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METRIX

ST ATHAN

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GEO-ENVIRONMENTAL
VALIDATION REPORT

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1. INTRODUCTION

In July 2009, Pell Frischmann (PF) were retained to design and manage an additional combined phase of geo-environmental and geotechnical site investigation to confirm the ground conditions at the site and to validate the previous works done by others across the St Athan site. This document comprises the validation of the ground conditions in terms of the geo-environmental aspects of the site investigation and incorporates a review of the historical data. The geotechnical validation report is presented separately as report SA-C100E-RP-XXX-PC-X-3130.

Site investigation and remediation works have been undertaken by Parsons Brinckerhoff (PB) on behalf of the Welsh Assembly Government (WAG) with the objective of providing a remediated site in compliance with prevailing environmental legislation.

This geo-environmental validation report considers the combined data from the site investigation undertaken by PF and the historical site investigation data, in terms of the following:

- The conclusions made in the previous site investigation reports and data;
- The effect of the change in the identified land use scenario from commercial/industrial to a residential end use;
- Modifications to the design and proposed layout of the project, and;
- Changes in the boundaries between the different land use areas.

1.1 DATA SOURCES

In the production of this validation report the results from the site investigation have been considered in conjunction with the reports listed below, which have been reviewed, referenced and relied upon (without prejudice). With a project of this size, scope and complexity, there is an extensive documentation library that has been viewed in the compilation of this report. However, for brevity and clarity unless the document has significantly contributed to the work undertaken on site or in the production of this report, it has not been referenced below:

- Defence Estates, RAF St Athan, East Camp, Land Quality Assessment, Phase Two: Intrusive Survey, Land Quality Assessment Report, Project No: 11945 – Final, Technical Report by Envirospine, November 2002;
- Defence Estates, RAF St Athan, Picketston Camp, Land Quality Assessment, Phase Two: Intrusive Survey, Land Quality Assessment Report, Project No: 11945 – Final, Technical Report by Envirospine, November 2002;

- Parsons Brinckerhoff, Volume 1 - Final, Aerospace Wales, RAF St Athan, Factual Report On Ground Investigation, Undertaken, February - March 2004, Welsh Development Agency, March 2004;
- Parsons Brinckerhoff, Volume 2 - Final, Aerospace Wales, RAF St Athan, Interpretative Report and Risk Assessment - Welsh Development Agency, May 2004;
- Parsons Brinckerhoff, Volume 3 - Draft, Aerospace Wales, RAF St Athan, Pollution Prevention Audit – Welsh Development Agency, March 2004, and;
- Parsons Brinckerhoff, Volume 4 - Final, Aerospace Wales, RAF St Athan, Outline Remediation Strategy – Welsh Development Agency, March 2004.
- Soil Mechanics, Factual and Interpretative Report on Ground Investigation Report No H9069 – Sodexo, March 2010.

1.2 VALIDATION REPORT OBJECTIVES

The reports listed above contain a significant amount of geo-environmental data, which due to changes in the project are no longer completely appropriate; primarily due to changes in the proposed layout of the development. The current proposed layout is presented on Drawing SA-C0XXX-TP-900-SB-X4005 in Appendix B.

The principal objective of this report is to compile the information from the various disparate sources and undertake a validation exercise against the current proposals. Part of the validation exercise is also aimed at addressing the outstanding planning condition detailed below:

Condition 59

“Save for the works to Eglwys Brewis Road, prior to the commencement of development approved by this planning permission (or such other date or stage in development as may be agreed in writing with the LPA), the following components of a scheme to deal with the risks associated with contamination of the site shall each be submitted to and approved, in writing, by the LPA:

A preliminary risk assessment which has identified:

- *all previous uses;*
- *potential contaminants associated with those uses;*
- *a conceptual model of the site indicating sources, pathways and receptors;*
- *Potentially unacceptable risks arising from contamination at the site.*

A site investigation scheme, based on (1) to provide information for a detailed assessment of the risk to all receptors that may be affected, including those off site.

The site investigation results and the detailed risk assessment (2) and, based on these, an options appraisal and remediation strategy giving full details of the remediation measures required and how they are to be undertaken.

A verification plan providing details of the data that will be collected in order to demonstrate that the works set out in (3) are complete and identifying any requirements for longer-term monitoring of pollutant linkages, maintenance and arrangements for contingency action.

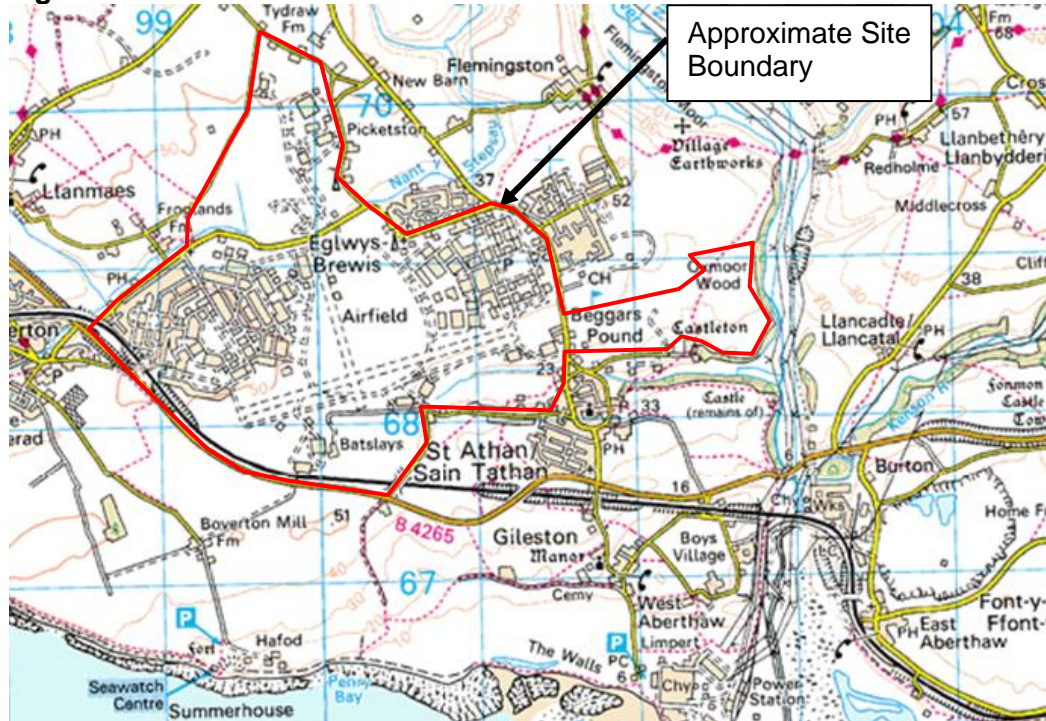
Any changes to these components require the express consent of the LPA. The scheme shall be implemented as approved unless otherwise agreed in writing by the LPA.”

