# Characterization of Suspended Sediment Plumes at the Port of Oakland and Port of Redwood City, California

**Douglas Clarke, Andrew Martin, Charles Dickerson, Kevin Reine & David Moore**

# Topics

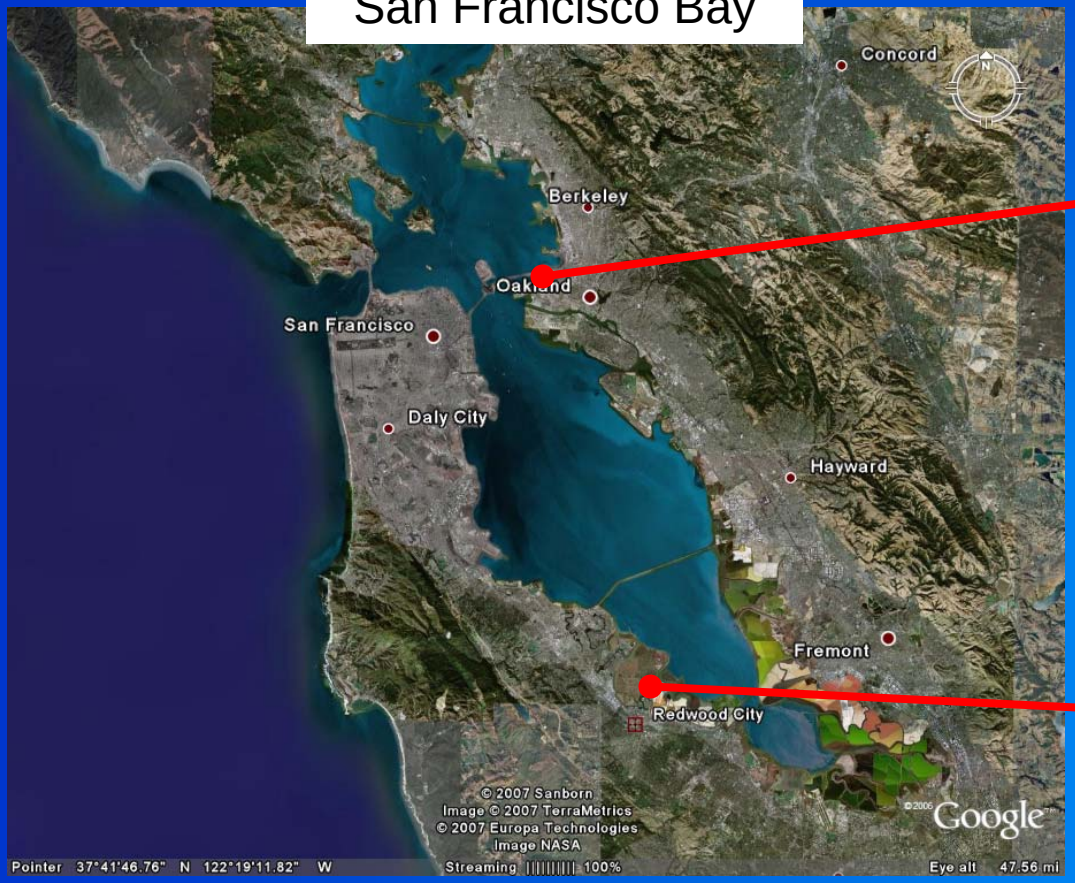
- Need for knockdown plume characterizations
  - Objectives
- Methodologies
  - Turbidity and total suspended solids
- Results
  - Plume spatial and temporal scales
  - Plume concentration gradients
- Utility of the data in relation to environmental resource protection

# Objectives

- Address priority need identified by SF Bay resource agencies and stakeholders within the LTMS process
- Knowledge gaps linked to environmental windows
- Major concerns in San Francisco Bay
  - Protection of migratory salmonids
  - Protection of Pacific herring spawning habitat

# Study Areas

San Francisco Bay




Outer Harbor,
Port of Oakland


Redwood Creek,
Port of Redwood City

# Outer Harbor, Port of Oakland Maintenance Dredging

- 12 cy closed bucket
  - Dredged material placed in a scow for disposal offsite
- Silty material
- Depths 12-13 m
- August, 2003


W.F.-9
PORTLAND, OREGON

# Port of Redwood City Maintenance Dredging

- Performed by knockdown
  - a.k.a. bed leveling, plowing, contouring
  - Dredged material relocated from “high spots” or “mounds” to deeper parts of the channel basin
- Approximately 3,000 cy of sandy silts
- Depths = 8.5 m
- October, 2004

# Dutra Dredging *Sharon Brusko*

# Knockdown Beam

# Methods

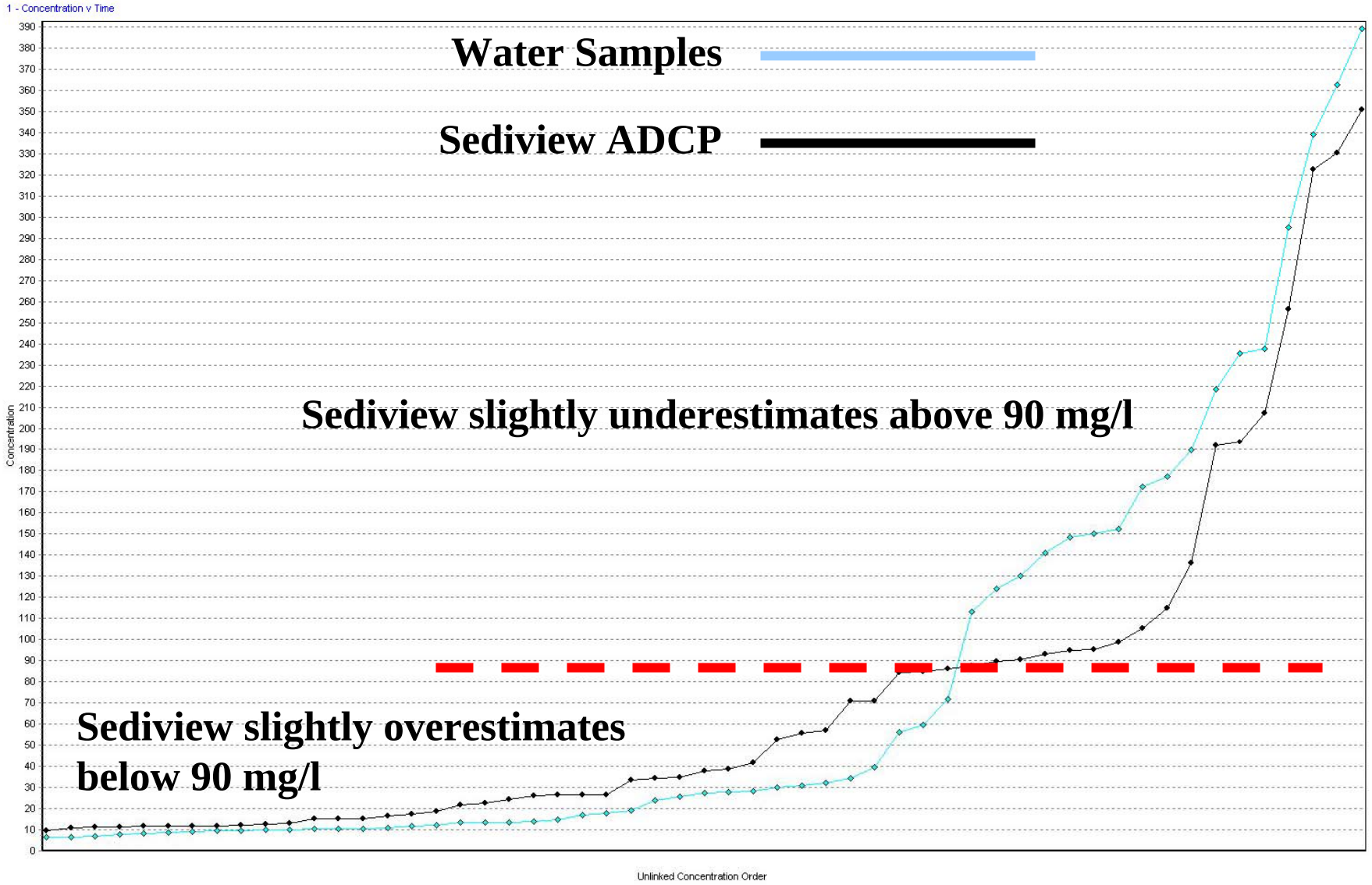
- Acoustic Doppler Current Profiler (ADCP)
  - Acoustic technologies allow detailed characterizations to be made of plume dynamics on large spatial scales
- ADCP backscatter data calibrated to discrete water samples analyzed for total suspended solids (TSS)
- Optical Backscatter Sensor (OBS) Arrays– (Redwood City only)
  - Provided continuous turbidity measurements at single location, multiple depths

ADCP in raised position

ADCP deployed

Rosette water sampler

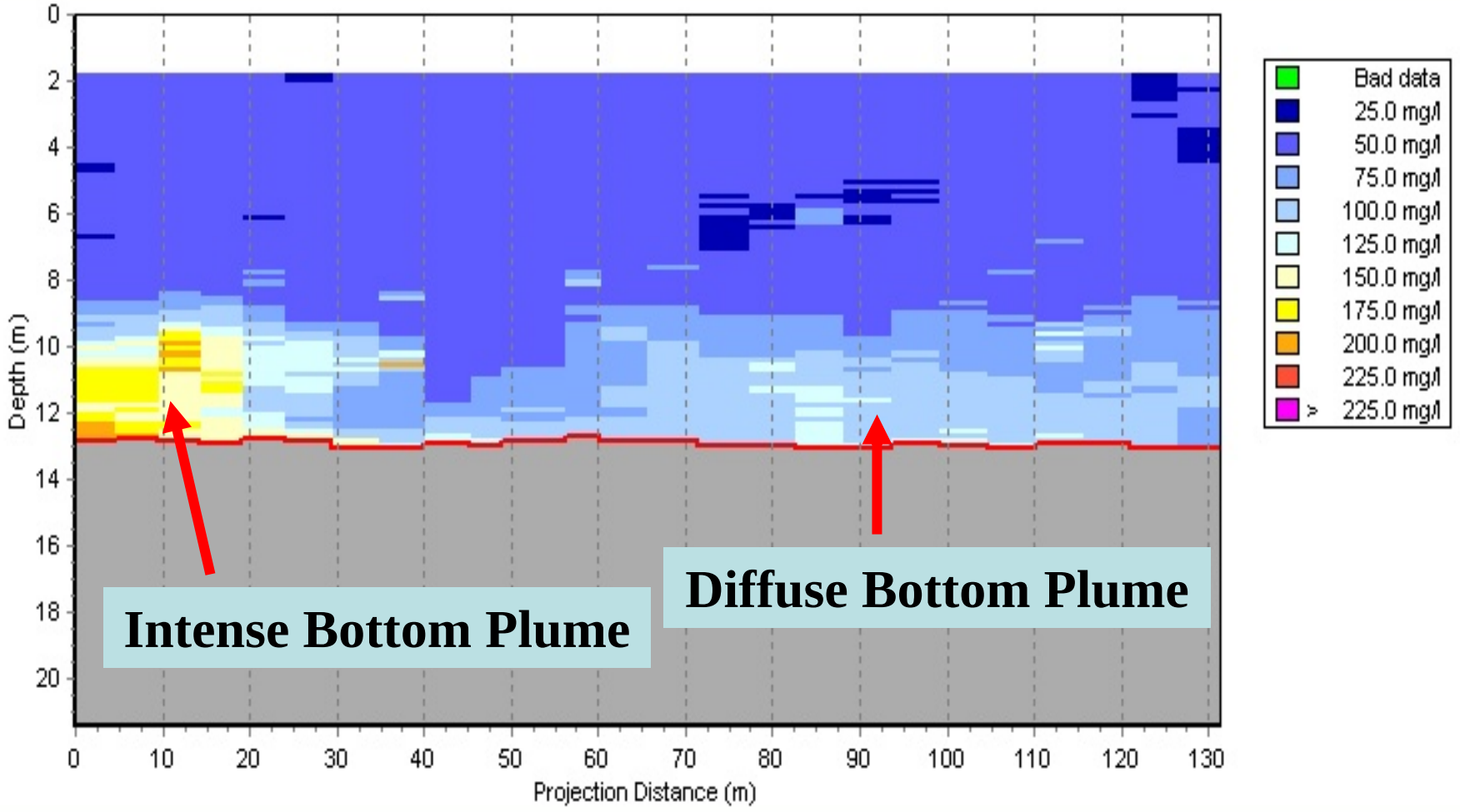
# Sediview Calibration File

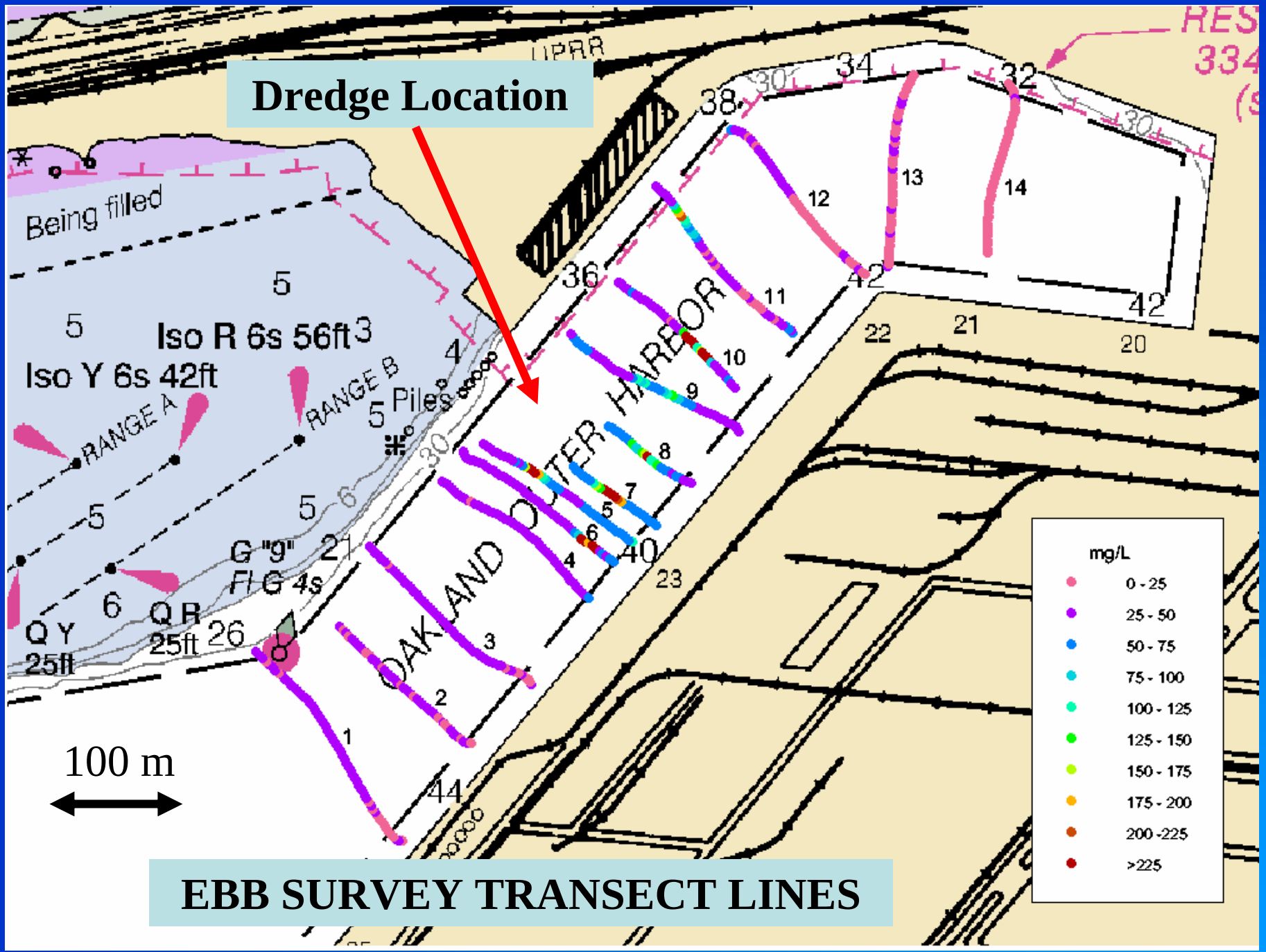


# Results
# Outer Harbor, Port of Oakland

# ADCP Transect #8 – Ebb Survey

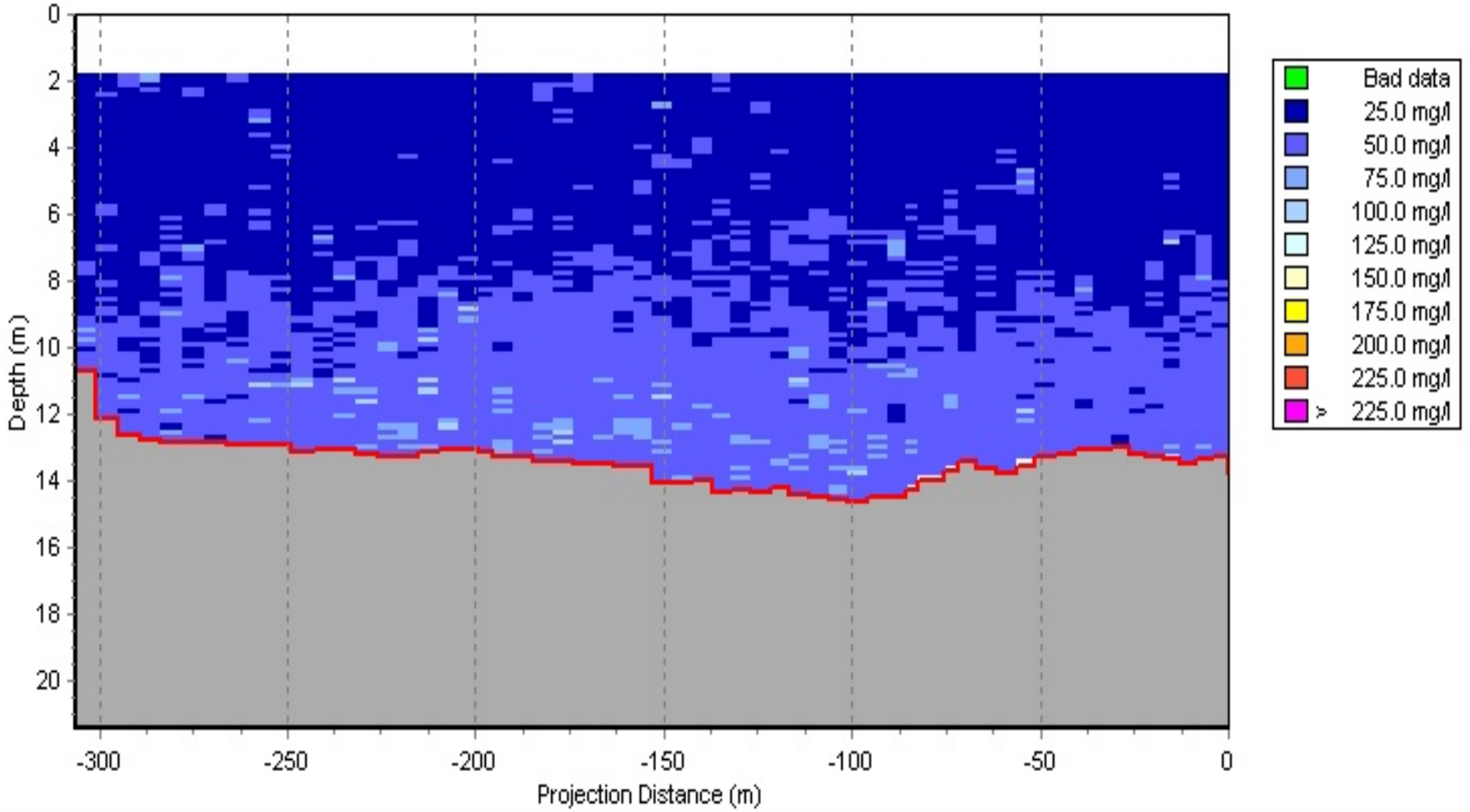
## 25 m up-current from dredge




Dredge Location
Being filled
Iso R 6s 56ft
Iso Y 6s 42ft
RANGE A
RANGE B
5 Piles
G "9"
Fl G 4s
Q Y
25ft
Q R
25ft
OAKLAND OUTER HARBOR
100 m
mg/L
0 - 25
25 - 50
50 - 75
75 - 100
100 - 125
125 - 150
150 - 175
175 - 200
200 -225
>225
EBB SURVEY TRANSECT LINES

