Updating the NHD in the Matanuska-Susitna Basin, Alaska

Final Project Report

Contract # AKFO-070114a-JD

GeoSpatialServices

Saint Mary's University OF MINNESOTA

Contents

List of Acronyms

CIR – Color Infra-red

DEM – Digital Elevation Model

DRG – Digital Raster Graphic

ESRI – Environmental Systems Research Institute

FGDC – Federal Geographic Data Committee

GINA – Geographic Information Network of Alaska

GIS – Geographic Information System

IfSAR – Interferometric Synthetic Aperture Radar

LiDAR – Light Detection and Ranging

MAT-SU – Matanuska-Susitna

NED – National Elevation Dataset

NHD – National Hydrography Dataset

NOAA – National Oceanic and Atmospheric Administration

NWI – National Wetland Inventory

ORI – Orthorectified Radar Image

PI - Photointerpretation

SDMI – Alaska Statewide Digital Mapping Initiative

SMUMN GSS – Saint Mary's University of Minnesota, GeoSpatial Services

TNC – The Nature Conservancy

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

USNPS – United States National Park Service

Acknowledgements

We would like to gratefully acknowledge the efforts of Jim DePasquale from The Nature Conservancy whose drive, determination and foresight resulted in the development and execution of this project . Thank you also to Becci Anderson and Brian Wright from the United States Geological Survey and Bill Rice from the United States Fish and Wildlife Service for funding support and technical review. In addition, thanks to the members of the Palmer Soil and Water Conservation District Office for their contribution of scientific and local ecological knowledge during the fieldwork portion of this project. Finally, thank you to Mike Plivelich, Alaska NHD Steward, for his work in getting the finished data uploaded to The National Map.

Abstract

The National Hydrography Dataset (NHD) for many parts of Alaska is out of date and in need of revision. The original digital hydrography data for much of Alaska was derived from the conversion of 1:63,360 paper topographic maps, digital raster graphics (DRG). These maps were developed from aerial imagery flown in the 1950's and then compiled and printed using traditional cartographic methods in the early 1960's. As a result, existing data has been subject to changes in the natural landscape, human development, and spatial data development methodologies. In addition, given the original compilation scale, this original hydrography is generalized and unsuitable for site specific applications.

The United States Geological Survey (USGS) National Geospatial Program (NGP) is the lead federal agency for hydrography mapping under the Office of Management and Budget Circular No. A-16 Revised. This data theme includes surface water features such as lakes, ponds, streams and rivers, canals, oceans, and coastlines. The USGS fulfills this responsibility through the management of the NHD, the surface water component of The National Map. There is no state agency in Alaska directly responsible for hydrography in Alaska, and as such, the most successful method of upgrading NHD in Alaska is to work with partner entities in local areas to make data improvements, particularly where there are established coordination relationships. Efforts to work through local partners are coordinated through the Alaska Hydrography Technical Working Group, but have broad support and participation from other state and federal agencies and NGOs as well.

In the fall of 2013, The Nature Conservancy (TNC) initiated a hydrographic mapping and analysis program in the Matanuska-Susitna (Mat-Su) Basin using newly available data to map all lakes, rivers and streams to a level of quality and technical specification suitable for ingestion into the USGS National Hydrographic Database (NHD). By meeting federal standards, this mapping program is designed to ensure that NHD updates are freely available for use by government agencies, private and public organizations to support decisions which affect Mat-Su freshwater resources. This project improves the National Hydrography Dataset component of The National Map by updating linear (1D) and polygon (2D) features for the NHD and ingesting 1D and 2D feature updates into the NHD for the Mat-Su Basin. This project also improves data for 1:25,000-scale US Topo products for Alaska, which uses the NHD to display surface water mapping.

The Mat-Su Basin hydrographic mapping program consisted of two phases; a modeling phase and a validation phase. The modeling phase employed newly available LiDAR and IfSAR elevation data to create an elevation-derived, synthetic network of hydrologic flowlines, or streams, in the Mat-Su Basin. The validation phase consisted of an independent photogrammetric review of modeled streams coupled with field observations to validate the final hydrography and ensure that the mapped features best reflected actual ground conditions. Once validated through these processes, the entire Mat-Su stream network was conflated to the USGS NHD from Alaska Hydro data schema following USGS specifications for 1:24,000 scale mapping. This project report summarizes the activities undertaken by Saint Mary's University of Minnesota to complete the validation of new Mat-Su Basin hydrography.

Background

Encompassing over 20,000 lakes and thousands of miles of streams and rivers, the Matanuska-Susitna Basin is a community rich in aquatic resources. However, current mapping of surficial water bodies and their associated floodplains and watersheds is out of date and inadequate to support critical needs in community and development planning, flood mapping, and public safety as well as recreational, commercial, and subsistence use of Mat-Su freshwater resources.

In recent years, significant investments have been made in the Mat-Su Basin to secure high resolution topographical data and aerial photography, largely through the Mat-Su LiDAR and Orthoimagery project and the Alaska Statewide Digital Mapping Initiative (SDMI). These projects make available, for the first time, highly detailed topographic information which can be used to measure and map hydrogeomorphic conditions at a fine scale over the 16,309,920 acre (25,484 square mile) Mat-Su Basin (Figure 1).

Figure 1: Matanuska Susitna Basin Extent

In the fall of 2013, The Nature Conservancy initiated a hydrographic mapping and analysis program in the Mat-Su Basin using these newly available data to map all lakes, rivers, and streams to a level of quality and technical specification suitable for ingestion into the USGS National Hydrographic Database. By meeting federal standards, this mapping program is designed to ensure that NHD updates are freely available for use by government agencies, private and public organizations to support decisions which affect Mat-Su freshwater resources.

Furthermore, this program also meets statewide specifications for hydrographic mapping by working under technical guidance from the Alaska Hydrography Technical Working Group (AHTWG). The AHTWG includes representatives from Alaska Department of Fish and Game (ADF&G), Alaska Department of Environmental Conservation (DEC), Alaska Department of Natural Resources (AK DNR), U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), Bureau of Land Management (BLM), National Oceanic and Atmospheric Administration (NOAA), National Park Service (NPS), U.S. Forest Service (USFS), and the University of Alaska. Its purpose is to oversee the development of a single, statewide map of Alaska's lakes, rivers and streams that is shared across agencies, used as a single jurisdictional source of hydrographic mapping data in Alaska.

This TNC cooperative agreement funded the validation of single line streams (1D), the capture of two dimensional polygon (2D) hydrography features, and the addition of missing 1D features in the Mat-Su Basin composed of the following HUC 8 sub-basins (Figure 2): Anchorage (19020401), Matanuska (19020402), Upper Susitna River (19020501), Chulitna River (19020502), Talkeetna River (19020503), Yentna River (19020504), and Lower Susitna River (19020505); as well as ensuring connectivity of 1D features through 2D features for that area. This agreement also funded passing the NHD compliant single line streams plus lakes, ponds and rivers through the AK Hydro Data Reviewer quality control tools in preparation for processing the data through the University of Alaska Southeast Extract, Transform, Load (ETL) conversion tools in preparation for conflation into the USGS National Map spatial database.

As a future step, the development and validation of updated NHD for the basin should also facilitate the generation of NHDPlus for the basin. This networked hydrography dataset will extend the scope of data analysis tools available to users in the Mat-Su and will support the integration of NHD data into local and regional planning, water planning, and management activities.

The Nature Conservancy provided central coordination of funding, partnerships and methods development for this project. Financial support for Saint Mary's University of Minnesota was arranged through a combination of contracts and cooperative agreements supported by TNC, Mat-Su Borough, USFWS, and USGS.

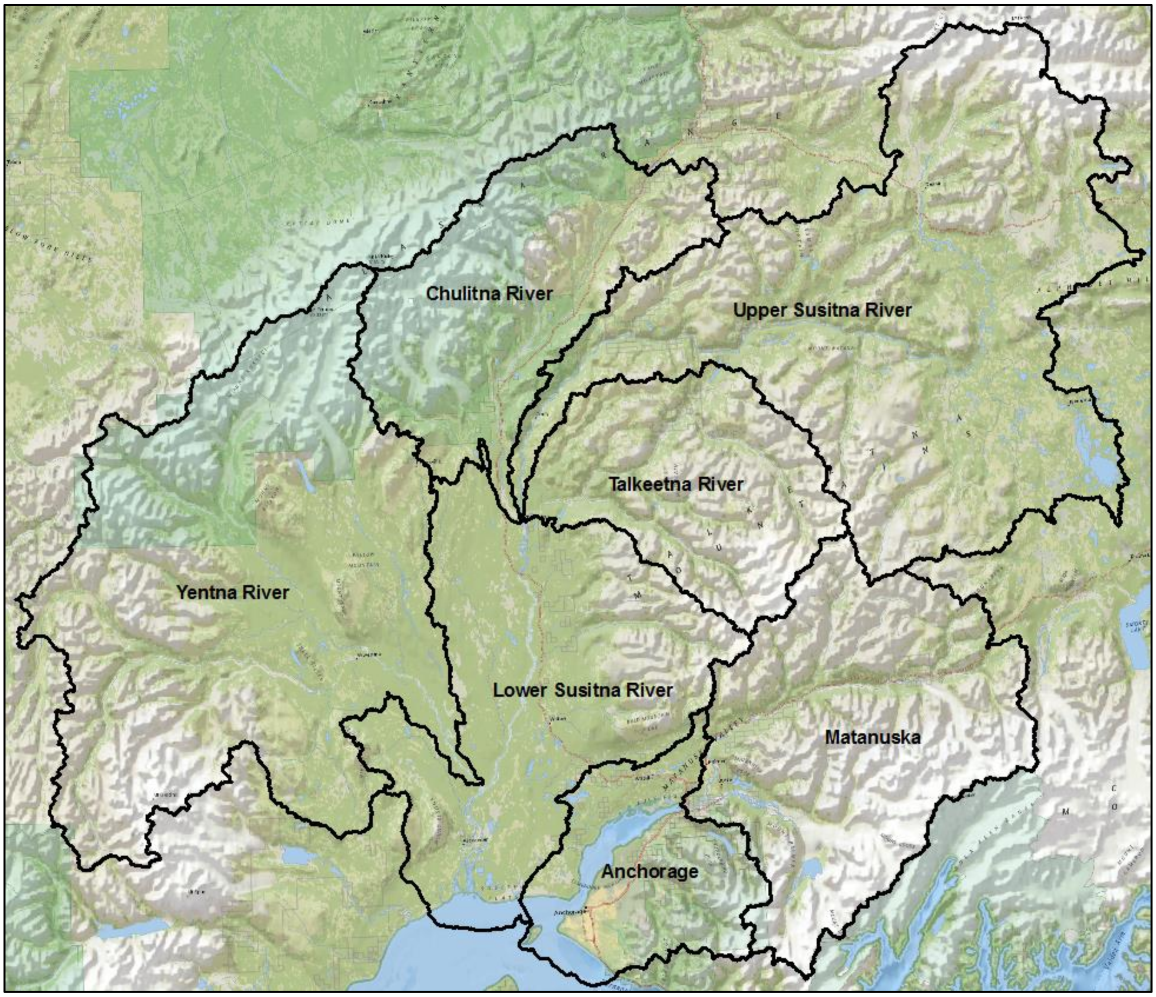


Figure 2: HUC 8 sub-basins within the Mat-Su Basin

Methods

The Mat-Su Basin hydrographic mapping program consisted of two phases; a modeling phase and a validation phase. The modeling phase employed newly available LiDAR and IfSAR elevation data to create elevation-derived, synthetic network of hydrologic flowlines, or streams, in the Mat-Su Basin. The validation phase consisted of a third party, independent photogrammetric review of modeled streams coupled with field observations which ensure that modeled streams best reflect actual ground conditions. Once validated through these processes, the entire Mat-Su stream network was conflated to the USGS NHD National Map from the AK Hydro data schema following USGS specifications for 1:24,000 scale mapping.

This specific project, funded by TNC, was designed to finalize the mapping protocols for the validation phase of this mapping program by designing and executing the required tasks for HUC 10 watersheds within the Mat-Su Basin. Specific project deliverables included the capture of missing 2D hydrography features and any missing single line stream features, as well as ensuring connectivity of 1D features through 2D features. This agreement also funded passing the NHD compliant project 1D flowline features and 2D features through the AK Hydro Data Reviewer quality control tools in preparation for editing and conflation into The National Map. All work was completed while adhering to 1:24,000-scale National Map Accuracy Standards, NHD and AK Hydro editing standards.

Traditional Mapping Methodologies in Alaska

The National Hydrography Dataset (NHD) is the surface water component of The National Map and is a digital vector dataset maintained by the United States Geological Survey (USGS) using geographic information systems (GIS) technology. It is a comprehensive set of digital spatial data representing the surface water of the United States using common features such as lakes, ponds, streams, rivers, canals, dams and oceans. These data are designed to be used in general mapping and in the analysis of surface-water systems using geographic information systems (GIS). These data are important to help understand hydrologic functions and their relationships to other natural and cultural resources.

While consistently mapped at 1:24,000 or better in the contiguous U.S., the NHD in Alaska was taken from 1950s-era USGS Historical Topographic Maps at 1:63,360-scale, and has seen few improvements or enhancements over the years. The dataset contains many errors including streams outside their channels, misrepresentations of flowlines, disconnected streams, and omission of existing streams. Harsh terrain, remote locations, rapidly changing landscapes and coastlines, seasonal extremes, dense cloud cover, tidal ranges, complex braided channels, expansive wetlands, and subsurface flow further challenge efforts to map the state's water.

Mat-Su NHD Automation Process

Over the past several years, the Alaska Statewide Digital Mapping Initiative (SDMI) has been in the process of acquiring new digital elevation models (DEMs) derived from IfSAR (Interferometric Synthetic Aperture Radar) sensors. These data were initially collected over large areas that included several Alaska NPS units and will ultimately be available for the entire state. The models were hydrologically enforced and suitable for application in the automated generation of both linear (1D) and polygonal (2D) hydrography which can then be used as input for automated updates of interior (non-coastal) NHD. In fact, IfSAR derived DEM data has already been tested by the Bureau of Land Management (BLM) in the National Petroleum Reserve Alaska (NPRA). The derived hydrography in NPRA had several limitations, including a lack of NHD attribution; however, it appeared to be an accurate representation of surface water flow paths and basins that had the potential to provide initial input to NHD updates.

The availability of accurate elevation data for use in the NHD updates provided the opportunity to investigate methods that were focused on the development of processes and tools by which hydrography could be updated using automation techniques based on IfSAR DEMs and existing NHD. This investigation evaluated and documented the various techniques and the associated estimates of quality assurance and manual editing required for automating NHD data updates using IfSAR. This addition to the stewardship strategy for Alaska was a very important step for moving forward with a cost effective and accurate NHD update process.

Synthetic Network Creation

The first step in preparing data was to generate new hydrography from the LiDAR and IfSAR elevation models. Two types of hydrography were required: lines, or one-dimensional (1D) features and polygons, or two-dimensional features (2D). Generation of new hydrography was conducted using tools in a mapping and modeling platform called Netstream by TerrainWorks Inc. There were nine primary tasks that TerrainWorks Inc. followed in the creation of the synthetic network:

1. Merge available elevation data to a single, contiguous DEM for the entire watershed.
2. Calculate topographic attributes used for network extraction.
3. Identify data sets to use for drainage enforcement.
4. Create a hydrologically conditioned DEM
5. Calibrate channel-initiation criteria.
6. Calculate flow accumulation, identify all channel initiation points, and trace all channels.
7. Smooth channel traces
8. Validate the delineated channel network
9. Update all datasets and adjust channel initiation criteria

For the full description of the process used to create the synthetic network please reference:

Miller, D., Benda, L., DePasquale, J., Albert, D., 2015, Creation of a digital flowline network from IfSAR 5-m DEMs for the Matanuska-Susitna Basins: a resource for NHD updates in Alaska.

Feature Simplification

Automated generation of features created large numbers of vertices within each 1D and 2D feature. Simplification or generalization techniques were applied to remove these vertices. The ESRI Simplification Tool was used with tolerance values that removed the excessive amount of vertices, but did not jeopardize the accuracy and shape of the features.

Densification

Densification describes the process of over-generating synthetic stream networks to ensure that all valid flow paths are represented in the final product. The synthetic network threshold values can be applied to vary stream initiation points and the amount of densification. For this project, researchers felt it was better to have more derived linears which could subsequently be deleted if necessary than it was to have fewer features that would then need to be added through image interpretation and manual editing.

Most of Alaska's current NHD datasets are only valid to the 1:63,360 scale. With current GIS technology and high resolution input datasets, mapping can be done at scales of 1:24,000 or better. This has led to many more linear features added to the new hydrography network and should enable a more in-depth range of analyses for the end users of the data.

Validation

Derived synthetic networks from high resolution elevation models are complex and are prone to the creation of features that do not coincide with visible surface hydrography. The value of the hydrography dataset is enhanced after a review of the derived features by interpreters using a variety of datasets, fieldwork, and local knowledge. For this project, 1D and 2D features were checked for spatial location, configuration and extent. In addition, missing features were identified and added where necessary.

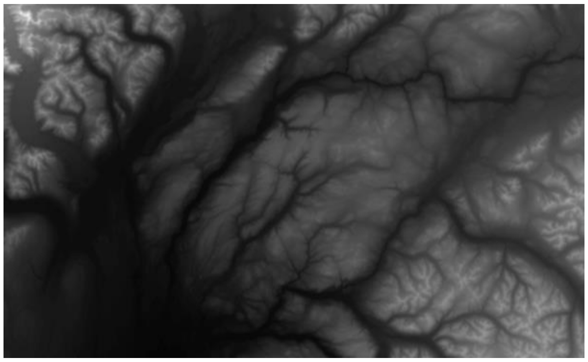
A variety of ancillary spatial databases were used to assist with the validation process. These "collateral datasets" typically consisted of hardcopy maps, photographs, scientific reports, and spatial layers that provided insight into the ecological and anthropogenic conditions across the project study area. While not created primarily for NHD mapping purposes, these various datasets provided additional information which researchers used to support NHD mapping decisions. The following is a summary of datasets which were used to support NHD validation in the Mat-Su Basin.

