



# Deriving Flood Risk, Vulnerability, Loss Estimation, and Utilization of Statistical Applications for Decision and Regulatory Support from USGS products

U.S. Geological Survey – Central Midwest  
Water Science Center



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Supervisory Hydrologist

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Physical Scientist

# USGS Flood Inundation Mapping

## Stage-Based Deterministic Inundation Mapping

- Location Services
- Historic Flooding
- Flood Categories
- HAZUS Loss Estimation
- Backwater Considerations.

<https://fim.wim.usgs.gov/fim/>

**USGS**  
science for a changing world

Flood Inundation Mapper

**Basemaps**

**Map Layers**

- National Weather Service Radar
- Flood Watches and Warnings
- AHPS Forecast Sites
- Major Flooding (0)
- Moderate Flooding (4)
- Minor Flooding (49)
- Action flooding (69)
- No flooding (1618)

Powered by **WIM**

**Water depth**  
Range: 14 - 15 ft

**Missouri Meremac River near Eureka**

Site Number: 07919000  
Selected Stage Height: 49ft  
Selected Stage Name: N/A/cts

View Satellite Imagery  
 View Depth Grids

**Flood Area Opacity:**

**NWS Stages**

- Major
- Moderate
- Minor
- Action
- Extended Rating
- Below Action

**Top 10 Annual Flood Peaks for Meremac River near Eureka**

Date	Stage Height (ft)
Corvet Stage	~0
Aug 23, 1915	~38
Jun 1, 1916	~38
Jul 2, 1917	~38
Sep 26, 1943	~38
Apr 14, 1994	~38
Dec 21, 2008	~38
Dec 30, 2015	~38
May 2, 2017	~38

Click on an historical flood to see the estimated extent. Due to changes in the channel and urbanization over time, these areas are only an estimate using 2015 modeled conditions. These numbers are provided for historical context only and are not reviewed inundation areas for the selected flood height.

\*Please use the USGS NWS Flood Peaks for more information on flood.

**USGS**

1:72,224  
38.476 | -90.396

# USGS Flood Inundation Mapping

## State of Missouri National Weather Service (NWS) Prediction

**National Weather Service**  
Advanced Hydrologic Prediction Service

Home News

National Observations WFO Observations Hydrograph

Weather Forecast Office St. Louis, MO North Central Region

Hydrograph River at a Glance

Auto Refresh: OFF

**JOACHIM CREEK AT DESOTO**  
Universal Time (UTC)

16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z
Feb 27	Feb 28	Feb 29	Mar 1	Mar 2	Mar 3	Mar 4	Mar 5	Mar 6	Mar 7	Mar 8	Mar 9	Mar 10	Mar 11
15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4

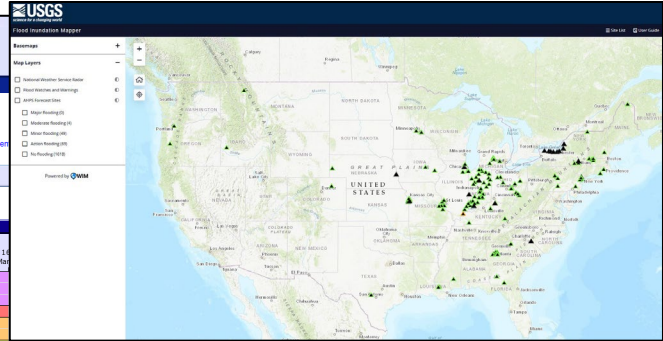
Latest observed value: 1.8 ft at 9:55 AM CST  
 Major: 11.0' Flood Stage is 10 ft  
 Minor: 12.0'

Action: 8.0'

Graph Created (10:25AM Mar 3, 2020) Observed Forecast (issued 9:55AM Mar 3)

NOTE: River forecasts for this location take into account past precipitation and the precipitation amounts expected approximately 48 hours into the future from the forecast issuance time.

Reliability of the Forecast: Based on current and forecast river, weather and reservoir.



**USGS**  
Flood Inundation Mapper

USGS Site No: 05331000  
 NWS Site ID: stpm5  
 Current Conditions  
 Discharge: 14,37ft  
 74800cfs  
 Selected Conditions  
 1:72,224  
 44,914 | -93,049 (center)  
 Gauge height: N/A/cfs  
 Elevation: 697.80cfs

Flood Tools

**USGS**  
Flood Inundation Mapper

JOACHIM CREEK AT DESOTO  
Universal Time (UTC)

16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z	16Z
Feb 27	Feb 28	Feb 29	Mar 1	Mar 2	Mar 3	Mar 4	Mar 5	Mar 6	Mar 7	Mar 8	Mar 9	Mar 10	Mar 11
15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4

Latest observed value: 1.8 ft at 9:55 AM CST  
 Major: 11.0' Flood Stage is 10 ft  
 Minor: 12.0'

Action: 8.0'

Graph Created (10:25AM Mar 3, 2020) Observed Forecast (issued 9:55AM Mar 3)

**USGS**  
science for a changing world

Prepared in cooperation with Missouri Department of Transportation, St. Charles County, and the Cities of O'Fallon and St. Peters, Missouri

**Flood-Inundation Maps for Dardenne Creek in St. Charles County, Missouri, 2019**

Scientific Investigations Report 2014-5180  
Version 1.1, April 2015

**USGS**  
science for a changing world

Prepared in cooperation with the City of Kansas City, Missouri

**Flood-Inundation Maps and Wetland Restoration Suitability Index for the Blue River and Selected Tributaries, Kansas City, Missouri, and Vicinity, 2012**

Scientific Investigations Report 2014-5180  
Version 1.1, April 2015

**USGS**  
science for a changing world

Prepared in cooperation with the city of De Soto, Missouri, and Jefferson County, Missouri

**Flood-Inundation Maps for Joachim Creek, Missouri, 2018**

Scientific Investigations Report 2019-5004

**USGS**  
science for a changing world

Prepared in cooperation with the U.S. Army Corps of Engineers, Metropolitan St. Louis Sewer District, Missouri Department of Transportation, Missouri American Water, Federal Emergency Management Agency Region 7, the city of Pacific, the city of Eureka, the city of Wildwood, and the city of Arnold

**Flood-Inundation Maps of the Meramec River from Eureka to Arnold, Missouri, 2018**

Scientific Investigations Report 2019-5004

U.S. Department of the Interior  
U.S. Geological Survey



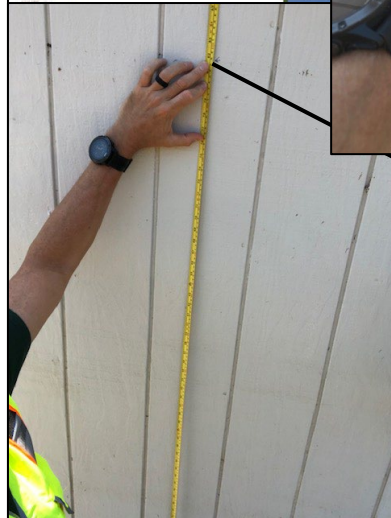
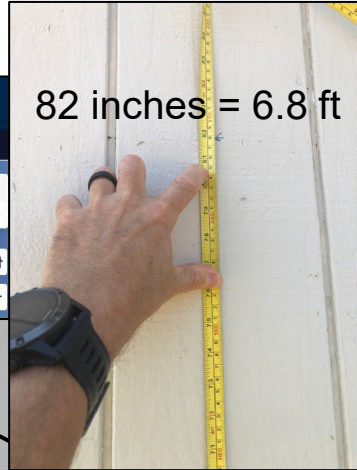


# USGS Flood Inundation Mapping

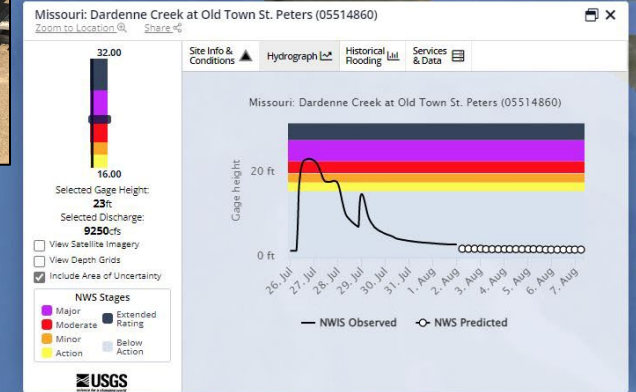
## Local Evaluation

<https://pubs.er.usgs.gov/publication/sir20205060>

Photographs by the U.S. Geological Survey



Water depth ⓘ  
Range: 6.5 - 7.5 ft



Photographs by the  
U.S. Geological Survey



# USGS Flood Inundation Mapping

## Local Evaluation

<https://pubs.er.usgs.gov/publication/sir20205060>

**USGS**  
science for a changing world

Flood Inundation Mapper

**Basemaps**

- Streets
- Satellite
- Hybrid
- Topo
- Terrain
- Gray
- OSM
- NatGeo
- Natl Map

**Map Layers**

- N
- P
- A
- 
- 
- 
- 
- 
- 
- 
- 
- 

**Missouri: Dardenne Creek at Old Town St. Peters**

Zoom to Location | Share

32.00

Site Info & Conditions | Hydrograph | Hoosing & Data

Missouri: Dardenne Creek at Old Town St. Peters (05514860)

Gage Height

20 ft

0 ft

26 Jul 27 Jul 28 Jul 29 Jul 30 Jul 31 Jul 1 Aug 2 Aug 3 Aug 4 Aug 5 Aug 6 Aug 7 Aug

— NWS Observed — NWS Predicted

Selected Gage Height: 16.00

Selected Discharge: 9250 cfs

View Satellite Imagery

View Depth Grids

Include Area of Uncertainty

**NWS Stages**

- Major
- Moderate
- Minor
- Action
- Extended Rating
- Below Action

**USGS**

**Edge of water debris line**

Photographs by the U.S. Geological Survey

**USGS**  
science for a changing world

Prepared in cooperation with Missouri Department of Transportation, St. Charles County, and the Cities of O'Fallon and St. Peters, Missouri

Flood-Inundation Maps for Dardenne Creek in St. Charles County, Missouri, 2019

Scientific Investigations Report 2020-6080

U.S. Department of the Interior  
U.S. Geological Survey

# USGS Notifications – Decision / Regulatory Support

## Enabling Text Message Alerts - Sensors and Data Dissemination

# USGS WaterAlert

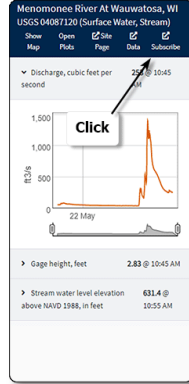
### 1 Find a monitoring location.

