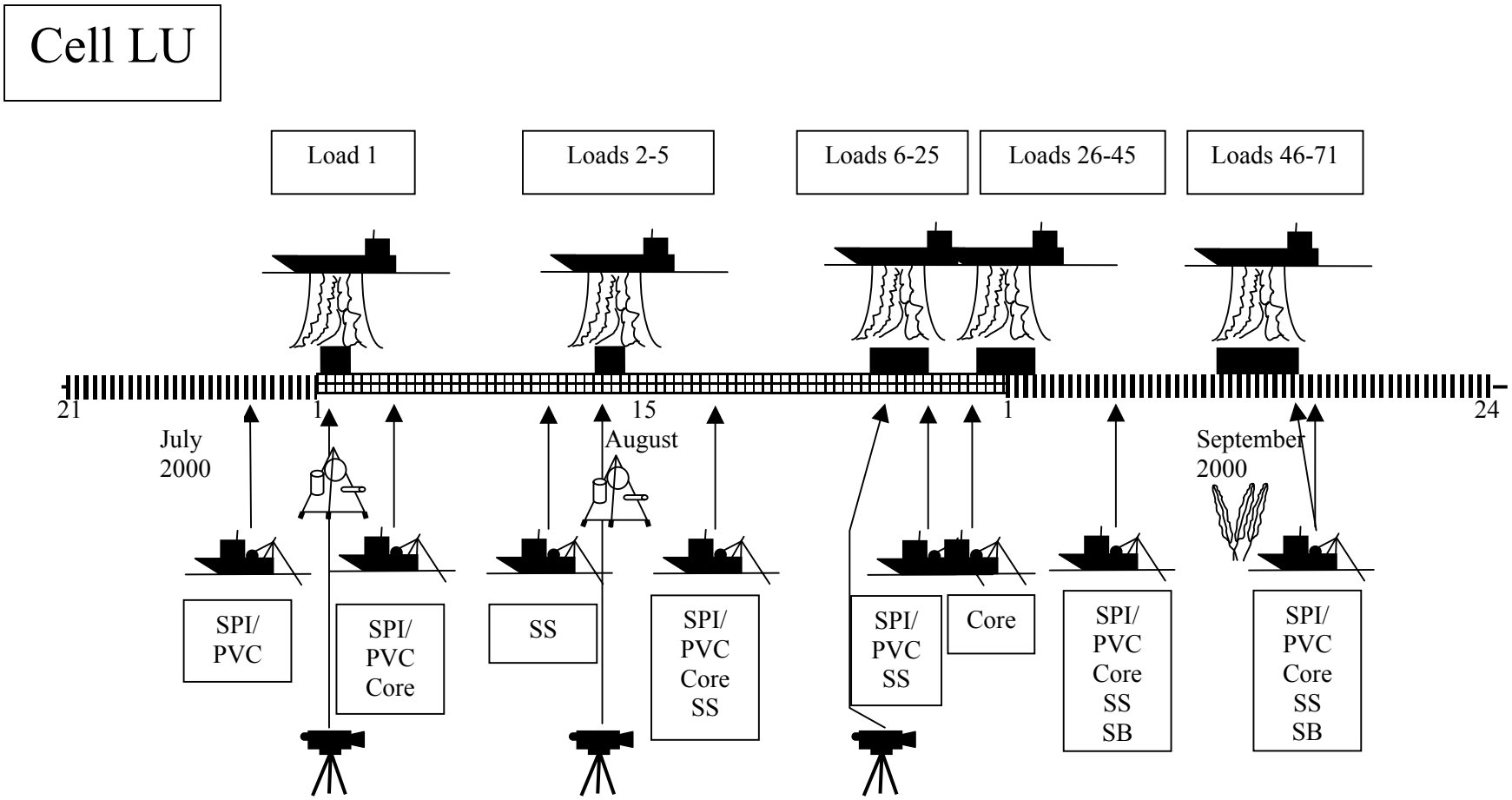

Figure 3.1-1. Activities time-line for Cell LU 21 July 2000-24 September 2000. Cap placement activities are indicated by the dredge symbol and solid bar. Monitoring activities are shown by the research vessel, current meter tripod, video camera, and kelp symbols. Monitoring activity codes associated with the research vessel symbol are SPI-Sediment Profile Imaging, PVC-Plan View Camera, Core-Coring survey, SS-Side Scan, SB-Sub-bottom profiling. The supplemental coring and SPI/PVC survey, conducted during February/March, 2001 is not shown on the timeline.

3.2 Hopper Dredge Monitoring during Cap Placement

3.2.1 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. In addition to the automated recording within ADISS, the First Mate on the dredge manually recorded the dredge heading during each placement event so that this information could be merged with the ADISS parameters that were recorded automatically. Other than attempts to acquire a digital record of the dredge's heading using a digital compass temporarily interfaced to ADISS, there were no significant deviations from the monitoring approach outlined in the FSP (SAIC 2001).

All cap material used for placements in Cell LU was dredged from the Queen's Gate Channel outside of the Long Beach Harbor breakwater. This dredging operation was part of an ongoing channel deepening project such that to obtain cap material for the Palos Verdes Pilot Cap Monitoring Program, the PV Shelf project had only to pay for the additional cost to transport the dredged material to the target cells. All placements of material in Cell LU were conducted using conventional, bottom-dump operations where the hopper dredge hull is hydraulically opened to release the entire hopper load rapidly at a specific geographic location while remaining stationary at the target location.

3.2.2 Review of Data Quality Objectives

As required by the DQOs for hopper dredge monitoring (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 essentially 100%. All critical dredge operational data were recorded during each of 71 placement events in Cell LU, except for a small portion of one placement event (number 37) during which erroneous dredge position data were acquired. Careful inspection of the ADISS record revealed that erroneous DGPS dredge position data were received for a period of 1 min, 15 sec during the 5 min, 49 sec placement event; consequently, these position data were eliminated from the final ADISS records. But because this gap in dredge position data occurred during the middle of the placement event, it was possible to use linear interpolation to generate an accurate approximation of the dredge track during this brief time period. Note that the data gap of 75 sec represents only 0.4% of the 5 hr 30 min 9 sec total operation for the 71 events in Cell LU.

3.2.3 Technical Considerations

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

3.2.4 Monitoring Results

For cap placement operations in Cell LU, ADISS recorded the dredge position and draft during the loading, transit from the dredging site to the cell, and placement of dredged material in the cell. Figure 3.2-1 presents an example ADISS dredge position data acquired during placement Event 2 on August 13, 2000, with points representing individual positions of the dredge during: 1) loading within Queen's Gate Channel, 2) transit to the Palos Verdes Shelf, and 3) placement operations within Cell LU. As discussed in more detail below, dredge positions were acquired more frequently during loading and placement phases than during the transit phase, thus the widely separated data points during the transit phase in Figure 3.2-1.

Figure 3.2-2 presents a closer view of placement Cell LU, with closely spaced data points representing the position of the dredge during the time that cap material was being released from the dredge in Cell LU. Figure 3.2-3 presents a companion plot of hopper dredge draft versus time during one entire operation leading up to the placement in Cell LU. Starting at the left side of the plot, dredge positions were recorded at 6-sec intervals while the dredge was being loaded (increasing draft). After the hopper was full and the dredge started to leave the vicinity of the Queen's Gate Channel, the ADISSPlay software automatically shifted to a 5-min recording rate during the transit operation; see widely spaced data points in Figure 3.2-1. 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 operation. Figure 3.2-3 illustrates ADISS dredge position data acquired during material loading in the channel. As seen in the figure, the material originated from the west side of the channel. In Figure 3.2-4, the transit phase is easily recognizable due to the separation of data points at 5-min intervals. Approaching the target cell, data points are closer together along the time line until the placement operation begins at 0732 GMT. When the dredge opened its hull to release the cap material, the draft decreased rapidly then slowed down until a minimum draft of roughly 17 ft was achieved at the end of the 3 min, 11 sec placement event. Dredge position and draft data continued to be recorded at 6-sec intervals as the dredge returned to the Queen's Gate Channel, but at approximately 0747 GMT the ADISS unit automatically stopped recording data to conserve data memory space. Note that the ADISS unit shut off automatically when the vessel had reached a preset longitude during its transit eastward.

As compiled in Table 3.2-2, 71 cap placement events were conducted in Cell LU during the period from August 2 to September 15, 2000. These placements were grouped into four cap placement (time) phases, with 5- to 9-day gaps between phases during which a variety of monitoring activities were conducted (Figure 3.1-1) within Cell LU (see subsequent report sections which describe monitoring activities and results). Figure 3.2-5 presents ADISS dredge position data collected during each of cap placement Events 1-5 constituting Phase 1. Each of these events was targeted for a common point at the center of the cell, designated as target position "A".

Under direction from the USACE technical representatives of the Palos Verdes Pilot Cap Monitoring Program, the hopper dredge was directed to place material at other locations within Cell LU. ADISS dredge positions during cap placement Events 6 through 25 of Phase 2 are presented in Figure 3.2-6. During this phase, the dredge was directed to place material at 20 specific locations within the cell. All material was placed around the center of the cell (position A) during Phase 2 in order to construct an even thickness of cap material over the majority of the cell (Figure 3.2-6).

During Phase 3, cap material was placed at 20 specific locations around the cell periphery (Figure 3.2-7) to add material to the perimeter of the region covered during Phase 2. Whereas during Phase 4, material was placed at 13 locations situated closer to the center of the cell (Figure 3.2-8), each of

which had been occupied during Phase 2 of the placement operations. Note that this last phase of cap placement operations in Cell LU entailed placement of an additional 1 to 4 loads of material at the various target locations (see inset table of Figure 3.2-8). The objective of this phase was to increase the thickness of the cap near the center of the cell. Figure 3.2-9 provides a composite of all 71 cap placement events in Cell LU.

Each placement event occurred during different environmental conditions (e.g., surface currents; wind speed and direction) and under differing engineering controls (e.g., different dredge captains; different abilities to maintain a constant heading of the dredge; slightly different rates at which the hopper was opened; etc.). For this reason, some of the placement events were accomplished very close to the designated target location(s) while others were conducted as the dredge drifted slowly away from its predetermined target position. Overall, the conventional cap placement operations in Cell LU were conducted accurately and successfully, and the majority of cap material was placed within a short distance from the target position. And recognizing that the hopper dredge was 85 m long and 16 m wide, this was quite an accomplishment at an open-ocean site. Table 3.2-3 presents an estimate of the average distance from the actual geographic position of the center of the hopper to the target placement location for each of the 71 events in Cell LU. This hopper position (actual center of the placement location) was computed from the average of hopper positions during the entire event. For all 71 placement events conducted in Cell LU, the average distance from the hopper center to the target placement location was only 18 m, which was comparable to the width of the dredge.

The total volume of cap material placed during the 71 events in Cell LU was 69,818 m^3 (Table 3.2-2). The average volume per event was 983 m^3 and the average duration of each event was 4 min, 39 sec. Nearly half of the material was placed near the center of the cell. The symmetry of placements within the cell is best illustrated when the cell is divided into three segments: southeast, center, and northwest (Tables 3.2-4). The difference in placed volume between the southeast and northwest segments was only 263 m^3, which is less than one hopper load. Figure 3.2-10 provides a summary of cap volume placed at each of 41 locations within Cell LU.

Table 3.2-1. Monitoring Objectives and Approach for Hopper Dredge Operation Data

Monitoring Objective	Data Requirements	Monitoring Approach	Field Decision Criteria/Performance Specifications
Record transit routes for hopper dredges during individual disposal events	Near-continuous navigational position data for individual barge transits to cap site	Install automated electronic tracking system on vessel to acquire and record navigational fixes/ coordinates during transit to capping sites	Navigational data based on differential GPS with accuracy of 3 to 5 meters
Record time and rate of release of cap materials	Near-continuous record of barge draft during discharge	Record vessel draft and tonnage during placement events	Pressure sensor is factory calibrated and checked prior to installation
Record locations of individual placement events	Navigational data for individual placement events	Merge timing of discharge events with transit routes	Navigational data based on differential GPS with accuracy of 3 to 5 meters

Table 3.2-2. Volume and Times of Cap Placement Events in Cell LU

Phase	Date	Placement Event	Placement Position	Volume (m^3)	Start Time (GMT)	End Time (GMT)	Duration (hh:mm:ss)
1	08/02/00	1	A	1022	19:21:03	19:24:04	0:03:01
	08/13/00	2	A	940	7:32:02	7:35:13	0:03:11
	08/13/00	3	A	1037	10:58:14	11:00:31	0:02:17
	08/13/00	4	A	954	16:59:09	17:01:52	0:02:43
	08/13/00	5	A	995	20:19:00	20:21:07	0:02:07
2	08/22/00	6	B	1174	9:15:50	9:19:17	0:03:27
	08/22/00	7	C	1009	12:37:27	12:42:52	0:05:25
	08/22/00	8	D	1223	16:54:24	16:59:29	0:05:05
	08/22/00	9	E	1119	20:14:48	20:18:40	0:03:52
	08/22/00	10	F	940	23:31:12	23:38:33	0:07:21
	08/23/00	11	G	956	3:10:51	3:15:00	0:04:09
	08/23/00	12	H	1036	6:34:11	6:38:11	0:04:00
	08/23/00	13	I	926	9:38:25	9:47:30	0:09:05
	08/23/00	14	J	1119	13:28:04	13:34:11	0:06:07
	08/23/00	15	K	926	16:56:46	17:01:24	0:04:38
	08/23/00	16	L	1243	20:41:02	20:49:42	0:08:40
	08/24/00	17	N	1216	00:43:40	0:47:10	0:03:30
	08/24/00	18	M	1132	04:04:53	4:08:12	0:03:19
	08/24/00	19	O	1203	07:27:10	7:32:24	0:05:14
	08/24/00	20	Q	1119	10:59:51	11:10:49	0:10:58
	08/24/00	21	R	1379	23:51:18	23:55:40	0:04:22
	08/25/00	22	P	1050	3:18:00	3:22:10	0:04:10
	08/25/00	23	T	1022	6:48:27	6:52:12	0:03:45
	08/25/00	24	U	1298	10:08:43	10:11:38	0:02:55
	08/25/00	25	S	1004	13:14:55	13:20:17	0:05:22
3	08/30/00	26	AA	926	18:10:46	18:17:10	0:06:24
	08/30/00	27	AB	1009	21:49:05	21:53:14	0:04:09
	08/31/00	28	AC	1009	1:30:52	1:36:39	0:05:47
	08/31/00	29	AF	1326	4:48:49	4:53:14	0:04:25
	08/31/00	30	AG	995	8:20:40	8:27:45	0:07:05
	08/31/00	31	AH	1091	12:04:01	12:09:35	0:05:34
	08/31/00	32	AI	941	20:34:12	20:39:48	0:05:36
	09/01/00	33	CA	1077	0:28:23	0:38:14	0:09:51
	09/01/00	34	CB	940	3:58:31	4:03:55	0:05:24
	09/01/00	35	CC	995	7:22:34	7:29:07	0:06:33
	09/01/00	36	BA	1200	11:21:31	11:26:07	0:04:36
	09/01/00	37	BB	1009	15:02:36	15:08:25	0:05:49
	09/01/00	38	BC	981	18:23:49	18:30:14	0:06:25
	09/01/00	39	BD	995	22:09:56	22:16:46	0:06:50
	09/02/00	40	BG	1009	3:47:22	3:52:02	0:04:40
	09/02/00	41	BH	895	7:01:04	7:05:15	0:04:11
	09/02/00	42	BI	1119	11:00:40	11:05:57	0:05:17
	09/02/00	43	DA	1077	14:36:41	14:45:35	0:08:54
	09/02/00	44	DB	1022	18:06:17	18:13:43	0:07:26
	09/02/00	45	DC	995	21:55:09	21:59:42	0:04:33

Table 3.2-2 (continued)

4	09/10/00	46	B	650	17:37:29	17:37:56	0:00:27
	09/10/00	47	C	692	21:11:53	21:14:27	0:02:34
	09/11/00	48	D	761	1:04:20	1:07:09	0:02:49
	09/11/00	49	E	1022	5:02:16	5:05:58	0:03:42
	09/11/00	50	F	816	8:56:35	9:00:52	0:04:17
	09/11/00	51	G	912	13:07:23	13:11:06	0:03:43
	09/11/00	52	H	1036	17:32:53	17:39:49	0:06:56
	09/11/00	53	I	709	21:26:04	21:27:17	0:01:13
	09/12/00	54	J	775	1:22:09	1:27:02	0:04:53
	09/12/00	55	K	775	5:27:17	5:32:36	0:05:19
	09/12/00	56	L	926	9:33:42	9:37:54	0:04:12
	09/12/00	57	N	1022	14:02:44	14:06:44	0:04:00
	09/12/00	58	M	871	18:19:23	18:24:28	0:05:05
	09/12/00	59	C	843	22:24:18	22:29:07	0:04:49
	09/13/00	60	E	664	2:33:11	2:36:45	0:03:34
	09/13/00	61	G	802	6:36:44	6:39:21	0:02:37
	09/13/00	62	I	871	11:17:44	11:21:52	0:04:08
	09/13/00	63	B	954	16:21:43	16:25:52	0:04:09
	09/13/00	64	C	885	20:20:47	20:25:36	0:04:49
	09/14/00	65	D	981	0:25:44	0:29:42	0:03:58
	09/14/00	66	C	788	5:35:44	5:38:36	0:02:52
	09/14/00	67	E	788	9:32:34	9:34:31	0:01:57
	09/14/00	68	F	940	13:39:48	13:42:24	0:02:36
	09/14/00	69	G	898	18:10:04	18:11:49	0:01:45
	09/14/00	70	H	898	22:07:01	22:09:31	0:02:30
	09/15/00	71	I	892	2:30:50	2:33:20	0:02:30

Table 3.2-3. Distance from Center of Hopper to Target Placement Position

Placement Position	Placement Number	Distance (m) from Hopper to Placement Position	Placement Position	Placement Number	Distance (m) from Hopper to Placement Position
AI	32	60	B	6	13
DC	45	54	T	23	13
BD	39	51	AF	29	12
BA	36	43	BB	37	12
BC	38	41	C	66	12
J	14	40	C	7	11
D	48	34	E	9	11
A	2	33	N	57	11
C	59	33	DB	44	10
B	46	32	G	69	10
C	64	31	J	54	10
CC	35	31	K	15	10
H	12	30	O	19	10
A	1	28	AC	28	9
H	52	27	BH	41	9
BI	42	26	E	60	9
Q	20	25	I	13	9
R	21	25	U	24	9
F	10	24	L	56	8
CA	33	23	M	18	8
AB	27	22	A	5	7
AA	26	21	C	47	7
I	71	21	D	8	7
P	22	20	E	49	6
G	11	19	H	70	6
K	55	19	BG	40	5
M	58	19	D	65	5
AG	30	18	CB	34	4
L	16	18	G	51	4
A	4	17	B	63	3
F	68	17	F	50	3
G	61	17	I	53	3
I	62	17	E	67	2
AH	31	16			
A	3	15			
DA	43	15			
N	17	15			
S	25	15			

Table 3.2-4 Summary of Cap Volume Placed within Three Geographic Segments of Cell LU

Cell	Segment	Average Volume (m^3)	Total Volume (m^3)	Total Trips
LU	SE	1,062	18,051	18
LU	CENTER	963	33,452	36
LU	NW	1,092	18,315	17
		Totals:	**61,818**	**71**

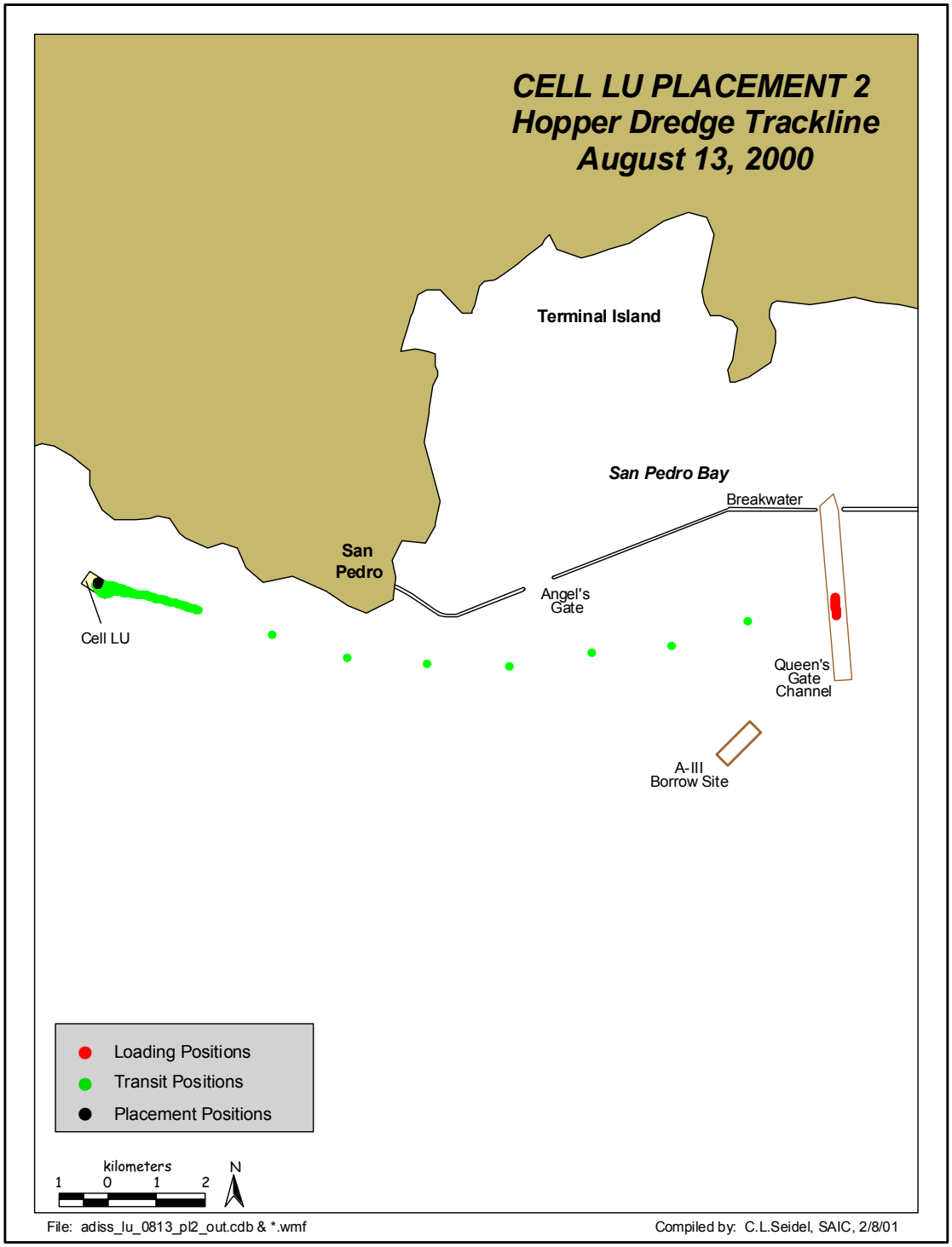

Figure 3.2-1. Map of Los Angeles/Long Beach Harbor region indicating the location of the dredging site within Queen's Gate Channel and the track of the hopper dredge *Sugar Island* during transit to Cell LU and placement of cap material during Event 2. Dredge position data were acquired by ADISS.

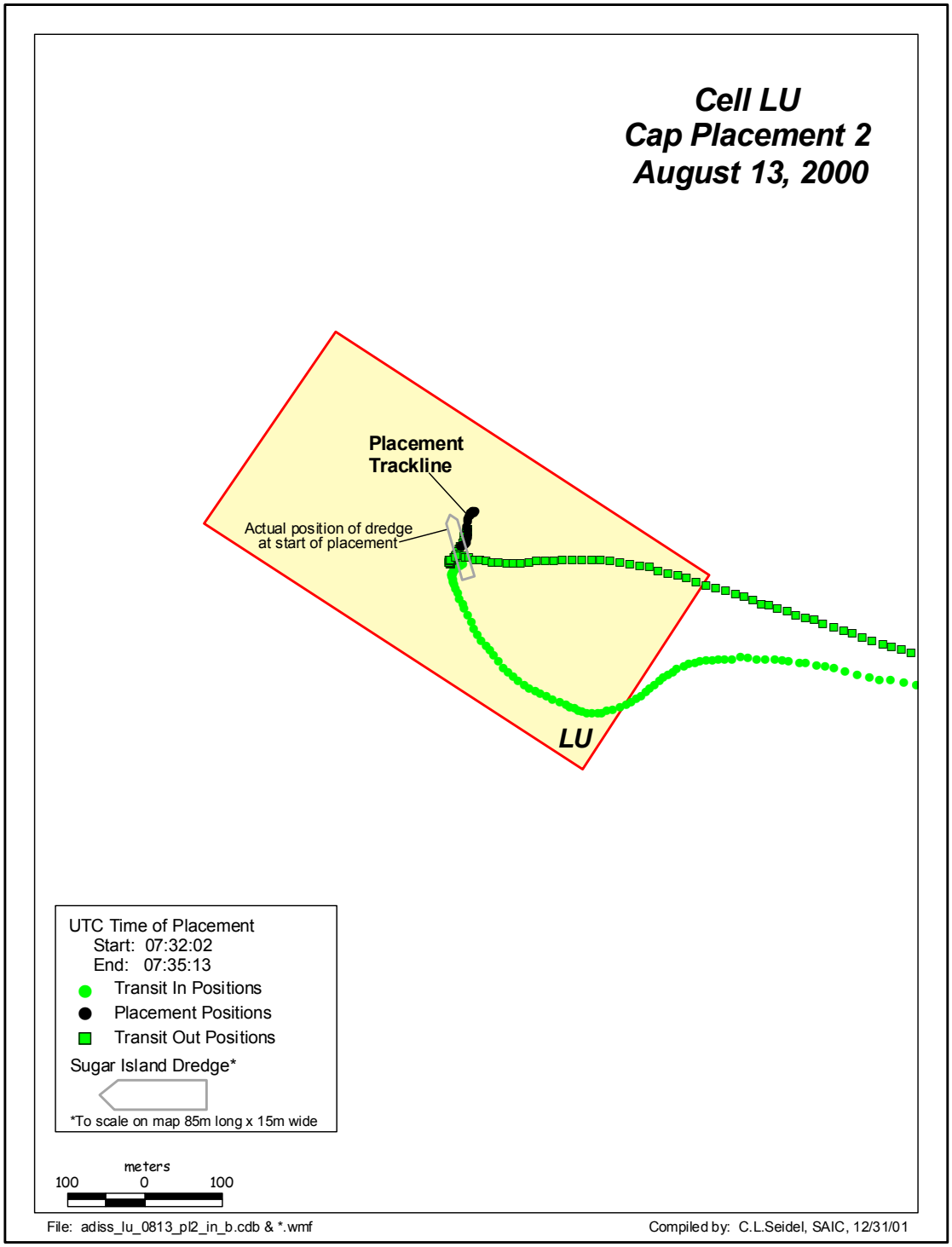

Figure 3.2-2. Map illustrating Cell LU on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* during placement of cap material during Event 2 on August 13, 2000. Dredge position data were acquired by ADISS.

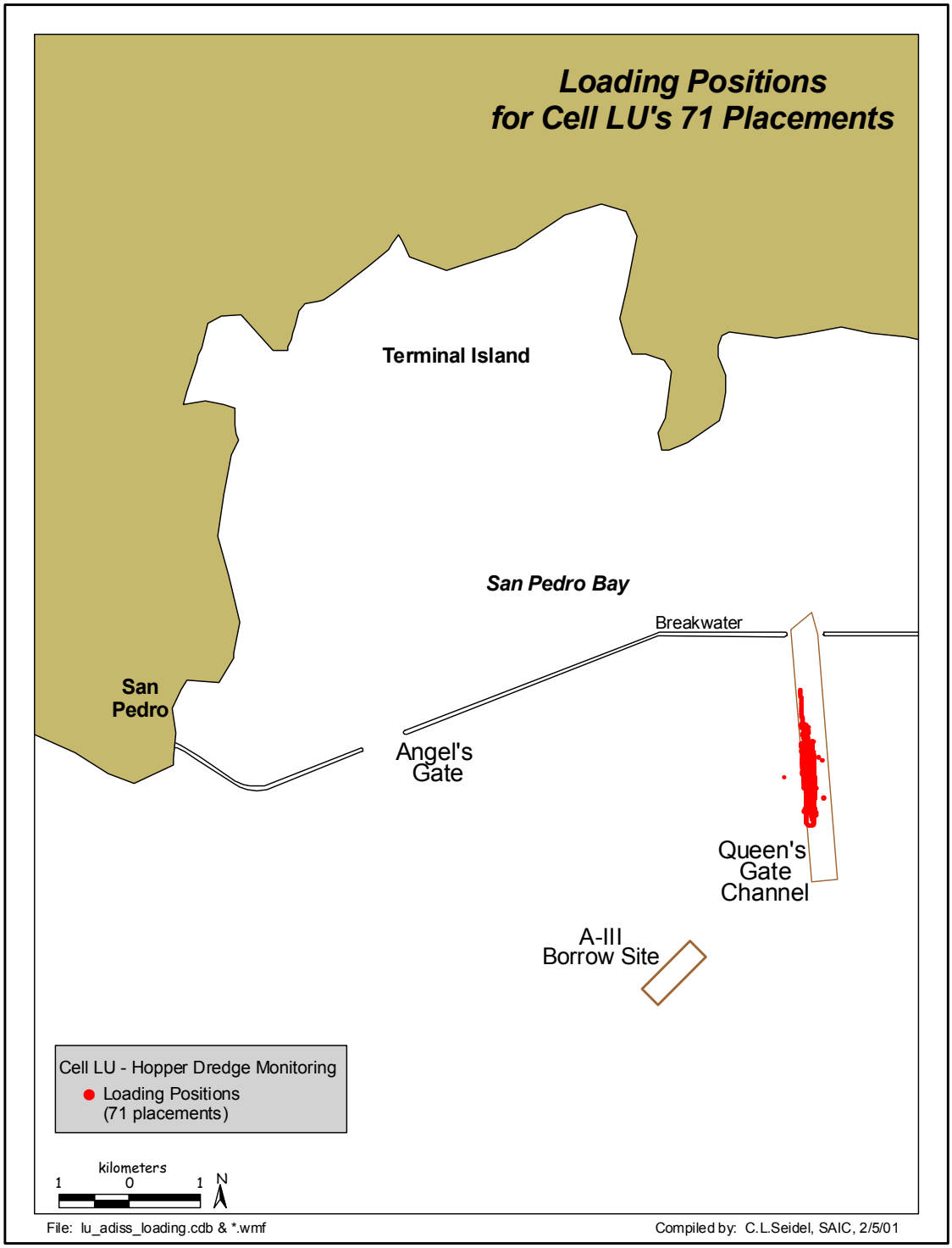

Figure 3.2-3. Map of Los Angeles/Long Beach Harbor region indicating the locations of the dredging within Queen's Gate Channel for material that was used for capping during Events 1-71 in Cell LU. Dredge position data were acquired by ADISS.

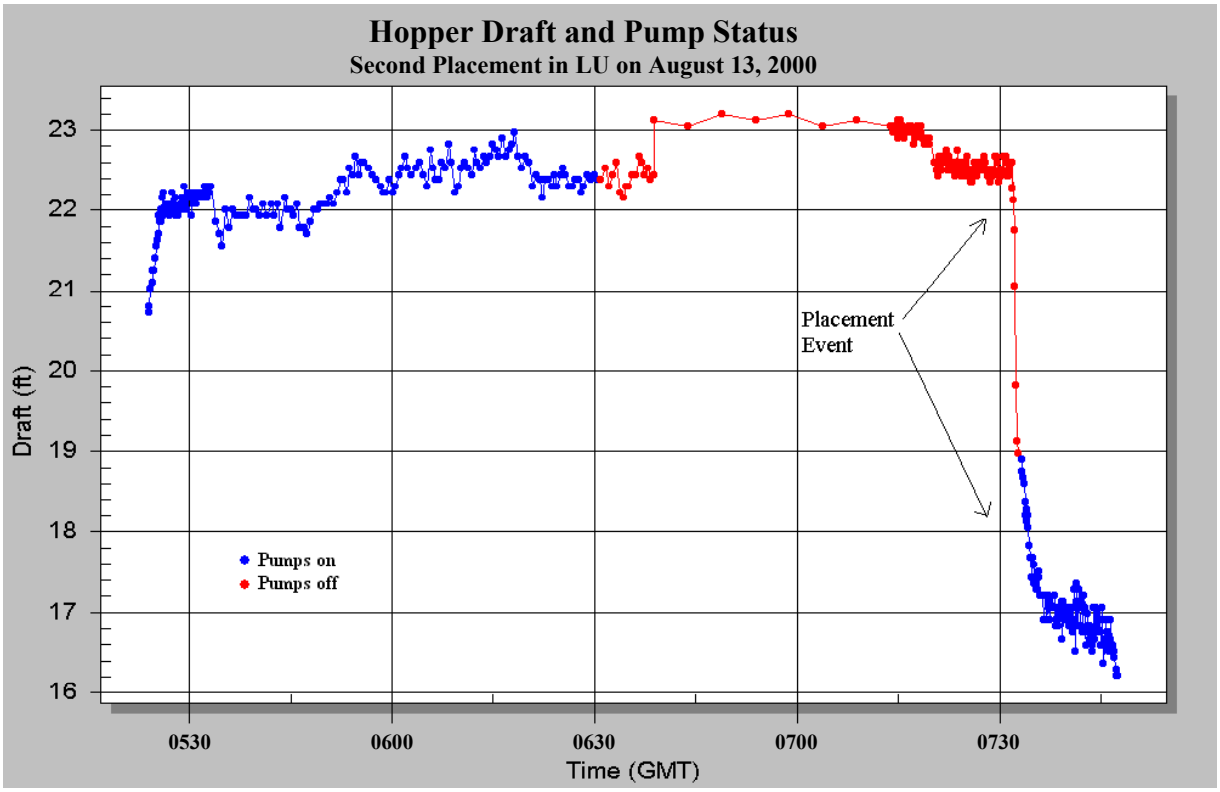

Figure 3.2-4. Time series plot of the draft of the hopper dredge *Sugar Island* during loading, transit, and placement of cap material in Cell LU during Event 2 on August 13, 2000. Dredge draft data were acquired by ADISS.

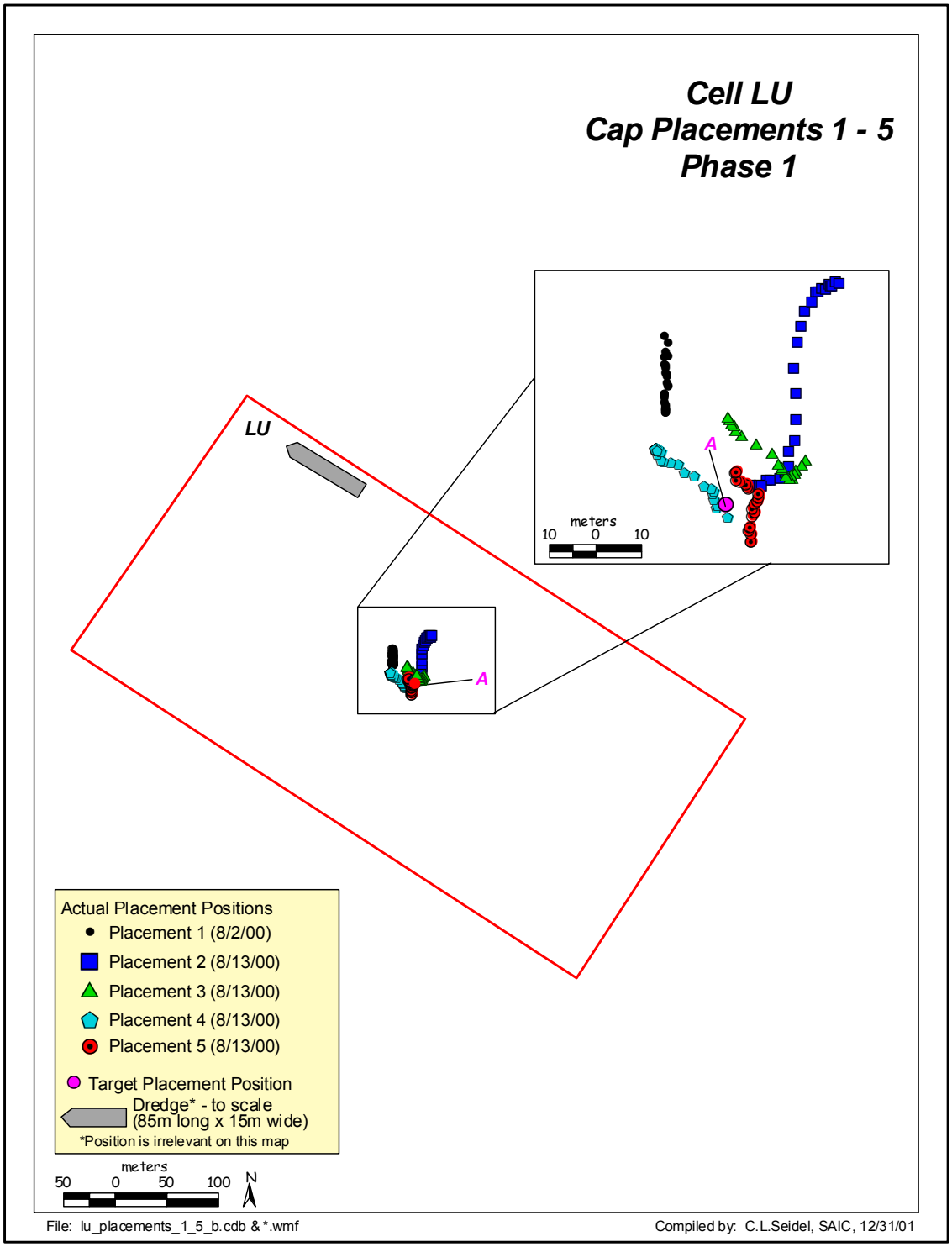

Figure 3.2-5. Map illustrating Cell LU on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* during placement of cap material during Events 1-5 in August 2000. Dredge position data were acquired by ADISS.

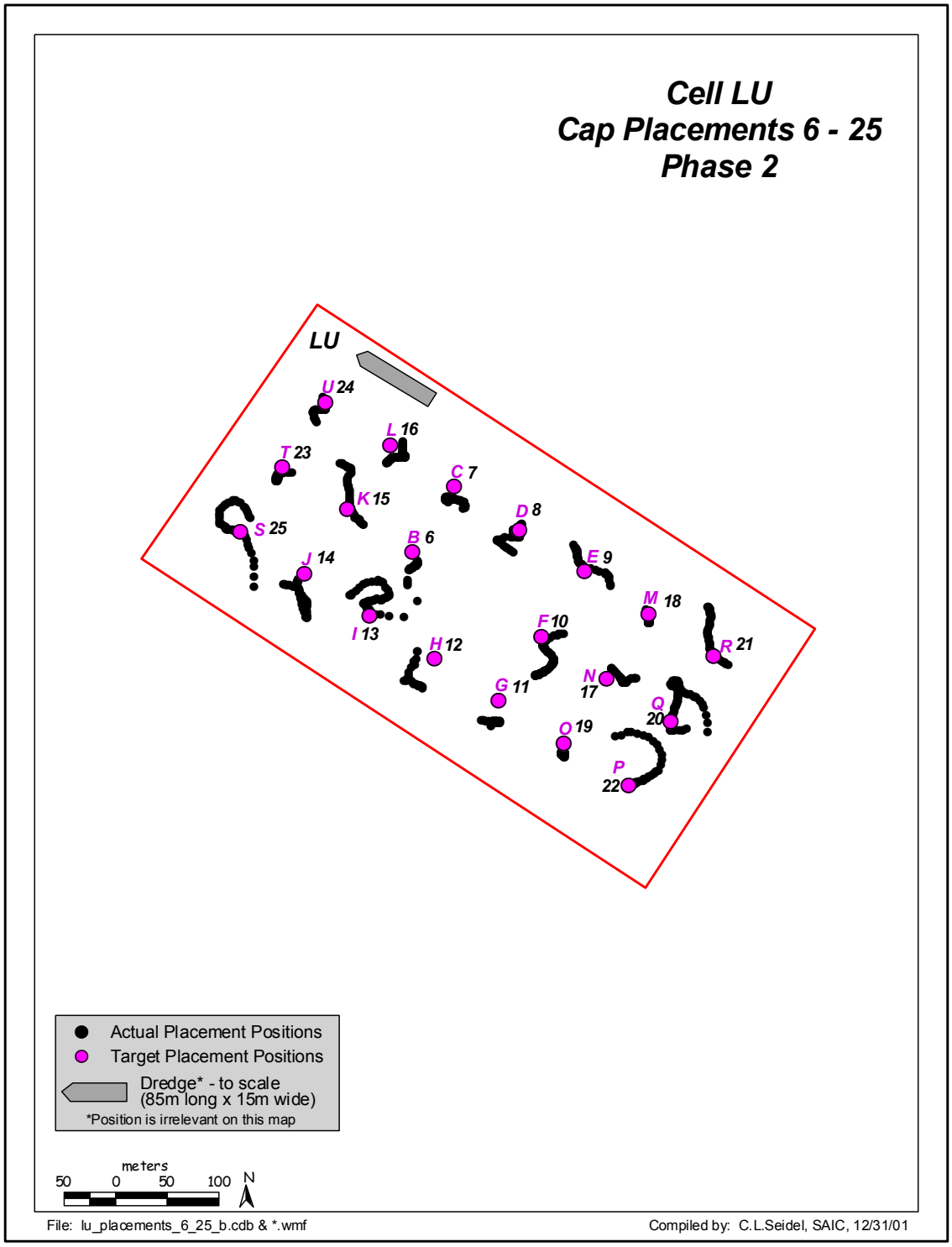

Figure 3.2-6. Map illustrating Cell LU on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* during placement of cap material during Events 6-25 in August 2000. Dredge position data were acquired by ADISS.

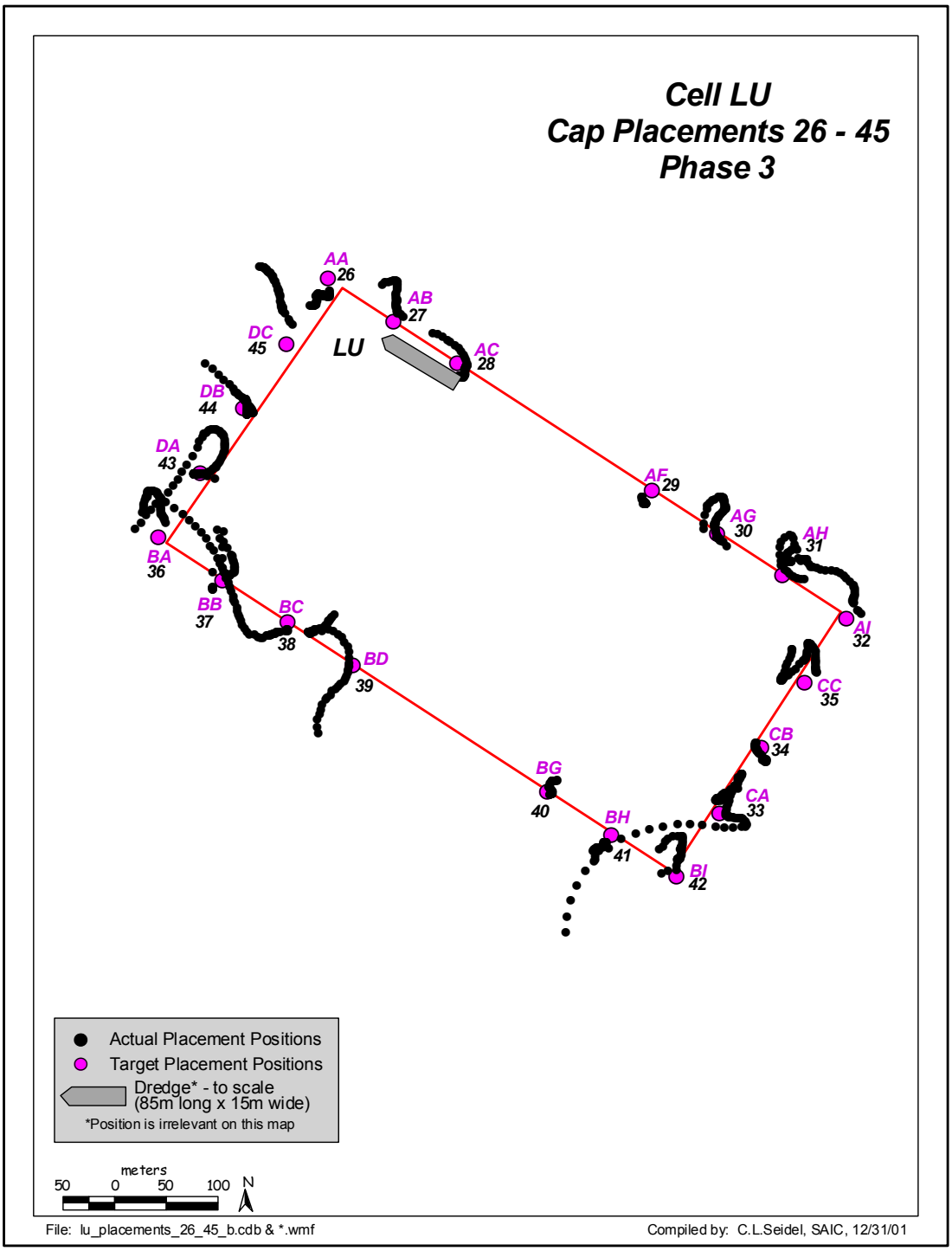

Figure 3.2-7. Map illustrating Cell LU on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* during placement of cap material during Events 26-45 in August and September 2000. Dredge position data were acquired by ADISS.

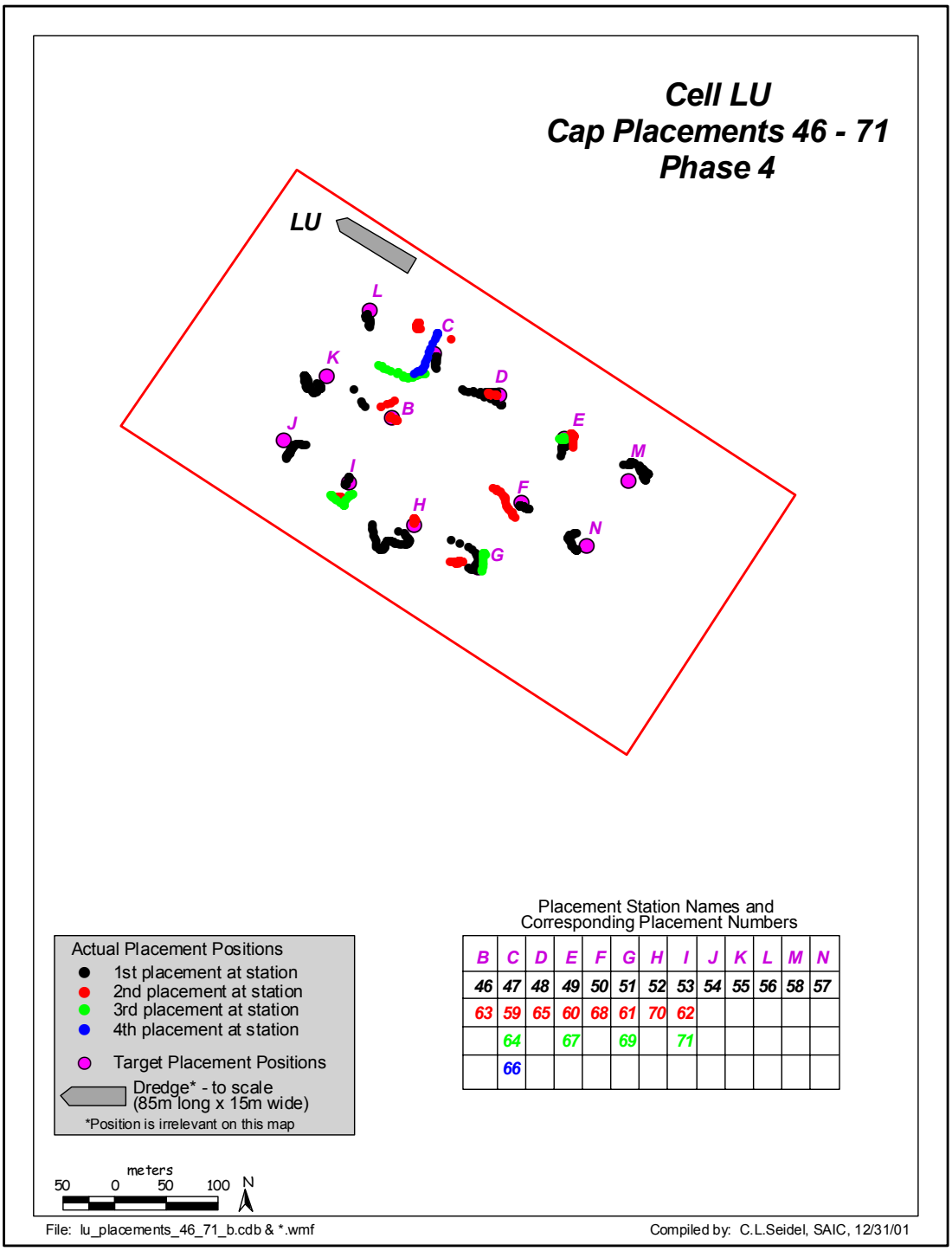

Figure 3.2-8. Map illustrating Cell LU on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* during placement of cap material during Events 46-71 in September 2000. Dredge position data were acquired by ADISS.

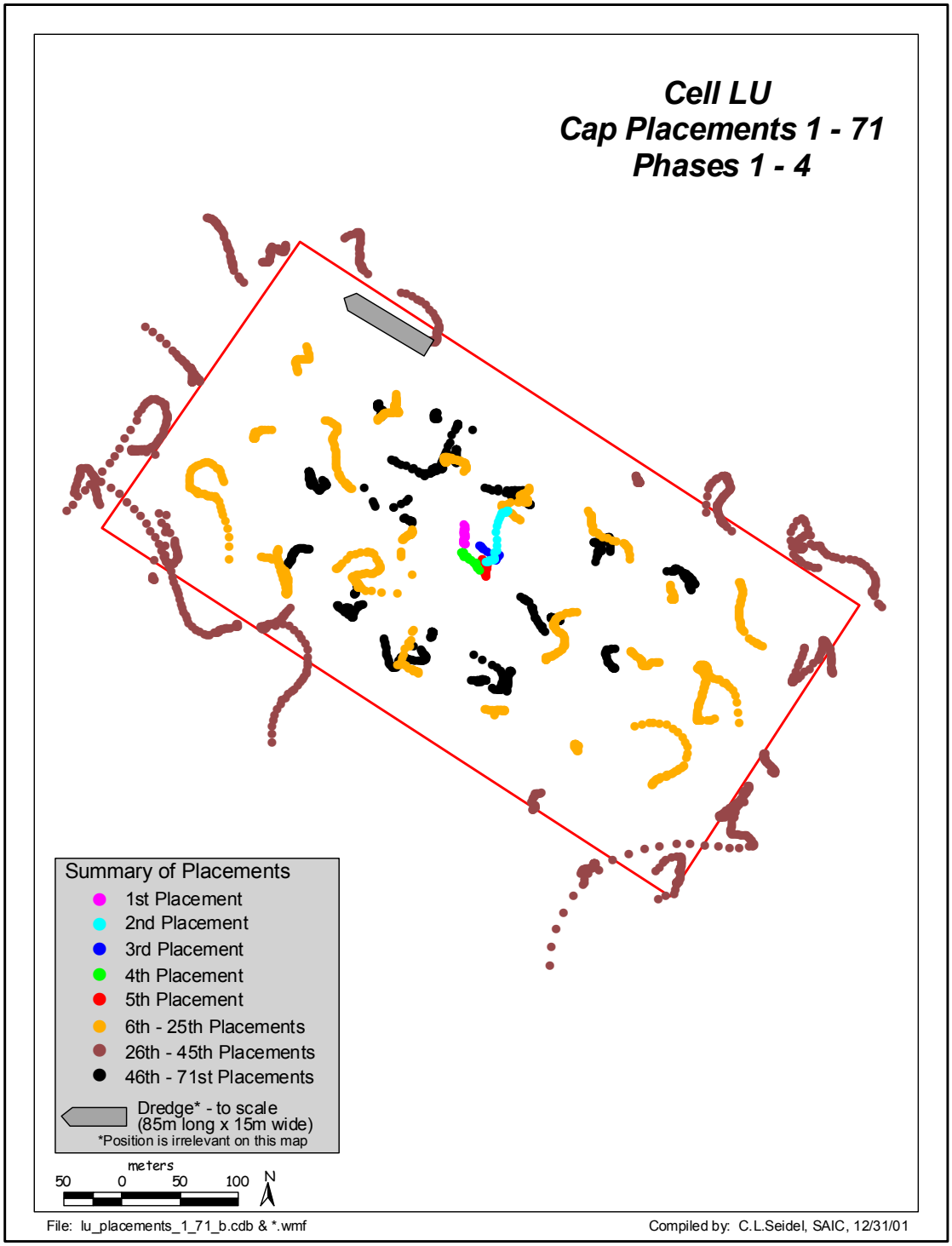

Figure 3.2-9. Map illustrating Cell LU on the Palos Verdes Shelf and positions of the hopper dredge *Sugar Island* during placement of cap material during Events 1-71 in August and September 2000. Dredge position data were acquired by ADISS.

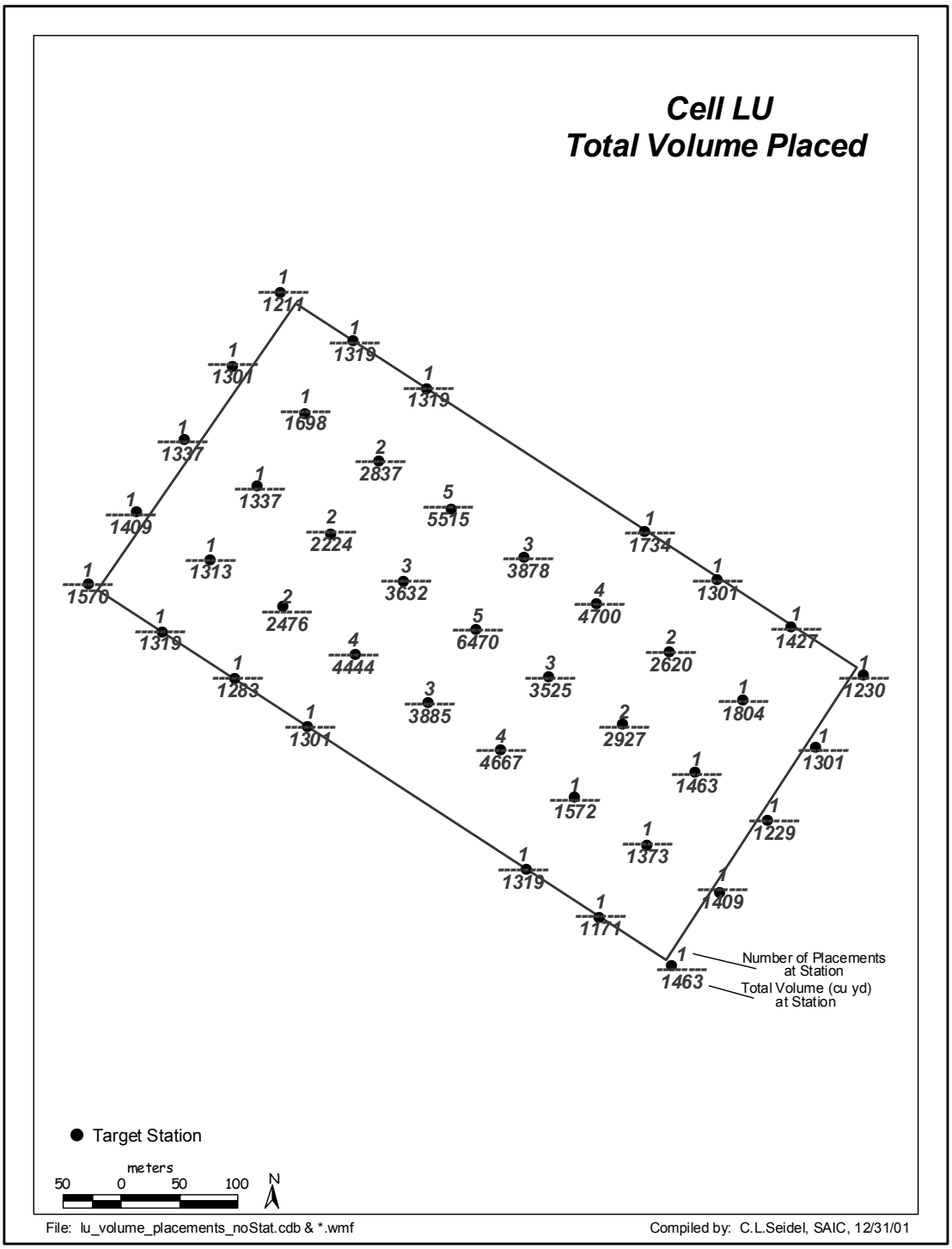

Figure 3.2-10. Map illustrating Cell LU on the Palos Verdes Shelf and the volume of cap material placed at the various target positions for all 71 events during August and September 2000. Cap placement data were acquired by ADISS.

3.3 Moored Measurements of Currents and Turbidity during Cap Placements in Cell LU

3.3.1 Overview of Field Sampling Plan

The scientific objective for the in situ measurements of near-bottom currents and water clarity (turbidity) was 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. It was anticipated that this downward momentum would be partially absorbed by the seafloor, with the remainder being converted to horizontal momentum. If the horizontal momentum was substantial, it should have been detectable as intensified near-bottom currents directed radially outward from the placement location. Additionally, this near-bottom current (surge) may have contained elevated concentrations of suspended sediments, whose origin may be cap material and/or resuspended EA sediments.

This surge monitoring activity utilized moored, internally recording, near-bottom current and turbidity sensors to monitor: 1) the speed, direction and persistence of the surge associated with individual cap placement events, 2) how this surge varied with distance from the placement location, and 3) whether the dissipation of surge momentum was affected by the local slope of the seafloor (e.g., upslope versus downslope). In addition to providing quantitative results that are presented in this report, the surge data may later be used for: a) tuning numerical models of cap material descent and horizontal spreading, b) evaluating the potential for turbidity flows that may be induced by cap placement operations, and c) input to the design of future cap placement scenarios on the Palos Verdes Shelf.

The Field Sampling Plan (FSP) of the PWP (SAIC 2001) specified that near-bottom current velocities and turbidity were to be measured at five locations during placement events: 75 m, 150 m and 250 m downslope, as well as 75 m and 150 m upslope from the cap material placement site that was at the center of Cell LU for each of the first five placement events in August 2000. Note, however, that equipment availability precluded measurements at five locations as discussed in further detail below. 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.

Current velocities were measured with three different instrument types, all of which utilize acoustic Doppler physics as the basis for their motion detection and data processing algorithms. The current measuring equipment consisted of:

- Acoustic current sensors manufactured by Aanderaa Instruments; these sensors were interfaced to SAIC's Automated Resuspension Surveillance System (ARESS) (Figure 3.3-1),
- Aquadopp acoustic current sensors manufactured by Nortek USA, and
- Acoustic Doppler Current Profilers (ADCPs) manufactured by RD Instruments

Measurements of turbidity in the near-bottom water were made using Optical Backscatter Sensors (OBSs) installed on the bottom-mounted arrays. These instruments measure the amount of emitted (infrared) light that is reflected back to the sensor. The greater the reflections, the greater the quantity of suspended particulate material in the volume of water being measured. OBS sensors were installed at two near-bottom levels on each of three ARESS arrays, and at one near-bottom level on each of two Aquadopp arrays. In each case, the OBS data were recorded simultaneously with the current data to assess correlations between current velocities and turbidity. Further details on instrument types and sampling schemes are provided in the FSP (SAIC 2001).

The temporal sampling objective required rapid (i.e., 1 Hz) sampling of near-bottom currents and turbidity during the relatively brief cap placement events in order acquire high-resolution data on surge characteristics during the first hour following material placement. Because all of the internally recording instruments had limited data storage capabilities, the moored arrays were typically deployed in the afternoon of the day preceding the cap placement event to be monitored. Arrays were recovered within one day following the cap placement event to facilitate prompt data retrieval and analysis, and redeployment. Current velocity and turbidity data acquired during extended (i.e., 12- to 24-hr) periods before and after the specific cap placement events were useful for characterizing the local background conditions and assessing the relative impacts of cap placement operations on the dynamics of the lower water column.

In addition to the moored arrays that were deployed within and adjacent to the placement cells during cap placement events, another upward-looking ADCP was deployed on the seafloor at a site to the southeast of Cells LU and SU (Figure 3.3-2) for the purpose of acquiring a 30-day record of ambient current velocities throughout the water column. This ADCP was installed within a Trawl Resistant Bottom Mount (TRBM) platform that was designed to protect the ADCP and associated acoustic release components from physical damage in the event that a fishing vessel dragged its gear over the array.

The ADCP/TRBM was initially deployed on August 3 and recovered on August 16, 2000. Unfortunately, no useful data were acquired during this time period because the instrument package was unknowingly placed upside down on the seafloor during the instrument deployment operation. A second deployment of the instrumentation was made from August 17 to September 24, but similar inverted-deployment problems precluded data recovery during this 39-day period. Consequently, no long-term records of current velocities were obtained.

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

3.3.1.1 Moored Array Deployment 1 during Cap Placement Event 1

Table 3.3-1 provides a summary of moored-array deployments within Cells LU, SU, and LD during the period from August 2-15, 2000. As indicated in the table, the first deployment in Cell LU spanned the time period of cap placement Event 1 during which 1,022 m^3 of material was placed within Cell LU during a 3-min release period on August 2 using the conventional (bottom dump) placement technique. The two arrays were actually deployed in the afternoon of August 1 and recovered in the afternoon of August 3. Data records were retrieved from the internally recording instruments and the equipment was prepared for redeployment in Cell SU approximately four days later. (See the Cruise Report [SAIC 2000b] for details on deployment times and field operations.)

Figure 3.3-3 illustrates the location of the two moored arrays that were in place near the seaward (southwest) boundary of Cell LU 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”).

Also shown in Figure 3.3-3 are the position and heading (121° T) of the hopper dredge during the placement operation. The dredge was stationary at the center of the cell upon commencement of cap material release, and drifted only slightly toward the south during the 3-min release period. As planned, this resulted in a “point release” of Queen’s Gate material at the center of the cell, upslope of the two moored arrays.

The instrumentation deployed during Event 1 is summarized in Table 3.3-2. At the 75 m downslope location, the bottom-mounted array was instrumented with: a) two ARESS current sensors

interfaced to two OBS turbidity sensors, b) one Aquadopp current sensor interfaced to one OBS turbidity sensor, and c) one upward looking ADCP for current measurements throughout the water column. The ARESS and Aquadopp current sensors were mounted in close proximity to each other to facilitate an intercomparison of current velocity data acquired by the two acoustic sensor types (see Section 3.3.3 for a discussion of the intercomparison results).

At the 150 m downslope location, the moored array was configured with a single Aquadopp current sensor and a single OBS sensor (Table 3.3-2). The water depth at the 150 m location (46 m) was only 1 m greater than that of the 75 m location, indicating a very flat bottom, void of small-scale features as confirmed by the baseline sidescan survey (see Section 3.10).

Percent data return from the moored instrumentation during Event 1 is presented in Table 3.3-3. Complete data records were acquired by all ARESS, Aquadopp, and OBS sensors during this event but unfortunately, the ADCP data record ended prior to the cap placement operation due to insufficient power provided by the new lithium batteries installed within the ADCP.

Results from the moored current and turbidity records acquired during placement Event 1 are presented in Section 3.3.4.

3.3.1.2 Moored Array Deployment 3 during Cap Placement Events 2 to 5

Table 3.3-1 indicates that six days after the first deployment in Cell LU, the instrument arrays were redeployed in Cell SU to monitor currents and turbidity during the first placement in this cell (see Section 4.3). Next, the arrays were deployed in Cell LU to acquire data during two additional cap placement Events (2 and 3). However, because the arrays were left in place for three days, it was possible to acquire data during placement Events 4 and 5 by some of the instruments that had sufficient battery power for this extended deployment period. As indicated in the table, each of these events were associated with conventional placement of roughly 918 to 1,032 m^3 of Queen's Gate material, and the placement events each had durations of 2 to 3 min. The arrays were deployed on August 11 and recovered on August 14 (see the Cruise Report (SAIC 2000b) for details on deployment times and field operations).

Figure 3.3-4 illustrates the location of four moored arrays that were in place during placement Event 2. In addition to the three arrays situated downslope of the cell's center point, one array was situated 75 m upslope of the center. Also shown in Figure 3.3-4 are the position and heading (344° T) of the hopper dredge during the placement operation. The dredge was stationary at the center of the cell upon commencement of cap material release, and drifted only slightly toward the north during the 3-min release period. This resulted in a point release of Queen's Gate material near the center of the cell between arrays D75 and U75. As will be discussed in Section 3.3.4, this release was closer to array location U75 than D75.

The instrumentation deployed during Events 2 to 5 is summarized in Table 3.3-2. At the 75 m upslope location, a relatively small array was equipped with one Aquadopp current sensor interfaced to one OBS sensor. At the three downslope locations, ARESS arrays were each equipped with one or two Aanderaa current sensors and two OBS sensors. An ADCP also was installed on the array at the 75 m downslope location. Water depth at the four array locations in Cell LU ranged from 42 to 47 m (Table 3.3-2).

Percent data return from the moored instrumentation during Events 2 to 5 is presented in Table 3.3-3. For Events 2 to 4, 100% data return was achieved by all ARESS, Aquadopp and OBS sensors. For Event 5, ARESS, Aquadopp, and OBS sensors acquired full data records at the 75 m upslope and 150 m downslope locations, but no data were acquired by the ARESS/OBS sensors at the 75 m and 250 m downslope locations because their batteries had expired due to the relatively long deployment at the continuous sampling rate. A complete data record was acquired by the upward-looking ADCP, spanning all four placement events. Alkaline batteries had remedied the problem encountered previously with the lithium battery.

Results from the moored current and turbidity records acquired during placement Events 2 to 5 are presented in Section 3.3.4.

3.3.2 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. Each of the objectives is discussed below.

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

This objective was achieved via high-resolution current measurements at various locations (within and adjacent to three placement cells), water depths (near-bottom and throughout the water column), and during multiple cap placement events as described in Section 3.3.1. Data return from the moored instrumentation is summarized in Table 3.3-3. Monitoring highlights and data deficiencies are identified below for Cell LU:

<u>General Results</u>

- All of the moored current records were of sufficient accuracy and resolution to allow indisputable delineation of the time and magnitude of the current surge associated with each of the seven cap placement events monitored. And for all records, the leading edge of the surge current had speeds that were significantly higher than the background currents.
- The near-bottom current direction data during surge events had sufficient accuracy to demonstrate that the surge spread radially (upslope and downslope) from the placement site.
- The horizontal spacing of moored arrays was sufficient to quantify the dissipation of horizontal momentum contained within the surge current, versus distance from the placement site.
- The vertical current profile data acquired by the ADCP had sufficient vertical and temporal resolution to quantify the thickness of the bottom-trapped surge current for all events.

<u>Cell LU</u>

- The initial plan was to acquire data during three separate cap placement events but a total of five events were monitored during two instrument deployment periods.
- 100% return of near-bottom current data was achieved at two locations during Event 1. Data were not acquired by the single ADCP deployed during Event 1 due to battery problems.
- The sampling plan called for moorings at three additional locations but this was not accomplished during Event 1 because the equipment for these additional moored arrays did not arrive at the project field site in time for the initial mobilization and deployment.
- 100% return of near-bottom current and ADCP data was achieved at four locations during Events 2, 3 and 4.
- 100% return of near-bottom current and ADCP data was achieved at two locations during Event 5. Near-bottom data were not acquired at two other measurement locations because the internal batteries

expired before the end of the 3-day deployment period. Note that the predetermined instrument sampling period was designed for a 2-day maximum deployment, but the hopper dredge was not available for cap placements during the first 32 hrs of the deployment period and the decision was made to leave the current measurement arrays in place rather than retrieve and redeploy before Events 2 through 5.

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 and during multiple cap placement events. Turbidity data return from the moored instrumentation is summarized in Table 3.3-3. Monitoring highlights and data deficiencies are identified below for Cell LU:

General Results

- All of the moored turbidity records were of sufficient accuracy and resolution to allow indisputable delineation of the time and magnitude of turbidity within the bottom surge current associated with each of the seven cap placement events monitored. And for all records, the leading edge of the surge had turbidities that were significantly higher than the characteristics of the background waters.
- The horizontal spacing of moored arrays was sufficient to quantify the temporal and spatial variations in turbidity within the surge current.

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- Five separate cap placement events were monitored.
- 100% return of near-bottom turbidity data was achieved at two locations during Event 1.
- 100% return of near-bottom turbidity data was achieved at four locations during Events 2, 3 and 4.
- 100% return of near-bottom turbidity data was achieved at two locations during Event 5. Near-bottom data were not acquired at two other locations because the internal batteries expired before the end of the 3-day deployment period.

3.3.3 Technical Considerations

Different Sampling Schemes of Moored Instrumentation

Regarding temporal sampling schemes: The moored ADCPs generated time series records of current velocity data that were averaged over 1-min time intervals, whereas the Aanderaa and Aquadopp current sensors sampled much more rapidly, resulting in accurate data that were averaged at 12-sec intervals.

Regarding depths of individual current velocity measurements: The Aanderaa and Aquadopp sensors each measured currents at specific depth levels within 1 m of the seafloor. The ADCP, on the other hand, acquired current velocity data throughout the water column, except within the lower 3 m and upper 5 m of the water. The final, processed ADCP data were averaged within a large number of 1 m thick layers of the water column, rather than providing data at a specific depth.

Because of these differences in temporal and spatial (vertical) sampling schemes of the near-bottom versus ADCP instrumentation, the various data sets were not directly comparable. For example, the maximum (12-sec averaged) current speeds that were measured during the surge events by the near-bottom sensors should not be compared with the 1-min-averaged ADCP current measurements from the 1 m thick layer situated 3 m above the bottom. The time bases of the various instruments were carefully synchronized so that the data were, however, comparable in terms of general current characteristics and persistence of the surge phenomenon.

Intercomparison of Aanderaa and Aquadopp Current Sensors

During the first instrument deployment period at the 75 m downslope location in Cell LU, an Aquadopp current sensor was mounted on the same ARESS array as an Aanderaa current sensor in order to acquire simultaneous current velocity data sets for assessment of comparability between instruments. The data acquired during this 42-hr intercomparison test exhibited excellent agreement between the two instrument types such that results from either instrument type are representative and comparable.

3.3.4 Monitoring Results

3.3.4.1 Observations during Cap Placement Event 1

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

Cap placement Event 1 in Cell LU began at 1921 GMT on August 2, 2000, while instrumentation was moored at positions of 75 m and 150 m downslope of the placement location. Detailed inspection of time series records from the moored instruments revealed that near-bottom current velocities and turbidity increased sharply during the horizontal surge event associated with the cap placement operation. For example, Figure 3.3-5 presents near-bottom current speed (cm/s), current direction (^{o}T), and turbidity (FTU) data acquired at the 75 m downslope location beginning at 1900 GMT on August 2 and extending for roughly 1 hr. This figure presents data from ARESS current and OBS sensors at heights of roughly 0.5 and 1.25 m above the seafloor.

Immediately prior to Event 1, near-bottom currents at the 75 m downslope location were relatively weak (10 to 20 cm/s) and directed toward the southwest or west (230° to 280° T; see Figure 3.3-5). Near-bottom turbidities also were consistently low: less than 10 FTU. Within one minute of commencement of cap placement operations (1921 GMT), currents increased sharply and veered toward the south-southwest (toward 210° T). Maximum current speeds of 120 cm/s were encountered briefly at the sensor positioned 1.25 m above the bottom. The slightly lower maximum speed of 110 cm/s that was observed at the sensor situated 0.5 m above the bottom may have been due to bottom friction effects on the horizontal surge current. Current speeds associated with this surge event dissipated rapidly, such that speeds returned to background (pre-placement) levels within 12 min of the placement event. Similarly, current vectors gradually shifted back toward the west within approximately 12 min, at both instrument levels.

Near-bottom turbidities during the surge of Event 1 also rose sharply above background levels, achieving a maximum of approximately 600 FTU at both sensor levels (Figure 3.3-5). These time series data illustrate that the maximum turbidity associated with the surge occurred somewhat before the maximum current speed, and that the high turbidity persisted somewhat longer than did the intensified currents. Turbidity levels did, however, generally return to their pre-placement background levels within about 14 min. Note that due to the different sampling rates and signal-to-noise ratios of the independent current and OBS sensors, their raw data had to be averaged over different time intervals (12 sec for currents and 20 sec for turbidity data) in order to achieve accurate and meaningful results. Consequently, the small (less than 30-sec) time lag between the maximum surge current and the maximum turbidity concentration may have partially been a result of different averaging schemes for the two measured variables.

Overall, these time series data illustrate that the surge current was brief but easily detectable above the background current and turbidity at the 75 m downslope mooring location. The maximum current speed (averaged over 12-sec intervals) was roughly 6 to 12 times that of the ambient near-bottom current, and turbidities were roughly 60 times greater than background levels (in terms of FTUs).

However, both the near-bottom current velocities and the turbidity concentrations returned to background levels within 14 minutes of the placement event.

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

Near-bottom currents immediately prior to Event 1 at the 150 m downslope location (Figure 3.3-6) were weak (approximately 10 to 15 cm/s) and directed toward the southwest (240° to 260° T) as had been observed at the 75 m downslope location. Near-bottom turbidities also were consistently low: less than 10 FTU. Within four minutes of commencement of cap placement operations, currents increased sharply and veered toward the south-southwest (toward 190° T). A maximum current speed of 57 cm/s (averaged over 12-sec intervals) was measured by the Aquadopp sensor positioned 1 m above the bottom. Current speeds associated with this surge dissipated rapidly such that speeds returned to background (pre-placement) levels within 7 min of the placement event. Current vectors gradually shifted back toward the southwest but this occurred over a longer time period (~22 min).

Near-bottom turbidities during Event 1 also rose sharply above background levels, achieving a maximum of approximately 505 FTU (Figure 3.3-6). The elevated turbidities decreased to background levels within approximately 22 min. These data demonstrate that maximum current speeds and maximum turbidities associated with the surge current occurred at the same time.

As had been observed at the 75 m downslope location, these time series data illustrate that the surge current was brief but easily detectable above the background currents and turbidity observed at the 150 m downslope mooring location. The maximum current speed (averaged over 12-sec intervals) was roughly four to six times that of the ambient near-bottom current, and turbidities were roughly 50 times greater than background levels (in terms of FTUs). However, both the near-bottom current velocities and the turbidity concentrations returned to background levels within 22 minutes of the placement event.

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. The decrease in maximum current speeds from 120 cm/s at the 75 m downslope location to 57 cm/s at the 150 m downslope location clearly documents this dissipation in horizontal momentum. As seen in Figure 3.3-7, which presents current speed and direction data from 1.25 m above the bottom at the 75 m downslope location and from 1 m above the bottom at the 150 m downslope location, the near-bottom current at the most distant location was significantly weaker and its maximum was reached 2 min after the maximum was encountered at the 75 m location. Close inspection of the two moored array locations and the exact position of the placement event as determined by the ADISS data (see Figure 3.3-3) reveal that the two arrays were actually situated 100 m and 165 m from the placement location and thus, were separated by a distance of 65 m (Table 3.3-5). If we divide this distance by the 2-min lag time between observations of maximum currents, we arrive at an average current velocity of 54 cm/s for the surge current that progressed from the 75 m (100 m) to the 150 m (165 m) downslope location. This average translational speed agrees well with a current speed of roughly 50 cm/s that persisted for the first few minutes at the 150 m array location.

Although there were no moored arrays positioned within 50 m of the placement site, it is likely that maximum current speeds near the point of cap material release were considerably higher than 120 cm/s. As illustrated in Figure 3.3-8, which presents a plot of the maximum near-bottom current speed observed at the two array locations during placement Event 1 versus the horizontal distance from the moored array location to the actual cap placement location (Table 3.3-5), the slope of the line suggests that the maximum horizontal current near the placement site may have exceeded 120 cm/s. Additional in situ measurements would have been needed to quantify this maximum current speed in close proximity to

the placement vessel, but the likelihood of damage to or loss of moored equipment made such deployments too risky.

Due to the lack of moored instrumentation that was available for this first deployment in Cell LU, no arrays were placed upslope of the cap placement site during Event 1. Upslope locations were, however, instrumented with moored arrays for all subsequent deployments as discussed below.

Vertical Profiles of Horizontal Currents during Placement Event 1

The ADCP mounted on the ARESS array nominally located 75 m (actually 100 m, Table 3.3-5) downslope of the placement site acquired accurate horizontal current velocity data throughout the water column for the first 15 hours of the deployment, but data recording ceased before commencement of cap placement Event 1 due to the internal battery problem discussed previously. The velocity data acquired by the ADCP consists of individual time series records (averaged over 1-min time intervals) from each of 39 depth layers starting 3 m above the bottom. Figure 3.3-9 presents a composite of current speed records from seven depth layers starting at 43 m and continuing upward through the water column to the 5 m layer, which was the shallowest level at which good-quality data were acquired; Figure 3.3-10 presents a companion plot of the same time series records for current direction at the same seven depth layers. A time series record of water temperature acquired by a sensor mounted within the ADCP pressure case and situated 1 m above the bottom also is presented at the top of the two figures.

The time series of current speed at the 43 m measurement level (lowest tier in Figure 3.3-9) illustrates relatively weak bottom currents that ranged from approximately 2 to 22 cm/s. Current speeds were considerably higher above 30 m depth, with maximum speeds near 50 cm/s at the 14 m and 24 m levels. In general, current speeds exhibited moderate vertical coherence, with maximum speeds being encountered at roughly the same time throughout the water column.

Current directions exhibited more variability with depth through the water column. For example, the current at 24 m depth exhibited a continual clockwise rotation from northwest through north, continuing toward the south and returning to the northwest over the 15-hr measurement period (Figure 3.3-10). At the 14 m level, flow was almost continually toward the northwest, whereas above this level, a continual clockwise rotation was again observed.

In the lower 5 m of the water column (lower three tiers in Figure 3.3-10), current directions were coherent but more bi-directional than had been observed in the upper water column. Near the bottom, currents turned clockwise from northwest to south-southeast then counter-clockwise, ending back toward the northwest where current directions remained relatively constant for six hours.

Also shown in Figures 3.3-9 and 3.3-10 are the times of high and low water measured at the NOAA National Water Level Observation Network in the Outer Harbor of Los Angeles (Station 9410660). Overall, current speeds in Cell LU were highest after high water when the flow was generally directed toward the west or northwest (Figure 3.3-9). When the flow turned toward the east (onshore), currents were weaker and more variable in direction throughout much of the water column. Eastward (onshore) flow began earlier in the lower portion of the water column than at other depth levels. Note, however, that currents at the 14 m depth level were directed toward the northwest or north for the 15-hr record with no periods of eastward (onshore) flow.

Near-bottom water temperatures varied gradually, over a range from 12.45°C to 13.75°C during the 15-hr measurement period but the fluctuations were not well correlated with water level or current directions in the lower water column.

To assess whether the ADCP current data from the 15-hr measurement period prior to placement Event 1 were comparable to the ambient near-bottom currents immediately prior to the placement, we can see from the ARESS data in Figure 3.3-5 that during the placement event, the ambient currents 1.25 m above the bottom were on the order of 15 cm/s and directed toward the northwest. High water at the NOAA Los Angeles water level station occurred at 1924 GMT on August 2, which was only three minutes after commencement of placement Event 1. For comparison, the ADCP data at the time of the first high water on August 2 (Figures 3.3-9 and 3.3-10) showed that the near-bottom currents during this same phase of the tide were between 15 and 20 cm/s and directed toward the northwest, were in close agreement with the ARESS observations made immediately prior to the placement event. Consequently, we believe that the ambient currents monitored by the ARESS arrays were representative of the near-bottom currents observed by the ADCP over the longer but non-concurrent measurement period.

3.3.4.2 Observations during Cap Placement Event 2

Near-Bottom Currents and Turbidity at the Array Locations

Cap placement Event 2 in Cell LU began at 0732 GMT on August 13, 2000 while instrumentation was moored at four locations: one upslope and three downslope from the cap placement site (Table 3.3-2). Inspection of time series records from the moored instruments revealed that near-bottom current velocities and turbidity increased sharply during the horizontal surge event associated with the cap placement operation, as had been observed during Event 1 in Cell LU. For example, Figure 3.3-11 presents near-bottom current speed, current direction, and turbidity data acquired at the 75 m downslope location beginning at 0710 GMT on August 13 and extending for roughly 1 hr. This figure also presents near-bottom ARESS current and OBS data from the moored array located 250 m downslope of the placement site (these data are discussed later in this subsection).

Immediately prior to Event 2, near-bottom currents at the 75 m downslope location were weak (0 to 10 cm/s) and generally directed toward the southwest (200° to 300° T; see Figure 3.3-11). Near-bottom turbidities also were consistently low: less than 10 FTU. Within two minutes of the commencement of cap placement operations, currents increased sharply and remained uncharacteristically steady toward the south-southwest (toward 210° T). Maximum current speeds of approximately 70 cm/s were encountered at the sensor positioned 1.25 m above the bottom. Current speeds associated with this surge event returned to background (pre-placement) levels within 16 min of the placement event.

Near-bottom turbidities during the surge of Event 2 also rose sharply above background levels at the 75 m downslope array location, achieving a maximum of approximately 660 FTU (Figure 3.3-11). These time series data illustrate that the maximum turbidity associated with the surge occurred at the same time as the maximum current speed, and that elevated turbidity nearly as long as the time period of intensified events.

Near-bottom currents during Event 2 at the 250 m downslope location (Figure 3.3-11) were much weaker than those observed at the 75 m downslope location. Approximately 13 min after commencement of cap placement operations, current speeds increased only slightly in association with the horizontal surge, achieving a maximum speed of approximately 16 cm/s which was 10 cm/s above the background current speed immediately prior to the placement event. Current directions during the weak current surge did not change significantly nor did their temporal characteristics, presumably because: 1) the surge was flowing in the direction of the ambient flow; and 2) the surge current was not significantly stronger than the ambient currents of the lower water column.

Near-bottom turbidities at the 250 m downslope location during Event 2 rose slightly above the low background levels, achieving a maximum of 105 FTU (Figure 3.3-11). The elevated turbidities decreased to background levels within approximately 8 min.

These results illustrate that the majority of the momentum (current speed) and suspended particulate load (turbidity) associated with the near-bottom surge from cap placement Event 2 had been dissipated by the time the surge had reached the 250 m downslope array location. At the 250 m location, the surge phenomenon was weak and short-lived. Not surprisingly, the surge effect at the 150 m array location (Figure 3.3-12) was less intense than observed at the 75 m array location, but more intense than at the 250 m location. This figure presents current speed and direction records from the ARESS sensor situated 1.25 m above the bottom, and OBS turbidity records from two sensors, at 0.3 and 1.25 m heights. Ambient currents were weak and directed toward the south-southwest prior to the placement operation. A maximum current speed of 33 cm/s was encountered during the surge while the near-bottom flow continued steadily toward the south-southwest. Maximum turbidities associated with the surge at this array location were approximately 310 FTU at the height of 1.25 m above the bottom.

A fourth array was moored during Event 2 and situated at the 75 m upslope location (Figure 3.3-4). The time series of currents and turbidity from this array are presented in Figure 3.3-13, along with data previously presented from the array moored at the 75 m downslope location. In this figure, we can clearly see that current speeds during this surge event were much greater at the upslope location than at the "symmetrically equivalent" downslope location (having a maximum speed of 70 cm/s). At the upslope location, current speeds in excess of 100 cm/s occurred for two minutes, and speeds in excess of 50 cm/s persisted for four minutes. Hence, this surge at the upslope array location was much stronger and more persistent than observed at the downslope location. It is important, however, to point out that the upslope array was actually 50 m from the actual placement location while the downslope array was 70 m from the placement location (Table 3.3-5).

With regard to the current direction at the 75 m upslope location, background currents were directed toward the south-southwest prior to the placement event (as also observed at the downslope locations), but swung sharply to the north-northeast and east (10° to 90° T) during the surge (Figure 3.3-13). This illustrates that the surge momentum was oriented upslope and directly away from the placement site. The current speed at this upslope location returned to low background levels within about 7 min, but the current direction at this location did not return toward the south for roughly 35 min. This may have been a result of the very weak background current at this time, rather than direct association with the surge process and dynamics.

An interesting physical result that is apparent from the time series records of turbidity at the upslope and downslope locations during Event 2 (Figure 3.3-13) is that the turbidity levels associated with the surge process at the upslope location were considerably lower than those observed at the "symmetrically equivalent" downslope location. For example, the maximum turbidity at the 75 m upslope location was only 400 FTU compared with 660 FTU at the 75 m downslope location. Furthermore, the average turbidity during the first four minutes of the surge event was roughly 200 FTU at the upslope location versus 400 FTU at the downslope location. The significance of this observation will be discussed below during the comparison of results from all placement events.

