Accessing the Authoritative Flood Model

FEMA Risk Map Support FY2018 Final Report

Task 1: Entities with legislative authority over engineering models

Task 2: Accessing flood models from authoritative entities

Task 3: Consistency between State/local approved engineering models and the FEMA authoritative flood model

Task 4: Evaluating NHD and CNMS as a method for enabling access to the authoritative flood models

Association of State Floodplain Managers

Flood Science Center

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Executive Summary

The objective of this research is to identify best practices that can be implemented by state and local Cooperating Technical Partners (CTP) related to providing access to the flood study engineering models. Furthermore the research identified ways to ensure that the engineering models provided are consistent with the FEMA "authoritative" model. ASFPM also evaluated how the National Hydrography Dataset and FEMA's Coordinated Needs Management Strategy (CNMS) geospatial datasets could improve access to flood study engineering models in the FEMA Engineering Library.

ASFPM identified 7 states, 2 regional entities and one community that have a website that provides access to flood study engineering models. With the exception of the one community all provide access via a clickable map. The State of Maryland website not only provides access to the flood study engineering models but also identifies the approved flood flows for all streams in the state and provides access to bridge and culvert data (cross sections and photographs) as a separate dataset.

One state and the 2 regional entities are FEMA Letter of Map Amendment (LOMR) review partners and therefore are assured of providing access to the FEMA "authoritative" flood study engineering model. FEMA Region V has a policy document that helps maintain consistency for the three states that provide model access in their region. This however is dependent upon FEMA's LOMR review staff consistently following written procedures which in some cases does not happen. As FEMA begins to expand the LOMR review partner program – providing preference to states and other entities that conduct flood study engineering reviews should improve the situation.

Access to flood study engineering models through FEMA is not as user friendly since the access is not via a clickable map. The FEMA CNMS is based upon a geospatial data set that could be used as a mechanism to improve access using clickable map technology. While FEMA is in the process of providing access to engineering models, the data is not nearly as complete as the state, regional and local cites that provide model access.

Acknowledgements

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Accessing the Authoritative Flood Model

Background 1

Entities with legislative authority over engineering models 5
- Delaware 6
- Indiana 7
- Kentucky 8
- Maryland 9
- Minnesota 10
- North Carolina 11
- Wisconsin 12
- Harris County Flood Control District 13
- San Antonio River Authority 14
- Louisville, KY 15

Accessing flood models from authoritative entities 17
- Delaware 19
- Indiana 21
- Kentucky 23
- Maryland 27
- Minnesota 31
- North Carolina 35
- Wisconsin 39
- Harris County Flood Control District 41
- Louisville Metropolitan Sewer District 45
- San Antonio River Authority 49
- Discussion 52
- FEMA FRiSEL - Flood Risk Study Engineering Library 53

Ensuring consistency between State/local approved engineering models and the FEMA authoritative flood model 59
- Delaware 61
- Indiana 62
- Kentucky 63
- Maryland 64
- Minnesota 66
- North Carolina 67
- Wisconsin 68
- Harris County Flood Control District 69
- Louisville Metropolitan Sewer District 70
- San Antonio River Authority 71

Evaluating NHD and CNMS as a method for enabling access to the authoritative flood models 73
- The National Hydrography Dataset 73
  - The First NHD and the Origins of NHDPlus and NHDPlus High Resolution 73
  - NHDPlus Version 1 and Version 2 74
  - NHDPlus High Resolution 76
- FEMA's Coordinated Needs Management Strategy 77
  - CNMS Viewer 78
- Discussion 79

Accessing the Authoritative Flood Model

Background

Floods are the nation's most common and costly natural disaster. To reduce the ever-growing expense to the federal government related to flooding, Congress established the National Flood Insurance Program (NFIP) in 1968. The objective was to provide flood insurance for existing development and map flood inundation areas so that new development would not be constructed at risk. The NFIP guarantees that flood insurance will be available in communities that agree to adopt land-use regulations so that new development is reasonably protected from flood damages. The NFIP flood inundation mapping has designated zones that are used to determine where flood insurance is required, determine the insurance rate and determine the level of regulation required for development and redevelopment. Maps depicting flood hazard areas are not only the foundation of the National Flood Insurance Program, but are also the basis of floodplain management at the State and local levels of government. If an area is not mapped as a flood hazard area, communities often have insufficient basis to enforce building codes and/or to regulate new development even if that area is known locally to be flood-prone.

Among other things, the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps (FIRMs) define: where the mandatory flood insurance purchase requirement applies, and where participating communities are required to regulate development. The flood models associated with flood studies are valuable data needed for managing development in the Special Flood Hazard Area.

A number of these States, local authorities, and basin commissions have higher standards that prompt an engineering review associated with activities in the floodplain. Some of these authorities have statutory requirements to review floodplain engineering studies. To carry out these functions, the entities often have engineers on staff responsible for reviewing engineering studies within their jurisdictions to ensure those studies meet higher standards.

Due to these legislated authorities, some of these entities over the decades have developed libraries of approved flood engineering models and have become a source from which the engineering model can be obtained via a publicly accessible website. A significant challenge these State or local engineering reviews often run into involve requests for Letters of Map Change (LOMCs). Often an applicant is required to submit a request to FEMA for a Letter of Map Revision (MT-2) for an activity that has been through State or local engineering or regulatory engineering review and results in changes to community Base Flood Elevations. If the FEMA MT-2 review contractor requires any changes to the engineering model during the Mt-2 review process – the engineering model approved by the State or local authority is no longer consistent with the FEMA "authoritative" model.

Floodplain Mapping Standards

Digital Flood Insurance Rate Map (DFIRM) Production Processes

Digital flood elevations are generated by computer models which represent the physical characteristics of the watershed and floodplains and historical flood information. The major components of a floodplain engineering study are:

Hydrology: multidisciplinary subject addressing the occurrence, circulation, and distribution of waters of the earth. In floodplain management, hydrology refers to the rainfall – runoff portion of the hydrologic cycle as it applies to extreme events. In a floodplain study, hydrology is used to estimate flood volumes expressed as a flood hydrograph. Common methods are stream gage analysis, rainfall-runoff models, or a combination of the two.

Hydraulics: study of the mechanical behavior of water in physical systems and processes. In floodplain management, hydraulics refers to determination of the flood heights and velocities associated with a flood of a particular magnitude. Hydraulics also encompasses the flow characteristics through hydraulic structures such as bridges, culverts, and dams. FEMA historically developed flood elevations, called base flood elevations (BFEs), only for urban areas via what has been called "detailed studies." Areas with BFEs were designated as AE Zones, and areas within the SFHA without BFEs were mapped using "approximate" techniques and designated as A Zones. Today, due to increased availability of automated hydrologic and hydraulic (H&H) tools, all floodplain engineering studies for FIS reports utilize floodplain engineering models that generate the flood elevations.

Flood Hazard Mapping: the flood elevations generated by the hydraulic engineering models are matched with best available topographic data to delineate the area inundated by the associated flood event.

Project Overview

Project Objective: Document state and local authorities who provide access to flood engineering models and evaluate the potential of using the National Hydrography Dataset in conjunction with the FEMA CNMS data layer to index the engineering models and enable access.

Approach: Identify and interview entities that provide access to flood engineering models and document the data structure, tools used and mechanisms used to stay in synch with FEMA. Document the methods for accessing flood models from the entities that provide ability to download models. Ascertain and document the processes in place for entities to keep locally approved models in sync with the FEMA approved flood study model. Finally, evaluate the ability of the National Hydrography Dataset and/or the FEMA CNMS dataset as a method for providing access to the authoritative flood model.

Accessing the Authoritative Flood Model consists of the four sections listed below with each section reporting on the quarterly tasks defined for the project.

Task 1: Entities with legislative authority over engineering models

Task 2: Accessing flood models from authoritative entities

Task 3: Ensuring consistency between State/local approved engineering models and the FEMA authoritative flood model

Task 4: Evaluating NHD and CNMS as a method for enabling access to the authoritative flood models

Entities with legislative authority over engineering models

First Task: Reach out to State Floodplain Coordinators to determine state & local entities that provide access and document legislative authorities

Results: ASFPM reached out to State Floodplain Coordinators and State Hazard Mitigation Officers to determine state & local entities that provide access to flood models via a publicly accessible website. ASFPM then documented these entities related legislative authorities. Entities identified that provide access to flood models are:

States with Legislated Authorities

- Delaware
- Indiana
- Kentucky
- Maryland
- Minnesota
- North Carolina
- Wisconsin

Local government

- Harris County Flood Control District, TX
- San Antonio Regional Authority, TX
- City of Louisville, KY

States with Legislated Authorities

Delaware

Delaware has a long-standing history of fostering stewardship of Delaware's natural resources, promoting wise land use, and ensuring water-quality and water-management practices. State policies, regulations, and programs have been developed to promote stormwater management, low-impact development, land conservation, riparian buffers, floodplain management, and land-use planning strategies to mitigate flooding and adapt to flood risks. In recent years, there has been great momentum to build upon Delaware's efforts in resiliency and adaptation.

In August 2011, Governor Markell signed Senate Bill 64 into law, authorizing DNREC to adopt guidance and minimum standards for reduction of flood risk. Specifically the Bill's purpose is to:

- Minimize flooding of water supply and sanitary sewage disposal systems;
- Maintain natural drainage;
- Reduce financial burdens imposed on the state, local community, its governmental units and its residents, by discouraging unwise design and construction of development in areas subject to flooding;
- Minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public;
- Minimize prolonged business interruptions and damage to public facilities and other utilities, such as water and gas mains, electric, telephone and sewer lines, streets and bridges;
- Reinforce that those who build in and occupy special flood hazard areas should assume responsibility for their actions;
- Prevent or minimize the impact of development on adjacent properties within and near flood prone areas; and
- Provide that the flood storage and conveyance functions of the floodplain are maintained and minimize the impact of development on the natural and beneficial functions of the floodplain.

As a result, DNREC adopted 15 floodplain standards and six drainage standards, along with a variety of recommendations that local governments may wish to incorporate into local codes.

Indiana

Indiana Flood Control Act (IC 14-28-1)

In 1945, the Indiana General Assembly determined that it was in the best interest of the citizens of the state to prevent and limit the damaging effects of floods by' regulating, supervising, and coordinating the construction, operation, and design of flood control works; alteration of streams; and keeping floodways free and clear. The Natural Resources Commission has been given primary authority concerning flood control activities in the state.

The Act provides that it is illegal to construct a permanent abode or place of residence in a floodway. Any other structure, obstruction, deposit, or excavation in the floodway of any stream in the state must first be approved by the Commission. The IDNR Division of Water has been given authority from the Commission to act on its behalf concerning flood control activities in the state. Proposed construction activities in a floodway are reviewed by the Department of Natural Resources to determine if the work will:

- adversely affect the efficiency of or unduly restrict the capacity of the floodway,
- create an unreasonable hazard to the safety of life or property, or
- result in unreasonably detrimental effects upon the fish, wildlife, and botanical resources.

Indiana Floodplain Management Act (14-28-3)

In 1973, the General Assembly directed the Natural Resources Commission to establish minimum standards for the delineation and regulation of all flood hazard areas within the state. The Commission promulgated rules and regulations (312 lAC 10) that are the minimum standards by which local units of government can develop floodplain management ordinances to regulate the flood hazard areas within their jurisdictions.

Kentucky

Kentucky Revised Statutes (KRS) 151.250 requires a stream construction permit from the Kentucky Division of Water prior to any development along or across a stream. The issuance of a Stream Construction Permit by the KYDOW is based on the Stream Construction Criteria found with 401 Kentucky Administrative Regulations 4:060.

The KYDOW Floodplain Management Section has the primary responsibility for the approval or denial of proposed construction and other activities in the 100-year floodplain of all streams in the Commonwealth. Typical activities permitted are dams, bridges, culverts, residential and commercial buildings, placement of fill, stream alterations or relocations, small impoundments and water and wastewater treatment plants. In addition, activities that result in physical disturbances to wetlands or streams may also require a Water Quality Certification Permit.

The process for obtaining a permit begins with the submittal of a completed application with a location map, plans of the proposed construction and the addressing of public notice. If there is existing flood data on the proposed site (i.e., National Flood Insurance Program flood maps, Corps of Engineers flood studies or previous permit data), then a permit review may begin. If there is no existing data, the submittal of survey information is required in order to perform an in-house flood study of the area.

Section engineers use the Corps of Engineers HEC-2 and HEC-RAS computer programs to analyze the effects of the proposed construction on existing flood conditions. Use of this program (or flood studies if they are available) enables the establishment of expected 100-year flood heights and the delineation of the floodway (a portion of the floodplain that is restricted to little or no construction). From this analysis, construction limits for fills and buildings and required elevations for finished floors or floodproofing can be provided. For all construction, especially bridges and culverts, a check is made to ensure that the project has only minimal impacts on existing flood levels. Regulations limit the effect to a maximum of 1 foot. If the proposed project is unacceptable based on the review, the applicant is sent a denial letter with possible options.

If the reviewer determines the project meets regulatory requirements and all deficiencies have been corrected and all necessary modifications to the drawings have been made, a draft permit is written to be reviewed by the supervisor and branch manager. If they concur that the proposal meets all state floodplain laws, regulations and standards, the permit is prepared and signed. Appropriate requirements and limitations are listed on the permit. If objections to the project have been raised, letters to those objecting are also sent with instructions as to their rights for a hearing under the statutes.

Maryland

Waterway Construction Statute

Lead agency/organization: Maryland Department of the Environment (MDE), - MDE Wetlands & Waterways Program

Chapter 526 of the Laws of 1933, (legislation based on recommendations of the 1931 Commission), established a permanent State Water Resources Commission. The legislation reflected concern about deficiencies in the policies and programs of the State of Maryland with respect to water resources.

The Water Resources Commission recognized that a manmade change to a stream or body of water in Maryland could diminish its course, current or cross-section. Today, waterway construction regulations assure that activities in a waterway or its floodplain, an area defined as waters of the State, do not create flooding on upstream or downstream property, maintain fish habitat and migration, and protect waterways from erosion. Authorization is required for construction or repair of the following projects in a waterway or a 100-year floodplain: Dams and reservoirs; Bridges and culverts; Excavation, filling or construction; Channelization; Changing the course, current or cross-section of any stream; Temporary construction (e.g. utility lines); or any other similar project.

Construction activities in waters of the State are guided by both statute and regulation. Title 5, Subtitle 5 of the Environment Article, Annotated Code of Maryland, establishes an administrative procedure that promotes public safety and welfare. This administrative procedure is further described in the regulations (COMAR) 26.17.04. These regulations govern the construction, reconstruction, repair, or alteration of a dam, reservoir, or waterway obstruction or any change of the course, current, or cross section of a stream or water body within the State, including changes to the 100-year frequency floodplain of free flowing waters.

The requirements of both statute and regulation are combined in the permit application review process. During the evaluation of an application, WSA may require an applicant to address issues relating to: Safety, operation and maintenance of the structure; Ability of all on-site construction to withstand the impacts of the 100-year flood event; Flooding on adjacent properties; Erosion of the construction site or stream bank; and Environmental effects, such as the project's impacts on non-tidal wetlands, existing in-stream fisheries, wildlife habitat, or threatened or endangered species.
The issuance of a permit at the conclusion of the permit application review process indicates that the project adequately preserves the public safety, promotes the general public welfare, and protects instream resources.

Minnesota

103F.105 Floodplain Management Policy
(a) The legislature finds:

(1) a large portion of the state's land resources is subject to recurrent flooding by overflow of streams and other watercourses causing loss of life and property, disruption of commerce and governmental services, unsanitary conditions, and interruption of transportation and communications, all of which are detrimental to the health, safety, welfare, and property of the occupants of flooded lands and the people of this state;

and (2) the public interest necessitates sound land use development as land is a limited and irreplaceable resource, and the floodplains of this state are a land resource to be developed in a manner which will result in minimum loss of life and threat to health, and reduction of private and public economic loss caused by flooding.

(b) It is the policy of this state to reduce flood damages through floodplain management, stressing nonstructural measures such as floodplain zoning and floodproofing, flood warning practices, and other indemnification programs that reduce public liability and expense for flood damages.

(c) It is the policy of this state:

(1) not to prohibit but to guide development of the floodplains consistent with legislative findings;

(2) to provide state coordination and assistance to local governmental units in floodplain management;

(3) to encourage local governmental units to adopt, enforce and administer sound floodplain management ordinances;

(4) to provide the commissioner of natural resources with authority necessary to carry out a floodplain management program for the state and to coordinate federal, state, and local floodplain management activities in this state; and

(5) to provide incentives for communities to participate in the national flood insurance program and for citizens of Minnesota to take actions such as purchasing and maintaining flood insurance to reduce future flood damage to private property.

History: 1990 c 391 art 6 s 3; 2Sp1997 c 2 s 17

North Carolina

NC Senate Bill 300 effective July 1, 2001, requires communities to be participating in the NFIP by August 1, 2002 in order to receive State disaster assistance in the form of public grants for flood damage.

In North Carolina, the governor has designated the Division of Emergency Management as the state coordinating agency for the NFIP. The state NFIP assistance office is housed in the Geospatial and Technology Management Section as a Floodplain Management Branch.

Notify of Watercourse Alterations. The Floodplain Administrator must notify (or require the applicant to notify) adjacent communities and the North Carolina Floodplain Management Branch prior to approving any proposed alteration or relocation of a watercourse. Evidence of such notification must also be submitted to the FEMA regional office.

NC Department of Environment and Natural Resources (NC DENR) – Listed below are the different division of NC DENR and which types of development they regulate. References should be made to specific divisions for related permits as needed.

Division of Coastal Management (NC DCM) or a Local Permitting Officer (LPO) for a CAMA permit under the Coastal Area Management Act of 1974 which covers the eastern part of the state along the coastline and the sounds. There are 20 counties covered by CAMA. Development in Areas of Environmental Concern (AECs) – permits. Setbacks based on erosion rates in Coastal High Hazard Area

Division of Environmental Health, On-Site Wastewater Branch - Septic systems not permitted in areas having a 10% annual chance of flooding unless watertight and to remain operable during a ten-year storm. Mechanical and electrical components of treatment systems located above 1% annual chance flood.

Division of Land Resources - Regulates mining, erosion and sediment control, and dam safety. Erosion and sedimentation control measures must provide protection from peak rate of runoff from 10% annual chance rainfall. Note that many communities may run this program at the local level.

Division of Water Quality - Prohibits wells in an area generally subject to flooding. Wetlands standards and 401 Water Quality Certification process. Riparian Buffer Protection Rules. Stormwater Management - Federal NPDES Stormwater Permitting Programs.

NC Department of Agriculture regulates the anchoring of propane tanks where necessary to prevent flotation due to possible high waters around above-ground or mounded containers therefore they need to know that the tanks are located within a special flood hazard area.

Wisconsin

WI ACT 87.30 requires "no floodplain zoning ordinance may be enacted unless the hydraulic and engineering studies necessary to determine the floodway or floodplain limits, or both, if both limits are deemed necessary by the department, have been made at state or federal expense. If the department utilizes hydraulic and engineering studies previously completed, the department shall be responsible for ensuring that the studies are reasonable and accurate."

Wisconsin has required communities (counties, cities, villages) to regulate floodplains since 1968 under Chapter NR 116, Wisconsin Administrative Code. Floodplain regulations are used to reduce flood risk and maintain the natural values of undeveloped floodplains. Wisconsin chose to enact floodplain management standards which exceed the minimum standards of the National Flood Insurance Program in order to ensure that development in flood prone areas has a reduced risk to flooding.

Higher standards include: 2 foot of freeboard, Dryland access for new development , most floodway development prohibited, a cumulative improvement standard set at 50%, and a zero surcharge standard for mapping floodways.

The WI floodplain management program responsibilities are to:

- Establish development/building protection standards and promulgate state regulations
- Provide technical assistance including training to local community/agency partners
- Under contract with FEMA, evaluate and document community/agency floodplain management activities
- Under FEMA contracts, provide mapping, engineering and contract management services for RiskMAP
- Review/approve engineering studies for map revision projects ♣ Respond to legislative inquiries

Department of Natural Resources staff reviews engineering studies for compliance with NR 116 Wis. Admin. Code. A floodplain study checklist [pdf] has been created to assist in preparing a floodplain study submittal to DNR for review.

Hydrologic and hydraulic model revisions due to development should follow the local community's floodplain ordinance. Specifically, refer to section 7.1 (2) (c) of the model ordinance [pdf].

Local Governments

Harris County Flood Control District

The Harris County Flood Control District is a special purpose district created by the Texas Legislature in 1937 in response to devastating floods that struck the region in 1929 and 1935. The District's jurisdictional boundaries are set to coincide with Harris County, a community of more than 4.5 million people (2015) that includes the City of Houston. The other boundaries in which we operate - those provided by nature - are of the 22 primary watersheds within Harris County's 1,777 square miles. Each has its own independent flooding problems. Each presents unique challenges.

Jurisdictional Authority

The Harris County Flood Control District does "not" have sole jurisdiction over flood-related matters in Harris County. In fact, there are many other entities involved that have special interests in their particular areas of responsibility. The City of Houston, for example, is one of the local floodplain administrators for the community's participation in the National Flood Insurance Program (NFIP). The city has its own criteria for design of its drainage systems - primarily the design of storm sewers and street drainage, but also stormwater detention for these systems.

Other incorporated areas are also floodplain administrators and have their own drainage design criteria for their road systems. In unincorporated areas of Harris County, the County Engineer's office is the floodplain administrator. In all, there are 34 floodplain administrators in the county. The Harris County Flood Control District is not one of them.

To complete the jurisdiction picture, there are four county commissioners' precincts. In all, with 34 floodplain administrators reporting to separate entities of government, there are nearly 250 elected officials involved in the administration of drainage and flooding issues in the county, including each municipality's building permit program.

The Harris County Flood Control District's Model and Map Management (M3) System is an interactive tool designed to manage changes to the Federal Emergency Management Agency's (FEMA) effective floodplain models for Harris County. The goal of the M3 System is to distribute FEMA effective models to the general public, track ongoing changes to the models resulting from development projects, and facilitate communication between FEMA, Harris County Flood Control District, Local Floodplain Administrators, and the community.

San Antonio River Authority

On May 5, 1937, the 45th Legislature of Texas created the San Antonio River Canal and Conservancy District. The focus of the District was to plan a barge canal for commercial transportation of goods and materials by commercial barge between San Antonio and the Texas coast. The lack of feasibility for the canal project, combined with a devastating flood in San Antonio in 1946, changed the emphasis of the District from navigation to flood control.

With a new focus on flood control, the District was renamed the San Antonio River Authority (SARA) in 1953. The San Antonio River Authority (SARA) promotes programs and activities that proactively inform residents and property owners of their potential risk for flooding. By providing the most accurate and up-to-date information on flood risk, SARA enhances the ability for governments, businesses and individuals to make informed decisions to manage flood risk and protect life, property and infrastructure from flooding.

As technical leaders and communicators, SARA's resources are directed toward creating and maintaining state-of-the art tools that most accurately model and map dynamic floodplains and flow patterns to ensure that communities throughout the basin have the best information possible to minimize flood risk and increase the flood disaster resiliency of the community. SARA also develops and implements communications programs to share this information publicly.

SARA is a Cooperating Technical Partner (CTP) for the Federal Emergency Management Agency (FEMA), and as a CTP, is promoting several Flood Risk Management initiatives. SARA is committed to providing the communities we serve with the most current information and technology available. By using this information, multiple Holistic Watershed Master Planning efforts are underway to identify flood risk by each watershed. These master plans identify structures (e.g. homes, businesses, roads, or other built infrastructure) in the floodplain using the latest modeling software and data, such as aerial imagery and Light Detection and Ranging (LiDAR) technology for better resolution of topography to increase accuracy and better determine risk (see Watershed Management position paper for more information on Holistic Watershed Master Plans).

SARA produced updated, digital floodplain maps and hydraulic and hydrology models for the San Antonio River Watershed and has the responsibility to keep the maps and models updated to reflect changes in the watershed.

SARA is a FEMA Letter of Map Revision (LOMR) Delegate, which will assure that all modeling standards are followed when proposed changes to Special Flood Hazard Areas are submitted to the community. These changes can impact the level of risk of structures near the floodplains. As the LOMR Delegate, SARA will account for this risk based on the best available data.

Louisville, KY

The Louisville/Jefferson County, KY–IN Metropolitan Statistical Area, commonly called the Louisville metropolitan area or Kentuckiana, is the 43rd largest[b] Metropolitan Statistical Area (MSA) in the United States. The primary city is Louisville, Kentucky.

It was originally formed by the United States Census Bureau in 1950 and consisted of the Kentucky county of Jefferson and the Indiana counties of Clark and Floyd. As surrounding counties saw an increase in their population densities and the number of their residents employed within Jefferson County, they met Census criteria to be added to the MSA. Jefferson County, Kentucky (contiguous with Louisville Metro), plus twelve outlying counties – seven in Kentucky and five in Southern Indiana – are now a part of this MSA. One other Kentucky county was part of the MSA in the 2000 and 2010 U.S. Censuses, but was spun off by the Census Bureau into its own Micropolitan Statistical Area in 2013.

The government of Louisville, Kentucky, administers Louisville Metro, a consolidation of the pre-2003 areas known as the City of Louisville and surrounding Jefferson County. It operates a unified mayor–council government, with an executive called the Mayor of Louisville Metro or "Metro Mayor" and a city council called the Louisville Metro Council or "Metro Council". Their administration oversees most of the responsibilities of both the former city and county; notable exceptions are the offices of County Clerk and Sheriff, which continue to operate separately due to continuing state constitutional requirements. Before merger, under the Kentucky Constitution and statutory law, Louisville was designated as a first-class city in regard to local laws affecting public safety, alcohol beverage control, revenue options, and various other matters. As of 2014, it is the only such designated city in the state.

The Office of Construction Review, a Division of Codes and Regulations as of January 1, 2017, is responsible for oversight of construction in Louisville Metro through a review process that includes review of construction plans and issuance of permits and inspections. This process is in place to ensure the safety of citizens and compliance with the Kentucky Building Code and associated codes and ordinances. Construction Review issues building, HVAC/mechanical, electrical, fire detection, fire suppression, moving, tent, and wrecking permits.

In addition to issuing building permits and conducting inspections, our division oversees the licensure and inspections of boarding and lodging houses homeless shelters, transitional shelters, donation bins, and billboard licenses.

The enforcement powers of the Construction Review Division are established by the Kentucky Building Code, through a contractual agreement with the State Department of Housing, Building and Construction and the Louisville Code of Ordinances, Chapter 150.

Accessing flood models from authoritative entities

Second Task: Document the data structure each state or entity has implemented to enable the download of the hydraulic model.

