



**US Army Corps  
of Engineers** ®  
New Orleans District

# Engineering Documentation Report

## EDR-OD-04

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### **Houma Navigation Canal GIWW to the Gulf of Mexico including Bayou Le Carpe**

#### **MLG to MLLW Vertical Datum Conversion**

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## LIST OF ACRONYMS

CO-OPS: Center for Operational Oceanographic Products and Services

EC: Engineering Circular

EDR: Engineering Documentation Report

EM: Engineering Manual

ER: Engineering Regulation

HNC: Houma Navigational Canal

HQUSACE: US Army Corps of Engineers Headquarters Office

LMSL: Local Mean Sea Level

MLG: Mean Low Gulf datum

MLLW: Mean Lower Low Water datum

MVN: Mississippi Valley Division, New Orleans District

NAVD 88: North American Vertical Datum of 1988

NGS: National Geodetic Survey

NTDE: National Tidal Datum Epoch

NOAA: National Oceanic and Atmospheric Administration

OPUS: Online Positioning User Service

USACE: US Army Corps of Engineers

# 1 Introduction

The US Army Corps of Engineers (USACE), New Orleans District is converting the vertical datum for all coastal navigation projects from the legacy Mean Low Gulf (MLG) terrestrial datum to the Mean Lower Low Water (MLLW) tidal datum in accordance with a 2014 HQ-USACE memorandum. This memorandum defined policy for federal navigation projects where the decision documents supporting project authorization and the project authorization in law do not reference the MLLW tidal datum.

According to the Memorandum “Navigation Projects Compliance with Vertical Datum Guidance” dated 24 October 2014:

“For federal navigation projects where the MLLW depth differs from the depths stated in the project authorization, an Engineering Documentation Report (EDR) shall be prepared in accordance with reference 1.d, paragraph 8.3 for each project and posted on a navigation home page for each district. The EDR will be of limited scope to document the datum change only.”

This report documents the conversion from the legacy, unmaintained MLG datum to the National Oceanic and Atmospheric Administration (NOAA) maintained MLLW tidal datum for the Houma Navigation Canal (HNC) from the GIWW to the end of the HNC Bar Channel. This report provides details on how this relationship was determined and will be applied.

A brief description of the primary datums referenced in this report are:

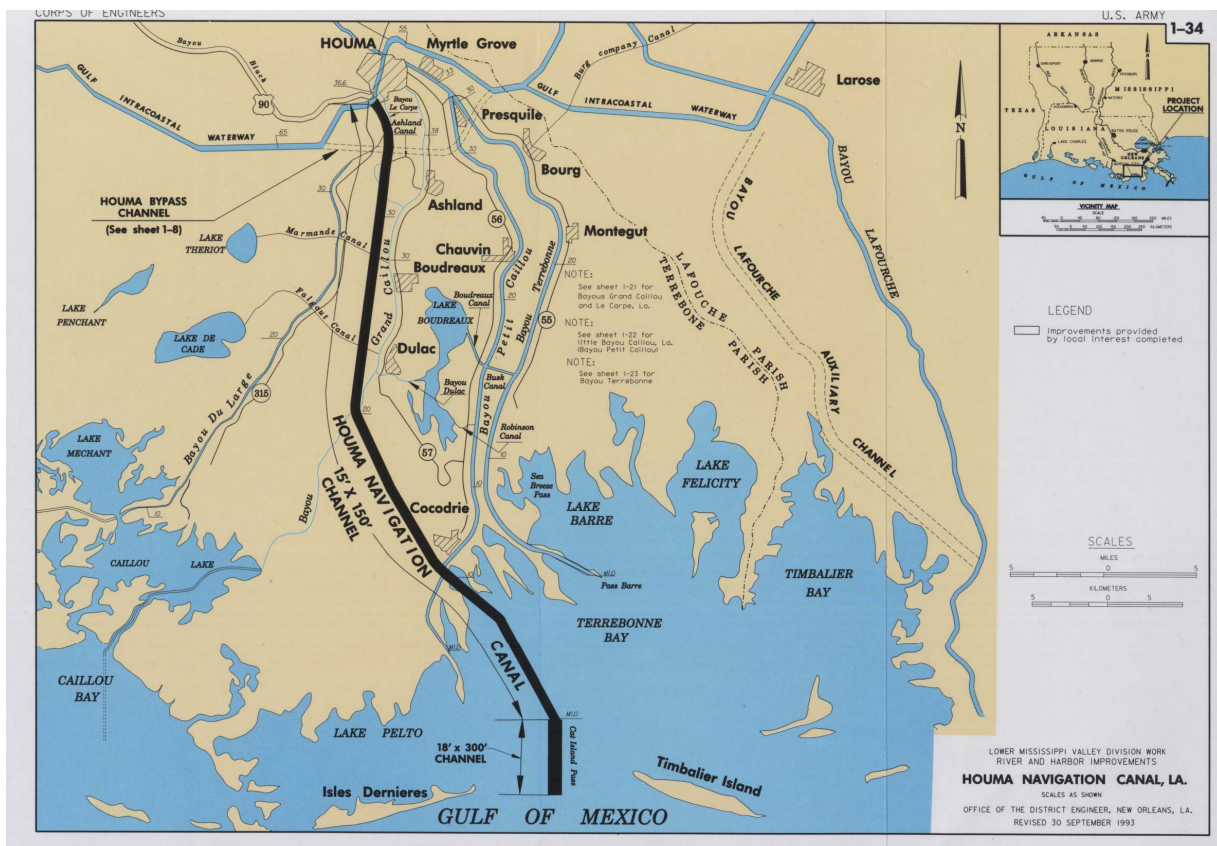
- The North American Vertical Datum of 1988 (NAVD 88) is a geodetic datum that is defined and maintained by the National Geodetic Survey (NGS). This datum is typically used for surveying (in addition to design and construction) and can be related to other datums as needed, to ensure project datums are referenced as required.
- Mean Lower Low Water (MLLW) as defined by the U.S. Department of Commerce and maintained by NOAA is the reference for project channel depths under the River and Harbor Act of 1915 and subsequent River and Harbor Acts. The same legislation states that project channel depths in rivers and nontidal channels shall reference the mean depth for a continuous period of fifteen days of the lowest water, as defined by the U.S. Department of Commerce, in the navigation season of any year. For ease of use on this project, the mean depth for a continuous period of fifteen days shall also be referred to as MLLW.
- Mean Low Gulf (MLG) is a local, legacy terrestrial datum that was originally defined relative to local mean sea level as observed in 1899 at a Biloxi, MS gage in the Gulf of Mexico. It has been used as a navigation and construction reference datum in coastal waterways such as the Gulf Intracoastal Waterway (GIWW) and the coastal portion of the Mississippi River navigation channel.

