



## Publication 18-H010

University-National Oceanographic Laboratory System (UNOLS)  
Absolute and Relative Gravity Survey  
Nimitz Marine Facility and Port of San Diego 10th Avenue Terminal  
San Diego, California

September-October 2017



**University-National Oceanographic Laboratory System (UNOLS)**

**Absolute and Relative Gravity Survey**

**University of California-San Diego**

**Nimitz Marine Facility**

**297 Rosecrans Street**

**And**

**Port of San Diego**

**Tenth Avenue Terminal**

**San Diego, California 92106**

**September-October 2017**

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1. Introduction

a. Background

This report presents the results of a gravity survey in support of University-National Oceanographic Laboratory System (UNOLS) at University of California-San Diego Nimitz Marine Facility and the Port of San Diego Tenth Avenue Marine Terminal. The survey was conducted by Mr. R. David Wheeler (575-679-2893) and Ms. Roberta L. Paz of the National Geospatial-Intelligence Agency (NGA). Survey dates were September 21-October 02, 2017.

b. Points of Contact:

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## 2. Requirements

Gravity values were requested at two locations, the Pier at the Nimitz Marine Facility and the Pier at the Tenth Avenue Marine Terminal, San Diego. The accuracy requirements for this survey were "best achievable".

## 3. Procedures

### a. Absolute Gravity:

The absolute gravimeter used for this survey, A10-010, was validated prior to deployment to San Diego with absolute gravimeter FG5-107 at Holloman AFB, New Mexico. A10-010 agreed with FG5-107 within the acceptable validation values. One absolute station, '**NMF AA**' was established, at the Nimitz Marine Facility, Building 3. Multiple day, independent measurements were made at the absolute station. A10-010 was then validated post deployment at Holloman and found to be within acceptable validation values.

### b. Relative Gravity:

Relative observations from the established absolute station '**NMF AA**' were made using a 1-2-3-3-2-1 type loop structure with three Scintrex CG-5 Autograv gravity meters (Serial Numbers 40244, 40245 and 40248). The loop structure included relative measurements at the Nimitz Marine Facility, gravity stations '**NMF AB**', '**NMF AC**', '**NMF AD**', '**NMF AE**', '**NMF AF**', '**NMF AG**', '**NMF AH**' and a second loop at the Tenth Avenue Marine Terminal, gravity stations '**SDUPD-015**', '**10 MT AB**', '**10 MT AC**'.

### c. Gravity Gradient:

Relative observations from the ground to a one meter tripod were made using a 1-2-1-2-1-2-1 type loop structure with three Scintrex CG-5 Autograv gravity meters (Serial Numbers 40244, 40245 and 40248). The loop

structure included a gravity gradient measurement at '**NMF AA**'; the gradient value is used to reduce absolute gravity measurements to the survey monument.

#### 4. Computations and Analysis

##### a. Absolute Gravity:

The absolute gravity value was determined from data collected with a Micro-g LaCoste A10 gravity meter. Four days of independent observations were taken at station '**NMF AA**'. A weighted mean of this observation was calculated at the station. The absolute precision terms were less than 0.011 mGal for station '**NMF AA**'. Using the Scintrex CG-5 relative meters, a gradient value (microGal /centimeter) at the absolute site was determined. This gradient was applied to the absolute gravity value to relocate it from the A10's measurement location (approximately 71 centimeters above) to the established gravity monument on the ground.

##### b. Relative Gravity:

A dynamic drift value is computed from the observations at the control station for each meter. This is applied to the individual observations, linearly; by time. The relative gravity value for each station was determined from data collected with the CG-5 meters. The output from these meters is automatically corrected for static drift and earth-tide effects. The output of stations '**NMF AF**', '**NMF AG**', '**NMF AH**' and '**SDUPD-015**', '**10 MT AB**', '**10 MT AC**' that are directly over water are then corrected for Water Slab. The value of +/- 0.045 milligals per meter of ocean tide is used to reduce the gravity value to the Mean Low Level Water height. The heights are published by the tidal gauge station, 9410170-San Diego, CA (located near the aircraft carrier USS MIDWAY) at six minute intervals of actual tide heights. These actual tide values can be found at: <http://tidesandcurrents.noaa.gov>. The delta gravity value of the observations from each meter is then processed with NGA proprietary GravNet software. These deltas are

then applied to the absolute station to determine the gravity value at each measured relative gravity station. The relative precision terms were less than 0.022 mGal for all stations. Over-water gravity stations listed below in the **Gravity Results** section are reported with and without the removal of the Local Ocean-Tide Gravitational Effect (Water Slab correction).

c. Gravity Gradient:

A dynamic drift value is computed from the observations at the control station for each meter. This is applied to the individual observations, linearly; by time. The relative gravity value for each station was determined from data collected with the CG-5 meters. The output from these meters is automatically corrected for static drift and earth-tide effects. The delta gravity value of the observations from each meter is then processed with NGA proprietary GravNet software. This delta is the gravity gradient. The relative precision terms were less than 0.005 mGal for all stations.

