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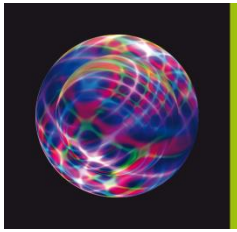
Nanaimo Water Pipes Utility Network ADE Sample



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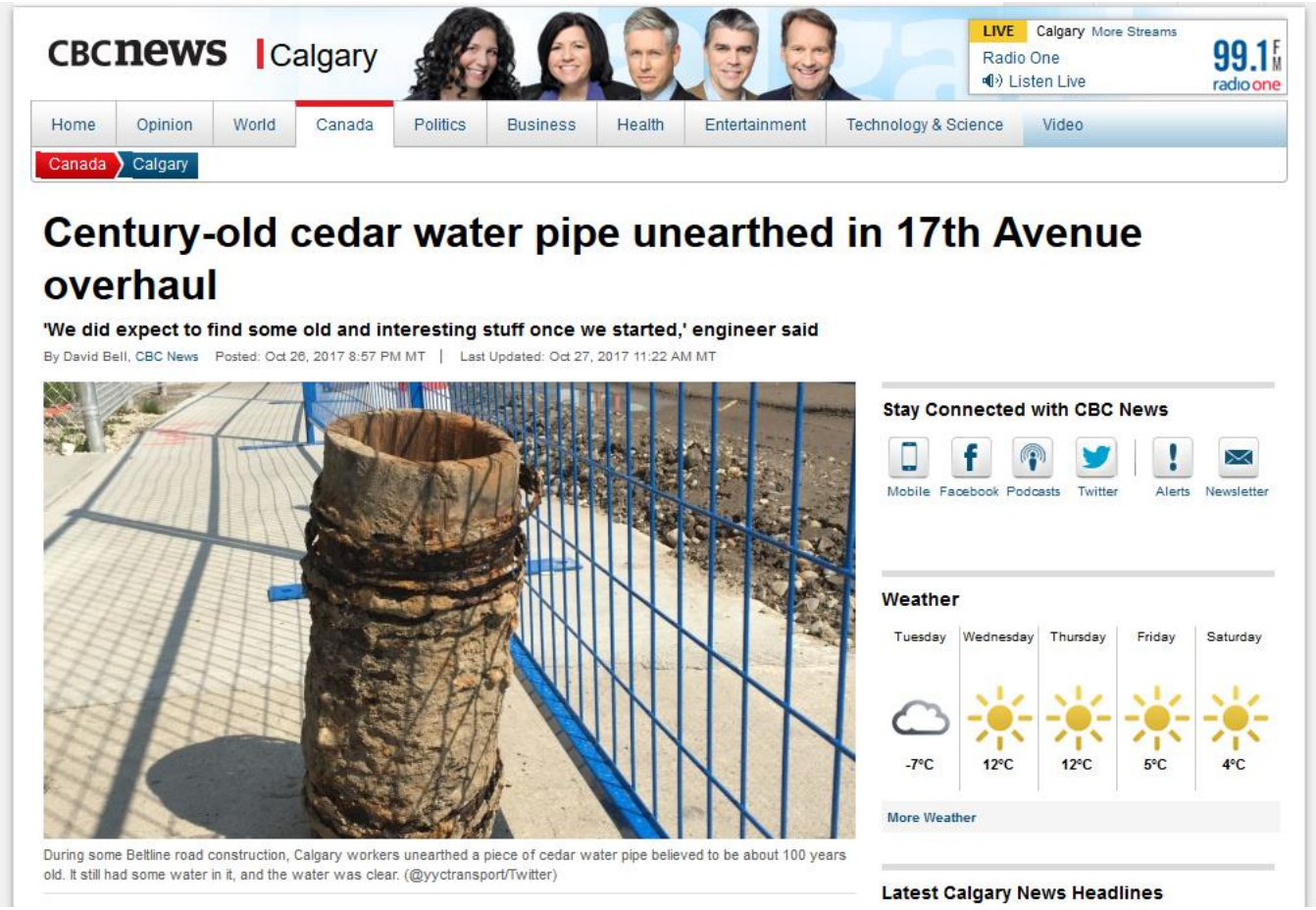
Current stage of development
2017-12-08

Technical University of Munich

EDF

KIT Karlsruhe Institute of Technology

New Material Type???



Source: http://www.cbc.ca/news/canada/calgary/cedar-pipe-found-beltline-construction-1.4374531

"These pipes were used in Calgary pre-1910 and they started to decommission them in the mid-1900s. This particular stretch of roadway had the water lines replaced about 100 years ago, give or take, and so this will be the second replacement in as many years,"

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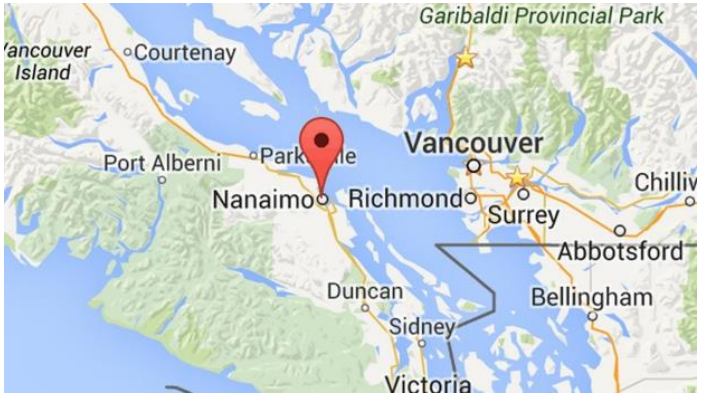
Recap – Study Area

Nanaimo

Small coastal city in British Columbia, Canada.

