



OWP | OFFICE OF
WATER
PREDICTION

Implementation of Forecast Flood Inundation Services To The Nation - An Update



David R. Vallee

*Director, Service Innovation and Partnership Division
NOAA/NWS Office of Water Prediction/National Water Center*

Outline



- Background on what got us to where we are today
- Progress to Date on our FIM Services Implementation for the Nation
- Examples of our new Experimental Flood Inundation Services
- Where you can access our Experimental National Water Model & Flood Inundation Services
- Field office training



Why are we doing this?

To fill a significant service gap!

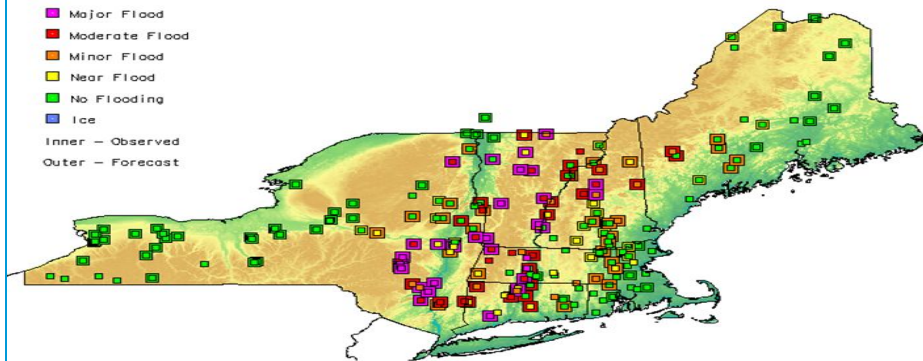
Current Flood Services

- Flood and Flash Flood Watches & Warnings
 - Providing general information on timing and impact on small streams
 - Detailed timing and impacts in the vicinity of our river forecast locations
- Impact-based Decision Support Briefings, packages and Webinars

Observed and Forecast River Conditions

August 28, 2011 7:11pm EDT

- Major Flood
- Moderate Flood
- Minor Flood
- Near Flood
- No Flooding
- Ice
- Inner - Observed
- Outer - Forecast



Source: NOAA/NWS/Northeast RFC

Partner feedback

- While our current services are tremendously valuable, **warnings lack specificity of location, timing and detailed impacts such as potential extent of inundation & duration of flooding**
- Lead time is critical in preparation
- Knowing what roadways, bridges, etc. could be impacted is invaluable

BULLETIN - EAS ACTIVATION REQUESTED
FLASH FLOOD WARNING
NATIONAL WEATHER SERVICE ALBANY NY
218 AM EDT SUN AUG 28 2011

THE NATIONAL WEATHER SERVICE IN ALBANY HAS ISSUED A

* FLASH FLOOD WARNING FOR...
GREENE COUNTY IN EAST CENTRAL NEW YORK...
THIS INCLUDES THE CITIES OF...HUNTER...CATSKILL...
ULSTER COUNTY IN EAST CENTRAL NEW YORK...
THIS INCLUDES THE CITIES OF...SAUGERTIES...NEW PALTZ...KINGSTON...
ELLENVILLE...

* UNTIL 815 AM EDT

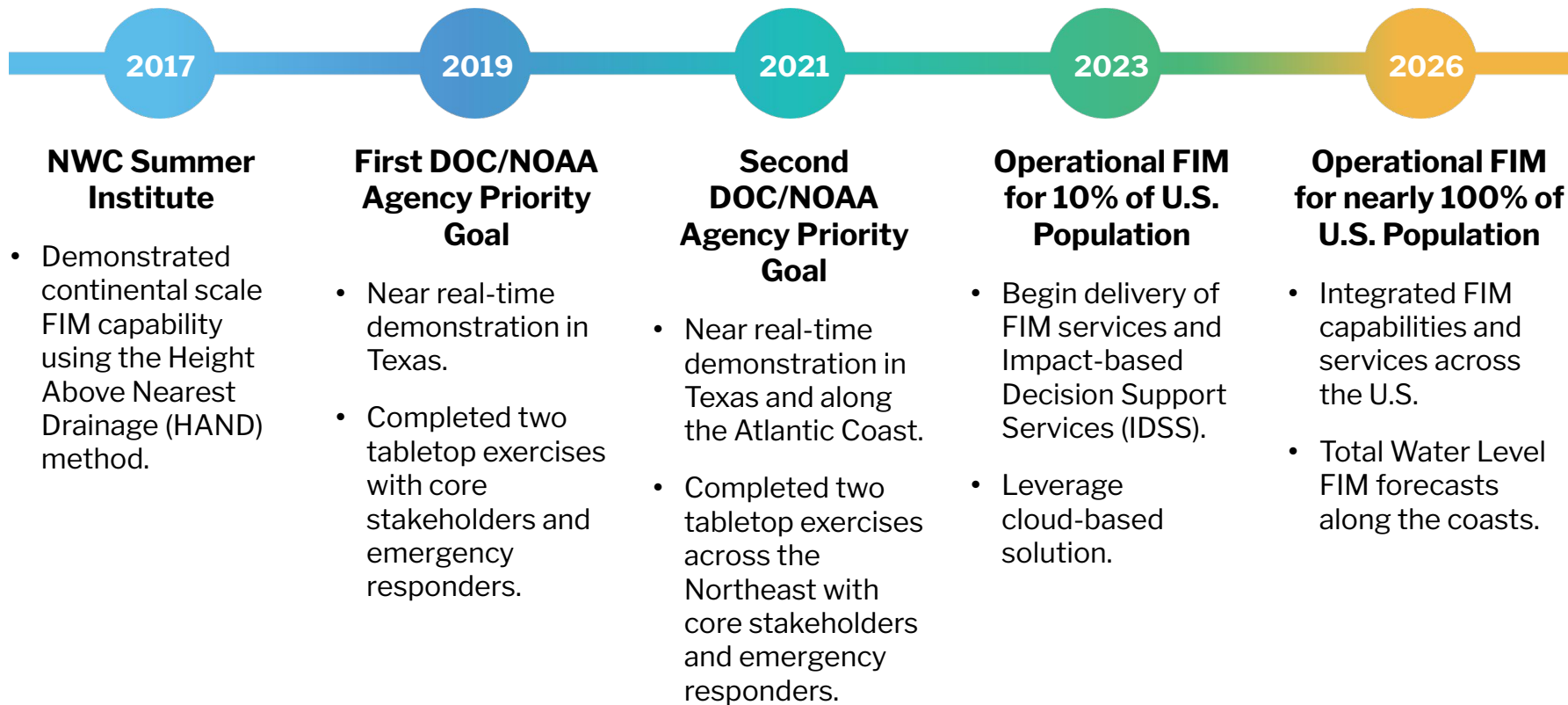
* AT 209 AM EDT...NATIONAL WEATHER SERVICE DOPPLER RADAR INDICATED
FLASH FLOODING FROM BANDS OF HEAVY RAIN WITH EMBEDDED
THUNDERSTORMS ASSOCIATED WITH HURRICANE IRENE.

* LOCATIONS IN THE WARNING INCLUDE BUT ARE NOT LIMITED TO NORTH-SOUTH
LAKE CAMPGROUND...NEW BALTIMORE...WINDHAM...PRATTSVILLE...COXSACKIE
AND ATHENS

PRECAUTIONARY/PREPAREDNESS ACTIONS...

ADDITIONAL RAINFALL AMOUNTS OF 2 TO 4 INCHES ARE POSSIBLE IN THE
WARNED AREA THROUGH 8 AM.

