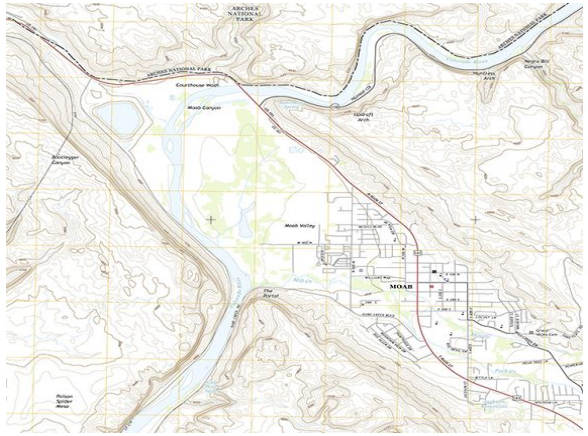
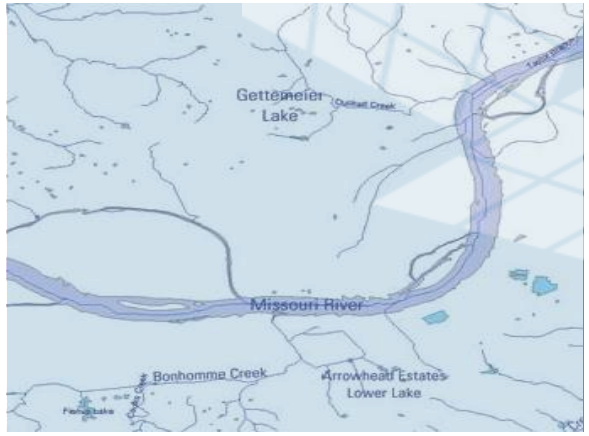
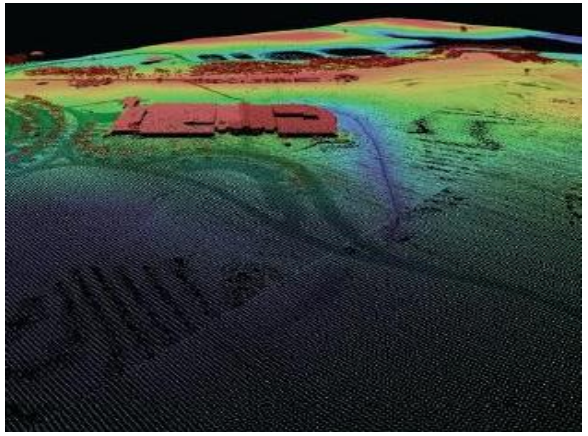
Building the Infrastructure to Update the NHD Using Elevation Data – Alaska Leads the Way







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Steve Aichele (Becci Anderson) and Amanda Lowe
U.S. Geological Survey
National Geospatial Program
May 19, 2021

We Need the National Hydrography Datasets

Why invest in hydrography data?

Hydrography data are essential to a broad range of critical applications and the current program provides $538M annual benefits*

What are the benefits?

A modernized 3D-enabled hydrography program could provide up to $1.14 billion annually in benefits if all user requirements are met*

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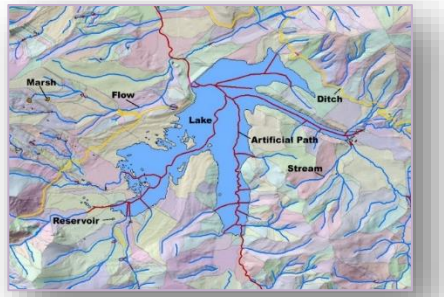
Conservative Annual Benefits
* Hydrography Requirements and Benefits Study, 2016

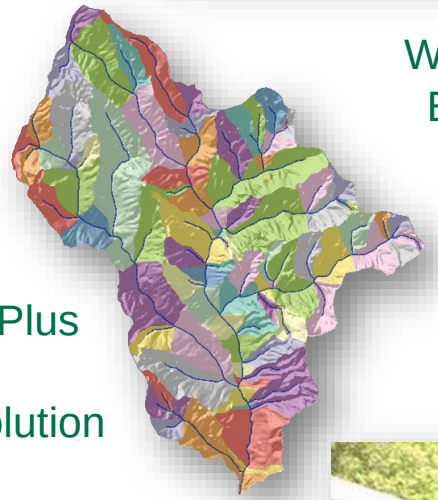
Current Data Management Approach

Collaborative Data Management

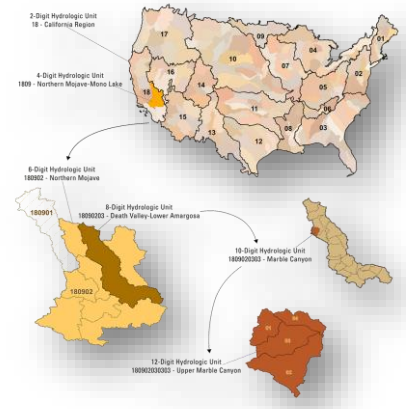
- The NHD portfolio of datasets is the most comprehensive and current data of the Nation's surface waters
  - 8.4 million miles stream of network, including 7.8 million waterbodies and over 130,000 nested hydrologic units
- NHD and WBD leverage local knowledge and updates through a stewardship program with participants from 41 states and DC
- However, updates aren't uniform
  - Some areas updated, others untouched and based on dated information – sometimes 40+ years old
  - National consistency has ***decreased*** over time
  - Issues with connectivity in the NHD network and with lingering delineation blunders in the WBD
  - Don't align well with current elevation data



National Hydrography Dataset



NHDPlus High Resolution



Watershed Boundary Dataset

Concept courtesy of Dr. Jason Stoker

Hydrography Derived from Elevation Offers a Solution!

Provide national consistency while meeting local needs

- Goal to standardize the NHD to align vertically, horizontally, and temporally with 3DEP data
  - Supports national and regional-level issues like flooding, contaminant spills, water quality and quantity, drought, climate change, etc.
  - Supports more accurate, updated modeling and analysis capabilities
  - Provides the basis for updating WBD and NHDPlus HR
- Hydrography Requirements and Benefits Study documented widespread need for integration of hydrography and elevation
- Stewards continue to provide local knowledge on attributes and flagging issues on the geometry with the markup tool

Early Work to Derive Hydrography from Elevation

- Experiments with various techniques
  - GeoNet
  - BotHat
  - ArcHydro
  - Others…
- None of the methods was really the magic bullet
- Each got a lot of things right
- Each required significant manual editing and rework

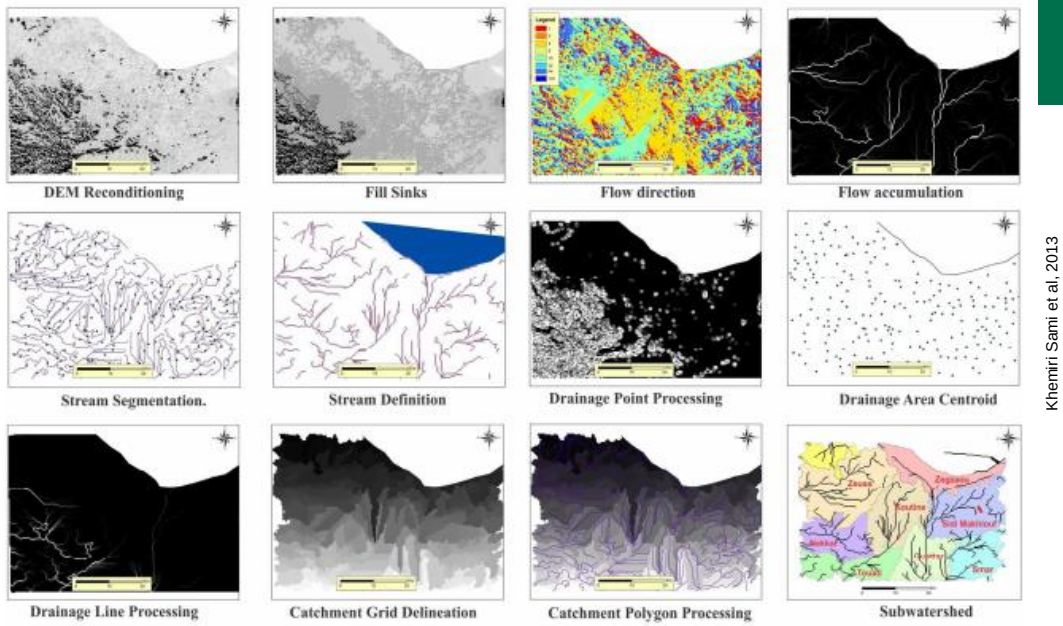
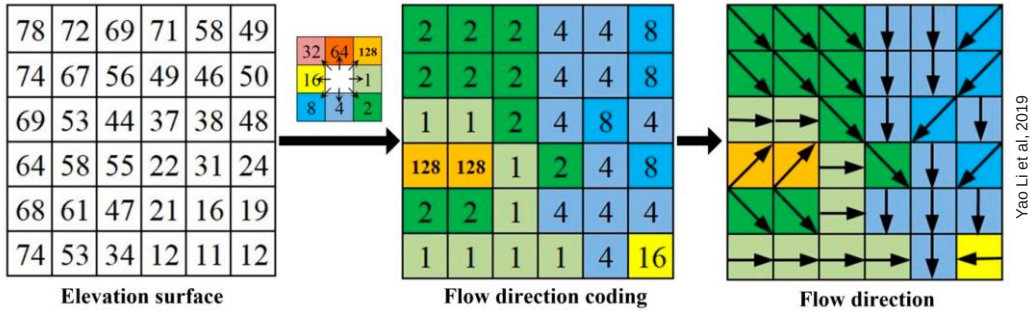


Figure 5. Different maps of flows extracted by Arc Hydro-tools.

