Generalisation of Hydrography Networks for a Vario-scale Basemap

IJ.D.G. Groeneveld

Supervised by:
Prof.dr.ir. P.J.M. van Oosterom - Professor GIS Technology
dr.ir. B.M. Meijers - Researcher GIS Technology
dr. R. Šuba - PhD Candidate GIS Technology

Co-reader: dr.ir. P. Nourian

February 1, 2018

Contents

Introduction

- Importance Hydrography features
- Started by paper maps and later digitised paper maps, now more and more digital maps
- Maps are abstract representations of the world around us

Source: A.G. Findlay (1849)

Source: Kadaster (2017)

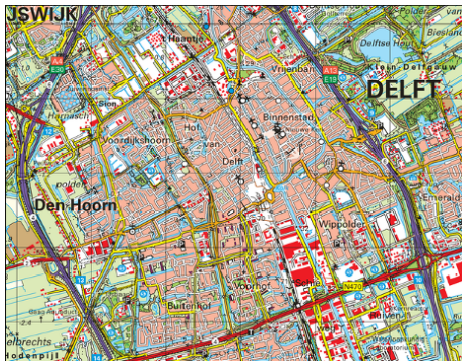
A. G. Findlay (1849). *Classical Atlas of Ancient Geography*.

Kadaster (2017a). *TOP10NL*. https://www.kadaster.nl/-/top10nl

Introduction

- Scale is defined as the ratio between the distance on the map to the corresponding distance in the real world
- Generalisation tools are used to create maps at different scales
- Generalisation involves e.g. the reductions of the amount of features, simplification and selection

1:25K



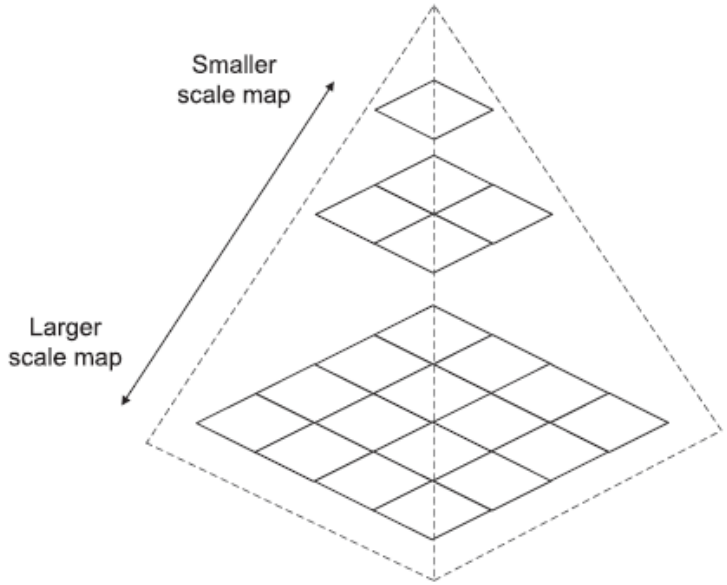
1:50k

1:100k

Kadaster (2017b). *TOPraster*. https://www.kadaster.nl/-/topraster

Introduction

- Maps at different scales are often stored in a multi-scale database (around 20 zoom levels for Google Maps, Bing Maps and Open Street Maps)
- Double storage and redundant data transfer
- Alternative approach: variable-scale (vario-scale for short)

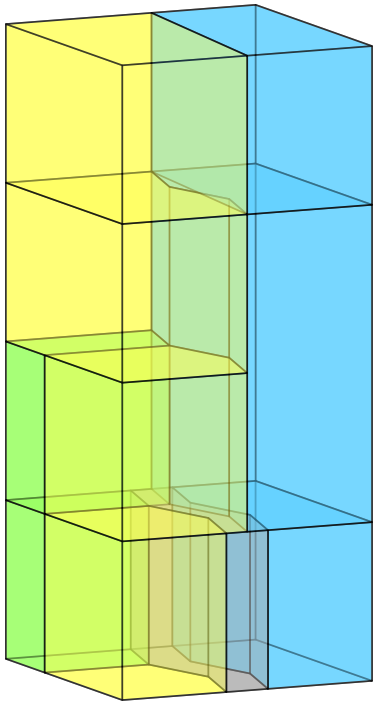


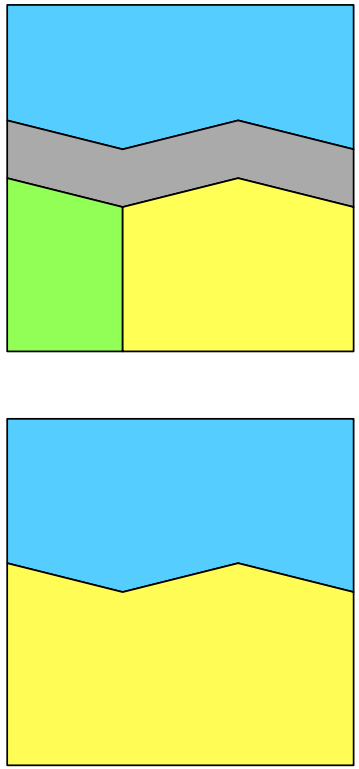
Source: S. Quinn and J.A. Dutton (2017)

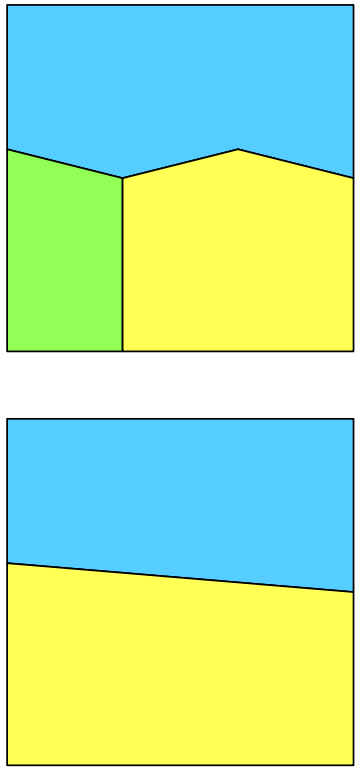
S. Quinn and J. A. Dutton (2017). *Why tiled maps?*. https://www.e-education.psu.edu/geog585/node/706. Last accessed on June 28, 2017

Vario-scale

- No more separate maps: one 3D model.
- Vario-scale approach where all scales are stored in a single data structure, see `http://varioscale.bk.tudelft.nl` for all information about the approach
- Planar partition, merge or split operation

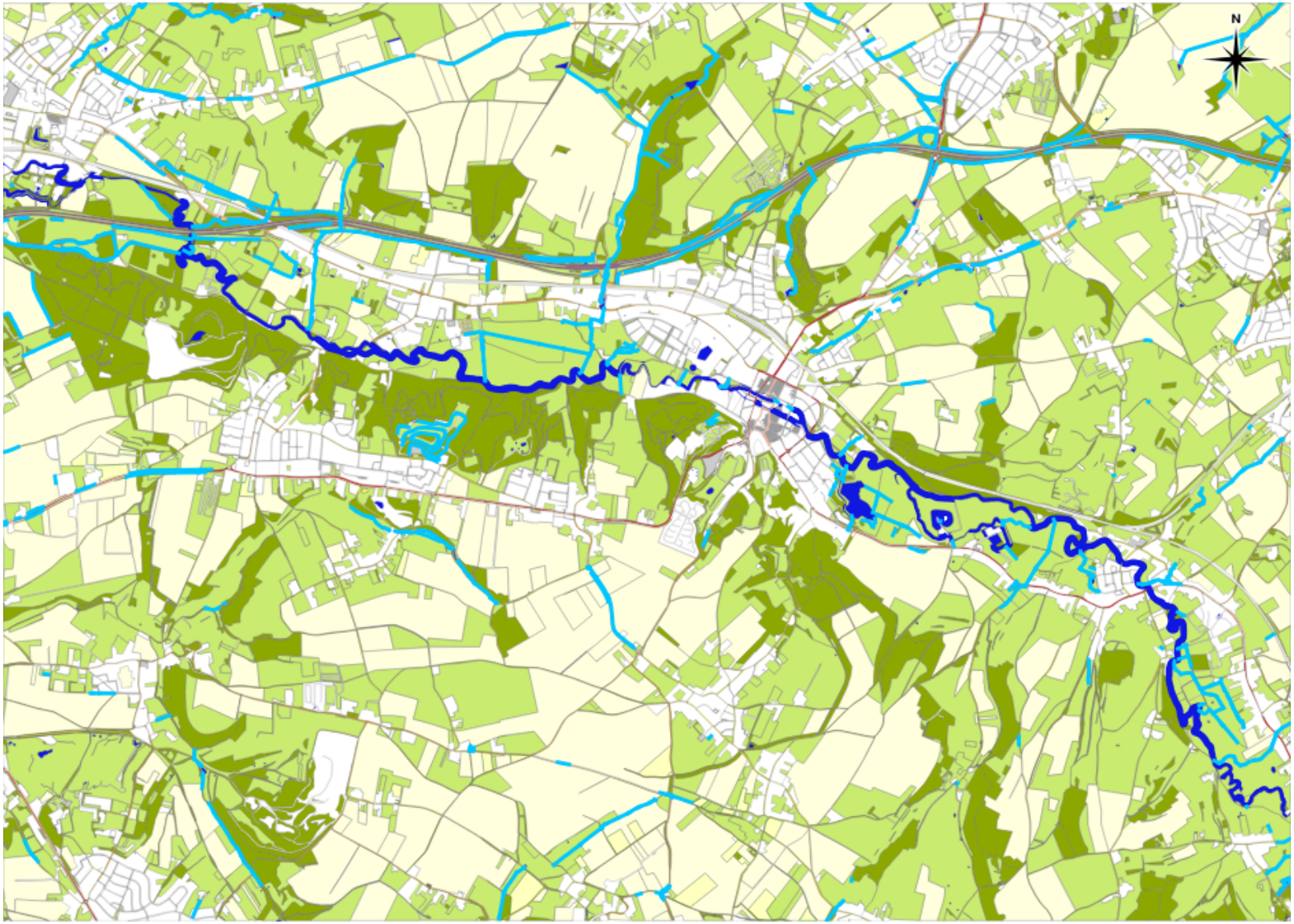






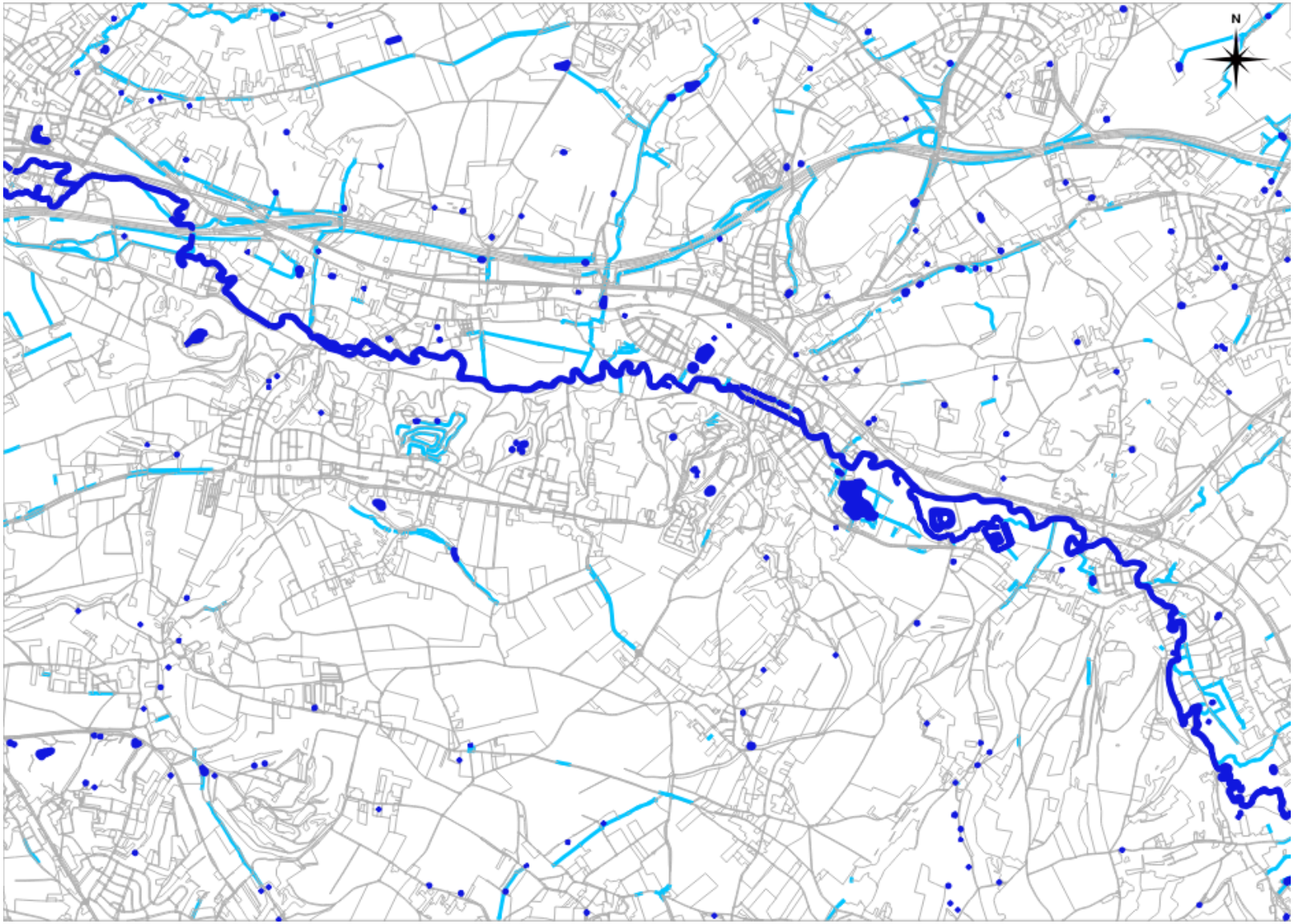
P. van Oosterom and M. Meijers (2013). "Vario-scale data structures supporting smooth zoom and progressive transfer of 2D and 3D data". In: *International Journal of Geographical Information Science* 28.3, pp. 455–478. DOI: 10.1080/13658816.2013.809724