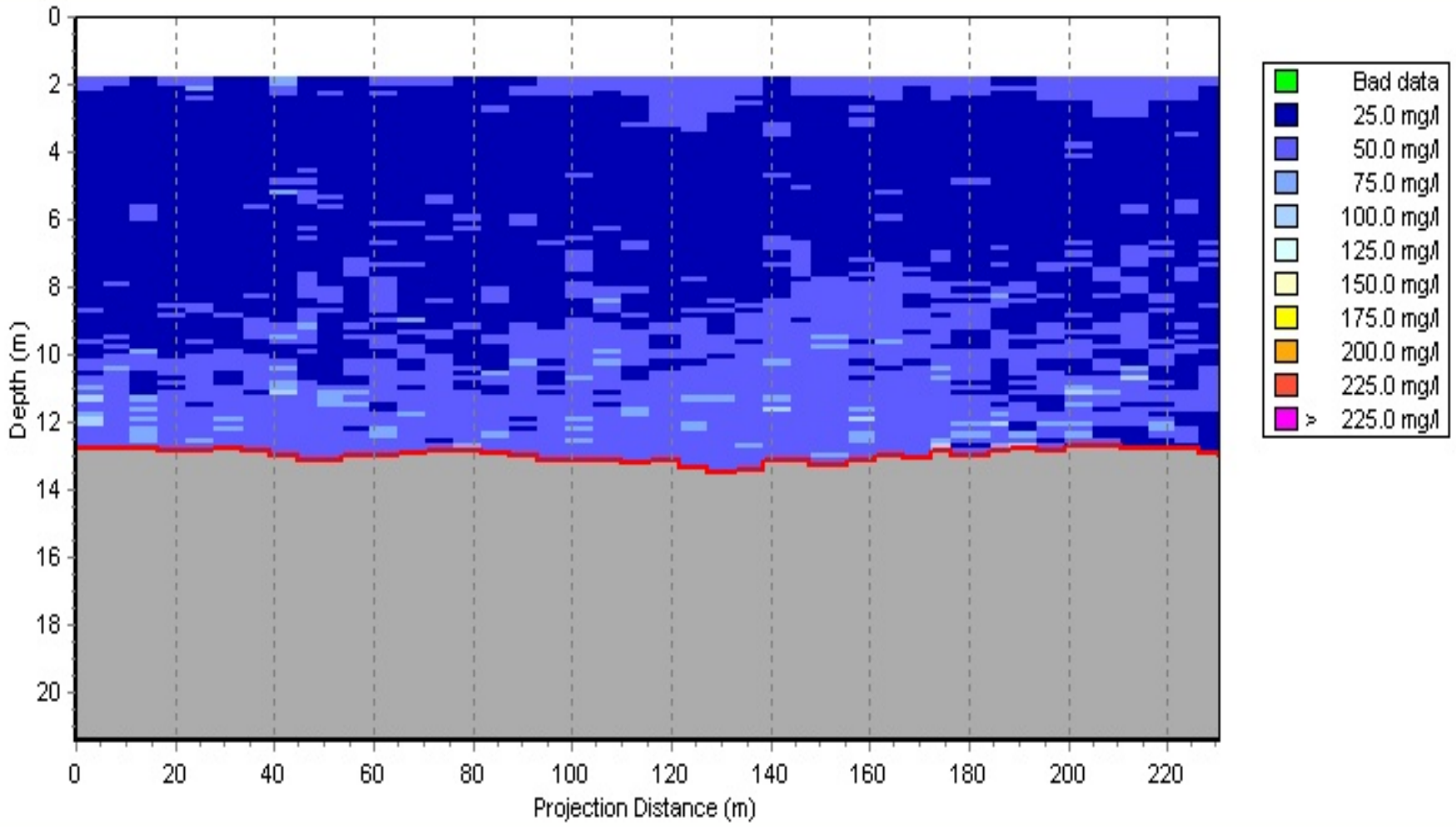
# ADCP Transect #1 – Ebb Survey

## 300 m down-current from dredge



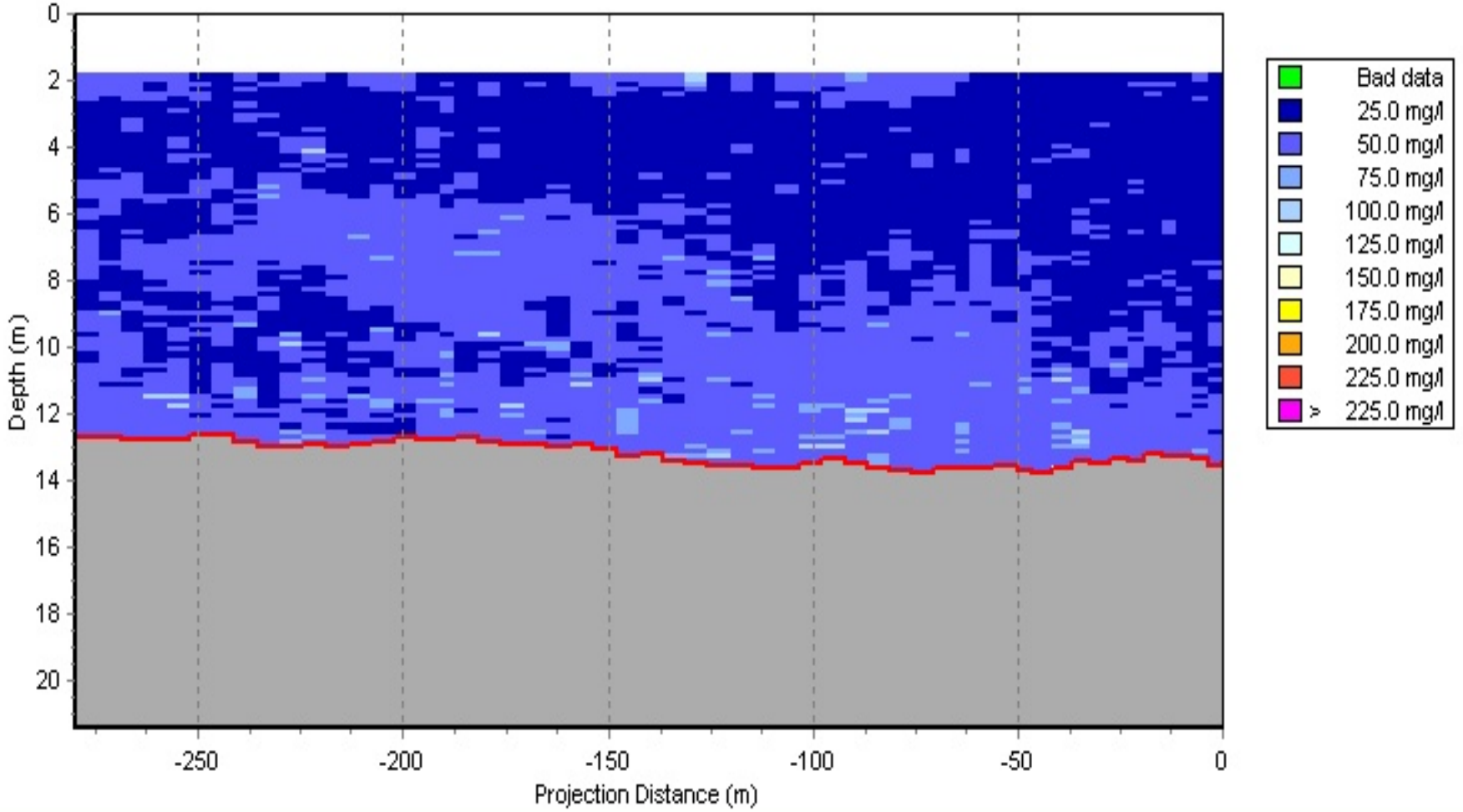
# ADCP Transect #2 – Ebb Survey

## 250 m down-current from dredge



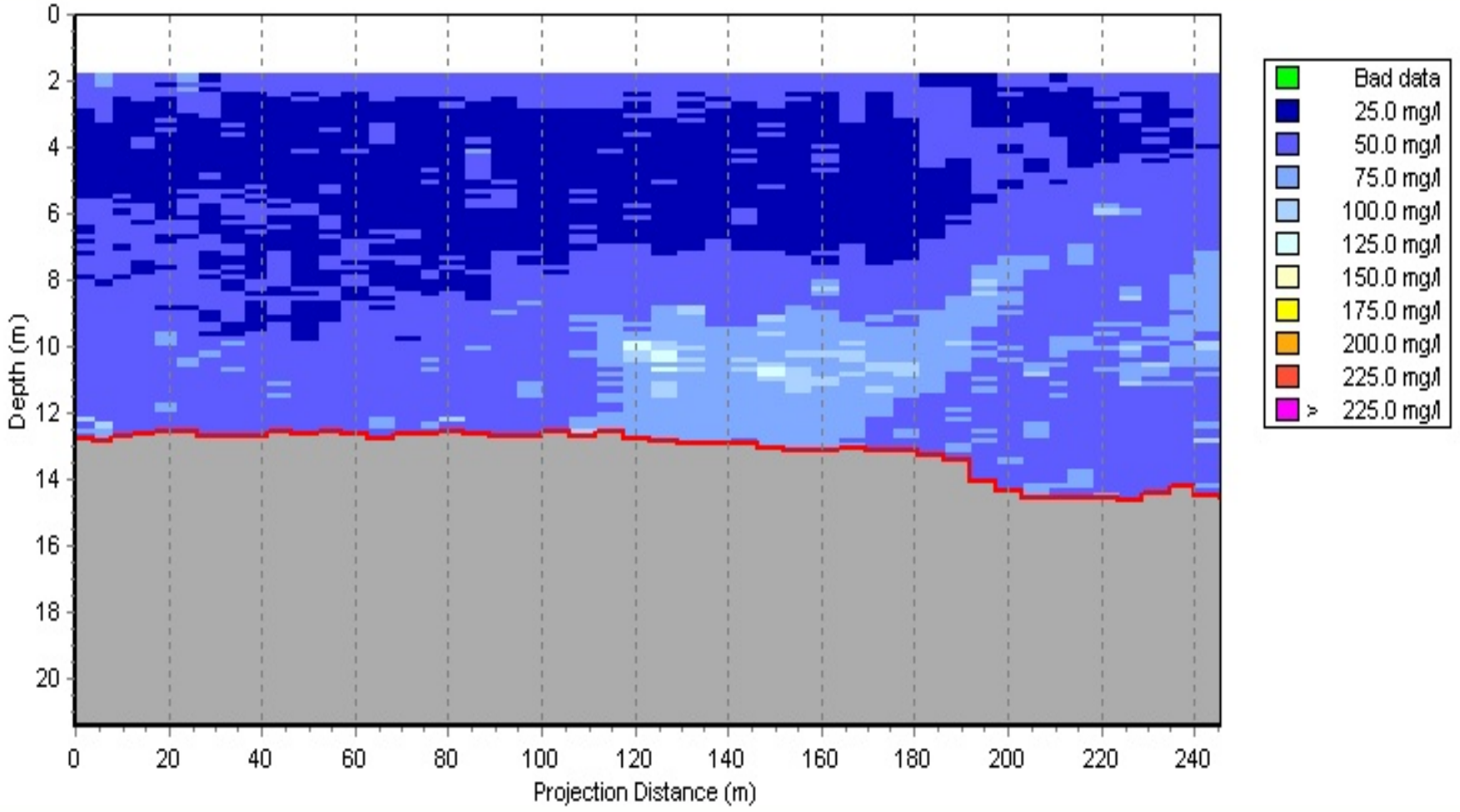
# ADCP Transect #3 – Ebb Survey

## 200 m down-current from dredge



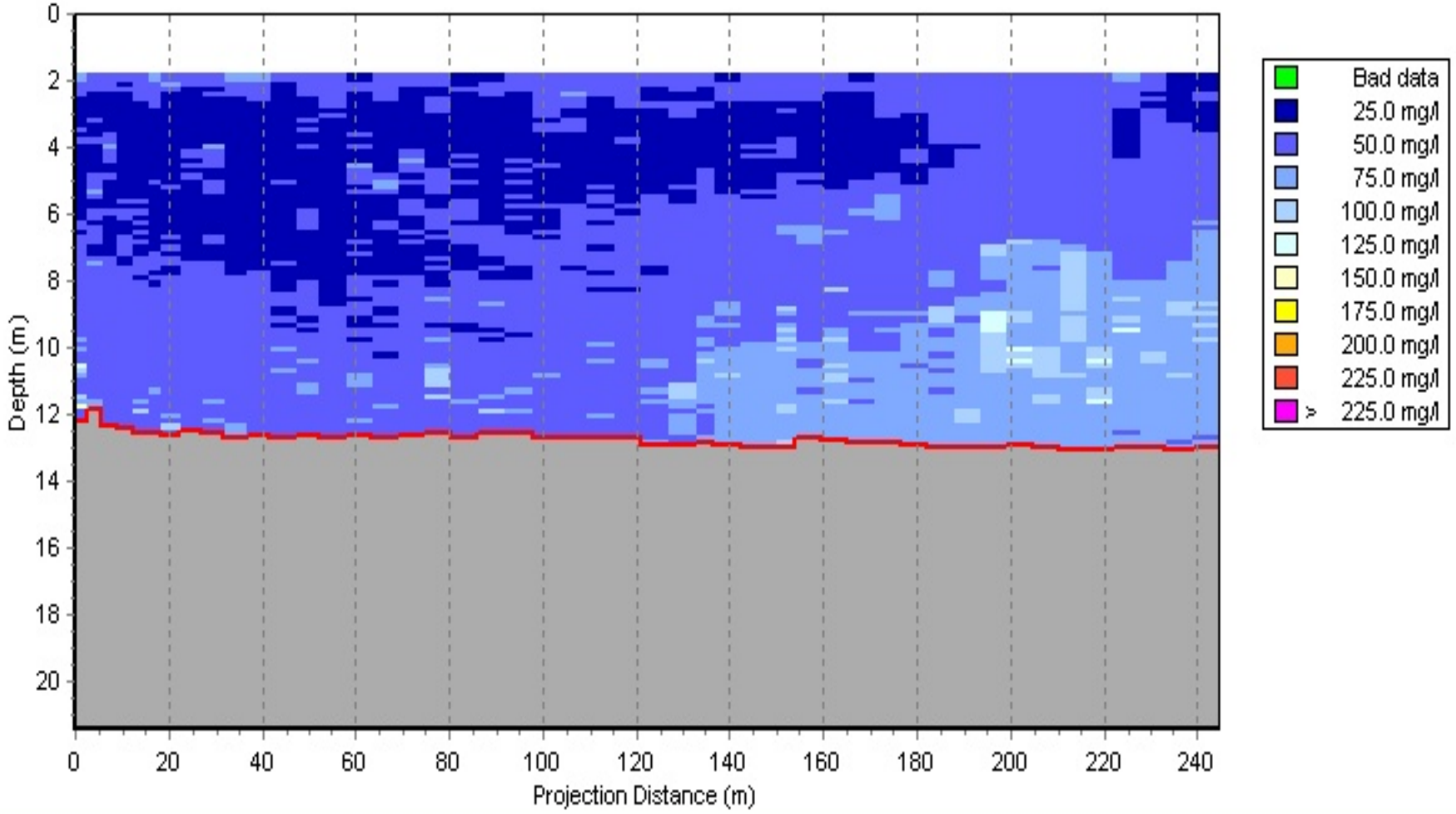
# ADCP Transect #4 – Ebb Survey

## 100 m down-current from dredge



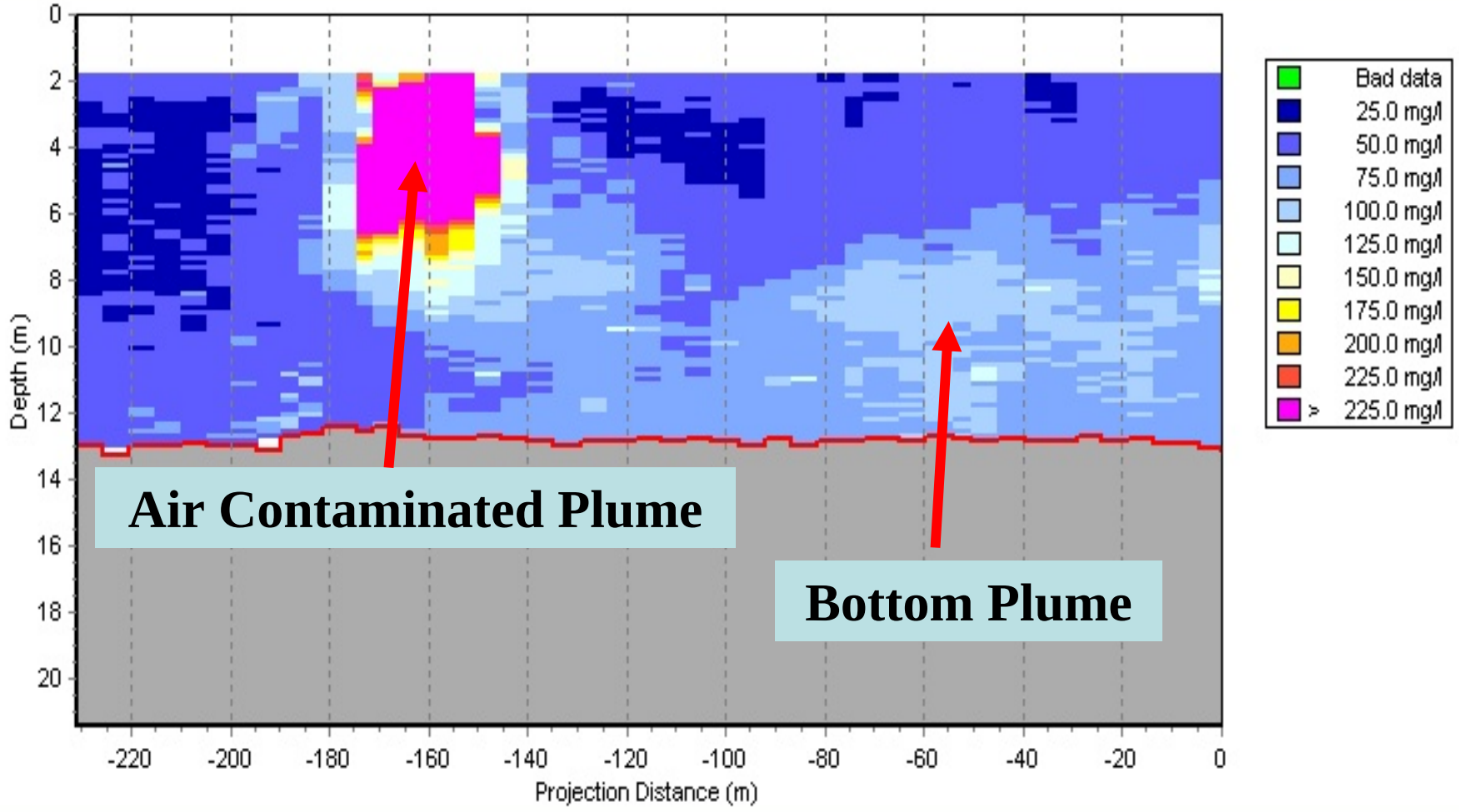
# ADCP Transect #5 – Ebb Survey

## 75 m down-current from dredge



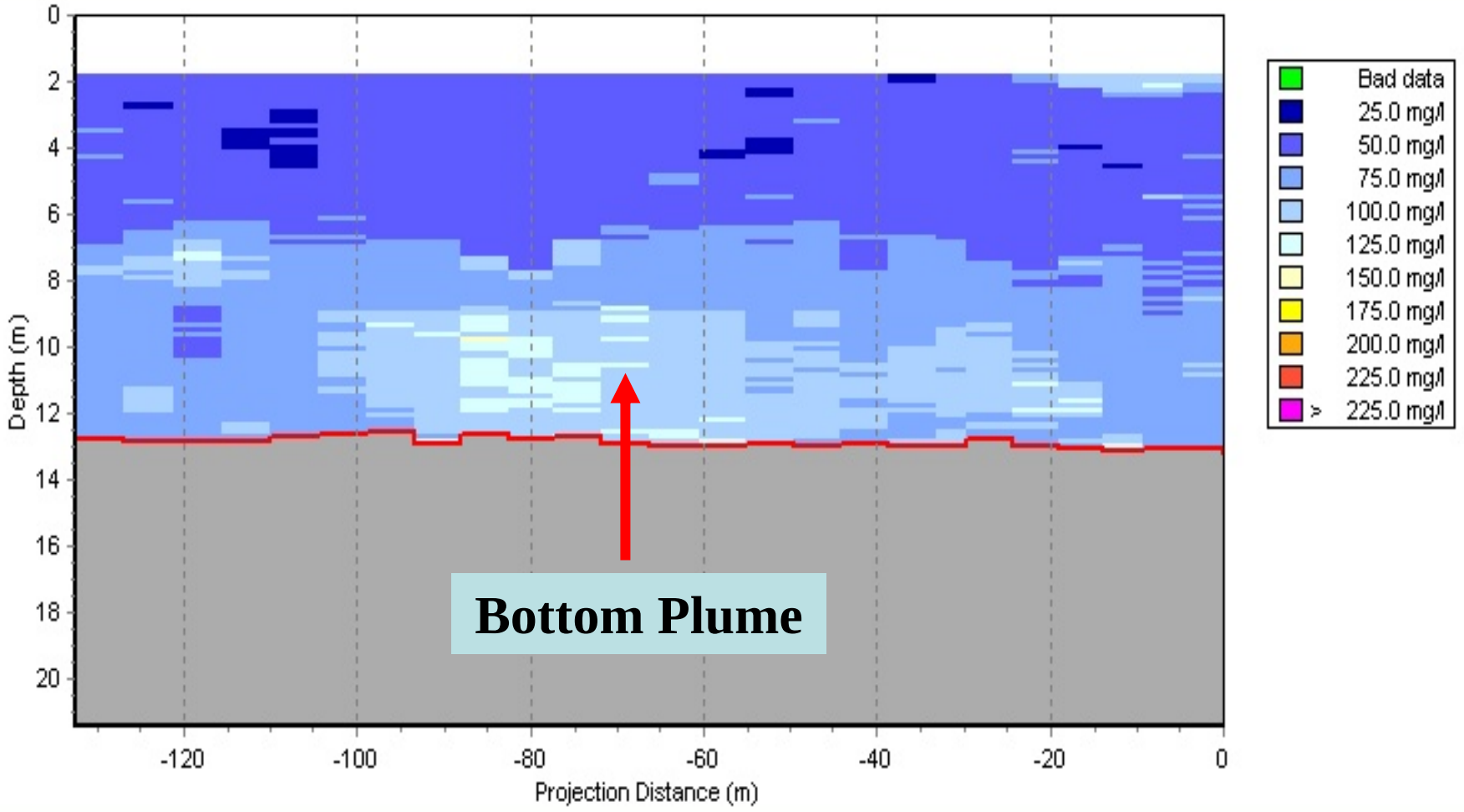
