Validating Kenai Peninsula National Hydrography for the Kenai Watershed Forum

Project Report: Sub-basins 19020301 and 19020302

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List of Acronyms

1D – Linear features 2D

– Polygon features

AHTWG – Alaska Hydrography Technical Working Group AK

Hydro – Alaska Hydrography

CIR – Color Infra-red

DEM – Digital Elevation Model

DRG – Digital Raster Graphic HUC

– Hydrologic Unit Code KWF –

Kenai Watershed Forum MHW –

Mean High Water

LiDAR – Light Detection and Ranging

NED – National Elevation Dataset NGO

– Non-governmental Organization NGP –

National Geospatial Program NHD –

National Hydrography Dataset NPS –

National Park Service

NWI – National Wetland Inventory

QA/QC – Quality Assessment/Quality Control SDMI

– Alaska Statewide Digital Mapping Initiative

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

– Système Pour l'Observation de la Terre Satellite

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

WBD – Watershed Boundary

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Abstract

The National Hydrography Dataset (NHD) for many parts of Alaska is out of date and in need of revision. The existing digital hydrography data for much of Alaska was derived from the conversion of 1:63,360 paper topographic maps and digital raster graphics (DRG). These maps were compiled and printed in the early 1960's (using traditional cartographic methods) based off aerial imagery flown in the 1950's. Changes in the natural landscape and the extent of human development have altered the regions hydrography. In addition, given the original compilation scale, this original hydrography is generalized and unsuitable for site specific applications. Advancements in spatial data development methodologies have led to cost-effective means to update this hydrographic data to capture the changes since the 1950's at a variety of scales more conducive to watershed planning and 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. In Alaska, there is no state agency directly responsible for managing the states hydrographic data. Upgrades to the NHD in Alaska have been most successful when entities in local areas partner 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 (AHTWG), but have broad support and participation from other state and federal agencies and NGOs (non-governmental organizations).

The Kenai Watershed Forum (KWF) is a non-profit organization which provides education, restoration and research programs for the protection of watersheds on the Kenai Peninsula. These watersheds are vital to not only the natural landscape and wildlife that exists there, but the Kenai is well known as a premier sport and commercial fishing destination. It is important to protect and enhance the native fish and aquatic resources of this region for both its natural beauty and its benefit to the economy. The NHD is useful for contributing to the KWF's planning efforts for habitat conservation and restoration. With its lakes and streams mapped the KWF and its partners can use this data to better assess where stream features may be affected negatively through land use. This data can also be used to inform policy makers of conditions affecting the watersheds on the Kenai Peninsula.

The purpose of this project was to review, validate and, where necessary, update the Kenai Peninsula NHD in order to meet the national quality standards identified by the USGS. This validation process is possible because up-to-date, large scale imagery and digital elevation data is now available for the Peninsula through the mapping efforts of the Kenai Borough, the US Fish and Wildlife Service (USFWS) and the Alaska Spatial Data Mapping Initiative (SDMI).

Introduction

The Kenai Watershed Forum (KWF) tasked Saint Mary's University of Minnesota GeoSpatial Services (GSS) with the completion of a comprehensive review and validation of both the one dimensional (1D or linear features) and two dimensional (2D or polygon features) NHD data for two hydrologic unit code (HUC) sub-basins (HUC-8 19020301 and HUC-8 19020302) on the Kenai Peninsula, Alaska (Figure 1). The NHD for a portion of these sub-basins were updated in 2012 using flowlines derived from a LiDAR based digital elevation model (DEM). The LiDAR data did not completely cover both HUC-8's and the resultant data outside the LiDAR coverage consisted of NHD that had not been created to the standards developed by the multi-agency Alaska Hydrography Technical Working Group (AHTWG).

