PROLINE-CE

WORKPACKAGE T2, ACTIVITY T2.1

SET UP OF PILOT SCECIFIC MANAGEMENT PRACTICES

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

PILOT ACTION 2.5: NEUFAHRN BEI FREISING

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1. Introduction

The drinking water protection zone of the water association Freising Süd in Neufahrn bei Freising has been established in 1992 with the primary goal to protect the well field Neufahrn from harmful impacts of anthropogenic activities. The well field comprises three shallow wells and six deep wells, whereof only the deep wells are used for the local drinking water supply due to the high nitrate concentrations registered in the upper aquifer (see Figure 7).

Given the assumption that both aquifers are interconnected as well as that evidence for exchange processes on relevant scales is given, a detailed analysis of water quantity and water quality trends as observed in the shallow wells along with hydrological modelling is useful to assess possible threats for the deep wells resulting from the upper aquifer.

Both, the understanding of the hydraulic interdependencies of the two considered aquifers as well as the modelling of the hydrological processes and trend analysis of relevant parameters (e.g. water level fluctuations, trends in nitrate concentrations) measured in the shallow wells are important for elaboration of drinking water protection measures.

During the last decades (late 1980's until 2016), a continuous decrease in nitrate concentrations measured in the shallow wells could be observed. The decrease of nitrate concentrations can be considered as positive regarding the quality of the shallow groundwater. In order to explain such decreasing trend, we have hypothesized three possible causes:

Agricultural activities are considered to be the major source of diffuse nitrate contaminations in the study area (primarily regarded as non-point sources); the observed decrease in nitrate concentrations may thus be dedicated to successful agricultural management practices. However, to which particular land use change that decreasing trend may be attributed and which land use activities jointly improved the quality of the water extracted from the shallow wells are open questions. The answer to these questions may help to derive best management practices for similar regions;

The shallow aquifer is strongly affected by the interaction with the Isar river, on the Eastern boundary. Another possible explanation for the observed trends in nitrate concentrations may be found in the hydrological processes, e.g. dilution processes through river water infiltration and/or increased groundwater recharge through percolation;

The reduction in livestock could have also contributed in decreasing the nitrate input in the shallow aquifer.

Those open questions have been the reason for choosing Neufahrn bei Freising as a pilot area for PROLINE-CE and need to be answered in order to determine Best Management Practices.

2. Basic data about pilot action

2.1. Geographical description

Neufahrn bei Freising (Figure 1) is a community situated in the district of Freising (Landkreis Freising), which belongs to the administration district of Upper Bavaria (Regierungsbezirk Oberbayern). The community covers an area of 45.51 km2 and has a population of 21.486 inhabitants. (Neufahrn, 2017)

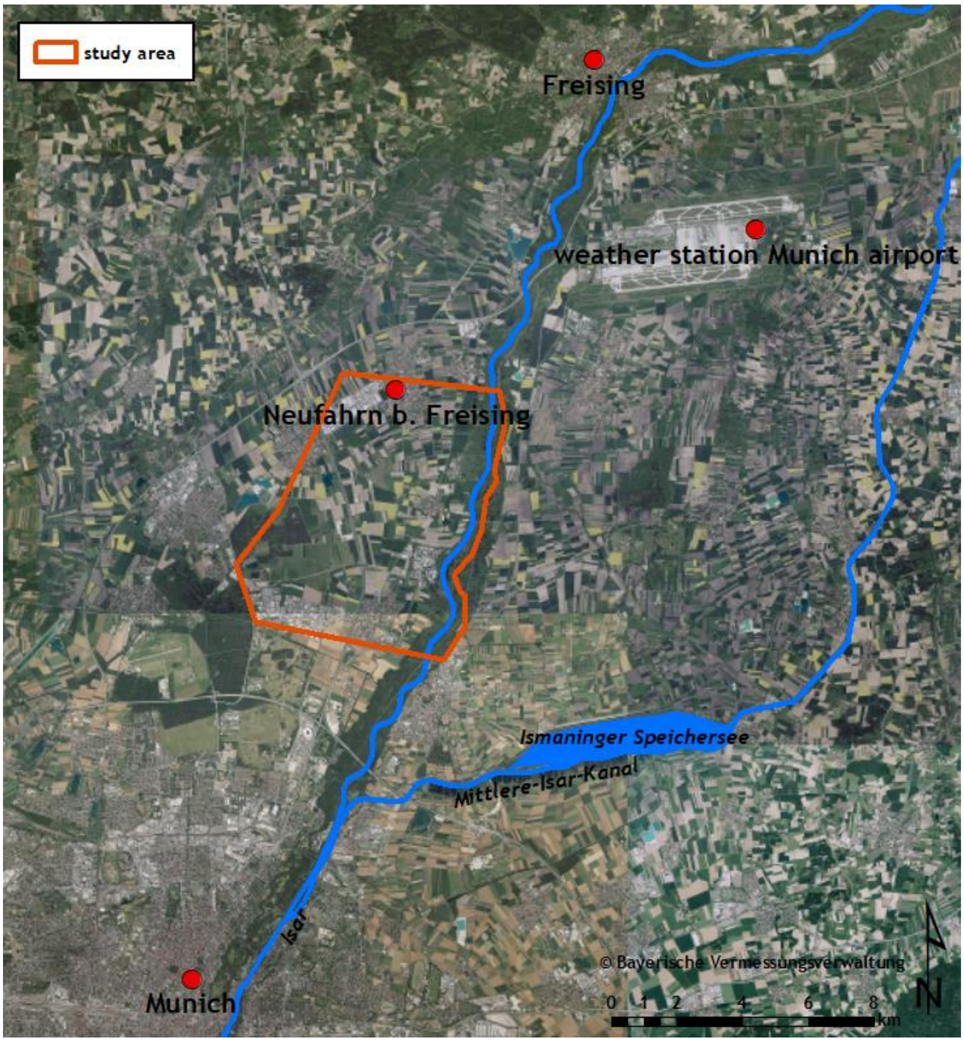

Figure 1: Geographical location of the pilot area Neufahrn bei Freising in the north of the city of Munich.

