PROLINE-CE

WORKPACKAGE T2, ACTIVITY T2.1

SET UP OF PILOT SPECIFIC MANAGEMENT PRACTICES

D.T2.1.4 DESCRIPTIVE DOCUMENTATION OF PILOT ACTIONS AND RELATED ISSUES

PILOT ACTION PAC2.1: *WELL FIELD DRAVLJE VALLEY IN LJUBLJANA*

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Date last release	December 2017

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1. Introduction

Land use and climate change have significant impacts on water resources in general and drinking water resources in particular. Drinking water protection is already an integrated part of some land-use management practises, but lagging behind with implementation and realisation. The main objective of PROLINE-CE project is improved protection of drinking water resources as well as protection against floods/droughts in an integrated land use management approach. PROLINE-CE will encompass efficient implementation of innovative best practices of land use and water protection in pilot actions, aiming at transnational levelling of fundamental visions, elaboration of policy support and implementation support at operational level.

The public company JP VODOVOD-KANALIZACIJA d.o.o. is the largest water supply company in Slovenia. In accordance with legislation, the public water supply service has to have the reserve drinking water source to increase reliability and safety of public water supply. On the basis of previous geological and hydrogeological research Dravje valley was selected for reserve water well field. Dravlje valley is a settled area, crossing by highway and with large open spaces adjacent to a Natural Park of hilly area. Because of its location in the suburbs of Ljubljana, there is also a high pressure on land use. Dravlje valley is also a flood area with not properly regulated surface waters coming from hinterland. Most of these waters are lead to the urban sewage system, which in high waters cannot receive so much water; on the other hand leading of surface waters to sewers is an adequate solution form the environmental point of view. In the future more frequent high waters because of climate change are foreseen; therefore solutions and measures for tackling this problem should be developed. For this harmonized land use and water resources management is a prerequisite for quality of life and drinking water in this area, therefore for Slovenian Pilot Action Dravlje valley in Municipality of Ljubljana was selected.

2. Basic data about pilot action

2.1. Geographical description

Selected pilot action area (PAA) represents Glinščica river basin. In the north side extents to the forest area of Toško Čelo and Mirni vrh. The east watershed goes from the urban area Dravlje and Šiška over the Šišenski hill and Rožnik to the watercourse Gradaščica, which represents the southernmost point of the basin. In the western direction the watershed goes through urban area from Brdo to Tičnica, and then towards the north via the Stražni vrh, Preval to Toško Čelo.

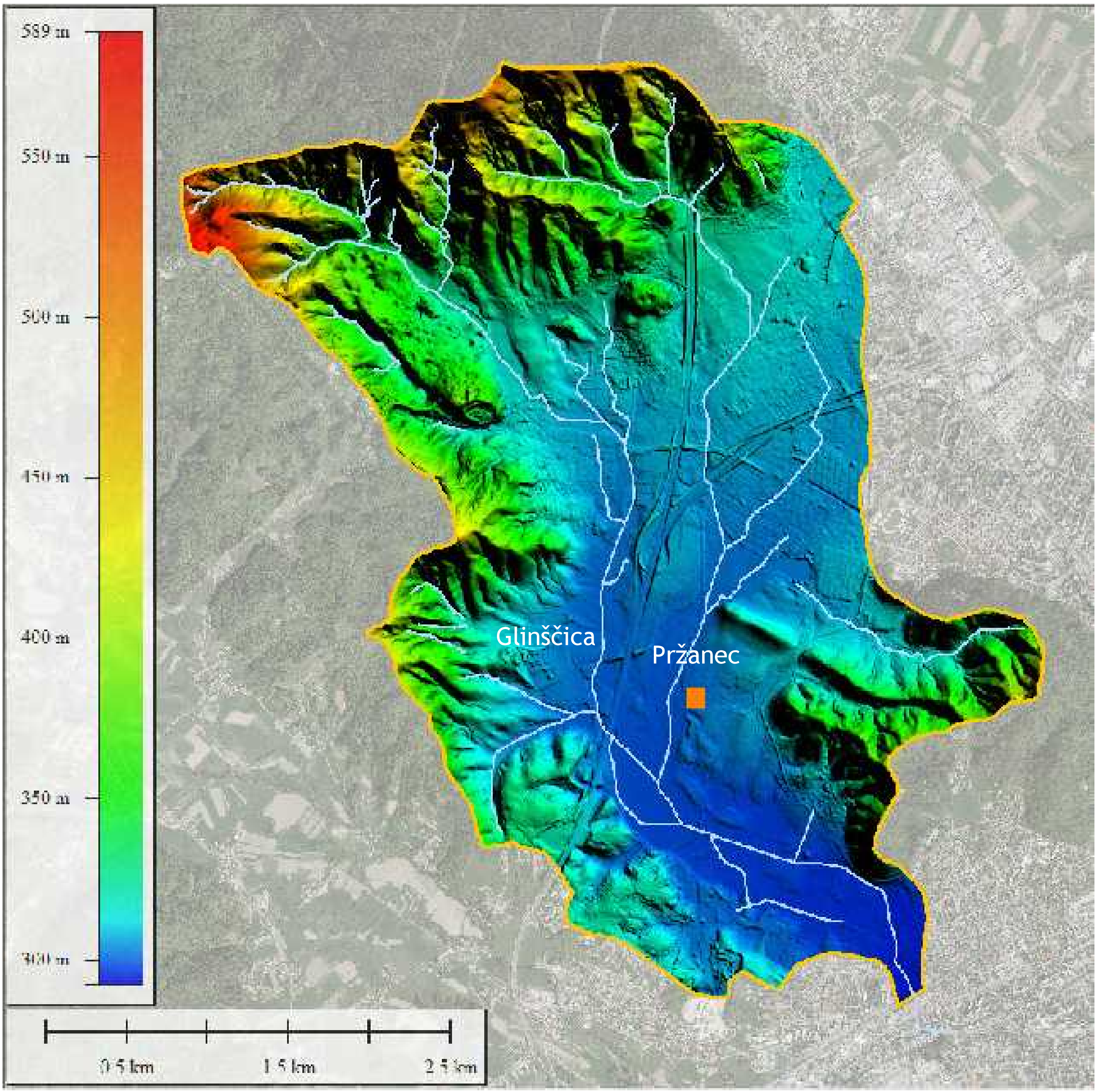

Figure 1: LIDAR (surface) data of the PAA (ARSOa, 2017)

River Glinščica spring is under a hill Toško Čelo, in Podutik enters the flatland of Ljubljana plain. Then it runs in the edge of Ljubljansko barje along hill Rožnik. In the urban area Vič Glinščica flows into Gradaščica (which then flows into the Ljubljanica). Relief of the Glinščica basin is quite diverse from hilly part in the east to the plain area in the southern part (Figure 1).

2.2. Geological description

The oldest rocks in the Pilot action Area (PAA) belong to the Carboniferous-Permian black clayish shales and Val Gardena clastic sedimentary rocks, separated by erosional disconformity. They are located on the slopes of Rožnik hill and Toško Čelo (Figure 1), which represent hinterland of watercourse Glinščica. Triassic beds are found with great lithologic diversity, which is characterized by lower Triassic layers rhythmically changing from sandy clay beds to Limestone and Dolomite. In the upper part dolomite (Main Dolomite) and limestone beds (Dachstein limestone with Megalodon shells) dominate, overlain by dolomite beds which continue to middle and upper Triassic. In lower Jurassic thick bedded Liassic limestone occurs (Grad & Ferjančič, 1976; Novak, 2000).

From the hills and slopes, river Glinščica and smaller streams transport sediments to the lower parts and flatland. The Piezometer OP-12/03 shows more than 80 meters of clay and gravel sediments transported and deposited in Koseze area. Clay prevails in the upper 15 m, from this depth downwards sandy gravels and conglomerate are deposited (Petauer, 2003).

