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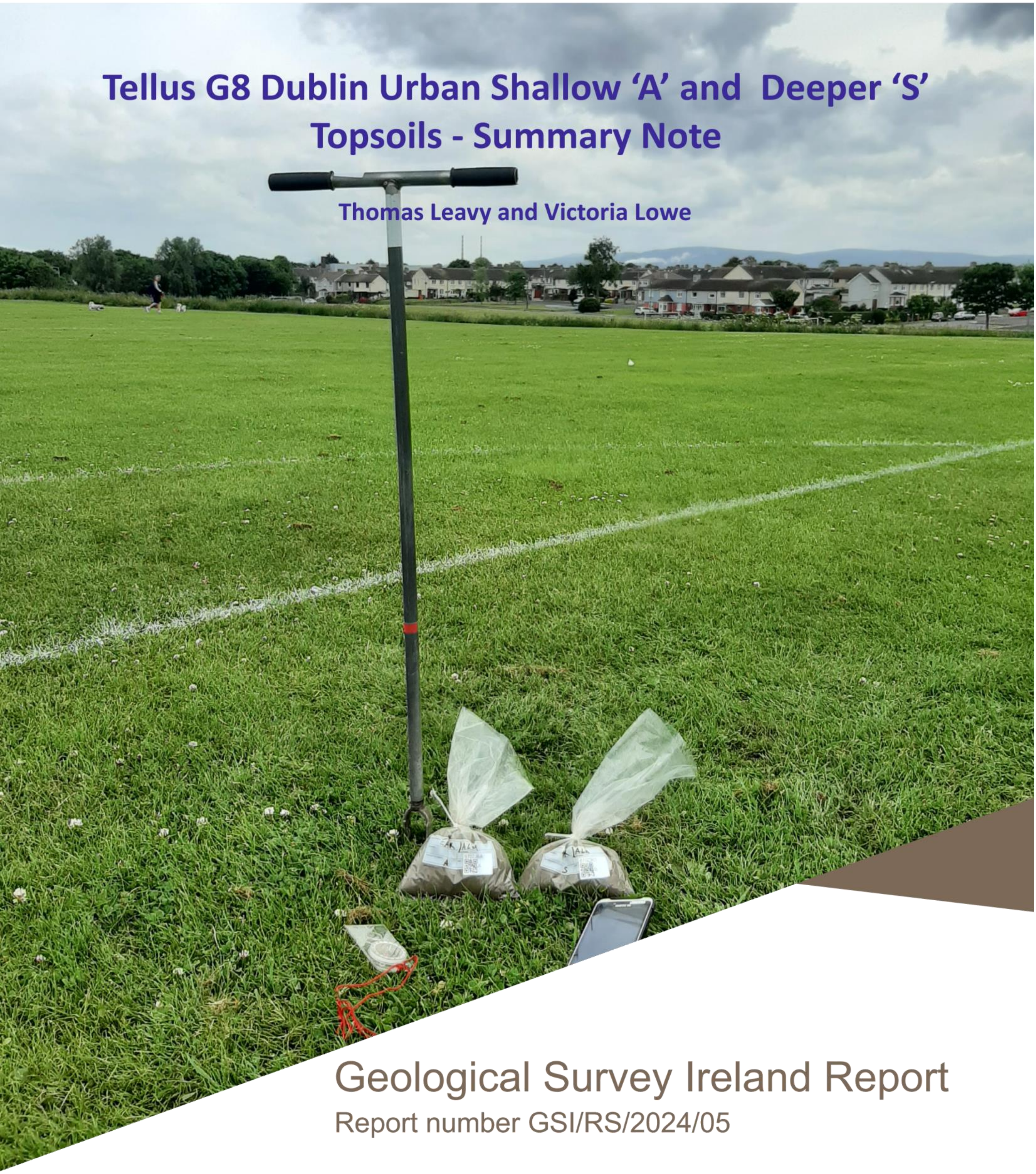
Tellus G8 Dublin Urban Shallow 'A' and Deeper 'S' Topsoils - Summary Note

Thomas Leavy and Victoria Lowe



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Executive summary

Geological Survey Ireland has completed geochemical mapping of Dublin city as part of the Tellus programme, Ireland's national mapping project. The city was part of the 'G8' block, with samples collected in 2021, and analysed in 2023-2024. In total, 877 sites were sampled, at a density of 0.25km^2, with two samples taken at each site, the first at a depth of between 0.05-0.20 m, designated 'A' samples, and the second between 0.35m – 0.5m depth, designated 'S' samples. These were then analysed for over 50 elements, pH, and Loss-on-Ignition (LOI). In general, the 'A' samples showed a stronger influence from anthropogenic activities, while the 'S' samples showed a stronger geogenic signature. Anomalies attributed to geological factors are seen at Howth Head and Bull Island in the northern half of the mapped area, along with the Leinster Granite in the south. Anomalies attributed to anthropogenic factors are prominent in the city centre, the docklands, and historic industrial areas. Recommendations for future work include an in-depth comparison to similar studies of the Dublin area, comparison with similar geochemistry surveys of other urban areas, detailed comparison between the 'A' and 'S' samples, and further research into the effect of historic land uses on the observed geochemical signatures.

Acknowledgements

Geological Survey Ireland and the Tellus geochemistry team gratefully acknowledge the efforts of all project partners, contractors and especially field samplers, and the kind co-operation of all landowners and stakeholders.

This publication is published with the approval of the Director, Geological Survey Ireland.

1. Introduction

1.1. Tellus Project

Tellus is a national programme to gather geochemical and geophysical data across the island of Ireland. The survey examines the chemical and physical properties of our soils, rocks and waters to inform the management of Ireland's environment and natural resources. The project is managed by Geological Survey Ireland and is funded by the Department of the Environment, Climate and Communications (DECC). See www.gsi.ie/Tellus for more information.

The Tellus geochemistry project began in 2011 in the border region, and aims to characterise the baseline chemistry of soils, stream waters and stream sediments across the country. Soil sample acquisition was completed in August 2024, with over 20,000 sites visited. Of these, 877 sites were in the Dublin Urban area, designated survey block 'G8'.

This report presents initial findings from the G8 Dublin Urban survey area. Key observations are made about the influence of both anthropogenic and geogenic factors on the geochemistry of the soils, and comparisons are made to previous soil geochemistry studies of the same study area.

1.2. G8 Dublin Urban Survey Area

Dublin is Ireland's capital and largest city, with a population of 1.2 million people (CSO, 2023). It is in the province of Leinster, on the east coast, and lies at the mouth of the river Liffey. It is bordered by the Dublin Mountains to the south, and flat farmland to the north and west.

The G8 Dublin Urban survey area is shown in Figure 1 below. It is largely bounded by the M50 motorway, and comprises Dublin city centre, and surrounding urban areas including Howth, Coolock, Finglas, Ballyfermot, Rathfarnham, Dundrum and Killiney – a total area of just over 200 km^2. The study area did not incorporate the whole of county Dublin. The following sections describe the land use history and the geological setting of the area.

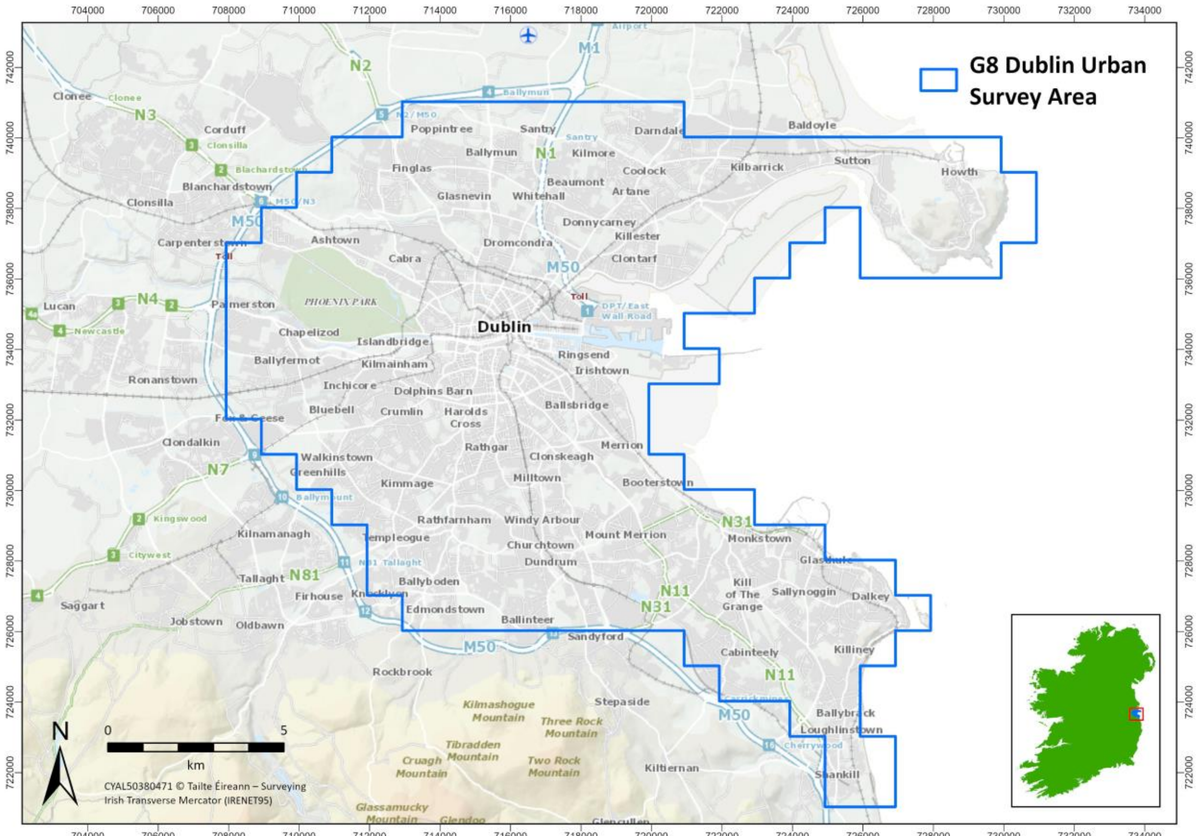

Figure 1: G8 Dublin Urban Survey Area

1.2.1. Land Use

In 2009, Geological Survey Ireland carried out the SURGE project, an urban geochemistry survey of Dublin city (Glennon, 2012). As part of this, Geological Survey Ireland tasked Carrig Conservation and Mary McMahon of the Urban Heritage Consultancy with producing a database of historic industry in Dublin (McMahon, 2011). This study aimed to identify potentially polluting historical industries in Dublin and their duration. It found that textiles were the main industry in Dublin throughout the 18th and 19th centuries, with over 124 sites related to the industry found throughout the city.

The second most important industry for Dublin was the drinks industry, with 21 breweries identified by the historical industry report. Many of these have since ceased, however Guinness is still brewed at the St James' gate brewery. There were many sites producing chemical products throughout the city. At the mouth of the river Tolka, vitriol (sulphuric acid) was produced and used in the textile industry to bleach linen. There were 6 soap factories identified, which also manufactured products for textiles. Another major chemical product was artificial fertiliser. Early production involved the crushing of bones and dissolving them in sulphuric acid, although mineral fertilizer eventually replaced this.

