

Supplementary material

Table S1. Municipal Solid Waste production and recycling data in Kazakhstan (data in kt/year)

Region	2018		2019		2020	
	MSW	Recycling	MSW	Recycling	MSW	Recycling
Kazakhstan	4319.2	497.1	4736.6	705.2	4,551,755	868,983
Akmola region	241.0	7.1	245.0	7.4	243,000	37,555
Aktobe	298.6	34.9	295.6	29.6	305,700	30,591
Almaty	628.7	170.1	624.3	145.4	600,000	102,000
Atyrau	207.8	3.5	191.7	20.0	233,642	45,680
East Kazakhstan	108.1	5.7	107.0	9.2	107,000	12,031
Zhambyl	95.7	3.0	80.9	6.9	76,550	9,688
Karaganda	651.3	106.8	660.0	115.0	655,000	190,000
Kostanay	250.0	24.1	216.7	22.3	229,802	27,410
Kyzylorda	147.0	10.9	122.0	13.1	117,000	21,000
Manghystau	182.3	2.6	188.3	63.6	110,520	39,013
Pavlodar	117.3	0.1	648.0	97.2	647,000	142,340
North Kazakhstan	66.1	5.0	74.7	7.6	86,539	11,290
Türkistan	138.0	9.9	128.1	12.9	122,771	15,962
Shygys Kazakhstan	183.6	8.9	164.7	5.4	171,576	30,873
Astana	307.6	37.7	318.6	50.7	198,601	59,085
Almaty	480.0	27.4	456.0	50.0	438,000	42,000
Almaty	216.2	39.5	215.1	49.0	209,054	52,465

Table S2 - Component composition of municipal solid waste to landfills, 2020 (data in kt/year)

MSW component	Kazakhstan	(%)	Akmola region	(%)
Food waste	18,166	1.63	*	-
Waste paper, cardboard and paper waste	111,968	10.04	1,637	14.67
Glass waste	83,051	7.44	497	4.45
Plastic, plastic, polyethylene and polyethylene terephthalate waste	136,632	12.26	145	1.30
Electronic and electrical equipment	710	0.07	-	-
Non ferrous and non-ferrous scrap metal	34,923	3.15	395	3.54
Tyres	1889	0.17	-	-
Wood, leaves	16,513	1.48	685	6.14
Clothing, textiles	5890	0.53	-	-
Other waste	705,055	63.24	7801	69.9
Total	1,114,797	100	11,160	100

