FINAL

GEOTECHNICAL & GEOENVIRONMENTAL DESK STUDY

Kemnay Flood Study

Project no. 4021839

Prepared for:

Aberdeenshire Council

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Enhancing lives, communities and the environment

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1. INTRODUCTION

1.1 Instruction

Binnies UK Limited (BUKL) was instructed by Aberdeenshire Council (Aberdeenshire), the Client, to provide a high level Geotechnical and Geoenvironmental Desk Study to aid the Kintore Flood Study.

1.2 Proposed works

Designs for the proposed flood protection works have not been finalised at the time of writing. Therefore, this report should be reviewed and may need to be amended accordingly once detailed designs are known.

1.3 Scope

The purpose of this Desk Study is to collate available geological and environmental data for the study area (and its environment) and provide a high level geotechnical and geo-environmental appraisal, with a site-specific conceptual site model. This enables a preliminary assessment of ground risks to be undertaken and, if necessary, provides information for the design of a ground investigation (GI). The scope of this report is based on the following objectives:

— Carry out a review of the historic developments of the study area and surrounding area;

— Assess the study area's anticipated ground conditions including geology, hydrology, and hydrogeology;

— Assess the risk of ground gas generation and accumulation, including radon;

— Assess the potential risks from past and present mining and quarrying activities;

— Review relevant information held by appropriate statutory authorities;

— Identify potential geotechnical risks in relation to the proposed works;

— Develop a preliminary conceptual site model (pCSM); and

— Compile a preliminary risk register considering the geotechnical and geoenvironmental constraints and hazards in relation to the proposed works.

This Desk Study has been carried out following relevant guidance documents published by the British Standards Institution the Environment Agency (EA) and the Association of Geotechnical & Geoenvironmental Specialists (AGS), as referenced throughout the report.

The "vicinity" of the study area for the purposes of this report is defined as locations situated within 250m of the study area, although features further than 250m that pose a significant risk may also have been considered.

At the time of writing, a site walkover has not been conducted by a Binnies Geotechnical or Geoenvironmental Engineer. No previous site investigation reports were made available for review.

1.4 Limitations and uncertainties

This report has been written to provide a high level overview of the geotechnical and geoenvironmental conditions at the study area and only freely available published information has been used to inform this report. Additional data sources are available at cost and further detailed study should be undertaken once design proposals have been finalised.

1.5 Sources of information

The following publicly available sources of information have been reviewed and all pertinent information has been summarised in this report.

- Topographical Maps ;
- British Geological Survey (BGS) Geological Maps, borehole records, and Memoirs;
- Aerial and Street View Photography;
- Records of Mines and Mineral Deposits ;
- UK Health Security Agency's Map of Radon ;
- Scotland's Environment Map , reviewed for environmental, visual, cultural, agricultural and habitats designations;
- Unexploded Ordnance (UXO);
- Hydrogeology – Published BGS map;
- Scottish Environmental Protection Agency (SEPA) register of Special Sites;
- Scottish Flood Hazard and Risk Information ;
- Drinking water protected areas – Scotland river basin district: maps ;
- Aberdeenshire Council public register of contaminated land;
- Scottish Pollution Release Inventory; and
- SEPA's waste site information.

2. SITE DETAILS

Kemnay ("the study area") is located in Aberdeenshire and is within the Aberdeenshire Council local authority catchment. The study area is centred at National Grid Reference NJ 73201 16186 (What3Words -shun.structure.batches) and the postcode for the village centre is AB51 5SS.

The village of Kemnay is located on land to the east of the River Don. The study area is a mixture of residential and commercial developments in need of flood protection. At the northern end of the study area sit Dalmadilly Ponds, a local nature reserve, and at the southern end is Kemnay House.

The surrounding area is primarily agricultural in nature, although Kemnay Quarry exists immediately to the north-east of the study area.

A site location plan including the extent of the study area (set to a 25m border of the River Don and its tributaries, Marshes Burn and two unnamed field drains) is provided in Figure 1: Study Area.

