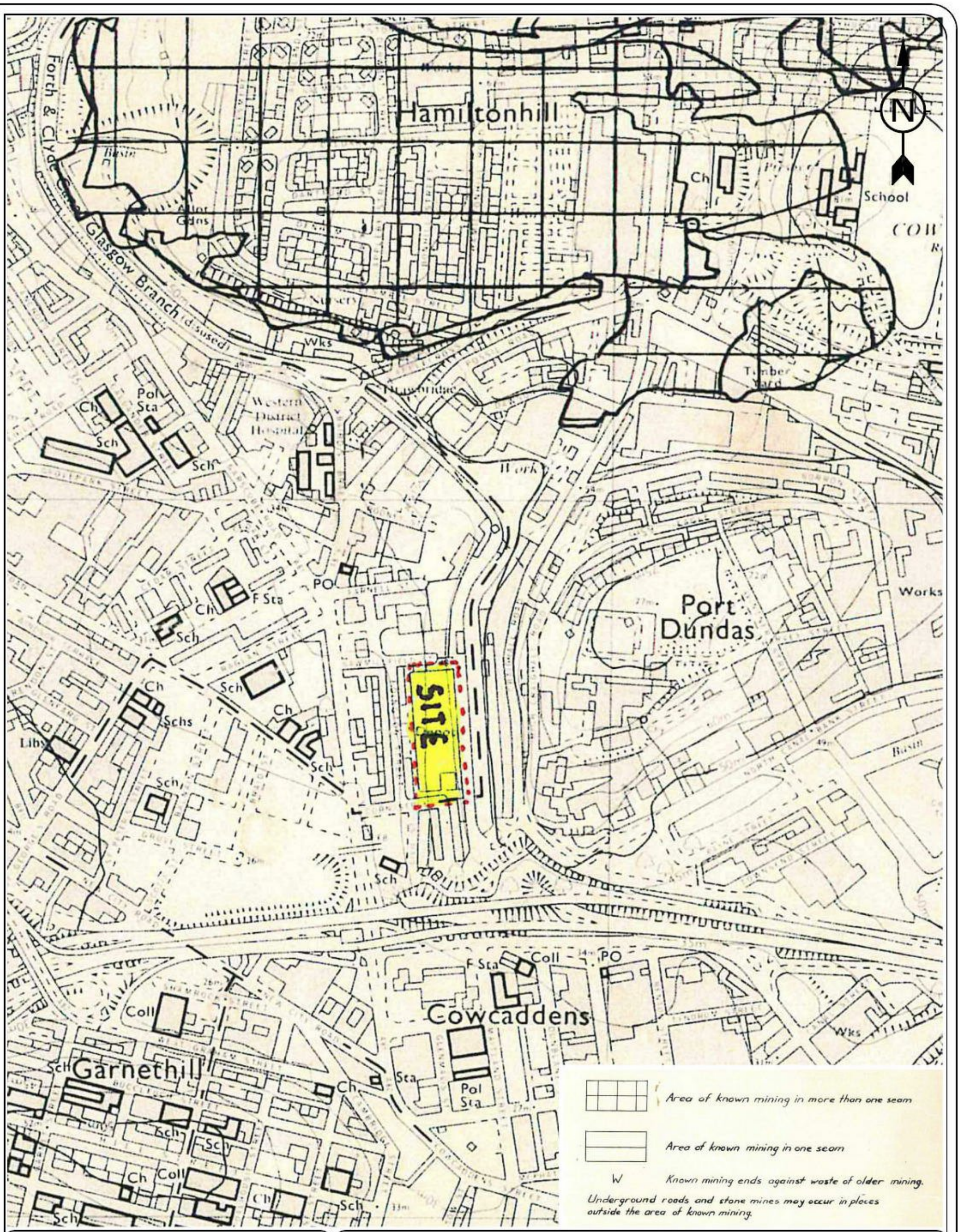

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project title: ROTTERDAM WHARF

drawing title: EXTRACT FROM PUBLISHED GEOLOGICAL SURVEY MAP (MINING INFORMATION)

project no:	drawing no:	revision:	date:	drawn by:	approved by:	scale:
P22/271	P22/271/DS/R/F/08		14.09.23	TR	AMcG	Not to Scale

