Determining potential customers for small- scale wastewater treatment systems

In this assignment, the goal is to analyze which properties on a given area are most likely connected to the wastewater network and which might have a need for residential wastewater treatment solutions (potential customers). The potential customers are further divided into two groups, depending on whether a property resides in a sensitive or a non- sensitive area.

Background

Wastewater collection systems can be categorized into centralized and decentralized systems. Centralized wastewater collection, or a sewerage network, collects wastewater from urban and semi-urban areas to treatment plants. Decentralized systems exist in areas with lower population densities.

The potential customers for small-scale residential treatment solutions can be identified using spatial data analysis. The aim is to assess which buildings on a given area are probably connected to the municipal sewer network and which might have a need for a small-scale treatment system. The potential customers will be categorized into two groups: A) all houses outside the centralized wastewater collection system (rural areas), and B) those that are located in rural areas within a groundwater area or near a water body (sensitive areas). Reasons for this division are stated below.

The Finnish law[1] requires properties in rural areas to treat wastewater to a sufficient degree. The requirements were updated in 2017 and are, in a simplified form, as follows. Properties with no running water typically have no requirements regarding water treatment. Those with running water either 1) need to have a system implemented by October 31, 2019, if they are located within a groundwater area or within a 100 m distance from a water body; or 2) need to install a treatment unit when the property is renovated.[1,2]

---

[1] The regulations are based on the Environmental Protection Act (English) http://www.finlex.fi/en/laki/kaannokset/2000/en20000086.
The following Decree eased the terms from the original Decree (Finnish):
https://www.finlex.fi/fi/laki/alkup/2017/20170157.
[2] More information in Finnish: https://ym.fi/-/haja-asutuksen-jatevesisaantelyn-kohtuullistaminen-voimaanhuhtikuussa

Task

You are expected to perform spatial analysis and answer the following questions using data covering the municipality of Hankasalmi:

1. What is the total market potential for on-site wastewater treatment in Hankasalmi (i.e. total number of buildings located in the rural areas of Hankasalmi? (35p)

2. How many of these buildings probably have had a wastewater collection system implemented by October 31 2019 (i.e. those located on sensitive areas)? (35p)

3. Group task: With your group. prepare one map depicting properties whose owners are potential customers (you can use the full buildings dataset of the municipality or the personal data set for one of the group members), separating potential customers in sensitive and in non-sensitive areas.

   The visualization of the results should include a title, north arrow, scale bar as well as a legend (10p). It should include all the buildings in the municipality separated with different colors depending on the market potential, as well as the sensitive areas separated into water bodies (including 100m buffer) and groundwater areas (10p). Finally, evaluation is conducted based on the clarity and interpretability of the maps (10p). The idea is to use these maps in your pitch presentations. (in total 30p)

Questions 1. and 2. are answered within the exercise quiz, and they will be automatically graded. The map created in Question 3. should be submitted to the "Submit you GIS exercise map here" submission box in MyCourses. **Note!** Questions 1. and 2. are individual assignments so each student needs answer them. However, map in Question 3 is a group assignment, so it suffices that one group member makes the submission.

You should use the following presumptions in the analysis:

- Buildings within dense and sparse population centres (*tiheä taajama-alue* and *harva taajama-alue*) are connected to centralized wastewater systems. Properties outside these population centres need on-site wastewater treatment solutions.
- Buildings on sensitive areas include those on groundwater areas and those within 100 meters from water bodies.

Data

All the data used in this exercise are openly available for anyone to download. We will be using the data specified in Table 1. **Note**! You will use a personalized dataset. As the data are not the same for everyone, you cannot check your answers to Questions *1.* and *2.* by comparing the numbers with your fellow students. The values may not match.

Table 1. Datasets.

Dataset	Provider
Administrative borders (Hallintorajat)	NLS/MML
Population centres (Taajamat)	SYKE
Groundwater areas (Pohjavesialue)	SYKE
Lakes and rivers	SYKE
Buildings	NLS/MML

You will find the download links to the required datasets in MyCourses in the exercise quiz.

Tools

The analyses are conducted with the QGIS software. QGIS is a free and open-source desktop GIS application with a relatively easy-to-use graphical user interface.

The preferred way of using QGIS is to use Aalto IT classrooms either onsite or remotely via vdi.aalto.fi. To see which computer classes have QGIS installed, you can check https://computers.aalto.fi/. Of course you can install QGIS on your laptop (https://qgis.org/) if you wish. Unfortunately, we cannot guarantee that we can help in troubleshooting potential problems that can arise in local laptop installations (we can try, though).

The QGIS quick guide (QGIS_quickguide.pdf) provides basic information about QGIS. it is available in MyCourses. The document has been written for QGIS (v. 3.10) but should work also at least for newer versions (tested also with 3.22.7).