562 quarry sites were identified throughout county Dublin, mainly providing building stone for the city. There were 103 lime kilns and 2 lime works, which produced lime for use in agriculture and tanning of hides, among other uses. These quarries typically had forges for

making tools, as well as stores of gunpowder. Mining was also prevalent, with a copper and lead mine at Fingal and Loughshinny. Several lead mines were also identified at Howth and Castleknock.

In more recent times, Dublin has become an important transport hub, with the country's largest airport located to the north of the city. All major railway lines converge on the city at two major railway stations - Heuston and Connolly. The Dublin Area Rapid Transport or DART is the city's suburban railway network, consisting of one line running primarily along the coastline from Greystones, Co Wicklow in the south to Malahide in the north. The Luas is Dublin's tram network, with two interconnected lines running primarily in the city centre. There are numerous bus routes operated by private and state-owned bodies. Dublin Port is used for ferry transport and for the import/export of goods. Finally, road congestion is a problem in Dublin. Numerous motorways converge on Dublin, connected by the M50 ring road.

Figure 2 below shows the CORINE land cover map of Dublin (CORINE, 2018). Much of the study area is classified as discontinuous urban fabric, while the inner city and Dun Laoghaire are classed as continuous urban fabric. The rest is mainly industrial, with pockets of green urban areas including the Phoenix Park in the northwest and Marlay Park in the south. To the north, Howth Head has mixed land uses, while Bull Island is classed as intertidal flats and beach sand.

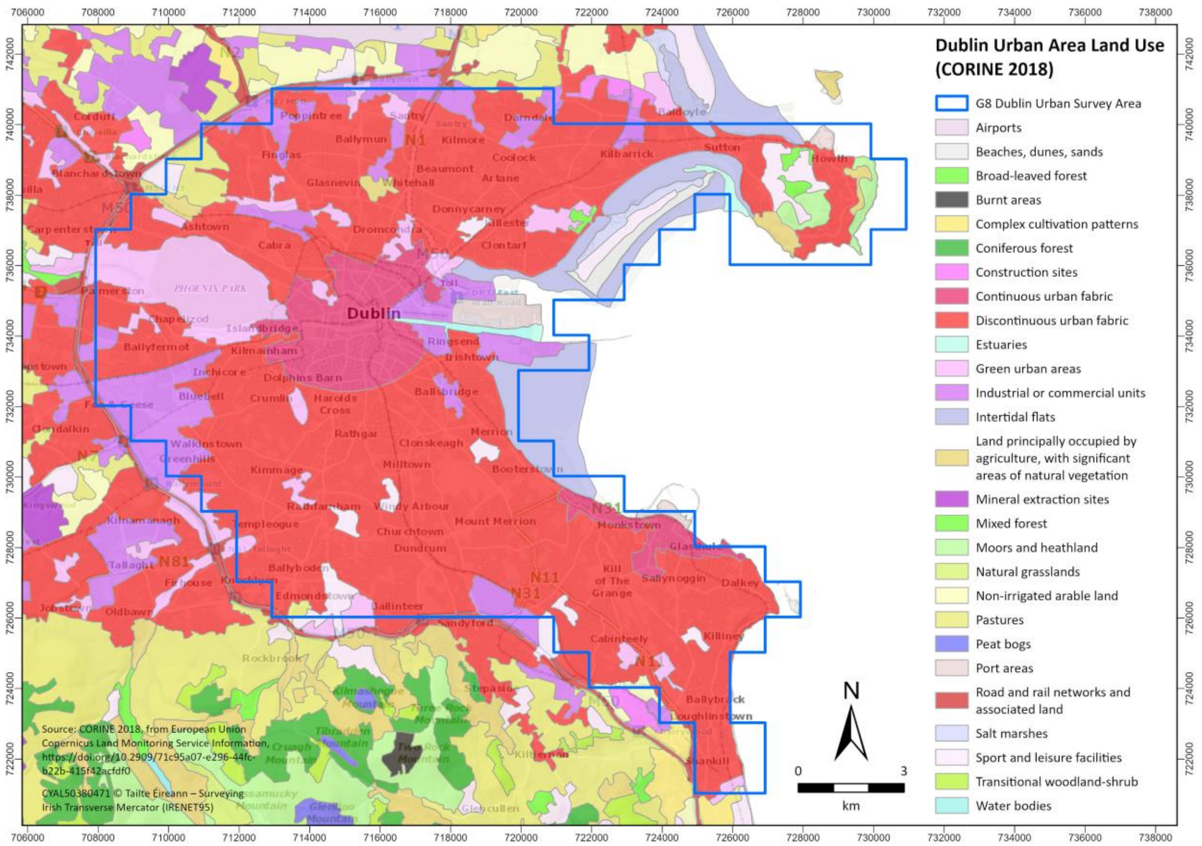

Figure 2: A map showing the land use of the Dublin urban area.

1.2.2. Bedrock and Subsoil Geology

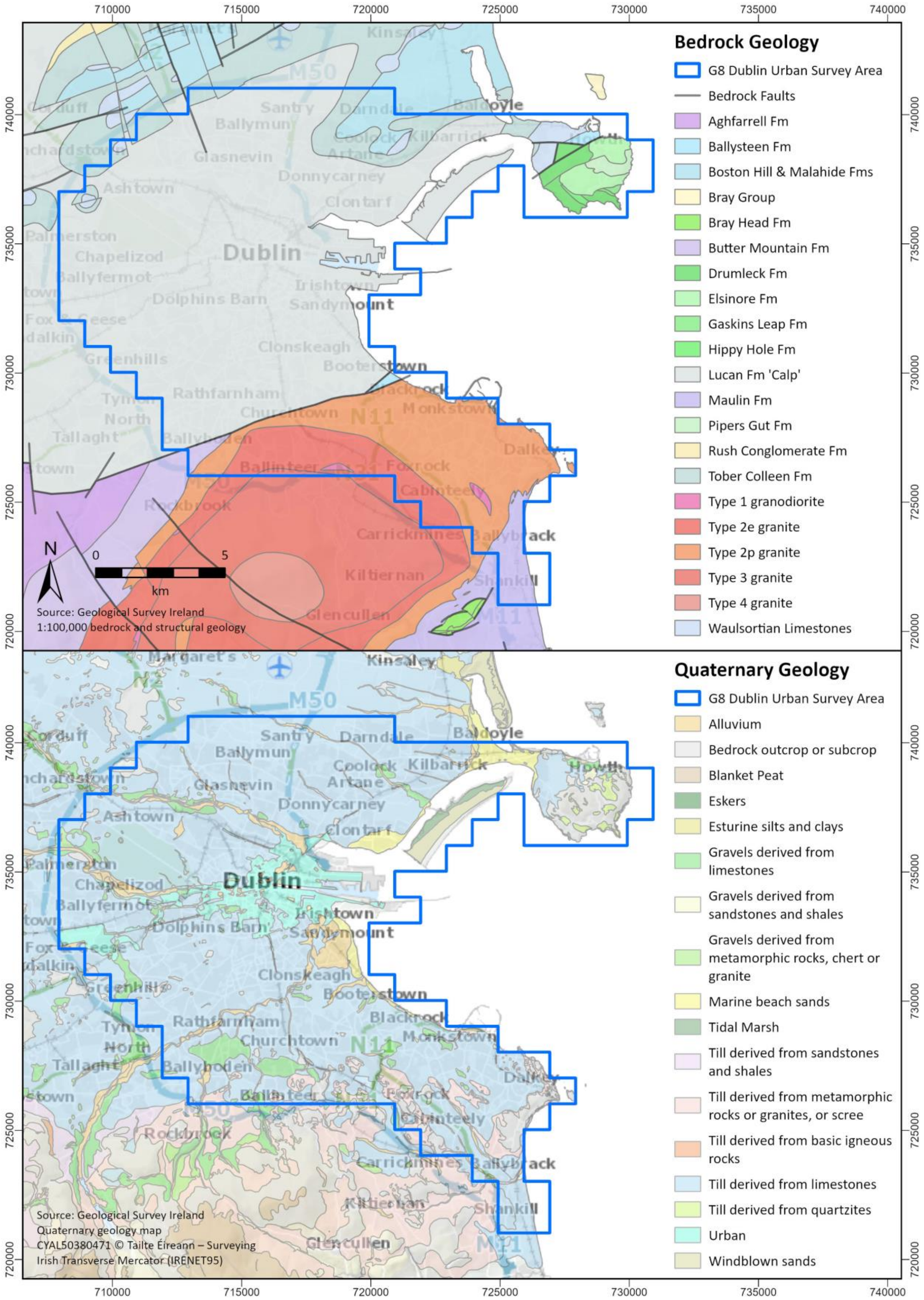

Figure 3: Bedrock geology map of Dublin (Top) and quaternary geology (bottom).

The bedrock and quaternary geology of the Dublin region is shown in Figure 3. The oldest rocks in the area are the quartzites of Howth Head, which date back 485 million years to the Cambrian Period. The second oldest rocks belong to the Leinster Granite, which help form the Wicklow Mountains. This granite dates back approximately 405 million years to the Devonian period and underlies the south of the study area. The final major rock unit of the study area is the Lucan Formation, which consists of dark limestones and shale. The formation covers much of the east and midlands of Ireland, ranging 300-800m thick in places, and dates to the Carboniferous period (298 million years ago). Waulsortian limestone (carbonate reefs) is seen in the northwest of the study area and also dates to the Carboniferous period.

The subsoil is primarily controlled by the bedrock geology, with glacial tills derived from limestone in central and northern parts of the city, and till or gravel derived from granites dominating in the south. Parts of the city centre are classed as urban soils. These are primarily soils that have been altered by human action and can contain a mix of natural and anthropogenic materials (e.g. rubble from construction). Another term commonly used is 'made ground'. There are alluvial deposits along the courses of the rivers Dodder, Liffey and Tolka. In Dublin Bay, Bull Island consists of sand dunes, estuarine silts and clays.

1.2.3. Previous Studies

The first systematic geochemical survey of the greater Dublin area was the SURGE project (Glennon, 2012). This aimed to generate a baseline dataset of soil geochemistry, to better inform planning and policy applications such as contaminated land and health risk assessments. A total of 1058 shallow topsoil samples (0 - 10 cm depth) were collected from randomly selected locations (Figure 4) and analysed for 31 inorganic elements including heavy metals. A subset of 194 samples were also analysed for persistent organic pollutants. The study found elevated levels of copper, mercury, lead and zinc in the inner city and industrial areas, which were attributed to anthropogenic activities. Conversely, the distribution patterns of several other inorganic elements, for example aluminium and lithium, were found to reflect the underlying bedrock parent material. The SURGE data can be found through this link.

Most subsequent studies focusing on the geochemistry of the Dublin area have utilised the SURGE dataset and built on the study's findings (e.g. Xu et al, 2023). However, the new Tellus G8 Dublin Urban 'A' and 'S' datasets are the only baseline surveys to be conducted since SURGE.

