Contaminated Site Investigation & Remediation

dekonta

Remediation Assessment Report

INCEL, Banja Luka, Republika Srpska, Bosnia and Hercegovina

15. 9. 2020

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LIST OF ABBREVIATIONS

US ATSDR	Agency for Toxic Substances and Disease Registry
a.s.l.	Above mean sea level
b.g.l.	Below ground level
BaH	Bosnia and Herzegovina
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
BZ	Business Zone INCEL
Cd	Cadmium
cm	Centimetre
COC	Contaminants of concern
CS_2	Carbon Disulphide
Cu	Copper
D1	Deliverable 1 – Conducted Fieldwork Report
DN	Diameter nominal
DKS	(local geodetic system – MGI_1901_Balkans_6)
DNAPL	Dense non-aqueous phase liquid
dw (d.m.)	Dry weight (or dry matter)
D1	Deliverable 1 (Conducted Fieldwork Report)
GIS	Geographic Information System
GWL	Groundwater level
Hg	Mercury
HNO_3	Nitric acid
ICSM	Initial Conceptual Site Model
INCEL	INdustrija CELuloze (Industry of Cellulose)
kg	Kilogram
km	Kilometre
LNAPL	Light non-aqueous phase liquid
LV	Limit value
m	Meter
mg	Milligram
MRL	Minimal Risk Level
m/s	Meters per second
NaCl	Sodium Chloride
NaOCl	Sodium Hypochlorite
NaOH	Sodium Hydroxide
Na_2S	Sodium Sulphide
Na_2SO_4	Sodium Sulphate
Ni	Nickel
Nm	Newton meter
PAHs	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCBs	Polychlorinated Biphenyls
PCDDs	Polychlorinated Dibenzo-p-dioxins
PCDFs	Polychlorinated dibenzofurans
PFAS	Per- and Polyfluoroalkyl substances
POPs	Persistent Organic Pollutants
PPE	Personal Protective Equipment
RA	Risk Analysis
RfD	Reference Doses

RIVM	National Institute of Public Health and the Environment of the Netherlands
S	Sulphur
SF	Slope Factor
TDI	Total Daily Intake
ToR	Terms of Reference
TS	Topsoil Sample
TPHs	Total Petroleum Hydrocarbons
UAV	Unmanned Aerial Vehicle
UNDP	United Nation Development Program
WGS84	World Geodetic System 1984
WHO	World Health Organisation
WWTP	WasteWater Treatment Plant

NON-TECHNICAL SUMMARY

Persistent Organics Pollutants (POPs), are a group of chemicals that are very toxic and can cause cancer and other adverse health effects. Due to their chemical composition, they are not easily degraded by natural processes, can enter the food chain and can travel long distances. Polychlorinated biphenyls or PCBs are a group of man-made POPs consisting of carbon, hydrogen and chlorine atoms in which the number of chlorine atoms and their location in a PCB molecule determine many of its physical and chemical properties.

The subject site, the former industrial complex INCEL Banja Luka Cellulose Factory, is in the city of Banja Luka, app. at 3 km distance from the city centre. Banja Luka is the second biggest city in Bosnia and Herzegovina with the population of around 185,000 (Census 2013). The site is situated in a basin 164 m above sea level. INCEL is a former company based in Banja Luka, originally manufacturing cellulose, viscose and paper products.

The factory was established in 1954 and has become the major industrial conglomerate in the field during the socialist era, employing up to 6,500 workers. Following a period of decline in the 1980s and the War in Bosnia and Herzegovina in the 1990s, the destroyed factory was subsequently split into several smaller enterprises. During the war of 1991-1995, the INCEL factory was not subject to attacks, however, it was abandoned and gradual deterioration of the buildings and technical equipment resulted in the emission of various toxic substances into the neighbouring environment.

INCEL area has been gradually rebuilt and the reclaimed premises were leased or sold (mostly) to numerous tenants. The refurbished buildings serve mainly as offices, warehouses, and facilities for light production (such as scrap metal processing, wood processing, paintshop and car repair etc.). However, within the area, there are still remnants of the old buildings and installations, of which the former power plant occupies the largest space, present. There are plans for reconstruction of the rest Business Zone in INCEL area, however, these plans are limited by the necessity of high investments. As the result, any future development of the area is expected to be slow.

A site investigation, carried out by DEKONTA in 2020, concluded that the priority pollutant present at INCEL area is the group of polychlorinated biphenyls (PCBs). Concentrations of PCBs in the investigated matrices exceed either U.S. EPA screening levels or the limits defined by the existing (or planned) local legislation.

Remediation target limit for the clean-up and redevelopment of the contaminated sites in INCEL was calculated by a risk assessment for the PCB contaminated topsoil (soil in a depth 0-20 cm b.t.) and for construction materials at the level of ∑ PCB: 3 mg/kg d.m.

Based on the limits, the topsoil and the construction materials present at the 7 following hotspots are contaminated with polychlorinated biphenyls (PCBs):

- Lukić Invest (former power plant)
- Business zone (in front of BC Metal)
- Business zone (Electrolysis)
- Business zone (north)
- TOP Metal

- Univerzum AD
- SHP CELEX (concrete platform)

The amount of soil for excavation (i.e. above proposed remediation target limit) was roughly estimated at the amount of 600 – 1,000 m^3 (i.e. 1,100 – 1,800 tons), the amount of construction materials exceeding the level of the remediation limits has been roughly estimated at the amount of 6 - 10 m3 (i.e. 13 – 22 tons). However, the exact amount of topsoil and construction materials to be remediated/excavated shall be verified by a detailed sampling prior starting the long-term remedial measures, the excavation of the PCB contaminated topsoil.

Since the contaminated hotspots are situated within the industrial area of INCEL, where local workers are at risk on a daily basis from contact with the contaminated construction materials from buildings and structures and surface soil, the remedial measures have been divided into short-term (urgent) measures that focused on immediate preventing of the local workers from exposure to the contaminated material and long-term remedial measures that focused on permanent elimination of the human health risks caused by the contaminated soil and materials.

The suggested short-term remedial measures include informing the local employees about the potential risks connected with the existing PCBs contamination and training the employees on the possible risks reduction measures and usage of personal protective equipment (PPEs). In addition, marking or fencing of areas where topsoil concentration of PCBs is above the remediation target limit value 3 mg/kg d.m. (see Annex 3 for the areas proposed for remediation) is suggested while any extensive earthworks at these sites should be stopped until long-term remediation measures are carried out. In general, entrances to these sites should be marked with warning signs and activities should be limited to a minimum stay in order to minimize exposure to contaminated soil and dust.

Any entry into the buildings where PCBs contamination of construction materials were confirmed (Lukić Invest – former power plant and Business zone – Electrolysis, see Annex 1 for map of locations where PCBs contamination was confirmed) may be permitted only with personal protective equipment (PPEs) like respirators, protective overalls, protective footwear and protective gloves.

For the long-term remedial measures, five options were evaluated in terms of protection of human health and the environment, efficiency, long-term effectiveness, compliance with the current environmental laws and regulations, implementability and cost.

From these five options, based on of screening assessments, the following remedial options (in order of priority) were selected as the most recommended options for remediation of contaminated areas at INCEL:

- (Option No. 1) Excavation and disposal of contaminated soil and construction materials to HW landfill or waste pre-treatment facility prior its disposal to HW/non-HW landfill in Bosnia and Herzegovina;
- (Option No. 2) Excavation and disposal of contaminated soil and construction materials to HW landfill or waste pre-treatment facility prior its disposal to HW/non-HW landfill abroad;
- (Option No. 4) Construction of a temporary landfill within INCEL area with the capacity approx. 1,000 m^3 and excavation/containment in capped depot(s) for contaminated soil and construction materials on site.

As a final remedial solution, the first two options are recommended. These options propose disposal of contaminated soil and construction materials in a secured hazardous waste landfill or waste pre-treatment facility (such as bioremediation, solidification/stabilization, etc.) prior its disposal to HW/non-HW landfill.

Alternatively, the option No. 4 can be recommended as a temporary solution. The contaminated soil and construction materials can be deposited in a secured temporary landfill constructed within INCEL area where contaminated soil and construction materials will be capped in order to prevent washing out of contamination by rainfall into the surrounding environment.

1 INTRODUCTION

1.1 General

With respect to the Contractor's duties and deliverables specified in the Contract signed between the United Nations Development Programme and DEKONTA a.s. on July 1, 2020 and Contract´s Amendment No. 1 signed on August 12, 2020, we present the third deliverable of the project.

This Remediation Assessment Report, based on the results presented in the Deliverable 2 – Site Assessment Report, presents DEKONTA's solutions for the next steps in the remediation of INCEL.

In the next sections of the report, details and a discussion about the potential technologies that can be used to address the PCBs contamination at the site are presented.

1.2 Summary of the implemented activities

In the period from 28. 7. 2020 to 10. 8. 2020, DEKONTA's team of experts held a sampling and information collection mission at INCEL. The samples were delivered in two batches to ALS laboratories in Czech Republic and the results were used to produce a Site Assessment Report that allowed our team of experts to identify sources of the PCB pollution, estimated the volume of the PCB contaminated soil (unsaturated zone), verified the sediments quality at the sewer effluent in the Vrbas river, verified the groundwater and surface water pollution and identify potentially-exposed groups of inhabitants and individual elements of the eco-system. The detailed description of this information is given in Deliverables 1 and 2.

The results of the survey confirmed that the priority pollutant present at INCEL area is the group of polychlorinated biphenyls (PCBs). As presented in the Deliverable 2, in some of the samples, the concentrations of PCBs in the investigated matrices exceed the limits used[1].

The Site Assessment Report (Deliverable 2) identified significant potential risks to human health for the employees working on the 7 identified hotspots at INCEL industrial area. To the certain extent and above the limits, topsoil and/or construction materials are contaminated with polychlorinated biphenyls (PCBs) at 7 hotspots listed below:

- Lukić Invest (former power plant)
- Business zone (in front of BC Metal)

[1] A 0.94 mg/kg for construction materials, topsoil inside INCEL area and soil probes (US EPA screening levels for industrial soil) and 0.01 µg/l for groundwater located inside INCEL area (Dutch intervention limit values for soil and groundwater, 2009).

- Business zone (Electrolysis)
- Business zone (north)
- TOP Metal
- Univerzum AD
- SHP CELEX (concrete platform)

At these hotspots, contamination with PCBs is exceeding the environmental limits used (described in detail in Section 3 of this report) and human carcinogenic and non-carcinogenic health risks for the future employees were confirmed. Other contaminants (PAHs, TPHs, heavy metals) do not exceed the permitted limit to the same extent as PCBs. In addition, more detailed evaluation of the contamination with other contaminants (PAHs, heavy metals) is limited due to limited number of analyses carried out.

Environmental risks were also evaluated and due to the very high toxicity of PCBs to living organisms generally with long-lasting effects and the fact that INCEL area is well accessible to small animals such as rodents it can be concluded that the risk of PCBs entering the animal food chain cannot be excluded. Furthermore, while the potential environmental risk of spreading contaminants through the rainwater sewage system was confirmed, the current environmental risk of spreading contaminants through groundwater is very low.

2 SITE CHARACTERISTICS

2.1 Site settings, history and land use

The subject site, former industrial complex INCEL Banja Luka (Fabruka Celuloze), is located in the city of Banja Luka, app. at 3 km distance from the city centre. Banja Luka is the second largest city in Bosnia and Herzegovina with the population of around 185,000 (Census 2013). The site is situated in a basin 164 m above sea level. INCEL is a former company based in Banja Luka, originally manufacturing cellulose, viscose and paper products.

The factory was established in 1954 and become the major industrial conglomerate in the field during the socialist era, employing up to 6,500 workers. Following a period of decline in the 1980s and the War in Bosnia and Herzegovina in the 1990s, the destroyed factory was subsequently split into several smaller enterprises (2, *Predrag Ilić et al. 2020*). During the war of 1991-1995, the INCEL factory was not subject to attacks, however, it was abandoned and gradual deterioration of the buildings and technical equipment resulted in the emission of various toxic substances into the neighbouring environment.

INCEL area has been gradually rebuilt and the reclaimed premises were leased or sold (mostly) to numerous tenants. The refurbished buildings served mainly as offices, warehouses and facilities for light production (such as scrap metal processing, wood processing, paint shop, car repair, etc. However, within the area, there are still present remnants of the old builds and technologies, of which the former power plant occupies the largest space. There are plans for reconstruction of the remaining Business Zone in INCEL area, however, any future development of the area is expected to be slowed by the necessity of large investments.

Based on Phase I assessment, it is found out that there is 1500 permanent employees and 1500 visitors and temporary workers (i.e. trespassers) every day. Current use of the site is in detail described in the Phase I assessment produced by TAUW in 2019 (1).

The Spatial Plan of Republika Srpska and the Energy Development Plan of Republika Srpska until 2030 envisages construction of a gas-fired power plant (150 MW) on the site of the former power plant at INCEL area.

There is a unified sewer system in INCEL area. Rainwater from roofs and paved surfaces together with sanitary wastewater is lead via two collectors DN 1200 mm and DN 1400 mm without pre-treatment into the Vrbas River[2].

INCEL area is surrounded by agricultural land (mainly to the north-east and east of the site, where cereals and vegetables are grown) with scattered residential settlements. The highest residential density is towards south and south-east of the site (up to 200 inhabitants per hectare). The area towards west, i.e. between INCEL and Vrbas River is occupied by an area of CELEX company (paper production plant), as well as with residential complexes that are currently being intensively developed. There are mainly industrial zones on the opposite bank of Vrbas River (i.e. to the west and north-west) of the site, as well as the university campus. The south surrounding of the site is partially residential business zone (residential complexes are being developed there too) and partially agricultural zone with enterprises focused on food production. Just behind gatehouse to INCEL area, there is an university building with classrooms, administrative offices of Business Zone employees with a small post office, public covered swimming pool (currently not in operation), canteen and restaurant with outside premises (inside the gatehouse), and administrative offices of Nova Banka, i.e. frequently visited facilities. The INCEL area is freely accessible e.g. by bikers, as well by trespassers collecting valuable scrap metals (field reconnaissance and communication with the local site manager). There is also a paintball arena and a rock club/cultural centre, located opposite to the remnants of the former power plant, with a capacity of 300 visitors.

All the city of Banka Luka is supplied from municipal water mains. Water for the mains is abstracted from areas distant to INCEL site, mostly on the south-east of Banja Luka (Novoselija, Bočac, Gašića Vrelo, Banjica, Crno Vrelo). Based on the spatial plan of Banja Luka, several groundwater catchment areas are located north-west from INCEL site in the settlements of Česma, Krčmarice, Delibašino selo, Gakovići, etc. at the opposite bank of the River Vrbanja.

Based on the spatial plan of Banja Luka, there are important dendrological plantations/alleys within the INCEL zone that are planned to be protected. Downstream of the Vrbas Rivers there are located forest parks, and large recreational and hunting areas with a high potential for tourism development. The largest area, Tourist zone Trapisti, comprises of Marija Zvijezda monastery, ZOO, etc. Vrbas river is used for swimming, as well as for fishing.

[2] Information based on field reconnaissance and communication with the local site manager.

2.2 Meteorology and air quality

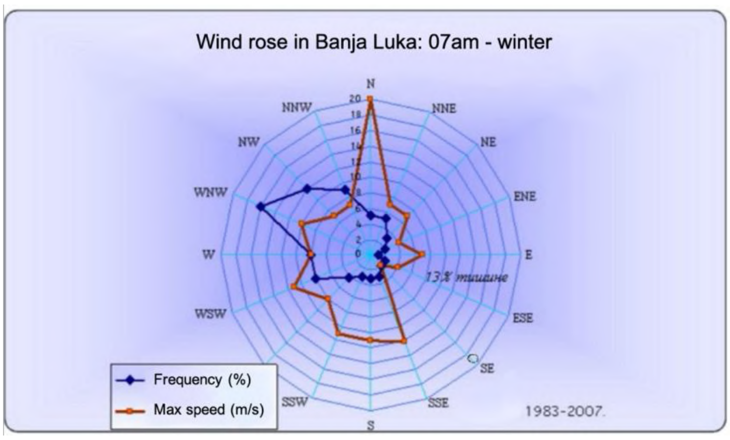

Figure 1: Diagram of the dominant wind direction in Banja Luka (at 07:00 a.m., winter period, 1983-2007)

The average annual temperature in the region reaches 10.7°C. Based on the wind rose from sixteen directions, the dominant wind direction during the year is west-northwest (WNW) (Figure 1). North winds blow more in winter and bring cold and dry weather, while south winds blow during summer bringing warm weather and precipitation. The highest frequency of winds is in January, and the highest calm is in August. Daytime winds are of low intensity, while evening currents are much stronger. Foehn wind and Dinaric foehn wind are common, most often in February and March. The prevailing quiet weather during the year is a consequence of the characteristics of air circulation in the valley, where air currents are mostly channelled by the direction of the river flow in the valley. Winds rarely exceed 15 m/s, and the maximum wind speed recorded (on November 22, 1977) was 22 m/s or 132 km/h[3].

Hydrometeorological institute of Republika Srpska measures meteorological data, as well as the air quality at three monitoring stations in Banja Luka – Centar, Paprikovac and Borik, from which Borik is the closest station to the INCEL site (approx. 1.5 km to the west). In the table below, there are average annual imission concentrations (in µg/m^3) of particulate matter measured at Borik monitoring station. The data was extracted from the annual reports of the Institute. Last report was from 2018.

Table 1: Average annual imission concentrations (µg/m^3) of particulate matter in Banja Luka

Year	$PM_{2.5}$	PM_{10}
2018	15	27
2017	21	36
2016	20	34
2015	20	33
Average	19	32.5

2.3 Geology and hydrogeology

Geology: A wider area of exploration is built (source geological map – Figure 2, see below) of Quaternary deposits. Quaternary deposits (t1) are represented by terrace sediments - gravels, sands and clays.

[3] Source: Local ecological action plan for Banja Luka, http://www.mojemjesto.ba/files/documents/LEAP_novo.pdf

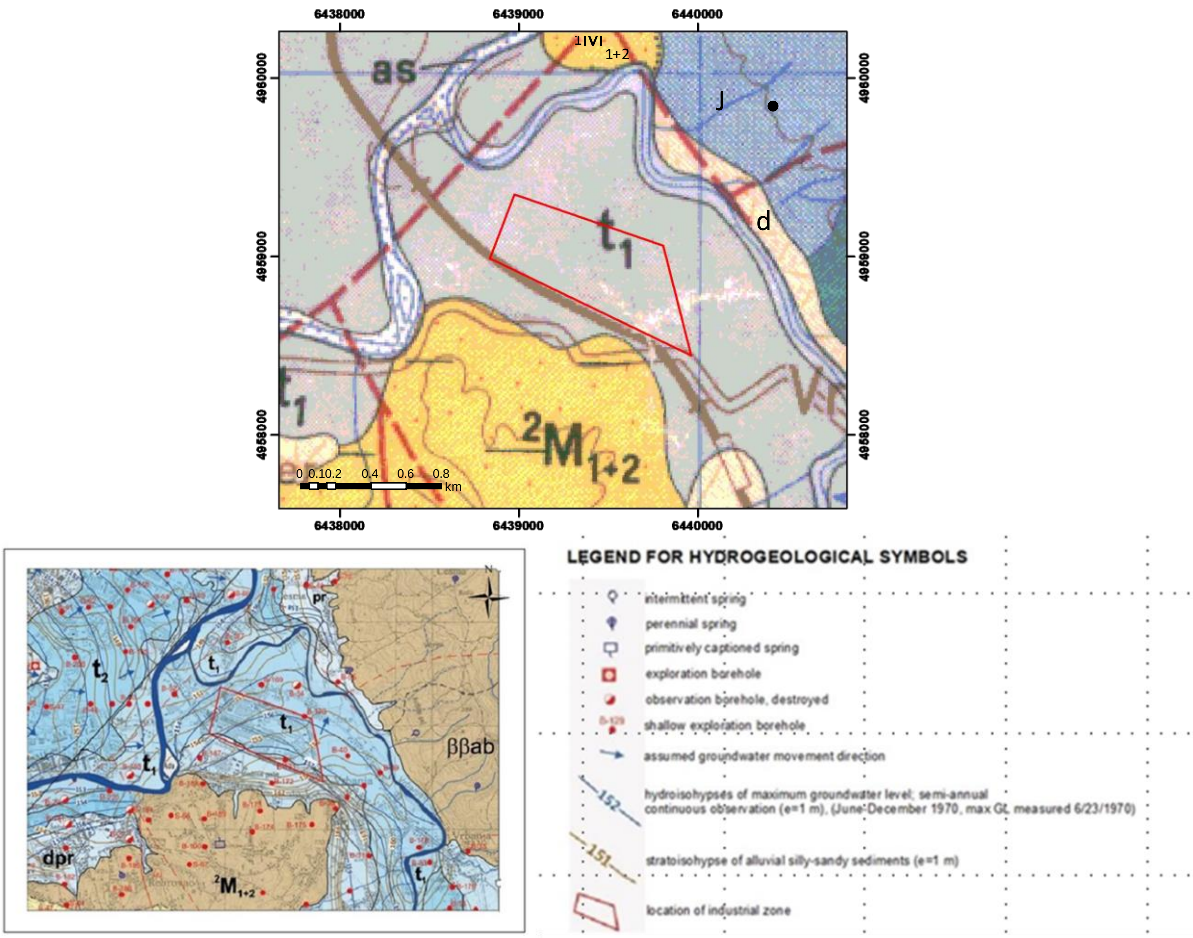

Figure 2: Geological and hydrogeological map of the area of INCEL (t1, t2 - first and second terrace, 2M1+2 - marls, sand and clay)

The area of INCEL is located on the sediments of the first river terrace of the Vrbas and Vrbanja rivers. The first terrace is made of clay, sandy clay and gravelly sandy clay. The gravels and sands are large to medium-grained. The thickness of the terraced sediments varies between 4 and 15 m. Based on findings of exploration boreholes drilled for various purposes (in the frame of previous projects) in the wider area of INCEL, the thickness of these deposits is up to 12 m. Miocene deposits were not found at probes drilled in the frame of the Project. Nevertheless, according to the previous findings, the base rock, clay marl and marl should be encountered at depth 4 up to 6 meters below surface.

The available borehole drilling profile shows that the Quaternary deposits extend mainly through the entire profile.

The thickness of the Quaternary deposits cannot be determined accurately because of deficiency of data due to shallow boreholes. According to the existing documentation, the minimum thickness is about 3 meters. To establish the maximum thickness it would be necessary to drill deeper boreholes. Quaternary deposits in the upper part of the profile, in the thickness between 2 and 6 m, are represented mainly by coherent materials, clays, and in the substrate, there are gravels and clayey gravels. The thickness of gravel layer is not precisely determined. The investigation revealed layer of backfilled materials with thickness variating in different boreholes up to the depth of 2.4 m.

Maximum drilling depth was 6 m, and in the lithological profile up to the final drilling depth, gravels, sandy gravels and gravel sands and very often backfilled material are represented.

Hydrogeology: Hydrogeological parameters of the area are conditioned by the lithological characteristics of the deposits. Hydrogeological features are influenced by geomorphological and climatic conditions of the area.

The alluvial deposits of the first terrace (t1) of the Vrbas river (Figure 2), gravels, sands and clays are represented in the area. Their porosity is primarily intergranular, and the permeability of these deposits depends on the granulometric composition, mainly the content of clay in them. Hydro-geologically, gravels and sands are classified as deposits of very good permeability, and clays as deposits of very low permeability. According to the data of exploratory drillings, the thickness of the clay deposits in the subject area is between 0.1 and 2 meters, and the thickness of the permeable gravelly-sandy deposits is not precisely determined.