Use [National Water Dashboard](#).



### 2 Tell WaterAlert which monitoring location.

Use [National Water Dashboard](#) to connect with WaterAlert.



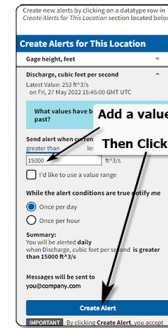
### 3 Select a water condition in which you have an interest.

In WaterAlert, sign in then click one of the water conditions rows - which water conditions are available is dependent on the sensors at the selected monitoring location.



### 4 Set your thresholds.

Enter a threshold value, click **Create alert** and you're done! WaterAlert will send you a notification when water conditions match your thresholds. In the meantime, check out the [User Guide](#).



**Create Alerts for This Location**

**Precipitation, total, inches**  
Sampling method: Calculated Total

**Important:** [Hints for creating effective precipitation alert subscriptions](#) and [Precipitation FAQ](#)

Latest Value: 0.00 in  
on Wed, 24 Aug 2022 13:15:00 GMT UTC

**Send alert when precipitation value is**

Accumulated over a period - one hour  
 Received from sensor

Time in hours

1	6	12	24
---	---	----	----

and value is **greater than**  in

I'd like to use a value range

**While the alert conditions are true notify me**

Once per day  
 Once per hour

**Summary:**  
You will be alerted **daily** when Discharge, cubic feet per second is greater than 15000 R^3/s.

Messages will be sent to dheimann@usgs.gov

**IMPORTANT:** By clicking **Create alert**, you accept the terms and conditions of our [Service Statement](#) and

<https://www.usgs.gov/tools/wateralert>




# NWS Notifications – Decision / Regulatory Support

## *Enabling Text Message Alerts - Hydrology*

- Flood Statements and Warnings
- Flash Flood Watches, Statements, and Warnings

<https://inws.ncep.noaa.gov/>

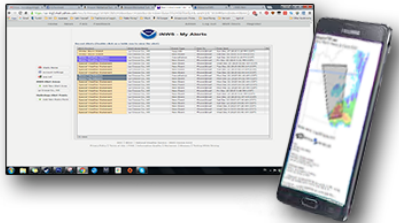




**iNWS - Interactive NWS**  
National Weather Service Mobile Decision Support Services (MDSS)

### iNWS MOBILE ALERTING

Receive customized text message and e-mail alerts for National Weather Service products that you care about.



#### Welcome

InteractiveNWS (iNWS) is the home of new mobile and desktop innovations of the National Weather Service. This application suite allows NWS partners to receive National Weather Service products in new and innovative ways, such as text messaging and mobile-enabled webpages. iNWS strives to fulfill our mission of protecting life and property by using technology to reach out to our customers.

#### Recent News

**Note:** If you are receiving alerts, but never signed up for them, they may be coming from a new FEMA public system called the Wireless Emergency Alerts (WEA). More information can be found at [Wireless Emergency Alerts Consumer Guide](#)

iNWS is an experimental service intended for NWS core partners: emergency managers, community leaders, other government agencies and the electronic media.

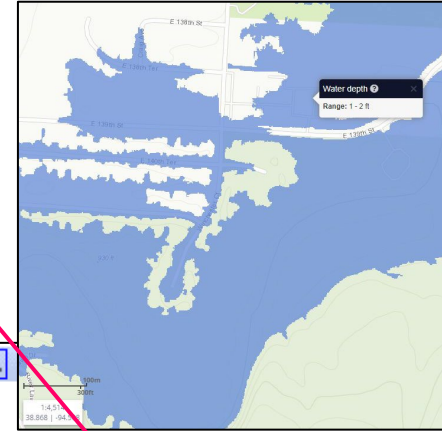
DOC | NOAA | National Weather Service - iNWS Version 6.7.7  
[Privacy Policy](#) | [Terms of Use](#) | [FOIA](#) | [Information Quality](#) | [Disclaimer](#) | [Glossary](#) | [Texting While Driving](#)



# USGS Flood Inundation Mapping

## Precipitation-Based Deterministic Inundation Mapping

Duration (hr.)	Incremental Magnitude (in)							
1	1.5	2.0	2.5	3.0	3.5			
2	2.0	2.5	3.0	3.5	4.0	4.5		
4	2.0	2.5	3.0	3.5	4.0	4.5	5.0	
6	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0



Photograph by the U.S. Geological Survey



**Precipitation Parameter(s):** [about this...](#)

- 1 hour
- 2 hours
- 4 hours
- 6 hours
- 12 hours
- 24 hours

**Alert Threshold Condition:** [about this...](#)

- Greater than (>)
- Less than (<)
- Outside a range (< or >)
- Inside a range (> and <)

Real-time value is greater than:



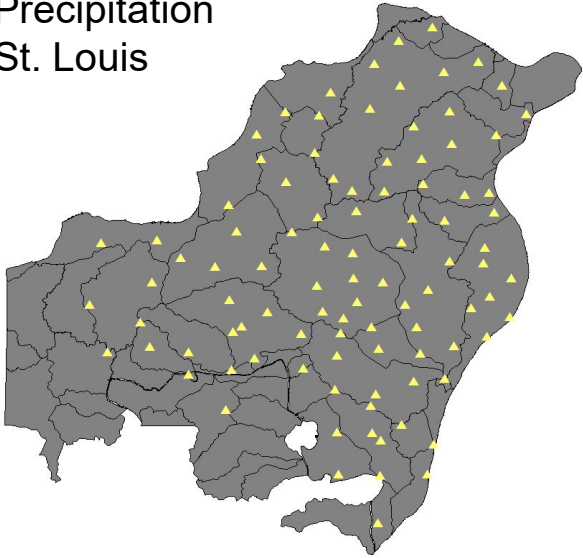
# USGS Flood Inundation Mapping

## *Precipitation-Based Deterministic Inundation Mapping*

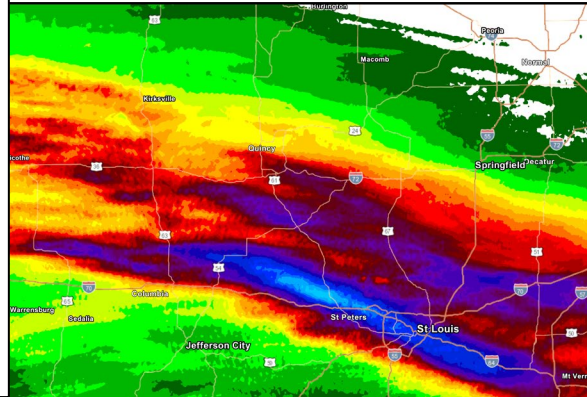
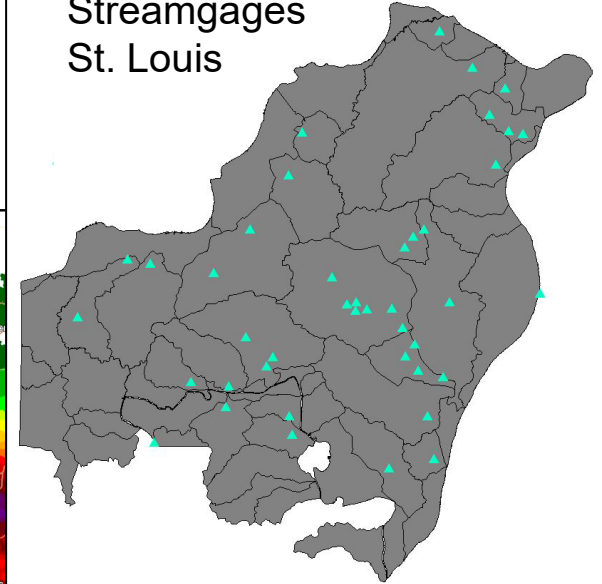
### Potential Application

*July 26th, 2022, Historic  
Flash Flooding in the St.  
Louis Metro Area*

Precipitation  
St. Louis



Streamgages  
St. Louis



<https://www.weather.gov/lx/July262022Flooding>

*Multi-Radar Multi-Sensor (MRMS) 24hr Radar-Estimated Rainfall as  
of 12pm on July 26th.*

# USGS Flood Inundation Mapping

## *Linking Precipitation Forecasts to Inundation Mapping*

### Quantitative Precipitation Forecasts

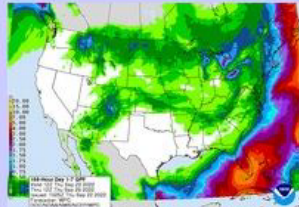
<a href="#">Day 1</a>	<a href="#">Days 1-2</a>	5- and 7-Day Totals
<a href="#">Day 2</a>	<a href="#">Days 1-3</a>	
<a href="#">Day 3</a>	<a href="#">Days 4-5 and Days 6-7</a>	

#### 5-Day Total Precipitation



Valid 12z 09/22/22 - 12z 09/27/22  
[contours only]

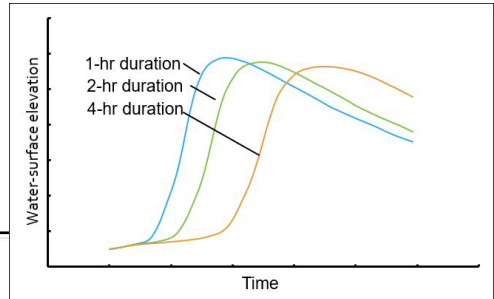
#### 7-Day Total Precipitation



Valid 12z 09/22/22 - 12z 09/29/22  
[contours only]

<https://www.wpc.ncep.noaa.gov/qpf/qpf2.shtml>

Forecasting is in 1-hr or 6-hr increments. How the precipitation is distributed will affect peak water-surface elevation.



