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Field Manager
Eniwetok Field Office
P. O. Box 5400
Albuquerque, New Mexico

June 10, 1953

Subject: Standard Surveying Methods of Holmes & Narver

Dear Sir:

As per request by UCRL letter COL-439 dated June 1, 1953, we are forwarding the following information relative to surveying techniques used by us in the Pacific Proving Grounds.

(1) Horizontal Control

The horizontal control established for each of the atolls includes a triangulation network by which the interrelation of the various islands, or groups of islands can be determined, traverses of the individual areas which are connected to the triangulation network and special surveys to determine the precise relation between particular structures.

The origin of all horizontal control at each atoll is a point of known latitude and longitude, or geographic position, and the geodetic azimuth of a line originating at this point. At both atolls the stations accepted for position and azimuth had been previously established by the U.S. Navy. As the accuracy of these positions is consistent with project requirements, reobserving for this purpose is unnecessary.

A triangulation network has been established at each atoll which consists of a net of triangles expanding from a measured baseline on one of the islands. Triangulation is generally referred to as being of first, second or third order or that the allowable discrepancy in the length of any line of the scheme shall not exceed 1:25,000 for first order, 1:10,000 for second order and 1:5000 for third order surveys. All test sites and islands where it is anticipated that important installations will be established are included in the primary network which is executed to second order accuracy. Locations of lesser

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NAME: J.D. Lopez	
DATE: 7/29/84	

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importance are connected to this net by third order surveys.

Specifications and procedures of the U. S. Coast and Geodetic Survey are followed in executing the surveys and the results are well within the specified tolerances. The control points are monumented and referenced and become the origin of horizontal control for the areas in which they are located. The geometry of the networks is such that if a station is destroyed it can generally be re-established by observing a triangle using a line between two of the existing stations as a base.

Local Control on the individual islands consists of monumented points which are located convenient to the work areas and connected to the primary control station in the area by traversing through these points. This control is generally of third order but may be of a higher degree of accuracy when justified by scientific requirements. Design surveys such as topography and hydrography are accomplished from these controls and they are the basis of construction layout.

Scientific structures are located to accuracy specifications furnished by the Users. Generally, the local control is sufficient but where precise location and orientation is required this is accomplished directly from the primary control stations.

Precise alignment or precise interrelation of structures requiring a high degree of accuracy is accomplished by establishing direct controls between the structures and may require specialized methods and equipment.

A plane coordinate grid has been established for each atoll. After completion of the triangulation survey an adjustment is applied in order that the values of a station will remain the same independent of the direction of computation through the net. Local traverses are adjusted for the same purpose. An assumed origin of North 100,000 and East 100,000 has been adopted for each atoll, so located that the coordinates of all locations within the atoll will be designated North and East. Coordinates are computed for all control stations and the relation of any point to these stations can be converted to coordinates.

Where it is necessary to set up a temporary coordinate system before the primary control net can be completed a preliminary coordinate system is used. This preliminary system is later converted to the master grid coordinates or a conversion factor is determined.

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(2) Vertical Control

The records of the earlier U. S. Navy surveys do not include data on vertical control. To meet the project requirements a datum or reference plane is established at each area by applying corrections to a series of tidal observations. This is a datum approximating "mean low water springs" which may be better understood by the following definition of tidal datum planes in use throughout the world.

A tidal datum is a plane or surface at a reference station which may be defined by the tides and which is used as a reference for heights or depths.

Mean sea level may be defined as the average height of the sea for all stages of the tide.

Mean low water may be defined as the mean of all low waters over a considerable period of time.

Mean lower low water may be defined as the mean of the lower of the two low waters of each day over a considerable period of time.

Mean low water springs may be defined as the mean of the low waters of the spring tides which occur within a day or two after the moon is new or full. At this time the maximum range occurs between high and low tide and the resulting datum is slightly lower than mean lower low water.

Lowest low water may be defined as the lowest low water which may be expected in a locality and is based on the lowest of the spring tides. As the theoretical tide level may be affected by indeterminates such as wind and current this datum is generally defined as approximate. The soundings recorded on hydrographic charts of the Marshall Islands are reduced to this datum.

Tide tables are published yearly in advance by the U. S. Coast and Geodetic Survey. These tables provide the tidal relation to various reference stations throughout the world. Correction factors are included which give the relation of other areas to these reference stations. The closest reference station in the Marshall Islands to the project areas is at Kwajalein and the datum used is mean low water springs. The time and height of tide at the various atolls in the areas is determined by applying corrections to the data for the Kwajalein reference station.

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The requirements for vertical control to date have been limited to the individual islands or group of islands and to the vertical relation of structures within an area. The vertical relation of all land areas within an atoll has not been required to a high degree of accuracy. Therefore, local datums have been established as required, based on corrected tidal observations.

The procedure is to erect a tide staff at a suitable location on the lagoon side of an island and take periodical readings of the water level. From the U. S. Coast and Geodetic Survey tide tables the theoretical height of the tide at the time of the reading is determined and the water level reading subtracted, or in the case of a minus tide added, to establish the zero elevation. The mean of these corrected readings is accepted as the datum for the area and is transferred to a permanent monument in the vicinity which becomes the origin of all vertical control for the area.

It has been determined that the mean of a dozen corrected readings will generally be within a range of two tenths of a foot from the individual readings. This method provides a datum well within the requirements for relation of construction to the surface of the sea or lagoon. A check was obtained of the datum established by the method at Eniwetok Island when an automatic tide gage was operated at this location for several months by the U. S. Coast and Geodetic Survey. A differential of 0.14 foot was determined which would be of little consequence in the tidal relation to project structures.

From the controlling reference marks in an area additional bench marks are established by differential leveling. The location and number of these marks is determined by the use of the area. They are generally of second order accuracy or a tolerance inclosure of 0.035 times the square root of the distance in miles. Precise leveling is required for some stations and is accomplished to first order specifications by use of precise methods and equipment.

For mapping purposes elevations 5.0 at Eniwetok Atoll and 6.0 at Bikini Atoll have been adopted for the high tide lines. As these are approximately the highest normal tides to be expected these planes are used to determine the extent of the land areas.

The terminology used for the various surveying and mapping functions is too extensive to be defined completely herein. Your attention is called to the following publications which should define any terminology used at this jobsite.

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Special Publication No. 242 of the U. S. Coast and Geodetic Survey. Definitions of terms used in geodetic and other surveys.

Special Publication No. 228 of the U. S. Coast and Geodetic Survey. Tide and current glossary.

Manual of Engineering Practice No. 15, published by the American Society of Civil Engineers. Definitions of Surveying terms.

Very truly yours,

HOLMES & NARVER, INC.

Original Signed By
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