* - no available data

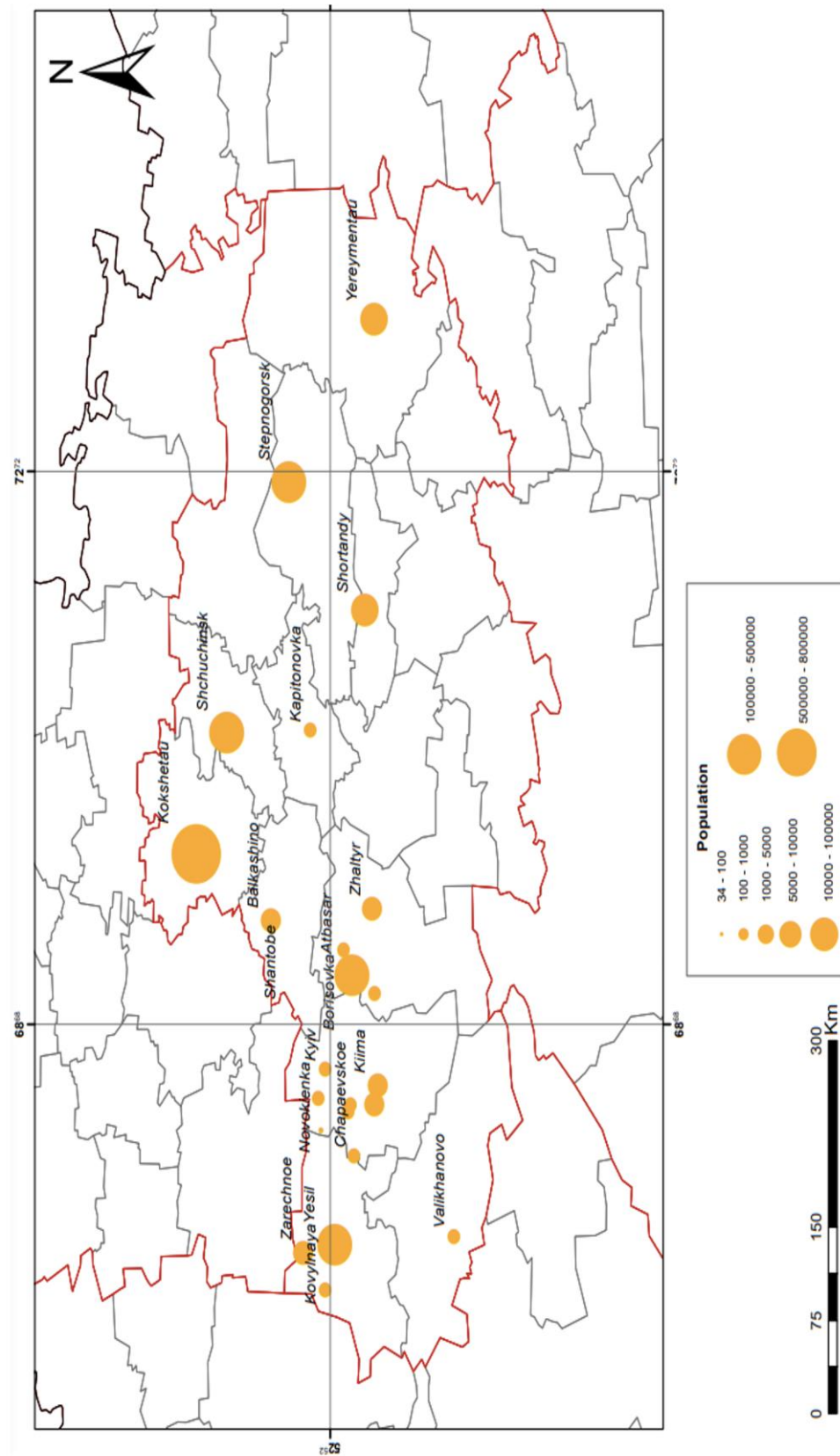


Figure S1. Location of the 24 landfills of the Akmola region and associated population