Previous studies have determined the filtration properties of alluvial deposits of Vrbas river. The average calculated value of the filtration coefficient of the gravely-sandy sediments of the first terrace for quasi - stationary flow conditions is $4.13x10^{-4}$ m/s, for non-stationary flow conditions 6.4 x 10^{-4} m/s, which indicates very good permeability of sediments.

The level of groundwater in the observed area is directly related to the water level of the Vrbanja and Vrbas rivers. Depending on the hydrological period and water levels, the rivers either supply or drain the surrounding terrain. According to the existing data obtained by exploratory drilling, groundwater levels in the conditions under which the exploration was carried out are registered at depth between 1.25 and 4.0 m, at the contact of impermeable clay and permeable gravel deposits or in gravelly-sandy deposits. Data of the water levels of the Vrbanja and Vrbas rivers were unknown at the time of the survey, therefore it is not possible to accurately determine the dependence of the groundwater level and the water levels of the rivers.

On the base of obtained data hydroizohypses were constructed. The map of groundwater table is attached in Annex 2. According to the map the main direction of groundwater flow is possible to establish as from north-east to south-west in the time of investigation works.

Seismology: The area of Banja Luka and specifically INCEL site belongs to the Zone with higher expectance of seismic activity with maximum expected intensity or earthquake of 9 Richter degrees[4].

2.4 Hydrology

The research area, Banja Luka business zone is in the area of the City of Banja Luka, on flattened terrain between two rivers, of size about 80 ha. The industrial zone on the west side is bounded by the Vrbas river, and on the north and east sides by the Vrbanja river, which flows into the Vrbas river nearby this zone. According to the existing geodetic survey recorded in the area of the Vrbanja river flow, the terrain along the Vrbanja riverbed is at a minimum 3 meters higher than the water surface of the river (1). Vrbanja river has an average flow of 15.5 m^3/s (IG Banja Luka, 2017).

INCEL area is located at the edge of active flooding zones of rives Vrbas and Vrbanja (Figure 3). The area of the industrial zone that surrounds the Vrbanja river from the north and east, in accordance

[4] Source:http://www.banjaluka.rs.ba/wp-content/uploads/pdf/prostorni_plan_grada_bl/3-6_Seizmicka_karta.pdf

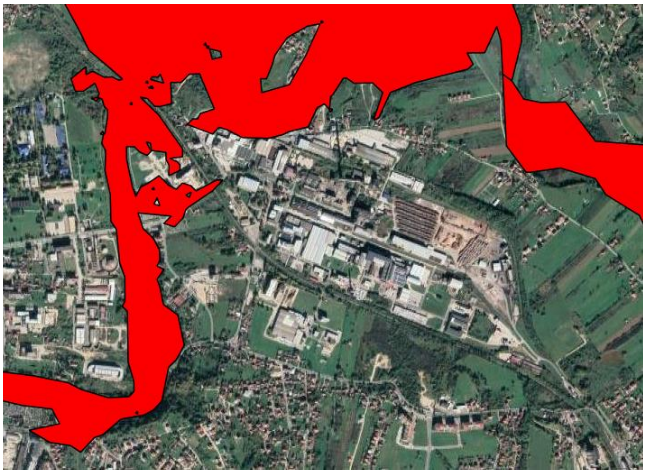

Figure 3: Flooding zones (500 years of water) of Vrbas and Vrbanja rivers (http://vrb.pmfbl.org/)

with its morphological characteristics, is exposed to flooding in the period of high-water level of Vrbanja river. According to the official BaH source of flood information[5], the north-western part of the INCEL area is potentially endangered in case of 500 years water, which is generally assumed for limitation of construction and economic areas development. In the event of catastrophic floods in May 2014, the low-laying part (i.e. southern part neighbouring to the railway) of the business zone was flooded.

A monitoring study of surface waters in Republika Srpska done in 2014 (21) includes monitoring points at the Vrbas river (V01 – Razboj , V03 – Novoselija both upstream of INCEL and V02 – Delibašino Selo, downstream of Incel). The results (Table 2) indicated that in terms of the physical and chemical parameters, the quality of the Vrbas river is indicated as the quality class II. Compared to the microbiological parameters from the location Delibašino selo, the quality of the Vrbas river is indicated as the worst quality (V class).

Table 2: Results of physical and chemical analysis - V02 Delibašino selo and microbiological parameters (21)

Identifikaciona oznaka uzorka		076-V/14	Klasa	0278-V/14-01-723	Klasa	426-V/14	Klasa	539-V/14-01-723	Klasa
Naziv serije		I serija		II serija		III serija		IV serija	
Datum uzorkovanja		26.03.2014.		17.06.2014.		13.08.2014		15.10.2014.	
Parametar									
Protok	m^3/sek	46	/	87,18	/	84.4	/	43.83	/
*Vodostaj	cm	70.0	/	90	/	90	/	80	/
*Temperatura vazduha	°C	12.0	/	17,9	/	24	/	16.0	/
Temperatura vode	°C	8.5±0.3	/	14.6±0.3	/	17.9±0.3	/	13.6±0.3	/
Rastvoreni kiseonik	g/m^3	10.98±0.19	1	9.67	1	7.47	1	9.38	1
* % zasićenja kiseonikom	%	116	2	96.2	1	78.0	2	98.4	1
pH		7.81±0.21	1	7.9±0.21	1	8.30±0.21	1	8.10±0.21	1
Elektroprovodljivost	µS/cm	390±23.5	1	388±23.5	1	387±23.5	1	404±23.5	2
HPK (O_2 bihromatni)	g/m^3	<5	1	18.8±2.04	2	<5	1	< 5	1
BPK_5	g/m^3	1.79±0.23	1	1.78±0.23	1	0.66±0.09	1	1.86±0.24	1
Ukupni alkalitet kao $CaCO_3$	g/m^3	206±6	1	193±5	1	210±6	1	211±6	1
Ukupne suspendovane materije	g/m^3	2.5±0.3	2	11.8±1.6	4	10.0±1.3	4	3.4±0.4	2
Suma kalcijuma i magnezijuma, ($CaCO_3$)	g/m^3	213±6	1	220±6	1	225±6	1	227±6	1
*Kalcijum	g/m^3	77.3±2.1	/	72.9±2	/	78.6±2.1	/	76.9±2.1	/
*Magnezijum	g/m^3	4.9	/	9.3	/	7.0	/	8.6	/
NH_4-N	g/m^3	0.06±0.006	1	0.14±0.01	2	0.06±0.006	1	0.16±0.016	2
NO_2-N	g/m^3	0.005±0.0004	1	0.009±0.001	1	0.005±0.0004	1	0.010±0.001	2
NO_3 -N	g/m^3	0.87±0.07	1	0.32±0.03	1	0.50±0.04	1	0.42±0.03	1
Ukupni N po Kjeldalu	g/m^3	<0.5	/	<0.5	/	<0.50	/	0.68±0.08	/
Ukupni N	g/m^3	1.38	2	0.83	1	1.00	2	1.11	2
Ukupni fosfor	g/m^3	0.028±0.003	2	0.038±0.004	3	0.040±0.004	3	0.031±0.003	3
Ortofosfati	g/m^3	0.014±0.001	/	0.005±0.0005	/	0.015±0.001	/	0.023±0.002	/
Arsen	mg/m^3	0.74±0.03	1	0.23	1	<0.23	1	<0.23	1
Bakar	mg/m^3	5.92±0.27	2	1.41±0.13	1	1.59±0.14	1	7.07±0.63	7
Cink	mg/m^3	22.74±1.09	/	25.2±2.42	/	14.07±1.34	/	1.88±0.18	/
Hrom	mg/m^3	<1	1	5.39±0.37	2	2.5±0.170	1	< 1.0	1

*Metoda za koju laboratorija nije akreditovana

[5] http://vrb.pmfbl.org

Redni broj	Datum	IBU	Vodotok	Profil	Oznaka profila	Određivanje ukupnog broja aerobnih heterotrofa na (22±2)°C u toku (68±4)h cfu/ml	Utvrđena klasa vodotoka	Određivanje ukupnog broja aerobnih heterotrofa na (36±2)°C u toku (44±4)h cfu/ml	Ukupan broj koliformnih bakterija kao najverovatniji broj MPN/100 ml	Utvrđena klasa vodotoka	Ukupan broj koliformnih bakterija fekalnog porekla određen kao MPN/100ml	Utvrđena klasa vodotoka	Određivanje ukupnog broja fekalnih streptokoka, MF cfu/100ml	Utvrđena klasa vodotoka
I ciklus istraživanja														
1	19.06.2014.	0277-V/14	Sana	Prijedor	U14	$1.95\cdot10^{4}$	III	$2.4\cdot10^{3}$	$1.2\cdot10^{4}$	III	230	II	$1.86\cdot10^{3}$	II
2	13.06.2014.	0264-V/14	Trebišnjica	Dražin Do	T03	$1.6\cdot10^{3}$	II	$6.68\cdot10^{2}$	2400	II	460	II	$8.24\cdot10^{2}$	II
3	24.06.2014.	0282-V/14	Bosna	Rudanka	B02	$2.85\cdot10^{5}$	IV	$1.73\cdot10^{5}$	$4.6\cdot10^{6}$	V	$1.5\cdot10^{5}$	V	$1.46\cdot10^{5}$	V
4	27.06.2014.	0292-V/14	Drina	Karakaj	D02	$8.9\cdot10^{4}$	III	$1.8\cdot10^{4}$	$9.3\cdot10^{5}$	V	$4.6\cdot10^{3}$	II	$1.27\cdot10^{5}$	V
5	19.06.2014.	0275-V/14	Sana	Novi Grad	U13	$5.1\cdot10^{4}$	IV	$2.1\cdot10^{4}$	$2.1\cdot10^{5}$	V	$1.1\cdot10^{4}$	III	$1.37\cdot10^{4}$	IV
6	17.06.2014.	0278-V/14	Vrbas	Delibašino Selo	V02	$2.28\cdot10^{5}$	IV	$6.1\cdot10^{4}$	$2.4\cdot10^{6}$	V	$2.4\cdot10^{5}$	V	$4.12\cdot10^{4}$	V
II ciklus istraživanja														
1	21.10.2014.	0537-V/14	Sana	Prijedor	U14	$1.95\cdot10^{4}$	III	$2.4\cdot10^{3}$	$1.2\cdot10^{4}$	III	230	II	$1.86\cdot10^{3}$	II
2	30.10.2014.	0558-V/14	Trebišnjica	Dražin Do	T03	$2.87\cdot10^{5}$	IV	$2.77\cdot10^{5}$	2280	II	300	II	$3.7\cdot10^{3}$	III
3	20.10.2014.	0543-V/14	Bosna	Rudanka	B02	$3.05\cdot10^{6}$	V	$1.42\cdot10^{6}$	$2.42\cdot10^{6}$	V	$2.42\cdot10^{6}$	V	$2.11\cdot10^{5}$	V
4	13.11.2014.	0547-V/14	Drina	Karakaj	D02	$6.5\cdot10^{3}$	II	$1.93\cdot10^{3}$	$8.13\cdot10^{3}$	II	$4.64\cdot10^{3}$	III	$1.17\cdot10^{4}$	IV
5	22.10.2014.	0536-V/14	Sana	Novi Grad	U13	$5.1\cdot10^{4}$	IV	$2.1\cdot10^{4}$	$2.1\cdot10^{5}$	V	$1.1\cdot10^{4}$	III	$1.37\cdot10^{4}$	IV
6	15.10.2014.	0539-V/14	Vrbas	Delibašino Selo	V02	$2.66\cdot10^{5}$	IV	$4.08\cdot10^{5}$	$1.73\cdot10^{5}$	V	$5.17\cdot10^{4}$	V	$1.82\cdot10^{5}$	V

3 OUTCOMES OF THE SITE INVESTIGATION AND RISK ASSESSMENT

Based on the study of available historical data for the INCEL area, especially outcomes of the previews sampling campaigns in 2019 (1), the list of potential hotspots was selected for detailed investigation work on the INCEL area:

1. Univerzum AD
2. Nova Banka AD
3. Lukić Invest (former power plant)
4. SHP CELEX AD
5. Business zone (Electrolysis)
6. Business zone (firefighting station)
7. Top Metal doo
8. Eco Trade
9. Business zone (next to Eco Trade)
10. Business zone (production of CS2)
11. Valentino
12. Business zone (in front of BC Metal)
13. Incel Trade
14. Bill Colour Metal (BC Metal)
15. DE-MI promet
16. Business zone (transformers of Viscosis)
17. Business zone (north)

Furthermore, the preliminary location of sampling points, number and type of samples, as well as analytical tests were proposed and described in the Sampling Plan (10), which was - after the Client's approval - used to select the detailed sampling locations at the site. Having in mind that all existing planning documents for development of INCEL industrial zone consider enhancing its industrial development, the great emphasis was placed on evaluating the level of contamination of soil and construction materials inside the INCEL area.

A detailed description of the performed field work is further described in the Deliverable 1 – Conducted Fieldwork Report (11).

In order to be able to assess the level of pollution, a number of legislative and methodological regulations were collected and reviewed. Great emphasis was placed on the use of regionally valid regulations. In case of soil samples from the terrain outside the INCEL area (i.e. agricultural soil samples) the following regulation was used:

- Ordinance on the permitted quantities of dangerous and harmful substances in agricultural land and irrigation water and methods for testing (Official Gazette of Republic of Srpska, no. 56/16)

Comparative limits specifically designed for industrial areas are usually not included in national legislations. The screening levels for industrial areas set by the US EPA (12), which are updated annually according to the latest available scientific knowledge, are therefore very appropriate for this purpose. Within the US EPA methodology, these screening levels are calculated for the specific target cancer risk of a particular contaminant and are suitable for studies that assess health risks from contaminated industrial sites. If any of these contaminants are not included in the US EPA screening levels database, limit values set by the regional regulations may be used.

For the purposes of parameters C10-C40 (Mineral oils) and ∑PAH assessment, the maximum permissible values of the following regulation were used:

- Decree on limit values for pollutants in surface and groundwater and sediment and deadlines for reaching them, 'Official Gazette of Republic of Serbia (50/2012)

Note: The Republic of Srpska and Bosnia and Herzegovina (as a whole state) do not have adequate legislation for groundwater and sediments, so the legislation of the Republic of Serbia was used.

This Serbian legislation regulates, among others, the limit values of sediments in the surface flow, which can be used to assess level of pollution in the sediment samples of the surface flow of the Vrbas River and also to assess the ecological risks associated with the INCEL area.

The Regulation on the water classification and categorization (O.G. of Republika Srpska, 42/01) sets range limits values for both surface and underground waters of different classes. Aiming for fixed limit value, and in order to assess the level of groundwater pollution, the intervention limits of the Dutch legislation, which are based on the legislative recommendations of the European Union, were used. In the case of the monitored pollutants, these values agree well with the legislative regulation, which is in Republika Srpska in the phase of preparation.

The comparative limits that were selected to evaluate the level of pollution at the INCEL site are summarized in the following table Table 3.

Table 3: Summary of mandatory regulations and methodical instructions

<table>
<tr><th rowspan="2">Type of matrix</th><th colspan="3">Comparative limits</th><th rowspan="2">Regulation / methodical instruction</th></tr>
<tr><th>∑PCB (7 congeners)</th><th>$C_{10} – C_{40}$</th><th>∑PAH</th></tr>
<tr><td rowspan="2">Top soil outside INCEL area</td><td>0.2 mg/kg</td><td rowspan="2">not analysed</td><td rowspan="2">not analysed</td><td>Ordinance on the permitted quantities of dangerous and harmful substances in agricultural land and irrigation water and methods for testing (Official Gazette of Republic of Srpska, no. 56/16)</td></tr>
<tr><td>0.23 mg/kg</td><td>US EPA screening levels for residential soil (12) [3)]</td></tr>
<tr><td>Construction materials</td><td>0.94 mg/kg</td><td>n.a.</td><td>n.a.</td><td>US EPA screening levels for industrial soil (12) [3)]</td></tr>
</table>

Type of matrix	Comparative limits			Regulation / methodical instruction
	ΣPCB (7 congeners)	**C_{10} – C_{40}**	**ΣPAH**	
+ Top soil inside INCEL area + Soil probes	0.2 mg/kg (max value)	**3,000 mg/kg (max. value)**	**10 mg/kg (max. value)**	Decree on limit values for pollutants in surface and groundwater and sediment and deadlines for reaching them, 'Official Gazette of Republic of Serbia (50/2012)
Sediments in the river [1)2)]	**0.02 mg/kg (target value)**	**50 mg/kg (target value)**	**1 mg/kg (target value)**	Decree on limit values for pollutants in surface and groundwater and sediment and deadlines for reaching them, 'Official Gazette of Republic of Serbia (50/2012)
Groundwater	**0.01 µg/l**	**600 µg/l**	not analysed	Dutch intervention limit values for soil and groundwater (2009) (17)
	0.01 µg/l	600 µg/l [4)]	not analysed	Draft Regulation on limit and remediation values of pollutants, harmful and hazardous substances in the land (Republika Srpska) (18)

Comment:
1) The target value is the limit value for the concentration of pollutant in the sediment below which the negative impacts on the environment are negligible and it represents a long-term goal of sediment quality. This value will be applied for ecological risk assessment.
2) There are no US EPA screening levels for groundwater and sediments in the river, therefore, the recommended regional regulations were used.
3) Calculated for the target cancer risk of 1E-06 and/or target hazard quotients of 1.0
4) Limit for C_6-C_{40}
n.a. = not available

3.1 Contamination of soil

The evaluation of soil contamination was performed based on the exact position of individual sampling points. Detailed information about the collected samples can be found in the annexes of previous Deliverable 1 – Conducted Fieldwork Report (D1). Annex V of D1 gives the borehole logs with information regarding the sampled horizon, the organoleptic observations and groundwater level for each borehole. Annex VI of D1 gives information about the sampling conditions for each of the collected samples, and Annex II of D1 gives the depths of each collected sample.

The exact coordinates of the topsoil samples TS were obtained from photogrammetry performed by a drone. Part of the INCEL site and its peripheral area was mapped using aerial photogrammetry. A portable light UAV (Unmanned Aerial Vehicle) DJI Phantom 4 PRO collected geodata using vertical photogrammetry images captured during a few-hours pre-programmed flight.

The DJI Phantom 4 Pro quadcopter is used for data collection, which is equipped with a 4K Ultra HD camera on a 3-axis stabilized suspension, with an integrated Lightbridge image transmission system, with a video positioning system, anti-collision sensors. The camera is equipped with a 1-inch 20-megapixel sensor, which is capable of recording 4K / 60fps video and taking sequential photos at 14 frames per second.

Drone Deploy is used for taking images. It is the leading cloud software platform for commercial drones, making access to and expanding the use of aeronautical data. Drone Deploy enables easy automated flight and data collection and allows you to explore and share high-quality interactive maps and 3D models.

Prior to the actual imaging, fitting points VP are created at the site, which are geodetically oriented in the required coordinate system and are clearly visible from the air.

Subsequently, the imagine parameters are set in the Drone Deploy application (area of the scanned area, required flight altitude, overlaps of individual images, camera sensitivity, etc.). The actual shooting already takes place fully automatically in a predetermined flight polygon.

After shooting, the individual photos are transferred to a PC and sent for further processing.

Images taken using a UAV (drone) are processed in the Agisoft Metashape photogrammetric software, in which each image is analysed and compared with other images and identical points are identified. Using the projection, the individual positions of the images are calculated and, based on the triangulation, a point cloud (each point has spatial coordinates) representing the surface of the scanned area is calculated. Using unambiguously determined interpolation points with coordinates determined using GNSS methods, the cloud is transformed into the required coordinate system.

The table below shows the topsoil samples TS coordinates of the samples obtained from the photogrammetric measurement.

Table 4: Coordinates of topsoil samples (TS)

Point marking	DKS SYSTEM		Point marking	DKS SYSTEM	
	Y	X		Y	X
TS1	6439037,18865	4959135,70753	TS25	6439175,03461	4958778,01230
TS2	6439133,36672	4959099,72279	TS26	6439135,86575	4958790,52721
TS3	6439104,59411	4959095,34217	TS27	6439306,96321	4958798,98702
TS4	6439171,38175	4959085,54899	TS28	6439302,08580	4958782,35207
TS5	6439177,35460	4959082,47753	TS29	6439119,60693	4958801,95545
TS6	6439215,14743	4959080,99819	TS30	6439136,64283	4958842,95621
TS7	6439203,05458	4959144,61873	TS31	6439159,62142	4958985,83134
TS8	6439198,41403	4959103,51936	TS32	6439191,17268	4958967,43549
TS9	6439177,14126	4959180,13539	TS33	6439231,60323	4958949,67522
TS10	6439116,17334	4959202,61872	TS34	6439267,91211	4958935,10909
TS11	6439018,15966	4959303,57864	TS35	6439257,52775	4958971,39674
TS12	6439119,82041	4959240,40895	TS36	6439299,01493	4958956,12964
TS13	6439133,15195	4959233,43412	TS37	6439310,59403	4958990,08647
TS14	6439097,85784	4959233,26165	TS38	6439282,34160	4959030,34887
TS15	6439092,73861	4959263,77211	TS39	6438942,68373	4959011,49786
TS16	6439085,81307	4959254,05019	TS40	6438950,92392	4959039,56741
TS17	6439140,97928	4958893,77574	TS41	6438962,51305	4959064,61081
TS18	6439107,34162	4958872,34486	TS42	6438966,09587	4959072,27969
TS19	6439180,71060	4958879,07112	TS43	6438766,99989	4959177,79216
TS20	6439199,22415	4958838,53725	TS44	6438814,22435	4959114,51259
TS21	6439231,02794	4958853,22749	TS45	6438732,15072	4959159,68019
TS22	6439251,63411	4958828,71412	TS46	6438794,03426	4959107,99050
TS23	6439134,32277	4958810,46916	TS47	6439592,86527	4959079,89384
TS24	6439172,66225	4958788,02289	TS48	6439548,24834	4959042,88109

Point marking	DKS SYSTEM	
	Y	X
TS49	6439717,06959	4959029,42196
TS50	6439660,49974	4958993,72529
TS51	6439330,29248	4959133,40853
TS52	6439368,06425	4959123,11423
TS53	6439623,88510	4958738,78365
TS54	6439635,07617	4958767,22439
TS55	6439577,81720	4958756,47179

Point marking	DKS SYSTEM	
	Y	X
TS56	6439616,96758	4958775,80452
TS57	6439522,93731	4958666,19594
TS58	6439535,86231	4958729,00182
TS59	6439556,43364	4958687,61313
TS60	6439544,63158	4958659,63799
TS61	6439104,79617	4958735,47089
TS62	6439083,03370	4958745,27670

As organoleptic observation did not suggest any concentration of contaminants (especially no oil/petroleum hydrocarbons features were observed) in the particular depths of the boreholes, the soil samples were collected as planned in pre-defined regular depth intervals listed in Table 5 below.

