

Crymlyn Tip Coed Darcy

Controlled Waters Risk Assessment

St Modwen Developments Ltd
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eNGLOBE

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1 Introduction

This report considers risk to controlled waters from residual impact of potential contaminants at the Crymlyn Tip via dissolved phase migration in the groundwater and derives site assessment criteria for groundwater. The history of site usage has resulted in some impact of the ground at the site with some potential contaminants, in particular petroleum hydrocarbons.

Various programmes of remediation have been undertaken in the past. Although significant additional works are being designed to improve conditions further, which will likely include some form of cut-off wall to replace existing NAPL containment arrangements and provision of a permeable cover to the landfilled area, the present study considers existing conditions without these works, as is required for permit surrender. The assessment has included numerical modelling of the groundwater system in the vicinity of the site. This modelling was undertaken to assist in development of the conceptual model with respect to the groundwater pathway and in order to allow predictions to be made as to the likely degree of dilution and attenuation of potential contaminants and their likely fate in the groundwater system. As such it assists in the quantification of the risks to controlled waters that may be associated with migration of any potential contaminants remaining on site and allows the development of defensible site-specific assessment criteria that are protective to controlled waters. The numerical modelling will also be used in design assessments for the proposed improvement works.



2 Initial Conceptual Model of Groundwater Flow

2.1 Topographical Setting and Surface Water Features

The tip site lies on the eastern edge of the Crymlyn Bog and has been constructed by placement of fill and waste materials over part of the former bog area. In particular, a bund was formed along the northern edge of the tip and wastes placed to the south. Ground levels rise to the east and south to an area that was formerly a large BP Refinery. The bog area to the north and west is typically at about 8 to 10 mAOD. Ground levels on the overall site area drop from about 16 mAOD in the north east to about 10 mAOD in the west.

Figure C1 shows the site's topographic setting with some topographic contours and surface water features highlighted for clarity.

Surface water features in the vicinity of the site are illustrated in Figure C2, selected topographic contours have been highlighted for clarity. Current surface water features are shown in light blue. Former streams, which have been traced from historical mapping and shown as dashed blue lines in Figure C2 and the Tennant Canal, which passes through the central bog area, is shown as dark blue.

2.2 Ground Conditions

Various phases of ground investigation have been undertaken on site and recently Englobe have undertaken some additional investigation works, including installation of further boreholes and wells and groundwater monitoring.

Mapping published by the British Geological Survey (BGS) shows the site to be underlain by solid strata of the Pennant Sandstone Formation of Carboniferous Age. The bedrock is overlain by glacial deposits that include clay till and granular fluvioglacial strata, which are generally represented by gravels. The glacial strata are overlain by the bog sediments that generally comprise soft clays overlain by peat.

Figure C3a shows an extract from the published geological map of the areas surrounding the site and Figure C3b shows a detail for the site area. Although mapped across most of the lower site area, intrusive investigation has indicated that peat is locally absent from some parts of the site area.

Made Ground, comprising tipped material from the refinery operations and some excavated peat, appears to have been placed straight over the original ground profile, with no attempt to remove the existing peat, soft clays, or vegetation.

2.3 Anticipated Pattern of Near Surface Groundwater Flow

Based on the site's topographic setting, the direction of near surface groundwater flow below the site could be expected to be to the west in the eastern site area and to the north in the south. Within the central northern site area the predominant flow direction would be expected to be to the north west, becoming more westerly in the western area, with discharge into the adjoining bog area and eventual discharge to a series of streams and drainage ditches within the bog, including the Tennant Canal. Previous experience from studies for sites adjoining other areas of the Crymlyn bog have suggested that the canal water level is generally in continuity with the groundwater and that groundwater usually discharges to the canal.

2.4 Hydrogeology and Potential Controlled Waters Receptors

The Peat and by inference other bog sequence deposits are considered to be Unproductive Strata. The underlying Glacial Till is considered to be an 'Undifferentiated' Secondary Aquifer. The Fluvioglacial strata, present but not mapped in the area, would generally be considered a Secondary 'A' Aquifer. The Pennant Formation is also considered to be a Secondary 'A' Aquifer. There are a number of surface water ditches and drains within the Crymlyn Bog area and, as noted above, groundwater likely discharges to the Tennant Canal. The drainage ditches to the north of the site appear to drain southwards and are discontinuous, presumably discharging water drained from upstream to the bog.

The Crymlyn Bog, is a designated Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC), Ramsar Site and a National Nature Reserve (NNR).



3 Measured Groundwater Conditions on Site

3.1 Groundwater Conditions

Data on groundwater levels within the site area are available from monitoring undertaken during two main periods; firstly from 1998 to 2003 and reported by URS and more recent from 2020 to 2022 and reported by PJA.

Inferred contours of groundwater level for each monitoring date for the 1998 to 2003 data are included in Addendum C1 and similar plots for the 2020 to 2022 data are included in Addendum C2. Data from some monitoring points that relate to wells that apparently reflect locally perched conditions within or on shallow clay layers have been omitted for these plots.

Note that for all contour plots the permit boundary is shown as a green line and the 'site' boundary as a red line.

Figures C4a and 4b show inferred contours of groundwater level based on average levels at each monitoring point for the periods 1998 to 2003 and 2020 to 2022, respectively. Average values have been used as no single dataset includes monitoring of all standpipes and the intention is to illustrate general trends. As noted above, contours for each individual dataset are included in Addenda C1 and C2.

The two data sets show reasonably consistent conditions although both data sets have only limited data in the southern and eastern site areas and several of the individual dates have no data at all in the eastern site area. Where sufficient data are available, they show relatively high groundwater levels in the east with a generally westerly flow direction. This becomes more northerly in the central site area and then more westerly in the extreme west. This is generally consistent with the anticipated directions of near surface groundwater flow inferred from the site's topographic location and discussed above.

Superimposed on this general pattern are local groundwater highs within the north central site area that are thought most likely to be related to the heterogeneity of the wastes in this area but could also potentially be partly due to changes in character of the bog sequence strata underlying the relevant areas. The local high levels imply that locally the vertical conductivity of the wastes is so low that infiltration is being restricted from migrating vertically downwards through the unsaturated zone. This could be due to locally higher clay content in the wastes or LNAPL presence reducing the effective hydraulic conductivity. There are also occasional areas of locally low groundwater level. These could be due to heterogeneity in the wastes but could also be due to locally higher vertical conductivity in the underlying bog sequence.

Some of the local highs and lows on some monitoring visits could be the result of product recovery activities that may have been ongoing at the time.

Figures C5a and C5b show plots of measured water level vs date for the two main datasets, respectively for selected standpipes. Generally the standpipes with the most complete set of monitoring dates have been included. All data are tabulated in the relevant monitoring reports. As noted in relevant monitoring reports, the main influence appears to be seasonal with highest levels generally in the period December to January and lowest September to November. Although there are some anomalies that generally relate to surface water levels in sumps or wells that appear to be reflecting perched conditions, most locations show only relatively small fluctuations and levels tend to rise and fall in unison, suggesting that the overall direction of groundwater flow is not changing markedly with the season. The impact of pumping activities is more evident in the 2020 to 2022 data.

For some monitoring well locations shallow and deep response zones were installed. Levels in the two are generally similar. Figure 6 shows a plot of measured water level in the deep installation vs the level in the shallow installation for the 1998 to 2003 data, for which more data are available. Generally, water levels in the deep standpipes either increase and decrease at a similar rate to the shallow levels or, more commonly, shallow levels increase more rapidly than the deep. This suggests that the fluctuations are due to changes in local infiltration, resulting in greater fluctuation in the shallow levels than the deeper. There are two exceptions to this general pattern; MSMW027, where deep water levels appear to reduce as shallow levels rise and MSMW035, where deep levels appear to fluctuate more than shallow but move in the same direction. The reason for these apparent anomalies is not clear. MSMW027 is in the extreme western end of the site, close to the bog. MSMW035 is in the north eastern site area, also close to the bog but also close to the higher ground. Figure 7 shows contours of the ratio of deep to shallow water level for the average of all readings. That is, for contour values greater than unity deeper levels exceed shallow. Near the bog, deeper data generally show higher levels than shallow whereas within the tip area the reverse is the case. This general pattern could be explained by an upward flow within the deeper bedrock and glacial strata as groundwater discharges to the bog and a downward flow within the tip area, where recharge is occurring. It also suggests that although the deeper and shallow groundwater levels are similar, that the bog sediment clays are acting as at least a partial aquiclude. The upward gradient of groundwater potential along the northern site boundary suggests that there is little potential for any dissolved phase contaminants, which may be emanating from the northern site boundary in near surface groundwater, to flow downwards into the underlying glacial or bedrock aquifers.

3.2 Compliance Criteria

The relevant compliance criteria are considered to be Environmental Quality Standards (EQS) for priority substances (and other pollutants) and Standards for Special Pollutants, where these have been published.

The Water Framework Directive (England and Wales) 2015 (WFD) term 'EQS' used for priority substances has also been applied more generally to include WFD 'specific pollutants environmental standards'. The WFD terms 'Annual Average' (AA) and 'Maximum Allowable Concentration' (MAC) for priority substances have also been used in lieu of the WFD terms of 'Annual Mean' and '95th Percentile' for specific pollutants.

Where these are not available, relevant UK Drinking Water Standards (DWS) will be adopted. Otherwise current EQS values for surface water and former DWS have been considered. Where the relevant standard is expressed as bioavailable but no data are available, PNEC values based on MBAT analysis as reported by PJ Associates 2022, will be adopted.

Compliance criteria for speciated TPH are based on the recommendations of CL:AIRE 2017, which are primarily based on the WHO Drinking Water Standards.

For PAHs, the 2015 WFD standards introduced for the first time annual average PAH EQS based on human health risks. These applied to Benzo(a)pyrene (as a marker compound for Benzo(a)pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[ghi]perylene, indeno[123-cd]pyrene) and Fluoranthene. The human health risk addressed by these annual average PAHs EQS relate to the human consumption of marine and freshwater fishery products (primarily freshwater crayfish, marine molluscs and marine cephalopods, as universal criteria across the whole of the EU). The remaining PAH EQS (AA/MAC) are still based on ecological receptors.

Given the purpose of the criteria within the controlled waters assessment for groundwater quality preliminary screening and for the ecological protection of groundwater that is discharging to a watercourse (with the obvious lack of a local cohort of people eating crayfish from the watercourse), it is not strictly appropriate to adopt the 2015 health-based PAH annual average EQS. As such, the ecological 2008 annual average EQS are arguably more relevant to the present assessment (these are also lower than the ecological 2015 MAC EQS). Nevertheless the 2015 EQS criteria have been adopted, which is considered very conservative.

Based on this approach, the following compliance criteria have been adopted (all in mg/l).

Table 1 Adopted Compliance Criteria

Substance	Adopted Controlled Waters Compliance Criterion for Preliminary Screening (mg/l)	Comment
TPH Aliphatic C5-C6	15	CL:AIRE 2017/WHO
TPH Aliphatic C6-C8	15	CL:AIRE 2017/WHO
TPH Aliphatic C8-C10	0.3	CL:AIRE 2017/WHO
TPH Aliphatic C10-C12	0.3	CL:AIRE 2017/WHO
TPH Aliphatic C12-C16	0.3	CL:AIRE 2017/WHO
TPH Aliphatic C16-C21	-	Not Modelled as toxicity based concentration exceeds solubility
TPH Aliphatic C21-C34	-	Not Modelled as toxicity based concentration exceeds solubility
TPH Aliphatic C35-C44	-	Not Modelled as toxicity based concentration exceeds solubility
TPH Aromatic C8-C10	0.3	CL:AIRE 2017/WHO
TPH Aromatic C10-C12	0.09	CL:AIRE 2017/WHO
TPH Aromatic C12-C16	0.09	CL:AIRE 2017/WHO
TPH Aromatic C16-C21	0.09	CL:AIRE 2017/WHO
TPH Aromatic C21-C35	0.09	CL:AIRE 2017/WHO
TPH Aromatic C35-C44	0.09	CL:AIRE 2017/WHO
Benzene	0.01	EQS
Toluene	0.074	EQS
Ethylbenzene	0.02	Former EQS
m-Xylene	0.03	EQS
o-Xylene	0.03	EQS
p-Xylene	0.03	EQS
Benzo[b]fluoranthene	0.000017	EQS MAC
Benzo[k]fluoranthene	0.000017	EQS MAC
Benzo[ghi]perylene	0.0000082	EQS MAC
Benzo[a]pyrene	0.00000017	EQS
Fluoranthene	0.0000063	EQS
Indeno[123-cd]pyrene	0.000002	EQS
Naphthalene	0.002	EQS
Anthracene	0.0001	EQS
Ammoniacal Nitrogen as N	0.3	EQS
Chloride	250	DWS
Arsenic	0.05	EQS
Cadmium	0.00025	EQS
Cobalt	0.003	EQS
Copper	0.049	PNEC using MBAT
Chromium	0.02	EQS
Lead	0.0072	EQS
Mercury	0.00005	EQS
Nickel	0.034	PNEC using MBAT
Selenium	0.01	DWS
Vanadium	0.02	EQS
Zinc	0.079	PNEC using MBAT

EQS = EQS, DWS = Drinking Water Standard, WHO = World Health Organisation

3.3 Distribution of Contaminants of Concern in Groundwater

Although historical groundwater data are available, recent data are available from monitoring rounds undertaken in 2022. Addenda C3 to C7 include inferred contours of concentration of potential contaminants in groundwater for all potential contaminants of concern measured above the detection limit. A red contour is included to indicate the adopted compliance criterion where this has been exceeded.

The following paragraphs summarise the measured conditions in each of the recent rounds:

Table 2 Summary of Measured Groundwater Chemical Data

Substance Group	January 2022	February 2022	March 2022	April 2022	May 2022
BTEX Compounds	Benzene elevated in central site area. Meets compliance prior to downstream site boundary. Other BTEX detected but not elevated.	Not detected.	Benzene elevated in central site area. Meets compliance prior to downstream site boundary. Other BTEX detected but not elevated.	Benzene elevated in central site area. Meets compliance prior to downstream site boundary. Others not detected.	Benzene meets compliance. others not detected.
Higher Aromatic TPH	C8-10 not elevated. C10 and higher fractions elevated in central site area but generally meet compliance prior to downstream site boundary.	C8-10 not elevated. C10 and higher fractions elevated in central site area but C10 to C21 meet compliance prior to downstream site boundary.	C8-10 not elevated. C10-16 elevated in central site area but C10 to C12 meets compliance prior to downstream site boundary. C12 and higher also locally elevated near northern site boundary.	C8-10 not elevated. C10-21 elevated in central site area but C10 to C12 meet compliance prior to downstream site boundary. C12 and higher also locally elevated near northern site boundary.	C8-12 not elevated. C12-16 elevated in central site area and also locally elevated near northern site boundary.
Aliphatic TPH	C12-16 elevated in central site area but meets compliance prior to downstream site boundary. Lighter fractions not elevated.	C10-16 elevated in central site area but meet compliance prior to downstream site boundary. Lighter fractions not elevated.	C10-12 elevated in central site area but meet compliance prior to downstream site boundary. C12-16 locally elevated near northern site boundary. Lighter fractions not elevated.	C12-16 locally elevated near northern site boundary and in southern site area. Lighter fractions not elevated.	C12-16 locally elevated near northern site boundary and in southern site area. Lighter fractions not elevated.
PAH Compounds	Elevated in central site area but meet compliance prior to downstream site boundary.	Elevated in central site area and some locally elevated near downstream boundary. Others meet compliance prior to downstream site boundary. Naphthalene not elevated.	Some elevated in central site area and some locally elevated near downstream boundary. Others meet compliance prior to downstream site boundary.	Anthracene elevated in central site area and some others locally elevated near downstream boundary. Naphthalene not elevated.	Anthracene elevated in central site area and some others locally elevated in central and/or northern site area. Naphthalene only locally marginally elevated.
Ammonium	Elevated in central and eastern site area.	Elevated in central and northern site area.	Elevated in central and north central site area.	Elevated in central and north central site area.	Elevated in central and north central site area.
Metals	Mercury and Vanadium locally elevated in central site area but meet compliance well before downstream site boundary.	Cadmium, Lead and Vanadium locally elevated in central site area but meet compliance well before downstream site boundary. Mercury not detected.	Vanadium locally marginally elevated in central site area but meet compliance well before downstream site boundary. All others not elevated.	Arsenic and Vanadium locally elevated in central site area but meet compliance well before downstream site boundary.	Cadmium, Mercury and Vanadium locally elevated in central site area but Cadmium and Vanadium meet compliance well before downstream site boundary. Mercury also locally elevated near northern boundary.

Elevated = Above Compliance Criterion.

LNAPL has been detected in some boreholes and has in the past been subject to removal operations.

In summary in terms of the major measured impacts in water samples are generally restricted to the central site area and sometimes locally near the northern (downstream) site boundary. Of the BTEX compounds, only benzene locally exceeds compliance and only in the central site area, always meeting compliance prior to the northern site boundary. TPH Aromatic Fractions C8-10 and Aliphatic C5-C10 always meet compliance. Although some metals are locally elevated, with only one exception on one of the recent monitoring visits, they all meet compliance well before the downstream site boundary. In terms of potential off-site impacts via dissolved phase migration therefore, only the following substances appear to be potentially leaving the site at significant concentrations above compliance and are therefore of potential concern:

- Aromatic TPH Fractions C10 and higher
- Aliphatic TPH Fraction C12-C16
- PAH Compounds, except Naphthalene
- Ammonium

The presence of LNAPL is leading to misleadingly high apparent measurements of dissolved phase concentration for organic contaminants. The following table compares maximum measured concentrations to solubility.

Table 3 Measured Groundwater Concentrations and Solubility

Substance	Water solubility (mg/l)	Maximum Measured Concentration (mg/l)				
		Jan-22	Feb-22	Mar-22	Apr-22	May-22
Anthracene	0.045	0.0121	0.0024	0.00157	0.00244	0.000474
Benzo[a]pyrene	0.0038	0.00353	0.000959	0.00472	0.0017	0.000259
Benzo[b]fluoranthene	0.002	0.00365	0.000881	0.00679	0.0019	0.00118
Benzo[ghi]perylene	0.000264	0.00169	0.000575	0.00769	0.00183	0.00011
Benzo[k]fluoranthene	0.0008	0.00101	0.000388	0.00263	0.00078	0.00152
Fluoranthene	0.23	0.0112	0.00404	0.0058	0.00261	0.00237
Indeno[123-cd]pyrene	0.0002	0.00112	0.000399	0.0000849	0.00156	
Naphthalene	19	0.0144	0.00171	0.00553	0.000988	0.00234
TPH Aliphatic C5-C6	36	0.084	0.04	0.098	0.046	0.046
TPH Aliphatic C6-C8	5.4	0.165	0.085	0.172	0.056	0.05
TPH Aliphatic C8-C10	0.43	0.097	0.134	0.151	0.07	0.052
TPH Aliphatic C10-C12	0.034	0.267	0.321	0.333	0.294	0.136
TPH Aliphatic C12-C16	0.00076	4.07	1.85	2.77	1.43	1.16
TPH Aromatic C8-C10	65	0.079	0.09	0.113	0.048	0.35
TPH Aromatic C10-C12	25	0.178	0.214	0.222	0.196	0.09
TPH Aromatic C12-C16	5.8	1.76	0.625	0.416	0.474	0.337
TPH Aromatic C16-C21	0.65	2.32	1.56	1.51	1.15	0.806
TPH Aromatic C21-C35	0.0066	11.3	3.83	10	5.34	4.14

 = Measured Value Exceeds Solubility

For the above, solubility has been based on data published by Gustafson et al. (1997) and no attempt has been made to reduce solubility to reflect the presence of multiple dissolved compounds. It is clear that for most TPH compounds and heavier TPH fractions, the measured concentrations must reflect presence of NAPL within the samples and as such overestimate the true dissolved phase concentration.



4 Development of Extended Conceptual Model

4.1 General

The volumes and patterns of groundwater flow beneath the site and between the site areas and the discharge points are important to the assessment of risks associated with the groundwater pathway. Although estimates of flow volumes may be made based on hydraulic gradient and estimated hydraulic conductivity of the site subsoils, the latter parameter in particular cannot be measured directly, is difficult to estimate and may be expected to vary quite significantly on a local level. By modelling of the catchment area, however, estimated flow volumes become less sensitive to exact assumed conductivity and more dependent on the net infiltration over the catchment and other boundary conditions, which, although uncertain, may be estimated with a relatively higher degree of confidence, compared to hydraulic conductivity. Based on such modelling, a combination of hydraulic conductivity and hydraulic gradient may be chosen that is consistent with the overall anticipated volume of groundwater flow and boundary conditions as well as site groundwater conditions. This 'water balance' approach has the advantage that modelled flow volumes are consistent with the conceptual model of the local hydrogeology. The risk of adopting values of hydraulic conductivity, gradient and aquifer thickness for RTM analysis that together imply an impossible volume of groundwater flow is avoided. Such modelling is also useful to assess the likely pattern of flow paths from the site area to discharge and thereby extend the conceptual model.

In order further to develop the conceptual model of general groundwater flow conditions, a plan view numerical model of flow within the local catchment area has been developed. Consideration of the surface water levels suggests that they are reasonably consistent with groundwater levels where known. It is considered therefore that local groundwater flow conditions may be adequately modelled by a consideration of conditions within the local surface water catchment area. Figure C8 shows the modelled area, which may be considered generally to represent the natural local surface water catchment area.

The catchment area is bounded to the west by the Tennant Canal and surface water streams to the north. The eastern and north western boundaries are mainly formed by inferred estimated short flow lines from topographic highs to the surface water features. The north western site boundary is formed by a variety of surface water features.

The model was developed partly to support the controlled waters risk assessment related to permit surrender and partly to allow the impact of potential remedial options, such as provision of cut-off walls etc.

4.2 Modelling Software

Numerical modelling undertaken as part of the present study has made use of the SEEP/W program developed by Geo-Slope International Ltd. This was chosen as it allows rapid parametric studies to be undertaken and the implications of various assumptions to be graphically displayed. The program is based on the well-established finite element method for continuum analysis. Although similar analysis may be undertaken using finite difference based methods, the finite element approach offers some advantages, in particular the method is less sensitive to such factors as node spacing as conditions are not assumed to be linear within elements. In this process, the study area is divided into a number of elements.

4.3 Rainfall and Potential Infiltration

The long term average rainfall for the Swansea area is of the order 1300 mm/a, but would be expected to be relatively higher in the upland areas that form parts of the catchment. Actual infiltration will be variable across the catchment given the variety of land uses. Long term average actual evaporation in vegetated areas would be expected to be of the order of 500 to 600 mm/a. These data suggest a long term average effective rainfall of the order of 800 mm, which was adopted for modelling purposes.

4.4 Finite Element Representation and Boundary Conditions

Previous experience has shown that, where practical, it is preferable to model the entire catchment area within which the study site lies as this reduces the uncertainties concerning model boundary conditions. The finite element mesh used for the plan view analysis is shown in Figure C8.

For modelling a local grid co-ordinate system was adopted, as follows:

Zero Easting = 268000 Easting National Grid
Zero Northing = 193000 Northing National Grid

As may be seen, the boundaries of the mesh follow the features that form the boundary of the catchment. For the surface water boundaries, the boundary condition was set to a head equal to the average water level at that point. Levels used were based on the topographic mapping. Inferred flow lines were modelled as no flow boundaries.

4.5 Model Calibration

4.5.1 General

The model must be calibrated such that, as far as practicable without introducing speculative complexity, conditions both assumed and predicted by the model, match known conditions. The important model parameters are:

- Boundary Conditions
- Surface infiltration
- Aquifer transmissivity and its spatial variation

In the present case, the boundary conditions are reasonably straightforward and have been discussed above. Although actual infiltration is not known with certainty, there is an approximately linear relationship between adopted infiltration and transmissivity inferred from inverse modelling to known groundwater levels so that, if necessary, the effect of varying average infiltration on inferred transmissivity may be readily estimated. At head boundaries, constant levels were assumed and seasonal variations in stream levels were ignored. This is considered reasonable for a simulation of average flow conditions as surface water levels are largely constrained by topographic features.

4.5.2 Transmissivity

It follows that the main phase of calibration with respect to modelling average flow conditions comprises the variation of catchment transmissivity until a reasonable match with measured conditions is achieved. This process, in which estimates of transmissivity are essentially derived from known groundwater conditions is termed inverse modelling (Anderson and Woessner 1992).

In reality, spatial variation in transmissivity will be complex and there may be additional internal drainage features that affect the overall or at least local water balance. Although these complexities are inevitable, it is not considered appropriate to introduce speculative variations in transmissivity within the catchment area simply to achieve an apparently better fit to measured conditions unless there is some other reason to justify the suspected heterogeneity. The available geological mapping (Figures C3a and 3b) suggest that the catchment could be divided into three main areas:

- Bog Area
- Higher Ground where generally till overlies bedrock and
- The site area where a significant thickness of made ground has been placed over natural soils

As a simplified model, the catchment area was initially divided into those three. Figure C9 shows the assumed distribution of material types in the vicinity of the site.

The transmissivities were varied until a reasonable match with measured groundwater levels was obtained. Predicted groundwater conditions within the site areas are not particularly sensitive to the value of transmissivity adopted for the till/bedrock areas or the bog area provided a reasonably high value was provided for the latter. A high transmissivity for the bog area is evidenced by the very flat hydraulic gradient present within the bog and inferred levels within the downstream surface water features, principally the Tennant Canal.

The following values of transmissivity give a reasonable match to site conditions.

- Bog 0.01 m²/s (864 m²/d)
- Site Area 0.001 m²/s (86.4 m²/d)
- Till/Bedrock Area 0.0005 m²/s (43.2 m²/d)

The allocation of three transmissivity zones is obviously a considerable simplification and, in particular, the actual nature of the natural and made ground deposits at the site is somewhat variable and clearly local high and low water levels that likely reflect that heterogeneity are not replicated. Nevertheless, the predicted pattern is considered to be a reasonable model for local flow conditions, particularly as the main purpose of the present study is to consider off-site migration of potential contaminants. The apparently significantly lower transmissivity in the site area than the bog could be due to the compression of bog sediments by the placed materials and apparent local absence of peat in some areas.

Figure C10a shows the general predicted pattern of groundwater flow in the overall catchment area based of calibrated average transmissivity. This gives a reasonably plausible groundwater levels, e.g. predicted discharge to streams and levels generally below ground surface. Accordingly, it is not considered that adoption of a more complex distribution of transmissivity is warranted for the overall catchment. Figure C10b shows the predicted conditions for the site area.

4.5.3 Implications for Conceptual Model

A review of available groundwater level information and numerical modelling have confirmed that discharge from the main waste area occurs in a northerly and westerly direction to the adjacent bog. From the areas of highest measured groundwater impaction within the tip area, based on most recent monitoring data and modelling, flow would be expected to be primarily to the north.



5 Previous Controlled Water Risk Assessments

URS Corporation Ltd (2006) undertook a detailed controlled waters risk assessment that concluded that no organic or inorganic contaminants posed any significant risk to controlled waters. Based on analysis undertaken it was concluded that the effects of contaminated groundwater discharge from the licensed area are unlikely to extend very far into the bog.

A further Hydrogeological Risk Assessment was undertaken by Atkins (2013). That study concluded:

"Groundwater monitoring data demonstrates that elevations of the COCs identified are not due to the presence of landfill material. For the most part, elevations and exceedances are sporadic, and a linkage cannot be made between the groundwater and potential landfill source. Further to this, concentrations of contaminants were generally found to be high in the boreholes outside of the permitted site boundary, particularly those to the south. This suggests that any contamination noted in the groundwater is the result of the Llandarcy Refinery."

No numerical modelling was deemed necessary in view of the available monitoring data.



6 Site Assessment Criteria for Potential Dissolved Phase Contaminants

6.1 General

The Environment Agency's Remedial Targets Methodology, Hydrogeological risk assessment for land contamination, was used to simulate conditions in the site area. The associated Remedial Targets Worksheet, Release 3.2 is rather awkward for use with multiple potential contaminants and an in-house spreadsheet was used for parametric studies. This uses the same algorithms as Remedial Targets Worksheet, Release 3.2 and has been validated against the Remedial Targets Worksheet, Release 3.2. All input data are included in the summary tables and output sheets Addendum C8 to allow check analysis using RTM Release 3.2, if necessary.

As the study is to assess risks posed by the present condition of the permitted area, only Level 3 Groundwater analysis is relevant.

6.2 Compliance Criteria Solubility

The relevant compliance criteria with respect to the surface water have been summarised above.

Some higher level TPH fractions and PAH compounds have very low aqueous solubility. Where the aqueous solubility is less than the adopted compliance criterion, more detailed analysis of potential fate and transport is not strictly warranted but these compounds have been included in the RTM analysis for completeness.

Within the RTM methodology, unless background concentrations are high, model outputs are directly proportional to the adopted compliance criterion so that it is not necessary to repeat analysis if the effect of varying compliance criterion is to be studied.

6.3 Level 3 Groundwater Parameters

6.3.1 Physiochemical and Aquifer Properties

The adopted parameters required for this assessment are as follows:

Table 4 RTM Level 3 Physiochemical Parameters

Physiochemical Parameters	Principal Source of Parameter Adopted
Organics	
Organic Carbon Partition Coefficient	EA 2008 (SR7 Report)/LQM 2015/EIC
Inorganics	
Soil Water Partition Coefficient	Lijzen et al 2001 (RIVM Report 711701 023)
Aquifer Properties	
Bulk Density	1.1 From URS Bog Study
Fraction of Organic Carbon	0.284 Average from URS Bog Study.
Porosity	0.4 From URS Bog Study.

Values of Koc for the various compounds and fractions have been based on EA Report SR7 (2008) and, for TPH fractions, LQM (2015). The latter are based primarily on TPHCWG recommendations (Gustafson et al 1997).

Longitudinal and lateral dispersivities were set 10% and 1 % respectively of the path length to discharge.

The width of the source area was assumed to be 220 m, which is considered conservative in relation to the observed distribution of potential impactation near the downstream site boundary.

Hydraulic gradient and conductivity have been chosen to be consistent with the water balance flow conditions derived from the numerical model assuming an effective aquifer thickness of the bog sediments of 10 m.

6.3.2 Attenuation Parameters

It is conservative in RTM analysis to ignore degradation. However, it is found that some degradation of organic compounds invariably occurs in the groundwater system and to ignore this effect is in most cases extremely conservative.

A very detailed site-specific study of lines of evidence for natural attenuation and associated degradation rates for petroleum hydrocarbons was undertaken by URS (2006), which for the bog area recommended the following degradation rates:

Table 5 Site Specific Degradation Rates

TPH Fraction	Degradation Rate (% per day)	Equivalent Half Life (days)
C6- C9	0.1	693
C10-C12	0.1	693
C13-C16	0.02	3465
C17- C21	0.02	3465
C22-C35	0.002	34650

These were based on reducing degradation rates observed in the tip area by a factor of five and are therefore considered very conservative.

Adopted degradation rates for other substances are based primarily on EA P2 228 (2002). The data presented in EA P2 228 for shallow sand and gravel aquifers are considered relevant to the present case as the near surface groundwater is unconfined. Generally, where a range of typical field values has been given, the upper limit has been adopted. These data are relevant to field conditions, i.e. not the 'dissolved phase only' option in the EA RTM Spreadsheet (see for example CL:AIRE 2017). In fact, as pointed out by Alvarez and Illman (2006), Wiedemeier et al (1999) and ASTM (1998), if it is assumed that degradation occurs only in the dissolved phase, then the degradation rate derived from field conditions should be multiplied by the retardation factor. If this is done, model outputs are in fact the same for either option.

With the exception of naphthalene, EA P2 228 (2002) does not report degradation rates for PAH compounds. Other PAH compounds are not generally critical with respect to controlled waters. This is because of low solubility and generally high partition coefficients. Data presented by Surampalli et al (2004), based on field studies, suggest typical half lives in unconfined shallow aquifers for PAH compounds of less than 2 years. For the present study arbitrary but relatively high half-life of 10 years has been adopted for PAH compounds other than naphthalene. More detailed assessment is not considered warranted as these compounds are not highly mobile in the groundwater environment and rarely are critical.

The adopted values for preliminary analysis are summarised in the table below:

Table 6 Assumed Degradation Rates for PAH Compounds

Substance	Half Life (days)	Source
Naphthalene	200	Upper Limit EA Report P2-228/TR
Other PAH Compounds	3650	Conservative High Value

With regard to ammonium it is recognised that attenuation rates are particularly site-specific. Generally highest measured impacts in recent monitoring have been in the south central area of the permit area at monitoring well CBH46. Concentrations reduce to the north in the direction of groundwater flow and there are a reasonable number of 'downstream' monitoring wells to define the rate of attenuation. Based on the contouring included in Addenda C3 to C7 Figure C11 shows the measured concentrations of ammonium versus distance from the peak values for recent monitoring rounds. These show a relatively rapid attenuation, although some minor secondary sources appear to be present in the downstream area for some of the data sets. In Figure C12 the average rate of attenuation, normalised as a percentage of peak, is compared to RTM derived values. Clearly site-specific attenuation rates are much greater than the RTM predictions.

6.4 Derived Site Assessment Criteria

RTM spreadsheets are included in Addendum C8, which also includes a summary table of all input values.

Derived site assessment criteria for soils groundwater with respect to controlled waters are summarised in the following tables. These should be used within the overall assessment in conjunction with pragmatic considerations and human health issues to develop appropriate overall site assessment criteria. Note that some of the derived assessment criteria exceed the likely solubility of some compounds. In such cases, the relevant substances may be assumed to be insufficiently leachable to pose any risk to controlled water. These factors should be considered in the overall assessment.

The high value of organic content within the bog leads to very slow potential rates of contaminant migration, as follows for the principal contaminants of concern:

Table 7 Derived Rates of Transport

Contaminant of Concern	Potential Travel Distance in (m)		
	10 years	100 years	1000 years
Benzo[b]fluoranthene	0.05	0.5	5
Benzo[k]fluoranthene	0.03	0.3	3
Benzo[ghi]perylene	0.01	0.1	1
Benzo[a]pyrene HH2015	0.04	0.4	4
Fluoranthene HH 2015	0.28	2.8	28
Indeno[123-cd]pyrene	0.06	0.6	6
Anthracene	0.16	1.6	16
TPH Aliphatic C12-C16	0.001	0.01	0.10
TPH Aromatic C10-C12	2.02	20.2	202
TPH Aromatic C12-C16	1.01	10.1	101
TPH Aromatic C16-C21	0.32	3.2	32
TPH Aromatic C21-C35	0.04	0.4	4

Note that these are independent of assumed rate of degradation. It follows that none of the PAH compounds, present potentially at slightly above assessment criteria at the northern site boundary, are likely to pose any significant risk to controlled waters.

In fact, even with an assumed distance to compliance of 10 m, none of the principal organic potential contaminants of concern have derived assessment criteria below solubility.

Site assessment criteria have been derived for two arbitrary assumed distances to compliance; 10 m and 50 m into the bog sediments. Along the northern boundary with the key receptor the distance between permit boundary and receptor is approximately 15 to 30 m and attenuation in this zone has been ignored in the derivation of assessment criteria, which is conservative.

In addition to the principal contaminants of concern, assessment criteria have been derived for other substances detected in groundwater in the permit area.

For ammonium, the assessment criteria are based on the site-specific derived attenuation rates (refer Figure C12).

As 220 m has been adopted for the width of the source, assessment criteria should be compared to the highest average values along the downstream boundary over that distance, not the peak concentrations.

Table 8 Case 1 Site Assessment Criteria

Coed Darcy Tip Case:	
1 = 10m to Compliance	
Substance	RTM Assessment Criteria Level 3 Groundwater (mg/l)
Benzene	0.016
Toluene	0.28
Ethylbenzene	0.27
m-Xylene	0.49
o-Xylene	0.36
p-Xylene	0.4
Benzo[b]fluoranthene	ES(>10,000)
Benzo[k]fluoranthene	ES(>10,000)
Benzo[ghi]perylene	ES(>10,000)
Benzo[a]pyrene HH2015	ES(>10,000)
Fluoranthene HH 2015	ES(0.7)
Indeno[123-cd]pyrene	ES(>10,000)
Naphthalene	1.4
Anthracene	ES(1,400)
TPH Aliphatic C5-C6	ES(900)
TPH Aliphatic C6-C8	ES(>10,000)
TPH Aliphatic C8-C10	ES(>10,000)
TPH Aliphatic C10-C12	ES(>10,000)
TPH Aliphatic C12-C16	ES(>10,000)
TPH Aromatic C8-C10	28
TPH Aromatic C10-C12	ES(1,100)
TPH Aromatic C12-C16	ES(12)
TPH Aromatic C16-C21	ES(5,300)
TPH Aromatic C21-C35	ES(1,100)
Arsenic	0.05
Cadmium	0.00025
Copper	0.049
Chromium	0.02
Lead	0.0072
Mercury	0.00005
Nickel	0.034
Selenium	0.01
Zinc	0.079
Vanadium	0.02
Ammoniacal Nitrogen as N	0.43
Chloride	250

ES = Target Exceeds Solubility

Table 9 Case 2 Site Assessment Criteria

Coed Darcy Tip Case:	
2 = 50m to Compliance	
Substance	RTM Assessment Criteria Level 3 Groundwater (mg/l)
Benzene	0.079
Toluene	11
Ethylbenzene	120
m-Xylene	ES(320)
o-Xylene	140
p-Xylene	180
Benzo[b]fluoranthene	ES(>10,000)
Benzo[k]fluoranthene	ES(>10,000)
Benzo[ghi]perylene	ES(>10,000)
Benzo[a]pyrene HH2015	ES(>10,000)
Fluoranthene HH 2015	ES(>10,000)
Indeno[123-cd]pyrene	ES(>10,000)
Naphthalene	ES(>10,000)
Anthracene	ES(>10,000)
TPH Aliphatic C5-C6	ES(>10,000)
TPH Aliphatic C6-C8	ES(>10,000)
TPH Aliphatic C8-C10	ES(>10,000)
TPH Aliphatic C10-C12	ES(>10,000)
TPH Aliphatic C12-C16	ES(>10,000)
TPH Aromatic C8-C10	ES(>10,000)
TPH Aromatic C10-C12	ES(>10,000)
TPH Aromatic C12-C16	ES(>10,000)
TPH Aromatic C16-C21	ES(>10,000)
TPH Aromatic C21-C35	ES(>10,000)
Arsenic	0.05
Cadmium	0.00025
Copper	0.049
Chromium	0.02
Lead	0.0072
Mercury	0.00005
Nickel	0.034
Selenium	0.01
Zinc	0.079
Vanadium	0.02
Ammoniacal Nitrogen as N	1.5
Chloride	250

ES = Target Exceeds Solubility



7 Sensitivity Analysis

The RTM analysis requires estimates to be made of a large number of parameters the exact values of which are generally unknown. In many cases sensible 'worst-case' values have been adopted as discussed above. The use of inverse modelling has reduced uncertainties in key hydraulic parameters.

The in-house implementation of the EA RTM approach allows automatic sensitivity analysis to be undertaken that is useful in highlighting the potentially most critical parameters. The resultant change in model outputs from any change in any parameter may be computed. The procedure adopted was to vary each parameter by +10% and compute the resultant percentage change to the derived site assessment criteria. This work is summarised below for Case 1 Benzene Soil and Groundwater.

Table 10 Sensitivity Analysis

Parameter	Effect of +10% change of parameter on Level 3 Assessment Criteria for Benzene, expressed as percentage resulting change in criterion - Case 1 Level 3 Groundwater	Comment on Selected Parameter
Saturated Aquifer Thickness	0	Not Critical
Mixing Zone Thickness	VS	EA recommended calculation method
Saturated Aquifer Porosity	+0.08	Reasonable Average Value
Length of Source	VS	Site dimension
Width of Source	VS	Site dimension
Aquifer Longitudinal Dispersivity	-0.2	Reasonable literature value adopted
Aquifer Transverse Dispersivity	VS	Reasonable literature value adopted
Aquifer Vertical Dispersivity	VS	Reasonable literature value adopted
Level 3 Hydraulic Gradient	-4.1	Based on modelling and site measurements.
Level 3 Hydraulic Conductivity	-4.1	Based on inverse modelling.
Aquifer Fraction of Organic Carbon	+2.8	Measured average site value
Saturated Aquifer Bulk Density	+4.6	Parameter not likely to change significantly
Level 3 Partition Coefficient	+4.6	EA Recommended Parameters for organics.
Half Life Saturated Zone	-4.1	Sensible Literature Upper Limit Adopted

VS = Very Small

As may be seen, highest levels of sensitivity generally relate to parameters related to predicted Level 3 attenuation. However, hydraulic conditions have been based on site- modelling to be consistent with the water balance and other parameters have been chosen to be conservative and shown to be so by comparison to site-specific attenuation rate data.

Particularly conservative assumptions inherent in the analysis include adopted degradation rates five times slower than evidenced from site-specific field data and the adoption of the Domenico Steady State algorithm given the very low derived transport rates.

Given the very high retardation factors for organic contaminants associated with the peat sediments, in the present case the sensitivity to assumed parameters is not critical to the main conclusion those substances would not result in any significant impact via the dissolved phase.

It also follows that the analysis is not sensitive to the potential effects of climate change. Although these are not known, the only credible significant effects on the analysis would be to lead to either an increase or decrease in infiltration over the upstream site catchment. In terms of the impact on Level 3 derived assessment criteria this could potentially lead to an increase or decrease in site hydraulic gradient and as shown above, a 10% change in gradient results only in a 4 % change in assessment criterion for the most potentially mobile organic substance considered.



8 Summary Conclusions

Groundwater emanating from the permit area is flowing generally northwards from the eastern and central site area and north westwards from the western site area, in both case with discharge to the Crymlyn Bog. Local groundwater highs within the permit area can be assumed to be due to relatively low vertical hydraulic conductivity in those areas, potentially partly due to presence of LNAPL within the pore spaces. There is evidence of an upward gradient in groundwater potential along the northern site boundary, which suggests that the bog sequence clays are at least a partial aquiclude and that there is little potential for any dissolved phase contaminants that may be present in the near surface groundwater to migrate downwards into the bedrock or glacial aquifers.

Some concentrations of potential contaminants above compliance criteria in water samples are present within the central part of the permit area, which is historically where wastes have been placed and remain. However, most areas of elevated concentrations are of limited lateral extent and do not extend as far as the northern site boundary. For organics, measured conditions are likely to overestimate the true dissolved phase concentration owing to the presence of NAPL. Based on the most recent five months of monitoring, only the following substances represent potential contaminants of concern with respect to potential dissolved phase off-site migration:

- Aromatic TPH Fractions C10 and higher
- Aliphatic TPH Fraction C12-C16
- PAH Compounds, except Naphthalene
- Ammonium

Site assessment criteria have been derived for the potential contaminants of concern using the Environment Agency's Remedial Target Methodology for two arbitrary compliance points downstream of the site. The high organic content levels of the bog sediments result in very high retardation factors in relation to migration of organic contaminants. For the majority of principal organic contaminants of concern, assessment criteria exceed solubility even for an assumed distance to compliance of just 10 m.

For the other potential contaminants of concern a reasonable initial conclusion, based on this assessment, is that no significant future impact of the bog area will result from dissolved phase migration of these

substances. This initial conclusion is based on an assumed 50 m point of compliance and with comparison to the highest average concentration over any 220 m length of the downstream boundary of the permit area, which is the source width assumed in RTM analysis. On this basis key compounds such as Ammoniacal Nitrogen and Benzene appear compliant, but a further aftercare monitoring programme is proposed.



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Addendum - C1 - C8



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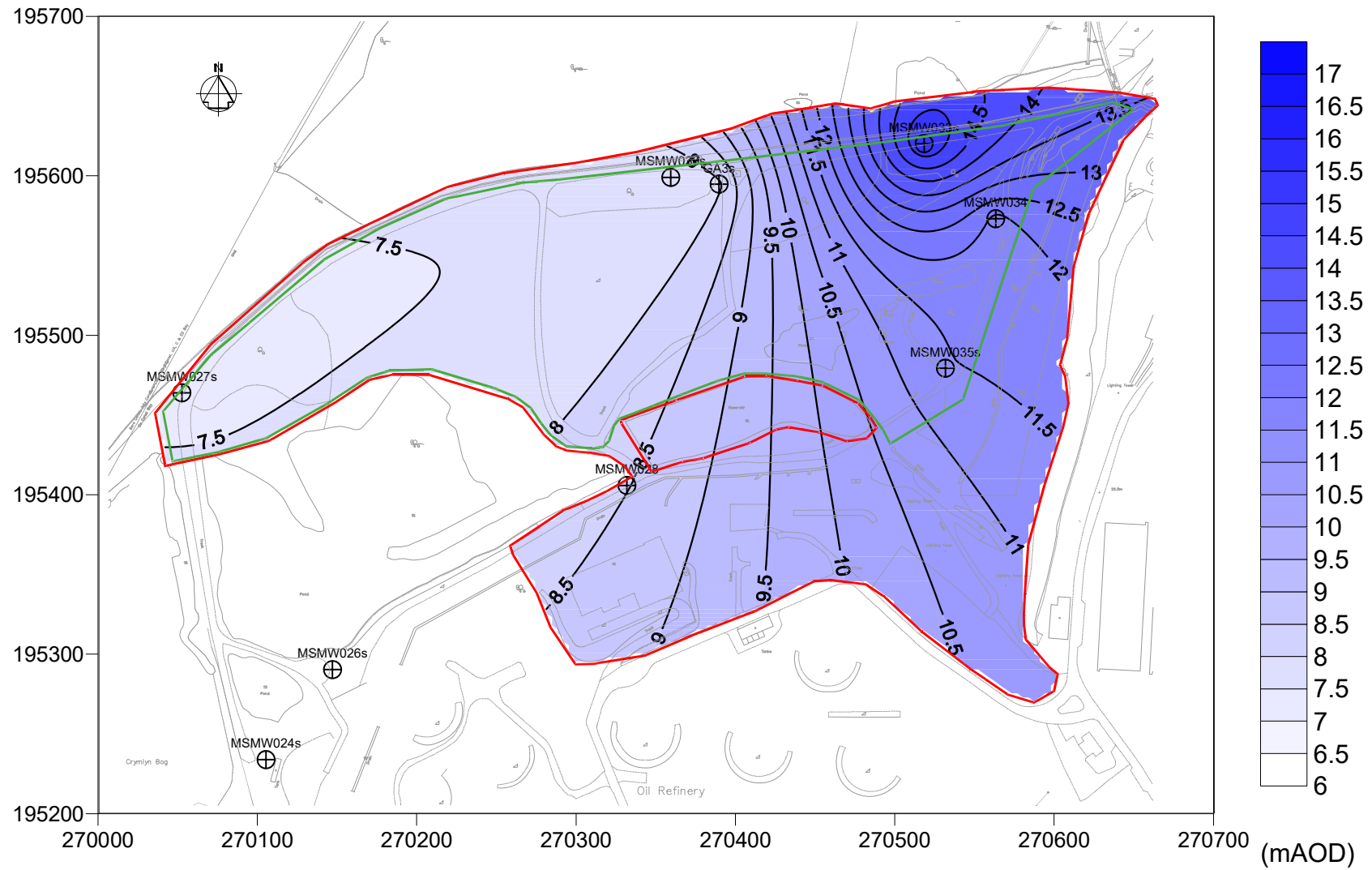
Addendum C1 - GW Contours 1998 2003



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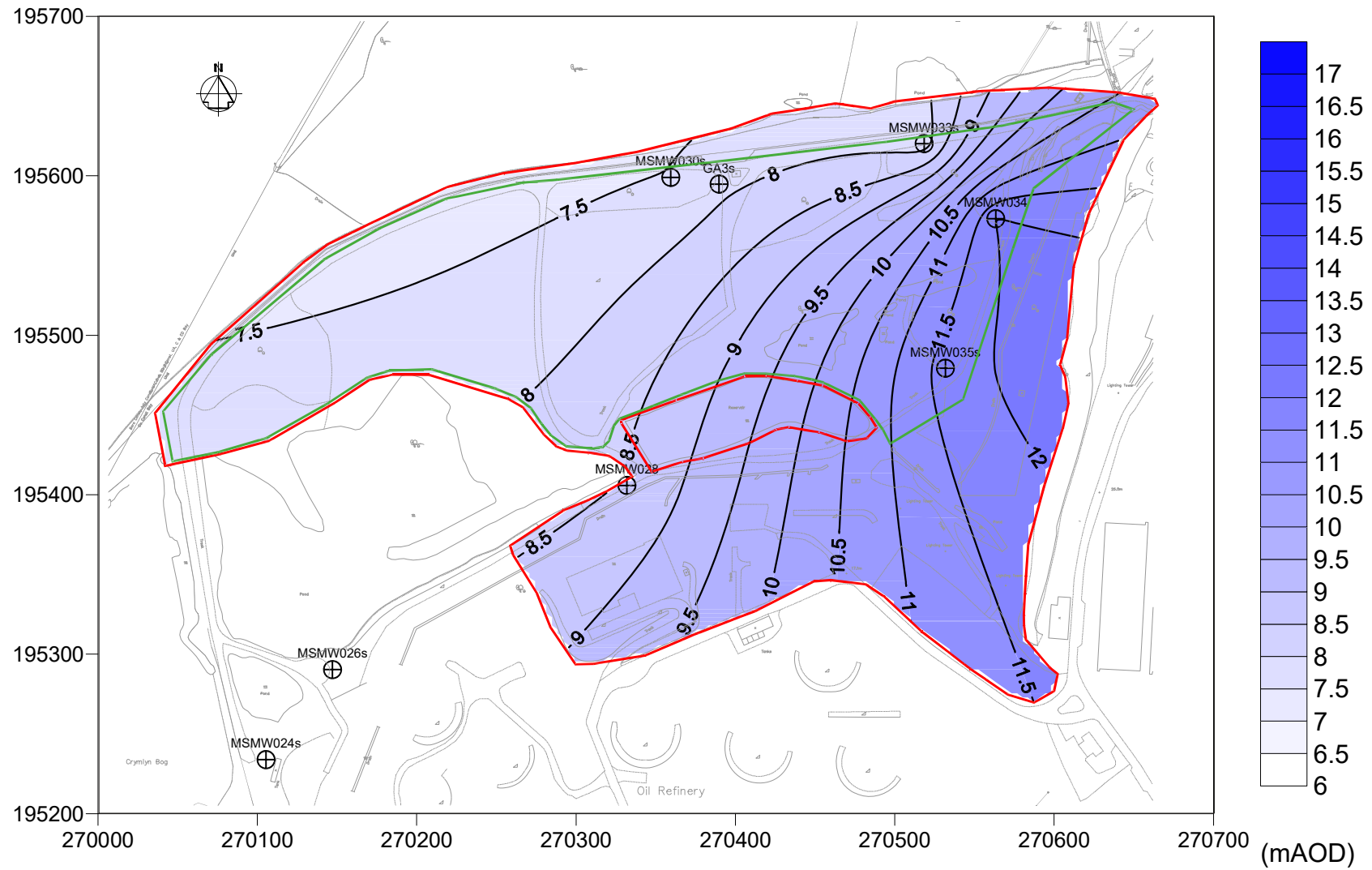
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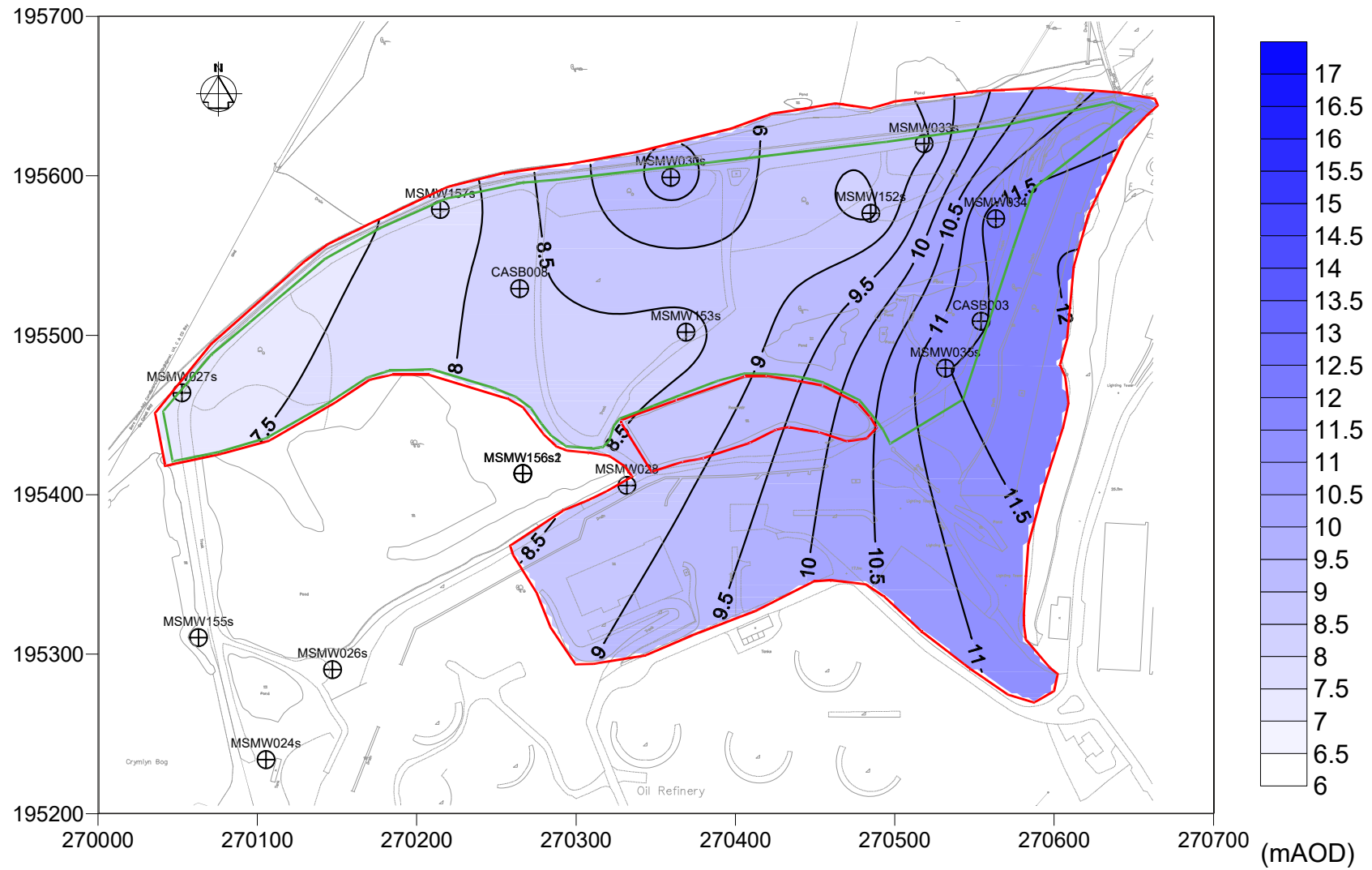
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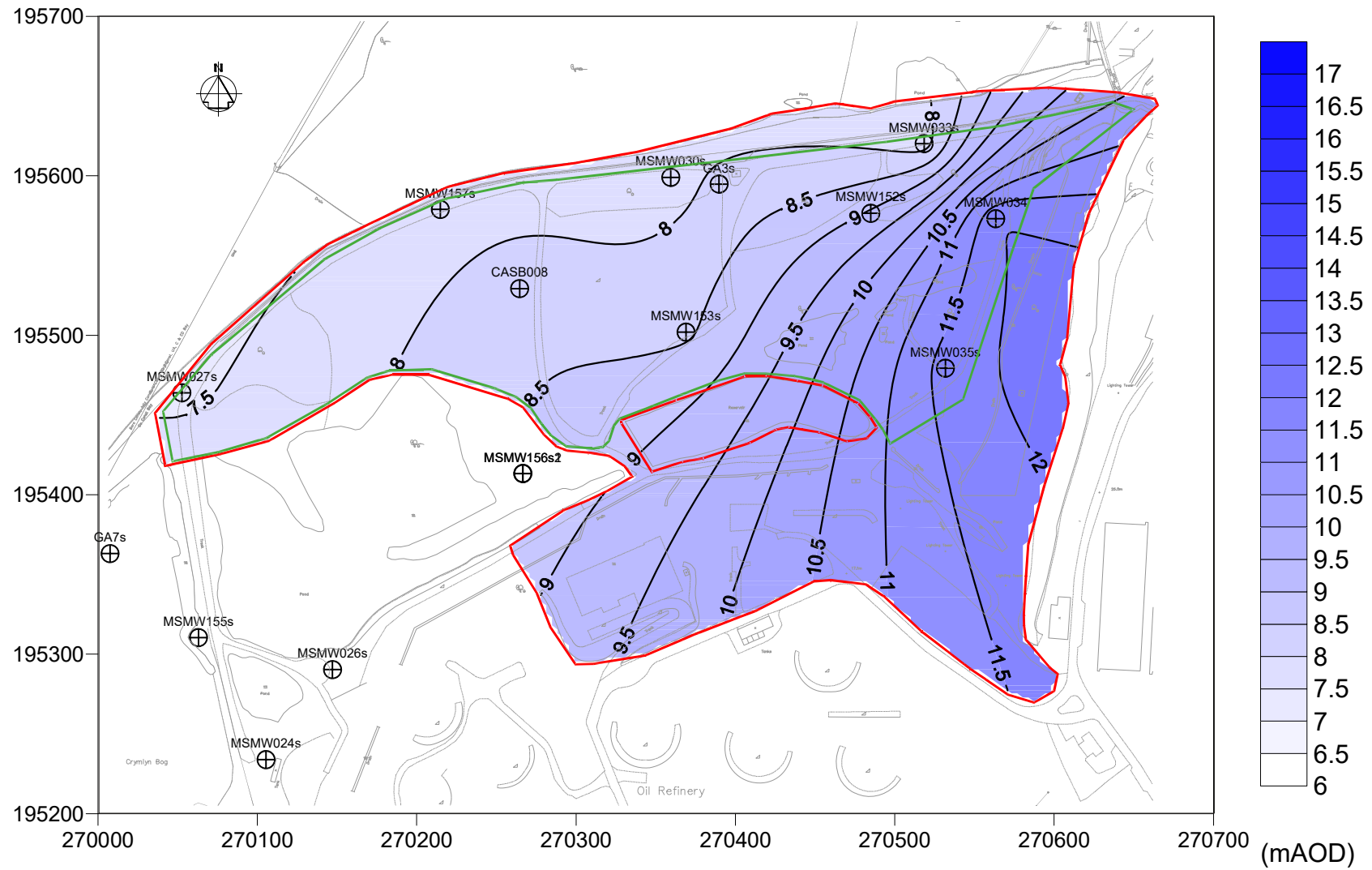
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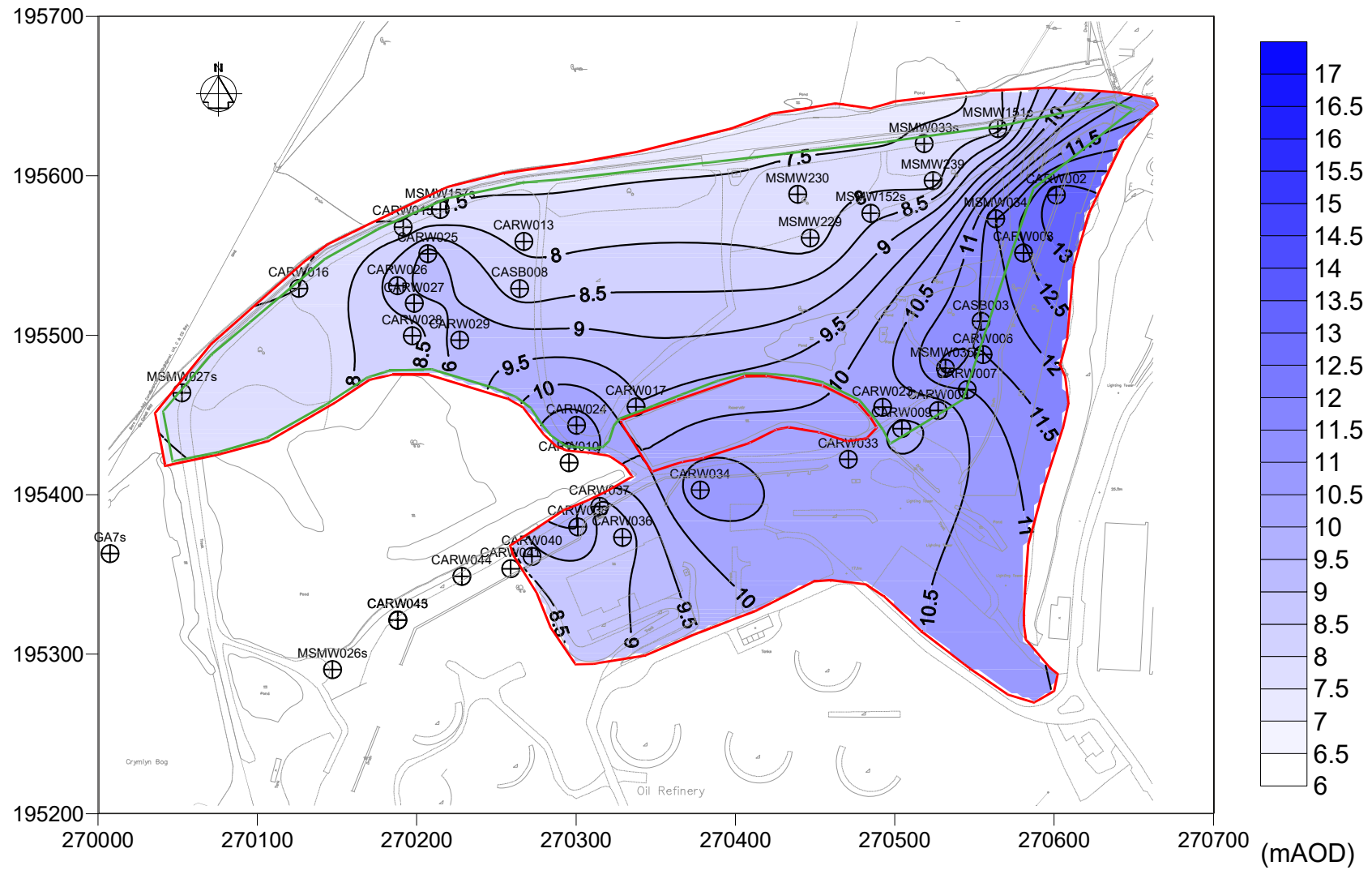
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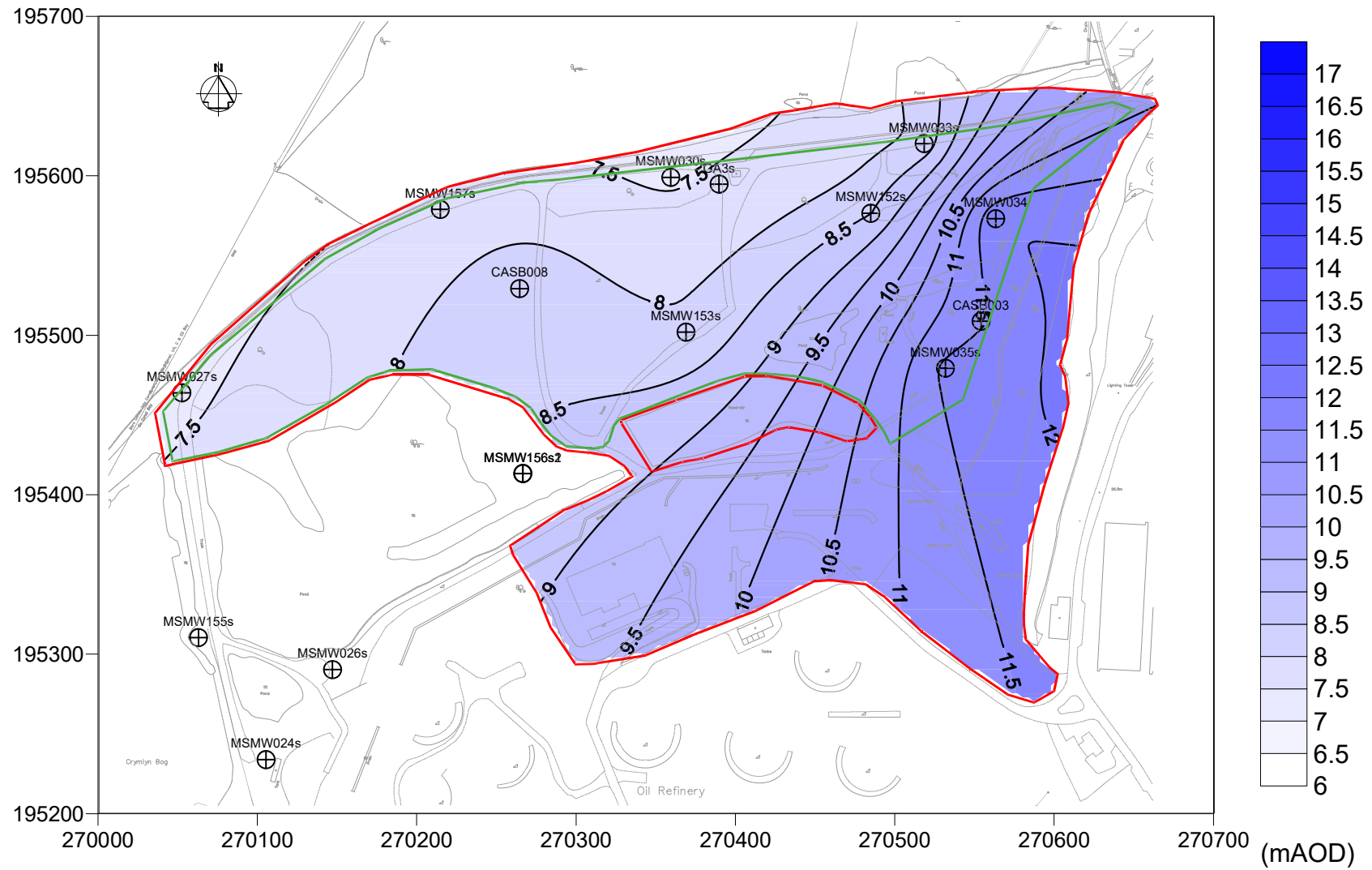
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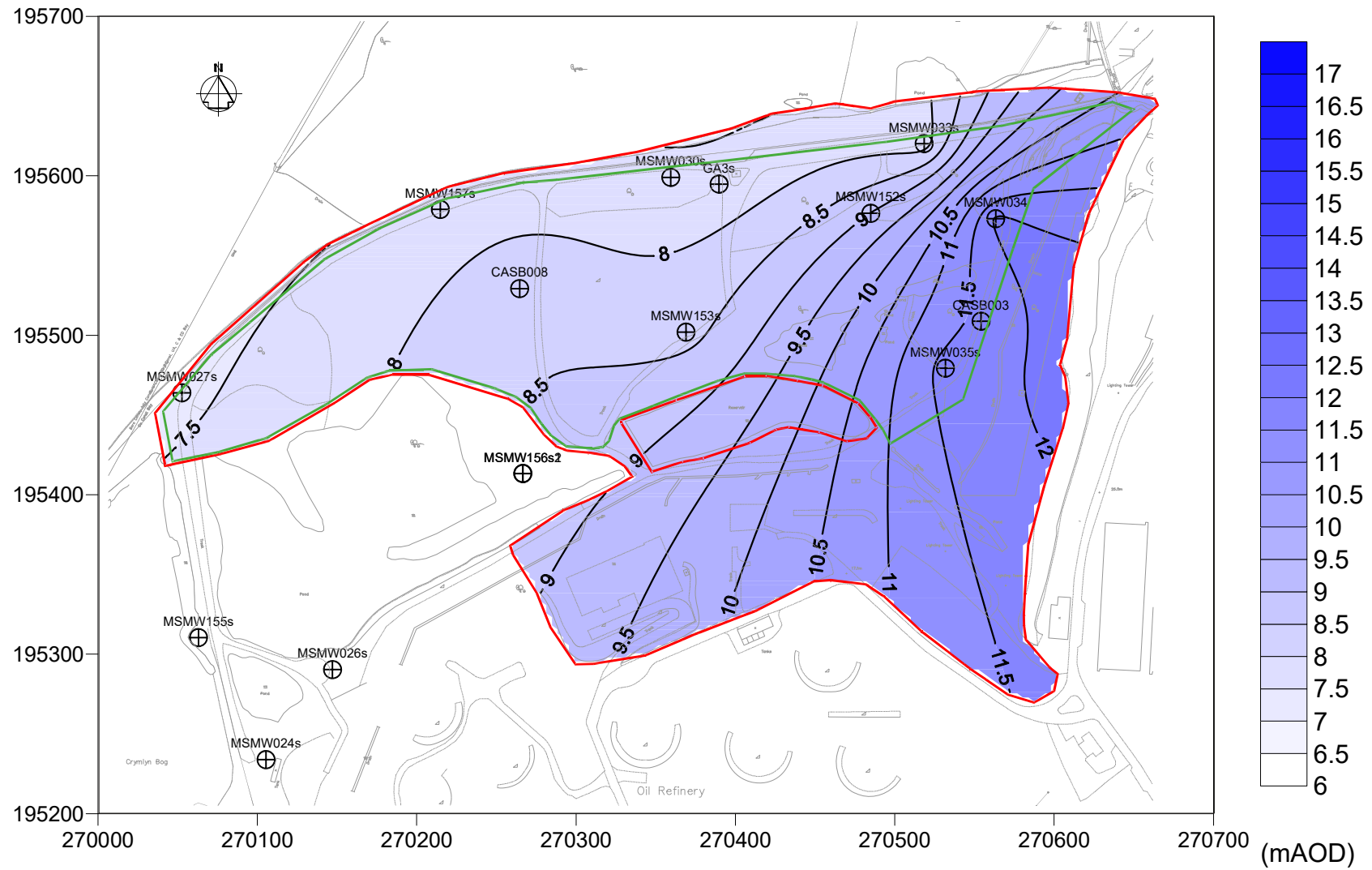
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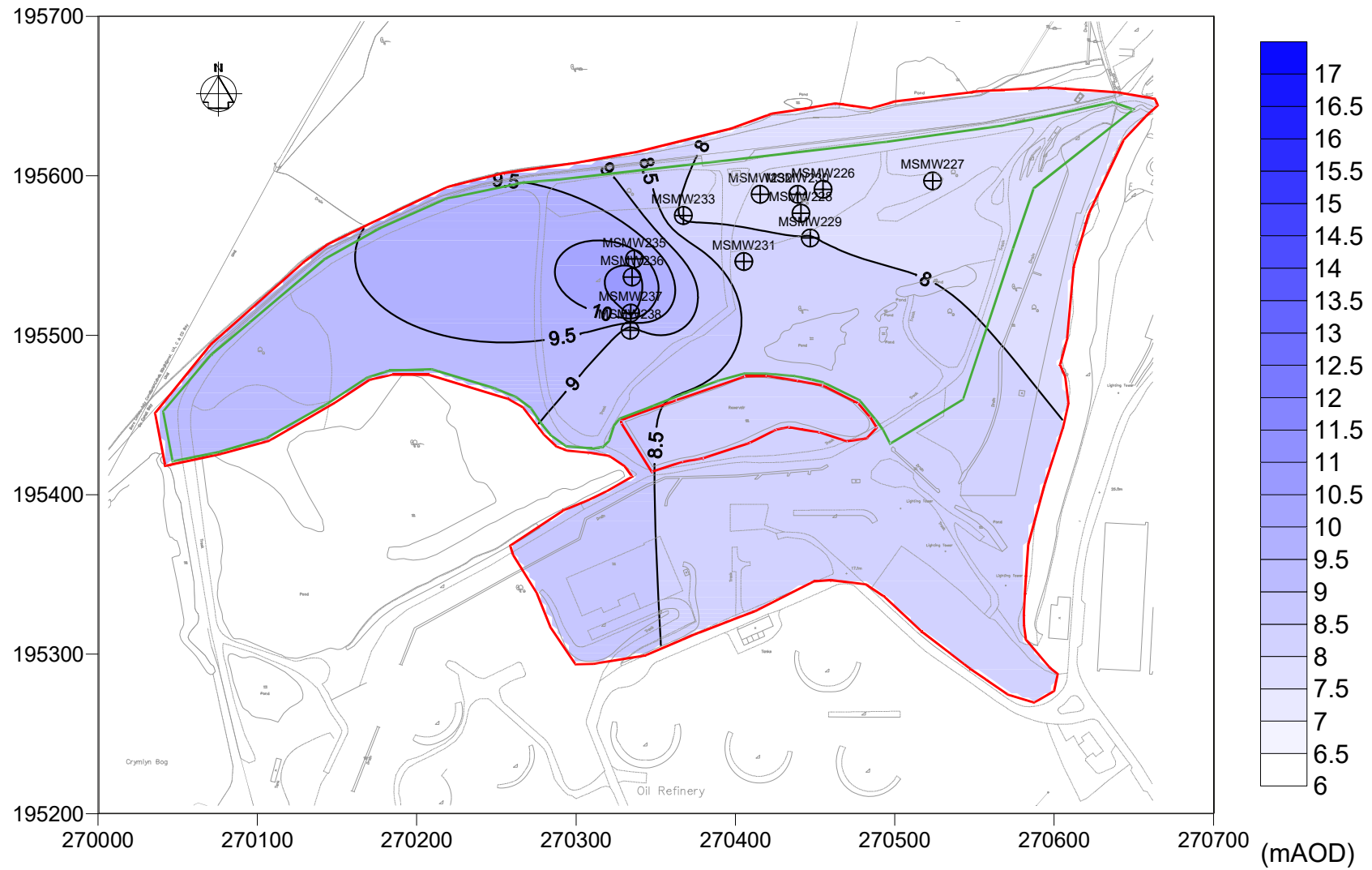
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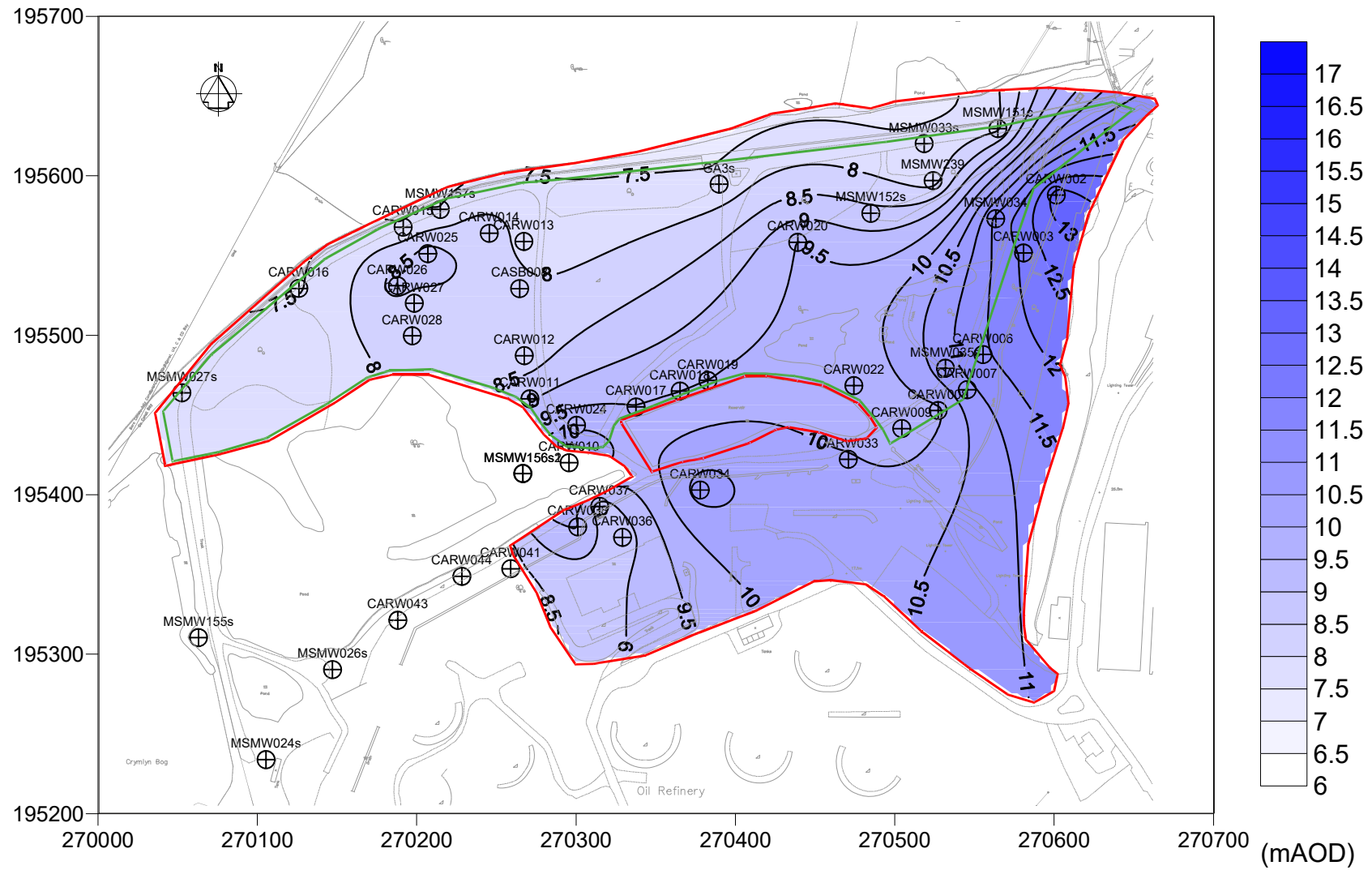
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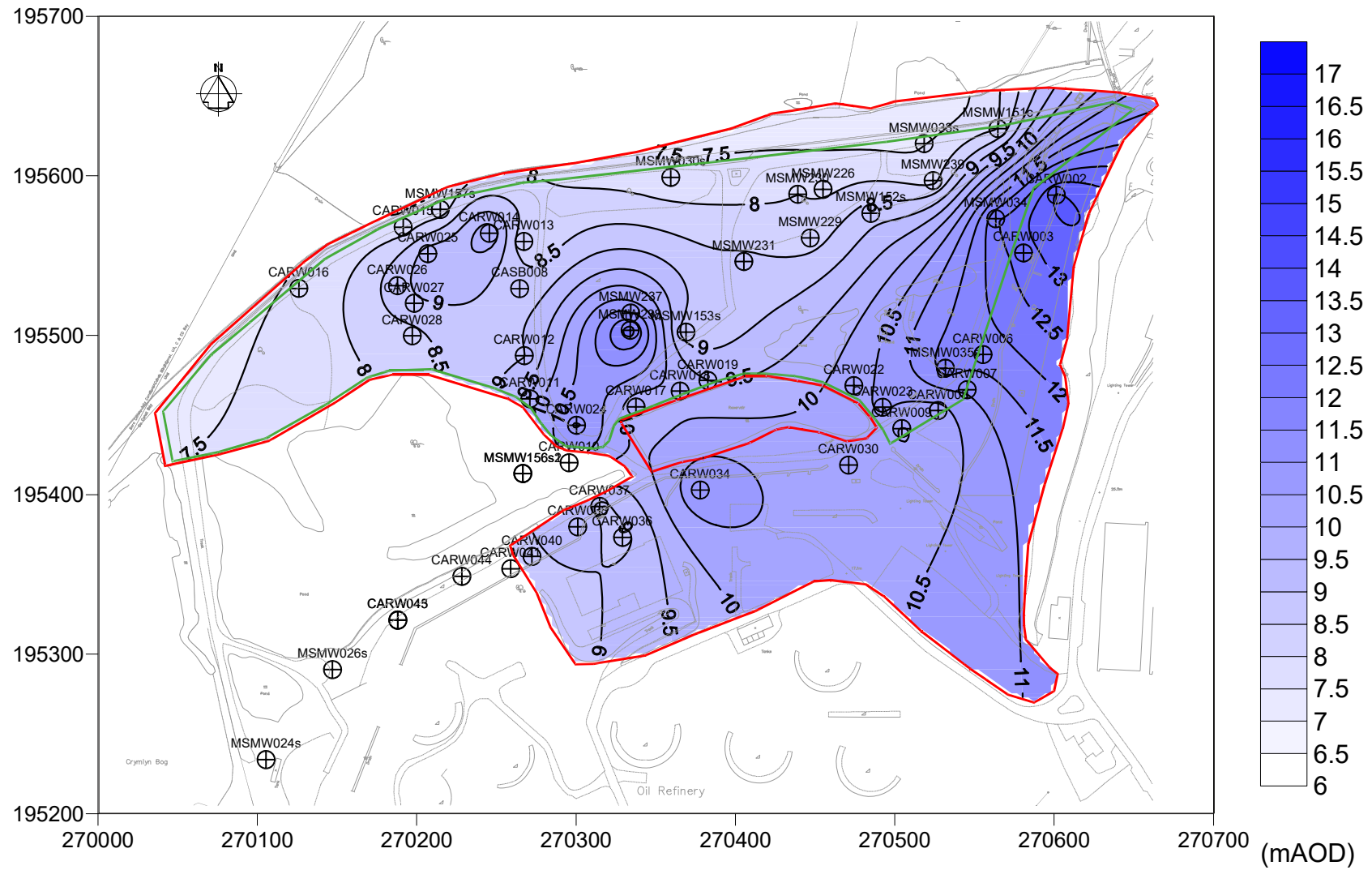
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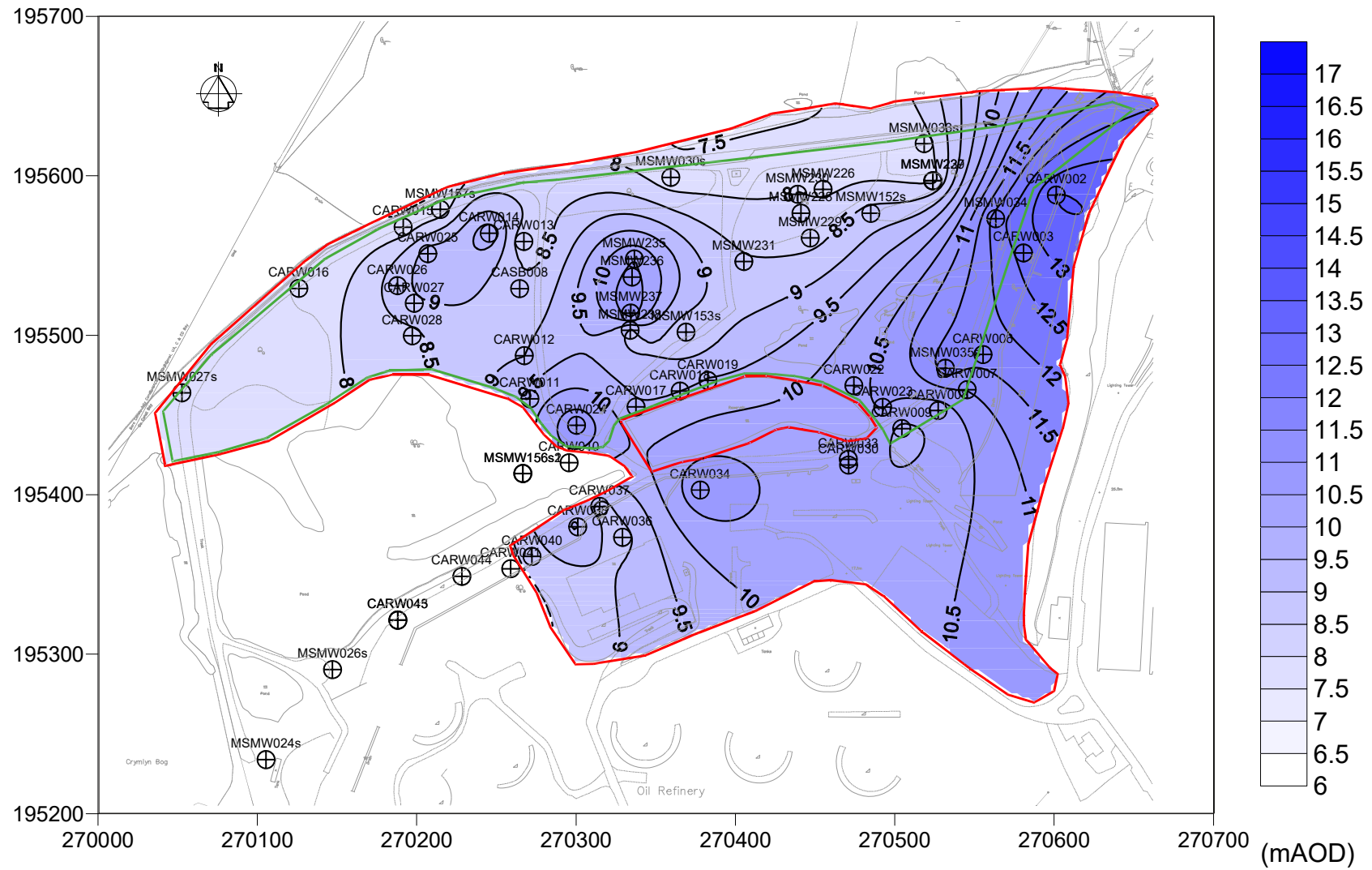
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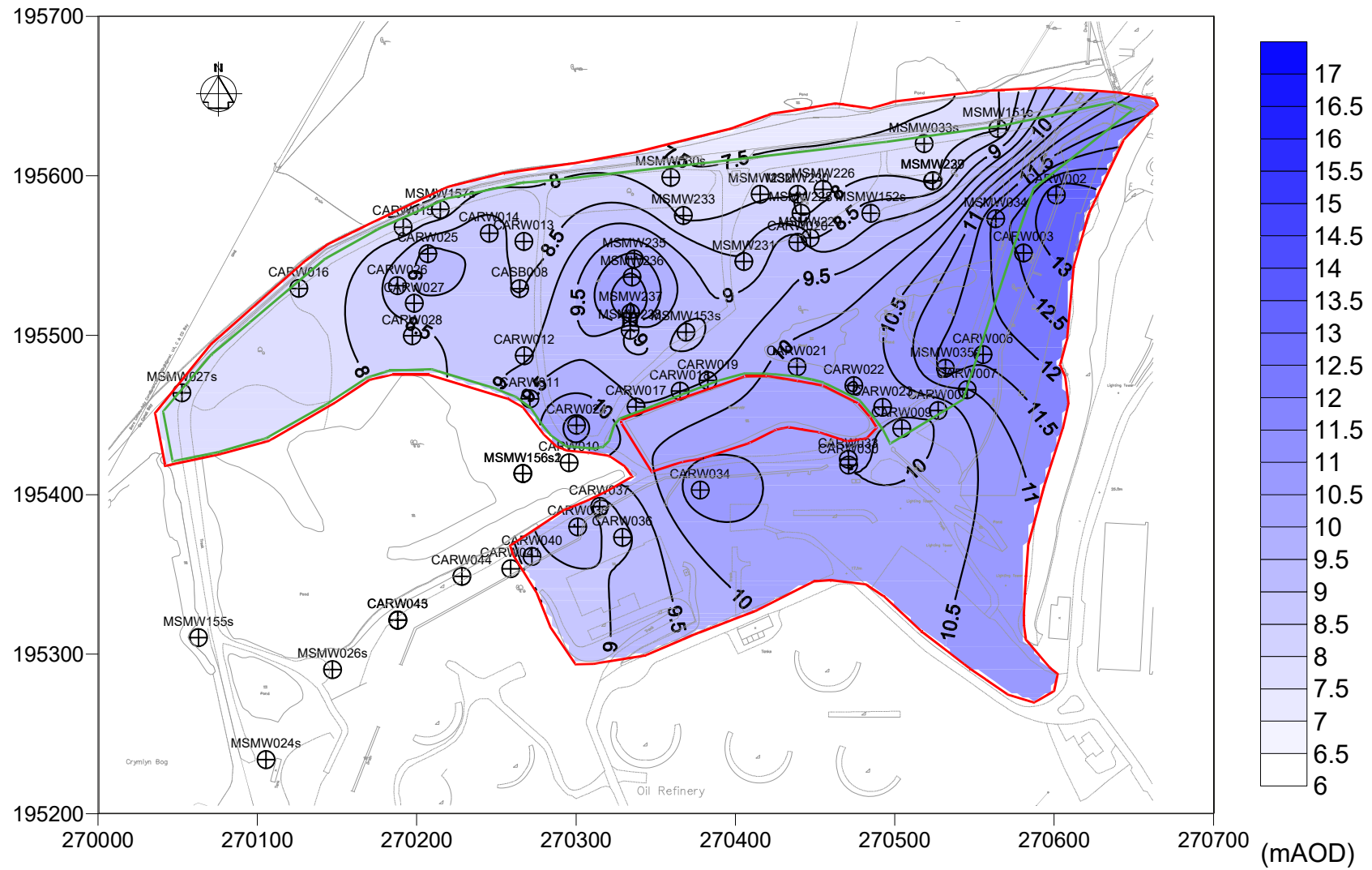
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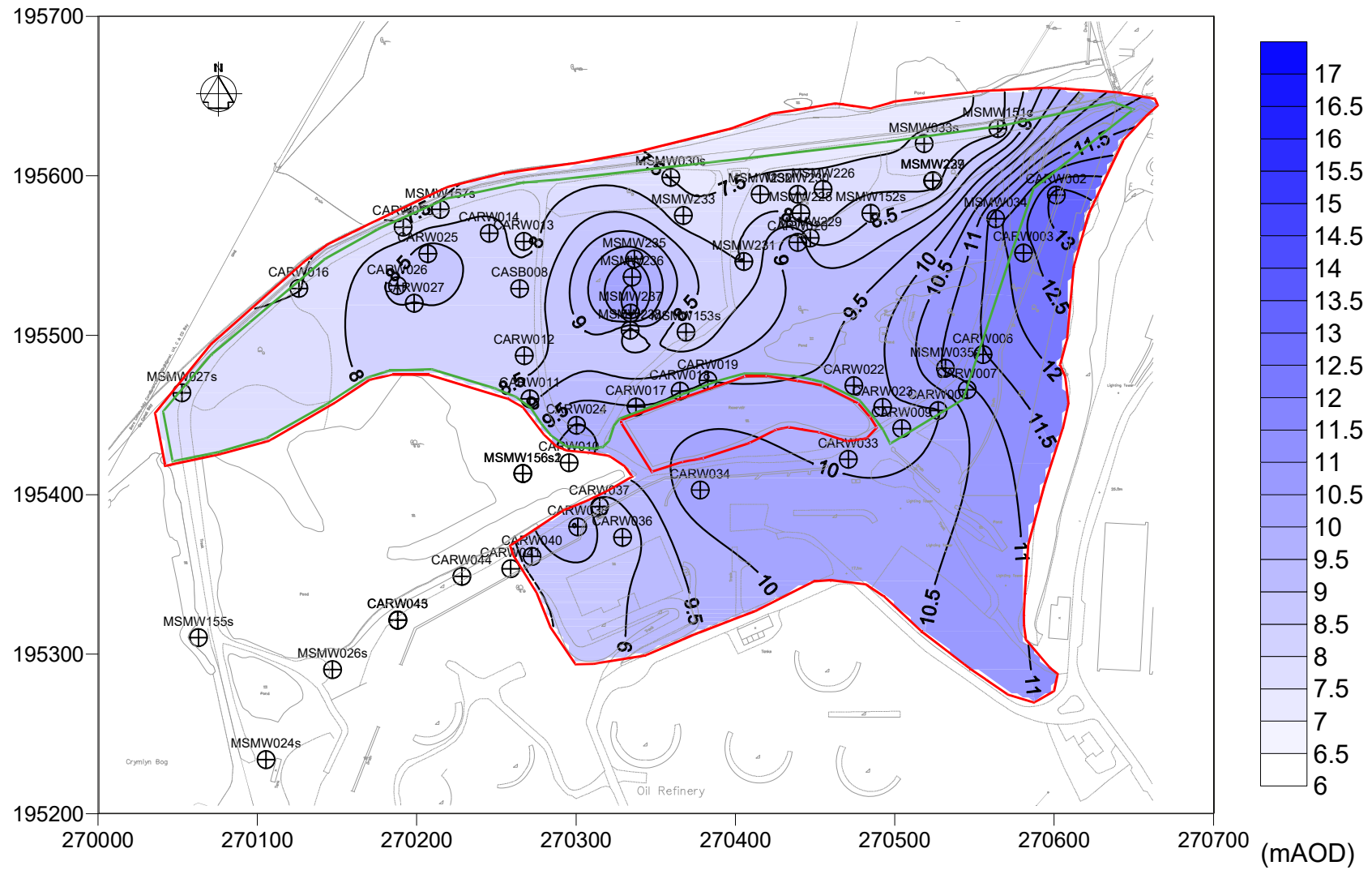
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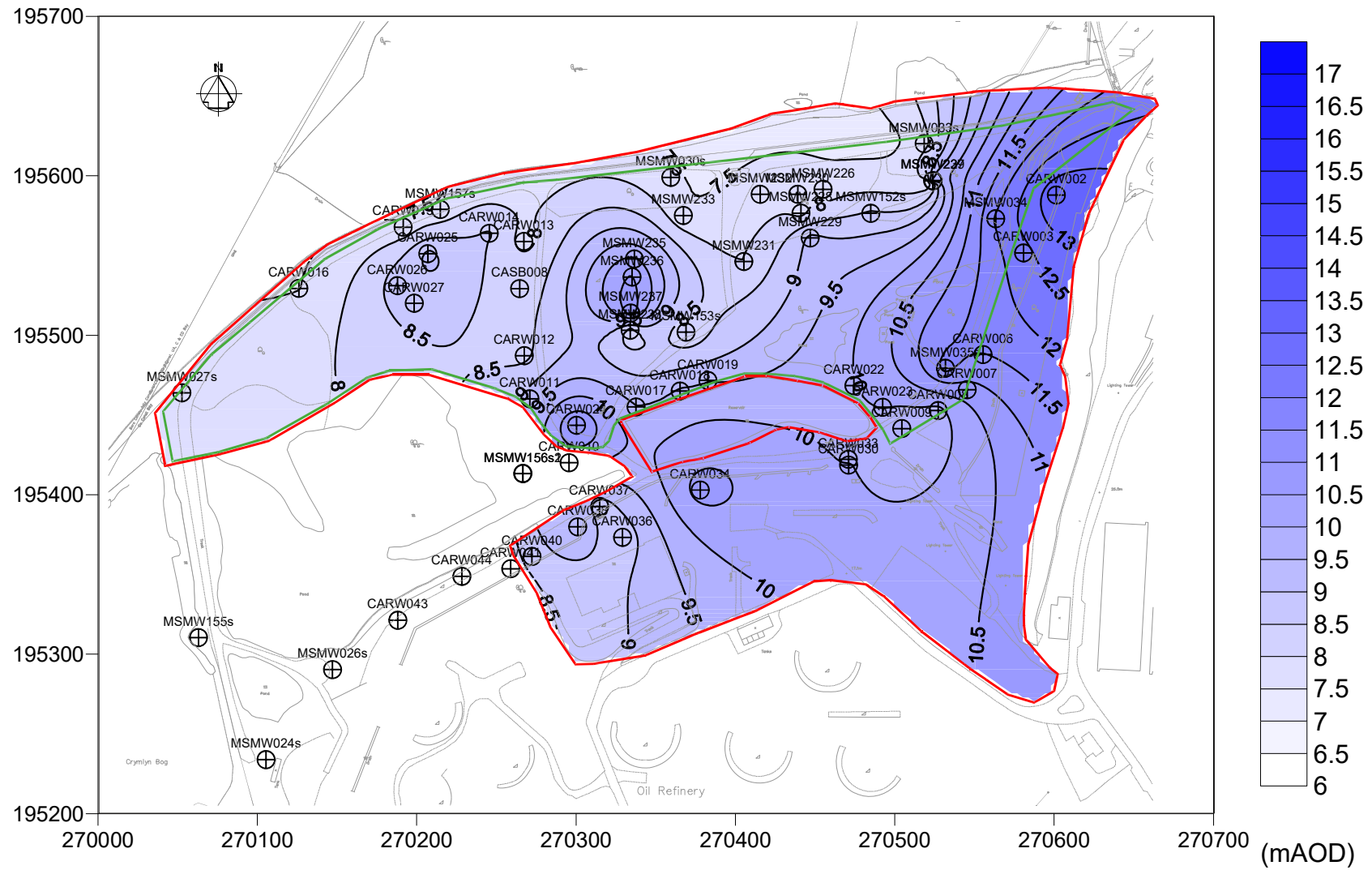
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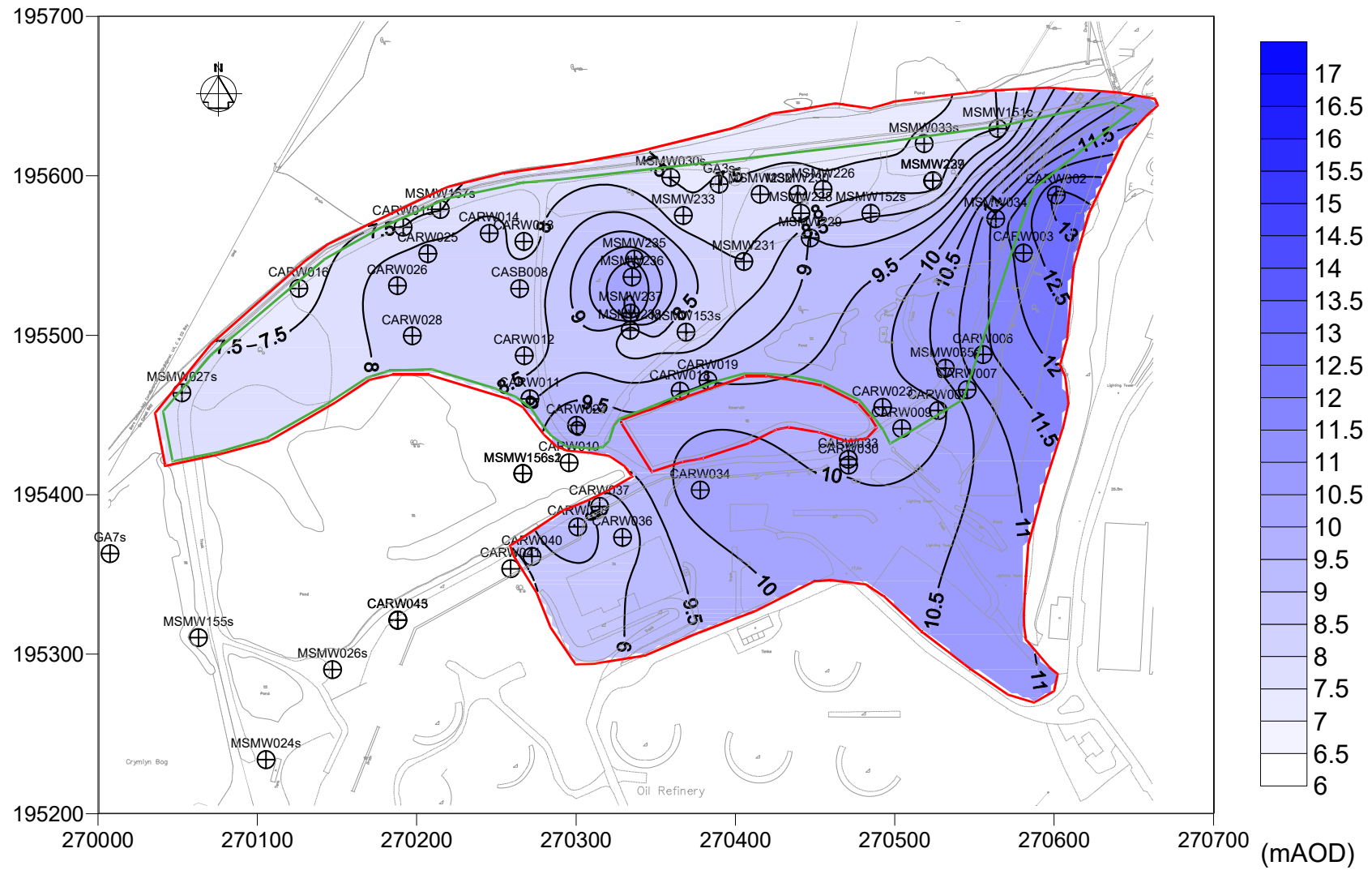


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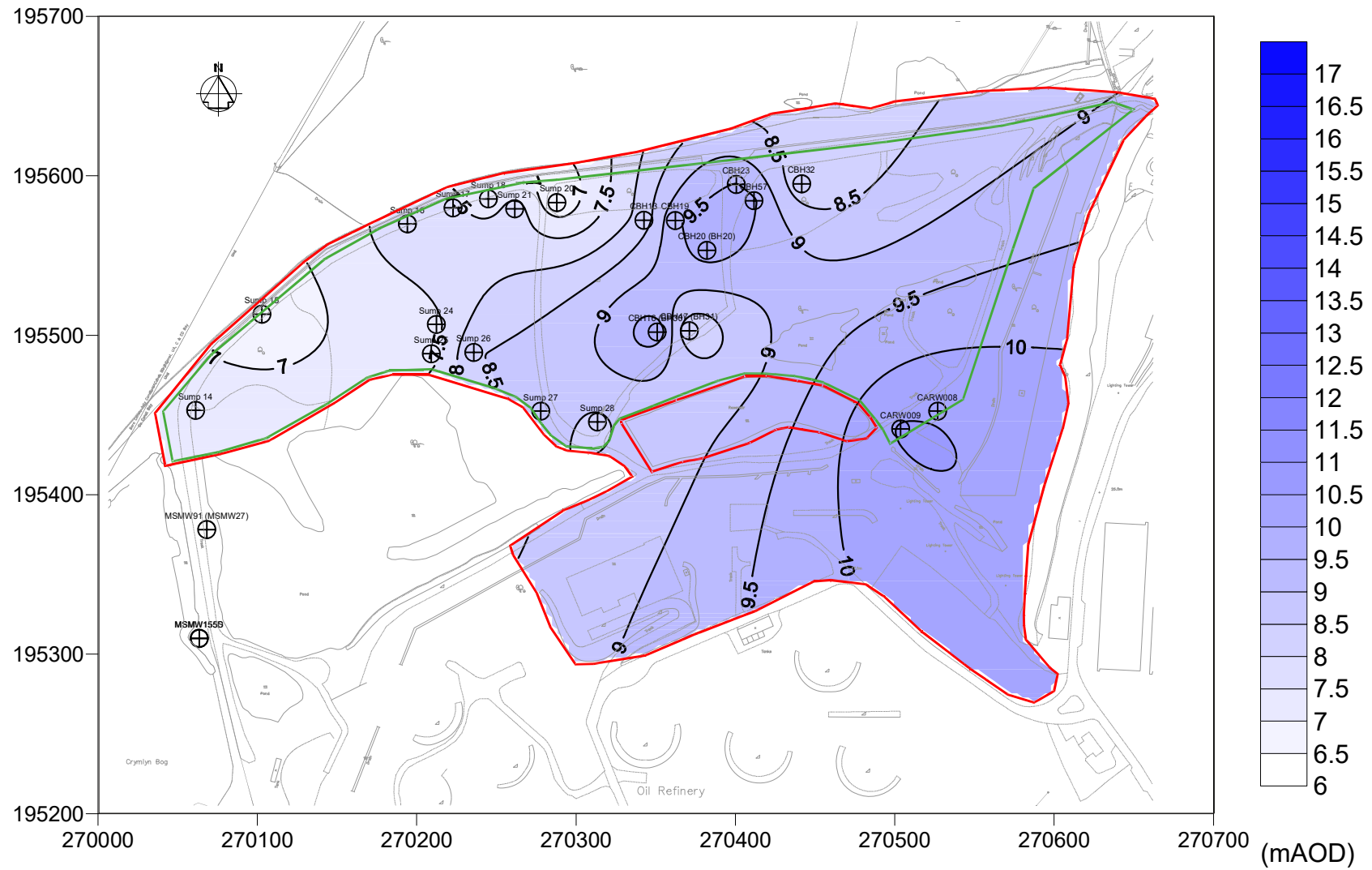
Addendum C2 - GW Contours 2020 2022



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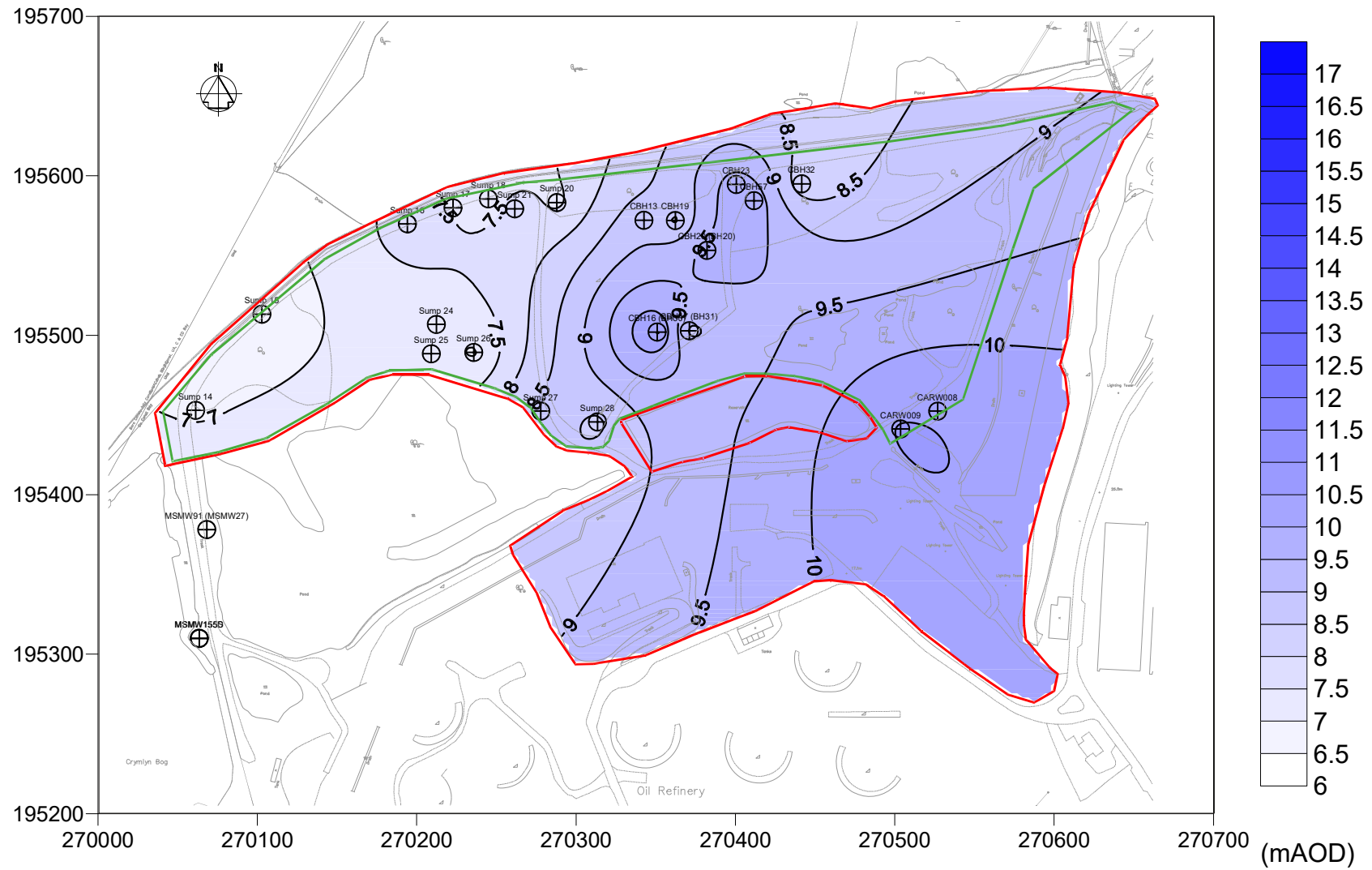
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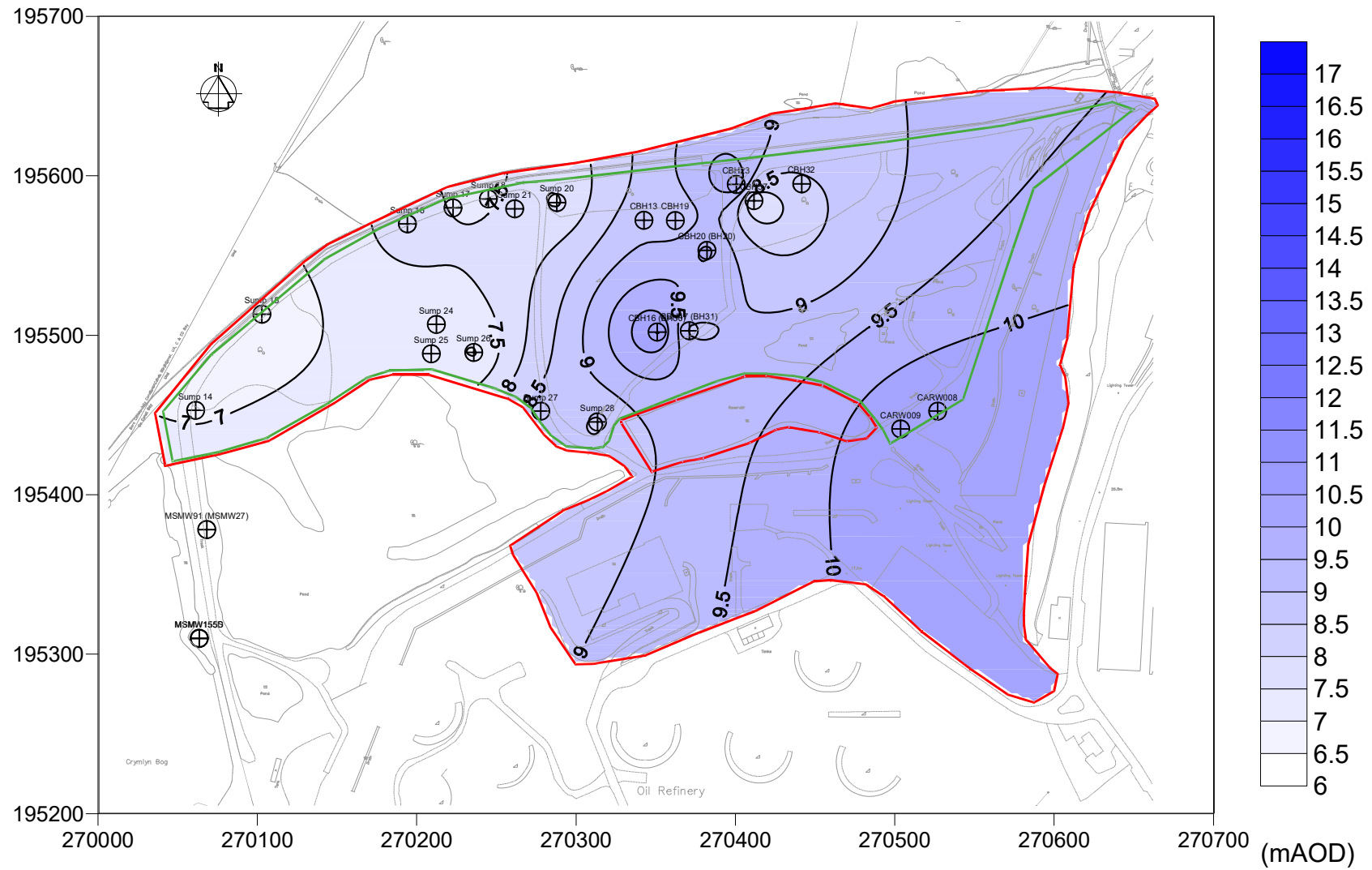
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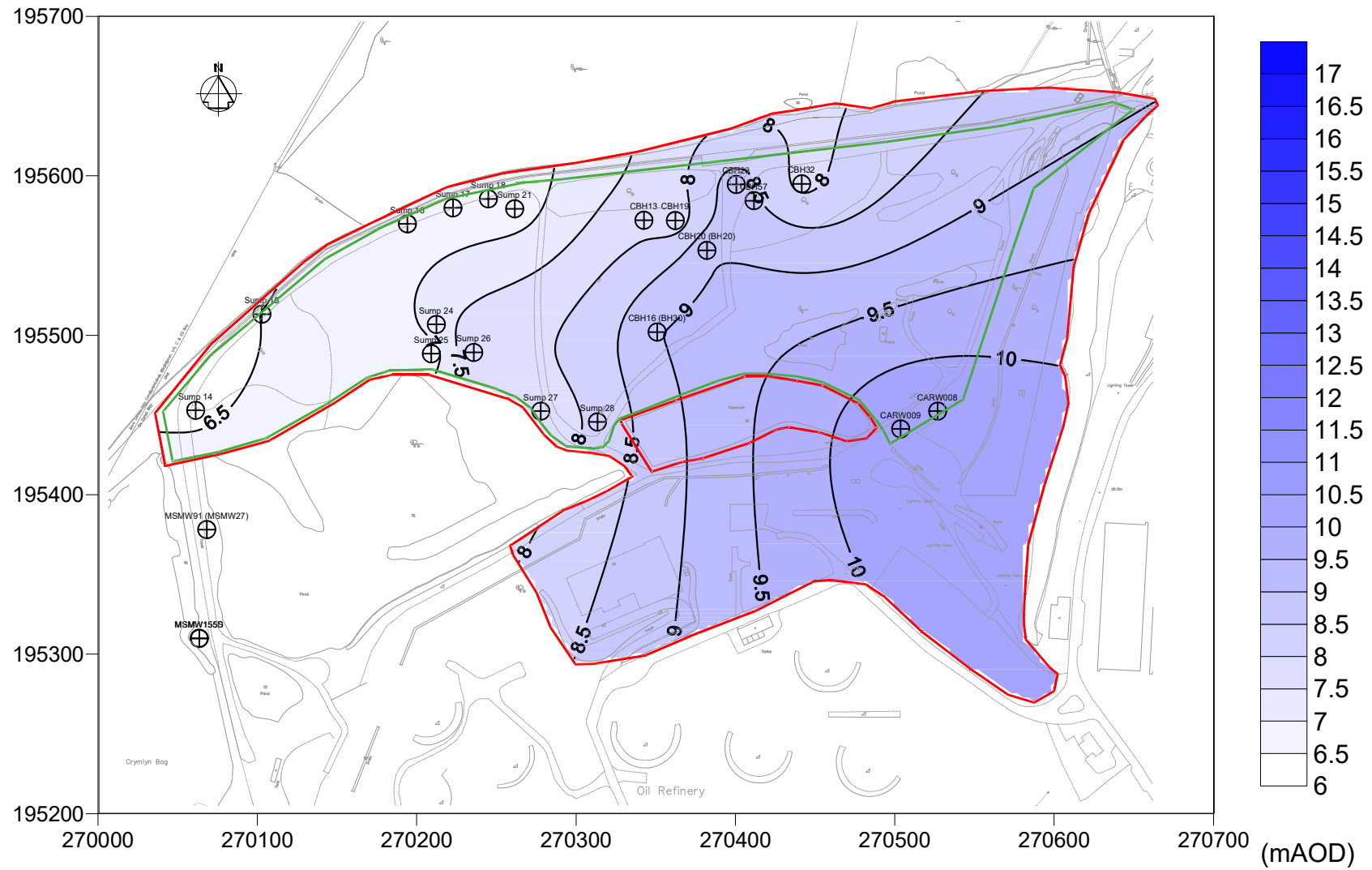
Coed Darcy Tip