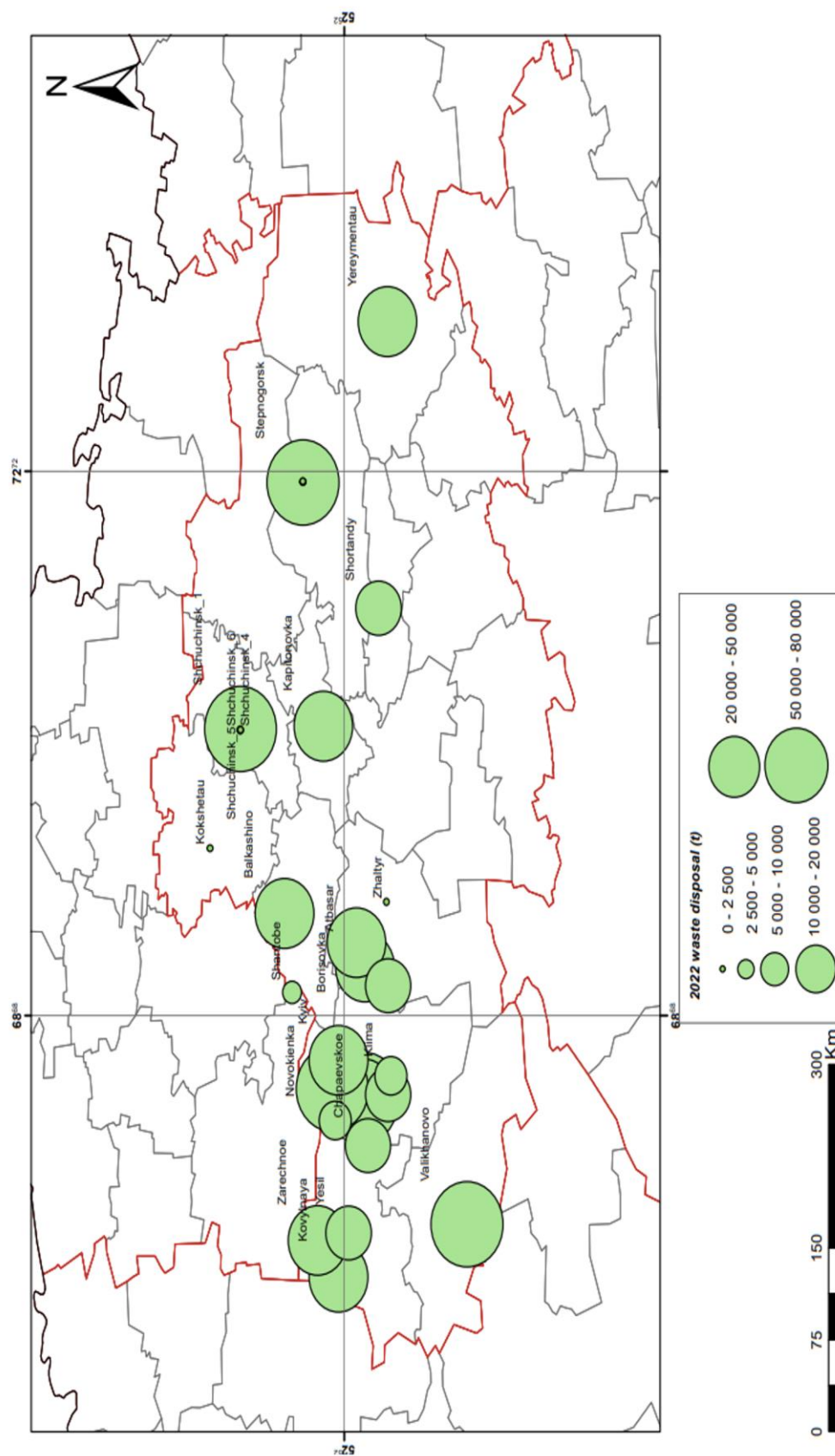


Figure S2. Annual disposal of waste in each landfill in 2022 (data in t)

Table S3 - Location of landfills in Akmola region and socio-economic characteristics of the regions

Nº	District	Landfill location	Population Nov 1 st 2022	Economic activity
1	-	Stepnogorsk	45,919	Mining: gold mining, uranium mining. Production of sulfuric acid
2	Burabay	Shchuchinsk	46,807	Factories: glass, non-metallic building materials, reinforced concrete, dairy, meat processing plant, clothing factory. The Borovoe resort is located 20km to the north-east.
3	Zharkai district	Valikhanovo	749	Large grain area, 99.2% of the crops were cereals and leguminous crops
4	Atbasar district	Atbasar	28,753	Railway junction, agricultural raw material processing center, flour production, bakery products.
5		Oktyabrskoye	792	
6		Borisovka village	920	
7	Zhaksyn district	Chapaevskoye	311	Agrobusiness and agriculture: agricultural production, processing and distribution to consumers
8		Belagash	942	
9		Kievskoe	535	
10		Novokienka	652	
11		Kiima	2659	
12		Kirovske	34	
13		Podgornoe	657	
14		Zaporizhzhya village	1899	
15	Yesil district	Zarechnoye	1220	Cultivation and sale of agricultural products, production of mixed fodder
16		Kovt. Kovyl'naya	523	
17		Esil	10,545	
18	Ereimentau district	Ereymtau	9130	Grain farming and animal husbandry (cattle, sheep, pigs, horses). Gold deposits Bestobe and Eshkolmes are being developed. Plants: crushed stone, reinforced concrete products, butter and bakery and others
19	Sandykktau	Shantobe	3543	Cultivation of fruit and berry products. Mothballed uranium mines
20	Shortanda district	Shortandy	6711	A polyethylene products manufacturing plant. Mining and processing facilities. Flour milling, agrarian, agricultural facilities. Facilities for the production of construction products
21	Astrakhan district	Zhaltyr Phase 1	4241	Livestock and crop production. Production of construction materials and furniture, maintenance of agricultural machinery. There are facilities for meat, dairy and flour industry
22		Zhaltyr Phase 2		
23	Bulandinsky	Kapitonovka	932	Cultivation of cereals, pulses, oilseeds and breeding of various animal breeds. Production of iron, sand, crushed stone, autoclaved gas blocks, wooden sleepers, rubber products
24	Sandykktau district	Balkashino	4813	Agricultural grain production, grain products, meat industry, sunflower oil production