# ADCP Transect #6 – Ebb Survey

## 50 m down-current from dredge



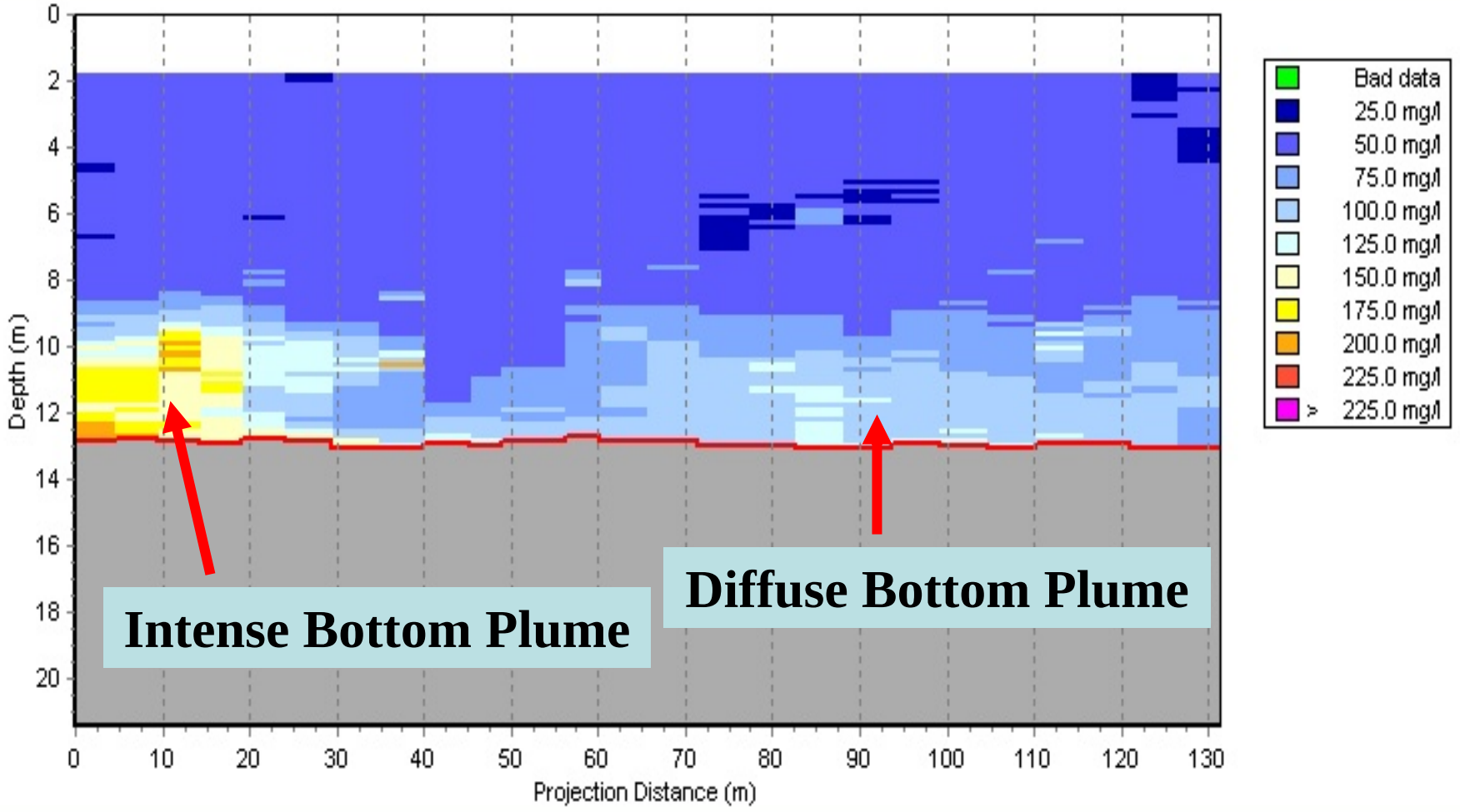
# ADCP Transect #7 – Ebb Survey

## 25 m down-current from dredge



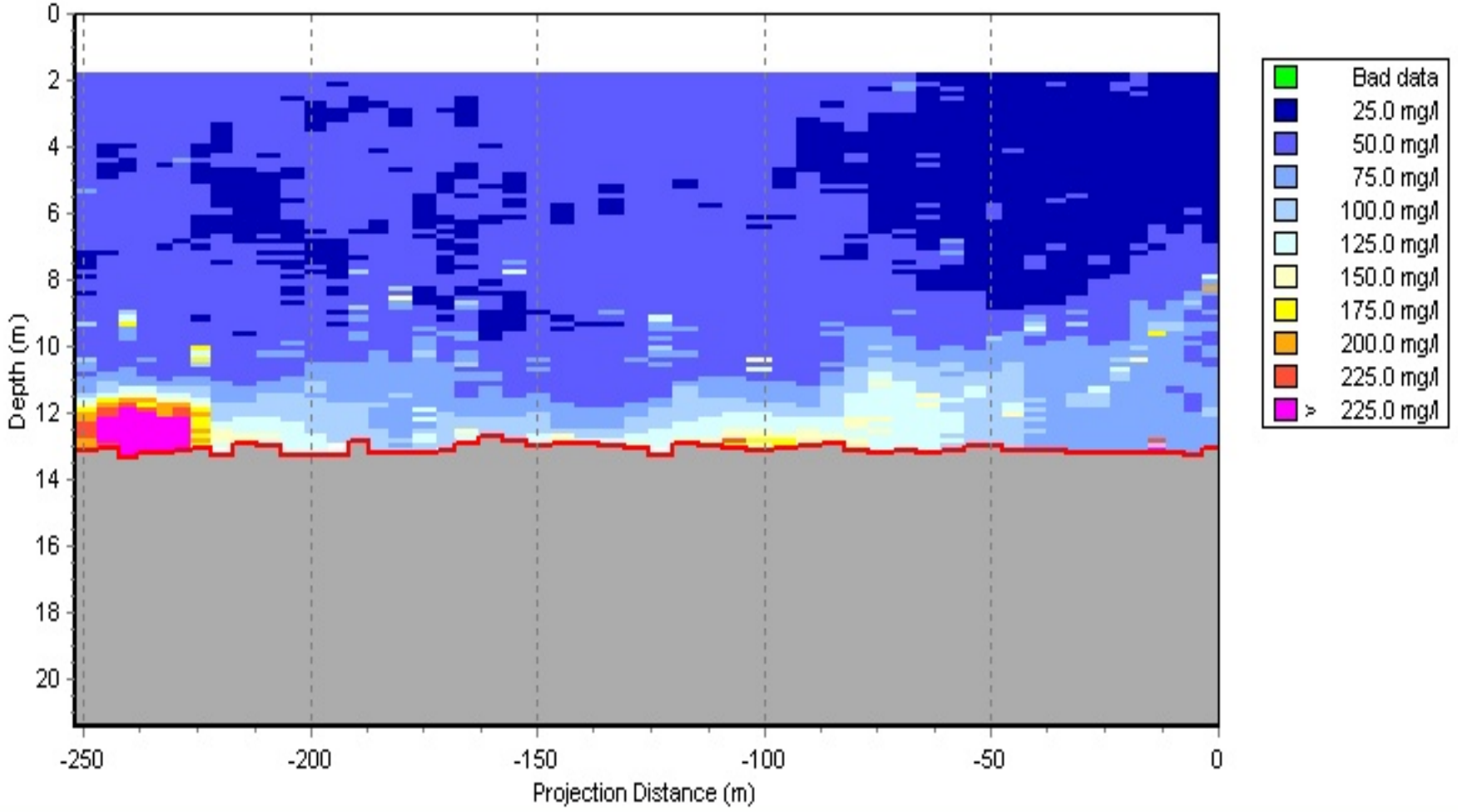
# ADCP Transect #8 – Ebb Survey

## 25 m up-current from dredge



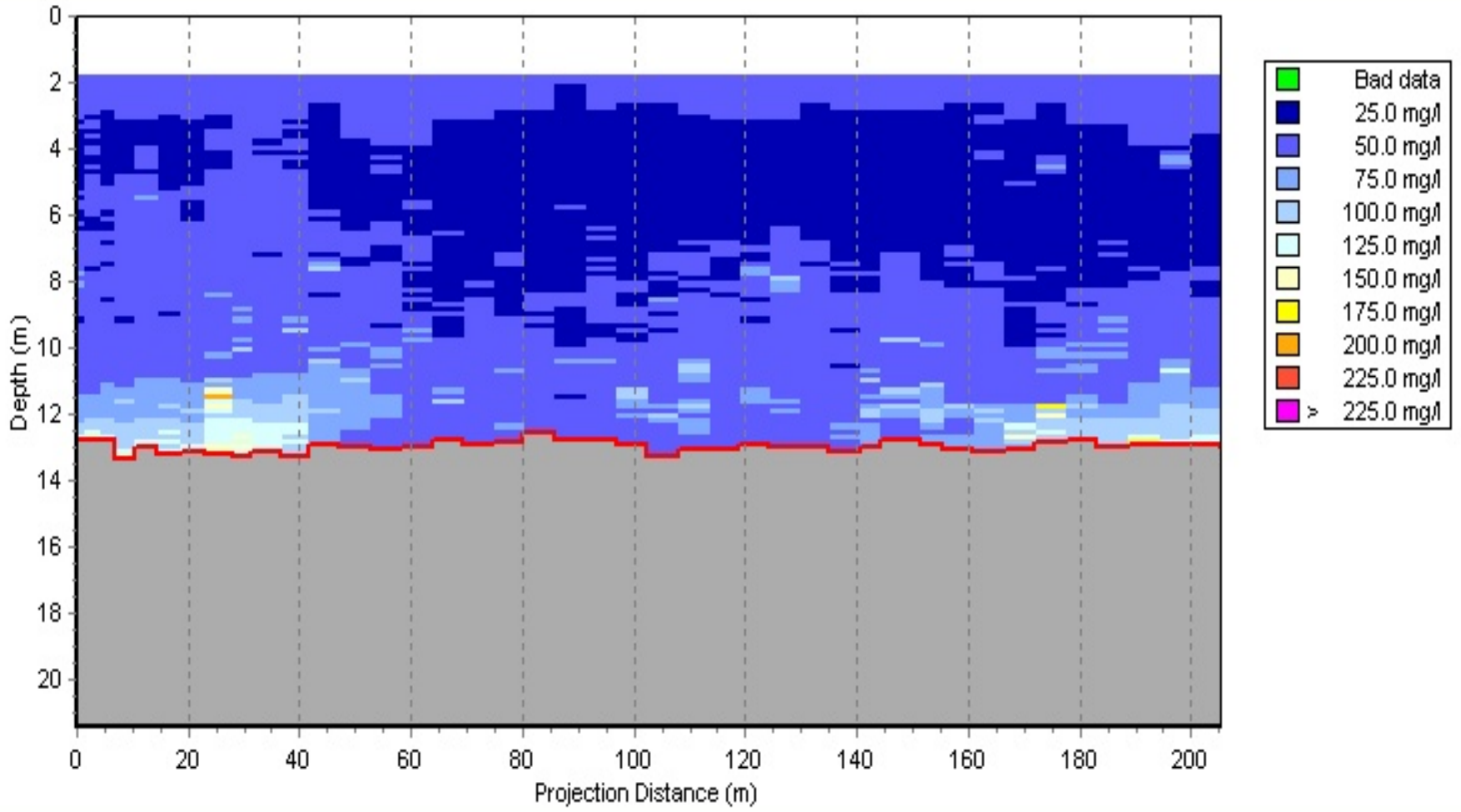
# ADCP Transect #9 – Ebb Survey

## 75 m up-current from dredge



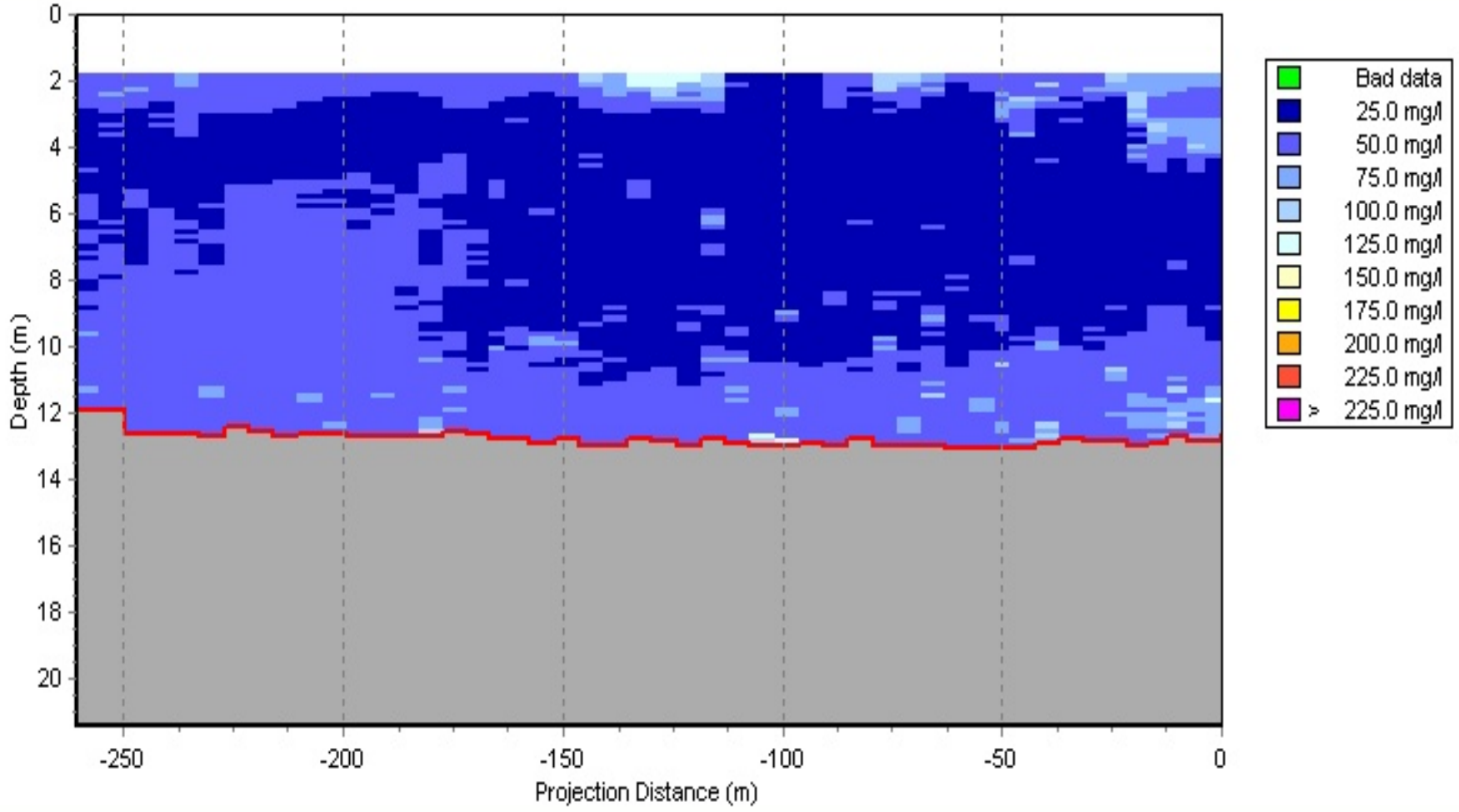
# ADCP Transect #10 – Ebb Survey

## 150 m up-current from dredge



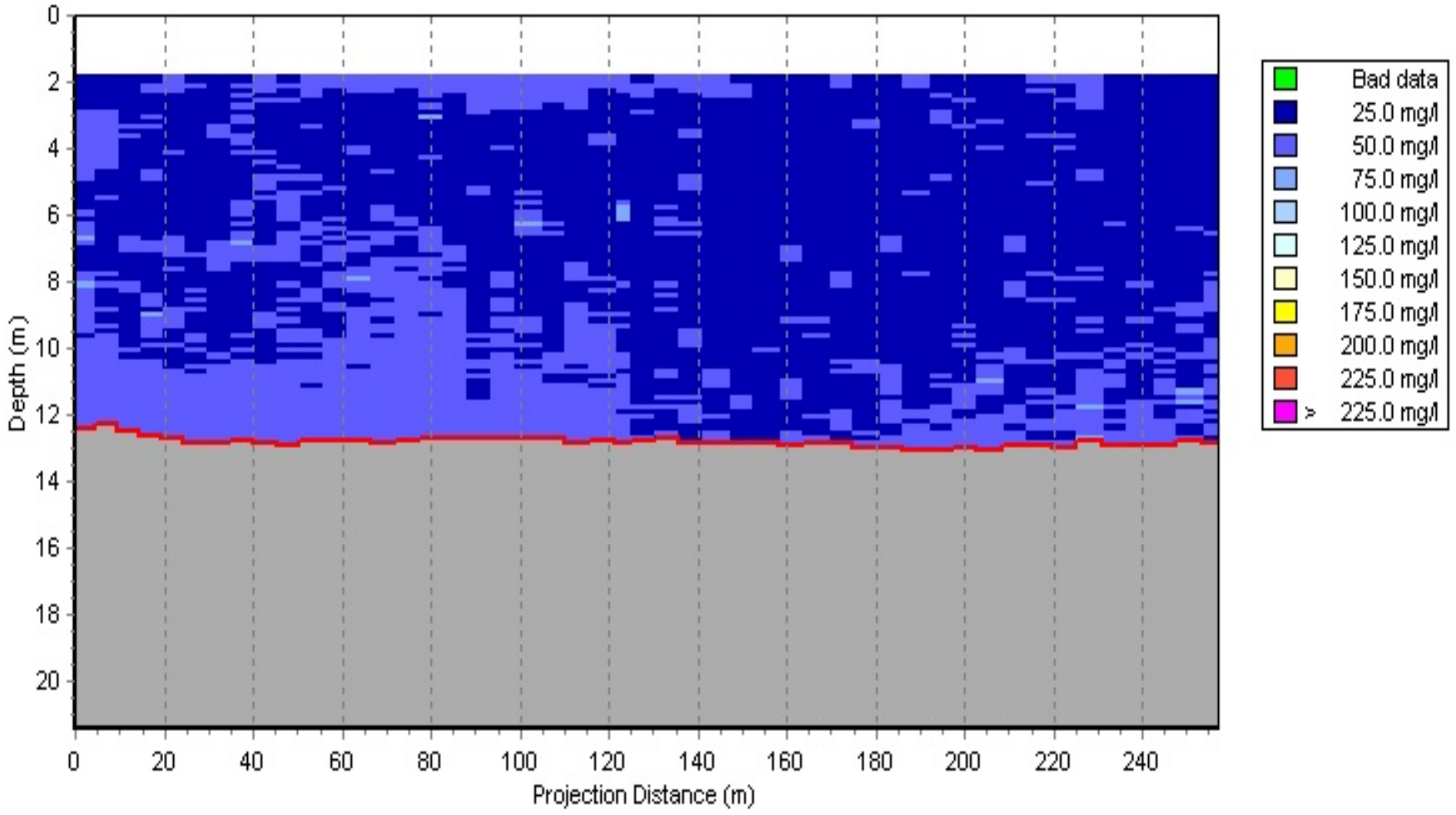
# ADCP Transect #11 – Ebb Survey

## 200 m up-current from dredge



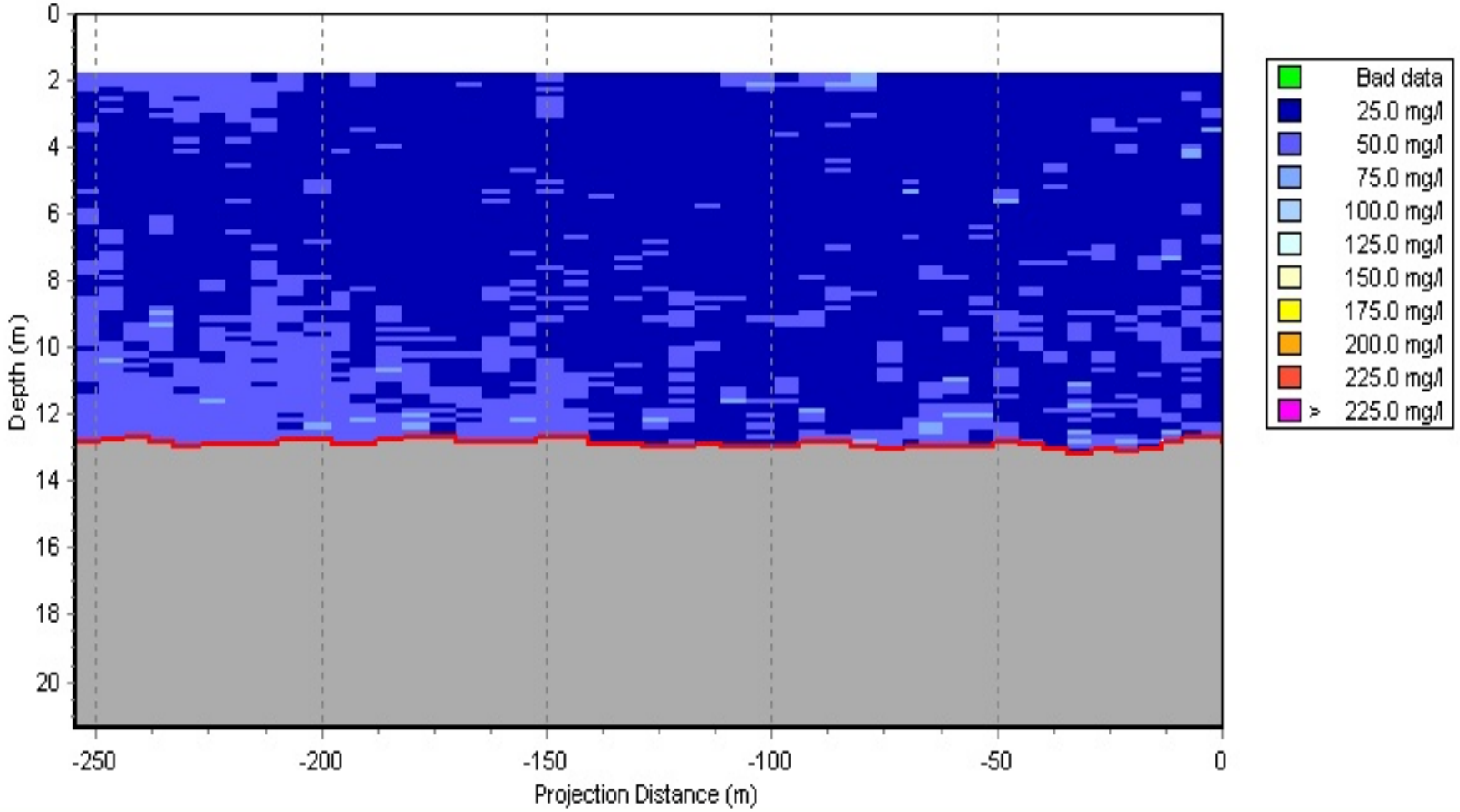