Inferred Contours of 20 03 20 Groundwater Level



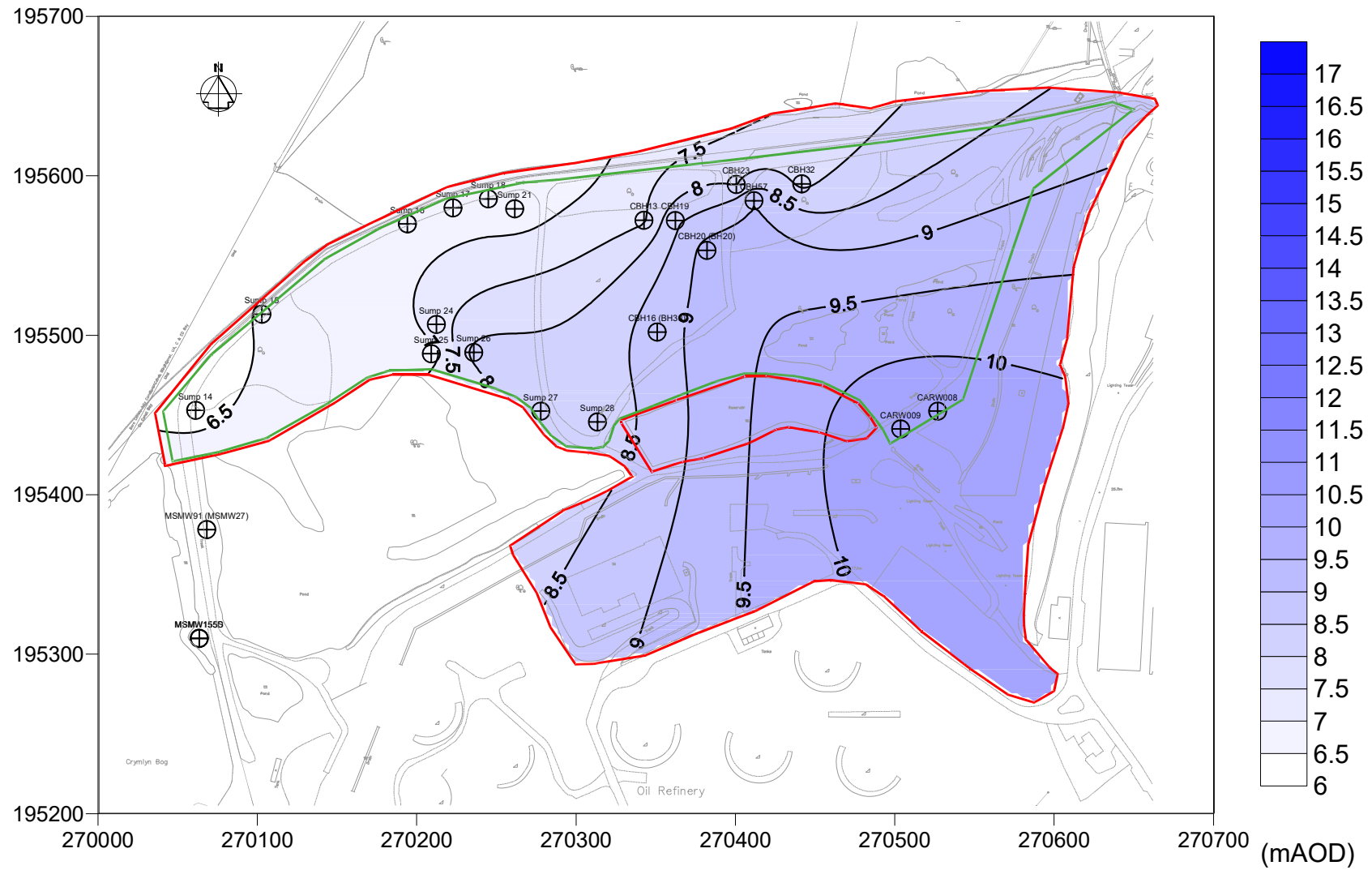
Coed Darcy Tip

Inferred Contours of 26 05 20 Groundwater Level



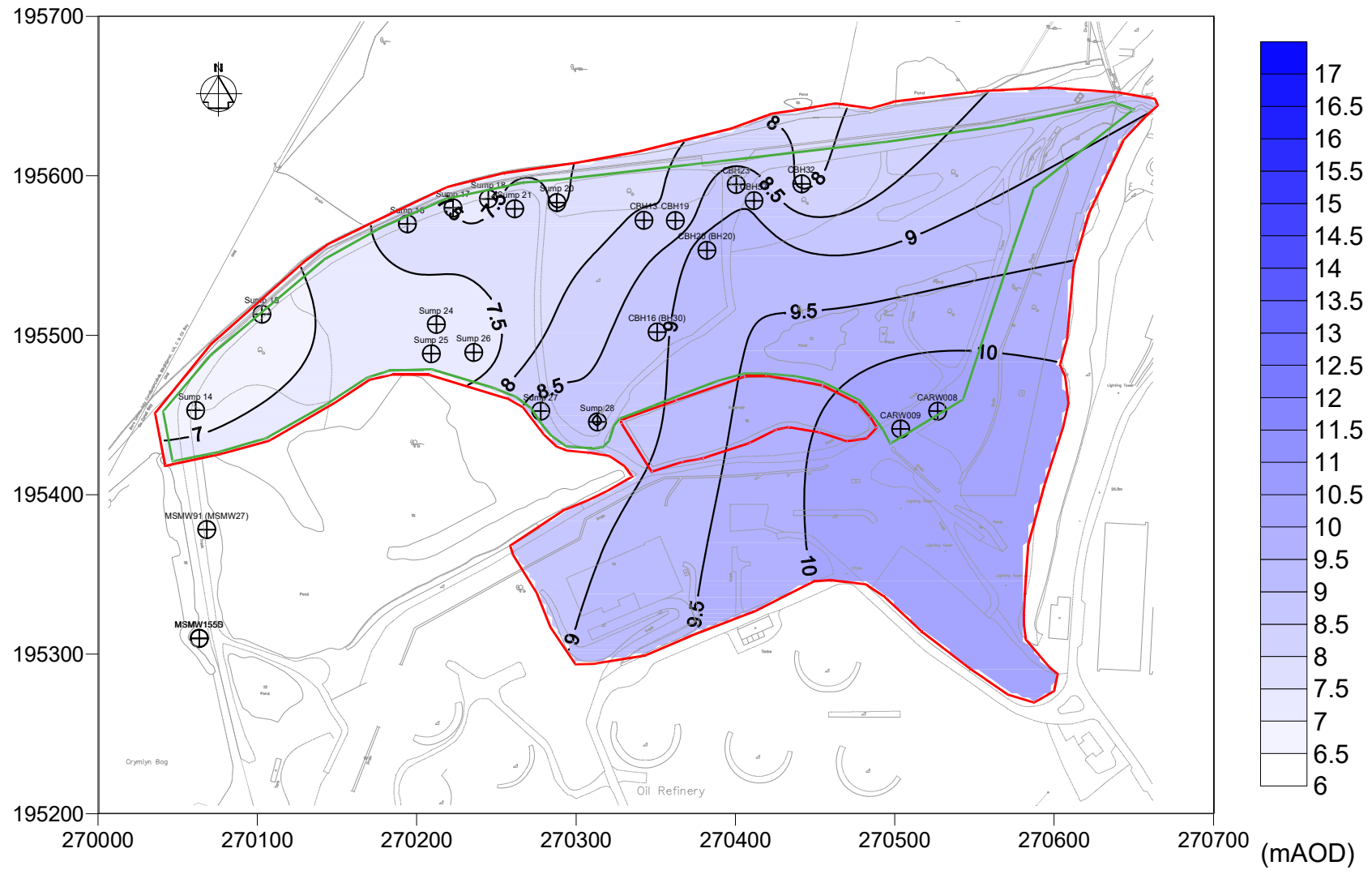
Coed Darcy Tip

Inferred Contours of 30 04 20 Groundwater Level



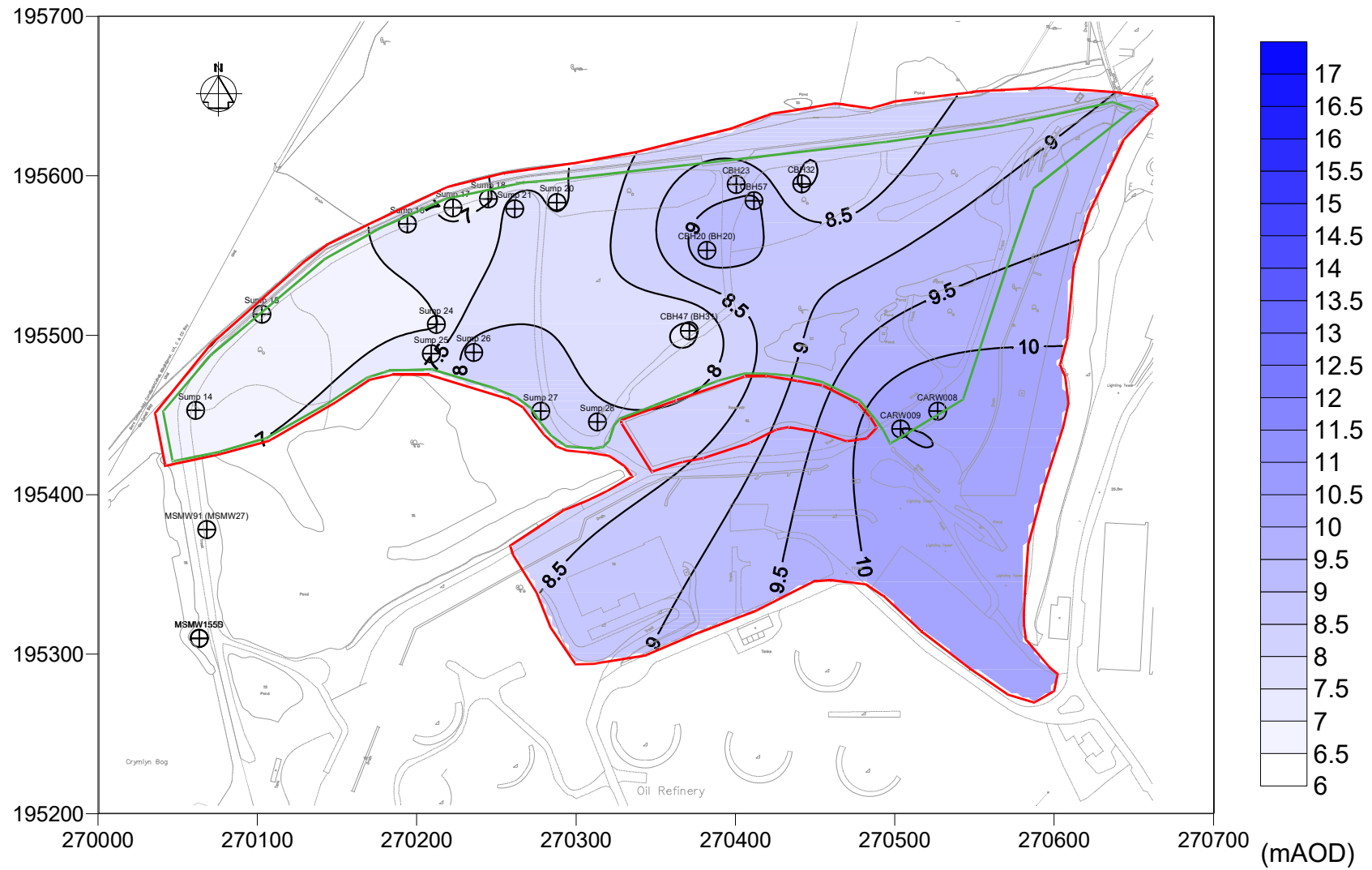
Coed Darcy Tip

Inferred Contours of 26 06 20 Groundwater Level



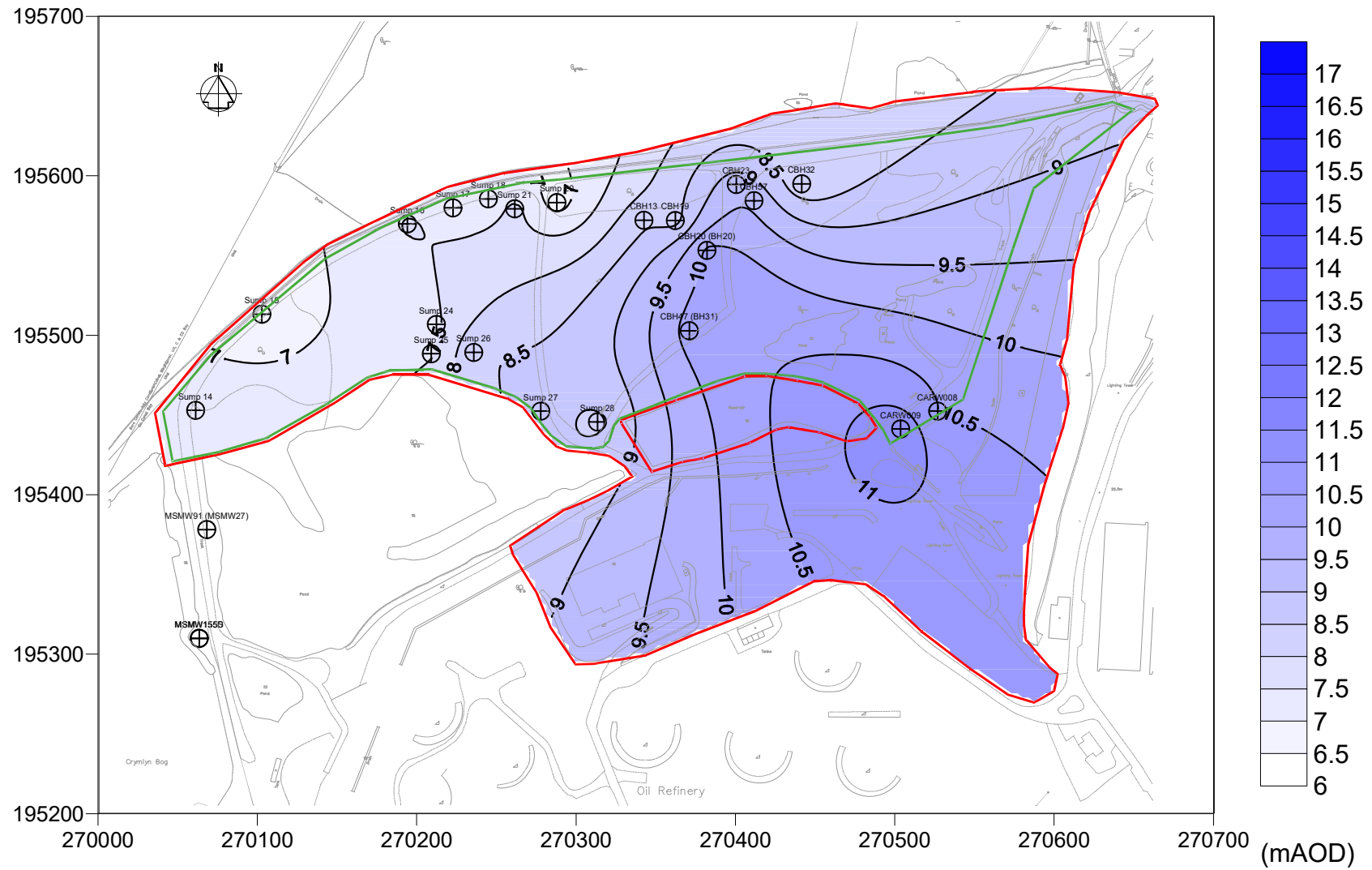
Coed Darcy Tip

Inferred Contours of 30 07 20 Groundwater Level



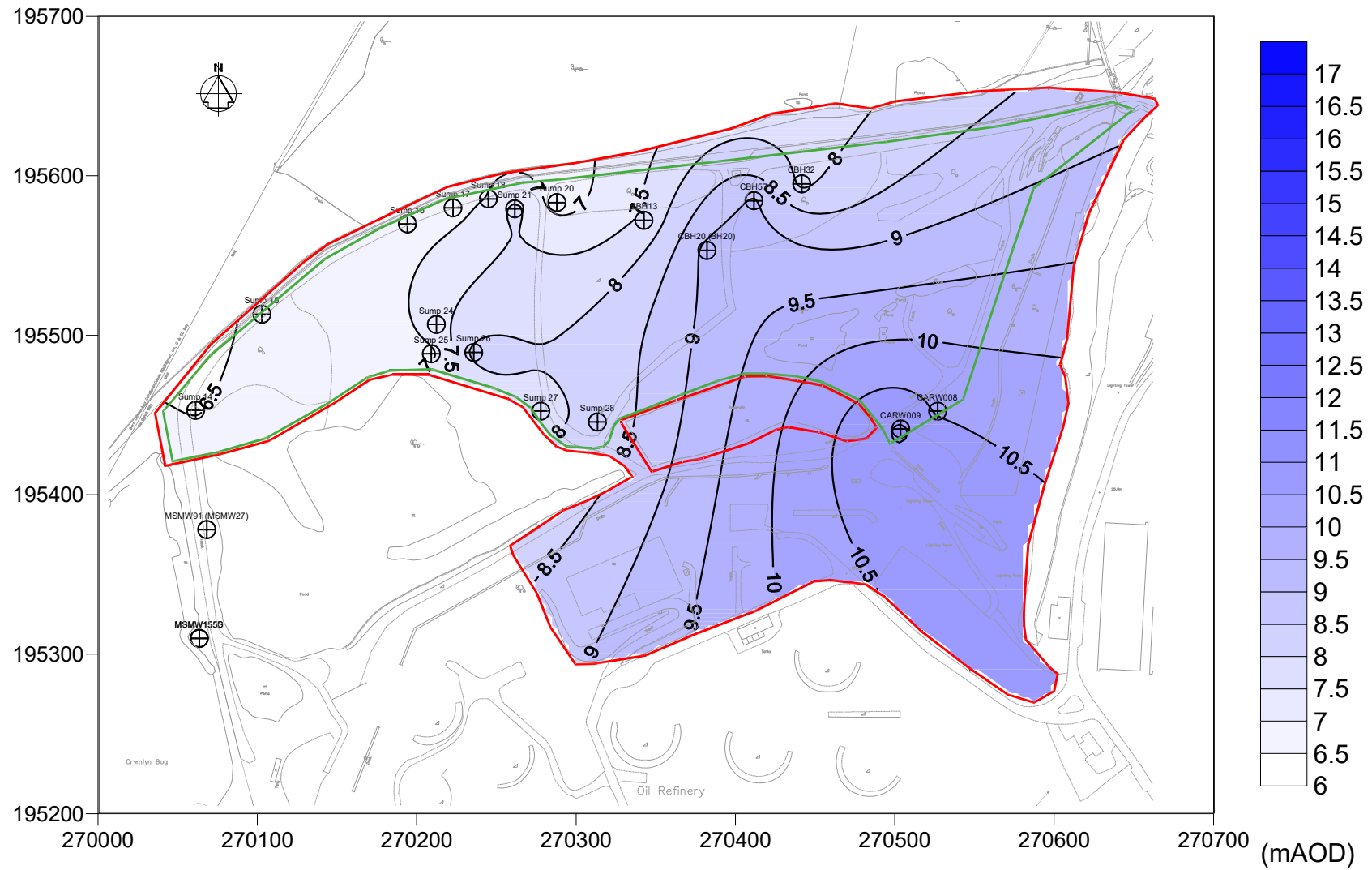
Coed Darcy Tip

Inferred Contours of 26 08 20 Groundwater Level



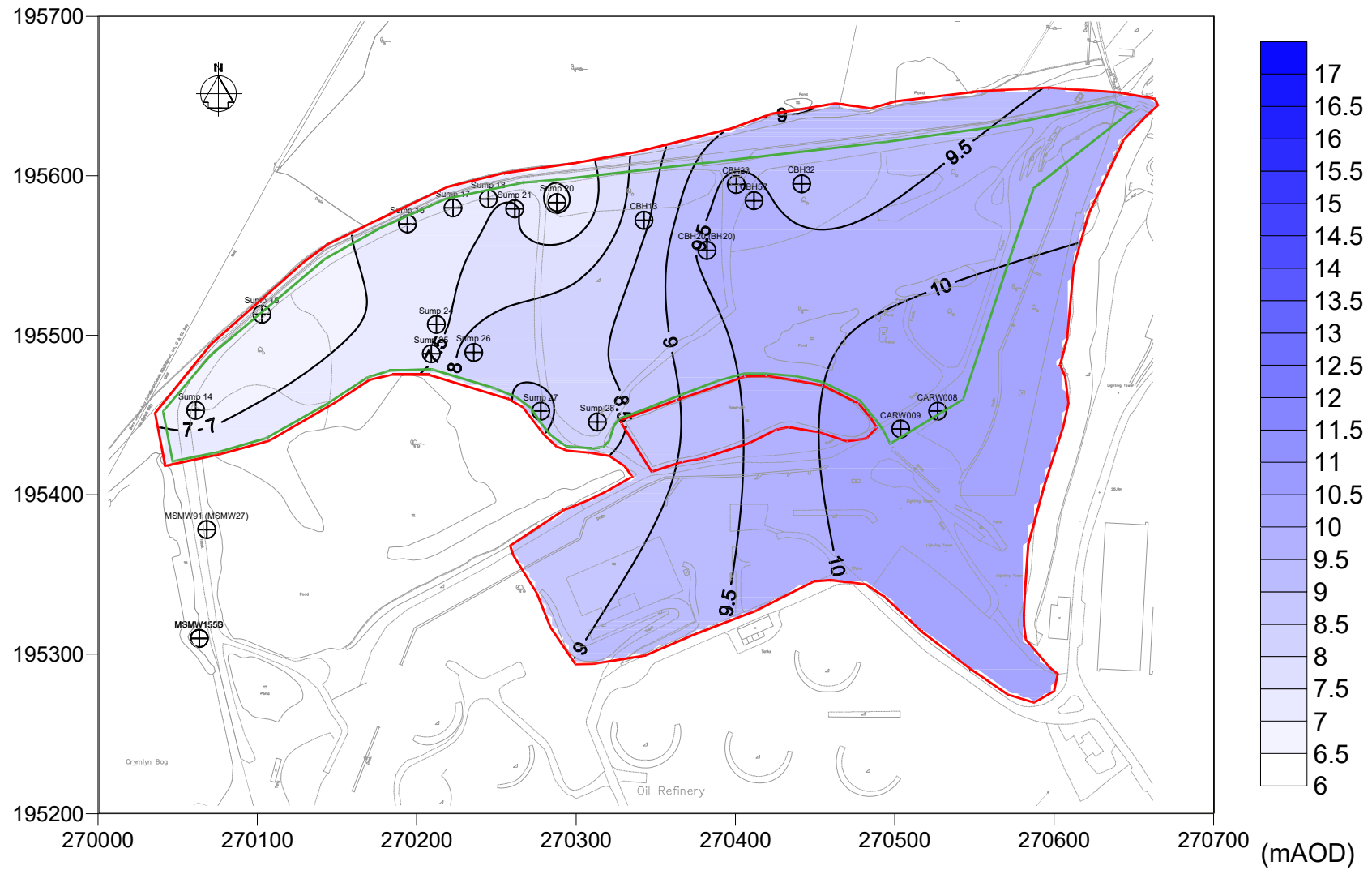
Coed Darcy Tip

Inferred Contours of 15 09 20 Groundwater Level



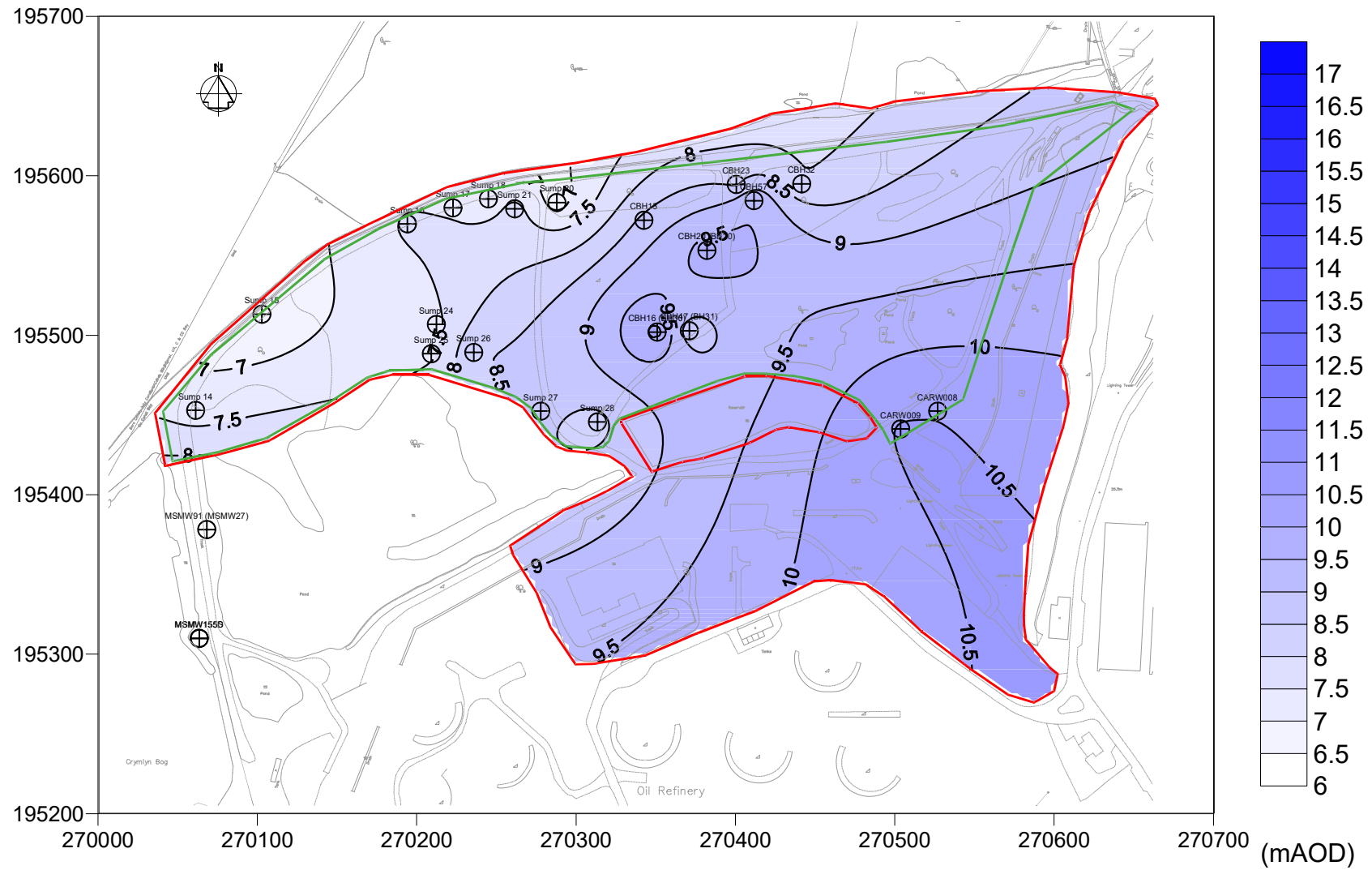
Coed Darcy Tip

Inferred Contours of 24 11 20 Groundwater Level



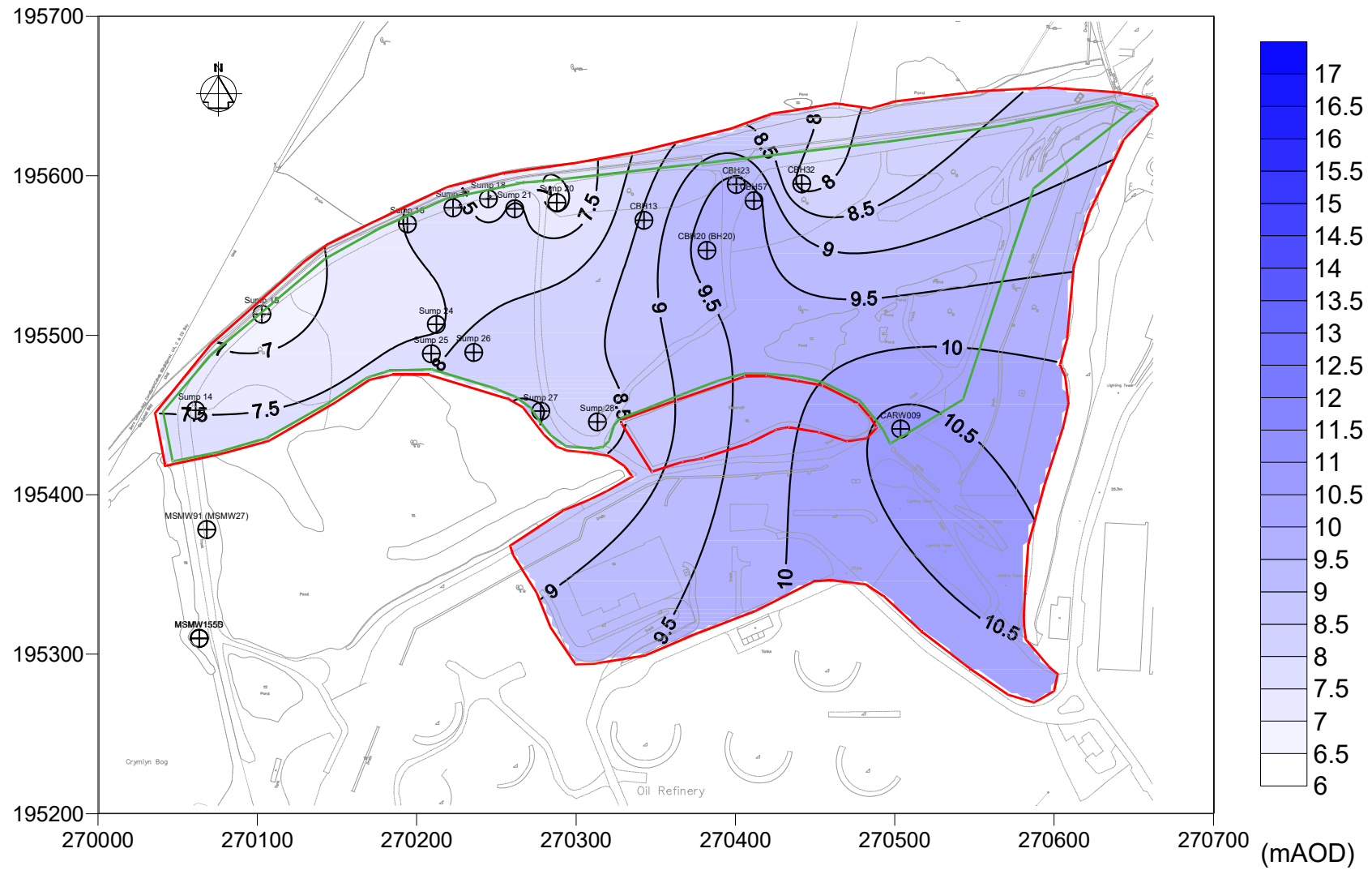
Coed Darcy Tip

Inferred Contours of 12 12 20 Groundwater Level



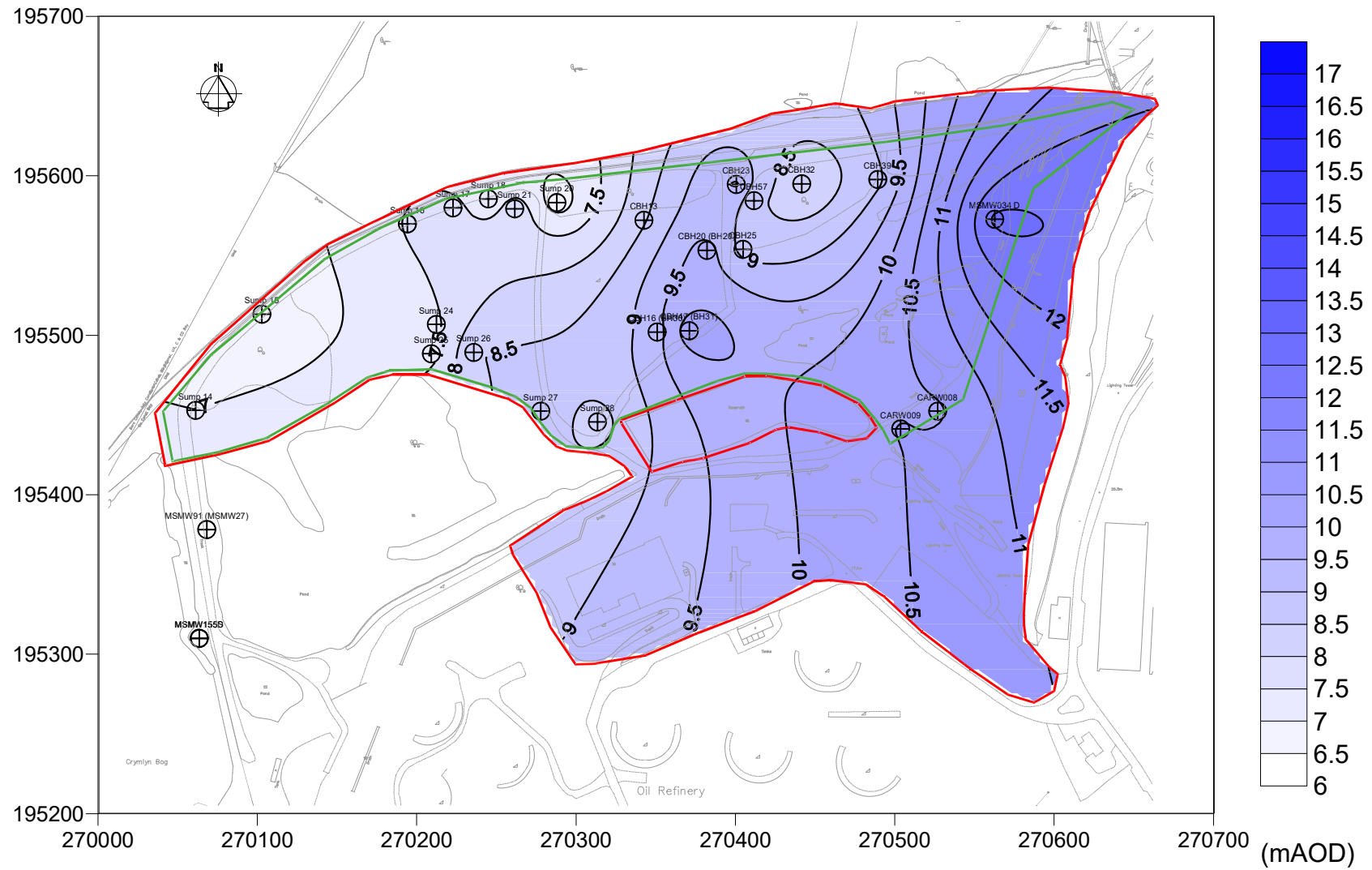
Coed Darcy Tip

Inferred Contours of 15 10 20 Groundwater Level

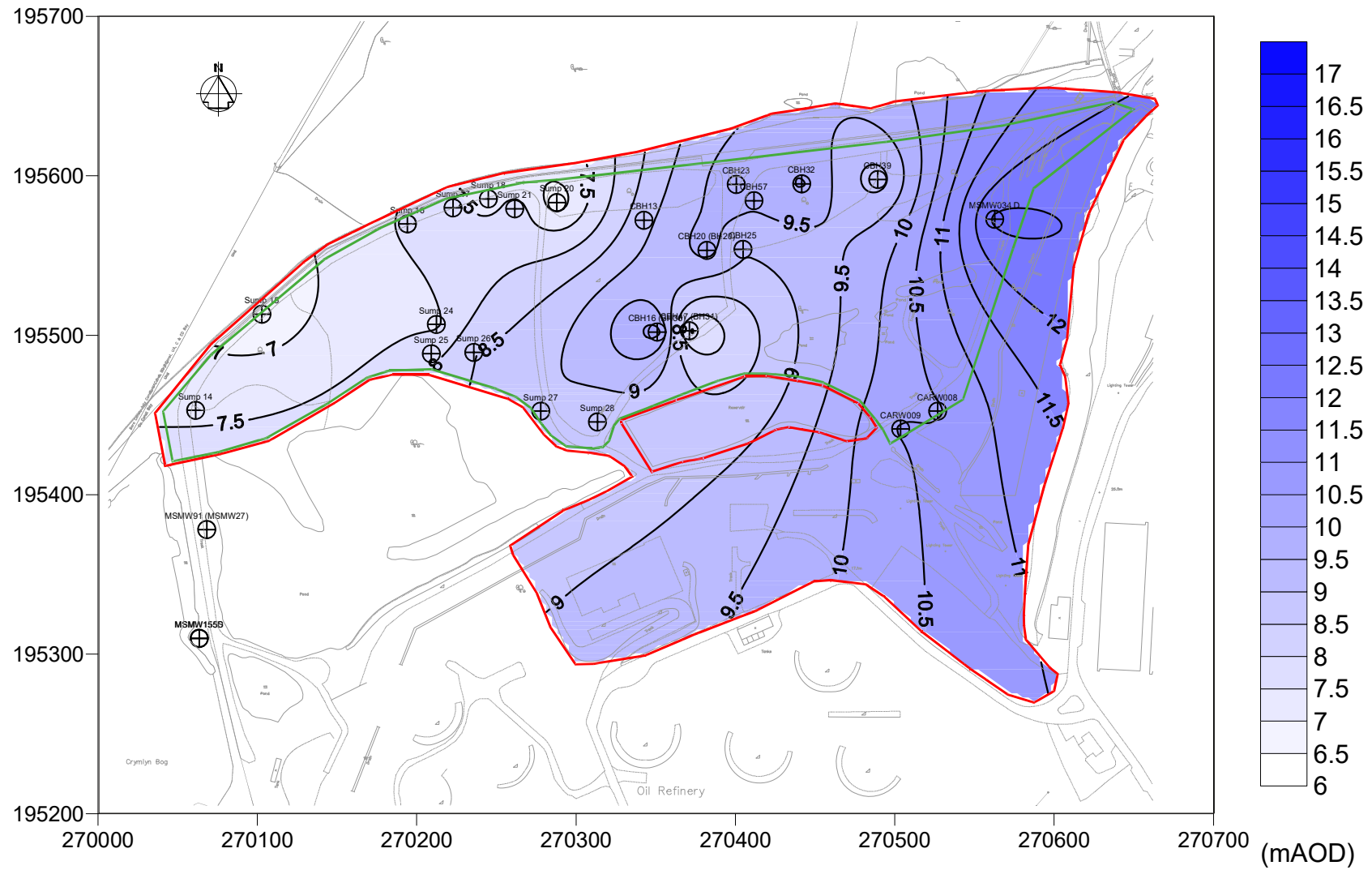


Coed Darcy Tip

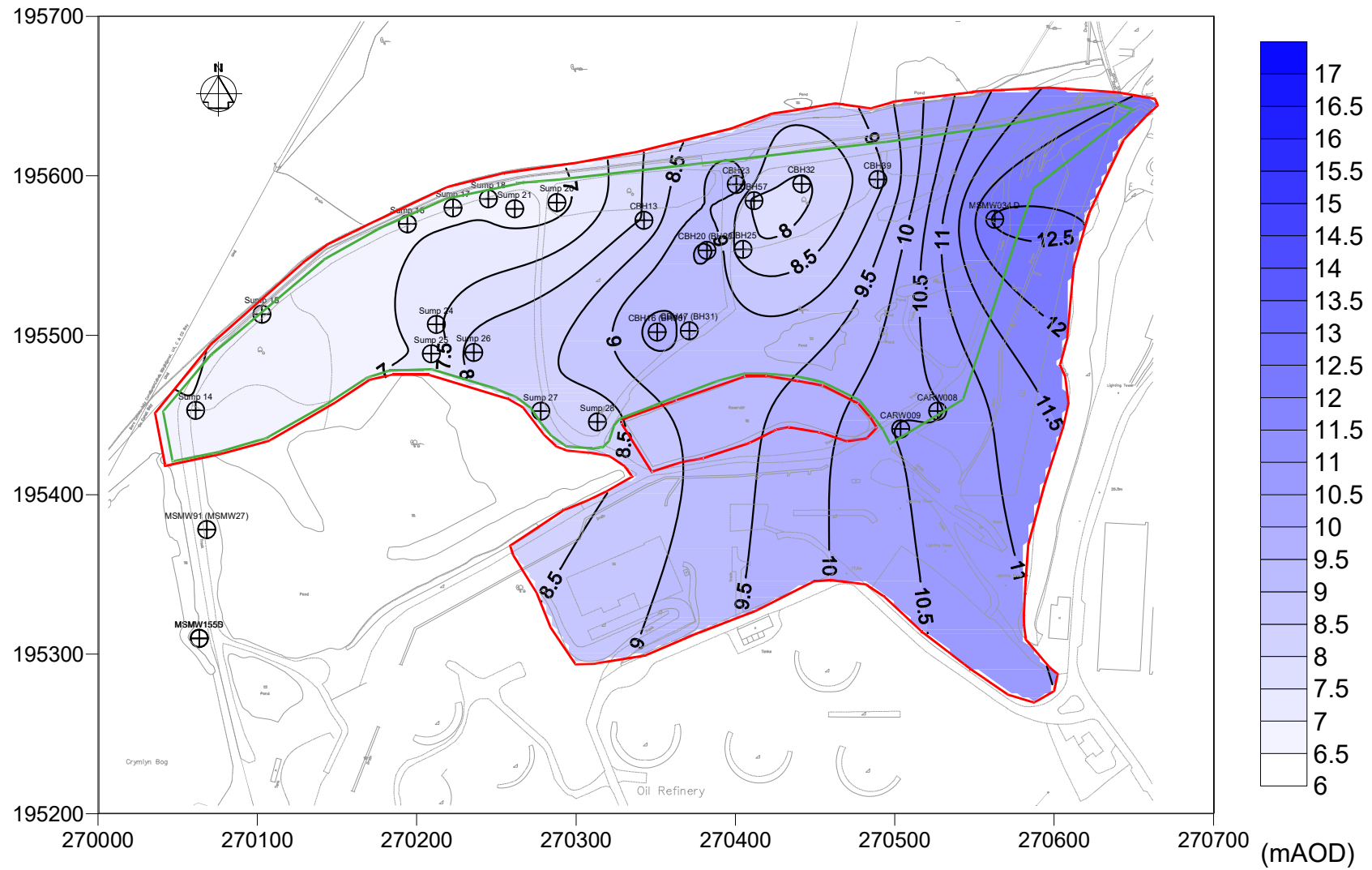
Inferred Contours of 19 02 21 Groundwater Level



