REPORT ON PILOT AREAS AND ACQUIRED DATA:
Taking control of the Urban Drainage System

Output 3.1 of Interreg Baltic Sea Region project NOAH

Protecting Baltic Sea from untreated wastewater spillages during flood events in urban areas

Contents

Introduction

NOAH project's Work package 3: Taking control and ensuring prevention focuses on decreasing spillages of untreated wastewater from urban drainage network to the Baltic Sea by enhancing capacity of water utilities responsible for urban drainage system operation. For that, WP3 will experiment and introduce new solutions in drainage system operation not widely used before in urban conditions. The idea is to install on-line sensors (measurement stations) and actuators (gates) into the existing system to utilize the capacity of the pipeline to accumulate excessive flows and thus avoid combined sewer overflows to the natural waters. In some cases adjustments in the operation of the existing facilities (pumping stations) is also helpful to achieve this target.
First activity of WP3 is data acquisition from pilot UDS systems in 6 partner towns and utilities (A3.1). The aim of the activity is to collect necessary information about the existing urban drainage system (UDS) in order to detect combined sewer overflows (CSO) and treatment plant bypasses (WWTPBP) that can be controlled by implementing real time control in A3.3. This activity serves as an input provider for the next activities in WP3. In the preparatory phase of NOAH, 6 pilot areas (Rakvere, Haapsalu, Jurmala, Ogre, Liepaja, Slupsk) with combined sewer system were selected. The pilot areas are situated in different regional conditions in 3 different countries. This is needed to eventually generalize the results and make them applicable for whole BS region regardless of the local regulations and environmental conditions.
Herein is the internal report (O3.1) on pilot areas, undertaken actions, faced deficiencies and found solutions.

1 Haapsalu

1.1 Description of the Haapsalu pilot area

Haapsalu is a town on West Estonia's Baltic coast, with of 13,000 inhabitants. The town is located on a southeastern-northwestern oasis, typical of the north-west coast of Estonia. The town's coastline length is 18 km and the area is 10.6 km^2. 67% of the town area is covered greenery (parks, recreational areas etc.). Due to the coastline length and ground elevation, the city is open to seawater flooding. Old drainage systems, bottlenecks in pipelines and overall incomplete information on the town's drainage system are contributing to rainwater flooding.

Figure 1-1 City map of Haapsalu with the (seawater) floodable area indicated (on the left) and the two pilot areas of Haapsalu (on the right)

Haapsalu's drinking and wastewater system, that includes 21 wells and a WWTP using mechanical, chemical and biological treatment technology, is managed by Haapsalu Waterworks (*Haapsalu Veevärk AS*).
Haapsalu City Government manages the rainwater system. Sewage and stormwater systems are separate.
The pilot area is divided into two areas located on the south part of Haapsalu (see in Fig.1-1), corresponding to actual stormwater system catchment areas.
Area 1. Activities include mapping rainwater systems and taking water samples from stormwater outflows. Rainwater outflow is a wetland that is a buffer before reaching the sea. The wetland is surrounded by a dam designed to protect seawater inflows into stormwater systems. The dam has 2 locks that are in very poor condition and release seawater to the wetland, which places a burden on stormwater systems.
Area 2. Activities include mapping the stormwater system.

1.1.1 Description of the changes and adjustments made in the pilot area

The pilot area was divided into two sub-areas corresponding to actual stormwater system catchments.

1.2 Data collection procedure

Existing information on the stormwater system was collected from the data of Haapsalu City Government and Haapsalu Water Company. A master plan and sewer pipeline information of the

pilot area were compiled. It was found that information about the stormwater system was inadequate and thus a procurement for geodetic survey was prepared.
The initial deadline of the geodetic survey (31.05.2019) was extended due to bigger than expected workload needed for mapping the system.
Additionally the Haapsalu City Government carried out a procurement for water quality analysis. There are no blueprints of existing water quality measurements available, as there are no historical measurements.

1.2.1 Acquired data

Haapsalu Waterworks shared its data on the separate sewerage system.
Ground elevation data was requested from the Estonian Land Board, which has LiDAR aerial scanning data. Precision of the height data is ±7 cm and the density of data points is 2.1 points per m^2 on average.
National Land Board also provided orthophotos obtained via aerial photography and information on permeable and impermeable areas and land use in general.
The Haapsalu City Government archive of the old pipelines of stormwater system were worked through. Data gaps were found and these were filled with geodetic survey.

1.2.2 Identification of missing data

The biggest data gaps were in the stormwater system. The layout of all the stormwater pipeline system with manholes and stormwater gullies was not known. Many stormwater manholes have been rebuilt in the past without documentation and the height of the manhole hatches has changed due to road construction or soil filling. Additionally, the available data is outdated, mainly due to changes in the elevation system (switch from Baltic Height System to European Vertical Reference System in 2018).
No historical water level/flowrate measurements are available from the UDS.

1.2.3 Action taken to fill data gaps

1. Conducting a geodetic survey. The aim of the procurement was to find and measure all the rainwater related objects in both pilot areas in Haapsalu. Data included manholes, routes, culverts, ditches, locks, outflows, etc. The invitation to tender was launched on 05.03.2019 and the contract was signed on 01.04.2019. Some of the works have been handed over and the survey work is ongoing.
2. Conducting water quality analyses. Water quality analyses have never been taken from the rainwater systems in the city of Haapsalu. TalTech prepared the technical specification for the procurement and Haapsalu City Government started the procurement procedure.
3. Conducting geodetic survey of the sluice in area 1 in preparation for the pilot investment

1.2.4 Data preparation and validation for the next activity

Next activities include:
1. Storm water samples to be taken and compared.
2. Procurement procedure for the samples to be finished in October, November 2019.
3. Validate the data from the geodetic survey and add the data into the model.
4. Development of the catchment area surface model.

5. Import of rainfall data into the model (individual seasonal scenarios).
6. Analysing the model for the next action plan.

1.3 Potential for RTC in UDS

There are no pumping stations in the stormwater system nor are there storage facilities built for stormwater detention. No automated control system (sensors, controlled devices etc.) is used for the UDS operation. In Haapsalu pilot area there is a SUDS solution present, viz. there is a bioswale area between the town and pedestrian road.
No CSOs exist in Haapsalu, all wastewater is treated and the stormwater system is mostly separate.
RTC can presumable applied to regulate the flow through the pedestrian road: to bioswale – in case of high seawater levels; and to the sea in case of low sea level. The gate should prevent seawater entering to the bioswale and urban drainage system in case of high seawater levels.
The area of the bioswale is ca 3.8 ha, water depth 0.5m

2 Jurmala

2.1 Description of the Jurmala pilot area

Jurmala is a resort city located 25 km West of the capital Riga. It is the 5th largest city in Latvia by population (57 653 PE) and 2nd largest by area (100 km^2). The city has elongated shape and is located between two water bodies – river Lielupe in the South and the Gulf of Riga in the North,

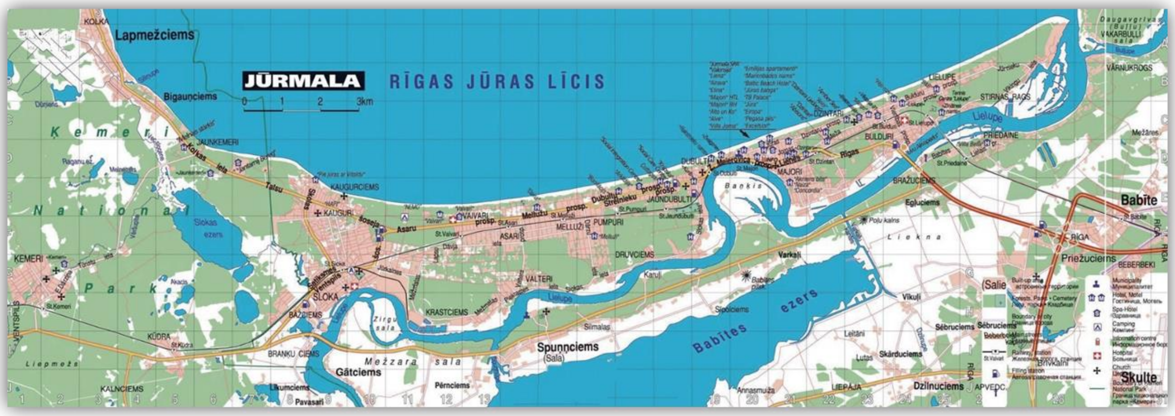


Figure 2-1 City map of Jurmala

as seen in Fig.2-1.
Jurmalas udens Ltd manages water supply communications (total length 303 km), waste water sewerage system (348 km) and maintains the stormwater system consisting of more than 50 km of closed pipelines and 115 km of ditches.
The pilot area has been distributed into three main sections located along the city line – A, B and C. This can be seen in Fig.2-2.