## 2 Project Summary

The River and Harbor Act of 23 October 1962 provides for the maintenance of the Houma Navigation Canal (HNC) to channel dimensions of 15 feet deep and 150 feet wide. The total length of improvement is 42.5 miles with 10.0 miles in Terrebonne Bay and 6.2 miles in the Gulf of Mexico.

Authority was granted on 23 August 1973 to increase the HNC project dimensions to 18 feet depth by 300 feet width between Mile 0 and the minus 18-foot depth contour in the Gulf of Mexico.

The HNC, including the HNC bar channel, extends from the GIWW to the Gulf of Mexico at Cat Island Pass. The HNC channel maintenance ends at the minus 18-foot depth contour at approximately 6.2 miles into the Gulf of Mexico. Also maintained is the Bayou Le Carpe Cutoff which extends approximately 1.5 miles from the GIWW to its confluence with the Houma Navigation Canal.



MAP 1- Houma Navigation Canal, LA

### 3 Vertical Datum Conversion Process

The datum relationships provided in this report bring the “Houma Navigation Canal, Louisiana” project into compliance with the requirements outlined in Engineering Regulation (ER) 1110-2-8160, Policies for Referencing Project Elevation Grades to Nationwide Vertical Datums, and Engineering Manual (EM) 1110-2-6056, Standards and Procedures for Referencing Project Elevation Grades to Nationwide Vertical Datums. These policy documents define the requirement for referencing datums on coastal navigation projects. The following EM excerpt addresses the requirement to establish the relation to MLLW for projects that are defined to a legacy datum, such as MLG (page 4-2):

*“USACE projects that are still defined relative to non-standard or undefined legacy datums (e.g., MLG, Gulf Mean Tide, MSL, NGVD, MLW, COEMLW, etc.) should have technically valid transforms to the NOAA MLLW chart/tidal datum for the area. In isolated cases, the legacy datum may be retained as the reference grade provided its relationship to NOAA MLLW datum is accurately defined based on current gage data at the project site. In such projects, depth data furnished to NOAA and other project users must indicate the primary reference gage, along with the tidal datum epoch period and the relationship between the legacy datum, NOAA MLLW, and NAVD 88. Legacy “Low Water” datums must be periodically updated for sea level change and regional subsidence using similar computational techniques established by NOAA for coastal waters.”*

The datum relationship between MLG, MLLW, and NAVD 88 was defined in accordance with EM 1110-2-6056. This datum relationship was used to determine the MLG-MLLW conversion value. See Section 4 for the relationship and conversion value.

#### 3.1 Project Datum

The HNC was completed in 1962 by local interests and its maintenance was authorized by the River and Harbor Act of 23 Oct 1962. Since that time, MLG has been the project datum for the entire project. As discussed in EM 1110-2-6056, some USACE civil works projects are, in effect, referenced to a local vertical datum. Many local datums are based on arbitrary, unknown, or perhaps archaic origins. Most hydraulic-based river datums and MSL/MLLW tidal datums are local datums when they are not properly modeled or kept updated. Mean Low Gulf was intended to represent the low water level of the Gulf of Mexico and it was defined in 1944 by New Orleans District Memorandum as being 0.78 ft below local mean sea level. At that time, Mean Sea Level (MSL) was defined by the Sea Level Datum of 1929 (SLD 29). SLD 29 was created by the U.S. Coast and Geodetic Survey (USC&GS) as the datum to adjust all vertical control to North America. SLD 29 was believed to be a MSL based datum, although MSL values were not consistent at the various gage locations. MSL values were not developed using the same epoch or period of record at each of the gages, so each gage was, in effect, a “local mean sea level” reference datum.