IfSAR

Interferometric Synthetic Aperture Radar (IfSAR) is an aircraft collected radar based product that is used to generate digital elevation models. Two vendors are currently under contract in Alaska to collect IfSAR elevation data across the state. Major funding contributors include the National Geospatial-Intelligence Agency (NGA), State of Alaska, and USGS. Supporting contributors include the Natural Resources Conservation Service (NRCS), Bureau of Land Management (BLM), the National Park Service (NPS), the US Fish and Wildlife Service (USFWS), and the US Forest Service (USFS).

These data consist of three products: a bare earth Digital Terrain Model (DTM), a first-return Digital Surface Model (DSM), and an Orthorectified Radar Intensity Image (ORI). The elevation models have a 5-meter post spacing, 22-foot contour equivalent accuracy, vertical accuracy of 3-meter LE90 (0-10 degree slope) and horizontal accuracy of 12.2-meter CE90. These data are used to generate topographic contour lines to be applied by USGS to complete the new 1:25,000 scale topography maps for Alaska.

In the absence of LiDAR data, the IfSAR elevation product is a useful collateral data product for tracking surface water flow and permits the project analyst to detect connectivity of surface hydrography to sustaining water bodies. In addition, IfSAR elevation data can be used to derive synthetic hydrography and topographic basins which can both be used as initial boundary delineations for surface hydrography features. Other derived surfaces which can be modelled from IfSAR elevation data to support NHD mapping projects include: compound topographic index, surface roughness, slope, aspect, and hillshade.



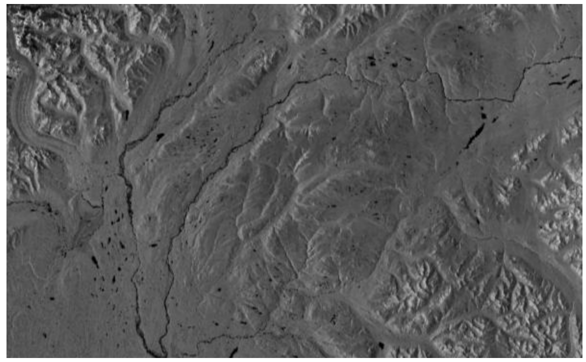


Figure 3: IfSAR DTM IfSAR Hillshade

LiDAR

Light Detection and Ranging (LiDAR) is a remote sensing method which uses light in the form of a pulsed laser to measure distances to the earth. These light pulses are combined with other data recorded resulting in precise information about the surface characteristics of the Earth. LiDAR is collected with a laser, a scanner, and a specialized GPS receiver. Airplanes and helicopters are the most commonly used platforms for acquiring LiDAR data over broad areas. Generated digital elevation models and LiDAR sourced products, such as contour-lines and hillshade, provide several advantages for NHD mapping.

The benefits of these sensors lie in the accuracy range of the elevation data they produce which varies from six inches to five meters depending on the collection procedures used to assemble the dataset. With respect to NHD mapping, these datasets are most useful for the identification of low areas, or basins, where surface hydrology is located. Project analysts have the additional capability to determine water flow direction and generate models of potential surface hydrology from LiDAR data.

Another significant advantage of LiDAR is that the data can be used to produce accurate contours through specialized computer software applications to assist the project analyst in visualizing study area landscapes. The resource can also be used to produce topographic wetness indexes and compound and position topographic indexes that may provide additional valuable information to the project analyst. LiDAR, however, does require a compromise, that being the resultant files are large in size and the volume of computer storage space required may be a prohibiting factor.

Figure 4: LiDAR DEM

Hillshade

Hillshade images are another ancillary dataset which can be generated from elevation data in support of NHD mapping. These hillshades may be readily created from digital elevation models using ESRI ArcMap and then applied as a collateral elevation source to aid researchers in determining basin location and depth. In areas of low elevation, there is not much elevation change displayed on the hillshade. For these areas, an exaggerated z-value can be applied in order to accentuate more subtle changes in local topography.

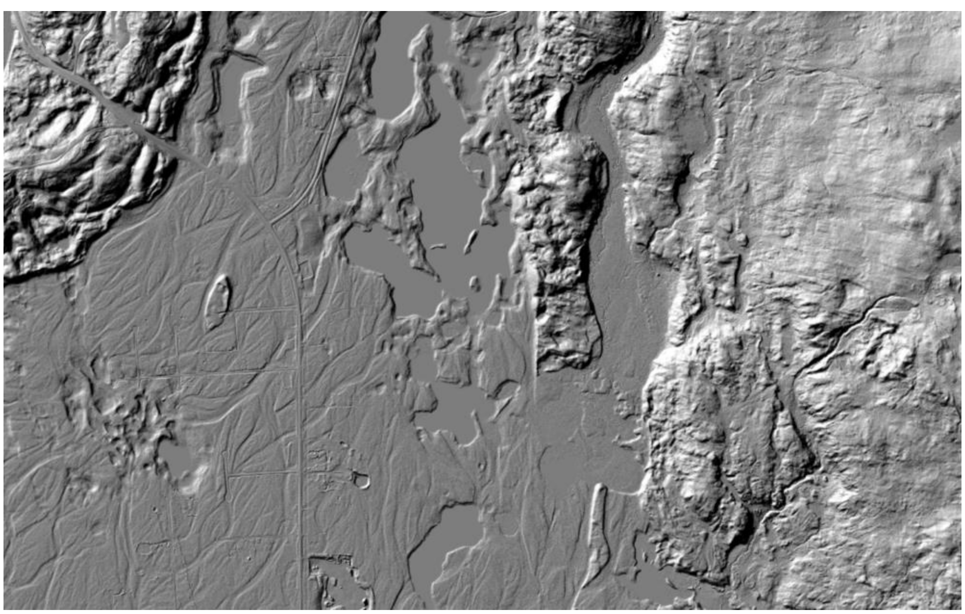


Figure 5: LiDAR derived hillshade

Contours

Contour lines generated from the IfSAR and LiDAR data are used to guide placement of 1D hydrography so that the feature location correlates to elevation data.

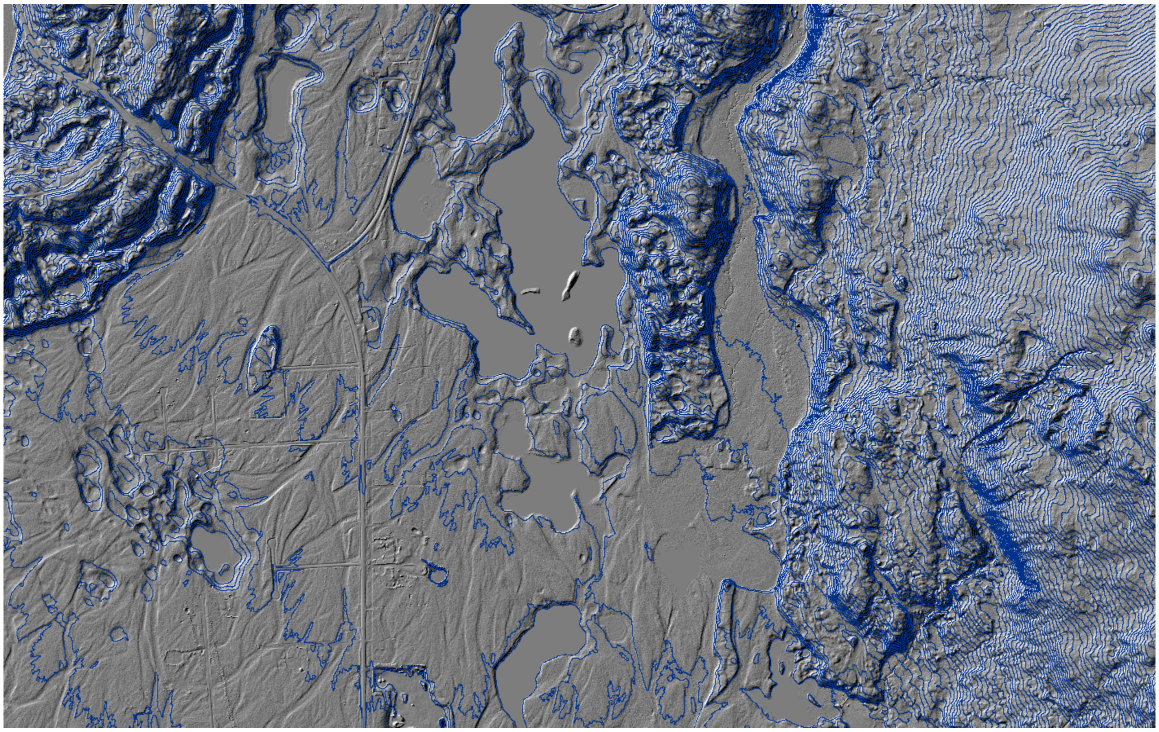


Figure 6: 3 meter contours over LiDAR derived hillshade

High Resolution Optical Imagery

AeroMetric, Inc. acquired high resolution imagery for a portion of the Mat-Su Basin. A frame-based digital mapping camera (DMC) was used aboard an aircraft to capture aerial photography along pre-defined flight lines. The data was delivered with a ground sample distance of 1 foot resolution. Image tiles were in a compressed MrSid2 format.

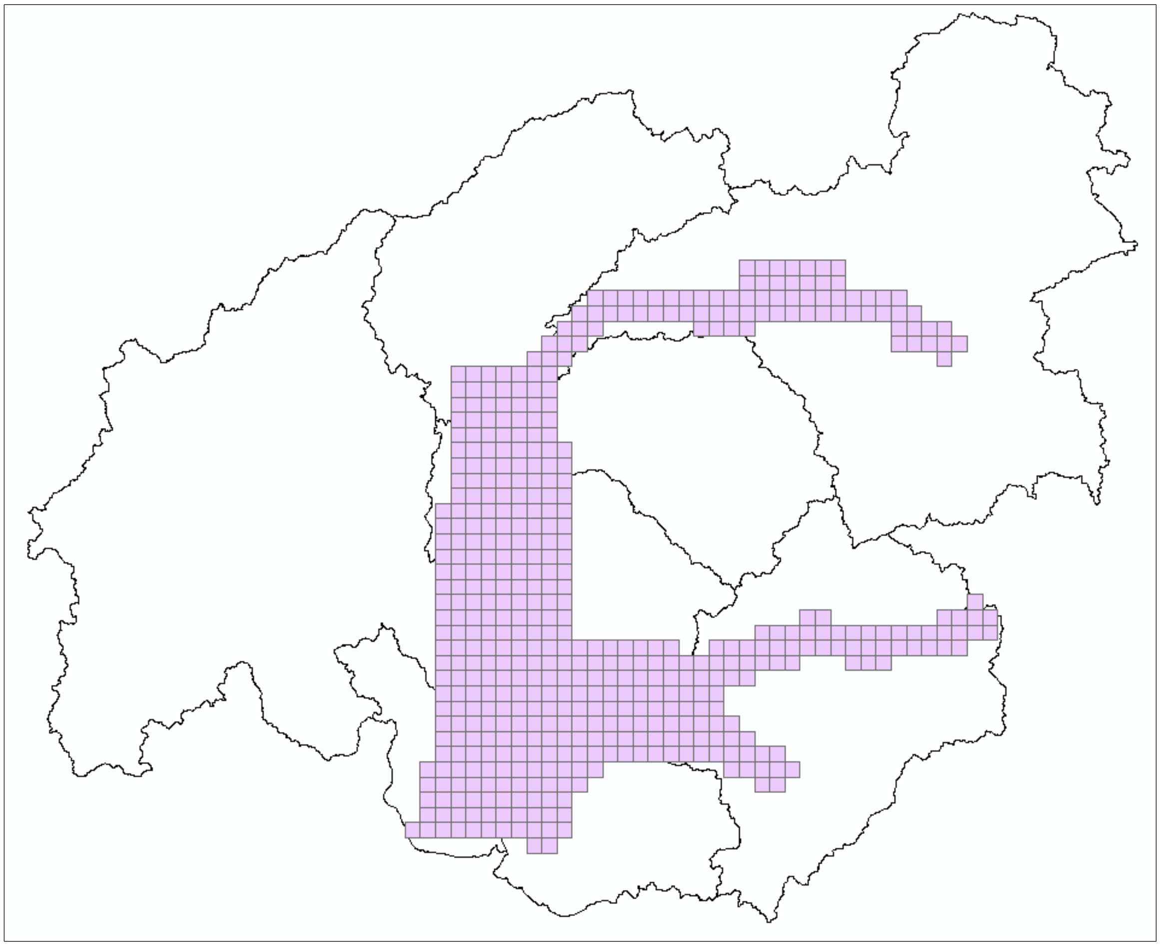


Figure 7: High Resolution Tile Coverage

SDMI SPOT 5

The Statewide Digital Mapping Initiative's (SDMI) SPOT 5 imagery was another key layer employed for visual validation of hydrography features across the basin. This dataset consisted of three different types of image emulsion: color infrared (CIR), panchromatic (PAN), and true color (RGB). Identification and validation of hydrography was most successfully accomplished from the CIR version of the imagery due to that fact that this sensor filtered blue light from the image and rendered water features in dark grey or black for improved interpretation. The CIR emulsion was also useful for distinguishing live, healthy vegetation from diseased, dying or dead vegetation.

The Panchromatic (PAN) image was useful for decision support while editing, especially in areas where there was excessive shadowing or a majority of dark features. This imagery rendered features in a series of gray tones ranging from black to white and often provided the image analyst with the ability to see through highly shadowed areas in order to better interpret landscape features. The true color emulsion was rarely accessed during hydrography interpretation.

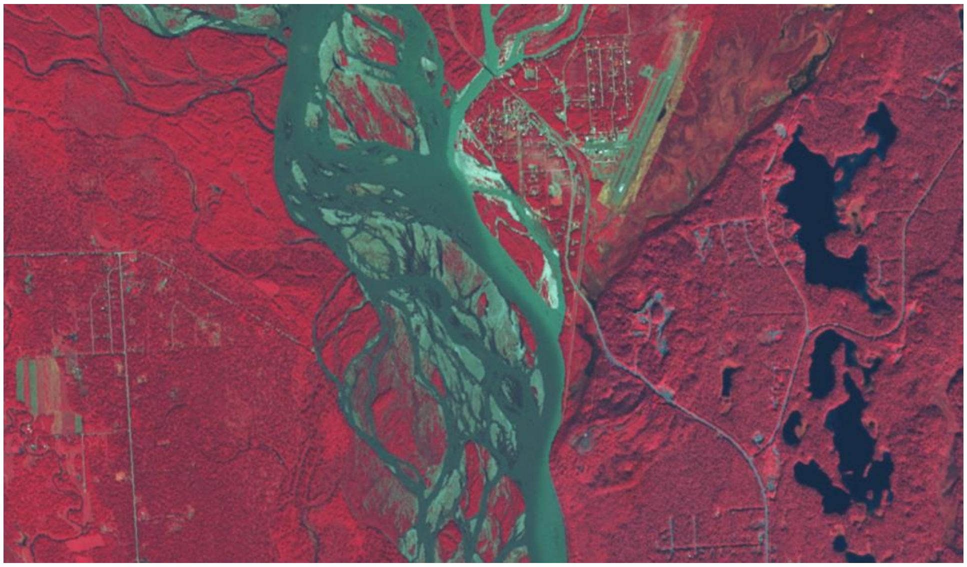


Figure 8: SDMI SPOT 5 CIR imagery

Wetlands

Given the direct relationship between wetlands and surface hydrography, an important collateral dataset for NHD mapping was wetland areas. The National Wetlands Inventory (NWI) is publicly available data distributed by the U.S. Fish and Wildlife Service (USFWS). Wetlands provided researchers with information regarding connectivity between hydrographic features with poorly defined channels. In addition, this data was used to determine the location of points of initiation for 1D flow lines.

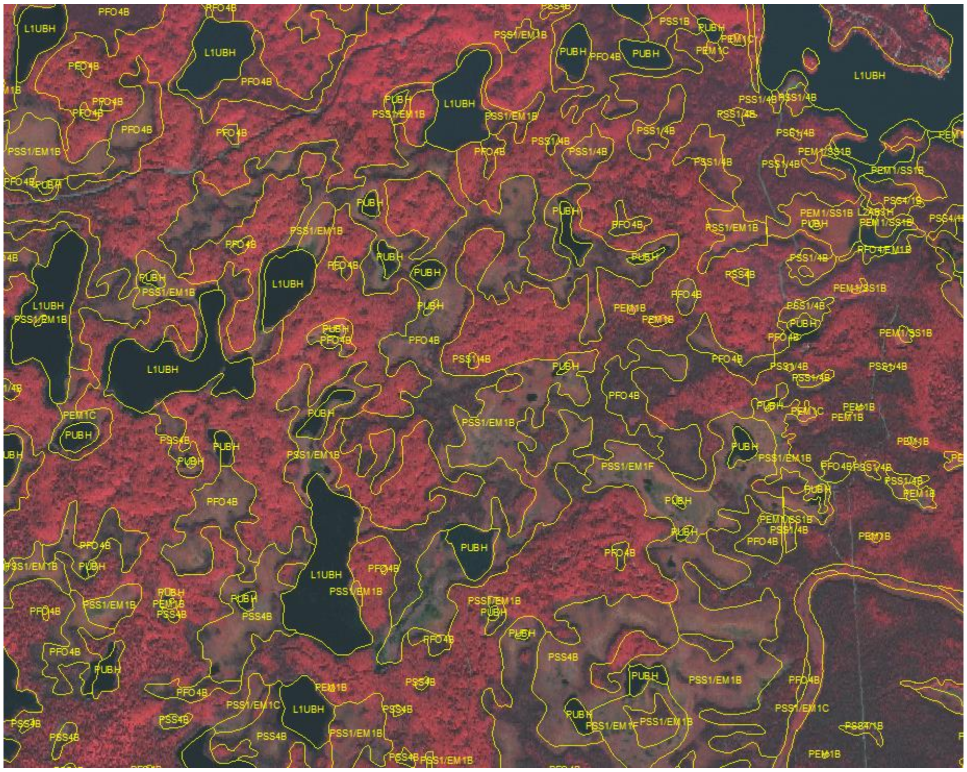


Figure 9: NWI with classification codes over SPOT 5 imagery

Hydrology

The most comprehensive spatial layer available for Alaska is the USGS National Hydrography Dataset (NHD). This dataset was derived from the original mapped hydrography on the 1:63,360 scale topographic maps and based on 1950’s era aerial photography. As a result, the datasets are out of date and are lacking the horizontal and vertical accuracy to be compatible with more recent image and elevation datasets.

