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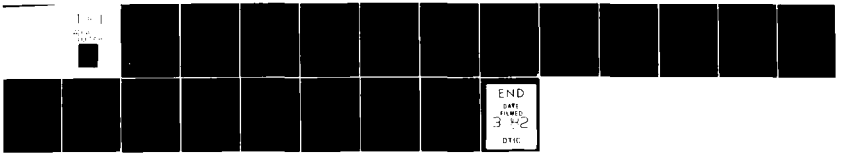

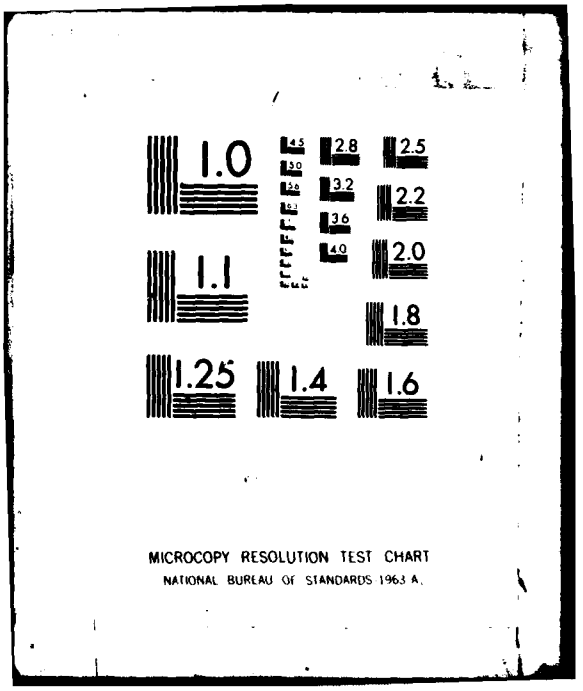
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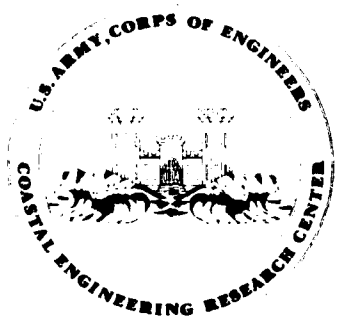
Guidelines for Establishing Coastal Survey Base Lines

by

J. Michael Hemsley

COASTAL ENGINEERING TECHNICAL AID NO. 81-15

NOVEMBER 1981



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Too frequently coastal surveys are performed without proper attention to establishing, referencing, and documenting the survey monuments. This report presents guidelines for establishing base lines for coastal surveys and for monumenting, documenting, and referencing those base lines and the profile lines.

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PREFACE

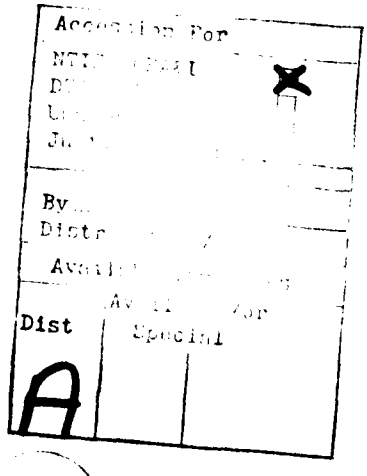
This report presents guidelines for establishing base lines for coastal surveys and for monumenting, documenting, and referencing those base lines and the profile lines. The work was carried out under the data collection part of the coastal engineering research program of the U.S. Army Coastal Engineering Research Center (CERC).

The report was prepared by J. Michael Hemsley, Hydraulic Engineer, under the general supervision of Dr. J.R. Weggel, Chief, Evaluation Branch, Engineering Development Division. Helpful reviews by W.A. Birkemeier and A.E. DeWall of CERC, R. Kloker of the U.S. Army Engineer District, Chicago, and R. Spies of the U.S. Army Engineer District, Philadelphia, are acknowledged and appreciated.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director



CONTENTS

FIGURE

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

GUIDELINES FOR ESTABLISHING COASTAL SURVEY BASE LINES

by
J. Michael Hemsley

I. INTRODUCTION

> "In the past there has been a lack of uniformity in the data secured and in the methods of making studies at beaches before designs for protective works were prepared" (Beach Erosion Board, 1938).