Hydrography Features in Vario-scale



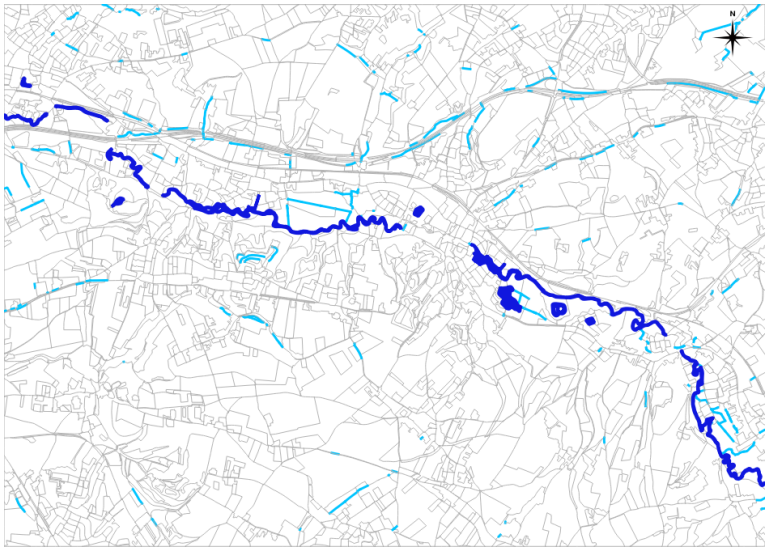
Initial tGAP data structure

Hydrography Features in Vario-scale

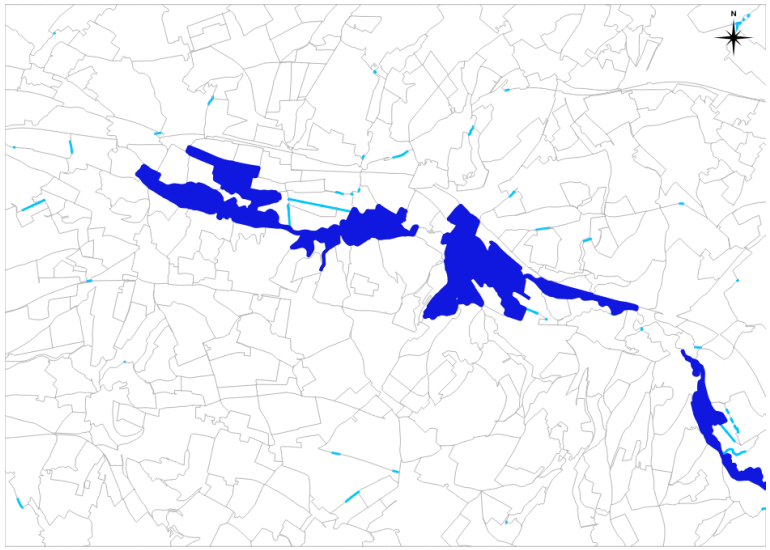


Initial tGAP data structure

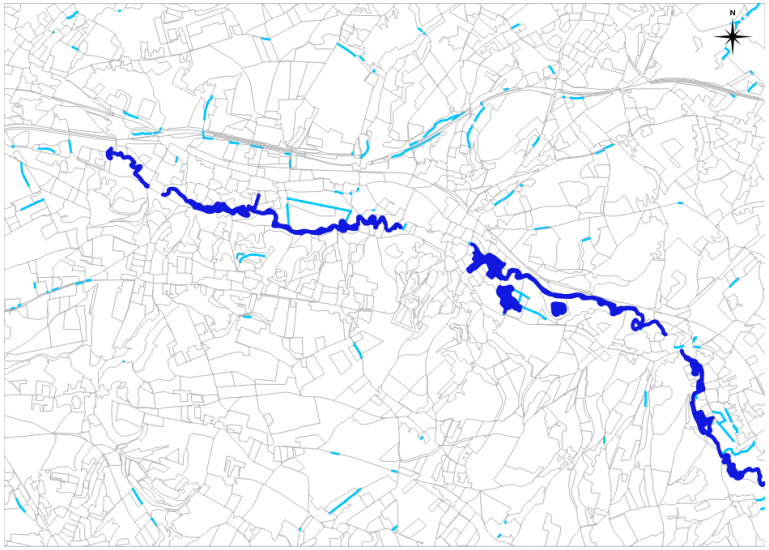
Hydrography Features in Vario-scale



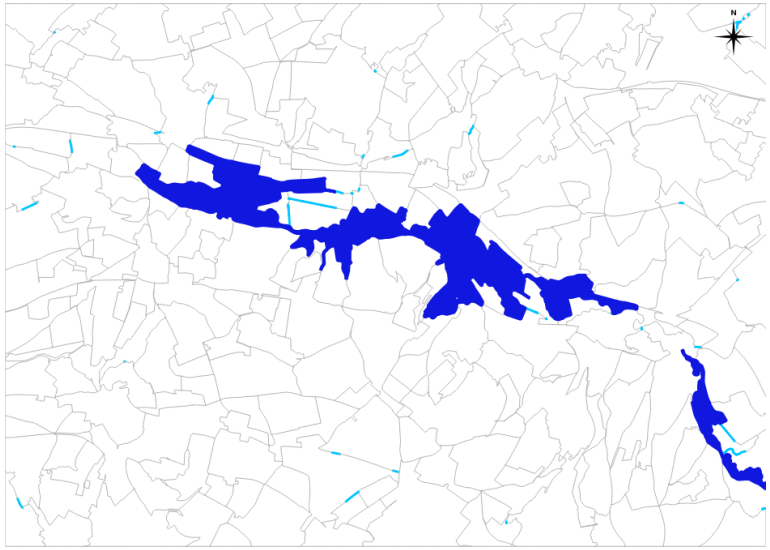
Generalisation step 8000 of 10354



Generalisation step 10000 of 10354

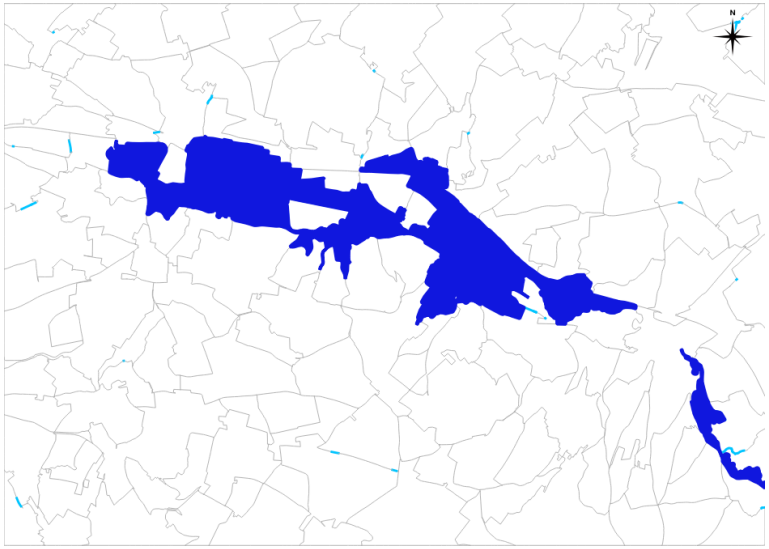


Generalisation step 9000 of 10354

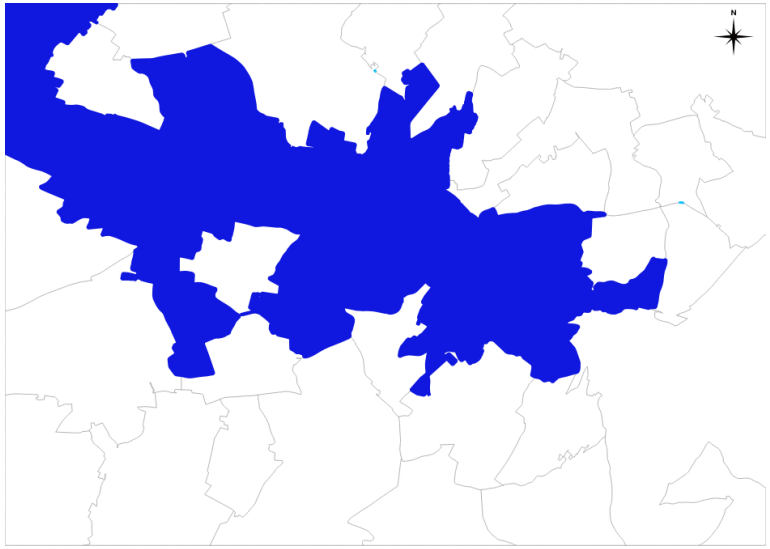


Generalisation step 10100 of 10354

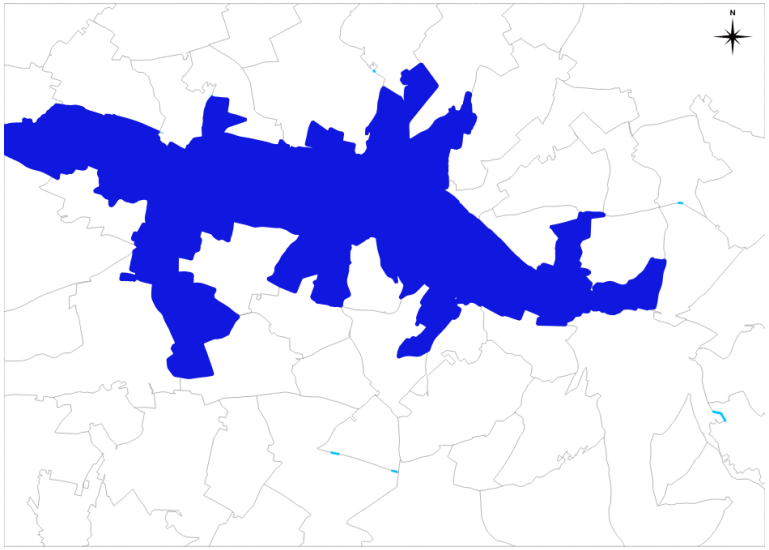
Hydrography Features in Vario-scale



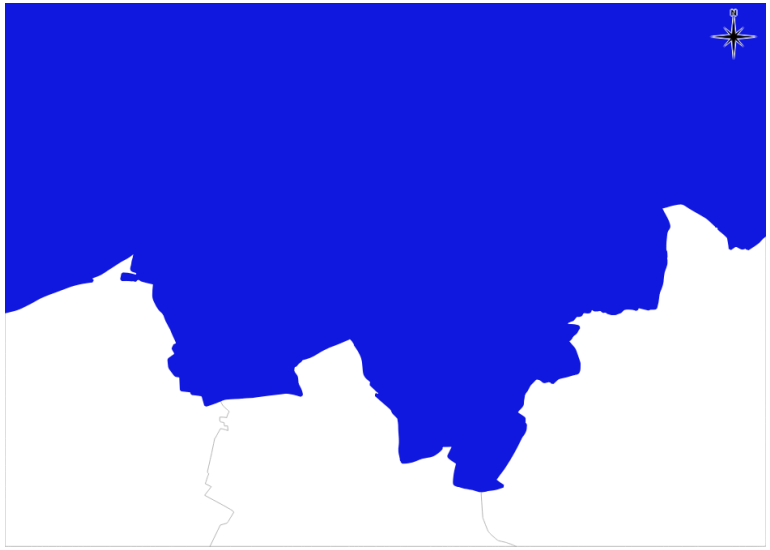
Generalisation step 10200 of 10354



Generalisation step 10325 of 10354



Generalisation step 10300 of 10354



Generalisation step 10350 of 10354

Research Question

Main Research Question

To what extent can hydrography networks be better incorporated in the vario-scale concept for creating a vario-scale basemap while maintaining the network structure?

Research Question

Sub Research Questions 1/2

- How to create a hydrography network based on hydrography features in the large scale topographic input data?
- Water normally flows from areas with higher elevation to areas with lower elevations, except in some man-made hydrography networks. How to include the flow direction in the hydrography network and how does this influence the generalisation result? Are additional data like e.g. elevation needed?

Research Question

Sub Research Questions 2/2

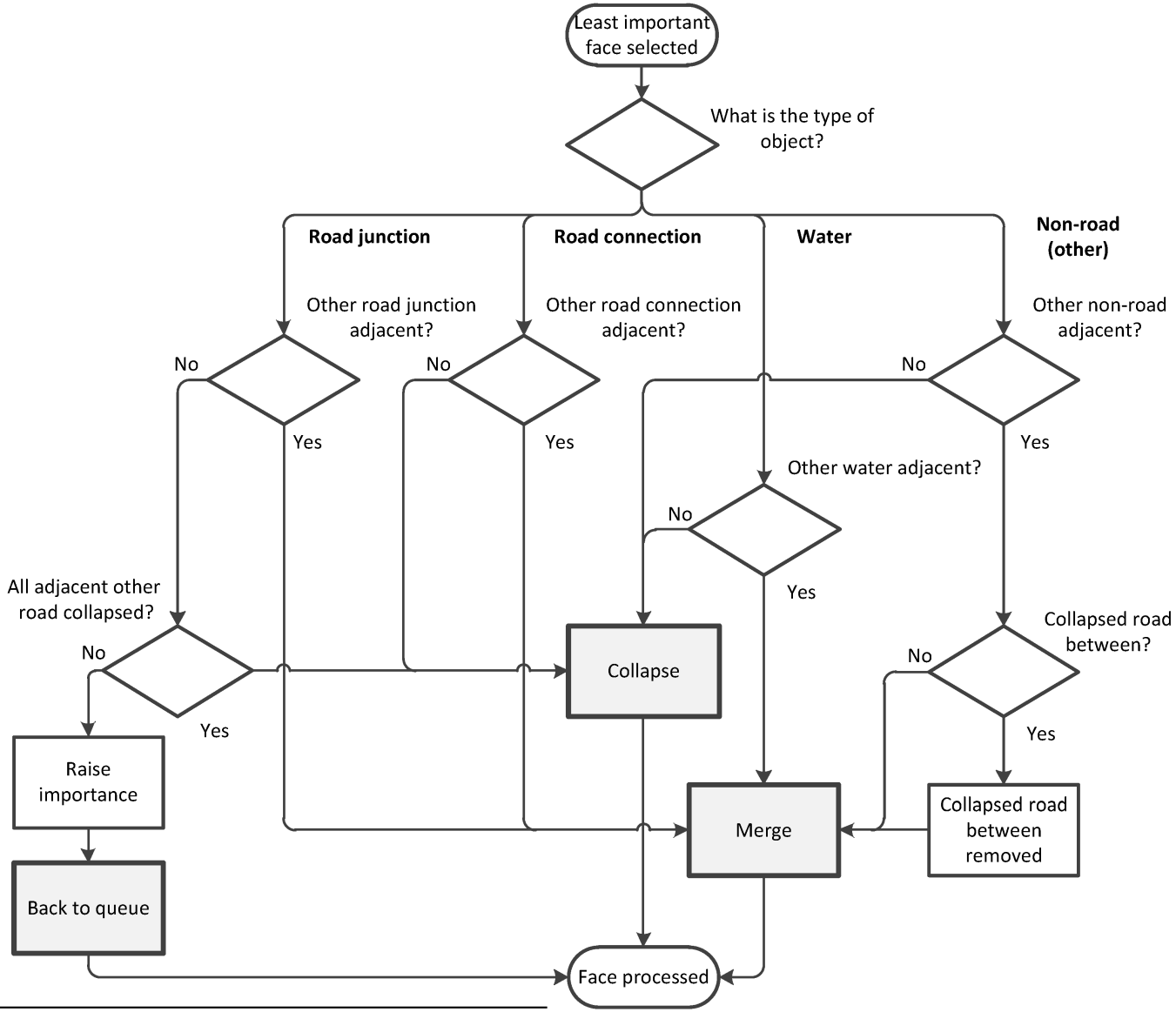
- How to implement the generalisation method for hydrography networks in the vario-scale concept? Which generalisation decisions need to be made in the process?
- What are the differences in the generalisation results with the introduced treatment of hydrography networks compared to the version that doesn't have this functionality? How to assess the hydrography networks throughout the scales in the vario-scale approach

Related Work

- Šuba et al. (2016) describes a method to included line features in the vario-scale approach and applied it to road networks

R. Šuba, M. Meijers, and P. van Oosterom (2016). "Continuous Road Network Generalization throughout All Scales". In: *ISPRS International Journal of Geo-Information* 5.8, p. 145. DOI: 10.3390/ijgi5080145