Table 5: Number of probes and collected soil samples

No.	Probe	Date	Depth	Sample ID				Total number of samples
			(m)	0.0-0.2 m	0.2-0.8 m	0.8-2.0 m	GW*	
1.	**S-1**	30.7.20	6.00	S1/TS	S1/1	S1/2	S1/GW	4
2.	S-2	30.7.20	4.80	S2/TS	S2/1	S2/2*		3
3.	S-3	30.7.20	4.80	S3/TS	S3/1	S3/2*	S3/GW**	4
4.	**S-4**	31.7.20	6.00	S4/TS	S4/1	S4/2	S4/GW**	4
5.	S-5	31.7.20	4.80	S5/TS	S/1	S5/2*		3
6.	S-6	31.7.20	4.80	S6/TS	S6/1	S6/2		3
7.	**S-7**	31.7.20	6.00	S7/TS	S7/1	S7/2	S7/GW	4
8.	S-8	31.7.20	4.80	S8/TS	S8/1	S8/2		3
9.	**S-9**	1.8.20	6.00	S9/TS	S9/1	S9/2	S9/GW	4
10.	S-10	1.8.20	3.60	S10/TS	S10/1	S10/2		3
11.	**S-11**	1.8.20	6.00	S11/TS	S11/1	S11/2	S11/GW	4
12.	S-12	1.8.20	3.60		S12/1	S12/2	S12/GW**	3
13.	S-13	3.8.20	3.60	S13/TS	S13/1			2
14.	**S-14**	3.8.20	6.00	S14/TS	S14/1	S14/2	S14/GW	4
15.	**S-15**	3.8.20	6.00	S15/TS	S15/1	S15/2	S15/GW	4
16.	S-16	3.8.20	4.80	S16/TS	S16/1	S16/2		3
17.	S-17	3.8.20	4.80	S17/TS	S17/1	S17/2		3
18.	S-18	3.8.20	4.80	S18/TS	S18/1	S18/2		3
19.	**S-19**	4.8.20	6.00	S19/TS	S19/1	S19/2	S19/GW	4
20.	S-20	4.8.20	4.80	S20/TS	S20/1			2
21.	S-21	4.8.20	4.80	S21/TS	S21/1	S21/2		3
22.	S-22	4.8.20	3.60	S22/TS	S22/1			2
23.	**S-23**	7.8.20	6.00	S23/TS	S23/1	S23/2		3

No.	Probe	Date	Depth (m)	Sample ID 0.0-0.2 m	0.2-0.8 m	0.8-2.0 m	GW*	Total number of samples
24.	S-24	7.8.20	4.80	S24/TS	S24/1	S24/2	S24/gran	3
25.	S-25	6.8.20	4.80	S25/TS	S25/1	S25/2		3
26.	S-26	6.8.20	3.60	S26/TS	S26/1	S26/2		3
27.	S-27	6.8.20	4.80	S27/TS	S27/1	S27/2	S27/3	4
28.	S-28	6.8.20	3.60	S28/TS	S28/1	S28/2		3
29.	**S-29**	7.8.20	6.00	S29/TS	S29/1	S29/2	S29/GW	4
30.	S-30	7.8.20	3.60	S30/TS	S30/1	S30/GW		3

** 20 cm interval at the level of the detected groundwater tablel*
*** Collected soil samples stored in archive without chemical analyses*

3.1.1 PCBs Contamination

Topsoil

In total 95 samples (91 inside INCEL and 4 outside INCEL) were collected from the uppermost soil strata (0 to 0.2 m b.g.) and analysed in the laboratory. PCBs were not detected in any of the 4 samples (TS-WEST1, TS-WEST2, TS-E and TS-SE) collected outside INCEL. The samples TS-WEST1 and TS-WEST2 were collected to the south-west (nearby by developing residential zone) from the site and the samples TS-E and TS-SE collected south-east from the site (agricultural soil).

Regarding the samples of topsoil collected inside INCEL, in 41.1% of the samples, the sum of the 7 PCBs analysed were bellow detection levels of the analytical method. Only in 16.5% of the samples collected was above the US EPA screening level for industrial soil (0.94 ppm). The remaining samples contained PCBs above detection limit of the analytical method, but below the US EPA screening levels for industrial soil.

The results are summarized in the Table 6 below. The detailed results for each individual sample are presented in Annex 2.

Table 6: Summary of the results of the PCBs analyses in topsoil

Hotspot Name	Average value of Σ7 PCBs (ppm)	Maximum value of Σ7 PCBs (ppm)
Lukic Invest (former power plant)	1.43	5.28
SHP CELEX	1.88	3.87
BZ in front of BC Metal	1.12	9.14
BC Metal	0.02	0.05
Valentino	0.05	0.09
INCEL trade	<0.0210	<0.0210
BZ transformers of Viscosis	0.03	0.09
BZ Electrolysis	0.84	3.91
Nova Banka	0.08	0.15
Univerzum	3.54	18.10
Top Metal	1.89	8.75
BZ firefighting station	0.03	0.07
BZ next to Eco-trade	0.03	0.06
Eco-trade	0.02	0.04
BZ production of CS2	0.02	0.04
DE-MI Promet	<0.0210	<0.0210
BZ North	0.79	5.14

BZ = Business Zone
PCB concentrations above the US EPA screening level 0.94 mg/kg
PCB concentrations below detection limit of the analytical method

The contamination was mainly found only at isolated locations and is at relatively low levels. With the exception of the area of the former power plant (now Lukić Invest) and south-eastern part of Celex, the contamination was not linked to compact areas within the particular hotpots.

Soil samples from the depth 0.2 m to the level of groundwater table

In total, 62 soil samples from 30 different sampling locations spread over 13 hotspots were analysed. None of the samples collected had concentrations of PCBs above the US EPA screening level for industrial soil (0.94 ppm). The results show that in 91.9% of the samples, the sum of the 7 PCBs analysed were bellow detection levels of the analytical method. The remaining samples had PCBs concentrations above detection limit of the analytical method, but below the US EPA screening levels for industrial soil.

The results are summarized in the Table 7 below. The detailed results for each individual sample are presented in Annex 2.

Table 7: Summary of the results of the PCBs analyses of soil samples collected from the depth 0.2 m to the level of groundwater table

Hotspot Name	Average value of Σ7 PCBs (ppm)	Maximum value of Σ7 PCBs (ppm)
Lukic Invest (former power plant)	0.01	0.05
CELEX	0.05	0.18
BZ in front of BC Metal	0.03	0.28
BC Metal	<0.0210	<0.0210
BZ Transformers of Viscosis	<0.0210	<0.0210
BZ Electrolysis	<0.0390	<0.0390

Hotspot Name	Average value of Σ7 PCBs (ppm)	Maximum value of Σ7 PCBs (ppm)
Nova Banka	0.02	0.04
Univerzum	0.1	0.44
Top Metal	<0.0210	<0.0210
BZ Firefighting Station	<0.0210	<0.0210
BZ next to Eco-trade	<0.0210	<0.0210
BZ Production of CS2	<0.0210	<0.0210
BZ North	<0.0210	<0.0210

BZ = Business Zone
PCB concentrations above the US EPA screening level 0.94 mg/kg
PCB concentrations below detection limit of the analytical method

3.1.2 *Other Contaminants*

While topsoil samples (0.0 – 0.2 m b.g.l.) outside of INCEL and soil samples bellow 0.20 m of depth were analysed only for PCBs, a group of topsoil samples from inside INCEL area was chosen also for analysis of other contaminants, such as asbestos, dioxins, heavy metals, PAHs, PCBs like dioxins and TPH. Results of the analyses are shown in the Table 8 below. The red text indicates that the contaminant exceeded its limit value. The detailed results for each individual sample are presented in Annex 2. The limit values for particular metals are listed in Annex 2 along with the results.

Table 8: List of topsoil samples (0.0 – 0.2 m b.g.l.) analysed for contaminants other than PCBs

Sample ID	Location	Analyses
TS-4	Lukić Invest (former power plant)	heavy metals (As, Be, Co, Cu, Ni), PAHs, dioxins, PCB like dioxins and TPH
TS-8	Lukić Invest (former power plant)	heavy metals (Sb, As, Ba, Cd, Cr, Co, Cu, Pb, Mo, Ni, Zn) and TPH
TS-20	BZ in front of BC Metal	heavy metals (As, Ba, Be, Co, Cu, Ni, Zn) and TPH
TS-24	BC Metal	heavy metals (Sb, As, Cd, Cu, Pb, Hg, Ni, Zn), PAHs, dioxins, PCB like dioxins and TPH
TS-25	BC Metal	heavy metals (As, Cd, Hg, Ni) and TPH
TS-38	BZ Electrolysis	asbestos
TS-44	Univerzum	heavy metals (As), PAHs and TPH
TS-47	Top Metal	heavy metals (Sb, As, Ba, Cd, Co, Cu, Hg, Mo, Ni, Zn), dioxins and PCB like dioxins
L-3A	Lukić Invest (former power plant)	asbestos
S1/TS	BZ transformers of Viscosis	TPH
S4/TS	BZ transformers of Viscosis	TPH
S7/TS	BZ in front of BC Metal	TPH
S8/TS	BZ in front of BC Metal	TPH
S9/TS	BZ in front of BC Metal	TPH
S11/TS	Nova Banka	TPH
S16/TS	Lukić Invest (former power plant)	TPH
S17/TS	Lukić Invest (former power plant)	TPH
S19/TS	Lukić Invest (former power plant)	TPH

Asbestos

Two samples (L-3A and TS-38) were collected and analysed qualitatively under optical microscopy for the presence of asbestos.

The results indicate that for L-3A chrysotile was present and for TS-38 no asbestos was detected.

Dioxins

Three samples of topsoil (TS-4, TS-24 and TS-47) were analysed for dioxins. No dioxins were detected in any of the samples.

Heavy Metals

Six samples of soil and topsoil (TS-4, TS-8, TS-20, TS-24, TS-25, TS-44 and TS-47) were analysed for 22 different metals and heavy metals.

It is important to note that there is no single regulation considering the concentrations of all heavy metal cations, as the US EPA's RBC screening level database considers for some heavy metals their compounds. For this reason, our team decided to use three regulations that, when combined, cover the majority of the metals.

The results of the analyses indicate that in majority of analysed samples; at least one of the analysed metals was present in concentrations above the limit set by, at least, one of the regulations used. The detailed individual results for all heavy metal analyses can be found in Annex 7 of Deliverable 2 – Site Assessment report.

PAHs

Three samples of topsoil (TS-4, TS-24 and TS-44) were analysed for PAHs. The sum of the 12 analysed PAH was lower than the detection limit of the method for the sample TS-4 and it was above detection limit in TS-24 and TS-44. TS-44 was the only sample were this sum was above the 10 mg/kg limit[6].

PCBs like dioxins

Three samples of topsoil (TS-4, TS-24 and TS-47) were analysed for PCBs like dioxins. The results showed that all samples presented results of the sum of the PCBs like dioxins above the detection limit of the method, but TS-4 showed a concentration above the US EPA limit of 0.94 ppm.

Total Petroleum Hydrocarbons (TPHs)

Fifteen samples of topsoil and soil from probes (TS-4, TS-8, TS-20, TS-24, TS-25, TS-44, S1/TS, S4/TS, S8/TS, S9/TS, S11/TS, S16/TS, S17/TS and S19/TS) were analysed for TPHs. The results showed that although 60 % of the samples presented the C10-C40 fraction above the detection limits of the method, no samples were above the 3000 mg/kg limit[7].

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[6] Decree on limit values for pollutants in surface and groundwater and sediment and deadlines for reaching them (Official Gazette of Republic of Serbia, No.50/2012)

[7] *Ibid.*

3.2 Contamination of groundwater

Groundwater samples were collected both inside and outside INCEL area. Detailed information about the samples can be found in the annexes of the D1 – Conducted Fieldwork Report.

Inside INCEL area

Table 9: Results of the PCBs analyses of the groundwater samples collected inside INCEL

Analyte	Sample	Lukić Invest			Univerzum
		S15 GW level 1.67 m b.g.l.	S19 GW level 2.5 m b.g.l.	P1 GW level 2.8 m b.g.l.	S29 GW level 2.2 m b.g.l.
	Units	mixed sample	mixed sample	mixed sample	mixed sample
PCB 101	µg/L	0.00162	0.501	0.0158	0.0102
PCB 118	µg/L	<0.0110	0.0814	0.00814	0.00205
PCB 138	µg/L	0.00357	0.771	0.119	0.0137
PCB 153	µg/L	0.00357	0.903	0.195	0.0116
PCB 180	µg/L	0.00179	0.441	0.113	0.0043
PCB 28	µg/L	<0.0110	0.0477	<0.0110	<0.0110
PCB 52	µg/L	<0.0110	0.121	<0.0110	0.00207
Sum of 7 PCBs	µg/L	0.0106	2.87	0.451	0.0439
Max PCBs in Area	µg/L		2.87		0.0439
Average PCBs in Area	µg/L		**1.11**		**0.0439**

***RED** – above limit (0.01 ug/l) according to "Decree on Water Classification and Categorization of Watercourses" (O. G. RS, no. 42/01)*
***GREEN** – bellow detection limit*

In total 14 samples of groundwater were collected from 10 newly established probes and 4 existing monitoring wells in INCEL area. All the sampling points with graphical evaluation are shown in the map in Annex 1. The table above presents just points (localities) where the level of contamination was detected above the limit. All the results of performed lab analyses are presented in Annex 2.

The samples were taken by using the method of Low Flow Sampling, which is in detail described in EPA Ground Water Issue EPA/540/S-95/504. The basic demands on sampling process are flow rates in the range of 0.01 – 0.05 l/sec, minimal drawdown and measuring water quality indicator parameters as pH, temperature, specific conductance, oxygen concentration etc. Generally, the method allows taking a sample of groundwater in dynamic state without purging – i.e. removing 3-5 casing volumes. Well purging is necessary when samples are to be collected from previously-drilled wells. Some of the main reasons for the well purging are: the presence of the air interface and higher oxygen concentration at water surface, loss of volatiles and chemical changes due to clay seals, filter pack or casing. Newly-drilled wells should be properly developed to remove fines created during emplacement. All the sampled probes were purged before taking samples by pumping of constant discharge.

All groundwater samples were taken as a mixed sample from the given monitoring well. The highest concentrations of PCBs were observed in borehole S-19 (2.87 µg/l) and P-1 (0.451 µg/l). Slight exceedance of the contamination limit for the sum of PCBs was also found in boreholes S-15 and S-29.

It can be stated that the extent of groundwater contamination is limited only to 2 hotspots: Universum AD (sample S29) and Lukić Invest – former power plant (samples S15, S19 and P-1). The volume of contaminated water cannot be estimated from the obtained results due to the scattered location of contaminated spots and strongly variating level of contamination. Groundwater PCBs contamination appears to be linked to isolated secondary sources of contamination in (un)saturated zone, perhaps due to previous incidents/leaks of transformer oil to soil. The pollutants migration is further discussed in detail in section 3.5 on page 33.

It must also be stated that no oil contamination has been detected in any groundwater sample within the INCEL area. Concentrations of TPH in all 7 collected samples were below detection limit.

Outside INCEL area

In total, three samples (W-1 at 3.5 m b.g.l, W2 at 1.5 m b.g.l. and W-3 at 2.9 m b.g.l) of groundwater from drinking wells located outside of INCEL were collected for PCBs analyses.

In all samples, the sum of the 7 PCBs analysed was bellow detection levels of the analytical method.

3.3 Contamination of sediment

3.3.1 PCBs Contamination

In total, three samples of sediment from the top 10 cm layer strata were collected from an area outside INCEL, at the margin of Vrbas river. One sample was collected at the sewage channel outlet (SED-CH) and two samples were collected upstream (SED-UP) and downstream (SED-DOWN) of the outlet.

The results show that the samples SED-DOWN and SED-CH presented concentrations of the sum of 7 PCBs above limit of 0.02 ppm set on the *"Decree on limit values for pollutants in surface and groundwater and sediment and deadlines for reaching them"* by the Official Gazette of Republic of Serbia' (50/2012). In the sample SED-UP, the sum of 7 PCBs was below the detection limit of the analytical method. The results are presented in the Table 10 below. In red are the samples in which the PCBs were above the Republic of Serbia Decree. In green are the hotspots in which the PCBs were below detection limit.

Table 10: Results of the PCBs analyses on sediment samples

Analyte	Sample Units	SED-UP SEDIMENT	SED-DOWN SEDIMENT	SED-CH SEDIMENT
PCB 101	mg/kg DW	<0.0030	<0.0030	0.0246
PCB 118	mg/kg DW	<0.0030	<0.0030	0.0092
PCB 138	mg/kg DW	<0.0030	0.0083	0.172
PCB 153	mg/kg DW	<0.0030	0.0084	0.177
PCB 180	mg/kg DW	<0.0030	0.0084	0.145
PCB 28	mg/kg DW	<0.0030	0.0261	<0.0030
PCB 52	mg/kg DW	<0.0030	0.0057	<0.0030
Sum of 7 PCBs	mg/kg DW	**<0.0210**	**0.0546**	**0.528**

RED *– above limit 0.02 ppm set out in the "Decree on limit values for pollutants in surface and groundwater and sediment and deadlines for reaching them" by the Official Gazette of Republic of Serbia' (50/2012)*
GREEN *– bellow detection limit*

3.3.2 *Other Contaminants*

In addition to PCBs, SED-UP and SED-DOWN were analysed for heavy metals and TPH, and SED-CH was analysed for heavy metals only. In the table below is a summary of the analysis. The detailed results for each individual sample are presented in Annex 2. The red text indicates that the contaminant exceeded its limit value.

Table 11: Summary of the results of sediment analyses

Sample ID	Analyses
SED-CH	heavy metals (Cu, Pb, Hg, Ni, Zn)
SED-UP	heavy metals (Ni) and TPH
SED-DOWN	heavy metals (Hg, Ni) and TPH

It is important to note that although 22 individual heavy metals were analysed, only 8 of them have limits set in the "*Decree on limit values for pollutants in surface and groundwater and sediment and deadlines for reaching them*" by the 'Official Gazette of Republic of Serbia (50/2012).

3.4 Contamination of construction materials

In order to assess contamination of construction materials, 21 samples were collected at various hotspots identified by the previous studies. Results of PCBs analysis together with description of sampling locations are listed in the Table 12 below. In red are marked concentrations of PCBs exceeding the limit value 0.94 mg/kg set forth in US EPA's screening levels for industrial soil (12), while in green the values below detection limit.

Table 12: PCBs concentration in construction materials

Position (hotspot)	No.	ID	Description	Sum of 7 PCBs [mg/kg d.m.]
SHP Celex	1	CX-1	Concrete panel fragment from an open area between chimney and Celex factory. Sample taken from a lowered area where sediment accumulates.	0,157
	2	CX-2	Concrete panel fragment from an open area between chimney and Celex factory. Composite sample of four locations across the area.	3,26
Lukić Invest (former power plant)	3	L-1	Small building with two transformer rooms. Samples taken from an inclined (sloped) concrete floor of transformer basin.	0,446
	4	L-2	Small building with two transformer rooms. Samples taken from an inclined concrete floor of transformer basin.	0,257
	5	L-3	Black sediment on concrete transformer basin (Figure 12). Transformers were being collected and dismantled here. Partially demolished room adjacent to a main building. Around piles of waste with fragments of asbestos roof.	<0,07
	6	L-4	Mortar fragment from the floor 2 m from location of transformer together with loose plaster fragments on the linoleum floor under metal structure transformers were fit on.	0,18

Position (hotspot)	No.	ID	Description	Sum of 7 PCBs [mg/kg d.m.]
	7	L-5	Surface scratched from a wall with white lime paint behind location of transformers.	0,466
	8	L-6	Concrete floor of a warehouse in use (soil piles, see Figure 6 and Figure 7). Transformers removed from Lukić building across street were stored here before being dismantled at another location (L-3).	1,56
	9	L-7	Transformer room in a building in front of the main Lukić building. Plaster from inclined floor. Concrete with pebbles (Figure 5).	9,03
Universum AD	10	UN-1	Concrete foundation below terrain level. Structure demolished; soil excavated from around there.	0,096
	11	UN-2	Concrete platform behind the storage containers with excavated soil.	0,243
Nova Banka	12	NB-1	Small room (former office) where fire took place. Composite sample of concrete floor and plaster of walls.	<0,035
	13	NB-2	Open concrete area. Sample 0-0,2 m drilled by probe (S12/CM).	<0,035
	14	NB-3	Blackened paint layer inside small room (former office) from under the window opening.	<0,035
	15	NB-4	Surface scratched from an external wall of the small room (former office), building in front of the University building.	<0,035
Top Metal	16	TM-CM	Composite sample taken from across the concrete area.	
Business zone (transformers of Viscosis)	17	BZ-T-1	Elevated platform in front of transformer rooms. Flat concrete, oily stains, petroleum smell.	<0,035
	18	BZ-T-2	Floor from inside a transformer room (concrete).	0,071
Business zone (Electrolysis, center, close to I-9)	19	BZ-C-1	Inclined (sloped) floor of a transformer basin (concrete) together with loose debris on the floor before transformer basin (Figure 9). Front wall demolished.	6,93
	20	BZ-C-2	Concrete floor of a large hall. Composite sample of an oily stain at the entrance and two samples of floor and concrete column (30 cm height) in a corner area with black deposits.	0,701
	21	BZ-C-3	Surface scratched from a wall. Location same as BZ-C-2.	<0,035

Contamination with PCBs above 0.94 mg/kg was found at 4 locations at INCEL – two in the area of Lukić Invest (former power plant, see Figure 4), one in the former factory of Electrolysis and one in the open concrete platform at SHP Celex.

The highest concentration of PCBs was detected in a sample (L-7) taken from concrete floor below former location of transformer (see Figure 5) in a room of a corner building across the street of the main Lukić Invest building (former power plant). PCBs were also detected in a sample taken nearby, at the entrance into a hall also belonging to Lukić Invest (see Figure 6 and Figure 7).

Figure 4: Lukić – sampling locations plan (in circle samples with PCBs concentration above 0,94 mg/kg)

Figure 5: Lukić Invest (former power plant, sample L-7)

Figure 6: Lukić Invest (former power plant, sample L-6)

Figure 7: Lukić Invest (former power plant, sample L-6)

Contamination with PCBs was also found in another transformer room (Figure 9), located in the former Electrolysis building (Figure 8).

Figure 8: Business zone - Electrolysis, center (sample BZ-C-1 from inside a transformer room on the left left and BZ-C-2,3 from inside the main hall with entrance on the right))

Figure 9: Business zone - Electrolysis, center (sample BZ-C-1)

Interestingly, no or very little contamination with PCBs was found in four similar transformer rooms (samples L-1, L-2, L-3 on Figure 11 and Figure 12, BZ-T-2) or location just below place where transformer was installed (sample L-4 on Figure 10) in INCEL. On the other hand, very high concentrations of total petroleum hydrocarbons and heavy metals were detected in sample L-3 at a spot (Figure 12) where removed transformers were being dismantled in the past (information from Mr. Ermin Tajić, a former INCEL employee), suggesting that not all transformer oil contained PCBs.

Figure 10: Lukić Invest (former power plant, sample L-4 from under the metal transformers structure, L-5 from the wall behind it)

Figure 11: Lukić Invest (former power plant, samples L-3 from outside on the right, L-4 and L-5 from inside the building on the right side)

Figure 12: Lukić Invest (former power plant, sample L-3)

Apart from PCBs, four samples were tested for heavy metals and two for total petroleum hydrocarbons. Contamination with heavy metals was found at Lukić (sample L-3, Figure 12) and former Electrolysis building (sample, Figure 8). The Table 13 below lists samples and analyses, the red text indicates that the contaminant exceeded its limit value. The detailed results for each individual sample are presented in Annex 7 of Deliverable 2 – Site Assessment Report.