Surface hydrology as depicted by the NHD has been identified as a high priority thematic data layer for revision for Alaska. A regionalized approach to provide this revision has been identified and deployed for southeast and south-central Alaska through collaboration of state, federal, and university partners. This update process, referred to as AK Hydro, standardizes the revision process utilizing GIS modeling techniques together with USGS NHD tools. Project partners utilize the AK Hydro dataset and editing process which makes use of staging databases to collaboratively edit, manage, and maintain hydrography information which is ultimately uplifted to the NHD.

Existing maps provide a valuable “snap shot in time” representation of the historical surface hydrography as it existed when these records were produced. These maps can be used as a starting point by image interpreters to assess conditions, review historical surface hydrography and distribution, and to develop estimates of change. In addition, these maps and reports typically included significant quality assurance and quality control processes which incorporated field investigations to validate the accuracy and comprehensiveness of the mapped product. These investigations and the resulting maps and documentation are quite often supported by ground level and oblique aerial photographs which are extremely valuable for current project analysts who are not able to visit the study area. One of the challenges of working with these records, however, is that they are not necessarily public documents and may be difficult to acquire. In addition, given the available technology at the time of creation, they are often not adequately georeferenced for use in modern mapping applications.

In some areas of Alaska, other state and federal agencies have created specific surface hydrology data layers such as the Alaska Department of Fish and Game (ADF&G) Anadromous Waters Catalog (AWC), Department of Natural Resources (DNR) hydro, Palmer Soil and Water Conservation District (PSWCD), and Mat-Su Borough Hydro. These data layers are all NHD datasets, but have different collection methods and attribution.

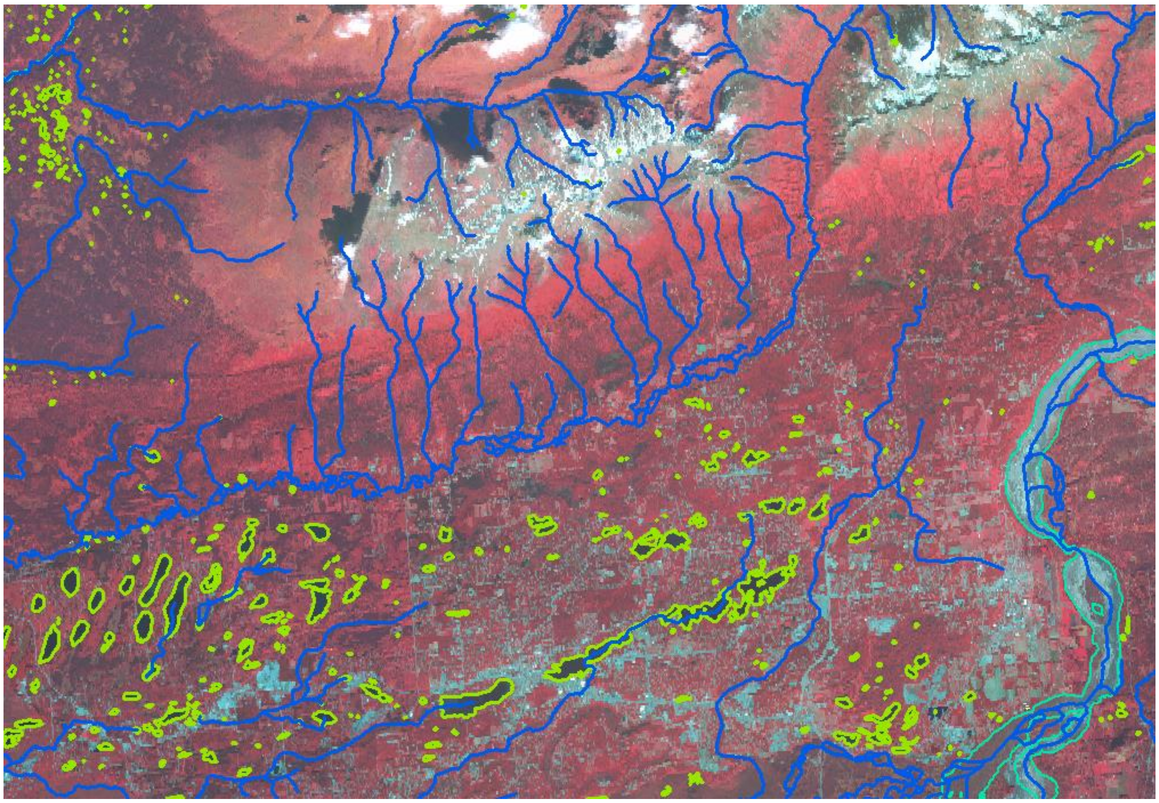


Figure 10: Original NHD over SPOT 5

Anadromous Waters Catalog

This catalog of water specifies various creek, streams, and rivers that are important for spawning, rearing, or migration of anadromous fishes. Where available, these regional and local scale spatial datasets can help inform NHD mapping decisions.

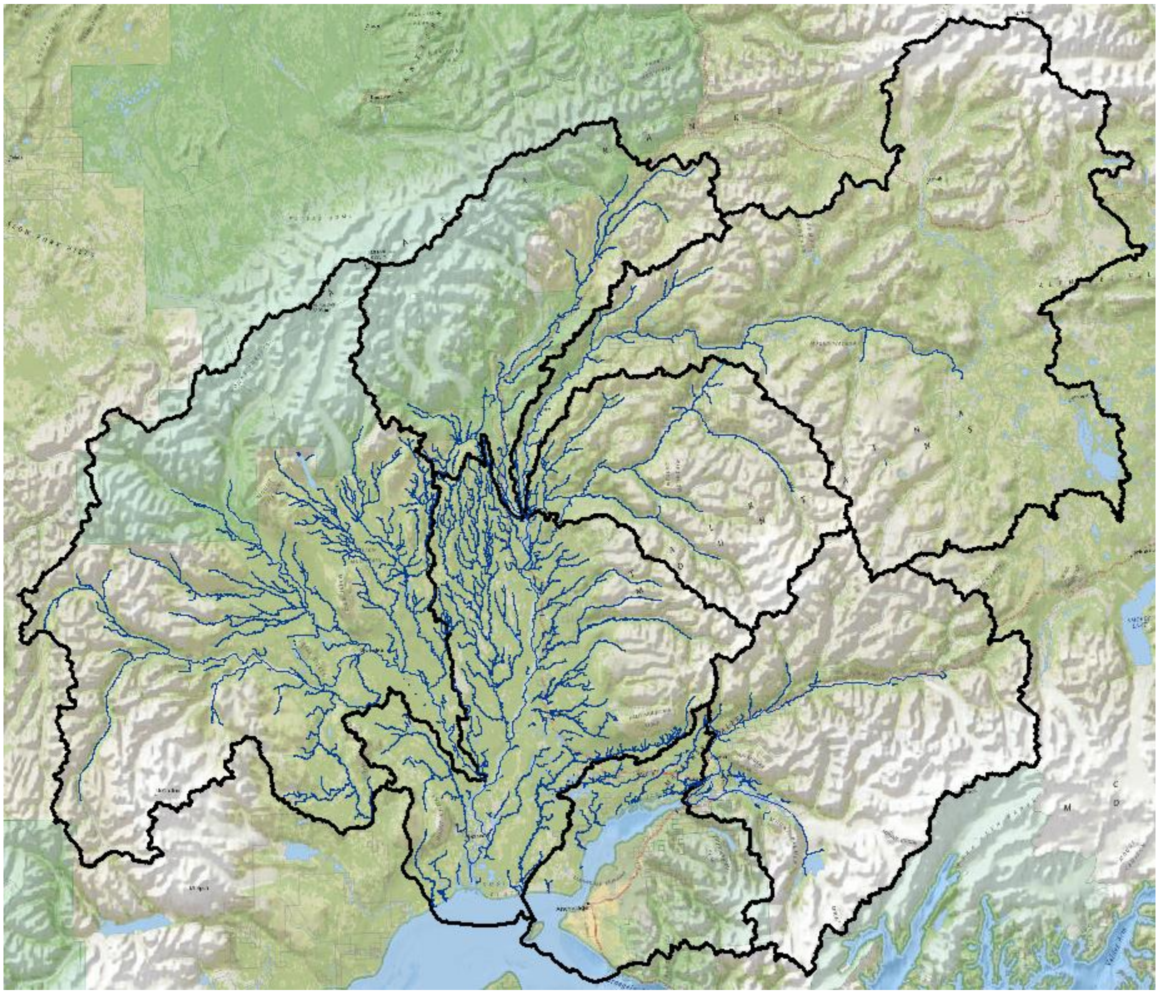


Figure 11: ADF&G Anadromous Waters Catalog within the Mat-Su Basin

Digital Raster Graphics

USGS topographic maps in the form of georeferenced Digital Raster Graphics (DRG) often provide useful information for the project analyst including: notations of marshes versus open water; elevation contours; vegetated ground; and, significant physical features of the landscape. DRGs are freely available for download without charge and provide an accurate representation of a project area landscape at the time of production. These maps are consistent and of high quality due to the standards and quality control procedures enforced during their original production. In Alaska, however, these maps do not necessarily represent an accurate depiction of current ground conditions due to their age.

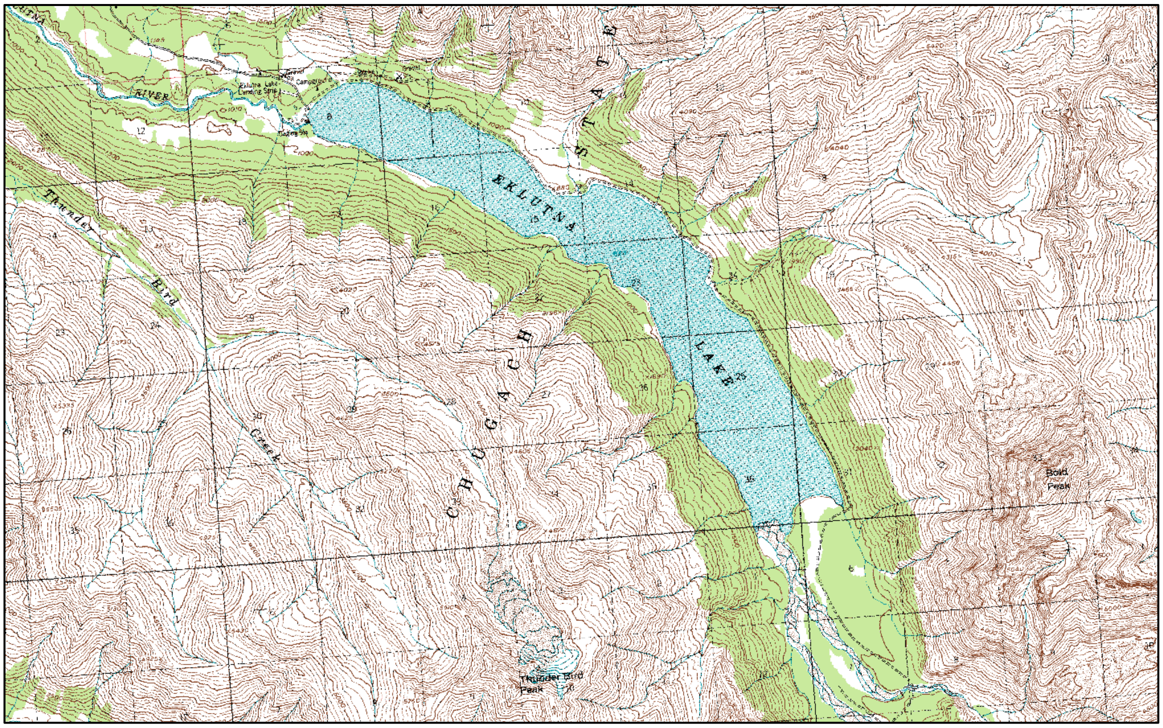


Figure 12: Digital Raster Graphic

SSURGO and STATSGO

Soils are complex and varied due to the unique geology and climate of a location such as Alaska. Soil data often provides valuable information for researchers. Of most importance is the consideration of hydric soils located in project areas which, along with certain vegetation, become indicators for saturated areas. Soils data may be available through the State Soil Geographic Database (STATSGO) and Soil Survey Geographic Database (SSURGO), maintained by the Natural Resources Conservation Service (NRCS), United States Department of Agriculture (USDA). These databases provide information about soil characteristics including water capacity, soil reaction, electrical conductivity, frequency of flooding, and yields for cropland, woodland, rangeland, and pastureland. They also provide information regarding limitations affecting recreational development, building site development, and other engineering uses.

In Alaska, the STATSGO database (small scale, generalized polygons) contains the broadest mapping coverage while the SSURGO database (large scale, comprehensive soil units) is only available for select areas. For most hydrography mapping applications the STATSGO data provides a general guideline for soil types at the regional level, however, the data do not provide specific support for NHD mapping. Where it is available, the higher resolution spatial data associated with the SSURGO database may help directly inform hydrography delineation and classification.

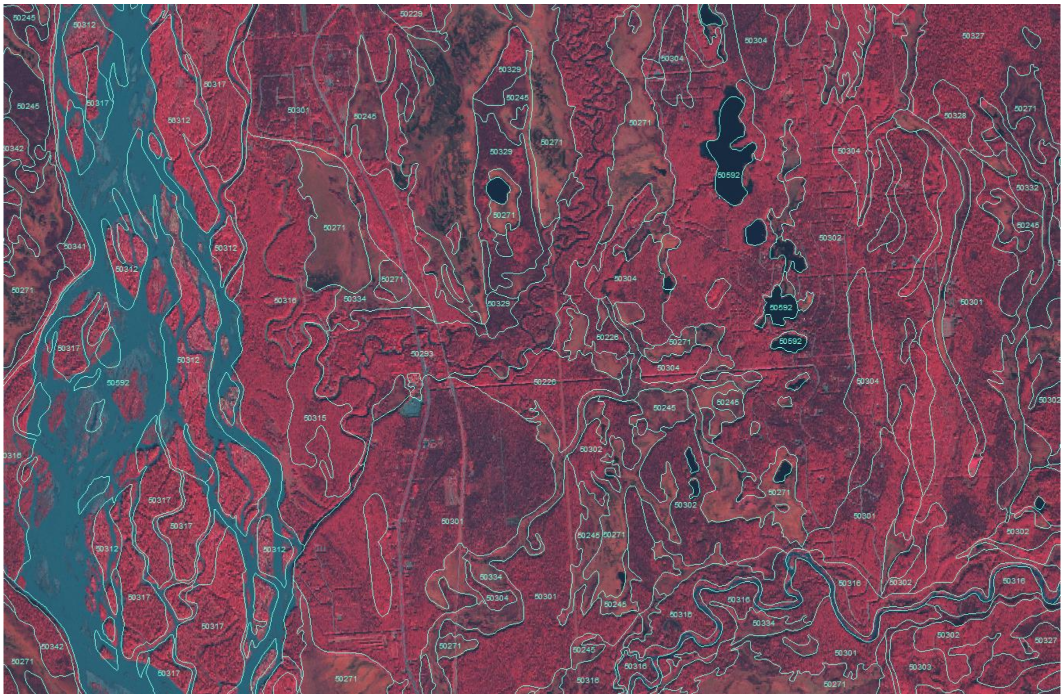


Figure 13: SSURGO with Mapunit Key over SPOT 5 imagery

Slope

A slope layer was created and symbolized using a channel gradient attribute that was within the synthetic network created by TerrainWorks Inc.

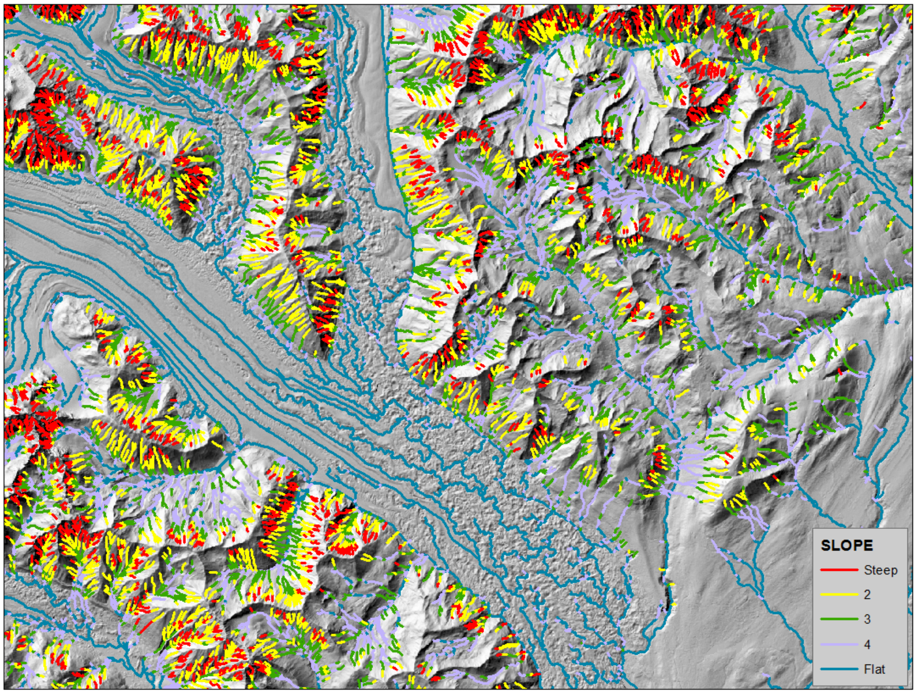


Figure 14: Slope layer over IfSAR hillshade

Culverts
A culverts layer (point features) for the project area was created by the Alaska Department of Fish and Game (ADF&G), the US Fish and Wildlife Service and the Matanuska-Susitna Borough. This layer was provide to researchers by The Nature Conservancy and was used to identify locations where stream flow was able to cross roads. Unfortunately, numerous locational errors were noted with this dataset and there were a number of missing features.