### Quantitative Precipitation Statement

Issued by NWS Missouri Basin, Pleasant Hill

[Home](#) | [Current Version](#) | [Previous Version](#) | [Graphics & Text](#) | [Print](#) | [Product List](#) | [Glossary On](#)  
Versions: [1](#) [2](#) [3](#)

***** EAX HSA *****									
1612	0.04	/	0.00	/	0.00	/	0.04	:	FAIRFAX LWR
1619	0.02	/	0.00	/	0.00	/	0.02	:	BURLINGTON JCT
1621	0.02	/	0.00	/	0.00	/	0.02	:	MARYVILLE
1622	0.09	/	0.00	/	0.00	/	0.09	:	ROSENDALE
1624	0.10	/	0.00	/	0.00	/	0.10	:	AGENCY
1625	0.13	/	0.00	/	0.00	/	0.13	:	CASTLE CREEK
1626	0.17	/	0.00	/	0.00	/	0.17	:	SMITHVILLE RES INF
1627	0.18	/	0.00	/	0.00	/	0.18	:	WILKERSON SECOND CR
1628	0.17	/	0.00	/	0.00	/	0.17	:	PLATTE CITY
1634	0.05	/	0.00	/	0.00	/	0.05	:	MILL CR
1635	0.06	/	0.00	/	0.00	/	0.06	:	GRAHAM
1640	0.06	/	0.00	/	0.00	/	0.06	:	BOLCKOW
1641	0.12	/	0.00	/	0.00	/	0.12	:	PLATTSBURG
1701	0.18	/	0.06	/	0.00	/	0.24	:	BANNISTER ROAD
1702	0.18	/	0.06	/	0.00	/	0.24	:	LONGVIEW RES INF
1703	0.18	/	0.06	/	0.00	/	0.24	:	BLUE SPGS RES INF



<https://forecast.weather.gov/product.php?site=NWS&issuedby=KRF&product=QPS>



# USGS Flood Inundation Mapping

## *Linking Precipitation Forecasts to Inundation Mapping*

National Weather Service National Headquarters  
National Weather Service

Home Site Map News Organization Search for:

Local forecast by "City, St" or Zip Code  
City, St  Go

**Quantitative Precipitation Statement**  
Issued by NWS North Central River Forecast Center

[Current Version](#) | [Previous Version](#) | [Text Only](#) | [Print](#) | [Prod](#)  
Versions: 1 2 3 4

**6-hour QPS**

[XML](#) [RSS Feeds](#)

### 6 – Hour Subbasin EADM7URB

```
.ER EADM7URB 20221109 Z DH1800/DC202211091435/PPQFM /DIH06  
.E1 0.000/0.000/0.000/0.000/0.000/0.000/0.000/0.002/  
.E2 0.000/0.000/0.000/0.000/0.000/0.000/0.000/0.000/  
.E3 0.000/0.000/0.000/0.000/0.000/0.000/0.000/0.000/  
.E4 0.000/0.000/0.000/0.000/
```

<https://www.wpc.ncep.noaa.gov/qpf/qpf2.shtml>






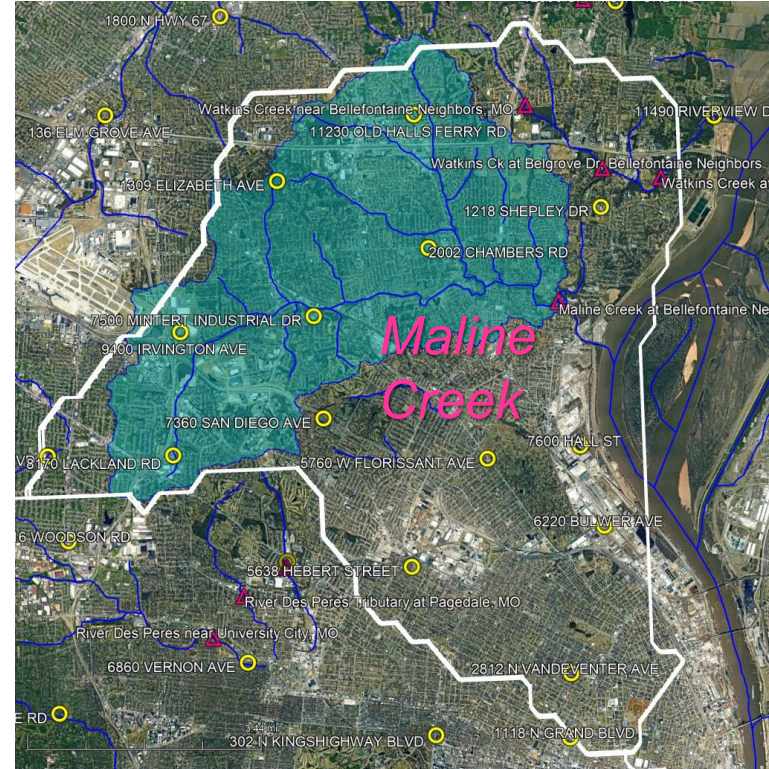
-  Streamgages
-  Precipitation Gages
-  Forecasting Subbasin Boundary

Image taken from Google Earth version 7.3.6



# USGS Flood Inundation Mapping

## *Linking Precipitation Forecasts to Inundation Mapping*



National Weather Service National Headquarters  
National Weather Service

Home Site Map News Organization Search for:

Local forecast by "City, St" or Zip Code  
City, St  Go

**Quantitative Precipitation Statement**  
Issued by NWS North Central River Forecast Center

Current Version | Previous Version | Text Only | Print | Prod  
Versions: 1 2 3 4

6-hour QPS

XML RSS Feeds

Response of 6-hr forecast values above threshold\* are simulated and available for display

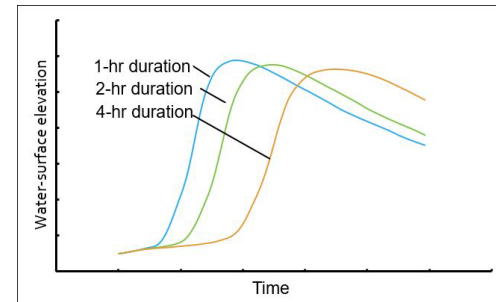
6 – Hour Subbasin EADM7URB

*Example:*

.E1 0.259/0.590/**1.204**/2.524/6.537/1.576/0.316/0.056

*\* Identified based on simulated effects of both magnitude and duration*

Hydrologic response determined for 1.2 inches distributed over 30 min, 1hr, 2hr, 3hr, 4hr, and 6 hr.



# USGS Flood Inundation Mapping

## *Linking Precipitation Forecasts to Inundation Mapping*



National Weather Service National Headquarters  
National Weather Service

Home Site Map News Organization Search for:

Local forecast by "City, St" or Zip Code  
City, St  Go

**Quantitative Precipitation Statement**  
Issued by NWS North Central River Forecast Center

Current Version | Previous Version | Text Only | Print | Prod  
Versions: 1 2 3 4

6-hour QPS

XML RSS Feeds

Response of 6-hr forecast values above threshold\* are simulated and available for display

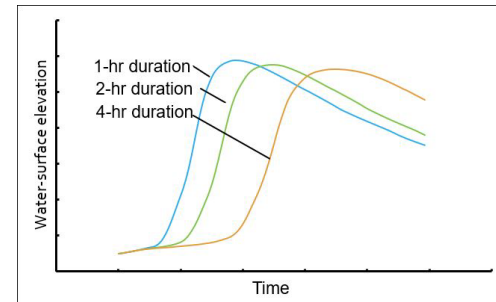
6 – Hour Subbasin EADM7URB

*Example:*

.E1 0.259/0.590/1.204/**2.524**/6.537/1.576/0.316/0.056

*\* Identified based on simulated effects of both magnitude and duration*

Hydrologic response determined for 2.5 inches distributed over 30 min, 1hr, 2hr, 3hr, 4hr, and 6 hr.