They have recently published some of their utility network data on their website.

http://www.nanaimo.ca/EN/main/departments/Engineering-Public-Works/GIS/DigitalData.html



Recap - Source Data

Nanaimo Water Pipe Network

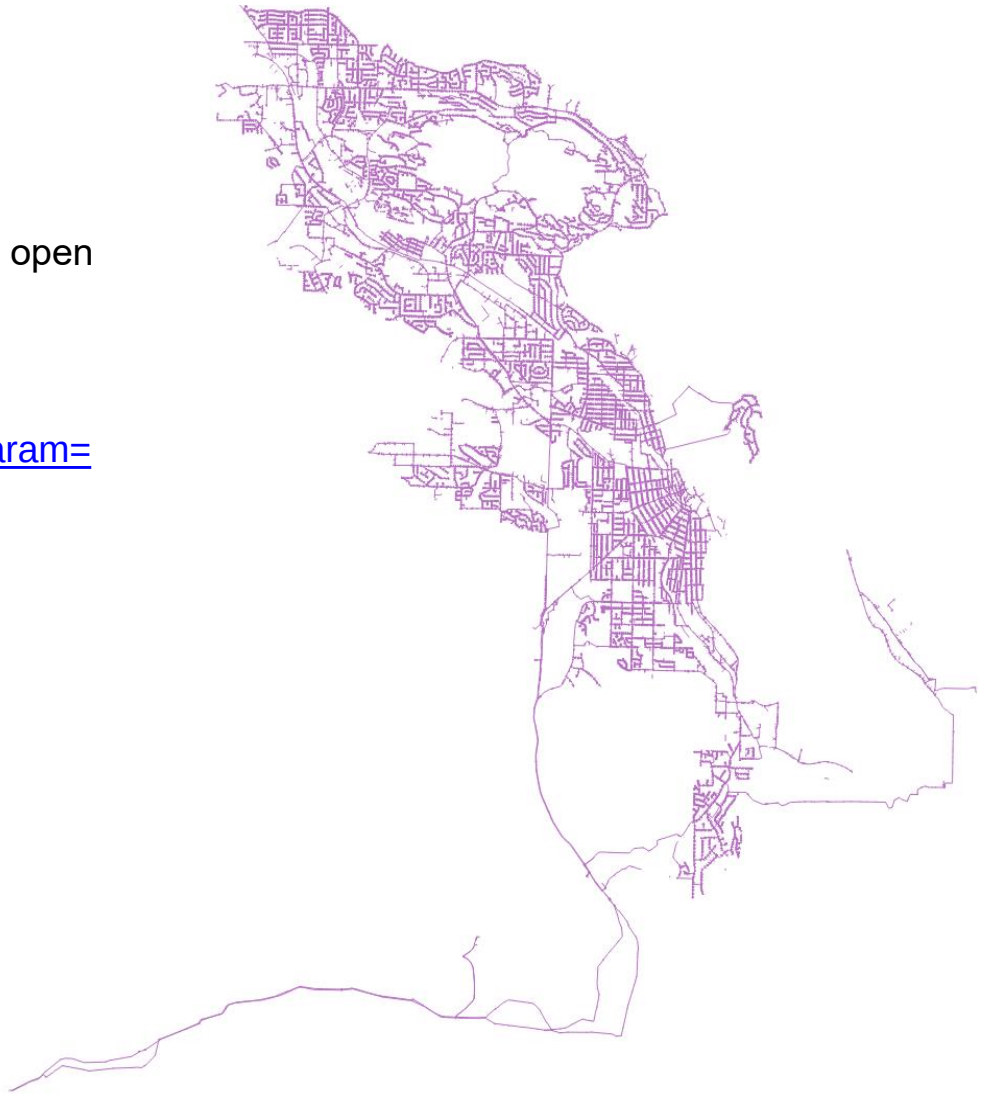
Published in “Nanaimo Data Catalogue” as open data.

https://www.nanaimo.ca/open-data-catalogue/DataBrowser/nanaimo/Water#param=NOFILTER--DataView--Results

Delivered in SHP format (among others)

Contains information about diameter, pipe material, installation date and locational accuracy.

There is also data for parcels and building footprints.