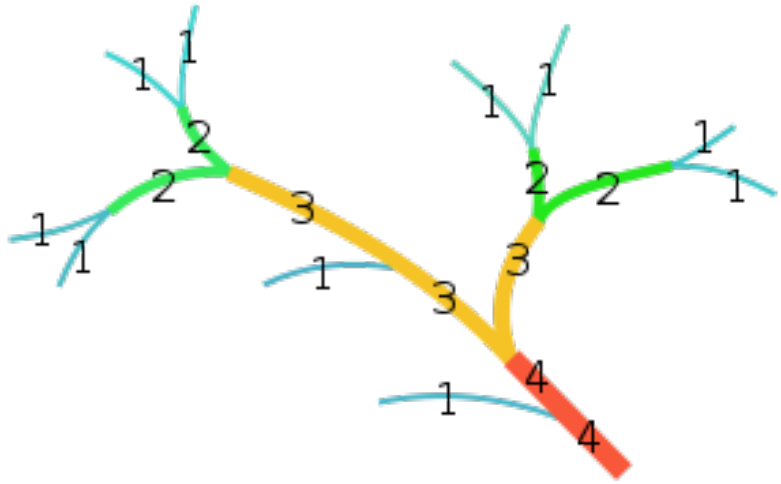
Related Work



R. Šuba, M. Meijers, and P. van Oosterom (2016). "Continuous Road Network Generalization throughout All Scales". In: *ISPRS International Journal of Geo-Information* 5.8, p. 145. DOI: 10.3390/ijgi5080145

Related Work

- Strahler (1952) developed the Strahler Order which assigns a number to a hydrography feature in a network based on the importance of the feature in the network



Source: Wikimedia Commons (2001)

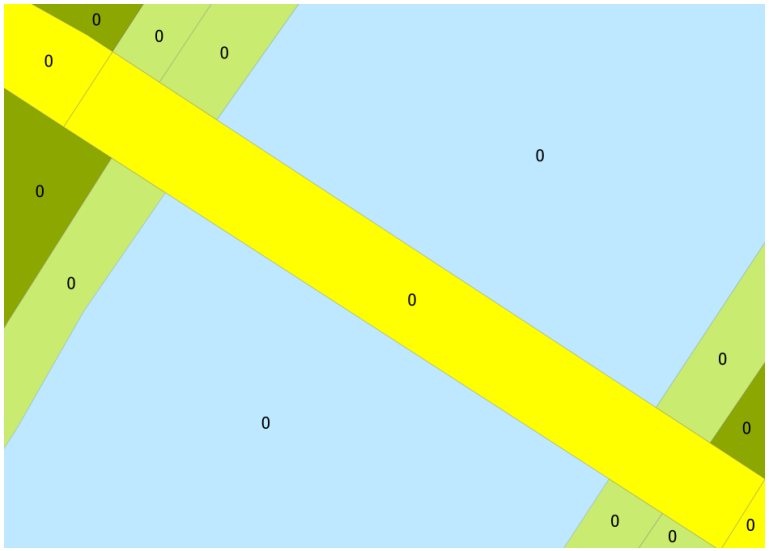
Wikimedia Commons (2011). *Flussordnung (Strahler)*. https://commons.wikimedia.org/wiki/File:Flussordnung_(Strahler).svg. Last accessed on May 04, 2017

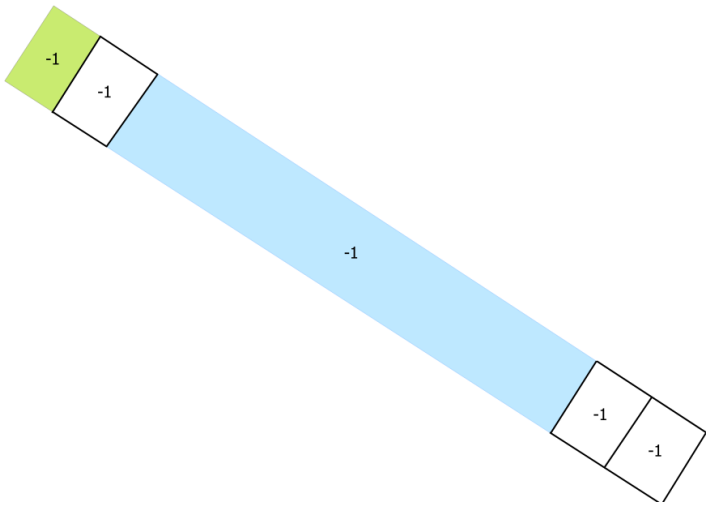
A. N. Strahler (1952). "Hypsometric (Area-Altitude) Analysis of Erosional Topography". In: *Geological Society of America Bulletin* 63.11, p. 1117. DOI: 10.1130/0016-7606(1952)63[1117:HAAOET]2.0.CO;2

Methodology and Development

Hydrography Polygon Features

- Topographic input data contains layers that are on top of each other, e.g. a hydrography feature beneath a bridge
- Store this information in the pre-processing

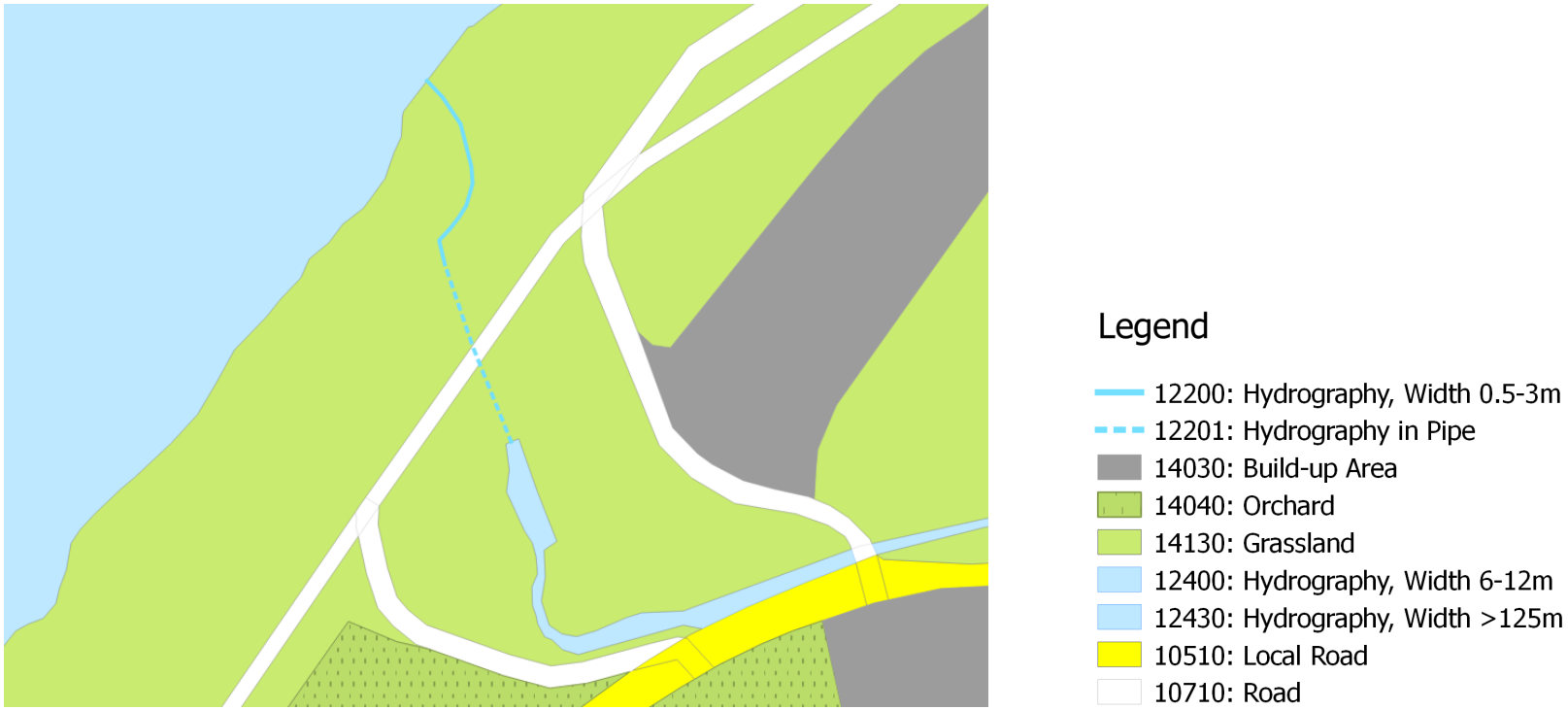




Methodology and Development

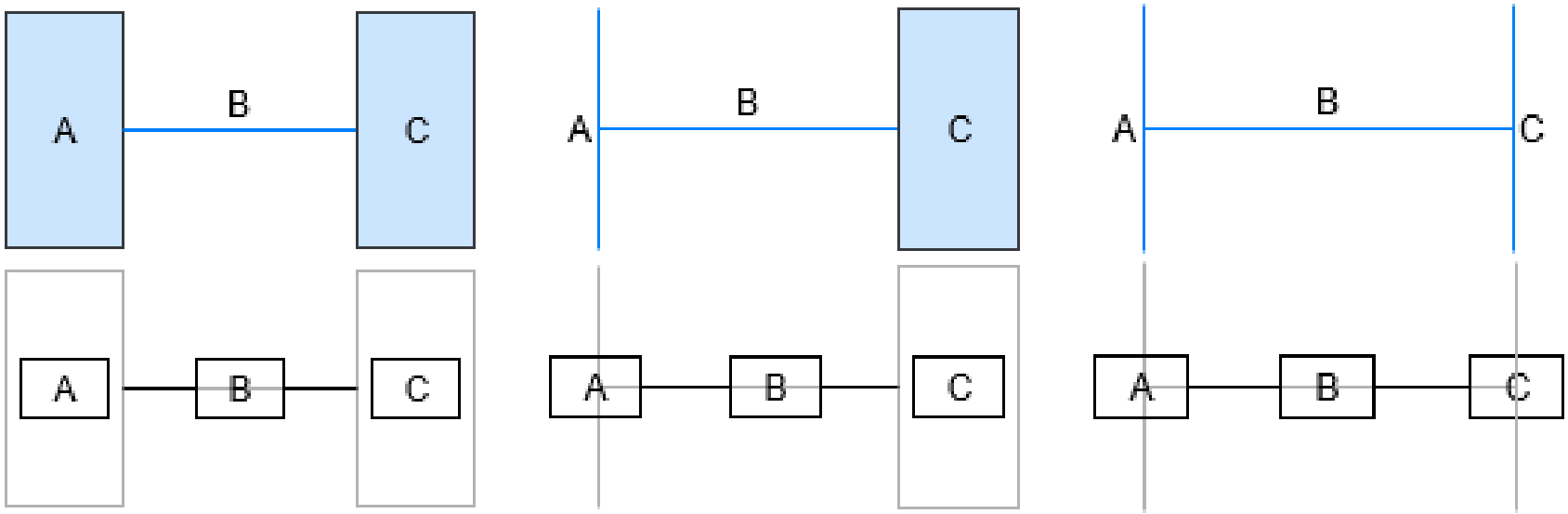
Hydrography Line Features

- Hydrography lines features in the topographic input data for the creation of the planar partition
- Use hydrography line features in pre-processing and store them



Methodology and Development

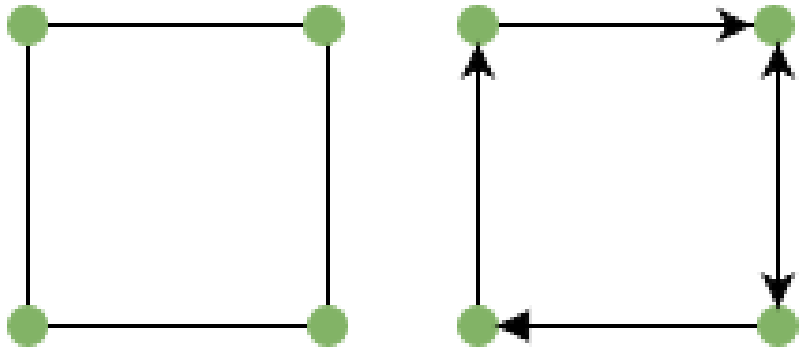
- Beside feature class more information or semantic information implicitly in the in the large scale input data set, however not explicitly modelled
- Wish to preserve the natural meaning of the hydrography network



Methodology and Development

Hydrography Networks

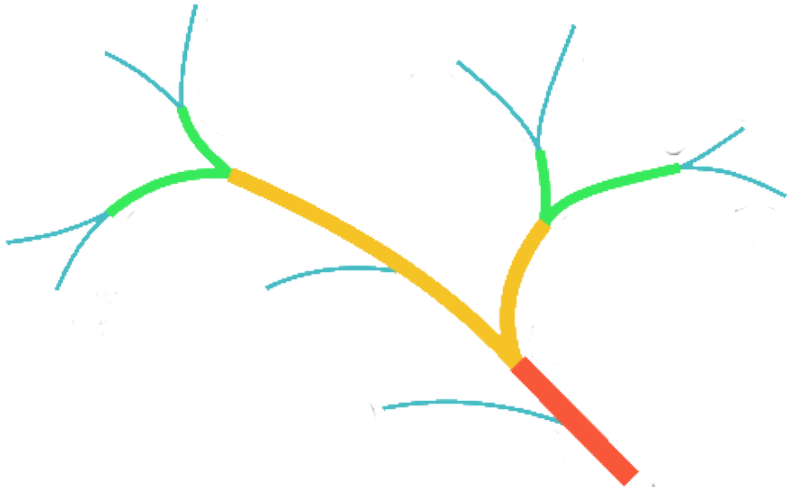
- Networks are collections of features which can be represented as graphs which are mathematical structures used to model pairwise relations between objects.
- Create Hydrography Graph



Methodology and Development

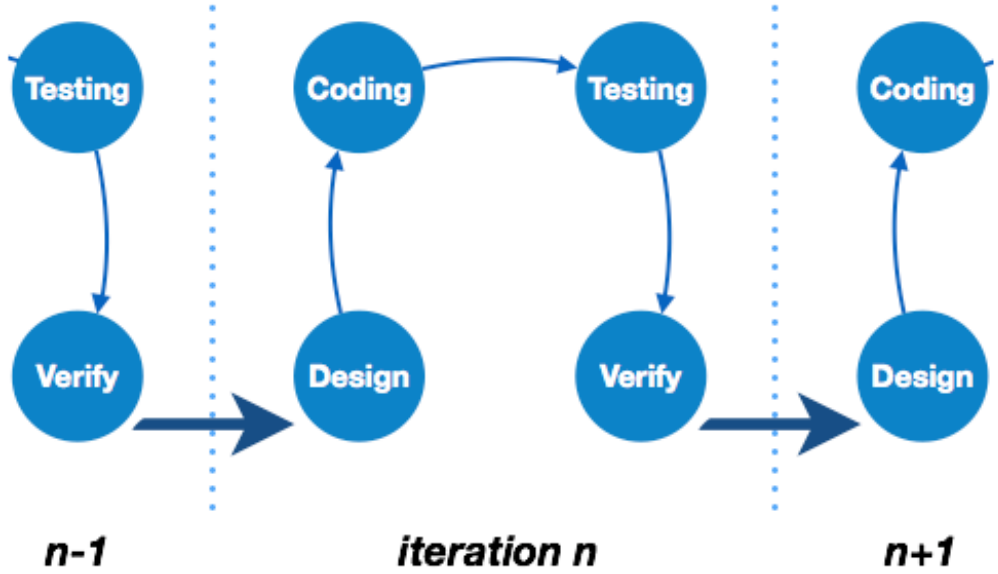
Flow direction in Hydrography Network

- Flow direction in Hydrography Networks
- Vario-scale approach should be generic, so if extra data is needed for determination of flow direction is should be publicly available
- Outlet point of the Hydrography Network
- Add Strahler Order



Methodology and Development

- Develop generalisation decisions for hydrography features in vario-scale concept
- Add extra decisions or improve existing decisions
- When to stop the development iterations?