Khemiri Sami et al, 2013

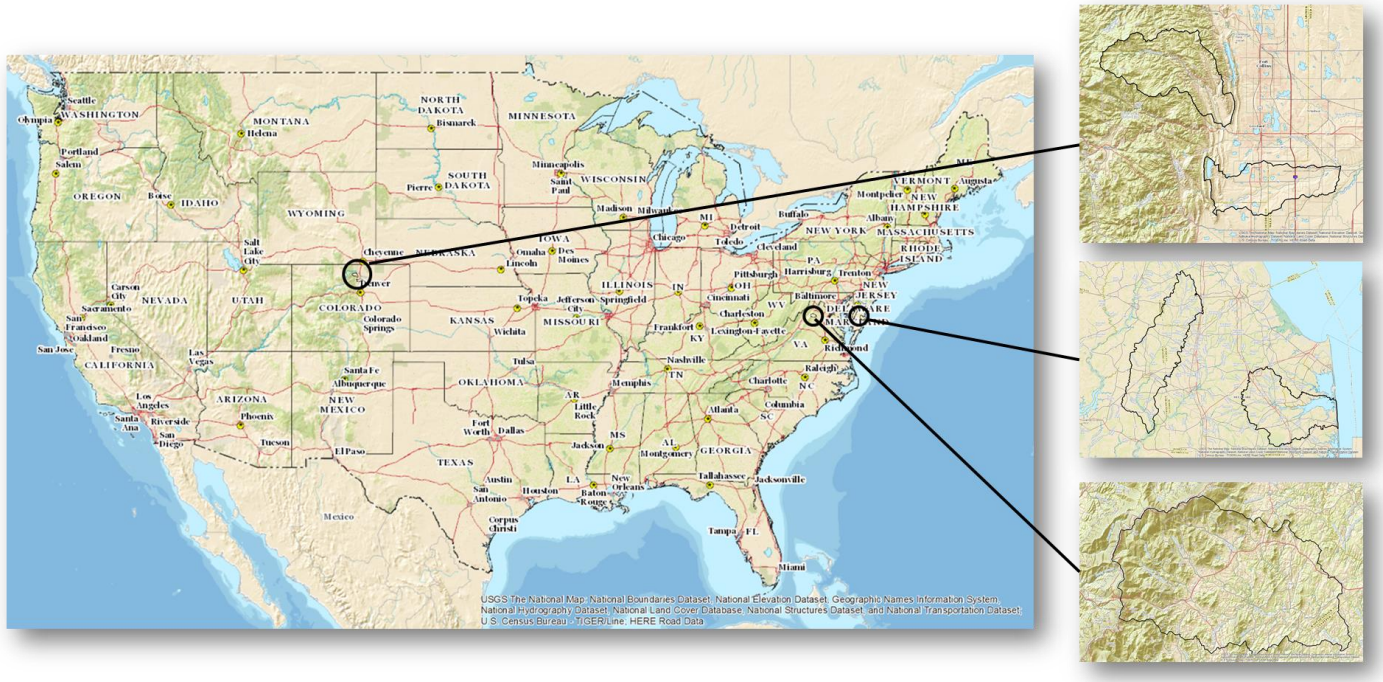


Elevation surface | Flow direction coding | Flow direction

Yao Li et al, 2019

Derive Hydrography from Elevation

2016 Pilot Projects

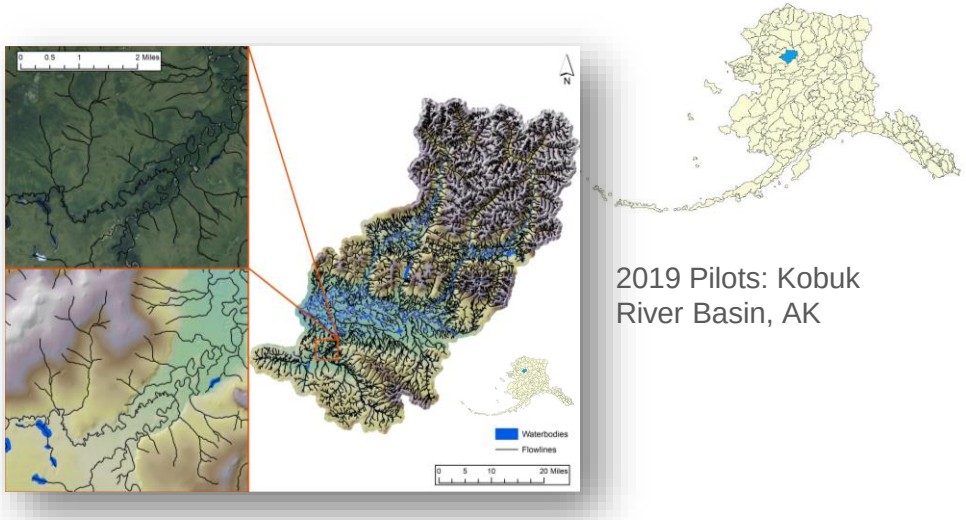


- Five HUC 10s in five different environments
- Experiments to figure out -
  - Likely costs for a nationwide program
  - Technical issues that would need to be resolved
- Long list of technical issues
  - Understanding of the NHD
  - Language and workflows for contracting
  - Quantifiable/testable standards and specifications
  - Tools and workflows for inspection and testing

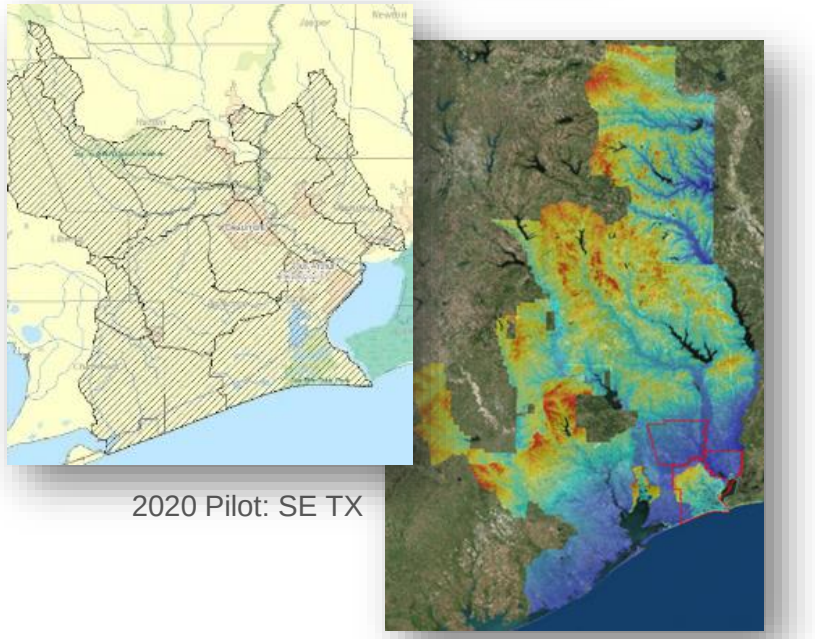
Derive Hydrography from Elevation

2019/2020 Pilot Projects – GPSC Contracts

- Goals of Pilots
  - Build inspection procedures and assess specifications
  - Understand costs and any issues with contracting
- Alaska Pilots - Kobuk River Basin
  - 3DEP 5m IfSAR as elevation base to update NHD and WBD
  - 3 contractor firms worked across four areas
  - Majority of data has been completed
- Southeast Texas Pilot
  - Updating the NHD and WBD using 3DEP QL2 lidar 1m DEMs
  - Part of a larger interagency project to create a seamless topography model above and below water
  - Important for improving hydrologic and hydraulic networks and inform decision making on flood prediction and response