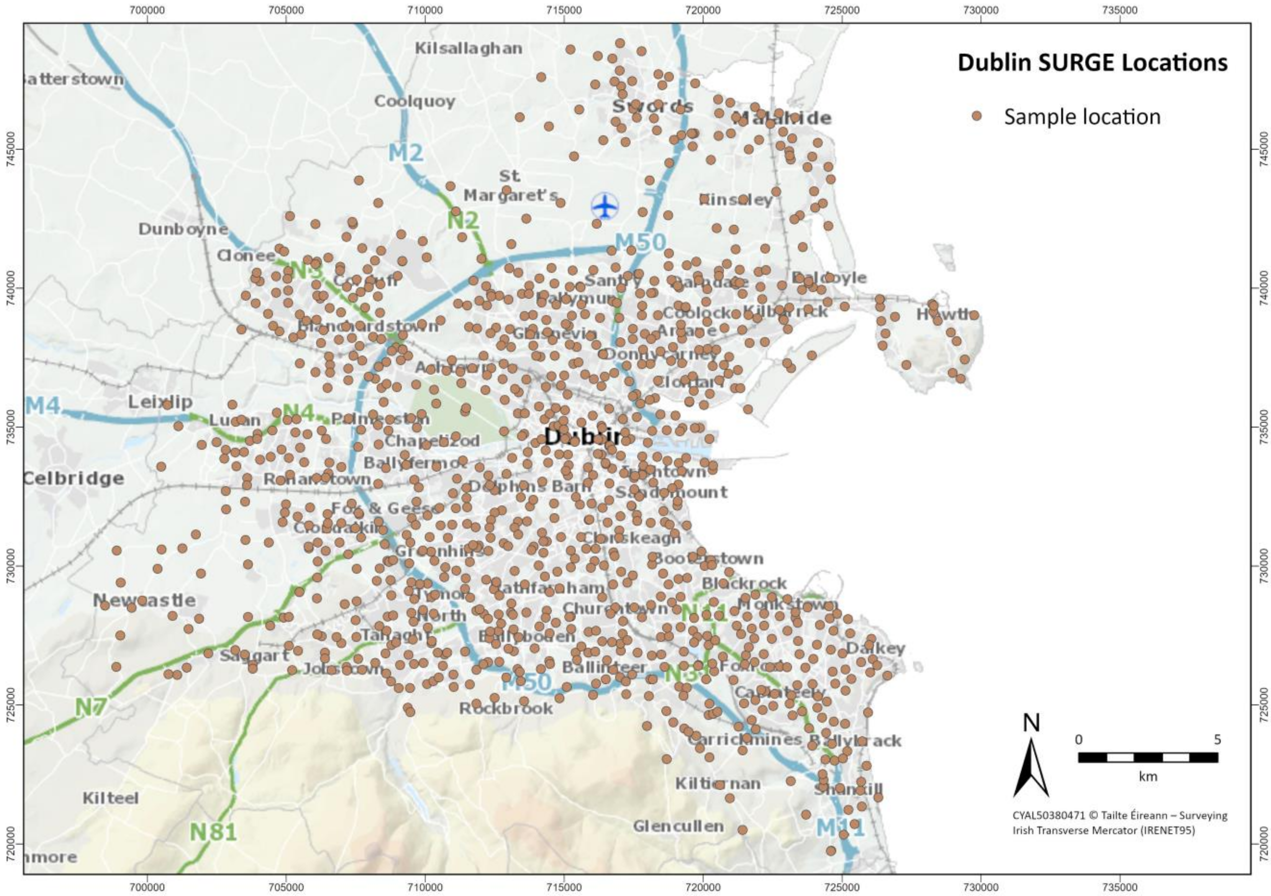

Figure 4: SURGE sampling locations.

2. Methodology

2.1. G8 Dublin Urban Sampling

2.1.1. Survey Design

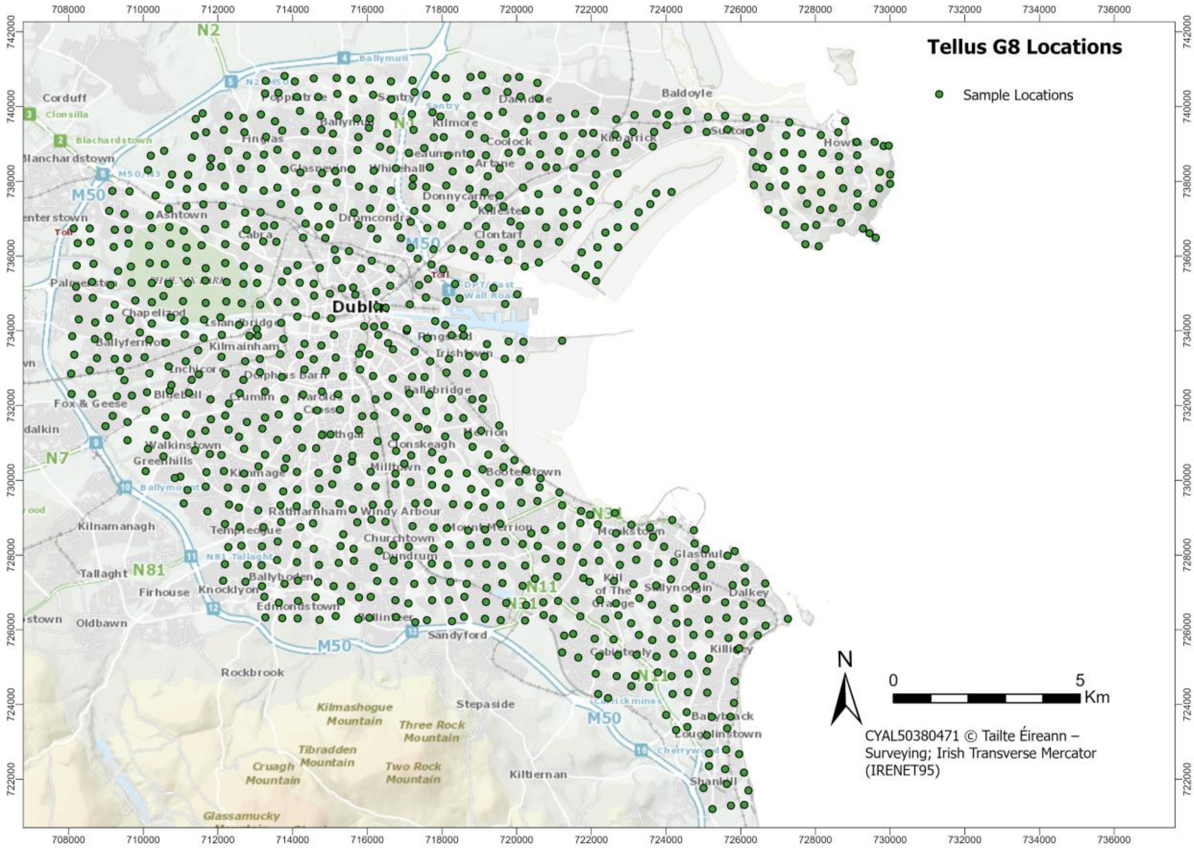

Figure 5: G8 sampling locations.

A map displaying the sample site locations is shown above in Figure 5. The survey design is based on a predefined fishnet grid of 0.5 km x 0.5 km cells, based on even easting and northing lines of the national projection co-ordinate system Irish National Grid (Geographic Coordinate System: GCS_TM65). Survey grid cells were planned using GIS. The result is a total of 877 sample sites from across the survey area, at a typical density of one sample per 0.25 km^2.

This incidence is sixteen times greater than the Tellus regional scale (one sample per 4 km^2) and four times greater than peri-urban scale surveyed in outer Dublin and Galway (at one sample per 1 km^2). A comparison of the different survey grid cell sizes is shown in Figure 6 below. Sampling at higher density allows for a greater resolution in geochemical data to assist in interpreting the more complex processes and influences present in the near surface urban environment.

Using similar sampling methods, sample depths and analytical methods to the regional Tellus soil survey will allow for the G8 data to be compared with the regional geochemical baselines. This will further assist the delineation between geogenic and anthropogenic signatures and sources in the urban soils.

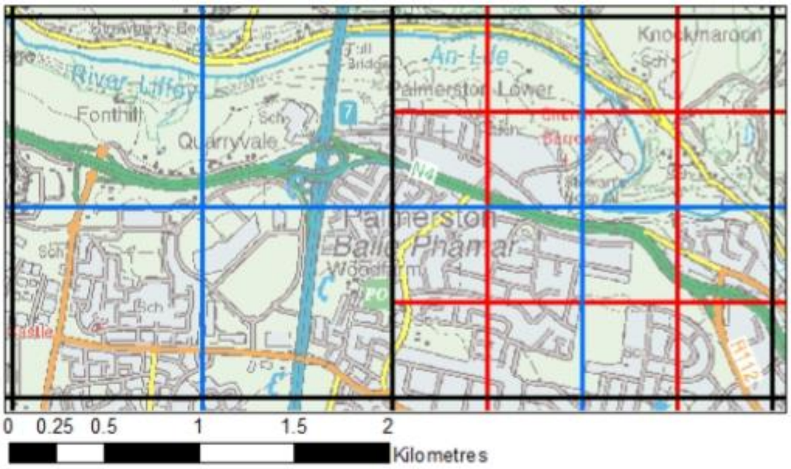

Figure 6: Comparisons of survey grid cells at different densities (black outline shows regional scale, blue outlines peri-urban and red outlines the urban scale)

2.1.2. Sample collection, analysis and QAQC

Two soil samples were taken at each site using an auger: a shallow topsoil from a depth interval of 0.05-0.20 m (designated 'A' samples) and a deeper topsoil from 0.35-0.50 m (designated 'S' samples). All soil samples were prepared in a trace-level facility without the use of metallic or otherwise potentially contaminating apparatus. Sample preparation was conducted at ALS Minerals Ltd. in Loughrea, Ireland. Samples were dried at 30 ˚C before being sieved and disaggregated to <2mm. They were then milled to <32µm, and different splits were created for loss on ignition (LOI), ICP-MS, and future XRFS analyses. Sample splits of coarse fraction (<2 mm) fraction were also prepared for pH analysis. Sampling methodology, sample preparation, analysis and quality control measures are fully described in the G8 'A' and 'S' QAQC reports (Gallagher, V., 2024a) (Gallagher, V., 2024b), which are available on the geochemistry data download page of the Geological Survey Ireland website (www.gsi.ie)

2.1.3. Mapping

Several maps are shown in this report which have been created using the Inverse Distance Weighted (IDW) method, which creates a classified surface using a linear weighted set of sample points. The further away a sample point is from a processing cell, the less influence it will have on that cell. The maps utilise percentiles and suggested interpolated mapping parameters given in the G8 'A' and 'S' QAQC reports (Gallagher V. , 2024a) (Gallagher V. , 2024b), and were generated for selected elements of interest based on an initial review of point data and with reference to findings from previous studies. The aim is to reveal patterns in the distribution of elements that may be attributed to either anthropogenic or geogenic sources. Readers are cautioned that other interpolation methods (e.g. kriging, spline) and different parameters may be more suitable for mapping depending on the application of the published data and purpose of work.