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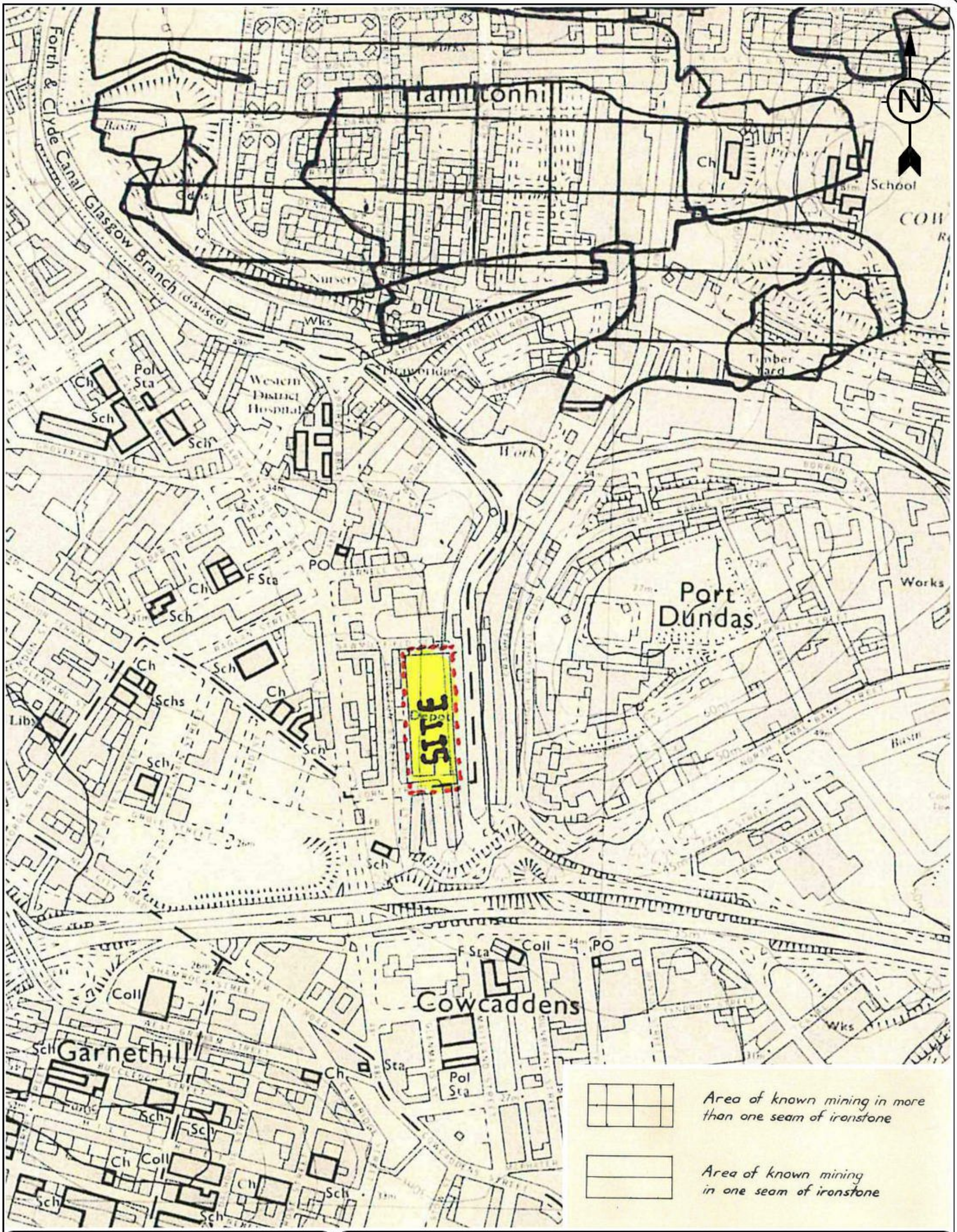