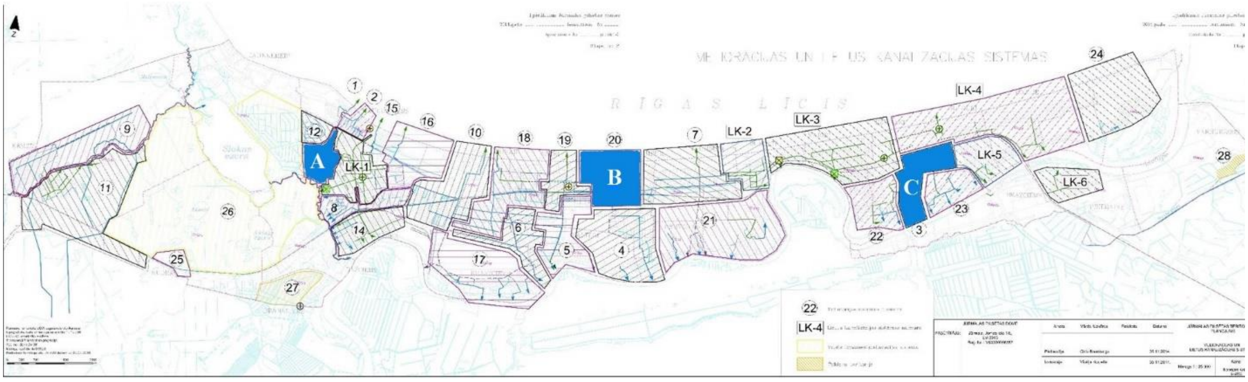


Figure 2-2 Pilot area sections A, B and C

These sections are actual storm water catchment sections chosen to study the city evenly along its line. Tasks and objectives of each pilot area section are listed in Table 1.

Table 1

Section	Task	Objective
A	A.1 Precipitation, storm water level and waste water flow measurements. A.2 Sampling.	A.1 Defining correlation between precipitation, storm water levels and flow in the waste water sewerage, hence defining critical spots in waste water sewerage system (potential defects etc.) causing its potential overflow and runoff into the storm water system. A.2 Taking storm water sapmles from the mahole for storm water quality control.
B	B.1 Precipitation, storm water level and waste water flow measurements. B.2 Sampling.	B.1 Defining correlation between precipitation, storm water levels and flow in the waste water sewerage, hence defining critical spots in waste water sewerage system (potential defects etc.) causing its potential overflow and runoff into the storm water system. B.2 Taking storm water samples from the mahole for storm water quality control.
C	C.1 Precipitation and storm water level measurements. C.2 Sampling. C.3 Potential contamination detection at storm water drainage outlets using a mobile multiparameter sensor. Sampling. C.4 Model development.	C.1 Measuring precipitation and storm water levels. C.2 Taking storm water samples from the mahole for storm water quality control. C.3 Detection and prevention of potential illegal activity – detecting untreated waste water sewerage outlets into the storm water system. No centralized waste water sewerage system in this section, hence larger probability of misconduct. C.4 Storm water process modelling.

2.2 Data collection procedure

Data collection procedure included sequential steps:

1. Pilot site mapping – initial pilot site definition on the city map.
2. Topographical overview – defining manholes for sensor installation and sampling, defining suspicious household outlets into storm water system (potential polluters) for further inspection with a multiparameter sensor using a more detailed topographical map.
3. On-site inspection of previously defined spots/locations, photo fixation of defined manholes.
4. Equipment overview - defining types of equipment required to carry out the set tasks – mobile multiparameter probe, waste water flow meters, storm water level sensors, local meteostations, automatic samplers.
5. Filling in data availability questionnaire.
6. RTU has taken storm water samples from one of the manholes for water quality analisys.
7. RTU is developing a storm water model.

2.2.1 Acquired data

All the data available in the digital topographical map – ground elevations, streets, roads, buildings, different types of networks, coordinates, diameters, elevation marks (inlet, outlet heights can be calculated), type of pipeline, pipe length.

Owner of the particular pipeline can also be defined – centralized (street) waste water sewerage network belongs to Jurmalas udens Ltd., centralized storm water system belongs to municipality, networks located in household yards/household connections to the centralized system belong to clients.

Pipe material information can be found in either construction project papers or in executive drawings (inventory documents), same for pipe cross section information.

Main data gaps are on pipe id, as well as the year of construction which cannot always be precisely defined.

In addition, there is a future development project on centralized waste water sewerage system construction in different areas throughout the city. One of such areas is pilot area section C. Currently there is no centralized waste water sewerage system in this section. Construction is planned to start in the year 2020 and should be finalized by the end of the year 2021.

2.2.2 Identification of missing data

Main data gaps are on pipe id, inlet and outlet node id, as well as the year of construction which cannot always be precisely defined.

Pipe id can be assigned for the purpose of modeling. It may also be possible to get an approximate date of pipeline construction.

During the creation of the hydraulic model, the main problem was with the identification of pipe material. The topographical map does not always specify correct materials. To clarify said issue, on-site inspections were performed.

No data from historical water quality measurements is available, even though there is information that measurements have been conducted. No water level/flowrate historical measurements are available from the UDS.

2.2.3 Action taken to fill data gaps

As the process is ongoing no actions are taken for now. Should there be a need, an external expertise or other institution (such as Engineering and Geodesy department of Jurmala) shall be engaged.
Problems associated with missing data for modeling were solved by performing on-site inspections.

2.2.4 Data preparation and validation for the next activity

Next activities include:
1. More storm water samples to be taken and further compared.
2. Procurement procedure for the equipment and installation to be carried out in the beginning of October 2019.
3. Equipment to be installed and first data gathered and analyzed in October 2019.
4. Development of the catchment area surface model.
5. Import of rainfall data into the model (individual seasonal scenarios; RCP4.5 and RCP8.5).
6. Formation of infiltration ditches.
7. Clarification of existing cross-sections of ditches.
8. Survey of objects in nature and supplementing model data.

2.3 Potential for RTC in UDS

There are three pumping stations in Jurmala UDS. No storage facilities (tanks) are built for stormwater detention and there are no SUDS. There are automated control system - sensors, controlled devices - used for UDS operation in the pumping stations.

3 Liepaja

3.1 Description of the Liepaja pilot area

City of Liepāja is in Western part of Latvia, between Baltic Sea and Lake of Liepāja. LMA “Komunala parvalde" defined to run NOAH project activities in several locations. Tebras Street catchment basin with separate storm sewer was chosen for detailed inventory. This pilot area is in the Eastern part of Liepāja (Figure 2-1).
The stormwater sewer (concrete pipe with diameter 500 mm) outlet of Tebras street catchment basin discharging water into Lake of Liepāja in the Natura 2000 protection area[1]. In the NOAH project, hydraulic model of Tebras street catchment basin will be developed to clarify: (a) how the sewer functions under different circumstances, i.a. the sewer operating like a tidal outfall (the outlet is submerged due to water level changes in Lake Liepāja and therefore for some period is not functioning); (b) Is it possible to add more new connections to this catchment basin in the future; (c) Understand the quality of water drained from the catchment basin. (d) Theoretically examine the possibility to use project partner

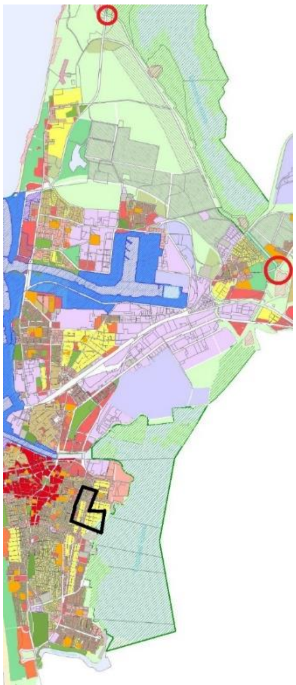


Figure 2-1 Functional zoning of Liepaja city 1 (In red – sensor locations on channel, in black – Tebras street catchment)

[1] https://ec.europa.eu/environment/nature/natura2000/index_en.htm

experience from Haapsalu (Estonia) in application of smart weir wall system or usage of tidal check valve, which would allow stormwater flow only in one direction.
The area of catchment basin is approximately 19 ha. Low-rise residential buildings (in yellow color in Figure 2-2) mostly occupy the area.