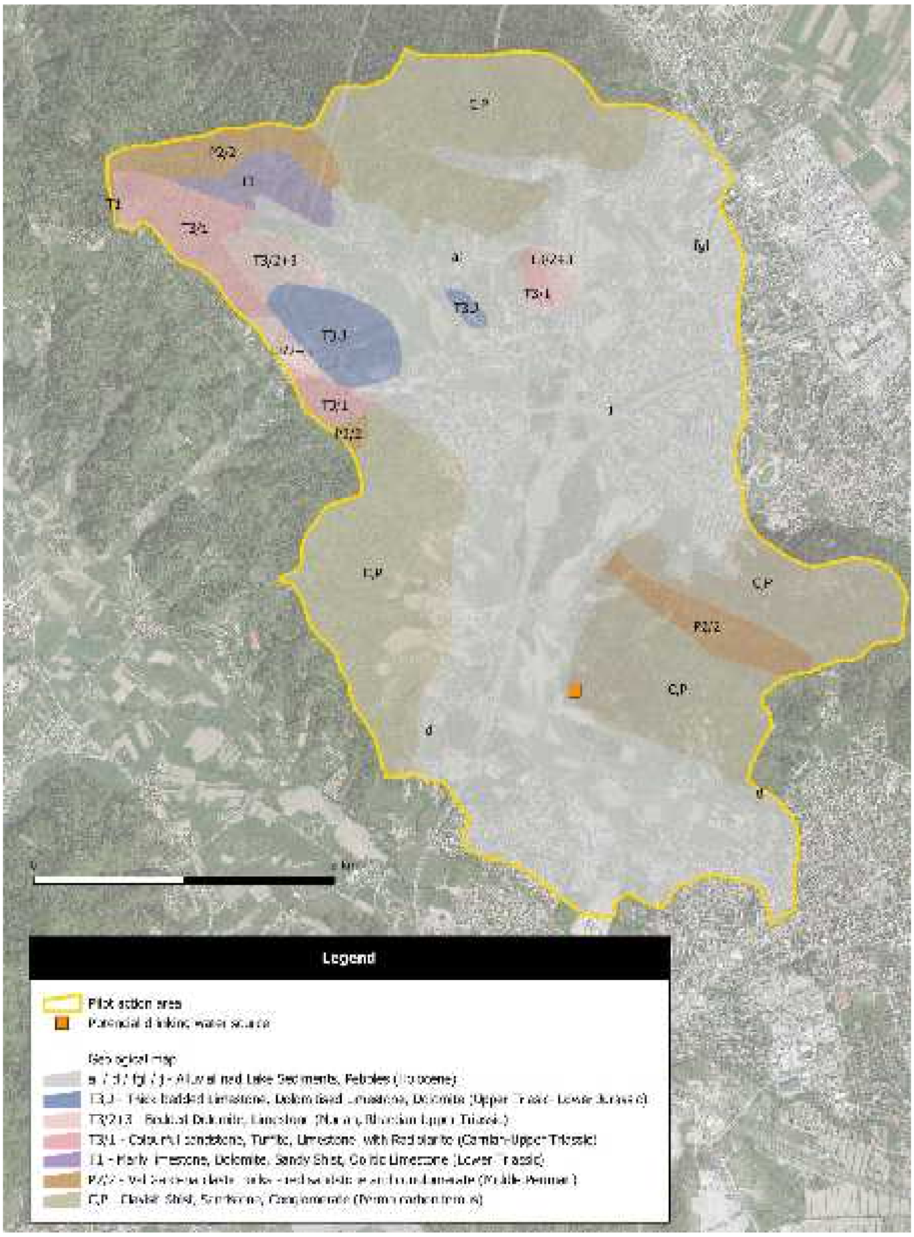

Figure 2: Geological map (GeoZS, 2017)

2.3. Pedology

The pedology in Pilot Area is very diverse. The area is covered by seven different types of soil (Figure 3). There are also urban areas and one Quarry. On the slopes of Toško Čelo and Šišenski hill, soil type Cambisol prevails. Cambisol is a young soil at depth 25 - 50 cm, with purely developed horizons or containing homogenous sand. Minor differences between soil subtypes are in colour: Chromic Cambisol is reddish coloured and in base saturation, whereas brownish Dystirc Cambisol contains less than 50% base saturation. On some smaller parts of slopes, Rendzinic Leptosol type of soil is present. Leptosols are soils with a very shallow profile depth, containing large amounts of gravel and they often cover mountain slopes on Limestone or Dolomite layers.

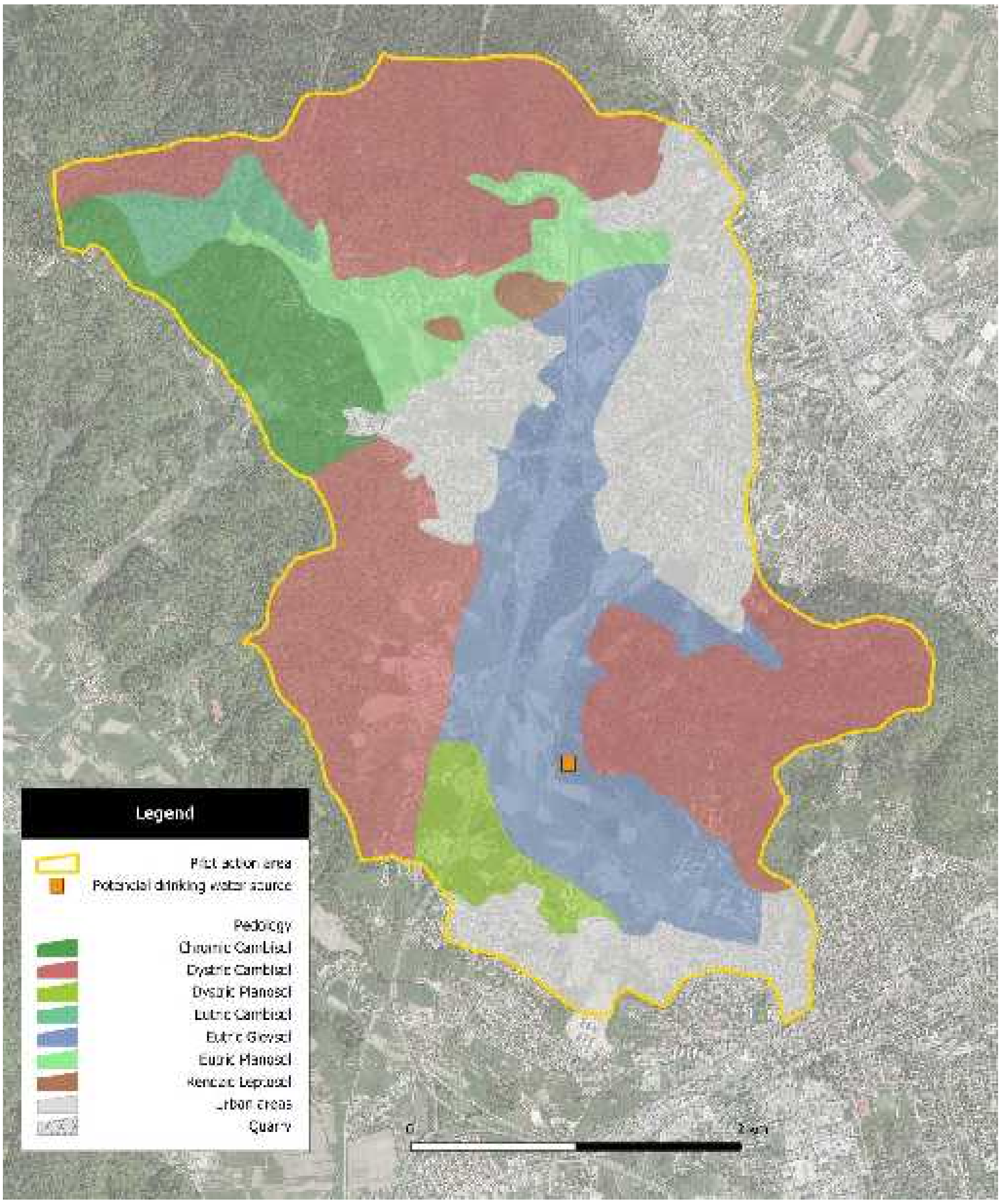

Figure 3: Pedological map (GURS, 2017)

In the Flatland where river Glinščica deposits river sediments, Gleyosol and Planosol are located. Both are Eutric subtype of soil and have 75 percent or more base saturation. Gleysols and Planosols are characterized by a subsurface layer of clay accumulation and are poor in plant nutrients (FAO, 2017).