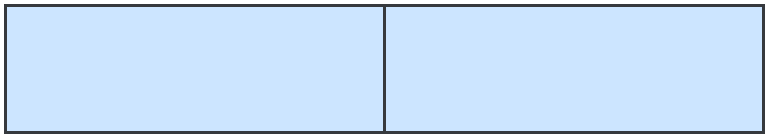
Source: Tutorials Point (2017)

Tutorials Point (2017). *Software Development Life Cycle*. http://www.tutorialspoint.com/software_engineering/software_development_life_cycle.htm. Last accessed on June 17, 2017

Methodology and Development

Generalisation Decisions

- Merge Hydrography

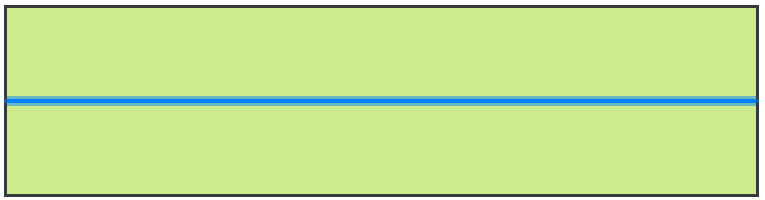


(a)

(b)

- Split Hydrography

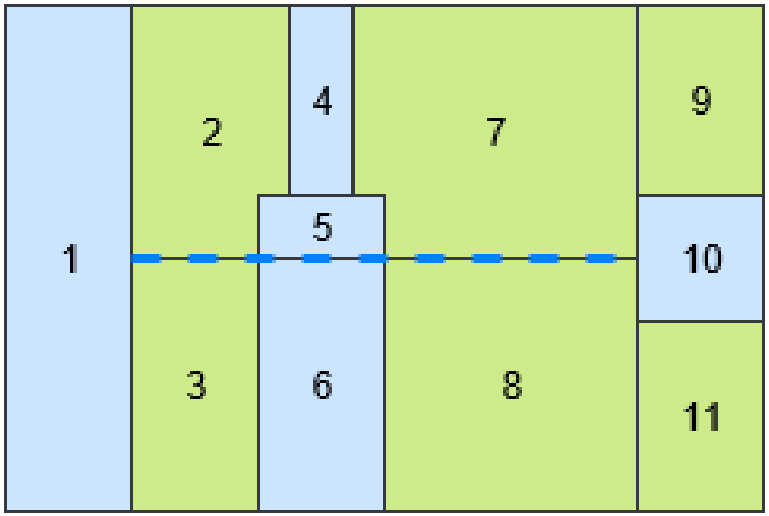
(a)



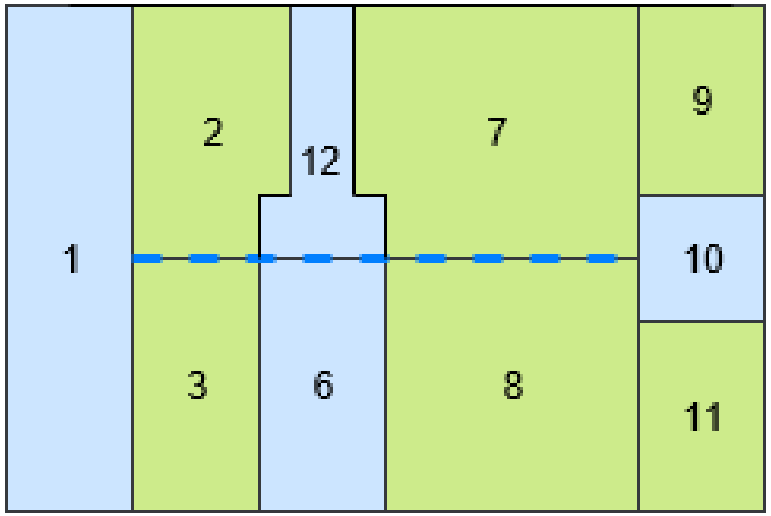
(b)

Methodology and Development

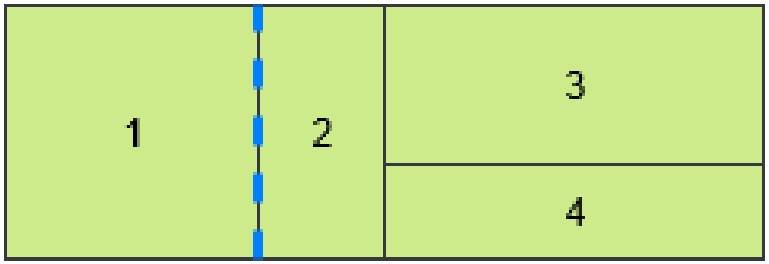
Generalisation Decisions



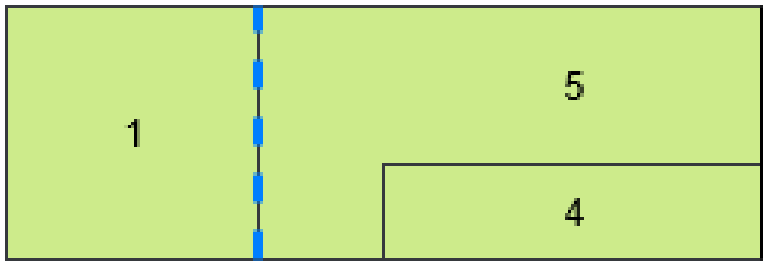
(a)



(b)

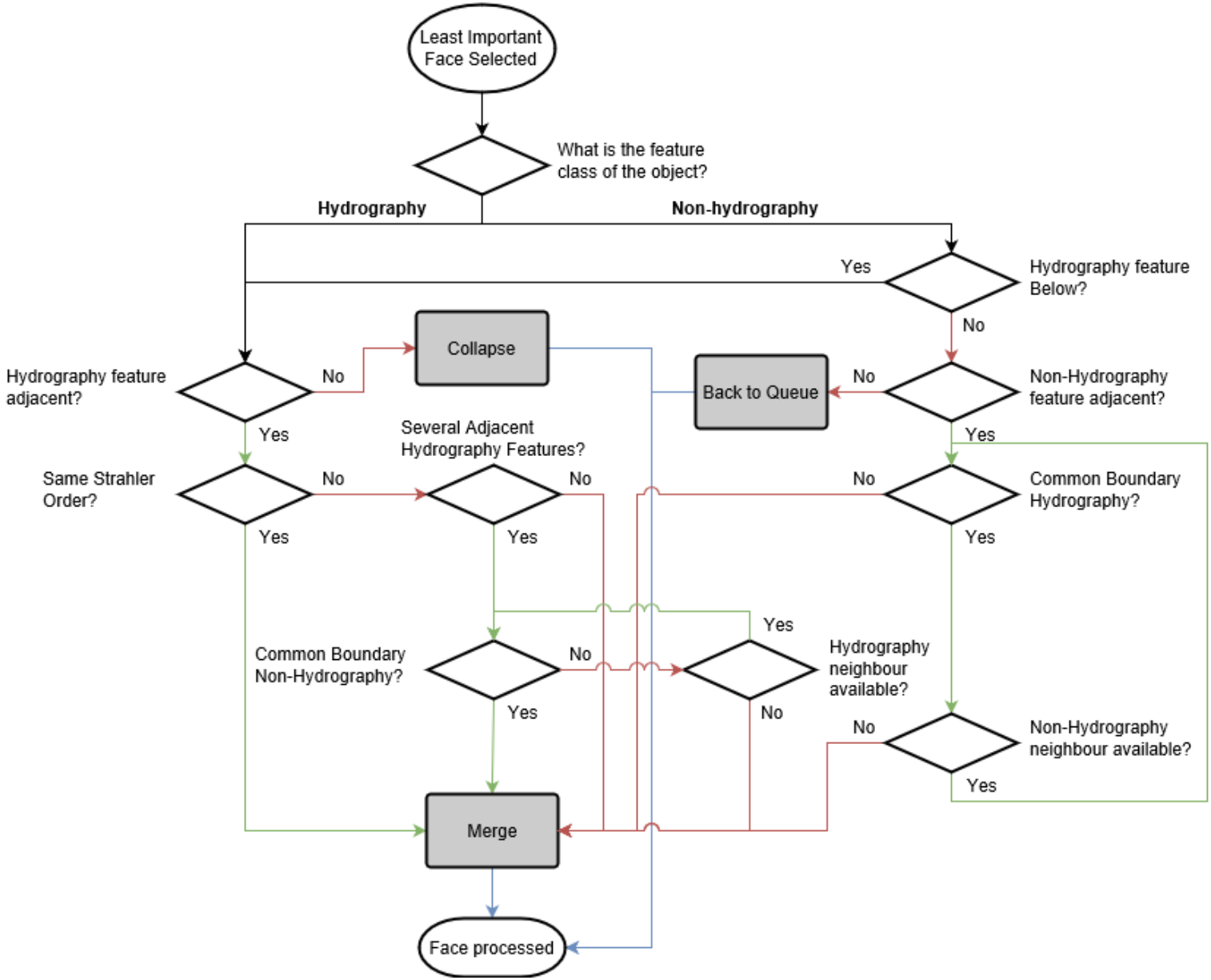


(a)



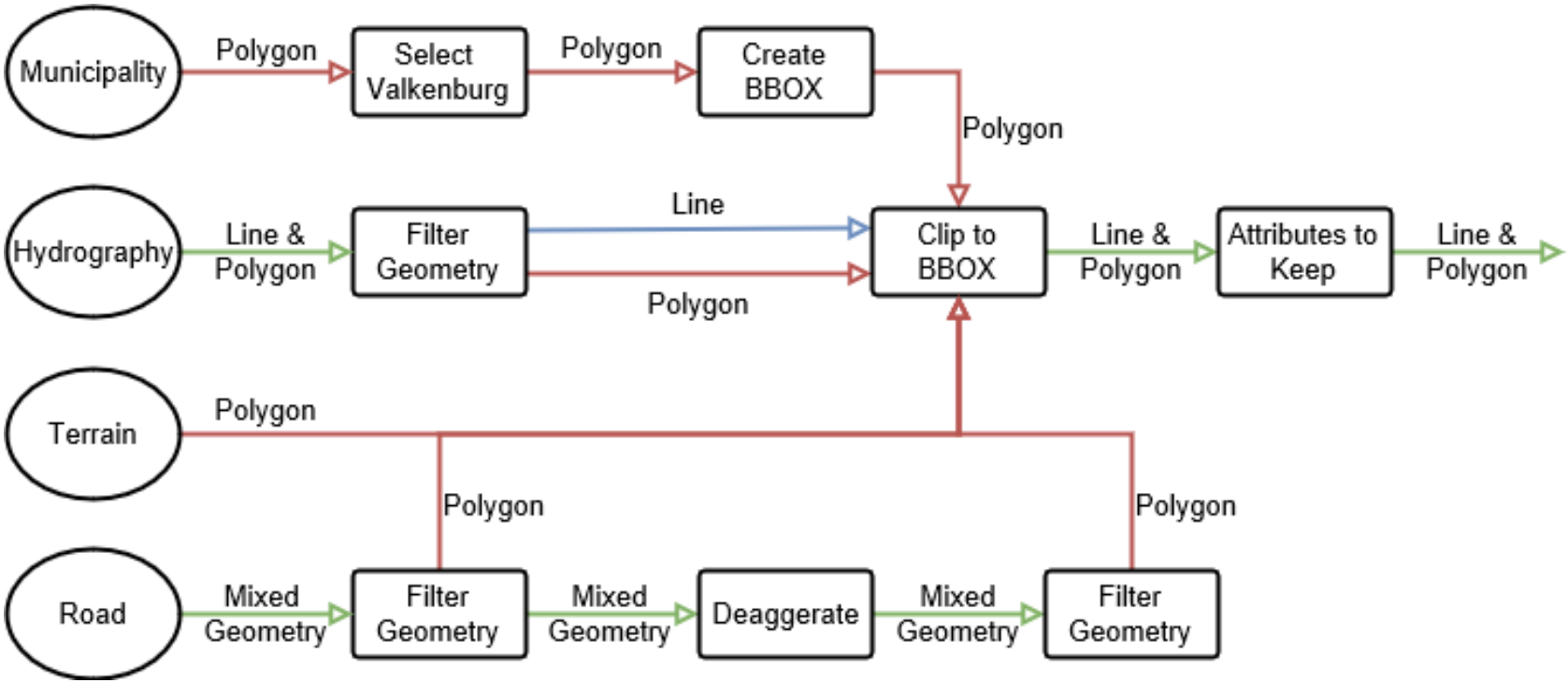
(b)