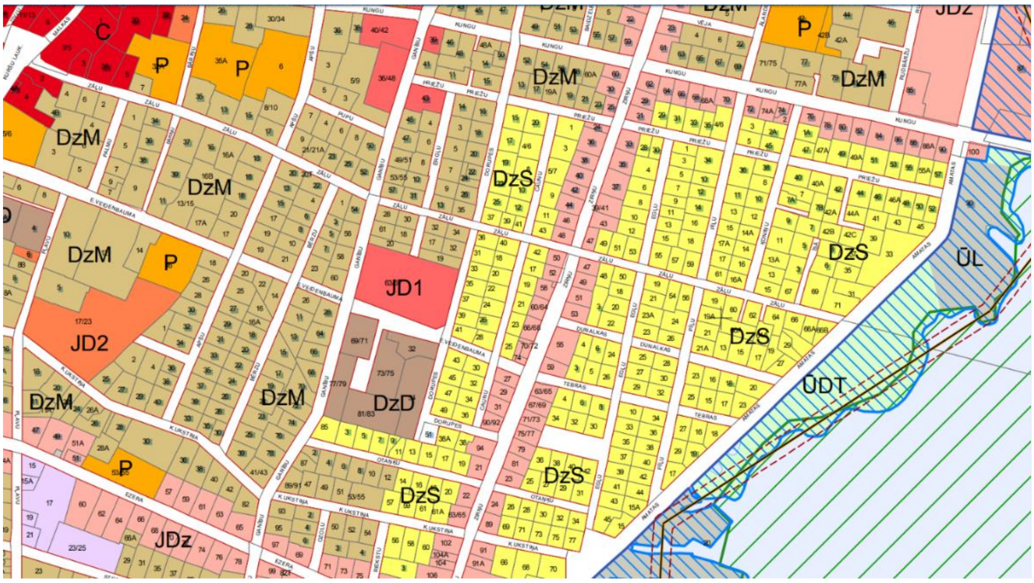


Figure 2-2 Functional zoning of Tebras street catchment basin.

Impervious surfaces are split as follows – roofs are 42% of total area and paved roads are 8% of total area.
It is being discussed in the city that in the future (without fixed term) there can be changes in area application regarding only the lakefront, which can be developed more usable for social activities. LMA “Komunala parvalde" is interested to perform stormwater sewer inventory for other territories important from city’s development perspective (Figure 2-3).

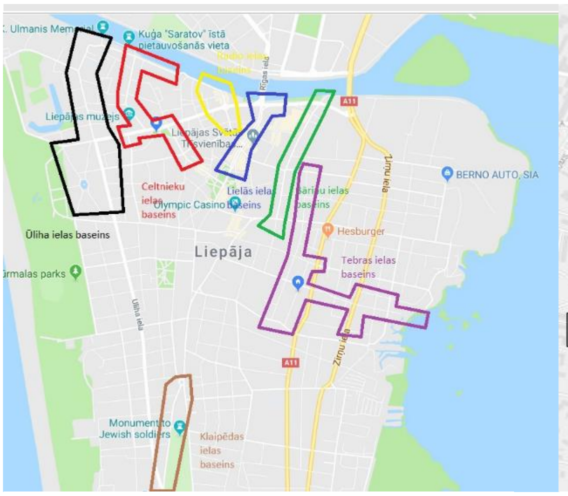


Figure 2-3 Other interested areas to be investigated.

Figure 2-4 Ground elevations in Tebras street catchment area and stormwater pipe layout

The other pilot activities planned by LMA "Komunala parvalde" will be performed in northern part of Liepaja city nearby Tosmare lake. This part of the city is enclosed by Cietokšņa channel/creek. There is a plan to install two water level sensors in Cietokšņa channel near Grīzupe street culvert and near Lībiešu street culvert (red dots in Figure 2-1). These territories around Cietokšņa channel are potential flood areas and sensors will indicated the water level rising in channel. Thus, they will be used to prevent flooding in areas Jaunā Liepāja, Aroniju, Slimnīcas street and others.
The main problem is that if the Cietokšņa canal outlet into the Baltic Sea is clogged, the adjacent areas are flooded.

3.1.1 Ground elevation data and information about water level seasonal changes in surrounding water bodies.

Ground elevation data for Tebras street catchment pilot territory was not clearly defined (Figure 2-4).
The water level in Lake Liepāja is almost the same as in the Baltic Sea in general. There are available data from LEGMC level hydrological monitoring stations (Figure 5 and 6).

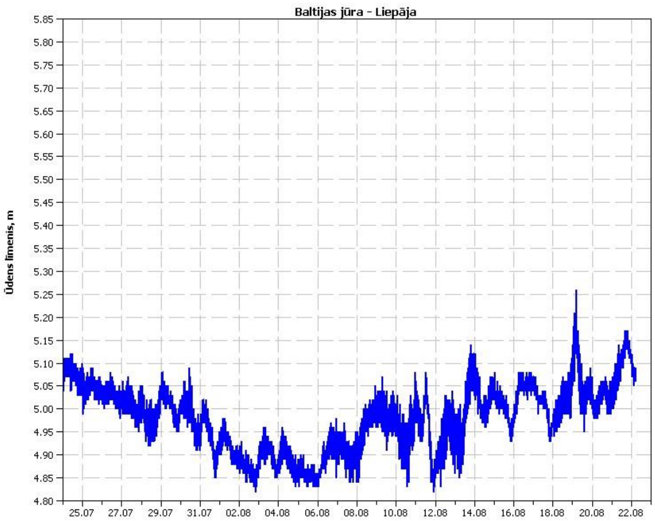


Figure 2-5 The water level in the Baltic Sea near Liepāja city

Figure 2-6 The water level in Lake Liepāja

3.1.2 Planning policy and regulations for land use planning and urban run-off management

There are no changes planned for this territory in near future. Tebras street basin pilot area territory survey is needed for the whole city development to better understand existing rainwater drainage and find out what else can connect to this existing basin.

3.1.3 Existing development plans

Existing development plan for Liepāja city can be found here - https://faili.liepaja.lv/teritorijas_planota_atlauta_izmantosana.pdf

3.2 Data collection procedure

Figure 2-7 Available GIS data before storm drain sewage system catchment area inventory

All data was collected according to the task by setting survey boundaries for pilot area. Main sources for data were existing Liepaja City Construction Board GIS information and surveys and inspections in nature by contracted survey company.

When data acquisition started the only source available was a primitive picture based navigation tool which showed limited data about the storm drain sewage system (Figure 2-7).

3.2.1 Acquired data

- Data about land use and soil types
- Ground elevation data, seasonal changes of water level in surrounding water bodies
- Existing development plans in the pilot area
- Outflows (coordinates, type e.g. free, submerged)
- Weirs (coordinates, type, height, measures)

3.2.2 Identification of missing data

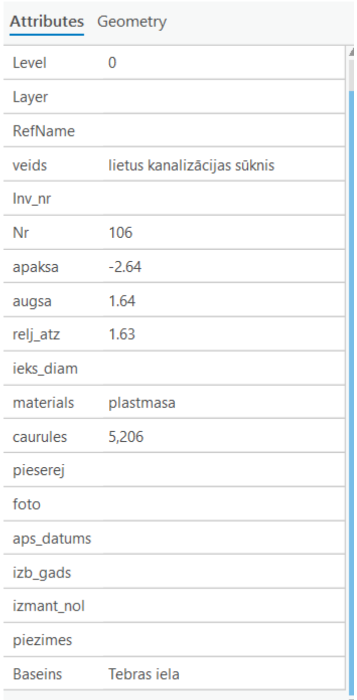
RTU identified that data about manholes, gullies and conduits was insufficient for model build-up. Liepāja City Construction Board provided data available in the form of a CAD, which was dated and did not match the situation in the field in most places. Some information was found to be missing and some unidentifiable, because topographical data was compiled a long time ago. Specific data for creating the planned GIS was missing.