Results: ASFPM created step-by-step instructions for accessing and downloading a hydraulic models from each state's or entity's publicly facing website. Each state or entity has a slightly different mode of access, but ultimately a user can download a model or can find the information necessary to request the model. This section contains a guide to accessing hydraulic engineering model from the states or entities identified in the previous section of this report:

Delaware
Indiana
Kentucky
Maryland
Minnesota
North Carolina
Wisconsin
Harris County Flood Control District, TX
Louisville Metropolitan Sewer District
San Antonio Regional Authority, TX
FEMA Flood Risk Study Engineering Library

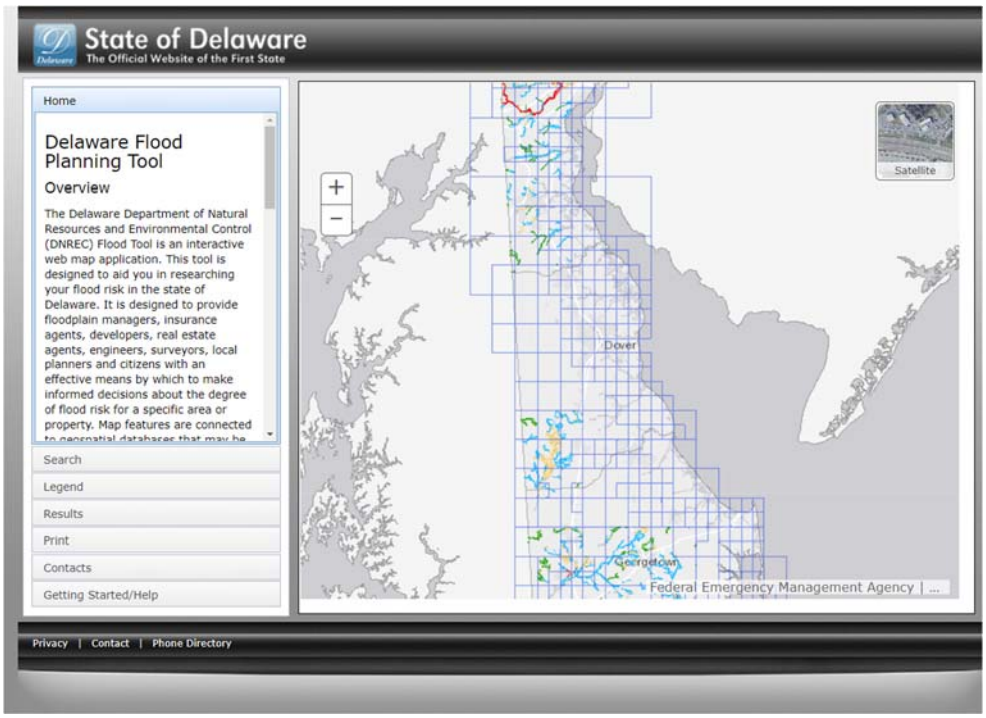
Summary: The subsection for each state or entity contains the following information:

- **Where to go:** the URL of the website where users can access models.
  - *Note: Some sites require user registration and log in.*
  - *Note: Some sites have restrictions on browser compatibility.*
- **How to get the model:** the steps necessary to access the models.
  - Step-by-step instructions and screenshots explain how a user can locate and download hydraulic models from each state or entity
  - *Note: Some sites may have additional ways to access models not described below.*
- **What is in the download:** the data found in the download.
  - Screenshots of example data that was downloaded from the state or entity

In addition to the 10 states and entities listed above, data was downloaded from FEMA's Flood Risk Study Engineering Library (FRiSEL) and compared to the data downloaded from the states in order to determine if the models were the same.

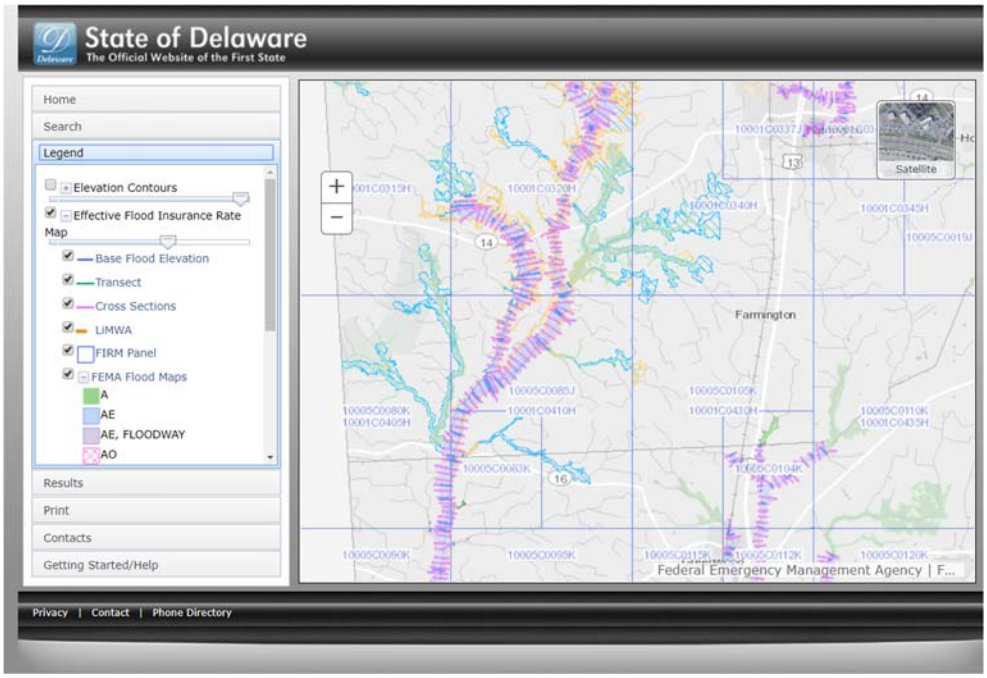
Delaware

Where to go: http://maps.dnrec.delaware.gov/floodplanning/default.html

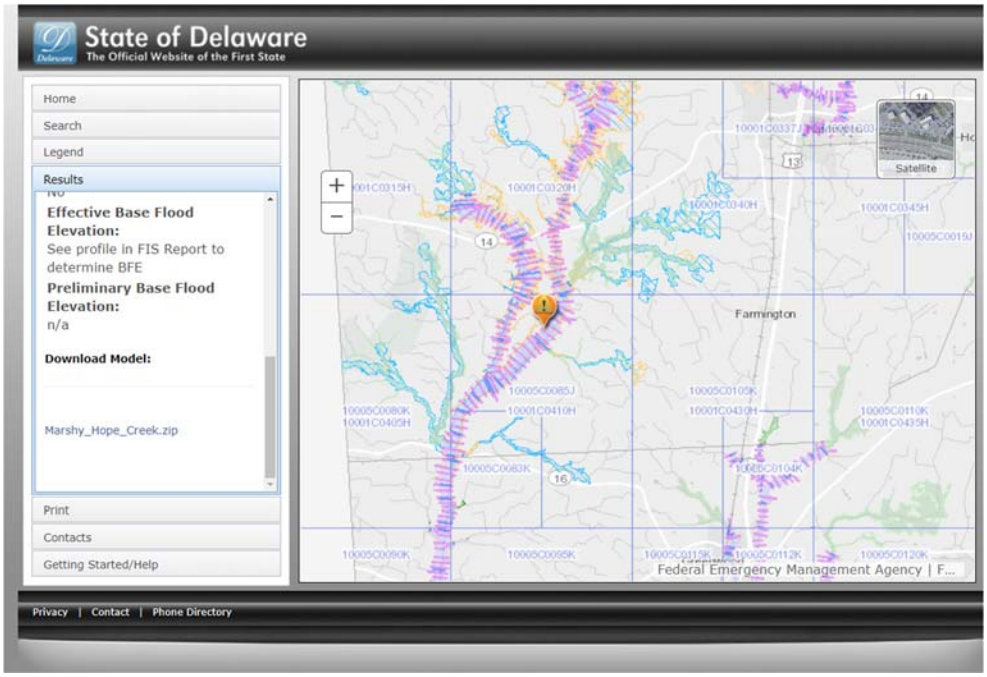


How to get the model:

1. Zoom in on the map to an area with mapped waterways.



2. Click on a waterway and notice the Results panel open on the left with data about the waterway. Scroll down in that Results window to see the link to download the model .zip file. Click the link to download.

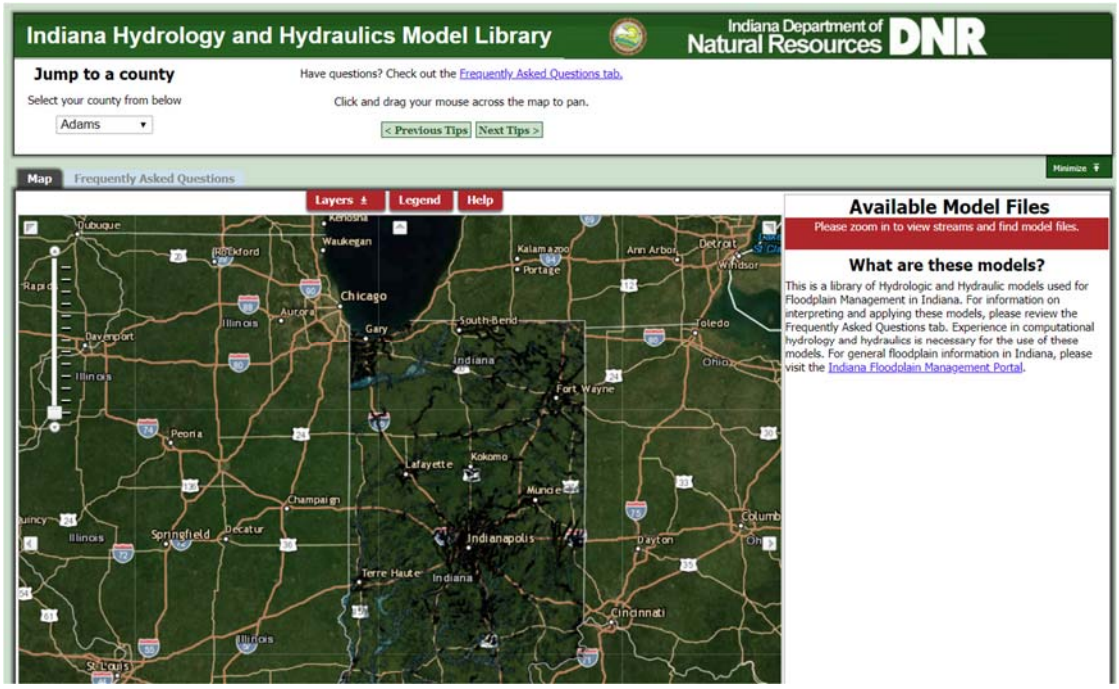


What is in the download: Contents of the downloaded model .zip file.

Name	Type	Size	Date modified
Marshy Hope Creek.f01	F01 File	2 KB	9/2/2008 12:28 PM
Marshy Hope Creek.g01	G01 File	161 KB	9/2/2008 12:28 PM
Marshy Hope Creek.O01	O01 File	263 KB	9/2/2008 12:29 PM
Marshy Hope Creek.p01	P01 File	1 KB	9/2/2008 12:28 PM
Marshy Hope Creek.prj	PRJ File	1 KB	9/2/2008 12:28 PM
Marshy Hope Creek.r01	R01 File	139 KB	9/2/2008 12:29 PM
Marshy Hope Creek.xml	XML File	943 KB	9/2/2008 12:28 PM

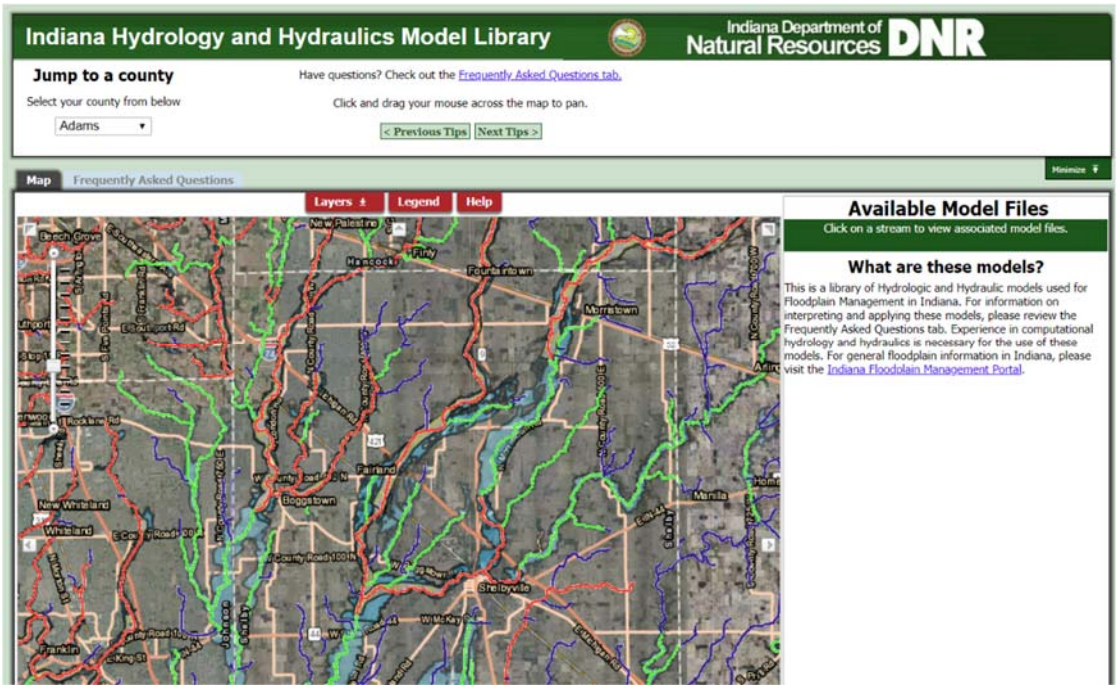
Indiana

Where to go: https://dnrmaps.dnr.in.gov/appsphp/model/index.php

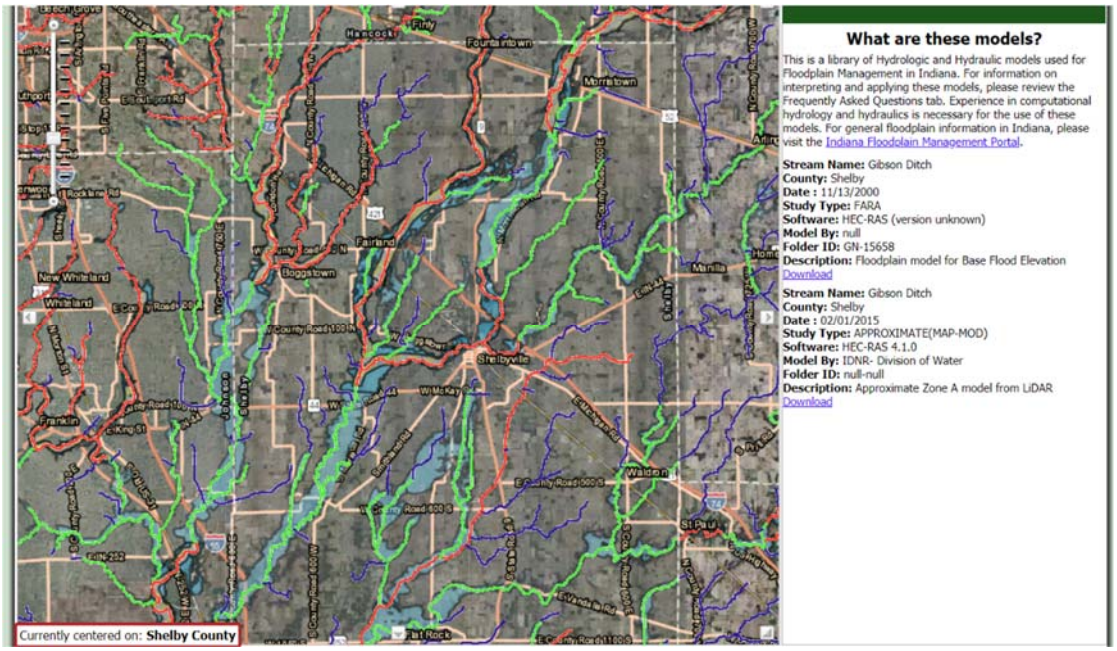


How to get the model:

1. Zoom in on the map to an area with mapped waterways.



2. Click on a waterway. The panel on the right displays data and there is a Download link to download the models along with the



What is in the download: Contents of the downloaded model .zip file.

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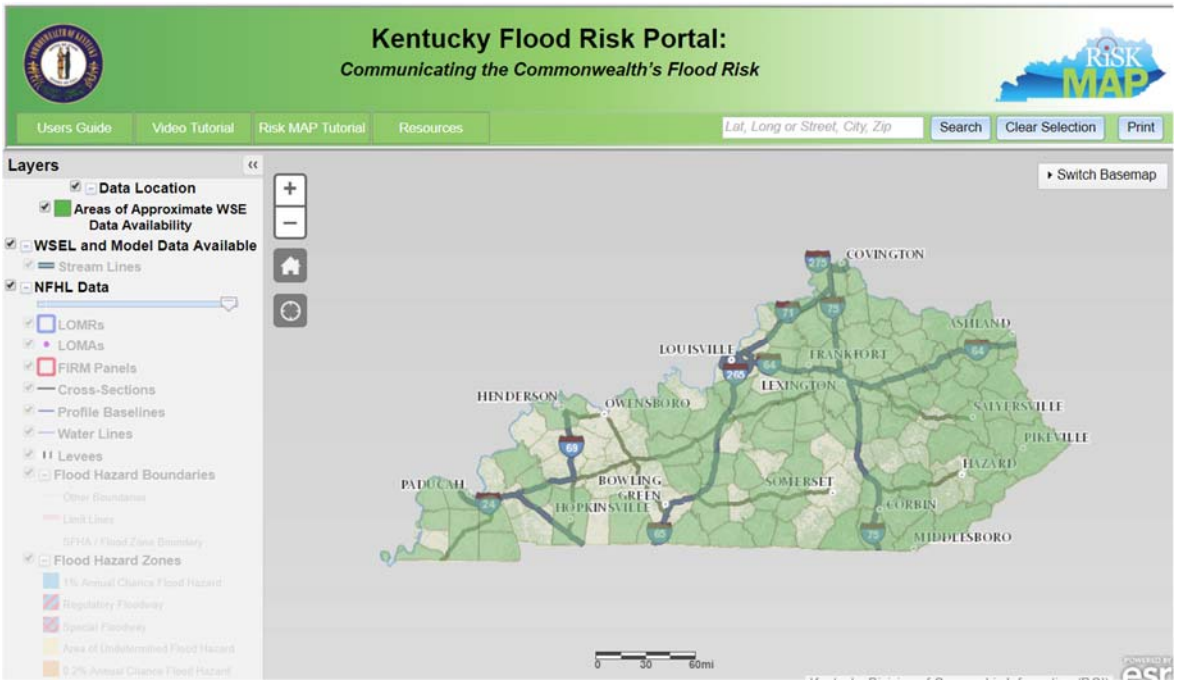
Backup.p01	P01 File	8 KB	6/2/2014 12:34 PM
GibsonDitch.f01	F01 File	2 KB	6/4/2013 10:49 AM
GibsonDitch.f02	F02 File	1 KB	6/4/2013 10:55 AM
GibsonDitch.g01	G01 File	861 KB	6/2/2014 3:36 PM
GibsonDitch.g01.gml	GML File	167 KB	6/2/2014 3:36 PM
GibsonDitch.O01	O01 File	325 KB	6/4/2013 10:49 AM
GibsonDitch.O01.xml	XML File	156 KB	6/4/2013 10:49 AM
GibsonDitch.O02	O02 File	138 KB	6/2/2014 3:35 PM
GibsonDitch.O02.xml	XML File	31 KB	6/2/2014 3:36 PM
GibsonDitch.p01	P01 File	4 KB	6/4/2013 10:49 AM
GibsonDitch.p01.comp_msgs.txt	TXT File	1 KB	6/4/2013 10:49 AM
GibsonDitch.p02	P02 File	8 KB	6/2/2014 2:37 PM
GibsonDitch.p02.back	BACK File	8 KB	6/2/2014 1:26 PM
GibsonDitch.p02.comp_msgs.txt	TXT File	1 KB	6/2/2014 3:35 PM
GibsonDitch.p99	P99 File	8 KB	6/2/2014 2:37 PM
GibsonDitch.prj	PRJ File	1 KB	6/2/2014 3:36 PM
GibsonDitch.r01	R01 File	693 KB	6/4/2013 10:49 AM
GibsonDitch.r02	R02 File	701 KB	6/2/2014 3:35 PM
Study635.import.sdf	SDF File	3,909 KB	6/4/2013 10:49 AM

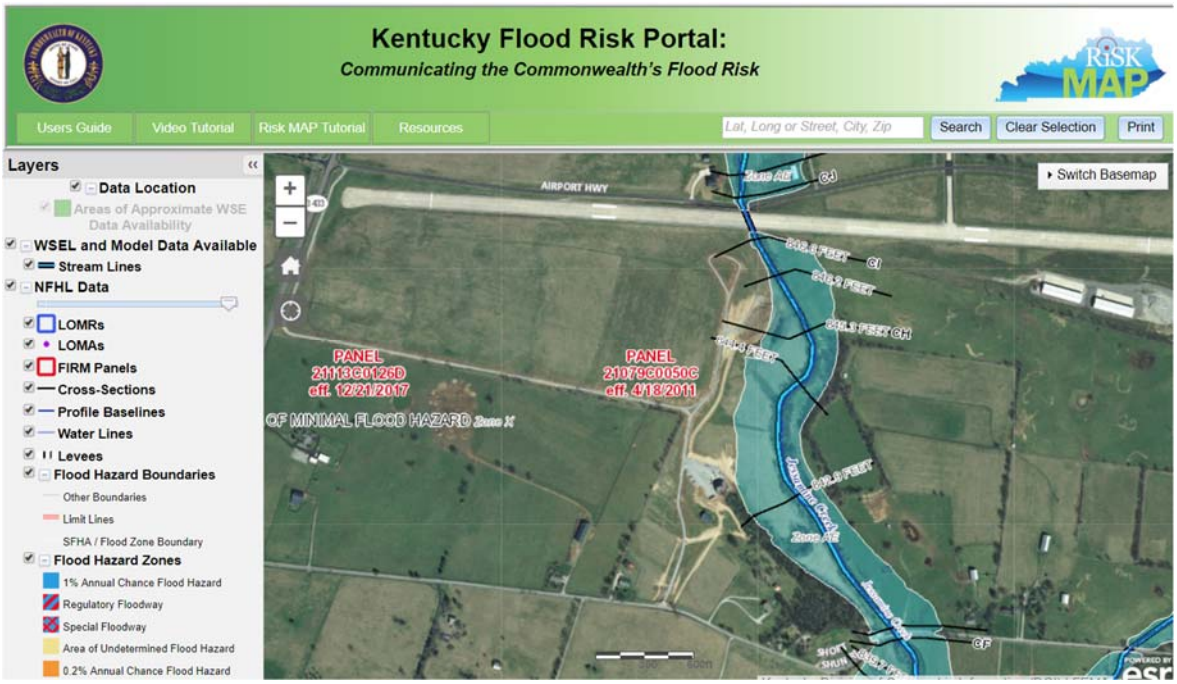
Kentucky

Where to go: http://watermaps.ky.gov/RiskPortal/

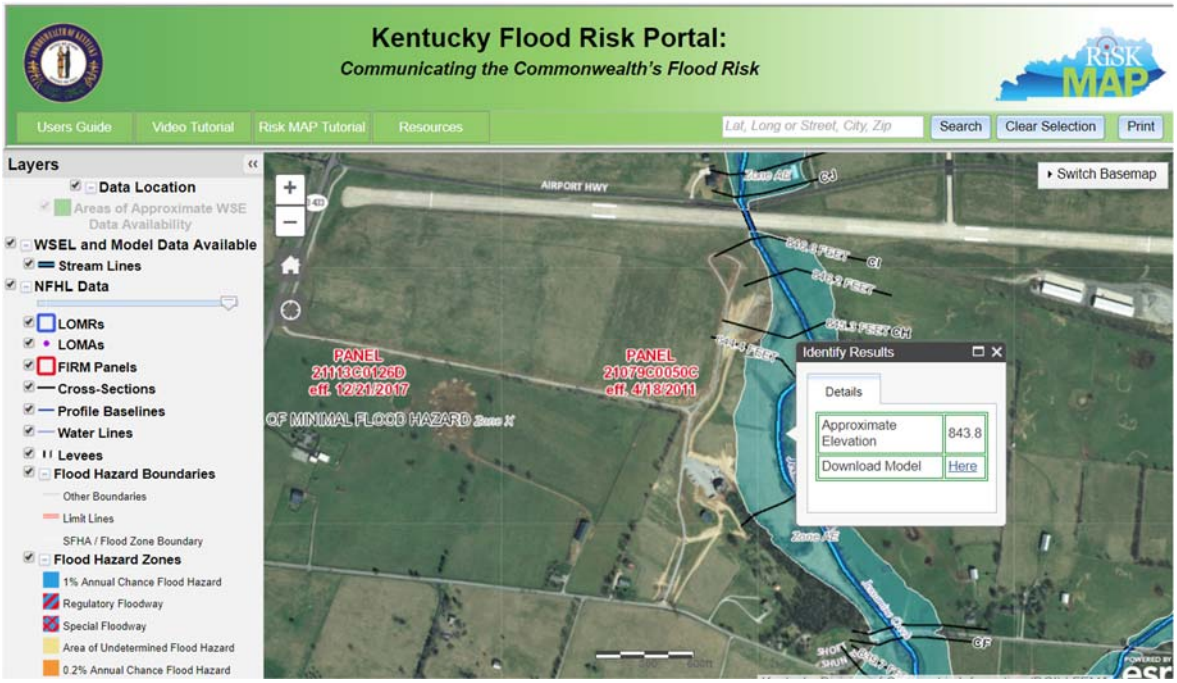


How to get the model:

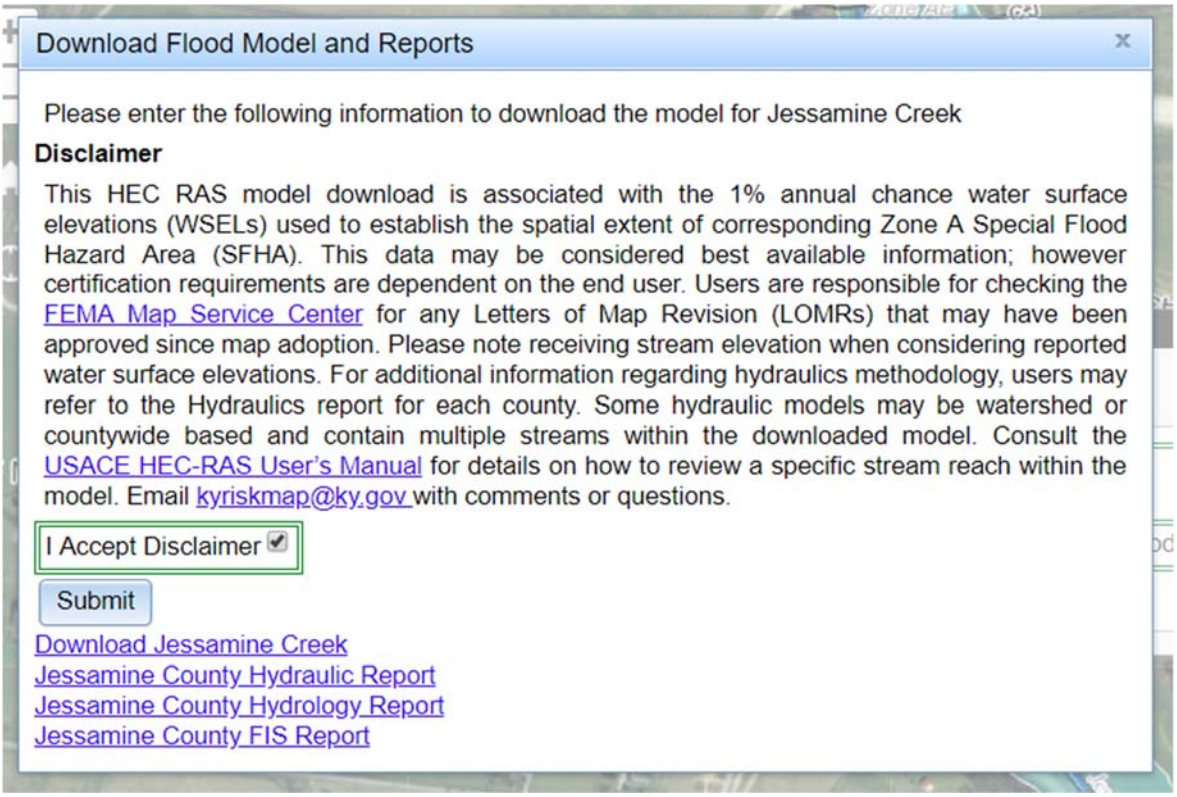
1. Zoom in on the map to an area with mapped waterways.