2019 Pilots: Kobuk River Basin, AK



2020 Pilot: SE TX

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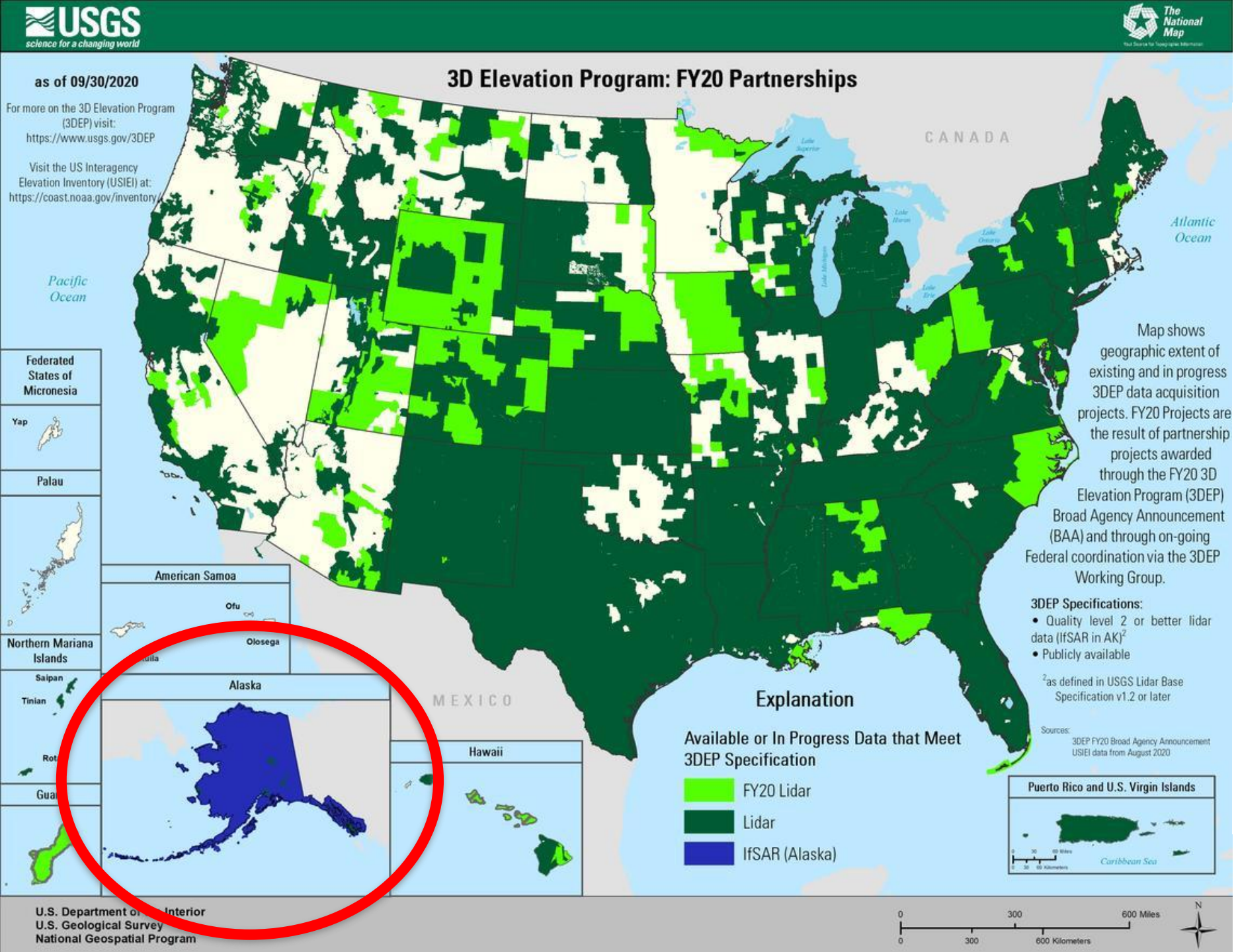
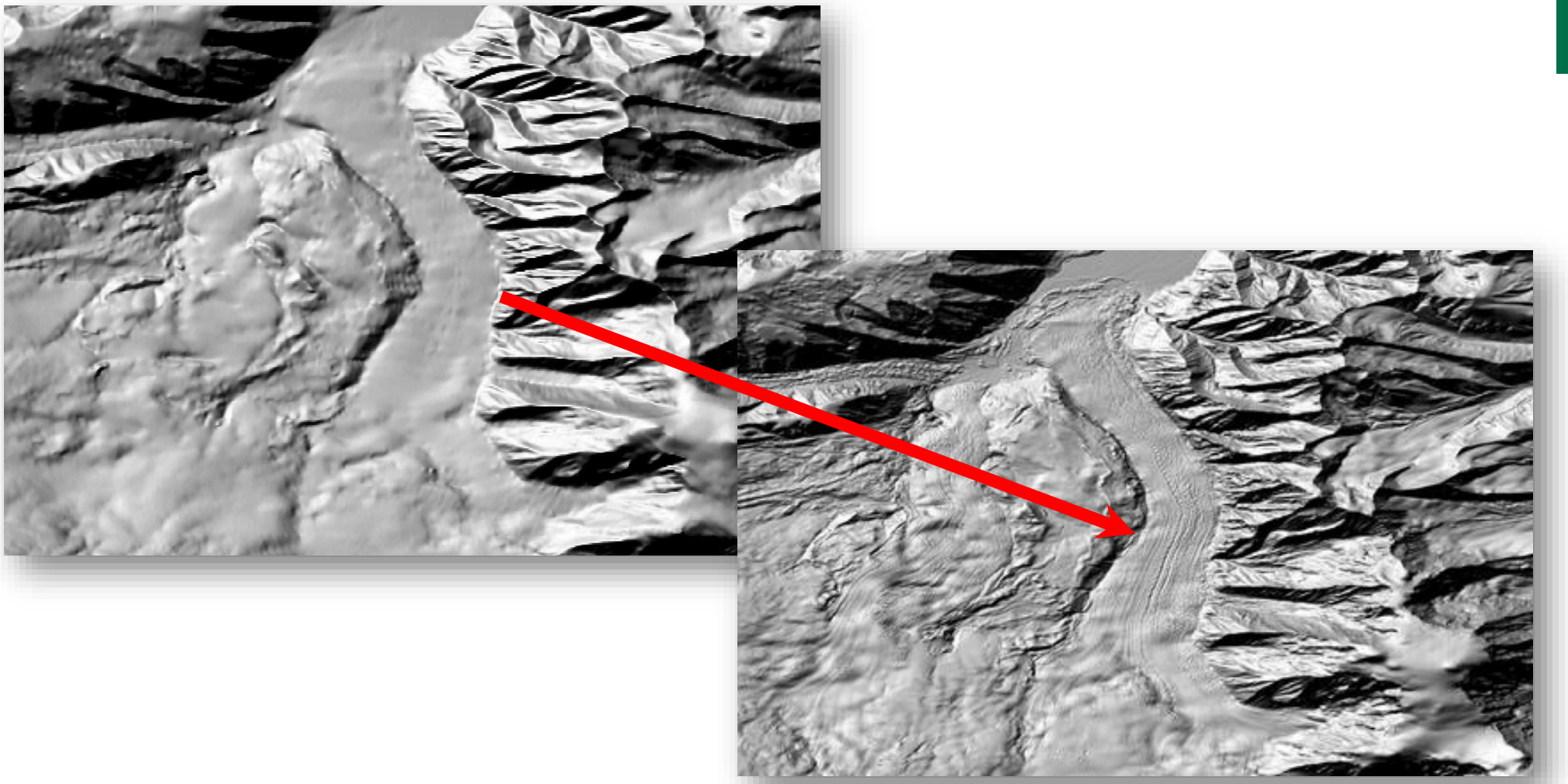


Ideal place to start? Alaska

- Complete 3DEP elevation data
- Less urban/engineered hydrology (fewer culverts)
- Governance structure - Alaska Mapping Executive Committee
- Current funding mechanism

3D Elevation Program 5 m QL5 IfSAR



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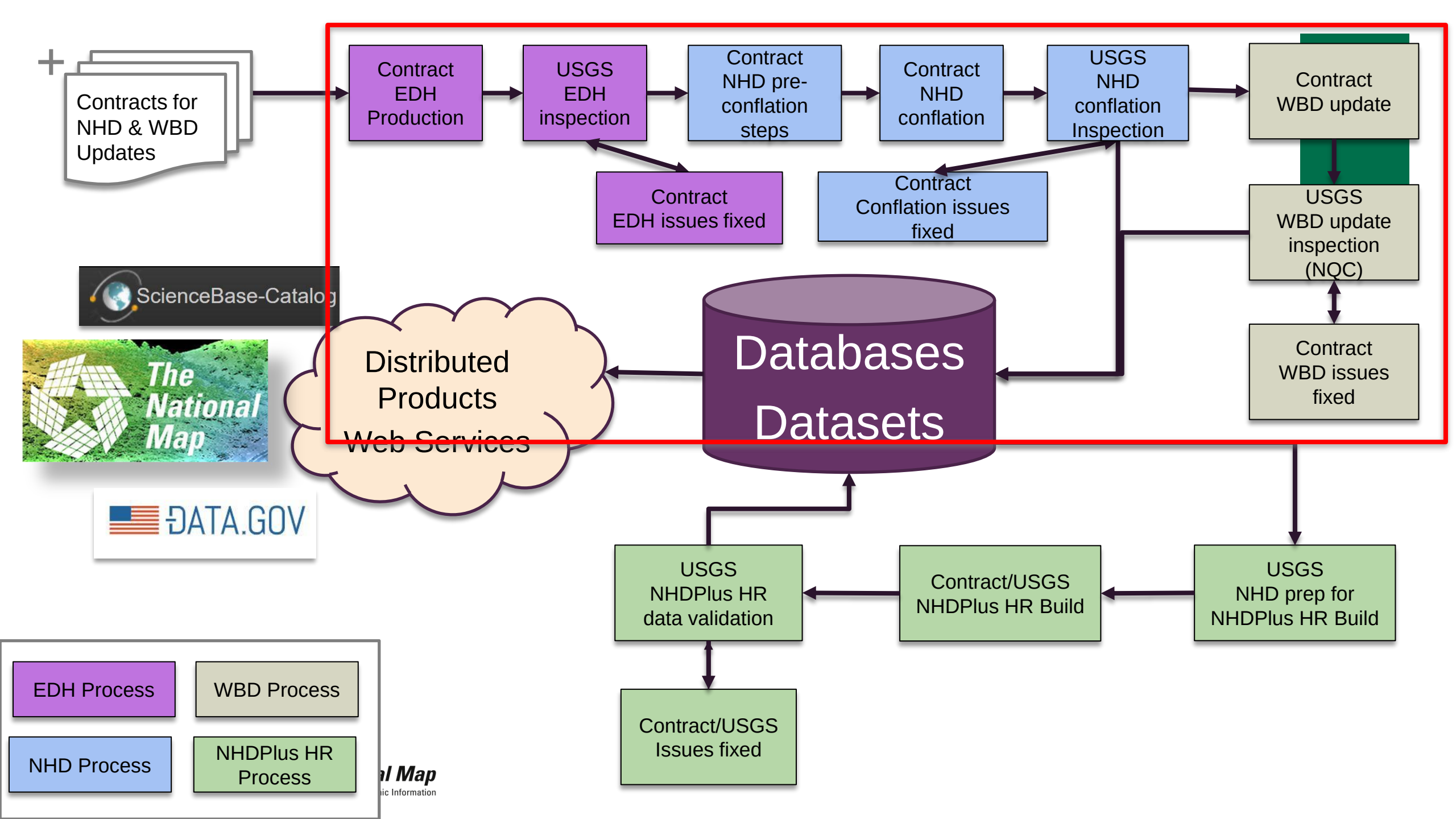