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P22/271	P22/271/DS/R/F/09		14.09.23	TR	AMcG	Not to Scale

A4 border: 277 x 190

4.5 Hydrology and Hydrogeology

4.5.1 Interpretation of the site hydrogeology required consideration of the general geological conditions. In this instance the available information indicates the ground conditions to be comprised of three geological units: made ground, glacial till and sedimentary bedrock. The typical permeabilities of each of these strata are recorded in Table 03.

Table 03 – Typical Material Permeability

Material	Permeability
Hardstanding (concrete or tarmac)	Low
Made Ground	Variable
Glacial Till	Low
Sedimentary Bedrock	Low to Moderate

4.5.2 At present, surface run-off on the site would be expected to high due to the majority of the site being developed hardstanding ground conditions. As such, surface water infiltration would likely be relatively low as the hardstanding surface conditions (concrete and tarmac) generally have a low permeability.

4.5.3 In areas underlain by made ground, vertical and lateral water movement could be anticipated as these soils have potentially high infiltration and permeability rates if unconsolidated.

4.5.4 The underlying natural soils were indicated to comprise glacial till, which is typically sandy, gravelly CLAY which would likely have a low permeability.

4.5.5 It is considered unlikely that a shallow groundwater body would exist within any glacial till deposits, due to the low permeability range of cohesive deposits. Groundwater may still be encountered within the cohesive soils underlying the site, though will likely be localised and perched, the result of surface water infiltration.

4.5.6 The nearest surface water body to the site was the Forth and Clyde Canal located to the east of the site. Given that the canal is topographically higher than the site and is separated by a significant retaining wall. Furthermore, this canal is a man-made contained body of water which will be lined, and therefore there would be no risk of contaminants from the site entering into this surface water feature. As such, we do not consider this to be a sensitive receptor in relation to the proposed development. No other surface water bodies were recorded within 1km.

4.5.7 SEPA did not indicate an aquifer to exist within the superficial deposits below the site. However, SEPA did record the 'Glasgow and Motherwell' bedrock aquifer to exist below the site (at depth). At this stage, this is considered to be the most sensitive water receptor in relation to the site.

4.5.8 In consideration of the available information regarding groundwater, the following general comments could be made.

Table 04 – Surface Water and Groundwater Pathways

Surface water run-off	Surface water run-off is anticipated to be high given that the site was predominantly noted to be surfaced in hardstanding concrete and tarmac. Consequently, the infiltration of surface water would therefore be expected to be low.
Groundwater migration through superficial materials	The underlying made ground deposits could allow vertical and lateral water movement if material constituents have high infiltration and permeability rates. The underlying natural glacial till deposits are expected to be prohibitive to vertical groundwater flow below the site. Consequently we would generally expect groundwater to be localised, perched and of low volume within the cohesive soils.

4.6 Correspondence with Glasgow City Council

4.6.1 As part of our desk study researches, we contacted Glasgow City Council's Contaminated Land and Trading Standard departments to obtain any available historical site information, including any knowledge of contaminated land uses and any known buried fuel tanks within the site.

4.6.2 In September 2023 the Trading Standards Department responded stating that they hold no records of fuel storage tanks within the specified site area. The Trading Standards Department did however, recorded two storage tanks in the immediate area. A 1x1000 Gallon tank was recorded at 27 Sawmillfield Street approximately 40 m to the west, the tank was recorded to be installed in 1955 and used for diesel storage. Another storage tank was located approximately 40 m to the north-west below Burns Street installed in 1939. Information relating to the current status of these tanks was not indicated.

4.6.3 If any further information is received (i.e. historic GI) from the council, we will review and if necessary, update our desk study to incorporate any relevant information.