An urban area contains small amount of soil, mainly high population density and infrastructure.

2.4. Climate characteristics

The climate in Slovenia is highly variable and offers varied seasons with strong winters and warm summers, pleasant spring and wet autumn. Average summer temperatures in Ljubljana are around 19 °C and average winter temperatures around -0.5 °C. Average yearly temperature is 9.2 °C and has increasing trend in the last 50 years (Figure 4).

Average yearly rainfall dated for Ljubljana's Topol weather station for the period 1981 - 2010 is 1649 mm and average snowfall is 178 mm. Snow lies mostly in highlands and lasts from November till April, while in low lands it lasts up to two months per year. Average yearly rainfall variation in the period 1961 – 2010 is depicted in Figure 4.

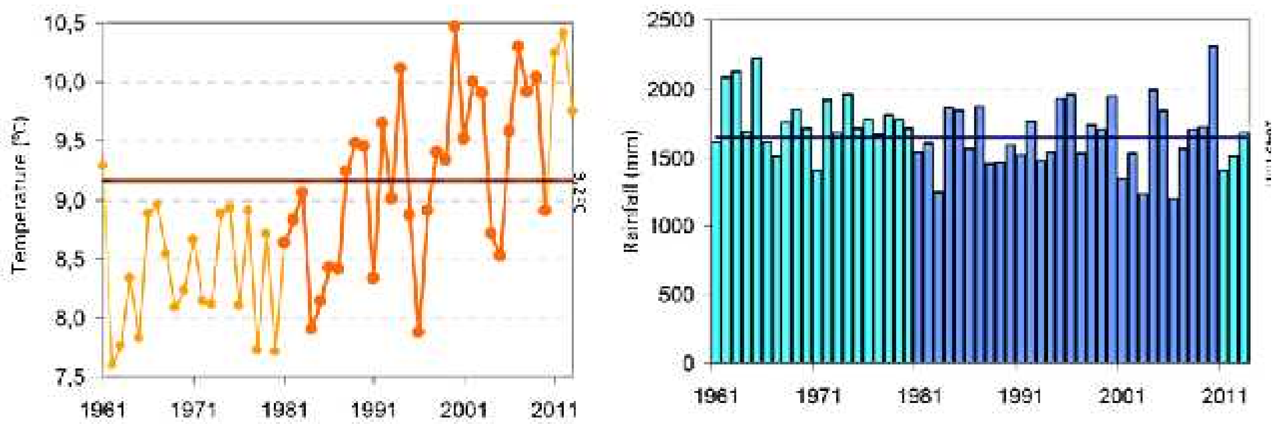

Figure 4: Average yearly temperature (left) and average yearly rainfall (right), measured 1981 – 2010; (ARSO, 2017b, 2017c)

Average monthly temperature is ranging from 0.6°C in winter months to 18,1°C in summer months (Figure 5). Significant peak of average monthly rainfall (Figure 5) is around 176 mm in autumn months (September to November), whereas the lowest average monthly rainfall is around 85 mm in winter (January and February). For Ljubljana the estimated mean monthly evapotranspiration ranges from a minimum 11 mm to a maximum of 136 mm (Figure 5). Yearly average of evapotranspiration in the period 1961 - 2010 is 766 mm (ARSO, 2017b).

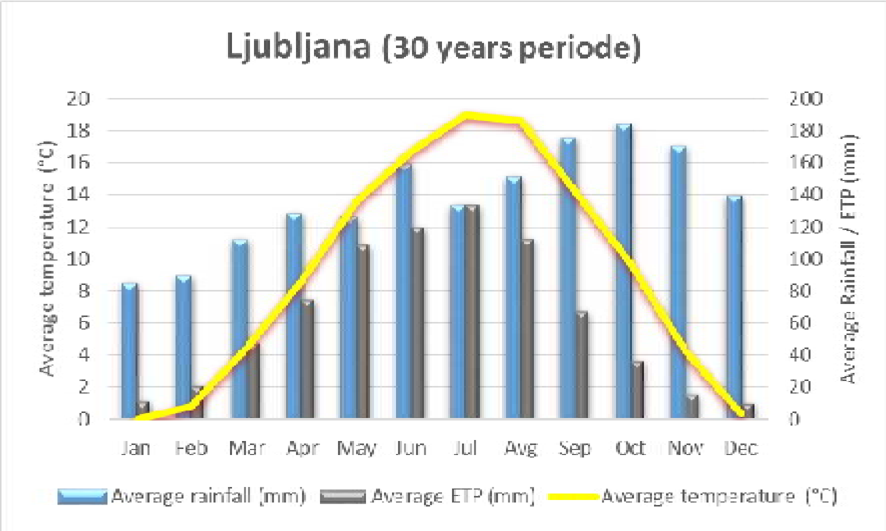

Figure 5: Average monthly rainfall, ETP and temperature for Ljubljana for the period 1981-2100 (ARSO, 2017c; ARSO, 2017d)

2.5. Hydrology

2.5.1. Surface waters

The main watercourse in our selected pilot action area is called Glinščica (Figure 6) and its biggest left tributary is Pržanec. The catchment area of Glinščica is 17.4 km^2. The position of the drainage within the urban area is determined by the drainage of meteoric water with the sewage system, therefore the orographic watershed does not coincide with the catchment area of Glinščica. The total catchment area of Glinščica is therefore slightly larger and covers 19.3 km^2 of area because the rainfall runoff from the Šentvid area is conveyed to the Glinščica basin through the meteoric sewerage network.