Methodology and Development



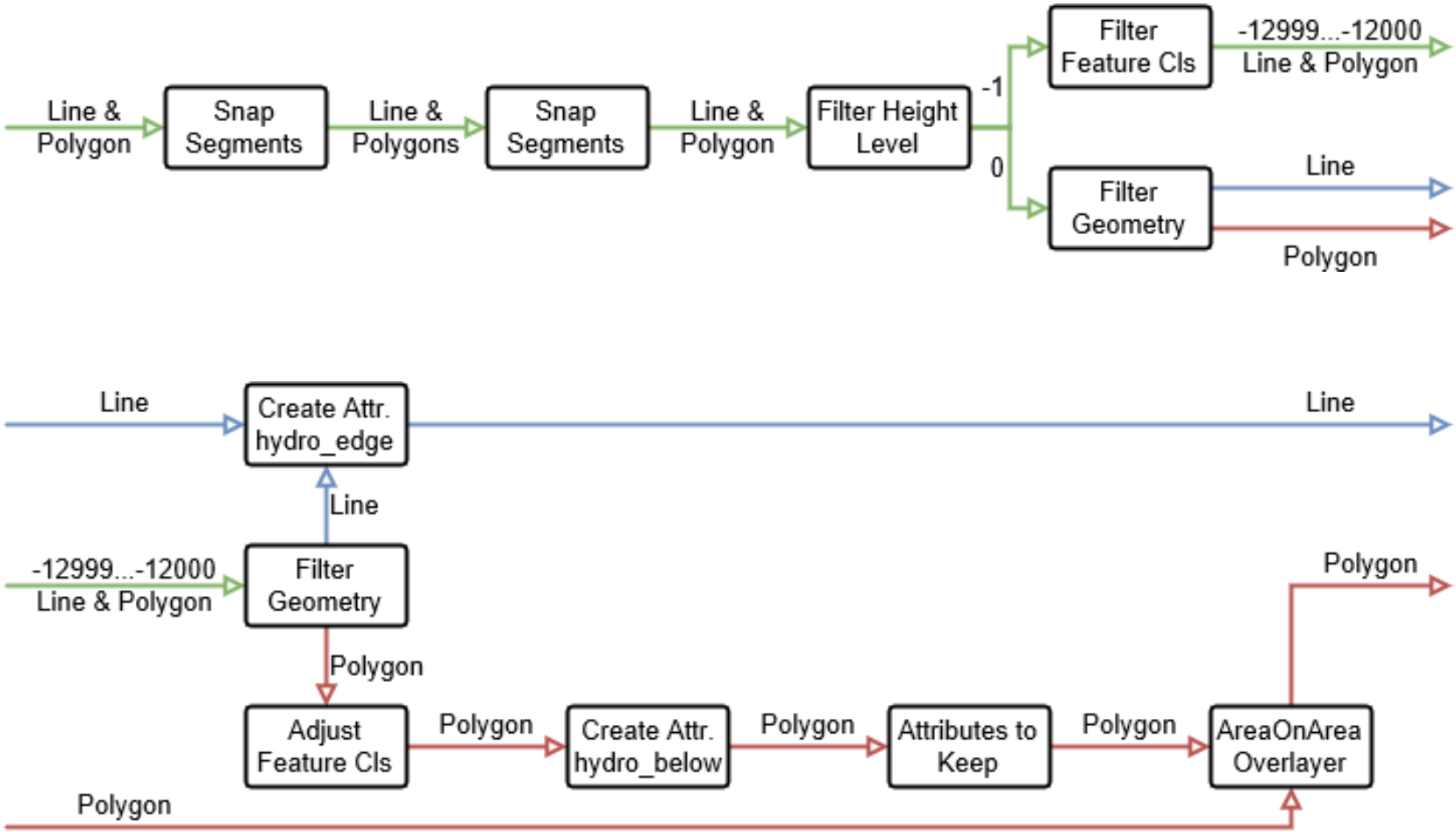
Implementation and Experiments

Pre-processing of input data



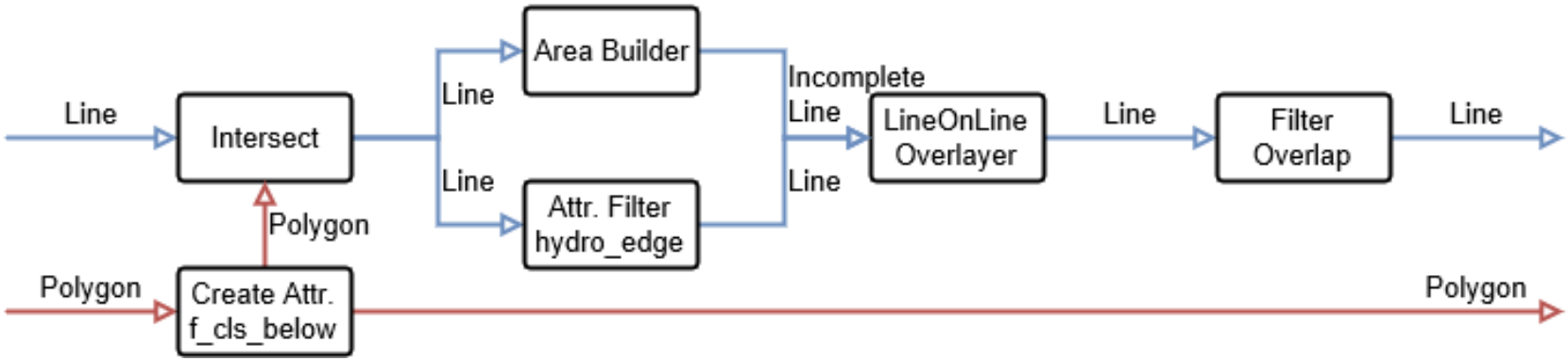
Implementation and Experiments

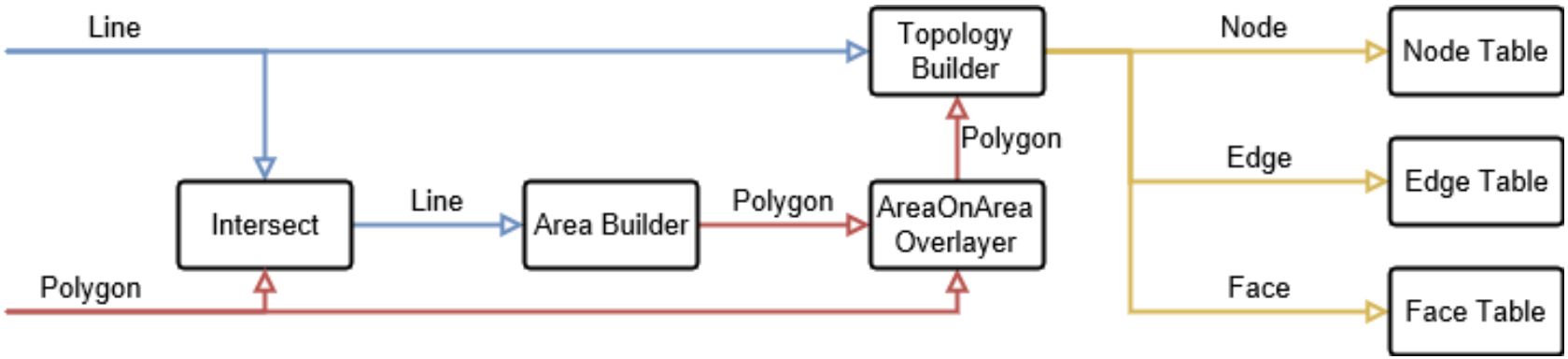
Pre-processing of input data



Implementation and Experiments

Pre-processing of input data





Implementation and Experiments

Pre-processing of input data

```
CREATE TABLE _node (
node_id integer);
```

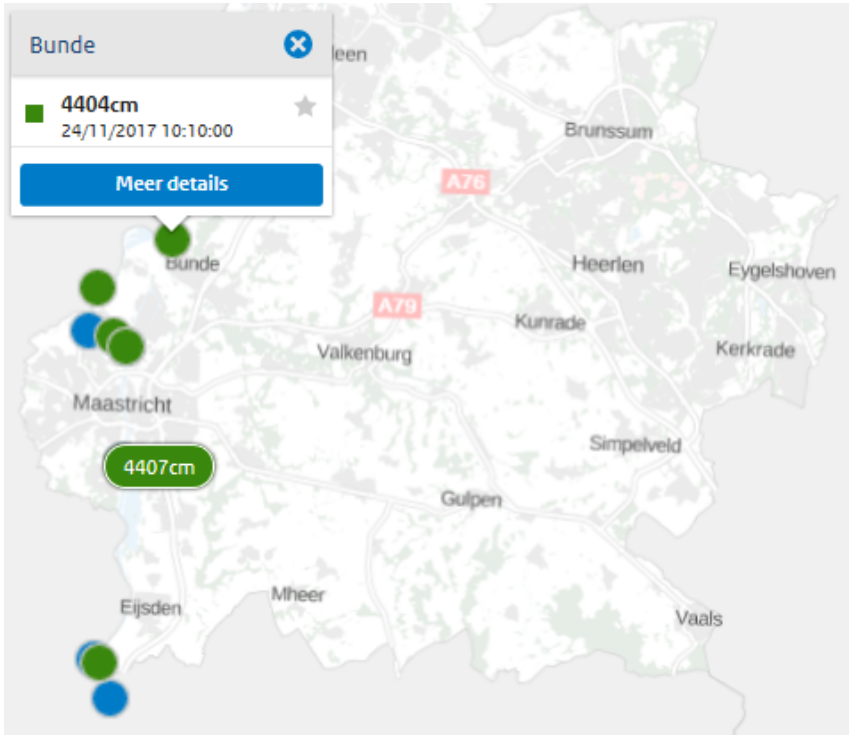
```
CREATE TABLE _edge (
edge_id integer,
right_face_id integer,
left_face_id integer,
start_node_id integer,
end_node_id integer,
edge_class integer);
```

```
CREATE TABLE _face (
face_id integer,
feature_class integer,
area float,
feature_class_below integer);
```

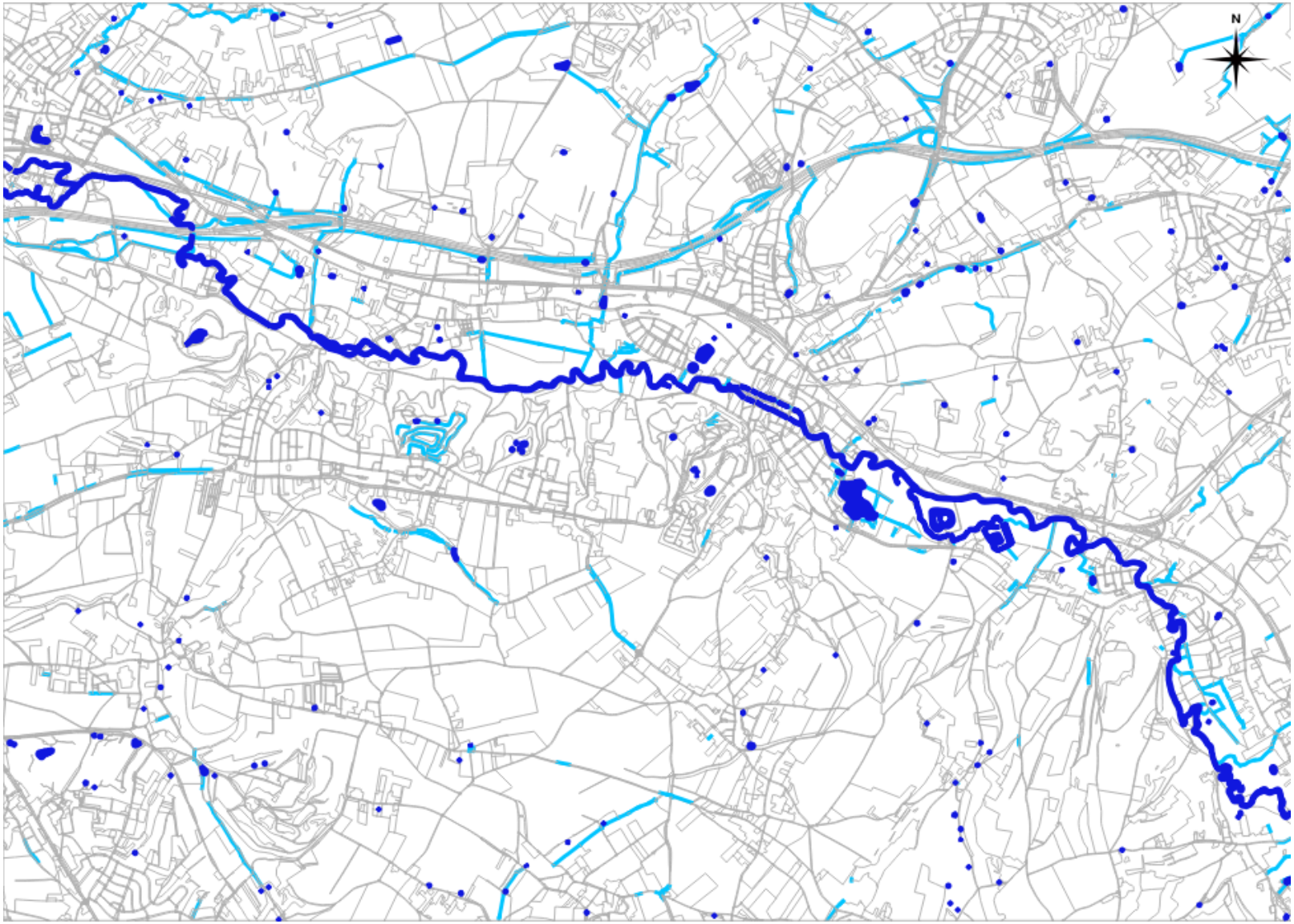
Implementation and Experiments

Determination flow direction in hydrography network

- Shuttle Radar Topography Mission DEM, resolution 30m
- Assigning elevation to hydrography features
- More detailed DEM, derived from AHN3 with a resolution of 0.5m and 5m
- Experiments give no satisfactory results
- Gauge data?