3.3.4.3 Observations during Cap Placement Event 3

Near-Bottom Currents and Turbidity at the Array Locations

Cap placement Event 3 in Cell LU began at 1058 GMT on August 13, 2000 while the instrumentation was still moored at five locations: one upslope and four downslope from the cap placement

site (Table 3.3-2). Inspection of time series records from the moored instruments revealed that near-bottom current velocities and turbidity increased sharply during the horizontal surge event associated with the cap placement operation, as had been observed during Events 1 and 2 in Cell LU. For example, Figure 3.3-14 presents near-bottom current speed, current direction, and turbidity data acquired at the 75 m and 250 m downslope locations beginning at 1040 GMT on August 13 and extending for roughly 1 hr.

Immediately prior to Event 3, near-bottom currents at the 75 m downslope location were very weak (0 to 10 cm/s) and generally directed toward the east but variable in direction when speeds were low (see Figure 3.3-14). Near-bottom turbidities also were consistently low: less than 10 FTU. Within two minutes of the commencement of cap placement operations currents increased sharply, reaching maximum speeds of 105 cm/s at the sensor positioned 1.25 m above the bottom. Current speeds associated with this surge event dissipated quickly, such that speeds returned to background (pre-placement) levels within 8 min of the placement event.

Currents during the surge event shifted suddenly to the south-southwest (toward 210° T) and remained uncharacteristically steady for the next 10 min until they began to rotate counterclockwise, achieving their original, generally eastward direction. Near-bottom turbidities during the surge of Event 3 rose sharply above background levels at the 75 m downslope array location, achieving a maximum of approximately 605 FTU (Figure 3.3-14). These time series data illustrate that the maximum turbidity associated with the surge occurred at the same time as the maximum current speed, and that the high turbidity persisted for about the same period of time as did the intensified currents.

As during Event 2, near-bottom currents during Event 3 at the 250 m downslope location (Figure 3.3-14) were much weaker than those observed at the 75 m downslope location. Thirteen minutes after commencement of cap placement operations (exactly the same amount of time observed for Event 2), current speeds increased, but only slightly, in association with the horizontal surge. Current directions did, however, change noticeably from eastward to south-southwestward during this weak surge event.

Near-bottom turbidities at the 250 m downslope location during Event 3 rose only slightly above the low background levels, achieving a maximum of 75 FTU (Figure 3.3-14). The elevated turbidities decreased to background levels within approximately 6 min.

These results agree with those of Event 2, further illustrating that the majority of the momentum and suspended particulate load associated with the near-bottom surge from cap placement Event 3 had dissipated by the time the surge had reached the 250 m downslope array location. At the 250 m location, the process was weak and short-lived.

Data from the fourth moored array, situated at the 75 m upslope location, are presented in Figure 3.3-15 along with data from the array moored at the 75 m downslope location to allow comparison of results from opposite sides of the placement site. For Event 3, maximum currents measured at the upslope array (80 cm/s) were somewhat less intense than those at the downslope array (105 cm/s). This differs with the result from Event 2 which exhibited stronger current speeds at the upslope location than were encountered at the equivalent downslope location. This result will be discussed at the conclusion of this section.

With regard to the current direction at the 75 m upslope location, background currents were directed toward the northeast prior to the placement event (as also observed at the downslope locations) and remained eastward during the surge event (Figure 3.3-15), confirming that the surge was oriented upslope and away from the placement site.

Again it was apparent from the turbidity data at the upslope and downslope locations (Figure 3.3-15) that turbidity levels at the upslope location were considerably lower than those observed at the symmetrically equivalent downslope location. For Event 3, the maximum turbidity at the 75 m upslope location was only 390 FTU compared with 605 FTU at the 75 m downslope location.

3.3.4.4 Summary of Observations during Cap Placement Events 1 to 5

Near-bottom observations of currents and turbidity levels during cap placement Events 4 and 5 were generally similar to those of Events 1 through 3 discussed above. Rather than present additional time series plots of individual surge events at specific array locations, here we present a group of tables that provide quantitative results from all five events monitored in Cell LU.

Maximum Speed of Surge Currents

Table 3.3-6 presents the maximum (12-sec averaged) current speed measured at each array location during individual cap placement events monitored in Cell LU. Note that the columns designating array location (i.e., Downslope 75) are approximate; the reader should refer to Table 3.3-5 for actual distances from the moored arrays to the cap placement sites. In this table, we see that maximum current speeds at the D75 location in Cell LU were generally higher than at all other array locations, ranging from 70 to 120 cm/s; as discussed previously, the speed from Event 2 was considerably lower than the other three event observations at location D75 in Cell LU.

Maximum speeds at the D150 location in Cell LU, ranging from 33 to 57 cm/s for the five events monitored (Table 3.3-6), were all substantially (~45%) lower than the average of the maximum speeds at the D75 location. And maximum speeds at the D250 location were much weaker than observed at location D150, with values ranging from 16 to 25 cm/s. Maximum speeds at the U75 location during four events in LU varied considerably, from 70 to 125 cm/s. While the maximum speed at U75 was considerably higher than that observed at D75 for Event 2, the reverse was observed during Events 3 and 4 when speeds at D75 exceeded those at U75.

To illustrate this consistency in results from the various array locations for the multiple events monitored in Cell LU, Figure 3.3-16 presents a composite plot of the maximum near-bottom current speed observed at all array locations during placement Events 1 to 5, versus the horizontal distance from the actual moored array locations to the actual cap placement locations. This figure illustrates the decrease in maximum current speed of the surge as it progressed from 75 m to 250 m downslope from the placement site. The data agree remarkably well at the 150 m and 250 m downslope locations for all events monitored. Nearer the placement site, at the 75 m downslope location, Event 2 had a considerably lower maximum speed than Events 1, 3 and 4, presumably because the hopper may have released its load of cap material as it was moving northward and closer to the upslope moored array that was actually situated only 50 m from the release point (see Table 3.3-5). In the absence of in situ data from closer to the cap placement site, numerical models could be used to predict the maximum horizontal current speed that was associated with the surge of horizontal momentum at the release site. Nevertheless, we can conclude from these results that the radially propagating surge current had lost an appreciable fraction of its initial momentum by the time it was 150 m from the release site at the center of Cell LU. This distance corresponds exactly with the seaward boundary of Cell LU as the cells had 300 m cross-slope dimensions. And it follows that the surge momentum that carried beyond this seaward boundary of Cell LU may not have persisted far before it was overtaken by the variable near-bottom currents in this area. All horizontal momentum may have been lost at a distance of 350 m from the release point at the center of the cell. Note also that the current data discussed here and presented in Figure 3.3-16 include both the surge effects and the ambient, background currents. If the near-bottom background current (i.e.,

~10 cm/s) was subtracted from the observations, the surge effect at the 250 m downslope location was very small.

The maximum currents observed at the upslope array locations in Cell LU exhibit more variability than at the downslope locations (Figure 3.3-16). The data from Events 3 and 4 suggest that currents at the upslope location were considerably less than currents at the same distance downslope from the placement site. Data from Event 2 suggest the opposite, and insufficient spatial data during Event 5 preclude statements about upslope/downslope differences.

Persistence of Surge Currents

To further assess the consistency in results of surge measurements among the five placement events monitored in Cell LU, the persistence of near-bottom current speed within the surge was analyzed. (Note that for this analysis, the speed of the weak (10 cm/s) background current has not been subtracted from the observed current speeds.) Table 3.3-7 presents the persistence (time duration) that currents exceeded specific speed levels for each placement event. For example, near-bottom current speeds exceeded 25 cm/s for durations ranging from 4.25 to 9.5 min at the 75 m downslope location, whereas this speed threshold was exceeded for only 0.25 min during a single placement event at the 250 m downslope location.

Current speeds exceeded 75 cm/s for 1 min during three of the four placement events at the 75 m downslope location but not farther downslope. Only during placement Event 2 did speeds exceed 75 cm/s for 1 min or longer at the 75 m upslope location.

Overall, the persistence results from the five cap placement events monitored demonstrated reasonable consistency and confirmed that intensified near-bottom currents had relatively short durations. Speeds did not exceed 100 cm/s for more than 30 sec at any of the measurement sites nor any of the placement events monitored.

Direction of Surge Currents

Even more consistency is apparent from the current direction results during the five cap placement events monitored in Cell LU. Table 3.3-8 presents a summary of the near-bottom current directions observed at the time of maximum current speed during the individual surge events. For the four events at location D75, the surge was always oriented toward 200 to 220°T, which was essentially downslope from the cap placement point. Downslope surge currents were also evident at the D150 and D250 locations, although more scatter in current directions were encountered, presumably due to a weakening of the surge current and more influence by the ambient near-bottom currents. Nevertheless, the surge current clearly progressed downslope as it transported suspended sediments away from the point of cap material release.

Similar consistency in the direction of the surge current was observed upslope of the cap placement site in Cell LU. At the U75 array location, current directions for four events ranged from 20 to 30° T (Table 3.3-8), which was nearly opposite in direction from the surge observed farther downslope, as would be expected from a point release of vertical momentum that is converted to horizontal momentum spreading radially outward. Figure 3.3-17 shows the direction and magnitude of the maximum-speed current vectors during the surge of Events 1 through 5 in Cell LU. Here we see the consistent direction of the surge spreading in both the upslope and downslope directions away from the central cap release point.

Turbidity Associated with Surge Currents

Table 3.3-9 presents the maximum near-bottom turbidity associated with the surge current as measured at each array location during individual cap placement events monitored in Cell LU. In this

table, we see that maximum turbidities at the D75 location in Cell LU were generally higher than those observed at other array locations, with maxima ranging from 400 to 660 FTU. Maximum turbidities at the D150 location in Cell LU, ranging from 305 to 505 FTU for the five events monitored (Table 3.3-9), were substantially lower than the maximum turbidities at the respective (event-correlated) D75 locations. Maximum turbidities at the D250 location were much weaker than those observed at location D150 and were moderately variable, with values ranging from 75 to 200 FTU among the three events monitored. Overall, these data demonstrate that turbidities contained within the downslope-propagating surge current decrease with distance away from the point of cap material release.

Maximum turbidities at the U75 upslope location during four events in LU were relatively consistent, ranging from 305 to 400 FTU. These values were considerably less than those observed at the same time (during the same event) at the downslope D75 location, indicating that the surge current possessed less suspended particulate matter as it moved upslope compared with the suspended load moving downslope.

To allow visual comparison of turbidity results from the various array locations for the multiple events monitored in Cell LU, Figure 3.3-18 presents a composite plot of the maximum near-bottom turbidity observed at all array locations during placement Events 1 to 5, versus the horizontal distance from the array locations to the cap placement locations. This figure illustrates the decrease in maximum turbidity of the surge as it progresses from 75 to 250 m downslope from the placement site. There was considerable scatter among the various downslope "maximum" observations, but more consistency among the surge events may have been achieved if the total load of suspended particulate were calculated rather than just the maximum value observed. The three observations at the 250 m location were, however, in close agreement. From these results we can conclude that the radially propagating surge current had lost a large fraction of its initial particulate load by the time it was 250 m from the release site at the center of Cell LU. The maximum turbidities at the 75 m upslope array locations in Cell LU were generally less than those observed at the same distance downslope from the placement site.

3.3.4.5 Vertical Profiles of Horizontal Currents during Placement Events 2 to 5

The ADCP mounted on the ARESS array located 75 m downslope of the placement site acquired current velocity data for approximately 3 days from August 11-14, 2000. This deployment period spanned placement Events 2 through 5, all of which occurred on August 13. The velocity data acquired by the ADCP consists of individual time series records (averaged over 1-min time intervals) from each of 39 depth layers starting 3 m above the bottom. Figure 3.3-19 presents a composite of current speed records from seven depth layers starting at 43 m and continuing upward to the 5 m layer; Figure 3.3-20 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 43 m measurement level (lowest tier in Figure 3.3-19) illustrates weak bottom currents that range from approximately 2 to 22 cm/s as had been observed during the initial ADCP deployment in Cell LU on August 1-2. Current speeds were considerably higher at the shallower 5 m depth, with maximum speeds near 50 cm/s. In general, current speeds exhibited strong vertical coherence in the lower 30 m of the water column, with maximum speeds being encountered at roughly the same time throughout much of the water column. Speeds near the surface were, on the other hand, uncorrelated with the lower layers. The highest current speeds encountered in the lower water column from August 11-14 occurred at 24-hr intervals, after alternate high tides as shown in Figure 3.3-19.

Current directions were generally onshore (northward or eastward) for the 3-day current record at the 5 m depth level (Figure 3.3-20). Directions were much more variable in the lower third of the

water column where currents were weaker. When current speeds were highest in the lower portion of the water column, this occurred when flow was northwestward (offshore) as had been observed during August 1-2 (Figures 3.3-9 and 3.3-10).

Near-bottom water temperatures varied over time scales of hours to days, with a range of variability of roughly 1°C over the 3-day record. Temperatures were not well correlated with changes in current speed or direction.

Also shown in Figure 3.3-19 are the times of cap placement Events 2 through 5. At the 43 m depth level, brief high-speed periods are observed at the time of each event, corresponding with intensified 1-min-averaged current speeds. These four high-speed events clearly stand out above the weak background currents near the bottom. Each of these speed maxima (one per event) exceed 30 cm/s for the 1-min averages at 43 m, compared to the background currents which were below 20 cm/s. Some of the brief events are also represented by intensified currents at higher levels in the water column, but above 40 m (6 m above the bottom), the effect of the surge current is sometimes difficult to distinguish from the background currents.

An expanded view of the ADCP current speed time series over the 16-hr period spanning placement Events 2 through 5 is shown in Figure 3.3-21. At the 43 m depth level, the brief surge events stand out above the weak background currents for all four events, but at 41 m only Events 3 and 5 are clearly distinguishable. At 29 m, only a hint of surge Events 3 and 5 is noticeable in the speed record. Event 3 was the only event that was detectable at the 40 m depth level (6 m above the bottom). Near the surface, the short-term variability in ambient current speed is sufficiently high that we cannot, with confidence, attribute any of the speed variability to placement events.

The near-bottom water temperature record from the ADCP (top tier in Figure 3.3-21) illustrates that the water and/or suspended particulate matter contained in the surge current was warmer than that of the ambient near-bottom waters. Relatively sudden temperature increases of 0.3 to 0.4°C correspond with each placement event.

The expanded time series of current direction from the ADCP, spanning placement Events 2 through 5 (Figure 3.3-22), shows a great deal of high-frequency variability that makes it difficult to identify the placement events. Close inspection of current directions at the 43 m depth level does, however, reveal that during each of the four events the brief surge current at this 75 m downslope array location was directed toward 200°T in agreement with the ARESS results presented in the previous subsection. The near-constant (onshore) current direction at the 5 m depth level contrasts greatly with the more variable current directions at greater depths.

3.3.4.6 Conceptual Model of Surge as Radially Spreading Annulus

The in-situ observations of near-bottom currents within the horizontal surge have been used to develop a conceptual model of this dynamic, radially spreading feature. For this discussion, data acquired during conventional placement Event 4 in Cell LU are used as a quantitative example of the dynamics and spatial characteristics of this surge feature. "Time 0" is defined as the time when material is being released from the stationary dredge. Immediately under the hopper dredge at Time 0, the downward momentum of the descending dredged material impacts the seafloor and much of this energy is transformed into a relatively strong horizontal current directed radially outward from the central placement position beneath the dredge. In the near-field region within 75 m of the placement site, horizontal current velocities in the leading edge of the surge were high (i.e., maximum speeds of 100 cm/s at the 75 m downslope location). As the surge passed the 75 m downslope (D75) array location,

intensified currents persisted for 11 min then subsided to pre-placement velocities. Thus, the surge feature propagated outward as an annulus (ring) with ever-increasing radius but with continually decreasing horizontal velocities. Current velocities at the leading edge of the annulus were substantially higher than those that followed. Similarly, near-bottom turbidity in the leading edge of the spreading annulus was much higher than values in the trailing portion of the surge. This observation supports the hypothesis that the surge may have (in close proximity to the placement site where current speeds were high) resuspended bottom sediments.

The observations of surge speed and persistence can be used to estimate the radial width of the annulus and its temporal/spatial variability. For example, when the annulus passed the D75 array location in Cell LU during Event 4, the surge persisted for 11 min. Using the average speed of the surge during its passage at the D75 location (33.2 cm/s), the radial dimension of the annulus was approximately 220 m (660 s times 33.2 cm/s). Figure 3.3-23 illustrates this annulus width at Time 1-D when the surge had ended at the D75 location. Time 1-U, Time 2 and Time 3 correspond with the end of the surge at the U75, D150 and D250 locations, respectively.

The surge during Event 4 at the U75 location had shorter duration (7 min) than at the D75 location and the average speeds were comparable at the two locations (37.3 cm/s at U75 vs 33.2 cm/s at D75). As the annulus propagated past the U75 location its width was 157 m, which was 20% less than observed at the same distance on the downslope side of the placement site. This observation indicates that the annulus was decaying at a greater rate in the upslope direction, most likely due to the bottom slope.

When the surge passed the D250 array, the radially directed currents persisted for only 6 min and the average speed was substantially lower (17 cm/sec) than observed nearer the placement site. These characteristics correspond with an annulus width of 61 m (at Time 3 in Figure 3.3-23) compared with 220 m when the annulus passed the D75 location. Thus, both the annulus propagation speed and the width of the annulus were decreasing with distance from the placement site. This was expected, based upon conservation of momentum within the radially spreading surge and energy dissipation from bottom friction. These results demonstrate that, a few hundred meters from the placement site, the radially spreading surge had lost most of its horizontal momentum and therefore, was much less effective at: 1) transporting suspended sediment originating from the placement site, and 2) eroding in-place bottom sediments in the path of the surge.

Table 3.3-1. Summary of moored array deployments during selected cap placement events in Cells LU, SU, and LD

Cell	Array Deployment	Placement Event	Placement Date	Material Source	Placement Technique	Material Volume Released (m^3)	Placement Duration (min:sec)	Local Placement Rate (m^3/min)
LU	1	1	8/2/2000	Queen's Gate	Conventional	1022	3:01	338.8
SU	2	1	8/8/2000	Queen's Gate	Conventional	1077	3:10	340.1
LU	3	2	8/13/2000	Queen's Gate	Conventional	939	3:11	295.0
LU	3	3	8/13/2000	Queen's Gate	Conventional	1037	2:17	454.2
LU	3	4	8/13/2000	Queen's Gate	Conventional	953	2:43	350.8
LU	3	5	8/13/2000	Queen's Gate	Conventional	995	2:07	470.1
LD	4	1	8/15/2000	Borrow Area	Spreading	967	10:07	*

* Rate not computed because dredge was not stationary at array location.

Table 3.3-2. Matrix of current/turbidity instrumentation used for the various deployments in Cells LU, SU, and LD

Cell	Material placement event	Material placement date	Material placement time (GMT)	Mooring deployment	Oceanographic dataset name	Mooring Location	Water Depth (m)	Aquadopp current sensors	OBS turbidity sensors	ARESS current sensors	OBS turbidity sensors	ADCP current profiler
LU	1	8/2/2000	19:21	1	PV-A-1	75 m Downslope	45	1	1	2	2	1
		"	"	"	PV-B-1	150 m Downslope	46	1	1			
SU	1	8/8/2000	18:34	2	Mooring Moved	150 m Upslope	59	1	1			
		"	"	"	PV-J-1	75 m Upslope	60	1	1			
		"	"	"	PV-G-1	75 m Downslope	64			2	2	1
		"	"	"	PV-H-1	115 m Downslope	65			2	2	
		"	"	"	PV-I-1	170 m Downslope	74			2	2	
		"	"	"	PV-K-1	475 m Downslope	174	1	1			
LU	2, 3, 4 & 5	8/13/2000	4 different times	3	PV-D-2	75 m Upslope	42	1	1			
		"	"	"	PV-A-2	75 m Downslope	45			2	2	1
		"	"	"	PV-B-2	150 m Downslope	46			1	2	
		"	"	"	PV-C-2	250 m Downslope	47			2	2	
LD	1	8/15/2000	19:15	4	PV-P-1	75 m Upslope	42	1	1			
		"	"	"	PV-L-1	75 m Downslope	43			2	2	1
		"	"	"	PV-M-1	150 m Downslope	48			1	2	
		"	"	"	PV-N-1	250 m Downslope	49			2	2	
East of cells LU and SU	None (array not within cells)	30-day record		2 separate deployments	PV-X	East of cells LU & SU	52					1

Table 3.3-3. Summary of data return from current measurement equipment deployed in Cells LU, SU and LD

						Array Locations							
Cell	**Material placement event**	**Material placement date**	**Material placement time (GMT)**	**Mooring deployment**		**150 m Upslope**	**75 m Upslope**	**75 m Downslope**	**115 m Downslope**	**150 m Downslope**	**170 m Downslope**	**250 m Downslope**	**475 m Downslope**
LU	1	8/2/2000	19:21	1				100%		100%			
								100%					
								Ended before placement					
SU	1	8/8/2000	18:34	2		Mooring moved	100%	No data	100%		100%		100%
								100%					
LU	2	8/13/2000	7:32	3			100%	100%		100%		100%	
								100%					
LU	3	8/13/2000	10:58	3			100%	100%		100%		100%	
								100%					
LU	4	8/13/2000	16:59	3			100%	100%		100%		100%	
								100%					
LU	5	8/13/2000	20:19	3			100%	Battery expired		100%		Battery expired	
								100%					
LD	1	8/15/2000	19:15	4			100%	100%		100%		100%	
								100%					

ARESS current sensor Aquadopp current sensor ADCP current profiler

Table 3.3-4. Data Quality Objectives for moored current and optical backscatter measurements

Monitoring Objective	Data Requirements	Monitoring Approach	Field Decision Criteria/Performance Specifications
Determine extent of current surge caused by placement of cap materials.	Surge velocities at varying distances from discharge point.	Measure currents during a single placement and interim placement events at varying distances from the planned placement point using multiple moored ADCP system for both conventional and spreading placement.	Geographic accuracy of both the moored arrays and cap placement point should be within 5 meters of specified coordinates.
Determine suspended particle levels in plume created by cap placement	Suspended sediment levels at specified distances from the cap placement location following placement event.	Measure suspended particle loads using moored optical backscatter sensor.	Same as above.

Table 3.3-5. Actual distances from moored arrays to cap placement locations for all events monitored in Cells LU, SU, and LD

			Actual distances (m) from moored arrays to placement locations					
Cell	**Deployment**	**Event**	**Upslope "150"**	**Upslope "75"**	**Downslope "75"**	**Downslope "150"**	**Downslope "250"**	**Downslope "475"**
LU	1	1	nd	nd	100	165	nd	nd
	3	2	nd	50	70	150	250	nd
	3	3	nd	55	80	160	260	nd
	3	4	nd	75	70	135	240	nd
	3	5	nd	75	60	140	240	nd
SU	2	1	*155	80	60	115	170	475
LD	4	1	nd	80	60	145	240	nd

nd = no deployment
*indicates array moved to downslope 475 location

Table 3.3-6. Maximum near-bottom current speeds observed at array locations during placement Events in Cells LU, SU, and LD. Current sensors were situated 1.0 to 1.25 m above the bottom

			Maximum near-bottom current speed (cm/s)					
Cell	**Deployment**	**Event**	**Upslope "150"**	**Upslope "75"**	**Downslope "75"**	**Downslope "150"**	**Downslope "250"**	**Downslope "475"**
LU	1	1			120	57		
	3	2		125	70	33	16	
	3	3		80	105	50	18	
	3	4		70	100	42	25	
	3	5		85	x	50	x	
SU	2	1	x	55	x	72	63	29
LD	4	1		35	35	33	20	

x = no data acquired

Table 3.3-7 Persistence of bottom surge current within various speed ranges for placement Events 1 to 5 in Cell LU

Cell LU - Velocity Data Summary

	75 m Upslope Array				*75 m Downslope Array*			
	Event 2	*Event 3*	*Event 4*	*Event 5*	*Event 1*	*Event 2*	*Event 3*	*Event 4*
Speed (cm/s)	Time*	Time*	Time*	Time*	Time*	Time*	Time*	Time*
>100	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
>75	2.25	0.25	0.00	0.50	1.00	0.00	1.00	1.00
>50	3.00	2.50	0.50	1.50	3.00	1.75	2.00	2.00
>25	6.00	6.50	6.00	4.50	9.50	4.25	4.75	6.75

	150 m Downslope Array					*250 m Downslope Array*		
	Event 1	*Event 2*	*Event 3*	*Event 4*	*Event 5*	*Event 2*	*Event 3*	*Event 4*
Speed (cm/s)	Time*	Time*	Time*	Time*	Time*	Time*	Time*	Time*
>100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>75	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
>50	1.25	0.00	0.25	0.00	0.25	0.00	0.00	0.00
>25	6.25	1.50	2.50	3.00	1.5	0.00	0.00	0.25

**Persistence time reported in minutes*

Table 3.3-8. Current directions at the time of maximum near-bottom current speeds (Table 3.3-6) observed at array locations during placement events in Cells LU, SU, and LD

			Current directions (deg T) at maximum near-bottom current speed					
Cell	**Deployment**	**Event**	**Upslope "150"**	**Upslope "75"**	**Downslope "75"**	**Downslope "150"**	**Downslope "250"**	**Downslope "475"**
LU	1	1			210	190		
	3	2		25	210	220	210	
	3	3		20	220	205	225	
	3	4		30	200	205	220	
	3	5		25	x	220	x	
SU	2	1	x	20	x	230	240	160
LD	4	1		20	200	230	250	

x = no data acquired

Table 3.3-9. Maximum near-bottom turbidity at the time of maximum current speeds (Table 3.3-6) observed at array locations during placement events in Cells LU, SU, and LD

			Maximum near-bottom turbidity (FTU)					
Cell	**Deployment**	**Event**	**Upslope "150"**	**Upslope "75"**	**Downslope "75"**	**Downslope "150"**	**Downslope "250"**	**Downslope "475"**
LU	1	1			600	505		
	3	2		400	660	310	105	
	3	3		390	605	490	75	
	3	4		305	400	305	200	
	3	5		395	x	360	x	
SU	2	1	x	360	x	510	505	270
LD	4	1		44	108	42	25	

x = no data acquired

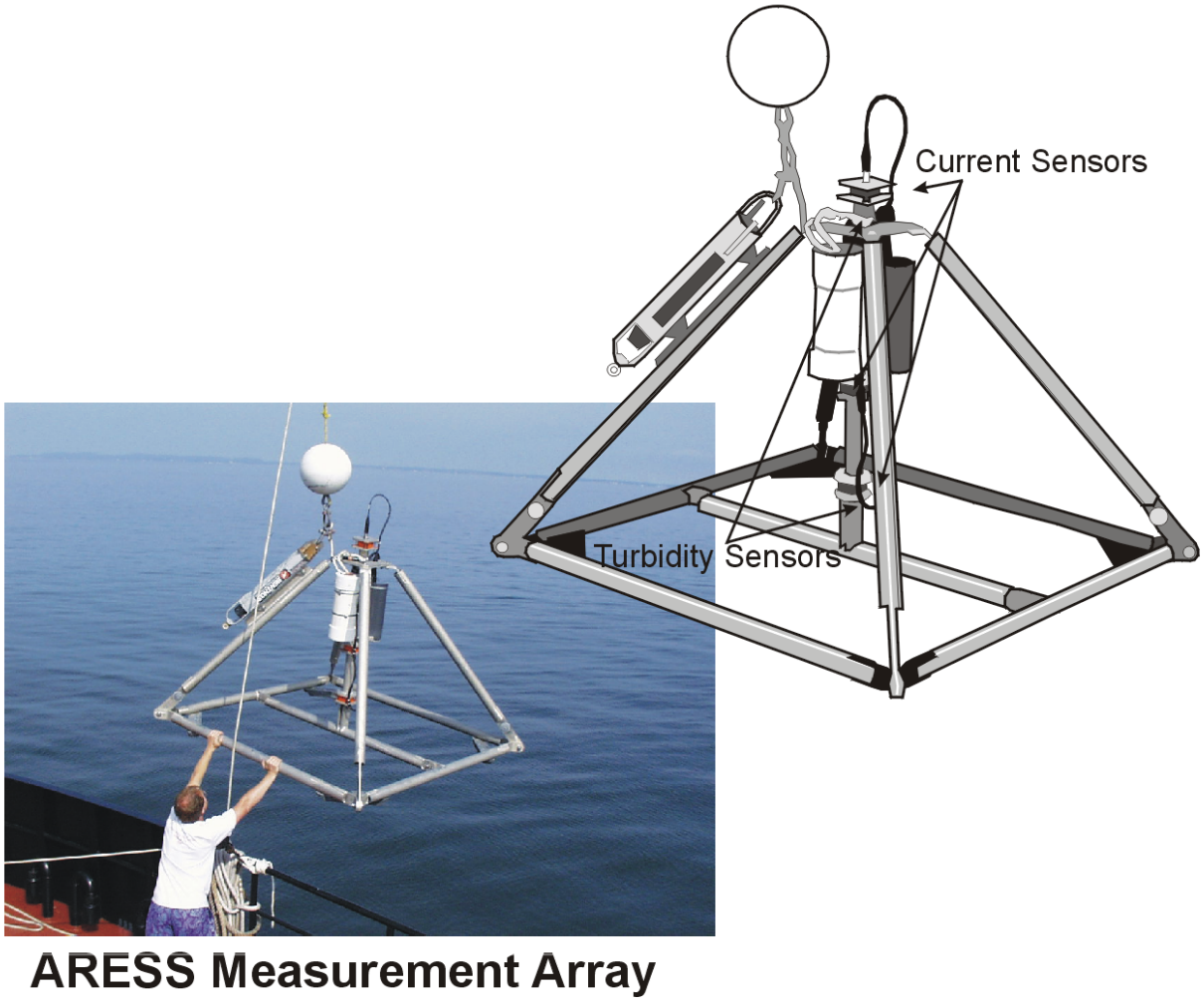


Figure 3.3-1. Photograph of ARESS array being deployed from a survey vessel.

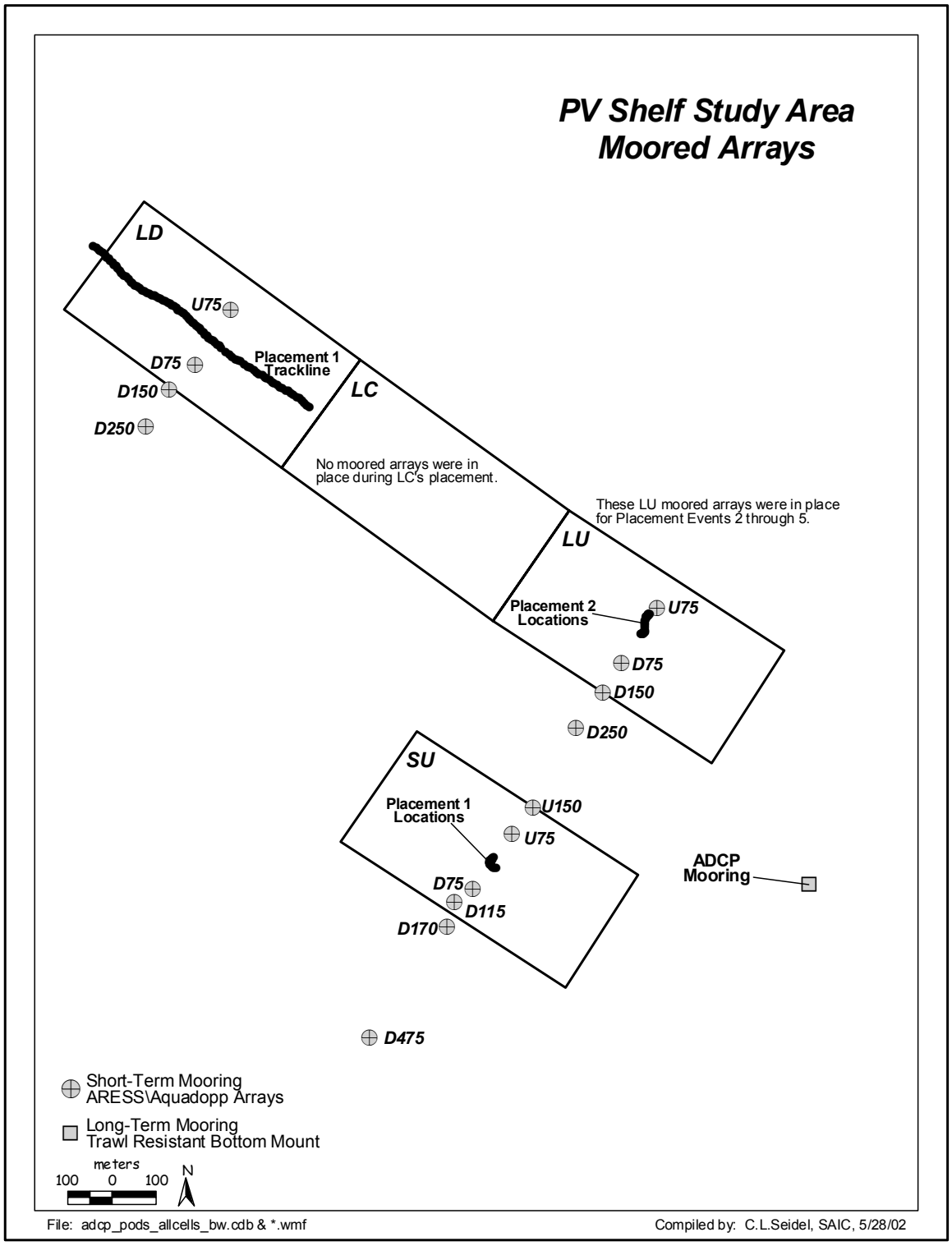


Figure 3.3-2. Map showing placement cells and location of moored instrumentation during placement events.

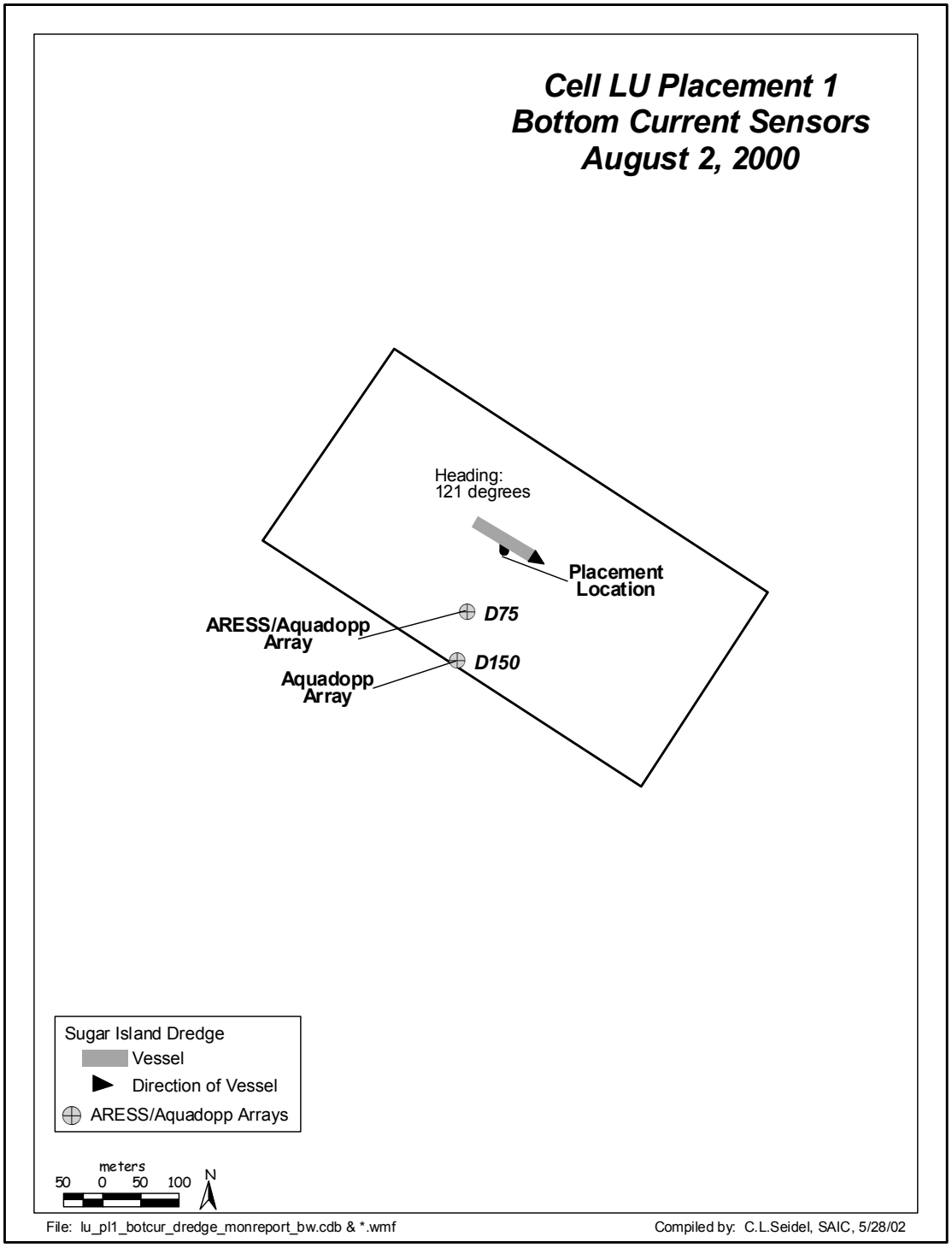


Figure 3.3-3 Map illustrating location of moored instrumentation during placement Event 1 in Cell LU, as well as the position and heading of the hopper dredge during the placement operation. The dredged drifted slightly to the south as shown in black.

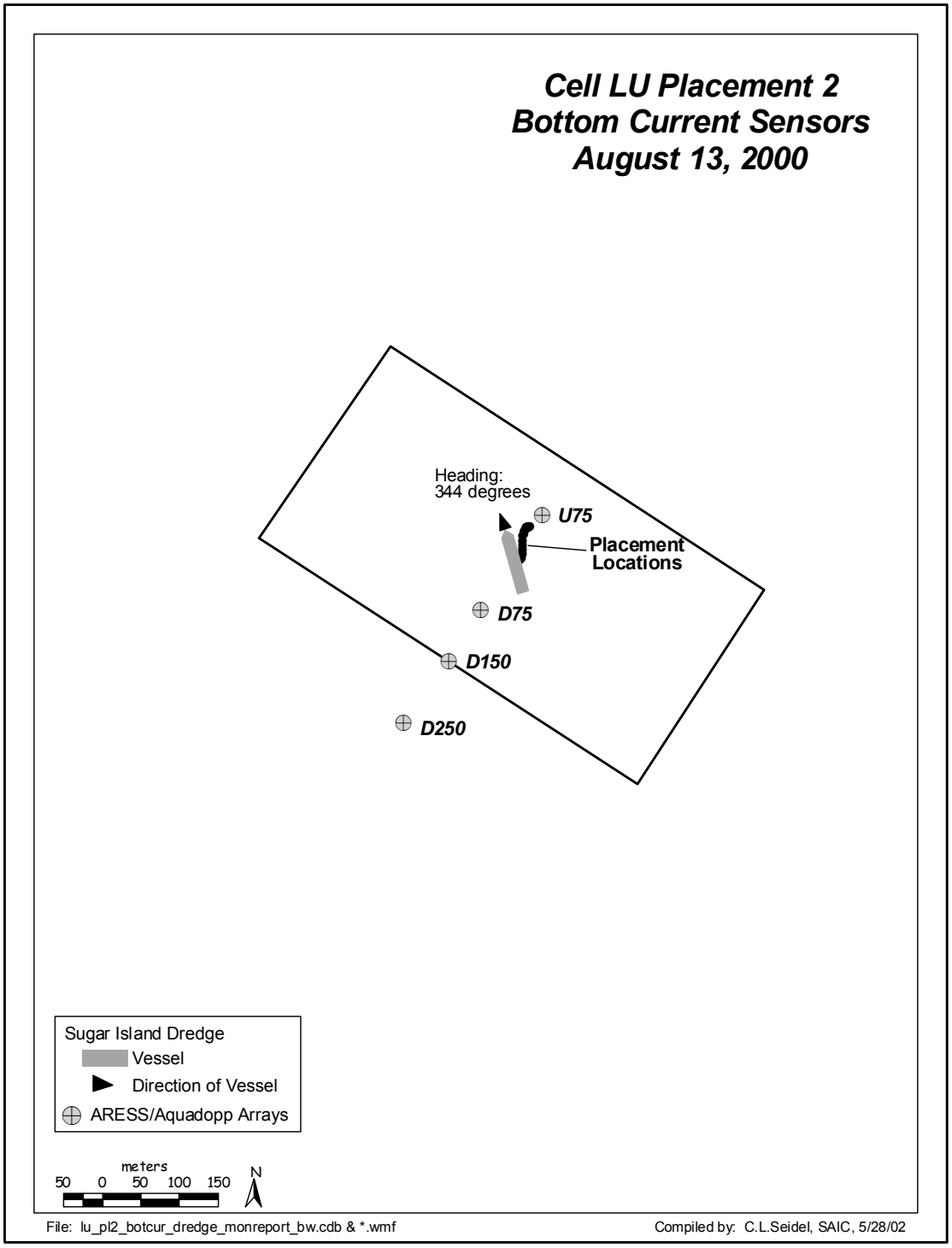


Figure 3.3-4. Map illustrating location of moored instrumentation during placement Event 2 in Cell LU, as well as the position and heading of the hopper dredge during the placement operation. The dredged drifted northward along the track shown in black.

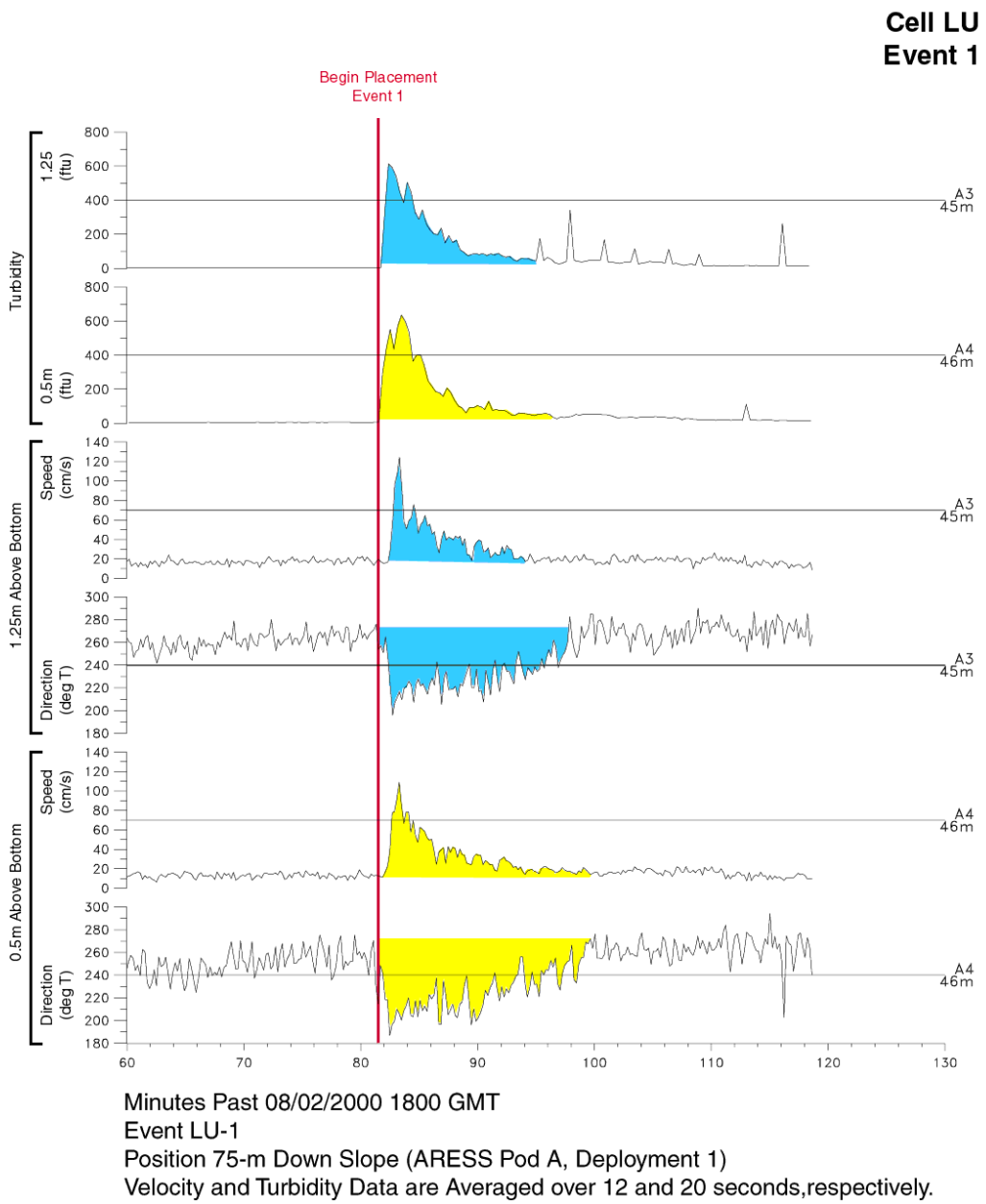


Figure 3.3-5. Time series plot of near-bottom data from the 75 m downslope location in Cell LU during cap placement Event 1 on August 2, 2000. Turbidity from two near-bottom sensor levels (upper two tiers); current speed and direction from 1.25 m above the bottom (middle two tiers); and current speed and direction from 0.5 m above the bottom (lower two tiers).

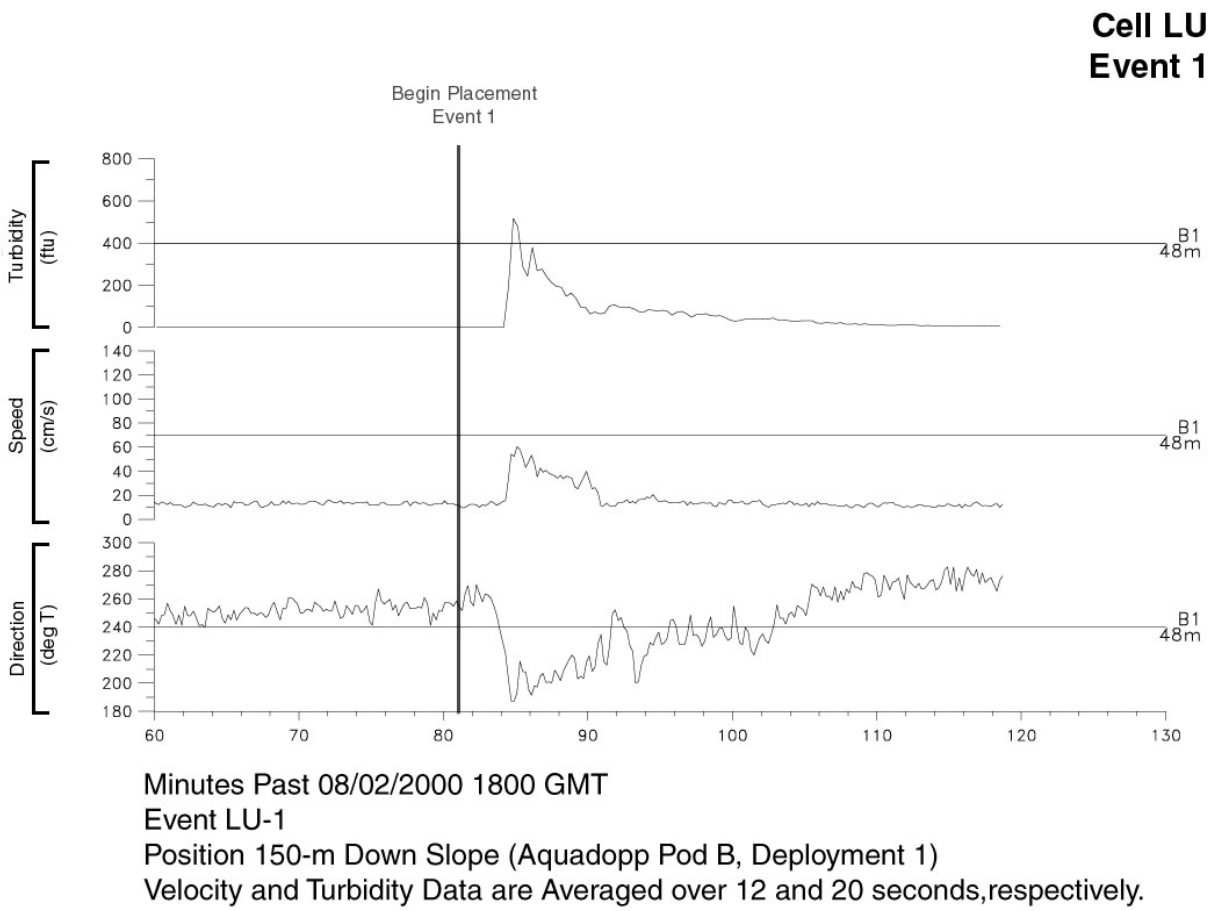


Figure 3.3-6. Time series plot of near-bottom data from the 150 m downslope location in Cell LU during cap placement Event 1 on August 2, 2000. Turbidity, current speed, and current direction from 1.0 m above the bottom.

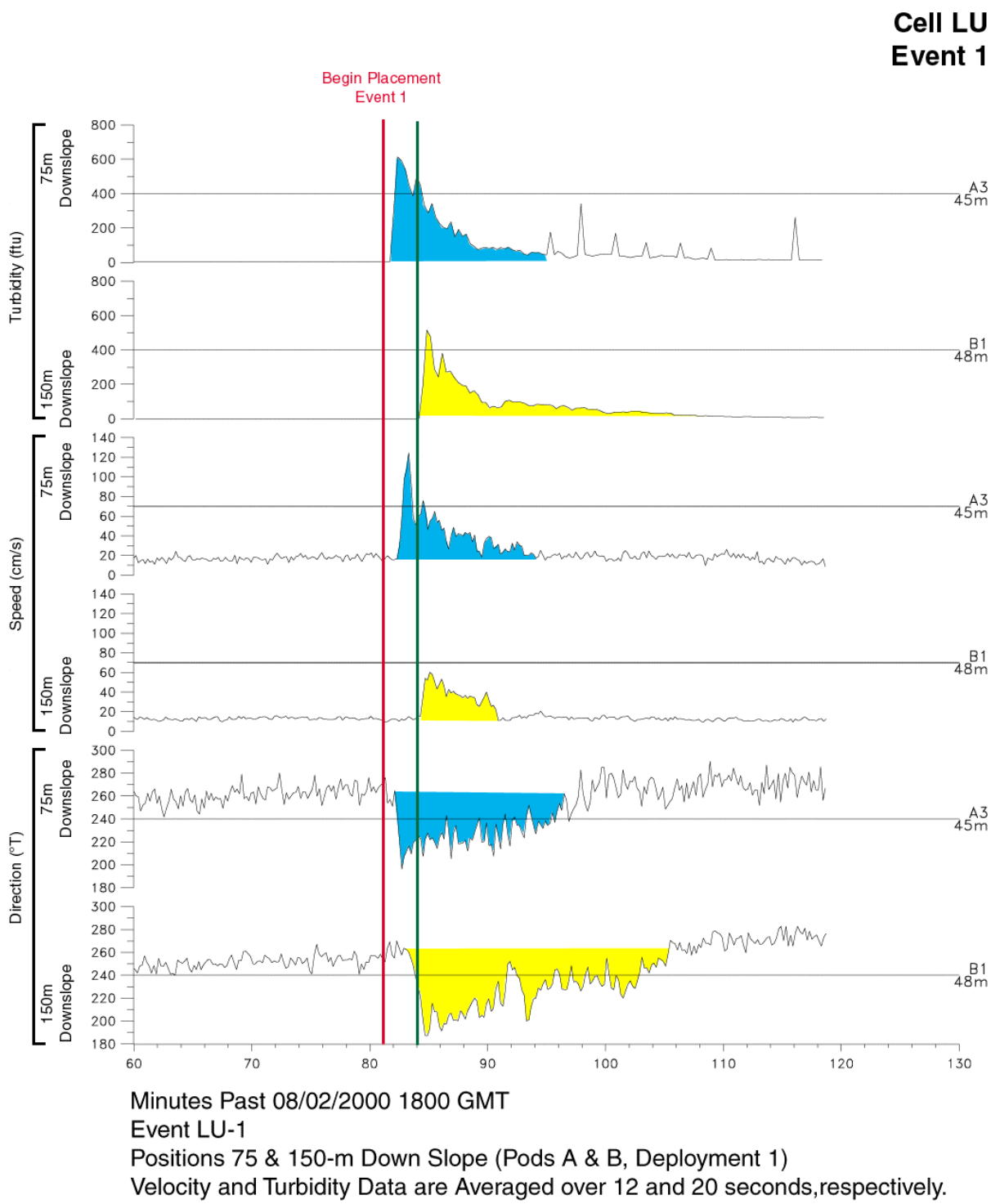


Figure 3.3-7. Time series plot of near-bottom data from the 75 m and 150 m downslope locations in Cell LU during cap placement Event 1 on August 2, 2000. Turbidity from the two locations (upper two tiers); current speed from the two locations (middle two tiers); and current direction from the two locations (lower two tiers).

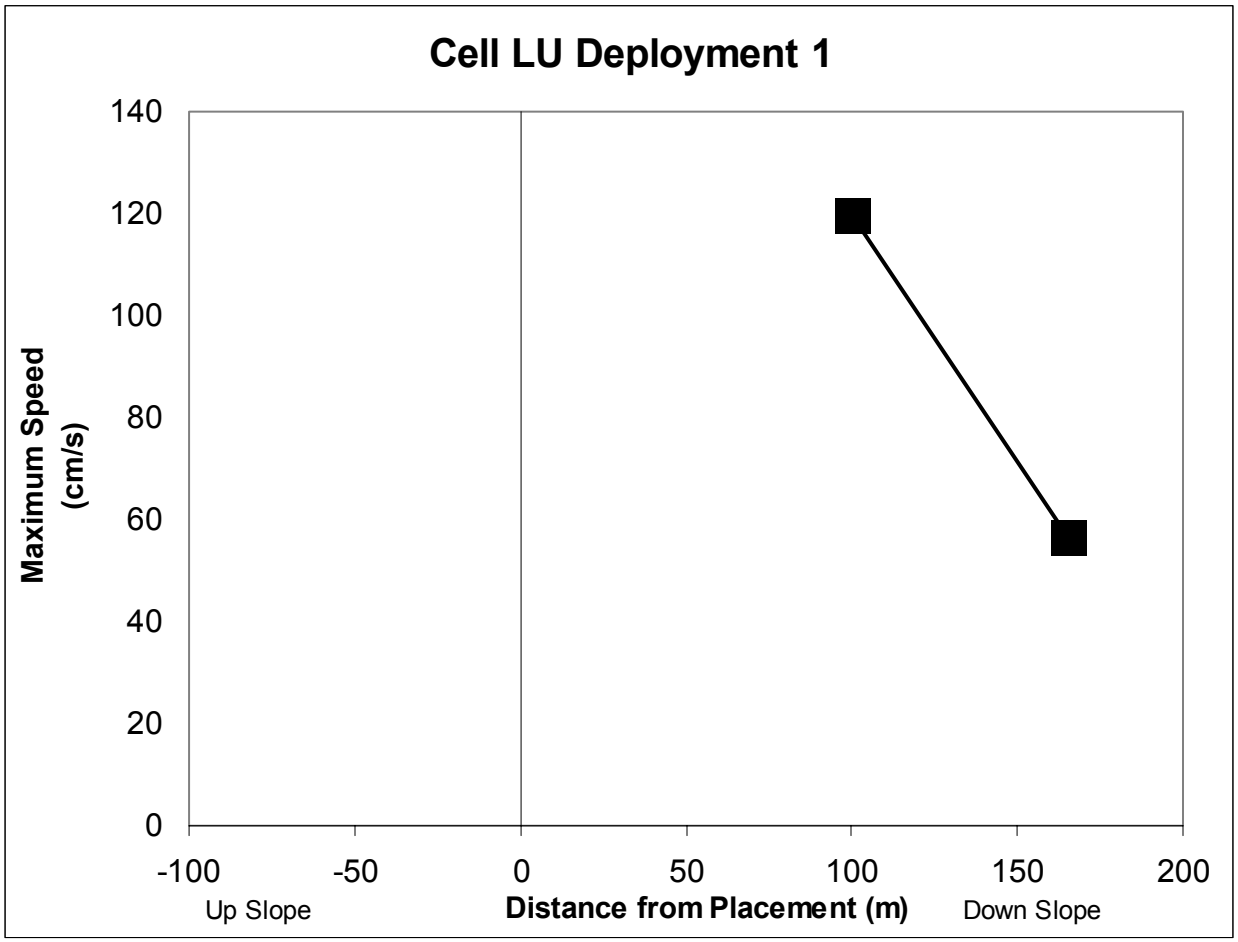


Figure 3.3-8. Plot of the maximum near-bottom current speed (y-axis) observed during cap placement Event 1 at two array locations within Cell LU versus the horizontal distance (x-axis) from the moored array location to the actual cap placement location (dredge position).

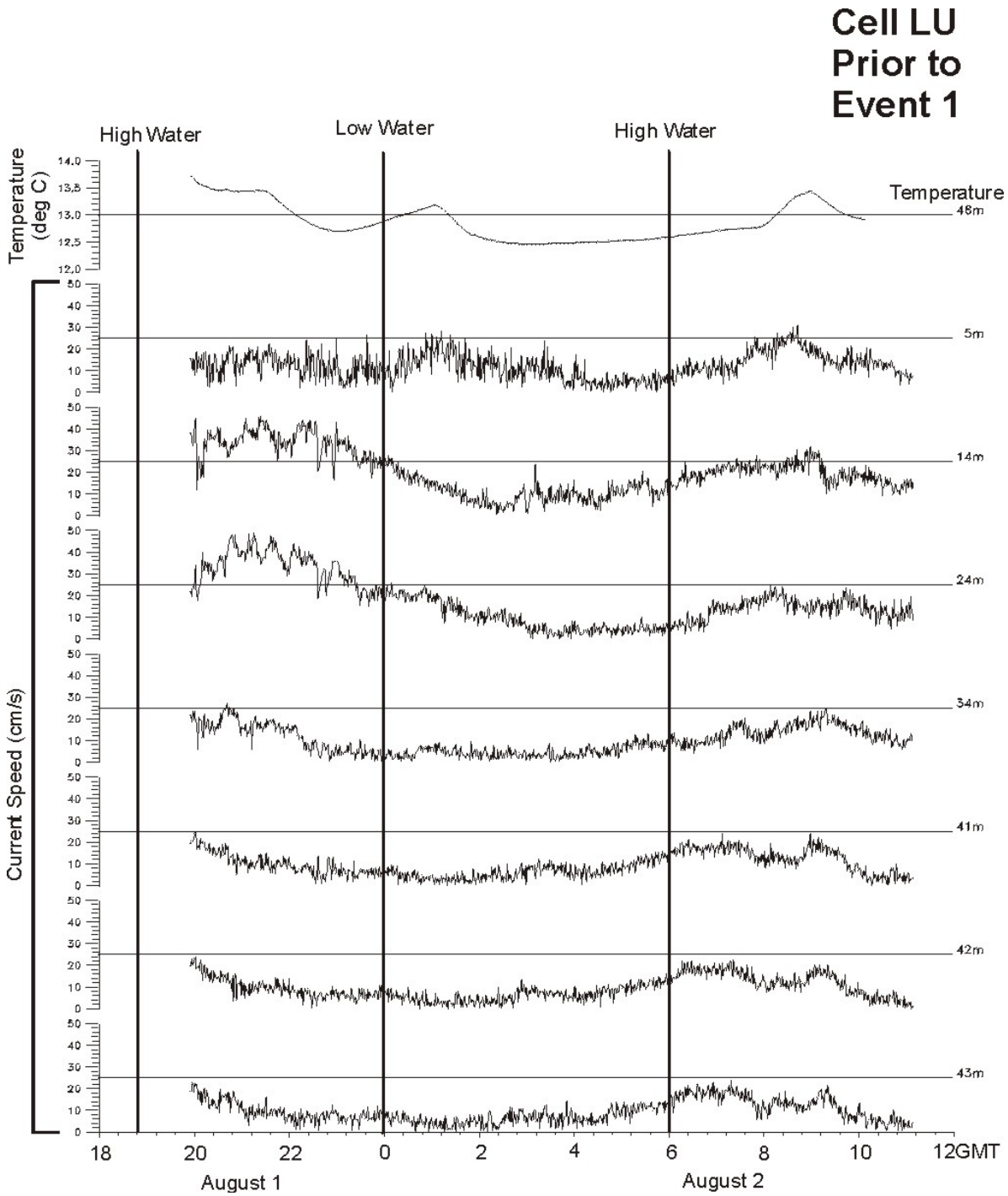


Figure 3.3-9. Time series plot of ADCP data from the 75 m downslope location in Cell LU on August 1-2, 2000 (prior to cap placement Event 1). Water temperature from 1 m above the bottom (top tier). Lower tiers present current speed data from seven 1 m thick depth levels extending from 5 m to 43 m (which was 3 m above the bottom). Data are 1-min averages. The times of high and low water at the NOAA tide station in Outer Los Angeles Harbor are also shown.

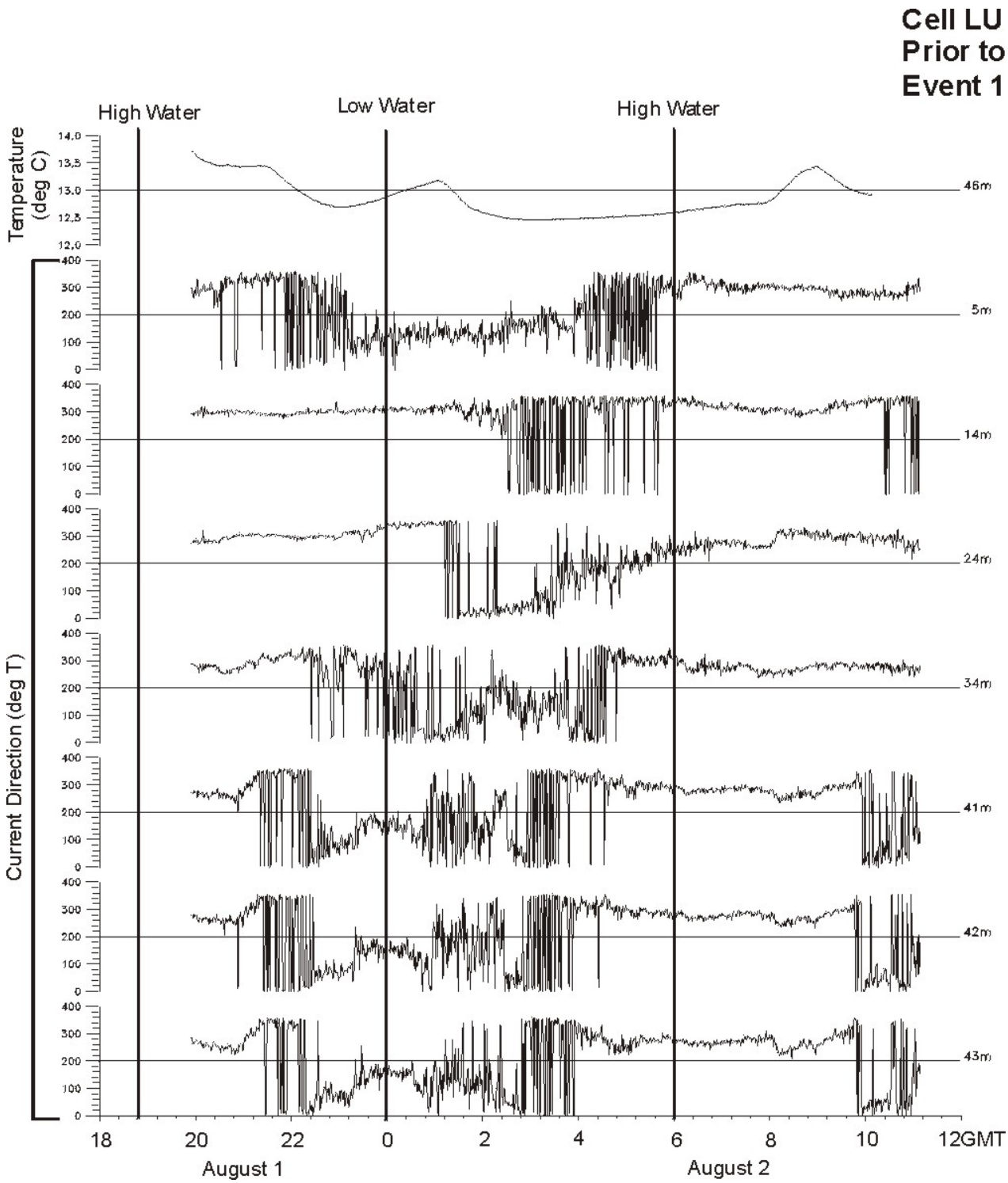


Figure 3.3-10. Time series plot of ADCP data from the 75 m downslope location in Cell LU on August 1-2, 2000 (prior to cap placement Event 1). Water temperature from 1 m above the bottom (top tier). Lower tiers present current direction data from seven 1 m thick depth levels extending from 5 to 43 m (which was 3 m above the bottom). Data are 1-min averages.

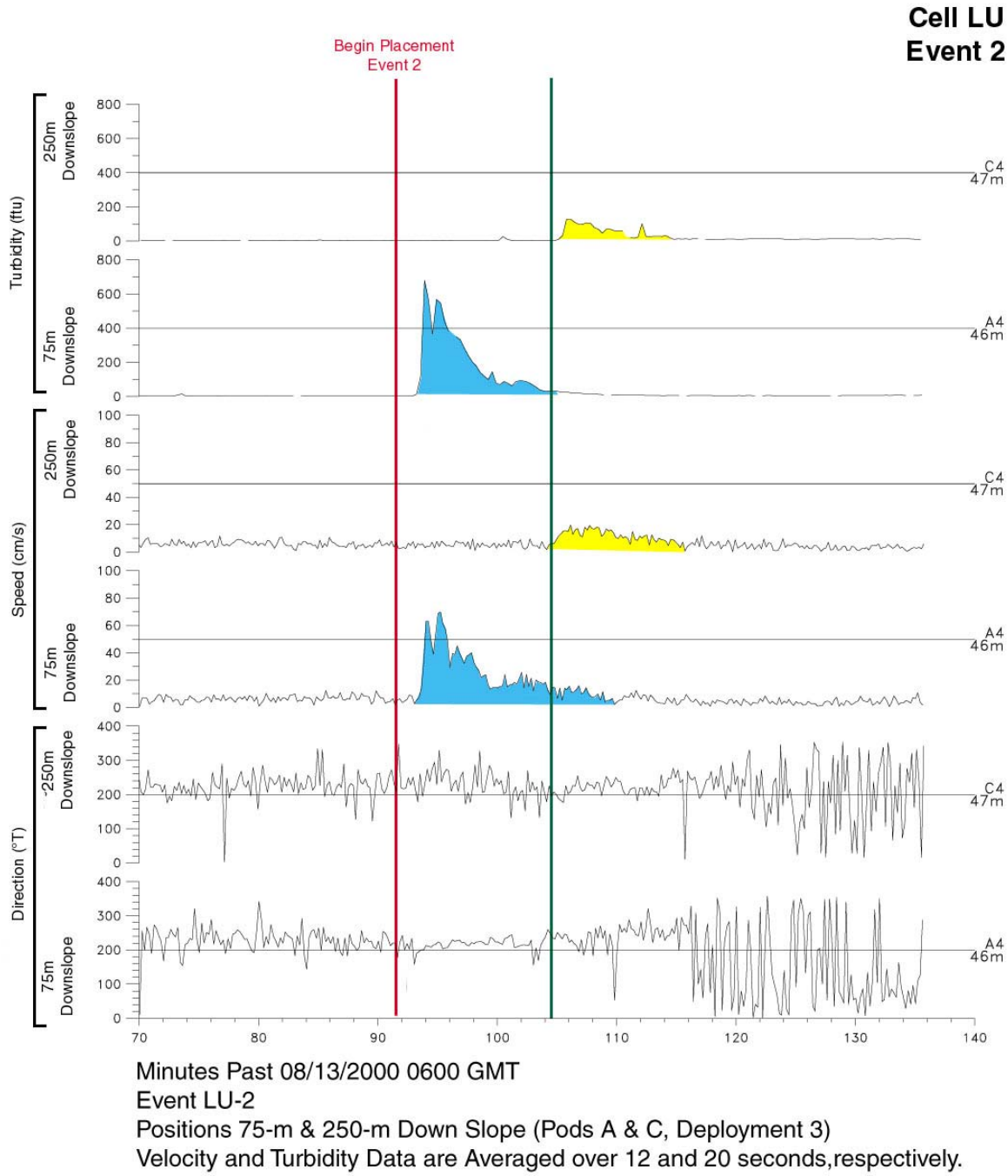


Figure 3.3-11. Time series plot of near-bottom data from the 75 m and 250 m downslope locations in Cell LU during cap placement Event 2 on August 13, 2000. Turbidity from the two locations (upper two tiers); current speed from the two locations (middle two tiers); and current direction from the two locations (lower two tiers).

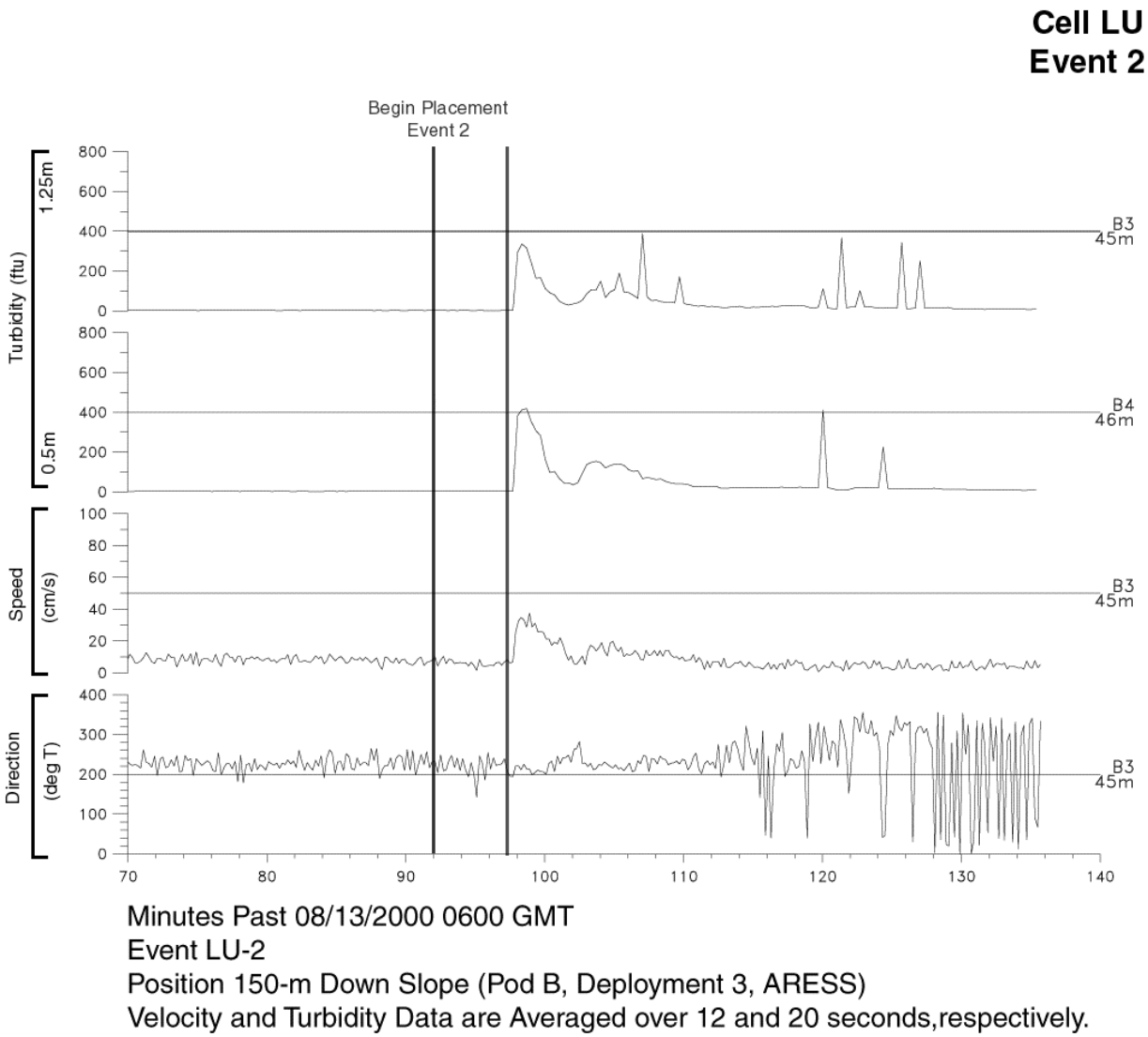


Figure 3.3-12. Time series plot of near-bottom data from the 150 m downslope location in Cell LU during cap placement Event 2 on August 13, 2000. Turbidity from two near-bottom sensor levels (upper two tiers); current speed and direction from 1.25 m above the bottom (lower two tiers).

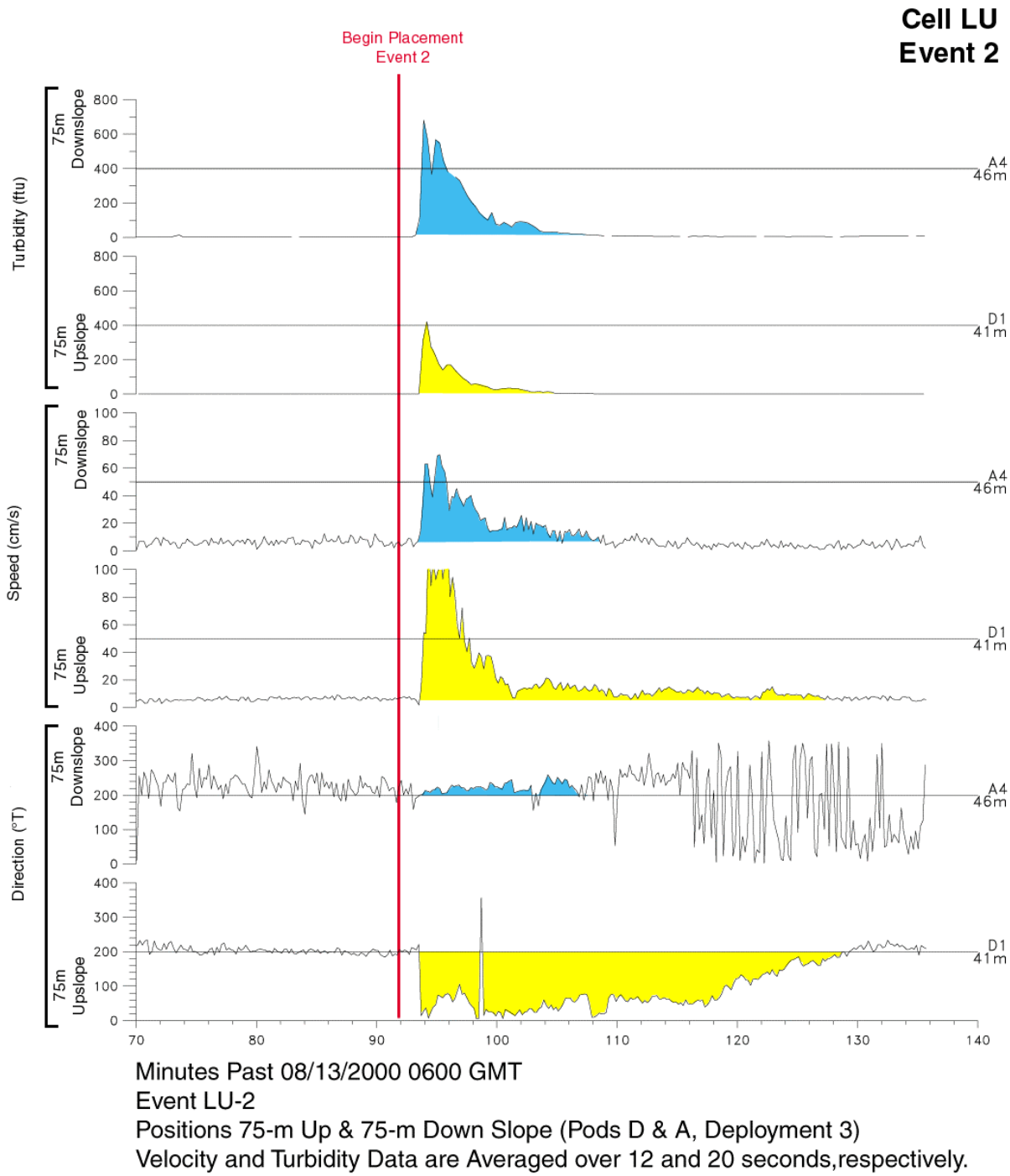


Figure 3.3-13. Time series plot of near-bottom data from the 75 m upslope and 75 m downslope locations in Cell LU during cap placement Event 2 on August 13, 2000. Turbidity from the two locations (upper two tiers); current speed from the two locations (middle two tiers); and current direction from the two locations (lower two tiers).

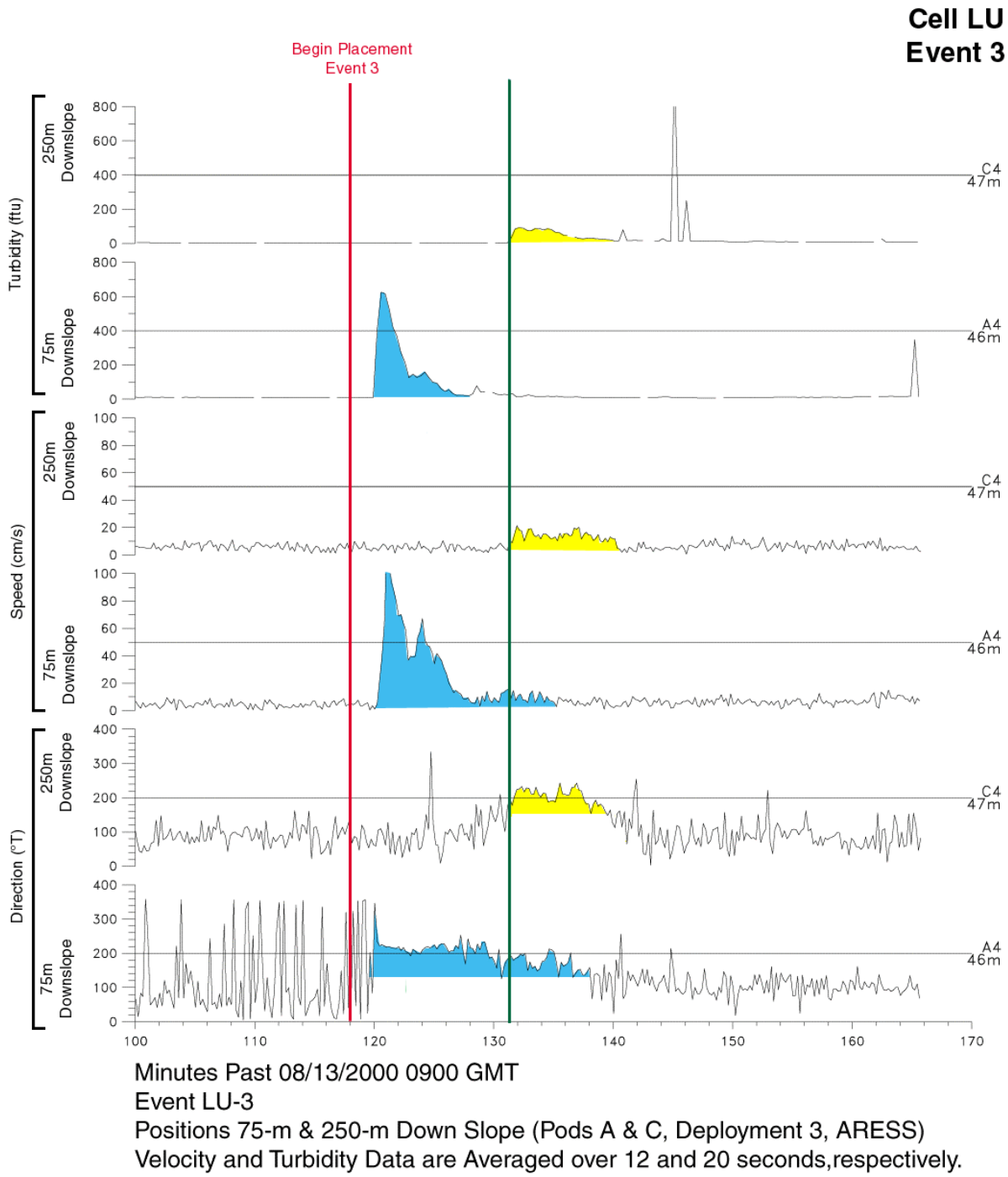


Figure 3.3-14. Time series plot of near-bottom data from the 75 m and 250 m downslope locations in Cell LU during cap placement Event 3 on August 13, 2000. Turbidity from the two locations (upper two tiers); current speed from the two locations (middle two tiers); and current direction from the two locations (lower two tiers).

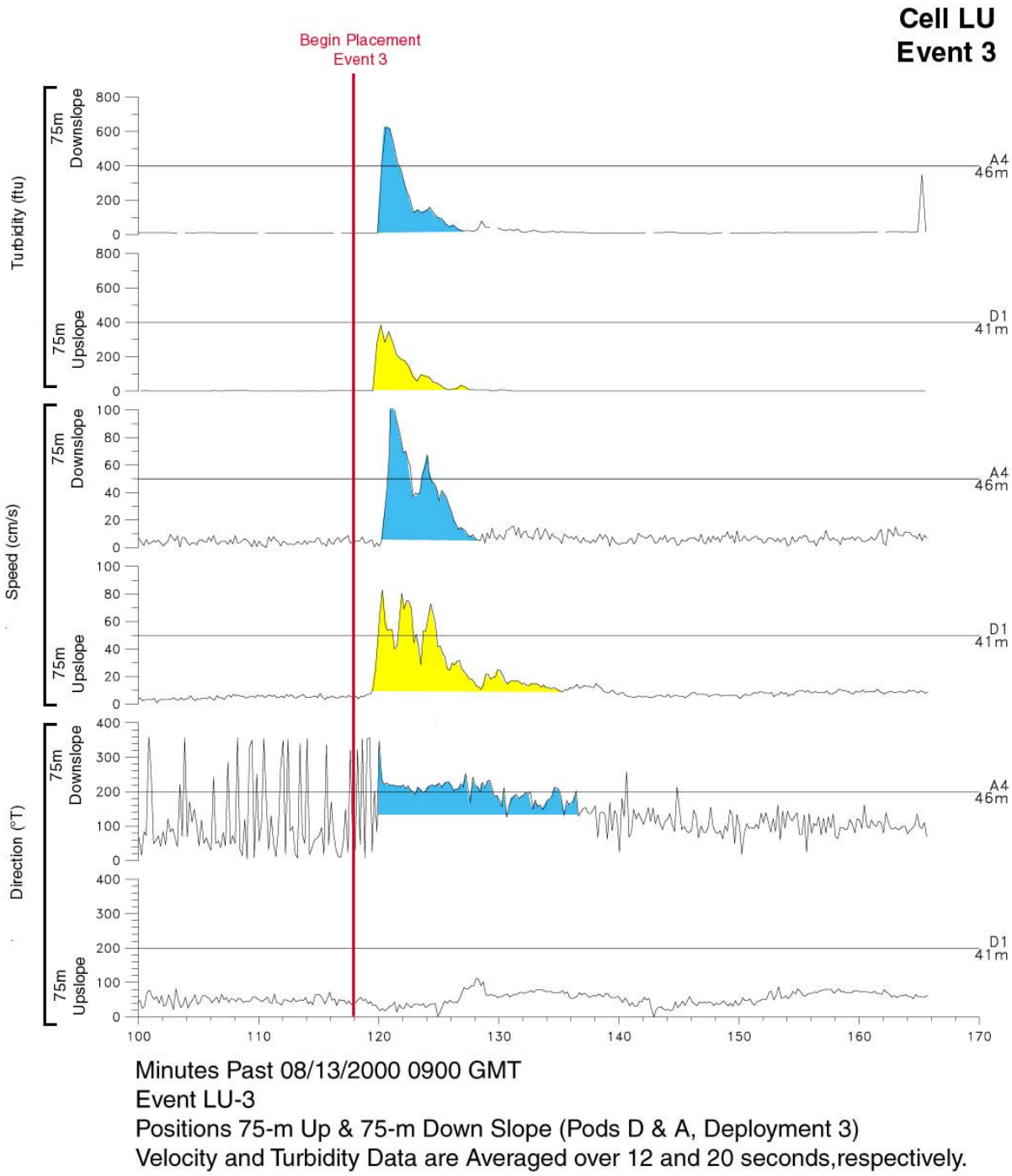


Figure 3.3-15. Time series plot of near-bottom data from the 75 m upslope and 75 m downslope locations in Cell LU during cap placement Event 3 on August 13, 2000. Turbidity from the two locations (upper two tiers); current speed from the two locations (middle two tiers); and current direction from the two locations (lower two tiers).

