



The Total Water Level Project

Creation of coastal water level forecast through the **G**raphical **F**orecast **E**ditor and dissemination of that data through **A**dvanced **H**ydrologic **P**rediction **S**ervice.

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A Little History...



During **Hurricane Sandy**, this is what the **AHPS** would have potentially looked like just a few hours prior to landfall.

Notice, most of the gages are showing no flooding. However, coastal flood warnings were in effect all along the coast.

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MDZ021>023-300900-  
/O.CON.KAKQ.CF.W.0001.000000T0000Z-121031T0000Z/  
DORCHESTER-WICOMICO-SOMERSET-  
856 PM EDT MON OCT 29 2012
```

```
...COASTAL FLOOD WARNING REMAINS IN EFFECT UNTIL 8 PM EDT  
TUESDAY...
```

```
A COASTAL FLOOD WARNING REMAINS IN EFFECT UNTIL 8 PM EDT TUESDAY.
```

```
* COASTAL FLOODING...MODERATE TO SEVERE COASTAL FLOODING EXPECTED  
WITH HIGH TIDE EARLY TUESDAY MORNING... FOLLOWED BY MODERATE TO  
SEVERE FLOODING TUESDAY AFTERNOON.
```

```
* TIMING...HIGH TIDE CYCLES THROUGH TUESDAY AFTERNOON.
```

```
* IMPACTS...WATER LEVELS ARE FORECAST TO REACH 2 TO 3 FT ABOVE  
NORMAL EARLY TUESDAY MORNING. THERE IS THE POTENTIAL FOR WATER  
LEVELS TO REACH 4 TO 6 FT ABOVE NORMAL ALONG LOCATIONS OF THE  
CHESAPEAKE BAY AND UP ALONG THE TRIBUTARIES FROM SOUTHERN  
DORCHESTER...SOUTHWEST WICOMICO...WESTERN AND SOUTHERN SOMERSET  
AND NORTHWEST ACCOMACK COUNTIES...RESULTING IN SEVERE TIDAL  
FLOODING. THE LATEST FORECASTS FOR TUESDAY AFTERNOON ARE 2 TO 3  
FT ABOVE NORMAL. MODERATE TO SEVERE TIDAL FLOODING IS  
EXPECTED...MAINLY WITHIN A FEW HOURS EITHER SIDE OF HIGH TIDE.
```

```
* TIDES...AT CAMBRIDGE...HIGH TIDE EARLY TUESDAY MORNING IS AT  
456 AM WITH A FORECAST WATER LEVEL OF 3.5 TO 3.9 FT MLLW. HIGH  
TIDE TUESDAY AFTERNOON IS AT 525 PM WITH A FORECAST WATER LEVEL  
OF 3.8 TO 4.2 FT MLLW. SEVERE FLOODING BEGINS AT 4.5 FT MLLW AND  
MODERATE FLOODING BEGINS AT 4.0 FT MLLW AT CAMBRIDGE.
```

```
* AT BISHOPS HEAD...HIGH TIDE EARLY TUESDAY MORNING IS AT 218 AM  
WITH A FORECAST WATER LEVEL OF 4.8 TO 5.3 FT MLLW. HIGH TIDE  
TUESDAY AFTERNOON IS AT 233 PM WITH A FORECAST WATER LEVEL OF  
4.5 TO 5.0 FT MLLW.
```