2.2. Geological description

The pilot area relates to the Alpine foreland of Bavaria and thus accounts for the sedimentary basin of the Alpine orogeny. For the purposes of the activities related to PROLINE-CE, the important and thus considered lithostratigraphical units are related to the Quaternary and the Tertiary ages. Both units are characterized by loose sediments, i.e. mostly gravels, sands and clay (lenses), which originates from the Alps. Both units are separated by an extensive marl layer from the Miocene age with an average thickness of 15m.

The sediments from the Quaternary age are mostly related to the Pleistocene age and can be described as glaciofluvial (terrace) deposits. During the Pleistocene, glacial and interglacial periods changed several times, resulting in different environmental and depositional periods. That dynamic variability of depositional conditions caused a heterogeneous distribution of sediments over the former landscapes which nowadays form the lithostratigraphical unit of the Quaternary age. From a geomorphological point of view, the deposits from the different glacial periods form typical terrace structures in today’s landscape. The Pleistocene deposits are complemented by Holocene deposits, mostly along the Isar river. (Bauer et al., 2005)

As mentioned before, the Tertiary sediments also consist of accumulated sediments from the Alpine orogeny. The considered lithostratigraphical unit relates to the Neogene age which represents the youngest geologic system of the Tertiary age. That unit is described as the Upper

Freshwater Molasse (‘Obere Süßwassermolasse’). Comparable to the structure of the Quaternary unit, the spatial distribution of the Tertiary deposits is strongly heterogeneous. However, primary due to a longer duration of the considered Tertiary unit, the thickness of the Upper Freshwater Molasse (ca. 80m on average) is greater as compared to the Quaternary layer (ca. 10m on average). As evidenced by Geotechnisches Büro (1992), the surface of the Tertiary layer shows a hilly structure.

2.3. Pedology

In the study area of Neufahrn we can distinguish three major soil types. The western part of the study area is covered by Pararendzina (Figure 2) resulting from the carbonate gravel, sand to silty floodplain deposits from the Quaternary age. The yellow areas in Figure 2 also indicate the Para-rendzina soil type resulting from similarly weathered deposits, however the difference between the western areas and the centre is that the Para-rendzina in the central part of PA is richer in organic matter and show average thicknesses of loamy overbank deposits. Finally, the eastern part of the study area which is located close to the Isar river is classified as Kalkpaternia resulting from carbonate, sandy to silty gravel floodplain deposits.