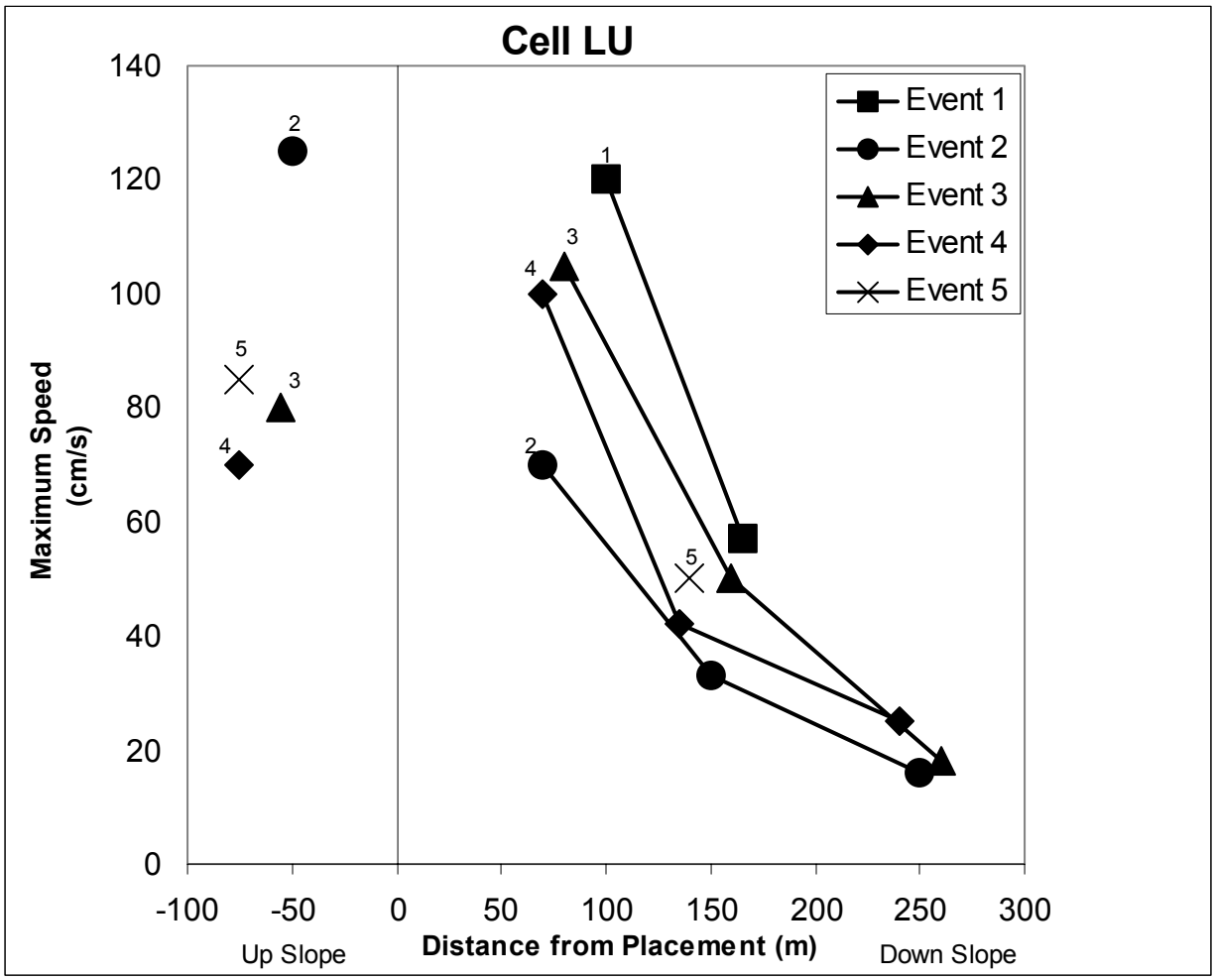


Figure 3.3-16. Plot of the maximum near-bottom current speed (y-axis) observed during cap placement Events 1 to 5 at multiple array locations within Cell LU versus the horizontal distance (x-axis) from the moored array locations to the actual cap placement locations (dredge positions).

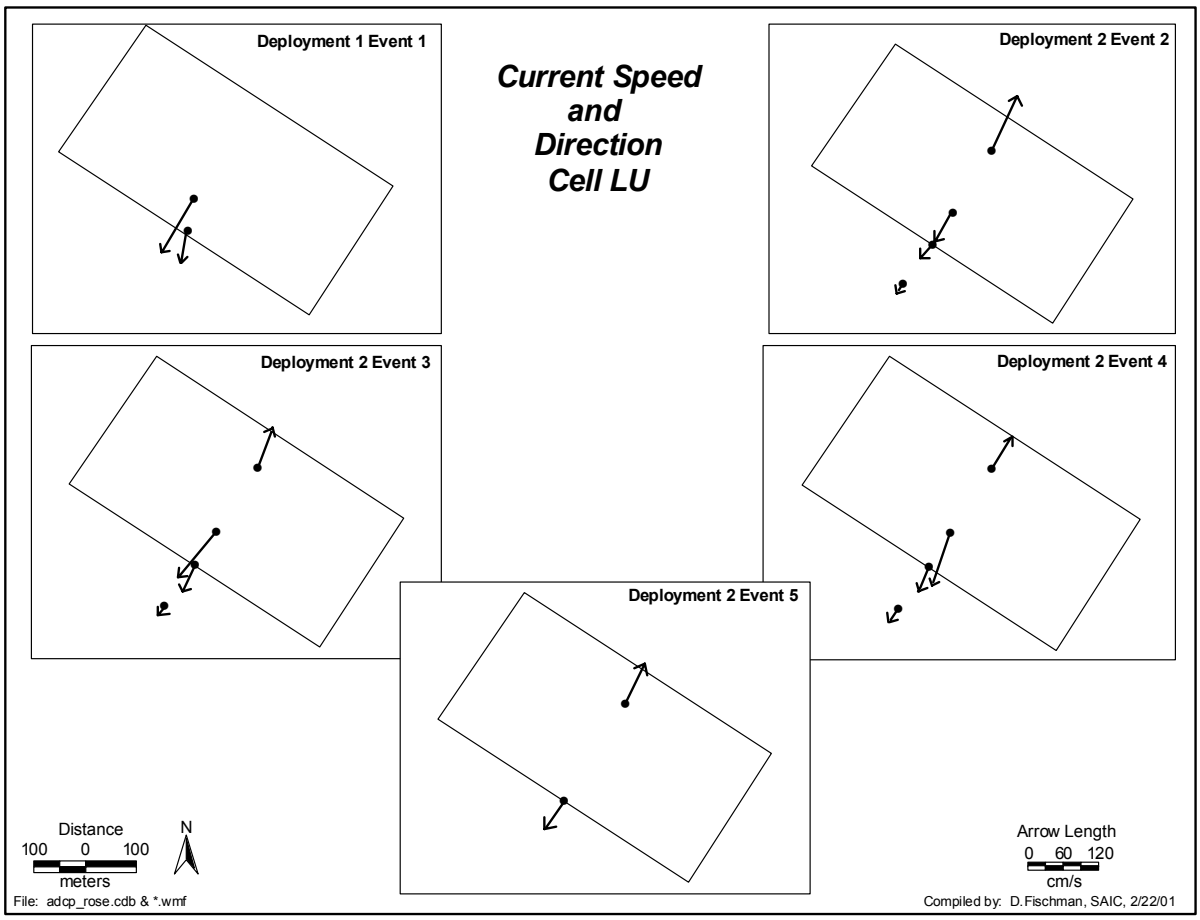


Figure 3.3-17. Maps showing current vectors at moored array locations in Cell LU during each of the five cap placement events monitored. The vectors are oriented in the direction of flow and their lengths are proportional to the maximum current speed observed during the surge events (see Table 3.3-6).

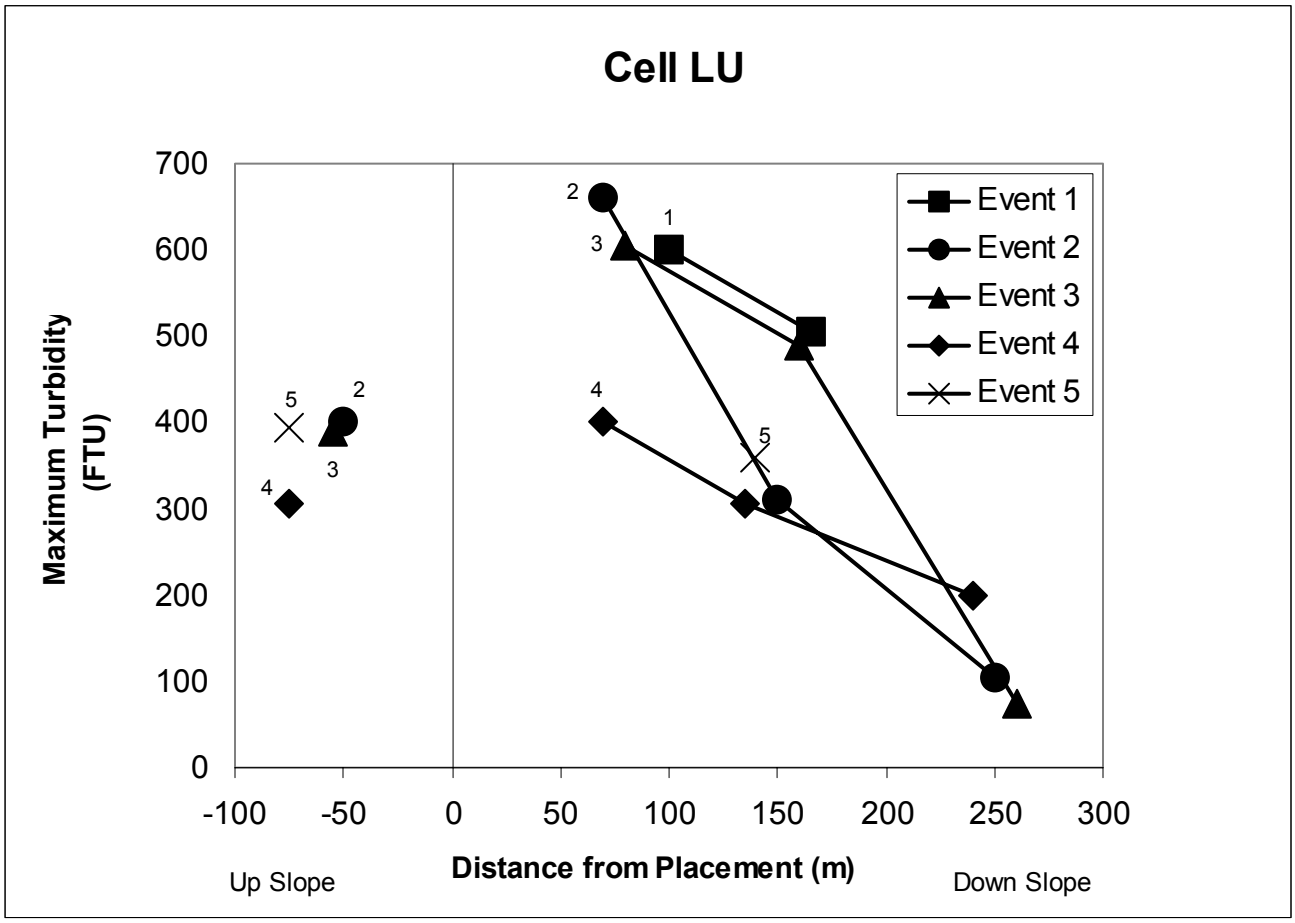


Figure 3.3-18. Plot of the maximum near-bottom turbidity (y-axis) at the time of maximum current speed observed during placement Events 1 to 5 at multiple array locations within Cell LU versus the horizontal distance (x-axis) from the moored array locations to the actual cap placement locations (dredge positions).

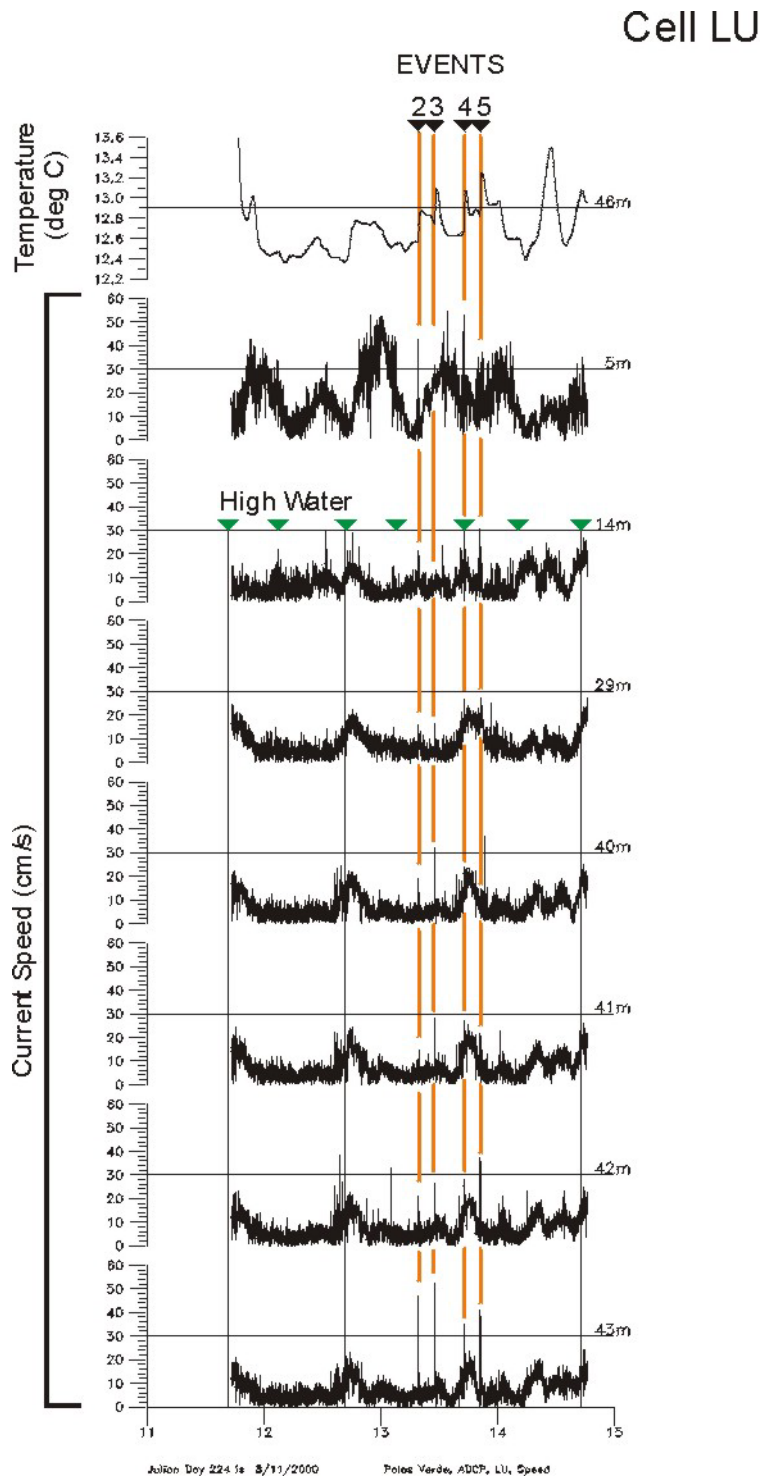


Figure 3.3-19. Time series plot of ADCP data from the 75 m downslope location in Cell LU bracketing cap placement Events 2 to 5 from August 11-14, 2000. Water temperature from 1 m above the bottom (top tier). Lower tiers present current speed data from seven 1 m thick depth levels extending from 5 to 43 m (which was 3 m above the bottom). Data are 1-min averages. The times of high and low water at the NOAA tide station in Outer Los Angeles Harbor are also shown.

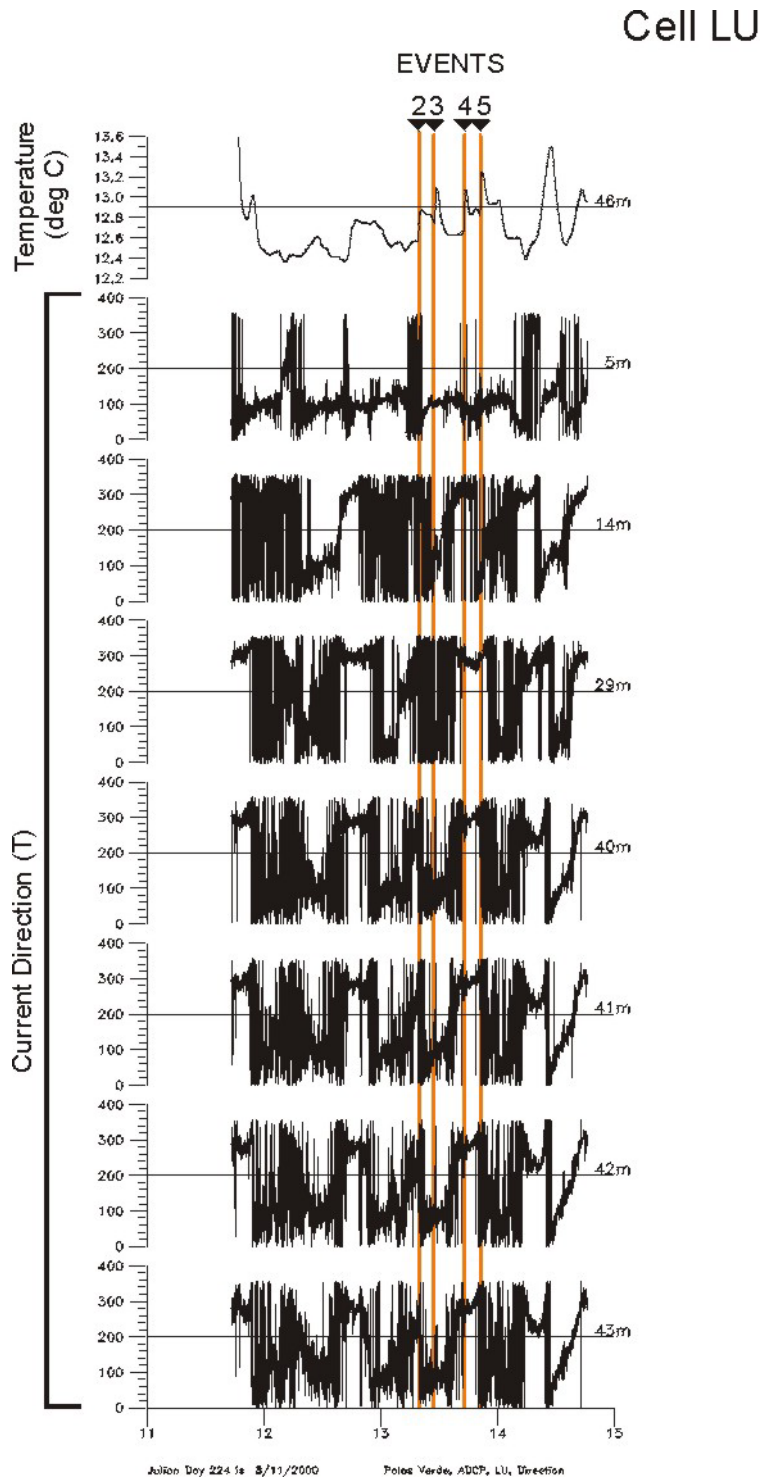


Figure 3.3-20. Time series plot of ADCP data from the 75 m downslope location in Cell LU bracketing cap placement Events 2 to 5 from August 11-14, 2000. Water temperature from 1 m above the bottom (top tier). Lower tiers present current direction data from seven 1 m thick depth levels extending from 5 to 43 m (which was 3 m above the bottom). Data are 1-min averages.

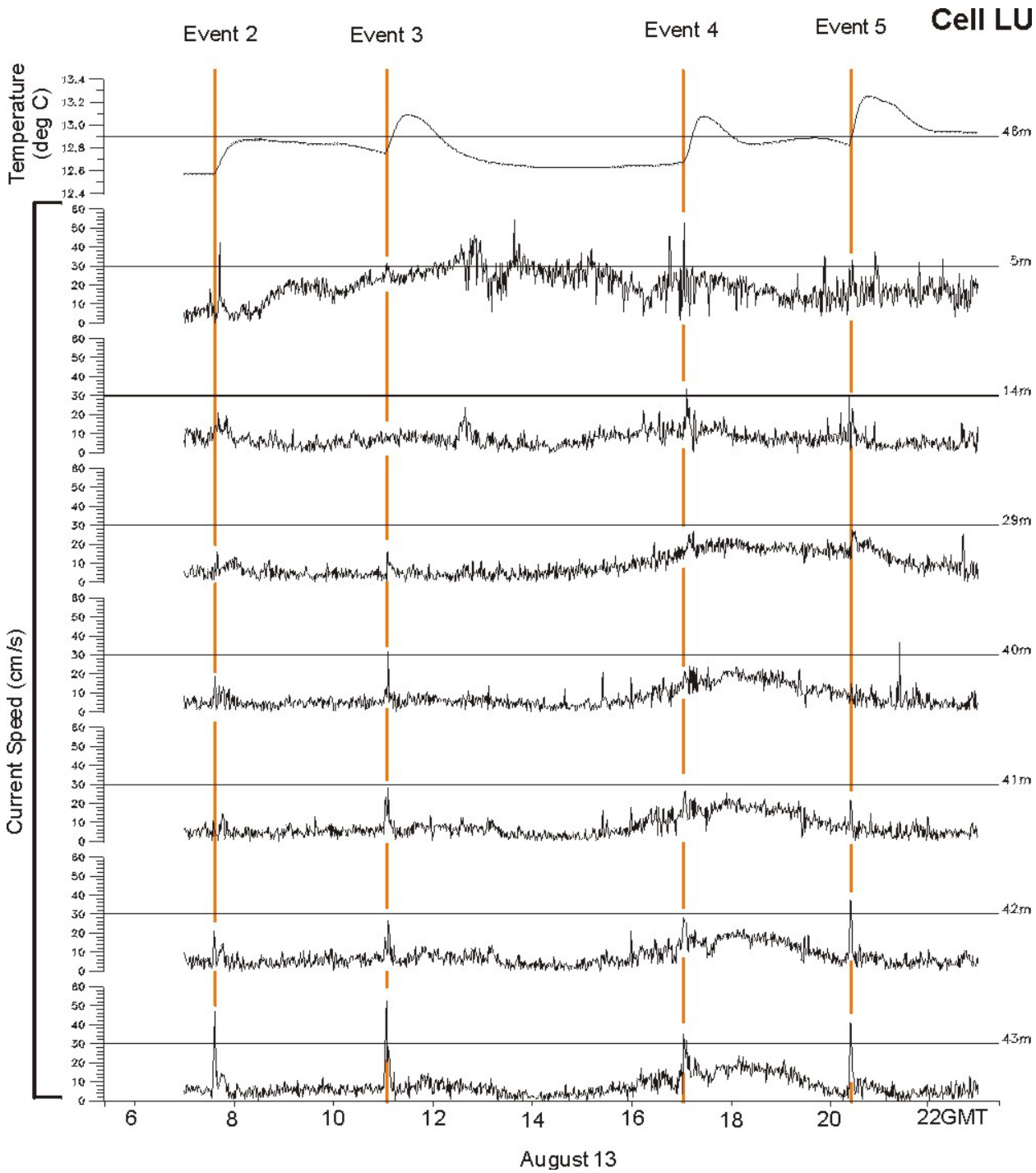


Figure 3.3-21. Expanded time series plot of ADCP data presented in Figure 3.3-18, from the 75 m downslope location in Cell LU bracketing cap placement Events 2 to 5 from August 11-14, 2000.

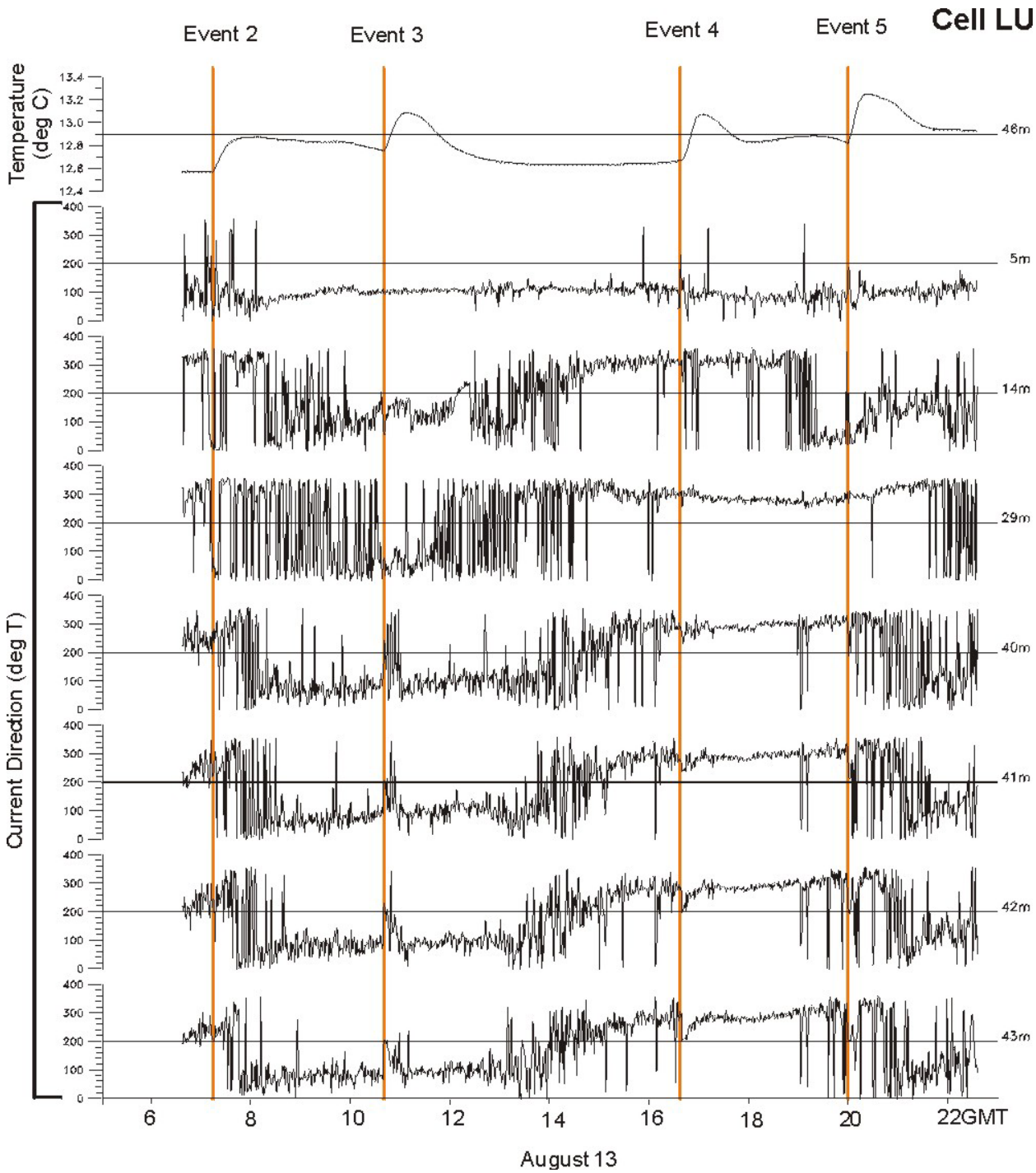


Figure 3.3-22. Expanded time series plot of ADCP data presented in Figure 3.3-19, from the 75 m downslope location in Cell LU bracketing cap placement Events 2 to 5 from August 11-14, 2000.

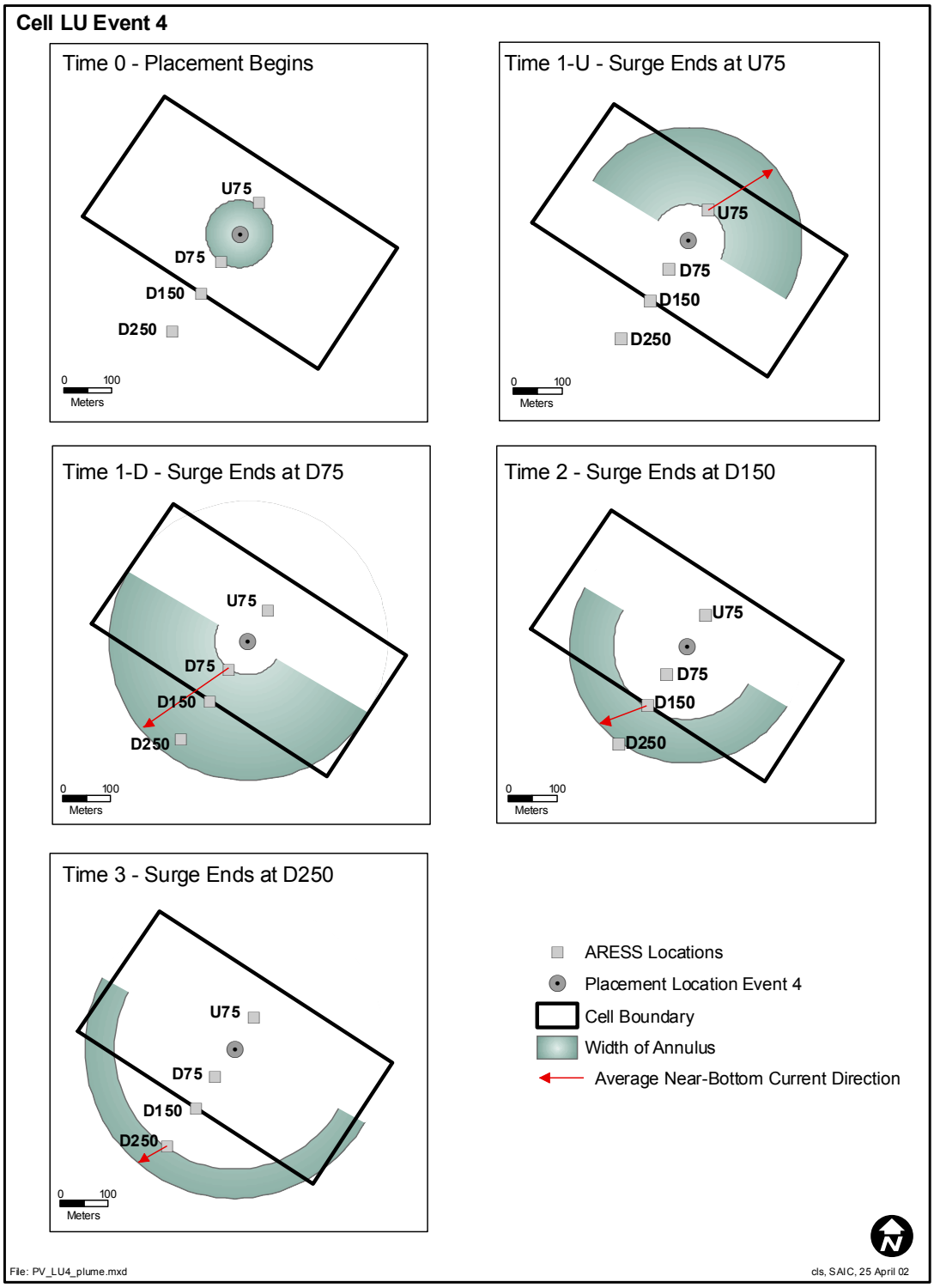


Figure 3.3-23. Diagram of the near-bottom surge process that spreads radially as an annulus. Time 0: leading edge of surge had reached the D75 array. Time 1D: surge had completely passed the D75 array. Time 3: surge had passed the D250 array.

3.4 Drogue Trajectory Results

3.4.1 Overview of Field Sampling Plan

The monitoring objectives for water quality measurements in Cell LU (Section 3.5) focus on sampling within the near-bottom plume of suspended sediments associated with the conventional (bottom-dump) placement of cap material in Cell LU. 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. Upon commencement of a conventional placement, the survey vessel could readily be positioned within 100 ft of the hopper dredge to ensure that the water column profiling device would be lowered into the near-bottom plume generated in close proximity to the dredge when the vertical momentum of the descending cap material impacted the seafloor and spread radially from the point of impact. As the near-bottom plume was advected away from the placement site by the ambient currents, it was critical to know the speed and direction at which the near-bottom plume was moving so that the survey vessel could remain above the plume to allow repeated sampling within the same near-bottom feature and thus monitor any temporal changes in water properties (e.g., a decrease in suspended solids concentrations) within the 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.

Note that the Field Sampling Plan of the PWP (SAIC 2001) had anticipated that a vessel-mounted ADCP, operated by the U.S. Army Engineer Research and Development Center, Waterways Experiment Station, would be aboard the same survey vessel as the water quality monitoring equipment, but the field logistics plan changed during the final two weeks prior to the survey, and the decision was made to have the ADCP on a separate survey vessel in order that it would be free to conduct transect operations while the water sampling survey vessel was stationary conducting measurements. Therefore, the vessel used for water quality measurements relied on the drogues for real-time positioning of the vessel at the best known location of the near-bottom plume during the two-hour monitoring periods. At a few times during each monitoring event, the vessel with the ADCP would call the water quality monitoring vessel to provide an independent estimate of the near-bottom currents observed by the ADCP, in addition to information on the location and thickness of suspended sediment plumes that also were detected by the acoustic backscatter signal from the ADCP.

3.4.2 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 (timing and geographical positioning) 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. 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, especially since two survey vessels were used rather than the original plan of one survey vessel for both ADCP and water quality measurements.

3.4.3 Technical Considerations

Drogue Configuration

Two water-following "holey-sock" drogues were deployed and visually tracked during monitoring of cap placement operations in Cell LU to obtain real-time information on horizontal currents at various depths in the water column. These drogues were constructed of a 5-m long by 0.6-m diameter, yellow nylon sock that was attached to a small surface buoy by a small diameter line (Figure 3.4-1). The nylon sock was separated into five 1-m long segments by PVC circular stiffening rods that provided physical support, preventing the sock from collapsing. Each segment was perforated on opposite sides by two 30-cm circular openings (one on each side) to allow for the unrestricted flow of water throughout the sock. The perforations of each segment were perpendicular to the perforations of the adjacent segments.

The surface marker buoy was attached to the bridle of the holey-sock via a small-diameter nylon line to provide flotation for the sock while drifting at a constant level in the water column and stretched vertically due to small weights at its bottom. Visual sighting of the surface buoy was aided by a small flag attached to the buoy by a fiberglass rod.

To obtain drogue positions, the survey vessel would stop alongside the surface buoy of the drogue and the DGPS position of the vessel (and adjacent drifter) would be 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.

Depths of Drogues

The water depth at the center of Cell LU was 43 m. Depths increase to the south (offshore) but decrease toward the north and east (onshore), reaching depths of 15 to 20 m roughly 1 km inshore of Cell LU. The optimum plan for following the near-bottom suspended sediment plumes as they were advected out of Cell LU would have been to tether a drogue such that it was situated 2 m above the seafloor as it moved with the horizontal currents. But because the tidal and low-frequency currents could possibly transport the near-bottom plumes toward shore and into shallower water, one drogue was tethered at a depth of 30 m below the surface. It was anticipated that this drogue would adequately characterize the near-bottom flow regime in the vicinity of Cell LU, but more importantly, it would not be "grounded" if the flow carried the near-bottom plume (and associated drogue) toward shore a distance of up to 0.5 km. During survey operations, this 30-m drogue was tracked visually by locating the yellow flag that was attached to the drogue's surface marker buoy.

As shown in Section 3.3.4, horizontal currents in the lower half of the water column in Cell LU were vertically coherent, supporting the assumption that the drogue tethered at 30-m depth would be representative of flow conditions from 30 m depth to the bottom.

A second drogue was tethered 15 m below the surface to provide an independent measurement of real-time currents in the upper one-third of the water column. The surface buoy of this shallow drogue contained a green flag to aid relocation.

3.4.4 Monitoring Results

Placement Event 1

Two drogues were deployed at 1921 GMT on August 2, 2000, which corresponded with the commencement of cap placement operations during Event 1 in Cell LU. As demonstrated in Figure 3.4-2, both drogues moved continually toward the northwest, with the shallow drogue traveling somewhat

farther and more northerly than the deeper (30-m) drogue. Table 3.4-1 indicates that the 15-m drogue traveled a distance of 2,428 m (equal to the length of four pilot cells) during the 2 hr, 9 min period the drogue was tracked by the survey vessel. The average horizontal speed of this shallow drogue was 31.2 cm/s on a heading of 295°T. The deeper, 30-m drogue exhibited an average speed of 21.9 cm/s on a heading of 285°T during its 2 hr, 18 min drift period.

Because high water on the PV Shelf occurred at 1924 GMT, the drogue tracks corresponded with ebb flow conditions in the study area. This northwestward flow at 15- and 30-m depths agrees well with the current meter data acquired by the moored, upward-looking ADCP in Cell LU (see Figures 3.3-9 and 3.3-10) which indicated flow toward the northwest throughout much of the water column prior to placement Event 1. During the exact time of placement Event 1, the near-bottom current meters demonstrated that background currents (see Figure 3.3-5) were directed toward the west at speeds of 10 to 20 cm/s (somewhat weaker than currents in the upper layers of the water column).

In summary, the two drogue tracks acquired during the first two hours following Event 1 in Cell LU demonstrated moderate currents toward the northwest and minimal vertical current shear in the mid and lower portions of the water column. Consequently, a near-bottom plume of suspended sediment would have been advected in the same general direction as particulates that remained in shallower layers of the water column.

Placement Event 4

As during the initial placement in Cell LU, two drogues were deployed at 1700 GMT on August 13, 2000, corresponding with the commencement of cap placement operations during Event 4 in Cell LU. As demonstrated in Figure 3.4-3, both drogues moved continually toward the northwest, with the shallow drogue traveling a shorter distance and more northerly than the deeper (30-m) drogue. Table 3.4-1 indicates that the 15-m drogue traveled a distance of 707 m during the 1 hr, 54 min period the drogue was tracked by the survey vessel. Its average horizontal speed was 10.3 cm/s on a heading of 321°T. The deeper, 30-m drogue exhibited an average speed of 12.7 cm/s on a heading of 304°T during its 2 hr, 28 min drift period.

Because high water on the PV Shelf occurred at 1700 GMT (the exact time of the cap placement), the drogue tracks corresponded with ebb flow conditions in the study area, as had been the case during Event 1 in Cell LU. This northwestward flow at 15- and 30-m depths agrees well with the current meter data acquired by the moored, upward-looking ADCP in Cell LU (see Figures 3.3-21 and 3.3-22) which revealed relatively weak (10 to 20 cm/s) flow toward the northwest throughout the water column during placement Event 4. The near-bottom current meters at the time of the placement event also demonstrated that background currents were directed toward the west at speeds of 15 to 20 cm/s.

In summary, the two drogue tracks acquired during the first two hours following Event 4 in Cell LU demonstrated moderate currents toward the northwest and minimal vertical current shear in the water column. Consequently, a near-bottom plume of suspended sediment would have been advected in the same general direction as particulates that remained in shallower layers of the water column. These results are very similar to those from Event 1 in Cell LU, most likely because they were both acquired at the beginning of the ebb tide.

Placement Event 5

As during the other two placement events monitored in Cell LU, two drogues were deployed, at 2020 GMT on August 13, 2000, corresponding with the commencement of cap placement operations during Event 5 in Cell LU. As demonstrated in Figure 3.4-4, the deep drogue moved toward the northwest and north, while the shallow drogue moved toward the northeast, traveling a shorter distance

than the deeper drogue. Table 3.4-1 indicates that the 15-m drogue traveled a distance of only 273 m during the 2 hr, 3 min period the drogue was tracked by the survey vessel. Its average horizontal speed was only 3.7 cm/s on a heading of 55°T. The deeper, 30-m drogue exhibited an average speed of 6.6 cm/s on a heading of 338°T during its 2 hr, 10 min drift period.

Because low water on the PV Shelf occurred at 2148 GMT (about 1.5 hrs after commencement of cap placement), the majority of the drogues' drift period corresponded with the end of the ebb tidal stage. The northeastward flow at the 15 m drogue depth agrees well with the current meter data acquired by the moored, upward-looking ADCP in Cell LU (see Figures 3.3-21 and 3.3-22) which indicated flow toward the northeast at 14-m depth. The ADCP data also revealed that currents at depths below 29 m were directed toward the northwest and north, at speeds that decreased with depth from 20 to 10 cm/s. The near-bottom flow was directed toward the north at roughly 10 cm/s during the time of placement Event 5.

In summary, the drogue track from 30 m depth that was acquired during the first two hours following Event 5 in Cell LU demonstrated weak currents toward the northwest and north. The drogue at 15 m depth also demonstrated weak flow but toward the northeast. Both of these drogue tracks agree with the current data acquired concurrently by the moored instrumentation in Cell LU (see Section 3.3). Overall, the drogue results from the three monitoring events in Cell LU are in agreement with past studies of currents on the PV Shelf. Noble (1994) observed considerable variability in currents at tidal periods, in addition to subtidal currents with speeds in excess of 30 cm/s and flow directions generally toward the northwest, parallel with the local isobaths, and strongest currents near the surface.

Table 3.4-1. Summary of drift statistics for drogues deployed during cap placement events in Cells LU, SU, LD, and LC during August and September 2000

Cell	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
LU-1	8/2/00	Green (15m)	Total Deployment	19:21:58	21:31:35	2:09:37	2,428	295	31.2	Ebb
			First 51min.	19:21:58	20:13:08	0:51:10	949	296	30.9	Ebb
			51min. to 68min.	20:13:08	20:30:45	0:17:37	206	250	19.5	Ebb
			Last 1hr	20:30:45	21:31:35	1:00:50	1,341	301	36.7	Ebb
		Yellow (30m)	Total Deployment	19:21:28	21:39:56	2:18:28	1,823	285	21.9	Ebb
			First 25min.	19:21:28	19:46:46	0:25:18	303	291	20.0	Ebb
			First 50min.	19:46:46	20:12:05	0:50:37	703	289	23.2	Ebb
			Last 1hr27min.	20:12:05	21:39:56	1:27:51	1,122	282	21.3	Ebb
LU-4	8/13/00	Green (15m)	Total Deployment	17:00:14	18:54:42	1:54:28	707	321	10.3	Ebb
			First 59min.	17:00:14	17:59:21	0:59:07	325	327	9.2	Ebb
			Last 55min.	17:59:21	18:54:42	0:55:21	386	315	11.6	Ebb
		Yellow (30m)	Total Deployment	17:00:14	19:28:47	2:28:33	1,135	304	12.7	Ebb
			First 68min.	17:00:14	18:08:46	1:08:32	547	306	13.3	Ebb
			Last 1hr20min.	18:08:46	19:28:47	1:20:01	589	302	12.3	Ebb
LU-5	8/13/00	Green (15m)	Total Deployment	20:20:20	22:24:01	2:03:41	273	55	3.7	Ebb/Flood
			First 63min.	20:20:20	21:33:40	1:13:20	113	63	2.6	Ebb
			Last 50min.	21:33:40	22:24:01	0:50:21	162	50	5.4	Ebb/Flood
		Yellow (30m)	Total Deployment	20:20:20	22:30:36	2:10:16	516	338	6.6	Ebb/Flood
			First 52min.	20:20:20	21:13:00	0:52:40	326	324	10.3	Ebb
			Last 1hr17min.	21:13:00	22:30:36	1:17:36	215	359	4.6	Ebb/Flood
SU-1	8/8/00	Green (15m)	Total Deployment	18:36:23	20:58:08	2:21:45	1,401	126	16.5	Flood
			First 71min.	18:36:23	19:48:09	1:11:46	638	126	14.8	Flood
			Last 69min.	19:48:09	20:58:08	1:09:59	763	125	18.2	Flood
		Yellow (30m)	Total Deployment	18:36:23	20:46:25	2:10:02	462	77	5.9	Flood
			First 76min.	18:36:23	19:53:15	1:16:52	211	75	4.6	Flood
			Last 53min.	19:53:15	20:46:25	0:53:10	251	78	7.9	Flood

Table 3.4-1. (continued)

Cell	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-1	8/15/00	Green (15m)	Total Deployment	19:23:52	21:37:51	2:13:59	1,430	310	17.8	Ebb
			First 69min.	19:23:52	20:33:39	1:09:47	714	304	17.1	Ebb
			Last 1hr4min.	20:33:39	21:37:51	1:04:12	724	316	18.8	Ebb
		Yellow (30m)	Total Deployment	19:23:52	21:27:55	2:04:03	835	285	11.2	Ebb
			First 43min.	19:23:52	20:07:34	0:43:42	304	292	11.6	Ebb
			Last 1hr20min.	20:07:34	21:27:55	1:20:21	535	280	11.1	Ebb
LC-1	9/8/00	Green (15m)	Total Deployment	0:33:55	2:13:39	1:39:44	216	95	3.6	Flood/Ebb
			First 50min.	0:33:55	1:23:56	0:50:01	116	115	3.9	Flood/Ebb
			Last 1hr4min.	1:23:56	2:13:39	0:49:43	115	74	3.9	Ebb
		Yellow (30m)	Total Deployment	0:33:55	2:36:20	2:02:25	296	32	4.0	Flood/Ebb
			First 25min.	0:33:55	0:59:19	0:25:24	61	68	4.0	Flood
			Last 1hr37min.	0:59:19	2:36:20	1:37:01	250	23	4.3	Flood/Ebb

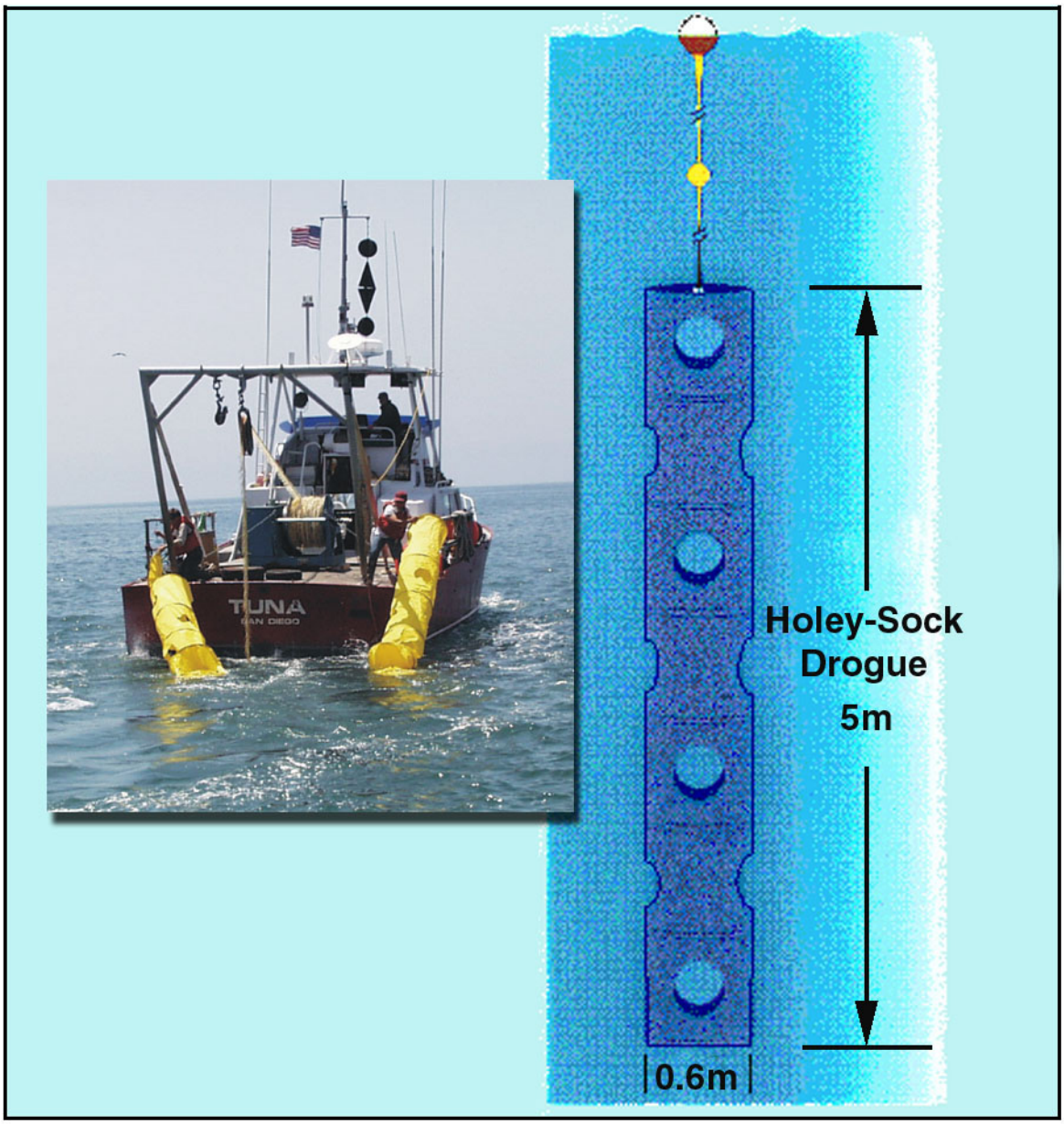


Figure 3.4-1. Sketch and photograph of holey-sock drogues used for plume tracking during water quality monitoring.

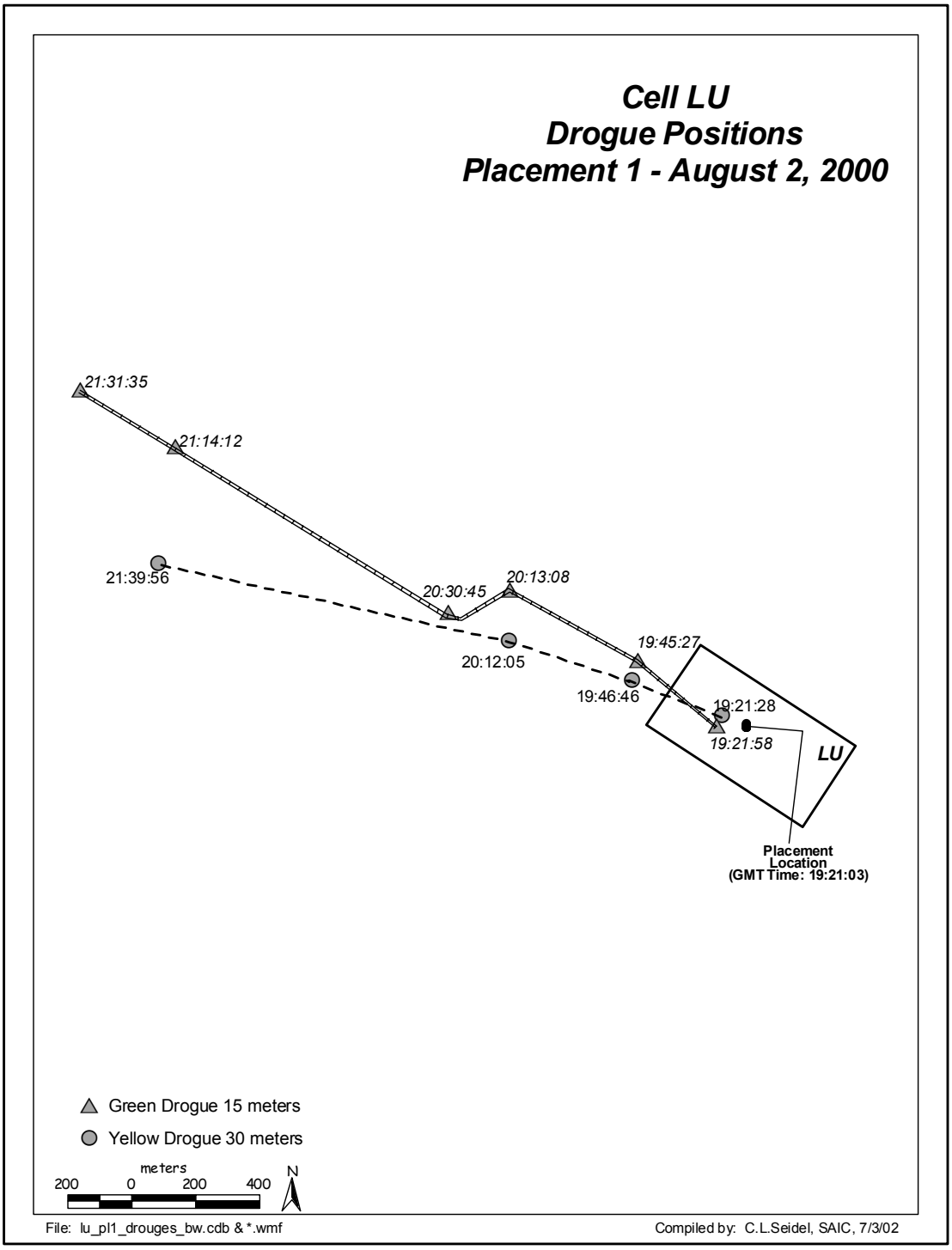


Figure 3.4-2. Map of Cell LU indicating trajectories of two drogues during water quality monitoring of placement Event 1 in Cell LU on August 2, 2000.

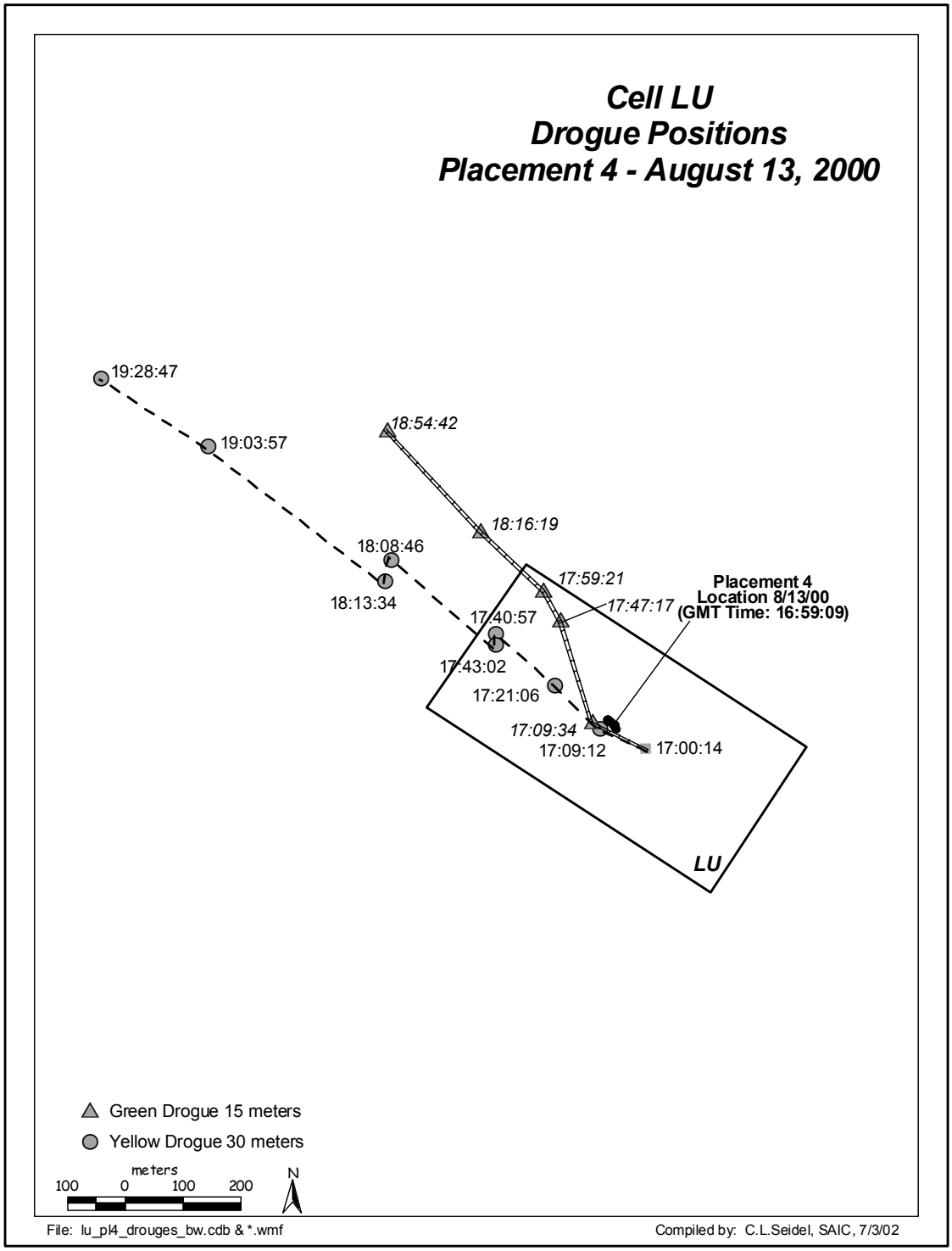


Figure 3.4-3. Map of Cell LU indicating trajectories of two drogues during water quality monitoring of placement Event 4 in Cell LU on August 13, 2000.

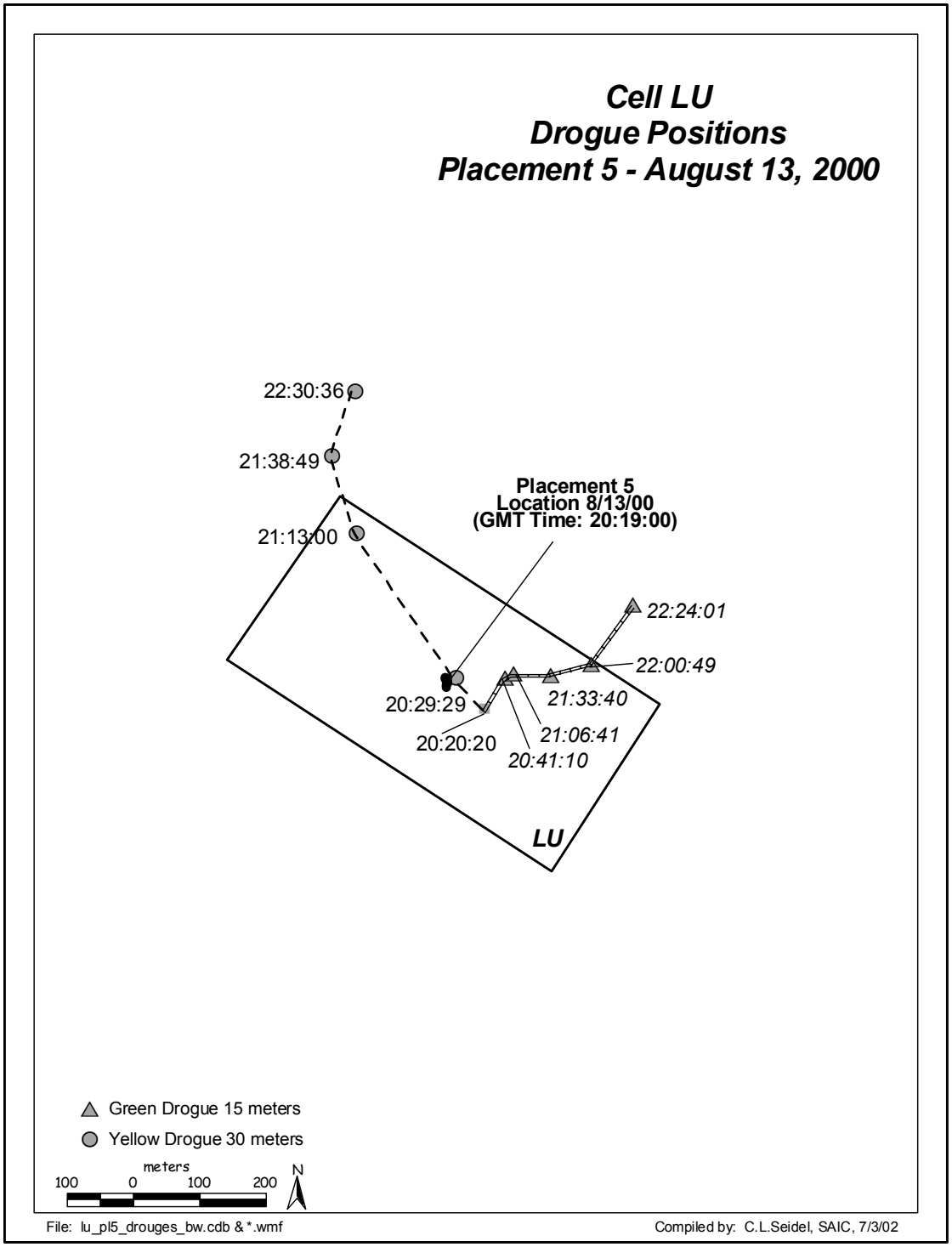


Figure 3.4-4. Map of Cell LU indicating trajectories of two drogues during water quality monitoring of placement Event 5 in Cell LU on August 13, 2000.

3.5 Water Column Monitoring Results

3.5.1 Overview of Field Sampling Plan

Cap placement operations on the PV Shelf have the potential of creating plumes of suspended particulate matter which may persist at various levels in the water column and be advected by the ambient currents. These plumes may consist of cap materials and/or resuspended bottom sediments, hereafter referred to as Effluent Affected (EA) sediments. In the upper water column, plumes would consist only of slowly descending cap material, whereas near the bottom, a plume may contain both cap material and resuspended EA sediments. Consequently, near-bottom plumes may have elevated concentrations of both dissolved and particulate contaminant concentrations in the vicinity of the cap placement location. Note that in this section, we discuss water properties within the near-bottom plumes that were essentially the same physical process/feature that was described as a bottom "surge" in Section 3.3. The brief, high-turbidity events observed by the moored instrument arrays during passage of the surge are the same feature as the near-bottom plumes tracked and sampled during the water column profiling operations. The moored instrument arrays monitored the surge/plume as it spread radially from the placement site. The water column profiling surveys, on the other hand, followed the plume as it was advected by the ambient currents during the first two hours after the placement event.

Immediately following a cap placement event, near-bottom concentrations of resuspended EA sediment and associated contaminants may initially be detectable (e.g., above their relatively low background levels), but concentrations were expected to decrease with time due to particle settling and dispersion by the near-bottom currents. In addition, subsequent cap placements in a specific placement cell were planned to occur over a cap layer that isolated the underlying EA sediments, thus minimizing resuspension of EA sediments during later cap placement events.

With regard to the water column profiling surveys of the Pilot Cap study, sampling operations were focused on three monitoring objectives:

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 specified number of cap placement events.

3. Determine the EA-derived contaminant concentrations in the near-bottom plume during the first two hours following a specified number of cap placement events.

Water column measurements were conducted using a conductivity, temperature, and depth (CTD) profiling device that was lowered repeatedly from the survey vessel. The CTD profiler also was equipped with an optical beam transmissometer, which measured the amount of light that could be transmitted through a 20-cm segment of the seawater. A low value of measured light transmittance represented a relatively high concentration of suspended particulate matter (turbidity) in the water. The CTD/transmissometer, in conjunction with the towed ADCP (Section 3.6) and water-following drogues (Section 3.4), was used to locate, delineate, and track the turbid plumes associated with the release of cap material from the hopper dredge.

In addition to the in situ measurement capabilities of the CTD profiling system, the electronics of the CTD were interfaced to a rosette water sampling device for collection of discrete water samples using 12, 10-liter Niskin water sampling bottles. During profiling operations, the real-time data provided by the CTD/transmissometer sensors were used to determine the depth, thickness, and maximum turbidity of the near-bottom plume. The sampling design specified that discrete water samples be acquired at intervals of 5, 20, 40, 60, 90, and 120 minutes following a cap placement event; minor deviations from this temporal sampling plan occurred as a result of survey vessel operations (e.g., collision prevention) as well as minor operational problems with the CTD profiler and rosette sampling equipment. Following the survey, the discrete water samples were shipped to analytical laboratories for analysis of Total Suspended Solids (TSS) and total recoverable (i.e., combined dissolved and particulate fractions) DDE concentrations. 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).

As discussed in Section 3.4, 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 profile using a vessel-mounted ADCP (see Section 3.6). 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 various plumes surveyed.

3.5.2 Data Quality Objectives

3.5.2.1 Water Quality Objectives

The monitoring objectives and approach for water quality measurements are presented in Table 3.5-1. These objectives included proper coordination of vessels (timing and geographic locations) for water column profiling and plume mapping (ADCP operations), and adequate sample volume collection to measure and detect changes in TSS and DDE concentrations over time following cap placement events. Integration of these data over time and space were required in order to properly interpret and evaluate the monitoring results. All water quality objectives were met with two exceptions. During a few of the water quality surveys, the mechanical components of the rosette water sampling device became clogged by descending cap material at the beginning of a cap placement operation when the survey vessel was very close to the dredge. Consequently, some water samples were not acquired during the first five minutes following commencement of capping. In all such cases, the problem with the rosette sampling device was rectified within 10 to 15 min and water sample collection resumed for the sampling event. In the future, water sampling with individual (e.g., Niskin) sample bottles and use of "messengers" rather than the rosette triggering device would be more reliable for collection of water samples during the first few minutes after placement operations (during the descent phase of the cap placement).

During the first two cap placement events that were monitored for water quality, procedural techniques of the CTD system operator resulted in some uncertainties in the exact time (±20 sec) that water samples were collected. For these initial profiles, the water quality data (e.g., TSS and DDE concentrations) from laboratory analyses of discrete water samples were carefully compared to the concurrent, in situ transmissometer data from these profile events to determine whether any major discrepancies were apparent. Any suspect data records from these events were identified and omitted

from the final results. The operational procedure for ensuring accurate timing of CTD profile data and water sample collection was rectified such that no further timing uncertainties arose.

3.5.2.2 Plume Mapping Objectives

The monitoring objectives and approach for plume mapping operations are presented in Table 3.5-2. These objectives were similar in scope to the data quality objectives for water quality monitoring. Plume mapping techniques were used to determine the spatial extent, direction of transport, and temporal variability in suspended sediment concentrations during the first two hours following placement of cap material during individual placement events. Real-time coordination between the two sampling vessels (for CTD and ADCP measurements) and the cap placement vessel (hopper dredge), the positioning accuracy for all vessels, and the accurate recording of sampling times were all critical activities for ensuring that all measurement data could later be merged and properly interpreted. Additionally, the water following drogues proved to be an excellent, real-time tool for predicting the location of the plumes (see Section 3.4).

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. It should be noted that some problems were encountered by the CTD sensors during the first few minutes following the initial descent of capping material. Similar to the problem encountered by the rosette sampler (see Section 3.5.2.1), descending cap material jammed the in situ seawater pump of the CTD profiler during some profiling events. This resulted in erroneous salinity and temperature data during these events but because these pump difficulties did not affect the performance of the in situ transmissometer, the overall data quality objectives for plume mapping were met.

Table 3.5-1. Monitoring Objectives and Approach for Water Quality Measurements

Monitoring Objective	Data Requirements	Monitoring Approach	Field Decision Criteria/Performance Specifications
Determine suspended sediment concentrations in the plume caused by resuspension of EA sediments following cap placement.	Background and post-placement water column TSS concentrations within near-bottom plumes.	Collect water samples for TSS analyses at varying times following a single hopper cap placement event for both conventional and spreading placement methods.	Coordination (timing and geographical locations) between the placement vessel and survey vessels supporting water quality measurements and plume mapping is critical for providing data that can be subsequently merged and used to evaluate the monitoring objectives.
Determine contaminant concentrations in the plume up to 2 hours following cap placement.	Background and post-placement water column total (dissolved + particulate) DDE concentrations.	Collect water samples from the centroid of plume, within 2 m of bottom, for total DDE analyses following single hopper placement events for both conventional and spreading placement methods.	Same as above; Adequate sample volume is needed to ensure that sufficient contaminant mass is present to detect and measure concentrations at levels appropriate for determining background concentrations, and numerical changes to these levels following cap placement.

Table 3.5-2. Monitoring Objectives and Approach for Plume Mapping

Monitoring Objective	Data Requirements	Monitoring Approach	Field Decision Criteria/Performance Specifications
Determine the spatial extent and transport directions of resuspended sediment plumes created by conventional and spreading placement of cap materials.	Three dimensional distribution of water column properties consistent with presence of high suspended particle concentrations for a period up to 2 hours following the single cap placement and the second and third placement events for both conventional and spreading placement.	Use an ADCP and transmissometer to track the vertical and horizontal boundaries and centroid of the suspended sediment plumes created by placement of cap materials for 2 hours following a placement event.	Plume delineation from ADCP measurements will be somewhat subjective and dependent upon the acoustic backscatter characteristics of the near-bottom suspended particulates that exist prior to cap placement. Plume delineation using light transmittance measurements will be somewhat subjective because the presence of natural particles as well as suspended cap particles will likely contribute to a variable background signal.
Determine the fall velocity and point of impact of individual cap material particles.	Measurements of sinking velocities for particles of varying size released from placement vessel and location of initial impact on the bottom.	Use an ADCP to measure particle sinking rates for cap materials for a single spreading placement event.	Particle sinking rate determinations from ADCP measurements will be somewhat subjective and dependent upon the acoustic backscatter characteristics of the near-bottom suspended particulates that exist prior to cap placement.
Determine potentials for onshore transport of cap materials and associated turbidity levels in vicinity of nearshore kelp beds.	Spatial distributions, relative to locations of nearshore kelp bed, of turbidity and suspended particle concentrations in the upper water column following cap placement events.	Use an ADCP and transmissometer to track the direction and extent of suspended sediment plumes in the upper water column for 2 hours following a placement event. Up to 27 TSS samples will be collected in conjunction with ADCP and OBS measurements.	Plume delineation from ADCP measurements will be somewhat subjective and dependent upon the acoustic backscatter characteristics of the near-bottom suspended particulates that exist prior to cap placement. Plume delineation using light transmittance and TSS measurements will be somewhat subjective because the presence of natural particles as well as suspended cap particles will likely contribute to a variable background signal.

3.5.3 Technical Considerations

The focus of the water quality studies was to track the movement and temporal evolution of the near-bottom suspended sediment plume following the release of cap material from the hopper dredge. Therefore, emphasis was placed on the analysis of numerous vertical profiles of turbidity (percent light transmittance) obtained from repeated lowerings of the CTD profiling system. Because the background (ambient) turbidity levels were very low throughout the water column on the Palos Verdes Shelf, elevated turbidities within the near-bottom plumes could easily be identified and undeniably associated with the cap placement operations. Although vertical profiles of temperature, salinity, and seawater density were acquired in conjunction with the vertical turbidity profiles, these data have been archived (and not presented herein) because analysis of these basic water properties was not within the primary scope of this study.

As described in Section 3.4, the water quality studies were conducted in conjunction with tracking of water-following drogues. For each of the three cap placement events monitored in Cell LU, holey sock drogues were situated at 15 m and 30 m depths (roughly 10 m above the bottom) and tethered to surface marker buoys to facilitate real-time tracking of the lateral movement of the near-bottom plume. This technique proved very effective, in the absence of real-time current profile data from an onboard ADCP profiler.

3.5.4 Monitoring Results

Water quality studies using the CTD, transmissometer, and Niskin bottles with rosette sampler were conducted at Cell LU during cap placement Events 1, 4, and 5. The Event 1 survey was conducted on August 2, 2000, and included the collection of background CTD profiles and water quality samples. Surveys conducted during Events 4 and 5 were both conducted on August 13, 2000. The sampling methodology for all surveys followed the Field Sampling Plan as summarized in Section 3.5.1.

3.5.4.1 Plume Survey during Cap Placement Event 1

The Event 1 survey in Cell LU was the first water column profiling survey conducted for the Palos Verdes Pilot Cap Monitoring Program. A summary of all CTD profile measurements and water samples collected during Event 1 is provided in Table 3.5-3. Specific details regarding the sampling operations can be found in the Cruise Report (SAIC 2000b).

During a 2-hr period prior to commencement of cap placement operations for Event 1, 10 CTD profiles were made within and adjacent to Cell LU to assess background water properties in the vicinity of the planned capping operation. Here we use the term “background” to represent local conditions (e.g., in close proximity to the EA region). 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. For example, Figure 3.5-1 presents vertical profiles of temperature, salinity, seawater density, and percent light transmittance (turbidity) acquired during baseline CTD Station 10, which was taken approximately 45 min prior to the cap placement event. The transmittance profile from this station showed that background levels ranged from roughly 67 to 81% over the extent of the water column; water depth at this location was 43 m.

At background Station 10 (Figure 3.5-1), temperature decreased gradually from the surface to approximately 25 m depth; below which waters were nearly isothermal. Salinities decreased minimally with depth in the upper 20 m, but were isohaline below. The density profile exhibited stratification in the upper half of the water column but density stratification was minimal below that level. This lack of

stratification in the lower water column meant that near-bottom plumes would not be inhibited from mixing vertically. Table 3.5-3 provides the minimum percent light transmittance (equivalent to maximum turbidity) for each of the ten background CTD stations made prior to Event 1 in Cell LU. These results illustrate that minimum transmittance values were very similar for all stations, ranging from 68 to 72%.

Cap placement Event 1 in Cell LU began at 1921 GMT on August 2. Upon initiation of material release from the hopper dredge, the CTD survey vessel was positioned in close proximity to the dredge (Figure 3.5-2) and the CTD profiler was situated 2 m above the bottom in order to detect the leading edge of the turbid plume associated with the radially spreading surge current. This feature was readily apparent, as percent light transmittance (PLT) decreased to zero as the surge passed the CTD sensors. Shortly after the surge arrived, the CTD was raised and lowered repeatedly, over the depth range from roughly 25 to 40 m, in order to determine the thickness and PLT within the near-bottom plume. At this first CTD station during Event 1 (designated as LU-1D-CTD1 in Table 3.5-3) four near-bottom profiles were acquired; a 6-min segment of the time series of PLT and CTD sensor depth during this CTD station is shown in Figure 3.5-3. At the beginning of this time series segment, the CTD/transmissometer was situated at a depth of 25 m where PLT values were high (near 75%) and representative of background waters having relatively low turbidity. As the transmissometer was lowered, low PLT values (high turbidities) were encountered at depths below 38 m (5 m above the bottom). The three near-bottom CTD profiles acquired during this brief time segment illustrated that very high turbidities (PLT values approaching 0%) were encountered within a near-bottom plume that was 5 to 8 m thick. Immediately above this plume, turbidity characteristics were comparable to those observed during background, pre-placement profiles. Near the end of CTD Station 1, the vertical profile of PLT (Figure 3.5-4) illustrated that the near-bottom plume extended to approximately 30 m depth, representing a plume thickness of roughly 13 m.

During the first 2 hrs following cap placement Event 1, a total of seven CTD profile stations were occupied. Table 3.5-3 indicates that 19 near-bottom profiles were acquired at these seven stations and a total of 32 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-1 equals 1 m above the bottom). As seen in this table, the minimum PLT rose from 0% for CTD 1 to 30% for CTD 6, which demonstrates that turbidity within the plume was decreasing gradually over the 2-hr monitoring period. The depth at which the minimum value of PLT was encountered generally increased with time after the placement event. The minimum PLT was initially observed within 1 m of the bottom but by CTD 6, which was made roughly 2 hrs after the placement event, the minimum PLT within the plume was situated well above the bottom, as discussed later.

To illustrate the characteristics of the near-bottom plume observed at approximately 1.5 hrs after the placement event, Figure 3.5-5 presents a 7-min segment of the time series of PLT and CTD sensor depth acquired during CTD 5. During this time segment, the CTD/transmissometer passed vertically through the plume on three occasions and minimum PLT values ranged from approximately 19 to 24%. The PLT value of 19% was encountered at a depth of 43 m, which was 10 m above the bottom at this station location. It is interesting to note that this 43 m plume depth is equivalent to the water depth at the location of the cap placement in the center of Cell LU. This observation suggests that the turbid plume was following a constant depth surface as it was advected away from the placement location and into regions of greater water depth. Figure 3.5-2 illustrates that CTD stations 1-6 were made at increasing distances to the west-northwest of the cap placement location in Cell LU. Each of these stations was purposely made in very close proximity (e.g., within 50 ft) of the drogue that was tethered at 30 m depth, because this drogue was used as a real-time indicator of the trajectory of the near-bottom flow. (See Section 3.4 for a discussion of drogue trajectories and near-bottom flow characteristics during Event 1.) Similarly, Section 3.3 presents moored current data acquired during Event 1, but

because these Eulerian current data were acquired at fixed locations in close proximity to the center of Cell LU, they are less useful for "far field" current velocity estimates than the Lagrangian (water following) data provided by the drogues.

Note that CTD Station 6 was made 2 hr after the placement event at a distance of approximately 1600 m from the site of the placement in Cell LU. In rough terms, this near-bottom plume was observed at a distance equivalent to six diameters of the initial surge plume, which was estimated at roughly 250 m in diameter from the other monitoring techniques: sidescan sonar survey results, the moored current velocity and turbidity data, and the SPI observations of cap footprint/thickness. This illustrates the rate at which the plume was advected horizontally away from the initial placement site.

At the end of water property monitoring activities for Event 1 (after completion of CTD Station 6), the survey vessel returned to the center of the cell to acquire another profile at the placement location. At CTD Station 7, the minimum PLT of 67% was observed very close to the bottom (Table 3.5-3); this turbidity was very low and comparable to background water properties. From this observation at 2.5 hours after the placement event, we can conclude that all remnants of the suspended sediment plume had settled to the seafloor and/or been advected away from placement site. To illustrate the temporal evolution of turbidity within the near-bottom plume resulting from placement Event 1, Figure 3.5-6 presents a plot of the minimum PLT observed during each of the seven CTD stations, versus time since the cap placement event. The gradual increase in PLT to 30% at CTD 6 is suggestive of plume mixing and dilution, but these transmittance data alone cannot be used to estimate suspended sediment concentrations nor the mass of suspended sediment contained within the three-dimensional plume. CTD 7 was not made with the plume but rather, back at the placement location.

A total of 32 water samples were collected within the near-bottom plume during the first 2 hrs following cap placement in Cell LU. Table 3.5-4 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 4 mg/L and ambient DDE concentrations were approximately 0.013 μg/L. Note, that "background" DDE concentrations measured at locations distant from the EA region would, presumably, be less than 0.013 μg/L.

To graphically illustrate the temporal characteristics of TSS and DDE from within the centroid of the near-bottom plume for placement Event 1, Figures 3.5-7 and 3.5-8 present the laboratory results (see Table 3.5-4) plotted versus the actual sample collection time following initiation of the cap placement operation. Before we discuss the laboratory data, it is important to point out that although the CTD/transmissometer was very capable of tracking the near-bottom plume of suspended sediments, and repeated lowerings with the CTD were useful for determining the thickness of the plume and the depth at which the maximum turbidity was situated, the transmissometer was not capable of determining the TSS characteristics within the plume. Consequently, the transmissometer data aided plume tracking and facilitated water sampling, but the data from discrete water samples represent the only true quantitative data on suspended sediment concentrations within the plume. Repeated and extended use of the transmissometer in the very concentrated plume may have rapidly clouded the light transmission windows, making direct comparisons difficult and inaccurate.

As illustrated in Figures 3.5-7 and 3.5-8, the concentration of DDE over time followed a pattern similar to the temporal characteristics of TSS. The highest concentration of DDE (0.29 μg/L) was measured in the same water sample as the highest TSS concentration (1,600 mg/L), 5 min after the cap

placement event. Concentrations of DDE fell quickly over time, dropping to 0.0043 μg/L 33 min after the peak concentration was measured. Thereafter, DDE concentrations within the plume remained low, with a concentration of 0.0047 μg/L at 2 hrs after cap placement. These concentrations were lower than the background concentrations of DDE (0.013 μg/L) measured prior to this first placement event (Figure 3.5-8). Similarly, the highest TSS concentrations were encountered within 5 min of the placement event, but concentrations dropped rapidly within the first half hour after the placement event (Figure 3.5-8).

The primary results from this plume survey during cap placement Event 1 in Cell LU 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 roughly 10 m thick shortly after the placement event and highest turbidity concentrations were observed close to the bottom. The plume remained at this 40 m depth as it was advected toward the northwest and into deeper water.
- TSS concentrations within the plume were very high within 5 min of the placement event, but decreased greatly within 30 min of the placement event. TSS concentrations within the plume were somewhat above background levels 2 hrs after the placement event.
- DDE concentrations within the plume also were elevated within 5 min of the placement event, but within 30 min, concentrations within the plume had decreased to levels that were less than background levels observed prior to the placement event.

3.5.4.2 Plume Survey during Cap Placement Event 4

The Event 4 survey in Cell LU was the second of three water column profiling surveys conducted in this cell. A summary of all CTD profile measurements and water samples collected during Event 4 is provided in Table 3.5-5. Specific details regarding the sampling operations can be found in the Cruise Report (SAIC 2000b).

Prior to commencement of cap placement operations for Event 4, two CTD profiles were made within Cell LU to assess background water properties in the vicinity of the planned capping operation. Background turbidity characteristics were generally similar at both stations, and vertical profiles exhibited only minor turbidity variations with depth from the surface to the bottom. Table 3.5-5 provides the minimum percent light transmittance for the two baseline CTD stations made prior to Event 4: minimum transmittance values were very similar, ranging from 70 to 72%.

Cap placement Event 4 in Cell LU began at 1659 GMT on August 13. Upon initiation of material release from the hopper dredge, the CTD survey vessel was positioned in close proximity to the dredge (Figure 3.5-9) and the CTD profiler was situated 2 m above the bottom in order to detect the leading edge of the turbid plume associated with the radially spreading surge current. This feature was readily apparent, as percent light transmittance (PLT) decreased to zero as the surge passed the CTD sensors.

During the first 2 hrs following cap placement Event 4, a total of seven CTD profile stations were occupied. Table 3.5-5 indicates that 15 near-bottom profiles were acquired at these seven stations and a total of 30 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 rose from 0% for CTD 1 to 33% for CTD 7, which demonstrates that turbidity within the plume was

decreasing gradually over the 2-hr monitoring period. For each of these stations, the minimum value of PLT was encountered roughly 1 m above the bottom. As indicated in Figure 3.5-9, the 30 m drogue moved northwestward, along the local isobaths, during the 2-hr monitoring period and the CTD stations were positioned along this same azimuth. Consequently, all CTD stations were made in water depths of approximately 41 to 43 m and because the suspended sediment plume remained at a constant depth level, it apparently maintained a near-constant height above the bottom. This contrasts the situation observed during Event 1 in Cell LU where the plume (and drogue) moved on a more westerly heading and into deeper water (Figure 3.5-2) such that the plume's height above the bottom continually increased as it was advected along a near-constant depth surface.

To illustrate the characteristics of the near-bottom plume observed at approximately 1 hr after the placement event, Figure 3.5-10 presents a 10-min segment of the time series of PLT and CTD sensor depth acquired during CTD 3. During this time segment, the CTD/transmissometer was raised and lowered twice to assess the thickness and intensity of the near-bottom plume. This record illustrates that the water column above 35 m depth had very low turbidity (PLT greater than 80%) whereas below that level, a nearly homogeneous plume existed. From 40 m to the bottom (43 m depth), PLT values were in the range of 22 to 25%. These data illustrate that, 1 hr after the placement event, the near-bottom plume was only about 5 m thick and the sharp vertical gradient in PLT at 35 m depth suggested that vertical mixing with the overlying, low turbidity water was minimal.

To illustrate the temporal evolution of turbidity within the near-bottom plume resulting from placement Event 4, Figure 3.5-11 presents a plot of the minimum PLT observed during each of the seven CTD stations, versus time since the cap placement event. The gradual increase in PLT from 26% for CTD 2 to 33% for CTD 7 is suggestive of gradual plume mixing and dilution, but it is evident that this plume could easily be tracked by the CTD/transmissometer because its turbidity was well above that of the background waters.

A total of 30 water samples were collected within the near-bottom plume during the first 2 hrs following cap placement in Cell LU. Table 3.5-6 presents the depth and PLT value measured by the CTD at the times that 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, independent of the transmissometer reading (which was acquired 1 to 2 m below the Niskin sample bottle). The three background (pre-placement) samples indicated that ambient TSS concentrations were 2 mg/L and ambient DDE concentrations were approximately 0.006 μg/L. Note that the background concentrations for both of these variables were roughly 50% less than those observed during Event 1 (see Table 3.5-4).

To graphically illustrate the temporal characteristics of TSS and DDE from within the centroid of the near-bottom plume for placement Event 4, Figures 3.5-12 and 3.5-13 present the laboratory results (see Table 3.5-6) plotted versus the actual sample collection time following initiation of the cap placement operation. As illustrated in Figure 3.5-12, the concentration of TSS over time followed a pattern similar to the temporal characteristics of turbidity (Figure 3.5-11). The highest TSS concentration (3,400 mg/L) was measured 1 min after the placement event, and concentrations decreased rapidly within the first 20 min. Over the time period from roughly 20 min to 2 hrs after the placement event, TSS concentrations within the centroid of the plume decreased gradually but remained above background levels.