Inferred Contours of 21 02 21 Groundwater Level

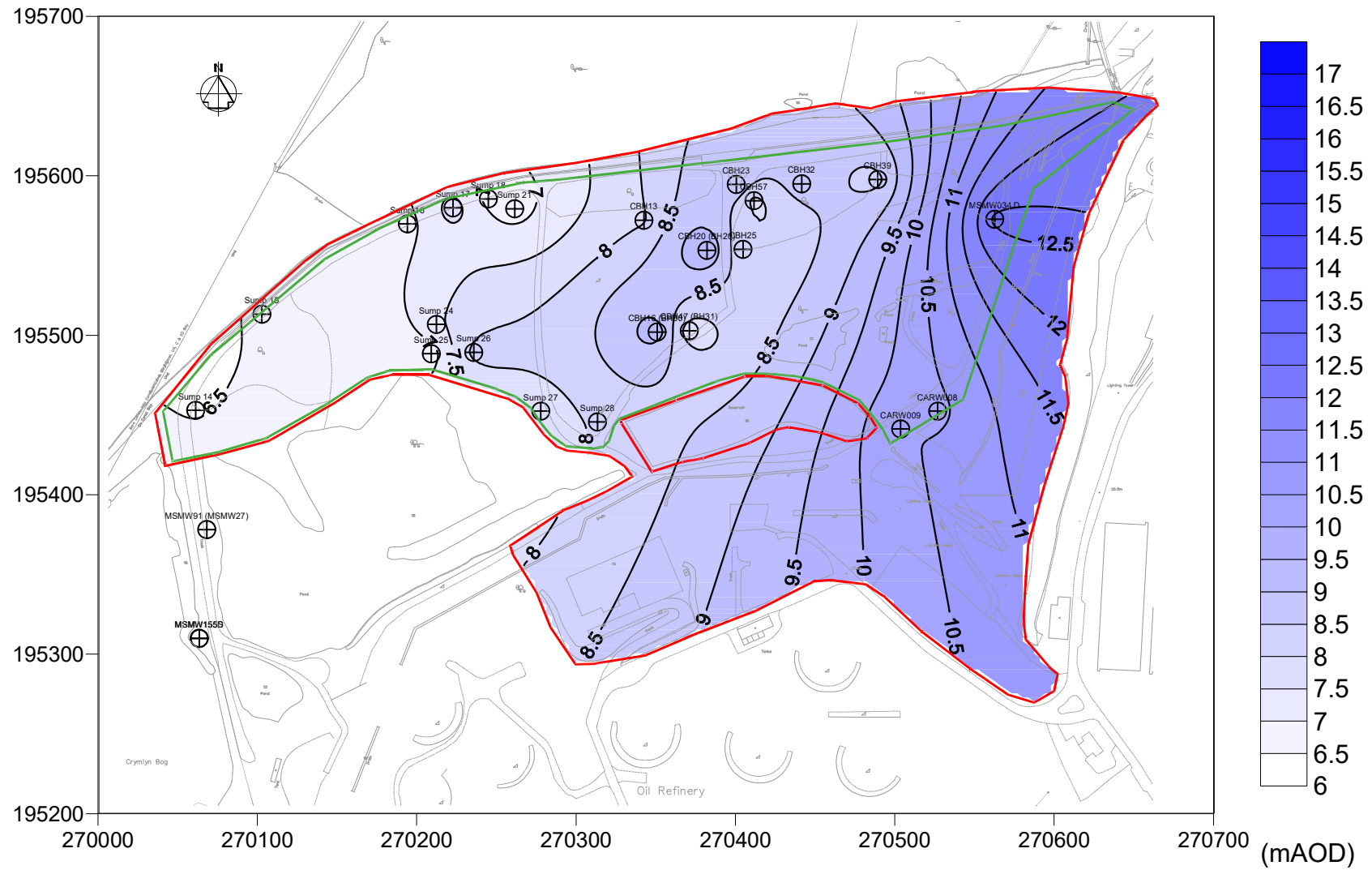


Inferred Contours of 23 03 21 Groundwater Level



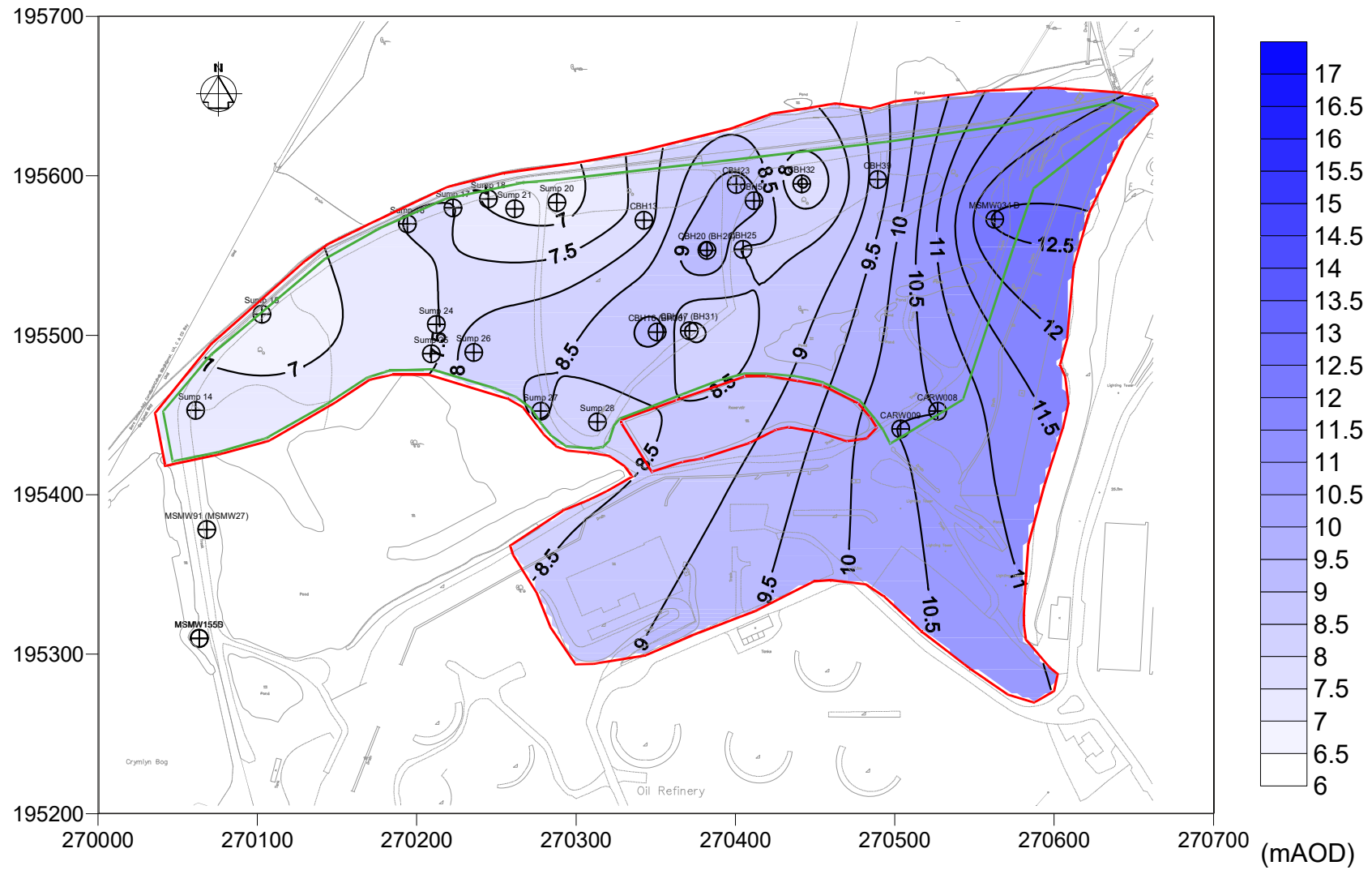
Coed Darcy Tip

Inferred Contours of 22 04 21 Groundwater Level



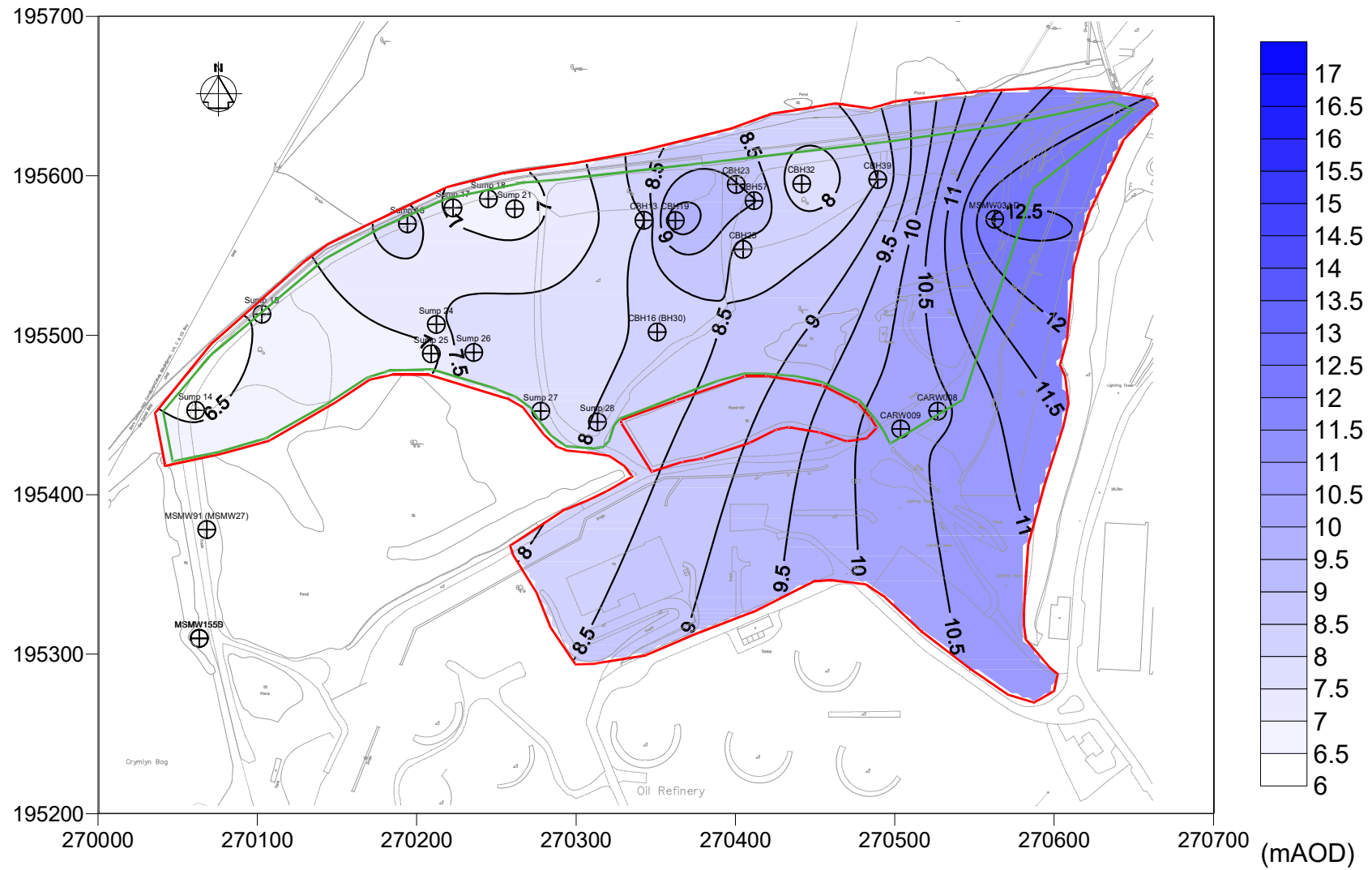
Coed Darcy Tip

Inferred Contours of 27 05 21 Groundwater Level



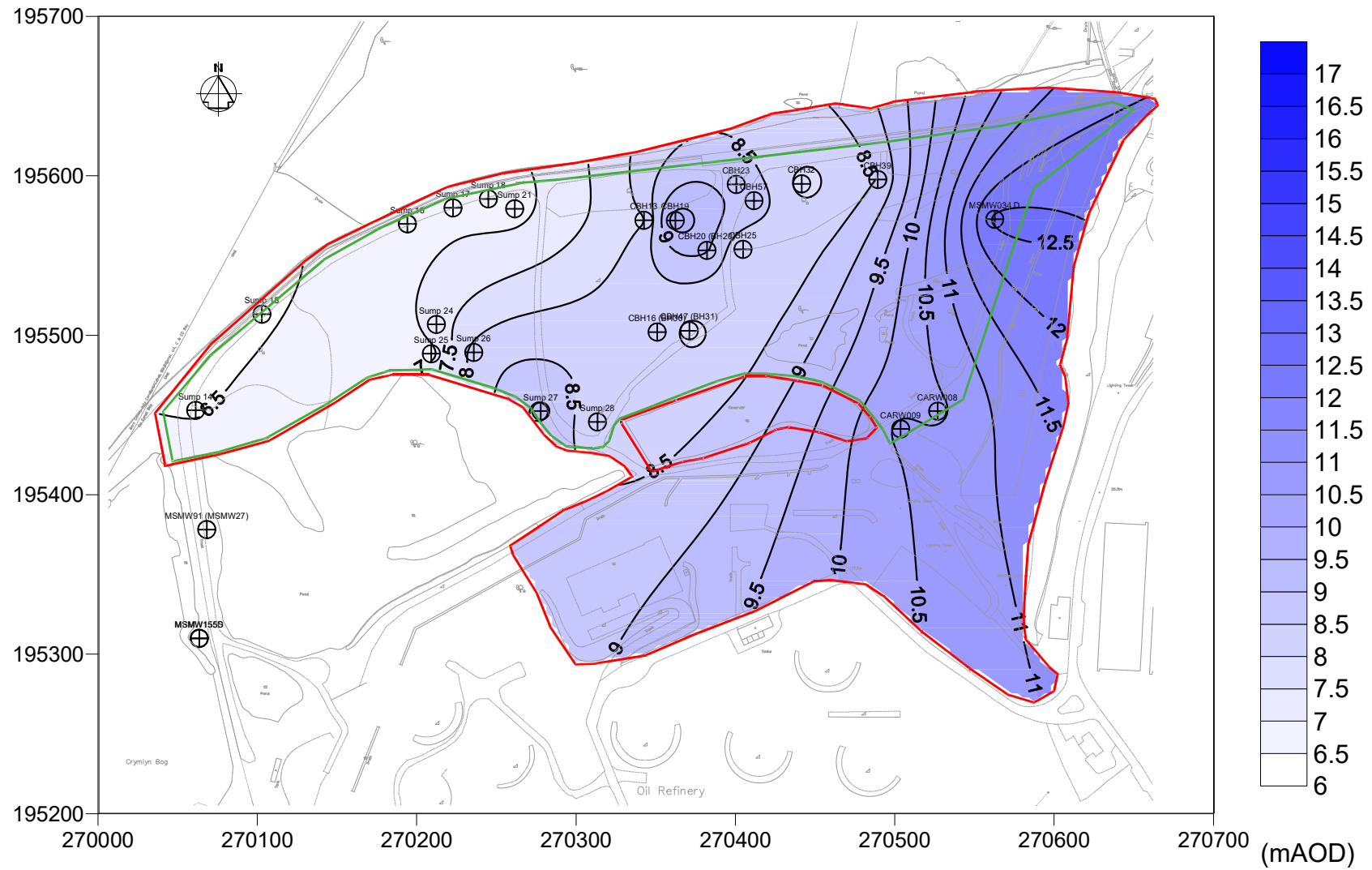
Coed Darcy Tip

Inferred Contours of 22 06 21 Groundwater Level

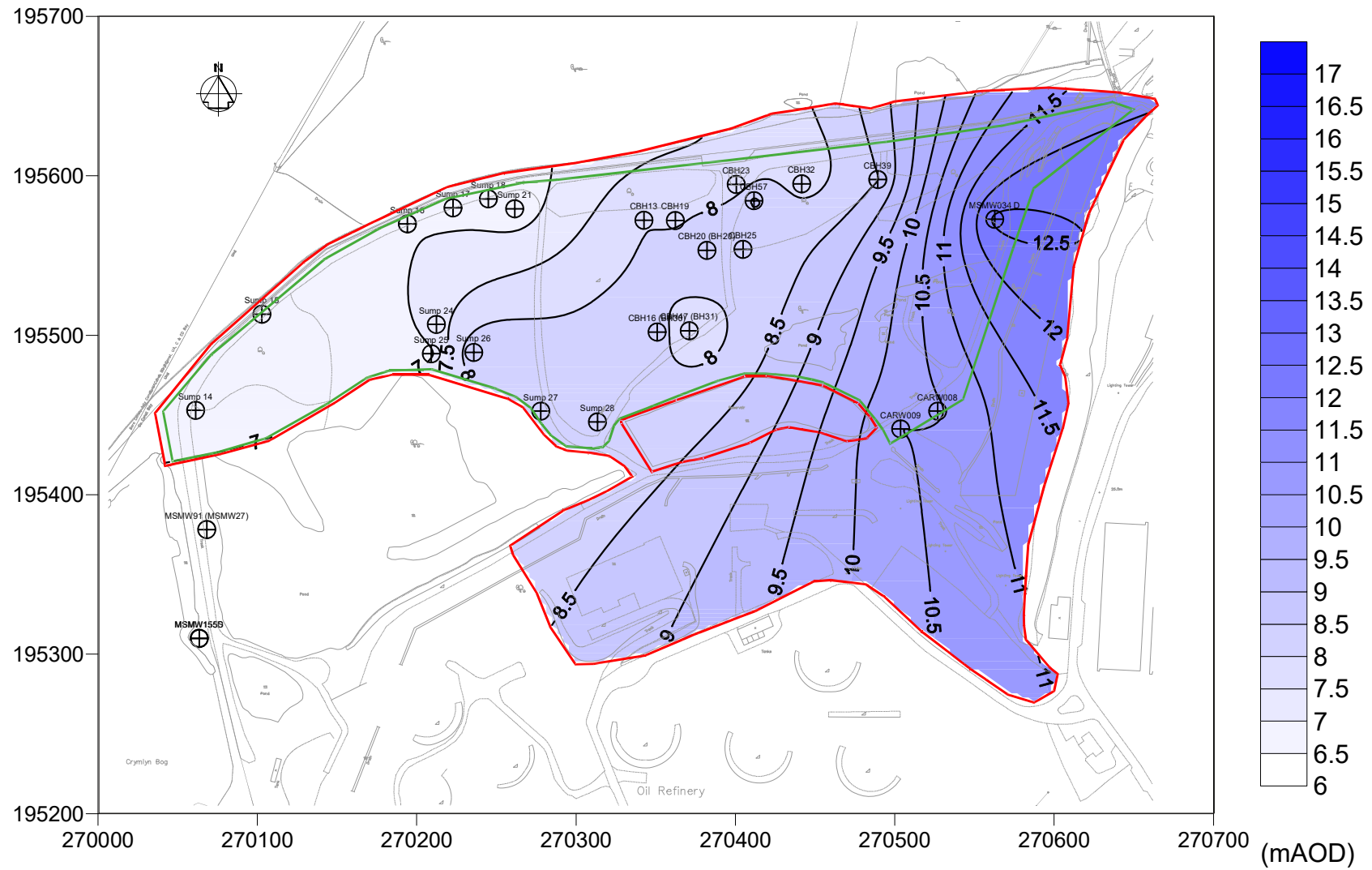


Coed Darcy Tip

Inferred Contours of 21 07 21 Groundwater Level

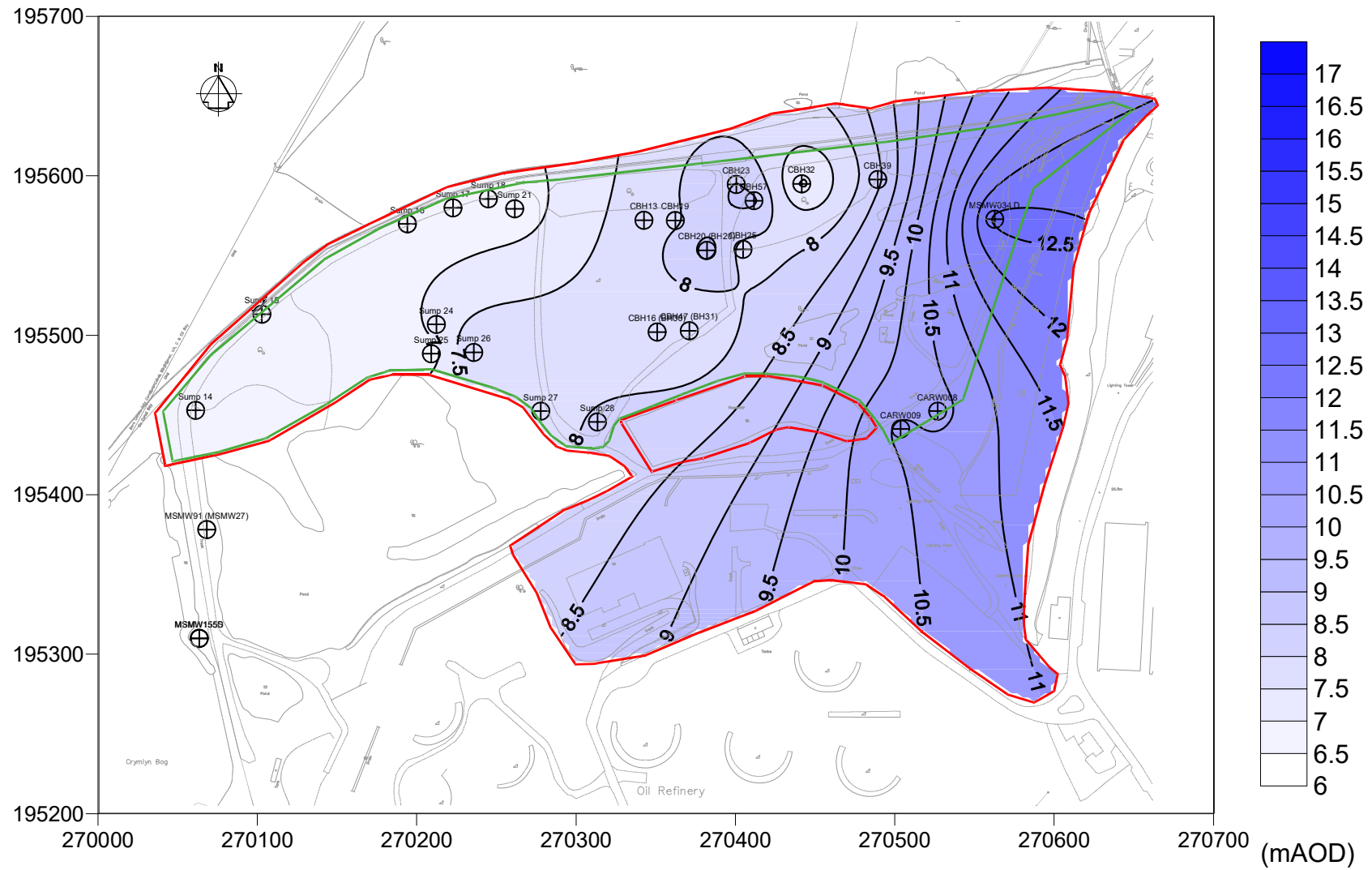


Inferred Contours of 17 08 21 Groundwater Level



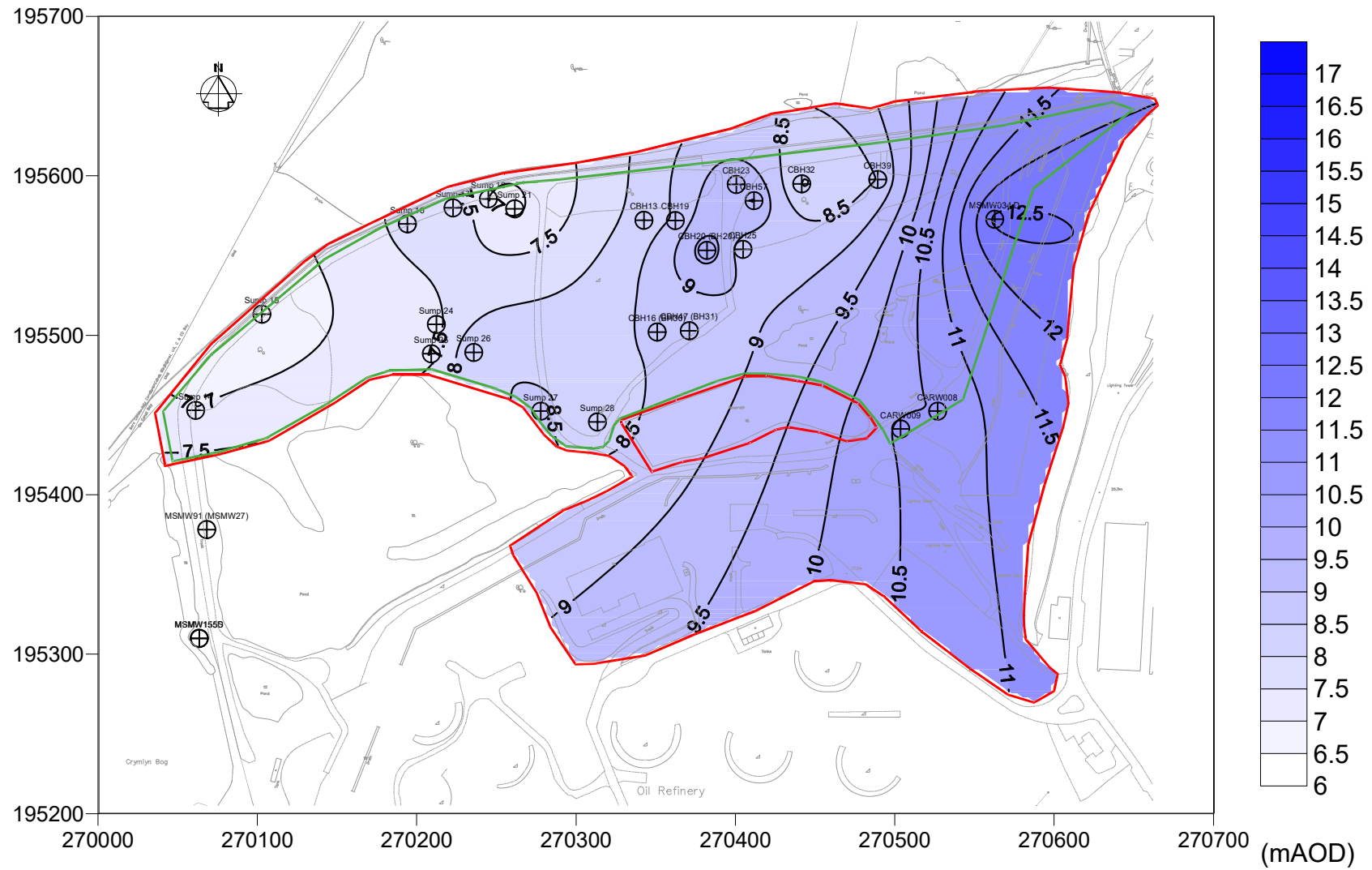
Coed Darcy Tip

Inferred Contours of 21 09 21 Groundwater Level



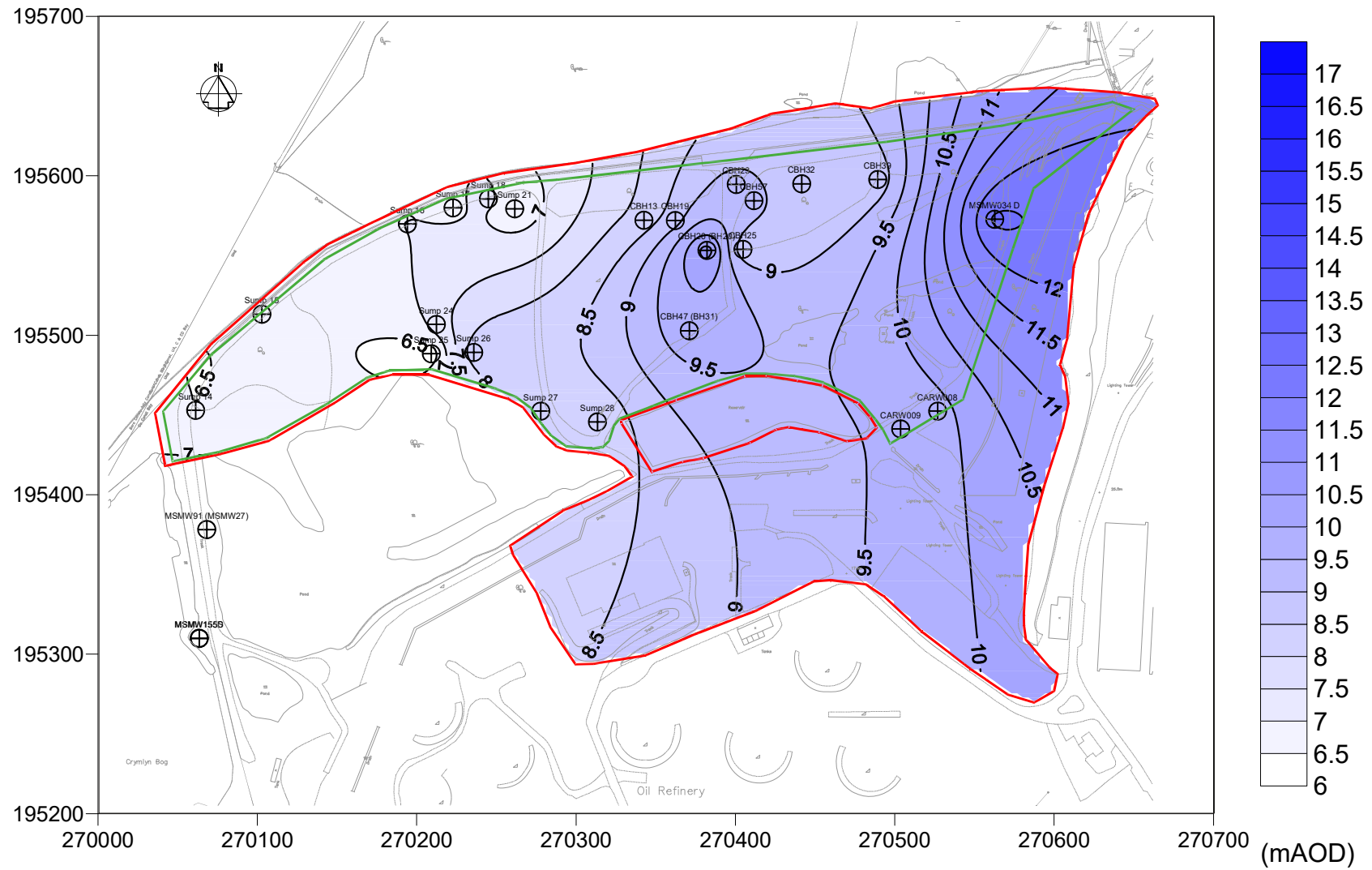
Coed Darcy Tip

Inferred Contours of 25 10 21 Groundwater Level



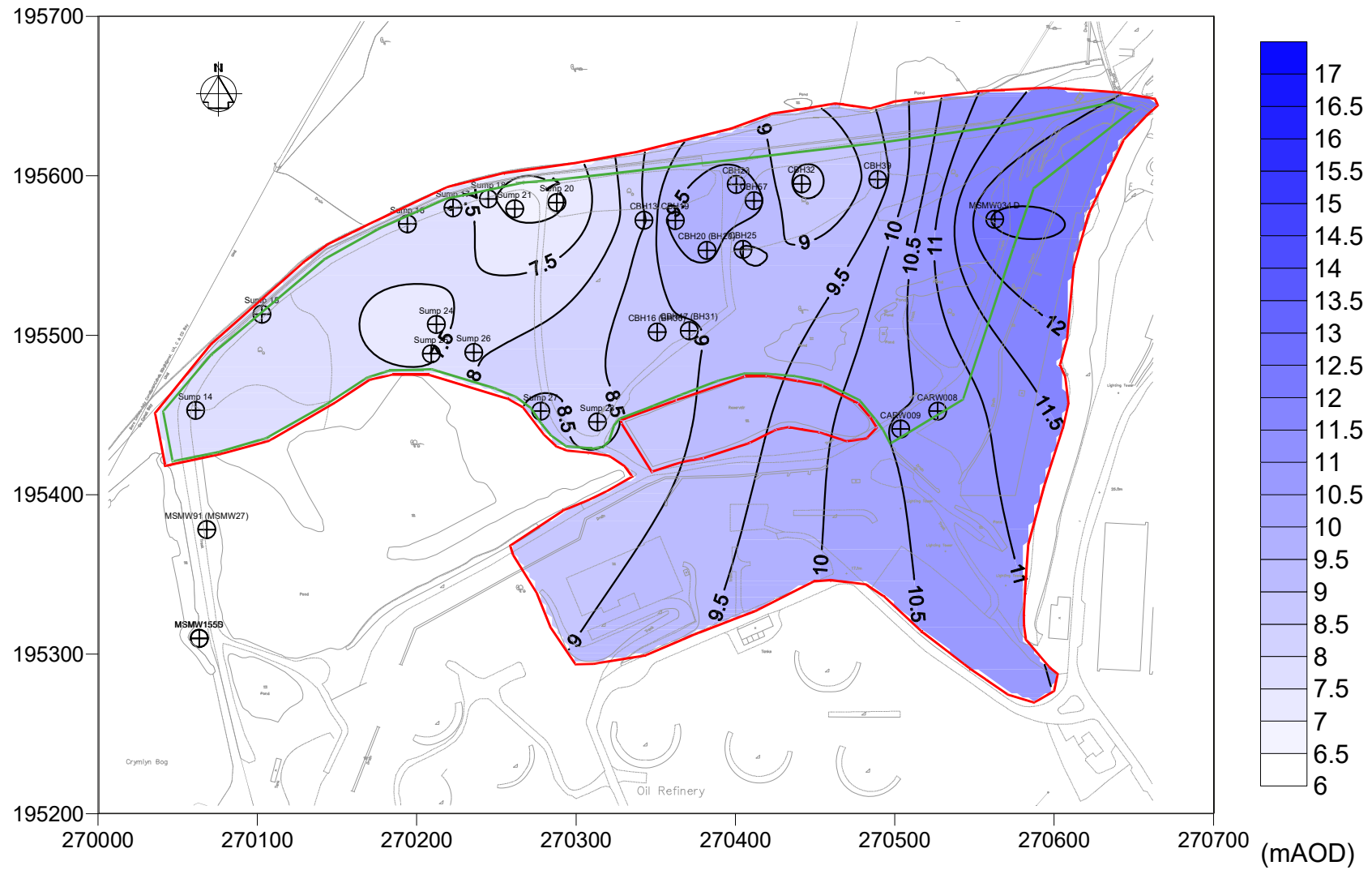
Coed Darcy Tip

Inferred Contours of 24 11 21 Groundwater Level

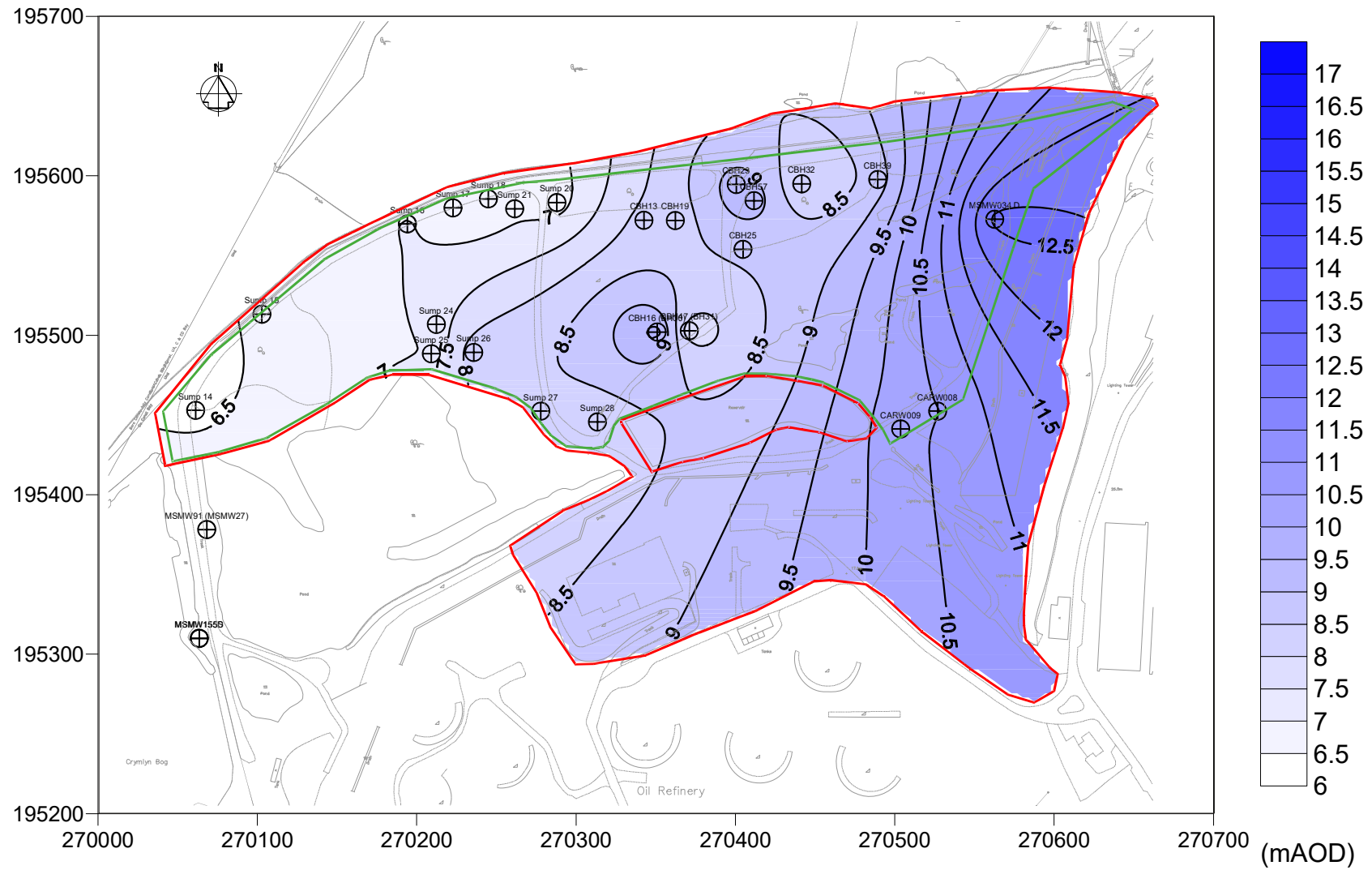


Coed Darcy Tip

Inferred Contours of 28 12 21 Groundwater Level



Inferred Contours of 24 01 22 Groundwater Level



Addendum C3 - Jan 2022

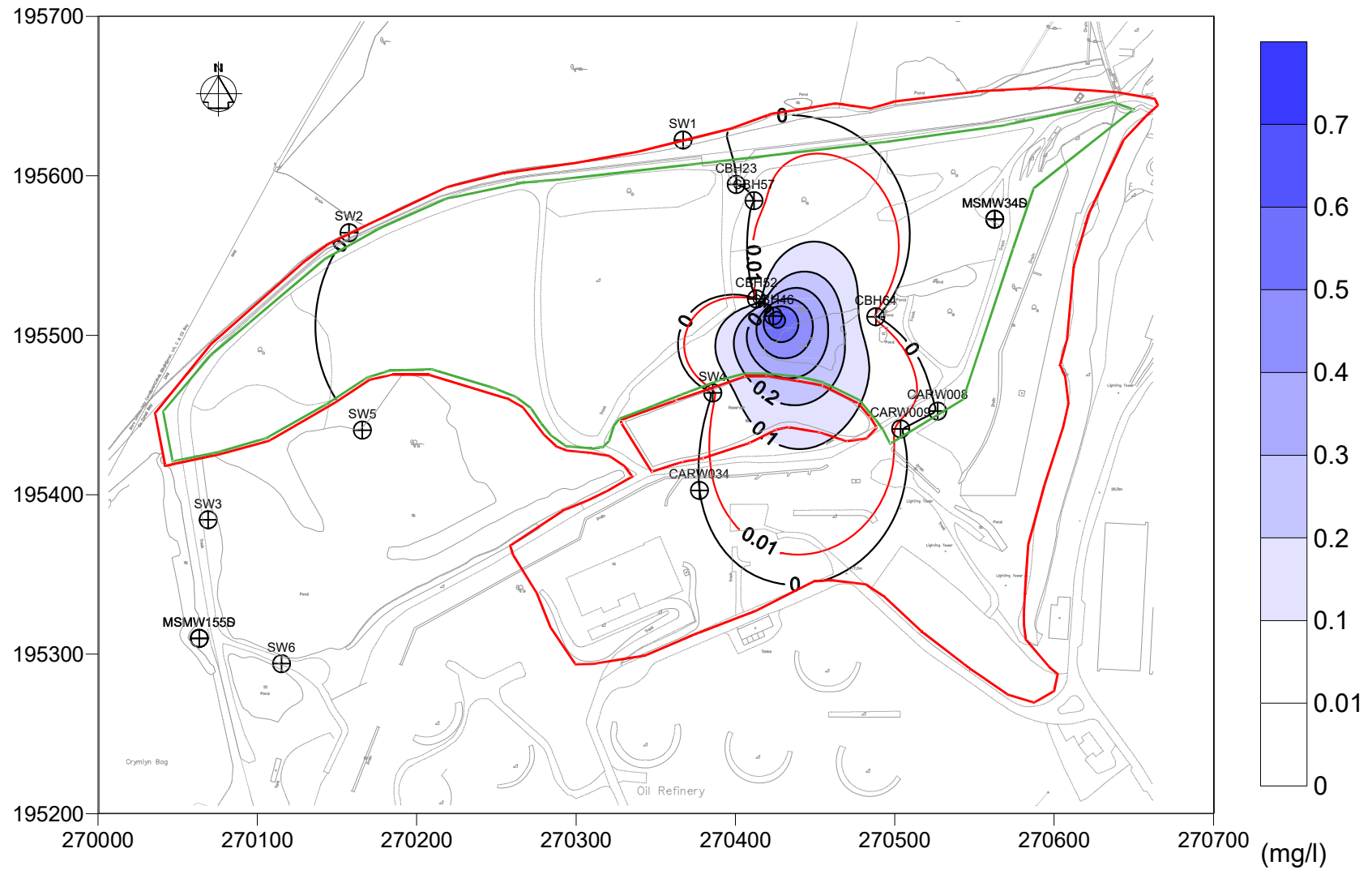
Chem Plots



ENGLOBE

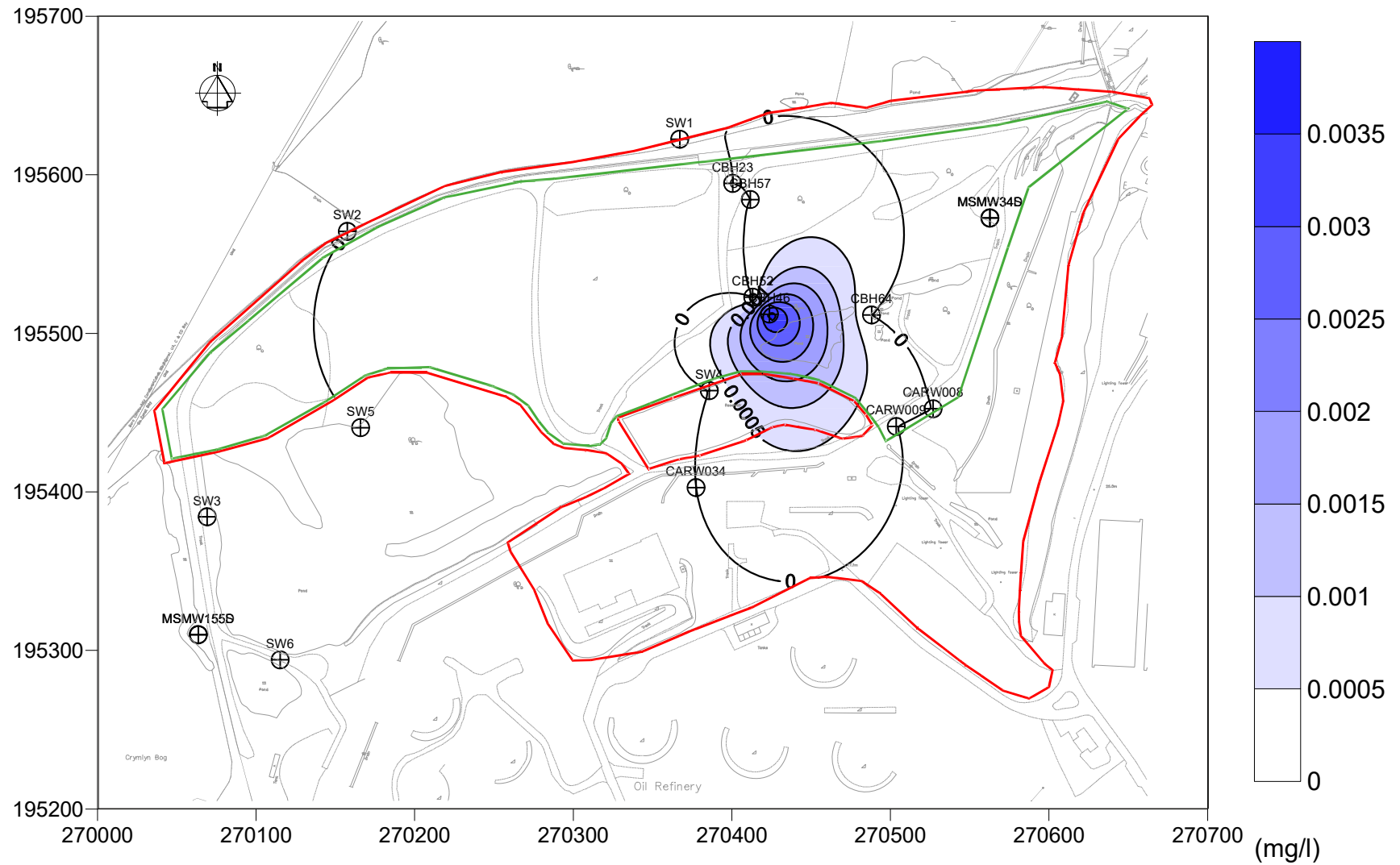
Coed Darcy Tip

Inferred Contours of Benzene in Groundwater January 2022



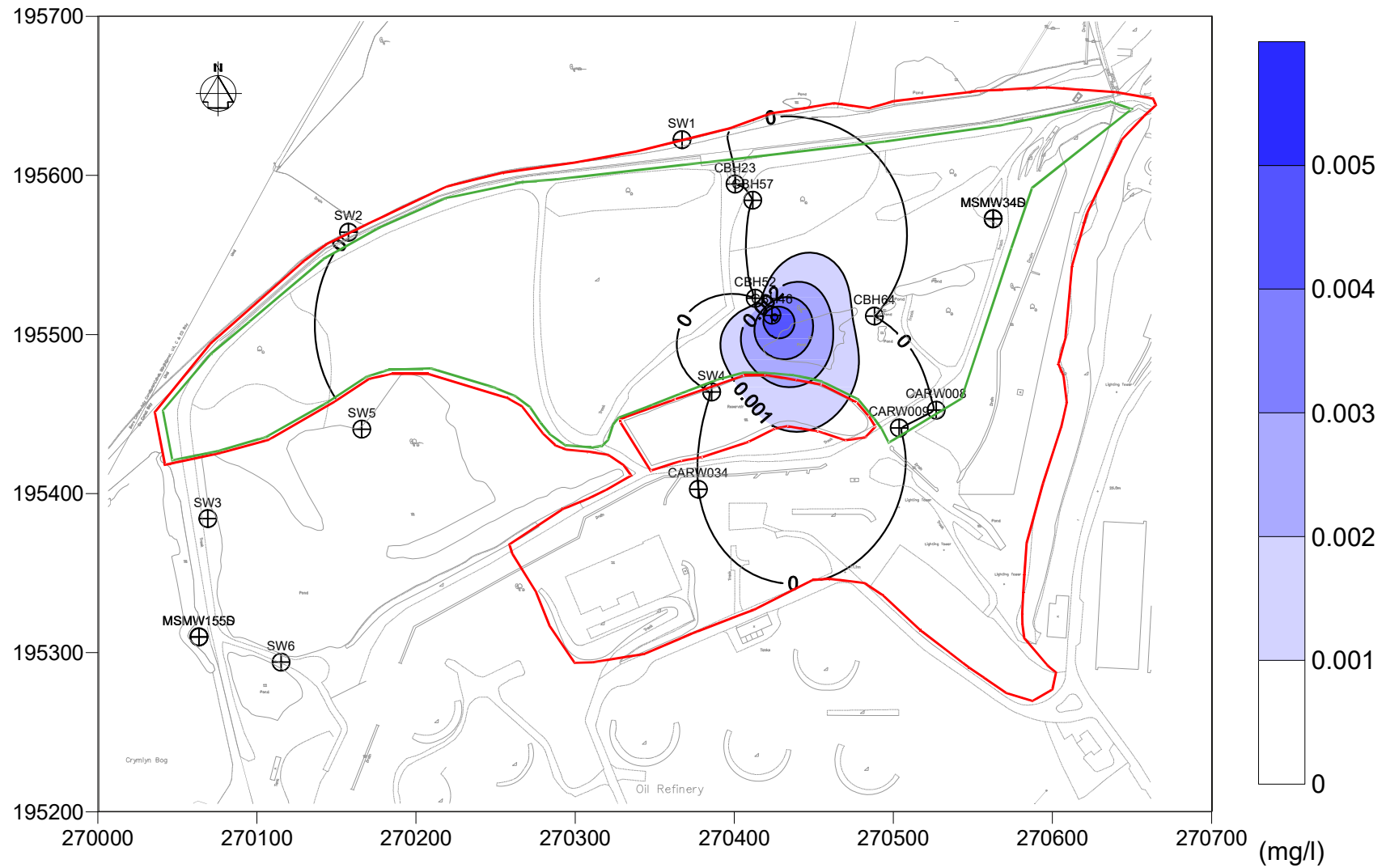
Coed Darcy Tip

Inferred Contours of Ethylbenzene in Groundwater January 2022

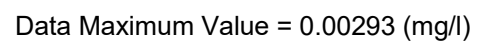


Coed Darcy Tip

Inferred Contours of m,p-Xylene in Groundwater January 2022

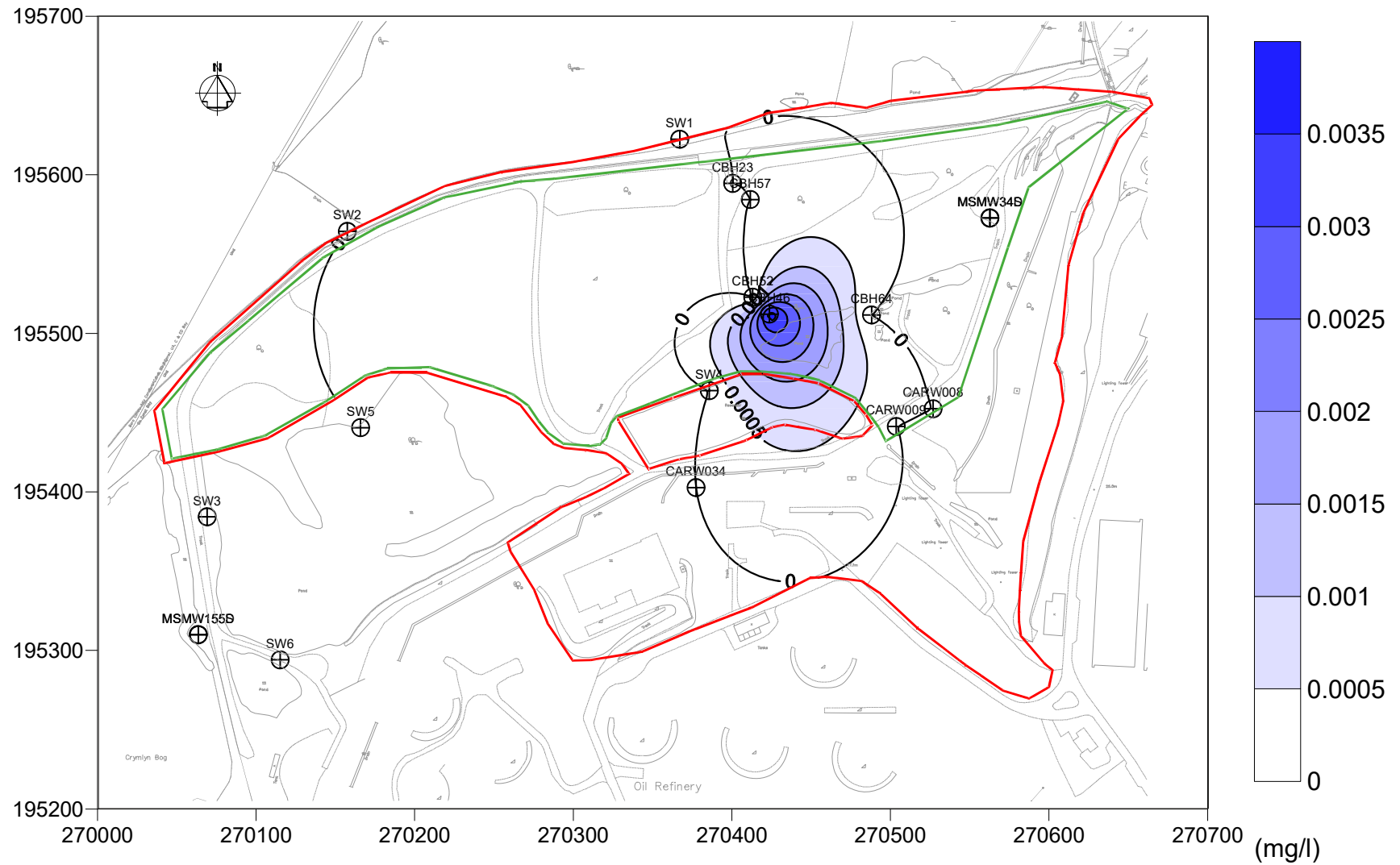


Inferred Contours of o-Xylene in Groundwater January 2022



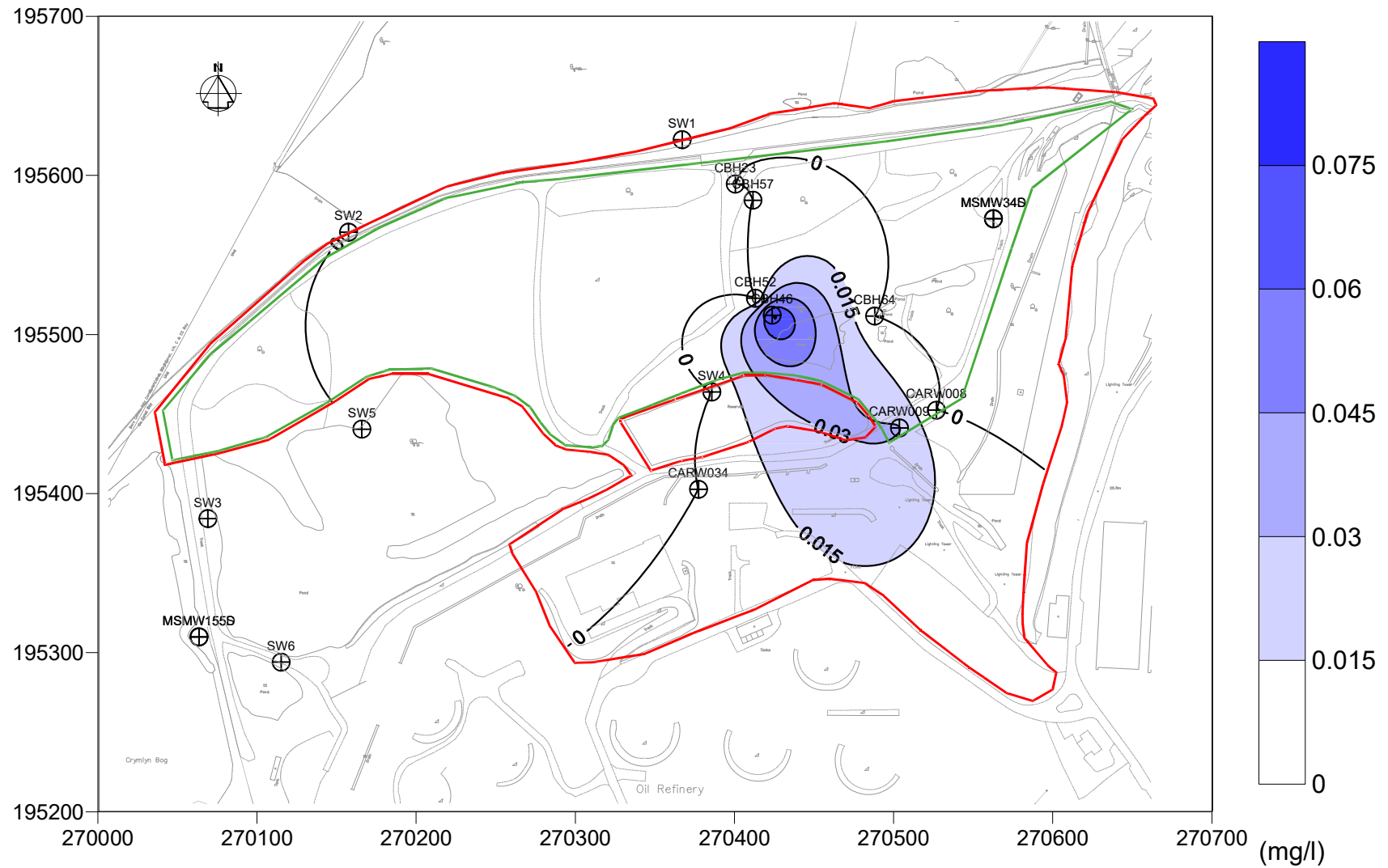
Coed Darcy Tip

Inferred Contours of Toluene in Groundwater January 2022



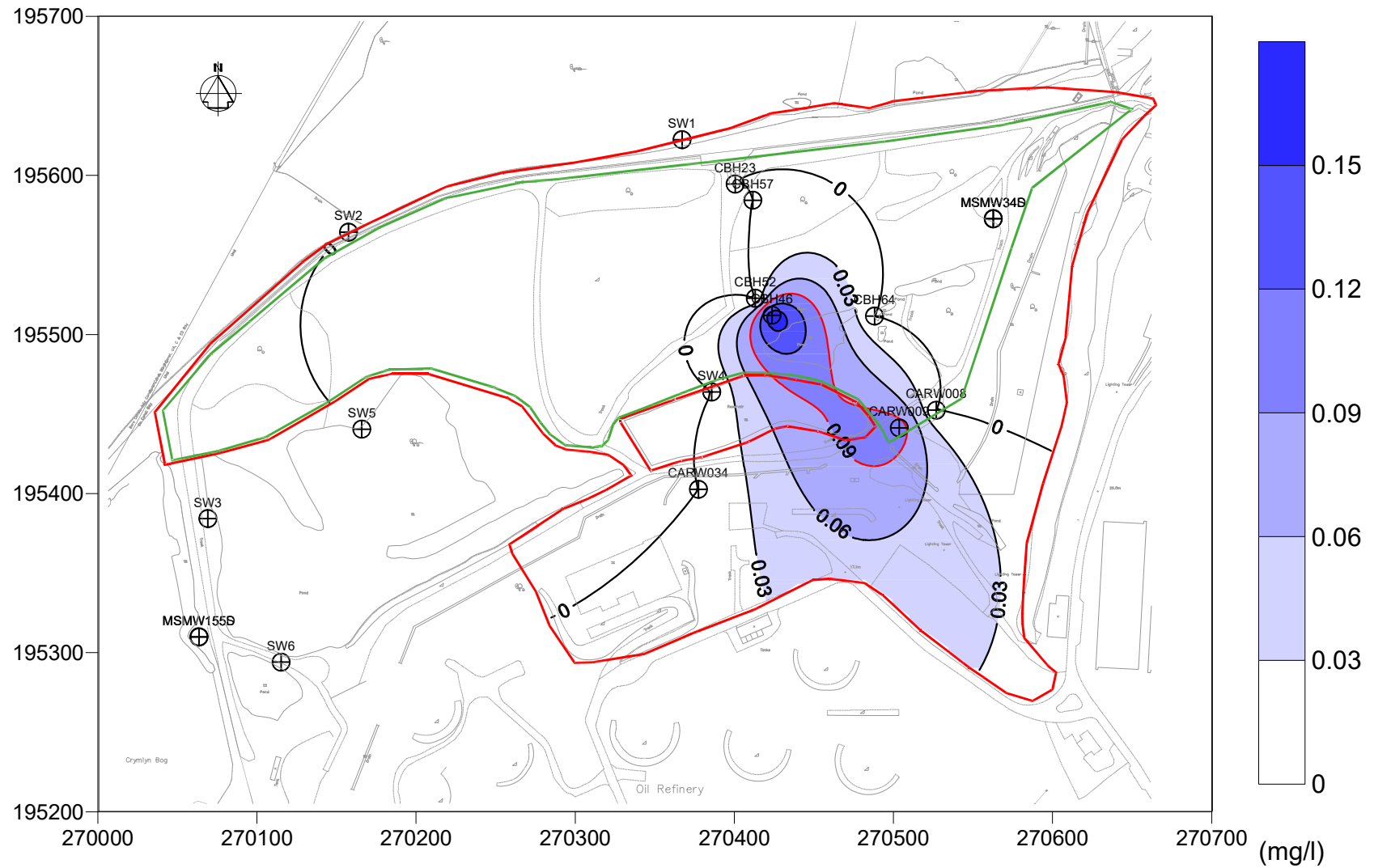
Coed Darcy Tip

Inferred Contours of Aromatics EC8-EC10 in Groundwater January 2022



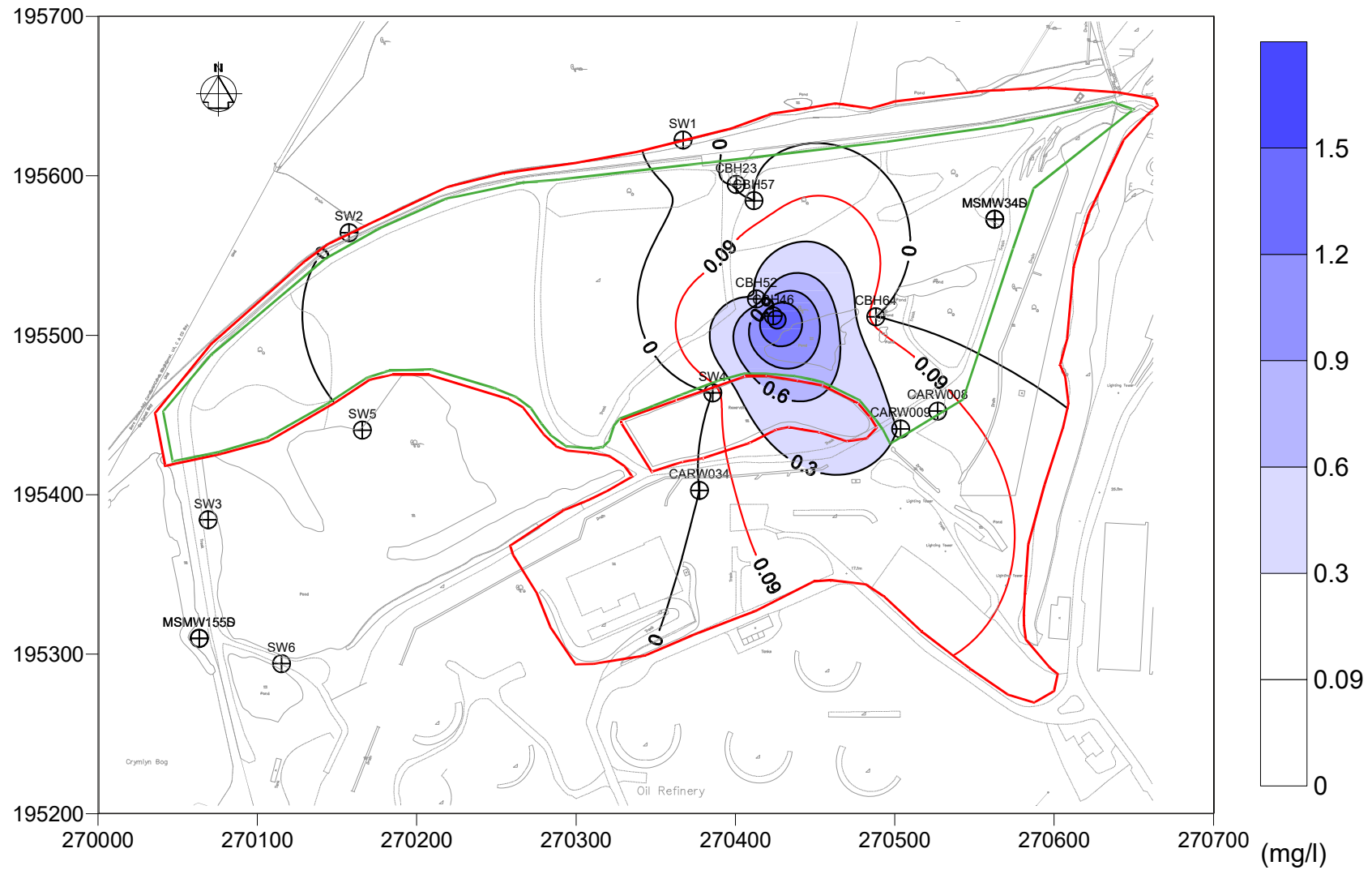
Coed Darcy Tip

Inferred Contours of Aromatics EC10-EC12 in Groundwater January 2022



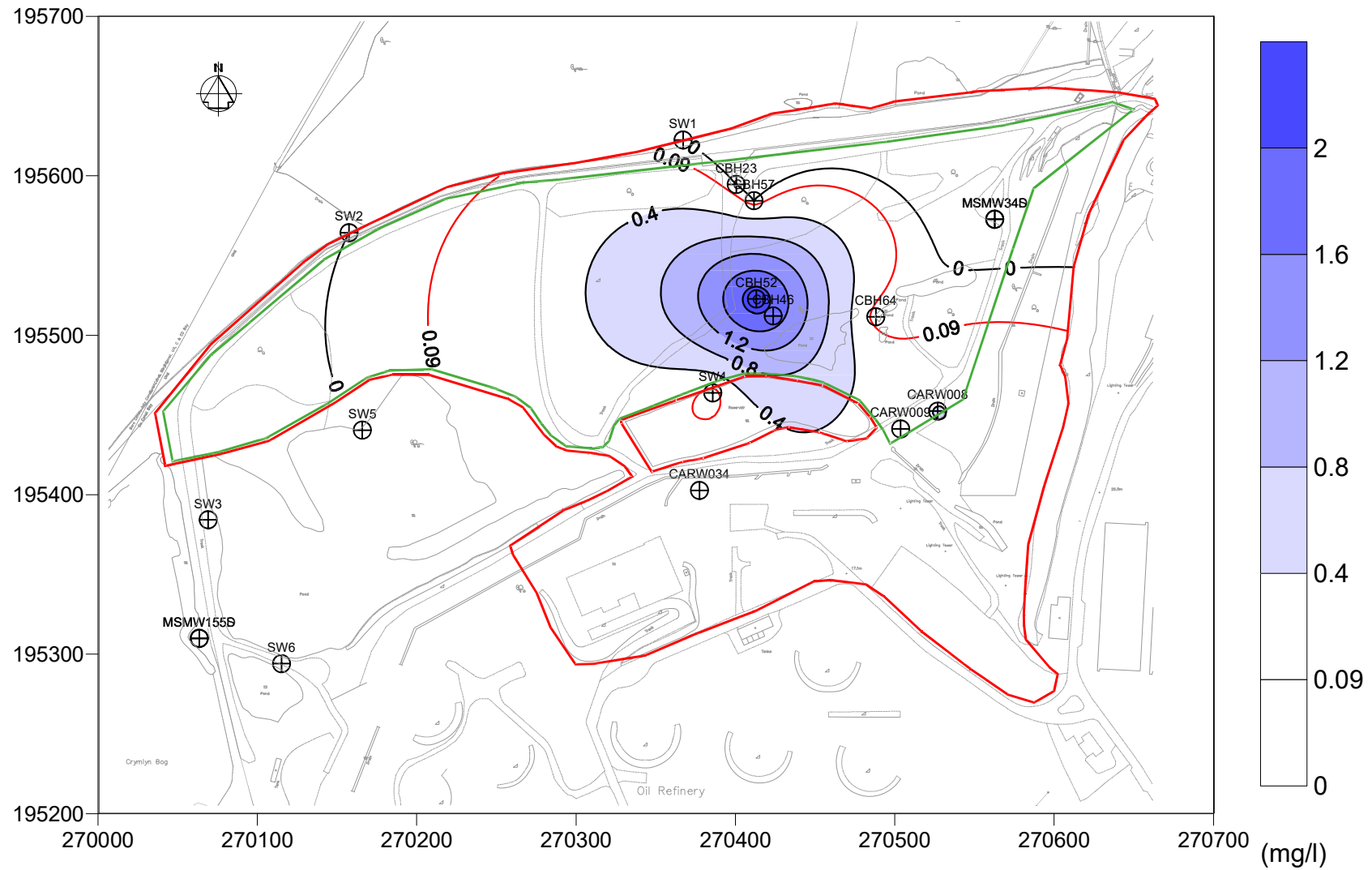
Coed Darcy Tip

Inferred Contours of Aromatics EC12-EC16 (aq) in Groundwater January 2022



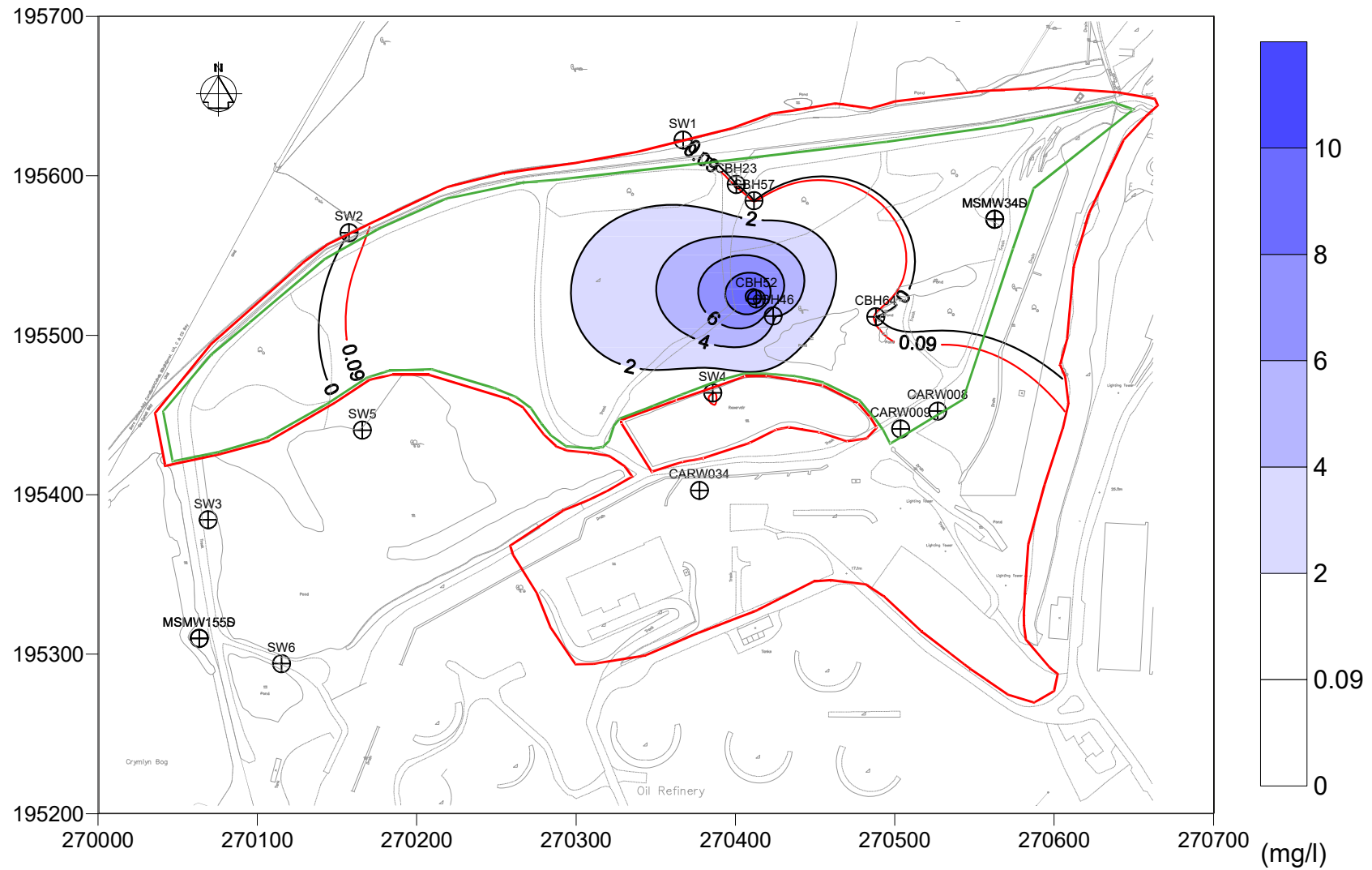
Coed Darcy Tip

Inferred Contours of Aromatics EC16-EC21 (aq) in Groundwater January 2022



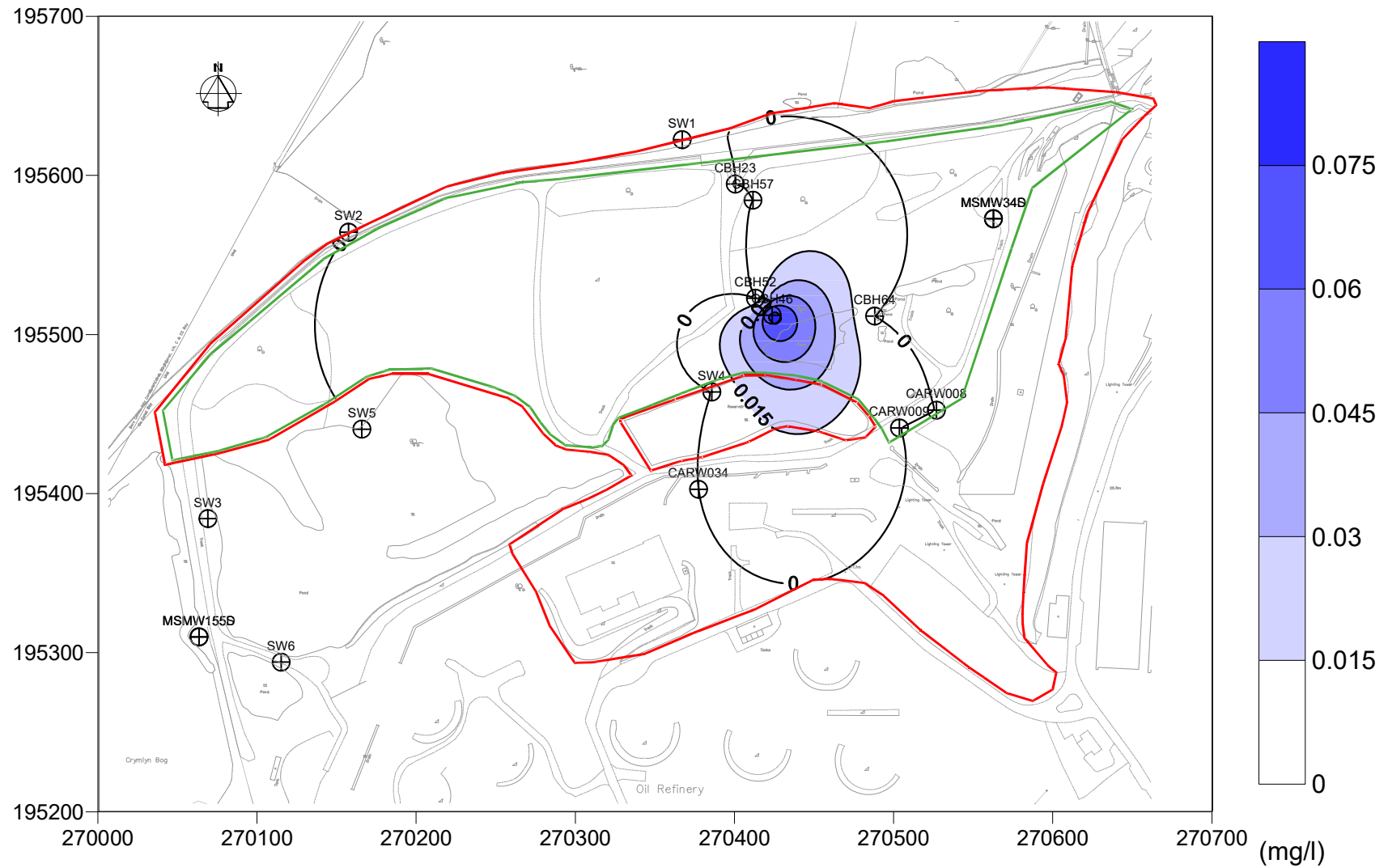
Coed Darcy Tip

Inferred Contours of Aromatics EC21-EC35 (aq) in Groundwater January 2022



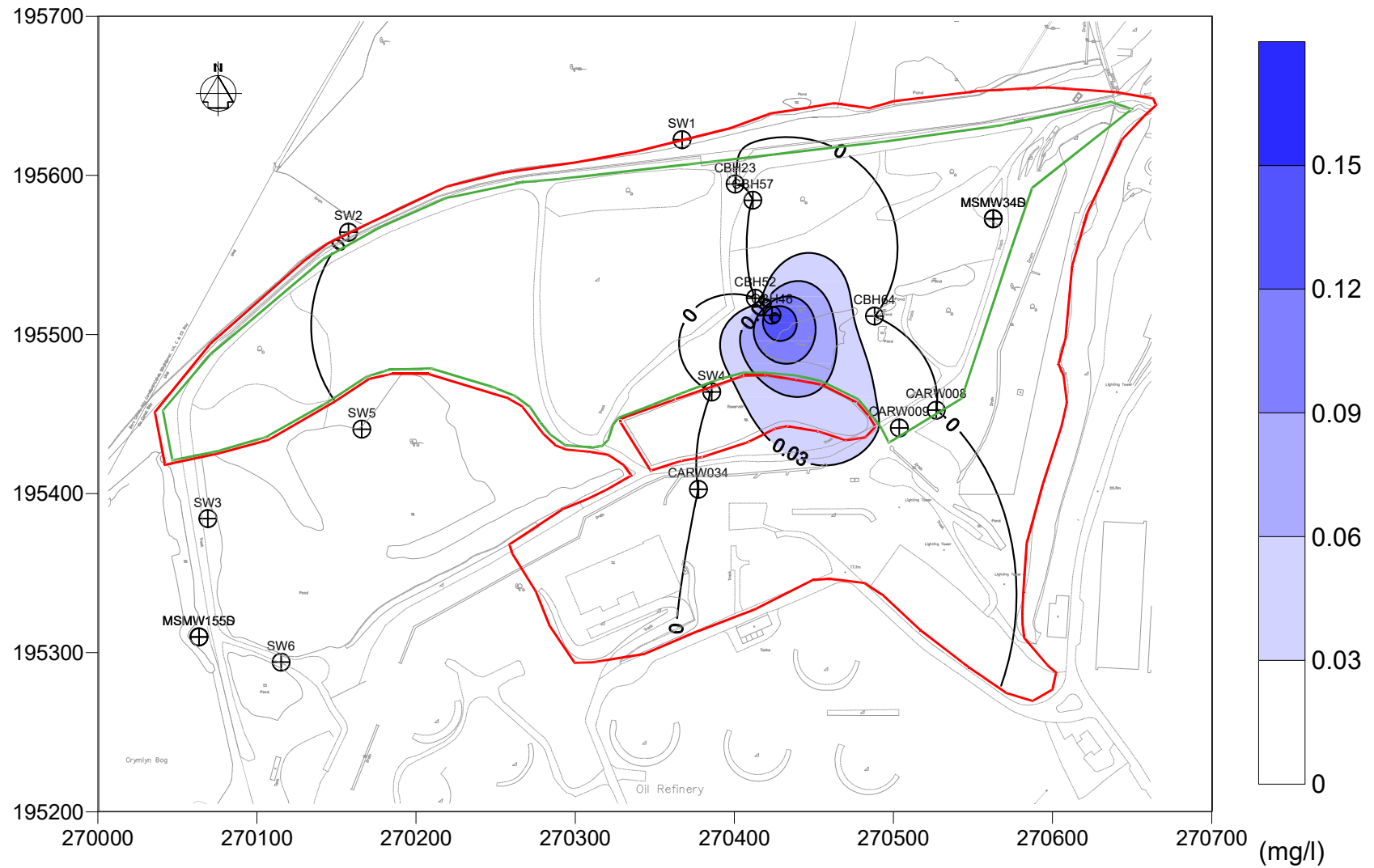
Coed Darcy Tip

Inferred Contours of Aliphatics C5-C6 in Groundwater January 2022



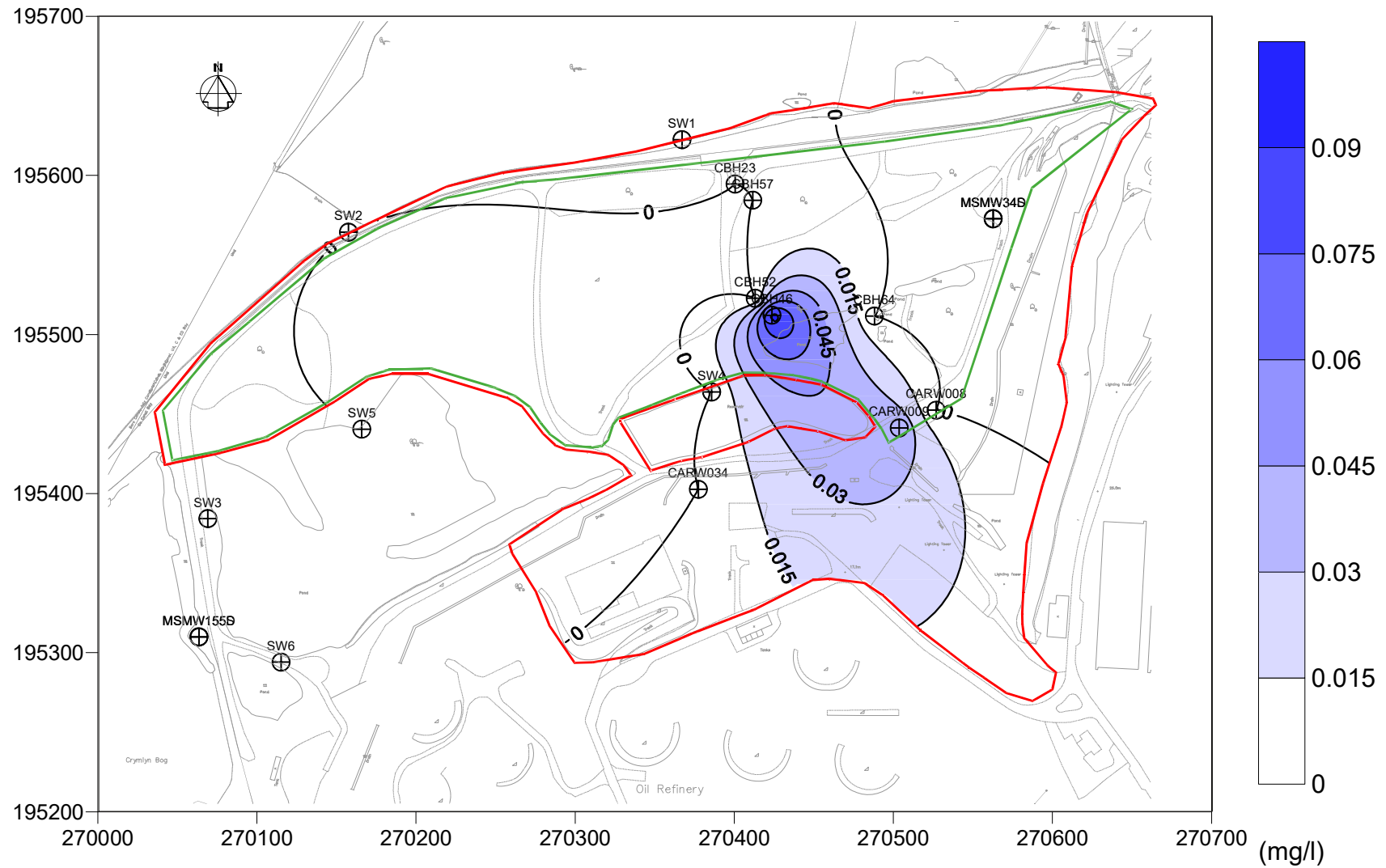
Coed Darcy Tip

Inferred Contours of Aliphatics C6-C8 in Groundwater January 2022



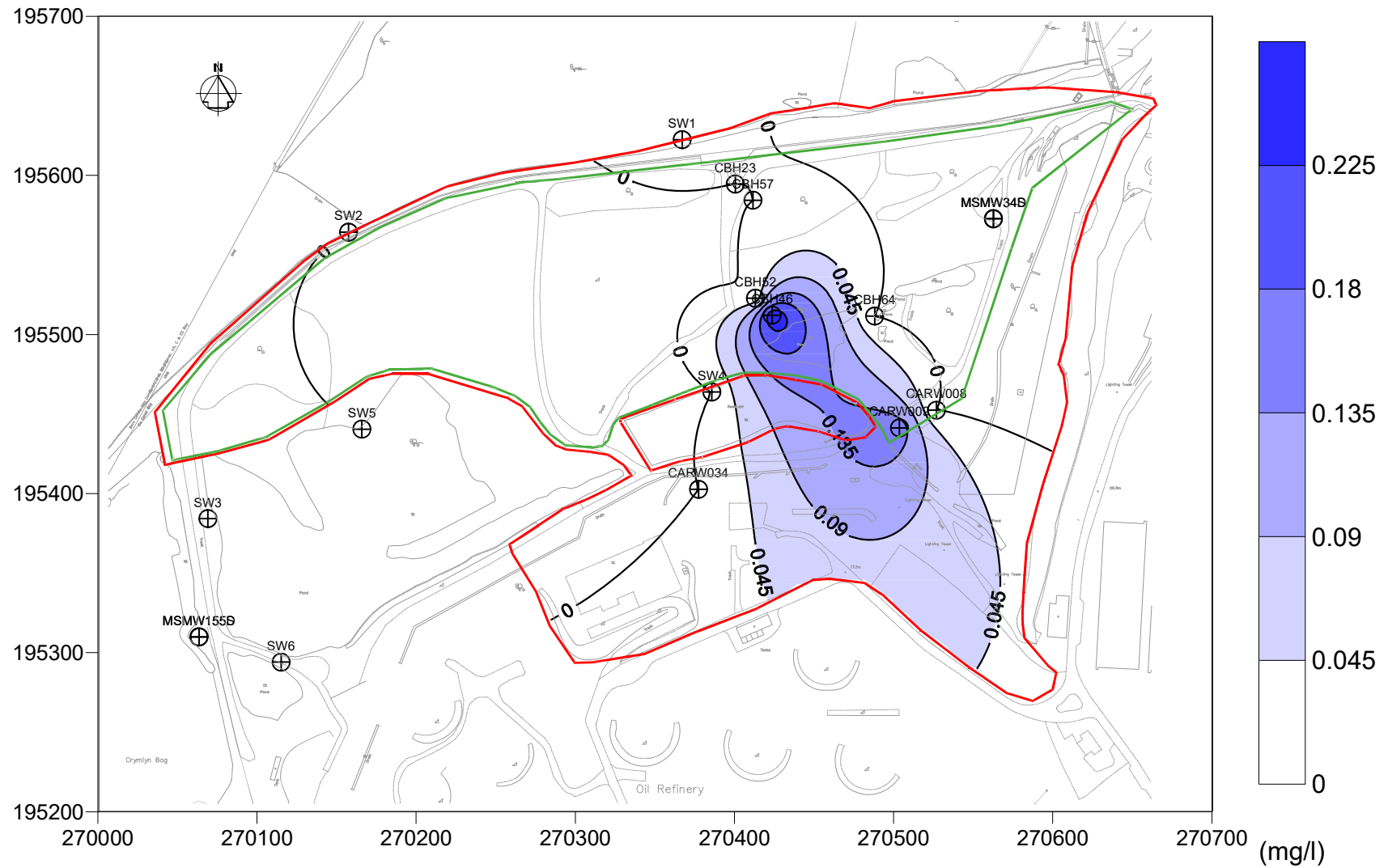
Coed Darcy Tip

Inferred Contours of Aliphatics C8-C10 in Groundwater January 2022



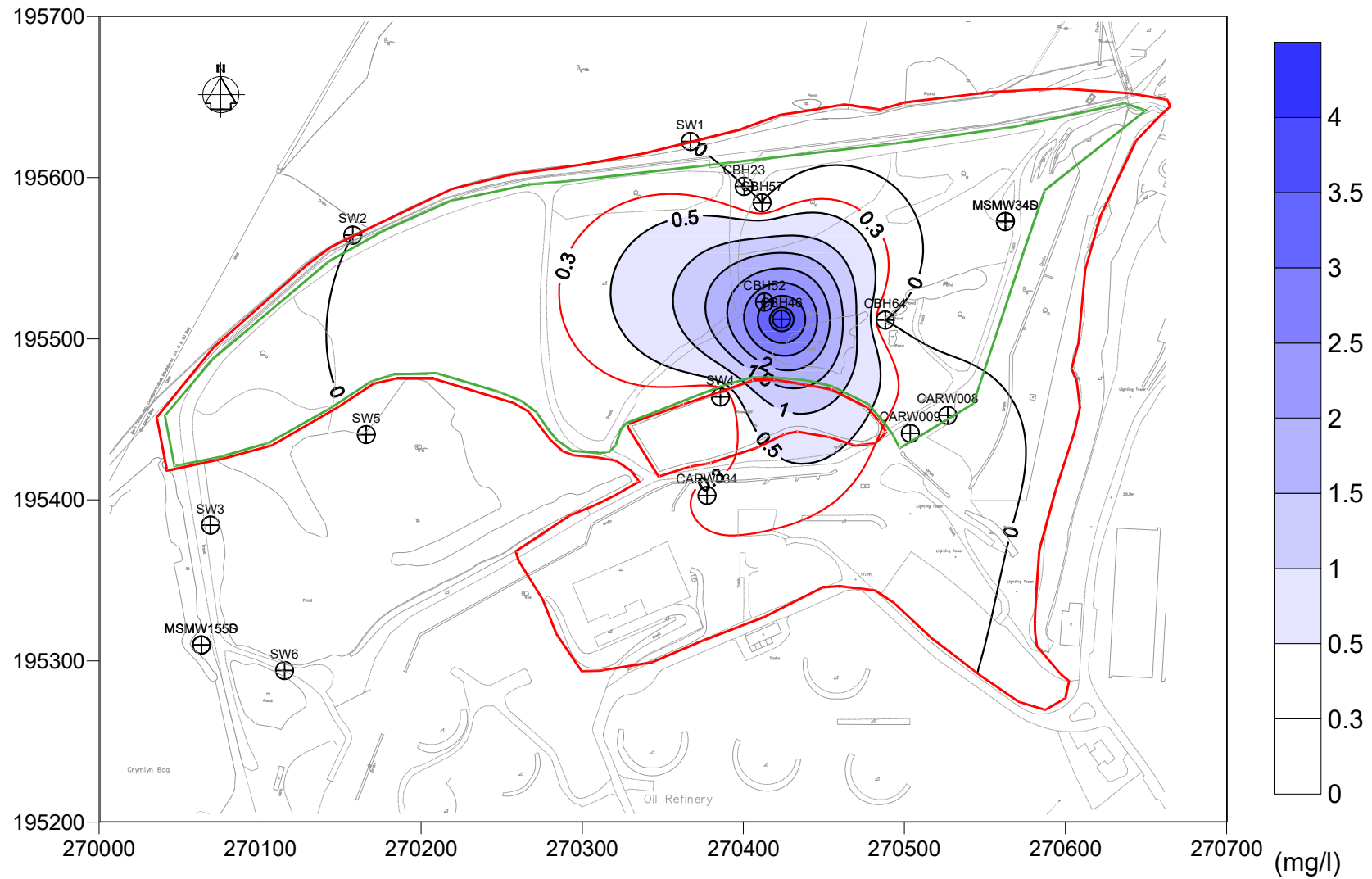
Coed Darcy Tip

Inferred Contours of Aliphatics C10-C12 in Groundwater January 2022



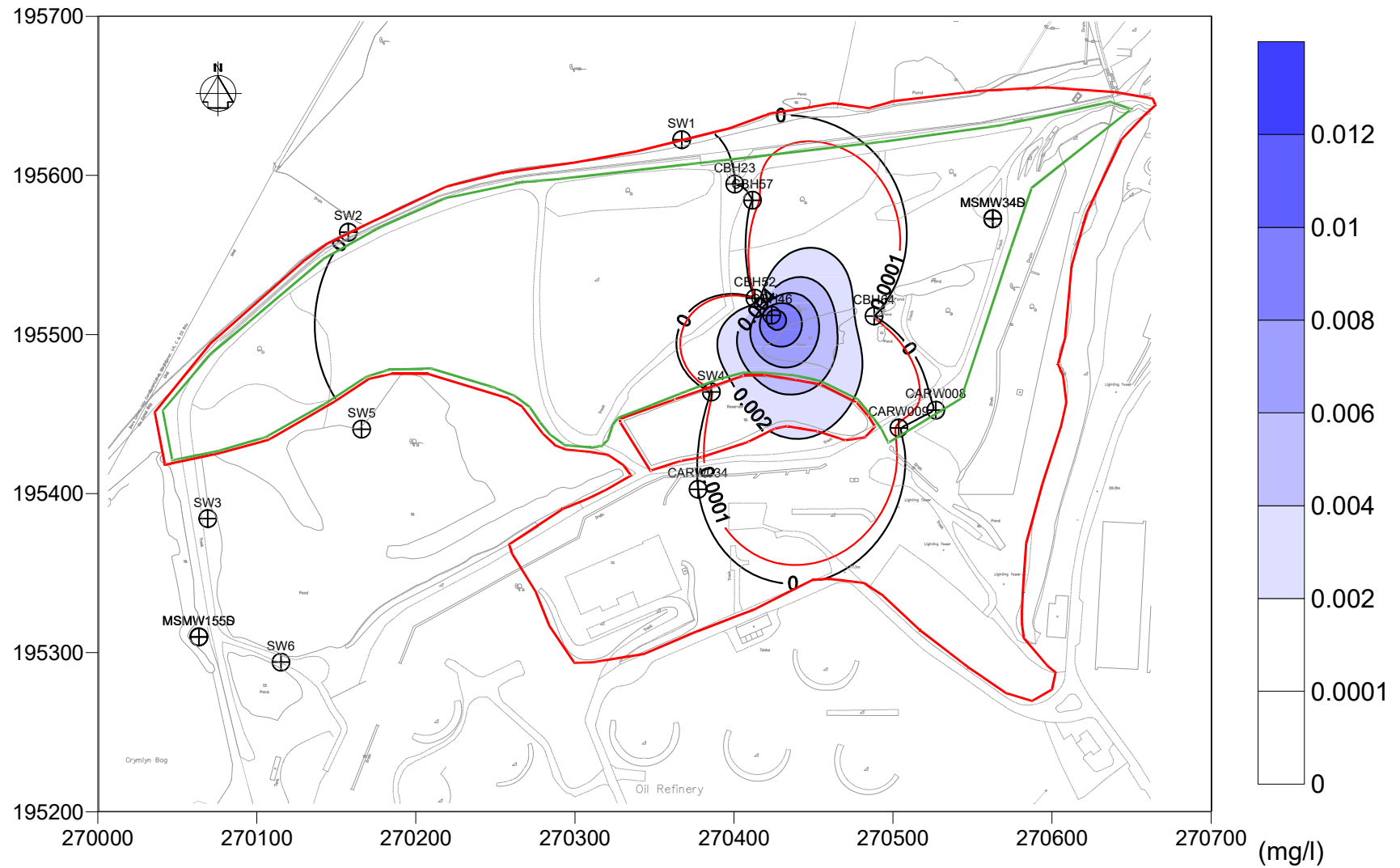
Coed Darcy Tip

Inferred Contours of Aliphatics C12-C16 (aq) in Groundwater January 2022

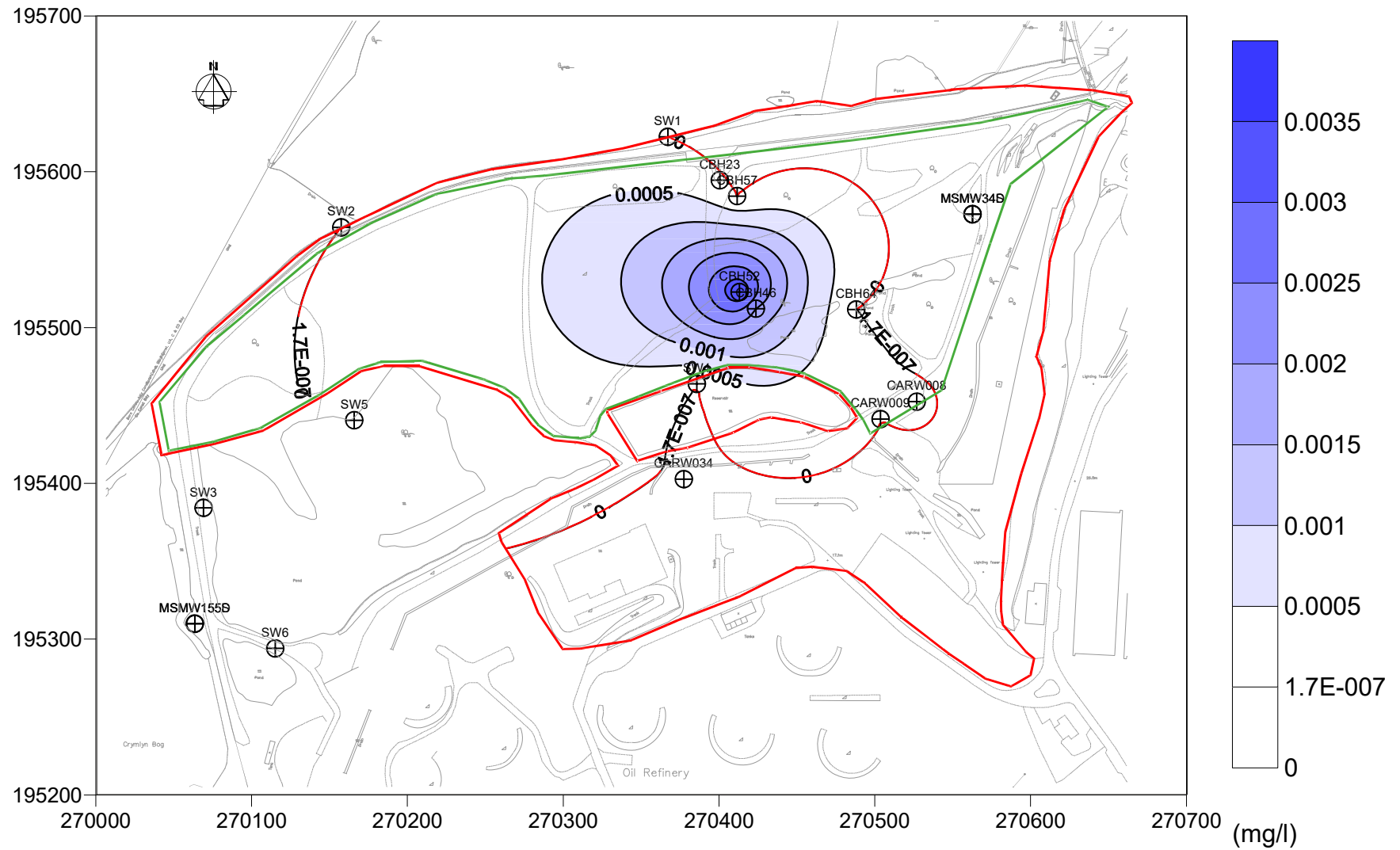


Coed Darcy Tip

Inferred Contours of Anthracene (aq) in Groundwater January 2022



Inferred Contours of Benzo(a)pyrene (aq) in Groundwater January 2022

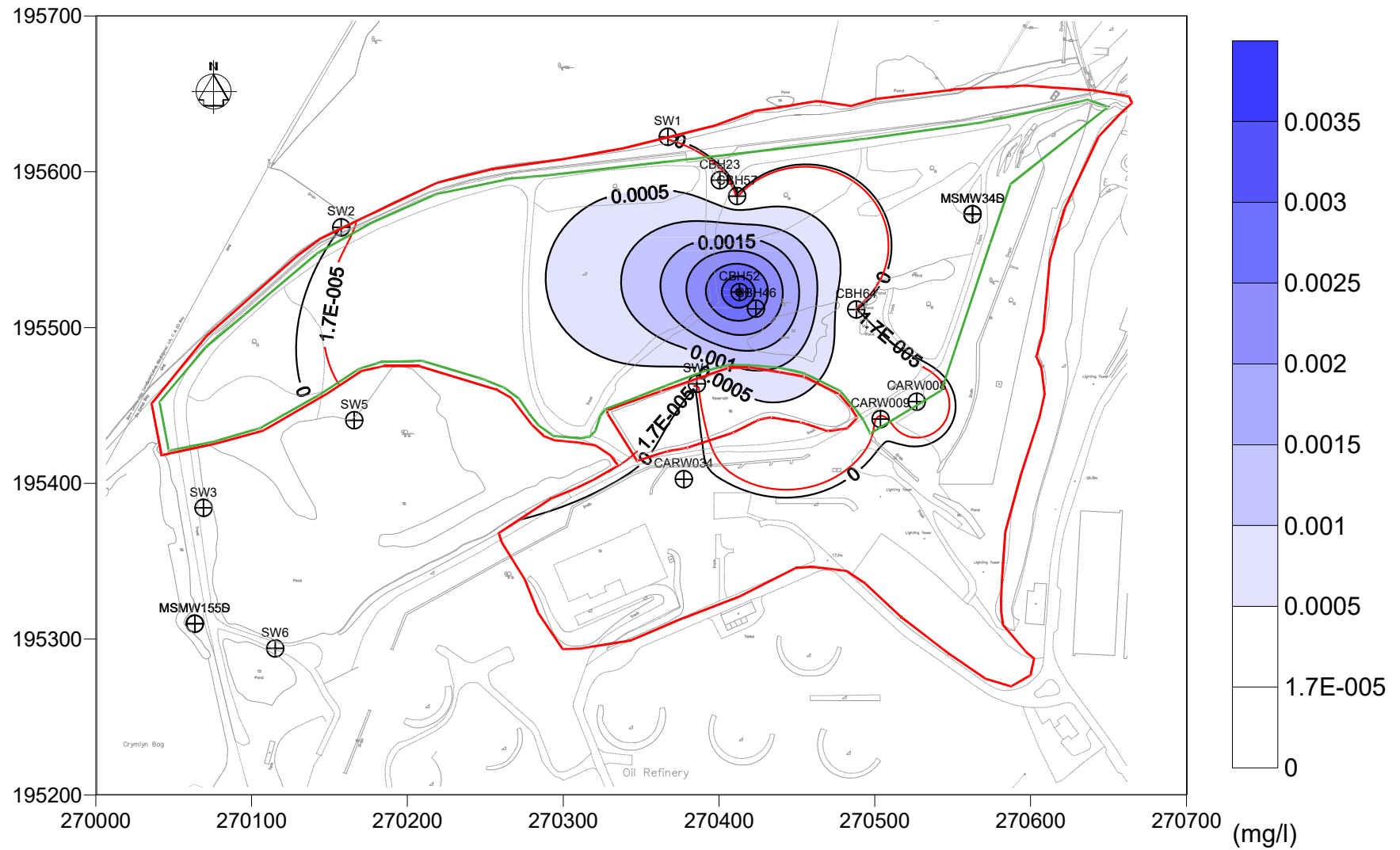


Compliance Criterion = 0.00000017 (mg/l)

Data Maximum Value = 0.00353 (mg/l)

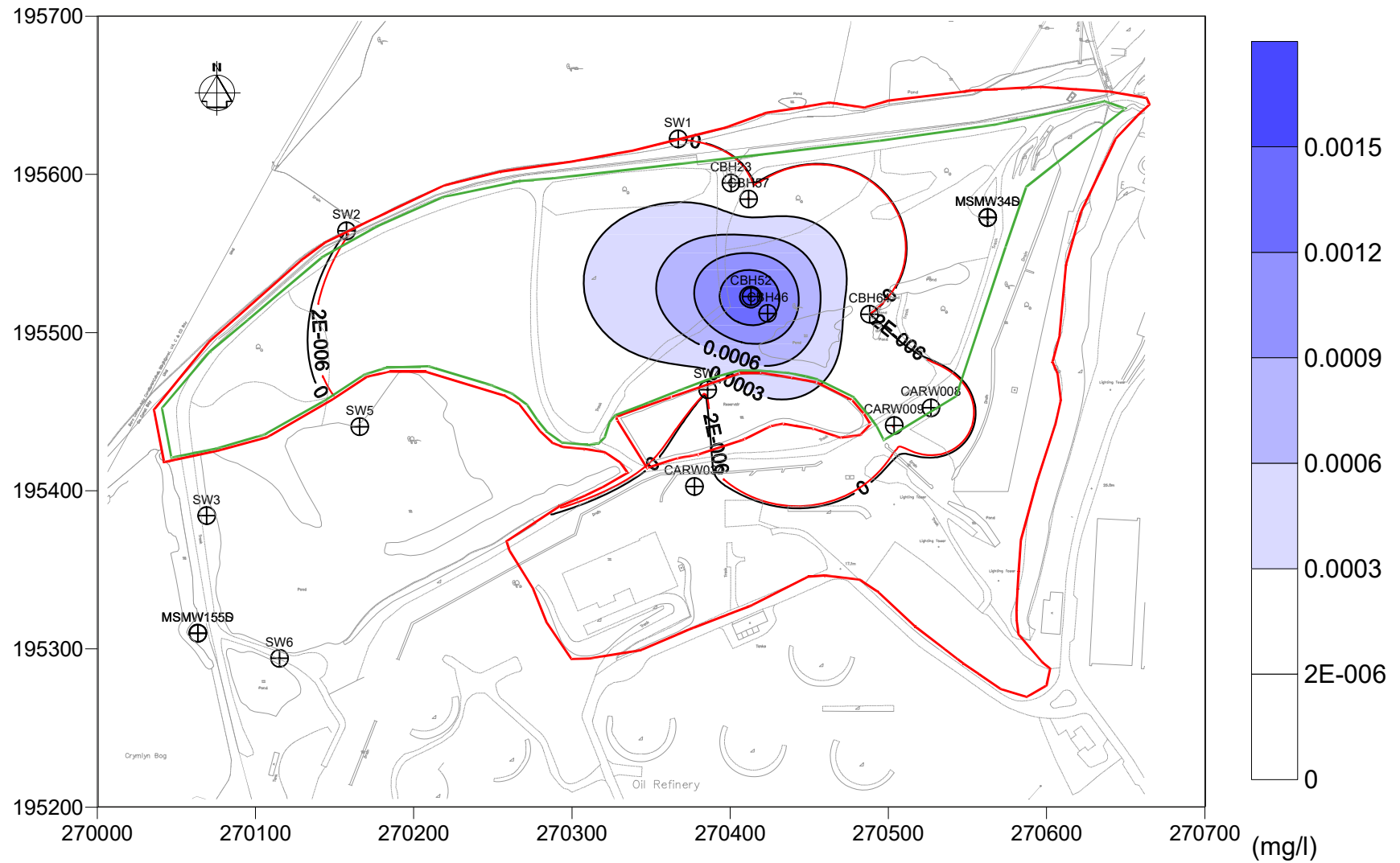
Coed Darcy Tip

Inferred Contours of Benzo(b)fluoranthene (aq) in Groundwater January 2022



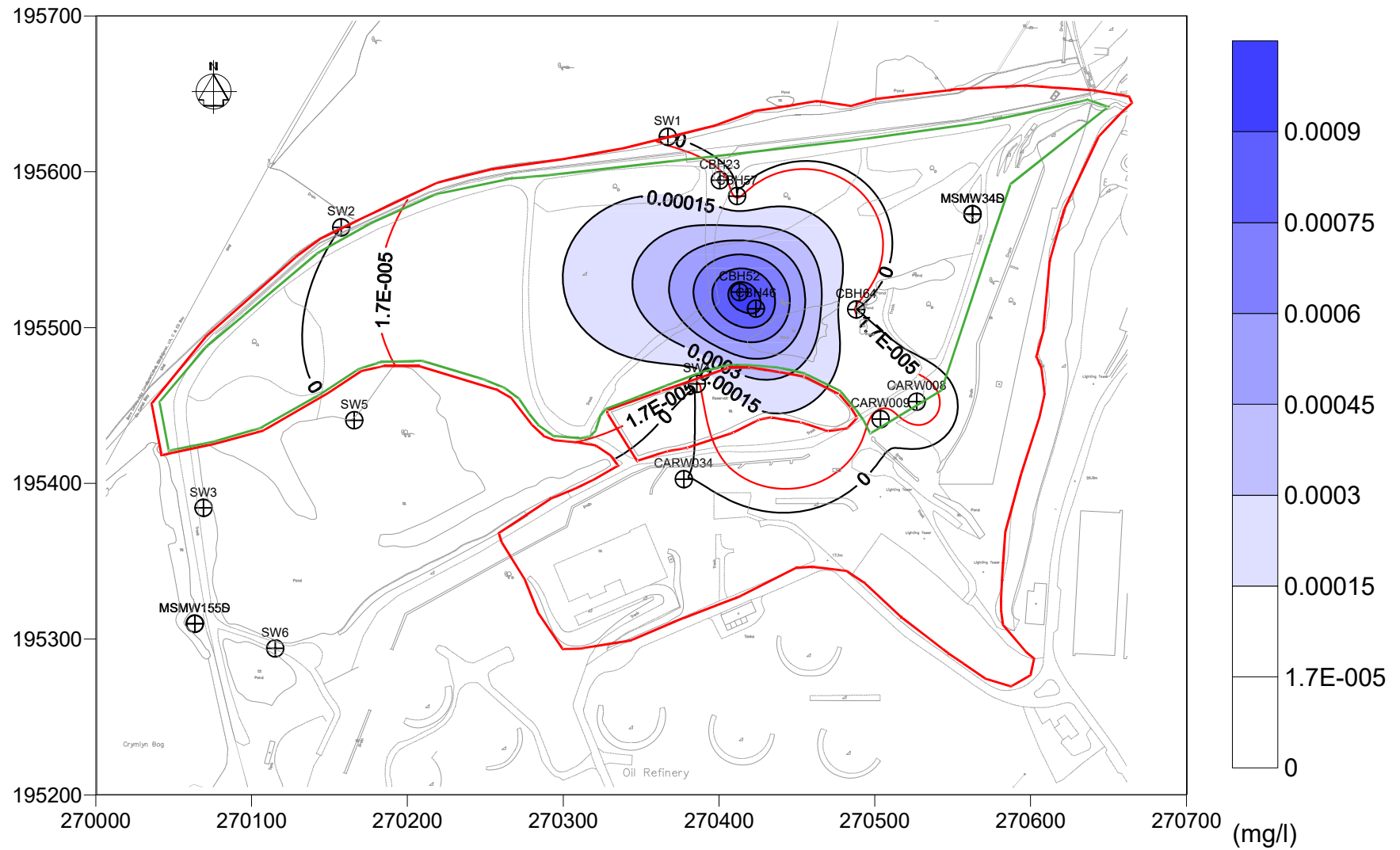
Coed Darcy Tip

Inferred Contours of Benzo(g,h,i)perylene (aq) in Groundwater January 2022



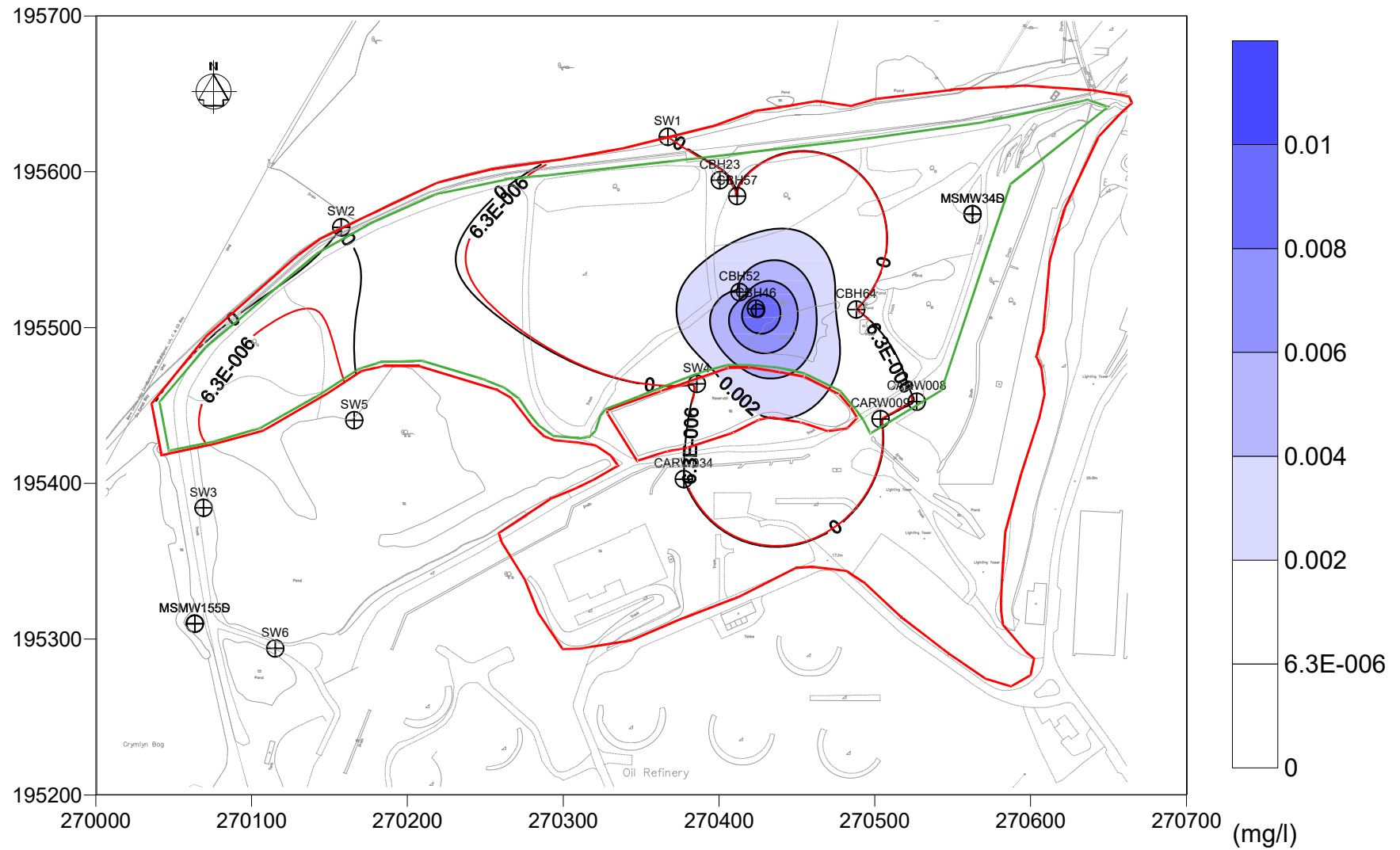
Coed Darcy Tip

Inferred Contours of Benzo(k)fluoranthene (aq) in Groundwater January 2022



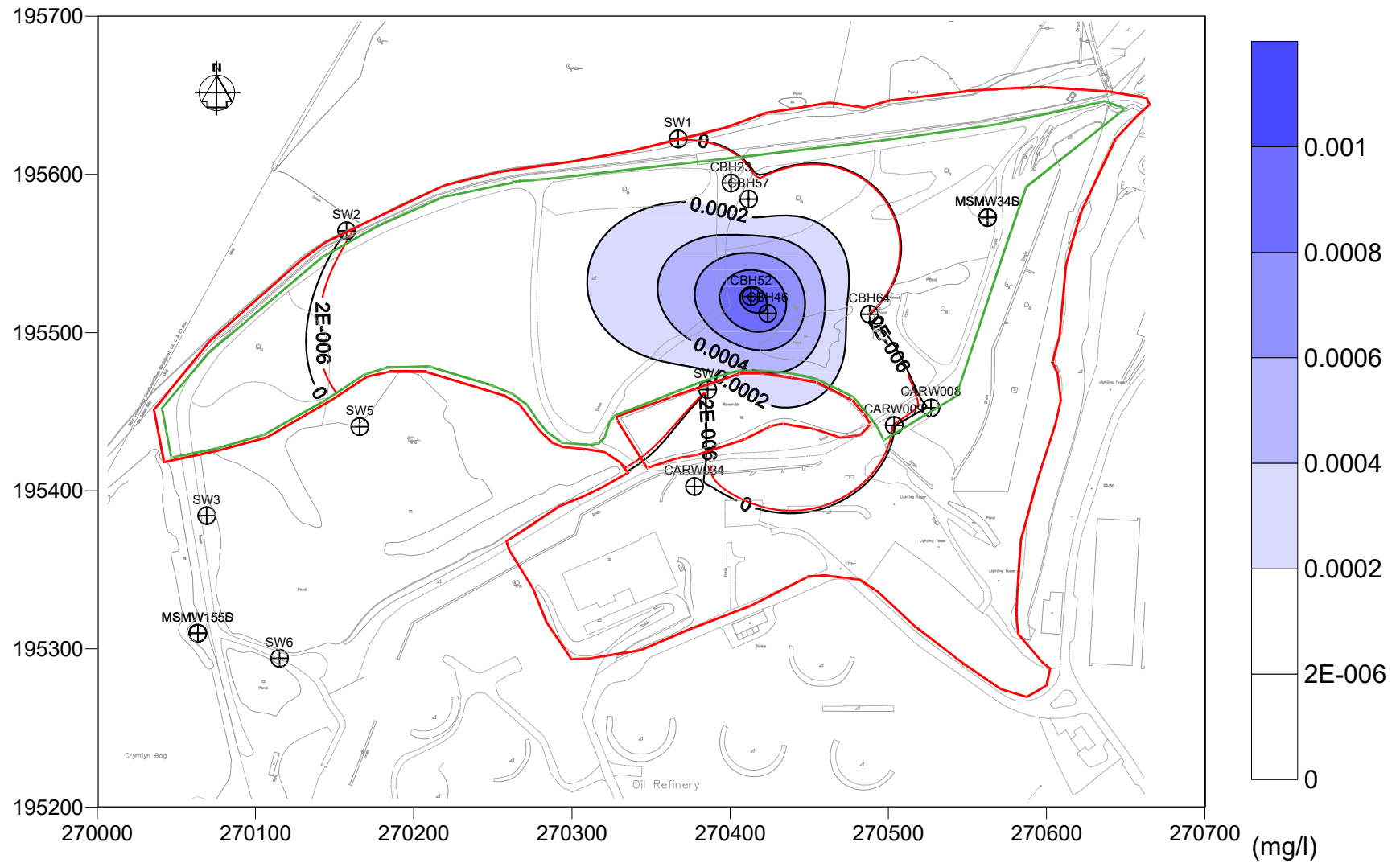
Coed Darcy Tip

Inferred Contours of Fluoranthene (aq) in Groundwater January 2022



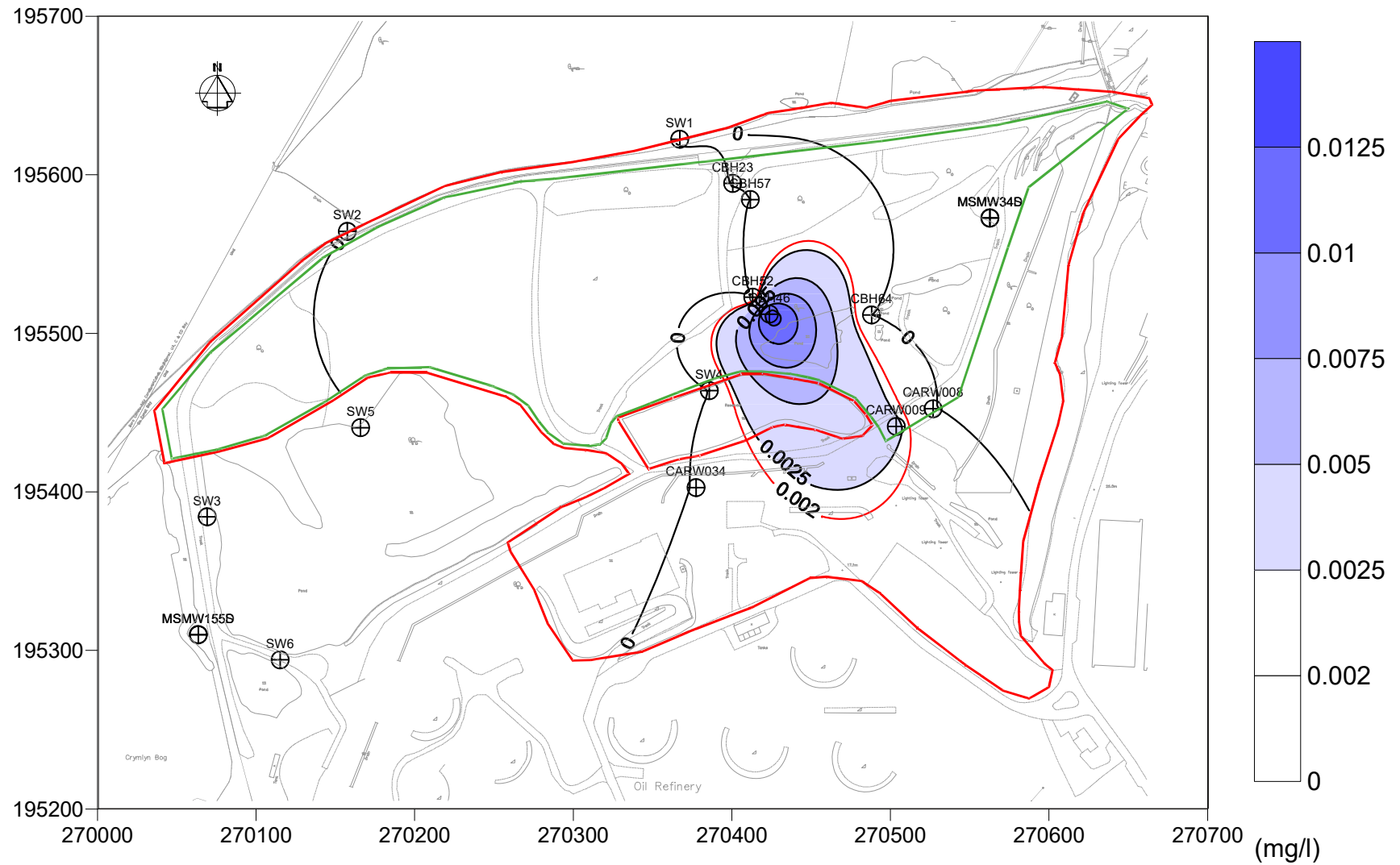
Coed Darcy Tip

Inferred Contours of Indeno(1,2,3-cd)pyrene (aq) in Groundwater January 2022



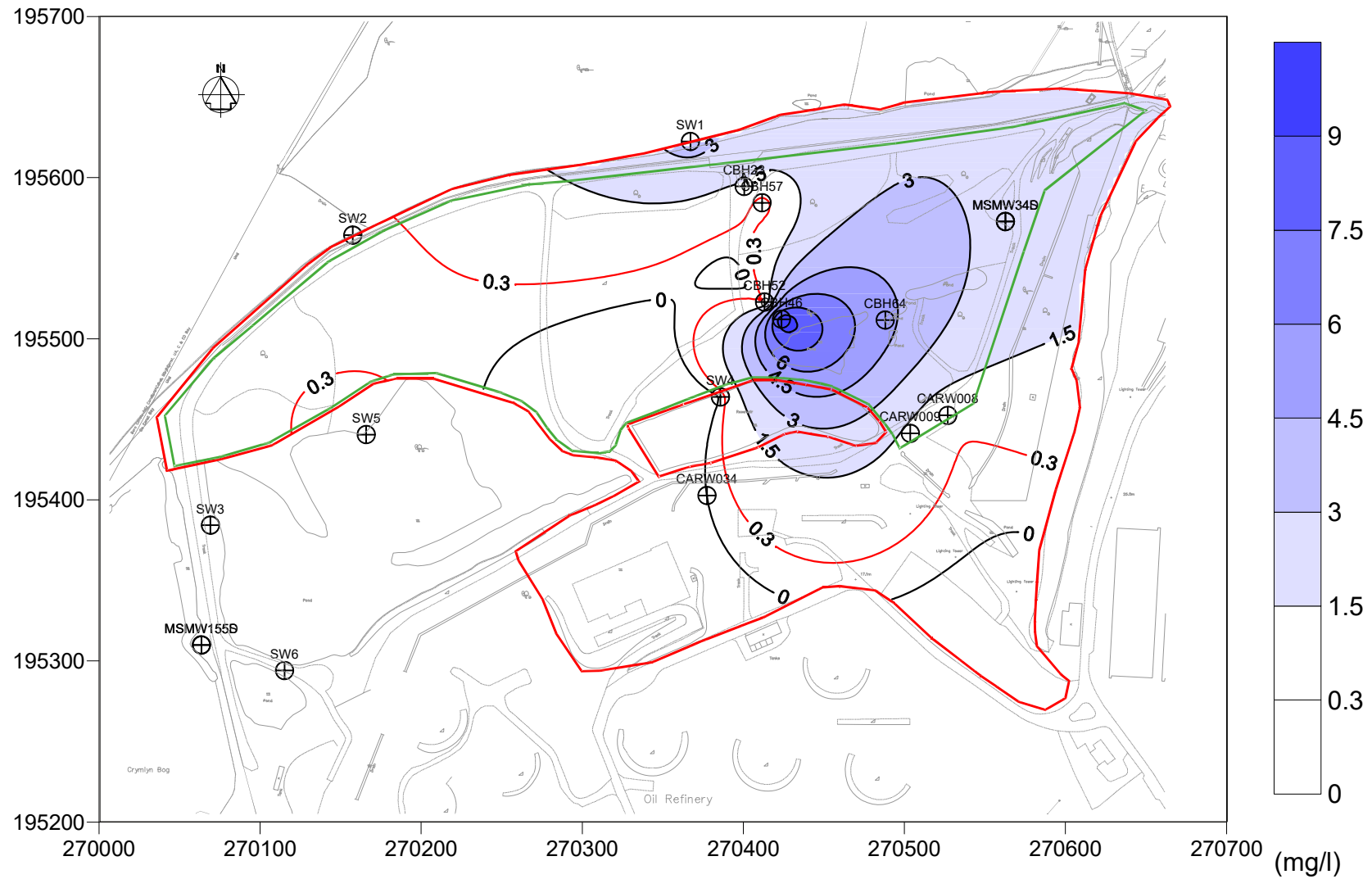
Coed Darcy Tip

Inferred Contours of Naphthalene (aq) in Groundwater January 2022



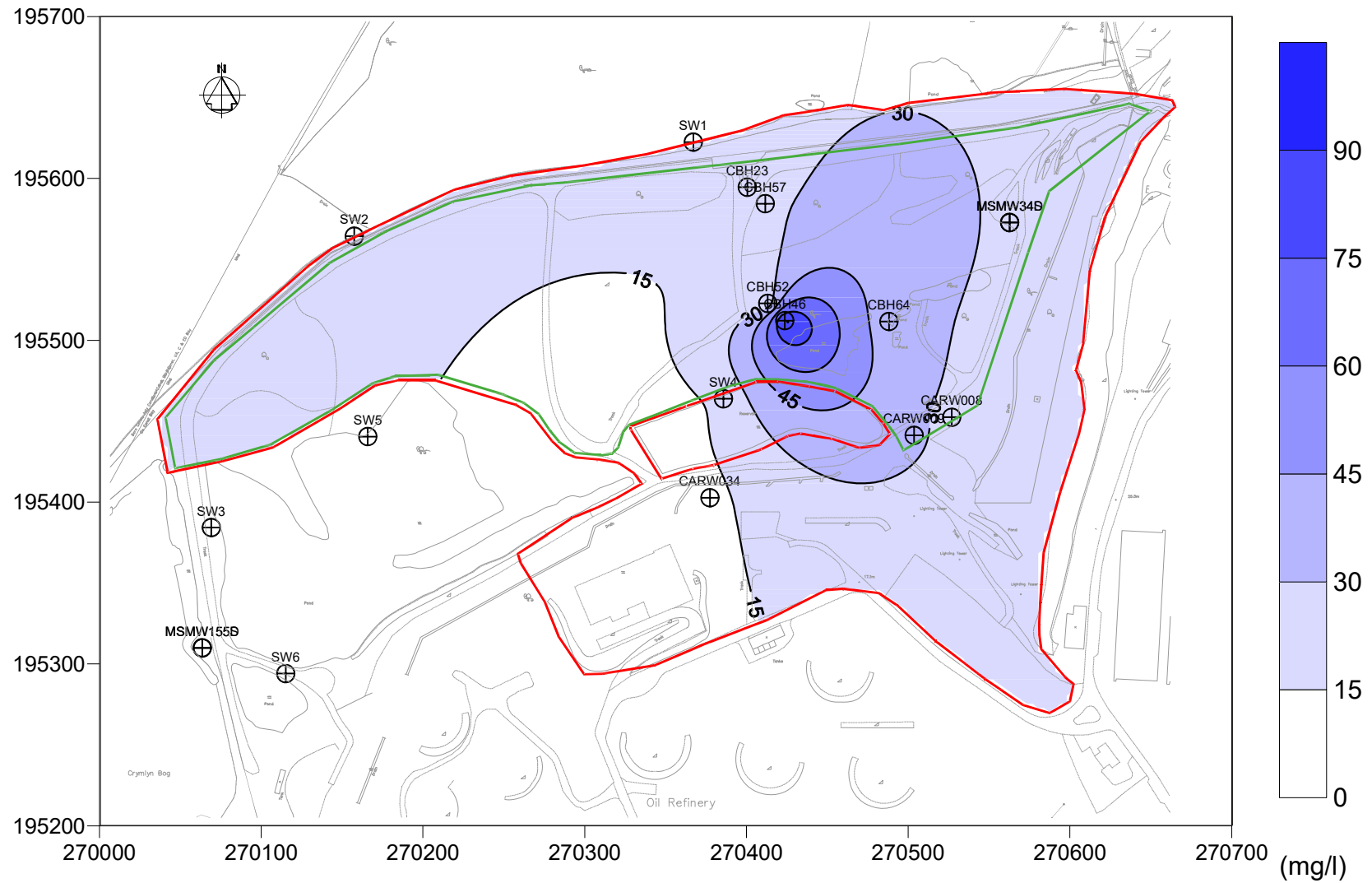
Coed Darcy Tip

Inferred Contours of Ammoniacal Nitrogen as N in Groundwater January 2022



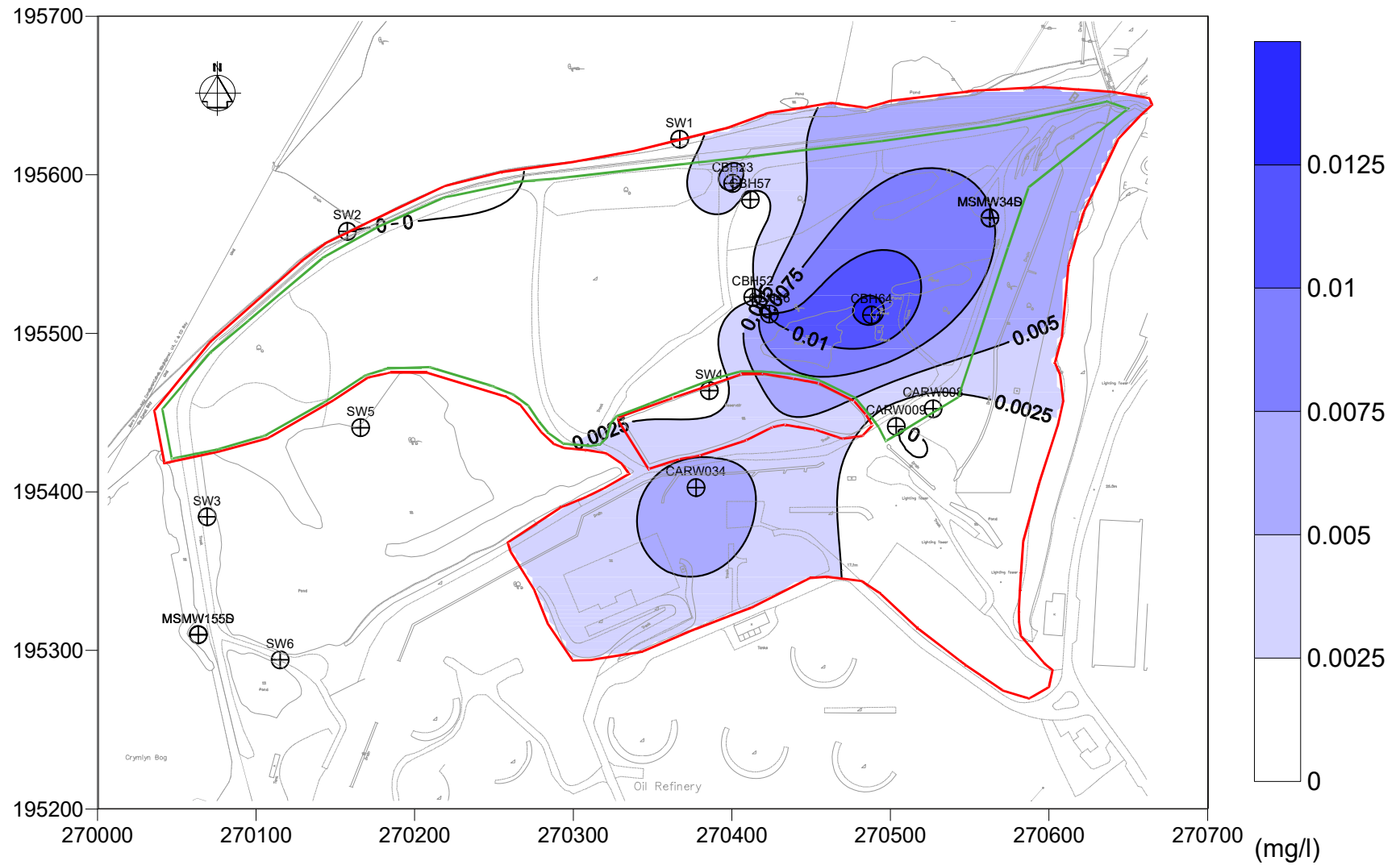
Coed Darcy Tip

Inferred Contours of Chloride in Groundwater January 2022



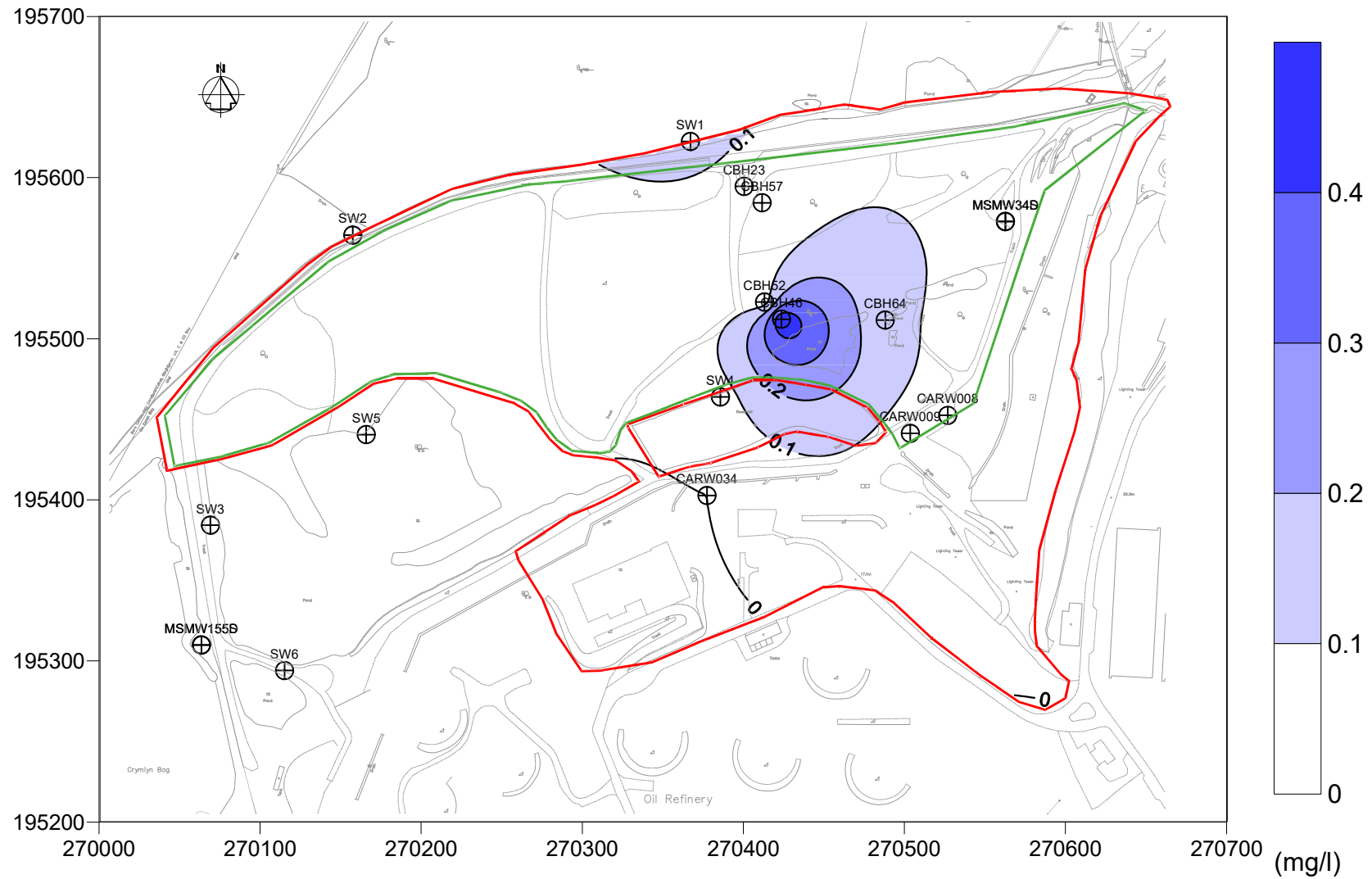
Coed Darcy Tip

Inferred Contours of Arsenic (diss.filt) in Groundwater January 2022



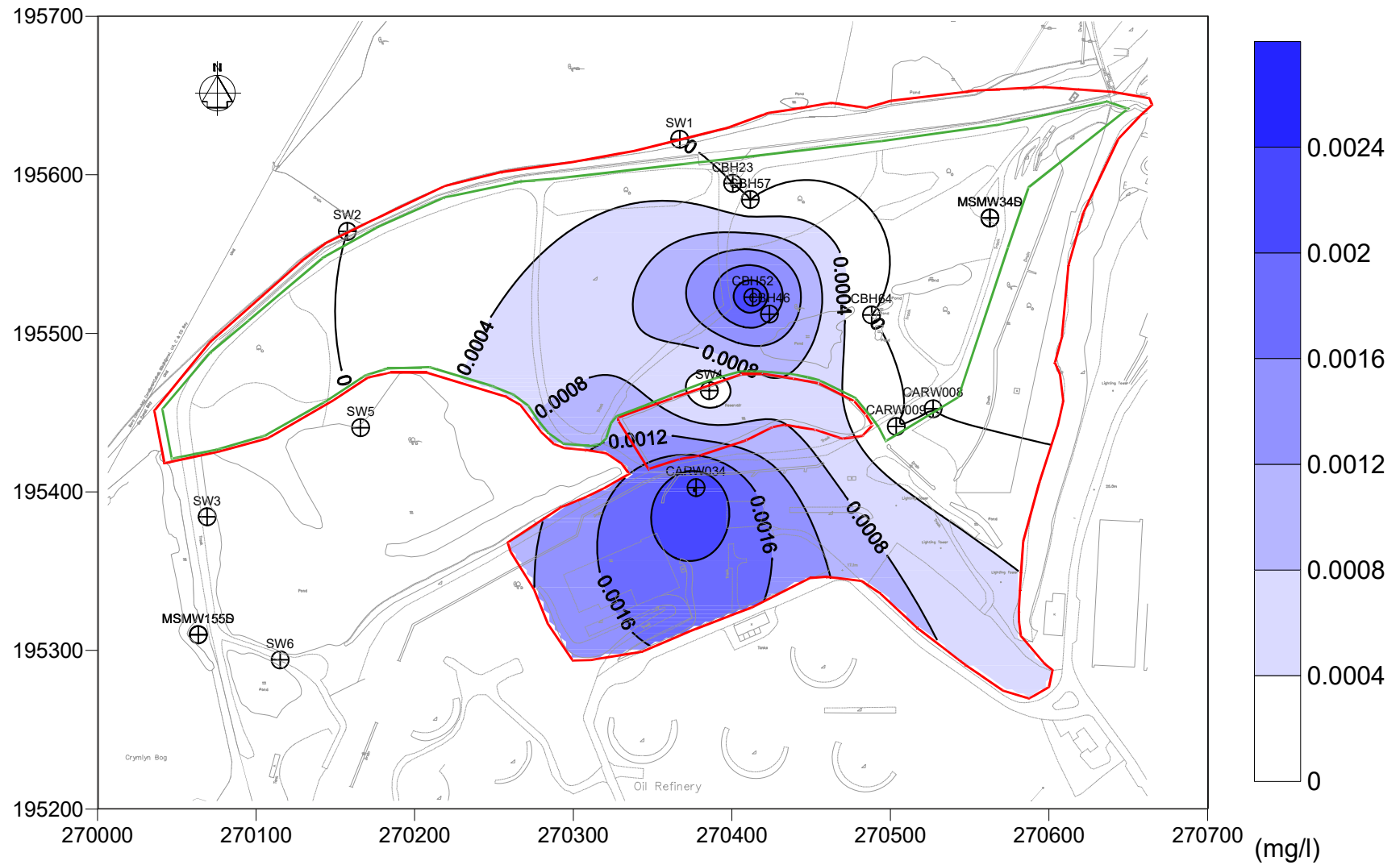
Coed Darcy Tip

Inferred Contours of Boron (diss.filt) in Groundwater January 2022



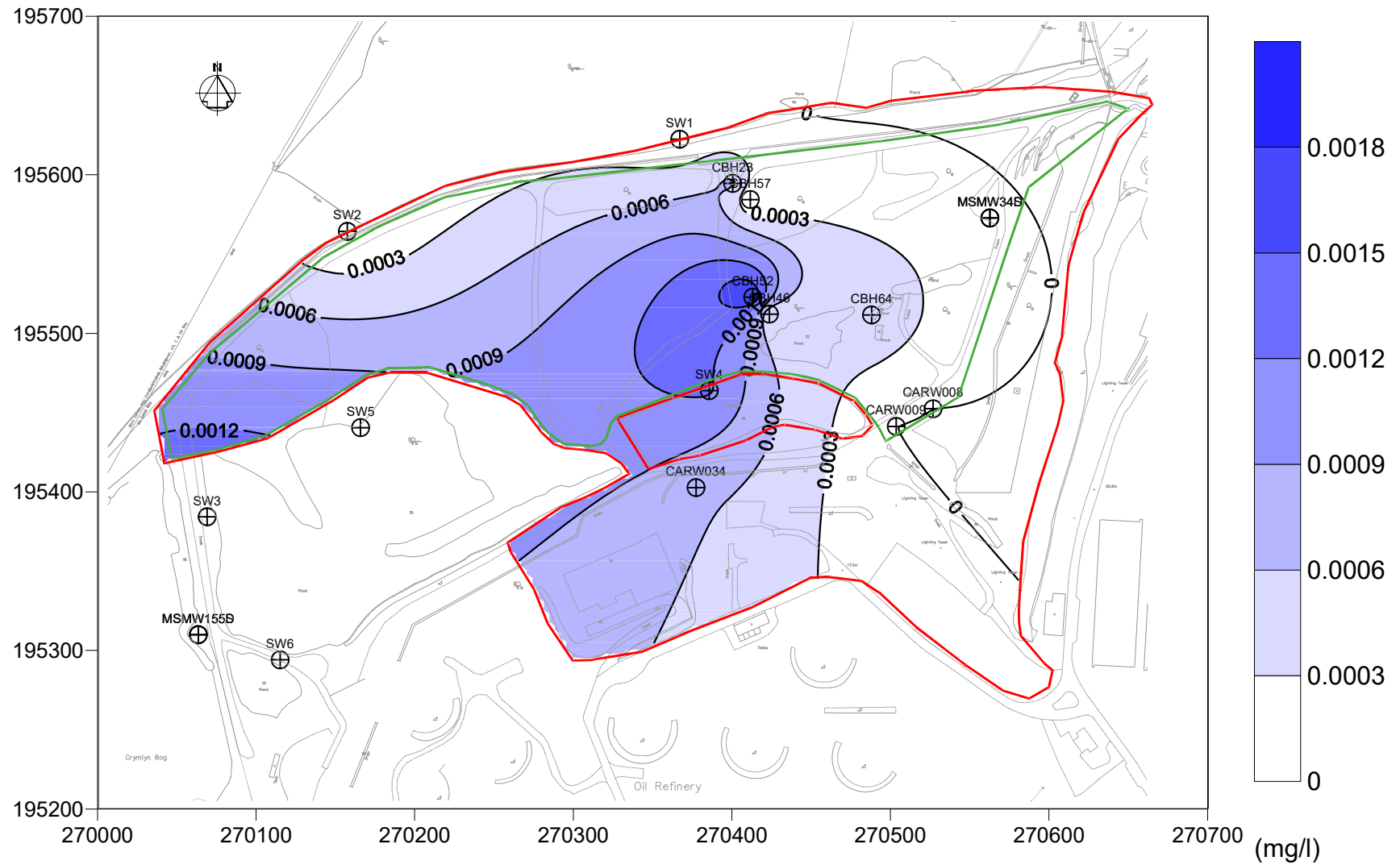
Coed Darcy Tip

Inferred Contours of Chromium (diss.filt) in Groundwater January 2022



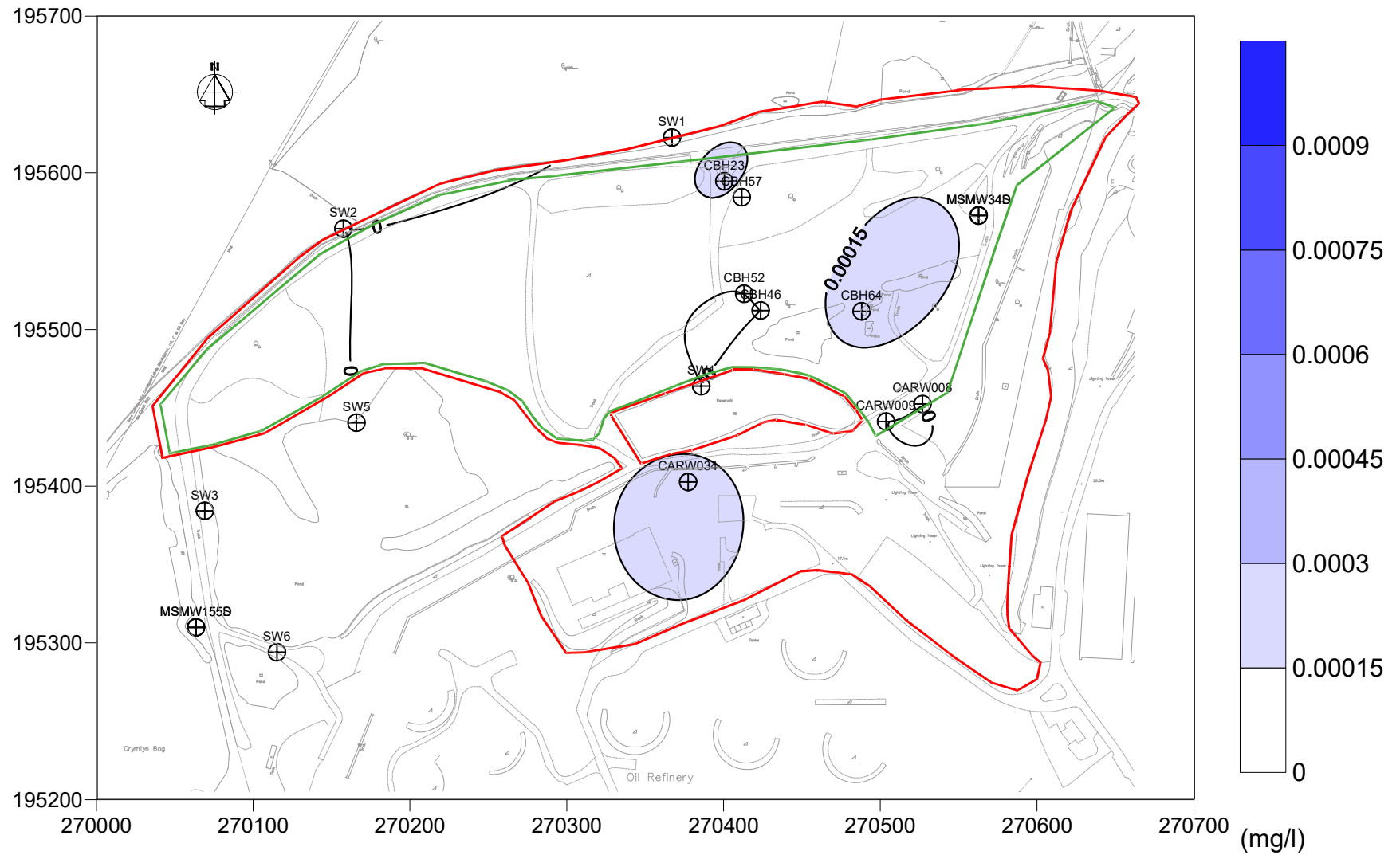
Coed Darcy Tip

Inferred Contours of Copper (diss.filt) in Groundwater January 2022



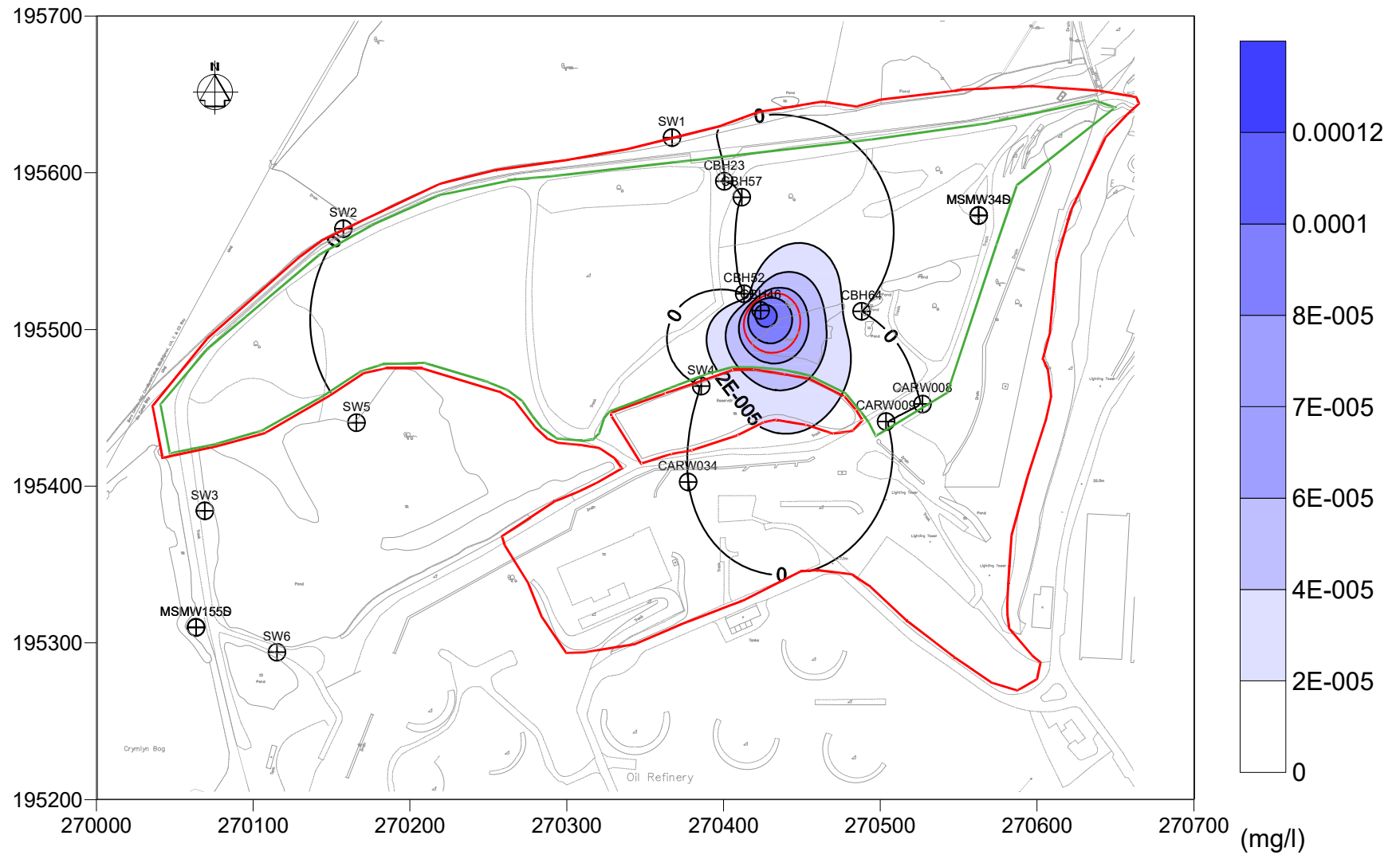
Coed Darcy Tip

Inferred Contours of Lead (diss.filt) in Groundwater January 2022



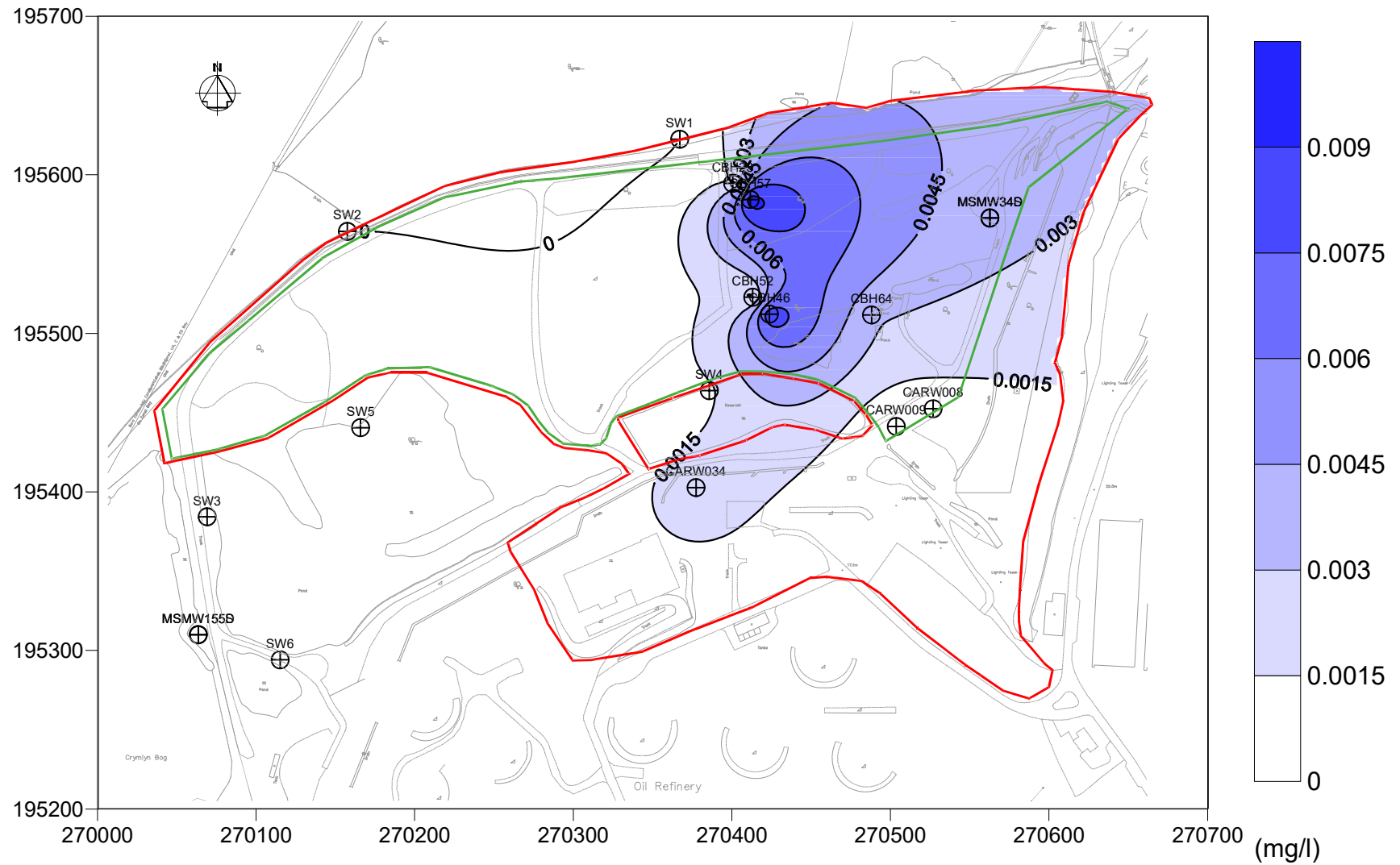
Coed Darcy Tip

Inferred Contours of Mercury (diss.filt) in Groundwater January 2022



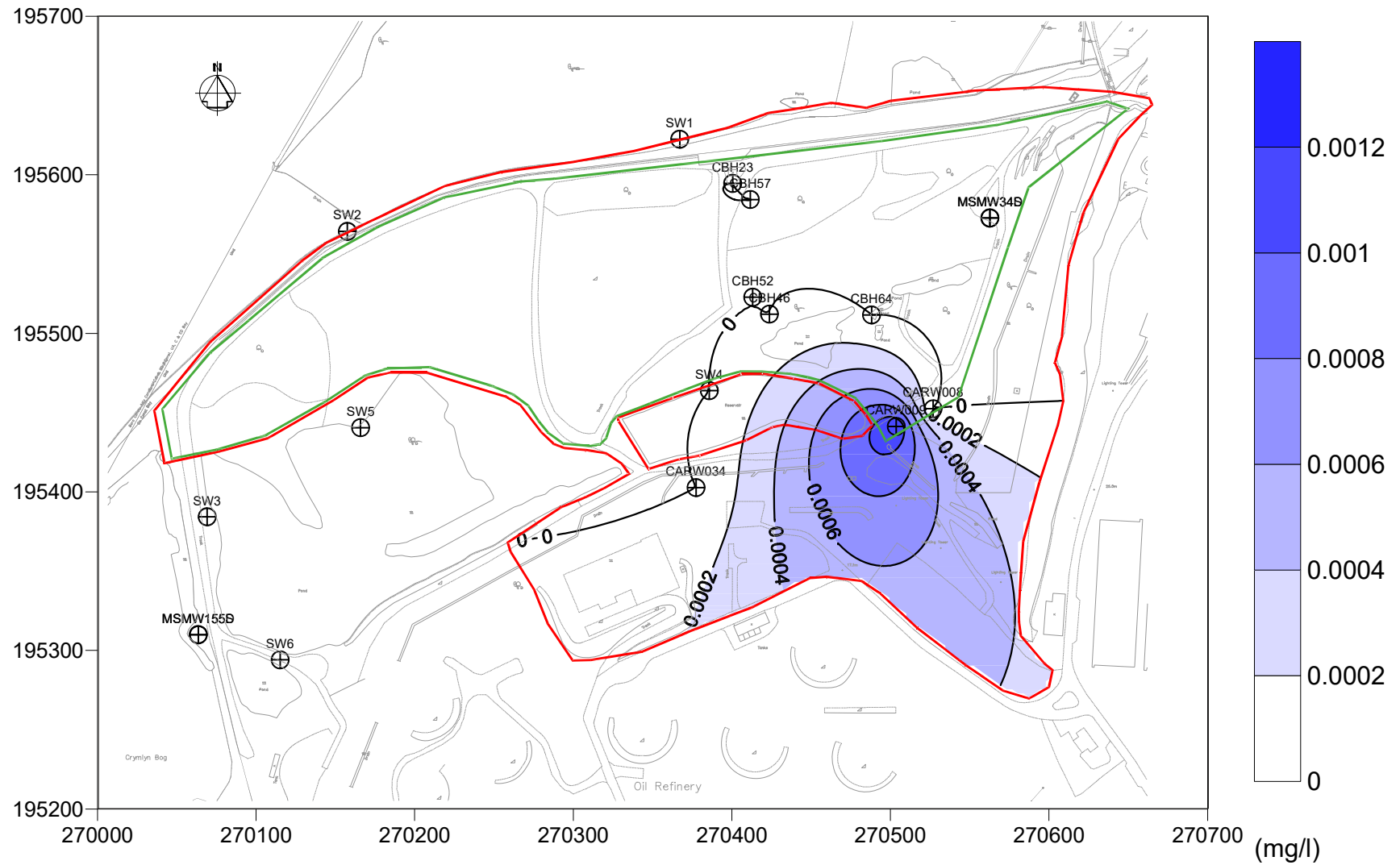
Coed Darcy Tip

Inferred Contours of Nickel (diss.filt) in Groundwater January 2022



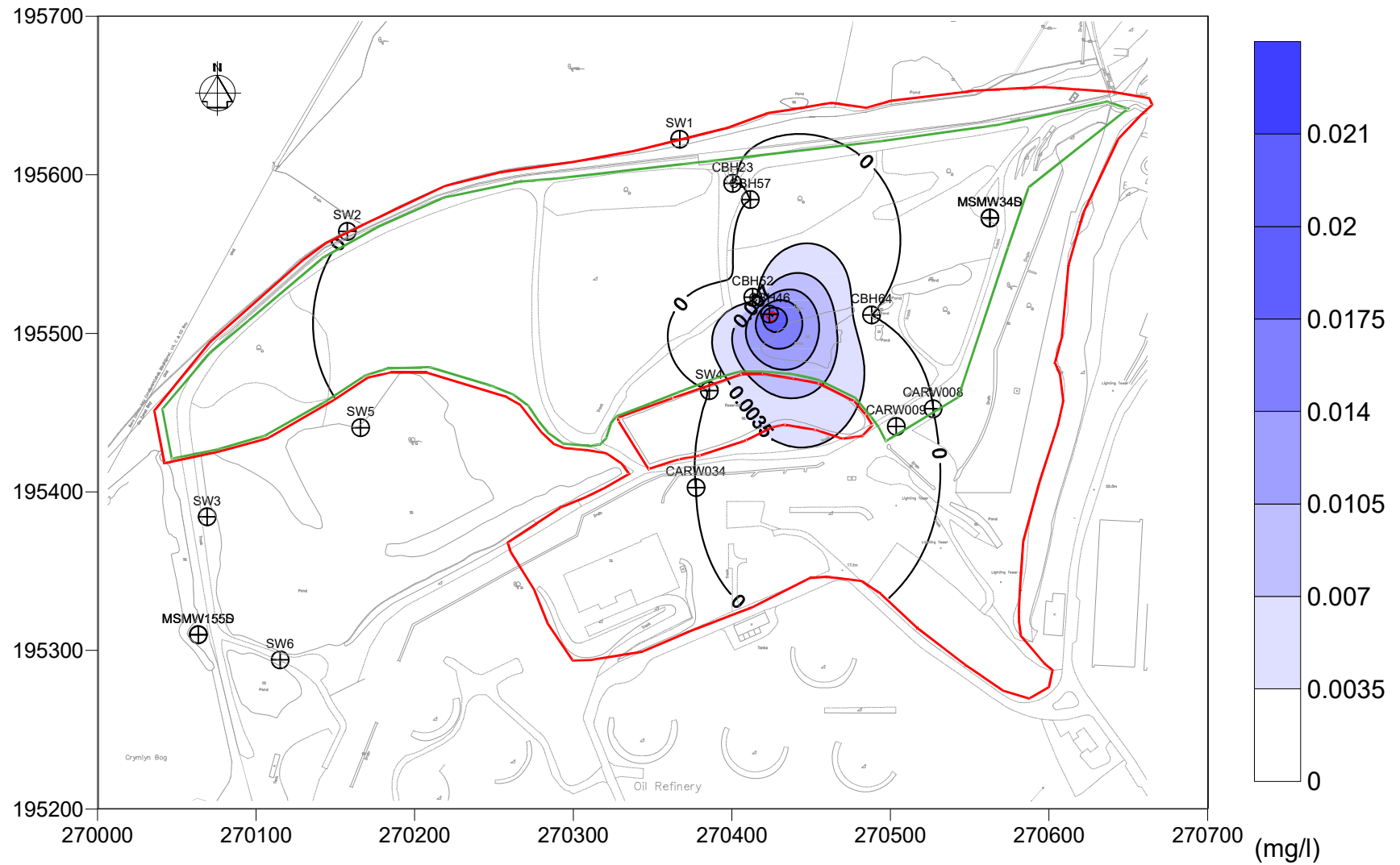
Coed Darcy Tip

Inferred Contours of Selenium (diss.filt) in Groundwater January 2022



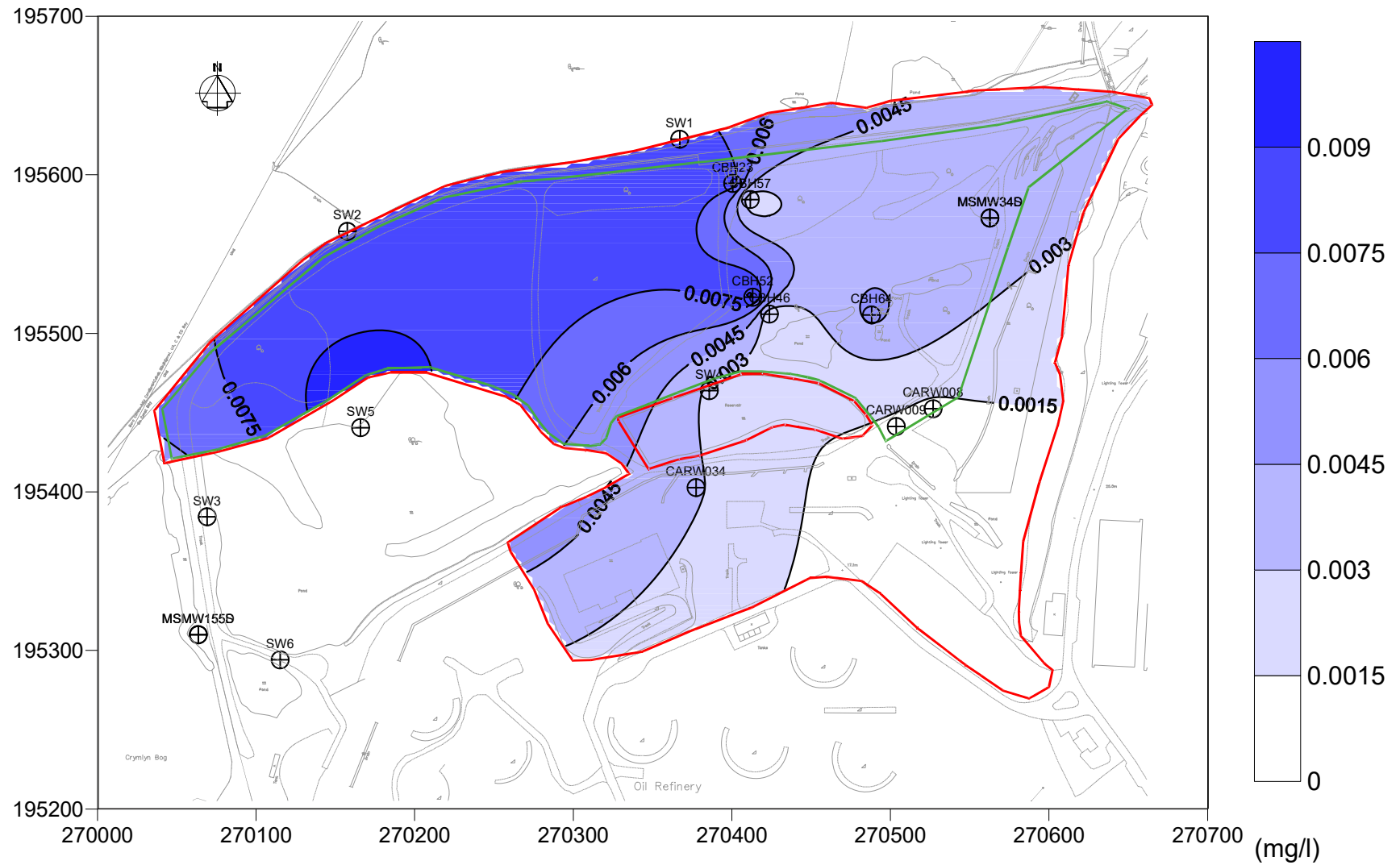
Coed Darcy Tip

Inferred Contours of Vanadium (diss.filt) in Groundwater January 2022



Coed Darcy Tip

Inferred Contours of Zinc (diss.filt) in Groundwater January 2022



Addendum C4 - Feb 2022

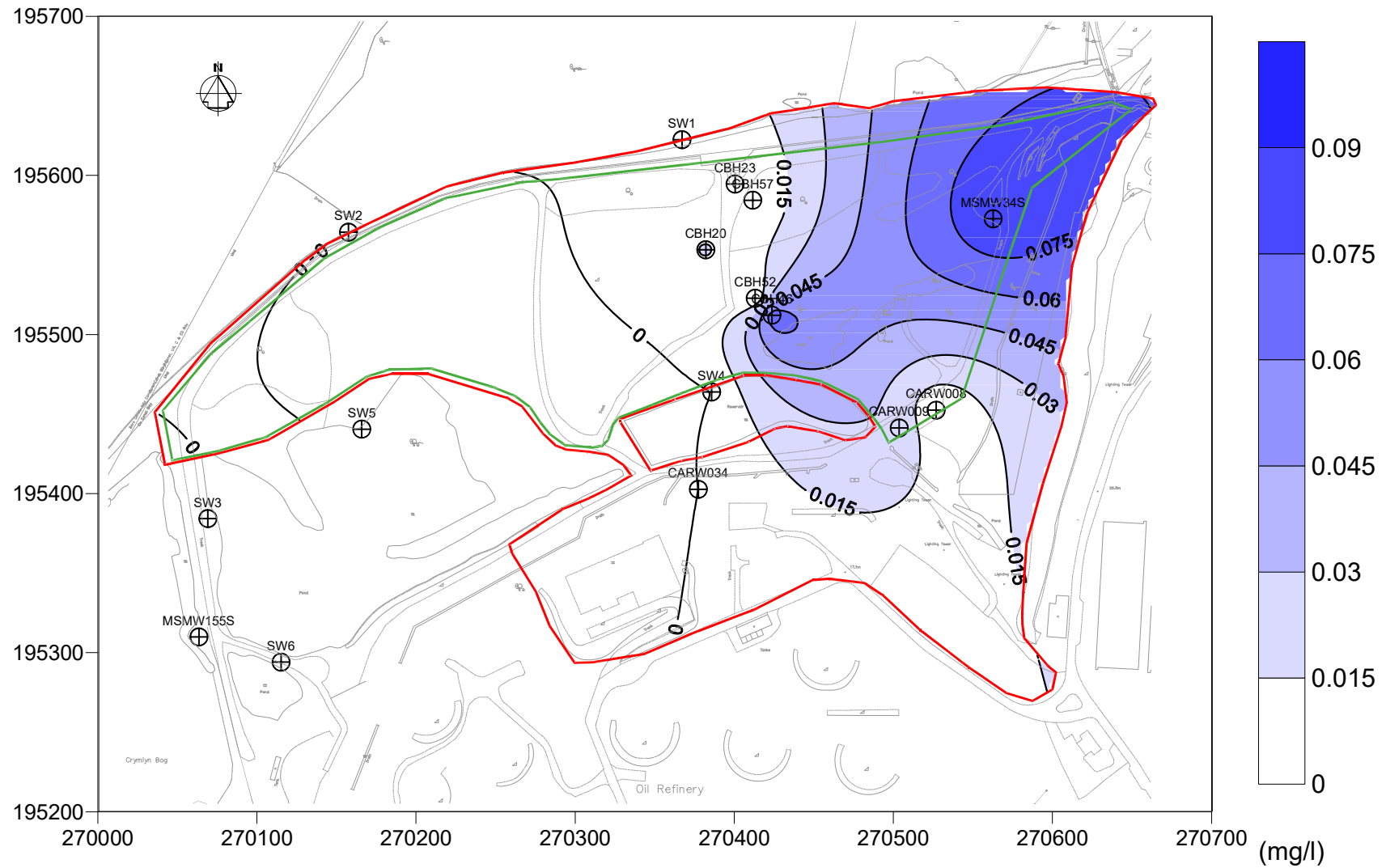
Chem Plots



eNGLOBE

Coed Darcy Tip

Inferred Contours of Aromatics EC8-EC10 in Groundwater February 2022

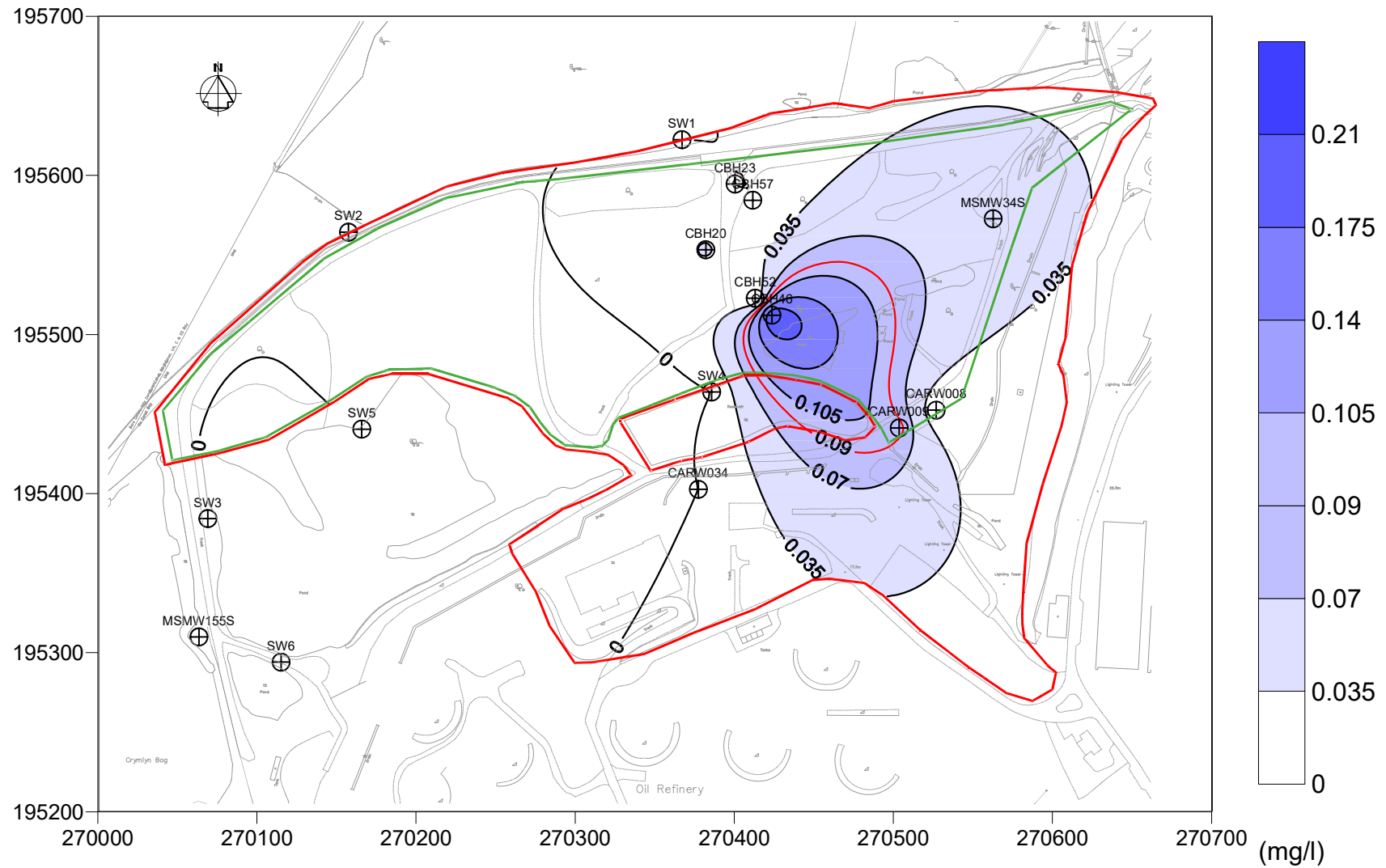


Compliance Criterion = 0.3 (mg/l) : Compliance Criterion Exceeds Data Maximum Value