2. Click on a waterway. A popup window appears with a link to download the model.



3. A disclaimer appears and when you accept the terms, additional links appear for you to download the model and other data inncluding the FIS Report.



What is in the download: Contents of the downloaded model .zip file.

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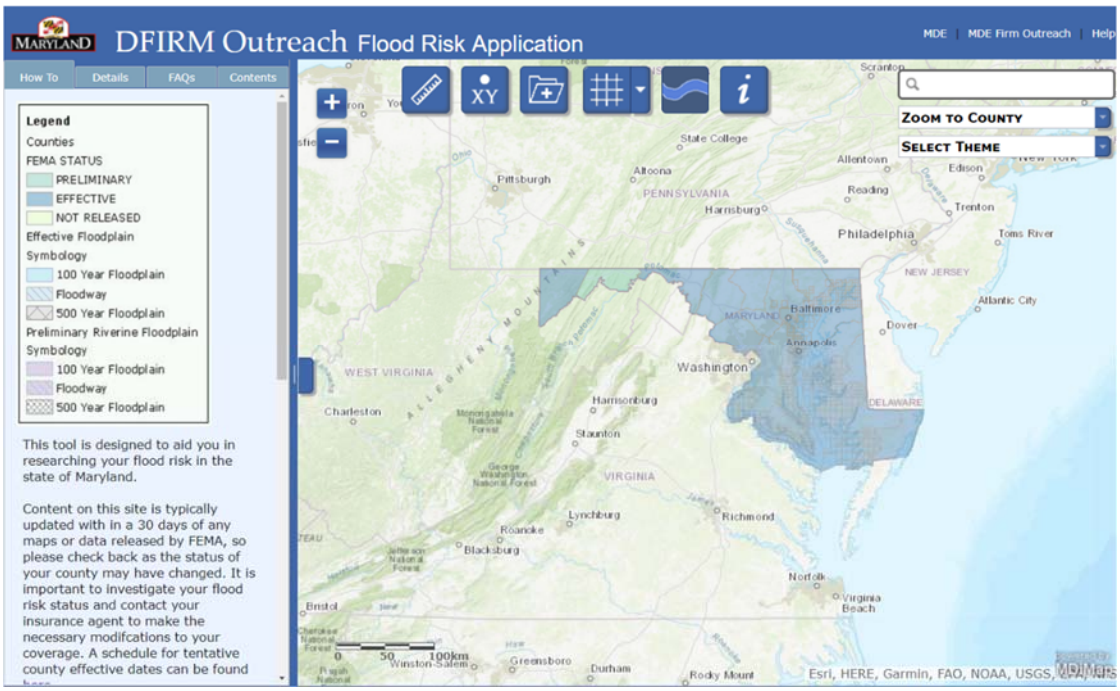
Backup.g01	G01 File	1,663 KB	9/18/2014 3:44 PM
Backup.p01	P01 File	15 KB	9/23/2014 1:02 PM
Jessamine Creek.f01	F01 File	3 KB	10/21/2014 10:02 ...
Jessamine Creek.f02	F02 File	2 KB	7/25/2014 3:39 PM
Jessamine Creek.f03	F03 File	1 KB	7/1/2014 2:01 PM
Jessamine Creek.g01	G01 File	1,664 KB	9/10/2015 3:19 PM
Jessamine Creek.g01.gml	GML File	167 KB	9/3/2015 9:56 AM
Jessamine Creek.O01	O01 File	1,057 KB	9/10/2015 3:19 PM
Jessamine Creek.O02	O02 File	438 KB	1/29/2016 12:42 PM
Jessamine Creek.O04	O04 File	1,057 KB	6/12/2015 1:12 PM
Jessamine Creek.p01	P01 File	4 KB	7/9/2014 2:53 PM
Jessamine Creek.p01.comp_msgs.txt	TXT File	1 KB	9/10/2015 3:19 PM
Jessamine Creek.p02	P02 File	15 KB	6/15/2015 4:17 PM
Jessamine Creek.p02.comp_msgs.txt	TXT File	1 KB	1/29/2016 12:42 PM
Jessamine Creek.p03	P03 File	1 KB	7/1/2014 2:01 PM
Jessamine Creek.p04	P04 File	4 KB	11/11/2014 8:14 AM
Jessamine Creek.p04.comp_msgs.txt	TXT File	1 KB	6/12/2015 1:12 PM
Jessamine Creek.prj	PRJ File	1 KB	1/29/2016 12:43 PM
Jessamine Creek.r01	R01 File	1,627 KB	9/10/2015 3:19 PM
Jessamine Creek.r02	R02 File	1,633 KB	1/29/2016 12:42 PM
Jessamine Creek.r04	R04 File	1,627 KB	6/12/2015 1:12 PM
Jessamine Creek.rasmap	RASMAP File	4 KB	8/25/2014 1:43 PM

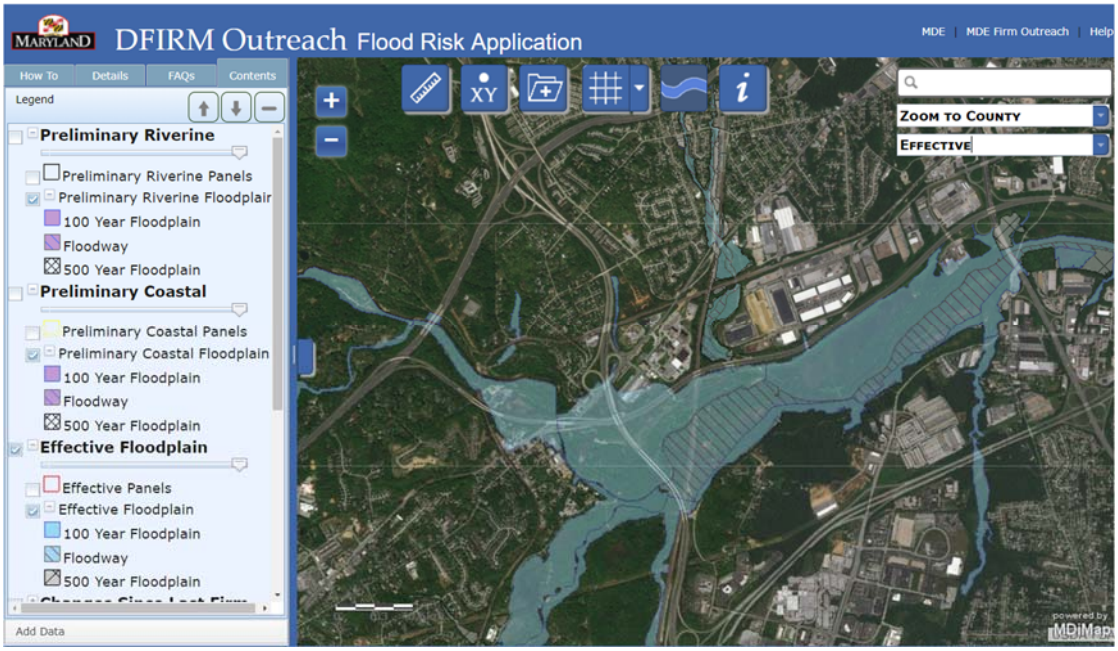
Maryland

Where to go: http://www.mdfloodmaps.net/dfirmimap/index.html

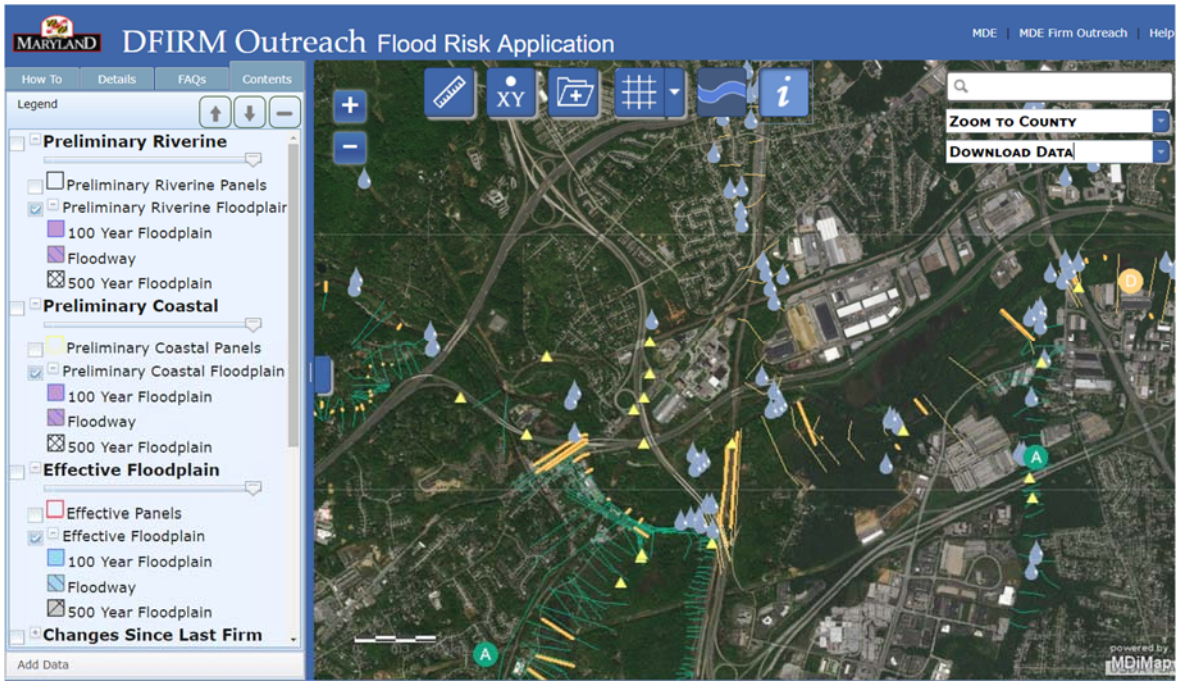


How to get the model:

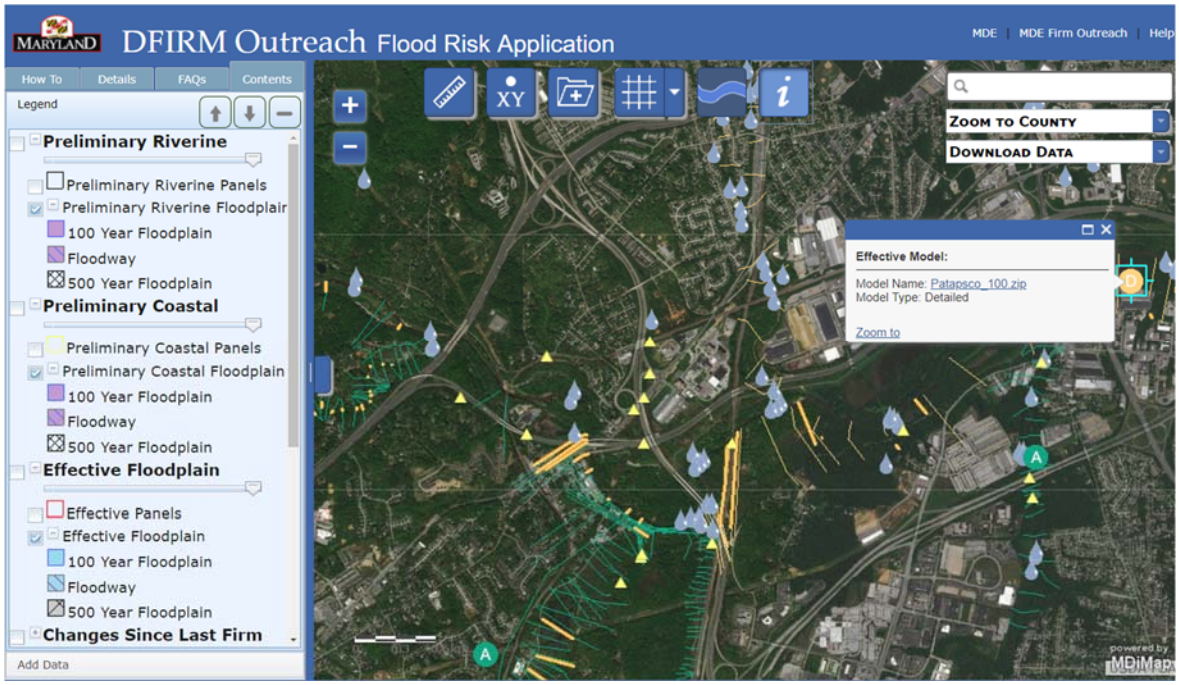
1. Zoom in on the map to an area with mapped waterways.



2. Change the dropdown in the upper right from "Effective" to "Download Data."



3. Click on the circle "D" for detailed study or "A" for approximate study and a popup window appears containing a link to download the model.



What is in the download: Contents of the downloaded model .zip file.

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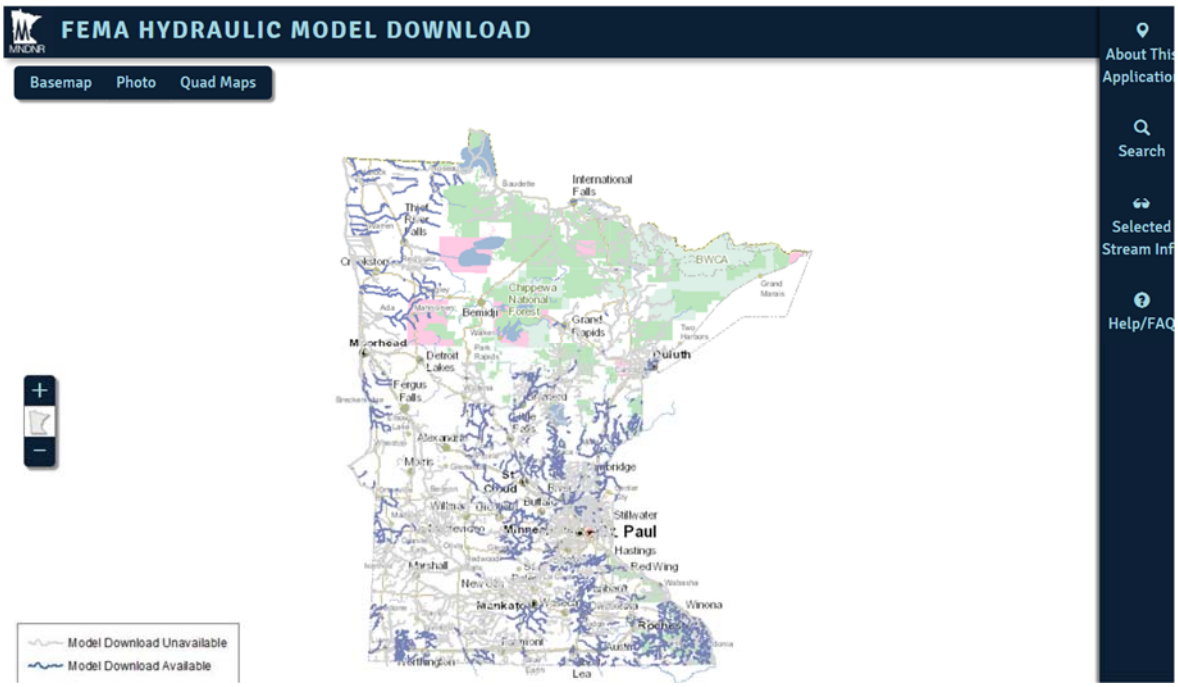
PatapscoRiver.br	BR File	40 KB	12/29/2008 2:00 PM
PatapscoRiver.f01	F01 File	2 KB	3/24/2009 2:25 PM
PatapscoRiver.f02	F02 File	1 KB	4/20/2009 5:02 PM
PatapscoRiver.g01	G01 File	349 KB	4/20/2009 5:25 PM
PatapscoRiver.nt	NT File	13 KB	12/29/2008 2:00 PM
PatapscoRiver.O01	O01 File	282 KB	5/6/2009 9:10 AM
PatapscoRiver.O02	O02 File	119 KB	4/21/2009 8:51 AM
PatapscoRiver.p01	P01 File	3 KB	4/20/2009 5:01 PM
PatapscoRiver.p01.comp_msgs.txt	TXT File	1 KB	5/6/2009 9:10 AM
PatapscoRiver.p02	P02 File	6 KB	4/20/2009 5:26 PM
PatapscoRiver.p02.comp_msgs.txt	TXT File	1 KB	4/21/2009 8:50 AM
PatapscoRiver.prj	PRJ File	1 KB	5/6/2009 9:10 AM
PatapscoRiver.r01	R01 File	409 KB	5/6/2009 9:10 AM
PatapscoRiver.r02	R02 File	413 KB	4/21/2009 8:50 AM
PatapscoRiver.RASexport.sdf	SDF File	49 KB	5/6/2009 9:10 AM
PatapscoRiver.RASexport.xml	XML File	78 KB	5/7/2009 9:11 AM
PatapscoRiver.rep	REP File	1,124 KB	12/29/2008 2:00 PM
PatapscoRiver.xs	XS File	6 KB	12/29/2008 2:00 PM

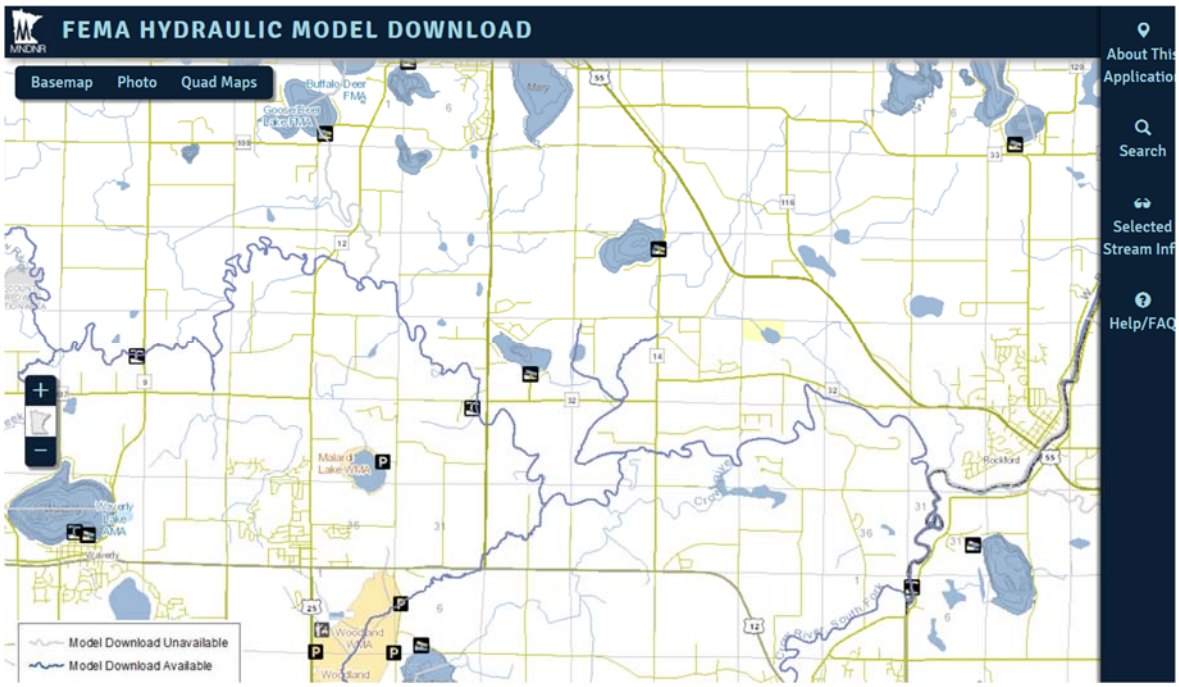
Minnesota

Where to go: https://arcgis.dnr.state.mn.us/ewr/hydra_model_download/index.html

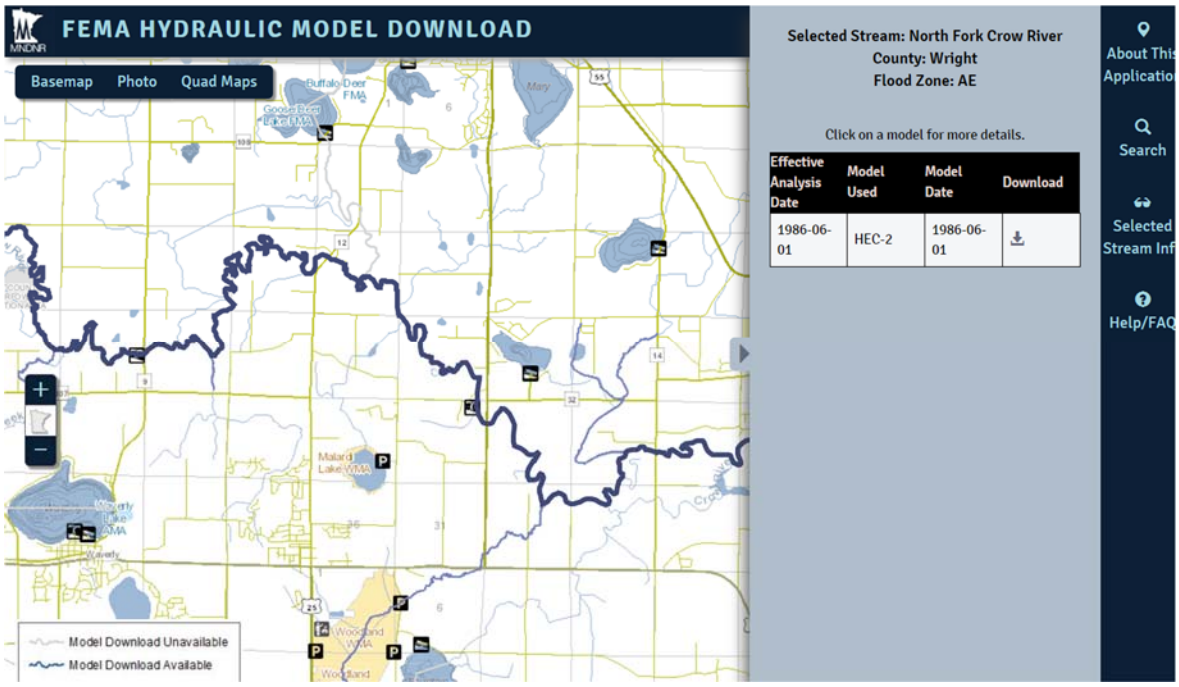


How to get the model:

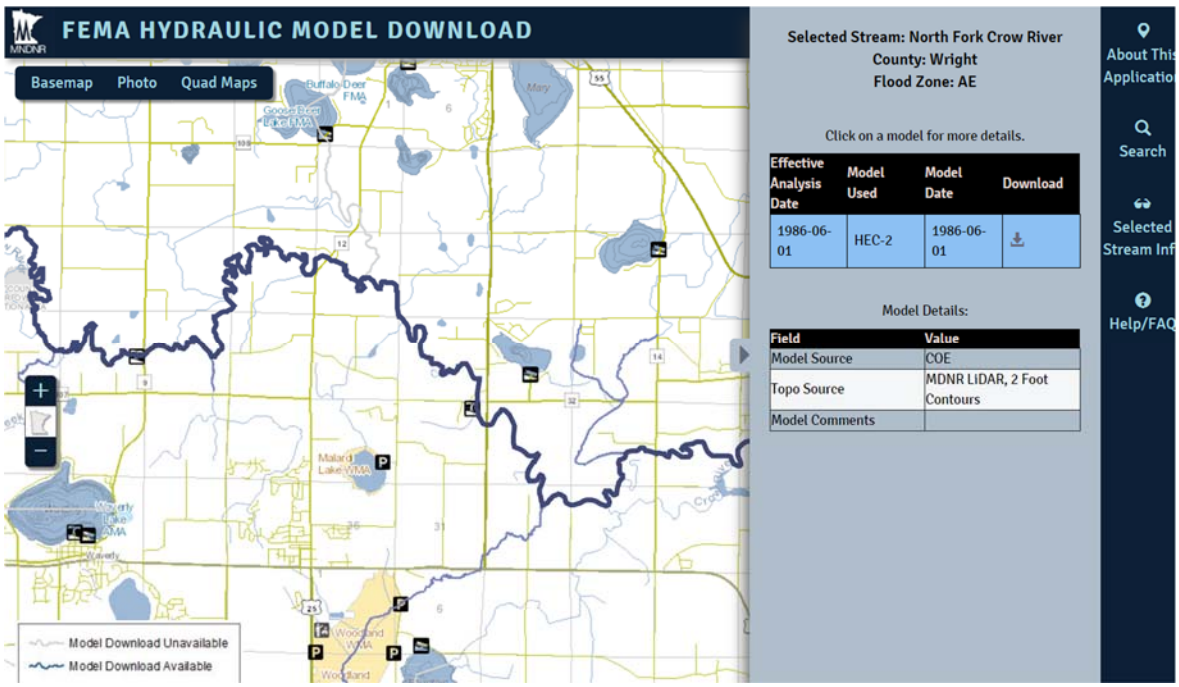
1. Zoom in on the map to an area with mapped waterways.



2. Click on a waterway. A panel appears on the right with a link to download the model. Click on the download icon to download the model.