The highest concentration of DDE (0.017 μg/L) was measured in the same water sample as the highest TSS concentration (3,400 mg/L), 1 min after the cap placement event. Note, that this maximum TSS concentration was approximately twice the maximum TSS concentration observed during placement

Event 1 (Table 3.5-4), whereas the maximum DDE concentration measured during Event 4 was 17 times less than that measured during Event 1 (0.29 μg/L). These differences between plume characteristics from Events 1 and 4 are discussed in Section 3.5.5.

DDE concentrations within the centroid of the near-bottom plume decreased by a factor of three during the first 20 min following cap placement, such that concentrations were comparable to or slightly above background levels thereafter (Figure 3.5-13).

The primary results from this plume survey during cap placement Event 4 in Cell LU 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 less than 10 m thick shortly after the placement event and highest turbidity concentrations were observed close to the bottom. The plume remained near the bottom as it was advected toward the northwest and over portions of the Palos Verdes Shelf that had water depths equal to that within Cell LU.
- TSS concentrations within the plume were very high 1 min after the placement event, but decreased greatly within 20 min of the placement event. TSS concentrations within the plume were above background levels 2 hrs after the placement event.
- DDE concentrations within the plume also were elevated within 1 min of the placement event, but decreased to background levels within 20 min after the placement event.

3.5.4.3 Plume Survey during Cap Placement Event 5

The Event 5 survey in Cell LU was conducted approximately 3 hrs after the Event 4 survey on August 13, 2000. A summary of all CTD profile measurements and water samples collected during Event 5 is provided in Table 3.5-7. Specific details regarding the sampling operations can be found in the Cruise Report (SAIC 2000b).

Prior to commencement of cap placement operations for Event 5, two CTD profiles were made within Cell LU to assess background water properties in the vicinity of the planned capping operation. Background turbidity characteristics were generally similar at both stations, and vertical profiles exhibited only minor turbidity variations with depth from the surface to the bottom. Table 3.5-7 provides the minimum percent light transmittance for the two baseline CTD stations made prior to Event 5: minimum transmittance values were very similar, ranging from 69 to 70%.

Cap placement Event 5 in Cell LU began at 2019 GMT on August 13. Upon initiation of material release from the hopper dredge, the CTD survey vessel was positioned in close proximity to the dredge (Figure 3.5-14) and the CTD profiler was situated 2 m above the bottom in order to detect the leading edge of the turbid plume associated with the radially spreading surge current. As during the other two surveys in Cell LU, the turbid plume was readily apparent, with percent light transmittance (PLT) decreasing to zero as the surge passed the CTD sensors.

During the first 2 hrs following cap placement Event 5, a total of six CTD profile stations were occupied. Table 3.5-7 indicates that 20 near-bottom profiles were acquired at these six 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 rose

from 0% for CTD 1 to 27% for CTD 6, which demonstrates that turbidity within the plume was decreasing gradually over the 2-hr monitoring period.

For each of the six CTD stations during Event 5, the minimum value of PLT was encountered within 3 m of the bottom. As indicated in Figure 3.5-14, the 30 m drogue moved toward the north-northwestward during the 2-hr monitoring period and CTDs 1-5 were positioned along this same azimuth in order to follow the apparent near-bottom flow. Consequently, these CTD stations were made at sites having water depths that were gradually decreasing. CTD 6 was made at the location of CTD 1, near the placement site.

To illustrate the characteristics of the near-bottom plume observed at approximately 1 hr after the placement event, Figure 3.5-15 presents an 11-min segment of the time series of PLT and CTD sensor depth acquired during CTD 3. During this time segment, the CTD/transmissometer was raised and lowered three times to assess the thickness and intensity of the near-bottom plume. This record illustrates that the water column above approximately 30 to 35 m depth had very low turbidity (PLT greater than 75%) whereas below that level, a turbid plume existed. From approximately 36 m to the bottom (40 m depth), PLT values were in the range of 6 to 15%. These data illustrate that, 1 hr after the placement event, the near-bottom plume was only about 5 m thick and the sharp vertical gradient in PLT at 36 m depth suggested that vertical mixing with the overlying, low turbidity water was minimal.

To illustrate the temporal evolution of turbidity within the near-bottom plume resulting from placement Event 5, Figure 3.5-16 presents a plot of the minimum PLT observed during each of the six CTD stations, versus time since the cap placement event. The increase in PLT from to 0 to 27% is suggestive of gradual plume mixing and dilution, and it is evident that this plume could easily be tracked by the CTD/transmissometer because its turbidity was well above that of the background waters. Another interesting result is that the near-bottom turbidity at CTD 6 (near the location of the cap placement) was comparable to that observed at CTD 5 located north of the cell. This suggests that the spatial extent of the near-bottom plume was quite large and that it had not been advected out of the cell, as had been seen following Event 1 (when near-bottom currents were stronger and oriented more westerly).

A total of 31 water samples were collected within the near-bottom plume during the first 2 hrs following cap placement in Cell LU. Table 3.5-8 presents the depth and PLT value measured by the CTD at the times that 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, independent of the transmissometer reading (which was acquired 1 to 2 m below the Niskin sample bottle). The three background (pre-placement) samples indicated that ambient TSS concentrations were 3 to 4 mg/L and ambient DDE concentrations were approximately 0.007 µg/L. Note that the background concentrations for both of these variables were very similar to those observed prior to Event 4, roughly 3 hours earlier (see Table 3.5-6).

To graphically illustrate the temporal characteristics of TSS and DDE from within the centroid of the near-bottom plume for placement Event 5, Figures 3.5-17 and 3.5-18 present the laboratory results (see Table 3.5-8) plotted versus the actual sample collection time following initiation of the cap placement operation. As illustrated in Figure 3.5-17, the concentration of TSS over time followed a pattern similar to the temporal characteristics of turbidity (Figure 3.5-16). The highest TSS concentration (2,700 mg/L) was measured 1 min after the placement event, and concentrations decreased rapidly within the first 30 min. Over the time period from roughly 30 to 60 min after the placement event (CTDs 1-3), TSS concentrations within the centroid of the plume decreased gradually. TSS data from CTDs 4 and 5 were not significantly different from background levels, although the CTD/transmissometer was able to detect (and follow) the remnants of a weakly turbid plume.

The highest concentration of DDE (0.1 μg/L) during Event 5 was measured in the same water sample as the highest TSS concentration (2,700 mg/L), 1 min after the cap placement event. Note that this maximum TSS concentration was between the maximum TSS concentrations observed during placement Events 1 and 4. Similarly, the maximum DDE concentration measured during Event 5 was between those measured during Events 1 and 4. These differences between plume characteristics from Events 1, 4 and 5 are discussed in Section 3.5.5.

DDE concentrations within the centroid of the near-bottom plume decreased greatly during the first 30 min following cap placement, such that concentrations were comparable to or less than background levels for all samples except those collected within the first 1 min after placement (Figure 3.5-18).

The primary results from this plume survey during cap placement Event 5 in Cell LU 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 less than 10 m thick shortly after the placement event and highest turbidity concentrations were observed close to the bottom. The plume remained near the bottom as it was advected toward the north-northwest and into regions having shallower depths than Cell LU.
- TSS concentrations within the plume were very high 1 min after the placement event, but decreased greatly within 30 min of the placement event. TSS concentrations within the plume were somewhat above background levels 1 hr after the placement event.
- DDE concentrations within the plume also were elevated within 1 min of the placement event, but decreased to background levels within 30 min after the placement event.

3.5.5 Discussion

Water column profiling studies were conducted to: 1) monitor the temporal evolution of the near-bottom disposal plume and 2) measure suspended solids and contaminant concentrations of the plumes within 2 hrs of the individual cap placement events. Three profile surveys were conducted at Cell LU, during Events 1, 4 and 5. During each event, the water-following drogues proved effective for indicating the trajectory of the near-bottom flow such that CTD profiles made in close proximity to the 30 m drogue appeared to be within the centroid of the plume. Consequently, the CTD survey vessel was able to focus its efforts on vertical profiling within the plume rather than horizontal surveying to delineate the plume's boundaries. Secondarily, the current velocity and acoustic backscatter data acquired in real-time by the towed ADCP aboard the other survey vessel provided an independent estimate of: 1) the depth of maximum backscatter intensity (turbidity) within the plume, and 2) the speed and general direction that the plume was being advected during the 2-hr water sampling operations.

Turbidity Profile Observations

Percent light transmittance data measured by the CTD/transmissometer revealed that near-bottom turbidity was highest within the first 5 min after release of cap material from the dredge. As indicated in Figure 3.5-19, the maximum turbidity (inverse of the minimum percent light transmittance) within the plume(s) gradually decreased after the placement operation, and results were similar for all three events monitored. Turbidity values were significantly above background levels 2 hrs after the placement event(s), confirming that water sampling operations were still being conducted within the plume associated with the placement activities.

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

TSS Observations from Discrete Samples

Water samples collected prior to the cap placement operations demonstrated that background TSS concentrations near the seafloor were very low, ranging from 2 to 4 mg/L. As the leading edge of the near-bottom surge (turbidity plume) passed the stationary CTD/transmissometer, TSS concentrations rose sharply, reaching maximum values that ranged from 1,600 to 3,400 mg/L for the three events monitored (Figure 3.5-20). These maximum values were achieved within the first 5 min after commencement of the placement operations. TSS concentrations dropped rapidly within 20 to 30 min, then decreased gradually thereafter. Concentrations within the near-bottom plume remained above local background levels for at least 2 hrs after the placement event.

DDE Observations from Discrete Samples

A subset of the water samples analyzed for TSS were also analyzed for DDE concentrations (typically 11-12 samples for each of Events 1, 4 and 5). Water samples collected prior to the cap placement operations demonstrated that background DDE concentrations near the seafloor were low, ranging from 0.006 to 0.013 μg/L. As had been observed for TSS, the maximum DDE concentration for each event was encountered within the first 5 min after commencement of the placement operations, and each corresponded with the maximum observed TSS concentration (i.e., samples were drawn from the same Niskin bottle). For all three events monitored, DDE concentrations dropped to background levels within 20 to 30 min and remained low (less than 0.01 μg/L) thereafter (Figure 3.5-21).

The highest DDE concentration (0.29 μg/L) was observed immediately after cap placement Event 1 when cap material was placed on exposed EA sediment. In contrast, the maximum DDE concentration observed immediately after Event 4 was 17 times lower (0.017 μg/L), suggesting that much less EA sediment was resuspended during this placement event, which purposely followed three prior cap placements at the same location. The maximum DDE concentration observed immediately after Event 5 (0.10 μg/L) was higher than that for Event 4 but significantly lower than the concentration observed during Event 1, suggesting that multiple cap placements in a cell were isolating the underlying EA sediments, and thus minimizing the resuspension of EA sediments during subsequent cap placement events.

It is interesting to note that the highest TSS concentration of all three events (3,400 mg/L) was encountered during placement Event 4, which had the lowest of the three maximum DDE concentrations. One may hypothesize that, at the location where this water sample was collected during Event 4, the near-bottom plume was comprised of higher concentrations of Queen's Gate cap material and lesser amounts of contaminated EA sediment than had been observed during Events 1 and 5.

Another interesting observation is that DDE concentrations in the near-bottom plume decreased to background levels within 20 to 30 min after each placement event, even though the plumes retained a significant turbidity signal for at least 2 hrs. This suggests that the persistent (albeit highly dilute) turbidity plume identified using the transmissometer did not retain significant amounts of DDE. The resuspended EA sediments that initially provided elevated concentrations of DDE were more rapidly re-deposited on the seafloor and hence, significant concentrations of DDE were not entrained in the suspended sediment plumes that persist for hours after placement. This result confirms that the cap material had a greater portion of very fine-grained material than the resuspended EA sediments.

Table 3.5-3. Summary of CTD profiles acquired and water samples collected prior to (designated as background) and during cap placement Event 1 in Cell LU on August 2, 2000. Also given is the maximum turbidity (minimum percent light transmission) observed by the transmissometer interfaced to the CTD system during each profile.

Station Type	Background	Background	Background	Background	Background	Background	Background	Background	Background	Background
Elapsed Time of Cast (h:min:sec)	0:11:21	0:07:23	0:15:33	0:05:16	0:07:31	0:06:14	0:07:10	0:10:22	0:12:58	0:09:41
CTD File Name	LU-1B-CTD1	LU-1B-CTD2	LU-1B-CTD3	LU-1B-CTD4	LU-1B-CTD5	LU-1B-CTD6	LU-1B-CTD7	LU-1B-CTD8	LU-1B-CTD9	LU-1B-CTD10
Total Water Column Profiles	1	1	1	1	1	1	1	1	1	1
Near Bottom Profiles	2	1	2	1	1	1	1	2	2	1
Water Samples Collected	0	0	2	0	0	0	0	0	0	1
Minimum % Light Transmittance (PLT)	69	70	68	71	72	71	70	70	71	71

Table 3.5-3. (continued)

Start Time After Placement (hr:min:sec)	-0:20:40	0:36:04	0:50:04	1:12:21	1:33:44	1:55:30	2:32:47
File End Time	0:19:33	0:46:40	0:58:08	1:26:43	1:54:34	1:59:57	2:35:32
Elapsed Time of Cast	0:40:13	0:10:36	0:08:04	0:14:22	0:20:50	0:04:27	0:02:45
CTD File Name	LU-1D-CTD1	LU-1D-CTD2	LU-1D-CTD3	LU-1D-CTD4	LU-1D-CTD5	LU-1D-CTD6	LU-1D-CTD7
Total Water Column Profiles	1	1	1	1	1	1	1
Near Bottom Profiles	4	3	3	2	4	2	1
Water Samples Collected	6	7	6	5	6	2	0
Minimum % Light Transmittance (PLT)	0	19	16	25	19	30	67
Depth of Minimum PLT (m)	B-1	B-8	B-6	B-6	B-10	B-15	B-1

Table 3.5-4. CTD Data and Laboratory Results from Discrete Water Samples collected during Cap Placement Event 1 in Cell LU on August 2, 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	LU-1B-CTD03	LU-1B-BOT-01	41*	74*	4	0.013	B-1	no
Background	LU-1B-CTD03	LU-1B-BOT-02	42*	72*	4	0.014	B-2	no
Background	LU-1B-CTD10	LU-1B-BOT-03	39.0	77.1	4	0.012	B-3	no
0	LU-1D-CTD1	LU-1D-BTA-01	41.4	60.5	9		1	no
1	LU-1D-CTD1	LU-1D-BTA-02	40.6	61.4	8		2	no
3	LU-1D-CTD1	LU-1D-BTA-03	40.8	0.0	7		3	no
3	LU-1D-CTD1	LU-1D-BTA-04	40.5	0.0	1,600	0.20	4	yes
3	LU-1D-CTD1	LU-1D-BTA-14	40.5	0.0	1,100		5	yes
5	LU-1D-CTD1	LU-1D-BTA-05	19.4	73.0	1,600	0.29	6	yes
35	LU-1D-CTD2	LU-1D-BTB-01	40.8	56.2	86		7	yes
36	LU-1D-CTD2	LU-1D-BTB-02	42.9	63.3	41		8	yes
37	LU-1D-CTD2	LU-1D-BTB-03	40.7	33.1	56		9	yes
38	LU-1D-CTD2	LU-1D-BTB-04	41.9	55.3	62	0.0043	10	yes
38	LU-1D-CTD2	LU-1D-BTB-05	41.6	54.3	37	0.0044	11	yes
38	LU-1D-CTD2	LU-1D-BTB-15	41.6	54.3	44		12	yes
42	LU-1D-CTD2	LU-1D-BTB-06	42.6	52.8	27		13	yes
49	LU-1D-CTD3	LU-1D-BTB-07	42.0	26.9	33		14	yes
53	LU-1D-CTD3	LU-1D-BTB-08	40.9	21.1	48		15	yes
54	LU-1D-CTD3	LU-1D-BTB-09	42.9	21.2	41		16	yes
55	LU-1D-CTD3	LU-1D-BTB-10	42.8	22*	37		17	yes
58	LU-1D-CTD3	LU-1D-BTB-11	38.1	22*	36		18	yes
58	LU-1D-CTD3	LU-1D-BTB-12	38.1	21*	27	0.0053	19	yes
81	LU-1D-CTD4	LU-1D-BTC-01	41.7	60.7	27		20	yes
82	LU-1D-CTD4	LU-1D-BTC-02	38.3	44.3	17		21	yes
85	LU-1D-CTD4	LU-1D-BTC-03	38.7	34.3	15	0.0054	22	yes
85	LU-1D-CTD4	LU-1D-BTC-13	38.7	34.3	15	0.0044	23	yes
86	LU-1D-CTD4	LU-1D-BTC-04	38.8	35*	17		24	yes
92	LU-1D-CTD5	LU-1D-BTC-05	38.5	64.8	18		25	yes
94	LU-1D-CTD5	LU-1D-BTC-06	44.0	33.2	14		26	yes
94	LU-1D-CTD5	LU-1D-BTC-16	44.0	33.2	38		27	yes
100	LU-1D-CTD5	LU-1D-BTC-07	41.7	31.9	23		28	yes
111	LU-1D-CTD5	LU-1D-BTC-08	41.8	51.5	13		29	yes
113	LU-1D-CTD5	LU-1D-BTC-09	4.1	75.1	7		30	no
116	LU-1D-CTD6	LU-1D-BTC-10	55.7	69.4	36		31	yes
118	LU-1D-CTD6	LU-1D-BTC-11	39.5	37.5	21	0.0047	32	yes

* denotes interpolated data

Table 3.5-5. Summary of CTD profiles acquired and water samples collected prior to (designated as background) and during cap placement Event 4 in Cell LU on August 13, 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**	**-0:08:00**	**0:22:51**	**0:56:56**	**1:25:51**	**1:42:03**	**1:52:52**	**1:54:53**
File/Cast End Time	Background	Background	0:09:24	0:39:52	1:12:32	1:34:40	1:50:39	1:54:22	2:00:09
Elapsed Time of Cast	0:14:02	0:17:54	0:17:24	0:17:01	0:16:24	0:09:11	0:08:36	0:02:30	0:06:44
CTD File Name	LU-2B-CTD1	LU-2B-CTD2	LU-2D-CTD1	LU-2D-CTD2	LU-2D-CTD3	LU-2D-CTD4	LU-2D-CTD5	LU-2D-CTD6	LU-2D-CTD7
Total Water Column Profiles	1	1	1	1	1	1	1	1	1
Near Bottom Profiles	1	1	1	3	3	5	1	1	1
Water Samples Collected	2	1	3	12	11	3	0	0	1
Minimum % Light Transmittance (PLT)	70	72	0	26	22	21	24	25	33
Depth of Minimum PLT			B-1 m	B-1 m	B-1 m	B-1 m	B-1 m	B-1 m	B-1 m

Table 3.5-6. Total suspended solids and DDE concentrations from discrete water samples collected during CTD profiling operations during cap placement Event 4 in Cell LU on August 13, 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	LU2BCTD1	LU-2B-BOT-01	40*	72*	2	0.006	B-1	no
Background	LU2BCTD2	LU-2B-BOT-02	39*	68*	2	0.0062	B-2	no
Background	LU2BCTD2	LU-2B-BOT-03	36*	71*	2	0.0071	B-3	no
0	LU2DCTD1	LU-2D-BTA-01	41.1	60.3	7		1	no
1	LU2DCTD1	LU-2D-BTA-02	41.1	0.0	3400	0.017	2	yes
1	LU2DCTD1	LU-2D-BTA-12	41.1	0.0	1300		3	yes
22	LU2DCTD2	LU-2D-BTB-01	40.6	32.0	77	0.0051	4	yes
22	LU2DCTD2	LU-2D-BTB-01	40.6	32.0	77	0.0064	5	yes
23	LU2DCTD2	LU-2D-BTB-02	42.3	33.4	41		6	yes
27	LU2DCTD2	LU-2D-BTB-03	38.4	47.4	33		7	yes
28	LU2DCTD2	LU-2D-BTB-04	42.3	39.2	31		8	yes
28	LU2DCTD2	LU-2D-BTB-05	42.0	41.8	18		9	yes
28	LU2DCTD2	LU-2D-BTB-05	42.0	41.8	13		10	yes
31	LU2DCTD2	LU-2D-BTB-07	42.0	45.5	22		11	yes
34	LU2DCTD2	LU-2D-BTB-08	40.8	31.1	27		12	yes
35	LU2DCTD2	LU-2D-BTB-09	41.2	29.3	34		13	yes
36	LU2DCTD2	LU-2D-BTB-10	42.0	29.7	37		14	yes
37	LU2DCTD2	LU-2D-BTB-11	41.7	27.9	33		15	yes
39	LU2DCTD2	LU-2D-BTB-12	41.8	29.4	37	0.0074	16	yes
56	LU2DCTD3	LU-2D-BTC-01	40.0	28.1	27		17	yes
57	LU2DCTD3	LU-2D-BTC-02	42.4	24.2	42		18	yes
58	LU2DCTD3	LU-2D-BTC-03	42.4	23.5	46		19	yes
59	LU2DCTD3	LU-2D-BTC-04	42.2	24.4	47	0.011	20	yes
59	LU2DCTD3	LU-2D-BTC-14	42.2	24.4	42	0.0083	21	yes
61	LU2DCTD3	LU-2D-BTC-05	1.8	82.8	4		22	no
64	LU2DCTD3	LU-2D-BTC-06	41.3	24.3	42		23	yes
65	LU2DCTD3	LU-2D-BTC-07	42.0	22.5	39		24	yes
70	LU2DCTD3	LU-2D-BTC-08	40.7	25.7	30		25	yes
71	LU2DCTD3	LU-2D-BTC-09	41.4	20.8	38		26	yes
72	LU2DCTD3	LU-2D-BTC-10	42.9	23.1	43		27	yes
85	LU2DCTD4	LU-2D-BTD-01	39.5	34.7	11		28	yes
90	LU2DCTD4	LU-2D-BTD-02	42.1	25.8	21	0.0062	29	yes
99	LU2DCTD4	LU-2D-BTD-03	42.0	22.5	19		30	yes
119	LU2DCTD7	LU-2D-BTD-04	43.0	33.5	11	0.008	31	yes

* Denotes interpolated data

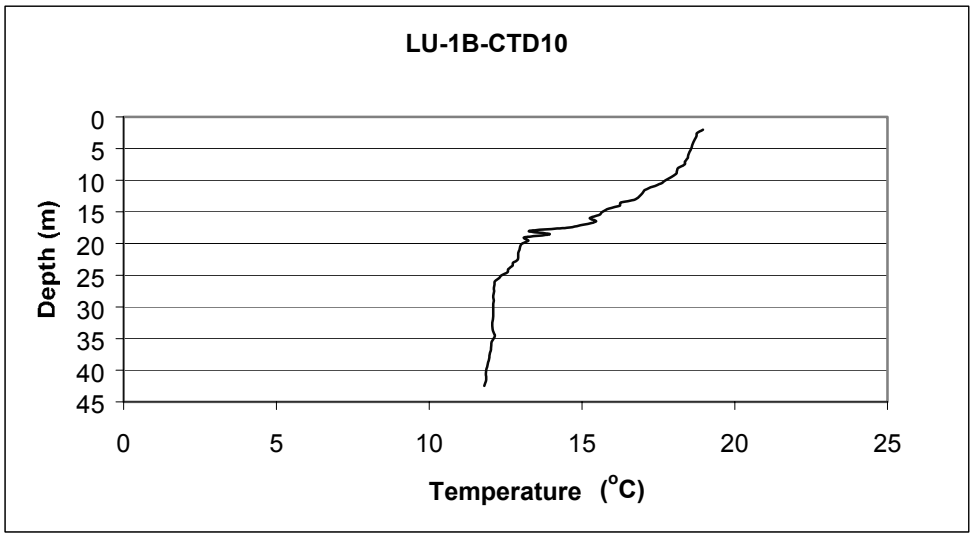
Table 3.5-7. Summary of CTD profiles acquired and water samples collected prior to (designated as background) and during cap placement Event 5 in Cell LU on August 13, 2000. Also given is the maximum turbidity (minimum percent light transmission) observed by the transmissometer interfaced to the CTD system during each profile.

Start Time After Placement (hr:min:sec)	Background	Background	-0:34:05	0:31:05	0:57:30	1:15:26	1:38:47	2:18:56
File/Cast End Time	Background	Background	0:07:30	0:43:46	1:09:28	1:29:42	2:08:25	2:28:13
Elapsed Time of Cast	0:17:45	0:11:02	0:41:35	0:12:41	0:11:58	0:14:16	0:29:38	0:09:17
CTD File Name	LU-3B-CTD1	LU-3B-CTD2	LU-3D-CTD1	LU-3D-CTD2	LU-3D-CTD3	LU-3D-CTD4	LU-3D-CTD5	LU-3D-CTD6
Total Water Column Profiles	1	1	1	1	1	1	1	1
Near Bottom Profiles	1	1	4	3	3	3	5	2
Water Samples Collected	2	1	3	13	11	4	0	0
Minimum % Light Transmittance (PLT)	69	70	0	0	6	8	28	27
Depth of Minimum PLT (m)			B-1 m	B-1 m	B-2 m	B-1 m	B-3 m	B-2 m

Table 3.5-8. Total suspended solids and DDE concentrations from discrete water samples collected during CTD profiling operations during cap placement Event 5 in Cell LU on August 13, 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	LU3BCTD1	LU-3B-BOT-01	43.0	74.8	3	0.0067	B-1	no
Background	LU3BCTD1	LU-3B-BOT-02	44.0	73.2	3	0.0066	B-2	no
Background	LU3BCTD1	LU-3B-BOT-03	44.1	72.7	4	0.0074	B-3	no
0	LU3DCTD1	LU-3D-BTA-01	41.2	72.1	3		1	no
1	LU3DCTD1	LU-3D-BTA-02	41.2	0.0	2,700	0.1	2	yes
32	LU3DCTD2	LU-3D-BTB-01	40.4	47.1	46		3	yes
33	LU3DCTD2	LU-3D-BTB-02	41.3	31.1	35		4	yes
34	LU3DCTD2	LU-3D-BTB-03	39.7	52.0	54	0.0058	5	yes
34	LU3DCTD2	LU-3D-BTB-03	39.7	52.0	54	0.005	6	yes
36	LU3DCTD2	LU-3D-BTB-04	41.4	0.0	57		7	yes
38	LU3DCTD2	LU-3D-BTB-05	40.6	17.8	97		8	yes
38	LU3DCTD2	LU-3D-BTB-15	40.6	17.8	51		9	yes
39	LU3DCTD2	LU-3D-BTB-06	40.3	5.9	65		10	yes
40	LU3DCTD2	LU-3D-BTB-07	37.5	26.4	35	0.0054	11	yes
40	LU3DCTD2	LU-3D-BTB-17	37.5	26.4	43		12	yes
41	LU3DCTD2	LU-3D-BTB-08	38.0	12.0	56		13	yes
42	LU3DCTD2	LU-3D-BTB-09	39.1	4.9	48		14	yes
42	LU3DCTD2	LU-3D-BTB-10	38.1	7.3	46		15	yes
58	LU3DCTD3	LU-3D-BTC-01	36.2	29.1	25		16	yes
59	LU3DCTD3	LU-3D-BTC-02	37.6	11.9	37		17	yes
60	LU3DCTD3	LU-3D-BTC-03	38.3	10.1	42	0.0071	18	yes
60	LU3DCTD3	LU-3D-BTC-03	38.4	10.1	42	0.0072	19	yes
61	LU3DCTD3	LU-3D-BTC-04	36.7	10.3	45		20	yes
61	LU3DCTD3	LU-3D-BTC-14	37.2	10.3	34		21	yes
63	LU3DCTD3	LU-3D-BTC-05	37.3	32.9	34		22	yes
64	LU3DCTD3	LU-3D-BTC-06	37.2	9.4	37		23	yes
64	LU3DCTD3	LU-3D-BTC-07	37.9	10.8	41		24	yes
64	LU3DCTD3	LU-3D-BTC-08	37.9	8.1	28		25	yes
65	LU3DCTD3	LU-3D-BTC-09	36.7	25.3	22		26	yes
65	LU3DCTD3	LU-3D-BTC-10	35.4	32.8	23		27	yes
68	LU3DCTD3	LU-3D-BTC-11	34.6	25.4	27		28	yes
85	LU3DCTD4	LU-3D-BTD-02	37.2	67.1	7		29	no
89	LU3DCTD4	LU-3D-BTD-04	30.1	57.1	4	0.0018	30	no
122	LU3DCTD5	LU-3D-BTD-06	28.9	68.9	4	0.0016	31	no
125	LU3DCTD5	LU-3D-BTD-08	34.6	54.9	6	0.004	32	no

EVENT 1 FIGURES



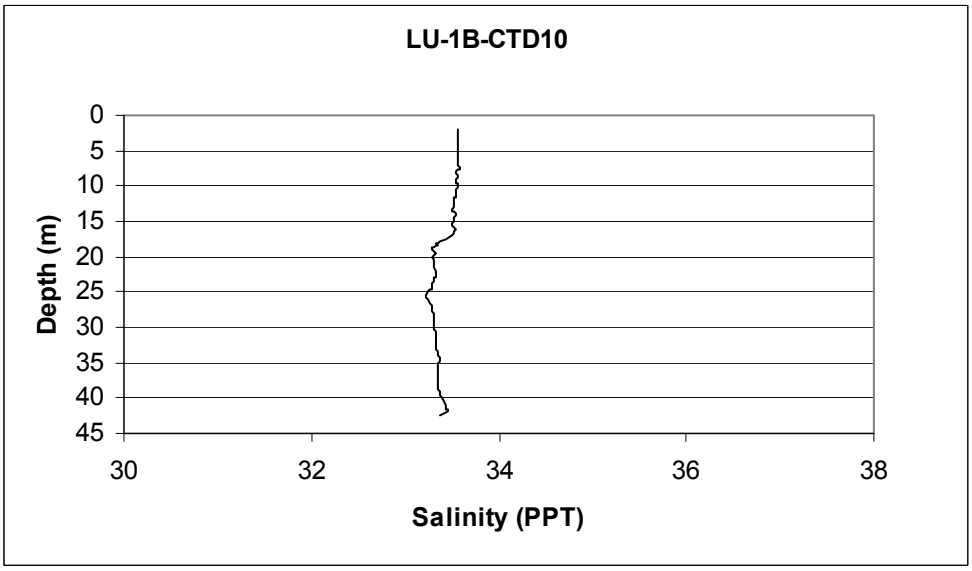
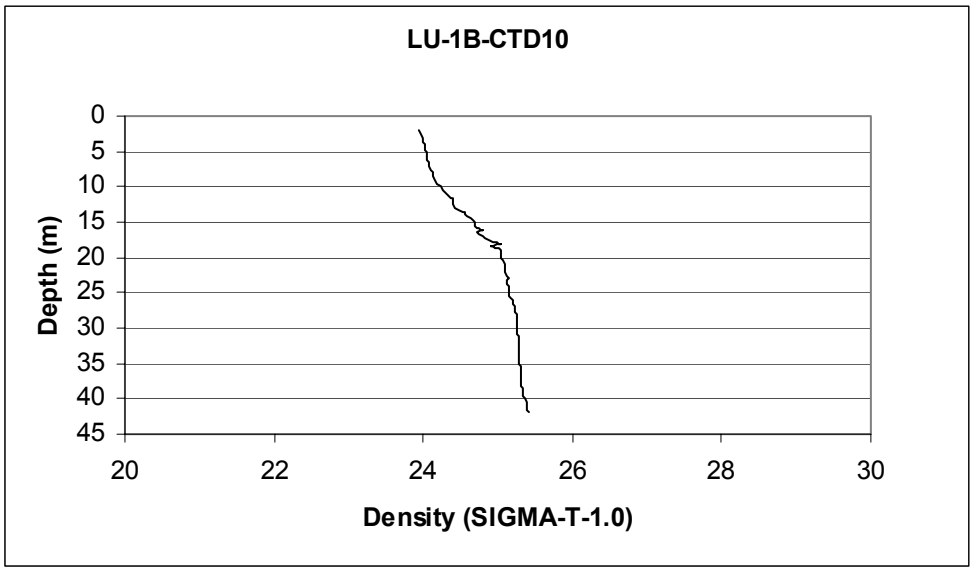


Figure 3.5-1a. Profile plot of temperature and salinity versus depth during baseline CTD Station 10 prior to cap placement Event 1 in Cell LU on August 2, 2000. Data are from the downcast profile only. See Table 3.5-3 for CTD profile information.



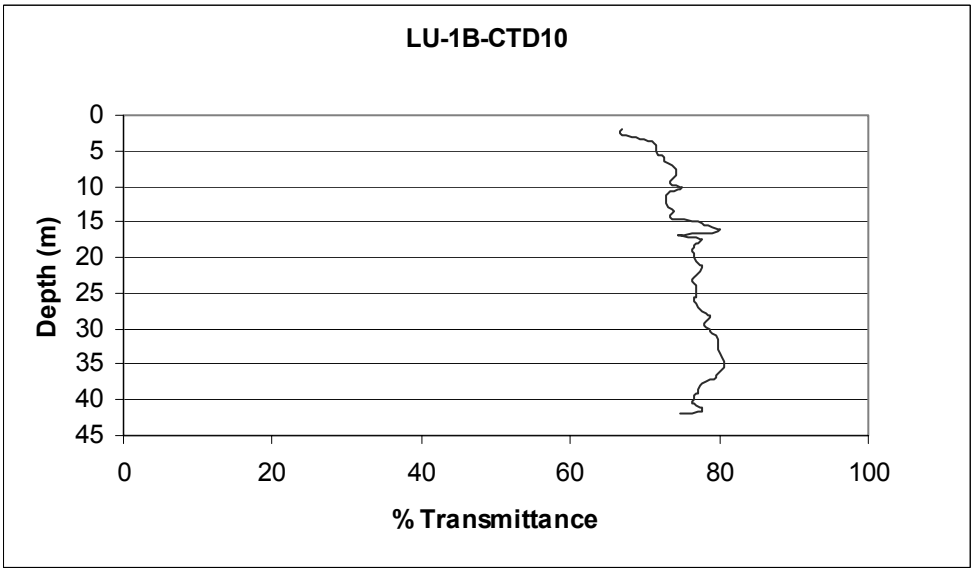


Figure 3.5-1b. Profile plot of percent light transmission and seawater density versus depth during baseline CTD Station 10 prior to cap placement Event 1 in Cell LU on August 2, 2000. Data are from the downcast profile only. See Table 3.5-3 for CTD profile information.

EVENT 1 FIGURES

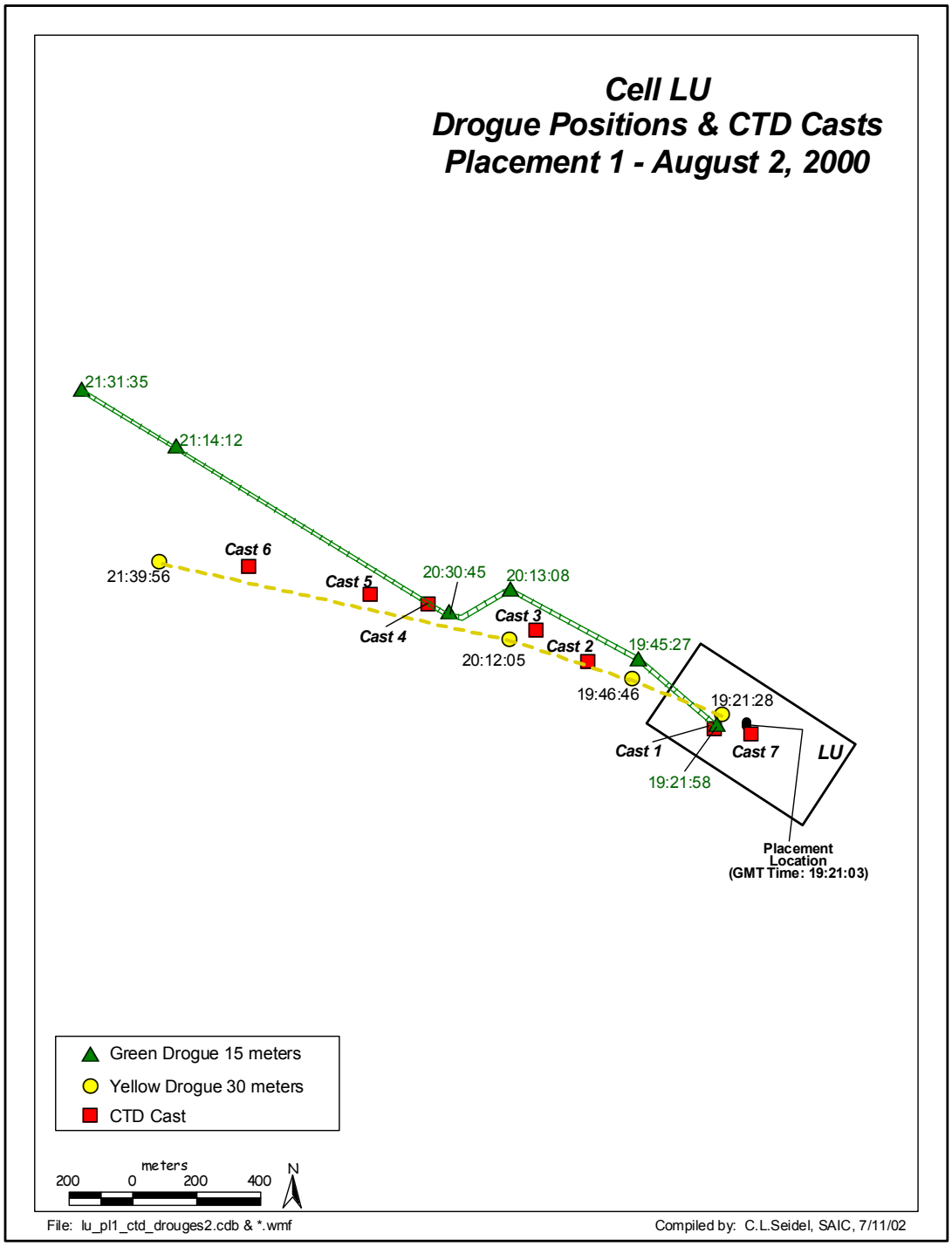


Figure 3.5-2. Map of Cell LU indicating drogue trajectories and CTD stations during cap placement Event 1 on August 2, 2000. Locations of selected ADCP lines also are shown (see Section 3.6).

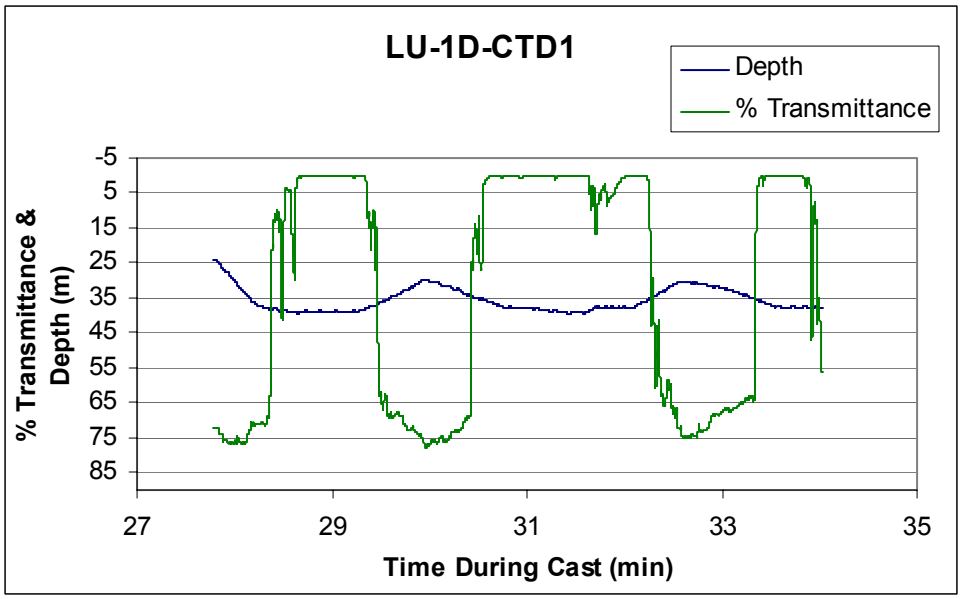
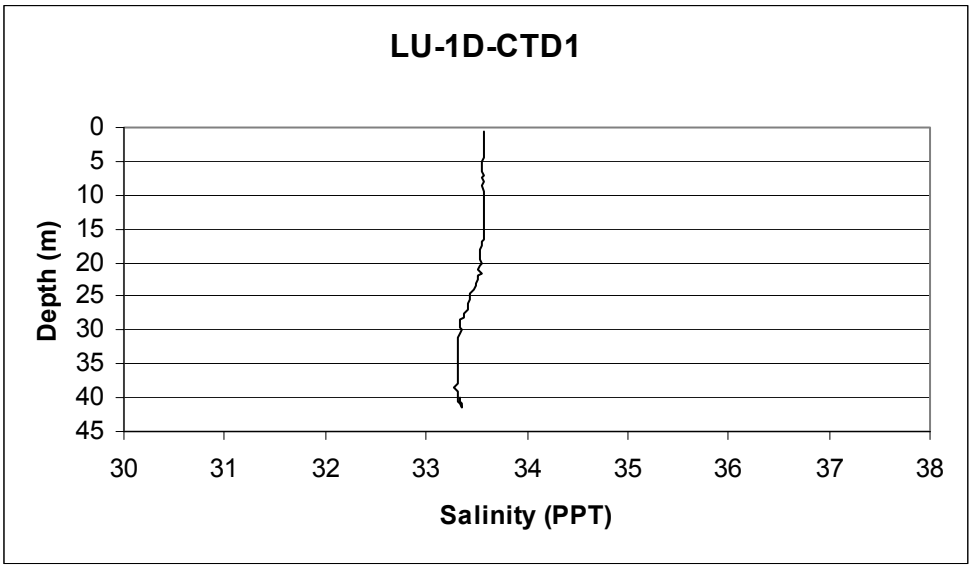


Figure 3.5-3. Time series plot of percent light transmission and sensor depth acquired during CTD Station 1 during cap placement Event 1 in Cell LU on August 2, 2000. See Table 3.5-3 for CTD profile information.



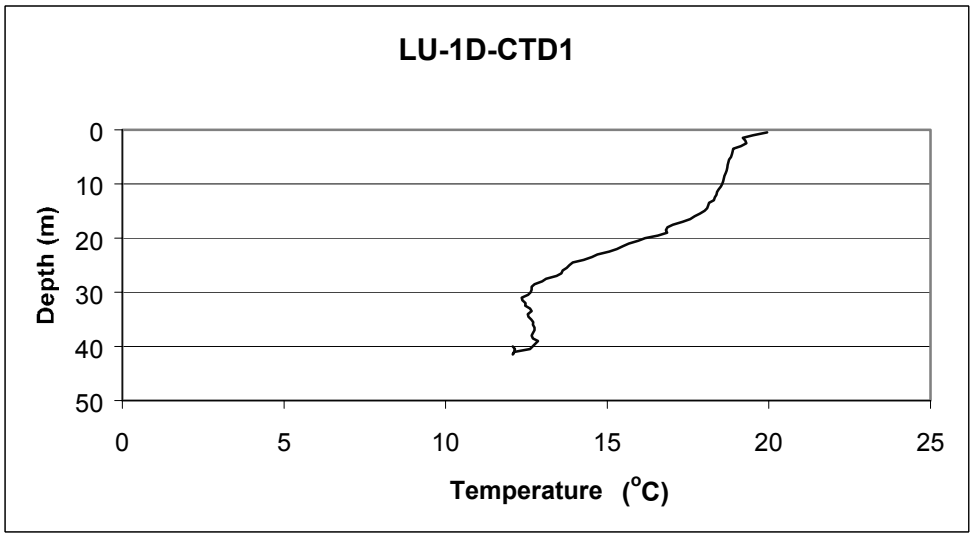
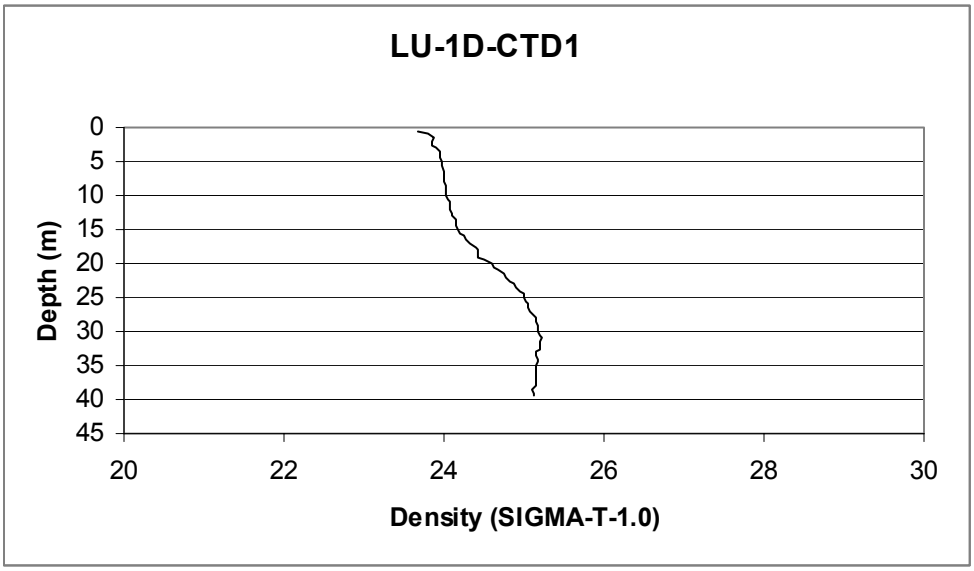


Figure 3.5-4a. Profile plot of temperature and salinity versus depth during CTD Station 1 during cap placement Event 1 in Cell LU on August 2, 2000. Data are from the downcast profile only. See Table 3.5-3 for CTD profile information.



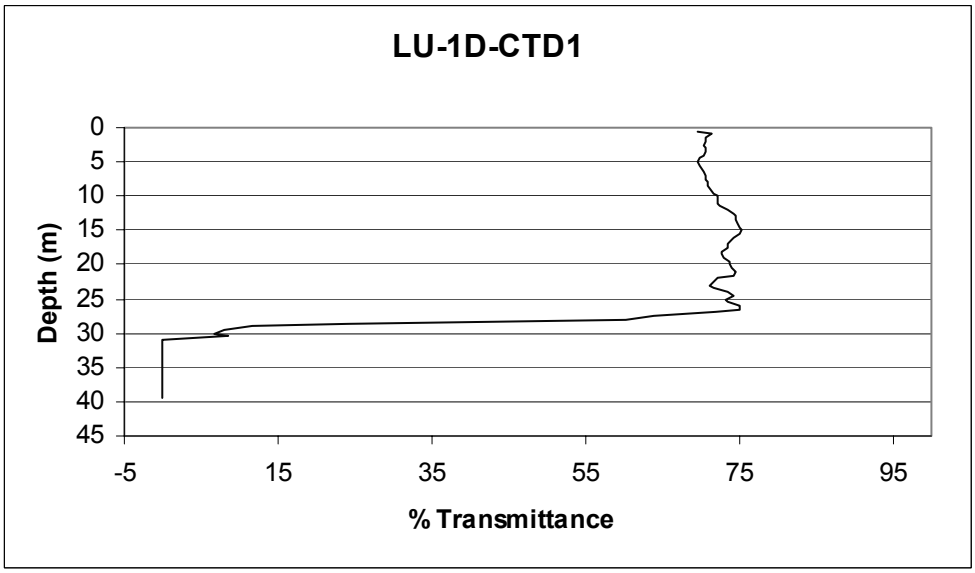


Figure 3.5-4b. Profile plot of percent light transmission and seawater density versus depth during CTD Station 1 during cap placement Event 1 in Cell LU on August 2, 2000. Data are from the downcast profile only. See Table 3.5-3 for CTD profile information.

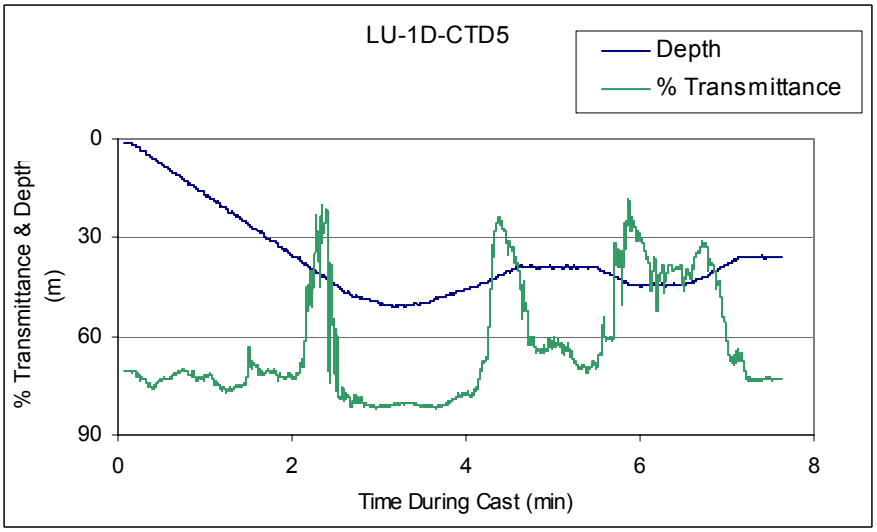


Figure 3.5-5. Time series plot of percent light transmission and sensor depth acquired during CTD Station 5 during cap placement Event 1 in Cell LU on August 2, 2000. See Table 3.5-3 for CTD profile information.

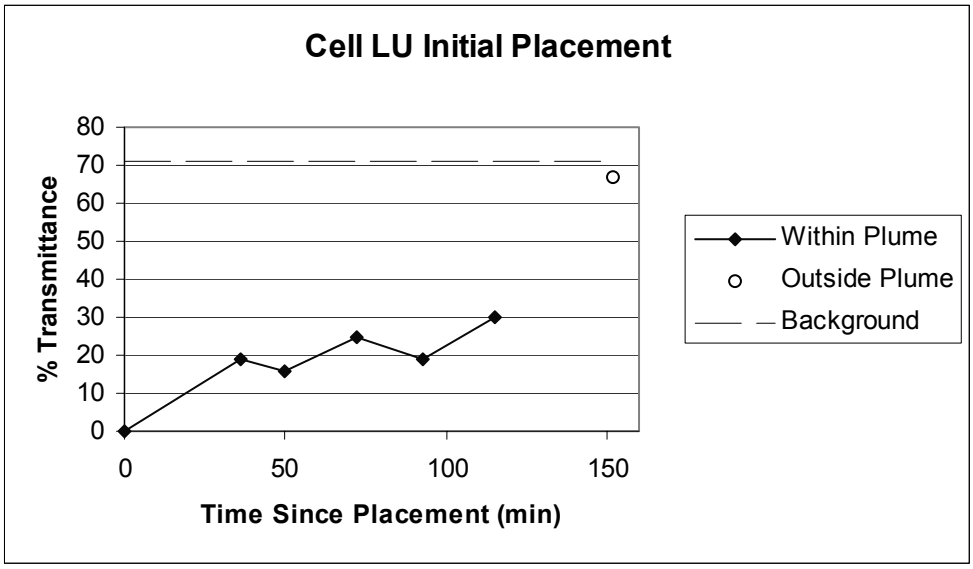


Figure 3.5-6. Time series plot of the minimum value of percent light transmission acquired during each CTD profile conducted during cap placement Event 1 in Cell LU on August 2, 2000. See Table 3.5-3 for CTD profile information.

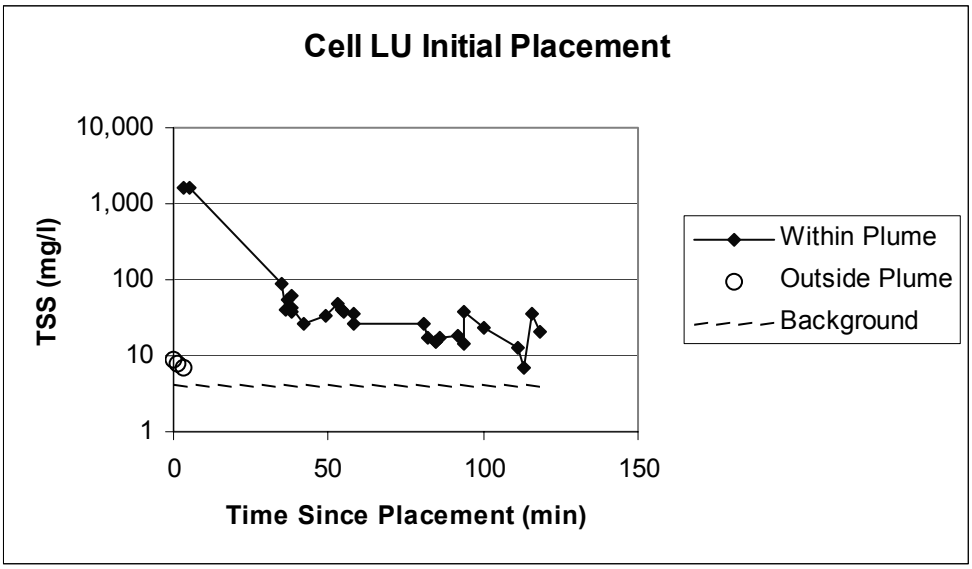


Figure 3.5-7. Plot of total suspended solids concentration versus time since cap placement event for discrete water samples collected during CTD profiling operations of cap placement Event 1 in Cell LU on August 2, 2000.

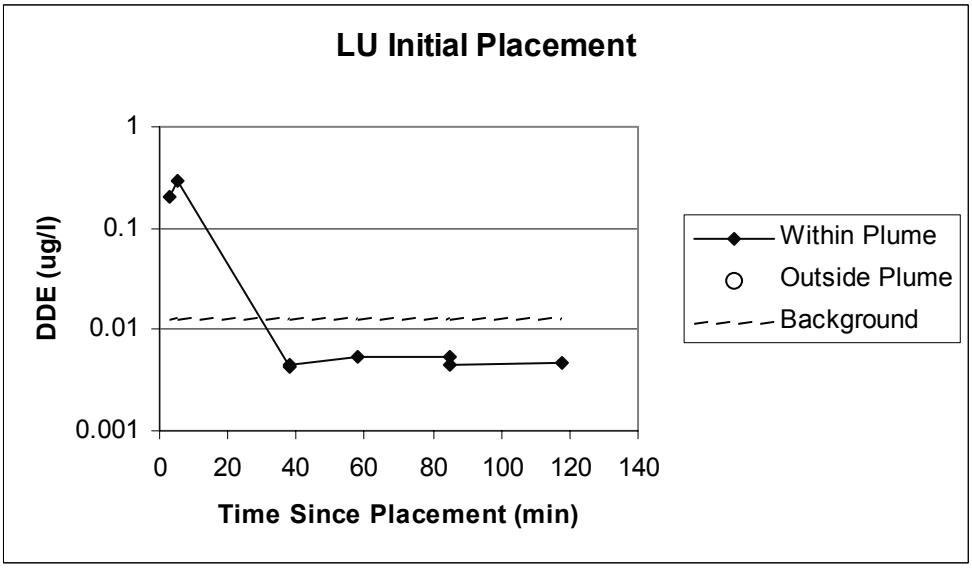


Figure 3.5-8. Plot of DDE concentration versus time since cap placement event for discrete water samples collected during CTD profiling operations of cap placement Event 1 in Cell LU on August 2, 2000.

EVENT 4 FIGURES

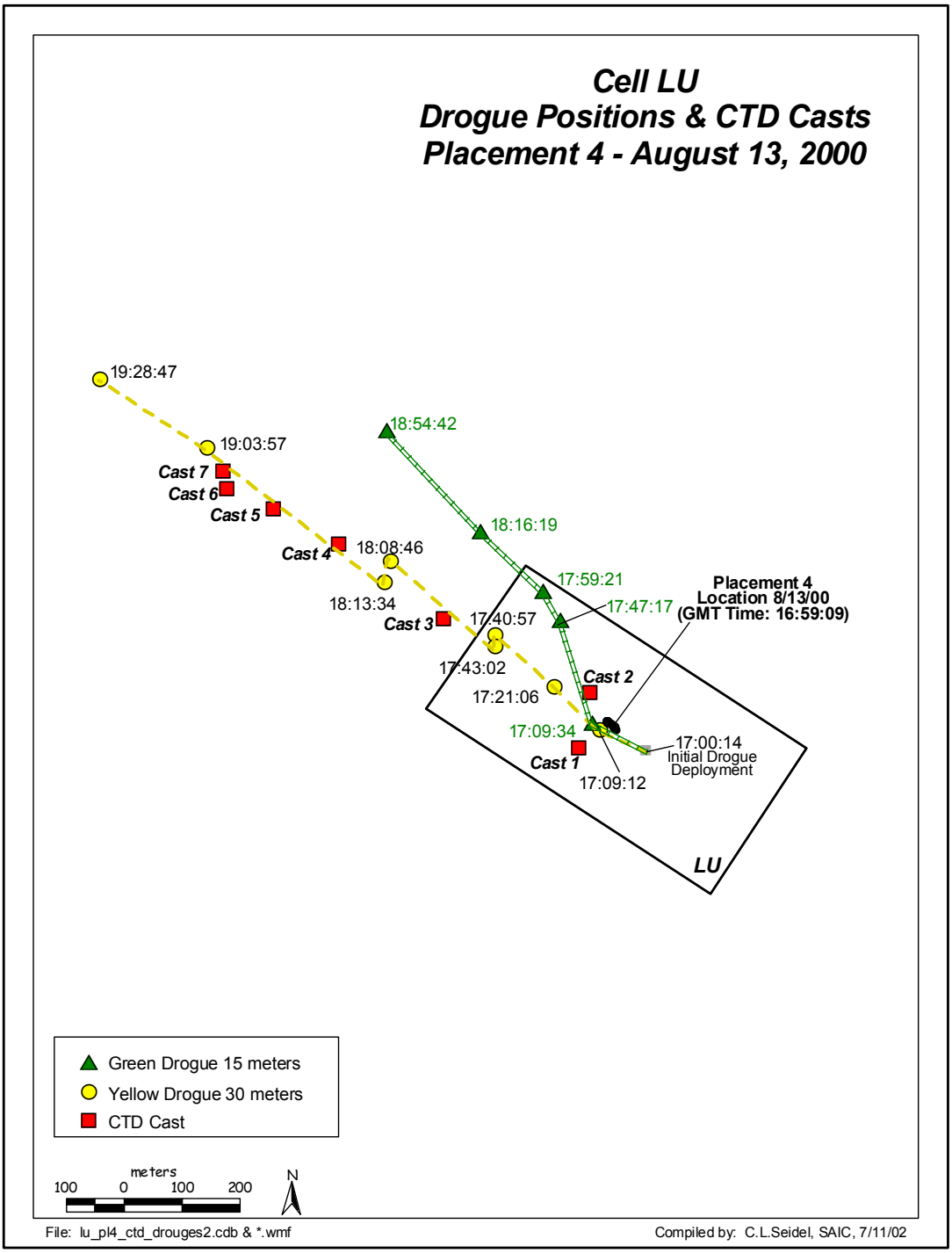


Figure 3.5-9. Map of Cell LU indicating drogue trajectories and CTD stations during cap placement Event 4 in Cell LU on August 13, 2000. Locations of selected ADCP lines also are shown (see Section 3.6).

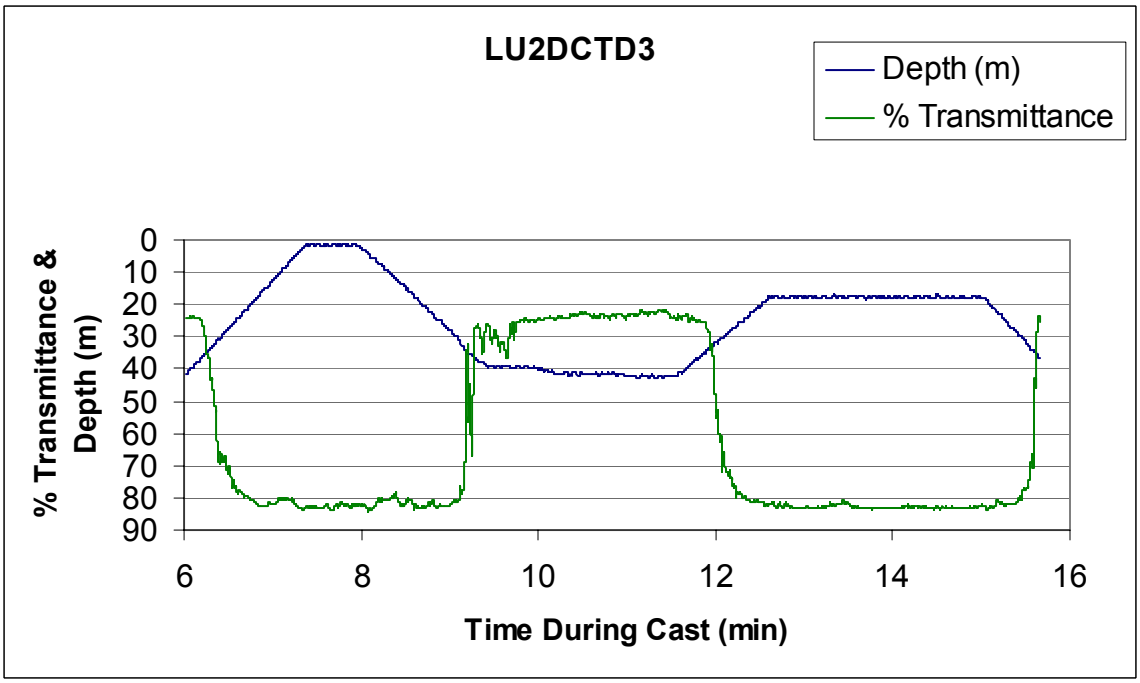


Figure 3.5-10. Time series plot of percent light transmission and sensor depth acquired during CTD Station 3 during cap placement Event 4 in Cell LU on August 13, 2000. See Table 3.5-5 for CTD profile information.

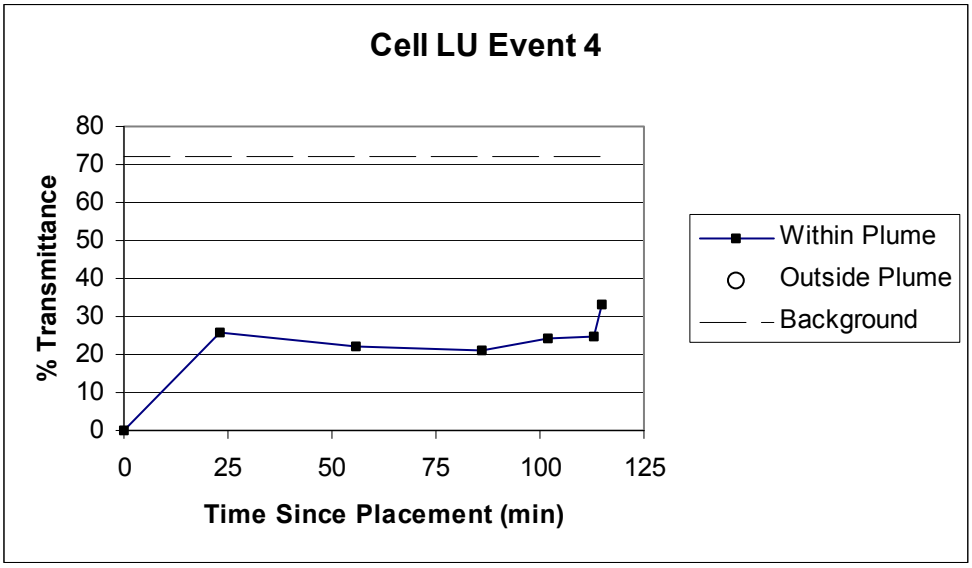


Figure 3.5-11. Time series plot of the minimum value of percent light transmission acquired during each CTD profile conducted during cap placement Event 4 in Cell LU on August 13, 2000. See Table 3.5-5 for CTD profile information.

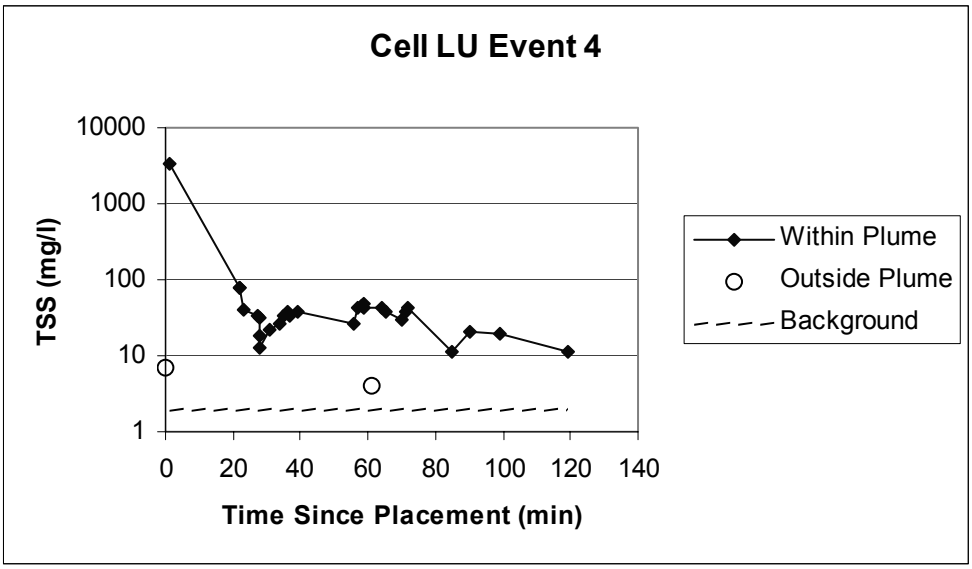


Figure 3.5-12. Plot of total suspended solids concentration versus time since cap placement event for discrete water samples collected during CTD profiling operations of cap placement Event 4 in Cell LU on August 13, 2000.

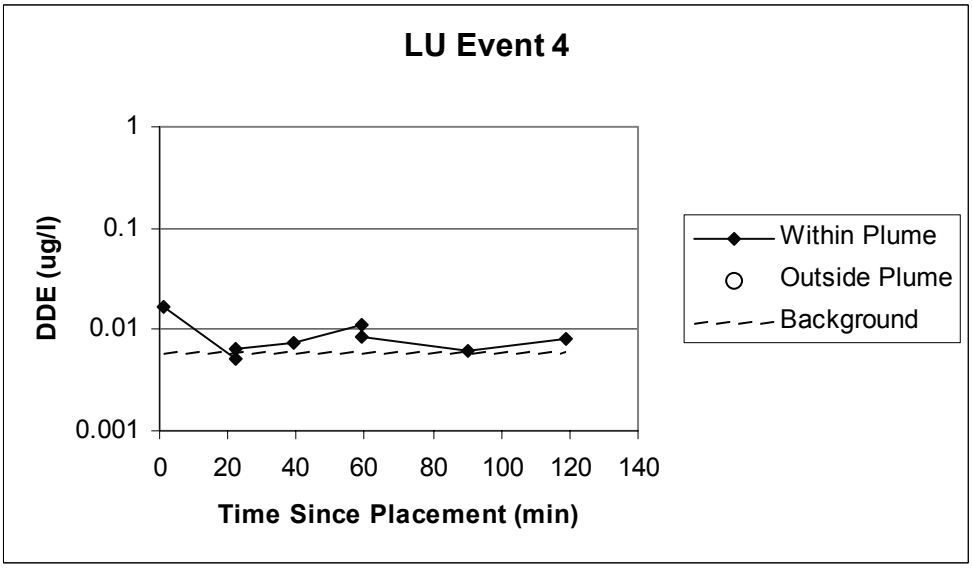


Figure 3.5-13. Plot of DDE concentration versus time since cap placement event for discrete water samples collected during CTD profiling operations of cap placement Event 4 in Cell LU on August 13, 2000.

EVENT 5 FIGURES

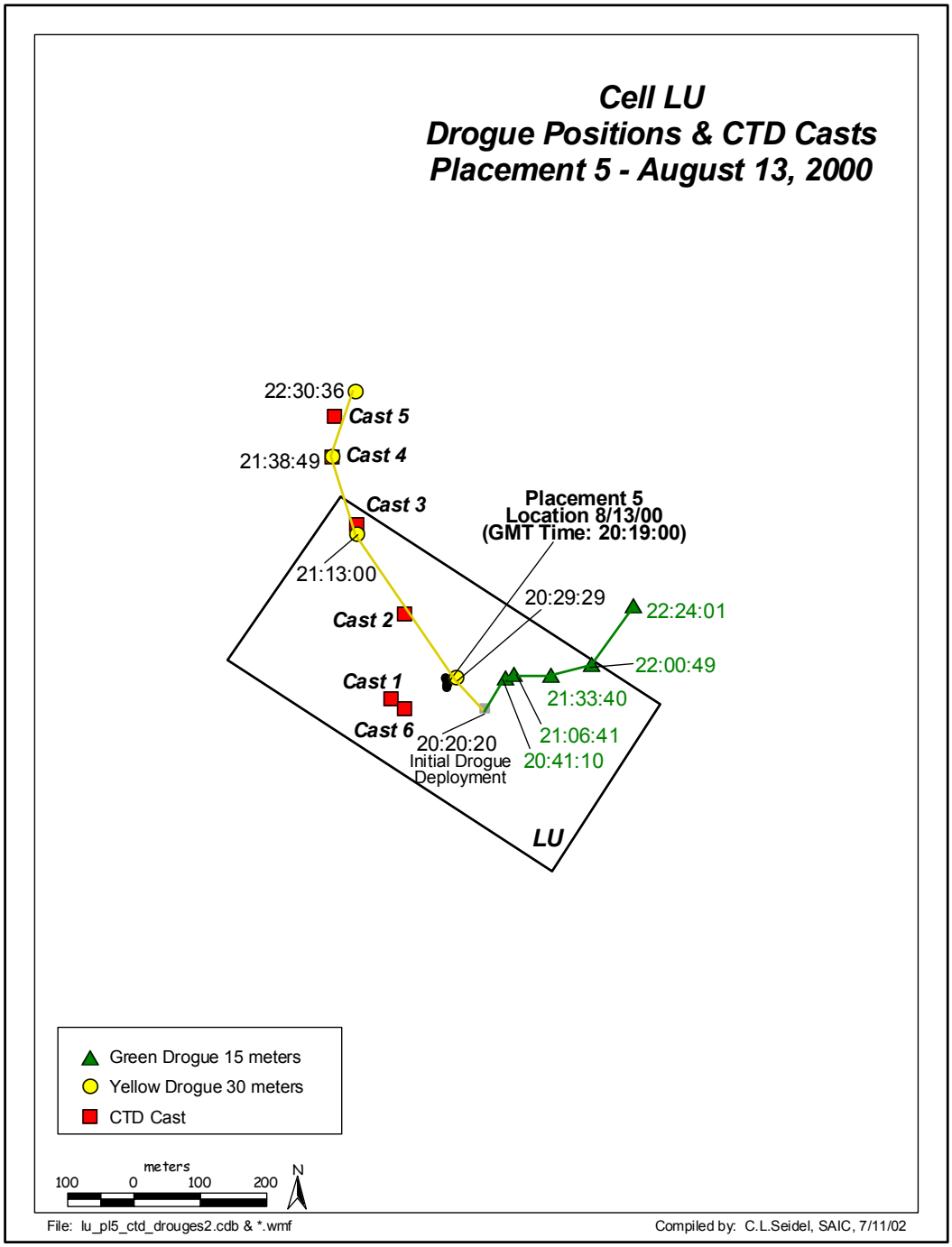


Figure 3.5-14. Map of Cell LU indicating drogue trajectories and CTD stations during cap placement Event 5 in Cell LU on August 13, 2000. Locations of selected ADCP lines also are shown (see Section 3.6).

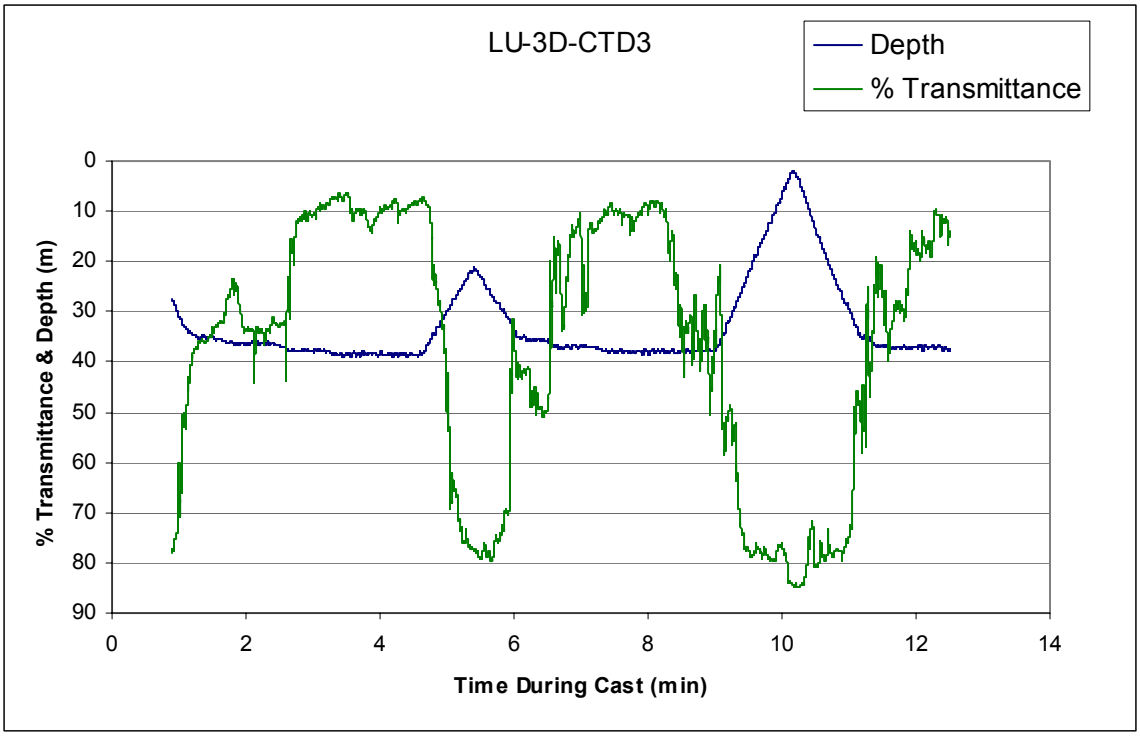


Figure 3.5-15. Time series plot of percent light transmission and sensor depth acquired during CTD Station 3 during cap placement Event 5 in Cell LU on August 13, 2000. See Table 3.5-7 for CTD profile information.

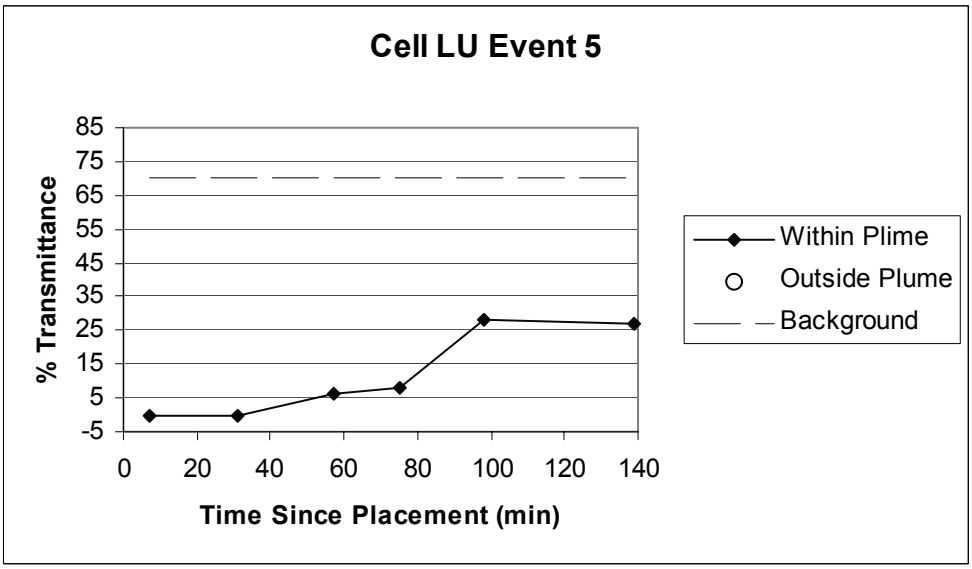


Figure 3.5-16. Time series plot of the minimum value of percent light transmission acquired during each CTD profile conducted during cap placement Event 5 in Cell LU on August 13, 2000. See Table 3.5-7 for CTD profile information.

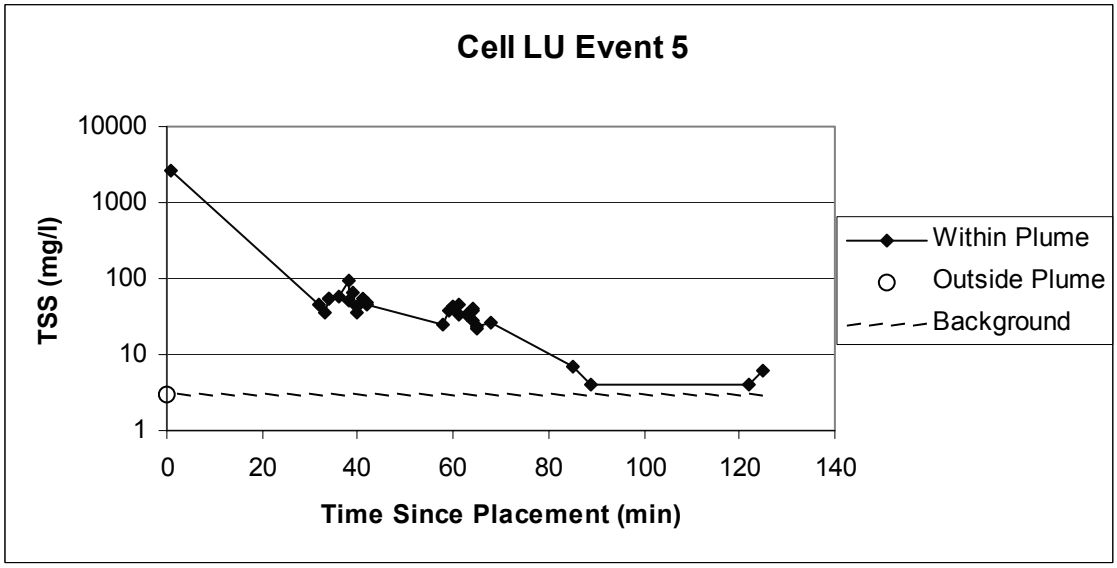


Figure 3.5-17. Plot of total suspended solids concentration versus time since cap placement event for discrete water samples collected during CTD profiling operations of cap placement Event 5 in Cell LU on August 13, 2000.

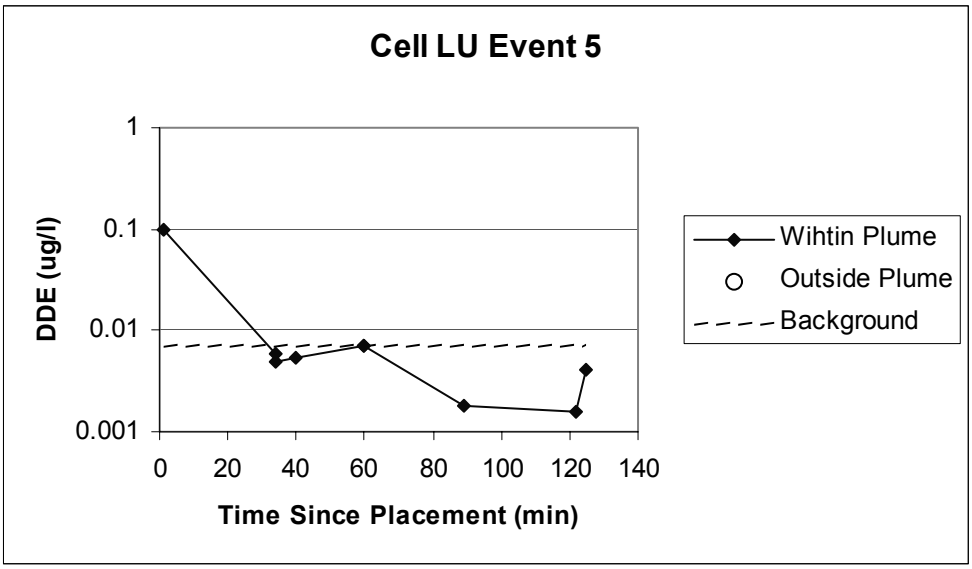


Figure 3.5-18. Plot of DDE concentration versus time since cap placement event for discrete water samples collected during CTD profiling operations of cap placement Event 5 in Cell LU on August 13, 2000.

COMPOSITE OF THREE LU EVENTS

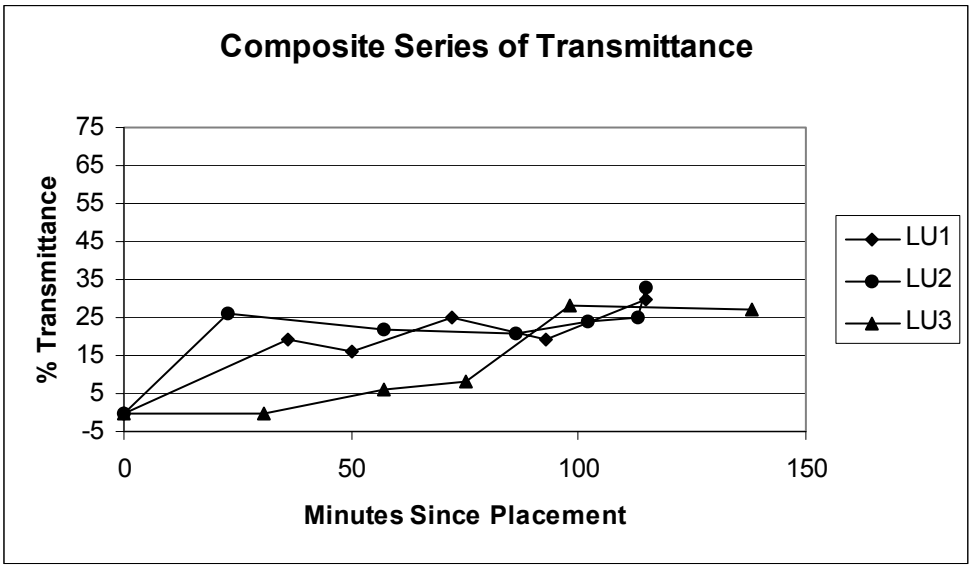


Figure 3.5-19. Composite time series plot of the minimum value of percent light transmission acquired during CTD profiles conducted during three cap placement events in Cell LU: LU1 = Event 1; LU2 = Event 4; LU3 = Event 5.

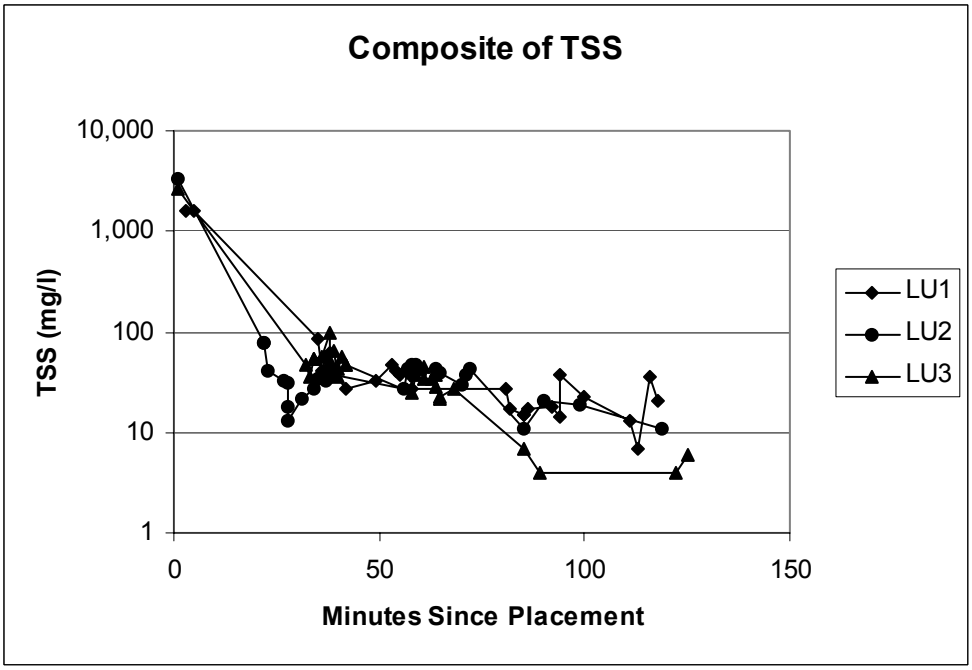


Figure 3.5-20. Composite plot of total suspended solids concentration versus time of sample collection (after initiation of cap placement) for discrete water samples collected during CTD profiling operations of three cap placement events in Cell LU: LU1 = Event 1; LU2 = Event 4; LU3 = Event 5.