## 5. Corrections to Absolute Gravity

a. Earth Tide and Ocean Loading

Earth Tide and Ocean Loading corrections (effects of lunar-solar attraction and tidal parameters) are applied to each drop. The 'g' software accommodates two Tidal Correction methods, ETGTAB and Berger. Within each it is possible to incorporate an ocean loading model. This collection utilized the ETGTAB for the earth tide model and the Schwiderski ocean tidal model. For more advanced information regarding the tide models visit <http://www.ecgs.lu>, or Dr. Oliver Francis at ([oliver@ecgs.lu](mailto:oliver@ecgs.lu)).

b. Polar Motion

Polar Motion corrections, defined as changes in the centrifugal acceleration due to the variation of the distance of the earth's rotational axis from the gravity station, are applied to each drop. The daily final polar motion coordinates (post-processed) were obtained from the International Earth Rotation Service (IERS), Bulletin B, found at <http://www.usno.navy.mil>.

c. Transfer Height

The transfer height at the observed absolute stations was 0.000 meters. This means that the gravity value is reported at the survey monument at ground level. The nearest observed gradient is used to transfer the observed gravity position to the transfer height. The observed gravity position is a known point made up of a fixed internal instrument height (71.40 cm).

d. Barometric Pressure

The observed gravity is normalized to the nominal air pressure at the station by applying a correction based on the observed atmospheric pressure during each drop of every set.



## 6. Gravity Results

<b>Absolute Gravity Values</b>			
STATION NAME	Location	ADJUSTED GRAVITY milliGal	PRECISION TERM milliGal
<b>NMF AA</b>	Nimitz Marine Facility (NMF), Building 3	979536.274	0.011

<b>Relative Gravity Values</b>			
STATION NAME	Location	ADJUSTED GRAVITY milliGal	PRECISION TERM milliGal
<b>NMF AB</b>	NMF	979536.297	0.012
<b>NMF AC</b>	NMF	979535.900	0.012
<b>NMF AD</b>	NMF	979536.286	0.013
<b>NMF AE</b>	NMF	979536.820	0.014

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<b>Relative Gravity Values NOT Water Slab Corrected</b>			
<b>NMF AF</b>	NMF	979536.397	0.014
<b>NMF AG</b>	NMF	979535.985	0.015
<b>NMF AH</b>	NMF	979534.665	0.018
<b>SDUPD-015</b>	10 <sup>TH</sup> Ave. Marine Terminal (MT)	979512.318	0.012
<b>10 MT AB</b>	10 <sup>TH</sup> Ave. MT	979511.991	0.013
<b>10 MT AC</b>	10 <sup>TH</sup> Ave. MT	979511.065	0.018

<b>Relative Gravity Values Water Slab Corrected</b>			
STATION NAME	Location	ADJUSTED GRAVITY milliGal	PRECISION TERM milliGal
<b>NMF AF</b>	NMF	979536.340	0.013
<b>NMF AG</b>	NMF	979535.929	0.015
<b>NMF AH</b>	NMF	979534.612	0.018
<b>SDUPD-015</b>	10 <sup>TH</sup> Ave. Marine Terminal (MT)	979512.251	0.012
<b>10 MT AB</b>	10 <sup>TH</sup> Ave. MT	979511.923	0.013
<b>10 MT AC</b>	10 <sup>TH</sup> Ave. MT	979510.996	0.018

DESCRIPTION OF GEODETIC STATION		
<b>STATION NAME</b> NMF AA 2017	<b>SITE CODE</b> NMF AA	<b>GRAVITY VALUE</b> 979536.274 milliGal
<b>LOCATION</b> Nimitz Marine Facility, Scripps Institute of Oceanography, University of California-San Diego, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located inside of Building 3 on Nimitz Marine Facility, San Diego, California, United States of America.