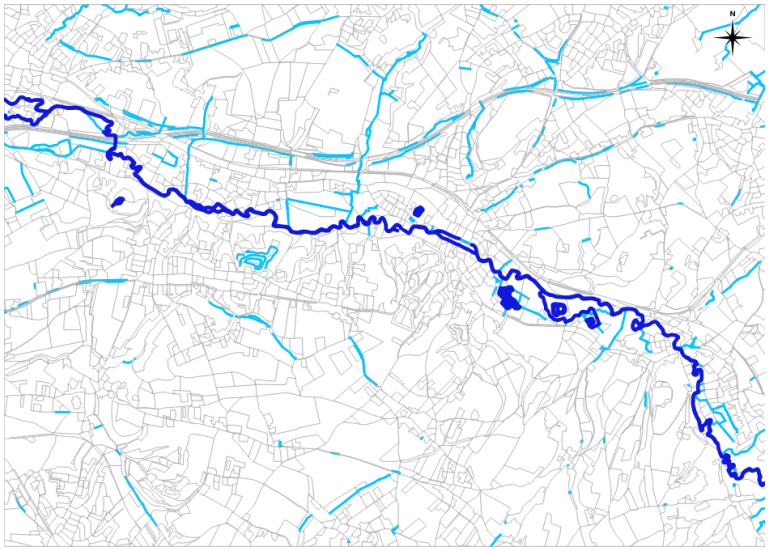
Results



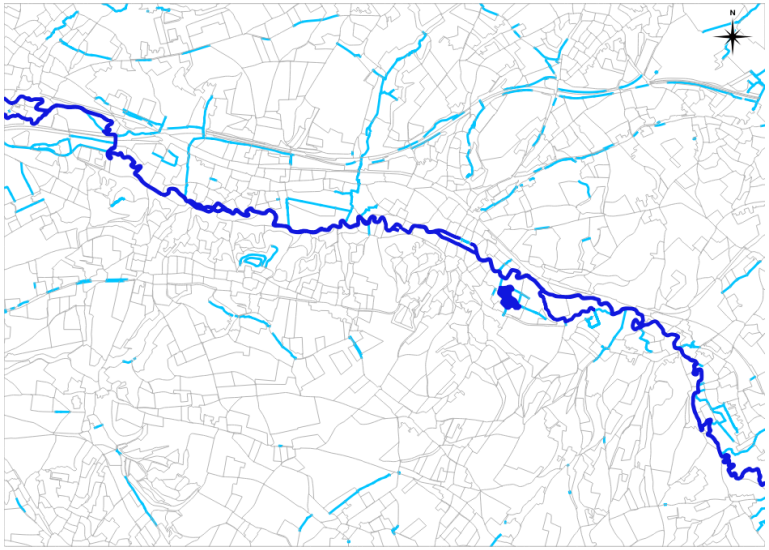
Initial tGAP data structure

Results

Vario-scale with Hydrography Decisions

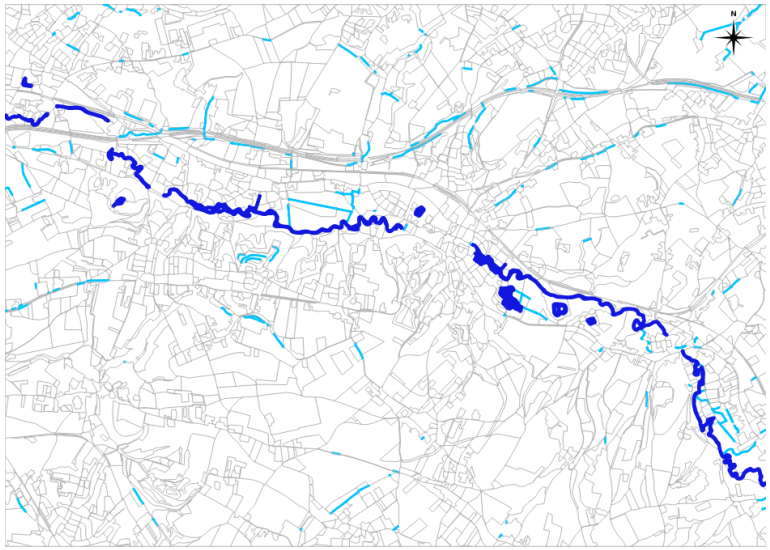


Generalisation step 8000 of 10354

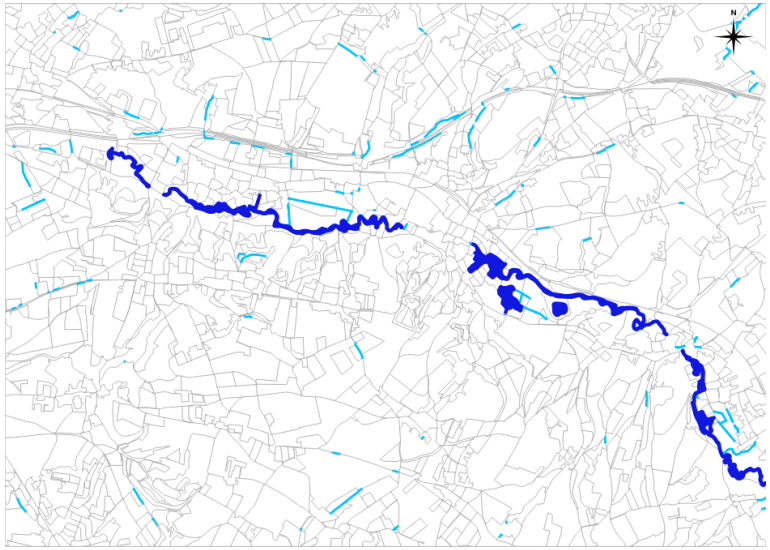


Generalisation step 9000 of 10354

Vario-scale without Hydrography Decisions



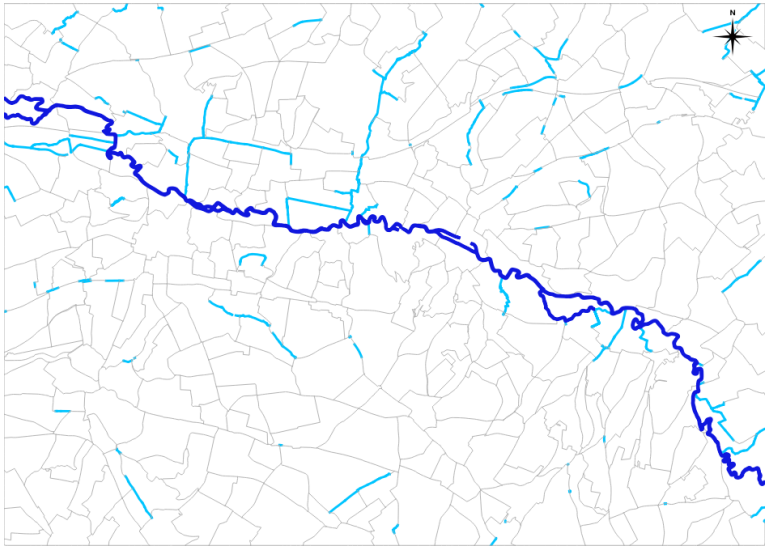
Generalisation step 8000 of 10354



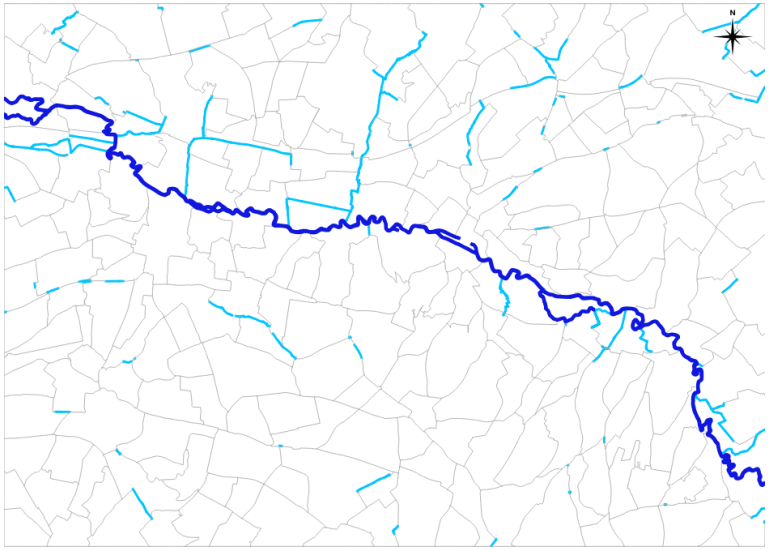
Generalisation step 9000 of 10354

Results

Vario-scale with Hydrography Decisions

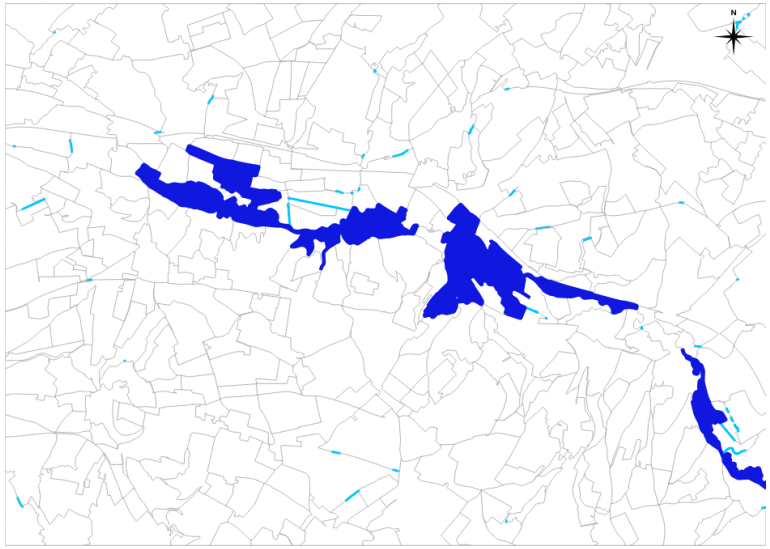


Generalisation step 10000 of 10354

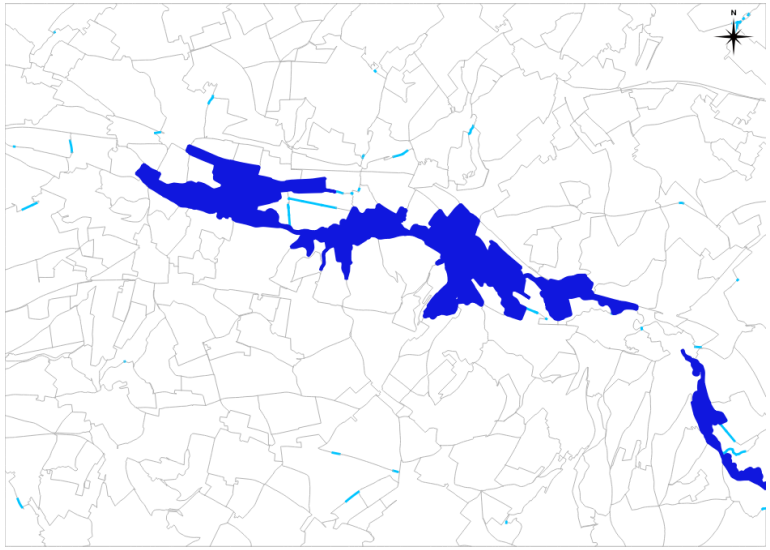


Generalisation step 10100 of 10354

Vario-scale without Hydrography Decisions



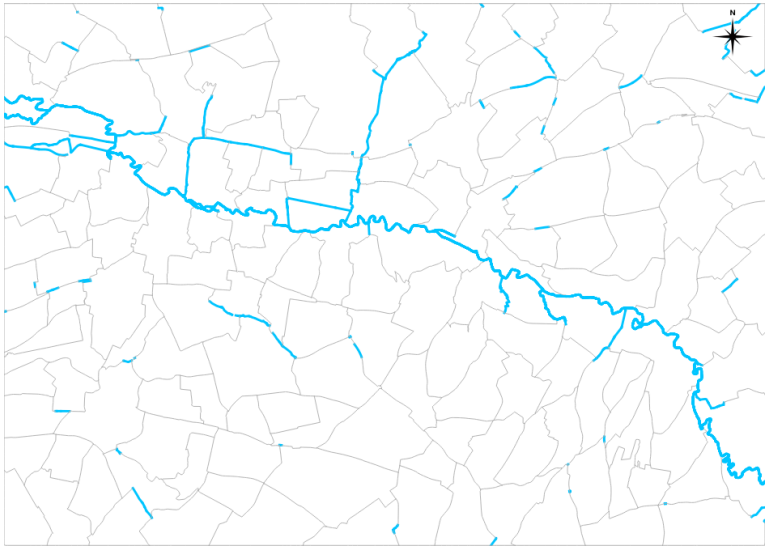
Generalisation step 10000 of 10354



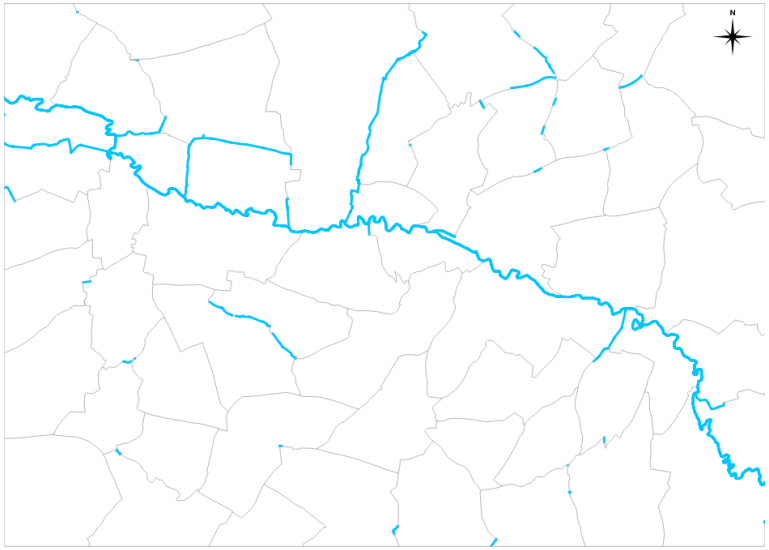
Generalisation step 10100 of 10354

Results

Vario-scale with Hydrography Decisions

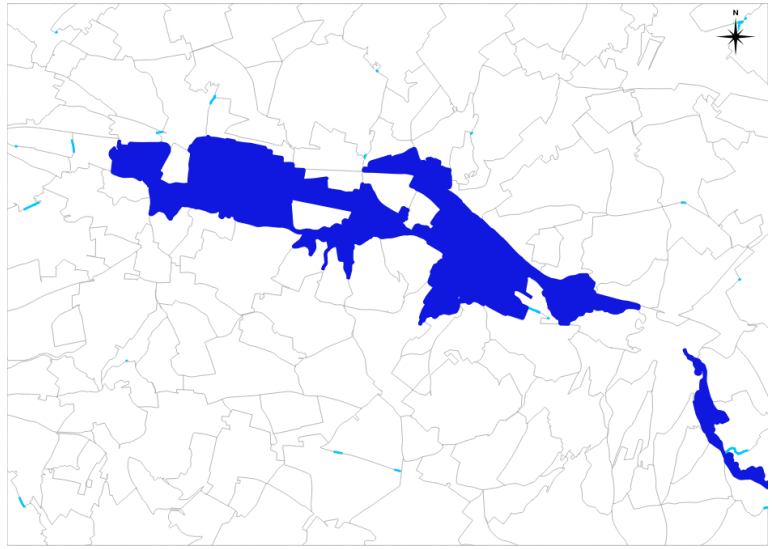


Generalisation step 10200 of 10354

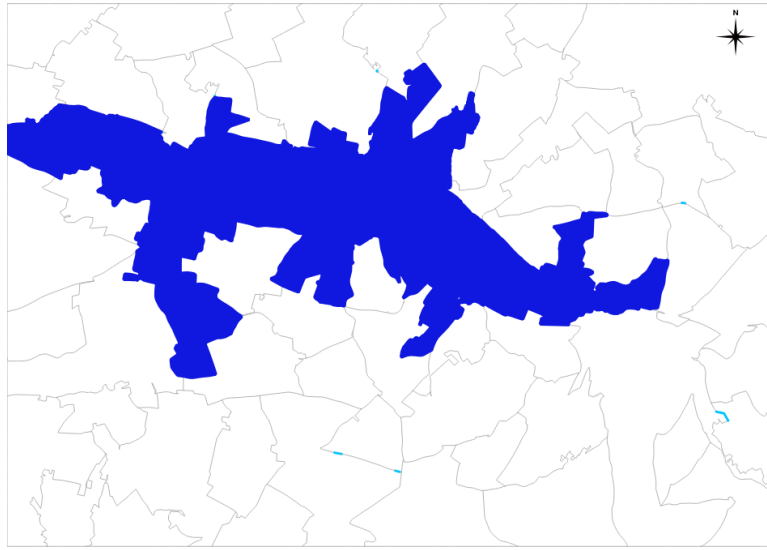


Generalisation step 10300 of 10354

Vario-scale without Hydrography Decisions