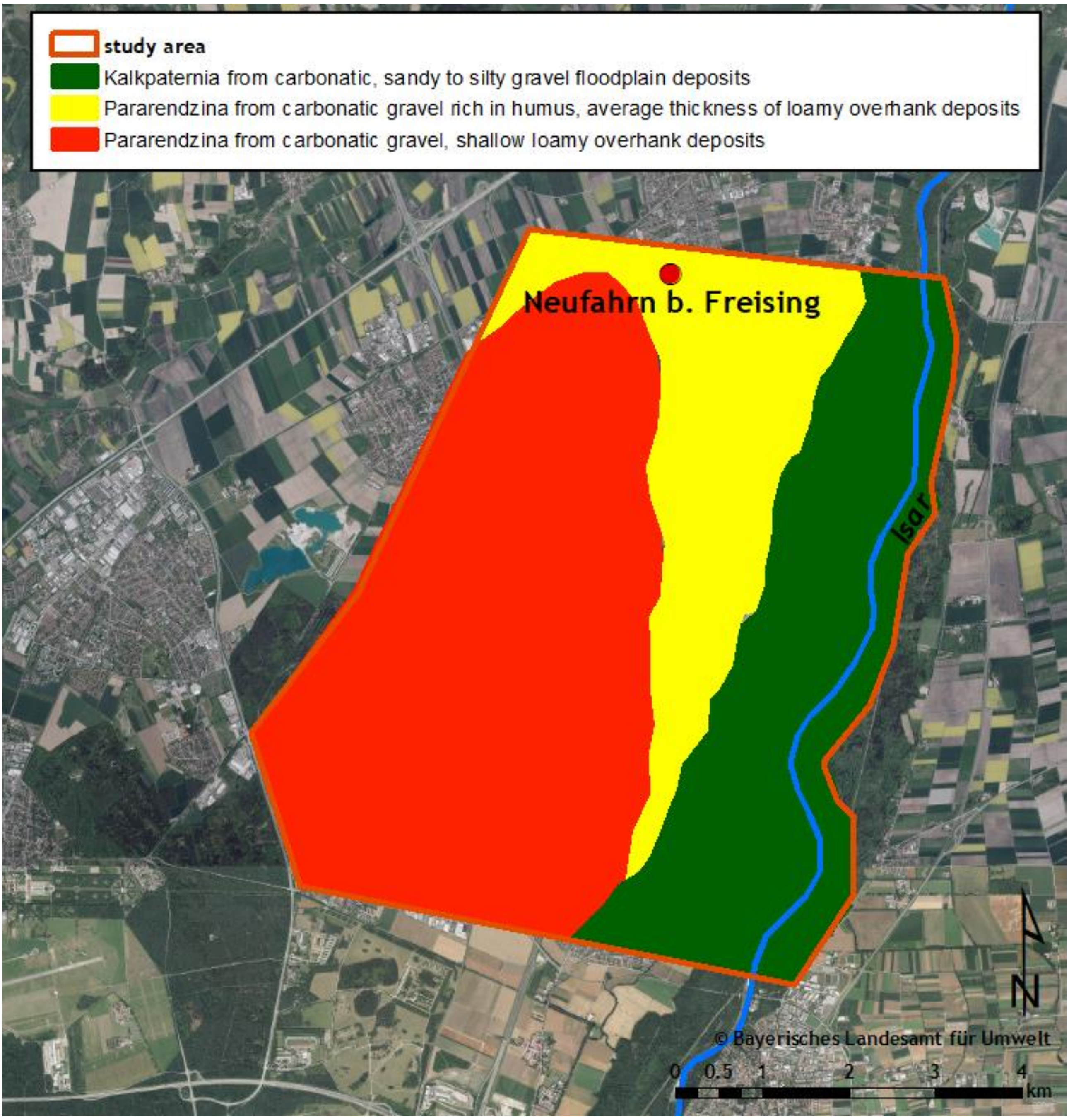

Figure 2: Soil map of the pilot area.

2.4. Climate characteristics

Table 1: Climate statistics from 1993 to 2016 based on daily observations at the DWD weather station at Munich airport. (DWD, 2017)

month	mean precipitation [mm]	min precipitation [mm]	max precipitation [mm]	mean temperature [°C]	min temperature [°C]	max temperature [°C]
January	44.04	1.80	122.50	-0.30	-4.30	4.30
February	33.40	10.60	59.80	0.67	-4.40	5.20
March	49.53	11.40	137.20	4.54	1.00	7.90
April	48.63	8.80	106.90	9.23	6.40	12.10
May	83.49	21.00	141.60	13.88	11.80	15.80
June	100.32	47.60	203.40	17.10	14.30	21.50
July	105.11	12.40	211.30	18.72	16.40	21.90
August	83.93	27.30	142.00	18.19	15.40	22.40
September	62.73	17.30	120.90	13.67	10.50	16.30
October	54.75	8.90	121.70	9.07	6.30	12.40
November	47.49	1.40	106.60	3.92	0.20	7.40
December	48.50	5.80	84.90	0.69	-3.50	3.70

Table 1 presents statistics of precipitation and temperature measurements from the weather station at Munich airport, which is located about 10 km in the north of the pilot area. Daily values for temperature and precipitation observed in the period from January 1993 to December 2016 have been used. In this time, a mean annual air temperature of 9.1 °C and a mean annual precipitation sum of 762 mm have been observed. Moreover, the German Meteorological Office (DWD) calculated an actual evapotranspiration rate of 522 mm/a as well as a potential evapotranspiration rate of 656 mm/a for the considered time span. (DWD, 2017)

The most precipitation occurs during the warm summer periods (Figure 3) which are typical for warm-moderate climatic conditions and thus typical for Bavaria.