Flood Inundation Mapping Timeline



Tabletop Exercises: Key Findings

1. Partners found the combination of the NWS briefings with the FIM Service was a powerful combination to help them understand the impacts

- **Deliver through web services briefed by a professional forecaster**

2. The capabilities provided by these FIM services would be a **“game changer”** for the emergency management community

- **These geospatial services allowed for the creation of a common operating picture**

3. Services would be most useful in staging and planning activities in the 1-3 day timeframe

- **County EM: *“Had I had this tool in 2011, we would have had a larger evacuation area established earlier, would have moved emergency assets out of the flood zone, pre-positioned support resources and been able to provide better information to the residents of the affected area.”***

4. Depth is tremendously important - as it determines the types of resources needed for the flood fight



West Warwick Wastewater Treatment Facility under siege, morning of April 1st, 2010 as the Pawtuxet River began to recede. Photo: RI ANG



Record flooding along Schoharie Creek in the town of Schoharie on the morning of Sunday, August 28th, 2011. Source: Kait Wood

Map Legend



Population served by **October 2023.**



Population served by **October 2024.**



Population served by **October 2025.**

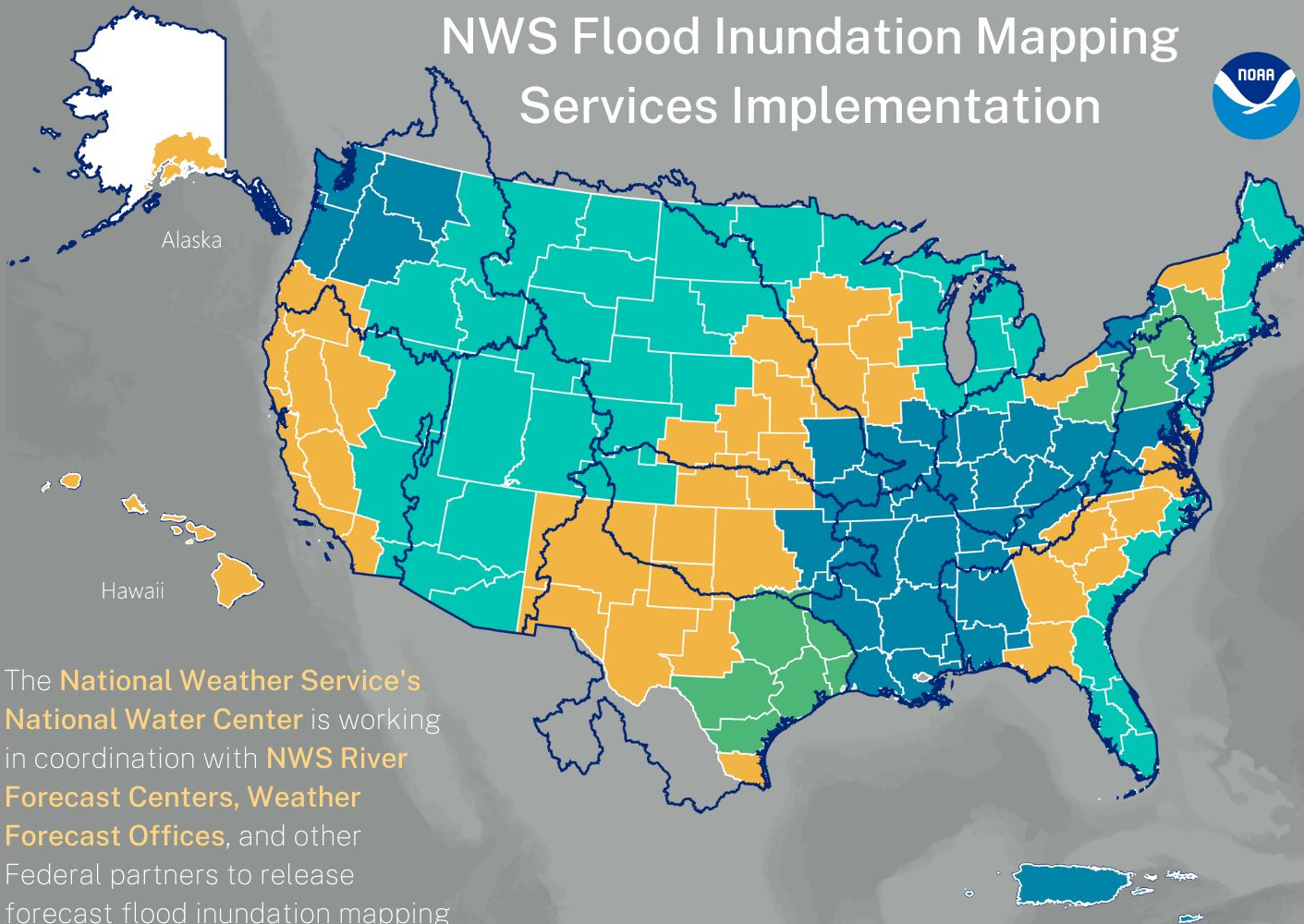


Population served by **October 2026.**

— NWS County Warning Areas

— NWS River Forecast Center Boundaries

NWS Flood Inundation Mapping Services Implementation



The **National Weather Service's National Water Center** is working in coordination with **NWS River Forecast Centers, Weather Forecast Offices**, and other Federal partners to release forecast flood inundation mapping services to the Nation.

*100% is approximate. Does not include all parts of Alaska, American Samoa, and Guam. Implementation areas are subject to change.

Puerto Rico & U.S. Virgin Islands

The Method behind FIM Services: Height Above Nearest Drainage (HAND)

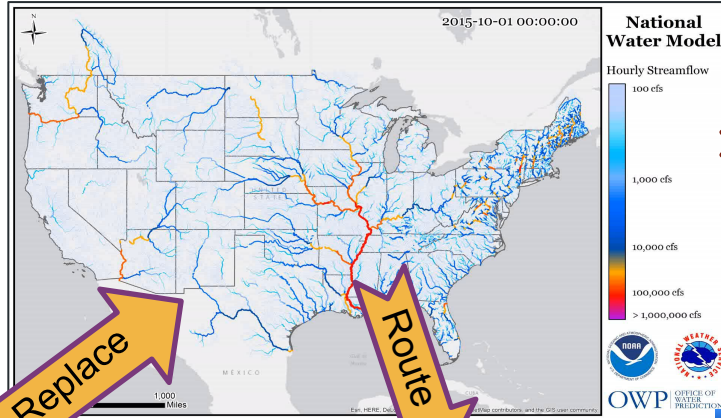
Deliver Forecast Flood Inundation Services

National Water Model Guidance

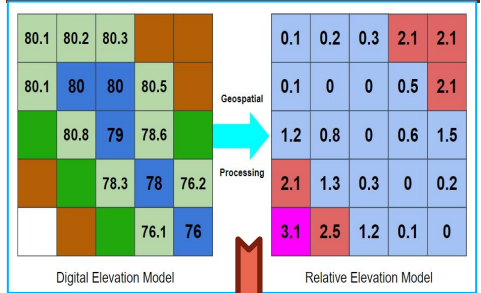
Completely automated process with no forecaster engagement – but provides complimentary guidance on ~3.4 million stream miles nationwide, including Puerto Rico and the Virgin Islands, Hawaii, and by the fall - portions of Alaska

River Center Forecasts

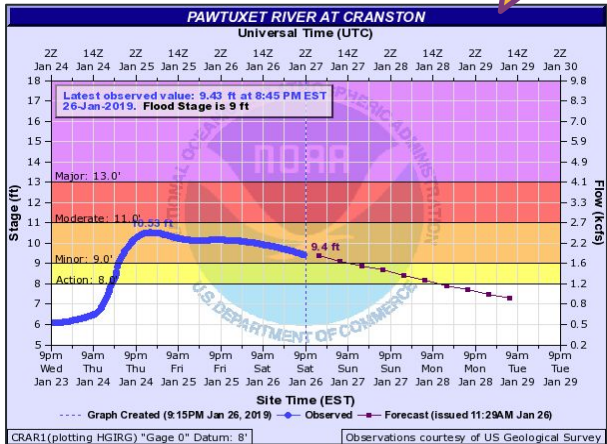
Forecasters heavily engaged in the forecast production