3. Key Observations

3.1 Geogenic signatures

The concentrations and spatial distribution of various elements are seen to reflect underlying bedrock, parent material and/or geogenic processes in several areas. Geogenic signatures are most apparent at Howth Head and Bull Island in the northeast of the survey area, south Dublin, and around the periphery of the survey area, particularly towards the northwest. Here we discuss five elements of interest that highlight these observations.

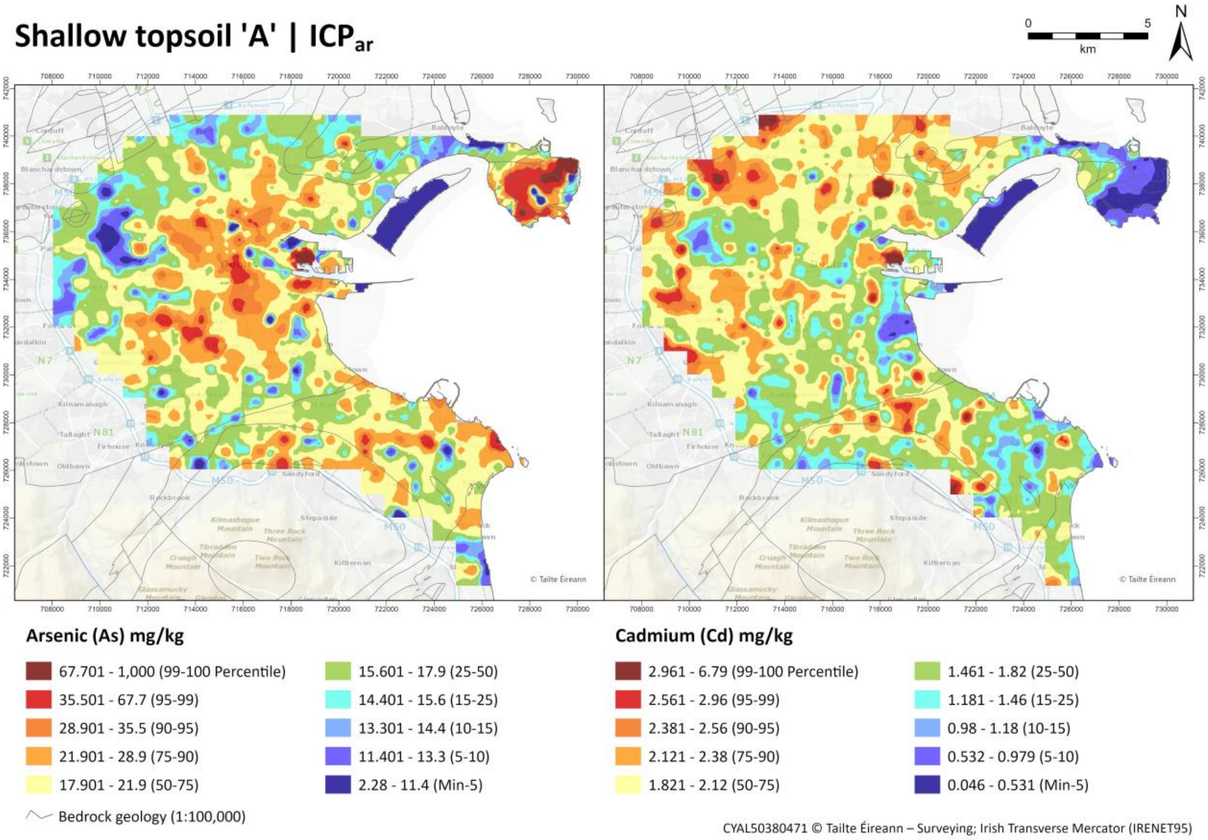

Figure 7: IDW maps showing Arsenic (left) and Cadmium (right)

3.1.1. Arsenic (As)

As can be seen in Figure 7 above, Howth Head appears as an area of elevated arsenic levels. This was also noted in the SURGE report, and is likely a result of the quartzites, argillaceous limestone, greywacke and shale that underlies Howth Head. Arsenic tends to be associated with sulphide bearing minerals (Madhavan, 2000), and the rocks of Howth Head are known to contain occurrences of the sulphide mineral arsenopyrite (FeAsS). This is likely the cause of the elevated concentrations of particular points in the northeast. The map also highlights the faulted boundary between these Cambrian quartzites on Howth Head, and the younger Carboniferous limestones to the west.

In the south of the study area, metamorphism associated with the Leinster Granite intrusion has also led to the creation of sulphide deposits (Kennan, 1986). There are elevated arsenic levels around Killiney, Blackrock, and Dundrum, which may partly be associated with mineralisation. Arsenic can also be associated with lead ores, which were historically mined in south Dublin, such as at Ballycorus. (Kennan, 1986, Normoyle, 2006)

Towards the city centre, elevated arsenic levels are interpreted as anthropogenic in origin, with possible sources including coal burning, pesticides, paint products, manufacturing and other industry.

3.1.2. Cadmium (Cd)

Cadmium is a relatively rare metal in Earth's crust, occurring primarily as a trace element in zinc, lead, and copper ores. (International Cadmium Association, 2021). The cadmium map in Figure 7 shows elevated concentrations to the northwest of the study area, which is underlain by impure Carboniferous limestones and shales of the Lucan Formation. This formation covers much of the east and midlands of Ireland and is the host to one of the world's largest zinc mines at Tara (Boliden, 2021), as well as other smaller Pb-Zn deposits. Perhaps the elevated cadmium levels seen here are related to similar mineralisation. The Soil Geochemical Atlas of Ireland (Fay, 2007) reported elevated Cd levels in Dublin, Kildare, and Meath, as did the Dublin Boulder Clay (DBC) project (Gallagher et al, 2022b). Both reports attribute it to the underlying impure 'Calp' limestones. A study into Cadmium levels in agricultural and grazing soils of Europe reported similar findings. (Birke et al, 2017)

Also of note are the much lower levels of Cd in the Cambrian quartzites of Howth Head. Other more isolated areas of higher-than-average concentrations are likely the result of anthropogenic activities.

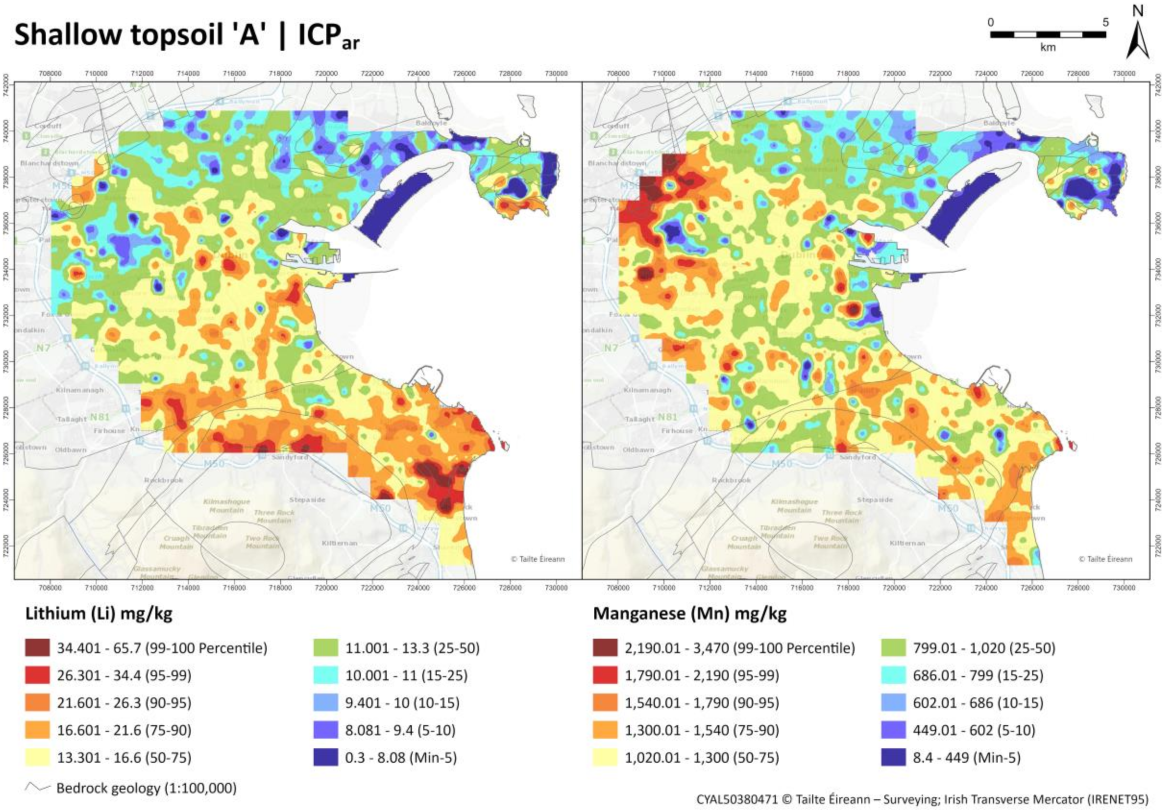

Figure 8: IDW maps showing Lithium (left) and Manganese (right)

3.1.3. Lithium (Li)

As can be seen in Figure 8, lithium concentrations are elevated to the south. This was also reported in the Soil Geochemical Atlas of Ireland (Fay, 2007), and in the SURGE report (Glennon, 2012). Since the 1970s, southeast Ireland has been the subject of mineral exploration for lithium. The Leinster Granite contains spodumene ($LiAl[SiO_3]_2$), a mineral containing 4% lithium (Geological Survey Ireland, 2021). This spodumene occurs in pegmatite dykes found along the eastern boundary of the Leinster Granite (Barros & Menuge, 2016). In 1990, Geological Survey Ireland completed a stream sediment survey of the Leinster Granite, which were reanalysed in 2014 (Gallagher V. , 2021). The results show lithium concentrations above the 99th percentile in the north of the Wicklow Mountains, not far from south Dublin, and it's possible that there are some pegmatites containing spodumene in the study area contributing to the lithium signal. The SURGE project sampled further south than the Tellus Project, and it had similar findings.

Relatively low concentrations of lithium are seen in soils to the north of the area, which is underlain predominantly by calcareous rocks. On the south side of Howth Head, elevated lithium levels may be attributed to anthropogenic activities.

3.1.4. Manganese (Mn)

Manganese tends to be high in soils or rocks with high clay content (Teagasc, 2017), such as those seen in the west of the study area. The geology map in Figure 3 above shows limestone and shale along with Waulsortian limestone further west. These impure limestones are high in clay content, which may be the source of the elevated manganese seen here.

There has been several boreholes drilled in the area, which are available on the GSI website data viewer (Geological Survey Ireland, 2024). Analysis of the logs from these boreholes suggests some dolomitization has occurred, particularly borehole AD-11 (Lat 53.4016905, Long -6.3444846) which notes reef limestone at a depth of approximately 6 metres that has been heavily dolomitized. Although this process is usually caused by magnesium ions replacing calcium ions, manganese can take the place of magnesium, and may be the cause of the elevated concentrations. In the southeast of the study area, slightly elevated manganese levels may again be associated with mineralisation resulting from the Leinster granite. Other spot values seen throughout the city are likely anthropogenic in origin.