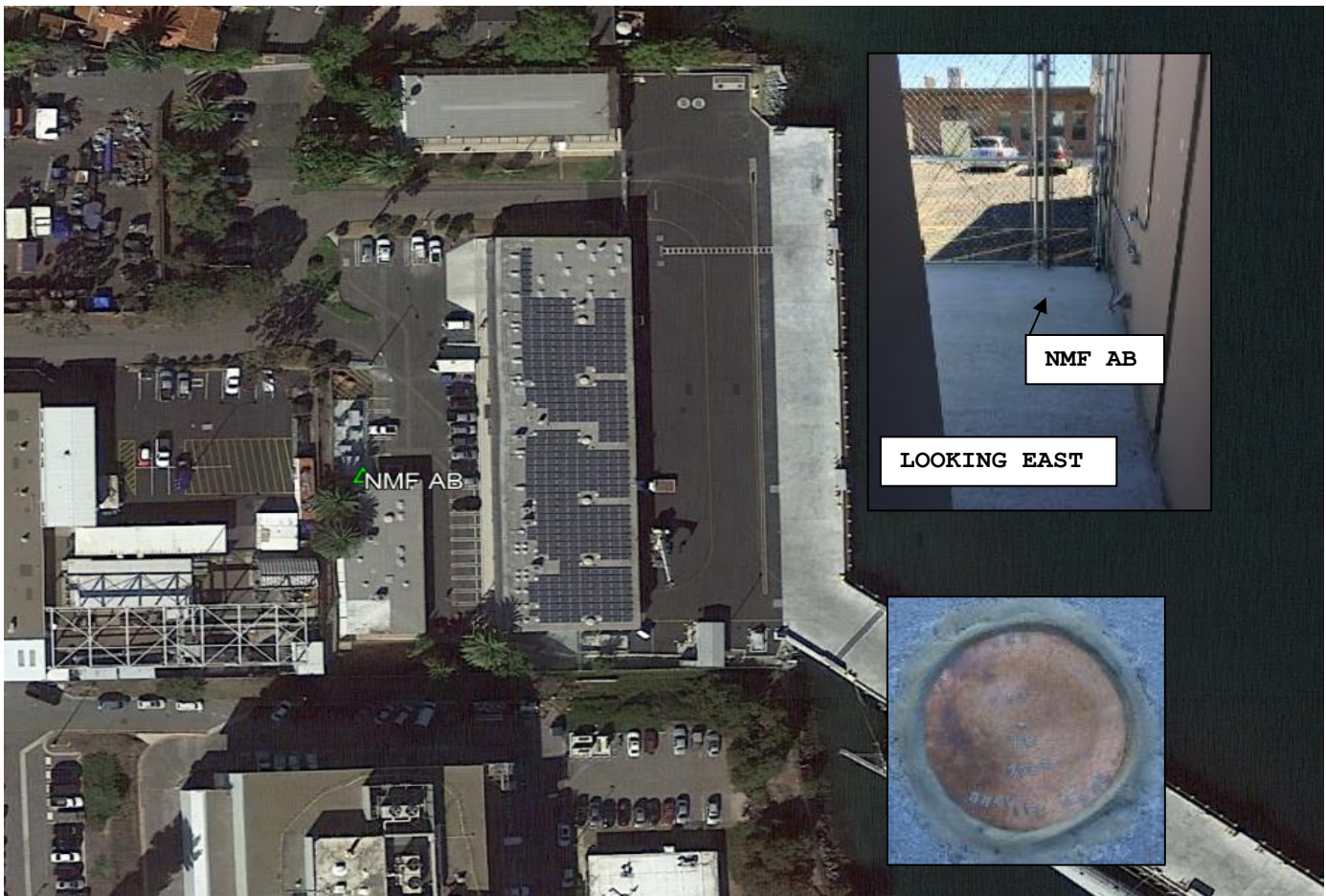
The bench mark is an NGA Survey Bench Mark disk stamped NMF AA 2017, set flush with flooring in the southwest corner of Building 3. Near the Fire Alarm Terminal Cabinet, 0.3 meter east of west wall and 0.35 meter north of south wall.



DESCRIPTION OF GEODETIC STATION		
<b>STATION NAME</b> NMF AB 2017	<b>SITE CODE</b> NMF AB	<b>GRAVITY VALUE</b> 979536.297 milliGal
<b>LOCATION</b> Nimitz Marine Facility, Scripps Institute of Oceanography, University of California-San Diego, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located on Nimitz Marine Facility, San Diego, California, United States of America.

