Sediment Tracer Study
at the Mouth of the Columbia River

An Investigation to Determine the FATE of Dredged Sediment

Placed at the Shallow Water Site (SWS)

THE TRACER TEAM

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U.S. Army Corps of Engineers, Portland District

US Army Corps of Engineers ®
Portland District

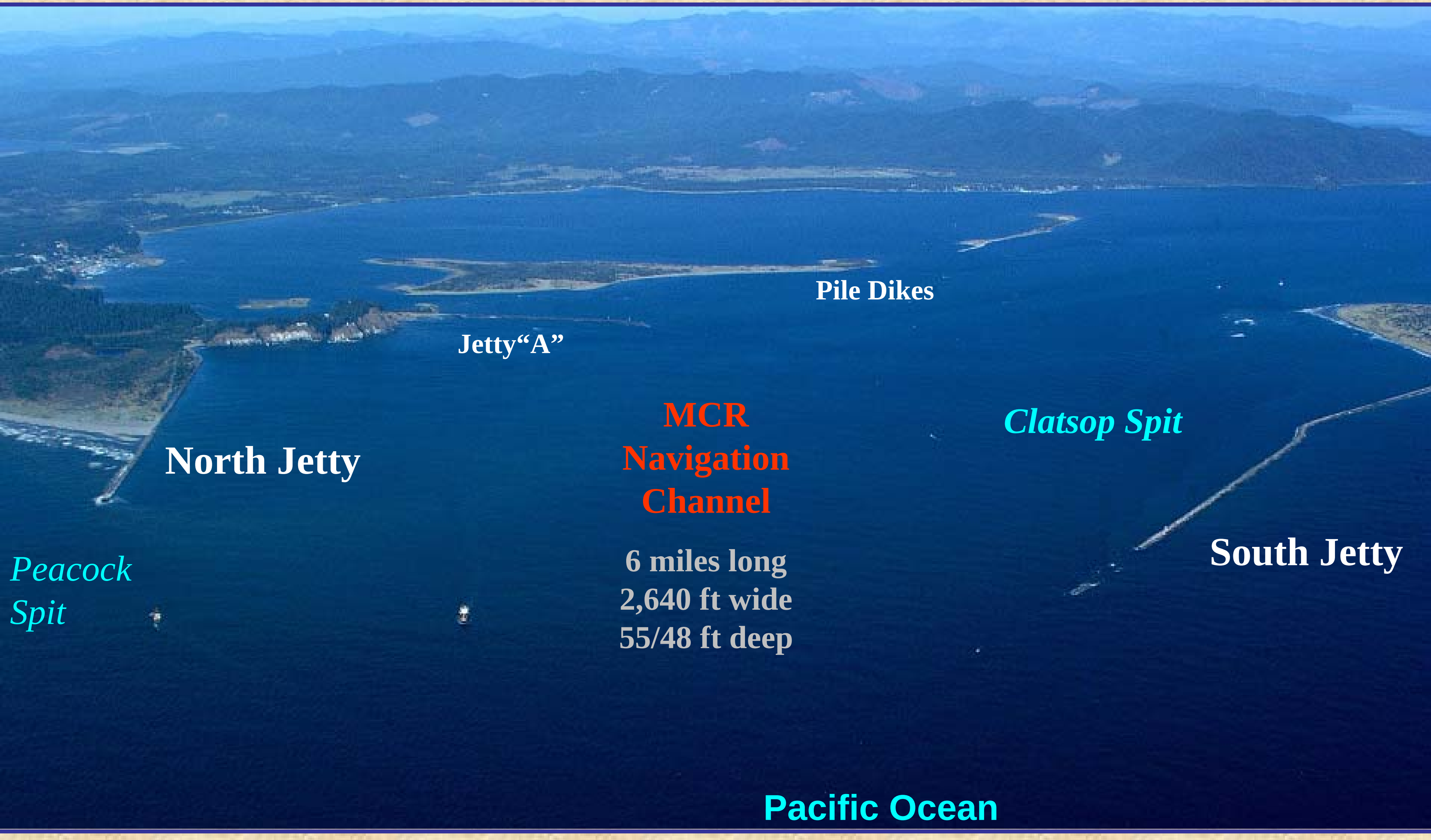
Overview

- MCR Dredging & Disposal - Motivation
- Sediment Tracer at MCR
- Tracer Execution
- Tracer Results to Date
- Future Studies
- Relevance & Benefits

MCR Channel (RM –3to 3): Annual O&M Dredging (4 miles) = <u>1 MCY/mile per year</u>

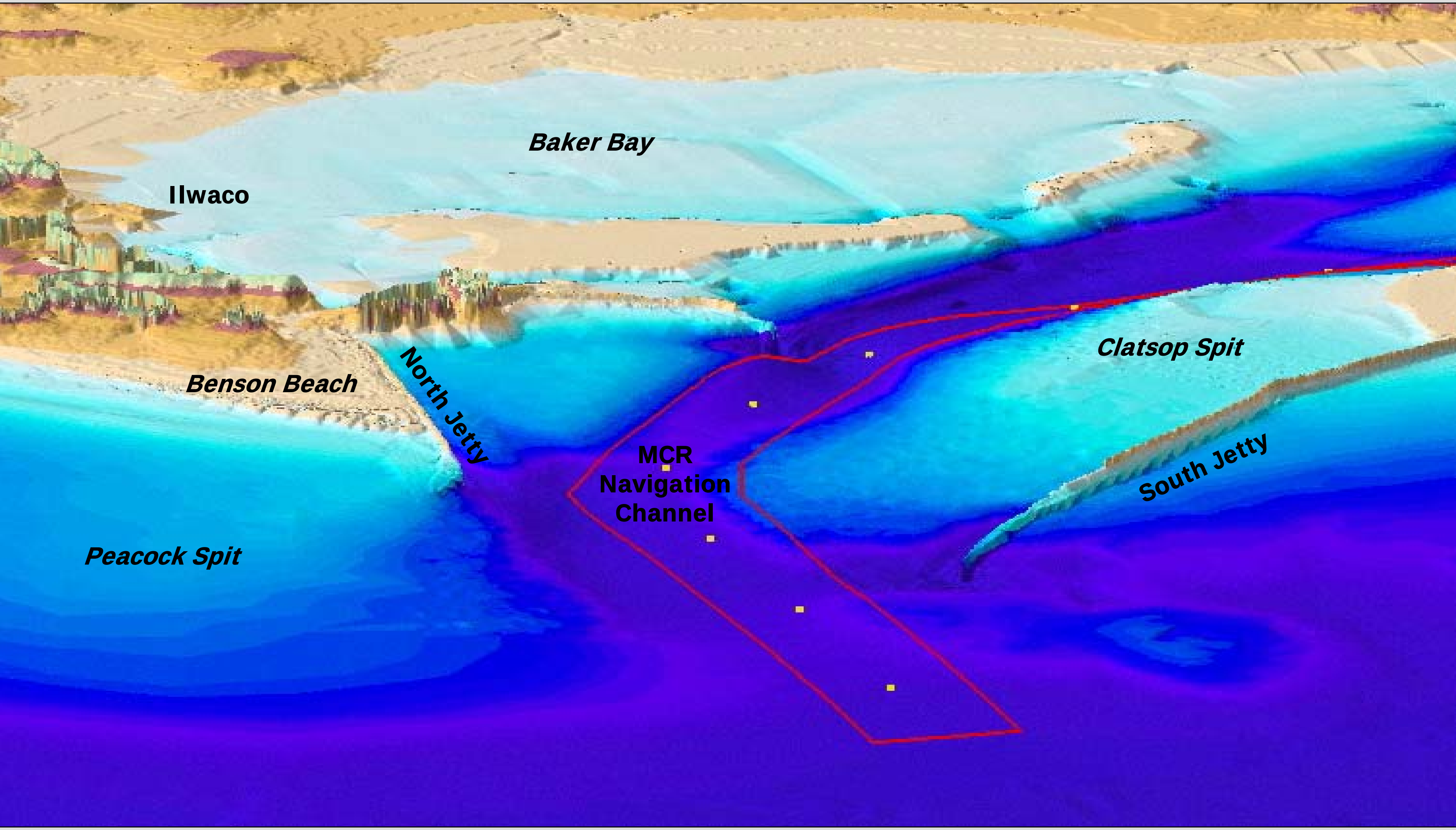
Mouth of the Columbia River

"CONSTRUCTED" 1885-1917



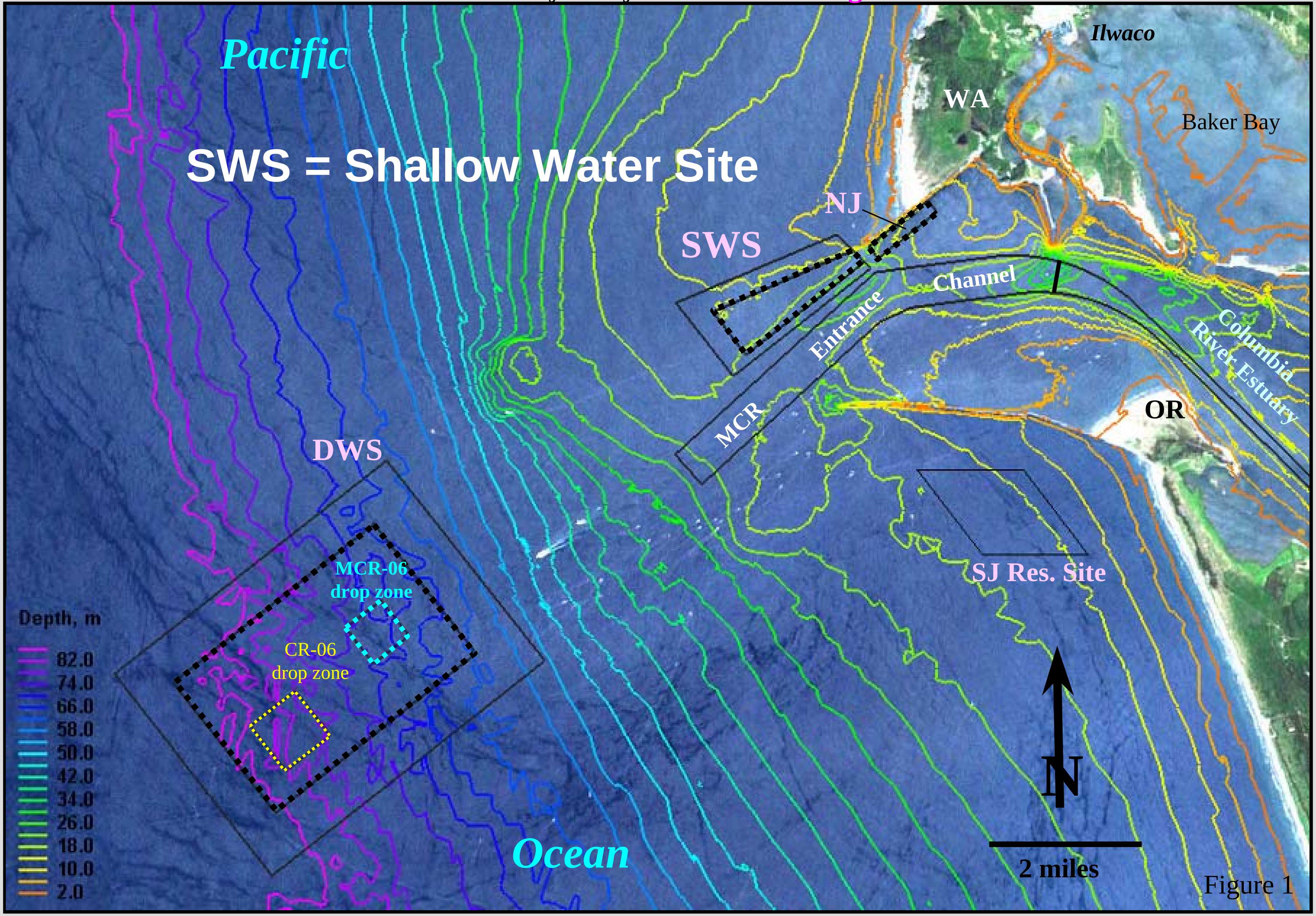
Bathymetry Showing Location of Shoals & Jetties

Excessive Erosion of Shoals Can Lead to Loss of Jetty Foundation = Loss of Jetty




Hopper Dredges working at MCR
Essayons
Sugar Island
3-5 Million cy of Sand Dredged from MCR Each Year
MCR Maintenance Dredging is Performed during June-Sept
Work is split between a GOVT and PRVT IND hopper dredge

Mouth of the Columbia River - Bathymetry and 2006 Dredged Material Placement Sites

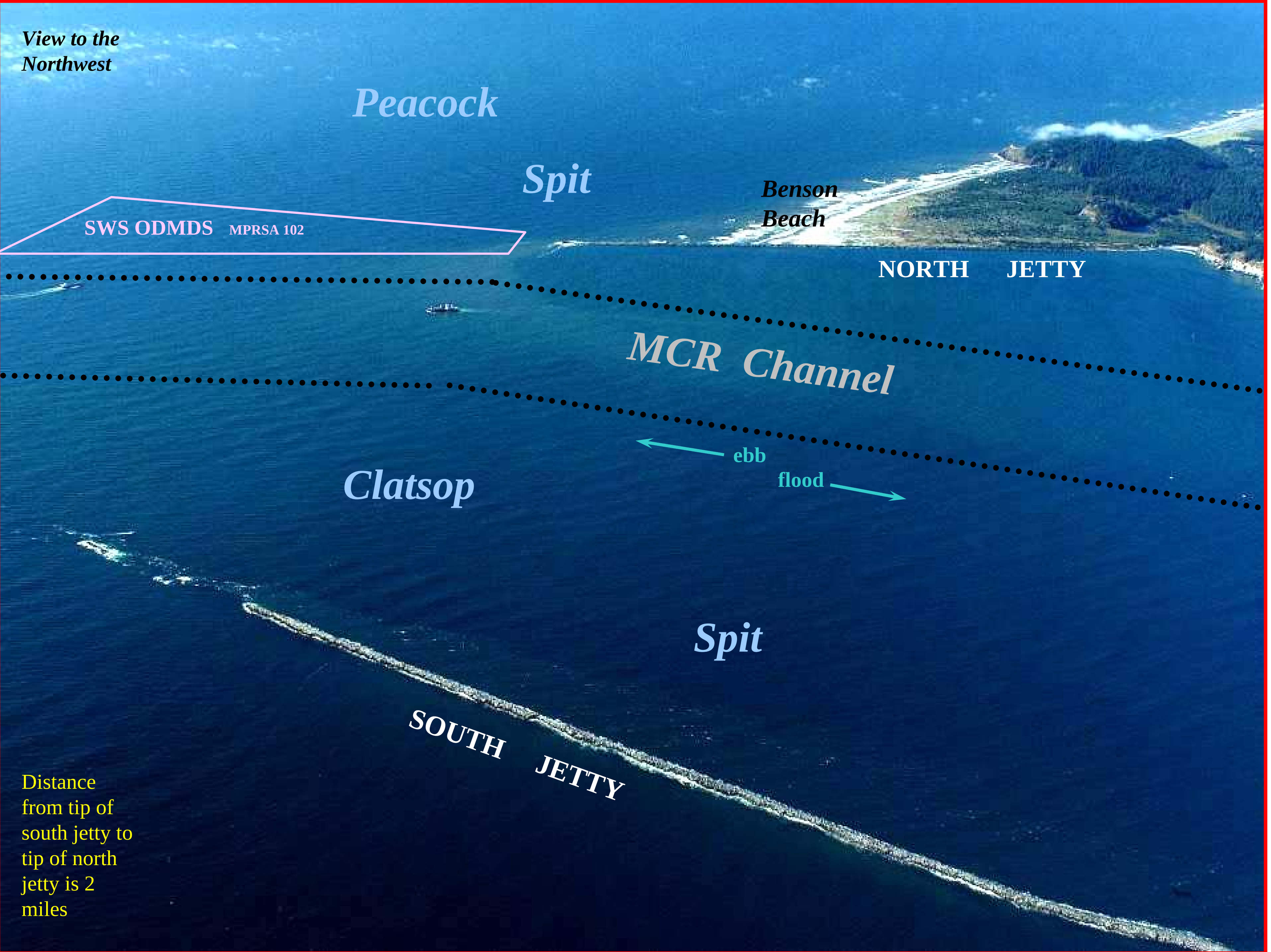


DWS= Deep Water Site, 102 MPRSA

SWS= Shallow Water Site, 102 MPRSA (formally Site E, 103 MPRSA)

NJ Site = North Jetty disposal site, 404 CWA

SJ Res. Site = South Jetty research site, restricted use by EPA permit


View to the Northwest
Peacock
Spit
Benson Beach
SWS ODMDS
MPRSA 102
NORTH JETTY
MCR Channel
ebb
flood
Clatsop
Spit
SOUTH JETTY
Distance from tip of south jetty to tip of north jetty is 2 miles

Opportunity for Intervention

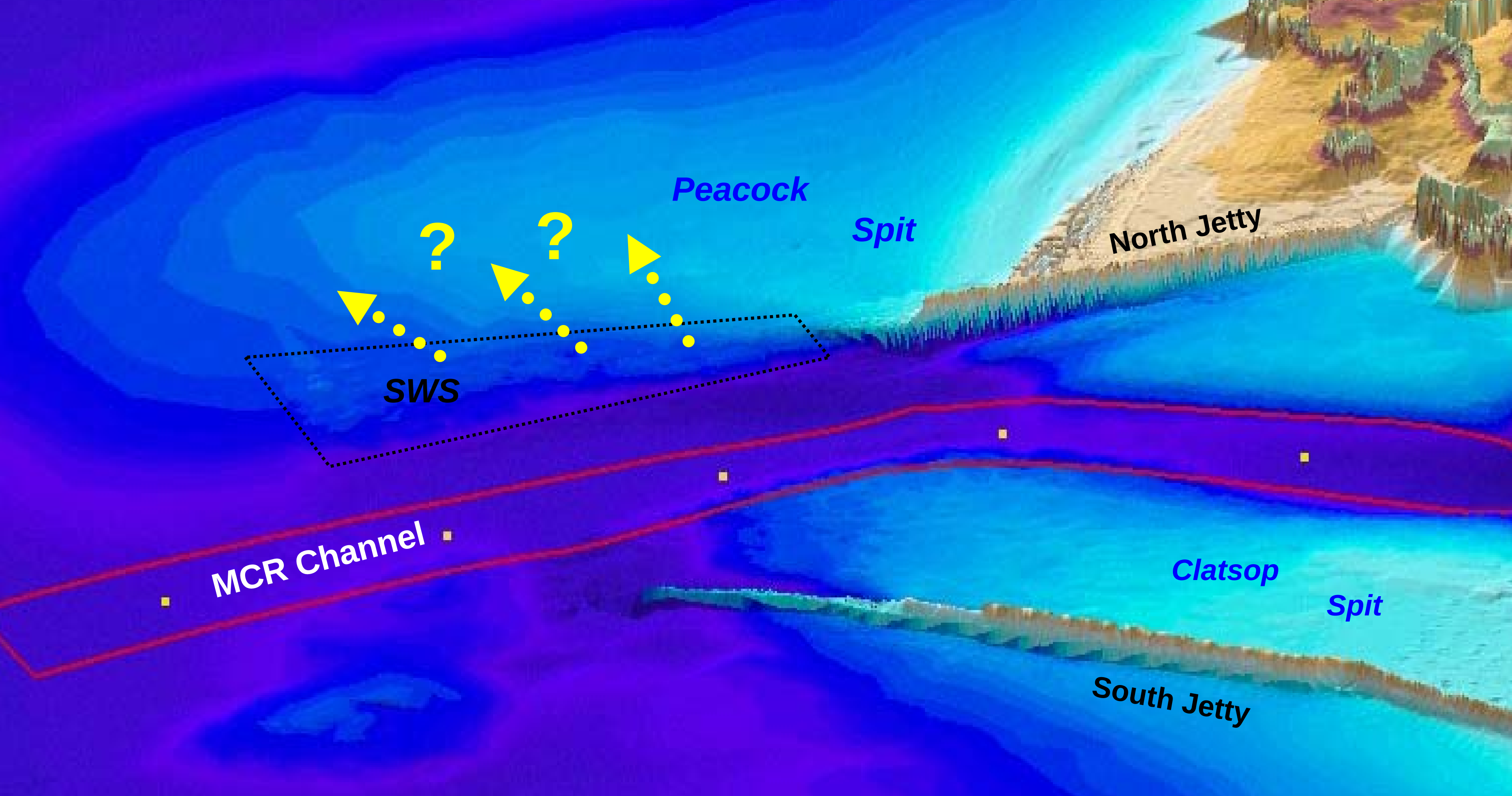
- **Benefits-** **Sustain sediment budget on north side of MCR Inlet.**