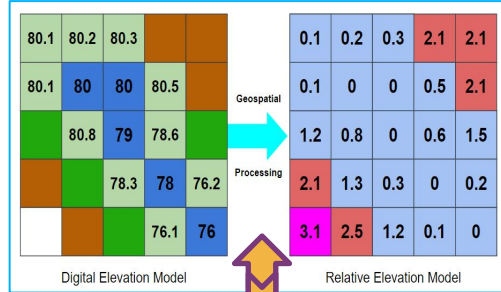
Height Above Nearest Drainage (HAND)



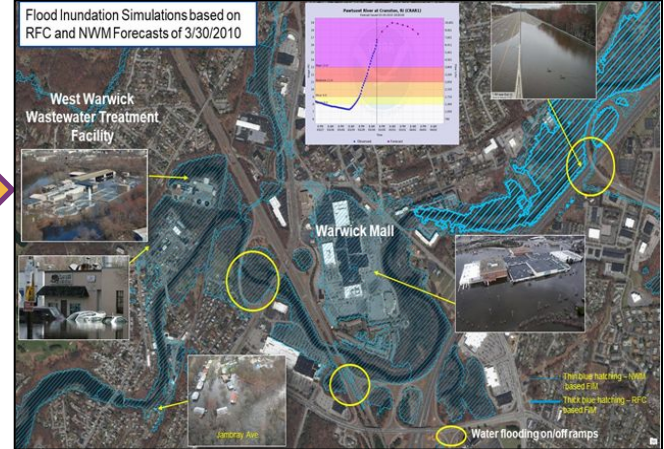
Pawtuxet River Valley – West Warwick/Warwick



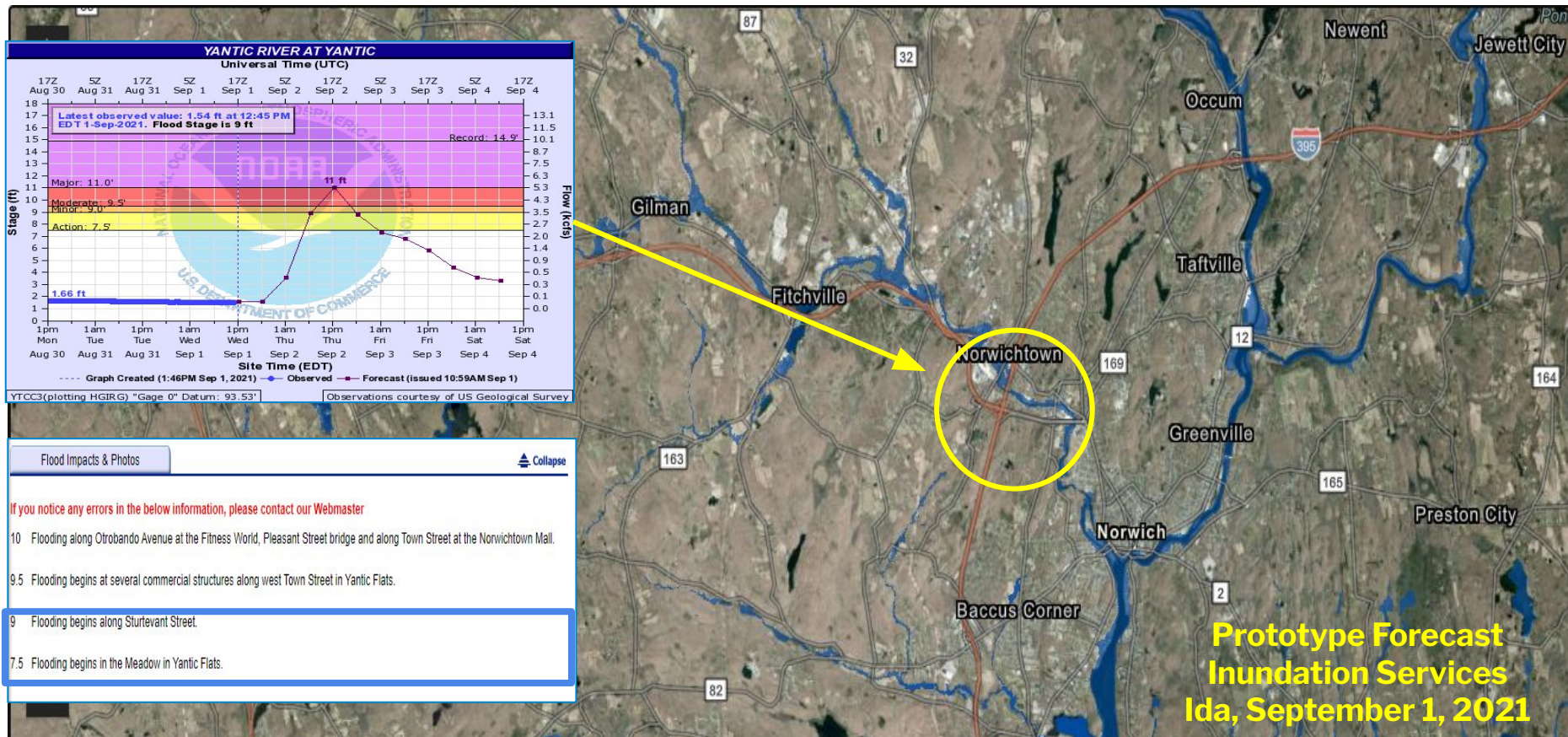
Height Above Nearest Drainage (HAND)



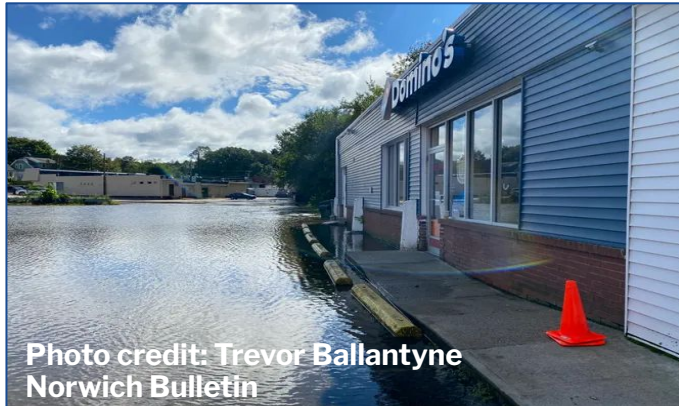
+RASToFIM & RASoREM techniques



Value of FIM Services - Visualizations to depict impacts



Value of FIM Services - Visualizations to depict impacts



Integrating FIM Services into our IDSS

Disclaimer: This experimental map represents the NWS's best approximation of inundation based upon modeled river discharge

Yantic River at Yantic, CT

Forecast Crest Height: 11 Feet

Map Height Shown: 11 Feet

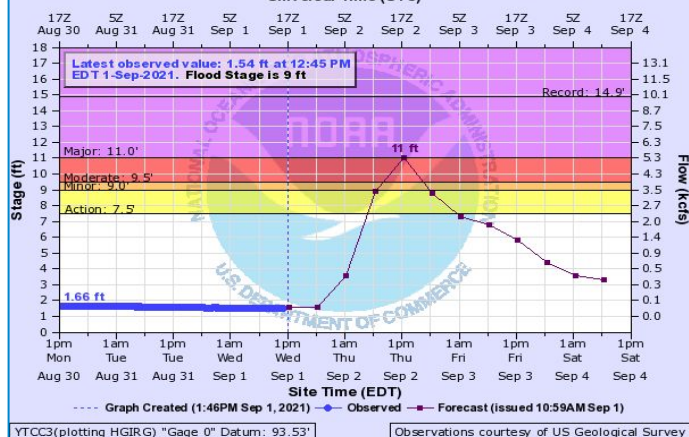
FIM Source: RFC FIM 5 Day Max Extent

FIM Type: Dynamic (Depth NOT Included)