Stream Classification
While undertaking updates, researchers attempted to classify streams as perennial, intermittent, or ephemeral. All delineated channels were initially assigned a perennial classification unless there was strong evidence that the channel was dry on the imagery or if the feature existed on steep slopes above the tree line.

Classification of the streams was based on a several factors including: frequency and duration of water in the channel; location on steep slopes; and, presence or absence of woody vegetation An understanding of classification was gained through discussions with stake holders in Alaska and through field work conducted in the Mat-Su Basin project area. When making decisions regarding classification based on available data, an array of collateral datasets and additional information was used to drive the decision process. Data contributing to the decisions were; vegetation cover, wetlands, glaciers, lakes, slope, snow cover, historic hydrography data, visual interpretation from high resolution imagery, contours, GPS points and lines, field notes, and soils.

Quality Control
Upon completion of a checkout, project analysts submitted their work for quality control review (Appendix C). In the first step of the quality control process, the project lead visually inspected all edits at 1:10,000 to ensure accuracy of the work. During this inspection, project leads checked for proper alignment with the base data, placement of flowlines, missing or remaining features and points of initiation. Once an assigned watershed area (HUC10) had been reviewed and corrected, they were loaded together into a single sub-basin geodatabase (HUC8) and overlapping errors edge matched together.

Once an entire sub-basin was edge matched, the next step was to check the topology of the data using the ESRI topology rules. If errors in topology were found, these were corrected and the review process was repeated until errors were no longer generated. The next step was to check flowline segmentation and connectivity through creation of a geometric network and validate continuous flow through the network.

Finally, project leads ran the data through the AK Hydro Data Reviewer Tools. These were a comprehensive set of checks that worked through the ESRI Data Reviewer Tool. Errors were identified in a table that the analyst could step through, examine, and resolve. The Data Reviewer Tools extension required a license from ESRI. Validation of mandatory attribute fields required for the AK Hydro schema was also included in this final step.

NHD Data Validation Process

The methodology developed and applied for the validation phase of the Mat-Su hydrographic mapping program included six data editing tasks as described below.

Task 1 – Validation of Elevation Model Derived Linears

This task included the review of the geometric configuration and the spatial accuracy of the derived line work when assessed using reference spatial datasets available for the Mat-Su Basin. These datasets included: Alaska Statewide Data Mapping Initiative (SDMI) SPOT 5 imagery, LiDAR, LiDAR collected reflectance imagery, LiDAR mission high resolution aerial imagery, SDMI IfSAR ORI, and SDMI IfSAR DTM. Incorporation of these high resolution spatial datasets in the editing process ensured that the horizontal accuracy of the resulting hydrography data produced by the validation process was consistent with the National Map Accuracy Standard (NMAS) of +/- 12 meters for 1:24,000 scale map data. This part of the project included a one week field validation exercise undertaken cooperatively with TNC and the Palmer Soil and Water Conservation District to validate stream initiation points and support the assignment of stream classifications into the following categories: “intermittent”, “perennial” and “ephemeral” where appropriate.

Task 2 – Capture of Missing 1D and 2D Features

This step included the capture of any missing 1D and 2D features from reference datasets available in the Mat-Su Basin; SPOT 5, LiDAR, LiDAR collected imagery, IfSAR ORI, and IfSAR DTM. Where available, 1D and 2D breaklines were utilized to supplement generated linework. Where 2D breaklines did not exist in either the LiDAR or IfSAR databases, additional 2D polygons were collected through image interpretation. These photo interpreted features were captured to the AK Hydro minimum mapping unit (MMU) of two acres.

Task 3 – Load 1D and 2D Hydrography into the AK Hydro Network Data Model

Task 3 in the project focused on loading the 1D and 2D hydrography features into the AK Hydro network data model. This step included creating those fields necessary to comply with the classification schema chosen by the AK Hydro data team and project stakeholders.

Task 4 – Inclusion of Anadromous Waters Catalog (AWC) Data

This task included the incorporation of Anadromous Waters Catalog (AWC) data into the accepted AK Hydro schema developed in Task 3. This data set was imported “as is” from the Alaska Department of Fish and Game and served as a reference dataset for comparison with the derived hydrography. No attempt was made to transfer or apply attribution from the AWC data to the derived hydrography; although this may be a future step in the process using a semi-automated conflation process augmented by editor supervision and conflict resolution.

Task 5 – Initial Preparation of NHD Ready Dataset

Once the AK Hydro data schema had been built and populated, the next step in the preparation of the data for submission to the NHD national database was undertaken. This step involved conversion of the preliminary data into a USGS compliant dataset (NHD-ready format) through a series of conversion scripts written by ESRI for the University of Alaska Southeast. These scripts converted the initial data into a USGS formatted database using pre-defined processing rules and upfront editing to ensure spatial network continuity and logical attribute consistency.

Task 6 – Submission of Data to the USGS

The final task was to run the USGS NHD compliant dataset through the NHD Edit tools and submit the data to the USGS for upload into the National Map (NHD master database). This typically involved several iterations of quality control review (e.g. database scheme, network connectivity, attribution, etc.) and data correction before the data passes all of the validation required for compliance with the National Hydrography Data model.

Results

Initial hydrography flowlines for the Mat-Su Basin NHD update project were modelled from LiDAR and IfSAR derived elevation surfaces by TerrainWorks Inc. Given that these flowlines were synthetically derived, it was necessary to undertake a process for validation of both the single line streams and area features such as lakes, ponds and rivers. The majority of features in the synthetic hydrography database were single line streams and the majority of effort in this project was focused on validation of these features. Once the single line streams had been finalized, additional project tasks were focused on adding missing features streams, lakes, ponds and rivers, loading the completed data into the AK Hydro data schema, and then converting the final data to USGS NHD compliant format.

Task 1 - Validation of Elevation Model Derived Linears

SMUMN validated the geometric configuration and spatial accuracy of the single line streams against available datasets for the Mat-Su Basin project area. This review was conducted using traditional image interpretation processes supported by high resolution elevation models and aerial photography that was simultaneously captured during the LiDAR data acquisition. In areas of the project outside of the LiDAR data collection zone, SPOT 5 satellite imagery from the Alaska SDMI program was used as the image source for validating hydrography. Decisions were further supported by IfSAR Orthorectified Radar Imagery, other collateral data sources such as soils, hillshade, existing wetlands, and reconnaissance field work conducted across the study area during the summer of 2014.

In order to ensure that the final hydrography data was structured as a comprehensive geometric network, the single line streams derived from the hydrologically enforced elevation model were run through topological and network flow checks to determine if gaps in the linear work exist. Invalid gaps were addressed by snapping one linear to another and downstream directionality was enforced. In cases where solutions to gaps required consultation, SMUMN made note of the locations and consulted project partners for guidance before making final changes.

In total, following the validation process, there were 171,900 single line streams and nearly 20,000 two dimensional lakes, rivers and ponds in the final Mat-Su Basin spatial dataset. During the editing process, image interpreters were inclusive with editing decisions as opposed to exclusive. That is to say, where decisions were supported by only marginal primary data and limited collateral data, the interpreters tended to include those features in the final product.

Image interpreters also attempted to assign a classification attribute of perennial, intermittent or ephemeral to each single line stream. Where the stream type was indistinct from the imagery or collateral data sources, interpreters defaulted to perennial as the classification.

Task 2 - Capture of Missing 1D and 2D Features

Single line streams that were not created through the hydrography modelling process were identified through image interpretation and field visits. These features were added to the project spatial database as they were encountered.

Since 2D hydrographic features (lakes, ponds and rivers) were not captured by the synthetic network modelling process, interpreters used hydrography breaklines layer from the LiDAR and IfSAR data collection as the starting point. Reshaping and boundary editing were completed as necessary to match configuration to the primary and collateral data. Additional features were added from both the image interpretation process and from field reconnaissance. The AK Hydro established minimum mapping unit (MMU) for 2D hydrographic data was two acres. This was used as guidance for the capture of new lakes and ponds from image interpretation, however, features with smaller dimensions were also captured through the use of LiDAR and IfSAR breaklines.

Task 3 - Load 1D and 2D Hydrography into the AK Hydro Network Data Model

During the scoping phase of this project, researchers consulted with various partners in the Alaska Hydrography Technical Working Group (AHTWG) to establish the appropriate database schema and corresponding editing standards for this work. The AK Hydro data model was adopted as the initial database schema with the intention of migrating data to USGS NHD database format for conflation to The National Map once editing was complete.

As a starting point, an empty replica of the AK Hydro data model was requested at the University of Alaska Southeast. Researchers loaded initial single line streams and two dimensional hydrographic features into this empty database and completed all edits as per the AK Hydro editing standards and project specific decision rules established with the project sponsor. There were several mandatory fields in the AK Hydro data schema that were populated by researchers during the data load and additional attribution regarding stream classification (perennial, intermittent and ephemera) was stored in the database comment field for access during data conversion to NHD. The Nature Conservancy had proposed adding a variety of stream descriptors to the AK Hydro version of this database in order to accommodate future user needs; however, this was not completed during the initial data load and was deferred to a future project.

Task 4 - Inclusion of Anadromous Waters Catalog (AWC) Data

The AK Hydro data schema included an attribute field that may ultimately be used to provide a link from the updated hydrography to the Anadromous Waters Catalog (AWC). This field was maintained in the final dataset for the project study area; however, it was not populated as part of the editing process. Further discussion is required to determine how single line streams and two dimensional waters will be split to accommodate AWC coding changes.

The AWC spatial database was used as a collateral data source during the validation and editing process in order to strengthen decisions about the location and classification of existing hydrography. In all cases, the geometry of hydrographic features was derived from the synthetic flowlines; however, the ANC data was used to guide the image interpreter to locations where streams had been field verified by the AWC program but were only minimally visible on the project imagery.

Task 5 - Initial Preparation of NHD Ready Dataset

Conversion of the AK Hydro database to NHD ready format was handled using the University of Alaska Southeast ETL conversion scripts. This process required review and validation in order to ensure that features were accurately converted and that connectivity of the geometric network was maintained.

Task 6 – Submission of Data to the USGS

It was initially intended that researchers from Saint Mary's University of Minnesota would lead both the update and conflation processes for the data load due to the extent of changes to the original NHD. However, upon further discussion with USGS, it was agreed that conflation of the dataset would be tested to determine the effectiveness of the loading process. Given that researchers did not have a functioning version of the USGS NHD GeoConflation Tool, this testing was assigned to the Alaska NHD Data Steward. The GeoConflation tools were designed to transfer attribute information across datasets while maintaining USGS NHD model integrity.

Conclusions and Recommendations

Initial hydrography flowlines that were modelled from LiDAR and IfSAR derived elevation surfaces for this project by TerrainWorks Inc. proved to be an excellent starting point for NHD updates. For most of the study area terrain, the model accurately depicted surface water flow paths or flowlines. The model did tend to overestimate the number of true single line streams in the study area and feature editing was focused on separating what was real from what was potential. There were a wide variety of terrain types within the project study area and field validation was important for determining where surface hydrography was accurately represented. In addition, there were some specific situations identified where the model extended representation of surface flow beyond the bed and bank of visible stream channels. It is expected that these areas will provide training opportunities to help refine future data processing.

The hydrography update for the Mat-Su Basin resulted in the collection of approximately 172,000 segments of linear stream and 20,000 water bodies. In addition, the final data contained 276 rivers and complex channels represented as polygonal features. This revised and networked dataset contained more than double the number of features than were present in the original NHD database and the mapping accuracy was improved to a level equivalent with the National Map Accuracy Standard for 1:24,000 scale spatial data. The entire costs of the project, including the initial development of the synthetic hydrography and all aspects of validation, amounted to approximately $10.00 per square mile; a cost that is approximately three times less expensive than initial estimates. This mapping methodology represents a cost effective approach for undertaking further NHD updates across the state. However, as with this project, partnerships between federal state and local agencies are essential for future success.

The data and techniques examined in this project support these additional observations and conclusions:

1. Wetlands were an important component of the surface hydrography for this project area. Future projects should consider the incorporation of accurate wetland boundaries into the hydrography layer in order to establish hydrographic connections that are currently absent in the dataset. Wetlands provided information on points of initiation for stream flow and basins and flats that were available for inline water storage.

2. The degree of update and densification achieved by utilizing modelled hydrography as a starting point for this project was significant. It would not have been possible to traditionally photo interpret the same level of detail and accuracy within the same time frame and budget using a heads-up data capture process. Having said that, it was also critical to recognize that an interpretive component, supported by field validation and collateral datasets was essential on this project in order to accurately identify valid hydrography.

3. The tools and elevation models had a more difficult time maintaining direction and accuracy in flat surface areas.

Figure 15: Derived linear (blue line) in flat area has jumped the bank. Original NHD (orange line)

4. This was far less the case in elevated areas, but even in those areas linears would “jump the banks” and run off in incorrect directions.