  ***Defer north jetty repair, stabilize inlet, reduce shoreline erosion north of MCR**

- **Risks -** **Dredged material does not "behave" as intended = Unintended consequences**

  *** Moves back into MCR Channel or AWAY from intended direction of transport**

Use the <u>SWS</u> to feed material onto *Peacock Spit* and Sustain the sediment budget north of MCR (<u>place 1.5-2.5 Mcy/yr</u>)*:*

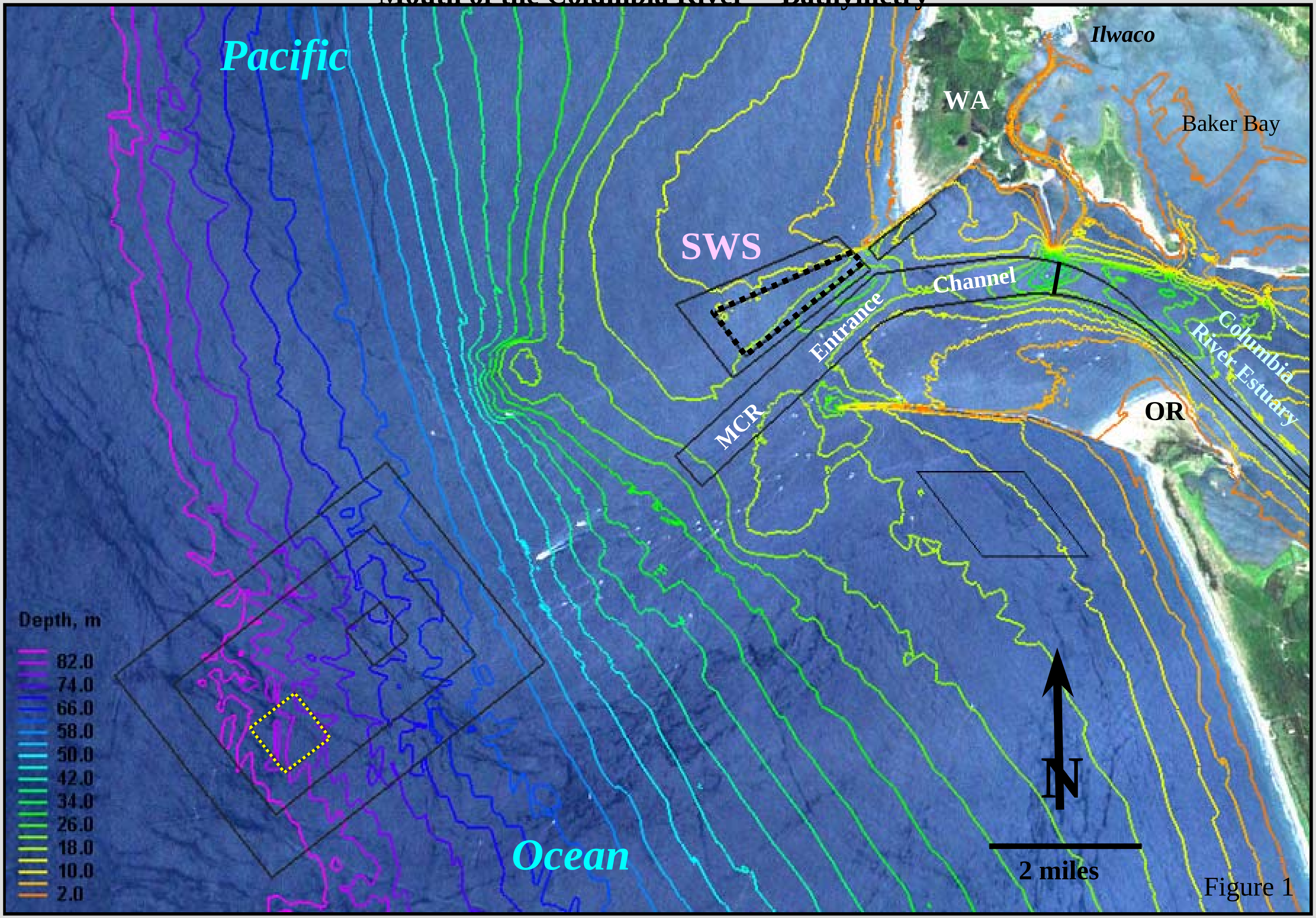


* Reduce the rate of erosion affecting the north jetty
* Reduce shoreline erosion along areas north of MCR

Table A1. Summary of SWS ODMDS utilization and dispersive properties of site.

YEAR	VOLUME PLACED IN SWS ODMDS % of MCR dredging	SPECIFICIED PLACEMENT METHOD ^ C=contractor G=government	MAXIMUM MOUND HEIGHT @ END OF DREDGING SEASON *	EFFECTIVENESS OF USING ENTIRE SW SITE TO DISPERSE DREDGED MATERIAL	TRANSPORT DURING DREDGING SEASON (CY) **	TRANSPORT DURING WINTER (CY) **	NET ANNUAL TRANSPORT OF SEDIMENT OUT OF SW SITE (CY) **
1997	1.0 MCY **68%**	None (C)	**2-3 ft** peak = 5 ft	20% of the Site Was Used	-400,000 (40%)	+614,000 60%	**+214,000** 20% accumulated
1998	3.5 MCY **81%**	Grid Cells (C) Uniformly (G)	**5-6 ft** peak = 6 ft	70% of the Site Was Used	-2,100,000 (60%)	-1,216,000 (35%)	**-3,315,000** (95% eroded)
1999	3.8 MCY **74%**	Grid Cells(C) Uniformly(G)	**6-7 ft** Peak = 7 ft	80% of the Site Was Used	-1,520,000 (40%)	-1,091,000 (30%)	**-2,611,000** (70% eroded)
2000	2.9 MCY **75%**	Grid Cells(C) Uniformly(G)	**6-8 ft** Peak = 8 ft	60% of the Site Was Used	-1,160,000 (40%)	-739,000 (25%)	**-1,899,000** (65% eroded)
2001	2.2 MCY **54%**	Disposal Lanes(C) Uniformly(G)	**6-7 ft** Peak = 9 ft	70% of the Site Was Used	-1,200,000 (50%)	-1,752,000 (73%)	**-2,952,000** (123% eroded)
2002	1.5 MCY **32%**	Disposal Lanes(C)	**6-7 ft** Peak = 8 ft	50% of the Site Was Used	-300,000 (20%)	-1,710,000 (113%)	**-2,010,000** (134% eroded)
2003	2.8 MCY **86%**	Grid Cells (C) Grid Cells (G)	**2-4 ft** Peak = 5 ft	>90% of the Site Was Used	-900,000 (32%)	-575,000 (21%)	**-1,475,000** (52% eroded)
2004	2.9 MCY **57%**	Grid Cells (C) Grid Cells (G)	**2-5 ft** Peak = 5 ft	>90% of the Site Was Used	-1,000,000 (34%)	-1,000,000 (34%)	**-2,000,000** (68% eroded)
2005	2.6 MCY **67%**	Grid Cells (C) Grid Cells (G)	**2-6 ft** Peak = 7 ft	>90% of the Site Was Used	-900,000 (35%)	-1,900,000 (73%)	**-2,800,000** (107% eroded)
2006	1.8 MCY **53%**	Grid Cells (C) Grid Cells (G)	**2-6 ft** Peak = 6 ft	>75% of the Site Was Used	-680,000 (37%)	-600,000++ (33%)	**-1,280,000++** (67% eroded)
	2.8 MCY **64%**	**AVERAGE VALUES**	**5-6 ft** Peak = 9 ft	**68%**	**39%**	**49%**	**88%**

Mouth of the Columbia River - Bathymetry



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MCR Bathymetry Difference: 1997 -2006

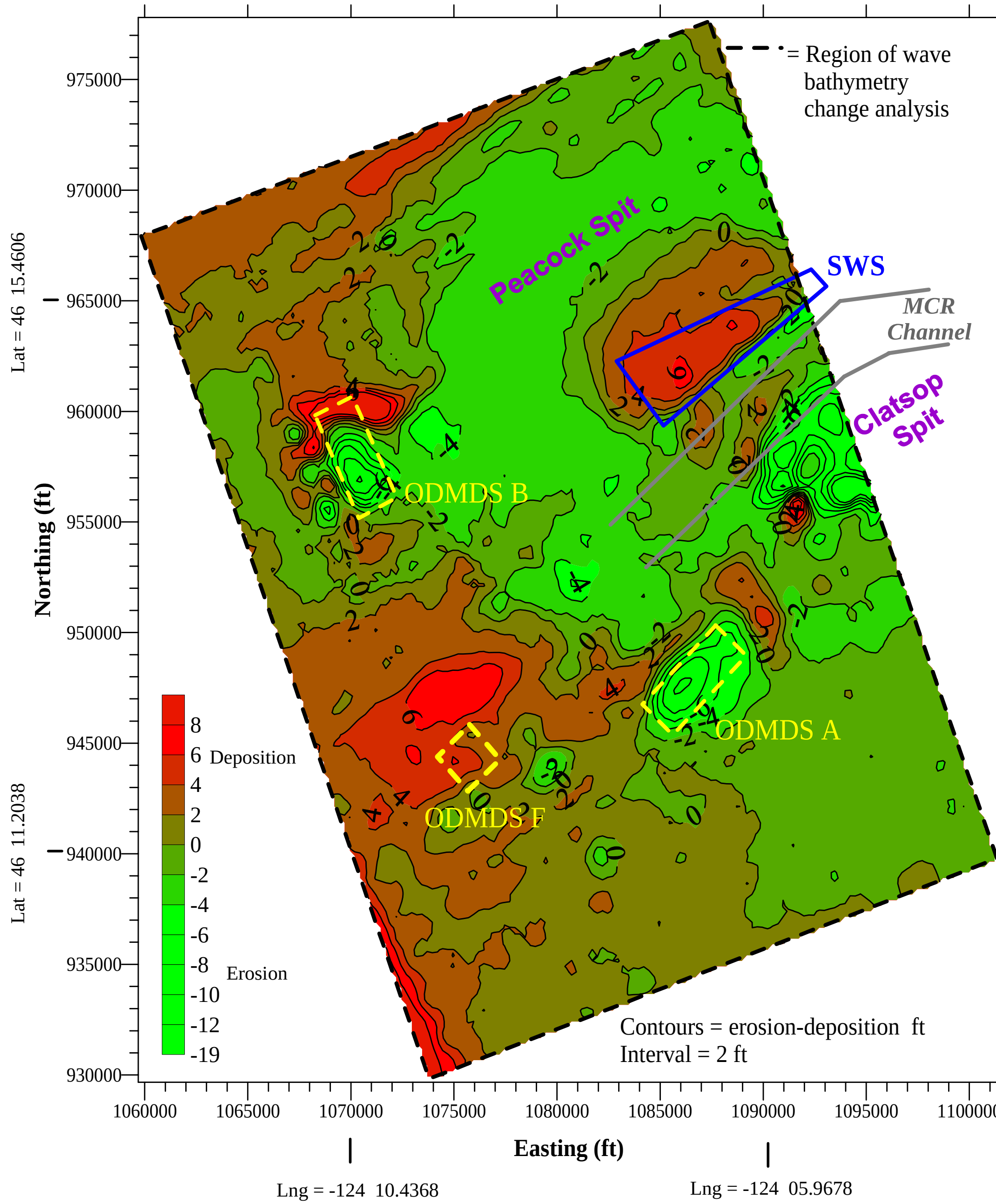
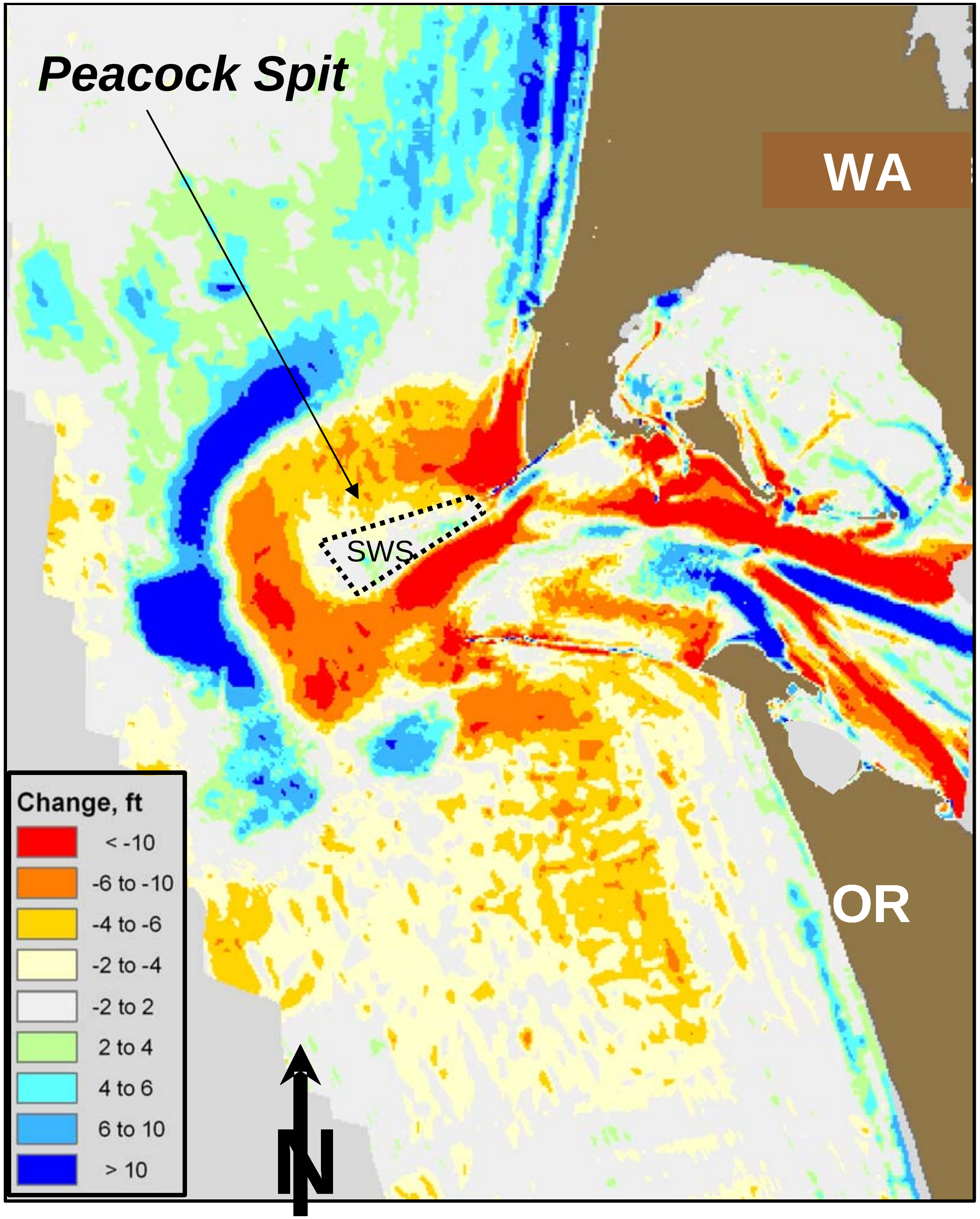