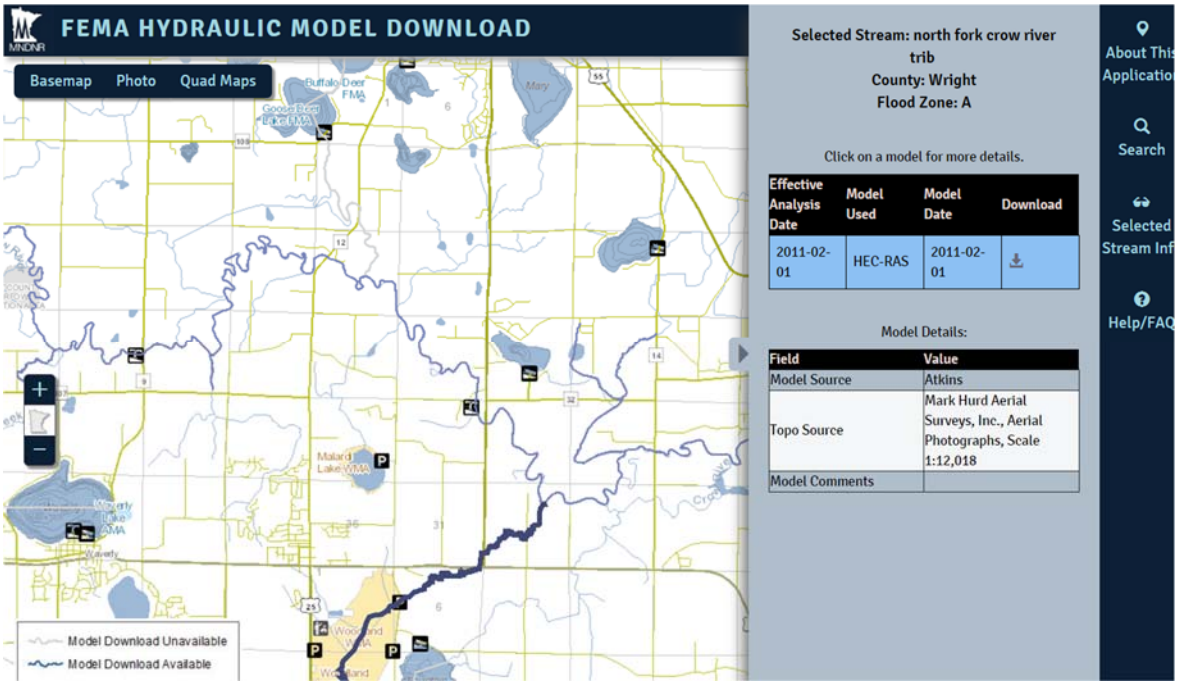
3. Additional data about the model including topo source appears when you click the download icon.



What is in the download: Contents of the downloaded model .zip file.

Name	Type	Size	Date modified
WRIGH28	File	83 KB	5/30/1990 11:52 AM

Another example, this time a HEC-RAS model (previous example was a HEC-2 model).

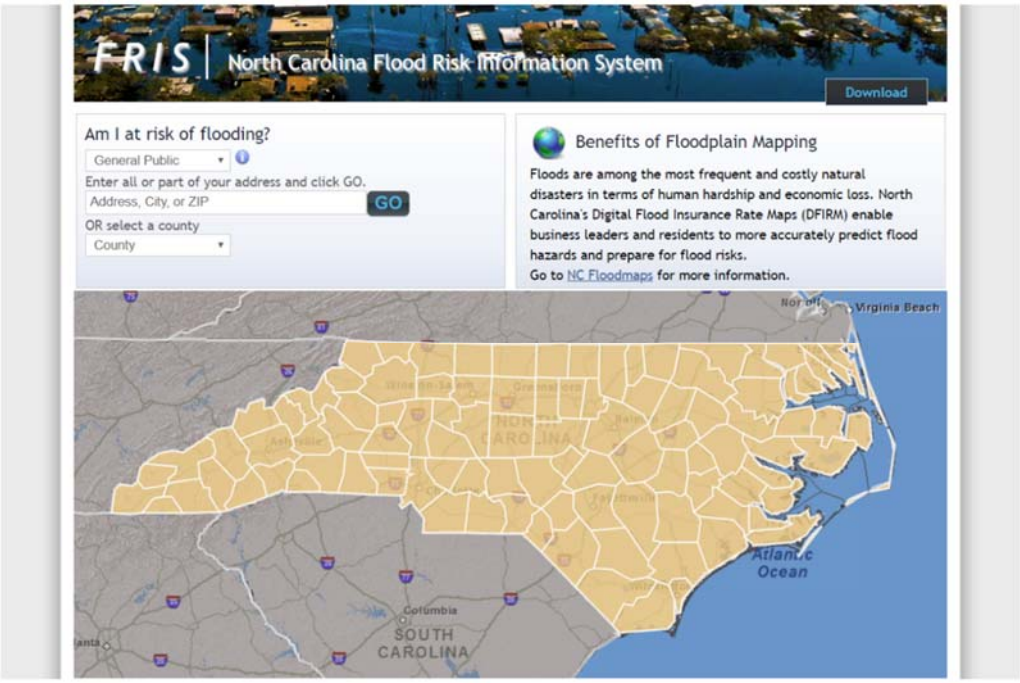


What is in the download: Contents of the downloaded model .zip file.

Name	Type	Size	Date modified
north_fork_crow_river_trib_5_ras.f01	F01 File	1 KB	1/27/2011 6:19 PM
north_fork_crow_river_trib_5_ras.g01	G01 File	258 KB	1/27/2011 6:19 PM
north_fork_crow_river_trib_5_ras.p01	P01 File	1 KB	1/27/2011 6:19 PM
north_fork_crow_river_trib_5_ras.prj	PRJ File	1 KB	1/27/2011 6:19 PM

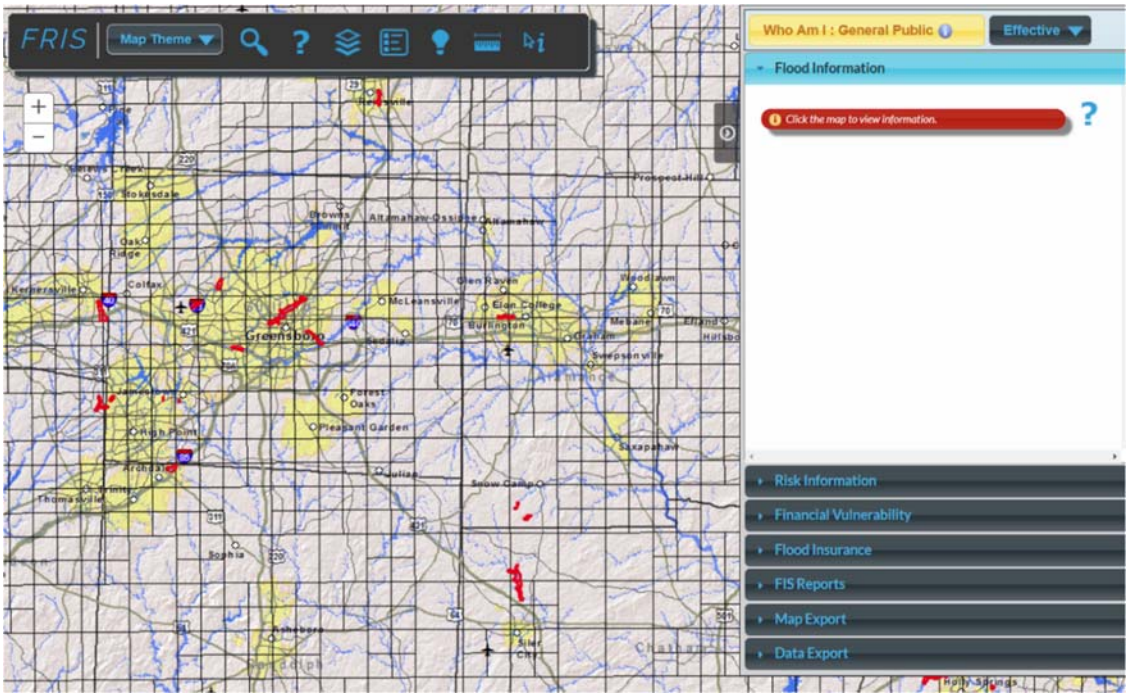
North Carolina

Where to go: http://fris.nc.gov/fris/Home.aspx?ST=NC

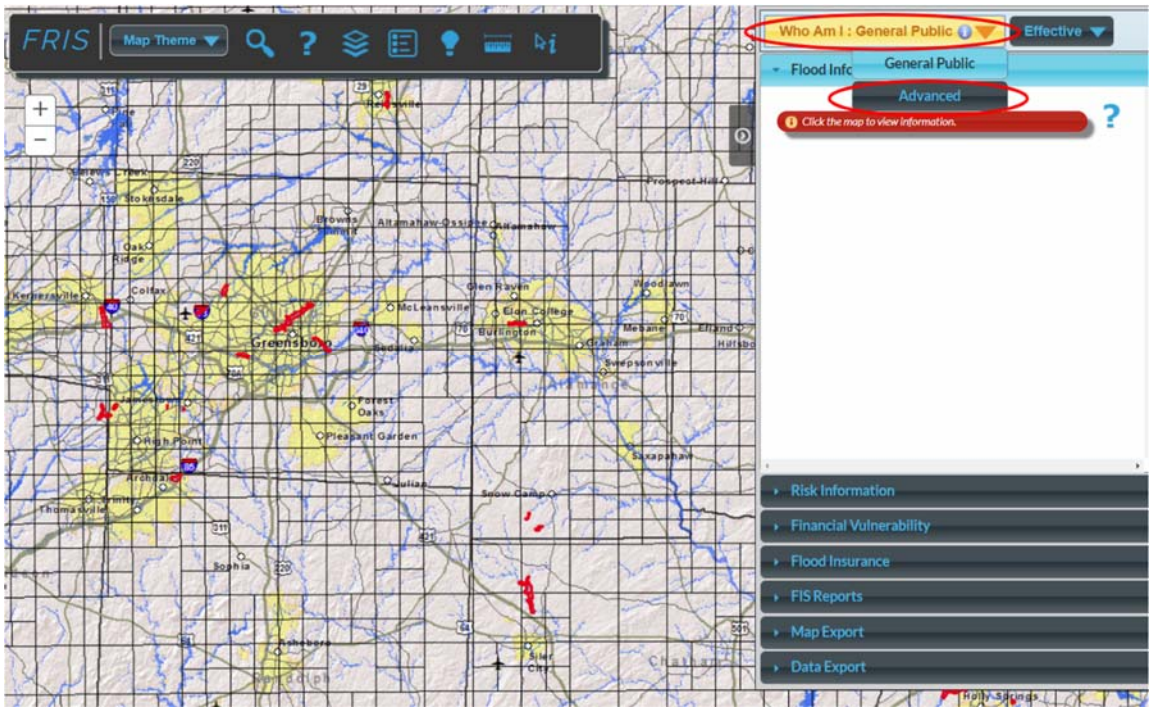


How to get the model:

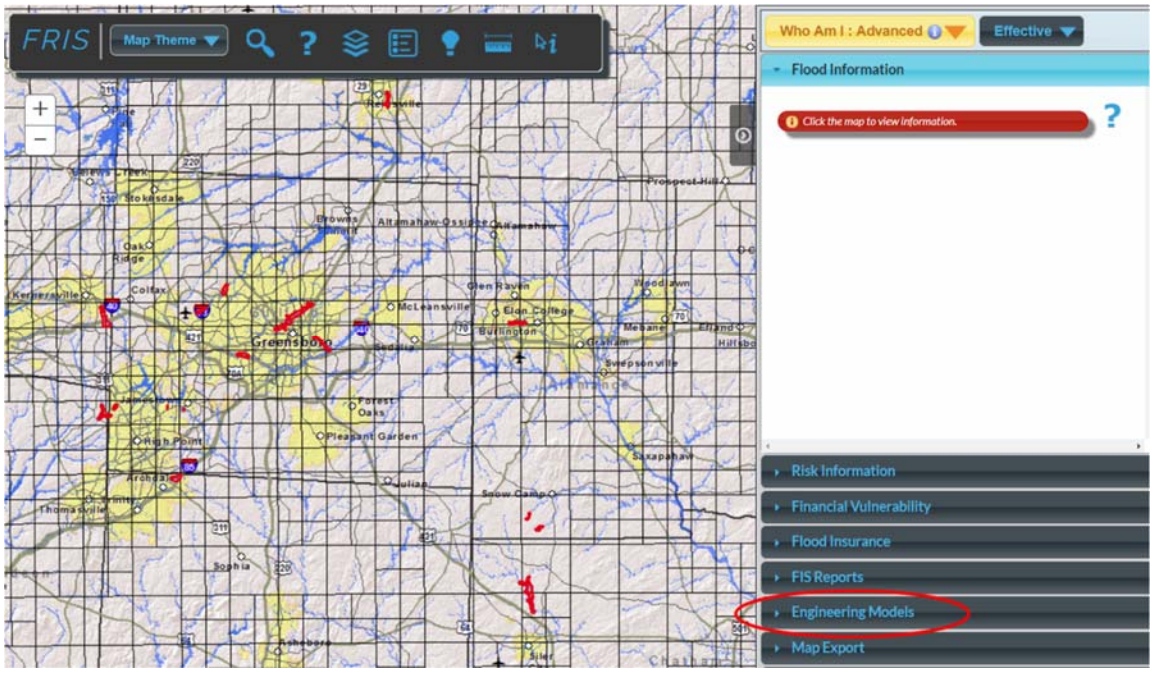
1. Zoom into the map by clicking a county or using the location finder in the upper left.



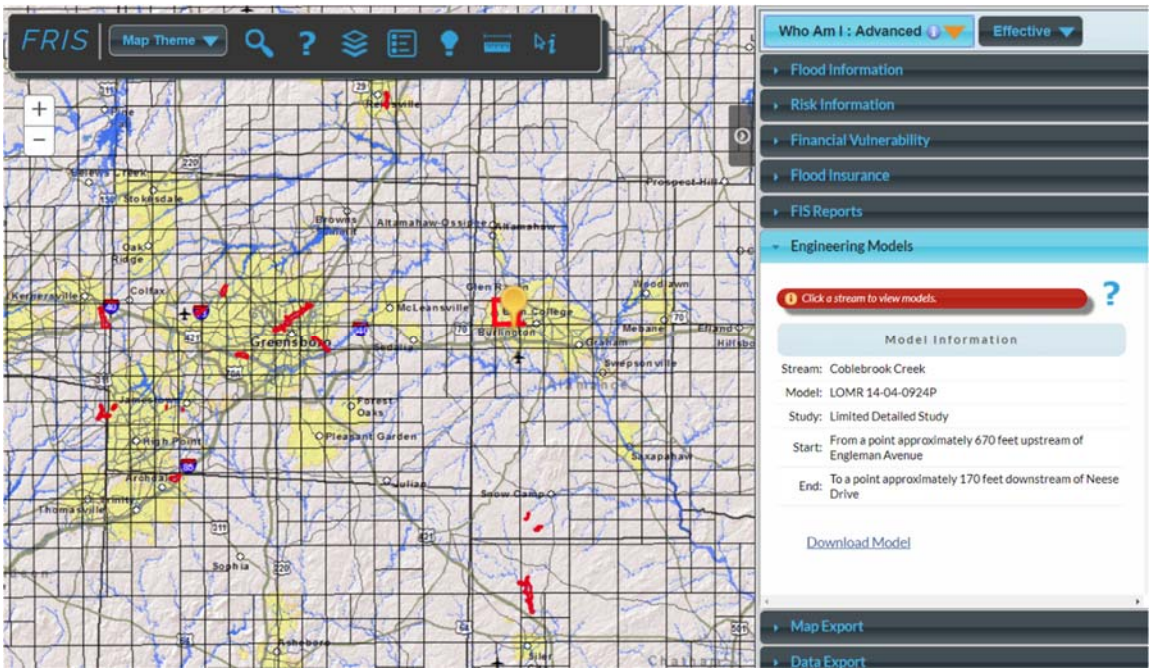
2. To access the engineering models, change the "Who Am I" dropdown in the upper right to "Advanced."



3. A new accordion panel appears called "Engineering Models."



4. Click the "Engineering Models" panel title and the accordion opens to that section. Click a stream segment on the map and data about the model appears in the panel with a download link.



What is in the download: Contents of the downloaded model .zip file.

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Coblebrook Creek.f01	F01 File	1 KB	4/30/2012 7:58 AM
COBLEBROOK CREEK.f02	F02 File	1 KB	4/30/2012 7:58 AM
COBLEBROOK CREEK.f03	F03 File	1 KB	4/30/2012 7:58 AM
COBLEBROOK CREEK.g01	G01 File	347 KB	4/30/2012 7:58 AM
COBLEBROOK CREEK.g02	G02 File	338 KB	4/30/2012 7:58 AM
COBLEBROOK CREEK.g03	G03 File	242 KB	4/30/2012 7:58 AM
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COBLEBROOK CREEK.O02	O02 File	155 KB	4/30/2012 7:58 AM
COBLEBROOK CREEK.O03	O03 File	108 KB	4/30/2012 7:58 AM
COBLEBROOK CREEK.O05	O05 File	155 KB	4/11/2013 1:32 PM
COBLEBROOK CREEK.p01	P01 File	5 KB	4/30/2012 7:58 AM
COBLEBROOK CREEK.p05	P05 File	4 KB	4/11/2013 1:33 PM
COBLEBROOK CREEK.PRJ	PRJ File	1 KB	4/11/2013 1:33 PM
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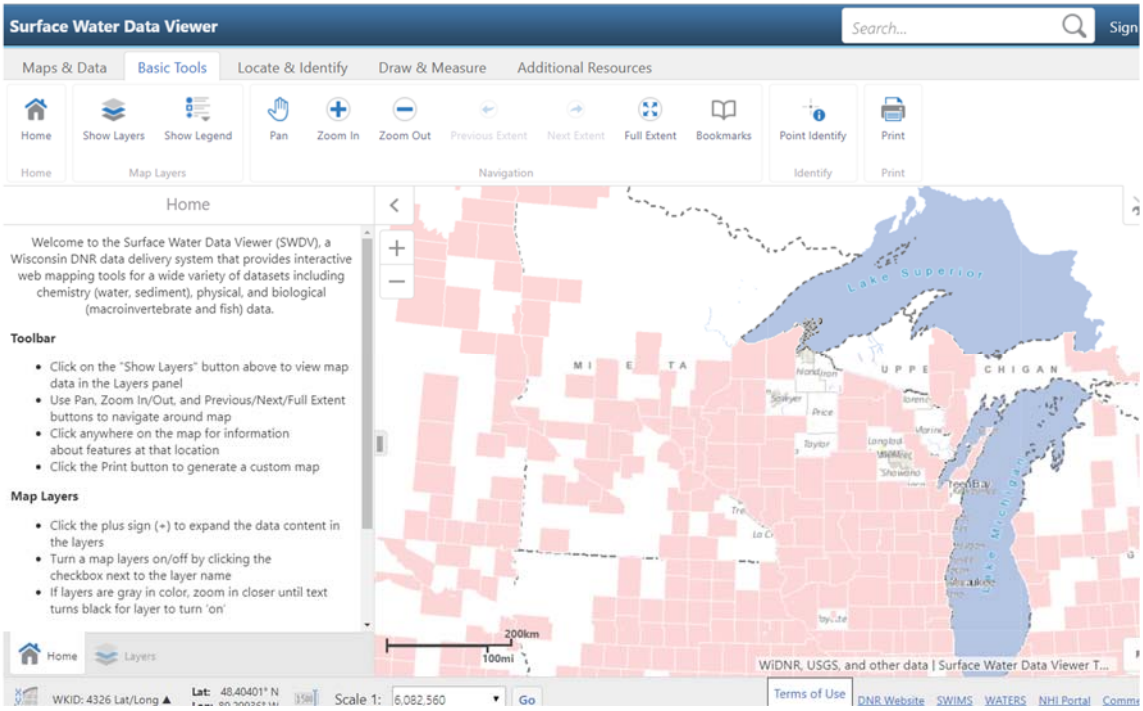
COBLEBROOK CREEK.RASexport.sdf	SDF File	45 KB	4/30/2012 7:58 AM
COBLEBROOK CREEK.RASexport.xml	XML File	72 KB	4/30/2012 7:58 AM
COBLEBROOK CREEK.rasmap	RASMAP File	4 KB	5/4/2012 1:28 PM
COBLEBROOK CREEK.rep	REP File	429 KB	4/11/2013 1:33 PM

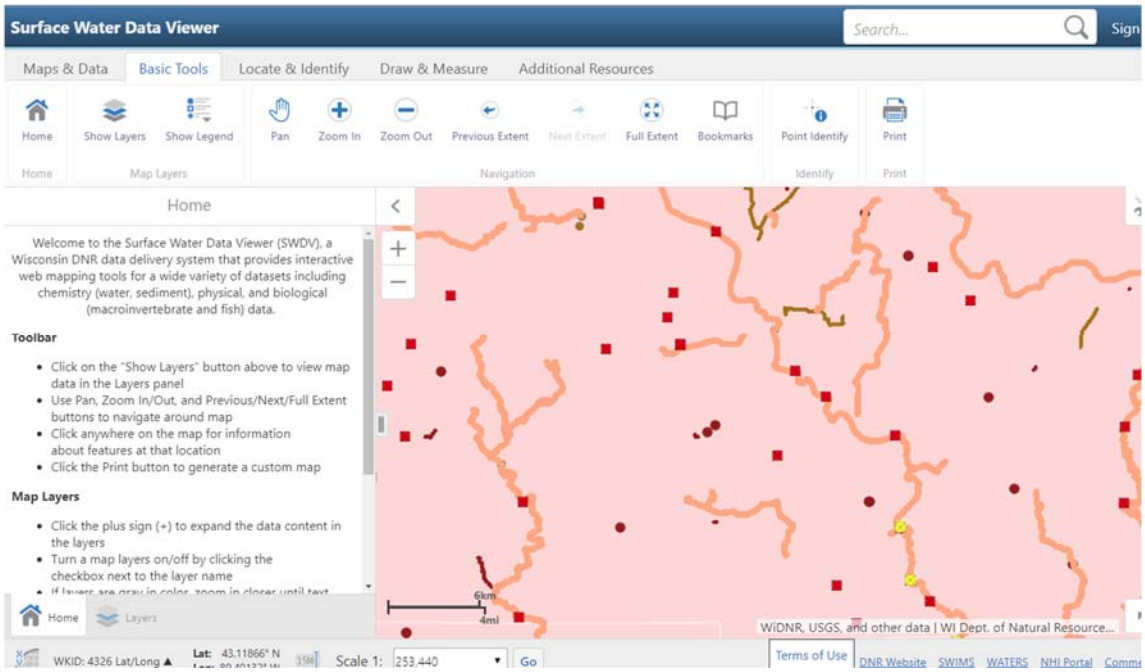
Wisconsin

Where to go: https://dnrmaps.wi.gov/H5/?viewer=SWDV&layerTheme=1

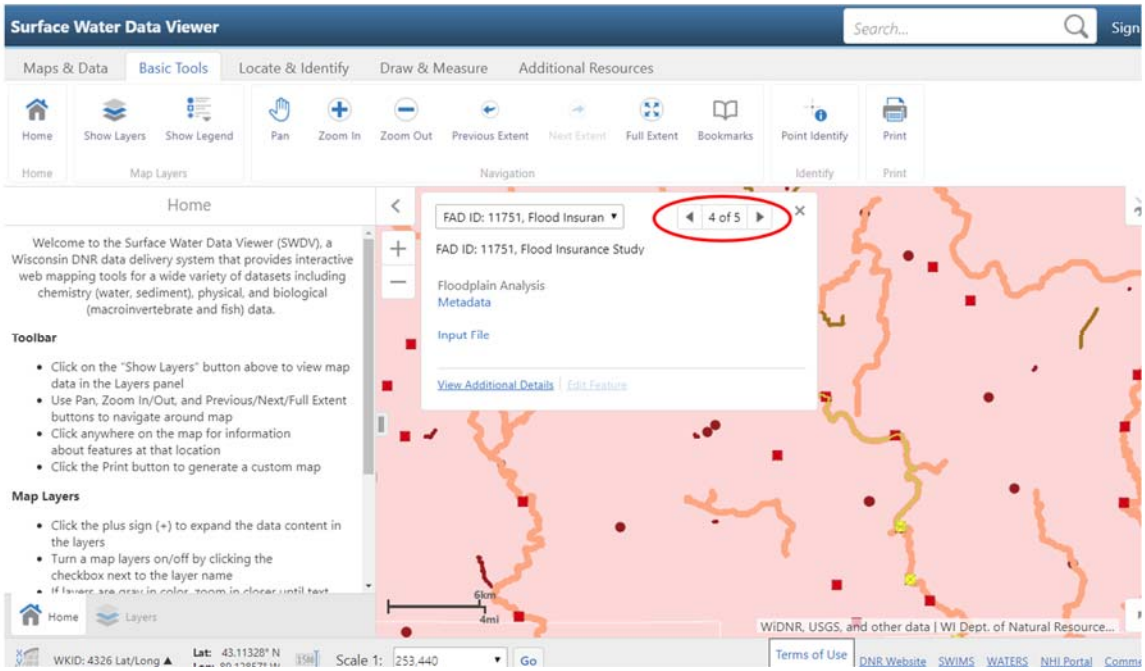


How to get the model:

1. Zoom in on the map to an area with mapped waterways.



2. Click on a waterway. Multiple layers are identified so you may have to page through the results with the arrows (red circle below). When there is a "Floodplain Analysis" layer, the model is accessible by clicking the "Input File" link.



What is in the download: Contents of the downloaded model .zip file.

Name	Type	Size	Date modified
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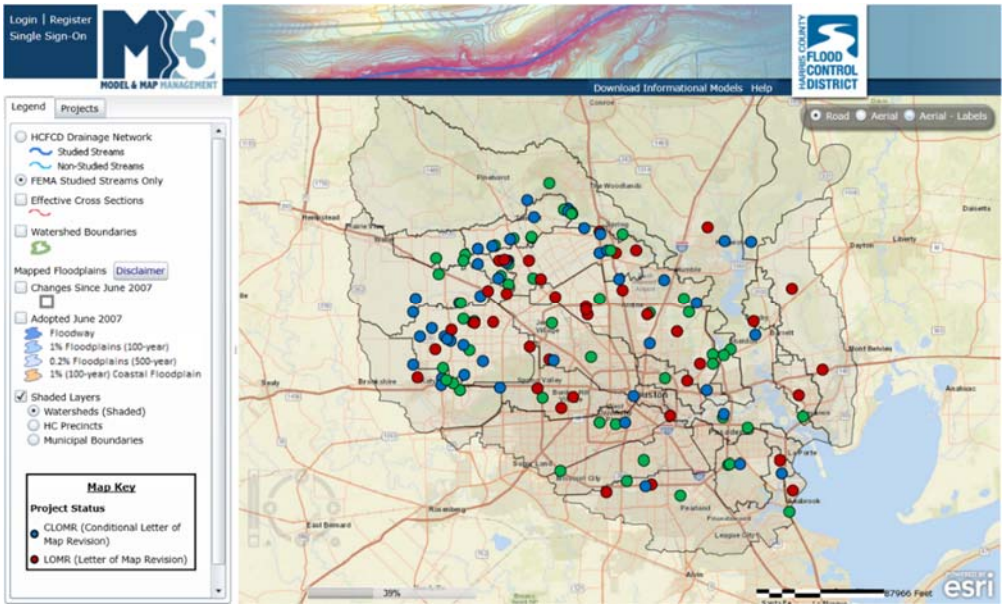
YaharaFinal.f02	F02 File	2 KB	8/21/2012 4:41 PM
YaharaFinal.f03	F03 File	2 KB	6/30/2006 11:19 AM
YaharaFinal.g01	G01 File	298 KB	8/21/2012 4:33 PM
YaharaFinal.O01	O01 File	488 KB	8/21/2012 4:31 PM
YaharaFinal.O02	O02 File	200 KB	8/21/2012 4:41 PM
YaharaFinal.O03	O03 File	230 KB	6/30/2006 12:09 PM
YaharaFinal.p01	P01 File	2 KB	6/28/2006 4:59 PM
YaharaFinal.p01.comp_msgs.txt	TXT File	1 KB	8/21/2012 4:31 PM
YaharaFinal.p02	P02 File	8 KB	8/21/2012 4:39 PM
YaharaFinal.p02.comp_msgs.txt	TXT File	1 KB	8/21/2012 4:41 PM
YaharaFinal.p03	P03 File	2 KB	6/30/2006 12:09 PM
YaharaFinal.prj	PRJ File	2 KB	8/21/2012 4:42 PM
YaharaFinal.r01	R01 File	209 KB	8/21/2012 4:31 PM
YaharaFinal.r02	R02 File	208 KB	8/21/2012 4:41 PM
YaharaFinal.r03	R03 File	192 KB	6/30/2006 12:09 PM

Harris County Flood Control District

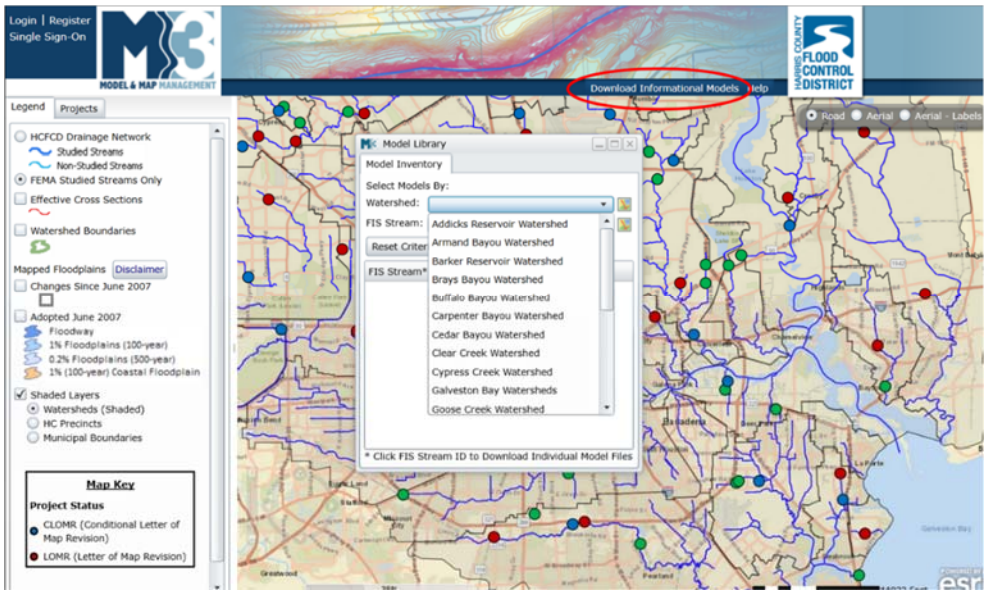
Where to go: http://www.m3models.org/#/Map

Note: Access requires Microsoft Silverlight plugin.