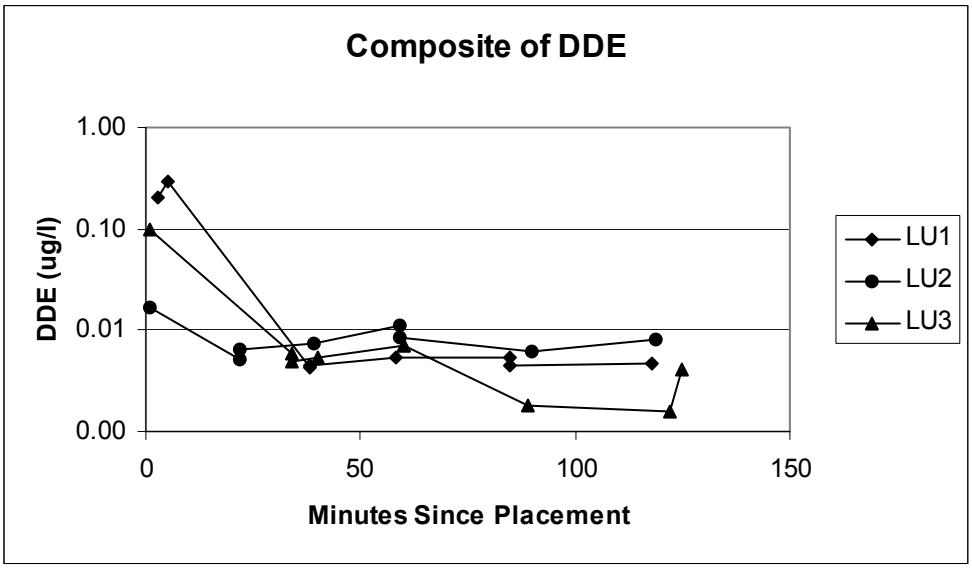


Figure 3.5-21. Composite plot of DDE concentration versus time of sample collection (after initiation of cap placement) for discrete water samples collected during CTD profiling operations of three cap placement events in Cell LU: LU1 = Event 1; LU2 = Event 4; LU3 = Event 5.

3.6 Underway Measurements of Acoustic Backscatter

3.6.1 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 operations in Cell LU. The measurements were conducted to provide a representative current speed and direction profile for each operation, and to provide information about the resulting spatial extent and transport of suspended sediments. The measurements were made remotely in profiles of 0.5 m depth-cells that started at a depth of approximately 4.5 m and extended to within approximately 1 m of the bottom. In Cell LU, the BBADCP was towed at a depth of about 3 m from the stern of the survey vessel R/V Tuna. Details of the system and methodology can be found in the Project Work Plan (PWP; SAIC 2001).

The sampling plan called for the collection of acoustic backscatter baseline data along survey lines, and a vertical profile of horizontal currents at the target placement location just prior to the dredge reaching the site for each operation. It also called for the monitoring of acoustic backscatter along survey lines during and after the placement operations to monitor the extent and transport of the suspended sediment plume. A grid of survey lines that covered the cell, and the adjacent area, was constructed before each monitored placement event. During the monitoring, the survey lines were chosen "on-the-fly" based on the transport of drogues set out during the placement operation (Section 3.4), and on the basis of acoustic backscatter observations made while searching for a suspended sediment plume after the placement operation. During both days when monitoring operations were conducted in Cell LU (August 2 and 13, 2000), all phases of the sampling plan were accomplished. Details of the sampling plan can be found in the PWP.

3.6.2 Review of Data Quality Objectives

The BBADCP performed to specification, and all data objectives were achieved. The primary objective for the BBADCP system was that it be able to clearly distinguish the acoustic backscatter from the plume of suspended sediments resulting from the placement operations, and to monitor the extent and transport of the residual plume for up to two hours after the placement operation. The plume was successfully monitored for more than 1.5 hr after three placement operations in Cell LU.

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

3.6.3 Technical Considerations

During a BBACDP survey, acoustic backscatter can be observed from sources other than suspended sediment resulting from the cap placement operation. The primary acoustic scatterers are naturally-occurring ambient suspended sediment, plankton, fish, and boat wakes. These are discussed in the PWP. Backscatter from naturally-occurring ambient sediment was relatively low and uniform in Cell LU. Therefore, this background backscatter was successfully removed by the statistical techniques described in the PWP. With the exception of vessels conducting the monitoring and the dredge, boat

traffic in the area was practically nonexistent, and conducting the BBADCP monitoring in a manner that avoided boat wake effects was effective. In Cell LU, there were no areas observed were acoustic backscatter from plankton or fish seemed to be a problem. There were a few insignificant observations where backscatter may have come from a school of fish.

The plots of the acoustic backscatter data are vertical slices of Acoustic Backscatter Above Background (ABAB). ABAB is a measure of acoustic backscatter, calculated with the intent of producing nonzero results only when suspended sediments or air bubbles from the placement operation are encountered. Larger values of ABAB cannot, in general, be interpreted as greater concentrations of suspended sediment. In essence, higher values of ABAB mean that there is greater confidence that the backscatter is associated with suspended sediment from the placement operation. In some cases, when the background variations in acoustic backscatter are spatially uniform over a given area, greater ABAB values in that area can mean greater relative suspended sediment concentrations in the area, however this was rare for the monitoring on the PV Shelf. Details of how ABAB is calculated are provided in the PWP.

3.6.4 Monitoring Results

3.6.4.1 Current Profiles

The four current profiles obtained in Cell LU are presented in this section. Consistent with the recommendations of the manufacturer of the BBADCP (RD Instruments), data from the lower 15% of the depth profile (i.e., very near the bottom) are not meaningful because of possible contamination of the data from acoustic side lobes.

Figure 3.6-1 shows the current profile obtained on August 2, 2000, in Cell LU at 1752 GMT. It is the result of a 15-min average of current speed and direction ending at 1807 GMT, 1 hr and 14 min before the placement operation began. The approximate location of all pre-placement current-profile measurements made in Cell LU was 33° 42.536’ N and 118° 20.717’W, which was close to the locations of the cap material placements.

Figure 3.6-2 shows the current profile obtained on August 13, 2000 in Cell LU at 1630 GMT. It is the result of a 15-min average of current speed and direction ending at 1645 GMT, 9 minutes before the first of the two placement operations monitored on that day began.

Figure 3.6-3 shows the current profile obtained on August 13, 2000, in Cell LU at 1905 GMT. It is the result of a 15-min average of current speed and direction ending at 1920 GMT, 2 hr and 18 min after the first of the two placement operations monitored on that day ended, and 59 minutes before the second placement operation began.

Figure 3.6-4 shows the current profile obtained on August 13, 2000, in Cell LU at 2204 GMT. It is the result of a 15-min average of current speed and direction ending at 2219 GMT, 1 hr and 58 min after the second of the two placement operations monitored on that day ended.

3.6.4.2 Acoustic Backscatter Monitoring During Placement Event 1

Figure 3.6-5 shows the survey lines run to monitor the acoustic backscatter from the suspended sediment resulting from the placement operation on August 2, 2000 (Table 3.6-1). Plots of the acoustic backscatter observed on these lines are shown in Figures 3.6-6 through 3.6-13.

Table 3.6-1. Start and End Times for ADCP Lines during placement Event 1 in Cell LU on August 2, 2000

Towed ADCP Lines		
Line Number	Start Time GMT	End Time GMT
1	19:13:01	19:24:12
2	19:26:23	19:30:00
3	19:33:22	19:37:54
4	19:40:04	19:44:20
5	19:46:52	19:51:36
6	19:54:50	19:59:43
7	20:04:43	20:10:17
8	20:19:36	20:30:15

3.6.4.3 Acoustic Backscatter Monitoring During Placement Events 4 and 5

3.6.4.3.1 Placement Event 4

Figure 3.6-14 shows the survey lines run to monitor the acoustic backscatter from the suspended sediment resulting from the first placement operation on August 13, 2000 (Table 3.6-2). Graphs of ABAB observed along these lines are shown in Figures 3.6-15 through 3.6-26.

Table 3.6-2. Start and End Times for ADCP Lines during placement Event 4 in Cell LU on August 13, 2000

Towed ADCP Lines		
Line Number	Start Time GMT	End Time GMT
1	17:00:48	17:01:49
2	17:02:47	17:05:51
3	17:06:53	17:09:27
4	17:10:46	17:13:23
5	17:14:29	17:15:52
6	17:19:09	17:22:30
7	17:25:22	17:31:02
8	17:33:09	17:39:26
9	17:41:42	17:45:55
10	17:47:45	17:53:13
11	17:56:25	18:01:50
12	18:05:17	18:10:46

3.6.4.3.2 Placement Event 5

Figure 3.6-27 shows the survey lines run to monitor the acoustic backscatter from the suspended sediment resulting from the second placement operation on August 13, 2000 (Table 3.6-3). Graphs of the ABAB observed along these lines are shown in Figures 3.6-28 through 3.6-35.

Table 3.6-3. Start and End Times for ADCP Lines during placement Event 5 in Cell LU on August 13, 2000

Towed ADCP Lines		
Line Number	Start Time GMT	End Time GMT
1	20:30:12	20:33:41
2	20:36:19	20:40:57
3	20:43:24	20:47:07
4	20:49:17	20:54:18
5	20:56:28	21:01:01
6	21:10:17	21:18:56
7	21:24:32	21:34:17
8	21:47:01	21:52:32

3.6.5 Discussion

3.6.5.1 Placement Event 1 on August 2, 2000

On August 2, 1 hr and 14 min before the placement operation, the currents were in a general southwesterly direction from top-to-bottom, and current speeds were 20 to 30 cm/s (Figure 3.6-1). Table 3.6-4 summarizes the information on the acoustic-backscatter transects. Table 3.6-4 shows that using the plume measured along Line 8 (Figure 3.6-13), the total transport rate of the suspended sediment during the survey was 26 cm/s toward 302°T.

3.6.5.2 Placement Event 4 on August 13, 2000

On August 13, approximately 9 min before the placement operation, a sheared current profile was measured (Figure 3.6-2). Currents were toward the east above approximately 12 m, and toward the northwest below this depth. Near-surface current speeds reached 22 cm/s. Current speeds were generally in the range of 10 to 17 cm/s in the lower part of the water column. Table 3.6-5 summarizes the information on the acoustic-backscatter transects.

A noteworthy characteristic of some of these plumes is the lack of ABAB in the center of the plume, giving them a “hollow” appearance. A good example of this is shown in Figure 3.6-20. This is believed to be a result of discharge of sediment from the dredge after the initial placement operation as it turns around and heads back to the harbor. The 180° turn required to do this is made to the north. In figures where this feature is apparent, the offshore section of the plume along the survey line is believed to be from suspended sediment resulting from the initial placement operation.

Table 3.6-4. Summary of Results of Acoustic Monitoring of Suspended Sediment for placement Event 1 on August 2, 2000

Survey Line	Elapsed Time[1] (min:sec)	Location[2] Distance (m)	Location[2] Bearing (°T)	Speed[3] (cm/s)	Characteristics
1	5:29	156	287	47	Suspended sediment plume was 200 m along line. ABAB from dredge's wake or from sediment discharged after the initial placement was at about 75 m. No bottom surge was apparent
2	6:03	168	313	44	Apparent bottom surge. Width of bottom surge along line was 380 m. Height of the bottom surge above the bottom was 2.5 to 9 m.
3	13:48	216	272	28	
4	20:43	296	327	24	Above 17 m depth, plume was displaced in the onshore direction relative to the portion from 17 m to the bottom.
5	26:42	348	299	22	Same displacement as on Survey Line 4.
6	35:18	456	304	22	Same displacement as on Survey Line 4. Above 17 m, plume was approximately 225 to 300 m wide along the survey line. Below 17 m it was approximately 400 to 500 m wide.
7	45:05	577	294	21	Plume started to disappear below 35 m depth.
8	58:15	897	302	26	Plume seen only between 5 and 35 m depth.

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

Table 3.6-5. Summary of Results of Acoustic Monitoring of Suspended Sediment for placement Event 4 on August 13, 2000

Survey Line	Elapsed Time[1] (min:sec)	Location[2] Distance (m)	Location[2] Bearing (°T)	Speed[3] (cm/s)	Characteristics
1	-1:18	86	105	NA	Suspended sediment plume was 175 m along line. No bottom surge was apparent. Discharge of dredged material just begun.
2	2:15	97	109	72	Apparent bottom surge. Width of surge could not be determined.
3	6:19	102	111	27	Apparent bottom surge. Offshore boundary of surge was 216 m from the placement site. Onshore boundary could not be determined. Height of surge above bottom was 1.0 to 9 m.
4	11:47	77	140	11	Apparent bottom surge. Onshore boundary of surge was 200 m from the placement site. Offshore boundary could not be determined. Height of surge above bottom was 1.0 to 7.5 m. Beginning with this survey line, the "hollow" appearance of the plume, believed to be caused by sediment discharged after the initial placement, was evident.
5	15:13	92	108	10	Apparent bottom surge. Boundaries of surge could not be determined.
6	20:21	111	316	9	Hollow appearance was major feature.
7	27:36	182	318	11	Offshore portion of bottom surge still apparent.
8	36:42	112	322	5	Hollow appearance was major feature.
9	43:08	283	324	11	Hollow appearance was major feature.
10	50:56	212	312	7	Hollow appearance was major feature.
11	58:27	278	322	8	Onshore portion of plume below approximately 25 m not visible. Plume started to disappear above 10 m.
12	68:21	480	304	12	Hollow appearance was major feature. Plume started to disappear above 17 m.

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

3.6.5.3 Placement Event 5 on August 13, 2000

The current profile measured after placement Event 4, and before Event 5, on August 13 is shown in Figure 3.6-3. Figure 3.6-4 shows the profile from data obtained immediately after the acoustic backscatter survey of placement Event 5. The data were similar to the earlier profile (Figure 3.6-2) in that there was a near-surface layer moving eastward, and lower in the water column the currents were orientated toward the northwest. However, current speeds seemed to have decreased over the entire profile as the survey progressed. This is supported by the smaller transport rates shown in Table 3.6-6, which summarizes the information on the acoustic backscatter transects.

Table 3.6-6. Summary of Results of Acoustic Monitoring of Suspended Sediment for the Placement Event 5 on August 13, 2000

Survey Line	Elapsed Time[1] (min:sec)	Location[2] Distance (m)	Location[2] Bearing (°T)	Speed[3] (cm/s)	Characteristics
1	11:53	92	338	13	Apparent bottom surge with uplift at onshore boundary. Onshore boundary was 305 m from the placement site. Offshore boundary could not be determined. Height of surge above bottom was 3.5 to 16.5 m.
2	18:26	38	357	3	Apparent bottom surge. Offshore boundary was 306 m from placement site. Onshore boundary was 287 m from placement site. Height of surge above bottom was 2 to 12.5 m.
3	24:44	154	345	10	Offshore portion of bottom surge still apparent. Beginning with this survey line, the "hollow" appearance of the plume, believed to be caused by sediment discharged after the initial placement, was evident.
4	32:09	125	350	6	Offshore portion of bottom surge still apparent. Hollow appearance was major feature.
5	38:43	207	350	9	Offshore portion of bottom surge still apparent. Hollow appearance was major feature.
6	54:28	293	303	7	Hollow appearance not apparent.
7	67:49	505	297	12	Hollow appearance not apparent.
8	70:15	107	358	3	Hollow appearance not apparent.

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

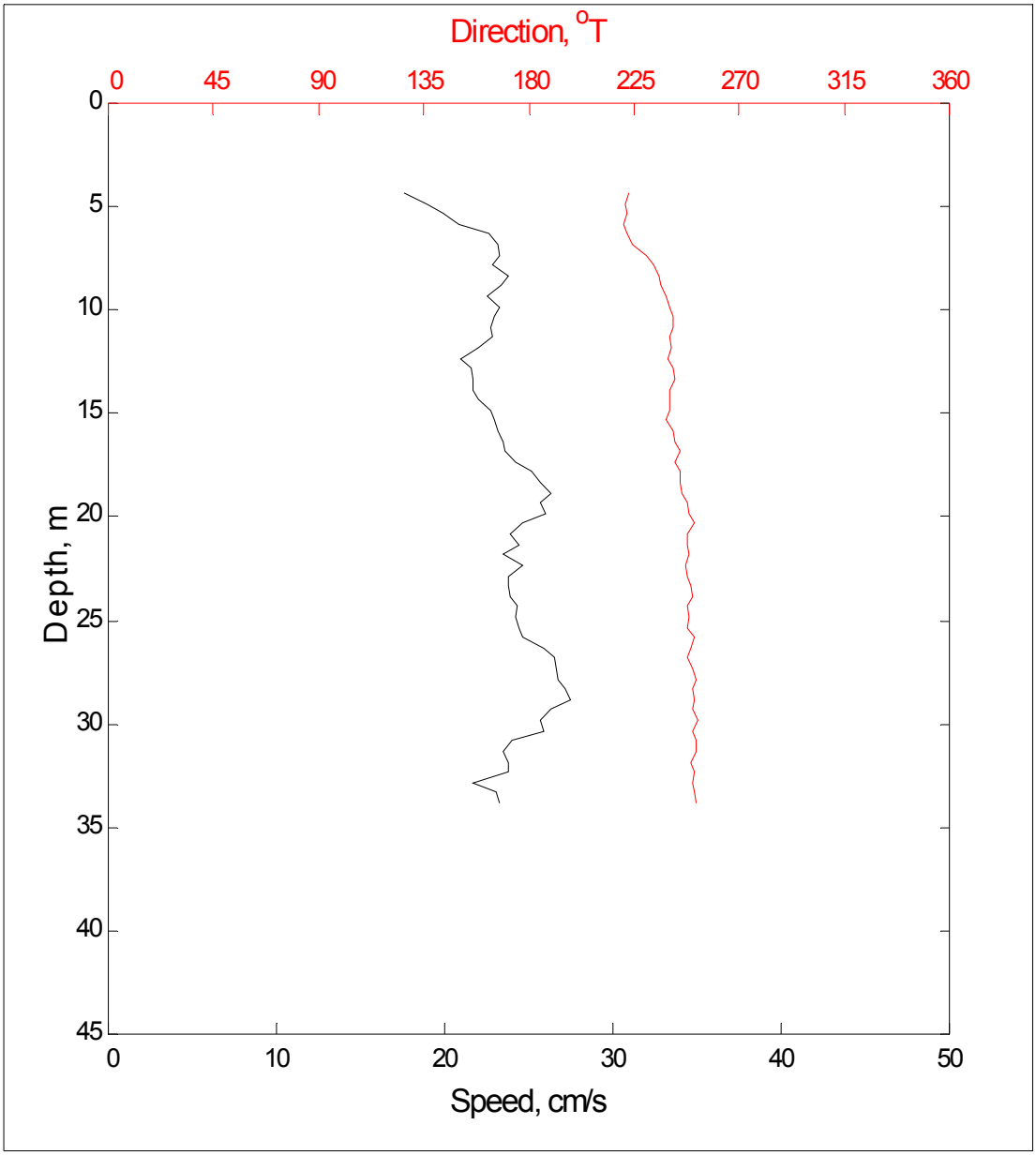


Figure 3.6-1. Vertical current profile on August 2, 2000 at 1752 GMT.

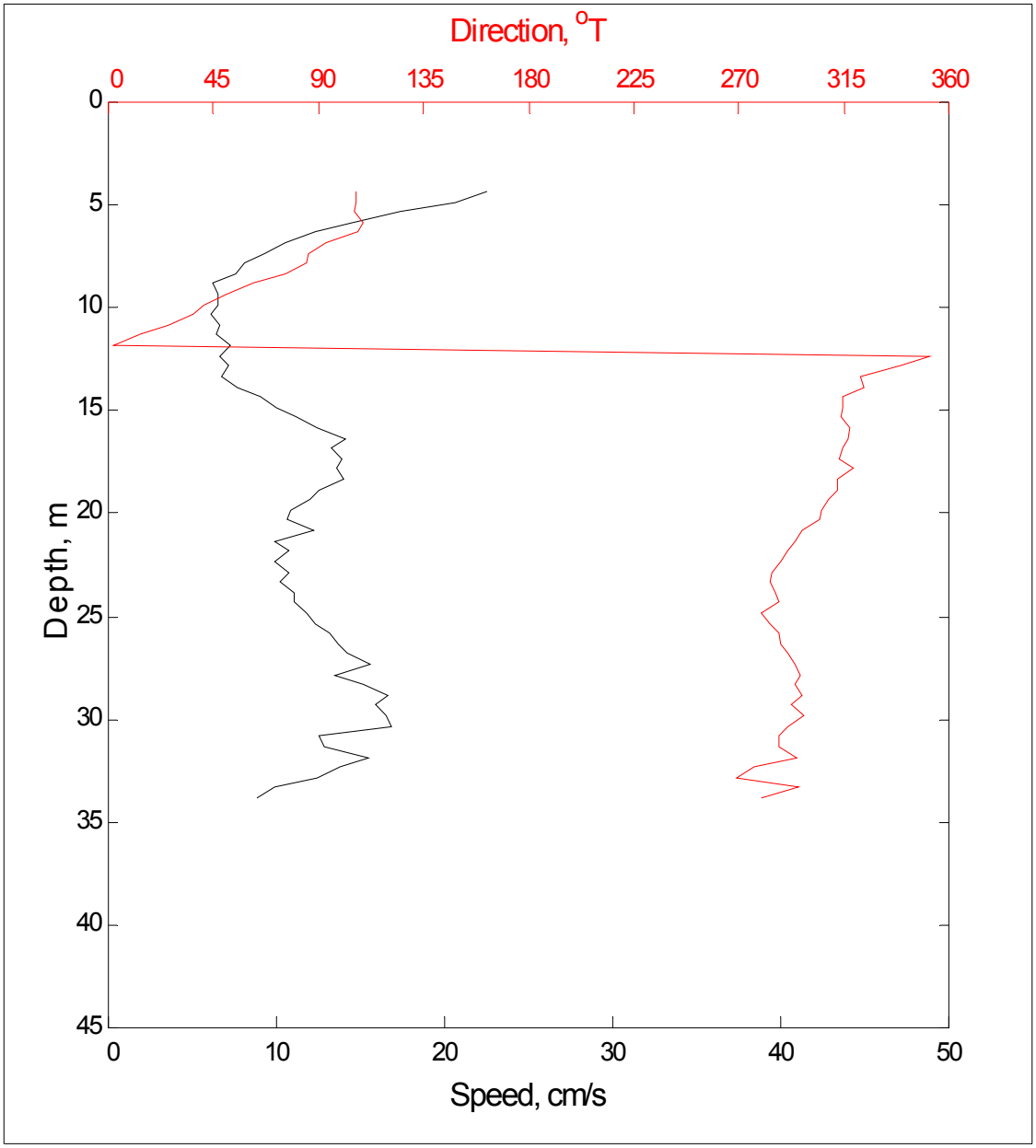


Figure 3.6-2. Vertical current profile on August 13, 2000 at 1630 GMT.

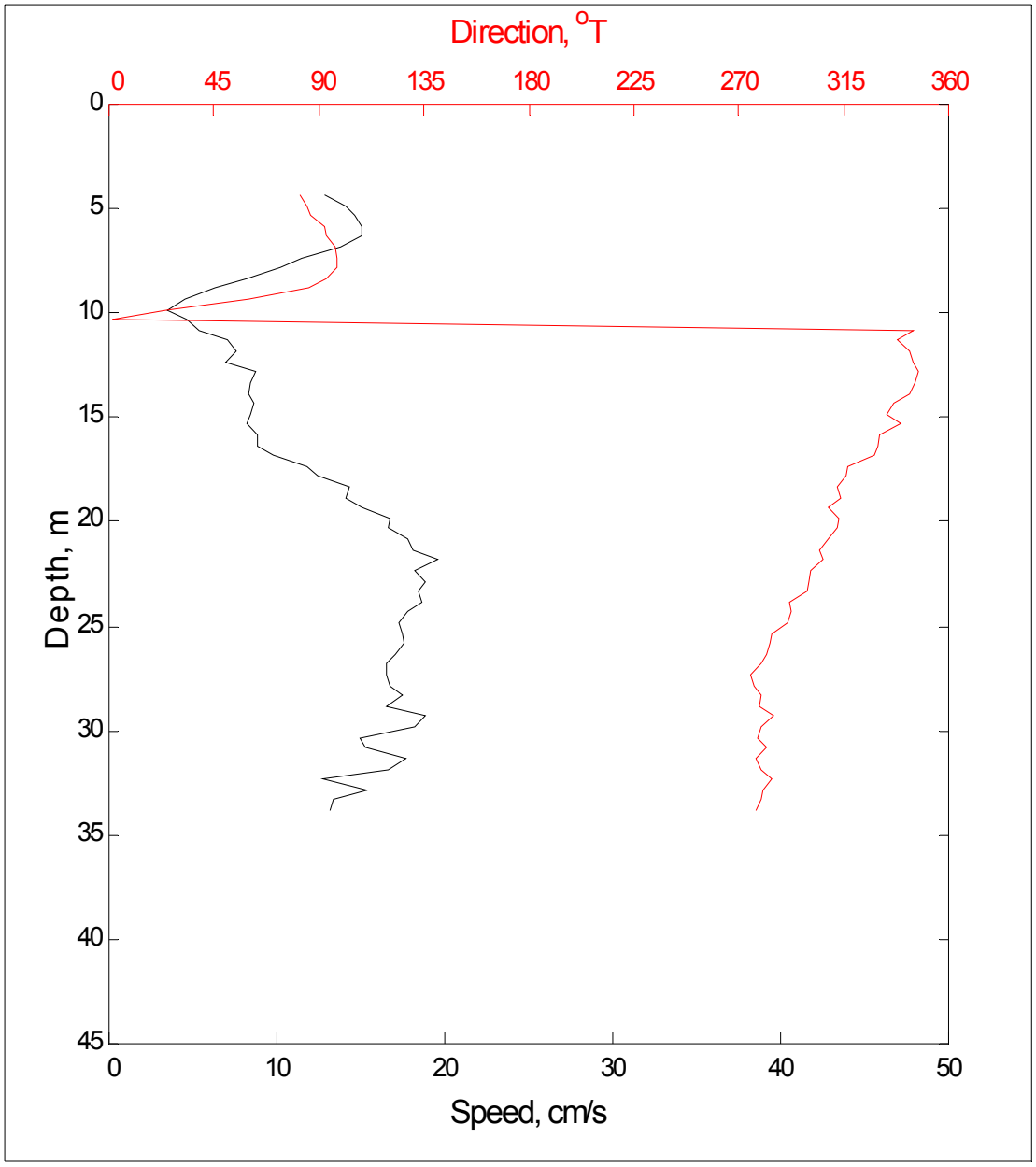


Figure 3.6-3. Vertical current profile on August 13, 2000 at 1905 GMT

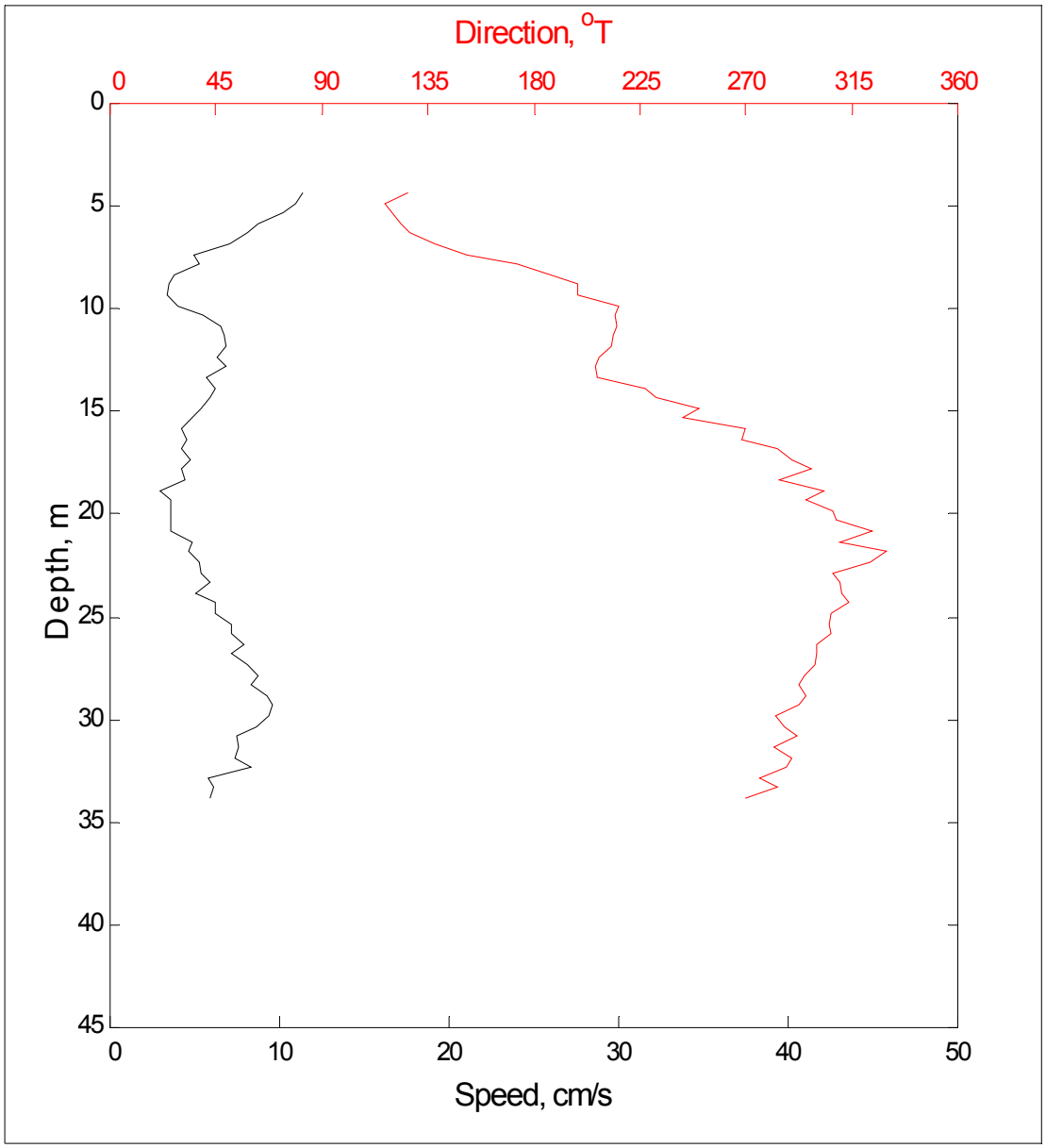


Figure 3.6-4. Vertical current profile on August 13, 2000 at 2204 GMT.

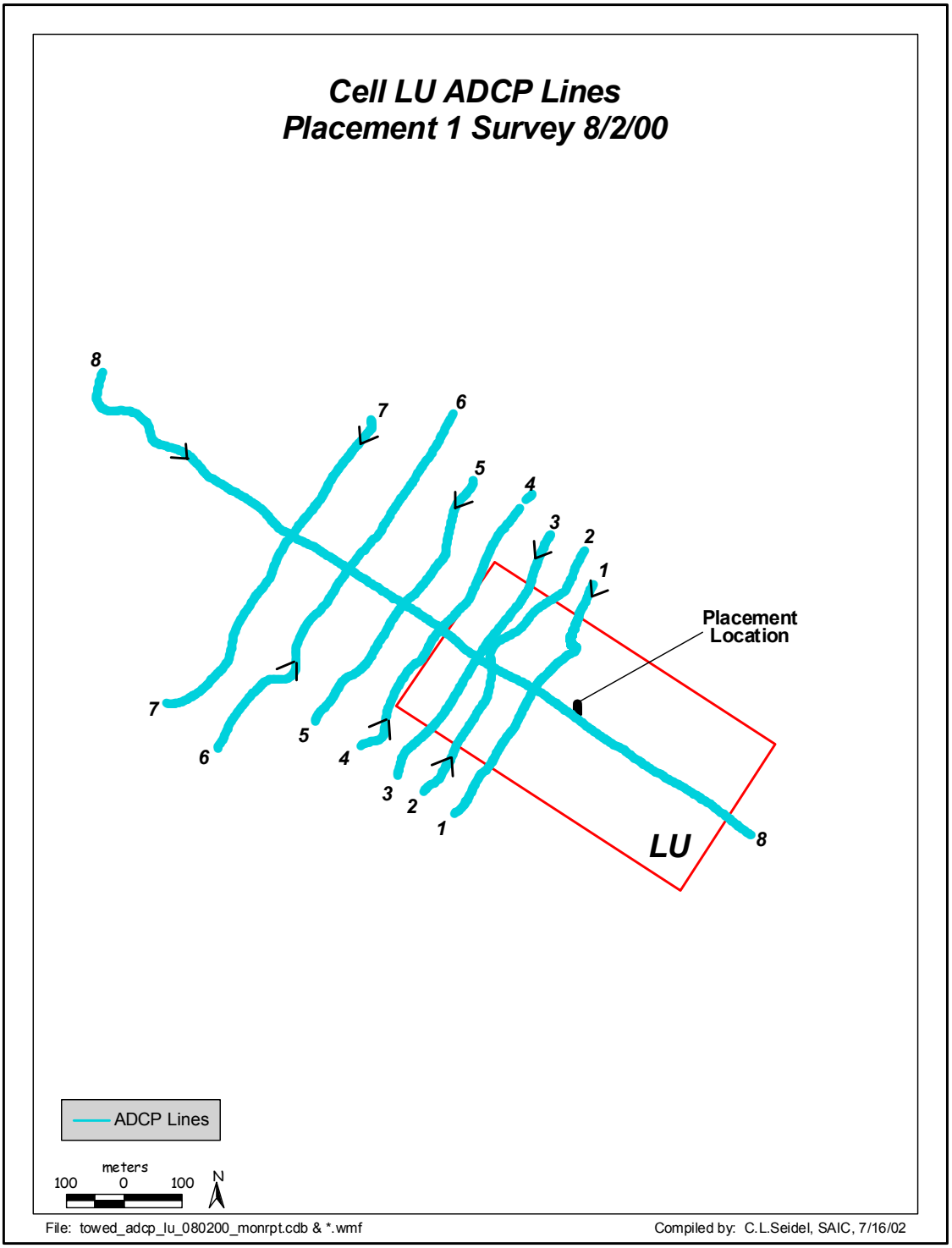


Figure 3.6-5. Survey tracklines for acoustic monitoring of suspended sediment on August 2, 2000.

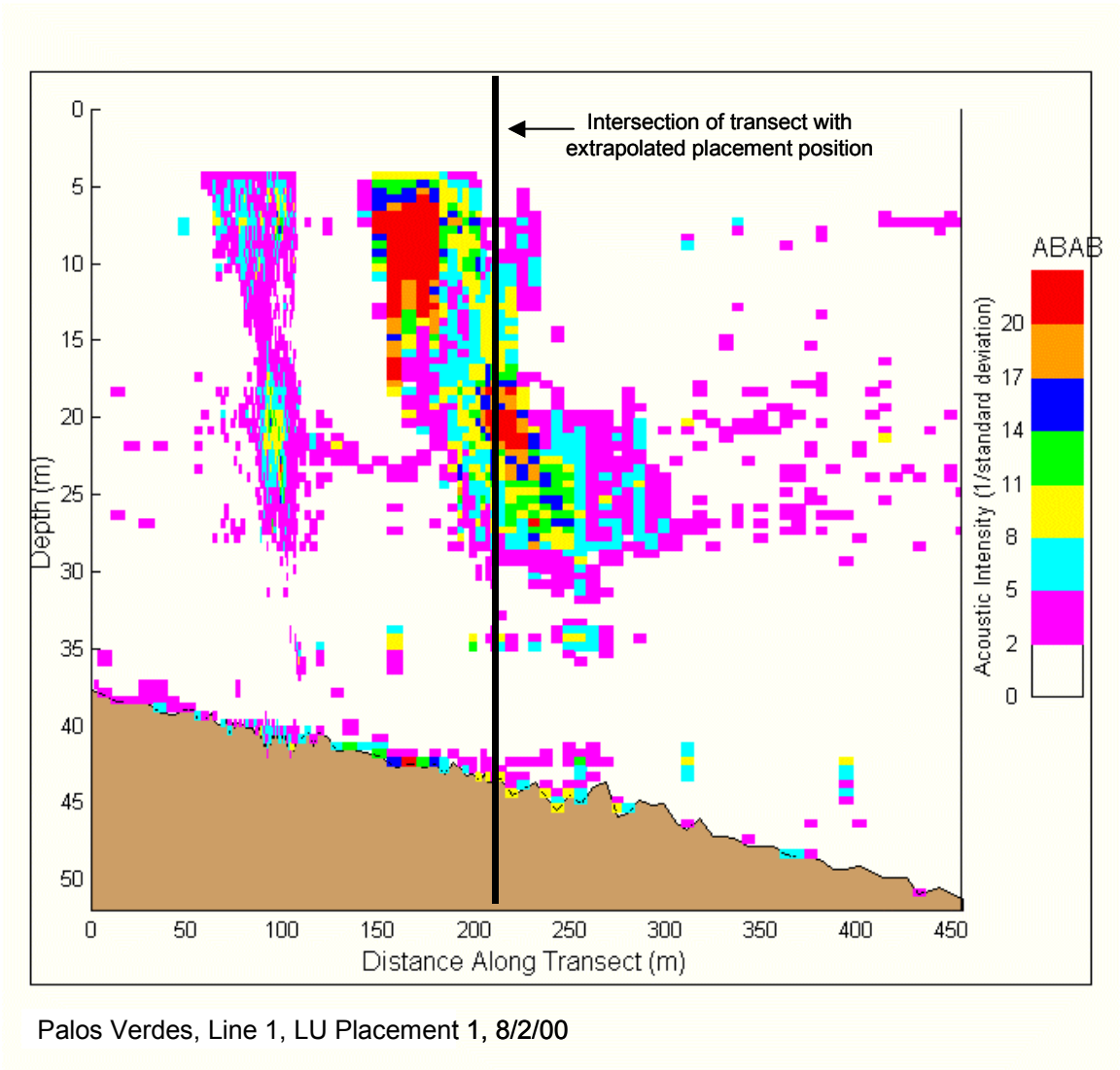


Figure 3.6-6. ABAB along Survey Line 1, run from northeast to southwest while the placement operation was occurring.

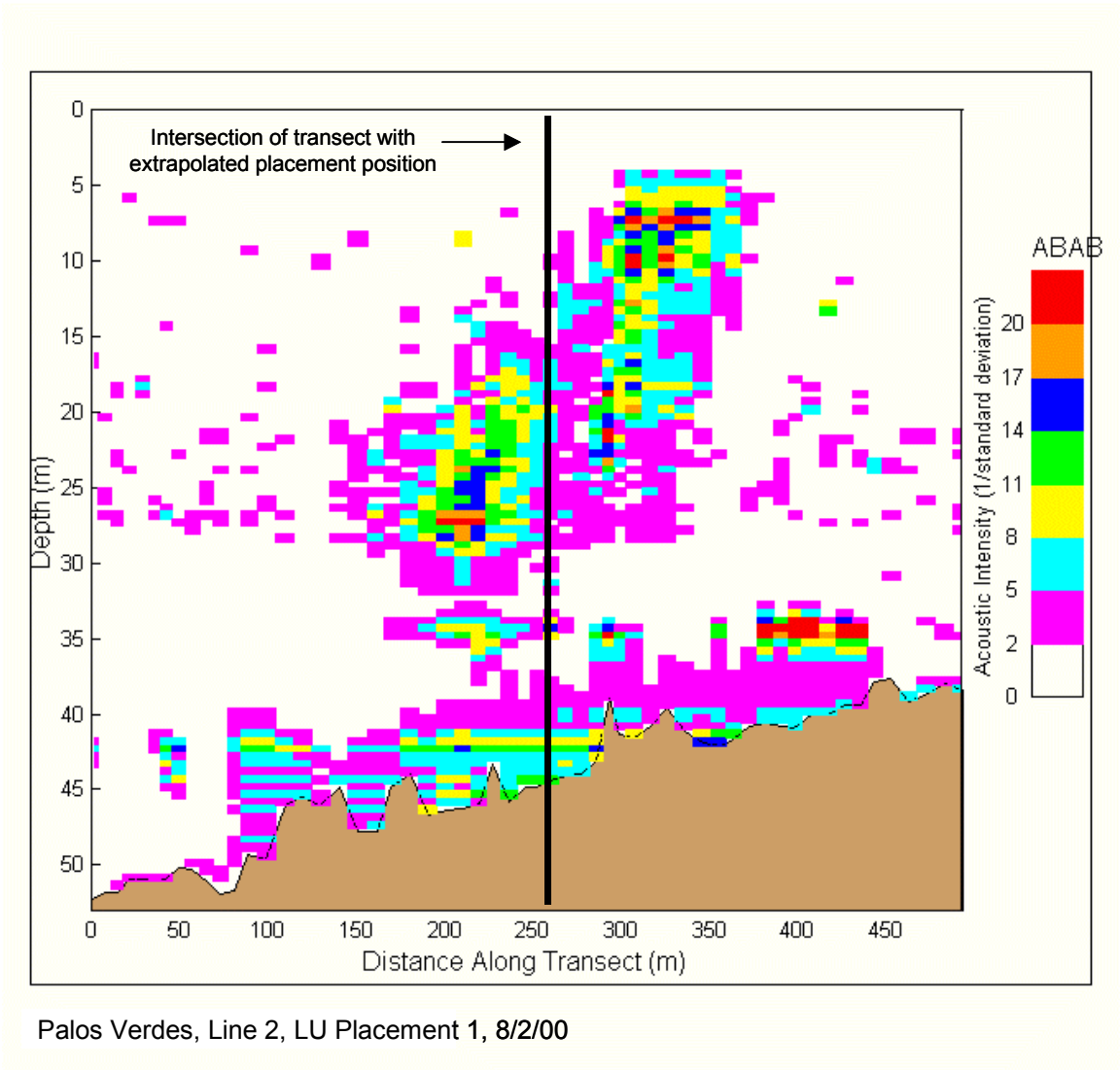


Figure 3.6-7. ABAB along Survey Line 2, run from southwest to northeast 2 min after the placement operation ended.

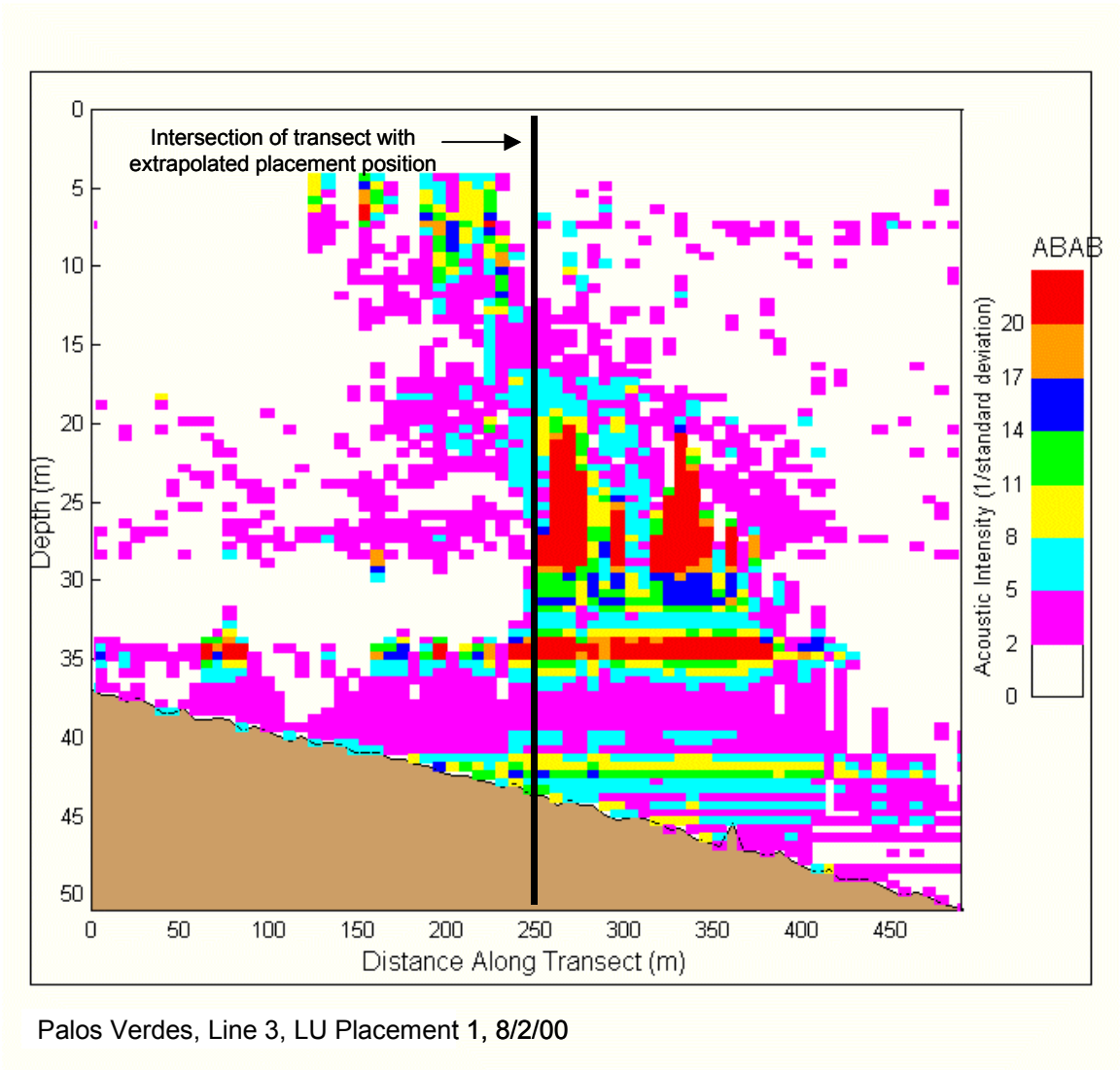


Figure 3.6-8. ABAB along Survey Line 3, run from northeast to southwest 9 min after the placement operation ended.

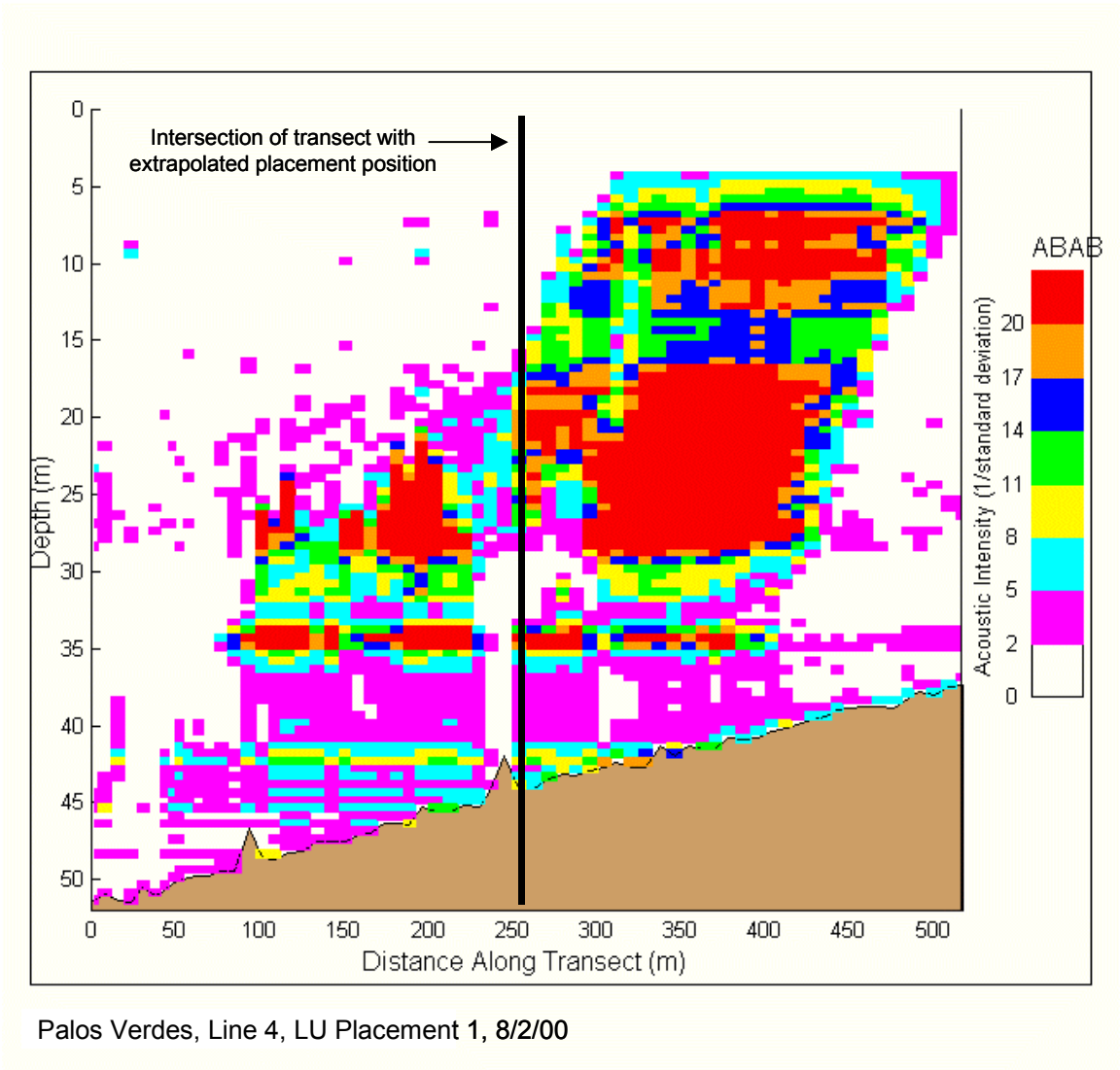


Figure 3.6-9. ABAB along Survey Line 4, run from southwest to northeast 16 min after the placement operation ended.

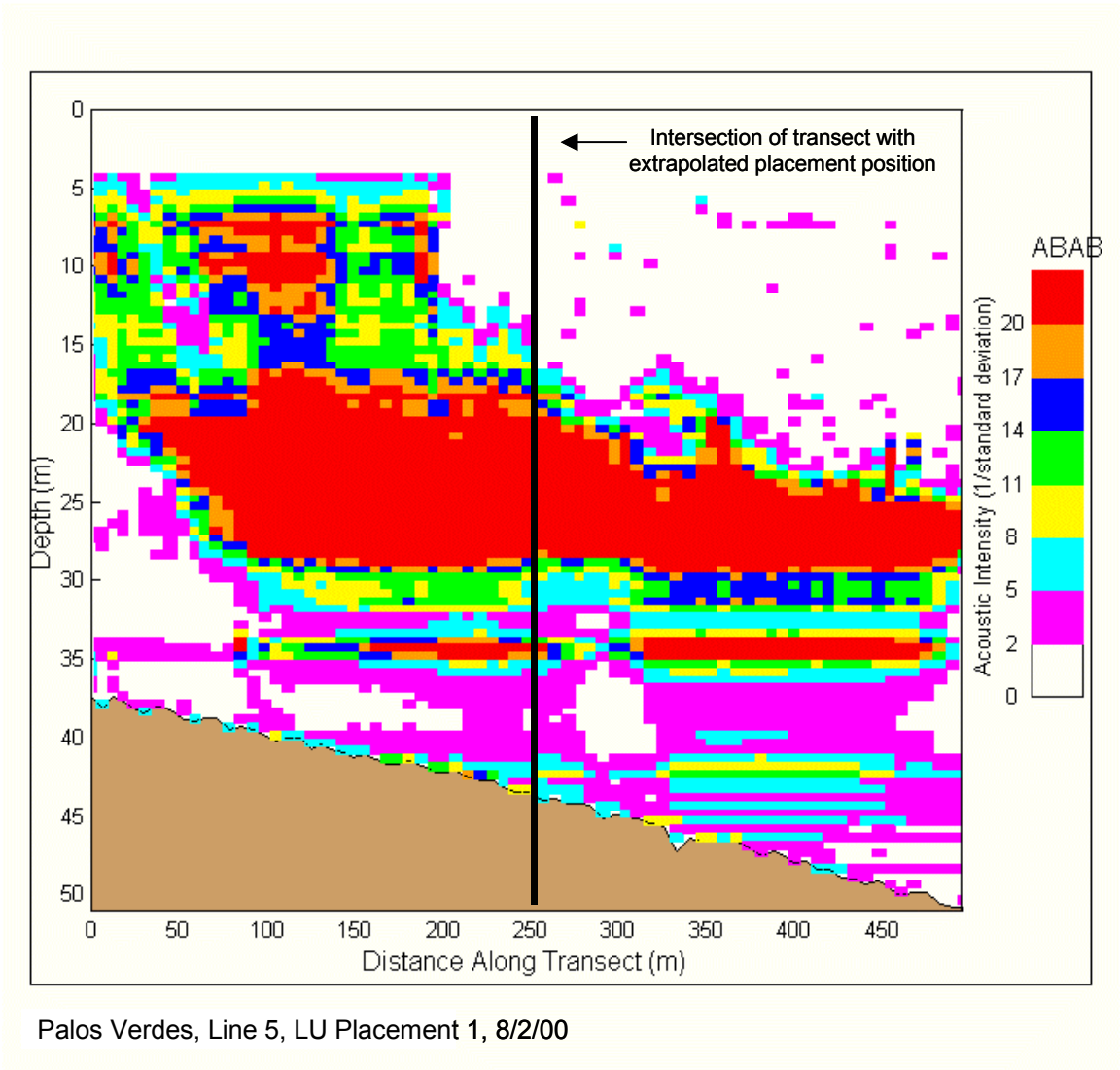


Figure 3.6-10. ABAB along Survey Line 5, run from northeast to southwest 22 min after the placement operation ended.

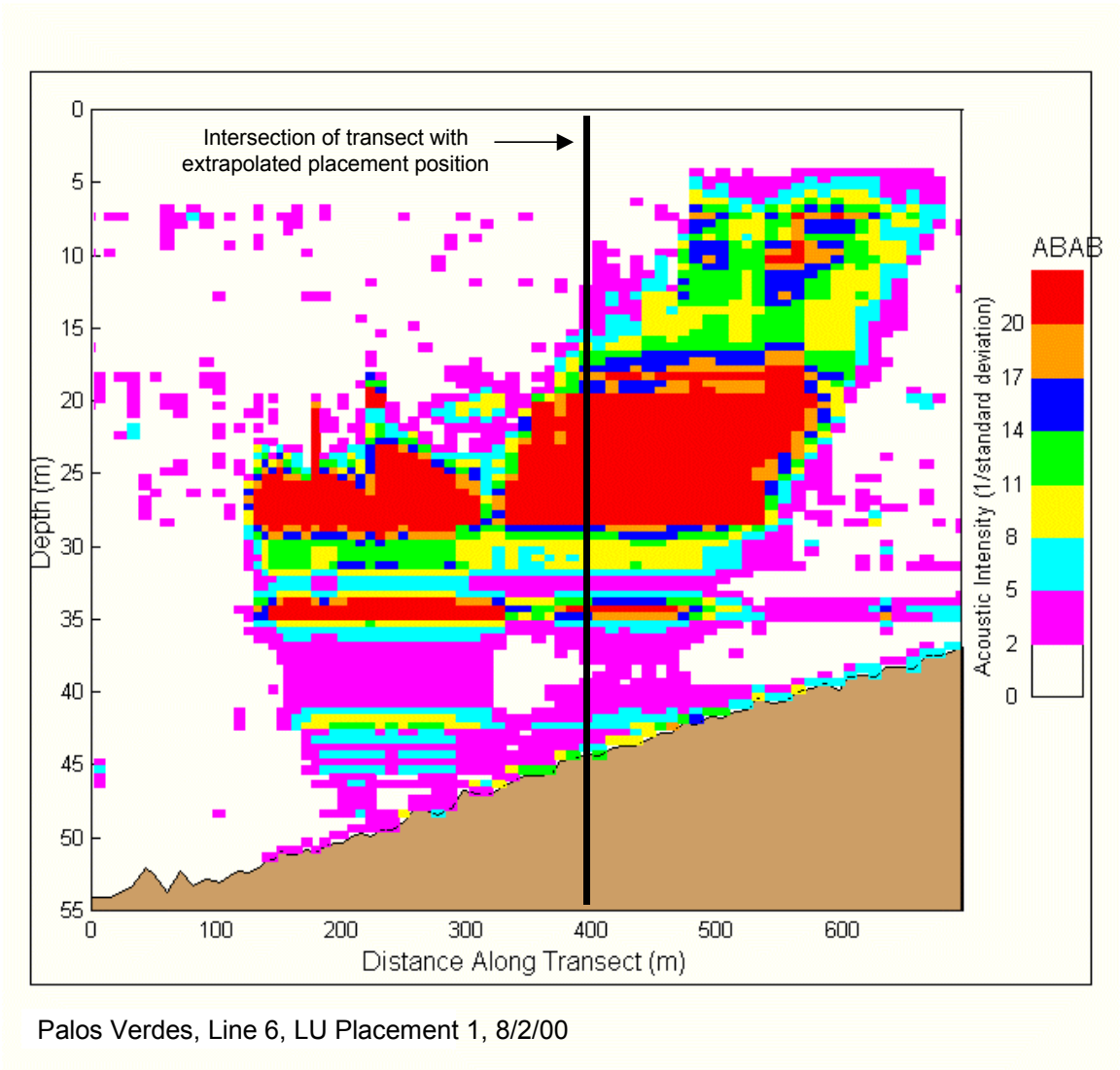


Figure 3.6-11. ABAB along Survey Line 6, run from southwest to northeast 30 min after the placement operation ended.

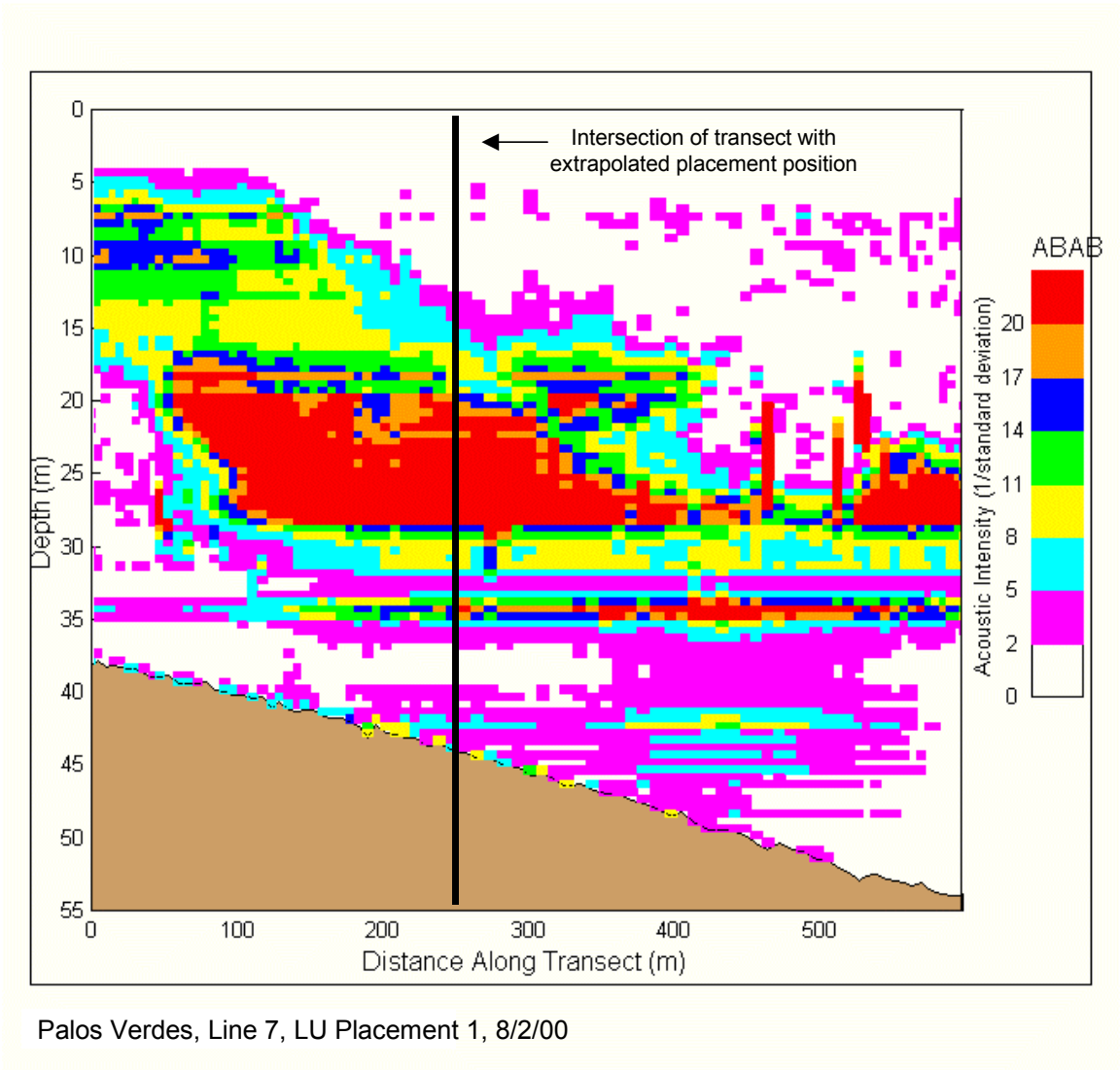


Figure 3.6-12. ABAB along Survey Line 7, run from northeast to southwest 40 min after the placement operation ended.

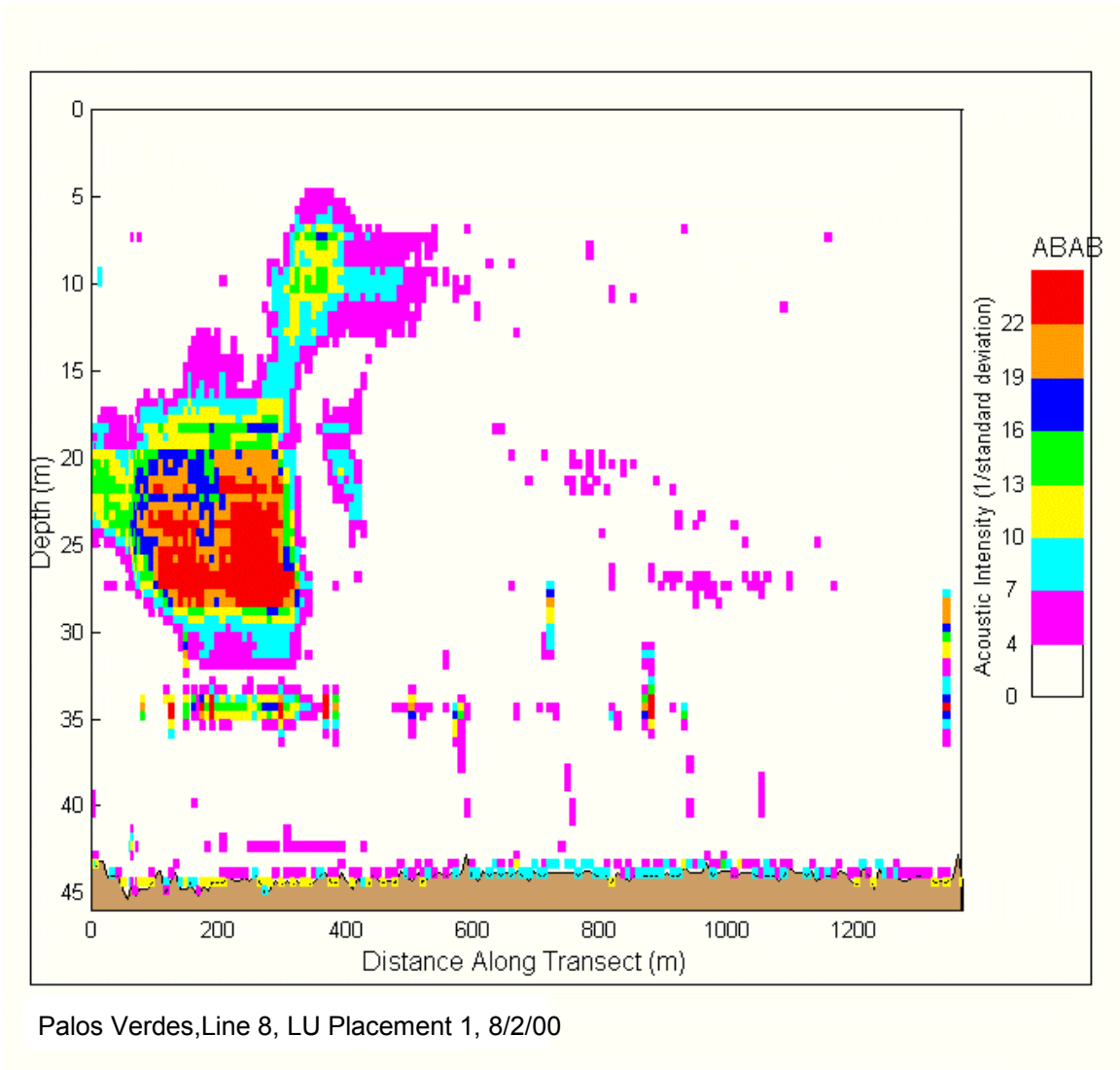


Figure 3.6-13. ABAB along Survey Line 8, run along the main axis of Cell LU 55 min after the placement operation ended.

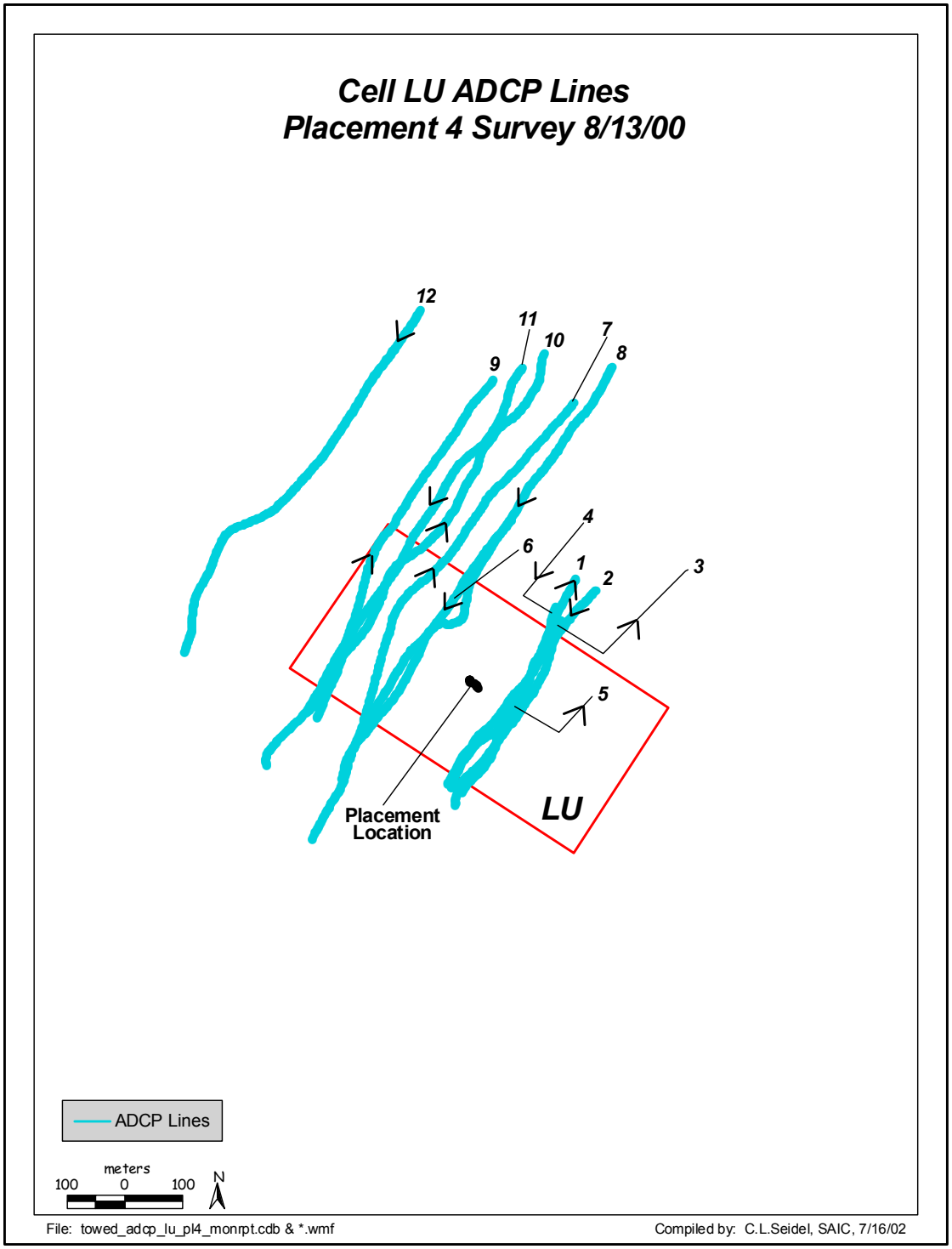


Figure 3.6-14. Survey tracklines for acoustic monitoring of suspended sediment on August 13, 2000 for placement Event 4.

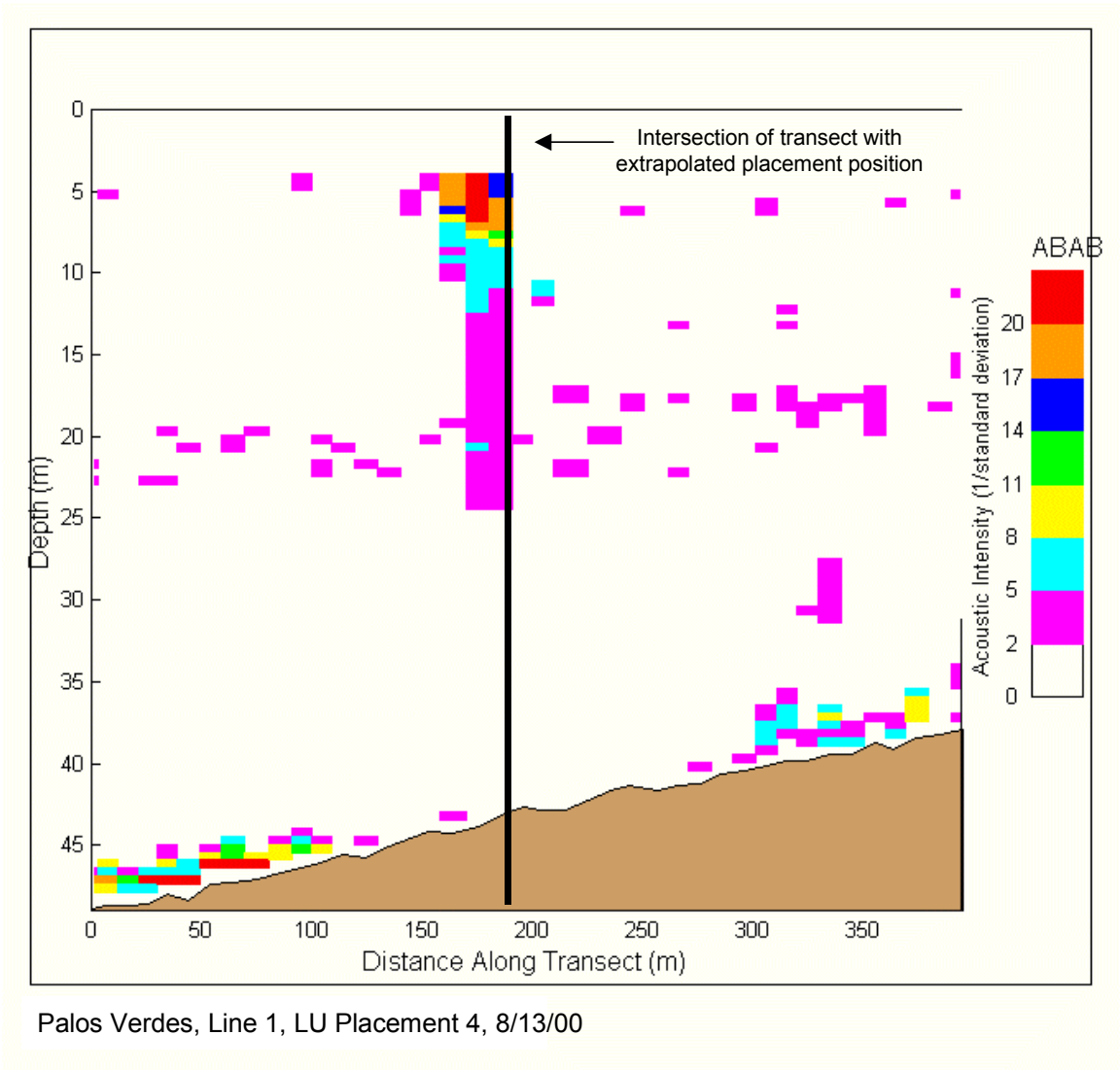


Figure 3.6-15. ABAB along Survey Line 1, run from southwest to northeast while the placement operation was occurring.

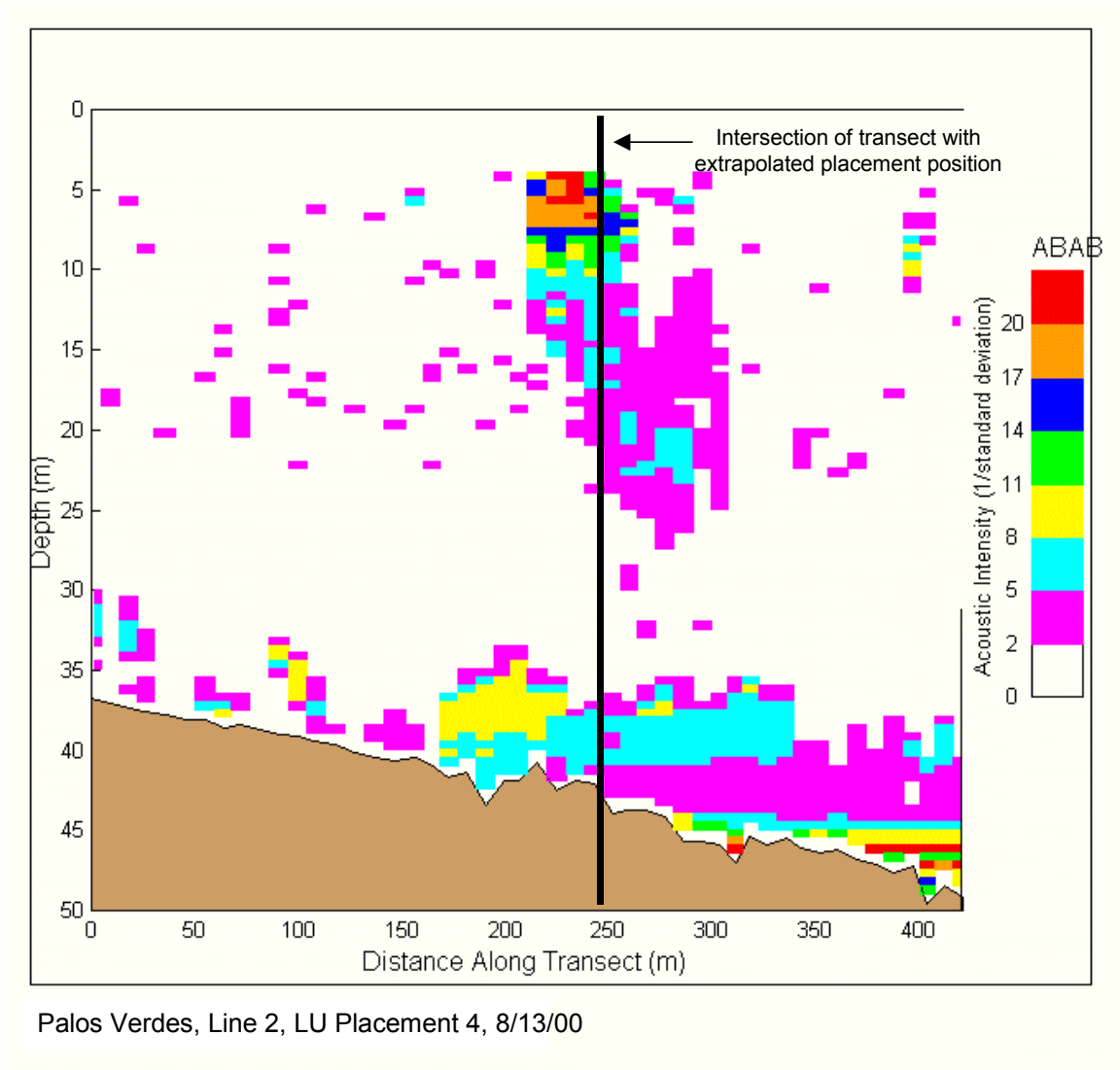


Figure 3.6-16. ABAB along Survey Line 2, run from northeast to southwest 2 min after the placement operation ended.

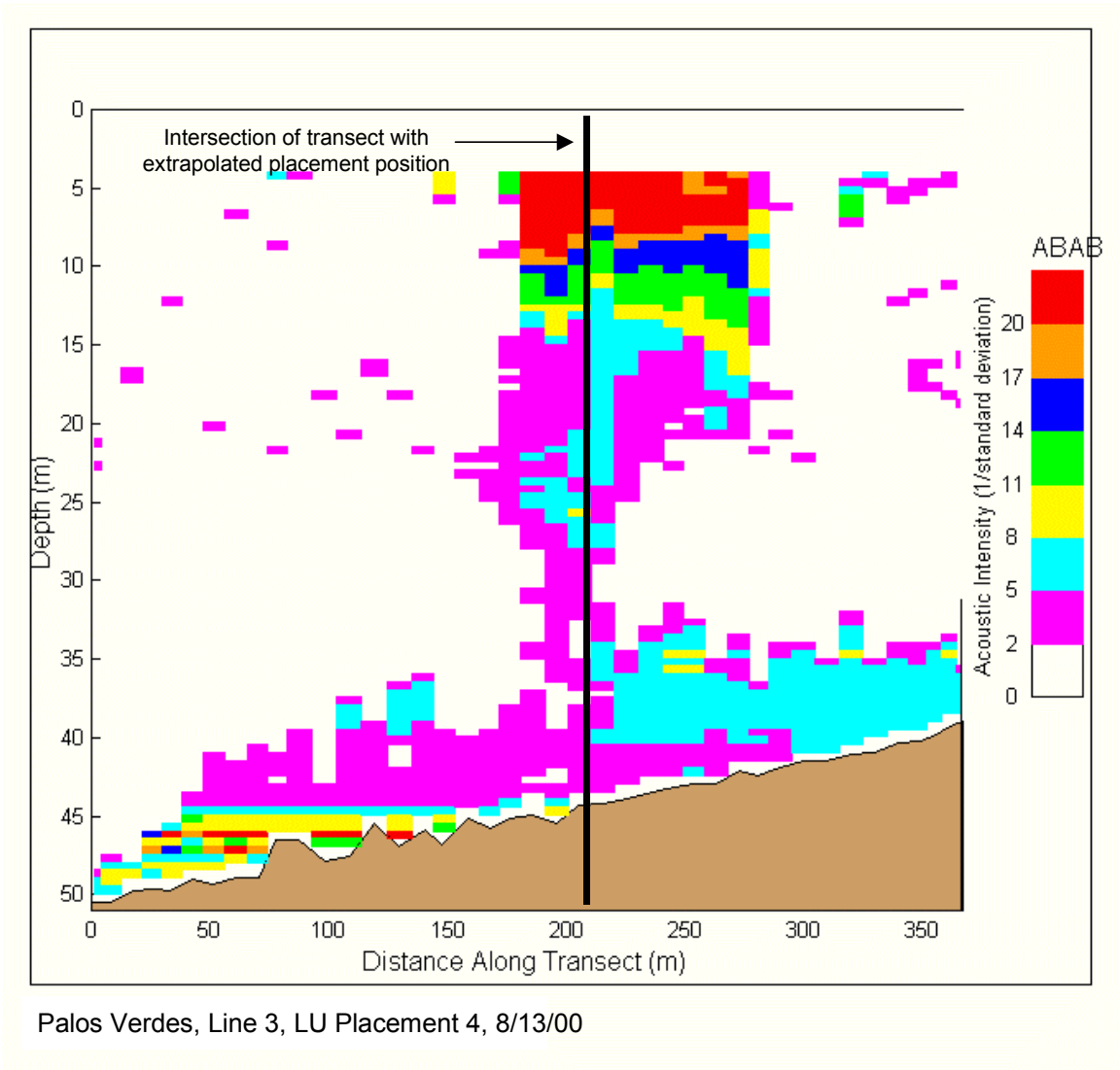


Figure 3.6-17. ABAB along Survey Line 3 , run from southwest to northeast 5 min after the placement operation ended.

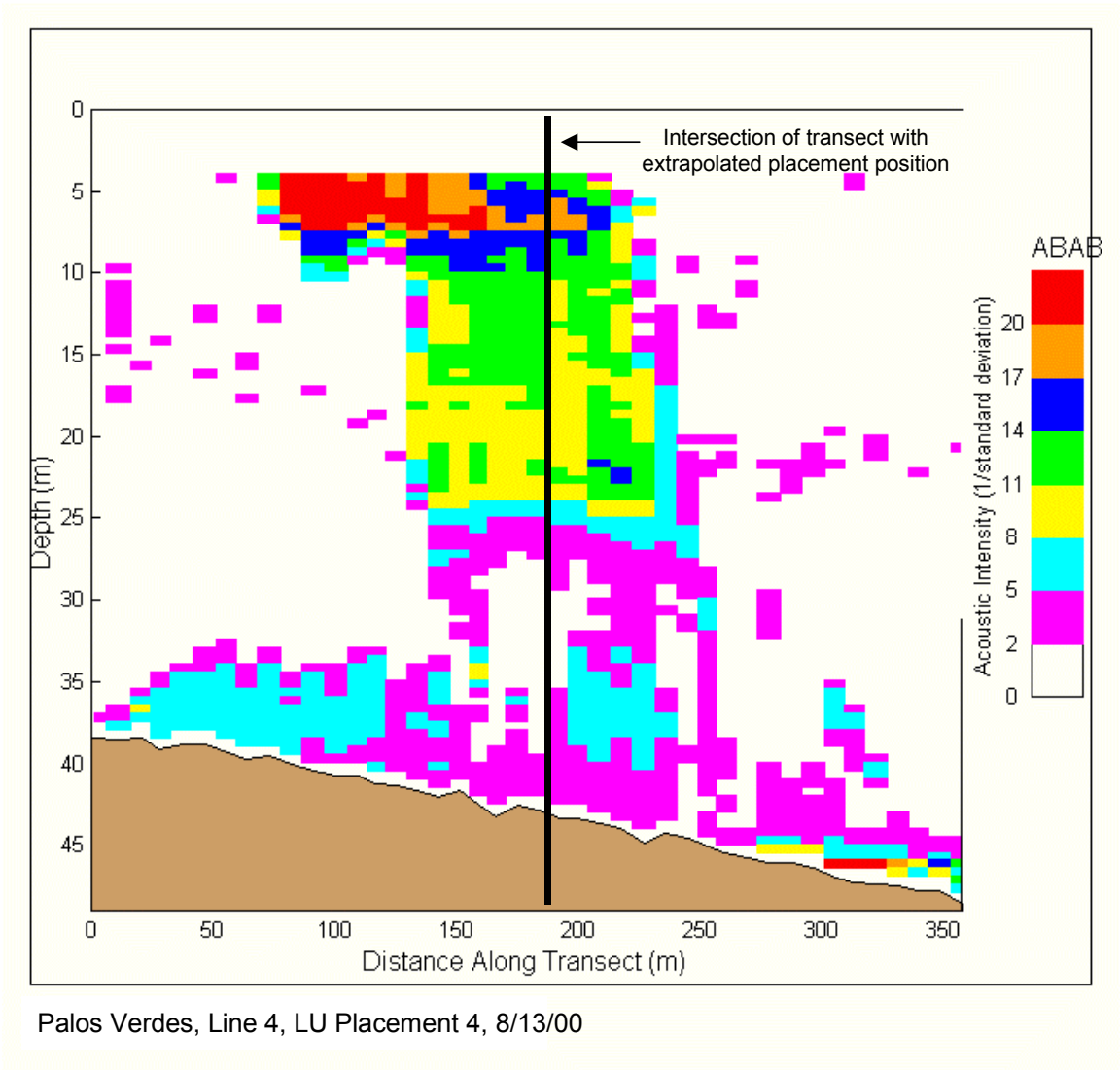


Figure 3.6-18. ABAB along Survey Line 4, run from northeast to southwest 8 min after the placement operation ended.