Data Maximum Value = 0.09 (mg/l)

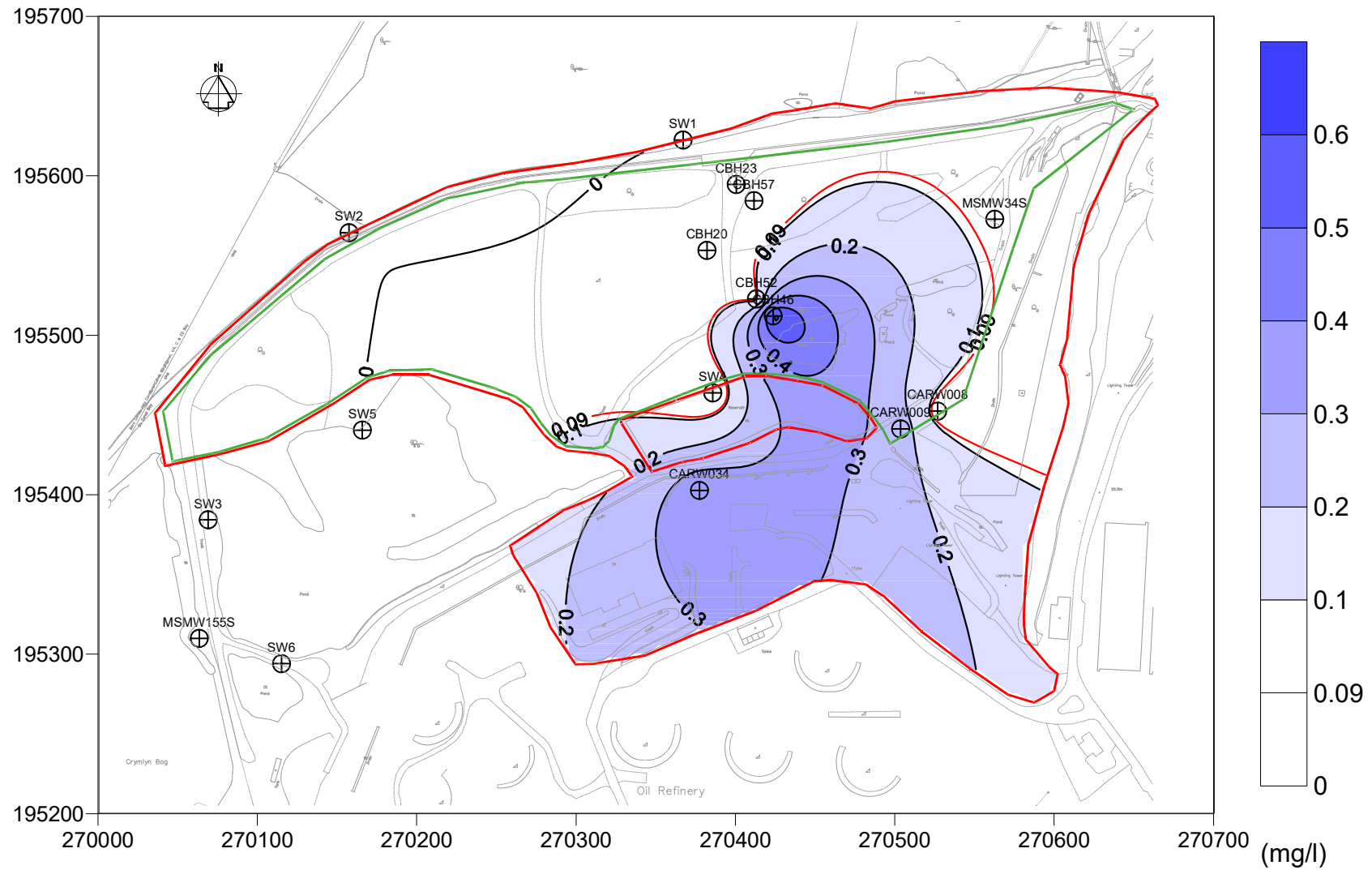
Coed Darcy Tip

Inferred Contours of Aromatics EC10-EC12 in Groundwater February 2022



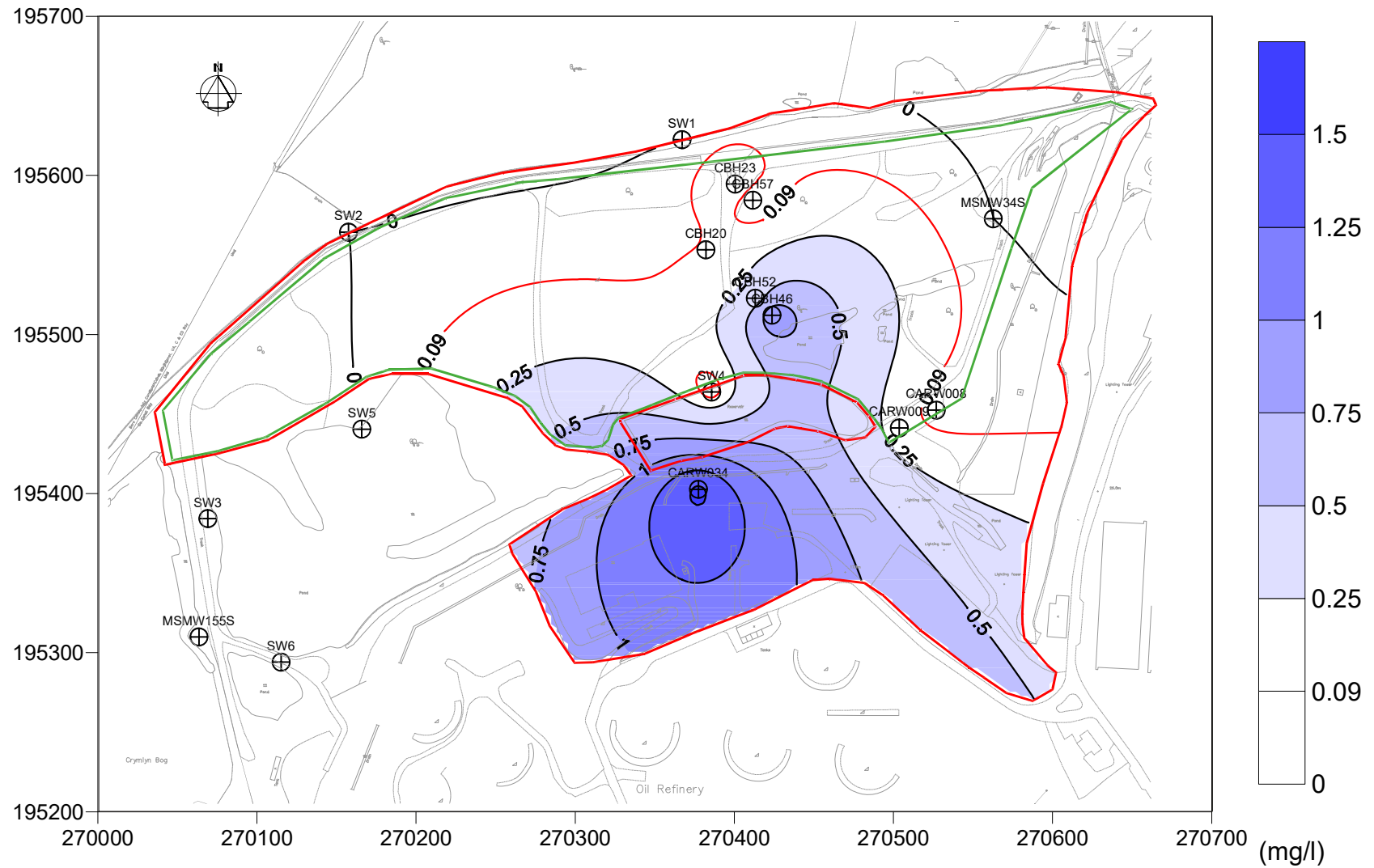
Coed Darcy Tip

Inferred Contours of Aromatics EC12-EC16 (aq) in Groundwater February 2022



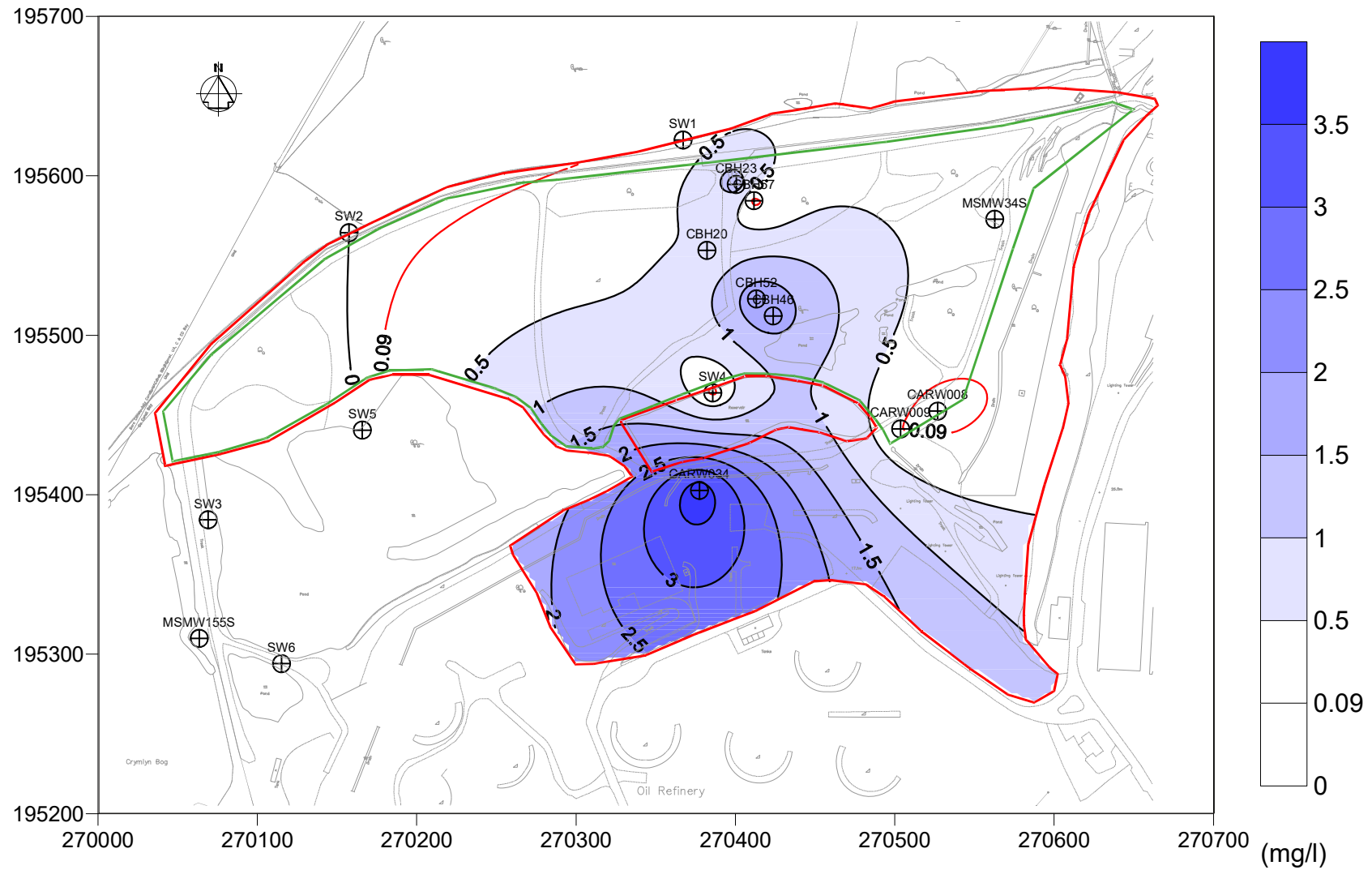
Coed Darcy Tip

Inferred Contours of Aromatics EC16-EC21 (aq) in Groundwater February 2022



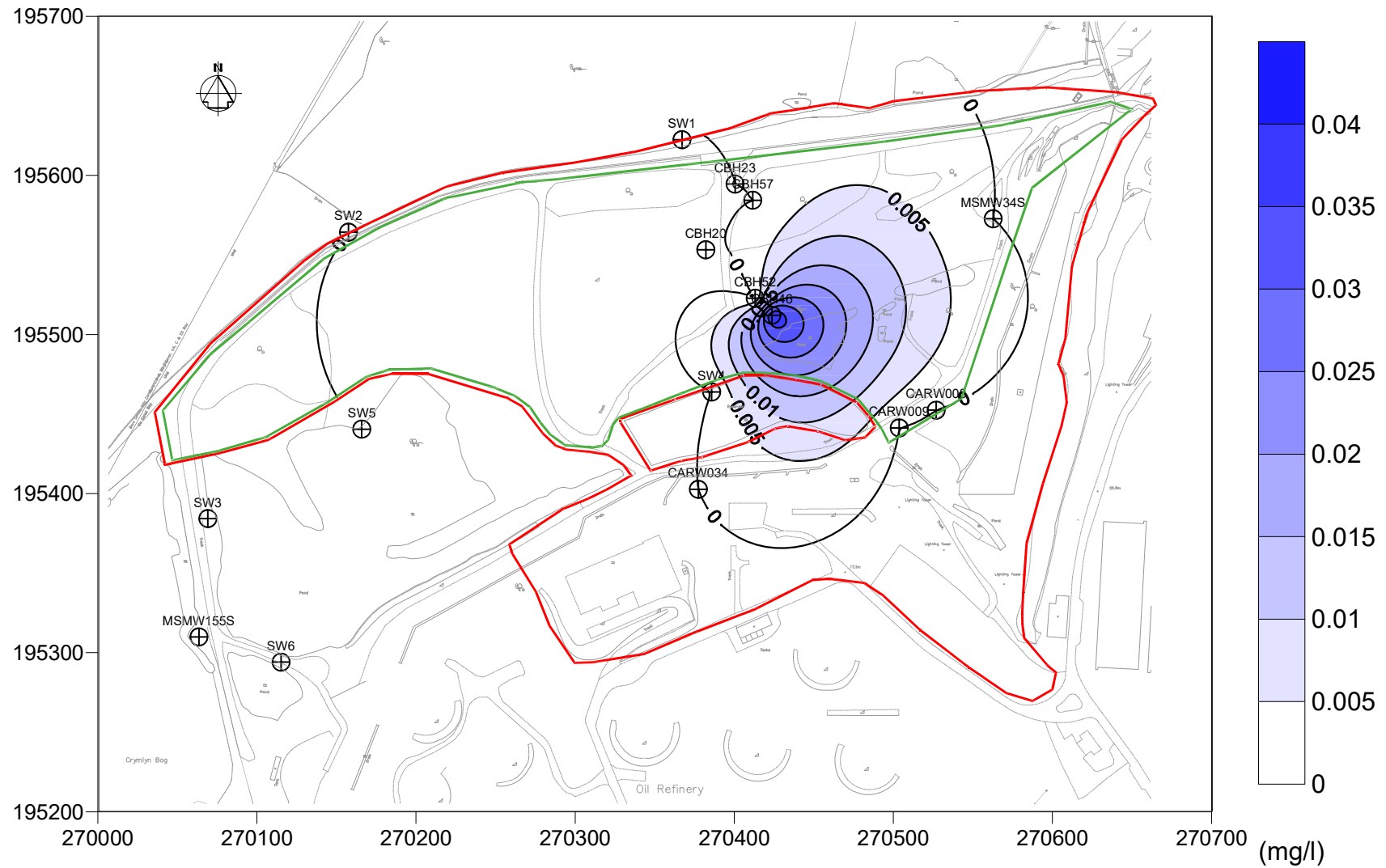
Coed Darcy Tip

Inferred Contours of Aromatics EC21-EC35 (aq) in Groundwater February 2022



Coed Darcy Tip

Inferred Contours of Aliphatics C5-C6 in Groundwater February 2022

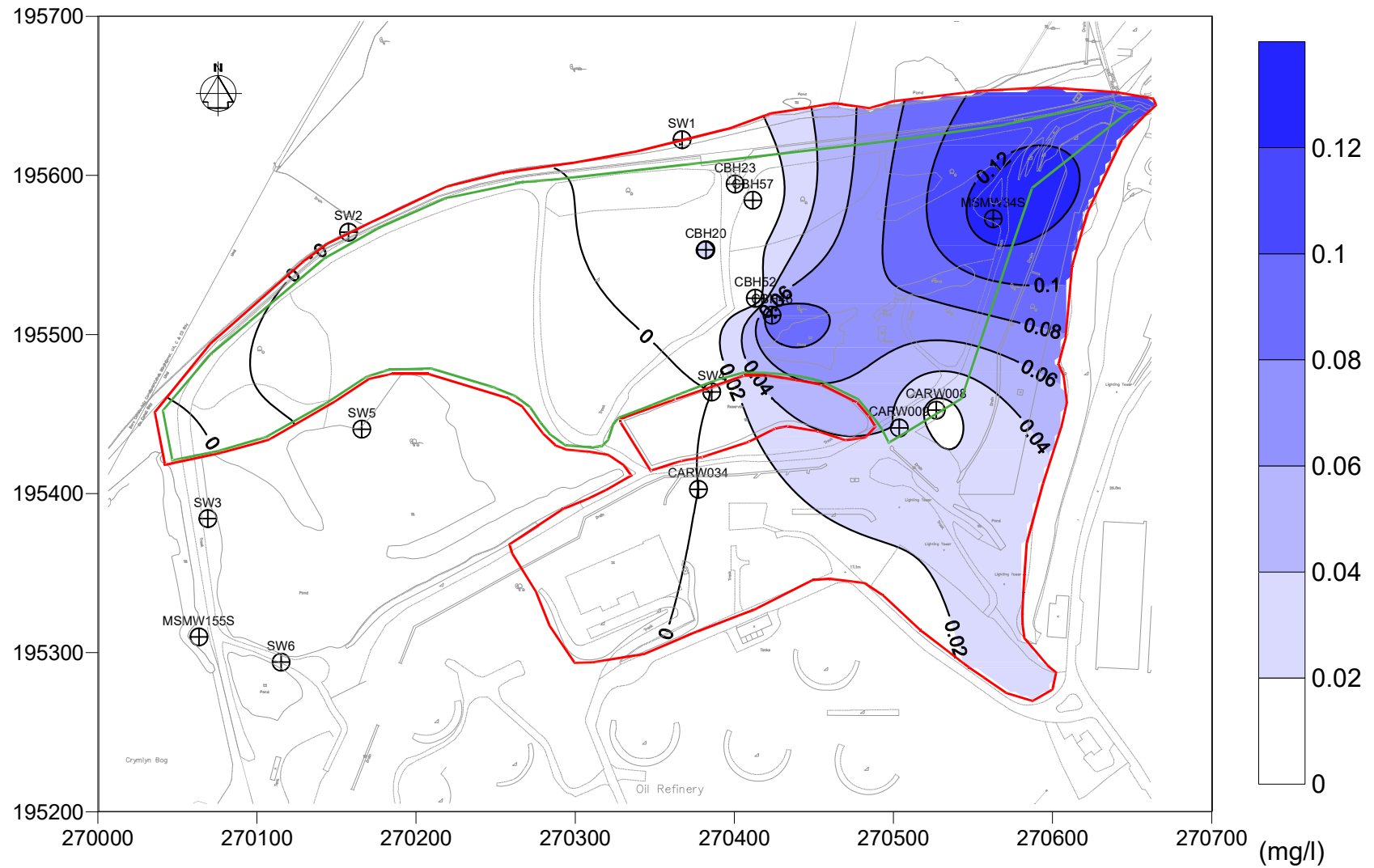


Inferred Contours of Aliphatics C6-C8 in Groundwater February 2022



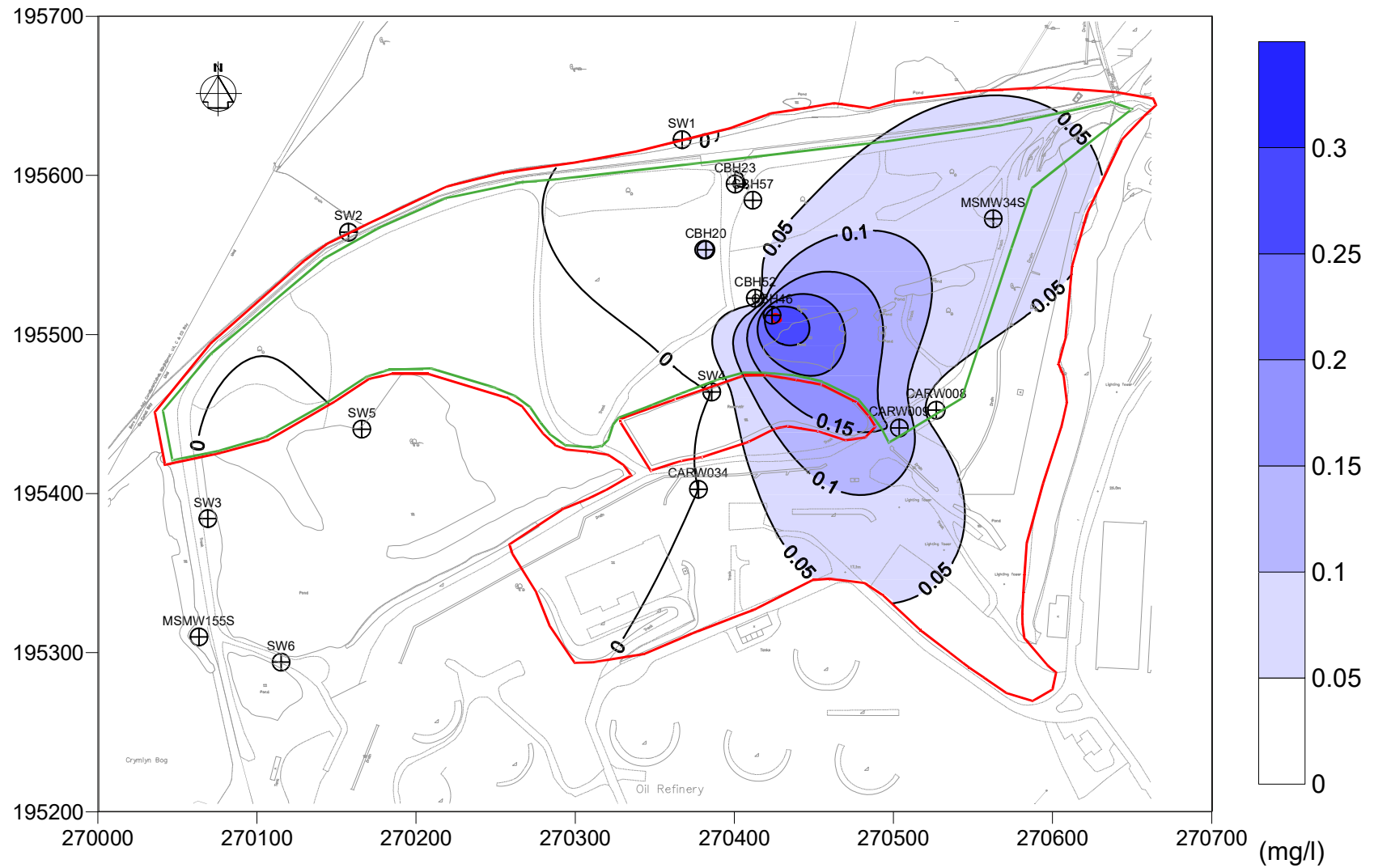
Coed Darcy Tip

Inferred Contours of Aliphatics C8-C10 in Groundwater February 2022



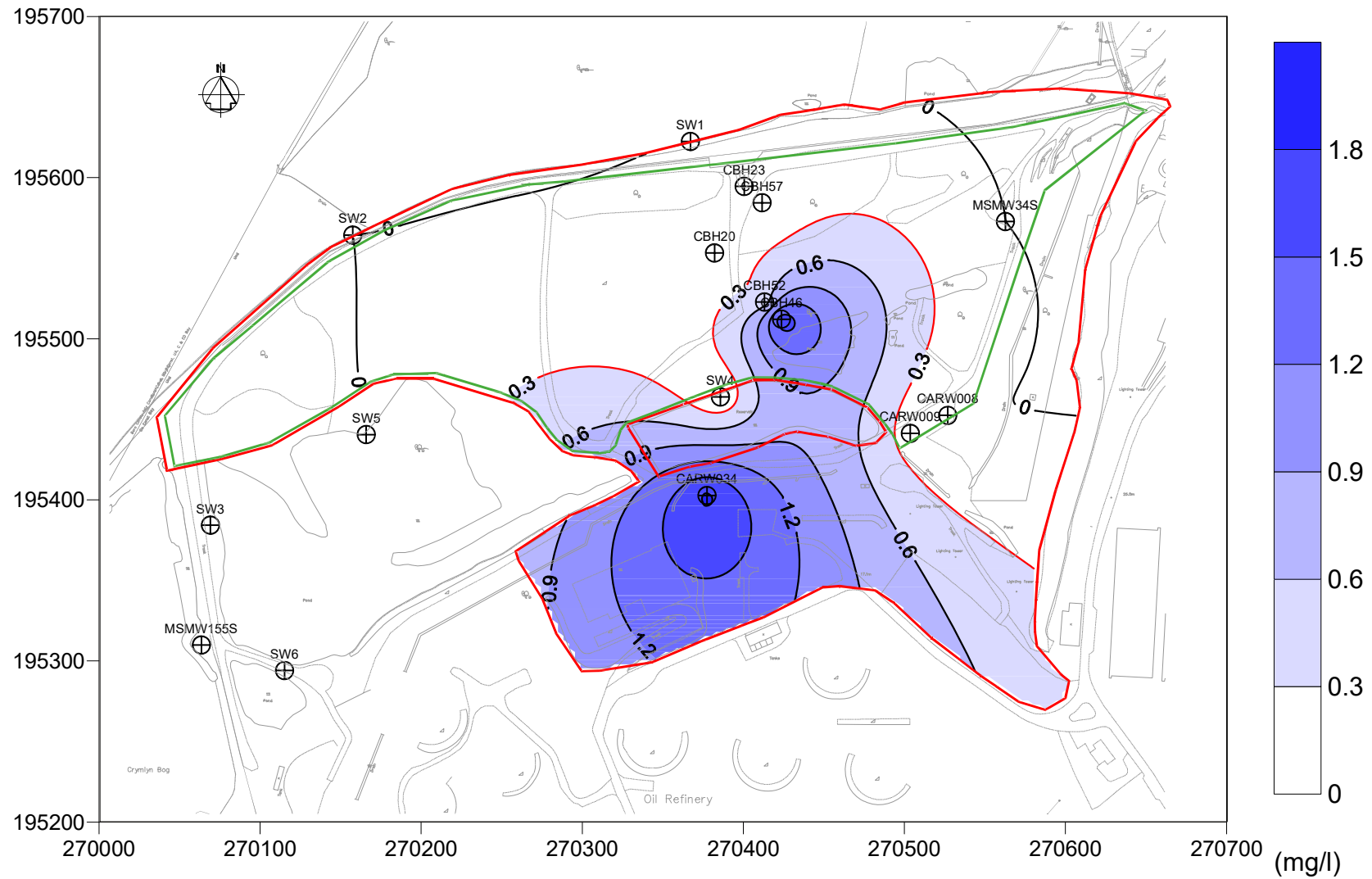
Coed Darcy Tip

Inferred Contours of Aliphatics C10-C12 in Groundwater February 2022



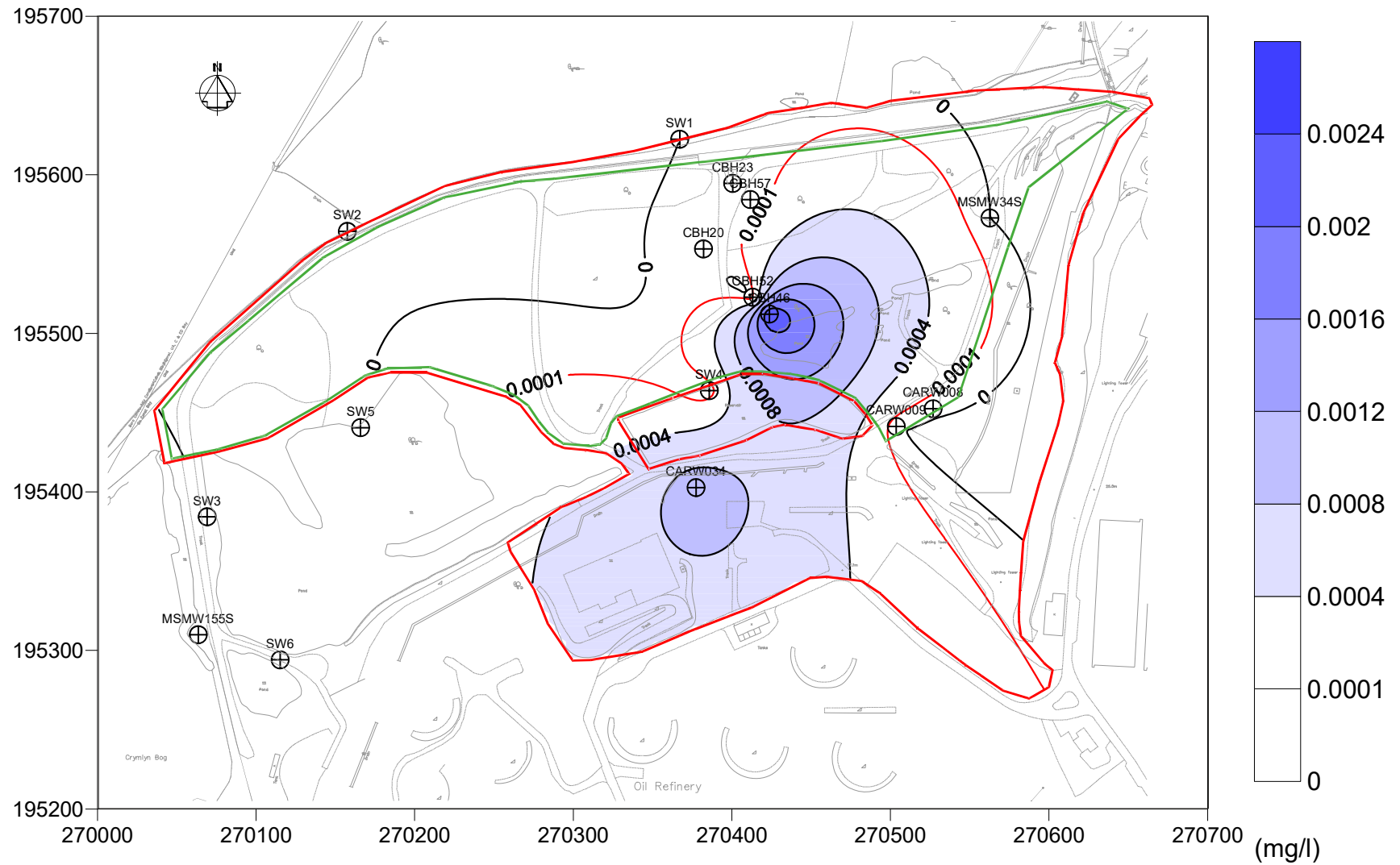
Coed Darcy Tip

Inferred Contours of Aliphatics C12-C16 (aq) in Groundwater February 2022



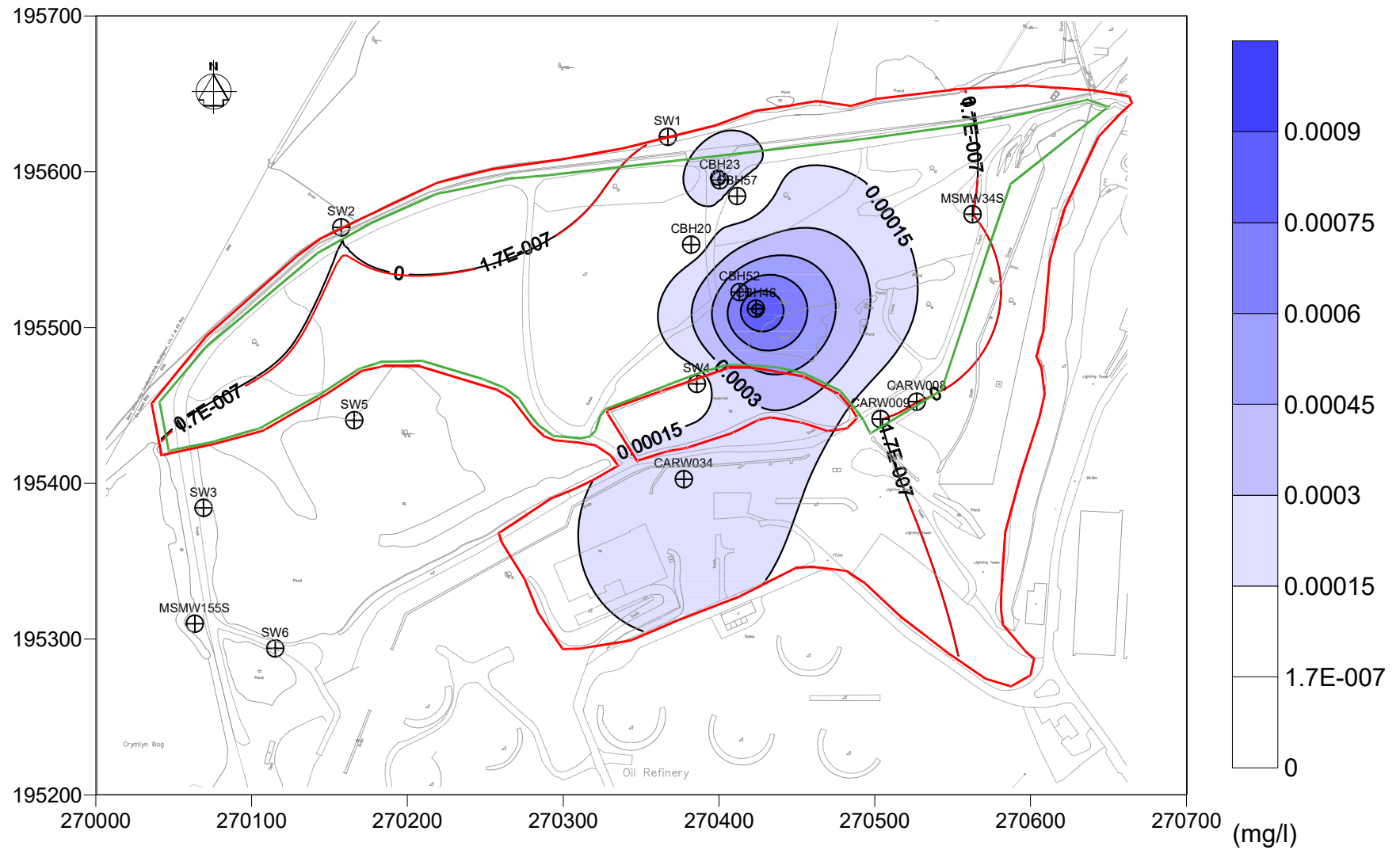
Coed Darcy Tip

Inferred Contours of Anthracene (aq) in Groundwater February 2022



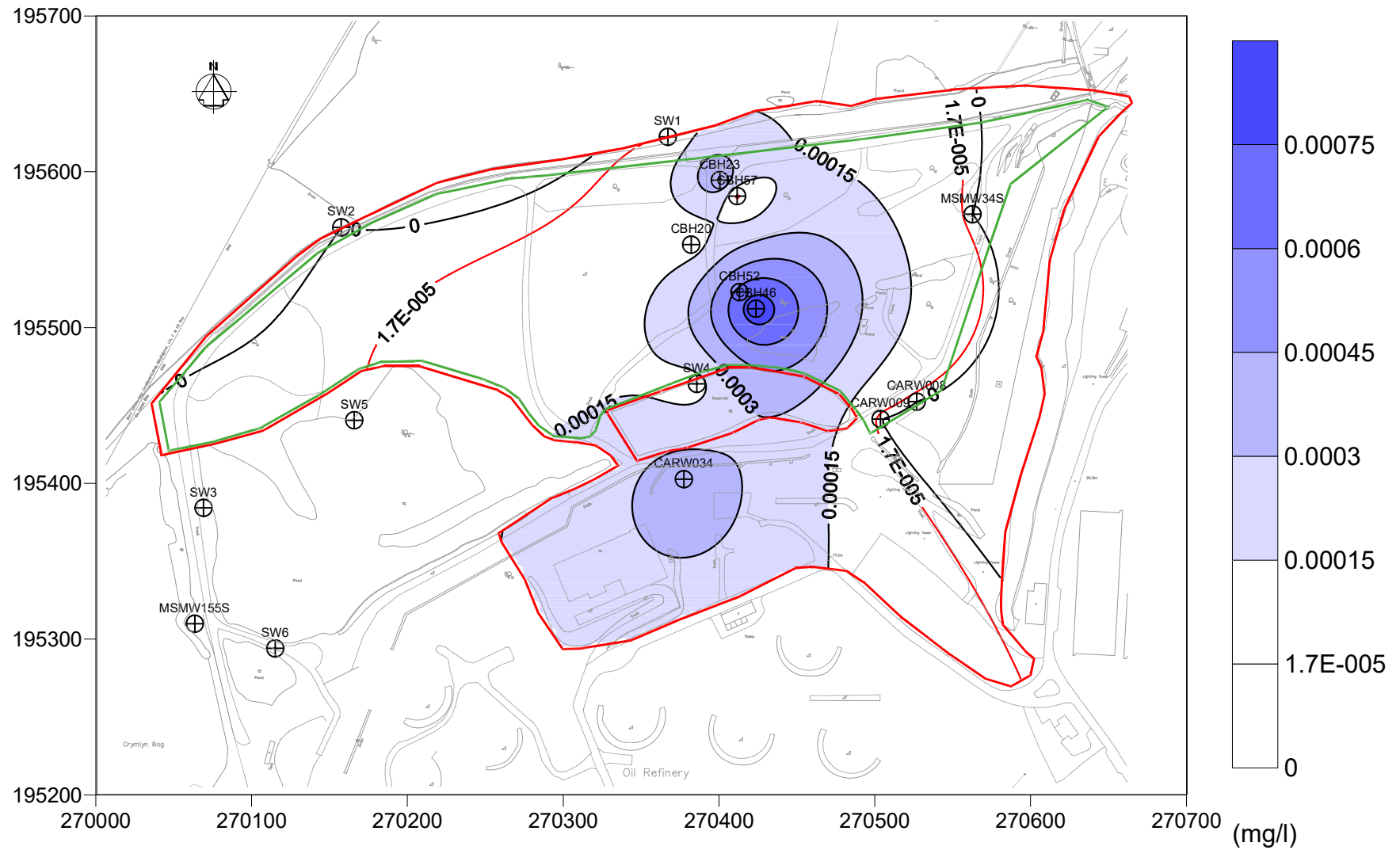
Coed Darcy Tip

Inferred Contours of Benzo(a)pyrene (aq) in Groundwater February 2022



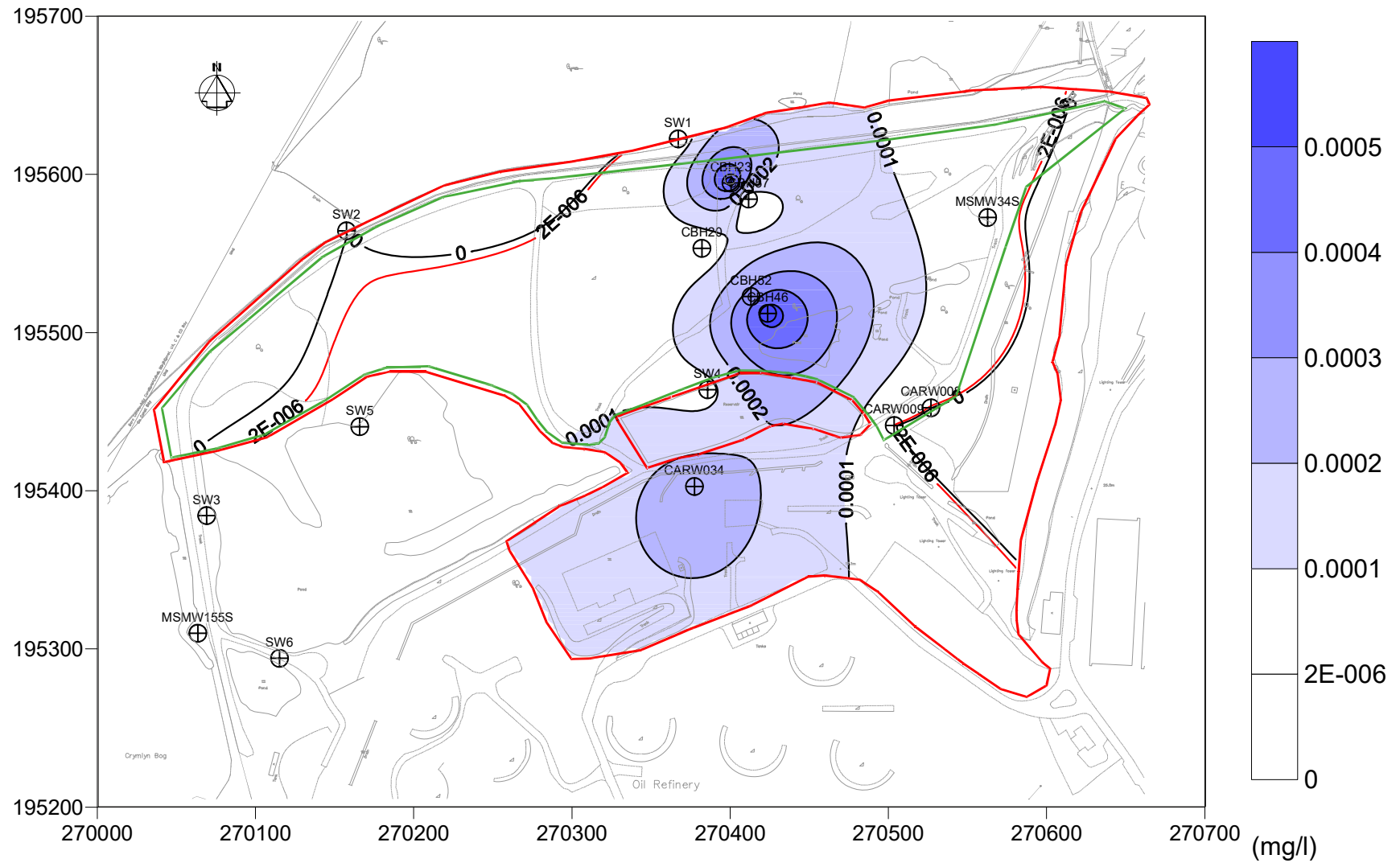
Coed Darcy Tip

Inferred Contours of Benzo(b)fluoranthene (aq) in Groundwater February 2022



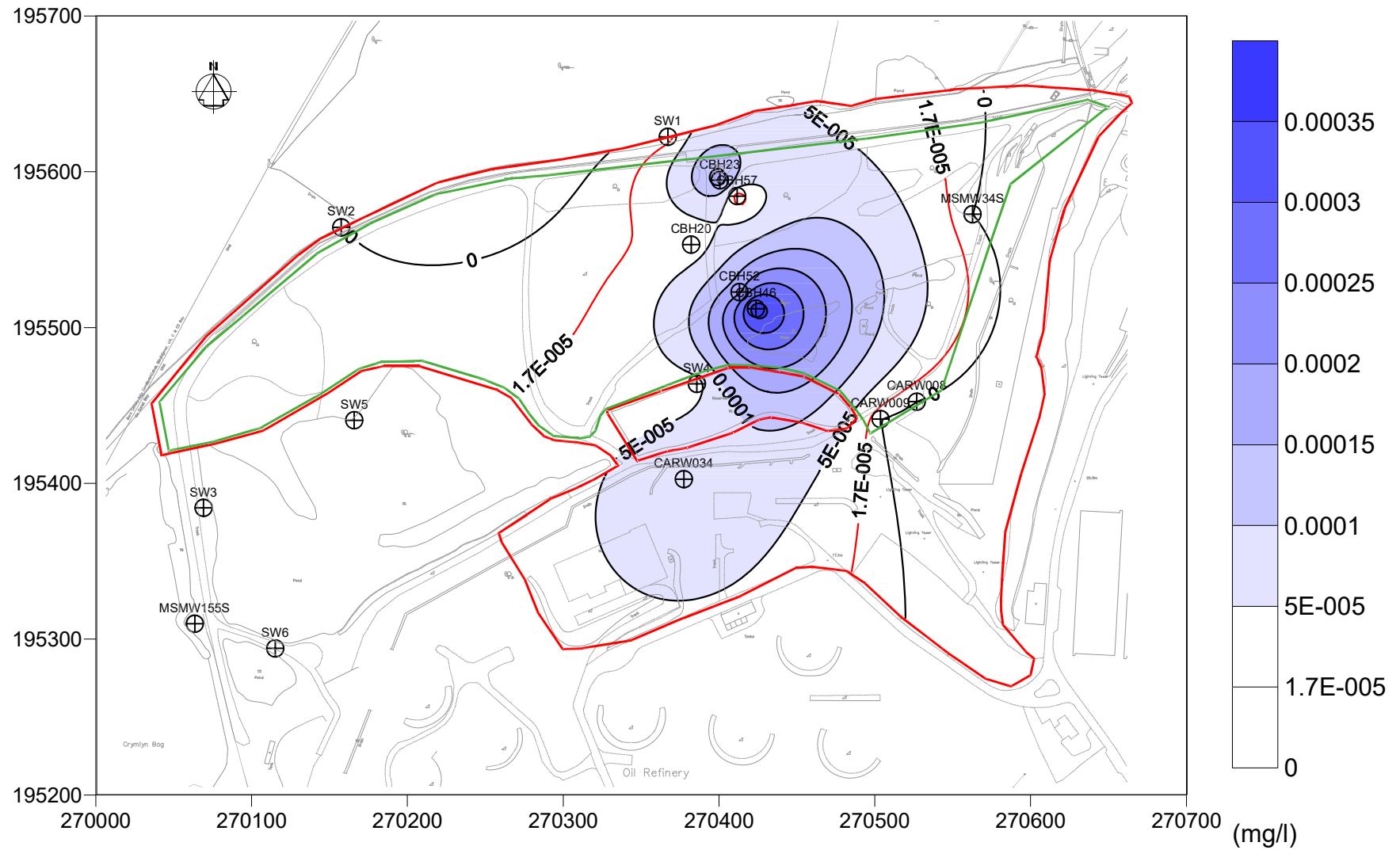
Coed Darcy Tip

Inferred Contours of Benzo(g,h,i)perylene (aq) in Groundwater February 2022



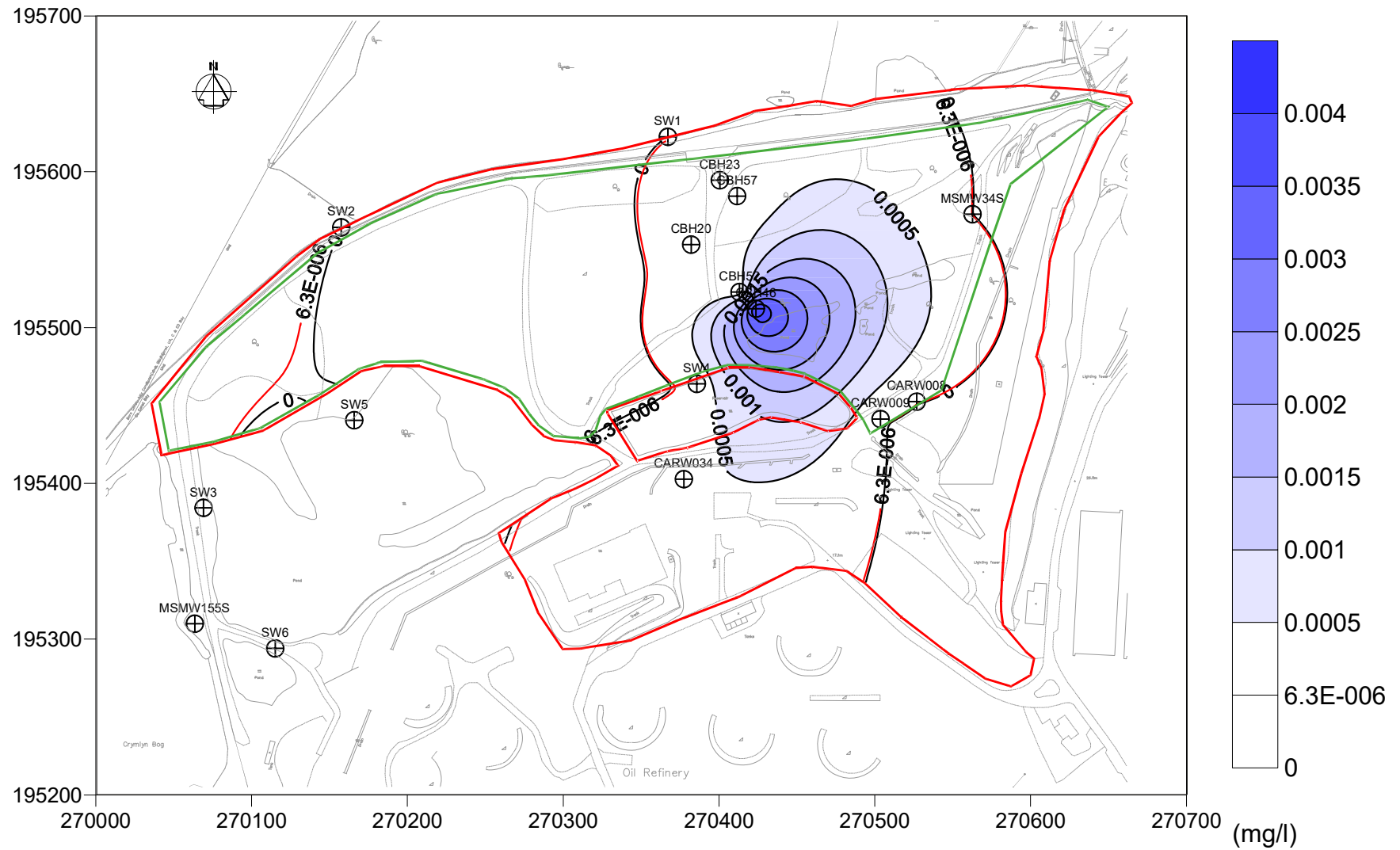
Coed Darcy Tip

Inferred Contours of Benzo(k)fluoranthene (aq) in Groundwater February 2022



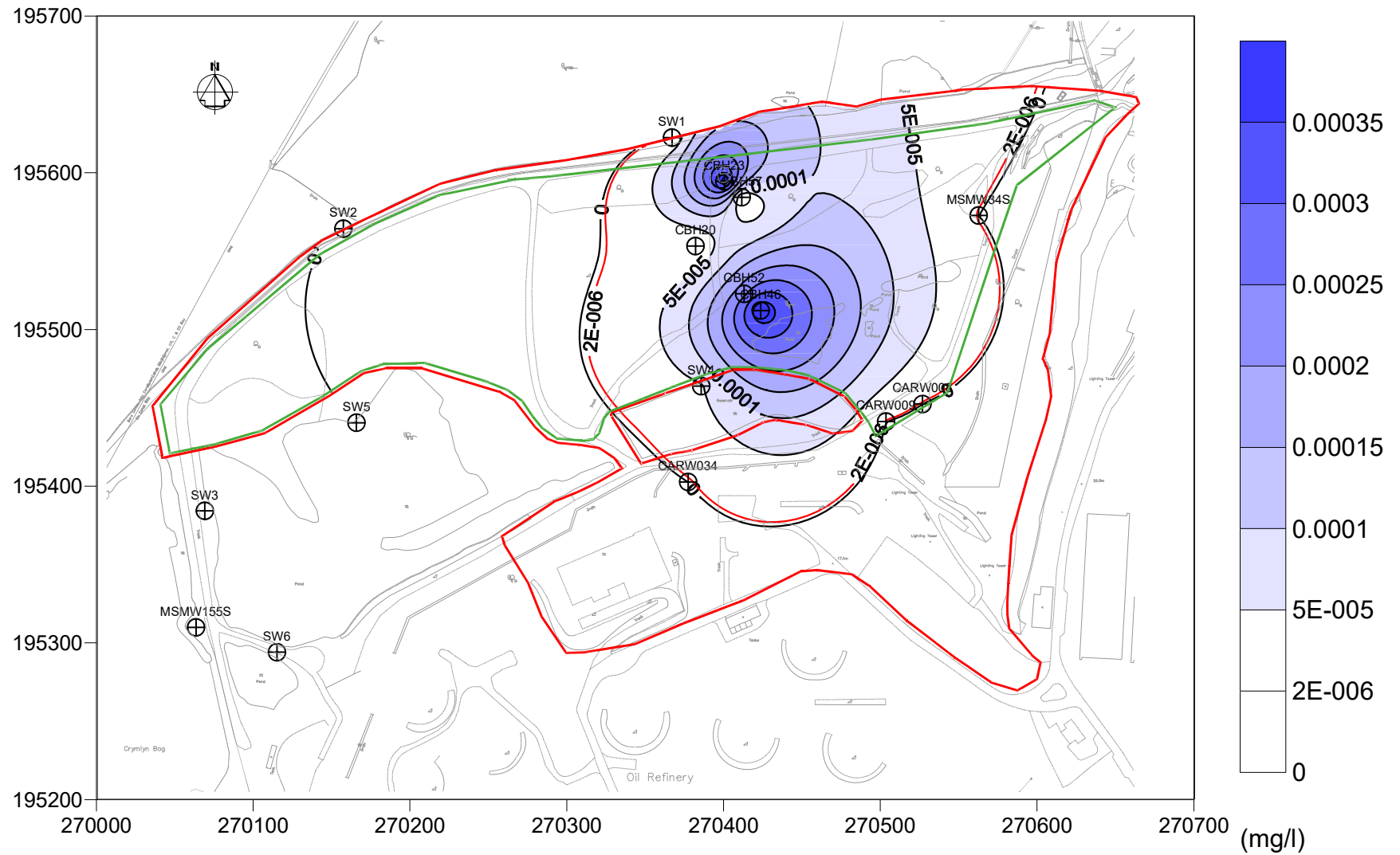
Coed Darcy Tip

Inferred Contours of Fluoranthene (aq) in Groundwater February 2022



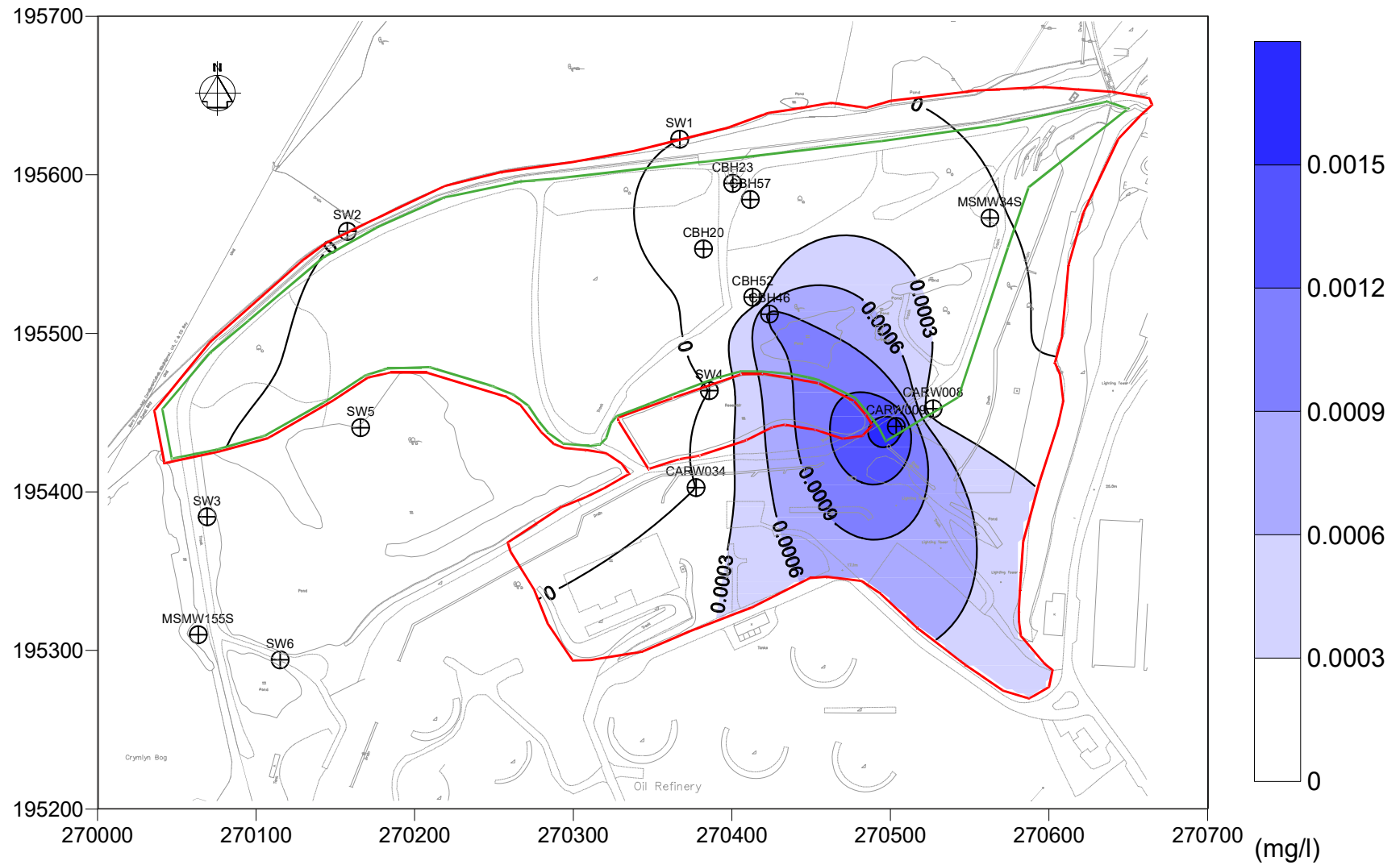
Coed Darcy Tip

Inferred Contours of Indeno(1,2,3-cd)pyrene (aq) in Groundwater February 2022



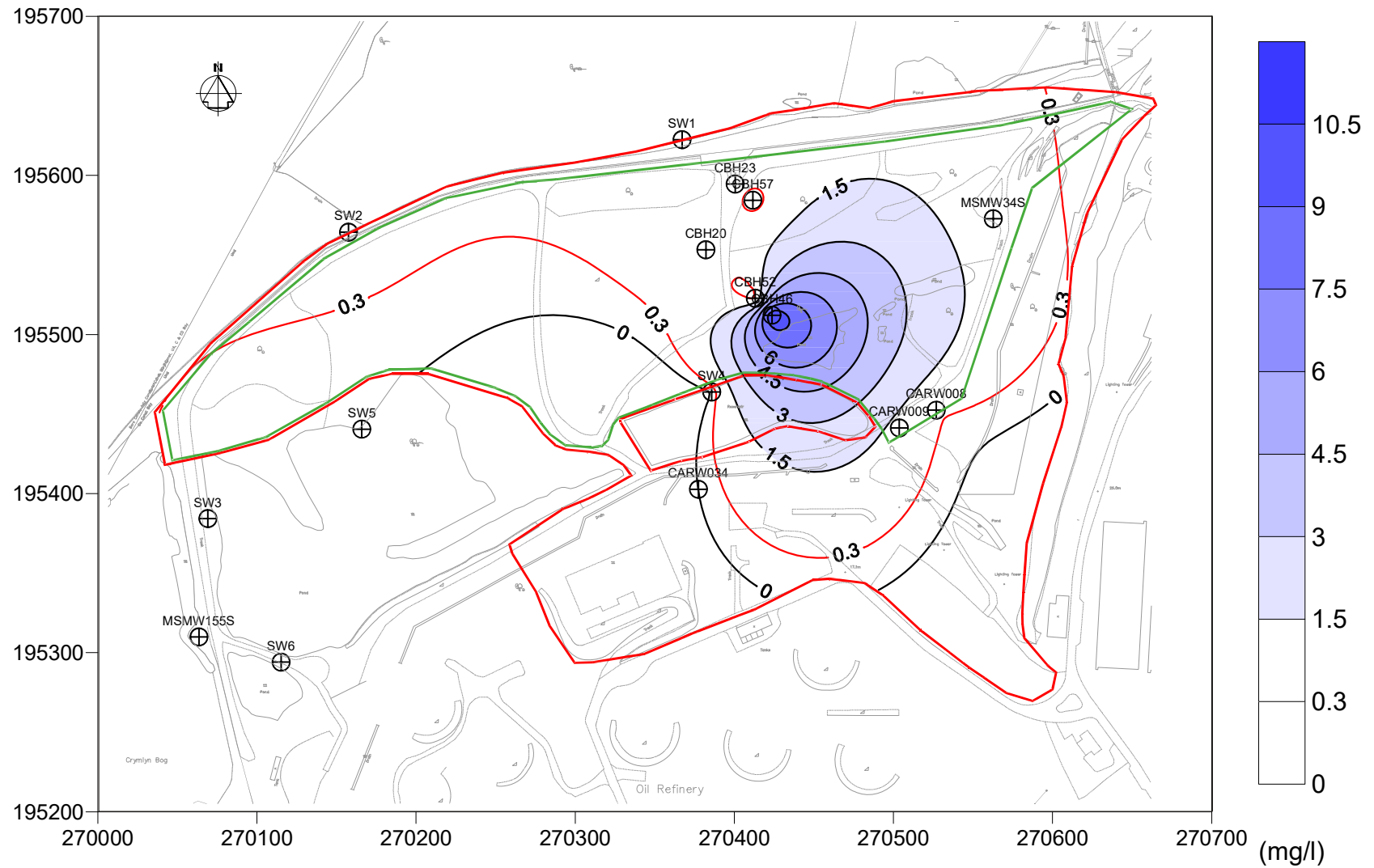
Coed Darcy Tip

Inferred Contours of Naphthalene (aq) in Groundwater February 2022



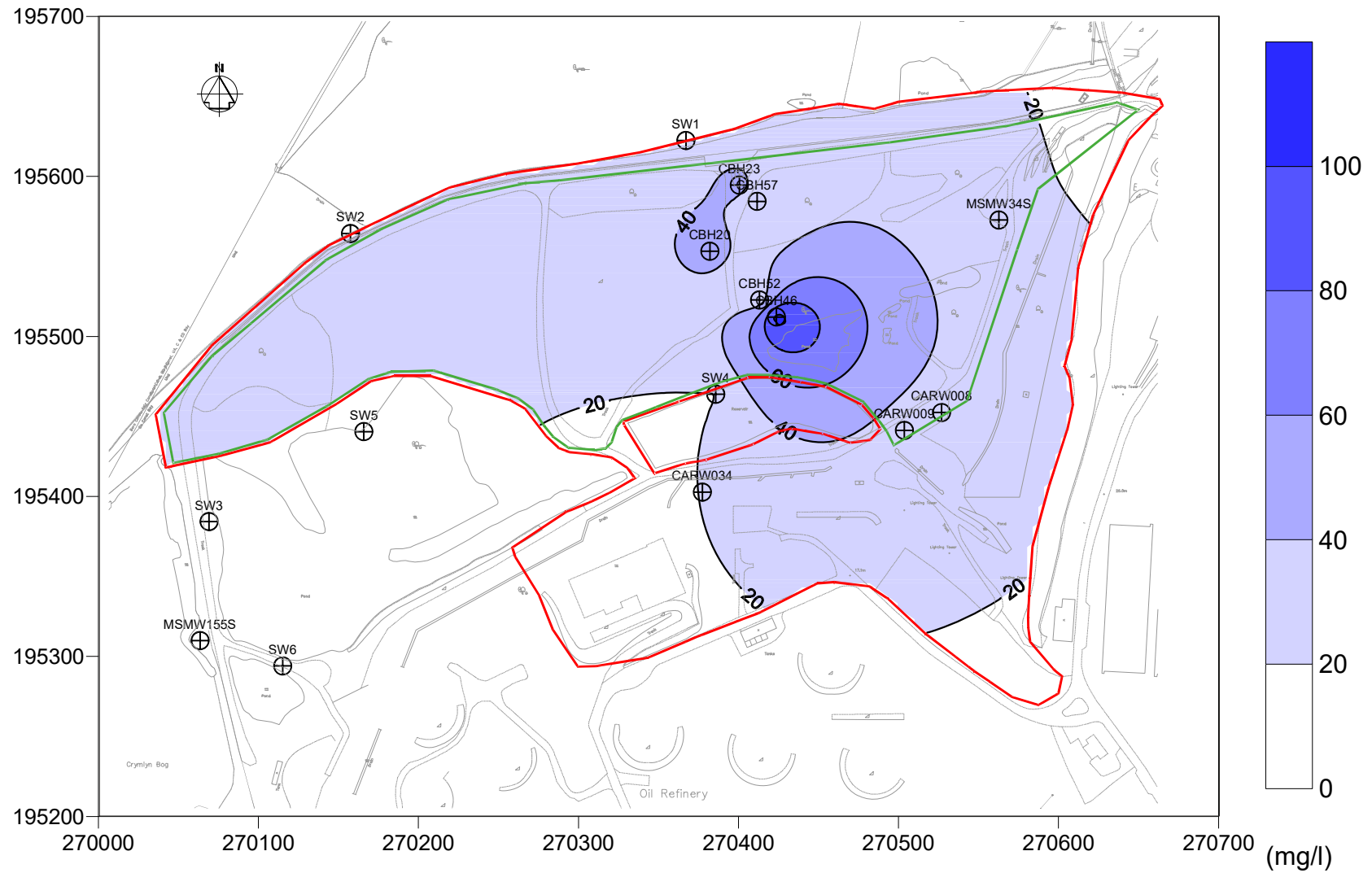
Coed Darcy Tip

Inferred Contours of Ammoniacal Nitrogen as N in Groundwater February 2022



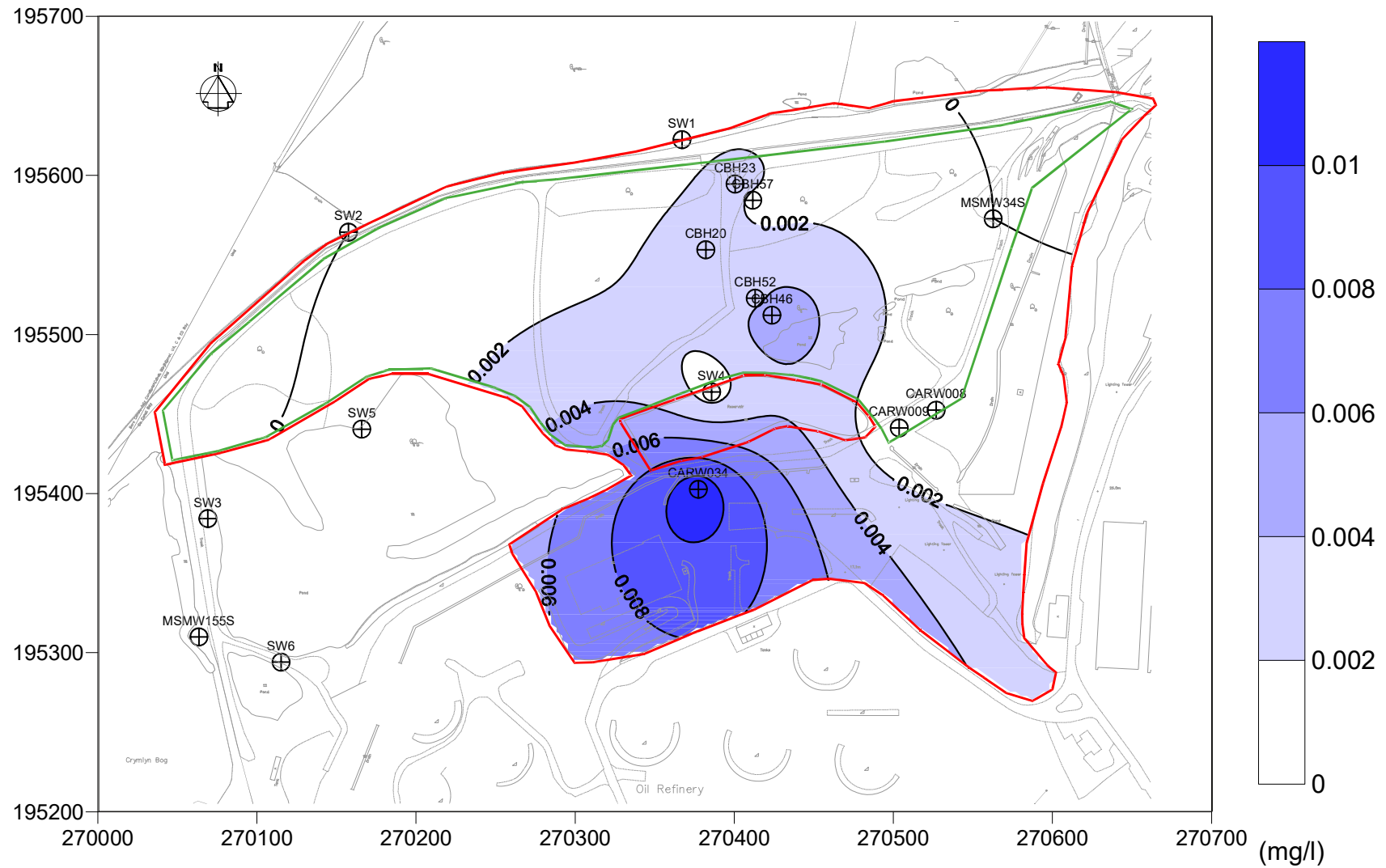
Coed Darcy Tip

Inferred Contours of Chloride in Groundwater February 2022



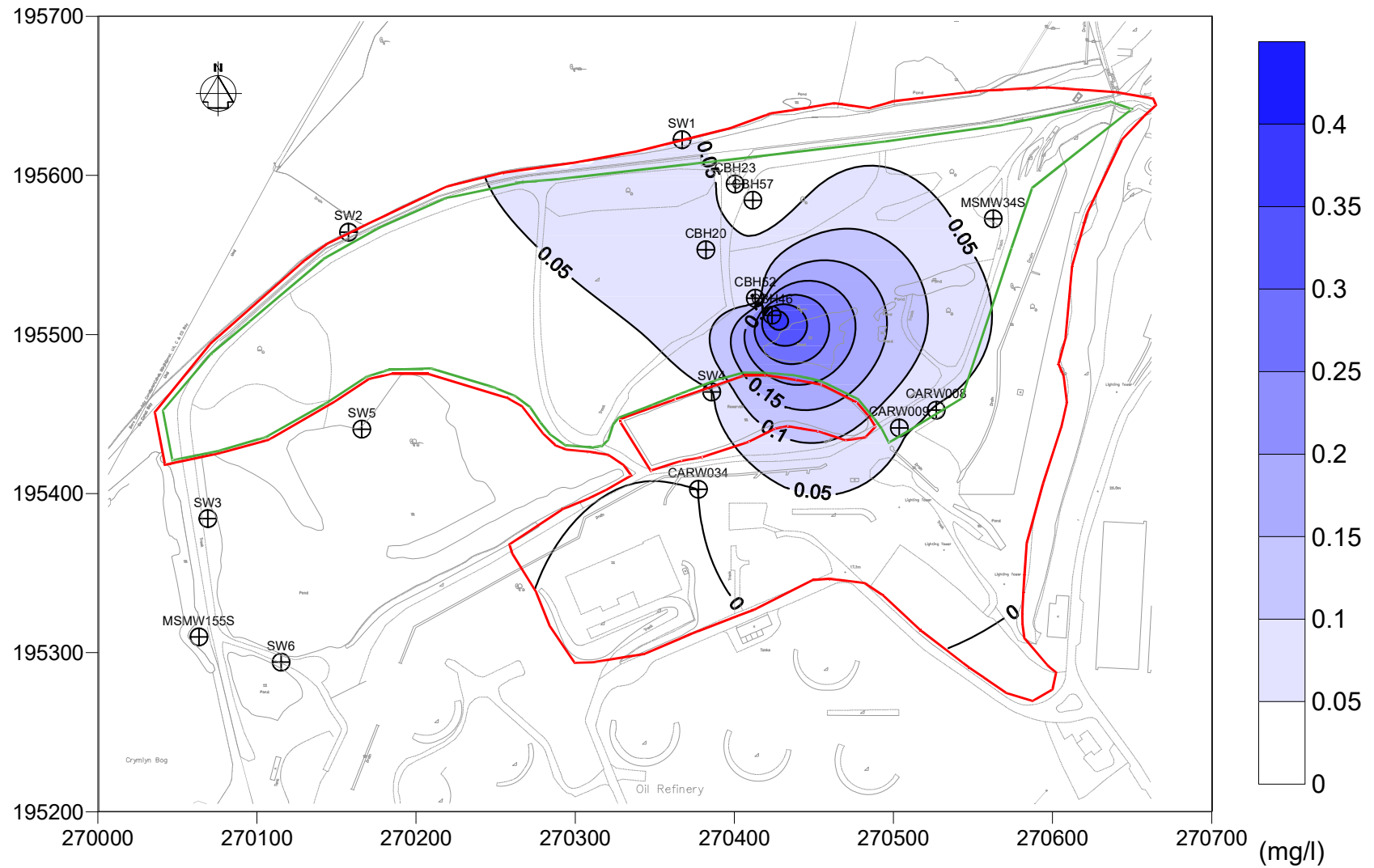
Coed Darcy Tip

Inferred Contours of Arsenic (diss.filt) in Groundwater February 2022

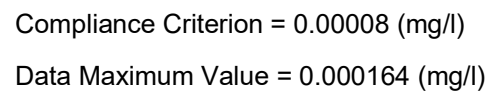


Coed Darcy Tip

Inferred Contours of Boron (diss.filt) in Groundwater February 2022

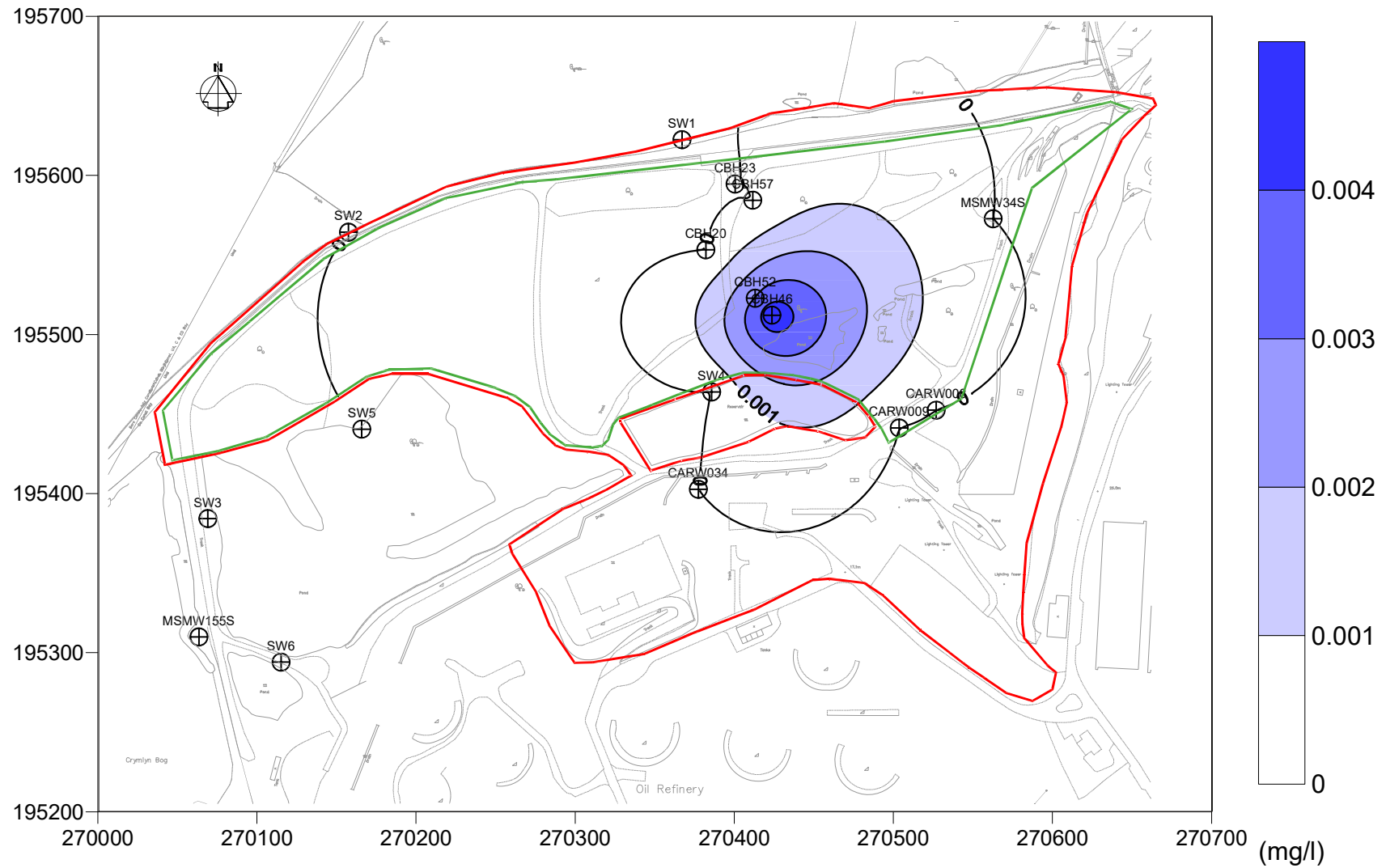


Inferred Contours of Cadmium (diss.filt) in Groundwater February 2022



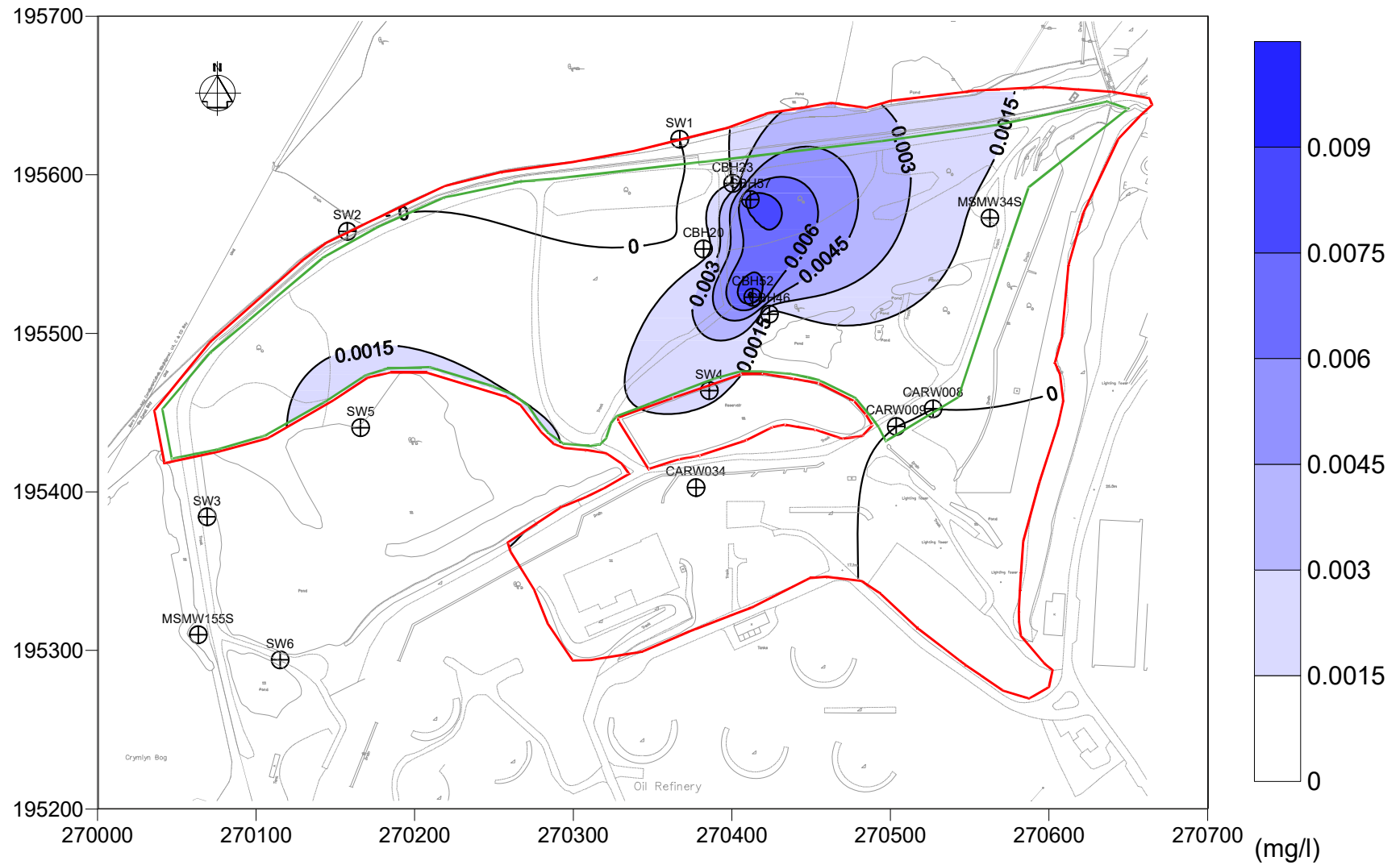
Coed Darcy Tip

Inferred Contours of Chromium (diss.filt) in Groundwater February 2022



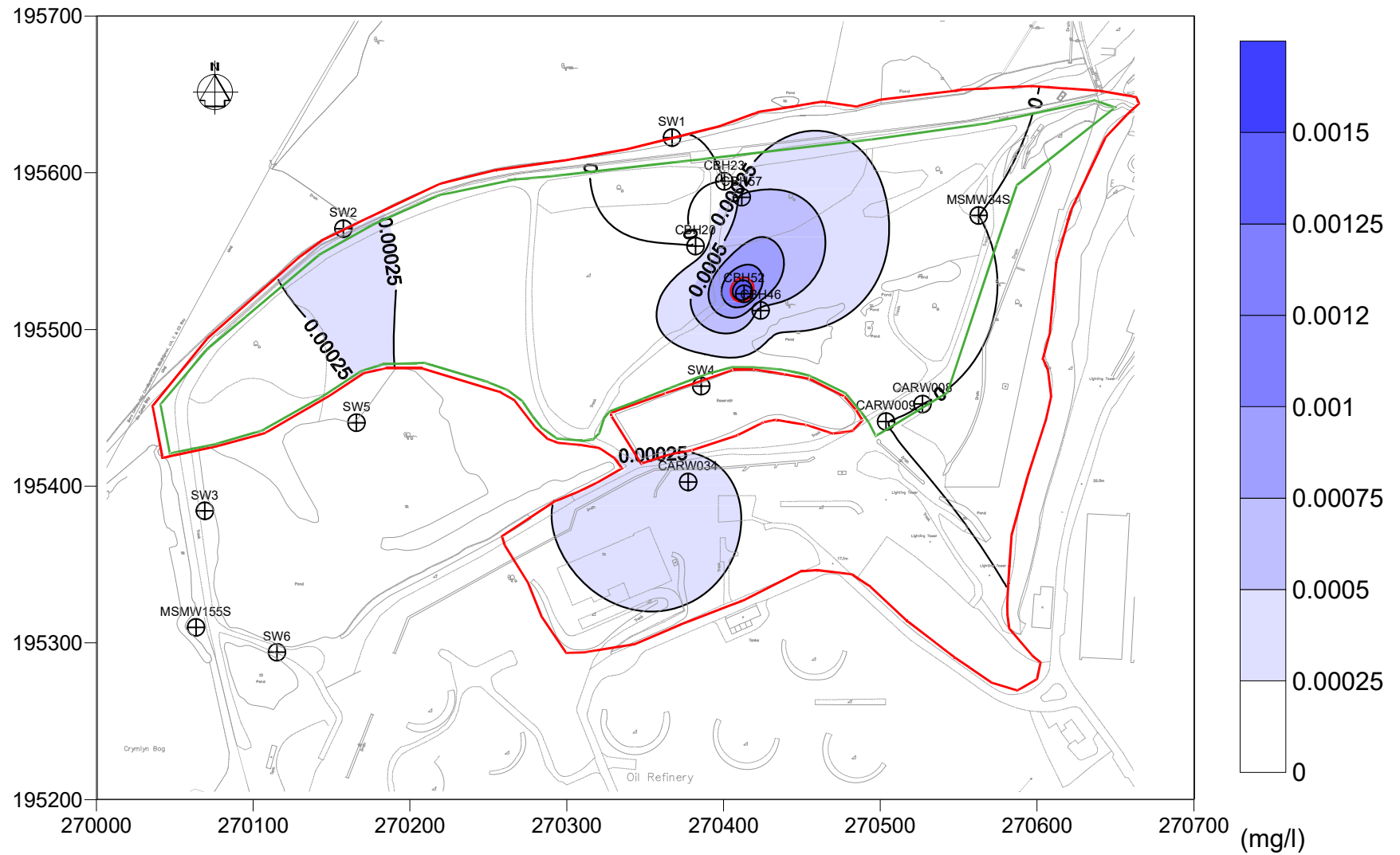
Coed Darcy Tip

Inferred Contours of Copper (diss.filt) in Groundwater February 2022



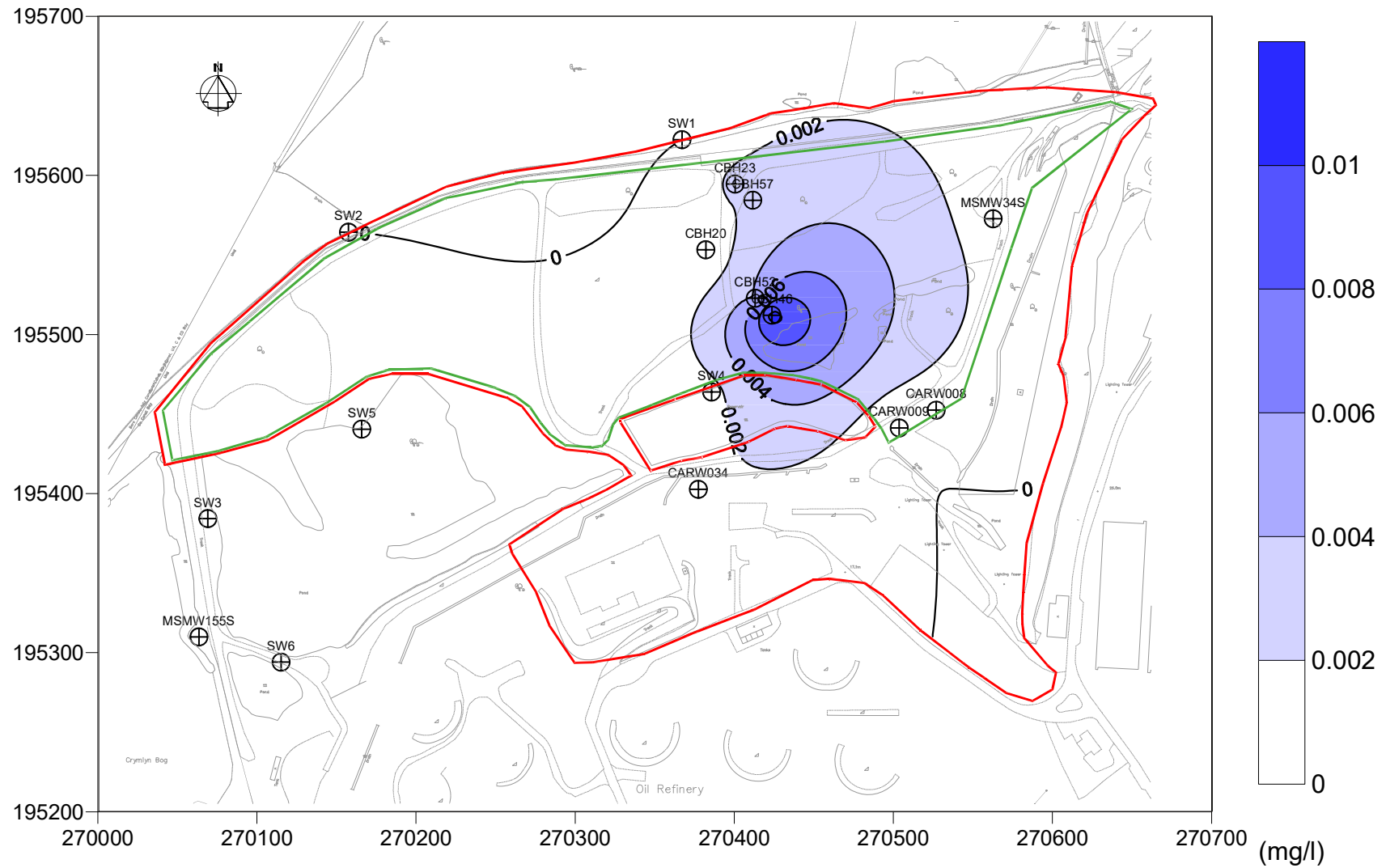
Coed Darcy Tip

Inferred Contours of Lead (diss.filt) in Groundwater February 2022



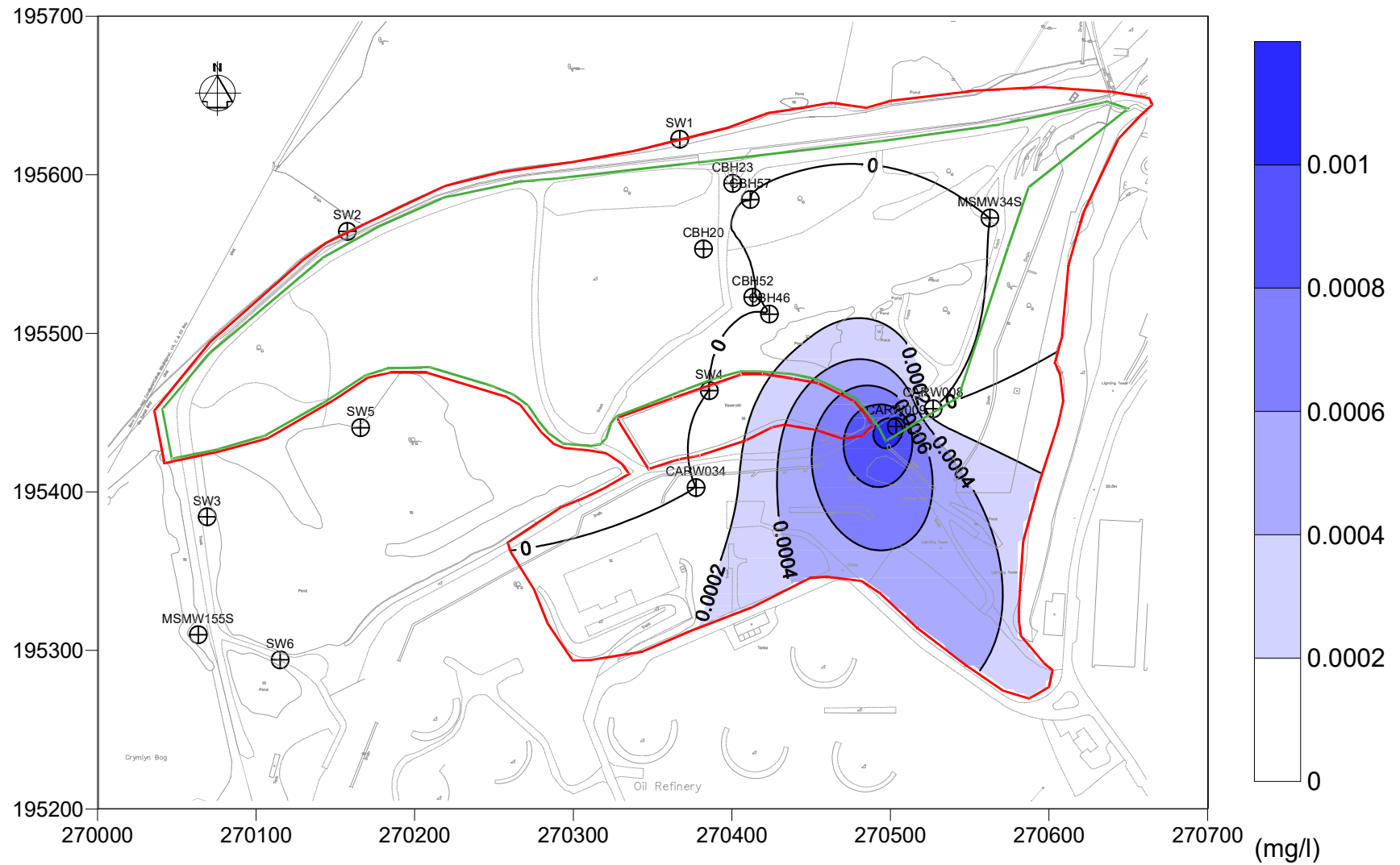
Coed Darcy Tip

Inferred Contours of Nickel (diss.filt) in Groundwater February 2022



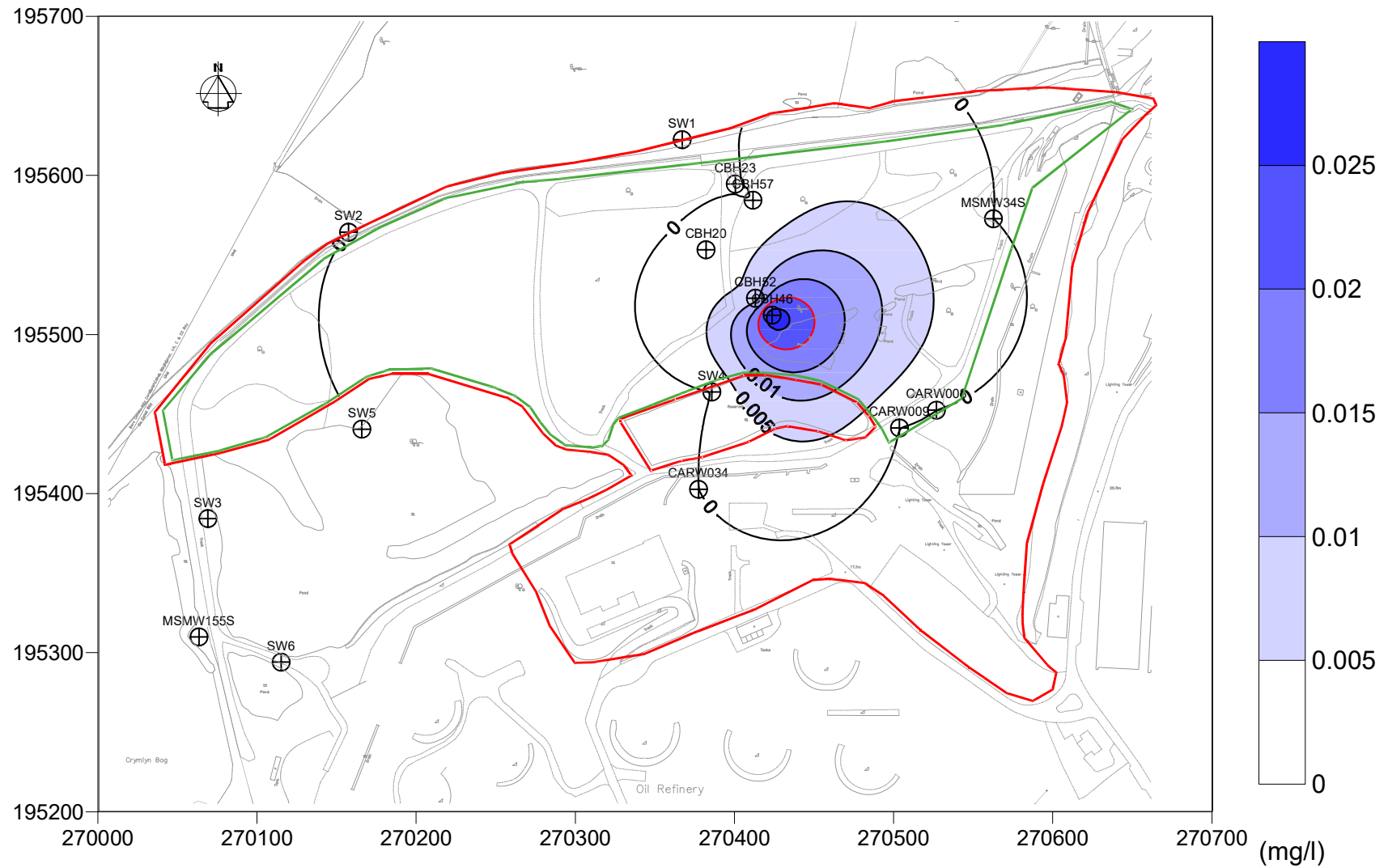
Coed Darcy Tip

Inferred Contours of Selenium (diss.filt) in Groundwater February 2022



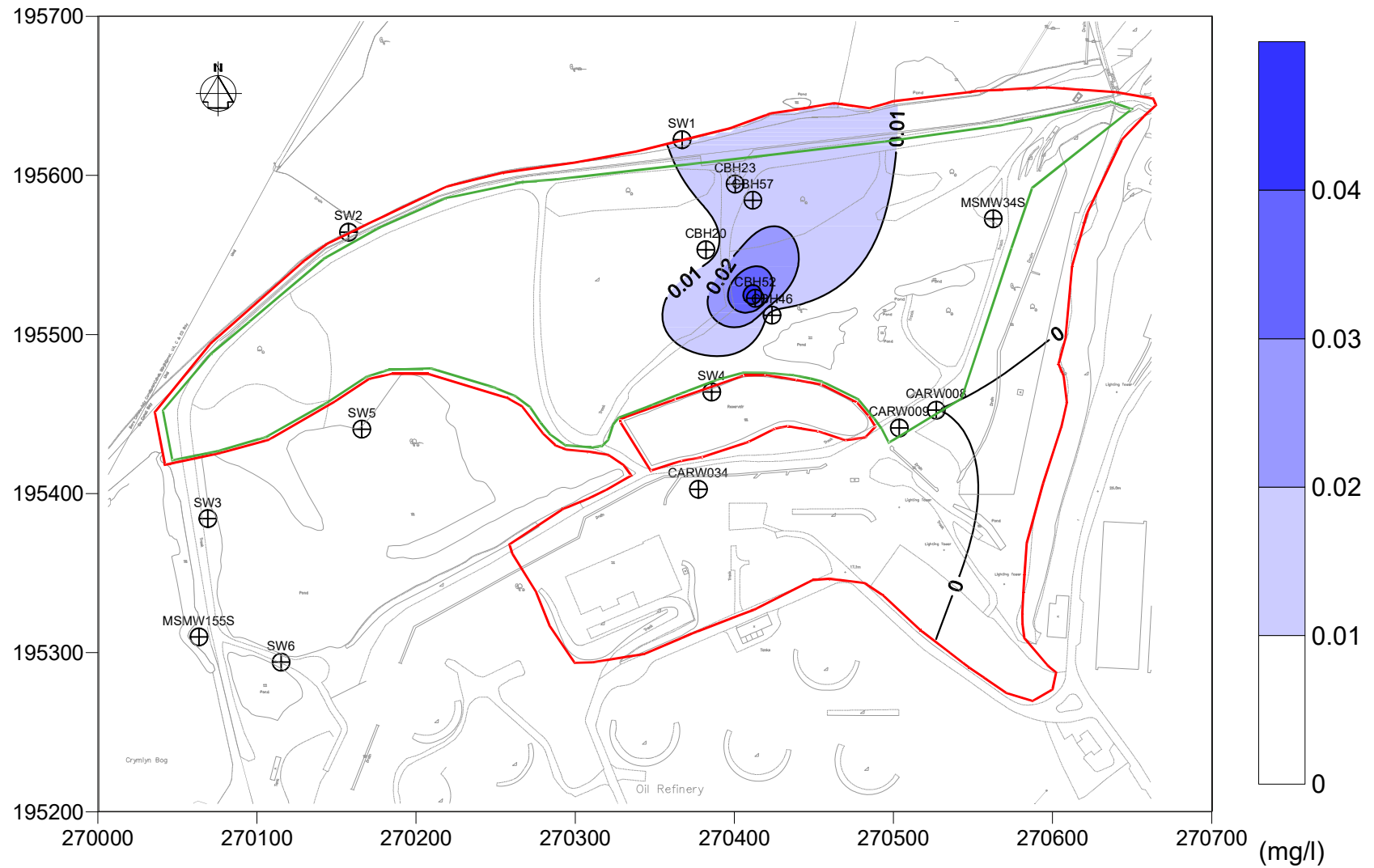
Coed Darcy Tip

Inferred Contours of Vanadium (diss.filt) in Groundwater February 2022



Coed Darcy Tip

Inferred Contours of Zinc (diss.filt) in Groundwater February 2022



Addendum C5 - Mar 2022

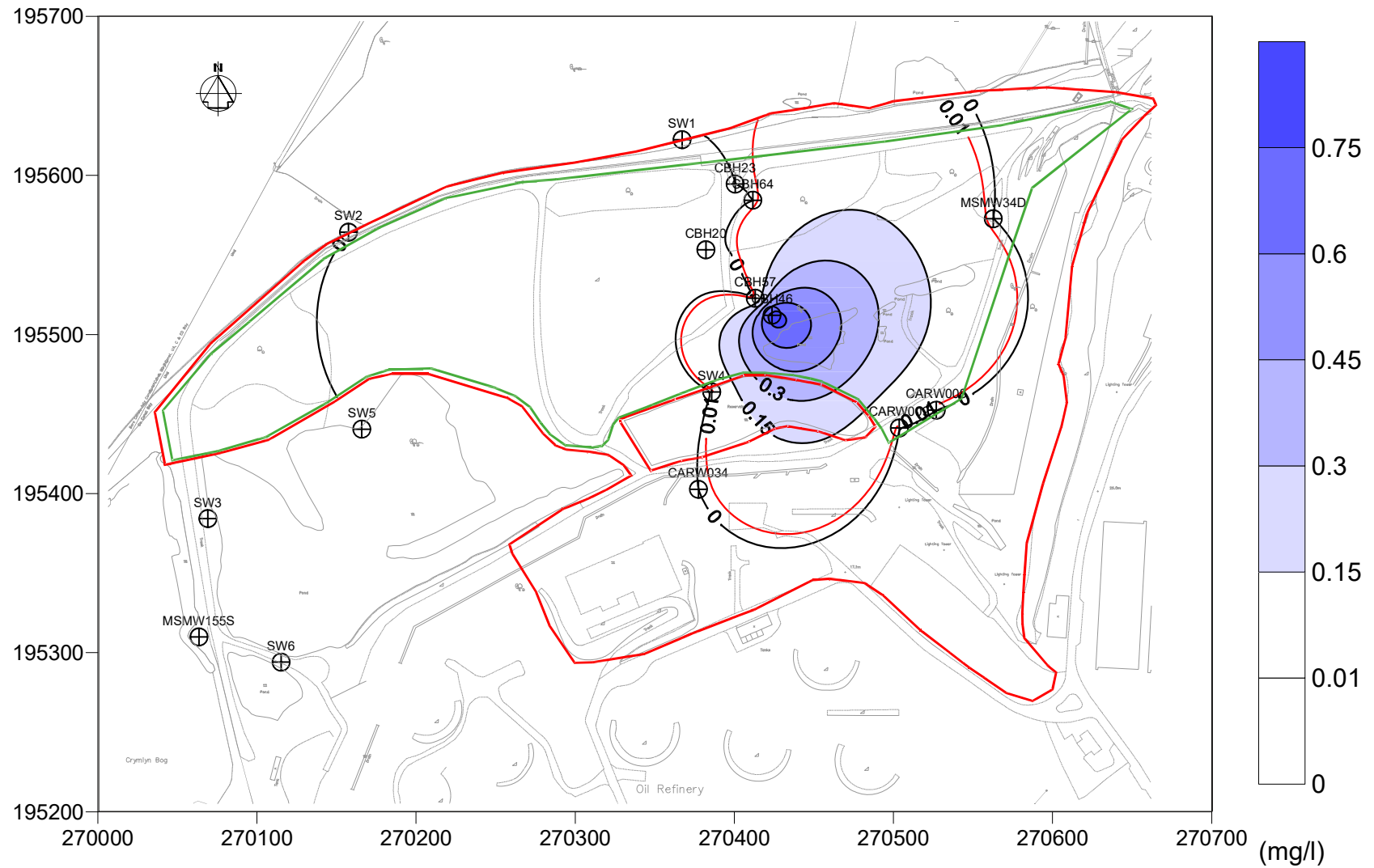
Chem Plots



eNGLOBE

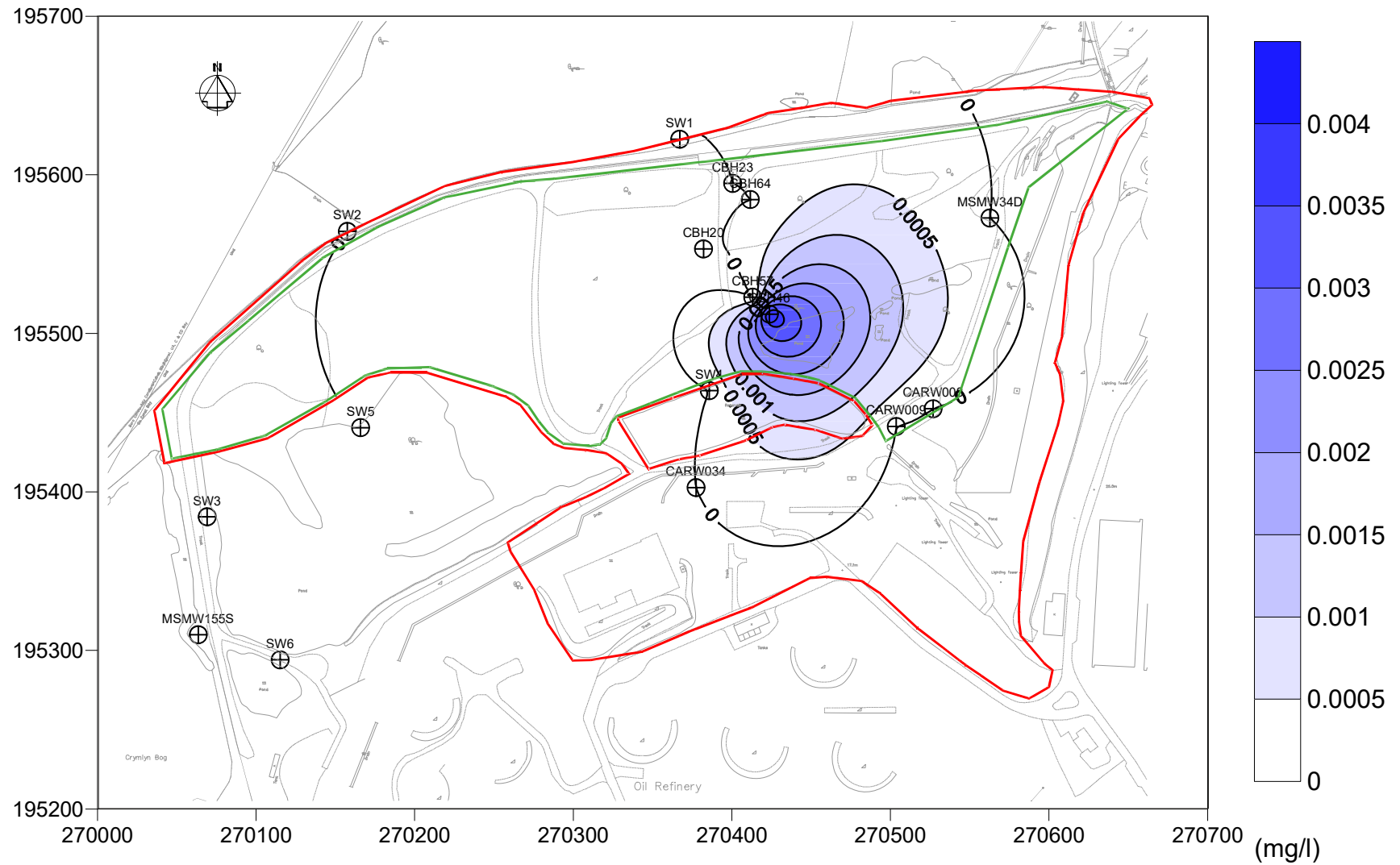
Coed Darcy Tip

Inferred Contours of Benzene in Groundwater March 2022



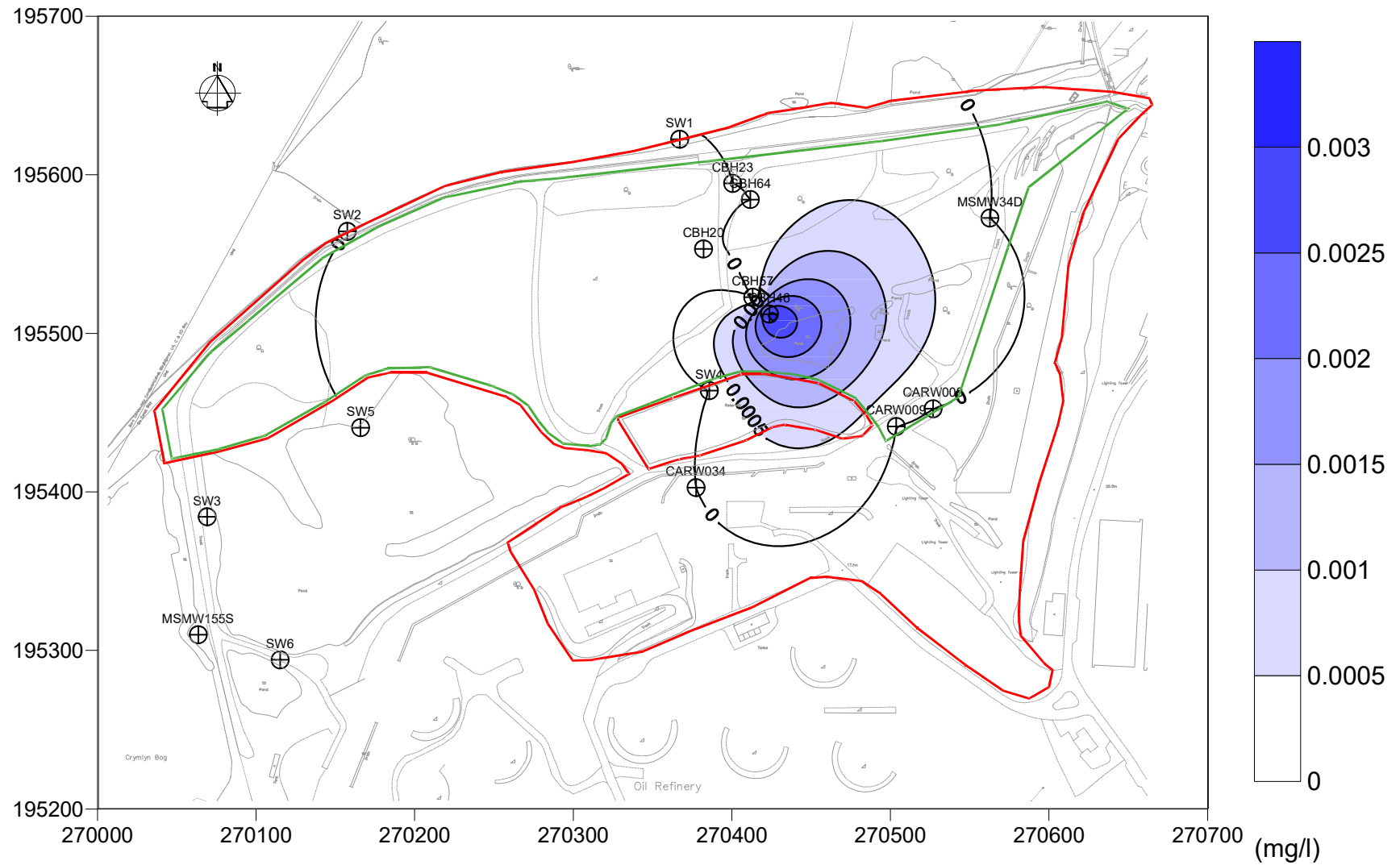
Coed Darcy Tip

Inferred Contours of Ethylbenzene in Groundwater March 2022



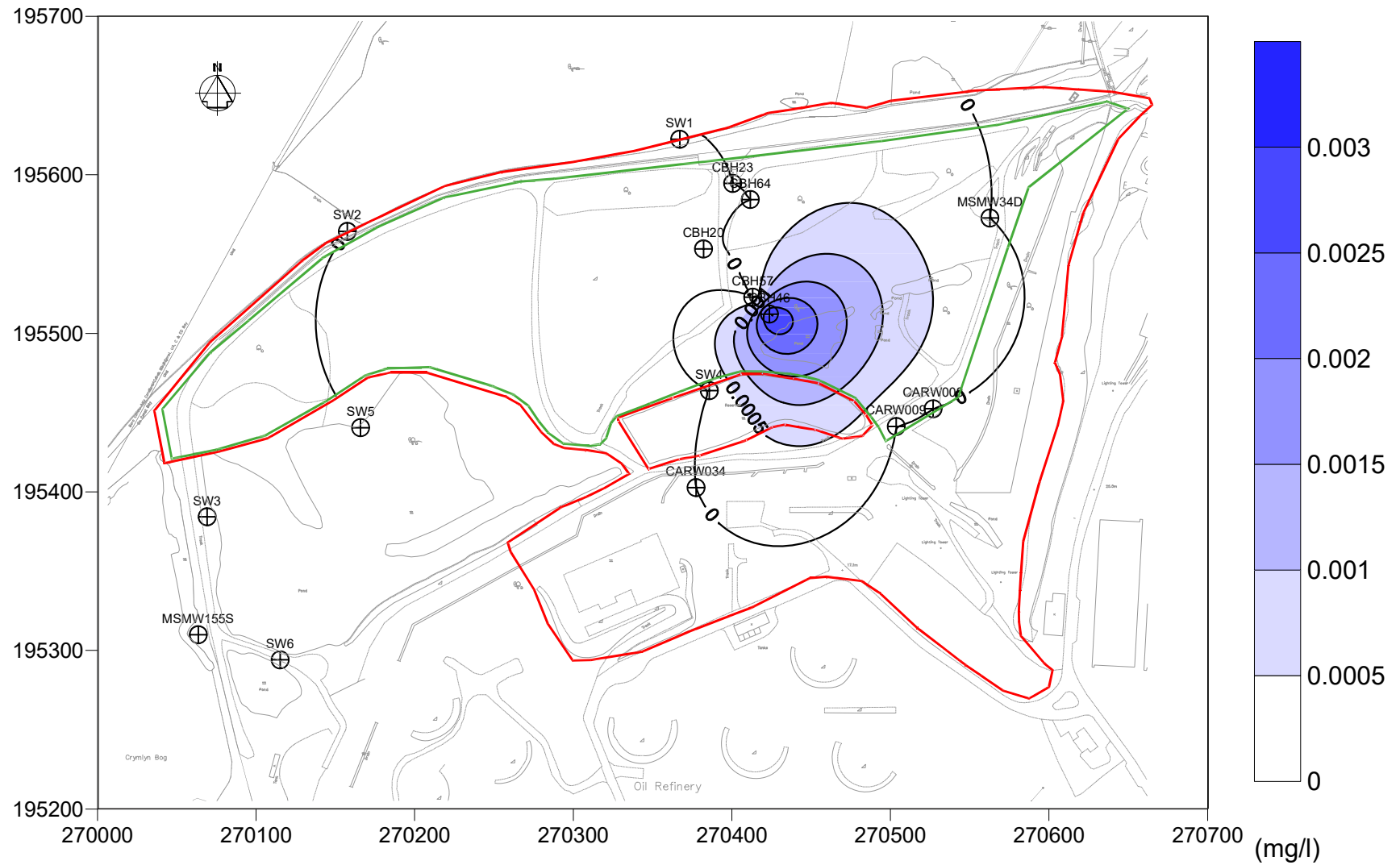
Coed Darcy Tip

Inferred Contours of m,p-Xylene in Groundwater March 2022



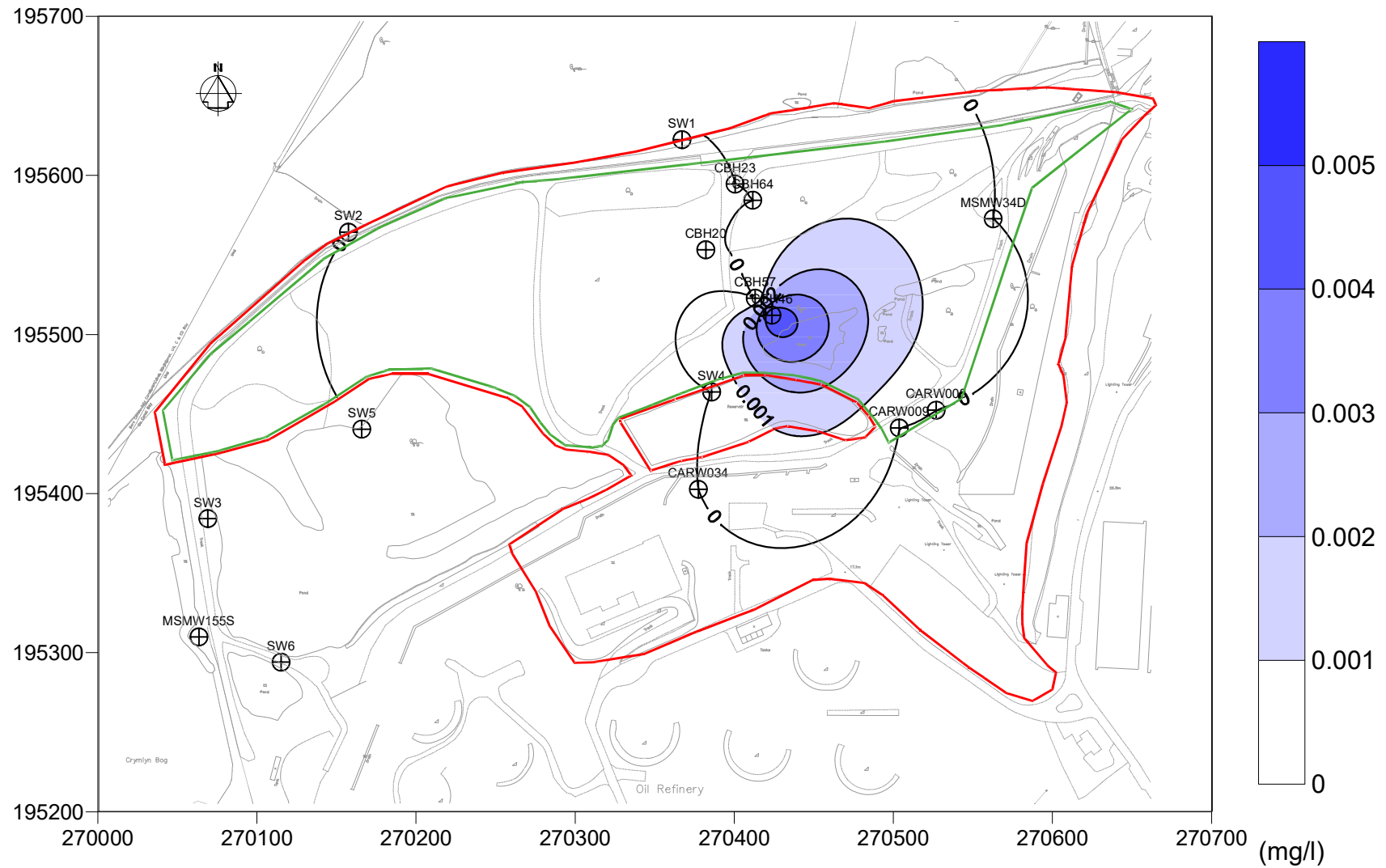
Coed Darcy Tip

Inferred Contours of o-Xylene in Groundwater March 2022



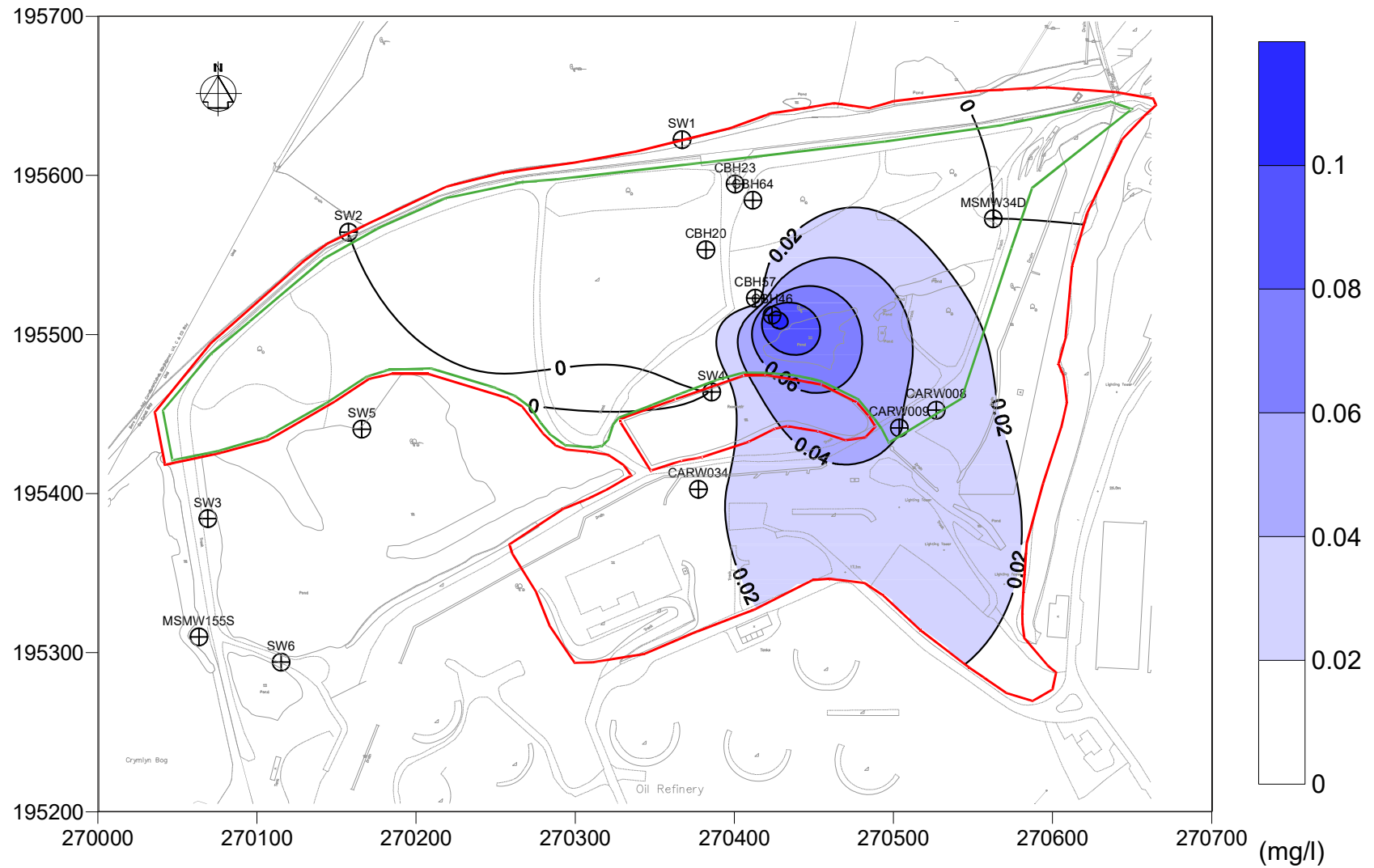
Coed Darcy Tip

Inferred Contours of Toluene in Groundwater March 2022



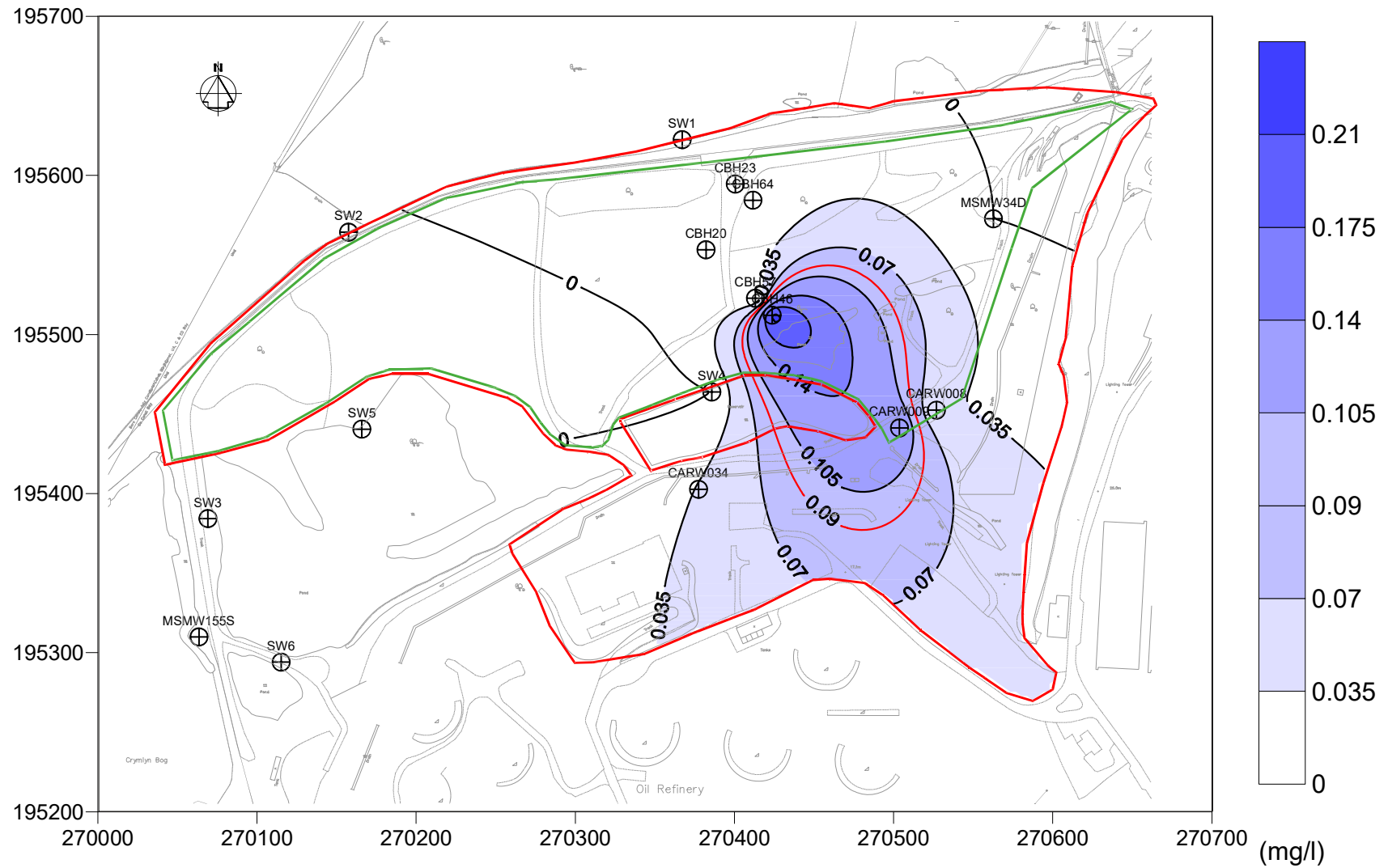
Coed Darcy Tip

Inferred Contours of Aromatics EC8-EC10 in Groundwater March 2022



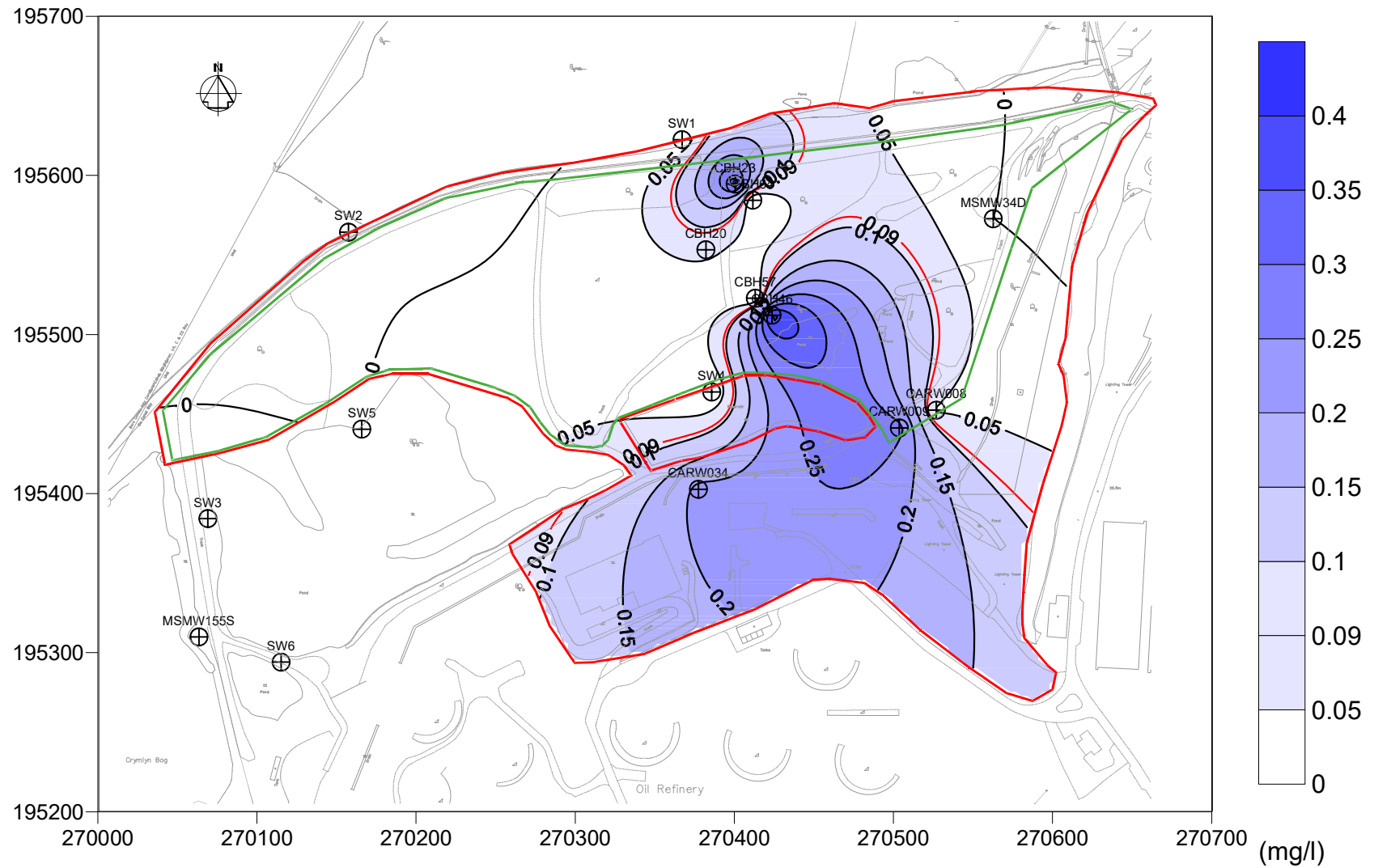
Coed Darcy Tip

Inferred Contours of Aromatics EC10-EC12 in Groundwater March 2022



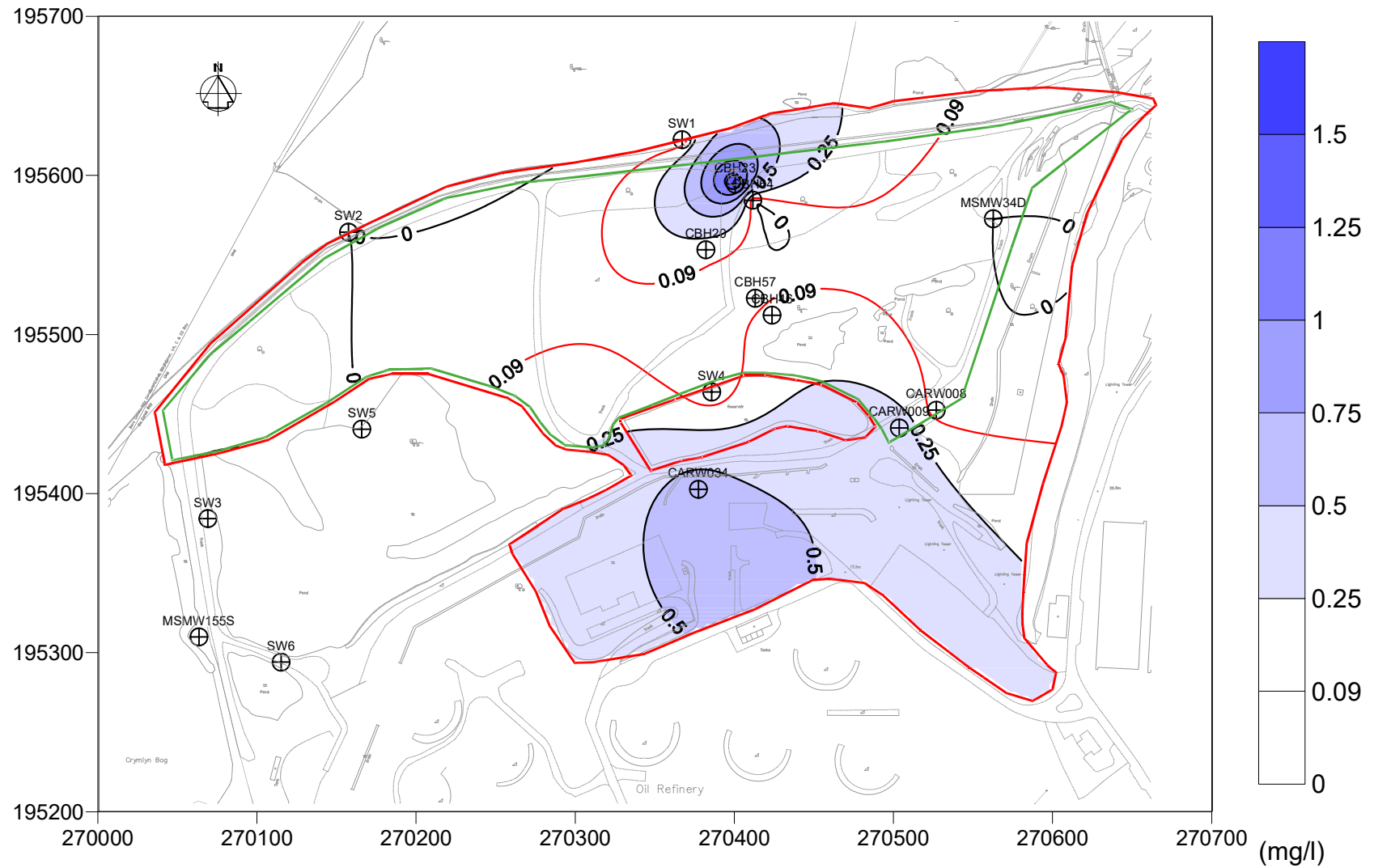
Coed Darcy Tip

Inferred Contours of Aromatics EC12-EC16 (aq) in Groundwater March 2022



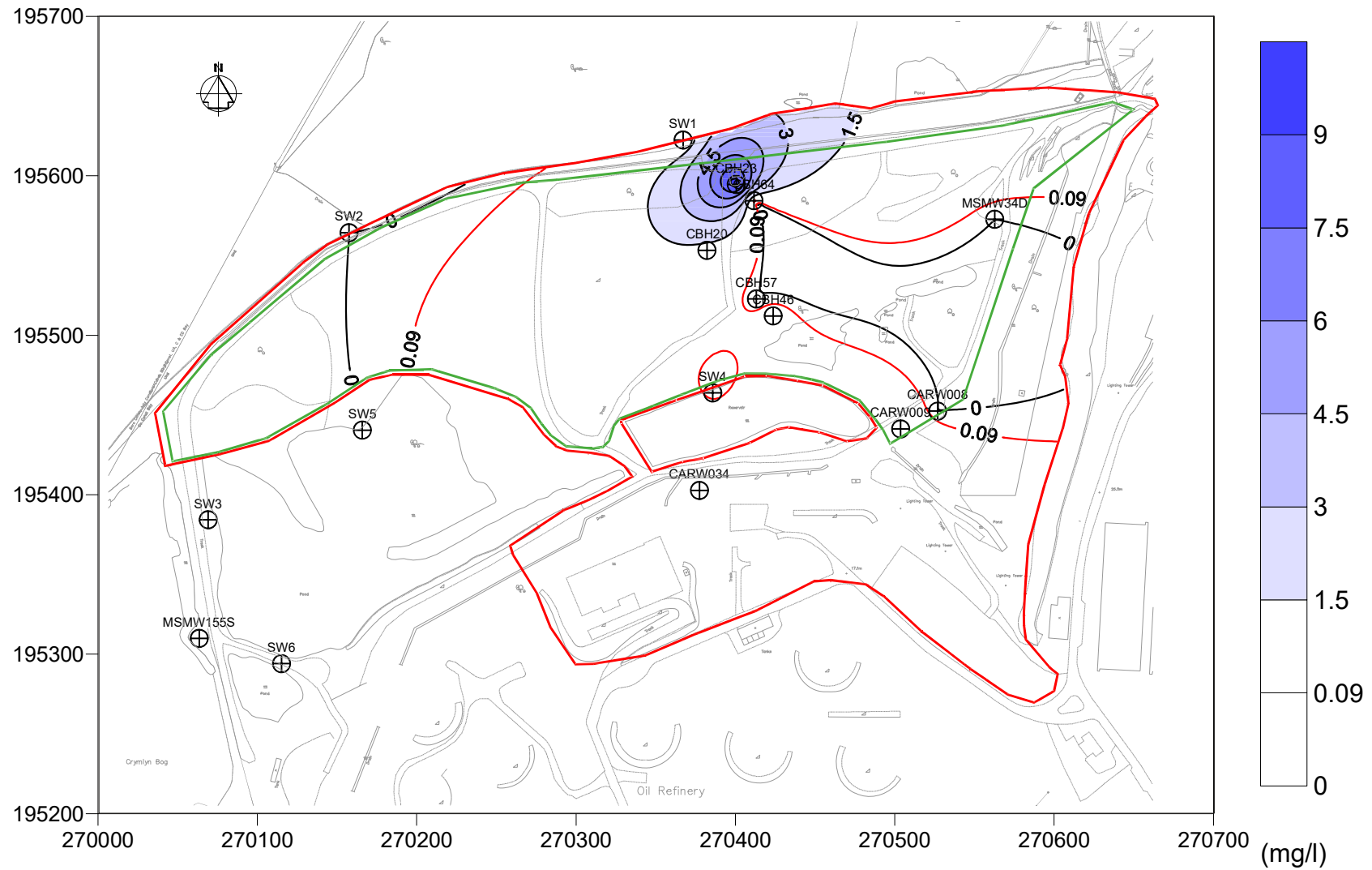
Coed Darcy Tip

Inferred Contours of Aromatics EC16-EC21 (aq) in Groundwater March 2022



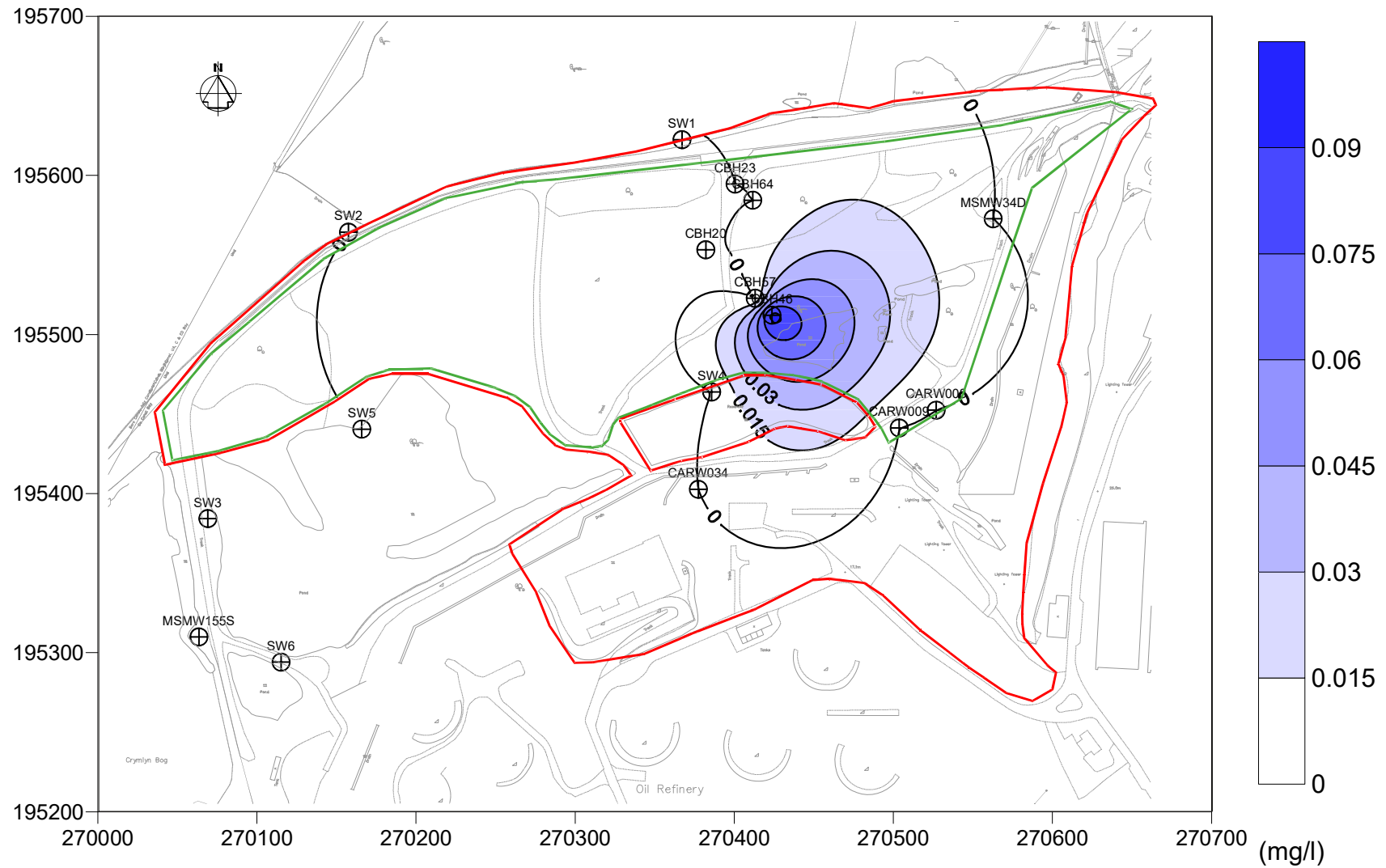
Coed Darcy Tip

Inferred Contours of Aromatics EC21-EC35 (aq) in Groundwater March 2022



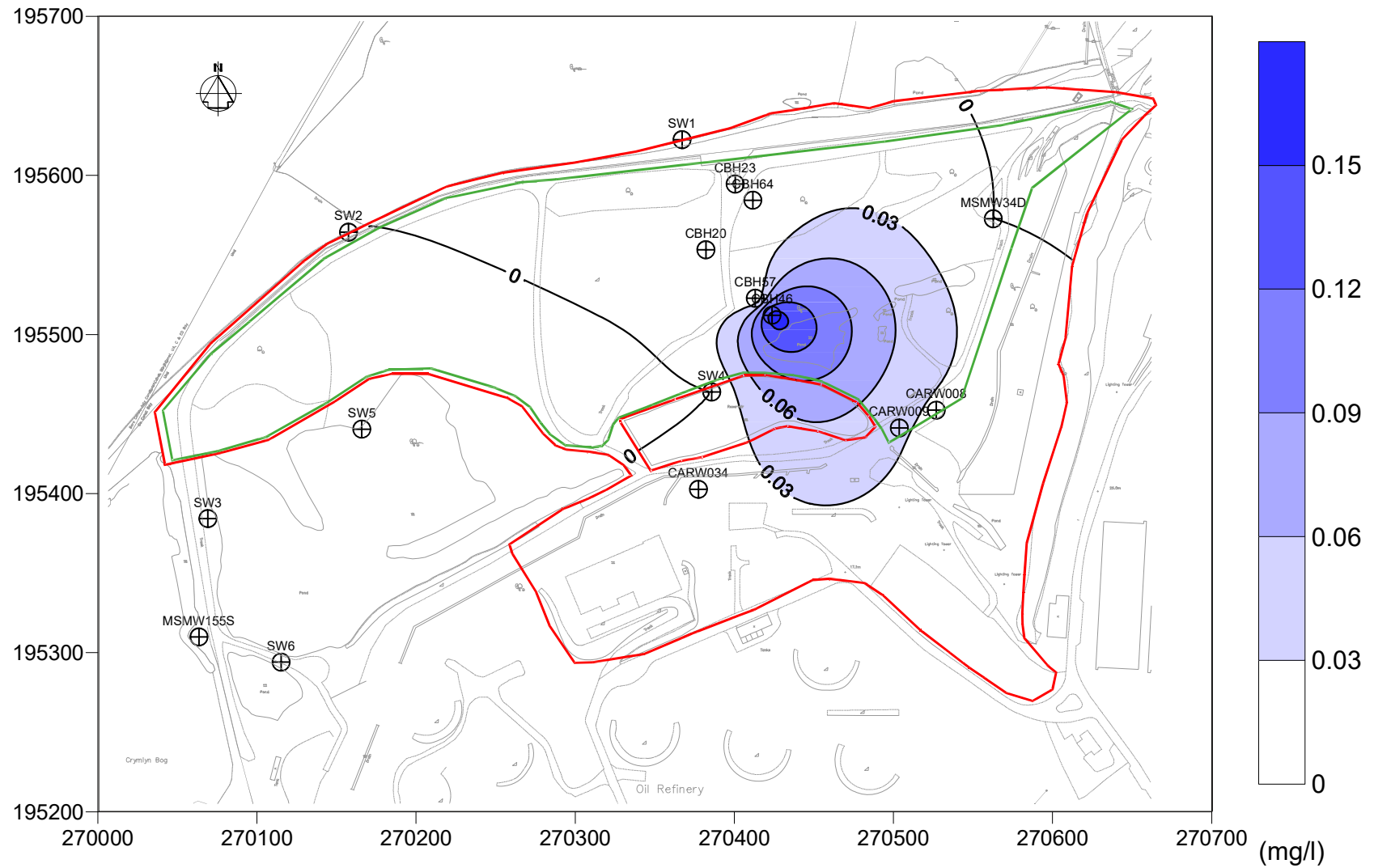
Coed Darcy Tip

Inferred Contours of Aliphatics C5-C6 in Groundwater March 2022



Coed Darcy Tip

Inferred Contours of Aliphatics C6-C8 in Groundwater March 2022

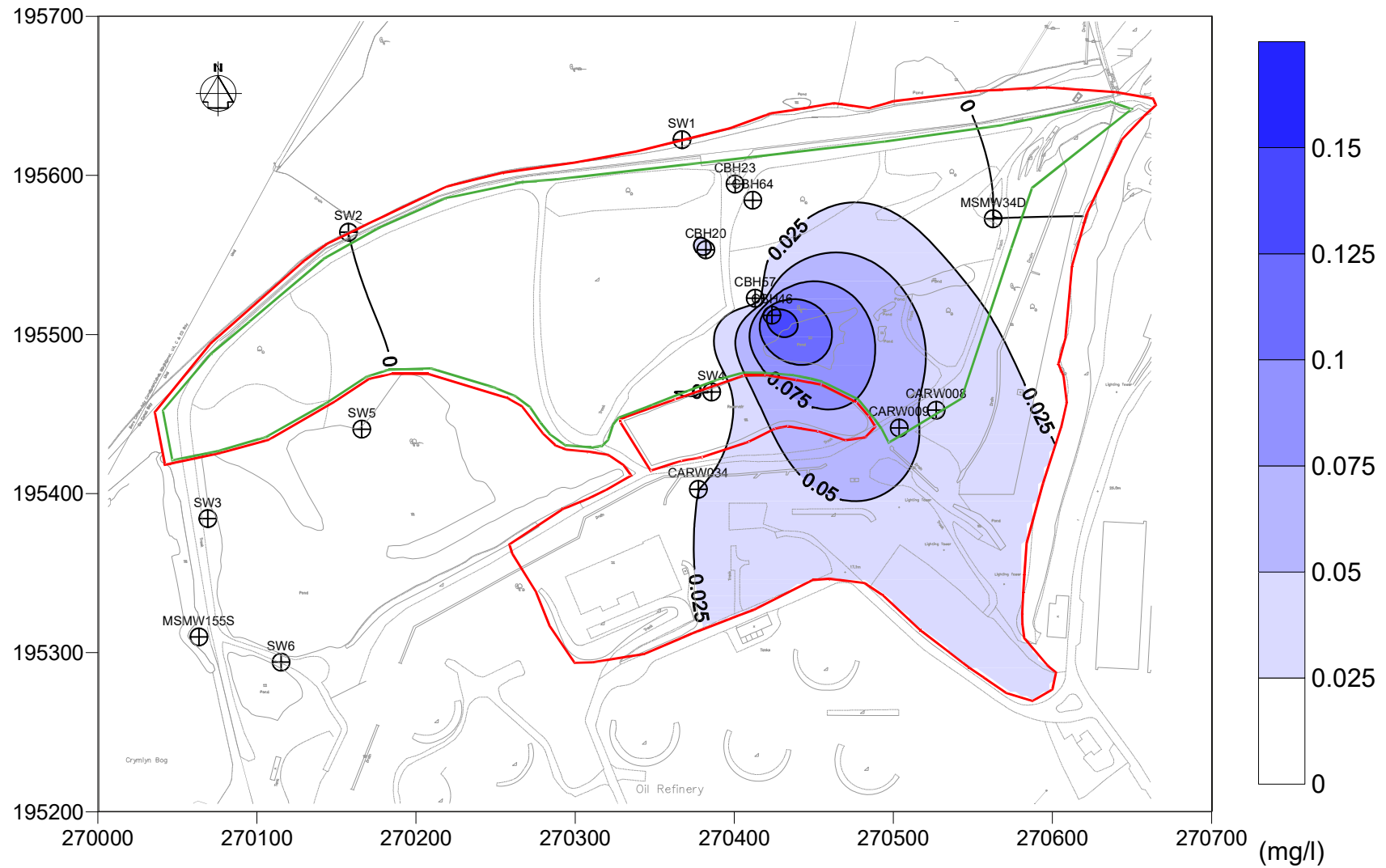


Compliance Criterion = 15 (mg/l) : Compliance Criterion Exceeds Data Maximum Value

Data Maximum Value = 0.172 (mg/l)