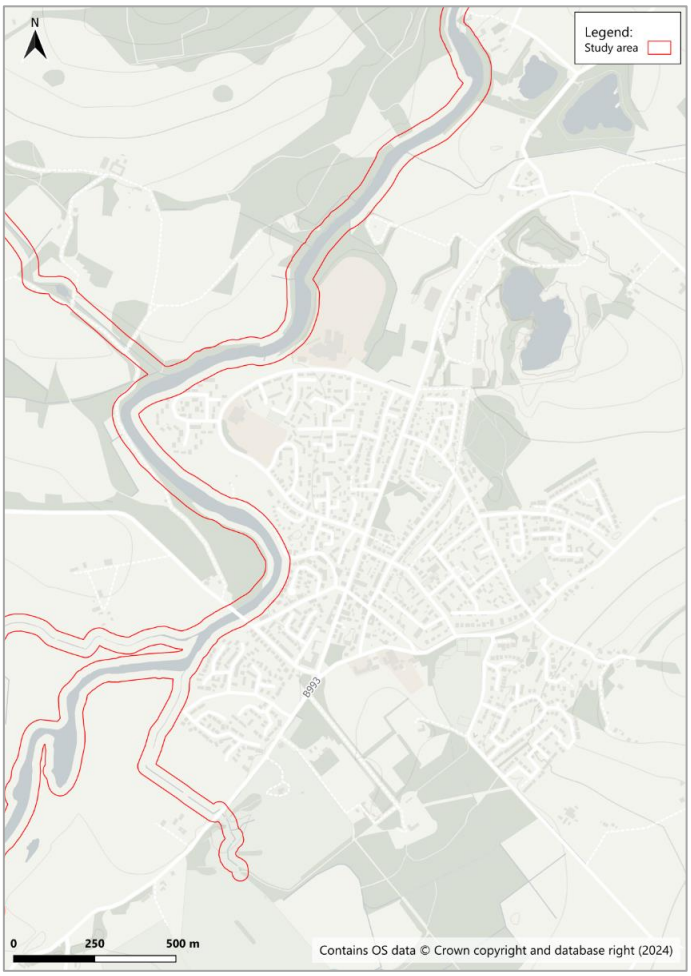

Figure 1: Study Area

3. HISTORICAL AND ENVIRONMENTAL SETTING

3.1 Topography

Ordnance Survey mapping indicates that the study area is situated along the Kemb Hills esker (winding ridge of low-lying stratified sand or gravel). Ground level is recorded in previous site investigations to range between 78 to 88m OD.

3.2 Historical developments

The historical developments of the study area and surrounding area have been determined by reviewing historical plans for Aberdeenshire sheet LXIV, aerial photography, and Google Street View photography, dating from 1869 to the present day. However, it is noted that the historical data available does have gaps and may not give a full chronology of the development of the study area and surrounding areas. Supplementary information has been found online.

A summary of the pertinent information is presented in Table 3-1, below. *Italicised text* represents potential receptors of importance. Figure 2 shows potential sources of contamination; figure references are included in parentheses where relevant.

Table 3-1: Summary of pertinent historical developments from available mapping

Revised Year	Series & Scale	On site developments	Vicinity of site
1867	Ordnance survey 25 inch to the mile	The majority of the study area is shown as a mixture of agriculture and woodland along the River Don and its tributaries. Notable land uses: • Alford Valley Railway running approximately south-west to north-east, crossing the Ton Burn in the south of the study area. (a)	Land in the vicinity of the study area is mapped as agriculture and woodland. Kemnay village, shown as "Mains of Kemnay", to the east of the study area. Several wells and field drains noted throughout the vicinity. Notable land uses within circa 250m of the study area include: • Approximately 380m to the east of the study area site at its northern end, Kemnay Quarries is shown with associate engine house and steam cranes. (o) • Kemnay station and railway sidings shown circa 160m to the east of the central portion of the study area. (b) • Gravel pits immediately north of station (125m east of study area). (c, e) • Aleshousewells with two associated ponds, sluices, and a spring shown slightly further north of these, 130m north-east of study area. (d)
1869	Ordnance survey 6 inch to the mile (1:10,560)	No significant changes from previous map edition.	Kirktown of Kemnay shown to the east of the study area. Notable changes to previous map edition: • Kembhill cottage shown at the study area of the "old gravel pit at figure reference (e)
1873	Ordnance survey	No significant changes from previous map edition.	No significant changes from previous map edition.

Revised Year	Series & Scale	On site developments	Vicinity of site
	25 inch to the mile		
1900	Ordnance survey 25 inch to the mile	No significant changes from previous map edition.	Kemnay has expanded to be a village. Notable changes to previous map edition: • Gravel pit at figure ID (c) has been redeveloped to be a hotel. • Ponds at (d) now labelled "mill dams". • Hydraulic Ram shown in the north, 380m east from the study area (f). Sand Pit shown in the north of the town, 560m east of the study area (g).
1901	Ordnance survey 6 inch to the mile	Gravel pit (h) at Miltown farm	Notable changes to previous map edition: • Tank and railway sidings shown at Kemnay quarry (o), 370m east of the study area. • Smithy in the centre-east part of the town, 780m east of the study area (j). • Tank (i) at Miltown farm, 25m south of the study area.
1958	Ordnance survey Sheet NJ 71 NW 6 inch to the mile (1:10,560)	Golf course in the south.	No significant changes from previous map edition. • Ponds no longer shown at (d)
1968	Ordnance survey Plan NJ7216 & NJ7316 Scale 1:2500	Only northern portion of the study area shown. No significant changes from other map editions.	Residential portion of village has expanded. Notable changes to previous map edition: • Refuse tips associated with Kemnay Quarry now shown approximately 600m to the east of the study area (p) • Sandpit at (g) no longer shown • Garages shown in centre of study area (k), (l), (r), and (s) (150m, 160m, 50m, and 790m east of the study area, respectively). • Railway labelled "dismantled"
1967	Ordnance survey Plan NJ7215 & NJ7315 1:2,500	Only southern portion of the study area shown. No significant changes from other map editions.	No significant changes from previous map edition.
1985	Aerial Photography	(unable to see details, too blurry)	(unable to see details, too blurry)
2007	Satellite photography	Treatment works shown in the centre portion of the study area, at (m) and (n)	Residential character significantly expanded to be largely in keeping with current village. *Kemnay Academy* (100m east) and *Alehousewell School* (160m to the north-east) now shown in the vicinity of the study area.

Revised Year	Series & Scale	On site developments	Vicinity of site
			The eastern of *Dalmadilly Ponds* is shown, possibly under construction (275m east of the study area). • Location of refuse tip (p) now restored to agriculture • Scrapyard shown approximately 250m to the south (q)
2012	Satellite photography	No significant changes from previous record.	The western *Dalmadilly* ponds now shown 80m east of the study area). • Industrial building shown in the north (near quarry, 310m east of the site)
2017	Satellite photography	No significant changes from previous record.	No significant changes from previous record.
2023	Current Satellite photography	No significant changes from previous record.	No significant changes from previous record.

