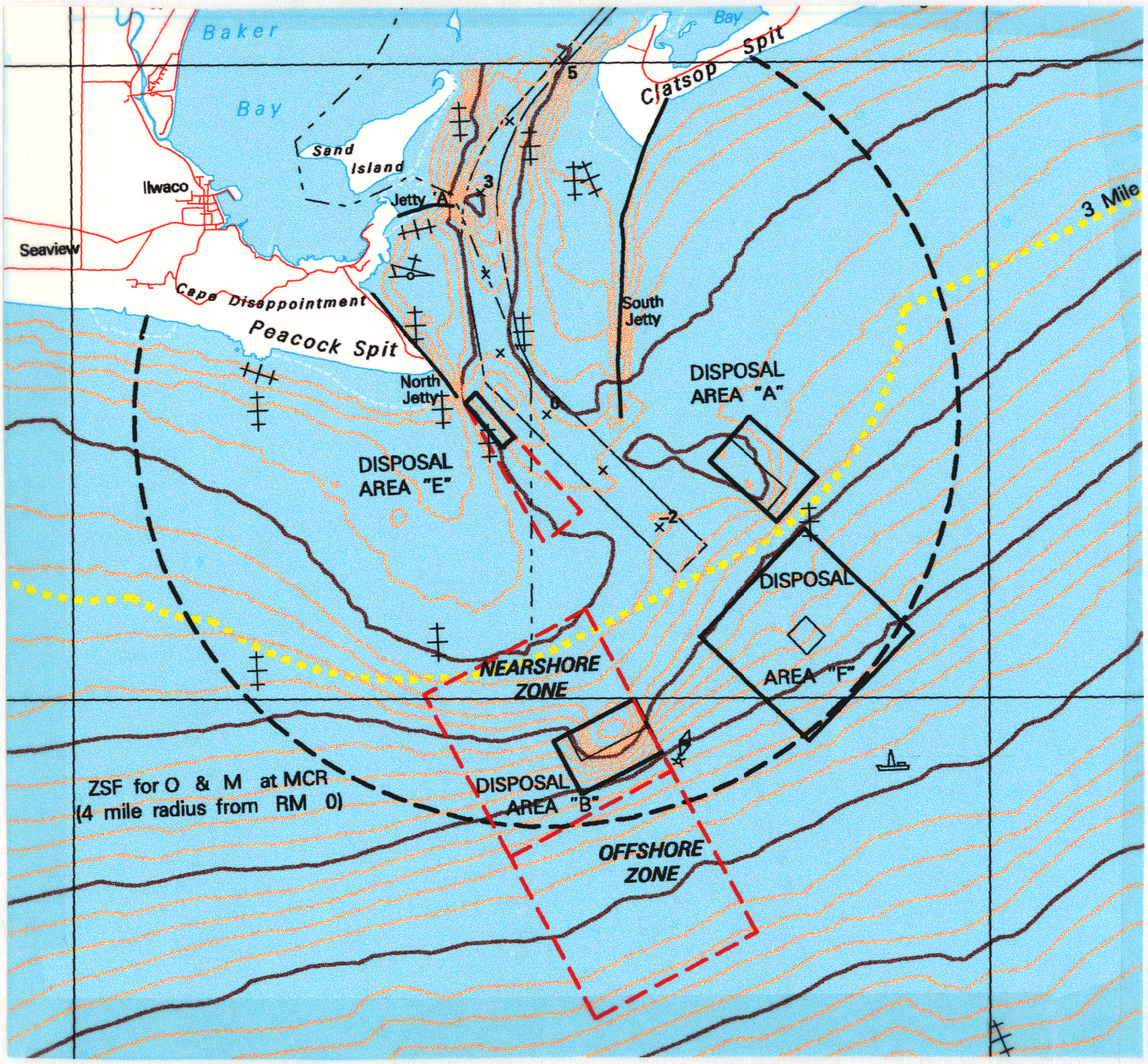
US Army Corps of Engineers
Portland District

EPA Region 10

Utilization of Existing MCR ODMDSs and Proposed Expansion of Sites "B" and "E"



FINAL REPORT **JUNE 1997**

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ACKNOWLEDGEMENTS

This report is a compilation of existing data and new analysis techniques that were used to investigate the behavior of dredged sediment when placed in open water disposal sites. The work reported herein was jointly sponsored by the U.S. Army Engineer District Portland (Corps) and the U.S. Environmental Protection Agency Region 10 (EPA). The following EPA staff were significant contributors to the development of this report; Mr. John Malek and Mr. Otto Moosburner. Corps Contributors included: Mr. Mark Siipola, Mr. Steve Stevens, Mr. Steve Chesser, Mr. Eric Braun, and Mr. Kim Larson.

Ocean Dredged Material Disposal Sites at the
Mouth of the Columbia River

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EXECUTIVE SUMMARY

Geographic Location: Northwest Pacific Coast of continental United States, deep draft ocean entrance to the Columbia River along Oregon and Washington

Organizational Oversight: U.S. Army Corps of Engineers - Portland District and U.S. Environmental Protection Agency - Region X

Project Features Addressed: Ocean Dredged Material Disposal Sites at the mouth of the Columbia River

This report describes the physical evaluation of sediment deposition and transport at the Mouth of the Columbia River. The report presents assessments and supporting analyses to permit informed decisions regarding the optimal use of existing ocean dredged material disposal sites (ODMDSs) at MCR and the rationale for temporary expansion of key ODMDSs. The report was compiled during June and December 1996. Final revisions were made in June 1997.

The report is composed of three sections. Section 1 describes the four (4) ODMDSs located at MCR in terms of site designation criteria and operational performance to date. Section 2 assesses the remaining site capacity for ODMDS F in terms of dredged material mounding and its effects upon the ambient wave environment. Section 3 develops a strategy for temporarily expanding ODMDSs B and E to facilitate optimal consideration of criteria specific to the oceanographic environment at MCR. Expanded site boundaries are proposed.

Ocean Dredged Material Disposal Sites at the
Mouth of the Columbia River

Utilization of Existing MCR ODMDSs and Proposed Expansion of Sites "B" and "E"

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Section 1
DISPOSAL OF DREDGED SEDIMENTS AT THE MOUTH OF THE COLUMBIA RIVER

MCR PROJECT BACKGROUND

The deep draft navigation project located at the ***Mouth of the Columbia River*** (MCR) consists of a dredged navigation channel 6 miles long which extends through a jettied entrance between the Columbia River and the Pacific Ocean (figure 1).

Substantial quantities of sediments have been dredged near the Mouth of the Columbia River (MCR) since 1885, when dredging was initiated to establish a 30-foot deep channel across the entrance bar formed by Clatsop spit. The natural channel had averaged about 25 feet deep and shifted frequently both during and between seasons. In order to maintain a consistent 30-foot channel across the bar, the south side of the river entrance was jettied between 1885-1889. Additional channel deepening to 40 feet was begun in 1905. In 1913, the north side of the entrance channel was jettied to prevent shoaling from Peacock spit. The north jetty is approximately 2.5 miles long and the south jetty is 6.6 miles long.

The MCR entrance channel was deepened to 48 feet in 1956. The channel was deepened to its present authorized depth of 55 feet in 1984. The authorized project (Rivers and Harbor Act of 1884, 1905, 1954; and Public Law 98-63) provides for a 2,640-foot-wide channel across the Columbia River Bar. The northerly 2,000 feet of the channel was deepened to 55 feet (plus 5-feet for over dredging), and the southerly 640 feet of the channel was deepened to 48 feet (plus 5-feet for over dredging).