Workflow

Essential steps are listed below.

Prepare data:

1. Extract Hankasalmi municipality from the administrative borders (municipalities) dataset

2. Extract the rural areas of Hankasalmi

3. Add groundwater areas. Consider extracting from the national data a region that you need for the analysis (this is not necessarily needed but makes the analysis much quicker).

4. Prepare a merged water body layer (lakes, small rivers, large rivers) for the region of interest.

5. Import the buildings data

Analysis:

6. Find buildings in the rural areas of Hankasalmi to discover which buildings presumably are not connected to the municipal wastewater network.

7. Create a dataset for sensitive areas:

    i.   Buffer surface water bodies with 100m

    ii. Merge buffered water body data with groundwater area data

8. Find those buildings that are located in the rural areas of Hankasalmi and in sensitive areas.

9. Prepare and export maps.

Administrative borders (municipalities.shp)

Open the *municipalities.shp* dataset as a layer in QGIS. After that, find Hankasalmi municipality from the attribute table (by right-clicking the *municipalities* layer) and select it. It should be visible on the map in yellow color. Now you can save the selected layer by right-clicking on the *municipalities* layer and then selecting 'Export – Save Selected Features As…'. Note: Save the file in:

- Format: ESRI Shapefile
- CRS: EPSG 3067 (This defines the geographic projection that the data is presented in)
- Note: setting CRS: EPSG 3067 is recommended for layers throughout the exercise.

Population centers (pop_centers.shp)

Taajama (in Finnish) is a population center with at least 200 inhabitants and the distance between houses less than 200 metres. The *pop_centers* dataset is used to identify areas with lower population densities which we will assume to depend on decentralized wastewater systems.

The *pop_centers* dataset includes both densely populated centres (*tiheä taajama-alue*) and more sparsely populated centres (*harva taajama-alue*). We will assume that both of these have centralized water services and do not need on-site wastewater treatment systems. Thus, the buildings outside these areas are those that we are interested in.

Next, you can crop the Hankasalmi polygon using the population centres data. You should endup with a polygon indicating those Hankasalmi areas that have low population densities.

One way to crop vector data is to use the *Difference* tool (*Vector – Geoprocessing Tools – Difference*). Input layer is the layer you want to crop (Hankasalmi) and Overlay layer includes the areas that you want to remove from the input layer (*pop_centers*). Remember to indicate a file path if you want to save the output to a file instead of a temporary layer (which may disappear if the program crashes…).

WAT-E1100 Water and Environmental Engineering
Spatial analysis exercise

Groundwater areas (gw_areas.shp)

The groundwater areas dataset is used to identify rural areas that are more sensitive to wastewater (note that also areas close to water bodies are included in the sensitive group). To include only those groundwater areas that are located in the rural parts of Hankasalmi we can use the *Clip tool* (*Vector – Geoprocessing Tools – Clip*).

The groundwater areas data set includes two subtypes (in a field *Subtype* in the attribute table): *Pohjavesialue* (Groundwater area) and *Varsinainen muodostumisalue* (Groundwater recharge area). We are only interested in the groundwater areas, so the recharge areas can be omitted. You can use the attribute table to remove groundwater recharge areas. Sort the column *Subtype* by clicking on the name of the field. You can then highlight all the rows that have *Varsinainen muodostumisalue*. Switch to editing mode (little pen on the upper left corner) and delete selected features (trash can icon).

Rivers and Lakes

The water river and lakes data include three different layers:

- Large rivers   large_rivers.shp
- Small rivers   small_rivers.shp
- Lakes   lakes.shp

Import those to QGIS, and combine them with *Vector – Data Management Tools – Merge* vector layers. Again, extract from the combined water bodies data a region that you need for the analysis.

Buildings

Import the buildings data set in QGIS. The buildings are in centroid format, which means that they are represented as a single point on the map.

Analysis

To find out the total number of buildings located in the rural areas of Hankasalmi, you can use the *Clip* tool and inspect the attribute table to see the number of buildings. **Note!** When using the clip tool with the buildings data set, QGIS doesn't allow saving the file as an ESRI Shapefile (seems that there is a bug in QGIS). Instead, you can save them in geopackage format or just as a temporary layer.

After this you can create a dataset for sensitive areas. Start by creating a 100 meter buffer (Buffer-tool with a distance of 100) around surface water bodies. Then you can combine the surface water bodies data with groundwater areas using the *Merge* tool. Finally, you can use these data and the *Clip* tool to find out which buildings located in rural areas are located also on sensitive areas.

Exporting maps

Exporting maps you can create a new print layout (*Select Project – New Print Layout*). A tutorial with good examples can be found here:

https://www.qgistutorials.com/en/docs/3/making_a_map.html