# ADCP Transect #12 – Ebb Survey

## 300 m up-current from dredge



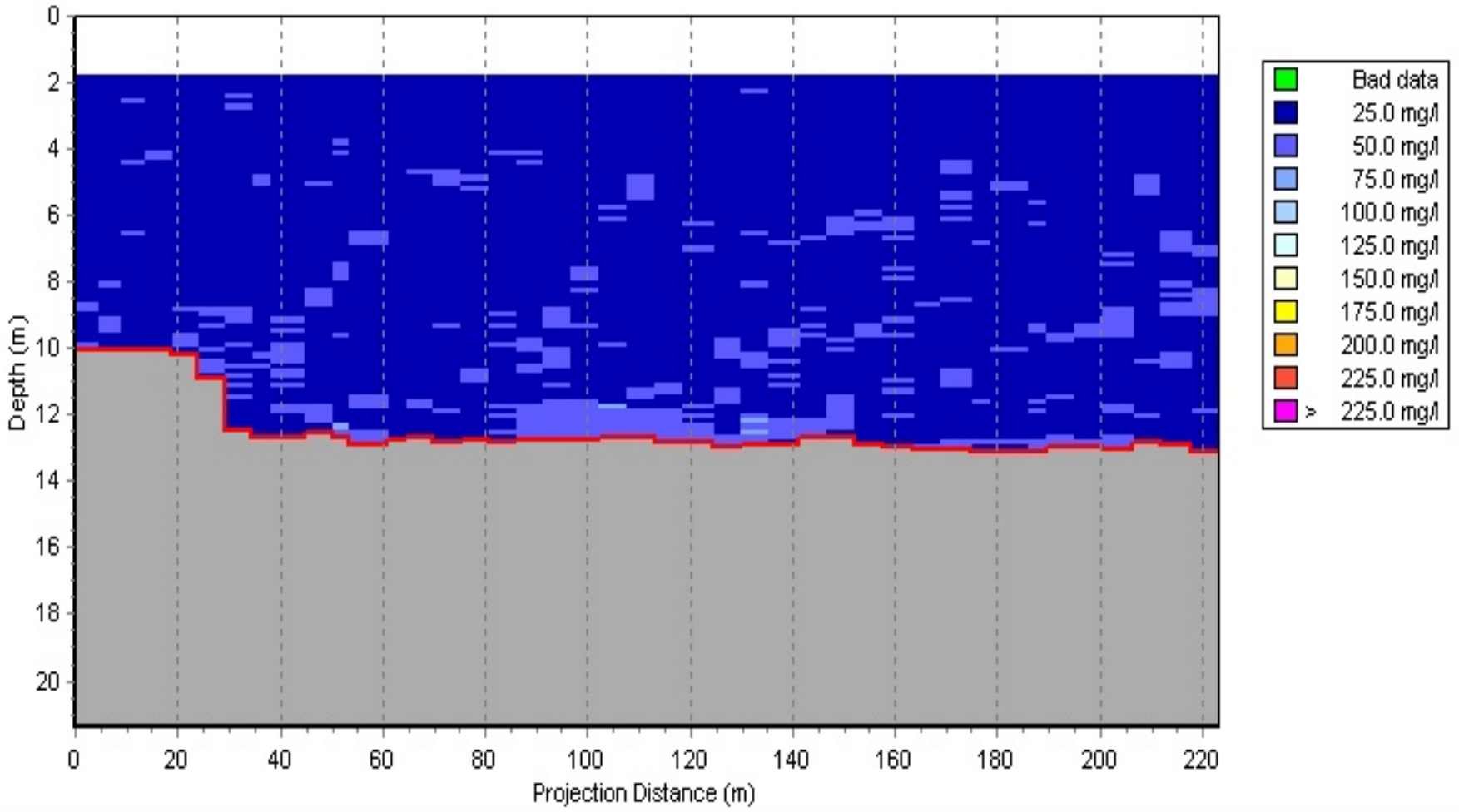
# ADCP Transect #13 – Ebb Survey

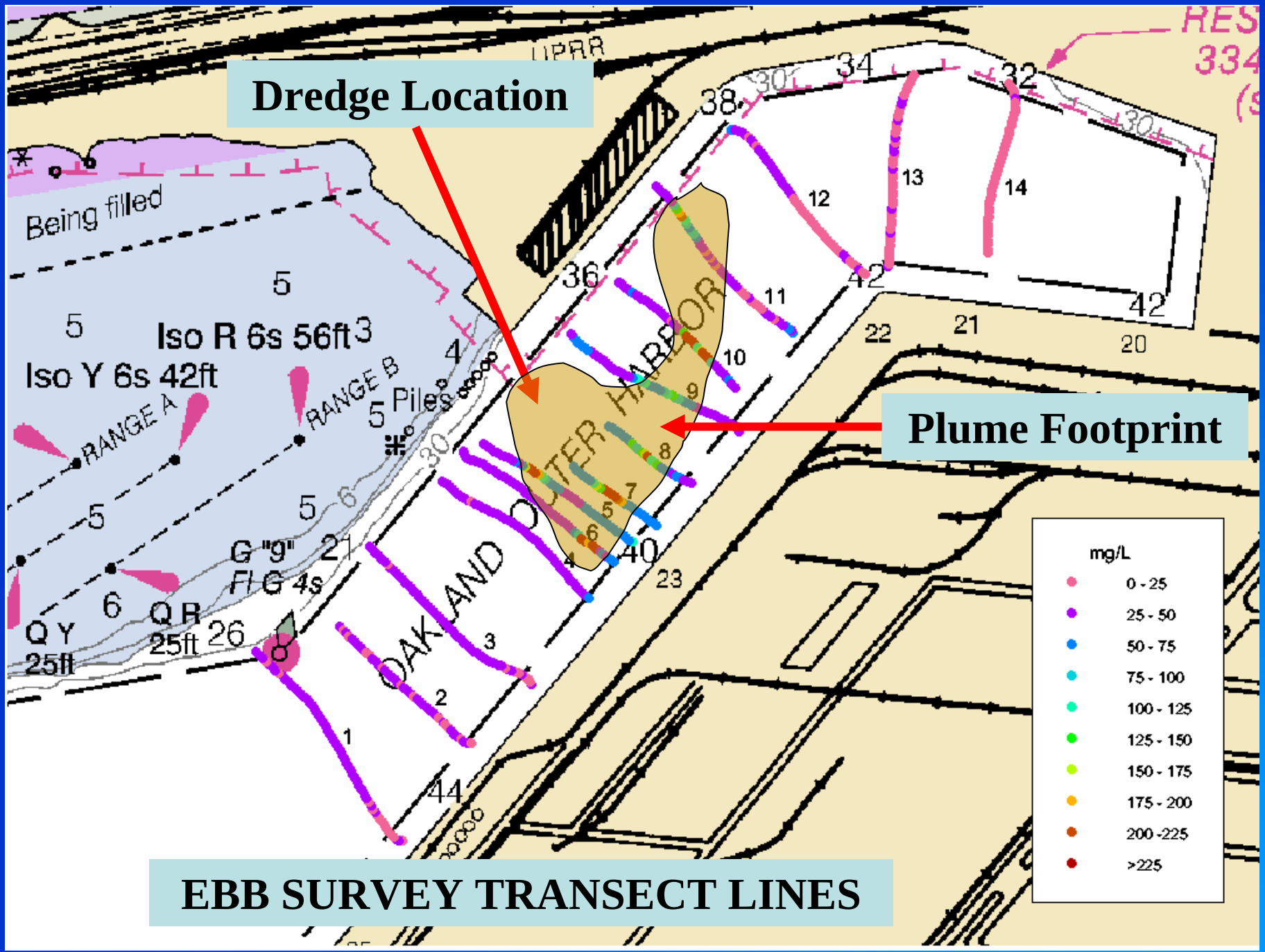
## 400 m up-current from dredge

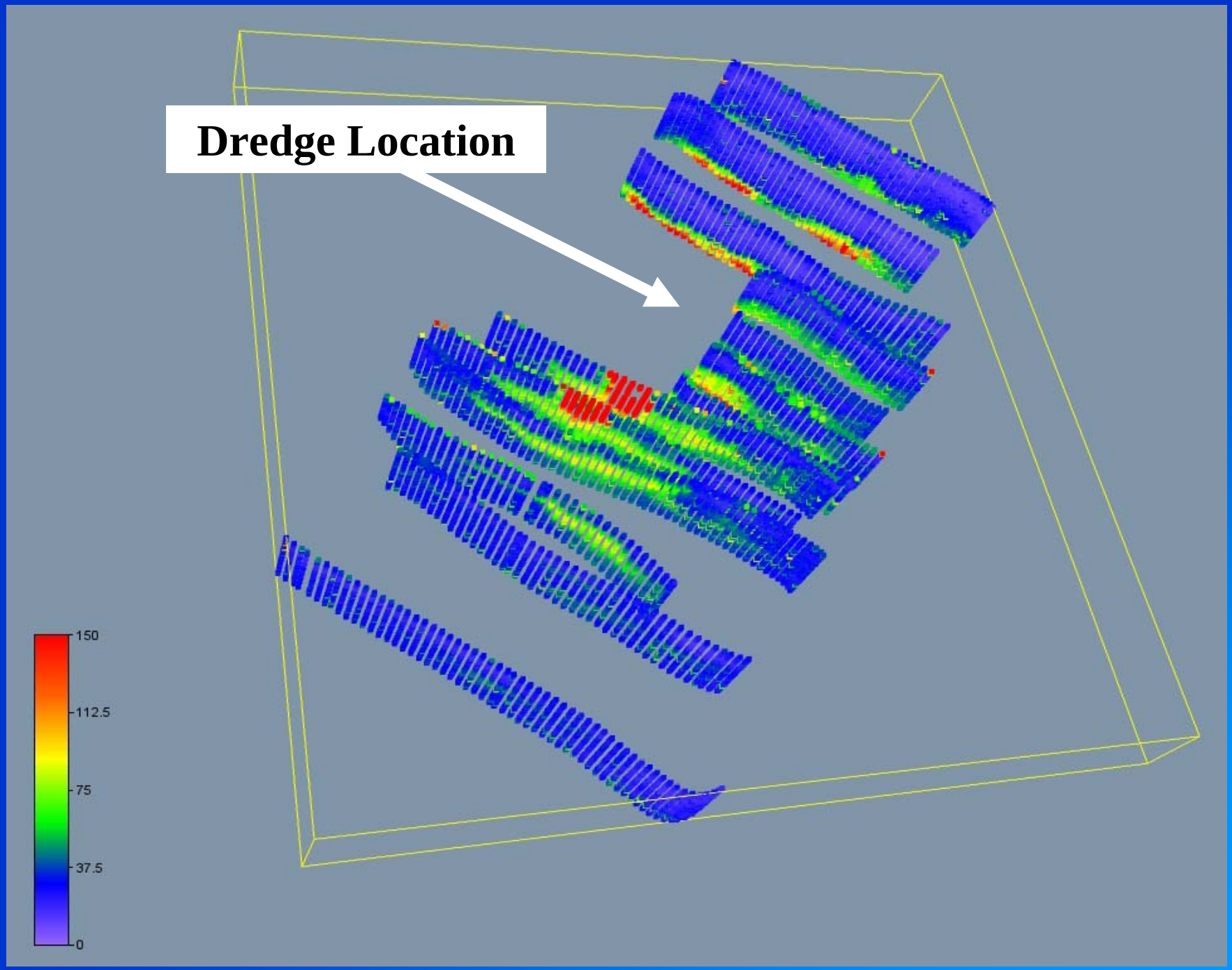


# ADCP Transect #14 – Ebb Survey

## 500 m up-current from dredge




Dredge Location
Plume Footprint
EBB SURVEY TRANSECT LINES
Being filled
Iso R 6s 56ft
Iso Y 6s 42ft
RANGE A
RANGE B
5 Piles
G "9"
Fl G 4s
Q Y
25ft
Q R
25ft
OAKLAND OUTER HARBOR
UPRR
mg/L
0 - 25
25 - 50
50 - 75
75 - 100
100 - 125
125 - 150
150 - 175
175 - 200
200 -225
>225