# USGS Flood Inundation Mapping

## *Linking Precipitation Forecasts to Inundation Mapping*

KSTL NBM V4.1 NBH GUIDANCE 2/06/2023 1000 UTC **4:00AM**  
 UTC 11 12 13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11

KSTL NBM V4.1 NBH GUIDANCE 2/06/2023 1100 UTC **5:00AM**  
 UTC 12 13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12

KSTL NBM V4.1 NBH GUIDANCE 2/06/2023 1200 UTC **6:00AM**  
 UTC 13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12 13

KSTL NBM V4.1 NBH GUIDANCE 2/06/2023 1300 UTC **7:00AM**  
 UTC 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14

KSTL NBM V4.1 NBH GUIDANCE 2/06/2023 1400 UTC **8:00AM**  
 UTC 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15

From 6-hour precipitation forecasts to **9:00AM...**  
 1-hour precipitation forecasts

*Why? How do we know where the bulk of the rain fell in 6 hours....*



NATIONAL WEATHER SERVICE  
 NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOME FORECAST PAST WEATHER SAFETY INFORMATION EDUCATION NEWS SEARCH ABOUT

National Blend of Models: Text Products Meteorological Development Laboratory

Weather.gov • Meteorological Development Laboratory • National Blend of Models: Text Products

Statistical Postprocessing Digital Forecasts Verification Storm Surge Decision Support Tools Web Services NOAA VLab About MDL

**Attention users**

Due to operational constraints, this site only will provide bulletins for Operational NBM text products for the following cycles: 01Z, 07Z, 13Z, 19Z. Bulk text files for ALL CYCLES are available at <https://nomads.ncep.noaa.gov/pub/datasets/ncep/blend/text/>

Navigation

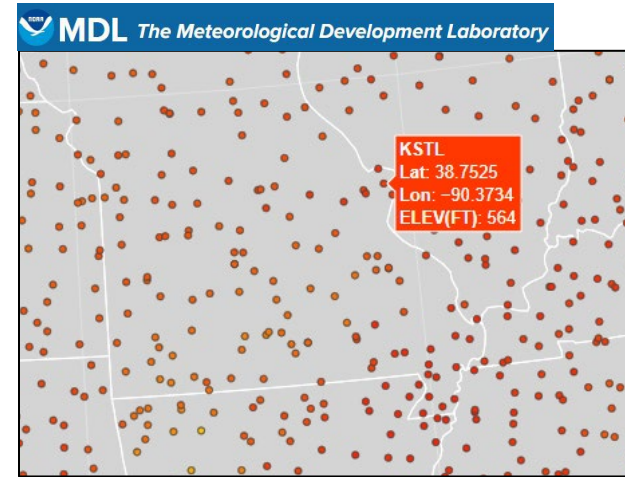
- MDL Home
- National Blend of Models
- NBM Web Page\* (NOAA login required)

**NBM Text Products**

**Note to users:**  
 This page is not updated by the operational job stream. Files may not be available for all dates and/or cycles, and the most recent cycle times may not always contain the most recent data.

Operational bulk text files can be found 24/7 for all cycles at: <https://nomads.ncep.noaa.gov/pub/datasets/ncep/blend/text/>

[https://www.weather.gov/mdl/nbm\\_text?ele=nbh,nbs&sta=klxt&download=yes](https://www.weather.gov/mdl/nbm_text?ele=nbh,nbs&sta=klxt&download=yes)



# USGS Flood Inundation Mapping

## *Precipitation-based Visualization for Decision and Regulatory Support*



<https://fim.wim.usgs.gov/fim/>

Web Informatics & Mapping

**Web Informatics & Mapping**

Modern Web Development in support of delivering the best of the USGS to the public.



**Muddy Creek at Harrisonville Precipitation-Driven Flood Inundation Mapper**

Select an antecedent moisture condition:  
DRY NORMAL WET

Select a precipitation duration (hours):  
2

Select a precipitation magnitude (inches):  
2.85

Precipitation Date/Time (CDT)	Precipitation Duration (hours)	Precipitation Total (inches)
Sep 23 16:00	0.5	0
Sep 23 15:30	1	0
Sep 23 14:30	2	0
Sep 23 13:30	3	0
Sep 23 12:30	4	0

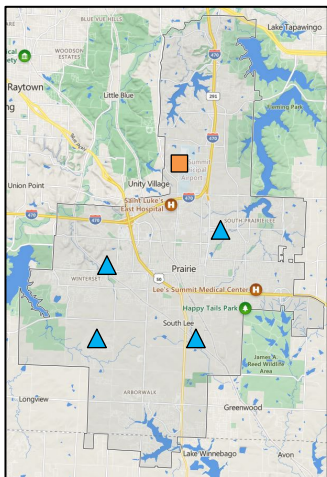
# USGS Flood Inundation Mapping

## Precipitation-based Visualization for Decision and Regulatory Support

### Interactive and Automated

Precipitation Gages  
Illustrative purposes only ▲

National Weather Service  
(NWS) Forecast location  
KLXT ■



NBH TEXT BULLETIN - STATION KLXT

# KLXT NBM V4.0 NBH GUIDANCE 12/08/2022 1300 UTC

UTC 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14

Basemaps

Flood Scenarios

Select an antecedent moisture condition:

DRY **NORMAL** WET ⓘ

Select a precipitation duration (hours):

0.5 1 2 3 4 6 8 12

Select a precipitation magnitude (inches):

1.67 1.96 2.45 2.85 3.42 3.86 4.3 4.76 5.37 5.83

Select an antecedent moisture condition:

DRY **NORMAL** WET ⓘ

Select a precipitation duration (hours):

0.5 1 2 3 4 6 8 12

Select a precipitation magnitude (inches):

1.67 1.96 2.45 2.85 3.42 3.86 4.3 4.76 5.37 5.83

Recent Precipitation Conditions ⓘ

Data Last Retrieved from NWS on Sep 23 at 16:32

Precipitation Date/Time (CDT)	Precipitation Duration (hours)	Precipitation Total (inches)
Sep 23 16:00	0.5	0
Sep 23 15:30	1	0
Sep 23 14:30	2	0
Sep 23 13:30	3	0
Sep 23 12:30	4	0

1-hour precipitation forecast updated every 6 hours

*"At a glance" 24-hr forecast with potential flooding in hours 9 and 10.*

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24

15-min	30-min	1-hr	2-hr	3-hr	4-hr	6-hr
986 ft	982 ft	980 ft				



Conceptual



# USGS Flood Inundation Mapping

## Precipitation-based Visualization for Decision and Regulatory Support

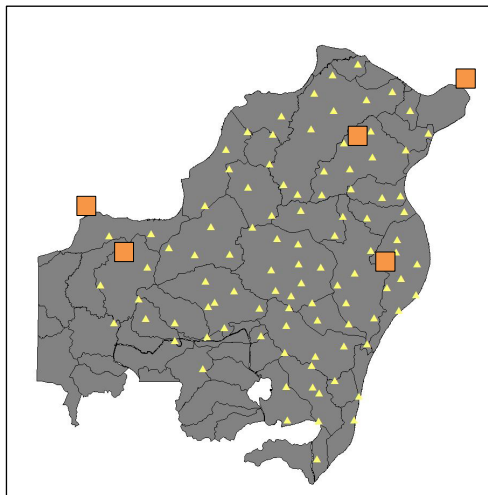
Interactive and Automated

Precipitation Gages

Illustrative purposes only ▲

National Weather Service

(NWS) Forecast locations ■



Conceptual

NBH TEXT BULLETIN - STATION KLXT

# KLXT NBM V4.0 NBH GUIDANCE 12/08/2022 1300 UTC

UTC 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14

Basemaps

Flood Scenarios

Select an antecedent moisture condition:

DRY **NORMAL** WET

Select a precipitation duration (hours):

0.5 1 2 3 4 6 8 12 24

Select a precipitation magnitude (inches):

1.67 1.96 2.45 2.85 3.42 3.86 4.3 4.76 5.37 6.83

Recent Precipitation Conditions

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Sep 23 12:30	4	0

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DRY **NORMAL** WET

Select a precipitation duration (hours):

0.5 1 2 3 4 6 8 12

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1.67 1.96 2.45 2.85 3.42 3.86 4.3 4.76 5.37 6.83

1-hour precipitation forecast updated every 6 hours

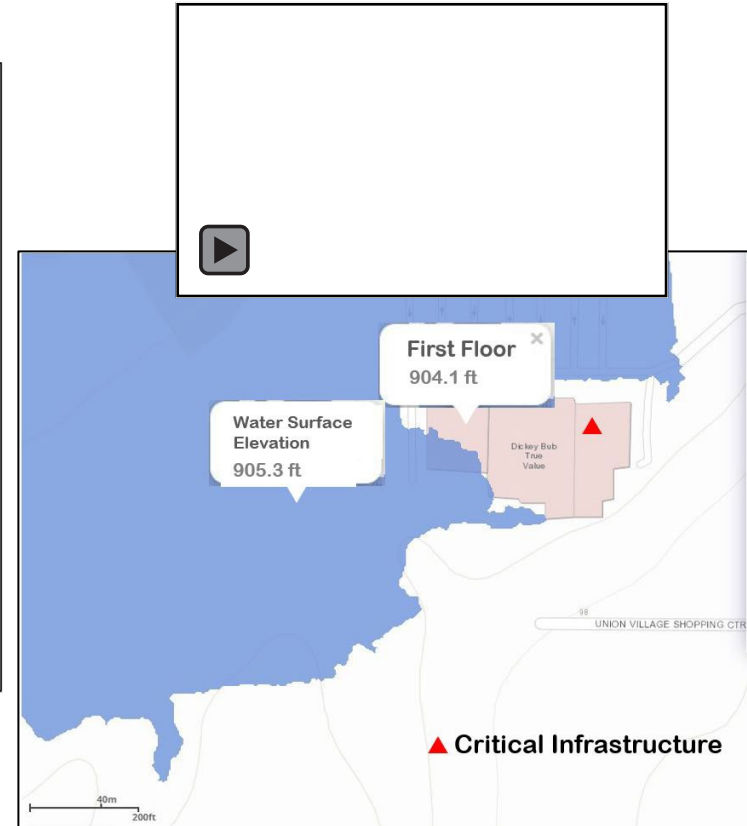
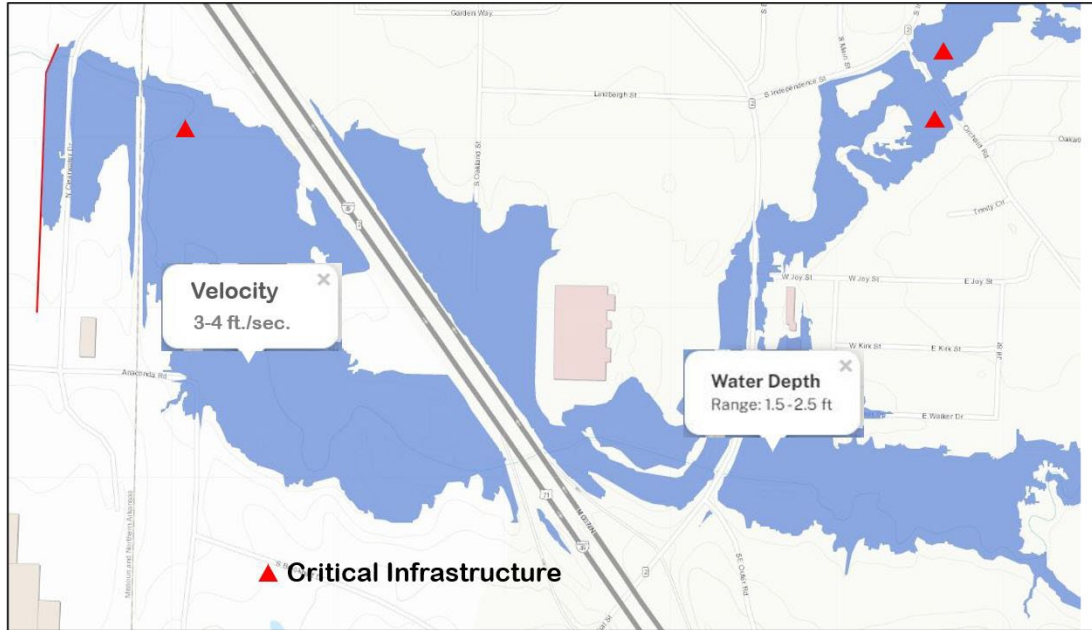
*"At a glance" 24-hr forecast with potential flooding in hours 9 and 10.*