Contracts for NHD & WBD Updates
Contract EDH Production
USGS EDH inspection
Contract NHD pre-conflation steps
Contract NHD conflation
USGS NHD conflation Inspection
Contract WBD update
Contract EDH issues fixed
Contract Conflation issues fixed
USGS WBD update inspection (NQC)
Contract WBD issues fixed
ScienceBase-Catalog
The National Map
Distributed Products
Web Services
Databases
Datasets
DATA.GOV
USGS NHDPlus HR data validation
Contract/USGS NHDPlus HR Build
USGS NHD prep for NHDPlus HR Build
Contract/USGS Issues fixed
EDH Process
WBD Process
NHD Process
NHDPlus HR Process

Internal Process Infrastructure to Update NHD…

What workflows do we need for nationwide update of NHD using elevation?

- Specifications
- Contracting language
- Inspection processes
- Examples / Practice
- Funding mechanisms

The infrastructure established for Alaska projects is paving the way for CONUS work to come

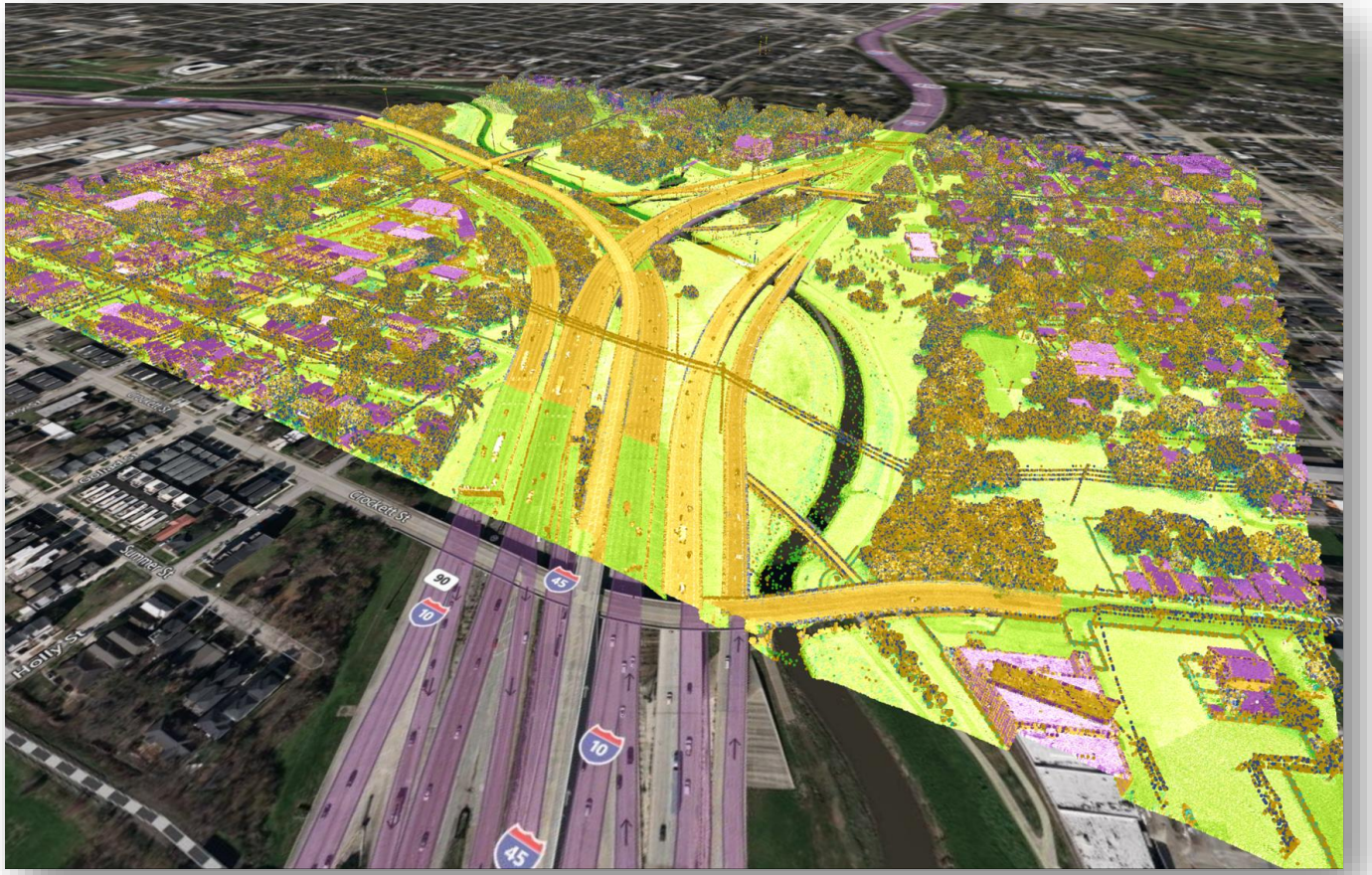
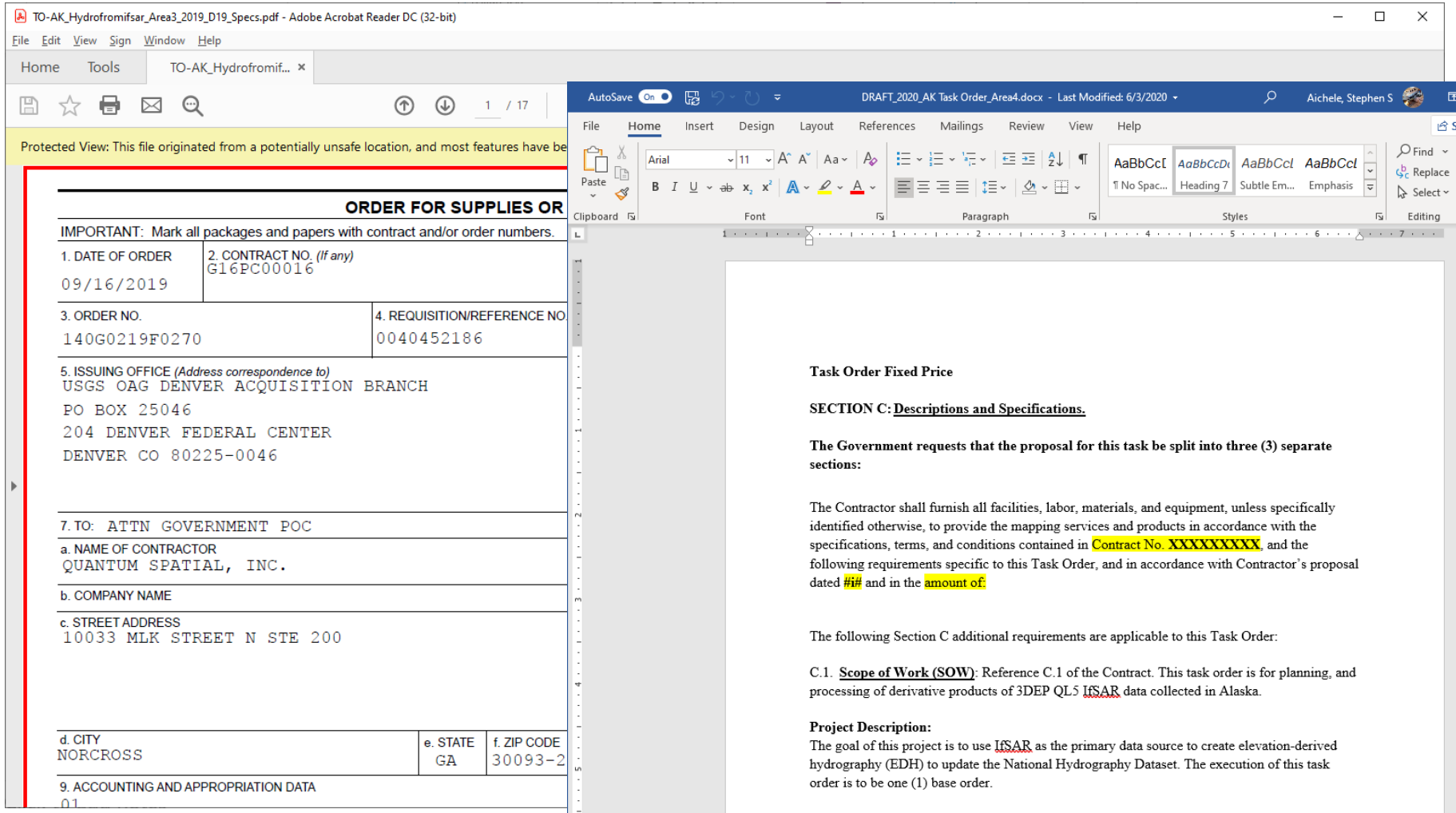