FIM Creation Time: Sept 1st, 1 pm

YANTIC RIVER AT YANTIC

Universal Time (UTC)



RFC 5-Day Max Inundation Extent Forecast

Maximum Inundation Extent

Maximum Inundation Extent

Maximum Inundation Extent

Maximum Inundation Extent

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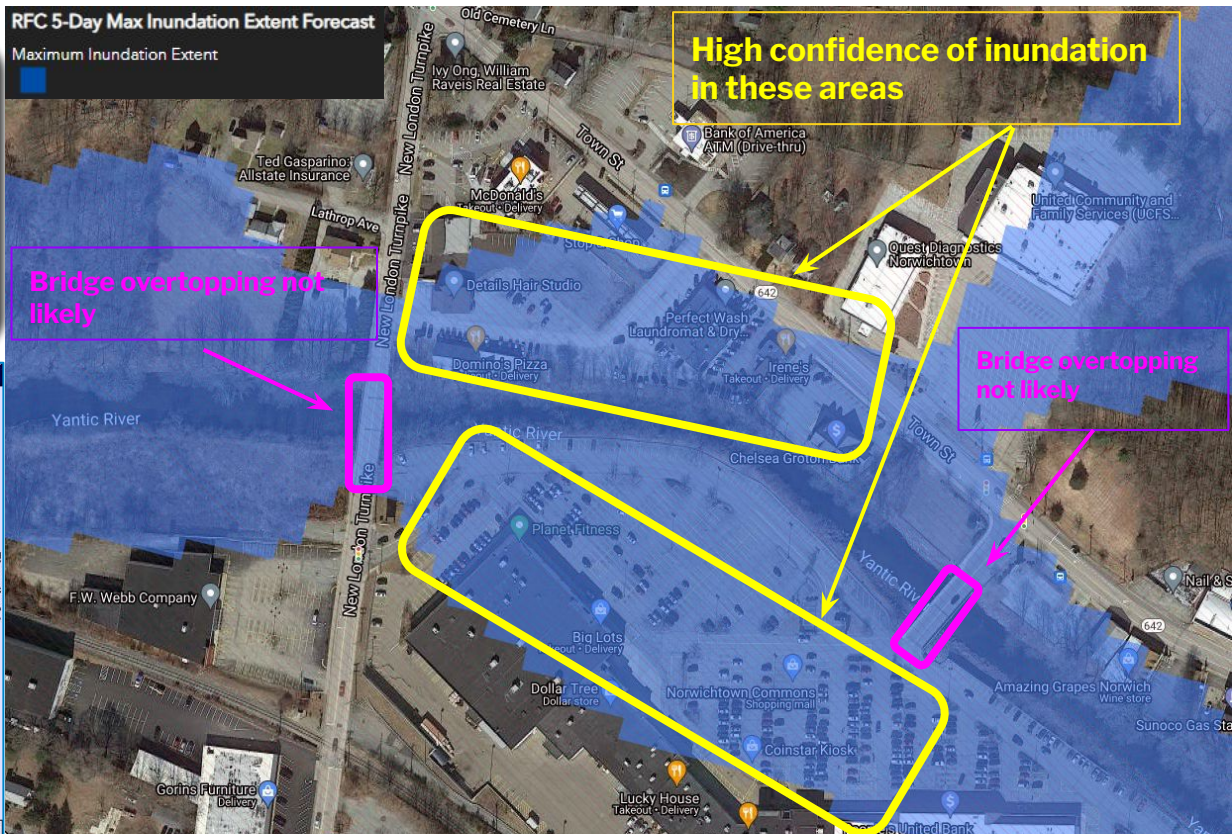
Maximum Inundation Extent

Maximum Inundation Extent

Maximum Inundation Extent

Maximum Inundation Extent

Maximum Inundation Extent




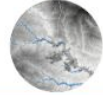
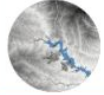
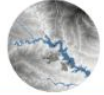
Initial FIM Rollout - National Viewer

Experimental Services - FIM for 10% of the U.S. population

- Services available on our NWS National Viewer alongside the existing NWM visualizations
 - (<https://viewer.weather.noaa.gov/water>)
 - High Water Arrival Time, Max High Flow Forecast, & High Water Probability Forecasts
 - Rapid Onset Flooding Forecasts & Probability Forecasts
- Actual services available for ingest into your local GIS systems



Dynamic FIM Services Comparison Table

FIM Service	NWM Latest Analysis FIM	RFC 5-Day Max FIM	NWM 5-Day Max FIM
			
Data Type	Observation based simulations [precip. estimates & USGS gage observations]	Forecast [5-day RFC forecasts]	Forecast [5-day GFS]
Total Latency	55 minutes	45 minutes	6 hours 30 minutes
Updates	Hourly	Hourly [if new forecasts available]	Every 6 hours
HAND Inputs	Flow	Flow	Flow
Threshold Source [NWM/RFC]	NWM High Water	RFC	NWM High Water
Error Sources	<ul style="list-style-type: none"> • RADAR or gage malfunctions • For unengaged reaches, errors associated with NWM & estimated precipitation • HAND errors [10m DEM resolution] 	<ul style="list-style-type: none"> • Rainfall forecast • RFC flow simulations • Routing of flow using NWM physics • HAND errors [10m DEM resolution] 	<ul style="list-style-type: none"> • GFS forecast • NWM flow simulations • HAND errors [10m DEM resolution]
FIM Domain	Entire NWM domain [CONUS, HI, PR, US Virgin islands]	Downstream of AHPs forecast points	CONUS
Mapping Threshold	Only available for reaches that meet and/or exceed the "High Water" threshold	Only available based on active RFC forecasts at or above "Action Stage"	Only available for reaches that meet and/or exceed the "High Water" threshold
When to Use	Use as a snapshot of the most recent modeled inundation	Use when RFC forecast is available	Use for rivers and streams not covered by RFC forecast

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NWM and FIM Services - NWS National Viewer

Search layers, folders and bookmarks

Map navigation and tool icons

500 km

Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

↑ N Scale: 1: 10,734,306 Zoom: 8.5 Location: 52.14837°, -124.11575° Projection: 3857: WGS84 Web Mercator

NWS GIS Viewer | Water

LAYERS

Clear Layers Collapse Folders

Flood Inundation Maps (FIM) (EXPERIMENTAL)

- NWM Latest Analysis (Zoom level 18+) ⁶⁰
- RFC 5-Day Max Forecast (Zoom level 18+) ⁶⁰
- NWM 5-Day Max Forecast (GFS) (Zoom level 18+) ⁶⁰
- FIM Coverage Domain ⁶⁰
 - Opacity :100%
- FIM Coastal Exclusion Zone ⁶⁰