```
* AT CRISFIELD...HIGH EARLY TUESDAY MORNING IS AT 139 AM...AND  
HIGH TIDE TUESDAY AFTERNOON IS AT 158 PM.
```

```
* AT SALISBURY...HIGH TIDE TUESDAY MORNING IS AT 410 AM...AND  
HIGH TIDE TUESDAY AFTERNOON IS AT 429 PM.
```

```
* FOR LOCAL TIDE AND SURGE FORECASTS IN YOUR LOCATION VISIT  
WEATHER.GOV/AKQ.
```



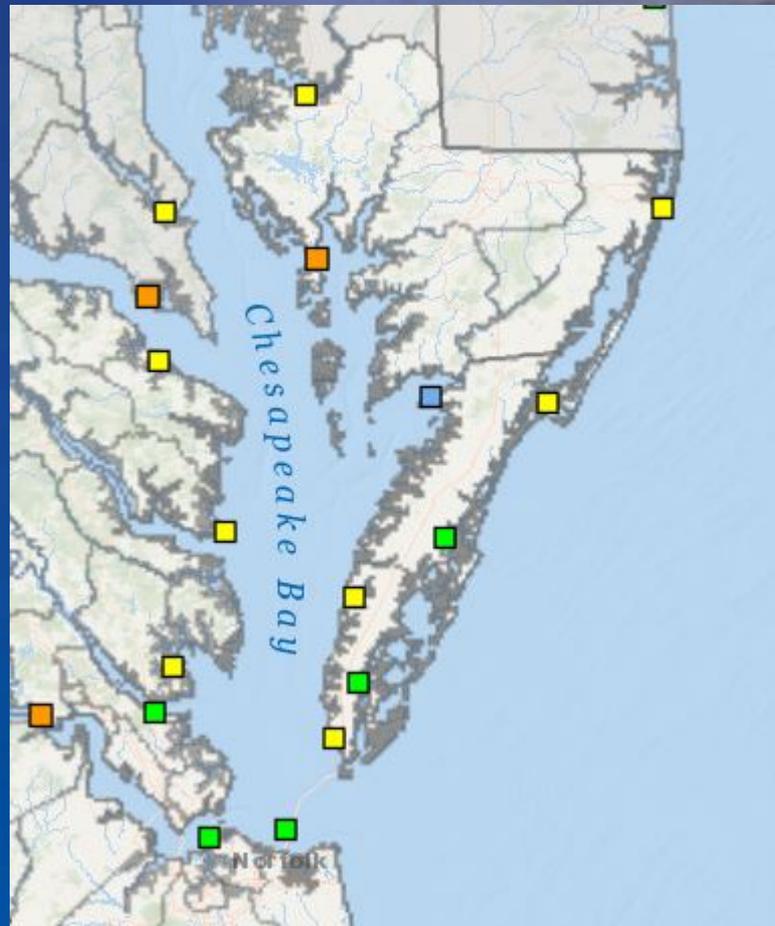
Wakefield CWA Coastal Flood Familiarization



2 Unique Water Systems

Chesapeake Bay (including tributaries) – particularly susceptible when water can't "escape" bay/rivers (i.e. "Bathtub Effect"). Freshwater runoff may also be a factor. Eastern Shore bayside counties (Accomack to Dorchester) also susceptible during southerly/westerly flow situations

Oceanfront – prolonged onshore (NNE -> ESE) winds main cause – usually accompanied by high surf





Total Water Level Inputs



- **Astronomical Tide** (lunar cycle)
- **Storm Surge** – Meteorological component (wind and pressure)
- **Sub-Tidal Anomaly** – Meteorological and Oceanographic component

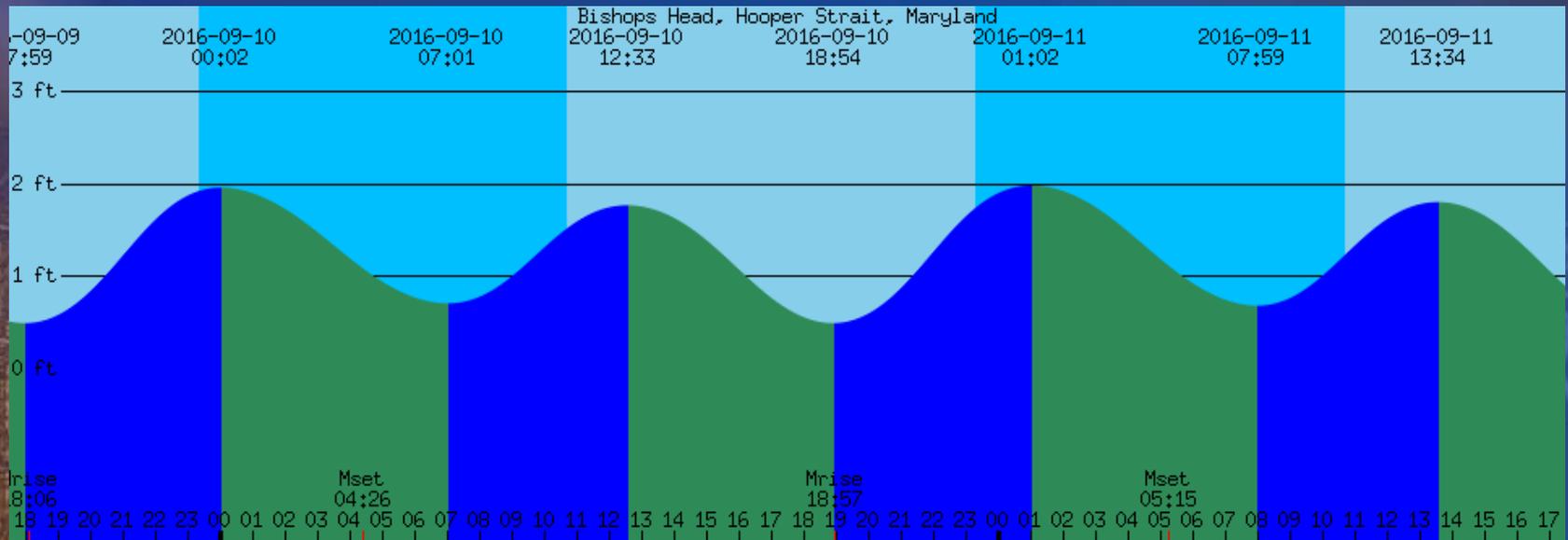


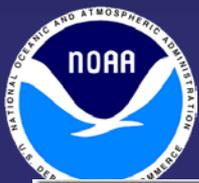


Astronomical Tide