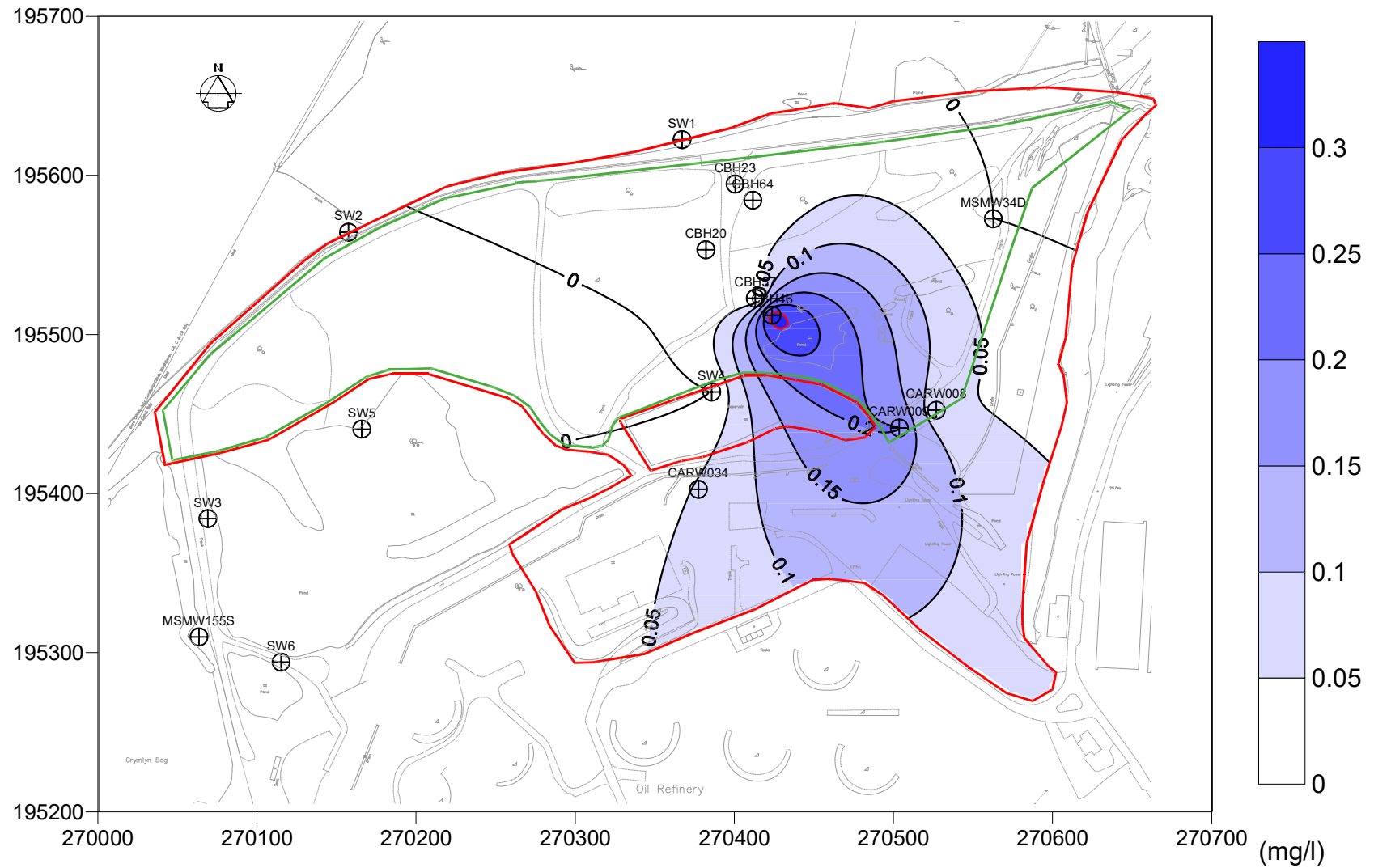
Coed Darcy Tip

Inferred Contours of Aliphatics C8-C10 in Groundwater March 2022



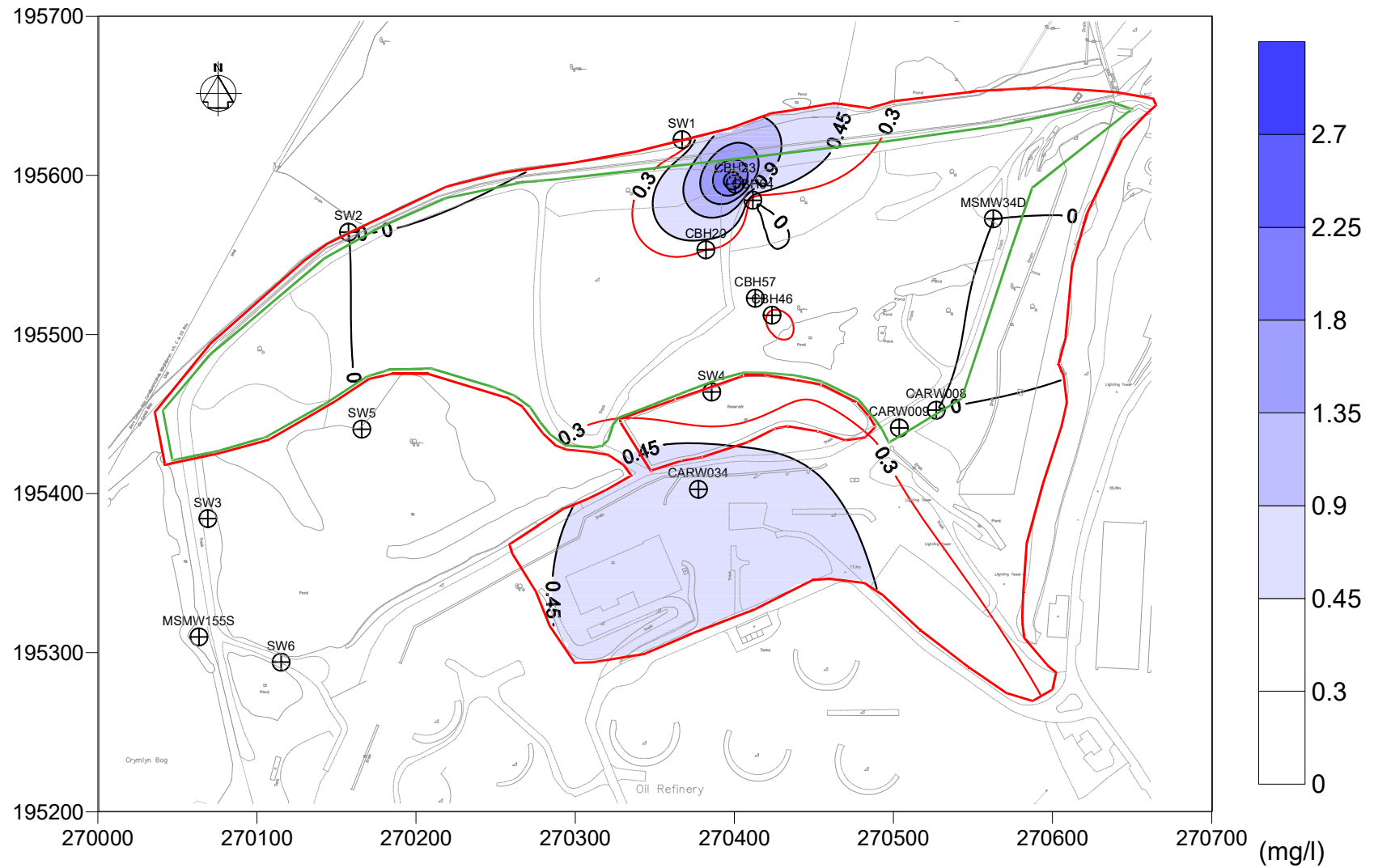
Coed Darcy Tip

Inferred Contours of Aliphatics C10-C12 in Groundwater March 2022



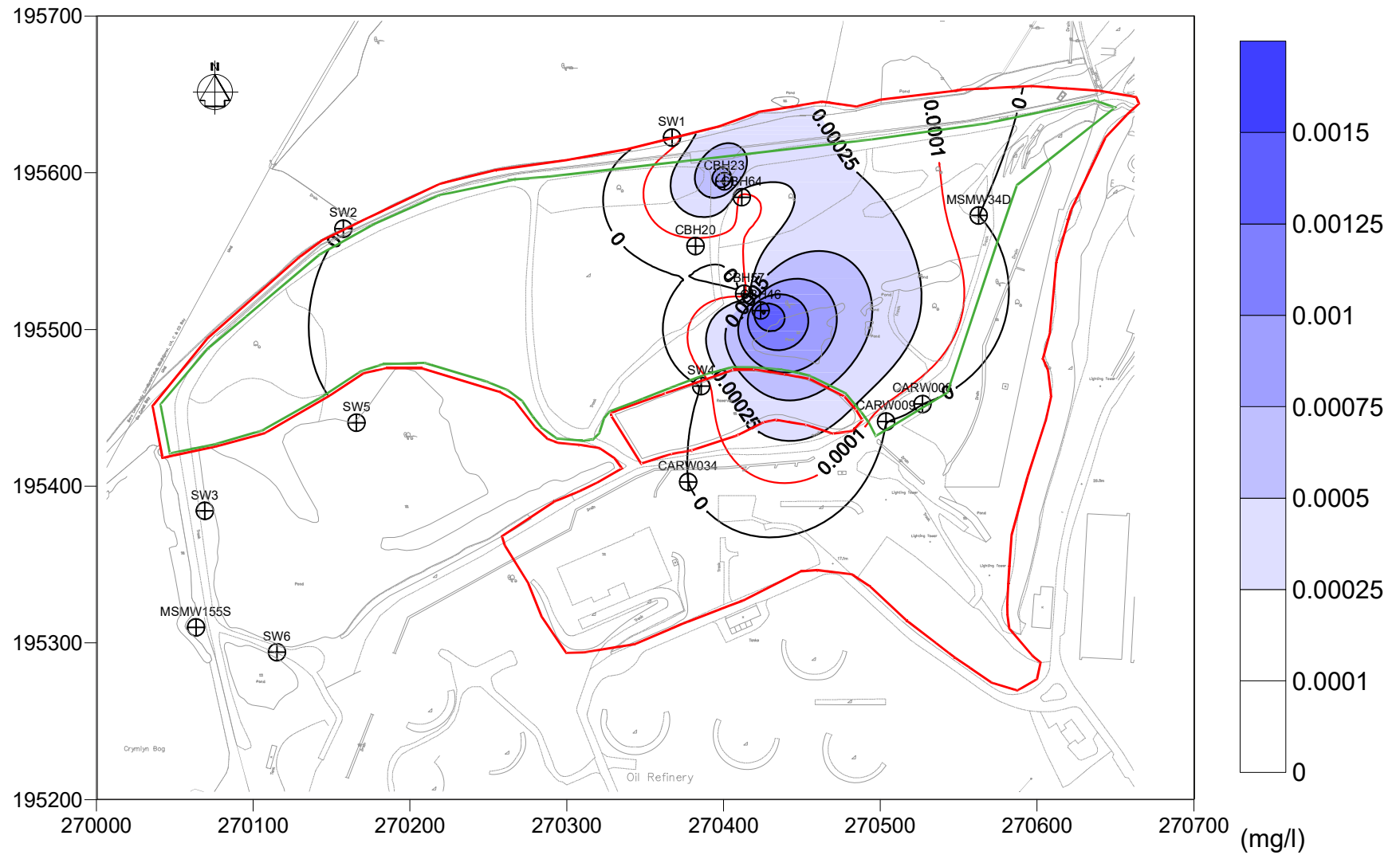
Coed Darcy Tip

Inferred Contours of Aliphatics C12-C16 (aq) in Groundwater March 2022



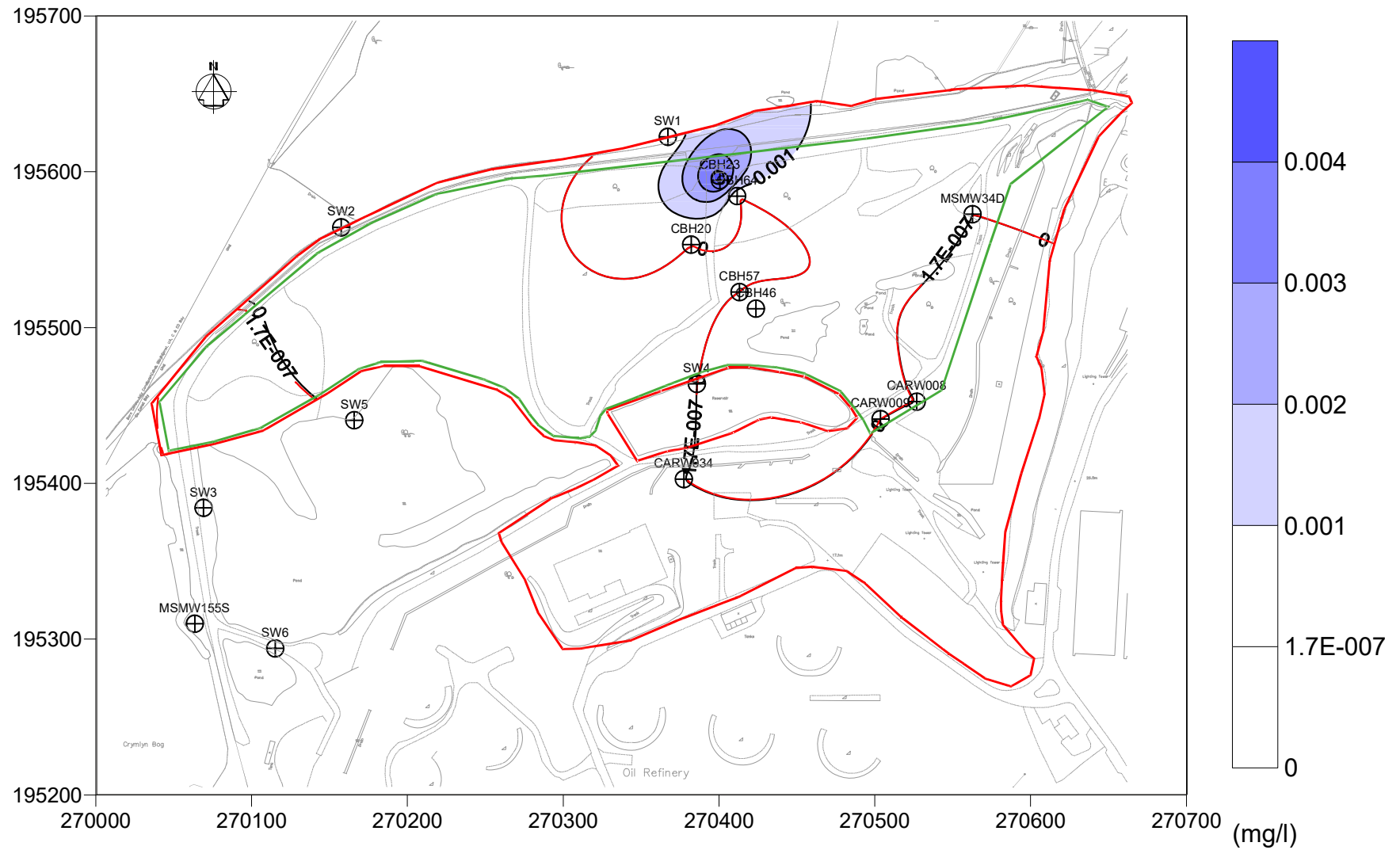
Coed Darcy Tip

Inferred Contours of Anthracene (aq) in Groundwater March 2022



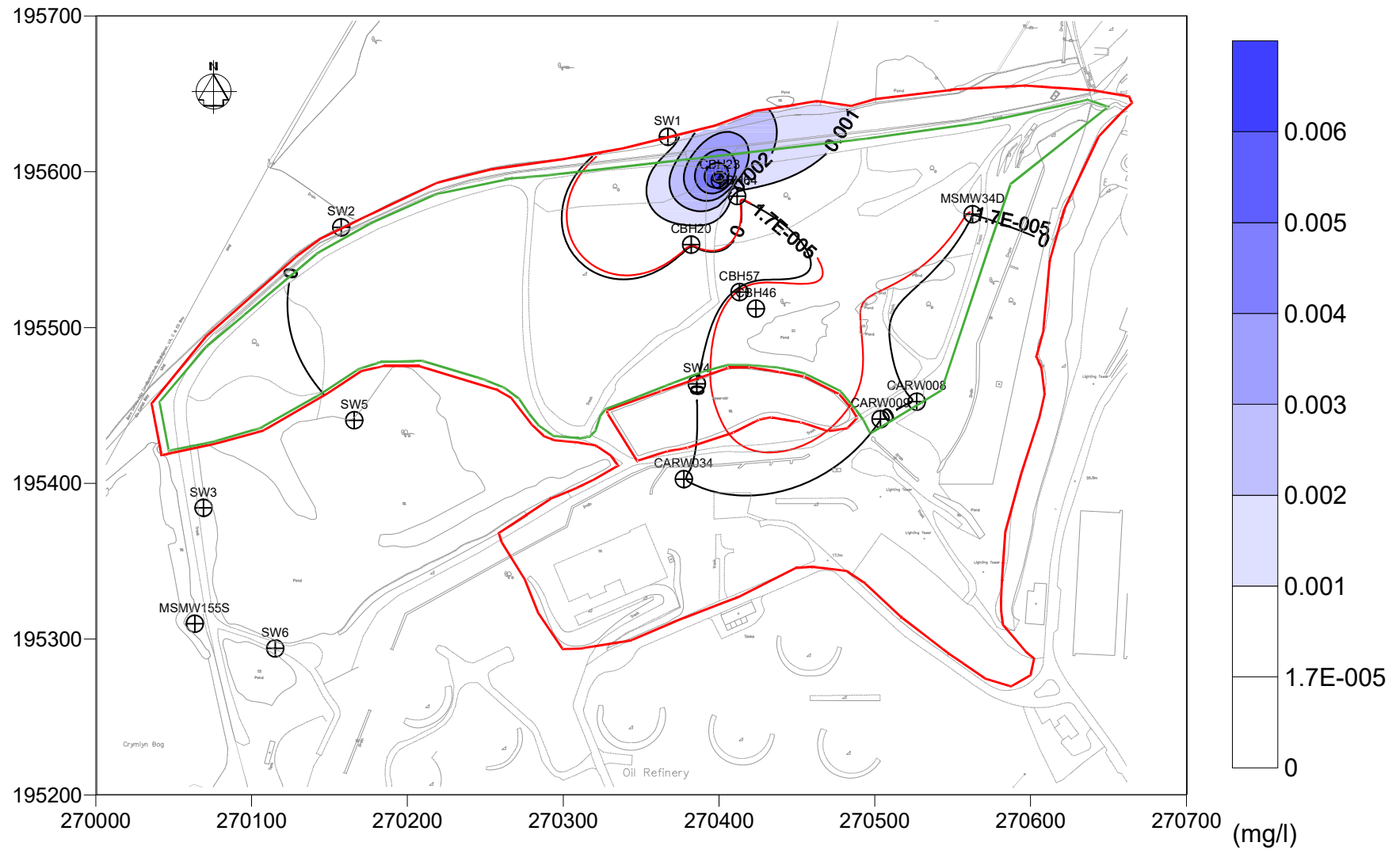
Coed Darcy Tip

Inferred Contours of Benzo(a)pyrene (aq) in Groundwater March 2022



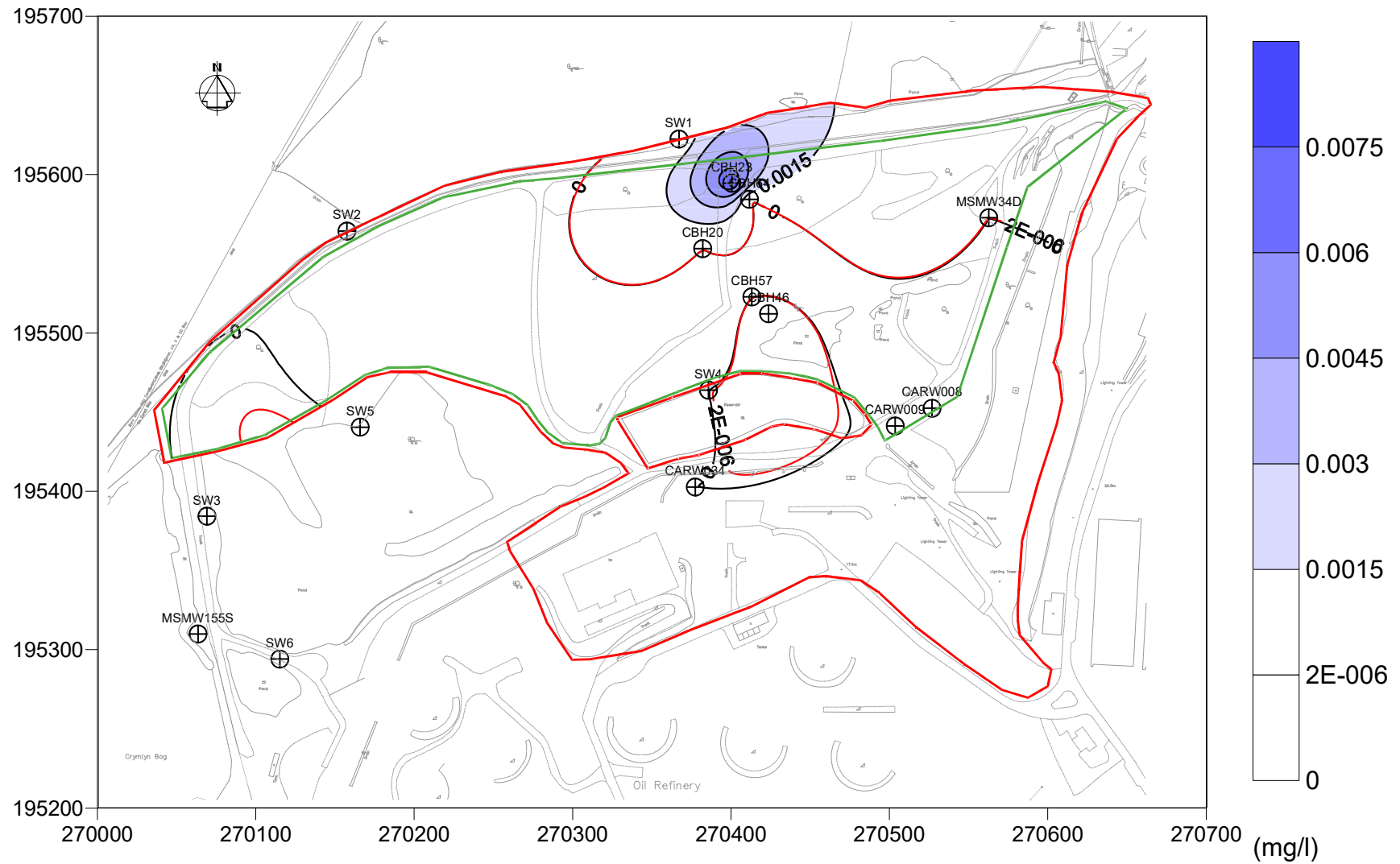
Coed Darcy Tip

Inferred Contours of Benzo(b)fluoranthene (aq) in Groundwater March 2022



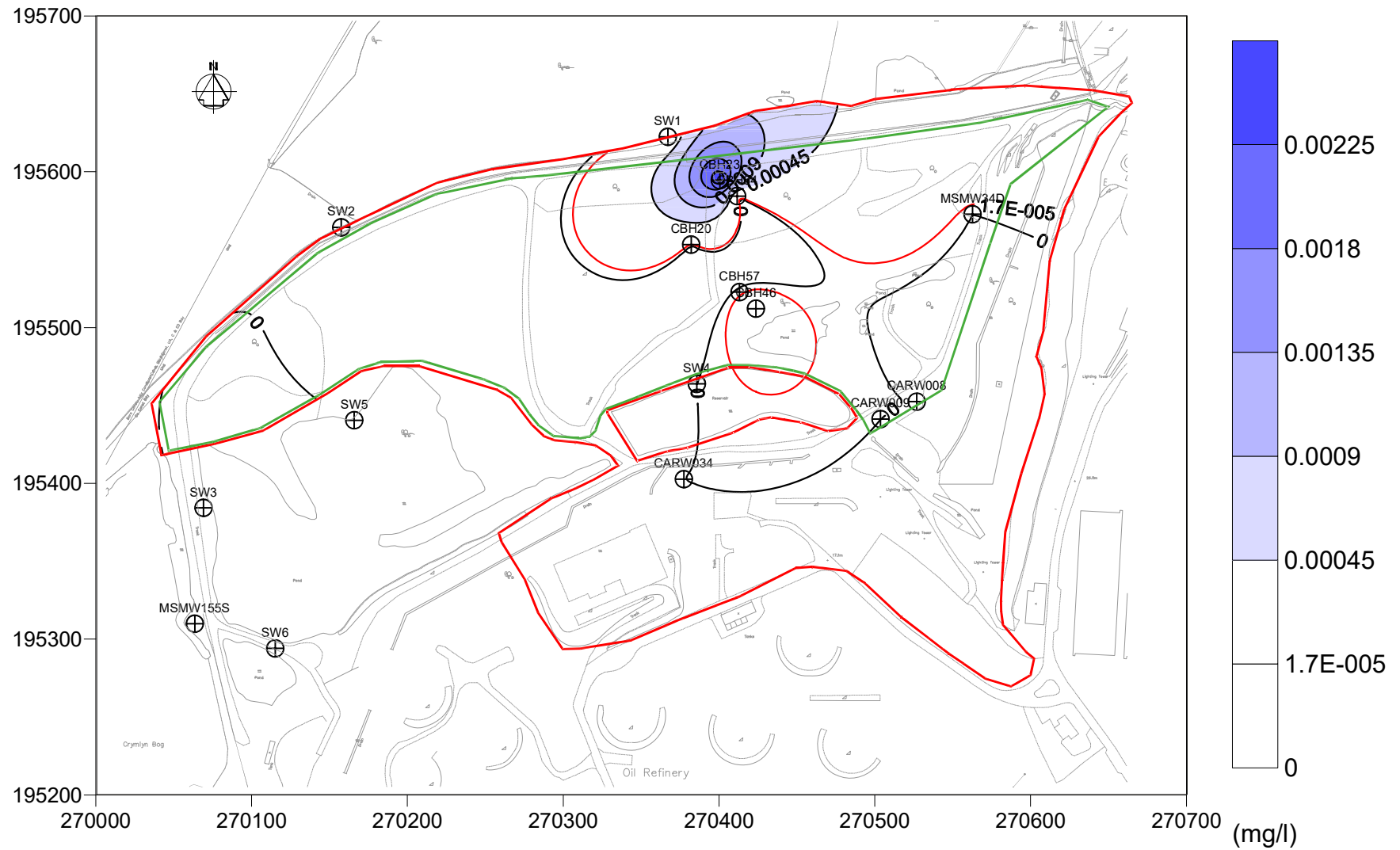
Coed Darcy Tip

Inferred Contours of Benzo(g,h,i)perylene (aq) in Groundwater March 2022



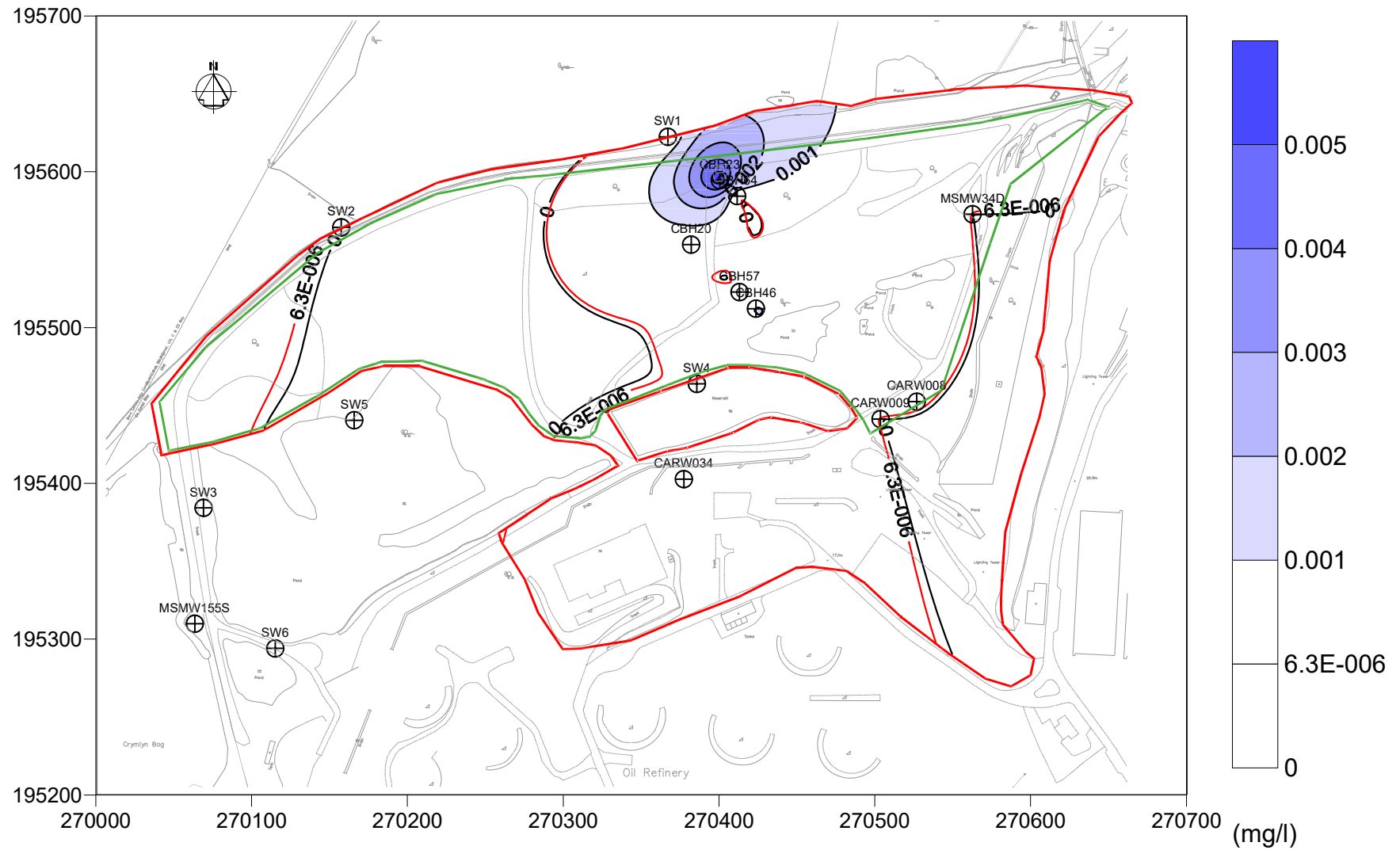
Coed Darcy Tip

Inferred Contours of Benzo(k)fluoranthene (aq) in Groundwater March 2022

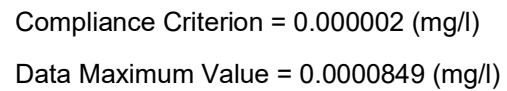


Coed Darcy Tip

Inferred Contours of Fluoranthene (aq) in Groundwater March 2022

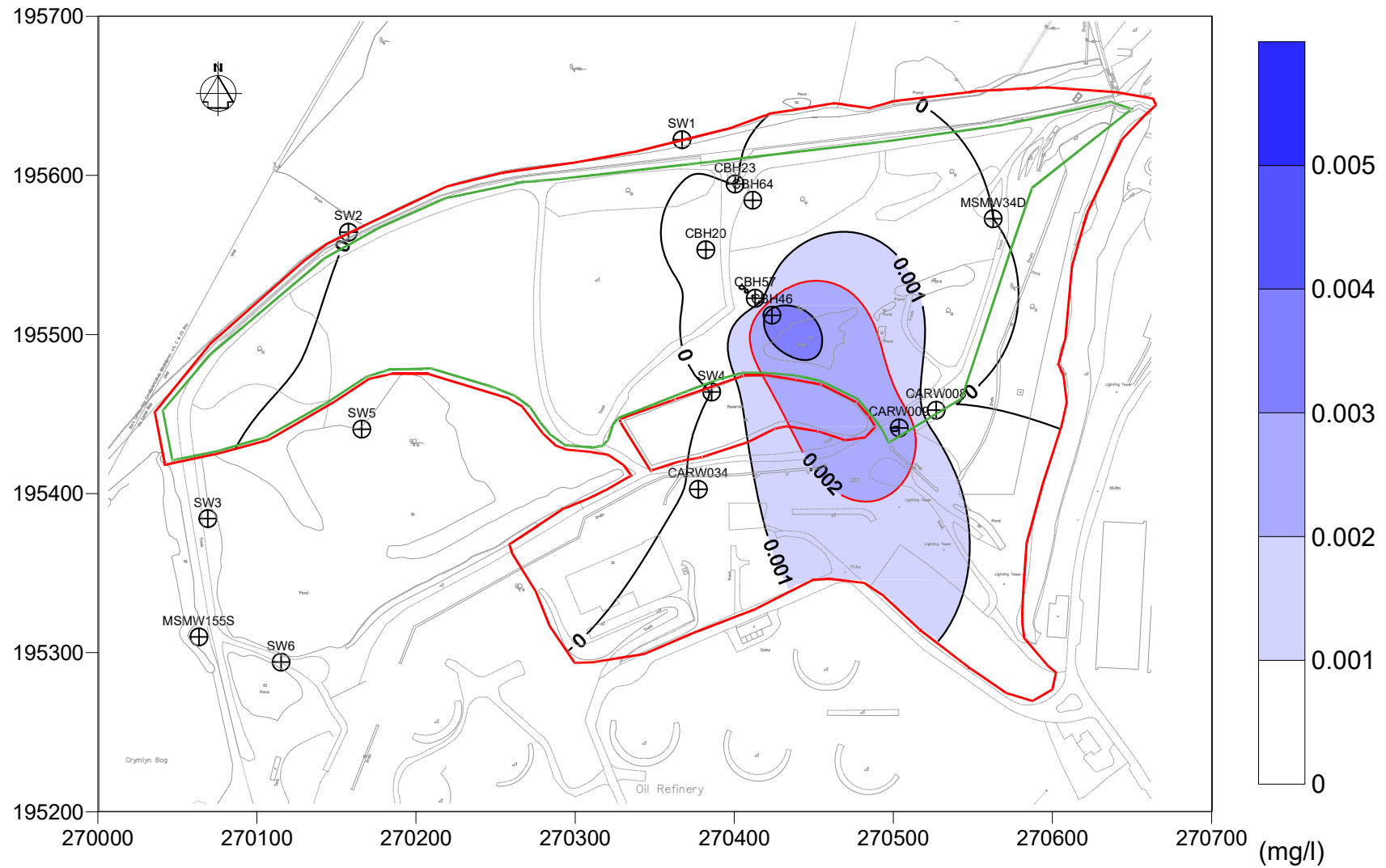


Inferred Contours of Indeno(1,2,3-cd)pyrene (aq) in Groundwater March 2022



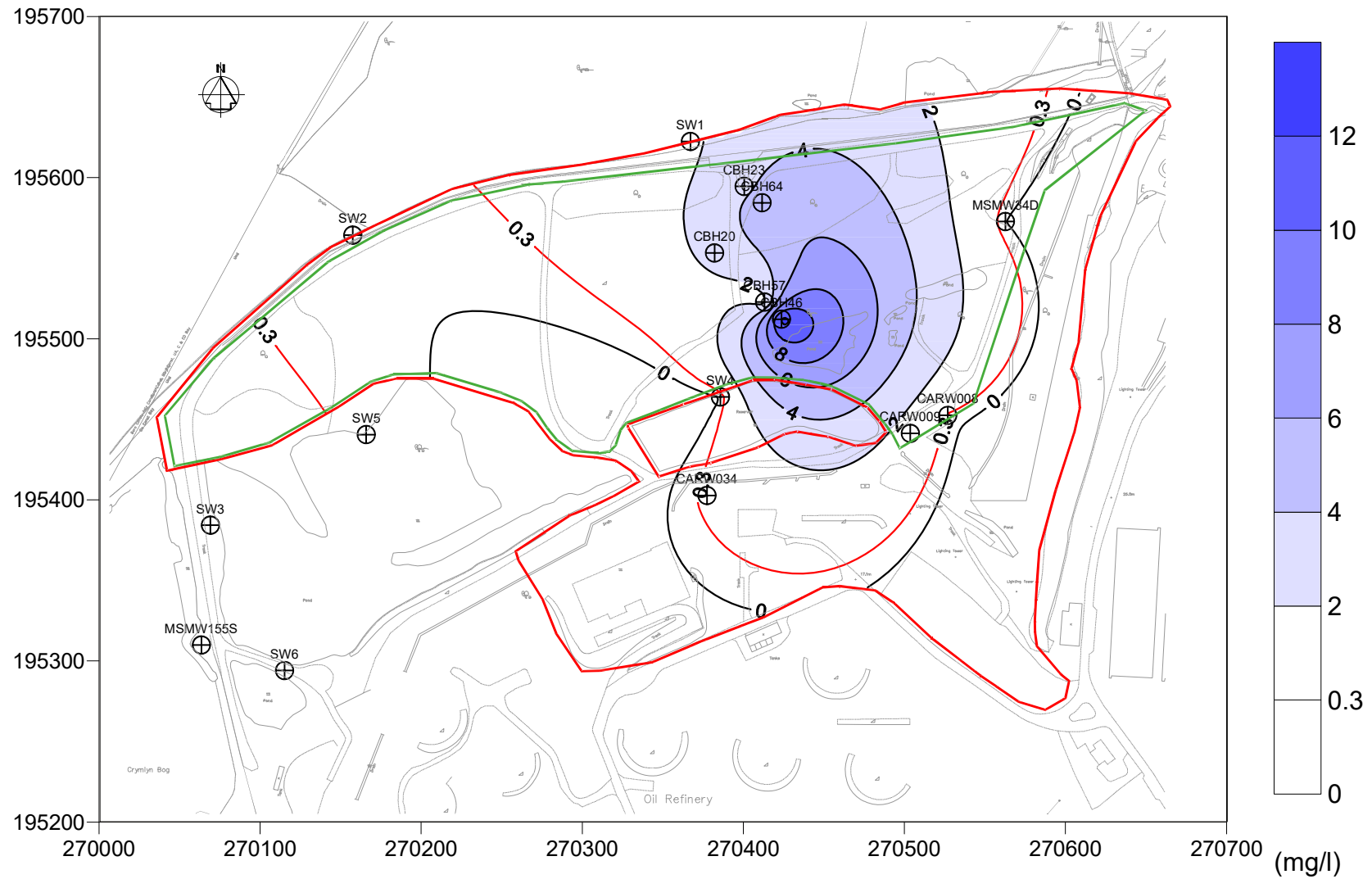
Coed Darcy Tip

Inferred Contours of Naphthalene (aq) in Groundwater March 2022



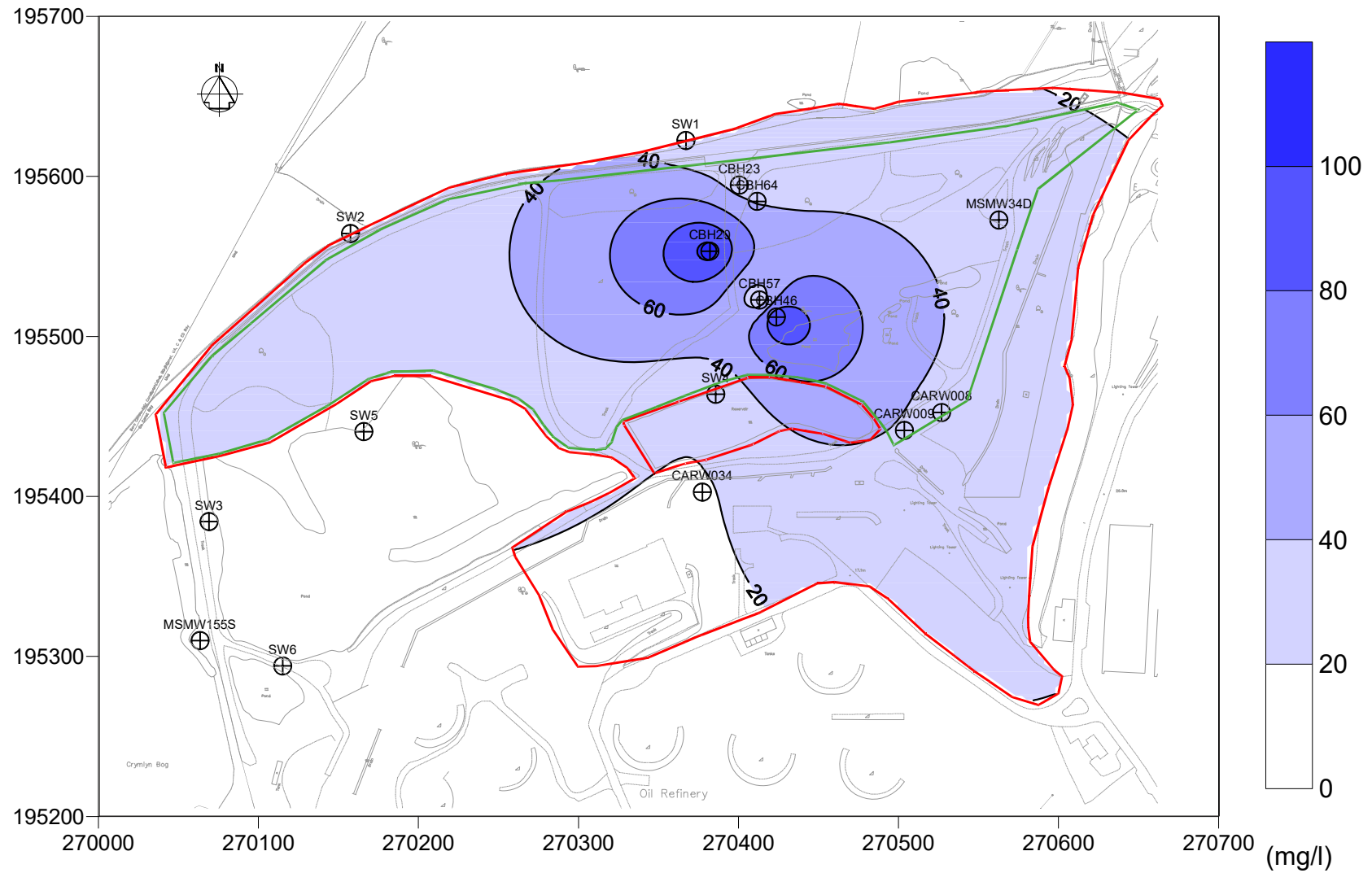
Coed Darcy Tip

Inferred Contours of Ammoniacal Nitrogen as N in Groundwater March 2022



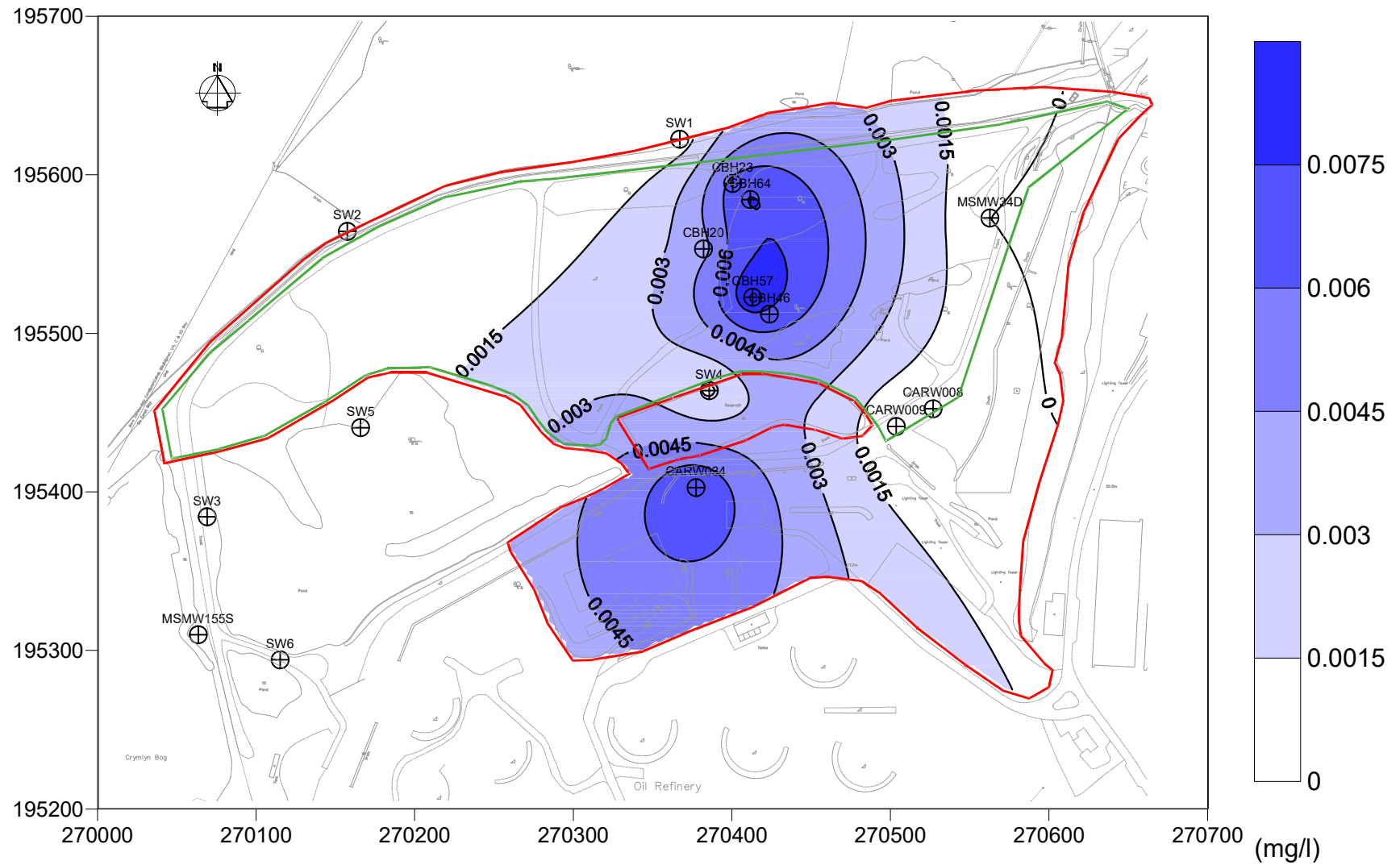
Coed Darcy Tip

Inferred Contours of Chloride in Groundwater March 2022



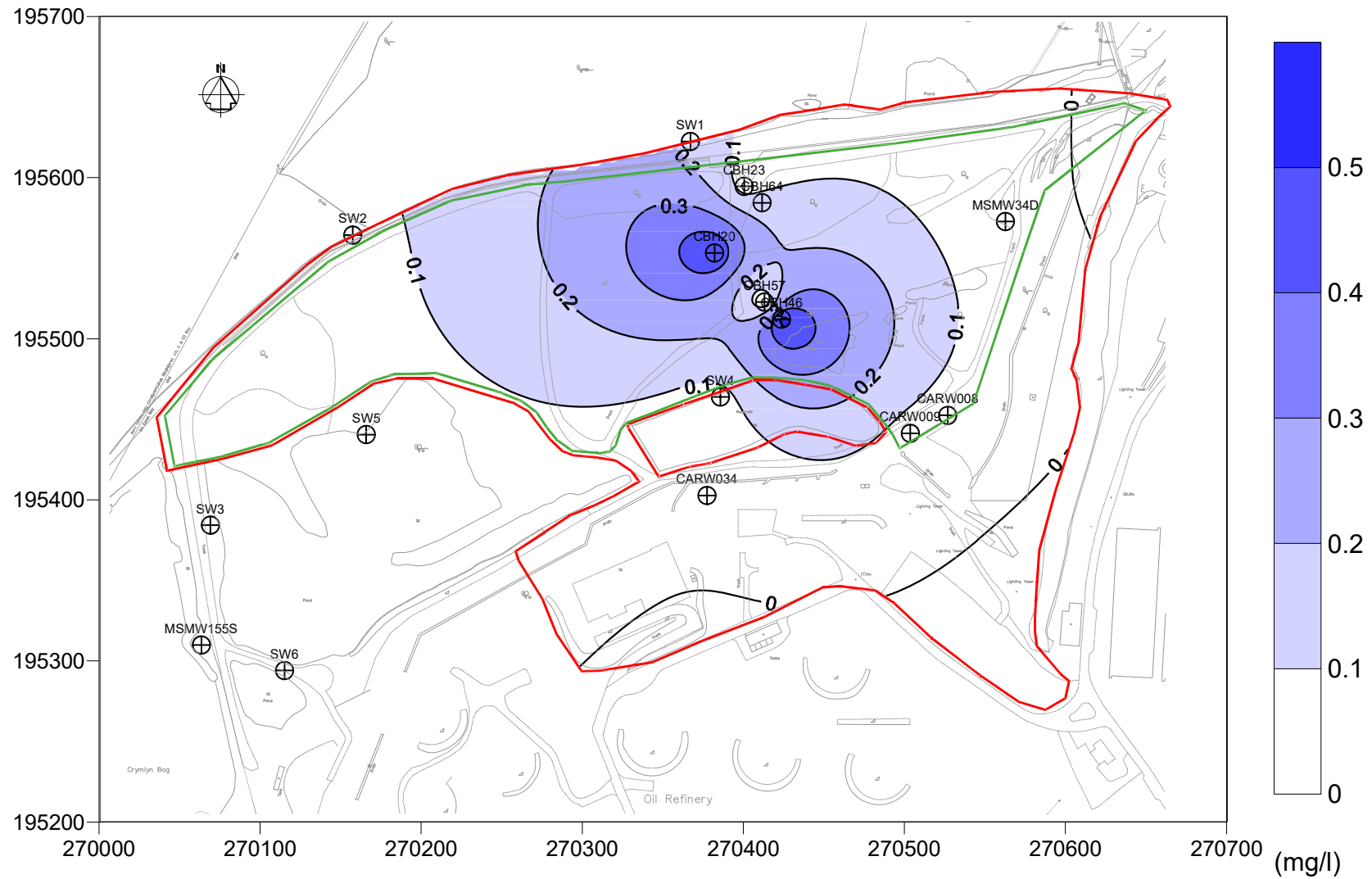
Coed Darcy Tip

Inferred Contours of Arsenic (diss.filt) in Groundwater March 2022



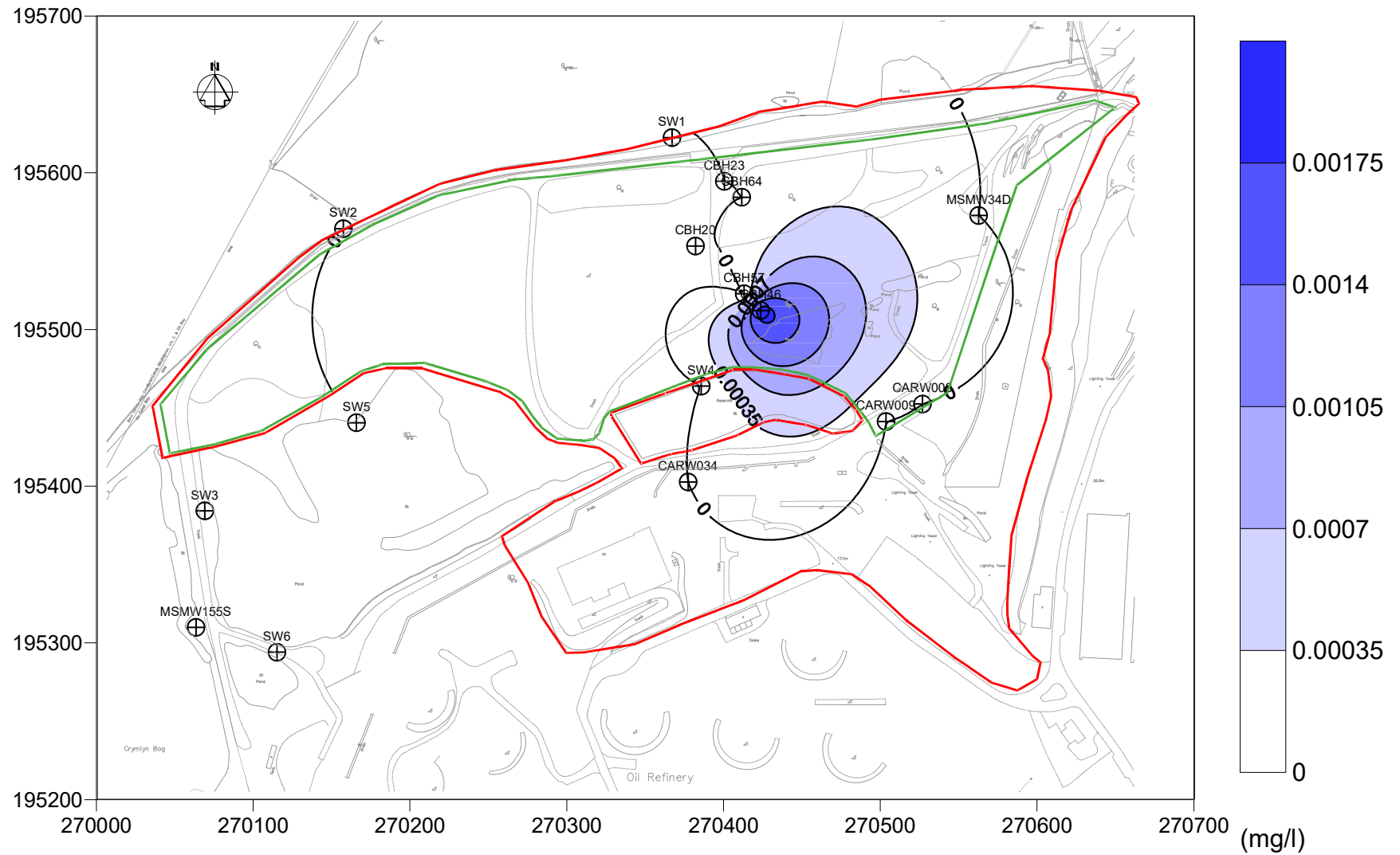
Coed Darcy Tip

Inferred Contours of Boron (diss.filt) in Groundwater March 2022



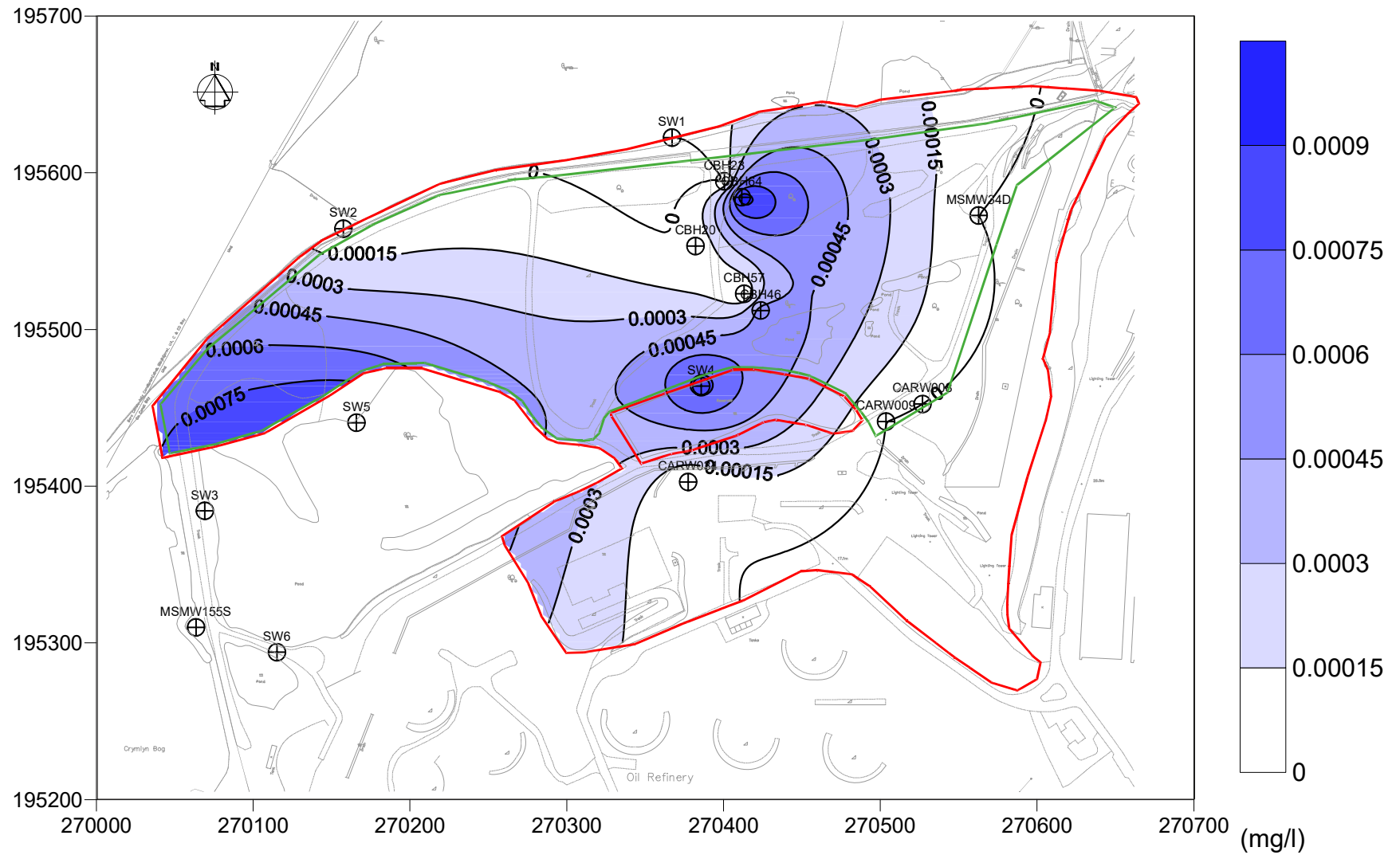
Coed Darcy Tip

Inferred Contours of Chromium (diss.filt) in Groundwater March 2022



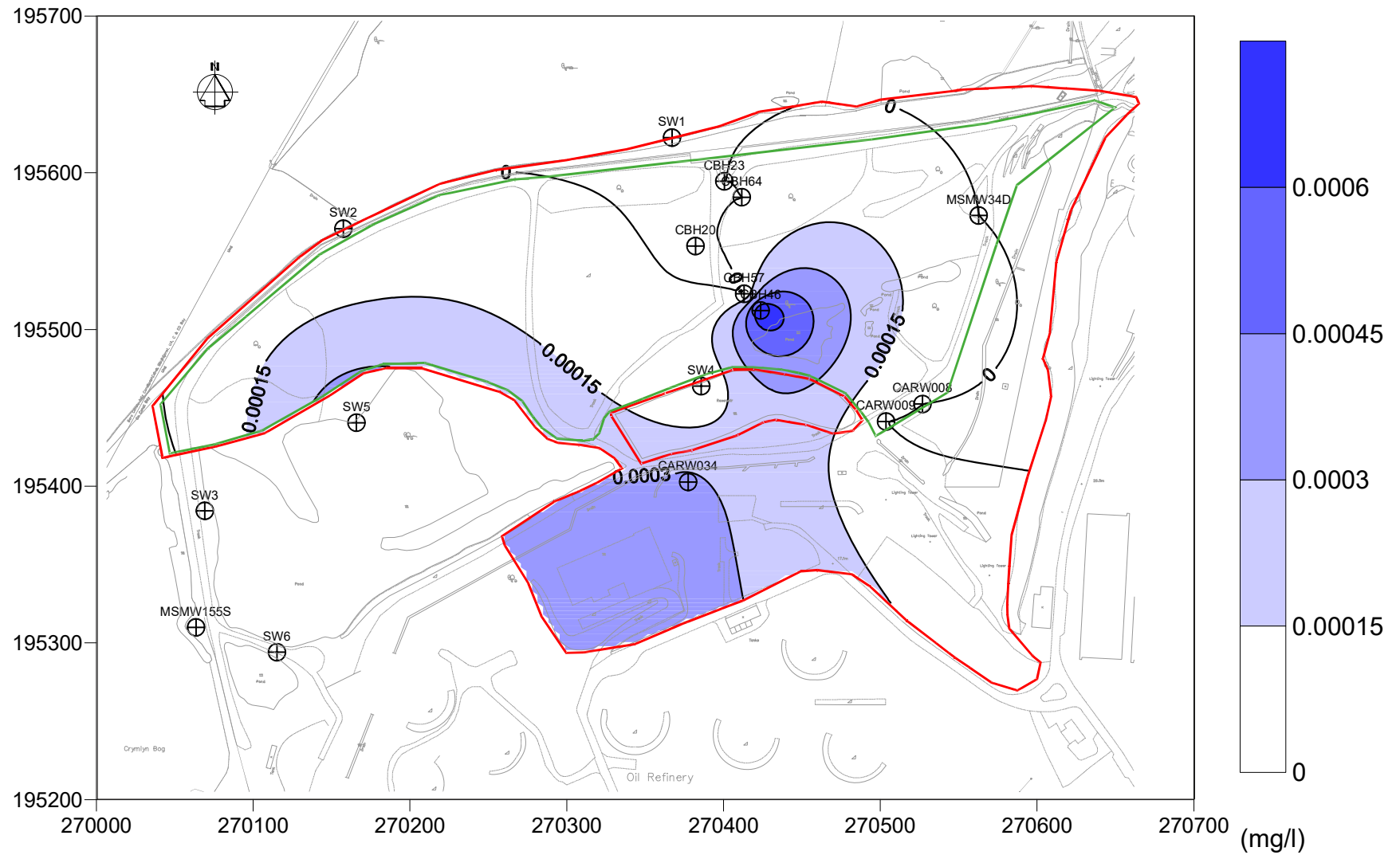
Coed Darcy Tip

Inferred Contours of Copper (diss.filt) in Groundwater March 2022



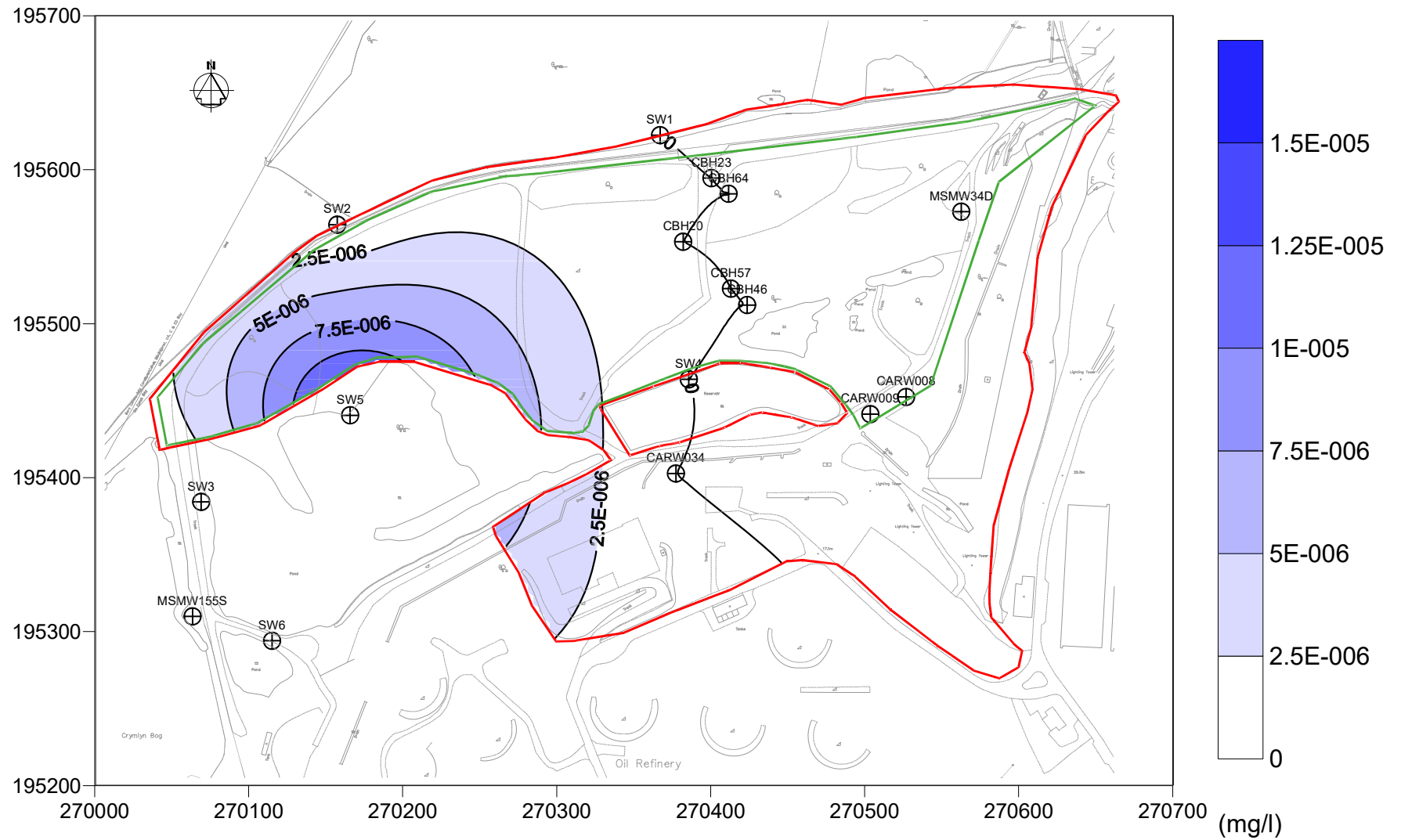
Coed Darcy Tip

Inferred Contours of Lead (diss.filt) in Groundwater March 2022



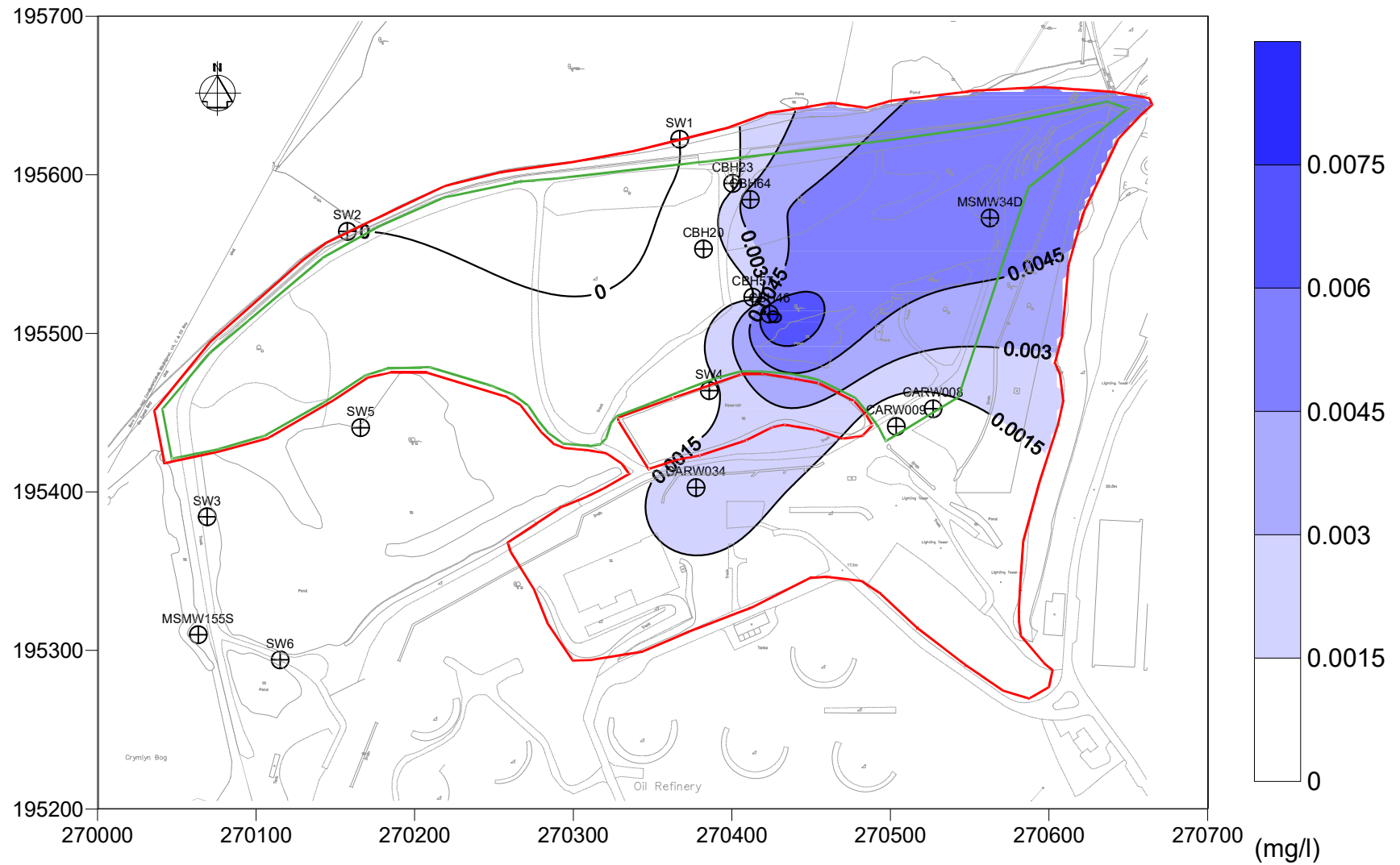
Coed Darcy Tip

Inferred Contours of Mercury (diss.filt) in Groundwater March 2022



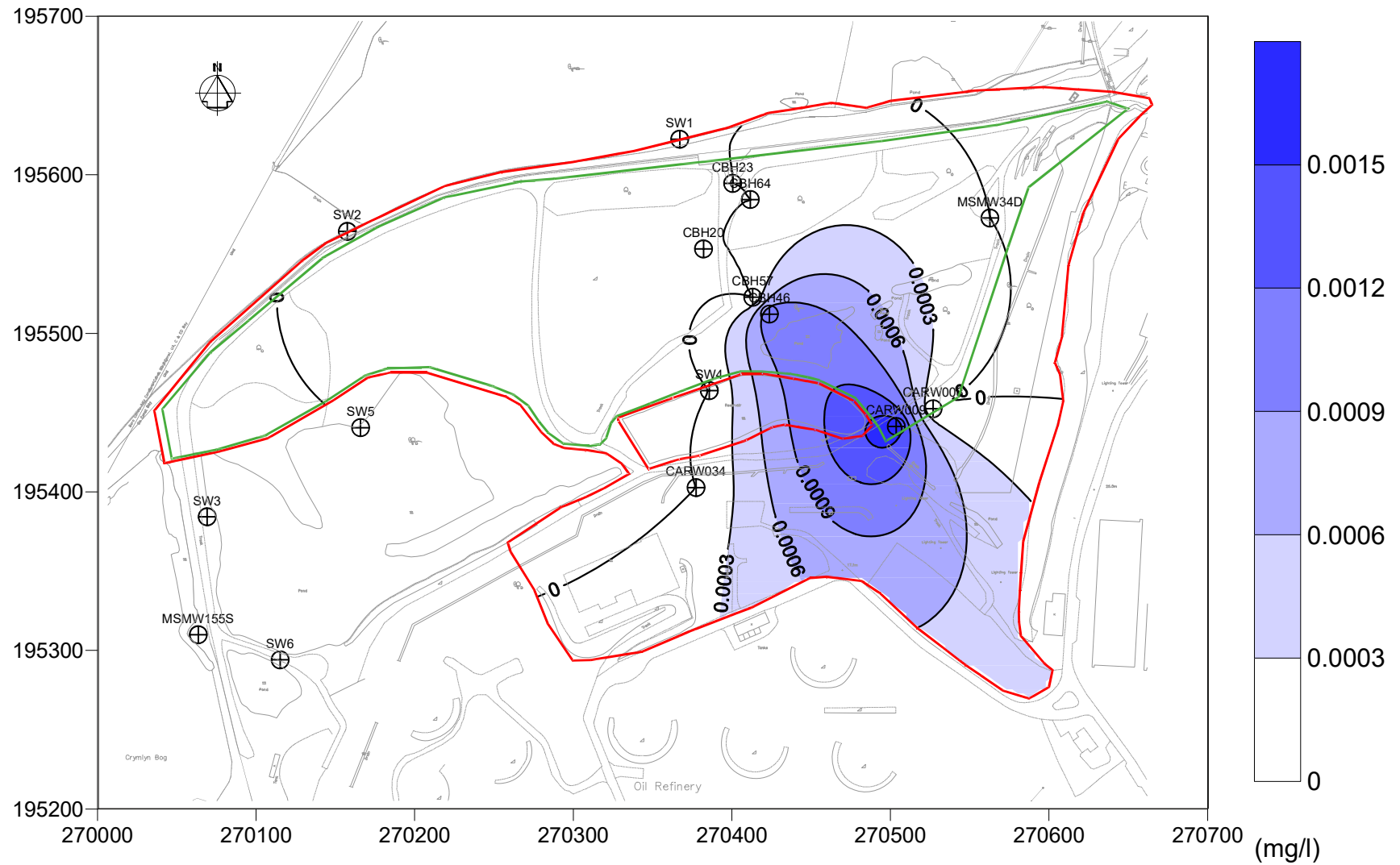
Coed Darcy Tip

Inferred Contours of Nickel (diss.filt) in Groundwater March 2022



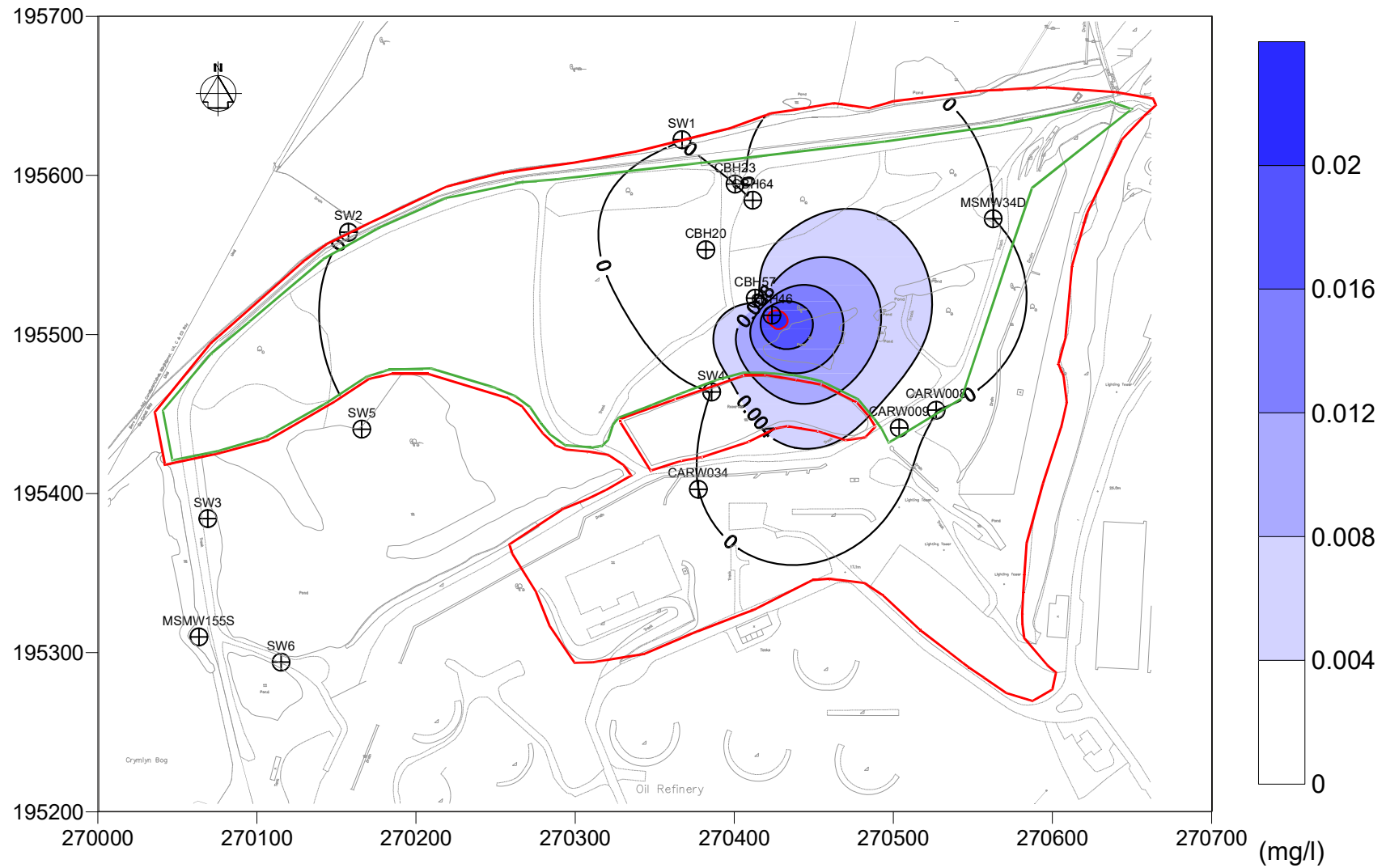
Coed Darcy Tip

Inferred Contours of Selenium (diss.filt) in Groundwater March 2022



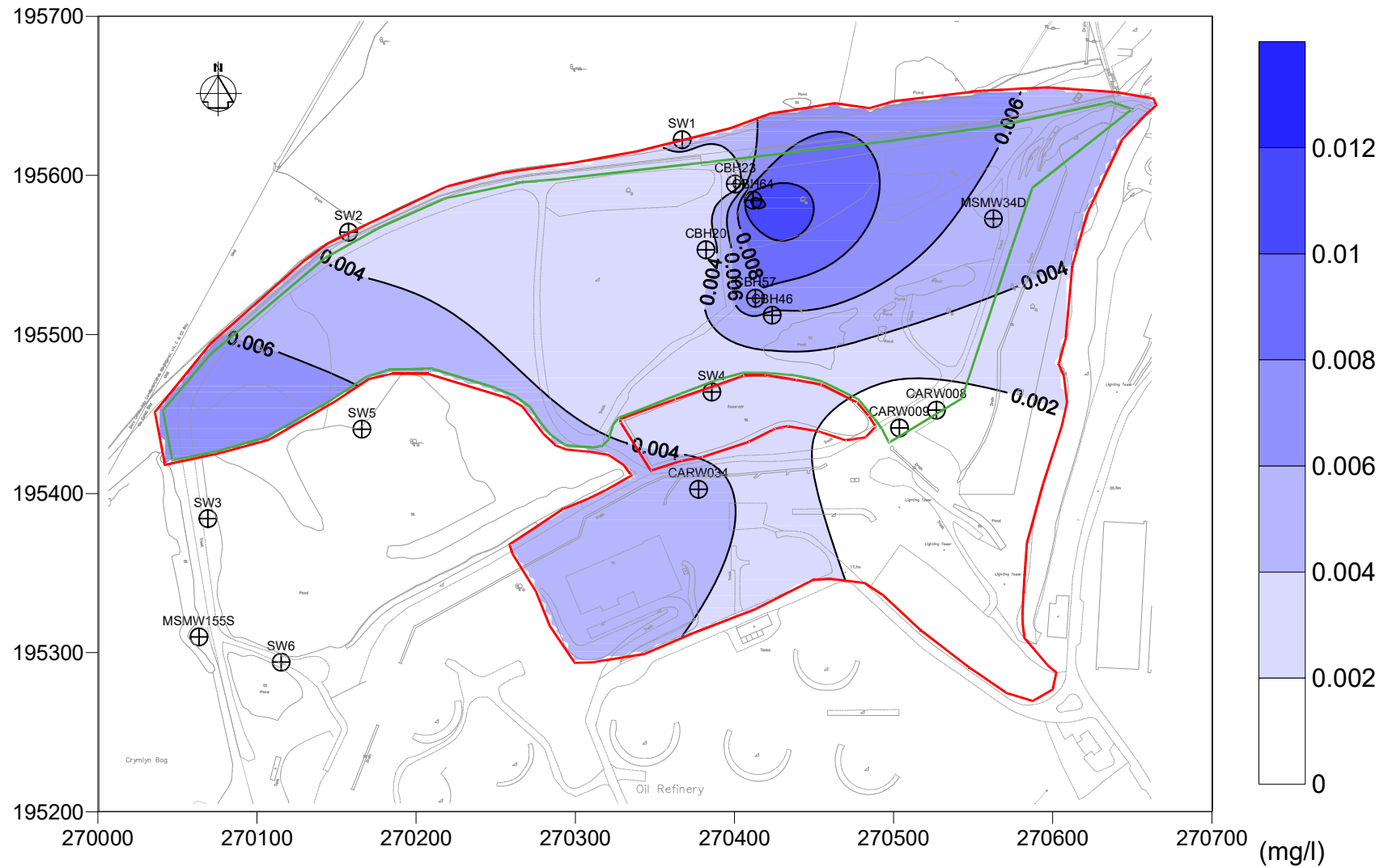
Coed Darcy Tip

Inferred Contours of Vanadium (diss.filt) in Groundwater March 2022



Coed Darcy Tip

Inferred Contours of Zinc (diss.filt) in Groundwater March 2022



Addendum C6 - Apr 2022

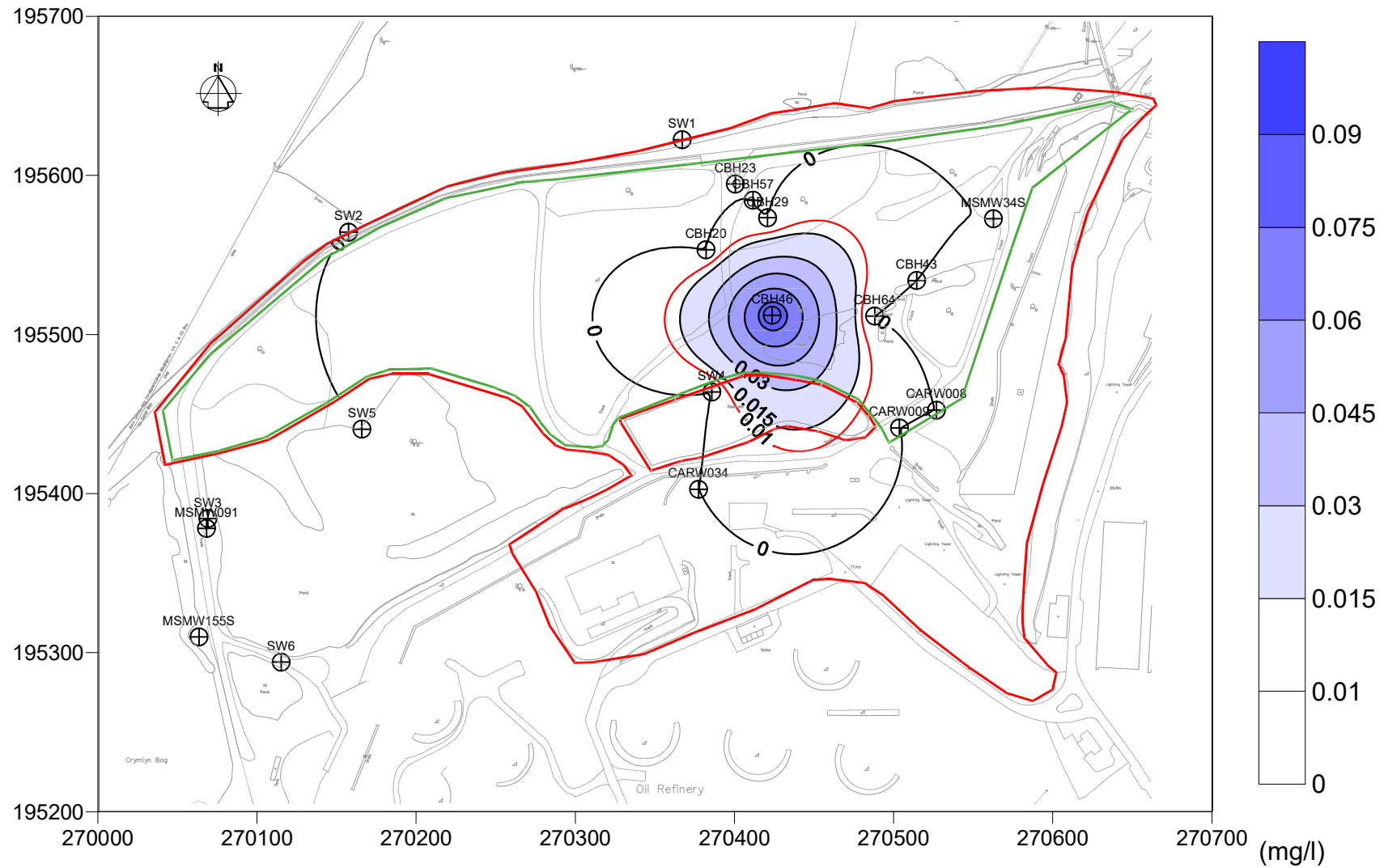
Chem Plots



eNGLOBE

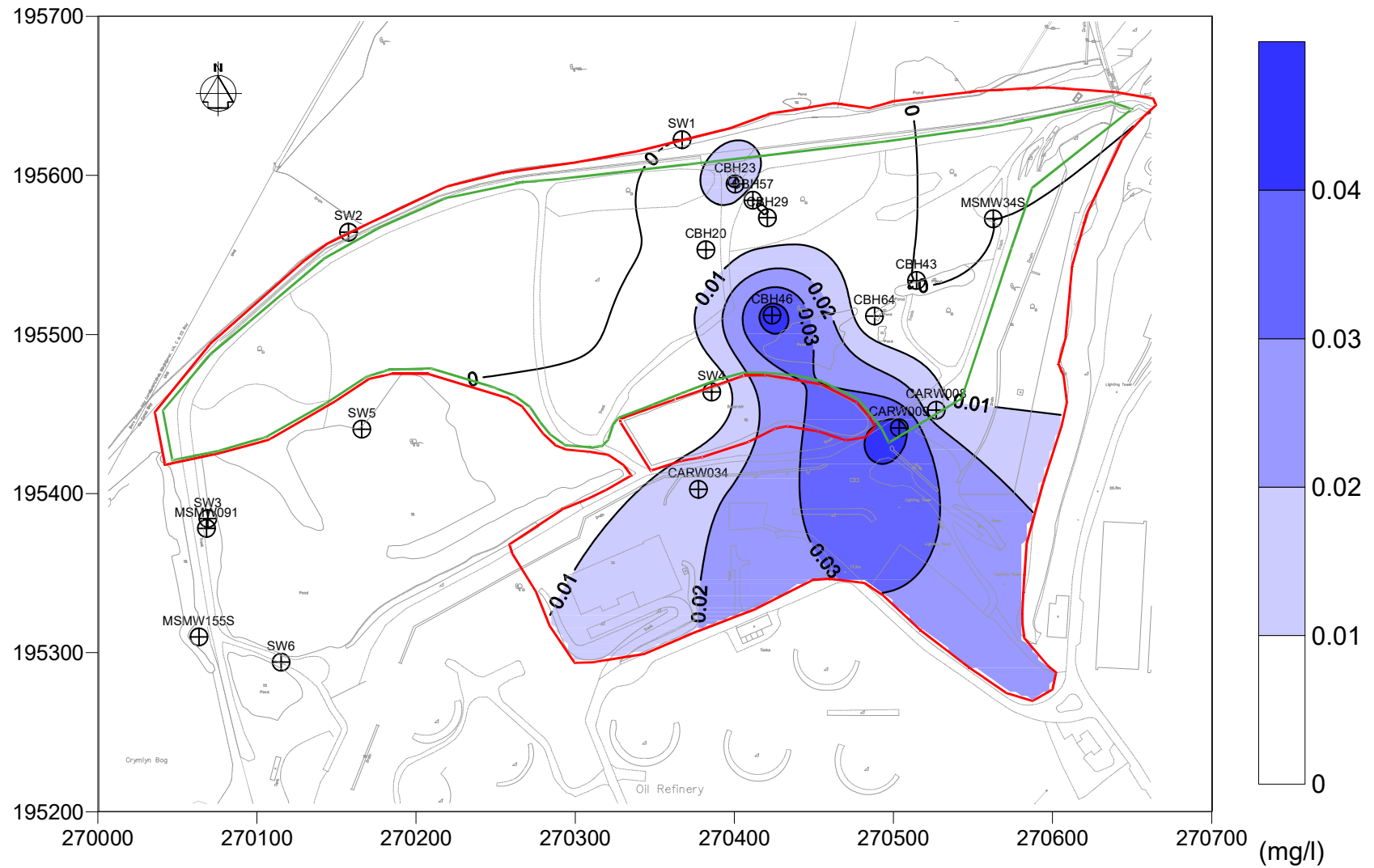
Coed Darcy Tip

Inferred Contours of Benzene in Groundwater April 2022



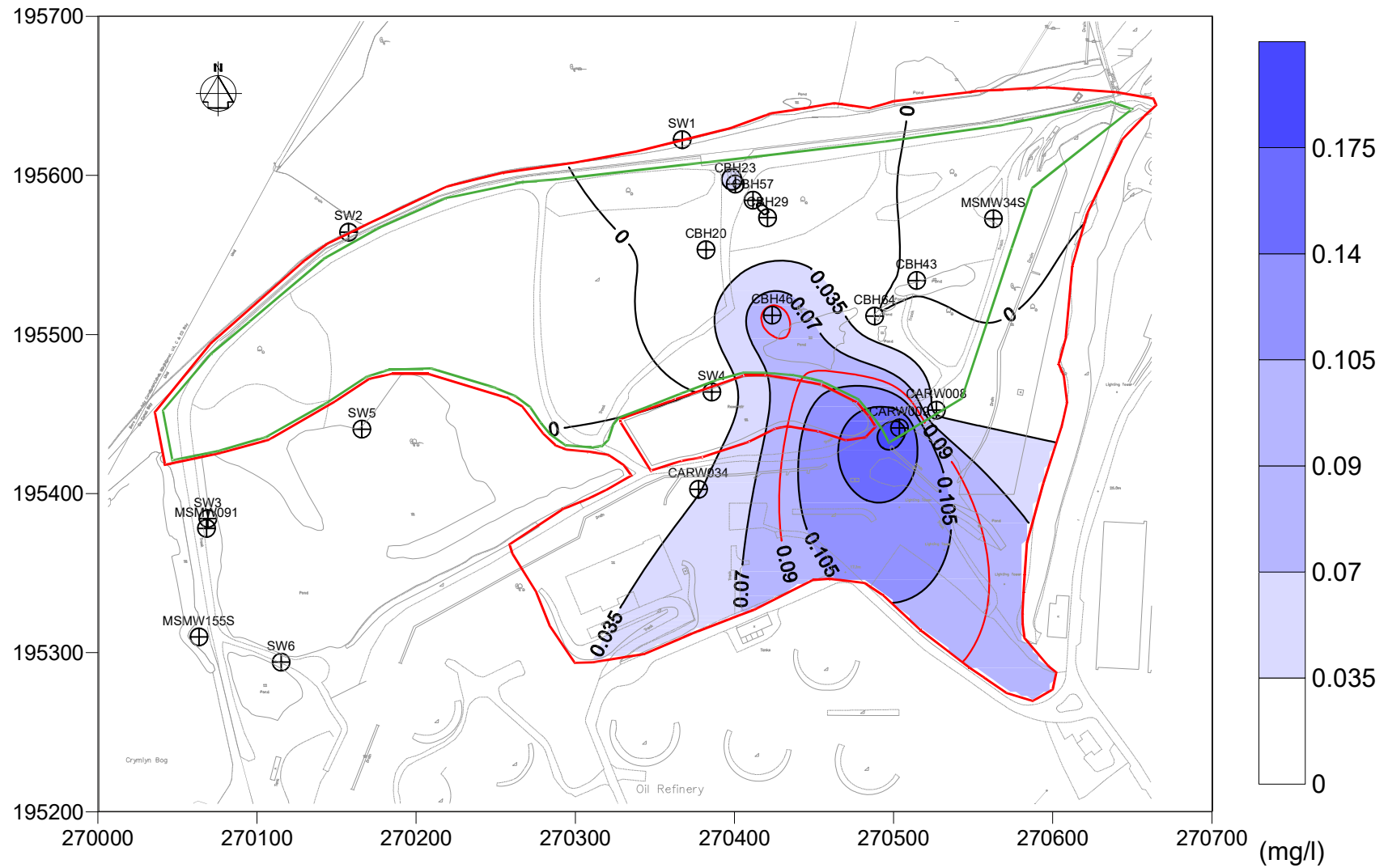
Coed Darcy Tip

Inferred Contours of Aromatics EC8-EC10 in Groundwater April 2022



Coed Darcy Tip

Inferred Contours of Aromatics EC10-EC12 in Groundwater April 2022

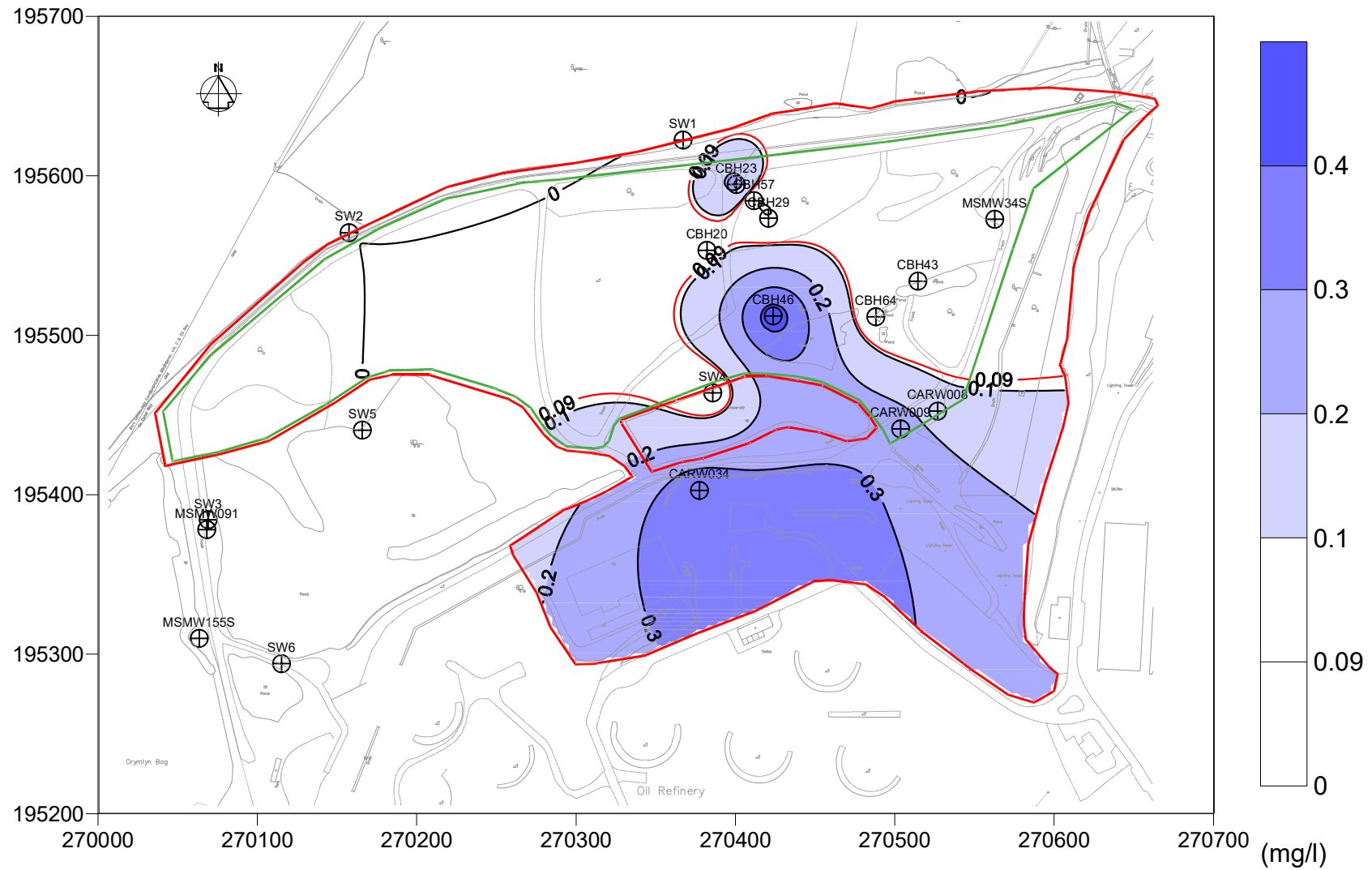


Compliance Criterion = 0.09 (mg/l)

Data Maximum Value = 0.196 (mg/l)

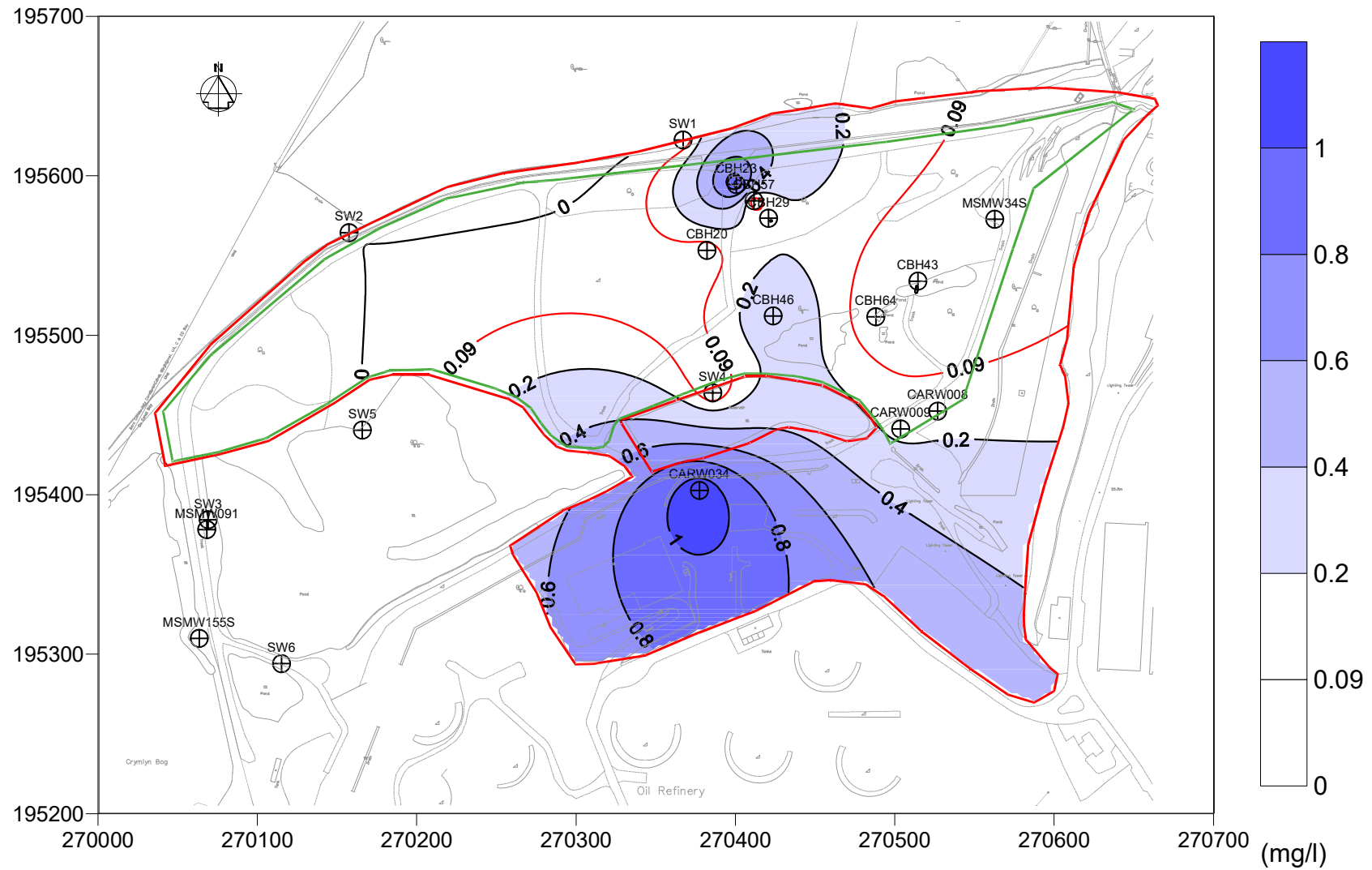