Flood Products

River Observations and Forecasts

Advanced Hydrologic Prediction Service (AHPS) River Gauges

Land Analysis

National Water Model (NWM) Output

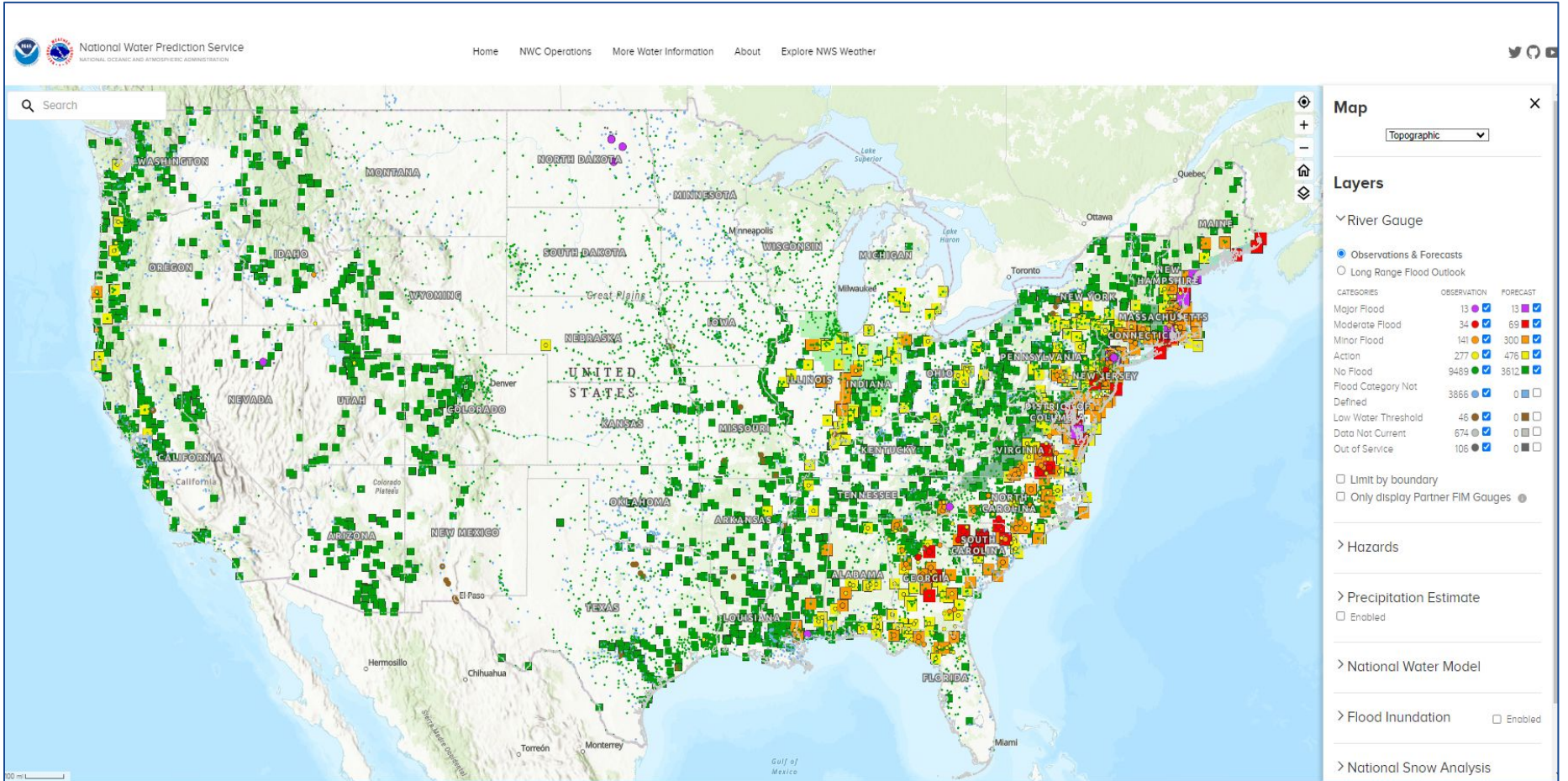
- CONUS Precipitation (inches) ⁶⁰
- Hawaii Precipitation (inches) ⁶⁰
- Puerto Rico Precipitation (inches) ⁶⁰

Streamflow Anomaly Analysis

- High Flow Magnitude Analysis
 - Medium-Range High Water Arrival Time Forecast
 - Medium-Range High Water Probability Forecast
 - Medium-Range Max High Flow Magnitude Forecast
 - 3 Days - Est. Annual Exceedance Probability ⁶⁰
 - 5 Days - Est. Annual Exceedance Probability ⁶⁰
 - Opacity :100%
 - 10 Days - Est. Annual Exceedance Probability ⁶⁰
- Medium-Range Rapid Onset Flooding Forecast
- Medium-Range Rapid Onset Flooding Probability
- Medium-Range Peak Flow Arrival Time Forecast
- Flowlines
- Short-Range High Water Arrival Time Forecast
- Short-Range High Water Probability Forecast
- Short-Range Max High Flow Magnitude Forecast
- Short-Range Rapid Onset Flooding
- Short-Range Rapid Onset Flooding Probability

This experimental map represents the NWS's best approximation of inundation extent based upon modeled river discharge

National Hydrologic Prediction System - coming in late March



National Hydrologic Prediction System - coming in late March

National Water Prediction Service
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Home NWC Operations More Water Information About Explore NWS Weather

FLVC3

← Upstream gauge (GTBM3)
Full Information >
Downstream gauge (GAYC3) →

Latest observed value: 6.84 ft
2:15 PM EST 11-Jan-2024
Flood Stage is 7 ft

NWSU: FLVC3, Reach ID: 7711932

Housatonic River at Falls Village

Stage (FT)

15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

Flow (CFS)

16,919.00
15,367.00
13,855.00
12,384.00
10,957.00
9,576.00
8,245.00
6,966.00
5,750.00
4,268.00
2,874.00
1,730.00
802.00
227.00

12 am Jan 9 12 am Jan 11 12 am Jan 13

Site Time (EST)

US Geological Survey Observations courtesy of U.S. Geological Survey FVLC3 (plotting HGRQ) "Gage 0" Datum: NAD 83, ft

Graph Created: 03:28 PM EST Jan 11 2024 - Forecast Issued: 03:13 PM EST Jan 11 2024

Zoom 1d 2d 7d 14d All Jan 8, 2024 - Jan 14, 2024

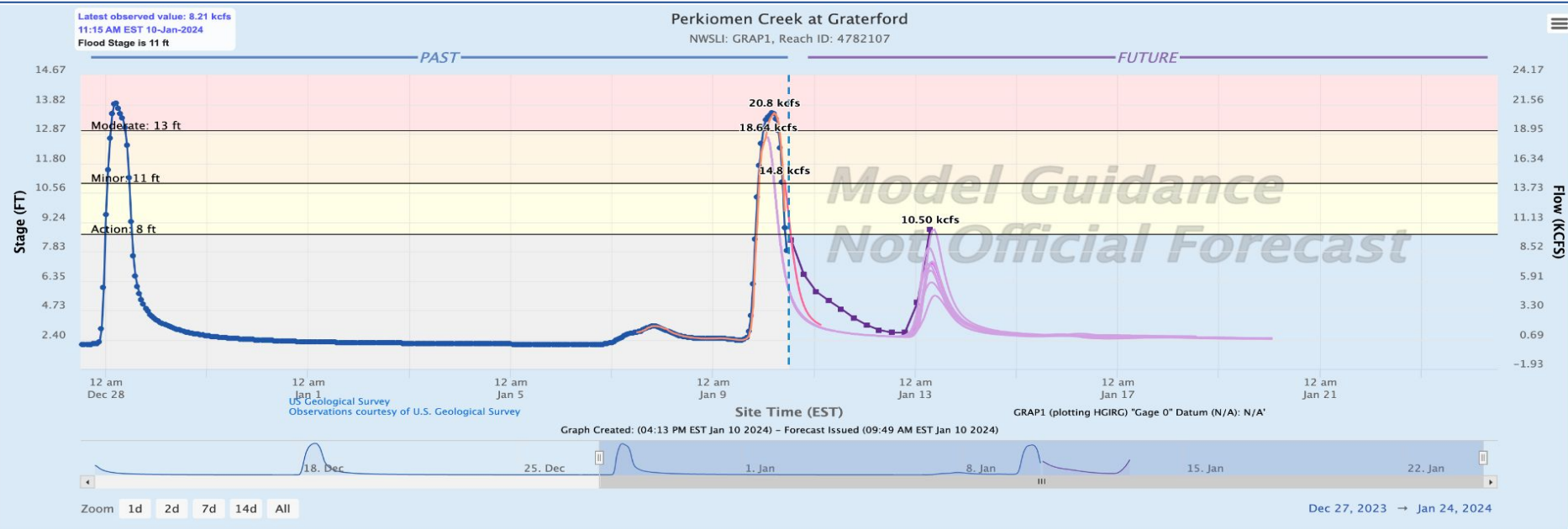
Scale to Flood Categories

Official	CATEGORY	STAGE
● Observed (OBS)	Major Flooding	15 ft
● Forecast (FCST)	Moderate Flooding	10 ft
● Record: 19 ft	Minor Flooding	7 ft
	Action Stage	6 ft

NOTE: Forecasts are issued as needed during times of high water, but are not routinely available.