2. SITE INFORMATION

2.1 SITE LOCATION

The site of RAF St Athan is located to the north of the B4265, midway between the villages of St Athan and Llantwit Major, and approximately 11km to the west of Cardiff (approximate NGR 300197, 168790) as detailed on Figure 1 below

Figure 1: Site Location Plan



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2.2 GENERAL SITE DESCRIPTION

The site of RAF St Athan occupies an irregular shaped parcel of land comprising an active RAF base and areas of privately farmed agricultural fields with a total area of approximately 450ha. The RAF base is bounded to the west by a single track railway line and a public highway designated the B4265, both of which are orientated in a northwest-southeast direction. The northern boundary is characterised by a road linking Llantwit Major and Eglwys Brewis, the latter of which is located at the northeast corner of the site. The eastern boundary is defined by an area of open ground comprising Flemingston Moor and the narrow north-south trending valley containing the River Thaw. The village of St Athan is located to the south east of the southern site boundary.

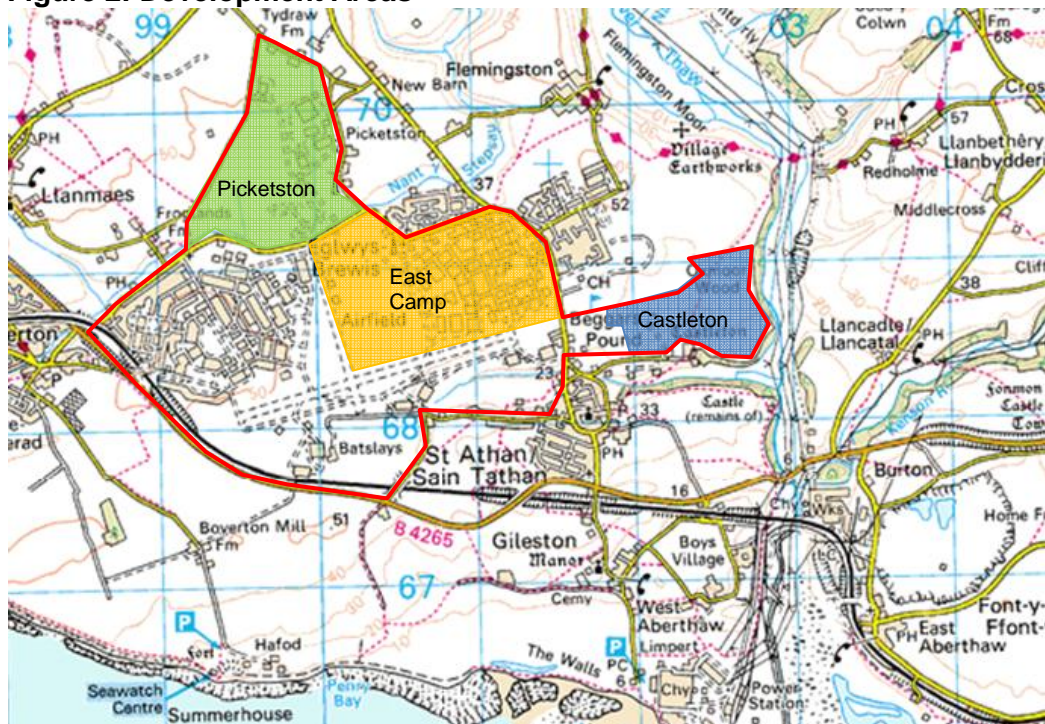
The current Ordnance Survey map indicates that the site is situated at an elevation of +50m above Ordnance Datum (aOD), with a gentle northwest-southeast trending slope. The slope to the northeast associated with the River Thaw, is of a moderate gradient to the east. The site and its general environs are situated in a predominantly rural setting, which is largely agricultural.

The site is occupied by a large number of buildings and infrastructure which comprise, but are not limited to, aircraft hangars, machine shops, residential accommodation, training facilities (both academic and practical), military stores (all types of logistic material associated with a working RAF base), bunkers, a police station, offices and catering facilities, runways etc.

2.3 PROPOSED DEVELOPMENT

It is proposed that the site is to be developed as a training facility with new buildings for residential accommodation. The report considers three principal areas of the site (See Figure 2) which are part of the proposed development in respect to the Defence Training College (DTC):

Figure 2: Development Areas



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Picketston Area – This is partially occupied by a number of buildings (in the eastern portion of the area) which are to be renovated and utilised as various training facilities. The western portion of this site is to be developed as sports pitches and recreational areas. It is proposed that a nursery is located in the south west corner of the Picketston area and Service Family Accommodation will bound the area to the west and south west.

East Camp – This area is currently occupied by a number of buildings which comprise residential, training, service and supporting infrastructure (Catering etc). This area of the camp is undergoing partial demolition and a number of new facilities are to be constructed. It is proposed to construct a mixed development comprising living accommodation, educational and training, health care, catering, offices, stores and a museum.

Castleton – This area is to be used for infantry training and battlefield simulation.

2.4 SITE HISTORY

The following review of the historical Ordnance Survey mapping, contained in Table 1 below, has been obtained from the Parsons Brinckerhoff report, Pollution Source Prevention Audit, October 2003, Volume 3.