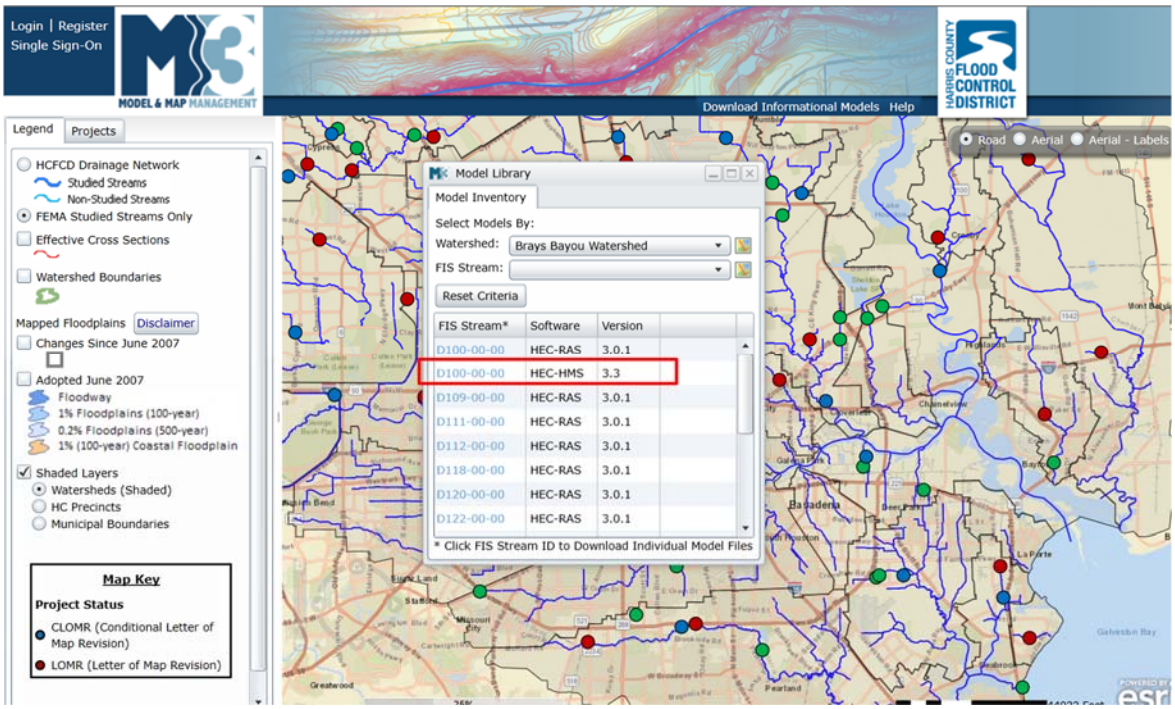


How to get the model:

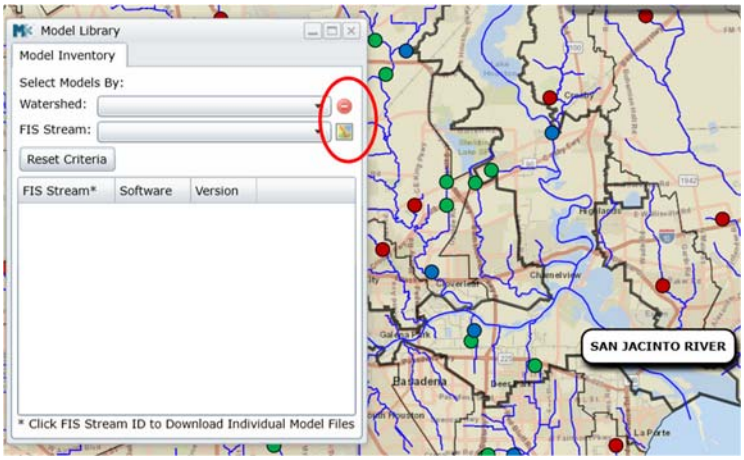
1. Access engineering models by clicking the "Download Informational Models" button at the top of the map. A popup window appears with a couple of dropdown menus and buttons. The first dropdown filters the models by watershed. The second dropdown allows you to select a model by the FIS Stream name. The buttons allow you to use the map to select either by watershed or by waterway.

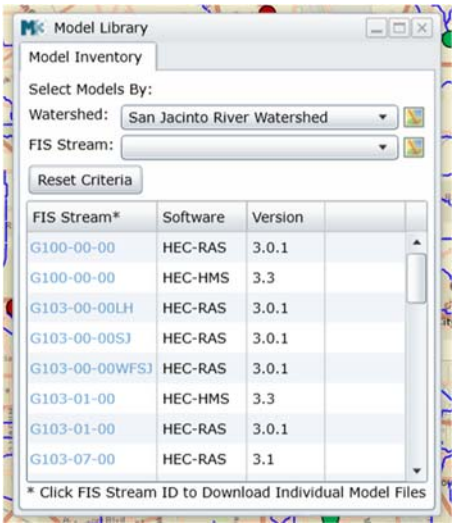


2. Selecting a watershed will filter those models into the lower portion of the popup where both hydrology model and hydraulic models for individual waterways can be downloaded.



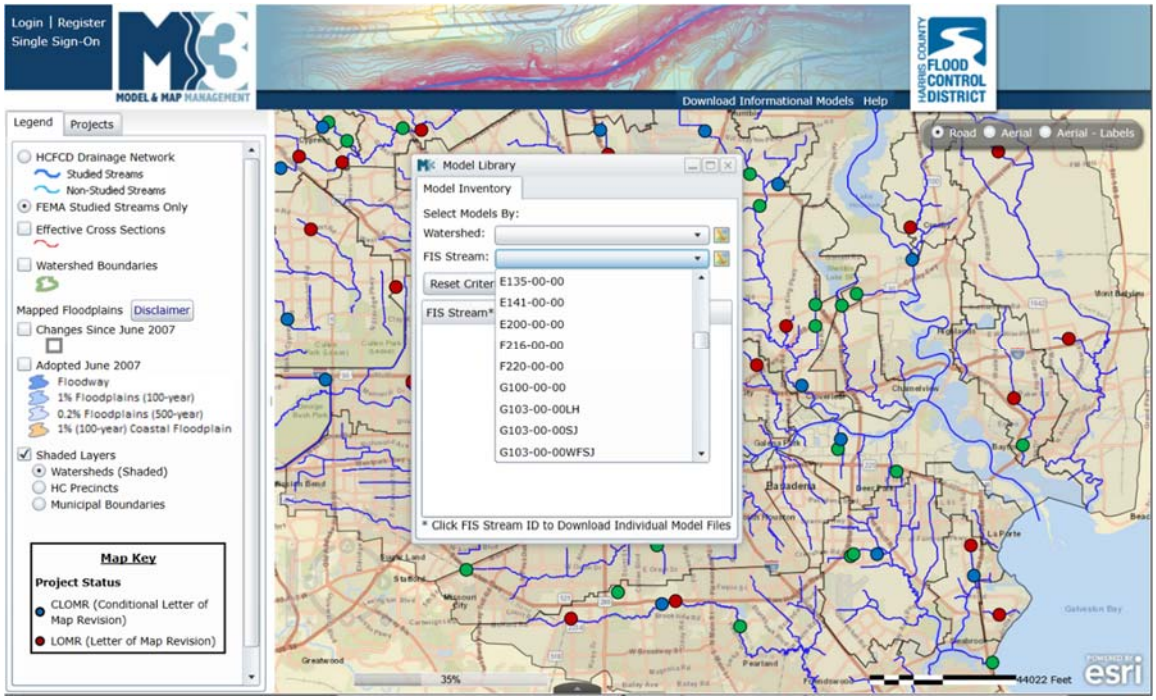
3. The button with the map icon to the right of the watershed dropdown allows you to select a watershed on the map. As you hover over the map, the boundaries of the watershed are outlined and the name is displayed. (Left)



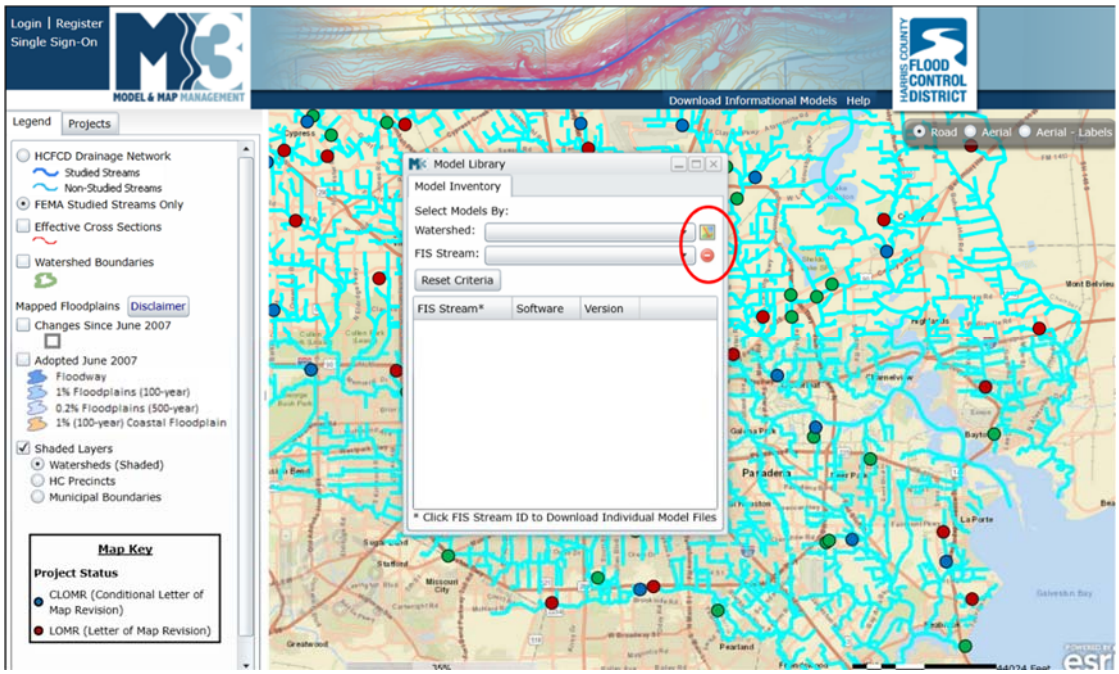


4. Clicking on a watershed filters those streams into the lower window, just as if it was selected from the dropdown. Again, hydrology models and hydraulic models for that watershed are listed and can be downloaded by clicking on the FIS Stream name. (Right)

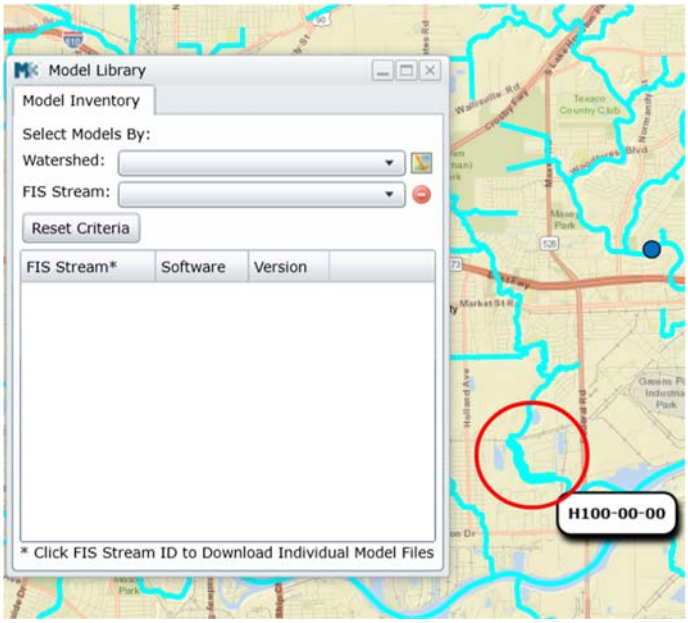
5. The second dropdown allows you to directly select the waterway by the FIS Stream name. Choosing a stream will display the hydraulic model in the lower window for download. It appears that the hydrologic models are available by selecting the first stream segment in the series.

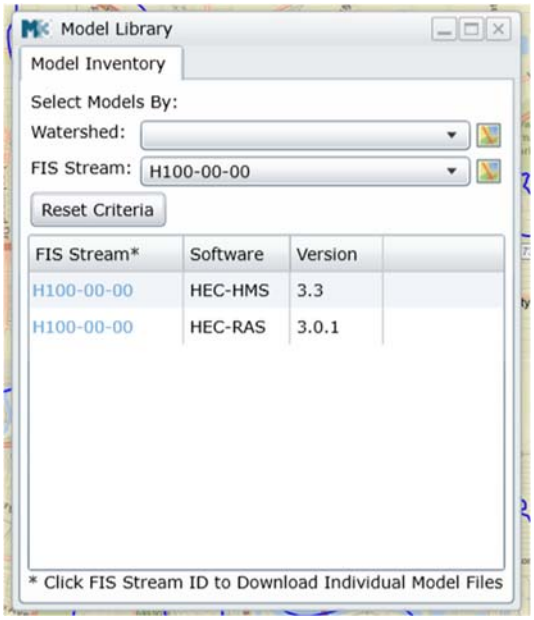


6. Use the map icon button to the right of the FIS Stream dropdown to select a stream on the map. Clicking this button will highlight all the stream segments.



7. Zoom the map and hover over stream segments to see the name. Clicking on a stream segment will put those models into the display window for download. The segment selected in this example has both the H&H models available.





What is in the download: Contents of the downloaded hydraulic model .zip file.

Name	Type	Size	Date modified
Support_Data	File folder		8/8/2016 1:48 PM
2007_Effective_H_H100-00-00_ReadMe.txt	TXT File	2 KB	6/24/2016 10:39 AM
H000050 Effective Model_H100-00-00_Re...	TXT File	2 KB	8/8/2016 1:48 PM
H100-00-00.f01	F01 File	4 KB	6/24/2016 10:42 AM
H100-00-00.f02	F02 File	3 KB	6/24/2016 10:42 AM
H100-00-00.g01	G01 File	1,096 KB	6/24/2016 10:41 AM
H100-00-00.O01	O01 File	983 KB	7/29/2016 9:24 AM
H100-00-00.O02	O02 File	504 KB	6/24/2016 10:43 AM
H100-00-00.p01	P01 File	4 KB	6/24/2016 10:39 AM
H100-00-00.p02	P02 File	16 KB	6/24/2016 10:41 AM
H100-00-00.prj	PRJ File	2 KB	7/29/2016 9:24 AM
H100-00-00.r01	R01 File	833 KB	7/29/2016 9:24 AM
H100-00-00.r02	R02 File	843 KB	6/24/2016 10:43 AM

Louisville Metropolitan Sewer District

Where to go:
https://stantecweb.com/swdms/swdmsmain.php

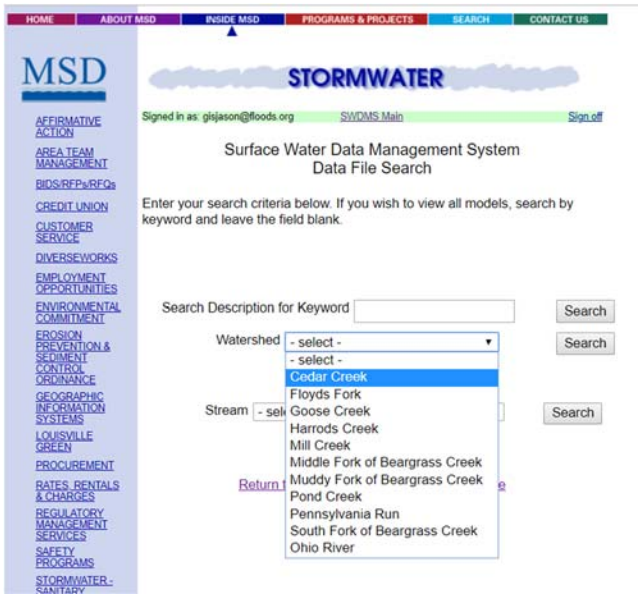
Note: Access is restricted to registered users, but you can register a user to access the models.

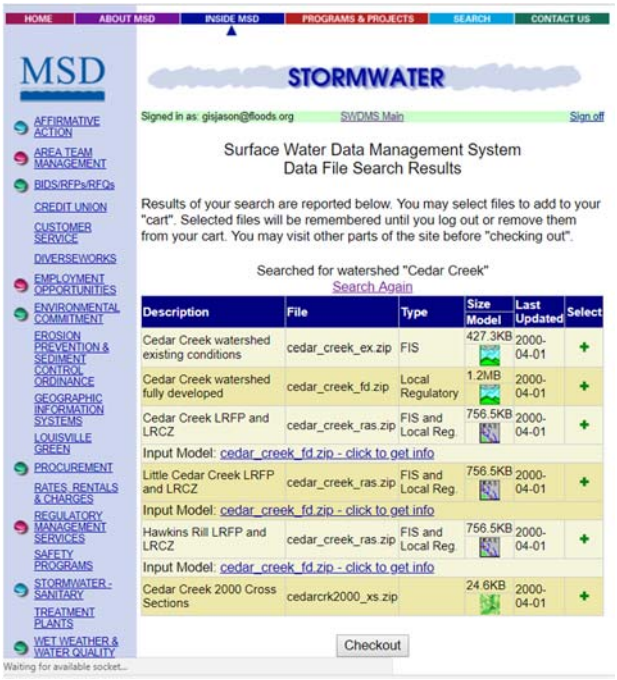
How to get the model:

1. After login, click "Search for Models" to find models to download.

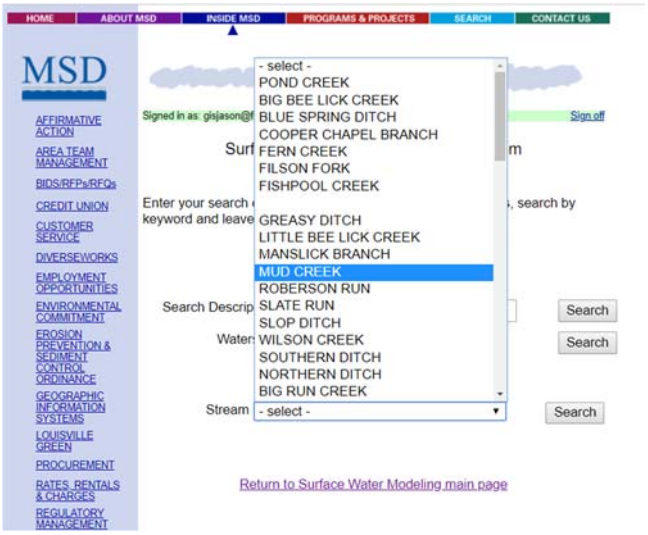
2. Users access the models either through a search box or one of two dropdowns. Search results conveniently include links to the Input Model.

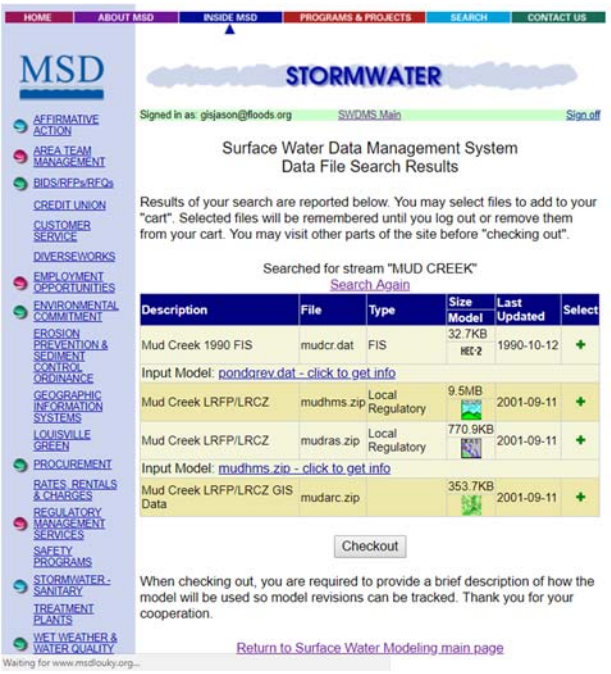
3. The first dropdown lists watersheds. Select a watershed then click the Search button to get to a page with the models available for download.



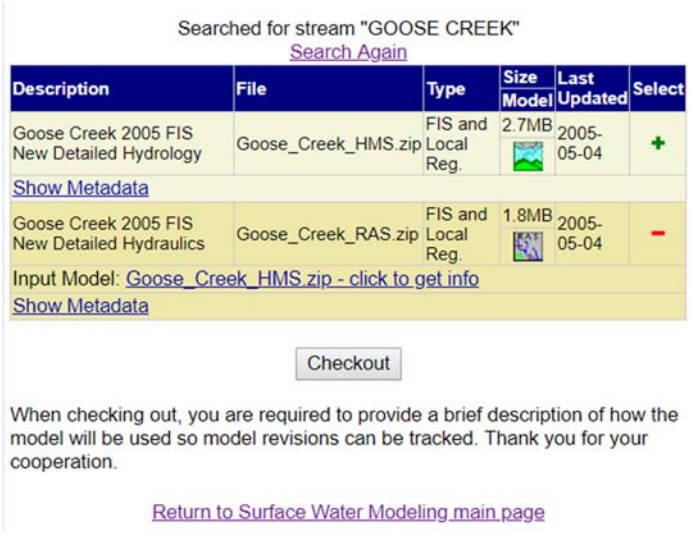


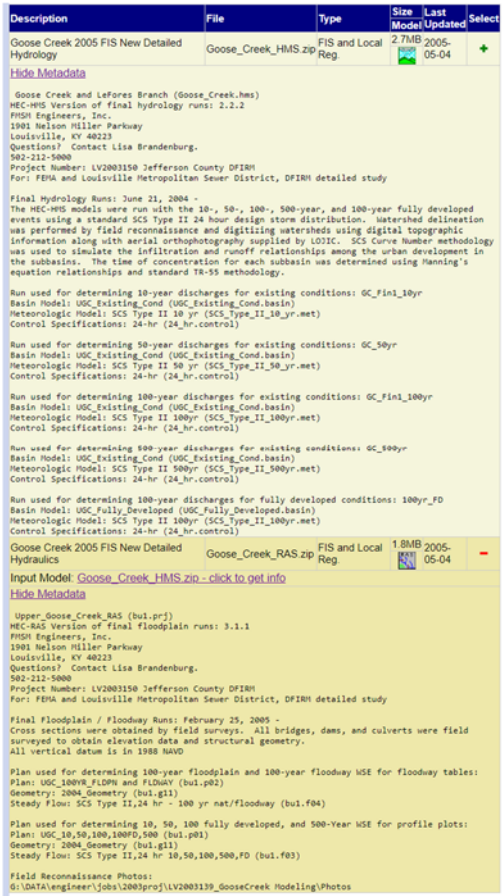
4. The second dropdown lets you select by stream name, bringing you to a similar download page.