However, over time, with sea level rise and other factors, SLD 29 was no longer considered a MSL datum. In 1973, the name of SLD 29 was changed to the National Geodetic Vertical Datum of 1929 (NGVD 29) because it no longer represented sea level<sup>1</sup>. However, the assumed equivalency of NGVD 29 to MSL was predominant in both government and academic texts published well after the 1973 redefinition. MLG for this project continued to be locally interpreted as 0.78 ft below NGVD 29. The MLG datum thus became disassociated from sea level.

The relationship between reference datums is often complex given they can deviate spatially over a region, due to a variety of reasons. The relationships may also have temporal deviations due to land subsidence or uplift, sea level changes, project reconstruction, periodic readjustments to the datum origin, or to redefined points on the reference surface. This is particularly true for this project due to the magnitude of subsidence in the region. Throughout the life of the gages, periodic updates have established adjustment values for these reasons.

The United States Geological Survey (USGS) has maintained a gage at GIWW at Houma referenced to NAVD 88 which collects continuous stage readings at 15-minute intervals. Publication of the readings was discontinued in 2019 although the 2018 record of continuous readings was obtained for this report. The U.S. Army Corps of Engineers, New Orleans District, Stream Gaging function has maintained gages at Front Range Marker 'B' in Terrebonne Bay and at Timbalier Island which are referenced to MLG and to NAVD 88. The gages were reset to NAVD 88 in 2019.

### **3.2 Methodology for Establishing Conversion Value**

In 2021, MLLW (2012-2016) was calculated at the Range 'B' Gage (88455) and the Timbalier Island Gage (88450) using the Monthly Mean Simultaneous Comparison method. This method uses the *Tidal Analysis Datum Calculator* developed by NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) in which local gage readings over a period are compared to gage readings at a control station where tidal ranges are known.

Using the *Tidal Analysis Datum Calculator*<sup>2</sup>, a MLLW value was calculated for Range 'B' and for Timbalier Island Gages based on comparison to NOAA's Grand Isle Station (Station 8761724). The comparison was based on gage readings at both sites taken at 15-minute intervals for three months from May 18, 2021, to August 20, 2021.

Those MLLW values were then correlated against MLLW values provided by NOAA's online *VDatum*<sup>3</sup>, a web-based version of NOAA's *VDatum* (Vertical Datum Transformation) program, a software tool developed jointly by NGS, Office of Coast

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<sup>1</sup> National Geodetic Vertical Datum of 1929 (NGVD 29): <https://www.ngs.noaa.gov/datums/vertical/national-geodetic-vertical-datum-1929.shtml>

<sup>2</sup> Tidal Analysis Datum Calculator: December 2017, <https://access.co-ops.nos.noaa.gov/datumcalc/>

<sup>3</sup> Online Vertical Transformation Tool: July 2016, <https://vdatum.noaa.gov/vdatumweb/>

Survey (OCS), and CO-OPS. *VDatum* utilizes a geospatial dataset of MLLW values defined on a 5 ft horizontal grid. These grid values are only assigned within geographic polygons defined as valid tidal areas as determined by *VDatum*. The difference between the measured values of -0.42 ft at Range 'B' and -0.51 ft at Timbalier Island and the *VDatum* obtained values of -0.44 ft was less than 0.10 ft at both locations therefore, the decision was made to hold the *VDatum* value of -0.44 ft for the tidal portion of the HNC. More detailed information about *VDatum* can be found at <https://vdatum.noaa.gov/>.

While portions of the HNC north of Station 1320+00 are tidally influenced, they are also influenced by other non-tidal factors which prevent an accurate determination of MLLW using the average of the lowest of the two daily low water heights; therefore, this area is considered non-tidal. (See Map 2 - Houma Navigation Canal from GIWW to the Gulf of Mexico.) 33 U.S. Code § 562 – “Channel depths and dimensions defined” states:

*“In the preparation of projects under this and subsequent river and harbor acts and after the project becomes operational, unless otherwise expressed, the channel depths referred to shall be understood to signify the depth at mean lower low water, as defined by the Department of Commerce for nautical charts and tidal predictions, in tidal waters tributary to the Atlantic and Gulf coasts and at mean lower low water, as defined by the Department of Commerce for nautical charts and tidal predictions, in tidal waters tributary to the Pacific coast and the mean depth for a continuous period of fifteen days of the lowest water, as defined by the Department of Commerce for nautical charts and tidal predictions, in the navigation season of any year in rivers and nontidal channels, and after the project becomes operational the channel dimensions specified shall be understood to admit of such increase at the entrances, bends, sidings, and turning places as may be necessary to allow of the free movement of boats.”*

Using data from the GIWW@Houma Gage (76320), all stage readings from 2018 were analyzed to identify the fifteen continuous days that represented the lowest water readings for 2018. It was observed that the fifteen days of lowest water were from January 12, 2018, to January 27, 2018, with an average value of -0.33 ft.

Since the location of GIWW@Houma Gage is at the north end of the non-tidal area which extends approximately 25 miles south to the tidal area at Station 1320+00, additional analysis was performed to determine if the MLLW value at GIWW@Houma could be used for the rest of the non-tidal portion of the HNC or if additional data was required.