The MCR project has two main shoaling areas. The outer (ebb tidal) shoal extends from approximately river mile (RM) -2 to RM -0.8. The inner (flood tidal) shoal, Clatsop Shoal, extends from approximately RM 0.3 to RM 2.6, beginning on the south side of the entrance and crossing the channel near RM 1.0 [Siipola & Braun, 1995]. In its present configuration, the entrance channel at MCR requires annual dredging of 3-5 million cubic yards of fine-medium

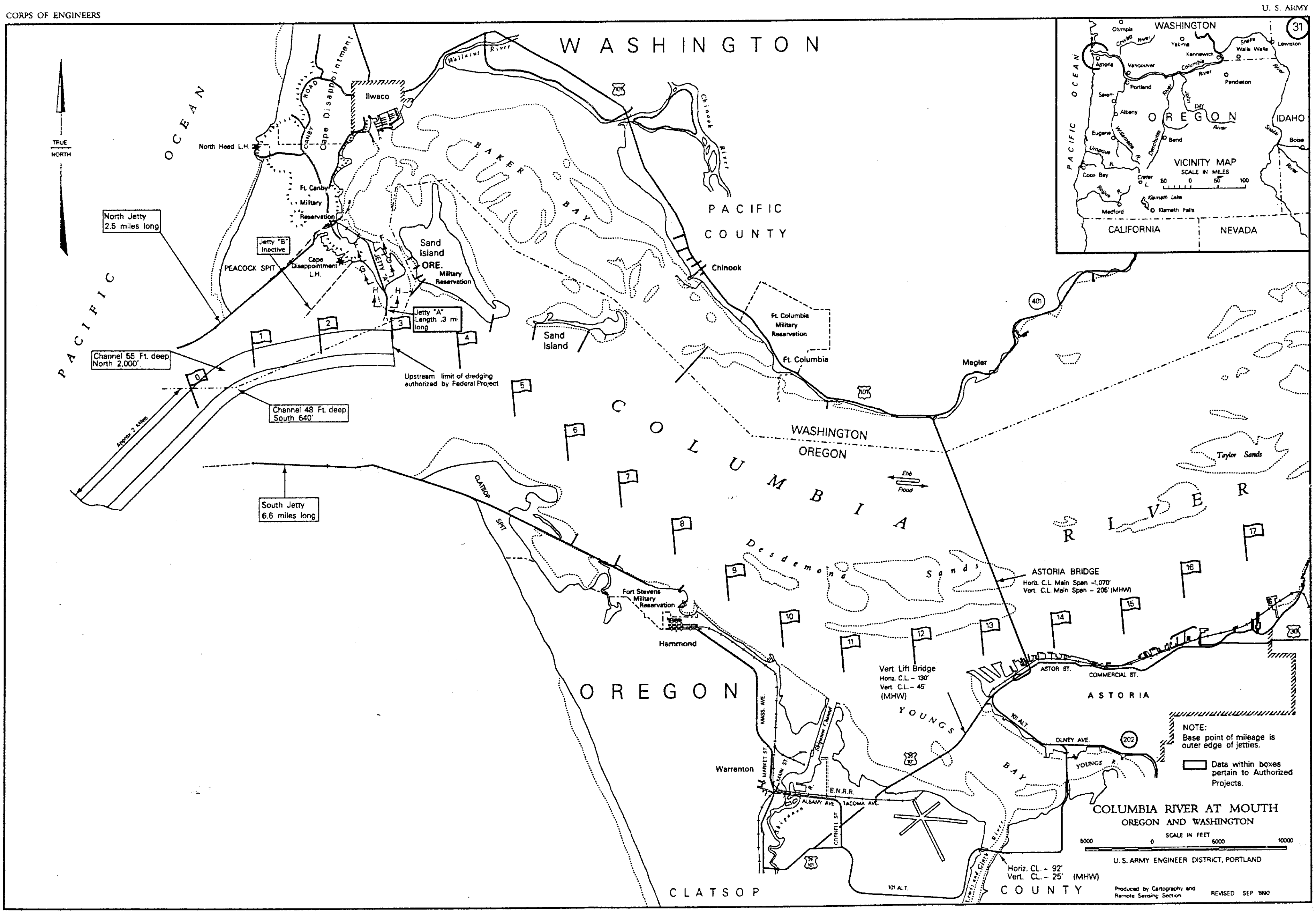


Figure 1. Mouth of the Columbia River project map

sand to maintain the navigation channel at the authorized depth. The sandy dredged material is placed in EPA designated ocean dredged material disposal sites. Dredging at the MCR is performed by hopper dredges. The use of open water sites for disposal of material dredged from MCR became regular after 1945 and has continued to the present.

OCEAN DREDGED MATERIAL DISPOSAL SITES

Before 1977, all ocean disposal sites were described only by approximate locations. Prior to EPA designation, the location of the disposal sites was not precisely specified and the placement of dredged material within the disposal sites was not strictly controlled.

In January 1977, disposal sites A, B, E, and F received interim designations when EPA issued the final Ocean Dumping Regulations (40 CFR 228). At the time of interim site designation, the boundaries for the rectangular disposal sites were fixed geographically in terms of corner coordinates. The interim designations were extended by EPA several times since promulgation of the CFR. An environmental impact statement (EIS) for final designation of the four sites was finalized in February 1983.

Ocean dredged material disposal sites (ODMDS) A, B, E, and F received final designation in August 1986 (51 FR 29923-29927). Figure 2 denotes the official boundaries for the EPA interim-designated sites A, B, E, and F dated 1977 (dashed line). During the period 1977 through 1996, material dredged from the MCR project has been placed at sites A, B, E, and F. In 1992, ODMDSs A, B, and F were expanded to address increased capacity needs (figure 2, solid line). The annual volume of dredged material placed at MCR ODMDSs since 1977 is summarized in table 1.

ODMDSs A and B have been the primary locations where MCR dredged material has been placed. These two ODMDSs are located on the westward boundary of the ebb-tidal shoal and are economical (in terms of haul distance) for disposal of sediments dredged from both the outer and inner bars at MCR. Since 1992, ODMDS B has received most of the MCR dredged material as concerns arose that sediments deposited in ODMDS A were accumulating, creating an adverse wave climate, and might migrate northward back into the entrance channel.

ODMDSs E and F have been used as secondary disposal sites for sediments dredged from the entrance channel at MCR. The use of site E is partially in response to a 1979 request from the Washington Department of Ecology to enhance sand by-passing and retard erosion of the coastal beaches north of MCR. Beginning in 1988, the volume of dredged material placed in ODMDS E was restricted to 1 million cubic yards/year to prevent dredged material accumulation (mounding) and limit transport of placed dredged material back into the MCR channel. Site F has been used only recently, motivated by the need for disposal of sediments dredged from locations other than MCR and additional site capacity requirements.