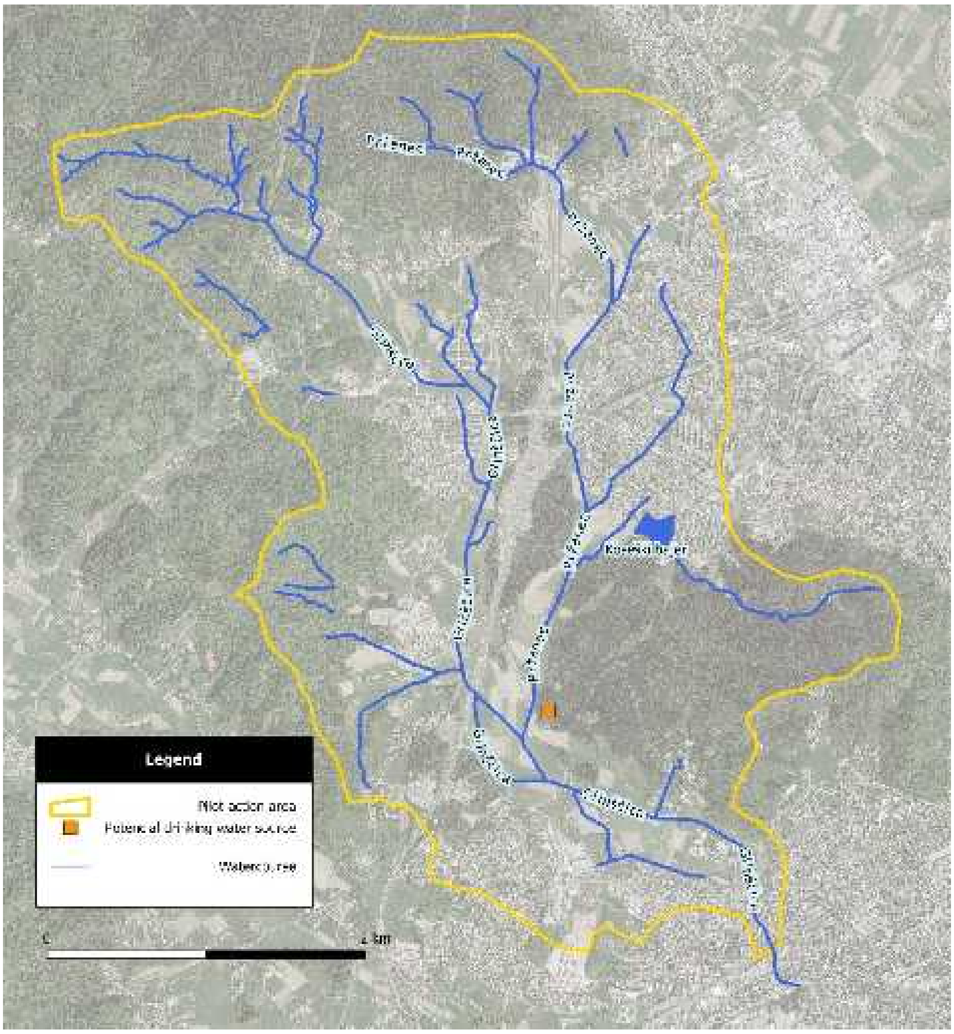

Figure 6: All watercourses in the PAA (ARSO, 2017a)

The hydrology of the watercourse basin changed significantly with the expansion of the paved impervious urban surfaces on the plains of the Glinščica basin. These flat areas contributed little to the formation of the runoff hydrograph peaks before the sealing. The runoff coefficient increased by increasing the share of impervious areas (sealing, traffic surfaces). The construction of the meteoric sewerage additionally contributed to reducing the concentration time. A rough estimate of the average runoff coefficient from the Glinščica catchment area, calculated from the average annual rainfall (1376 mm) and the average annual flow of Glinščica (0.383 m^3/s), is 0.58, which is an indicator of intensive drainage of rainfall waters in the Glinščica stream (Rusjan, et al., 2003).

There is no automatic or even regular flow measurements in the watercourse Glinščica, but now and then measurements are made. Some measurements were made during the thesis work of Koprivšek (2006) in the year of 2005 and 2006. There were six measurement locations selected (five along the watercourse Glinščica and one on its tributary Pržanec). Water flow varies between 0.03 and 0.37 m^3/s in the GLIN5 profile.

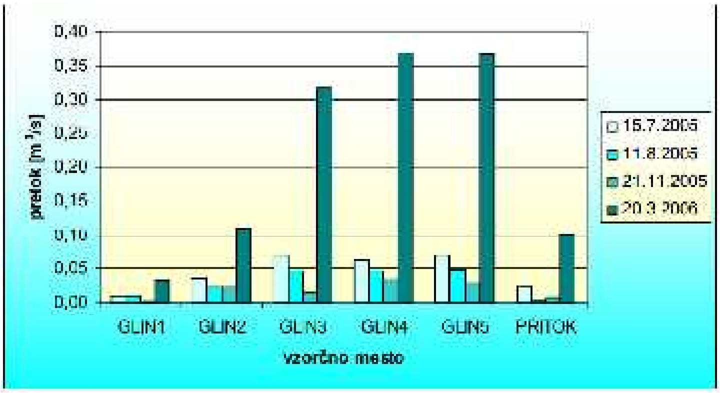

Figure 7: Water flow on selected locations of various sections of Glinščica and tributary Pržanec on four different days (Koprivšek, 2006)

2.5.2. Flood issues

Before the regulation works, the Glinščica watercourse channel gently meandered along its course. The channel was 3 to 6 m wide and 60 to 90 cm deep. The banks were 30 to 60 cm above the normal water level and the river bottom was muddy. The Glinščica flooded the adjacent areas (Ljubljana's sub region Vič) in rainy periods. Until the end of World War II, the Glinščica watercourse was mostly unregulated upstream of Rožna dolina with a natural meandering channel. The channel area was overgrown and both, the banks and bottom were natural. Along the stream course, deep stream reaches with pools and shallow reaches alternated. The structure of fish population was varied and among fish species, the trout could also be found in the Glinščica. Larger pools were suitable for swimming. With Rožnik, Mali Rakovnik and Veliki Rakovnik and Večna pot the Glinščica provided an attractive natural gateway for promenading (Rusjan, et al., 2003).

After World War II, regulations took place on the Glinščica channel from the outfall section (regulation from 1928) upstream. This was not a planned regulation. The channel was being cleaned by landowners of the surrounding land, some drainage ditches were excavated, and meanders were cut off from the new straightened river channel. Before the regulation in 1974, the Glinščica channel was neglected, especially in the urbanized area (Ljubljana's sub region Vič). The result of the regulation from 1974 is a concrete channel bottom in the section from the outfall into the Gradaščica river to Brdnikova street. The line of the channel was completely straightened. In the channel bottom, a 1 m wide and 25 cm deep concrete ditch was arranged. This ditch conveys the average annual and low summer (dry) waters. A part of the channel banks, with a slope from 1 : 3 to 1 : 2, is paved with concrete plates (Rusjan, et al., 2003).

The decision of arranging a concrete ditch on the channel bottom was based on the fact that the central concrete ditch assures sufficient velocity of flowing water in periods of average annual and even low summer water levels. In this way, the gathering of all sorts of pollution and waste inside the channel cross section is disabled. The channel reach from Jamnikarjeva street (downstream end point) to Brdnikova street (upstream end point) is 1173 m in length (Figure 1: LIDAR (surface) data of the PAA (ARSOa, 2017)and 6). The bottom of the paved channel is covered with fine sediments and other particles, which are transported from the upper reaches, where the channel bottom material remained natural and from the outlets of the urban drainage system. As mentioned before, the intensive depositing of sediments at low summer water levels is disabled by a uniform water velocity profile in the concrete ditch. Where the concrete pavement is damaged, vegetation grows through the cracks. There is no variety in the water current and no changes in stream width and depth. Some algae (periphyton) are present on the concrete bottom. The channel is almost completely unshaded on the reach discussed (Rusjan, et al., 2003).