This quote is the opening sentence of the Beach Erosion Board's (BEB) "Manual of Procedure in Beach Erosion Studies," written in 1938 (U.S. Army, Corps of Engineers, Beach Erosion Board, 1939). Unfortunately, little has changed since that report was written. Data are still being taken on some profile lines that are inadequately documented or have poorly established survey monuments. Thus, profile lines are difficult to reestablish or relate to other lines established in the study area, and subsequent calculations suffer from the resulting uncertainties.

Because the beach is a dynamic environment, survey monuments are typically short lived. Use of a properly referenced base line will ensure the recovery of profile lines for repetitive surveys during a study, as well as for subsequent studies. This report reviews the techniques for establishing a survey base line and discusses the monumenting, referencing, and documenting of base lines and profile lines. For consistency, the term *profile line* throughout this report means a line, generally perpendicular to the beach, along which the profile of the beach and foreshore is measured. Profile line is used in lieu of transect, range, and similar terms. For simplicity, the term *base line* means a control line, generally parallel to the shore, used to accurately locate a series of profile lines. The techniques discussed in this report can also be applied to situations where widely spaced profile lines are located by monumented control points not on a base line.

Beach profiles are obtained to determine changes in the shape of the beach through time. It is important that the profile lines be accurately located, both horizontally and vertically, so that the profile data can be reliably used. For example, small errors in the relocation of a profile line and, therefore, in the beach profile can cause substantial errors in the volume changes calculated between surveys of the profile line. The haphazard location of profile lines can jeopardize the reliability of the data. Surveys are expensive so it is important to ensure the accuracy of the data. One benefit of properly establishing a base line is that the likelihood of reoccupying the profile lines in the future is increased, making the data more valuable since they can be readily compared to profile data obtained in subsequent studies.

II. ESTABLISHING A BASE LINE

1. Locating the Base Line.

Once the study area has been selected, the duration of the study determined, and the profile lines tentatively located, it is time to locate the base line. Whether an actual base line or a series of control points is used, it is good

practice to have the base line located and monumented prior to any survey of the profile lines.

Considerable preliminary work in locating the base line can be done in the office to reduce the time spent in the field. The first step is to establish the long-term erosion rate for the area so the base line will be placed far enough landward to ensure a 20- to 30-year lifespan or longer. This is desirable even in a short-term study to allow the profile lines to be reoccupied in the future or to prevent the lines from being lost during a severe storm. Next, an approximate base line trace should be located on available topographic maps or aerial photography. This trace can be checked and modified on the ground at a later time. Once this tentative trace has been selected, a source check should be made for existing horizontal and vertical control in the study area. Sources of this information include the Corps of Engineers, U.S. Geological Survey, National Ocean Survey, National Park Service, and State and local highway departments. The latter often have an established control tied in to the State coordinate system for building and maintaining roads. Whenever possible, existing monuments should be used to minimize the effort required to establish the base line and ensure the recoverability of the profile lines. In every case that an existing monument is to be used, the control data should be examined to determine whether the monument has been recently recovered or has been affected by a recent disturbance, such as a storm or road construction. A monument should not be considered a permanent part of the control until its worth has been proven.

The lack of established or permanent monuments nearby need not delay the initial survey of the profile lines. If it is determined that establishing control would be time consuming, an assumed elevation may be assigned to a monument and the rest of the control set from that monument. So that it is obvious, the assumed elevation should be highly exaggerated. The profile lines can then be surveyed, but, before the data are analyzed, control for the base line must be established and the data adjusted.

Selections of the sites for base line monuments must consider certain requirements such as the permanence of the bench marks, wishes of property owners, proximity to the area of interest, and accessibility. The final selections, which will require considerable judgment in determining, will usually be based on a compromise of these requirements.

First, the base line must be located in a stable area where it is not in danger of immediate damage from erosion. In their report on coastal construction in Florida, Purpura and Sensabaugh (1974) list the following considerations for determining a setback line which can also be applied to determining the location of a base line:

(a) Ground elevation in relation to historical storm and hurricane tides,

(b) predicted maximum wave uprush,

(c) beach and offshore ground contours,

(d) vegetation line,

(e) erosion trends,

(f) the dune or bluff line, and

(g) existing upland development.

While it is impossible to predict the changes that will occur at a site over a period of years, it is the responsibility of the reconnaissance engineer to consider the possibilities to the best of his ability and establish the marks with some degree of permanence. Even in the short run, changes are difficult to predict, but good judgment and common sense help. In establishing a base line, certain events can be considered likely: relative sea level will continue to change, areas of rapid erosion will continue to erode, bluffs will recede, roads will be widened or repaved, open areas will be developed, etc. The person establishing a base line must consider these incidents at the potential location of each monument and the possible benefits of tying the base line into an established grid system.