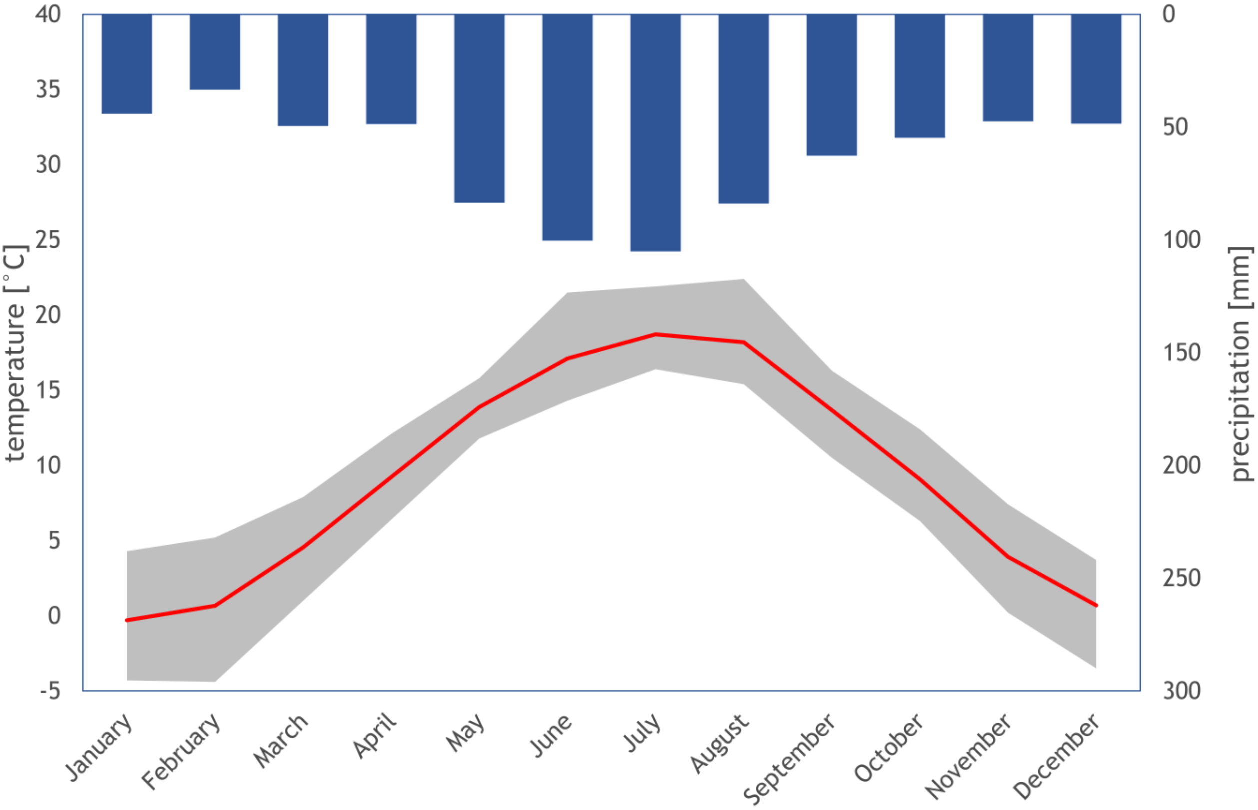

Figure 3: Mean monthly temperatures (red line) and mean monthly precipitation sums (blue bars) averaged over the period from 1993 to 2016. The grey area illustrates the difference between the max. mean monthly temperature and the min. mean monthly temperature observed during the considered time period. Data provided by DWD (2017) from the weather station at Munich airport.

2.5. Hydrology

2.5.1. Surface waters

Despite the Isar river and a few small (artificial) lakes (lake Eching, Baggersee am Hart, lake Hollern, lake Mallertshof, lake Garching), no further considerable surface waters are located in the pilot area. The lakes are mostly used as recreation areas. Unfortunately, the Isar river discharge is not gaged in the pilot area. The closest river gages are located in Munich and Freising. However, water management issues as well as natural exchange processes between the Isar river and the underlying aquifer lead to totally different observed hydrographs at these gages. The discharge in the Isar river decreases between the gages in Munich and Freising (Figure 4). The hydrographs observed at these gages are very different when focussing on the peak discharges in particular during summer floods and during low flow conditions. Those observations can be described by both, the diversion of the Isar river in the Mittlere-Isar-Kanal (see Figure 1) and river exfiltration processes into the connected groundwater aquifer.

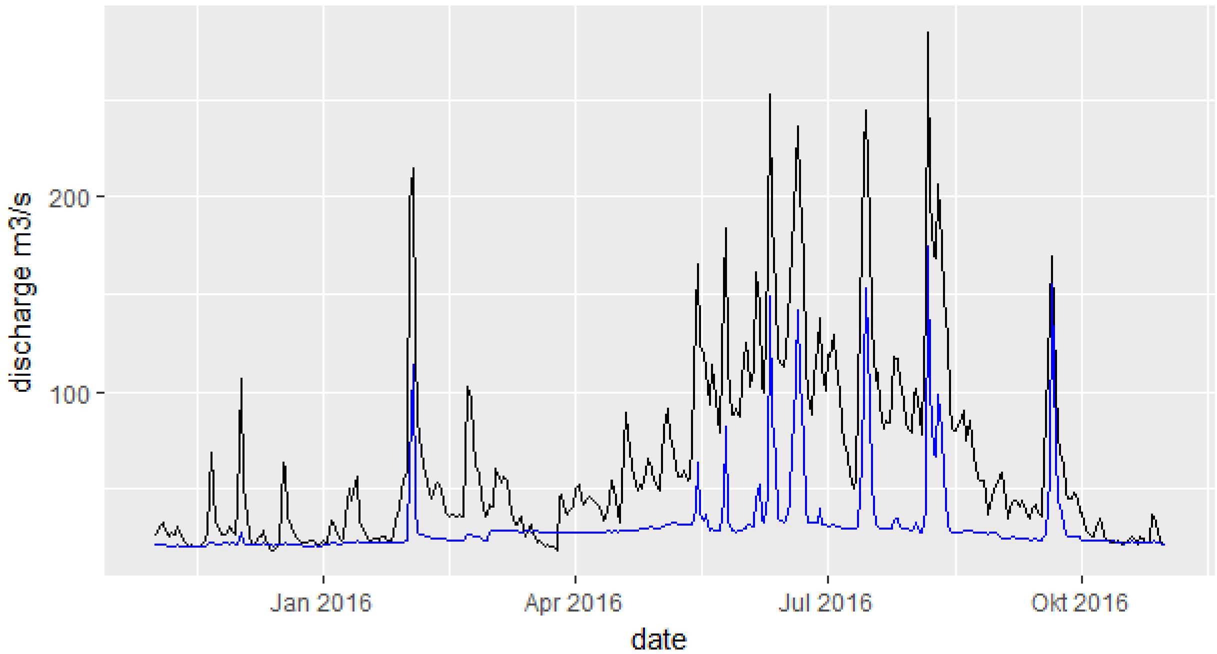

Figure 4: Isar river discharge measured at the gages in Munich (black line) and Freising (blue line) during the hydrological year 2016 (Nov. 2015 – Oct. 2016). (GKD Bayern, 2017)

2.5.2. Flood issues

Figure 5 shows the potential inundation areas of a HQ100 and a HQextreme event for the considered study area. The HQextreme represents 1.5 x the discharge of a HQ100 event of the Isar river. Focusing on the different figures shown in Figure 5, it can be seen that (surface) flood issues are not present in the study area, mostly because of the restored floodplain. The only anthropogenic infrastructures which are located close to the Isar river are the indicated waste water treatment plants Gut Marienhof (treatment plant for the city of Munich) and Grüneck (treatment plant for settlements within the study area). Even for the HQextreme event, the resulting floods are not prospected to reach those infrastructures, as also past events have shown (e.g. Merkur.de, 2010).