3.1.5. Calcium (Ca)

The calcium signal is not as strong as other elements discussed. In Figure 9 below, the limestone bedrock of the centre, north and west of Dublin has resulted in a moderate but widespread calcium signature, while values are low in the south over the Leinster Granite and on Howth Head over the Cambrian quartzite.

On Bull Island, a slight calcium signature can be seen, unlike the majority of the other elements which show generally low concentrations. This is likely down to the fact that Bull Island is a man-made island, resulting from the creation of the Bull Wall in 1825. This wall prevented silting in Dublin’s port area, diverting much of the sediment northwards and creating Bull Island. Its lack of underlying bedrock means elements such as those previously discussed are low with the island consisting of mostly sand, silt and clay. Interestingly, the calcium signature is slightly stronger on the eastern side where it is exposed to the sea and may be the result of deposition of marine shells and debris.

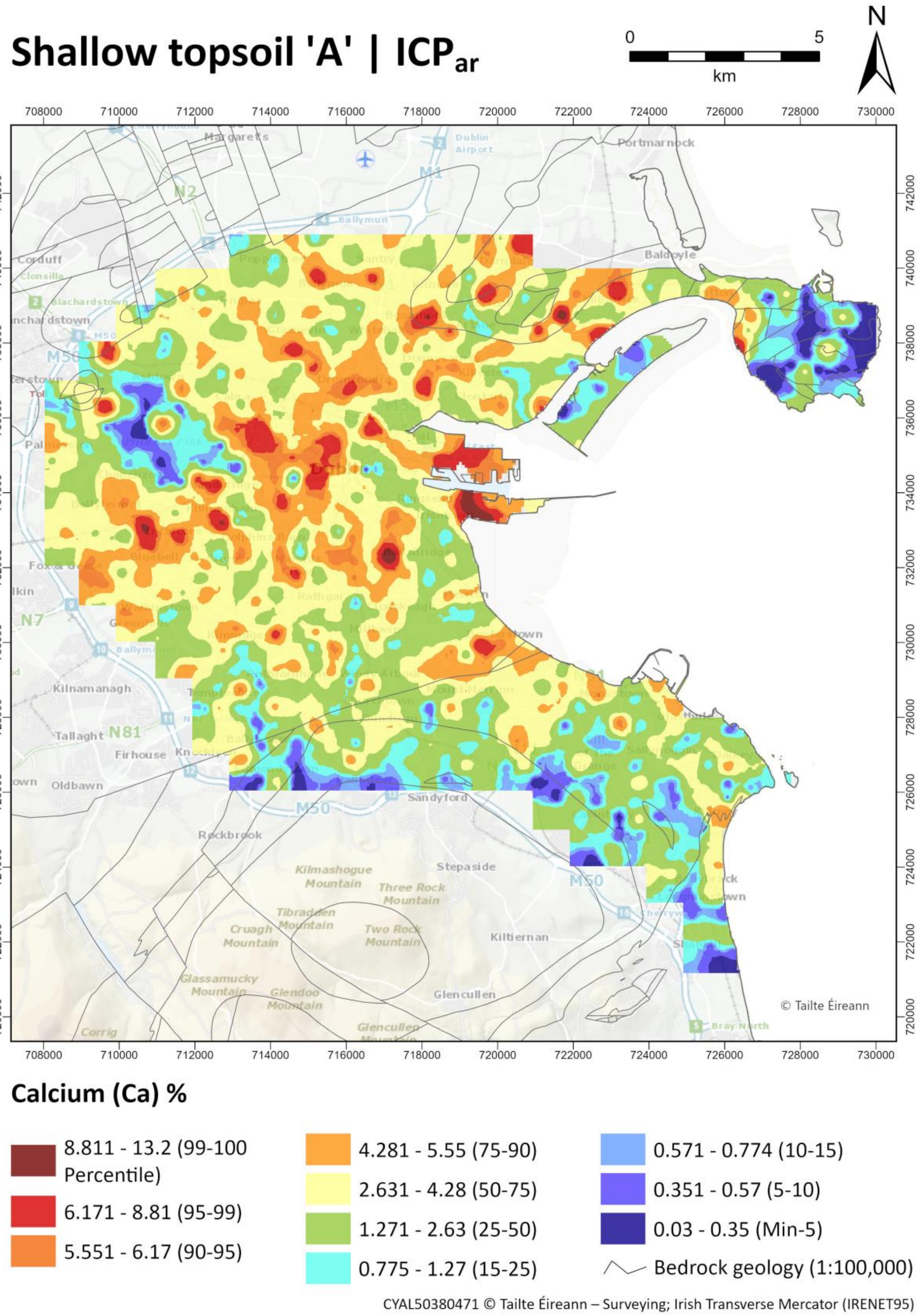

Figure 9: IDW Calcium map.

3.2 Anthropogenic signatures

The centre of Dublin tends to show elevated concentrations for a number of elements, which then decrease with distance from the city centre, creating a 'bullseye' effect. Other hotspots are located throughout the city, including Dublin port, Howth Head, and other industrial areas. Here, five elements that illustrate these trends are discussed.

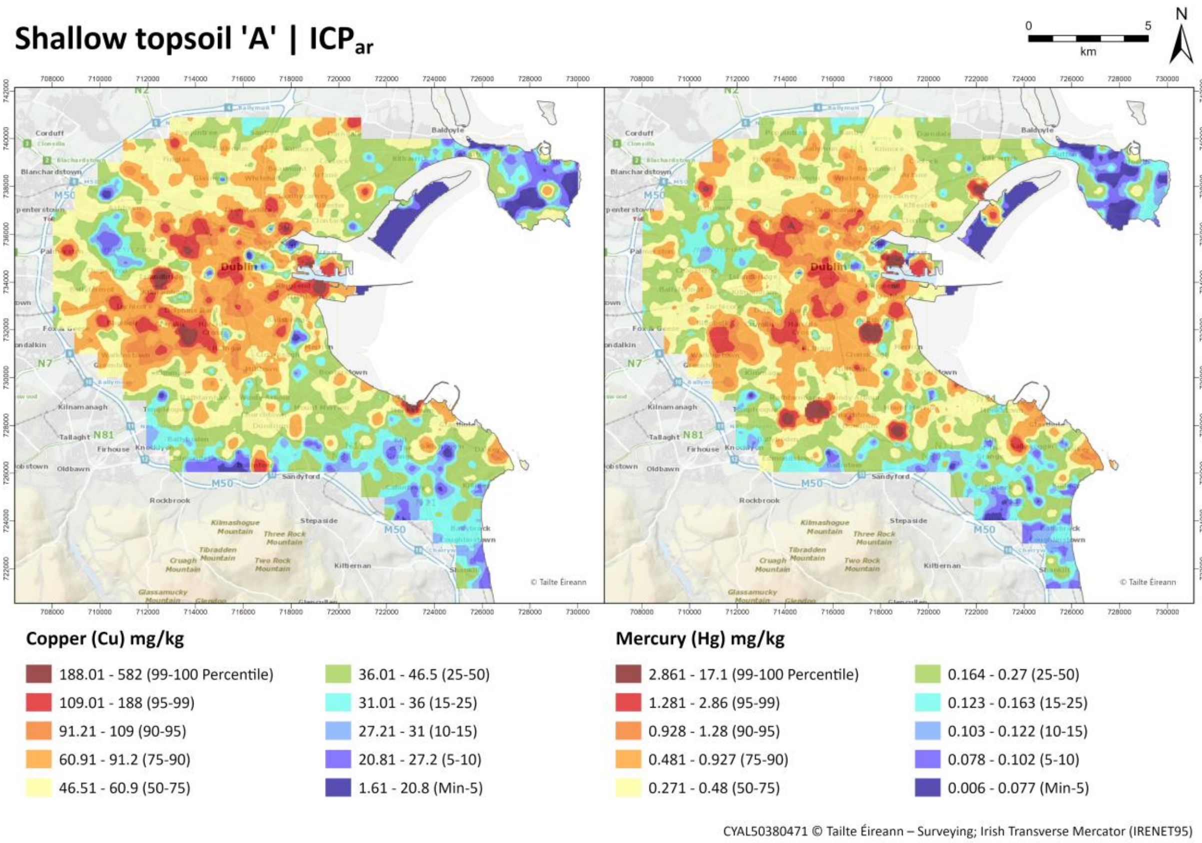

Figure 10: IDW maps showing copper (left) and mercury (right)

3.1.6. Copper (Cu)

Copper concentrations are highest in the city centre, with this being the oldest area of Dublin and so has been exposed to anthropogenic activities longer than surrounding areas. Concentrations generally decrease with distance from the city centre, although there are certain areas of elevated values e.g. Crumlin, to the west of the city centre. This is quite an old area of Dublin, with a long history of habitation and industry. A refuse tip is marked on the first edition Ordnance Survey 6-inch maps (Tailte Éireann), which date from 1829-1834. The refuse tip is marked in Figure 11 below, which suggests a potential correlation between the refuse tip and the high Cu anomaly of over 188 mg/kg.

The Dublin Port area also displays elevated copper values, with concentrations in the 99th percentile. The port has a long history of human activity, dating back 300 years (Dublin Port Company), and is a likely cause of the high concentrations. The docklands were also an area of significant land reclamation, with construction rubble and industrial waste commonly used as infill material, as was ash from coal burning.

Coal burning is a significant source of copper and other contaminants. In the 1990s, a ban on the sale and distribution of bituminous coal (smoky coal) was introduced to combat black smog issues in Dublin. Coal had been the main energy source for industry, with many factories located around the port through which coal was imported (McMahon, 2011). This may contribute to the elevated copper values seen around the docklands and in the city centre.