Table 13: Summary of heavy metals and TPH analyses in construction materials

Sample ID	Location	Analyses
L-3	Lukić Invest (former power plant)	heavy metals (Sb, As, Ba, Cd, Cr, Co, Cu, Pb, Hg, Mo, Ni, V, Zn) and TPH
L-6	Lukić Invest (former power plant)	heavy metals (Ba, Hg, Ni)
UN-2	Universum AD	heavy metals
BZ-C-2	Business zone (Electrolysis)	heavy metals (Sb, Ba, Cd, Cr, Co, Cu, Pb, Hg, Mo, Ni, Zn) and TPH

3.5 Contamination's migration potential

Based on the results of topsoil samples collected outside INCEL area (Annex 1) (i.e. to the south-west and south-east from the area), it can be concluded that the PCB contamination is not spreading outside the area into its surroundings. The samples of topsoil TS-E, TS-SE, TS-WEST1 and TS-WEST2 were collected in the prevalent wind direction. All the analytical results were below the detection limit of the used analytical method.

Another way of contamination migration outside INCEL area is through the rainwater wash-off and trough the sewer system present at the site. This was confirmed by the increased concentrations of PCBs in the sediment at the outlet from sewers (sample SED-CH) and in Vrbas river's sediment collected downstream, near this outlet (sample SED-DOWN). The environmental risk of spreading the contaminants through the rainwater sewage system is summarized in section 5.2.1 of Deliverable 2 – Site Assessment Report.

The pollution can also infiltrate with the rainwater into groundwater and can be potentially transported through the groundwater into the Vrbas river. The higher contamination of groundwater by PCB inside the INCEL area was confirmed in four groundwater samples S19, S15, P1 and S29 (Annex 1). Three samples are situated in Lukić Invest hotspot (former power plant) and one sample is situated in Univerzum AD hotspot. The environmental risk of spreading contaminants through groundwater is summarized in detail in section 5.2.2 of Deliverable 2 – Site Assessment Report.

Floods may also contribute to the migration of pollution at INCEL. The floods are well documented in the INCEL area, and can significantly accelerate the mobility of contaminants.

3.6 Summary of human health risk assessment and environmental risk assessment

3.6.1 Summary of human health risk assessment

The sites in INCEL area where PCB-contamination (in soil and/or construction materials) was found, can be, for the purposes of the risk assessment, divided into isolated contaminated sites characterized in Table 14.

Table 14: Basic characteristic of the assessed contaminated sites in INCEL area

Potential hotspot No.	Hotspot or group of hotspots	Activities	Employees, visitors	Future activities
1	Univerzum a.d.	Truck repair, scrap metal and other secondary raw materials storage and selling	Up to 10 employees and up to 10 visitors daily	Development of the area is not likely
3 5 17	Lukić Invest (former power plant); BZ (electrolysis) BZ (north)	Abandoned area, ruins of old buildings and installations	Trespassing to gain valuable materials	Expected substantial reconstruction of the sites, employment of >100 people
4	SHP CELEX (concrete platform)	External storage area (currently not used), abandoned green area	Max. 1 employee who visits the site once per a week, no visitors	Expected development of the area (building of a warehouse) and employment up to 100 persons

Potential hotspot No.	Hotspot or group of hotspots	Activities	Employees, visitors	Future activities
7	Top Metal d.o.o.	Parking trucks and storing equipment at a paved area	1 employee who visits the site once per a week, no visitors	No information is available
12	Business zone (in front of BC Metal)	Green area, in its vicinity recycling of batteries, work-rooms, storages, ironmongery	Up to 100 employees (mostly men) and up to 100 daily visitors in the surrounding areas	Development of the area is likely, altogether > 100 employees in the area and its surroundings

Using the results of the field investigation within the Site Assessment and with the use of historical works and studies, the realistic exposure scenarios for the PCB sites in the INCEL area were proposed (Table 15).

Table 15: Relevant exposure scenarios assumed for the INCEL area and its surroundings

No.	Exposure scenario
1a	Dermal contact of the current employees working at contaminated sites with the contaminated surface soil and construction materials.
1b	Dermal contact of the future employees working at contaminated sites with the contaminated surface soil and construction materials.
2a	Accidental ingestion of soil and dust from surface soil and construction materials by the current employees working at contaminated sites.
2b	Accidental ingestion of soil and dust from surface soil and construction materials by the future employees working at contaminated sites.
3a	Inhalation of contaminated ambient air by the current visitors and employees working at contaminated sites due to the dust particles spreading from the contaminated surface soil and construction materials.
3b	Inhalation of contaminated ambient air by the future visitors and employees working at contaminated sites due to the dust particles spreading from the contaminated surface soil and construction materials.
3c	Inhalation of contaminated ambient air by the current visitors and employees working at non-contaminated sites due to the dust particles spreading from the contaminated surface soil and construction materials from the contaminated sites in INCEL area.
4	Aquatic ecosystem of Vrbas river affected by the surface water run-off from INCEL industrial area through the existing drainage system.
5	Terrestrial ecosystem inside the INCEL industrial area and bio-accumulation of PCBs in the terrestrial food chain.
6	Dermal contact of trespassers and construction workers with the contaminated construction materials and soil during demolition, rebuild and excavation works.
7	Accidental ingestion of dust from the contaminated construction materials and soil during demolition, rebuild and excavation works by the trespassers and construction workers.
8	Inhalation of contaminated air by trespassers and construction workers due to the dust particles spreading from the contaminated construction materials and soil during demolition, rebuild and excavation works.
9	Aquatic ecosystem of Vrbas rivers affected by the contaminated groundwater drained into surface water.

For the scenarios summarized in Table 15, health risks were assessed according to the US EPA methodology. The outcomes of the risk assessment can be summarized as follows:

- Even for the maximum concentrations of total PCBs in surface soil (or in the construction materials), the unacceptable levels of health risks, i.e. HQ ≤ 1 and ELCR ≤ 1.0×10^{-5} (for a group of up to 100 individuals), related to the **current use of the contaminated sites** were **not breached**. Thus, current visitors and employees at the contaminated sites are not in an immediate health risk from the present PCB contamination. However, the significance of health risks will increase with the increasing number of people occurring at the contaminated sites and their surroundings.
- The assessment also confirmed that current (and also future) visitors and employees working at the **non-contaminated sites** within INCEL area are **not subject to unacceptable health risks** connected to inhalation of contaminated soil particles and dust originating from the contaminated sites.
- Without any substantial remedial action, the future use (for industrial purposes) of the contaminated sites No. 3, 5, 17 and 12 leads to an **unacceptable carcinogenic risk** (ELCR > 1×10^{-6} for a group of more than 100 exposed persons) for the **future employees**, who will get into contact on regular long-term basis with the contaminated soil and/or dust from the contaminated construction materials **at the redeveloped sites**. To reduce these health risks, application of risk reduction measures is required. Since the assessment of the health risks for the future use of the sites is connected with the high level of uncertainty – how many people will be present at the sites after their redevelopment, a conservative approach towards mitigation of health risks at the sites No. 4 and 7 was used. Therefore, **performing a remedial action** at these sites is also **recommended**.
- Works leading to **redevelopment of the contaminated sites** (i.e. demolition, remedial or excavation works) are connected with the **significant non-carcinogenic health risks to workers**, who will get into contact with the contaminated materials. These results confirm necessity of using protective equipment and secured regime of work during any excavation work or remedial work at the contaminated sites.

The following Table 16 summarizes in detail outcomes of the health risk assessment, i.e. carcinogenic and non-carcinogenic health risks associated with the assumed exposure scenarios for both current and future use of the contaminated sites in INCEL area, as well as for the phase of their redevelopment.

Table 16: Summary of the health risks connected with the assumed exposure scenarios

No.	Exposure scenario	Confirmed health risk at the contaminated sites: (1) Univerzum	(3) Lukić Invest (5) BZ - Electrolyis, (17) BZ (north)	(4) SHP CELEX	(7) Top Metal	(12) BZ (in front of BC Metal)
1a	Dermal contact of the current employees working at contaminated sites with the contaminated surface soil and construction materials.	No	No	No	No	No
2a	Accidental ingestion of soil and dust from surface soil and construction materials by the current employees working at contaminated sites.	No	No	No	No	No
3a	Inhalation of contaminated ambient air by the current visitors and employees working at contaminated sites due to the dust particles spreading from the contaminated surface soil and construction materials.	No	No	No	No	No
1b	Dermal contact of the future employees working at contaminated sites with the contaminated surface soil and construction materials.	YES	**YES**	YES	YES	**YES**
2b	Accidental ingestion of soil and dust from surface soil and construction materials by the future employees working at contaminated sites.	YES	**YES**	YES	YES	**YES**
3b	Inhalation of contaminated ambient air by the future employees and visitors due to the dust particles spreading from the contaminated soil and construction materials.	No	No	No	No	No
3c	Inhalation of contaminated ambient air by the current visitors and employees working at non-contaminated sites due to the dust particles spreading from the contaminated surface soil and construction materials from the contaminated sites in INCEL area.	No	No	No	No	No
6	Dermal contact of trespassers and construction workers with the contaminated construction materials and soil during demolition, rebuild and excavation works.	**YES**	No	No	No	No
7	Accidental ingestion of dust from the contaminated construction materials and soil during demolition, rebuild and excavation works by the trespassers and construction workers.	**YES**	YES	No	YES	**YES**
8	Inhalation of contaminated air by trespassers and construction workers due to the dust particles spreading from the contaminated construction materials and soil during demolition, rebuild and excavation works.	No	No	No	No	No

YES *– confirmed health risk for the assessed exposure scenario*

YES – health risks connected with the assessed exposure scenario cannot be completely excluded due to high level of uncertainty

3.6.2 *Summary of environmental risk assessment*

In addition to human health risks, the potential environmental risks caused by contamination of the INCEL site were also assessed. Within the exposure scenarios that were evaluated as part of the investigation at the INCEL site, there are three scenarios from which potential environmental risks arise. The following Table 17 shows these scenarios.

Table 17: Exposure scenarios representing potential environmental risk

Scenario No.	Exposure pathway / scenario
5	Terrestrial ecosystem inside the INCEL industrial area and bio-accumulation of PCBs in the terrestrial food chain.
4	Aquatic ecosystem of Vrbas river affected by the surface water run-off from INCEL industrial area.
9	Aquatic ecosystem of Vrbas rivers affected by the contaminated groundwater drained into surface water.

Scenario No. 5: Terrestrial ecosystem inside the INCEL industrial area and bio-accumulation of PCBs in the terrestrial food chain

From the point of view of the maximum concentrations in topsoil exceeding the allowed environmental limits, it is evident that the real environmental risk is contamination with PCBs. Other contaminants do not exceed the allowed limit to the same extent as PCBs. Due to the very high toxicity of PCBs to live organism generally with long-lasting effects and the fact that INCEL area is well accessible to small animals such as rodents (the site is not well fenced) the risk of PCBs entering the animal food chain cannot be excluded. However, since no input data for this scenario was available and was not the subject of field work performed (e.g. animal tissues sampling at single hotspot sites), the environmental risks posed by PCBs cannot be quantitatively assessed. If the contaminated topsoil identified in the individual potential hotspots are not removed, there is a risk of long-term bioaccumulation of PCBs in small animals and thus biomagnification of PCBs throughout the food chains.

Scenario No. 4: Aquatic ecosystem of Vrbas river affected by the surface water run-off from INCEL industrial area

Aquatic ecosystems of Vrbas river might be affected by the wash out of contaminated soil particles from the hot-spots in INCEL area. Rainwater run-off is led by the rainwater drainage and trough the unified sewer system into the Vrbas river. Contamination accumulates in river sediment and may affect in first time benthic organisms, secondly fish and other higher organisms trough accumulation in the food chain.

The results described in Deliverable 2 – Site Assessment Report (22) confirm that the concentrations of contaminants in sediments in the Vrbas river near the outlet of the sewage system which drains the INCEL area exceed the target value for priority contaminants - PCB and Petroleum hydrocarbons (C10-C40). The target value is the limit value for the concentration of pollutant in the river sediment, below which the negative impacts on the environment are negligible and it represents a long-term goal of sediment quality. Therefore, it can be stated that the environmental risks of spreading contaminants through the rainwater sewage system have been confirmed. If the source of contamination in the hotspots of the INCEL area is not removed, accumulation of contaminants in the sediments and thus a subsequent bioaccumulation in the organisms of the river ecosystem will continue.

At the same time, it is evident, that flood events, which are documented in the given area, might significantly accelerate the mobility of contaminants and contribute to the environmental risks connected with the hotspots.

Scenario No. 9: Aquatic ecosystem of Vrbas rivers affected by the contaminated groundwater drained into surface water

The pollution can also infiltrate with the rainwater into groundwater and be transported through the groundwater into the rivers. The analytical results of the monitored contaminants in the groundwater in the Incel area confirmed the presence of PCB in four monitoring wells. These are mainly located at the hotspot of the former power plant (Lukić Invest) and the Univerzum hotspot. According to the previous sections, which describe the hydrogeological conditions at the site, the spread of the contaminants in the direction of groundwater flow towards the Vrbas river is not excluded. As it is in detail evaluated in the Site Assessment Report (22), the current environmental risk of spreading contaminants through groundwater is very low, but in case of potential long-term releasing of the contaminant into groundwater, the situation could change.

3.7 Recommendation of remediation target limits

In order to reduce the human health risks to an acceptable level it is necessary to clean-up the contaminated topsoil to an acceptable residual concentration, which does not cause any adverse effects in terms of long-term exposure of the personnel working in the subject area. Such level of concentration is called the "remediation target limit" and is determined from the riskiest exposure scenario, i.e. future usage of the contaminated areas without any remedial activities.

By means of back-calculation (in detail described in the Site Assessment report (22) the remediation target limit for the total PCBs in the topsoil (0 – 20 cm b.t.) and for construction materials was determined.

Topsoil in a depth 0 – 0.2 m below the terrain and construction materials: **Cs ∑ PCB: 3 mg/kg d.m.**

The following remediation target limit should be applied for the clean-up and redevelopment of the contaminated sites in INCEL area:

- (No. 3) Lukić Invest (former power plant)
- (No. 12) Business zone (in front of BC Metal)
- (No. 5) Business zone (Electrolysis)
- (No. 17) Business zone (north)
- (No. 7) TOP Metal
- (No. 1) Univerzum AD
- (No. 4) SHP CELEX (concrete platform)

4 REMEDIAL OBJECTIVES

The biggest concern associated with soil contamination is the harm it can cause to human health and the surrounding environment. There are significant health risks involved with direct contact with contaminated soil, the vapours from the contaminants and even secondary contamination of water supplies. For these reasons, treating contaminated soil is extremely important to avoid potential risks caused by the contaminants.

In general, soil contamination has been handled by abandoning of contaminated soil and/or restricting the use of contaminated site, capping or encapsulating the soil in situ with water-resistant material and covering with a layer of clean topsoil, excavating the contaminated soil and disposing of it at a hazardous waste landfill or treating the contaminated soil using insitu or exsitu methods.

The choice of the general remedial approach, however, depends on several factors that include the current and future site use and the use of the site surroundings, soil type, soil composition physical properties of soil, contaminant nature, feasibility of contaminant isolation, handling intensity, cost and etc.

It is important to mention that implementing remedial measures involves several risks that must be considered and appropriately eliminated before starting the remedial measures. These risks include, for instance, improper excavation of contaminated unsaturated zone and non-responsible handling the contaminated soil that may cause spreading out the contamination and eventually uncontrolled washing out of contaminants into the surrounding environment and, also, excessive production of dust particles causing transport of contamination out of the remediation area. For this reason, remediation works should be implemented by dully licensed and experienced experts.

In INCEL, the main contaminant of concern is PCBs. The soil contamination at the mentioned hotspots is exceeding the limits for human carcinogenic and non-carcinogenic health risks for people working on these hotspots. This was confirmed after the evaluation of the results of the site investigation.

In addition to the human health risks, environmental risks have been confirmed and supported by the general high environmental hazards of PCBs resulting from their high toxicity, persistency and bioaccumulation potential. To eliminate and/or to reduce to acceptable levels the aforementioned human health risks and the environmental risks, it is necessary to carry out the necessary remedial measures at the contaminated sites/hotspots.

Since the identified contaminated hotspots are situated within the open industrial area of INCEL, where the local workers at these hotspots are at risk upon contact with the contaminated building structures and/or surface soil and/or concrete, the remedial measures are divided into short-term (urgent) measures that focused on immediate preventing the local workers from exposure to the contaminated soil and material and long-term remedial measures that focused on permanent elimination of the human health risks caused by the contaminated materials.

The next sections preliminarily describe the proposed remedial measures, including the technical, temporal and financial scope of these measures. The final design of the measures shall be developed in detail as the exact amount of contaminated topsoil and construction materials to be remediated/excavated are established by a detailed sampling prior starting the implementation of the long-term remedial measures.

5 SHORT-TERM REMEDIAL MEASURES

Short-term remedial measures are designed to immediately prevent contact of local employees, visitors and trespassers moving at the contaminated sites (hotspots) with contaminated soil and/or construction materials. The aim of the short-term remedial measures is minimizing the human health risks until long-term and permanent remedial measures are implemented (which includes development of project documentation, its approval by relevant state authorities and ensuring funding sources, etc.). Since no immediate unacceptable health risks were identified with connection of the current use of the contaminated sites, the proposed measures, based on the precautionary principle, should lead to minimizing the health risk for the current employees, visitors and trespassers at a minimum level. These measures will become more important if the number of people occurring at the contaminated sites and their surroundings would increase.

The short-term remedial measures include:

- Informing the local employees about the potential risks connected with the existing PCB contamination at the identified hotspots. The information campaign should include training of employees that will carry out works at these hotspots on the possible risks reduction measures and usage of personal protective equipment (PPEs).
- Areas having the PCB contamination of topsoil above the remediation target limit value 3 mg/kg d.m. (see Annex 3) should be marked out or fenced. Extensive earthworks at these sites should be stopped until long-term remediation measures are carried out. Warning signs informing about the health hazard should be placed at the entrance into these areas. Other activities should be limited to a minimum at the contaminated sites to minimize exposure to contaminated soil and dust at these sites.
- Any entry into the following buildings where PCBs contamination of construction materials were confirmed (Lukić Invest - former power plant and Business zone – Electrolysis, see Annex 1) may be permitted only with the following PPEs:
  - Respirator;
  - Protective overall;
  - Protective footwear;
  - Protective gloves.

6 LONG-TERM REMEDIAL MEASURES

6.1 Summary of volume of soil and construction materials to be remediated

Investigation works and subsequent risk assessment identified significant potential risks to human health for the employees working at the contaminated areas (7 hotspots) and buildings.. Topsoil and/or construction materials present at 7 hotspots listed below are contaminated, to the certain extent and above the limits, with polychlorinated biphenyls (PCBs):

- (No. 3) Lukić Invest (former power plant)
- (No. 12) Business zone (in front of BC Metal)
- (No. 5) Business zone (Electrolysis)
- (No. 17) Business zone (north)
- (No. 7) TOP Metal
- (No. 1) Univerzum AD
- (No. 4) SHP CELEX (concrete platform)

The amount of topsoil and construction materials exceeding the level of the remediation target limit has been roughly estimated based on the investigation in the range of 600 – 1,000 m^3 (i.e. 1,100 – 1,800 tons). This volume does not include contaminated concrete platform at SHP CELEX for which an individual remediation method is proposed.

More detailed specification of contaminated areas and volume of contaminated topsoil (0-20 cm b.g.l.) per each hotspot is summarized in Table 18 below.

Exact amount of topsoil and construction materials to be remediated/excavated shall be established by a detailed pre-remedial monitoring, i.e. sampling prior starting the long-term remedial measures (section 7.2 on page 49) or during the remedial measures. Areas proposed for the remediation are visually depicted in Annex 3.

Table 18: Hotspots and areas proposed for the remediation

Hotspot	No.	Area of soil contaminated in the range between screening level (0.94 mg/kg of PCBs) and remediation target limit (3 mg/kg of PCBs) (m^2)	Area of soil contaminated above remediation target limit (3 mg/kg of PCBs)	Volume of soil contaminated above remediation target limit (m^3) **	Tonnage of soil contaminated above remediation target limit (t)*	Area of concrete contaminated above remediation target limit (3 mg/kg of PCBs - m^2)	Volume of concrete contaminated above remediation target limit (m^3)	Tonnage of concrete contaminated above remediation target limit (t)*
Lukić Invest (former power plant)***	3	1,800 - 3,300	1,100 - 2,000****	220 - 400	400 - 720	6 – 10	2 - 4	5 - 10
BZ in front of BC Metal	12	-	400 - 750	80 - 150	150 - 270			
BZ Electrolysis	5	-	150 - 250	30 - 50	50 - 90	6 - 10	2 - 4	5 - 10
BZ North	17	-	600 - 1,100	120 - 220	220 - 400			
Top Metal	7	-	50 - 100	10 - 20	20 - 40			
Univerzum AD	1	-	250 - 500	50 - 100	90 - 180			
SHP CELEX**	4	-	850 - 1,600	45 - 80	80 - 150	3,500 – 6,500***	Not relevant**	Not relevant**
Total		**1,800 - 3,400**	**3,400 - 6,200**	**600 - 1,000**	**1,100 – 1,800**	**3,500 – 6,500*** **	**4 - 8**	**10 - 20**

Notes:

**) Expected density for soil 1.8 g/cm3 and construction materials 2.2 g/cm3 was used.*

***) Thickness of contaminated topsoil 20 cm has been applied. Only one exception is SHP CELEX hotspot where thickness 5 cm of soil laying on concrete panels was used.*

****) Topsoil from Lukić Invest hotspot contains mainly demolition debris.*

*****) Area proposed for remediation within Lukić Invest hotspot include, besides the specific sub-areas with elevated contamination above remediation target limit confirmed by this investigation, also the sub-areas (mainly grass strip south of the building) where content of PCBs was close to remediation target limit, but previous investigations found significant PCBs contamination there.*

******) PCB contamination at hotspots "SHP CELEX" represents only surface part of concrete panels. It should be also noted that the total area is an estimation only, based on a limited amount of samples (1 composite sample of 4 locations). More detailed sampling (e.g. 5m grid for concrete area at SHP CELEX) should be carried out for remediation design.*

6.2 Proposal of remediation of large concrete platform at SHP CELEX hotspot

For large surfaces of "SHP CELEX" formed from relatively solid concrete it is assumed that contamination can be easily removed by proper sweeping and mechanical brushing.

Due to a relatively low content of PCB, there is no need to demolish and dispose of these concrete structures.

However, the following minimum technical requirements must be met:

- The final sampling of the concrete structures (desk, floor, platform) must confirm PCB concentration under the risk level.
- The adequate PPEs will be used by the workers during the implementation of the remedial measures: respirator, protective clothing covering the whole body, protective footwear and protective gloves.
- If it is not possible to reduce the PCB contamination level in concrete structures below the recommended remediation limit, the concrete structures where the PCB contamination risk is present should be removed and disposed of as hazardous waste in a suitable external facility for the disposal of hazardous waste (see details below).

Expected costs of remedial measures at "SHP CELEX" hotspot" are in the range of 10,000 – 20,000 EUR.

6.3 Identification of promising technologies for soil/construction materials remediation

Identification of promising technologies or remedial options was focused on selection of a feasible method(s) for clean-up of PCBs contaminated topsoil and construction materials to ensure that the remedial target limits are met.

The following remedial options were identified and used for further screening and evaluation.

Ex situ and off site treatment/disposal

- **Option 1: Excavation and disposal of contaminated soil and construction materials to a HW landfill or waste pre-treatment facility prior its disposal to a HW/non-HW landfill in Bosnia and Herzegovina**

This option includes excavation of contaminated topsoil and construction materials (at the areas where contamination above remediation target limit will be proved by detailed pre-remedial monitoring) and further disposal of at HW landfill (alternative No. 1) or waste pre-treatment facility (alternative No. 2) where content of contaminants (PCBs) will be reduced or stabilized to achieve the requirements for waste disposal to HW/or non-HW landfill in Bosnia and Herzegovina. Possible treatment methods are sieving to separate construction materials and soil and subsequent bioremediation, co-composing, thermal desorption, solidification/stabilization, chemical oxidation, etc. of the soil. The separated not-contaminated construction materials will be disposed of at a non-HW landfill in Bosnia and Herzegovina.