Image courtesy of equatorstudios.com

Task Orders for Contracts



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Task Order Supporting Documentation

- Data Templates and Schema
- Contractor questions and responses
- Drainage density targets
- Updates and interpretations of the specifications
- Scheduling
- Communications/records

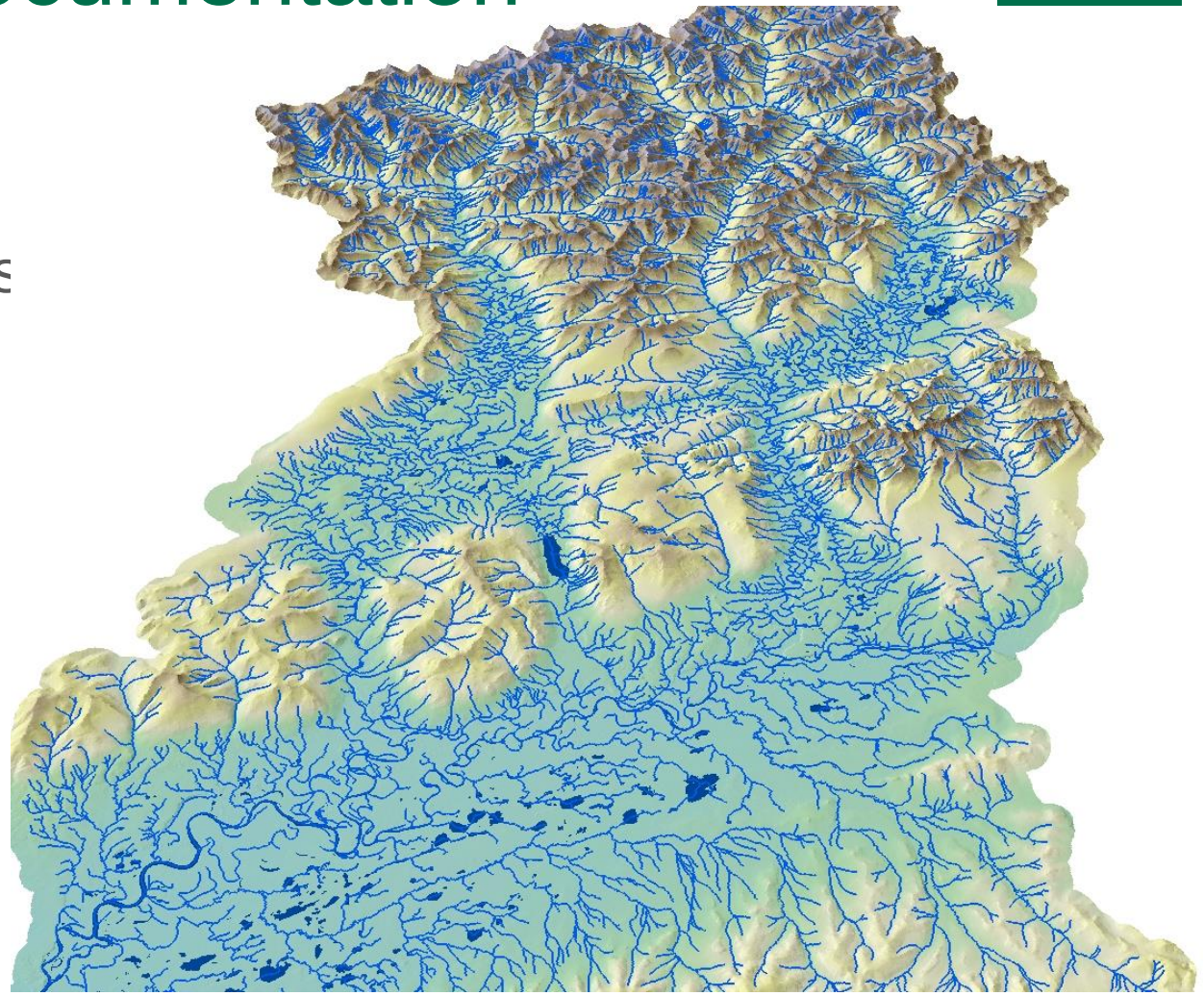
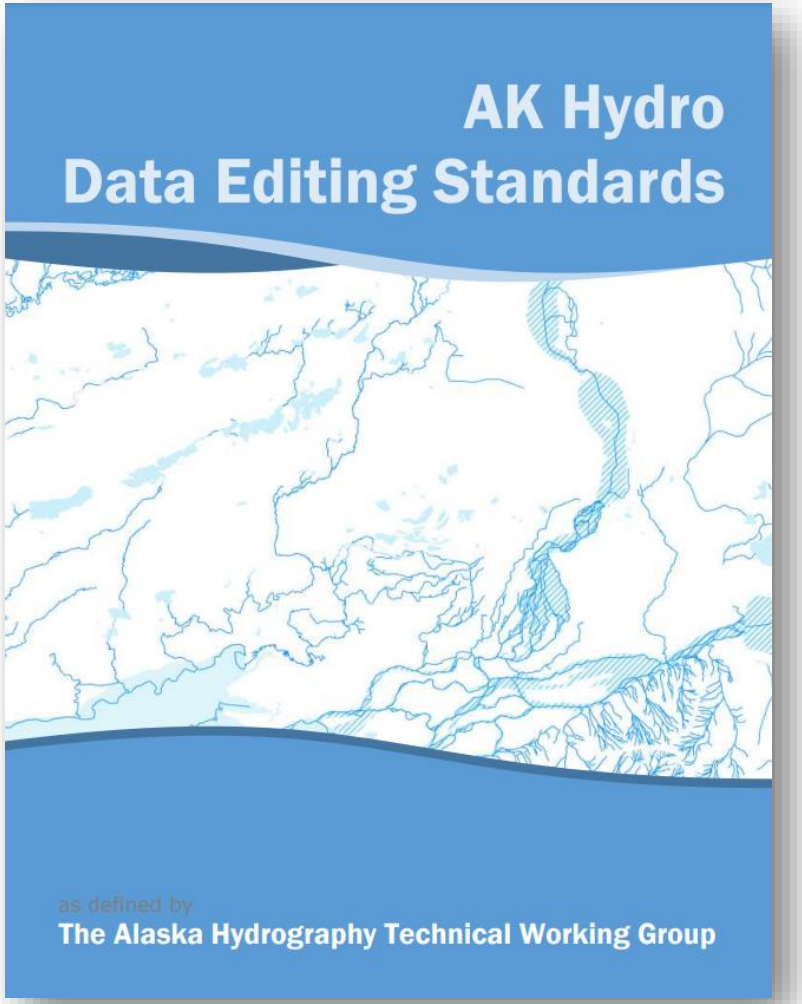


Image by NV5

Specifications

Alaska-specific – Pre-specification Publication (FY19 Task Orders)