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24

15-min	30-min	1-hr	2-hr	3-hr	4-hr	6-hr
986 ft	982 ft	980 ft				

# USGS Flood Inundation Mapping

*Precipitation-based Visualization for Decision and Regulatory Support*  
*Value-added Data Analytics*



<https://fim.wim.usgs.gov/fim/>

# USGS Flood Inundation Mapping

## USGS – FEMA Partnership Loss estimation



<https://fim.wim.usgs.gov/fim/>



# FEMA

Hazus Loss Library
About Library Use Cases Help

Grandview, MO (Gage 06893750)

### Little Blue River at Grandview, MO (Gage 06893750)

Hazus Report Generated: 12-24-2021

USGS Flood Inundation Mapper

Basemaps + Map Layers -

Missouri Little Blue River at Grandview

Water depth: 5.5 - 7.5 ft

#### FEMA Hazus Risk Report - Flood

##### Lbgrandmo\_21

Economic Loss by Occupancy Type

Economic Impacts by Census Block (25 Blocks with Losses)

Water Depth (ft)

Top Census Blocks	County	State	Total
290950134161028	Jackson	MO	\$4,388
290950134161017	Jackson	MO	\$3,249
290950134161022	Jackson	MO	\$2,238
290950134161031	Jackson	MO	\$1,874
290950134033002	Jackson	MO	\$749K
290950134161032	Jackson	MO	\$710K
290950134161009	Jackson	MO	\$666K

Top Census Blocks	Displaced Population	Total Disasters	People Needing Shelter
290950134161028	93	5	5
290950134161017	75	7	7
290950134161022	72	6	6
290950134033002	68	2	2
290950134161031	37	3	3
290950134161042	27	1	1
290950134161029	26	3	3

Type	Tons
Fish	409K
Foundation	7,32K
Structure	264K

Loss Estimates	View Full Table																														
<table border="1"> <thead> <tr> <th>Stage (ft)</th> <th>Total Loss (\$)</th> <th>Building Loss (\$)</th> <th>Content Loss (\$)</th> <th>Total Content Loss (\$)</th> </tr> </thead> <tbody> <tr> <td>19</td> <td>8,872,000</td> <td>4,584,000</td> <td>2,165,000</td> <td>528</td> </tr> <tr> <td>20</td> <td>10,999,000</td> <td>6,295,000</td> <td>2,920,000</td> <td>749</td> </tr> <tr> <td><b>21</b></td> <td><b>17,651,000</b></td> <td><b>8,328,000</b></td> <td><b>4,117,000</b></td> <td><b>937</b></td> </tr> <tr> <td>22</td> <td>22,702,000</td> <td>10,037,000</td> <td>5,318,000</td> <td>1,141</td> </tr> <tr> <td>23</td> <td>29,744,000</td> <td>13,991,000</td> <td>7,439,000</td> <td>1,462</td> </tr> </tbody> </table>	Stage (ft)	Total Loss (\$)	Building Loss (\$)	Content Loss (\$)	Total Content Loss (\$)	19	8,872,000	4,584,000	2,165,000	528	20	10,999,000	6,295,000	2,920,000	749	<b>21</b>	<b>17,651,000</b>	<b>8,328,000</b>	<b>4,117,000</b>	<b>937</b>	22	22,702,000	10,037,000	5,318,000	1,141	23	29,744,000	13,991,000	7,439,000	1,462	
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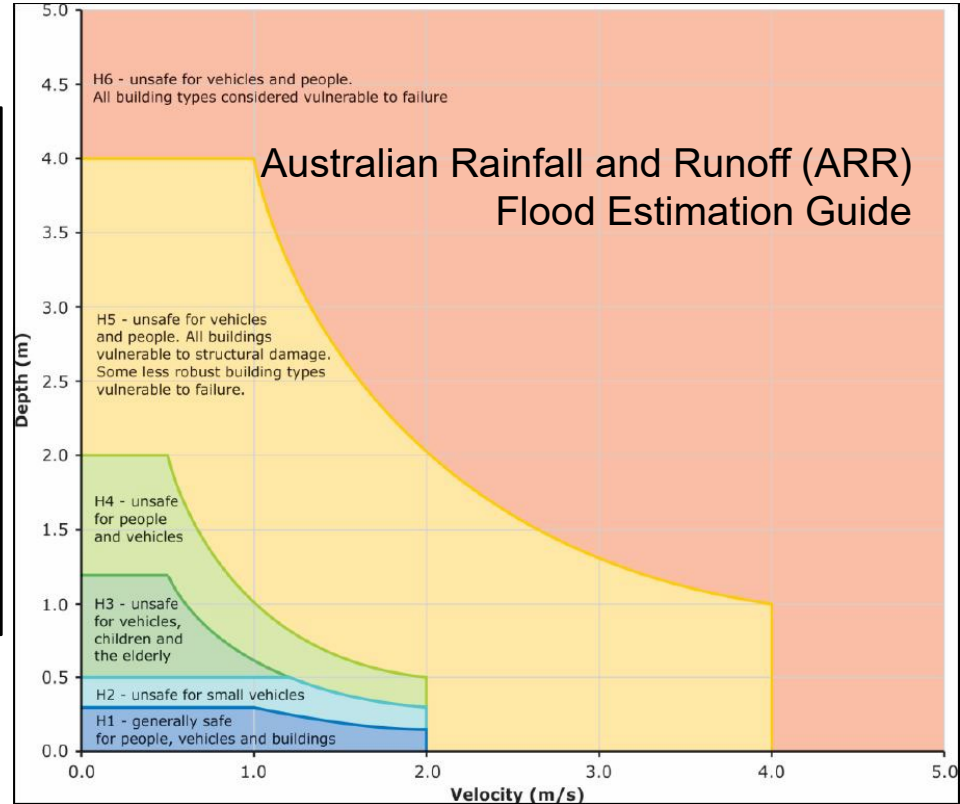


# USGS Flood Inundation Mapping

*Visualization for Decision and Regulatory Support  
People, Vehicles, and Buildings*

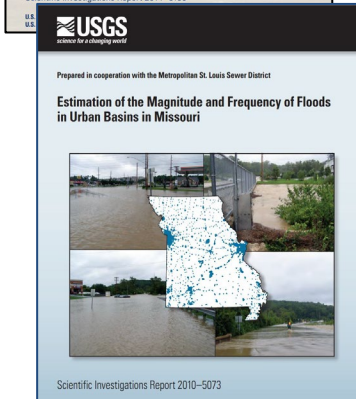
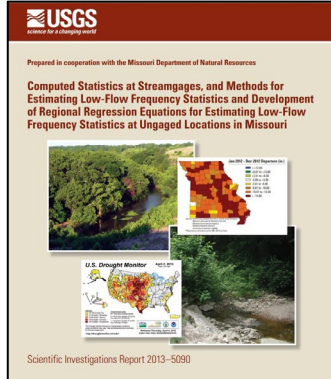
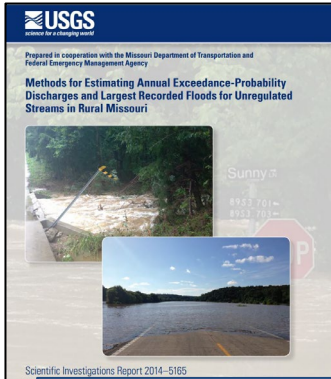


<https://arr.ga.gov.au/home>



# USGS Streamstats

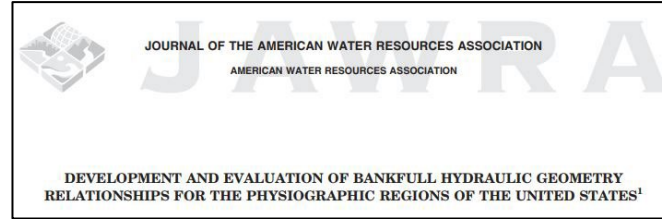
Core Function: Basin Characteristics => State-based Regional Regression Equations => Streamflow Statistics



### Regression Based Scenarios

- Peak-Flow Statistics
- Low-Flow Statistics
- Bankfull Statistics
- Maximum Probable Flood Statistics

### Basin Characteristics



<https://streamstats.usgs.gov/ss/>

USGS StreamStats

SELECT A STATE / REGION  
Missouri

IDENTIFY A STUDY AREA  
Basin Delineated

Step 5: Your delineation is complete. You can now clear, edit, or download your basin, or choose a state or regional study-specific function (if available). Click **continue** when you are ready.

