SOILS2SEA DELIVERABLE NO. 1.2

BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

Requirements Report

SOILS2SEA

Reducing nutrient loadings from agricultural soils to the Baltic Sea via groundwater and streams

3.6 Pregolya

This will not be a full case study, but can be understood as part of WP 6.4.

3.6.1 Description

All the main water systems of the Kaliningrad Oblast are transboundary. These are the coastal waters of the Baltic Sea, the Vistula Lagoon catchment and the Curonian Lagoon catchment.

The Vistula Lagoon is classified as a low salinity non-tidal estuarine lagoon (Chubarenko, Margonski, 2008) and is a transboundary (Andrulewicz et. al., 1994) water body itself (Figure 3-15). Its volume and area equal 2.3 km^3 and 838 km^2 respectively, 64% of the lagoon volume (1.47 km^3) and 56% (472.5 km^2) of the lagoon water area belong to Kaliningrad Oblast (the Russian Federation), and the rest belongs to Poland (Solovjev, 1971). Since the Baltiysk Strait, as a single inlet connecting the lagoon with the Baltic Sea, is situated on the Russian territory, the Kaliningrad Oblast is formally responsible for the quality of waters coming into the Baltic Sea from the lagoon (Chubarenko, 2008).

The biggest part (64% of the lagoon catchment) is formed by the transboundary basins of Lyna-Lava and Angrapa-Wangorapa rivers (both are 56% of the lagoon catchment) and a catchment of the main stream of Pregolya passing across the Kaliningrad Oblast (Figure 3-17). A small part of the lagoon basin (90 km^2 or 0.4%) belongs to the catchment of Vishtynets Lake in Lithuania.

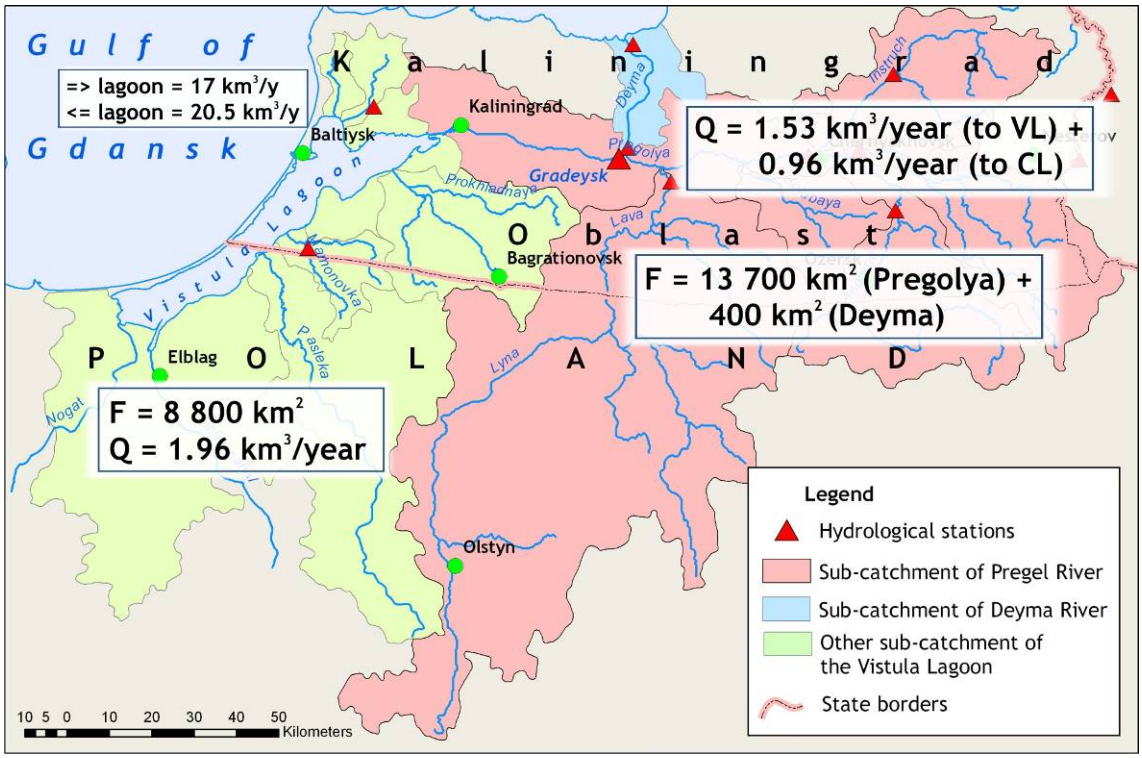

Figure 3-15 Catchment area of the Vistula Lagoon (Domnin, Chubarenko, 2011)