A more relevant issue of river floods, however, are the rising groundwater levels resulting from the infiltration of river water during and after a flood event. Due to constantly high groundwater levels in the shallow groundwater aquifer, river floods pose a risk for groundwater quality, engineering structures as well as for arable lands during the main cropping seasons.

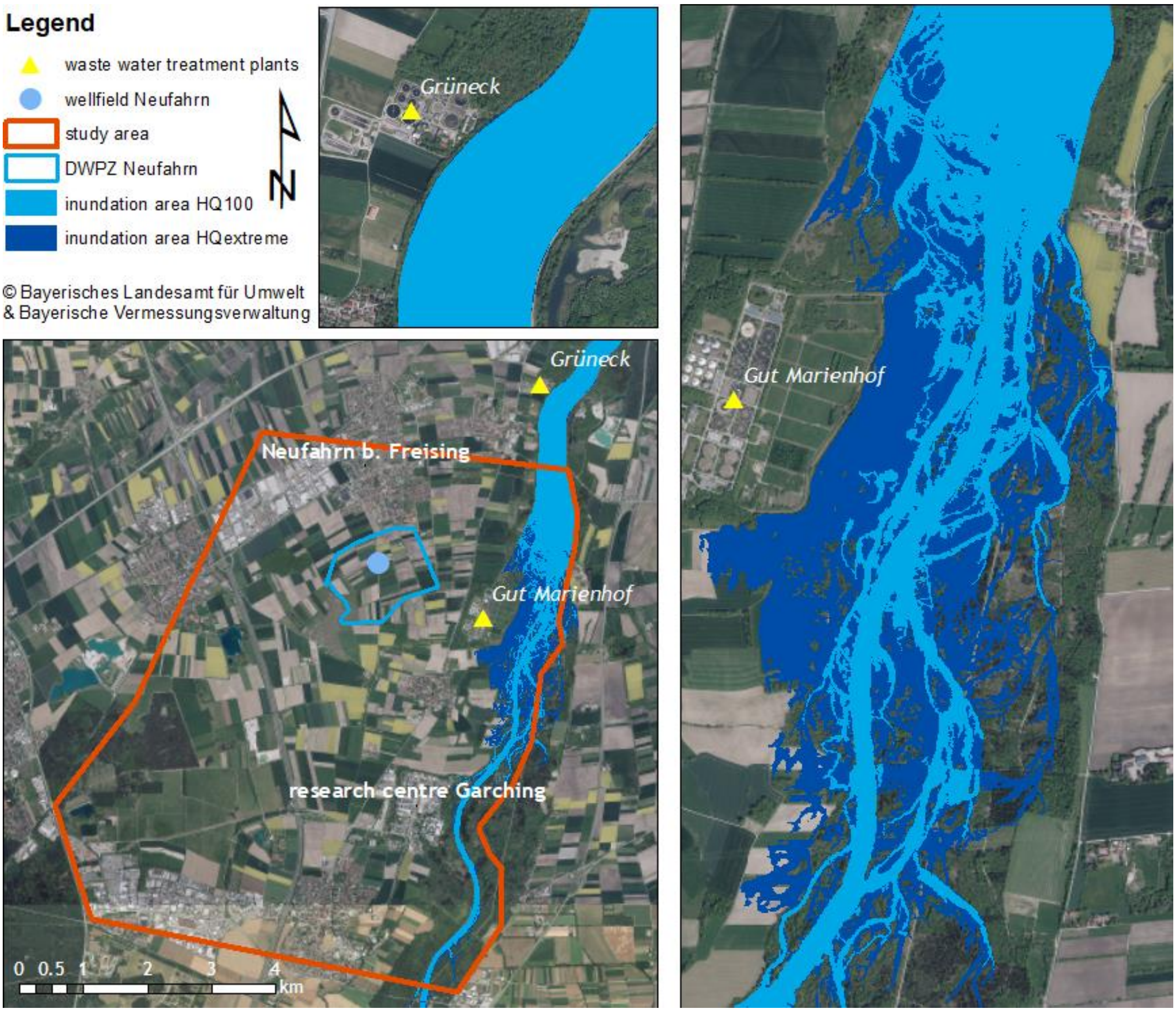

Figure 5: Inundation areas for HQ100 and HQextreme events in the pilot area Neufahrn bei Freising.

2.6. Hydrologeology

From a hydrogeological point of view, the pilot area comprises two major aquifers which are related to the Quaternary (upper aquifer, 0 to -10m from the surface) and the Tertiary (lower aquifer, -30 to – 110m from the surface) lithostratigraphical units.

Based on pumping tests performed within the scope of the hydrogeological expertise from the geotechnical survey (Geotechnisches Büro, 1992), the mean hydraulic conductivity is 1 x 10-3 m/s in the upper aquifer. Such high hydraulic conductivities further confirm the idea of an upper aquifer which primarily consists of gravel and sand.

The lower aquifer mostly consists of silt, sand and gravel from fresh depositional conditions during the Neogene. Those sediments are mostly cemented but still are very permeable and primarily considered to behave like a porous aquifer. The extensively distributed marl lenses from the Miocene have low permeability and partially build an aquitard between the Quaternary and the Tertiary aquifer. (Geotechnisches Büro, 1992)

2.7. Land use

Based on the GIS analysis performed with the CORINE land cover data from 2012 (BKG, 2012) and validated through orthophoto maps and site visits, land use types were determined and are presented in table 2 and Figure 6.