There was difficulty interpreting CAD drawings of existing stormwater drainage system. In some places, new data had been drawn over old data, while old networks that are no longer functional

were still present. The contracted survey company inspected these places further after the Tebras street catchment basin storm drainage system was inventoried to make sure all data is correct.
There are no water quality historical measurements available from the outlets nor water level/flowrate historical measurements available from the UDS.

3.2.3 *Action taken to fill data gaps*

RTU prepared a template for inventory of missing data in Tebras street catchment basin pilot area so it was possible to export the data directly in to GIS format.
A land and territory surveying company (SIA "Metrum") was hired to collect all missing data in accordance with Liepaja City Construction Board and responsible municipal authorities.
After inventory of the area, RTU received GIS data of the whole system as an Esri Shapefile (Figure 2-8).


Attributes Geometry

Level	0
Layer	
RefName	
veids	lietus kanalizācijas sūknis
Inv_nr	
Nr	106
apaksa	-2.64
augsa	1.64
relj_atz	1.63
ieks_diam	
materials	plastmasa
caurules	5,206
pieserej	
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Figure 2-8 Example of filled attribute table of manhole data after inventory

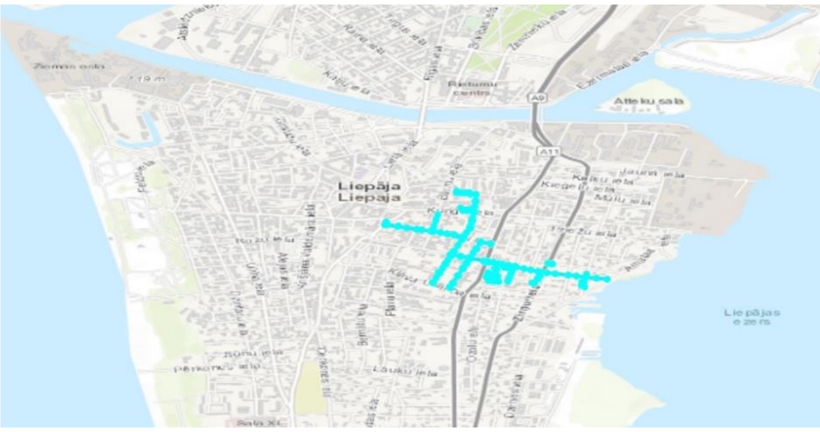

Figure 2-9 Stormwater pipe layout in Tebras street catchment area after inventory

3.2.4 *Data preparation and validation for the next activity*

All data was collected according to project guidelines. All final results available in this link prepared by RTU and provided to LMA "Komunala parvalde": http://lscm.lv/LIEPAJA_TEBRA.html
GIS data will be acquired for all other catchment basins defined in Figure 2-3 by the end of autumn 2019.
RTU will provide further activities, including hydraulic model for pilot area – Tebras street basin.
Regarding water level measurement in Cietokšņa channel LMA "Komunala parvalde has prepared procurement procedure for level sensor purchase in autumn 2019.

3.3 Potential for RTC in UDS

There is one pumping station in the UDS, located near Veidenbauma and Ganibu street junction. There are no storage facilities (tanks) built for stormwater detention, no SUDS (bioswales etc.) in the pilot area and no automated control system - sensors, controlled devices - used for UDS operation. The total basin volume in the sewer system in ~30km^2.

4 Ogre

4.1 Description of the Ogre pilot area

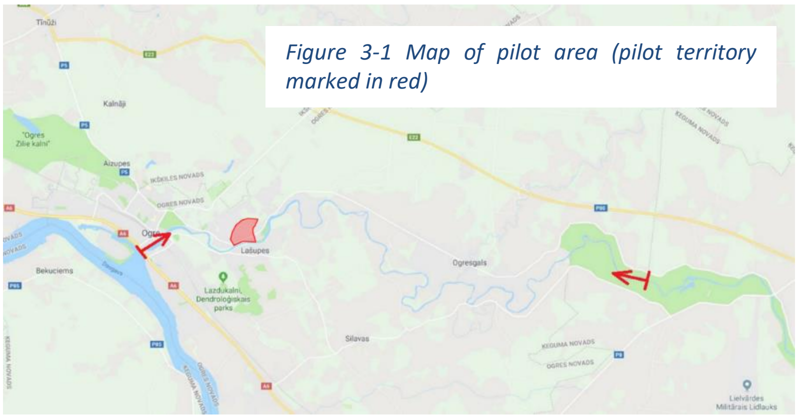

Figure 3-1 Map of pilot area (pilot territory marked in red)

Ogre town is located 36 km from Riga on the right bank of the Daugava River near Ogre mouth of the Daugava. The total area of the town is 13.6 km² with a total population of 25,380.

The pilot area (Figure 3-1) is alongside Ogre river in Ogre town and Ogresgals parish. This area has been selected as it has a major flood problem and it is strongly affected by a climate change. Accordingly, the municipality needs to understand the flood risks better and to adapt to climate change.

Project activities:

* Measurements of the Ogre riverbed upwards from Daugava river water reservoir (including measurement data processing and cartographic material preparation);
* Identification and evaluation of sensory locations, the technical design of automatic hydrological stations;
* Installation/construction of at least 2 automatic hydrological stations (AHS) in Ogre municipality.

The following types of land use are defined in the territory of Ogre municipality (Land use data taken from existing general development plans):

1. Residential housing building area:
    - 1.1. High-density private housing building area;
    - 1.2. A limited-territory private housing building area;
    - 1.3. Garden housing building area;
    - 1.4. Apartment housing building area;
2. Public building area;
3. Town centre building area;
4. Manufacturing building area;
5. The traffic infrastructure area;
6. Technical or public utilities building area;
7. Green area:
    - 7.1. Parks;
    - 7.2. Forests;
8. Agricultural area;
9. Water area.

All other planned developments in pilot area: *recreational areas.*

4.1.1 Ground elevation data and information about water level seasonal changes in surrounding water bodies:

According to the legislation of the Republic of Latvia, engineering topographic survey is carried out before the start of the construction project. The municipality does not carry out regular measurements of the surface of the land.
According to LEGMC, there are two existing water level measuring stations: one in Ogre and other in Lielpeci. From 2016, there have been measurements in Ogre HPP reservoir at Ogre municipality territory, but since August 2018 water level measuring station is working in Palienes Street 4, Ogresgals. States energy company "Latvenergo" has acquired water level data for Daugava water reservoir. Therefore, water level can be monitored and controlled, especially during flood period, when it needs to be lowered.

4.1.2 Planning policy and regulations for land use planning and urban run-off management:

Land use planning and urban run-off management are in accordance with the spatial plan and all the laws in the Republic of Latvia, which determine the spatial planning documents.
The Ogre municipality issues technical regulations for construction intentions that support sustainable urbane drainage solutions, encouraging for the implementation of sustainable water management practices. Ogre municipality staff review and evaluate project solutions in collaboration with the town's communications holders.

4.1.3 Existing development plans

Ogre municipality has two major development plans:
- Sustainable Development Strategy of Ogre municipality 2013 – 2037 (long-term development plan) is a long-term territorial development-planning document, which defines the long-term development vision, goals, priorities and spatial development perspective of Ogre municipality. This strategy is the highest hierarchical planning document for municipal development.
- Ogre municipality Development Program 2014-2020. Program is a medium-term planning document, which is a set for implementation of the long-term priorities of the municipality from 2014 to 2020. This document ensures a balanced long-term development of the Ogre area and serves as a basis for attraction of investments in the private and public sectors.