The catchments of Vistula and Curonian Lagoons are connected by the Deyma arm, which is often called as Deyma Branch (Chubarenko, 2008). Deyma (Figure 3-16), being an arm of the Pregolya River, outflows from main Pregolya stream at the City of Gvardeysk and connects Pregolya with the Curonian Lagoon. This means an overlapping of the catchments of the Vistula and Curonian lagoons. Approximately 34% of the Pregolya River runoff is turning towards the Curonian Lagoon through Deyma Branch (Silich, 1971). Thus, the catchment of the Pregolya River, that is above the City of Gvardeysk, including transboundary catchments of the rivers Lyna-Lava, Angrapa-Wangorapa and Pissa (13,700 km^2 in total), belongs to both the Vistula and Curonian lagoons' catchments. This overlapping of the catchments of the two Baltic lagoons isn`t usually taken into account (Markova&Nechai, 1960). The total Pregolya River catchment is usually attributed to the Vistula Lagoon catchment (Silich, 1971), and the only catchment of the Deyma Branch itself, and the total runoff from Deyma are referred to the Curonian Lagoon (Kucheriaviy, 2002). A little part of the river basin (about 60 km^2) is located in Lithuania (close to Vishtynets Lake).

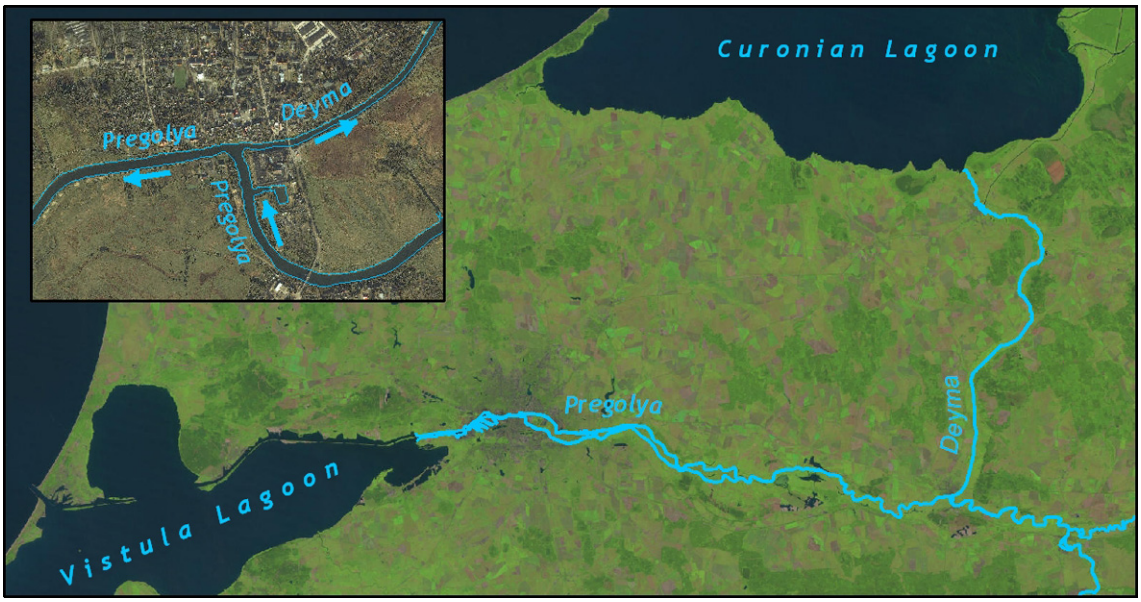

Figure 3-16 The lagoon-estuarine system of Vistula Lagoon - Pregolya River - Deyma Branch - Curonian Lagoon (Domnin et al., 2013)

Pregolya River is the main river that feeds the Vistula Lagoon. It is formed by the confluence of the Instruch and Angrapa rivers and runs on the territory of the Kaliningrad oblast. Pregolya River is a peneplain river. Its bed began to form after deglaciation of the Baltic, about 15,000 years ago (Geography of the Amber region of Russia, 2004).