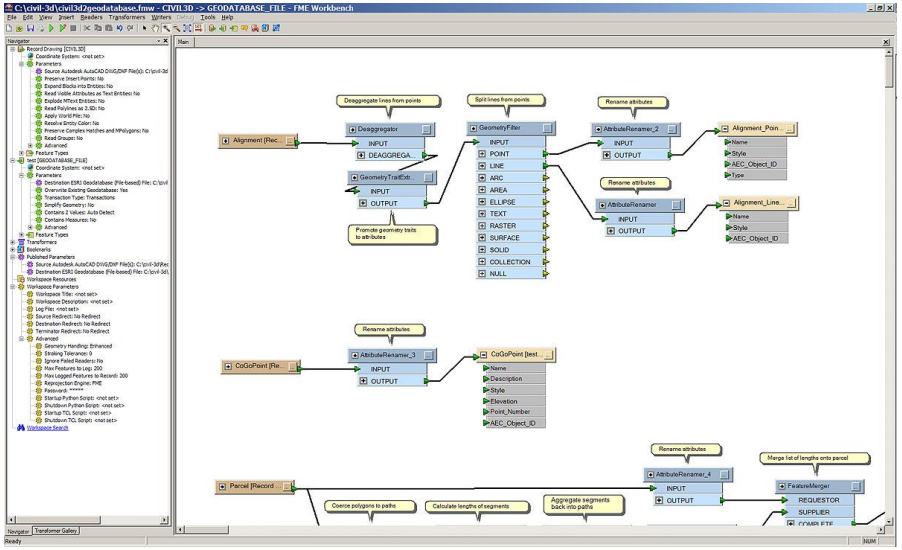


Recap - Feature Manipulation Engine (FME)

Proprietary (but flexible for students/researchers) software used to translate data from one format to another.

Graphical programming, uses connected “transformers” to manipulate the data from input “readers” to output “writers”

Allows for highly-customizable workflows to solve complex transformation problems.



Recap – Last Version

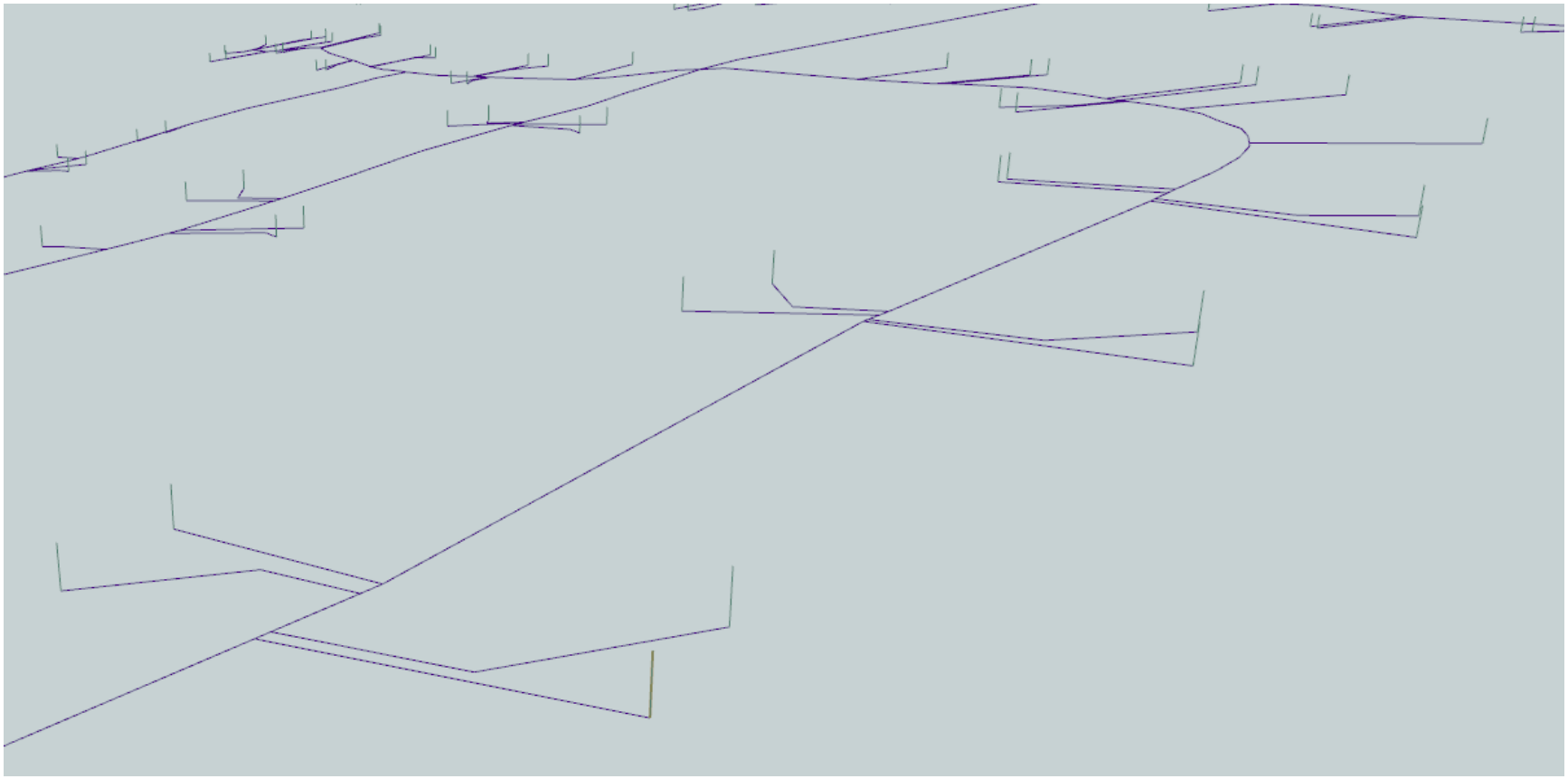
The last version of the FME workbench and produced data sample focused on a subset of the source data.