Clear Basin

Edit Basin

Download Basin

or

Continue

SELECT SCENARIOS

BUILD A REPORT

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Exploration Tools

Roark Creek

Layers

- Base Maps
- Application Layers
- Streamgages
- Slough Station Continuous Record
- Low-Flow Partial Record
- Peak-Flow Partial Record
- Peak and Low-Flow Partial Record
- Stage Only
- Low-Flow Partial Record Stage
- Microhabitat Record
- Unknown
- Basin Clicked Point

Zoom Level: 13  
Map Scale: 1:72,223  
Lat: 36.8566, Lon: -93.3568



# USGS Streamstats

## Customizations: Bankfull Statistics

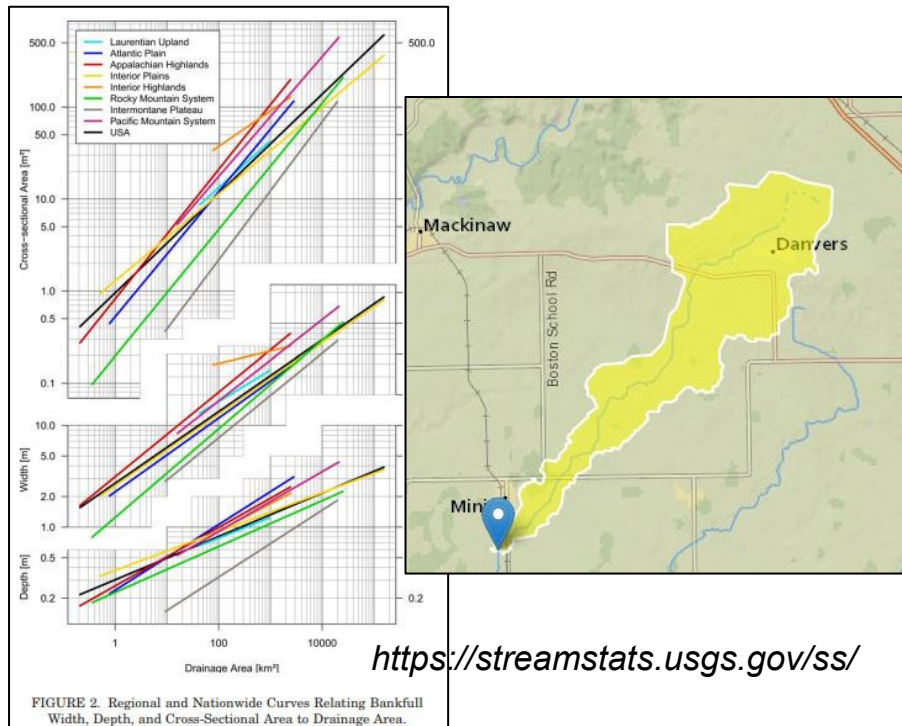


FIGURE 2. Regional and Nationwide Curves Relating Bankfull Width, Depth, and Cross-Sectional Area to Drainage Area.



Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G., 2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p.

### Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	23.16	square miles	0.07722	59927.7393

### Bankfull Statistics Flow Report [Interior Plains D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	35.3	ft
Bieger_D_channel_depth	2.73	ft
Bieger_D_channel_cross_sectional_area	95.1	ft <sup>2</sup>

### Bankfull Statistics Flow Report [Central Lowland P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	39.3	ft
Bieger_P_channel_depth	3.16	ft
Bieger_P_channel_cross_sectional_area	88.4	ft <sup>2</sup>

### Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	37.4	ft
Bieger_USA_channel_depth	2.35	ft
Bieger_USA_channel_cross_sectional_area	93.3	ft <sup>2</sup>

### Bankfull Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Bieger_D_channel_width	35.3	ft
Bieger_D_channel_depth	2.73	ft
Bieger_D_channel_cross_sectional_area	95.1	ft <sup>2</sup>
Bieger_P_channel_width	39.3	ft
Bieger_P_channel_depth	3.16	ft
Bieger_P_channel_cross_sectional_area	88.4	ft <sup>2</sup>
Bieger_USA_channel_width	37.4	ft
Bieger_USA_channel_depth	2.35	ft
Bieger_USA_channel_cross_sectional_area	93.3	ft <sup>2</sup>



# USGS Streamstats

## Customizations: Bankfull Statistics

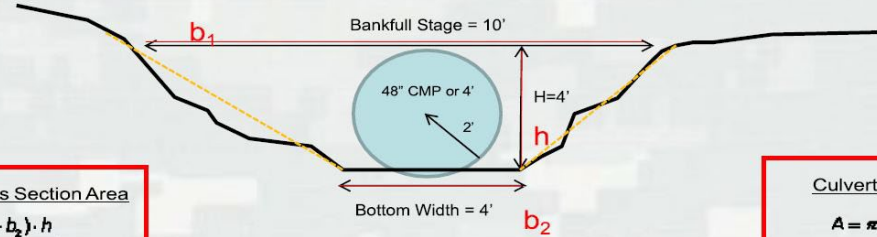
Missouri Nationwide Regional Permitting  
Regional Conditions (2021)

Stream Type	% of crossing profile that shall remain open
Perennial	Designed to allow an 85% opening to include the culvert(s) and area above the crossing up to the bankfull area.
Intermittent	Designed to allow a 50% opening to include the culvert(s) and area above the crossing up to the bankfull area.

## Regional Condition 1 – Stream Crossings

Intermittent Stream  
Approximate Minimum Area

Culvert cross-sectional area must be ~50% of stream x-sectional area



Channel Cross Section Area

$$A = \frac{(b_1 + b_2) \cdot h}{2}$$

$$\text{Area} = \frac{(10 + 4) \cdot 4}{2} = 28\text{ft}^2$$

$$28\text{ft}^2 \times 50\% = 14\text{ft}^2$$

Culvert Area

$$A = \pi \cdot r^2$$

$$\text{Area} = 3.14(2)^2 = 2.6\text{ft}^2$$

~50% ?

<https://www.mvs.usace.army.mil/Portals/54/docs/regulatory/permits/2021MONWPRC.pdf?ver=2GGFgQfT4aJgycG0OVU4lg%3d%3d>



Graphic is not to scale



BUILDING STRONG®

# USGS Streamstats - Iowa

## Customizations: Flow Anywhere – Flow Duration Curve Transfer

Flow-Duration Statistics Flow Report [Statewide Flow Duration 2012 5232]

PI: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
1 Percent Duration	1800	ft <sup>3</sup> /s	23.5
5 Percent Duration	608	ft <sup>3</sup> /s	23.6
10 Percent Duration	324	ft <sup>3</sup> /s	24.2
15 Percent Duration	251	ft <sup>3</sup> /s	24.6
20 Percent Duration	188	ft <sup>3</sup> /s	22.1
30 Percent Duration	126	ft <sup>3</sup> /s	17.1
40 Percent Duration	84.8	ft <sup>3</sup> /s	14.9
50 Percent Duration	61.1	ft <sup>3</sup> /s	16.4
60 Percent Duration	41.9	ft <sup>3</sup> /s	22.1
70 Percent Duration	25.7	ft <sup>3</sup> /s	32.4
80 Percent Duration	9.66	ft <sup>3</sup> /s	40.1
85 Percent Duration	6.97	ft <sup>3</sup> /s	42.5
90 Percent Duration	4.86	ft <sup>3</sup> /s	51
95 Percent Duration	2.45	ft <sup>3</sup> /s	74.9
99 Percent Duration	1.15	ft <sup>3</sup> /s	

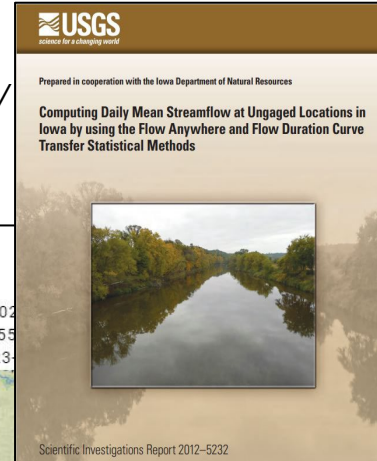
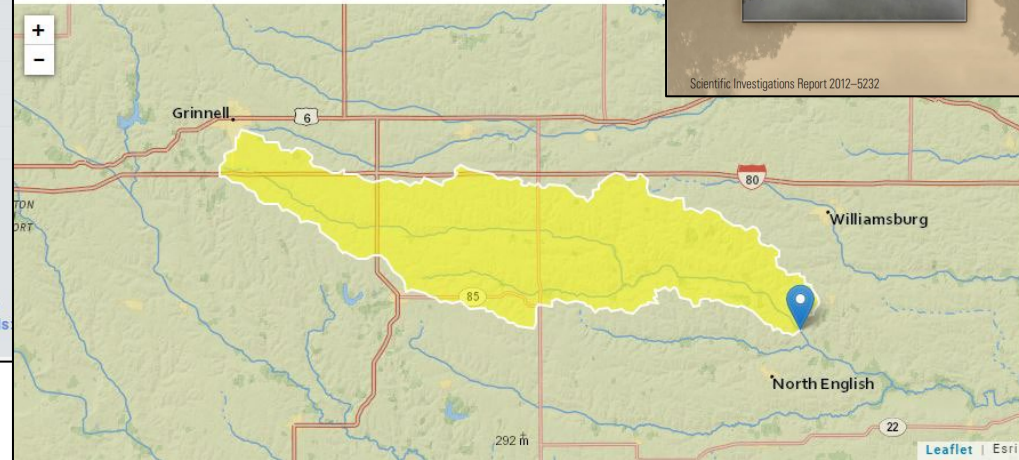
Flow-Duration Statistics Citations

Linhart, S.M., Nania, J.F., Sanders, C.L., Jr., and Archfield, S.A., 2012, Computing daily mean streamflow at ungaged locations in Iowa by using the Flow Anywhere and Flow Duration Curve Transfer statistical methods Geological Survey Scientific Investigations Report 2012-5232, 50 p.