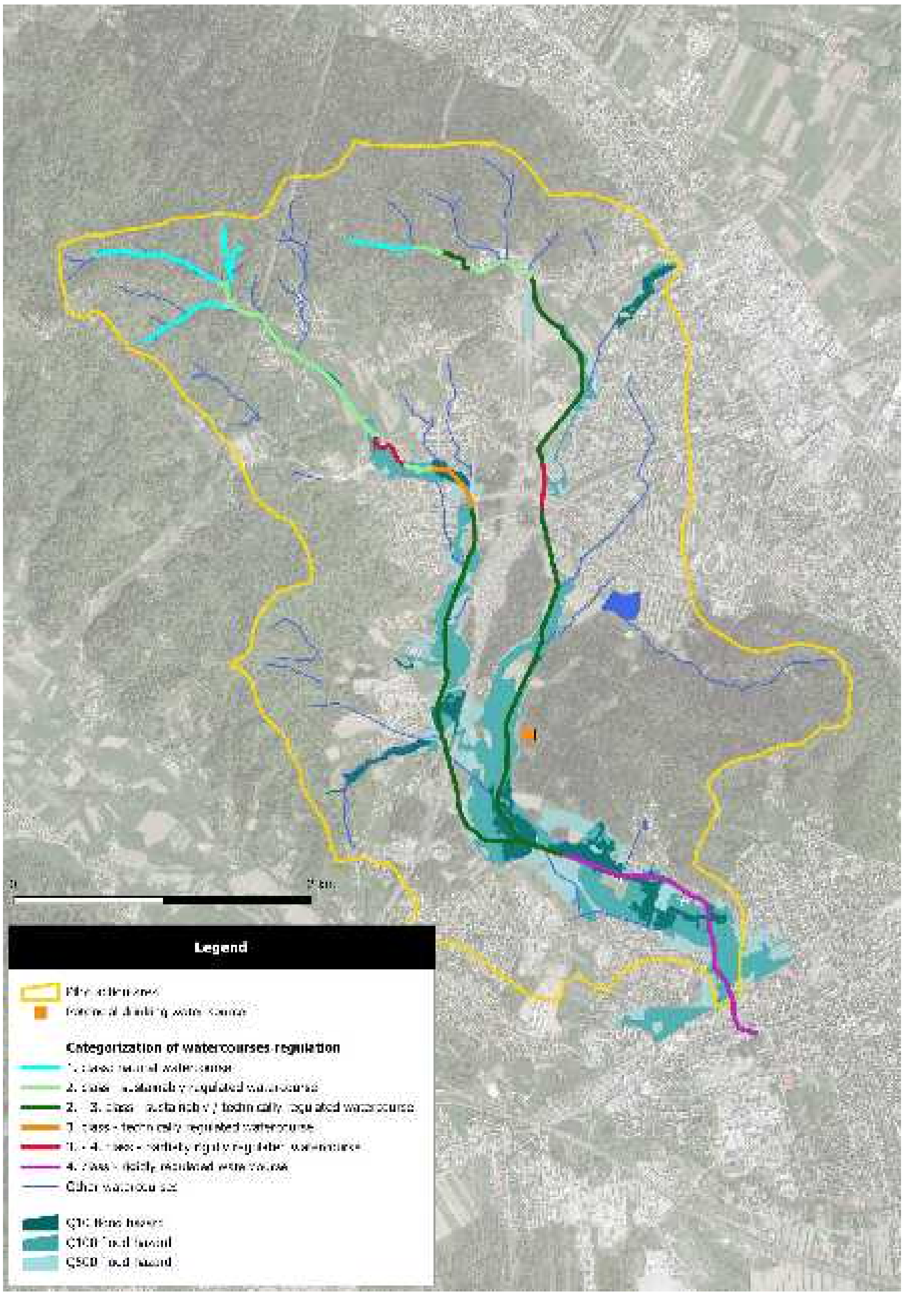

Figure 8: Flood hazard map with categorization of watercourses regulation (ARSO, 2017a)

High waters of different frequencies in different sections of Glinščica were determined in the study C-681 Glinščica-Pržanec (VGI Ljubljana, 1999) and are summarized in Environmental report (2011). Results are shown in the Table 1.

Table 1: High waters of Glinščica - the existing state (Environmental report, 2011)

Cross-section	Q5 m^3/s	Q10 m^3/s	Q20 m^3/s	Q50 m^3/s	Q100 m^3/s	Q500 m^3/s
Glinščica - Pržanec	6,3	9,1	12,1	16,2	19,3	27
Pržanec -Glinščica	5,1	7,4	10,2	14,9	19,2	26,8
Glinščica -Gradaščica	14,2	18,5	22,2	31	39	54,6

Glinščica, downstream of Brdnikova street, was already regulated in the past. The bottom and bottom of the slopes are secured with concrete slabs; the slopes are covered with grass. Downstream of the Brdnikova road there are several outflows from overflows and meteor channels. The river crosses 5 wooden footbridges (Environmental report, 2011).

In the current situation, with intense precipitation, a large part of the rainwater from the existing urbanized areas of Brdo drains towards the southern edge of the Glinščica valley towards the peripheral ditch and flows into a channel, which, however, is not sufficient for the smooth flow of high waters. This high water threatens the inhabited area of the right bank of this channel and at even higher levels of the Biotechnical Faculty, which is on the left bank (Environmental report, 2011).

In order to reduce the flood risk of the area near Glinščica in the area of Rožna dolina, the construction of a retention facility on Brdnikova Street in Ljubljana has started in spring of 2017. The planned embankment - the canton of Brdnikova ulica up to 1.40 m will additionally activate the current flood area between Brdnikova road and the western bypass. The peak discharge of the Q_{100} will decrease in the cross section of Brdnikova Street from the current 38 m^3/s at 18 to 20 m^3/s. The retention volume is 484000 m^3 (Fazarinc, 2010).

2.6. Hydrogeology

At the surface there is 15 to 22 meters thick layer of alluvial and lake sediments (Figure 2: Geological map (GeoZS, 2017) and Figure 9:), which contain clay, organic clay, peat, marl, sand, clayish gravel and sandstone, forming an aquitard (Železnik, 2005). Beneath this layer are sandy gravels with conglomerate, which form confined porous aquifer. The Piezometer OP-12/03 (Figure 8) showed 15 m of mostly clay and underneath from 15 to 82,8 m sandy gravels with conglomerate. Conglomerate prevails in the bottom (depth 66-83 m), till Groeden (Val Gardena) sandstone which represent geological basement (Petauer, 2003).

Pumping test in piezometer OP-12/03 showed that hydraulic conductivity of confined porous aquifer is very good - more than $1x10^{-3}$ m/s. The confined porous aquifer is with 14 to 20 m thick layer of clay protected from pollution. The aquitards permeability was measured on several locations of the Pilot area and all were around $1x10^{-8}$ m/s (Železnik, 2005).

The groundwater level along river Glinščica is nearest to the surface, where its depth reaches 0,5 and 1,5 m, while in the NW part of the area, two layers of groundwater were found. First is on 3 m depth (aquitard) and the second between 6 to 9 m (confined porous aquifer) under the surface (Železnik, 2005).

According to hydrogeological classification (Figure 8), the main aquifer is intergranular (porous) aquifer (type 1.2), which is mainly overlaid by aquitard (type 3.3). Toško Čelo represents hinterland of river Glinščica and minor aquifer with local and limited GW resources (Type 3.1), the same as Šišenski hill in the southeastern and hills in the southwestern part of the PA. The northwestern parts represent fissured aquifer of Polhograjski dolomiti, more specifically discontinuous productive aquifers (Type 2.2). There is a minor part of limestone, presenting karst-fissured aquifer (local extensive and highly productive aquifer; Type 2.1)