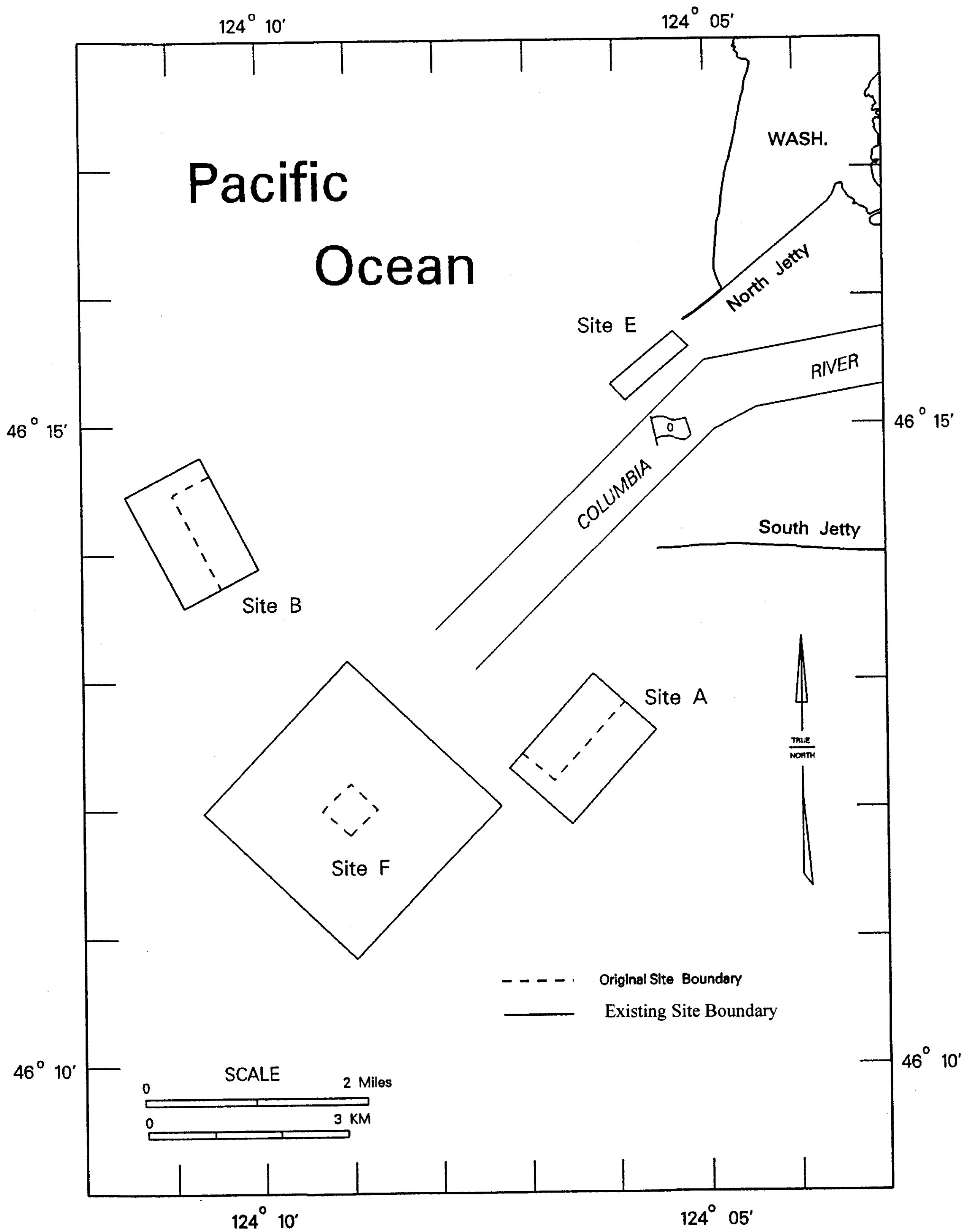


Figure 2. Mouth of the Columbia River - ocean dredged material disposal sites (ODMDS).

Disposal of Dredged Material at MCR ODMDSs (1977-1996)

Disposal Sit	A	B	E	F	Total cubic yards
Year		cy	cy	cy	cy
1977	2,612,514	3,184,528	3,327,732	0	9,124,774
1978	1,268,177	1,545,846	1,615,360	0	4,429,383
1979	1,490,504	1,816,852	1,898,552	0	5,205,908
1980	11,142	118,686	2,675,722	0	2,805,550
1981	2,254,321	9,180	3,042,896	0	5,306,397
1982	971,209	12,240	3,086,514	0	4,069,963
1983	1,124,466	199,969	606,218	0	1,930,653
1984	4,060,853	3,864,247	989,600	0	8,914,700
1985	1,326,150	2,068,927	4,126,429	0	7,521,506
1986	2,037,455	3,387,376	2,926,412	0	8,351,243
1987	1,593,550	1,209,358	1,183,050	0	3,985,958
1988	1,447,240	4,533,756	478,864	0	6,459,860
1989	647,458	3,456,285	568,522	2,030,954	6,703,219
1990	2,729,358	1,119,663	507,201	0	4,356,222
1991	1,486,938	1,956,570	380,142	0	3,823,650
1992	874,700	2,888,028	796,198	0	4,558,926
1993	0	1,629,208	988,208	2,288,431	4,905,847
1994	408,924	1,002,668	397,621	1,500,407	3,309,620
1995	0	2,480,664	988,547	0	3,469,211
1996	0	1,693,145	726,336	2,205,113	4,624,594
Totals	26,344,959	38,177,196	31,310,124	8,024,905	
Average for 1990 - 1996	785,703	1,824,278	683,465	856,279	***4,149,724***
	Total Volume placed in ODMDSs (cy), 1977-1996				***103,857,184***

Table 1. Volume of Dredged Material Placed at MCR ODMDSs since 1977.

The lineal dimensions, boundary coordinates, and water depth variation for the ***present*** configuration of ODMDSs A, B, E, and F are described below. Disposal boundary coordinates are in state plane, Oregon north zone, NAD 27 (ft). These boundaries apply to present ODMDS configuration (figure 2, dashed line). Based on the findings presented in this report, the ***new*** dimensions and corner coordinates for recommended expansion of ODMDSs are presented in section 3 of this report.

ODMDS "A": dimensions = 6,000 ft x 4,000 ft, azimuth = 225°, average depth = 65 ft
1994 elevation variation = -90 MLLW to -42 MLLW

Northwest corner - Easting=1,083,484 ft, Northing=946,096 ft
Northeast corner: - Easting=1,087,695 ft, Northing=950,370 ft
Southwest corner: - Easting=1,086,334 ft, Northing=943,289 ft
Southeast corner: - Easting=1,090,544 ft, Northing=947,563 ft

ODMDS "B": dimensions = 6,000 ft x 4,000 ft, azimuth = 332°, average depth = 125 ft
1994 elevation variation = -150 MLLW to -54 MLLW

Northwest corner - Easting=1,066,034 ft, Northing=959,898 ft
Northeast corner: - Easting=1,069,662 ft, Northing=961,582 ft
Southwest corner: - Easting=1,068,559 ft, Northing=954,455 ft
Southeast corner: - Easting=1,072,188 ft, Northing=956,139 ft

ODMDS "E": dimensions = 4,000 ft x 1,000 ft, azimuth = 229°, average depth = 50 ft
1994 elevation variation = -75 MLLW to -46 MLLW

Northwest corner - Easting=1,089,288 ft, Northing=963,990 ft
Northeast corner: - Easting=1,092,271 ft, Northing=966,392 ft
Southwest corner: - Easting=1,089,958 ft, Northing=963,250 ft
Southeast corner: - Easting=1,093,020 ft, Northing=965,649 ft

ODMDS "F": dimensions = 10,000 ft x 10,000 ft, azimuth = 225°, average depth = 145 ft
1994 elevation variation = -180 MLLW to -90 MLLW

Northwest corner - Easting=1,068,886 ft, Northing=944,684 ft
Northeast corner: - Easting=1,076,130 ft, Northing=951,578 ft
Southwest corner: - Easting=1,075,780 ft, Northing=937,440 ft
Southeast corner: - Easting=1,083,024 ft, Northing=944,334 ft

Capacity Limitations for Existing MCR ODMDSs

The existing (1994-95) bathymetry for MCR and vicinity is shown in figure 3. Since 1985, unanticipated bathymetric ***mounding*** has occurred at ODMDSs A and B due to rapid accumulation of placed dredged material. The accumulation of dredged material at MCR ODMDSs is illustrated by noting the change in bathymetry between 1985 and 1994