Table 1: Site History

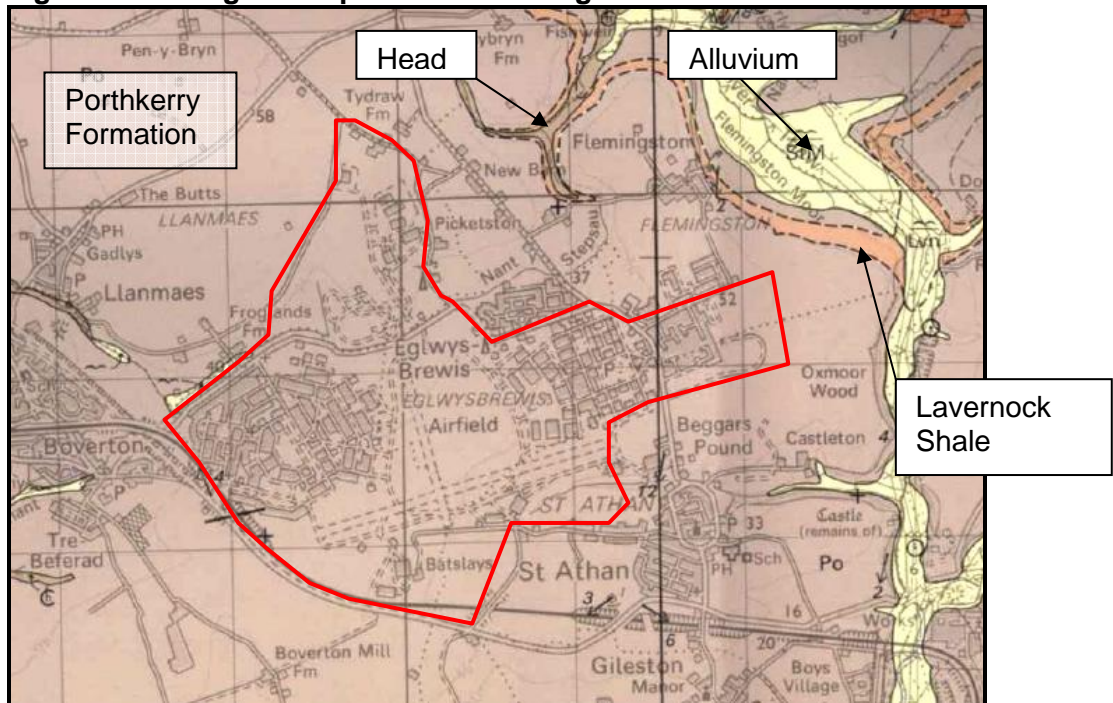
Year	Description
1885 (1:10,560)	The map shows that the site is largely undeveloped farmland. A small number of residential properties are located at Picketston to the north of the site and Batslays to the south of the site. A watercourse, referred to as Nant y Stepsau flows in an easterly direction along the north of the site. The Boverton Brook is shown to flow in a south westerly direction along the north western boundary of the site, and a third watercourse flows along the site's southern boundary from West Orchard along St John's Valley. All three watercourses originate from either springs or marshy ground around the site. Eglwys Brewis Farm, a Smithy and Church and rectory are located on land now part of East Camp.
1900 (1:10,560)	The map shows an Old Quarry located at West Orchard in close proximity to the remains of West Orchard Castle. The rest of the site remains unchanged.
1921, 1951, 1964 (1:10,560)	The incomplete 1921 map identifies a tank located on the site to the south of Picketston. The contents of this tank are unknown. Even though other historical information indicates that the site was opened in 1939 the incomplete 1951 map shows the site to remain undeveloped farmland. It should be noted that post war maps (up until the late 1960s) do not show sensitive military locations for security reasons.
1969 (1:10,560)	The incomplete map shows the site's Airfield and East Camp along with hangars at Batslays, West Orchard, Beggars Pound and Picketston.
1972, 1984, 1972/90 (1:10,000)	The map refers to the site as RAF Station St Athan and shows the extent of development on both East and West Camps along with Batslays, West Orchard, Beggars Pound and Picketston. The map shows the presence of a number of tanks on East Camp, which has undergone some redevelopment with the demolition of a number of hangars around Eglwys-Brewis. The incomplete 1984 map shows no noteworthy change on East Camp and the composite 1972/90 map shows little change across the rest of the site.
1999 (1:10,000)	The map indicates that a new hangar has been developed on West camp at the northern end of the north/south runway and that a number of small structures have been constructed along the eastern edge of the same runway. The remainder of the site remains relatively unchanged.

2.5 GEOLOGY, HYDROGEOLOGY AND HYDROLOGY

2.5.1 Geology

The geology of the site and the surrounding area is shown on the British Geological Survey (BGS) map for Bridgend (Sheet 262 – Solid and Drift Edition, 1:50,000, 1990). An extract of the geological map is shown in Figure 3. The geological map indicates that the site is wholly underlain by the Lower Lias Porthkerry Formation. There are no drift deposits or fault lines on or within potential influencing distance of the site.

Figure 3: Geological map extract covering RAF St Athan



Key:

- Brown (Porthkerry Formation)
- Orange (Lavernock Shales)
- Yellow (Alluvium)
- Dark brown (Head)

The Lower Lias Porthkerry Formation is described in the BGS memoir as comprising up to 120m of fractured, interbedded fine-grained limestones (See Plate 1 below) and calcareous shaley mudstones, which are subdivided into four units (D to A) as detailed below:

- Unit D: easily eroded and poorly preserved unit with high mudstone content. Not exposed in this area but is given a minimum thickness of around 100m;
- Unit C: up to 5m of massive, composite limestone beds;
- Unit B: 26.5m of massive and planar-bedded limestones, commonly in amalgamated beds 1m (or more) thick, with thin mudstone partings (See Plate 2 below); and,
- Unit A: 36m of thin, impersistent, nodular and wavy bedded limestones and interbedded mudstones.

Unit A is the (geologically) oldest unit and has a gradational contact over about 2m with the underlying Lavernock Shale.

A ribbon-like outcrop of the Lower Lias Lavernock Shales is present on the western flank of the River Thaw Valley trending approximately northwest-southeast. These strata are described in the geological memoir as a sequence of dark grey, calcareous, bioturbated, shaly mudstones, with subordinate thin beds of nodular limestone and variable amounts of skeletal material. They are generally around 12m thick.

Plate 1: Photograph showing fractured and interbedded fine-grained limestones.



Plate 2: Photograph showing thin mudstone partings.



2.5.2 Hydrogeology

The Environment Agency (EA) classifies the Lower Lias Porthkerry Formation as a Minor Aquifer, which overlays the Major Aquifer of the Carboniferous Limestone. The Porthkerry Formation has interbedded limestones and mudstones. The interbedded highly permeable limestones and less permeable mudstones provide

a high level of tortuosity to the vertical migration of groundwater and therefore any associated mobile contamination.

The groundwater pathway through the Carboniferous Limestone Major Aquifer is primarily through preferential pathways through primary fracturing of the rock; and through potential solution features.

The majority of the soils underlying the site are classified as having High Leaching Potential (H3), indicating that they are coarse textured with the ability to transmit non-adsorbed pollutants and liquid discharges readily, but with some ability to attenuate adsorbed pollutants because of the natural content of clay or organic matter. Soils beneath Batslays and a narrow strip between Picketston and the airfield are classified as being of Intermediate Leaching Potential.

2.5.3 Hydrology

There are a four surface water features within potential influencing distance of the site, these are as follows:

- Boverton Brook;
- Nant-y-Stepsau;
- Rhyl Stream;
- Hoddnant, and;
- Afon-col-Huw.

The surface water bodies detailed above all terminate into the Bristol Channel, either directly or indirectly by intersecting with each other

3. PF VALIDATION SITE INVESTIGATION

3.1 OBJECTIVES

Pell Frischmann designed and managed an additional phase of intrusive site investigation works to confirm the findings of the previous site investigations and to address any potential data gaps which had occurred due to the change in the proposed end use and design of the proposed layout ensuring that the assessment is relevant to the development detailed on Drawing SA-C000X-TP-900-SB-X-4005 presented in Appendix B.

The additional phase of site investigation was undertaken by Soil Mechanics between 17th August and the 20th October 2009. During the site investigation, a total of one hundred and sixty nine trial pits, seventeen boreholes, twenty one windowless sample holes and seventy one surface samples were undertaken. This Validation Report is limited to the exploratory works which took place at Picketston, East Camp and Castleton.