4.1.4 About pilot project area in Loka street neighbourhood:

The Loka Street neighbourhood has developed from a low swampy meadow. The surface water runoff has been organized with a network of open ditches along the streets, draining into the Ogre River. Due to intensive detached housing construction, the traffic volume has increased, and part of the ditches have been arbitrarily filled or the culvert elevation marks after construction have not been aligned with each other. That has led to a loss of functionality of the existing drainage network.
In order to control the surface runoff, the municipality must provide rainwater drainage from the street and adjacent areas by creating a single network. Therefore, municipality has already started the gradual construction of a rain drainage piping system. A main rainwater collecting manifold is intended to be built with a possibility for house owners to connect their own local rainwater collection pipeline system without the need to rebuild the newly created road covers.

4.2 Data collection procedure

Main data collected:

- Pre-project documentation on the cleaning of the Ogre estuary in the Riga HPP Reservoir (State Ltd. “Meliorprojekts”, 2012);
- Conclusions on Ogre River Dam and Deposits at the River Ogre estuary in the Daugava (State Ltd. “Meliorprojekts”, 2014);
- Hydrological and hydraulic calculations, hydrological mathematical model development for the reconstruction of the old dam (Brīvības Street 60 - 80, Ogre) and construction of a new dam at the mouth of the Ogre River in the Daugava (Ltd. “Nāra”, 2016);
- Water levels (Figures 3-2 and 3-3) – according to LEGMC two existing measuring stations in Ogre and Lielpeci;
- Measurements in Ogre HPP reservoir (from 2016) and Palienes Street 4, Ogresgals (from 2018).

Figure 3-2 A view from the web-camera (Yellow dot in Figure 2).(http://www.ogresnovads.lv/lat/vide/udens_limenis_ogres_hes/)

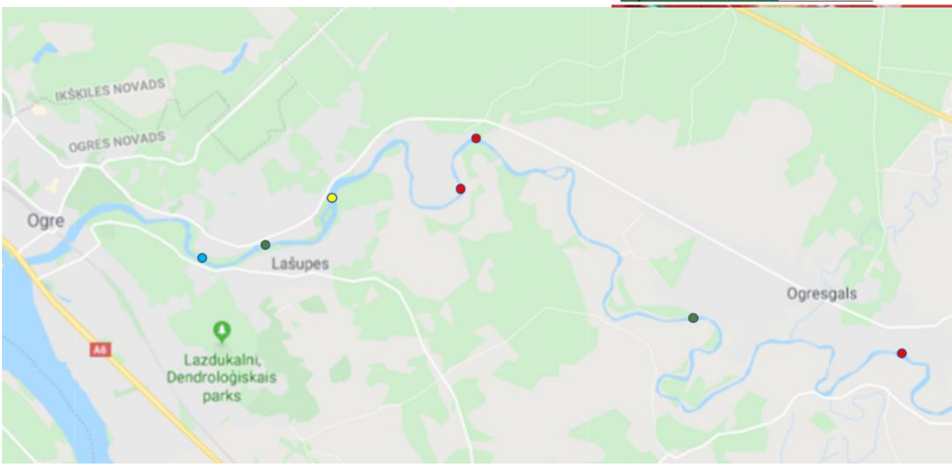

Figure 3-3 Water level monitoring. Green – existing LEGMC level monitoring stations (the one at right calculates flow); Blue – level monitoring at pumping station; Yellow – level monitoring from web-camera (Figure 3); Red – other level monitoring stations. The one most to the right is still to be constructed within NOAH project.
←

4.2.1 Satellite data

Satellite data over Ogre pilot territory was used from Sentinel-1 and Sentinel-2 polar-orbiting missions which are part of European Union’s Earth observation Copernicus program. Data were collected from Copernicus Scientific data HUB.

Sentinel-1 SAR Interferometric Wide swath (IW) ground range detected high-resolution data were collected over the Ogre pilot area, with a spatial resolution of 10 m, available from five different relative orbits. Satellite overpass from these orbits is 2 to 5 days.

Sentinel-2 high-resolution optical data with the same spatial resolution of 10 m were collected from 3 different relative orbits. However, due to frequent cloud cover during autumn, winter and spring months, data are used mainly for reference purposes. Satellite overpass from these orbits is 2 to 3 days.

4.2.2 Acquired data

- Data about land use and soil types;
- New planned developments in the pilot area;
- Ground elevation data, seasonal changes of water level in surrounding water bodies;
- Existing development plans in the pilot area;
- The layout of the CSO-s and WWTPBP-s;
- Existing water quality data from CSO-s and WWTPBP-s;
- Policy and regulation for urban run-off management and UDS operation (including regulation for CSO activation);
- Description of the existing SCADA system;
- Outflows (coordinates, type e.g. free, submerged);
- Weirs (coordinates, type, height, measures);
- Flow division in the system.

4.2.3 Identification of missing data

The main issues Ogre municipality identified:

- Fragmented databases;
- No information on drainage network and rainwater collection network in Ogre town (much rebuilt, no information passed to construction board);
- Currently large human resources are being involved in river water level monitoring during flood event;

A lot of human resource is needed to conduct the announcement and initiation of evacuation.
There are no water quality historical measurements available from the outlets, however there are 3 sets of water level/flowrate historical measurements available from the UDS.

4.2.4 Action taken to fill data gaps

- There have been ice, water and surface inspections using FLIR on airborne platforms for all Ogre river area in Ogre city and Ogresgals parish. The extraction of digital data from the Ogre river and coastal areas is necessary to prepare a 3D model from aerial surveys.
- Ogre river bed profiling in low water period completed by the 15th of September 2019. In order to be able to evaluate the Ogre River bed, its peculiarities, as well as ice movement in the Ogre River, it is necessary to carry out the Ogre River Bed Survey during the low water period, thus achieving accurate riverbed cross-sectional data.

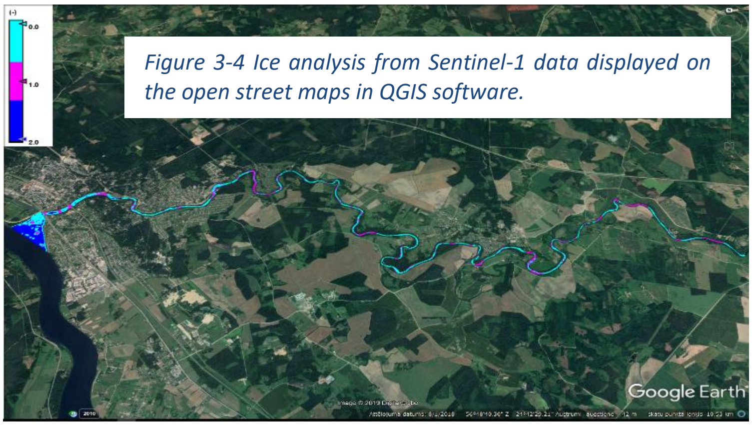

Figure 3-4 Ice analysis from Sentinel-1 data displayed on the open street maps in QGIS software.

During winter and spring seasons, information about ice condition is relatively hard to acquire manually, especially during freeze-up and breakup periods, which are characterized by ice jamming and extensive flooding. To fill this information gap, such satellite data can be used that provide data over a large area and long river stretch with relatively frequent

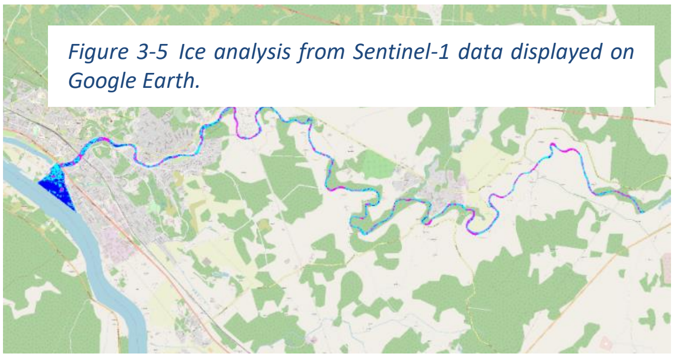

Figure 3-5 Ice analysis from Sentinel-1 data displayed on Google Earth.

revisit time of a few days. Radar satellites acquire data in all weather and day and night conditions, which also minimizes data gaps, which are profound during winter-spring seasons in northern latitudes.

Figures 3-4 and 3-5 present ice condition analysis using Sentinel-1 IW data on February 23, 2019, in Ogre river, inside the pilot territory. Due to relatively small river size and satellite image resolution, the river stretch was divided into three classes: ice-free areas and areas with low and high ice concentration.