Figure 20

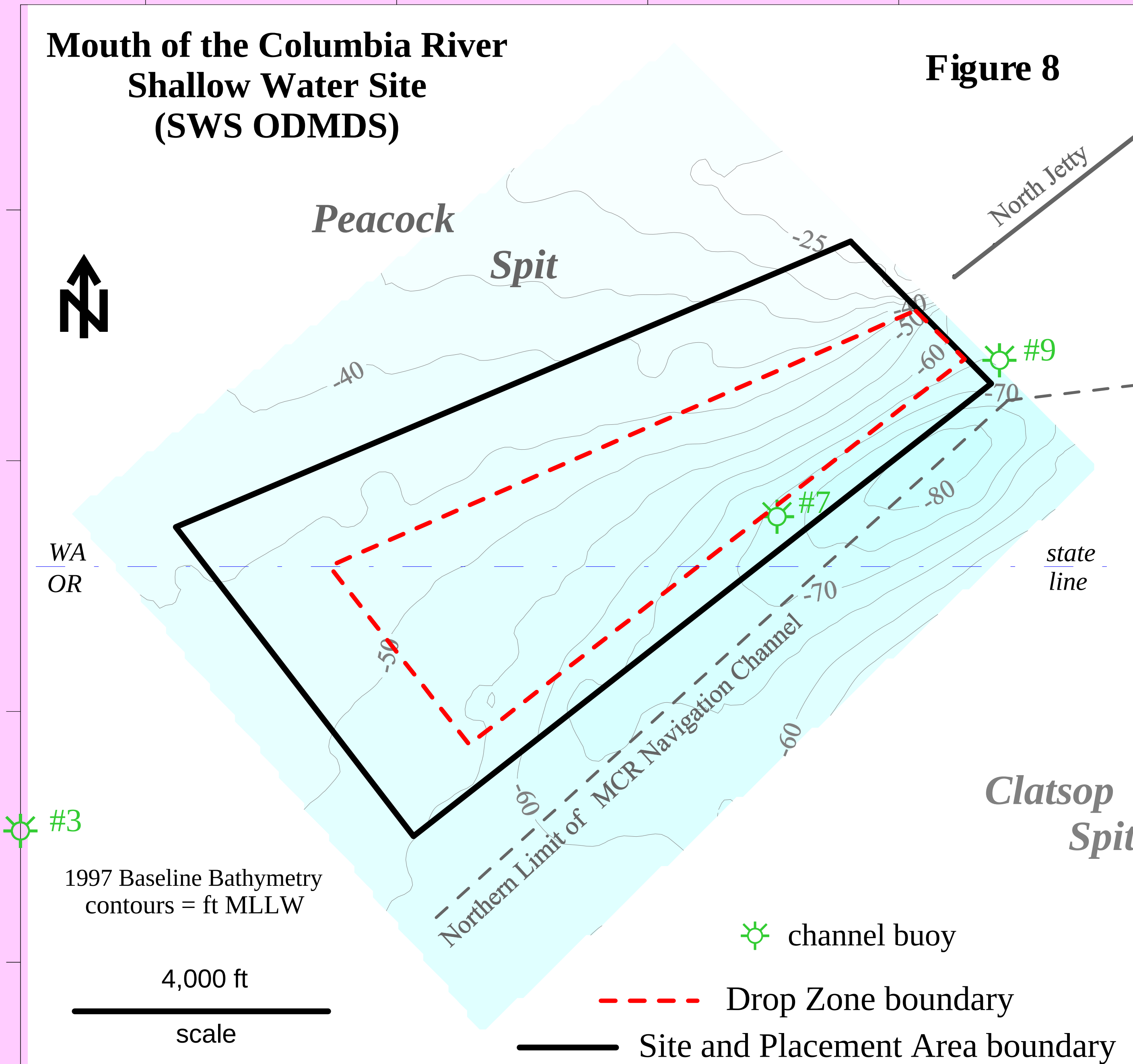


1958 to 2003 Bathymetric Change

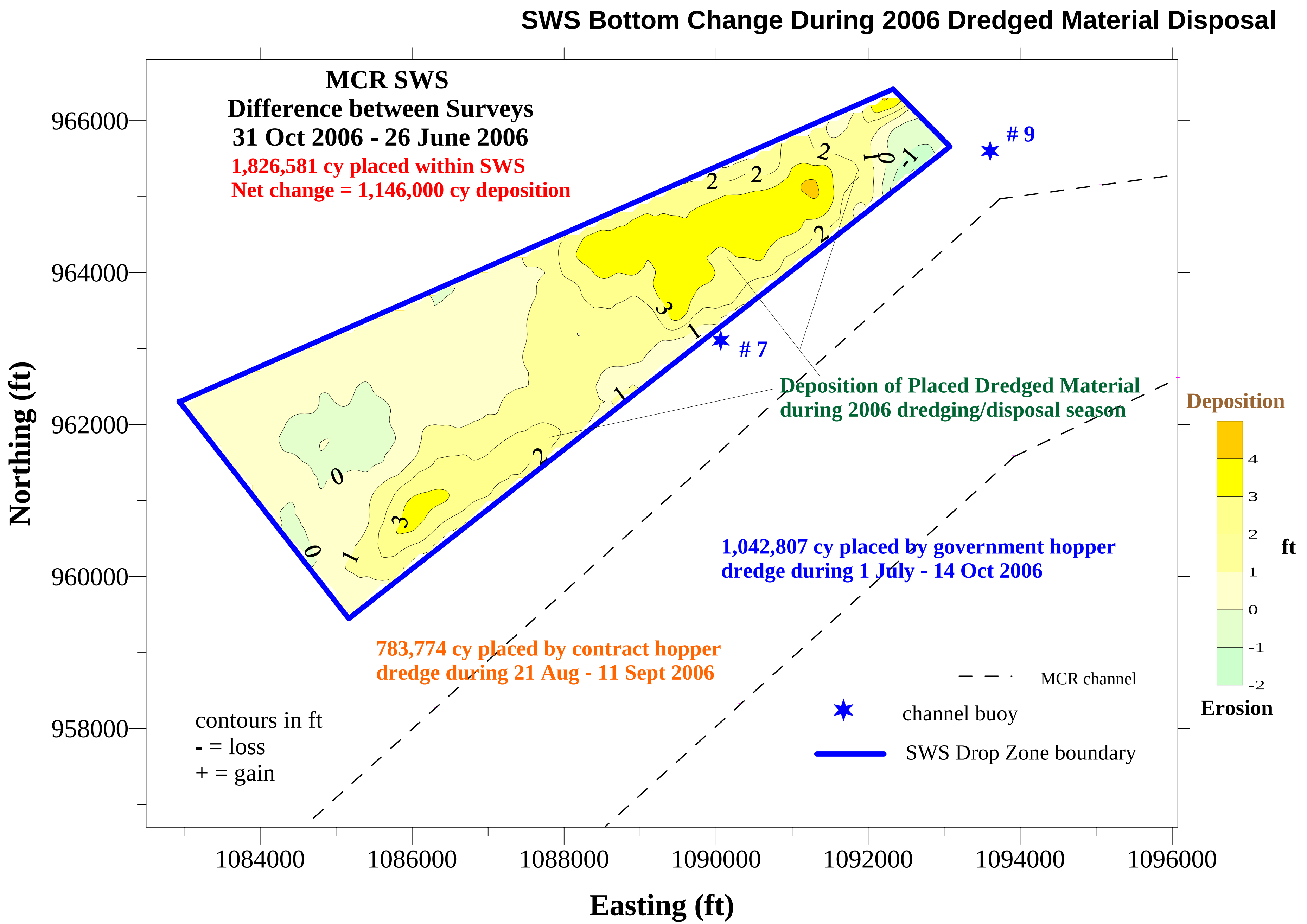
Use of the SWS has reduced the rate of erosion affecting Peacock Spit.

Sustain the Peacock Spit, and it will protect the north jetty and inlet.

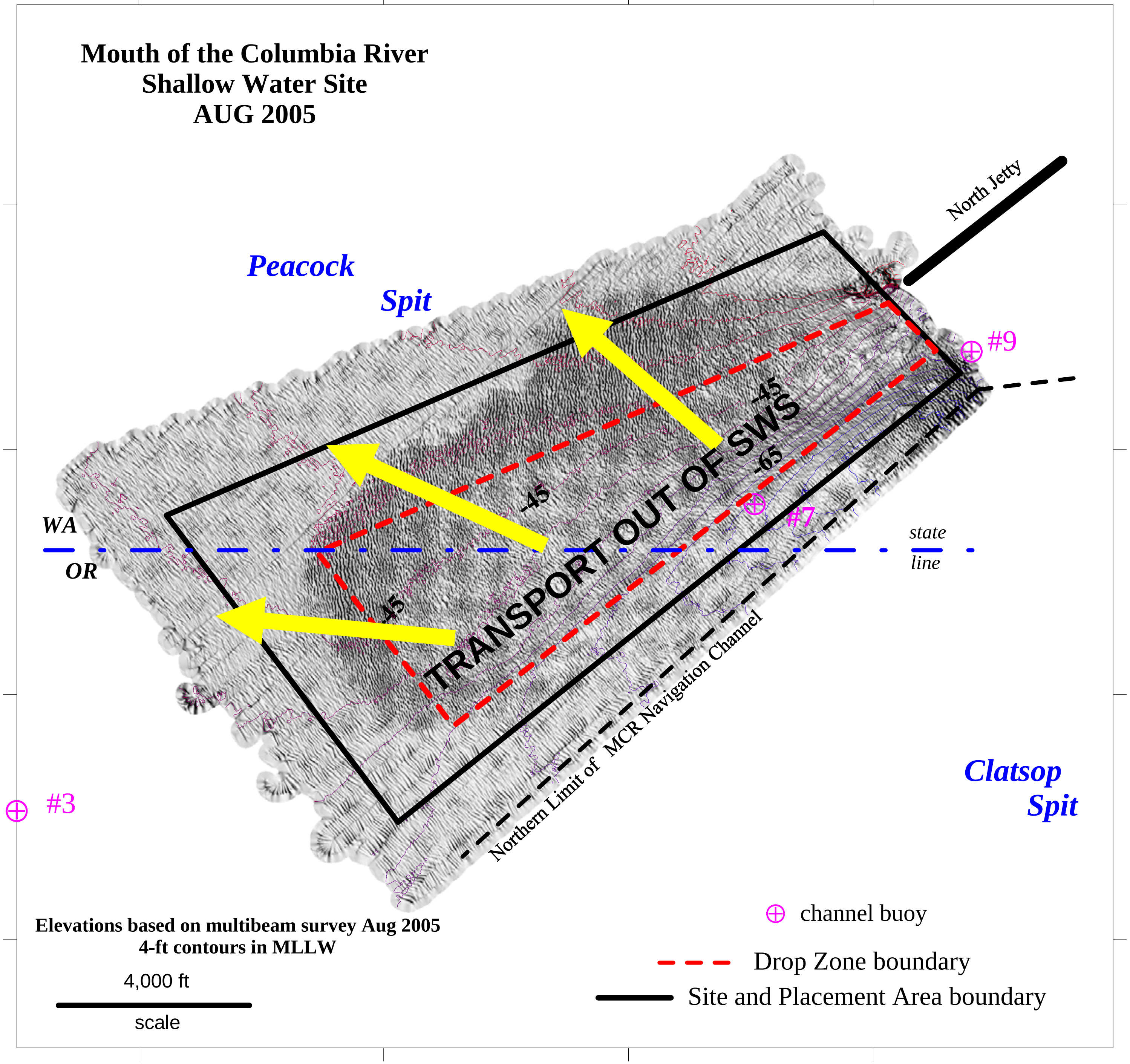
BASELINE CONDITION



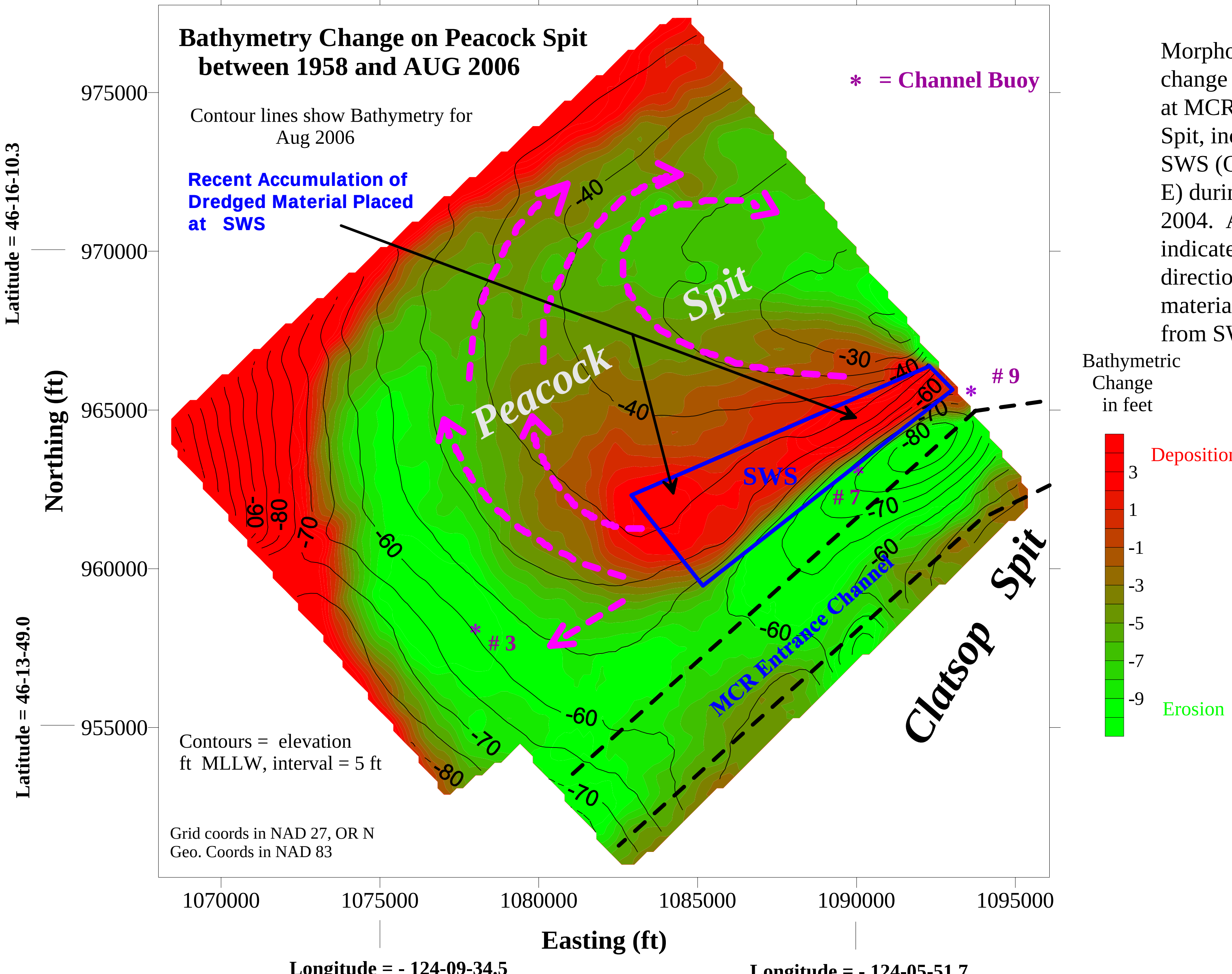
BASELINE CONDITION



SWS Bottom Change During 2006 Dredged Material Disposal
MCR SWS
Difference between Surveys
31 Oct 2006 - 26 June 2006
1,826,581 cy placed within SWS
Net change = 1,146,000 cy deposition
9
7
Deposition of Placed Dredged Material
during 2006 dredging/disposal season
1,042,807 cy placed by government hopper
dredge during 1 July - 14 Oct 2006
783,774 cy placed by contract hopper
dredge during 21 Aug - 11 Sept 2006
contours in ft
- = loss
+ = gain
MCR channel
channel buoy
SWS Drop Zone boundary
Deposition
Erosion
ft
Northing (ft)
Easting (ft)
966000
964000
962000
960000
958000
1084000
1086000
1088000
1090000
1092000
1094000
1096000



Mouth of the Columbia River
Shallow Water Site
AUG 2005
Peacock
Spit
North Jetty
#9
-45
TRANSPORT OUT OF SWS
-65
-45
#7
WA
OR
state
line
-45
Northern Limit of MCR Navigation Channel
Clatsop
Spit
#3
Elevations based on multibeam survey Aug 2005
4-ft contours in MLLW
4,000 ft
scale
channel buoy
Drop Zone boundary
Site and Placement Area boundary



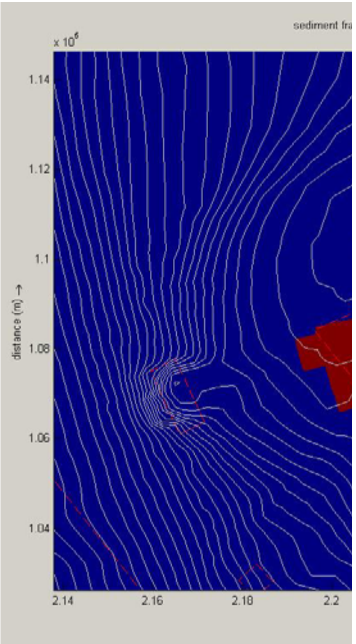
Morphology change observed at MCR Peacock Spit, including SWS (ODMDS E) during 1956-2004. Arrows indicate transport direction of material eroded from SWS.

Figure 34

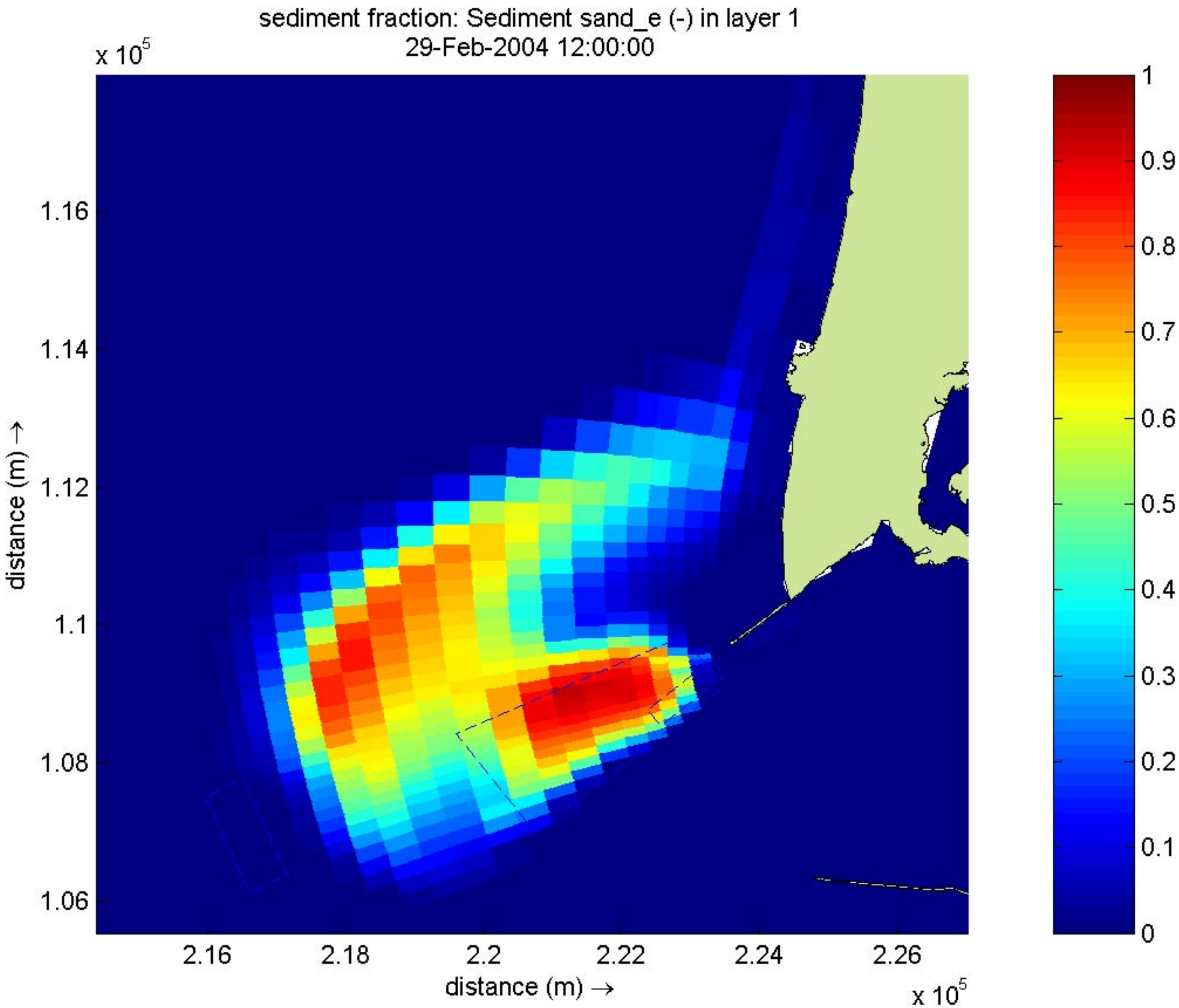
1973-1997: 50 M cy of dredged sand placed in SWS

1997-2006: 25 M cy has been placed ---- 3 M cy remain within SWS

Recent results **DELFT 3-D Model USGS**



Initial distributi
of “SWS” sanc
(and fixed laye



"Final" distribution of site E disposal sand in the top 5cm of bed at the end of February 2004

Tracer Study Objectives

Study designed to assess seabed mobility and the fate of dredge material once on the seabed;

No dispersion associated with the initial placement of the dredged sediments.

The sediment tracer was to be placed on the seabed rather than introducing the tracer in the dredge hopper and releasing it as part of the dredged dumping operations.

The sediment tracer must 'behave' in the same way (in terms of sediment transport) as the dredged sediment placed in the disposal site. The tracer would be moved (or became suspended) by waves and currents along with the dredged material.

Verify if dredged sediment placed in nearshore disposal sites (<60 feet depth), becomes part of the littoral budget and provide direct measurement of the transport pathways.

a) Does MCR dredged material placed at the SWS move northward onto Peacock Spit and ultimately onto Benson Beach, offshore toward deeper water, southward toward the MCR navigation channel, or inshore toward the interior of the MCR inlet?

b) What is the rate that dredged material is transported out of the SWS for each of the above pathway scenarios?