MOUTH OF COLUMBIA RIVER

Regional Bathymetry and USACE ODMDS Locations

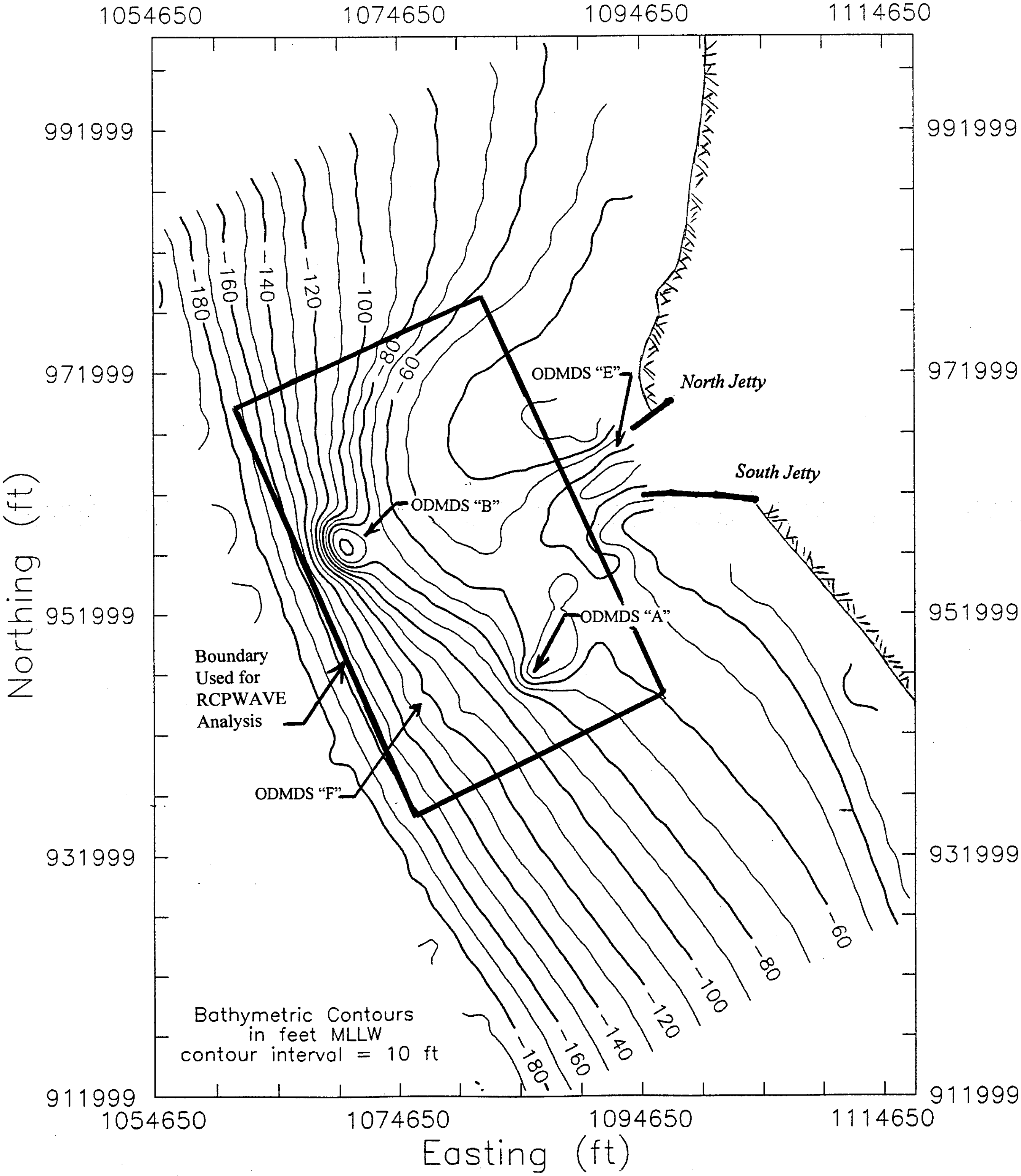
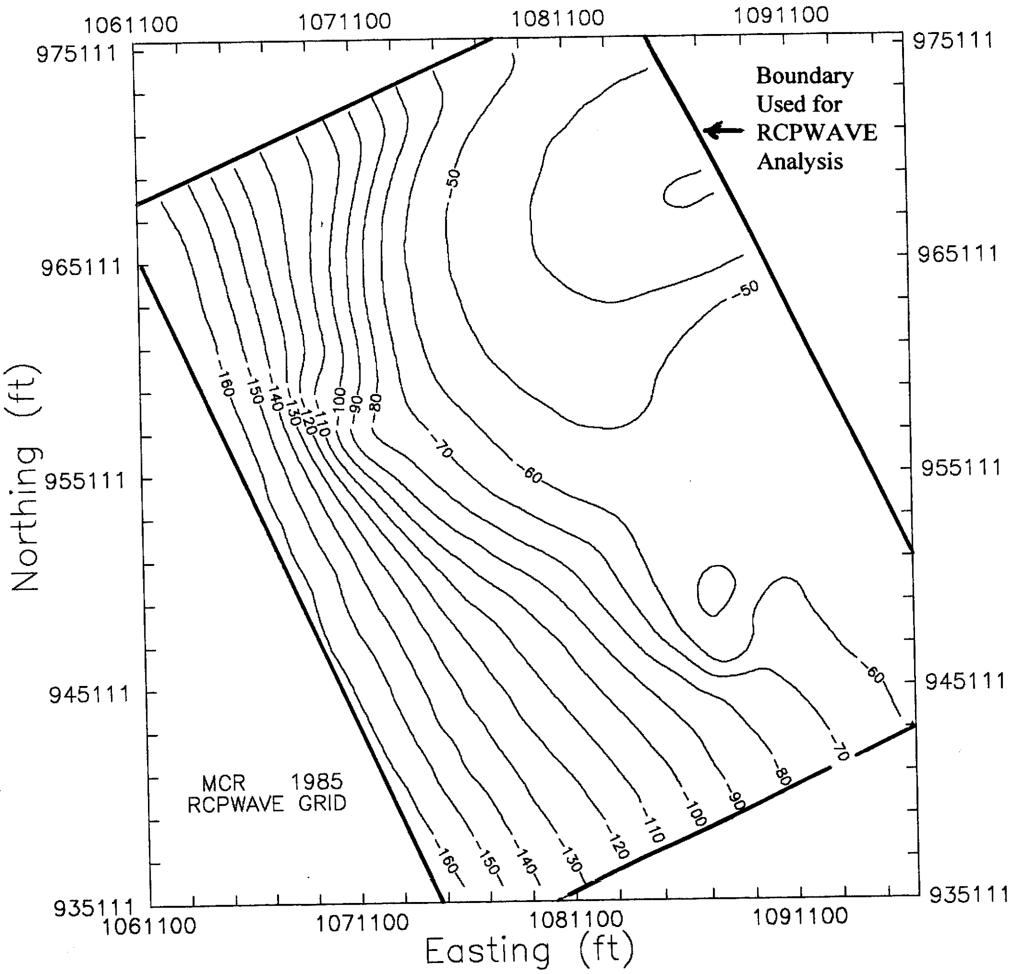