Coed Darcy Tip

Inferred Contours of Aromatics EC12-EC16 (aq) in Groundwater April 2022



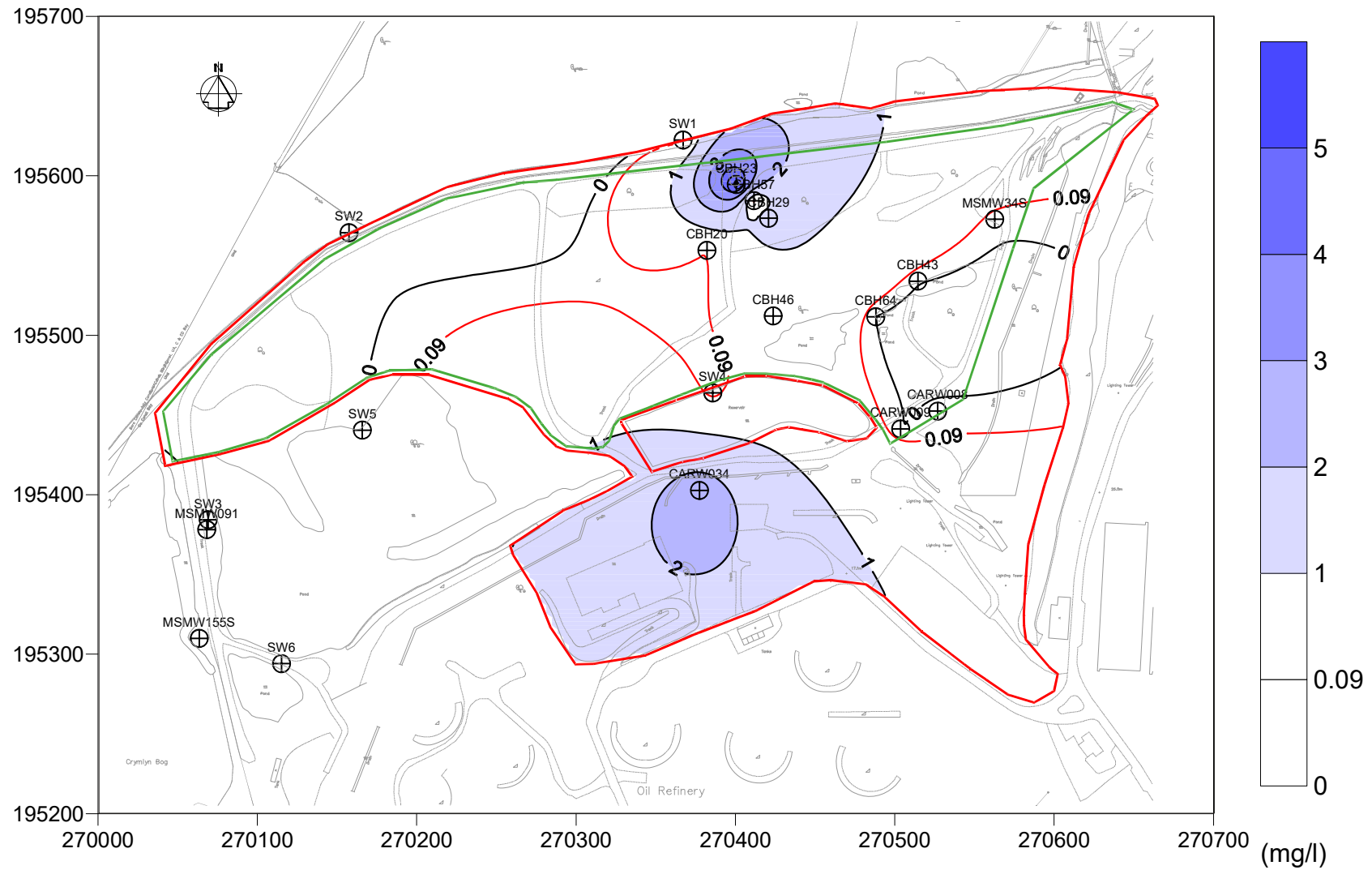
Coed Darcy Tip

Inferred Contours of Aromatics EC16-EC21 (aq) in Groundwater April 2022



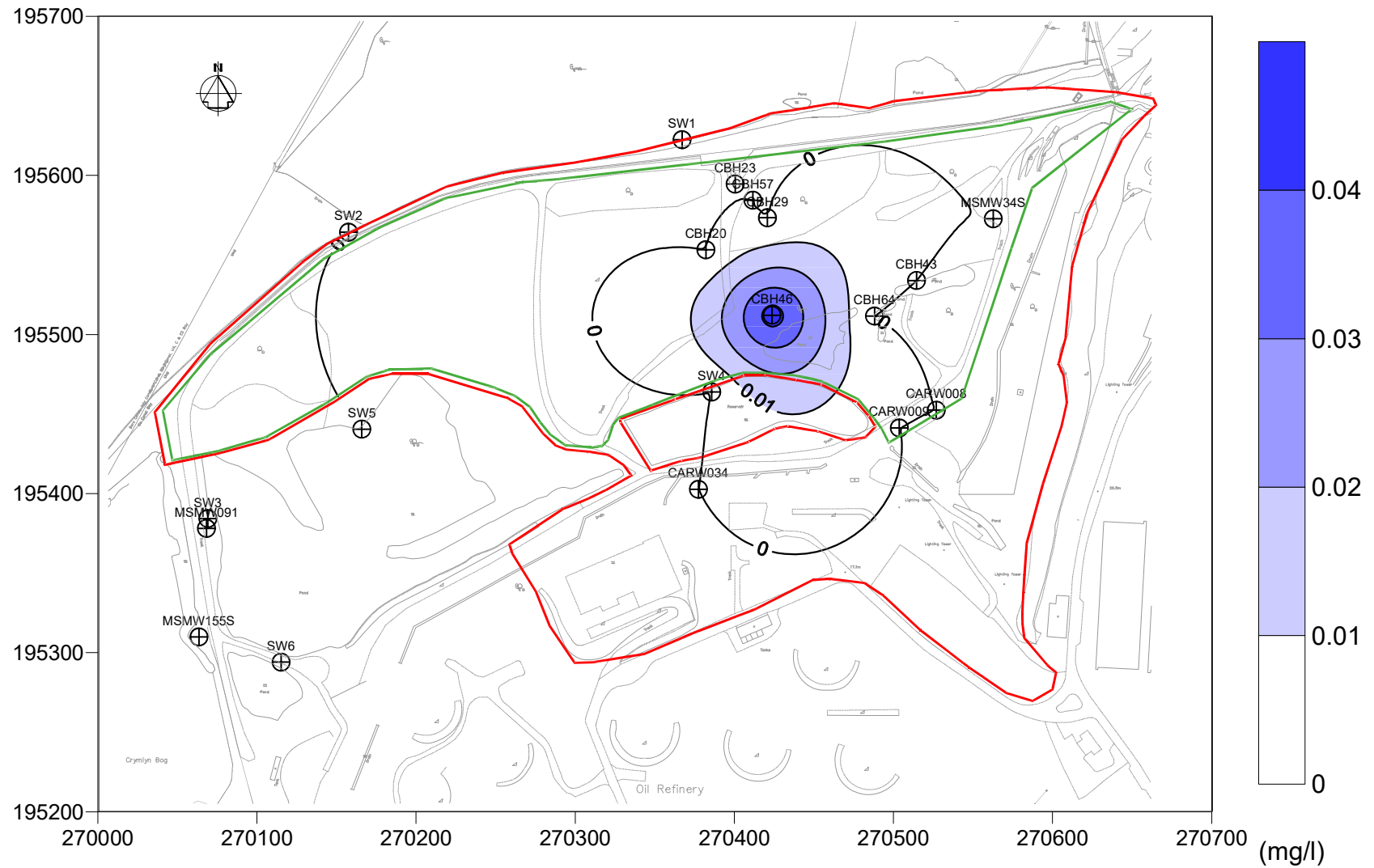
Coed Darcy Tip

Inferred Contours of Aromatics EC21-EC35 (aq) in Groundwater April 2022



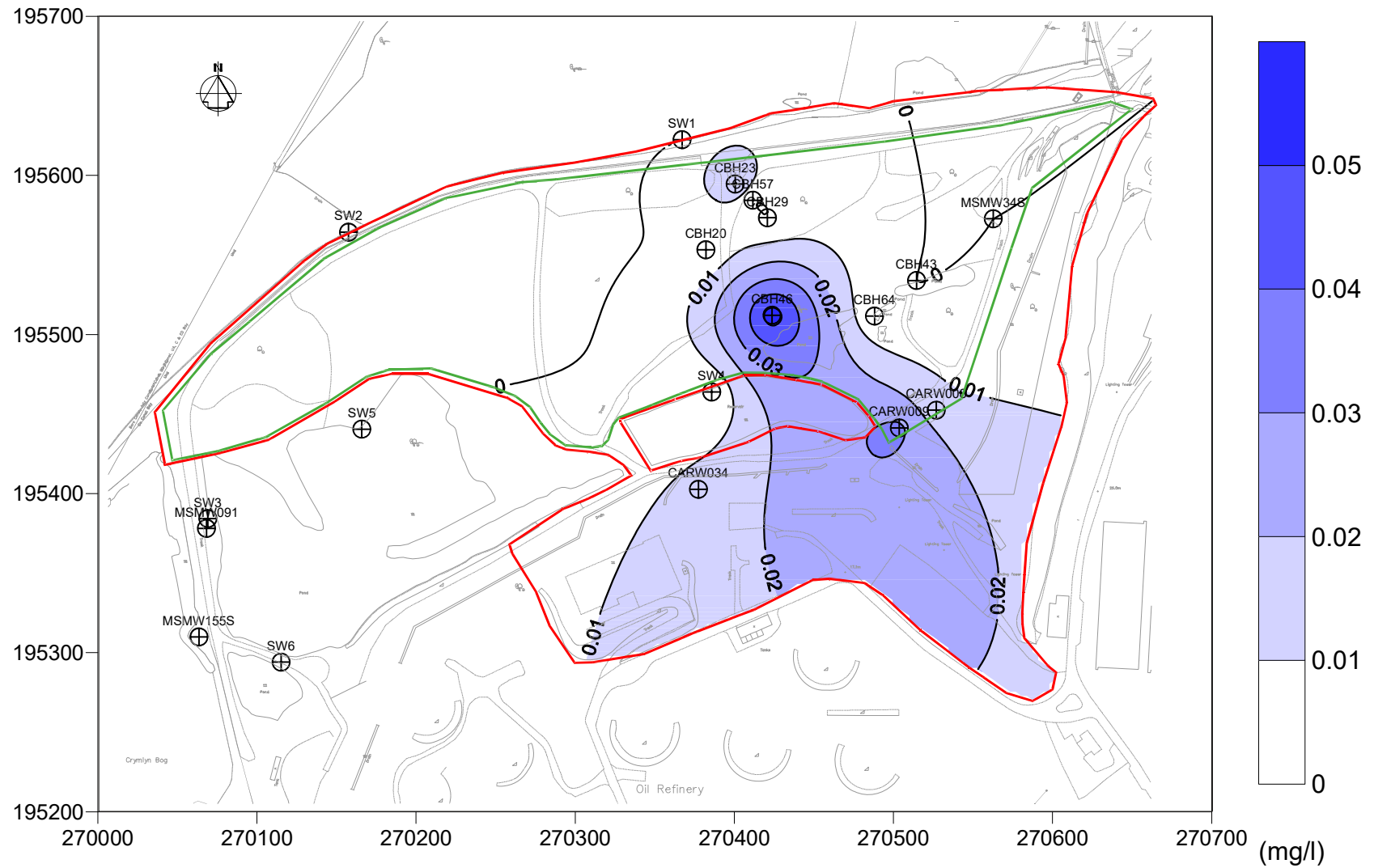
Coed Darcy Tip

Inferred Contours of Aliphatics C5-C6 in Groundwater April 2022



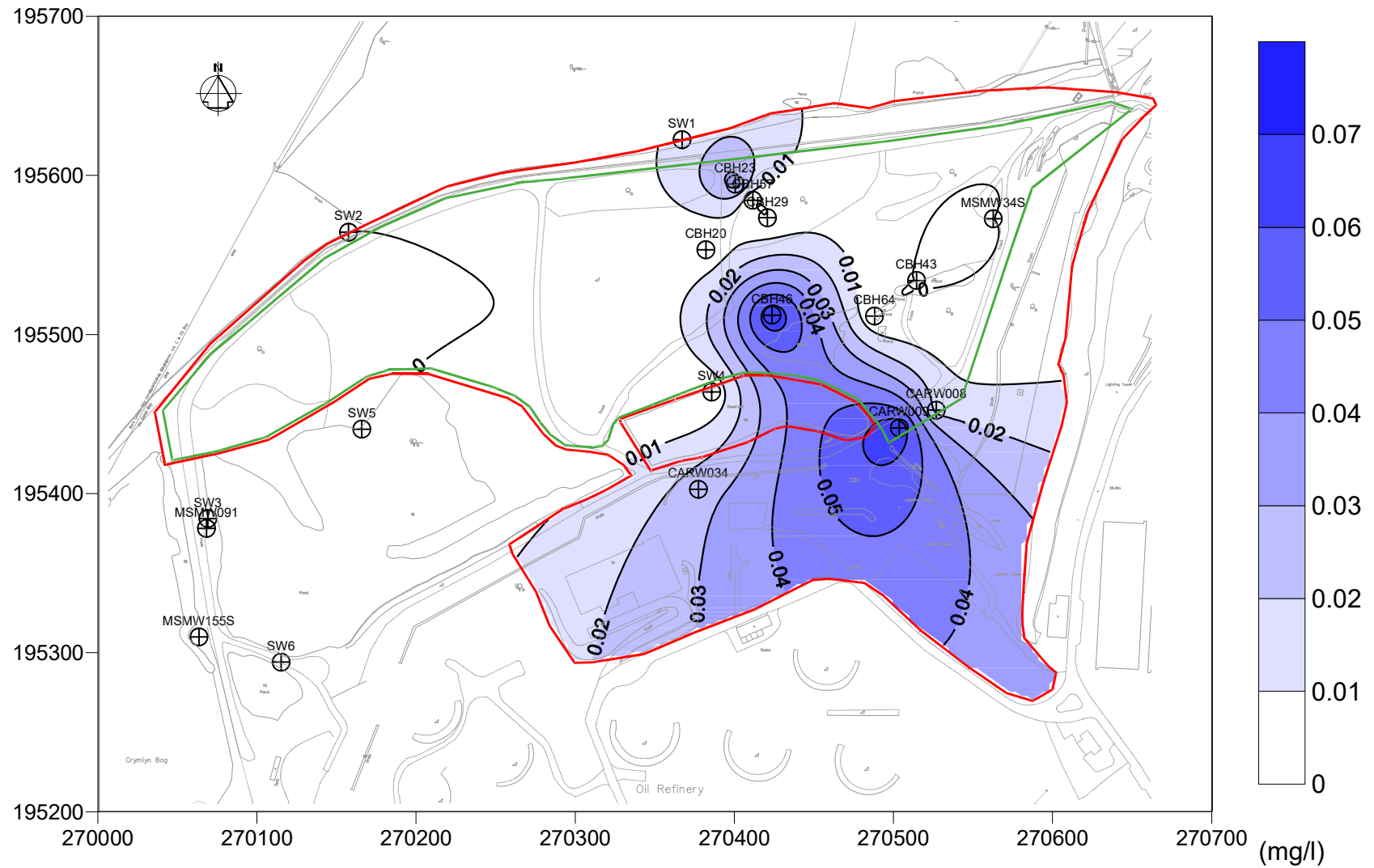
Coed Darcy Tip

Inferred Contours of Aliphatics C6-C8 in Groundwater April 2022



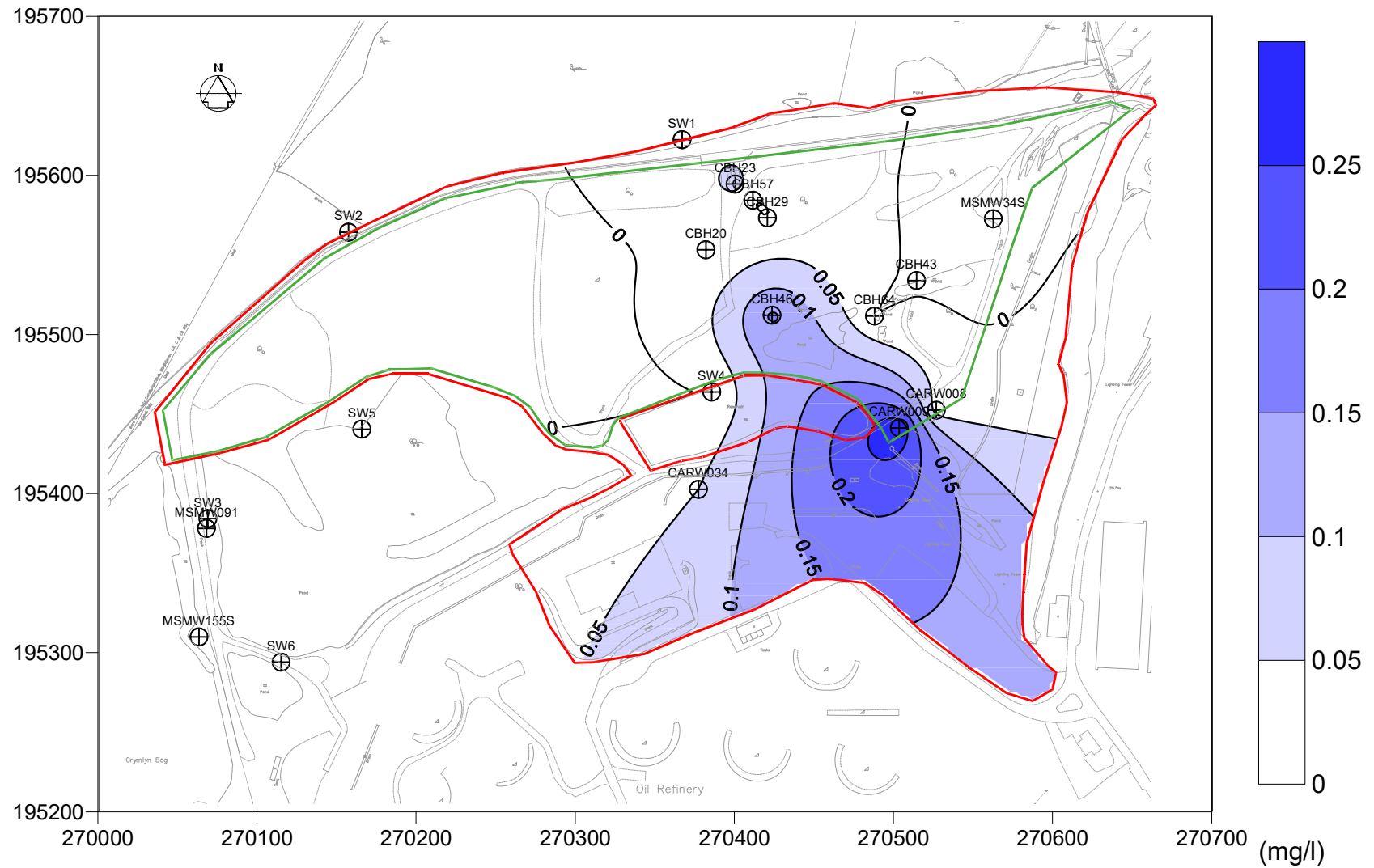
Coed Darcy Tip

Inferred Contours of Aliphatics C8-C10 in Groundwater April 2022



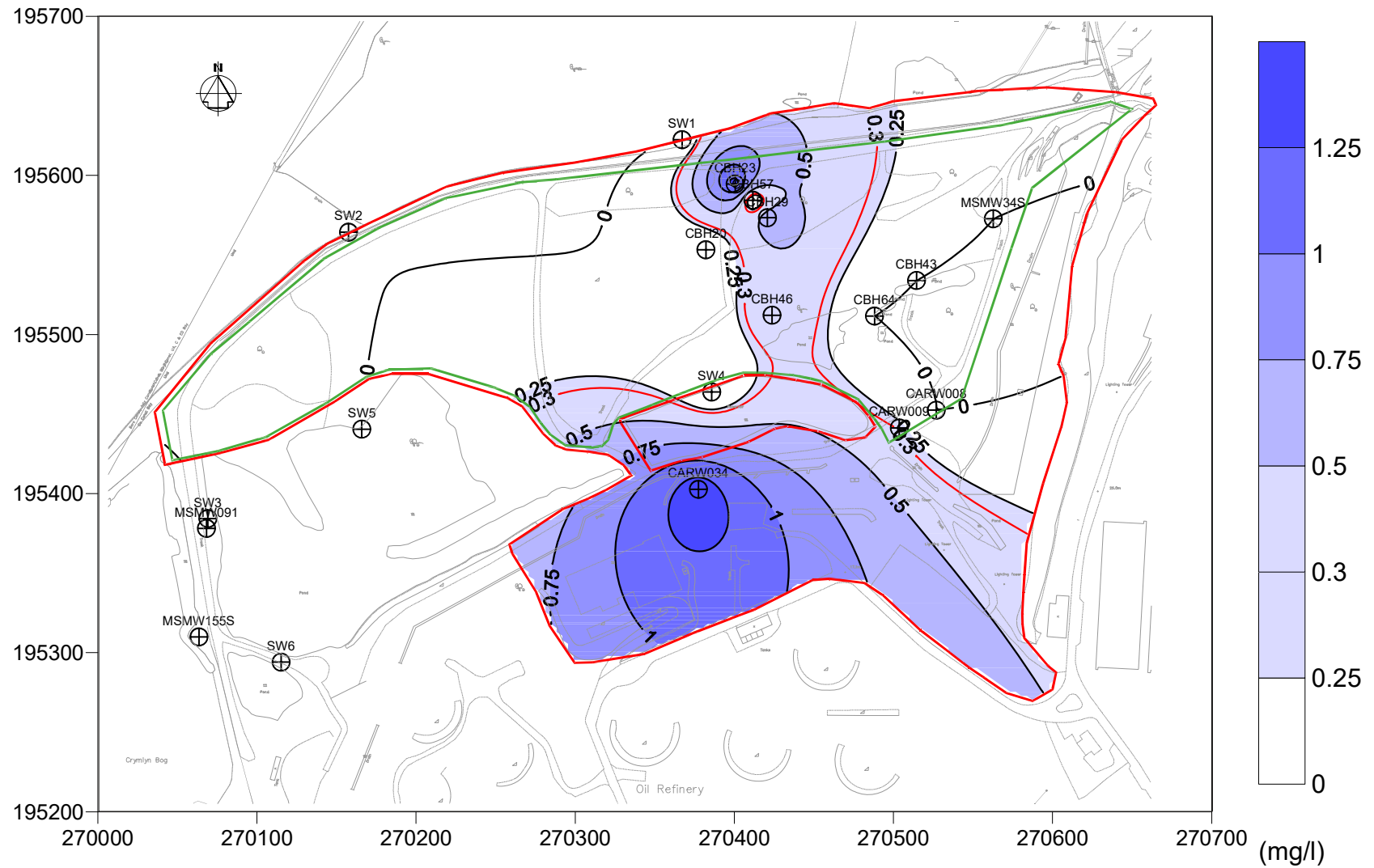
Coed Darcy Tip

Inferred Contours of Aliphatics C10-C12 in Groundwater April 2022



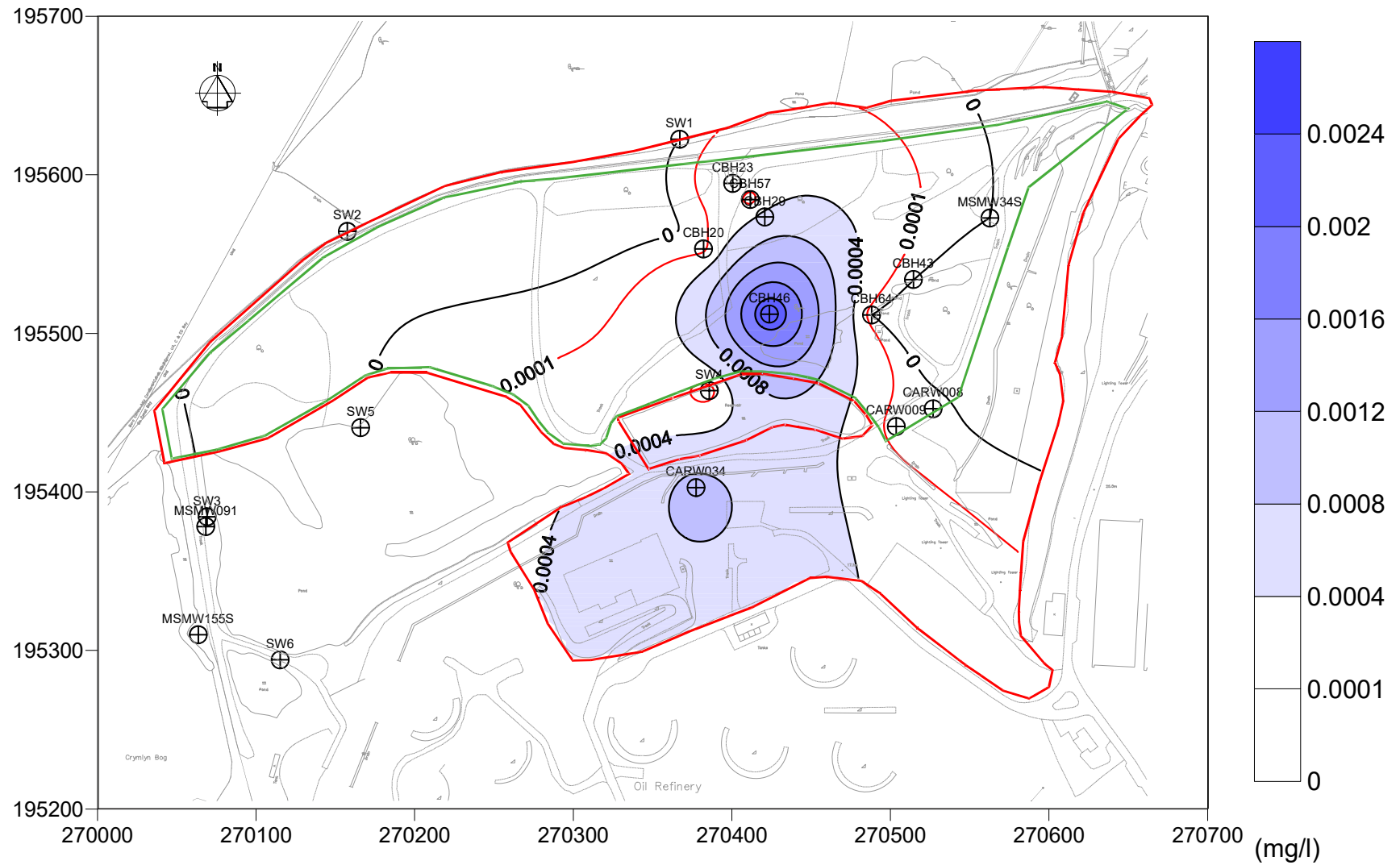
Coed Darcy Tip

Inferred Contours of Aliphatics C12-C16 (aq) in Groundwater April 2022



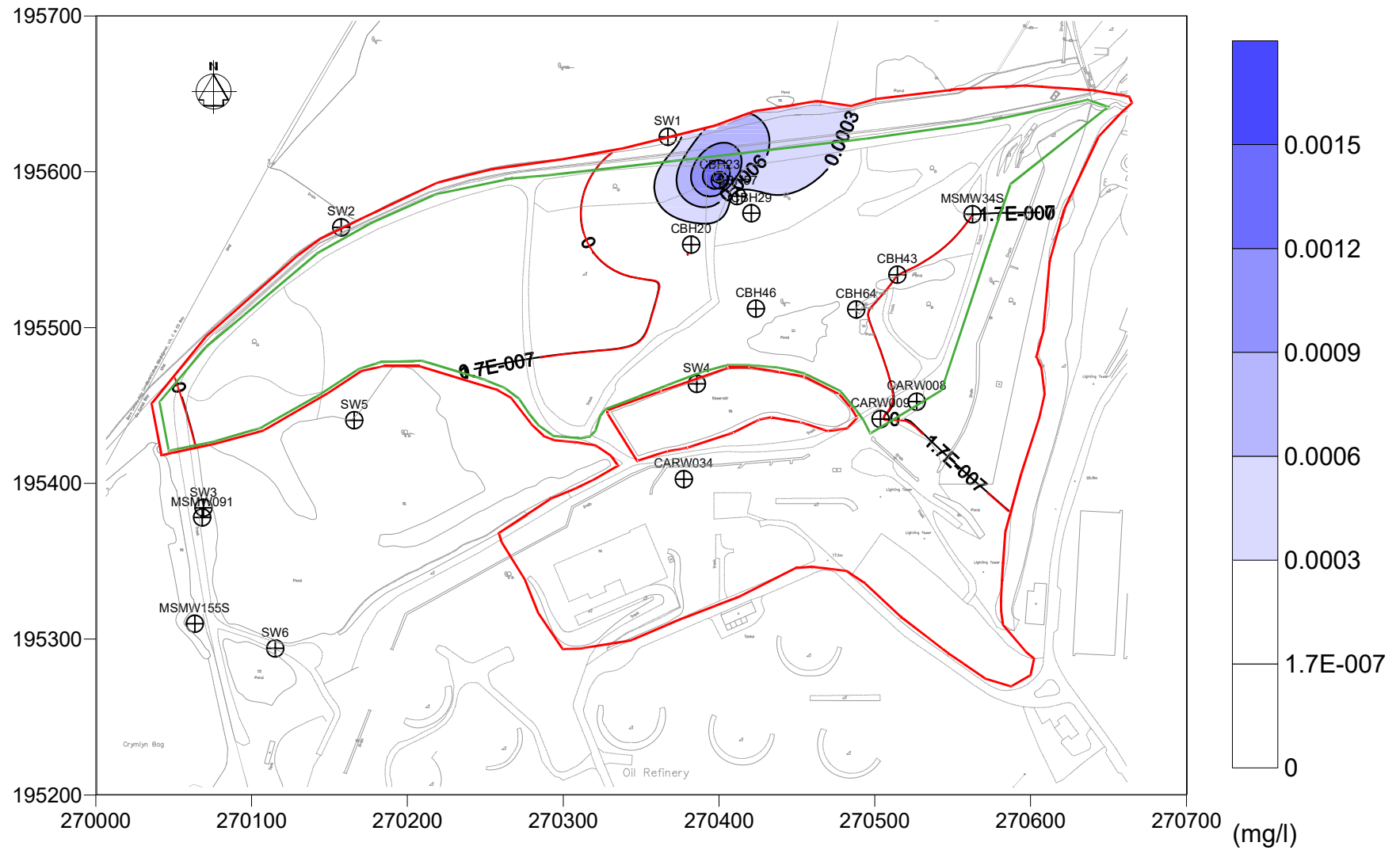
Coed Darcy Tip

Inferred Contours of Anthracene (aq) in Groundwater April 2022



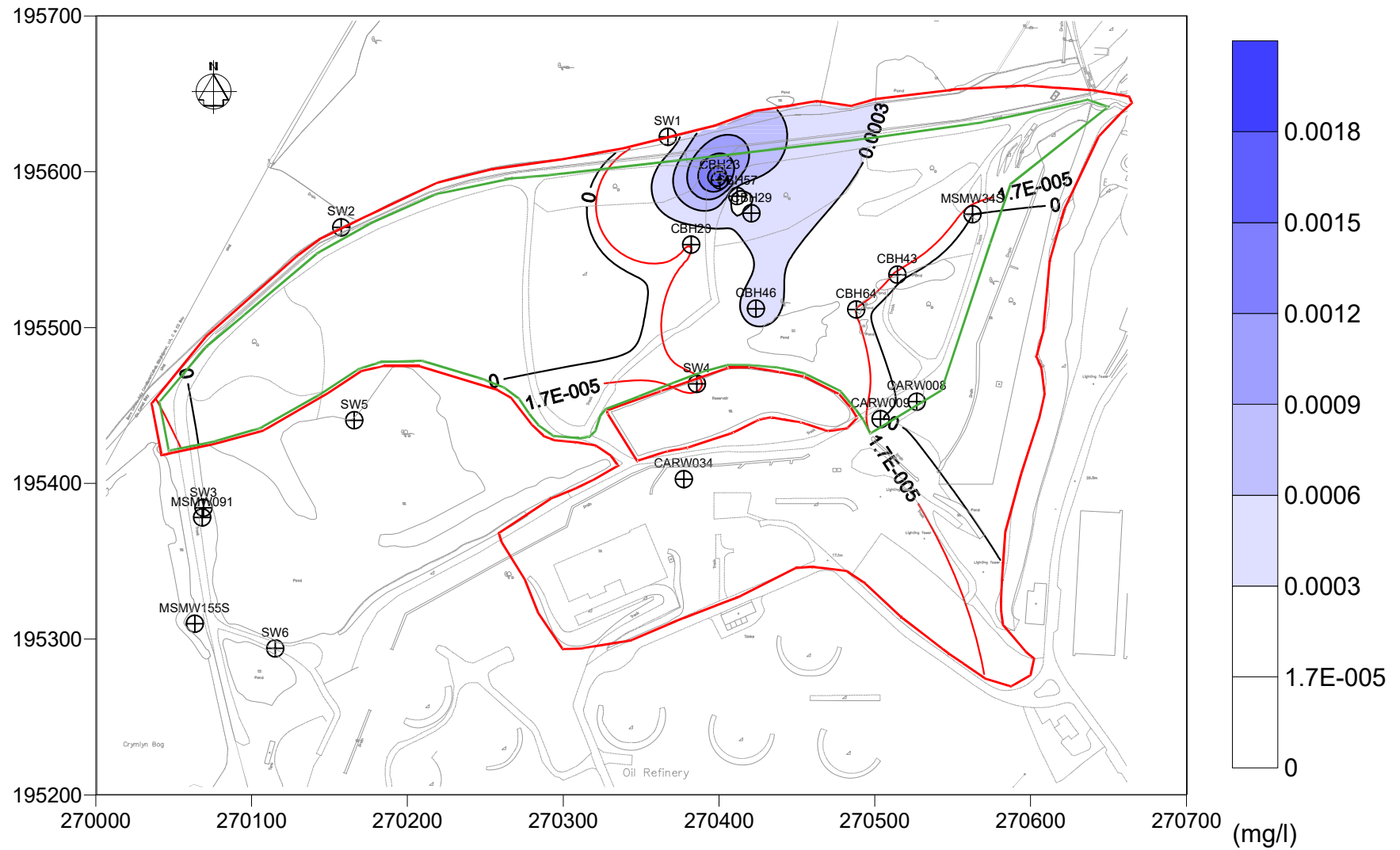
Coed Darcy Tip

Inferred Contours of Benzo(a)pyrene (aq) in Groundwater April 2022



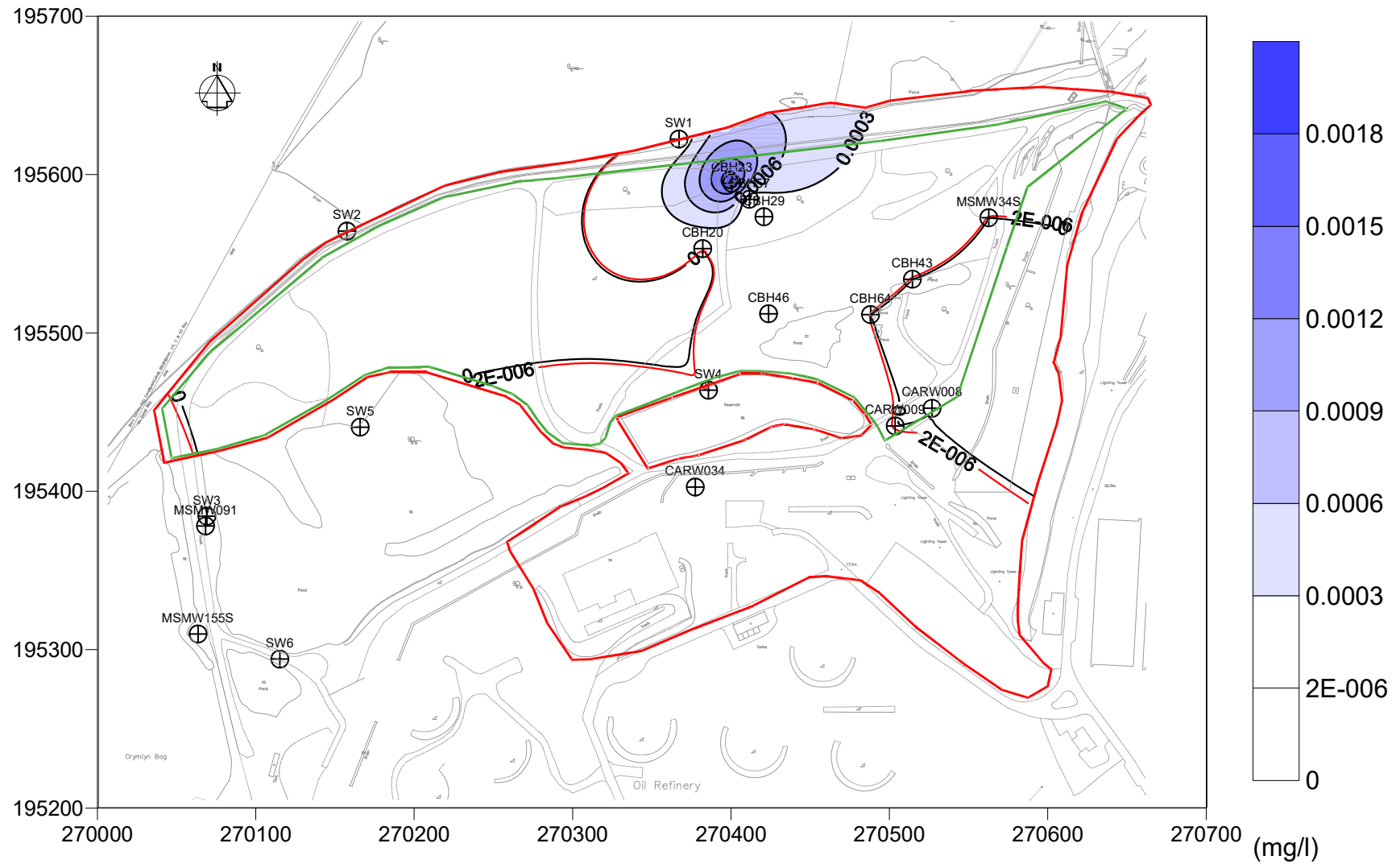
Coed Darcy Tip

Inferred Contours of Benzo(b)fluoranthene (aq) in Groundwater April 2022



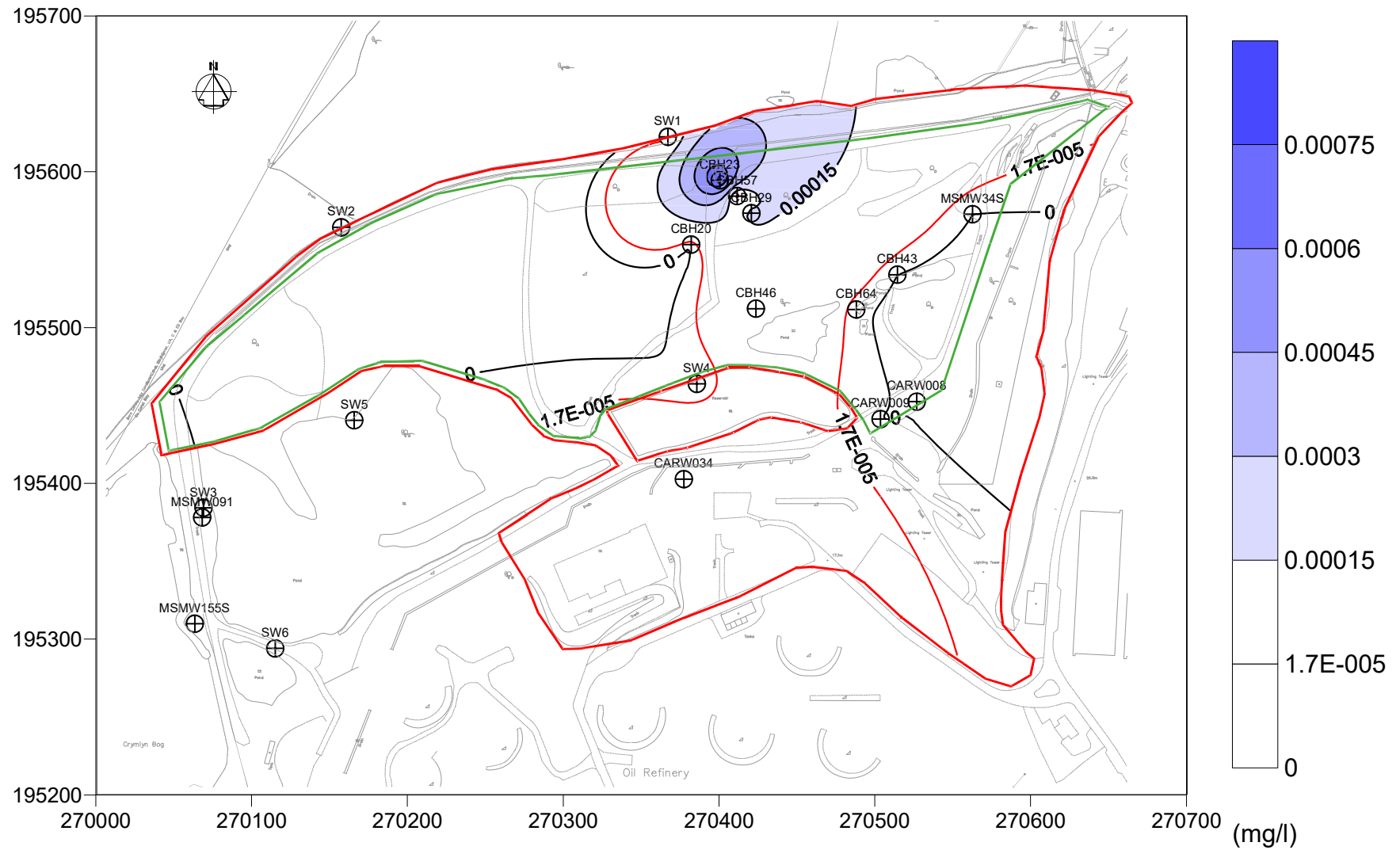
Coed Darcy Tip

Inferred Contours of Benzo(g,h,i)perylene (aq) in Groundwater April 2022



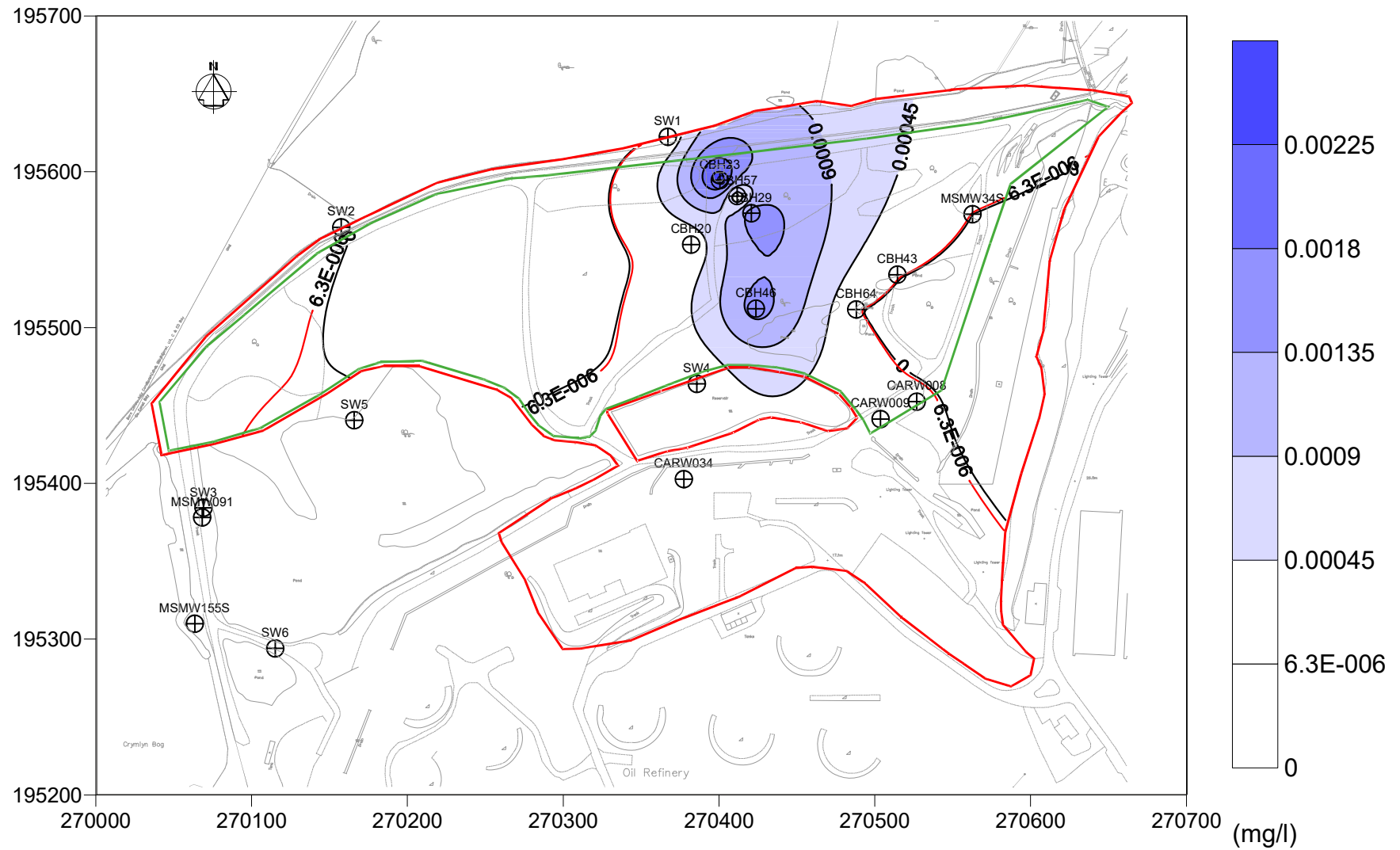
Coed Darcy Tip

Inferred Contours of Benzo(k)fluoranthene (aq) in Groundwater April 2022



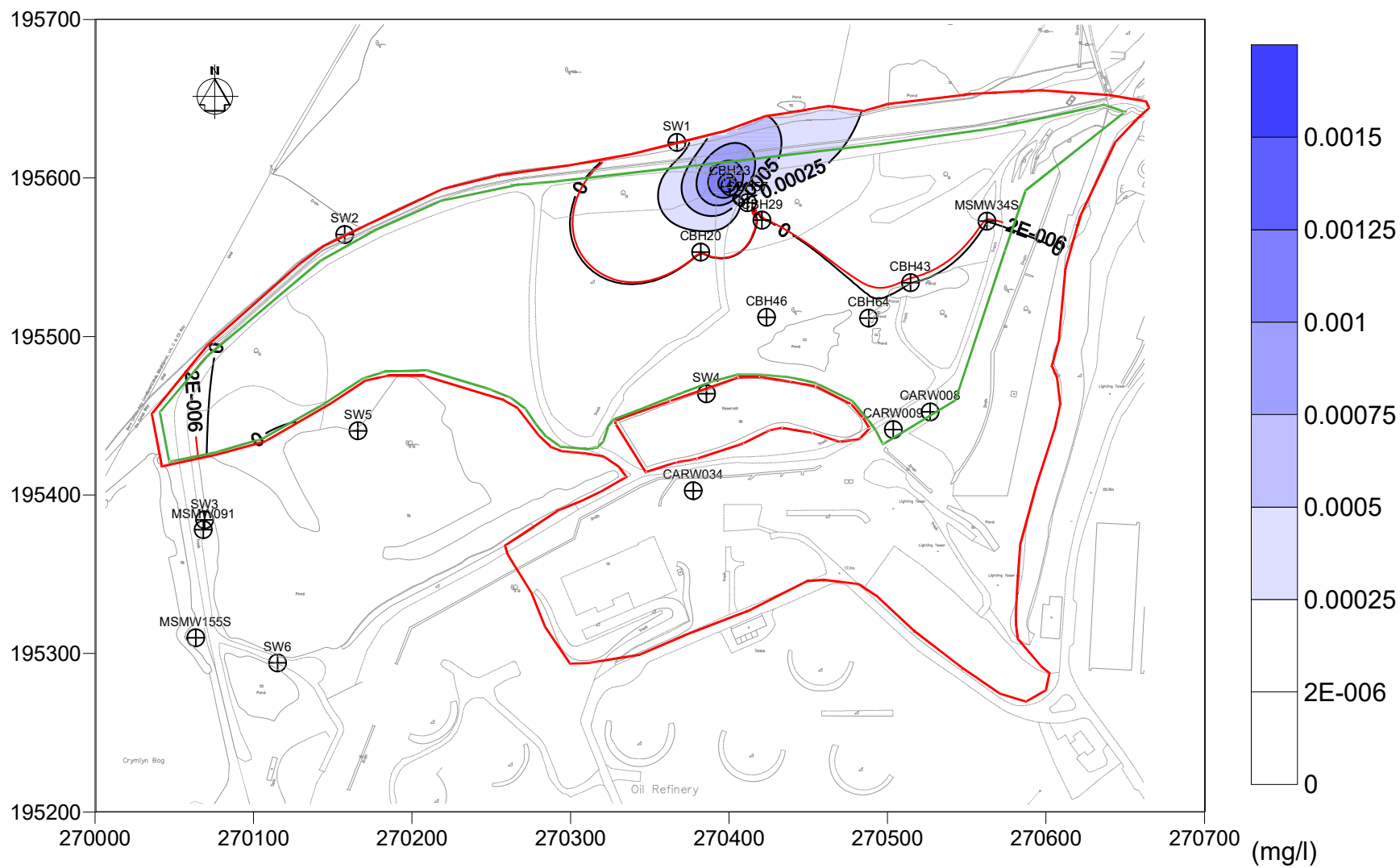
Coed Darcy Tip

Inferred Contours of Fluoranthene (aq) in Groundwater April 2022



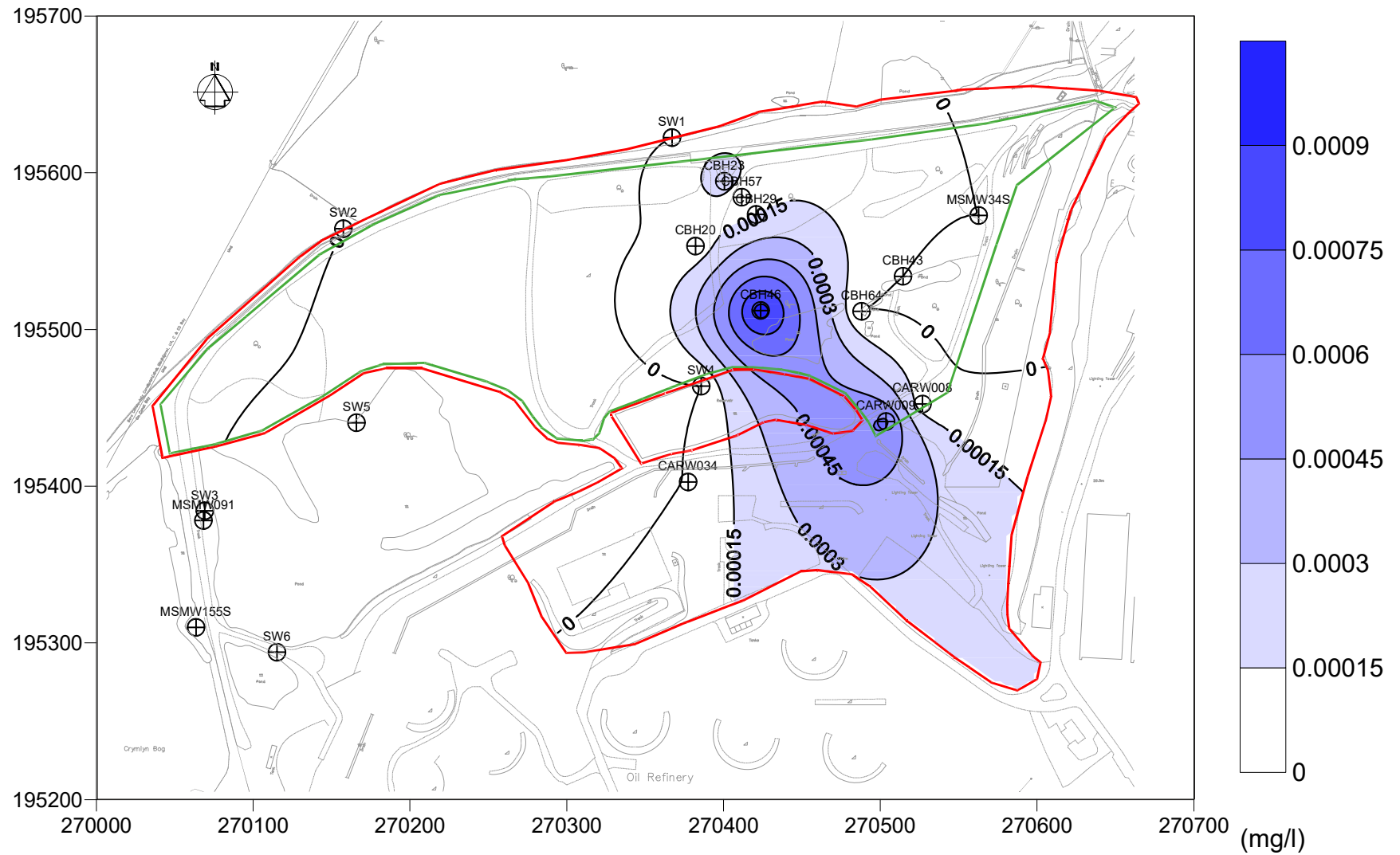
Coed Darcy Tip

Inferred Contours of Indeno(1,2,3-cd)pyrene (aq) in Groundwater April 2022



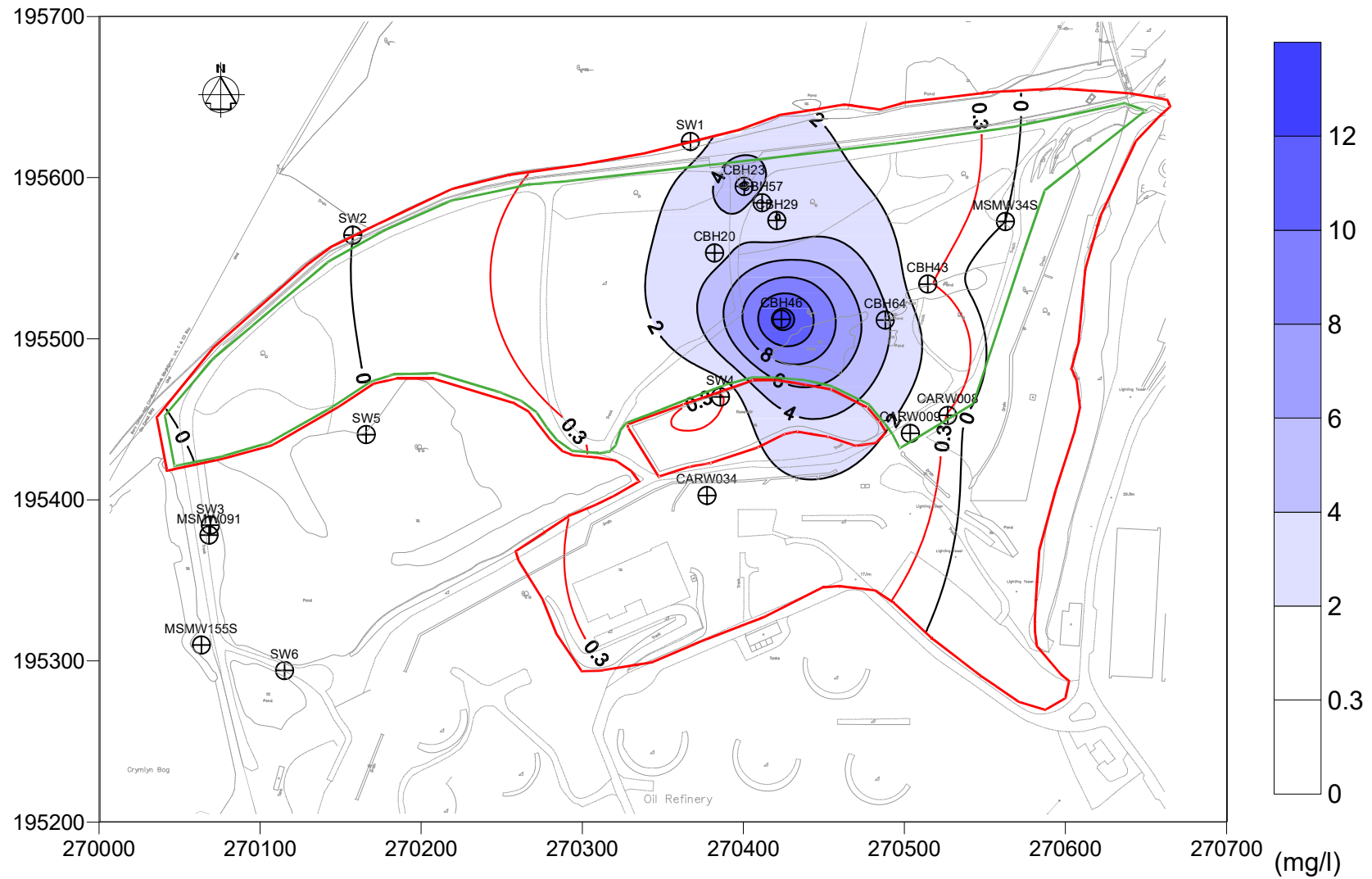
Coed Darcy Tip

Inferred Contours of Naphthalene (aq) in Groundwater April 2022



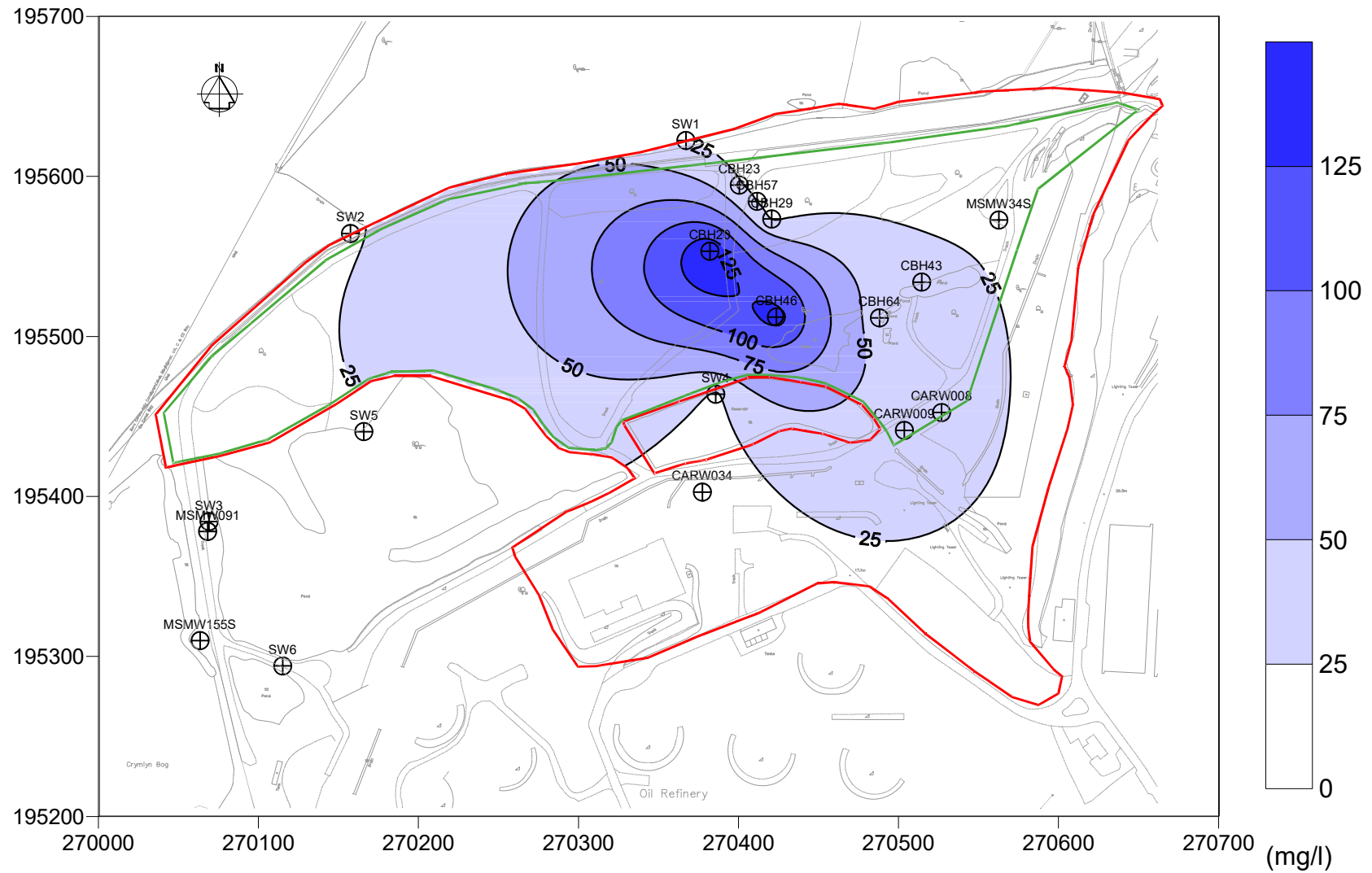
Coed Darcy Tip

Inferred Contours of Ammoniacal Nitrogen as N in Groundwater April 2022



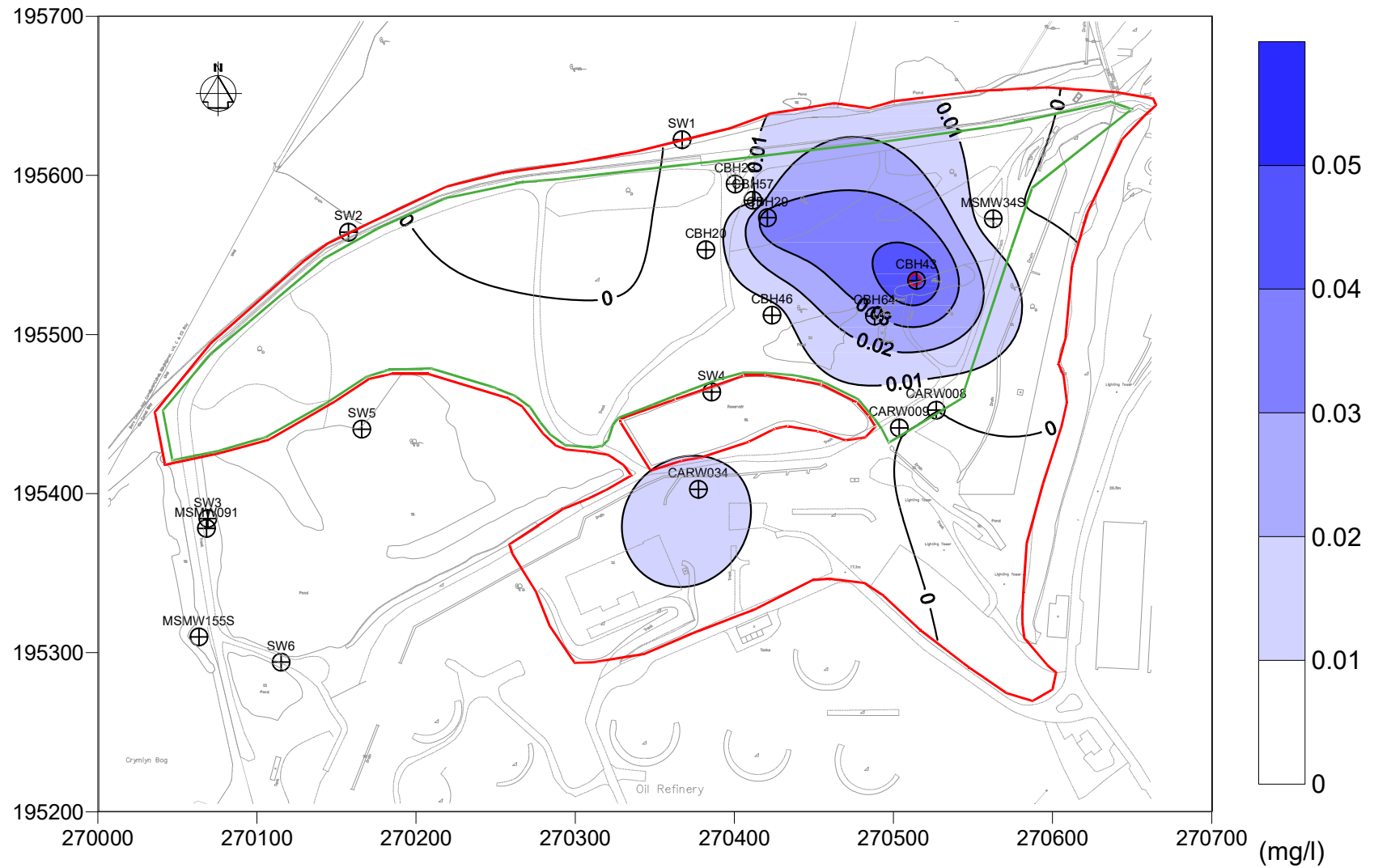
Coed Darcy Tip

Inferred Contours of Chloride in Groundwater April 2022



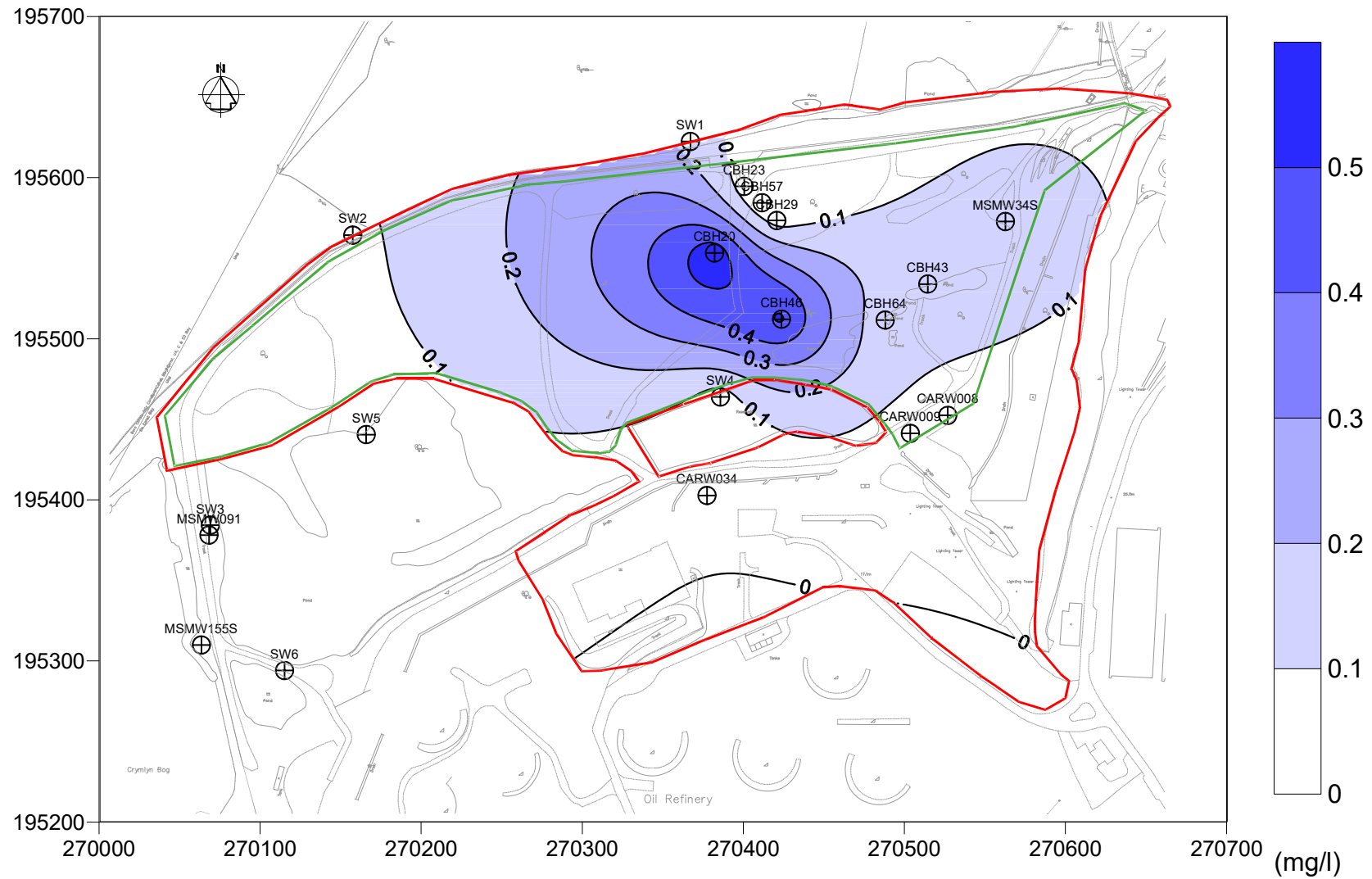
Coed Darcy Tip

Inferred Contours of Arsenic (diss.filt) in Groundwater April 2022



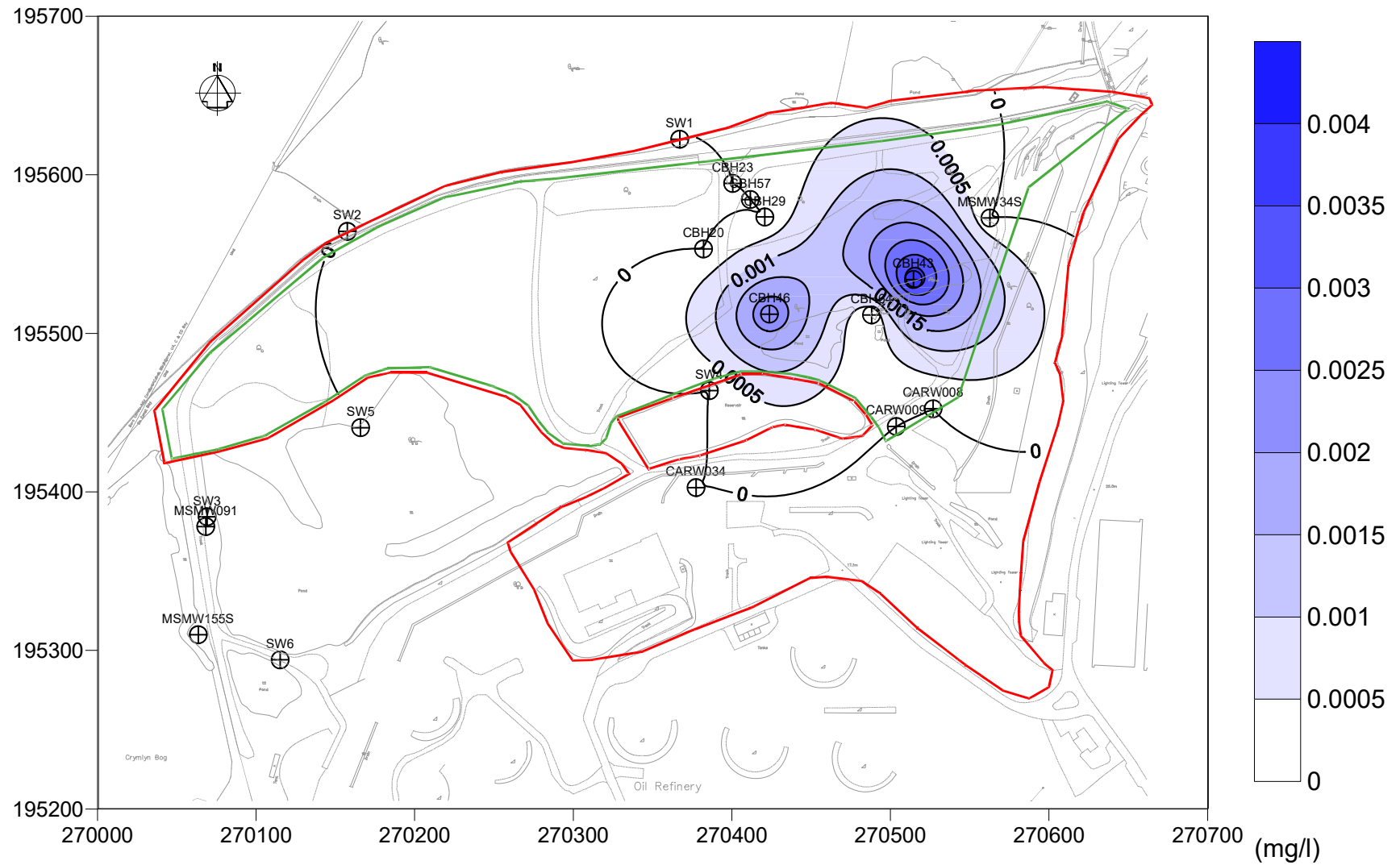
Coed Darcy Tip

Inferred Contours of Boron (diss.filt) in Groundwater April 2022



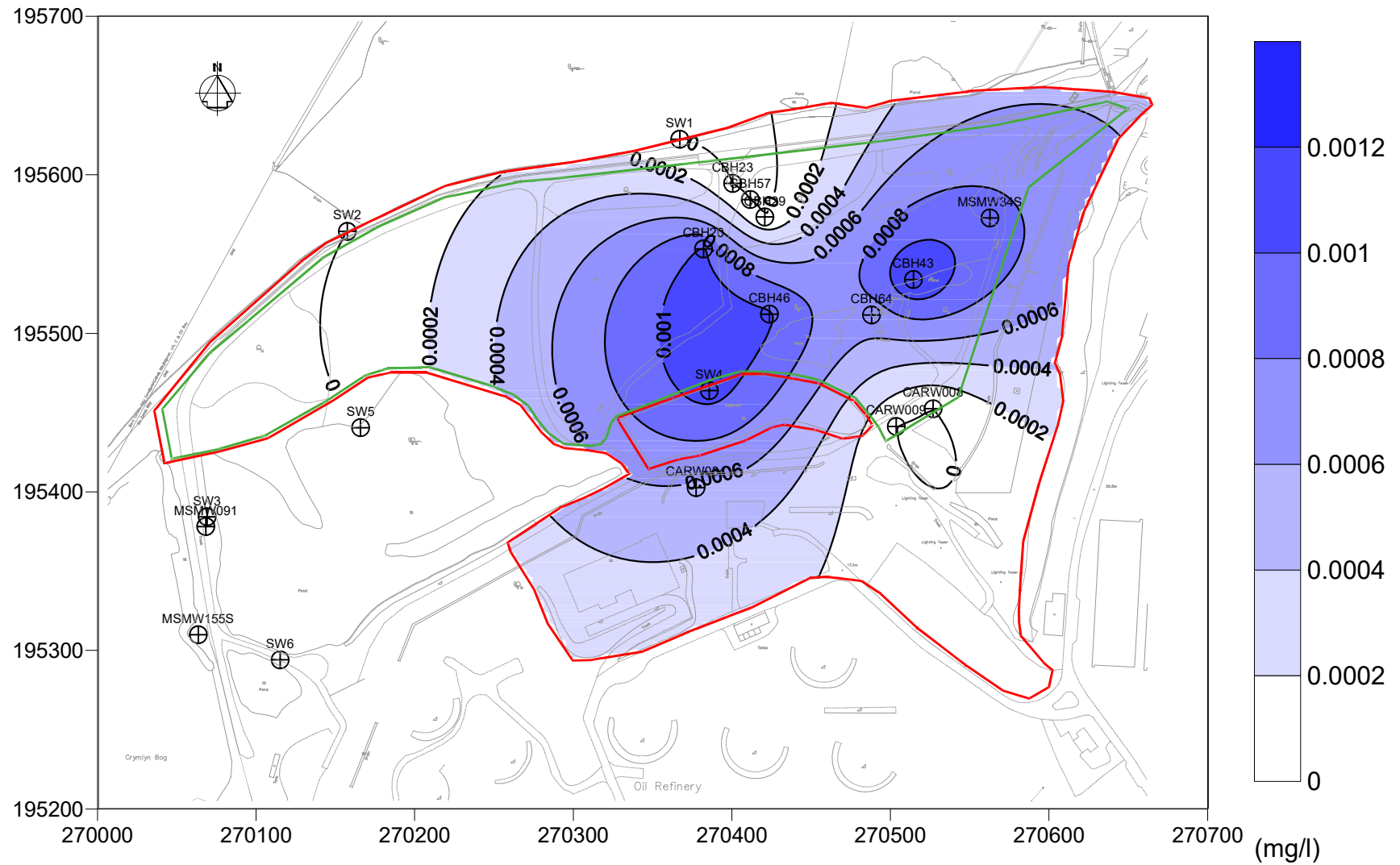
Coed Darcy Tip

Inferred Contours of Chromium (diss.filt) in Groundwater April 2022



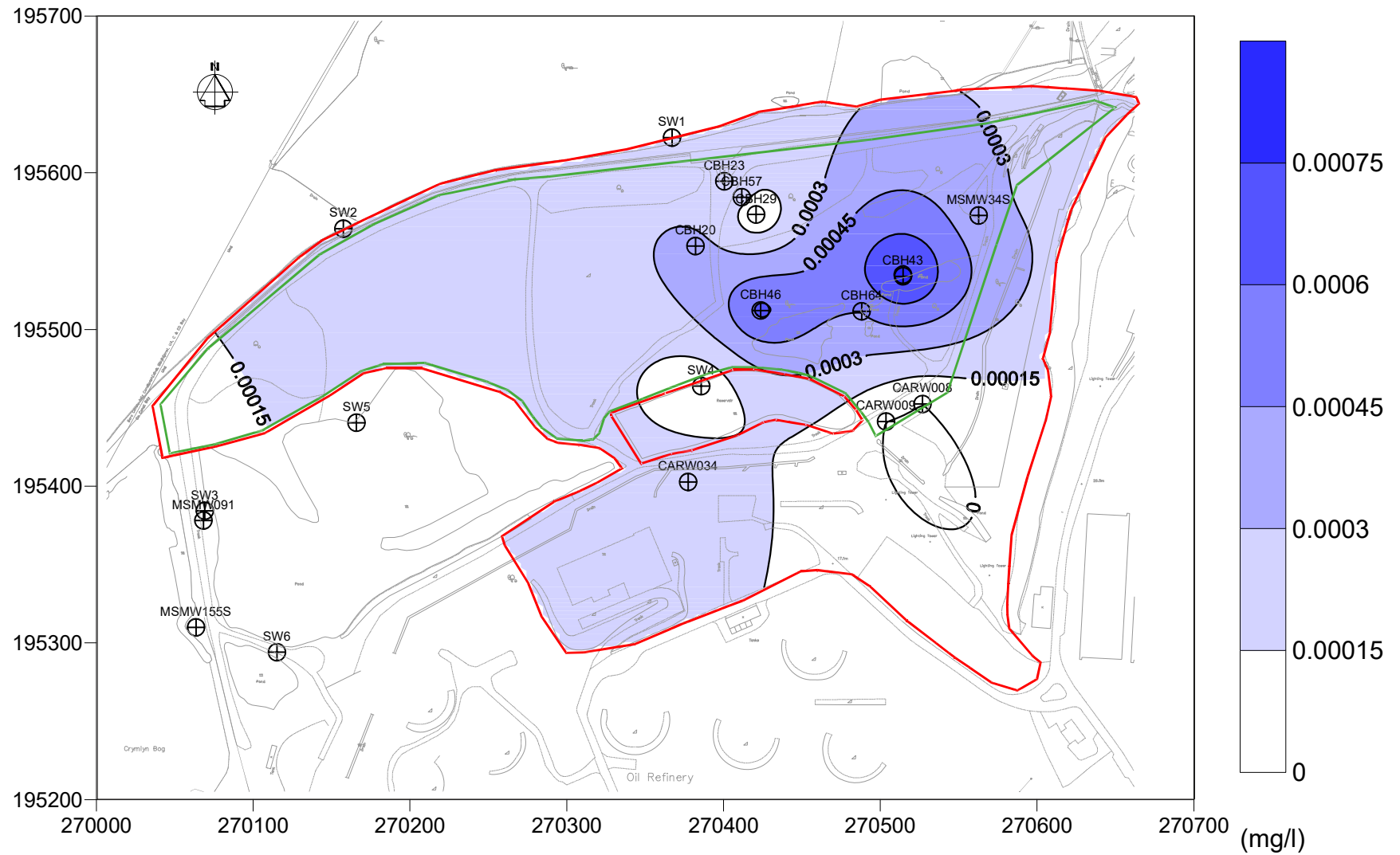
Coed Darcy Tip

Inferred Contours of Copper (diss.filt) in Groundwater April 2022



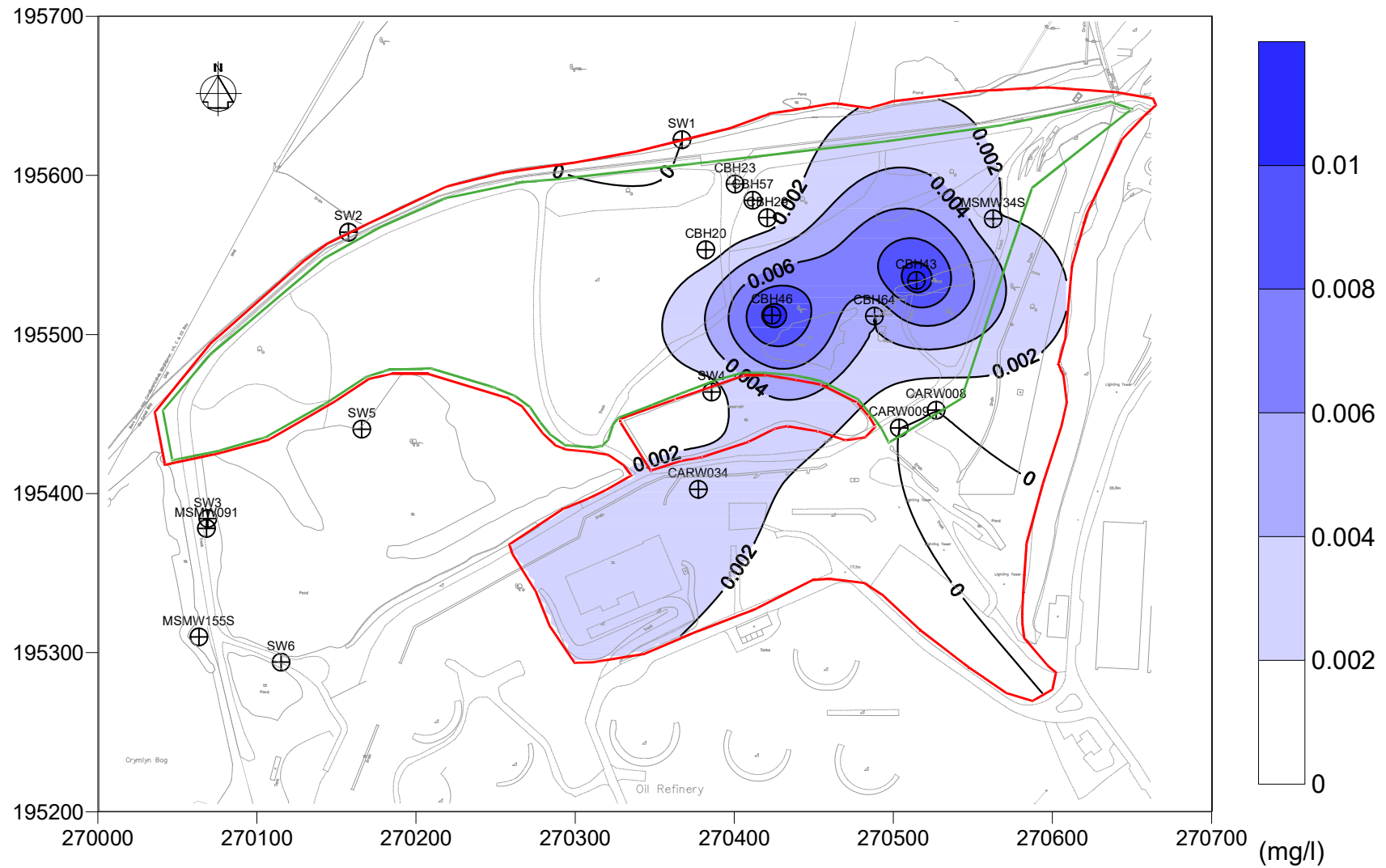
Coed Darcy Tip

Inferred Contours of Lead (diss.filt) in Groundwater April 2022



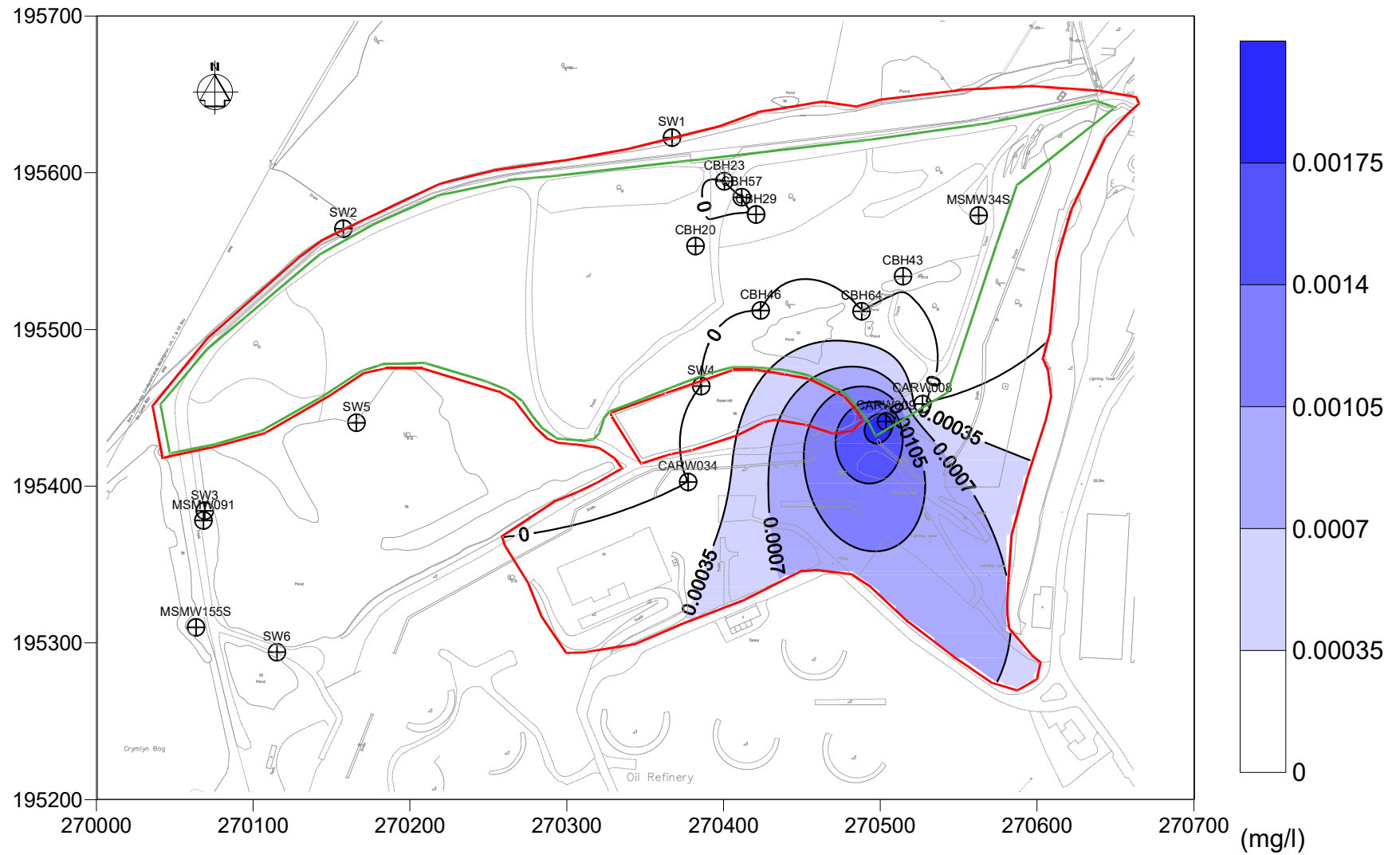
Coed Darcy Tip

Inferred Contours of Nickel (diss.filt) in Groundwater April 2022



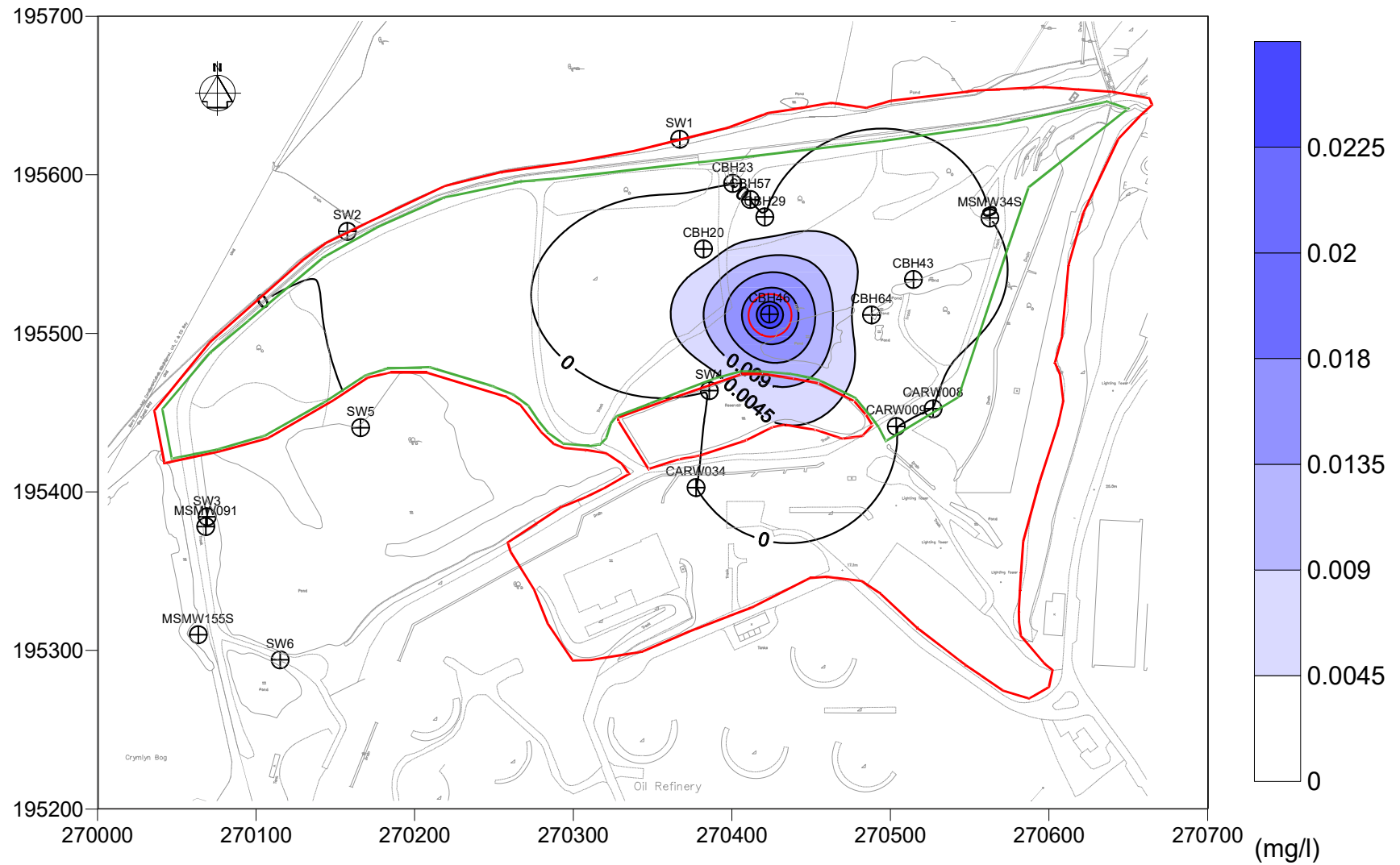
Coed Darcy Tip

Inferred Contours of Selenium (diss.filt) in Groundwater April 2022

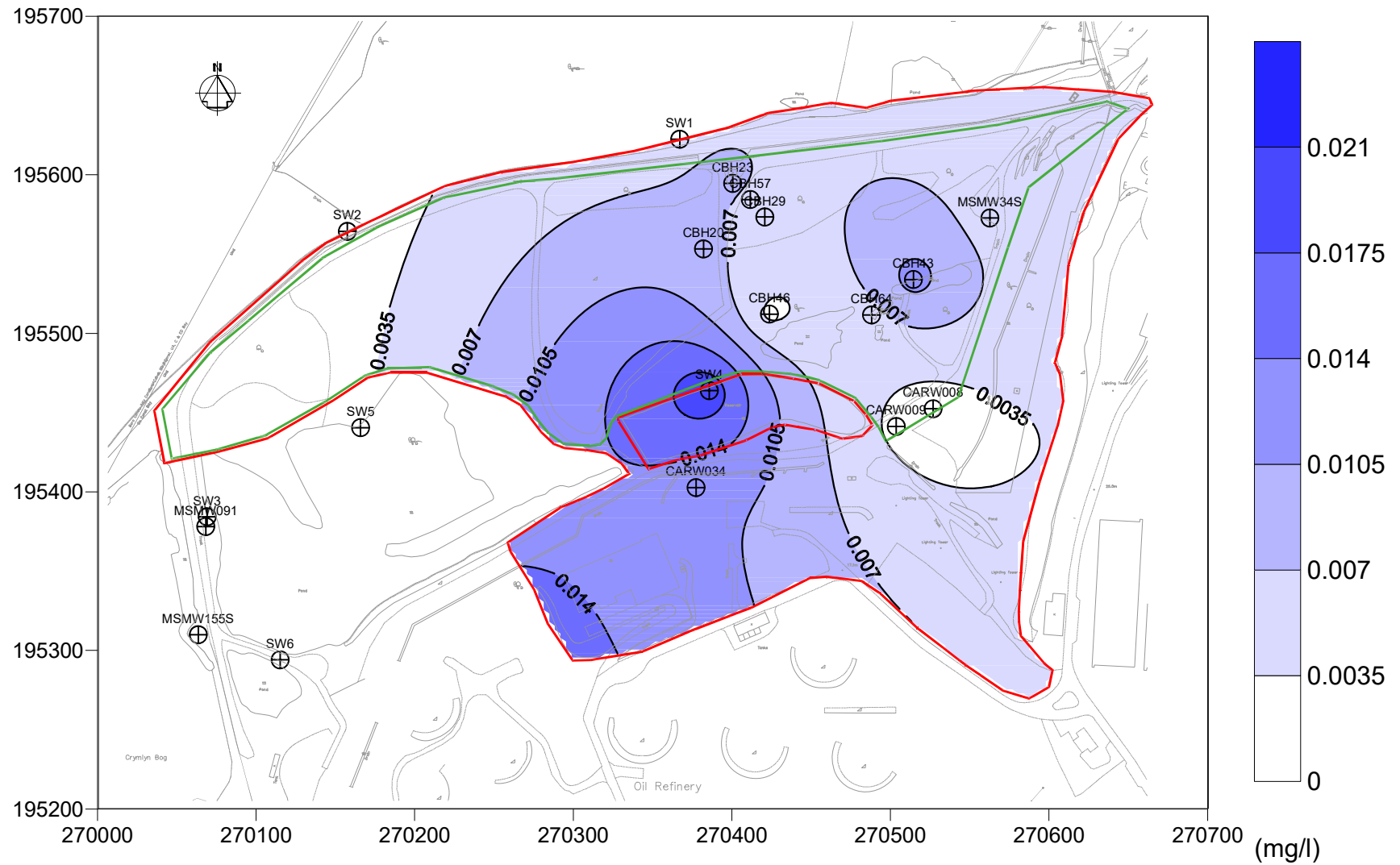


Coed Darcy Tip

Inferred Contours of Vanadium (diss.filt) in Groundwater April 2022



Inferred Contours of Zinc (diss.filt) in Groundwater April 2022



Compliance Criterion = 0.079 (mg/l) : Compliance Criterion Exceeds Data Maximum Value