- Alaska Hydro Data Editing Standards
- DRAFT Alaska NHD Specifications

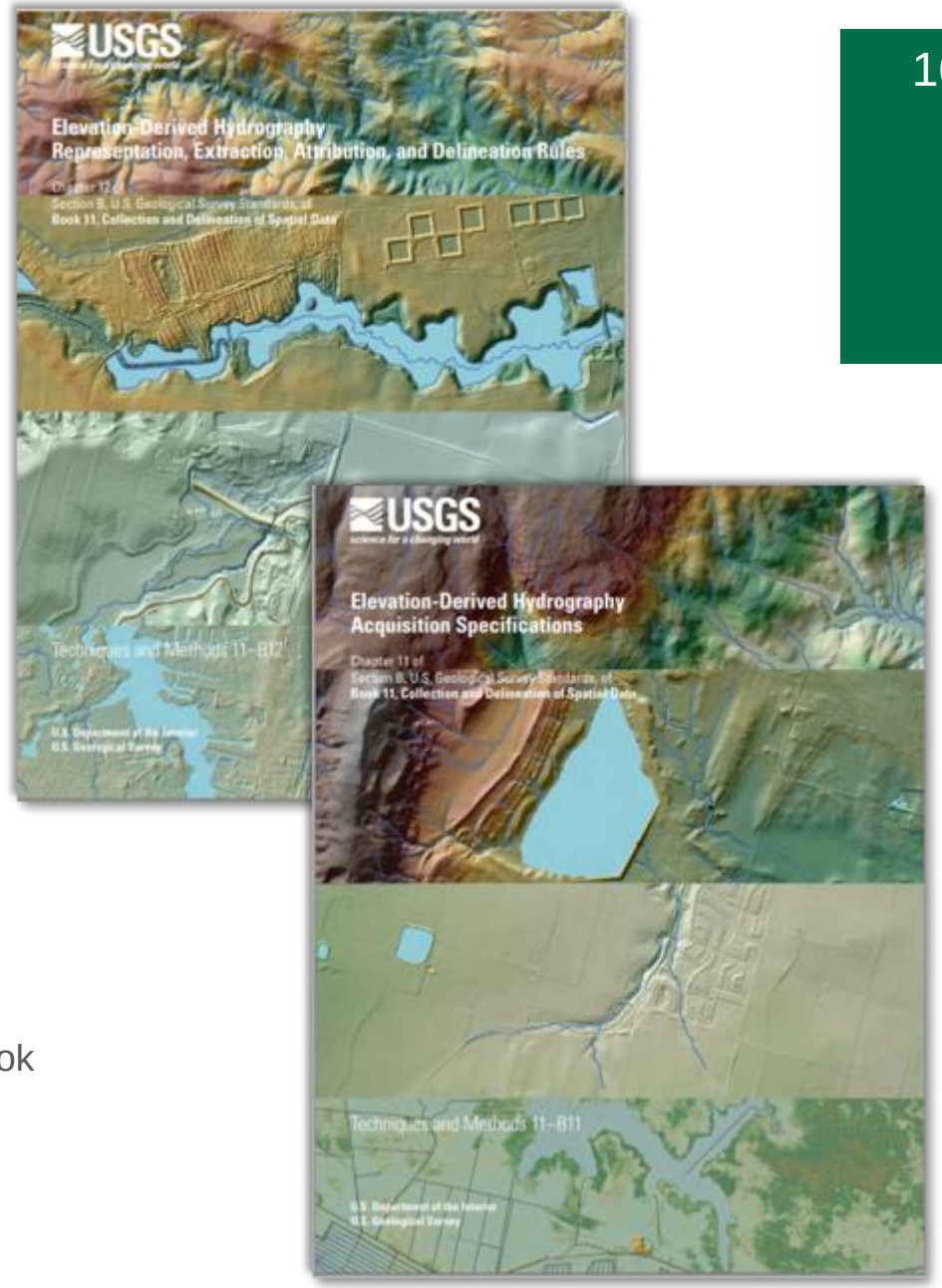


Specifications

Published July 2020

- **USGS Techniques and Methods 11–B11: Elevation-Derived Hydrography Acquisition Specifications**
  - **Suggested citation:** Terziotti, S., and Archuleta, C.M., 2020, Elevation-Derived Hydrography Acquisition Specifications: U.S. Geological Survey Techniques and Methods, book 11, chap. B11, 74 p., https://doi.org/10.3133/tm11B11.

- **USGS Techniques and Methods 11–B12: Elevation-Derived Hydrography—Representation, Extraction, Attribution, and Delineation Rules**
  - **Suggested citation:** Archuleta, C.M, and Terziotti, S., 2020, Elevation-Derived Hydrography—Representation, Extraction, Attribution, and Delineation Rules: U.S. Geological Survey Techniques and Methods, book 11, chap. B12, 60 p., https://doi.org/10.3133/tm11B12.



Specifications

Guidance

Inspection References:

- Examples for Each Error Flag
- Geomorphic Indicators
- Using Profiles to flag streams that are outside channel

Data Collection:

- EDH Lines Crossing Ridges
- Guidelines for Indefinite Flow - Surface and Subsurface
- Inclusion or Omission of NHD Waterbodies
- Low Relief Areas - Flow Direction and Connectivity Guidance
- Stream Channel Capture Conditions
- Underground Conduit examples
- Waterbodies and Islands