Information from the village website indicates that Dalmadilly ponds were formed from a sand and gravel quarry that operated from 1993. The nature reserve was proposed by quarry management in 2008 and established by 2016 .

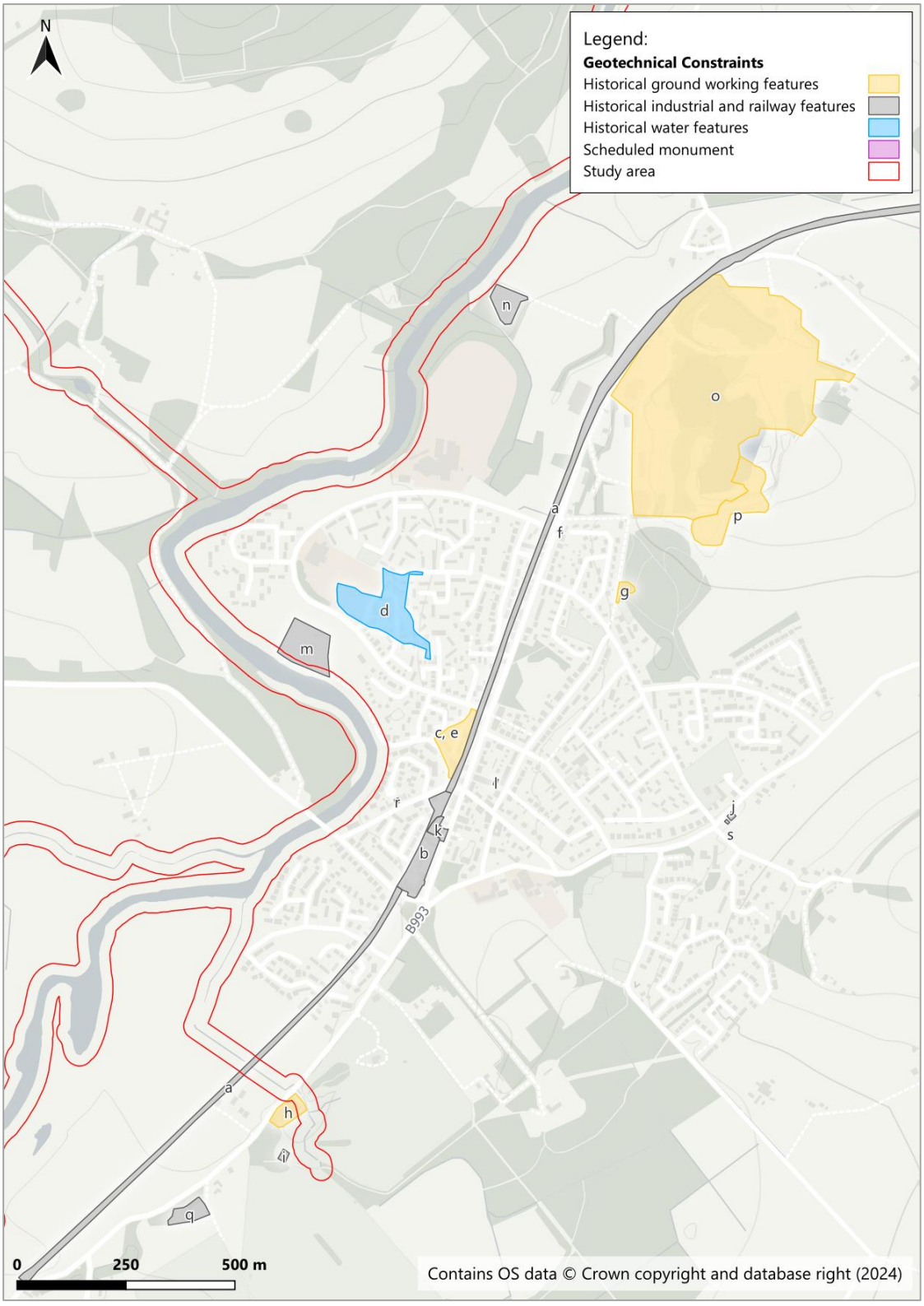

Figure 2: Historic map observations

3.3 Utilities and buried services

At the time of writing, detailed service plans were not available for the study area. Consequently, the exact locations and types of existing underground services could not be confirmed. It is

recommended that utility surveys be conducted prior to any intrusive works to avoid potential risks associated with unknown services.

3.4 Published geology

Geology maps and memoirs

The geology underlying the study area is shown on the British Geological Survey (BGS), England and Wales, New Series 1:63,360/1:50,000 geological map series, 76, Inverurie, Solid and Drift and on the British Geological Survey online interactive mapping service GeoIndex Onshore .

Superficial deposits are mapped as Alluvium along the River Don, with primarily Glaciofluvial sheet deposits (gravel, sand, and silt) beyond, beneath much of Kemnay village.

Mapping indicates that solid geology at the study area is primarily granite of the Kemnay Pluton. To the far north of the study area (from approximately the line of Dalmadilly farmhouse) solid geology may comprise the Aberdeen Formation, a Psammite and Semipelite (metamorphic rock formed from medium to fine sandstone).

BGS boreholes

The BGS GeoIndex Interactive Map shows 19 no. records of historical ground investigations that are applicable to the study area, eleven of which are associated with Mill Farm in the north of the study area. A summary of the available exploratory logs and other pertinent information from previous investigations indicating the geology of the study area is presented in Table 3-2, below.