The bench mark is an NGA Survey Bench Mark disk stamped NMF AB 2017, set flush in concrete on the southeast corner of electrical substation to the north of Building 3. Along the east fence, 0.70 meter west from edge of east concrete ledge, 0.65 meter north of north exterior wall of Building 3.

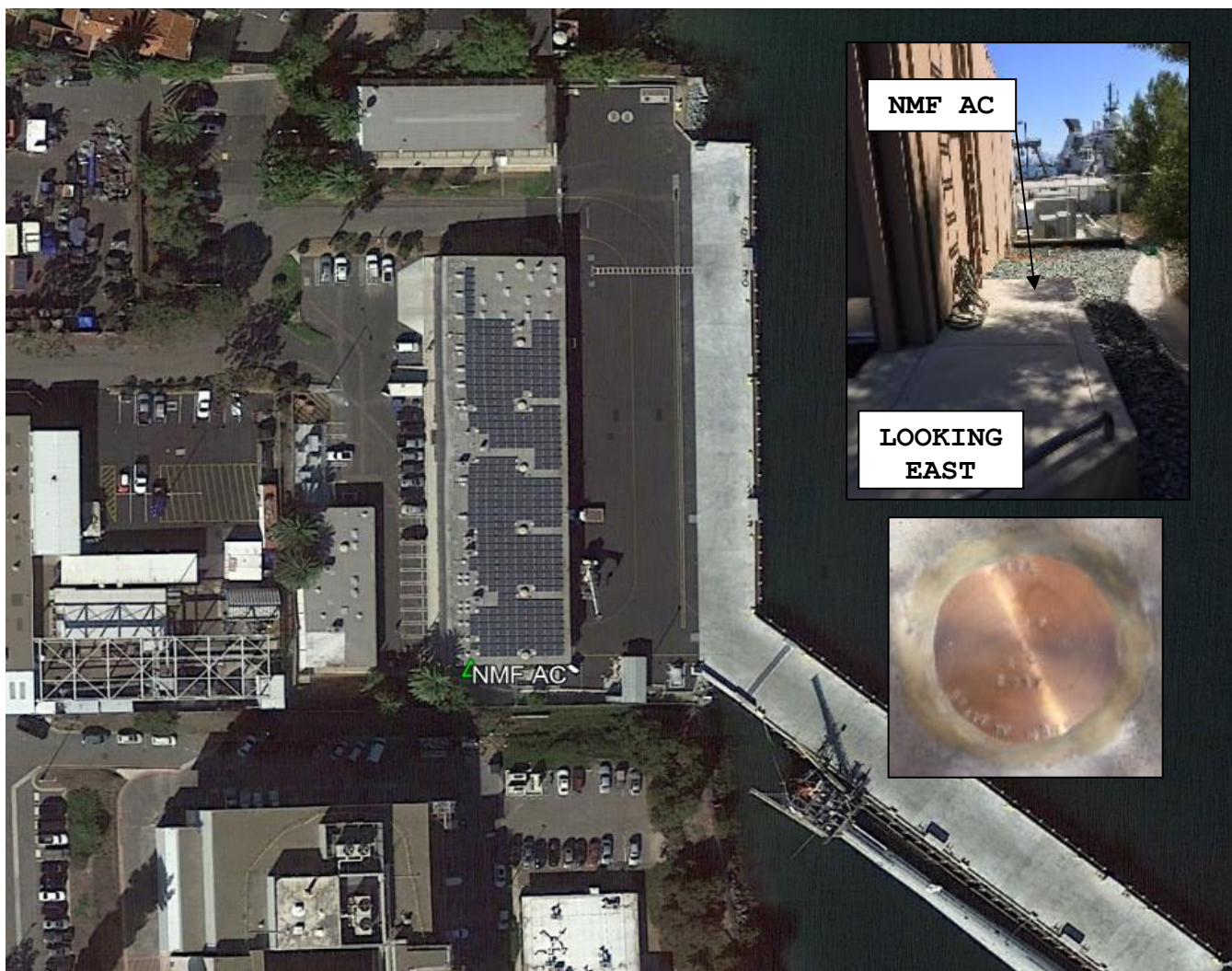




DESCRIPTION OF GEODETIC STATION		
<b>STATION NAME</b> NMF AC 2017	<b>SITE CODE</b> NMF AC	<b>GRAVITY VALUE</b> 979535.900 milliGal
<b>LOCATION</b> Nimitz Marine Facility, Scripps Institute of Oceanography, University of California-San Diego, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located on Nimitz Marine Facility, San Diego, California, United States of America.