Figure 1. Kenai Peninsula – Upper and Lower Kenai Sub-Basins

During this process GSS used a range of available imagery and collateral datasets to validate feature location and accuracy, add missing 1D and 2D features, and reconcile existing features to the project image base. This imagery and collateral datasets included:

1. Kenai Peninsula Borough (KPB) Fixed Wing Imagery
2. SDMI Système Pour l'Observation de la Terre Satellite (SPOT) 5 Imagery
3. USGS NHD
4. Alaska Anadromous Waters Catalog
5. KPB Managed Streams
6. KPB Hillshade
7. National Elevation Dataset DEM
8. Lowland Wetlands
9. USFWS National Wetland Inventory (NWI)
10. DRGs
11. Contours
12. KWF Culverts
13. KPB Culverts
14. Synthetic Flowline Networks

GSS has worked on several similar projects for a variety of partners in Alaska including The Nature Conservancy, the National Park Service (NPS) and the USFWS. As a result of this previous work, GSS has developed a range of workflow processes for identifying and editing surface hydrography to the USGS NHD standards. These workflow processes were applied to this project with the KWF based on discussions regarding needs and available budget.

Methodology

Editing tasks to add or adjust the 1D or 2D features were conducted using the existing NHD data for

the Kenai Peninsula extracted from the University of Alaska AK Hydro database. GSS completed the updates to the NHD data using the following workflow process:

1. Selection of project base imagery for the validation work. This will incorporate imagery that was captured during the LiDAR data acquisition and SPOT5 satellite imagery from the Alaska Spatial Data Mapping Initiative (SDMI) for areas outside of the LiDAR collection zone;
2. Establishment of data editing and tolerance standards for feature additions, data weeding and stream classification (perennial, intermittent, canal, etc.);
3. Checkout replica geodatabases from AK Hydro and establish editing environment at GSS;
4. Conduct full data review and addition of missing 1D and 2D features;
5. Deletion of existing extraneous 1D features remaining from flowline creation;
6. Realignment of 1D and 2D features to match current large scale imagery from Kenai Borough and SDMI;
7. 1D stream classification (perennial, intermittent, canal, etc.);
8. Update of Mean High Water (MHW), Foreshore and Bay-Inlet 2D features;
9. Field-level reconnaissance work to validate editing and classification decisions;
10. Revision of data edits in response to field work results;
11. Conduct comprehensive AK Hydro quality assurance/quality control (QA/QC) and check-in of replica;
12. Confirmation of processes for conflation of data edits back to USGS through AK Hydro.

The first step in this workflow was to gather the necessary base and collateral data. Available KPB high resolution fixed wing aerial imagery, LiDAR elevation data (**Figure 2**) and KWF culverts layer were provided to GSS by KWF on portable hard drives. The lowland wetlands, managed streams and culverts layers were downloaded from the KPB website.

The review process identified the presence of data gaps in the imagery and elevation data within the KPB data for the project area. Imagery gaps were filled using the SDMI SPOT5 imagery and best available elevation models. Elevation data gaps were filled with KPB hillshade layer and National Elevation Dataset (NED) DEMs. Necessary collateral datasets not freely available for download were created in ArcMap 10.2.2 from existing data (e.g., elevation product derived hillshade, contours and synthetic flowline networks). Available DRG’s and the original USGS NHD provided useful collateral information and were available for download from the USGS.