5. Linears could be found going over hills or uphill direction. Flow cannot go uphill.

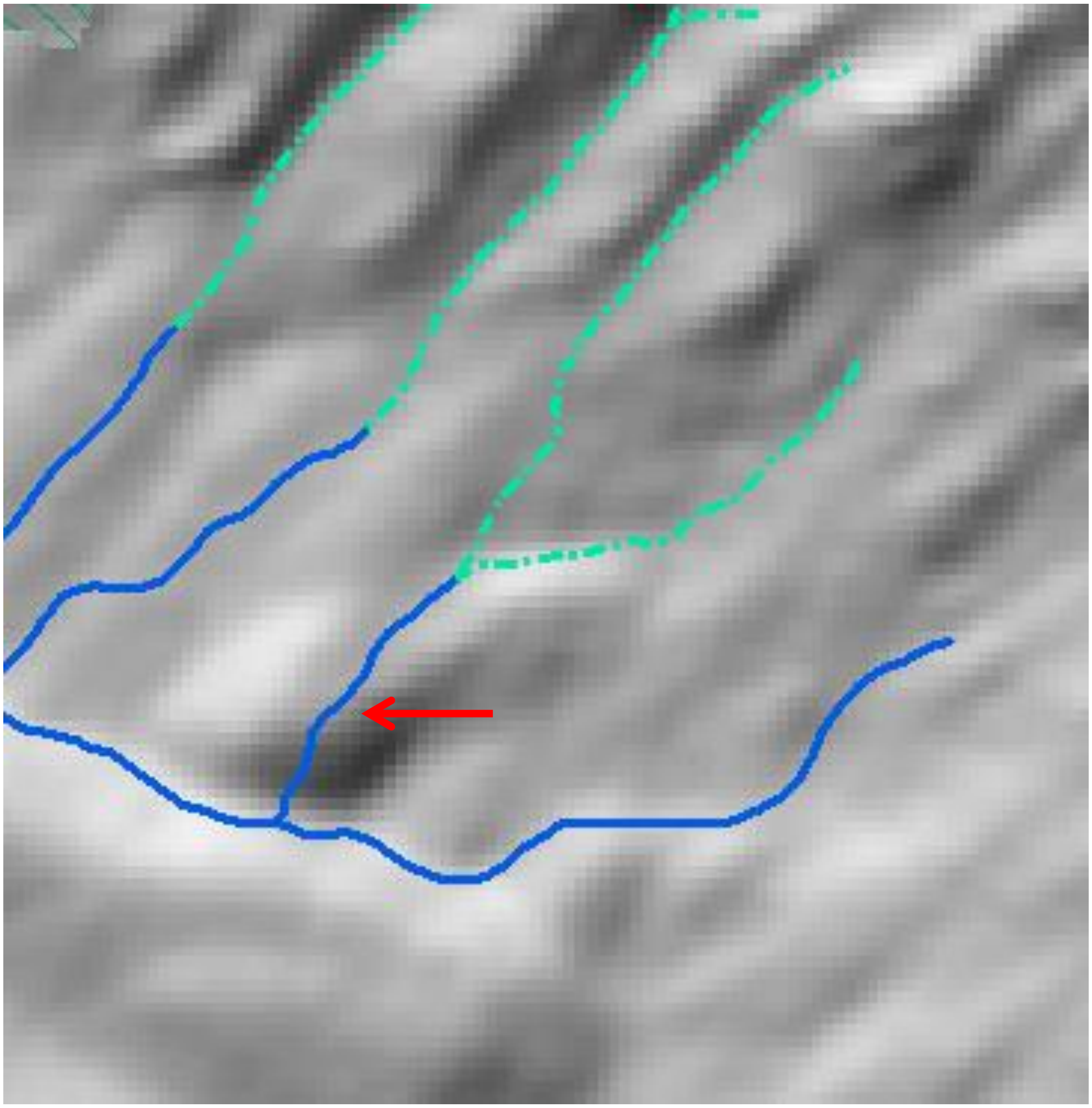


Figure 16. Small hill shown on hillshade

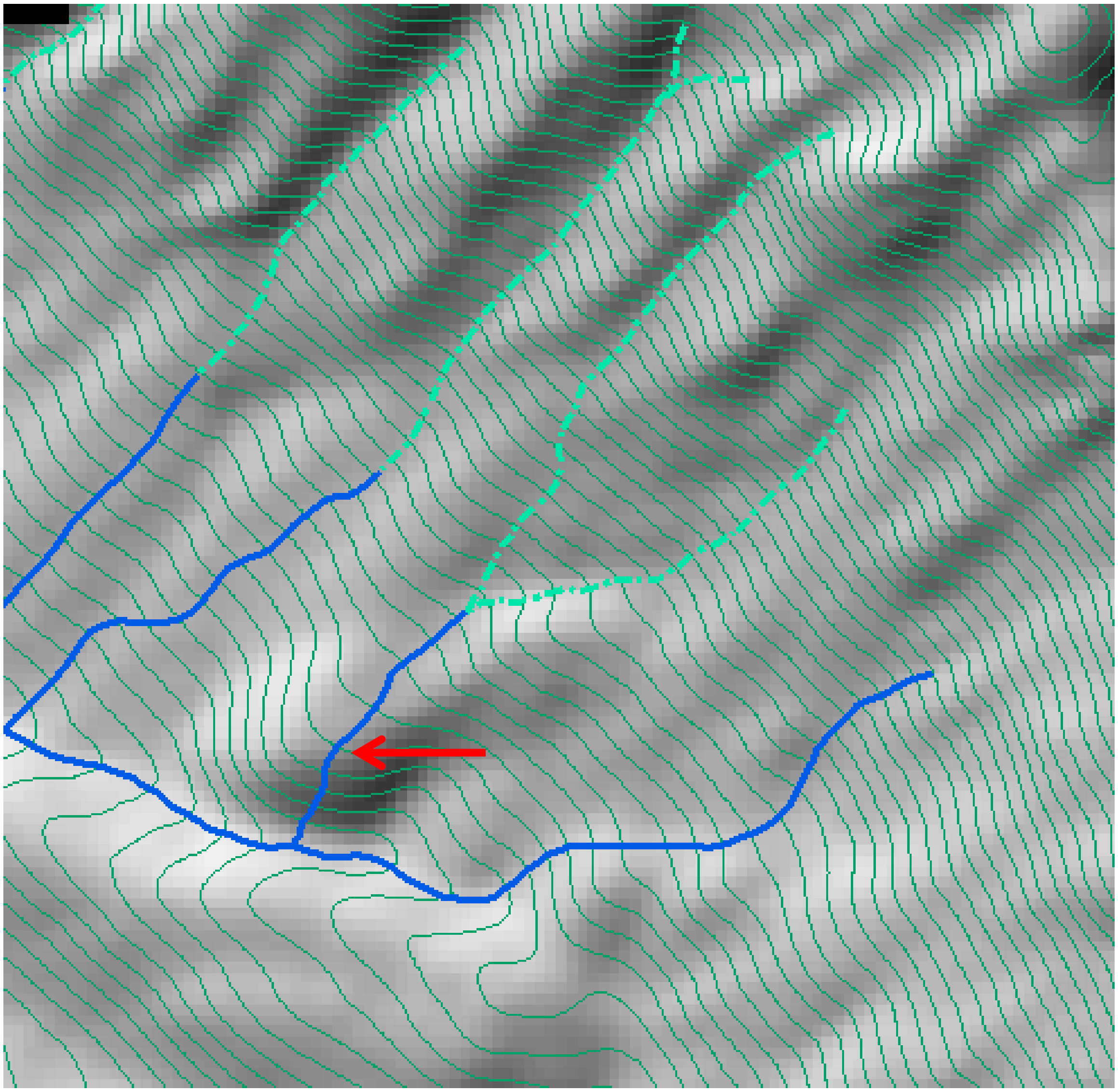


Figure 17. Small hill shown on contours

6. Some significant linears were missing in the synthetic network and needed to be added. In many cases, the stream was seen on the ORI, but no linear was found representing it in the synthetic network.

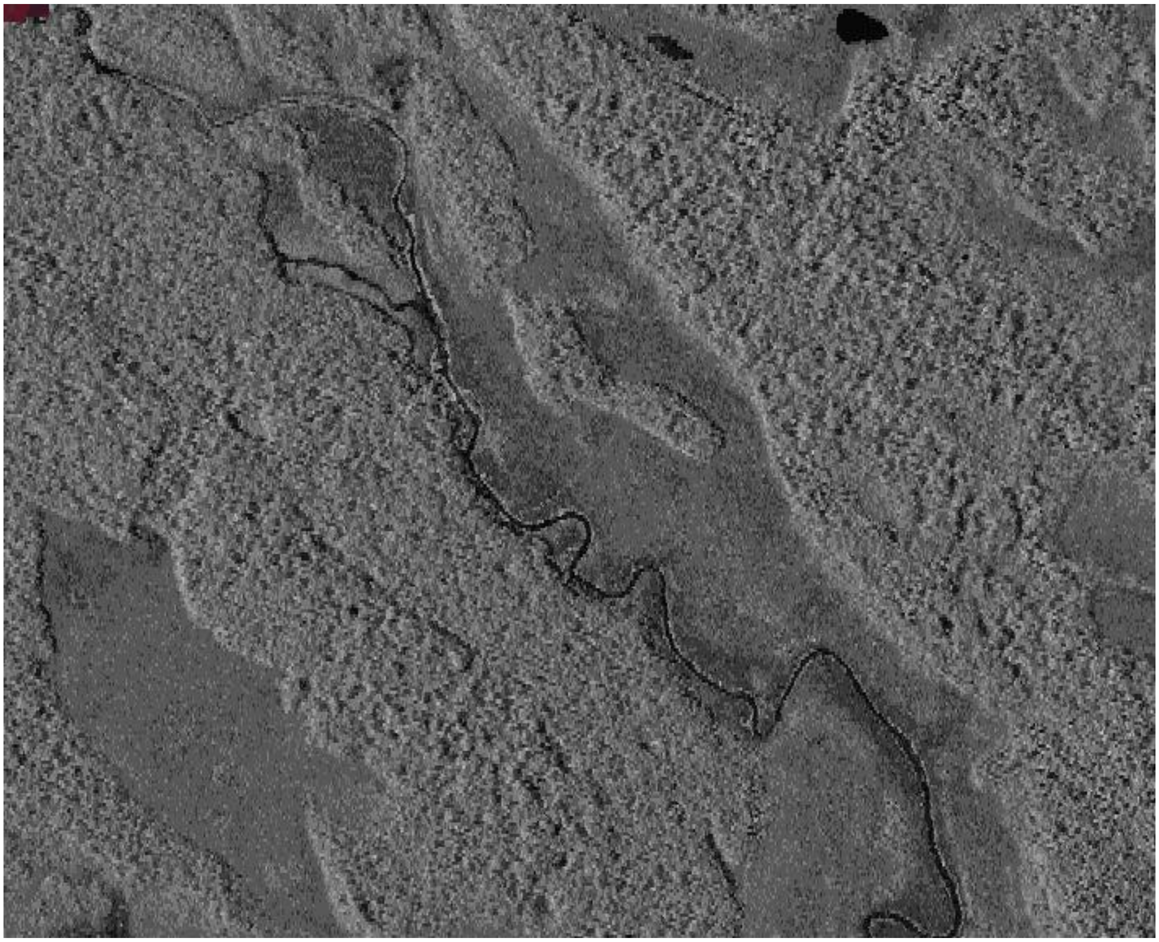


Figure 18: Small stream missing from derived synthetic network

7. There were many times when the derived synthetic network followed true flow whereas historic NHD was well off the correct location for the stream flow. Historic NHD was only used as a guide.

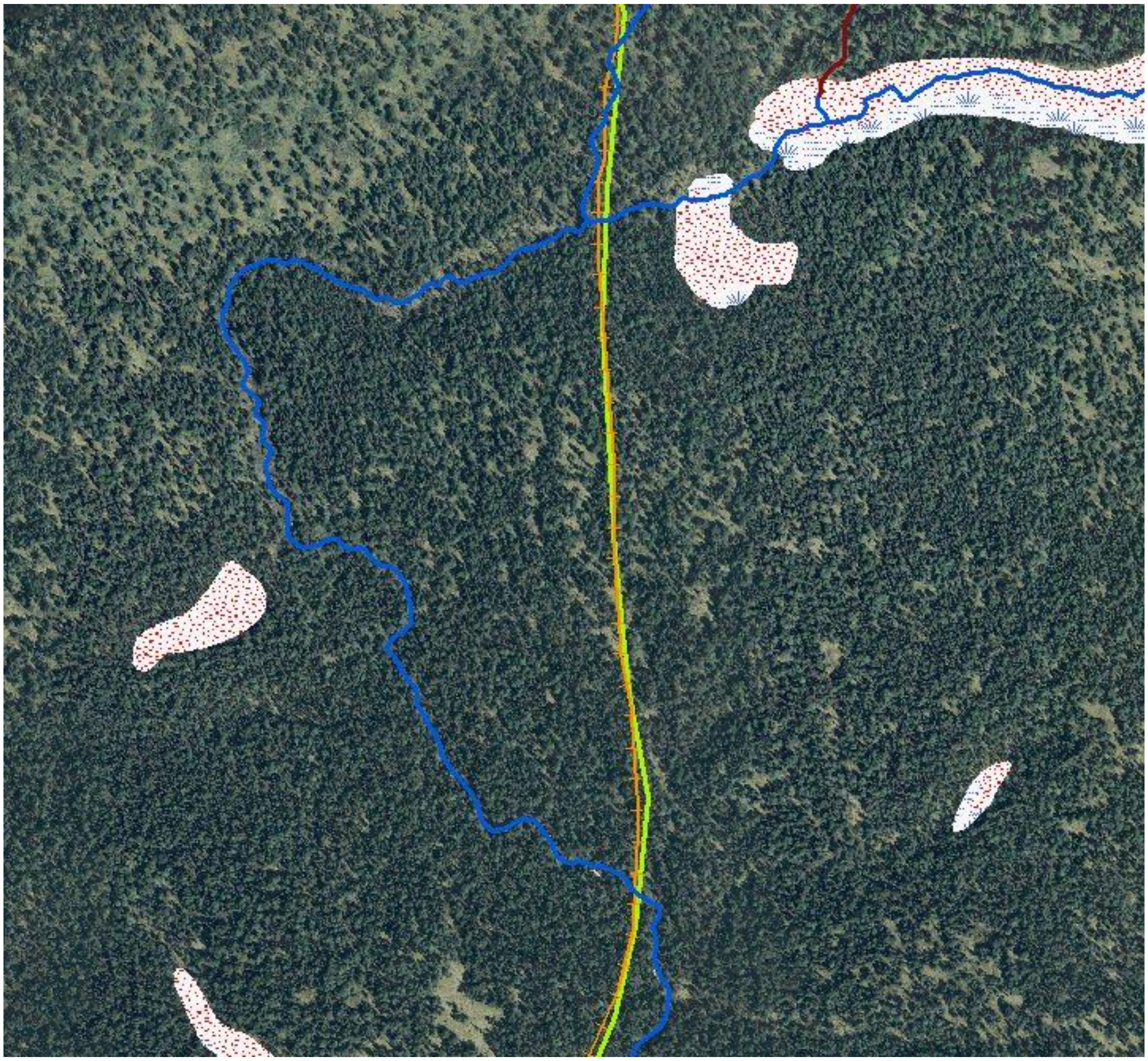


Figure 19: Correct flow path is derived linear (blue line)

8. The classification of hydrography into perennial, intermittent and ephemeral categories was difficult to determine from the project imagery and collateral data. Researchers ended up making some broad determinations (e.g. defaulting to perennial flow unless there was proof to classify as intermittent).

9. It was important to have a decision rule in the editing process to handle disconnected streams. In portions of the study area, there were perennial streams that flowed into wetlands, had no defined channel for significant stretches, and then re-emerged. In these areas, editors created logical connectors between the defined stream channels in order to provide consistency within the geometric network and for habitat representation.

10. Derived features, by means of their creation, had an excessive numbers of vertices which caused issues with editing, slowed zooming speeds, and interfered with ingestion into The National Map. It was necessary to conduct a simplification process to remove many of these vertices prior to starting the edit process. Attention must be made to tolerances to ensure that the removal of vertices did not negatively affect the shape and alignment of the final features.

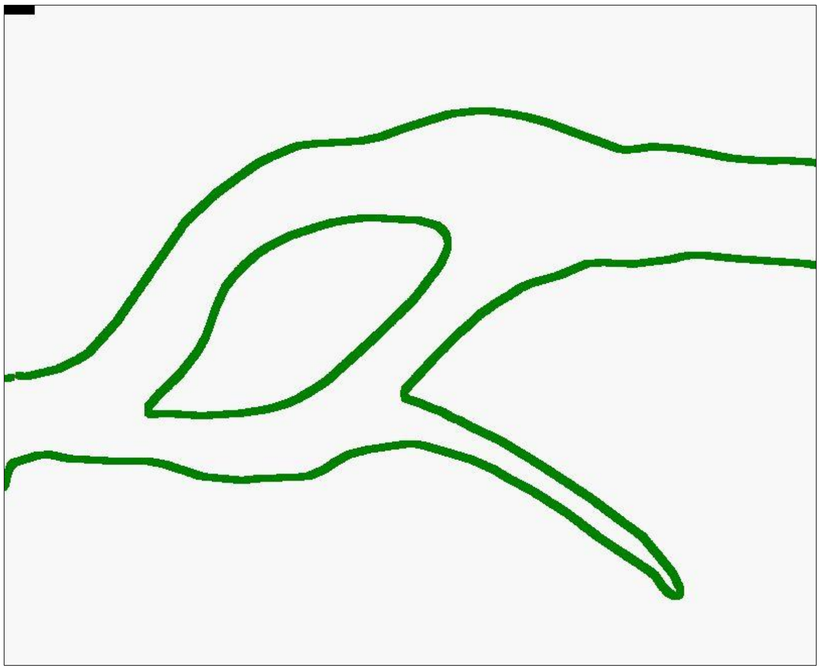


Figure 20: Excessive vertices on 2D stream

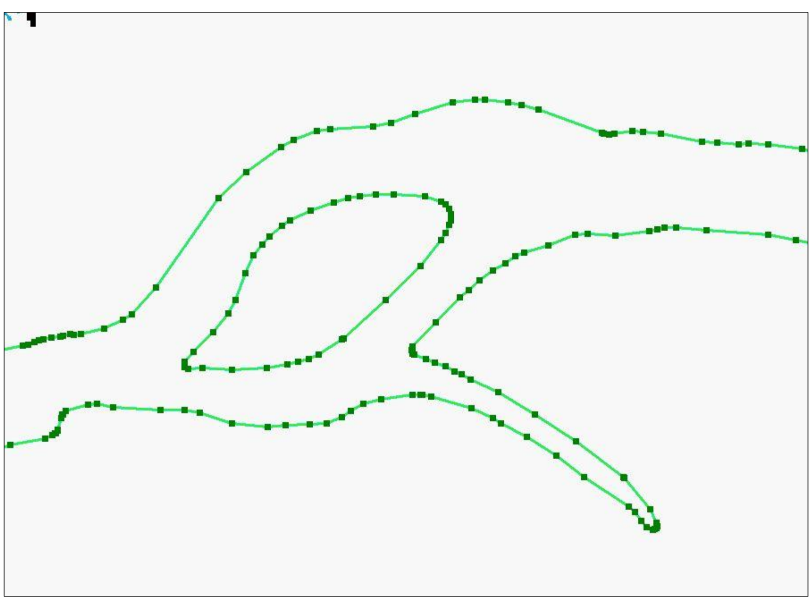


Figure 21: After processing through simplification tool

11. In some cases where there were many parts of a 2D feature that did not contain a large amount of vertices. The simplification process did not have a negative effect on these areas when using the predetermined tolerance.

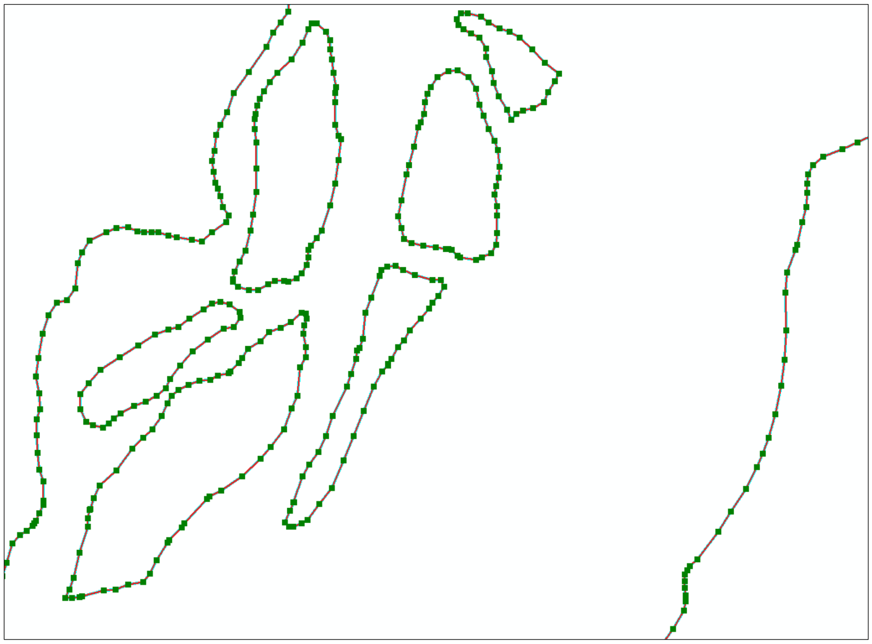


Figure 22: Non excessive vertices prior to simplification

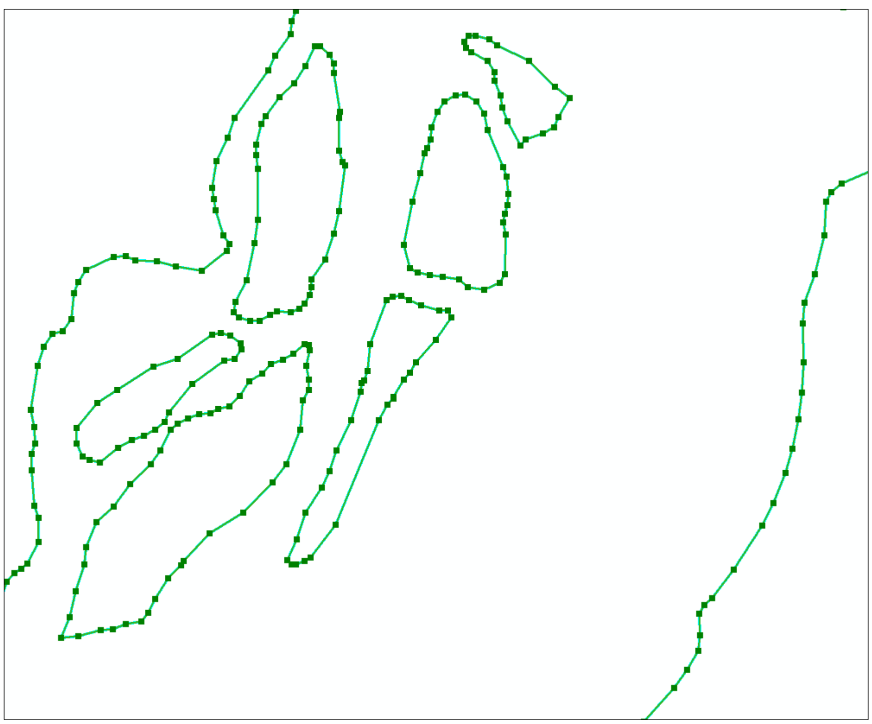


Figure 23: After processing through simplification tool

12. If smoothing was planned for features, researchers needed to make certain that a smooth tool was used that did not create features that had Bezier curves.