- Use **X-Tide** program to gather tide data and create a CSV file.
- Script in **AWIPS** takes the CSV file to create hourly astronomical grids in **GFE** out to 72 hours. This script runs once per day.



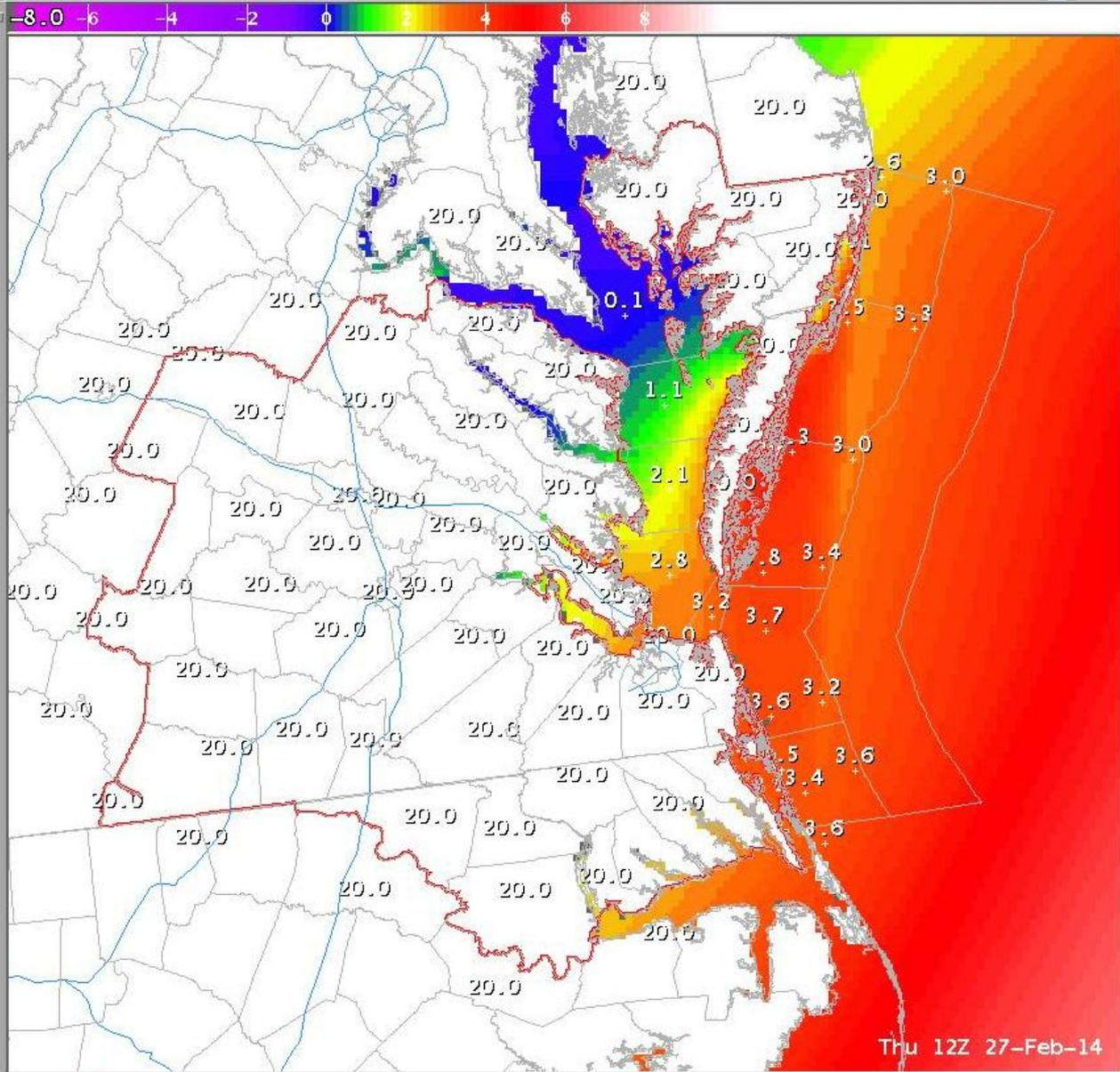


GFE AstroTide



Today: Feb 26 18 Tonight: Feb 27 06 Tomorrow: Feb 28 18 06 (Thu)

- Hazards SFC Fcst (AKQ)
- Wind SFC Fcst (AKQ)
- WaveHeight SFC Fcst (AKQ)
- AstroTide SFC Fcst (AKQ)
- StormSurge SFC Fcst (AKQ)
- TideAnomaly SFC Fcst (AKQ)
- TideDeparture SFC Fcst (AKQ)
- StormTide SFC Fcst (AKQ)
- AstroTide SFC AKQTide_2608
- StormSurge SFC ESTOFS_2606
- StormSurge SFC ESTOFS_2600
- StormSurge SFC Official (AKQ)
- TideDeparture SFC Official





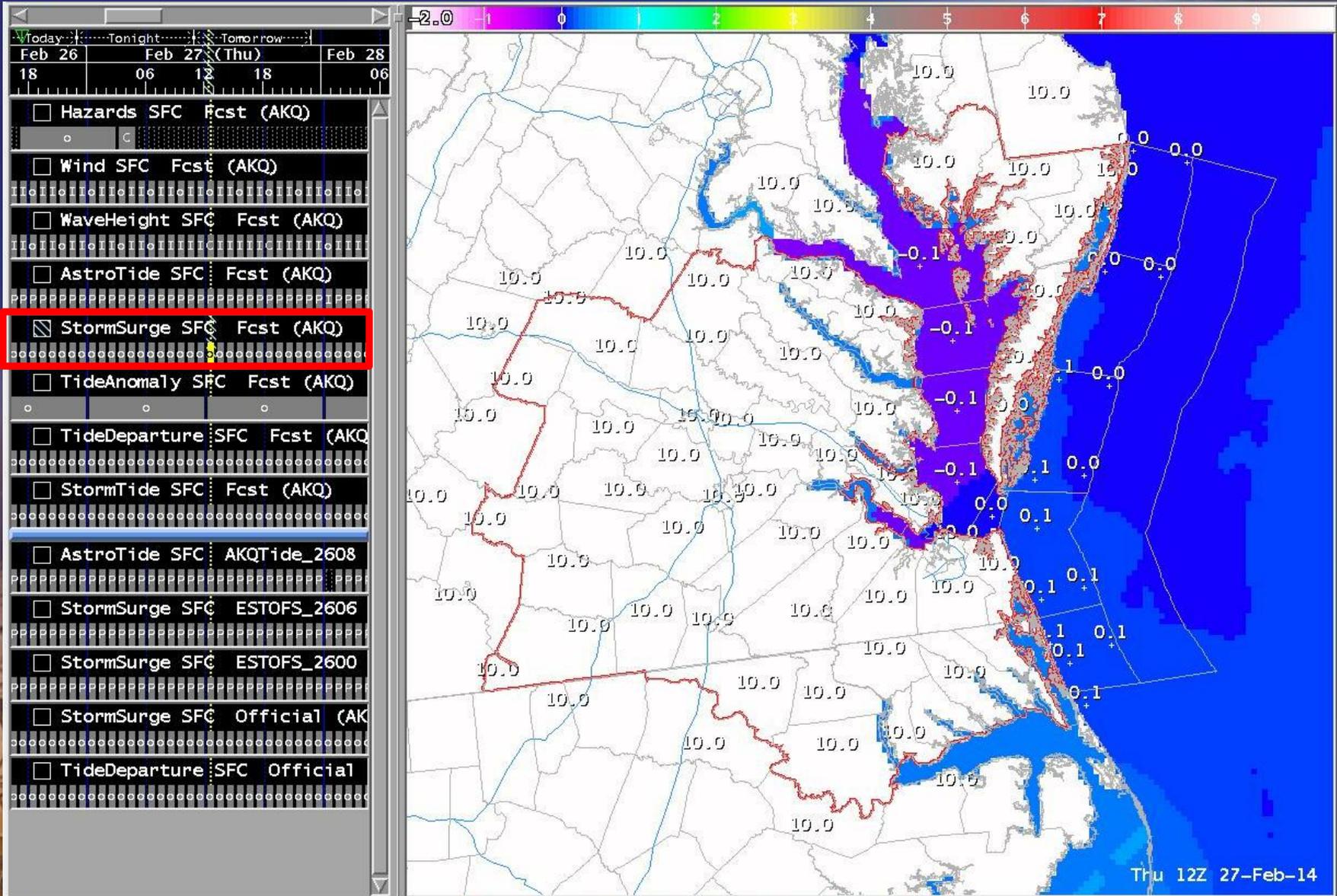
Storm Surge Guidance



- **Extratropical Storm Surge (ETSS)** – Point based and map based guidance derived from GFS model. No tidal forcing. Produced by MDL and is available in GFE.
- **Chesapeake Bay Operational Forecast System (CBOFS)**
– Uses NAM model wind/pressure fields, and a different oceanographic model. Incorporates tides. Produced by NOS.