Results were stored on the UtilityNetwork ADE github:
https://github.com/TatjanaKutzner/CityGML-UtilityNetwork-ADE

The sample contained examples of:

1. A Network Element
2. A NetworkGraph Element
3. LiquidMedium Element
4. ExteriorMaterial Elements
5. RoundPipe Elements
6. TerminalElements
7. Node Elements
8. InteriorFeatureLink Elements
9. FeatureGraph Elements
10. InterFeatureLink Elements

Recap – Last Version



3D View of the last version of the data sample. Picture from FME Data Inspector.

Scope

The previous version only worked for a small spatial subset of the source data. Further, it used a manually-preprocessed version of this subset.

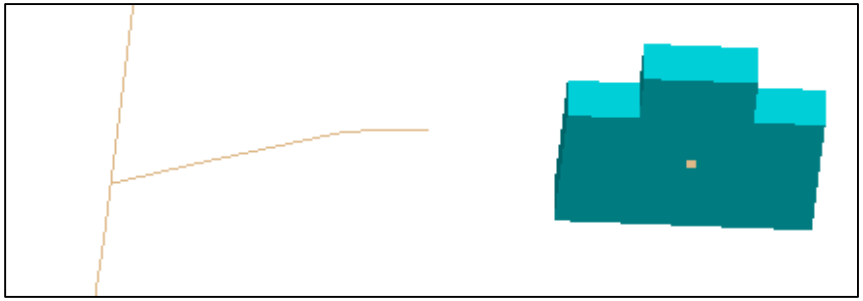
The new version now works for the entire source data, and does all the necessary preprocessing at the beginning of the workbench. The preprocessing is explained in greater detail in the supplementary info.

However, when converted to CityGML, the sample is very large (~440MB). Difficulties are likely to be encountered and rendering this amount of data on a non-high-performance computer.

Buildings & TerminalElements

Buildings have been added as Building elements (LoD1 extrusions) from the “Building Footprint” and “Parcel” shapefiles.

TerminalElements (along with an associated punctual FeatureGraph) have been created as the centroid of the base of the Building elements. Buildings are related to their respective TerminalElements via their “connectedCityObject” property.

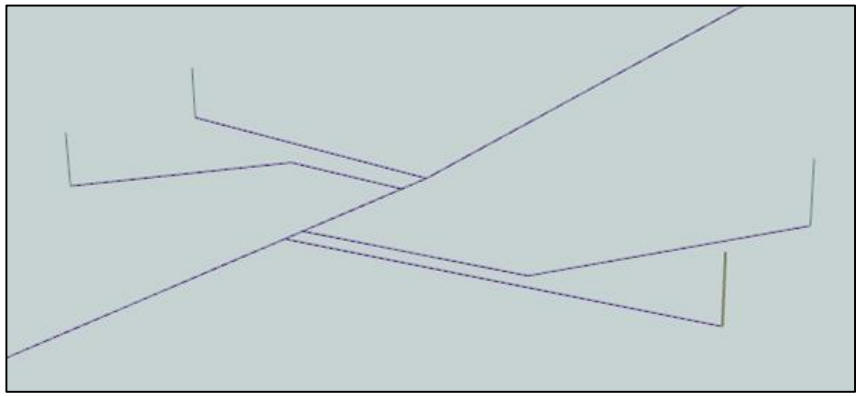


Buildings and associated TerminalElements in the new sample.
This view is looking upwards from under the building. (Image from FZKViewer)

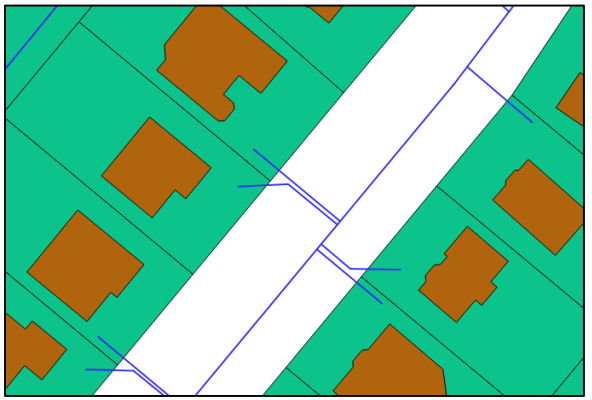
Service Lines

The previous version used a method by which the associated parcels dataset from the Nanaimo Data Catalogue were used to create vertical pipes where the house service line pipes entered them.

While aesthetically appealing, it was not geometrically accurate, nor logical, because the resultant pipes both did not exist, and did not necessarily connect to the buildings associated with each parcel.