Table S4 - Statistical data on licensed landfills in the Akmola region

Nº	District	Population centre	Operation period	Site area (m²)	Total waste capacity in the period (t)	Waste disposed in 2022 (t)	Location	Air pollutant emissions, (t/year)
1	-	Stepnogorsk	2019-2028	203,356	121,000	56,350	1.0 km from residential area. 5 km to the Aksu River	7765 / 862.8
2	Burabay	Shchuchinsk	closed in 2014 but still operational	54,000	500,000	76,370	2 km from the city border	No data available
3	Zharkai district	Valikhanovo	2018-2027	100,000	130,780	63,640	0.8 km from a residential area	179.63 / 18.36
4	Atbasar district	Atbasar	2010-2020	100,000	453,788	38,615	1.1 km from a residential area	No data available
5		Oktyabrskoye	2019-2026	100,000	42,718	19,218	1.1 km from a residential area	65.5228 / 8.19
6		Borisovka village	2016-2025	60,000	30,333	21,083	1.4 km from a residential area	1187.155 / 118.7
7	Zhaksyn district	Chapaevskoye	2019-2028	60,000	30,331	10,771	2 km from residential area	44.36/ 4.78
8		Belagash	2019-2028	60,000	192,780	72,123	1.15 km from a residential area	125.15/ 13.49
9		Kievskoe	2019-2028	60,000	69,329	24,725	1.6 km from a residential area 2.3 km from river	134.46 / 14.42
10		Novokienka	2019-2028	90,000	164,714	58,556	1.15 km from a residential area	252.46/ 27.12
11		Kiima	2019-2028	60,000	22,808	8108	1.3 km from a residential area	98.86 / 10.6
12		Kirovskoe	2019-2026	60,000	13,086	5,887	1.5 km from residential area 1.5 km from the Kumai River	12.67/ 7.52
13		Podgornoe	2019-2028	90,000	214,778	76,598	1.25 km from residential area 143 km to the Ak15kairakty river16	114.40/ 12.27
14		Zaporizhzhya village	2020-2024	100,000	28,081	16,067	0.5 km 17from a residential18l area	182/ 36.4
15	Yesilskiy district	Zarechnoye	2016-2025	43,000	46,572	32,600	1500 metres in the north direction from Zarechnoye village and 700 metres in the north-west direction from Dalneye village. North of the village of Zarechnoye and 700 metres north-west of the village of Dalneye	734.8/ 73.48

16		Kovt. Kovylnaya	2019-2023	45,000	60,780	48,624	1.0 km from residential area. 4 km to the Janyspai River.	30.44/ 6.09
17		Esil	2021-2030	70,000	108,951	18,391	1.4 km from the city border	-
18	Ereimentau district	Ereimentau	2019-2028	70,000	101,814	40,134	0.5 km from a residential area	1362.51/ 113.79
19	Sandykktau	Shantobe	2019-2028	30,000	7181.6	2609	1.4 km from a residential area	1362.9/ 126.8
20	Shortanda	Shortandy	2019-2028	100,000	30,380	11,476	3.2 km from the city border	817.69/ 222.16
21	Astrakhan district	Zhaltyr	2017-2021	100,000	91,637	69,897	2.2 km from residential area	311.93 / 62.4
22		Zhaltyr	2021-2030	100,000	144,662	22,984	2 km from the Boksuk River	231.46/ 24.11
23	Bulandinsky district	Kapitonovka	2017-2022	60,000	50,263	38,118	1.1 km from a residential area.	No data available
24	Sandykktau district	Balkashino	2020-2023	80,000	31,256	23,256	1.7 km from a residential area.	718.05 / 179.51