- **Extratropical Surge and Tide Operational Forecast System (ESTOFS)** – Utilizes GFS and ADCIRC Ocean prediction model. Incorporates tides and is baseline guidance in GFE for TWL project.
- **VIMS Tidewatch** – Uses ETSS Guidance and a 30 day Sub-Tidal anomaly. It updates hourly based upon observed data.



GFE StormSurge



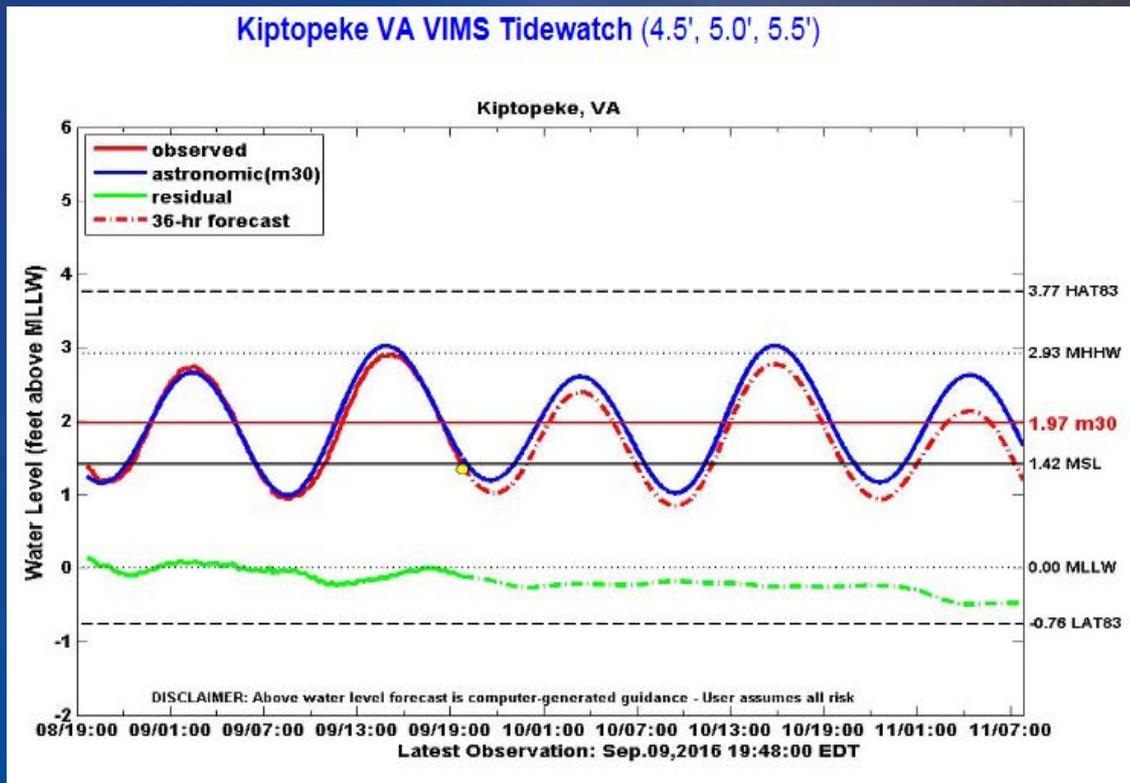


Subtidal Anomaly

Subtidal anomaly — Extra water caused by meteorological and/or oceanographic effects. It is the water either left behind or removed that the models think should or should not be there.

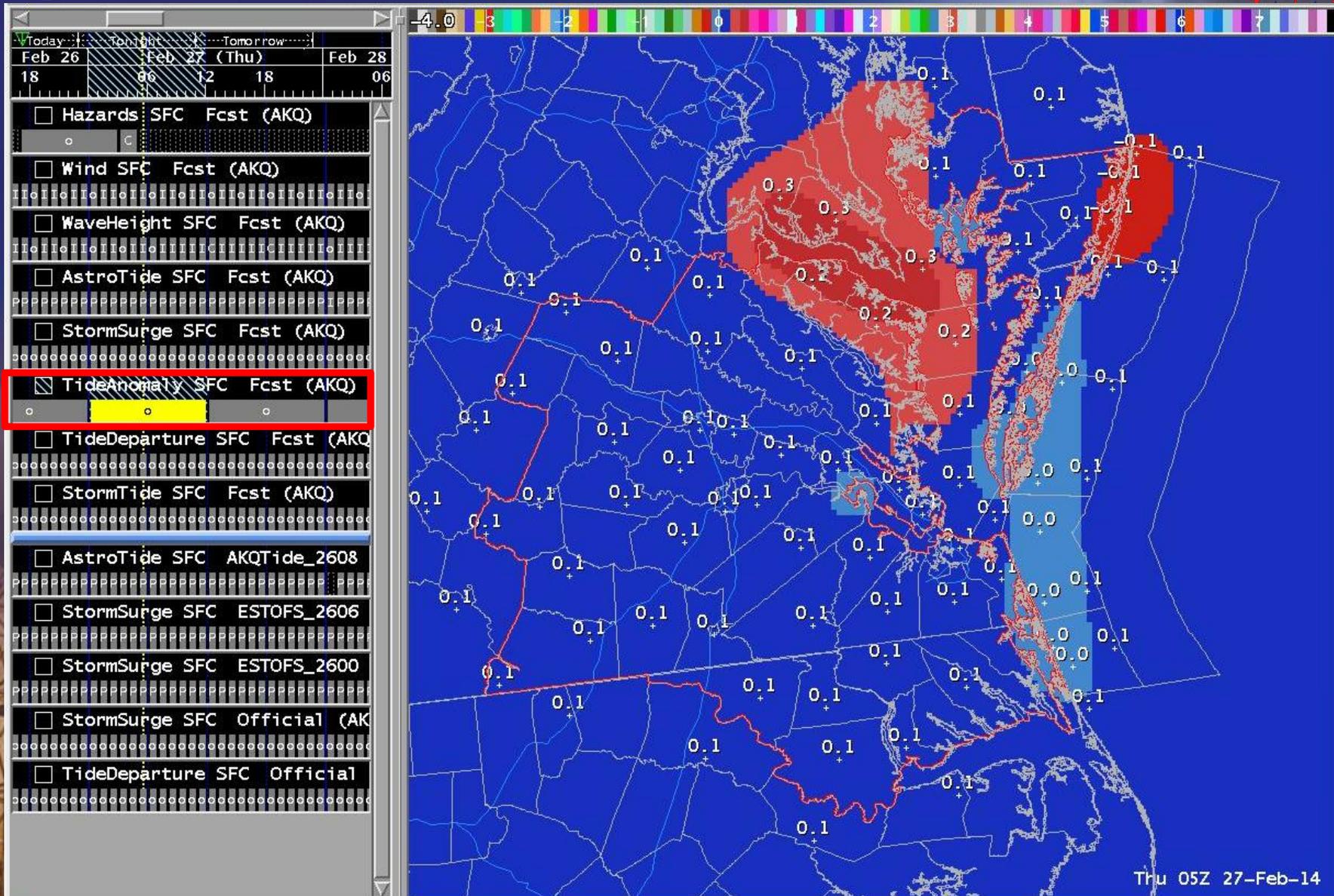
ETSS - 5 day average anomaly (Green line on ETSS graphs)

VIMS Tidewatch - 30 day anomaly (difference between m30 and MSL values)





GFE TideAnomaly

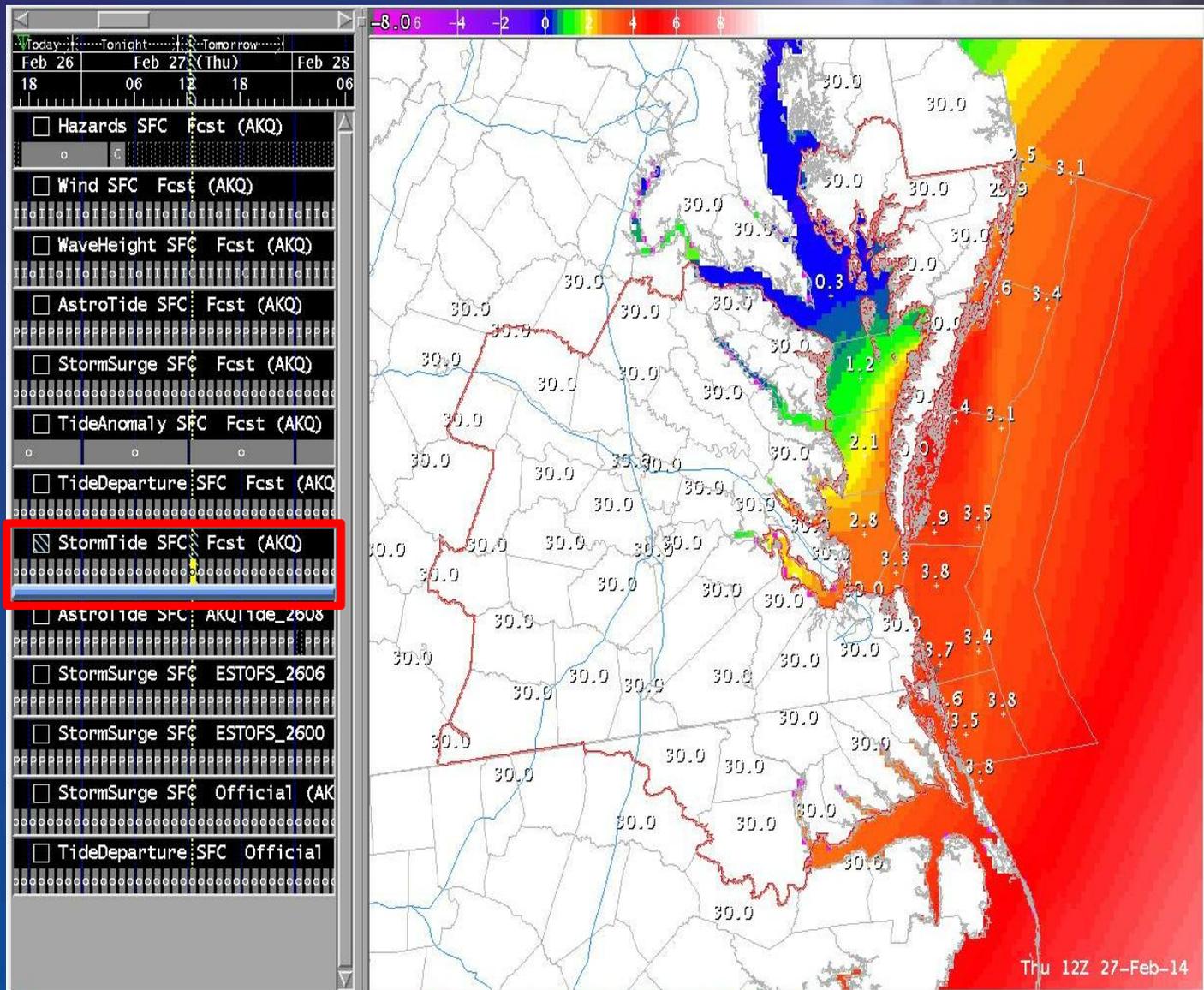




GFE StormTide



The Storm Tide grid is the sum of the Astro Tide, Storm Surge and Tide Anomaly grids.





RR9AKQ Product



- StormTideSHEF -- Creates Hourly Point forecasts for 17 forecast locations across the Chesapeake Bay and Atlantic Coastal regions in MLLW.
 - 10 are NOS tidal gage locations
 - 6 are USGS gage locations
 - 1 is a UVA gage location
- The RR9AKQ product is used to populate AHPS forecast graphs.