While accessibility is important when a station is being established or reestablished, the most accessible sites are often the most exposed. Accessibility, therefore, must often be subordinated somewhat to other conditions affecting the permanence of a mark. The most accessible sites are sometimes not very representative of local conditions and trends. For example, a profile line established at the end of a street is certainly accessible, but it is far from representative of local conditions if the end of the street is followed by a pathway or vehicle access over the dunes or by a storm drain outfall. Profile lines, and therefore the base-line monuments, must be sited carefully to accurately represent the area of interest.

2. Protocol.

A sometimes overlooked aspect of establishing a base line is the contacting of property owners and local authorities. Local authorities and governing bodies in the study area should be contacted in person, if possible, to answer any questions that might arise so misconceptions concerning the purpose of the study can be avoided. Frequently, local officials can provide valuable information such as changes to monuments by local survey or maintenance crews, or areas that experience unusual or recurring conditions that should be recorded or avoided. If a personal visit is not possible, a letter should be sent before any surveying is done. Although this coordination is considered a courtesy, failure to coordinate may produce bad feelings toward the Corps.

Similar rapport must be established with the property owners upon whose land a monument is to be established or whose land is to be crossed during a survey. The contact should be in person, if possible, so the purpose and importance of the study can be briefly and simply explained. A person who would normally grant a request may resent what appears to be the taking of undue liberties and refuse to give permission to use his property without his prior consent. Unfortunately, once a person is committed to that attitude he is likely to stick to it. If a personal visit to the landowner is not possible, a letter explaining what is to be done and requesting his consent should be sent to him along with a self-addressed franked envelope. Since some landowners in the past have neglected to reply, the letter should be written so that failure to reply denotes consent. However, it is important to give the owner a chance to state any objection he might have. If it is determined that

the property is sold during a survey period, the new owner should be contacted to explain the work that has been done on his property and the purpose of the study. The importance of the continued use of his land must be stressed.

3. Procedures for Establishing a Base Line.

Survey accuracy for establishing local control for base lines should be third order, one part in 5,000 for horizontal control and $0.05\sqrt{d}$ or 12 millimeters $\sqrt{K}$, where d and k are the distance of level line in miles or kilometers, respectively, for vertical control. Traversing and leveling, or other third-order techniques, should be used to establish the horizontal and vertical control, respectively.

III. MONUMENTING, REFERENCING, AND DOCUMENTING

1. Monumenting.

In order for it to serve its intended purpose, a base line must be properly monumented. The monuments must have a degree of permanence, be positively identified, and be easy to locate and occupy. The Appendix provides a helpful checklist for monumenting.

Because the permanence of a monument is affected by the weather, waves, erosion, and man's activities, including vandalism, consideration must be given to the monument's construction and placement. The potentially harsh environment on the beach must also be considered when selecting the type of monument to be used. The lifespan of the materials to be used and the resistance of the monuments to movement are important in an area where a monument may be subjected to freeze-thaw, windblown sand, waves, and erosion.

Detailed descriptions of the types of monuments, their construction, and placement can be found in a variety of sources, including Larrabee (1954), Gossett (1959), Woodward (1967), and Baker (1968) for a general discussion of monuments; Davis, Foote, and Raynor (1928) on pipe monuments; Kulp (1970) on deep control points; and U.S. Army (1970) on concrete monuments. While a detailed discussion of monumenting is beyond the scope of this report, there are some considerations that should be raised. First, fixed points may be used instead of actual monuments. These fixed points could be any stable objects, such as a fire hydrant, telephone pole, foundation corner, or curb. One advantage of using such points is that they are less attractive to vandals. A second advantage is that objects such as piles, poles, and hydrants are likely to be resistant to waves and currents. Disadvantages of such features include settlement and the possibility of disturbance.

There are several procedures that can be used to discourage vandalism, although each introduces other difficulties. Obviously, a monument can be hidden in an area of dense foliage or can be buried, but these techniques make it more difficult to find. This can be a significant problem when frequent surveys are planned so the monument location must be very accurately described.

Another technique is to simply increase the size of a monument, thereby discouraging vandalism because of the effort required to move it. This has the added advantage of reducing the necessity for repairs due to storms or other natural or accidental events. When using a pipe as a monument, a plate

can be welded to the bottom of the pipe, making it more difficult to remove by vandals. Unfortunately, it is also more difficult to install.