According to estimations via GIS tool (Domnin, Chubarenko, 2008), the basin of Pregolya River itself amounts to 1,700 km^{2,} the Instruch River catchment is 1,350 km^2, the Angrapa River catchment is 2,200 km^2, the catchment of Pissa (with the basin of Vishtynets Lake) totals 1,500 km^2, the Golubaya River catchment amounts to 540 km^2, and the Lava River catchment is 7,200 km^2. The mean difference between the magnitudes of the differ catchment areas amounts to about 3% depending on literature source.

The length of the Pregolya River is 123 kilometers, and its length with Angrapa is 292 kilometers. The width of the riverbed is 40-80 m in the middle reachesand 200-300 m at the mouth (meteo39.ru).

The Pregolya River is located in transitional climate zone from moderate-continental to marine area. This region is characterized by a very mild winter, often without the formation of stable snow cover, warm and rainy autumn, moderately warm summer and high humidity throughout the year. The region is under the influence of cyclonic circulation six months of the year. About 175 fronts pass through the region annually causing overcast sky conditions, moderate and strong winds. The average annual temperature is around 8°C with 17°C in July and -3°C i January. The average number of rainy and snowy days is 185 and 55 snow, respectively. The prevailing wind direction is western with an average speed of 4 m/s (vsereki.ru). The annual average water discharge of the Pregolya river is 90 m^3/s, generally formed by rainy waters (40%), groundwater discharge (25%), and snow melt (35%). Floods on the Pregolya River occur in March and April, while low flows are observed in summer and autumn. Strong western winds can cause surges, leading to coastal flooding (Markova, 1999).

Marshes and lakes form parts of the Pregolya River floodplain (bogginess - 3%, lake's area - 1%). There are several former river-beds, the largest of them are Voronie and Pustoe (Silich, 1971).

The average slope of the downstream part of Pregolya River is 0.009 m/km causing this part of the river system to be an estuarine system. Water masses penetrate from the Vistula Lagoon upstream to riverbed of the Pregolya River and from the Curonian Lagoon upstream to Deima river almost unimpeded during wind surges. So all river flow near Gvardeysk is dumped into the Curonian Lagoon during western winds and into the Vistula Lagoon during northern winds.

The Pregolya catchment lies in landscapes formed byglaciers with the following dominating landscape areas (Geography of the Amber region of Russia, 2004):

- *Pregolya plain.* This area is located at the southern part of the Pregolya River valley. The landscape was formed by glacial waters. Moraine sediments cover flat monotonous surfaces, composed of clays. The soils of this area are waterlogged due to the flat relief and poor drainage conditions of the clay soils. The area is therefore covered by a network of drainage canals and subsurface drainage. A large part of the land use is forest, while agriculture as well as upland and lowland bogs cover considerable areas.
- *Valley of Pregolya River.* It is formed by the confluence of Angrapa and Instruch and crosses the central part of the Kaliningrad Oblast in the latitudinal direction from east to west. The natural shape of the river has been changed significantly by human activities. Shifting riverbeds have created a well-developed floodplain with alluvial sediments. A significant part of it is swampy and drained using polders. Woody vegetation is almost absent due to long-standing land development. Willow thickets and small islands of pine-bilberry are located on ancient alluvial sediments along the riverbed (Figure 3-18). The dominating soils are alluvial sod soils, occu-

pied by grass-forb meadows with an admixture of sedge marsh. Floodplain lands are used for hay, pasture, and partly arable.

Figure 3-17 The Pregolya River Valley.

- *Instruch hill.* This area occupies the right bank of the Instruch River and part of the Pregolya River with a ridge composed of moraine loams extending up to 40-70 m. There are small tracts of coniferous and deciduous forests in the southern part of the area with oak, spruce and birch as the main species. Ravines and gullies dissect the eastern slope of the moraine ridge. They are fixed by broad-leaved trees (linden, oak, hornbeam). The area is mainly used as farmland.
- *Angrapa-Sheshupe plain.* It is located in the eastern part of the Kaliningrad Oblast and occupies the territory between the Instruch and Sheshupe rivers. The average elevations are 20-25 m. The area is characterized by increasingly continental cli-

mate. Agricultural lands cover territory of spruce-broadleaf forests. The soil consist of well-cultivated soddy weakly podzolic and cryptopodzolic soils.