The factual site investigation information is presented in the Soil Mechanics Factual and Interpretative Report on Ground Investigation (Report No H9069, March 2010).

3.2 SAMPLING STRATEGY

3.2.1 Picketston

The site sampling strategy in Picketston was based on three distinct areas. Firstly, further exploratory works were required in the eastern portion of the site to confirm the findings of the previous site investigations and to address potential concerns regarding the structures which are to be retained and refurbished. The rationale behind these latter locations was to verify that significant areas of Made Ground were not present; and that buildings had not been used as a cover for contaminated material.

Secondly, exploratory works were required in the area of the agricultural fields in the western portion of the Picketston area as previous exploratory works had not been undertaken within this area.

Site investigations were also undertaken in the southern portion of the site to gain a better understanding of the potential near surface total petroleum hydrocarbon (TPH) and polycyclic aromatic hydrocarbon (PAH) contamination which had been identified by Parsons Brinckerhoff (PB) during previous site investigations. The area was also targeted for the presence of perfluorooctane sulphonate (PFOS), a constituent of fire fighting foams which are believed to have been used in the area. PFOS is a persistent organic pollutant which may have locally impacted soils and groundwater.

3.2.2 East Camp

The main aims of the exploratory works within East Camp were to undertake additional exploratory holes with associated sampling to obtain near surface soil

and groundwater samples. In addition, groundwater samples were obtained from existing exploratory locations. Trial pit locations were primarily designed to ascertain the depth to rock head and other general geotechnical information. Some of the trial pit locations were relocated or added to target specific features and areas of concern; the details of the sampling strategy are included as Appendix C. Appendix B also includes a drawing denoting specific areas of concern which were generally targeted and investigated during the site investigation.

The geochemical testing of the soil samples was based on a broad ranging suite of determinants and was primarily undertaken to ensure that there was significant coverage of the site as a whole and that the strategy would provide a statistically robust data set. The geochemical suite employed is expanded upon further within Appendix C and in Section 7 of this report.

The geochemical testing of the groundwater samples was based on the previous results reported extensively by PB, an overview of which is included as Appendix D. The testing also comprised a primary broad based testing suite which was supported by further specific testing for identified determinants such as PFOS. (See Appendix D)

3.2.3 Castleton

The sampling strategy for the Castleton area of the site was aimed at obtaining near surface soils from across the general area; and to investigate a number of historical features with targeted trial pitting.

The geochemical testing was based on the historical usage of the area as agricultural land and was principally limited to metals, asbestos and pesticides, which may be represent a risk to the personnel undergoing training in this area. The testing suite did not include any significant amounts of organic testing, as this was felt to have a very low potential of being present, based on the preliminary risk assessment undertaken for the Castleton area.

3.3 SCOPE OF WORKS

3.3.1 Picketston

Sixty nine trial pits, five rotary boreholes and thirteen windowless sample locations were advanced across the Picketston area. Fifty seven soil samples were retained and subsequently scheduled for geochemical analysis during the site investigation within this area. Twenty three samples were analysed from the Made Ground and thirty four samples were analysed from the natural strata. All five rotary boreholes were installed with monitoring wells. Surface soil samples were obtained from the location of the fire fighting training area.

The locations of all the exploratory holes are presented on Drawings SW Appendix B-04 presented in Appendix B.

3.3.2 East Camp

Ninety six trial pits, twelve rotary boreholes and eight windowless sample locations were advanced across the East Camp. Sixty two soil samples were retained, and subsequently underwent geochemical analysis during the site investigation. Twenty one samples from the Made Ground and forty one samples were analysed from the natural strata. Nine of the rotary boreholes were installed with monitoring wells; however, the “air side” locations situated around the super hangar (BH-B02 to BH-B04) were not installed due to ongoing access restrictions and the potential risk of damaging taxiing aircraft.

The locations of all the exploratory holes are presented on Drawings SW Appendix B-05 and 06 presented in Appendix B.

3.3.3 Castleton

Seventy one surface samples and four trial pits were advanced across the Castleton area during the site investigation. Twelve soil samples were retained which subsequently underwent geochemical analysis; two samples from the Made Ground and ten samples were analysed from the natural strata.

The locations of all the exploratory holes are presented on Drawings SW Appendix B-07 presented in Appendix B.

4. GROUND CONDITIONS

4.1 PREVIOUS INVESTIGATIONS

The ground conditions which were encountered during previous investigations (in particular by PB and Enviros) are summarised in Appendix E.

4.2 PELL FRISCHMANN FINDINGS

4.2.1 Ground conditions

The published geological map covering the site, BGS Sheet 262 (1990), show the geology to comprise bedrock of the Lower Lias Limestone of Jurassic Age. No drift deposits are indicated on the geological plan though superficial deposits derived from the weathering of the bedrock would be expected.

The ground investigations have all encountered generally uniform ground conditions comprising topsoil/Made Ground underlain by drift deposits over bedrock. Made ground is generally thin, and associated with the development of RAF St Athan. The drift deposits consist of weathered bedrock and comprise sandy gravelly clay with varying gravel content. Lower Lias bedrock was typically encountered from between 0.4m and 2m below ground level. The bedrock was encountered as a horizontally bedded strong to very strong light grey limestone with occasional fossil fragments. The rock was found to be intermittently but regularly interbedded with a weak to medium strong dark grey siltstone or shale, as layers up to 0.35 m thick.

4.2.2 Groundwater

The monitoring results carried out to date indicate groundwater depths in the range of 3.20m and 9.98m below existing ground level (33.19m and 42.73m AOD) in East Camp and in the range 0.32m and 3.32m below existing ground level (41.12m and 42.59m AOD) in Picketston. The shallowest groundwater levels were in the lowest part of the site, along the line of Boverton Brook and the Eglwys-Brewis Road that divides the main camp and Picketston.

From the monitoring results it appears that the groundwater table lies possibly within the bedrock. Given the topography a local down-slope hydraulic gradient would be expected towards the south of the site.

It will be appreciated that seasonal fluctuations in groundwater level occur. Other effects such as investigation and constructional excavation may also change groundwater levels.

Three permeability tests carried out in East Camp standpipes within the limestone measured permeabilities of 2×10^{-6} m/sec to 3×10^{-6} m/sec. Within Picketston two permeability tests carried out in the lower part of the site suggested high permeabilities, with the tests unable to record a drawdown.

5. RISK ASSESMENT METHODOLOGY

5.1 LEGISLATIVE BACKGROUND

The primary legislative mechanism for contaminated land management in the UK is Part 2A of the Environmental Protection Act, 1990 (EPA). Part 2A was introduced into the EPA under Section 57 of the Environment Act 1995 to help deal with the substantial legacy of land contamination. It focuses on the identification and remediation of land which is in such a condition by reason of contamination that it gives rise to significant harm or the significant possibility of significant harm to certain named receptors, or gives rise to pollution of controlled waters or the likelihood of such pollution. Part 2A applies where there is unacceptable risk, assessed on the basis of the current use and the relevant circumstances of the land. It is not directed to assessing risks in relation to a future use of the land that would require a specific grant of planning permission.