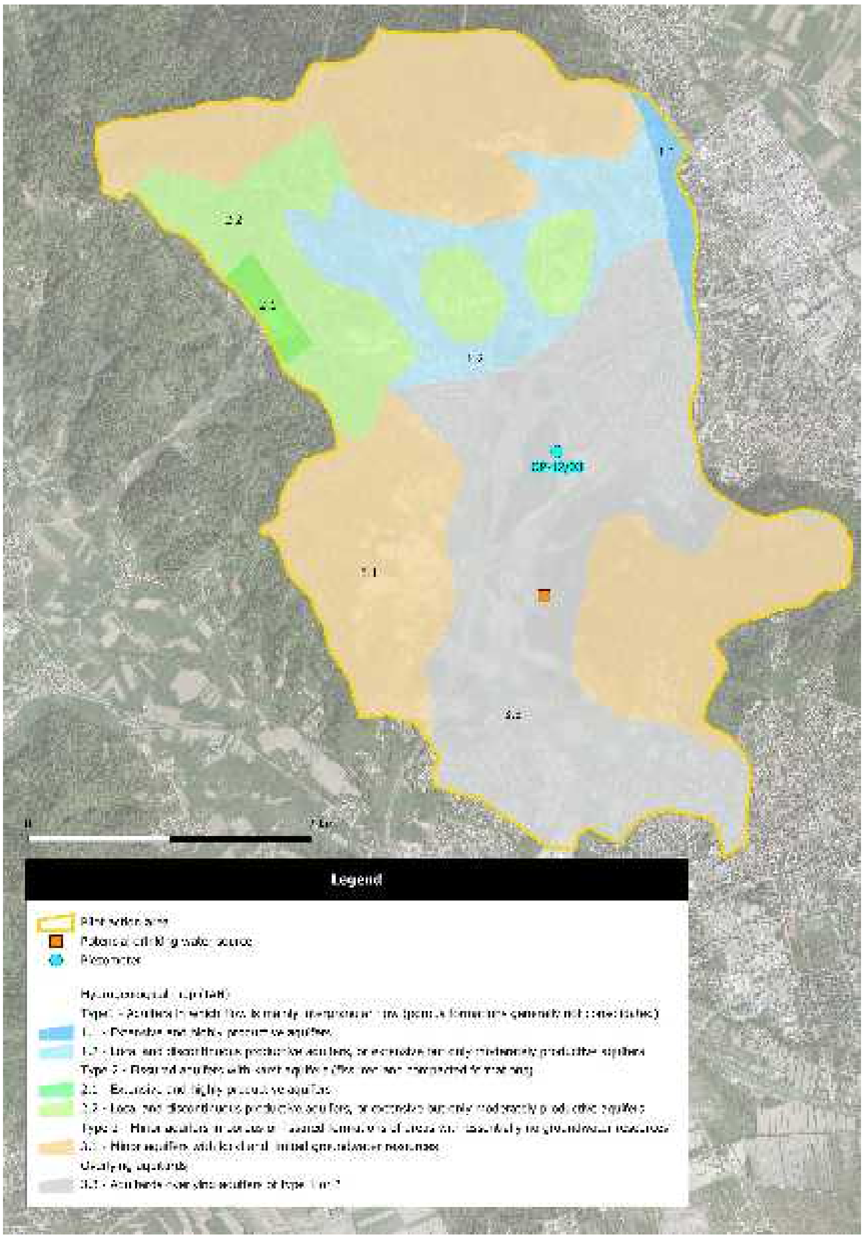

Figure 9: Hydrogeological map (IAH) (ARSOa, 2017)

2.7. Land use

Instead of Corine Land Cover 2012 data, we have used Actual land use data. Typology of actual land use in Slovenia was made on the basis of ECE draft international standards for classification of land use and also following the example of the Land Use Statistical Framework and Corine Land Cover nomenclature. Update was based on the project "Development of Information System for Ministry of Agriculture, Forestry and Food". It was adapted to the needs of agriculture in Slovenia and is therefore in some cases more detailed than the basic ECE classification.

The actual land use is determined by the natural elements of the earth's surface caused by natural factors or human activity (use). Data on actual use are kept in the land cadastre and managed independently from the boundaries of the parcels. The data is managed and maintained by The Surveying and Mapping Authority of the Republic of Slovenia.

Particular actual land use of the pilot action area is presented in Figure 10. Percentages of particular actual land use are listed in Table 2.

Table 2: Actual land use in PAA

Land class	Type of land use	Type of actual land use	Surface area (km^2)	Percentage
Other	Other non-agricultural surfaces	Other wetland	0,012	0,07%
Forest	Other agricultural surfaces	Trees and shrubs	0,272	1,63%
Forest	Other agricultural surfaces	Abandoned agricultural land	0,159	0,95%
Forest	Forest	Forest	7,538	45,26%
Field	Other agricultural surfaces	Not-cultivated agricultural land	0,092	0,55%
Field	Farmland and gardens	Farmland	1,155	6,94%
Field	Farmland and gardens	Greenhouse horticulture	0,006	0,04%
Built up	Other non-agricultural surfaces	Built-up area	5,125	30,77%
Grassland	Permanent crops	Rough or meadow orchard	0,084	0,50%
Grassland	Permanent crops	Orchard	0,017	0,10%
Grassland	Grassland	Meadow	2,122	12,74%
Water	Other non-agricultural surfaces	Water	0,072	0,43%

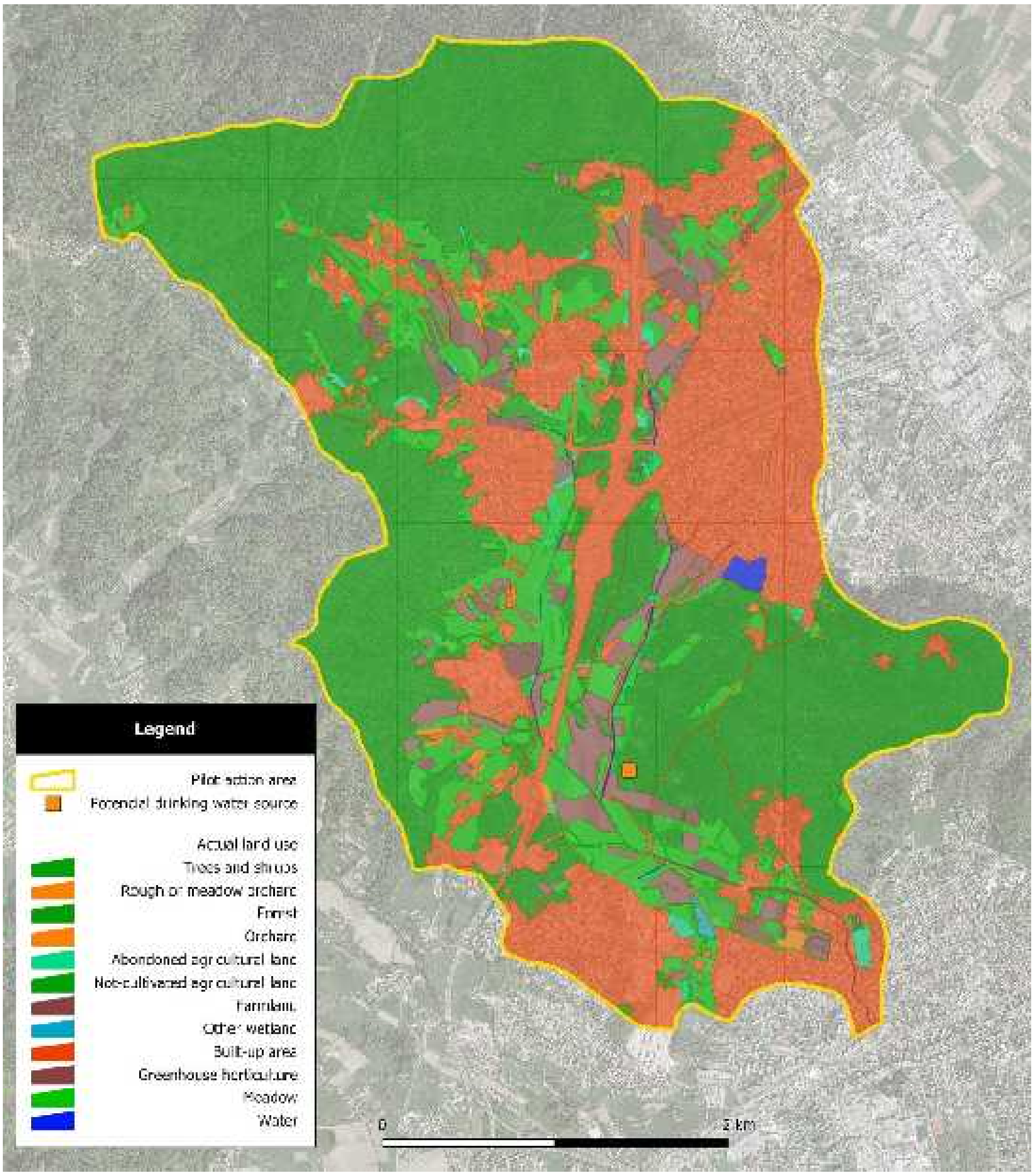

Figure 10: Actual land use in PAA (MKGP, 2017)

3. Water supply in the pilot action

3.1. Drinking water sources

In Dravlje valley Ljubljana marsh aquifer pass into Ljubljana field aquifer. The groundwater flow is from Barje aquifer through the Dravlje valley to Ljubljana field Aquifer.