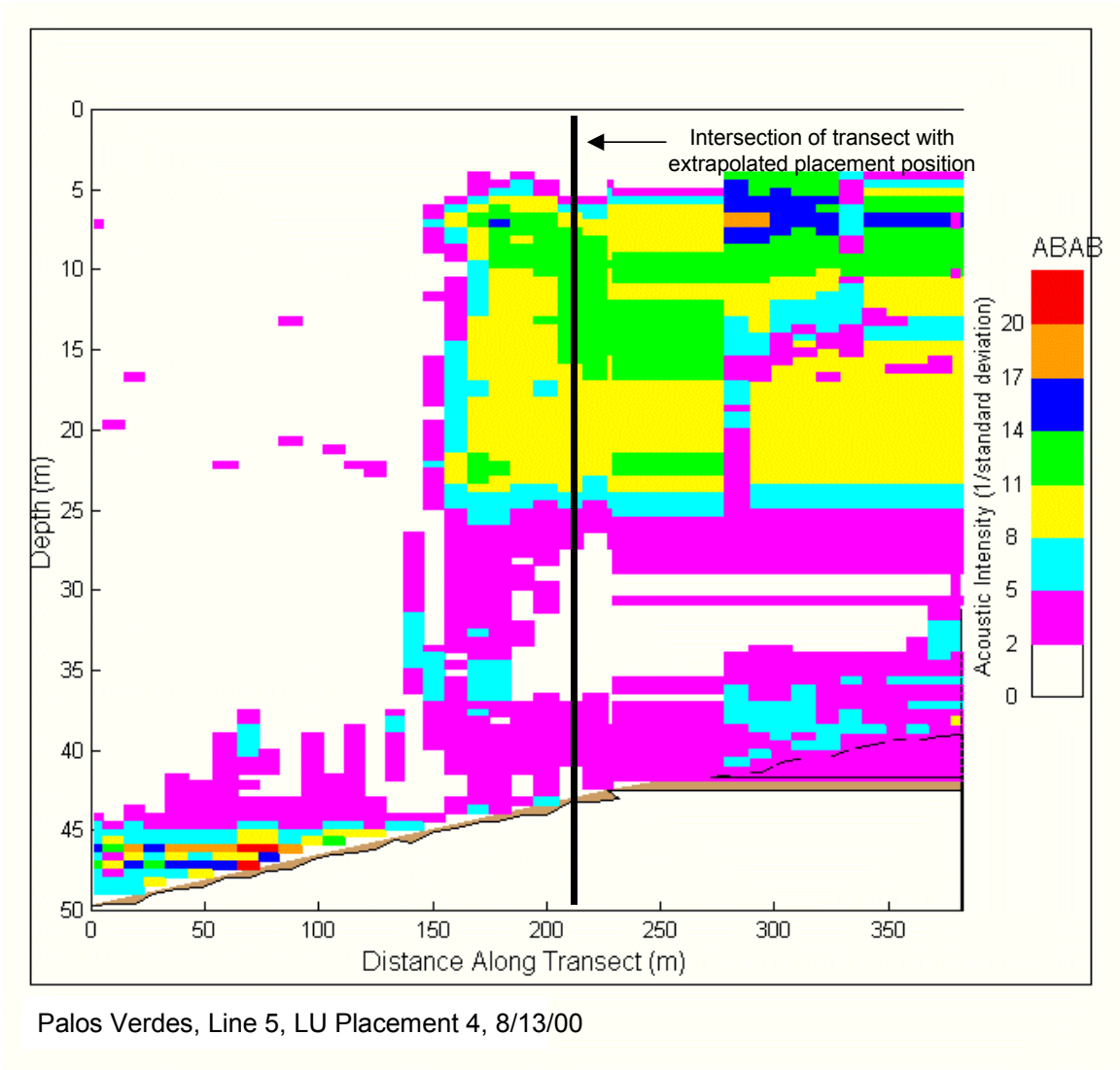


Figure 3.6-19. ABAB along Survey Line 5, run from southwest to northeast 12 min after the placement operation ended.

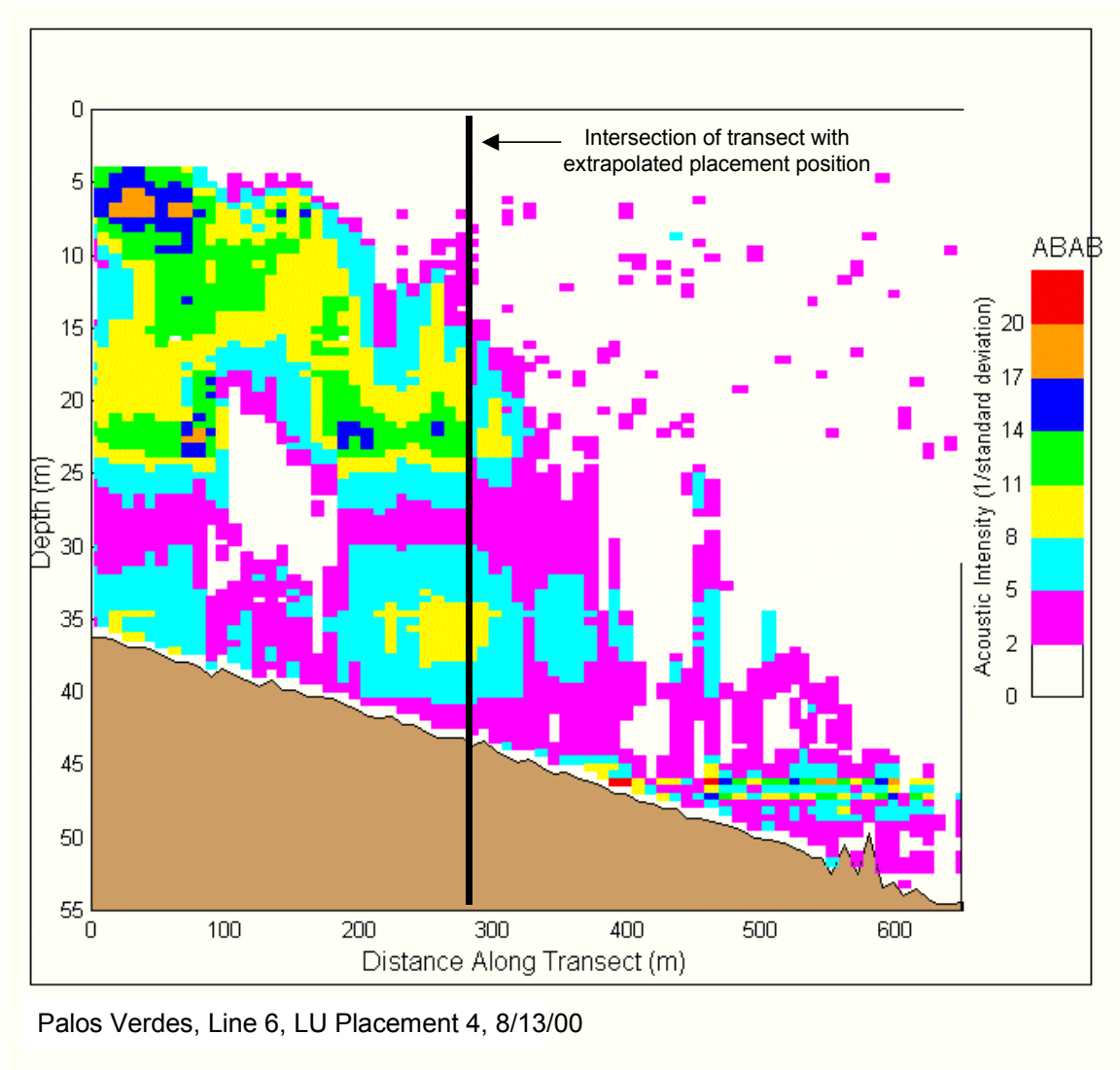


Figure 3.6-20. ABAB along Survey Line 6, run from northeast to southwest 17 min after the placement operation ended.

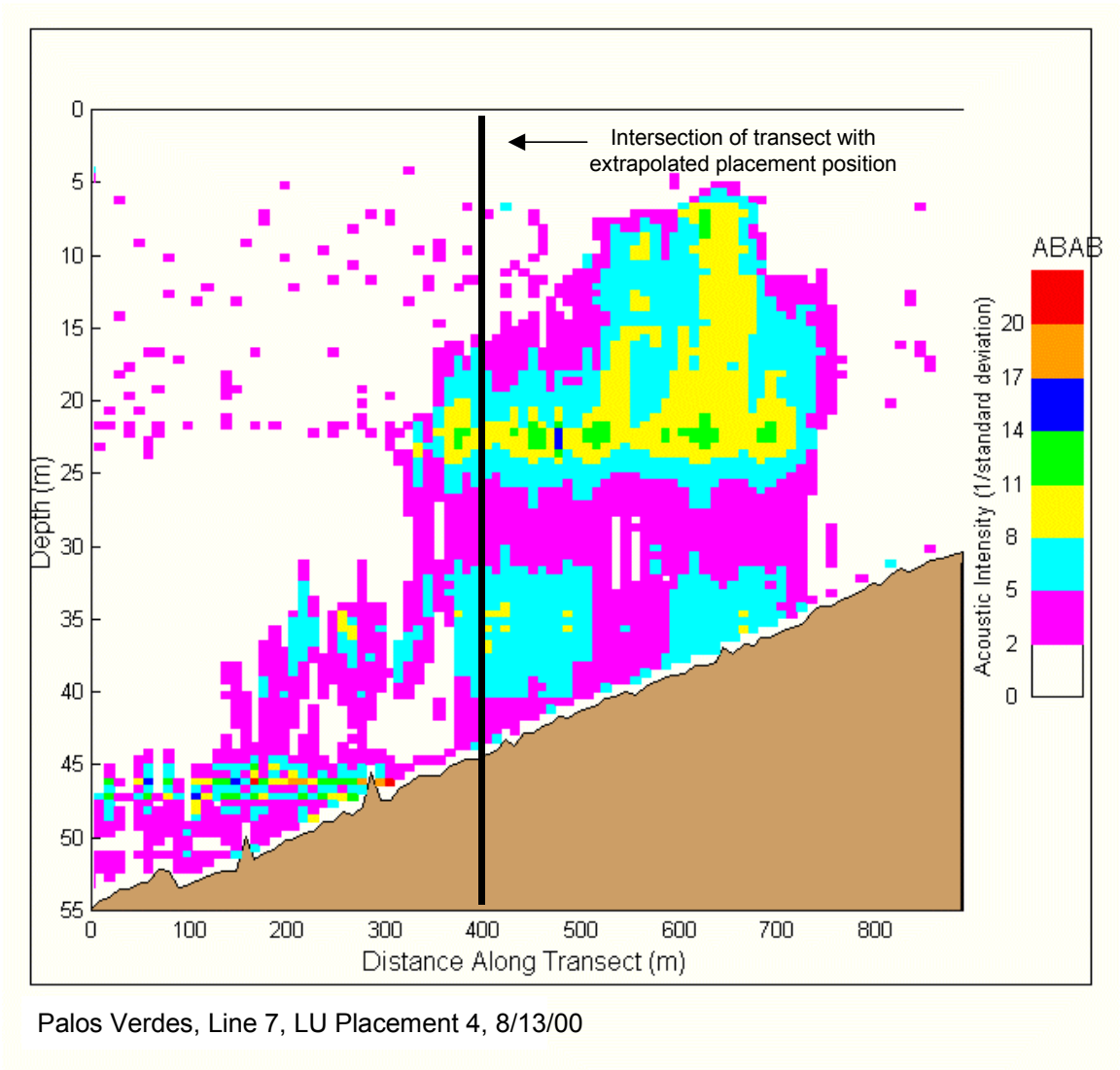


Figure 3.6-21. ABAB along Survey Line 7, run from southwest to northeast 23 min after the placement operation ended.

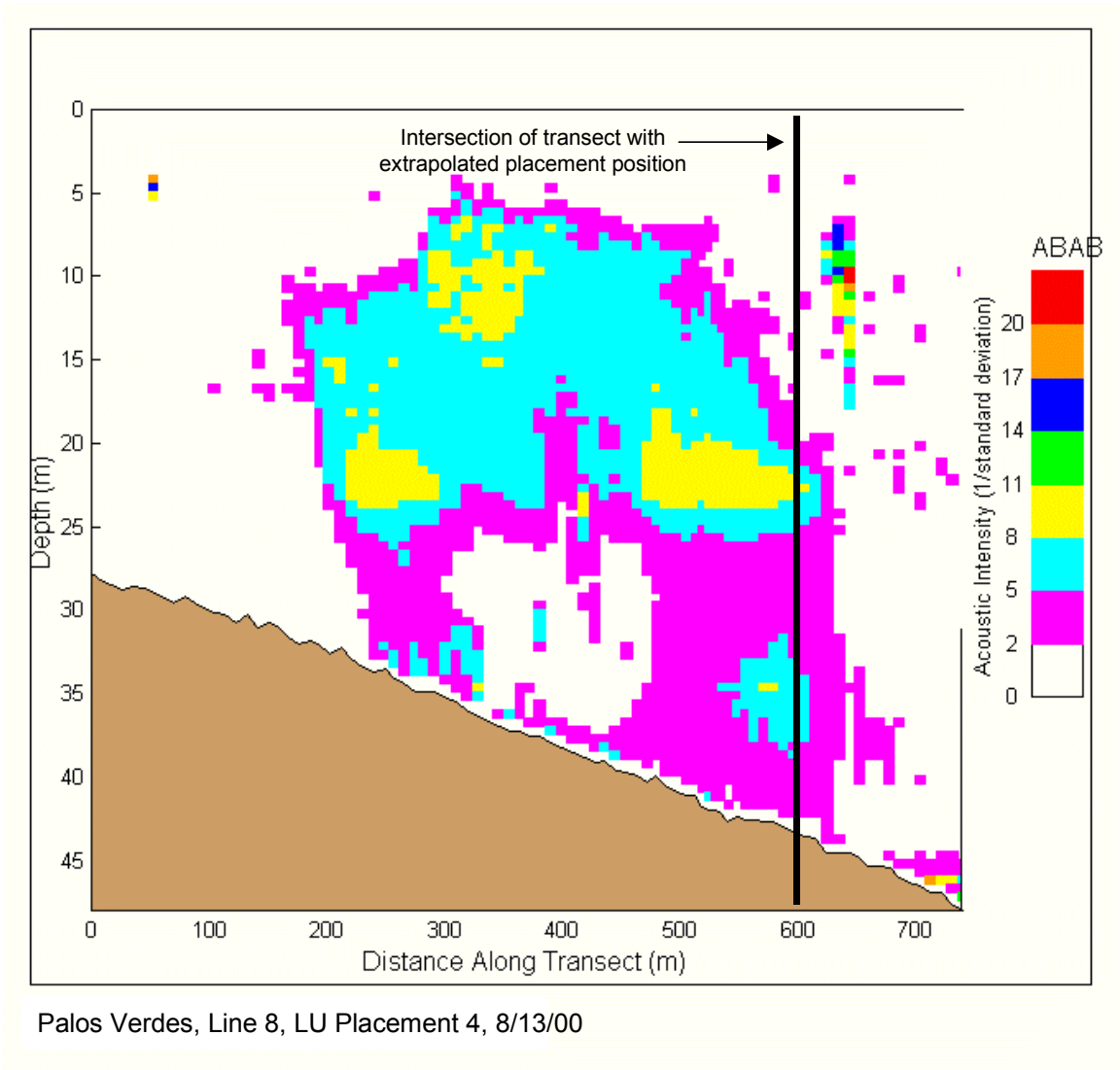


Figure 3.6-22. ABAB along Survey Line 8, run from northeast to southwest 31 min after the placement operation ended.

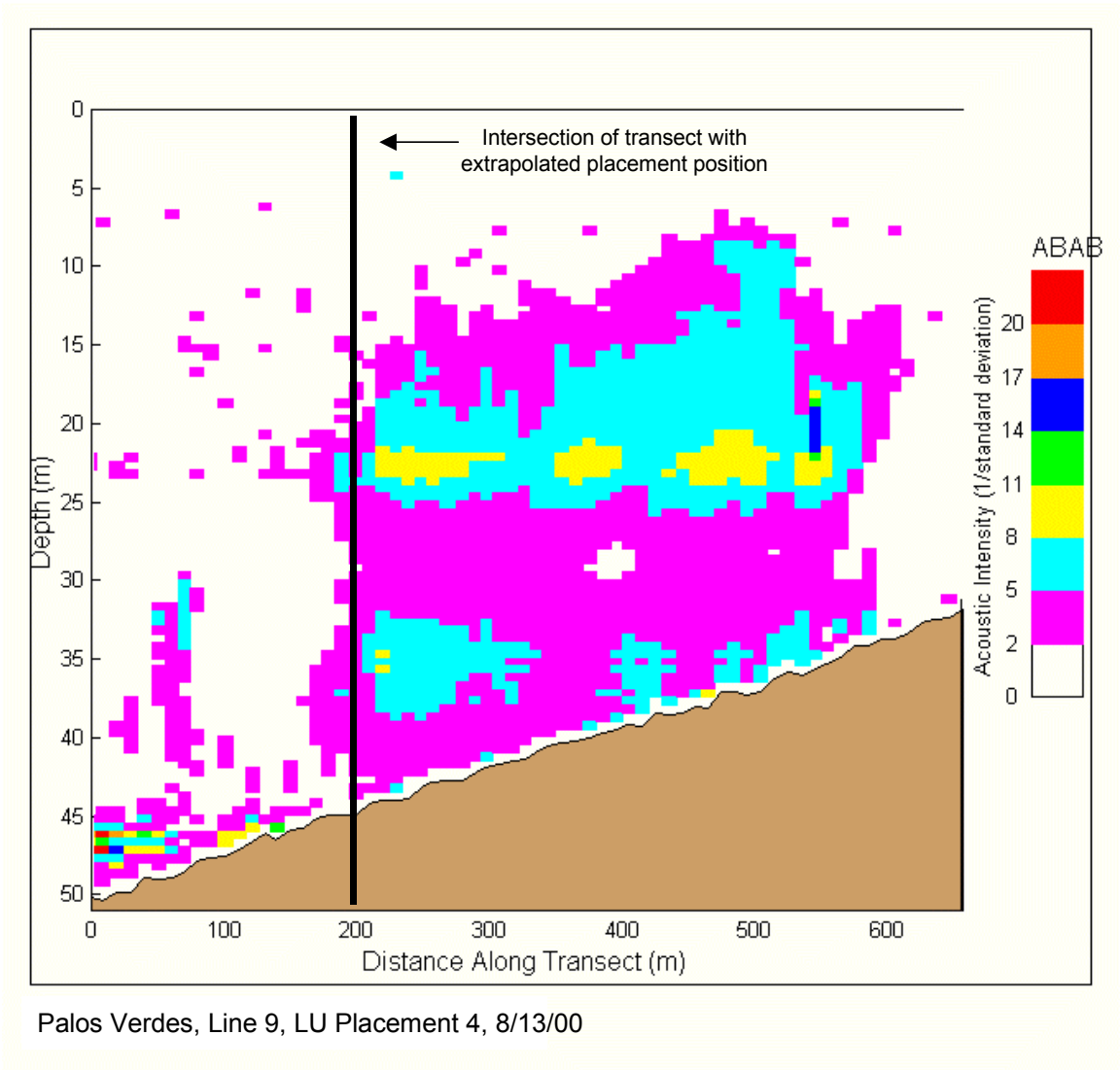


Figure 3.6-23. ABAB along Survey Line 9, run from southwest to northeast 39 min after the placement operation ended.

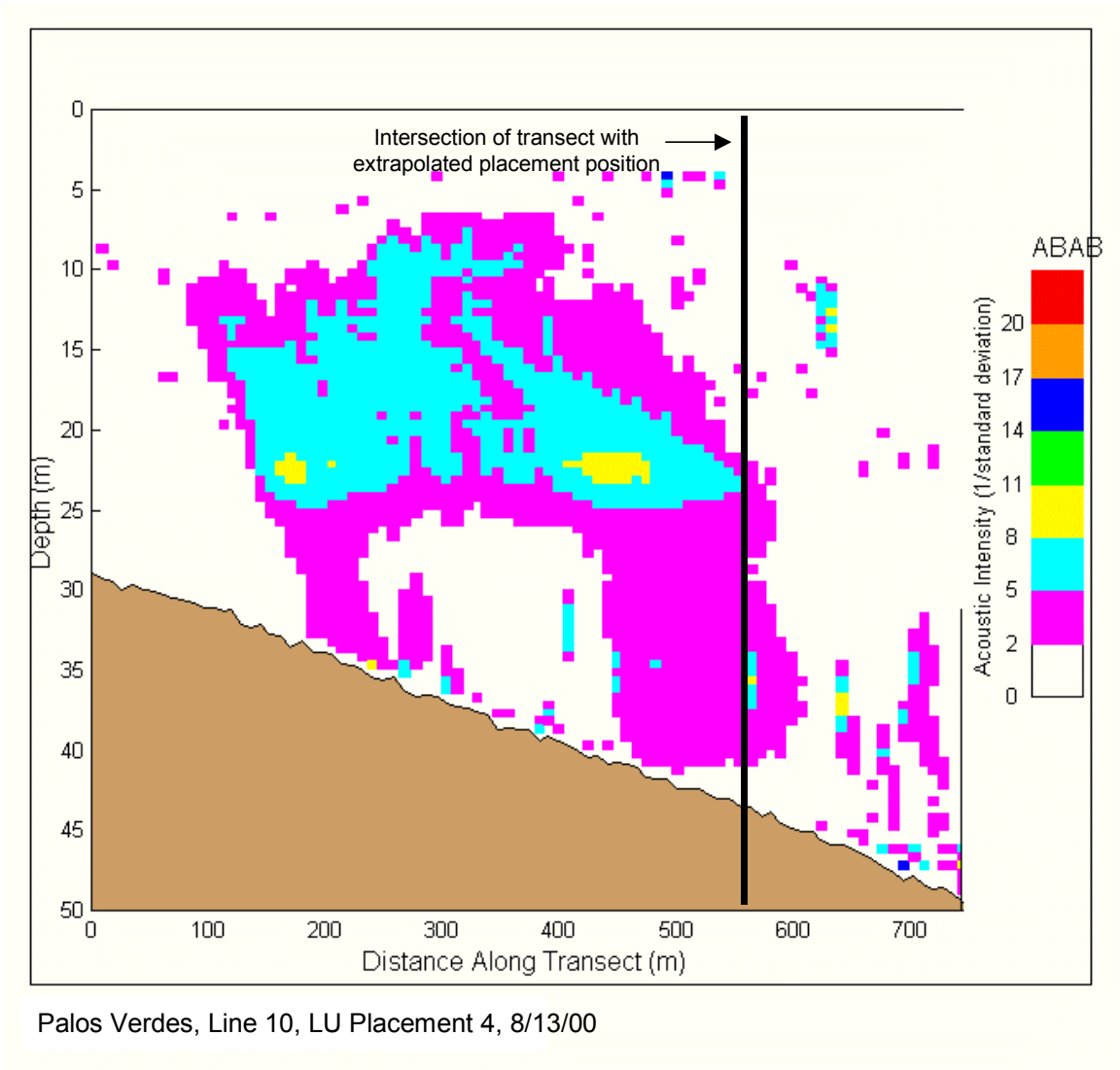


Figure 3.6-24. ABAB along Survey Line 10, run from northeast to southwest 45 min after the placement operation ended.

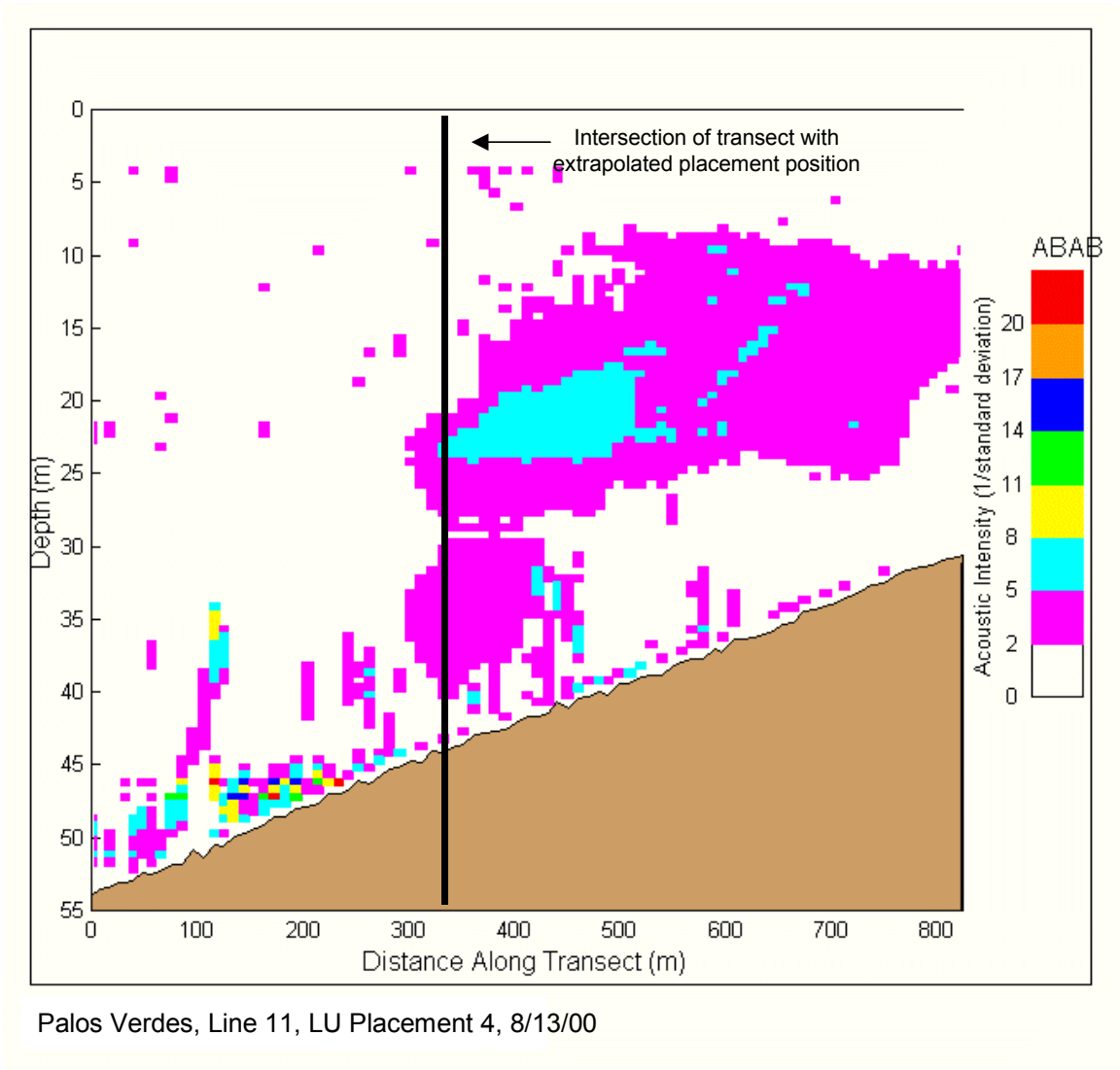


Figure 3.6-25. ABAB along Survey Line 11, run from southwest to northeast 54 min after the placement operation ended.

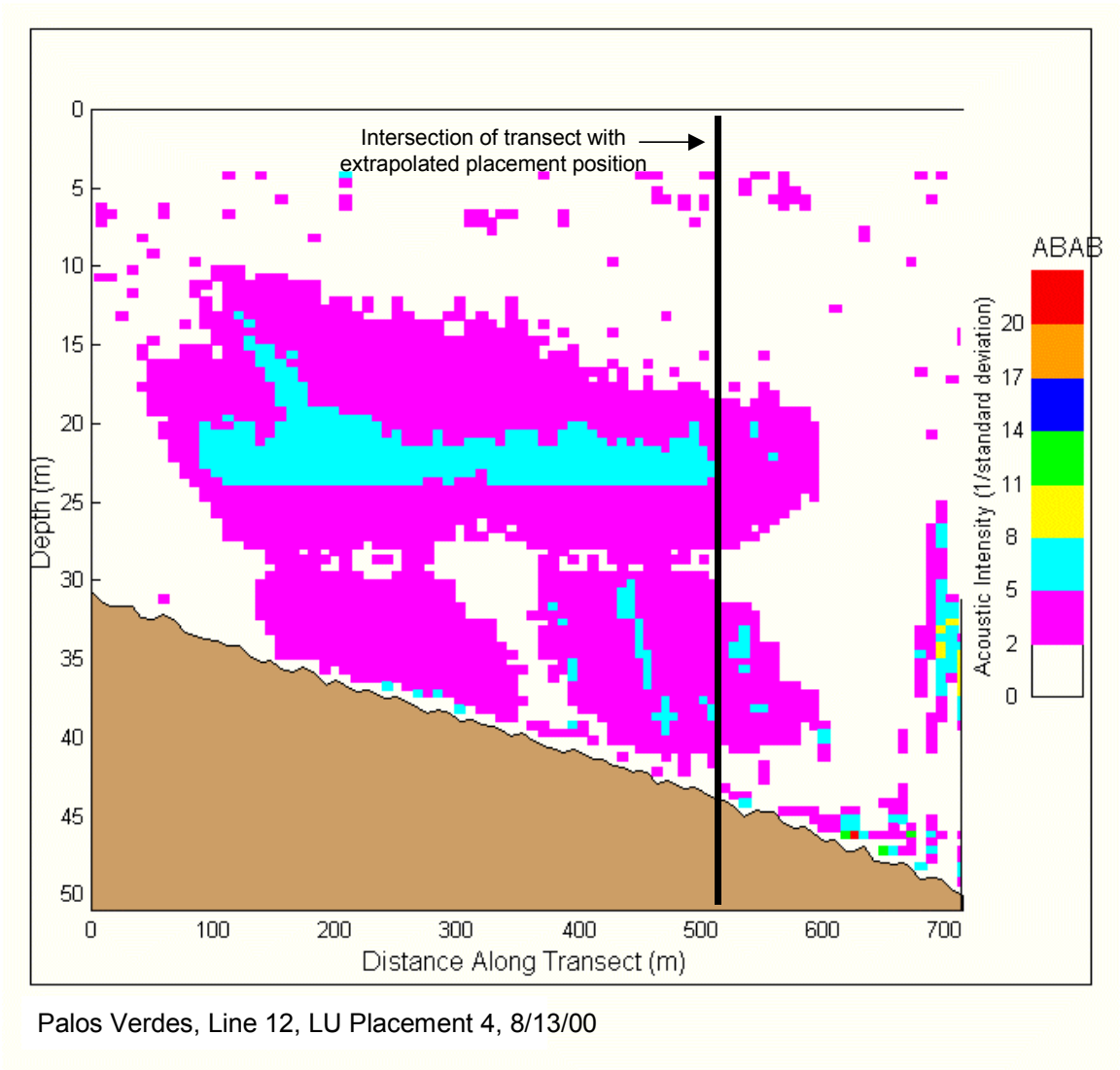


Figure 3.6-26. ABAB along Survey Line 12, run from northeast to southwest 1 hr and 3 min after the placement operation ended.

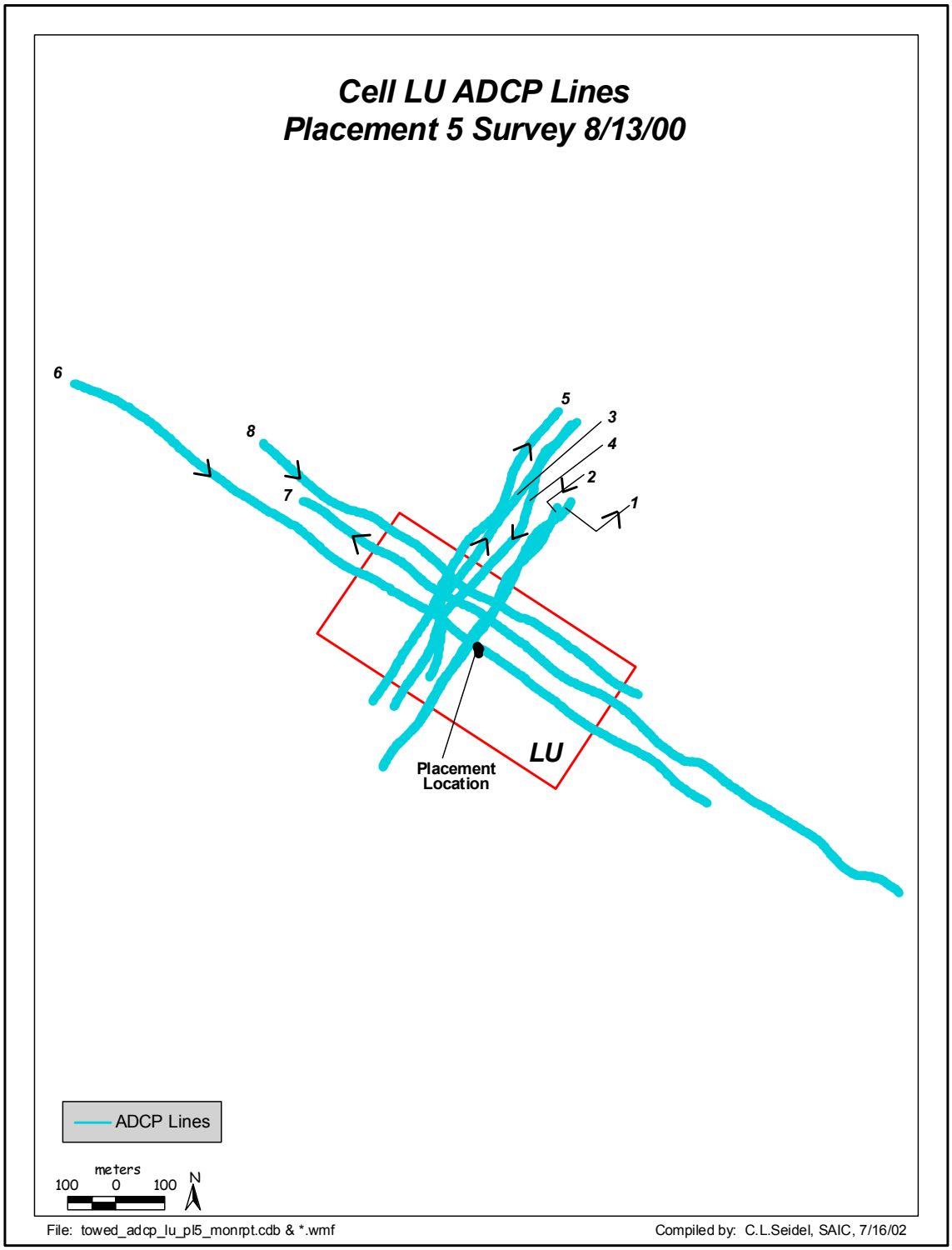


Figure 3.6-27. Survey tracklines for acoustic monitoring of suspended sediment on August 13, 2000 for placement Event 5.

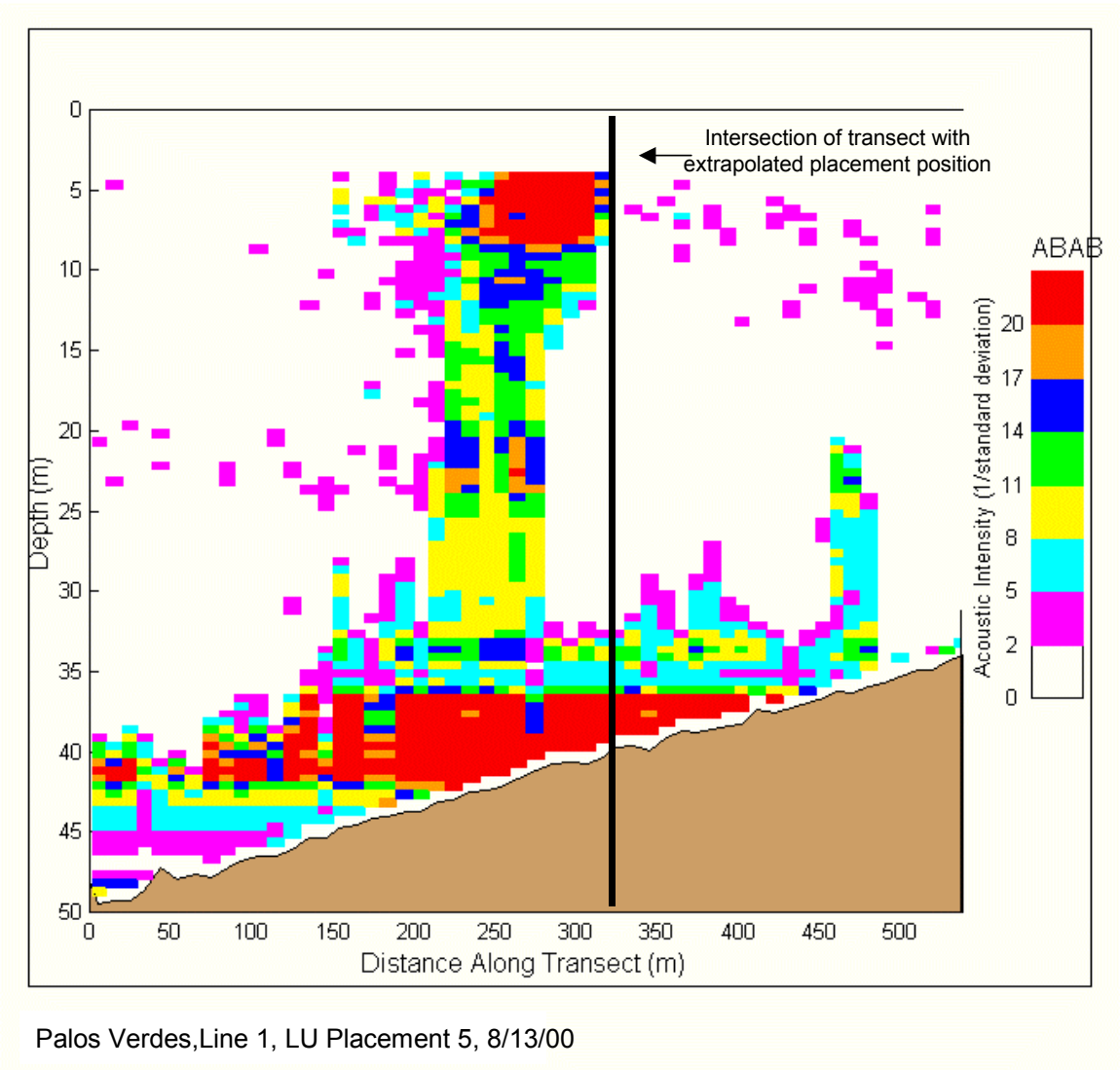


Figure 3.6-28. ABAB along Survey Line 1, run from southwest to northeast 8 min after the placement operation ended.

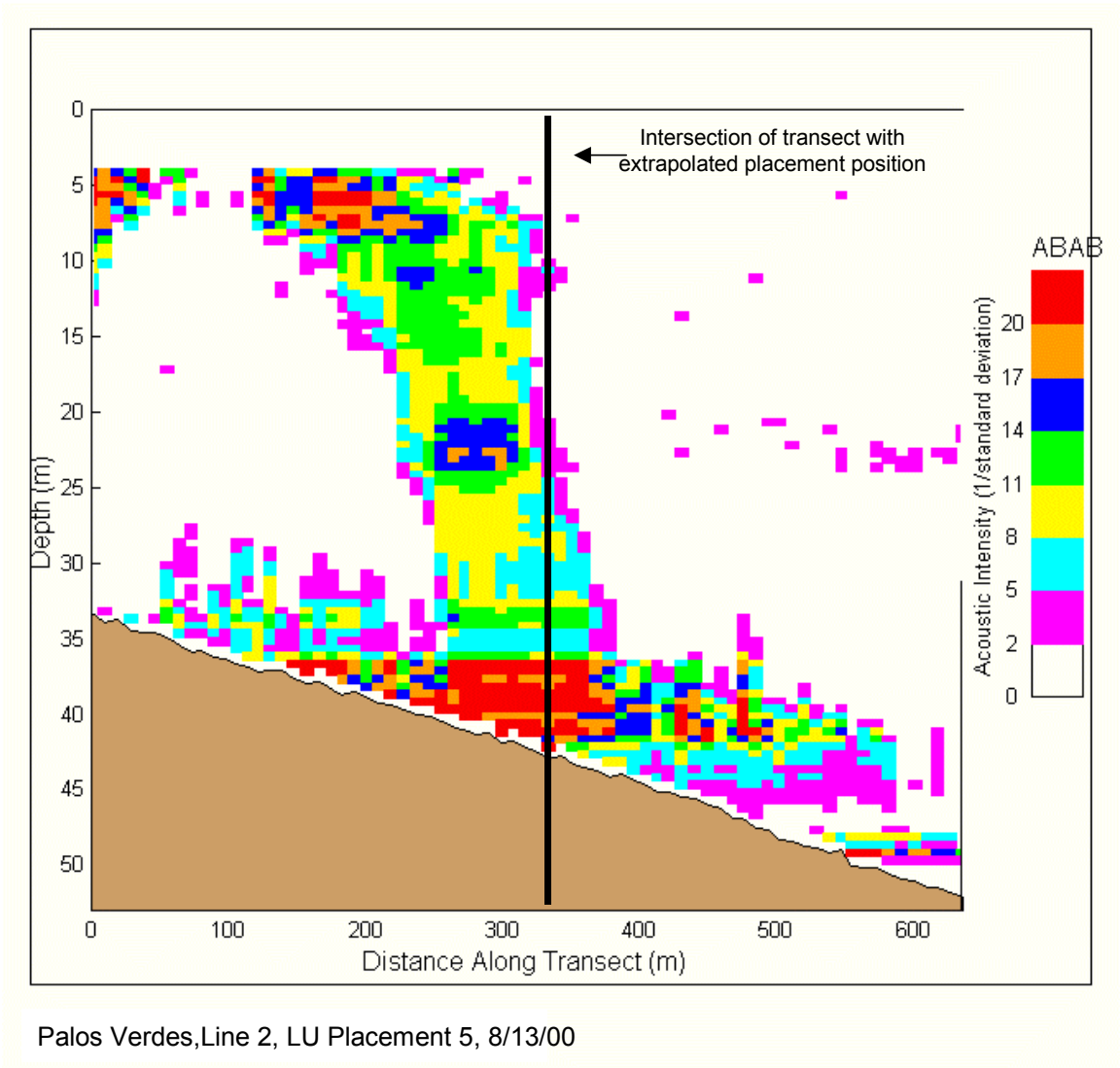


Figure 3.6-29. ABAB along Survey Line 2, run from northeast to southwest 15 min after the placement operation ended.

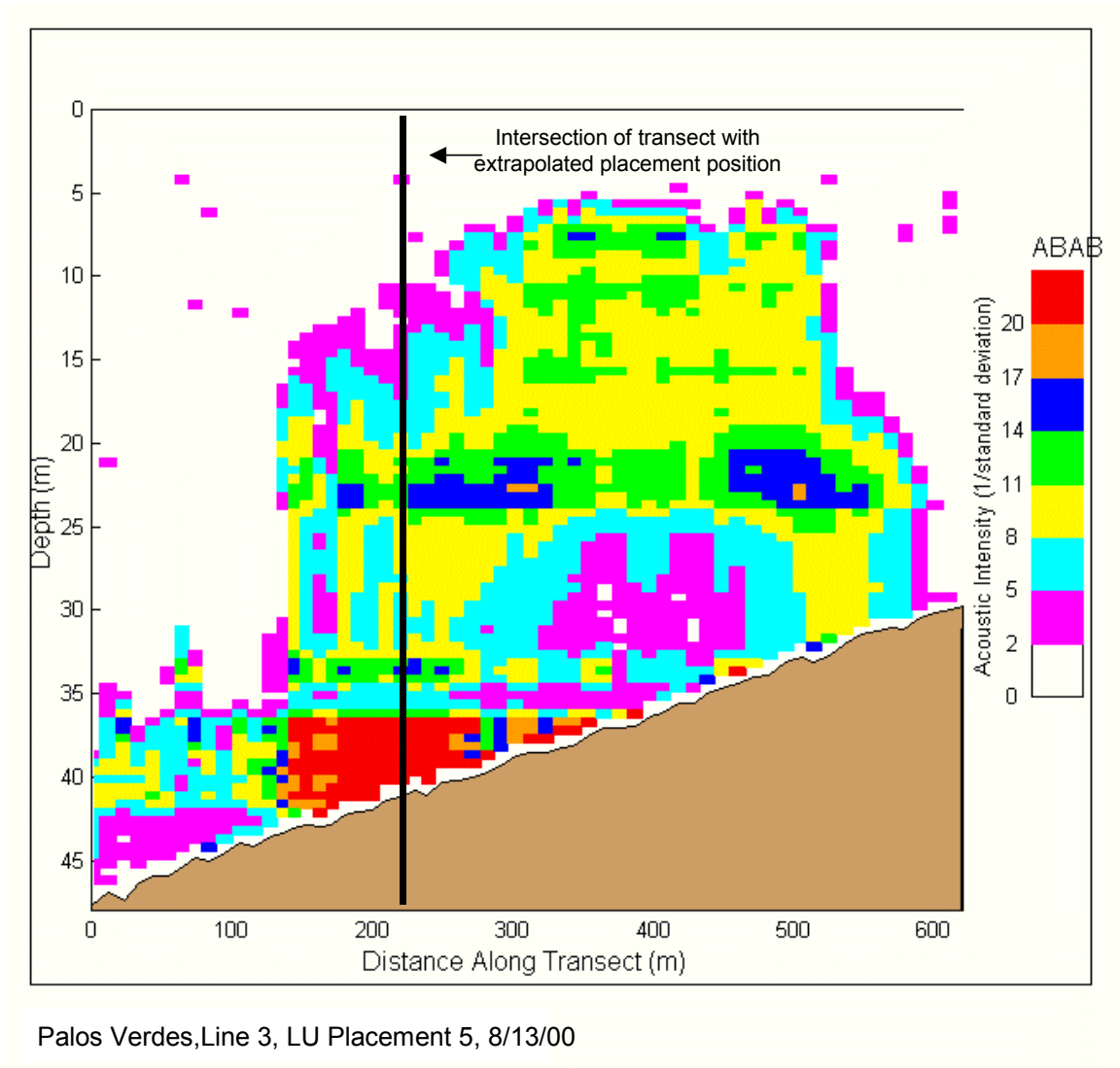


Figure 3.6-30. ABAB along Survey Line 3, run from southwest to northeast 22 min after the placement operation ended.

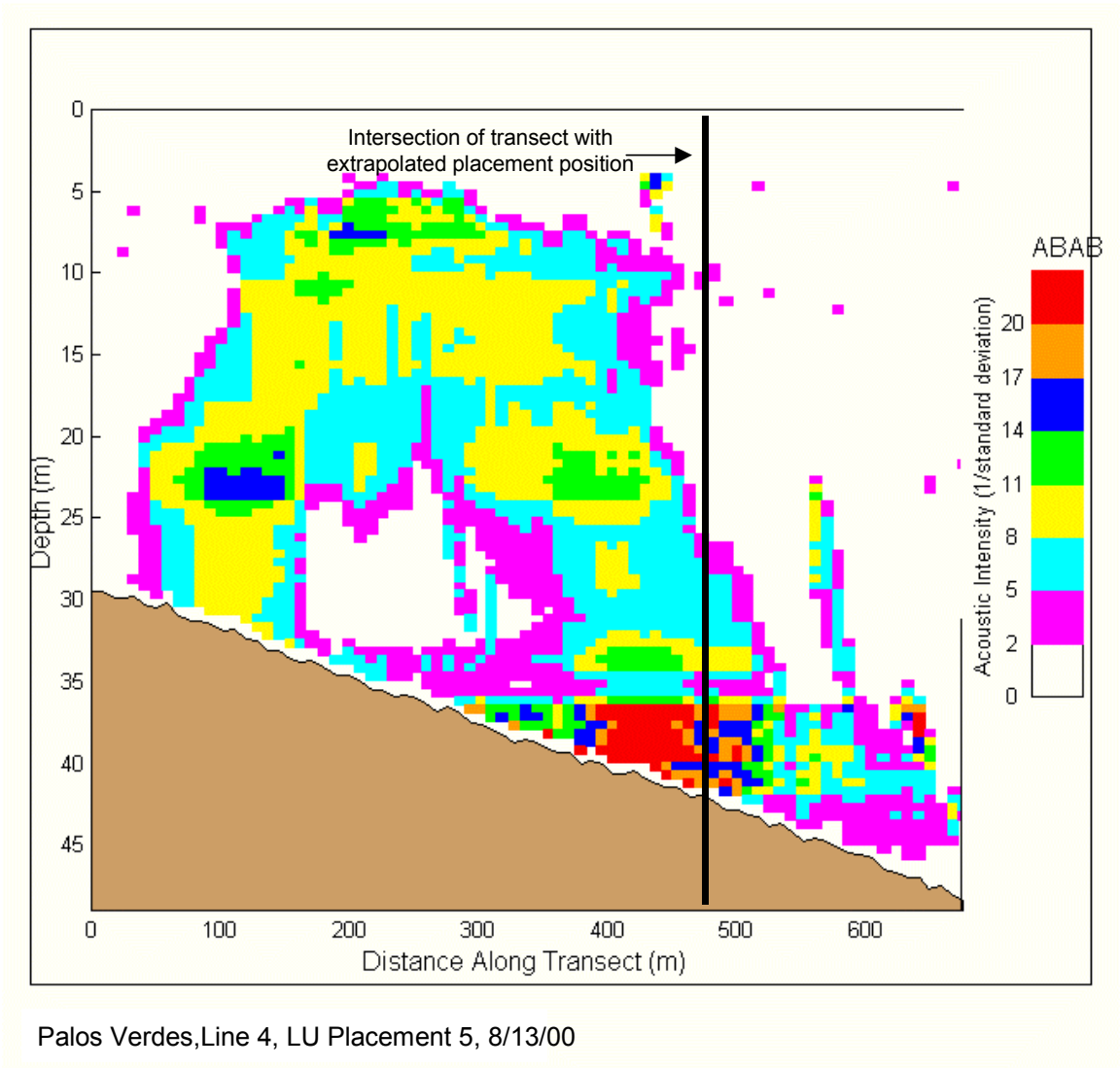


Figure 3.6-31. ABAB along Survey Line 4, run from northeast to southwest 28 min after the placement operation ended.

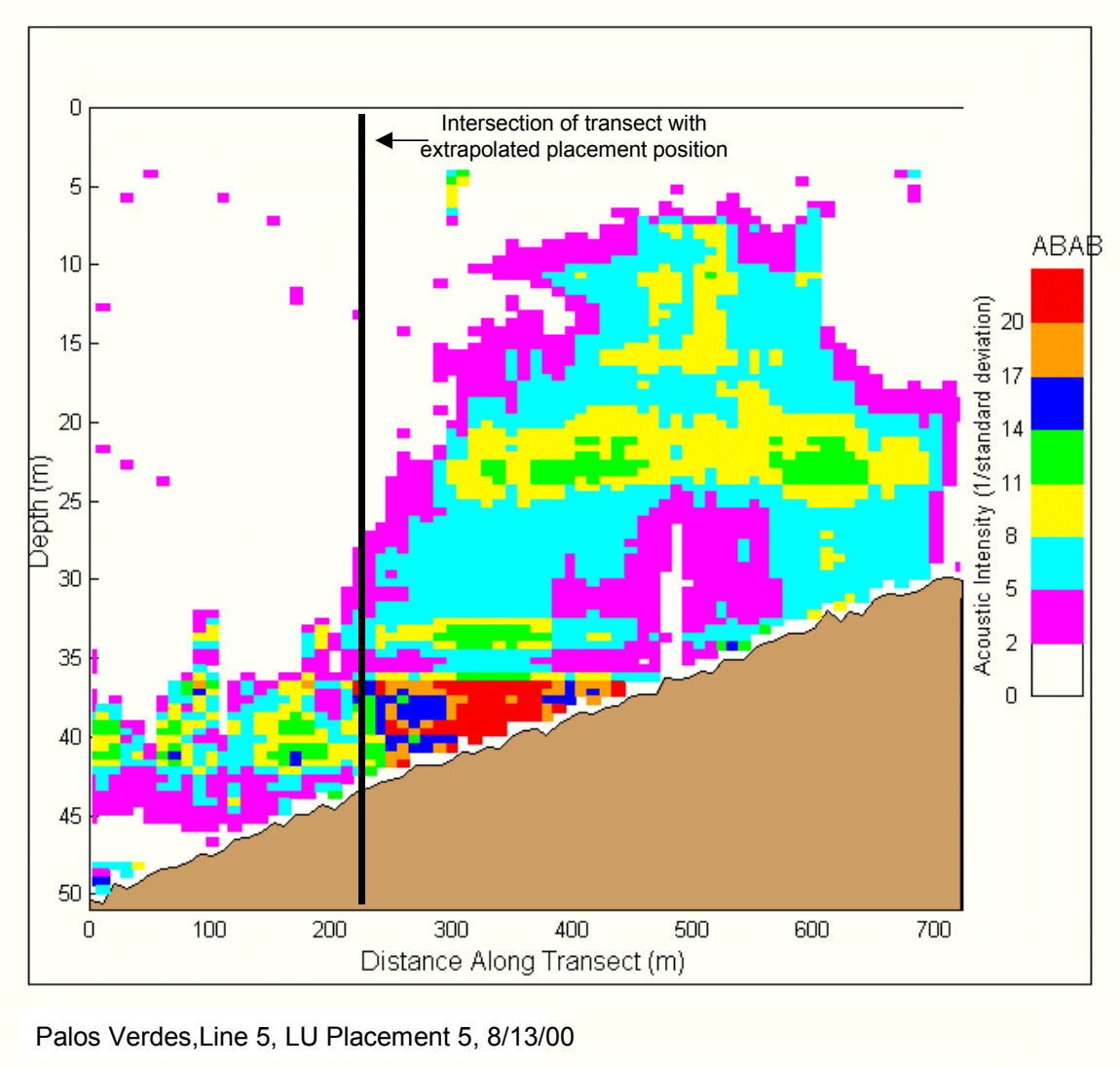


Figure 3.6-32. ABAB along Survey Line 5, run from southwest to northeast 35 min after the placement operation ended.

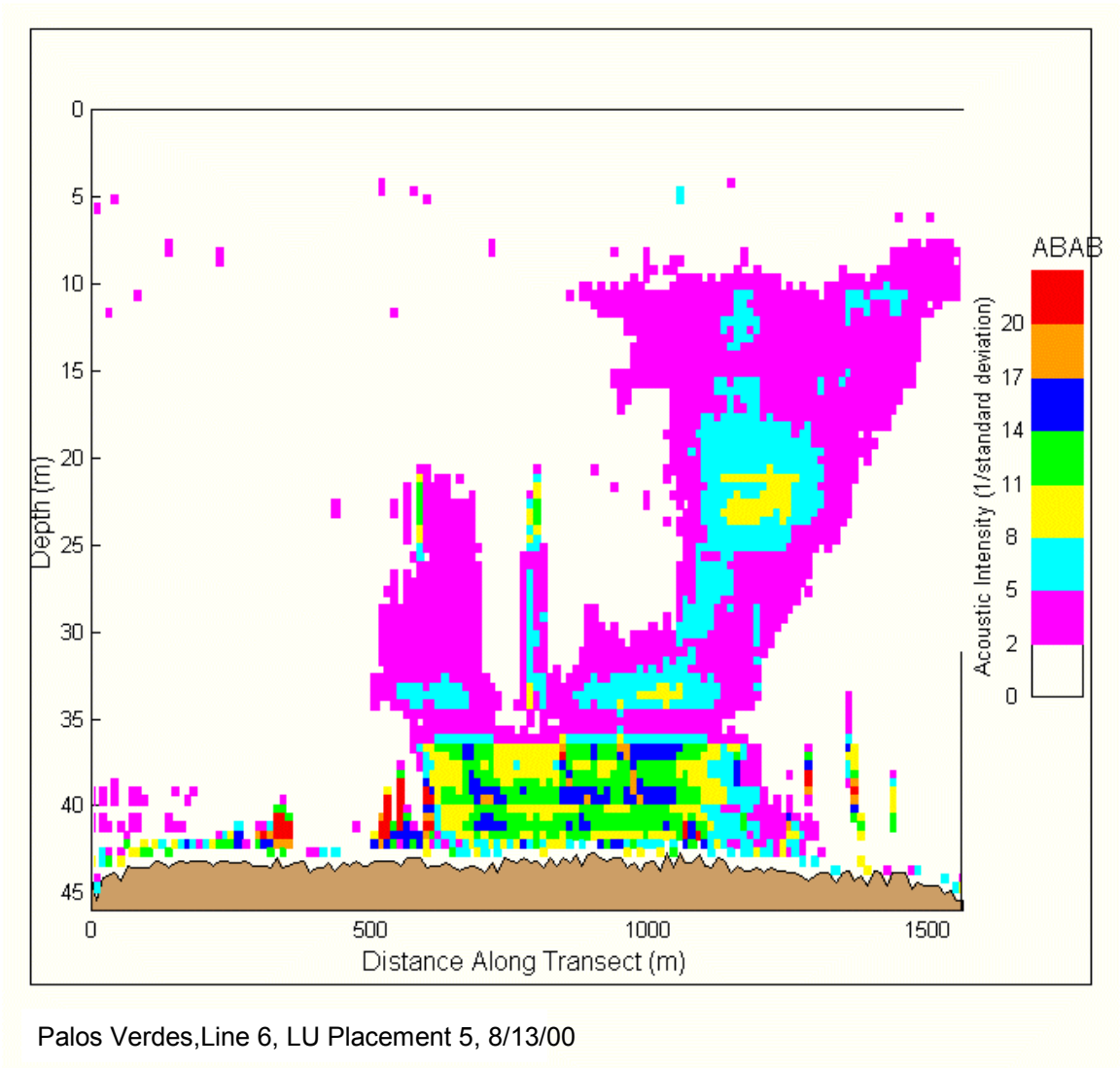


Figure 3.6-33. ABAB along Survey Line 6, run from northwest to southeast 49 min after the placement operation ended.

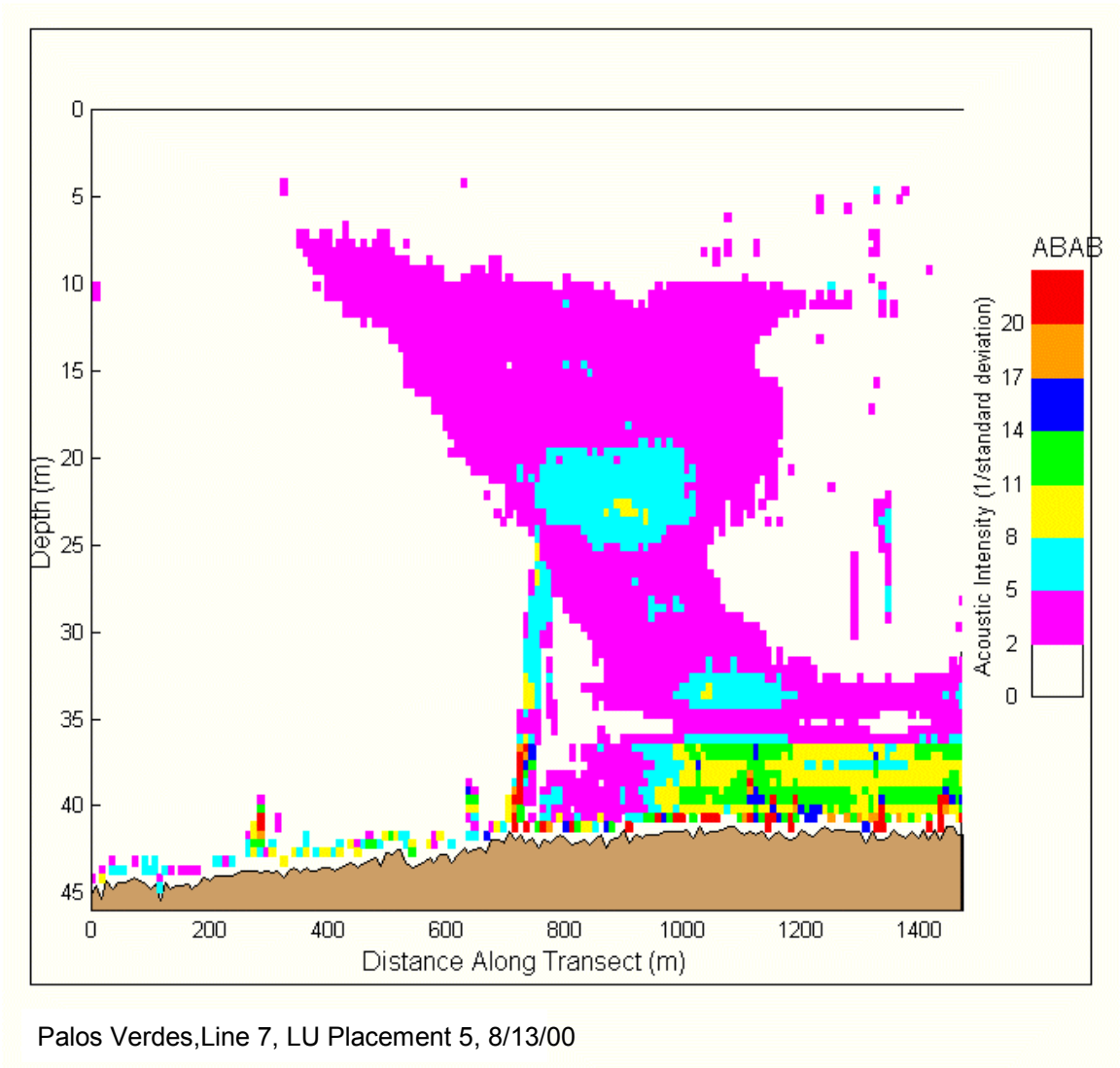


Figure 3.6-34. ABAB along Survey Line 7, run from southeast to northwest 1 hr and 3 min after the placement operation ended.

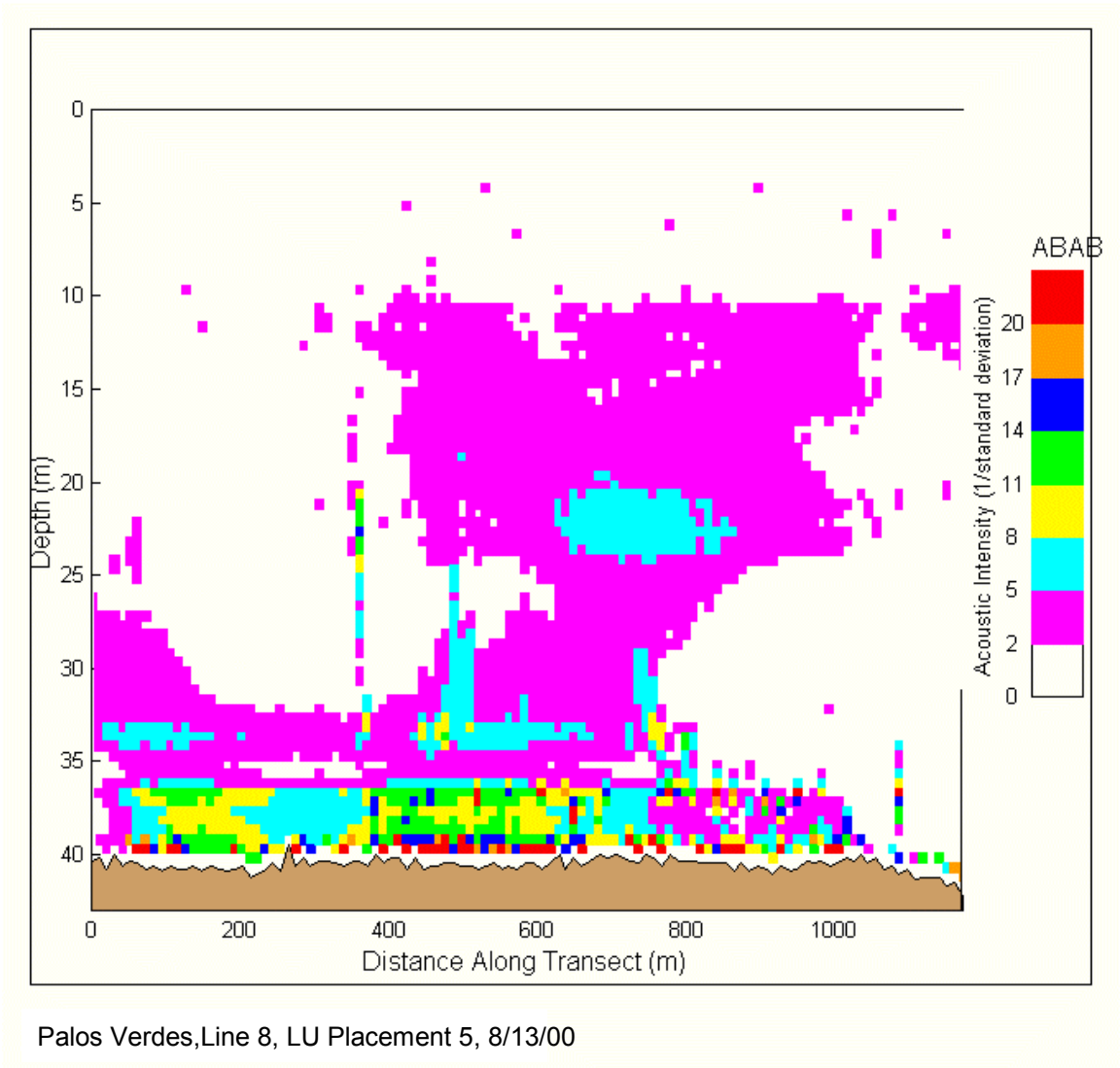


Figure 3.6-35. ABAB along Survey Line 8, run from northwest to southeast 1 hr and 26 min after the placement operation ended.

3.7 Sediment Profile Imagery Results

3.7.1 Overview of Field Sampling Plan

Field sampling activities for sediment profile camera (SPC) surveys in Cell LU followed the methods described in the Baseline and Interim/Postcap PWPs (SAIC 2000a, 2001). All of the SPC surveys specified in the PWPs were completed during the summer of 2000, including a baseline survey to characterize seafloor conditions immediately before the commencement of capping operations, surveys scheduled to follow a specific number of cap placement events (e.g., Post 1, Post 5, Post 25 and Post 45), and one flex survey (Post 64). In addition, a supplemental SPC survey was performed in conjunction with a supplemental vibracoring survey in Cell LU in February 2001 to evaluate cap thickness 5 months following the completion of the pilot cap placement activities. In all of the surveys, photographs taken with a plan view camera (PVC) were obtained simultaneously with the sediment profile images at each station, such that all of the SPC and PVC surveys presented in this report are coincident. However, for purposes of clarity and organizational efficiency, the plan view imaging results are presented in a separate section (Section 3.8).

Several of the SPC surveys involved sampling at additional "flex" stations; this provided improved coverage of the seafloor and better delineation of the cap material footprint. Table 3.7-1 provides a summary of SPC field sampling activities in Cell LU and indicates the number of stations planned (required) versus those actually sampled. Additional details regarding the number and location of stations for each survey are presented in the "monitoring results" section below.

3.7.2 Review of Data Quality Objectives

The data quality objectives (DQOs) for the baseline and interim/postcap SPC monitoring are described in detail in the PWPs and summarized in Tables 3.7-2 and 3.7-3. The purpose of this section is to provide a brief assessment of the degree to which these DQOs were met. It should be noted that these DQOs were not established for the individual pilot cells, but rather for the SPC monitoring in general. Therefore, the DQO assessment presented in this section is applicable not just to Cell LU, but to all of the baseline and interim/postcap SPC monitoring.

For both the baseline (background) and interim/postcap SPC monitoring, one of the key DQOs was a completeness goal of 100%. As indicated in section 3.7.1 above for Cell LU and in corresponding sections for the other pilot cells, all of the SPC surveys scheduled to occur in each cell were completed successfully (i.e., 100% survey completeness). This includes all of the surveys that were scheduled before the monitoring began, as well as several "flex surveys" that were planned for and implemented on an "as needed" basis over the course of the monitoring program. Within each survey, sampling always was completed at the required number of stations, and several surveys involved sampling at additional stations (i.e., >100% station completeness). Finally, for the baseline monitoring, three replicate images were successfully collected and analyzed at each station in Cells LD, LU, and SU (i.e., 100% completion goal met for replication at each baseline station).

For the interim and postcap monitoring, one image was to be collected and analyzed at most of the stations, with three replicate images analyzed at a random subset of stations. In practice, three replicate images (i.e., triplicates) were collected and analyzed for cap material thickness at almost all stations; this represents greater than 100% completeness achieved for SPC replication in the interim and postcap monitoring phases. Analyses of three replicate images at each station facilitated assessment of

the amount of variability in cap material thickness across relatively small spatial scales (i.e., on the order of several meters between replicate images).

A second key DQO identified in Table 3.7-2 for the baseline SPC monitoring was to determine the physical and biological sediment characteristics in each of the three pilot placement cells, immediately prior to capping operations. Physical and biological characteristics were to be determined with sufficient accuracy to permit distinctions between the EA sediments and cap material. As described in the monitoring results section for each cell, baseline SPC surveys were largely successful in providing a detailed characterization of the physical and biological sediment characteristics. All of the replicate images obtained in each cell were of sufficient clarity and resolution to allow subsequent measurement of key parameters, including sediment grain size major mode, sediment color and fabric, apparent redox potential discontinuity (RPD) depth, small-scale surface boundary roughness, infaunal successional stage, and Organism-Sediment Index. It must be noted that in the baseline survey in Cell SU, the RPD in many of the replicate images was partially obscured due to cohesive black mud adhering to the cutting edge of the sediment profile camera. However, the RPD depth typically could be estimated from an unobstructed portion of each image (i.e., an area of the RPD without any mud smears), thereby eliminating the effects of this smearing artifact.

A final DQO for the baseline SPC monitoring was to confirm that the thickness of EA sediment exceeded 10 cm in each of the three pilot capping cells. The average penetration depth of the sediment profile camera at each background station generally exceeded 10 cm, and the images suggested that EA sediment extended continuously from the sediment-water interface to below the penetration (imaging) depth. Based on these results, it was assumed that the EA sediment deposit was at least 10 cm thick in each of the three pilot cells.

For the interim and postcap SPC monitoring, a key DQO was to distinguish between EA sediment and cap material in order to measure the thickness of the cap layer, evaluate mixing or erosion of EA sediment, and determine the lateral extent of the cap material (Table 3.7-3). This DQO was met successfully because cap material was distinctly different from EA sediment in terms of color, texture, and composition. As described in later sections (3.11), cap material from Queen's Gate Channel consisted of gray-colored fine sand that was mixed to varying degrees with shell fragments and cohesive mud clasts. The color and texture of this material, and presence of the shell fragments and mud clasts, allowed it to be clearly distinguished in sediment profile images from the fine-grained, olive-colored, EA sediment (Figure 3.7-1). Likewise, cap material from A-III Borrow Area consisted of golden fine sand that was easily distinguished in the sediment profile images from the fine-grained EA sediment (Figure 3.7-1).

A final DQO for the interim and postcap SPC monitoring was to determine biological conditions, particularly benthic recolonization, of the cap layer. This DQO was met by visually examining each sediment profile image and recording whether or not any organisms or organism structures were visible within or at the surface of the cap material layer.

3.7.3 Technical Considerations

For the baseline monitoring survey in Cell LU, each sediment profile image was analyzed for a full suite of standard measurement parameters. The theoretical basis and specific techniques employed for each measurement are explained in detail in the PWPs for the baseline and interim/postcap monitoring and therefore not repeated here.

The primary objective of the SPC surveys performed in Cell LU (and the other cells) during and following the capping operations was to determine the spatial distribution and thickness of any cap

material layers observed on the seafloor. Therefore, three replicate images obtained at each station were analyzed for the following parameters: 1) cap material presence/absence, and 2) thickness of the cap material layer (in cm, where present). The resolution of sediment profile images was sufficient to allow detection and measurement of relatively thin depositional layers of cap material (i.e., on the order of about 1 cm). In images where the cap material layer appeared to be less than 1 cm thick, the layer was described as "patchy" or a "sprinkle" of material.

As capping operations progressed in each cell, the resultant cap material layers on the seafloor became thicker and more difficult to penetrate with the sediment-profile camera. The ability to use sediment profile images to determine cap layer thickness was limited by the 20-cm maximum penetration or "imaging" depth of the sediment profile camera. In some SPC surveys, there were a significant number of images in which the cap material extended from the sediment surface to below the penetration (imaging) depth. In such cases, the measured thickness of the cap layer is reported with a "greater than" sign. It is important to note that such measurements represent a "conservative" or minimum estimate of the total cap material thickness present at a particular location.

For each SPC survey, the presence/absence and thickness measurements were compiled in a database and used to prepare a series of contour maps showing the horizontal distribution or "footprint" of cap material on the seafloor for specific placement milestones.

All cap material thickness contour lines were delineated using ArcView's Spatial Analyst extension. All individual image results for cap material thickness were plotted, excluding stations where cap material thickness was indeterminate. Data for each survey were individually analyzed using the following parameters: (1) analysis extent equal to that of the plotted station results; (2) grid cell size equal to 25 m; (3) interpolation using inverse distance weighting (IDW); (4) the number of neighbors or input points was 12; (5) contour interval of 1 cm.

The IDW interpolation method assumes that points closer to the processing cell have a greater influence than the points further away, thereby giving more weight to data closer to the processing cell. Setting the number of neighbors specifies that the 12 nearest points to the processing cell will be used to determine the output value for that cell. The resulting contour lines represent the best estimate of the average cap material thickness on the actual surface.

Shaded or filled cap material thickness polygons were calculated in ArcInfo. The survey's contour line file, calculated according to the method described above, was used as the input file. The ArcInfo procedure converts the polylines or contours into polygons and assigns an average cap material thickness value to each polygon. For example, if a polygon is bordered on one side by a cap material thickness contour of 8 cm and on the other side by a cap thickness contour of 9 cm, the resulting polygon will have an average cap thickness of 8.5 cm. This contour line to filled contour process merely permits displaying cap material thickness results as a continuous surface, allowing a more intuitive visualization of the data.

When the sediment profile camera was lowered to the seafloor at each station, it penetrated the sediment and obtained the first replicate image. The camera was then raised a few feet above the bottom and immediately dropped back down to obtain the second replicate. By repeatedly lowering and raising the camera in this manner, three replicate images were obtained at each station. The maximum horizontal distance traveled by the camera between replicates was estimated to be approximately 3 to 5 meters. Therefore, analyzing three replicate images at each station allows for an assessment of the variability in cap material thickness across relatively short horizontal distances.

To evaluate within-station variability in the measured thickness of the cap layer, the lowest cap thickness value measured at each station was subtracted from the highest value to obtain a "maximum difference." For example, if two of the replicate images at a particular station had a measured cap thickness of 6 cm, and the third replicate had a thickness of 3 cm, the maximum difference among the replicates at this station was 3 cm. In contrast, if all three replicate images at a particular station had a measured cap thickness of 3 cm, the maximum difference was zero. Frequency distributions of "maximum difference" values were prepared for each survey to illustrate the degree of within-station variability in cap thickness. It must be noted that this assessment of within-station variability is only applicable to those stations where a discrete cap material layer was measured; the calculation is not valid where cap material thickness exceeded the prism penetration depth.

A second objective of SPI surveys was to evaluate the degree to which the cap material mixed with or disturbed the existing ambient sediment. To address this objective, an estimate of the "depth of disturbance" was made. The depth of disturbance is defined as the depth (in centimeters) to which EA sediment appeared to be removed or displaced as a result of placement of cap material. This disturbance depth was estimated based on how much of the pre-capping RPD (redox depth) was visible in each image, as illustrated in Figures 3.7-2 and 3.7-3. At some of the stations, the depth of disturbance was estimated by comparing the RPD in the postcapping image to the average RPD measured during the baseline survey. At stations where no background RPD was evident, the average background RPD over the entire cell was used. The depth of disturbance could not be estimated at some stations because remnants of the pre-capping RPD were obscured or occurred below the imaging depth (i.e., cap material thickness was greater than penetration depth).

A third and final objective of the surveys performed in each of the cells during and following the capping operations was to evaluate the degree to which the cap material was recolonized by benthic organisms. The presence of any organisms or organism structures (e.g., fecal mounds, burrow openings) observed within or at the surface of the cap material layer was recorded in the database for each replicate sediment profile image.

3.7.4 Monitoring Results

3.7.4.1 Baseline Survey

The SPC baseline survey was conducted on July 27, 2000, to evaluate basic physical and biological characteristics of surface sediments in and around Cell LU, immediately prior to the first placement of cap material. In accordance with the original sampling plan, three replicate sediment profile images were obtained at each of 25 primary stations located both inside and outside the cell boundaries (inside stations I-01 through I-15 and outside stations O-01 through O-10; Figure 3.7-4). Sampling also was conducted at 20 additional stations comprising two long transects to the northwest of Cell LU (stations O-23 through O-42; Figure 3.7-4). The purpose of this additional sampling was to obtain a background characterization of the seafloor well outside the boundary of Cell LU, to permit mapping of the cap material footprint in the event that it extended into this far field area.

A complete set of image analysis results for the baseline SPC survey in Cell LU is provided in DAN-LA; these results are summarized in Table 3.7-4. In the sediment-profile images from the baseline survey, the surface sediments appeared to consist predominantly of silt-clay, having a grain size major mode of >4 phi (Table 3.7-4). This grain size major mode corresponds to a grain diameter of less than 0.0625 mm (refer to Table 3.7-5 for grain size cross-unit conversions). At most of the Cell LU baseline stations, the images suggested there was a significant component of very fine sand (grain size major mode of 4 to 3 phi) mixed with the silt-clay, particularly at and near the sediment-water interface (upper 5 cm of

the sediment column; Figure 3.7-5). Laboratory analysis of samples obtained in the baseline coring survey in Cell LU showed that very fine sand (4 to 3 phi) was actually the dominant grain size fraction in the Cell LU surface sediments, with minor but significant proportions of silt and clay (see section 3.11). The two distal upslope SPC stations (O-02 and O-03) had grain size major modes of 3 to 2 phi (fine sand) and 4 to 3 phi (very fine sand), respectively. This suggests that the surface sediments became coarser moving shoreward into the shallower water upslope of Cell LU.

Boundary roughness values, a measure of small-scale surface relief, ranged from 0.7 to 5.3 cm at the background stations (Table 3.7-4). The overall mean value of 1.6 cm indicates a moderate amount of small-scale surface relief across the area, primarily attributed to the widespread presence of biogenic structures such as burrow openings and fecal mounds at the sediment surface.

The apparent RPD is a measure of the depth of oxygen penetration into the sediment. The apparent RPD depths at Cell LU background stations ranged from 1.1 to 5.0 cm, with an overall average of 2.8 cm (Table 3.7-4). In general, RPD depths of about 2 or 3 cm observed at most stations are considered indicative of moderately deep aeration of the surface sediments in and around Cell LU. The RPD was particularly important to the monitoring objectives in each of the pilot cells because this layer of light-colored surface sediment served as a visual marker in the sediment profile images useful for estimating the depth of sediment disturbance following cap material placement.

Of the 135 total replicate sediment profile images obtained and analyzed for the Cell LU baseline survey, 89 (66%) showed an infaunal successional stage of either Stage III or Stage I on Stage III (I on III), while 46 (34%) had an infaunal successional stage designation of Stage I only (Table 3.7-4). The Stage I on III successional stage designation was assigned to an image with both tube-dwelling, opportunistic polychaetes at the sediment surface (Stage I) and feeding voids (evidence of larger-bodied, Stage III deposit feeders) at depth (Figure 3.7-5). This situation is not unusual in productive seafloor areas receiving relatively high inputs of organic matter, sufficient to maintain a diverse benthic population of both suspension- and deposit-feeders. Overall, the widespread abundance of Stage III taxa in and around Cell LU reflected a mature (i.e., "equilibrium") benthic community. A higher proportion of the baseline images in Cell LU were dominated by Stage I only compared to either Cell SU or LD. The apparent abundance of Stage I may have reflected higher rates of organic loading associated with the relative proximity of Cell LU to the LACSD wastewater outfall.

The REMOTS® Organism-Sediment Index (OSI) is a summary parameter used to indicate overall benthic habitat quality. OSI values at Cell LU stations ranged from +3.7 to +11, with an overall average of +7.7 (Table 3.7-4). Over 95% of the mean OSI values for each station were greater than or equal to +6; such values are considered indicative of relatively undisturbed or stable benthic habitat quality. The high OSI values reflected the widespread presence of an abundant and diverse benthic community comprised of both Stage I and Stage III taxa. Bioturbation by this community has served to irrigate and aerate the surface sediments, resulting in RPD depths generally exceeding 2 cm in and around Cell LU.

3.7.4.2 Post 1 Survey

The Post 1 SPC survey was conducted on August 3 and 9, 2000, following the first cap material placement event in Cell LU (conventional placement of a single hopper load of Queen's Gate dredged material; Figure 3.1-1). The survey on August 3 involved sampling at 40 of the 45 stations occupied in the baseline survey, as well as at 12 additional stations located outside the cell boundary (stations O-11 through O-22; Figure 3.7-6). Following an initial review of the survey results, additional "flex" sampling was conducted on August 9 at 10 stations located inside the cell boundaries to allow better definition of the cap material footprint and thickness (stations I-20 through I-29; Figure 3.7-6). Therefore, a total of 62 stations were sampled in the Post 1 survey in Cell LU.

Each of the replicate images obtained at each station was analyzed for cap material presence/absence, cap layer thickness, estimated depth of EA sediment disturbance, and benthic recolonization of the cap material. A complete set of results for this analysis is presented in DAN-LA.

Cap material was visible in sediment profile images at a subset of stations as a distinct, continuous, well-defined, surface depositional layer composed primarily of gray-colored, fine sand (Figure 3.7-7). The thickness and appearance of the cap material varied among replicate images. The gray sand from Queen's Gate Channel contained minor and variable amounts of both white shell fragments and white or gray cohesive clay clasts (Figure 3.7-8). Cap material was detected in replicate sediment-profile images at only 10 stations in the post-initial survey, all located near the center of Cell LU (Figure 3.7-9). Cap material was not detected at the remaining stations inside the cell boundary or at any of the outside stations.

Cap layer contours in Figure 3.7-9 are based on the average measured thickness of the cap material layer at each station (mean of n = 3 replicate images), while each colored circle represents the cap material thickness measurement for an individual image. The measured thickness of the cap material layer in the individual images ranged from a maximum of 7 cm in replicate image A at station I-26 near the center of the deposit to less than 1 cm (trace) in replicate image A at station I-05 near the outer edge (see DAN-LA database).

A frequency distribution used to illustrate within-station variability in the measured cap thickness shows that the maximum difference among the three replicates was 2 cm or less at the majority of stations where a cap material layer was observed and measured (Figure 3.7-10). In general, these results indicate a relatively minor amount of variation in the thickness of the cap material layer (i.e., on the order of a few centimeters) across relatively small horizontal distances (i.e., on the order of a few meters between replicate images) in the Post 1 survey.

Contours in Figure 3.7-9 indicate that the cap material deposit on the seafloor was roughly circular, with a diameter ranging between 200 and 250 meters. Average cap material thickness ranged from about 5 cm at the center of the deposit to less than 1 cm at the outer edge (Figure 3.7-9). The center of the cap material deposit on the seafloor was located about 50 m to the northwest of the hopper placement location at the sea surface (Figure 3.7-9). These results suggest that cap material experienced only a minor amount of lateral displacement to the northwest as it fell through the water column; this direction is consistent with the prevailing along-slope current movement.

As described previously in section 3.7.3, the depth to which the EA sediment was disturbed or removed as a result of cap material placement was estimated by measuring the remnant RPD in sediment profile images (see Figures 3.7-2 and 3.7-3). The estimated depth of EA sediment disturbance was greatest at stations I07 and I08 near the center of the cap material deposit (Figure 3.7-11). At these two stations, it appeared that the entire layer of light-colored EA sediment comprising the RPD had been removed as a result of cap material placement, and the depth of disturbance was mapped as a conservative estimate (i.e., greater than the former RPD of about 2.5 cm at each station; Figure 3.7-11). At other stations where cap material was present, the estimated depth of EA sediment disturbance ranged from 0.1 to 2.4 cm (Figure 3.7-11). At the remaining stations outside the cap material footprint, disturbance of EA sediment was not evident (i.e., depth of disturbance = 0 cm because the RPD was still present at roughly the same depth as before the cap placement event; Figure 3.7-11).

3.7.4.3 Post 5 Survey

The Post 5 SPC survey was conducted on August 17 and 18, 2000, following the conventional placement of a cumulative total of 5 hopper loads of Queen's Gate cap material in the center of Cell LU. Sediment profile images were obtained at 19 stations located within the cell, including the original 15 inside stations from the baseline survey and 4 additional stations located near the four corners of the cell (Figure 3.7-12).

A surface layer of cap material was present at all stations, with the exception of the four stations (I16 through I19) located near the corners of the cell (Figure 3.7-13). Cap material thickness measured in individual images ranged from >10 cm in replicate image A at station I-04 near the center of the cell to less than 1 cm at stations on the outer edge of the deposit (DAN-LA database and Figure 3.7-14). As previously indicated, the "greater than" sign indicates that cap material extended from the sediment surface to below the penetration (imaging) depth of the sediment profile camera (Figures 3.7-13 and 3.7-14A). The cap material layer extended below the camera imaging depth (greater than penetration) in two replicate images at station I-08 and in all three replicate images at stations I-04, I-09 and I-12 near the center of the cell.

Average cap material thickness depicted by the contour lines in Figure 3.7-13 ranged from >8 cm at the center of Cell LU to less than 1 cm at the outer southeastern- and northwestern-most edges. The diameter of the cap material deposit lengthwise across the cell was >400 m following the 5 placement events. Contouring of the full cap material footprint in Figure 3.7-13 was limited by the number and positioning of the stations; it is likely that the cap material layer extended outside the cell boundary in both the northeast and southwest directions (i.e., both landward and seaward of the cell).