13. The ESRI freehand construction tool was never used to create features as those had Bezier curve geometry which was invalid in the NHD data model.

14. The derived synthetic network came with the linears segmented into numerous small parts. It was necessary to merge them together and explode to generate longer individual segments that could be edited more easily.

15. Preliminary classification was done for the intermittent linears based on slope. All other linears were left as NULL. At the end of the visual editing/validation process intermittent linears were selected, the selection was switched to select all linears not intermittent, and those selected linears clipped with the 2D boundaries. All linears within the 2D boundaries were called artificial paths and all those linears outside the 2D boundaries that were not intermittent, were called perennial. This approach of only having to classify the intermittent during the editing process saved time.

16. Hydro breaklines created from the elevation models were advantageous to use for the lake/ponds, 2D streams, and areas of complex channels; however, the derived linear did not necessarily follow a main channel and sometimes ran outside of 2D feature. Reshaping was required to ensure the linear was within the 2D feature as an artificial path.

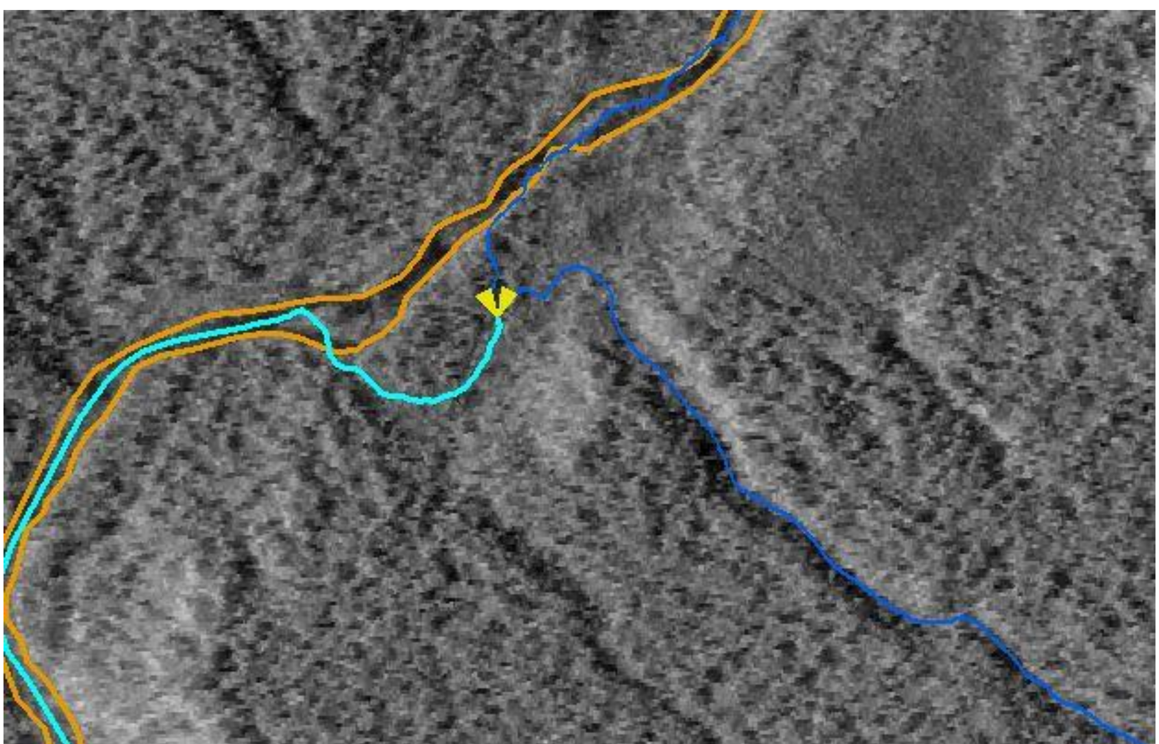


Figure 24: Derived linear (blue line) outside 2D stream (orange polygon)

17. Some valid linears crossed watershed boundaries. In flat regions the linears were not drawn over the watershed boundary unless there was an AWC linear present. In these cases the new linear was allowed to go over the boundary to comply with the AWC.

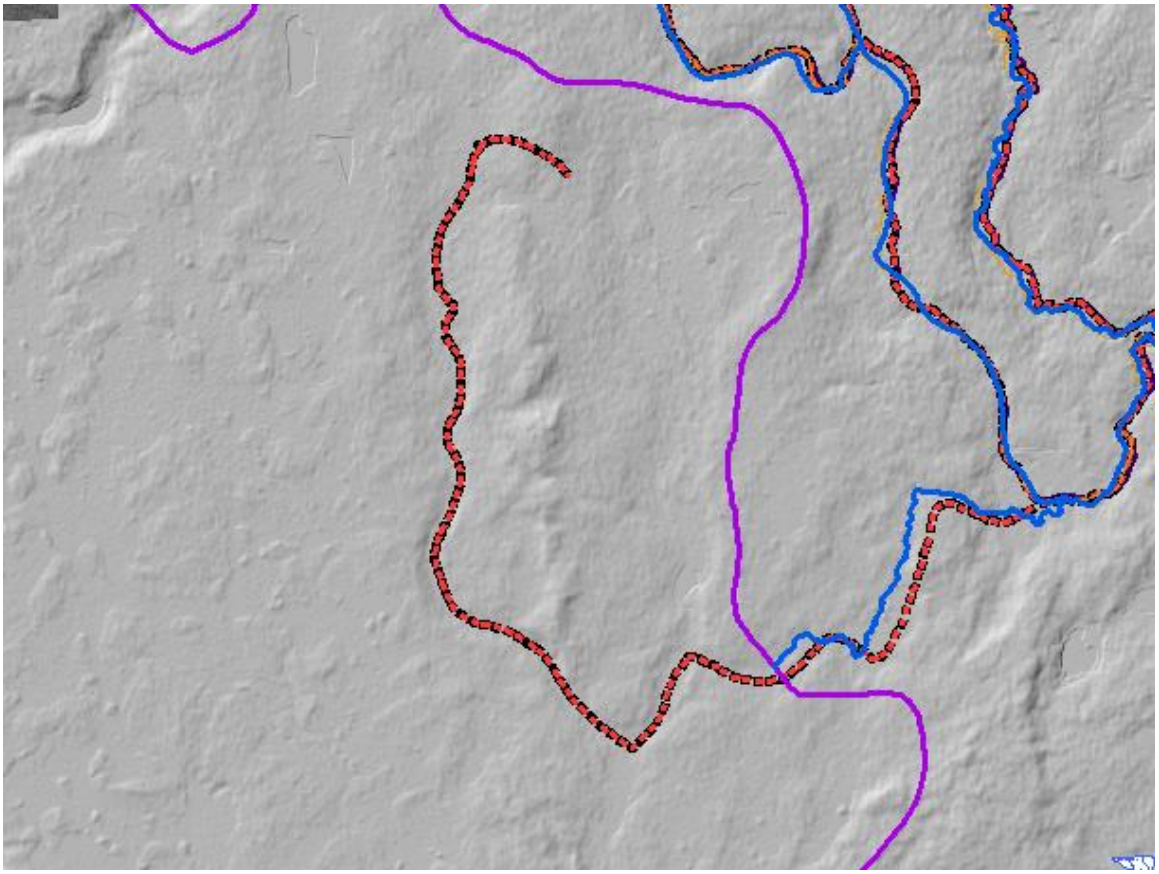


Figure 25: AWC (red dashed line) linear crossing watershed boundary (purple line)

18. In some instances the linears within 2D features contained “noise”. These required mostly deleting the erroneous linears and reshaping the main network linears going through the 2D feature.

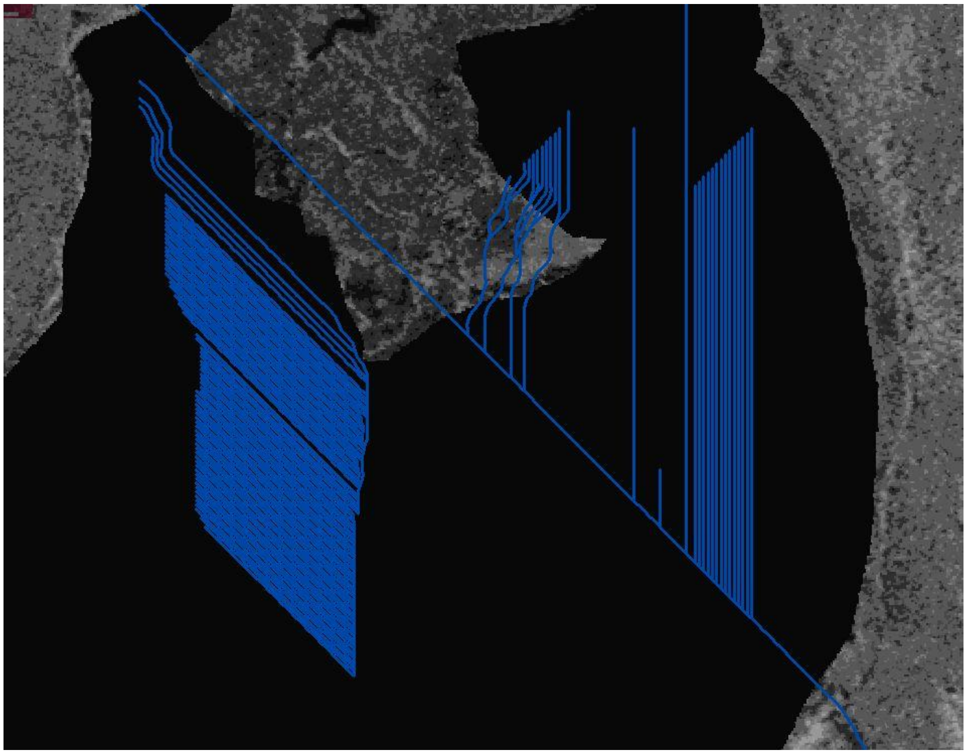


Figure 26: Linear segment “noise” within a 2D lake

Figure 27: Noise within a 2D stream

19. The culvert layer features were not always in the correct location.

Figure 28: Culvert (green point) is not in correct location

20. The channel gradient attributes were contained in the derived synthetic layer and were a useful resource to help determine stream flow characteristics.

21. Stream order was calculated within ESRI's ArcMap and was then used to scale the NHD data to the user's needs.

Future mapping activities should focus on refinement of the methods outlined in this report as well as migration of updated NHD datasets to the NHDPlus data model. The Environmental Protection Agency, under the auspices of the Clean Water Act, mandates that States maintain water quality monitoring and mitigation protocols. NHDPlus is a vital dataset used to address water quality reporting and to support additional management efforts. One of the requirements for NHDPlus is updated and accurate hydrography. Alaska is proceeding in this effort with NHD update projects that focus on updating, densifying, and classifying of 1:24,000 scale hydrography. An updated hydrography dataset lends itself to a variety of user needs; such as, hydrologic modeling, flood plain inundation modeling, stream habitat classification, stream functional assessment, fish habitat mapping, community planning and water management.

Appendix A: Field Validation Summary

Field Trip Summary Report for Verification of Derived Flow Network
Matanuska Susitna Watershed Hydrography
Mat-Su Watershed
July 13th to 18th, 2014

Purpose

The week of July 14-18 SMU was in Alaska conducting fieldwork with the Palmer Soil and Water Conservation District personnel. We split our efforts to examine areas of high terrain, flat wetlands, and urbanization to get an understanding of the terrain and the validity of the flow network. Although the main focus at this point is the Goose Bay watershed, field work was conducted in a variety of locations. The team also had the opportunity to do some helicopter work. This trip originated from Talkeetna airport. Field sites were entered in the GPS to navigate from site to site. While in the field SMUMN used maps to document what was occurring at the field sites.

Field Verification Team

Jim DePasquale – Spatial Ecologist, The Nature Conservancy, Anchorage Alaska Field Office
Dave Iansen – Environmental Program Specialist, Palmer Soil and Water Conservation District
Gooseberry Peter – Natural Resources Technician, Palmer Soil and Water Conservation District
Louisa Branchflower – GIS Technician, Palmer Soils and Water Conservation District
Andy Robertson– Administrative Lead, GeoSpatial Services, SMUMN
Jeff Knopf – Project Manager, GeoSpatial Services, SMUMN

Methods

The field-verification process involved three stages; check-site selection, in-field verification, and post-trip documentation.

Check-site Selection:

Digital orthomosaic's (1 foot pixel resolution) based on aerial photography acquired in 2011 by AeroMetric, Inc. were reviewed for check site locations. A point shapefile was created in ArcMap 10.2 identifying the location of interested.

Check sites were collected in advance for areas that posed questions as to the validity of the flowlines and compared to collateral data sources. Digital elevation models, hillshade, contours, Palmer Soil and Water Conservation District centerlines, AWC data from Alaska Fish and Game, National Wetland Inventory data, and soils were examined to formulate the questions and better understand the contribution each would provide to making calls on the flowlines.

Field verification points were located at those locations where imagery signatures indicated that flowlines were most likely not valid. Further investigation with collateral data aided in the determination to establish a check site.

Other field check points were selected to give the field crew a better understanding of the terrain. The watershed encompasses flat wetland, urban, and elevated mountainous terrain.
190 field sites were pre-selected based on the above criteria. Hard-copy maps were created for each check site. Each map included the base imagery with the flowlines at a scale of 1:10,000 for the main map. The two inset maps included the flowlines and contours at scales of 1:15,000 and flowlines and soils at a scale of 1:20,000.

Field check sites for the helicopter work had been forwarded to Jim DePasquale, Spatial Ecologist, The Nature Conservancy, in both shapefile and GPS format so the pilot could have the opportunity to load them into the helicopter GPS. Helicopter field work was conducted Monday morning of July 14, 2014.

An in-person meeting was held at the Palmer Soil and Water Conservation District office in the afternoon of July 14. Louisa Branchflower, GIS Technician, Palmer Soil and Water Conservation District, complied the field check sites SMUMN forwarded to PSWCD, prior to arriving in Alaska, into logical groupings for each day of fieldwork. Field work logistics for each day were planned and the PSWCD personnel determined who would be going out into the field on which days. The primary field work team consisted of Dave Iansen , Environmental Program Specialist, Palmer Soil and Water Conservation District and Gooseberry Peter, Natural Resources Technician, Palmer Soil and Water Conservation District.

Field maps and GPS were used during all the trips. A laptop computer running a ArcMap 10.2 project was used each day. The ArcMap project contained all the base and collateral datasets. Sites and routes were recorded by GPS directly into the ArcMap project.

Field Verification:

The field work consisted of navigating to each field check site and investigating what the model was deriving. If addition questions arose, further field investigation continued up and down stream of the check site to gain further understanding. In many cases the team stopped along roads to investigate what was occurring regardless if there was a specific field check site at that location.

Appendix B: Editing Protocols

Flats/urban area

1. Look at derived linears
2. Check elevation models for crenulation
3. Can you see water in the base imagery
4. Consult collateral datasets
    a. Hillshade – LiDAR and IfSAR
    b. DEM- LiDAR and IfSAR
    c. Contours – Flow direction, slope
    d. Possible flow dataset
    e. High resolution Imagery
    f. ORI
    g. SPOT
    h. NWI wetalnds – Cannot always see a defined channel, but wetlands provide a water source and seepage.
    i. Gracz wetlands
    j. Glaciers
    k. AWC 2013 Linears
    l. PSWCD Center lines
    m. Other flowlines from previous field work
    n. Mat-Su Borough Hydro - msbhydrol_MatSu
    o. USGS NHD
    p. DNR Hydro
    q. Soils
    r. Culverts layer
    s. SLOPE model
    t. Lakes and Streams
    u. DRG
5. Has urban change transformed landscape so it is not possible to flow
6. Did the model jump the bank or follow wrong path
7. Look up and down stream and get a feel for what is happening hydrologically
8. Is there a source – Pond/Lake, wetlands, glacier, snow

Attributing – There has been a preliminary process done to locate and attribute intermittent (int) streams. Take a look at these as they are based only on slope values and no vegetation was examined, but attribution has been accurate.