Gauge reading may be affected by ice. Forecast flows are unadjusted for ice.

National Hydrologic Prediction System - coming in late March



Official
 ● Observed (OBS)
 ● Forecast (FCST)

CATEGORY	STAGE
Major Flooding	16 ft
Moderate Flooding	13 ft
Minor Flooding	11 ft
Action Stage	8 ft

National Water Model

- Analysis (ANA)
- Medium Range Blend (MRB)
- Short Range (SR)

▼ **Medium Range Ensembles**

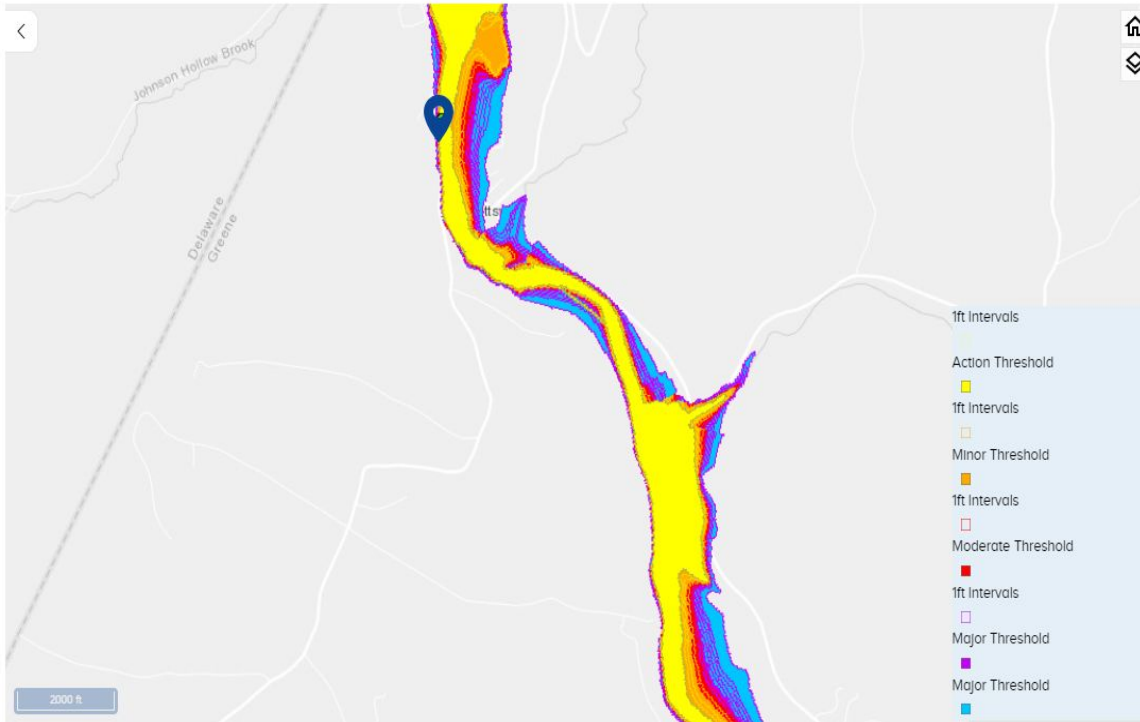
- Medium Range Ensemble Mean (MRM)
- Medium Range Ensemble 1 (MR 1)
- Medium Range Ensemble 2 (MR 2)
- Medium Range Ensemble 3 (MR 3)
- Medium Range Ensemble 4 (MR 4)

Example of NWM Guidance for Perkiomen Creek, January 10th, 2024

National Hydrologic Prediction System: Categorical FIM

Gauge Location

- Action 1ft Intervals
- Action Threshold
- Minor 1ft Intervals
- Minor Threshold
- Moderate 1ft Intervals
- Moderate Threshold
- Major 1ft Intervals
- Major Threshold
- Major Threshold



- Display PTVN6 marker
- Activate PTVN6 FIM Gauge
- Deactivate PTVN6 CATFIM
- Display FEMA's National Flood Hazard Layers

Current Stage:

3.89 ft at 2023-12-01 23:22:05 UTC

Highest Forecast: 6.3 ft

Current Mouse Location

Recent Crests

- 13.85 ft on 10-26-2021 (P)
- 17.53 ft on 12-25-2020 (P)
- 13.55 ft on 10-30-2017
- 12.03 ft on 02-25-2016
- 13.71 ft on 09-07-2011

[SHOW ALL CRESTS](#)

Historic Crests

- 24.38 ft on 08-28-2011
- 19.57 ft on 03-05-1979
- 19.5 ft on 01-26-1978
- 19.39 ft on 01-19-1996
- 19.14 ft on 10-16-1955

[SHOW ALL CRESTS](#)