Data Management

Data delivery, contractor feedback, and corrections

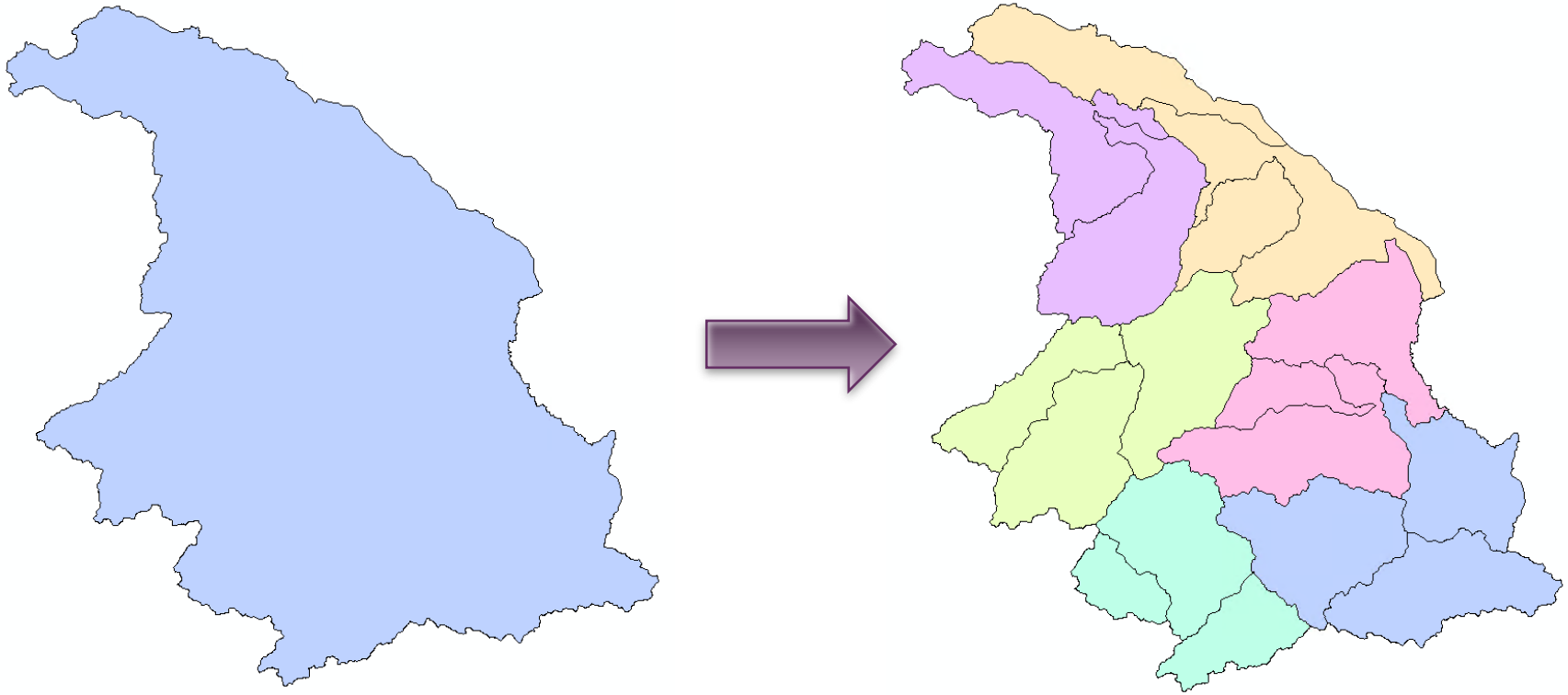
Contractor Delivery via FTP

Distribution to Data Validation Team

Feedback to Contractor, Corrections Requested

Data Management

Data delivery, distribution, and corrections



HUC 8 Delivery

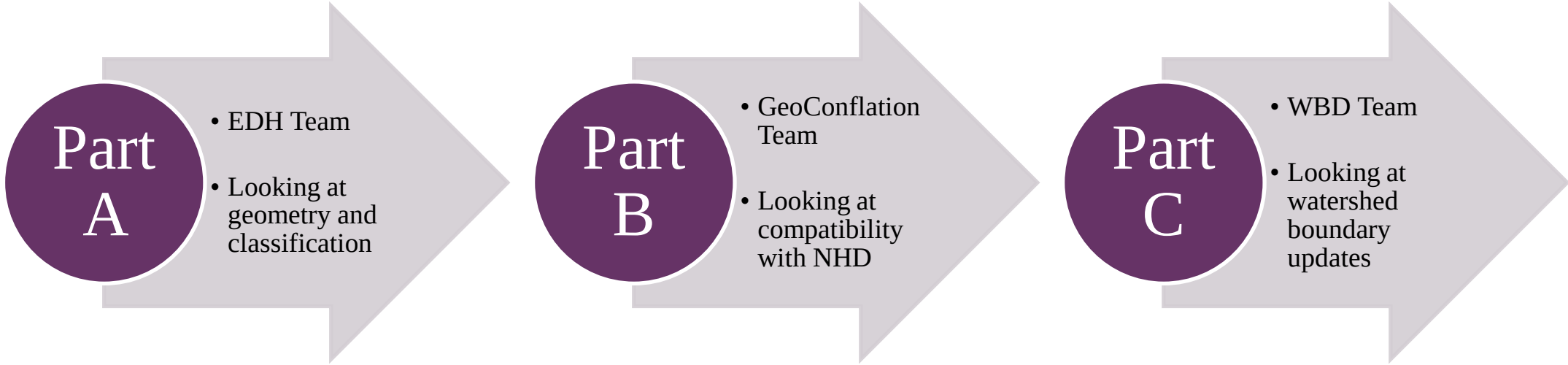
Automated Prescreening

HUC 10 Groupings

Manual Inspection

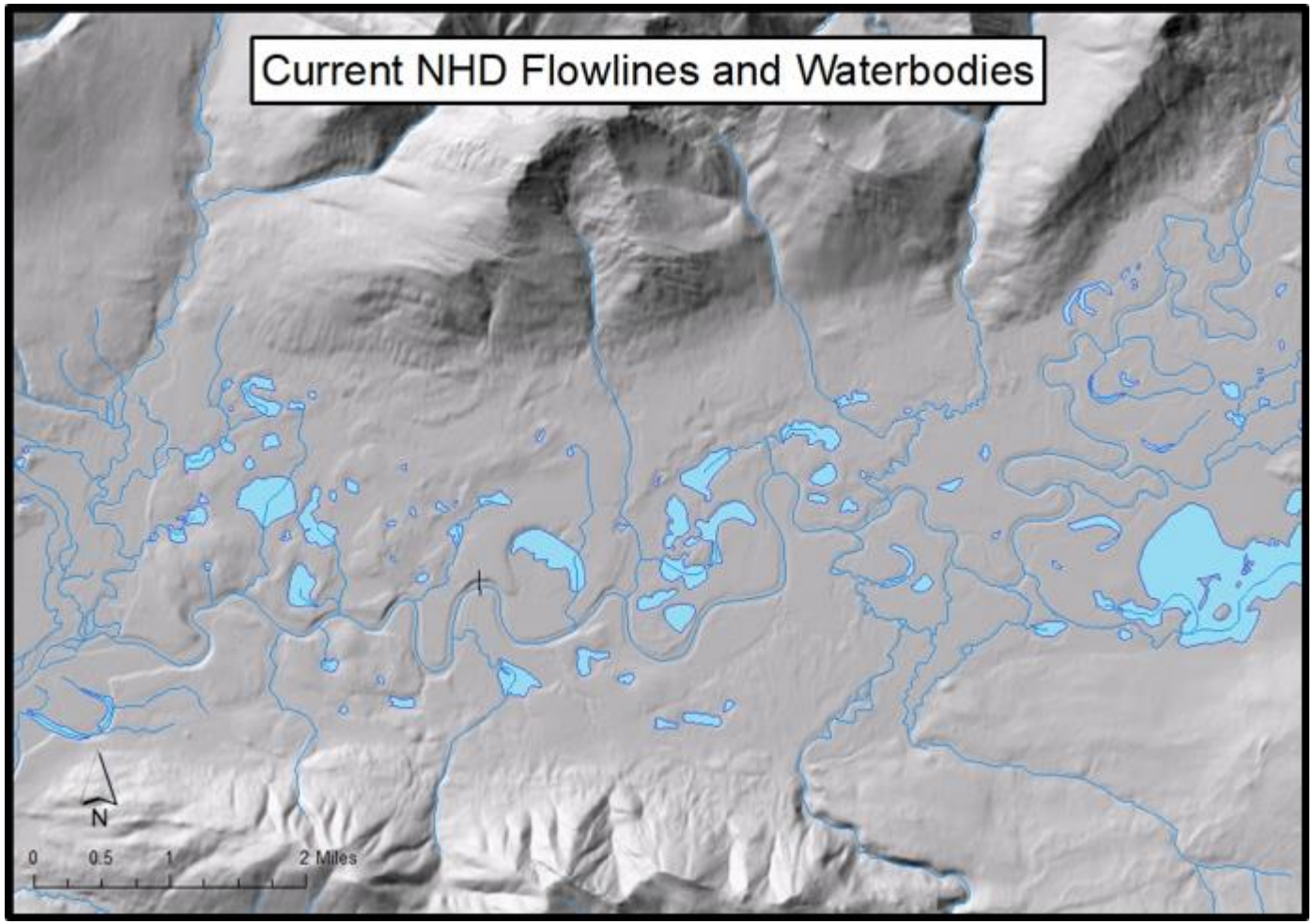
Inspection Process

From 100% Manual Review to Statistical Sampling



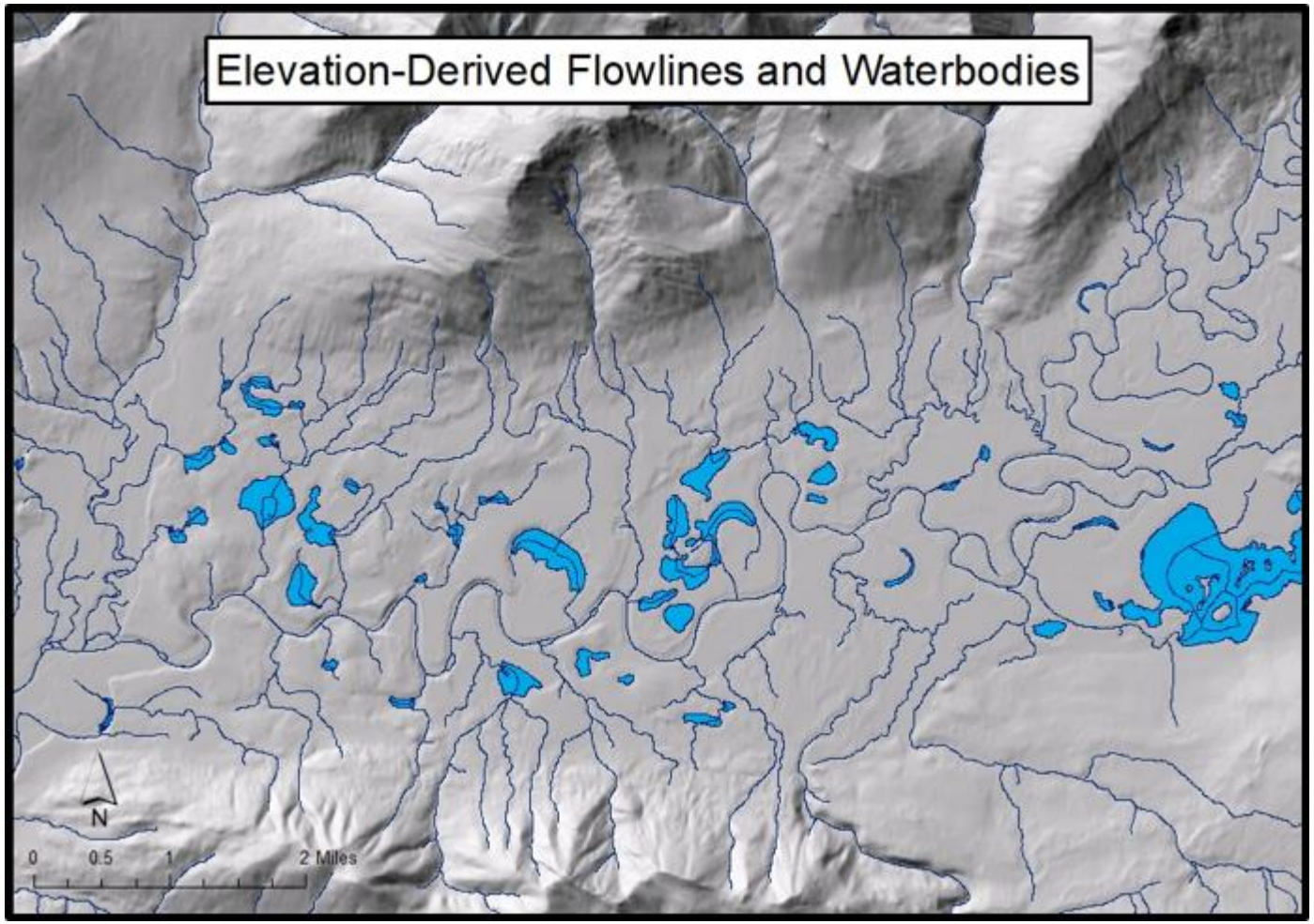
Inspection Process

From 100% Manual Review to Statistical Sampling



Inspection Process

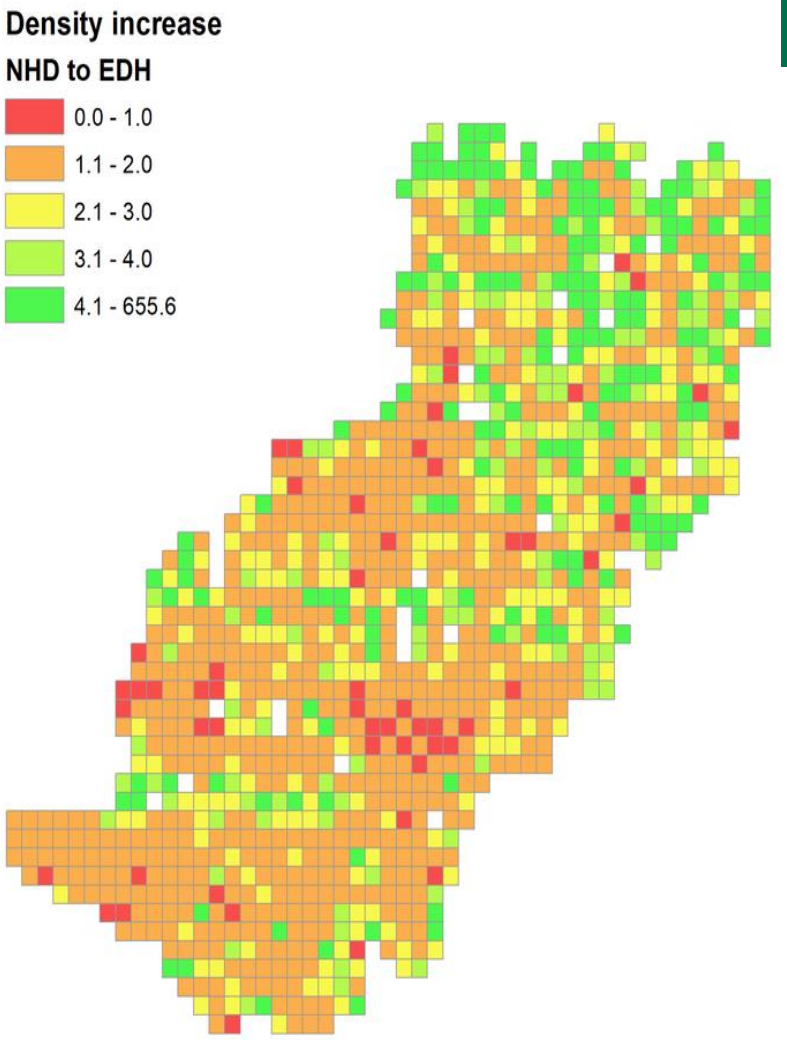
From 100% Manual Review to Statistical Sampling