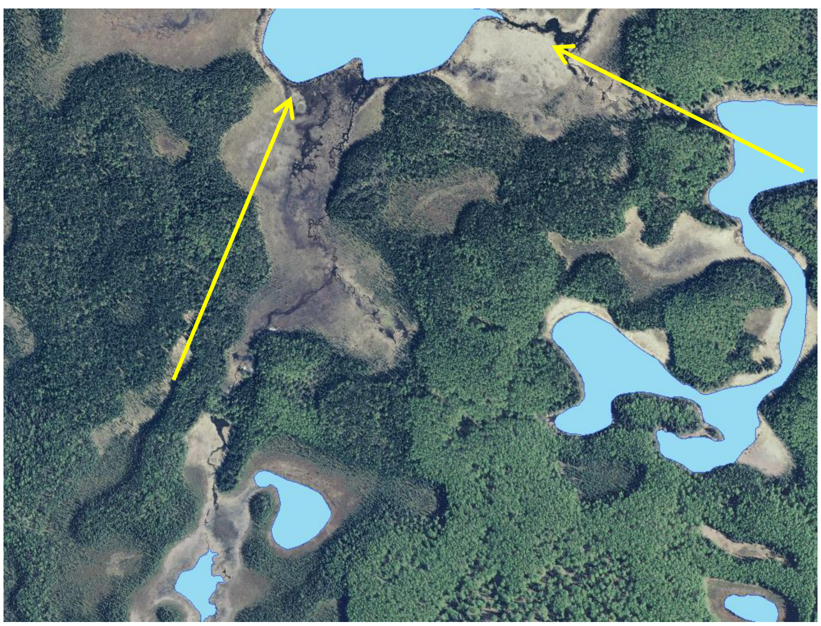
Assume that a linear is perennial until proven to be intermittent. Establish a reason behind the decision for intermittent. In some cases in the lower urban area landscape change has made it so there is no longer flow.   Wetlands have been dried or drained. Can still be perennial as natural wetlands come back. It might be a dry season (s) or dry time of the year. Base high resolution imagery was acquired June 2011. The SPOT can vary over different years and months.

The most reliable historic NHD layer is the msbhydrol_MatSu hydro layer. However, examine all relevant collateral. The AWC is a critical layer to make sure it is represented in the new data.

Each linear will have a green from vertex and a red to vertex. Flow goes from the green to the red vertex. Make sure that you delineate flow in the correct direction. If you run the linear from the main network up stream -   **You MUST "flip" the flow if you delineate upstream.** Water cannot flow uphill.

TNC wants to put more emphasis on the DEM and derived flowlines, however, there are areas where you can see that the model has done something strange and the flowline does not even conform to the hillshade. These can be fixed with reshaping. This occurrence is what is called "jumping the bank".

Lakes and ponds can be isolated, but are a good source for water (point of initiation). Look around them and with the collateral data see if there is outflow to the main network.



We have field work notes to aid in decisions. At times Google Earth can assist with some pseudo-field checks.

Disconnected Arc Fixes - Disconnected arcs are not allowed. There are a couple of ways to resolve them

1. Connector – This will be used where a connection is needed that goes through urban, along roads, parking lots. It is not showing flow through natural features.
2. Ephemeral – This will be used where there is natural features along the path of the connection, wetlands, forests, prairie, farm fields.

Culverts Point Layer – Culverts layers are not comprehensive

Culvert point not in dataset. Scale is 1:1500

Culvert can be seen from scale of 1:800

Higher elevation flowlines as Perennial or Intermittent

From the helicopter/field work it is best to assume all is perennial unless it can be proven intermittent. Ephemeral streams being limited in time of flow to a few hours to days does not appear to apply in these areas. Seasonal snow melt would be a contributing water source for a longer period of time than that.

1. DEM Hillshade – The hillshade can be helpful in showing a path of flow. Crenulation can be used to determine if it is intermittent or should be deleted. High elevation/slope flowlines that follow a defined crenulation and adhere to the other criteria can be intermittent. If it just sheet flow and not crenulation then remove the linear. Also determine if the short ones are valid. Do they really contribute the overall network of flow? If not delete them. Also look at the amount of intermittent contributing to the flow, are they needed or valid of just extra linears. In most cases the straightest/longest intermittent linear flowing to the main is the worthwhile one and the secondary flow can be removed.

2. Imagery – Look at the vegetation structure. At the higher elevations the vegetation will be sparse or brown/gray in color or nonexistent (Intermittent). For example, not as lush due to a lack of water source. In those areas with green, strong vegetation there is water (Perennial). **NOTE:** In those tall vegetation areas (tall trees) call the flowline perennial due to strength of vegetation. The helicopter field work showed many of these to be flowing and were only seen when right on top of them in a low flying helicopter. Better to be all perennial than a mixture of perennial and connector or intermittent. Look for wetness in the crenulation.

3. Slope – Use the slope layer to determine slope. Where there is a high degree of slope those flowlines on the high degree of slope will drain water faster and therefore water does not stay. Where the slope decreases the water can stand longer and in many cases the water is visible on the imagery. **NOTE:** when following the stream at times there will be visual breaks in the stream. In these areas still call it perennial as they most likely are flowing with average precipitation. This too is better than a series of splitting the flowline into perennial and connector along its path. We also **don't** want to have intermittent, perennial, intermittent, perennial along a linear. The upper most part will likely be intermittent, but then you can go to perennial as you move down slope. Not the other way around.

4. Contours – Contour lines can be used to help determine if a linear is intermittent or if it should be deleted. They also identify flow direction. Contours can identify possible flow when vegetation obscures the imagery.

5. Historic NHD layers - Examine these for assistance

6. NWI – Where available wetland data is useful in determining moisture and initiation.

7. Turn on Glaciers to verify if there are any in your watershed – We do not reshape or delineate glaciers.

8. It is best to keep Stream PL and Lake PL on while editing to ensure that linears flow through them.

9. Linears above glaciers - Linears above glaciers that are on rock and high slope are most often intermittent. Where there is clear crenulation it can be kept and called intermittent. When there is vegetation it can be used to determine if it is perennial, but in most cases they contribute little to the flow out of the glacier and are intermittent. If there is no crenulation or vegetation, delete out the linear. Refer to the original NHD to see if there are linears that need to be left in, we want to try and default to the historic NHD as it is a good base of knowledge. Also, clean up the flow lines through the glaciers. Linears through them can be reduced to one or two main flowlines to maintain the connectivity to the main network.

10. Attributing – There has been a preliminary process done to locate and attribute intermittent (int) streams. Take a look at these as they are based only on slope values and no vegetation was examined, but attribution has been accurate.

NOTES: Be on the lookout for wetlands that contribute flow to the network. Glaciers, snow, high altitude lakes and ponds are good points of initiation. Not all are though! There are isolated lakes and ponds. Look for features contributing water to the system.

Areas of complex channels – Map only the level 1 and 2 streams (channels). No need to map all the smaller ones because the area of complex channels polygon is there to reflect a large amount of tributaries flowing through the area

Original NHD – The most accurate historic NHD is the msbhydrol_MatSu layer. However, still use the other datasets as they too have information to be gained from them.

Appendix C: Quality Assessment / Quality Control

QAQC Checks

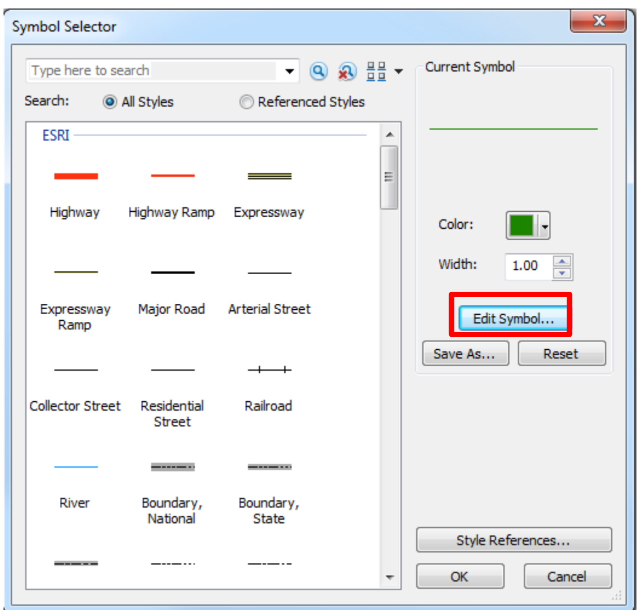
All these QAQC checks are intended to be done in the AK Hydro schema as the last checks before a deliverable product (HUC8) is ready. It is advantageous to be mindful of the flow direction while you are doing the initial editing. **TIP**: with the exception of the Data Reviewer Checks, do these QC checks on each HUC10. HUC10's are more manageable and can save time on the HUC8 checks

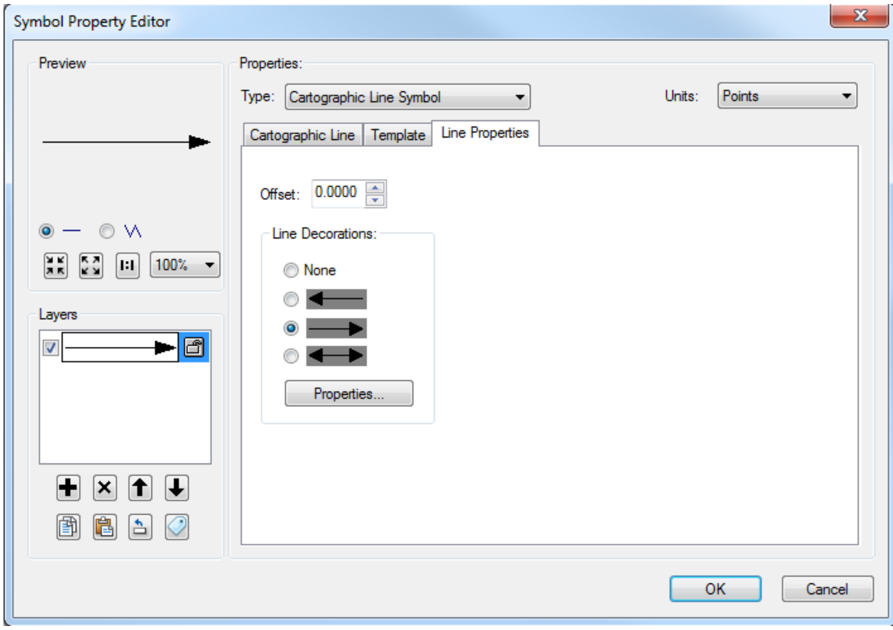
Complete a visual inspection of the data

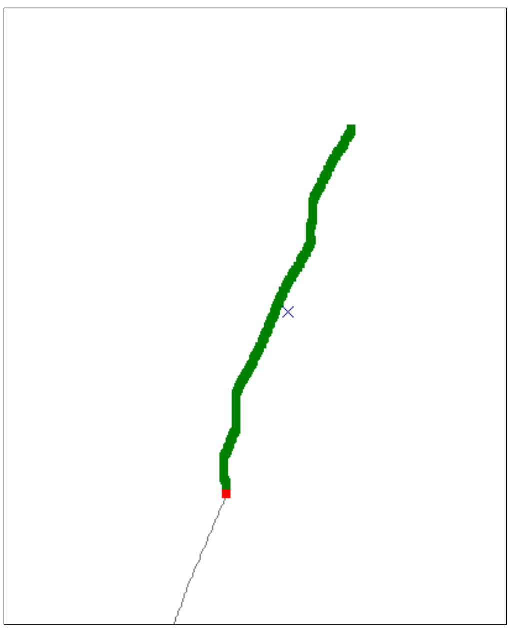
Explode all the linears and polygons

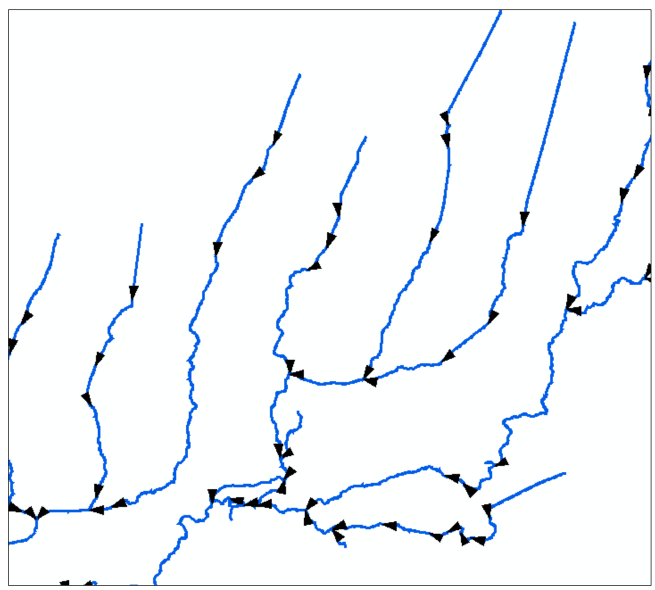
Verify Flow Direction as part of the visual checks

As this is a hydro network the linears must flow in a logical/natural direction, (ie. Not uphill). If you have not done this already while editing the linears, put arrows on the linear symbology showing direction of flow (FROM green vertex TO red). Make sure to *FLIP* the linear direction for those that need it before moving on to next QAQC checks. NOTE: Always add linears in the direction of flow.

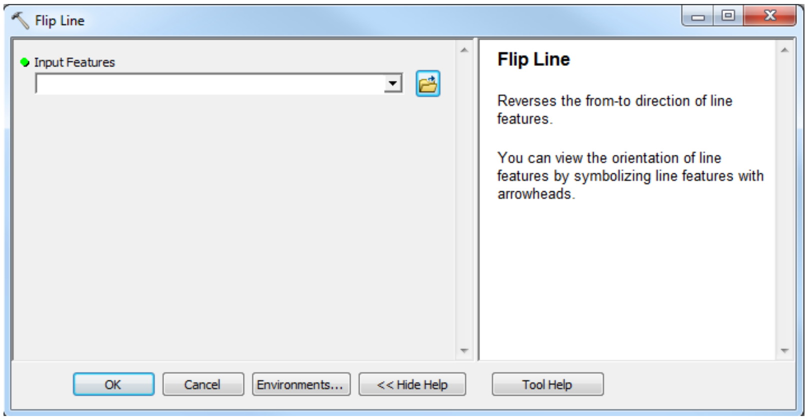


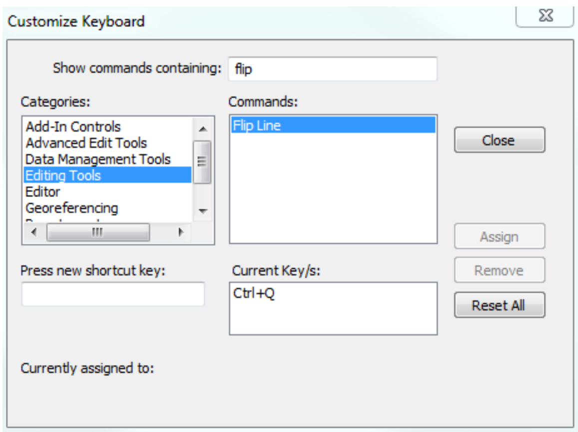






FLIP – There are two wasy to do this. One is to edit vertices, right click on the vertices, FLIP. The other is to use the FLIP Line tool. The FLIP Line tool allows for many lines to be flipped at once.





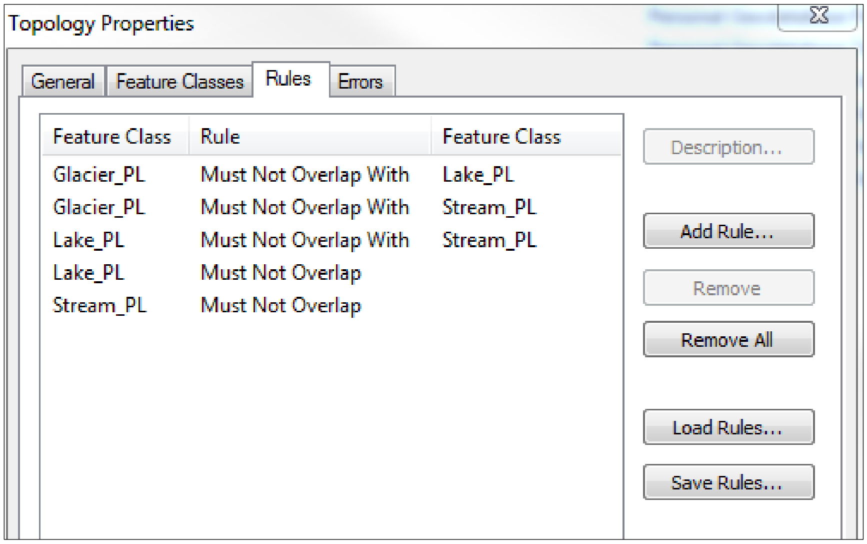
Shape_Length Check

Linears must be at least 4 meters in length. Anything less needs to be fixed

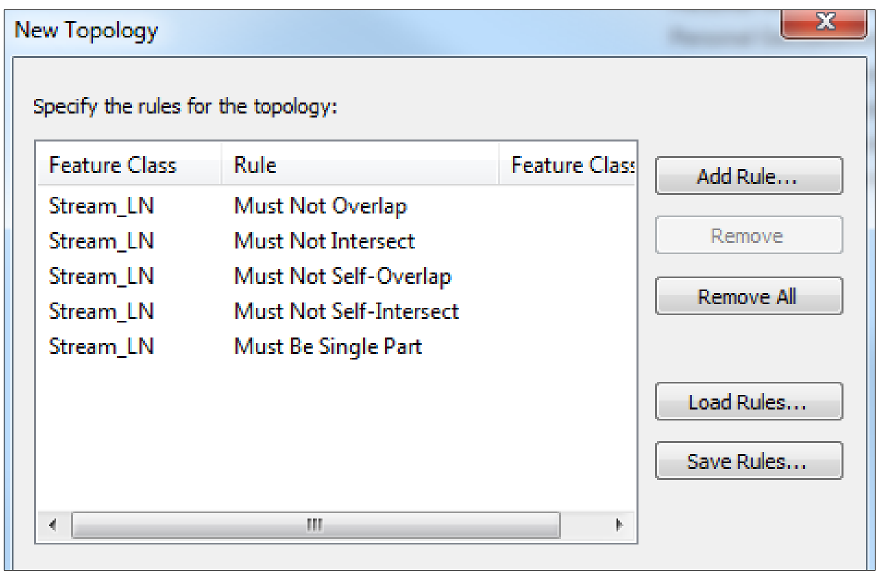
TIP: You can select by attribute in the table, merge all the same features (e.g. perennial), then explode. This will help to eliminate small linears.