Municipality of Ljubljana has a large central water supply system covering the urbanised lowland of Ljubljana. The JP VODOVOD-KANALIZACIJA manages a 1100 km water-supply system. The system has 40.500 connections that supply water to 315.00 users. It is supplied from four waterworks on the Ljubljana field, namely Kleče, Šentvid, Hrastje, Jarški Brod and one waterworks, Brest on the Ljubljana marsh. The system comprises a total of 44 active water-pumping wells. Groundwater is being pumped from wells reaching depths of 40 to 100 m. The wells are equipped with submersible deep well pumps that can deliver 15 to 100 l/s, depending on well and aquifer capacity. The Kleče waterworks have remained at the heart of the city's water-supply system for the entire century.

In accordance with legislation, the public water supply service has to have the reserve drinking water source to increase reliability and safety of public water supply. Anticipating water well field Dravlje groundwater quantity was determined of 100 l/s in the piezometer OP-12/03. This piezometer is the only existing piezometer in the PA area and is located on west edge of Ljubljana field, therefore measurements are not completely reliable and more piezometers have to be installed in this area. The aquifer is covered with 12 m thick clay layer and protected from any pollution and the groundwater quality is good (Železnik, 2003).

3.2. Drinking water protection

Drinking water protection zones (DWPZ) are established for the purpose of the protection of groundwater and surface water sources. The rules are described in the Rules on criteria for the designation of a water protection zone (Official Gazette of the Republic of Slovenia 64/2004, 5/2006, 58/2011, 15/2016). DWPZ are divided into inner areas due to different levels of protection:

- wider area with the moderate protection regime (III)
  - subzone with milder protection regime (IIIA)
  - subzone with mild protection regime (IIIB)
- narrow area with the rigorous (strict) protection of the water protection regime (II)
  - subzone with strict protection regime (IIA)
  - subzone with less strict protection regime (IIB)
- the narrowest area with the most rigorous protection regime (I)

Pilot Action Dravlje valley lies at the border of two groundwater bodies (Figure 11: 11): the Ljubljana field aquifer (pink border) and the Ljubljana marsh aquifer (blue border) and is within DWPZs for Ljubljana field and Ljubljana marsh well fields.

Pilot Action Dravlje is a location for potential water well filed, which is for now only a reserved area in the spatial plan of the Municipality of Ljubljana. DWPZs (Figure 11:) of Ljubljana field aquifer and the Ljubljana Moor aquifer cover 71.7% (11.94 km^2) of the Pilot Action area. In the northern part of the pilot area there is the second DWPZ of the Ljubljana field aquifer with the rigorous protection regime (IIB) and the third DWPZ with moderate protection regime (IIIA and IIIB). In the southern area thre is the third DWPZ of the Ljubljana Moor with moderate protection regime (III).

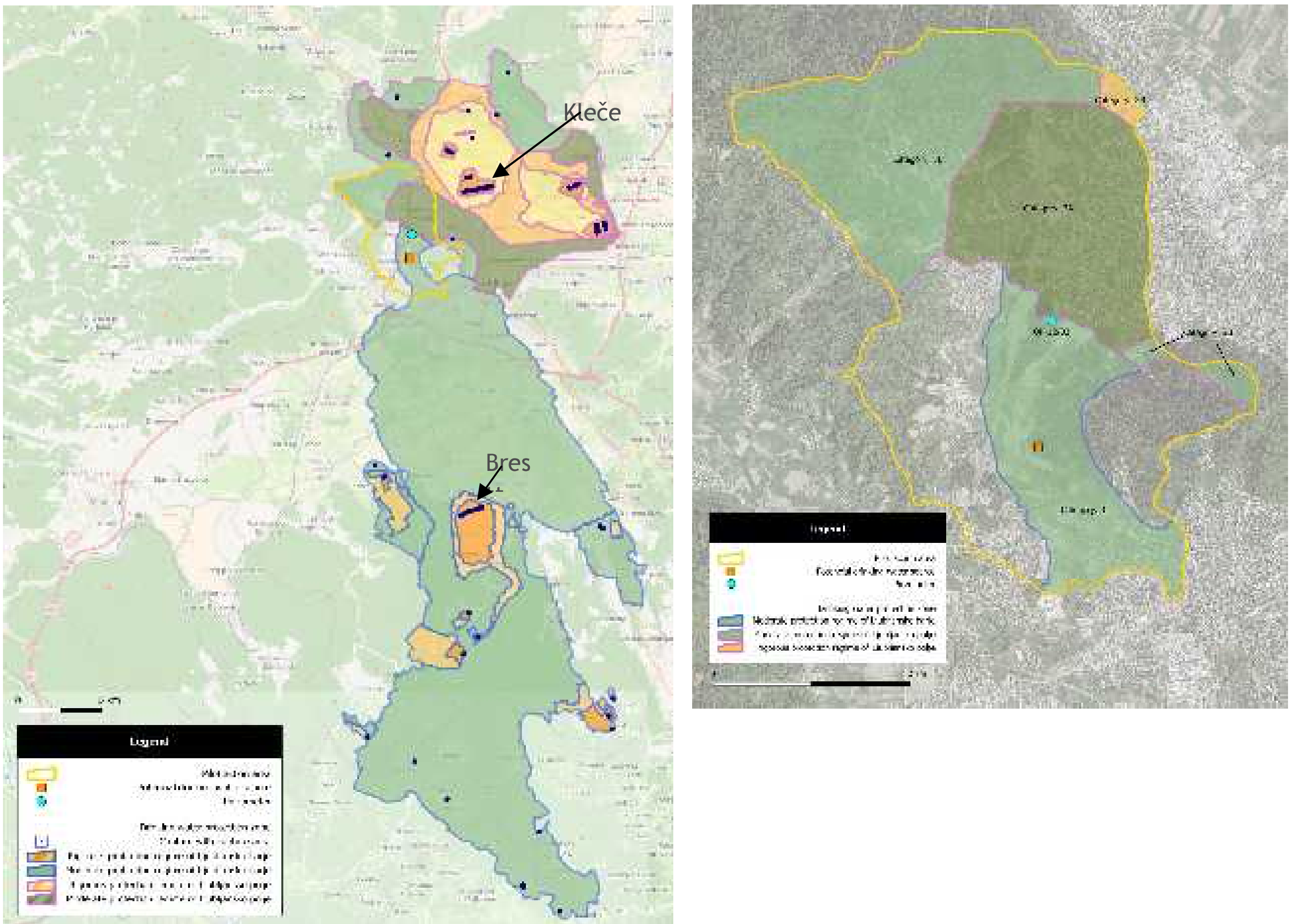

Figure 11: Map of drinking water protection zones (ARSO, 2017a)

4. Protected areas

In the Pilot Action area there are many protected areas with restrictions (Figure 12): two nature parks and several natural heritage sites.

For its unique ecological, biotical and landscape heritage Ljubljana's city park Tivoli, Rožnik and Šišenski hill and also the Polhograjski Dolomiti area were proclaimed for a Natural park and Natural reserve.