- *Vishtynets hill.* It is located to south-east of the Kaliningrad Oblast within the sediments of the South-Lithuanian stage and is a spur of the Baltic Ridge. This area is characterised by a hilly moraine hill with a distinct ridge-hilly relief. The height decreases from south-west to north-east from 200 to 50 meters. The largest absolute mark in the Kaliningrad Oblast is Mount Bezymyannaya - 230 m. The Vyshtynets Lake, the largest lake in the Kaliningrad Oblast, is located here.

More than half of the catchment area (54%) is occupied by agricultural areas, while both deciduous and mixed forests occupy 16% each, and coniferous forest 9%. 3% of the land is occupied by cities and 2%by open water bodies (Figure 3-18).

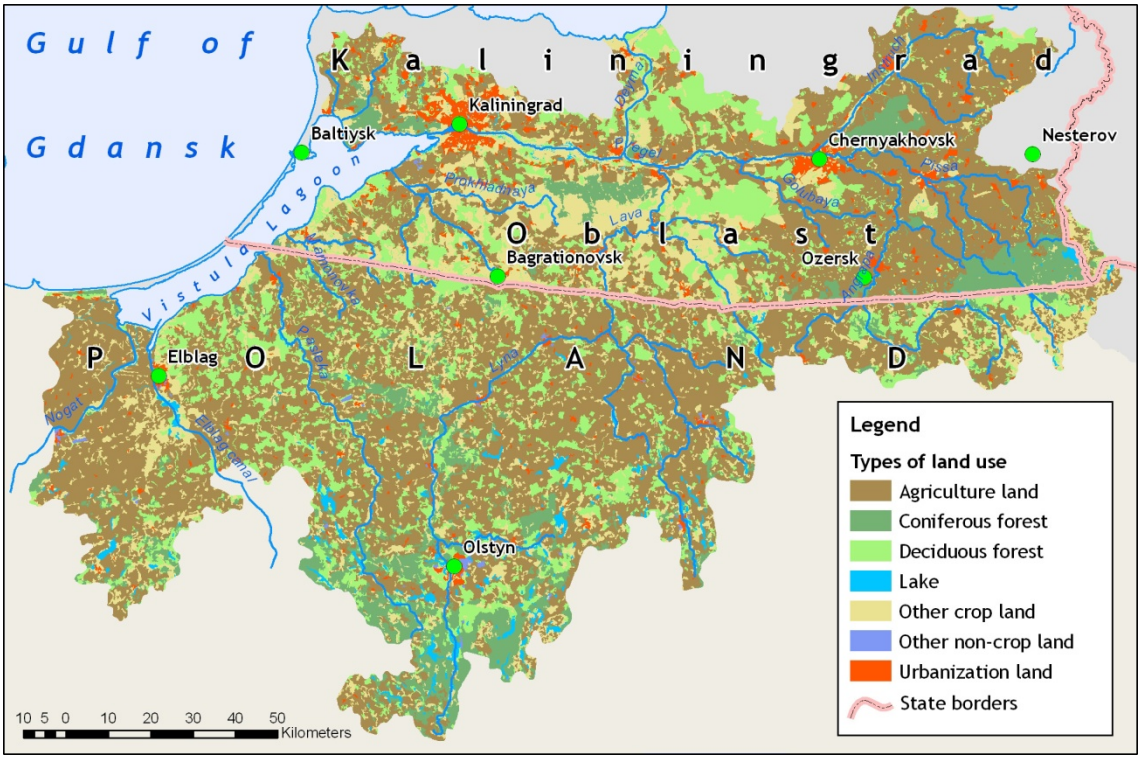

Figure 3-18. Scheme of land use of the catchment basin of the Vistula lagoon (Domnin, 2013)

3.6.2 Data availability and previous studies

The availability of data for the study area is good enough. However, there are problems with data comparability for different territories due to transboundary and different measurement techniques and data sources.