Table 3-2: Summary of historical ground investigation exploratory holes

Exploratory hole Reference	Year	Final depth (m bgl)	Ground level (mOD)	Grid reference	
				Easting	Northing
NJ71NW5498/T1/4	1974	3.0	unknown	373794	817842
NJ71NW5498/T1/2	1974	2.4	unknown	373802	817908
NJ71NW5498/T1/3	1974	3.0	unknown	373805	817970
NJ71NW5498/T1/5	1974	3.0	unknown	373839	817826
NJ71NW5498/T1/6	1974	3.0	unknown	373862	817743
NJ71NW5498/T3/2	1975	3.0	unknown	373886	817568
NJ71NW16	1984	15.0	88	373890	817640
NJ71NW5498/T3/1	1975	3.0	unknown	373905	817646
NJ71NW5498/T3/5	1975	2.1	unknown	373993	817532
NJ71NW5498/T3/4	1975	3.0	unknown	373997	817613
NJ71NW5498/T3/3	1975	3.0	unknown	374012	817741
NJ71NW12	1984	6.0	78	372360	816360
NJ71SW9	1984	2.0	unknown	372380	814730
NJ71NW13	1984	7.0	unknown	372400	815100
NJ71NW10	1984	3.0	83	372810	817150

Exploratory hole Reference	Year	Final depth (m bgl)	Ground level (mOD)	Grid reference Easting	Northing
NJ71NW14	1984	13.0	88	373080	815410
NJ71NW14343/1	1999	2.6	unknown	373170	816230
NJ71NW14343/2	1999	2.7	unknown	373180	816220
NJ71NW5498/T1/1	1974	3.0	unknown	373747	817856

Exploratory position NJ71NW16 (located at E373890, N817640) was abandoned at 15.3m bgl due to running sand.

Geological summary

Based on reviewed information, the anticipated geological succession and spatial distribution has been summarised in Table 3-3, below.

Table 3-3: Summary of encountered geology

Stratum	Thickness (m)	Description & Commentary
Made Ground	0.5 to 0.8	Hardcore. Encountered only in the two trial pits in centre of village but anticipated to be present at most built up locations within the study area.
Topsoil	0.1 to 0.5	Not present in all locations. Sometimes recorded as mixed with "very dirty" sand or sand and gravel.
Sand and gravel	0.3 to 7.2+	Medium to coarse clayey sand and gravel with cobbles and boulders. Interpreted as Glaciofluvial deposits in the south.
Sand	0.8 to 2.0	Medium to coarse sand. Frequently underlying sand and gravel in north of site.
Clay	0.4 to 2.0	Sandy or silty gravelly brown clay. Described as "till" in the borehole logs where present. Encountered sporadically throughout the study area.
Peat	0.9	Dark brown sandy or with pockets of sand, fibrous or slightly fibrous. Encountered only in the two trial pits in centre of village (circa 200m east of the study area) but may exist elsewhere.
Granite	Not proven.	Grey "Caledonian" granite. Weathered in one borehole. Encountered 3.7 to 12.5 m bgl

3.5 Geotechnical hazards

Landslides, running sand conditions, shrink swell clays, collapsible deposits, compressible deposits, and ground dissolution are conditions which may present a geotechnical hazard. The GeoSureHex data and professional judgement were used to assess the risks associated with these conditions for the study area**.**

The National Landslides Database is the definitive source of landslide information for Great Britain. No records from this database appear in the study area . GeoSureHex mapping indicates a low risk of landslides.

Although GeoSureHex mapping indicates a low level of susceptibility to running sand for this area, the borehole NJ71NW16 (located in the north of the study area) was abandoned due to running sand conditions**.** There is a risk that these conditions could be encountered elsewhere in the study area and a moderate risk is assumed for running sands.

Shrink swell clays are not anticipated to be a major issue within this site, as limited quantities of clay were encountered during the previous site investigations. GeoSureHex mapping indicates a low or moderate level of susceptibility to shrink swell. While this risk cannot be ruled out, it is considered low.

Collapsible deposits are those with a mixture of silt/clay and larger particles, where if the finer particles wash away, voids have the potential to form. GeoSureHex mapping indicates a low level of susceptibility to collapsible ground.

Compressible deposits are typically ones comprised of very soft and soft material (e.g.: peat or putrescible landfilled waste). The GeoSureHex mapping indicates a low level of susceptibility to compressible deposits. Large quantities of peat have not been encountered in the study area. While some areas of landfilling or suspected quarry backfilling do exist in and near the study area, it is not known what the contents were. Therefore, this risk cannot be ruled out in the areas of former quarries.

Ground dissolution is associated with chalk, limestone, gypsum, and salt. As none of these are present in the study area and the GeoSureHex mapping indicates a low level of susceptibility to ground dissolution for this area, the risk is considered very low.

3.6 Hydrology

The study area is within the River Don surface water body catchment (water body ID 23293). This is currently classed at a good or high status.

Several field drains and streams were shown in the historic mapping; detailing these is beyond the scope of this report.

A review of the available flood maps shows a high likelihood (annually 10% chance) of flooding from the River Don in the western portion of the study area, and along an unnamed burn or field drain in the north . The study area is not located within a surface water Drinking Water Protected Area.

3.7 Hydrogeology

The hydrogeological conditions beneath the study area have been inferred from data available on the Scotland's Environment mapping and the BGS Hydrogeological map of Scotland 1:625,000 .

A summary of the hydrogeological setting of the study area, with respect to the anticipated geological sequence is presented below in Table 3-4.

Table 3-4: Hydrogeological summary

Condition	Description
Aquifer characteristics	The study area is underlain by low productivity aquifers, the Argyll Group in the north (to the north of Dalmadilly farmhouse) and an unnamed igneous intrusion under the majority of the study area. Flow in both is characterised as through fractures and discontinuities.