4.7 Invasive Plant Species

4.7.1 An invasive plant species survey has not been carried out as yet, due to access restrictions into certain areas of the site (notably the southern vegetated area of land). However, this should be undertaken once access has been made possible and later incorporated into future site investigation reporting.

5.0 CONCEPTUAL SITE MODEL

5.1 General

5.1.1 In order to fully evaluate the potential presence and impact of contamination at the site, the area must be considered in an environmental context taking account of its geology, topography, past and present land-use. From this review, the current guidance requires the development of a 'Conceptual Site Model' as defined in the R & D Publication CLR10 published by the Department for the Environment and Rural Affairs (DEFRA). The model then forms an integral part of the contamination assessment for the proposed development site, looking at conventional source-pathway-receptor linkages.

5.1.2 The key parameters of the model are the conjectured ground conditions at the site, the potential sources of contamination, migration pathways and possible receptors in the vicinity. During the initial stages of the investigation, a preliminary conceptual model can be developed using information obtained during the desk study phase, prior to site investigations being carried out. This should then be revised during a subsequent phase of investigation.

5.2 Environmental Qualitative Risk Assessment

5.2.1 Part IIA of the Environmental Protection Act 1990 (inserted by Section 57 of the Environment Act 1995) has created a new regime for the identification and remediation of contaminated land. A revised Statutory Guidance Edition 2 (Paper SE/2006/44) to the Act was published by the Scottish Executive in May 2006.

5.2.2 Both Part IIA and the planning regulations it impacts on, embrace the "suitable for use" approach, with remedial actions only required where there are unacceptable risks to health or the environment, taking into account the current and proposed land uses and its environmental setting.

5.2.3 It is based on the principles of risk assessment, including the concept of a ***pollutant linkage*** between a ***source*** contaminant and a ***receptor***, by means of a ***pathway.*** We would highlight that the approach, while perhaps rendering the site suitable for its current use, may prove inappropriate to a change in site designation or specific land use, arising from existing site conditions.

5.2.4 The presence of all three elements identifies a plausible pollutant linkage. An assessment of the potential sources, pathways and receptors constitutes a conceptual model for the site.

5.3 Receptor Characterisation

5.3.1 Potential receptors at the site are defined on the basis of the site proposals, which are understood to include the development of a five-storey extension to the existing Scottish Opera building, plus the development of two separate residential flatted properties (up to 18-storey) within the northern and southern site areas. The location of the site relative to any off site receptors has also been considered. The following receptors are considered relevant to this project:

- Humans – site end users and construction workers (outdoor),
- Humans – site end users (indoor),
- Buildings and services,
- Water Environment (deep bedrock groundwater i.e. 'Glasgow and Motherwell' aquifer),
- Vegetation/fauna.

5.4 Source Characterisation

5.4.1 The potential on-site sources of contamination identified by this desk study are:

- Deposition of contaminated materials associated with made ground deposits.
- Spillage of and leakages of contaminants.
- Generation and accumulation of ground gases associated with made ground.
- Generation and accumulation of mine gas associated with any potential mine workings.

5.4.2 The potential off-site sources of contamination identified by this desk study are:

- Deposition of contaminated materials from the neighbouring developments (commercial units and roads).
- Spillage of and leakages of contaminants.
- Contaminants transported from surface water run-off.
- Generation and accumulation of ground gases associated with made ground.

5.4.3 The following table summarises the typical contaminants which we would anticipate at the site, although any testing schedule should be developed in cognisance of the materials encountered.