<https://pubs.usgs.gov/sir/2012/5232/sir2012-5232.pdf>

### StreamStats Report

Region ID: IA  
Workspace ID: IA202  
Clicked Point (Latitude, Longitude): 41.55  
Time: 2023



<https://streamstats.usgs.gov/ss/>

# USGS Streamstats - Colorado

Customizations: Peak flow for small basins/storm runoff tools

Implementation of TR-55 and Rational Methods

**Study Area Storm Event Runoff Summary**

TR55 Rational Method

Enter custom values below or Calculate Missing Parameters. Click Continue to view peak discharge and hydrograph.

24 Hour 100 Year Precipitation

Precipitation (inches): 1

Drainage Area (square miles): 5

Runoff-Curve Number (dimensionless): 68

Peak Runoff from 24 Hour 100 Year Precipitation (TR55)

Clear All Recalculate Results

USGS StreamStats

SELECT A STATE / REGION  
Colorado

IDENTIFY A STUDY AREA  
Basin Delineated

Clear Basin Edit Basin

Specific Functions  
additional functions are Colorado.

For Upstream Regulation  
in Storm Runoff Models

Download Basin

or

Continue

SELECT SCENARIOS

BUILD A REPORT

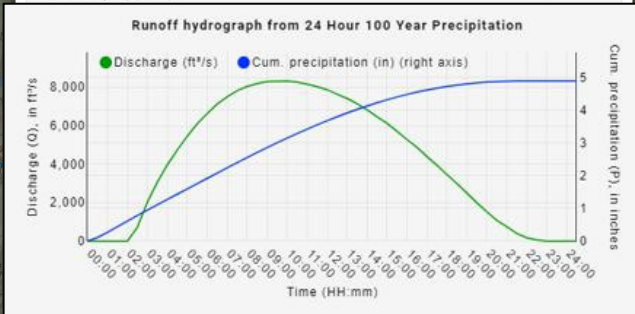
POWERED BY WIM

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Accessibility FOIA Privacy Policy & Notices

Peak Runoff from 24 Hour 100 Year Precipitation (TR55)

Summary

Peak runoff (cubic feet per second):	8330
Total infiltration (inches):	2.4
Total excess precip (inches):	2.49



Tabular Hydrograph

Time	DRNAREA	P	RCN	Duration	Ia	S	dP	P-Ia	PI	Pe	dPe	Q
00:00	15.7	0.00	76.48	24	0.615	3.08	0	-0.615	0	0	0	0
00:30	15.7	0.11	76.48	24	0.615	3.08	0.111	-0.504	0.111	0	0	0
01:00	15.7	0.27	76.48	24	0.615	3.08	0.156	-0.349	0.156	0	0	0
01:30	15.7	0.44	76.48	24	0.615	3.08	0.171	-0.177	0.171	0	0	0
02:00	15.7	0.61	76.48	24	0.615	3.08	0.174	-0.00381	0.174	0	0	0
02:30	15.7	0.78	76.48	24	0.615	3.08	0.171	0.167	0.162	0.00859	0.00859	725
03:00	15.7	0.95	76.48	24	0.615	3.08	0.167	0.334	0.143	0.0326	0.0241	2030
03:30	15.7	1.11	76.48	24	0.615	3.08	0.163	0.497	0.127	0.0691	0.0365	3080
04:00	15.7	1.27	76.48	24	0.615	3.08	0.162	0.659	0.115	0.116	0.0471	3980
04:30	15.7	1.43	76.48	24	0.615	3.08	0.161	0.82	0.105	0.172	0.0563	4750
05:00	15.7	1.60	76.48	24	0.615	3.08	0.161	0.981	0.0966	0.237	0.0648	5470
05:30	15.7	1.76	76.48	24	0.615	3.08	0.162	1.14	0.0895	0.31	0.0724	6110
06:00	15.7	1.92	76.48	24	0.615	3.08	0.161	1.3	0.0826	0.388	0.0788	6650
06:30	15.7	2.08	76.48	24	0.615	3.08	0.161	1.47	0.0767	0.473	0.0846	7150

Report About Help

Layers

- Base Maps
- Application Layers
- Regulation Points
- CO Map Layers
- National Layers

Lyons Niwot Boulder Superior

Golden



<https://streamstats.usgs.gov/ss/>



# USGS Streamstats - Colorado

Customizations: Peak flow for small basins/storm runoff tools

Implementation of TR-55 and Rational Methods

<https://streamstats.usgs.gov/ss/>

Study Area Storm Event Runoff Summary

SELECT A STATE / REGION  
Colorado

TR55 Rational Method

Enter custom values below or Calculate Missing Parameters. Click

6 Hour 2 Year Precipitation

Precipitation Intensity (inches/hour)

0.5

Drainage Area (acres)

120

Soil Runoff Coefficient (dimensionless)

0.4

Clear All

## Typical Runoff Coefficient Table

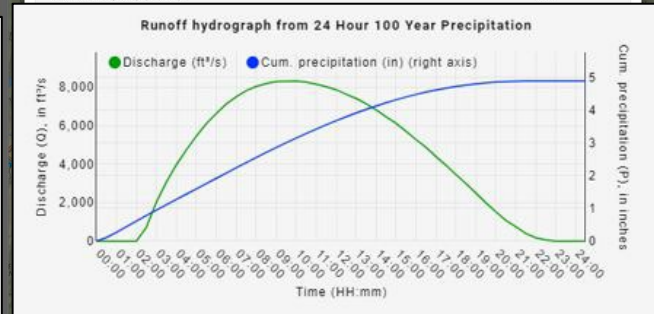
Rural Land Use	Lower Bounds	Upper Bounds
Cultivated Land, Sand & Gravel Soils	0.25	0.35
Cultivated Land, Sandy Loam Soils	0.20	0.52
Cultivated Land, Clay & Silt Loam Soils	0.40	0.72
Cultivated Land, Tight Clay Soils	0.50	0.82
Pasture, Sandy Loam Soils	0.10	0.22
Pasture, Clay & Silt Loam Soils	0.30	0.42
Pasture, Tight Clay Soils	0.40	0.60
Meadow	0.10	0.50
Woodland, Sandy Loam Soils	0.10	0.30
Woodland, Clay & Silt Loam Soils	0.30	0.50
Woodland, Tight Clay Soils	0.40	0.60
Bare Rock	0.82	0.94
Desert	0.30	0.55

USGS StreamStats

Peak Runoff from 24 Hour 100 Year Precipitation (TR55)

Summary

Peak runoff (cubic feet per second):	8330
Total infiltration (inches):	2.4
Total excess precip (inches):	2.49



Tabular Hydrograph

Time	DRNAREA	P	RCN	Duration	Ia	S	dP	P-Ia	PI	Pe	dPe	Q
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01:00	15.7	0.27	76.48	24	0.615	3.08	0.156	-0.349	0.156	0	0	0
01:30	15.7	0.44	76.48	24	0.615	3.08	0.171	-0.177	0.171	0	0	0
02:00	15.7	0.61	76.48	24	0.615	3.08	0.174	-0.00381	0.174	0	0	0
02:30	15.7	0.78	76.48	24	0.615	3.08	0.171	0.167	0.162	0.00859	0.00859	725
03:00	15.7	0.95	76.48	24	0.615	3.08	0.167	0.334	0.143	0.0326	0.0241	2030
03:30	15.7	1.11	76.48	24	0.615	3.08	0.163	0.497	0.127	0.0691	0.0365	3080
04:00	15.7	1.27	76.48	24	0.615	3.08	0.162	0.659	0.115	0.116	0.0471	3980
04:30	15.7	1.43	76.48	24	0.615	3.08	0.161	0.82	0.105	0.172	0.0563	4750
05:00	15.7	1.60	76.48	24	0.615	3.08	0.161	0.981	0.0966	0.237	0.0648	5470
05:30	15.7	1.76	76.48	24	0.615	3.08	0.162	1.14	0.0895	0.31	0.0724	6110
06:00	15.7	1.92	76.48	24	0.615	3.08	0.161	1.3	0.0826	0.388	0.0788	6650
06:30	15.7	2.08	76.48	24	0.615	3.08	0.161	1.47	0.0767	0.473	0.0846	7150

Report About Help

Layers

- Base Maps
- Application Layers
- Regulation Points
- CO Map Layers
- National Layers

Lyons

Niwot

Boulder

Louisville

Superior

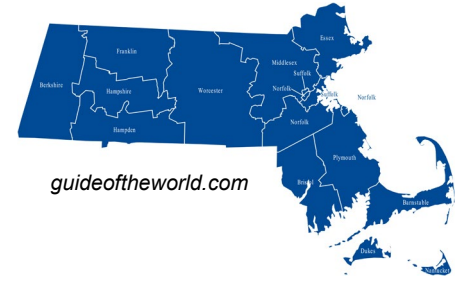
Wheat Ridge

Golden



# USGS Streamstats

## *Massachusetts: Statewide Hydraulic Modeling Pilot*



### Goal:

To give communities the ability to create a preliminary design for a new or existing stream crossing replacement.