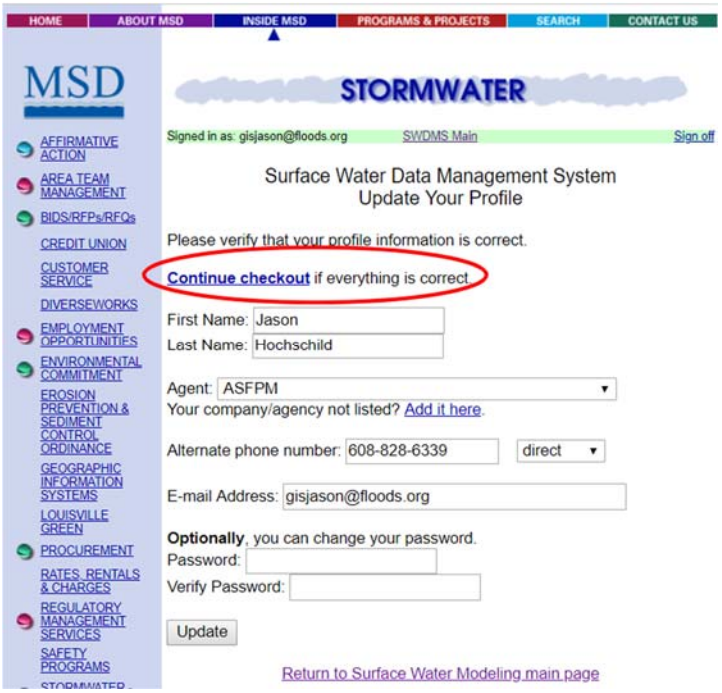


5. This site uses a checkout style system where clicking on the green plus to the right of each model turns it into a red minus indicating it is now selected and able to be deselected. (Below) This is convenient if you follow the path of the Input Model and add other models to the cart. Also convenient is the Show Metadata button. (Right)

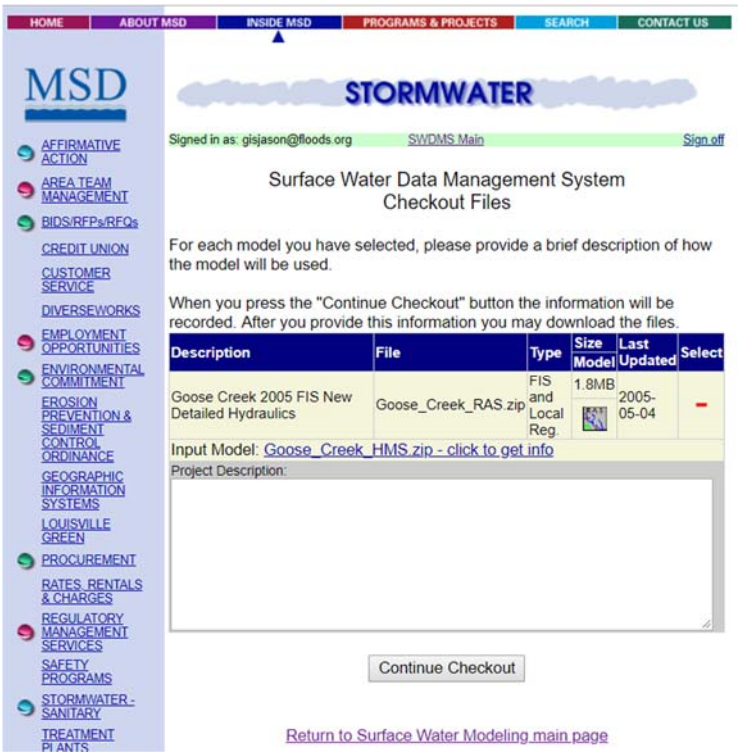




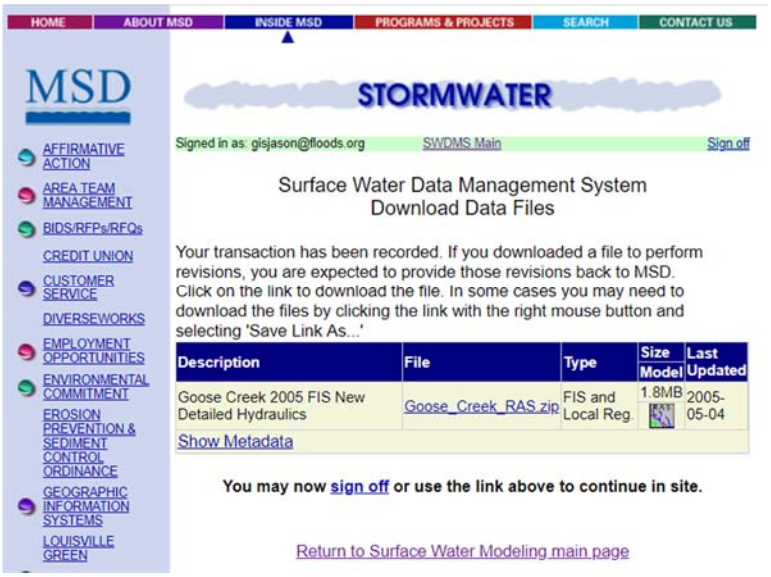
6. Clicking the Checkout button takes you to a page where you are asked to verify that your profile information is correct. Find the Continue to checkout link.



7. On this page the site asks you to provide a project description before you hit the Continue Checkout button.



8. The checkout concludes with a page where the model can be downloaded.



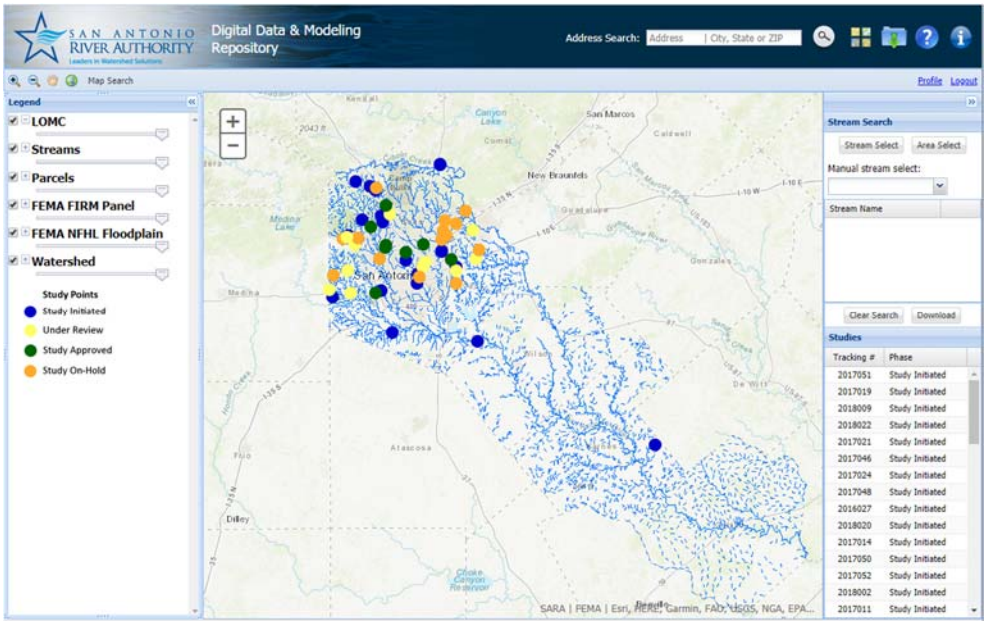
What is in the download: Contents of the downloaded model .zip file.

Name	Type	Size	Date modified
bu1.100E-FD.mp	MP File	22 KB	6/30/2004 8:31 AM
bu1.100YR.br	BR File	90 KB	6/30/2004 8:28 AM
bu1.100YR.nt	NT File	30 KB	6/30/2004 8:28 AM
bu1.100YR.xs	XS File	14 KB	6/30/2004 8:29 AM
bu1.EX.mp	MP File	40 KB	6/30/2004 8:30 AM
bu1.f01	F01 File	2 KB	4/12/2004 3:20 PM
bu1.f02	F02 File	3 KB	4/13/2004 3:56 PM
bu1.f03	F03 File	4 KB	7/1/2004 1:18 PM
bu1.f04	F04 File	3 KB	6/23/2004 9:17 AM
bu1.FW.br	BR File	122 KB	6/30/2004 8:35 AM
bu1.FW.fw	FW File	42 KB	6/30/2004 8:36 AM
bu1.FW.nt	NT File	30 KB	6/30/2004 8:36 AM
bu1.FW.xs	XS File	15 KB	6/30/2004 8:37 AM
bu1.g11	G11 File	664 KB	6/30/2004 2:37 PM
bu1.O01	O01 File	1,194 KB	9/10/2004 5:26 PM
bu1.O02	O02 File	503 KB	7/6/2004 2:16 PM
bu1.O10	O10 File	503 KB	6/18/2004 4:56 PM
bu1.p01	P01 File	85 KB	9/10/2004 5:27 PM
bu1.p02	P02 File	91 KB	7/6/2004 2:17 PM
bu1.p10	Certificate Request	85 KB	4/12/2004 3:20 PM
bu1.prj	PRJ File	3 KB	4/28/2005 4:54 PM
bu1.r01	R01 File	480 KB	9/10/2004 5:26 PM
bu1.r02	R02 File	485 KB	7/6/2004 2:16 PM
bu1.r10	R10 File	479 KB	6/18/2004 4:56 PM
bu1.rep	REP File	2,086 KB	9/10/2004 5:03 PM
bu1.xs	XS File	15 KB	6/30/2004 8:35 AM
README_BU1.txt	TXT File	2 KB	5/4/2005 12:14 PM

San Antonio River Authority

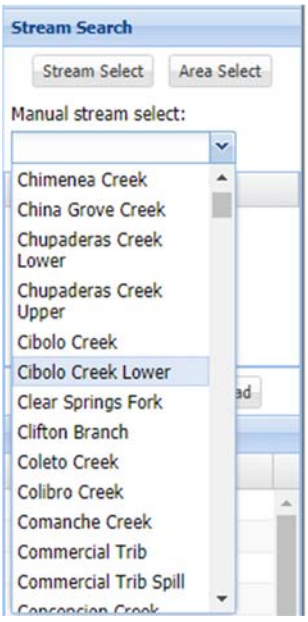
Where to go: http://gis.sara-tx.org/D2MR/

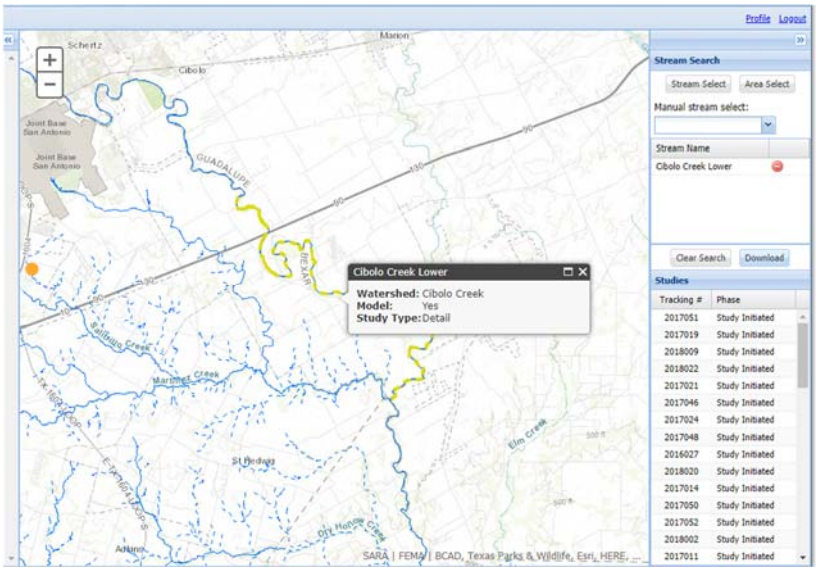
Note: Access is restricted to registered users, but you can register a user to access the models.



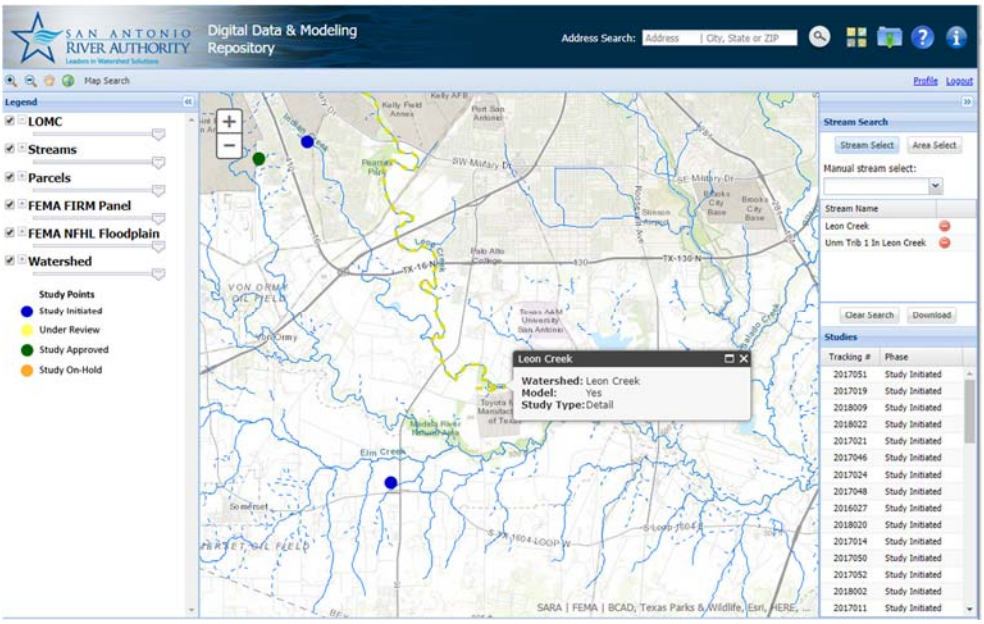
How to get the model:

1. Use the Manual stream select dropdown in the upper right of the display to select a stream. (Left) The map zooms to the stream extents and displays the name in the Stream Name window just below the dropdown. Click the Download button to get the model. (Right)

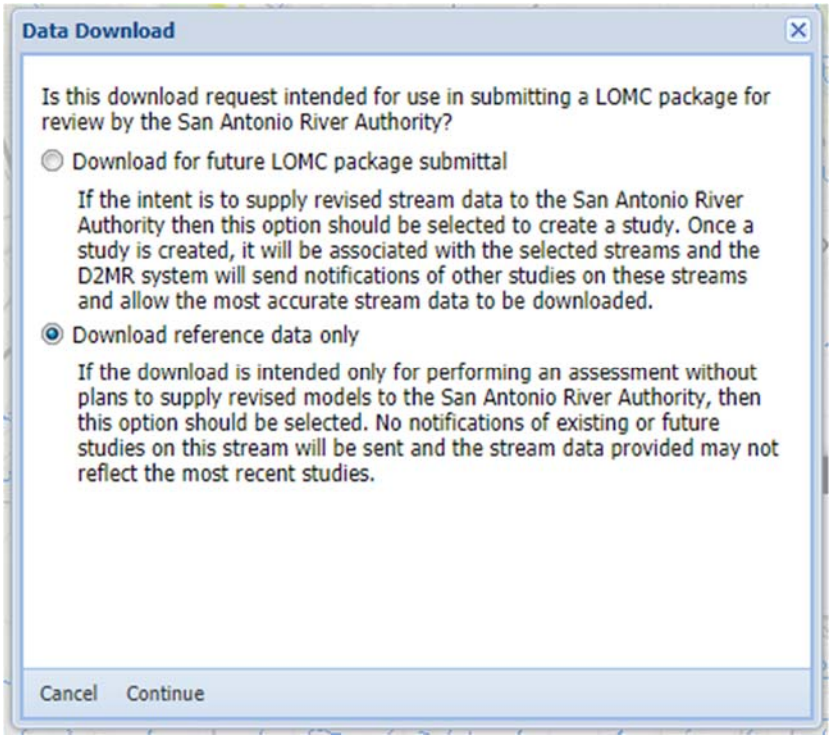




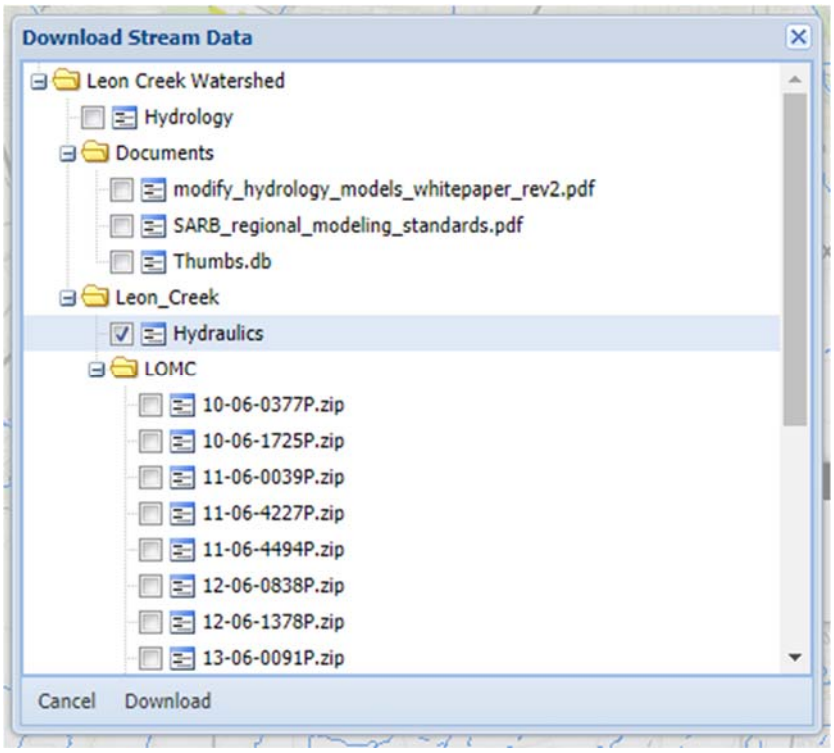
2. Alternatively, you can zoom in on the map to an area with mapped waterways and use the Stream Select or Area Select buttons in the upper right corner to choose a stream or streams that are then added to the Stream Name window for download. Click the red Remove button next to each stream name to remove it from the download list or click the Clear Search button to remove all streams.



3. Clicking the download button brings up this question of whether or not you will use the downloaded data when submitting a LOMC for review.



4. The Download Stream Data window provides access to the Hydraulic and Hydrology models. Check one or more boxes and then the download button.



What is in the download: Contents of the downloaded model .zip file.

Name	Type	Size	Date modified
Backup.p01	P01 File	2 KB	9/22/2009 4:57 PM
BPIAppeal.f04	F04 File	2 KB	8/20/2009 3:51 PM
BPIAppeal.g03	G03 File	360 KB	8/19/2009 5:17 PM
BPIAppeal.p02	P02 File	2 KB	8/19/2009 7:24 PM
BPIAppeal.prj	PRJ File	2 KB	8/20/2009 5:00 PM
Leon Creek Park_n_Ride_Readme.doc	Microsoft Word 9...	27 KB	9/1/2009 5:16 PM
LeonCreek.f01	F01 File	8 KB	8/22/2009 11:31 PM
LeonCreek.g05	G05 File	4,644 KB	9/1/2009 5:11 PM
LeonCreek.O02	O02 File	4,633 KB	9/22/2009 4:55 PM
LeonCreek.p02	P02 File	2 KB	9/1/2009 5:12 PM
LeonCreek.prj	PRJ File	1 KB	9/1/2009 5:12 PM
LeonCreek.r02	R02 File	4,283 KB	9/22/2009 4:37 PM
Park_n_Ride_Spill.f02	F02 File	2 KB	8/20/2009 4:52 PM
Park_n_Ride_Spill.g01	G01 File	20 KB	9/1/2009 1:04 AM
Park_n_Ride_Spill.p01	P01 File	2 KB	8/17/2009 3:13 PM
Park_n_Ride_Spill.prj	PRJ File	1 KB	9/1/2009 5:14 PM

Discussion

All the states and entities discussed above provide access to download models through a clickable map with the exception of Louisville Metropolitan Sewer District, which uses a table based on stream names. For a small entity, Louisville's method is acceptable, but for regional or statewide datasets, the methods that use a map to access the models appears to be the most user friendly approach.

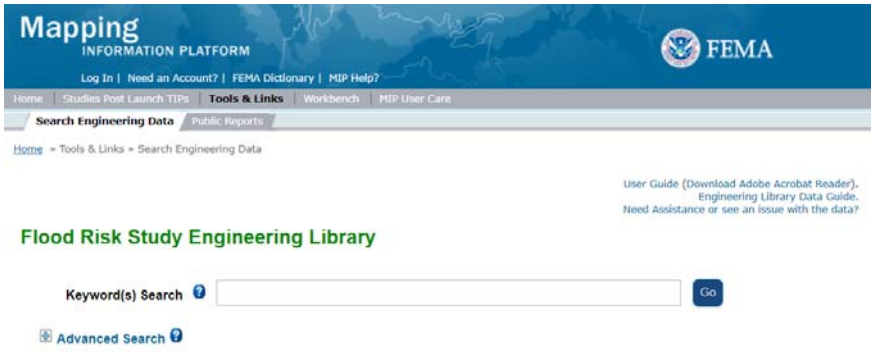
Maps are inherently data rich images and many people are already used to interacting with maps on the internet. Maps can provide the spatial reference for users that is difficult to show in a list of available models. Furthermore, many streams that have floodplain maps are unnamed or only have only numerical designations in relation to the flood study so a map can more easily provide the necessary context for users to define the geographical extent where they are interested in locating models.

Using a map as the access point for downloading engineering models also gives states and entities an easy method to provide access to additional data that is relevant to floodplain mapping. As shown in its section above, Maryland provides access to the flood study engineering models via a clickable map on a publicly accessible website. In addition to the flood study engineering (HEC-RAS) models, the site has data associated with approved stream flows for all streams in the state and data associated with bridges and culverts (cross sections and photographs) as separate data sets associated with the waters of the State of Maryland. This is in contrast to the standard practice in which the bridge data is imbedded in the engineering models. The models and supporting information have all been georeferenced and are shown on the website in their actual mapped locations. With this information, staff can respond to engineering data requests and FEMA Letter of Map Amendment processing in less time and at less cost.

The additional data that can be made available through a map or that can be made accessible based on a geographic extent can help provide a more holistic understanding of the data required to make accurate floodplain maps. In the case of the Maryland example, the availability of bridge and culvert data alongside the hydraulic model data provides end users with a simple solution to gather the necessary data from one location instead of searching across numerous websites and data portals.

FEMA FRiSEL - Flood Risk Study Engineering Library

Where to go: https://hazards.fema.gov/wps/portal/frisel

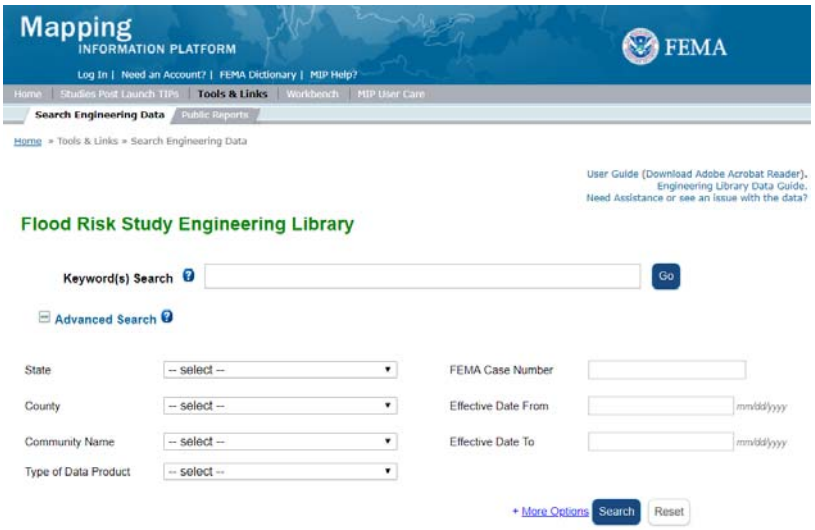


Users can also access FRiSEL through FEMA's Mapping Information Platform home page at https://hazards.fema.gov/femaportal/wps/portal. Go to the **Tools & Links** page from the main menu bar then click on the **Search Engineering Data** tab on the secondary menu bar.

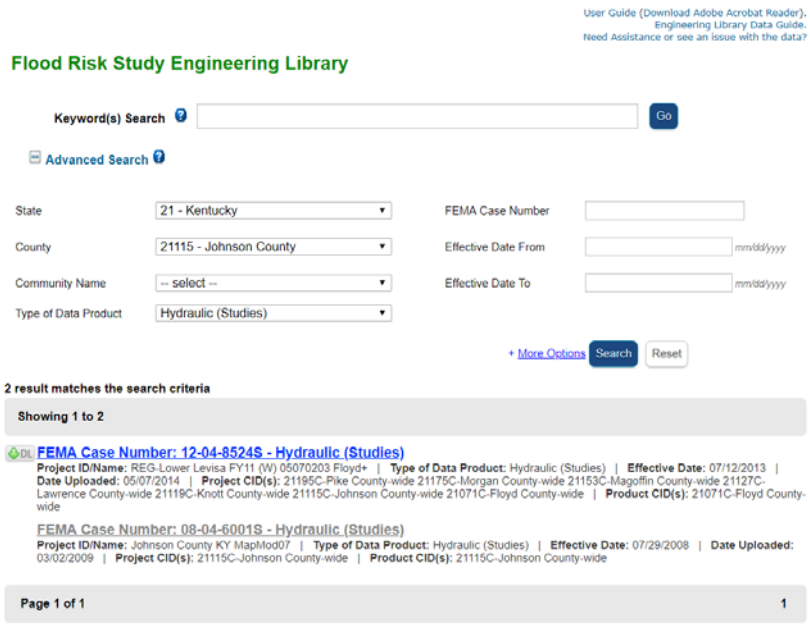
How to get the model:

1. Note the help guides available to users using the link on the right of the page:
   FRiSEL User Guide.
   FRiSEL Data Guide

2. Expand the **Advanced Search** fields. Enter a state, county, and/or community name (or a FEMA case number, or an effective date range). For **Type of Data Product** choose "Hydraulic (Studies)" and then click the **Search** button. (Click **More Options** next to the Search button to get additional search parameters.)



3. Search results are displayed at the bottom of the page.

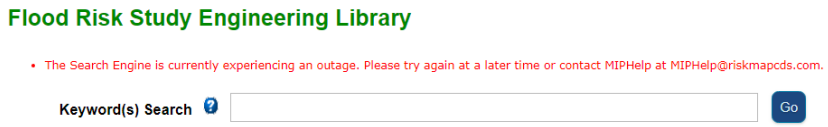


   a. Identified issue: Search results with multiple pages are displayed with a "Next" button to access the additional pages. The "Next" button stops working after using it 2 times. The workaround is that a user has to click on the number that denotes the next page, then after that, the Next button stops working again after 2 clicks.

   b. Results with a link and a 

image have data available for download while results without a link are displayed in gray and are either older studies or do not have data available for download.[1]

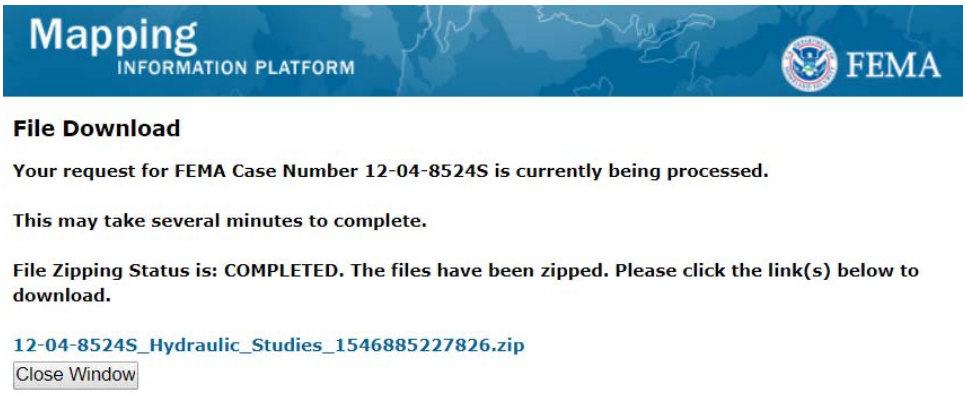
   c. Oftentimes an error will be shown saying there is an outage. Reload the page and try again.