Data Maximum Value = 0.0223 (mg/l)

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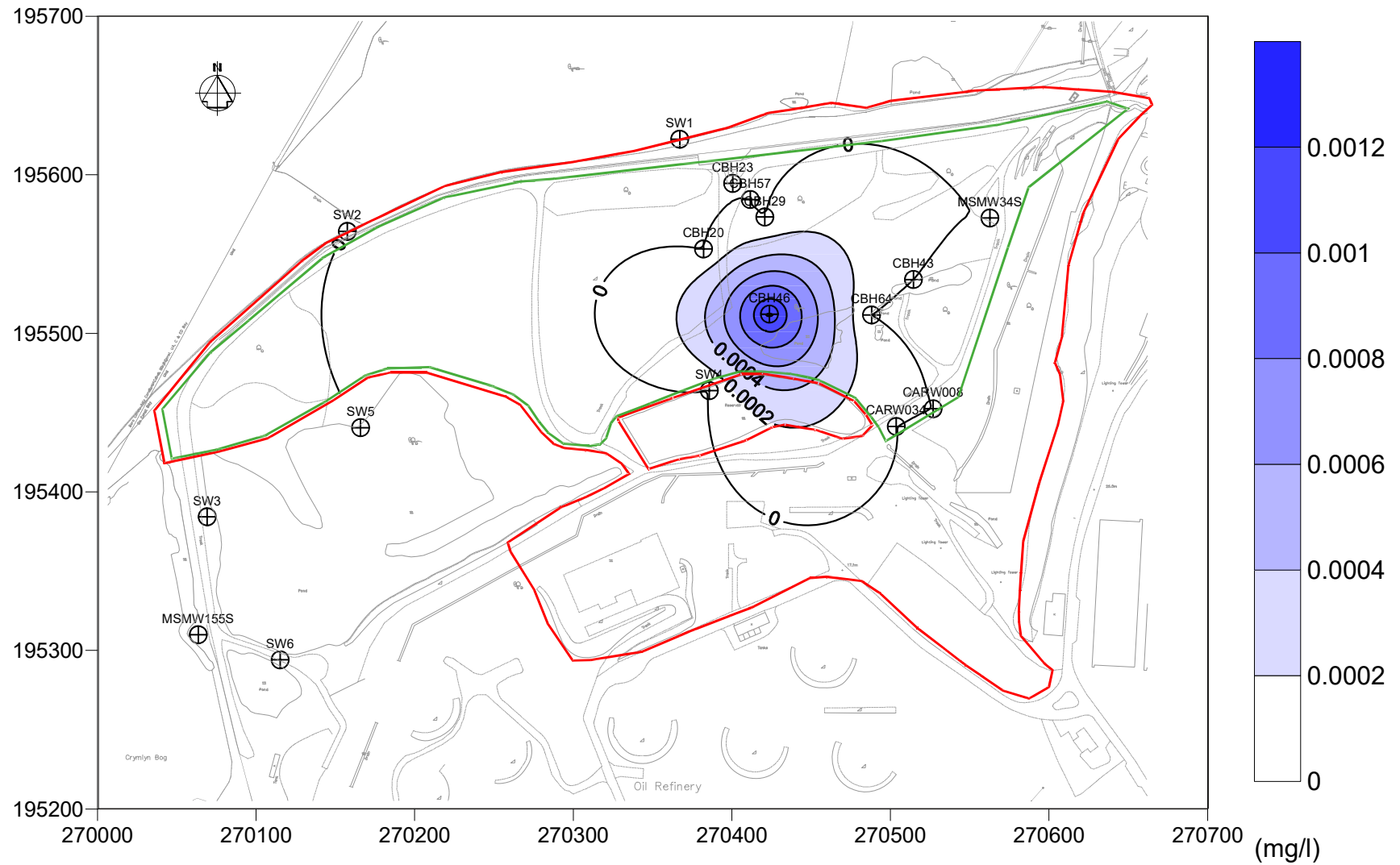
Chem Plots



eNGLOBE

Coed Darcy Tip

Inferred Contours of Benzene in Groundwater May 2022

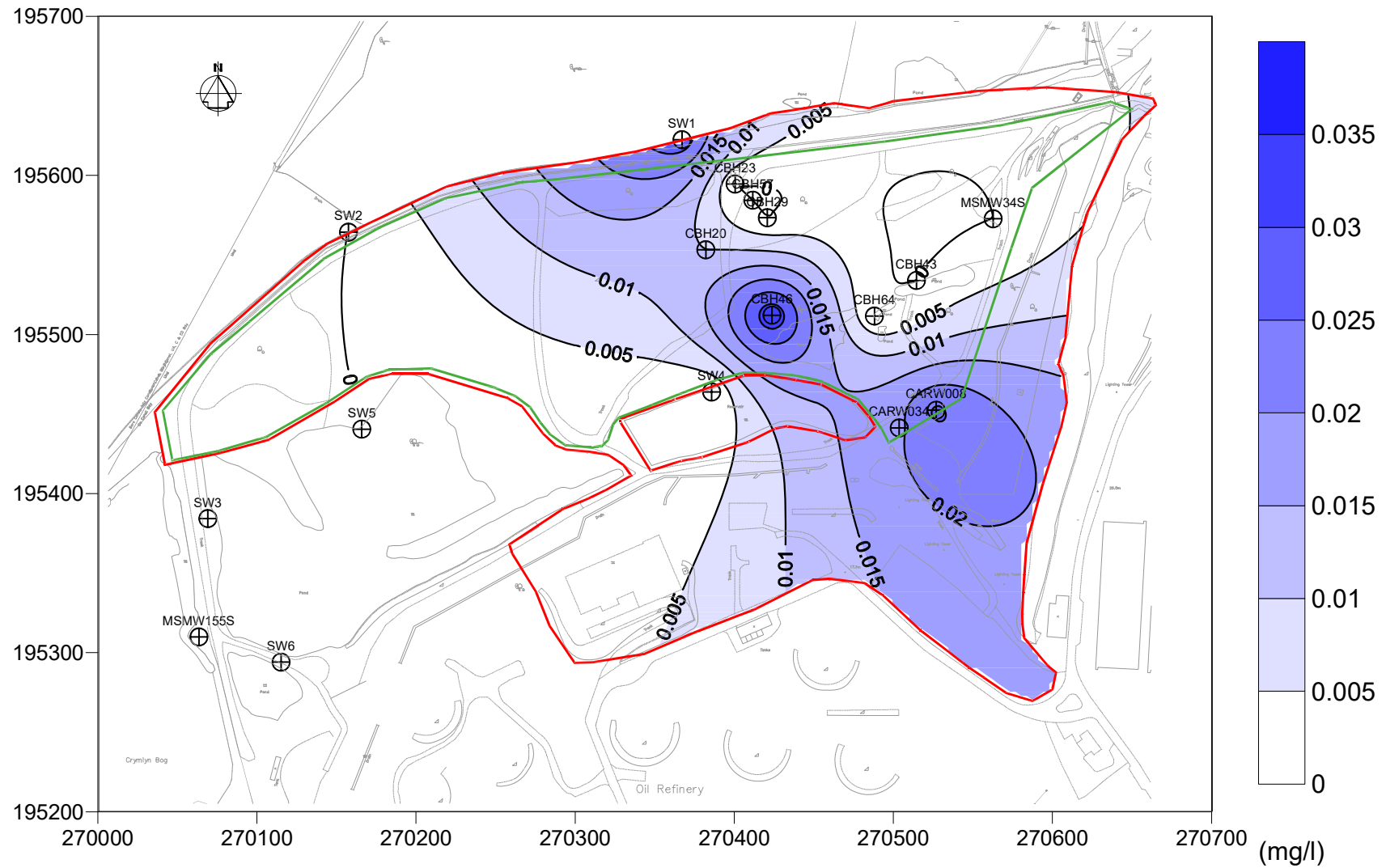


Compliance Criterion = 0.01 (mg/l) : Compliance Criterion Exceeds Data Maximum Value

Data Maximum Value = 0.00125 (mg/l)

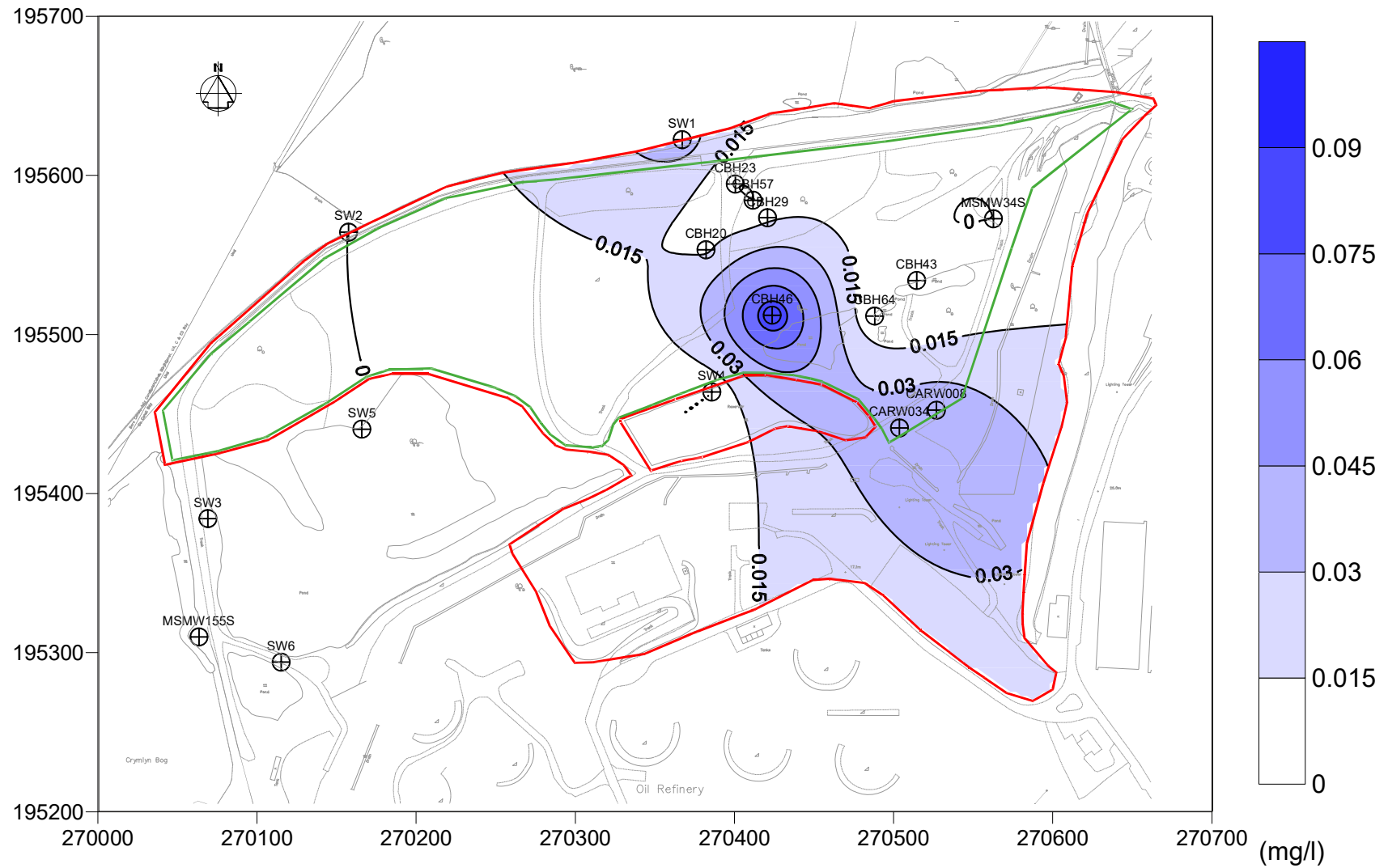
Coed Darcy Tip

Inferred Contours of Aromatics EC8-EC10 in Groundwater May 2022



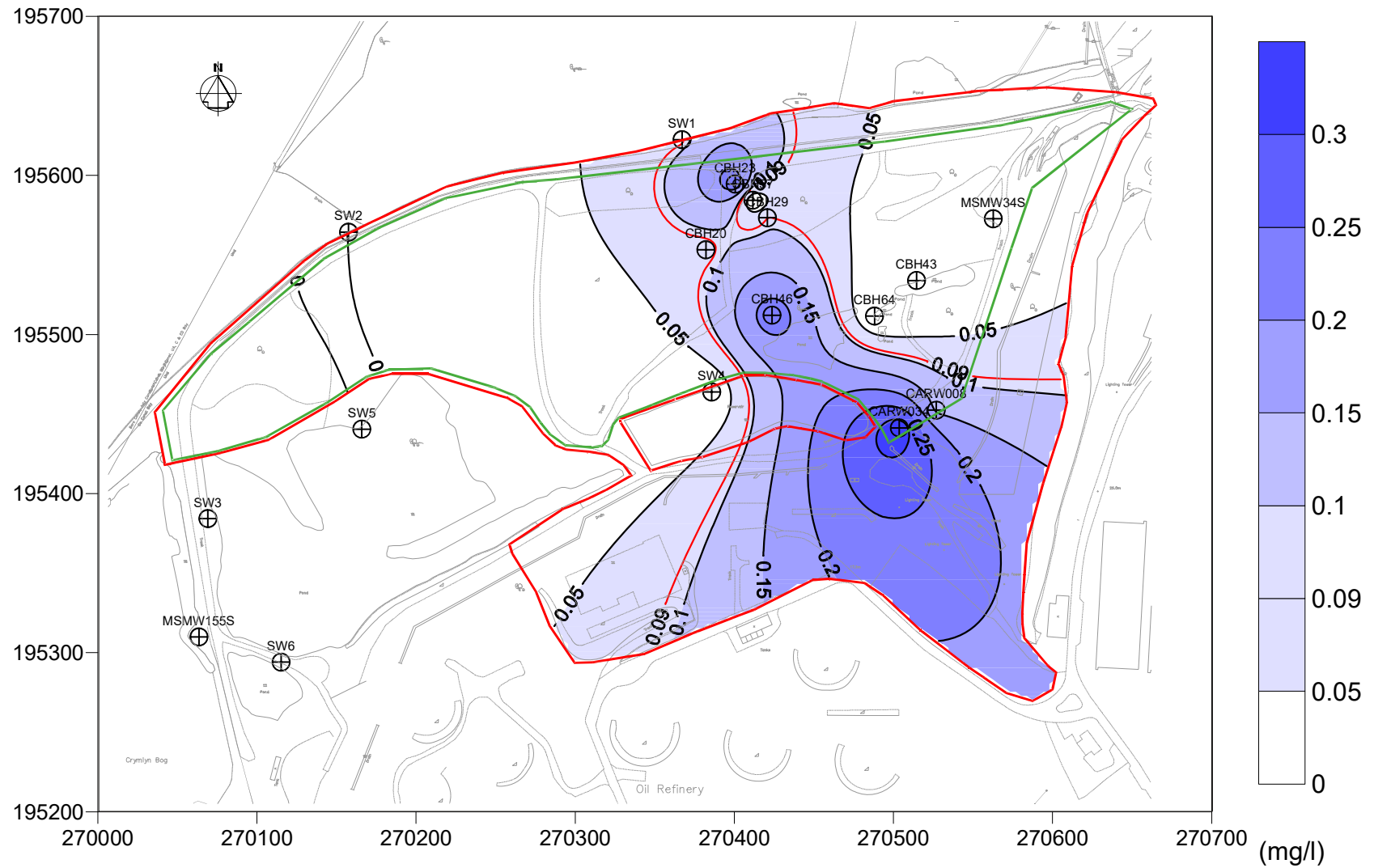
Coed Darcy Tip

Inferred Contours of Aromatics EC10-EC12 in Groundwater May 2022



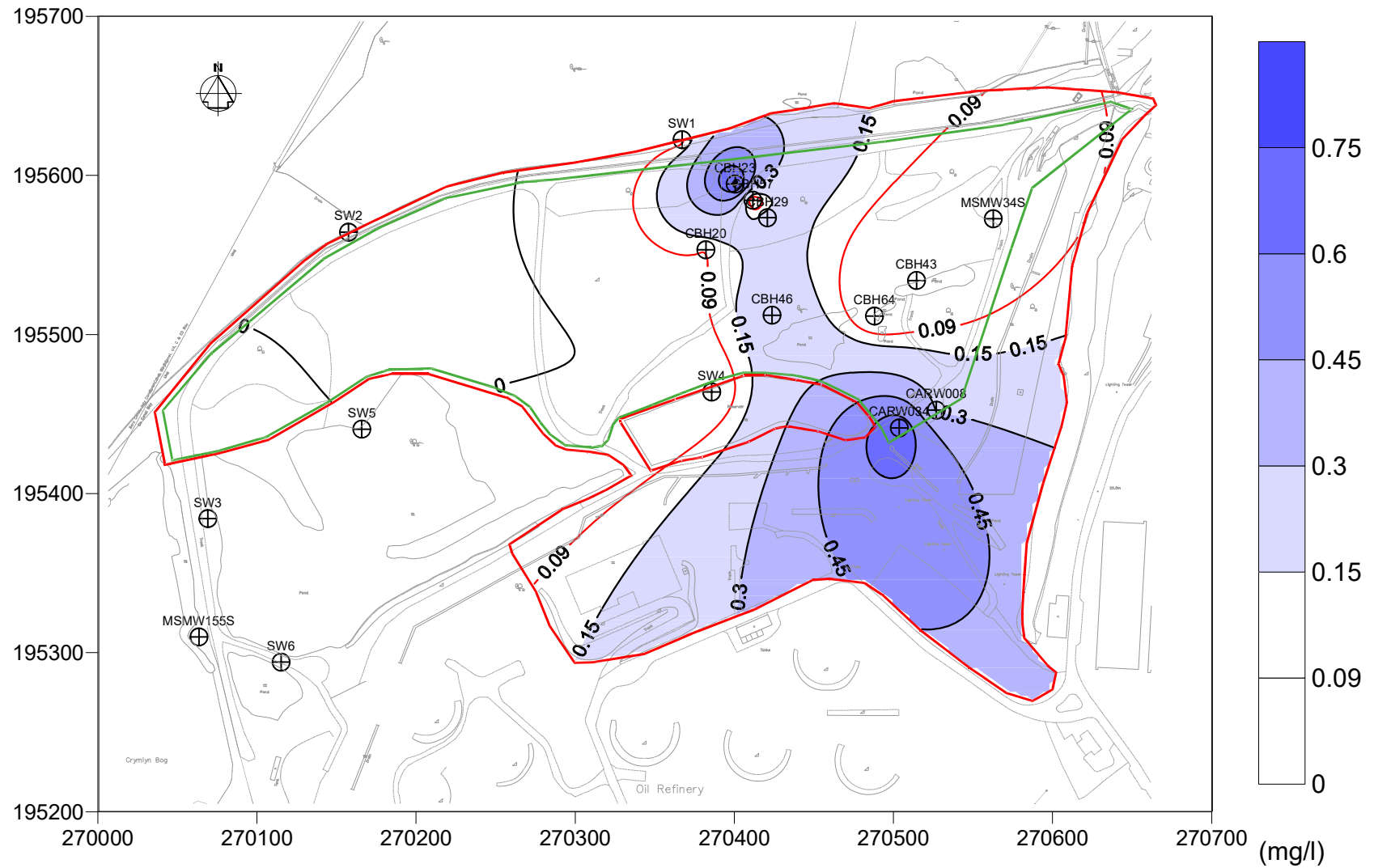
Coed Darcy Tip

Inferred Contours of Aromatics EC12-EC16 (aq) in Groundwater May 2022



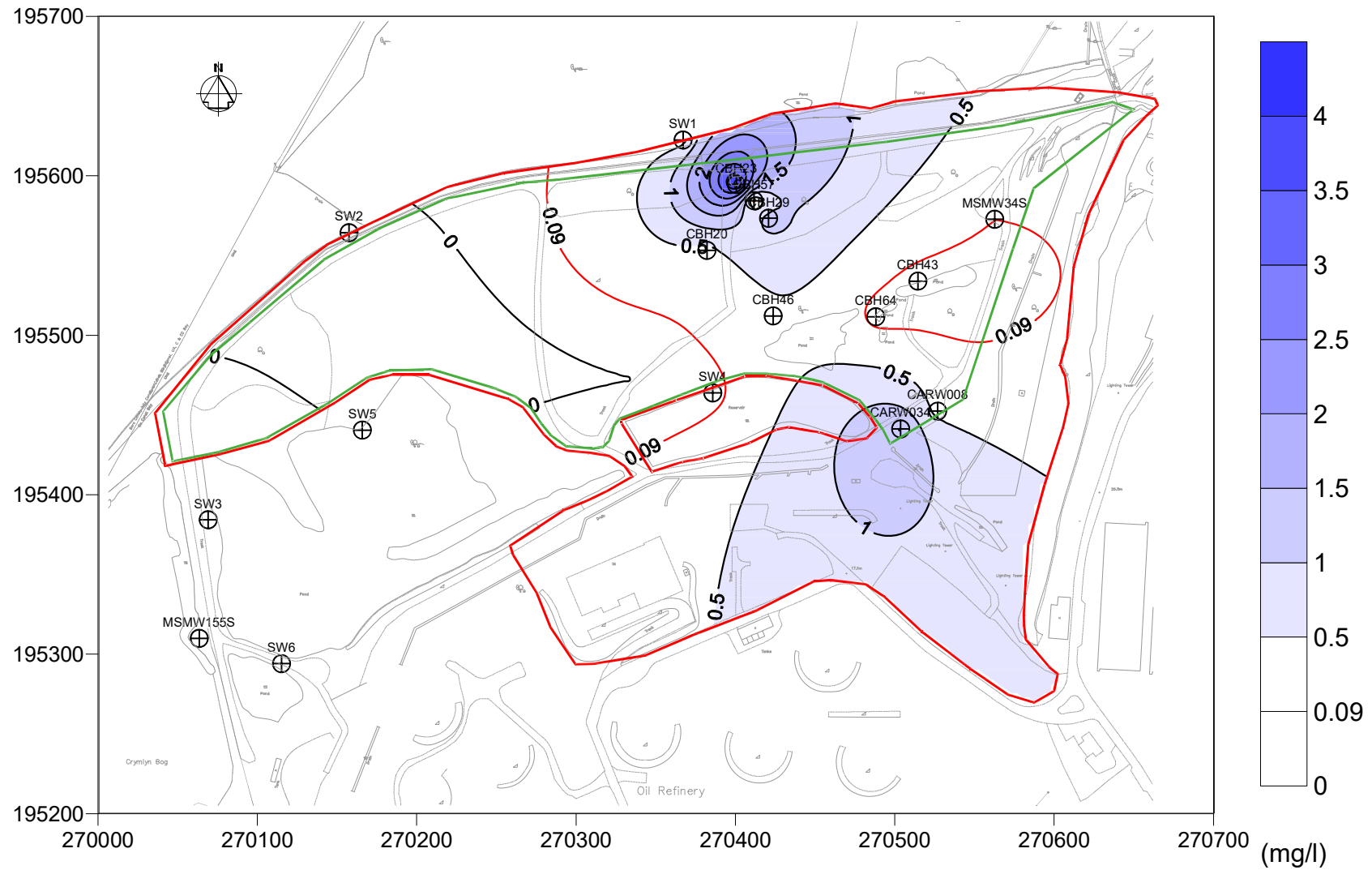
Coed Darcy Tip

Inferred Contours of Aromatics EC16-EC21 (aq) in Groundwater May 2022



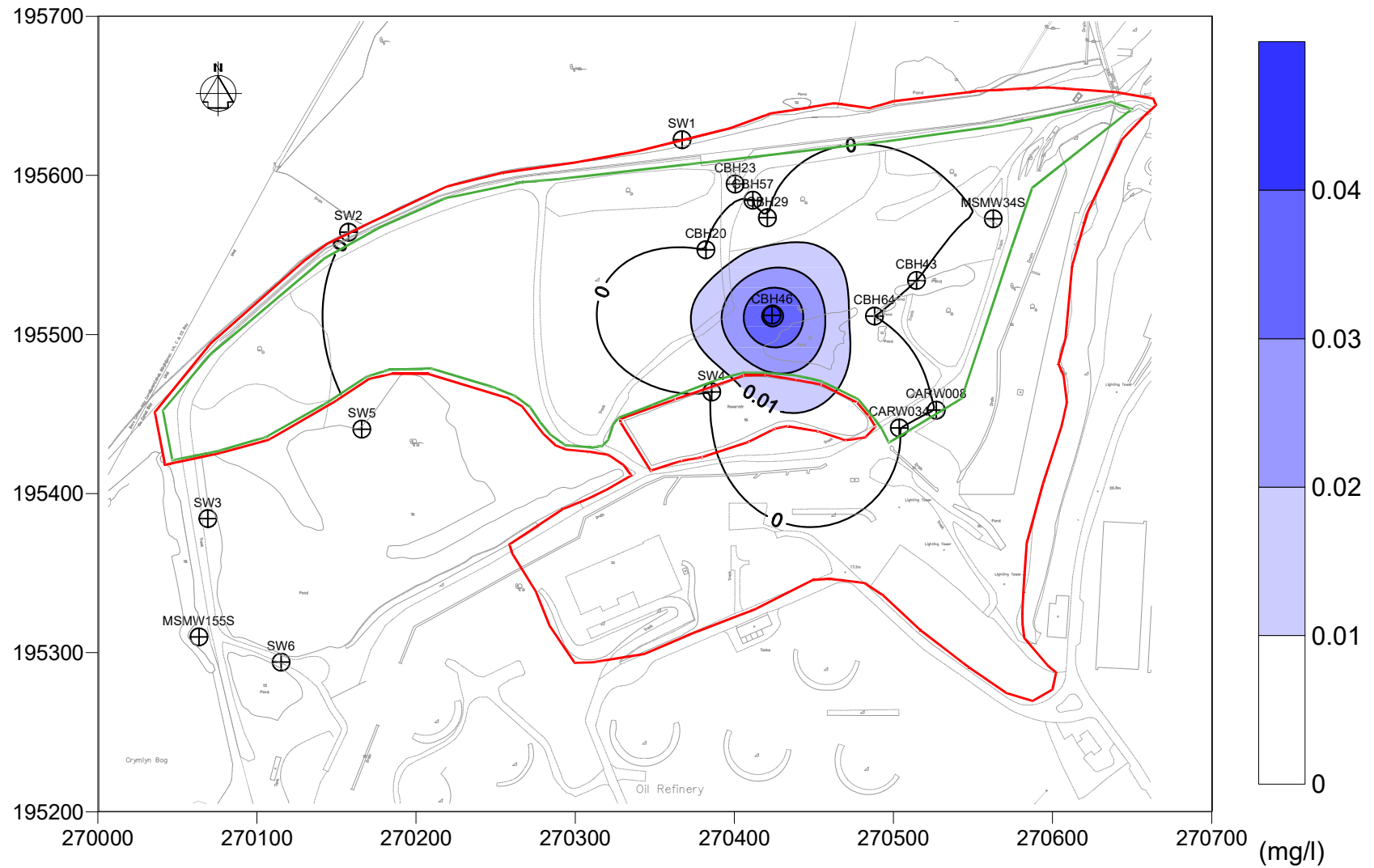
Coed Darcy Tip

Inferred Contours of Aromatics EC21-EC35 (aq) in Groundwater May 2022



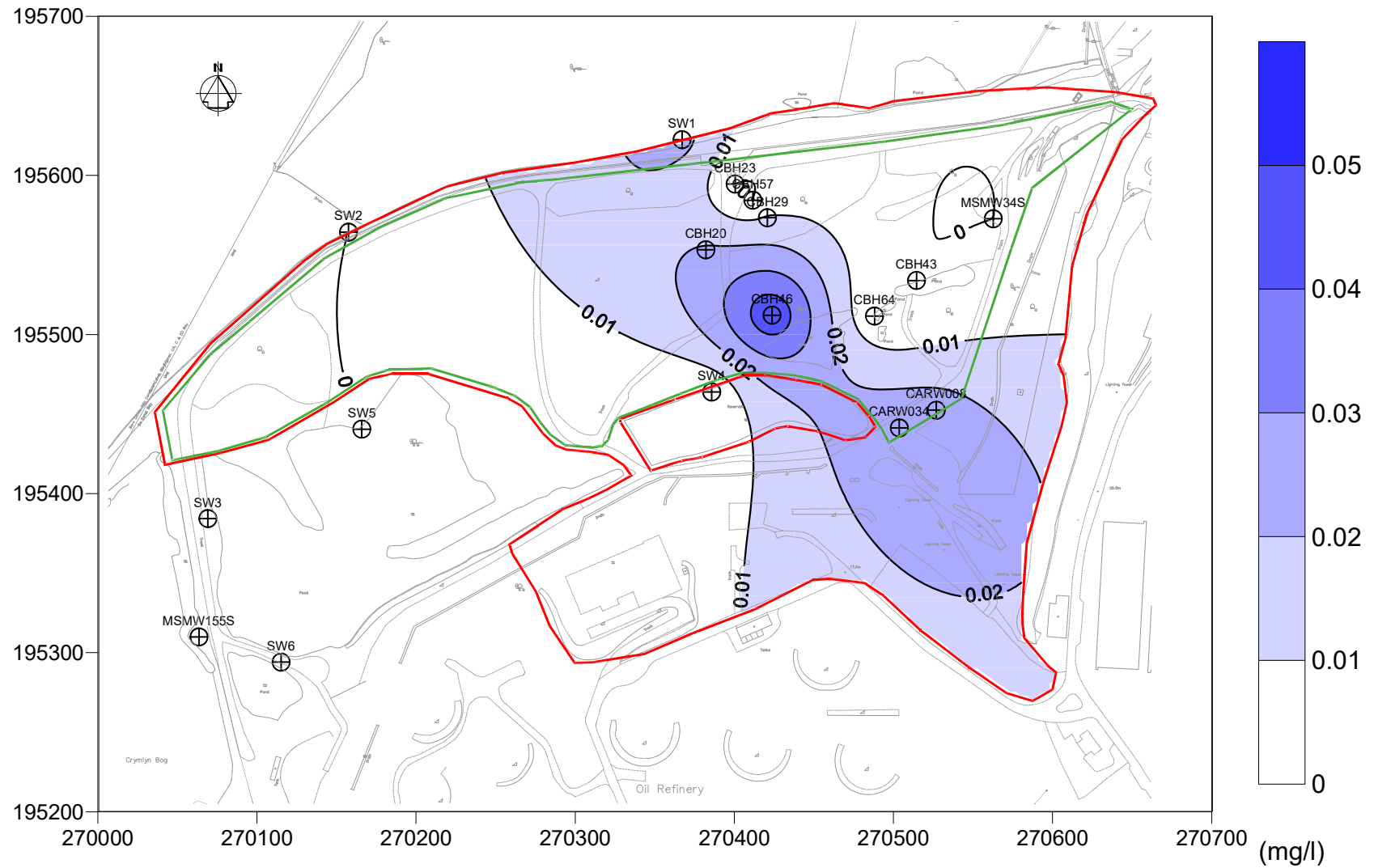
Coed Darcy Tip

Inferred Contours of Aliphatics C5-C6 in Groundwater May 2022



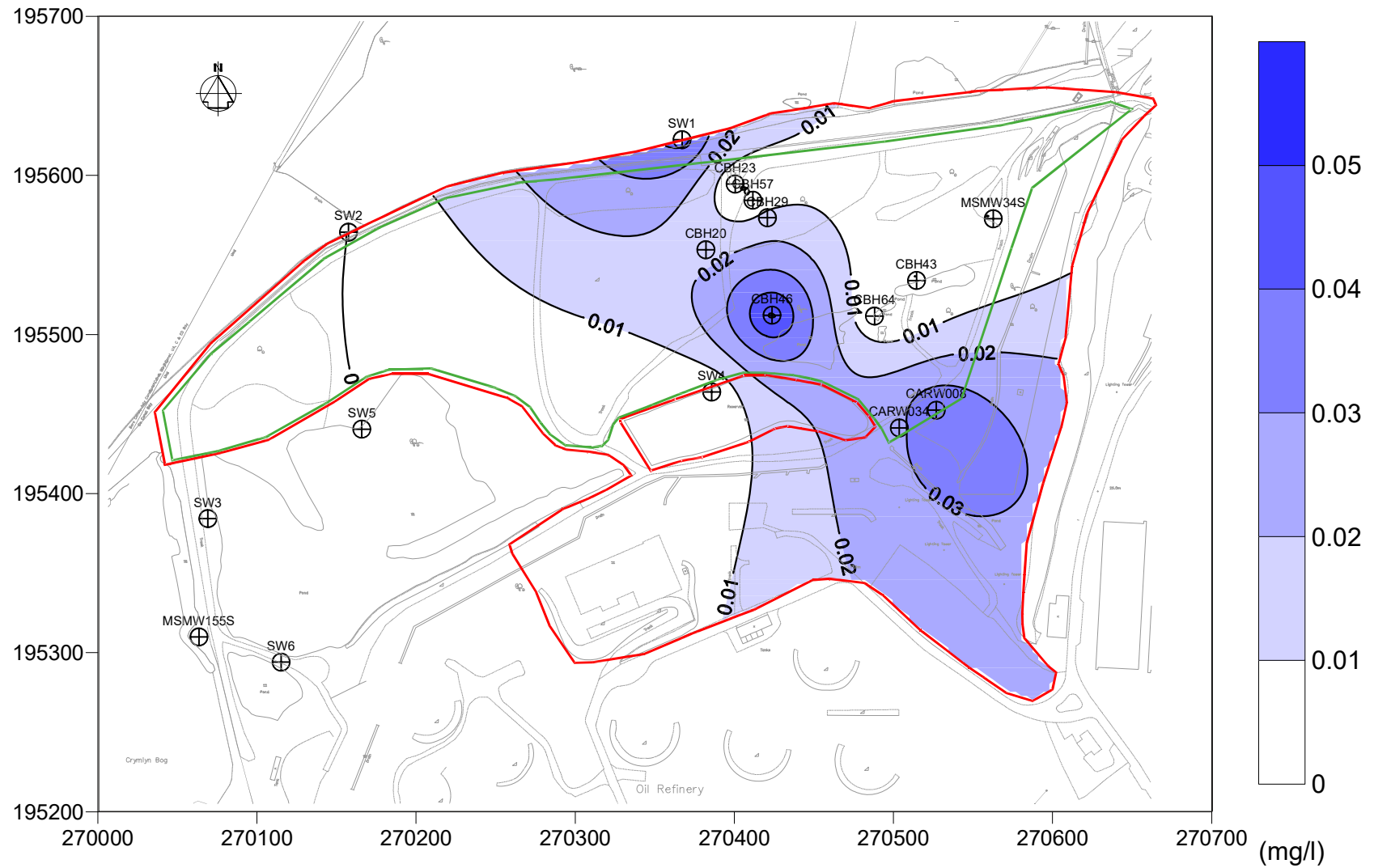
Coed Darcy Tip

Inferred Contours of Aliphatics C6-C8 in Groundwater May 2022

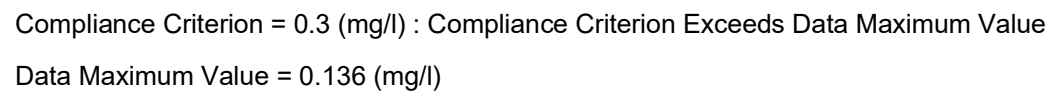


Coed Darcy Tip

Inferred Contours of Aliphatics C8-C10 in Groundwater May 2022

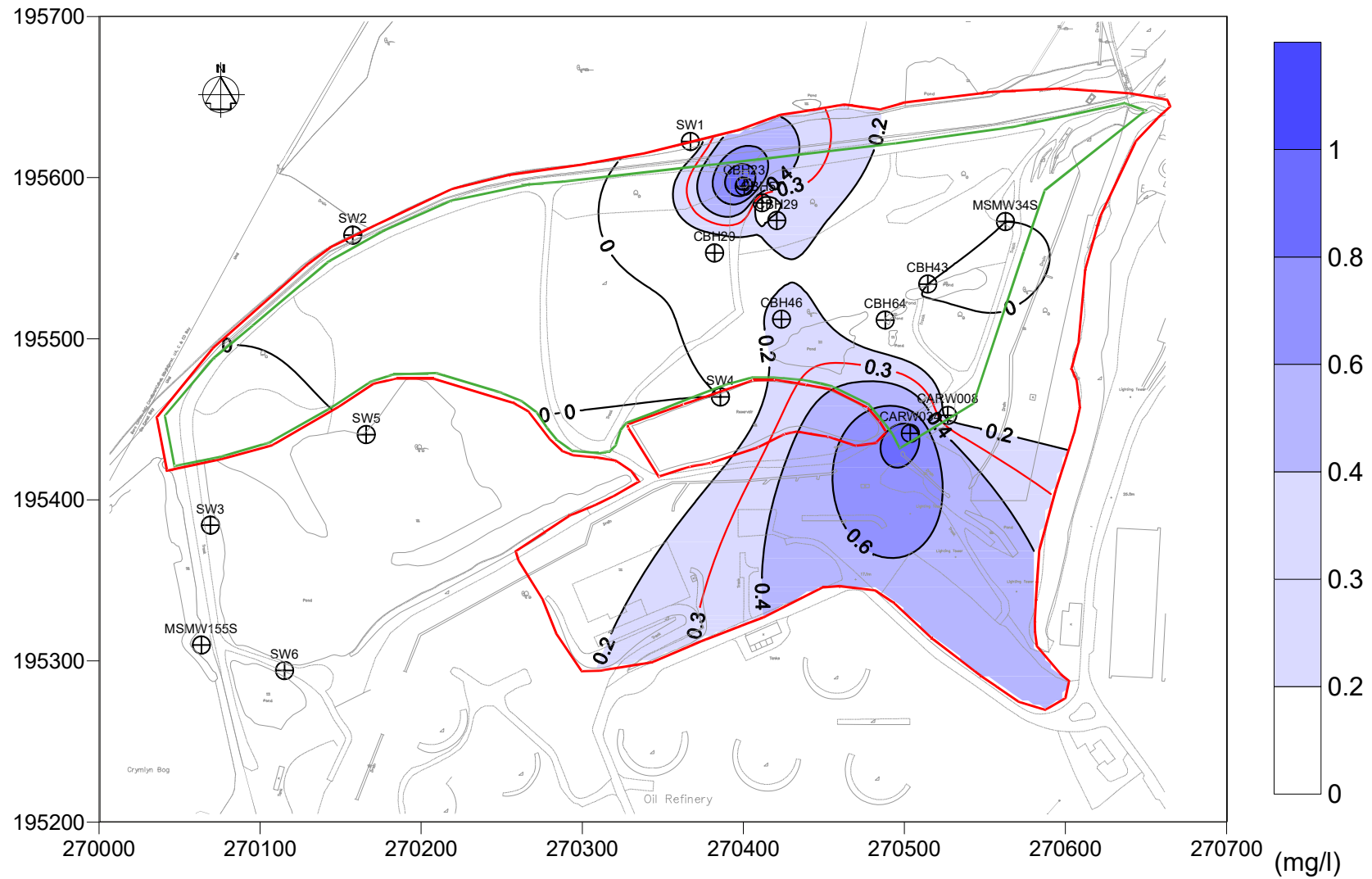


Inferred Contours of Aliphatics C10-C12 in Groundwater May 2022



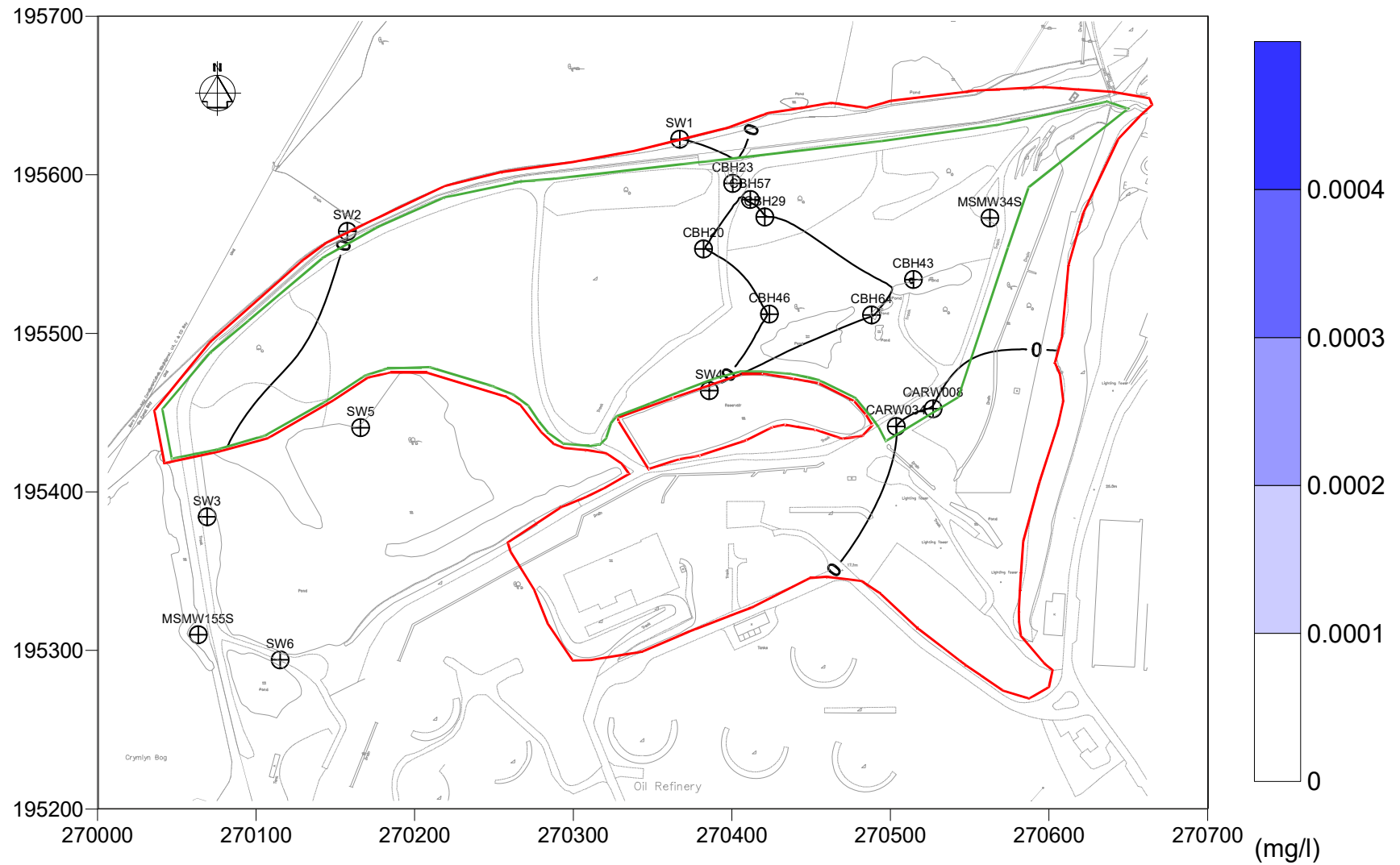
Coed Darcy Tip

Inferred Contours of Aliphatics C12-C16 (aq) in Groundwater May 2022



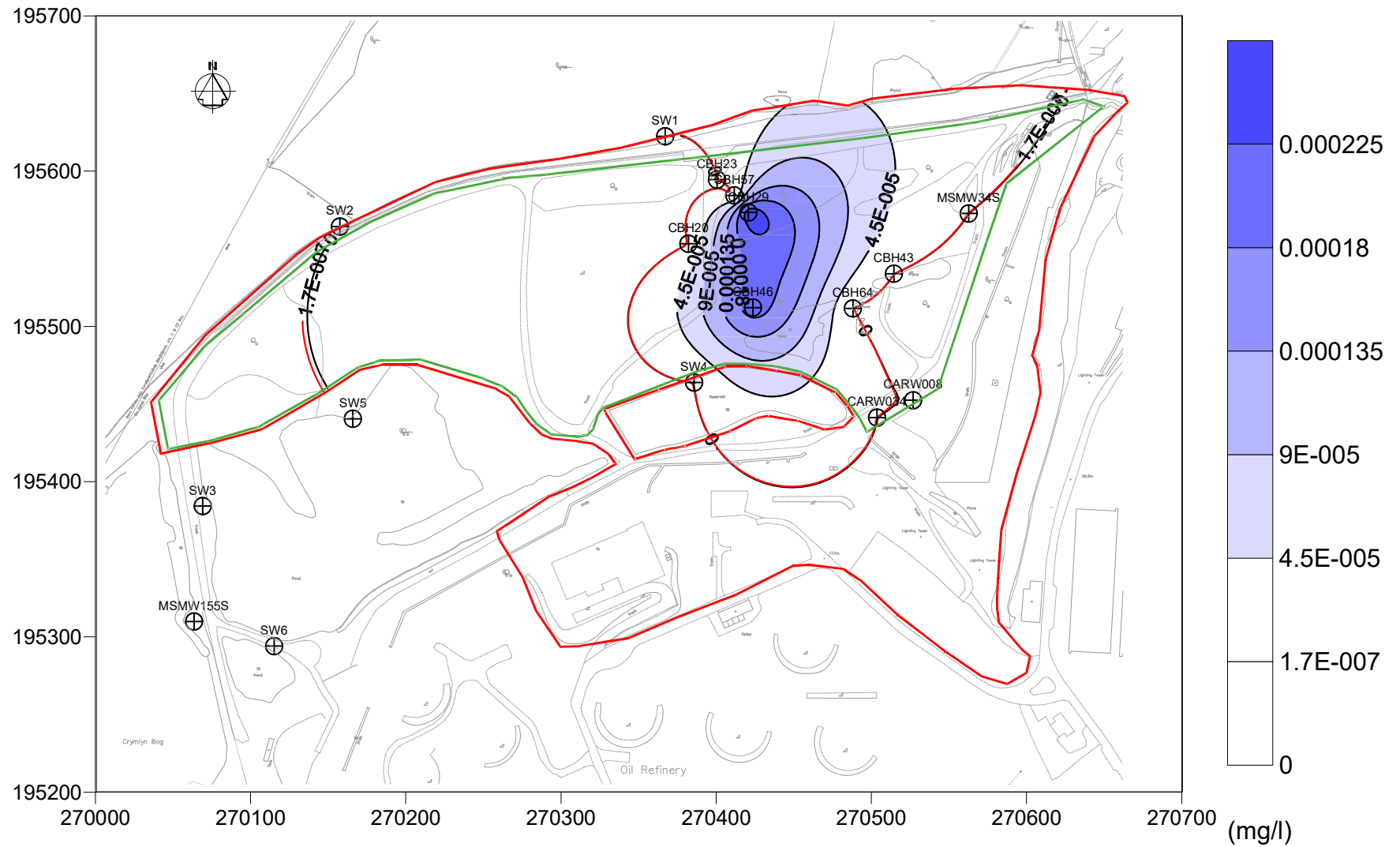
Coed Darcy Tip

Inferred Contours of Anthracene (aq) in Groundwater May 2022



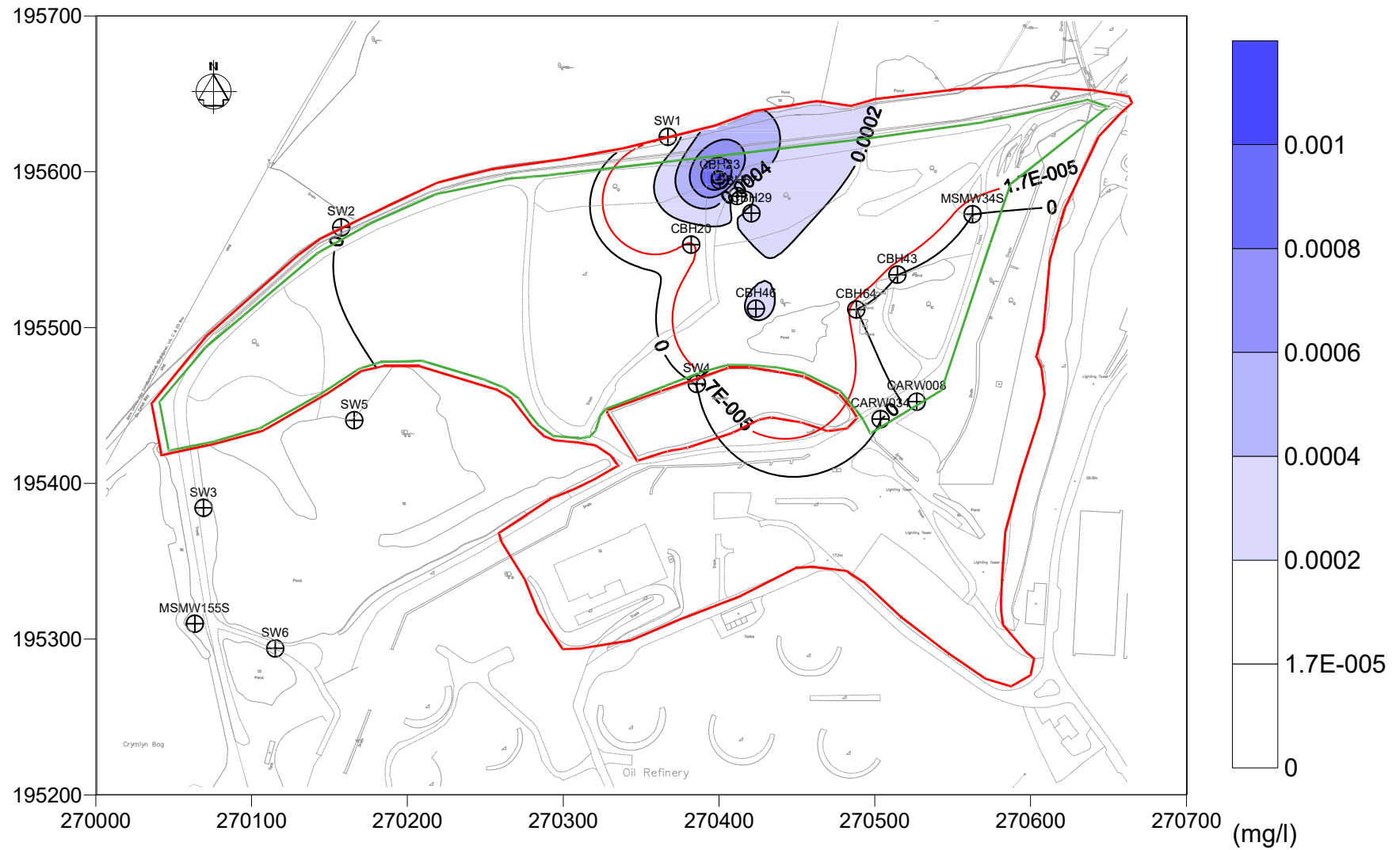
Coed Darcy Tip

Inferred Contours of Benzo(a)pyrene (aq) in Groundwater May 2022



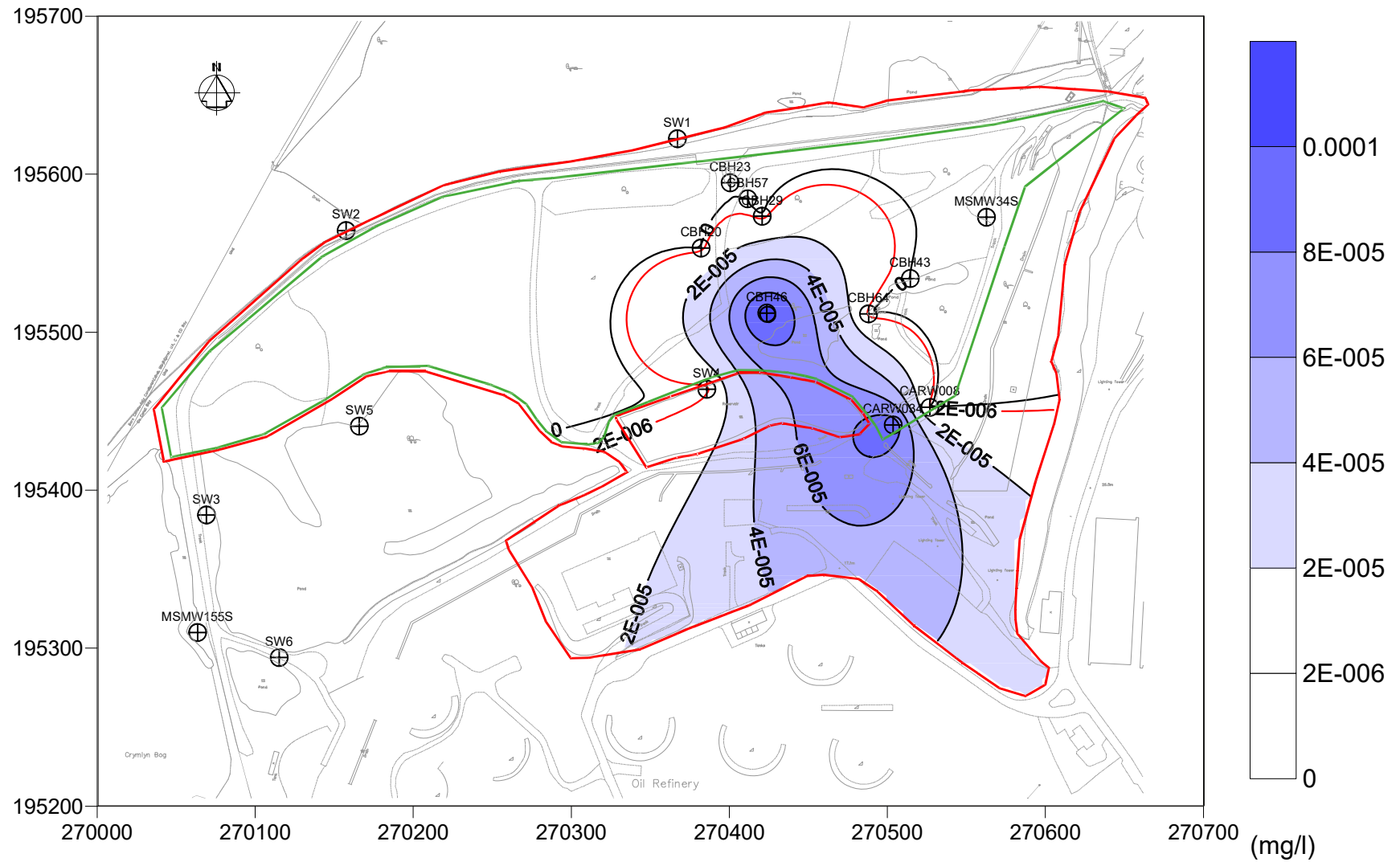
Coed Darcy Tip

Inferred Contours of Benzo(b)fluoranthene (aq) in Groundwater May 2022



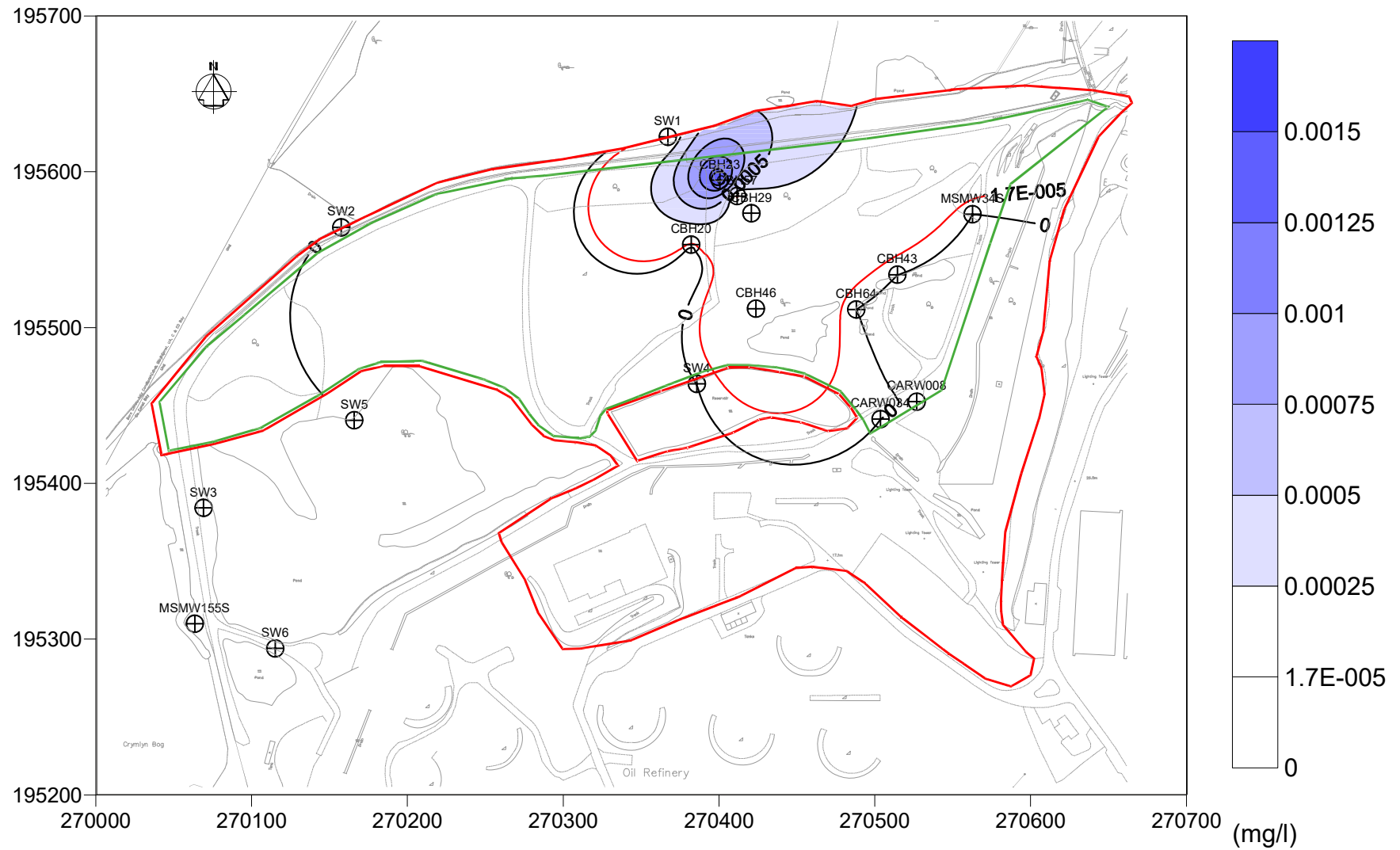
Coed Darcy Tip

Inferred Contours of Benzo(g,h,i)perylene (aq) in Groundwater May 2022

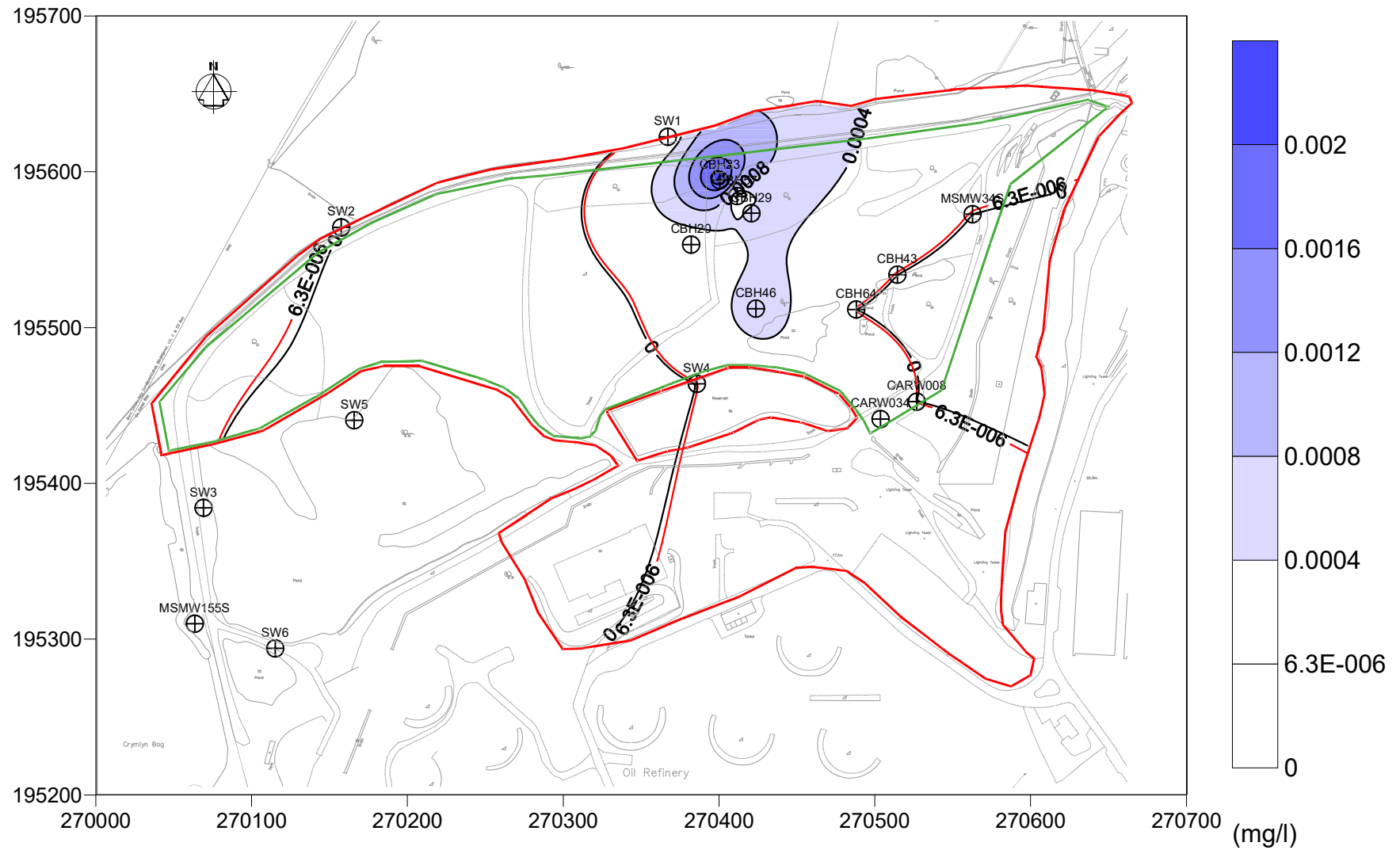


Coed Darcy Tip

Inferred Contours of Benzo(k)fluoranthene (aq) in Groundwater May 2022



Inferred Contours of Fluoranthene (aq) in Groundwater May 2022

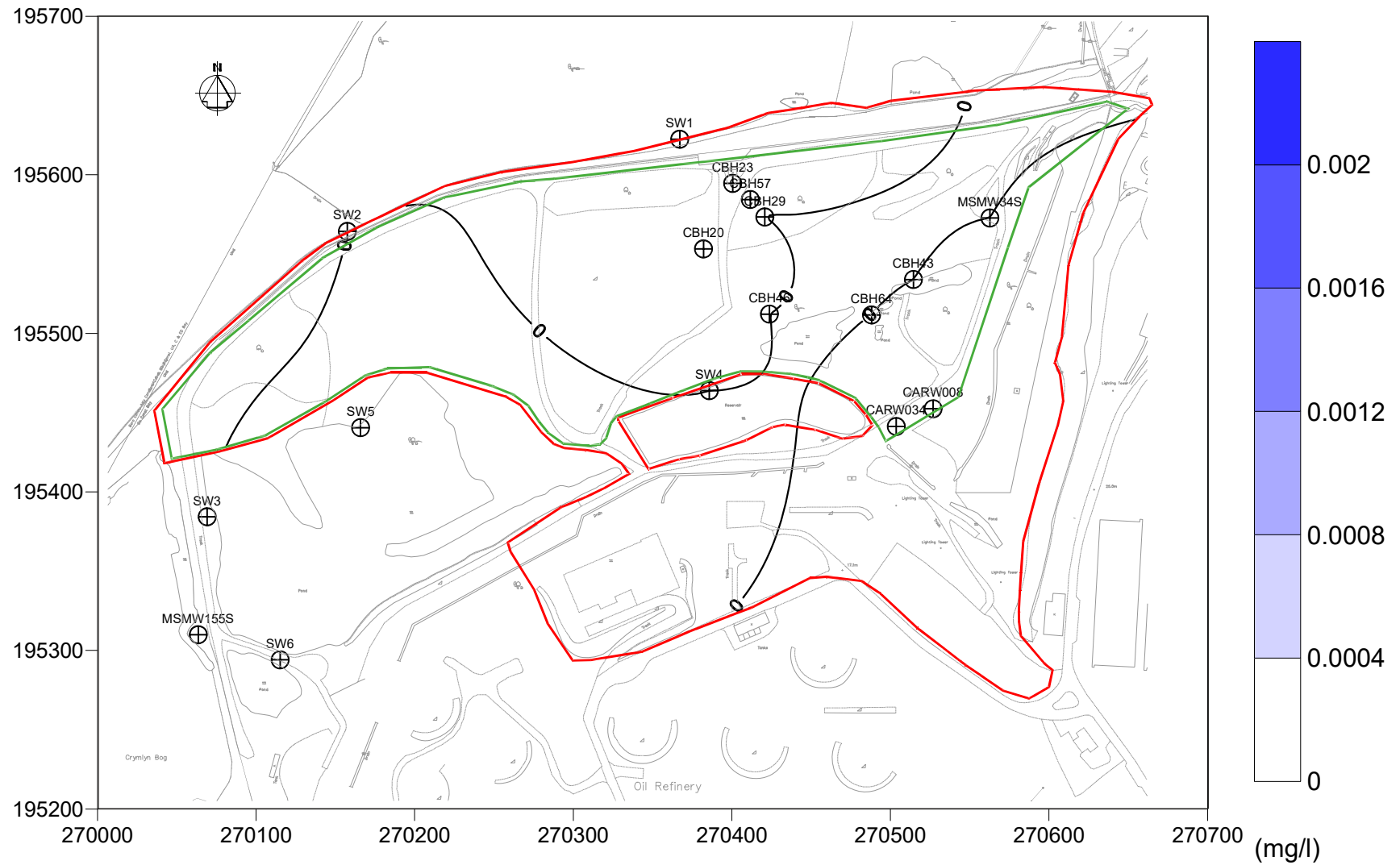


Compliance Criterion = 0.0000063 (mg/l)

Data Maximum Value = 0.00237 (mg/l)

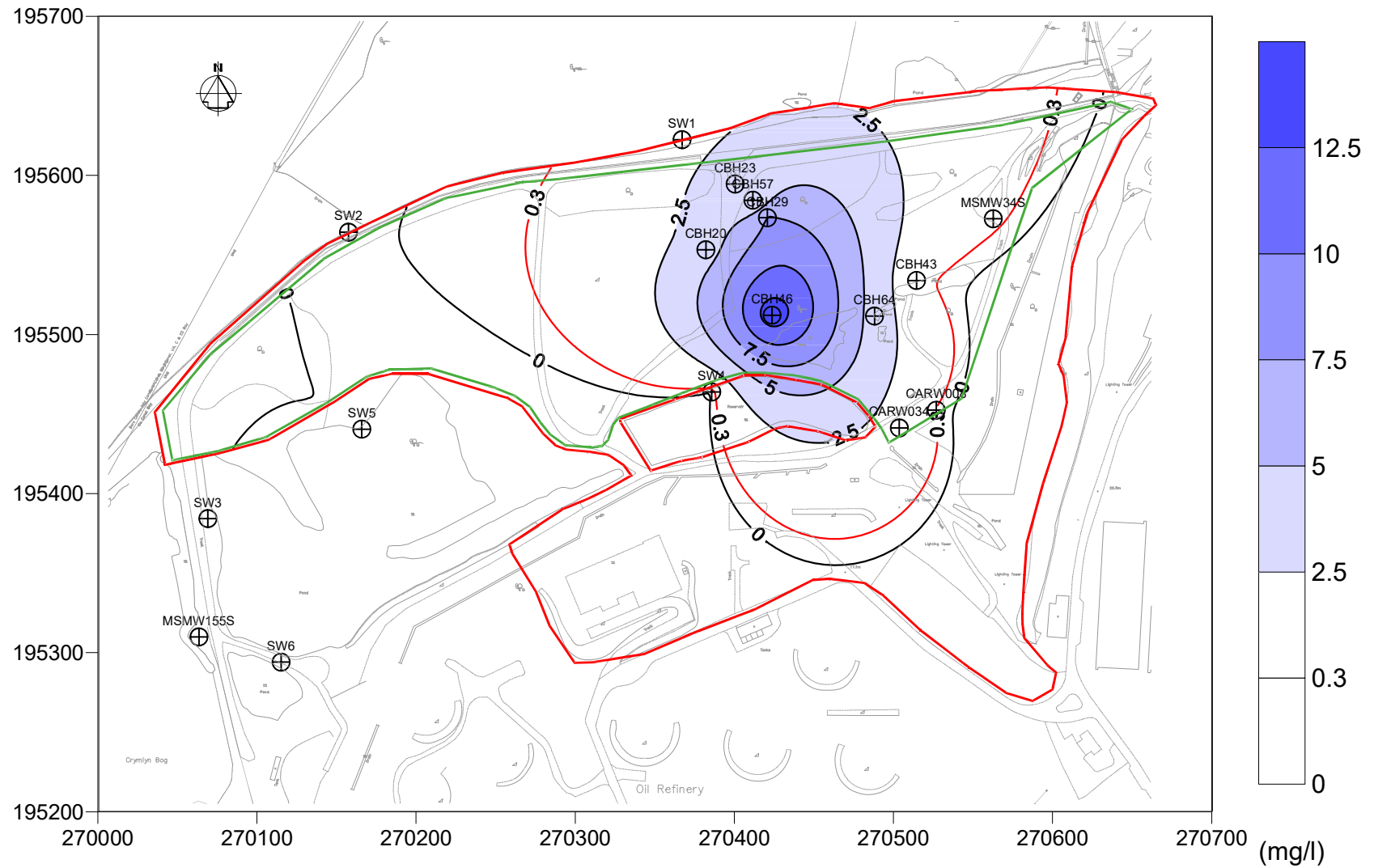
Coed Darcy Tip

Inferred Contours of Naphthalene (aq) in Groundwater May 2022



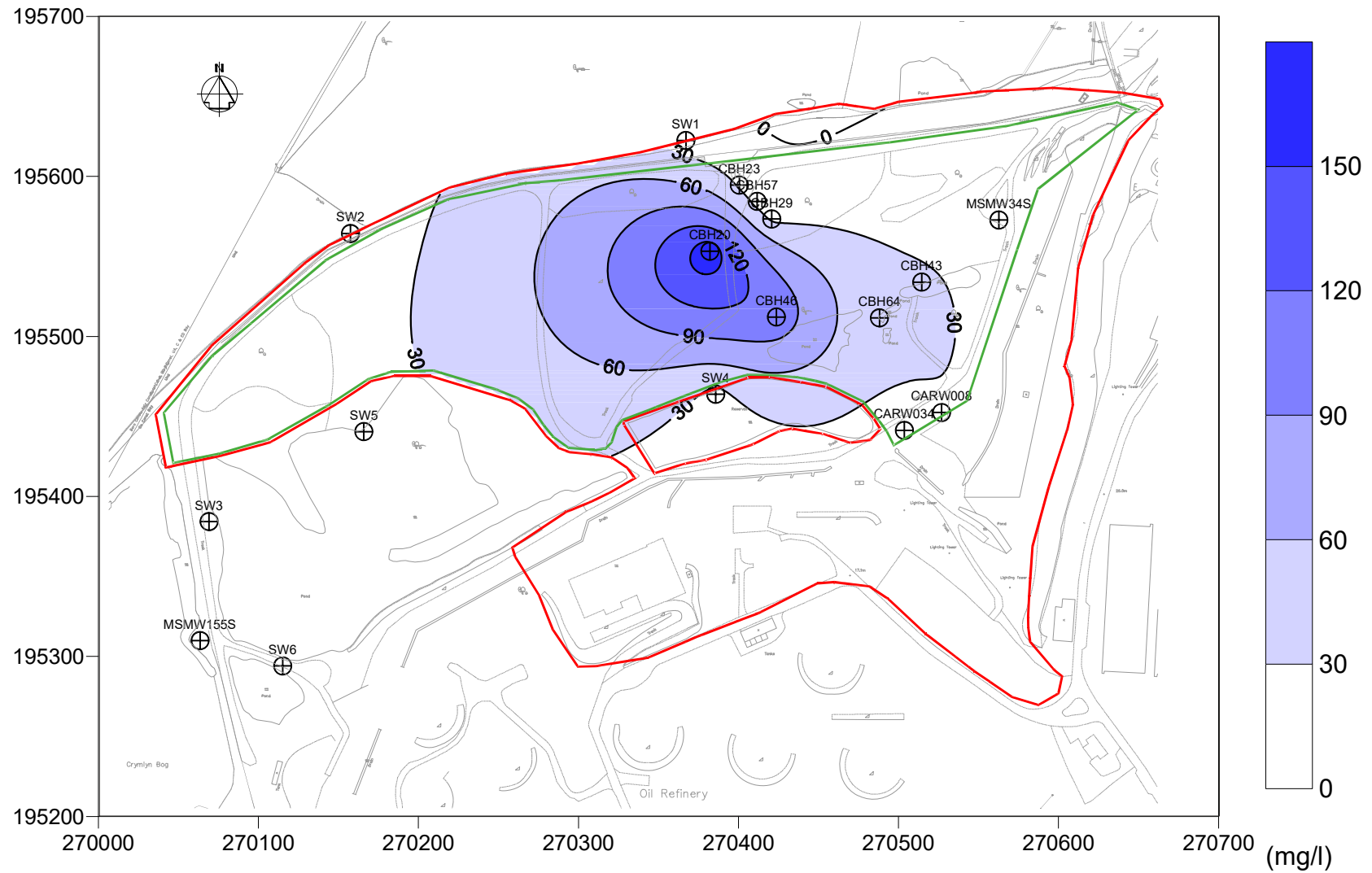
Coed Darcy Tip

Inferred Contours of Ammoniacal Nitrogen as N in Groundwater May 2022



Coed Darcy Tip

Inferred Contours of Chloride in Groundwater May 2022

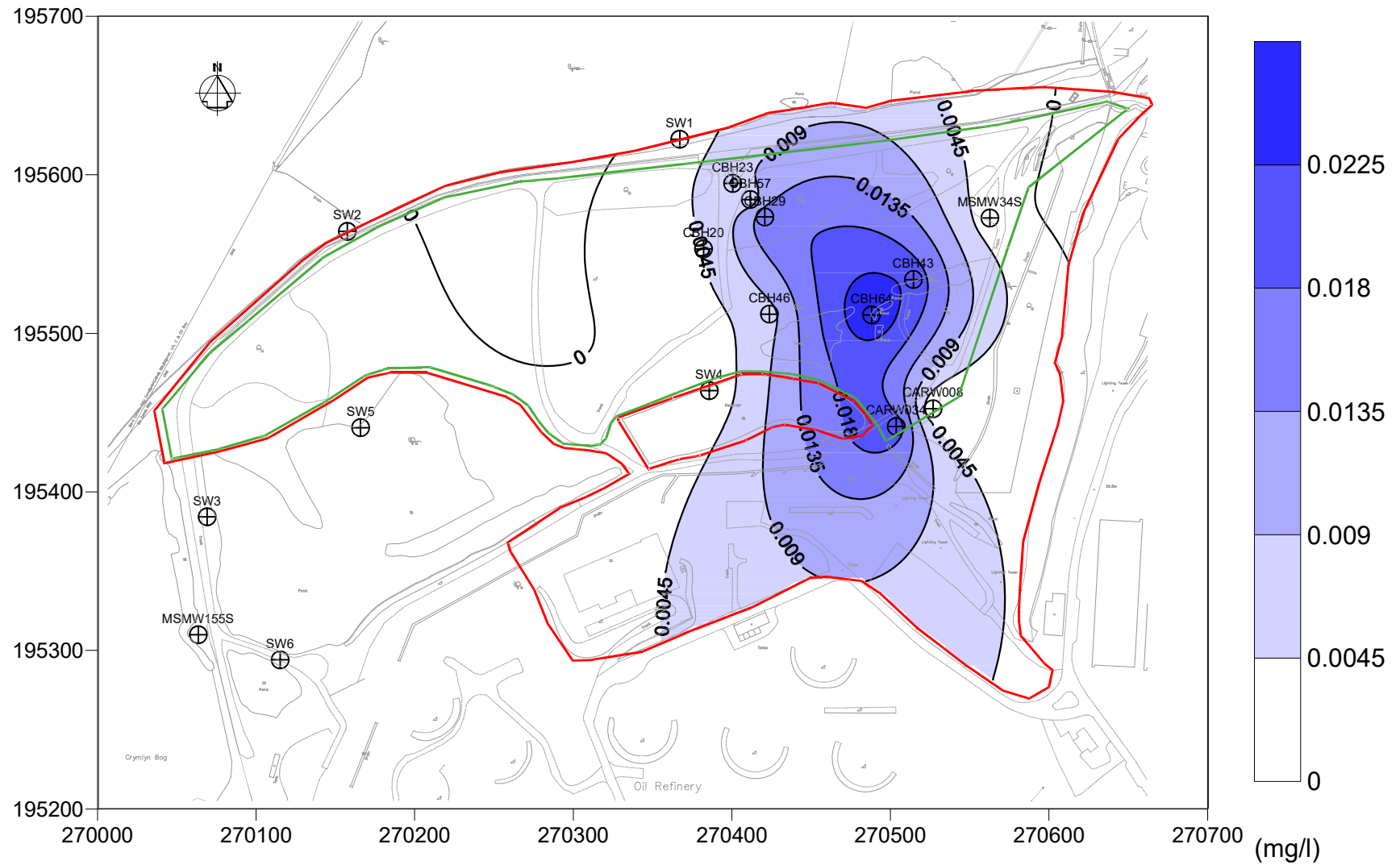


Compliance Criterion = 250 (mg/l) : Compliance Criterion Exceeds Data Maximum Value

Data Maximum Value = 170 (mg/l)