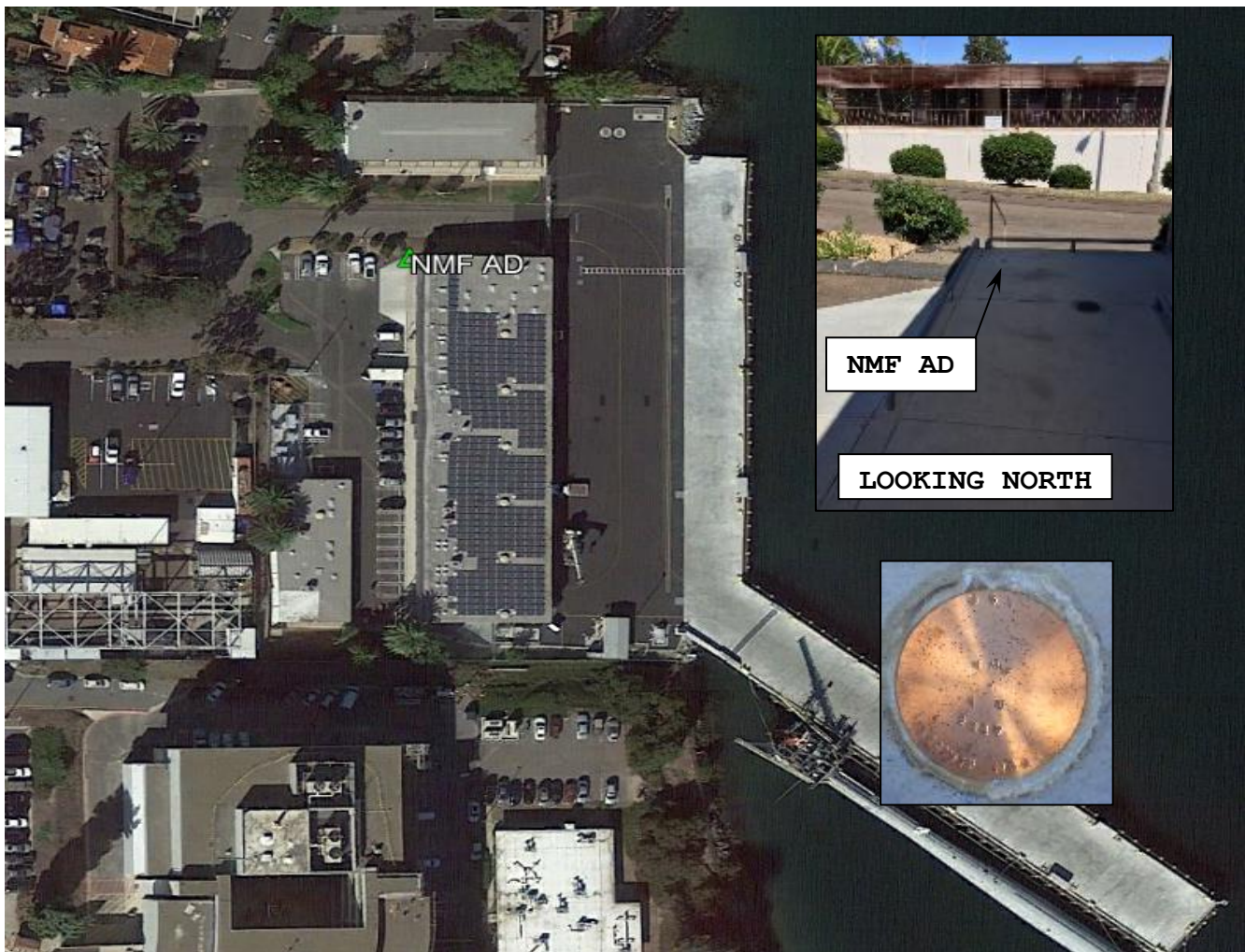
The bench mark is an NGA Survey Bench Mark disk stamped NMF AC 2017, set flush in concrete on the southwest corner of Building 2. Near the permanent ladder to top of building, 0.35 meter west from east edge of concrete ledge, 0.35m north of south concrete ledge.