Table 2: Surface cover in the pilot area Neufahrn bei Freising, classified with the CORINE Land Cover dataset from 2012 (CLC 2012), provided by BKG (2016).

CLC code	LABEL 3	Surface area (%)	Surface area (ha)
112	Discontinuous urban fabric	8.57	418.19
121	Industrial or commercial units	11.99	585.00
122	Road and rail networks and associated land	0.02	0.96
142	Sport and leisure facilities	1.22	59.68
211	Non-irrigated arable land	44.86	2189.45
231	Pastures	13.05	637.14
311	Broad-leaved forest	13.76	671.76
312	Coniferous forest	2.10	102.42
313	Mixed forest	1.80	88.08
321	Natural grasslands	1.59	77.53
324	Transitional woodland-shrub	1.03	50.49

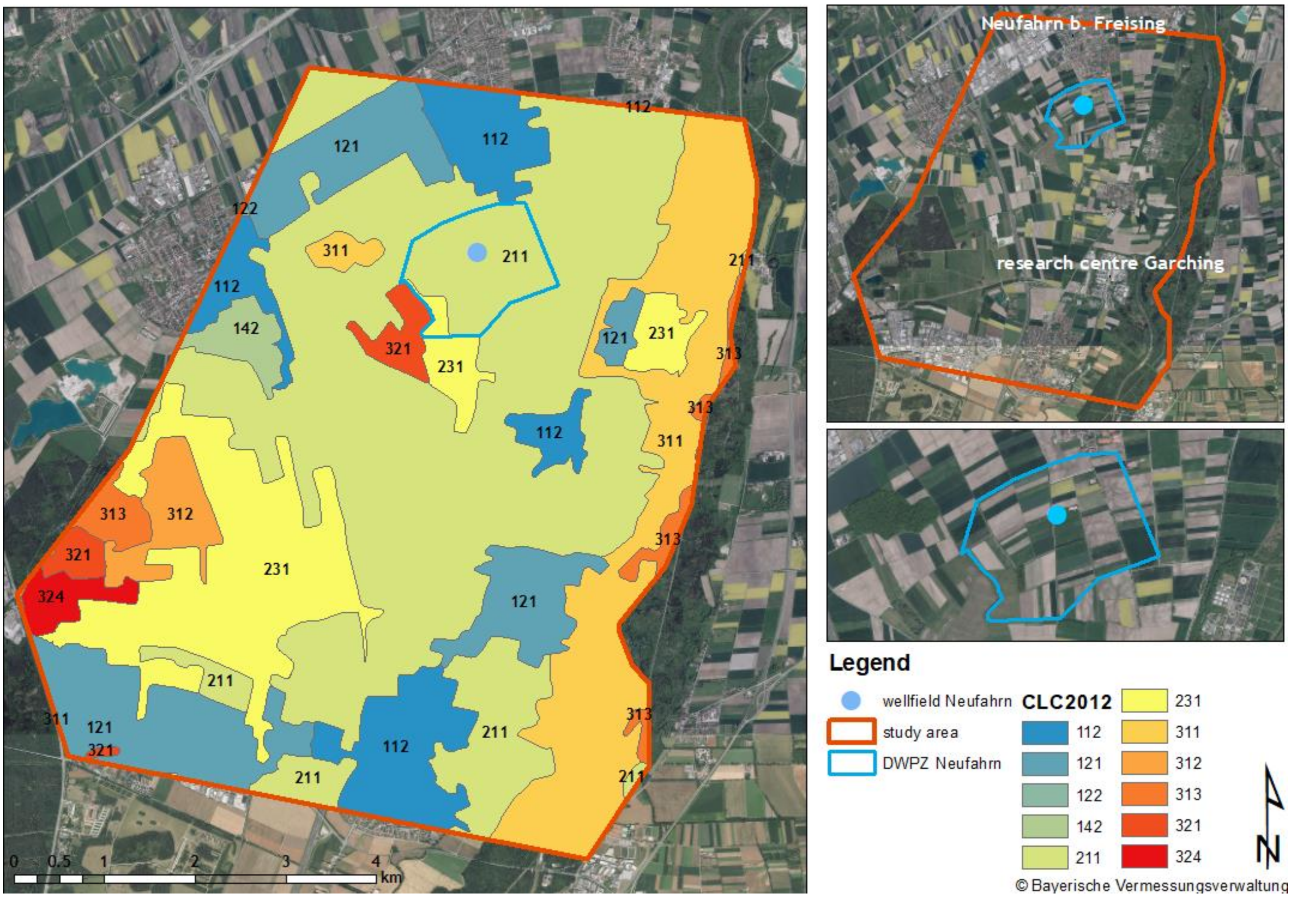

Figure 6: Land use in the Neufahrn pilot area based on CLC 2012, provided by BKG (2016).

The land use in the pilot area is dominated by (non-irrigated) arable land (44.86 %). As shown in the orthophoto map in Figure 6, the size of the cultivated fields is small if compared with the typical size of cultivated fields in other areas of Bavaria and Germany (Bauernverband.de, 2012). The socio-economic reasons for such conditions are currently under investigation. It is important to mention that even though those areas are defined as non-irrigated arable lands in the CLC 2012 classification, we know that irrigation systems are used widely spread in the pilot area during dry periods (e.g., summer 2017). The main irrigation system is based on sprinklers.