It is important to mention that while much of the damage to monuments is caused by vandalism, some of it results from a misunderstanding of what the monument is actually for. If possible, every monument should be clearly marked by a plate or sign briefly describing its function and the penalties resulting from its disturbance. While this will not eliminate vandalism, it will reduce the number of monuments lost.

Other considerations, identified by Larrabee (1954) and Czerniak (1972b), that contribute to the value of a monument include marking the monument with its station along the base line and its date of placement, the provision of a definite center or point, and the placement of a protective flag or pole where there is danger of displacement.

Because the base line should be some distance from the beach, it is often convenient to establish a temporary control point to facilitate the surveying of a profile line. When a temporary control point is used, it should be established with sufficient accuracy to allow recovery of the point within 1 foot of the original location and within ±0.05 foot of the original elevation (Czerniak, 1972a), which is normally accurate enough. With the exception of the accuracy of placement, a temporary control point should be established in the same manner as a base-line monument. Since it can be easily reestablished from the base line, its permanence is not critical and it can be made of wood or pipe placed close to the beach. One technique to quickly determine if a temporary or any other control point has been disturbed is to install two points. By comparing the two, it can be easily determined if they have been disturbed. Proper referencing of a temporary control point will reduce the effort required to verify its correct location, as well as the time required to reestablish it.

2. Referencing.

The ability to accurately reestablish a survey monument is very important, because it ensures that the data will be comparable both throughout the study and with data acquired years later. The inability to accurately relocate a monument lost through man's activity or natural events can result in costly survey data becoming worthless. Proper referencing of a monument can be achieved quickly by tying the monument to nearby established cultural (manmade) features. Whenever possible, the monuments, whether for the base line or profile line, should also be tied into a national or State coordinate system. These techniques will ensure the accurate relocation of a monument.

In referencing, redundancy is important to ensure that a monument can be relocated or, if necessary, that the entire base line be reestablished. Periodically, each monument should be inspected and resurveyed, especially during a long study, to determine if it has been disturbed. Regular inspection of the monuments can provide some warning of the imminent loss of a monument, thus allowing relocation and continued use of the profile lines affected.

a. Referencing to Nearby Cultural Features. When referencing a monument, no fewer than three reference points should be used so that some redundancy is provided. These points should be within a tape length's distance of the

monument so that its location can be reestablished by swinging arcs from any two of the points. When an existing control point is not nearby, auxiliary control points should be established near the profile after the elevation of the monument is determined. If the monument is temporarily assigned an assumed elevation, the auxiliary control points should be established using the same assumed datum. When the actual elevation of the monument is determined, all the assumed elevations can be corrected.

Poststorm photos of coastal areas show that telephone poles, piles, and similar objects stay in place through storms very well, due to their shape and good foundations, making them excellent reference points. Examples of such objects that may be found near a beach are (1) power, phone and light poles; (2) pier and boardwalk piles; (3) house piles; (4) stubby pile-type road barricades; and (5) fire hydrants. Other good references include objects not likely to be affected by storms, such as manhole cover seats, concrete abutments or curbs, and corners of buildings or foundations. For long-term projects, consideration must be given to the potential stability of cultural features. For example, over the course of several years a road may be repaved or widened, an addition added to a house, or a boardwalk improved.

When using a reference point as a position reference, the actual spot on the object should be clearly defined in the documentation and marked with paint. An elevation reference can be provided by using the tops of short piles, spikes in phone poles, or another solid, defined location on a reference point. It must be noted, though, that placing spikes or nails in phone or power poles creates a potentially dangerous condition for linemen using climbing spikes and is illegal in some states, such as Pennsylvania. If no stable references are available in the vicinity of the monument, additional monuments must be set to serve as reference points. These monuments should be placed even farther landward than the base line to ensure that they are in a stable location and allow for the reestablishment of the base line if lost. To provide additional permanence, consideration should be given to extending each of the profile lines landward to include a very stable section. This stable section would be surveyed for only a few of the profile lines during each periodic survey, but frequently enough to detect long-term changes. This infrequent survey of the landward extension of each profile line will provide additional data in the event of major beach changes, as well as for future comparison.

b. Referencing to Grid System. Even though a base line may be established for only a short-term study, consideration must be given to referencing the base line to some type of control system, such as a state or national grid system or geodetic coordinates, to provide some degree of permanency. The cost of such a referencing program, which has been reduced significantly with the advent of electronic distance measuring equipment, must be weighed against the value of the need to reoccupy the profiles in 10 or 20 years or after a particularly severe storm. This decision need not be made at the start of a study; if the data produced are judged to be valuable for future comparison, the base line can be permanently referenced later during the study. This allows the option of maximizing the long-term use of good data or minimizing the cost of referencing and documenting a study subsequently found to have been poorly conducted or to have produced results of questionable value. If funding limitations will not allow referencing to a grid system, the study should be brought to the attention of appropriate State or Federal agencies in the event that they would want to provide more permanent reference for their own future use.