Table 05 – Contaminants of Concern

THE SITE	Industrial Activity/ Site Use	Potential Pathways	Associated Potential Contaminants
CURRENT	• Scottish Opera production studio building. • Car park. • Sub-station.	• Deposition of waste materials. • Spillages and leakages of contaminants. • Generation of ground gases.	Metals: As, Cd, Cr, Ni, Zn, Cu, Hg, Pb Organics: Fuel oils, PAH, Phenol Ground Gases: CO_2, CH_4, H_2S Asbestos PCB's
PREVIOUS	• Timber Yard. • Iron Works. • Electric Generating Station. • Maintenance Depot.	• Deposition of waste materials. • Spillages and leakages of contaminants. • Generation of ground gases.	Metals: As, Cd, Cr, Ni, Zn, Cu, Hg, Pb Organics: Fuel oils, PAH, Phenol Ground Gases: CO_2, CH_4, H_2S Asbestos PCB's
IMMEDIATE SURROUNDING AREA	**Industrial Activity/ Site Use**	**Potential Pathways**	**Associated Potential Contaminants**
CURRENT	• Commercial units. • Roads. • Skatepark.	• Deposition of waste materials during development works. • Spillages and leakages of contaminants (i.e., fuel spillages onto localised hardstanding areas). • Generation of ground gases.	Metals: As, Cd, Cr, Ni, Zn, Cu, Hg, Pb, V Organics: Fuel oils, PAH, Phenol Ground Gases: CO_2, CH_4, H_2S Asbestos
PREVIOUS	• Commercial industry units. • Roads. • Iron Foundry located to the north.	• Deposition of waste materials during development works. • Spillages and leakages of contaminants. • Generation of ground gases.	Metals: As, Cd, Cr, Ni, Zn, Cu, Hg, Pb, V Organics: Fuel oils, PAH, Phenol Ground Gases: CO_2, CH_4, H_2S Asbestos

5.5 Pathway Characterisation (Pollutant Linkages)

5.5.1 The pathways by which sensitive receptors may be exposed to potential sources of contamination, as determined by the proposed end use for the site are as follows.

1. Humans – site end users and construction workers (outdoor)
   - Dermal (skin) contact with contaminated soil, fugitive dust and the absorption of any contaminants through the skin into the body.
   - Inhalation of fugitive soil dust or vapour.
   - Ingestion of soil by hand to mouth activity

2. Humans – site end users (indoor)
   - Inhalation of any ground gas migrating into buildings.
   - Inhalation of soil derived dust.

3. Buildings
   - Potential soil gas generated in the ground vertically migrating and pooling within the structure.
   - Contact with aggressive or acidic soils will affect the concrete design of the foundations.

4. Services
    - Direct contact with contaminated soil or groundwater.
    - Leaching of contaminants through the soil.
    - Service trenches acting as preferential migration pathways for contamination.
    - Permeation of plastic water supply pipes.

