A General Outline for the Procedure to Determine the Water Level at a Transportation Project Site

To establish the correct water level elevation at a project site, two different issues have to be addressed. The first is how to determine the current Mean High Water (MHW) value at the project site. The MHW elevation is established from analysis of tidal data and selection of a height Datum such as NGVD 29 or NAVD 88. The second issue to be addressed in the process of determining the correct water level elevation at a project site is the implementation the computed MHW elevation at the project site. In other words, benchmarks with elevation in the selected datum have to be established around the project area so that the computed MHW could be implemented correctly. The first issue is a tide issue while the second is a surveying issue.

Determining the MHW at a Project Site.

a) The first step is to determine the project location in terms of Latitude, Longitude, quad-map sheet, Straight Line Diagram (SLD) and other location information indices that will help in gathering information about the project site. Some of the information that should be compiled (mainly from SLD) is:
   a) Mile post, County, and Municipality
   b) Control Section (NJ-DOT indexing system)
   c) Bridge Number and type. This information can be used to locate the bridge plans on which profile elevations and possibly MHW elevations, which existed at the time of construction, may be recorded.
   d) Contract date. The date can help in researching, right-of-way (ROW) titles, Grant lines and other grants that are associated with the project area.
   e) The identification of the Quad map is very useful.

2. The next step is to determine the claim lines at the project area. The DEP, TIDELANDS UNIT, maintains an index of claim line delineations and maps (atlas) of these claim lines. To determine the claim lines at the project area, one has to find the proper atlas sheet of the project. The indexing of the atlas sheets is based on the NAD 27 State Plane Coordinate values (the thousands digits of Northing followed by the thousands digits of the Easting.)

Once the appropriate atlas sheet is identified, the detailed claim lines as plotted on DEP's “tideland atlas” have to be overlaid onto the project plans. The tideland atlas is available at NJ-DEP in Trenton, at some courthouses or on a CD. The claim line CD is a digitized version of the atlas in a GIS compatible format.

If the DEP index of claim line diagrams does not cover the construction area, the contractor has to research County, Township or other offices for relevant records. For example, Tax maps may have flood line and other water related information.
3. Place the claim lines on the project’s topographic map, construction plans or ROW maps. A significant problem of this step is to merge two or more plans or plots that do not necessarily have common coordinate systems. If the CD is used and the project plans are also in GIS compatible format, overlaying the claim lines on the plans if almost trivial. Otherwise, some form of coordinate transformation has to be employed. The use of CORPCON or other similar transformation software is acceptable for this purpose.

Location of the claim lines should preferably be on State Plane Coordinate System. Otherwise, location information should be in terms of Lot, Block, Tax map, etc., so that one can quickly locate the project area.

4. Establish the Current MHW

a) Contact NJ Geodetic Survey (NJGS) to find Geodetic Control points and tidal benchmarks. Tidal benchmark information can also be found in the index of tidal stations for NJ or from the WWW site of CO-Ops (NOS/NOAA). The stations are listed from North to South along the Atlantic coastline. Along the Delaware River the stations are listed from South to North.

Notes: the existence of a tidal benchmark does not mean that there is an active tidal gauge at that site.

Note: The NJ Geodetic Survey is not the agency responsible for maintaining and updating the Tidal Bench Mark data information. This Tidal Bench Mark network was established in the late 70’s by NJDEP. The NJGS has copies of this data that they will provide.

The USGS (has river gauges that must not be confused with tidal gauges. The river gauges are for measuring river flow and other river related parameters, not tides.

b) From NGS site search for tidal benchmarks for the project area. The NGS benchmark description includes a diagram showing the relationship between MHW, NGVD 29 and NAVD 88. This diagram is very helpful when the tidal benchmark elevation is transferred to the project area.

c) There are only five active permanent primary tidal stations around NJ. They are located at Battery Park, NY, Sandy Hook, NJ, Atlantic City, Cape May and in Philadelphia. At least 2 stations on both sides of the project have to be analyzed for the difference between the 1977 datum elevation values and the predicted ones. This analysis can be useful in understanding water level trends and long term water level values considerations.
d) Ideally, a tertiary tidal gauge station and at least 3 Bench Marks should be installed at any bridge construction over a navigable waterway where the span is 20 feet or longer. Alternatively, any bridge that has a legal clearance requirement from the US Coast Guard (USCG) should have a tertiary tidal station installed for more accurate water level determination. The ACORS (Active Continuing Operating Remote System) or another appropriate method should be used to determine the MHW.

e) Clearance values as shown on nautical charts are not sufficient for establishing bridge clearances. These values could be outdated. The contractor should call the USCG for up to date clearance values.

If the debris line is higher than the computed MHW, it should be given a due consideration and evaluated and compared to the computed MHW. The debris line may be an indication of the High Tide Line.

f) Tidal benchmark evaluations should have values in an established datum such as NGVD 29 or NAVD 88. If the tidal benchmarks do not have elevations in such datum, a leveling run should be conducted to establish such elevation values from existing NGS or NJGS bench marks.