- **Option 2: Excavation and disposal of contaminated soil and construction materials to a HW landfill or waste pre-treatment facility prior its disposal to a HW/non-HW landfill abroad**

This option includes excavation of contaminated topsoil and construction materials (at the areas where contamination above remediation target limit will be proved by detailed pre-remedial monitoring), transboundary transportation and further disposal of at HW landfill (alternative No. 1) or waste pre-treatment facility (alternative No. 2) where content of contaminants (PCBs) will be reduced or stabilized. Possible treatment methods are sieving to separate construction materials and soil and subsequent bioremediation, co-composing, thermal desorption, solidification/stabilization, chemical oxidation, etc. of the soil. The separated construction materials are disposed of at a HW/or non-HW landfill.

- **Option 3: Excavation of contaminated soil and construction materials and thermal treatment of the contaminated soil in an incineration plant or thermal desorption plant abroad**

This option includes excavation of contaminated topsoil and construction materials (at the areas where contamination above remediation target limit will be proved by detailed pre-remedial monitoring). The excavated topsoil and construction materials will be separated on-sites. The contaminated soil and crushed contaminated materials will be transported abroad for thermal treatment. The separated not-contaminated construction materials will be disposed of at a non-HW landfill in Bosnia and Herzegovina.

Ex situ and on site treatment/containment:

- **Option 4: Construction of a temporary landfill within INCEL area with the capacity approx. 1,000 m^3 and excavation/containment in capped depot(s) for contaminated soil and construction materials on site.**

This option includes construction of a temporary landfill within INCEL area with the capacity approx. 1000 m^3. Contaminated topsoil and construction materials with the content of PCBs above remediation target limit will be excavated and disposed of at this landfill. Landfill closure will be completed by a proper capping with the insulation layer (HDPE 1 mm is proposed as minimum) to prevent leaching of contaminants by rainwater, spreading of contaminants by wind and to prevent human or animal contact with the contaminated materials.

- **Option 5: Excavation and disposal of contaminated soil and construction materials in a thermal desorption plant which will be installed on-site**

This option includes import and installation of thermal desorption unit within the INCEL area. Contaminated topsoil and construction materials with the content of PCBs above remediation target limit will be excavated and treated by thermal desorption technology on site. Construction materials (predominantly concrete) will be crushed before processing. Thermal desorption allows separation of PCBs from the soil and the concrete matrix. Treated soil can be further used for backfilling.

6.4 Screening of remedial options

6.4.1 Screening criteria

Multi-criteria screening of selected applicable remediation technologies/options has been performed using the following criteria:

- Protection of human health and the environment;

- Efficiency;
- Long-term effectiveness;
- Compliance with the current environmental laws and regulations;
- Implementability;
- Time;
- Cost.

The above-mentioned criteria have been used for screening of applicable options for the remediation (disposal of) topsoil and construction materials contaminated above remediation target limits.

Each of these evaluation criteria is described below.

Protection of human health and the environment

This evaluation criterion provides a final check to assess whether each alternative provide adequate protection of human health and the environment.

Efficiency

Consideration of efficiency focuses on the degree of reliability of the remediation/treatment process that can be expected for the specific types of hazardous waste and the physical condition at the site. Other considerations are the likelihood of meeting the remedial target limits and the possible risks generated during implementation.

Long-term effectiveness

The evaluation of effectiveness includes the potential risks remaining at the site after remedial measures are completed. Long-term effectiveness is evaluated according to (1) magnitude of residual risk remaining at the site after implementation of the remedial measures and (2) the adequacy and reliability of remedial controls.

Compliance with environmental legislation

The assessment of this criterion describes how the remediation options complies with the current environmental legislation or if a waiver is required and how it is justified.

Implementability

Implementability encompasses the technical and administrative aspects for implementing a remedial technology. Factors in considering implementability include the availability of the hazardous waste treatment facilities in BaH, equipment and labour required for the proposed remedial technologies.

Time

This criterion includes expected time framework required for the completion of remedial option, incl. design, preparatory and implementing phases. Nevertheless, permits issuance procedures are not included in the estimated range of months.

Cost

The cost estimates were prepared as the part of the overall evaluation of remedial options. The estimates were based on information available at the time of Remedial Assessment report completion and on contraction assumptions that are reasonable for the state of the practice in BaH and other EU countries where hazardous waste can be disposed of.

The availability and cost of remedial services is expected to change, so these cost estimates should be refined in further stages of project designing or as new information becomes available.

Final project costs will depend on actual labour and material costs, the capabilities of local contractors, the amount of imported equipment and labour, actual site conditions, productivity, actual health and safety requirements, competitive market conditions, final project scope, final project schedule, the firm selected for final engineering design and other factors.

6.4.2 Screening summary

On the basis of screening assessments three remedial options were selected as the most recommended options for remediation of contaminated areas at INCEL. These three remedial options are listed below and are sorted in descending order of priority:

- Option 1: Excavation and disposal of contaminated soil and construction materials to HW landfill or waste pre-treatment facility prior its disposal to HW/non-HW landfill in Bosnia and Herzegovina
- Option 2: Excavation and disposal of contaminated soil and construction materials to HW landfill or waste pre-treatment facility prior its disposal to HW/non-HW landfill abroad
- Option 4: Construction of a temporary landfill within INCEL area with the capacity approx. 1000 m^3 and excavation, containment in capped depot(s) for contaminated soil and construction materials on-site.

As a final remedial solution, the options No. 1 and No. 2 are recommended. These options propose disposal of contaminated soil and construction materials in a secured hazardous waste landfill or waste pre-treatment facility (such as bioremediation, solidification/stabilization, chemical oxidation, etc.) prior its disposal to HW/non-HW landfill.

Expected costs of remedial measures leading to risk elimination connected with contaminated topsoil and contaminated materials landfilling or pre-treatment and are in the range of 350 – 550 thousand EUR (in case the waste disposal within BaH) or 550 – 850 thousand EUR (in case the waste will be transported abroad).

Note: In case limit value 1 mg/kg of PCBs will be applied (new legislation in process), volume of soil may be approx. 1.5 times higher and expected costs for soil disposal 525 – 875 thousand EUR (in case waste disposal within BaH), or 825 – 1,315 thousand EUR (in case waste will be transported abroad).

Remedial option No. 4 has been included with regard to the situation that the funds needed for the final remediation of the INCEL site shall not be available and therefore reduction of human health and environmental risks shall be achieved by this temporary solution.

The contaminated soil/construction materials can be deposited in a secured temporary landfill constructed within INCEL area where contaminated soil and construction materials will be capped in order to prevent washing out of contamination by rainfall into the surrounding environment.

The selected technologies are favoured because of advantages in efficiency, implementability, cost, or a combination of features. The reasons for using the remedial technologies in the overall alternatives are presented in the Table 19 below.

Options No. 3 and No. 5 are not recommended due to higher cost estimates and the fact that in all topsoil samples the concentration of PCBs is below 50 mg/kg, so according to the EC Regulation 2019/1021 of 20th June 2019 on persistent organic pollutants there is no need for thermal disposal of the waste (i.e. in a HW incinerator or by thermal desorption technology).

The results of technology screening are not intended to eliminate or preclude consideration of other remedial technologies during future stages of remedial study or design. The screening is intended to show the rationale for technology selection at this point of completion of Remediation Assessment report. As new information will become available, other remedial technologies may become favourable, warranting changes to the remedial alternatives.

Table 19: Remedial technologies overview

No.	Remedial option	Protection of human health and the environment	Efficiency	Long-term effectiveness	Compliance with environmental legislation	Implementability	Time	Cost
1	Excavation and disposal of contaminated soil and construction materials to a HW landfill or waste pre-treatment facility prior its disposal to a HW/non-HW landfill in Bosnia and Herzegovina	Very good	Very good	Very good	Limited, no detailed legislation for HW characterization in terms of leaching limits, exclusion of HW properties after waste treatment	Limited, no existing HW landfill in BaH now	6-12 months (not incl. HW landfill construction)	250 - 400 €/ton; in total 350 – 550 thousand €
2	Excavation and disposal of contaminated soil and construction materials to a HW landfill or waste pre-treatment facility prior its disposal to a HW/non-HW landfill abroad	Very good	Medium, transportation over long distances	Very good	Limited, legislative permits for waste cross-border transporting required	Good	6-12 months	400 - 600 €/ton; in total 550 – 850 thousand €
3	Excavation of contaminated soil and construction materials and thermal treatment in incineration plant or thermal desorption plant abroad	Very good	Low, transportation over long distances and low content of PCBs to be treated	Very good	Limited, legislative permits for waste cross-border transporting required	Good	6 – 12 months	1,000 - 1,600 €/ton; in total 1,400 – 2,200 thousand €
4	Construction of a temporary landfill within INCEL area with the capacity approx. 1,000 m^3 and excavation/ containment in capped depot(s) for contaminated soil and construction materials on site	Good	Good	Low, temporary solution	Limited, Environmental and Waste management permits of site owner required	Medium	15 – 25 months	in total 150 – 300 thousand €
5	Excavation and disposal of contaminated soil and construction materials in a thermal desorption plant which will be installed on-site	Limited, effective monitoring of ambient is required	Medium, low content of PCBs to be treated	Very good	Operating and legislative permits required (EIA?)	Medium	12 – 24 months	570 - 850 €/ton; in total 800 – 1,200 thousand €

6.5 Other requirements related to long-term corrective measures for elimination of environmental risks

The environmental risks of spreading contaminants through the rainwater sewage system have been confirmed. At the same time, the flood events might significantly accelerate the mobility of contaminants and contribute to the environmental risks connected with the existing hotspots.

The following corrective measures are proposed to eliminate the environmental risks of spreading contaminants through the rainwater sewage:

- Removal of contaminated topsoil and construction materials that occur in individual hotspots where health risks have been confirmed (Annex 3).
- Revision and cleaning of the sewage system, which drains rainwater from the INCEL area. In case that waste (soil, construction materials, wastewater) is generated during cleaning, the disposal of this waste must be done according to the valid legislation. It is currently not possible to quantify the scope and costs of this measure, as the revision of sewage system has not been carried out.
- Wastewater from the INCEL area should be treated at a waste water treatment plant (WWTP), the newly reconstructed areas within the area should be equipped with a separated sewer system from sanitary wastewater and rainwater.
- Introduction of a management system that will regularly control wastewater discharge from individual operations in the INCEL area.

Corrective measures to eliminate the environmental risks of spreading contaminants through the rainwater sewage system make an integrated part of the long-term corrective measures and must be part of the operational management of the INCEL industrial area. These corrective measures are therefore not part of the proposal for remedial measures to eliminate the urgent human health risks identified by the risk assessment.

The environmental risk of spreading contaminants through groundwater was not confirmed within the current state of the site, but cannot be excluded in case of potential long-term releasing of the contaminant into groundwater.

In case of any future plans for use of groundwater for drinking water or service water supply it is recommended to assess the health risks of using groundwater is such a way. At the same time, it is highly recommended to design a network of monitoring wells for regular monitoring of groundwater quality.

7 MONITORING ACTIVITIES

7.1 Groundwater monitoring

Investigation works performed in INCEL industrial area and its vicinity did not show groundwater contamination by PCBs, except in 3 wells within “Lukić Invest (former power plant)” and + one well within “Univerzum AD” hotspots.

However, due to planned remedial measures at the site, contamination may be released during the excavation work and may be washed out into groundwater. It is therefore recommended to carry out monitoring program of groundwater focused on PCBs contamination in existing and newly constructed hydrogeological wells or piezometers in the following extent:

- Before commencement of remedial measures, during remedial measures and 2 years after completion of remedial measures to monitor twice a year the quality of groundwater at the area of hotspots proposed for remediation and in the direction of groundwater flow from these hotpots.
- It is recommended to monitor PCBs and also Total Petroleum Hydrocarbons (TPHs) as the parameter relevant to transformer oils.

7.2 Soil and construction materials monitoring

Before the commencement of the remedial works a detailed pre-remedial monitoring of topsoil and construction materials contamination shall be carried out in order to exact delineate the areas for excavation/demolition and minimize the volume of waste to be disposed of and in a consequence also total costs of remediation.

It is recommended to collect topsoil and construction materials samples from marked sub-areas of each hotspot (see Annex 3) in a grid of 5 x 5m and analysed them in accredited laboratory for the following parameters:

- PCBs (all samples);
- TPHs (when visual or organoleptic pollution will be observed);
- TOC (2-3 composite samples per hotspot);
- Analyses of heavy metals, DOC and pH water leachate (2-3 composite samples per hotspot);
- Ecotoxicity or other parameters required by HW disposal facility (on request).

8 CONCLUSION

Remediation target limit for the clean-up and redevelopment of the contaminated sites in INCEL was calculated by means of back-calculation **for topsoil soil (soil in a depth 0-20 cm b.t.) and for construction materials at the level of ∑ PCB: 3 mg/kg d.m.**

Topsoil and/or the construction materials at 7 following hotspots are contaminated above the remediation target limit of polychlorinated biphenyls (PCBs):

- (No. 3) Lukić Invest (former power plant)
- (No. 12) Business zone (in front of BC Metal)
- (No. 5) Business zone (Electrolysis)
- (No. 17) Business zone (north)
- (No. 7) TOP Metal
- (No. 1) Univerzum AD
- (No. 4) SHP CELEX (concrete platform)

The remedial measures have been divided into:

- **short-term (preventive) measures** focused on preventing the local workers and visitors from exposure to the contaminated material, and

- **long-term remedial measures** focused on permanent elimination of the unacceptable human health and environmental risks caused by the contaminated materials.

Short-term remedial measures are designed to immediately prevent contact of local employees, visitors and also trespassers moving at the contaminated sites with contaminated soil and/or construction materials. The aim of the short-term remedial measures is minimizing the human health risks until long-term and permanent remedial measures are implemented. **The short-term remedial measures include**:

- Informing of the local employees about the potential risks connected with the existing PCB contamination.
- Marking out or fencing of the areas having the PCB contamination of topsoil above the remediation target limit value 3 mg/kg d.m. and restrictions for the future use of these sites until long-term remediation measures are carried out.
- Recommendations for the use of PPEs for entry into the buildings where PCBs contamination of construction materials were confirmed (Lukić Invest – former power plant and Business zone - Electrolysis).

The amount of topsoil and construction materials exceeding the level of the remediation target limit has been roughly estimated on the basis of the investigation in the range of 600 – 1,000 m^3 (i.e. 1,100 – 1,800 tons). This volume does not include contaminated concrete platform at SHP CELEX for which an individual remediation method is proposed. The exact amount of topsoil and construction materials to be remediated/excavated shall be verified by a detailed pre-remedial monitoring, i.e. sampling prior starting the long-term remedial measures.

Selected 5 feasible remedial technologies or remedial options leading to reduction of the human health and environmental risks to acceptable level have been proposed and evaluated:

- (No. 1) Excavation and disposal of contaminated soil and construction materials to a HW landfill or waste pre-treatment facility prior its disposal to a HW/non-HW landfill in Bosnia and Herzegovina.
- (No. 2) Excavation and disposal of contaminated soil and construction materials to a HW landfill or waste pre-treatment facility prior its disposal to a HW/non-HW landfill abroad.
- (No. 3) Excavation of contaminated soil and construction materials and thermal treatment in incineration plant or thermal desorption plant abroad
- (No. 4) Construction of a temporary landfill within INCEL area with the capacity approx. 1,000 m^3 and excavation/containment in capped depot(s) for contaminated soil and construction materials on site.
- (No. 5) Excavation and disposal of contaminated soil and construction materials in a thermal desorption plant which will be installed on-site.

Multi-criteria screening of 5 selected applicable remediation technologies/options has been performed using the following criteria: protection of human health and the environment, efficiency, long-term effectiveness, compliance with the current environmental laws and regulations, implementability and cost.

As a final remedial solution, the options No. 1 and No. 2 were selected as the most recommended options. These options propose disposal of contaminated soil and construction materials in a secured hazardous waste landfill or waste pre-treatment facility (such as bioremediation, solidification/stabilization, etc.) prior its disposal to HW/non-HW landfill. Expected costs of remedial measures leading to risk elimination connected with contaminated topsoil landfilling or pre-treatment and are in the range of 350 – 550 thousand EUR (in case waste disposal within BiH) or 550 – 850 thousand EUR (in case waste will be transported abroad).

Alternatively, the option No. 4 can be recommended as a temporary solution. The contaminated soil/construction materials can be deposited in a secured temporary landfill constructed within INCEL area where contaminated soil/construction materials will be capped in order to prevent washing out of contamination by rainfall into the surrounding environment. Expected costs of remedial option No. 4 is in the range of 150,000 – 300,000 EUR.

For large paved surfaces of “SHP CELEX”, made of relatively solid concrete, it is assumed that contamination can be easily removed by proper sweeping and mechanical brushing.

Specific corrective measures were proposed for elimination of the environmental risks of spreading contaminants through the rainwater sewage system. These corrective measures include, besides excavation and removal of contaminated topsoil and construction materials, also revision and cleaning of the sewage system which drains rainwater from the INCEL area, (re)construction of wastewater treatment plant (WWTP), introduction of a sound management of wastewaters in INCEL area.

Specific monitoring activities for groundwater, soil and construction materials have been proposed as a part of the remedial measures.

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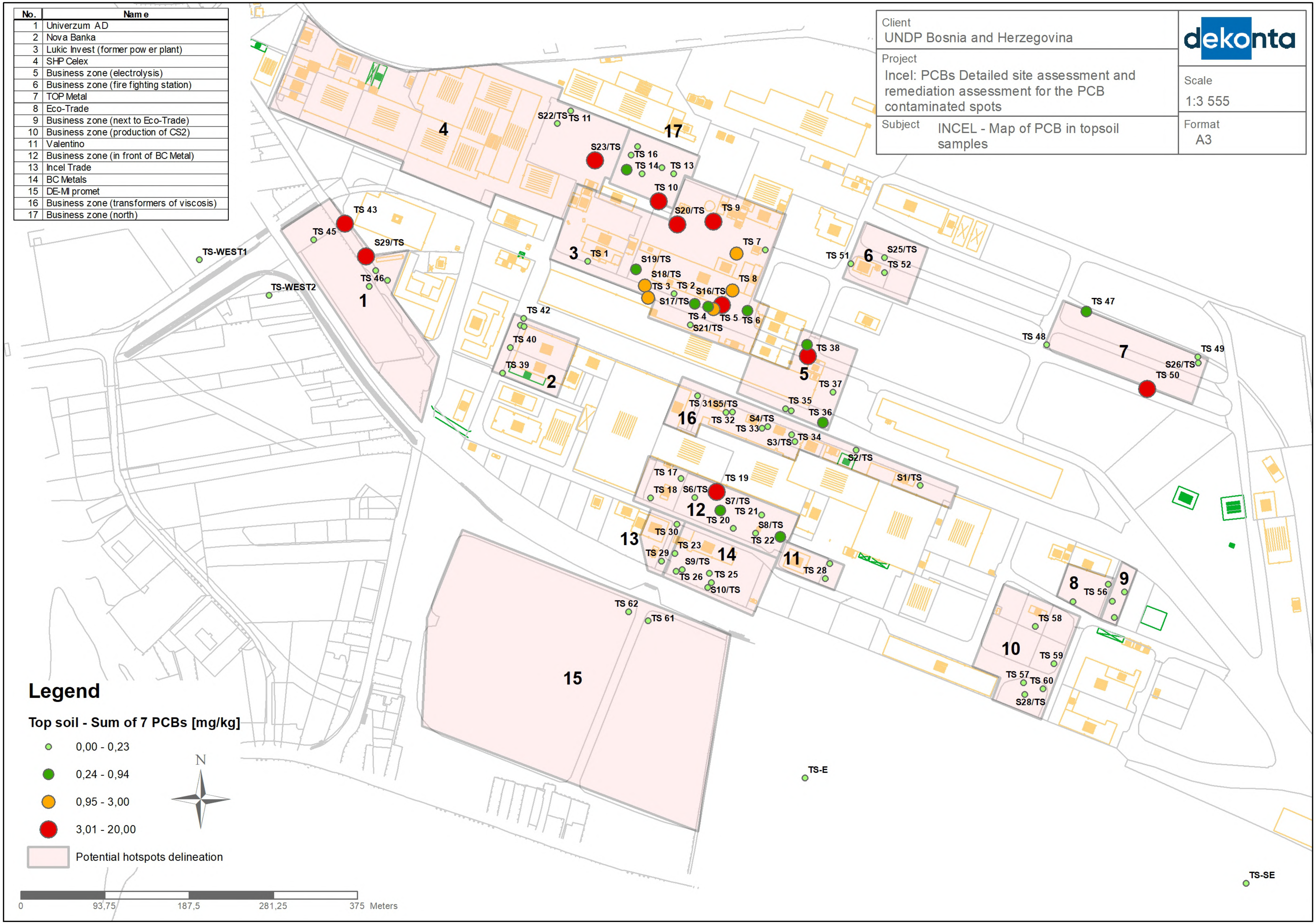
(18) https://www.vladars.net/sr-SP-Cyrl/Vlada/Ministarstva/mgr/Documents/Правилник%20о%20граничним%20и%20ремедијационим%20вриједностима%20радна%20верзија_048729396.pdf

(19) Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part A, Baseline Risk Assessment). U.S. EPA (1989, 1999).

(20) Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). U.S. EPA (2004).

(21) https://rhmzrs.com/wp-content/uploads/2018/09/Monitorings_skr_2014.pdf

(22) Site Assessment Report (DEKONTA 2020) under project: “INCEL, Banja Luka, PCBs Detailed site assessment and remediation assessment for the PCB contaminated spots“, DEKONTA, August, 2020.