Condition	Description
	Superficial deposits are characterised as a concealed aquifer, aquifers of limited potential, or region without significant groundwater.
Groundwater vulnerability	Groundwater quality is classified by SEPA as 'Good' in the Scotland's Environment mapping.
Groundwater Flooding	There is no indication that the study area is at risk of groundwater flooding.
Groundwater depth, elevation and flow	Limited information on groundwater exists in the previous ground investigations. The groundwater table is anticipated to be at a depth of 1.5m to 2.5m bgl (75.5 to 81m OD where recorded), but may be shallower closer to the river, given the granular nature of the shallow soils. Shallow groundwater in the study area is anticipated to flow in a north-westerly direction, i.e. towards and in the direction of flow of the River Don.
Licensed groundwater abstractions	No information has been obtained regarding groundwater abstractions.
Source protection zones	Mapping from SEPA indicates that the study area is in a Drinking Water Protected Area (Groundwater).

3.8 Unexploded Ordnance

A review of publicly available unexploded ordnance (UXO) risk maps indicates that the study area is located in an area with low potential for wartime bombs to be present .

3.9 Radon and ground gas potential

The potential sources of methane and associated gases requiring consideration are generally from organic soils or bedrock, landfills, significant degradable/putrescible materials in made ground, mine workings, wetlands, sewers and gas mains.

Organic soils in the form of peat were encountered at a location in the centre of Kemnay village. Additionally, Alluvium is considered to have the potential to contain organic material in gas-generating quantities. Landfilling and infilled ponds both exist in or near the study area and these pose a potential risk for ground gas generation. Further investigation, including monitoring, would be warranted should proposals include confined spaces.

With regards to the risk of radon generation and migration to the study area, the UK radon risk map has been reviewed. A maximum radon potential of 10-30% is indicated for the north-western portion of the study area and 3-5% in the south-east. Further information should be sought regarding protection measures, should buildings be constructed in association with this flood protection scheme.

3.10 Mining and quarrying

Evidence has been sought to identify any mining, quarrying, and land reclamation operations, past and present, which have taken place within the vicinity of the study area.

Coal Mining

Information from the Coal Authority indicates the study area is not located within a Coal Mining Reporting Area. As such, a mining report is not required for this site.

Quarrying and Shallow Workings

Sand and or gravel extraction took place at one location in the south of the study area, and at four locations within 500m of the study area. All of these are noted in the "mines and quarries" layer of the GeoIndex .

The sand and gravel workings are all assumed by their size and short term representation in the historic mapping to be minor surface workings and are not likely to cause any unidentified void hazards.

3.11 Regulatory Agency Information

Relevant environmental permits and incidents made publicly available are summarised below in Table 3-5.

Table 3-5: Summary of environmental database information

Data type	Entries on-site	Entries off-site	Details
Agency and hydrological			
Pollution Prevention and Control (PPC) permits	0	1	PPC B licence associated with Kemnay Concrete Works (at site of Kemnay Quarry)
Waste and Landfill			
Active or recent landfills.	0	0	
Historic / closed landfills.	0	0	
Waste Management Licence	0	1	End of life vehicles approximately 250m to the south
Hazardous substances/ industrial land uses			
Contaminated land Part 2A register entries and notices.	0	0	
Scottish Pollution Release Inventory	0	0	
Aberdeenshire public register of contaminated land	0	0	
**Entries have only been included within the table where they are located within a 250m radius of the study area or where they fall outside of this radius but are considered to comprise a significant entry.*			

3.12 Cultural heritage

Records on the Scotland's Environment map regarding cultural heritage were reviewed. No Geological Conservation Review Sites, country or national parks, battlefield inventory sites,

Gardens and designed landscapes, or world heritage sites were noted within 250m of the study area.

3.13 Environmentally sensitive sites

The study area is not located within 1km of an environmentally sensitive designation (SSSI, SPA, SPC, RAMSAR). It is understood that Dalmadilly Ponds are a local nature reserve although it is not clear whether these are as of yet designated as such.

4. PRELIMINARY GEOENVIRONMENTAL ASSESSMENT

4.1 Conceptual Site Model (pCSM)

In order to summarise the key risks associated with the study area, a preliminary conceptual site model (pCSM) has been produced to summarise the key geoenvironmental risks anticipated at the study area. This represents the understanding of the potential pollutant linkages assumed to exist on-site before undertaking any intrusive investigations.

Methodology

A pollutant linkage and therefore a risk of harm exists when a contaminant, receptor and pathway to this receptor are present. The terminology used is as follows:

- A contaminant – a substance that is in, on or under the land and has the potential to cause pollution of controlled waters.
- A receptor – in general terms, something that could be adversely affected by a contaminant, such as people, an ecological system, property, or a water body.
- A pathway – a route or means by which a receptor can be exposed to or affected by a contaminant.
- Risk - a combination of the probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

The pCSM is summarised in Table 4-1 along with comments and qualitative risk ratings based on professional judgment. The resultant potential pollutant linkages have been assigned qualitative risk ratings in line with Table 7-1 and Table 7-3, in Appendix A.