Extending the non-tidal MLLW value of -0.33 ft south along the HNC to Station 1320+00, it was determined to be in agreement with the *VDatum* values for the area (-0.44 ft  $\pm$  0.1 ft). This comparison provides corroboration, that the MLLW value determined at GIWW@Houma could be held as constant along the non-tidal portion of the HNC to Station 1320+00. Since a MLLW value was determined to be -0.33 ft for the non-tidal portion of the HNC and *VDatum* provides a somewhat consistent MLLW value of -0.44 ft (plus/minus 0.03 ft), the decision was made to round the MLLW value for the entire HNC to -0.4 ft.

To determine a relationship between MLG and MLLW, legacy MLG and MLLW were compared and found to be roughly 1.0 ft apart at the point of least separation. Therefore, a calibration value of 1.0 ft MLLW-MLG is determined to be valid for the HNC as:

$$\mathbf{0.0\ ft\ MLLW = 1.0\ ft\ MLG}$$

MLLW, and subsequently MLG, is determined to be flat for the non-tidal portion of the HNC from GIWW to Station 1320+00. MLLW, and subsequently MLG, for the tidal area of the HNC from Station 1320+00 to the minus 18 ft contour in the Gulf of Mexico is defined and will continue to be defined by *VDatum*.

The MLLW values currently in use by *VDatum* are based on the modified National Tidal Datum Epoch (NTDE) of 2002-2006. With each new modified NTDE, NOAA analyzes the change in Local Mean Sea Level (LMSL) from the 2002-2006 epoch to the current epoch. If the change in LMSL is less than the Maximum Cumulative Uncertainty of 17.1 cm for the transformational grid, then *VDatum* MLLW values are not updated. Therefore, even though the modified NTDE for *VDatum* is reported as 2002-2006, we will consider the derived MLLW values as being referenced to the 2012-2016 modified NTDE.

The MLLW and NAVD 88 datum relationships will continue to be periodically updated to incorporate future sea level rise and local subsidence, as well as other factors that may affect these datums (i.e., geoid model changes, epoch updates). MLLW for the non-tidal portion of the HNC is currently defined by measurement of a continuous period of fifteen days of the lowest water in 2018. This conversion value will also need to be updated on a regular basis. Periodic observations of at least one year duration will need to be made once every five years or whenever the *VDatum* MLLW values are updated so that the non-tidal portion can correspond to the tidal portion of the HNC.

Of note, these periodic updates will not change the MLLW to MLG conversion value of 1.0 ft. This value will remain constant, which will allow dredging templates to rise over time along with changes to MLLW due to sea level rise and other factors.



**MAP 2-** Houma Navigation Canal from GIWW to the Gulf of Mexico



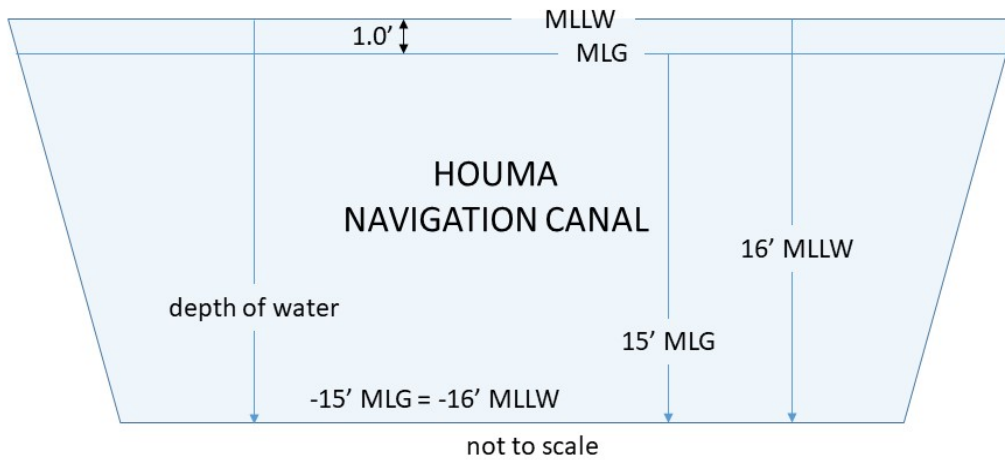
**MAP 3-** Houma Navigation Canal at GIWW and Bayou Le Carpe

## 4 Datum Conversion

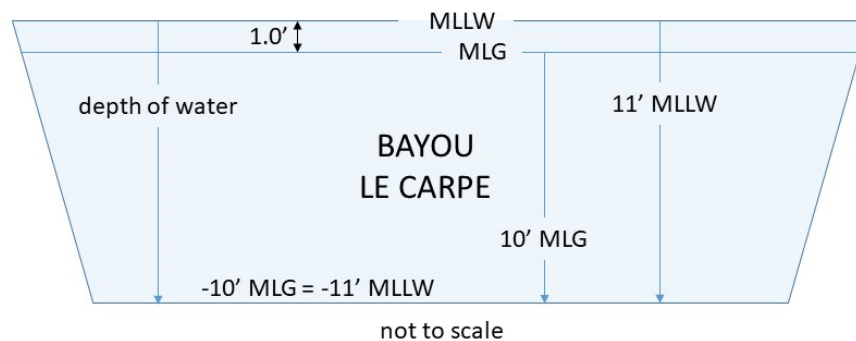
This section reports the actual conversion from MLG to MLLW for Houma Navigation Canal and Bayou Le Carpe. The MLG to MLLW conversion value has been defined as:

$$0.0 \text{ ft MLLW} = 1.0 \text{ ft MLG}$$

**FIGURE 1:  
Datum Conversion Definition Sketch  
Houma Navigation Canal**



**FIGURE 2:  
Datum Conversion Definition Sketch  
Bayou Le Carpe**



This conversion value of 1.0 feet will be used to define MLG for this area, by directly referencing MLLW and add 1.0 feet to MLG. This conversion value has been determined by referencing the Modified National Tidal Datum Epoch of 2012-2016 and will be held with future updates to MLLW. This conversion value is discussed further in Section 3.2 of this report.