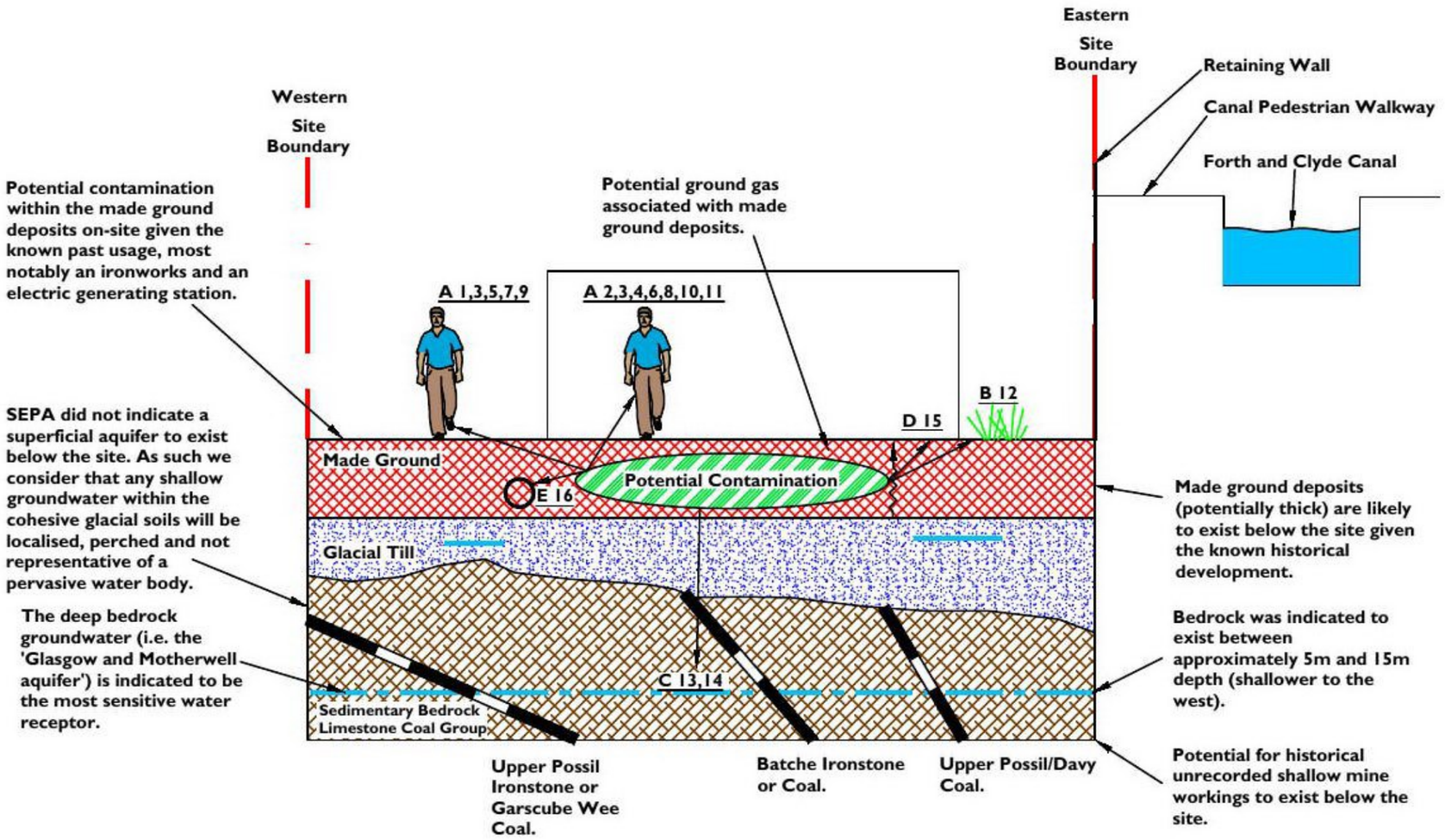
5. Water Environment
    - Leaching of contaminants from the soil to groundwater.
    - Contaminant migration beyond the site boundary.

6. Vegetation
    - Uptake of contamination in plant roots.
    - Direct contact with contaminated soil or groundwater.

5.5.2 On the basis of the above, a qualitative risk assessment is described in Table 06 below and the potential source-pathway-receptor relationships identified at the site, based on the preliminary qualitative risk assessment, are summarised in Drawing No. P22/271/DS/R/F/10 - Preliminary Conceptual Site Model (CSM).

Table 06 – Preliminary Qualitative Risk Assessment – On Site

Source	COCs	Pathway	Receptors (s)	Assessment	Further Investigation Required
On site: MADE GROUND	Metals: As, Cd, Cr, Ni, Zn, Cu, Hg, Pb Organics: Fuel oils, PAH, Phenol Ground Gases: CO_2, CH_4, H_2S Asbestos PCB's	Dermal contact, ingestion, inhalation	Human – site workers Humans – end users (outdoor)	Made ground materials may have been deposited within the site associated with previous development/demolition works in the surrounding area.	Yes
		Leaching through soil or direct migration	The water environment – groundwater (bedrock aquifer)	Contaminants may be leached and potentially mobilised from the soil by the infiltration of rainwater and possibly by shallow groundwater movement.	Yes
		Direct contact, leaching through soil, groundwater migration	Buildings and services	Potential for aggressive chemical environments for concrete due to sulphate and acidic conditions. Presence of contaminants in soil that may permeate water supply pipes.	Yes
		Gas/vapour inhalation, vertical/lateral migration	Buildings and services Humans – end users (indoor)	Contamination may include gas/vapour producing materials or compounds that could vertically migrate into overlying buildings producing a potentially asphyxiating or explosive environment.	Yes
		Migration in the groundwater	The water environment	Contaminated soils/ groundwater within the site could migrate in the groundwater beyond the site boundary.	Yes
		Direct Contact/ Plant Uptake	Vegetation	Direct contact with, or uptake of contaminated soils or groundwater could adversely affect plant growth.	Yes