TRACER EXECUTION

Tracer contract scoping-negotiation-award

Apr 06 **28 Aug 06**

Concurrent with dredged material disposal

Dredged Material Placement at SWS

1 Jul 06 **14 Oct 06**

Tracer manufacture

Sep 06

Tracer deployment:

1 Oct 06

Tracer Sampling Period #1 **2 days after Placement**

3 Oct 06

Tracer Sampling Period #2 **60 days after Placement**

4 Dec 06

Tracer Sampling Period #3 **(planned) 180 days after deployment**

May-Jun 07

Mouth of the Columbia River - Bathymetry and 2006 Dredged Material Placement Sites

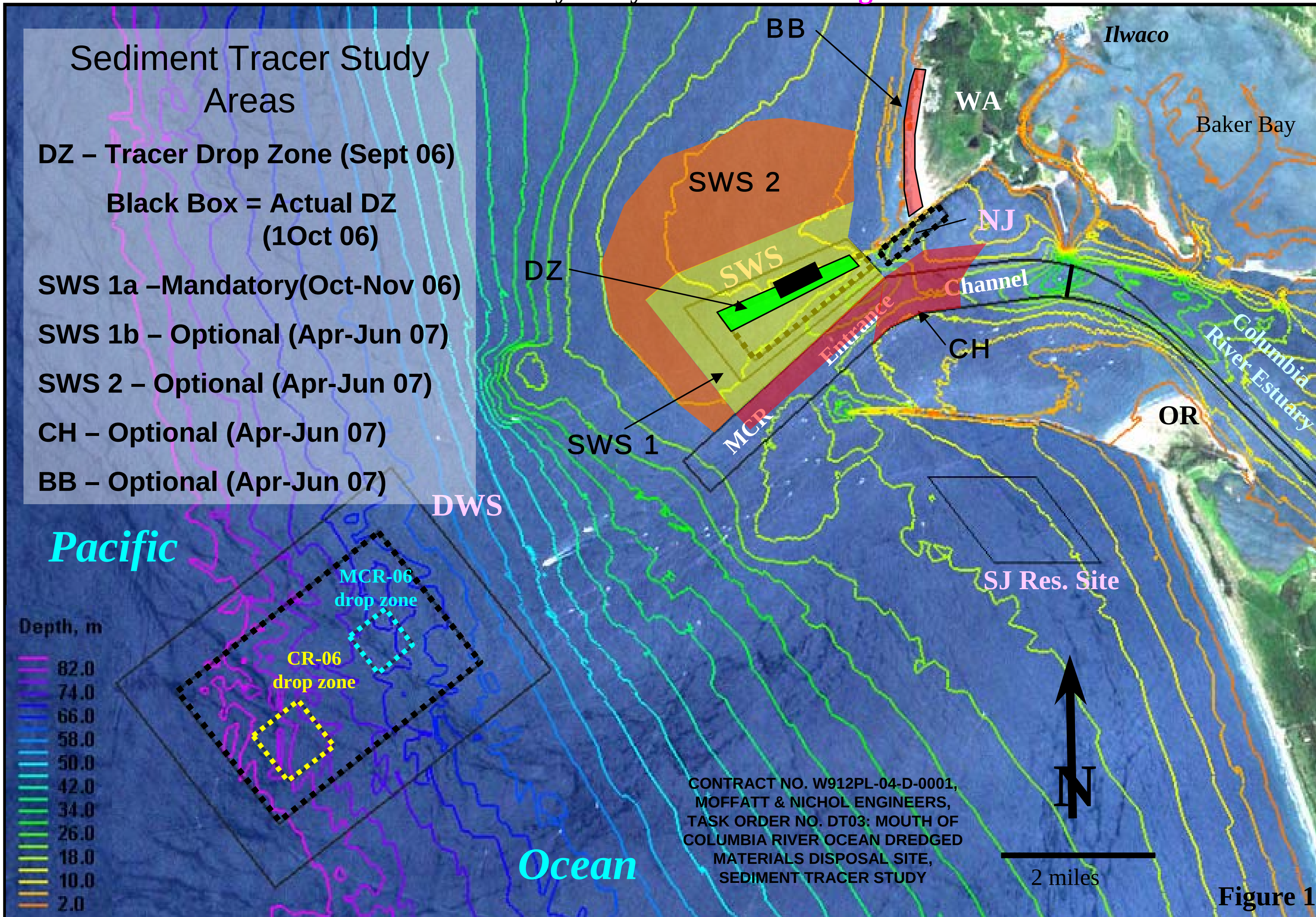


Figure 1

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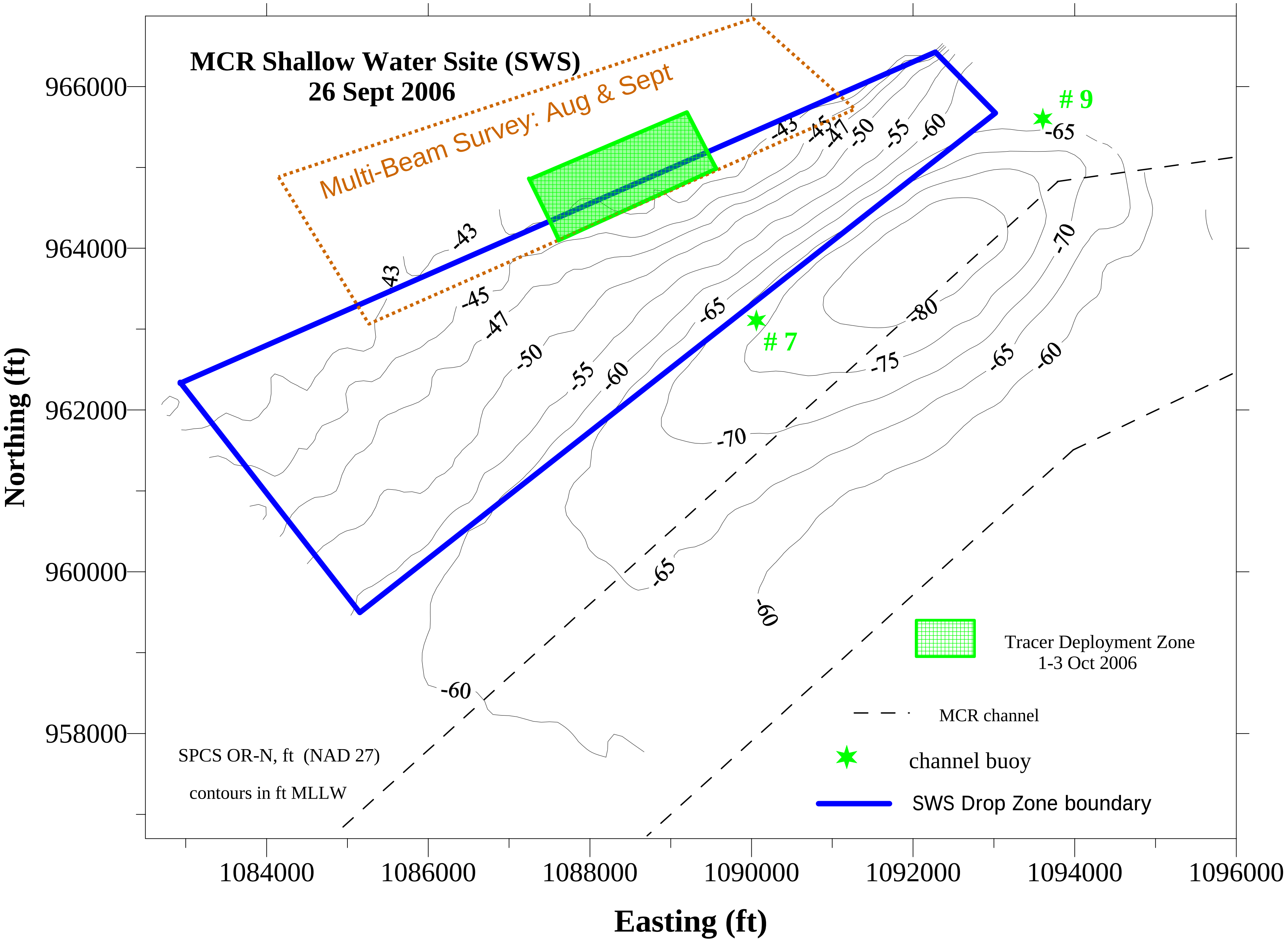
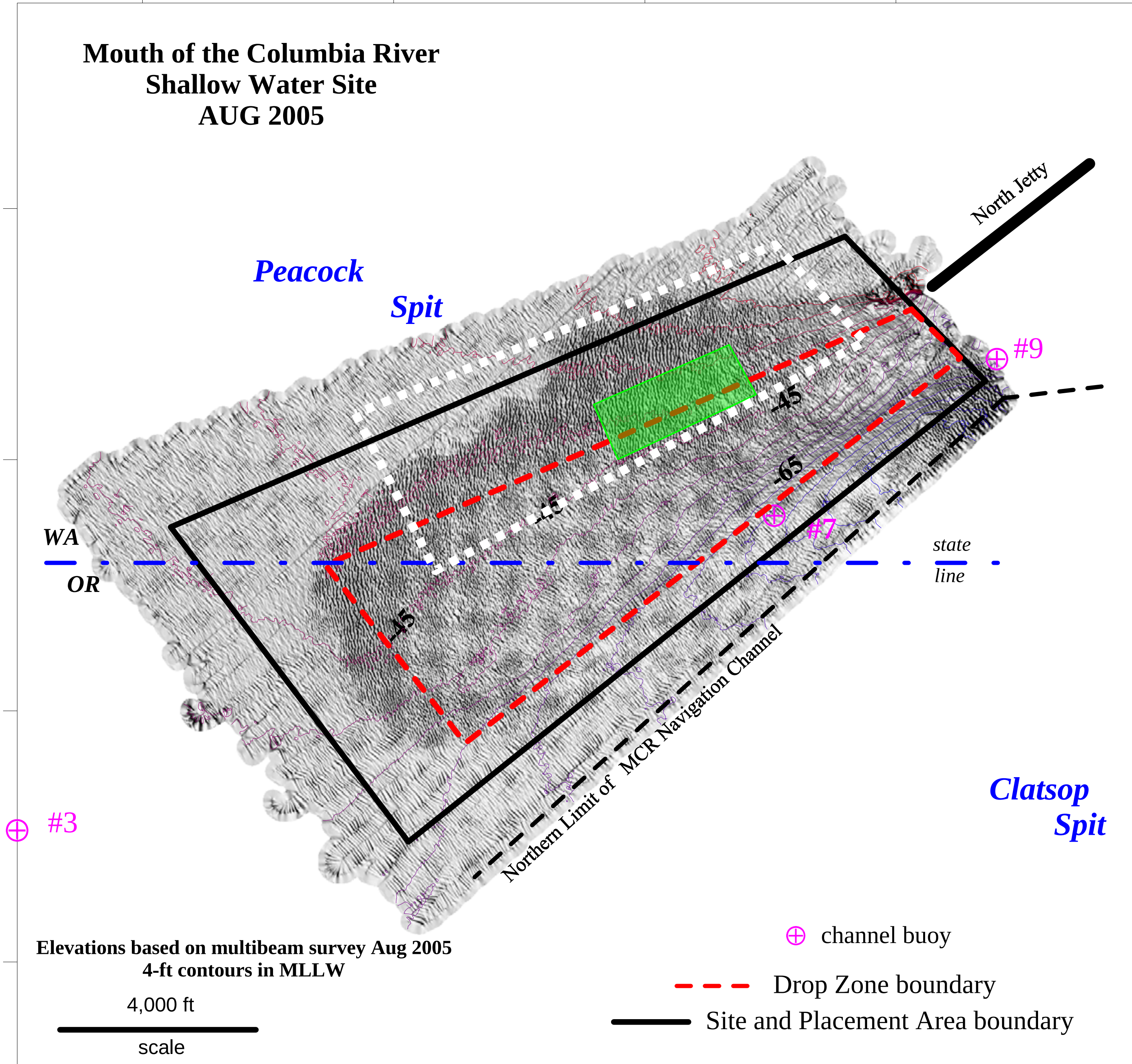


MCR Shallow Water Ssite (SWS)
26 Sept 2006
Multi-Beam Survey: Aug & Sept
9
7
Tracer Deployment Zone
1-3 Oct 2006
MCR channel
channel buoy
SWS Drop Zone boundary
SPCS OR-N, ft (NAD 27)
contours in ft MLLW
Northing (ft)
Easting (ft)
966000
964000
962000
960000
958000
1084000
1086000
1088000
1090000
1092000
1094000
1096000



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state
line
Northern Limit of MCR Navigation Channel
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Spit
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Elevations based on multibeam survey Aug 2005
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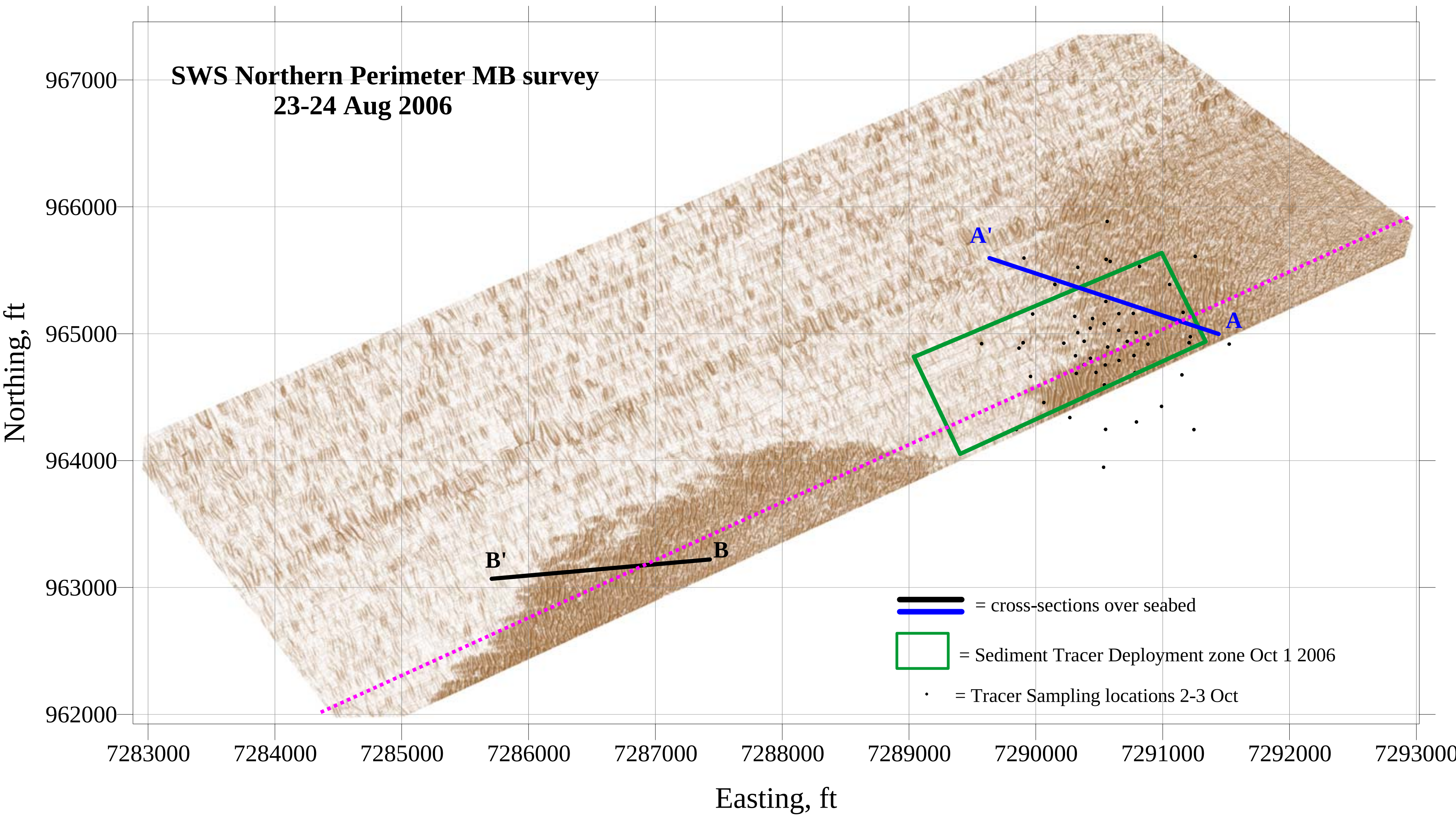
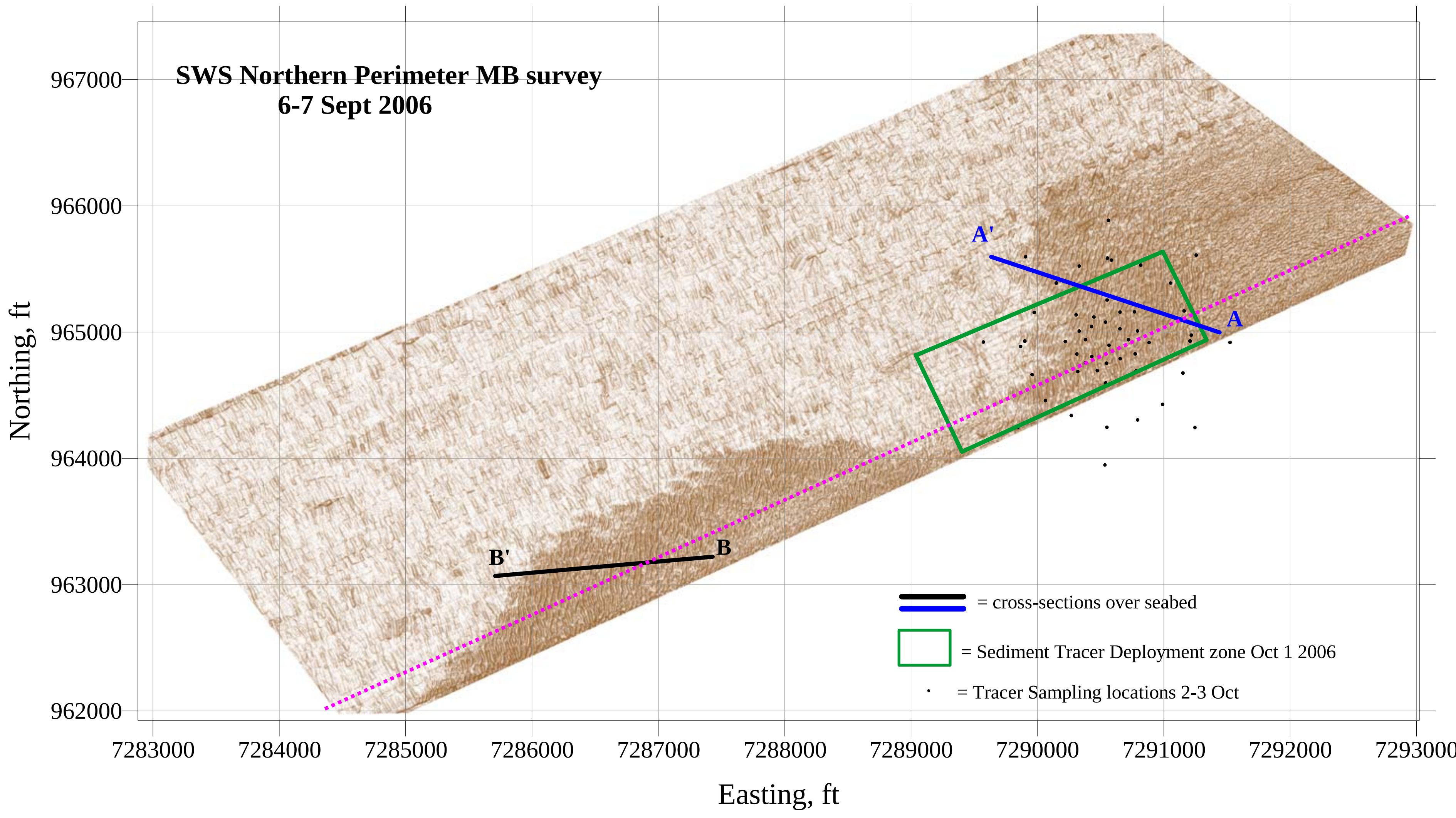
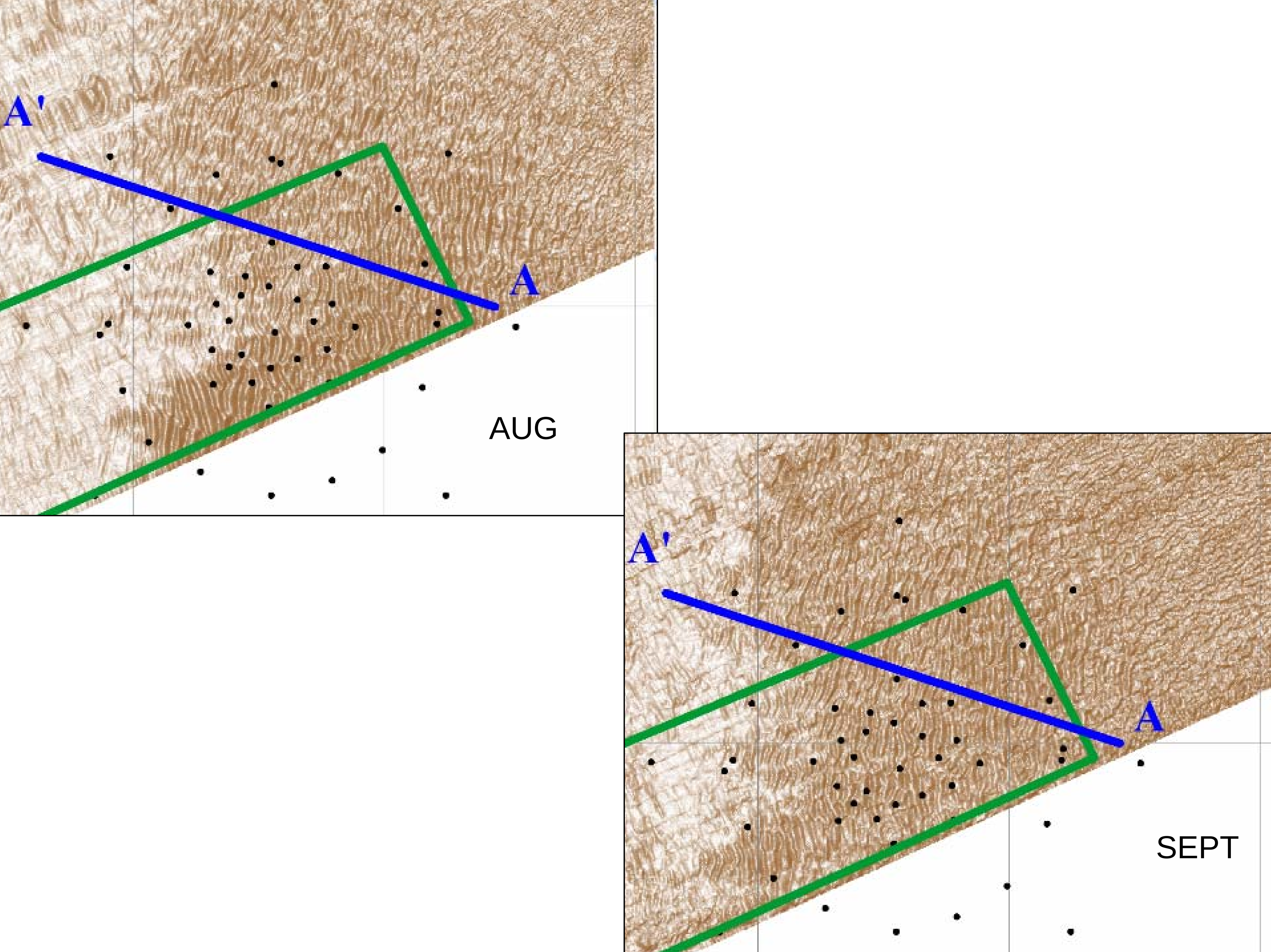
4,000 ft
scale
channel buoy
Drop Zone boundary
Site and Placement Area boundary