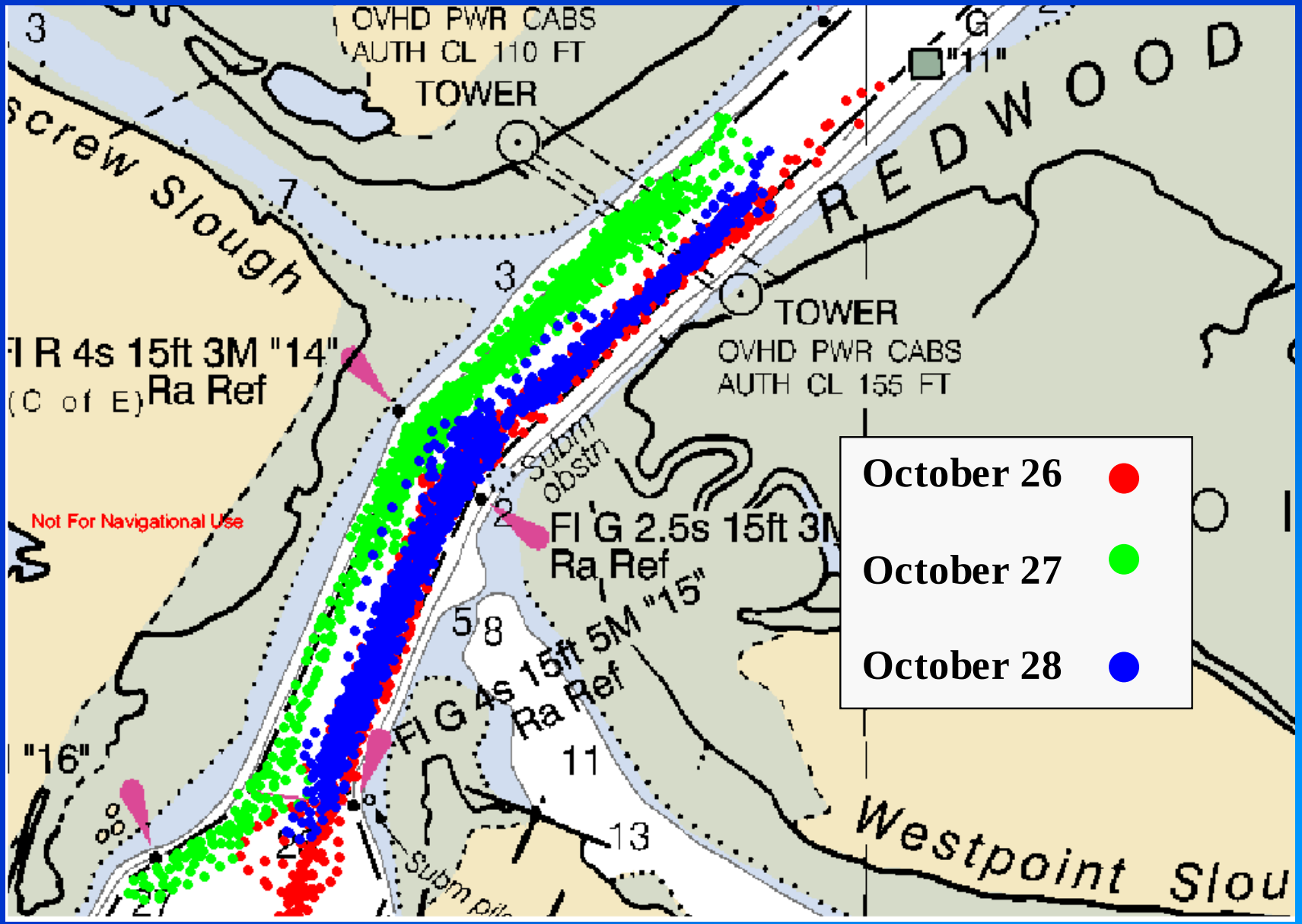

Dredge Location
150
112.5
75
37.5
0

# Conclusions
# Port of Oakland

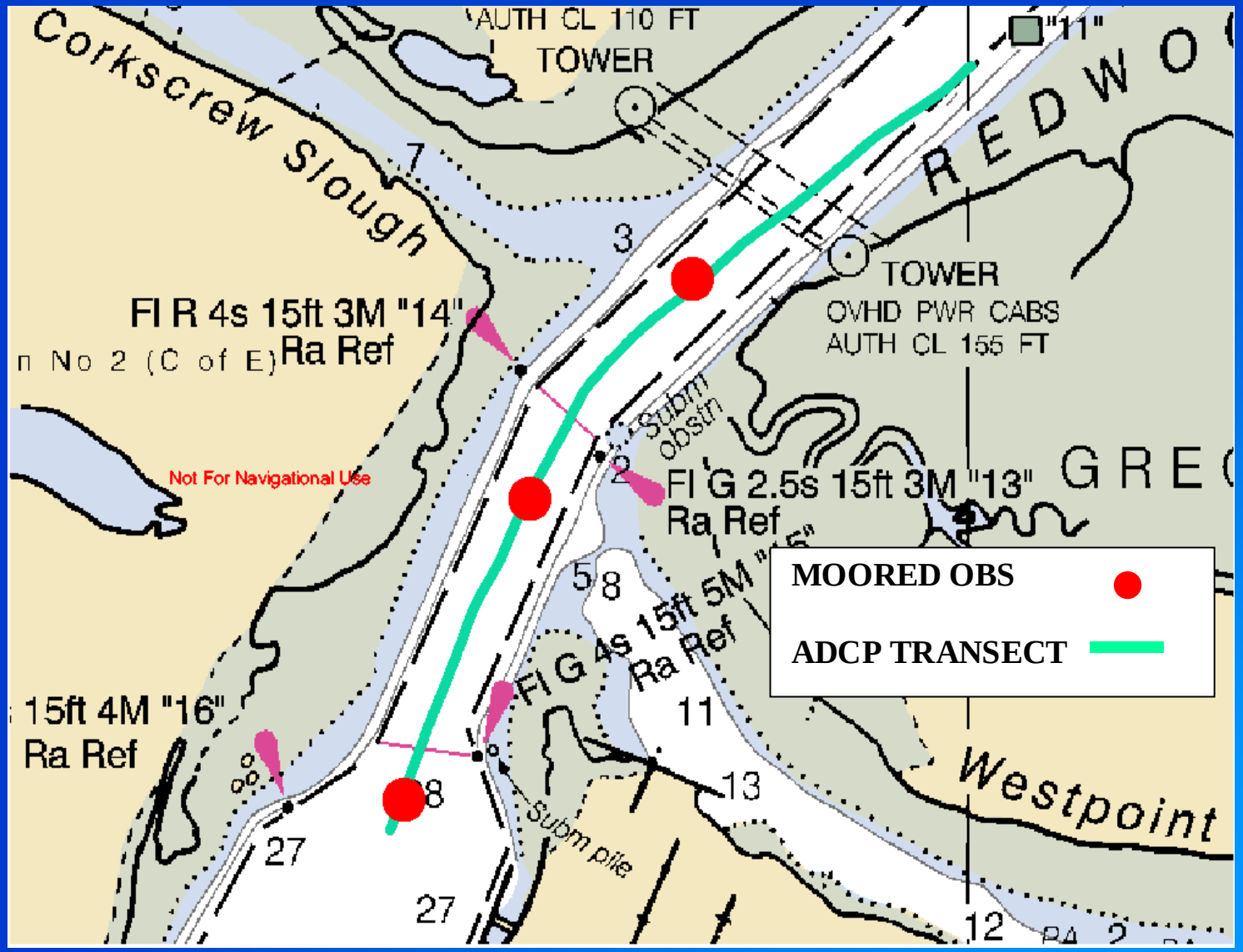
- Ambient conditions were
  - 10 - 15 mg/L at surface
  - 25 – 50 mg/L at bottom
- Plumes were
  - Driven by weak currents during flood and ebb tides (<25 cm/sec)
  - Largely confined to lower water column
  - Minimized by closed bucket
  - Peak concentrations ~ 275 mg/l except at source
  - Decayed to background within ~ 400 m