Potential Source

- Made ground (containing toxic/phytotoxic contaminants and acting as a source of ground gas).
- Mine workings (acting as a source of mine gas).

Potential Exposure Pathways

1. Outdoor ingestion of dust.
2. Indoor ingestion of dust.
3. Consumption of homegrown vegetables.
4. Ingestion of soil attached to vegetables.
5. Skin contact with outdoor soil.
6. Skin contact with indoor dust.
7. Outdoor inhalation of dust.
8. Indoor inhalation of dust.
9. Outdoor inhalation of soil vapour.
10. Indoor inhalation of soil vapour.
11. Inhalation of ground gases.
12. Contaminant uptake by vegetation.
13. Leaching of contaminants to the groundwater.
14. Contaminant migration in the groundwater.
15. Detrimental effects on buried concrete.
16. Permeation of plastic water supply pipes.

Potential Receptors

A. Site users / construction personnel.
B. Vegetation / fauna.
C. Groundwater.
D. Buried concrete (Service and foundations)
E. Plastic water supply pipes.

NOTES

- An invasive plant species survey is to be undertaken once access into vegetated areas is made possible.

REV	DATE	DETAILS

SCOTTISH OPERA
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GLASGOW
G2 4PT

PROJECT TITLE

ROTTERDAM WHARF

DRAWING TITLE

PRELIMINARY CONCEPTUAL SITE MODEL

DRAWN BY	CHK'D BY	APP'D BY	DATE	SCALES
LD	JW	AMcG	15.09.23	Not to Scale

PROJECT No.	DRAWING No.	REVISION
P22/271	P22/271/DS/R/F/10	

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6.0 CONCLUSIONS AND RECOMMENDATION ON DEVELOPMENT

6.1 General

6.1.1 Phase I desk study researches have indicated that there is a potential risk that the site is impacted by soil contamination due to made ground deposits and potential landfill material. This would require detailed evaluation through Phase II investigations, including the testing of soil/water samples, and examining the characterisation of the soils and groundwater beneath the site. In addition, potential gas emissions, sourced from any biodegradable soils, require to be assessed through monitoring. Foundation options for any new development will be influenced by the thickness and condition of any made ground soils as well as the condition of the natural superficial deposits and the underlying bedrock. Finally, the mineral stability of the site will require to be further assessed.

6.2 Current Site Conditions

6.2.1 The site area was predominantly surfaced in hardstanding (concrete or tarmac) with the Scottish Opera production studio building occupying a large proportion of the site.

6.3 Historical Site Usage

6.3.1 Historically the site has been developed since the earliest available OS maps dating back to 1860, including a timber yard until approximately 1870, an iron works until approximately 1895, an electricity generating station until approximately 1970, a maintenance depot until approximately 1990 and a Scottish Opera production studio with associated areas of hardstanding, which remains to the present day.

6.4 Conjectured Ground Conditions

6.4.1 We consider that MADE GROUND deposits will exist below the site associated with previous historical development.

6.4.2 The underlying natural subsoils were indicated to comprise glacial till (i.e. boulder CLAY) deposits, which were indicated to be shallower below the north-west of the site at around 7 m and thicker below the south-east of the site at around 17 m (based on historical borehole records and from the review of BGS drift thickness map).