Table 4-1: Preliminary Conceptual Site Model (pCSM)

Sources and contaminants	Potential pathways	Receptor	Probability	Severity	Risk	Mitigation / Comment
On-site • On-site quarrying (backfill of unknown origin). • Made Ground. • Railway land (on-site). • On-site water or sewage treatment works. Depending on location of works, potential contaminants include metals, hydrocarbons (including petroleum hydrocarbons, VOCs, SVOCs, PAHs, BTEX, phenols), PFAS, inorganic compounds (particularly sulphates, chlorides, ammonium, and nitrates), pathogens, ash, asbestos, and/or ground gas (methane, carbon dioxide, hydrogen sulphide).	Inhalation of soil-derived dust, gases, vapours and asbestos fibres. Ingestion of or dermal contact with soil and soil-derived dust.	Human Health- construction and maintenance workers.	M	3	AR	Ground investigation to determine if sources are present and pollutant linkage exists. Remediation may be required if significant sources identified. Residual risks are to be managed through appropriate PPE, good personal hygiene and good working practices.
	Ingestion of plants grown in contaminated soil. Inhalation of soil-derived dust, gases, vapours and asbestos fibres. Ingestion of or dermal contact with soil and soil-derived dust.	Human Health- residents, school users.	L	4	AR	
	Leaching and dissolution with vertical/lateral migration, and migration along preferential pathways into groundwater.	Controlled Waters- Shallow Groundwater.	M	3	AR	
	Vertical/lateral migration within groundwater and surface water run-off.	Controlled Waters- Surface water.	M	3	AR	
	Direct contact with sulphate and other aggressive chemicals, or chemicals may flow with groundwater into contact with concrete buildings.	Buildings (structural damage).	L	2	A	

Sources and contaminants	Potential pathways	Receptor	Probability	Severity	Risk	Mitigation / Comment
On-site • Railway land (on-site). Potential contaminants may include: Metals, hydrocarbons (including petroleum hydrocarbons, PAHs, BTEX, phenols), sulphate, and/or asbestos.	Vertical/lateral migration, and migration along preferential pathways and surface water run-off. Plant uptake.	Local nature reserve (Harm to ecological receptor, plant death).	L	4	AR	Ground investigation to determine if sources are present and pollutant linkage exists. Remediation may be required if significant sources of identified. Residual risks are to be managed through appropriate PPE, good personal hygiene and good working practices.
Off-site • Scrapyard (off-site). • Quarrying with associated landfilling (off-site). • Former ponds (backfill of unknown origin) (off-site). • former smithy (off-site). • Garages (off-site). Depending on location of works, potential contaminants include hydrocarbons (including petroleum hydrocarbons, PAHs, BTEX compounds, VOCs, SVOCs, phenols), metals, inorganic compounds (particularly sulphates, chlorides, ammonium, and nitrates), asbestos, and/or ground gas (methane, carbon dioxide, hydrogen sulphide)	Ingestion, inhalation and dermal contact of soil-derived dust, gases, vapours and asbestos fibres. Inhalation of VOCs from shallow groundwater.	Human Health- construction and maintenance workers, residents, school users.	L	4	AR	Ground investigation to determine if sources are present and pollutant linkage exists. Remediation may be required if significant sources of identified. Residual risks are to be managed through appropriate PPE, good personal hygiene and good working practices.
	Leaching and dissolution with vertical/lateral migration, and migration along preferential pathways into groundwater.	Controlled Waters- Shallow Groundwater.	L	3	A	
	Inhalation of gases.	Human Health- construction and maintenance workers, residents, school users.	VL	3	A	

5. PRELIMINARY GROUND RISK REGISTER

The ground risks have been considered for the proposed works, using the information presented in this report and our current understanding and knowledge of the scheme. A risk matrix identifies the potential risks to the scheme during the feasibility, design and construction stages. For each potential hazard or risk identified, a risk rating is assigned prior to identification of risk consequence and mitigation measures. The full risk assessment methodology is presented in Appendix A. Currently anticipated risks and mitigation measures for the scheme are given in Table 5-1.

Table 5-1: Ground Risk Register

Risk ID	Hazard	Consequence	Likelihood	Severity	Risk	Mitigation Measures
1	Made Ground	Variable ground, differential settlement, and the potential to encounter buried structures.	H	3	AR	Further GI to determine depth and extent of Made Ground underlying the proposed works.
		Potential land contamination.	H	3	AR	
		Compressible deposits in former quarries	M	3	AR	
2	Unanticipated ground conditions	Failed structures (e.g. retaining wall)	L	3	A	Further GI underlying the proposed works to confirm ground conditions.
3	Potential for high groundwater levels along river	Excavation instability	M	3	AR	Further GI underlying the proposed works to confirm ground conditions. Dewatering measures may be required during excavations, depending on excavation depth.
4	Potentially contaminated ground	Risk to Human Health and Controlled Waters. Soils unsuitable for reuse on site. High cost to dispose excavated soils off-site. Delays in program	H	3	AR	Carry out ground investigation to provide date for a Generic Quantitative Risk Assessment and waste classification of proposed excavated soils.
5	Running sands	Difficult conditions for construction.	M	2	A	Ground investigation to characterise situation. Appropriate dewatering measures.
6	Shrink swell clay	Softened material difficult to work on.	M	3	AR	Insufficient information to assess risk. Ground investigation to properly characterise situation. Control surface water during excavation, proper excavation management (e.g. appropriately battered sides).
7	Potential for ground gas	If trapped in buildings or other confined spaces, could provide a human health or explosive risk.	L	3	A	Insufficient information to assess risk. If buildings or other confined spaces are proposed, a full ground gas investigation should be undertaken to characterise the situation.
8	Potential for radon gas	If trapped in buildings, could provide a human health risk	M	4	AR	If buildings are proposed in association with this flood protection scheme, further information should be sought from a suitably qualified specialist.

6. CONCLUSIONS AND RECOMMENDATIONS

The risks identified in the Ground Risk Register (Table 5-1) should be transferred to the project risk register.