The frequency distribution used to illustrate within-station variability in measured cap thickness shows that the maximum difference among the triplicates was 2 cm or less at the majority of stations where a discrete cap material layer was observed and measured (Figure 3.7-15). These results again indicate relatively minor variation in cap layer thickness across relatively small horizontal distances (i.e., on the order of a few meters between replicate images) in the Post 5 survey.

As in the Post 1 survey, the estimated depth of EA sediment disturbance in the Post 5 survey was greatest at stations I07 and I08 near the center of the cap material deposit (Figure 3.7-16). At these two stations, it appeared that the entire layer of light-colored EA sediment comprising the RPD had been removed as a result of cap material placement, and the depth of disturbance was mapped as a conservative estimate (i.e., greater than the former RPD of roughly 2 to 3 cm at each station; Figure 3.7-16). At the other stations where cap material was present, the estimated depth of EA sediment disturbance ranged from 0.1 to 2.6 cm (Figure 3.7-16). At stations I16 through I19, where cap material was not present, no disturbance of EA sediment was apparent (Figure 3.7-16). Thus, the overall pattern of EA sediment disturbance in the Post-5 survey was consistent with that observed initially in the Post-1 survey. Disturbance was limited to the initial point of cap material impact and significantly less at outlying stations.

3.7.4.4 Post 25 Survey

The Post 25 SPC survey was conducted on August 25, 2000, following the conventional placement of a cumulative total of 25 hopper loads of Queen's Gate material in Cell LU. Sediment profile images were obtained at 31 stations located inside the cell boundary (Figure 3.7-17).

Cap material placement locations were distributed throughout the cell, and cap material was observed in sediment profile images at all stations (Figure 3.7-18). Cap layer thickness exceeded the

camera penetration depth in 77 of the 94 replicate images obtained at the 31 stations (see DAN-LA database). Cap thickness ranged from >14 cm in one image from station I32 to 6 cm in one replicate image at station I05. At the majority of stations (27 of 31), at least one of three replicate images had cap material greater than penetration. The exceptions were stations I30 and I36 on the northwestern edge of the cell and stations I15 and I33 in the eastern half (Figure 3.7-18).

Contour lines in Figure 3.7-18 indicate that average thickness of the cap material layer across the cell ranged from >9 to >11 cm. Again, it is emphasized that these values represent a minimum estimate of the actual cap material thickness. There was some variation in cap material thickness among stations within the cell, as evidenced by the discrete cap material layers (i.e., not greater than penetration) measured at stations I15, I30, I33, and I36. At two of these stations (I15 and I33), there was also some variation in cap thickness among the three replicate images (on the order of 4 to 5 cm; Figure 3.7-19).

Because most stations in the Post 25 SPC survey had cap layer thickness which exceeded the penetration depth of the sediment profile camera, it was not possible to estimate the depth of EA sediment disturbance. At those stations where a discrete layer was present and the former RPD could be observed, the estimated depth of EA sediment disturbance ranged from 1 to 3 cm (Figure 3.7-20).

3.7.4.5 Post 45 Survey

The Post 45 SPC survey was conducted on September 5 and 7, 2000, following conventional placement of a cumulative total of 45 hopper loads of Queen's Gate material. Sediment profile images were obtained at a total of 49 stations, located both inside and outside the cell boundary (Figure 3.7-21).

Hopper placement locations were distributed evenly within the cell boundary and around the outer perimeter of the cell (Figure 3.7-22). A depositional layer of cap material was observed in images at all stations located inside the cell boundaries. Average thickness of cap material exceeded the camera penetration depth at all stations, ranging from >9 to >15 cm within the cell. Contours in Figure 3.7-22 indicate that the cap layer was, on average, at least 9 to 11 cm thick across the entire cell. Again, this represents a conservative or minimum estimate of the actual cap thickness because it is constrained by the penetration depth of the sediment profile camera.

At stations located immediately outside the cell (i.e., within about 50 m of the boundary), average thickness of cap material ranged from 10 cm to >12 cm. At stations located greater than 100 m beyond cell boundary, average cap material thickness generally ranged from 2 to 6 cm. Cap material layers having an average thickness of 6 cm and 2 cm were observed, respectively, at stations O-06 and O-05 located downslope of the cell, but no cap material was observed at the downslope station O-08. Likewise, a 3-cm cap material layer was observed at the along-slope distal stations O-15 and O-21. In the upslope direction, only a patchy, "sprinkle" layer of cap material (less than 1 cm thick) was observed at station O-12, while no cap material was observed at distal stations O-02, O-03, and O-10 (Figure 3.7-22).

The frequency distribution used to evaluate within-station variability in measured cap thickness shows that the maximum difference among three replicates was 2 cm or less at stations where a discrete cap material layer was observed and measured (Figure 3.7-23). These results again indicate relatively minor variation in the thickness of cap material across relatively small horizontal distances (i.e., on the order of a few meters between replicate images) in the Post 45 survey.

Depths of EA sediment disturbance could not be estimated at stations within the cell boundary because the remnant RPD could not be viewed (i.e., cap material greater than penetration). At stations located outside the cell in the seaward (downslope) direction, it appeared that the entire RPD had been removed as a result of cap material placement, and the depth of disturbance was conservatively estimated

to be greater than 2 or 3 cm (Figure 3.7-24). At stations outside the cell boundary in the landward (upslope) direction, the depth of EA sediment disturbance was estimated to be limited to about 1 or 2 cm (Figure 3.7-24).

3.7.4.6 Post 64 Survey

The Post 64 SPC survey in Cell LU was conducted on September 13, following the conventional placement of a cumulative total of 64 hopper loads of Queen's Gate cap material. Sediment profile images were obtained at 15 stations outside the cell. These 15 stations were spaced 25 m apart and aligned in two transects of 7 and 8 stations, respectively (Figure 3.7-25). One transect began 125 m northeast of the Cell LU boundary, and the other began at a distance of 100 m to the southeast. The objective of sampling along each transect was to determine the location of the outer edge of the cap material deposit.

The 64 hopper placement locations were distributed within and along the outer perimeter of the cell (Figure 3.7-26). No cap material was observed at any of the stations on the transect located to the northeast, upslope of the cell, while a relatively thin cap layer was observed at the first five stations of the southeast transect (Figure 3.7-26). Average cap material thickness at these stations ranged from about 7 cm at the first transect station to 1 cm at the fifth station. Average thickness decreased consistently with distance along this transect, and no cap material was observed at the three distal stations. The results suggest 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 extended less than about 125 to 150 m beyond the boundary to the northeast (upslope). However, these results concerning the upslope spread of material must be viewed with caution. The northeast transect in Figure 3.7-26 was located at some distance away from the upslope placement locations. It is possible that the material spread farther in the upslope direction at locations closer to the placement points.

3.7.4.7 Supplemental Survey

The Supplemental SPC survey was conducted on February 24, 2001, five months following the last cap placement event in Cell LU. Sediment profile images were obtained at a total of 13 stations located outside the cell boundary, primarily in the southwest, or downslope, direction (Figure 3.7-27). Nine of these thirteen stations had been sampled in the Post-45 survey, and the remaining four stations were unique to the supplemental survey.

Figure 3.7-28 shows the average cap material thickness measured at each station in the supplemental survey and, for comparative purposes, presents the average cap material thickness measured five months previously in the Post-45 survey. At seven of the eight stations where cap material had been observed in the Post-45 survey, it was also observed in the supplemental survey (Figure 3.7-28). It was not possible to determine whether cap material remained present at the eighth station (station O05), because the images obtained in the supplemental survey were of poor quality. Relatively thin (2 to 3 cm) cap material layers also were observed at the four new stations sampled in the supplemental survey (stations O74 through O77). Cap material was not observed at station O08 in either the Post-45 or supplemental surveys (Figure 3.7-28).

The average thickness of the cap material layer at each station in the supplemental survey ranged from 1.5 to >8.5 cm (figure 3.7-28). In general, the average cap thickness measured at each station in the supplemental survey was consistent with that measured in the Post-45 survey. However, at all eleven stations where cap material was noted in the supplemental survey, a surface depositional layer of brown, fine-grained sediment was visible on top of the cap material layer (Figure 3.7-29). This surface layer of muddy sediment on top of the cap material was not observed in the September 2000 Post-45 SPC survey,

indicating that it had been deposited during the intervening 5 months (Figure 3.7-30). The average thickness of this new surface depositional layer of fine-grained sediment ranged from 2 to 7.3 cm at the eleven stations (Figure 3.7-31). The origin of this layer is unknown, but it may be due to natural transport and deposition of fine-grained sediment and organic matter in the PV shelf.

Table 3.7-1. Summary of SPC Field Sampling Activities in Cell LU

Survey Name	Number of Survey Stations		Completeness
	Required	Sampled	
Baseline	25	45	180%
Post 1	37	62	168%
Post 5	14	19	136%
Post 25	14	31	221%
Post 45	37	49	132%
Post 64 (Flex Survey)	15	15	100%
Supplemental Survey	13	13	100%

Table 3.7-2. Summary of DQOs for the Baseline SPC Monitoring

Monitoring Objective	Data Requirements	Monitoring Approach	Field Decision Criteria/ Performance Specifications
Determine physical and biological sediment characteristics in each of the three pilot placement cells.	Full suite of measurement parameters: Grain size major mode RPD depth Thickness of depositional layers Infaunal successional stage Organism-Sediment Index Presence of epifauna Plan view surface features	Collect three replicate sediment-profile images/plan view images at each of 25 sampling stations located in each of the three pilot placement cells. Sampling is to occur immediately prior to (within one week) the pilot capping operations.	Navigational accuracy should be ±1 to 3 m. Three replicate images suitable for analysis must be collected at each station (100% completeness goal).
Determine physical and biological characteristics of sediments in the proposed placement cells with sufficient accuracy to permit distinctions between ambient sediments and cap material (dependent also on characteristics of cap material).	Physical: Sediment grain size Sediment color Sediment fabric RPD depth Biological: Infaunal successional stage	Same as above.	Sediment grain size, color, fabric, and RPD should be clearly distinguishable in each image. Agreement between sediment-profile image and sediment coring grain size results should be 90% or greater.
Confirm that the thickness of EA sediments exceeds 10 cm in the proposed placement cells.	Thickness of EA sediment layer in each image. Overall average EA sediment layer thickness for all images.	Same as above.	Measure EA sediment layer thickness in each image to the nearest 1 cm.

Table 3.7-3. Summary of DQOs for the Interim/Postcap SPC Monitoring

Monitoring Objective	Data Requirements	Monitoring Approach	Field Decision Criteria/Performance Specifications
Determine thickness of cap layer and mixing or erosion of EA sediments.	Thickness of depositional layers Grain size major mode Plan view surface features RPD depth	Collect sediment-profile/ plan view camera images at specified sampling stations following a single hopper load and at specified intervals during and following cap construction for both conventional and spreading placement methods (see FSP).	One image will be collected at each station, with replicate (triplicate) images from randomly selected stations at specified frequency (100% completeness goal). To the extent possible, the prism of the sediment profile camera should penetrate below the cap layer/EA layer boundary. Image must be collected within 5 m radius watch circle. Methodology and performance specifications should be identical to those used for Baseline Monitoring.
Determine lateral extent of capping materials.	Same as above. Sediment grain size Sediment color Sediment fabric RPD depth	Same as above.	Same as above. Sediment grain size, color, fabric, and RPD should be clearly distinguishable in each profile image.
Determine biological conditions (i.e., recolonization) of cap layer.	Infaunal successional stage Organism-Sediment Index	Same as above.	Not specified, in part, because recolonization will reflect the time since cap placement.

Table 3.7-4. Summary of image analysis results for the baseline SPC survey in Cell LU. Values for RPD depth, boundary roughness, and Organism-Sediment Index are averages for the three replicate images obtained and analyzed at each station

STATION	GRAIN SIZE MAJOR MODE (phi)	CAMERA PENETRATION MEAN (cm)	BOUNDARY ROUGHNESS MEAN (cm)	APPAREANT RPD THICKNESS MEAN (CM)	SUCCESSIONAL STAGES PRESENT (# of replicates)	OSI MEAN
INSIDE STATIONS						
LUBI01	>4	11.5	1.9	3.0	ST I (1), ST I on III (2)	8.0
LUBI02	>4	11.4	1.8	4.5	ST I (1), ST III (1), ST I on III (1)	9.0
LUBI03	>4	12.2	1.4	3.2	ST I (2), ST I on III (1)	7.0
LUBI04	>4	10.9	2.7	2.5	ST I (2), ST I on III (1)	6.0
LUBI05	>4	11.6	1.5	2.2	ST I on III (3)	8.3
LUBI06	>4	12.5	1.3	3.0	ST I (3)	5.0
LUBI07	>4	11.2	1.9	2.5	ST I (2), ST I on III (1)	6.0
LUBI08	>4	10.9	1.6	2.9	ST I (1), ST I on III (2)	7.7
LUBI09	>4	9.2	3.2	2.5	ST I (2), ST I on III (1)	6.3
LUBI10	>4	11.8	0.9	2.0	ST I (3)	4.0
LUBI11	>4	11.7	1.4	1.9	ST I (3)	3.7
LUBI12	>4	11.8	1.3	3.2	ST I on III (3)	9.7
LUBI13	>4	12.8	2.3	2.3	ST I (1), ST III (2)	7.3
LUBI14	>4	13.1	1.1	2.1	ST I (3)	4.3
LUBI15	>4	11.6	2.2	2.3	ST I (2), ST I on III (1)	5.7
OUTSIDE STATIONS						
LUBO01	>4	11.1	1.4	4.8	ST III (1), ST I on III (2)	11.0
LUBO02	3 to 2	9.9	4.0	5.0	ST III (3)	11.0
LUBO03	4 to 3	10.7	1.4	3.5	ST I (2), ST I on III (1)	7.3
LUBO04	>4	11.5	0.9	3.2	ST I (2), ST I on III (1)	7.0
LUBO05	>4	14.0	2.2	2.2	ST III (1), ST I on III (2)	8.3
LUBO06	>4	15.2	0.7	1.8	ST I on III (3)	8.0
LUBO07	>4	13.2	1.8	1.9	ST I on III (3)	8.0
LUBO08	>4	13.4	0.9	1.1	ST I on III (3)	7.0
LUBO09	>4	12.4	1.3	2.2	ST I (1), ST I on III (2)	7.0
LUBO10	>4	11.4	1.5	3.5	ST I (2), ST I on III (1)	7.7
LUBX23	>4	12.7	1.4	2.4	ST I on III (3)	8.7
LUBX24	>4	12.3	1.2	2.4	ST I (2), ST I on III (1)	6.0
LUBX25	>4	11.8	1.4	2.7	ST I (3)	5.0
LUBX26	>4	12.4	1.0	2.3	ST I (1), ST I on III (2)	7.3
LUBX27	>4	12.2	1.1	1.8	ST I (1), ST I on III (2)	6.7
LUBX28	>4	11.8	2.5	3.1	ST I (1), ST I on III (2)	8.3
LUBX29	>4	12.6	1.0	2.7	ST I (1), ST I on III (2)	7.7
LUBX30	>4	11.6	3.5	2.3	ST I on III (3)	8.3
LUBX31	>4	12.6	1.4	2.9	ST I on III (3)	9.3
LUBX32	>4	12.6	0.7	2.3	ST I on III (3)	8.7
LUBX33	>4	10.6	0.9	3.1	ST I (2), ST I on III (1)	6.3
LUBX34	>4	12.9	0.9	3.8	ST I on III (3)	10.3
LUBX35	>4	11.3	1.8	3.4	ST I (1), ST I on III (2)	8.7
LUBX36	>4	12.2	1.2	2.7	ST I (1), ST I on III (2)	7.7
LUBX37	>4	10.1	5.3	2.6	ST I on III (3)	9.0
LUBX38	>4	12.2	1.7	3.5	ST I on III (3)	10.0
LUBX39	>4	12.0	1.4	2.9	ST I on III (3)	9.0
LUBX40	>4	12.8	0.8	2.9	ST I on III (3)	9.0
LUBX41	>4	12.4	1.4	3.3	ST I on III (3)	9.7
LUBX42	>4	11.9	0.8	3.1	ST I on III (3)	9.7
MINIMUM	>4	9.2	0.7	1.1	ST I	3.7
MAXIMUM	>4	15.2	5.3	5.0	ST I on III	11.0
MEAN		12.0	1.6	2.8		7.7

Table 3.7-5. Grain Size Scales for Sediments

ASTM (Unified) Classification[1]	U.S. Std. Sieve[2]	Size in mm	Phi (Φ) Size	Wentworth Classification[3]
Boulder		4096.	-12.0	
		1024.	-10.0	Boulder
	12 in (300 mm)	256.	-8.0	
		128.	-7.0	Large Cobble
Cobble		107.64	-6.75	
		90.51	-6.5	Small Cobble
	3 in (75 mm)	76.11	-6.25	
		64.00	-6.0	
		53.82	-5.75	
		45.26	-5.5	Very Large Pebble
Coarse Gravel		38.05	-5.25	
		32.00	-5.0	
		26.91	-4.75	
		22.63	-4.5	
	3/4 in (19 mm)	19.03	-4.25	Large Pebble
		16.00	-4.0	
		13.45	-3.75	
		11.31	-3.5	
		9.51	-3.25	Medium Pebble
Fine Gravel	2.5	8.00	-3.0	
	3	6.73	-2.75	
	3.5	5.66	-2.5	
	4 (4.75 mm)	4.76	-2.25	Small Pebble
	5	4.00	-2.0	
	6	3.36	-1.75	
Coarse Sand	7	2.83	-1.5	
	8	2.38	-1.25	Granule
	10 (2.0 mm)	2.00	-1.0	
	12	1.68	-0.75	
	14	1.41	-0.5	
	16	1.19	-0.25	Very Coarse Sand
	18	1.00	0.0	
Medium Sand	20	0.84	0.25	
	25	0.71	0.5	
	30	0.59	0.75	
	35	0.50	1.0	Coarse Sand
	40 (0.425 mm)	0.420	1.25	
	45	0.354	1.5	
	50	0.297	1.75	
	60	0.250	2.0	Medium Sand
	70	0.210	2.25	
	80	0.177	2.5	
Fine Sand	100	0.149	2.75	
	120	0.125	3.0	Fine Sand
	140	0.105	3.25	
	170	0.088	3.5	
	200 (0.075 mm)	0.074	3.75	
	230	0.0625	4.0	Very Fine Sand
	270	0.0526	4.25	
Fine-grained Soil:	325	0.0442	4.5	
	400	0.0372	4.75	
		0.0312	5.0	
Clay if PI ³ 4 and plot of PI vs. LL is on or above "A" line*		0.0156	6.0	Coarse Silt
Silt if PI < 4 and plot of PI vs. LL is below "A" line*		0.0078	7.0	
		0.0039	8.0	
		0.00195	9.0	Medium Silt
		0.00098	10.0	Fine Silt
*and the presence of organic matter does not influence LL.		0.00049	11.0	Very Fine Silt
		0.00024	12.0	Coarse Clay
		0.00012	13.0	Medium Clay
		0.000061	14.0	Fine Clay

1. ASTM Standard D 2487-92. This is the ASTM version of the Unified Soil Classification System. Both systems are similar (from ASTM (1993)).
2. Note that British Standard, French, and German DIN mesh sizes and classifications are different.
3. Wentworth sizes (in inches) cited in Krumbein and Sloss (1963).

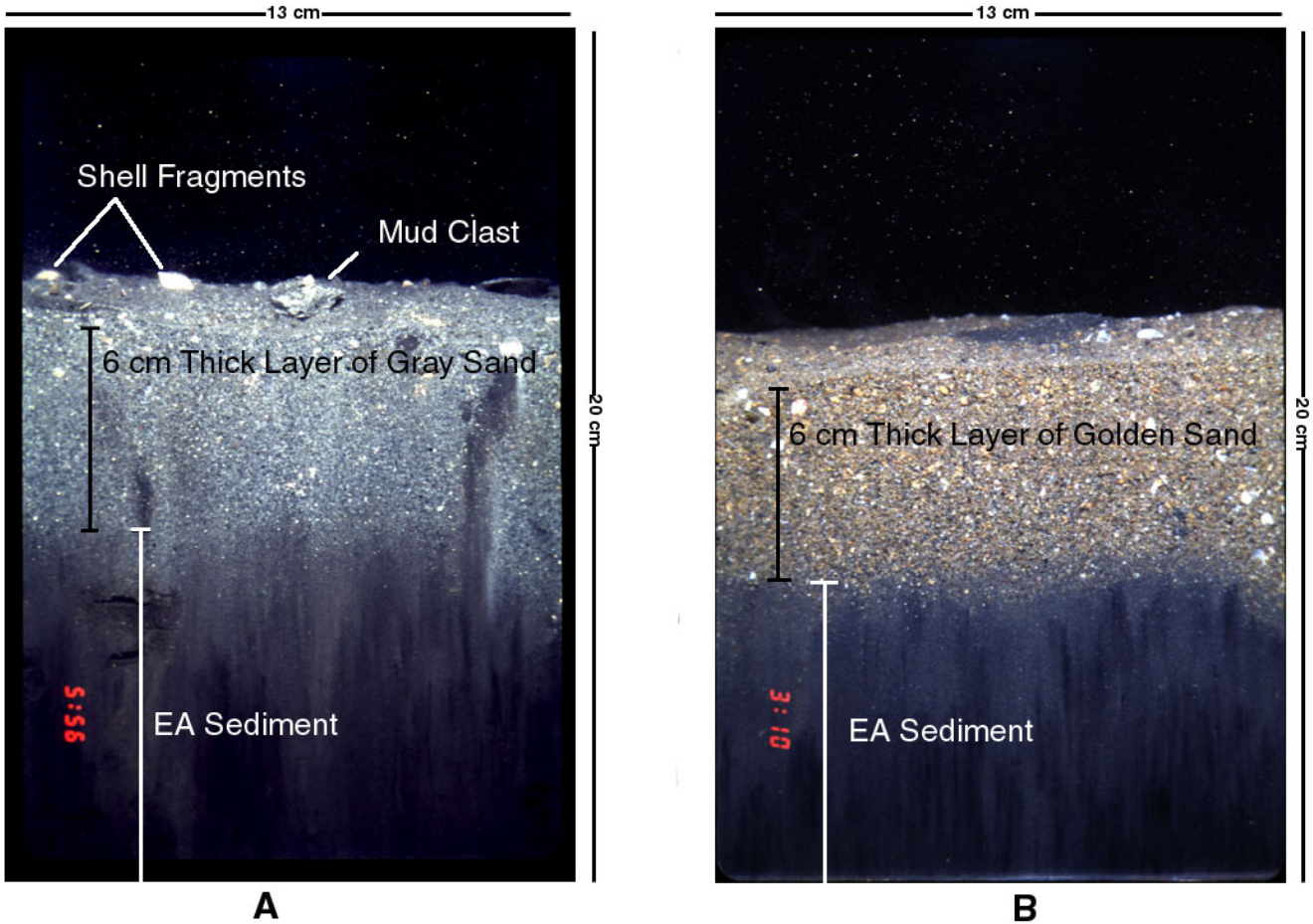


Figure 3.7-1. Two representative sediment profile images that illustrate clear distinctions between cap material and EA sediment. Image A shows a 6-cm thick depositional layer of cap material from Queen's Gate overlying fine-grained EA sediment at depth. The layer of Queen's Gate cap material is distinguished based on it gray color and the presence of shell fragments and cohesive mud clasts compared to the brown mud at depth. Image B shows a 6-cm thick depositional layer of cap material from A-III Borrow Area overlying fine-grained EA sediment at depth. In this case, the Borrow Area sand is clearly distinguished based on its golden color and coarser texture relative to the darker, underlying EA sediment.

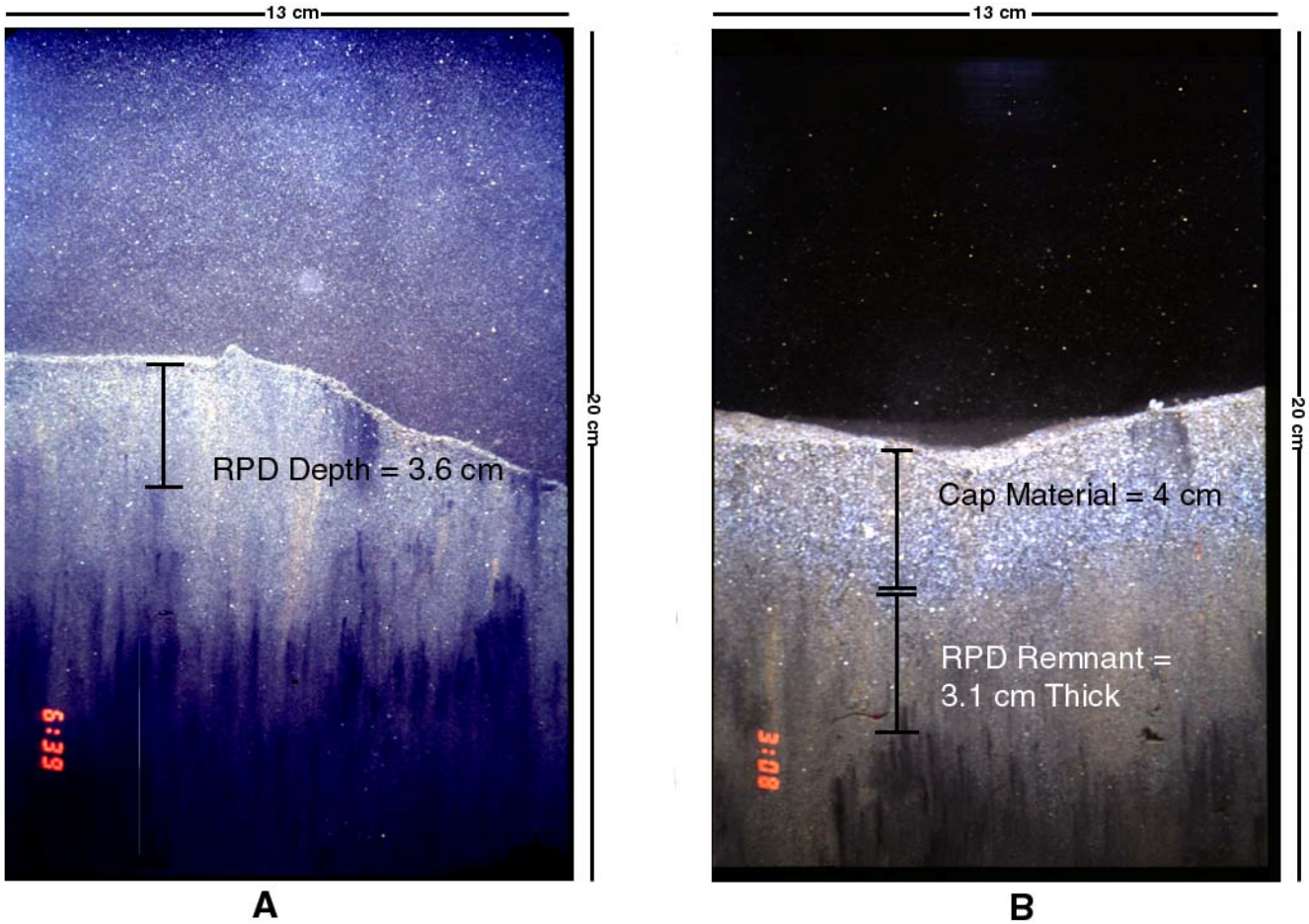


Figure 3.7-2. Two sediment profile images from Cell LU station I01 which illustrate how the RPD depth was used to estimate the depth to which EA sediment was removed as a result of cap material placement. Image A from the baseline survey shows the existing, fine-grained EA sediment with an RPD depth measuring 3.6 cm. In image B, the "remnant" bottom of the RPD is still visible underneath a surface depositional layer of cap material. The remnant of the RPD measures 3.1 cm in image B, compared to the former measurement of 3.6 cm in image A. This suggests that a 0.5 cm surface layer of EA sediment was removed as a result of the cap material placement.

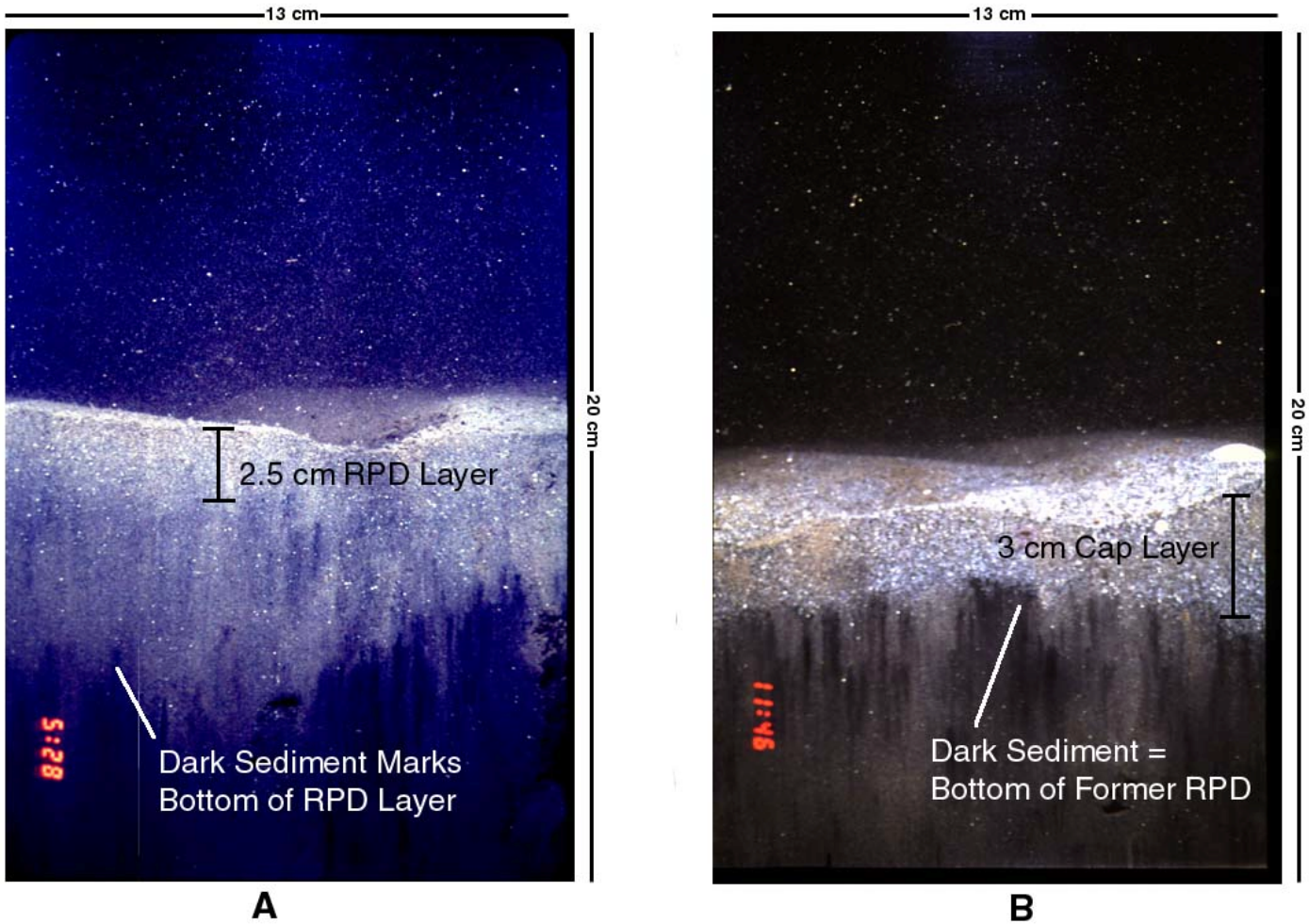


Figure 3.7-3. Two sediment profile images from Cell LU station I07, which illustrate how the RPD depth was used to estimate the depth of EA sediment removal as a result of cap material placement. Image A from the baseline survey shows the existing fine-grained EA sediment with an RPD depth measuring 2.5 cm. In image B from the Post-5 survey, it appears that the RPD has been removed, and a layer of cap material occurs over the darker-colored sediment that marked the bottom of the former RPD. In this case, the depth of disturbance of the EA sediment is estimated to be greater than 2.5 cm (i.e., the depth of the former RPD).

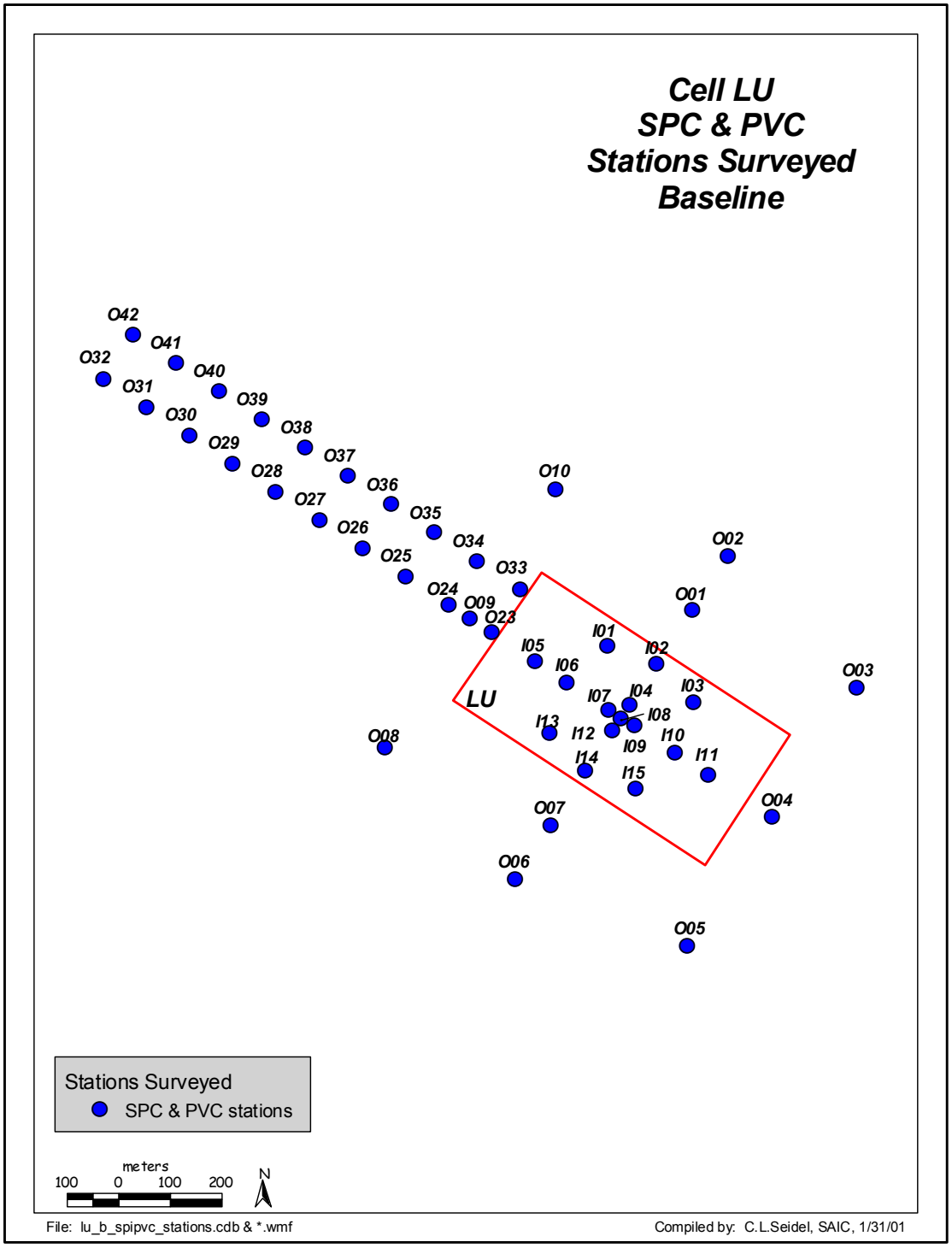


Figure 3.7-4. Station locations for the baseline SPC survey in Cell LU.

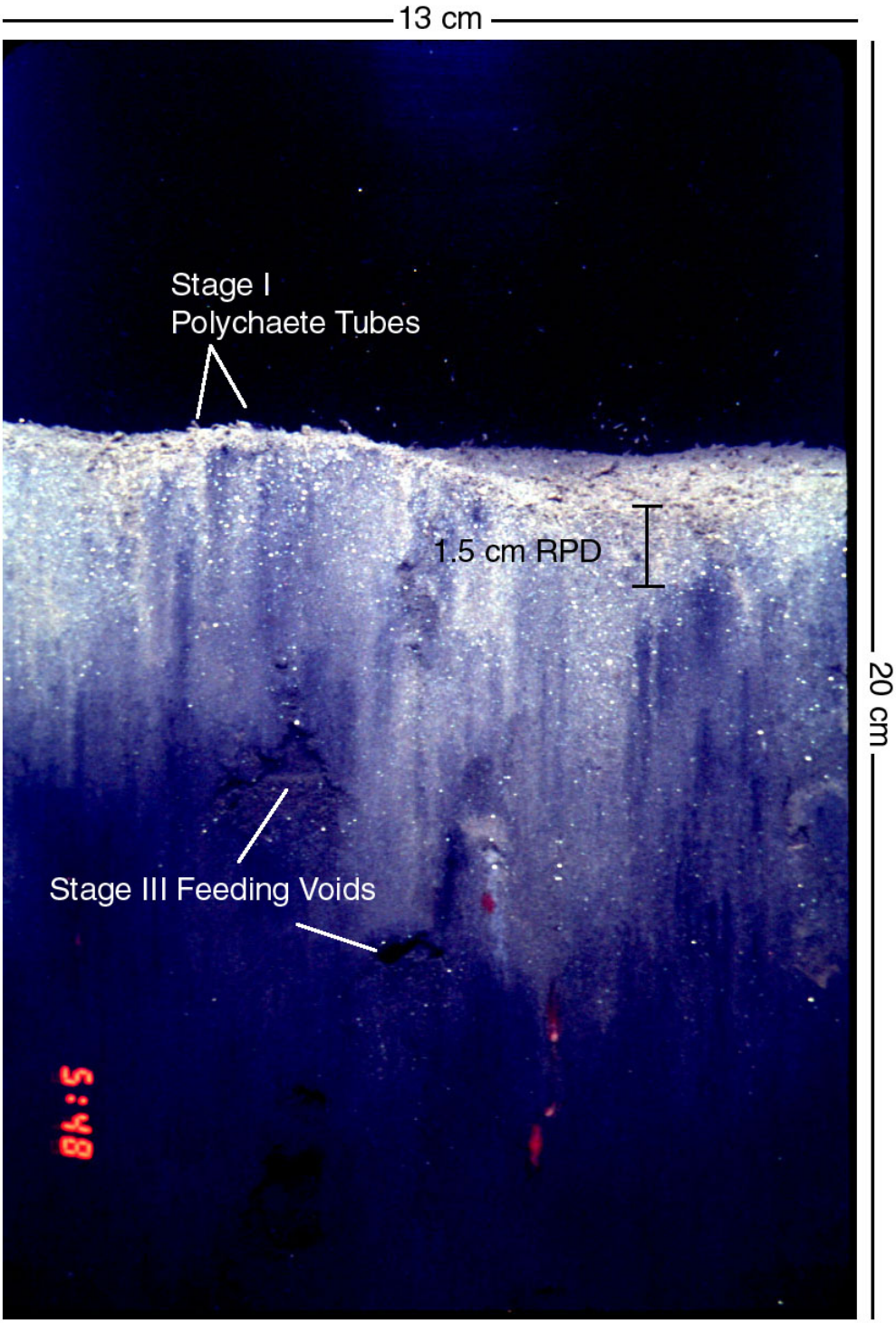


Figure 3.7-5. Sediment-profile image from Station O07 (image A) showing typical background seafloor conditions in and around Cell LU. The sediment is predominantly very fine sand mixed with silt-clay. The apparent RPD depth in this image is 1.5 cm. Stage I polychaete tubes are visible at the sediment surface, and several Stage III feeding voids occur at depth (Stage I on III).

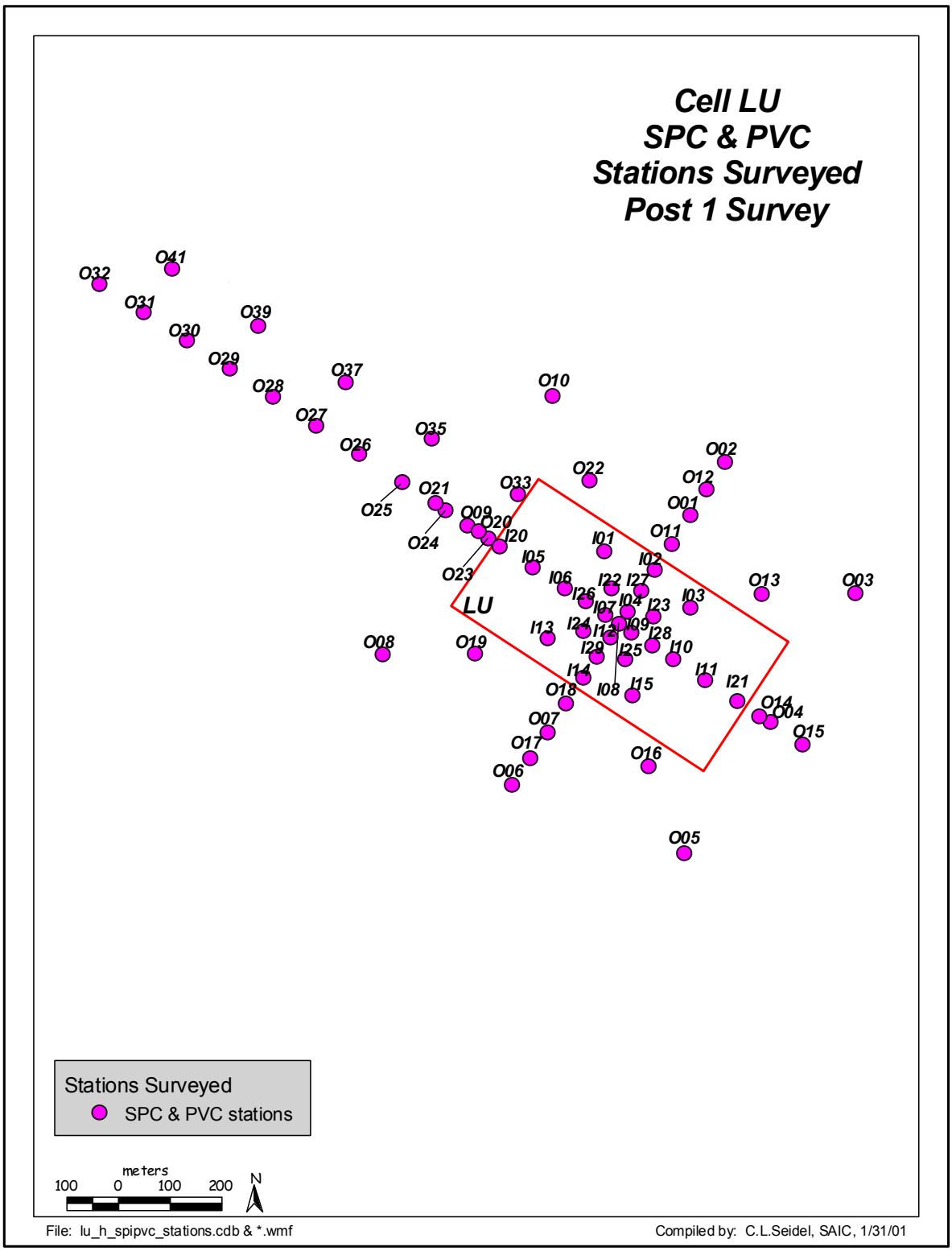


Figure 3.7-6. Station locations for the Post 1 SPC survey in Cell LU.

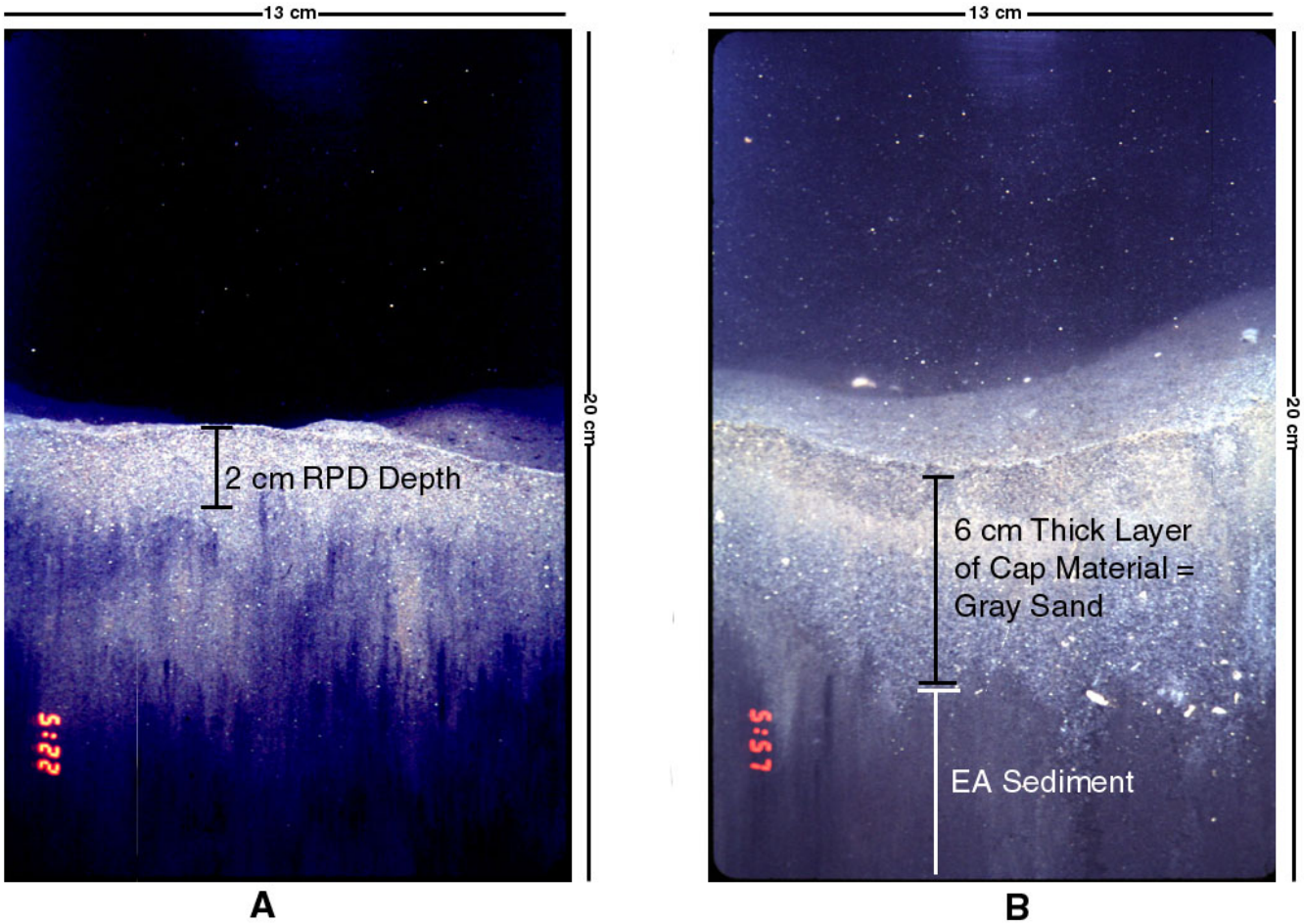


Figure 3.7-7. Two sediment-profile images from station I08 to illustrate the appearance of the cap material layer on the seafloor following the single hopper placement event in Cell LU. Image A from the baseline survey shows the existing fine-grained sediment prior to cap material placement, with an RPD depth of 2.0 cm. Image B from the Post-1 survey shows a distinct depositional layer of gray-colored, fine sand overlying the existing fine-grained sediment at depth. The point of contact between the cap material layer and underlying existing sediment is distinct. The light-colored, fine-grained sediment comprising the RPD in the left image has been replaced, in effect, by the depositional layer of capping sand at right.

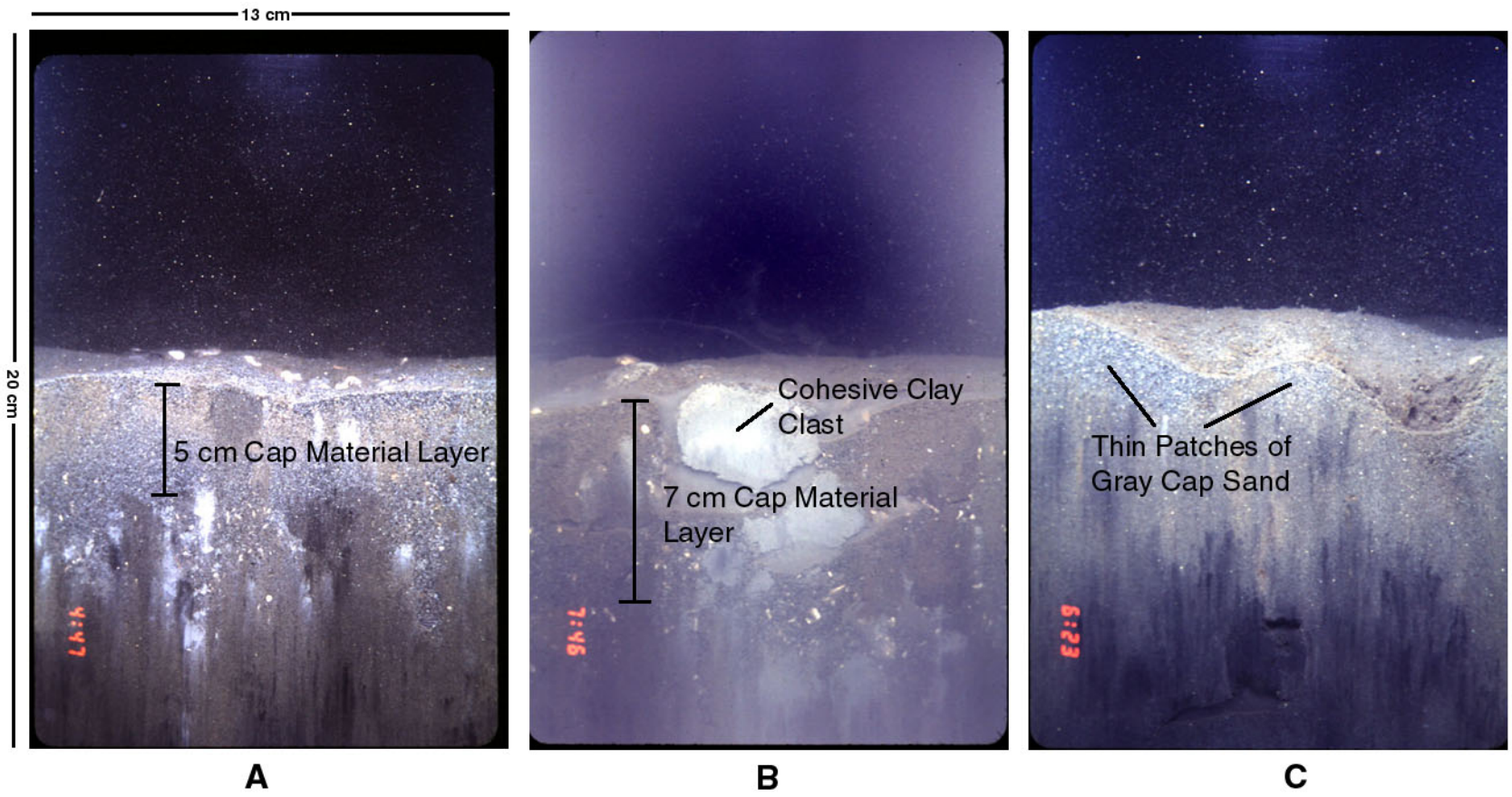


Figure 3.7-8. Sediment profile images from Cell LU Post-1 survey stations I-12 (image A), I-26 (image B), and I-05 (image C) illustrating variations in the appearance and thickness of the cap material layer. The gray sand comprising the cap material in image A is mixed with small white shell fragments; this layer has a thickness of 5.0 cm. The point of contact between the cap material layer and the underlying sediment is distinct (i.e., no visible mixing between the two). The distinct cap material layer in image B is 7.0 cm thick and also composed mostly of gray sand, mixed with several clasts of cohesive gray clay. The thin "patch" of cap material at the sediment surface in image C illustrates the ability of the sediment profile camera to resolve layers of this material less than 1 cm thick.

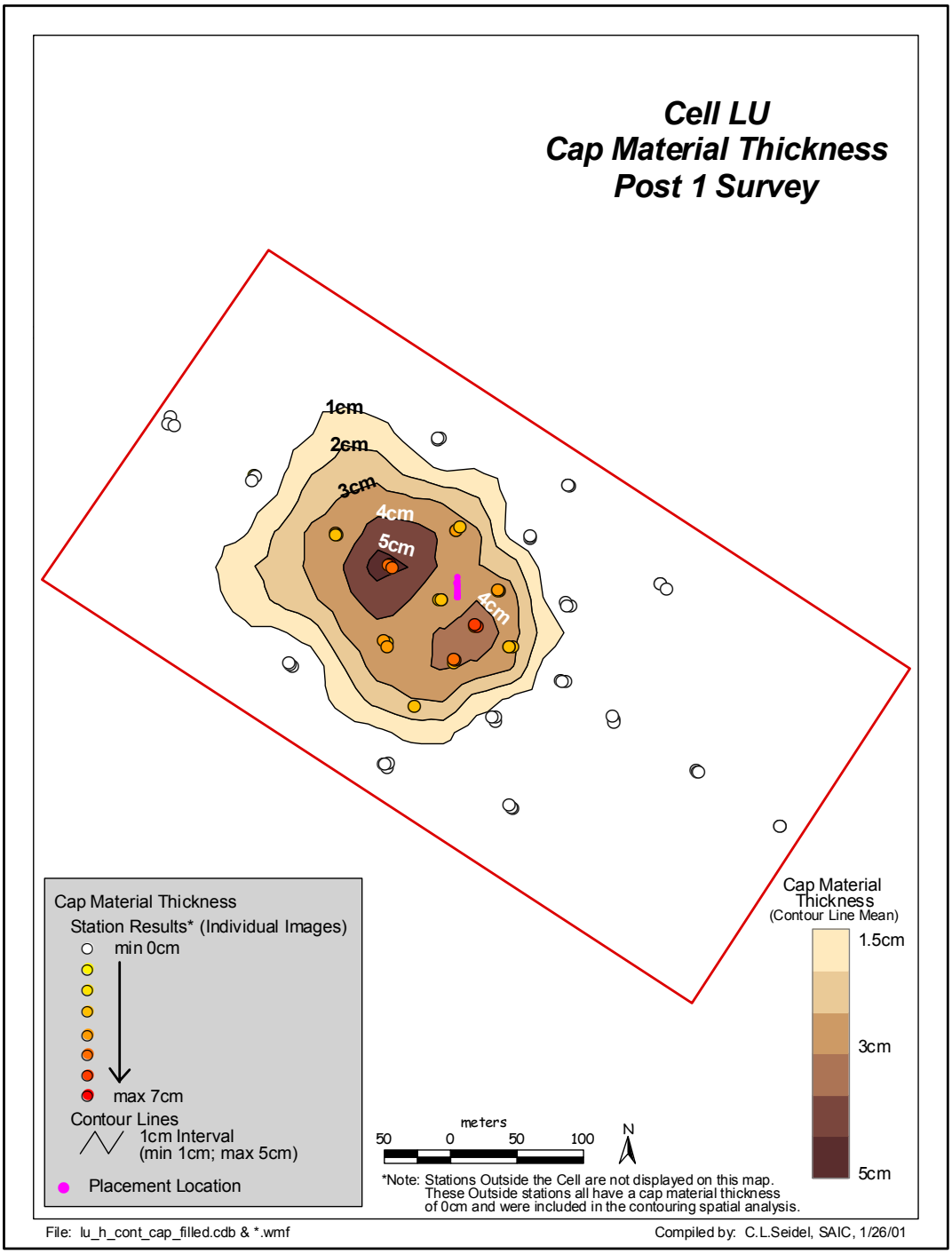


Figure 3.7-9. Placement location and thickness of cap material on the seafloor in Cell LU for the Post 1 SPC survey. Contour lines are based on the average measured thickness of the cap material layer at each station (mean of n = 3 replicate sediment profile images), while each plotted circle depicts the cap material thickness measurement for an individual replicate image.

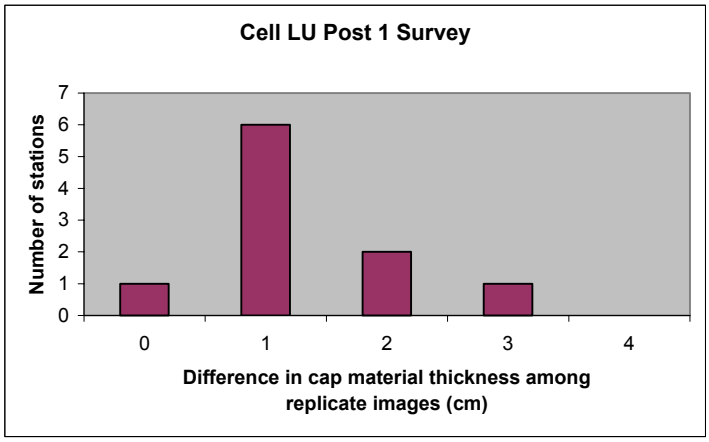


Figure 3.7-10. Frequency distribution of stations with a given maximum difference in cap material thickness among triplicate images, Cell LU Post 1 survey.

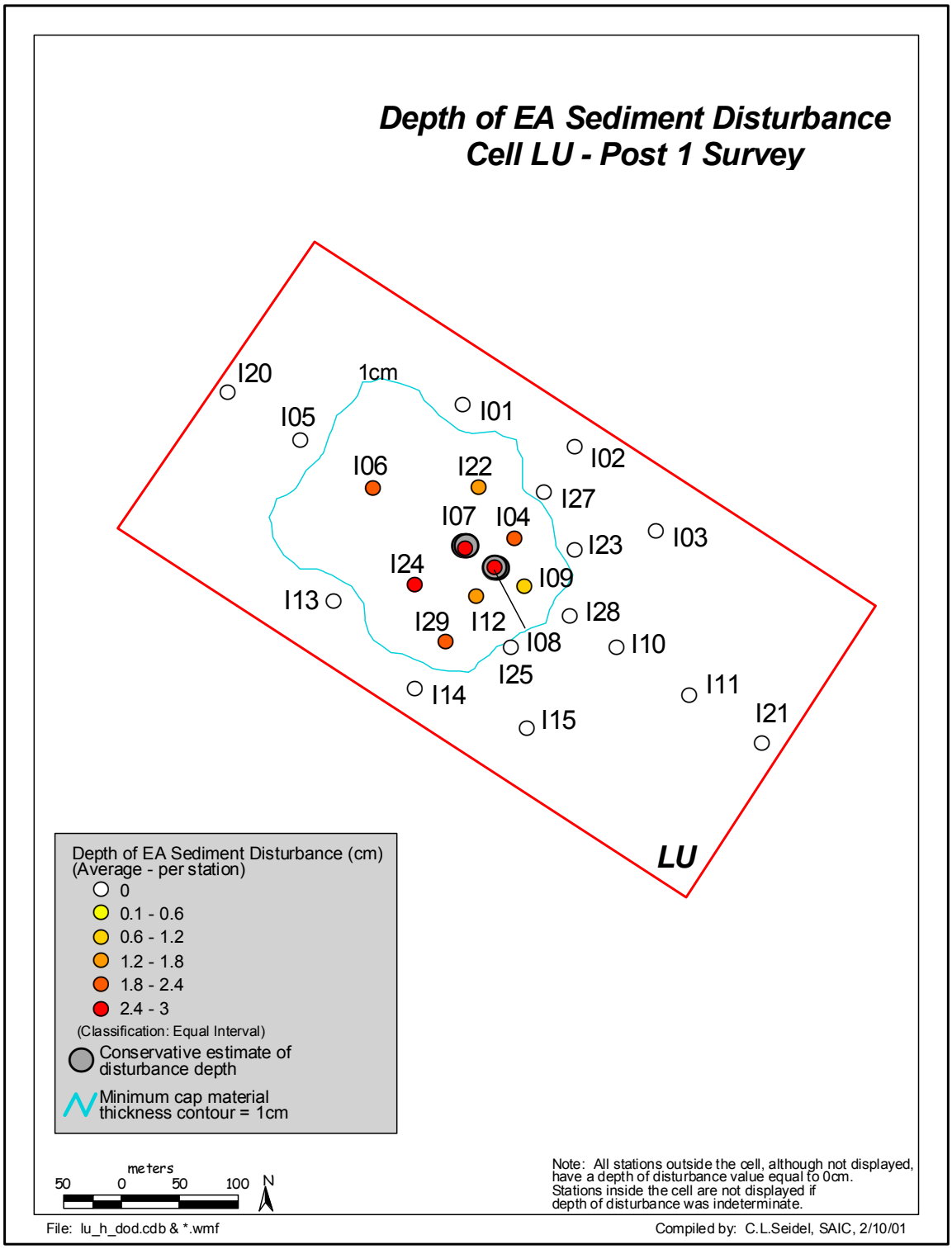


Figure 3.7-11. Estimated depth of disturbance of EA sediment (in cm) as a result of cap material placement for the Post 1 survey.

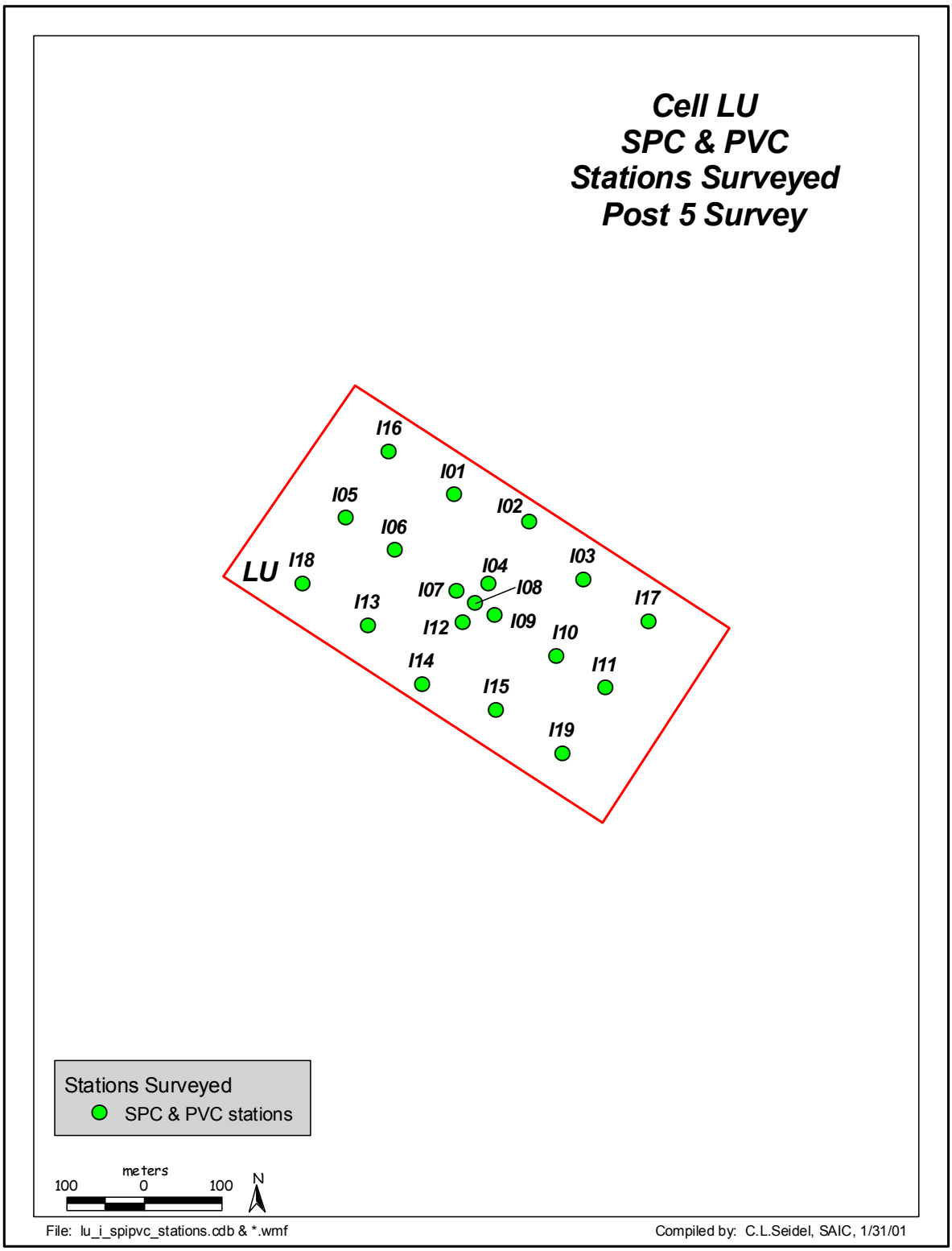


Figure 3.7-12. Station locations for the Post 5 SPC survey in Cell LU.

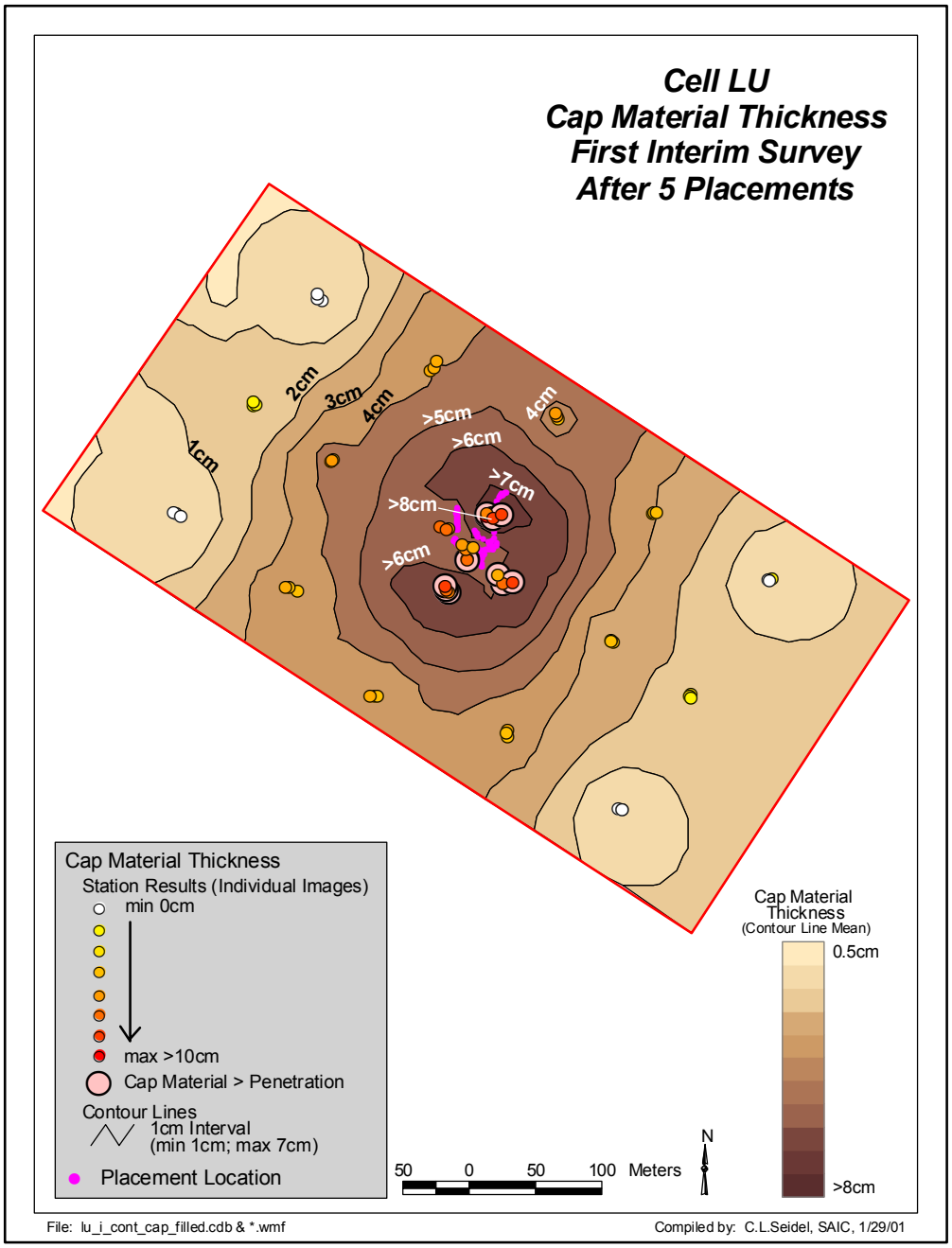


Figure 3.7-13. Placement locations and thickness of cap material on the seafloor in Cell LU for the Post 5 SPC survey. Contour lines are based on the average measured thickness of the cap material layer at each station (mean of n = 3 replicate sediment profile images), while each plotted circle depicts the cap material thickness measurement for an individual replicate image. Note that the cap material layer thickness exceeded the penetration depth of the sediment profile camera in a number of images near the center of the cell (cap material > penetration).

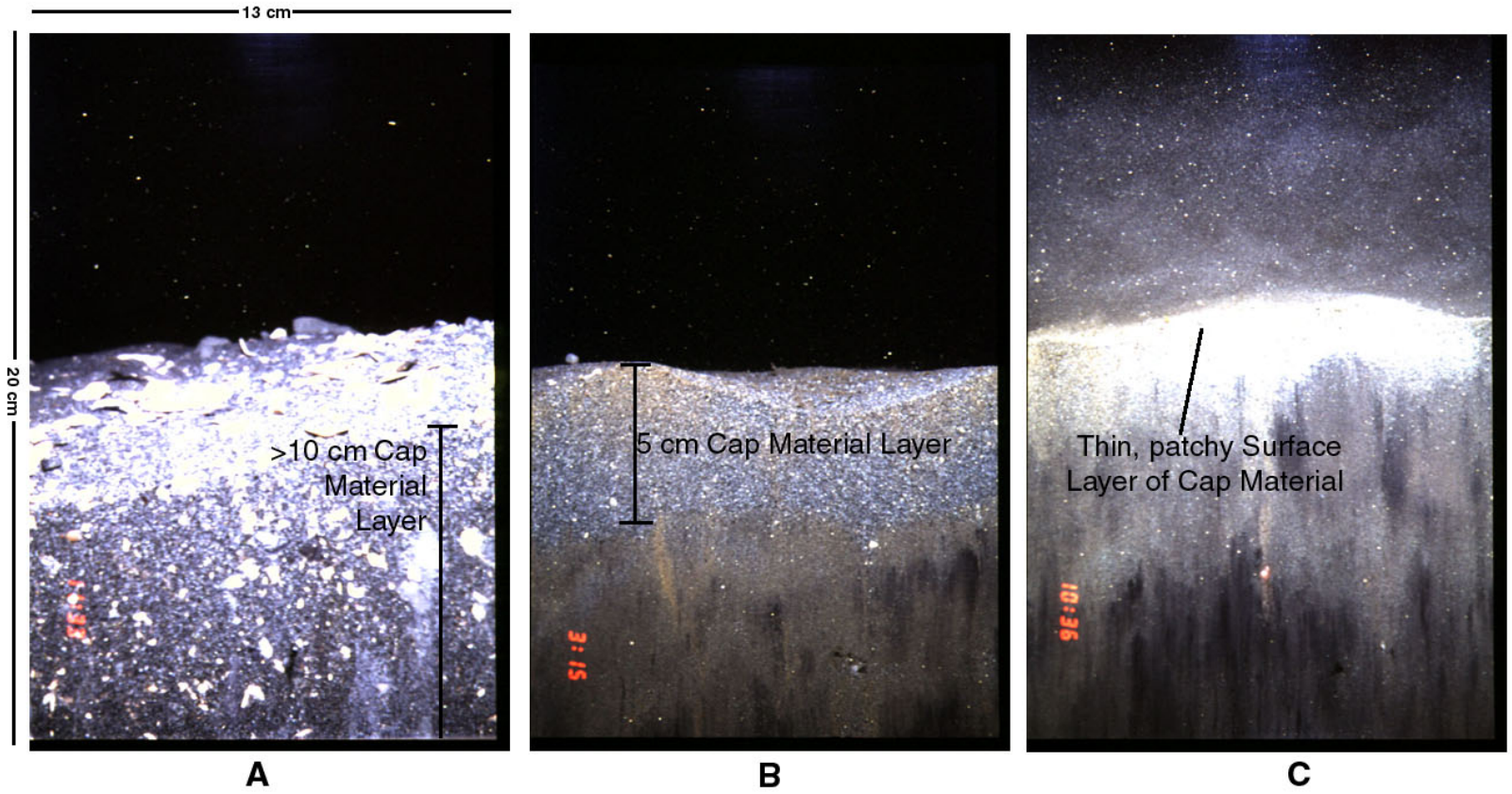


Figure 3.7-14. Sediment profile images from Stations I-04 (image A), I-02 (image B) and I-11 (image C) illustrating the varying thickness and appearance of the cap material layer in Cell LU during the Post-5 survey. Image A near the center of the deposit shows a layer of cap material composed of gray sand mixed with numerous shell fragments extending from the sediment-water interface to below the camera imaging depth (i.e., cap material thickness >10 cm). Image B shows a discrete surface depositional layer of gray cap sand (5 cm thick) over the background fine-grained sediment, while image C from the outer edge of the deposit shows only a patchy, thin (less than 1 cm thick) surface layer of gray cap sand over the existing background sediment.

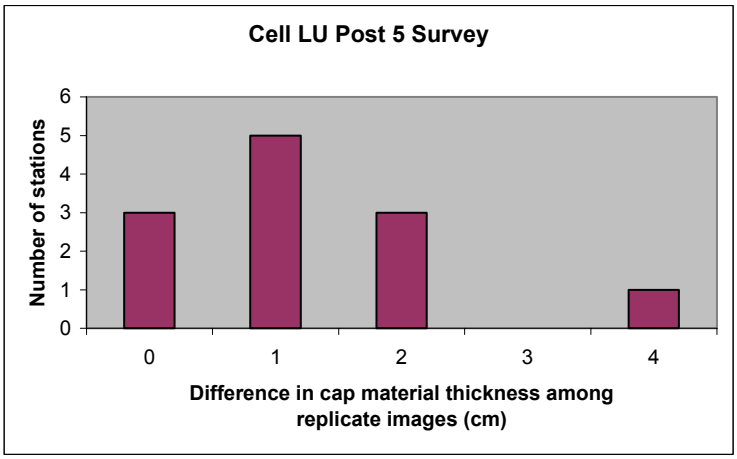


Figure 3.7-15. Frequency distribution of stations with a given maximum difference in cap material thickness among the triplicate images, Cell LU Post 5 survey.

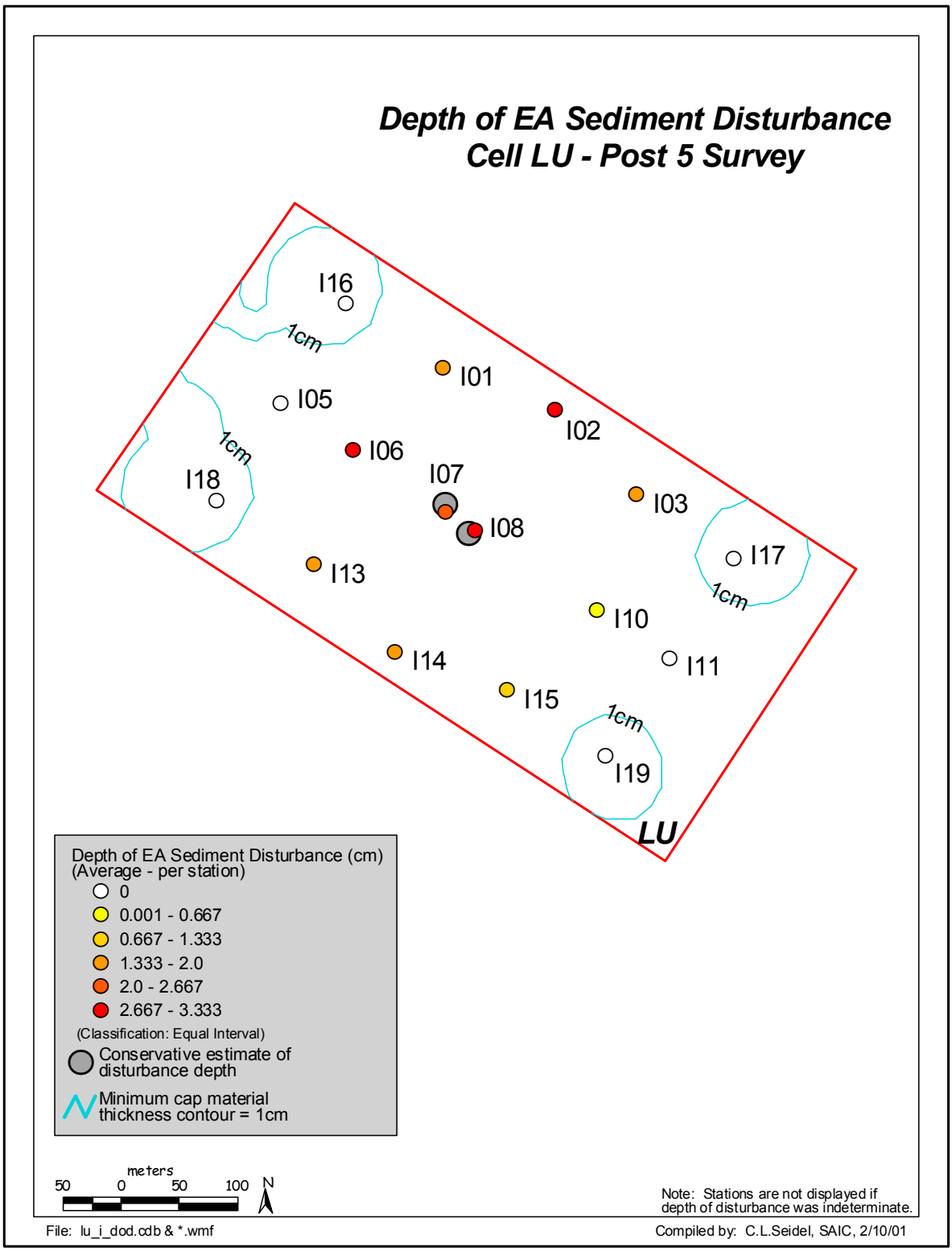


Figure 3.7-16. Estimated depths of disturbance of EA sediment (in cm) as a result of cap material placement for the Post 5 survey.

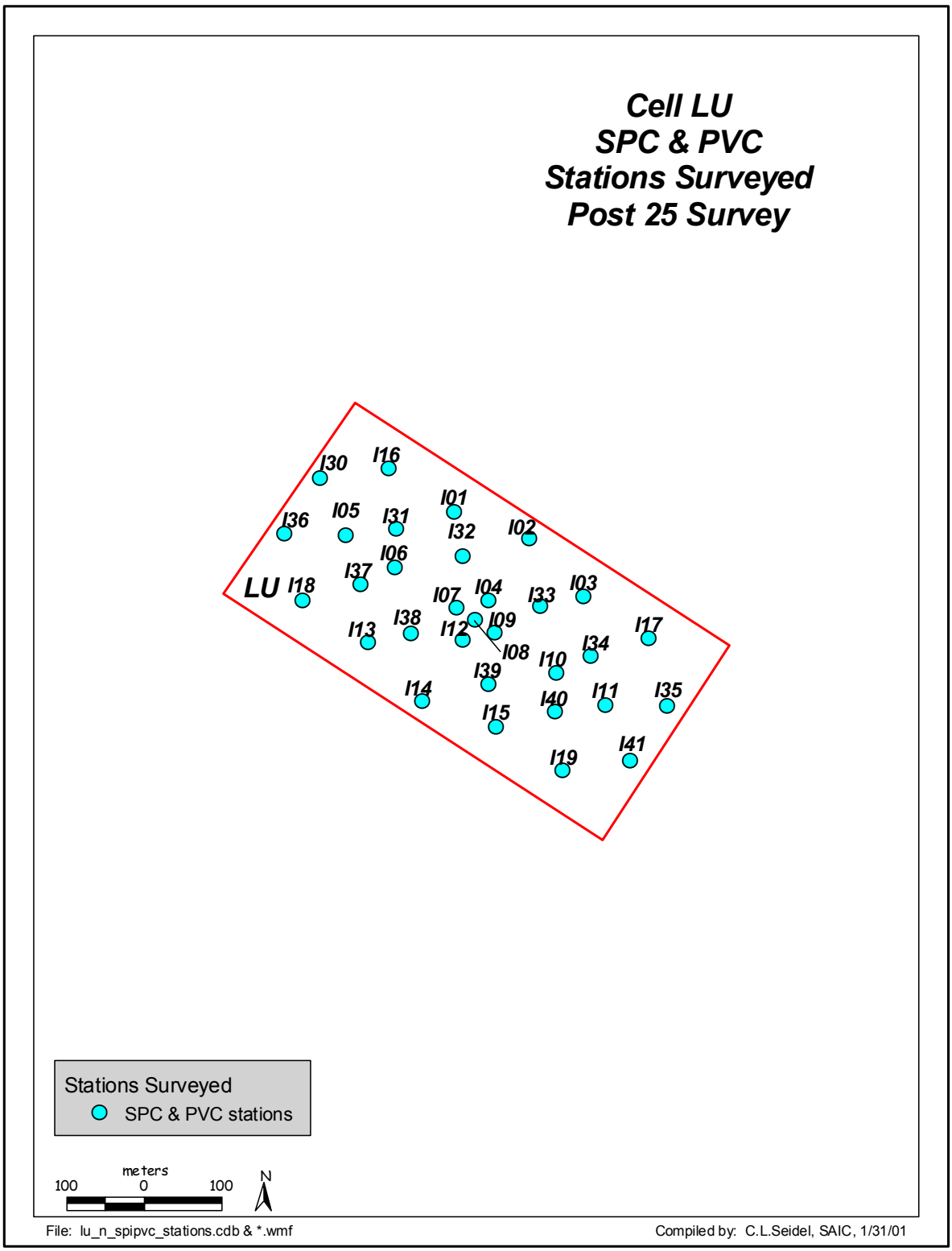


Figure 3.7-17. Station locations for the Post 25 SPC survey in Cell LU.

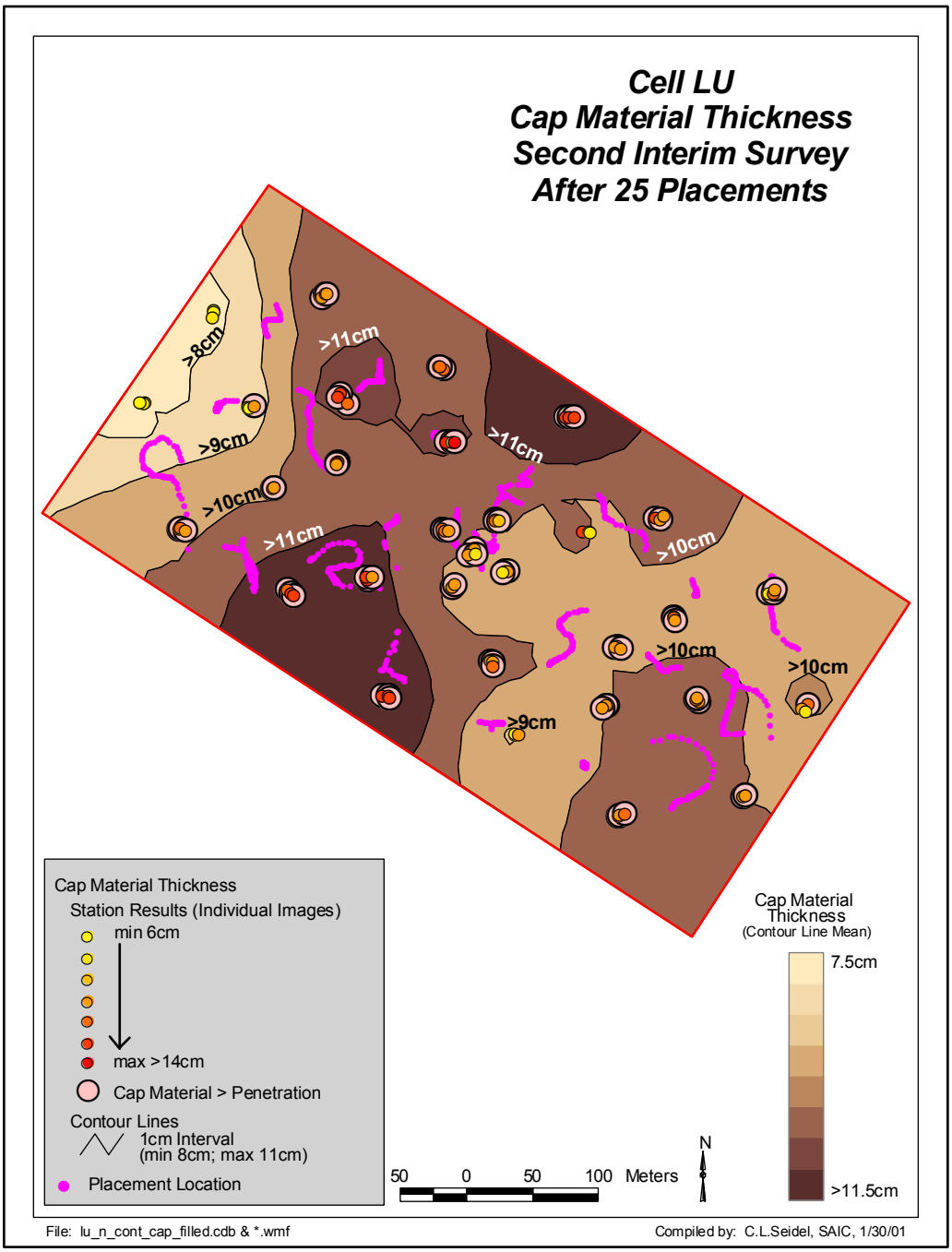


Figure 3.7-18. Placement locations and thickness of cap material on the seafloor in Cell LU for the Post 25 SPC survey. Contour lines are based on the average measured thickness of the cap material layer at each station (mean of n = 3 replicate sediment profile images), while each plotted circle depicts the cap material thickness measurement for an individual replicate image. Note that the cap material layer thickness exceeded the penetration depth of the sediment profile camera in the majority of images (cap material > penetration). Therefore, the contours suggesting differences in cap material thickness within the cell must be viewed with caution, as they are potentially misleading.