**Implementation of MHW at the Construction Site.**

1) Research for 2nd order or higher vertical control in the area. A minimum of 3 BMs should be connected to. This information is available from maps of leveling runs at the NJ Geodetic Survey.

Note: vertical control from reliable sources such as NGS or NJ Geodetic Survey benchmarks should be used. If elevation has to be established at the project site, appropriate differential or GPS leveling methods should be employed. As a general rule, leveling lines of up to 6 miles can be surveyed with traditional differential leveling methods while GPS methods are preferable for longer lines.

Vertical control that is connected to and brought in from different leveling runs and adjustments should be analyzed and evaluated to avoid a biased elevation of a particular adjustment.

Ties to at least three benchmarks should be made for each project.

Monumentation (as per NJ-DOT survey manual) of project benchmarks is required. As a minimum two benchmarks must be established and located at each side of the project area.

A detailed report on which control was used and why this control was selected must be submitted for the project.
Example of Water Level Analysis

Establishing vertical control in the area of Rt 49 & the Cohansey River.

The Tidal Range
Mean Average is 6.00 feet (1.829 meters)
Mean Higher High Water (MHHW) is 6.51 (1.984 meters) feet higher than Mean Lower Low Water elevation.

BASED on the field elevation of TIDAL BENCHMARKS 853-7353 (Tyndalls Wharf, NJ) B, C, D, and E the MHW elev. (1966-1984 TIDAL EPOCH) is =

<table>
<thead>
<tr>
<th>Datum</th>
<th>Elevation (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGVD29</td>
<td>+3.71 (+1.130 M)</td>
</tr>
<tr>
<td>NAD88</td>
<td>+2.70 (+0.823 M)</td>
</tr>
</tbody>
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AN ADJUSTMENT OF ABOUT 0.20 feet (estimate) MUST BE MADE FOR THE CONDITIONS AS THEY EXIST IN THE YEAR 2000.

THE Adjusted VALUES TO BE USED FOR THE PROJECT.

<table>
<thead>
<tr>
<th>Datum</th>
<th>Elevation (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGVD29</td>
<td>+3.91 (+1.192 M)</td>
</tr>
<tr>
<td>NAVD88</td>
<td>+2.90 (+0.884 M)</td>
</tr>
</tbody>
</table>

BASED ON THE ADJUSTED (yr 2000) VALUES (NGVD29)

<table>
<thead>
<tr>
<th>Elevation Level</th>
<th>Elevation (meters)</th>
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</thead>
<tbody>
<tr>
<td>Mean Higher High Water</td>
<td>+1.330 M</td>
</tr>
<tr>
<td>Mean High Water</td>
<td>+1.192 M</td>
</tr>
<tr>
<td>Mean Low Water</td>
<td>-0.593 M (-1.946)</td>
</tr>
<tr>
<td>Mean Lower Low Water</td>
<td>-0.654 M (-2.146ft)</td>
</tr>
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Note:
The debris line approximate elevation at Rt 49 is elevation + 1.13 M Compared to the MHW of +1.192m.

THESE ELEVATIONS MUST BE VERIFIED IN THE FIELD BY THE DESIGNER BY ADDITIONAL SECOND ORDER LEVELING AND MAKING A VERTICAL BENCH RUN LOOP TO INCLUDE RECOVERED NGS BENCHMARKS

J 9 (PID 0947)
H 9 (PID 0946)
G 9 (PID 0943)
others

The Vertical Benchrun is to be constrained to BMs J9, H9, and G9.

A US Army Corps of Engineer's (USACOE or COE) Benchmark called "TENDER 1987" is located on the Rt 49 over the Cohansey River and must be leveled to by the consultant.
This monument must be protected and permission must be received from the USACOE if the Benchmark is to be transferred to a new location.

The designer must establish existing inverts and elevations on outfall pipes, wood pilings, fenders, and must establish the present vertical clearance from MHW to the bottom of the bridge structure.

The USACOE should be contacted about information that they may have in their database as this portion of the Cohansey is under their jurisdiction.

The designer must consider that proper design for caissons, cofferdams, fenders, weep holes require that the spring tide elevations, high tide line elevations, or higher high water elevation may have to be determined in the field.

It is strongly recommend that the designer uses tide prediction software in the determination of these elevations.

The modified-range ratio method

\[
\begin{align*}
MLW &= MTL - (0.5\times MN) \\
MHW &= MLW + MN \\
MLLW &= DTL - (0.5\times GT) \\
MHHW &= MLLW + GT
\end{align*}
\]

MTL - Mean Tide Level
MN - Mean Range
DTL - Diurnal Tide Level (Average of MHHW and MLLW)
GT - Great Tropic Range (MHHW - MLLW)