Based on the local statistics for 2010 (LfStat, 2016), about 60 % of the arable land, is used for grain farming. The most frequent grain types are wheat, winter and spring barley. Further important crops are winter oilseed rape (ca. 15 % of the total arable land), maize (ca. 13 % of the total arable land) and potatoes (ca. 3.6 % of the total arable land).

It is particularly important to embed the role of potato farming in the context of land use changes in the regarded pilot area. The statistics provided by LfStat (2016) show that potato farming has halved from 1999 to 2010. As noted by several stakeholders, potato farming was the dominant land use during the last decades of the 20th century since the purchase of the gains was ensured by an international potato product production company (Pfanni) in Munich. However, the decrease of potato farming has two reasons; on the one hand, the operations of the mentioned company stopped in the 1990's, causing the cessation of a secured purchase. On the other hand, potato farming requires more manpower as compared to other, profitable crops. Since the younger generation is neither willing to help on the fields, nor to take over the family business in the adult age, potato farming has lost its profitability.

As indicated by different stakeholders in the interviews carried on during the project, a further considerable change occurred in the early 1990's. They indicated a rush reduction of livestock of about 30% in the study area. The cause behind this rapid change can be related to two main reasons. First, a decrease to unprofitable milk prices: in 2016 dairy farmers were earning less than 30 cents per litre and in some cases as little as 18 cents a litre. That is a drastic loss in earning in comparison with 2013, when they earned as much as 42 cents on each litre. Farmers say they need to earn at least 40 cents a litre to make ends meet (Munchies.vice.com, 2016; Spiegel.de, 2016; Thelocal.de, 2016). Second, a change in the social structures occurred: The younger generation is moving from agricultural and livestock business towards more profitable activities and is not willing to take over the farms of their families. As a consequence, the viability of grasslands for fodder production decreased in parallel, so that a decrease of 30% can be assumed for grasslands as well.

Settlements (CORINE codes 112 and 121) present 20.56 % of the pilot area. These include discontinuous urban fabrics as well as industrial and commercial units. With a considerably lower areal extent as compared to the arable land, forested areas and pastures present 17.66 % and 13.05 % of the pilot area, respectively. Also this kind of land use has faced important changes in the last decades. The economic crisis and business relocation lead to the closure of some of the largest industries in the area (e.g., Avon cosmetics and the Müller-Brot bread production company closed in 2011) while new industrial and commercial sites have been built close by. (Neufahrn, 2017)

2.8. Protected areas

There are no further protected areas in the pilot areas beside the drinking water protection zone which is the object of this study.

3. Water supply in the pilot action

3.1. Drinking water sources

The well field comprises three shallow wells and six deep wells, whereof only the deep wells are used for the local drinking water supply due to the high nitrate concentrations registered in the upper aquifer (see Figure 7). Those deep wells are screened in the hydrostratigraphical units of the Upper Freshwater Molasse (screened at about 30 m to 80 m depth, lower aquifer). The shallow wells, by contrast, are used to provide water for technological processes to the Garching research centre and as cooling water for industrial operations. Those wells are screened in the Quarternary deposits (upper aquifer) at about -4 to -10m below surface.

The whole supply area of the water association Freising Süd comprises 225 km² and provides drinking water to 63.000 inhabitans. Moreover, the process water supplied to the research centre Garching accounts for an additional inhabitant equivalent of 17.000 inhabitants. Regarding only the extraction systems used for drinking water supply, the considered (deep) wells in Neufahrn have a pumping capacity of about 580 l/s. Further considering that two more well fields exist in the supply area, well fields Eichet and Fahrenzhausen, the well field Neufahrn contributes to about 75% of the total pumping capacity of all drinking water wells. (Zweckverband Wasserversorungsgruppe Freising-Süd, 2017)

3.2. Drinking water protection

Since only the deep wells are used to provide drinking water to the municipality, the protection zones are limited to the near surroundings of the wells (Fig. 7). The inner zones represent the protection areas just around the wells (zone I), the second inner zone is zone II and the outermost zone represents zone III. In 1986, the administrative district of Freising announced the ordinance about the legislative framework for the protection zones. In terms of agricultural practices, the ordinance prohibits the following actions in zones 1 to 3: application of organic and synthetic fertilizers, exposed storage of organic and synthetic fertilizers, factory farming, implementation of drainage systems and conversion of permanent pastures. Moreover, the ordinance regulates the treatment of water pollutants and building use.