3D View of the vertical RoundPipes added in the old version of the data sample.

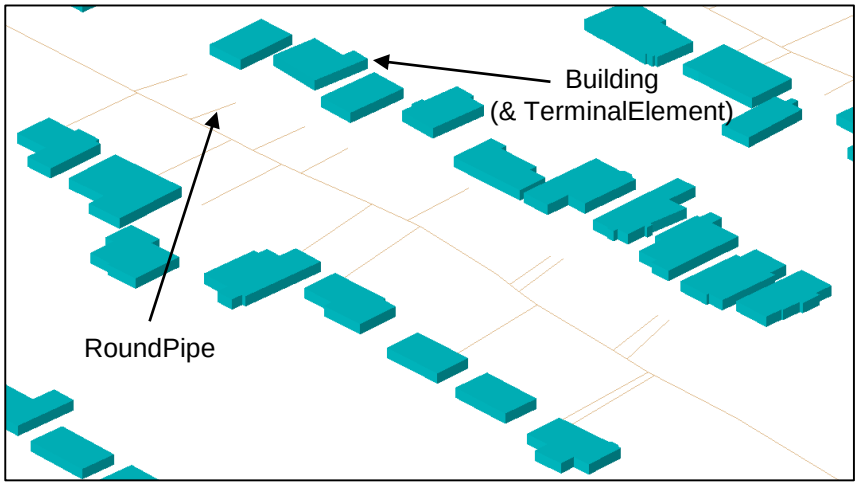


2D View of the source data shapefiles, showing that the service lines do not end under the buildings.

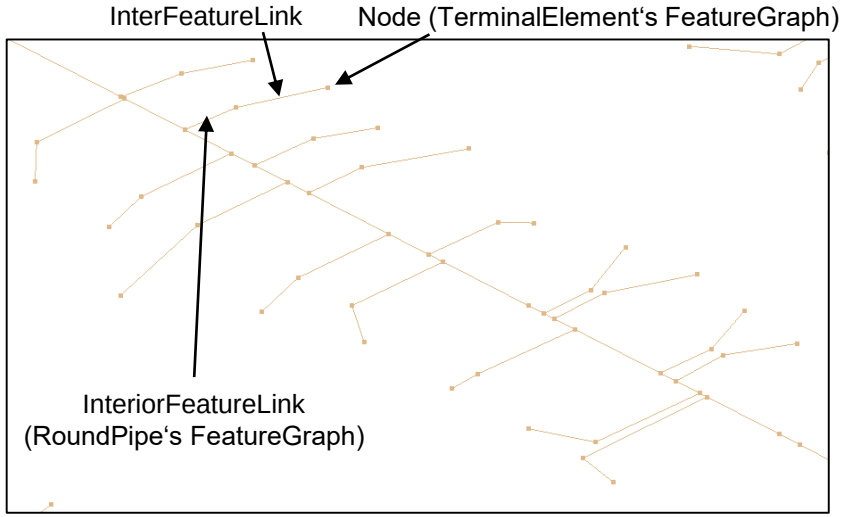
Service Lines

In the new version, no additional pipes are created.

Instead, the geometrical representation (RoundPipes) is left alone, but the topological representation is given a new InterFeatureLink connecting the Nodes representing the end of the service line and the Building's TerminalElement.



Geometrical representation (3D) - RoundPipes, Buildings &TerminalElements (Points directly under Buildings). Picture from FZKViewer.



Topological representation (2D) – InteriorFeatureLinks, Nodes & InterFeatureLinks. Picture from FZKViewer.

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Service Lines

This better handles the lack of data about the connection between the water pipe network and the houses by employing a conceptual separation of geometry (real) and topology (abstract).

The realization geometry helps to visualize the connection from service line to building without assuming any physical features or properties.

It also handles better cases where a single parcel may contain multiple buildings.

An instance of many buildings, all from the same parcel having their TerminalElement Nodes connected to the NetworkGraph at the same service line node. Picture from FME Data Inspector.