Figure 3. Regional bathymetry for MCR - 1994 approach survey



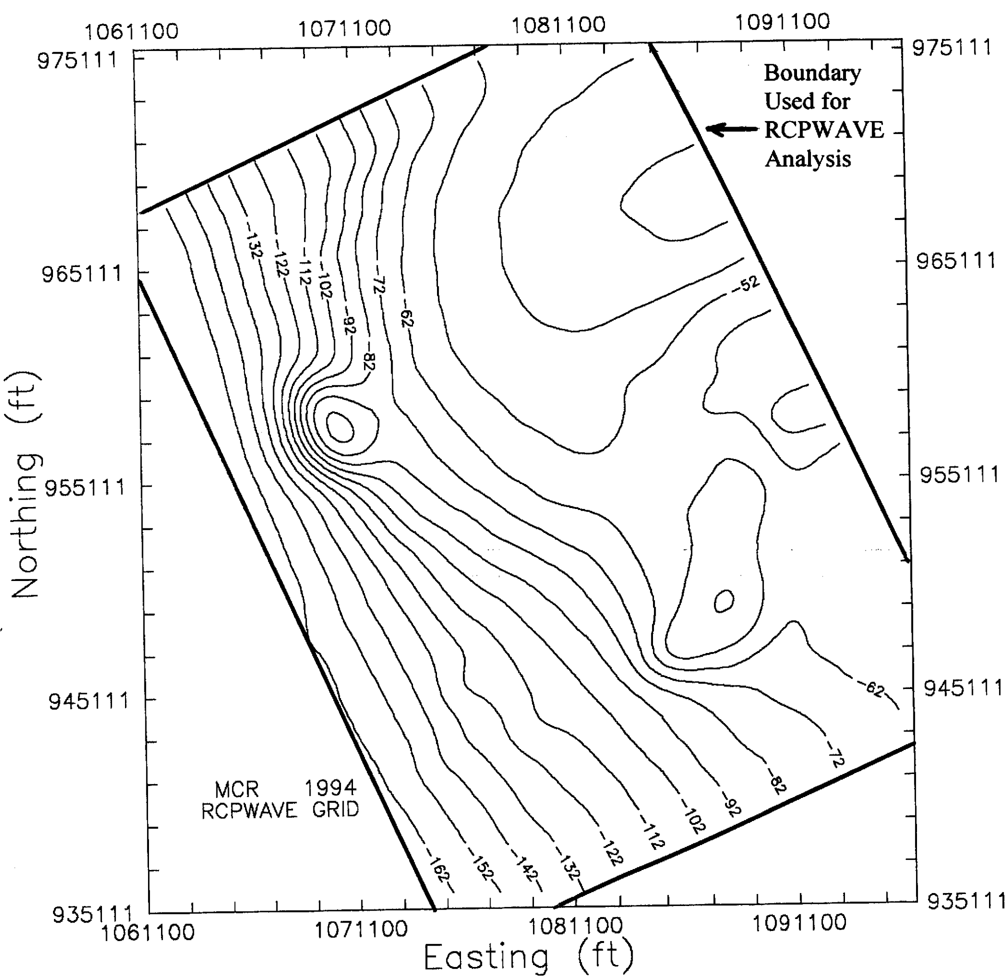


Figure 4. MCR Regional Wave Analyses Bathymetry for 1985 (top) and 1994 (bottom).

as shown in figure 4 (which is the sub-area "boxed" within figure 3.) The top half of figure 4 shows the MCR bathymetry for 1985, the bottom half for 1994 (note the seabed change at ODMDSs A and B). The present dredged material mounding problem at MCR has limited the annual volume of dredged material which can be placed at ODMDS A and B.

ODMDS A

Mounding at ODMDS A reached -36 ft MLLW in May 1991 (the mound was 36 ft high relative to the 1981 bathymetry). Since 1992, placement at ODMDS A was restricted to a maximum of 1.5 million cubic yards (cy) annually. Only the outer third of this site was used, and only during the summer months when nearshore currents are directed southward. Even though ODMDS A was expanded in 1992, it has received only 1.3 million cy of dredged material since 1992. In 1993 and 1995-96, ODMDS A received no dredged material. Between May 1993 and July1996, the mound height at ODMDS A was reduced by 6 feet , -36 ft MLLW to -42 ft MLLW (less than 2 ft/yr), through sediment dissipation by waves and currents. Given the small amount of mound reduction observed at ODMDS A, this site is considered to be non-dispersive with respect to the amount of dredged material placed. Placement of dredged material in ODMDS A is currently restricted, due to the present mounding and related adverse (wave) effects upon navigation. ODMDS A is near its capacity to handle additional dredged material disposal.

ODMDS B

The highest point of bathymetry within ODMDS B reached -48 ft MLLW in September 1992: The dredged material mound had accumulated 78 ft in height relative to the 1981 bathymetry [Siipola and Braun 1995]. Prior to 1990, there were no restrictions as to timing or volumes of dredged material placed in ODMDS B. Dredges were directed to distribute material evenly in the site to avoid mounding. In 1990, dredged material placement was restricted to the outer (western) one third of the original site boundaries. After 1992, when ODMDS B was expanded, the site was divided into six 2,000'x2,000' cells: The dredged material disposal was managed by designating specific cells available for placement each year. In 1993 and 1994, dredged material placement was restricted to the deeper portion of the site (the 3 western-most cells).

In Fall of 1994 , the high point of the mound at site B was still -48 ft MLLW: There had been little change since 1992. It is likely that some material was placed on top of the existing mound during the initial stages of "cell" management. To minimize potential interference with navigation, the mound at site B was reduced 5-10 ft by dredging the top to -53 ft MLLW. The material was placed in the 3 western-most cells of the site. Dredged material mound at ODMDS B extended 3,000 ft beyond the original site boundaries. Between Fall 1994 and Summer 1996, the high point of the mound at ODMDS B was further reduced by 5 feet, -53 ft MLLW to -58 ft MLLW, through sediment dissipation by waves and currents.

The total volume gain associated with bathymetric change at ODMDS B between 1983 and 1994 was calculated to be 23.5 million cy (based on survey differencing). The actual volume of dredged material placed in ODMDS B during 1983-94 was estimated to be 27 million cy (NPP dredge logs). Based on the difference of the above, approximately 13% of the dredged material placed at site B since 1983 can not be accounted for using bathymetric survey volume calculations. The dredged material has been either transported out of the ODMDS and vicinity (to an apron thickness undetectable by surveys) or the material has experienced self-weight consolidation. In either case, ODMDS B is ***not*** considered to be a dispersive site. During 1993-1996, about half of the volume of dredged material normally placed in ODMDS B was diverted to ODMDS F in order to prevent further mound accumulation at site B. Future disposal within the existing boundaries of ODMDS B will be limited after 1996, due to adverse mounding affects on waves and navigation. For example, in FY 1997, it is anticipated that only 600,0000 cy will be placed in the western quarter of site B in order to maximize site capacity and ensure minimum wave amplification due to mounding. ODMDS B is near its capacity to handle additional dredged material disposal. Total remaining capacity for site B is estimated to be 1.5 million cy.

ODMDS E

ODMDS E is now used only during spring and early fall when nearshore sediment transport of material from the site is thought to be northward along Long Beach (Peacock Spit). ODMDS E is not used during the midsummer when the nearshore currents are believed to flow southward, across the entrance channel. If dredged material disposal were conducted at site E during the summer oceanographic season, dredged material could rapidly re-deposit in the MCR navigation channel. Because ODMDS E is only 1,000 ft north of the entrance channel, the volume placed is restricted to a maximum of 1 million cy annually. The dredged material placed at ODMDS E each year appears to be completely transported out of the site by the following year: ODMDS E is considered a highly dispersive site. The present dispersive capacity for ODMDS E is considered to be at least 1 million cy/yr.

ODMDS F

Historically, ODMDS F was rarely used for the disposal of sediments dredged from the MCR due to ODMDS F lying directly in the path of the shipping approaches to the Columbia Bar and its small areal extent (as originally designated). In 1992 ODMDS F was expanded by a factor of 30-fold. It was anticipated by USACE and EPA that dredged material disposal at ODMDSs A and B would be decreased while disposal at site F would increase due to its increased capacity: ODMDS F would become the primary ODMDS for MCR dredging disposal. The expanded ODMDS F was divided into sixteen 2,000'x2,000' cells. ODMD F is surrounded by a 1,000-foot buffer zone: Placement of dredged material is not permitted within or outside the buffer zone. Dredged material disposal is managed by designating a limited number of cells available for placement each year. The Portland District has minimized the interference of dredging disposal activities with shipping/commerce by utilizing and closely coordinating the use of Corps-operated dredges in areas of high maritime traffic such as ODMDS F. Beginning in 1993, ODMDS F has been used more extensively to reduce the amount of dredged material placed in ODMDSs A and B. Based on previous investigations [Siipola et al 1993 and Siipola 1994] dredged material placed at site F is not subject to significant annual dispersal. The capacity of site F to handle additional future dredged material disposal was assessed; results follow in Section 2 of this report.