No.	Name
1	Univerzum AD
2	Nova Banka
3	Lukic Invest (former power plant)
4	SHP Celex
5	Business zone (electrolysis)
6	Business zone (fire fighting station)
7	TOP Metal
8	Eco-Trade
9	Business zone (next to Eco-Trade)
10	Business zone (production of CS2)
11	Valentino
12	Business zone (in front of BC Metal)
13	Incel Trade
14	BC Metals
15	DE-MI promet
16	Business zone (transformers of viscosis)
17	Business zone (north)

No.	Name
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14	BC Metals
15	DE-MI promet
16	Business zone (transformers of viscosis)
17	Business zone (north)

Client
UNDP Bosnia and Herzegovina

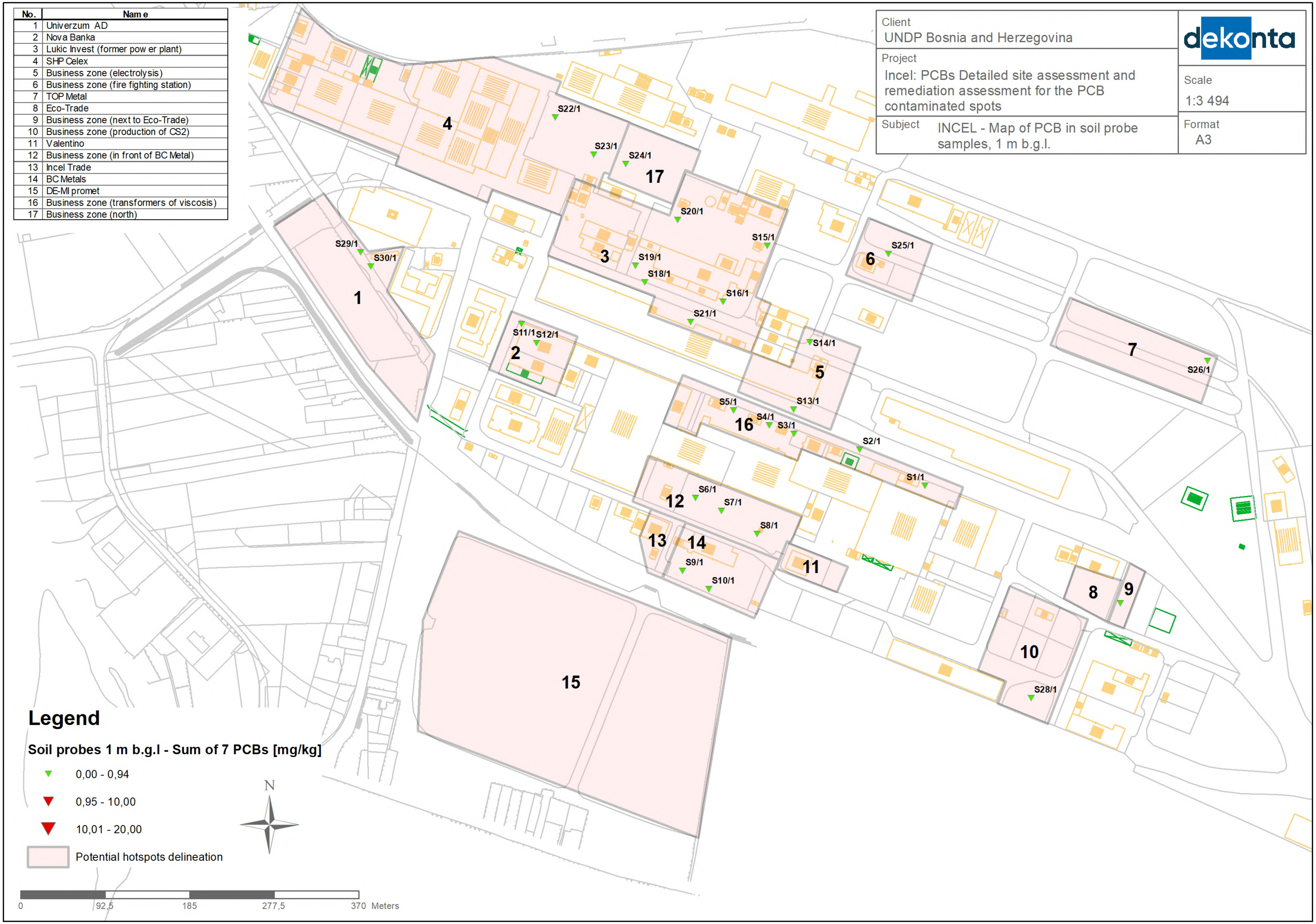
Project
Incel: PCBs Detailed site assessment and remediation assessment for the PCB contaminated spots

Subject
INCEL - Map of PCB in soil probe samples, 1 m b.g.l.

dekonta

Scale
1:3 494

Format
A3

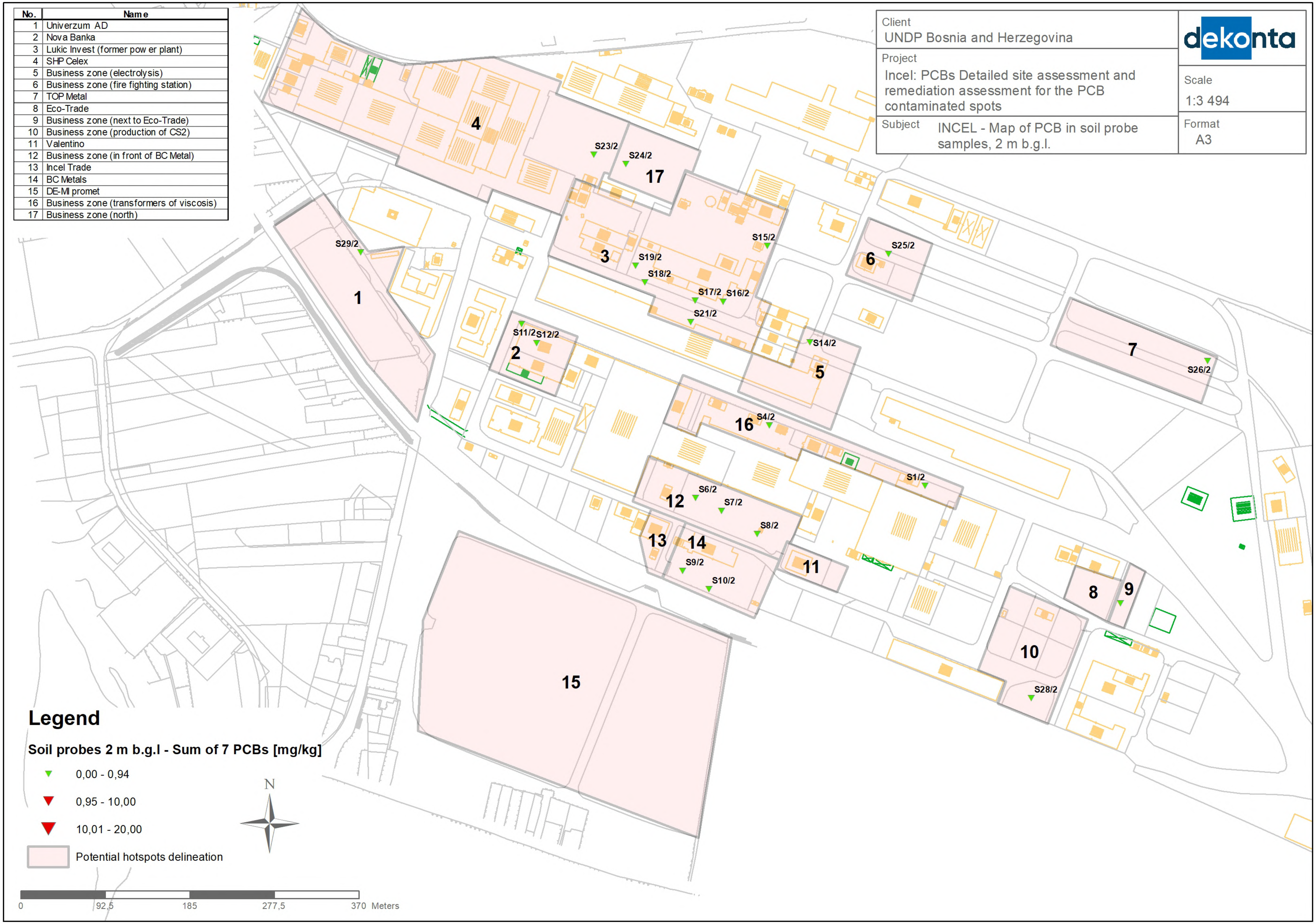


Legend

Soil probes 1 m b.g.l - Sum of 7 PCBs [mg/kg]

- 0,00 - 0,94
- 0,95 - 10,00
- 10,01 - 20,00
- Potential hotspots delineation

0 92,5 185 277,5 370 Meters



No. Name
1 Univerzum AD
2 Nova Banka
3 Lukic Invest (former pow er plant)
4 SHP Celex
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6 Business zone (fire fighting station)
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12 Business zone (in front of BC Metal)
13 Incel Trade
14 BC Metals
15 DE-MI promet
16 Business zone (transformers of viscosis)
17 Business zone (north)
Client
UNDP Bosnia and Herzegovina
Project
Incel: PCBs Detailed site assessment and remediation assessment for the PCB contaminated spots
Subject
INCEL - Map of PCB in soil probe samples, 2 m b.g.l.
Scale
1:3 494
Format
A3
S23/2
S24/2
S29/2
S15/2
S19/2
S18/2
S25/2
S17/2
S16/2
S21/2
S11/2
S12/2
S14/2
S26/2
S4/2
S1/2
S6/2
S7/2
S8/2
S9/2
S10/2
S28/2
Legend
Soil probes 2 m b.g.l - Sum of 7 PCBs [mg/kg]
0,00 - 0,94
0,95 - 10,00
10,01 - 20,00
Potential hotspots delineation
N
0
92,5
185
277,5
370 Meters

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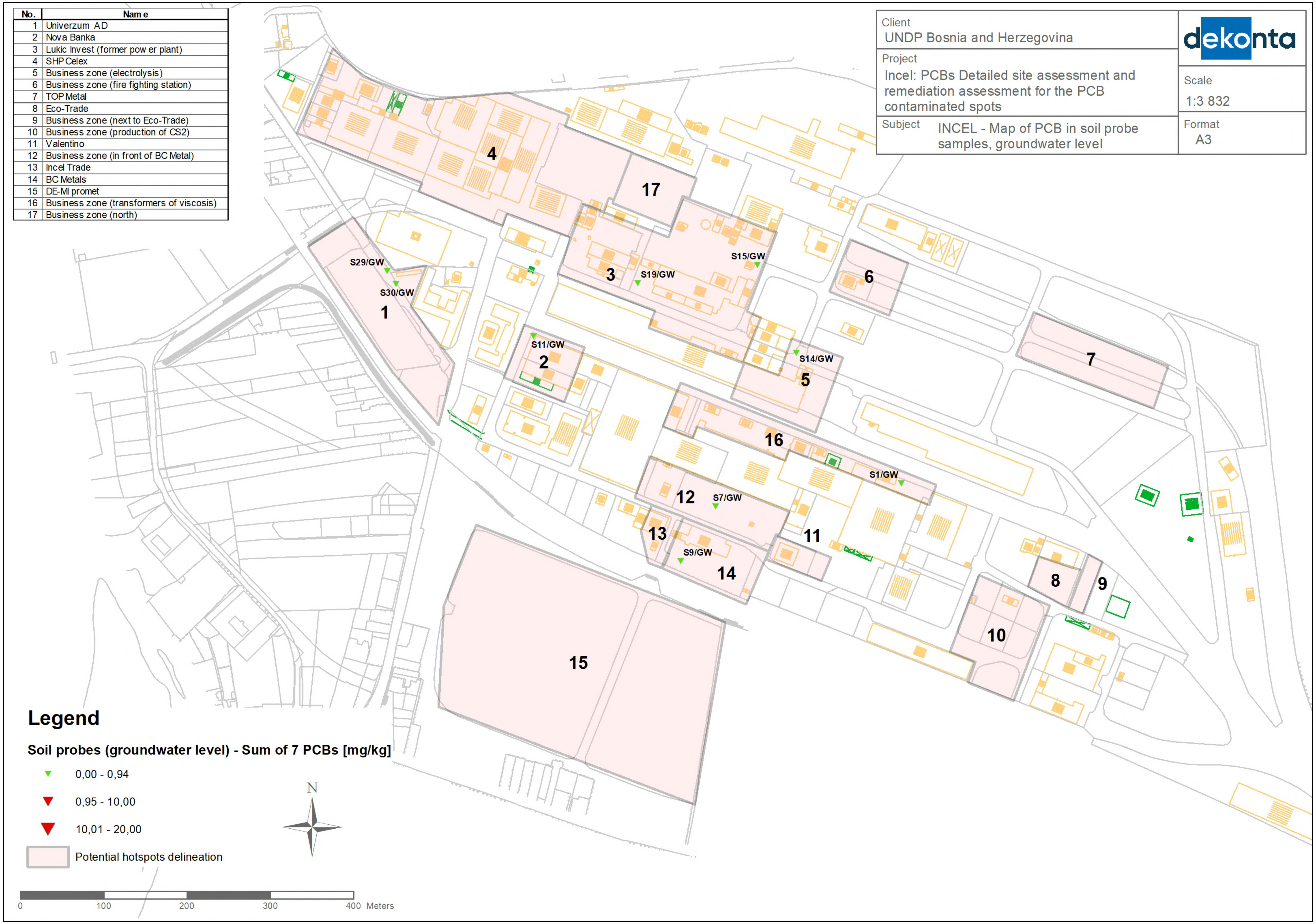
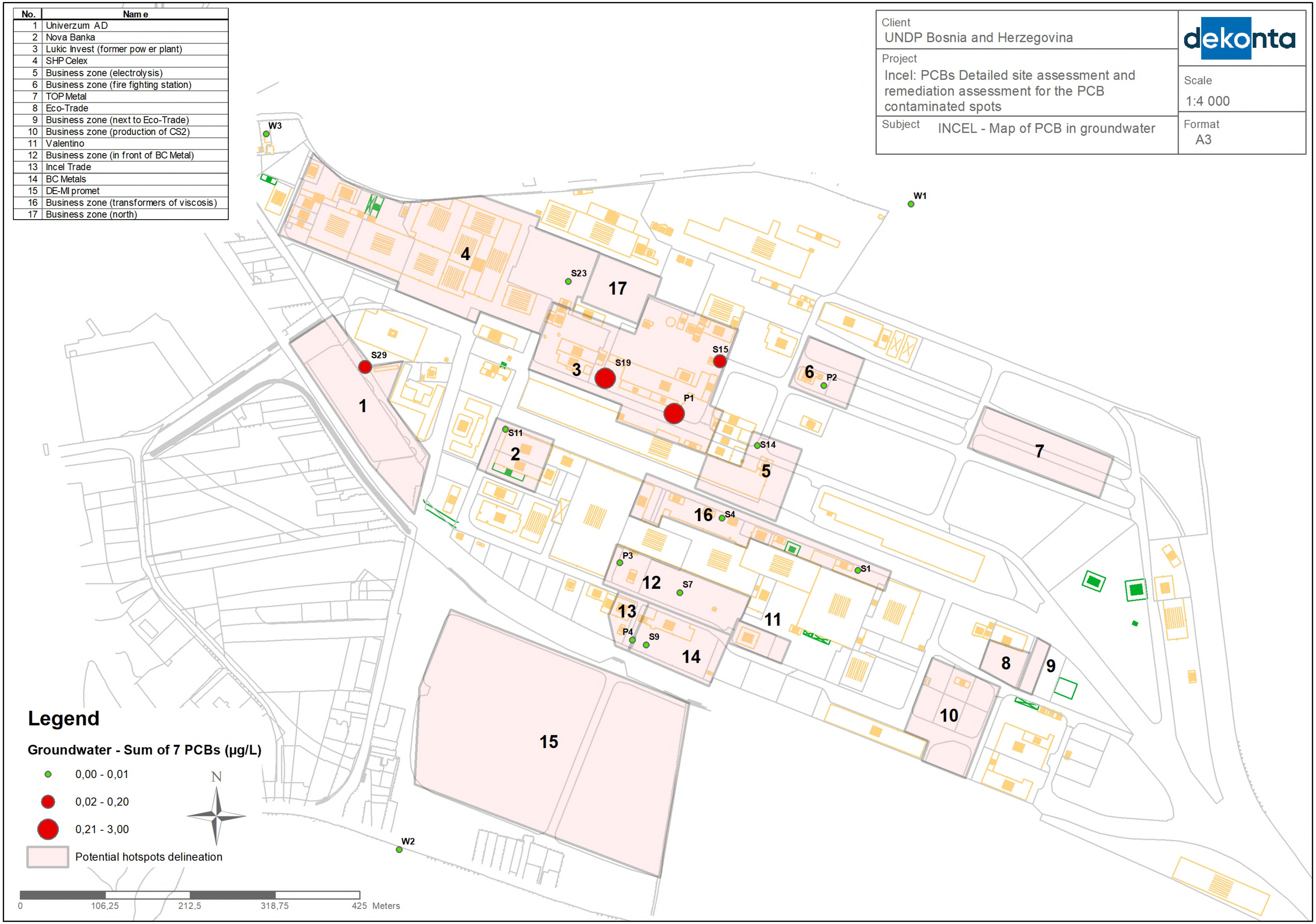
13	Incel Trade
14	BC Metals
15	DE-MI promet
16	Business zone (transformers of viscosis)
17	Business zone (north)





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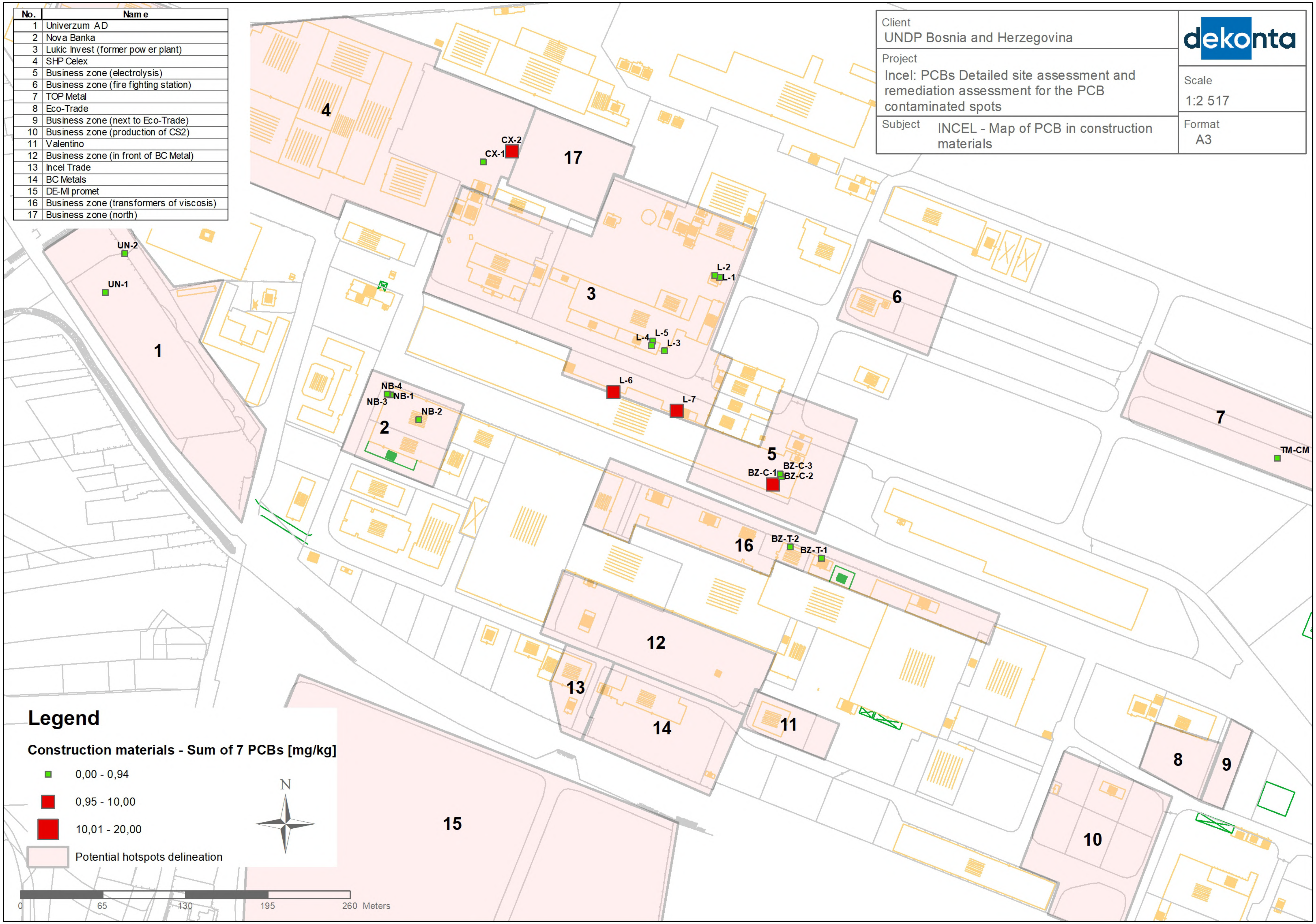

No. | Name
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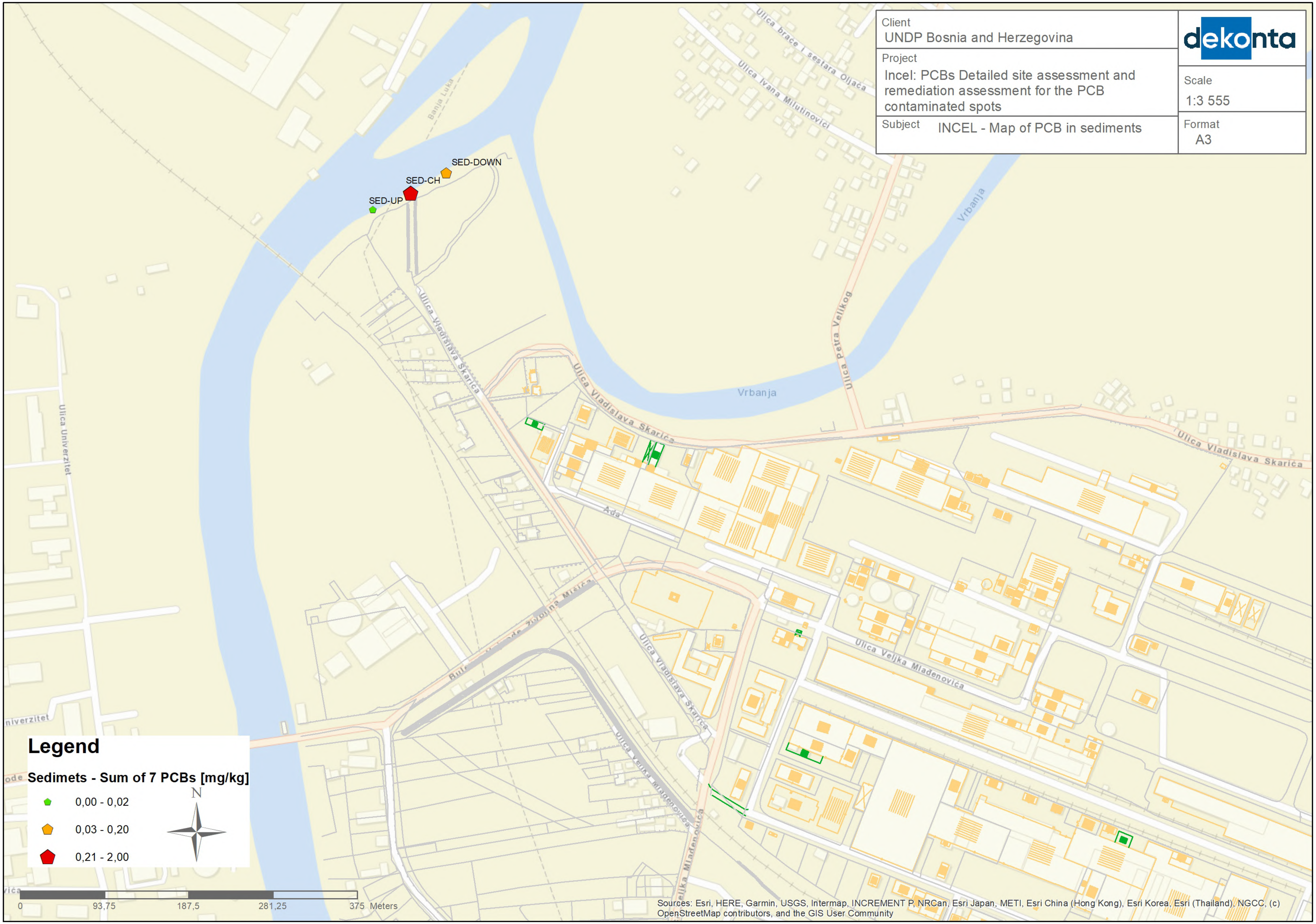
15 DE-MI promet
16 Business zone (transformers of viscosis)
17 Business zone (north)
Client
UNDP Bosnia and Herzegovina
dekonta
Project
Incel: PCBs Detailed site assessment and remediation assessment for the PCB contaminated spots
Scale
1:2 517
Subject
INCEL - Map of PCB in construction materials
Format
A3
CX-2
CX-1
UN-2
UN-1
L-2
L-1
L-4
L-5
L-3
L-6
L-7
NB-4
NB-1
NB-3
NB-2
BZ-C-3
BZ-C-1
BZ-C-2
BZ-T-2
BZ-T-1
TM-CM
Legend
Construction materials - Sum of 7 PCBs [mg/kg]
0,00 - 0,94
0,95 - 10,00
10,01 - 20,00
Potential hotspots delineation
N
0
65
130
195
260 Meters