```

TTAA00 KAKQ 041500
RR9AKQ

TOTAL COASTAL WATER LEVEL FORECAST...EXPERIMENTAL
NATIONAL WEATHER SERVICE WAKEFIELD VA
1000 AM EST THU DEC 4 2014

: ALL WATER LEVELS IN FT ABOVE MEAN LOWER LOW WATER
:
: CAMBRIDGE MD
:
.E CAMM2 1204 Z DH15/DC1412041500/HMIFMZ/DIH1/
.E1 0.6/ 1.0/ 1.7/ 2.3/ 2.4/ 2.3/ 2.2/ 1.8/ 1.3/ 1.0/ 0.7/ 0.6/
.E2 0.5/ 0.8/ 1.3/ 1.7/ 2.0/ 2.1/ 1.9/ 1.5/ 1.1/ 0.7/ 0.5/ 0.4/
.E3 0.4/ 0.8/ 1.3/ 1.9/ 2.3/ 2.6/ 2.6/ 2.4/ 2.0/ 1.6/ 1.2/ 0.9/
.E4 0.9/ 1.0/ 1.3/ 1.8/ 2.2/ 2.6/ 2.7/ 2.4/ 2.0/ 1.5/ 1.2/ 0.9/
.E5 1.0/ 1.1/ 1.5/ 2.0/ 2.6/ 3.1/ 3.3/ 3.3/ 2.9/ 2.5/ 2.1/ 1.6/
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: BISHOPS HEAD MD
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.E BISM2 1204 Z DH15/DC1412041500/HMIFMZ/DIH1/
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.E3 1.9/ 2.3/ 2.6/ 2.6/ 2.4/ 2.0/ 1.5/ 1.1/ 0.8/ 0.6/ 0.7/ 1.2/
.E4 1.6/ 2.1/ 2.5/ 2.7/ 2.6/ 2.1/ 1.7/ 1.3/ 1.0/ 1.0/ 1.1/ 1.5/
.E5 2.0/ 2.5/ 3.0/ 3.2/ 3.2/ 3.0/ 2.5/ 2.1/ 1.7/ 1.4/ 1.2/ 1.2/
.E6 1.4/ 1.9/ 2.3/ 2.5/ 2.2/ 2.0/ 1.6/ 1.2/ 0.7/ 0.4/ 0.1/-0.2
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: SOLOMONS ISLAND MD
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.E SLIM2 1204 Z DH15/DC1412041500/HMIFMZ/DIH1/
.E1 1.0/ 1.4/ 1.4/ 1.4/ 1.3/ 1.0/ 0.9/ 0.4/ 0.2/ 0.5/ 0.6/ 0.7/
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: LEWISSETTA VA
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.E LWIV2 1204 Z DH15/DC1412041500/HMIFMZ/DIH1/
.E1 1.8/ 1.9/ 1.8/ 1.5/ 1.3/ 0.9/ 0.8/ 0.4/ 0.3/ 0.6/ 0.7/ 1.0/
.E2 1.2/ 1.4/ 1.5/ 1.3/ 1.0/ 0.7/ 0.5/ 0.4/ 0.4/ 0.6/ 0.9/ 1.2/
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.E4 1.3/ 1.5/ 1.7/ 1.7/ 1.5/ 1.2/ 1.0/ 0.8/ 0.7/ 0.8/ 1.0/ 1.4/
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.E6 1.5/ 1.8/ 2.0/ 2.0/ 1.9/ 1.7/ 1.4/ 1.1/ 0.9/ 0.8/ 0.6/ 0.7
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: WINDMILL POINT VA
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.E WNDV2 1204 Z DH15/DC1412041500/HMIFMZ/DIH1/
.E1 1.8/ 1.5/ 1.1/ 0.8/ 0.5/ 0.2/ 0.1/ 0.4/ 0.7/ 1.2/ 1.5/ 1.7/
.E2 1.6/ 1.5/ 1.2/ 0.9/ 0.6/ 0.5/ 0.4/ 0.7/ 1.0/ 1.5/ 1.8/ 2.0/
.E3 2.0/ 1.9/ 1.7/ 1.4/ 1.0/ 0.7/ 0.5/ 0.6/ 0.8/ 1.2/ 1.6/ 1.8/
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.E5 2.4/ 2.4/ 2.2/ 2.0/ 1.5/ 1.2/ 1.0/ 0.8/ 0.9/ 1.3/ 1.6/ 2.0/
.E6 2.2/ 2.2/ 2.1/ 2.0/ 1.8/ 1.7/ 1.5/ 1.3/ 1.3/ 1.4/ 1.8/ 2.2