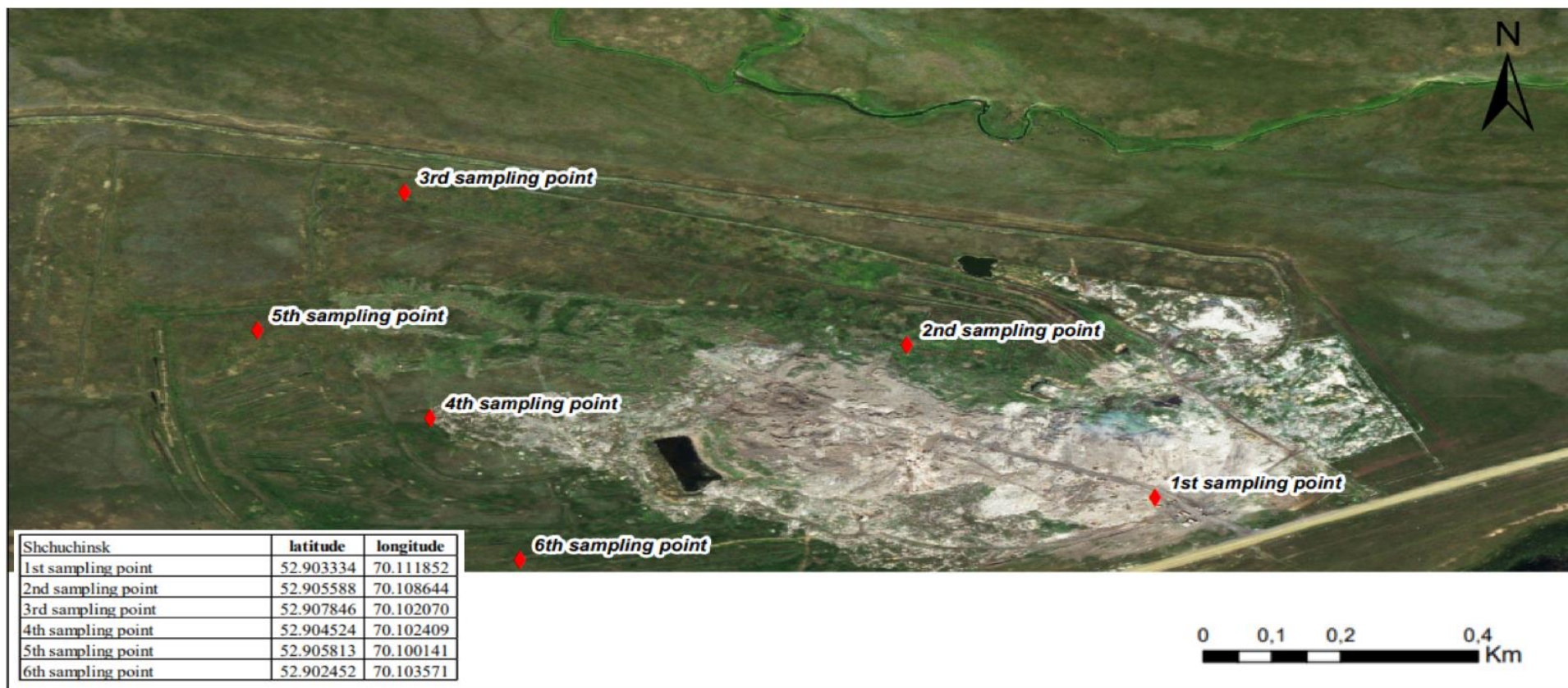


Figure S3.- Locations of sampling sites at the MSW landfill of Shchuchinsk