3. Documentation.

Any program of repeated beach profile surveys requires suitable documentation of the monuments and profile lines. The documentation must include enough information to permit the accurate reestablishment of the monuments, including pertinent notes on the local conditions in the vicinity of each profile line. Proper documentation ensures the compatibility and comparability of expensive data throughout the life of the study, the adequacy of the information needed to correctly interpret the data, and the capability of reoccupying the profile lines for future comparisons. Essentially, the documentation should allow someone unfamiliar with the study area to quickly and accurately locate and reoccupy the profile lines. It is through documentation that a degree of permanency is provided the profile lines.

Considerable information is required to properly document a study area. DA Form 1959, Description or Recovery of Horizontal Control Station (Fig.), is typically available to Corps surveyors and may be used for documentation, although any form that provides adequate documentation is acceptable.

a. Data on Monuments.

(1) Type of Monument. Provide a description of the monument or reference point used to locate the position of the base line or profile line in the field. For a profile line, this is typically the landwardmost point (0+00).

(2) Description of Location. Provide written description of the location of the monument.

(3) Map Coordinates and Grid Control. If the base line or profile line is referenced to a coordinate system, the grid coordinates and name of the grid to which they refer should be shown for the monument. If the profile control point is not referenced to a U.S. Geological Survey (USGS) or U.S. Coast and Geodetic Survey (USCGS), now National Ocean Survey (NOS) monument, details on how the coordinates were obtained should be provided.

(4) Latitude and Longitude. Again, if the base line or profile line is referenced to a coordinate system, the latitude and longitude of the control point should be given.

(5) Elevation and Datum. The datum to which the control point elevation refers should be provided. If the profile control point is referenced to a permanent monument, the order of the leveling between the two points, the order of the originating points (two originating points are required to verify that these points are accurate), the date the elevation of the profile control point was established, and any information on changes of the profile control point should be listed.

(6) Tie-In Data. The data of the survey and lengths and angles of the ties between the profile control point and the permanent control points should be given.

(7) Base Line Data. If the profile line is tied into a surveyed permanent base line, sufficient information for permanently referencing the profile line to the base line should be provided.

COUNTRY	TYPE OF MARK	STATION
U. S. A.	COE disk set in conc.mon.	Profile line 5 BE-E Sta 0+35
LOCALITY	STAMPING ON MARK	AGENCY (CAST IN MARK)	ELEVATION
Ludlam Island Strathmere, NJ	BE-E 0+35	Corps of Engineers	5.59 (FT) XXX
LATITUDE	LONGITUDE	DATUM	DATUM
39°11'13.36"	74°39'58.79"	North American, 1927	NGVD (1929)
(NORTHING)(EASTING) (FT)	(EASTING)(NORTHING) (FT)	GRID AND ZONE	ESTABLISHED BY (AGENCY)
128 824 XXX	2 000 095 XXX	NJ Trans. Merc.	Corps of Engineers
(NORTHING)(EASTING) (PT) (M)	(EASTING)(NORTHING) (FT) (M)	GRID AND ZONE	DATE: Dec 1974 / ORDER: 3d

TO OBTAIN GRID AZIMUTH, ADD ° ' " TO THE GEODETIC AZIMUTH

TO OBTAIN GRID AZ. (ADD)(SUB.) ° ' " TO THE GEODETIC AZIMUTH

OBJECT	AZIMUTH OR DIRECTION (GEODETIC)(GRID) (MAGNETIC)	BACK AZIMUTH	GEOD. DISTANCE (METERS) (FEET)	GRID DISTANCE (METERS) (FEET)
	° ' "	° ' "		