1. Make sure to Explode Linears
2. Sort Shape_Length assending
3. Address any linears that are less than 4 meters

Polygons Topology



Linears Topology

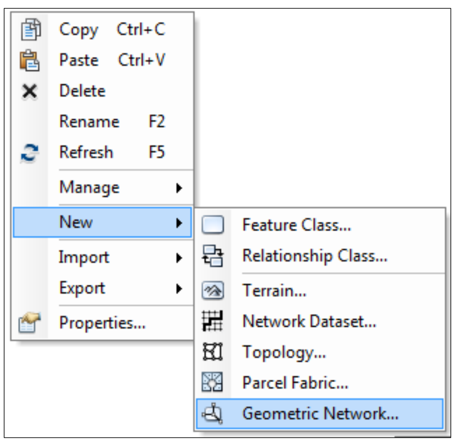


Data Reviewer Orphan Line Check

1. Create topology for the linears – Must Not Have Dangles
2. Add the topology layer to ArcMap like you would to run topology
3. No need to edit or run topology
4. In the Data Reviewer Tool - Topology Checks –Orphan Check
5. Select Always Run on Full Database
6. Click OK
7. Click the Run Data Check button
8. Validate for Full Database
9. When done running, the tool will display a window noting the number of errors found

Network Check –Create Geometric Network

Once the above are fixed you can check network issues. You must build a geometric network first



Load the xxxx_Hydro_Net network feature into ArcMap.

** If you get network build errors they will be identified in a table and they need to be fixed before proceeding. They are identified in ESRI Network Build Errors Table (ie. xxxx_Hydro_Net_BUILDERR). You will need to search by ObjectID to find the ones listed in the Errors Table

Repairing SEAK Hydro Network Directionality

This tool is needed as after each edit to the network you will need to re-establish directionality. The instructions below describe the process developed and used by SEAK Hydro Technical Stewards to repair the network functionality on SEAK Hydro any time replication or synchronization occurs.

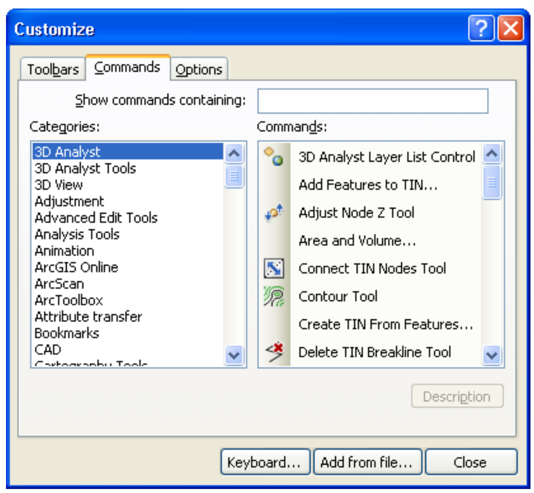
Install AK Hydro Tools

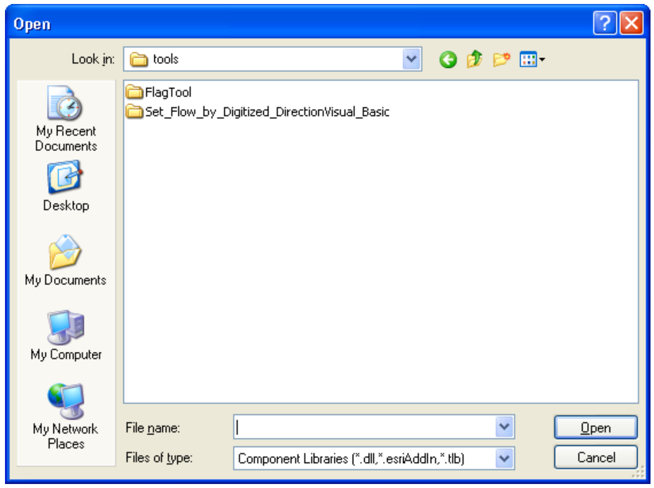
1. If needed download the SEAK Hydro geometric network tools and save locally - http://seakgis.alaska.edu/gis_library/CheckOutTemplate/SeakHydroNetworkTools.zip

2. Unzip and save the files on the local PC, then open a new instance of ArcMap.

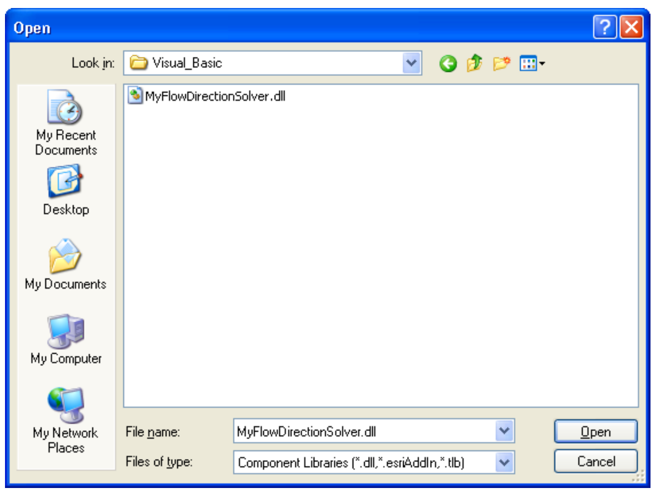
3. Within ArcMap, right-click in the gray area and select Customize, OR select the Customize menu > Toolbars > Customize.

4. Within the Customize window, select the Commands tab and click "Add from file".

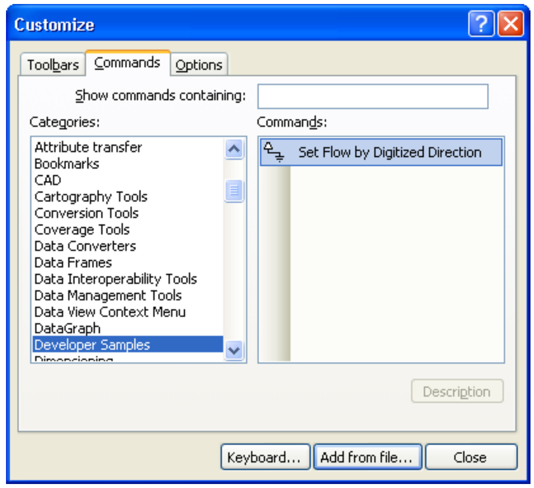




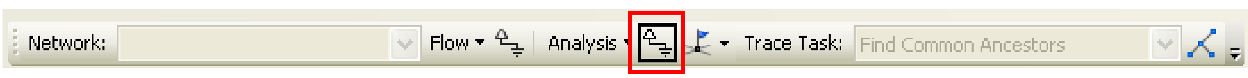
5. Navigate to the file titled "MyFlowDirectionSolver.dll" within the directory you just unzipped and saved at ...\tools\Set_Flow_by_Digitized_DirectionVisual_Basic\Visual_Basic. Selec the file and click Open.



6. Click OK and the tool is added to the Developer Samples toolset in the Commands tab of the Customize window.

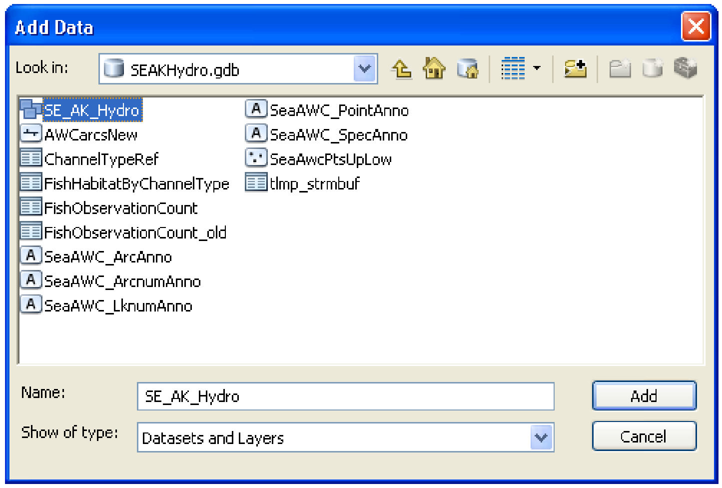


7. Drag and drop the "Set Flow by Digitized Direction" tool onto an existing commonly used toolbar in ArcMap. The tool is shown highlighted on the Utility Network Analyst toolbar below.

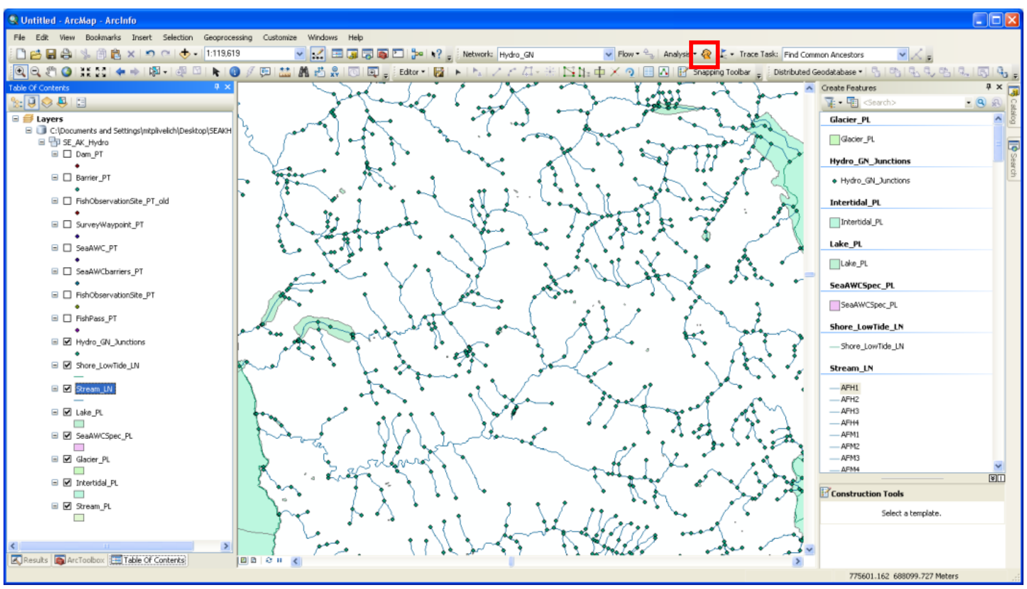


8. Because the tool by default uses a commonly used arrow symbol within ArcMap, it is recommeded users change the image to a unique symbol so it is easy to distinquish for future use. This is done by right-clicking the tool (while the Customize window is still open) > selecting Change Button Image > and selecting a different symbol. This type of change is shown with a dog like symbol below (which by the way is useful since its easily differentiated).

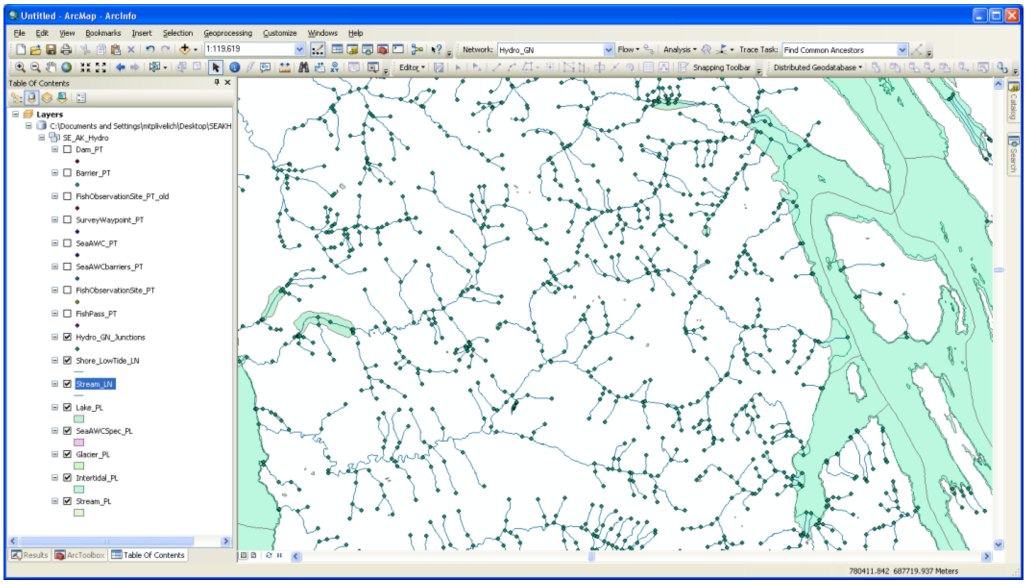
9. Close the Customize window and add the SE_AK_Hydro feature dataset from the local SEAK Hydro database that requires its network directionality to be reset.



10. Start an edit session in ArcMap. If the network directionality needs to be reset, the newly added "Set Flow by Digitized Direction" tool will be highlighted/available on the toolbar to which it was added as shown below. If the directionality is intact from its previous state then the tool will be unavailable.



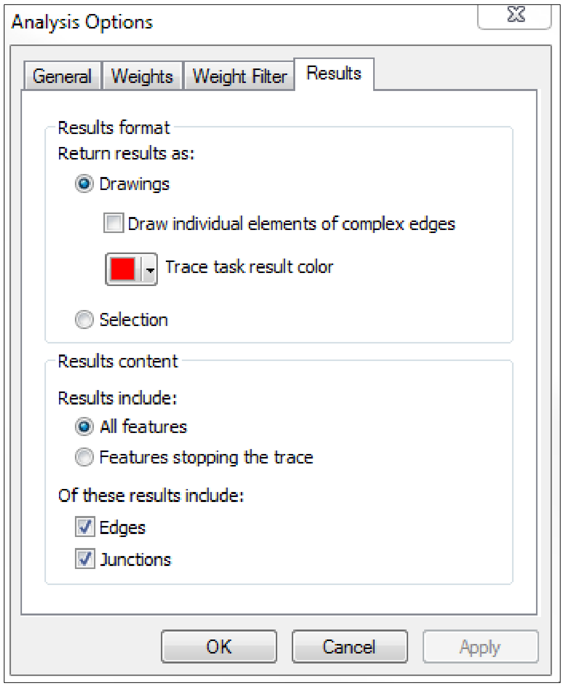
11. Click the "Set Flow by Digitized Direction" tool (Dog), save edits and stop editing when the tool becomes grayed out. The tool typically takes a few seconds to complete and there is no status/progress window shown when the tool is run – it will just become unavailable once the directionality is reset.



12. Once edits have been saved, close ArcMap without saving the map document. Finished.

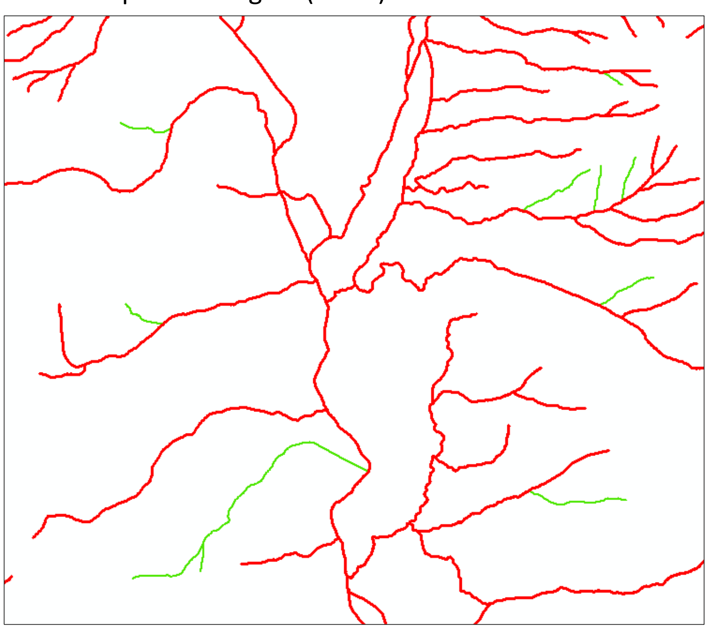
Flow Checks

After the network is created above, I use the add junction flag tool  to put a flag at the bottom of the network where the HUC flows out (pour point). Then click the Set Flow Direction by Digitized Direction (the dog) . Then run (Solve): 

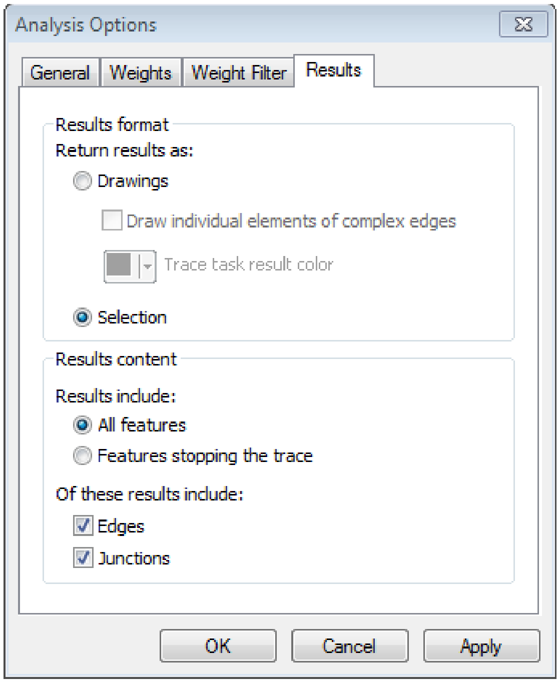


1. Analysis Options - Choose Selection
2. Check Trace Upstream
3. Find Disconnected (green lines) – Select these and with the geometric network editing tool bar 

click the connect button . In some cases the vertex may not be snapped to the line or the flow is in the wrong direction. Even if it looks like it, zoom in and snap it. Run again (Solve) to see if it is fixed



4. Once you feel all disconnected and flipped linears have been addressed – Analysis Options – Choose Selection



5. Trace Upstream
6. In the Stream_LN table switch selection
7. Address the ones with issues

Run Data Reviewer Tools

These tools are required by AK Hydro for final quality control check of the NHD data. These tools and documentation on their correct usage can be acquired through the Alaska NHD Steward.

Table Check

Check the table to confirm the necessary fields are attributed – RevDate, Source Agency, DataSource, HztlAccuracy, Surveyed, RsrcMgmtRegion, Type or FlowType.