MCR OCEAN DREDGED MATERIAL DISPOSAL SITE MANAGEMENT

The transition in ODMDS management at MCR is characterized by three (3) important shifts in USACE and EPA policy which are outlined below.

MCR Ocean Dredging Disposal Before 1977

Prior to 1977, ODMDSs at MCR were sited only in terms of approximate location and areal configuration. Placement of dredged material within the ODMDSs was governed by the need to minimize navigational impact from dumped dredged material being transported back into the navigation channel. Mounding did not appear to be a major concern due to the spatial variability of dredged material disposal within a given site: The site boundaries were not fixed and it was not required to place material strictly within the disposal site. The operational "flexibility" of disposal site boundaries and vessel control during material placement resulted in a higher degree of dredged material dispersal during placement than at present. Prior to 1977, dredged material was placed over a wider areal expanse than the configuration of the ODMDSs indicate [Soderlind 1995].

MCR Ocean Dredging Disposal: 1977 to 1986

Between 1977 and 1986, the management of the ODMDSs at MCR was characterized by the transition from unregulated dredged material disposal to a regulated program. In January 1977, active ocean disposal sites at MCR received interim designations as such when EPA issued the final Marine Protection Research and Sanctuaries Act and associated regulations (40 CFR 228). The exact position for each of the interim ocean disposal sites was fixed by specification of the corner coordinates, by EPA, in order to abide by the rules of the MPRSA. The interim ocean disposal sites received final designation in August 1986. The final EPA approved configuration for each ODMDS was governed by the requirement to minimize the benthic area of impact due to openwater disposal of dredged sediments. The areal size of designated ODMDSs at MCR was based on:

ODMDS length = average dumping run for one dump
= (disposal vessel speed while dumping) **x** (time to empty disposal vessel)

ODMDS width = average turn during one dump = disposal vessel turning radius while dumping

ODMDS long axis orientation = preferential approach-heading during dredged material disposal.
(site orientation is set by disposal vessel operators and is based on dumping efficiency and vessel sea-keeping due to incident wave direction)

Prior to the 1980's, sediment dredged at MCR and placed in ODMDSs was accomplished using government hopper dredges. Government hopper dredges utilize a series of "doors" located on the hull bottom to gradually release dredged material from the vessel. Contractor hopper dredges normally used at MCR are split-hull vessels. Dredged material released from a split-hull hopper dredge is rapidly placed on the seabed, in a manner much more quickly (efficiently) than bottom-door hopper dredges. While the use of split-hull hopper dredges reduces the time required for material disposal, split-hull dredges reduce the horizontal dispersal of dumped dredged material on the seabed while increasing the vertical extent of accumulation per dump (see figure 22). After 1980, approximately half of the material dredged at MCR was accomplished using contractor split-hull hopper dredges.

Beginning in 1981, ocean disposal site management was somewhat effective in restricting placement of dredged material within the designated disposal sites. At this time, placement of dredged material within the ocean disposal sites was done randomly at some "radius" from an assigned disposal coordinate or buoy. Efficiency-oriented dredging contractors most likely placed dredged material on the extreme channel-side of the disposal area (or buoy location) in order to shorten the haul distance. This could have enhanced the accumulation of dredged material over a small area.

MCR Ocean Dredging Disposal: 1987 to Present

After final EPA approval of the MCR ODMDSs in 1986, disposal site management became increasingly proactive in the year to year operation of ODMDSs. Disposal site management has been progressively improved and enhanced in order to maximize site capacity utilization of the EPA designated ODMDSs. The unintended consequence of using the areally restricted ODMDSs has been creation of potentially adverse impacts to navigation at MCR, by mounding of placed dredged material.

In 1990, accurate navigation and positioning control became available for hopper dredges operating on the open coast. This was possible with the installation of shore-based microwave towers that were used to determine the ship's position (x,y) through electronic trilateration. The ship's position was known to several meters accuracy, on a real-time basis. Hence, the hopper dredges could reliably place dredged material within the assigned ODMDS locations during all times of operation [Soderlind 1995]. Instead of placing material within some marginal "radius" from a pre-determined location, hopper dredges could return to the exact assigned dump coordinate (ODMDS centroid) and place dredged material within a very limited area. The rapid accumulation of dredged material within ODMDSs A and B (formation of high mounds) during the late 1980s and early 1990s is attributed to three factors:

(A) The restriction of dredged material disposal within relatively small EPA-designated ODMDSs, rather than in large unconfined areas and in a dispersive manner of placement.

(B) Increased use of split-hull hopper dredges, which tend to enhance the vertical extent of dredged material placed on the seabed within the ODMDSs.

(C) The improvement of ODMDS navigation in 1990 allowing for precise positioning control during disposal and repeated dumping at the same location.

Due to rapid accumulation of dredged material (mounding problems) at ODMDSs A and B, those two sites and site F were expanded in 1992 (figure 2, solid line). The temporary expansion of sites A, B and F were coordinated with regional resource agencies and special management options implemented [Siipola & Braun 1995]. The 1992 temporary expansion of MCR ODMDSs was intended to "buy time" until additional studies could be completed and final expanded or new ODMDSs could be designated. Despite the temporary site expansions, mounding has continued to be problematic at these sites. Beginning in 1995, placement of additional material at ODMDS A was restricted and placement at ODMDS B was limited to 2 million cy/yr. By 1997, dredged material disposal within the existing site B boundaries will be highly limited in terms of the location, timing, and volume of dredged material placed at this site.

Ocean dredged material disposal sites which were intended to be moderately dispersive and have a 20 year life-cycle, have reached capacity within 10 years of initial operation in spite of limited site expansion. ***ODMDS capacity*** is defined as that quantity of material which can be placed within the legally designated disposal site without extending beyond the site boundaries or interfering with navigation [Poindexter-Rollings 1990]. Presently, exceedence of ODMDS capacity at MCR creates three operational problems for the Portland District:

- The overall footprint of dredged material contained within existing ODMDSs extends beyond the sites' formally permitted boundaries, by as much as 3,000 feet in some cases.

- Dredged material within the ODMDSs has accumulated to an areal and vertical extent which may create adverse sea conditions. In some cases, mounds rise 40-70 ft above surrounding bathymetry. Mariners report that the ODMDS "mounds" cause waves to steepen or break in vicinity of the ODMDSs and that these wave conditions are hazardous to navigation at MCR.

•Management of MCR dredged material within the existing ODMDSs is becoming increasingly constrained due to continual reduced site capacity. Without increased ODMDS capacity, it will not be possible to maintain the existing MCR entrance channel to the authorized depth.

SIMULATING MCR WAVE CONDITIONS AND BATHYMETRIC CHANGE DUE TO DREDGED MATERIAL DIPSOSAL IN OPEN WATER

This report attempts to describe future MCR ***ODMDS capacity*** by predicting the behavior of dredged material as it is placed in open water and assess wave affects due to newly formed mounds on the seabed.