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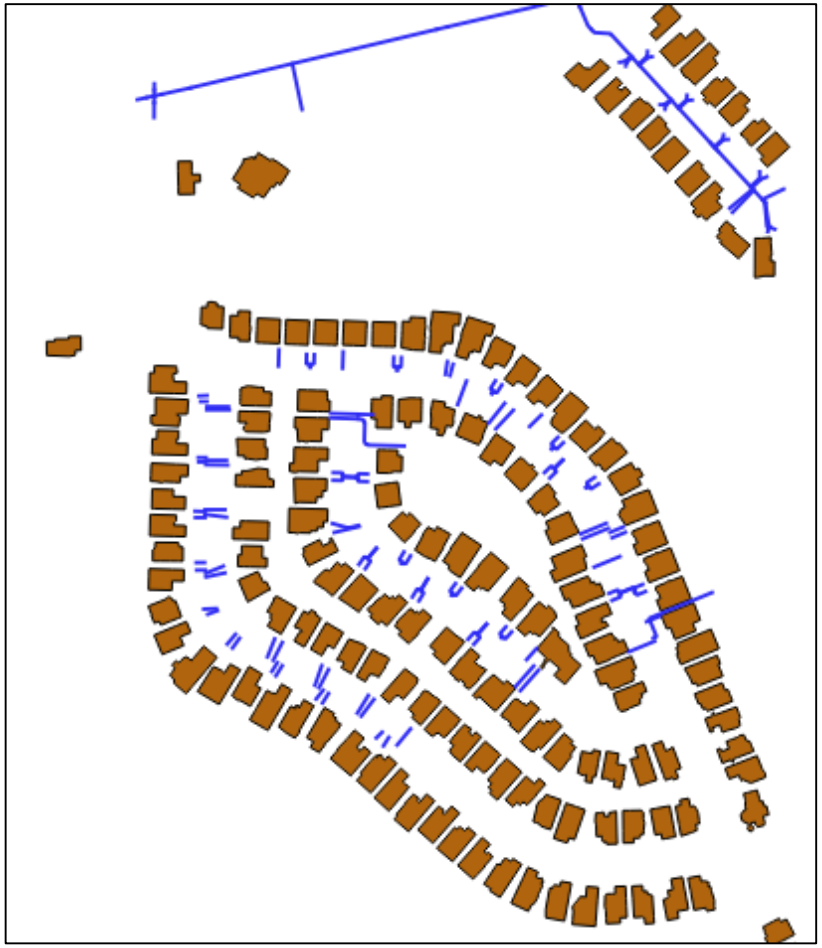
Incomplete Data

There are still some challenges in creating the sample.

The source data still has some imperfections that sometimes prevent complete conversion, for example missing pipes.

Currently, the method for dealing with this is to exclude all “orphaned” service lines (service lines with no connected main line).

Future…



Missing main lines in source data. Picture from QGIS.

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Agglomerations

Another challenge is the handling of complex agglomerations.

Most notably in the downtown area, there are buildings that span multiple parcels.

Sometimes, pipes run directly through parcels.

A method should be devised to partition the buildings per parcel in these cases.

Downtown area of Nanaimo showing complex building Agglomerations spanning multiple parcels. Picture from QGIS.

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New Data Sample

The new data sample is an improvement on the last version.

Moving the preprocessing steps into FME allows for a “plug-and-play” mentality where any or all of the data can consistently be converted from its original format.

The addition of buildings with associated TerminalElements will be beneficial for modeling consumption.

The new system of modeling the connections from the service line pipes to the buildings conforms better to the “dual representation” principle on which the UtilityNetwork ADE is based.

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Reservoir #1 Energy Recovery Facility

Further research into the Nanaimo data infrastructure has led us to an interesting case of network coupling.

“Reservoir #1” is a water processing facility in Nanaimo that leverages the height differential between itself and the water treatment plant to generate electricity.

Reservoir #1 Electricity Generation Facility
(Photo courtesy of City of Nanaimo)

Overhead view of Reservoir #1
(Screenshot courtesy of Google Maps)

Reservoir #1 Energy Recovery Facility

Before the treated water enters the new reservoir it ***passes through a turbine which in turn generates electricity.*** *The energy recovery component currently generates enough to power for 60-70 homes. The energy produced (approximately* ***680 mega watt hours****) reduces the City's carbon footprint and the revenue generated (approximately $72,000 per year) by selling the power back to [the local electric company] will help recoup operating costs of the water supply system.*

- City of Nanaimo Reservoir #1 Project Website (https://www.nanaimo.ca/your-government/projects/projects-detail/reservoir-no-1)

The project is a source of local pride in Nanaimo, as it demonstrates commitment to increasing local energy production from clean sources.