Inspection Process

Prescreening

- Drainage density by HU12 based on guidance
- Artificial paths outside, or streams inside, polygons
- Monotonicity
- Vertex Spacing
  - Vertices must be no closer than1.5 meters from another vertex
- Vertical Placement, above and below ground
  - No vertex z-values above DTM surface,
  - No vertex z-values more than 2 meters below DTM surface
- Horizontal Placement
- XYZ coordinates of intersections and waterbody vertices relative to hydroflattened surface
- Topology
- Geometric network



Inspection Process

Manual Inspection

- Some features will have a 100% inspection, and some will have a sample inspected
  - 100% inspection
    - Subsurface Connection Features: underground conduits, connectors, culverts
    - Glaciers
    - Features with new capture conditions: areas of complex channels, coastlines
  - Sample
    - Streams
    - Drainageways
    - Artificial Paths
    - Lake/pond, reservoir, and double line streams

Inspection Process

Manual Inspection

Completeness

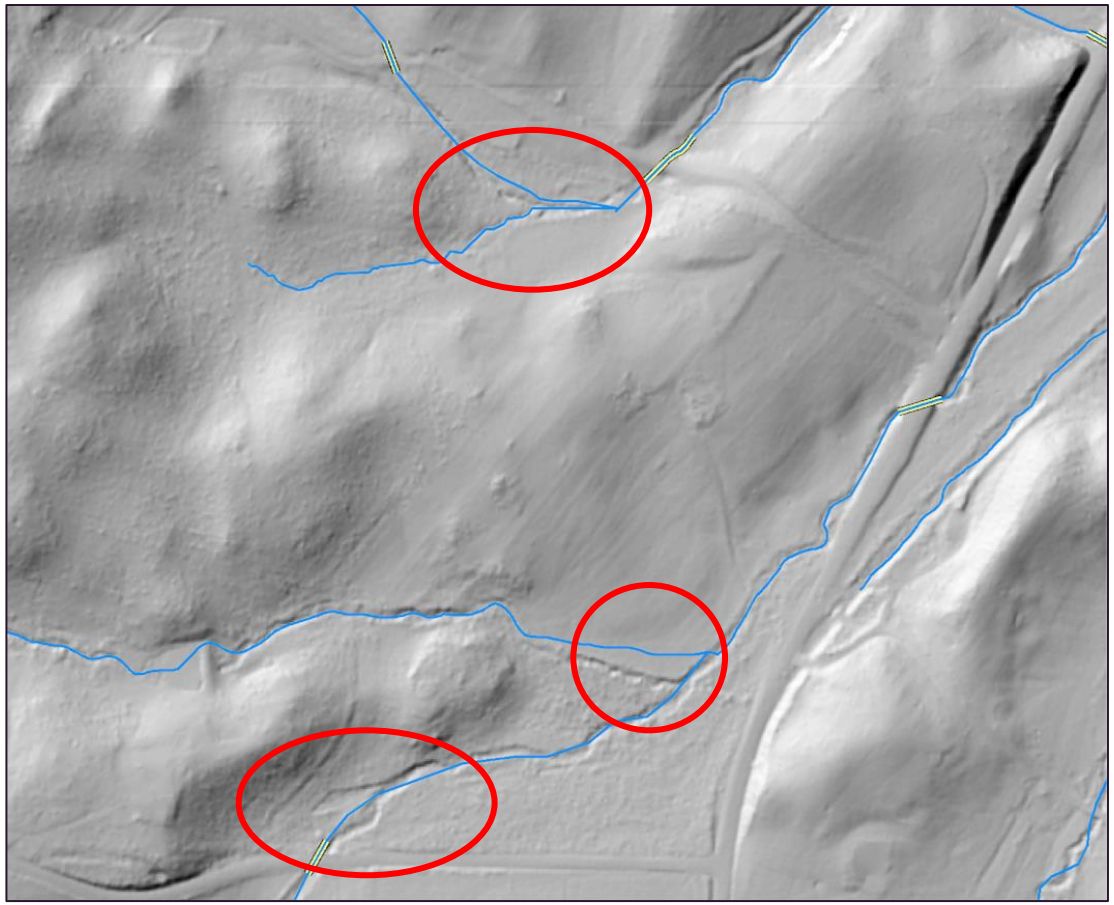
- Omission
- Commission

Integrity

- Schema and codes
- Hydrography types

Placement

- Horizontal
- Vertical



Horizontal Placement Errors

Inspection Process

Reporting

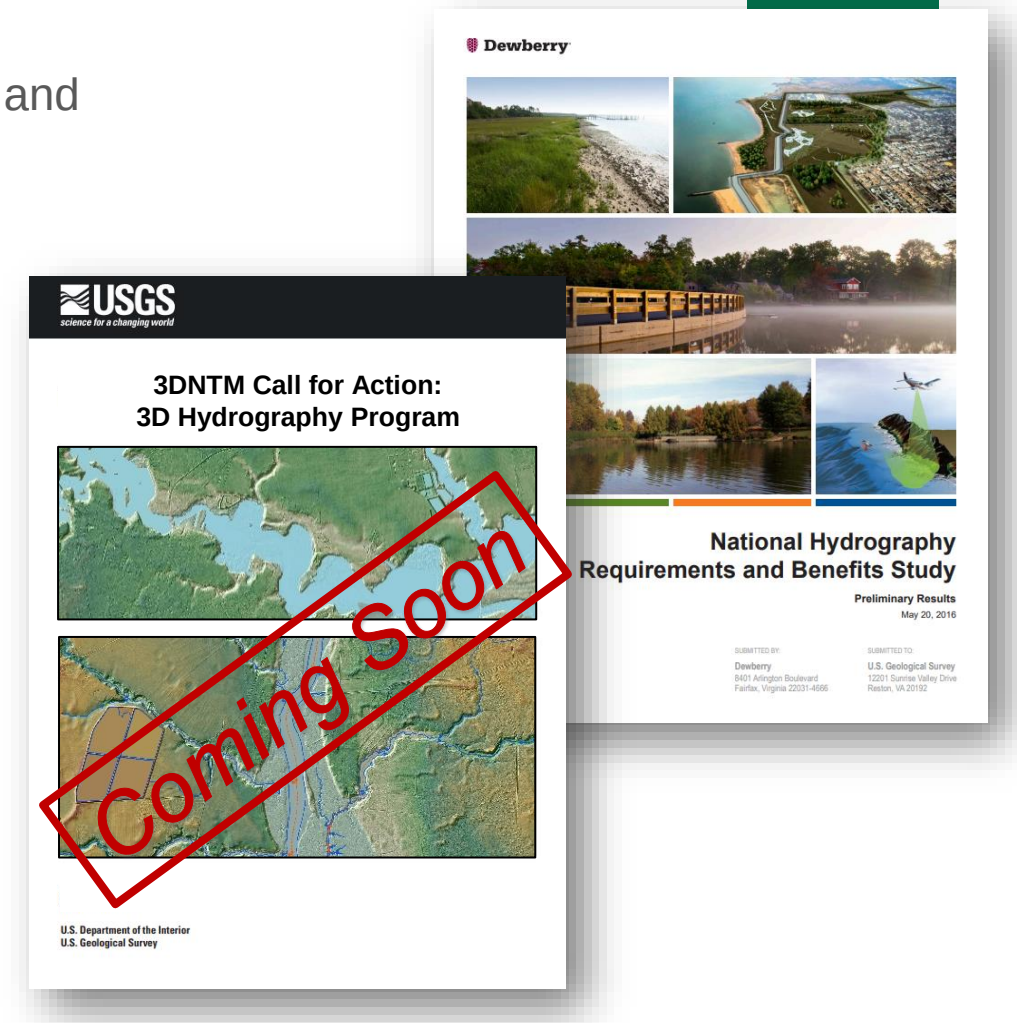
- Errors are compiled from Prescreening and Manual Inspection
  - Manual Inspection Errors are flagged spatially and categorized by Error Type
  - Summary Report is written
- Feedback is provided to Contractor

Vertical Placement			Delivery 2	Percent Error		Delivery 1	Percent Error
EDH UNINTEGRATED VERTEX REPORT 2020-06-04 14:55:02.866000							
Z FLAGGING DISTANCE: 2.0 METERS							
	UNINTEGRATED VERTICES:		2734			1260	
	EDH LINES WITH AT LEAST ONE UNINTEGRATED VERTEX:		399			227	
	PERCENTAGE OF EDH LINES WITH AT LEAST ONE UNINTEGRATED VERTEX:			4.86%			4.26%
4.86% of features have vertical placement errors. The criterion for passing is less than 10% of all features shall have vertical placement errors.							

Snapshot of Prescreening Report

What's Next? 3DNTM Call for Action Part 1: 3DHP

- Currently in draft, plan to publish by end of 2021
- The 3D National Topography Model will integrate USGS elevation and hydrography data to model the Nation's topography in 3D
- 3DNTM vision includes the next generation of 3D Elevation Program (3DEP) and establishing the **3D Hydrography Program**
- Based on HRBS and building on two decades of national hydrography mapping experience and contributions
- 3DHP Overview
  - Operationalize **deriving hydrography from lidar/**IfSAR
  - Enable better accounting of the hydrologic cycle by adding **connections to groundwater, engineered hydrologic systems and wetlands**
  - Fully implement the **National Hydrography Infrastructure** as the mechanism for sharing and discovering water information



Questions?

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