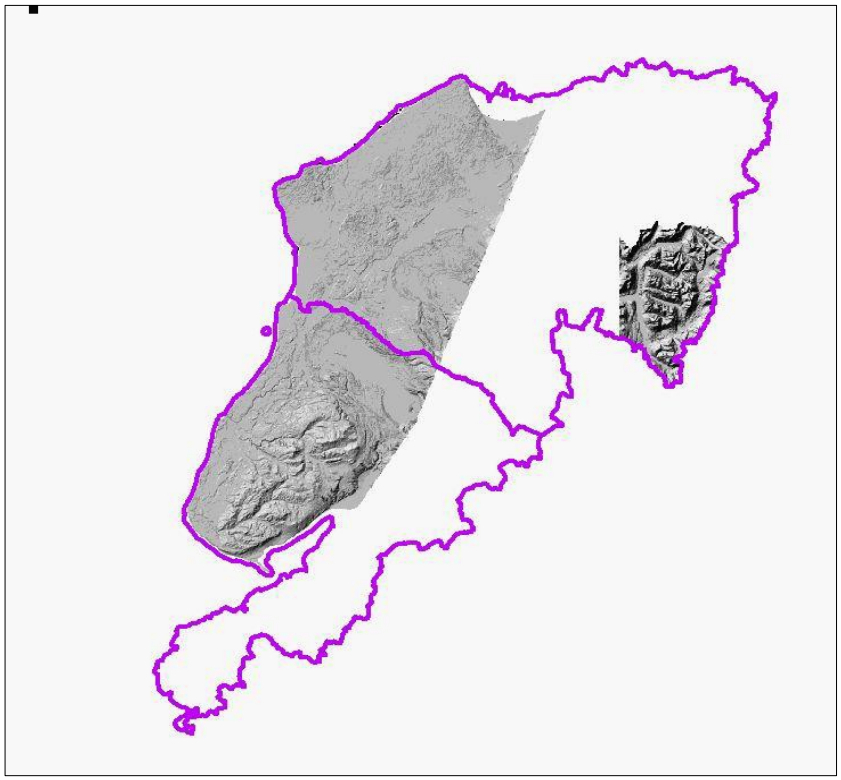


Figure 2. LiDAR hillshade data coverage

GSS employed editing and feature classification standards that were used on previous NHD editing projects completed for The Nature Conservancy and the NPS. These standards are compliant with the AK Hydro editing standards. Due to the diversity of the project landscape, additions to the standards were incorporated (as needed) based on discussions between the project partners.

All editing was based on replica check-out geodatabases created from the AK Hydro master dataset. The checked-out geodatabase for each HUC-8 coincided with the USGS HUC-8 watershed boundary layer (WBD). The replication process was completed by the Alaska State NHD Steward and each check-out was delivered to GSS. The actual editing of the data was done on a copy of the replica geodatabase with the original replica kept for loading of the revised data and delivery of the final data to AK Hydro.

The existing hydrography features of each sub-basin replica geodatabase were examined for the need to realign, densify (adding new features), or remove 1D and/or 2D features. These identification processes were conducted concurrently. Alignment issues, and the need for reshaping to correct these issues, where determined through the use of the KPB imagery and SDMI SPOT5 base data. Densification or removal of 1D and/or 2D features along with classification of new features was based on the base and collateral data compiled or created for the project.

The Kenai Peninsula's MHW 2D features were edited using the KPB's imagery, supplemented with the SDMI SPOT5 imagery. In instances where edits to the MHW polygon affected the location of the intertidal foreshore, this boundary was also edited. GSS image interpreters utilized best professional

judgement to position the new MHW feature as the available image sources were not tidally timed to reflect MHW. The positioning of the new MHW line was based on interpretive clues that included:

drift and debris lines, distinct vegetative changes, location of exposed mud flats, gravel bars and shoreline features, and the position of tidal gut or coastal channel features.

Reconnaissance level investigation sites were selected for areas that could not be clearly identified as having surface flow; or valid road crossings; or where there were questionable points of stream initiation. All available collateral datasets were used to aid the interpreter with identification of these check sites. Field verification points were placed at those locations where imagery signatures indicated that flow might exist, but could not be verified from available datasets. Other check site points included where road crossings (culverts) needed clarification. Example point placements include; where existing hydrography lines indicate flow however it is not discernable on the imagery and where locations of road crossing culverts were neither identified in the culvert layers nor were discernable from the imagery. A total of 218 check sites were pre-selected based on the above criteria (Appendix A). Field crews were supplied with hard-copy printed images showing accessible check sites for use in field verification. Paper copies of 1:8,000 scale topographic maps were also used in the field so that notes and delineation could be added directly to the maps in the field. Any revisions to the hydrography that were needed were addressed after field crews returned to the office.