The control of development and land use in the future is the responsibility of the planning system. A fundamental principle of sustainable development is that the condition of land, its use and its development should be protected from potential hazards. Planning Policy Statement (PPS) 23 Planning and Pollution Control details the process by which Local Planning Authorities should take decisions on applications in relation to development on land affected by contamination and how the planning regime should integrate with Part 2A of the EPA.

PPS 23 states that 'it remains the responsibility of the land owner/developer to identify land affected by contamination and to ensure that remediation is undertaken to secure a safe development'.

Where development is proposed, the developer is responsible for ensuring that the development is safe and suitable for the proposed end use for which it is intended. In particular, the developer should carry out an adequate investigation to inform a risk assessment to determine:

- Whether the land in question is already affected by contamination;
- Whether the proposed development will create new pollutant linkages (e.g. pathways by which existing contamination might reach existing or proposed receptors and whether it will introduce new vulnerable receptors); and
- Whether mitigation action is needed to break those linkages, avoid the introduction of new ones and deal with unacceptable risks to enable safe development and future occupancy of the site and neighbouring land.

PPS 23 states that the assessment of land affected by contamination requires a risk assessment that identifies sources, pathways and receptors. PPS 23 also states that it is necessary to develop a conceptual site model (CSM), which identifies plausible pollutant linkages as a basis for assessing the risks and appraising the options for remediation.

The range of sensitive receptors which require consideration is wider under the planning regime than under Part 2A and includes for example, general fauna and flora. However, it is considered that the risks should be assessed and acted upon in accordance with Part 2A principles.

5.2 ASSESSMENT PROCESS

The approach to human health risk assessment adopted in this report is consistent with the Environment Agency's Model Procedures (CLR11), Welsh Assembly Government's Part 2A Statutory Guidance on Contaminated Land and other guidance (including SR3, BS10175:2001 and PPS23). In line with this guidance, a tiered approach to the assessment of risks has been undertaken. Using such an approach allows a focus on the main risk drivers whilst having regard to statutory guidance and UK government policy.

There are three tiers used in the Model Procedures for the assessment of land contamination, as follows:

- Tier 1 Preliminary Risk Assessment – This commences with the development of an initial CSM and establishes whether there are potentially unacceptable risks.
- Tier 2 Generic Quantitative Risk Assessment (GQRA) – This process establishes whether generic assessment criteria (GACs) and the associated assumptions made in generating these values are applicable to the site. If so, then the GACs are used to establish whether there are unacceptable risks. It also determines the need for further more detailed risk assessment. This is principally the purpose of this report.
- Tier 3 Detailed Quantitative Risk Assessment (DQRA) – Tier 3 uses more detailed site-specific information and criteria to decide whether there are unacceptable risks. In this report, where GACs have been exceeded for a particular determinant, an assessment has been made as to whether a DQRA should be undertaken, for example where exposure characteristics can be refined to develop Site Specific Assessment Criteria (SSACs) using CLR 10 algorithms. The factors taken into consideration when deciding whether a DQRA is appropriate would include the extent of exceedances of the GAC and whether the additional site specific information would make a significant difference to the screening value.

Appendix G provides further details of the Tier 2 Generic Assessment which has been undertaken with Section 6 below summarising the findings.

6. GENERIC QUANTITATIVE RISK ASSESSMENT - SOILS

The following sections represent a summary of the Generic Quantitative Risk Assessment (GQRA) which has been undertaken for the site. The full assessment is presented as Appendix G.

6.1 PICKETSTON

The results from the geochemical analysis from the site investigation undertaken by Pell Frischmann and the previous works undertaken by PB and Enviros have been combined and assessed together.

6.1.1 Made Ground

6.1.1.1 Metals

The geochemical analysis for the following metals and metalloids within the Made Ground was undertaken on up to fifty three samples:

- Antimony;
- Arsenic;
- Barium;
- Beryllium;
- Boron;
- Cadmium;
- Chromium (III);
- Copper;
- Lead;
- Mercury;
- Molybdenum;
- Nickel;
- Selenium;
- Vanadium, and;
- Zinc.

The risk assessment presented in Appendix G identifies that the metals and metalloids in the Made Ground should not pose a significant risk to future end users for the proposed end use.

6.1.1.2 Non Metals and Geochemical Properties

The geochemical analysis for the following non-metals and geochemical properties within the Made Ground was undertaken on up to sixty one samples:

- Phenol Index;
- Cyanide(Total);
- SO₄-(H₂O sol) mg/l;
- Sulphide as S;
- Total Sulphur;
- Nitrate (2:1): mg/l;
- Sulphate (SO₃);
- pH units;
- Asbestos, and;
- Total Organic Carbon.

The risk assessment presented in Appendix G indicates that the recorded concentrations of phenol and cyanide in the Made Ground should not represent a significant risk to human health. The screening of soil samples at the laboratory did not reveal the presence of asbestos fibres.

6.1.1.3 Total Petroleum Hydrocarbons

The geochemical analysis for TPH undertaken on twenty soil samples from the Made Ground, determined that the levels recorded potentially represent a risk to human health.

Assessment of the analytical results obtained using the 5-phase split revealed the following in terms of the risk that TPH represents at the site:

- From the 12 samples assessed, five of the samples exceeded at least one of the GAC;
- Four samples exceeded the GAC within the EC>16-24 range, these were obtained from PI-TP06, PI-TP17, PI-WS31 and PI-WS34 with results of 490, 4980, 1150 and 676mg/kg respectively, and;
- Three samples exceeded the GAC within the EC>24-40 range, these were obtained from PI-TP06, PI-WS31 and PI-WS34 with results of 5920, 2730 and 2170mg/kg respectively.
- One sample exceeded the GAC within the aromatic EC>21-35 range from TPC28 with a result of 1470.

Therefore, further consideration and assessment needs to be undertaken on the potential risk that TPH represents to human health at the Picketston site.

Appendix I contains a distribution plot of the identified TPH contamination within the Made Ground for the Picketston Site.