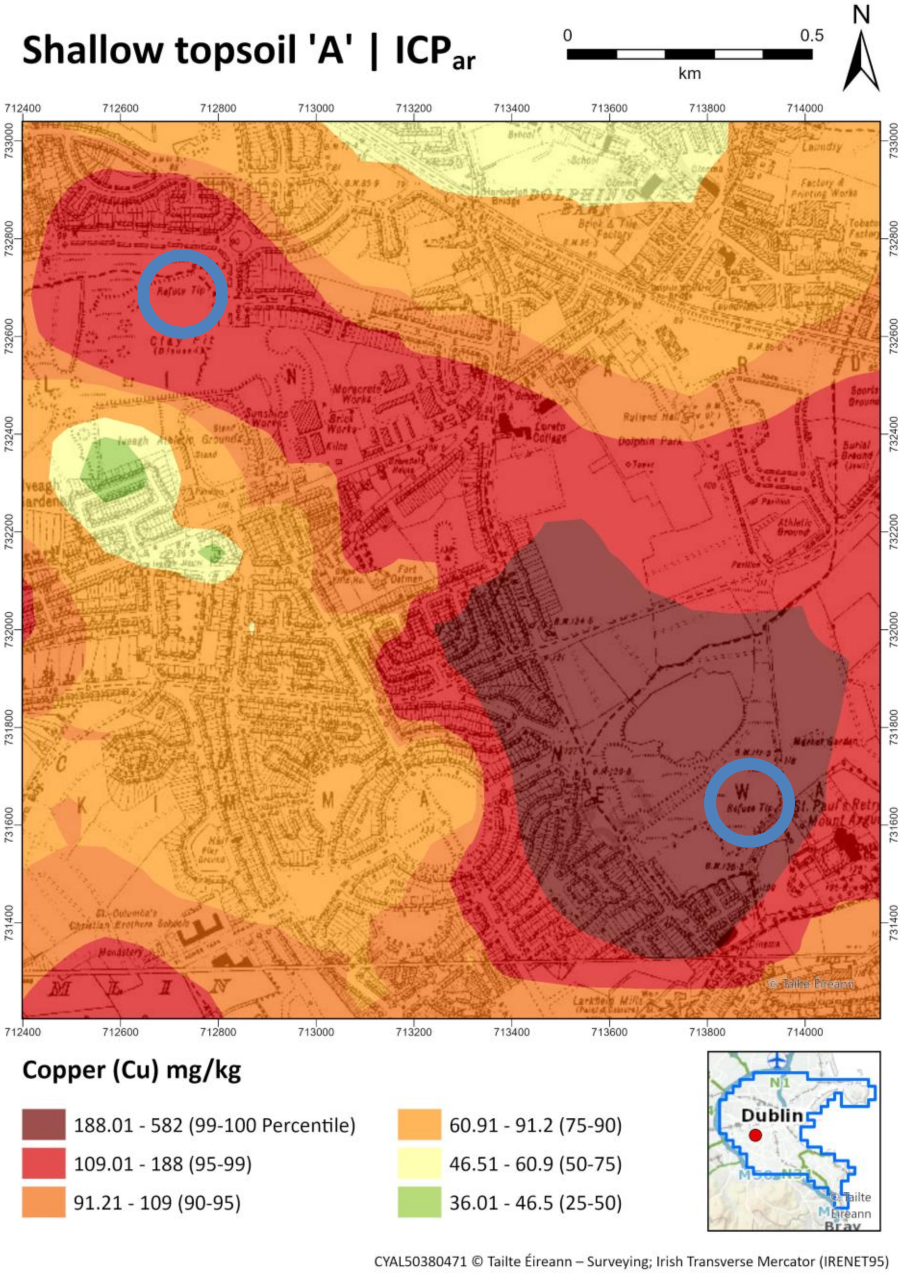

Figure 11: The last edition six-inch maps overlain with the Cu concentrations from this study. The historical map shows refuse tips (circled), which may correlate with the elevated Cu levels in the area.

3.1.7. Mercury (Hg)

Mercury concentrations are highest in the city centre and decrease outwards from here. Bull Island was typically low in nearly all elements as previously mentioned. However, the mercury map in Figure 10 shows an anomaly which is likely a modern, localised point source contamination. The signal may be from traffic on the road connecting Bull Island to the mainland, as vehicles can emit mercury through exhaust fumes and wear-and-tear of parts.

Like copper, coal burning is also a major source of mercury and has likely contributed to the strong signal seen in the city centre, which has a long history of human activity. Infilling of areas for land reclamation and unregulated waste disposal may also be a source of mercury.

Mercury concentrations above the 99th percentile in Ballsbridge may be attributed to the bleach mill, which is marked on first edition 6-inch maps. Mercury was used in the process to make chlorine (Czaika, 2013), which was commonly used in the textile industry to bleach cotton and linen, and so it's possible this is the source of mercury in the area. Figure 12 below shows the location of the historic bleach mill (circled)

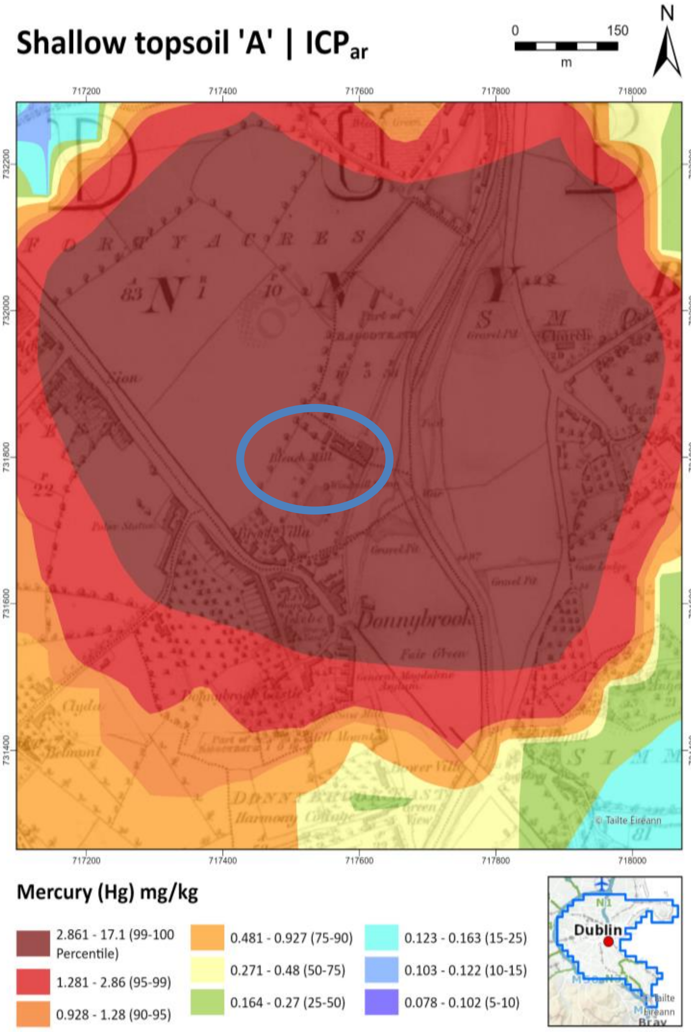

Figure 12: The first edition six-inch map overlain with the Hg concentrations from this study. The historical map shows the bleach mill in Donnybrook, with the mercury anomaly overlain.

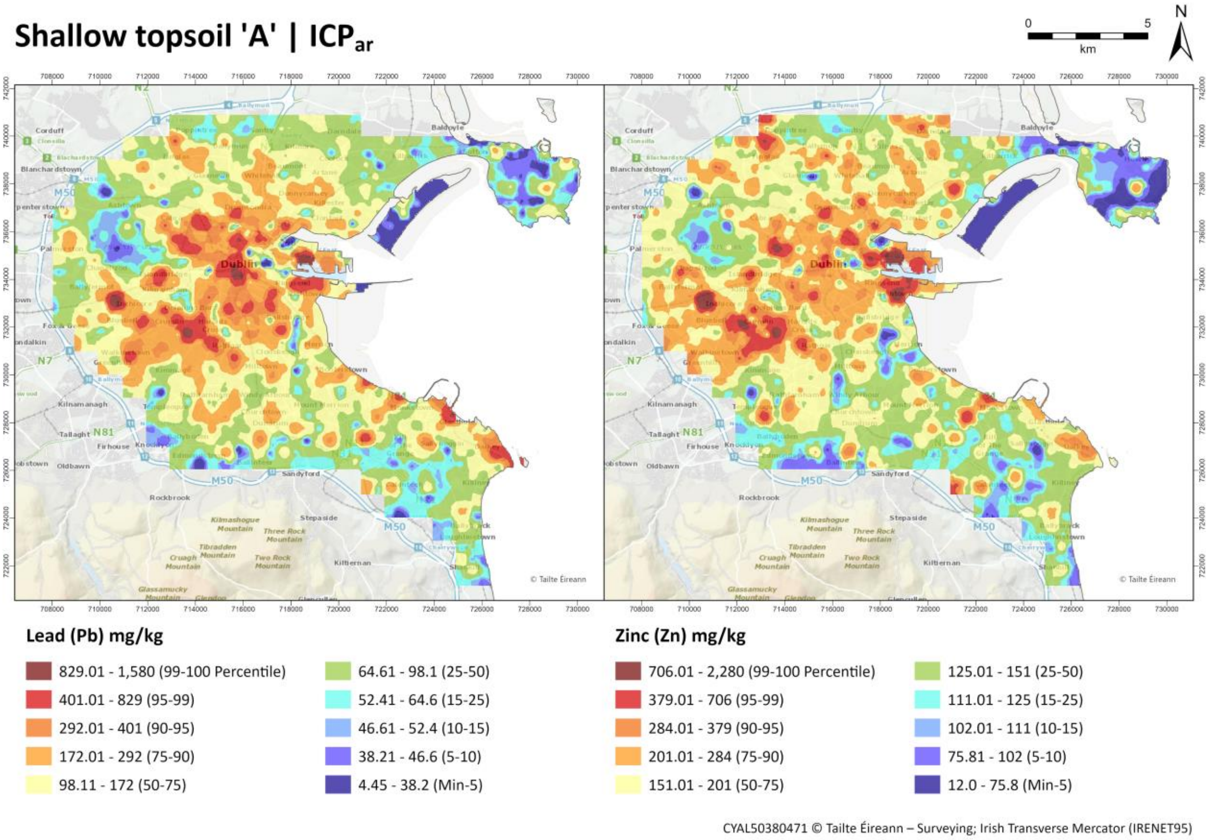

Figure 13: IDW maps showing Lead (left) and Zinc (right).

3.1.8. Lead (Pb)

The lead signature again shows the 'bullseye' pattern, with high concentrations in the city centre. Lead was a common additive in petrol, and so it can be prevalent in areas that experience heavy traffic. Lead was used in water pipes and roofing, which may end up as fill material in reclaimed ground. Pesticides and lead based paints can also be weathered and release lead into the environment, although lead based products are now banned.

Outside the city centre, areas with long histories of human settlement such as Killiney, Blackrock and Howth Head show elevated lead concentrations. The lead signature on Howth Head roughly follows the roads, and so again may be linked to traffic. The same can be said for the access road to Bull Island. High concentrations in Crumlin may be associated with industry.

There may also be a geogenic source of lead. Geological Survey Ireland records show lead mineral occurrences throughout Dublin, in both the Lucan Formation and along the margin of the Leinster Granite. Galena (PbS) is a lead ore that can be found on the shore at Killiney and was historically mined and smelted at Ballycorus, just south of the study area. Other lead mineral occurrences are to be found at Dalkey, Kilmainham and Clontarf (Cowman, 2001)

3.1.9. Zinc (Zn)

Sources of zinc in urban areas can include burning of fossil fuels, wearing of tyres and refuse incineration. Unsurprisingly, the city centre shows high levels of zinc, particularly Dublin Port and docklands, likely down to the long history of heavy industry and large areas of made ground. A similar anomaly can be seen on the southwest side of Howth Head, where the first edition 6-inch map shows a manganese and lime works with three surrounding quarries. It’s possible this is the source of the elevated levels; however, it may also be a more modern signal related to a nearby road and boatyard.

A high zinc anomaly can be seen at a rail depot in Inchicore. Since the 1800s, trains and carriages have been maintained here, which may be a possible source of contamination. This is supported by one study which found that railway transport is a source of Zn, Cd and Pb (Vaiškūnaitė & Jasiūnienė, 2020). Figure 14 shows the first edition 6-inch map with the zinc anomaly overlain.