Client
UNDP Bosnia and Herzegovina
Project
Incel: PCBs Detailed site assessment and remediation assessment for the PCB contaminated spots
Subject
INCEL - Map of PCB in sediments
dekonta
Scale
1:3 555
Format
A3
SED-DOWN
SED-CH
SED-UP
Vrbanja
Ulica Vladislava Skarica
Ulica Veljka Mladenovića
Ulica Petra Velikog
Ulica Ivana Milutinovići
Ulica braće i sestara Oljača
Ulica Univerzitet
Ada
Legend
Sedimets - Sum of 7 PCBs [mg/kg]
0,00 - 0,02
0,03 - 0,20
0,21 - 2,00
N
0
93,75
187,5
281,25
375 Meters
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Annex 7: Tables with analytical results

Concentrations of PCBs in topsoil samples

Analyte		Lukic Invest															INCEL Trade		Univerzum						SHP Celex				BZ Next to Eco-trade			DE-MI Promet	
	Sample	TS 1	TS 2	TS 3	TS 4	TS 5	TS 6	TS 7	TS 8	S15/TS	S16/TS	S17/TS	S18/TS	S19/TS	S20/TS	S21/TS	TS 29	TS 30	TS 43	TS 44	TS 45	TS 46	S29/TS	S30/TS	TS 9	TS 11	S22/TS	S23/TS	TS 53	TS 54	S27/TS	TS 61	TS 62
	Units	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
PCBs																																	
PCB 101	mg/kg DW	<0,0030	0.0096	0.0755	0.042	0.151	0.039	0.213	0.215	<0,0030	0.284	0.0532	0.0764	0.0193	0.321	0.0062	<0,0030	<0,0030	0.308	<0,0030	<0,0030	<0,0030	1.83	<0,0030	0.289	<0,0030	<0,0030	0.226	<0,0030	0.0036	<0,0030	<0,0030	<0,0030
PCB 118	mg/kg DW	<0,0030	0.0031	0.0216	0.012	0.0388	0.0094	0.0472	0.0464	<0,0030	0.0668	0.0141	0.019	0.0044	0.0648	<0,0030	<0,0030	<0,0030	0.0953	<0,0030	<0,0030	<0,0030	0.564	<0,0030	0.0696	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 138	mg/kg DW	0.0147	0.0521	0.304	0.2	0.596	0.177	0.821	0.882	<0,0030	1.63	0.232	0.356	0.0919	1.38	0.0264	0.0079	<0,0030	1.06	<0,0030	<0,012	0.0146	6.26	0.0083	1.19	0.0088	<0,0030	0.904	<0,0030	0.0228	<0,0030	<0,0030	0.0069
PCB 153	mg/kg DW	0.0117	0.0444	0.28	0.197	0.617	0.172	0.772	0.834	<0,0030	1.7	0.255	0.344	0.107	1.3	0.0205	0.0055	<0,0030	0.864	<0,0030	<0,0030	0.0114	5.19	0.0058	1.23	0.01	<0,0030	1.07	<0,0030	0.0162	<0,0030	<0,0030	0.0051
PCB 180	mg/kg DW	0.012	0.0414	0.259	0.172	0.567	0.144	0.776	0.721	<0,0030	1.59	0.189	0.319	0.0649	1.28	0.0188	0.0044	<0,0030	0.707	<0,0030	<0,0030	0.0102	4.05	0.006	1.08	0.0084	<0,0030	1.42	<0,0030	0.0152	<0,0030	<0,0030	0.0049
PCB 28	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,00390	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0132	<0,0030	<0,0030	<0,012	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 52	mg/kg DW	<0,0030	<0,0030	0.0054	<0,0030	0.0074	<0,0030	0.0163	0.0121	<0,0030	0.0115	<0,0030	0.0034	<0,0030	0.0169	<0,0030	<0,0030	<0,0030	0.0237	<0,0030	<0,0030	<0,0030	0.184	<0,0030	0.016	<0,0030	<0,0030	0.0137	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
Sum of 6 PCBs	mg/kg DW	0.0384	0.148	0.924	0.611	1.94	0.532	2.6	2.66	<0,0018	5.22	0.729	1.1	0.283	4.3	0.0719	<0,018	<0,018	2.96	<0,018	<0,0270	0.0362	17.5	0.0201	3.8	0.0272	<0,018	3.63	<0,018	0.0578	<0,018	<0,018	<0,018
Sum of 7 PCBs	mg/kg DW	0.0384	0.151	0.946	0.623	1.98	0.541	2.64	2.71	<0,0210	5.28	0.743	1.12	0.288	4.36	0.0719	<0,0210	<0,0210	3.06	<0,0210	<0,0030	0.0362	18.1	<0,0210	3.87	<0,0030	<0,0210	3.63	<0,0210	0.0578	<0,0210	<0,0210	<0,0210
Max PCBs in Area	mg/kg DW	5.28															<0,0210		18.10						3.87				0.058			<0,0210	
Average PCBs in Area	mg/kg DW	1.43															<0,0210		4.243						1.88				0.026			<0,0210	

Analyte		Business Zone in front of BC Metal										BC Metal					Top Metal					Business Zone Transformers of Viscosis									BZ Firefighting Station		
	Sample	TS 17	TS 18	TS 19	TS 20	TS 21	TS 22	S6/TS	S7/TS	S8/TS	S9/TS	TS 23	TS 24	TS 25	TS 26	S11/TS	TS 47	TS 48	TS 49	TS 50	S26/TS	TS 31	TS 32	TS 33	TS 34	S1/TS	S2/TS	S3/TS	S4/TS	S5/TS	TS 51	TS 52	S25/TS
	Units	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
PCBs																																	
PCB 101	mg/kg DW	0.0096	0.0061	0.378	<0,0030	0.0317	0.012	<0,0030	0.0137	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0431	0.0045	0.0048	0.438	<0,0030	<0,0030	0.007	0.0086	0.0031	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0045	<0,0030	<0,0030
PCB 118	mg/kg DW	<0,0030	0.0038	0.0978	<0,0030	0.0077	0.0033	<0,0030	0.0065	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0504	0.0032	0.0042	0.418	<0,0030	<0,0030	<0,0030	0.0034	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 138	mg/kg DW	0.0559	0.0427	2.88	0.0156	0.076	0.115	0.0109	0.0725	0.0058	<0,0030	<0,0030	<0,0030	0.0031	<0,0030	0.0231	0.0441	0.0082	0.0247	0.458	<0,0030	0.0119	0.0252	0.0374	0.0129	<0,0030	<0,0030	<0,0030	0.0065	<0,0030	0.0236	0.0042	<0,0030
PCB 153	mg/kg DW	0.039	0.033	3.27	0.0121	0.0543	0.073	0.0078	0.0604	0.0042	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0146	0.024	0.0059	0.018	0.317	<0,0030	0.008	0.018	0.0249	0.0092	<0,0030	<0,0030	<0,0030	0.0047	<0,0030	0.0204	0.0036	<0,0030
PCB 180	mg/kg DW	0.0337	0.022	2.51	0.011	0.0355	0.0868	0.0063	0.0525	0.0039	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.015	0.0076	0.0037	0.0124	0.232	<0,0030	0.007	0.0108	0.0203	0.0075	<0,0030	<0,0030	<0,0030	0.0044	<0,0030	0.0229	0.0041	<0,0030
PCB 28	mg/kg DW	<0,0030	<0,0030	<0,0030	0.003	<0,0030	<0,0030	<0,0030	0.0603	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.31	0.005	0.0046	4.84	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 52	mg/kg DW	<0,0030	<0,0030	0.0093	<0,0030	0.0034	<0,0030	<0,0030	0.0113	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0839	0.004	<0,0030	2.05	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
Sum of 6 PCBs	mg/kg DW	0.138	0.104	9.05	0.0417	0.201	0.287	0.025	0.271	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	0.0527	0.513	0.0313	0.0645	8.34	<0,018	0.0269	0.061	0.0912	0.0327	<0,018	<0,018	0.0182	<0,018	<0,018	0.0714	<0,018	<0,018
Sum of 7 PCBs	mg/kg DW	0.138	0.108	9.14	0.0417	0.209	0.29	0.025	0.277	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	0.0527	0.563	0.0345	0.0687	8.75	<0,0210	0.0269	0.061	0.0946	0.0327	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	0.0714	<0,0210	<0,0210
Max PCBs in Area	mg/kg DW	9.14										0.05					8.75					0.0946									0.071		
Average PCBs in Area	mg/kg DW	1.02										0.02					1.89					0.029744444									0.031		

Analyte		BZ North							Nova Banka					Valentino		Eco-trade		BZ Production of CS2					Business Zone Electrolysis					
	Sample	TS 10	TS 12	TS 13	TS 14	TS 15	TS 16	S24/TS	TS 39	TS 40	TS 41	TS 42	S11/TS	TS 27	TS 28	TS 55	TS 56	TS 57	TS 58	TS 59	TS 60	S28/TS	TS 35	TS 36	TS 37	TS 38	S13/TS	S14/TS
	Units	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
PCBs																												
PCB 101	mg/kg DW	0.344	<0,0030	<0,0030	<0,0030	0.0053	<0,0030	0.0162	<0,0030	0.0058	0.0087	<0,0030	<0,0030	0.019	<0,0030	0.003	<0,0030	<0,0030	0.0042	<0,0030	<0,0030	<0,0030	0.0178	0.0663	0.0039	0.261	0.005	<0,0030
PCB 118	mg/kg DW	0.0853	<0,0150	<0,0030	<0,0030	<0,0030	<0,0030	0.0045	<0,0030	0.0031	0.0036	<0,0030	<0,0030	0.0133	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0107	0.0421	0.0032	0.0341	<0,0030	0.0554
PCB 138	mg/kg DW	1.62	0.0599	0.0048	<0,0030	0.0153	<0,0150	0.0731	0.0043	0.049	0.0552	0.0267	0.0231	0.0157	<0,0030	0.0163	<0,0030	<0,0030	0.0157	<0,0030	<0,0030	<0,0030	0.0727	0.143	0.0146	0.984	0.0215	0.0172
PCB 153	mg/kg DW	1.59	<0,06	0.0045	<0,0030	0.0113	<0,0030	0.0694	0.0036	0.028	0.0388	0.0188	0.0146	0.0098	<0,0030	0.0102	<0,0030	<0,0030	0.0106	<0,0030	<0,0030	<0,0030	0.048	0.0996	0.0102	1.14	0.0141	0.146
PCB 180	mg/kg DW	1.47	<0,0450	0.0043	<0,0030	0.0086	0.0059	0.0747	0.0038	0.0324	0.0403	0.0214	0.015	0.0064	<0,0030	0.0098	<0,0030	<0,0030	0.0075	<0,0030	<0,0030	<0,0030	0.0443	0.0662	0.0085	1.44	0.0152	0.107
PCB 28	mg/kg DW	0.0067	<0,0150	<0,0030	<0,006	<0,0030	0.0163	<0,0182	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0038	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0034	<0,0030	0.0921
PCB 52	mg/kg DW	0.0227	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0268	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0036	0.0168	<0,0030	<0,0450	<0,0030	0.0087
Sum of 6 PCBs	mg/kg DW	5.05	<0,183	<0,018	<0,0210	0.0405	<0,042	0.233	<0,018	0.115	0.143	0.0669	0.0527	0.0815	<0,018	0.0393	<0,018	<0,018	0.038	<0,018	<0,018	<0,018	0.186	0.392	0.0372	3.87	0.0558	0.409
Sum of 7 PCBs	mg/kg DW	5.14	<0,198	<0,0210	<0,024	0.0405	<0,042	0.238	<0,0210	0.118	0.147	0.0669	0.0527	0.0948	<0,0210	0.0393	<0,0210	<0,0210	0.038	<0,0210	<0,0210	<0,0210	0.197	0.434	0.0404	3.91	0.0558	0.426
Max PCBs in Area	mg/kg DW	5.14							0.147					0.0948		0.039		0.038					3.91					
Average PCBs in Area	mg/kg DW	0.79							0.079					0.05265		0.025		0.016					0.84					

RED: Concentration above the limit of 0.94 mg/kg according to the US EPA screening levels for industrial soil

GREEN: Concentration below the detection limit of the analytical method

PCBs concentration in soil samples taken below 0.2 m of depth

Analyte	Sample / Units	BZ Tranformers of Viscosis								BZ in front of BC Metal								BZ Electrolysis				Top Metal	
	Sample	S1/1	S1/2	S1/GW	S2/1	S3/1	S4/1	S4/2	S5/1	S6/1	S6/2	S7/1	S7/2	S7/GW	S8/1	S8/2	S9/1	S13/1	S14/1	S14/2	S14/GW	S26/1	S26/2
	Units	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
PCBs																							
PCB 101	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0049	<0,0030	<0,0030	<0,0030	<0,0030
PCB 118	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 138	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0056	<0,0030	<0,0030	<0,0030	<0,0030
PCB 153	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0078	<0,0030	<0,0030	<0,0030	<0,0030
PCB 180	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0081	<0,0030	<0,0030	<0,0030	<0,0030
PCB 28	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.003	<0,0030	<0,0030	<0,0030	<0,0030
PCB 52	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,018	<0,0030	<0,0030	<0,0030	<0,0030
Sum of 6 PCBs	mg/kg DW	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,036	<0,018	<0,018	<0,018	<0,018
Sum of 7 PCBs	mg/kg DW	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0390	<0,0210	<0,0210	<0,0210	<0,0210
Max PCBs in Area	mg/kg DW	<0,2010								<0,2010								<0,2010				<0,2010	
Average PCBs in Area	mg/kg DW	<0,0210								<0,2010								<0,2010				<0,2010	

Analyte	Sample / Units	Univerzum					SHP Celex				Nova Banka					BZ Production of CS2		BC Metal				BZ North
	Sample	S29/1	S29/2	S29/GW	S30/1	S30/GW	S22/1	S23/1	S23/2	S24/2	S11/1	S11/2	S11/GW	S12/1	S12/2	S28/1	S28/2	S9/2	S9/GW	S10/1	S10/2	S24/1
	Units	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
PCBs																						
PCB 101	mg/kg DW	0.0436	<0,0030	<0,0030	0.004	<0,0030	0.021	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0048	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 118	mg/kg DW	0.0136	<0,0030	<0,0030	<0,0030	<0,0030	0.01	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 138	mg/kg DW	0.154	<0,0030	<0,0030	0.0189	<0,0030	0.063	0.0053	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0143	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0036
PCB 153	mg/kg DW	0.129	<0,0030	<0,0030	0.0148	<0,0030	0.0371	0.0057	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0111	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0036
PCB 180	mg/kg DW	0.0966	<0,0030	<0,0030	0.0132	<0,0030	0.0354	0.0052	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.008	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0031
PCB 28	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.003	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 52	mg/kg DW	0.0034	<0,0030	<0,0030	<0,0030	<0,0030	0.0174	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
Sum of 6 PCBs	mg/kg DW	0.427	<0,018	<0,018	0.0509	<0,018	0.174	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	0.0382	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018
Sum of 7 PCBs	mg/kg DW	0.44	<0,0210	<0,0210	0.0509	<0,0210	0.184	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	0.0382	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210
Max PCBs in Area	mg/kg DW	0.44					0.184				0.0382					<0,2010		<0,2010				<0,0210
Average PCBs in Area	mg/kg DW	0.10					0.05				0.0160					<0,2010		<0,2010				<0,0210

Analyte	Sample / Units	Lukic Invest														BZ Firefighting Station		BZ Eco-trade		
	Sample	S15/1	S15/2	S15/GW	S16/1	S16/2	S17/2	S18/1	S18/2	S19/1	S19/2	S19/GW	S20/1	S21/1	S21/2	S25/1	S25/2	S27/1	S27/2	S27/3
	Units	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
PCBs																				
PCB 101	mg/kg DW	<0,0030	<0,0030	<0,0030	0.003	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0037	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 118	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 138	mg/kg DW	<0,0030	<0,0030	<0,0030	0.0056	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0142	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 153	mg/kg DW	<0,0030	<0,0030	<0,0030	0.007	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0143	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 180	mg/kg DW	<0,0030	<0,0030	<0,0030	0.0031	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	0.0157	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 28	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
PCB 52	mg/kg DW	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030	<0,0030
Sum of 6 PCBs	mg/kg DW	<0,018	<0,018	<0,018	0.0187	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018	0.0479	<0,018	<0,018	<0,018	<0,018	<0,018	<0,018
Sum of 7 PCBs	mg/kg DW	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	0.0479	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210	<0,0210
Max PCBs in Area	mg/kg DW	0.0479														<0,2010		<0,2010		
Average PCBs in Area	mg/kg DW	0.01														<0,2010		<0,2010		

RED: Concentration above the limit of 0.94 mg/kg according to the US EPA screening levels for industrial soil

GREEN: Concentration below the detection limit of the analytical method

Concentrations of PCBs in groundwater samples

		BZ Transformers of Viscosis		BC Metal		Nova Banka	BZ Electrolysis	Lukic Invest			CELEX	Univerzum	BZ Firefighting	BZ in front of BC Metal	
Analyte	**Sample**	**S1**	**S4**	**S9**	**P4**	**S11**	**S14**	**S15**	**S19**	**P1**	**S23**	**S29**	**P2**	**ST7**	**P3**
	Units	**WATER**	**WATER**	**WATER**	**WATER**	**WATER**	**WATER**	**WATER**	**WATER**	**WATER**	**WATER**	**WATER**	**WATER**	**WATER**	**WATER**
PCBs															
PCB 101	µg/L	<0,000750	<0,000750	<0,000750	<0,000750	<0,000750	<0,0008	0.00162	0.501	0.0158	<0,000750	0.0102	<0,000750	<0,000750	<0,000750
PCB 118	µg/L	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	0.0814	0.00814	<0,0110	0.00205	<0,0110	<0,0110	<0,0110
PCB 138	µg/L	<0,012	<0,012	<0,012	<0,012	<0,012	0.00315	0.00357	0.771	0.119	0.00152	0.0137	<0,012	<0,012	<0,012
PCB 153	µg/L	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	0.00242	0.00357	0.903	0.195	0.00147	0.0116	<0,0110	<0,0110	<0,0110
PCB 180	µg/L	<0,000950	<0,000950	<0,000950	<0,000950	<0,000950	0.00252	0.00179	0.441	0.113	<0,000950	0.0043	<0,000950	<0,000950	<0,000950
PCB 28	µg/L	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	0.0477	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110
PCB 52	µg/L	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	<0,0110	0.121	<0,0110	<0,0110	0.00207	<0,0110	<0,0110	<0,0110
Sum of 6 PCBs	µg/L	<0,0062	<0,0062	<0,0062	<0,0062	<0,0062	0.00809	0.0106	2.78	0.443	<0,0062	0.0419	<0,0062	<0,0062	<0,0062
Sum of 7 PCBs	µg/L	<0,00730	<0,00730	<0,00730	<0,00730	<0,00730	0.00809	0.0106	2.87	0.451	<0,00730	0.0439	<0,00730	<0,00730	<0,00730
Max PCBs in Area	µg/L	<0,00730		<0,00730		<0,00730	0.00809	2.87			<0,00730	0.0439	<0,00730	<0,00730	
Average PCBs in Area	µg/L	<0,00730		<0,00730		<0,00730	0.00809	1.11			<0,00730	0.0439	<0,00730	<0,00730	

Analyte	**Sample**	W-1	W-2	W-3
	Units	WATER	WATER	WATER
PCBs				
PCB 101	µg/L	<0.000750	<0.000750	<0.000750
PCB 118	µg/L	<0.00110	<0.00110	<0.00110
PCB 138	µg/L	<0.00120	<0.00120	<0.00120
PCB 153	µg/L	<0.00110	<0.00110	<0.00110
PCB 180	µg/L	<0.000950	<0.000950	<0.000950
PCB 28	µg/L	<0.00110	<0.00110	<0.00110
PCB 52	µg/L	<0.00110	<0.00110	<0.00110
Sum of 6 PCBs	µg/L	<0.00620	<0.00620	<0.00620
Sum of 7 PCBs	µg/L	<0.00730	<0.00730	<0.00730

RED: Concentration above limit (0.01 ug/l) according to Dutch intervention limit values for soil and groundwater (2009)

GREEN: Concentration below the detection limit of the analytical method

Concentrations of PCBs in sediment samples

Analyte	Sample Units	Sediment Samples		
		SED-UP	SED-DOWN	SED-CH
		SEDIMENT	SEDIMENT	SEDIMENT
PCBs				
PCB 101	mg/kg DW	**<0.0030**	**<0.0030**	**0.0246**
PCB 118	mg/kg DW	**<0.0030**	**<0.0030**	0.0092
PCB 138	mg/kg DW	**<0.0030**	0.0083	**0.172**
PCB 153	mg/kg DW	**<0.0030**	0.0084	**0.177**
PCB 180	mg/kg DW	**<0.0030**	0.0084	**0.145**
PCB 28	mg/kg DW	**<0.0030**	**0.0261**	**<0.0030**
PCB 52	mg/kg DW	**<0.0030**	0.0057	**<0.0030**
Sum of 6 PCBs	mg/kg DW	**<0.018**	**0.0546**	**0.519**
Sum of 7 PCBs	mg/kg DW	**<0.021**	**0.0546**	**0.528**

RED: Concentration above the limit of 0.02 ppm according to the Decree on limit values for pollutants in surface and groundwater and sediment and deadlines for reaching them, 'Official Gazette of Republic of Serbia (50/2012)
GREEN: Concentration below the detection limit of the analytical method

Concentrations of PCBs like dioxins in topsoil samples

Analyte	Sample	TS 4	TS 24	TS 47
	Units	SOIL	SOIL	SOIL
PCBs like dioxins				
PCB 105	ng/g DW	5	0.48	80
PCB 114	ng/g DW	0.27	0.029	2.9
PCB 118	ng/g DW	66	1.1	170
PCB 123	ng/g DW	0.13	0.031	3.9
PCB 126	ng/g DW	0.44	0.0022	0.38
PCB 156	ng/g DW	34	**<0,098**	8.7
PCB 157	ng/g DW	2.6	0.015	2.3
PCB 167	ng/g DW	26	**<0,046**	4.6
PCB 169	ng/g DW	0.072	**<0,00170**	0.0059
PCB 170	ng/g DW	380	0.33	13
PCB 180	ng/g DW	890	0.66	21
PCB 189	ng/g DW	13	0.016	0.52
PCB 77	ng/g DW	0.6	0.34	49
PCB 81	ng/g DW	0.025	0.013	1.9
Sum of 14 PCBs	ng/g DW	**1418.137**	3.08905	358.2059