After editing and field verification was completed, a comprehensive QA/QC assessment was conducted and the required AK Hydro table of common elements attribution was finalized. The final data was loaded back into the original replica check-outs and prepared for delivery. Each replica was returned to the Alaska State NHD Steward for uploading to the AK Hydro master database and ultimately conflation to the USGS National Map. Conflation is an attribute transfer tool that maintains many of the linear reach codes and transfers names to the revised feature geometry. The first step in the conflation process is the conversion of the AK Hydro formatted data to a USGS compliant database schema. This is followed by a detailed USGS QA/QC protocol to ensure that the data is ready for conflation using the USGS processing tools.

Results

LiDAR elevation data is a high resolution data set that provides support for detailed editing and

decision making. A number of derived datasets can be created from the LiDAR that are also useful for decision making due to their high level of detail. One of these products is the hillshade dataset. The hillshade dataset provided visual documentation of hydrologic flow paths and stream beds not visible in the aerial imagery due to vegetation cover. Elevation contours derived from LiDAR can be used to help interpret flow direction and slope. Contours were also important as 1D features matched to the contours provided better analysis where NHD data was used in conjunction with elevation models (e.g., NHDPlus).

High resolution aerial imagery is preferred for delineation of features. Due to acquisition costs and availability, these images were only available for limited portions of the project study area. Where available the aerial imagery aided greatly in visually identifying: feature misalignment (**Figure 3**); locations where new 1D and 2D features should be added; and, where the extents of 1D and 2D features needed to be revised (**Figure 4**).

Figure 3. Feature realignment, orange is misaligned and blue is corrected

Figure 4. Blue 1D features are additions (densification) to the flowline network

SPOT5 imagery data was readily available through the SDMI web mapping service as color infra-red (CIR), panchromatic and true color layers. The processes employed to create the statewide SPOT5 mosaic tends to washout or blend the colors causing the imagery to be not as vibrant in contrast. As this data was delivered as a web mapping service, the ability for GSS interpreters to manipulate the spectral band histograms was not available. This caused a limitation to the possibility of creating contrast for better identification of features, however, it did provide consistency in the imagery for every interpreter.

A critical collateral dataset for the validation and classification of NHD features was the Kenai Borough wetlands. The wetland features provided valuable insight into water table levels and points of initiation, in addition to improved confidence in classification decision making. While not every wetland indicates that a 1D features is present in that location, the presence of a wetland does verify for the interpreter that surface water is present for some portion of the year.

1D features often cross roads, but in some instances there is no clear identification of a culvert on the imagery. In these cases, assumptions were made to validate the crossing. Field verified culvert layers resolved many of the occurrences where (or if) 1D features cross anthropogenic structures (**Figure 5**). If the intent of projects is to hydro-condition the elevation model for the purpose of generating synthetic networks then identified culvert locations are a required layer necessary to break digital dams (features inherent in the resultant DEM that restrict or impede flow, such as, roads).

Figure 5. Star validates a culvert is present for allowing flow across road

As part of the update process, GSS interpreters attempted to classify streams as perennial, intermittent, or canal. All delineated channels were initially assigned a perennial classification unless strong evidence indicated that the channel was dry on the imagery or if the feature existed on steep slopes above the tree line. The assignment of stream classification was based on a several factors including: frequency and duration of water in the channel; location on steep slopes; and, presence or absence of vegetation. GSS interpreters used all available data, collateral datasets plus other ancillary information to drive the decision process regarding stream classification.

The accurate location of coastal MHW is an interpretive effort complimented by the analysis of the landscape and natural processes. In locations where there is no tidally referenced data available, high resolution imagery was studied to locate mud flats and their extent, lines of vegetation, where the debris is located along the beach and tidal guts (**Photo 1**). Based on these natural features, GSS interpreters used best professional judgment to establish where the various tidal levels are throughout the cycle.