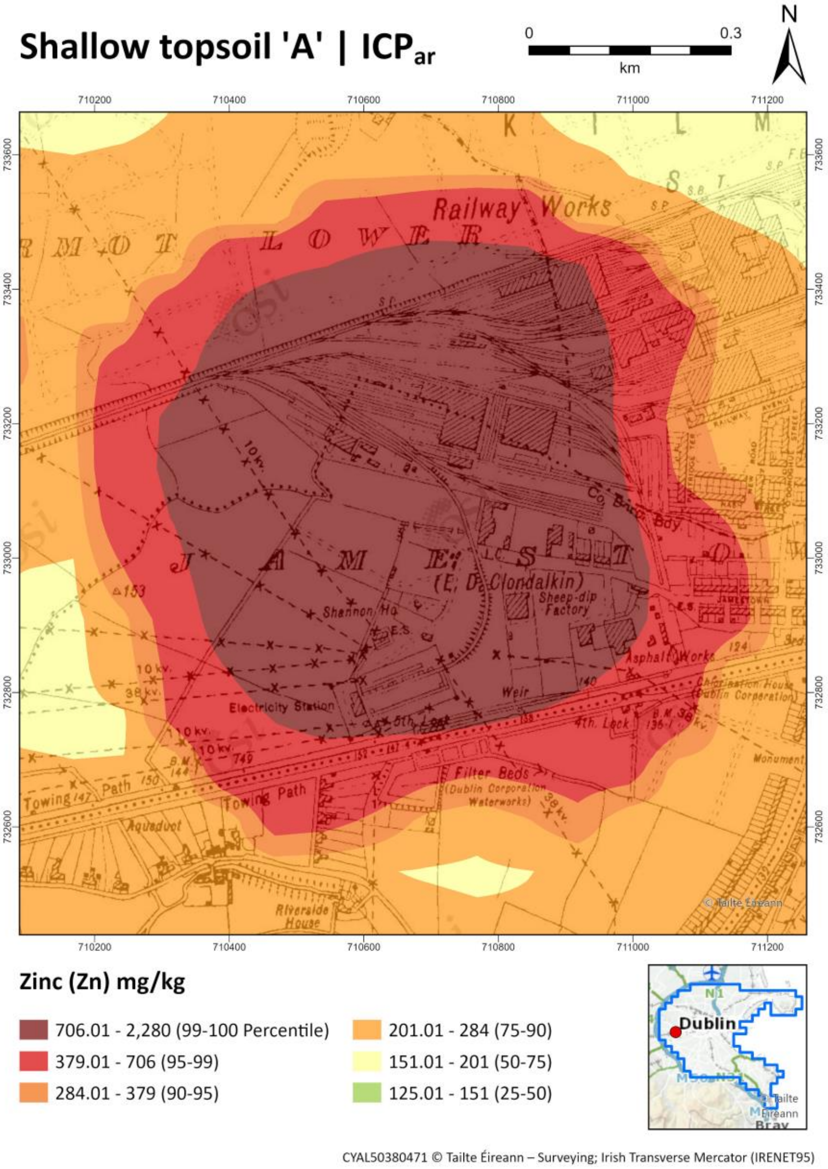

Figure 14: A map showing the old rail depot, with the zinc anomaly overlain.

The Soil Geochemical Atlas of Ireland (Fay, 2007) noted that zinc levels were high across counties Meath, Westmeath, Kildare, and Dublin, attributing it to high zinc levels in the Dublin Basin Limestone. Towards the far northwest, there is a possible geogenic zinc signature, which may be similar to cadmium. As previously mentioned, cadmium can be an impurity in lead and zinc ores and there may be a possible zone of mineralisation here like what is seen in the limestones of the midlands and northeast. Zinc is also to be found in mineralisation associated with the Leinster Granite in the south of the study area.

In all the anthropogenic signatures discussed, an obvious trend can be seen in the Phoenix Park. Samples from here were typically low in all element concentrations and this is likely because it is a managed park, with different land uses compared to the rest of the Dublin area. A similar island affect can be seen in Marlay Park to the south.

3.3 SURGE Comparison

It is difficult to make a direct statistical comparison between the Tellus survey and the SURGE project, as both projects used different sampling, preparation, and analysis methods. Despite this, the spatial patterns of both are largely similar. Similar findings were made relating to elevated concentrations in the city centre and at the port, with the 'bullseye' pattern evident in both projects. The results for cadmium and copper were particularly similar.

There are however localised differences. One such example is the mercury anomaly on Bull Island, seen in the Tellus results but not the SURGE results, likely due to a very local source. The north side of the docklands shows elevated arsenic levels in the Tellus results, which are not seen in the SURGE report. This may be a result of the samples being taken in different areas, with certain areas being exposed to higher levels of local contamination from industry for example. There are also differences between the two zinc maps from both projects.

From the Tellus results, probable geogenic signatures were identified on Howth Head and in the south of the city towards the Dublin mountains. Given that the SURGE survey collected shallower samples to a depth of approximately 10 cm, conclusions about whether certain anomalies are anthropogenic or geogenic in nature are difficult to make. This is one benefit of the more detailed Tellus data, taken at two depth profiles.

3.4 A & S comparison

Whilst a comprehensive comparison between results for the A soils and S soils has not been undertaken, some initial observations have been made. The docklands area was consistently high for several elements in both A and S samples, likely due to its long history of industry and the fact that much of the area is reclaimed land. Meanwhile, the Phoenix Park shows a strong contrast between the 'A' and 'S' samples for both cadmium and manganese. This is highlighted in Figure 14 below, which shows the 'A' maps on top and the 'S' maps on the bottom. The 'S' maps show higher concentrations for both elements, possibly reflecting a stronger geogenic signature than the 'A' maps.

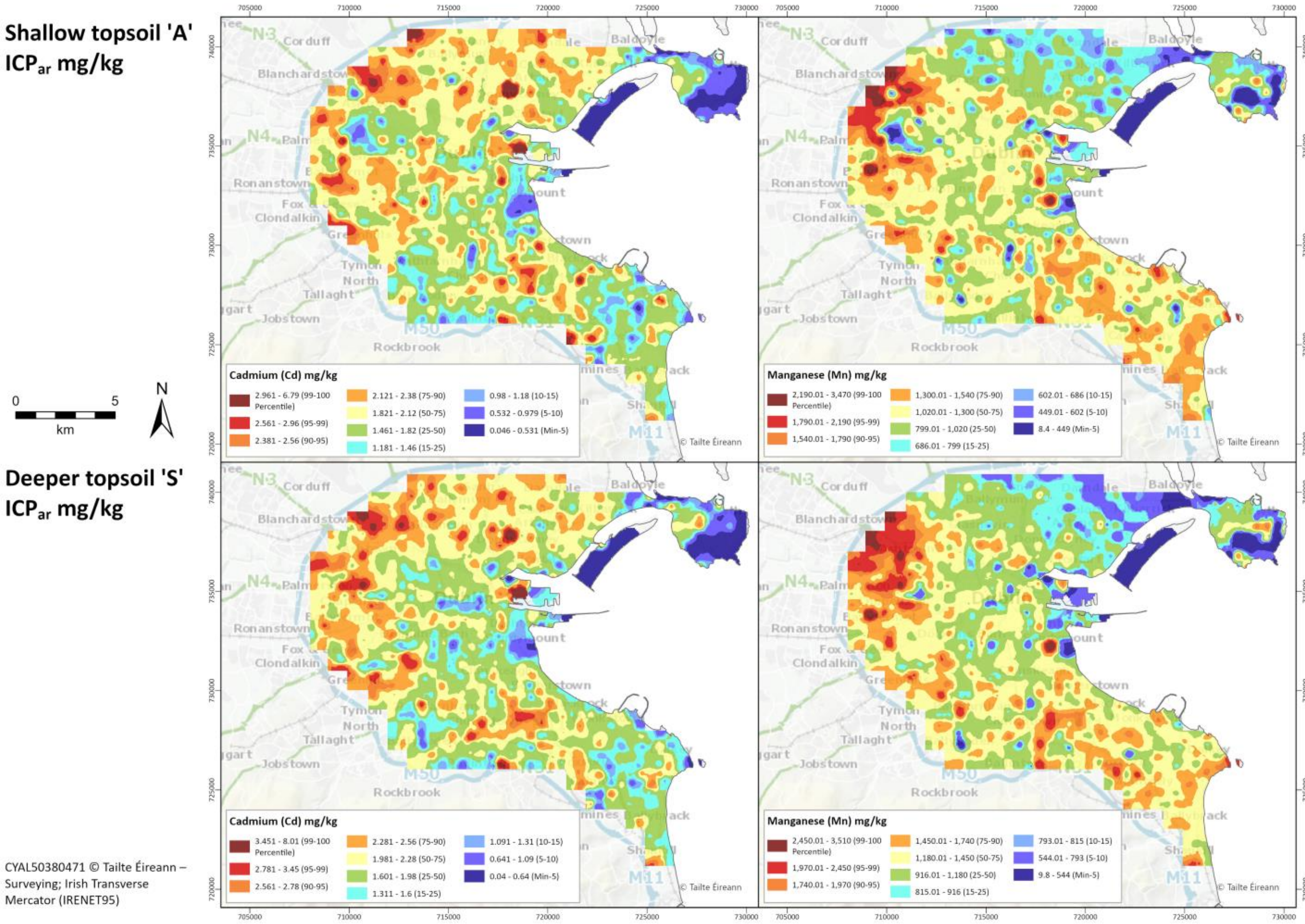

Figure 15: A comparison between the A and S maps for both cadmium and manganese.

Table 1 below shows the median values for every element in both the A and S samples. Values for both are largely similar, but the anthropogenic signature is slightly stronger in the ‘A’ samples and the geogenic signature is slightly stronger in the ‘S’ samples. Percentage differences have been calculated to highlight the largest differences. The median loss-on-ignition value for the S samples is less than that of the A, likely because the A samples are closer to vegetation growing on the surface, or there may have been topsoil/manure applied to the area. Large differences can also be seen in P and Pb, which have higher medians in the ‘A’ samples compared to the ‘S’ samples. While Ca and Sr have higher medians in the ‘S’ samples.

A report comparing the A and S values of Tellus data from northern half of Ireland (Gallagher et al, 2022) also reported elevated P levels in ‘A’ samples when compared to ‘S’ samples, suggesting fixation of P by organic matter as a contributing factor, with organic matter tending to be higher in ‘A’ samples. However, they also noted that addition of artificial fertiliser on agricultural land may also be a contributory factor.