It is considered likely that further information on the ground conditions will be needed to determine the geotechnical design of the proposed flood protection scheme. Likewise, the land contamination risks identified should be further quantified where development is proposed. Ground investigation would also inform a soil reuse and disposal options assessment.

The finalised scope of an intrusive ground investigation should be determined following confirmation of the detailed design. However, at this stage, it is considered likely that further information would be required to:

- establish the ground conditions underlying the area of the proposed works including the extent and thickness of any made ground;
- investigate specific potential sources of contamination identified in the pCSM;
- determine groundwater depth and flow conditions;
- assess geotechnical properties of soils;
- address data gaps; and
- further quantify, address and mitigate ground related risks identified.

The ground investigation should be carried out in general accordance with the recommendations of BS5930:2015+A1:2020, which maintains compliance with BS EN 1997-1 and 1997-2 and their related standards. Potentially contaminated sites should be investigated in accordance with BS 10175:2011+A2:2017 'Investigation of potentially contaminated sites'. It should be noted that the ground investigation works recommended are indicative and may be subject to change once designs are finalised. Further investigations may also be required in the event that unforeseen ground conditions are encountered or if there are any changes to final designs post investigation.

Prior to conducting intrusive works, utility service plans should be obtained and buried service clearance undertaken in line with PAS128 guidance.

It is a requirement that the full ground investigation (GI) works as described above are carried out prior to the detailed design of any scheme being taken forward.

7. REFERENCES

Aberdeenshire Council, 2011. *Public Regsiter of Contaminated Land.* [Online]
Available at: https://www.aberdeenshire.gov.uk/media/17044/public-register-of-contaminated-land-index-nov11.pdf
[Accessed September 2024].

AGS, 2021. *Assessment and Control of Asbestos Risk in Soil- Part 1: Protection of personnel working on Ground Investigations,* s.l.: s.n.

AGS, 2021. *Assessment and Control of Asbestos Risk in Soil- Part 2: Protection of Personnel working in Geotechnical and Geoenvironmental Laboratories,* s.l.: s.n.

BGS, 1984. *Borehole log for NJ71NW16.* [Online]
Available at: https://api.bgs.ac.uk/sobi-scans/v1/borehole/scans/items/636328
[Accessed September 2024].

BGS, 1988. *Hydrogeological map of Scotland (1:625,000).* [Online]
Available at: https://webapps.bgs.ac.uk/data/maps/home.html
[Accessed September 2024].

BGS, 2002. *British Geological Survey, 1:50,000, Sheet 76, Inverurie, Solid and Drift edition.* [Online]
Available at: https://webapps.bgs.ac.uk/data/MapsPortal/map.html?id=11118300011118

BGS, 2020. *BGS GeoSure5km hex grid.* [Online]
Available at: https://www.bgs.ac.uk/datasets/bgs-geosure-5-km-hex-grid/
[Accessed September 2024].

BGS, 2022. *The BGS Lexicon of Named Rock Units.* [Online]
Available at: https://webapps.bgs.ac.uk/lexicon/
[Accessed March 2022].

BGS, 2024. *BGS maps portal.* [Online]
Available at: https://www.bgs.ac.uk/information-hub/bgs-maps-portal/
[Accessed 2024].

BGS, 2024. *GeoIndex Onshore.* [Online]
Available at: https://bit.ly/3cnZmMd
[Accessed September 2024].

BRE, 2005. *Special Digest 1 Concrete in aggressive ground. 3rd edition (Includes February 2017 amendments).* [Online]
Available at: https://bregroup.com/

BSI, 2007. *BS EN 1997-2:2007 Eurocode 7: Geotechnical design. Ground investigation and testing (incorporating corrigendum June 2010),* s.l.: s.n.

BSI, 2013. *BS8576:2013. Guidance on investigations for ground gas – permanent gases and volatile organic compounds (VOCs),,* s.l.: s.n.

BSI, 2014. *BS EN 1997-1:2004 Eurocode 7: Geotechnical design. General rules (+A1:2013) (incorporating corrigendum February 2009),* s.l.: s.n.

BSI, 2015. *BS 5930:2015 Code of practice for ground investigations (+A1:2020),* s.l.: s.n.

BSI, 2017. *BS 10175:2011+A2:2017 Investigation of potentially contaminated sites - code of practice,* s.l.: s.n.

BSI, 2019. *BS 8485:2015+A1:2019. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.,* s.l.: s.n.

BSI, 2020. *BSI 21365: 2020 Soil quality - Conceptual site models for potentially contaminated sites,* s.l.: s.n.

CIRIA, 2001. *Contaminated land risk assessment: A guide to good practice,* Basingstoke: CIRIA.

CIRIA, 2009. *CIRIA Report C682. The VOCs Handbook. Investigating, assessing and managing risks from inhalation of VOCs at land affected by contamination.,* s.l.: s.n.

CIRIA, 2014. *Special Publication SP 168 Asbestos in soil and made ground: a guide to understanding and managing risks.* [Online]
Available at: https://www.ciria.org/

CL:AIRE, 2016. *CAR-SOIL: Control of Asbestos Regulations 2021, Interpretation for Managing and Working with Asbestos in Soil and Construction and Demolition Materials: Industry guidance,* s.l.: s.n.

Coal Authority, 2024. *The Coal Authority Interactive Viewer.* [Online]
Available at: https://www.groundstability.com/public/web/home.xhtml

DEFRA, 2012. *Contaminated Land Statutory Guidance: Environmental Protection Act 1990:Part 2A,* s.l.: s.n.