Map Legend



Population served by **October 2023.**



Population served by **October 2024.**



Population served by **October 2025.**

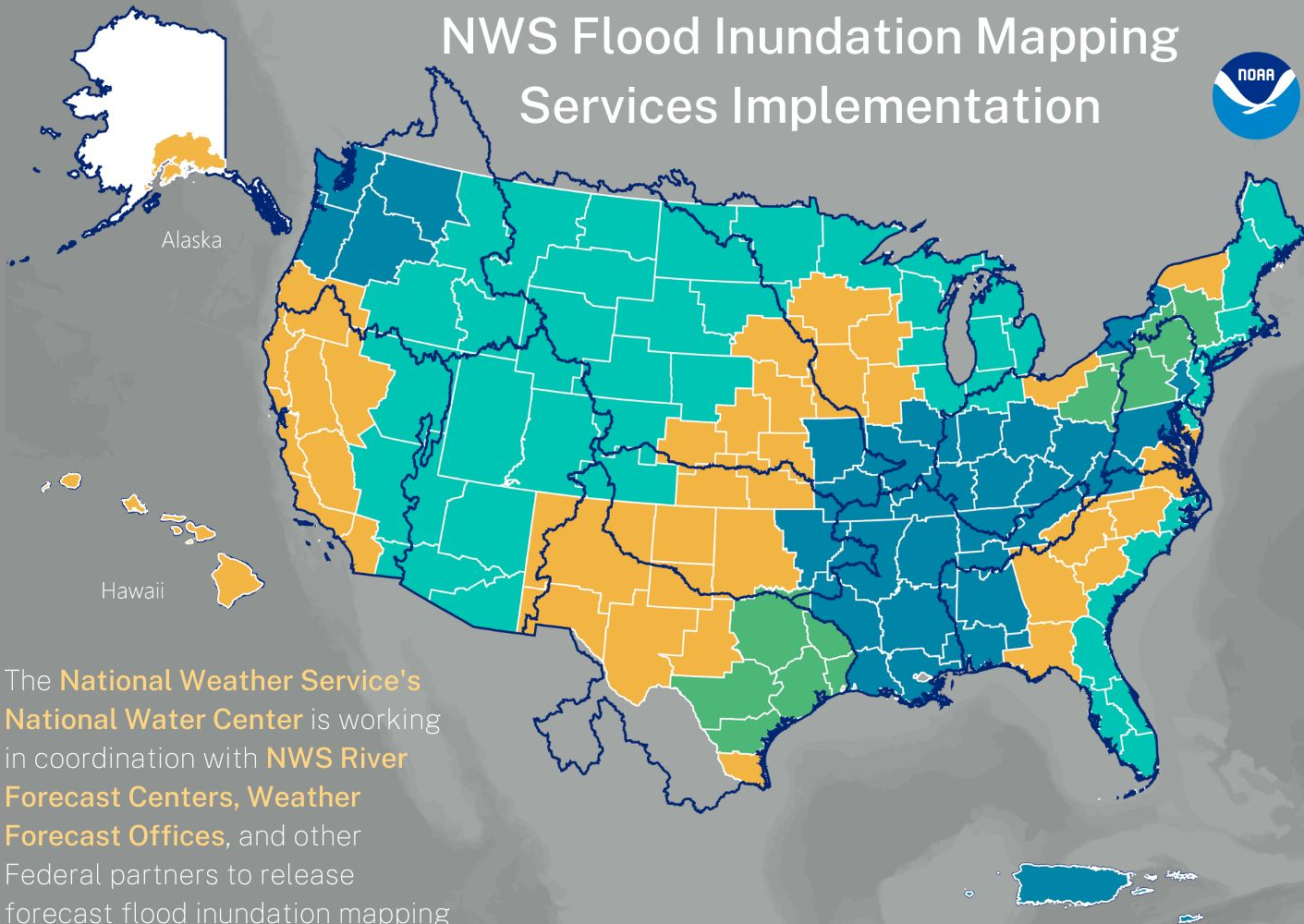


Population served by **October 2026.**

— NWS County Warning Areas

— NWS River Forecast Center Boundaries

NWS Flood Inundation Mapping Services Implementation



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Puerto Rico & U.S. Virgin Islands

FIM IDSS workshops for field SMEs

- Intensive 3 day workshop
- 2 people per WFO/RFC
- Digging into the Science
- Exercising the tools
- Working actual events and delivering IDSS to partners
- Facilitators included SMEs from the 10% offices!
- Since November of 2022 we've trained:
 - **~ 133 field staff in 52 offices**
 - **10 RFCs, 42 WFOs, 4 ROCs, and the NWS NOC!**



Local Office Training Resources



National
Water
Center

▼ NWC Operations

▲ Flood Inundation
Mapping

▲ Training &
Outreach

▲ Training Local
Office Staff

Local
Summary
Sheets

▼ Training Partners
& Stakeholders

▼ FIM 10%

▼ FIM 30%

FIM 60%

Training Local Office Staff

[Presentations & Best Practices](#)

[Example Training Plans](#)

[Additional Resources](#)

Presentations & Best Practices

FIM Field Office Training Framework Slide Deck

Presentation Slide Deck Talking Points

HAND Method Module Key Takeaways

Slide 04

- HAND [Height Above Nearest Drainage] is the method by which water elevation in a stream or reach is applied to a grid representing the terrain to depict inundation extent (GIF on this slide represents that process).
- Another way to define/remember this method: HAND is a geoprocessing technique that converts a Digital Elevation Model (DEM) to a Relative Elevation Model (REM) depicting the elevation of the surrounding terrain above the river to which it drains.
- Primary inputs for HAND include:
 - Catchments
 - Reaches
 - DEMs [Digital Elevation Models]
- Hydroconditioning converts a DEM to an REM [Relative Elevation Model], retaining the elevation of the terrain to the elevation of the channel thalweg [zero reference point].
 - DEM (smooth raster image) is divided into a 10x10 meter grid (this is the resolution used by the National Water Center).
 - Each grid cell represents an elevation value above a common datum (usually mean sea level).
 - The HAND value of each REM grid cell indicates the water depth needed to inundate that cell.
 - REM values are obtained by subtracting the elevation of each river channel cell from the elevation of each catchment cell that drains into that channel cell. The resulting values represent each cell's vertical height above its channel drainage.

FIM Training Instructional Best Practices

This instructional guide provides recommendations for implementing and facilitating FIM training at your field office. To request assistance, please fill out and submit this brief [request form](#), and our training team will work to respond within 24 hours, excluding weekends and holidays. Please remember that your success is our mission, so please do not hesitate to contact your M2 support team when seeking assistance.

Our five core principles for ensuring optimal learning outcomes are content delivery, logistical considerations, facilitation methods, reflection, and follow-up support.

1. Content Delivery

Before beginning your training, you will have the opportunity to customize the provided [slide deck](#) presentation to meet the needs of your respective office. Customization will ensure that the training materials are relevant and effective for your learners.

Best practices for content delivery include

- Reviewing the agenda at the start of each session
- Stating the key objectives and goals
- Implementing a variety of teaching techniques
 - Breakout groups, Q&A sessions, and presentations
- Incorporating visuals and grounding theoretical knowledge using concrete examples and, wherever possible, localized scenarios
- Providing opportunities for learner engagement
 - Knowledge checks/conversations/open-dialogue

FIM 10% Field Office Training Sample Post - Workshop Survey Questions

1. Please rate your overall experience on a scale of 1 to 5:
 - a. 1- Poor
 - b. 2
 - c. 3
 - d. 4
 - e. 5 - Excellent
2. Please rate your overall technical understanding of the training content.
 - a. 1- Poor
 - b. 2
 - c. 3
 - d. 4
 - e. 5 Excellent
3. What remaining questions do you have?
 - a. Open ended:
4. Please summarize the most important take away you learned.
 - a. Open ended:
5. Do you have any additional feedback you'd like to share?
 - a. Open ended:

Partner Training Resources

Partner Summary Sheets

This page complements FIM Partner Training and Outreach efforts provided by local offices. It serves as a reference for partners to understand the strengths and limitations of available FIM services and how to access additional resources and assistance.

[Visuals/GIFs](#)

[Print/Download](#)

[NWS FIM StoryMap](#)

[FIM Fact Sheet and FAQs](#)

[National Viewer Guides](#)

[Placeholder-NWPS guide](#)

Visuals/GIFs

- [HAND Schematic Model \[with limitations\]](#)
- [Stage-Based CatFIM Summary](#)
- [FIMPact Layers Summary](#)
- [Synthetic Rating Curves \[SRC\] Summary](#)
- [Synthetic Rating Curves \[SRC\] Skills Summary](#)
- [Dynamic FIM Services Summary](#)
- [Dynamic FIM Services Comparison Table](#)
- [\[PR/VI\] Dynamic FIM Services Comparison Table](#)
- [Static FIM Services Summary](#)
- [Static FIM Services Comparison Table](#)

Print/Download

[HAND Schematic Model \[with limitations\]](#)

[Dynamic FIM Services Comparison Table_PDF](#)

[Stage-Based CatFIM_PDF](#)

[Dynamic FIM Services Summary_PDF](#)

[Synthetic Rating Curves \[SRC\] Summary_PDF](#)

[\[PR/VI\] Dynamic FIM Services Comparison Table_PDF](#)