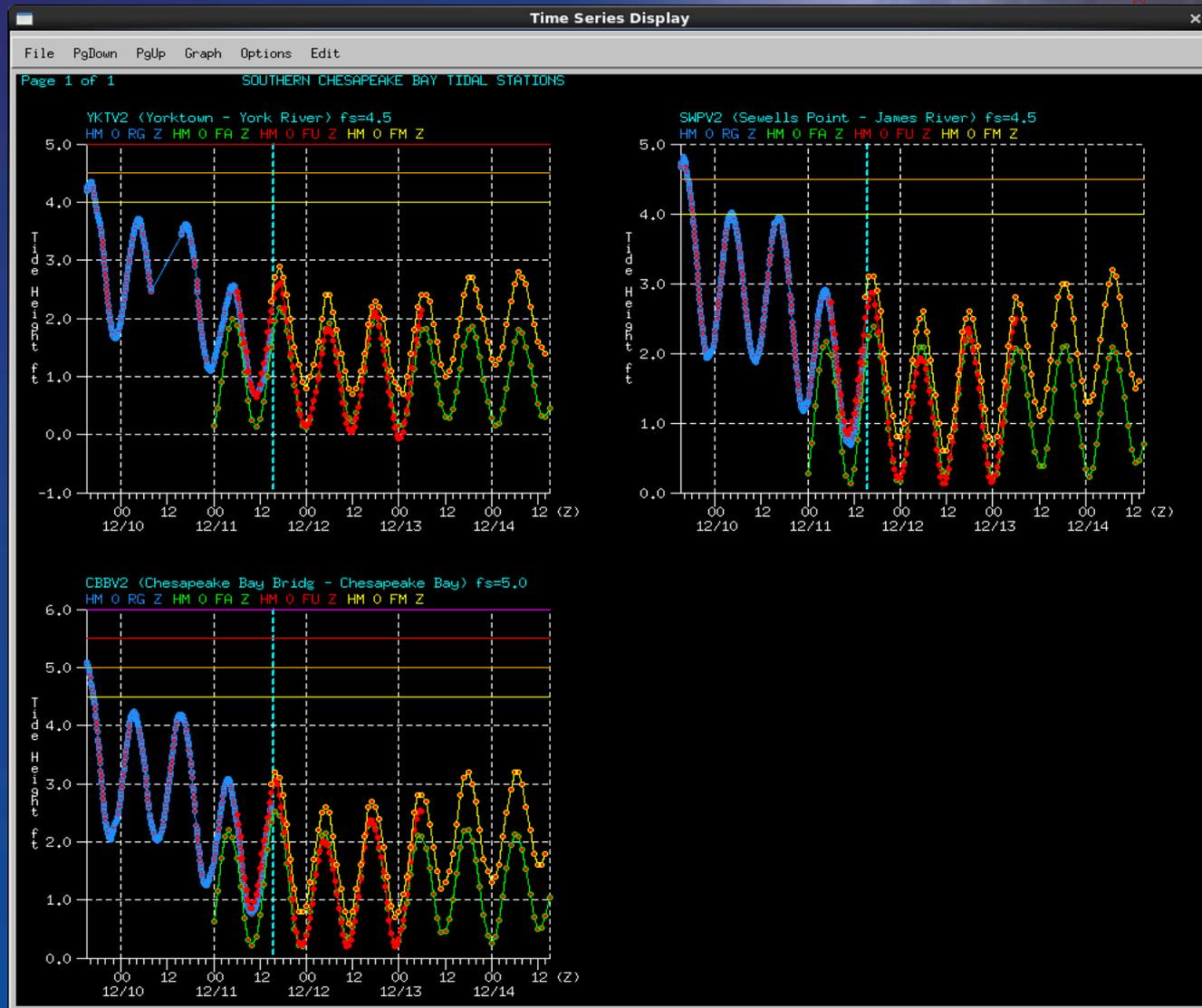
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RR9AKQ Product QC



The last step before sending the forecast to **AHPS** is to view the hydrographs in **Hydroview**.