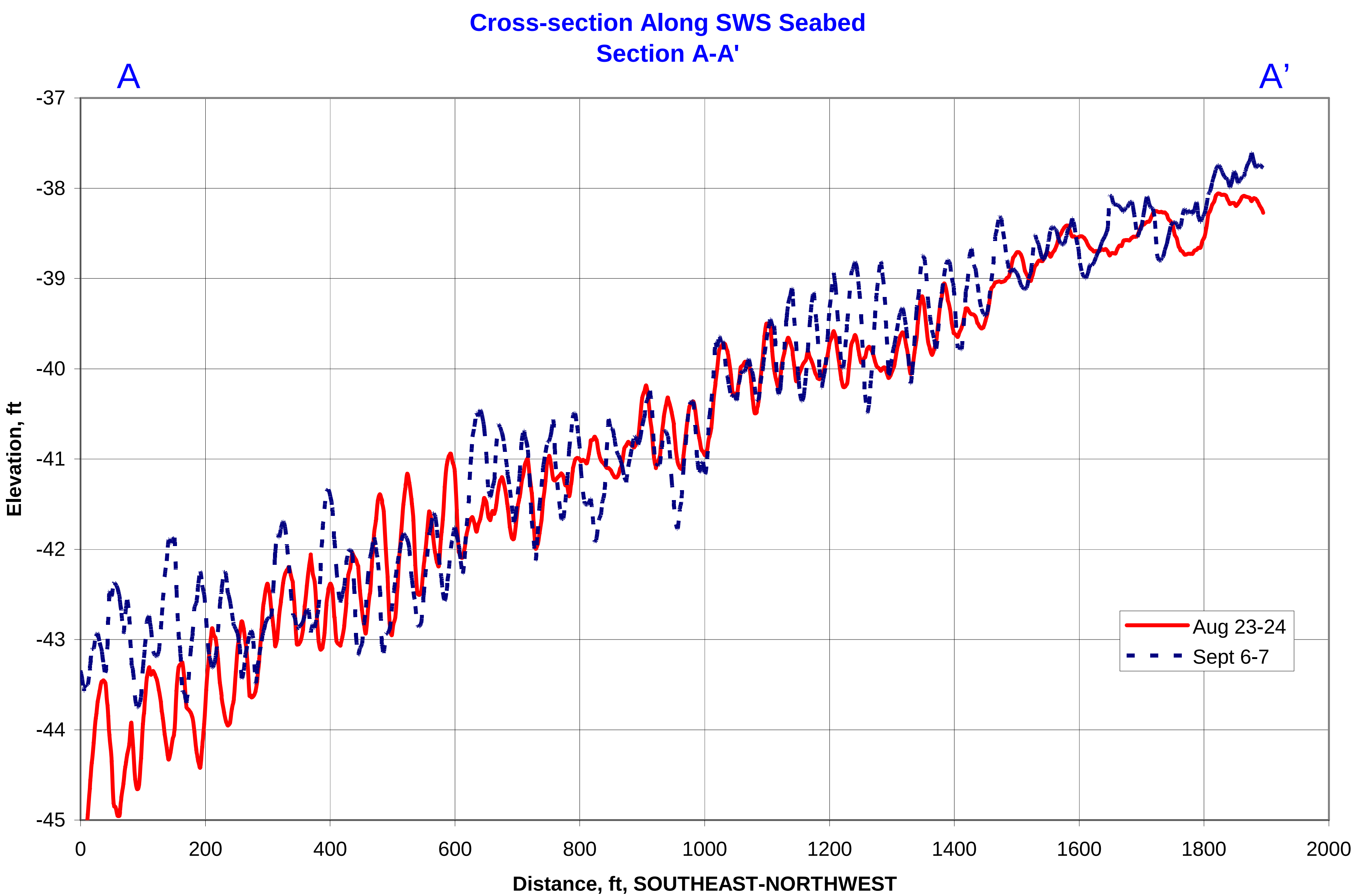

SWS Northern Perimeter MB survey
23-24 Aug 2006
Northing, ft
967000
966000
965000
964000
963000
962000
7283000
7284000
7285000
7286000
7287000
7288000
7289000
7290000
7291000
7292000
7293000
Easting, ft
A'
A
B'
B
= cross-sections over seabed
= Sediment Tracer Deployment zone Oct 1 2006
= Tracer Sampling locations 2-3 Oct



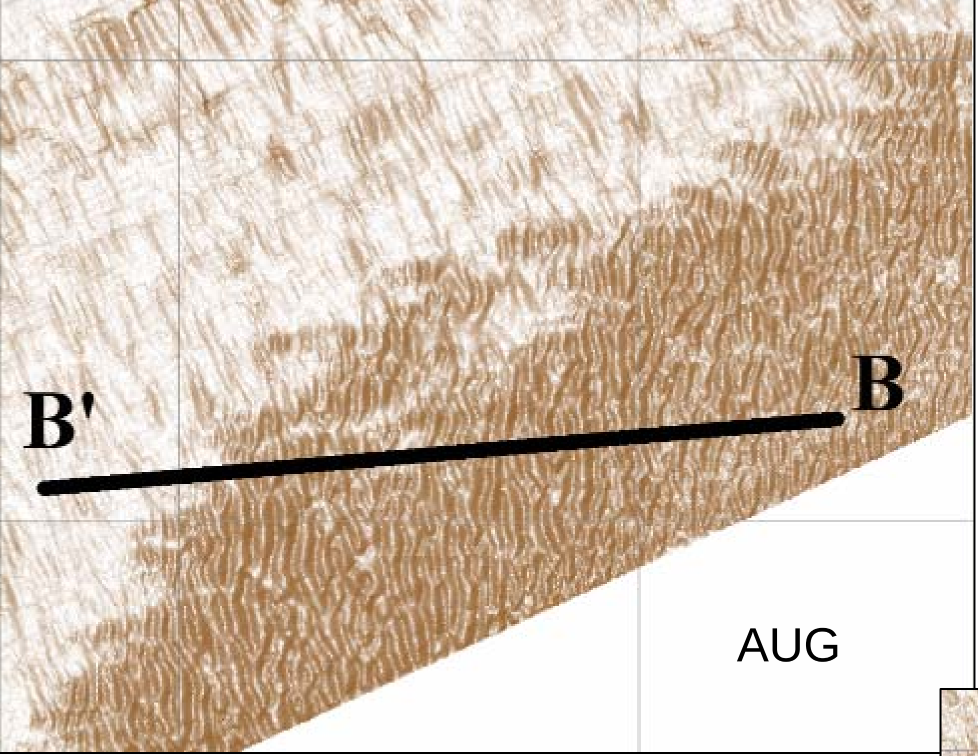
SWS Northern Perimeter MB survey
6-7 Sept 2006
967000
966000
965000
964000
963000
962000
Northing, ft
7283000
7284000
7285000
7286000
7287000
7288000
7289000
7290000
7291000
7292000
7293000
Easting, ft
A'
A
B'
B
= cross-sections over seabed
= Sediment Tracer Deployment zone Oct 1 2006
= Tracer Sampling locations 2-3 Oct



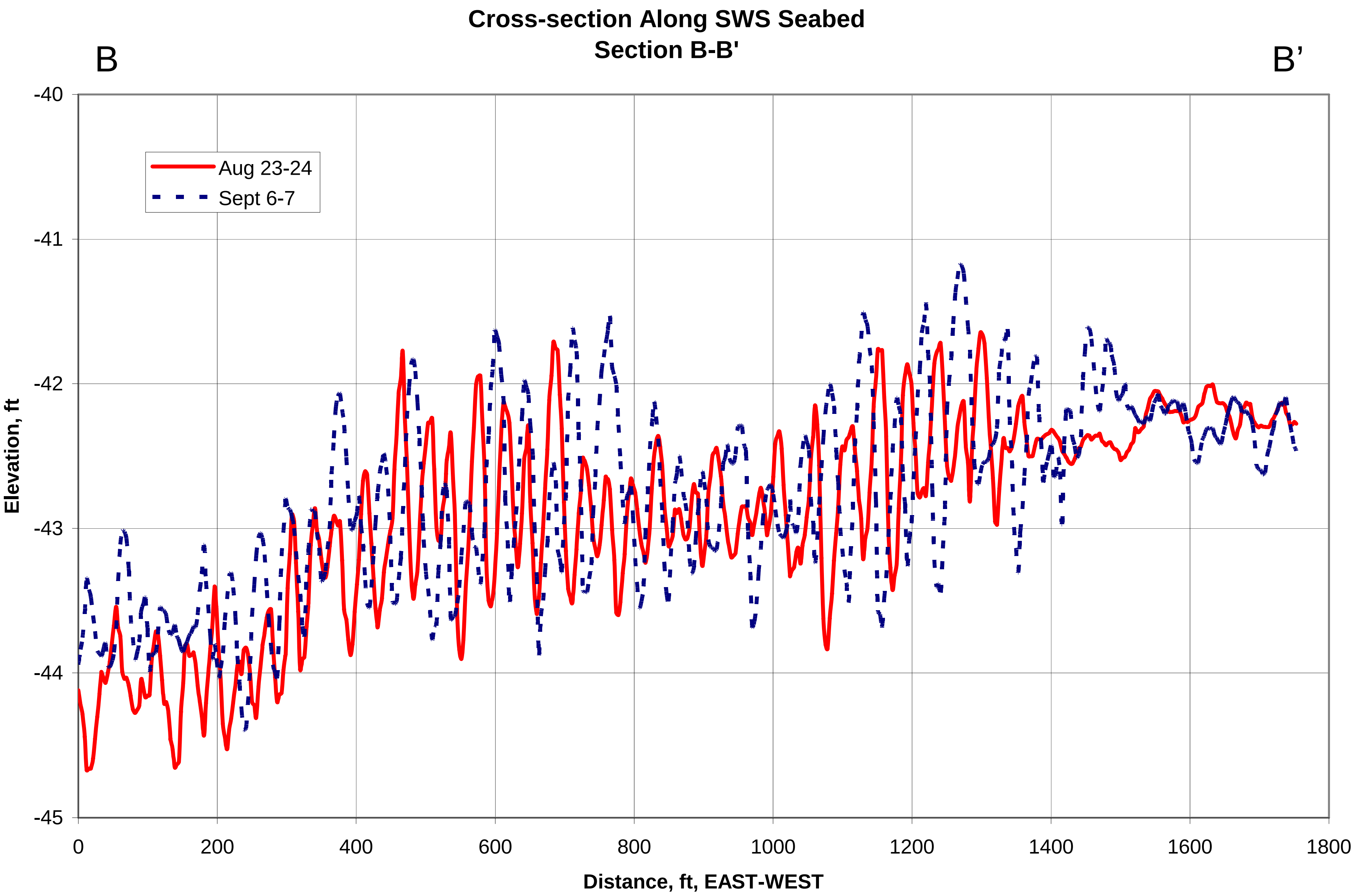
A'
A
AUG
A'
A
SEPT



Cross-section Along SWS Seabed
Section A-A'
A
A'
-37
-38
-39
-40
-41
-42
-43
-44
-45
Elevation, ft
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Distance, ft, SOUTHEAST-NORTHWEST
Aug 23-24
Sept 6-7


B'
B
AUG


B'
B
SEPT



Cross-section Along SWS Seabed
Section B-B'
B
B'
Aug 23-24
Sept 6-7
Elevation, ft
-40
-41
-42
-43
-44
-45
0
200
400
600
800
1000
1200
1400
1600
1800
Distance, ft, EAST-WEST

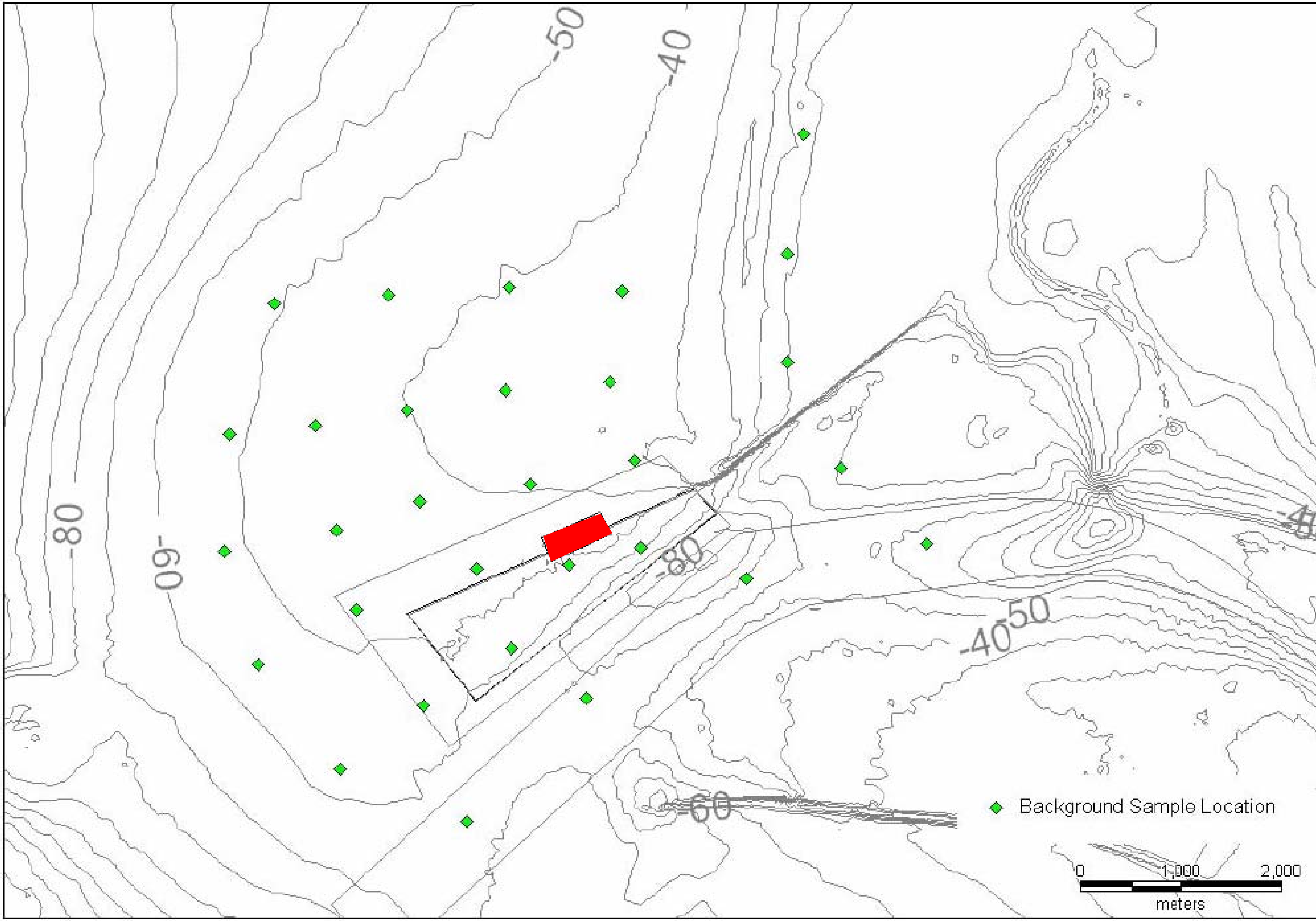


Figure 3.6: Background grab sampling sites, 21 & 22 September 2006

Figure 3.5: Tracer:sediment being transferred from the storage box into the hopper prior to being placed into the dissolving bags.