## 4.1 Datum Offsets for HNC Gages

Table 1 provides the datum offsets at the gages that are currently used by the USACE New Orleans District, Operations Division to maintain the HNC.

**TABLE 1-** Datum Offsets Relative to NAVD 88

Datum Offsets to NAVD 88					
Gage ID	Gage Name	NAVD 88	Gage Datum	MLLW	MLG
76320	GIWW at Houma (abandoned in 2019)	0.00'	---	0.40'	1.40'
76305	Bayou Petit Caillou at Cocodrie	0.00'	0.52'	0.40'	1.40'
88455	Front Range Marker 'B'	0.00'	0.18'	0.40'	1.40'
88450	Timbalier Island	0.00'	-0.11'	0.40'	1.40'

**NOTES:** For Gages 76320 and 76305, MLLW is referenced to the measured 15-day Low Water Average as determined in January 2018. For Gages 88455 and 88450, MLLW is referenced to the current VDatum values at their respective locations and is understood to represent the 2012-2016 modified NTDE.

For Gage 76320, NAVD 88 refers to NAVD 88 (2009.55). For Gages 76305, 88455, and 88450, NAVD 88 is referenced to an OPUS measurement made in April 2019 and the values determined using GEOID 12B.

**TABLE 2-** Datum Offsets Relative to Gage Datum

Datum Offsets to Gage Datum					
Gage ID	Gage Name	Gage Datum	NAVD 88	MLLW	MLG
76320	GIWW at Houma (abandoned in 2019)	---	0.00'	0.40'	1.40'
76305	Bayou Petit Caillou at Cocodrie	0.00'	-0.52'	-0.12'	0.88'
88455	Front Range Marker 'B'	0.00'	-0.18'	0.22'	1.22'
88450	Timbalier Island	0.00'	0.11'	0.51'	1.51'

**NOTES:** For Gages 76320 and 76305, MLLW is referenced to the measured 15-day Low Water Average as determined in January 2018. For Gages 88455 and 88450, MLLW is referenced to the current VDatum values at their respective locations and is understood to represent the 2012-2016 modified NTDE.

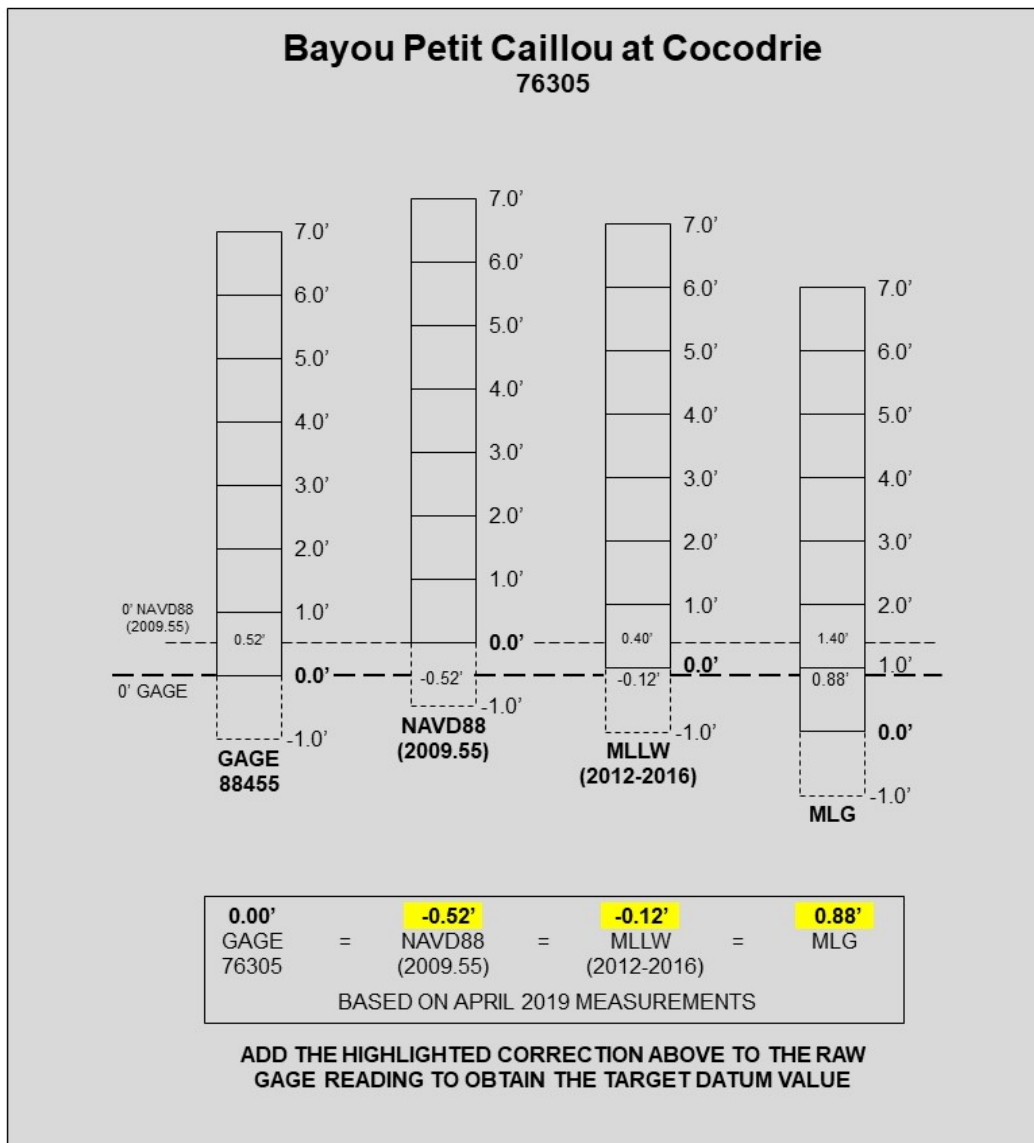
For Gage 76320, NAVD 88 refers to NAVD 88 (2009.55). For Gages 76305, 88455, and 88450, NAVD 88 is referenced to an OPUS measurement made in April 2019 and the values determined using GEOID 12B.