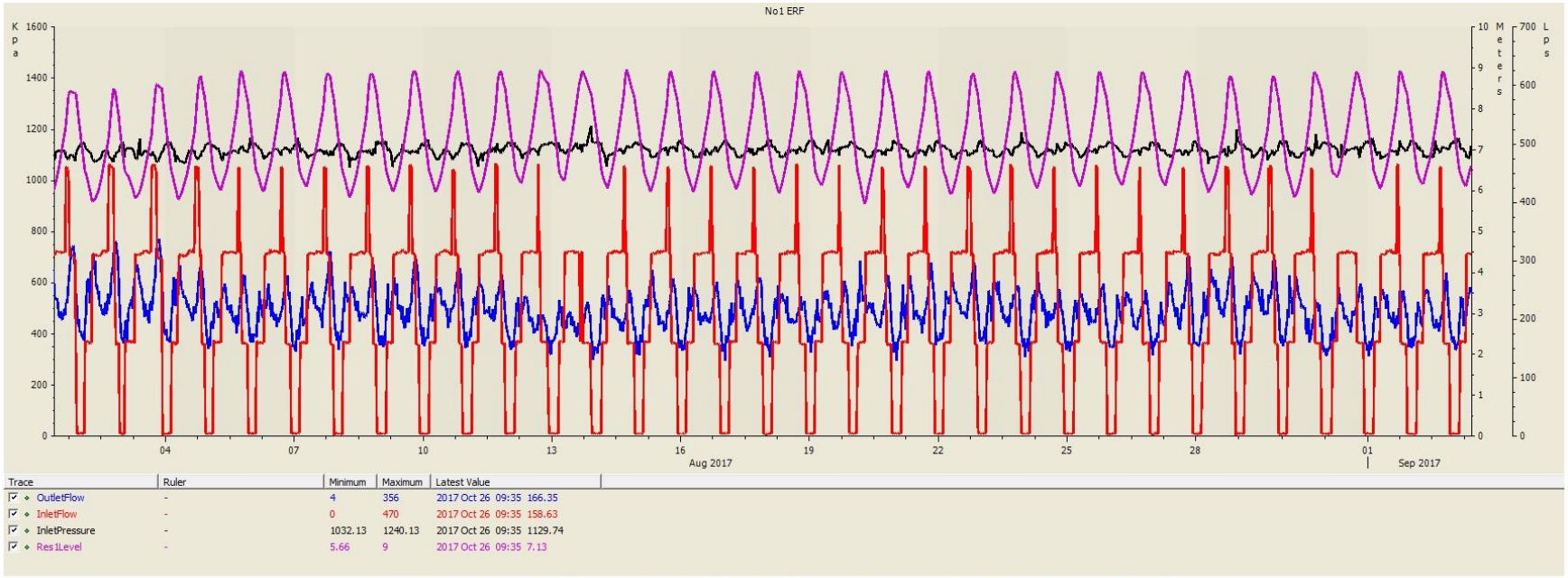
Reservoir #1 Energy Recovery Facility

EIFER has made contact with the Water Resources Manager in Nanaimo, Mr. Bill Sims (AScT, Ptech), who was heavily involved in the Reservoir #1 Project.

He was kind enough to share details of the project with us, as well as provide us with usage data entailing approximately one month of raw usage data from August 2017, including:

- Outlet Flow
- Inlet Flow
- Pressure Upstream of Turbine
- Pressure Downstream of Turbine
- Reservoir Level
- Energy Produced

Further work



Water Utility.1-Operations.Outstations.Number One.No1ReservoirERF.No1FlowPressureTrend

Graphical Representation of Reservoir #1 Electricity Recovery Facility Usage Data for August 2017, courtesy of Bill Sims (AScT, Ptech), Nanaimo Water Resources Manager

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Reservoir #1 Energy Recovery Facility

Some parts of the Reservoir #1 Facility are visible in the open water network data that we already have.

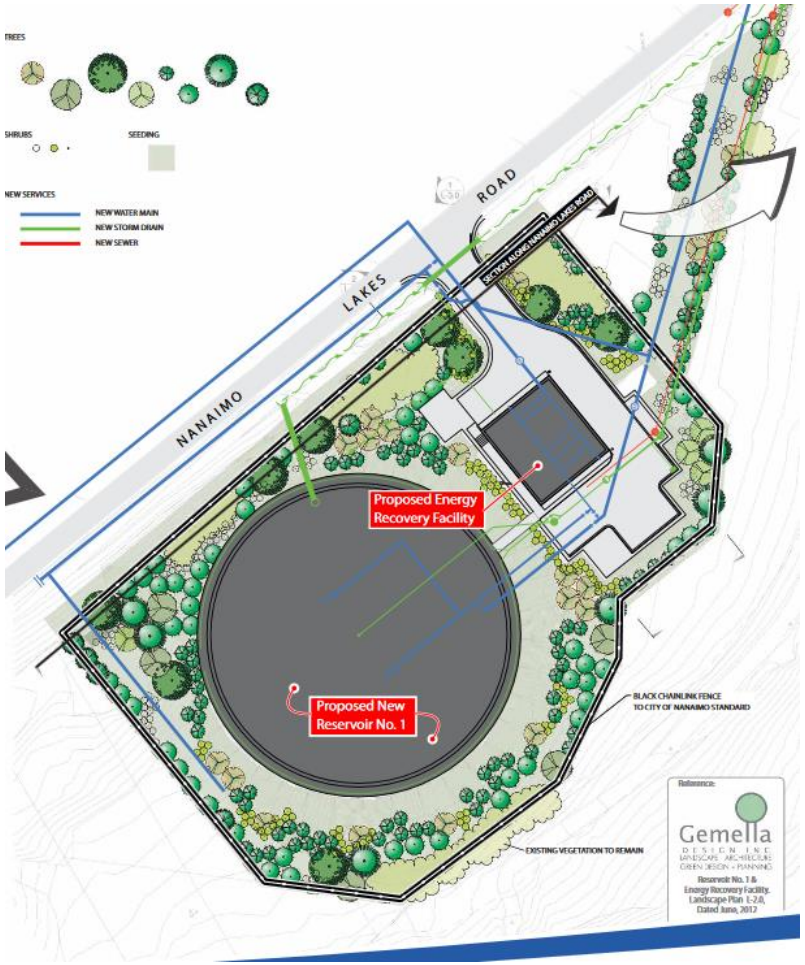
While there is no electrical network data published by the Nanaimo Open Data Catalogue, we are actively looking for some sources.

Nanaimo Open Water Network Data overlaid on OpenStreetMap
In the vicinity of the Reservoir #1 Electricity Recovery Facility.