CREW


Ziploc

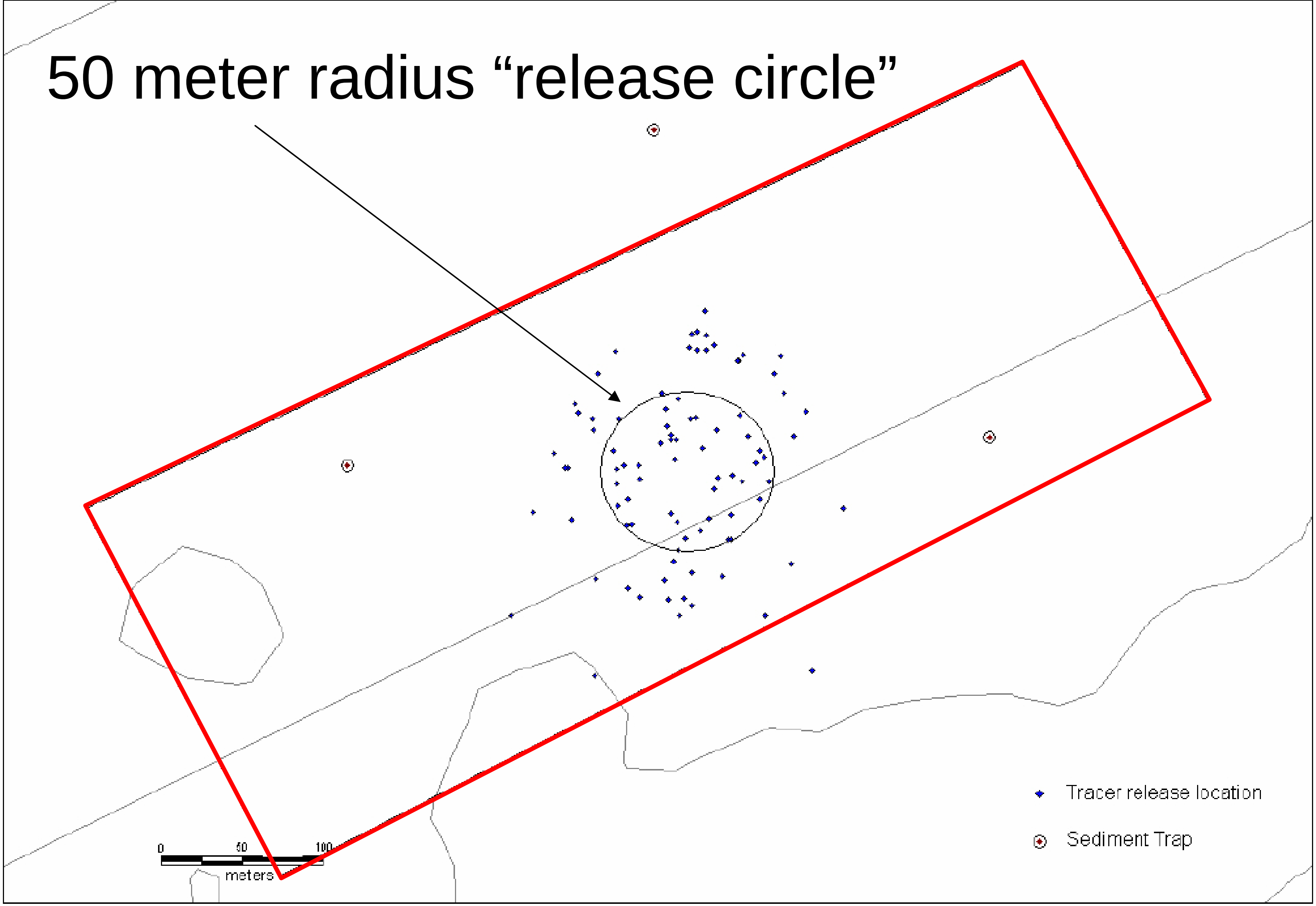


Figure 3.4: Map showing locations of sediment deployments relative to the main tracer release area and individual tracer placements.

Figure 3.3: Deployment of the sediment traps, 1 October 2006

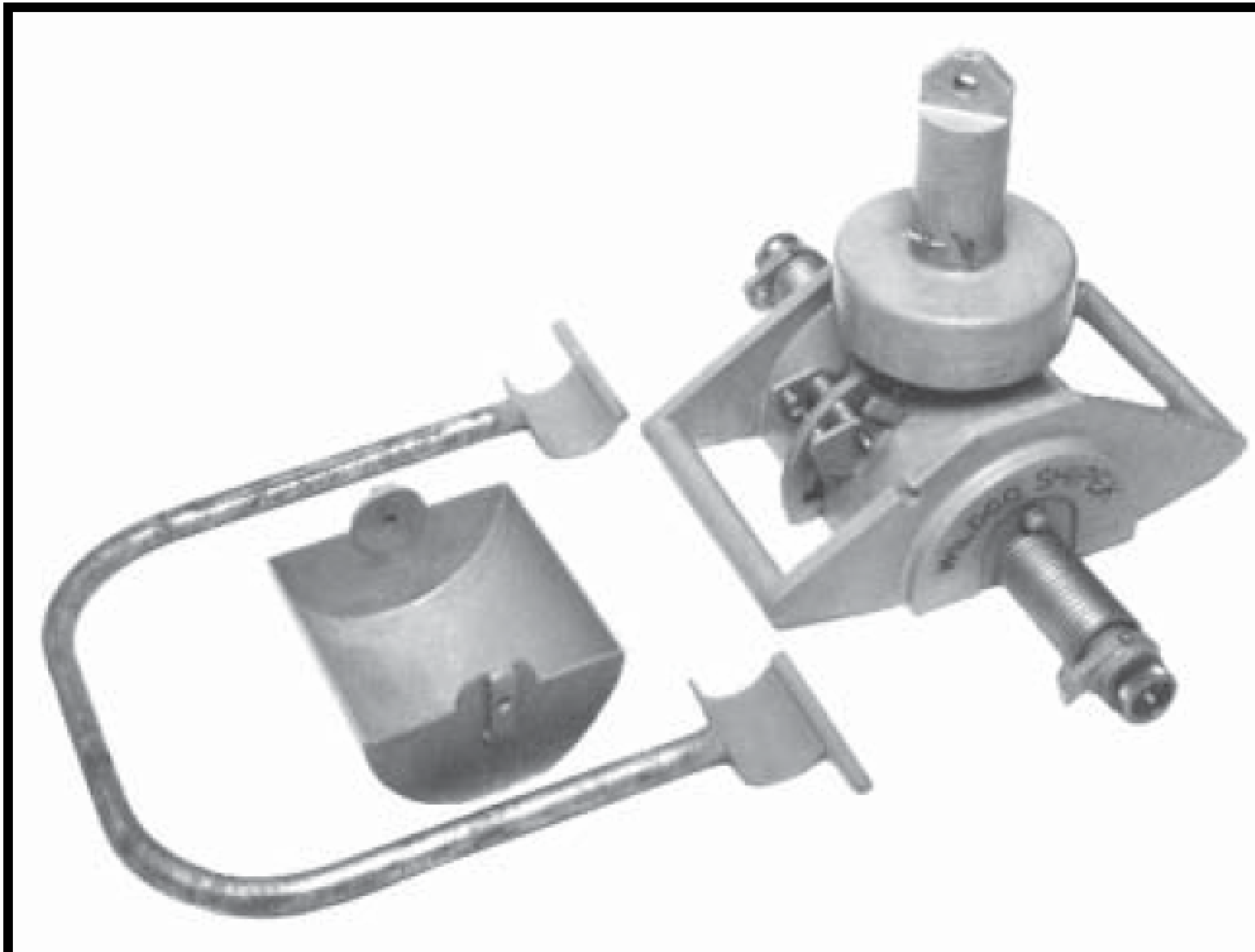


Figure 3.1: Shipek grab

Figure 3.2: Shipek grab being deployed at MCR

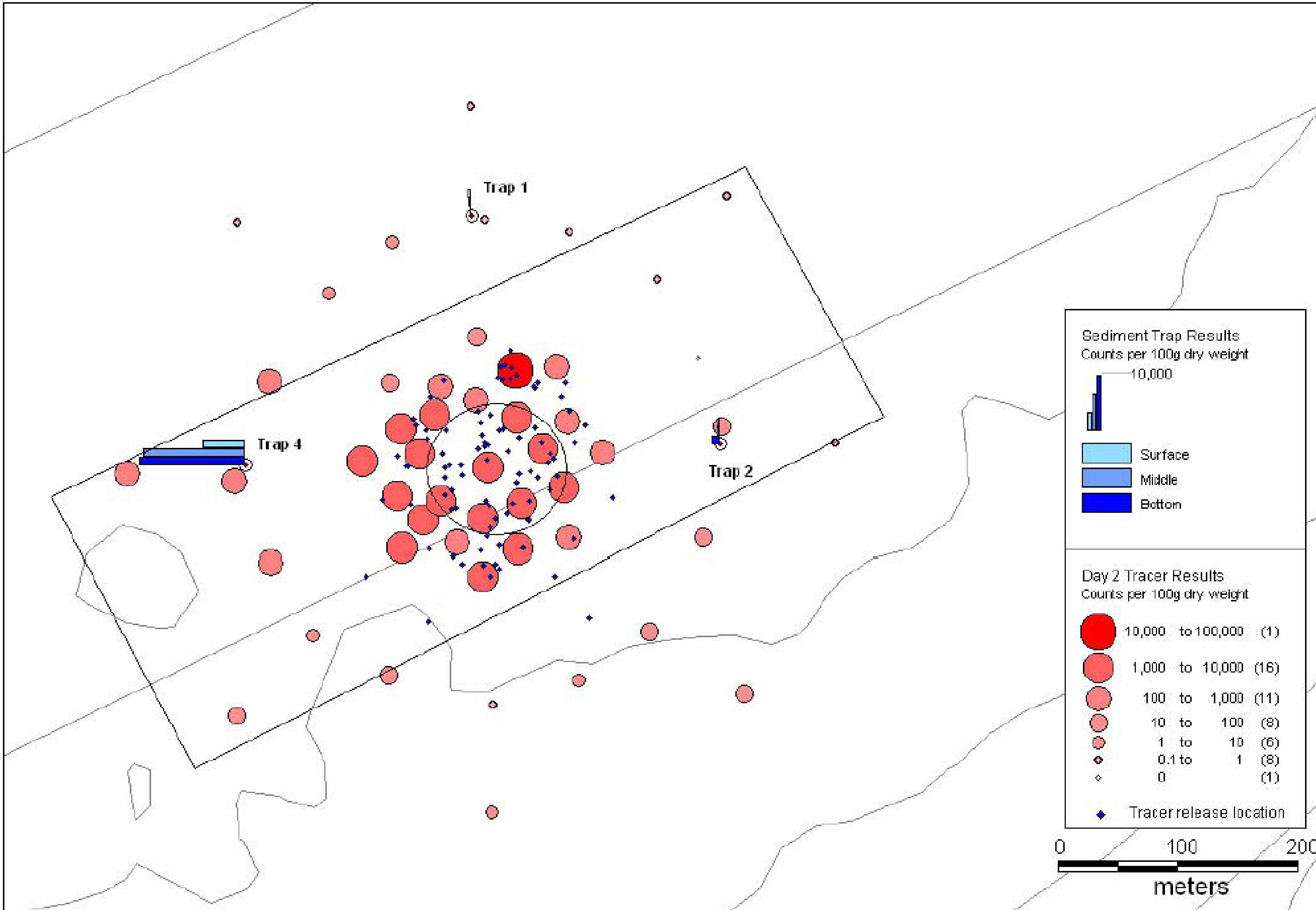


Figure 4.3: Day 2 grab samples and sediment traps 3rd October

Table 6: Mass budget analysis summary Day 2

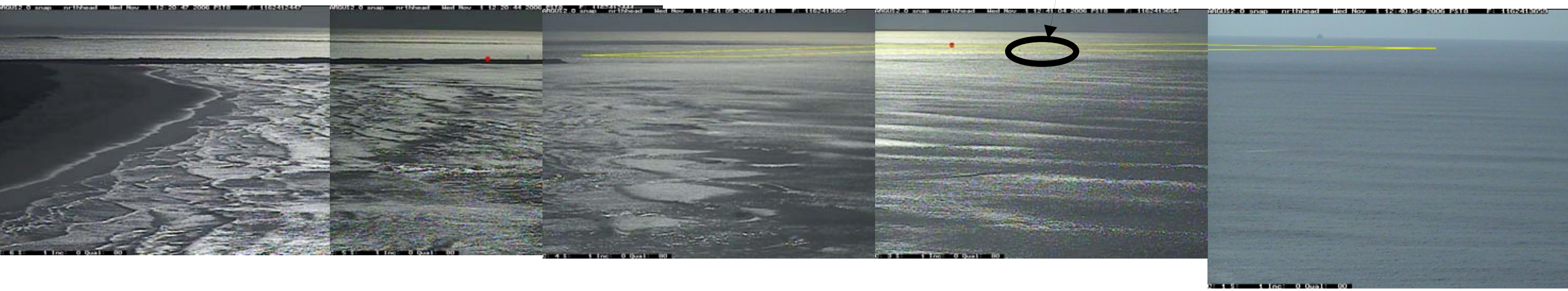
	Area 1 (0–100 m radius)	Area 2 (100–300 m annulus)	Total
Area	31,416 m^2	251,327 m^2	282,743 m^2
Depth of sediment sampled	0.05 m	0.05 m	
Volume of sediment	1,571 m^3	12,566 m^3	14,137 m^3
Mass of dry sediment in volume	8.2×10^6	3.7×10^7	4.5×10^7
Total tracer particles measured in grabs in Area	1.38×10^{11}	1.70×10^{10}	1.55×10^{11}
Total tracer particles released			1.5×10^{11}
Percentage accounted for in Area	92%	11%	103%

Based on the relatively recent disposal 2 days prior, it is estimated that minimal burial of the tracer had taken place.

ARGUS Cameras

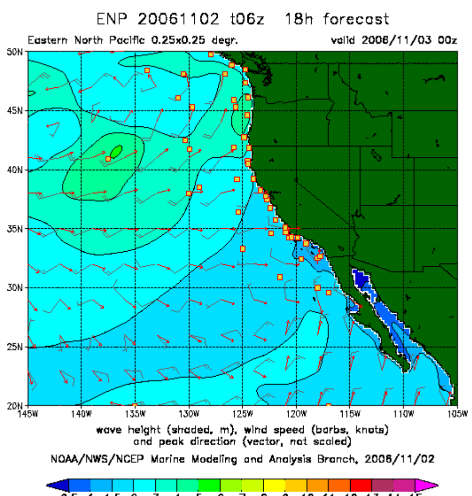
http://zuma.nwra.com/north_head/

Tracer Release Zone



View from North Head ARGUS Station

ALL WAS CALM on 1 NOV 2006



BUT Times were a Changing.

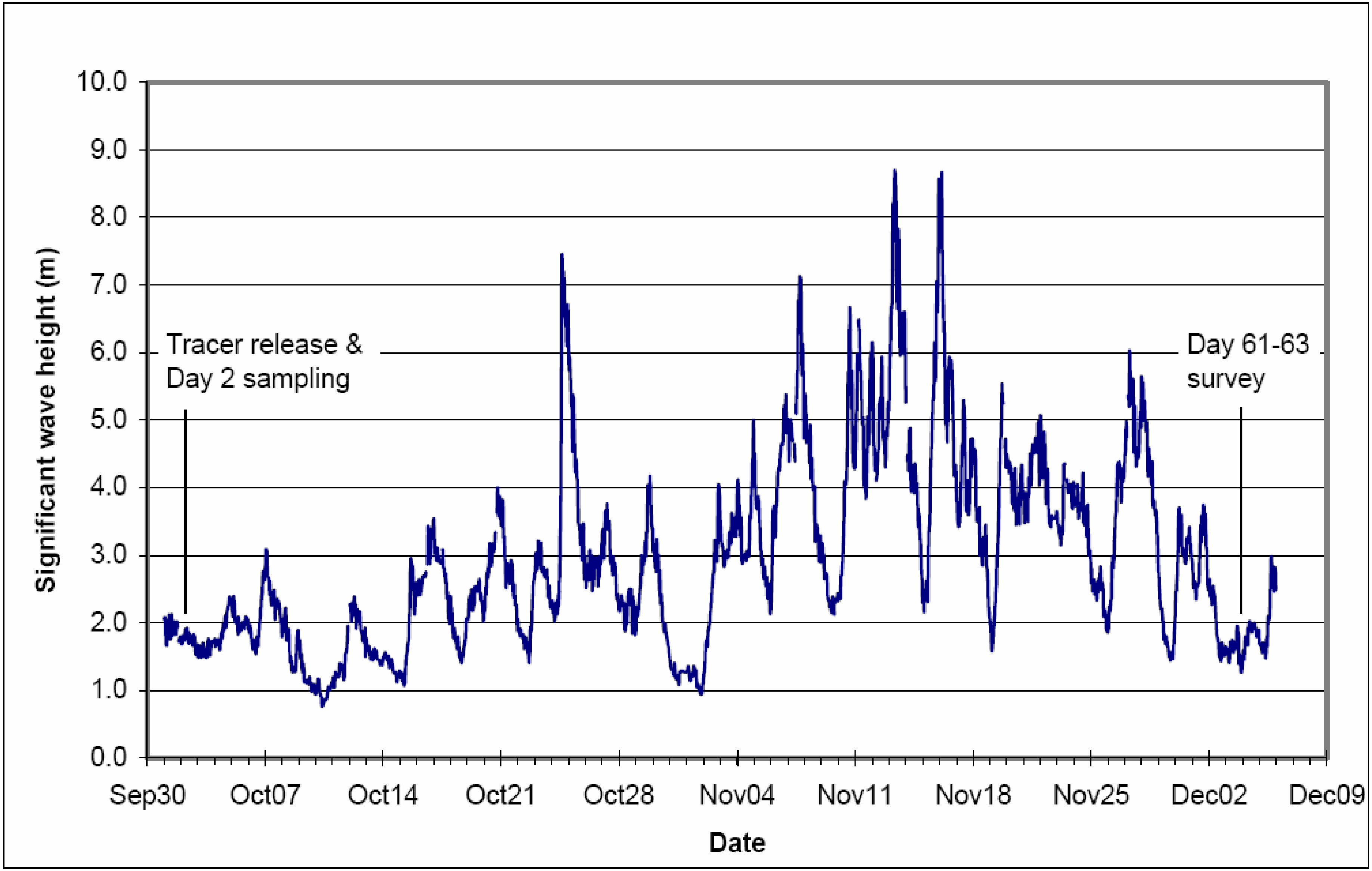
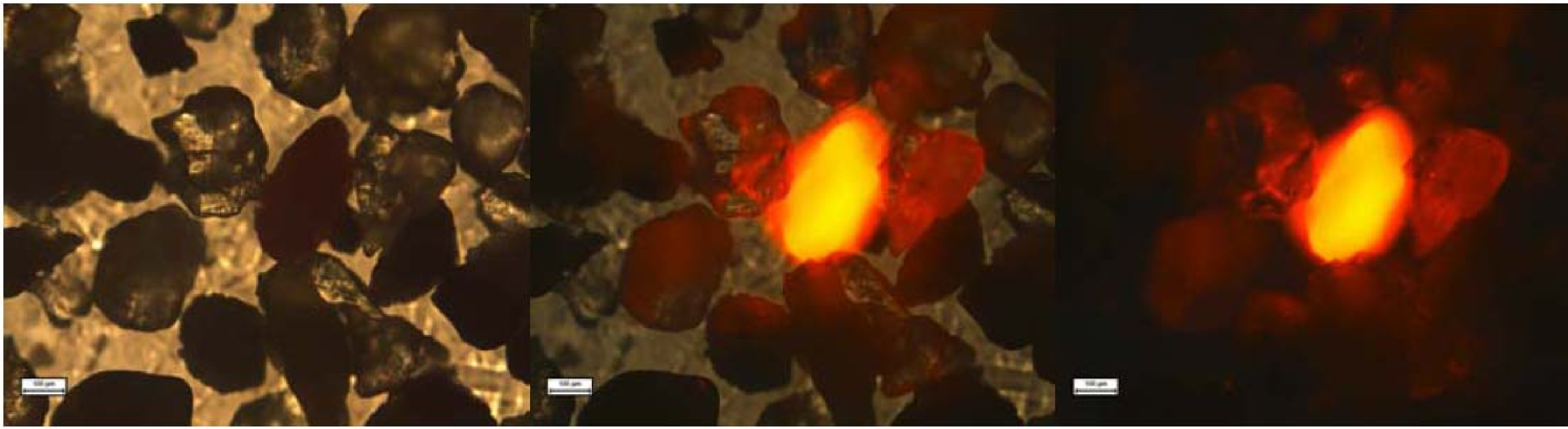


Figure 4.1: Significant wave height data from 1st October to 5th December 2006



Tracer particle in native sand white light only, no fluorescence illumination.

Tracer particle in native sand White light and fluorescence illumination

Tracer particle in native sand No white light, fluorescence illumination only.