6.1.1.4 Polycyclic Aromatic Hydrocarbons

The geochemical analysis and the subsequent risk assessment for PAH within the Made Ground, determined that the levels recorded potentially represent a risk to human health; the assessment was undertaken on up to thirty four samples. The following list of PAHs (USEPA 16) were analysed for:

- Acenaphthene;
- Acenaphthylene;
- Anthracene;
- Benzo[a]anthracene
- Benzo[a]pyrene;
- Benzo[b]fluoranthene
- Benzo[g,h,i]perylene;
- Benzo[k]fluoranthene
- Chrysene;
- Dibenzo[a,h]anthracene;
- Fluoranthene;
- Fluorene
- Indeno[1,2,3-cd]pyrene;
- Naphthalene;
- Phenanthrene, and;
- Pyrene

The geochemical analysis indicated that PAH contamination in the form of the following determinants potentially represents a risk to human health and requires further consideration and assessment. A distribution plot of the identified PAH

concentrations presented within Appendix I indicates that the exceedances are distributed in the region of the fire fighting training area:

- Benzo[a]anthracene;
- Benzo[a]pyrene;
- Benzo[b]fluoranthene;
- Benzo[k]fluoranthene;
- Chrysene;
- Dibenzo[a,h]anthracene, and;
- Indeno[1,2,3-cd]pyrene.

6.1.1.5 Volatile Organic Compounds

A range of Volatile Organic Compounds (VOCs) were tested for on two samples of Made Ground. The samples were obtained from locations which were identified during the design of the site investigation, as most likely to contain VOC contamination. The results of the geochemical analysis undertaken did not reveal the presence of any VOC contamination. The range of VOC determinants analysed for is detailed within Appendix C and Appendix F.

6.1.1.6 Pesticides

Two Made Ground samples were tested for a wide ranging pesticide suite, the contents of which and the results are contained within Appendix C. The sampling strategy was based on the assumption that pesticides are widely applied in an agricultural setting through crop spraying. The samples were obtained from two potential fields, which had been identified as containing arable crops. The results of the pesticide analysis recorded all concentrations below the limit of laboratory detection. The range of pesticides analysed for is detailed within Appendix C and Appendix F.

6.1.1.7 Perfluorooctane Sulphonate (PFOS)

Four samples of the surface soils (Made Ground) obtained from the fire fighting area were analysed for PFOS, these were SS-C02, SS-C04, SS-C06 and SS-C08, the results of the analysis ranged from 3.60 to 85µg/kg.

The guidance on the potential risk that PFOS represents to human health, groundwater and the wider environment needs further consideration and consultation with the Environment Agency. PFOS testing has also been undertaken on groundwater samples which are commented on in the groundwater section of this report.

6.1.1.8 Summary of Contaminants of Concern

In summary, the following determinants have been identified as potential contaminants of concern in the Made Ground at the Picketston area which require either further assessment and/or remediation:

- Total Petroleum Hydrocarbons

- Polycyclic Aromatic Hydrocarbons
- PFOS

6.1.2 Natural Strata

6.1.2.1 Metals and Metalloids

The geochemical analysis and the subsequent risk assessment for metals and metalloids within the natural strata, determined that the levels recorded do not represent a significant risk to human health; the assessment was undertaken on up to sixty five samples. The range of determinants analysed for is listed above in Section 6.1.1.1.

6.1.2.2 Non-Metals and Geochemical Properties

The geochemical analysis and the subsequent risk assessment for non-metals geochemical properties within the natural strata, determined that the levels recorded do not represent a significant risk to human health; the assessment was undertaken on up to sixty five samples. The range of determinants analysed for is listed above in Section 6.1.1.2.

6.1.2.3 Total Petroleum Hydrocarbons

The geochemical analysis and the subsequent risk assessment for TPH within the natural strata, determined that the levels recorded should not represent a significant risk to human health; the assessment was undertaken on up to twenty three samples.

6.1.2.4 Polycyclic Aromatic Hydrocarbons

The geochemical analysis and the subsequent risk assessment for TPH within the natural strata, determined that the levels recorded do not represent a significant risk to human health; the assessment was undertaken on up to twenty seven samples. The range of determinants analysed for is listed above in Section 6.1.1.4.

6.1.2.5 Volatile Organic Compounds

A range of Volatile Organic Compounds (VOCs) were tested for at two samples of natural strata. The samples were obtained from locations which were identified during the design of the site investigation, as most likely to contain VOC contamination. The results of the geochemical analysis undertaken did not reveal the presence of any VOC contamination. The range of VOC determinants analysed for is detailed within Appendix C and Appendix F.

6.1.2.6 Summary of Contaminants of Concern

In summary, contaminant concentrations recorded within the natural strata in the Picketston area are considered not to represent a significant risk to human health for the proposed end use.

6.2 EAST CAMP

The results from the geochemical analysis from the site investigation undertaken by Pell Frischmann and the previous works undertaken by PB and Enviros have been combined and assessed together.

6.2.1 Made Ground

6.2.1.1 Metals and Metalloids

The geochemical analysis for metals and metalloids within the Made Ground determined that the levels recorded should not represent a significant risk to human health. The range of determinants analysed for is listed above in Section 6.1.1.1.

6.2.1.2 Non Metals and Geochemical Properties

The geochemical analysis for non-metals and geochemical properties within the Made Ground, determined that the concentrations recorded (Phenol and Cyanide) do not represent a significant risk to human health. The screening of soil samples at the laboratory did not reveal the presence of asbestos fibres.

6.2.1.3 Total Petroleum Hydrocarbons

The geochemical analysis for Total Petroleum Hydrocarbons within the Made Ground determined that the levels recorded should not represent a significant risk to human health for the proposed end use.

6.2.1.4 Polycyclic Aromatic Hydrocarbons

The geochemical analysis and the subsequent risk assessment for PAH within the Made Ground, determined that the levels recorded potentially represent a risk to human health; the assessment was undertaken on up to thirty four samples. The range of determinants analysed for is listed above in Section 6.1.1.4.

A distribution plot of the PAH concentrations contained within Appendix G indicates that the exceedances are distributed across a wide area of the site. The PAHs below were determined to represent a significant risk to human health:

- Benzo[a]anthracene;
- Benzo[a]pyrene;
- Benzo[b]fluoranthene;
- Dibenzo[a,h]anthracene, and;
- Indeno[1,2,3-cd]pyrene.

6.2.1.5 Summary of Contaminants of Concern

In summary, Polycyclic Aromatic Hydrocarbons have been identified as potential contaminants of concern in the Made Ground at East Camp area which require either further assessment and/or remediation.

6.2.2 Natural Strata

6.2.2.1 Metals and Metalloids

The geochemical analysis and the subsequent risk assessment for metals and metalloids within the natural strata, determined that the levels recorded do not represent a significant risk to human health; the assessment was undertaken on up to sixty five samples. The range of determinants analysed for is listed above in Section 6.1.1.1.

6.2.2.2 Non-Metals and Geochemical Properties

The geochemical analysis and the subsequent risk assessment for non-metals and geochemical properties within the natural strata, determined that the levels recorded should not represent a significant risk to human health. The assessment was undertaken on up to ninety three samples. The range of determinants analysed for is listed above in Section 6.1.1.2.