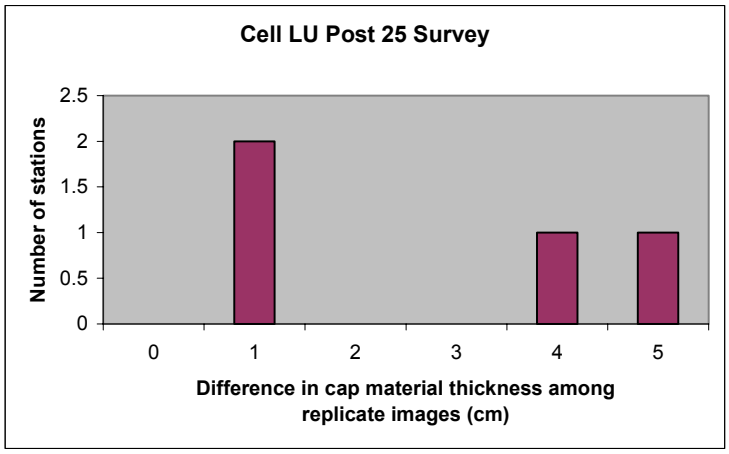


Figure 3.7-19. Frequency distribution of stations with a given maximum difference in cap material thickness among triplicate images, Cell LU Post 25 survey.

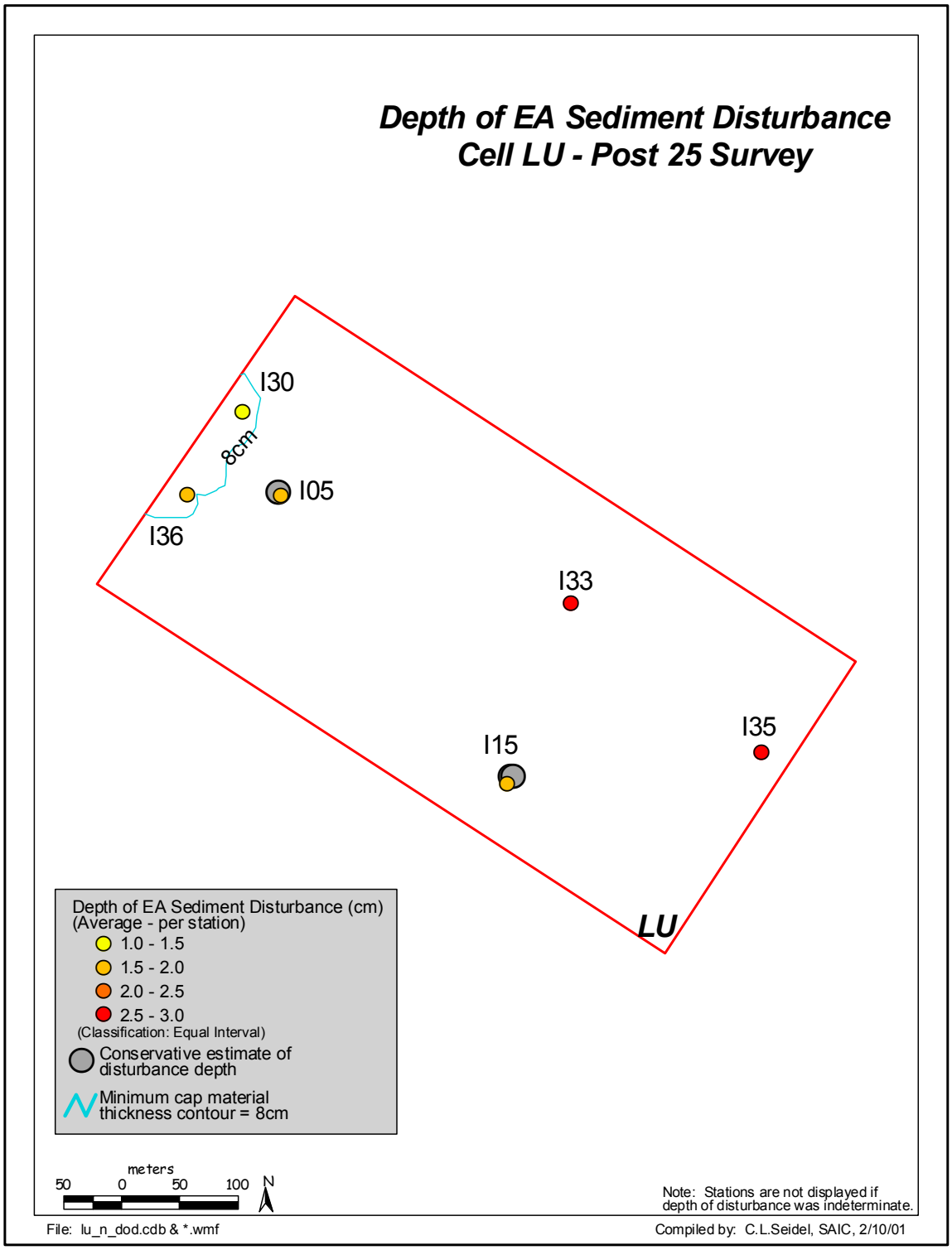


Figure 3.7-20. Estimated depth of disturbance of EA sediment (in cm) as a result of cap material placement for the Post 25 survey.

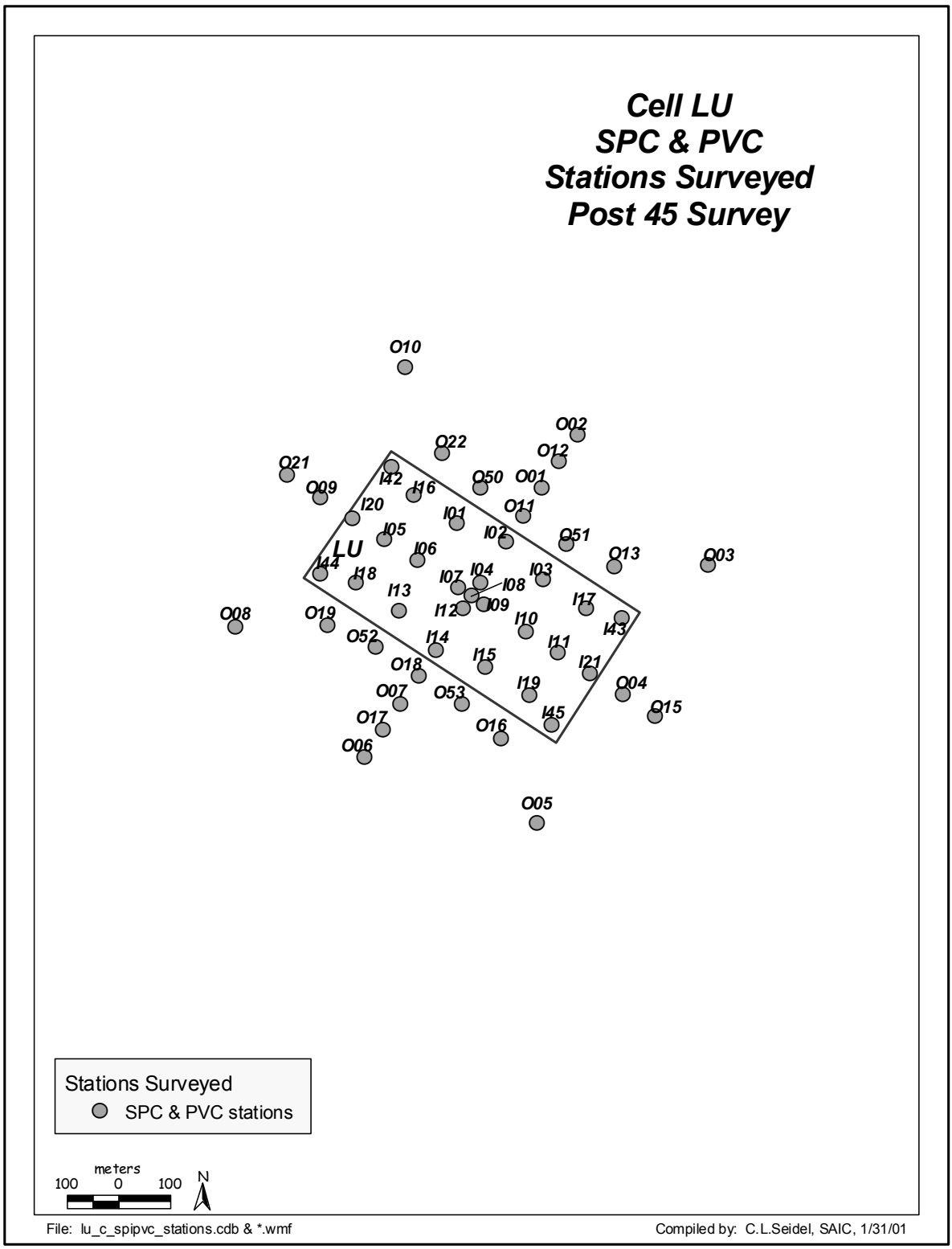


Figure 3.7-21. Station locations for the Post 45 SPC survey in Cell LU.

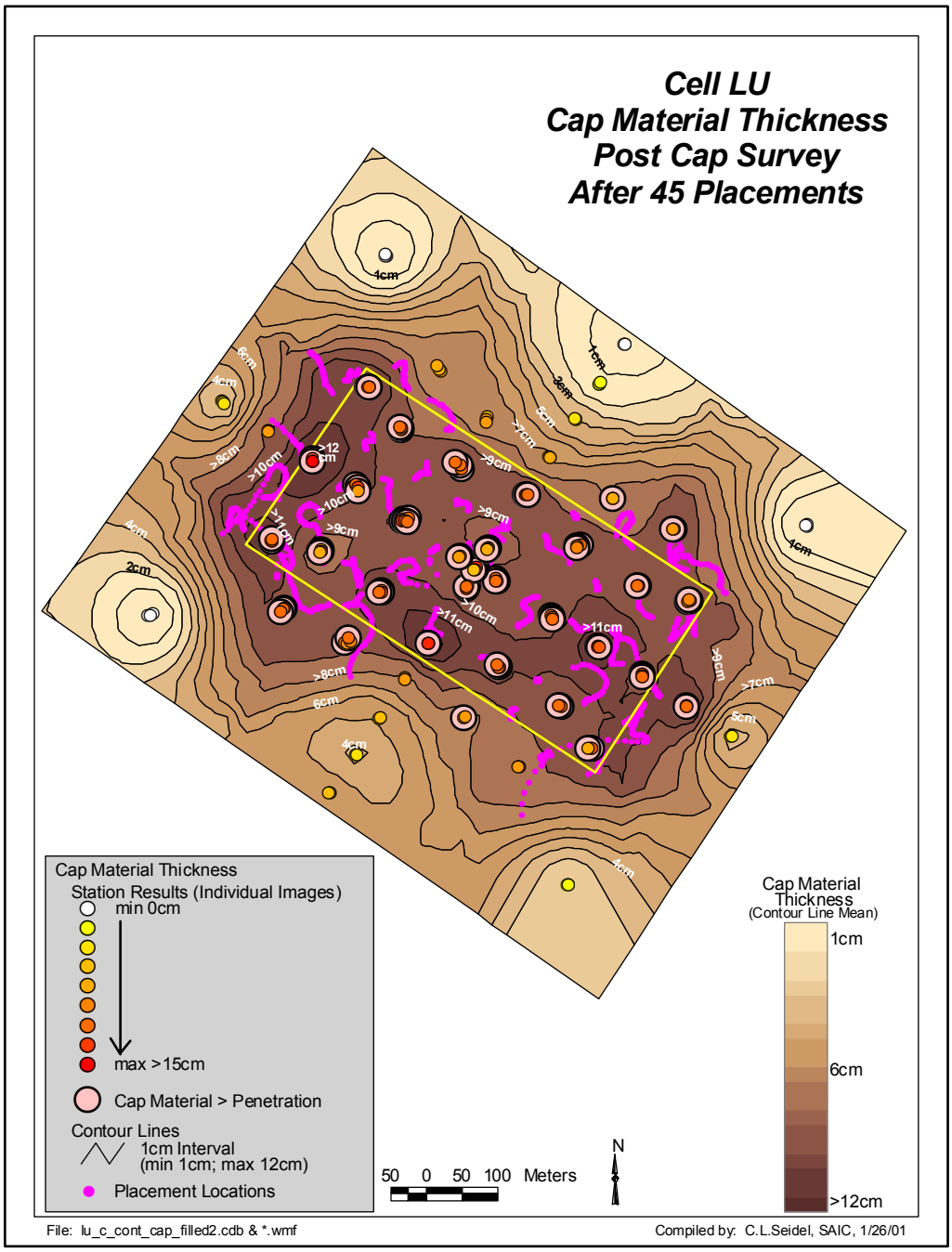


Figure 3.7-22. Placement locations and thickness of cap material on the seafloor in Cell LU for the Post 45 SPC survey. Contour lines are based on the average measured thickness of the cap material layer at each station (mean of n = 3 replicate sediment profile images), while each plotted circle depicts the cap material thickness measurement for an individual replicate image. Note that the cap material layer thickness exceeded the penetration depth of the sediment profile camera in the majority of images (cap material > penetration).

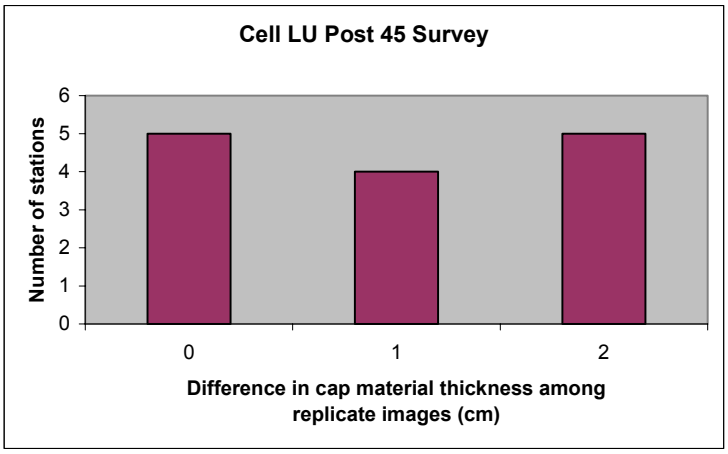


Figure 3.7-23. Frequency distribution of stations with a given maximum difference in cap material thickness among triplicate images, Cell LU Post 45 survey.

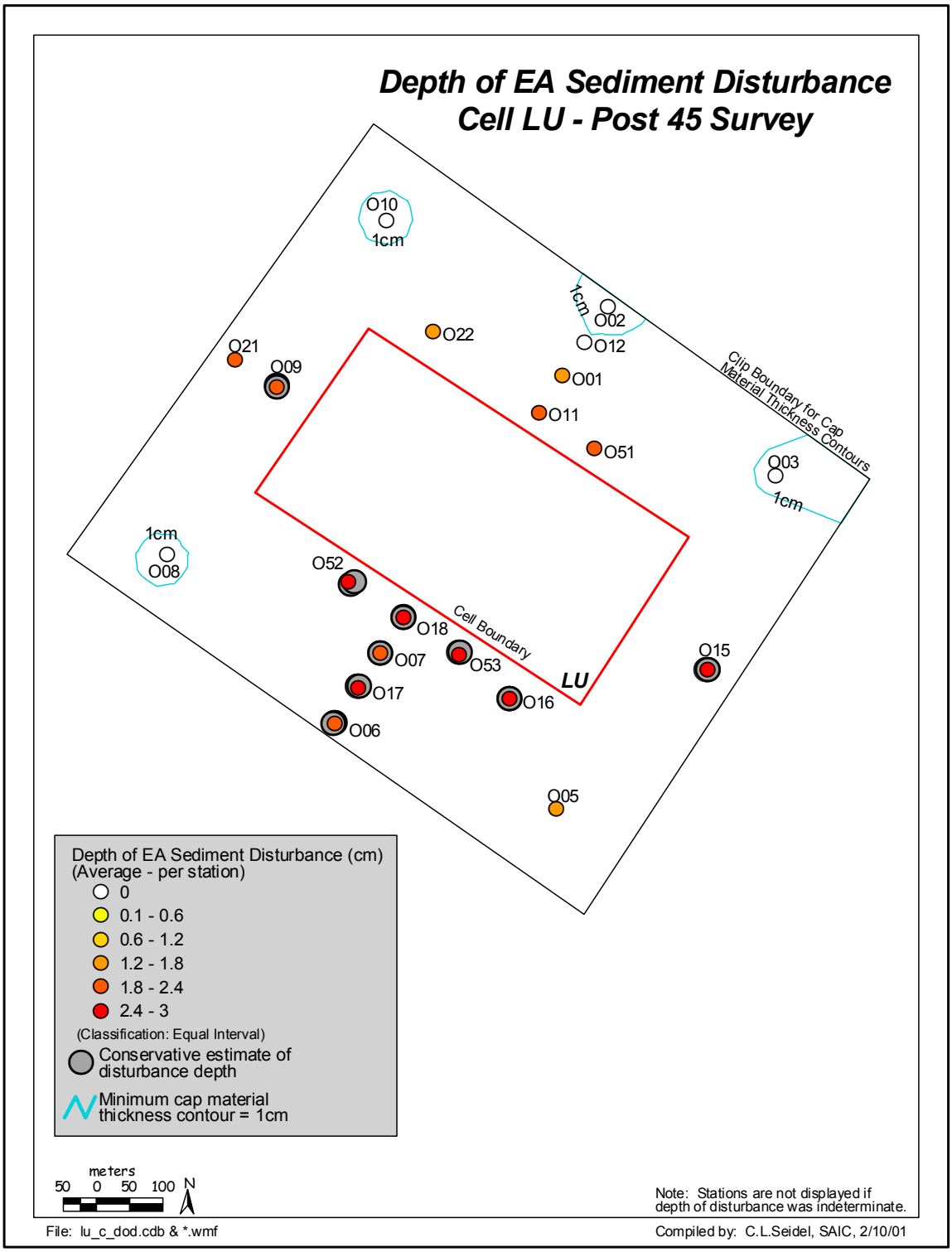


Figure 3.7-24. Estimated depth of disturbance of EA sediment (in cm) as a result of cap material placement for the Post 45 survey.

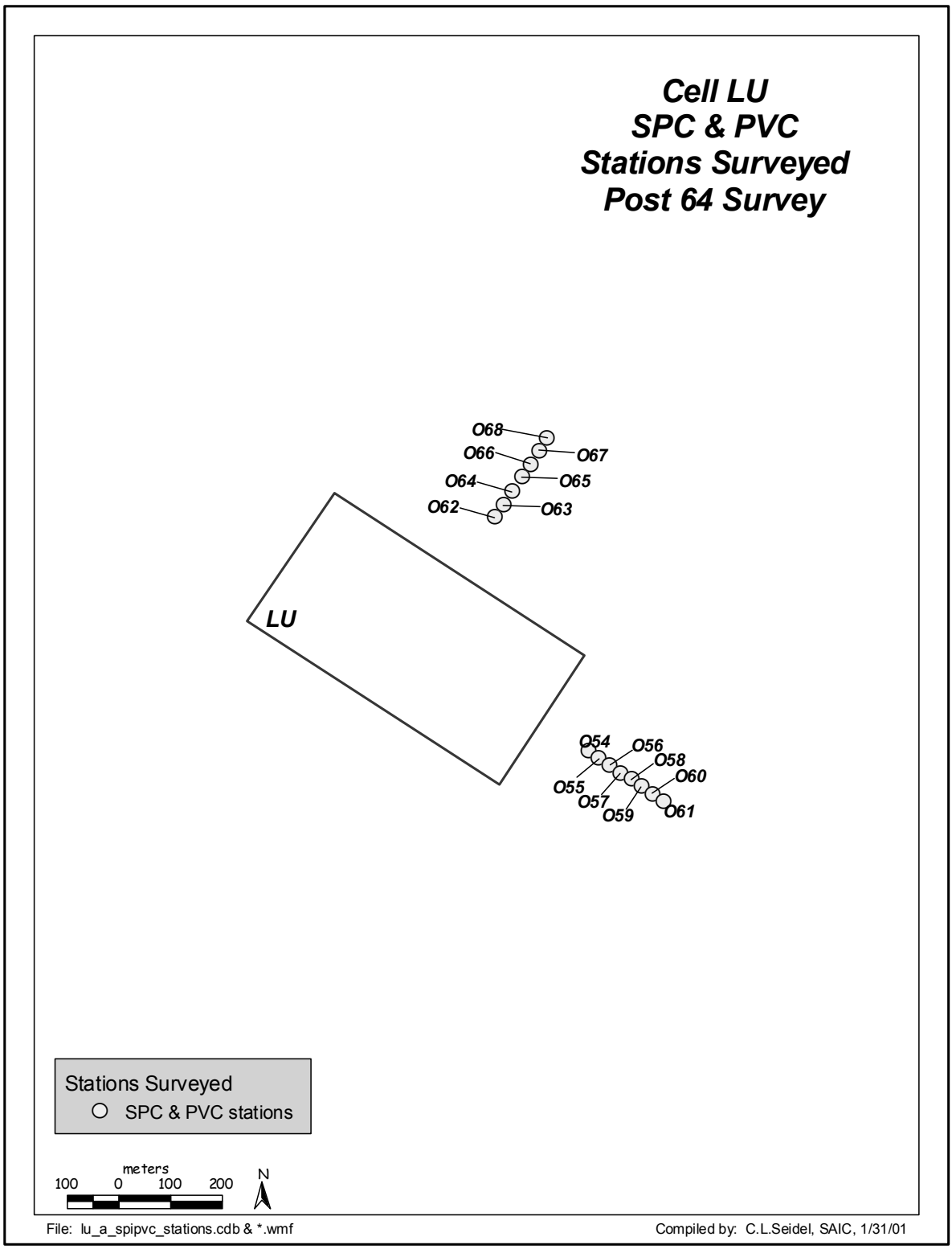


Figure 3.7-25. Station locations for the Post 64 SPC survey in Cell LU.

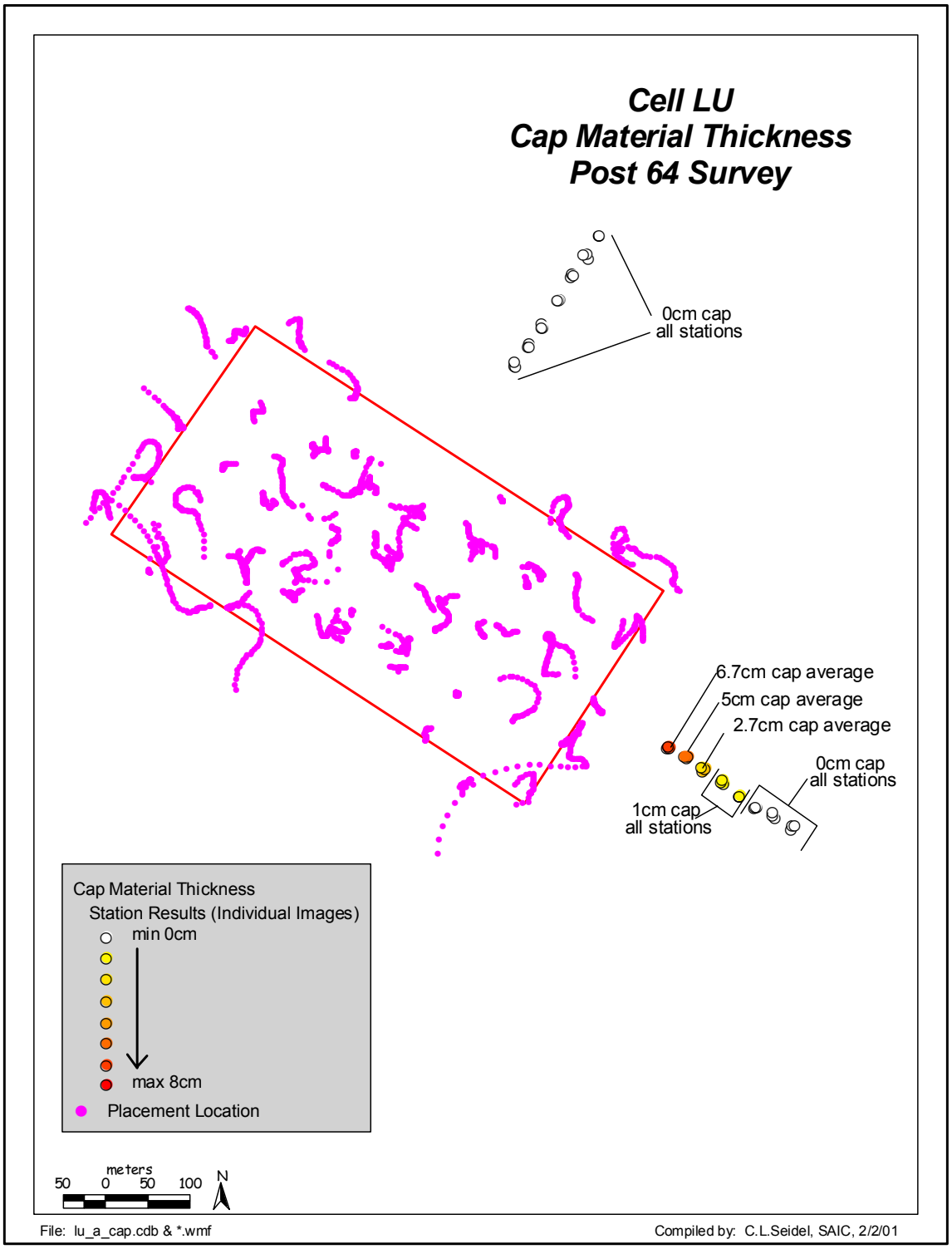


Figure 3.7-26. Placement locations and cap material thickness on the two transects occupied in the Post 64 SPC survey in Cell LU.

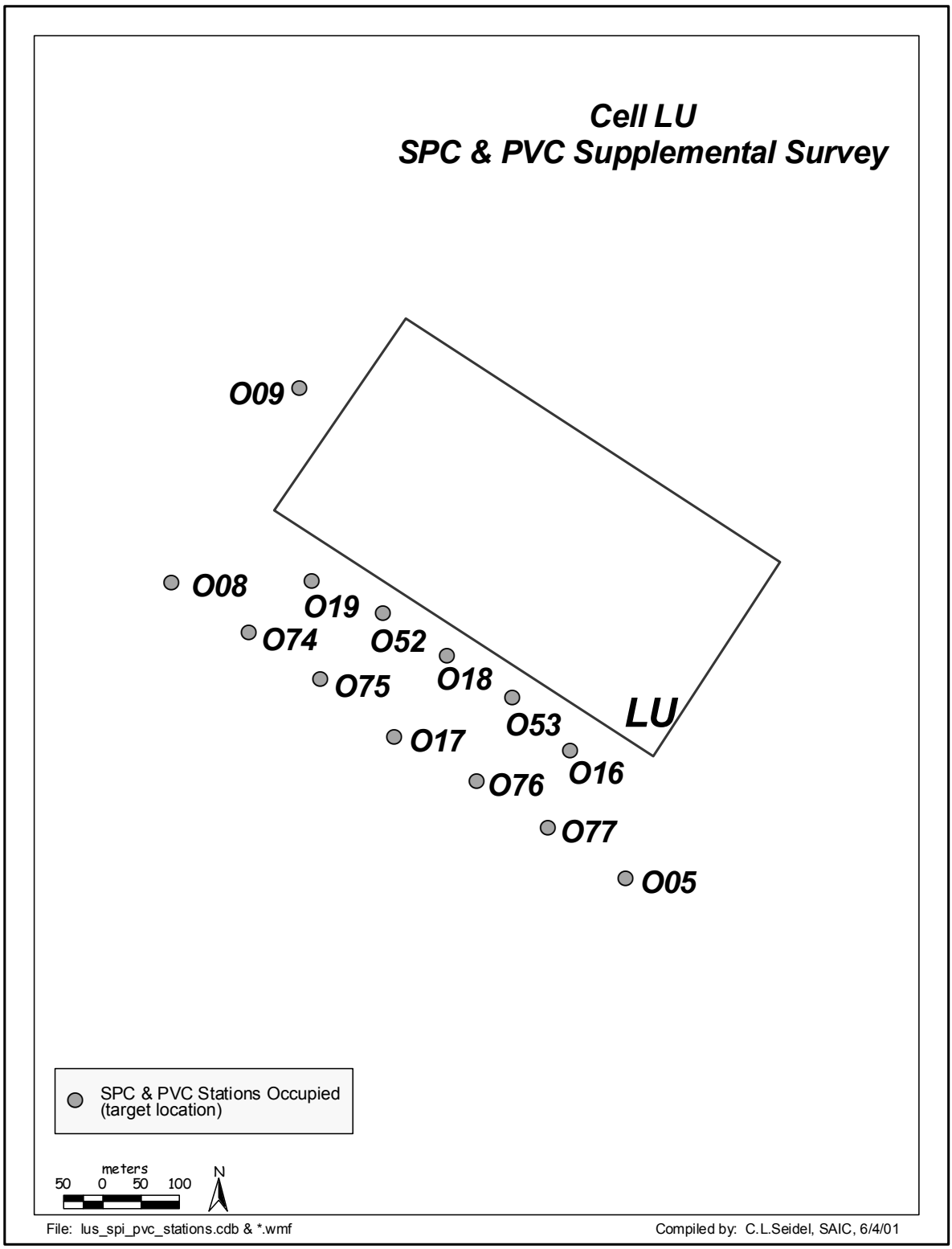


Figure 3.7-27. Station locations for the February 2001 Supplemental SPC survey in Cell LU.

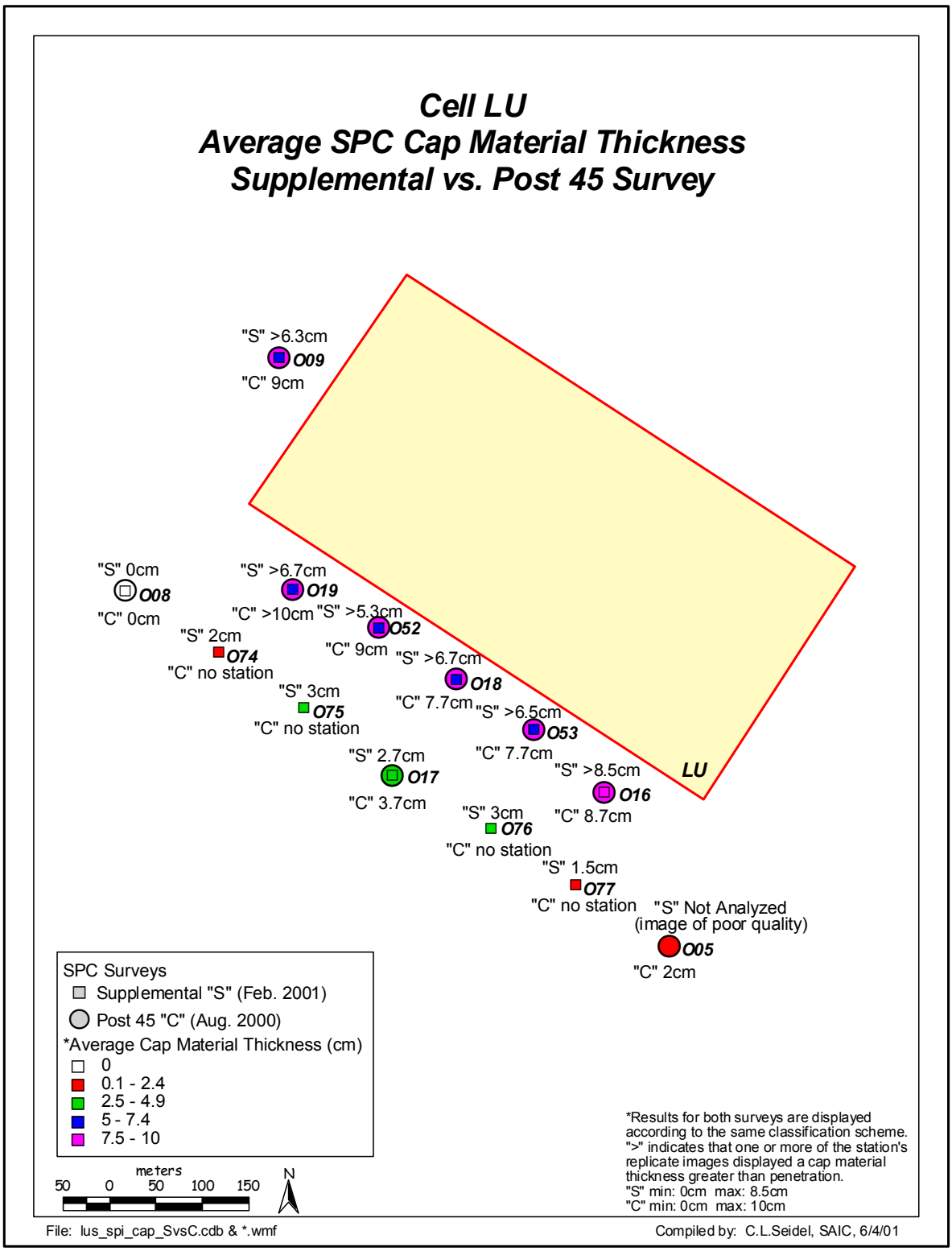


Figure 3.7-28. Average thickness of the cap material layer observed at each station in the Post-45 survey of September 2000 versus the supplemental survey of February 2001.

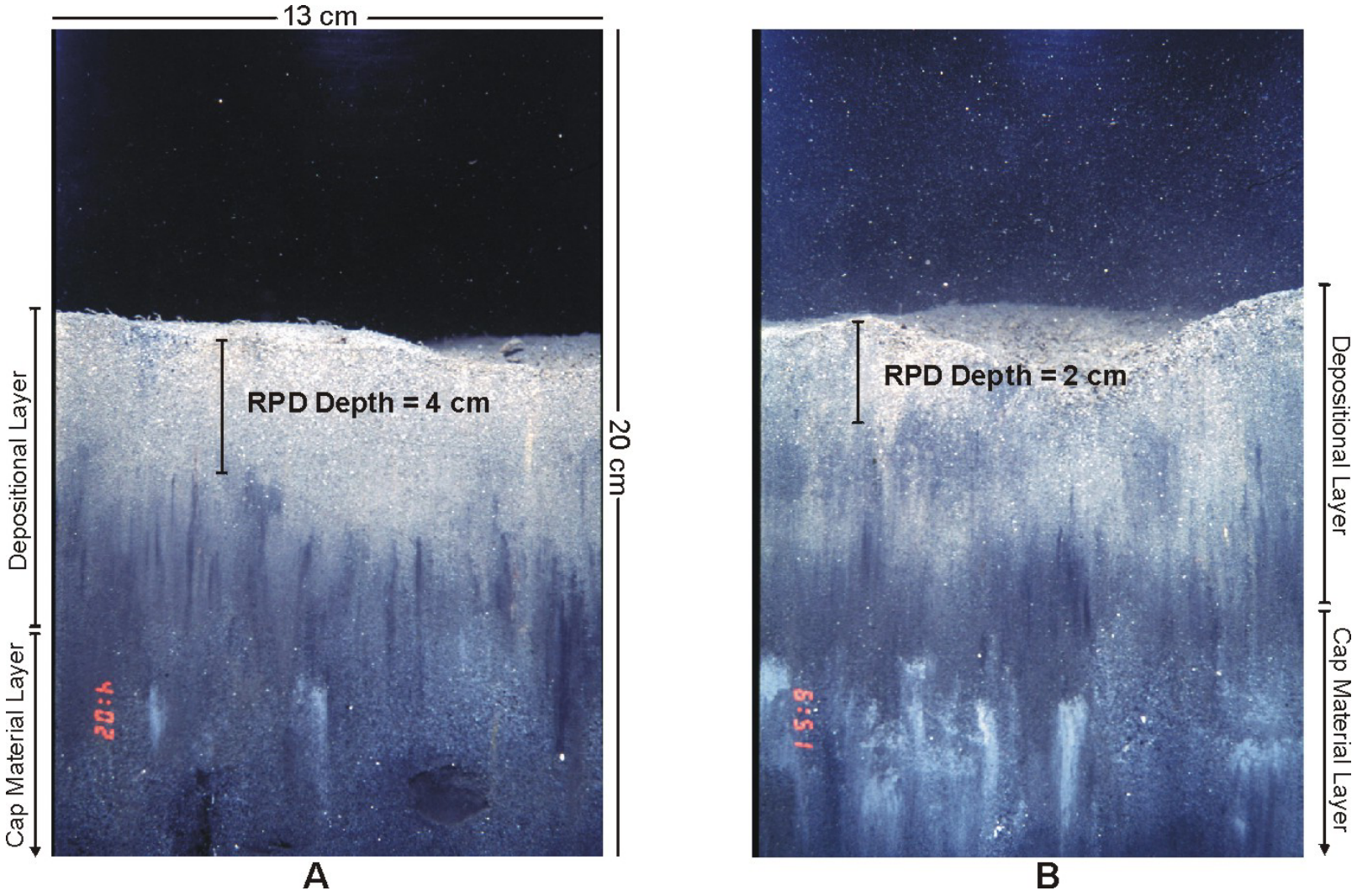


Figure 3.7-29. Sediment profile images obtained during the February 2001 supplemental survey at stations O09 (image A) and O16 (image B). Both images show a layer of cap material at depth (grey sand mixed with grey cohesive mud clasts), which extends below the imaging depth of the sediment profile camera. A new surface depositional layer of brown, fine-grained sediment having a visible RPD overlies the cap material layer in both images.

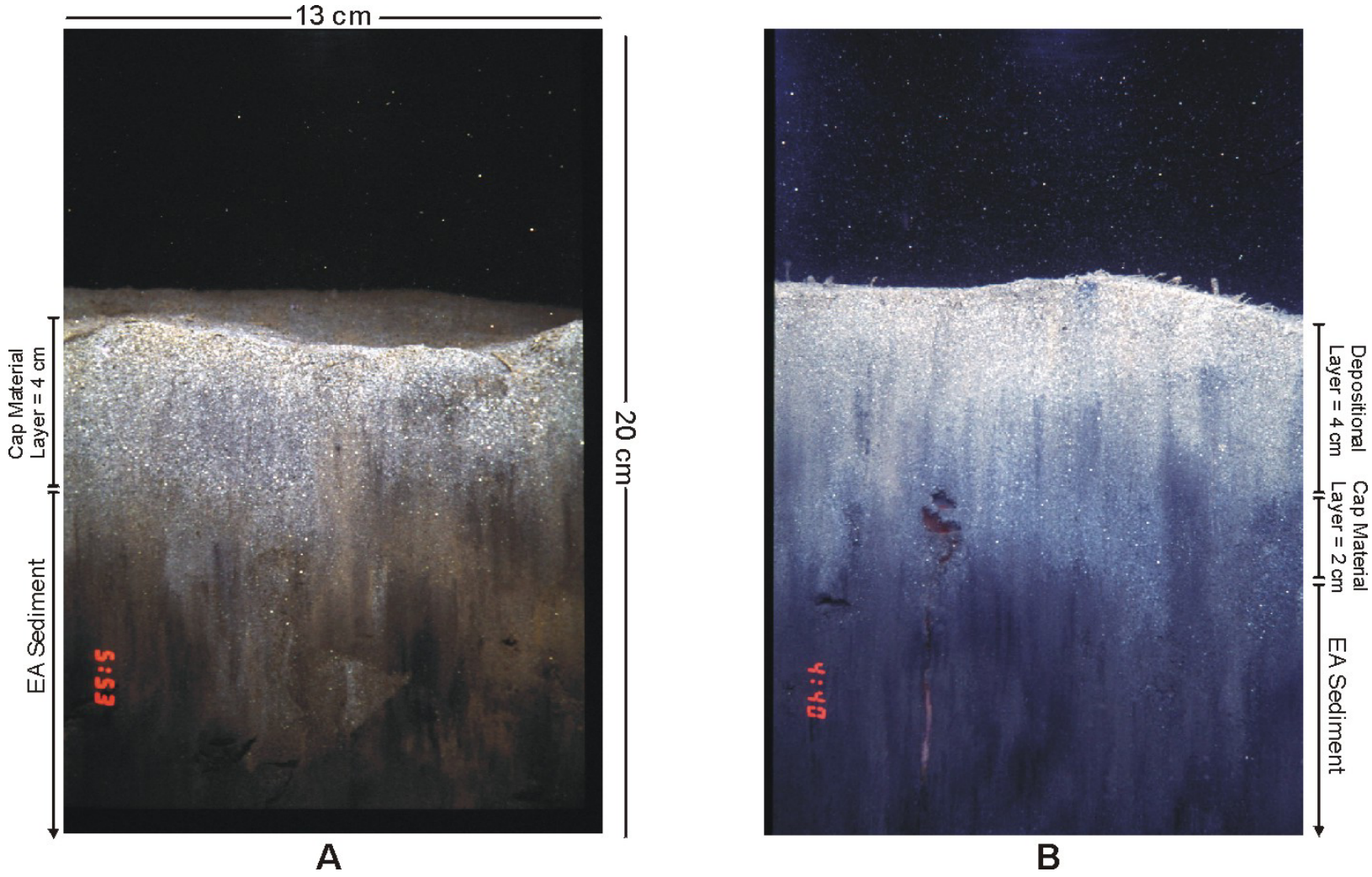


Figure 3.7-30. Sediment profile images obtained at station O17 in the Post-45 survey of September 2000 (image A) and the supplemental survey of February 2001 (image B). Image A shows a 4-cm thick surface layer of grey sand (cap material from Queen's Gate channel) overlying EA sediment. In image B, the cap material layer is still visible as a faint horizon of grey sand at depth, with an overlying surface layer of brown, fine-grained sediment. The thickness of the buried cap material layer in image B is 2 cm, while the new surface depositional layer is 4 cm thick.

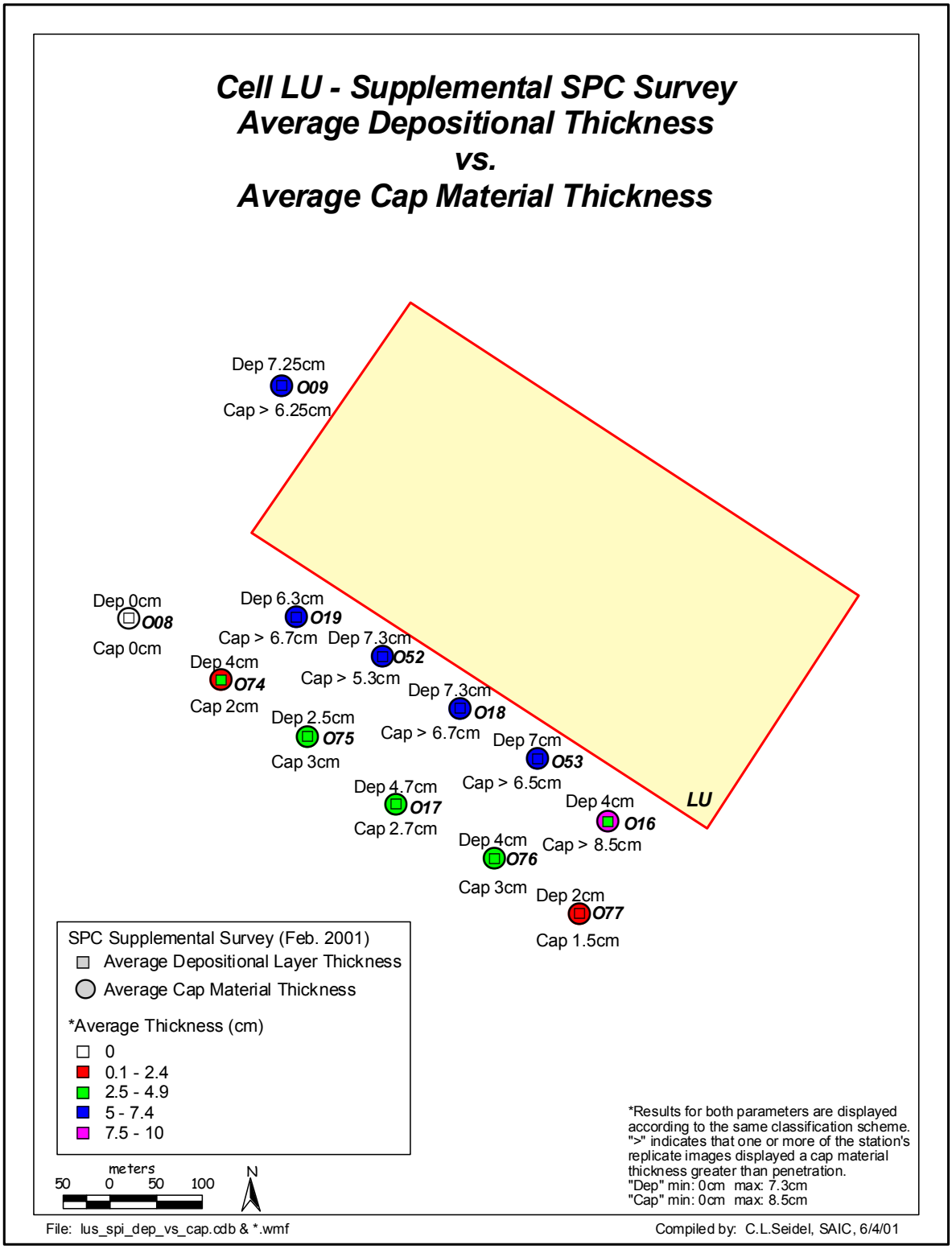


Figure 3.7-31. Map showing the average thickness of both the surface depositional layer of fine-grained sediment and the underlying cap material layer at each station.

3.8 Cell LU Plan View Image Results

3.8.1 Overview of Field Sampling Plan

The field sampling plan for the sediment profile camera (SPC)/plan view Camera (PVC) surveys in Cell LU followed the methods described in the Field Sampling Plan (FSP) of the Baseline and Interim/Postcap PWPs (SAIC 2000a and 2001). All SPC/PVC surveys that were specified in the FSP were occupied. 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 LU in February 2001 to evaluate the presence of cap material and assess biological activity in the sediments approximately five and one half months after the completion of the pilot cap placement activities. Table 3.8-1 summarizes the PVC field sampling activities that were conducted in Cell LU 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 3.8.4 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 sediment profile images (SPI) can be found separately in Section 3.7.

Table 3.8-1. Summary of SPC/PVC Field Sampling Activities – Cell LU

CELL LU SURVEY	NUMBER OF SURVEY STATIONS		PERCENT COMPLETENESS
	REQUIRED	SAMPLED	
Baseline	25	45	180%
Post-1	37	62	168%
Post-5	14	19	136%
Post-25	14	31	221%
Post-45	37	49	132%
Post-71 (Flex Survey)	15	15	100%
Supplemental Survey	12	12	100%

3.8.2 Review of Data Quality Objectives

Table 3.8-2 presents a summary of the Data Quality Objectives (DQOs) for the SPC/PVC surveys. A more detailed description of the DQOs can be found in the PWPs (SAIC 2000a and 2001). The purpose of this section is to provide a brief assessment as to whether these DQOs were met. It should be noted that these DQOs were not established for the individual pilot cells, but rather for the PVC monitoring in general. Therefore, the DQO assessment presented in this section is applicable not only to Cell LU, but to all of the baseline and interim/postcap PVC monitoring. The primary purpose of the plan view images was to provide information on the biological and physical conditions of the seafloor prior to and during cap material disposal events. This information is used in conjunction with the data obtained via the sediment profile camera (SPC).

The plan view image surveys were successful in providing information for the three monitoring objectives listed in Table 3.8-2. The potential erosion of cap materials was determined by qualitatively describing the surface sediment topography from at least one replicate plan view image at each station. As described in the PWP, FSP and the Technical Considerations (Section 3.8.3), surface sediments consisting of sand ripples caused by physical processes (i.e., currents) can indicate the potential of surface erosion of EA and/or cap materials.

The plan view images were also successful in identifying the lateral extent of cap materials upon placement (Section 3.8.4). This was accomplished by analyzing at least one replicate image per station for the presence or absence of cap material sediments as well as the lateral extent of cap material shell fragments and/or the presence or absence of clay clasts.

Biological conditions of the seafloor prior to and after disposal events were also obtained by the PVC system. Baseline and post-placement biological conditions were assessed by determining the presence, absence and extent of biological burrowing and the presence or absence of epifaunal and infaunal organisms. These conditions provided additional information on biological activity beyond that observed in the SPC images. However, the images provided little information in the successful recolonization of the cap layer since very little time had passed between disposal and survey events.

Throughout all surveys, PVC images were collected within a 5 m radius watch circle. If the survey vessel drifted outside this watch circle during acquisition, the vessel was immediately re-positioned and the replicate images taken again. The number of plan view surveys also met or exceeded the DQO requirements for completeness (Table 3.8-1).

Although the SPC/PVC system was deployed a minimum of three times at each station, a small number of PVC stations do not have one analyzable image associated with them. This was due primarily to the sensitivity of the trigger system of the PVC. As described in the PWP, the PVC uses a tension trigger to activate the camera and strobe system. This mechanism is very sensitive to motion and can be activated prematurely due to normal field conditions including boat heave and winch operation, causing the camera to acquire an image prior to or immediately after the PVC reaches the bottom. This sometimes resulted in missed images.

Table 3.8-2. Summary of DQOs for the Interim/Postcap PVC Monitoring

Monitoring Objective	Data Requirements	Monitoring Approach	Field Decision Criteria/Performance Specifications
Determine thickness of cap layer and mixing or erosion of EA sediments.	Thickness of depositional layers Grain size major mode Plan view surface features RPD depth	Collect sediment-profile/ plan view camera images at specified sampling stations following a single hopper load and at specified intervals during and following cap construction for both conventional and spreading placement methods (see FSP).	One image will be collected at each station, with replicate (triplicate) images from randomly selected stations at specified frequency (100% completeness goal). To the extent possible, the prism of the sediment profile camera should penetrate below the cap layer/EA layer boundary. Image must be collected within 5 m radius watch circle. Methodology and performance specifications should be identical to those used for Baseline Monitoring.
Determine lateral extent of capping materials.	Same as above. Sediment grain size Sediment color Sediment fabric RPD depth	Same as above.	Same as above. Sediment grain size, color, fabric, and RPD should be clearly distinguishable in each profile image.
Determine biological conditions (i.e., recolonization) of cap layer.	Infaunal successional stage Organism-Sediment Index	Same as above.	Not specified, in part, because recolonization will reflect the time since cap placement.

3.8.3 Technical Considerations

3.8.3.1 Methods for the Analysis of Plan View Images

The data obtained from the plan view images was used to supplement the more detailed sediment-profile camera (SPC) image data (Section 3.7). Many of the parameters that were analyzed in the plan view images were more qualitative (descriptive) in nature than quantitative. Even in instances where a quantitative analysis could be performed (i.e., number of burrows present, diameter of burrow openings) the numbers recorded represented estimates of these parameters and do not represent an exact number. At least one replicate image from each station was analyzed as described in the Baseline Analyses and Post-Disposal Analyses below. Where possible, additional replicates were analyzed to provide more information on a number of the more subjective parameters (e.g., presence and type of epifauna, presence or absence of cap material). A more detailed description of the methods used to analyze the plan view images are described in the Baseline Analyses and Post-Disposal Analyses below.

The primary focus for this report is to present the results of the presence or absence of cap material. The complete data set will be provided as part of the DAN-LA information system.

Baseline Analyses

The primary focus of the analyses during the baseline surveys was to document seafloor conditions in terms of: 1) the composition and characteristics of surface sediments, 2) bottom topography,

3) presence or absence of shell material and 4) presence or absence of clay clasts. The images were also analyzed to document the biological conditions of the EA sediments including the evidence of epifauna, infauna and the presence, absence and number of open biological burrows.

The composition and characteristics of surface sediments were classified either as *sandy* or *muddy* for at least one replicate image per station. The determination of the composition of surface sediments is somewhat limited using plan view photography in that the system does not have the ability to accurately resolve subtle differences in sediment grain sizes like the SPC system does. Therefore, the determination of the composition and characteristics of surface sediments using the PVC system represents a combination of apparent grains size, sediment color and background information on seafloor characteristics from additional survey technologies (i.e., SPC).

Bottom topography is characterized by the degree in which physical processes (i.e., currents) are affecting the morphology of seafloor sediments. For the plan view analysis, images were characterized as exhibiting *smooth* bottom topography (little or no physical disturbance) or *rippled* bottom topography (being affected by currents as seen by the presence of sand waves). Surface disturbances attributed to biological processes (i.e., extensive burrowing) were not considered a bottom topography parameter for this analysis (the extent of burrowing is included in the biological analysis described below).

The presence of epifauna and/or infauna was recorded only if there was direct evidence of either taxonomic group existing (e.g., fish in image, worm tubes on surface sediments). The presence of biological burrows did not constitute epifaunal or infaunal activity.

Post-Disposal Analyses

The primary objective of the post-disposal analyses was to determine the presence or absence of cap material at each station in order to determine the spatial extent of the cap material footprint. In addition to the presence or absence of material, the amount of re-excavation of cap material by biological organisms was also assessed. This information provided insight into the feasibility of effectively isolating contaminated organisms with clean cap material.

The presence or absence of material was determined based on the following parameters: 1) the lack of biological burrows compared to baseline conditions (due to the filling of the burrows with cap material) 2) the presence or absence of shell material fragments compared to baseline conditions and 3) the presence or absence of clay clasts compared to baseline conditions. A descriptive analysis for each of these parameters (e.g., degree of cap material and/or shell material coverage) was also recorded. The degree of cap material coverage was classified as *complete, partial* or *trace* amount. Shell materials were classified as stations that appeared to have a *large, medium,* or *small* amount of shell material (Figure 3.8-1).

3.8.4 Monitoring Results

3.8.4.1 Baseline Survey

The Cell LU Baseline PVC survey was conducted on July 27, 2000. The purpose of the survey was to provide additional information about the physical and biological characteristics of the seafloor prior to the placement of cap material within the cell. A total of 45 stations were occupied during the baseline survey (Figure 3.8-2). Fifteen of these stations (I01-I15) were located inside the cell. Ten stations (O01-O10) were located outside of the cell boundaries. Twenty additional stations (O23-O42) located on the outside of the cell and extending to the northwest of the cell's edge, were also occupied during the baseline survey.

The results of the Cell LU baseline PVC survey indicated that the bottom topography throughout the cell was relatively smooth. Of the 45 stations sampled, only three stations (I01-03) were characterized as being slightly rippled. 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 LU 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 (Figure 3.8-3). Many of these burrows had burrow channel openings approximately 0.3 to 3.5 cm in size.

3.8.4.2 Post 1 Survey

The Post 1 plan view survey was conducted on August 3 and 9, 2000, after the placement of the initial single hopper load of Queen's Gate dredged material in Cell LU. The purpose of the Post 1 PVC survey (and all subsequent PVC post-disposal surveys) was to help determine the spatial distribution of the cap material after disposal.

The survey on August 3 involved sampling at 40 of the 45 stations occupied in the baseline survey, as well as at 12 additional stations located outside the cell boundary (Stations O-11 through O-22; Figure 3.8-4). Following an initial review of the survey results, additional sampling was conducted on August 9 at 10 stations located inside the cell boundaries to allow better definition of the cap material footprint and thickness (Stations I-20 through I-29). Therefore, a total of 62 stations were sampled in the Post 1 survey in Cell LU.

Cap Material Footprint

Biological burrows filled with cap material indicated that the majority of the cap material remained primarily within the center of the cell (Stations I04, I06-09 and I12, I22, I24, I26, I29) and extended to the northwest of the center point, Station I08 (Figure 3.8-5). Inner Stations I04, 06-08, 12, 24, 26, and 29 exhibited complete cap material coverage. Station I09 exhibited only partial cap material coverage.

In addition to the filled burrows, cap material was also discernable based on the slight differences in sediment colors between the darker Queen's Gate material and the EA sediments (Figure 3.8-6). This was primarily the case only in areas of complete cap material coverage. In areas where the presence of cap material was questionable (e.g., may exist in small amounts) the color distinction was not enough to positively identify the presence or absence of the Queen's Gate material.

The spatial distribution of cap material based on the presence of shell fragments resulted in a slightly larger cap material footprint than that delineated (Figure 3.8-5). This footprint extended primarily further to the northwest than the SPI footprint based on filled burrows described above. In addition to those stations, shell material was evident at inside Stations I01, 05 and 14. Stations exhibiting a large amount of shell fragments generally correlated with the stations that also had complete cap material coverage (sediment). These shell fragments tended to be larger in size as well. Shell fragment coverage that was categorized as a medium amount generally correlated with the presence of a lesser amount of cap material and tended to be smaller in size (medium to small). The presence of small amounts of shell fragments did not correlate well with the presence of cap material sediments. The presence of fragments in these cases was due most likely to the horizontal transport of the fragments in the water column. These fragments tended to be quite small in size.

Biological Activity

The re-excavation of burrows was evident at many stations but was not consistently seen at all stations where cap material was present. Burrows were considered re-excavated if a burrow channel (hole) could be seen where it was apparent that the station was completely covered with cap material (all baseline burrows filled) and there now existed an obvious "new" channel through this material (Figure 3.8-7). Typically only a small number of re-excavated burrows existed at each station replicate. The size of the burrows were generally quite large (approximately 1 to 3.0 cm) and suggest that re-excavation was due most likely to macrofaunal activity. It was assumed that the re-excavation was attributed to organisms that were present before the placement of cap material.

Epifaunal activity (e.g., organism tracks, snails, starfish) was also evident in many of the plan view images. Nearly all of the stations where cap material was not present exhibited epifaunal activity, mainly in the form of small snails. Stations where cap material was present varied in the number and type of epifaunal activity. Organism tracks were the primary evidence at these stations and were mostly likely attributed to small fish that were foraging on the freshly deposited material (Figure 3.8-8). The physical presence of small fish was seen in a number of images as well (where cap material was and was not present).

3.8.4.3 Post-5 Survey

The Post-5 plan view survey was conducted on August 17 and 18, 2000 following the conventional placement of a cumulative total of five hopper loads of Queen's Gate cap material in the center of Cell LU. Plan view images were acquired at 19 stations located within the cell, including the original 15 inside stations from the baseline survey and four additional stations located near the four corners of the cell (Figure 3.8-9).

Cap Material Footprint

The cap material footprint following the Post-5 survey showed the majority of the cap material to be located at the inside center Stations I04, 07-09 and 12 (Figure 3.8-10). Inside I02, located to the northeast of these stations and near the edge of the cell, also indicates the presence of cap material as the biological burrows appeared to be filled.

The re-excavation of burrows was present at a number of these stations, including I04 as evidenced by a sea pen worm extending up from the surface sediments. The number of re-excavated burrows was quite small (1 to 3) in each replicate and the size of the burrows was typically quite large (approximately 1.5 to 3.0 cm in diameter).

The cap material footprint based on the presence of shell fragments for the Post-5 survey was nearly identical to the footprint found for the Post-1 survey (Figure 3.8-10). The shape of the footprint was essentially semi-circular with the leading edge extending to the northwest from Station I09 (trailing edge). The primary concentration of shell fragments (categorized as a large amount) was found clustered at inside Stations I04, 07-09 and 12. Inside Stations I01, 02, 06, and 14 exhibited small amounts of shell fragments. Inside Station I17, located in the far-eastern corner of the cell and independent of the overall shell material footprint, was classified as having a medium amount of shell material fragments.

Biological Activity

The re-excavation of biological burrows appeared to be minimal for this survey. The number of re-excavated burrows for stations with cap material is quite small (approximately 1 to 3). The size of the re-excavated burrow openings appeared to be 1.5 to 2 cm in diameter, suggesting that re-excavation was

primarily being accomplished by macrofauna. One replicate image at Station I04 also suggested successful infaunal re-excavation due to the presence of a pen worm in a newly re-excavated burrow.

The epifaunal activity for the Post-5 survey was also similar to what was observed in the Post-1 survey. Epifanuna observed in the Post-5 survey included small fish, starfish and large and small snails. Stations throughout the cell where cap material was not present also showed many organism tracks. The stations where cap material was present showed very few epifauna or evidence of epifaunal recolonization and/or activity.

3.8.4.4 Post-25 Survey

The Post-25 PVC survey was conducted on August 25, 2000, following the conventional placement of a cumulative total of 25 single hopper loads of Queen's Gate dredged material in Cell LU. Plan view images were obtained at a total of 31 stations located inside the cell boundary (Figure 3.8-11).

Cap Material Footprint

The presence of cap material sediment was evident at all stations located throughout Cell LU (Figure 3.8-12). Each station showed the presence of filled biological burrows and the sediments appeared homogenous in both color (darker gray) and texture (very fine sand with little mud or surface flocculent). Although the images showed complete coverage, a number of replicates indicated the re-working of the cap material via natural processes (sand ripples) and biological activity (re-excavation) (Figure 3.8-13).

Plan view results for the Post-25 survey showed two separate shell fragment material footprints located on each end of Cell LU (Figure 3.8-12). Both of these footprints were in general circular in shape. The majority of the stations within the footprint in the northwest corner of the cell (Stations I22, 30, 31 and 36-38) contained only a small amount of shell fragments. Station I18 had a medium amount of shell fragment. The images from Stations I05 and I16 showed a large amount of shell material.

The stations in the shell material footprint located in the southwestern end of the cell contained primarily a medium amount of shell material (Stations I19, 35, 40 and 41). The results for Stations I17 and 34 consisted of a large amount of shell material. Station I11 showed only a small amount of material.

A number of replicates also showed the presence of large clay clasts (~10 cm diameter) throughout the cell (Stations I01, 05, 06, 16, 18, 30, 35, 36, 40 and 41). These stations correlated well with the stations that also showed the presence of shell material fragments.

Biological Activity

Results for the Post-25 survey showed little epifaunal activity throughout the cell. The only indication of activity is occasional small organism tracks at various stations. The only image showing the presence of infauna was Station I33 in the form of a pen worm.

The re-excavation of biological burrows appeared evident at a number of stations throughout the cell. As with the Post-1 and Post-5 surveys, the size of the re-excavated burrows appeared to be approximately 1 to 5 cm in diameter. A number of re-excavated burrows appeared at the inside Stations I04 and I09. Stations I08 and I12 did not show evidence of re-excavation. A number of replicates from Stations I04, 09, 11, 13 and 30 also suggested the re-working of the surface sediments by currents in the form of small sand ripples.

3.8.4.5 Post-45 Survey

The Post-45 survey was conducted on September 5 and 7, 2000, following the conventional placement of a cumulative load of 45 hopper loads of Queen's Gate cap material. Plan view images were acquired at a total of 49 stations located both inside and outside of the cell boundaries (Figure 3.8-14). The hopper placement locations were distributed evenly within the cell boundary and around the outside perimeter of the cell.

Cap Material Footprint

Determining the presence or absence of cap material for the Post-45 survey was more difficult than the previous surveys. Many of the stations appeared to have undergone biological re-working of the cap material, resulting in many images that resembled the baseline conditions that were used to determine the presence or absence of cap material (e.g., extensive burrowing, presence of organism tracks). The results for this plan view analysis were based on evidence that suggested that there were a significant number of filled burrows remaining at each station.

The results of the Post-45 survey indicated the presence of cap material sediment at all of the inside and outside stations of Cell LU, with the exceptions of outside Stations O01-03, 08, 10 and 12 (Figure 3.8-15). Each station showed the presence of filled biological burrows and the sediments appeared primarily homogenous in color (darker gray).

The results for the Post-45 shell material footprint showed that shell fragments existed in three distinct spatial distributions (Figure 3.8-15). The amount of fragments at the majority of these stations was classified as small. Stations that exhibited a large amount of shell material included inside Stations I13 and 45 and outside Station O52. Stations that were classified as having a medium amount of shell fragment material included inside Stations I20, 42 and 43 and outside Stations O06, 09, 13, 16, 50 and 51.

Medium-sized clay clasts (~5 cm) were visible in a number of replicate images and generally correlated with the presence of shell materials.

Biological Activity

Evidence of epifaunal activity included both small and large organism tracks in many images, as well as a medium and large sized fish. A replicate from inside Station I14 suggested a possible feeding event by epifauna (fish) on infauna and/or other organisms (Figure 3.8-16).

The re-excavation of burrows appeared to be quite extensive at many of the stations throughout the cell. The burrow channel openings ranged in size from approximately 0.3 cm to 2.5 cm in diameter.

3.8.4.6 Post 64 Survey

The Post 64 SPC survey in Cell LU was conducted on September 13, following the conventional placement of a cumulative total of 71 hopper loads of Queen's Gate cap material. Plan view camera images were obtained at 15 stations located outside the cell. These 15 stations were spaced 25 m apart and aligned in two transects of 7 and 8 stations, respectively (Figure 3.8-17). One transect began at a distance of 125 m northeast of the Cell LU boundary, and the other began at a distance of 100 m to the southeast. The objective of sampling along each transect was to determine the location of the outer edge of the cap material deposit. The 64 hopper placement locations were distributed within and along the outer perimeter of the cell.

Cap Material Footprint

The presence of cap material for the Post 64 survey appeared to be minimal at all stations (Figure 3.8-18). All stations appeared to retain many of the features that were found as part of the baseline survey for Cell LU (i.e., many burrows, biological and physical bedforms). The stations that most closely resembled the presence of cap material were outside Stations O62-68. However, results from the Post 64 SPC survey indicate that Stations O62-68 had ambient sediment characteristics that were very similar in appearance to the Queen's Gate material. Therefore, these stations were not considered to have cap material present.

Shell material was observed at six of the 15 stations that were surveyed (Stations O54-56, 61 63 and 65; Figure 3.8-18). All of these stations were classified as having a medium or small amount of shell material present. The shell material fragments at Stations O63 and 65 were suspect and most likely not attributable to the placement of cap material as they appeared to be established and part of the ambient sediment. No baseline plan view images were acquired for these stations to determine the presence or absence of shells prior to placement operations. The results suggested that the outer edge of the shell material deposit extended as far as 275 m beyond the cell boundary to the southeast (along slope) but extended less than about 100 m beyond the boundary to the northeast (upslope).

Biological Activity

No direct evidence of epifaunal or infaunal activity was discernable in the images with the exception of Station O68, which showed a sea pen worm extending from the sediments.

3.8.4.7 Supplemental Survey

The Cell LU supplemental survey was conducted on February 24, 2001, approximately five and one-half months after the Post 64 survey (conducted on September 13, 2001). A total of 15 stations were occupied outside of the Cell LU boundaries during the supplemental survey (Figure 3.8-19). One station (station O09) was classified as a primary station and was located to the northwest of the cell. The remaining fourteen stations were classified as secondary stations and were located in the area between Cell LU and Cell SU. Four replicate images were obtained at the primary station (O09) and three replicates were obtained at each of the secondary stations.

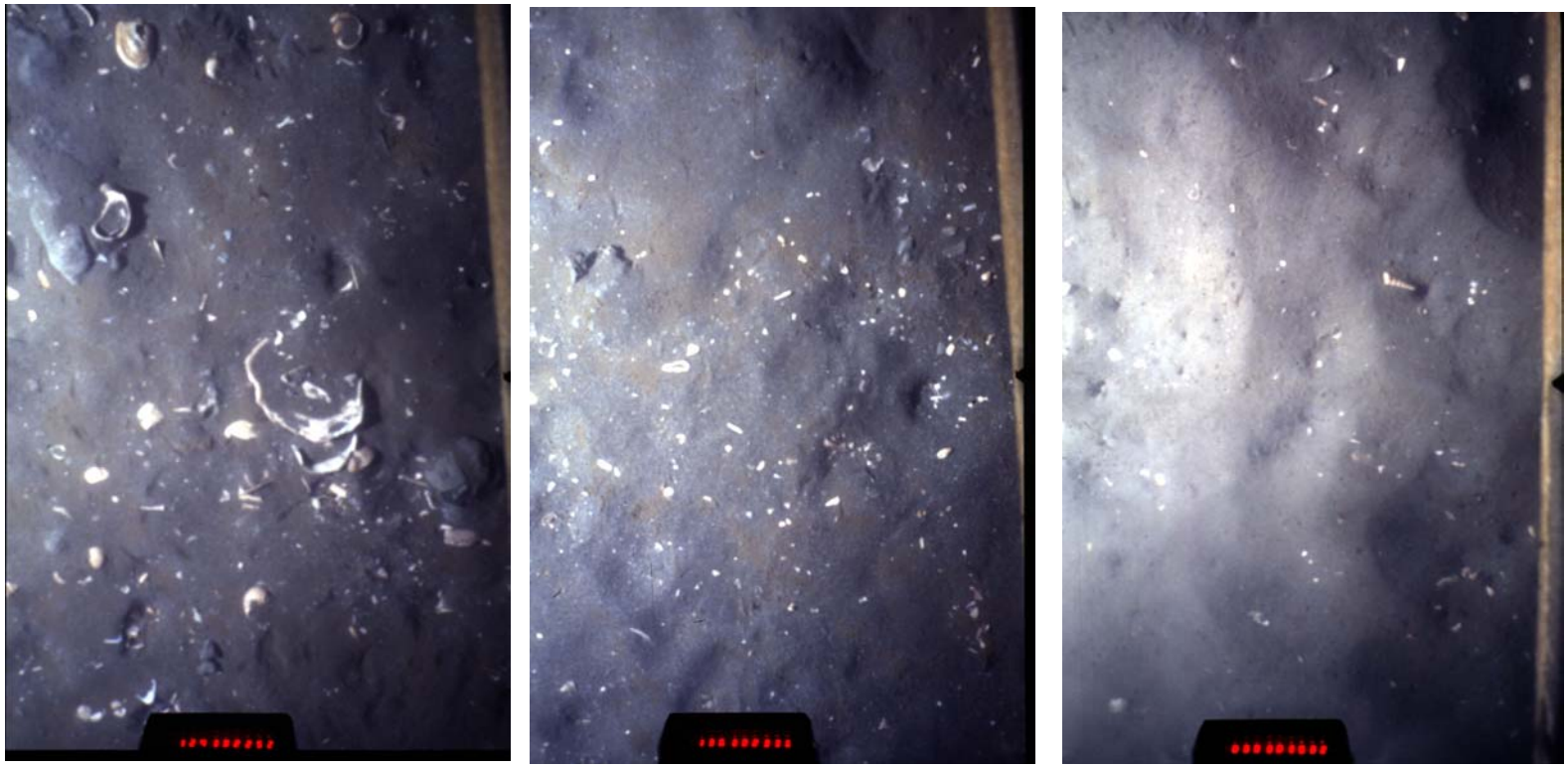
Cap Material Footprint

The presence or absence of Queen's Gate material for the Cell LU Supplemental Survey was inconclusive as the sediments appear to be very similar to back ground conditions both biologically (many burrows) and in terms of sediment color (Figure 3.8-20). All replicate images showed the presence of gray colored sediments, but whether or not these sediments were comprised of Queen's Gate material can not be determined from the plan view images. The parameters typically used to determine the presence of cap material (i.e., filled biological burrows and/or shell material, etc.) were not seen in the images.

Many of the images showed a significant amount of physical surface re-working in the form of small (~ 3 to 5 cm wide) sand ripples (Figure 3.8-20). These results suggested that the lateral transport of surface sediments was possible within the cell.

Biological Activity

A number of biological burrows existed within most of the plan view images. The size of the burrow channel openings ranged from approximately 0.5 to 1.25 cm (Figure 3.8-20). Epifauna found in the images included a starfish at station LUSO 19.



A B C

Figure 3.8-1. Degree of shell material coverage. Images A, B and C show the scale used to assess the amount of shell material fragments during the PVC analysis. The images represent a large, medium and small amount of material, respectively. Note the clay clasts that can be seen in images A and B.

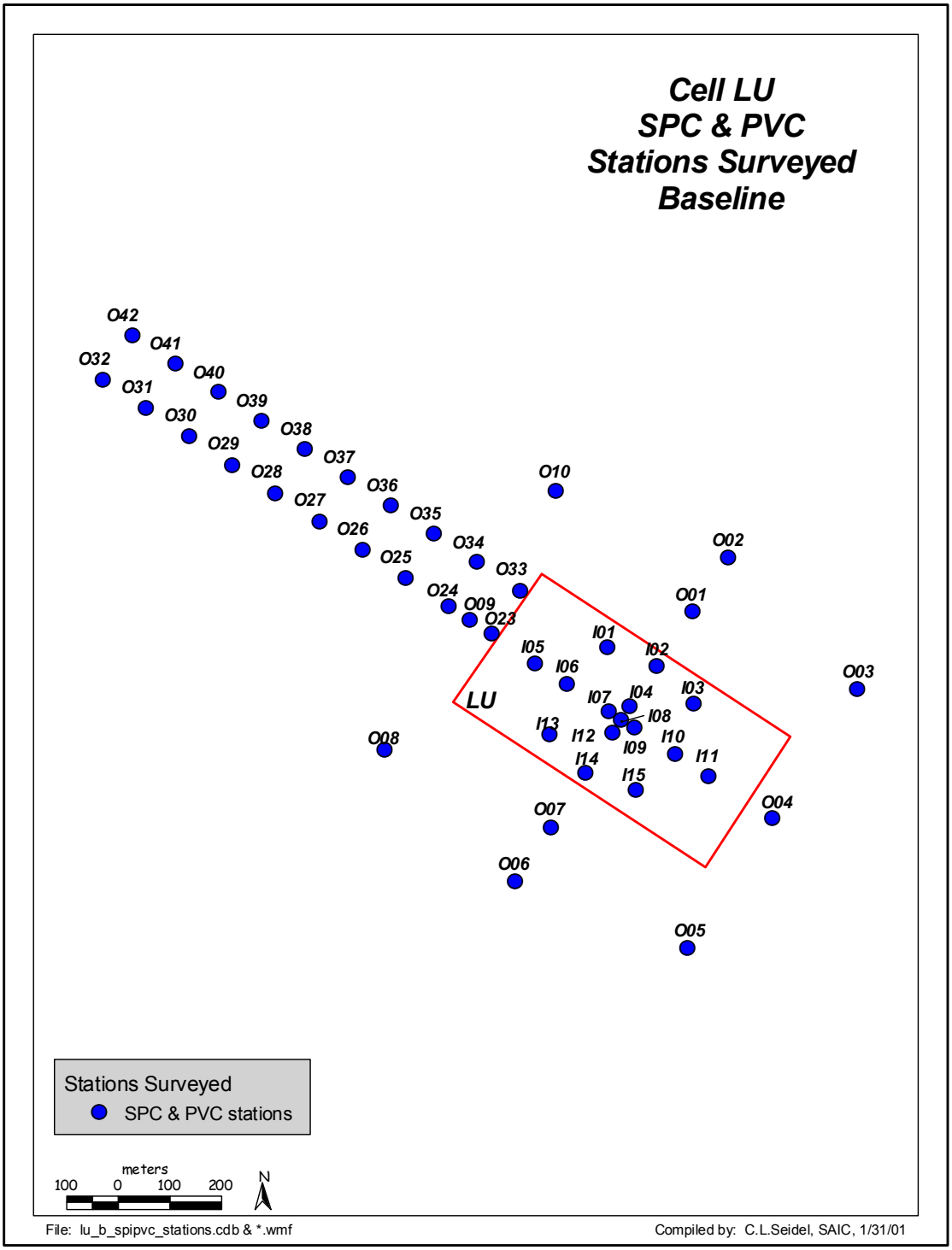


Figure 3.8-2. Cell LU SPI and PVC stations surveyed during baseline survey.

Figure 3.8-3. Biological burrows. This image, taken during the baseline survey at Cell LU, Station 02, typifies the type and amounts of biological burrows found on the Palos Verdes Shelf prior to cap placement.

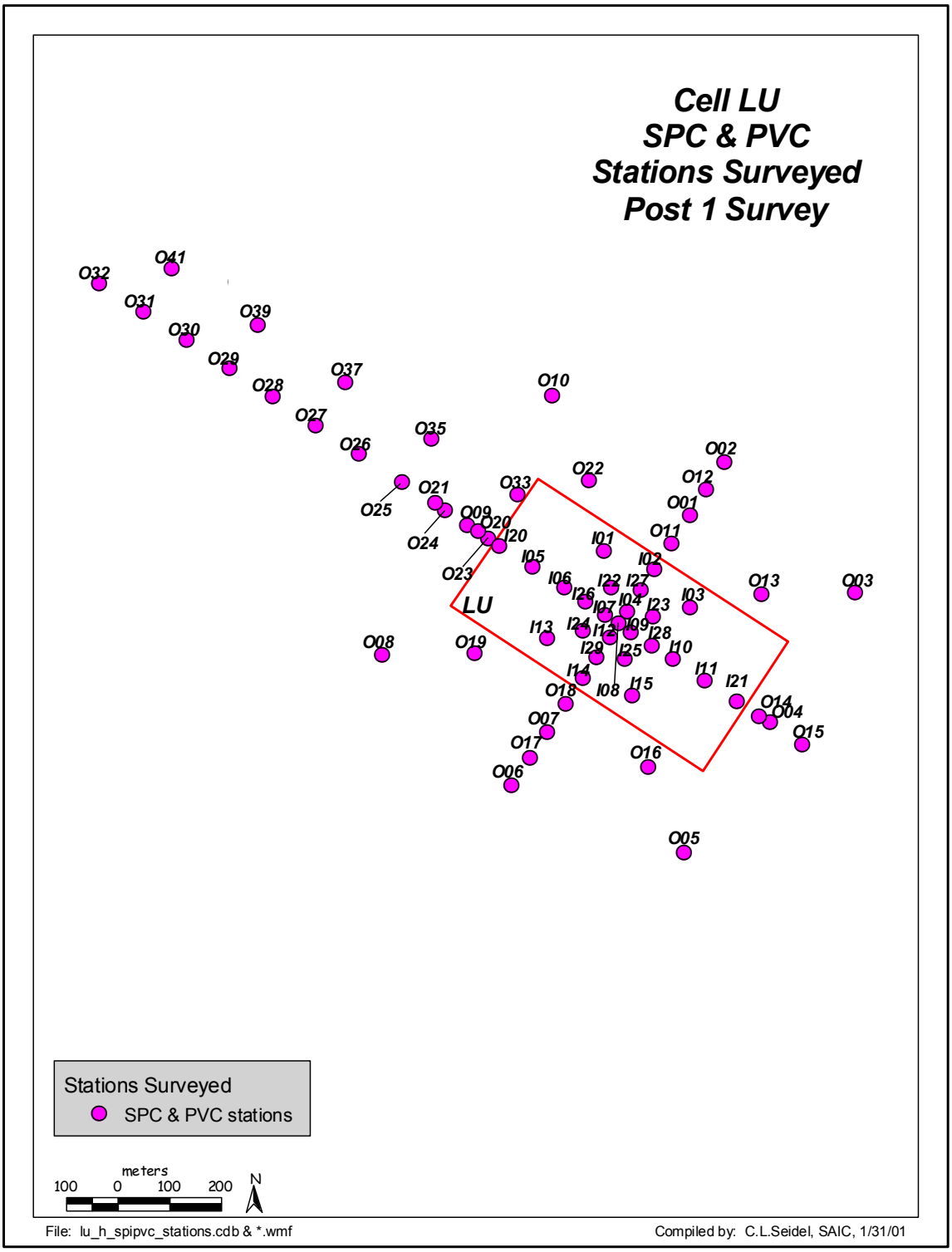


Figure 3.8-4. Cell LU SPI and PVC stations surveyed during Post 1 survey.

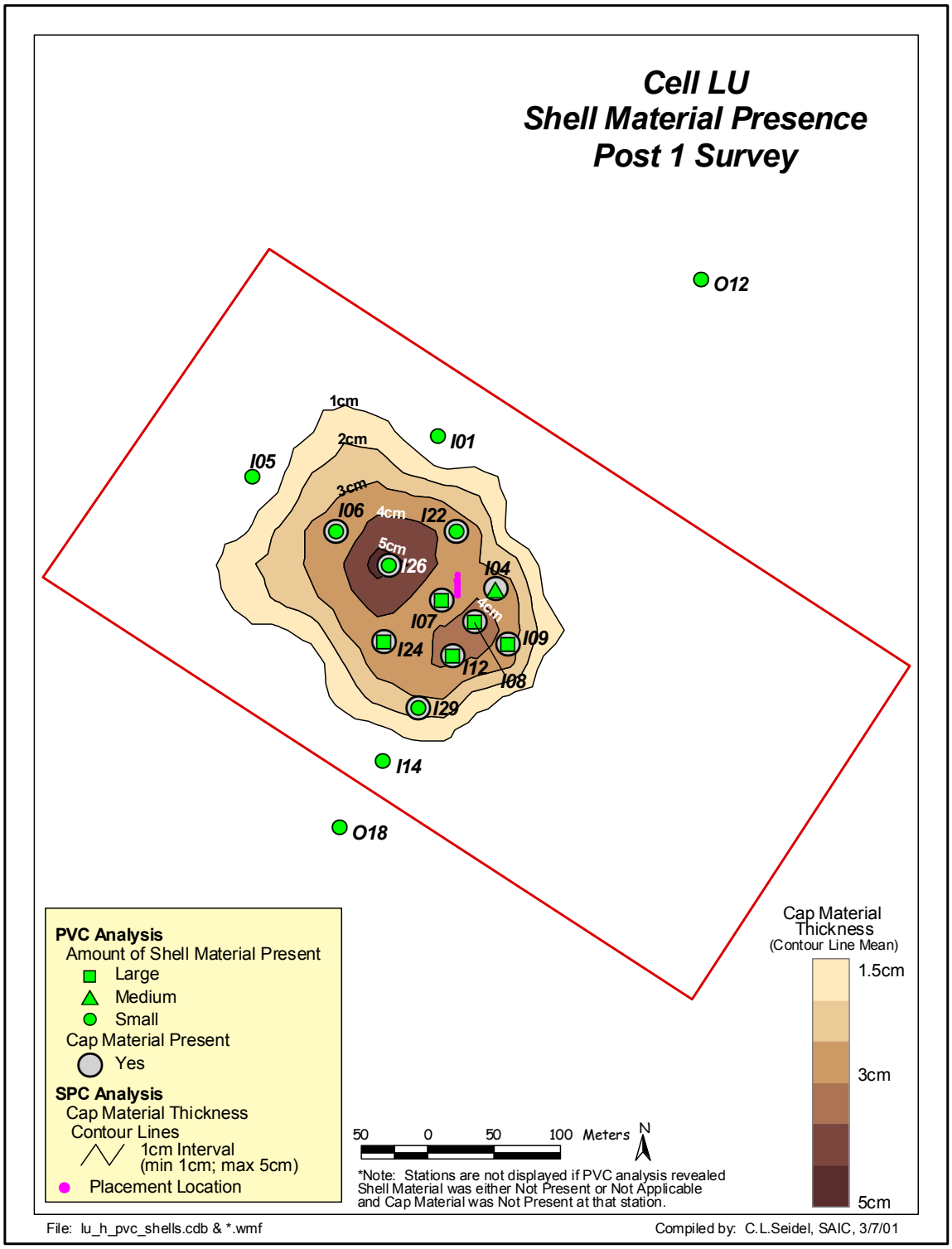


Figure 3.8-5. Lateral extent of cap material based on plan view image (PVI) analysis, Post 1. The plan view image data are overlain on the SPI cap material footprint.

Figure 3.8-6. Cap material color. These images, taken at Cell LU Stations I11 and I12 during the Post 1 survey, display the differences in color between the lighter colored EA sediments on the left (I11) and the darker cap material on the right (I12). Note the thin flocculent layer on top of the cap material on the right. This difference was not consistently seen during the other surveys throughout the project.

Figure 3.8-7. Re-excavated burrows. This image, taken at Station I04 during the Post 1 survey, shows the re-excavation of a biological burrow. The image, measuring 40 cm × 60 cm would suggest that the burrow entrance measures approximately 3 to 5 cm in diameter.