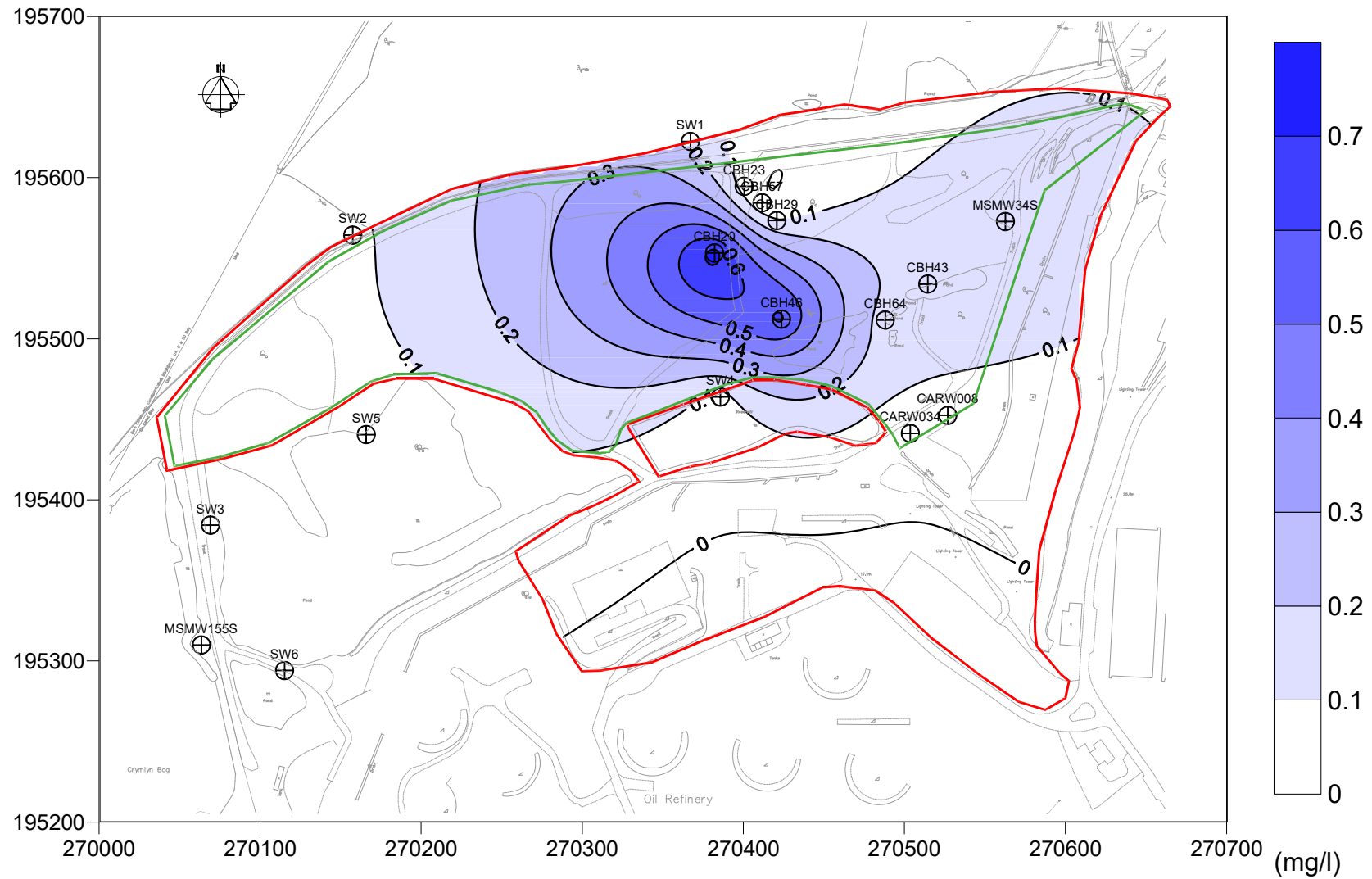
Coed Darcy Tip

Inferred Contours of Arsenic (diss.filt) in Groundwater May 2022



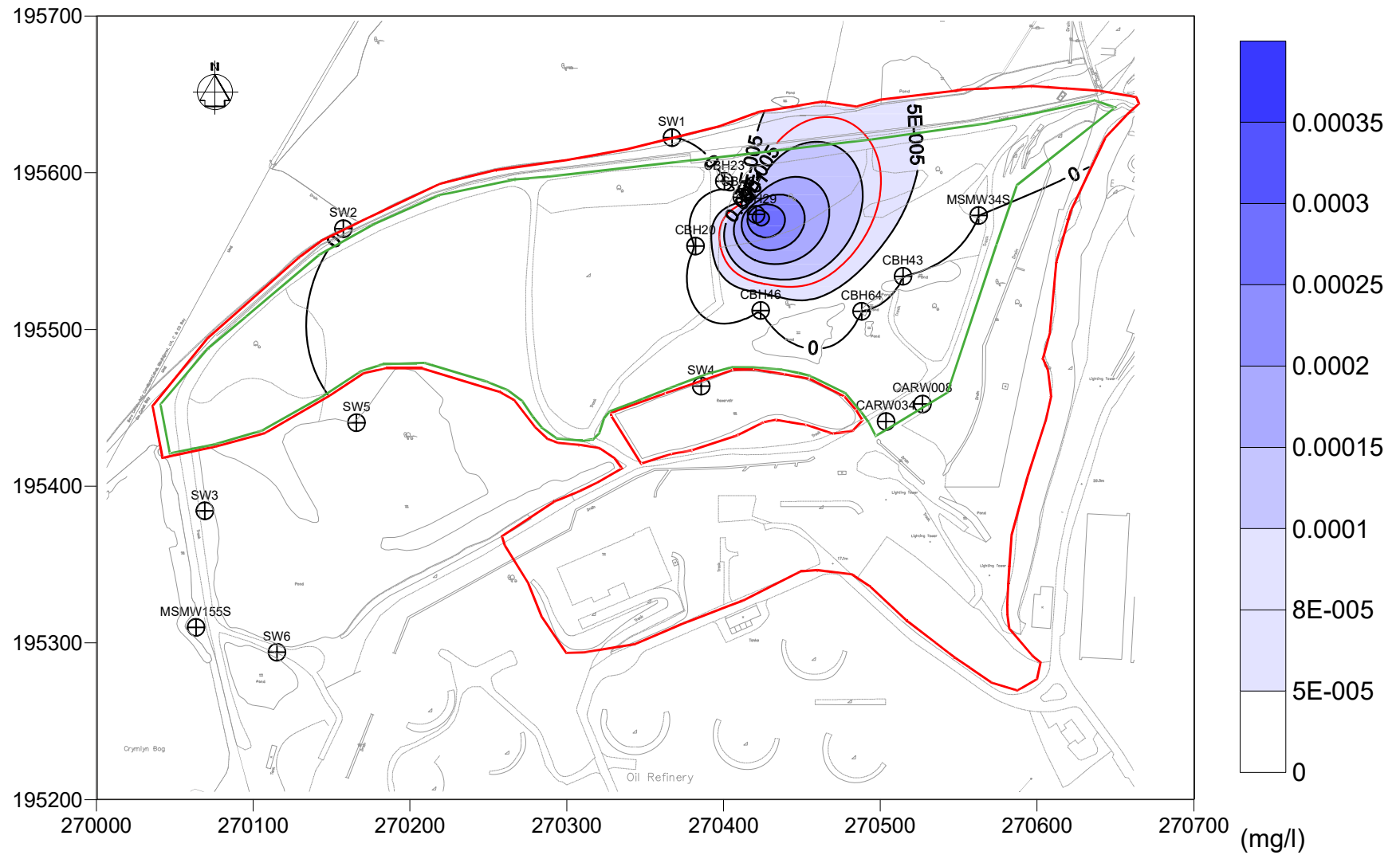
Coed Darcy Tip

Inferred Contours of Boron (diss.filt) in Groundwater May 2022



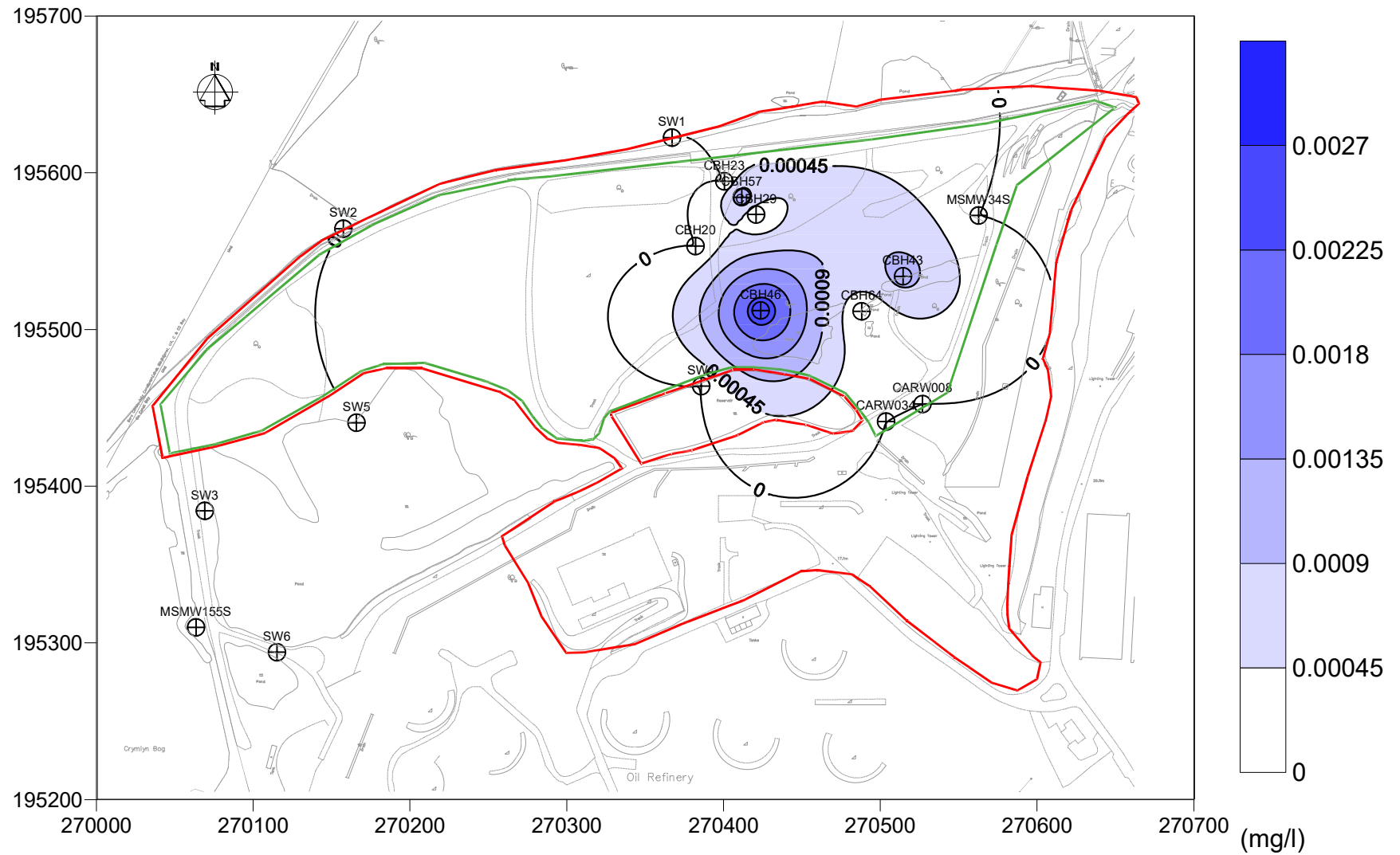
Coed Darcy Tip

Inferred Contours of Cadmium (diss.filt) in Groundwater May 2022



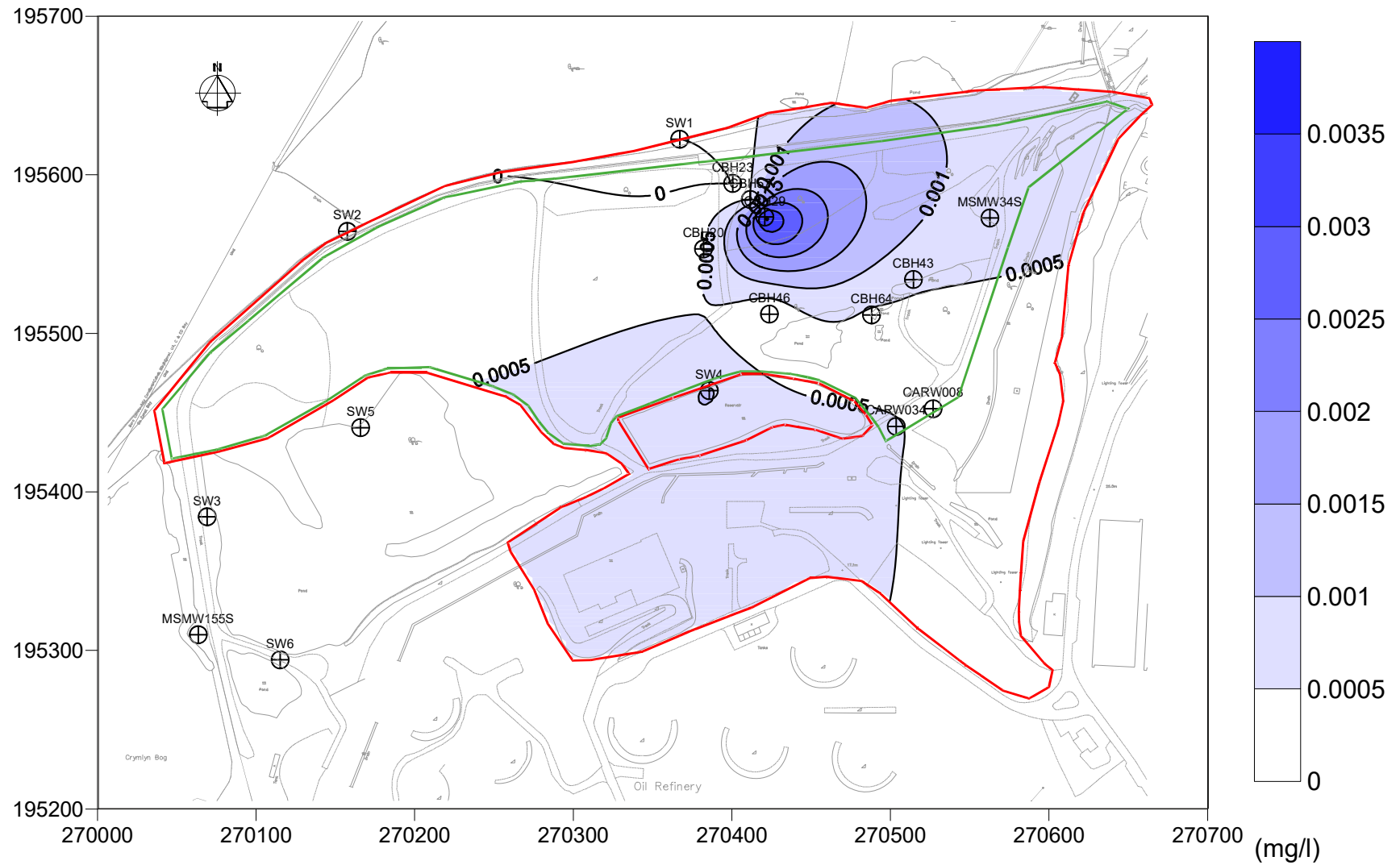
Coed Darcy Tip

Inferred Contours of Chromium (diss.filt) in Groundwater May 2022



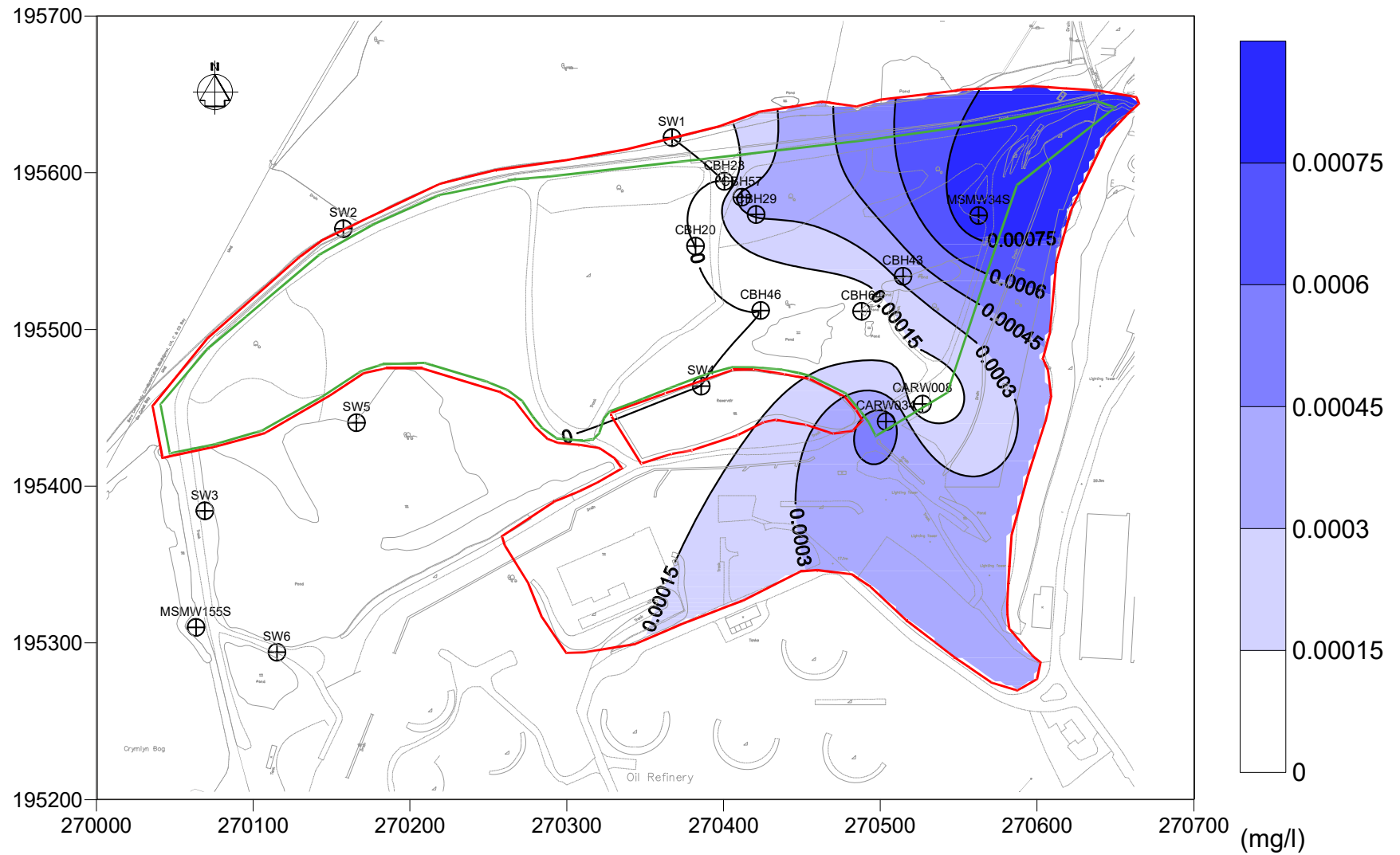
Coed Darcy Tip

Inferred Contours of Copper (diss.filt) in Groundwater May 2022



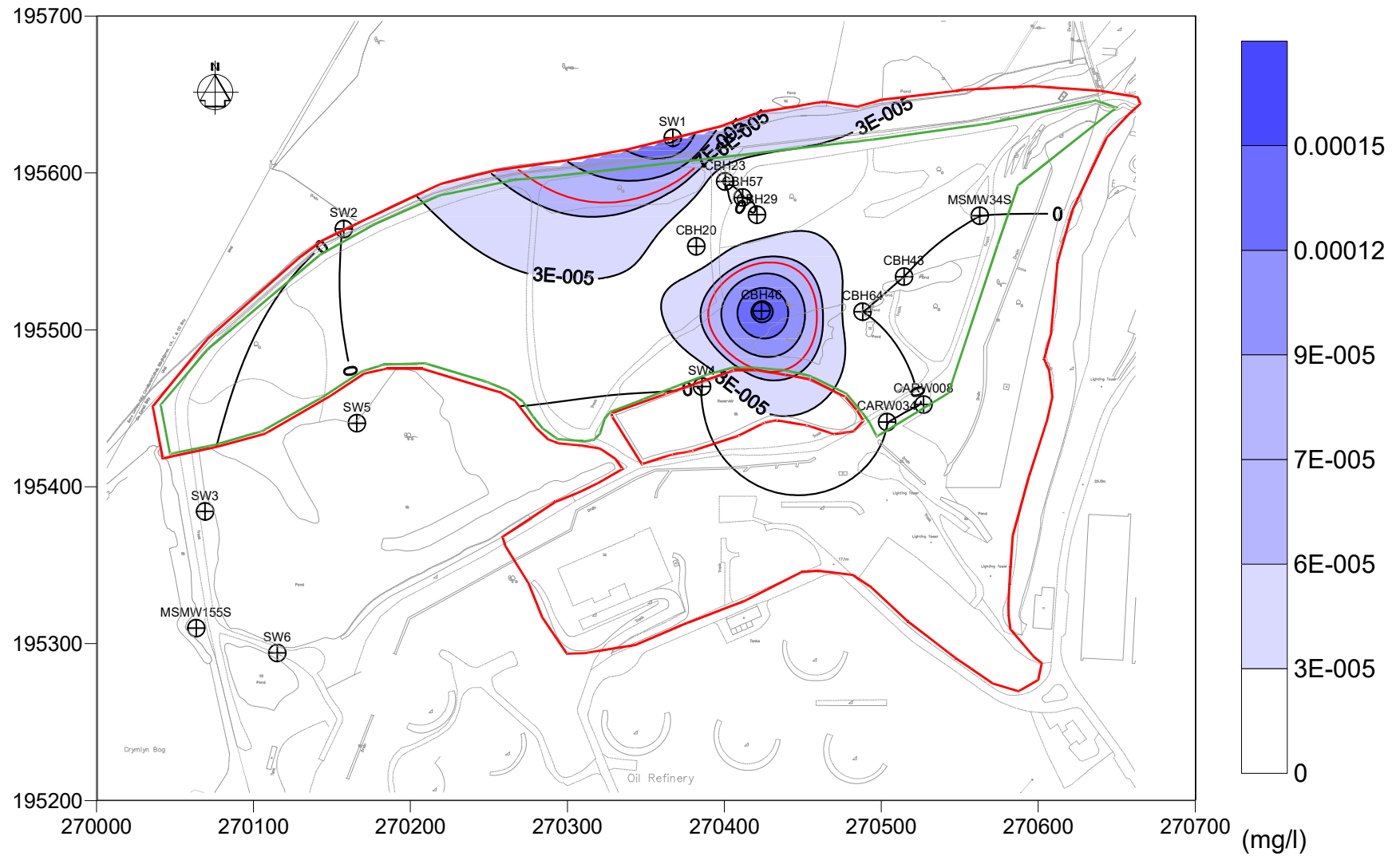
Coed Darcy Tip

Inferred Contours of Lead (diss.filt) in Groundwater May 2022



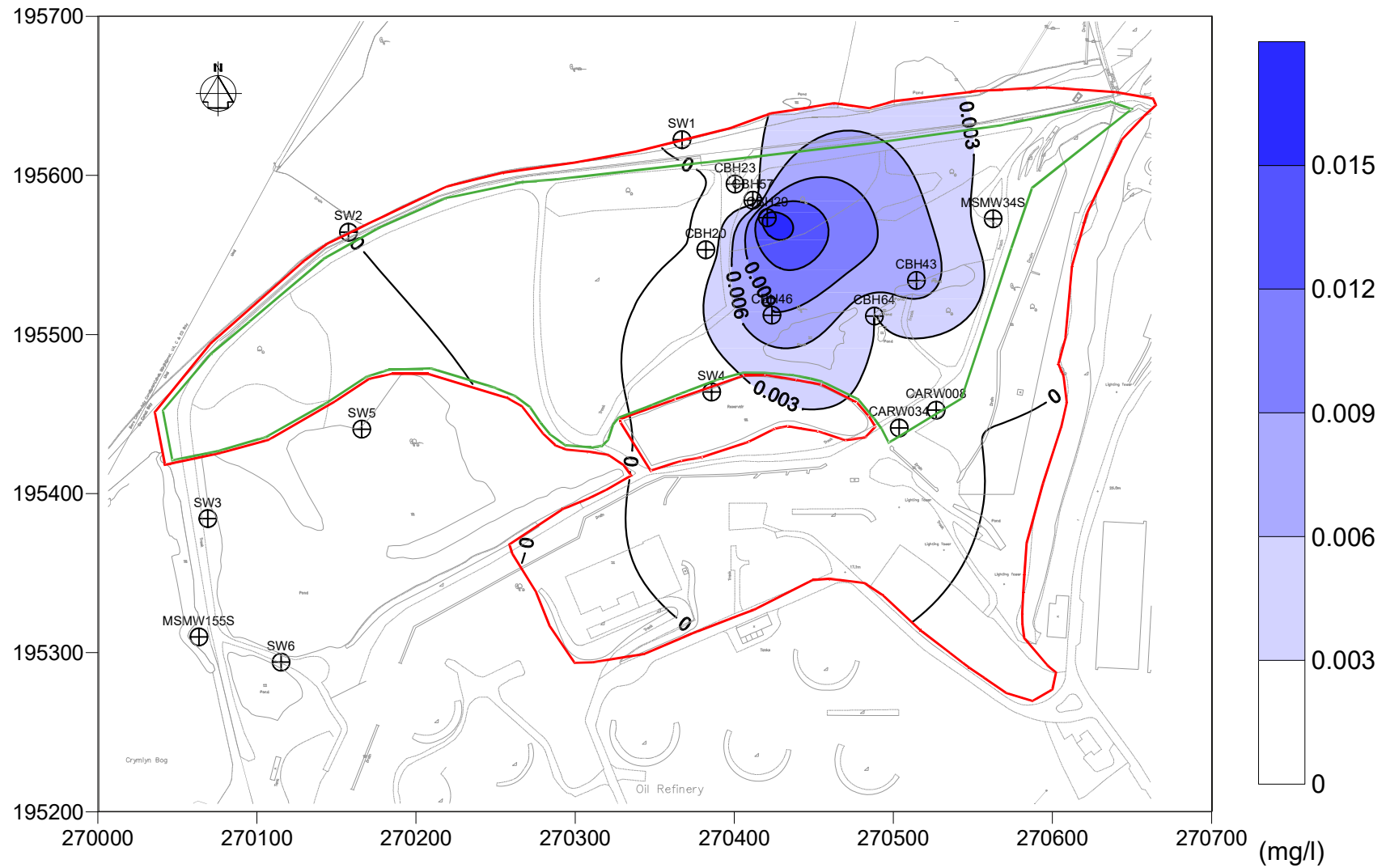
Coed Darcy Tip

Inferred Contours of Mercury (diss.filt) in Groundwater May 2022



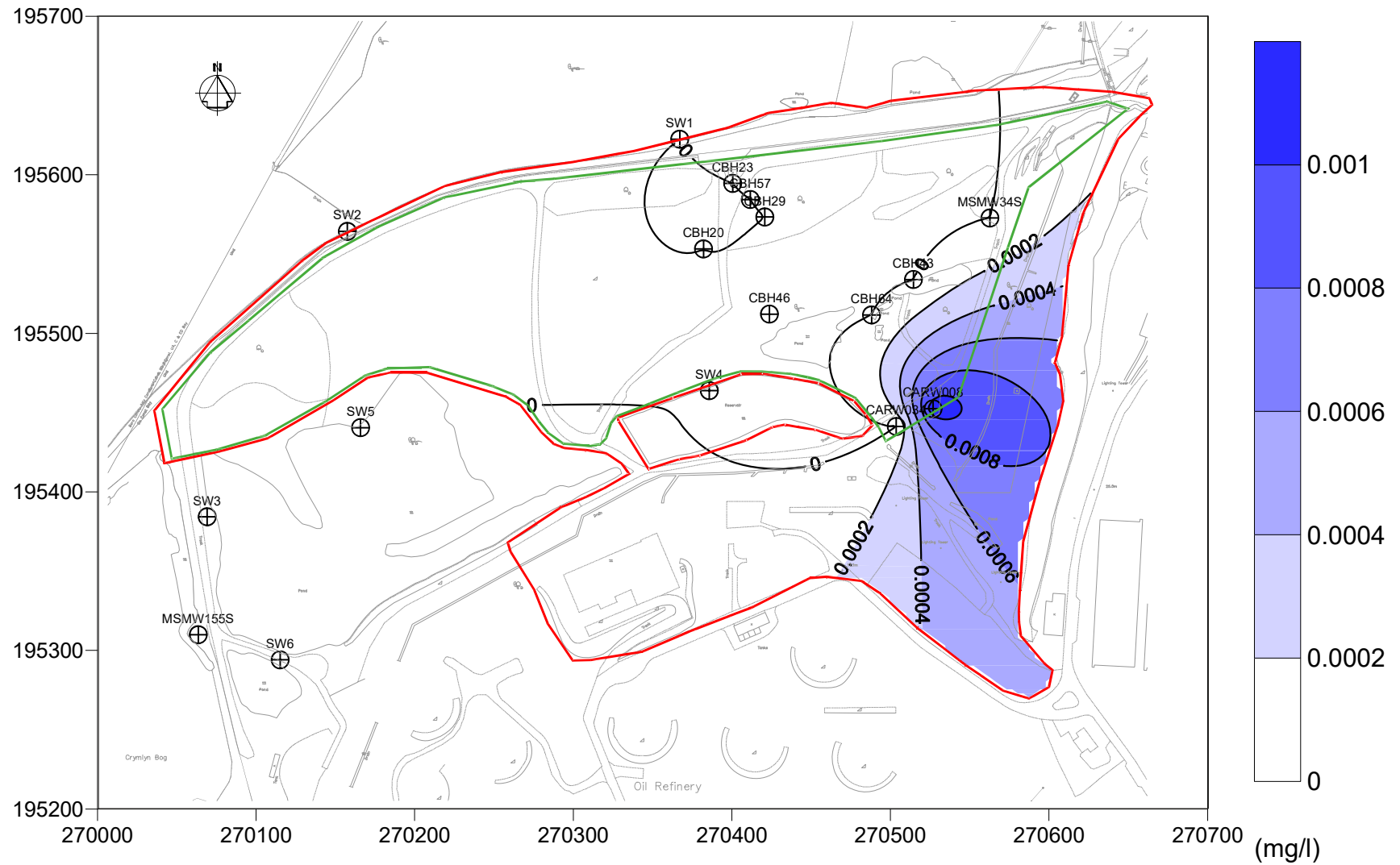
Coed Darcy Tip

Inferred Contours of Nickel (diss.filt) in Groundwater May 2022



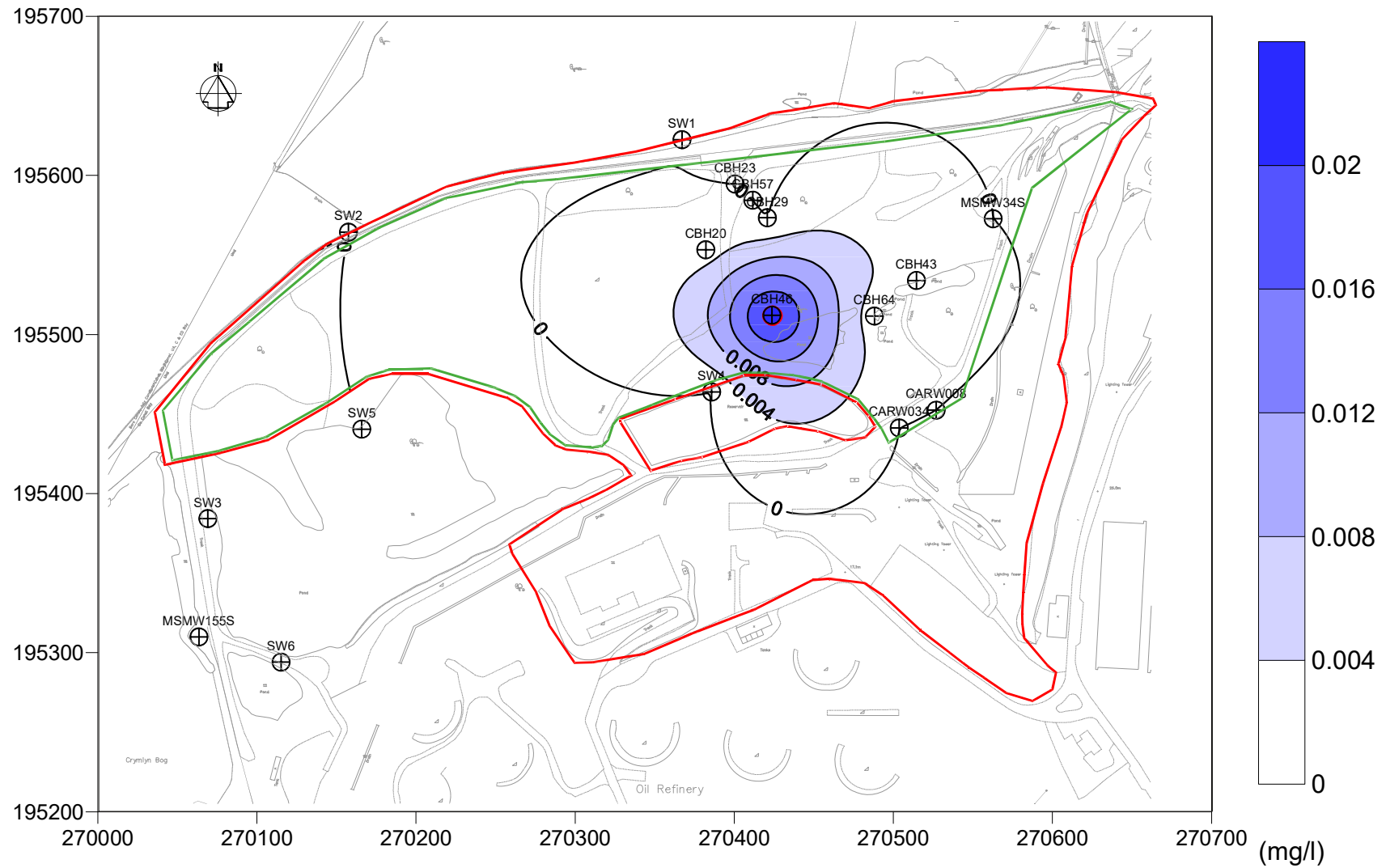
Coed Darcy Tip

Inferred Contours of Selenium (diss.filt) in Groundwater May 2022



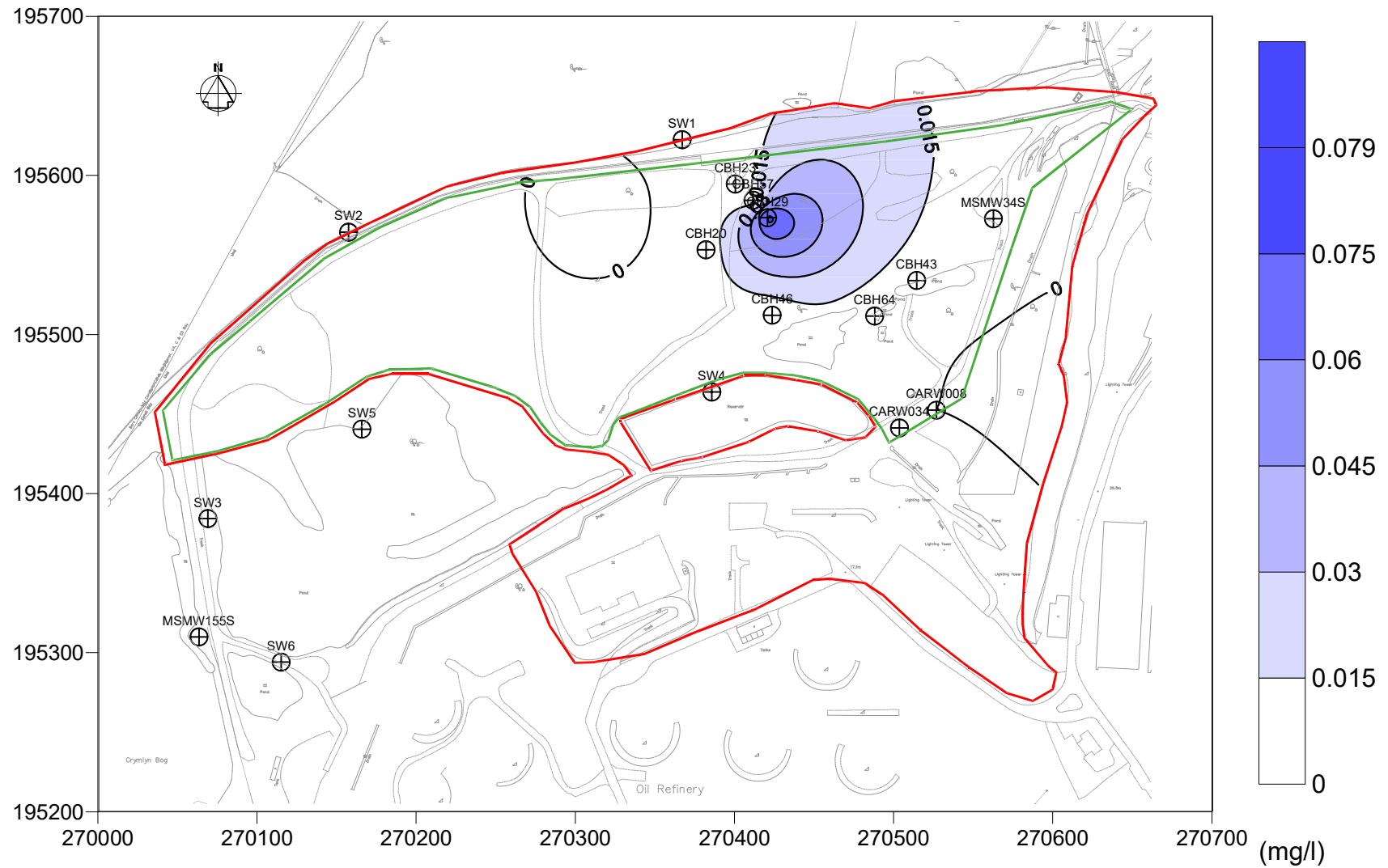
Coed Darcy Tip

Inferred Contours of Vanadium (diss.filt) in Groundwater May 2022



Coed Darcy Tip

Inferred Contours of Zinc (diss.filt) in Groundwater May 2022



Addendum C8 - RTM Spreadsheets



eNGLOBE

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet

Site Name:	Coed Darcy Tip	Case:	1 = 10m to Compliance
Site Address:	Llandarcy		
Completed by:	JAS		
Date:	07/10/2022		

Number of Substances = 36

Substance	Type	Compliance C	Comment	Henry's Law C	Water solubility	Koc	Kd	Reference	Half Life	Reference
		mg L ⁻¹		cm ³ cm ⁻³	mg L ⁻¹	Log (cm ³ g ⁻¹)	cm ³ g ⁻¹		days	
Benzene	organic	1.00E-02	Former EQS	1.16E-01	1.78E+03	1.83E+00		SR7	693	P2-228
Toluene	organic	7.40E-02		1.15E-01	5.90E+02	2.31E+00		SR7	693	P2-228
Ethylbenzene	organic	2.00E-02		1.39E-01	1.80E+02	2.65E+00		SR7	693	P2-228
m-Xylene	organic	3.00E-02		1.12E-01	2.00E+02	2.69E+00		SR7	693	P2-228
o-Xylene	organic	3.00E-02		9.20E-02	1.73E+02	2.63E+00		SR7	693	P2-228
p-Xylene	organic	3.00E-02		1.07E-01	2.00E+02	2.65E+00		SR7	693	P2-228
Benzo[b]fluoranthene	organic	1.70E-05	2015 ECO	2.05E-06	2.00E-03	5.02E+00		SR7	3650	See Text
Benzo[k]fluoranthene	organic	1.70E-05	2015 ECO	1.74E-06	8.00E-04	5.17E+00		SR7	3650	See Text
Benzo[ghi]perylene	organic	2.00E-06	2015 ECO	2.36E-06	2.64E-04	5.62E+00		SR7	3650	See Text
Benzo[a]pyrene HH2015	organic	1.70E-07	WFD 2015 HH	1.76E-06	3.80E-03	5.11E+00		SR7	3650	See Text
Fluoranthene HH 2015	organic	6.30E-06	WFD 2015 HH	6.29E-05	2.30E-01	4.26E+00		SR7	3650	See Text
Indeno[123-cd]pyrene	organic	2.00E-06	2015 ECO	2.05E-06	2.00E-04	4.94E+00		SR7	3650	See Text
Naphthalene	organic	2.00E-03	2015 ECO	6.62E-03	1.90E+01	2.81E+00		SR7	300	P2-228
Anthracene	organic	1.00E-04	2015 ECO	1.60E-03	4.50E-02	4.50E+00		TR1	3650	See Text
TPH Aliphatic C5-C6	organic	1.50E+01	CLAIRE	2.10E+01	3.60E+01	2.90E+00		LQM	693	See Text
TPH Aliphatic C6-C8	organic	1.50E+01	CLAIRE	2.73E+01	5.40E+00	3.60E+00		LQM	693	See Text
TPH Aliphatic C8-C10	organic	3.00E-01	CLAIRE	4.15E+01	4.30E-01	4.50E+00		LQM	693	See Text
TPH Aliphatic C10-C12	organic	3.00E-01	CLAIRE	6.44E+01	3.40E-02	5.40E+00		LQM	693	See Text
TPH Aliphatic C12-C16	organic	3.00E-01	CLAIRE	1.71E+02	7.60E-04	6.70E+00		LQM	3465	See Text
TPH Aromatic C8-C10	organic	3.00E-02	EQS BTEX	2.53E-01	6.50E+01	3.20E+00		LQM	693	See Text
TPH Aromatic C10-C12	organic	9.00E-02	CLAIRE	7.22E-02	2.50E+01	3.40E+00		LQM	693	See Text
TPH Aromatic C12-C16	organic	9.00E-02	CLAIRE	1.26E-02	5.80E+00	3.70E+00		LQM	3465	See Text
TPH Aromatic C16-C21	organic	9.00E-02	CLAIRE	6.95E-04	6.50E-01	4.20E+00		LQM	3465	See Text
TPH Aromatic C21-C35	organic	9.00E-02	CLAIRE	2.48E-05	6.60E-03	5.10E+00		LQM	34650	See Text
Arsenic	inorganic	5.00E-02	EQS		1.25E+06		1800	RIVM	9.00E+09	
Cadmium	inorganic	2.50E-04	EQS		1.62E+06		2560	RIVM	9.00E+09	
Copper	inorganic	4.90E-02	PNEC using MBAT		1.38E+06		2120	RIVM	9.00E+09	
Chromium	inorganic	2.00E-02	EQS		5.85E+05		4800	RIVM	9.00E+09	
Lead	inorganic	7.20E-03	EQS				36000	RIVM	9.00E+09	
Mercury	inorganic	5.00E-05	EQS		7.40E+04		7500	RIVM	9.00E+09	
Nickel	inorganic	3.40E-02	PNEC using MBAT		2.50E+06		2000	RIVM	9.00E+09	
Selenium	inorganic	1.00E-02	DWS		2.17E+06		50	EA SGV Re	9.00E+09	
Zinc	inorganic	7.90E-02	PNEC using MBAT		4.32E+06		2600	RIVM	9.00E+09	
Vanadium	inorganic	2.00E-02	EQS				50	USEPA 199	9.00E+09	
Ammoniacal Nitrogen as N	inorganic	3.00E-01	EQS		8.99E+05		0.65	ea	1.28E+03	ea/qjeg
Chloride		2.50E+02	DWS				1		9.00E+09	

Level 3 Groundwater Site Parameters

Bulk density of aquifer materials:	1.1
Effective porosity of aquifer:	0.4
Distance to compliance point from source:	10
Width of plume at source:	220
Fraction of organic carbon in aquifer:	0.284
Longitudinal Dispersibility ax:	1
az:	0.1
ay:	0.01
Hydraulic Gradient:	0.005
Hydraulic Conductivity:	86
Mz = Sy	9.6329518
Length of source	0
Distance from centre of source to compliance x	10

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet

Site Name:	Coed Darcy Tip	Case:	1 = 10m to Compliance
Site Address:	Llandarcy		
Completed by:	JAS		
Date:	07/10/2022		

Number of Substances =

36

		Compliance Criteria			Site Measured Concentrations		Physiochemical Properties						
Substance	Type	Other	Base Case	Comment	Measured Soil	Measured GW		Kaw (H)	Water solubility	Koc	Kow	Kd	Reference
		mg L ⁻¹	mg L ⁻¹		mg kg ⁻¹	mg L ⁻¹		cm ³ cm ⁻³	mg L ⁻¹	Log (cm ³ g ⁻¹)	Log (ratio)	cm ³ g ⁻¹	
Benzene	organic		1.00E-02	Former EQS				1.16E-01	1.78E+03	1.83E+00	2.13E+00		SR7
Toluene	organic		7.40E-02					1.15E-01	5.90E+02	2.31E+00	2.73E+00		SR7
Ethylbenzene	organic		2.00E-02					1.39E-01	1.80E+02	2.65E+00	3.15E+00		SR7
m-Xylene	organic		3.00E-02					1.12E-01	2.00E+02	2.69E+00	3.20E+00		SR7
o-Xylene	organic		3.00E-02					9.20E-02	1.73E+02	2.63E+00	3.12E+00		SR7
p-Xylene	organic		3.00E-02					1.07E-01	2.00E+02	2.65E+00	3.15E+00		SR7
Benzo[b]fluoranthene	organic		1.70E-05	2015 ECO				2.05E-06	2.00E-03	5.02E+00	6.08E+00		SR7
Benzo[k]fluoranthene	organic		1.70E-05	2015 ECO				1.74E-06	8.00E-04	5.17E+00	6.26E+00		SR7
Benzo[ghi]perylene	organic		2.00E-06	2015 ECO				2.36E-06	2.64E-04	5.62E+00	6.81E+00		SR7
Benzo[a]pyrene HH2015	organic		1.70E-07	WFD 2015 HH				1.76E-06	3.80E-03	5.11E+00	6.18E+00		SR7
Fluoranthene HH 2015	organic		6.30E-06	WFD 2015 HH				6.29E-05	2.30E-01	4.26E+00	5.13E+00		SR7
Indeno[123-cd]pyrene	organic		2.00E-06	2015 ECO				2.05E-06	2.00E-04	4.94E+00	5.97E+00		SR7
Naphthalene	organic		2.00E-03	2015 ECO				6.62E-03	1.90E+01	2.81E+00	3.34E+00		SR7
Anthracene	organic		1.00E-04	2015 ECO				1.60E-03	4.50E-02	4.50E+00	4.50E+00		TR1
TPH Aliphatic C5-C6	organic		1.50E+01	CLAIRE				2.10E+01	3.60E+01	2.90E+00	3.30E+00		LQM
TPH Aliphatic C6-C8	organic		1.50E+01	CLAIRE				2.73E+01	5.40E+00	3.60E+00	4.10E+00		LQM
TPH Aliphatic C8-C10	organic		3.00E-01	CLAIRE				4.15E+01	4.30E-01	4.50E+00	5.20E+00		LQM
TPH Aliphatic C10-C12	organic		3.00E-01	CLAIRE				6.44E+01	3.40E-02	5.40E+00	6.30E+00		LQM
TPH Aliphatic C12-C16	organic		3.00E-01	CLAIRE				1.71E+02	7.60E-04	6.70E+00	7.90E+00		LQM
TPH Aromatic C8-C10	organic		3.00E-02	EQS BTEX				2.53E-01	6.50E+01	3.20E+00	3.70E+00		LQM
TPH Aromatic C10-C12	organic		9.00E-02	CLAIRE				7.22E-02	2.50E+01	3.40E+00	3.90E+00		LQM
TPH Aromatic C12-C16	organic		9.00E-02	CLAIRE				1.26E-02	5.80E+00	3.70E+00	4.30E+00		LQM
TPH Aromatic C16-C21	organic		9.00E-02	CLAIRE				6.95E-04	6.50E-01	4.20E+00	4.90E+00		LQM
TPH Aromatic C21-C35	organic		9.00E-02	CLAIRE				2.48E-05	6.60E-03	5.10E+00	6.00E+00		LQM
Arsenic	inorganic		5.00E-02	EQS					1.25E+06			1.80E+03	RIVM
Cadmium	inorganic		2.50E-04	EQS					1.62E+06			2.56E+03	RIVM
Copper	inorganic		4.90E-02	PNEC using MBAT					1.38E+06			2.12E+03	RIVM
Chromium	inorganic		2.00E-02	EQS					5.85E+05			4.80E+03	RIVM
Lead	inorganic		7.20E-03	EQS								3.60E+04	RIVM
Mercury	inorganic		5.00E-05	EQS					7.40E+04			7.50E+03	RIVM
Nickel	inorganic		3.40E-02	PNEC using MBAT					2.50E+06			2.00E+03	RIVM
Selenium	inorganic		1.00E-02	DWS					2.17E+06			5.00E+01	EA SGV Report
Zinc	inorganic		7.90E-02	PNEC using MBAT					4.32E+06			2.60E+03	RIVM
Vanadium	inorganic		2.00E-02	EQS								5.00E+01	USEPA 1996
Ammoniacal Nitrogen as N	inorganic		3.00E-01	EQS					8.99E+05			6.50E-01	ea
Chloride			250	DWS								1.00E+00	

Remedial Targets Worksheet

Site Name: Coed Darcy Tip Case: 1 = 10m to Compliance

Level 3 - Groundwater - Domenico Steady State Equation

Site Parameters			Source of parameter value		
Bulk density of aquifer materials:	1.1	g/cm ³	ρ		Calculated or from Level 2:
Effective porosity of aquifer:	0.4	fraction	n		Hydraulic Gradient: 5.00E-03
Distance to compliance point from source:	10	m			Hydraulic Conductivity: 86
Width of plume at source:	220	m	Sz		Mz = Sy 9.632951795
Fraction of organic carbon in aquifer:	0.284				Length of source 0
	1		ax		Distance from centre of source to compliance x 10
	0.1		az		
	0.01		ay		

= Remedial Target Exceeds Solubility

	Compliance Criteria															Level 3 Remedial Targets			
Substance	DWS		EQS	Measured GW	Koc	Kd	Rf	Apply Decay	u	Half Life		λ	ced/co	AF	Groundwater (mg/l)		Water Level Exceeds Level 3 Target		
								1 = Dissolved											
	mg L ⁻¹	mg L ⁻¹	mg L ⁻¹	Log (cm³ g ⁻¹)	cm³ g ⁻¹	fraction	Phase Only	m/d	days			fraction	fraction	fraction	DWS	EQS	DWS	EQS	
Benzene		1.00E-02	100	1.83E+00	1.92E+01	5.38E+01		2.00E-02	693	P2-228	1.00E-03	6.20E-01	1.61E+00			1.61E-02		Yes	
Toluene		7.40E-02	100	2.31E+00	5.80E+01	1.60E+02		6.70E-03	693	P2-228	1.00E-03	2.67E-01	3.74E+00			2.77E-01		Yes	
Ethylbenzene		2.00E-02	100	2.65E+00	1.27E+02	3.50E+02		3.07E-03	693	P2-228	1.00E-03	7.53E-02	1.33E+01			2.66E-01		Yes	
m-Xylene		3.00E-02	100	2.69E+00	1.39E+02	3.84E+02		2.80E-03	693	P2-228	1.00E-03	6.14E-02	1.63E+01			4.88E-01		Yes	
o-Xylene		3.00E-02	100	2.63E+00	1.21E+02	3.34E+02		3.22E-03	693	P2-228	1.00E-03	8.30E-02	1.21E+01			3.62E-01		Yes	
p-Xylene		3.00E-02	100	2.65E+00	1.27E+02	3.50E+02		3.07E-03	693	P2-228	1.00E-03	7.53E-02	1.33E+01			3.98E-01		Yes	
Benzo[b]fluoranthene		1.70E-05	100	5.02E+00	2.97E+04	8.18E+04		1.31E-05	3650	See Text	1.90E-04	3.33E-15	3.01E+14			5.11E+09		No	
Benzo[k]fluoranthene		1.70E-05	100	5.17E+00	4.20E+04	1.16E+05		9.31E-06	3650	See Text	1.90E-04	2.71E-18	3.69E+17			6.28E+12		No	
Benzo[ghi]perylene		2.00E-06	100	5.62E+00	1.18E+05	3.26E+05		3.30E-06	3650	See Text	1.90E-04	1.46E-31	6.86E+30			1.37E+25		No	
Benzo[a]pyrene HH2015		1.70E-07	100	5.11E+00	3.66E+04	1.01E+05		1.07E-05	3650	See Text	1.90E-04	5.42E-17	1.85E+16			3.14E+09		No	
Fluoranthene HH 2015		6.30E-06	100	4.26E+00	5.17E+03	1.42E+04		7.56E-05	3650	See Text	1.90E-04	9.02E-06	1.11E+05			6.98E-01		Yes	
Indeno[123-cd]pyrene		2.00E-06	100	4.94E+00	2.47E+04	6.80E+04		1.58E-05	3650	See Text	1.90E-04	9.14E-14	1.09E+13			2.19E+07		No	
Naphthalene		2.00E-03	100	2.81E+00	1.83E+02	5.05E+02		2.13E-03	300	P2-228	2.31E-03	1.42E-03	7.05E+02			1.41E+00		Yes	
Anthracene		1.00E-04	100	4.50E+00	8.98E+03	2.47E+04		4.35E-05	3650	See Text	1.90E-04	6.98E-08	1.43E+07			1.43E+03		No	
TPH Aliphatic C5-C6		1.50E+01	100	2.90E+00	2.26E+02	6.21E+02		1.73E-03	693	See Text	1.00E-03	1.66E-02	6.04E+01			9.05E+02		No	
TPH Aliphatic C6-C8		1.50E+01	100	3.60E+00	1.13E+03	3.11E+03		3.46E-04	693	See Text	1.00E-03	2.96E-06	3.38E+05			5.07E+06		No	
TPH Aliphatic C8-C10		3.00E-01	100	4.50E+00	8.98E+03	2.47E+04		4.35E-05	693	See Text	1.00E-03	1.74E-19	5.76E+18			1.73E+18		No	
TPH Aliphatic C10-C12		3.00E-01	100	5.40E+00	7.13E+04	1.96E+05		5.48E-06	693		1.00E-03	2.86E-57	3.50E+56			1.05E+56		No	
TPH Aliphatic C12-C16		3.00E-01	100	6.70E+00	1.42E+06	3.91E+06		2.75E-07	3465		2.00E-04	8.73E-116	1.15E+115			3.44E+114		No	
TPH Aromatic C8-C10		3.00E-02	100	3.20E+00	4.50E+02	1.24E+03		8.68E-04	693		1.00E-03	1.07E-03	9.38E+02			2.81E+01		Yes	
TPH Aromatic C10-C12		9.00E-02	100	3.40E+00	7.13E+02	1.96E+03		5.48E-04	693	See Text	1.00E-03	8.20E-05	1.22E+04			1.10E+03		No	
TPH Aromatic C12-C16		9.00E-02	100	3.70E+00	1.42E+03	3.92E+03		2.75E-04	3465	See Text	2.00E-04	7.50E-03	1.33E+02			1.20E+01		Yes	
TPH Aromatic C16-C21		9.00E-02	100	4.20E+00	4.50E+03	1.24E+04		8.68E-05	3465	See Text	2.00E-04	1.70E-05	5.87E+04			5.28E+03		No	
TPH Aromatic C21-C35		9.00E-02	100	5.10E+00	3.58E+04	9.83E+04		1.09E-05	34650	See Text	2.00E-05	8.10E-05	1.23E+04			1.11E+03		No	
Arsenic		5.00E-02	100		1.80E+03	4.95E+03		2.17E-04	9E+09		7.70E-11	1.00E+00	1.00E+00			5.00E-02		Yes	
Cadmium		2.50E-04	100		2.56E+03	7.04E+03		1.53E-04	9E+09		7.70E-11	1.00E+00	1.00E+00			2.50E-04		Yes	
Copper		4.90E-02	100		2.12E+03	5.83E+03		1.84E-04	9E+09		7.70E-11	1.00E+00	1.00E+00			4.90E-02		Yes	
Chromium		2.00E-02	100		4.80E+03	1.32E+04		8.14E-05	9E+09		7.70E-11	1.00E+00	1.00E+00			2.00E-02		Yes	
Lead		7.20E-03	100		3.60E+04	9.90E+04		1.09E-05	9E+09		7.70E-11	1.00E+00	1.00E+00			7.20E-03		Yes	
Mercury		5.00E-05	100		7.50E+03	2.06E+04		5.21E-05	9E+09		7.70E-11	1.00E+00	1.00E+00			5.00E-05		Yes	
Nickel		3.40E-02	100		2.00E+03	5.50E+03		1.95E-04	9E+09		7.70E-11	1.00E+00	1.00E+00			3.40E-02		Yes	
Selenium		1.00E-02	100		5.00E+01	1.39E+02		7.76E-03	9E+09		7.70E-11	1.00E+00	1.00E+00			1.00E-02		Yes	
Zinc		7.90E-02	100		2.60E+03	7.15E+03		1.50E-04	9E+09		7.70E-11	1.00E+00	1.00E+00			7.90E-02		Yes	
Vanadium		2.00E-02	100		5.00E+01	1.39E+02		7.76E-03	9E+09		7.70E-11	1.00E+00	1.00E+00			2.00E-02		Yes	
Ammoniacal Nitrogen as N		3.00E-01	100		6.50E-01	2.79E+00		3.86E-01	1280	ea/qjeg	5.42E-04	9.86E-01	1.01E+00			3.04E-01		Yes	
Chloride		2.50E+02	100		1.00E+00	3.75E+00		2.87E-01	9E+09		7.70E-11	1.00E+00	1.00E+00			2.50E+02		No	

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet

Site Name:	Coed Darcy Tip	Case:	1 = 50m to Compliance
Site Address:	Llandarcy		
Completed by:	JAS		
Date:	07/10/2022		

Number of Substances =

36

		Compliance Criteria			Site Measured Concentrations		Physiochemical Properties						
Substance	Type	Other	Base Case	Comment	Measured Soil	Measured GW		Kaw (H)	Water solubility	Koc	Kow	Kd	Reference
		mg L ⁻¹	mg L ⁻¹		mg kg ⁻¹	mg L ⁻¹		cm ³ cm ⁻³	mg L ⁻¹	Log (cm ³ g ⁻¹)	Log (ratio)	cm ³ g ⁻¹	
Benzene	organic		1.00E-02	Former EQS				1.16E-01	1.78E+03	1.83E+00	2.13E+00		SR7
Toluene	organic		7.40E-02					1.15E-01	5.90E+02	2.31E+00	2.73E+00		SR7
Ethylbenzene	organic		2.00E-02					1.39E-01	1.80E+02	2.65E+00	3.15E+00		SR7
m-Xylene	organic		3.00E-02					1.12E-01	2.00E+02	2.69E+00	3.20E+00		SR7
o-Xylene	organic		3.00E-02					9.20E-02	1.73E+02	2.63E+00	3.12E+00		SR7
p-Xylene	organic		3.00E-02					1.07E-01	2.00E+02	2.65E+00	3.15E+00		SR7
Benzo[b]fluoranthene	organic		1.70E-05	2015 ECO				2.05E-06	2.00E-03	5.02E+00	6.08E+00		SR7
Benzo[k]fluoranthene	organic		1.70E-05	2015 ECO				1.74E-06	8.00E-04	5.17E+00	6.26E+00		SR7
Benzo[ghi]perylene	organic		2.00E-06	2015 ECO				2.36E-06	2.64E-04	5.62E+00	6.81E+00		SR7
Benzo[a]pyrene HH2015	organic		1.70E-07	WFD 2015 HH				1.76E-06	3.80E-03	5.11E+00	6.18E+00		SR7
Fluoranthene HH 2015	organic		6.30E-06	WFD 2015 HH				6.29E-05	2.30E-01	4.26E+00	5.13E+00		SR7
Indeno[123-cd]pyrene	organic		2.00E-06	2015 ECO				2.05E-06	2.00E-04	4.94E+00	5.97E+00		SR7
Naphthalene	organic		2.00E-03	2015 ECO				6.62E-03	1.90E+01	2.81E+00	3.34E+00		SR7
Anthracene	organic		1.00E-04	2015 ECO				1.60E-03	4.50E-02	4.50E+00	4.50E+00		TR1
TPH Aliphatic C5-C6	organic		1.50E+01	CLAIRE				2.10E+01	3.60E+01	2.90E+00	3.30E+00		LQM
TPH Aliphatic C6-C8	organic		1.50E+01	CLAIRE				2.73E+01	5.40E+00	3.60E+00	4.10E+00		LQM
TPH Aliphatic C8-C10	organic		3.00E-01	CLAIRE				4.15E+01	4.30E-01	4.50E+00	5.20E+00		LQM
TPH Aliphatic C10-C12	organic		3.00E-01	CLAIRE				6.44E+01	3.40E-02	5.40E+00	6.30E+00		LQM
TPH Aliphatic C12-C16	organic		3.00E-01	CLAIRE				1.71E+02	7.60E-04	6.70E+00	7.90E+00		LQM
TPH Aromatic C8-C10	organic		3.00E-02	EQS BTEX				2.53E-01	6.50E+01	3.20E+00	3.70E+00		LQM
TPH Aromatic C10-C12	organic		9.00E-02	CLAIRE				7.22E-02	2.50E+01	3.40E+00	3.90E+00		LQM
TPH Aromatic C12-C16	organic		9.00E-02	CLAIRE				1.26E-02	5.80E+00	3.70E+00	4.30E+00		LQM
TPH Aromatic C16-C21	organic		9.00E-02	CLAIRE				6.95E-04	6.50E-01	4.20E+00	4.90E+00		LQM
TPH Aromatic C21-C35	organic		9.00E-02	CLAIRE				2.48E-05	6.60E-03	5.10E+00	6.00E+00		LQM
Arsenic	inorganic		5.00E-02	EQS					1.25E+06			1.80E+03	RIVM
Cadmium	inorganic		2.50E-04	EQS					1.62E+06			2.56E+03	RIVM
Copper	inorganic		4.90E-02	PNEC using MBAT					1.38E+06			2.12E+03	RIVM
Chromium	inorganic		2.00E-02	EQS					5.85E+05			4.80E+03	RIVM
Lead	inorganic		7.20E-03	EQS								3.60E+04	RIVM
Mercury	inorganic		5.00E-05	EQS					7.40E+04			7.50E+03	RIVM
Nickel	inorganic		3.40E-02	PNEC using MBAT					2.50E+06			2.00E+03	RIVM
Selenium	inorganic		1.00E-02	DWS					2.17E+06			5.00E+01	EA SGV Report
Zinc	inorganic		7.90E-02	PNEC using MBAT					4.32E+06			2.60E+03	RIVM
Vanadium	inorganic		2.00E-02	EQS								5.00E+01	USEPA 1996
Ammoniacal Nitrogen as N	inorganic		3.00E-01	EQS					8.99E+05			6.50E-01	ea
Chloride			250	DWS								1.00E+00	

Remedial Targets Worksheet

Site Name: Coed Darcy Tip Case: 1 = 50m to Compliance

Level 3 - Groundwater - Domenico Steady State Equation

Site Parameters			Source of parameter value		
Bulk density of aquifer materials:	1.1	g/cm ³	ρ	Calculated or from Level 2:	
Effective porosity of aquifer:	0.4	fraction	n	Hydraulic Gradient:	5.00E-03
Distance to compliance point from source:	50	m		Hydraulic Conductivity:	86
Width of plume at source:	220	m	Sz	Mz = Sy	9.632951795
Fraction of organic carbon in aquifer:	0.284			Length of source	0
	5		ax	Distance from centre of source to compliance x	50
	0.5		az		
	0.05		ay		

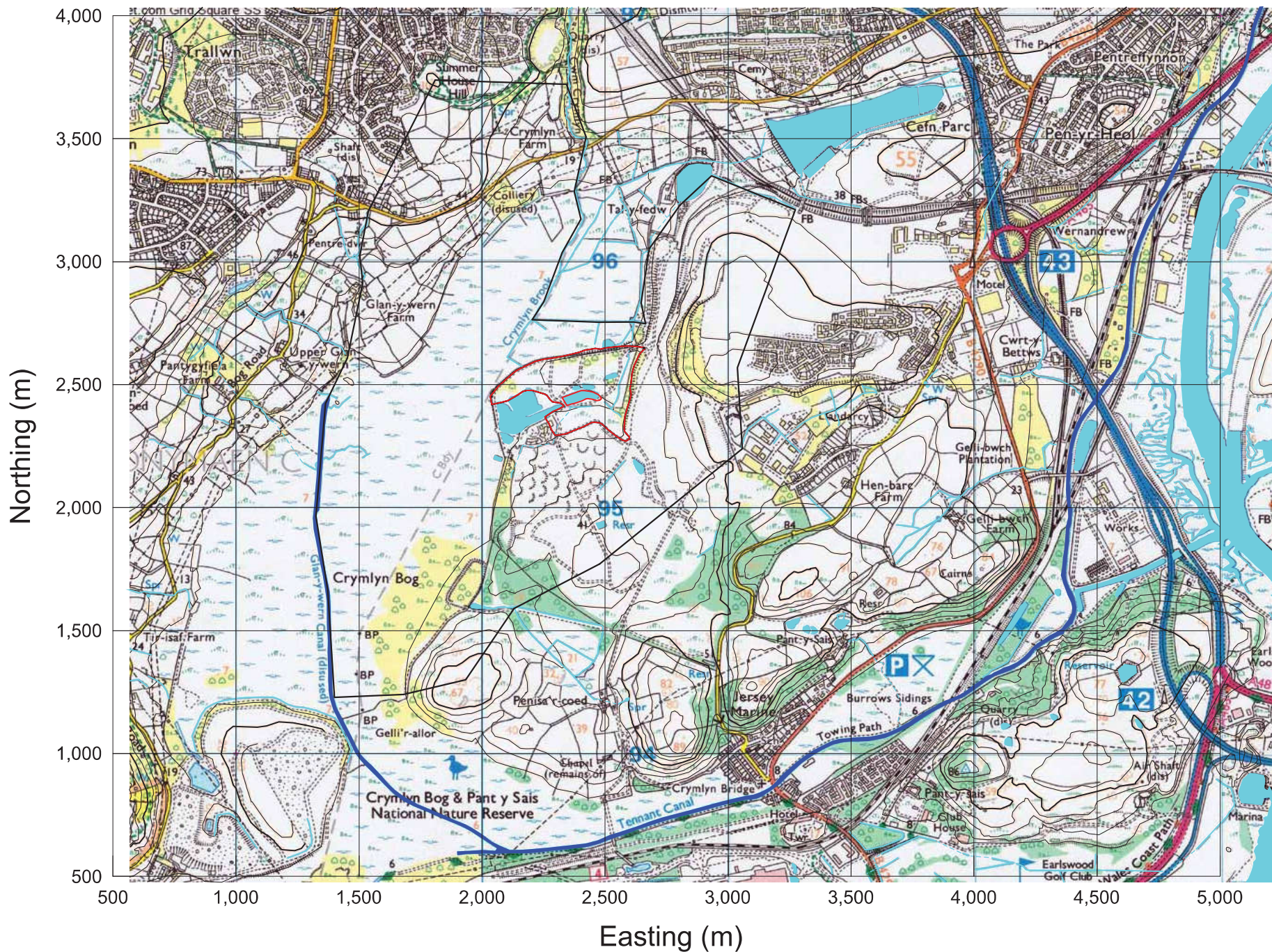
= Remedial Target Exceeds Solubility

	Compliance Criteria			Level 3 Remedial Targets													
Substance				Groundwater (mg/l)												Water Level Exceeds Level 3 Target	
	DWS	EQS	Measured GW	Koc	Kd	Rf	Apply Decay	u	Half Life		λ	ced/co	AF				
	mg L ⁻¹	mg L ⁻¹	mg L ⁻¹	Log (cm ³ g ⁻¹)	cm ³ g ⁻¹	fraction	1 = Dissolved Phase Only	m/d	days			fraction	fraction	DWS	EQS	DWS	EQS
Benzene		1.00E-02	100	1.83E+00	1.92E+01	5.38E+01		2.00E-02	693	P2-228	1.00E-03	1.26E-01	7.95E+00		7.95E-02		Yes
Toluene		7.40E-02	100	2.31E+00	5.80E+01	1.60E+02		6.70E-03	693	P2-228	1.00E-03	6.86E-03	1.46E+02		1.08E+01		Yes
Ethylbenzene		2.00E-02	100	2.65E+00	1.27E+02	3.50E+02		3.07E-03	693	P2-228	1.00E-03	1.66E-04	6.02E+03		1.20E+02		No
m-Xylene		3.00E-02	100	2.69E+00	1.39E+02	3.84E+02		2.80E-03	693	P2-228	1.00E-03	9.49E-05	1.05E+04		3.16E+02		No
o-Xylene		3.00E-02	100	2.63E+00	1.21E+02	3.34E+02		3.22E-03	693	P2-228	1.00E-03	2.17E-04	4.60E+03		1.38E+02		No
p-Xylene		3.00E-02	100	2.65E+00	1.27E+02	3.50E+02		3.07E-03	693	P2-228	1.00E-03	1.66E-04	6.02E+03		1.81E+02		No
Benzo[b]fluoranthene		1.70E-05	100	5.02E+00	2.97E+04	8.18E+04		1.31E-05	3650	See Text	1.90E-04	1.57E-35	6.36E+34		1.08E+30		No
Benzo[k]fluoranthene		1.70E-05	100	5.17E+00	4.20E+04	1.16E+05		9.31E-06	3650	See Text	1.90E-04	1.77E-42	5.64E+41		9.59E+36		No
Benzo[ghi]perylene		2.00E-06	100	5.62E+00	1.18E+05	3.26E+05		3.30E-06	3650	See Text	1.90E-04	3.10E-72	3.22E+71		6.44E+65		No
Benzo[a]pyrene HH2015		1.70E-07	100	5.11E+00	3.66E+04	1.01E+05		1.07E-05	3650	See Text	1.90E-04	1.49E-39	6.72E+38		1.14E+32		No
Fluoranthene HH 2015		6.30E-06	100	4.26E+00	5.17E+03	1.42E+04		7.56E-05	3650	See Text	1.90E-04	4.28E-14	2.34E+13		1.47E+08		No
Indeno[123-cd]pyrene		2.00E-06	100	4.94E+00	2.47E+04	6.80E+04		1.58E-05	3650	See Text	1.90E-04	2.74E-32	3.65E+31		7.30E+25		No
Naphthalene		2.00E-03	100	2.81E+00	1.83E+02	5.05E+02		2.13E-03	300	P2-228	2.31E-03	6.63E-09	1.51E+08		3.02E+05		No
Anthracene		1.00E-04	100	4.50E+00	8.98E+03	2.47E+04		4.35E-05	3650	See Text	1.90E-04	5.90E-19	1.69E+18		1.69E+14		No
TPH Aliphatic C5-C6		1.50E+01	100	2.90E+00	2.26E+02	6.21E+02		1.73E-03	693	See Text	1.00E-03	2.98E-06	3.35E+05		5.03E+06		No
TPH Aliphatic C6-C8		1.50E+01	100	3.60E+00	1.13E+03	3.11E+03		3.46E-04	693	See Text	1.00E-03	3.23E-15	3.09E+14		4.64E+15		No
TPH Aliphatic C8-C10		3.00E-01	100	4.50E+00	8.98E+03	2.47E+04		4.35E-05	693	See Text	1.00E-03	3.70E-45	2.70E+44		8.11E+43		No
TPH Aliphatic C10-C12		3.00E-01	100	5.40E+00	7.13E+04	1.96E+05		5.48E-06	693		1.00E-03	8.96E-130	1.12E+129		3.35E+128		No
TPH Aliphatic C12-C16		3.00E-01	100	6.70E+00	1.42E+06	3.91E+06		2.75E-07	3465		2.00E-04	1.18E-260	8.48E+259		2.54E+259		No
TPH Aromatic C8-C10		3.00E-02	100	3.20E+00	4.50E+02	1.24E+03		8.68E-04	693		1.00E-03	3.33E-09	3.01E+08		9.02E+06		No
TPH Aromatic C10-C12		9.00E-02	100	3.40E+00	7.13E+02	1.96E+03		5.48E-04	693	See Text	1.00E-03	7.41E-12	1.35E+11		1.22E+10		No
TPH Aromatic C12-C16		9.00E-02	100	3.70E+00	1.42E+03	3.92E+03		2.75E-04	3465	See Text	2.00E-04	4.01E-07	2.50E+06		2.25E+05		No
TPH Aromatic C16-C21		9.00E-02	100	4.20E+00	4.50E+03	1.24E+04		8.68E-05	3465	See Text	2.00E-04	1.88E-13	5.33E+12		4.80E+11		No
TPH Aromatic C21-C35		9.00E-02	100	5.10E+00	3.58E+04	9.83E+04		1.09E-05	34650	See Text	2.00E-05	7.20E-12	1.39E+11		1.25E+10		No
Arsenic		5.00E-02	100		1.80E+03	4.95E+03		2.17E-04	9E+09		7.70E-11	1.00E+00	1.00E+00		5.00E-02		Yes
Cadmium		2.50E-04	100		2.56E+03	7.04E+03		1.53E-04	9E+09		7.70E-11	1.00E+00	1.00E+00		2.50E-04		Yes
Copper		4.90E-02	100		2.12E+03	5.83E+03		1.84E-04	9E+09		7.70E-11	1.00E+00	1.00E+00		4.90E-02		Yes
Chromium		2.00E-02	100		4.80E+03	1.32E+04		8.14E-05	9E+09		7.70E-11	1.00E+00	1.00E+00		2.00E-02		Yes
Lead		7.20E-03	100		3.60E+04	9.90E+04		1.09E-05	9E+09		7.70E-11	1.00E+00	1.00E+00		7.20E-03		Yes
Mercury		5.00E-05	100		7.50E+03	2.06E+04		5.21E-05	9E+09		7.70E-11	1.00E+00	1.00E+00		5.00E-05		Yes
Nickel		3.40E-02	100		2.00E+03	5.50E+03		1.95E-04	9E+09		7.70E-11	1.00E+00	1.00E+00		3.40E-02		Yes
Selenium		1.00E-02	100		5.00E+01	1.39E+02		7.76E-03	9E+09		7.70E-11	1.00E+00	1.00E+00		1.00E-02		Yes
Zinc		7.90E-02	100		2.60E+03	7.15E+03		1.50E-04	9E+09		7.70E-11	1.00E+00	1.00E+00		7.90E-02		Yes
Vanadium		2.00E-02	100		5.00E+01	1.39E+02		7.76E-03	9E+09		7.70E-11	1.00E+00	1.00E+00		2.00E-02		Yes
Ammoniacal Nitrogen as N		3.00E-01	100		6.50E-01	2.79E+00		3.86E-01	1280	ea/qjeg	5.42E-04	9.33E-01	1.07E+00		3.22E-01		Yes
Chloride		2.50E+02	100		1.00E+00	3.75E+00		2.87E-01	9E+09		7.70E-11	1.00E+00	1.00E+00		2.50E+02		No

Figures - C1 - C12



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Unit 8, Commerce Park
Barnard Road
Reading
RG2 4AG
01188 167340

Columbus House
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Tongwyclas
Cardiff
CF11 7UE
02920 358636

Client

St. Modwen Developments Limited

Project

Crymlyn Tip Restoration and Surrender

Title

Site Topographic Setting

Drawn by

Checked Date

Authorised Date

Original Scale

Date Nov, 2022

Rev 0

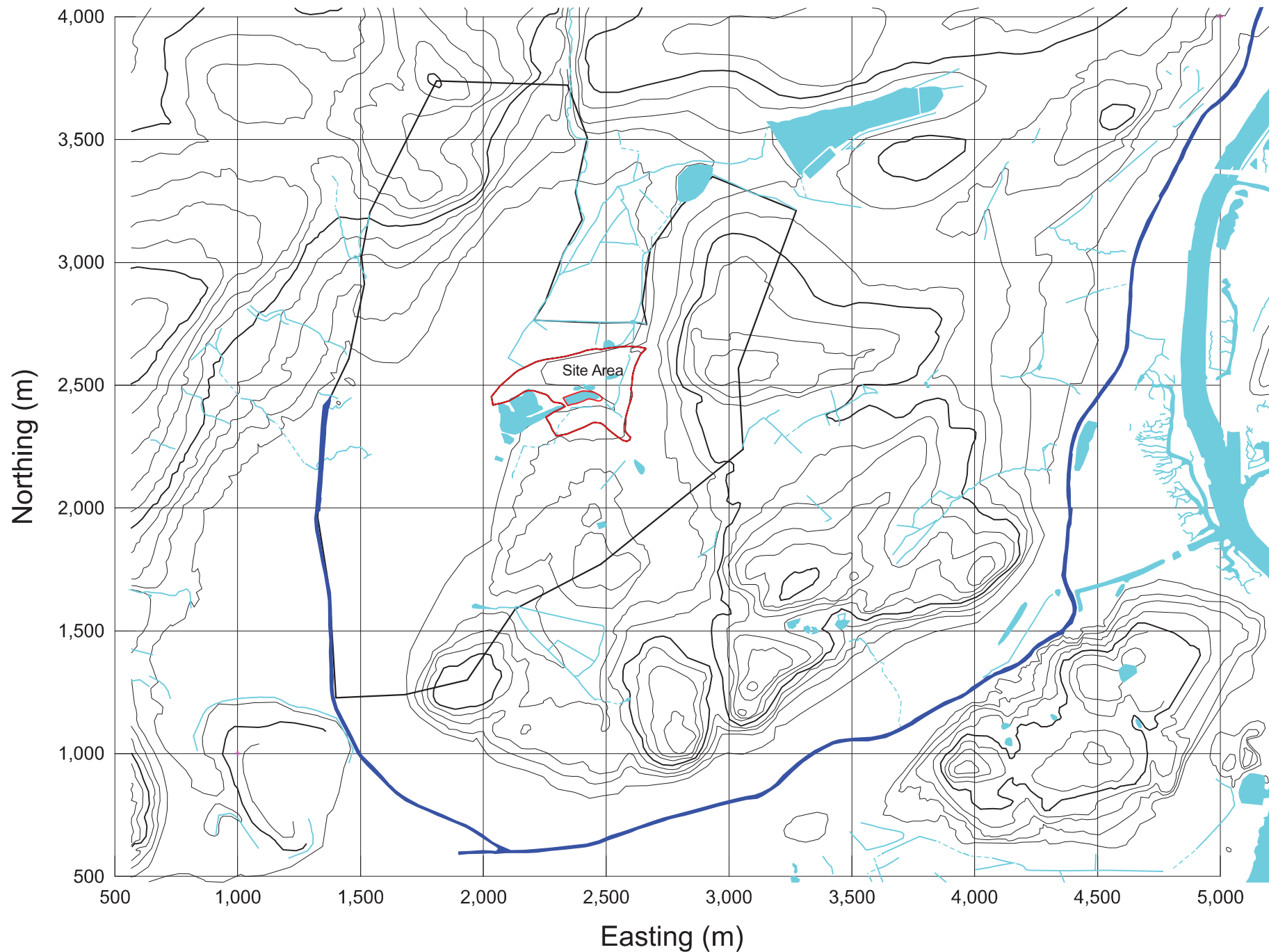
Paper A4

Contract Number

C1870

Drawing Number

C1



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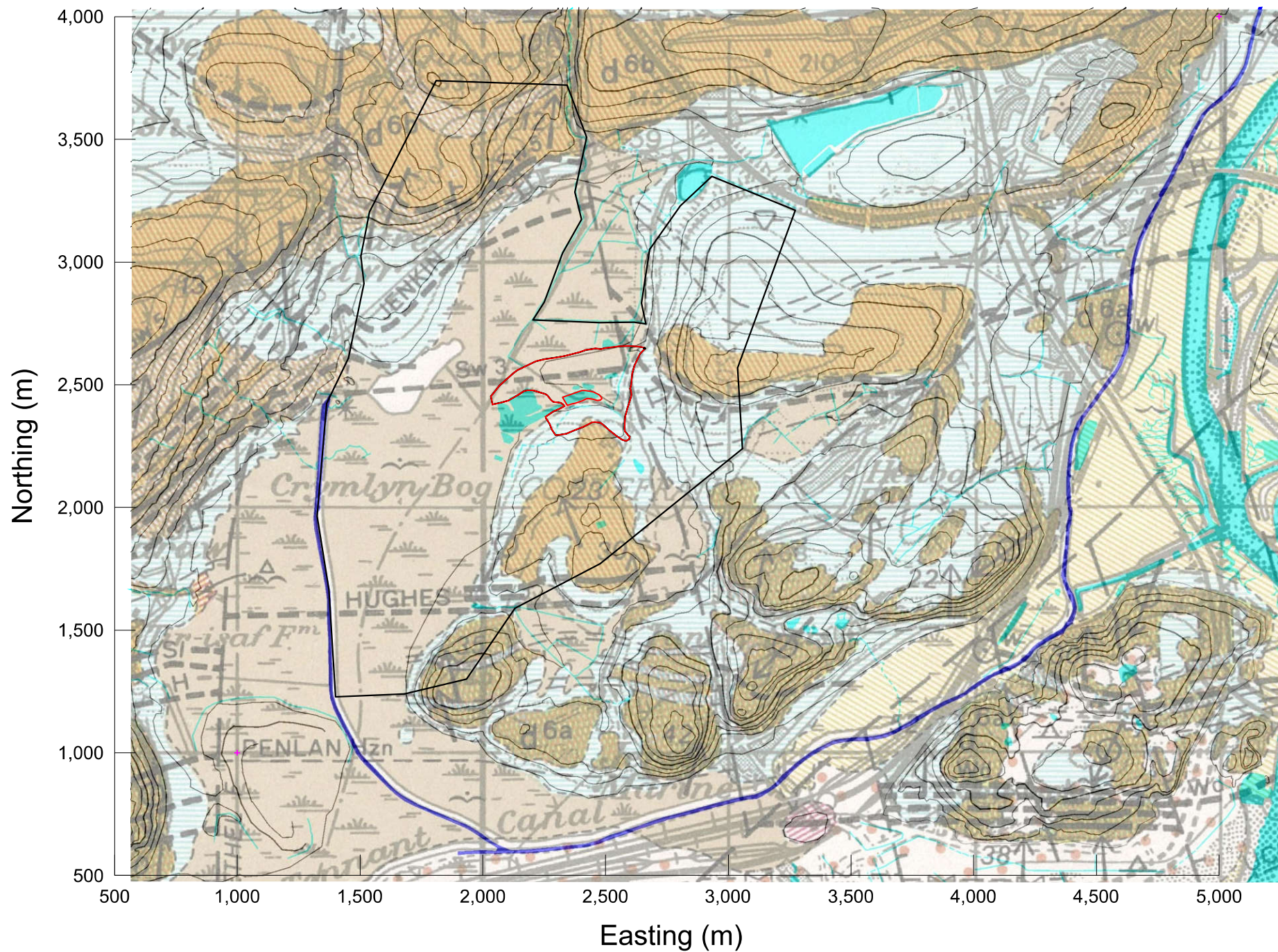
Unit 8, Commerce Park Blund Road Thrale Reading RG2 4AG 01188 167340	Columbus House Greenmeadow Springs Froggylands Cardiff CF15 7NE 02920 358635	www.englobeglobal.com www.englobeglobal.com
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Client
St. Modwen Developments Limited

Project
Crymlyn Tip Restoration and Surrender

Title
Surface Water Features in Vicinity of Site

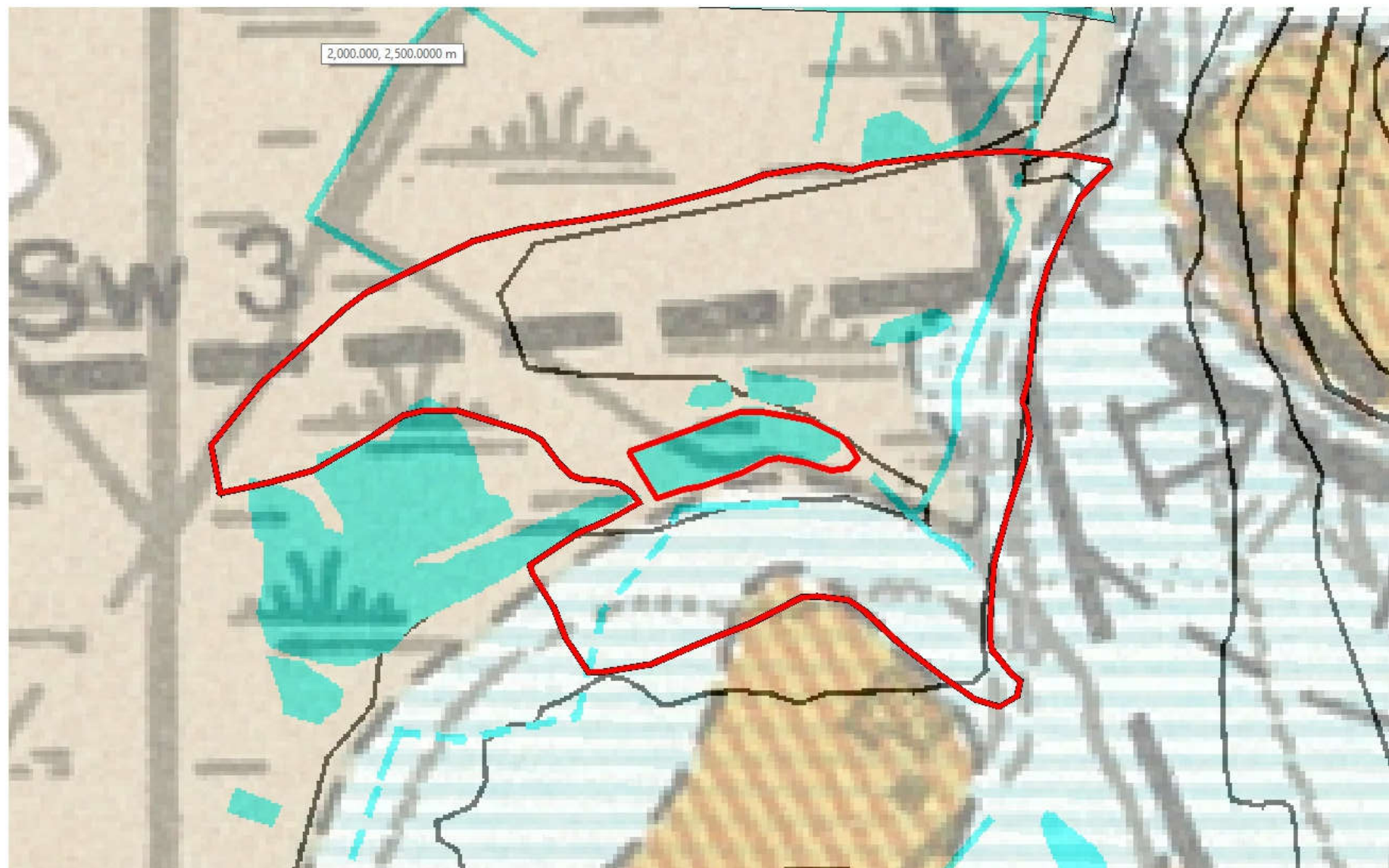
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Contract Number C1870	Drawing Number C2			



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Client			
St. Modwen Developments Limited			
Project			
Crymlyn Tip Restoration and Surrender			
Title			
Geology - Surrounding Area			
Drawn by	Checked	Date	Authorised Date
Original Scale	Date	Rev	Paper
Contract Number	Drawing Number		
C1870	C3a		

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Client
St. Modwen Developments Limited

Project
Crymlyn Tip Restoration and Surrender

Title
Site Geology

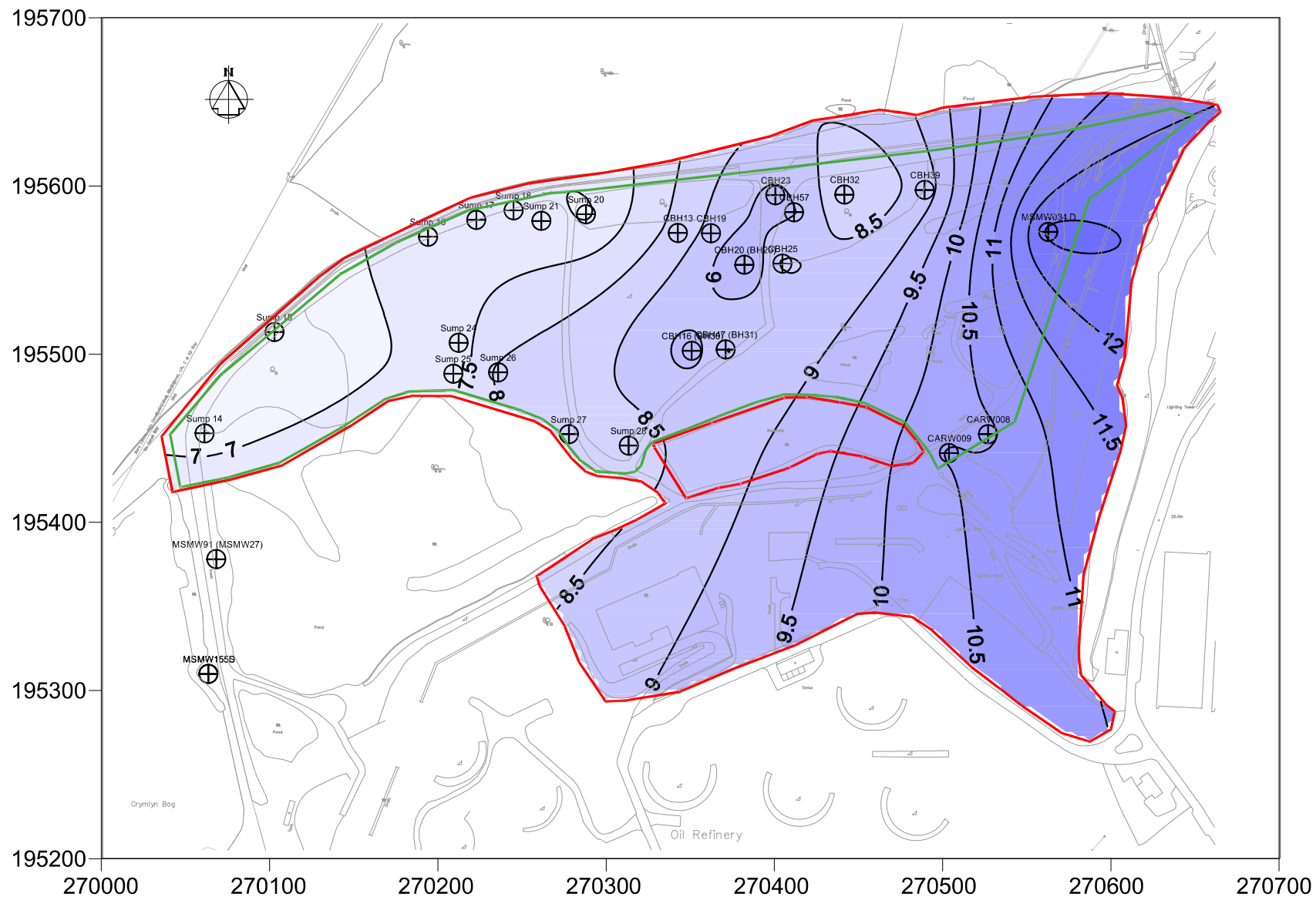
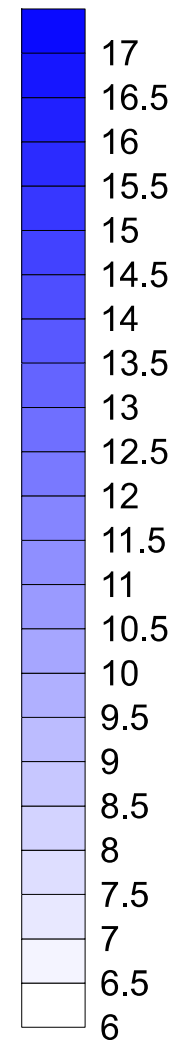
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	Nov, 2022	0	A4

Contract Number	Drawing Number
C1870	C3b



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Client	St. Modwen Developments Limited
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Project	Crymlyn Tip Restoration and Surrender
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Title	Inferred Contours of Average Water Level
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	2020 to 2022
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Original Scale	Date	Rev	Paper
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Contract Number	Drawing Number
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C1870	C4b
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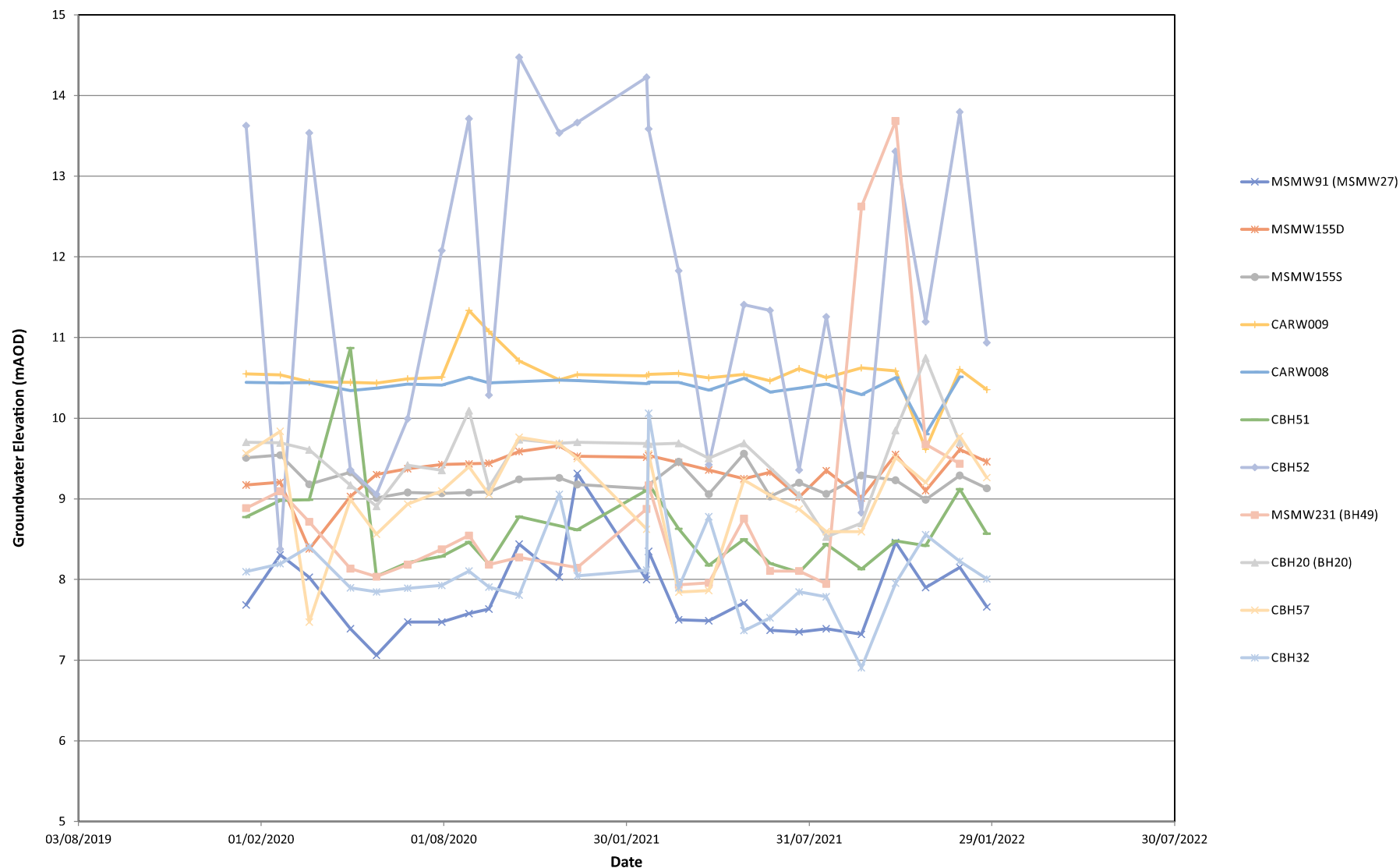
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ENGLOBE			
Unit 8, Commerce Park Blund Road Thrale Reading RG7 4AB 01188 167340		Columbus House Greenmeadow Springs Froggysdale Cardiff CF15 7NE 02920 358636	
enquiries@englobeglobal.com www.englobeglobal.com			
Client St. Modwen Developments Limited			
Project Crymlyn Tip Restoration and Surrender			
Title Selected Measured Groundwater Levels vs Date (1998 to 2003 data)			
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Original Scale	Date	Rev	Paper
	Nov. 2022	0	A4
Contract Number C1870		Drawing Number C5a	



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Client
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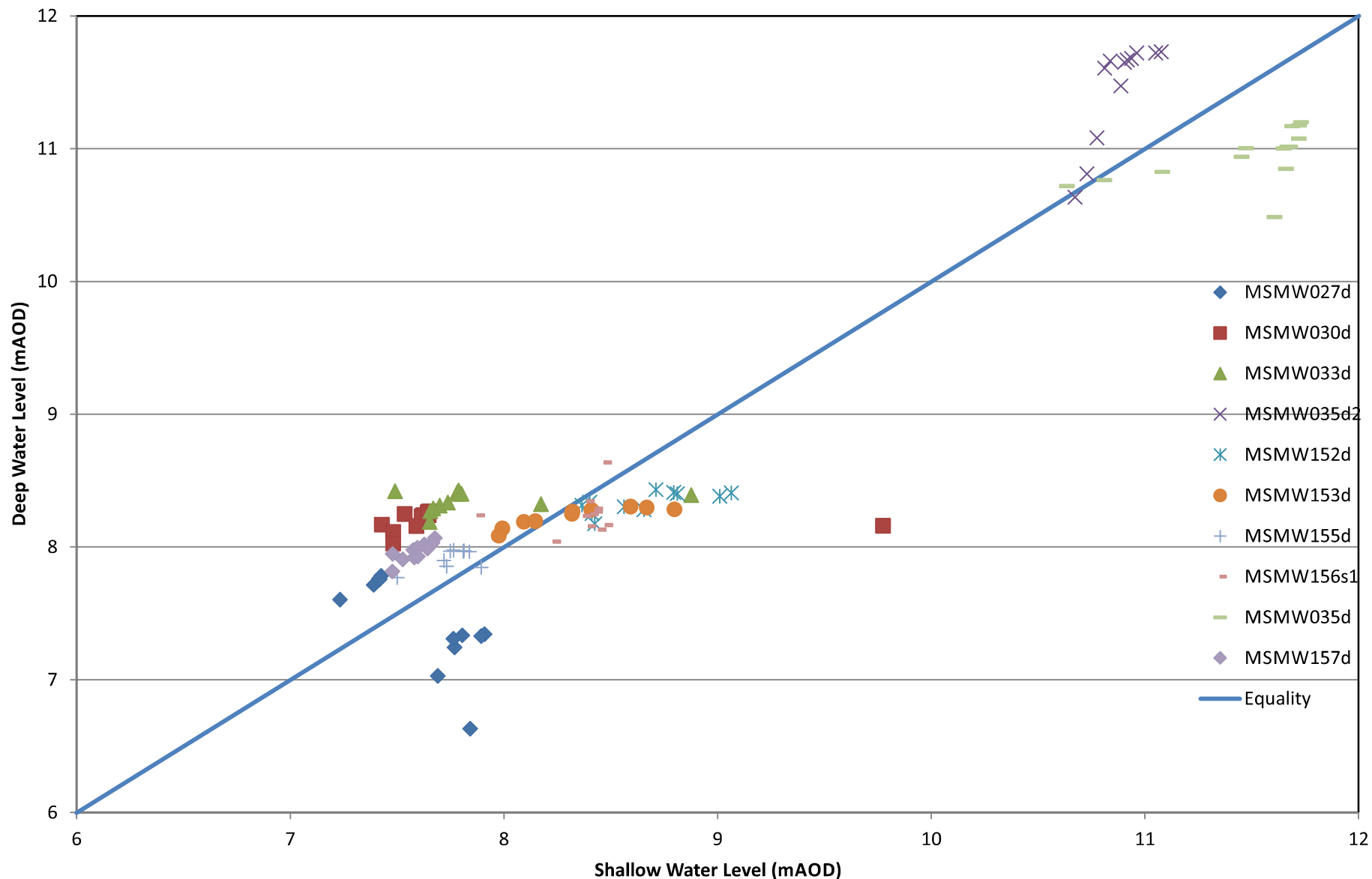
Project
Crymlyn Tip Restoration and Surrender

Title
Selected Measured Groundwater
Levels vs Date
(2020 to 2022 data)

Drawn by	Checked	Date	Authorised	Date
Original Scale	Date	Rev	Paper	
	Nov. 2022	0	A4	
Contract Number C1870	Drawing Number C5b			



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Client
St. Modwen Developments Limited

Project
Crymlyn Tip Restoration and Surrender

Title
Deep vs Shallow Water Level for Double Installations

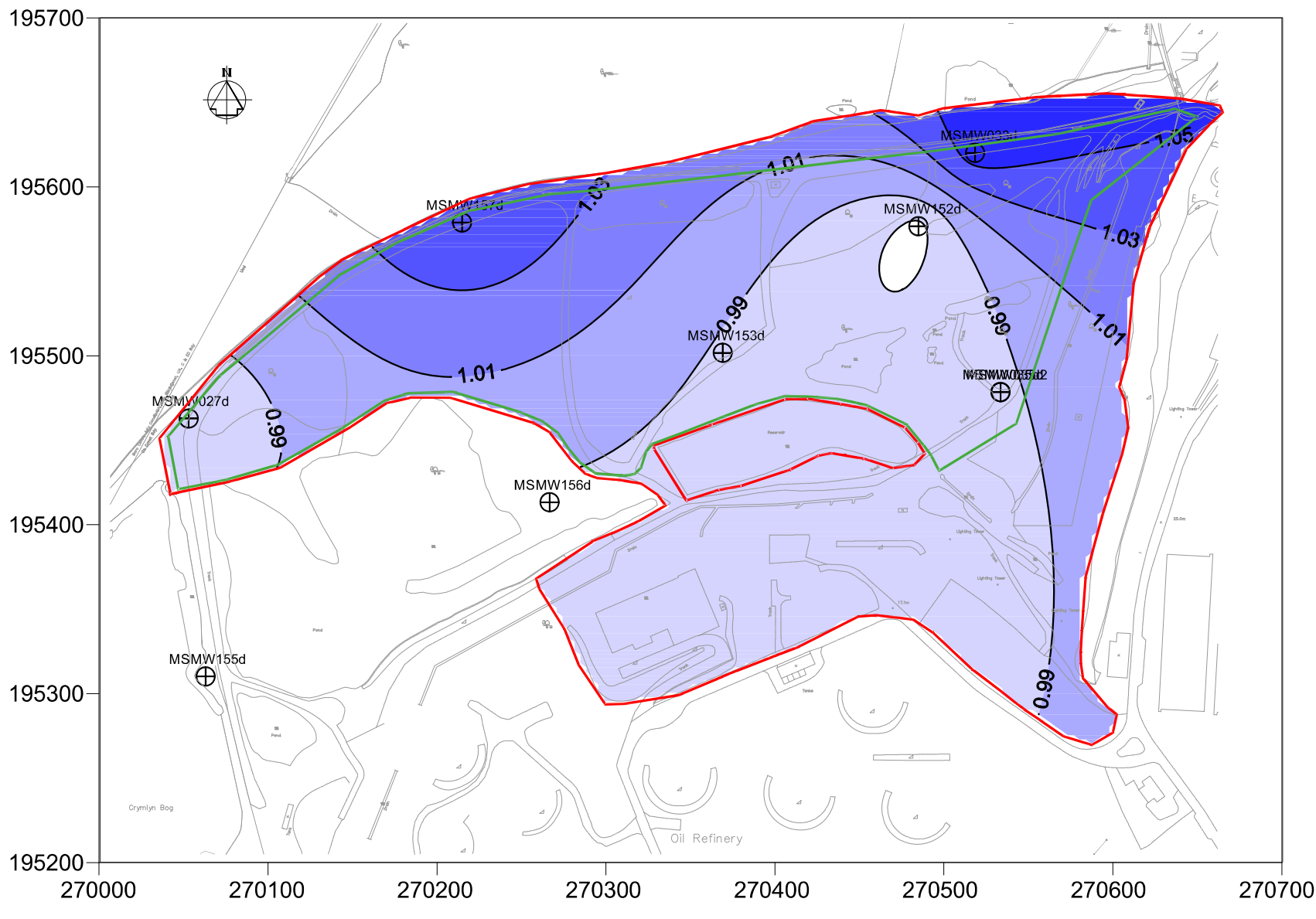
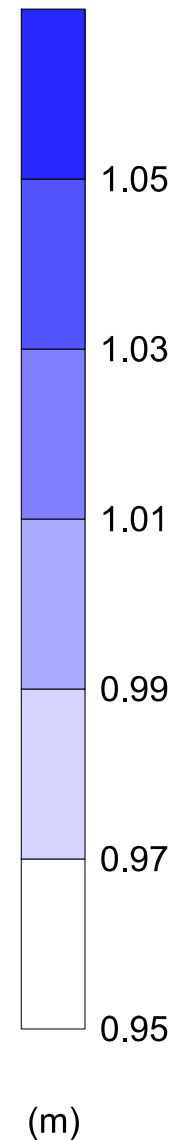
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Original Scale	Date	Rev	Paper
	Nov, 2022	0	A4

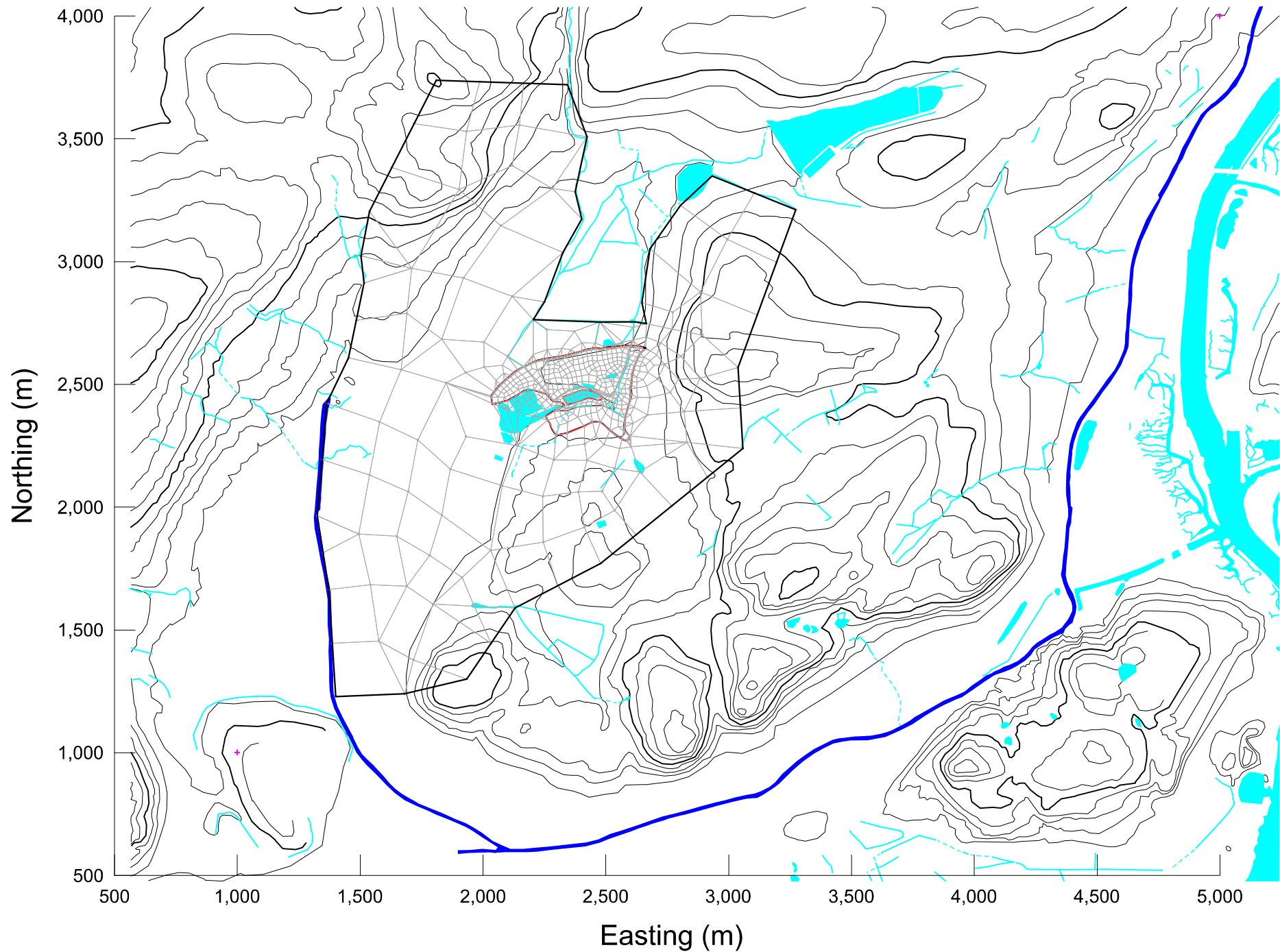
Contract Number	Drawing Number
C1870	C6



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Unit 8, Commerce Park Brunel Road Theale Reading RG7 4AS 01189 167340		Columbus House Greenmeadow Springs Tongwynlais Cardiff CF15 7NE 02920 358636	
www.englobecorp.com			
Client St. Modwen Developments Limited			
Project Crymlyn Tip Restoration and Surrender			
Title Contours of Ratio of Deep to Shallow Water Level			
Drawn by		Checked	Date
Original Scale		Date	Rev
		Nov, 2022	0
Contract Number C1870		Drawing Number C7	

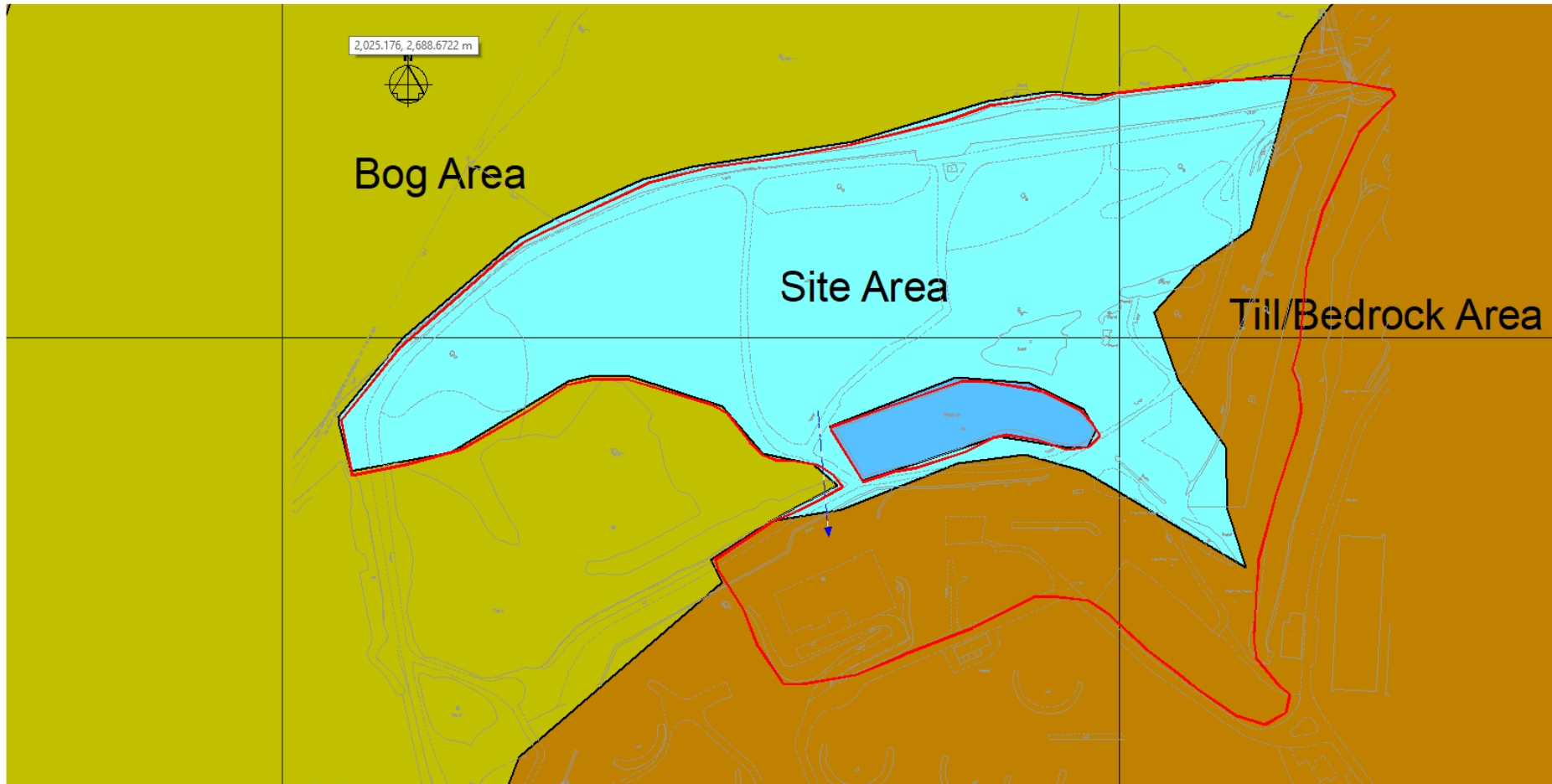


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Unit 8, Commerce Park Blundell Road Thrale Reading RG27 4AG 01188 167340	Columbus House Greenmeadow Springs Froggylands Cardiff CF15 7NE 02920 356535	www.englobeglobal.com www.englobeglobal.com
Client St. Modwen Developments Limited		
Project Crymlyn Tip Restoration and Surrender		
Title Assumed Catchment Area & Finite Element Mesh		
Drawn by	Checked	Date
Original Scale	Date	Rev
Contract Number	Drawing Number	Paper
C1870	C8	A4



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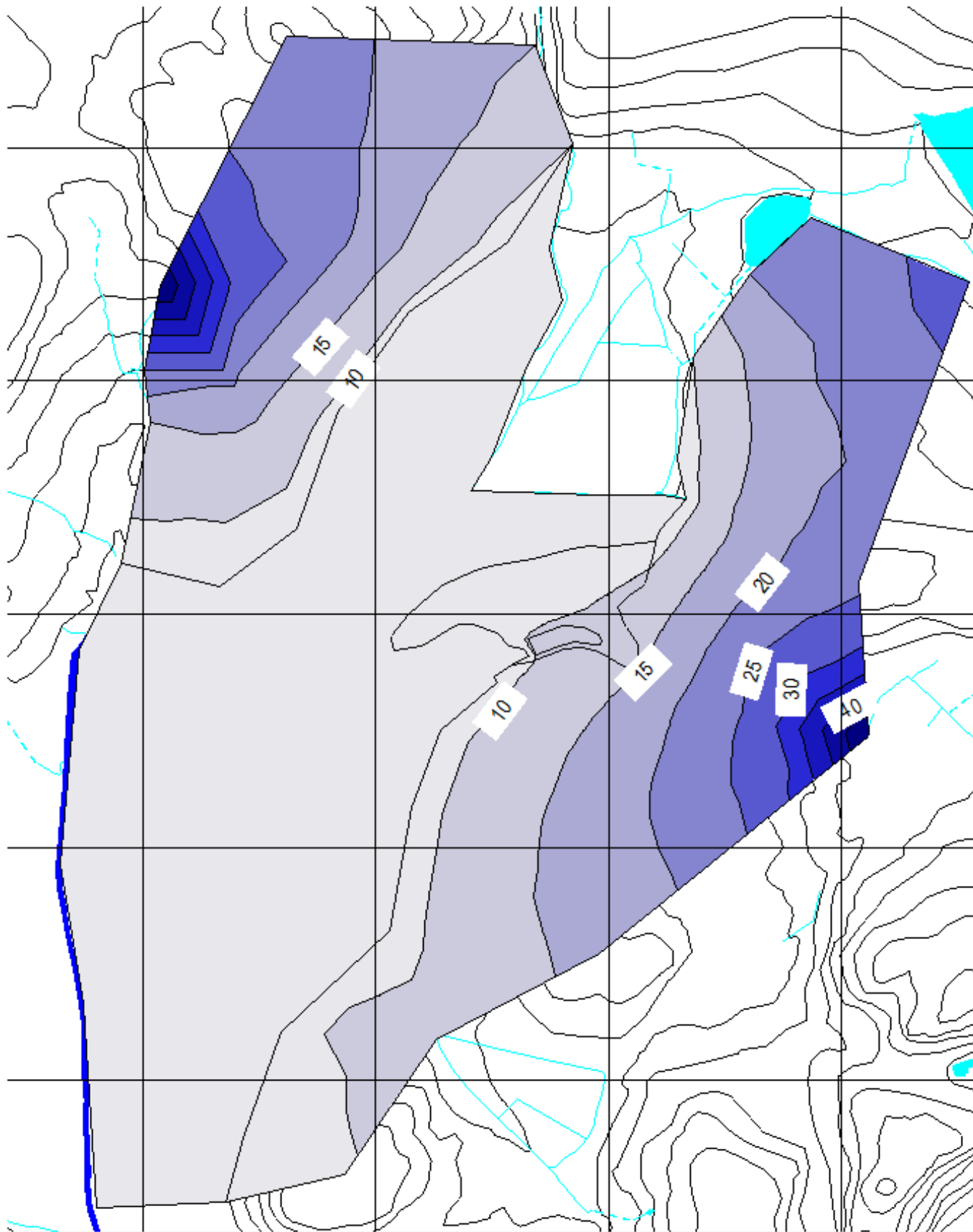
Unit 8, Commerce Park Blunel Road Thrale Reading RG2 4AG 01188 167340	Columbus House Greenmeadow Springs Froggydas Cardiff CF10 7UE 02920 358636	www.englobecorp.com
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Client
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Project
Crymlyn Tip Restoration and Surrender

Title
Assumed Distribution of Material Types

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Original Scale	Date	Rev	Paper	
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Contract Number	Drawing Number			
C1870	C9			



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Client
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Project
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Title
Predicted Groundwater Flow Conditions -
Catchment

Drawn by	Checked	Date	Authorised	Date

Original Scale	Date	Rev	Paper
	Nov. 2022	0	A4

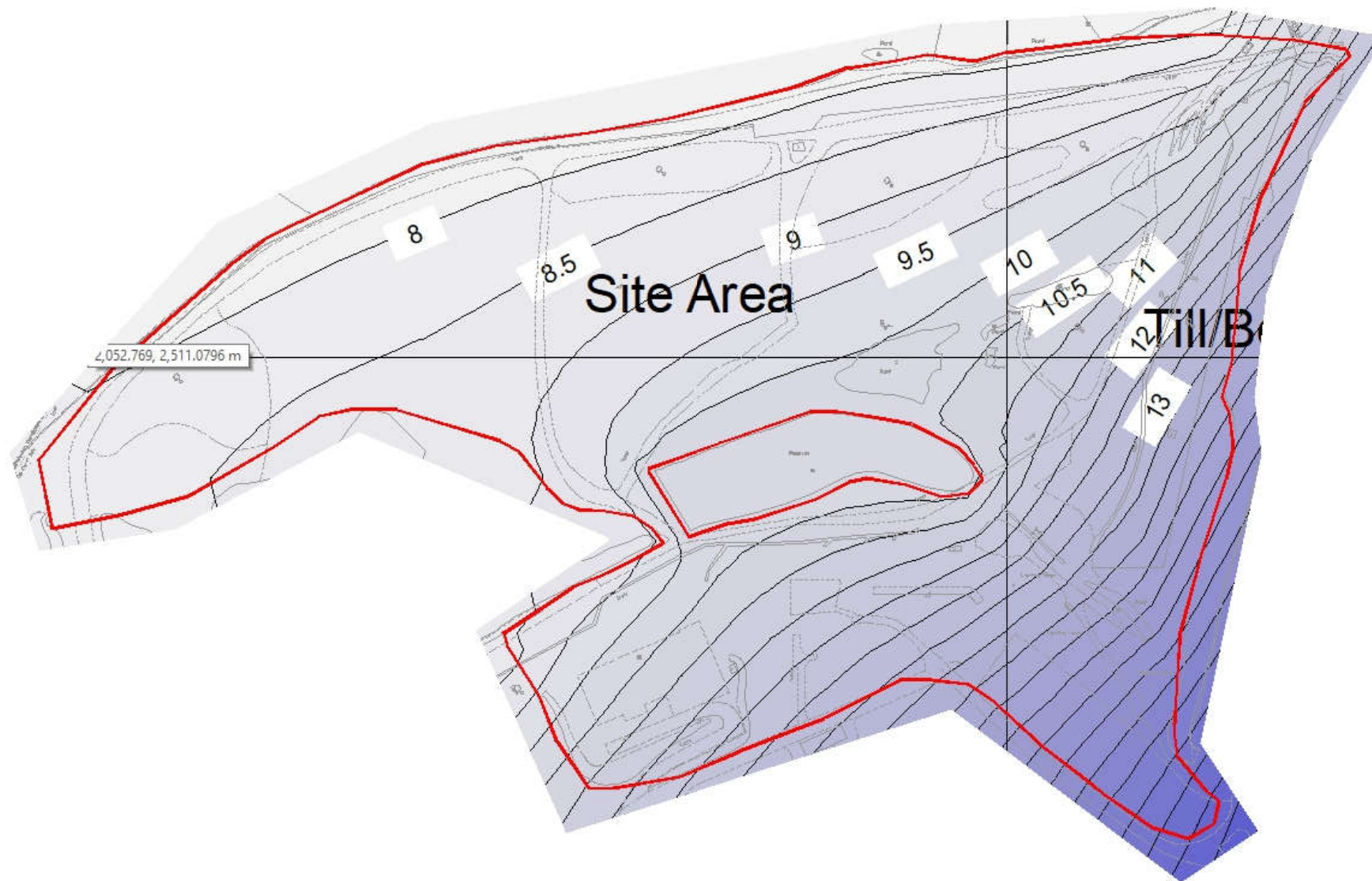
Contract Number
C1870

Drawing Number
C10a

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REV. COMMENT

DATE

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Columbus House
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Cardiff
CF10 7UE
02920 358636

Client
St. Modwen Developments Limited

Project
Crymlyn Tip Restoration and Surrender

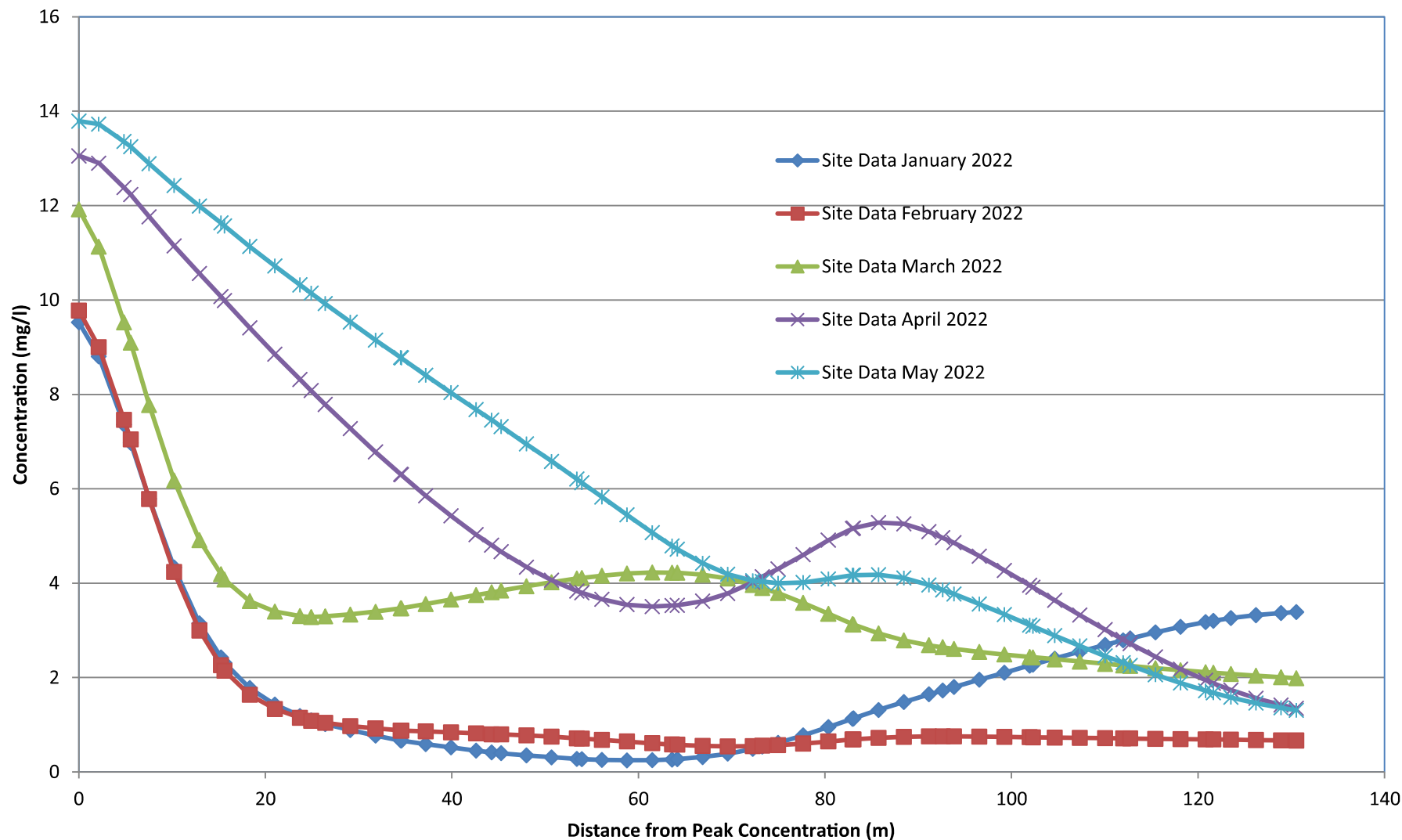
Title
Predicted Groundwater Flow Conditions -
Site Area

Drawn by Checked Date Authorised Date

Original Scale Date Nov, 2022 Rev 0 Paper A4

Contract Number C1870 Drawing Number C10b

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Client	St. Modwen Developments Limited
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Project	Crymlyn Tip Restoration and Surrender
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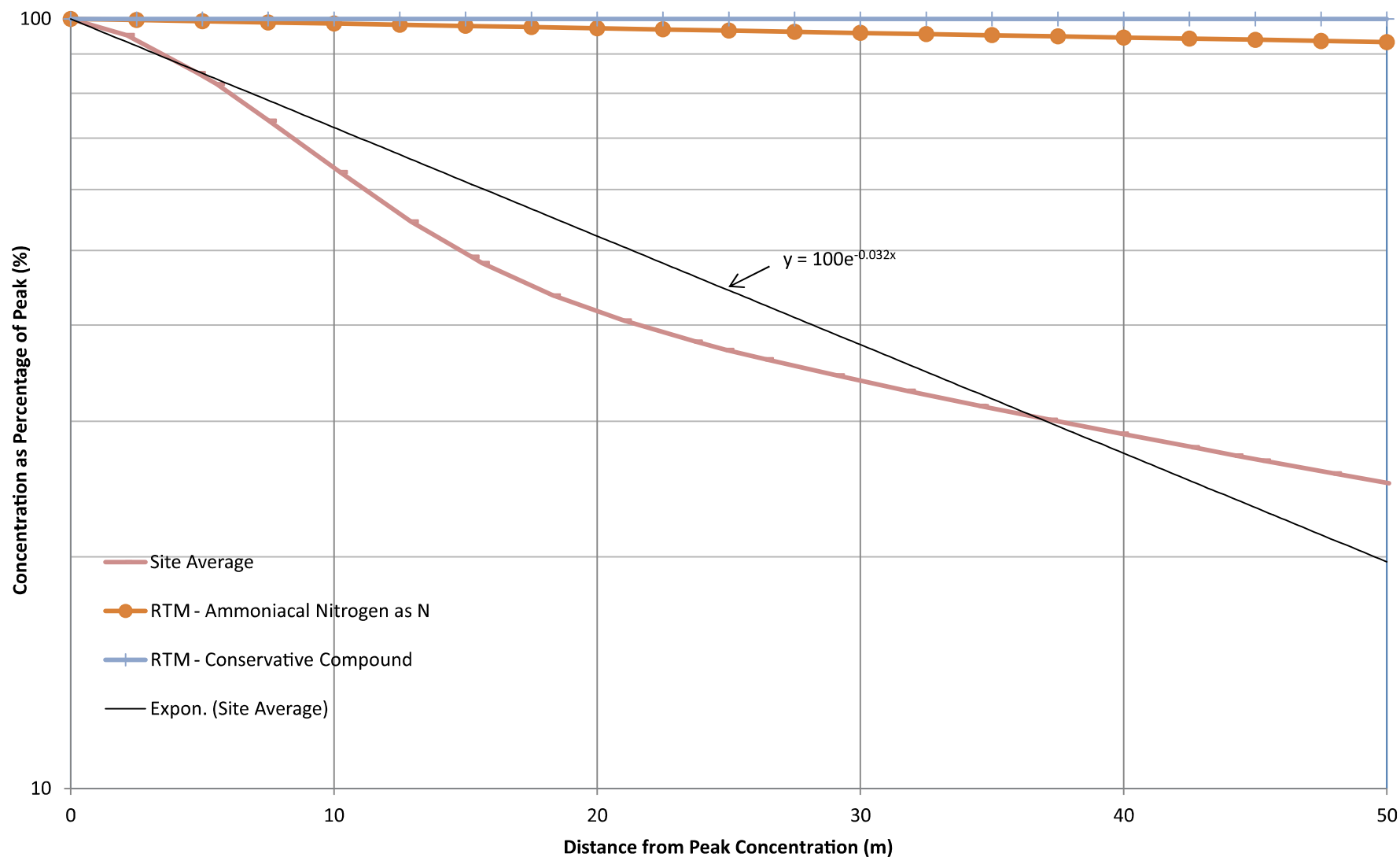
Title	Measured Groundwater Attenuation Rates for Ammonium
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Drawn by	Checked	Date	Authorised	Date
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Original Scale	Date	Rev	Paper
	Nov, 2022	0	A4

Contract Number	Drawing Number
C1870	C11

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Unit 8, Commerce Park Blunel Road Reading RG2 4AB 01188 167340	Columbus House Greenmeadow Springs Froggydas Cardiff CF10 7UE 02920 358636

Client	St. Modwen Developments Limited
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Project	Crymlyn Tip Restoration and Surrender
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Title	Comparison of Measured and RTM Predicted Attenuation Rates for Ammonium
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Original Scale	Date	Rev	Paper	
Contract Number	Drawing Number			
C1870	C12			