DESCRIPTION OF GEODETIC STATION		
<b>STATION NAME</b> NMF AD 2017	<b>SITE CODE</b> NMF AD	<b>GRAVITY VALUE</b> 979536.286 milliGal
<b>LOCATION</b> Nimitz Marine Facility, Scripps Institute of Oceanography, University of California-San Diego, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located on Nimitz Marine Facility, San Diego, California, United States of America.

The bench mark is an NGA Survey Bench Mark disk stamped NMF AD 2017, set flush in concrete on the northwest corner of Building 2. 0.45 meter south of north edge of concrete ledge, 0.45m east of west concrete ledge.

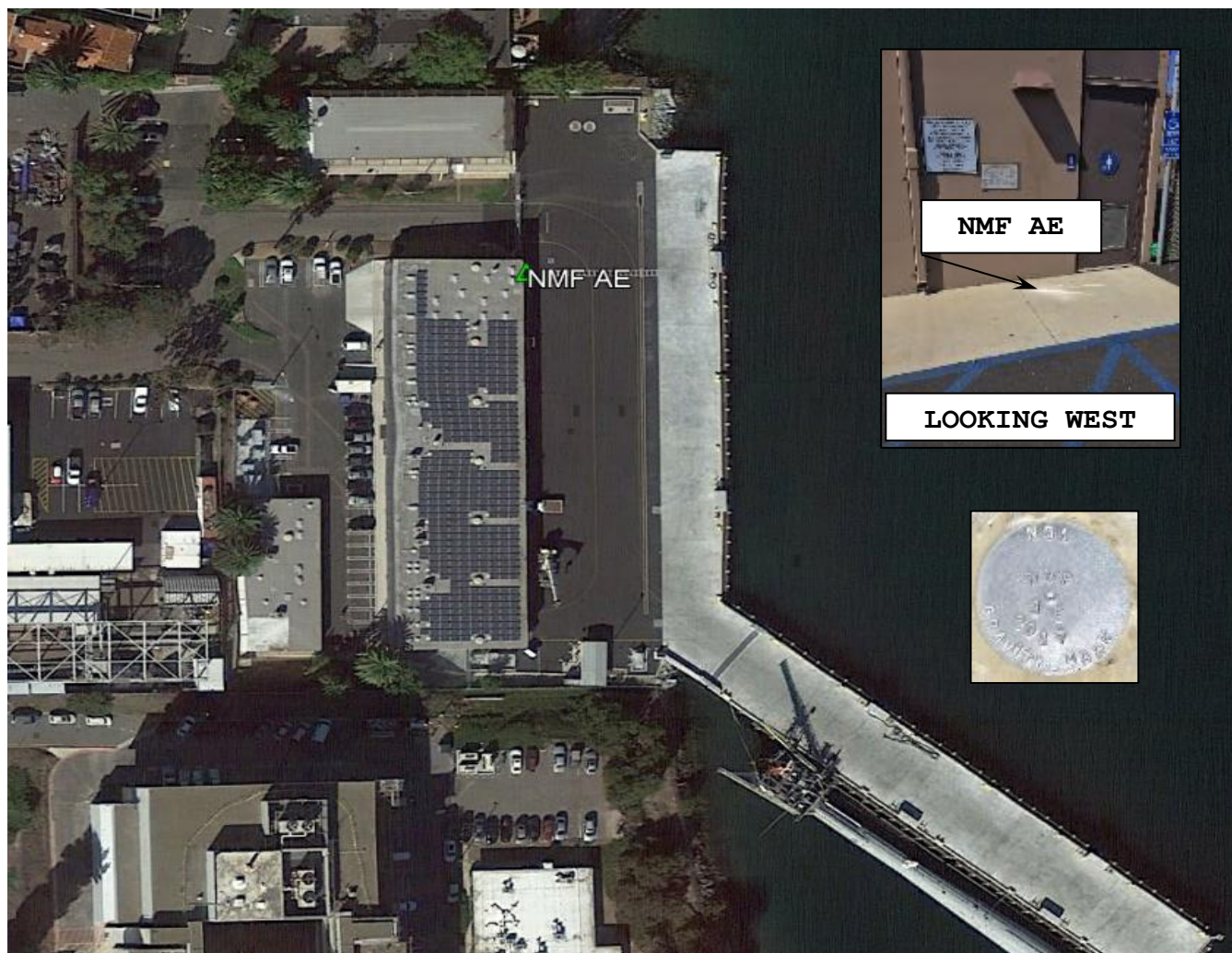




DESCRIPTION OF GEODETIC STATION		
<b>STATION NAME</b> NMF AE 2017	<b>SITE CODE</b> NMF AE	<b>GRAVITY VALUE</b> 979536.820 milliGal
<b>LOCATION</b> Nimitz Marine Facility, Scripps Institute of Oceanography, University of California-San Diego, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located on Nimitz Marine Facility, San Diego, California, United States of America.