# Results
# Redwood Creek,
# Port of Redwood City

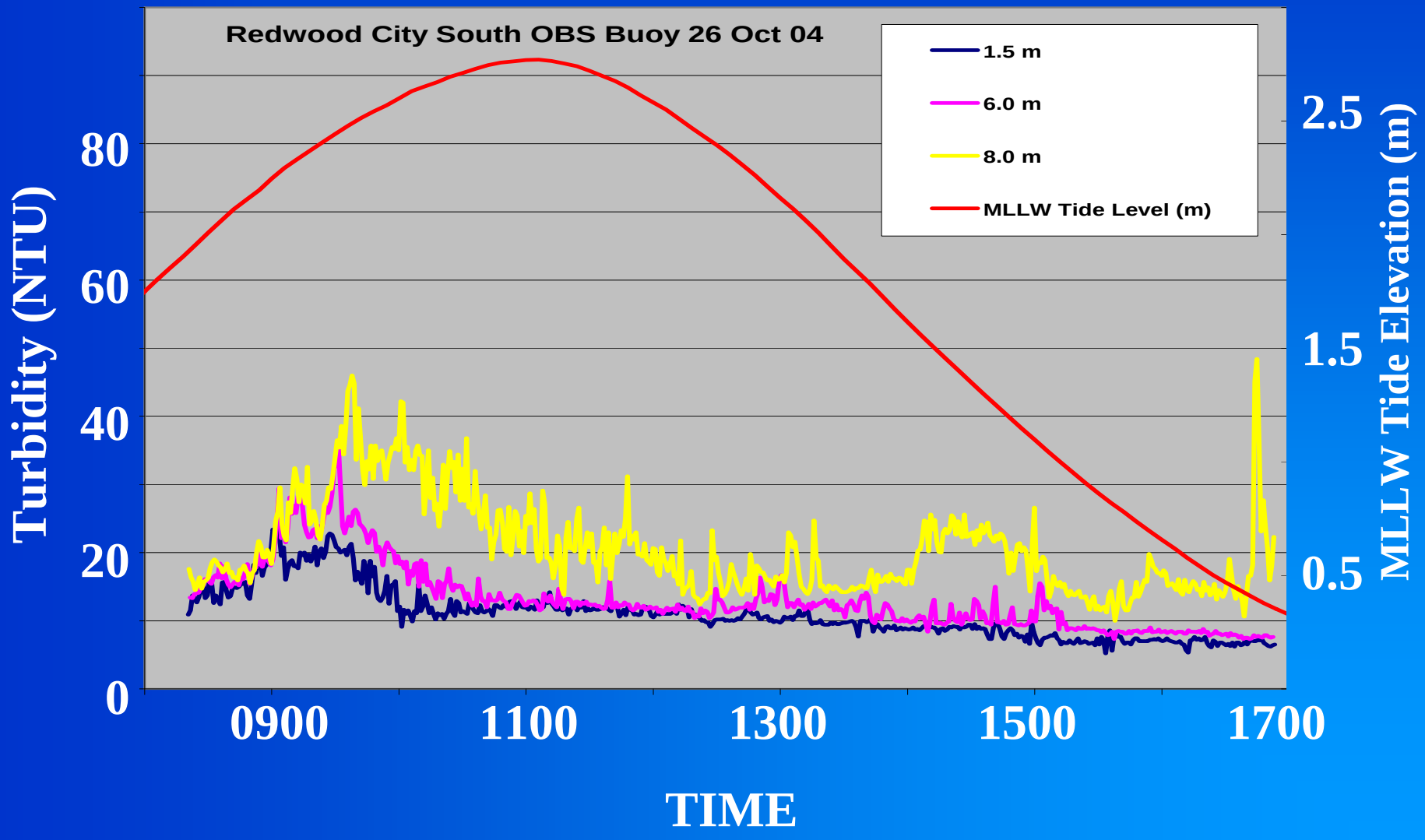
# Knockdown Operations



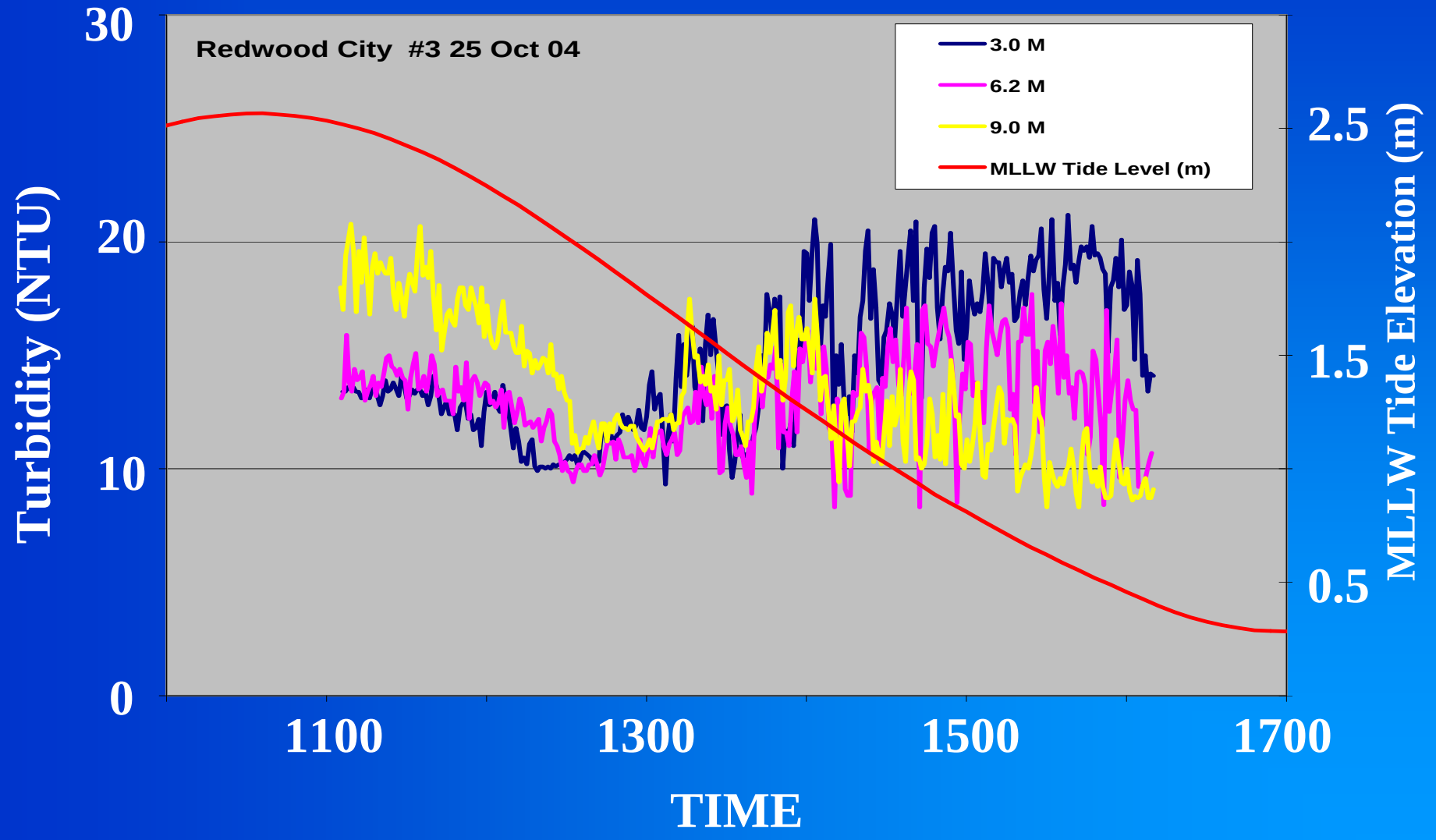
# Ambient Turbidity Stations



# Ambient Turbidity At Port-side Buoy

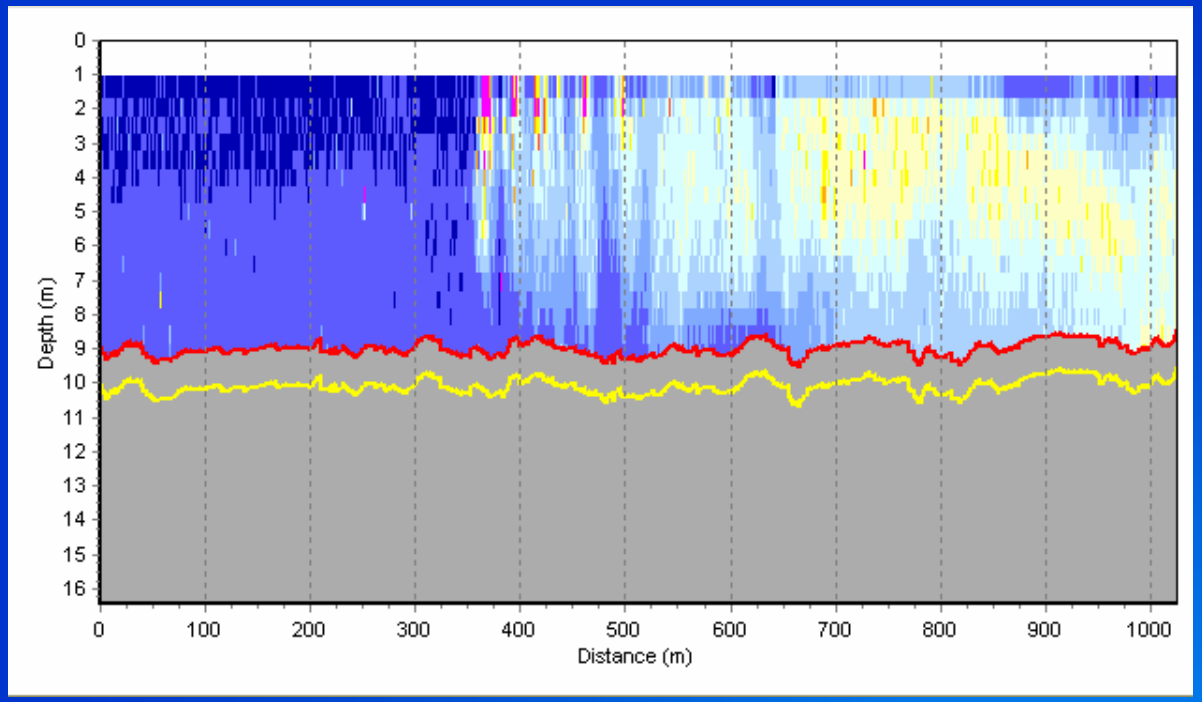


# Ambient Turbidity At Bay-side Buoy

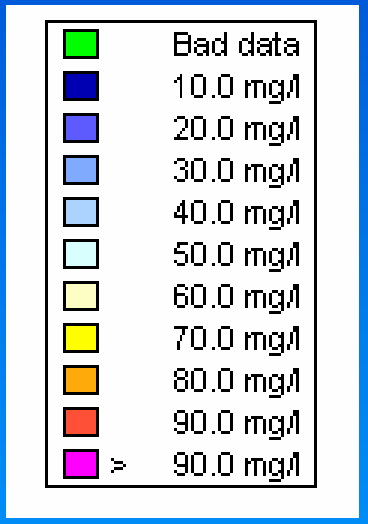


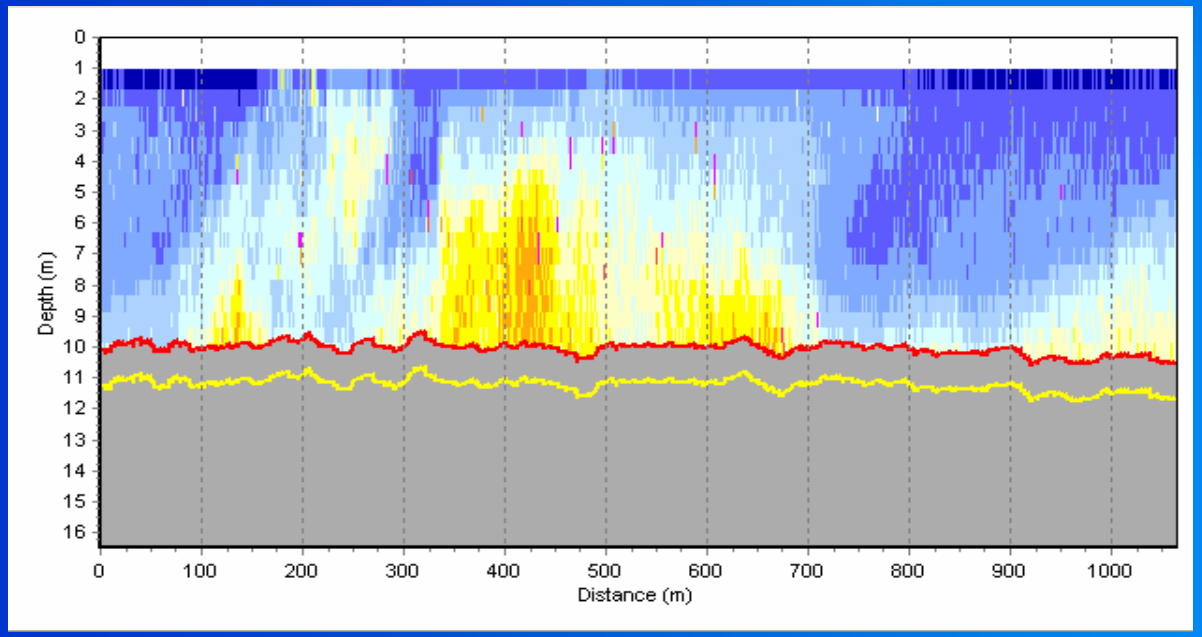
Corkscrew Sough


Westpoint Slough




## Ambient Ebb Tide Profile



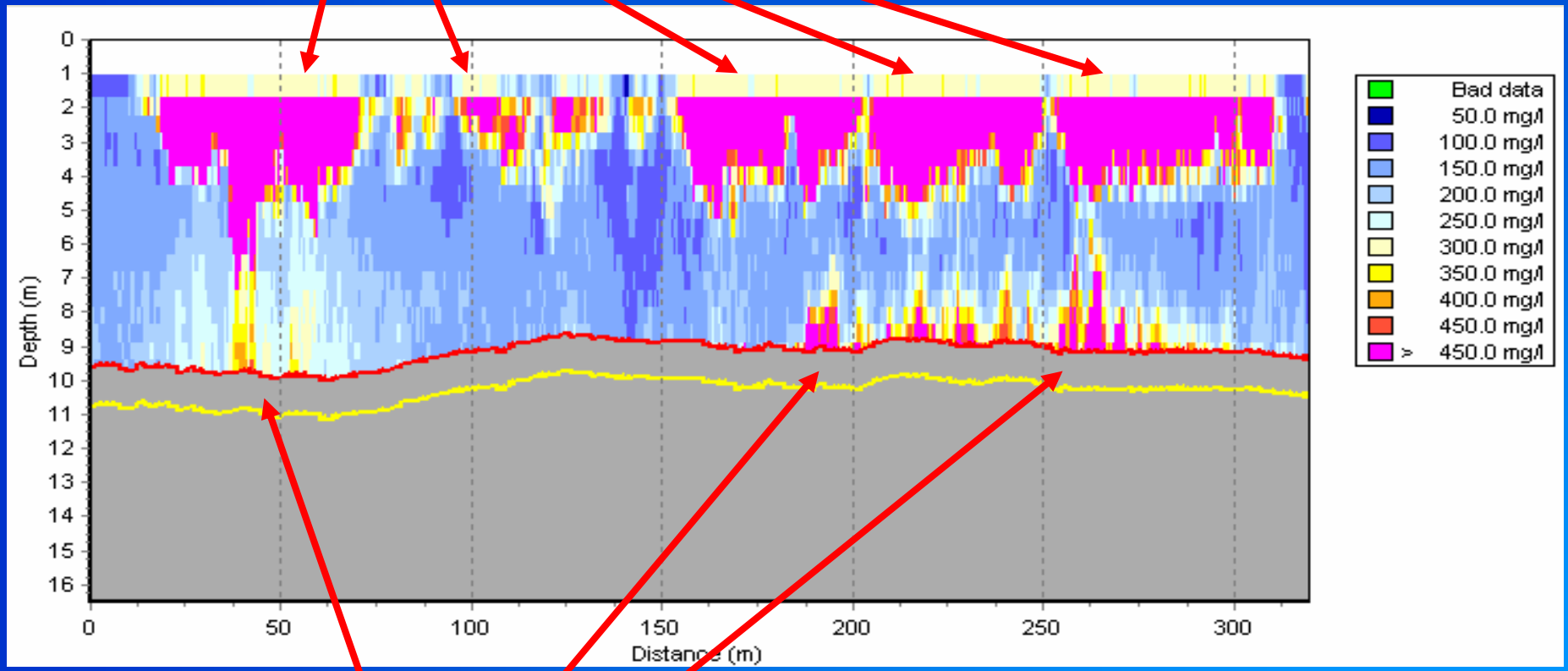




## Ambient Flood Tide Profile


**Parallel Surveys Conducted At Consistent Distance Behind Barge**

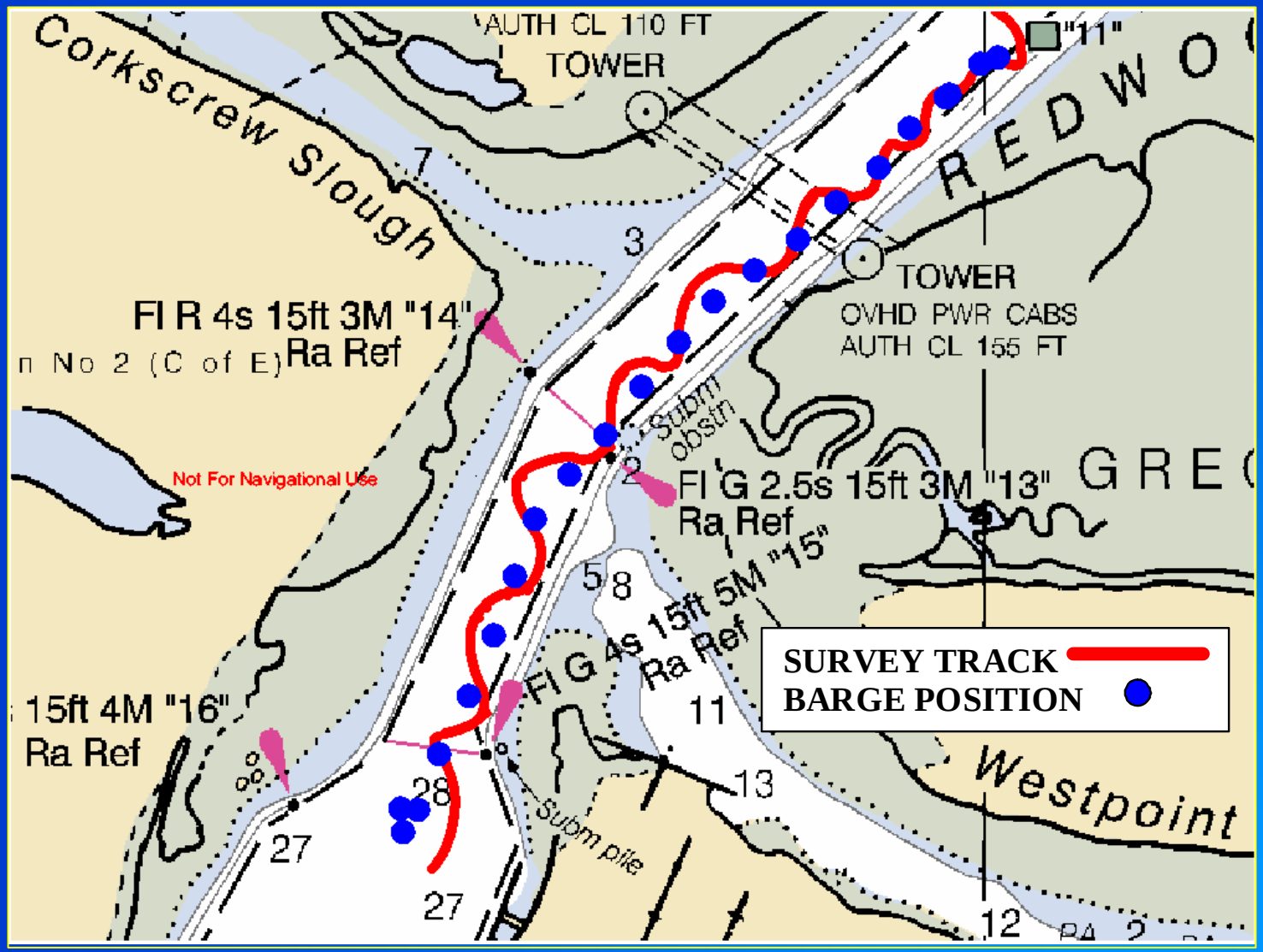
# Parallel Transect 55 Meters From Barge