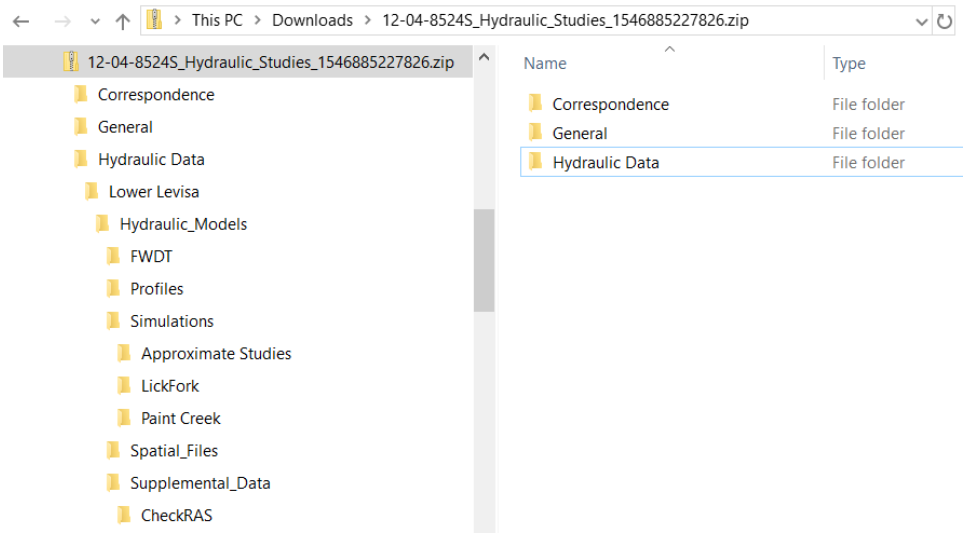
[1] Note: Older data not found in the MIP can be requested through the File Trail at https://filetrail.msc.fema.gov/, a file tracking system used to track the FEMA Engineering Library's inventory of information that was submitted to be archived.

4. Click on the  button to download all the results. Click on the link text to see the data available.

5. Choose the **Download All** button or use the checkboxes to choose individual files and use the **Download Selected File(s)** button to download the results.



6. A window will pop up while the system zips together the download request. After the file zipping status is complete, click on the link to download the zip file locally.



What is in the download:

Note: Attempts were made to download models from the FEMA site to see if they match what is available from the states. It appears most models are not available on the FEMA site. There are search results but either the link is not active or there is no download available. On the majority of those found that were available for download, the only thing available was a metadata .xml file or other miscellaneous files that were not the models.

Another issue encountered is that many models are part of a county wide download so in order to get individual models it requires a large download that takes the website a bit of time to package together.

Indiana, Blue River:

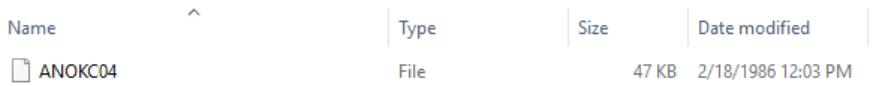
Name	Type	Size	Date modified
BlueRiver.br	BR File	10 KB	4/13/2012 10:17 AM
Backup.f01	F01 File	1 KB	4/13/2012 9:31 AM
BlueRiver.f01	F01 File	1 KB	4/13/2012 9:50 AM
Backup.g01	G01 File	10 KB	4/13/2012 9:31 AM
BlueRiver.g01	G01 File	10 KB	4/13/2012 8:01 AM
BlueRiver.g02	G02 File	10 KB	4/13/2012 9:49 AM
BlueRiver.nt	NT File	4 KB	4/12/2012 4:13 PM
BlueRiver.O01	O01 File	13 KB	4/13/2012 11:46 AM
BlueRiver.O02	O02 File	19 KB	4/13/2012 10:56 AM
BlueRiver.p01	P01 File	4 KB	10/19/2011 9:38 AM
BlueRiver.p02	P02 File	4 KB	3/22/2012 9:43 AM
BlueRiver.prj	PRJ File	1 KB	4/13/2012 11:46 AM
BlueRiver.r01	R01 File	10 KB	4/13/2012 11:45 AM
BlueRiver.r02	R02 File	13 KB	4/13/2012 10:56 AM
BlueRiver.rep	REP File	50 KB	4/13/2012 10:12 AM
BlueRiver.p01.comp_msgs.txt	TXT File	1 KB	4/13/2012 11:45 AM
BlueRiver.p02.comp_msgs.txt	TXT File	1 KB	4/13/2012 10:56 AM
BlueRiver.xs	XS File	3 KB	4/12/2012 4:13 PM

FEMA, Blue River:

Name	Type	Size	Date modified
04372.br	BR File	66 KB	3/30/2018 4:02 PM
04372.dsc	DSC File	2 KB	3/30/2018 4:02 PM
04372.dss	DSS File	18 KB	3/30/2018 4:02 PM
04372.f01	F01 File	1 KB	3/30/2018 4:02 PM
04372.f02	F02 File	2 KB	3/30/2018 4:02 PM
04372.f03	F03 File	2 KB	3/30/2018 4:02 PM
04372.fw	FW File	16 KB	3/30/2018 4:02 PM
04372.g01	G01 File	6 KB	3/30/2018 4:02 PM
Backup.g01	G01 File	142 KB	3/30/2018 4:02 PM
04372.g02	G02 File	135 KB	3/30/2018 4:02 PM
04372.g03	G03 File	31 KB	3/30/2018 4:02 PM
04372.g04	G04 File	137 KB	3/30/2018 4:02 PM
04372.mp	MP File	12 KB	3/30/2018 4:02 PM
04372.dss.msg	MSG File	2 KB	3/30/2018 4:02 PM
04372.nt	NT File	10 KB	3/30/2018 4:02 PM
04372.O01	O01 File	46 KB	3/30/2018 4:02 PM
04372.O03	O03 File	232 KB	3/30/2018 4:02 PM
04372.O04	O04 File	232 KB	3/30/2018 4:02 PM
04372.p01	P01 File	2 KB	3/30/2018 4:02 PM
04372.p03	P03 File	6 KB	3/30/2018 4:02 PM
04372.p04	P04 File	6 KB	3/30/2018 4:02 PM
04372.prj	PRJ File	2 KB	3/30/2018 4:02 PM
04372.r01	R01 File	8 KB	3/30/2018 4:02 PM
04372.r03	R03 File	87 KB	3/30/2018 4:02 PM
04372.r04	R04 File	87 KB	3/30/2018 4:02 PM
04372.rep	REP File	205 KB	3/30/2018 4:02 PM
04372.RASexport.sdf	SDF File	56 KB	3/30/2018 4:02 PM
04372.p04.comp_msgs.txt	TXT File	1 KB	3/30/2018 4:02 PM
04372.xs	XS File	7 KB	3/30/2018 4:02 PM

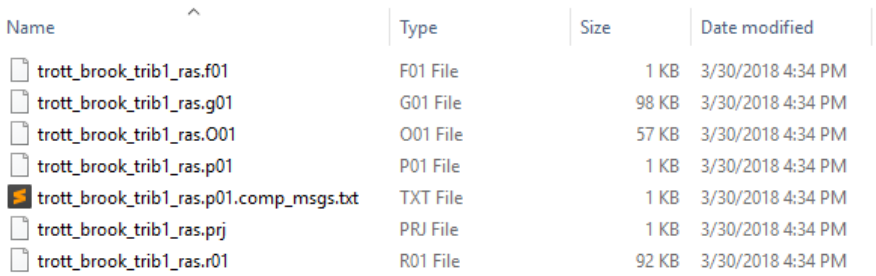
Result: Files sizes and contents are different.

Minnesota, Trott Brook:



Name	Type	Size	Date modified
ANOKC04	File	47 KB	2/18/1986 12:03 PM

FEMA, Trott Brook:



Name	Type	Size	Date modified
trott_brook_trib1_ras.f01	F01 File	1 KB	3/30/2018 4:34 PM
trott_brook_trib1_ras.g01	G01 File	98 KB	3/30/2018 4:34 PM
trott_brook_trib1_ras.O01	O01 File	57 KB	3/30/2018 4:34 PM
trott_brook_trib1_ras.p01	P01 File	1 KB	3/30/2018 4:34 PM
trott_brook_trib1_ras.p01.comp_msgs.txt	TXT File	1 KB	3/30/2018 4:34 PM
trott_brook_trib1_ras.prj	PRJ File	1 KB	3/30/2018 4:34 PM
trott_brook_trib1_ras.r01	R01 File	92 KB	3/30/2018 4:34 PM

Result: Different models.

Ensuring consistency between State/local approved engineering models and the FEMA authoritative flood model

Third Task: Document the processes these entities have put in place to ensure that the state/locally approved flood study models stay in synch with the FEMA approved flood study model.

Results: ASFPM identified the following entities that provide access to flood models:

Delaware
Indiana
Kentucky
Maryland
Minnesota
North Carolina
Wisconsin
Harris County Flood Control District, TX
Louisville Metropolitan Sewer District
San Antonio Regional Authority, TX

LOMR Review Partners

The State of North Carolina, Harris County Flood Control District and the San Antonio Regional Authority are FEMA LOMR Review Partners. Being LOMR Review Partners ensures that any engineering models approved are consistent with the engineering models these entities make available for public access.

FEMA Regional Guidance Document

FEMA Region V has developed a *"Guidance for Flood Risk analysis and Mapping - State Specific Preferences"* document that is intended to address issues with consistency for states in the region with higher standards. The Indiana and Wisconsin sections of this document states:

> Approval required for all LOMRs and CLOMRs. If a project scope changes during the processing of the request, the requestor will need to obtain re-approval of the project from the state. Any H&H revision due to a FEMA review requires an amended DNR approval.

The Minnesota section of the document does not include this statement.

However, while the document indicates "Any H&H revision due to a FEMA review requires an amended DNR approval", when checking with the States IN could not confirm that it actually happens in all cases.

The WI NFIP coordinator (Michelle Staff) is cced on any review documents that go to engineering consultants requesting modifications to the engineering model associated with a LOMR as an FYI. This information is then passed on to the regional engineer that conducted the state review and issued the approval who then should request the revised engineering model from the engineering consultant to ensure that the revisions meet State standards and upload the revised model into the State system. It could not be confirmed that this happens in all cases. In addition, Wisconsin engineering staff indicated that there have been documented cases where the FEMA LOMR Review Contractor issued a LOMR approval for a project that had not been reviewed and approved by the State of Wisconsin.

Similar to WI, the MN NFIP coordinator (Ceil Strauss) is cced on any review documents that go to engineering consultants requesting modifications to the engineering model associated with a LOMR. This information is passed on to the area hydrologist that conducted the state review and approved the project who then should request the revised engineering model from the engineering consultant to ensure that the revisions meet State standards and upload the revised model into the State system.

No Formal Process Established

There is no formal process established for Delaware, Kentucky, Maryland or the City of Louisville, KY. However, the City of Louisville must sign-off on any LOMRs submitted and therefore are aware of changes associated with engineering models made available on their website.

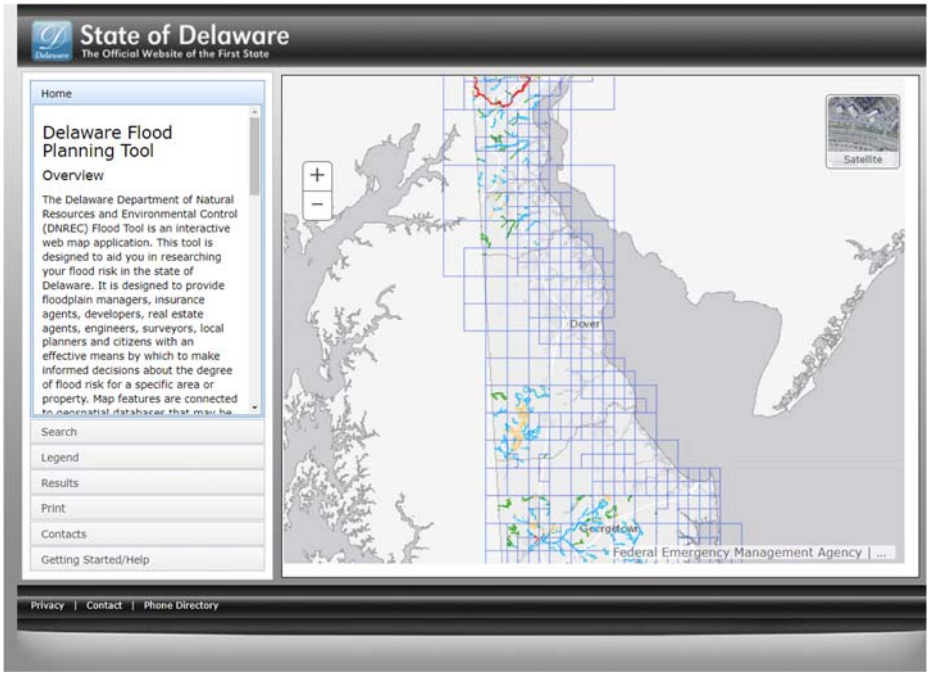
Summary: The best case scenario is where the floodplain authorities are LOMR Review Partners. Being LOMR Review Partners ensures that any engineering models approved are consistent with the engineering models these entities make available for public access. FEMA Region V has developed a guidance document that helps maintain consistency. However, it could not be confirmed that this happens in all cases and specific examples were highlighted where the procedures were not followed. Any proposed LOMRs must be signed-off by the community. Therefore, the Louisville Metropolitan Sewer District is aware of when engineering models are updated and provides the most updated model on the web site.

For 3 of the entities there is no formal process in place. For these entities, a significant effort is needed on their part to monitor federal register notices related to the issuance of LOMRs.

Following are summaries for each entity highlighting the mechanisms in place to ensure that the state/locally approved flood study models stay in synch with the FEMA approved flood study models.

Delaware

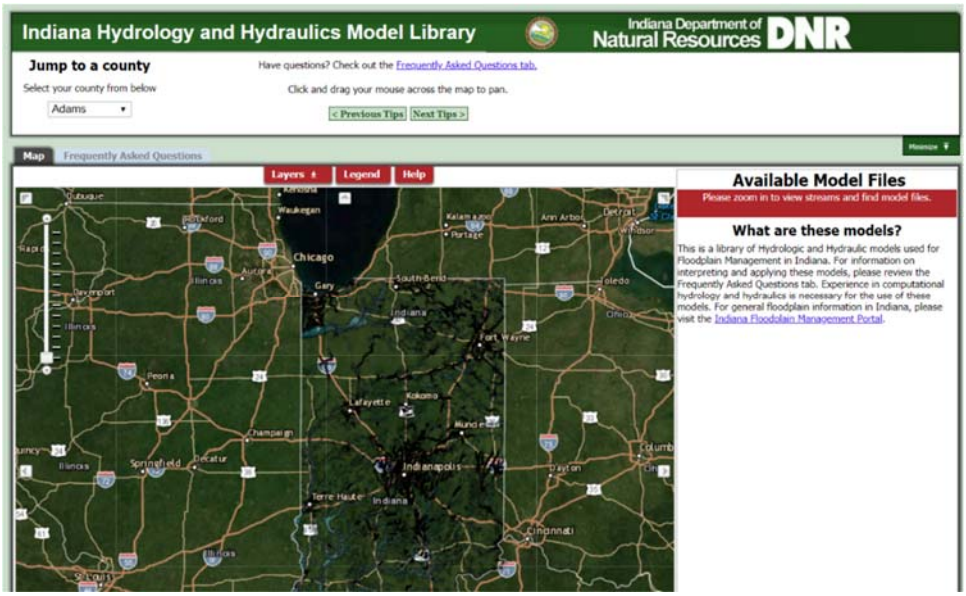
http://maps.dnrec.delaware.gov/floodplanning/default.html



The State Floodplain Manager indicates that he believes that their IT group is on a subscription service to receive a notice when there are updates to an engineering model. However, he was unsure that this process was actually working. He indicates that it has been difficult to get confirmation that there have been no changes to effective models that originally developed by the State of Delaware via a Cooperating Technical Partner agreement.

Indiana

https://dnrmaps.dnr.in.gov/appsphp/model/index.php



Region V has developed a "Guidance for Flood Risk analysis and Mapping - State Specific Preferences" document that is intended to address issues with consistency for states in the region with higher standards.

The Indiana section of this document states:

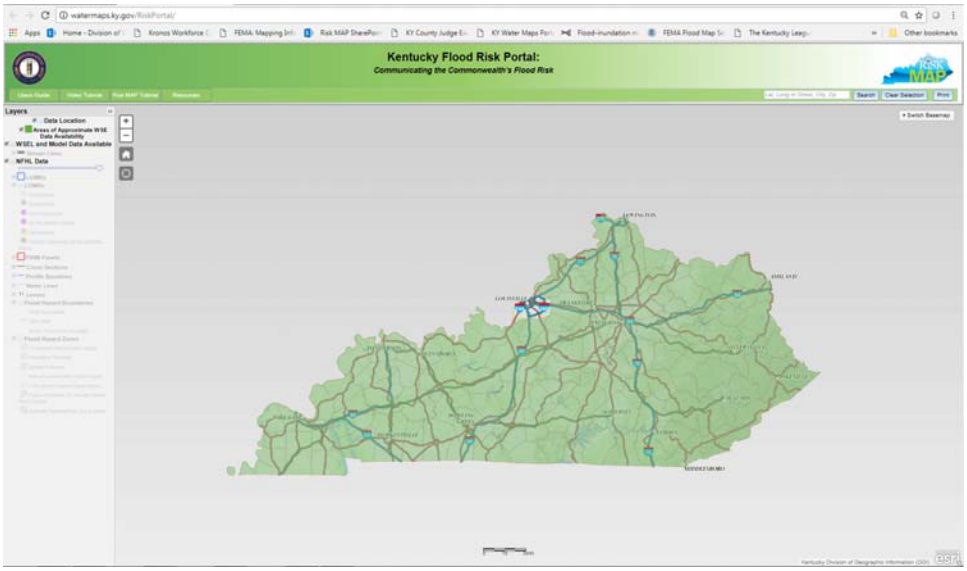
> Approval required for all LOMRs and CLOMRs. If a project scope changes during the processing of the request, the requestor will need to obtain re-approval of the project from the state. Any H&H revision due to a FEMA review requires an amended DNR approval.

Issues with respect to the Indiana Flood Control Act and state Construction in a Floodway approvals are addressed in a letter from FEMA dated February 5, 1998. Consultation with the Indiana DNR ahead of a MT-2 review is suggested. The DNR review process is detailed in The General Guidelines for the Hydrologic-Hydraulic Assessment of Floodplains in Indiana. Also note that the Indiana Flood Control Act requires the Indiana DNR to review projects based on the cumulative effects of past, present, and reasonably foreseeable future projects.

However, while the document indicates "Any H&H revision due to a FEMA review requires an amended DNR approval", when checking with the States IN could not confirm that it actually happens in all cases.

Kentucky

http://watermaps.ky.gov/RiskPortal/

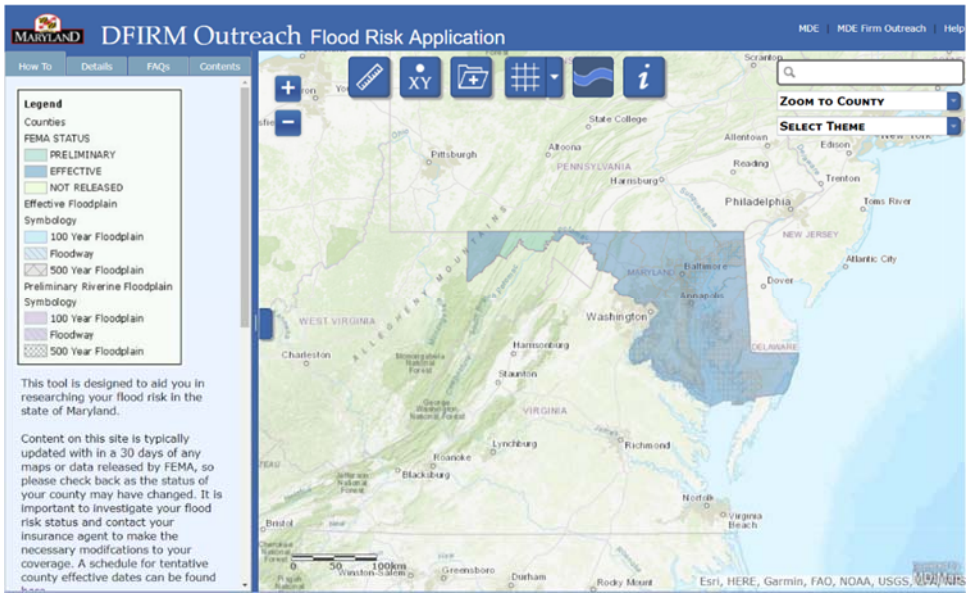


The Commonwealth of Kentucky indicates that maintaining engineering model consistency is a challenge. Kentucky is in the process of making their engineering library portal more robust by offering an opportunity to download, and eventually upload revised engineering models to the library. This will help make the Commonwealth aware of instances where engineering data and models have been modified.

When the Kentucky Division of Water is aware of a modification via LOMC, they archive the "authoritative" model from the MIP if the CIP case number is available. Currently, DOW only learns of cases where engineering and mapping data have changed when they get a notice from the Map Service Center or when it is published in the federal register.

Maryland

http://www.mdfloodmaps.net/dfirmimap/index.html



MDE has been a Cooperating Technical Partner since 2006. As a CTP MDE has produced over 2300 Geo-referenced floodplain (HEC-RAS) models based upon LiDAR data and include information on all bridges and culverts. Following is a summary of issues associated with maintaining consistency between the engineering models available on the MDfloodmaps website and the FEMA Engineering Library.

MDEs Waterway Process: Since the 1930's the State has issued permits for activities within a Nontidal (Riverine) stream and its associated floodplain. Beginning in the 1970's, due to the advent of FEMA maps and regulations, that meant a dual process and analysis of activities within a FEMA mapped floodplain was required. MDE processes approximately 500 permits a year for activities in a Nontidal stream or its associated floodplain. Approximately 20% of those applications fall within a FEMA mapped floodplain. When the impact or change warrants a full floodplain study or analysis, the project is reviewed and analyzed for impacts in the immediate area to determine impacts on adjacent properties.

FEMA Process: FEMA reviews and addresses changes in their mapping limits via their Letter of Map Revision (LOMR) process.

NFIP Community: In Maryland there are 140 communities that participate in the National Flood Insurance Program. As part of their agreements with FEMA, each community is required to maintain record, and issue permits for activities within their floodplains. Most communities have the ability to review and issue building permits within their floodplains, but most do not have the ability to review and approve larger impacts that require a floodplain study. They believe that the State Waterway Construction Permit process covers them technically and that the FEMA

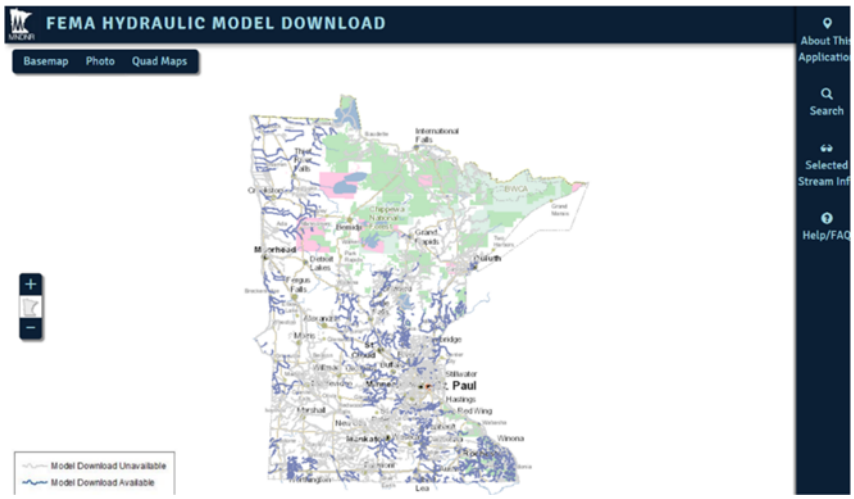
LOMR process is the final documentation of any changes. Unfortunately, projects that are completed using two distinct processes (State and FEMA) have created gaps or mismatched data for the community to resolve. The current fallback for the community is to always use FEMA data and approvals to remain in the NFIP program.

Present Status: In checking with the FEMA LOMR review contractor, MDE has learned that there have been 6 LOMRs approved since MDE has completed the flood study engineering models for most of the streams in the State. So of the 2300 engineering models developed by MDE, 6 are likely no longer consistent with what FEMA would identify as being the "authoritative" model.

MSHA and One Combined Process: One State Agency continuously caught in this double analysis loop is the (MSHA) Maryland State Highway Administration – Bridge Development Division. Since MDE is updating the floodplain maps, an opportunity exists for FEMA, MDE, and the community to coordinate and maintain the floodplain study of record. MSHA had an interest in working with MDE to develop a coordinated process that they could utilize to reduce their overall costs and when feasible design schedules. To that end - MSDE and MSHA formed a Hydraulics Panel to document the process for both Agencies to use and prepare a report with recommendations. Once adopted the report will be distributed for others to use and as a guide for communities to understand where they stand in the FEMA/MDE review process overall.

Minnesota

https://arcgis.dnr.state.mn.us/ewr/hydra_model_download/index.html



Region V has developed a "Guidance for Flood Risk analysis and Mapping - State Specific Preferences" document that is intended to address issues with consistency for IN, WI and MN. The Indiana and Wisconsin sections of this document state:

> Approval required for all LOMRs and CLOMRs. If a project scope changes during the processing of the request, the requestor will need to obtain re-approval of the project from the state. Any H&H revision due to a FEMA review requires an amended DNR approval.

The Minnesota section of the document does not include this statement. However, the document does include the following statement: "Email all determination documents for MT-2 cases to the following each month: Ceil Strauss: Ceil.Strauss@state.mn.us." The State indicates that when the FEMA MT-2 review contractor receives a MT-2 request that does not include a copy of the State approval letter they include the following statement in the letter requesting additional data (the 316-AD letter):

> The State of Minnesota requires that any revision request that involves Part 65 of the National Flood Insurance Program (NFIP) regulations must receive State approval. Please submit a copy of a letter notifying the Minnesota Department of Natural Resources (MNDNR) of your request and documentation of MNDNR approval.

The MN Floodplain Engineer indicates that while not universal, in most cases the FEMA MT-2 review contractor does reach out to the State when the engineering model is modified. There have been instances where when someone has requested an engineering model from the Map Service Center and they do not have it, they have suggested the person "try the MN DNR because they usually have it".