Photo 1. Mud flats, tidal guts, estuarine vegetation – Chickaloon Bay

Much of the field work planning can and should be done in the office, however good field work will evolve while the crew is in the field and new questions arise. On-site observations of natural occurrences drive and develop the interpreters understanding of the interconnectedness and processes affecting the local hydrology. Additionally, it can be expected that once the field work findings are incorporated into the editing process, changes in understanding of the natural landscape and hydrologic function will result in revisions to previous editing and data capture decisions. In some cases, field check site points are included that are not readily accessible. These points are instrumental in observations of visual evidence of flow where vegetation obscures a potential stream bed on the imagery. Other examples of inaccessible field check points include large features like a coastal bay or field check points located in valleys visible from the road side, but not accessible by vehicle or on foot. Aerial observations also contribute to the understating of what is occurring hydrologically (Appendix B).

It is important to note that, while in the field, identifying what features are not present is as important as those that are. Dry swales and road-side ditches may appear to be places of consistent flow, but their primary purpose is flow re-direction and property protection during the wettest of conditions as opposed to permanent water passage.

The final data verification was conducted using the AK Hydro Data Reviewer Tools. These represent a comprehensive set of data integrity checks accessed through the ESRI Data Reviewer Tool. Errors

are identified in a table that can be stepped through to examine and resolve issues. Validation of the mandatory attribute fields required for the AK Hydro schema were also included in this final step.

Conflation of the dataset to the National Map was provided by the Alaska NHD Data Steward. This process utilized the USGS GeoConflation tools for ArcGIS 10.2 which were designed to transfer attribute information across datasets while maintaining NHD data model integrity.

Recommendations

Work on the NHD updating project for the KWF identified several recommendations. As a future step in the hydrography mapping process, KWF should consider conversion of this updated NHD dataset to the NHDPlus data model. Specifically, 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 key dataset used to address water quality reporting and to support additional management efforts. This dataset provides enhanced analysis capabilities and would better serve KWF and other agencies on the Kenai Peninsula in planning and assessing stream habitat, flood plain modeling, stream functional assessment and fish habitat mapping. In order to generate the NHDPlus a high resolution DEM is needed. Currently the State of Alaska is in the process of acquiring IfSAR data for the entire state, which would provide the high resolution (5 meter) elevation product needed as an input to generate NHDPlus. Revised watershed boundaries could then be generated/updated from the IfSAR elevation model.

Additional planning and management benefits are also achievable through the integration of NHD with the NWI or other wetland databases. Although the NHD data model supports inclusion of wetland features within the database, these features are typically not populated. Wetland databases hold information on ecological functions such as surface water detention, flood water attenuation, wildlife habitat, surface flow connectivity and streamflow maintenance. When these features are absent from the NHD, valuable information about surface water supply and water quality is unavailable for management purposes.