Figure 2.5: Fluorescence micrographs of an MCR tracer particle

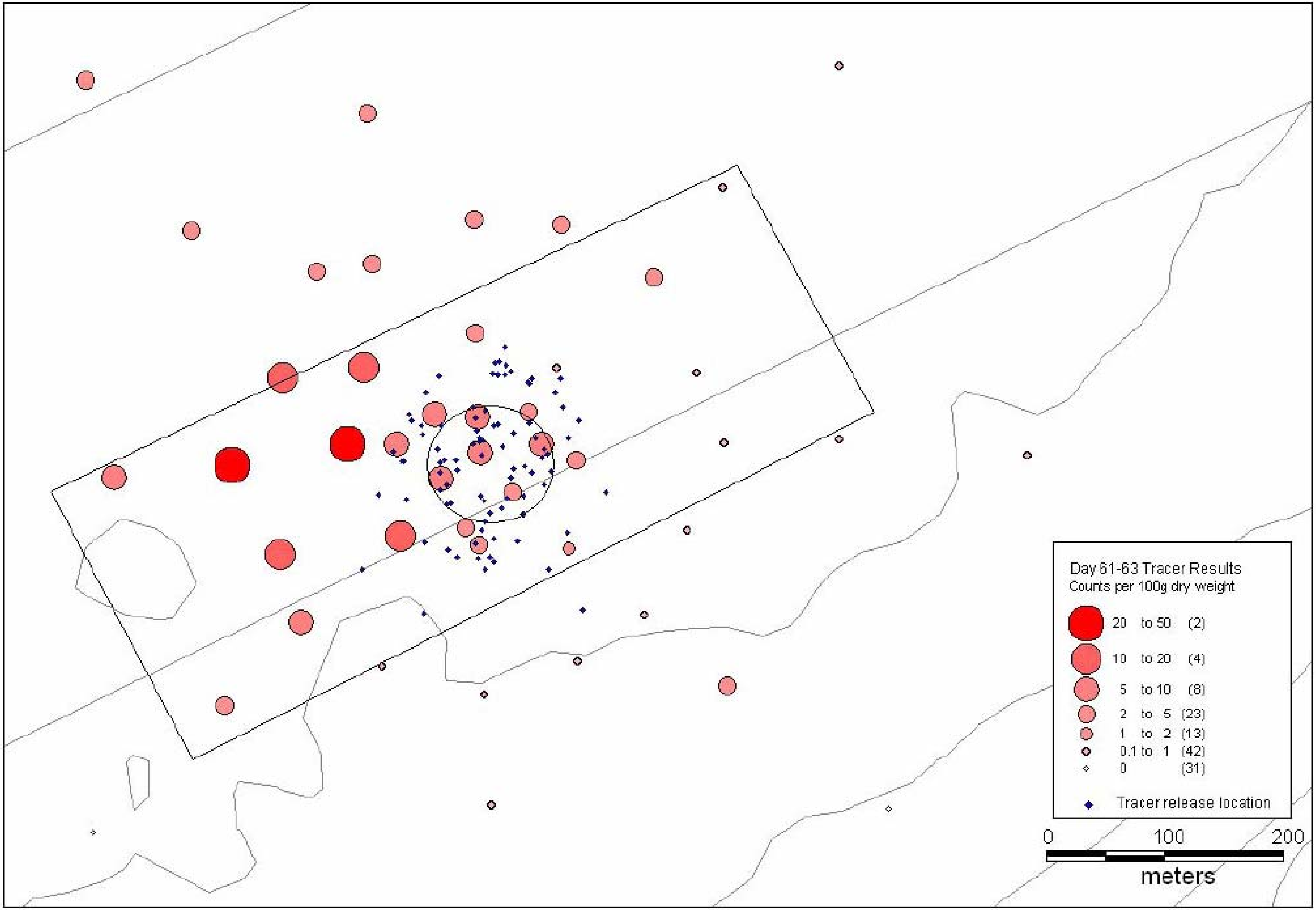


Figure 4.4: Tracer concentrations measured in grab samples collected Day 61–63 (around the tracer release area)

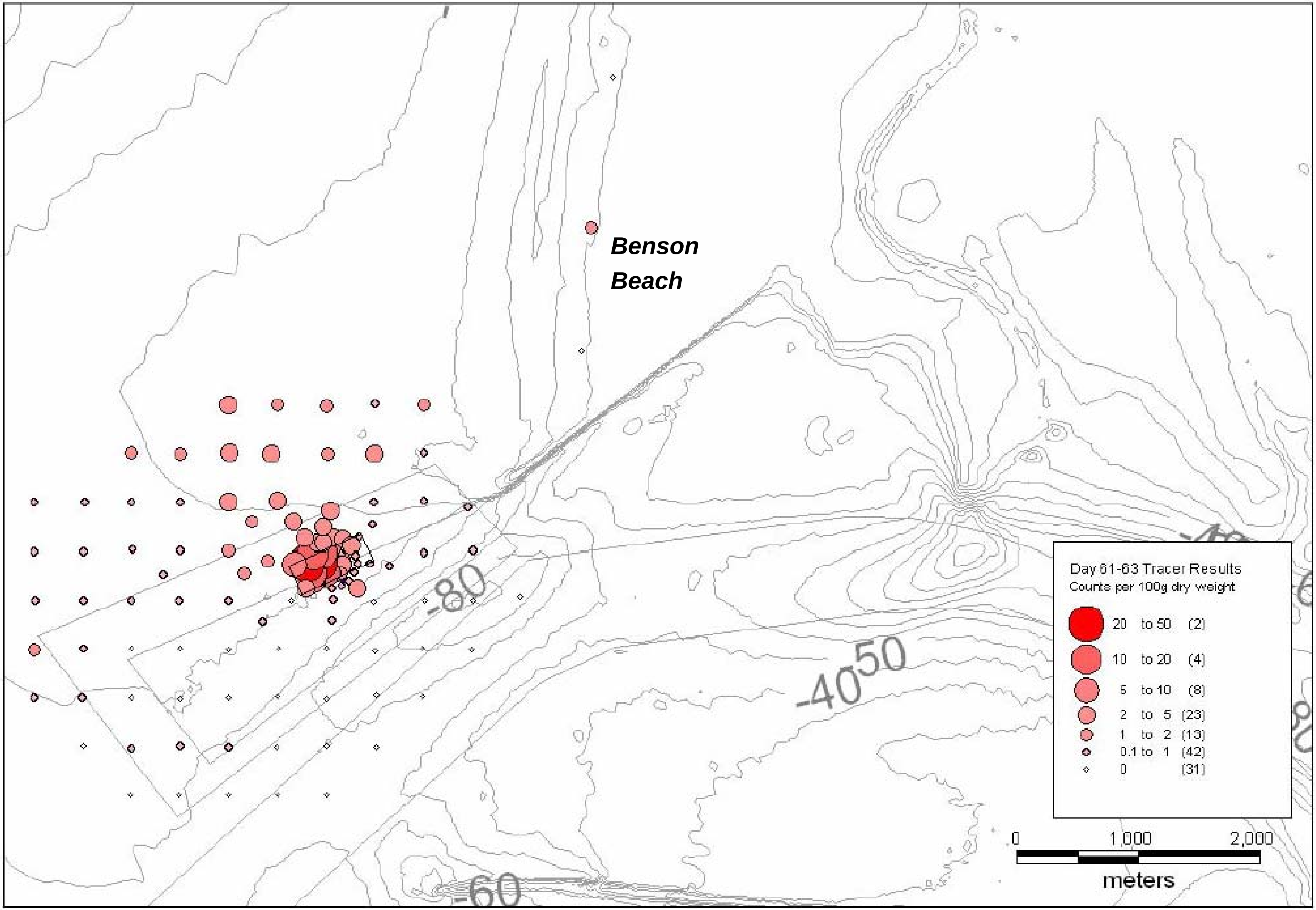


Figure 4.5: Tracer concentrations measured in grab samples collected Day 61–63 including Benson Beach

Table 7: Mass budget analysis summary Day 61–63

	Area 1 (0–100m radius)	Area 2 (100–300m annulus)	Area 3 (Outwith 300m radius)	Total
Area	31,416 m^2	251,327 m^2	1.12×10^7 m^2	1.16×10^7 m^2
Depth of sediment sampled	0.05 m	0.05 m	0.05 m	0.05 m
Volume of sediment	1,571 m^3	12,566 m^3	560,200 m^3	582,300 m^3
Mass of dry sediment in volume	8.2×10^6	3.7×10^7	1.33×10^9	1.38×10^9
Total tracer particles measured in grabs in Area	7.96×10^8	1.42×10^9	9.34×10^9	1.16×10^{10}
Total tracer particles released				1.5 × 1011
Percentage accounted for in Area	0.53%	0.95%	6.3%	7.7%

Interim Conclusions

Did the tracer ‘behave’ in the same way as dredged sediment in SWS disposal site

The tracer particles had a density, particle size D50 and range, and fall velocity very similar to the natural sediment.

The Study Team concluded that the tracer did have the same physical characteristics as the natural sediment.

Interim Conclusions

Does dredged sediment disposed in nearshore shallow water areas become part of the littoral budget?

Based on the Day 61–63 grab sample data, there is strong and consistent evidence that the

tracer was mobile and transported in a north or northwest direction in line with longshore

transport at SWS. These data indicate that the material did become part of the littoral

budget.

Caveat

The data indicates that a significant proportion of the tracer has not moved very far from the original release area.

One uncertainty surrounding the pattern of deposition is the fact that samples were collected using a grab sampler in an area with active sand waves,

consequently, a significant amount of the tracer may be at a depth greater than that sampled.

<u>Interim Conclusions</u>

Does sediment from SWS move northward onto Peacock Spit and ultimately Benson Beach?

The tracer results directly show that the tracer particles released in SWS <u>did move north</u> onto Peacock Spit and as far as Benson Beach within 2 months, with both very fine and fine sand tracer particles detected.

The fact the tracer was detected in one Benson Beach sample relatively quickly is very interesting and supports CENWP's inferred sediment transport

……that dredged sediment from SWS is likely to nourish the beaches to the north along the Washington coastline. The sediment tracers proved the existence of a pathway.

Continued sampling would help to understand the significance and volume of movement.

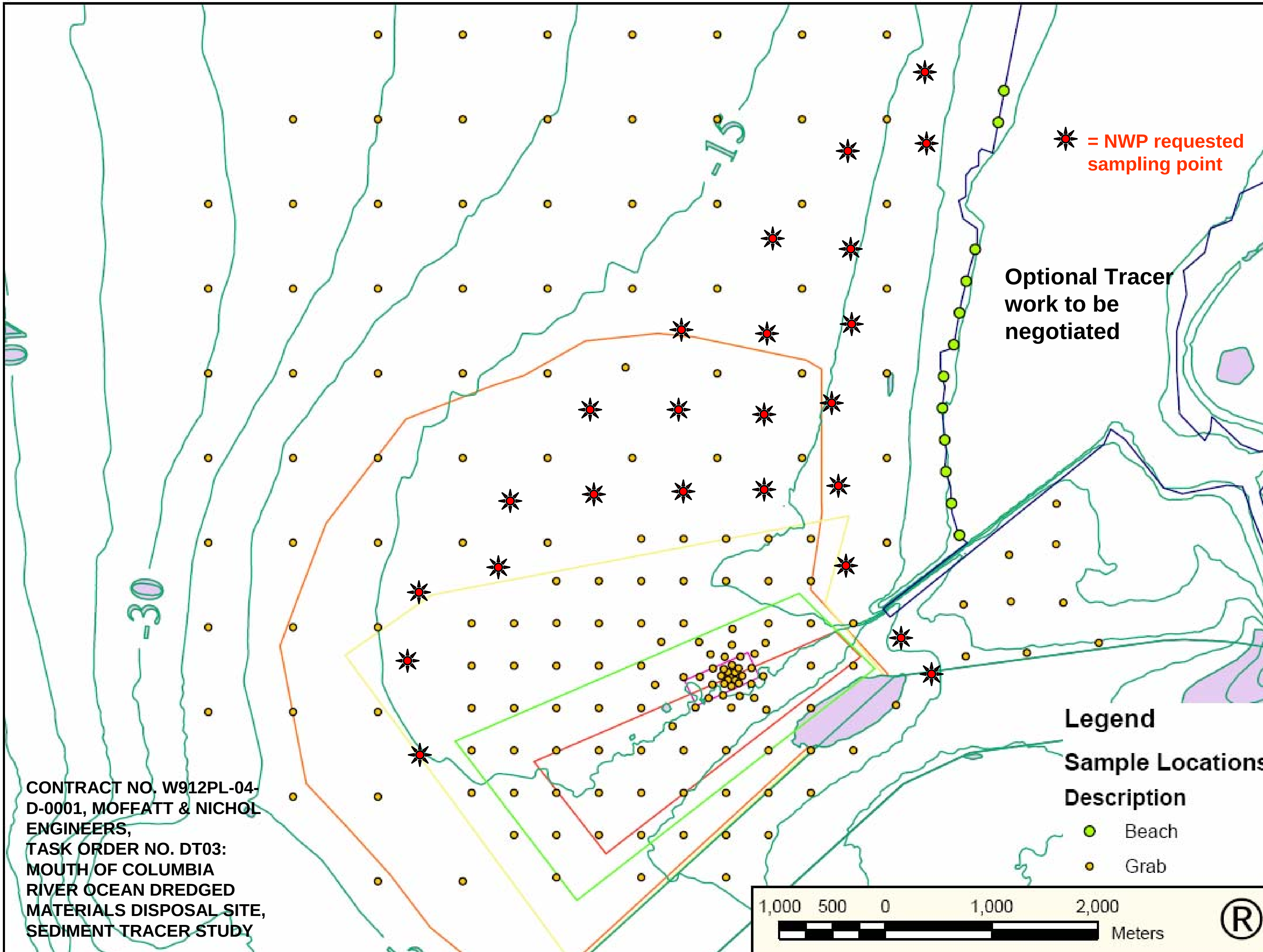

-15
-30
= NWP requested sampling point
Optional Tracer work to be negotiated
Legend
Sample Locations
Description
Beach
Grab
1,000 500 0 1,000 2,000
Meters
CONTRACT NO. W912PL-04-D-0001, MOFFATT & NICHOL ENGINEERS,
TASK ORDER NO. DT03: MOUTH OF COLUMBIA RIVER OCEAN DREDGED MATERIALS DISPOSAL SITE, SEDIMENT TRACER STUDY

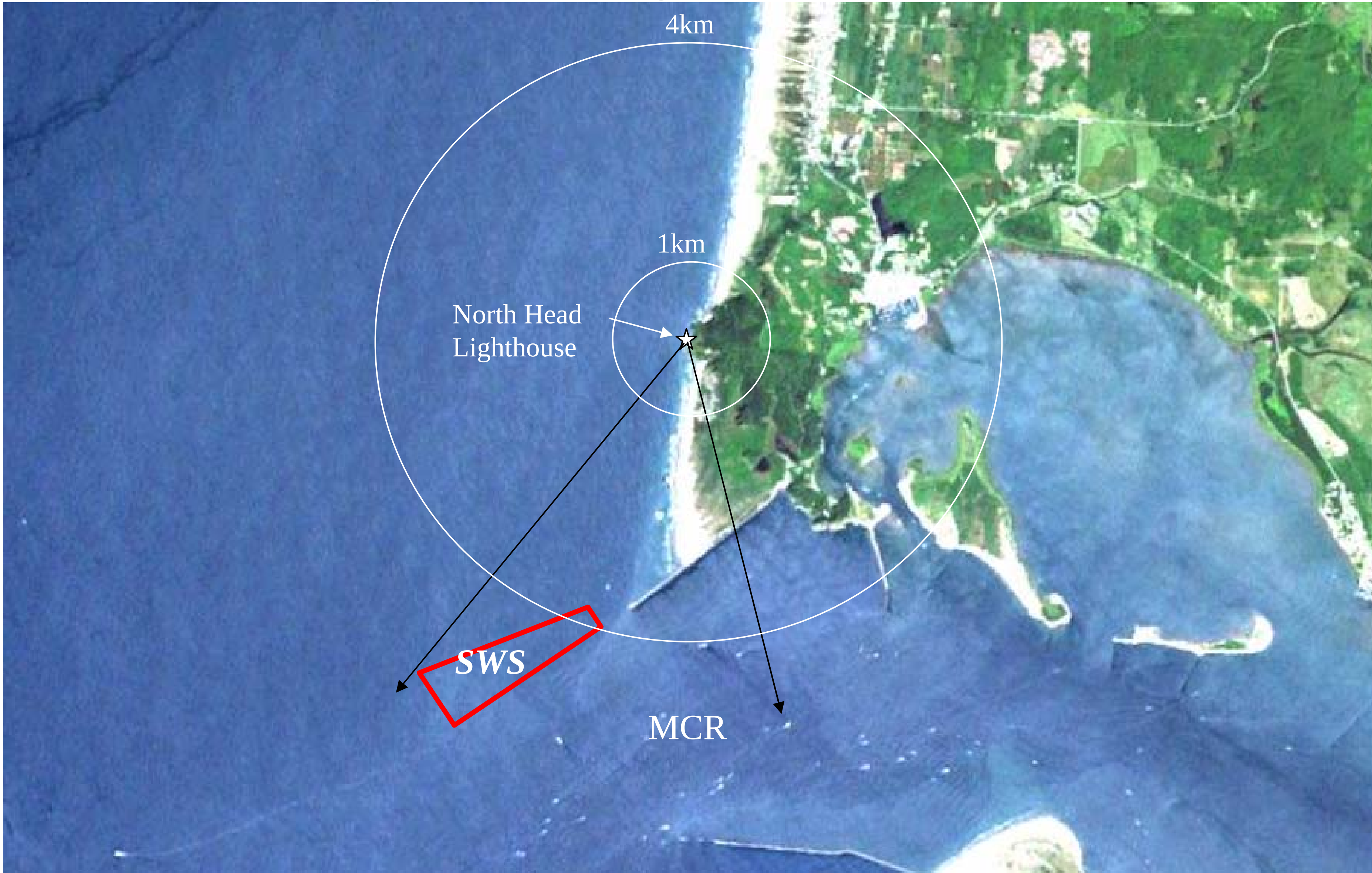
Figure 1

As Peacock Spit Erodes, The MCR North Jetty is subjected to scour and wave attack


ARGUS2.0 snap nrthhead Wed Sep 1 08:20:47 2004 PST8 F: 1094055647
South Jetty
North Jetty, 25 ft high
Benson Beach
Low Tide
C: 6 S: 1 Inc: 0 Qual: 80


ARGUS2.0 snap nrthhead Thu Dec 9 09:20:46 2004 PST8 F: 1102612846
25 ft wave
Storm Tide
C: 6 S: 1 Inc: 0 Qual: 80

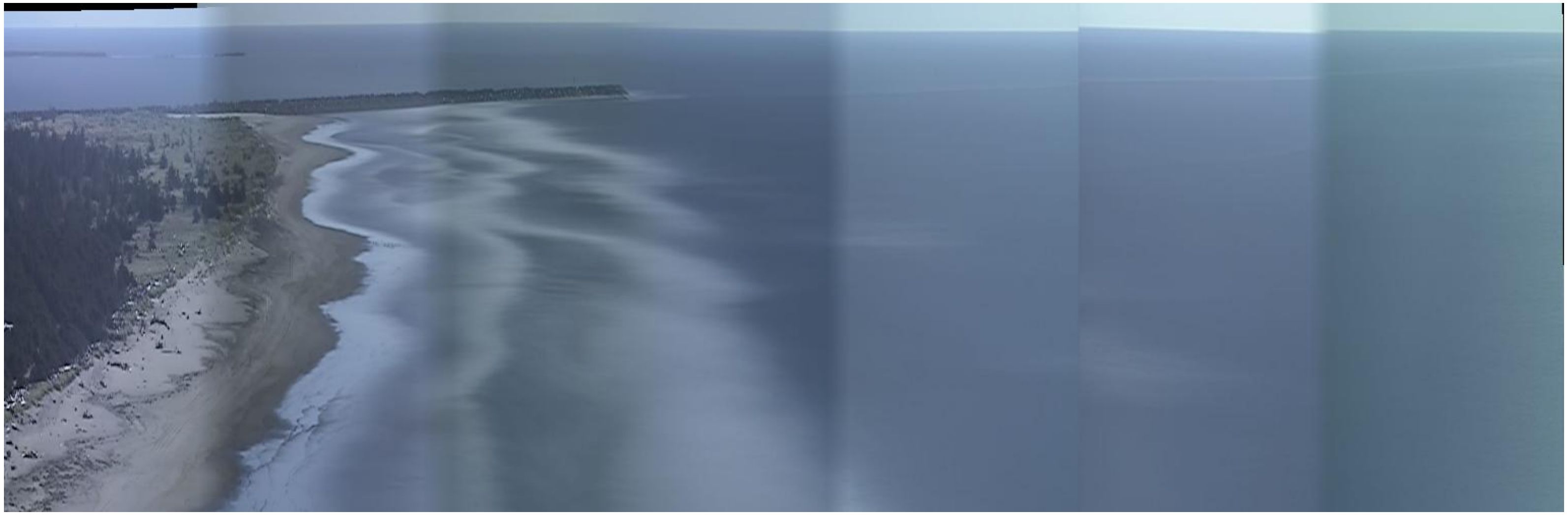
Cameras Located within North Head Lighthouse
Keep an EYE on Things at MCR – Public Access to Website