Prop Wash

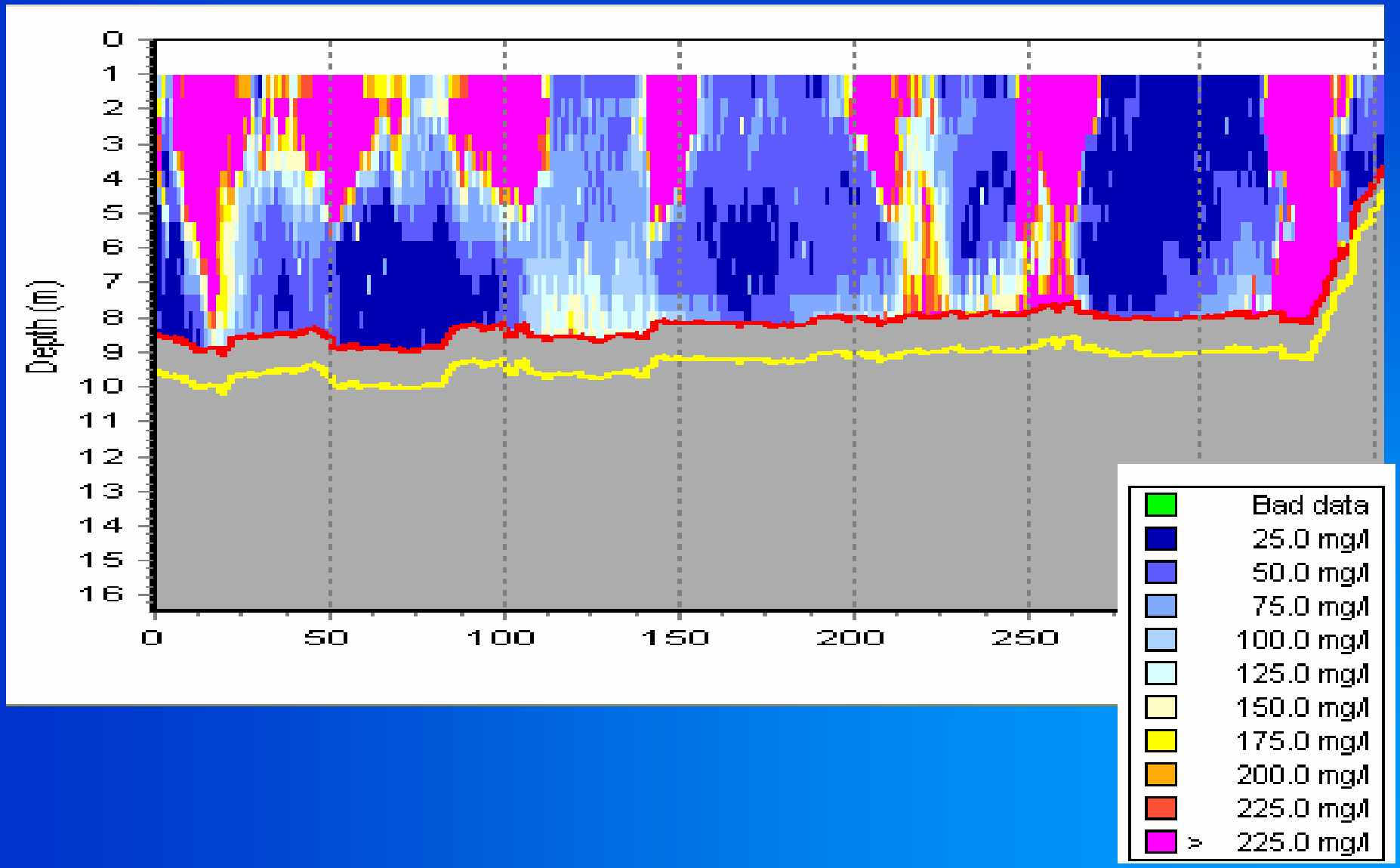



Resuspension

# Zig-Zag ADCP Survey Lines



# ZIG-ZAG SURVEYAT 70 METERS FROM BARGE

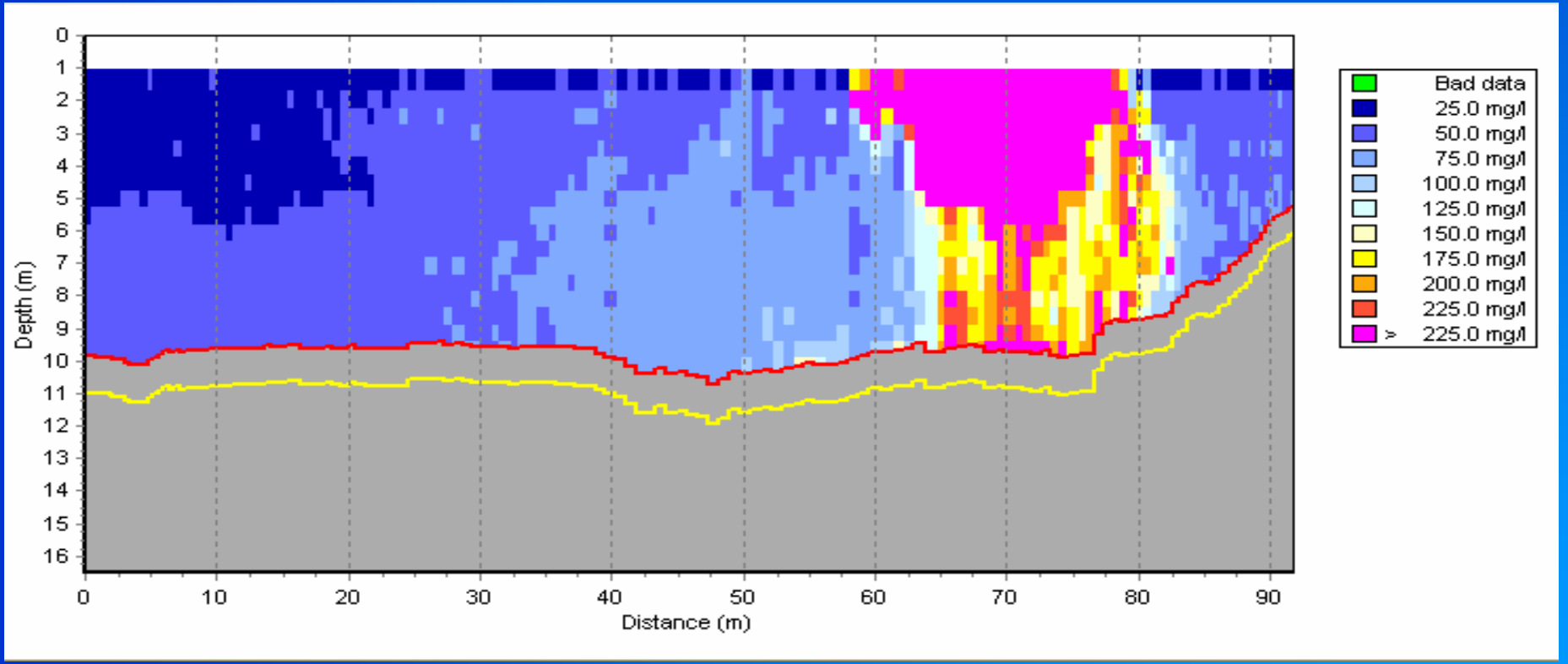


# ADCP Repetitive Perpendicular Transect Time Series 1 - Ebb Survey

# ADCP Transect – Ebb Survey

## Time Reference = 0

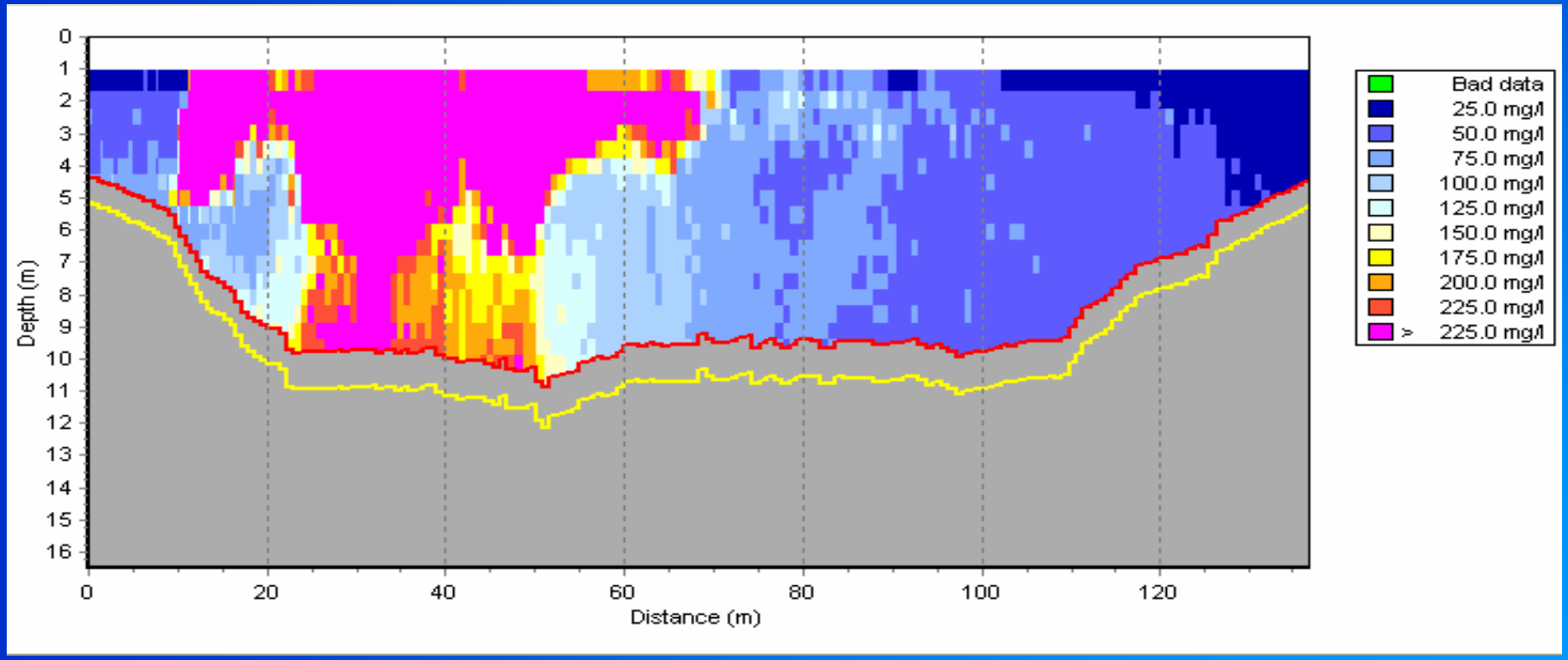
## Distance to Barge = 60 m



# ADCP Transect – Ebb Survey

## Time Reference = 2 minutes

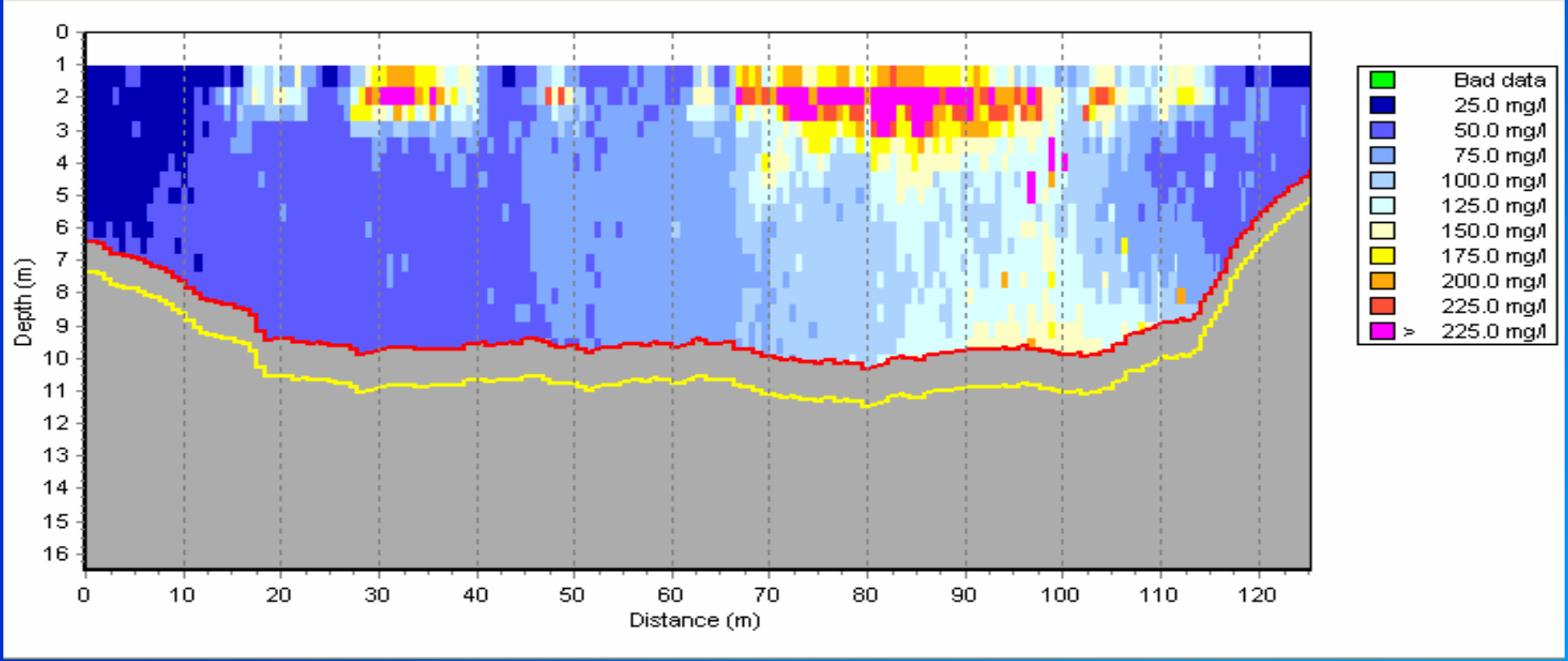
## Distance to Barge = 200 m



# ADCP Transect – Ebb Survey

## Time Reference = 5 minutes

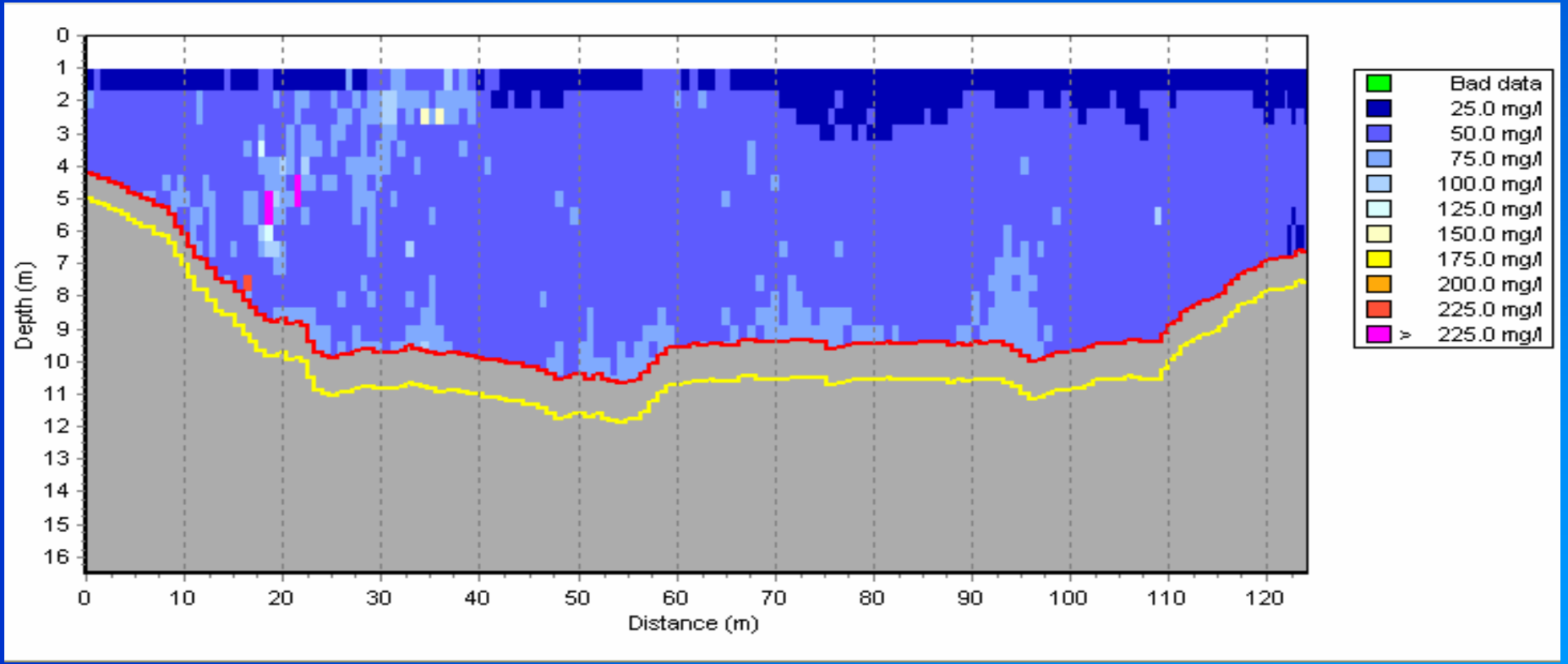
## Distance to Barge = 235 m



# ADCP Transect – Ebb Survey

## Time Reference = 7 minutes

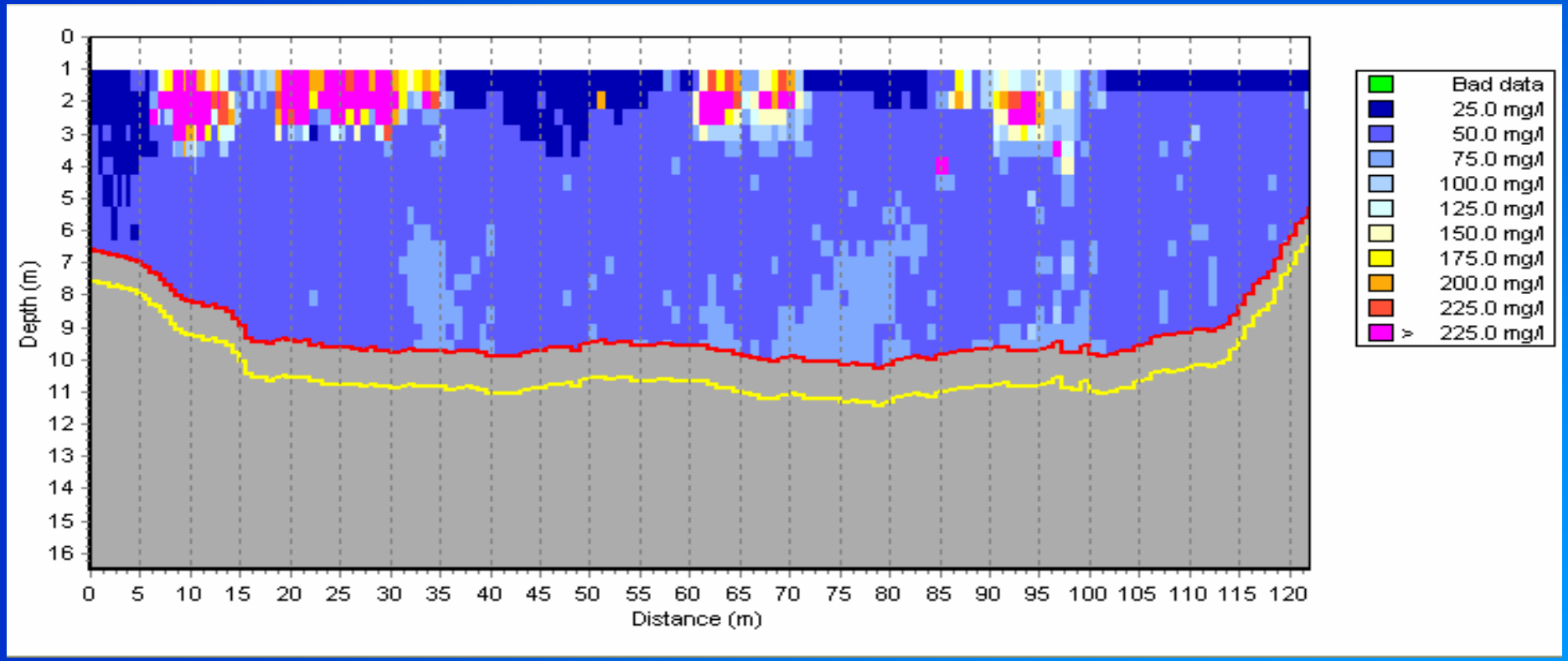
## Distance to Barge = 300 m



# ADCP Transect – Ebb Survey

## Time Reference = 9 minutes

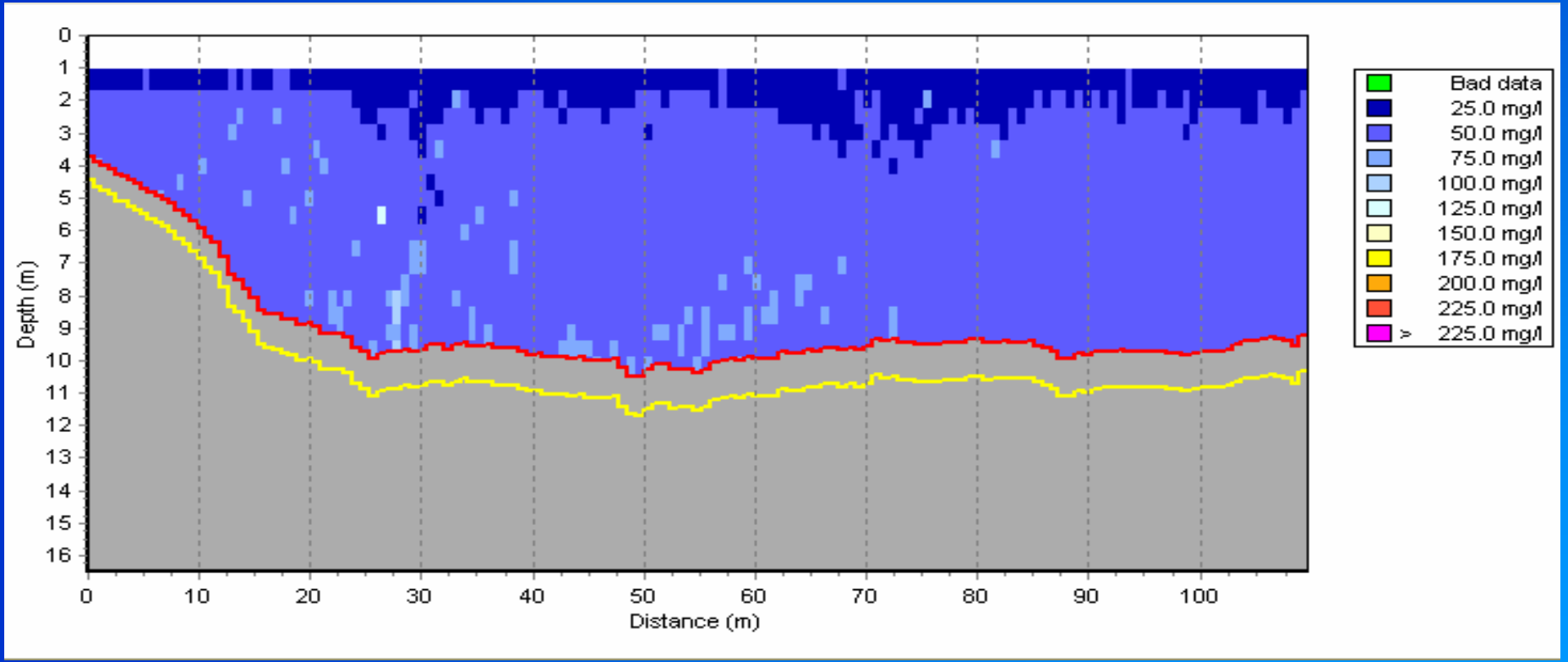
## Barge Approaching



# ADCP Transect – Ebb Survey

## Time Reference = 11 minutes

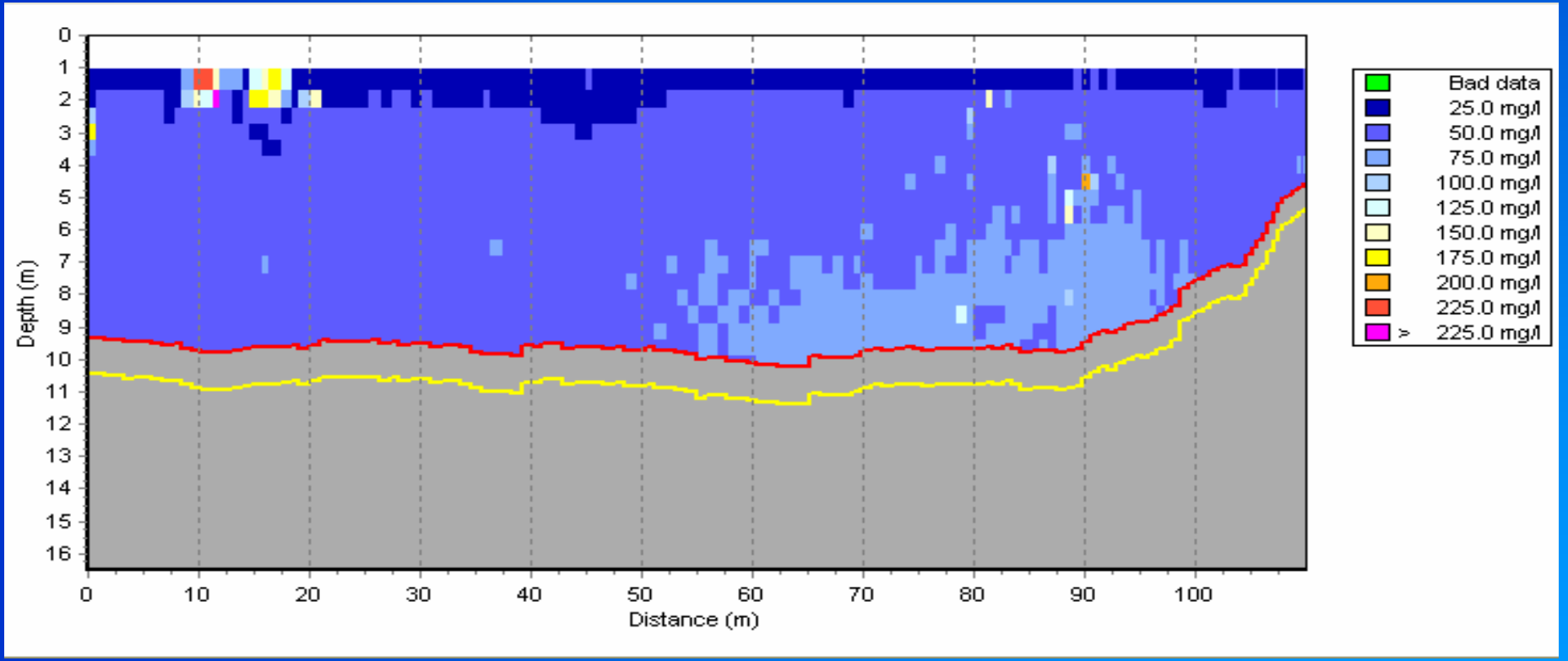
## Barge Approaching



# ADCP Transect – Ebb Survey

## Time Reference = 13 minutes

## Barge Approaching

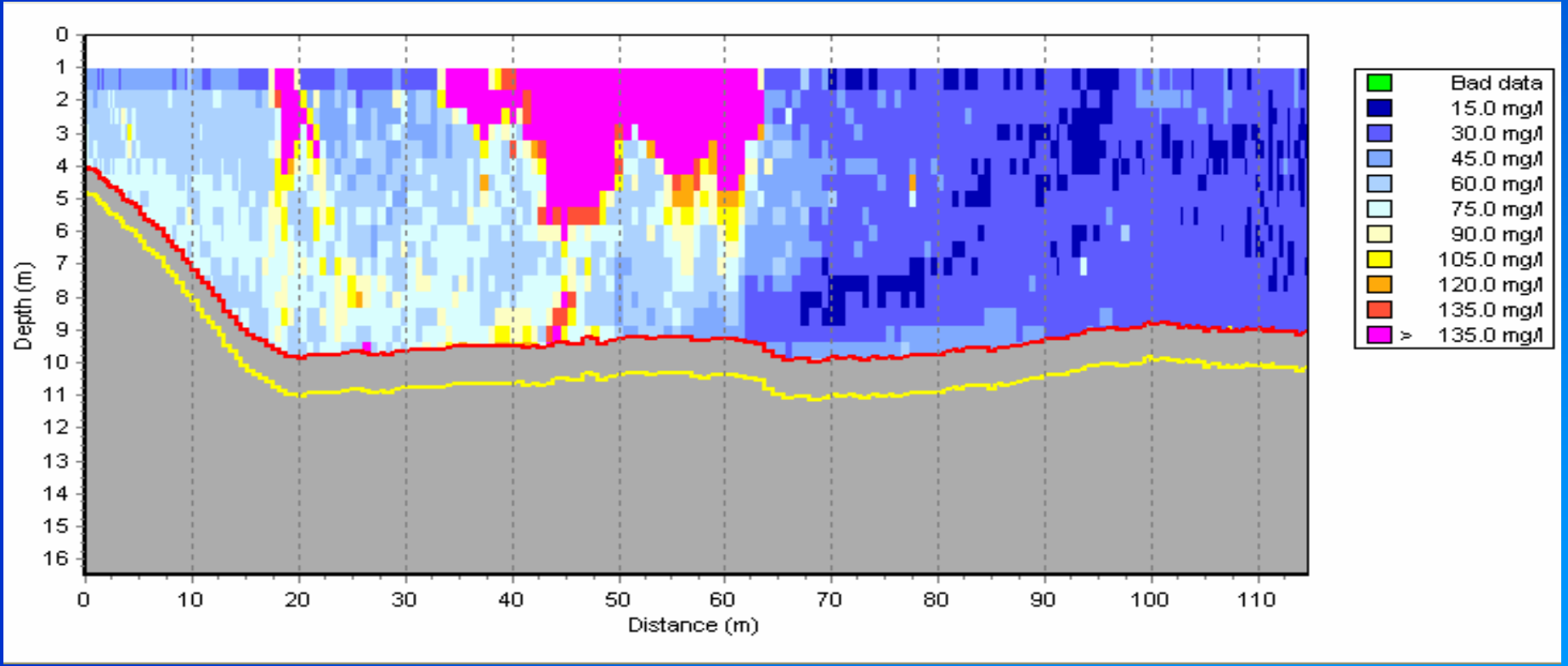


# ADCP Repetitive Perpendicular Transect Time Series 2 - Ebb Survey

# ADCP Transect – Ebb Survey

## Time Reference = 0

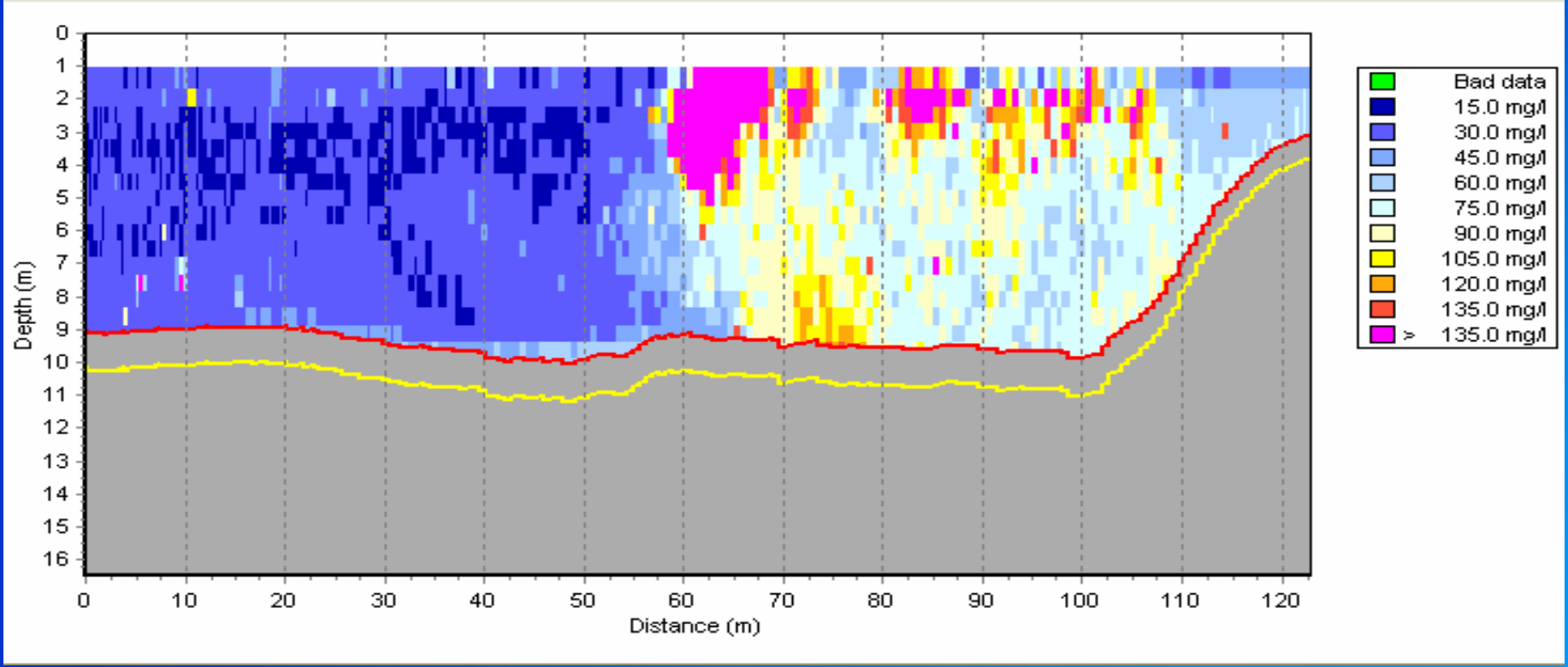