The bench mark is a 2" NGA aluminum disk stamped NMF AE 2017, set flush in concrete on the northeast corner of Building 2. Near the restrooms, 0.42 meter east of east exterior wall of Building 2, 1.60m south of north concrete edge.



DESCRIPTION OF GEODETIC STATION		
<b>STATION NAME</b> NMF AF 2017	<b>SITE CODE</b> NMF AF	<b>GRAVITY VALUE</b> 979536.340 milliGal*
<b>LOCATION</b> Nimitz Marine Facility, Scripps Institute of Oceanography, University of California-San Diego, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located on Nimitz Marine Facility, San Diego, California, United States of America.

The bench mark is an NGA Survey Bench Mark disk stamped NMF AF 2017, set flush in concrete on the northeast corner of wharf. Near the northeast bollards, 0.33 meter south of north concrete wharf, 0.33 m west of east concrete wharf.

**\*Gravity Value is corrected for water slab.**





**DESCRIPTION OF GEODETIC STATION**

<b>STATION NAME</b> NMF AG 2017	<b>SITE CODE</b> NMF AG	<b>GRAVITY VALUE</b> 979535.929 milliGal*
<b>LOCATION</b> Nimitz Marine Facility, Scripps Institute of Oceanography, University of California-San Diego, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located on Nimitz Marine Facility, San Diego, California, United States of America.

The bench mark is an NGA Survey Bench Mark disk stamped NMF AG 2017, set flush in concrete at the intersection of the wharf and pier. Near the south bollards, 0.40 meter southwest of concrete joint.