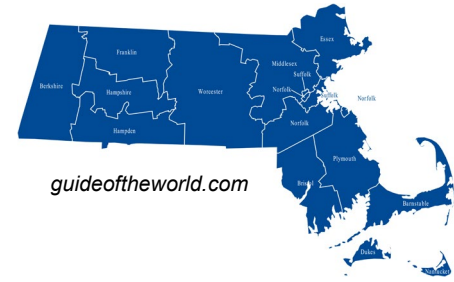
### Proposed MA Statewide Hydraulic Modeling Tool:

Help communities facilitate permitting of replacement projects that will meet Wetlands Protection Act requirements while minimizing associated adverse impacts.

Provide preliminary evaluation of hydrology and hydraulics and ecological conditions for potential replacements projects.

# USGS Streamstats

## Massachusetts: Statewide Hydraulic Modeling Pilot



guideoftheworld.com

**NAACC** AQUATIC CONNECTIVITY Stream Crossing Survey DATA FORM

Crossing Code: \_\_\_\_\_ Local ID: \_\_\_\_\_

Date Observed: \_\_\_\_\_ Lead Observer: \_\_\_\_\_

Town/County: \_\_\_\_\_ Stream: \_\_\_\_\_

Road: \_\_\_\_\_ Type:  MULTILANE  PAVED  UNPAVED

GPS Coordinates (Decimal degrees): \_\_\_\_\_ % Latitude: \_\_\_\_\_

**CROSSING DATA**

Location Description

Crossing Type:  BRIDGE  CULVERT  MULTIPLE CULVERT  FORD  NO CROSSING  REMOVED CROSS  BURIED STREAM  INACCESSIBLE  PARTIALLY INACCESSIBLE  NO UPSTREAM CHANNEL  BRIDGE ACKG

Photo IDs:  PRELIT  DOWNLIT  UPSTREAM  DOWNSTREAM

Flow Condition:  NO FLOW  TYPICAL-LOW  MODERATE  HIGH  Crossing Condition:  CR  F

Tidal Site:  YES  NO  UNKNOWN  Alignment:  FLOW-ALIGNED  SKEWED <45°  Road Fill Height: \_\_\_\_\_

Bankfull Width: \_\_\_\_\_ Confidence:  HIGH  LOW/ESTIMATED  Construction:  SEVERE  M

Tailwater Scour Pool:  NONE  SMALL  LARGE  SINKS-FILL CHANNEL & BANK

Crossing Comments: \_\_\_\_\_

**STRUCTURE 1**

Structure Material:  METAL  CONCRETE  PLASTIC  WOOD  ROCK/STONE

Outlet Shape:  BELL  BOX  BAY  BENT  UNKNOWN  REARDED  Outlet Arming: \_\_\_\_\_

Outlet Grade: \_\_\_\_\_ AT STREAM GRADE  FREE FALL  CASCADE  FREE FALL DRYD/CASCADE  CLOS

Outlet Dimensions: A. Width: \_\_\_\_\_ B. Height: \_\_\_\_\_ C. Substrate/Water Width: \_\_\_\_\_

Outlet Drop to Water Surface: \_\_\_\_\_ Outlet Drop to Stream Bottom: \_\_\_\_\_ E. Abutment Hgt: \_\_\_\_\_

L. Structure Length: \_\_\_\_\_ (Channel length from water to water)

**INLET**

Inlet Shape:  1  2  3  4  5  6  FORD  UNKNOWN  REMOVED

Inlet Type:  PROJECTING  HEADWALL  WINGWALLS  HEADWALL & WINGWALLS  MITERED TO SLOPE  OTHER

Inlet Grade: \_\_\_\_\_ AT STREAM GRADE  INLET DROP  PERCHED  CLOGGED/COLLAPSED/SUBMERGED

Inlet Dimensions: A. Width: \_\_\_\_\_ B. Height: \_\_\_\_\_ C. Substrate/Water Width: \_\_\_\_\_

Slope %: \_\_\_\_\_ Slope Confidence:  HIGH  LOW  Internal Structures:  NONE  BAFFLES

Structure Substrate Matches Stream:  NONE  COMPARABLE  CONTRASTING  NOT APPROPRIATE  UNK

Structure Substrate Type: \_\_\_\_\_ NONE  25%  50%  75%  100%  UNKNOW

Structure Substrate Coverage:  NONE  25%  50%  75%  100%  UNKNOW

Physical Barriers:  NONE  DEBRIS/SEDIMENT/ROCK  DEFORMATION  FREE FALL  FENC

Severity: \_\_\_\_\_ (Changes checked based on barrier type(s) above)  NONE  MINOR  MODERATE  SEVERE

Water Depth Matches Stream:  YES  NO-HALLOWER  NO-DEEPER  UNKNOW  DRY

Water Velocity Matches Stream:  YES  NO-FASTER  NO-SLOWER  UNKNOW  DRY

Dry Passage through Structure?:  YES  NO  UNKNOW  Height above Dry Passage: \_\_\_\_\_

Develop elevation derived DEMs from Quality Level 2 (QL-2) lidar

Survey 16 culverts/bridges and associated stream channel elevations and complete stream crossing assessments

Complete NAACC stream crossing assessments in pilot watershed (UMass Amherst)

Compile a GIS aquatic habitat quality and connectivity restoration potential data layers for stream crossing locations (UMass Amherst)

Develop hydraulic model runs for a selected MassDOT hydraulic design flow(s) and to meet the Massachusetts Stream Crossing Standards

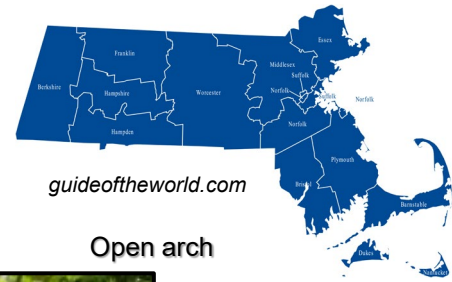
Integrate the hydraulic modeling tool developed for the pilot watershed into the USGS StreamStats web application





# USGS Streamstats

## Massachusetts: Statewide Hydraulic Modeling Pilot



0.82 Openness ratio

Large span, 1.2x bankfull width

Open arch

Embedment

Natural substrate



Photograph by Paul Nguyen  
University of Massachusetts, Amherst

Banks, dry passage

Comparable depth and velocity, up & downstream

**MASSACHUSETTS RIVER AND STREAM CROSSING STANDARDS**  
Developed by the  
**RIVER AND STREAM CONTINUITY PARTNERSHIP**  
Including:  
University of Massachusetts Amherst  
The Nature Conservancy  
Massachusetts Division of Ecological Restoration-Riverways Program  
American Rivers  
March 1, 2006  
Revised March 1, 2011

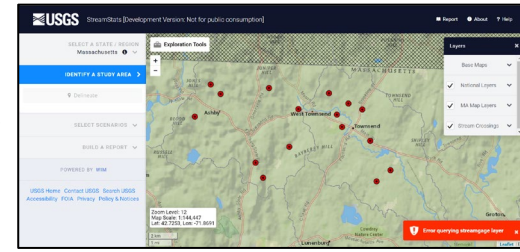


# USGS Streamstats

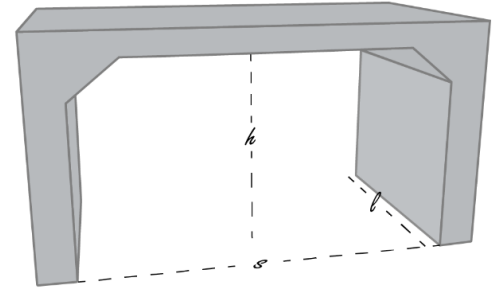
## Massachusetts: Statewide Hydraulic Modeling Pilot

### Summary:

- Site location
- North Atlantic Aquatic Connectivity Collaborative (NAACC)
- Aquatic habitat quality, stream connectivity restoration potential, and Maximum Extent Practicable (MEP) scores
- MassDOT highway functional classification and hydraulic design flow
- USGS peak flow and bankfull channel geometry equations
- Preliminary box, arch, and pipe culvert dimensions and relation to MRSCS



Preliminary 3-Sided Box Culvert Design meeting the 10- and 25-Year Flood Flows and Stream Crossing Standards



Parameter Name	10-Yr Flow	25-Yr Flow	Meets SCS	Unit
Box Culvert Span	12.0		17	Feet
Box Culvert Height	2.0		2	Feet
Box Culvert Length	42.6	42.6	42.6	Feet
Box Culvert Area	24.0		34	Square Feet
Box Culvert Material	Concrete	Concrete	Concrete	
Box Culvert Upstream Channel Invert Elevation	978.2	978.2	978.2	Feet - NAVD88
Box Culvert Downstream Channel Invert Elevation	977.2	977.2	977.2	Feet - NAVD88
Box Culvert Road Deck Elevation	981.7	981.7	981.7	Feet - NAVD88
Box Culvert Maximum Flow to Pass Through	10		10	Year
Box SCS Culvert Type	3-sided Box	3-sided Box	3-sided Box	
Box SCS Embedment	None	None	None	Feet
Box SCS Substrate	Natural	Natural	Natural	
Box Water Depth and Velocity Ratio				
Box SCS Span Ratio	0.9		1.2	
Box SCS Openness Ratio	0.60		0.8	

Hydraulic Model Citations

Massachusetts Department of Fish and Game, Division of Ecological Restoration, 2012, Massachusetts stream crossing handbook, 2nd edition, accessed August 1, 2021 at <https://www.mass.gov/doc/massachusetts-stream-crossing-handbook/download>.



<https://dev.streamstats.usgs.gov/ma-culverts/>

Questions?  
Thank you....

USGS Presentation Photos  
Teams Conference  
Circa 2007 ☺



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