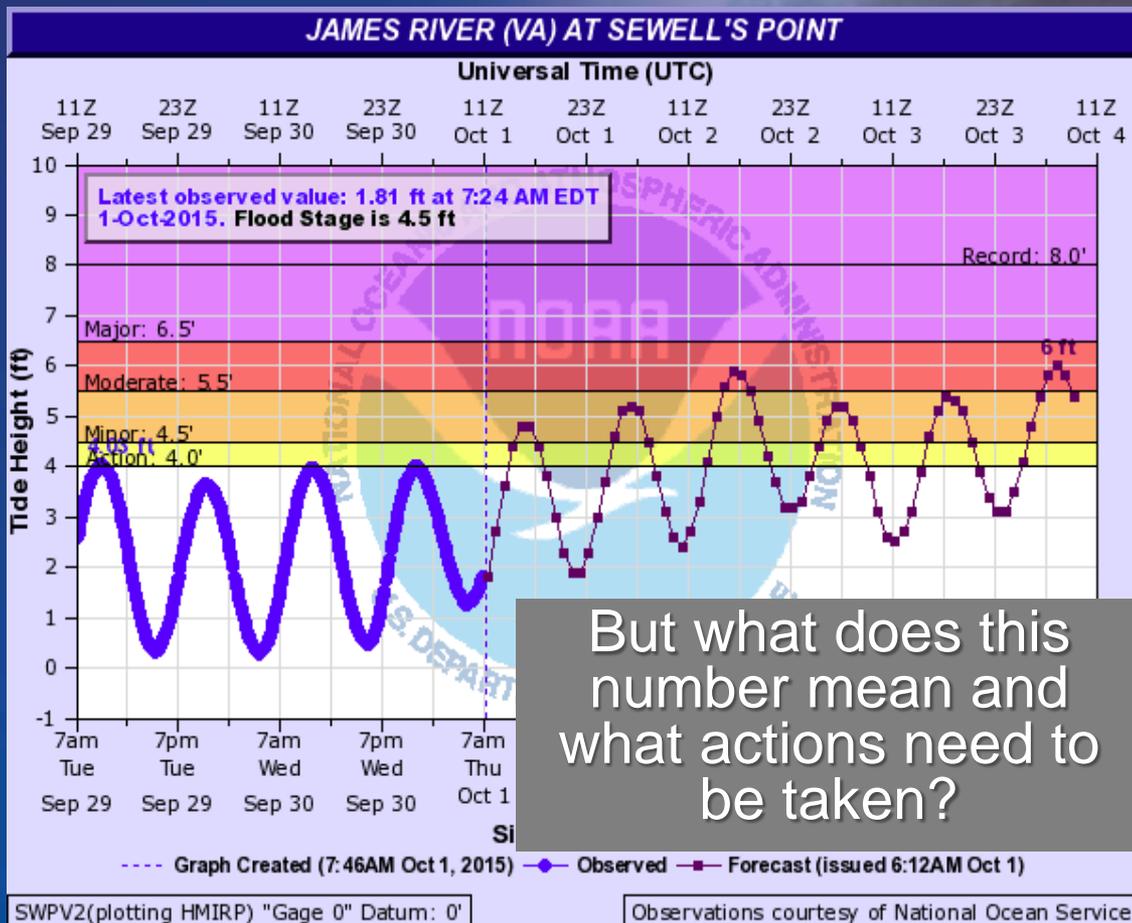


Final Product on AHPS



The hydrograph on AHPS now shows a true total water level instead of either pure model data or astronomical tide data.

The high tide values are also captured in a text product and included in all CFW products, allowing for consistency in messaging.



But what does this number mean and what actions need to be taken?

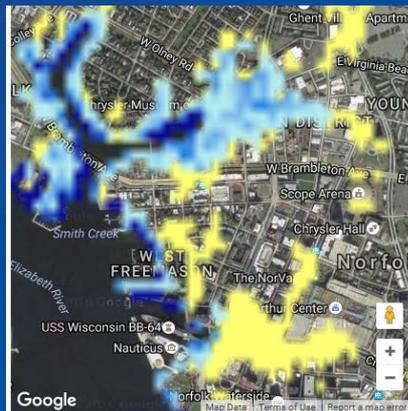


Developing The Tools



GOAL: Create a mapping tool to visualize tidal flooding, like that typically seen from coastal storms and hurricanes, within the forecast area of the Wakefield WFO.

- Leverage datasets and tools being applied by academia and emergency management
- Ensure underlying data is consistent. Compare output with similar tools (e.g. Norfolk Titan Portal)
- Incorporate best forecast data available within an easy to use interface portraying the extent of flood impacts





Developing The Basins



Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors. Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

Develop inundation basis/watersheds for each tide gage based on hydrography tools in ArcGIS

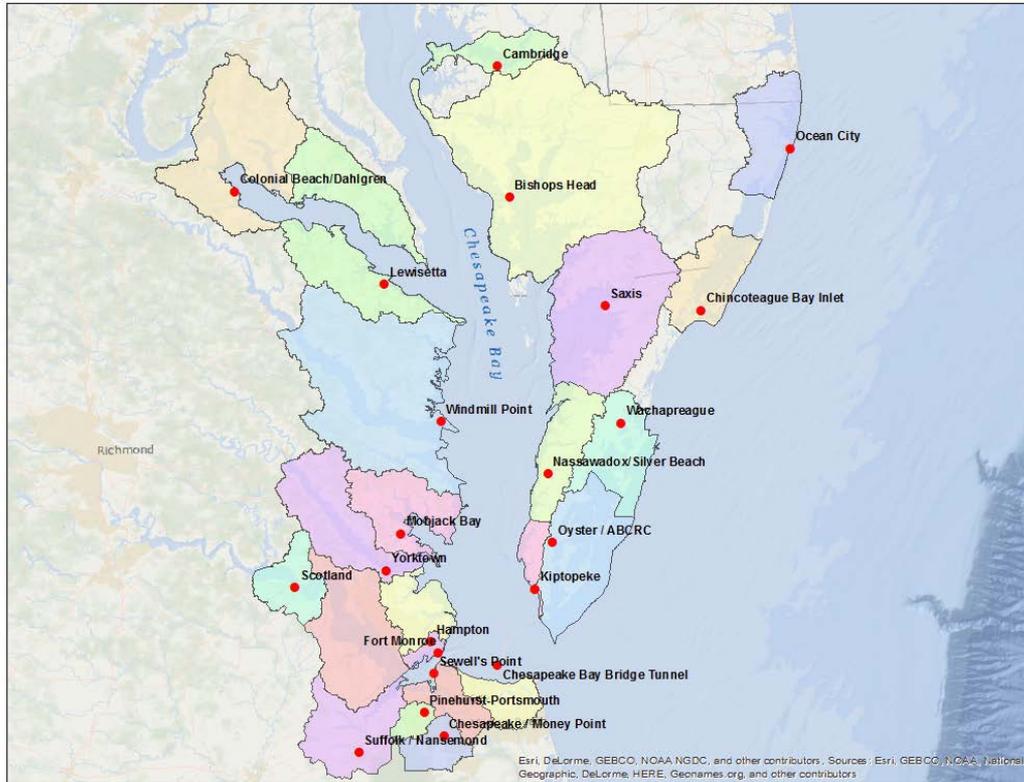
Identify tide gages (NOS & USGS) for which forecasts are generated



Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors. Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors



The Basins



The first step was to complete a web query for available LiDAR DEM's.