The results of analysis can be shared in formats suitable for GIS software to use in different thematical maps (Figure 3-4) or Google Earth *.kmz format (Figure 3-5) for even easier data sharing, as the file size is very small.

Sentinel-2 optical data can be used as reference information or to fill the gaps between Sentinel-1 acquisitions, as the clear images in visible spectrum provide a good overview of ice conditions in the Ogre river (Figure 3-6). The Sentinel-2 data contain 13 different spectral bands that can be used in different combinations to acquire different information on the ice conditions (Figure 3-7).

Figure 3-6 Visible ice cover on Ogre river in the pilot territory (Sentinel-2 image, Feb 21, 2019).

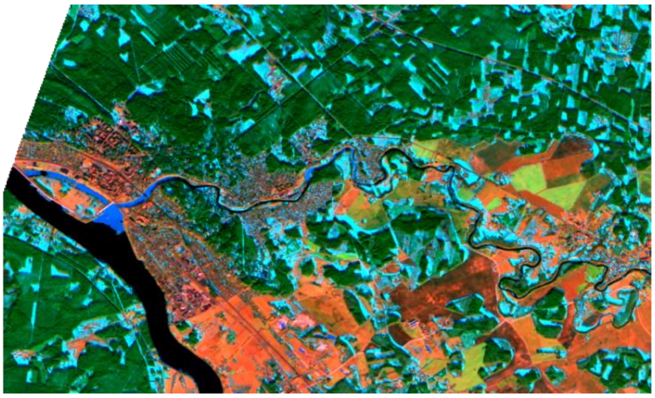

Figure 3-7 Ice cover on Ogre river in the pilot territory (Sentinel-2 image – natural colours with atmospheric removal, Feb 21, 2019).

4.2.5 Data preparation and validation for the next activity

After ice, water and surface inspection using FLIR on airborne platforms for all Ogre river area in Ogre city and Ogresgals parish, there has been development of a 3D model for Ogre river and coastal area. Further, based on gained information, the municipality will be able to asses a sufficiency of current Automatic Hydrological Stations and if needed move existing level sensors to different locations or install additional ones.

Satellite data preparation and analysis was done using the respective toolboxes from the European Space Agency's Sentinel Application Platform (SNAP).

Sentinel-2 data preparation involves atmospheric corrections and subsetting image over the region of interest. Depending on the weather conditions, histogram adjustment can be done, but in order to use information across the all available spectral bands, image resampling is necessary.

Sentinel-1 SAR data have many specific properties; therefore, data preparation requires several steps that also requires subsetting image over the region of interest for faster data processing. Regarding the data properties, data calibration, noise filtering and correction of distortions are required. After data preparation, ice analysis is carried out based on the backscattering values.

4.3 Potential for RTC in UDS

There are four stormwater pumping station in the UDS. There are storage facilities (tanks) built for stormwater detention. In Ogre there are SUDS (bioswales etc.) in the pilot area and automated control system - sensors, controlled devices (3 adjustable gates/weir/orifices) - used for UDS operation. The total basin volume in the sewer system in ~30km^2.

5 Rakvere

5.1 Description of the Rakvere pilot area

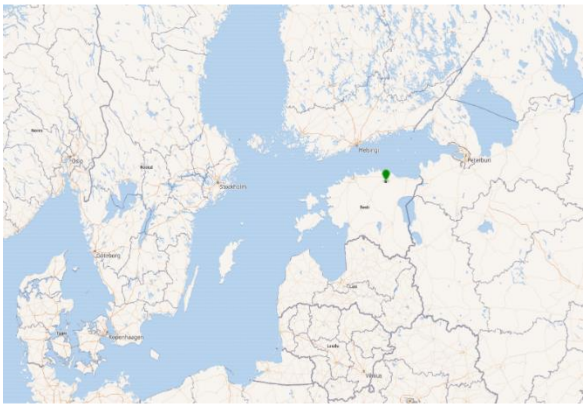

Figure 5-1 Location of Rakvere

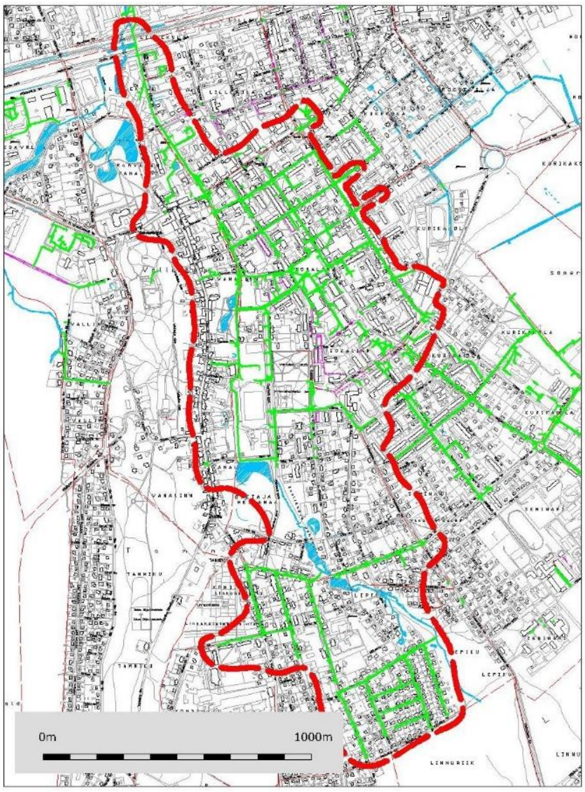

Figure 5-2 Rakvere pilot area

Rakvere (area 10,73 km^2) is a town in northern Estonia and the capital of Lääne-Viru County, 20 km south of the Gulf of Finland of the Baltic Sea. There are approximately 15,100 inhabitants in Rakvere.
There are two waterbodies in Rakvere, which are included in Estonian Nature Information System – Soolikaoja creek and Tobia main-ditch. The Tobia main-ditch flows down to the Soolikaoja creek, The Soolikaoja flows down to the river named Selja and the Selja river flows to the Baltic sea. The Tobia main-ditch catchment area is 31,8 km^2 and the Soolikaoja catchment area is 122,1 km^2.

The selected pilot area of about 1 km^2 is located in the middle of the town. This area is the most over flooded area in Rakvere.
Rakvere Vesi AS manages water supply communications (total length 156 km), waste water sewerage system (132 km) and maintains stormwater system, consisting of more than 45 km of closed pipelines and 115 km of ditches.
In the lower part of the selected area, there is a pond, instrumental to avoiding stormwater flooding in the center of the town. The pond will be used as a reservoir to temporarily hold surplus rainwater until the central town pipeline is free to take the rainwater from the southern part of the town.

5.1.1 *Description of the changes and adjustments made in the pilot area*

Borders of the pilot area were clarified. It was decided to use a bigger pilot area.

5.2 Data collection procedure

1. Mapping the pilot area on the Rakvere map.
2. Procurement of topographical overview – surveying of stormwater systems and data processing
3. Aggregation of data, surveying and forming a single database, that is suitable for developing a calculation model of stormwater systems.
4. Collecting archive data of topographical plans on pilot area, and surveying the manholes without data.
5. Surveying the cross profile of the Soolikaoja in five places.
6. AS Rakvere Vesi will make the procurement for taking and analyzing the samples from stormwater that comes from the pilot area.
7. TalTech is developing a storm water model.

5.2.1 Acquired data

All the data from surveying the manholes is collected - 108 manholes in total. 25 manholes remained unexplored. In summary, data for 83 manholes (coordinates, diameters, elevation marks ((inlet, outlet heights can be calculated)), type of pipeline, pipe length) was obtained.
There are historical water quality measurements available from 6 stormwater outlets, 4 of which are situated in the pilot area.

5.2.2 Identification of missing data

Data gaps on manholes remained due to many reasons. Some of them were under road surface and some of them were full of soil.
It may be possible to get an approximate data of pipeline from old construction plans.
There are no water level/flowrate historical measurements available.

5.2.3 Action taken to fill data gaps

For now, AS Rakvere Vesi cleaned some manholes to get the data. As the process is ongoing, there may be a need to get data on some manholes under the road surface.
Missing data on the amount of stormwater and its quality will be obtained after taking samples from stormwater in the framework of the procurement, that AS Rakvere Vesi is organizing.