National
Water
Center

▼ NWC Operations

^ Flood Inundation
Mapping

^ Training &
Outreach

▼ Training Local
Office Staff

^ Training Partners
& Stakeholders

**Partner
Summary
Sheets**

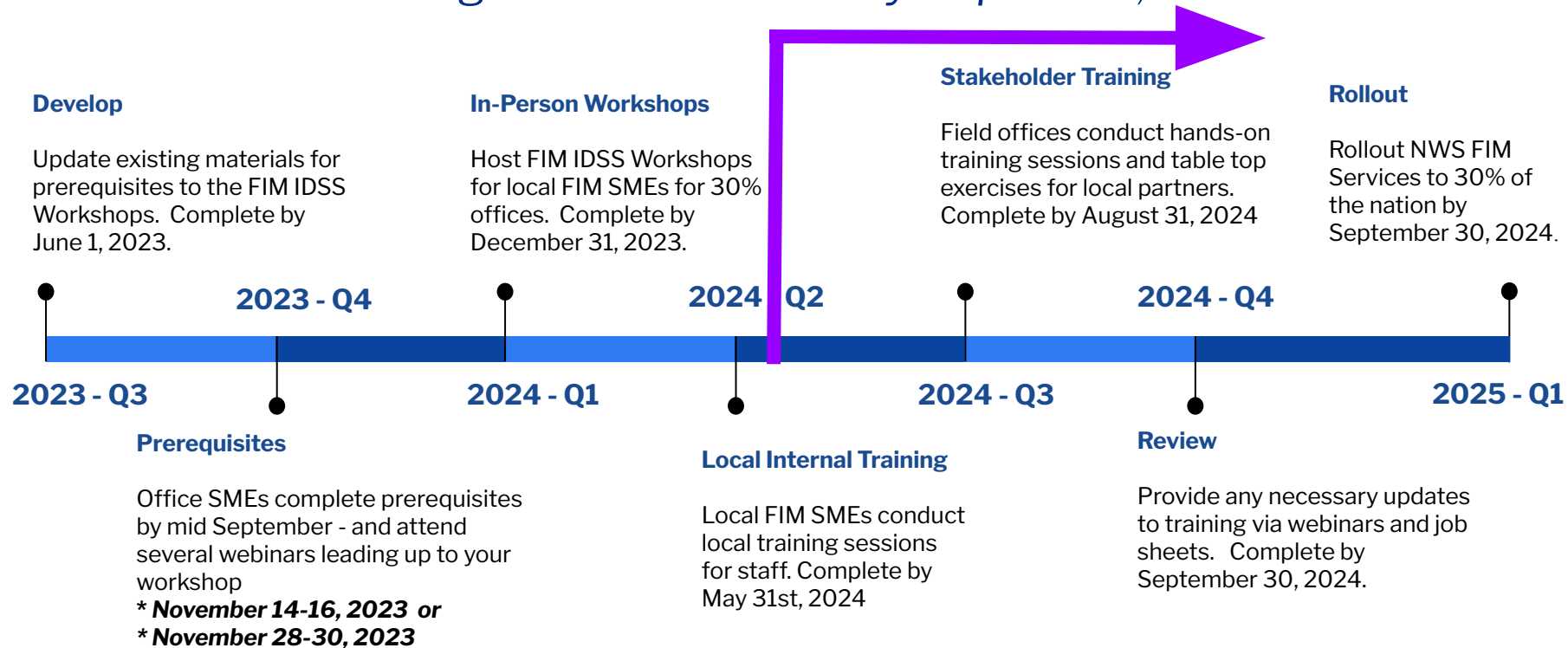
▼ FIM 10%

▼ FIM 30%

FIM 60%

FIM CONOPS Training Roadmap - Field Office Plan

Activities to executing FIM IDSS deliver by Sept 30th, 2024



Disclaimer: Dates for webinars ahead of each workshop TBD - and will be recorded!



Integration into the IMS Prototype

IDSS Management System (IMS)

Purpose

- The IDSS Management System will deliver the database capacity to vastly improve NOAA's understanding of community partnerships and their key vulnerabilities to environmental hazards, especially related to flooding.

Major Milestones

- *Hire 7 Developers - CY23*
- *Set up operational cloud environment 09/23*
- *Add SVI and FIM as layers to prototype 11/23*
- Initial Operating Capability (IOC) (Q3/FY24)
- Agile Development and Deployment of IMS Capabilities Exceeding IOC (FY26)

Benefits

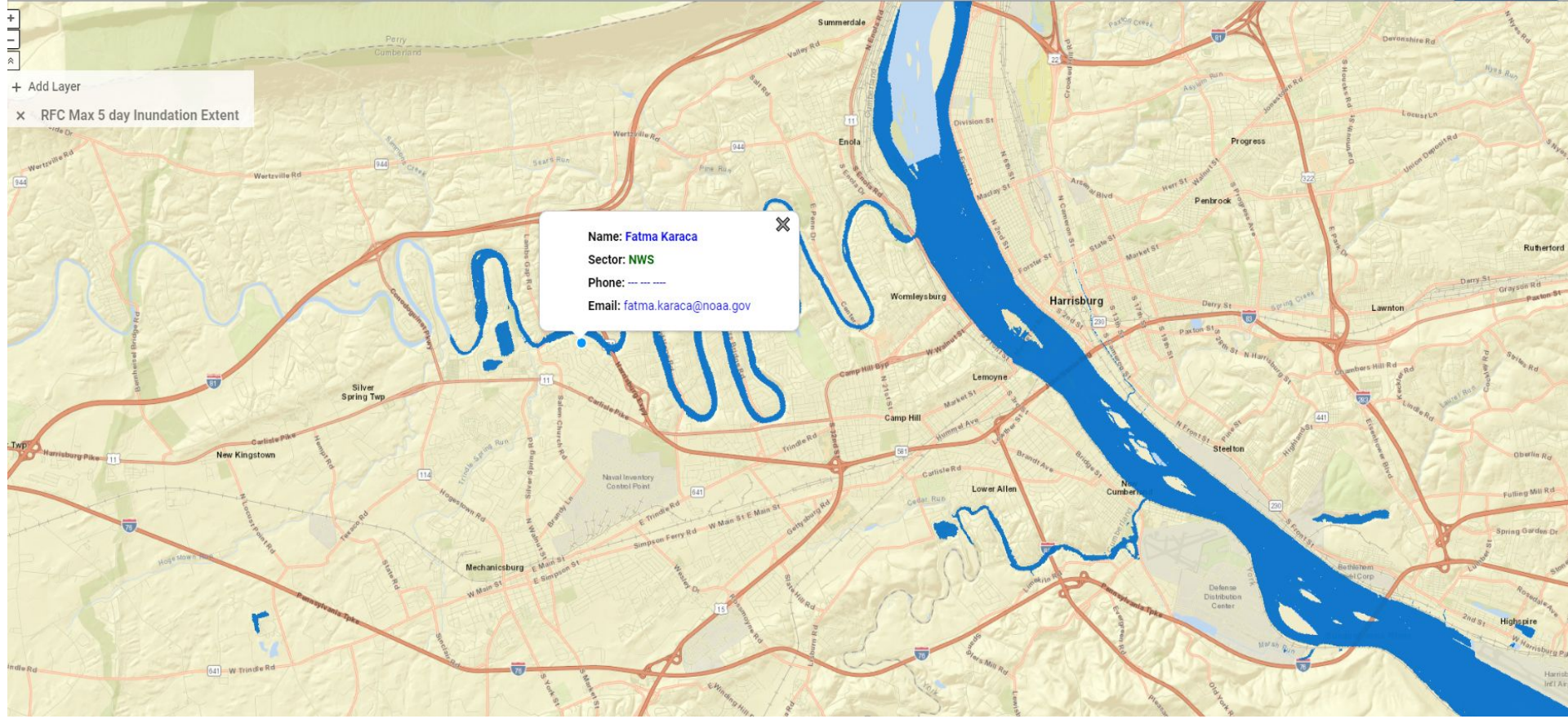
- It will allow NOAA to consistently provide decision support and communication to our community partners throughout the life cycle of an environmental hazard occurrence.

Accomplishments to Date

- Multiple Developers (Associates and Contractors) have recently started, including our first ever User Experience Designer.
- Field Test and Evaluation (FT&E) with a diverse set of 25 NWS offices started in October 2023. Contact storing/mapping capabilities were the first capabilities released.
- 52 tickets from FT&E have been completed to date, including UI tweaks, bugs, and iterative feature requests.



Prototype integration into IMS



+ Add Layer
x RFC Max 5 day Inundation Extent



OWP | OFFICE OF
WATER
PREDICTION

Implementation of Forecast Flood Inundation Services To The Nation - An Update



David R. Vallee

*Director, Service Innovation and Partnership Division
NOAA/NWS Office of Water Prediction/National Water Center*