Dredged Material Disposal and Bathymetric Change at MCR ODMDSs

In the simplest of terms, the physical processes affecting dredged material placed in open water include gravity, waves, and currents. At the point of release from the disposal vessel, dredged material falls through the water column, convects/diffuses laterally, and eventually comes to rest on the seafloor. This is referred to as *short-term fate*. The dredged material can be spread out on the seabed to varying degrees, depending upon the speed of the disposal vessel, water depth, water column current, and other variables. The numerical model STFATE [Johnson 1990,1995] was used to predict the bathymetric distribution ("foot-print") of dredged material placed at sites B and E, on an individual dump basis, after it has passed through the water column. STFATE results are described in Section 3 of this report.

After dredged material has come to rest on the seabed, it can be eroded by waves and currents. If the dredged material is cohesive, it can experience self-consolidation due to gravity. If many loads of dredged material are placed one on top of another such that a steep aggregate mound develops on ambient bathymetry, the mound will avalanche and material will be transported downslope. The combination of these processes define the *long-term fate* of dredged material placed in open water. The numerical model MDFATE [Moritz 1994,1995 and Scheffner et al 1995] was used to predict the long-term fate of dredged material placed in ODMDS B, E, and F. MDFATE results are described in Sections 2 and 3 of this report.

Present Wave Conditions at MCR ODMDSs

As waves (swell or locally generated seas) travel from offshore locations (deep water) to inshore areas (shallow water), the waves shoal (wave height is increased) and steepen as they encounter progressively shallower water. Eventually, the waves will reach a critical steepness and break. In the case of a long stretch of uniform sloping shoreline, the area where waves break (breaker line) is fairly consistent (predictable) for a given set of offshore wave conditions. This is not the case with an irregular shoreline or complex bathymetry, where incoming waves can shoal, break unexpectedly, and add risk to navigation. This is the case with the approaches to the MCR, where the ebb-tidal shoal is neither uniform in areal configuration or bottom slope. The presence of large underwater mounds, such those at the existing MCR ODMDSs, can further exacerbate wave shoaling and breaking. The numerical model RCPWAVE [Ebersole et al 1986] was used to predict behavior of waves as they are refracted and diffracted by the bathymetry that the waves pass over.

The RCPWAVE model was used to compare the present MCR wave climate, due to the present ODMDS bathymetry (1994, bottom of figure 4), with the past wave climate before prominent mounds were formed at the ODMDSs (1985, top of figure 4). Results of this wave comparison are discussed below. Figure 4 represents a subset of the regional MCR bathymetry extent, shown in figure 3.

The issue of dredged material mounds at existing ODMDSs creating potentially hazardous wave conditions for navigation MCR is illustrated in figures 5 - 7. These figures describe the estimated change (amplification) in wave height due to the change in bathymetry at MCR between 1985 and 1994: Figure 5 for 6-second period waves, figure 6 for 10-second period waves, and figure 7 for 16-second period waves. Effects due to currents are not included. The outline border for figures 5-7 corresponds to the "boxed" RCPWAVE analysis area shown in figure 4.

Based on the above results, existing dredged material mounds at ODMDSs A and B may have increased the height of incident waves within or in proximity to the ODMDSs by: 30% for 6-second waves, 60% for 10-second waves, and 80% for 16-second waves, as compared to 1985. A 10% increase in wave height due to shoaling could cause a wave to break. The areas most affected by dredged material mounds at ODMDSs A and B are located immediately north and south of the MCR entrance.

Presently, the safest ocean approach to the MCR entrance channel is directly in-line with ODMDS F. The present wave condition at MCR requires that strict site management measures be implemented to:

- Prevent additional mounding at ODMDSs A and B

- Prevent the formation of new mounds at ODMDS F which could adversely affect incoming waves to the MCR.

<u>Sections 2 and 3</u> of this report address the need for ODMDS management to minimize adverse impacts arising from site use and ensure adequate year to year disposal capacity.

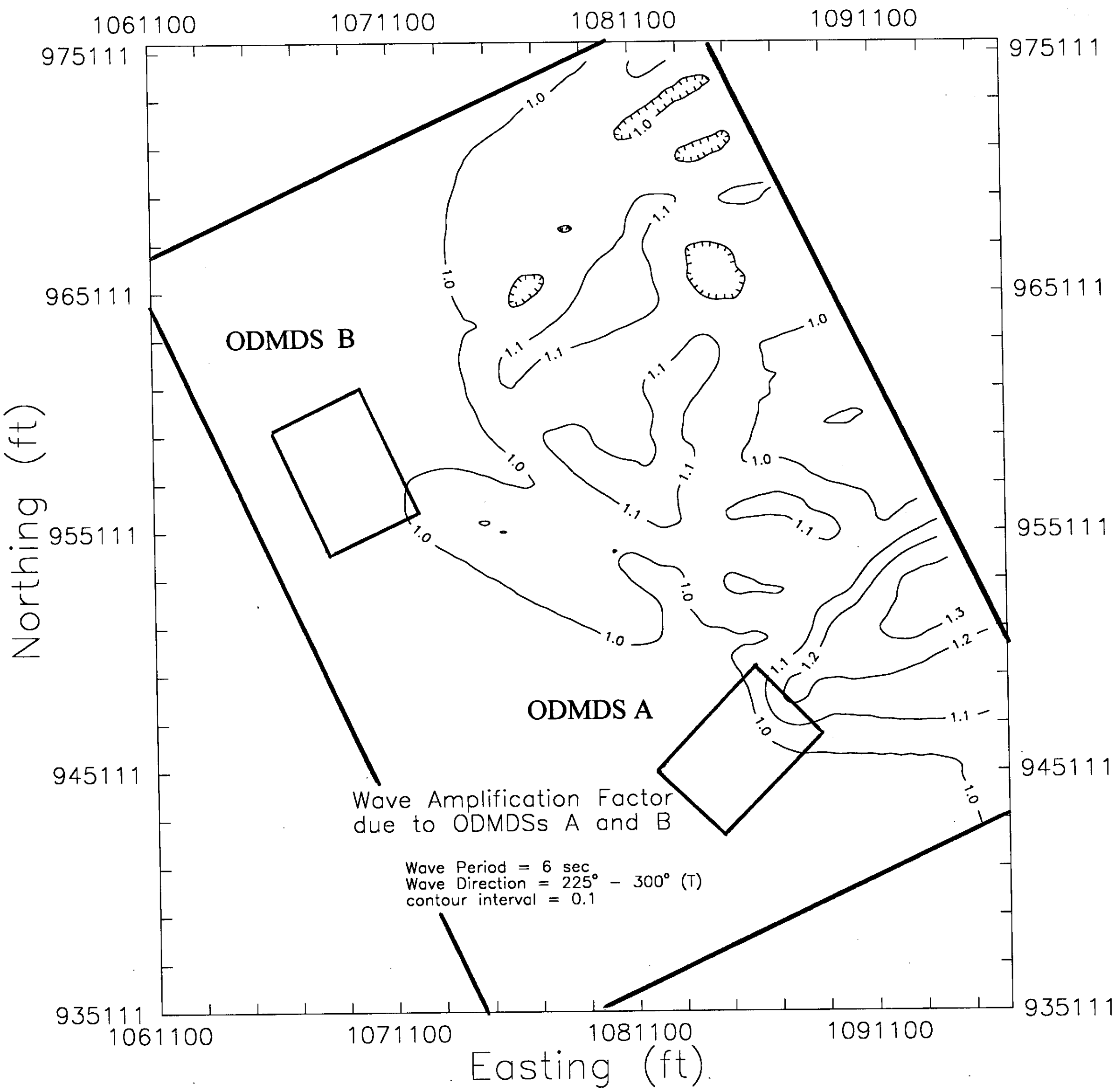


Figure 5. MCR Wave Analysis Results for 6 second Wave Period.