5.2.4 Data preparation and validation for the next activity

Next activities include:
1. More storm water samples will be taken and further compared.
2. Procurement procedure for taking samples from stormwater will take place in October 2019.
3. Equipment will be installed and first data set will be gathered and analyzed in October 2019, second data set in October 2020.
4. Development of the catchment area surface model.
5. Clarification of existing cross-sections of the Soolikaoja.
6. Survey of objects in nature and supplementing model data.

5.3 Potential for RTC in UDS

There are no stormwater pumping station in the UDS. There is a minor system of storage and infiltration in the UDS. In Rakvere there are SUDS in the new development area at Pika/Tallinna street and some minor ponds and ditches in pilot area. No automated control system - sensors, controlled devices are used for UDS operation. RTC can presumable applied to Süsta pond (see the map). The pond has area 6500 m^2, it is having static (concrete) overflow to the main stormwater collector. The level of the pond can be raised up to 0.3 - 0.5m (will be specified on the basis of as-build measurements) to accumulate extra flow during heavy storms.

6 Slupsk

6.1 Description of the Slupsk pilot area

Słupsk is located in north-western Poland 20 kilometers from the Baltic Sea (Figure 6-1). The area of city is 43.15 km^2 and is dominated by urban areas (nearly 50%). Remaining part of the city is covered mainly by agricultural areas (36%) and forests or other green areas (13%)[2].

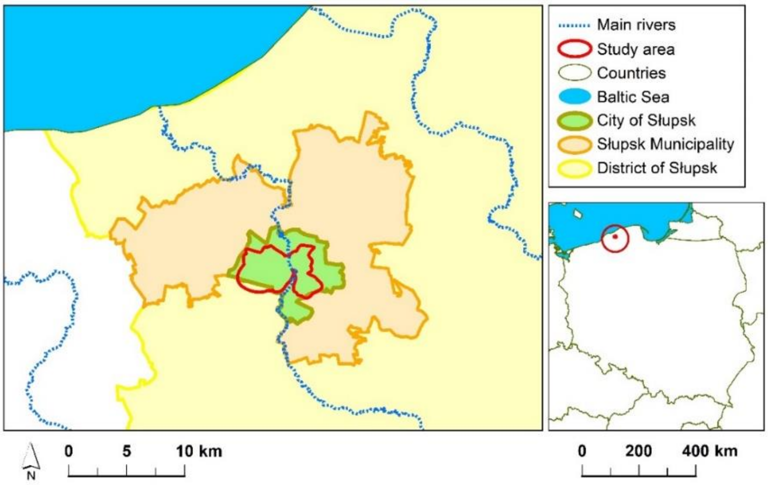

Figure 6-1 Location of Słupsk and the pilot site

The study area (pilot site) does not include the entire sewer system operated by the Słupsk Water Supply but the most densely built-up area of 22.03 km^2 where both, the separate and combined sewer systems exists (Figure 6-2). Just before the main pumping station (which serves as an outfall in the pilot area) there is an overflow, which separates an excess of the wastewater and directs it to the Słupia River. The pilot area is a main source of inflow to the Wastewater Treatment Plant (WWTP) of which 30% is the storm water. Therefore, it is necessary to assess sources of pollution in the inflow to the WWTP and in the overflow, and to prepare tools which will give a basis for the wastewater and storm water control system.

[2] Waklowiak J., Karkowski A., Pająk W. 2015. PROJEKT: Program ochrony środowiska Miasta Słupska na lata 2016-2020. Green Key Joanna Masiota-Tomaszewska.

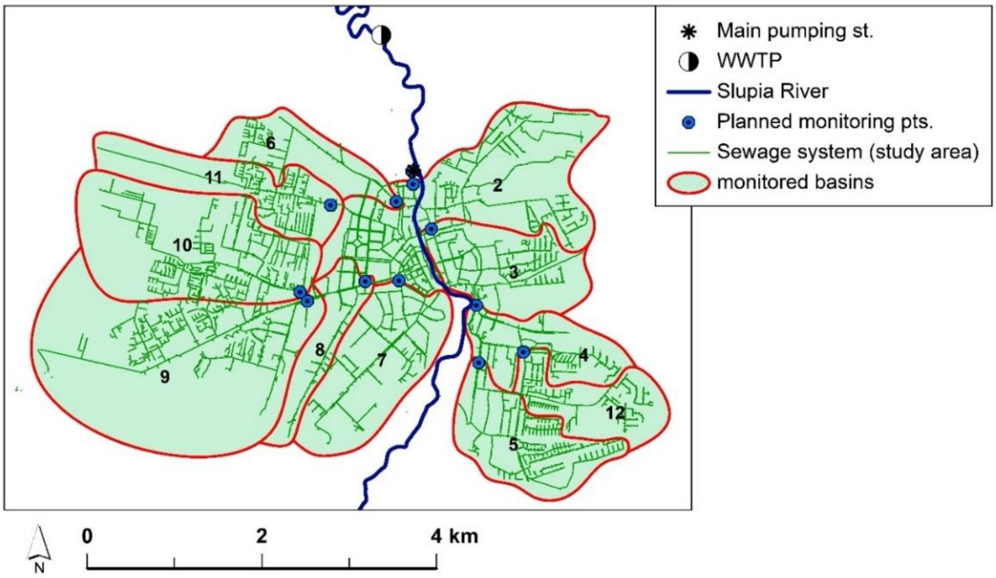

Figure 6-2 The pilot area in Słupsk, Poland

6.2 Data collection procedure

The scope of data to be collected for the purpose of the NOAH project for the Polish pilot site was defined by the Gdańsk University of Technology. Data were collected collaboratively by: 1) the Słupsk Water Supply, which was responsible for the gathering of all data regarding the structure and characteristics of the sewer system, provision of the information about the study site in the context of water supply and management of storm water and wastewater, and finally, for the design and the (ongoing) implementation of a new, online monitoring of the precipitation and the wastewater / water stage in the sewer system; and 2) the Gdańsk University of Technology, which was responsible for the collection of data regarding among others meteorological conditions, flow rate and water stage in the Słupia river (wastewater and storm water receiving water body) land use and elevation, for the design of model-based information and forecasting system for the sewer system and for the processing of data required by the system.

Main sources of gathered data include: the Słupsk Water Supply (GIS/CAD and monitoring data regarding the operation of the sewer system), the Institute of Meteorology and Water Management – National Research Institute (meteorological data, flowrate and water stage in the Słupia River), the Head Office of Geodesy and Cartography (land use and elevation, administrative boundaries) and the National Water Management Authority (stream networks and watersheds).

6.2.1 Acquired data

For the purpose of the NOAH project, and particularly for the needs of the hydraulic model, following data have been collected and analyzed based on source data provided by the Słupsk Water Supply:

- Data for pipes:
  ID, inlet and outlet ID, coordinates of a pipe junction, type of the network (sewerage / storm water), pressure pipe, diameter or other measures, material, inlet and outlet height, function (house connection / street pipe), shape of the pipe cross section, operational pipes and pipe length.

- Data for nodes:
  ID, coordinates, type of the network (sewerage / storm water), Z - height of the ground, max. depth, function (pumping station, flow dissipation, oil/sand separator, tank), cover diameter, manhole diameter and material of the manhole.
- Data for pumping stations:
  ID, type, inlet and outlet node ID, operational status, node ID (if the pump is linked with a manhole – node) and type of the network (sewerage / storm water).

Most of data were provided in a form of vector maps. A part of data mentioned above is not complete and require (or required) filling of gaps. These datasets and gaps are described in the next section.

In addition to the abovementioned, the acquired data include also: land use and ground elevation, meteorological data, water stage and flow rate in the Słupia River, location and type of CSOs, WWTP and outflows (no weirs and flow division devices in the pilot site), and finally, the information on existing and planned monitoring system and planned developments in the pilot area.

The land use and elevation data were provided by the Head Office of Geodesy and Cartography in a form of vector maps consisted of 22 land use classes and 30 types of buildings in the pilot site and a digital elevation model in a form of LIDAR data (4-12 pts/m^2) and a 1 m raster map. Data regarding the atmospheric precipitation and the water stage / flow rate were collected for the period of 2005-2018 and 2004-2018 respectively. Data collected by the SCADA system include the wastewater flowrate at the outflow from pilot site, water inflow to individual sectors of the pilot area (used as a part of input to the sewage system) and water stage and flow rate in the Słupia River in the location of the CSO. All these data have been collected for the period of at least one year.