The following data types are available to use for research in basin of the Pregolya River:

- *Climate data*. The measured data of temperature and precipitation, required for modelling, cover the periods: 1989, 1992-1996, 1998-2013 for meteorological stations located inside of the catchment area (Kaliningrad, Baltiysk, Chernyahovsk,

Olsztyn, Elbląg). In addition, there are data from climate model projections (1981-2098 years).

- *Hydrological information (water level and discharge)*. The main hydrological measuring point for the Pregolya River is located near the City of Gvardeysk. It is located 56 km upstream from the mouth of the Pregolya River just upstream the divergence point Pregolya-Deyme (Figure 3-15). There are data covering the period 1981-1996, 2001-2013.
- *Hydrological information (salinity and temperature)*. ABIORAS has monitored the Russian part of the Vistula Lagoon, Kaliningrad Marine Canal and the mouth of the Pregolya River since 1994. There are 12 monitoring stations at the mouth of the Pregolya River (nn 24-30), covering only the lowest part of the estuary within the Kaliningrad city. At 2012 the network of stations has been extended upstream covering both the lower branches: New Pregolya (northern branch) and Old Pregolya (southern branch) (Figure 3-19).

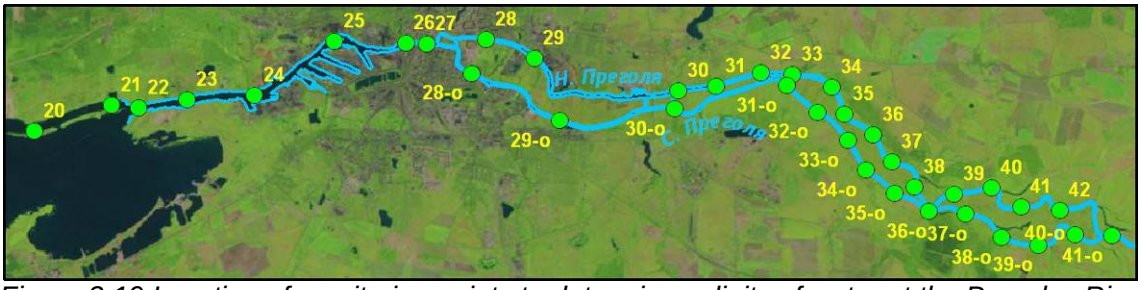

Figure 3-19 Location of monitoring points to determine salinity of water at the Pregolya River. The stations located in the Old Pregolya are marked by "o".

- *Soil texture*. Soil maps for the Kaliningrad Oblast of Russia (Lazareva, 2002) and Poland (Dobrzanski, 1974), calculation by GIS.
- *Land use*. Map of land use of the Kaliningrad Oblast (Scheme..., 2008), data of Corine Land Cover for Poland (Corine Land Cover), calculation by GIS.
- *Topography*. Data of Satellite Radar Topographical Monitoring SRTM (SRTM: CGIAR-CSI SRTM 90m DEM Digital Elevation Database, http://srtm.csi.cgiar.org/), including values of relief heights gridded with a spacing of 90 meters and a height resolution of 1 meter, calculation by GIS.
- *River network geometry*. Data of geographical maps (Dobrzanski et.al., 1974, E-HYPE) and satellite photos *LandSAT 7 ETM*, calculation by GIS (TauDEM, ArcHydro).

Data collected in previous studies can also be used:

- Specialized geographic information system for the analysis of river catchment basins and conduction on its basis of modeling of hydrological processes (grant of RFBR 10-05-90713-mob_st: Domnin, Chumachenko, 2010) was formed. It combined spatial information for river network, DEM, administrative and catchment borders, and time series for water discharge, precipitation, temperature. Also the mathematical modelling of the response of freshwater component of the water balance of the Vistula Lagoon were studied during grants RFBR 08-05-92421-BONUS_a (Chubarenko, Domnin, 2008-2011) and grant RFBR11-05-90727-mob_st (Domnin, Kondratyev, 2011,). Issues of inflow from the Vistula lagoon to es-

tuarine part of the Pregolya River were studied during grant RFBR 12-05-31248_mol a (Domnin, 2012-2013).