RED: Concentration above the limit of 0.94 mg/kg according to US EPA screening levels for industrial soil
GREEN: Concentration below the detection limit of the analytical method

dekonta

Concentrations of TPH in topsoil samples

		Lukic Invest		BZ BC Metal	BC Metal		Univerzum	BZ - transformers of Viscosis		BZ - in front of BC Metal			Nova Banka		Lukić Invest (former power plant)	
Analyte	Sample	TS 4	TS 8	TS 20	TS 24	TS 25	TS 44	S1/TS	S4/TS	S7/TS	S8/TS	S9/TS	S11/TS	S16/TS	S17/TS	S19/TS
	Units	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Hydrocarbons																
Fraction	mg/kg	<2.0	<2.0	<2.0	<2.0	<2.0	<3.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	7,4
Fraction	mg/kg	<3.0	3,4	<3.0	<3.0	<3.0	<4.5	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3,5
Fraction	mg/kg	12	105	17	<10	**11**	323	58	11	68	153	<10	42	581	<10	125
Fraction	mg/kg	<5.0	20	<5.0	<5.0	<5.0	54,8	6	<5.0	11,6	31,1	<5.0	17,1	71,9	<5.0	20,4
Fraction	mg/kg	<20	130	22	<20	<20	382	66	<20	81	185	<20	61	656	<20	157

Concentrations of TPH in soil samples taken below 0.2 m of depth

		BZ Tranformers of Viscosis				BZ in front of BC Metal						Nova Banka		Lukic Invest							
Analyte	**Sample**	S1/TS	S1/1	S4/TS	S4/1	S7/TS	S7/1	S8/TS	S8/1	S9/TS	S9/1	S11/TS	S11/1	S16/TS	S16/1	S16/2	S17/TS	S17/1	S19/TS	S19/1	S19/2
	Units	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Petroleum Hydrocarbons																					
C10 - C12 Fraction	mg/kg	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	7.4	<2.0	<2.0
C10 - C40 Fraction	mg/kg	<10	<10	66	<10	81	<10	185	<10	<10	<10	61	<10	656	<10	<10	<10	52	157	86	20
C12 - C16 Fraction	mg/kg	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3.5	<3.0	<3.0
C16 - C35 Fraction	mg/kg	16	<10	<2.0	<10	68	<10	153	<10	<10	<10	42	<10	581	<10	<10	<10	41	125	69	20
C35 - C40 Fraction	mg/kg	<5.0	<5.0	6	<5.0	11.6	<5.0	31.1	<5.0	<5.0	<5.0	17.1	<5.0	71.9	<5.0	<5.0	<5.0	9.6	20.4	16.3	<5.0

Concentrations of TPH in construction materials samples

Analyte		Lukić (former power plant)	Business Zone - Electrolysis
	Sample	L-3	BZ-C-2
	Units	SOIL	SOIL
Petroleum Hydrocarbons			
C10 - C12 Fraction	mg/kg	<20	<10
C12 - C16 Fraction	mg/kg	<30	<15
C16 - C35 Fraction	mg/kg	22600	8240
C35 - C40 Fraction	mg/kg	129	688
C10 - C40 Fraction	mg/kg	22800	22800

RED: Concentration above the limit of 3000 mg/kg according to the Decree on limit values for pollutants in surface and groundwater and sediment and deadlines for reaching them, 'Official Gazette of Republic of Serbia (50/2012)

GREEN: Concentration below the detection limit of the analytical method

Concentrations of TPH in sediment samples

Analyte		Sediment Samples	
	Sample	SED-UP	SED-DOWN
	Units	SEDIMENT	SEDIMENT
Petroleum Hydrocarbons			
C10 - C12 Fraction	mg/kg	<2.0	<2.0
C12 - C16 Fraction	mg/kg	<3.0	<3.0
C16 - C35 Fraction	mg/kg	40	178
C35 - C40 Fraction	mg/kg	<0.40	<0.40
C10 - C40 Fraction	mg/kg	54	202

RED: Concentration above the limit of 50 mg/kg according to the Decree on limit values for pollutants in surface and groundwater and sediment and deadlines for reaching them, 'Official Gazette of Republic of Serbia (50/2012)

GREEN: Concentration below the detection limit of the analytical method

Concentrations of TPH in groundwater within INCEL

Analyte		BZ Transformers of Viscosis	BC Metal	Nova Banka	BZ Electrolysis	Lukic Invest		CELEX
	Sample	S1	S9	S11	S14	S15	P1	S23
	Units	WATER	WATER	WATER	WATER	WATER	WATER	WATER
Petroleum Hydrocarbons								
C10 - C12 Fraction	µg/L	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
C12 - C16 Fraction	µg/L	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
C16 - C35 Fraction	µg/L	<30.0	<30.0	<30.0	<60.0	<30.0	<30.0	<30.0
C35 - C40 Fraction	µg/L	<10.0	<10.0	<10.0	<20.0	<10.0	<10.0	<10.0
C10 - C40 Fraction	µg/L	<50.0	<50.0	<50.0	<100	<50.0	<50.0	<50.0

RED: Above limit (600 ug/l) according to Dutch intervention limit values for soil and groundwater (2009)

GREEN: Concentration below the detection limit of the analytical method

Concentrations of PAHs in topsoil samples

Analyte	Sample	TS 4	TS 24	TS 44
	Units	SOIL	SOIL	SOIL
Polycyclic Aromatic Hydrocarbons				
Naphthalene	mg/kg DW	**<0.010**	**<0.010**	0.054
Phenanthrene	mg/kg DW	0.011	0.031	0.523
Anthracene	mg/kg DW	**<0.010**	0.019	0.245
Fluoranthene	mg/kg DW	0.016	0.276	2.4
Pyrene	mg/kg DW	0.011	0.244	2.05
Benz(a)anthracene	mg/kg DW	**<0.010**	0.096	1.01
Chrysene	mg/kg DW	**<0.010**	0.124	1.76
Benzo(b)fluoranthene	mg/kg DW	0.01	0.233	3.02
Benzo(k)fluoranthene	mg/kg DW	**<0.010**	0.072	0.803
Benzo(a)pyrene	mg/kg DW	**<0.010**	0.099	1.03
Indeno(1.2.3.cd)pyrene	mg/kg DW	**<0.010**	0.066	0.572
Benzo(g.h.i)perylene	mg/kg DW	**<0.010**	0.076	0.772
Sum of 12 PAH (waste)	mg/kg DW	**<0.120**	1.34	**14.2**

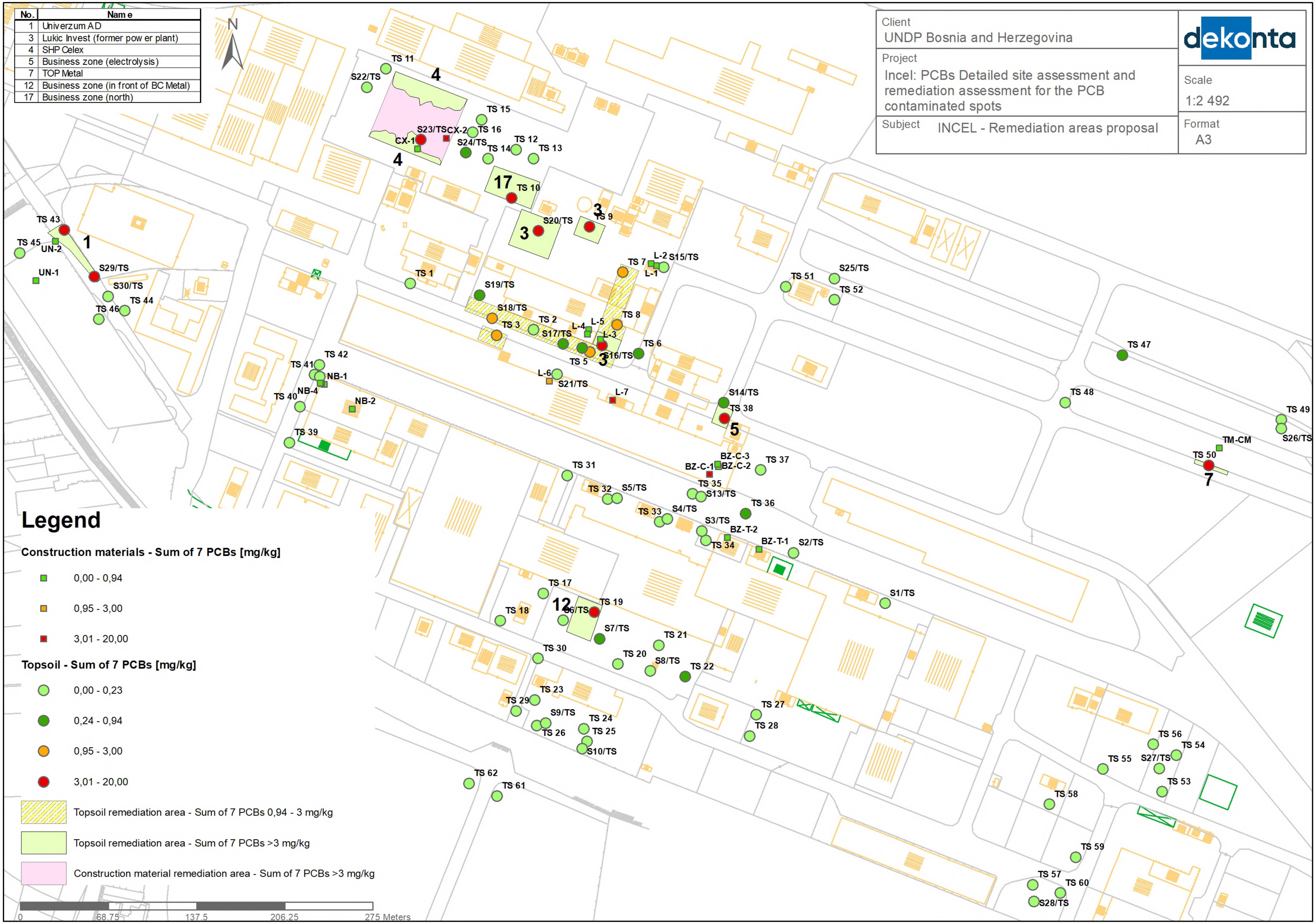
RED: Concentration above the limit of 10 mg/kg according to US EPA screening levels for industrial soil

GREEN: Concentration below the detection limit of the analytical method

Heavy metals concentrations

Metal	Results														Limits			
	Topsoil							River sediment			Construction Materials				Topsoil and constr. materials limit			River sediment
	TS 4	TS 8	TS 20	TS 24	TS 25	TS 44	TS 47	SED-UP	SED-DOW	SED-CH	L-3	BZ-C-2	L-6	UN-2	(1) US EPA's RBC limis database (industrial soil)	(2) Official Gazette of Republic of Serbia 50/2012 (sediments)	(3) Draft Regulation (Republica Srpska)	Official Gazette of Republic of Serbia 50/2012 (river
Cation (ALS Lab. results)	mg/kg DV	mg/kg DV	mg/kg DV	mg/kg DV	mg/kg DV	mg/kg DV	mg/kg DW	mg/kg DV	mg/kg DV	mg/kg DW	mg/kg DV	mg/kg DV	mg/kg DV	mg/kg DV	screening level [mg/kg]	max. allowed conc.	max. value for soil/sediment [mg/kg]	target concentrati on for river
Antimony	<0,50	21,4 (3)	<0,50	1,13 (3)	<0,50	<0,50	6,48 (3)	<0,50	0,75	2,52	106	3,86	1,04	<0,50	n.a.	n.a.	3	n.a
Arsenic	17,2 (1)	53,9 (1,2,3)	14,8 (1)	10,4 (1)	15,8 (1)	5,25 (1)	16,4 (1)	6,1	3,75	9,85	108	22,8	13,8	1,39	3,00	42	29	29
Barium	155	473 (3)	278 (3)	134	130	140	456 (3)	27	32,5	118	411	384	430	18,9	220000	n.a.	160	n.a.
Beryllium	1,16 (3)	0,954	1,1 (3)	0,68	1,02	0,191	0,809	0,196	0,184	0,658	0,4	0,366	0,45	0,048	2300	n.a.	1,1	n.a.
Cadmium	<0,40	2,12 (3)	<0,40	1,85 (3)	<0,40	<0,40	3,44 (3)	<0,40	<0,40	0,63	3,4	0,87	0,41	<0,40	980	6,4	0,8	0,8
Chromium	99,2	199 (3)	99,1	101 (3)	119 (3)	12,3	125 (3)	29	50,5	68,9	188	104	55,3	4,5	n.a.	240	100	100
Cobalt	23,1 (3)	31,2 (3)	21,8 (3)	20,6 (3)	22,1 (3)	1,74	25,3 (3)	6,27	5,41	13,9	30,8	10	7,21	0,78	350	n.a.	9	n.a.
Copper	54,6 (2,3)	357 (2,3)	57,1 (3)	112 (2,3)	52,8 (3)	6,4	202 (2,3)	25,9	33,7	64,7	977	641	31	4,9	47000	110	36	36
Iron	42700	192000	35700	33600	35900	5160	63100	12500	11800	25500	227000	67300	15000	1410	820000	n.a.	n.a.	n.a.
Lead	32,7	1700 (1,2,3)	73,3	138 (3)	275 (3)	19,5	79,5	15	35,5	106	4430	138	25,5	4,4	800	310	85	85
Lithium	47	44,7	49,1	35,3	45,2	7,6	39,4	16,5	13,4	41,6	23,8	23,7	29,3	4,1	2300	n.a.	n.a.	n.a.
Manganese	1290	1700	1300	929	1530	232	2420	390	382	911	1700	633	996	34,4	26000	n.a.	n.a.	n.a.
Mercury	<0.20	<1.00	<0.20	<0.20	0,82 (3)	<0.20	0,94 (3)	<0.20	2,03	18,9	3,14	500	0,82	<0,2	46	1,6	0,3	0,3
Molybdenum	0,86	19,1 (3)	0,85	0,45	0,94	<0,40	4,73 (3)	<0,40	1,51	1,02	18,7	5,11	0,99	<0,40	5800	n.a.	3	n.a.
Nickel	133 (2,3)	234 (2,3)	142 (2,3)	113 (2,3)	178 (2,3)	7	146 (2,3)	43,1	51,2	82,7	208	59,5	46,6	6,4	n.a.	44	35	35
Phosphorus	537	386	568	806	917	147	1050	336	470	792	326	242	246	113	n.a.	n.a.	n.a.	n.a.
Silver	<0,50	<2.50	<0,50	<0,50	<0,50	<0,50	<0,50	0,56	<0,50	0,7	<2,5	7,91	<0,50	<0,50	5800	n.a.	n.a.	n.a.
Strontium	40,1	167	53,9	13,6	31,2	117	62,5	204	155	144	128	154	96,4	107	700000	n.a.	n.a.	n.a.
Thallium	<0,50	<2.50	<0,50	<0,50	<0,50	<0,50	<0,50	<0,50	<0,50	<0,50	<2,5	<0,50	<0,50	<0,50	n.a.	n.a.	n.a.	n.a.
Tin	1,7	22,3	1,4	1,4	1,4	<1.0	9	<1	1,3	3	51,9	5,7	<1	<1	700000	n.a.	n.a.	n.a.
Vanadium	54,3 (3)	67,8 (3)	54,9 (3)	52 (3)	58,9 (3)	7,52	39	15,4	13	36,7	43,6	25,1	20,6	8,97	5800	n.a.	42	n.a.
Zinc	80,6	1010 (2,3)	333 (3)	171 (3)	84,8	27,4	994 (2,3)	131	73,5	454	1290	325	74,6	33,3	350000	430	140	140

n.a. = not applicable



No.	Name
1	Univerzum AD
3	Lukic Invest (former power plant)
4	SHP Celex
5	Business zone (electrolysis)
7	TOP Metal
12	Business zone (in front of BC Metal)
17	Business zone (north)

Client UNDP Bosnia and Herzegovina		dekonta
Project Incel: PCBs Detailed site assessment and remediation assessment for the PCB contaminated spots		Scale 1:2 492
Subject	INCEL - Remediation areas proposal	Format A3

Legend

Construction materials - Sum of 7 PCBs [mg/kg]

- 0,00 - 0,94
- 0,95 - 3,00
- 3,01 - 20,00

Topsoil - Sum of 7 PCBs [mg/kg]

- 0,00 - 0,23
- 0,24 - 0,94
- 0,95 - 3,00
- 3,01 - 20,00
- Topsoil remediation area - Sum of 7 PCBs 0,94 - 3 mg/kg
- Topsoil remediation area - Sum of 7 PCBs >3 mg/kg
- Construction material remediation area - Sum of 7 PCBs >3 mg/kg

No.	Name
1	Univerzum AD
3	Lukic Invest (former power plant)
4	SHP Celex
5	Business zone (electrolysis)
7	TOP Metal
12	Business zone (in front of BC Metal)
17	Business zone (north)

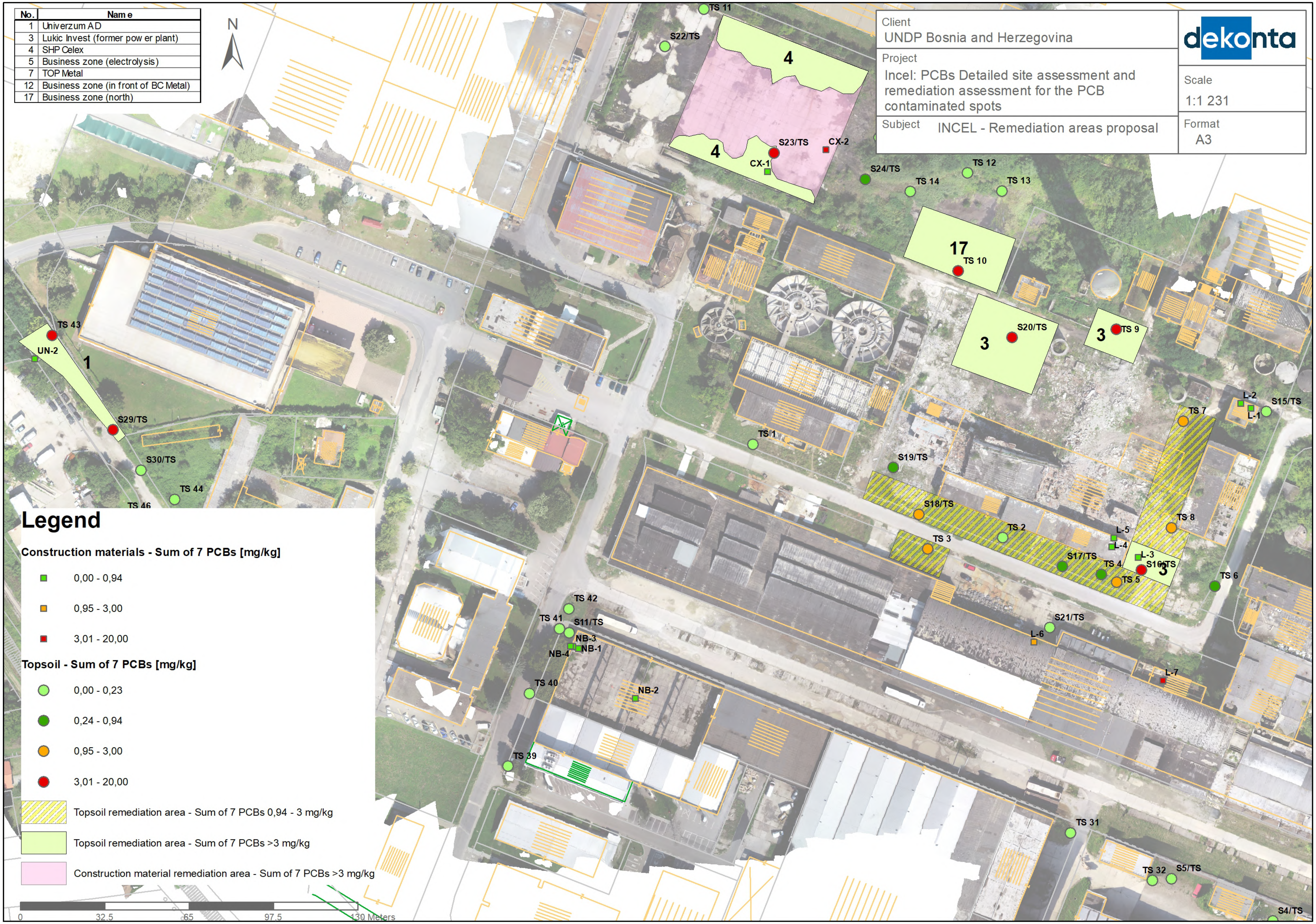
Client: UNDP Bosnia and Herzegovina

Project: Incel: PCBs Detailed site assessment and remediation assessment for the PCB contaminated spots

Subject: INCEL - Remediation areas proposal

Scale: 1:1 231

Format: A3



Legend

Construction materials - Sum of 7 PCBs [mg/kg]

- 0,00 - 0,94
- 0,95 - 3,00
- 3,01 - 20,00

Topsoil - Sum of 7 PCBs [mg/kg]

- 0,00 - 0,23
- 0,24 - 0,94
- 0,95 - 3,00
- 3,01 - 20,00
- Topsoil remediation area - Sum of 7 PCBs 0,94 - 3 mg/kg
- Topsoil remediation area - Sum of 7 PCBs >3 mg/kg
- Construction material remediation area - Sum of 7 PCBs >3 mg/kg


No. | Nam e
1 Univerzum AD
3 Lukic Invest (former pow er plant)
4 SHP Celex
5 Business zone (electrolysis)
7 TOP Metal
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17 Business zone (north)
N
Client
UNDP Bosnia and Herzegovina
Project
Incel: PCBs Detailed site assessment and remediation assessment for the PCB contaminated spots
Subject
INCEL - Remediation areas proposal
dekonta
Scale
1:775
Format
A3
Legend
Construction materials - Sum of 7 PCBs [mg/kg]
0,00 - 0,94
0,95 - 3,00
3,01 - 20,00
Topsoil - Sum of 7 PCBs [mg/kg]
0,00 - 0,23
0,24 - 0,94
0,95 - 3,00
3,01 - 20,00
Topsoil remediation area - Sum of 7 PCBs 0,94 - 3 mg/kg
Topsoil remediation area - Sum of 7 PCBs >3 mg/kg
Construction material remediation area - Sum of 7 PCBs >3 mg/kg
L-7
S14/TS
5
TS 38
BZ-C-3
BZ-C-2
BZ-C-1
TS 37
TS 35
S13/TS
TS 32
S5/TS
TS 36
TS 33
S4/TS
S3/TS
BZ-T-2
TS 34
BZ-T-1
S2/TS
TS 17
TS 19
12
TS 18
S6/TS
S7/TS
TS 21
TS 30
TS 20
S8/TS
0
20
40
60
80 Meters


No.
Name
1 Univerzum AD
3 Lukic Invest (former power plant)
4 SHP Celex
5 Business zone (electrolysis)
7 TOP Metal
12 Business zone (in front of BC Metal)
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N
Client
UNDP Bosnia and Herzegovina
Project
Incel: PCBs Detailed site assessment and remediation assessment for the PCB contaminated spots
Subject
INCEL - Remediation areas proposal
dekonta
Scale
1:400
Format
A3
TS 49
S26/TS
TM-CM
TS 50
7
Legend
Construction materials - Sum of 7 PCBs [mg/kg]
0,00 - 0,94
0,95 - 3,00
3,01 - 20,00
Topsoil - Sum of 7 PCBs [mg/kg]
0,00 - 0,23
0,24 - 0,94
0,95 - 3,00
3,01 - 20,00
Topsoil remediation area - Sum of 7 PCBs 0,94 - 3 mg/kg
Topsoil remediation area - Sum of 7 PCBs >3 mg/kg
Construction material remediation area - Sum of 7 PCBs >3 mg/kg
0
10
20
40 Meters