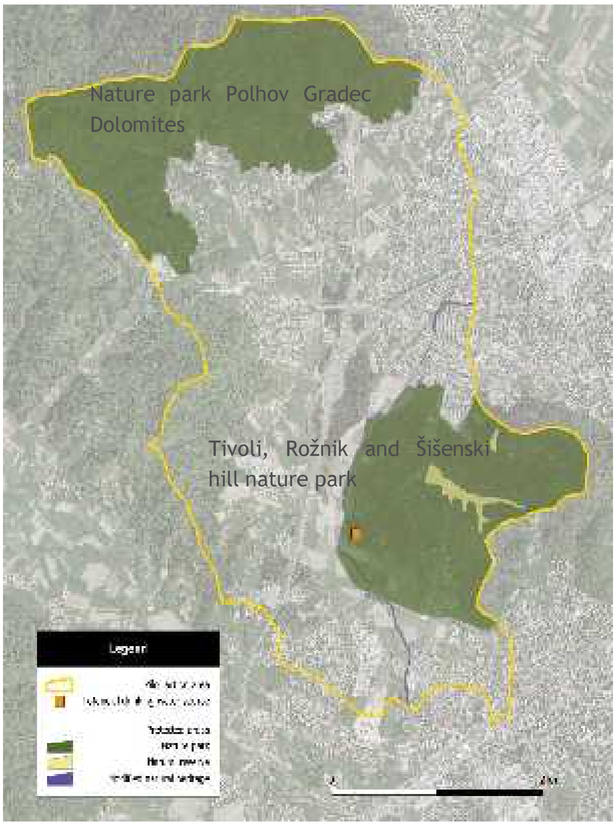

Figure 12: Map of protected areas (ARSO, 2017)

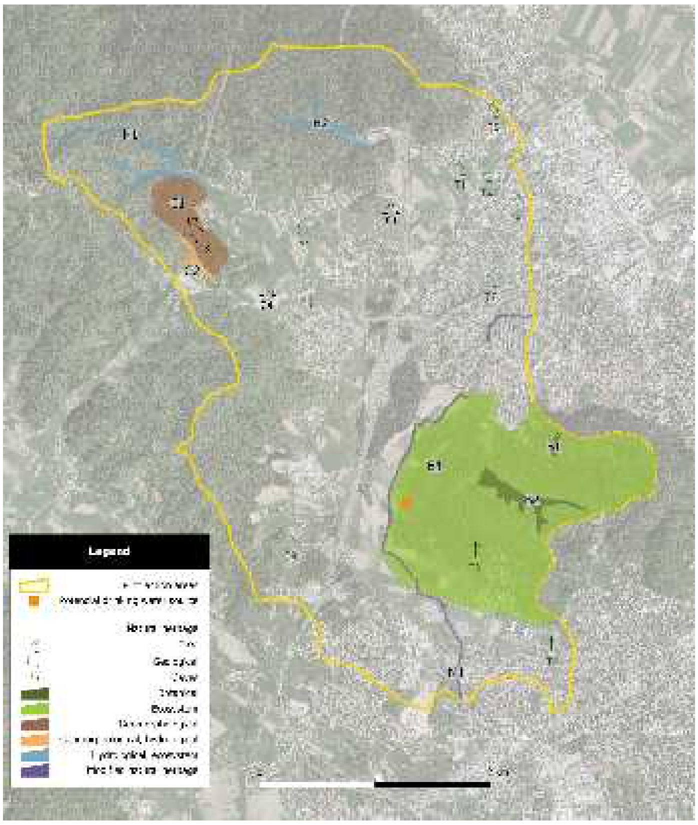

Figure 13: Map of natural heritage sites(ARSO, 2017)

In the Pilot Action area there are eight sites of Natural heritage (Figure 13) due to its high value of ecosystems, hydrology, flora and geomorphology:

- Rožnik, Šišenski hrib and Koseški boršt with habitats of protected and endangered species in Ljubljana (E1);
- Transiented Marshes near Mostec in Ljubljana (B1).
- Left tributary of Gradaščica river upstream from Glinica near Ljubljana (H1).
- Left tributary of Glinščica with moisture surfaces upstream from river Pržanec near Ljubljana (H2).
- Path of remembrance and comradeship in Ljubljana (M1).

- Karst Valley with sinking stream near Podutik in Ljubljana (G2).
- Area of typical isolated karst near Podutik in Ljubljana (G1).
- Transiented Marshes under Rožnik hill in Ljubljana (B2).

Natural heritage sites are also caves, a quarry and trees. There are four caves: Šišenska cave (C1), great Brezarjev abyss (C2), small Brezarjev abyss (C3) and Podutik abyss (C4). The Podutik Quarry was exploited of upper Triassic Limestone beds containing Megalodon Shells (S1). Stone from the Quarry was partly used for building Triple Bridge in Ljubljana's City Center. Botanical heritage of the area includes a Cherry (T9), few Oak trees (it's subtype *Quercus robur*) (T2, T4, T7 and T8), a Beech (T3), a Tilia (T6), a Metasequoia (T5) and a Willow (T1) (ATLAS OKOLJA, 2017).

5. Main identified problems / conflicts

Although Slovenian pilot area's geological setting shows the groundwater from well field Dravlje is well protected, land use and climate change have significant impact on water resources. Following gaps should be considered seriously and their legislations implementation should be established in order to protect groundwater as a source of drinking water.

Around half of the grassland is within DWPZ of existing drinking water sources, where ploughing of permanent grassland is prohibited which helps to enhance and preserve drinking water sources, however applications of fertilizers in the period, when it is not allowed should be diminished and control over the purchased and used quantity of fertilizers should be established.

Sewage system and individual small wastewater treatment plants (WWTP) are present in the PA area, but some septic tanks can still be found. The control of local sewage condition and control of septic tanks (quantities, cleaning etc.) should be arranged.

Agriculture covers around 10% of the PA area and all is inside the DWPZ III (wider area with the moderate protection regime) subsequently is regularly inspected and supervised. However, control on use of fertilizers in the time ban should be established and also control of the purchased and used quantity of fertilizers and control of storages of manure and slurry (sealing, quantities, etc.).

Through the entire PA area runs the Western part of Ljubljana's motorway, which is one of the busiest roads in Slovenia due to the strategically important position and the concentrated economic life in the capital city. Discharge of meteoric water from motorway and other public roads and on majority of side roads are managed according to 'Decree on the emission of substances in the discharge of meteoric water from public roads'. However, excessive use of solvents in winter and application of fertilizers on the roadsides should be prevented, also collecting and control of discharge of meteoric water from public roads should be arranged, particularly in the area of planned Koseze Waterworks.

Due to urban forest in the PA there is no timber productions present and due to location within DWPZ, fertilization is not allowed. However tourism dominates over forest protection.

In the PA there are two nature parks: Nature park Tivoli, Rožnik and Šišenski hill and also the natural park Polhograjski Dolomiti, where activities are limited according to Ordinance for each Nature park in order to protect nature but the inspection of activities present a great challenge.

There are only few industries, which can impact on environment and waters in Dravlje valley pilot action area but they have only internal control of waste and emissions and no external control of activities impacting on environment and/or waters.

Because floods are present in the Dravlje valley PA area, some measures and limitations have already been performed in order to establish flood protection. The monitoring of flood events and permanent validation of flood hazard maps should be arranged.

Challenges in supervision and inspection of mplementation of best management practices will be studied in the continuation of the PROLINE-CE project. The biggest challenge to implement BMPs into daily operation and even more challenging is implementation of BMPs into legislation in order to become obligatory.

These conflicts and best management practices identified in T1 and D.T2.1.2 will be the focus of activities within this PA.

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