This included the *NOAA Office of Coastal Management* in Charleston, South Carolina and the GIS center at Old Dominion University in Norfolk, Virginia.

LIDAR data in NAVD88, was adjusted to the MLLW datum to match forecast values. Conversions were made using the NOS VDatum software with interpolations between gages.



Creating Inundation Images



Subtract DEM values from the desired water surface/flood height to determine the inundation depth grid. This tells us water depths across the watershed under a particular flood level.

Differentiate those areas directly connected to the water sources versus those disconnected but at or below the defined water level.





Coupling Forecasts With Impacts



Prototype interactive inundation interface utilizing depth grids

<http://weather.gov/akq/inundation>

Hampton Roads Flood Page

Wakefield, VA
Weather Forecast Office

[Weather.gov](#) > [Wakefield, VA](#) > Hampton Roads Flood Page

LEGEND

-Flooded Areas/Inundation

-Potential Flooding

-Tide gauge

Minor Moderate Severe - Flood Categories

Water levels and inundation based on Mean Low - Low Water (MLLW)

Norfolk / Portsmouth: Off

Lynnhaven-Little Crk: Off

Western Branch: Off

Hampton-Ft Monroe: Off

Money Point: Off

Suffolk: Off

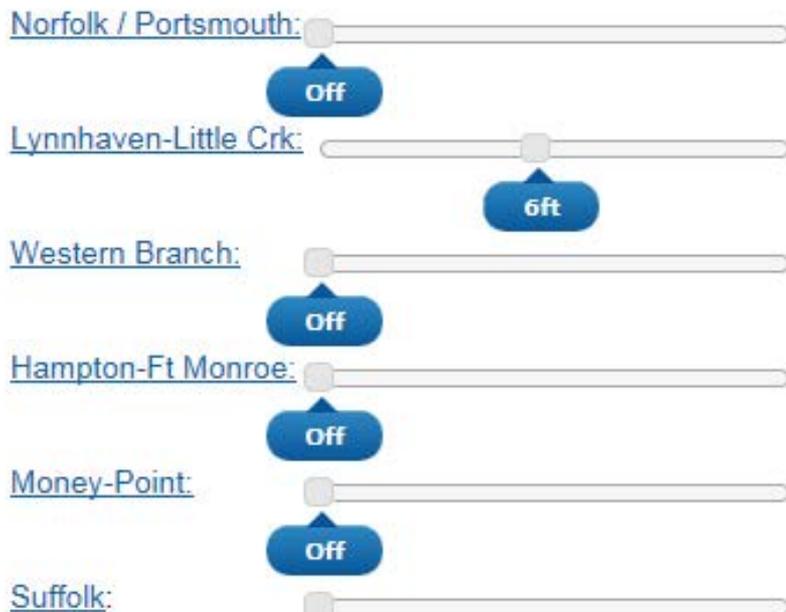
Poquoson: Off

Yorktown: Off

Mobjack Bay: Off



Little Creek Example





Accounting For Differing Water Levels



In every event water levels vary from one location to another from the coast to the Bay and estuaries.

Need a visualization tool which can take varying water level forecasts into account.

Hampton Roads Flood Page

[Weather.gov](#) > [Wakefield, VA](#) > Hampton Roads Flood Page

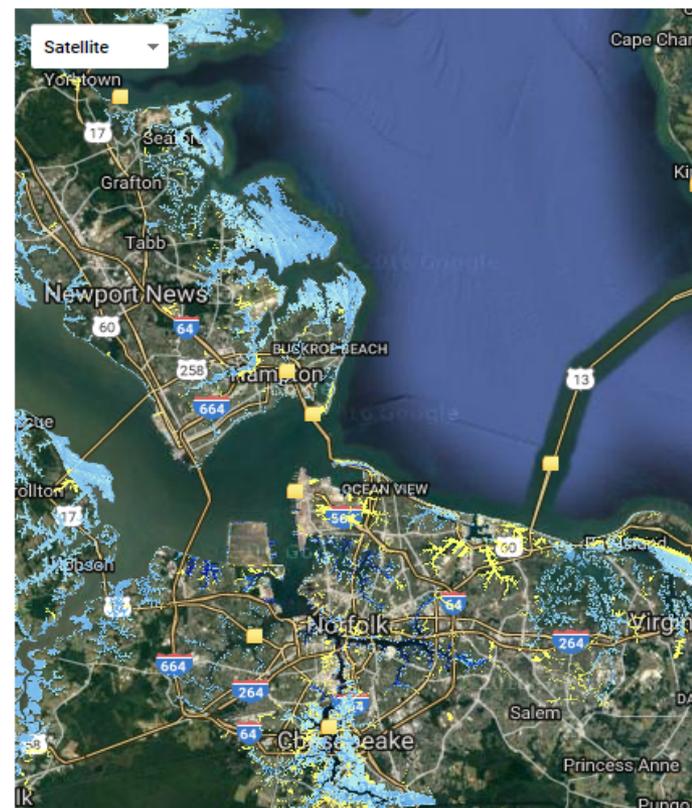
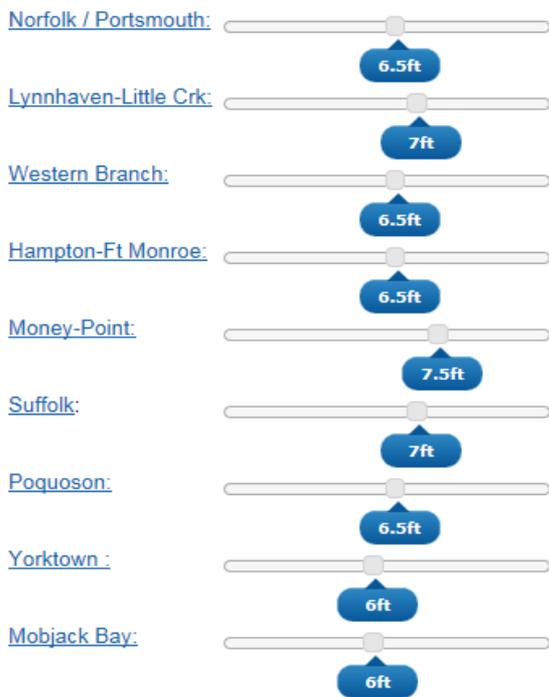
Wakefield, VA
Weather Forecast Office

LEGEND

-Flooded Areas/Inundation -Potential Flooding -Tide gauge

Minor Moderate Severe - Flood Categories

Water levels and inundation based on Mean Low - Low Water (MLLW)





Are There Any Questions?



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