Element	Unit	A Median	S Median	Percentage Difference (%)
pH	pH Unit	6.9	6.8	1.46
LOI	%	11.5	8.32	32.09
Ag	mg kg^{-1}	0.263	0.25	5.07
Al	%	1.04	1.06	1.90
As	mg kg^{-1}	17.9	18.7	4.37
B	mg kg^{-1}	6.9	6.8	1.46
Ba	mg kg^{-1}	107	112	4.57
Be	mg kg^{-1}	1.14	1.17	2.60
Bi	mg kg^{-1}	0.226	0.219	3.15
Ca	%	2.63	3.47	27.54
Cd	mg kg^{-1}	1.82	1.98	8.42
Ce	mg kg^{-1}	24.7	25.9	4.74
Co	mg kg^{-1}	10.9	11.7	7.08
Cr	mg kg^{-1}	21.5	22	2.30
Cs	mg kg^{-1}	0.469	0.525	11.27
Cu	mg kg^{-1}	46.5	46.4	0.22
Fe	%	2.28	2.4	5.13
Ga	mg kg^{-1}	3.1	3.24	4.42
Ge	mg kg^{-1}	0.0615	0.0611	0.65
Hf	mg kg^{-1}	0.0979	0.0926	5.56
Hg	mg kg^{-1}	0.27	0.266	1.49
In	mg kg^{-1}	0.0241	0.0244	1.24
K	%	0.138	0.132	4.44
La	mg kg^{-1}	12.6	13	3.13
Li	mg kg^{-1}	13.2	13.9	5.17
Mg	%	0.241	0.254	5.25
Mn	mg kg^{-1}	1020	1180	14.55
Mo	mg kg^{-1}	3.17	3.24	2.18
Na	%	0.0182	0.0177	2.79
Nb	mg kg^{-1}	0.344	0.342	0.58
Ni	mg kg^{-1}	43.1	46.2	6.94
P	mg kg^{-1}	1020	864	16.56
Pb	mg kg^{-1}	98.1	93.2	5.12
Rb	mg kg^{-1}	8.96	9.37	4.47
Re	mg kg^{-1}	0.00113	0.00132	15.51
S	%	0.0785	0.0578	30.37
Sb	mg kg^{-1}	1.63	1.52	6.98
Sc	mg kg^{-1}	3.42	3.74	8.94
Se	mg kg^{-1}	0.978	0.978	0.00
Sn	mg kg^{-1}	4.56	4.27	6.57

Sr	mg kg^{-1}	78.7	102	25.79
Ta	mg kg^{-1}	0.00074	0.00065	12.95
Te	mg kg^{-1}	0.0303	0.0313	3.25
Th	mg kg^{-1}	1.26	1.43	12.64
Ti	%	0.00529	0.00525	0.76
Tl	mg kg^{-1}	0.216	0.227	4.97
U	mg kg^{-1}	0.882	0.927	4.98
V	mg kg^{-1}	37.3	38.6	3.43
W	mg kg^{-1}	0.144	0.113	24.12
Y	mg kg^{-1}	16	16.3	1.86
Zn	mg kg^{-1}	151	140	7.56
Zr	mg kg^{-1}	3.26	3.16	3.12
Au	mg kg^{-1}	0.00383	0.00326	16.08
Pd	mg kg^{-1}	0.0000318	0.0000328	3.10
Pt	mg kg^{-1}	0.00067	0.00068	1.48

Table 1: The median values of every element for both the A and S samples.

4. Recommendations

4.1. Further work

Note that findings in this report are not exhaustive and constitute only an initial overview of key observations.

Further work should include more detailed ‘A’ and ‘S’ comparison, more detailed comparison with SURGE and Dublin boulder clay data, research into historic land uses and links with observed elemental values/geochemical signatures, potential impact of current land-use vs historic land use on geochemistry e.g. locations that have been remediated.

Results from Dublin could be compared to similar studies in other cities, although caution should be taken as other studies may consist of different sampling methods, sample preparation, analytical method, and detection limits. It would still be beneficial to review studies from other cities and put the Dublin results in a broader context. This would include other cities and urban areas in Ireland, which have been sampled as part of the Tellus G12 block and are due to be analysed shortly.

4.2. Possible uses of data

All data is freely available and can be found on the Tellus geochemistry data page at https://www.gsi.ie/en-ie/data-and-maps/Pages/Geochemistry.aspx.

This report provides a brief interpretation of the data, however further investigation on the links between soil and public health is needed. It is becoming increasingly important to understand the geochemistry of urban environments, to manage potentially harmful substances and minimize the risk to both human health and the environment. One of the key aspects of the Tellus data is the opportunity to study the influence of both geogenic and anthropogenic factors on soil geochemistry. Not all excess elemental levels are the result of industry and may reflect naturally high geochemical signatures. However, where humans have influenced the soil geochemistry, the Tellus data will support the identification of these areas which may require remediation.

The EU’s development of the Soil Health Monitoring Law, which aims to make soil health monitoring obligatory in all member states, is a significant step forward. The Tellus project can play a vital role in this by providing data to protect and manage Dublin’s soils. The results can also be compared to future geochemistry surveys, acting as a baseline to identify any changes in the environmental health of Dublin city.

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Appendix A – Borehole AD-11

IRISH BASE METALS LIMITED

EXPLORATION DEPARTMENT

DIAMOND DRILL HOLE LOG

HOLE NO: AD - 11

LICENCE NO: 1534

TOWNLAND: Cappagh

AREA: AD - POPPINTREE

CO-ORDINATES:

NATIONAL GRID REFERENCE:

ELEVATION: c. 270 ft OD

LENGTH: 263 feet

ANGLE: - 90°

AZIMUTH:

ANGLE TEST: NIL

MATERIALS LEFT IN HOLE: NIL

DOWN HOLE LOGGING: NIL

HYDROGEOLOGICAL DATA: -

DATE DRILLED: August 1980

CONTRACTOR: Priority Drilling Ltd

LOGGED BY: [redacted]

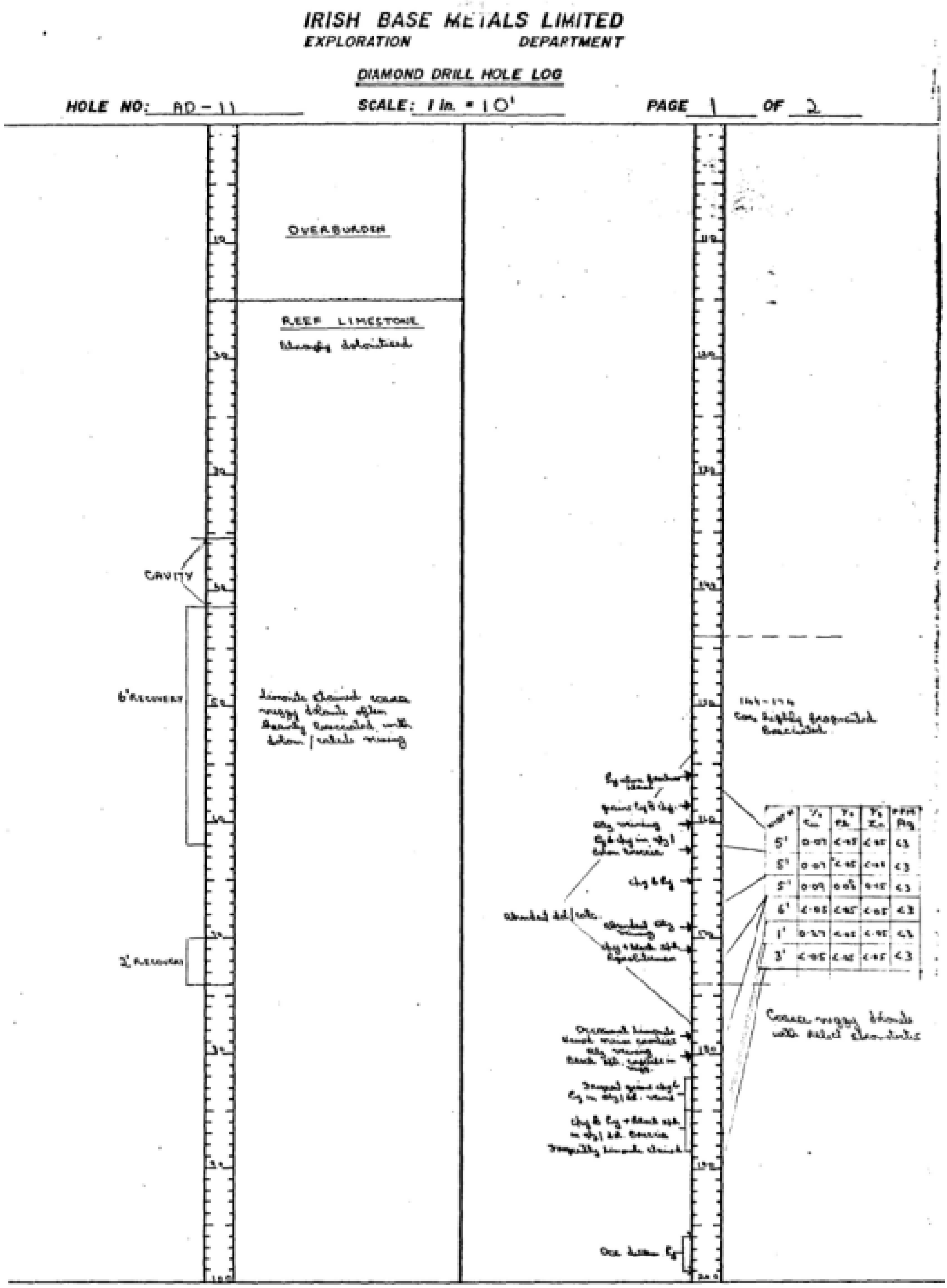
SUMMARY LOG: -

0 - 15	Overburden
15 - 263	Reef Limestone
	15 - 250 strongly dolomitised
	250 ? Fault
	250 - 263 abundant crinoids
	partially dolomitised
	Hole completed at 263 ft.

P. L. No. 2697		
O. F. No.	Period	
211 – 8	1980 – 1981	5

A.P./I.J.m.

IX/MCMLXXIX


IRISH BASE METALS LIMITED
EXPLORATION DEPARTMENT
DIAMOND DRILL HOLE LOG
HOLE NO: AD-11
SCALE: 1 In. = 10'
PAGE 1 OF 2
OVERBURDEN
REEF LIMESTONE
CAVITY
6' RECOVERY
144-174
Coarse vuggy dolomite
% Cu
% Pb
% Zn
ppm Ag
5'
0.07
<.05
<3
6'
1'
0.37
3'

IRISH BASE METALS LIMITED
EXPLORATION DEPARTMENT

DIAMOND DRILL HOLE LOG

HOLE NO: AD-11 **SCALE:** 1 In. = 10' **PAGE** 2 **OF** 2

[illegible] & [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible]. [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible]

[illegible] [illegible] [illegible] [illegible]

FAULT

REEF LIMESTONE

Partly dolomitised with abundant [illegible] [illegible]

HOLE ENDS AT 263 FEET.

SLUDGE VALUES

	ppm Cu	ppm Pb	ppm Zn	ppm Mn	% Fe
0-5	112	400	400	2400	1.96
5-10	110	230	315	2200	1.86
10-15	151	590	345	2500	1.60
15-20	11	35	370	1100	4.49
20-25	444	1326	620	3000	2.45
25-30	455	2000	841	14600	3.24
30-35	322	1485	617	5800	2.49
35-40	361	4120	515	1400	2.90
40-45	284	1327	545	2400	4.34