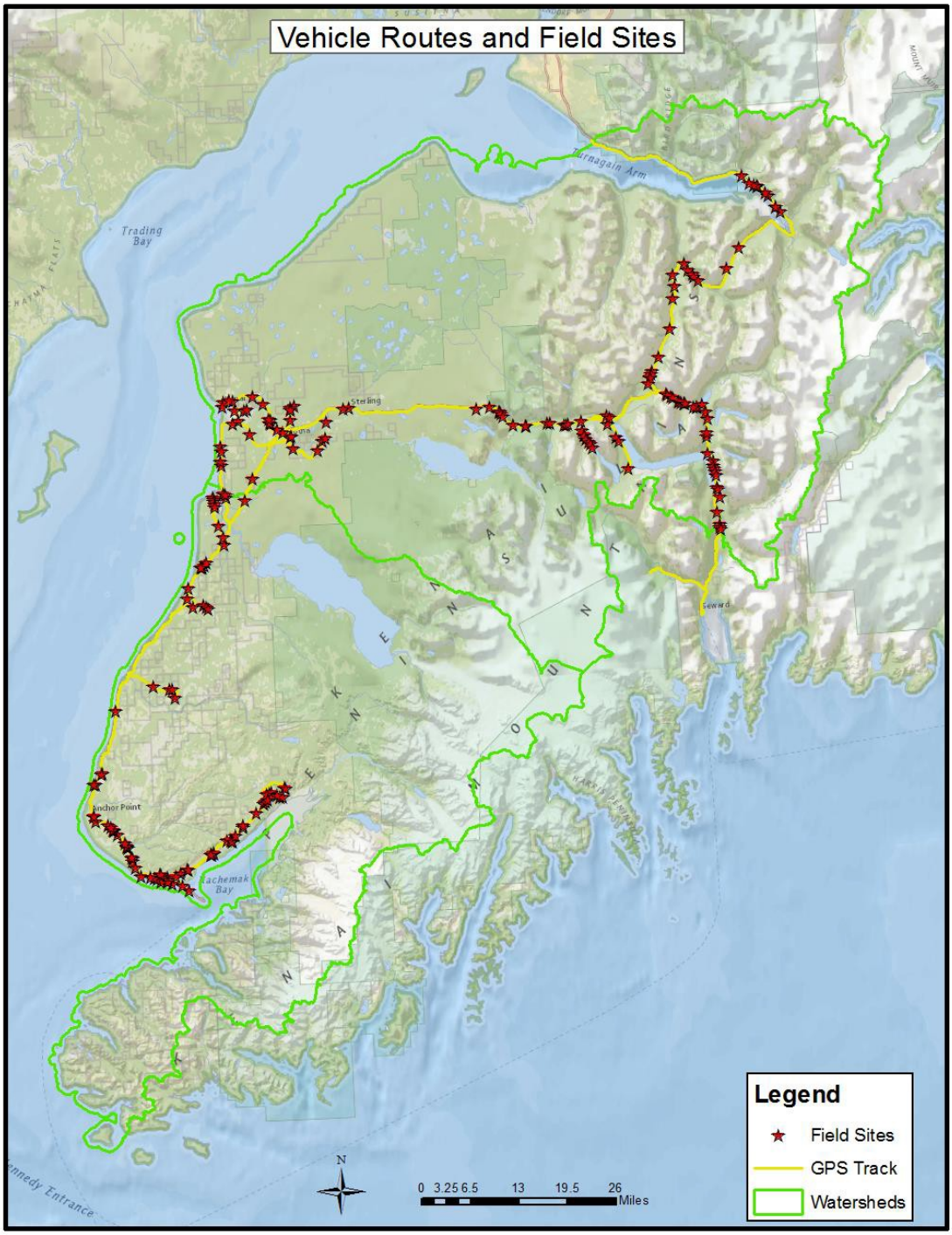
From a process standpoint, current wetland data, either collected or updated, could be integrated as swamp/marsh features directly into the NHD dataset. Swamp/marsh features are found within the USGS NHD Waterbodies feature class and provide for identification of wetland structures that contribute to water retention and point sources for NHD surface water flow. A swamp/marsh is defined by the USGS as a non-cultivated, vegetated area that is inundated or saturated for a significant part of the year and where the vegetation is adapted for life in these saturated soil conditions. This definition, although not a direct correlation with Federal Wetland Mapping Standard, can be used to determine which NWI system, subsystem, class and water regime are representative of a NHD swamp/marsh.

A final recommendation is that future mapping effort be focused on the capture and refinement of the MHW line feature in the NHD database. For much of Alaska, the MHW line represents the demarcation between municipal, state and federal jurisdiction over a particular land base. Using best professional judgment and traditional image interpretation techniques supported by field reconnaissance, it is possible to approximate a MHW demarcation for the NHD. This line can be

much more accurately defined, however, if tidally timed, orthorectified aerial imagery is captured and interpreted for a project study area. KWF should consider the acquisition and interpretation of such imagery as a future adjustment to the current NHD.

Appendices

Appendix A. Field Trip Routes and Check Sites



Appendix B. Flight paths