- Nutrient loads were estimated by monitoring and modelling for the Instruch River (Project HarmoBalt, 2009, lead. Chubarenko B.V., responsible executor: Gorbunova Yu.A.), for the Primorskaya River (Project Moment-Pri, 2012, lead. Chubarenko B.V., executors: Gorbunova Yu.A., Domnin D.A.), for the Mamonovka River (Project BaltHazar, 2012, lead. Chubarenko B.V., responsible executor: Domnin D.A.).

3.6.3 Water management issues

Most river basins in the South-Eastern Baltic are transboundary (Chubarenko, 2008). The non-coincidence of natural and administrative boundaries makes water management in the region rather complicated. Furthermore, the transboundary catchments have different management experience and legal basis in the respective countries. Lithuania and Poland as members of European Union are obliged to follow the EU Water Framework Directive, while Kaliningrad Oblast as a part of the Russian Federation uses Russian Water Code as a principal law of water usage and protection. To achieve a sustainable management of water resources joint goals needs to be established and the same standards and procedures in water usage, water quality control, water monitoring and management should preferably be implemented within all shared catchments.

The territory of the Kaliningrad Oblast belongs to the Baltic Basin District, which covers part of the Russian part of the Neman river basin and other river basins of the Baltic Sea in the Kaliningrad Oblast (Baltic Basin District, 2008). This water management area borders with Lithuania to the north and east, with Poland to the south, and borders the Baltic Sea to the west. The Baltic Basin District is divided in three sub-districts (for the Neman River, Pregolya River and other rivers). The Pregolya River sub-district (7100 km^2) covers the Pregolya River catchment and of small rivers flowing into the Vistula Lagoon. Deyma Branch officially belongs to the third sub-district “Rivers of the Baltic Sea basin within the Kaliningrad Oblast without the Pregolya and the Neman rivers” (4300 km^2). Russian Water Code is the main legislation to regulate water use issues in the Russian Federation (Water Code, 2005).

The Agreement signed on 07.17.1964 (Warsaw, Poland) between the governments of the Union of Soviet Socialistic Republic and the Government of the Polish People's Republic on the water sector in boundary waters is a bilateral agreement for protection of water resources, regulating the activity of hydro-constructions, water supply, flood control and erosion of river basins of Neman, Pregolya and Vistula. This Agreement is still the single document which regulate bi-lateral relations between Russia and Poland, as non- and EU counties, as Water Framework Directive (WFD) is not applied to non-EU countries.

The main authorities that regulate water use in the Kaliningrad Oblast are:

- Government of Kaliningrad Oblast
- Neva-Ladoga Water Basin Administration Department (Kaliningrad office)
- Kaliningrad Center for Hydrometeorology and Monitoring of Environment

3.6.4 Case study focus

The objectives of the Soils2Sea project for the Pregolya River study are:

- To analyse impacts of changes in climate and land use on nutrient loads from the Pregolya River catchment.
- To assess the possibility for retention of nutrients by surface water in the Pregolya River catchment.

3.6.5 Planned field and modelling studies

- Tasks 2.1&2.4: Develop joint land use and climate change scenarios and scenarios for the Baltic Sea basin
  - Review of scenarios of land use for transboundary areas of the Pregolya river catchment and probable climate changes (2014-2015);
  - Analyses of retention scenarios of nitrogen and phosphorus from territory of Pregolya River catchment (2014-2015);
  - Analyses of scenarios of South-East Baltic region development (2014-2015).
- Tasks 6.3&6.4: Test of policy instruments and monitoring concepts for differentiated regulations
  - Screening-monitoring of nutrients concentration for the Pregolya River catchment (2014-2016).
- Task 5.2: Testing basin scale model setup for simulations in Pregolya catchment
  - Testing of a numerical model to nutrients retention in the Pregolya river catchment (2014-2016);
  - Testing of modelling results for nutrient load on historical data for a long time period (2016);
  - Analyses of results of nutrients retention by different mid-catchment areas of the Pregolya River catchment (2016)
  - Zoning area of Pregolya River Catchment by retention capacity of nutrients in the basin scale (2016).
- Task 6.5 Policy Brief
  - To recommend measures to reduce loads from the catchment basin (2016).

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