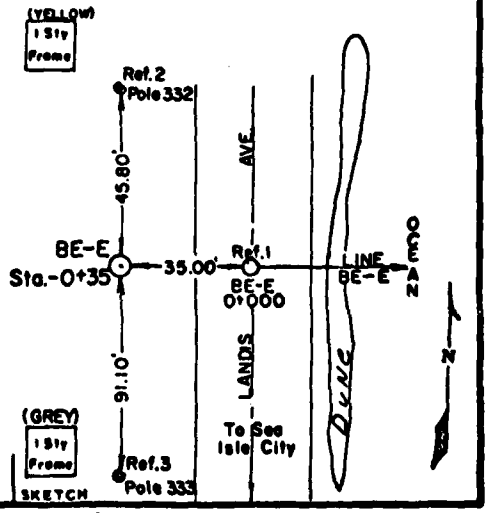
The station is located on Ludlam Island, 0.65 miles south on Landis Avenue from the intersection of Commonwealth Avenue (Landis Avenue extended) and Putnam Road in Strathmere, New Jersey. It is approximately 14 feet west of the west edge of the roadway and on line with the pole line. The monument is flush with the ground.

Reference 1 is a railroad spike in the centerline of Landis Avenue, 35.00 feet east of the station. (Station 0+00 on the section line)

Reference 2 is a PK nail, 1.0 feet above the ground, in Pole 332-09802, 45.80 feet north of the station.

Reference 3 is a PK nail, 1.0 feet above the ground, in Pole 333-W17021, 91.10 feet south of the station.

NJ Grid Azimuth of Line BE-E 304°47'



DA FORM 1 OCT 64 1959 REPLACES DA FORMS 1959 AND 1960, 1 FEB 57, WHICH ARE OBSOLETE.

DESCRIPTION OR RECOVERY OF HORIZONTAL CONTROL STATION

For use of this form, see TM 5-237; the proponent agency is U.S.Continental Army Command.

Figure. Example of monument documentation.

(8) References. The distances and angles from each monument to its referencing points, as well as the elevations of reference points, should be provided.

(9) Distance Between Profiles. The distances and azimuths between profile lines must be provided if grid coordinates are not given.

(10) Photos. Photos should be taken of each monument and its vicinity to assist in its description. The general direction of each photo should be noted. When possible, aerial photography should be acquired to show the base line, which should be marked so that points are visible on the photos.

b. Data on Profile Lines.

(1) Azimuth. The azimuth of each profile line from land to sea should be provided. It may be referenced to any standard, such as true north or the base line, as long as the standard is consistent between profile lines and throughout the study.

(2) Change in Location. The date and details of any change in the location or orientation of a profile should be added to the documentation.

(3) Photos. Photos taken looking seaward from the survey control point, landward and seaward from other significant features, and landward from the waterline are useful in the description of the profile if they show stable, identifiable features.

(4) Directions. In order to survey a profile line, it must first be found by the surveyor. Written directions or a map should be provided to each monument from the main routes of access.

IV. SUMMARY

The proper monumenting, referencing, and documenting of base line and profile lines is cost effective, ensures the viability of the profile data throughout the study period, and allows the reoccupation of profile lines years after their establishment. The proper establishment of base lines and profile lines, which is a requirement for a good study, reduces the chance for misinterpretation of the data and supports the accuracy of the data obtained.

When establishing base lines and profile lines, the monuments should be:

(a) Made relatively permanent by (1) locating the monuments far enough back from the shore to be in a stable area, and (2) protecting the monuments from vandalism.

(b) Located horizontally with enough redundancy to ensure reestablishment if lost or destroyed.

(c) Located vertically such that their elevation with respect to other bench marks and datums, such as a tidal datum, is known.

(d) Checked periodically for location and elevation.

(e) Documented carefully, both when originally established and if updated or changed.

LITERATURE CITED

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APPENDIX

CHECKLIST FOR MONUMENTING

1. Have I contacted the appropriate local officials and property owners?

2. Is the base line located far enough from the beach to be in a relatively stable area?

3. Are the monuments located and constructed to avoid vandalism?

4. If I gave my documentation to a reasonably competent surveyor, would he or she be able to locate all monuments and know their elevation?

5. If a monument is lost, can it be accurately reestablished or a new monument placed so that the profile line can be reused?

6. Is the monument referenced with enough redundancy that it can be reestablished even if one reference point is lost?

Hemsley, J. Michael

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Too frequently coastal surveys are performed without proper attention to establishing, referencing, and documenting the survey monuments. This report presents guidelines for establishing base lines for coastal surveys and for monumenting, documenting, and referencing those base lines and the profile lines.

1. Bench marks. 2. Surveying. 3. Coasts. I. Title. II. Series.

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