Słupsk Water does not have any development plan for the analyzed area, which should be a subject of the model simulations. However, the area is included in several strategy papers, which (to some extent) describe development plans of the Słupsk municipality. Large part of the study area is classified as degraded and is a subject of the "Regeneration Programme"[3]. One of the Programme's actions is the restoration of the recreational and natural areas and maintenance of the ecological corridor along the Słupia River crossing the study area. Furthermore, the development of blue and green infrastructure is one of priorities in the "Strategy of the Słupsk Development for 2017-2022"[4]. This document proposes measures aimed at the protection of water resources, improvement of the land management procedures, rainwater harvesting and use. These priorities and actions are consistent with the "Climate change adaptation plan"[5] which defines the water management and biodiversity as key sectors vulnerable to the effects of climate changes.

[3] "Municipal Regeneration Programme 2017-2025+" (Gminny Program Rewitalizacji Miasta Słupska 2017-2025+), City Council Decision No XL/527/17 of 28 June 2017.
[4] „Strategy of the Słupsk Development for 2017-2022" (Strategia Rozwoju Miasta Słupska na lata 2017-2022), City Council Decision No XXXV/415/17 of 25 January 2017.
[5] „Cimate change adaptation plan for the city of Słupsk" (Plan adaptacji do zmian klimatu dla miasta Słupska), City Council Decision No IV/50/19 of 30 January 2019.

6.2.2 Identification of missing data

Part of collected data (especially spatial data) have gaps, which were identified during the preparation of input files for the hydraulic model. For example 6.06% of pipe sections had unknown material of pipes, 1.23% had missing cross-section shape and 18.08% had missing inlet or outlet height. In case of nodes (junctions) the missing data account for 40% as far as the material and diameters are concerned, while the elevation of ground and the maximum depth are not known for 3.52 and 4.68% of nodes respectively. What is more, for some characteristics of the sewer system, only rough data are available, e.g. for the material of manhole covers (concrete manholes have usually the cover diameter of 600 mm, and "plastic" have the cover diameter of 400 and 315 mm), and for features such as year of construction, owner, type and material of the manhole cover, characteristics and flowrate of pumping stations, the data are not available at all.

So far, part of information covered by this report (namely data about soil types, water quality from CSOs and the WWTP and the information about policy and regulation for urban run-off management and UDS operation) has not been gathered and the data availability has not been fully investigated.

No data from historical water quality measurements is available and no water level/flowrate historical measurements are available from the UDS.

6.2.3 Action taken to fill data gaps

Gaps in a part of datasets have been already filled. For example, missing material and cross-section data for pipes were generated based on the material of the upstream pipe or basing on the material of other pipes which are connections to the same upstream pipe. It was agreed with the sewer system operator, that in most cases the pipes inlet and outlet depth are the same as the depth of the linking node. Therefore, the missing depth data were generated for nodes only and not for pipes. Missing values for nodes depth were generated based on the depth data for conduits (if available for specific location) or based on a linear interpolation of the depth of two closest nodes – one upstream and one downstream the node with missing value. If the available data include the elevation of downstream node and distance only (mostly in cases of the last nodes in a line), the missing elevation was calculated based on a standard minimum slopes for the sanitary sewers. It was decided by the Słupsk Water Supply, that the remaining gaps in spatial data can be filled by an extrapolation or interpolation of features of surrounding pipes and nodes or based on the digital elevation model in the case of missing ground elevation of nodes.

Collection of detailed data regarding the characteristic of pumping stations is not a priority in the Polish pilot site, because there are only 43 pumping stations of a local impact and almost all of them (40) are household sewage pumps.

6.2.4 Data preparation and validation for the next activity

Most of data collected for the Polish pilot site include spatial characteristics of the sewer system and of the pilot area. All these data will serve as an input to the hydraulic model, which will be a core of the system that is aimed to provide real-time information and forecasts regarding the sewer system operation. Temporal data collected for the pilot area (meteorology, flow rate and water stage in the Słupia river, flow rats in the sewage system and inflow to the water distribution system) will be used for the model calibration and validation. The model will be also fed with the forecast of precipitation and online monitoring data (precipitation and water level in sewer system) which will be available after the finalization of the procedure for the purchase of monitoring devices.

6.3 Potential for RTC in UDS

There is one pumping station in the Slupsk UDS. There are two storage facilities (tanks) built for stormwater detention. There are no SUDS (bioswales etc.) in the pilot area. There are automated control systems used for UDS operation. There are two basins (including WWTP) connected to Combined Sewer Overflow (CSO) structures. The total basin volume in the sewer system is combined of WWTP: 4312 m^3 and main pumping station: 800 m^3.

7 Exceptions of local policy and regulation requirements on CSO and WWTPBP operation

7.1 Estonia

Water Act regulates CSO and WWTPBP operation in Rakvere & Haapsalu, Estonia. Storm water from the combined sewer system can be lead into the receiving waterbody during cloudbursts with wastewater in the ratio of at least four to one. Combined sewer overflows have to be designed in such a manner that they are activated only if the discharged water is one part wastewater and at least four parts stormwater. The ratio of storm- to wastewater is determined computationally in the construction project.

7.2 Latvia

Pollutant emissions into environment are regulated by the law “On Pollution” (https://likumi.lv/ta/en/en/id/6075).

A water management company obtains a polluting activity permit (based on Republic of Latvia Cabinet Regulation No.404 and No.1082) for the whole water management it provides/ supervises, and this permit determines pollutants limits that can be exposed into environment.

“Water Management Law” (https://likumi.lv/ta/en/en/id/66885) in Section 13 defines Temporary Exceptions for the Achievement of Environmental Quality Objectives, stating that such exceptions are possible if pollution occurs due to exceptional circumstances or extreme weather events and all measures are taken to further minimize such events. Based on “Natural Resources Tax Law” (https://likumi.lv/ta/en/en/id/124707) Section 22 , the tax for pollution during extreme conditions is calculated for emitting period based on permit`s limit values if reported to authorities, or tenfold the amount if not reported.

Republic of Latvia Cabinet Regulation No. 34 in Section 36.3 refers to the need to minimize surface water pollution caused by overload or accidents during rainfall. In Section 41.4 it refers to treatment plant design that allows taking samples in rainwater overflow chambers and emergency overflows. Republic of Latvia Cabinet Regulation No.327 regulates the construction of sewerage structures, stating that rainwater overflow chambers and emergency by-passes need to be constructed but does not specify anything else regarding this topic.

In practice, if the WWTP needs to open a bypass line, the operator monitors the amount of water flowing though it and provides the sampling to determine water quality. Further, Natural Resources tax must be paid. As issued polluting activity permit covers all water management sector, it also covers CSOs. However, there was no information found about monitoring pollution during their operation.

7.3 Poland

According to Polish law, it is possible to transport sewered run-off (rainwater or snowmelt) without treatment directly to the receiver (such as water, water devices or - in some cases - ground), if it is discharged from unpolluted areas (i.e. residence areas, pavements etc.)
From heavily contaminated areas (i.e. industrial areas, roads, airports, fuel storage and distribution facilities) it is permitted, if following quality parameters are not exceeded: TSS concentration of 100 mg/L and concentration of petroleum substances of 15 mg/L.
In case of water reservoirs (including lakes) with constant inflow/outflow of surface waters, it is allowed to discharge stormwater from overflows, if the average annual number of discharges from individual overflows does not exceed 5.
Under no circumstances, can rainwater/stormwater be discharged to groundwater as well as to water devices - in case of rainwater that contains substances, which are considered to be particularly harmful to aquatic environment.
In exceptional situations (with the permission of the competent authority):
1) run-off (rainwater/snowmelt) or stormwater from overflows can be discharged into receiver (surface water or ground) less than 1 km from bathing areas,
2) it is possible to discharge rainwater or snowmelt to lakes and their tributaries, if the time of inflow of these waters to the lake is shorter than 24 hours,
only if it does not interfere with water quality requirements.