Reservoir #1 Energy Recovery Facility

Furthermore, there are more detailed maps concerning the Reservoir #1 project that have been made public.

The existing Nanaimo water network data, combined with data derived from these more detailed maps, as well as continuing cooperation with Mr. Sims could form the basis of the first public data sample demonstrating network interdependency modeling with UtilityNetwork ADE.



Site Plan for Reservoir #1 Energy Recovery Facility, subset of larger document: https://www.nanaimo.ca/docs/your-government/Projects/2012-reservoir-no-1/754ea6391b316d6b9fc9ff00001037d2.pdf

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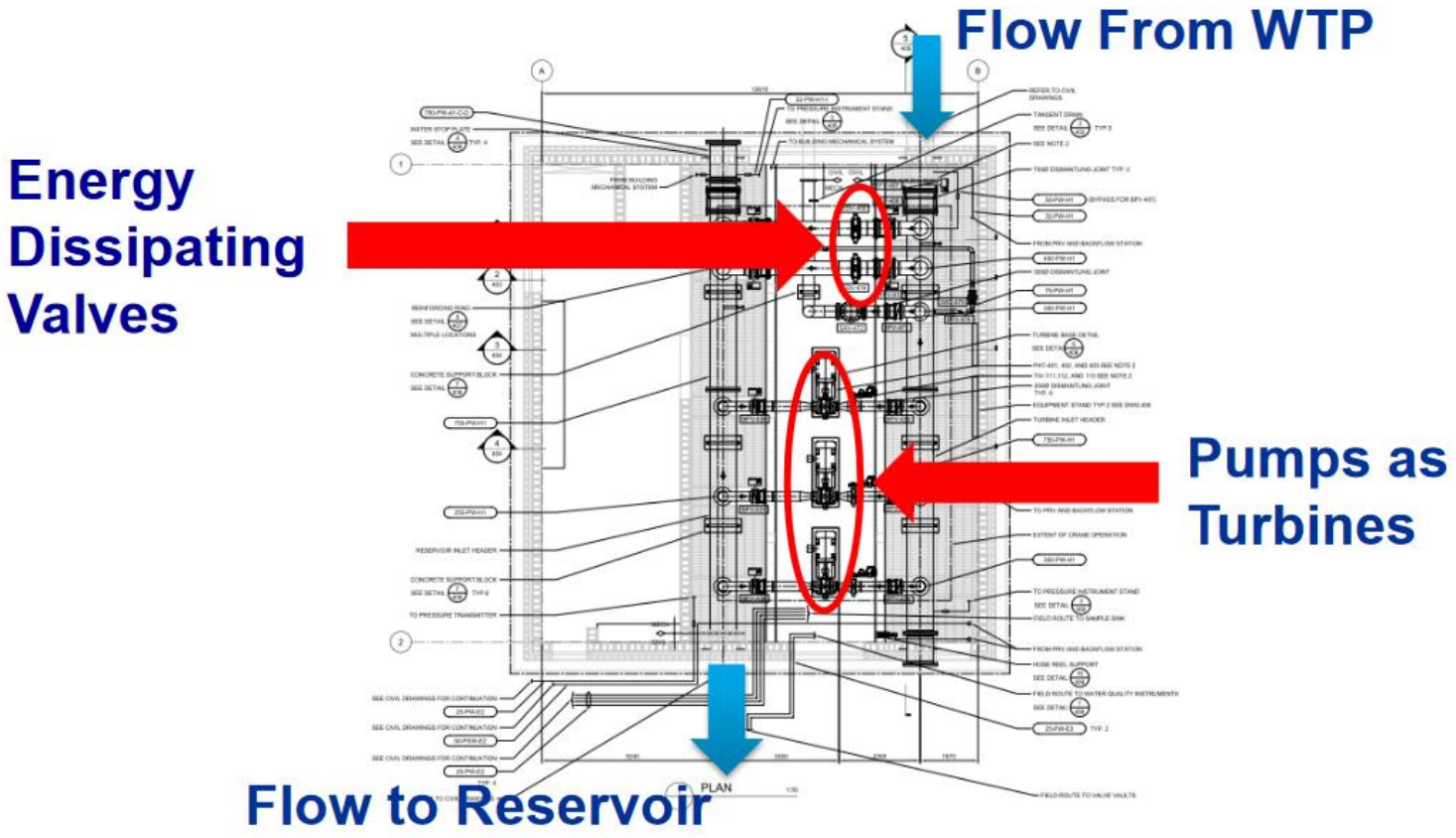
Reservoir #1 Energy Recovery Facility



Engineering Plans for Reservoir #1 Energy Recovery Facility, from:
https://www.bcwwa.org/resourcelibrary/Stream3_MacraeL_05282015.pdf

Reservoir #1 Energy Recovery Facility

More Information:

https://www.nanaimo.ca/your-government/projects/projects-detail/reservoir-no-1

http://www.toolkit.bc.ca/Success-Story/Nanaimo%E2%80%94Harvests-Energy-Drinking-Water-Support-System

https://www.bcwwa.org/resourcelibrary/Stream3_MacraeL_05282015.pdf

Thank you…

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