Generalisation step 10200 of 10354

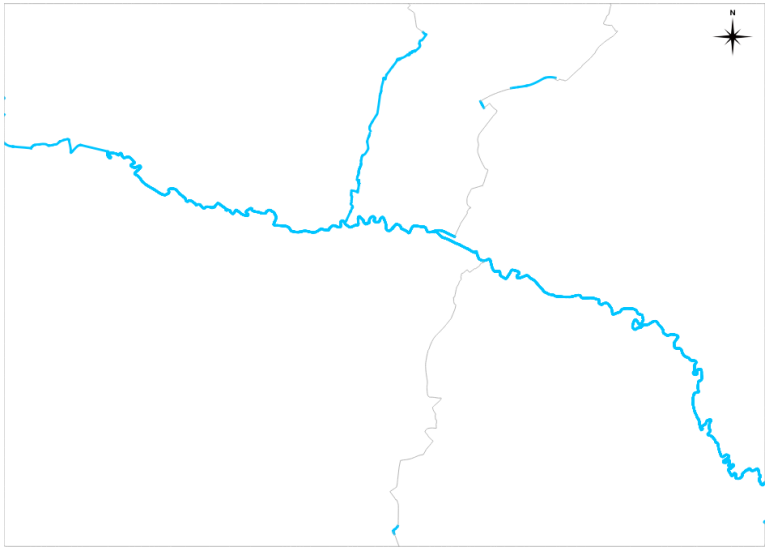


Generalisation step 10300 of 10354

Results

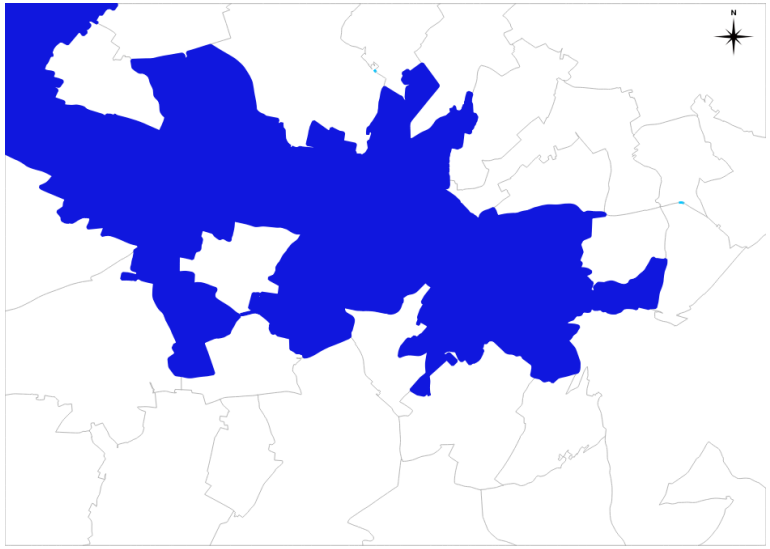
Vario-scale with Hydrography Decisions

Generalisation step 10325 of 10354

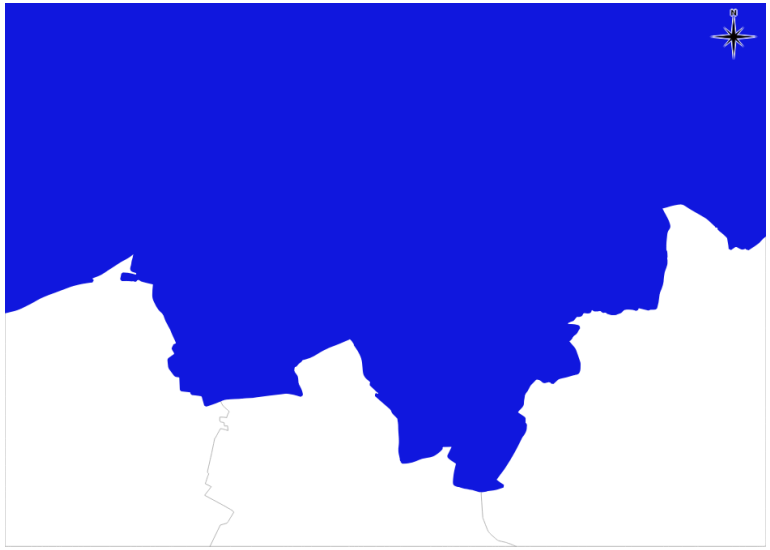


Generalisation step 10350 of 10354

Vario-scale without Hydrography Decisions

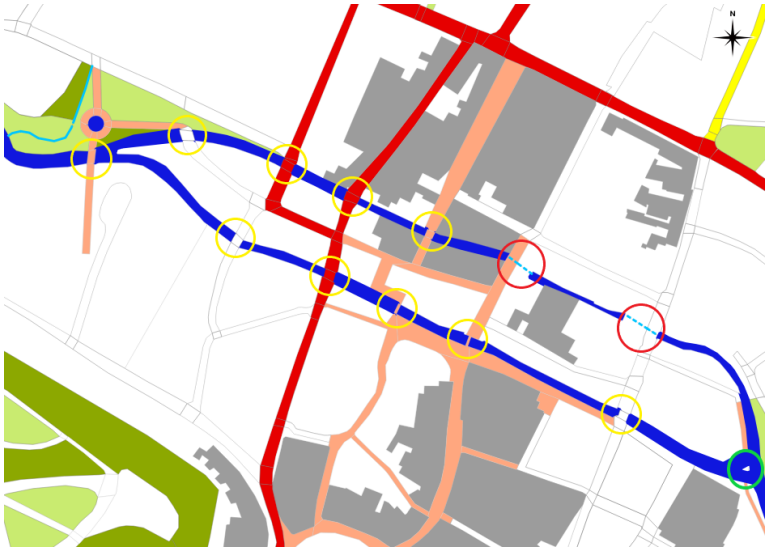


Generalisation step 10325 of 10354

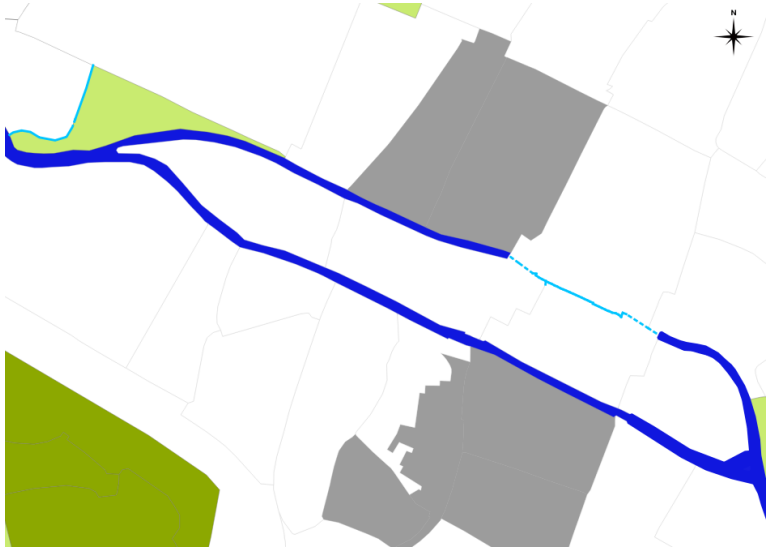


Generalisation step 10350 of 10354

Results

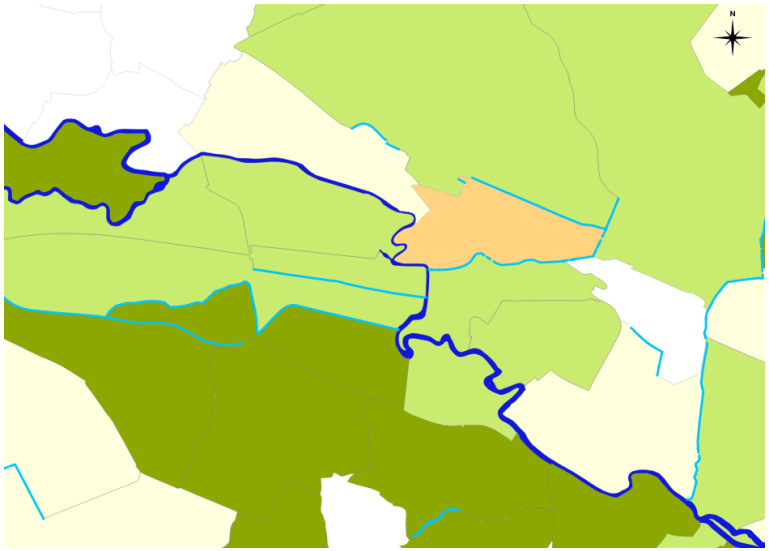


Initial

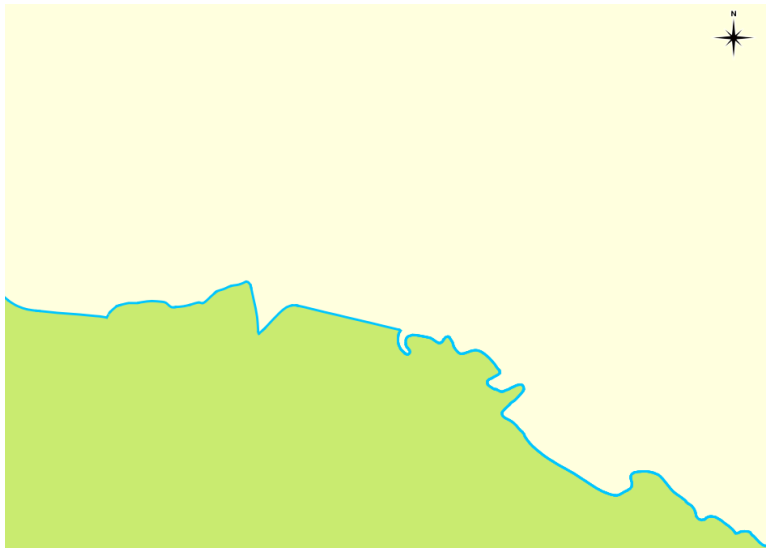


Generalisation step 8000 of 10354

Results



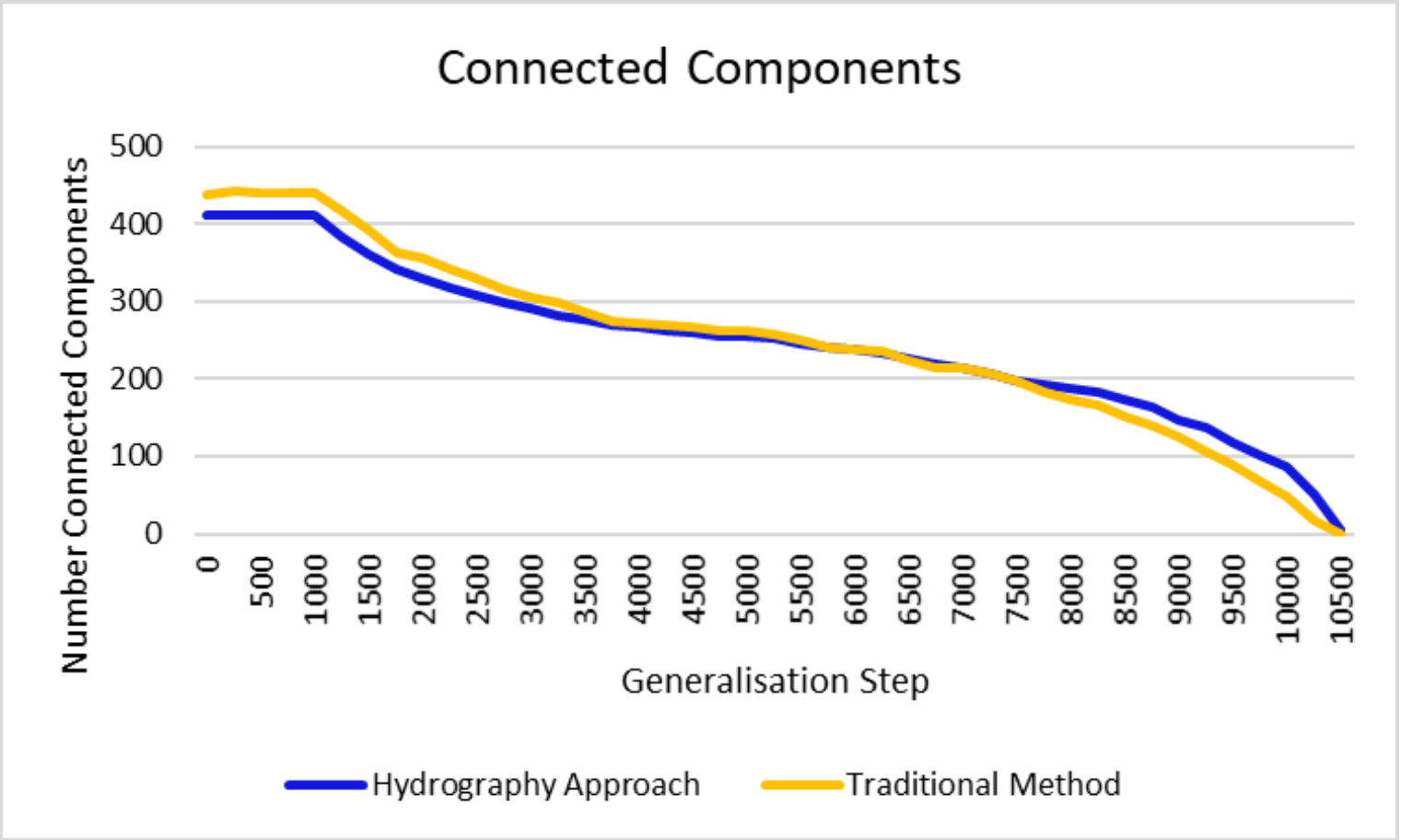
Generalisation step 10000 of 10354



Generalisation step 10350 of 10354

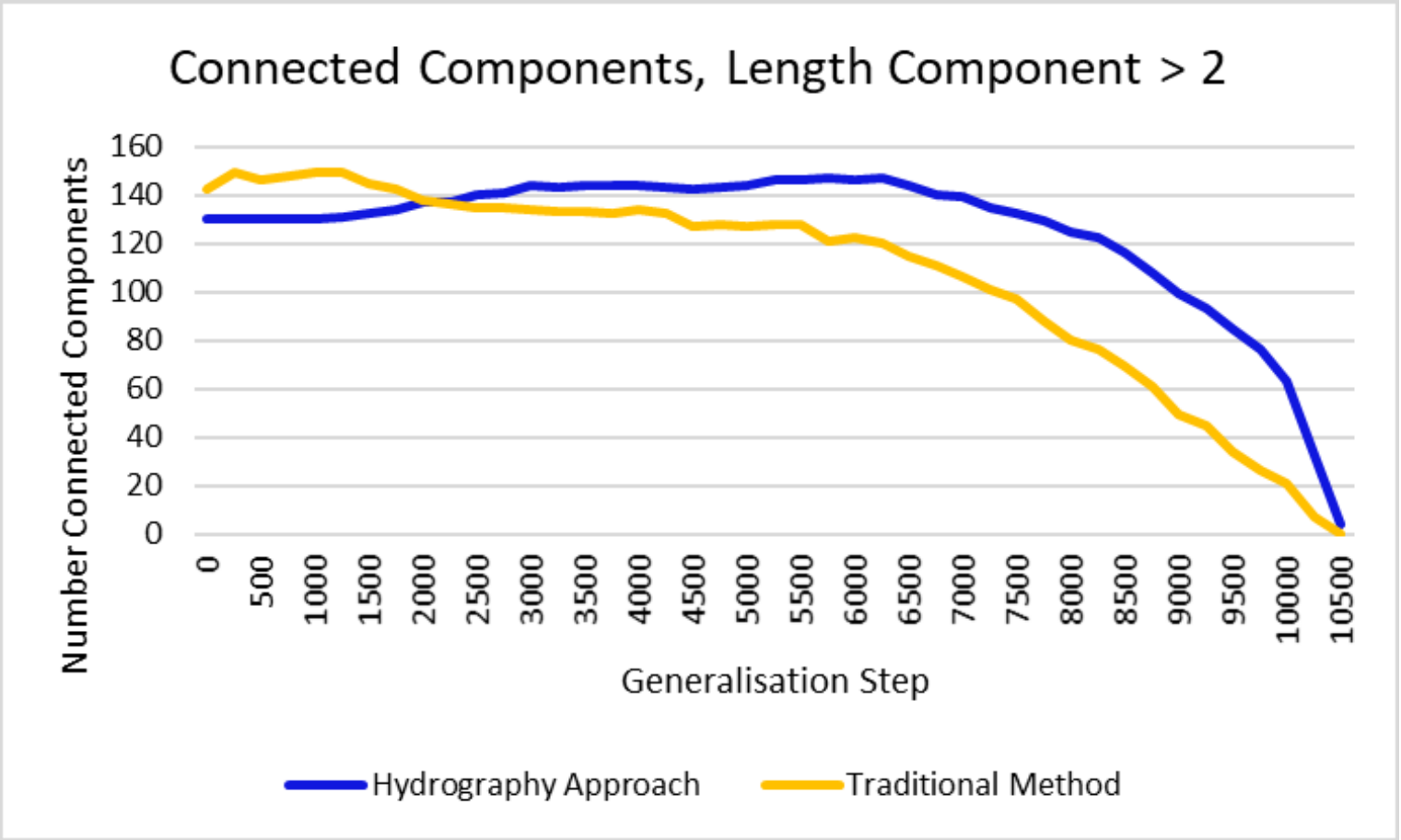
Results

Connected Components



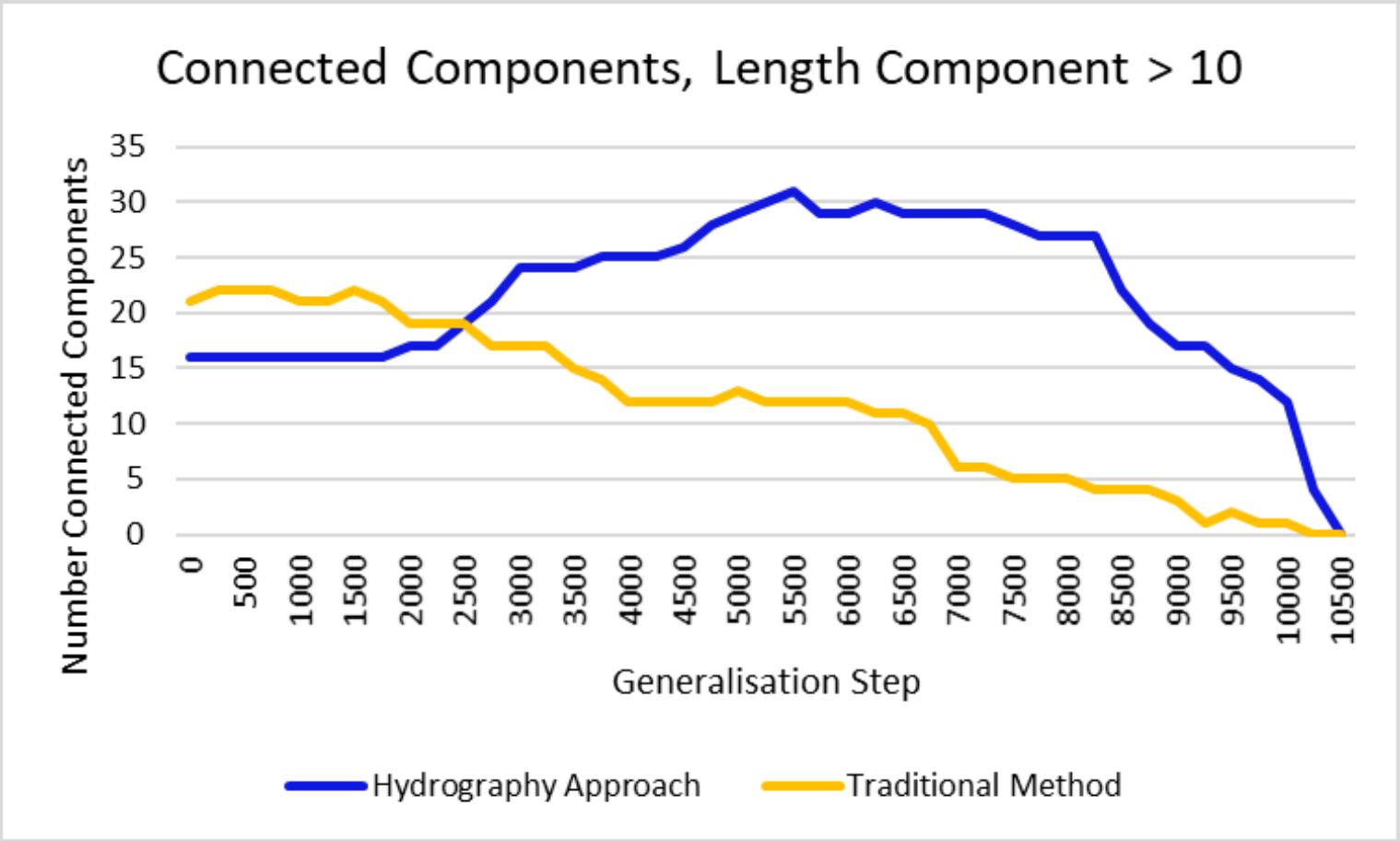
Results

Connected Components



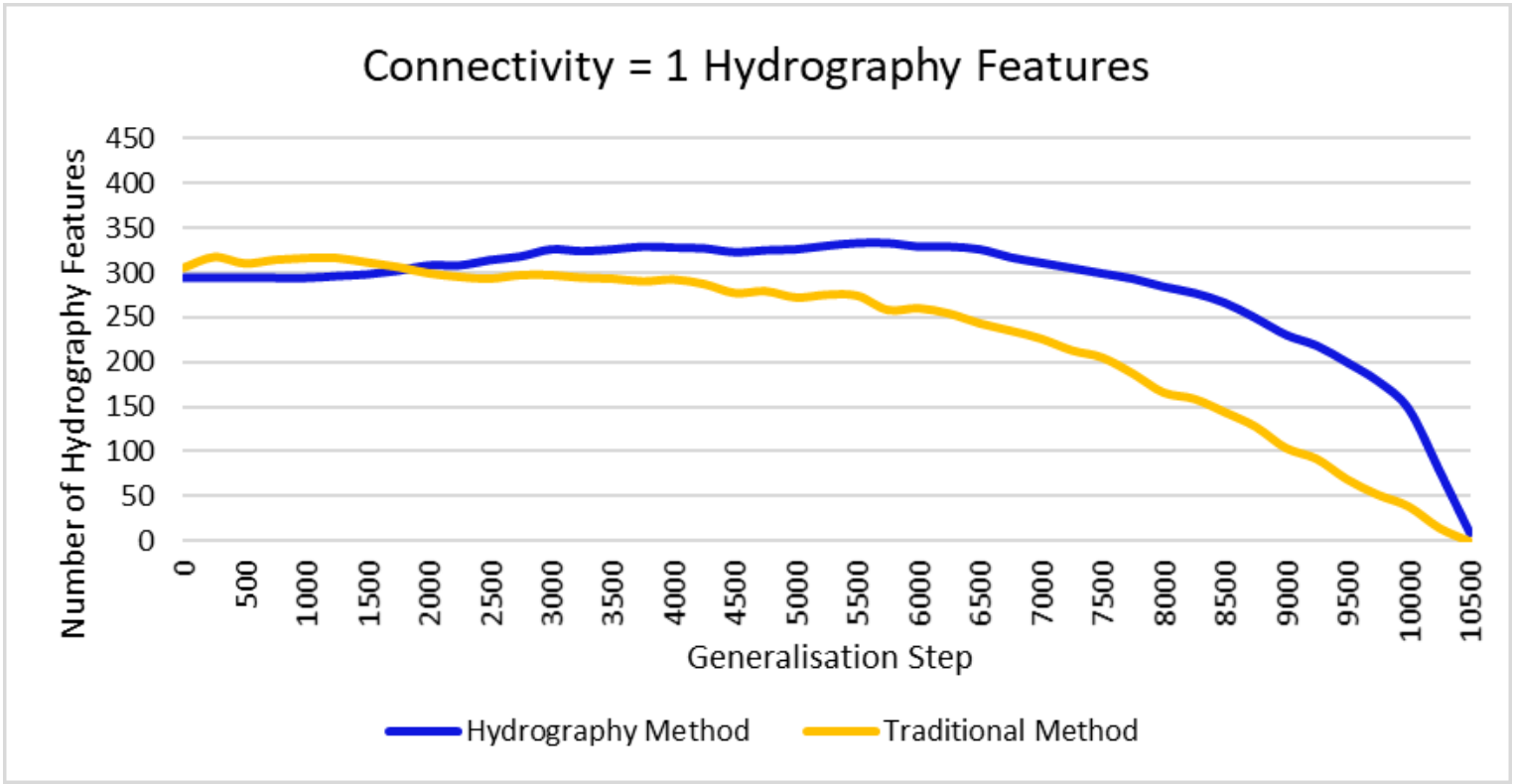
Results

Connected Components



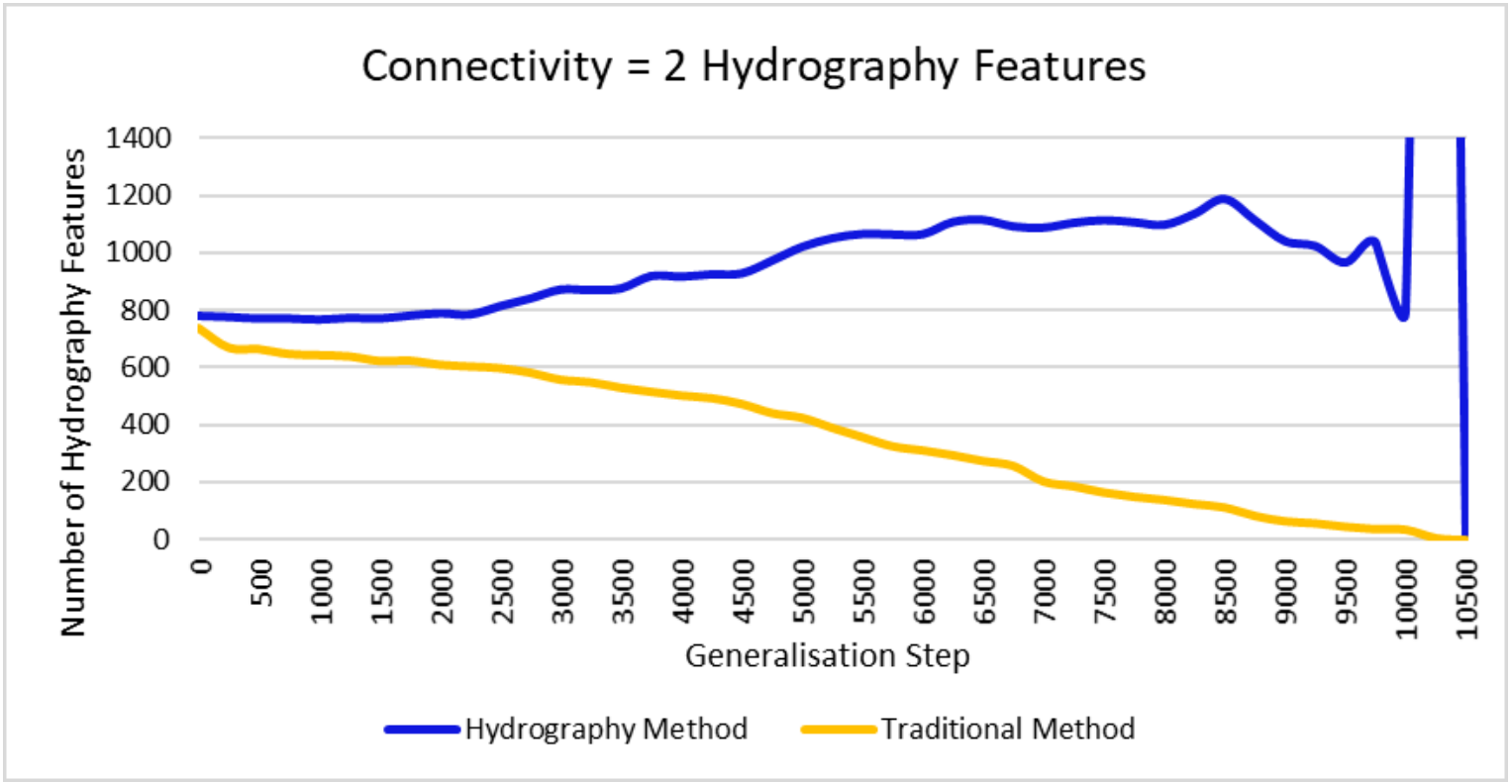
Results

Connectivity



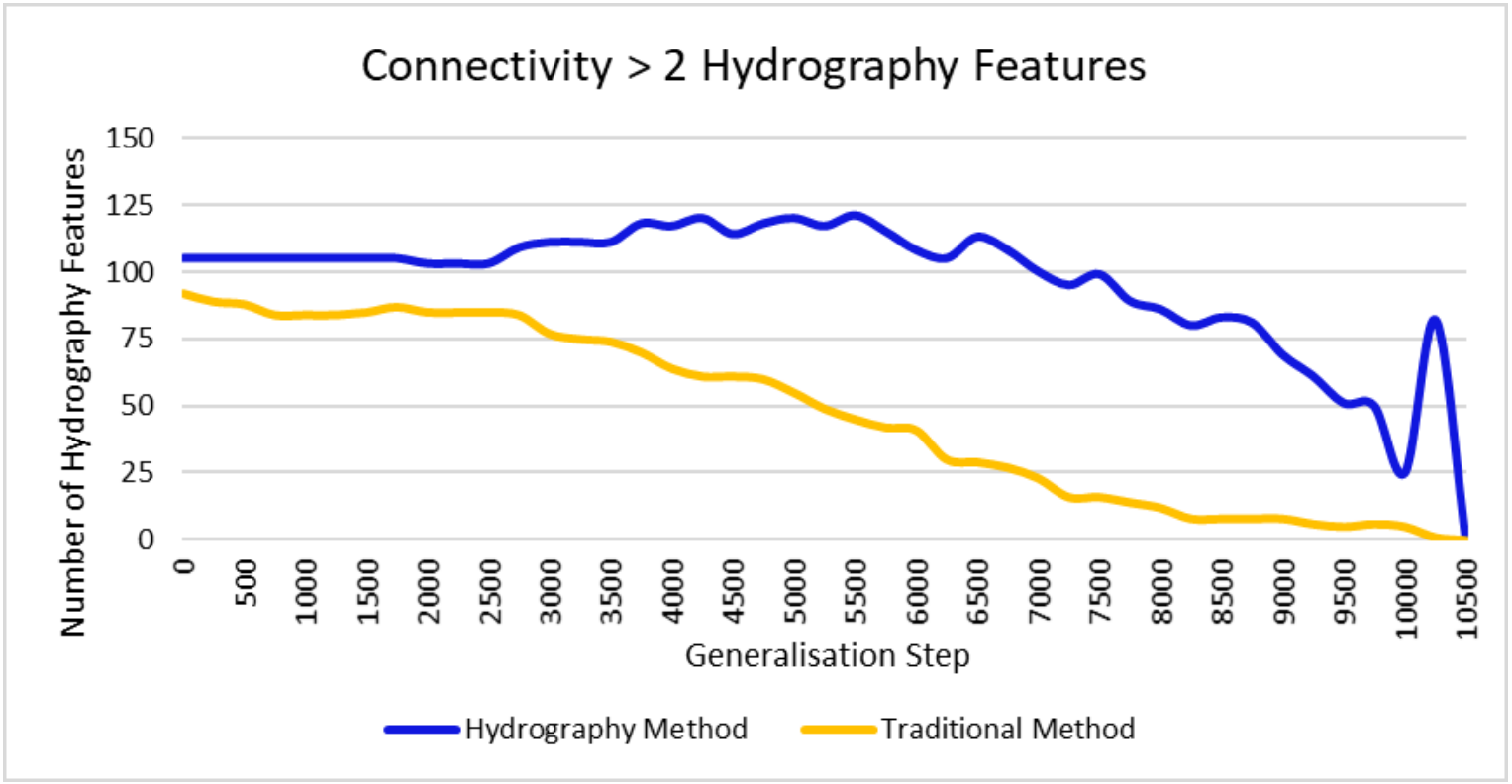
Results

Connectivity



Results

Connectivity



Conclusions

- Hydrography features that are directly below another feature are incorporated in the vario-scale concept
- Hydrography line feature are used from the start (already in initial tGAP data structure)
- Construction of hydrography networks
- Flow direction in hydrography networks
- Generalisation decisions for hydrography features does improve the generalisation results for a vario-scale basemap
- Contributes to ongoing research on vario-scale concept

Recommendations and Future Research

- Create a generic generalisation toolbox that can handle all kinds of networks e.g. road networks, hydrography network, power networks and rail networks. User provide needed information via a database table
- Line simplification
- Tests with other data sets, larger or smaller starting scale
- Integration road networks and hydrography networks
- Test with large data sets
- Scale dependent decisions?
- Add labels to features
- Importance Function for selecting which face to process
- Other purpose of map, besides basemap
- Lines in the processing queue

Thanks for your attention!

IJsbrand Groeneveld
i.j.d.g.groeneveld@student.tudelft.nl