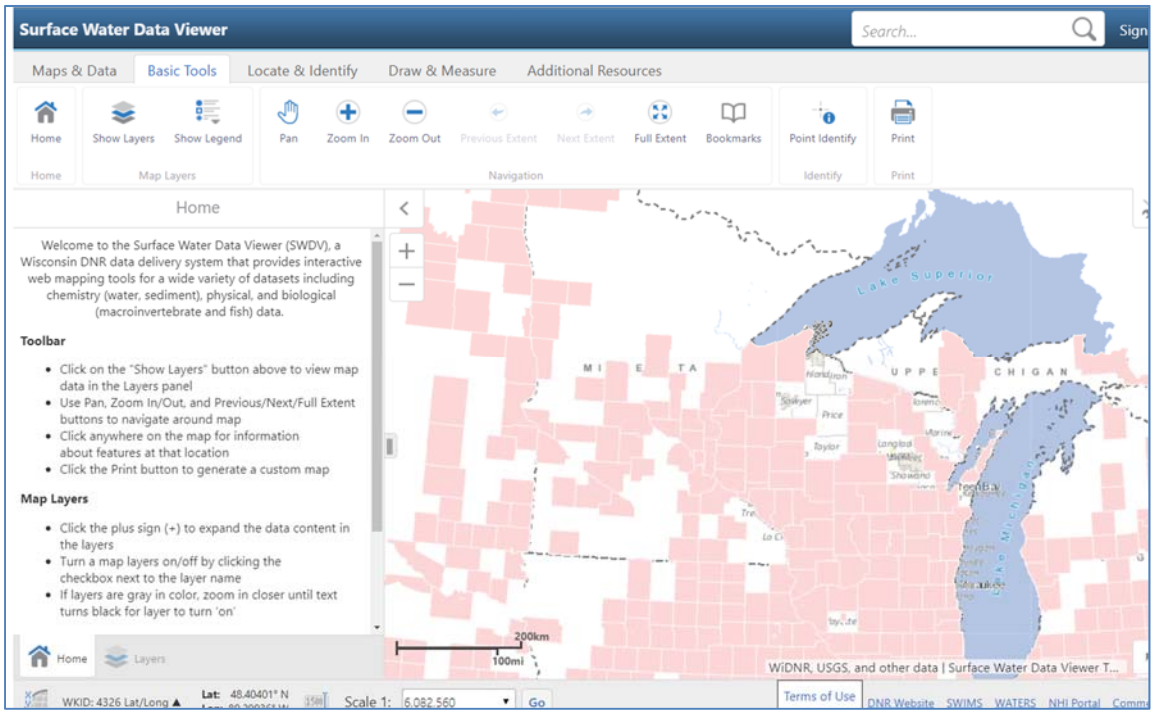
North Carolina

http://fris.nc.gov/fris/Home.aspx?ST=NC

In 1999, Hurricane Floyd flooded thousands of square miles of eastern North Carolina. This disaster highlighted the State's vulnerability to natural disasters and the need for accurate, up-to-date floodplain maps. In 2000, the Federal Emergency Management Agency (FEMA) designated North Carolina a Cooperating Technical Partner State, formalizing an agreement between FEMA and the State to modernize flood maps. This partnership resulted in creation of the North Carolina Floodplain Mapping Program (NCFMP). As a CTS, the State assumed primary ownership and responsibility of the Flood Insurance Rate Maps (FIRMs) for all North Carolina communities as part of the National Flood Insurance Program (NFIP). This project includes conducting flood hazard analyses and producing updated, Digital Flood Insurance Rate Maps (DFIRMs). The North Carolina Floodplain Mapping Program (NCFMP) became a LOMR review partner on July 1, 2006. The State is responsible for processing and issuance of all North Carolina MT-2 Letters of Map Change (LOMCs). This ensures that the NC website has the most up-to-date engineering models available for download.

Wisconsin

https://dnrmaps.wi.gov/H5/?viewer=SWDV&layerTheme=1



Region V has developed a "Guidance for Flood Risk analysis and Mapping - State Specific Preferences" document that is intended to address issues with consistency for states in the region with higher standards.

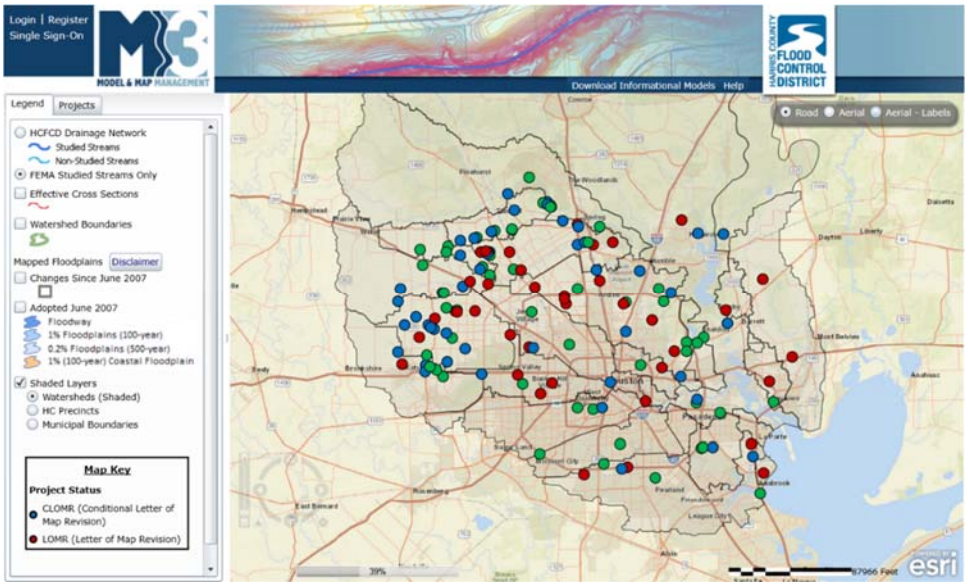
The Wisconsin section of this document states:

> Approval required for all LOMRs and CLOMRs. If a project scope changes during the processing of the request, the requestor will need to obtain re-approval of the project from the state. Any H&H revision due to a FEMA review requires an amended DNR approval.

The WI NFIP coordinator (Michelle Staff) is cced on any review documents that go to engineering consultants requesting modifications to the engineering model associated with a LOMR as an FYI. Michelle then passes this information on to the regional engineer that conducted the initial state review who then should request the revised engineering model from the engineering consultant to ensure that the revisions meet State standards and upload the revised model into the State system. It could not be confirmed that this happens in all cases.

Harris County Flood Control District

http://www.m3models.org/#/Map *Note: Access requires Microsoft Silverlight plugin.*



In the aftermath of Tropical Storm Allison, FEMA and the District initiated the Tropical Storm Allison Recovery Program (TSARP) www.hcfcd.org/tsarp.asp. For TSARP, both agencies updated the flood hazard data throughout the county's approximate 1,700 square mile area, including 22 major watersheds and 35 communities. The District developed a set of GIS standards, naming conventions and models standards for providing public access to the updated modeling. The District requested to become custodian of all models including FEMA models. The District created MOUs with all communities in which the District agreed to review all models before allowing into repository ensuring all models met standards they setup for repository.

Once these MOUs were in place, FEMA agreed to have the District become the custodian of the modeling via the FEMA Cooperating Technical Partners program. They became a FEMA LOMR review partner. The standards established require HEC-RAS for all models used for LOMR submittals.

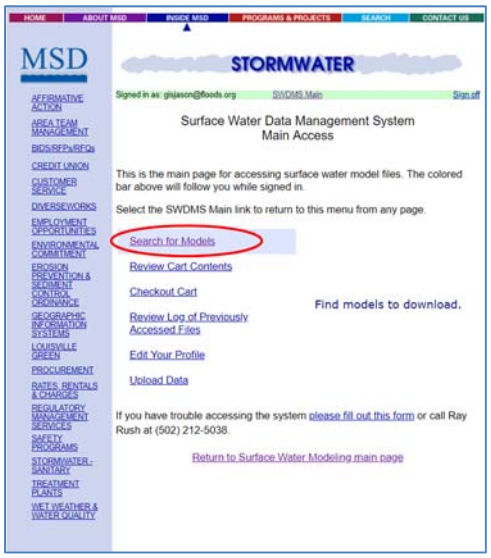
Model Repository site is called the Model & Map Management System (M3). The FEMA MSC sends anyone that requests Harris County models to the HCFCD M3 site.

The District conducts a community workshop every 6 months. The workshop provides an opportunity to meet with every community. Workshop topics include: how to do modeling, how to do mapping and how to do LOMRs and map changes.

Louisville Metropolitan Sewer District

https://stantecweb.com/swdms/swdmsmain.php

Note: Access is restricted to registered users, but you can register a user to access the models.

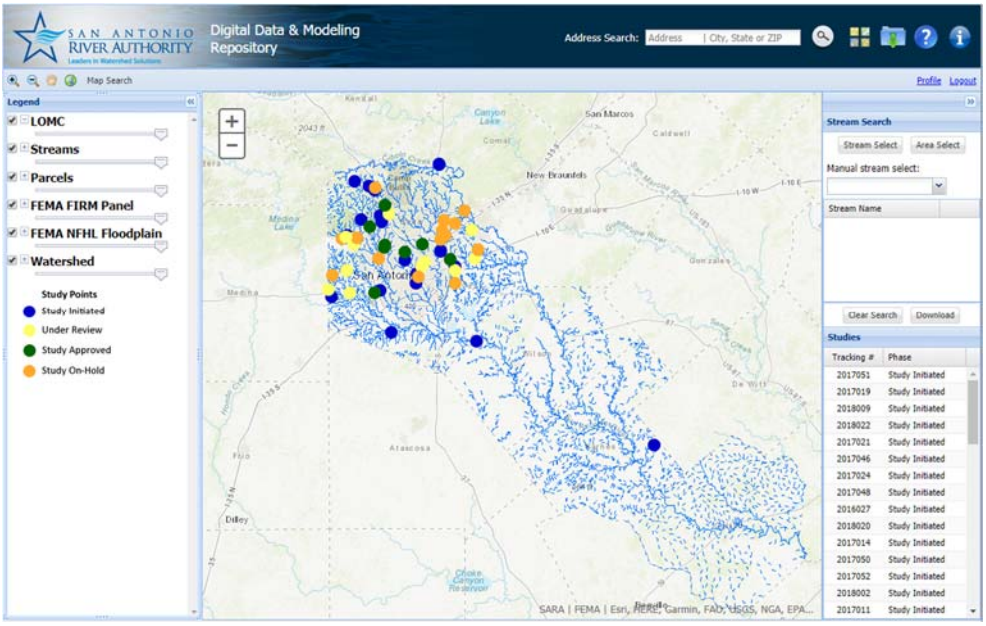


Any proposed LOMRs must be signed-off by the community. Therefore, the Louisville Metropolitan Sewer District is aware of when engineering models are updated and provides the most updated model on the web site.

San Antonio River Authority

http://gis.sara-tx.org/D2MR/

Note: Access is restricted to registered users, but you can register a user to access the models.



SARA produced updated, digital floodplain maps and hydraulic and hydrology models for the San Antonio River Watershed and has the responsibility to keep the maps and models updated to reflect changes in the watershed. SARA is a FEMA LOMC review partner so all revisions are reviewed and approved by SARA staff and then provided to FEMA.

Evaluating NHD and CNMS as a method for enabling access to the authoritative flood models

Fourth Task: Evaluate the potential of using the National Hydrography Dataset (NHD) in conjunction with the FEMA Coordinated Need Management Strategy (CNMS) data layer to index the engineering models and enable access.

Results: ASFPM provided background information on the NHD and CNMS datasets. Three states that are data stewards of CNMS (Indiana, Minnesota and Kentucky) were interviewed to document how each state mapping partner utilizes the NHD when making updates to stream segments in CNMS. ASFPM recommends as a best practice to update the NHD and CNMS datasets when new riverine studies redelineate stream network lines. ASFPM also recommends an upgrade to the CNMS map viewer that would incorporate the ability to provide access to download the authoritative models.

The National Hydrography Dataset

The National Hydrography Dataset represents the water drainage network of the United States with features such as rivers, streams, canals, lakes, ponds, coastline, dams, and streamgages. The NHD is used to represent surface water on maps and is also used to perform geospatial analysis. The current version of NHD has evolved through a number of incarnations. A brief overview of each version is provided in the subsections below. See *Making the Digital Water Flow: The Evolution of Geospatial Surfacewater Frameworks* for a detailed history of NHD.

The First NHD and the Origins of NHDPlus and NHDPlus High Resolution

The first medium scale NHD dataset was finished in 1998 after US EPA and USGS initiated a project in 1994 to fully integrate the 1:100,000-scale EPA Reach File Version 3 (RF3) stream network and names with the latest USGS 1:100,000-scale hydrography. The goal of the initial NHD project was to develop an application-ready, maintainable stream network. In support of the project, a Memorandum of Understanding was signed by the

EPA Office of Water, the EPA Office of Information Resources Management, the USGS Water Division and the USGS National Mapping Division. Ultimately, this collaboration, which leveraged EPA's water applications expertise with USGS's geospatial data production and maintenance infrastructure, yielded what we now know as the medium-resolution National Hydrography Dataset.[2]

In the early 2000s, EPA assumed the role of primary custodian for the NHD Medium Resolution to support their applications and those of other medium resolution users. Around that same time, the USGS, U.S. Forest Service, and additional partners initiated the production of a version of NHD at a 1:24,000 scale or better.[3] This initiative to create a higher resolution hydrography dataset resulted in the creation of the NHDPlus HR dataset that is described in a later section.

While USGS and USFS were developing the higher resolution dataset, what would later become NHDPlus HR, EPA embarked on a joint effort with the USGS Water Division to develop streamflow estimates for the medium-resolution NHD. A fundamental requirement of this effort was to delineate the local drainage area, or catchment, for each NHD stream segment so that ingredient data for estimating streamflow, such as precipitation and temperature, could be associated with each segment.[4] This effort resulted in the creation of a geospatial product suite known as NHDPlus, described next.

NHDPlus Version 1 and Version 2

NHDPlus is an integrated suite of application-ready geospatial data sets that incorporate many of the best features of the National Hydrography Dataset (NHD), the National Elevation Dataset (NED), the National Land Cover Dataset (NLDC), and the Watershed Boundary Dataset (WBD).[5]

NHDPlus Version 1, release in 2006, was developed by the EPA and maintained in partnership with the U.S. Geological Survey. In addition to the stream network, catchments and streamflow estimates, NHDPlus includes other value-added attributes

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[2] *Making the Digital Water Flow: The Evolution of Geospatial Surfacewater Frameworks*, T.Dewald, USEPA, Office of Water, Washington, DC. June, 2015. Revised June, 2017.
[3] "National Hydrography Dataset," USGS, accessed September 2018, https://www.usgs.gov/core-science-systems/ngp/national-hydrography/national-hydrography-dataset.
[4] *Making the Digital Water Flow: The Evolution of Geospatial Surfacewater Frameworks*, T.Dewald, USEPA, Office of Water, Washington, DC. June, 2015. Revised June, 2017.
[5] "Use of the National Hydrography Dataset and NHDPlus," US EPA, accessed September 2018, https://cfpub.epa.gov/watertrain/module.cfm?module_id=38&object_id=747.

that enable rapid stream network navigation, many of which drew on concepts from the original EPA Reach Files.[6] NHDPlusV1 consisted of ten components:[7]

- 2006 version of the 1:100K National Hydrography Dataset (NHD)
- 2004 version of the 30 meter National Elevation Dataset (NED)
- A set of value added attributes to enhance stream network navigation, analysis and display
- An elevation-based catchment for each flowline in the stream network
- Catchment characteristics
- Headwater node areas
- Cumulative drainage area characteristics
- Flow direction and flow accumulation grids
- Flowline min/max elevations and slopes
- Flow volume & velocity estimates for each flowline in the stream network

The widespread positive response to NHDPlus Version 1 is what prompted the NHDPlus team to pursue an improved NHDPlus Version 2 that was released in 2012. NHDPlusV2 consists of the following components:[8]

- Greatly improved 1:100K National Hydrography Dataset (NHD)
- Greatly improved 1 arc-second (approximately 30 meter ground spacing) National Elevation Dataset (NED)
- Nationally complete Watershed Boundary Dataset (WBD)
- A set of value added attributes to enhance stream network navigation, analysis and display
- An elevation-based catchment for each flowline in the stream network
- Catchment characteristics
- Headwater node areas
- Cumulative drainage area characteristics
- Flow direction, flow accumulation and elevation grids
- Flowline min/max elevations and slopes
- Flow volume & velocity estimates for each flowline in the stream network
- Catchment attributes and network accumulated attributes
- Various grids from the hydro-enforcement process including the hydro-enforced DEM.

NHDPlus Version 2 was used as the basis to create NHDPlus High Resolution, described next.

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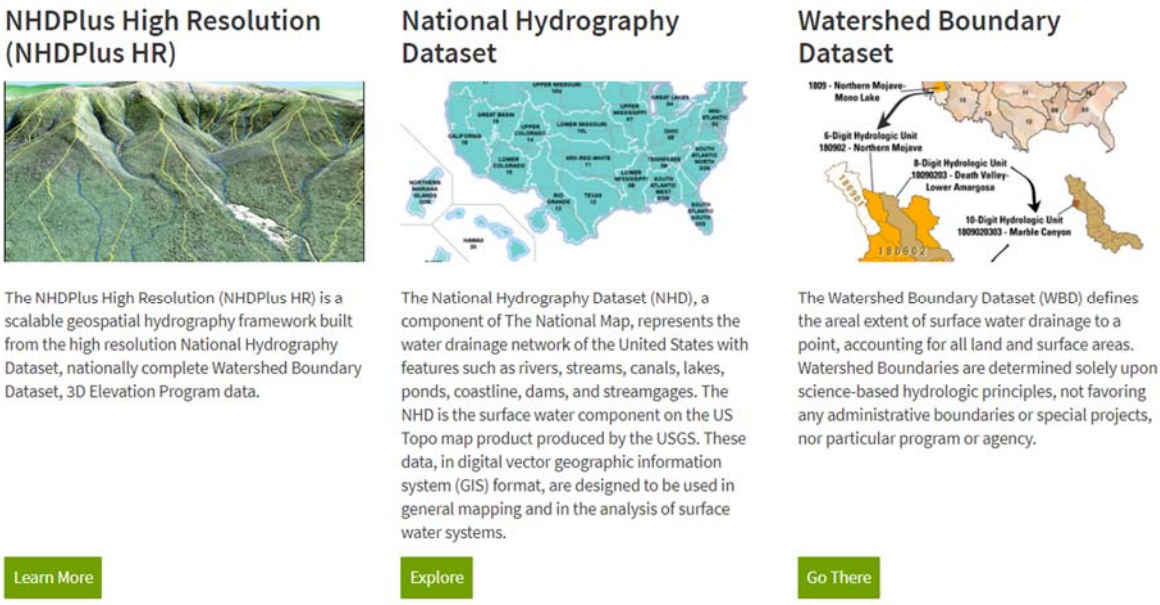
[6] *Making the Digital Water Flow: The Evolution of Geospatial Surfacewater Frameworks*, T.Dewald, USEPA, Office of Water, Washington, DC. June, 2015. Revised June, 2017.

[7] "NHD Plus - NHDPlus Version 1 (Archive)," Horizon Systems, accessed September 2018, http://www.horizon-systems.com/nhdplus/nhdplusv1_home.php

[8] "NHD Plus - NHDPlus Version 2," Horizon Systems, accessed September 2018, http://www.horizon-systems.com/NHDPlus/NHDPlusV2_home.php

NHDPlus High Resolution

The most current version of the National Hydrography Dataset, the NHD High Resolution, is mapped at a scale of 1:24,000 or higher (the exception is Alaska where the scale is 1:63,360 or higher). This higher resolution NHD, along with the Watershed Boundary Dataset (WBD) and 3D Elevation Program (3DEP) data, is used to create the NHDPlus High Resolution.[9] Like the NHDPlusV2, the NHDPlus HR is comprised of a nationally seamless network of stream reaches, elevation-based catchment areas, flow surfaces, and value-added attributes that enhance stream network navigation, analysis, and data display. Users will find that the NHDPlus HR, which increases the number of features nationally from about three million in the NHDPlusV2 to over 30 million, provides richer, more current content that also can be used at a variety of scales.[10] However, due to the richness of the high resolution data, it should be noted that increased computational power and storage capacity is necessary for those working with the NHDPlus HR dataset as compared to NHDPlusV2.



Screenshot of NHDPlus HR, NHD and WBD overview.[11]

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[9] "National Hydrography Dataset," USGS, accessed September 2018, https://www.usgs.gov/core-science-systems/ngp/national-hydrography/national-hydrography-dataset.
[10] "NHDPlus High Resolution," USGS, accessed September 2018, https://www.usgs.gov/core-science-systems/ngp/national-hydrography/nhdplus-high-resolution.
[11] "About National Hydrography Products," USGS, accessed September 2018, https://www.usgs.gov/core-science-systems/ngp/national-hydrography/about-national-hydrography-products.

FEMA's Coordinated Needs Management Strategy

FEMA is the official custodian of the Coordinated Needs Management Strategy, a geospatial inventory system comprised of a geodatabase for each FEMA region. CNMS was created to provide FEMA a process and database to organize, store, and analyze flood hazard mapping needs information for communities, along with the validity of flood studies in its flood hazard mapping inventory.[12] Through CNMS, FEMA identifies and tracks the lifecycle of mapping needs of the FEMA flood hazard mapping program by classifying stream segments as New, Valid, or Updated Engineering (NVUE) and updating the validation statuses of flood hazard studies near streamline flooding sources. Users access the data in the CNMS geodatabase through FEMA's CNMS Viewer. FEMA mapping partners have access to and can submit changes to CNMS through their FEMA region and CNMS updates are published quarterly.

While the CNMS geospatial database contains much more than just the information described in this section, it does not contain the hydraulic models used to create the flood studies nor does it contain links to access the authoritative models. FEMA stores the flood models in the Mapping Information Platform (MIP) and provides access through the Flood Risk Study Engineering Library (FRiSEL). See the FEMA FRiSEL subsection of the Accessing flood models from authoritative entities section of this report for instructions on downloading models from the MIP.

CNMS is useful at providing the base streamline data as it existed at the time that the hydraulic modeling was produced. CNMS contains a lot of historical linework that is required to verify older hydraulic modeling. Engineers cannot use newer stream lines to validate an older study because the resulting flood extents would not match the original study.

Each CNMS regional geodatabase lists the source of the hydrography linework in the [SOURCE] field. All sources are listed in the table below:

SOURCE	DESCRIPTION
DFIRM	County DFIRM database
DFIRM_PRELIM	County DFIRM database acquired during study period
DIGITIZED	Digitized
NFHL	National Flood Hazard Layer
NHD-HIGH	National Hydrography Dataset High Resolution
NHD-LOW	National Hydrography Dataset Low Resolution
NHD-MEDIUM	National Hydrography Dataset Medium Resolution
RFHL	Regional Flood Hazard Layer
COAST	FEMA Coastal CNMS Nov2016

Table 1: Sources of stream segment linework in the regional CNMS geodatabases.

[12] "CNMS - Coordinated Needs Management Strategy," FEMA, accessed September 2018, https://msc.fema.gov/cnms/.

Each CNMS regional geodatabase lists the validation status of the hydrography linework in the [VALIDATION_STATUS] field and the status type in the [STATUS_TYPE] field. The combination of these two fields results in each stream segment falling into one of the categories below:

VALIDATION_STATUS	STATUS_TYPE
Assessed	Being Studied
	Deferred*
	To be Studied*
Unknown	Being Assessed
	Being Studied
	Deferred
	To be Assessed
Unverified	Being Studied
	To be Studied
Valid	Being Studied*
	NVUE Compliant

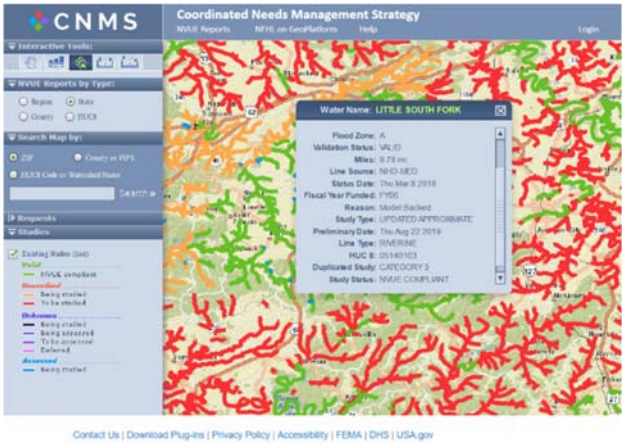
Table 2: CNMS validation status and status type.
* Layer not displayed in CNMS Viewer

Validation status and status type in the online CNMS Viewer legend

The validation statuses and status types listed in the table above are the categories used in the legend of FEMA's online CNMS Viewer, which is discussed in the next section.

CNMS Viewer

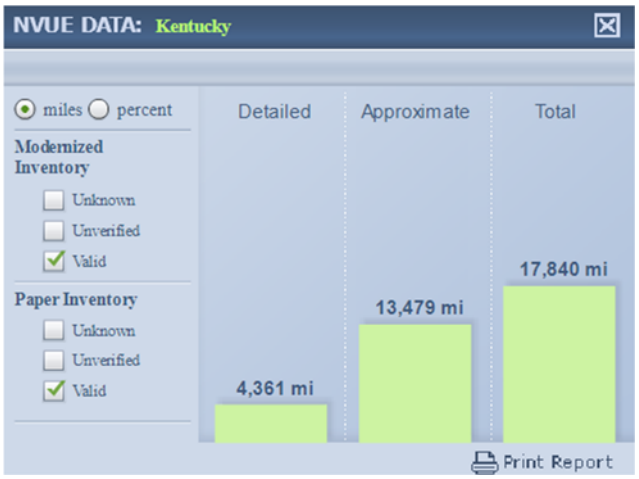
FEMA also maintains a public version of the CNMS dataset as an online mapping application, the CNMS Viewer, which displays the validation status of the stream segments in the geodatabase. Users can use the "Identify" tool to click on the stream segments and access the data in the underlying database, such as stream name, flood zone, validation status, line source, miles, study type, etc.



Screenshot of CNMS Viewer application.[13]

[13] "CNMS Viewer," FEMA, accessed March 2019, https://msc.fema.gov/cnms/.

The CNMS viewer also allows users select a region, county, state or HUC8 to get a New, Valid, or Updated Engineering (NVUE) report that aggregates the total stream miles for the geography selected broken out by detailed and approximate studies. The report is interactive so users can choose to display the totals by miles or percent and allows users to include paper inventory in the totals as well as unknown or unverified validation statuses.



Discussion

The NHD exists to maintain accurate data on the locational and network connectivity of streams in the U.S. and provides a rich dataset for engineers to leverage when producing floodplain maps. When new data is collected during a floodplain study that can support an upgrade to the NHD, those data should be mandated to be shared in furtherance of federal interagency cooperation goals. The best path forward for improved floodplain mapping is to have states, mapping partners and the federal government focus on continually updating NHD and pushing those changes into CNMS.

ASFPM recommends workflows that include interagency or interdepartmental communication to help facilitate investment in updates to the NHD when flood mapping efforts by FEMA and state mapping partners occurs. If flood modeling produces hydrology data of a higher quality than currently available in the NHD, workflows should ensure that the NHD is updated accordingly.

CNMS is an inventory and tracking system for FEMA flood mapping studies. The hydrologic linework from various sources and vintages found in the CNMS geodatabase are useful to engineers as a snapshot of the stream at the time of flood modeling. CNMS serves as an important tool for determining the status of floodplain mapping across the nation but does not directly link users to the underlying models. The streamlines feature class in the CNMS geodatabase consists of many NHD stream segments merged in one segment with lengths that can be modified to match the extent of the flood models. The data table

for the stream linework contain a [MILES] data field that holds segment lengths. This field's accuracy is essential for reporting regional and national totals for stream miles mapped.

The CNMS Viewer application requires the Adobe Flash browser plugin that is set to deprecate in 2020.[14] The CNMS Viewer application should be migrated to the FEMA GeoPlatform ArcGIS Online framework as soon as possible. During migration to a new platform would be the optimal time to add functionality to the viewer to allow access to the hydrologic and hydraulic models used to create the effective flood maps.

ASFPM strongly recommends the CNMS Viewer application be migrated to another mapping platform as soon as possible because the underlying display technology is obsolete. The application should also be modified to provide download access to the hydrologic and hydraulic models using a clickable map like many of the states and entities identified in this report.

[14] "Flash & The Future of Interactive Content," Adobe Blog, accessed September 2018, https://theblog.adobe.com/adobe-flash-update/.