**\*Gravity Value is corrected for water slab.**

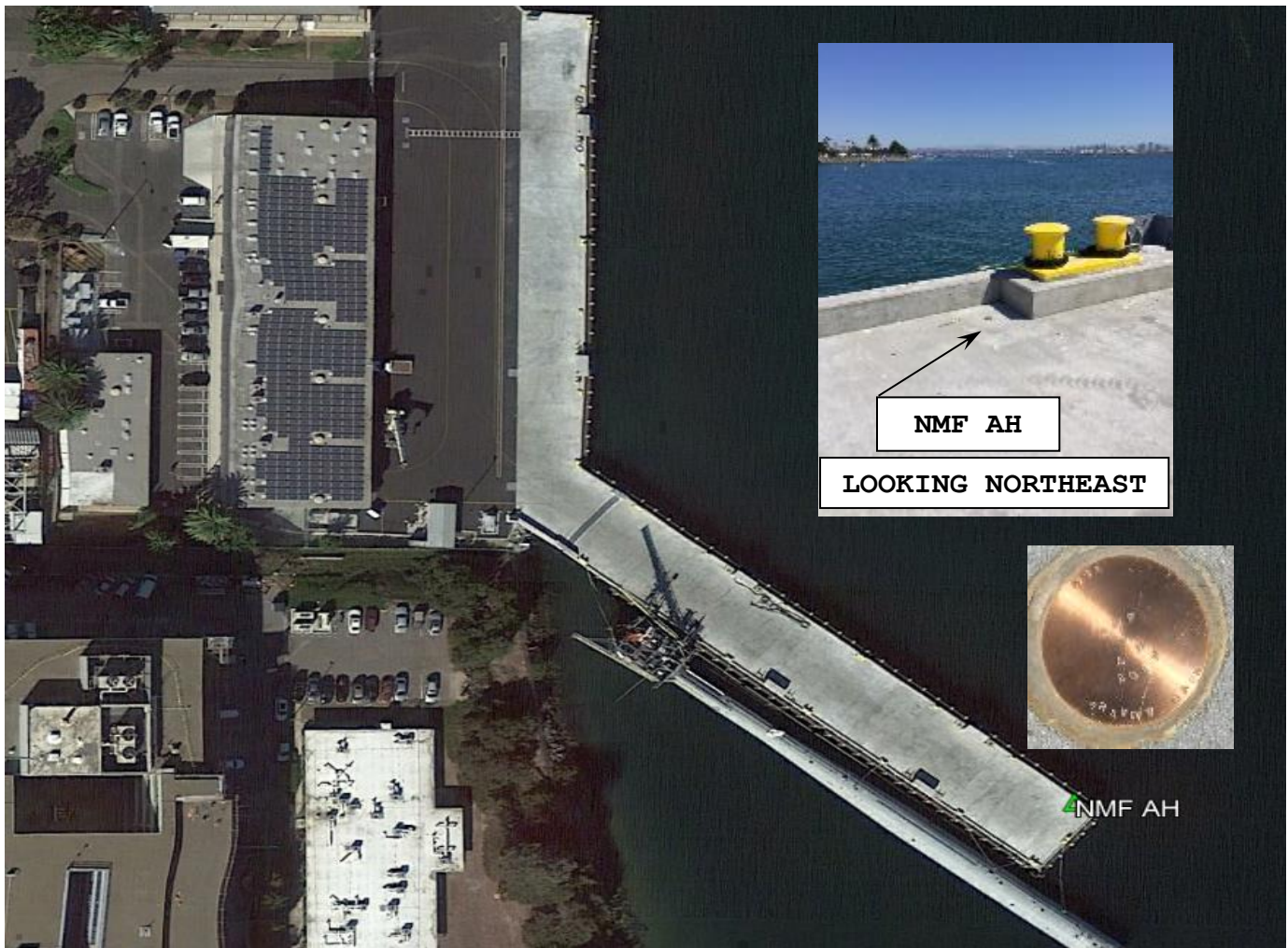


DESCRIPTION OF GEODETIC STATION		
<b>STATION NAME</b> NMF AH 2017	<b>SITE CODE</b> NMF AH	<b>GRAVITY VALUE</b> 979534.612 milliGal*
<b>LOCATION</b> Nimitz Marine Facility, Scripps Institute of Oceanography, University of California -San Diego, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located on Nimitz Marine Facility, San Diego, California, United States of America.

The bench mark is an NGA Survey Bench Mark disk stamped NMF AH 2017, set flush in concrete at the southeast corner of the concrete pier. Near the southeast bollards, 0.30 meter south of north concrete joint, 0.25m west of east concrete joint.

**\*Gravity Value is corrected for water slab.**





DESCRIPTION OF GEODETIC STATION		
<b>STATION NAME</b> SDUPD-015	<b>SITE CODE</b> SDUPD-015	<b>GRAVITY VALUE</b> 979512.251 milliGal*
<b>LOCATION</b> Port of San Diego, Tenth Avenue Terminal, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located on Port of San Diego, Tenth Avenue Terminal, San Diego, California, United States of America.

The bench mark is a Port of San Diego Survey Bench Mark disk stamped SDUPD-015, set flush in concrete at the 11-25 station. 0.20 meter east of west concrete wall, 0.20m east of concrete and asphalt joint.

**\*Gravity Value is corrected for water slab.**



DESCRIPTION OF GEODETIC STATION		
<b>STATION NAME</b> 10 MT AB 2017	<b>SITE CODE</b> 10 MT AB	<b>GRAVITY VALUE</b> 979511.923 milliGal*
<b>LOCATION</b> Port of San Diego, Tenth Avenue Terminal, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located on Port of San Diego, Tenth Avenue Terminal, San Diego, California, United States of America.

The bench mark is an NGA Survey Bench Mark disk stamped 10 MT AB 2017, set flush in concrete at the 19-00 station. 0.25 meter east of west concrete wall, 0.25m east of concrete and asphalt joint.

**\*Gravity Value is corrected for water slab.**





DESCRIPTION OF GEODETIC STATION		
<b>STATION NAME</b> 10 MT AC 2017	<b>SITE CODE</b> 10 MT AC	<b>GRAVITY VALUE</b> 979510.996 milliGal*
<b>LOCATION</b> Port of San Diego, Tenth Avenue Terminal, San Diego, CA		<b>DESCRIBED BY</b> R. Paz
<b>ESTABLISHED BY</b> NGA		<b>DATE</b> September 2017

The station is located on Port of San Diego, Tenth Avenue Terminal, San Diego, California, United States of America.

The bench mark is an NGA Survey Bench Mark disk stamped 10 MT AC 2017, set flush in concrete at the 34-50 station. 0.20 meter east of west concrete wall, 0.20m east of concrete and asphalt joint.

**\*Gravity Value is corrected for water slab.**