Environment Agency, 2021. *Land contamination risk management (LCRM).* [Online]
Available at: https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm
[Accessed 2023].

Google Earth, 2024. *Google Earth.* [Online]
Available at: https://earth.google.co.uk
[Accessed 2024].

Google, 2024. *Google Maps Street View.* [Online]
Available at: https://www.google.com/streetview/
[Accessed 2024].

Highways England, 2020. *CD 622 Managing Geotechnical Risk,* s.l.: Highways England.

Kemnay Village Community Council, 2024. *Kemnay Village Dalmadilly Ponds.* [Online]
Available at: https://kemnay.info/community/places-of-interest/1862-2/
[Accessed 18 09 2024].

Munro, M., 1986. *Geology of the country around Aberdeen. Memoir British Geological Survey, Sheet 77 (Scotland).* online: https://webapps.bgs.ac.uk/memoirs/docs/B01918.html ed. London: Her Majesty's Stationery Office.

National Library of Scotland, 2022. *National Library of Scotland index online viewers.* [Online]
Available at: https://maps.nls.uk/

Scottish Government, 2024. *Scotland's Environment Map.* [Online]
Available at: https://map.environment.gov.scot/sewebmap/
[Accessed September 2024].

SEPA, 2014. *Drinking water protected areas - Scotland river basin district: maps.* [Online]
Available at: https://www.gov.scot/publications/drinking-water-protected-areas-scotland-river-basin-district-maps/
[Accessed 19 09 2024].

SEPA, 2022. *Scottish waste sites and capacity tool.* [Online]
Available at: https://www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/waste-site-information/
[Accessed September 2024].

SEPA, 2024. *Scottish Flood Hazard and Risk Information.* [Online]
Available at: https://map.sepa.org.uk/floodmaps
[Accessed 19 09 2024].

SEPA, 2024. *Special Sites.* [Online]
Available at: https://www.sepa.org.uk/regulations/land/contaminated-land/special-sites-in-scotland/
[Accessed September 2024].

SEPA, 2024. *The Scottish Pollutant Release Inventory.* [Online]
Available at: https://informatics.sepa.org.uk/SPRI/
[Accessed September 2024].

UK Health Security Agency, 2024. *UK Radon Indicative Map.* [Online]
Available at: https://bit.ly/2zFVte3
[Accessed 2024].

Zetica, 2024. *UXO Risk Assessment.* [Online]
Available at: https://bit.ly/2DMxh9W
[Accessed 2024].

APPENDICES

APPENDIX A RISK ASSESSMENT METHODOLOGY

The criteria used for risk assessment are based on CD622 and C552 guidance documents. The severity and probability is classified according to the criteria in Table 7-1 and Table 7-2. The overall evaluation of the level of risk is shown in Table 7-3 and recommended associated actions shown in Table 7-4.

Table 7-1: Likelihood/probability of the risk occurring

Code	Meaning	Geotechnical Risks (CD622)	Geoenvironmental Risks (Ciria C552)
VL	Improbable/Negligible	So unlikely that it can be assumed that it will not occur, or it cannot occur	Contaminant linkage may be present but the circumstances under which harm would occur are improbable
L	Remote/Low likelihood	Unlikely but possible	Contaminant linkage may be present, and there is a possibility of the risk occurring although there is no certainty that it will do so.
M	Occasional/Medium likelihood	Likely to occur at some time	Contaminant linkage may be present, and it is probable that the risk will occur over the long term
H	Probable/Reasonably foreseeable	Likely to occur several times	
VH	Frequent/High likelihood	Likely to occur many times	Contaminant linkage may be preset, and risk is almost certain to occur in the long term, or there is evidence of harm to the receptor.

Table 7-2: Severity/consequence of risk

Code	Meaning	Geotechnical Risks (CD622)	Geoenvironmental Risks (Ciria C552)
1	Negligible	Resulting in no injury and no loss of working time	Damage to non-sensitive ecosystems or species Minor damage to buildings or structures No harm or pollution of water
2	Marginal	Resulting in a minor 'first aid' injury or a minor loss of working time	No significant harm to human health in either short or long term No pollution of sensitive controlled waters, no more than slight pollution of non-sensitive waters Significant damage to buildings or structures Requirements for protective equipment during site works to mitigate health effects
3	Serious	Resulting in an injury or illness which causes a period of absence from work	Harm to human health from long-term exposure Slight pollution of sensitive controlled waters (surface waters or aquifers) or pollution of other water bodies Significant effects on sensitive ecosystems or species
4	Critical	Resulting in a severe injury with much lost time	
5	Catastrophic	Resulting in a fatality or major disruption	Acute risks to human health Catastrophic damage to buildings/property (e.g. by explosion) Direct pollution of sensitive water receptors or serious pollution of other controlled water (watercourses or groundwater) bodies.

Table 7-3: Assessed Risk

SEVERITY / LIKELIHOOD		Negligible 1	Marginal 2	Serious 3	Critical 4	Catastrophic 5
Improbable/Negligible	VL	N	N	A	A	A
Remote/Low likelihood	L	N	A	A	AR	AR
Occasional/Medium likelihood	M	A	A	AR	AR	UA
Probable/Reasonably foreseeable	H	A	AR	AR	UA	UA
Frequent/High likelihood	VH	A	AR	UA	UA	UA

Table 7-4: Risk Response

Code	Meaning	Response needed
UA	Unacceptable	Action essential. Remediation, mitigation or site investigation required.
AR	Action required	Action required if reasonably practicable. Site investigation required.
A	Acceptable	Risk to be managed.
N	Negligible	No action required.