6.2.2.3 Total Petroleum Hydrocarbons

The geochemical analysis and the subsequent risk assessment for TPH within the natural strata, determined that the levels recorded should not represent a significant risk to human health.

6.2.2.4 Polycyclic Aromatic Hydrocarbons

The geochemical analysis and the subsequent risk assessment for PAH within the natural strata, determined that the levels recorded do not represent a significant risk to human health. The assessment was undertaken on up to thirty six samples. The range of determinants analysed for is listed above in Section 6.1.1.4.

6.2.2.5 Summary of Contaminants of Concern

In summary, contaminant concentrations recorded within the natural strata in the East Camp area are considered not to represent a significant risk to human health for the proposed end use.

6.3 CASTLETON

The results from the geochemical analysis and subsequent risk assessment from the site investigation undertaken by Pell Frischmann on the Castleton area of the site were as followed.

6.3.1 Made Ground and Natural Strata (Combined)

6.3.1.1 Metals

The geochemical analysis for metals and metalloids from across the site as a whole, determined that the levels recorded should not represent a significant risk

to human health. The range of determinants analysed for is listed above in Section 6.1.1.1.

6.3.1.2 Non Metals and Geochemical Properties

The geochemical analysis for non-metals and geochemical properties, as given in Section 6.1.2, from across the site as a whole, was undertaken on up to ten samples. The geochemical analysis revealed that the concentrations recorded (Phenol and Cyanide) should not represent a significant risk to human health. The screening for asbestos did not reveal the presence of any fibres.

6.3.1.3 Pesticides

Geochemical analysis was undertaken on using a broad ranging pesticide suite, the results of which were all below the limit of detection. Therefore, pesticides are not considered to represent a significant risk to human health.

6.3.1.4 Summary of Contaminants of Concern

In summary, contaminant concentrations recorded within the Made Ground and natural strata in the Castleton area are considered not to represent a significant risk to human health for the proposed end use.

7. GENERIC QUANTITATIVE RISK ASSESSMENT - GROUNDWATER

The groundwater at the site has been the subject to an extensive monitoring and remediation programme of works, which has been undertaken under the direction and control of Parsons Brinckerhoff. The works undertaken have been extensively covered within the following reports:

- Parsons Brinckerhoff, Volume 1 - Final, Aerospace Wales, RAF St Athan, Factual Report on Ground Investigation, Undertaken , February - March 2004, Welsh Development Agency, March 2004;
- Parsons Brinckerhoff, Volume 2 - Final, Aerospace Wales, RAF St Athan, Interpretative Report and Risk Assessment - May 2004, Welsh Development Agency, May 2004;
- Parsons Brinckerhoff, Volume 3 - Draft, Aerospace Wales, RAF St Athan, Pollution Prevention Audit – March 2004, Welsh Development Agency, March 2004, and;
- Parsons Brinckerhoff, Volume 4 - Final, Aerospace Wales, RAF St Athan, Outline Remediation Strategy – July 2004, Welsh Development Agency, March 2004.

Parsons Brinckerhoff has also produced a number of letter reports and has received correspondence from the Environment Agency in response to these works.

After the completion of the 2009 site investigation undertaken by Soil Mechanics, sixty five groundwater samples were obtained from the monitoring wells installed during the current program of site work and from the previous site works undertaken.

The results have been compared to the most appropriate environmental standard. The assessment standards applied have been both the EQS Freshwater and the UK Drinking Water Standard. Both standards have been used to ascertain the risk to the surface water receptors and the potential risk from the extraction of potable drinking water from both the Major Aquifer and potentially the overlying Minor Aquifer. However, where no suitable assessment criteria is available the most conservative, and suitable international standard has been applied such as the World Health Organisation (WHO) drinking water standard.

7.1 METALS AND METALLOIDS

Fifty four groundwater samples have been analysed for a range of metals, the results of which are summarised in Appendix H.

From the metals and metalloids analysed only two determinants revealed concentrations which were either equal to or exceeded the GAC applied, these were as follows:

Arsenic

The results for the analysis of arsenic indicated that one sample exceeded the Drinking Water Standard (10µg/l); the sample was obtained from EC-B26 (East Camp) with a result of 24µg/l.

Zinc

The results for the analysis of zinc indicated that one sample exceeded the Freshwater EQS (AA) 500µg/l; the sample was obtained from BH-B12 with a result of 571µg/l. Given that the freshwater EQS is an annual average and only one sample out of 54 exceeded the EQS, it is considered that zinc would not pose a risk to groundwater or surface waters.

7.2 POLYCYCLIC AROMATIC HYDROCARBONS

Fifty nine samples have been retained and analysed for the standard USEPA 16 PAH contamination suite, which are representative of PAH contamination as a whole, the results of the analysis and assessment are summarised in Appendix H. The following summary discusses the determinants recorded in the groundwater where the concentrations exceed the relevant assessment standard applied.

Naphthalene

The groundwater samples obtained from the site revealed two samples where the Freshwater EQS (10µg/l) was exceeded. These were PB-BH09 (20.4µg/l) and EC-BH35 (86.3µg/l).

Benzo[a]pyrene

The groundwater samples obtained from the site revealed nineteen samples where the UK Drinking Water Standard of 0.01 µg/l was exceeded with values ranging from >0.01µg/l to 0.894µg/l. The locations of the exceedance are included in Appendix F.

In addition, the sum of 4 PAH DWS was also exceeded in those locations where the benzo[a]pyrene concentrations criteria was exceeded.

The remaining PAH contamination requires a DQRA to be undertaken in order to be able to produce a site specific SSAC to allow an appropriate and robust assessment.

The modelled distribution of the PAH contamination within the groundwater is given in Appendix H as a Surfer Plot.

7.3 TOTAL PETROLEUM HYDROCARBONS

Thirty eight groundwater samples were retained and analysed for Total Petroleum Hydrocarbons (TPH) with an aliphatic and aromatic speciation. The results of the analysis and assessment for TPH are summarised in Appendix H.

The assessment of TPH contamination revealed that there were a number of results indicating the presence of both aliphatic and aromatic hydrocarbons within the aquifer. The surfer plot contained within Appendix I gives a graphical

representation of the distribution. There are currently no current UK drinking water or EQS for TPH. However, the World Health Organisation (WHO) have released proposed standards for drinking water which is based on a value which is 10% of the reference dose. These values are presented in Table H3 of Appendix H. These indicate that TPH would not be a concern on the site. However these values would require consultation with the Environment Agency and it is likely that they would require the TPH contamination to be assessed using a Detailed Quantitative risk Assessment (DQRA).

A review of the primary distribution of the aromatic/aliphatic TPH contamination indicates that the contamination within the groundwater is in the >EC8 to EC16 range, which is indicative of kerosene or Jet A1 aviation fuel. This hypothesis would be fitting with the context of the site as an air base. However, further sampling would need to be undertaken in order to be able to undertake a reliable assessment.