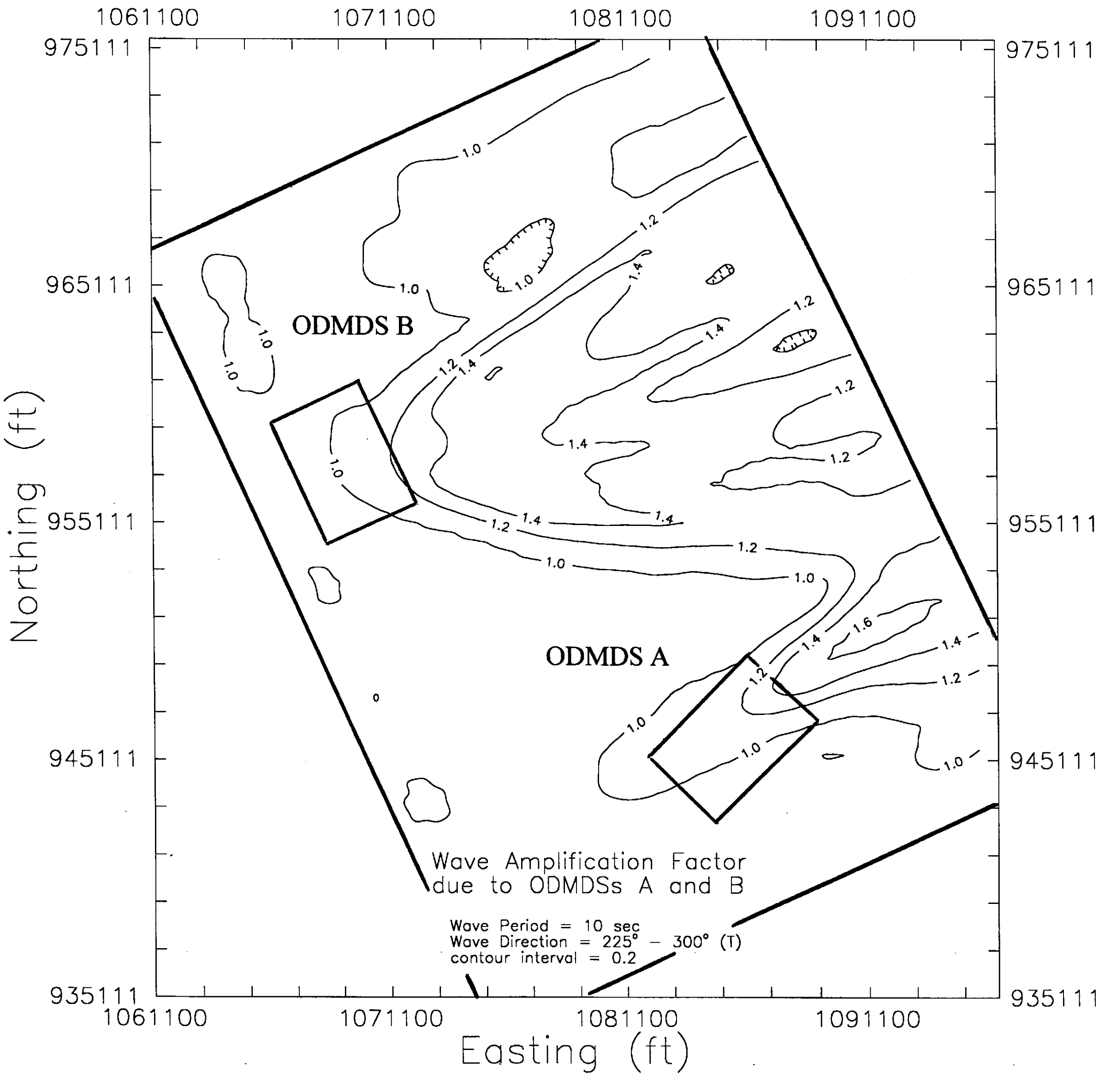


Figure 6. MCR Wave Analysis Results for 10 second Wave Period.

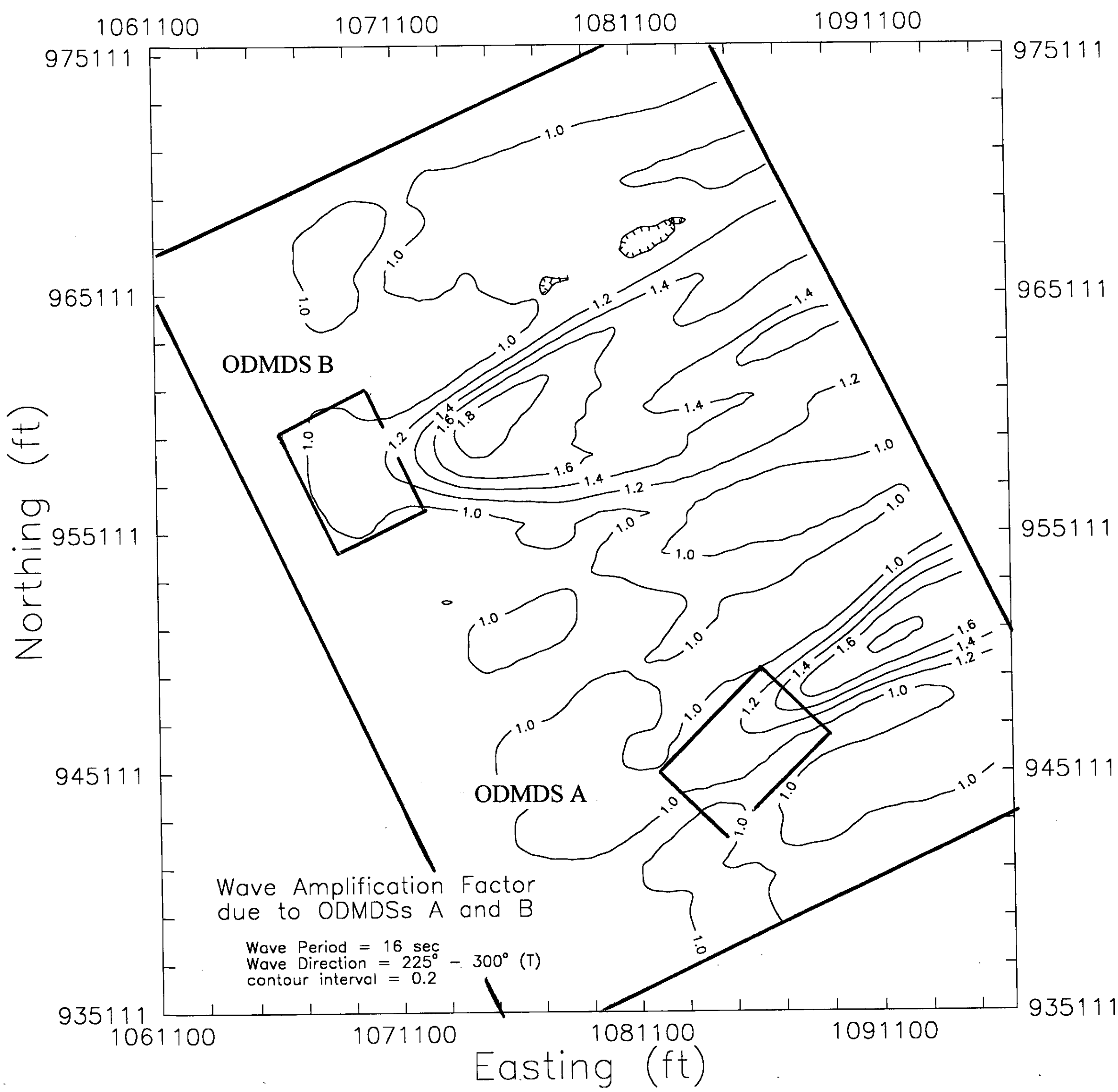


Figure 7. MCR Wave Analysis Results for 16 second Wave Period.