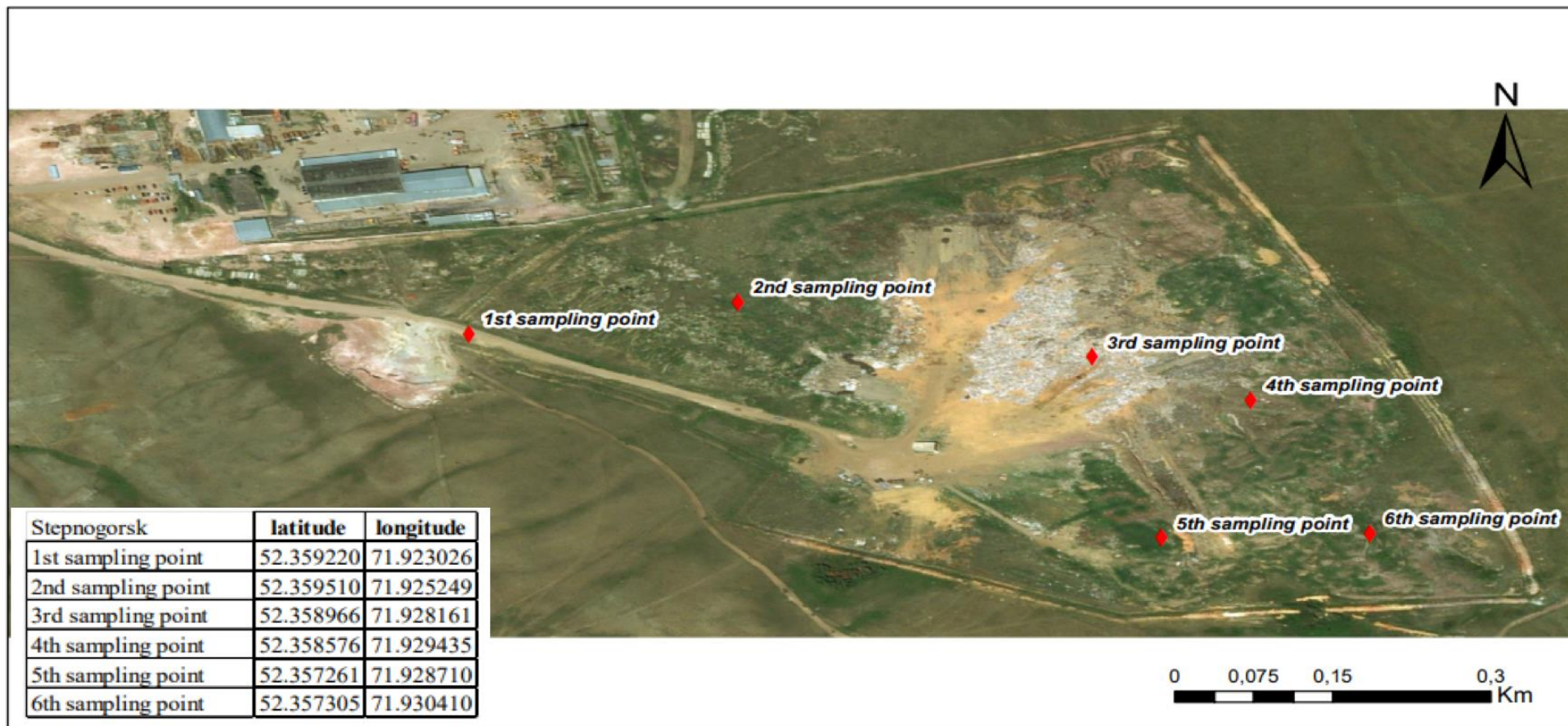


Figure S4 - Location of Sampling Sites at Stepnogorsk Landfill