The offsets supplied in this table can be added to the raw gage readings to adjust them to the specified datum.

## 4.2 Datum Offsets for Gage 76305

Figure 2 shows the datum relationships that were determined for the USACE Gage 88455. The NAVD 88 - MLG and NAVD 88 - MLLW relationships are valid as of August 2021.

**FIGURE 3:  
Datum Offsets for USACE Gage 76305**

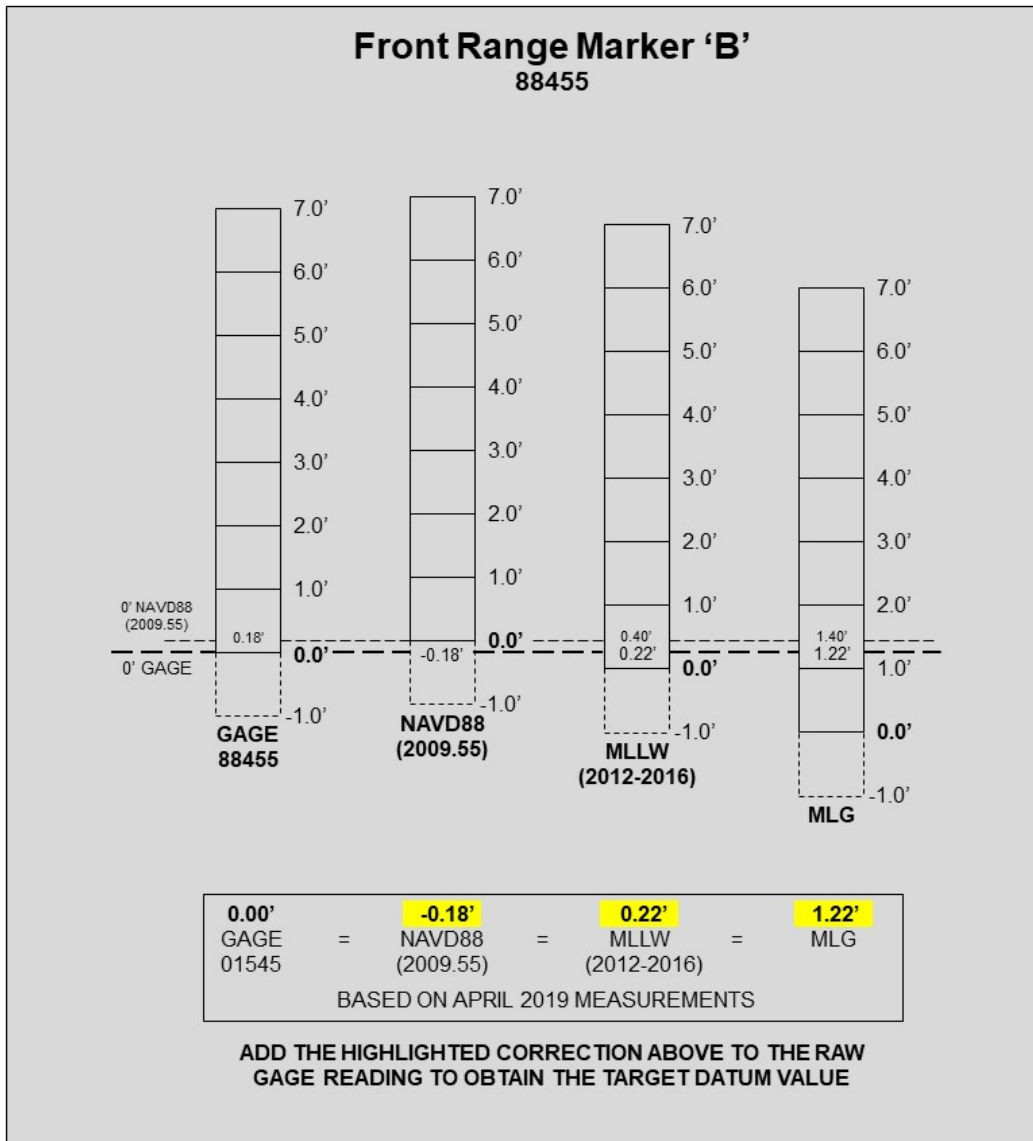




### 4.3 Datum Offsets for Gage 88455

Figure 2 shows the datum relationships that were determined for the USACE Gage 88455. The NAVD 88 - MLG and NAVD 88 - MLLW relationships are valid as of August 2021.