6.5 Chemical Contamination

6.5.1 The historical appraisal indicated the presence of made ground materials potentially containing extraneous material below the site. Therefore, we consider the possibility that chemical contamination of soils and groundwater may have taken place.

6.5.2 Intrusive site investigations, supplemented by detailed chemical analyses and risk assessments will be required to assess the potential risks to sensitive receptors such as construction workers, site users, vegetation and the water environment.

6.6 Gas Emissions

6.6.1 Our researches indicate (potentially thick) made ground to exist beneath the site, and as such, there is significant potential for elevated ground gas emissions to exist below the site. In addition, our researches have indicated the potential for shallow unrecorded mine workings to exist below the site, which could pose a mine gas risk below the site.

6.6.2 A detailed ground/mine gas risk assessment, including a programme of gas monitoring from standpipes installed in boreholes, will therefore be required. Any future ground gas risk assessments should be in line with CIRIA C665 and BS 8485 (2015) guidance, whilst mine gas risk assessments should be in line with the CL:AIRE publication entitled; 'Good Practice for Risk Assessment for Coal Mine Gas Emissions, dated October 2021'.

6.6.3 The site is not at risk from radon gas.

6.7 Foundations

6.7.1 Given the proposed development is for multi-storey buildings with presumed large loading capacities, abnormal foundation solutions (such as piles) would likely be required onto either the glacial soils or the underlying sedimentary bedrock.

6.7.2 Investigations are therefore required to determine the depth to, and condition of the underlying natural subsoils and bedrock and confirm a suitable foundation bearing horizon.

6.7.3 Investigations should aim to assess the ground conditions by exploratory excavations and in-situ testing, augmented by laboratory testing of samples, to determine a practical and economic foundation solution for the development.

6.8 Flood Risk

6.8.1 SEPA indicated that the majority of the site is not at risk of flooding. However, there are localised areas that are at low to medium risk from surface water flooding in the north of the site. If more detail is required, we would recommend a detailed flood risk assessment be undertaken.

6.9 Mining and Quarrying

6.9.1 Our desktop researches indicate that unrecorded shallow workings potentially exist beneath the site at the level of the Upper Possil Ironstone or Garscube Wee Coal (0.80 m thick), the Batchie Ironstone or Coal (up to 0.70 m thick) and/or the Upper Possil / Davy Coal. As such, mineral investigations will be required in order to confirm (or otherwise).

6.9.2 The Coal Authority did not record any mine entries within the site or immediate surrounding area. However, it should be highlighted that as in all areas of past mining, unrecorded mine entries could exist.

6.9.3 The site is not considered to be at risk of ground instability as a result of historical quarrying activities.

6.10 Development Considerations

6.10.1 A number of development geo-environmental considerations could arise from the recommended Phase II investigations. These include:

- *Remediation of contaminated land.*
- *Off-site disposal of excess soils.*
- *Requirement for gas preclusion measures.*
- *Mining consolidation works.*
- *Abnormal foundations, which will ultimately be determined by the load requirements, the thickness of any potential made ground deposits and the thickness / condition of the underlying natural subsoils plus the depth and strength of the bedrock.*

We highlight that these considerations are speculative without the more detailed information that would arise following Phase II investigations, following which the impact of each should be re-assessed. The advised scope of these investigations may include:

- Trial pits to assess the shallow soils and ground conditions.
- Soil boreholes with installations for gas and groundwater monitoring.
- Mineral bores to determine if shallow mine workings exist.
- Rotary bores (including rock coring) to assess the strength and condition of bedrock in relation to future foundations.
- Deep wells within the bedrock to monitor for mine gases and to collect possible bedrock aquifer samples.
- Geo-environmental testing of soil and (possible) groundwater plus rock samples.
- Monitoring of ground gas concentrations and groundwater depths.
- Phase II Geo-environmental Investigation Report.

We trust that this will meet your current requirements. However, should you require any further information, please do not hesitate to contact us.

[redacted]

Scott Armstrong
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