## Distance to Barge = 30 m



# ADCP Transect – Ebb Survey

## Time Reference = 2

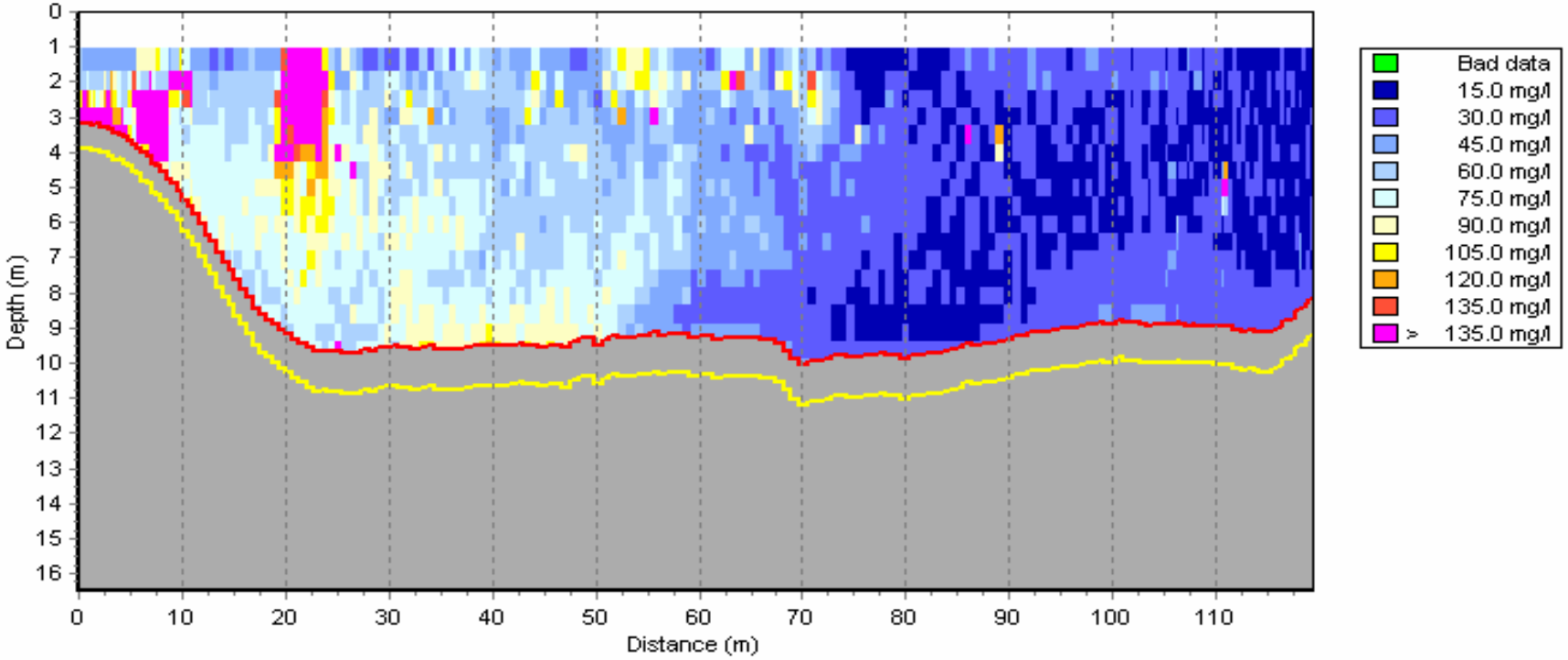
## Distance to Barge = 240 m



# ADCP Transect – Ebb Survey

## Time Reference = 5 minutes

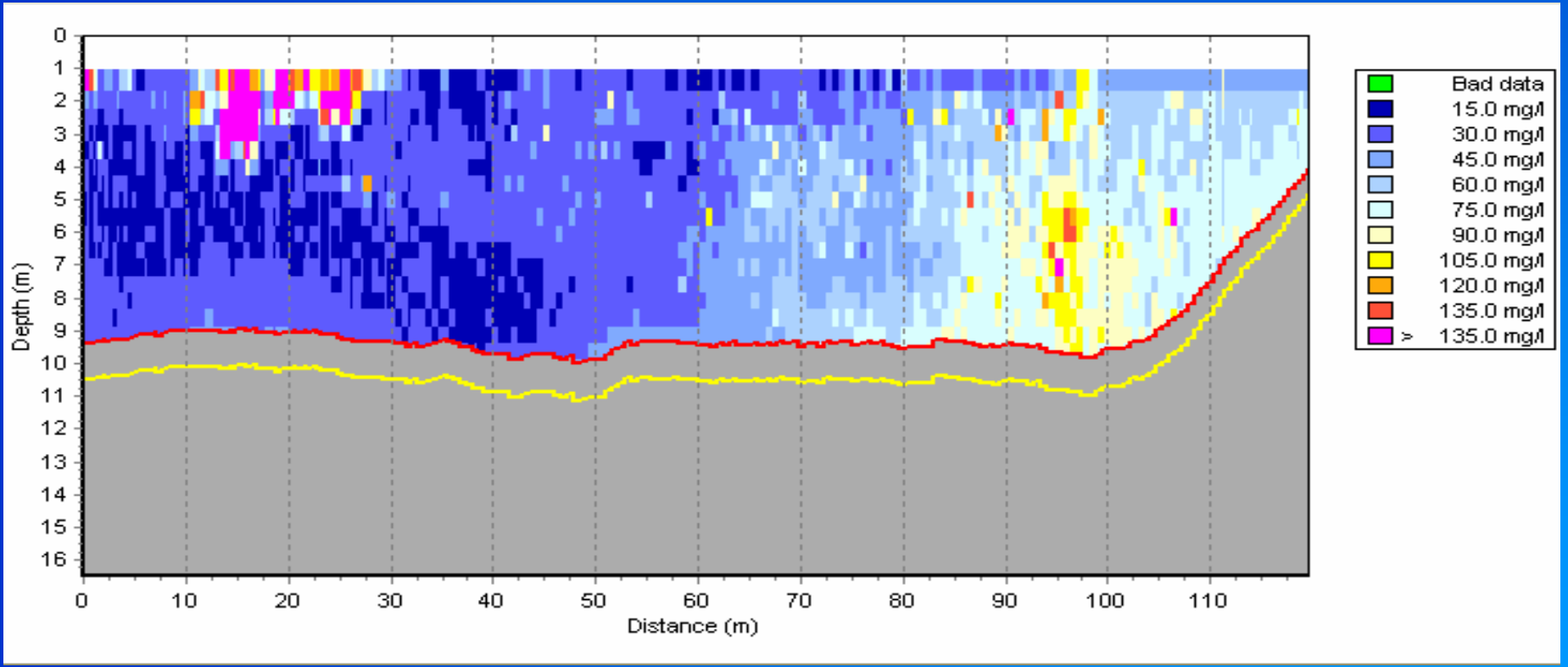
## Distance to Barge = 445 m



# ADCP Transect – Ebb Survey

## Time Reference = 7 minutes

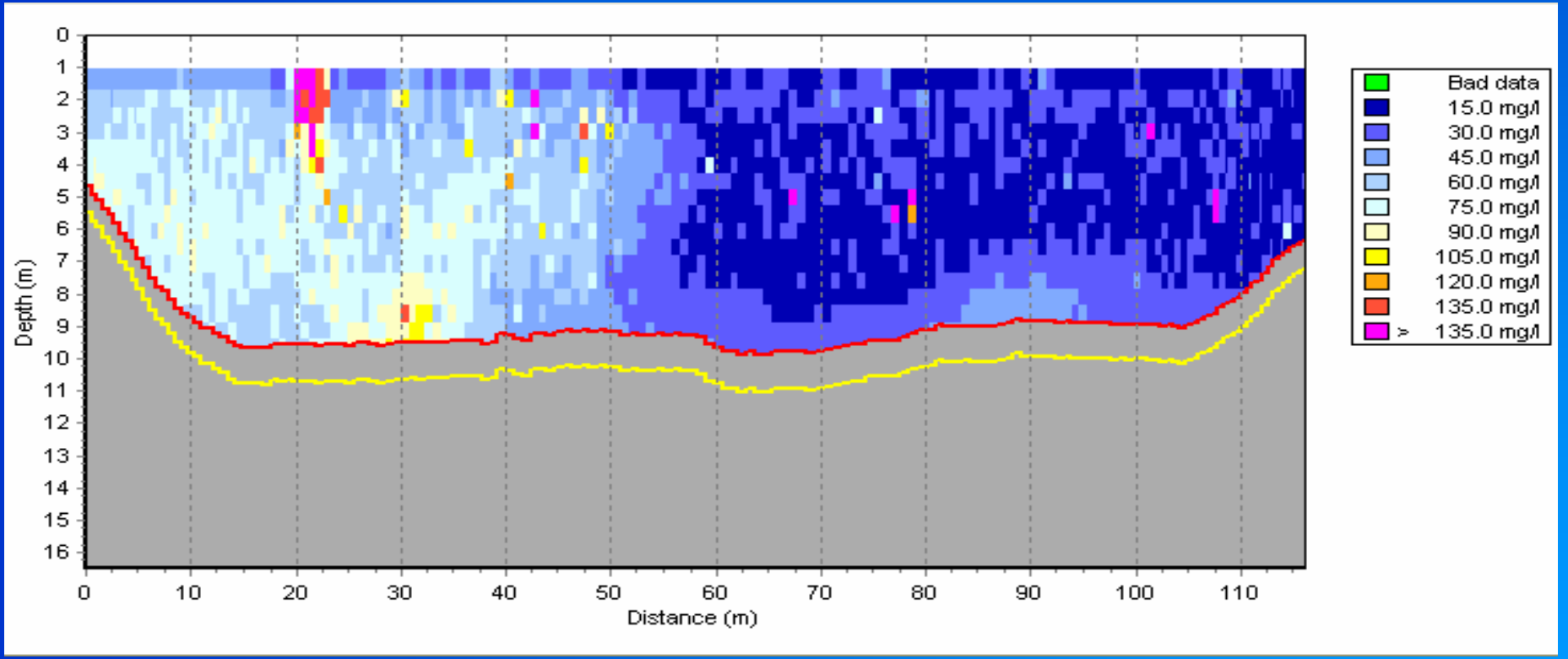
## Barge Turning Around



# ADCP Transect – Ebb Survey

## Time Reference = 9 minutes

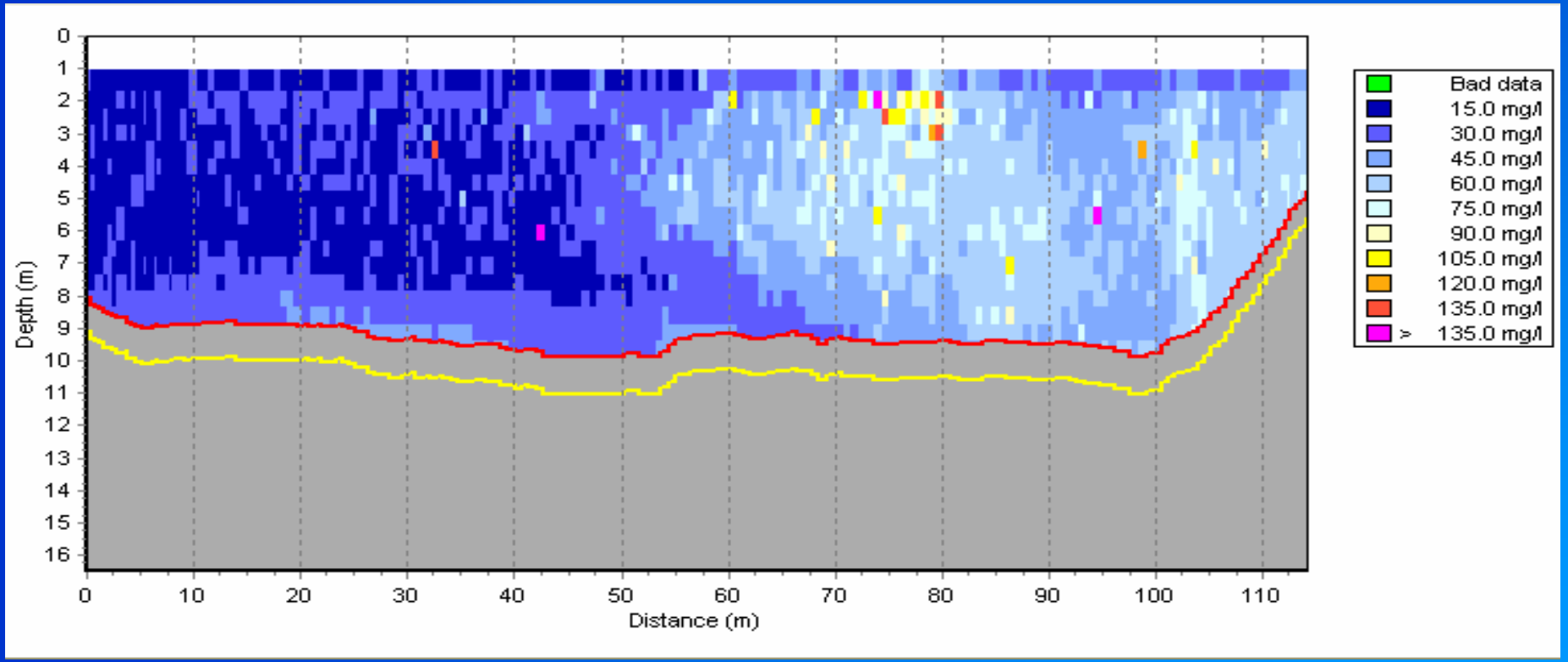
## Barge Approaching



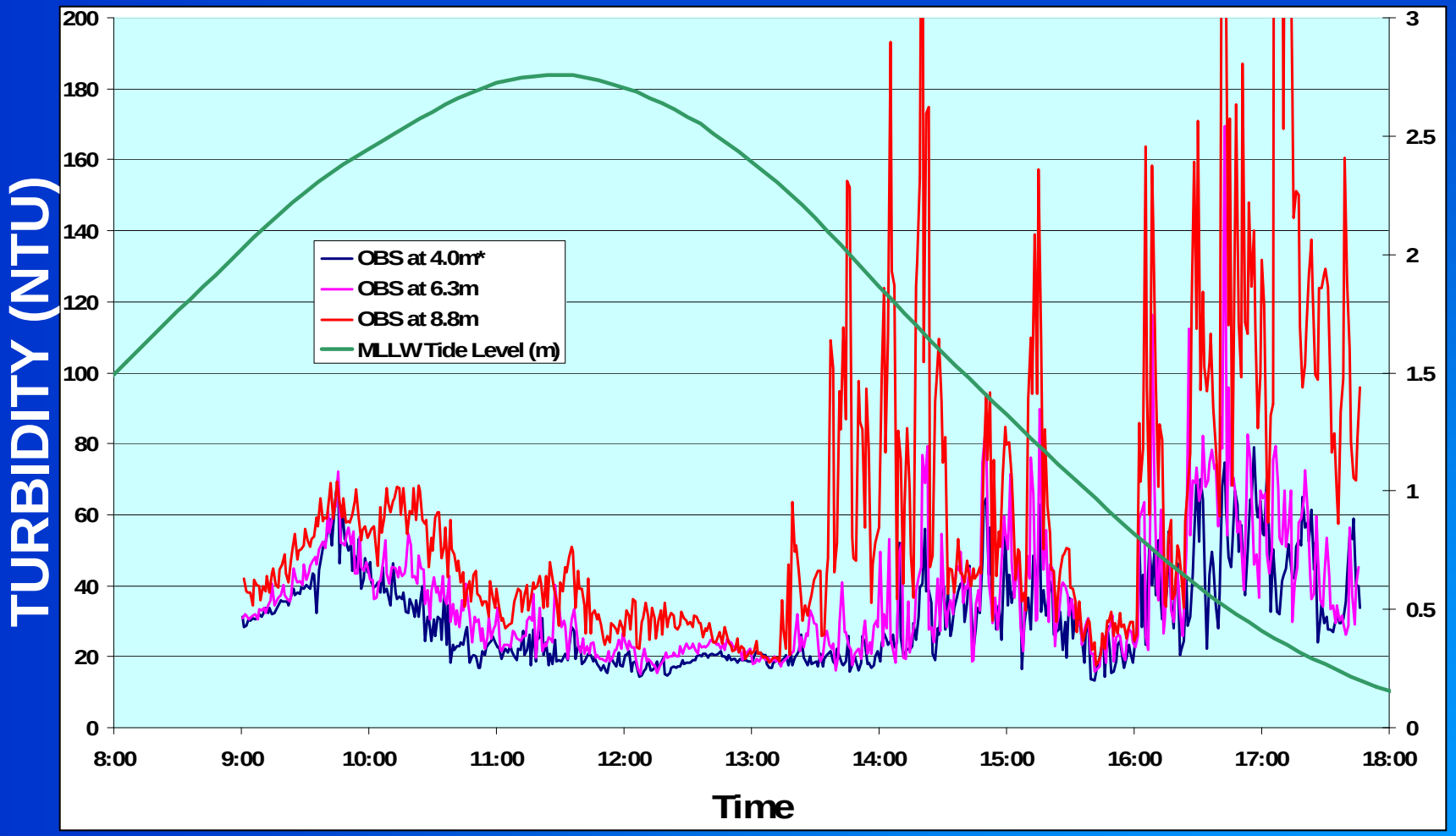
# ADCP Transect – Ebb Survey

## Time Reference = 11

## Barge Approaching



# Turbidities At Bay-side Buoy On 27 Oct 2004



# Conclusions
# Port of Redwood City

- Ambient conditions were
  - 10 - 60 mg/L at surface
  - 30 - 90 mg/L at bottom
- Plumes were
  - Temporally variable, spatially consistent
    - Spatial dependent on footprint of deposit and power applied by tug to “dig” with beam
  - Higher concentrations largely confined to lower water column
  - Peak concentrations ~ 600 mg/L after passage of beam
  - Decayed to ~ 200 mg/L within 5 – 6 minutes
  - Residual plumes (~ 50 - 100 mg/L) can persist between cycles of barge

# Plume Monitoring

- How much is enough?
- Is it adaptive?
- Can the need for an environmental window be evaluated with existing data?
- What insights can be gained into the effectiveness of compliance monitoring?