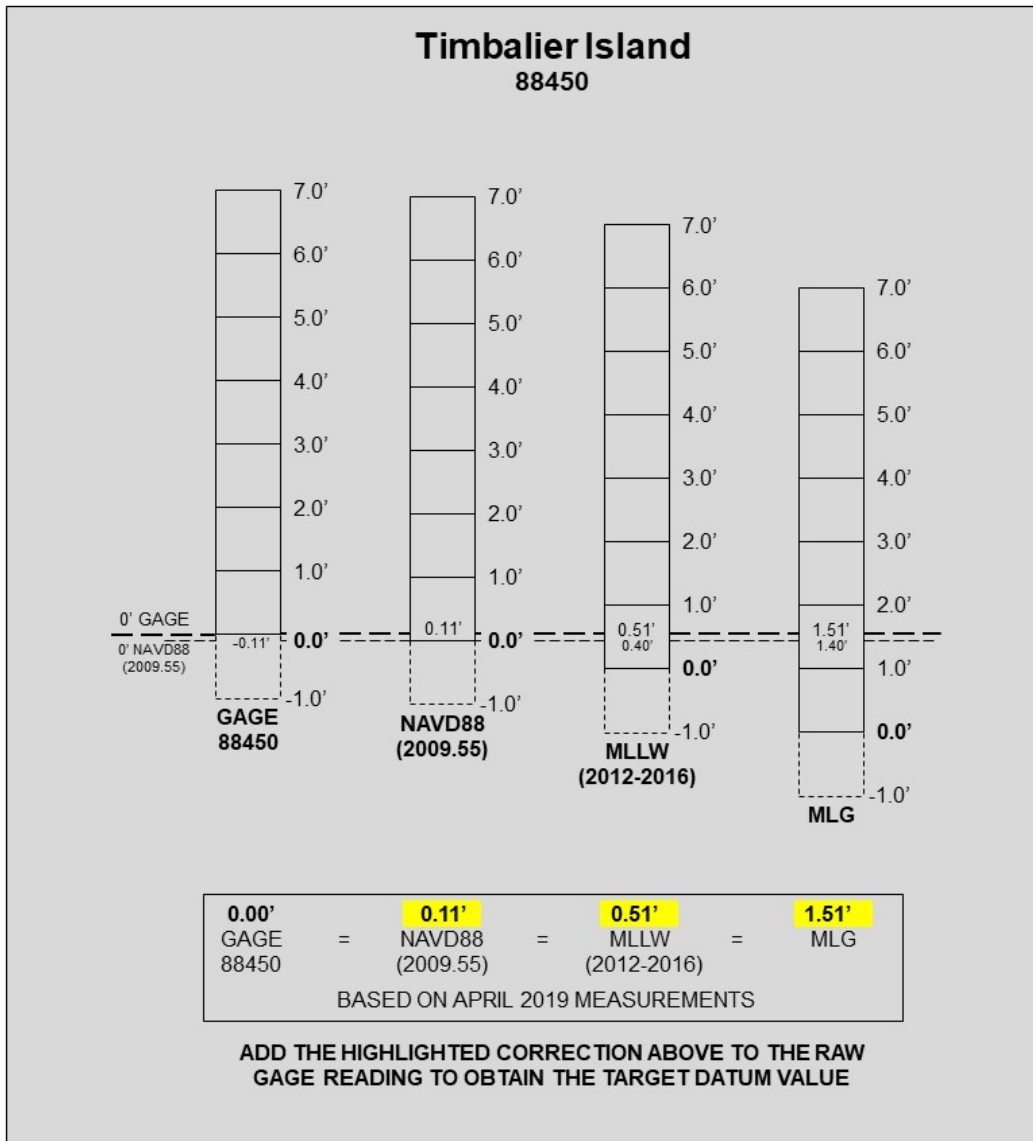
**FIGURE 4:  
Datum Offsets for USACE Gage 88455**



## 4.4 Datum Offsets for Gage 88450

Figure 3 shows the datum relationships that were determined for the USACE Gage 88450. The NAVD 88 - MLG and NAVD 88 - MLLW relationships are valid as of August 2021.