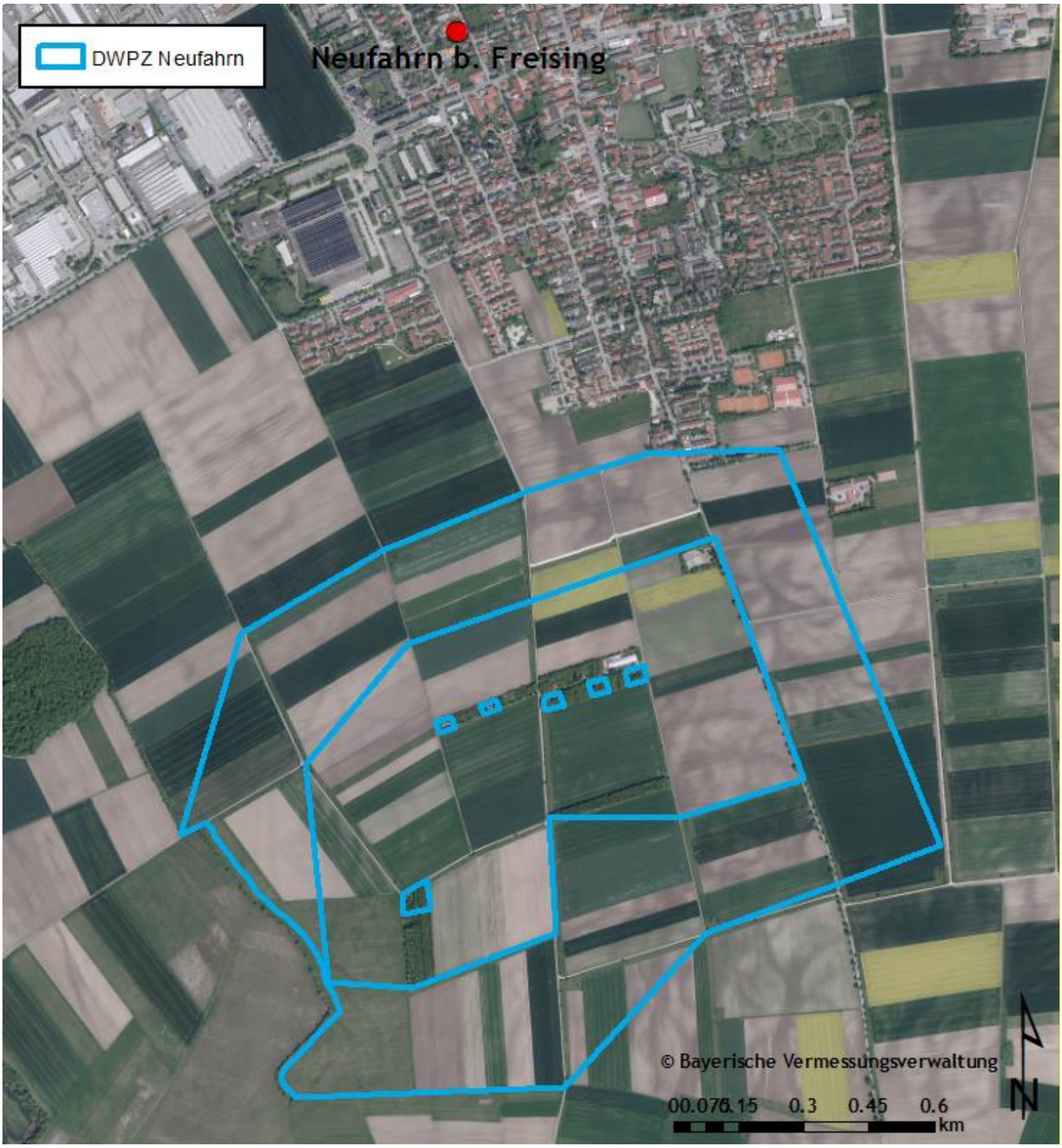

Figure 7: Drinking water protection zones in Neufahrn bei Freising.

4. Main identified problems / conflicts

Main identified conflicts in the considered pilot area are as follows:

Agricultural activities represent the main pressure due the large areas covered by arable land and related inputs of fertilizers (e.g. nitrate).

A further threat is posed by river water-groundwater interaction. The Isar river is assumed to exchange a relevant amount of water with the aquifer representing therefore a potential contamination source. Moreover, the complex interaction between surface water and groundwater considerably increase the uncertainty related to the groundwater flow direction and hence to the definition of an appropriate groundwater protection zone.

Moreover, the waste water treatment plant Gut Marienhof may represent a threat for the well field in case of system failure.

Socio-economic changes are rapidly occurring in the pilot area. In particular, a decrease in interest for agricultural activities may lead to important changes in land use and land management in the next years. Moreover, also the urban area is rapidly changing, with the construction of new commercial and residential areas and a change in the industrial activities. Such a dynamic environment represents a challenge for water management when they need to choose the most appropriate land use management practices.

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

5. References

Bauer, M., Thuro, K., Scholz, M., and Neumann, P. (2005): The geology of Munich (Germany) and its significance for ground modelling in urban areas. Geotechnik, 28(2):454.

BKG (2016): Corine Land Cover 2012. Bundesamt für Kartographie und Geodäsie. http://sg.geodatenzentrum.de/web_download/dlm/clc10/utm32s/shape/clc10.utm32s.shape.zip (December 26th, 2016).

DWD (2017): German Meteorological Service. ftp://ftp-cdc.dwd.de/pub/CDC/ (September 3rd, 2017).

Geotechnisches Büro (1992): Hydrogeologisches Basisgutachten. Zweckverband Wasserversorgungsgruppe Freising-Süd – Abgrenzung des Einzugsgebietes der Flachbrunnen I bis III. Geotechnisches Büro, Prof. Schuler, Dr. Gödecke.

GKD Bayern (2017): Gewässerkundlicher Dienst Bayern. Abfluss Isar. http://www.gkd.bayern.de/fluesse/abfluss/karten/index.php?gknr=4&thema=gkd&rubrik=fluesse&produkt=abfluss&tab= (September 3rd, 2017).

LfStat (2016): Statistik kommunal 2015. Gemeinde Neufahrn bei Freising. Bayerisches Landesamt für Statistik.

Neufahrn (2017): http://www.neufahrn.de (September 14th, 2017).

Zweckverband Wasserversorgungsgruppe Freising-Süd (2017): https://www.wasserzv.de/ (September 18th, 2017).