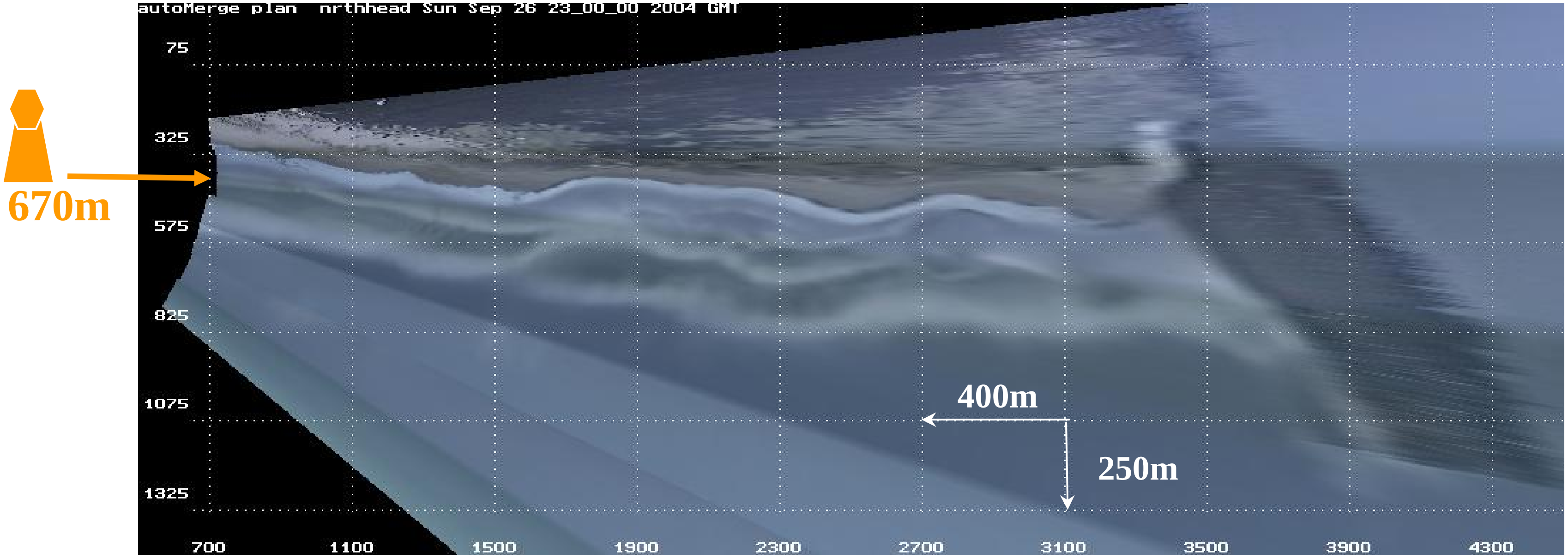
2 miles; 3.22 km

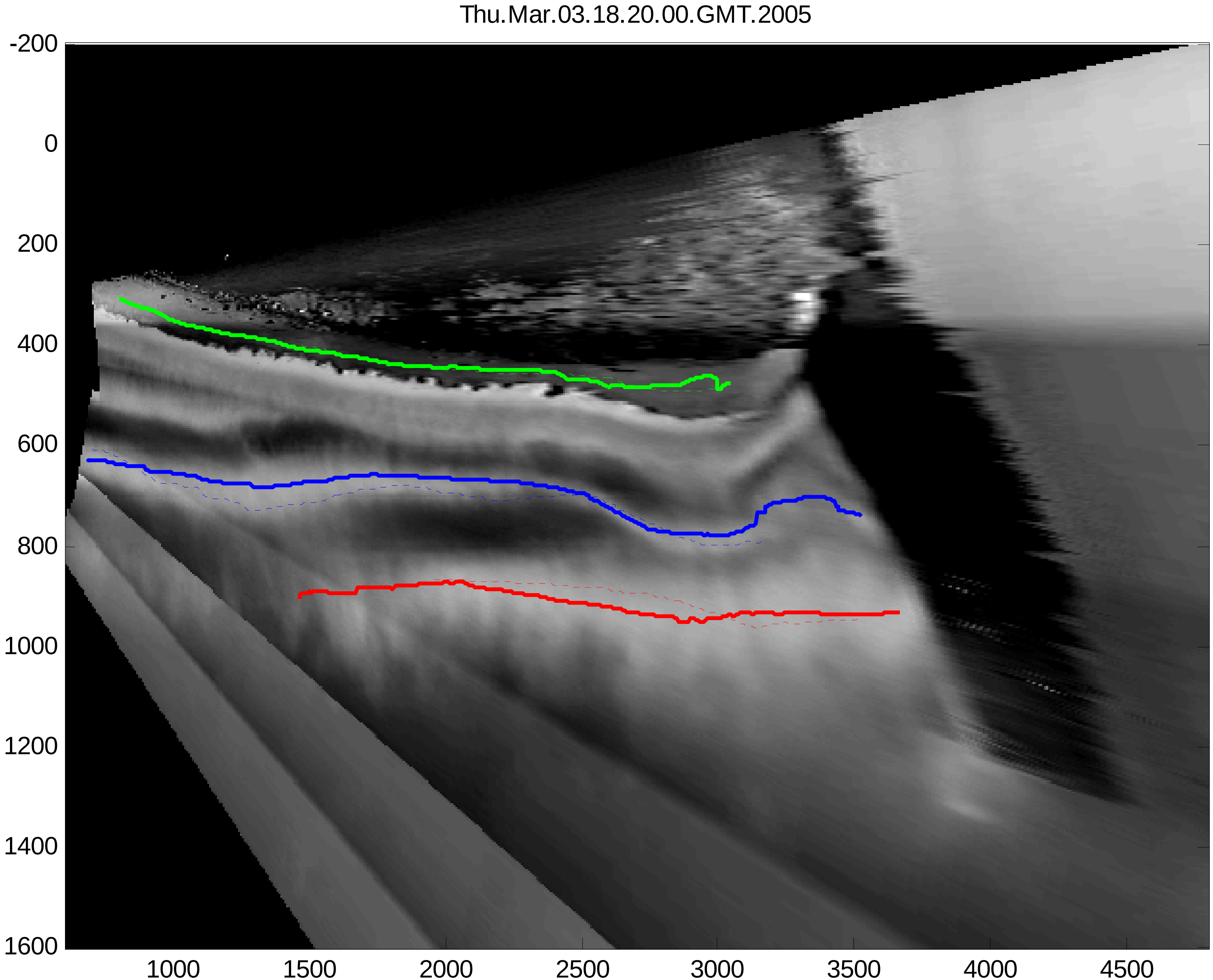
ARGUS Cameras

http://zuma.nwra.com/north_head/



Panoramic to Plan Views – 26 Sept 04

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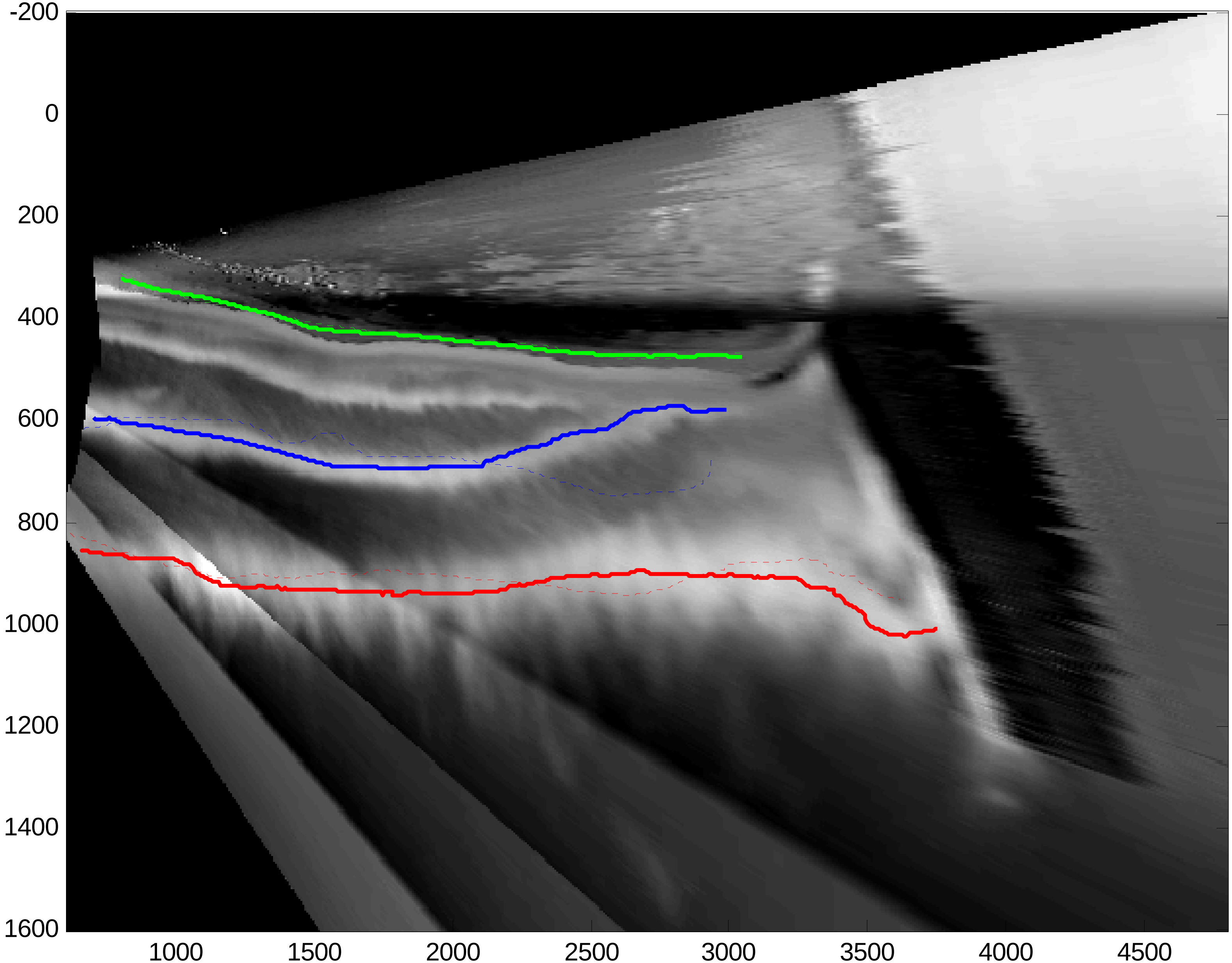

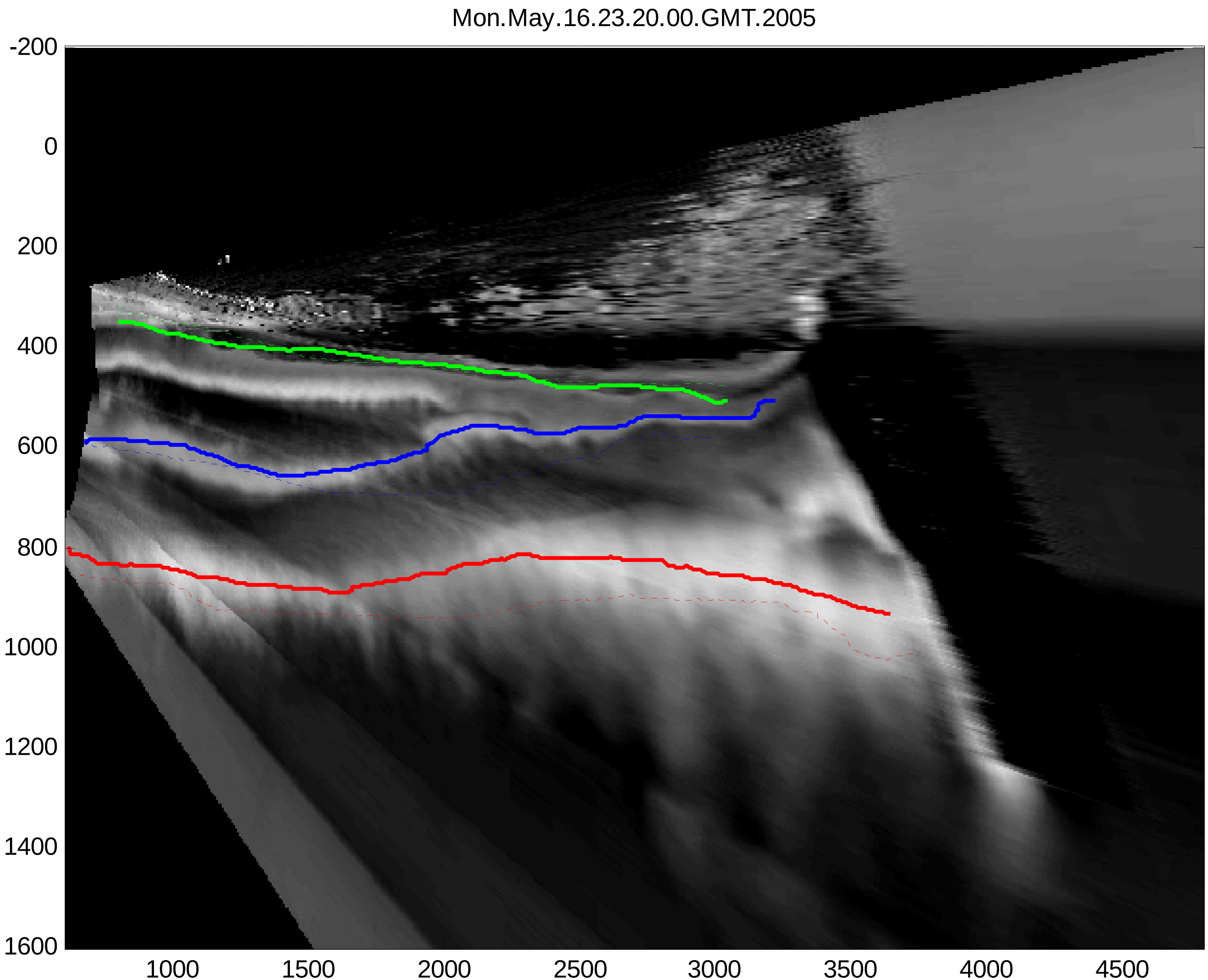
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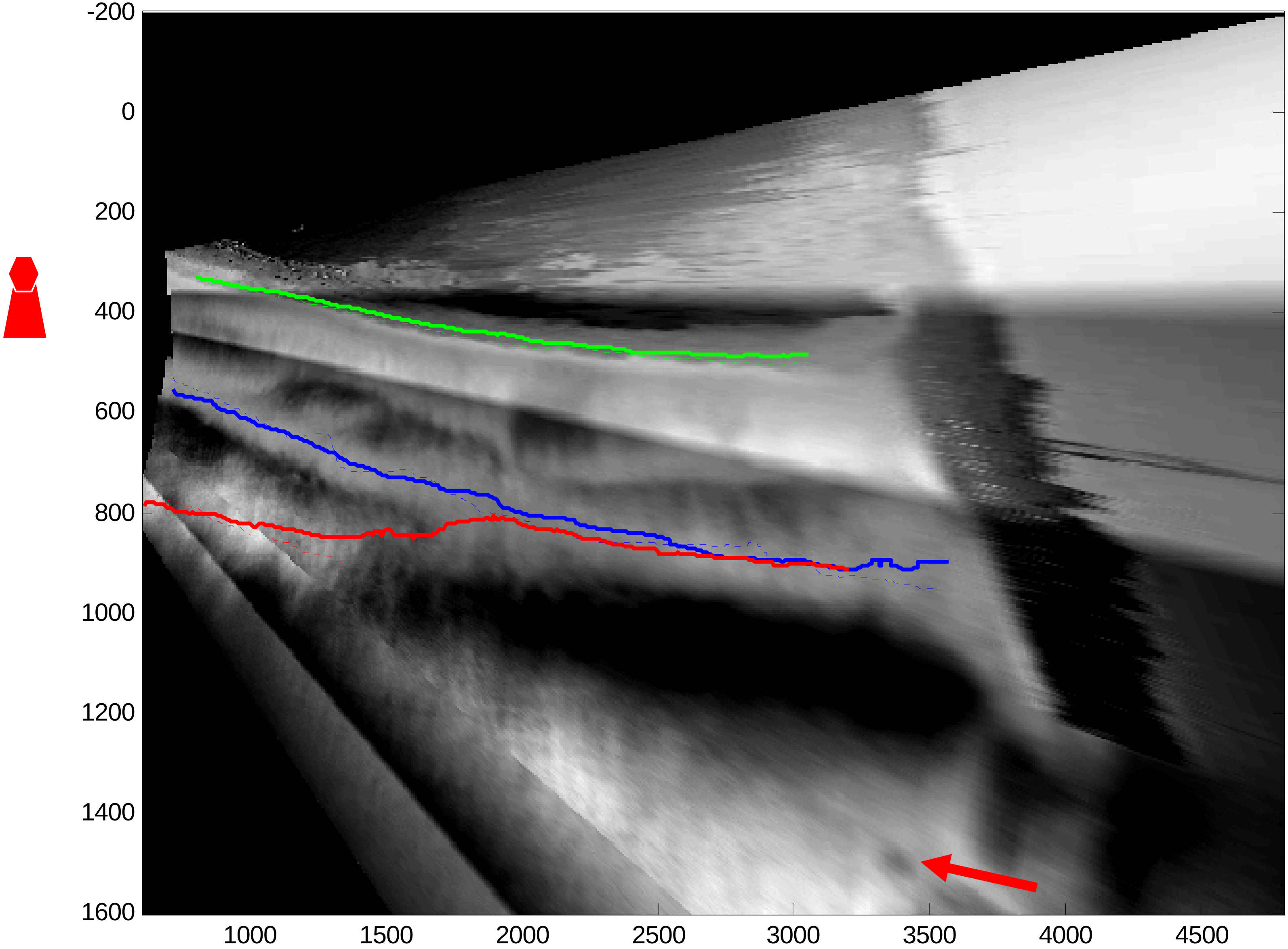
Why are the waves breaking there: Sediment Moving out of SWS?



October 2005 – end of SWS material placement

26 MAY 2006 ARGUS Beach Monitoring System at North Head cameras 5 & 6

Additional Erosion (cutting) of Beach Scarp during winter '05-'06

Sand from "Sand Bars" being transported onshore

Note lighter color of sand migrating shoreward from sand bars covering darker sands

The darker color sands contain hematite and other heavy minerals. The darker sands are more dense and less mobile than the lighter color sands, and tend to stay on the beach during the winter wave season. The dredged sediment placed at the SWS has likely contributed to the sand supply of Peacock Spit. The lighter color sands may come from the dredged sand placed at the SWS.