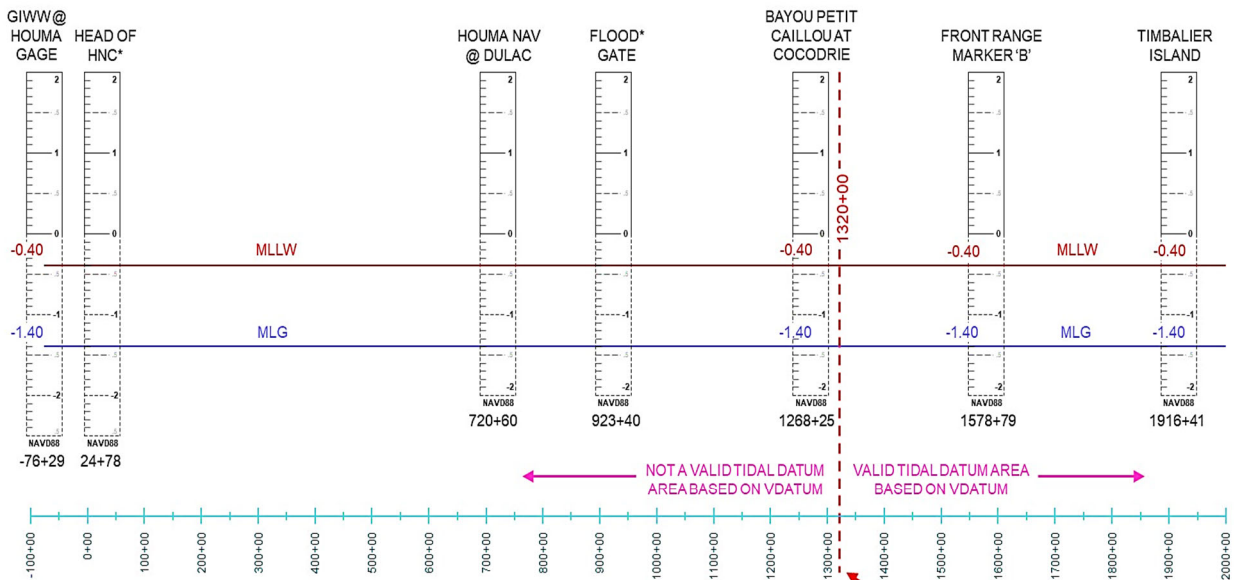
**FIGURE 5:  
Datum Offsets for USACE Gage 88450**



## 4.5 Datum Offset Chart

The following chart (Figure 4) shows the MLG/MLLW/NAVD 88 datum offsets for the HNC gages from GIWW to the Gulf of Mexico.

**FIGURE 6:  
Datum Offset Chart**



1. MLLW value of (-)0.33 ft for the non-tidal area north of Station 1320+00 is based upon the 15-day low water average of the lowest water in 2018 as measured at the GIWW @ HOUMA Gage.
2. MLLW value of (-)0.44 ft is the V-Datum derived value at Front Range Marker 'B' and Timbalier Island Gages.
3. The rounded value of (-)0.4' will be held as the MLLW value for both tidal and non-tidal portions of the HNC.
4. \* There are no physical gages at these two locations.

STA. 1320+00 IS THE APPROXIMATE LANDWARD LIMIT OF THE VALID TIDAL AREA PER VDATUM.

Due to regional subsidence and global sea-level rise, the elevations of the tidal datum values at the referenced gages (as well as the datum relationships) are time dependent and subject to change. Therefore, the information contained in this report shall be updated on a regular basis and/or as new information becomes available.

## **5 Future updates to MLLW-NAVD 88**

The MLLW-NAVD 88 datum offsets defined in this report are time dependent and will have to be regularly verified/updated. The EM 1110-2-6065 indicates that the periodic reassessments of controlling elevations and datum relationships should be performed at least every five years.

These reassessments will not change the MLLW-MLG conversion value; only changing the MLLW-NAVD 88 relationships that will be used to define MLLW for the HNC.

It is anticipated that in 2023, NOAA will publish an updated National Tidal Datum Epoch for the period of observations from 2017 to 2021, which will require an update of the HNC MLLW-NAVD 88 relationship and a corresponding update of the relationship to MLG.

## **6 Summary**

This conversion value is considered absolute and documents current practices. It will not be redefined for the HNC. However, the relationship between MLLW and NAVD 88 will need to be periodically updated to incorporate the future sea level rise and local subsidence.

Dredging design templates and other associated documents shall be updated to directly reference and utilize MLLW depths, and the relationship to MLG shall be included as a note. Providing the MLG relationship will allow users to relate these project documents back to authorization language as needed.

## REFERENCES

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4. USACE, 1999. ER 1110-2-1150: Engineering and Design for Civil Work Projects, 31 August 1999.
5. USACE, 2007. Engineering Circular (EC) 1110-2-6065: Engineering and Design, Comprehensive Evaluation of Project Datums, Guidance for a Comprehensive Evaluation of Vertical Datums on Flood Control, Shore Protection, Hurricane Protection, and Navigation Projects, 1 July 2007.
6. USACE, 2009. EC 1110-2-6070: Engineering and Design, Comprehensive Evaluation of Project Datums, Guidance for a Comprehensive Evaluation of Vertical Datums on Flood Control, Shore Protection, Hurricane Protection, and Navigation Projects, 1 July 2009.
7. USACE, 2010. EM 1110-2-6056: Engineering and Design, Standards and Procedures for Referencing Project Elevation Grades to Nationwide Vertical Datums, 31 December 2010.
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11. Online Vertical Transformation Tool, NOAA and the National Ocean Service: July 2016, <https://vdatum.noaa.gov/vdatumweb/>

All related supporting documentation may be found on the MVN ProjectWise server at:

pw:\\PWINT-CPC.EIS.DS.USACE.ARMY.MIL:CEMVN01\Documents\Civil Works\HNC - Houma Navigation Channel\MLG-to-MLLW Engineer Documentation Report\