Previous site investigations, which are summarised in Appendix D revealed TPH (Total) concentrations in the vicinity of ECBH09, ECBH10 and PB-BH1 of TPH $8.07E^{15}$ mg/l. Monitoring at ECBH09 and ECBH10 during the recent phase of investigations revealed concentrations of total aliphatic (>EC8 – 40) of 0.036 and 0.01mg/l and total aromatic (>EC8 – 40) of 0.012 and 0.028mg/l for ECBH09 and ECBH10 respectively which are significantly lower than previously, indicating that remedial works undertaken to date have improved the groundwater quality.

7.4 VOLATILE ORGANIC COMPOUNDS

A maximum of fifty four water samples were retained and analysed for Volatile Organic Compounds (VOC), the results of the analysis and assessment are summarised in Appendix H.

The assessment of the VOC contamination revealed that there was localised exceedance of the assessment criteria for ethyl benzene, and xylenes. However, other VOCs are present for which no current standard is available (1,3,5-Trimethylbenzene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, Dimethylphenols.) These require a DQRA to be undertaken in order to be able to produce a site specific SSAC to allow an appropriate assessment.

The exceedance of the EQS for ethyl benzene, and xylenes all occurred at ECBH35. Therefore these contaminants of concern require a DQRA to be undertaken in order to appropriately assess the risk to both ecological and human health receptors.

Previous site investigations identified extensive VOC contamination within the aquifer, a summary of which is included in Appendix D. The groundwater contamination underwent a remediation program, which was agreed and monitored by the Environment Agency. Building 324 in the vicinity of monitoring wells ECBH09, ECBH10 and PB-BH1 identified the following levels of contamination within the groundwater as follows:

- TCE at 6900 mg/l;
- Cis 1,2 DCE at 4.56 mg/l;

- *1,1 DCA at 1.20E+07 mg/l;*
- *Ethylbenzene at 4.05E+06 mg/l; and,*
- *Xylene at 8.77E+04 mg/l.*

The groundwater sampling undertaken by PF revealed that the levels of contamination of the aforementioned contaminants had decreased to below the limit of detection in ECBH09 and ECBH10. However, the monitoring location at PB-BH1 was damaged and no sample could be obtained. It is recommended that further sampling and analysis be undertaken at all three locations as part of the proposed combined earthworks remediation solution to verify the findings to date. A further well should be advanced in the near vicinity of PB-BH1 if it proves impossible to extract any water from this location.

A further area of concern was identified in the near vicinity of Building 377 where the following levels of contamination were recorded in the location of PB-BH15.

- *1,1 DCA at 1160 mg/l.*

The groundwater monitoring program undertaken by Pell Frischmann revealed that the concentrations at this location had decreased to below the limit of detection, however, this is based on a single sample and further sampling should be undertaken in order to validate this finding as part of the proposed combined earthworks remediation solution.

7.5 PERFLUOROOCTANE SULPHONATE

Ten groundwater samples have been analysed for Perfluorooctane Sulphonate (PFOS) which have ranged in value from the limit of detection (0.1µg/l) to 0.4µg/l. The summary given in Appendix H indicates the results obtained to date, with a Surfer Chart indicating the general locations is included in Appendix I.

The sampling was undertaken in the area around the fire fighting training simulator at the Picketston area of the site (BH-B01, BH-C01, BH-C02, BH-C03, BH-C04 and BH-C05), however, a further sample has been tested at a location which is approximately 500m from the original location (BH-B01). This positive result indicates that the PFOS contamination may potentially be diffuse throughout the entire aquifer and further sampling and analysis is recommended from all monitoring locations across the site to assess the veracity of this supposition.

The Health Protection Agency have produced health criteria guidance for PFOS (“Maximum acceptable concentrations of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) in drinking water”) which recommends a maximum acceptable concentration of PFOS in drinking water of 0.3µg/l. In addition the Drinking Water Inspectorate (“Guidance on the Water Supply (Water Quality) Regulations 20001 specific to PFOS (perfluorooctane sulphonate) and PFOA (perfluorooctanoic acid) have provided guidance with regard to PFOS contamination in drinking water. This guidance state that where drinking water concentrations between 0.3µg/l and 1µg/l are encountered, levels should be monitored further and consultation be undertaken with local health professionals. Only where concentrations exceed 1µg/l should measures be implemented to reduce levels to below 1µg/l as soon as practicable.

Therefore it is recommended that further monitoring is undertaken, but it is not considered that intervention is required with regard to the groundwater concentrations.

7.6 SUMMARY OF CONTAMINANTS OF CONCERN

In summary, the following determinants have been identified as potential contaminants of concern in the groundwater at the site which require either further assessment and/or remediation:

- Total Petroleum Hydrocarbons
- Polycyclic Aromatic Hydrocarbons

7.7 CHEMICAL AND PHYSICAL PROPERTIES

A maximum of thirty six samples have been analysed for a range of chemical and physical properties. The pH concentrations range from 6.35 to 7.75, which represents a very slightly acidic to slightly alkaline conditions. This is similar to the conditions observed within the soils at the site.

8. LAND CONTAMINATION ASSESSMENT SUMMARY

Following a review of the background geo-environmental information on the site and the site investigation results, a conceptual site model has been formulated to identify sources of contamination, potential pathways and potential receptors on and in the immediate vicinity of the site.

The guidance provided in CLR11 indicates the CSM should identify those contaminants, pathways and receptors which are 'likely' to represent an 'unacceptable' risk either to human health or the surrounding environment.

8.1 CONTAMINATION SOURCES

8.1.1 Potential Sources Identified During the Desk Based Review

The land contamination assessment of this validation exercise has been undertaken to further assess the potential outstanding risk and gaps in the current knowledge base formulated during the previous site investigations and risk assessments.

The previous risk assessments and a general review undertaken by PF of the work undertaken during the previous site investigations identified the following significant potential sources of contamination at the site:

- (i) The use of the site itself as an RAF base and the associated infrastructure consummate with these operations; and,
- (ii) The destruction of aircraft in the period of time after 1945.

8.1.2 Potential Sources Identified During previous investigations

The previous investigations identified the following potential contamination sources:

- Metals and Metalloids;
- Asbestos
- Total Petroleum Hydrocarbons;
- Polycyclic Aromatic Hydrocarbons, and;
- Volatile Organic Compounds.

8.1.3 Potential Sources Identified During current investigations

8.1.3.1 Picketston

The following determinants have been identified as potential contaminants of concern in the Made Ground at the Picketston area:

- Total Petroleum Hydrocarbons
- Polycyclic Aromatic Hydrocarbons

8.1.3.2 East Camp

Polycyclic Aromatic Hydrocarbons have been identified as potential contaminants of concern in the Made Ground at East Camp area

8.1.3.3 Castleton

Potential contaminants of concern were not identified in the Castleton Area

8.2 POTENTIAL RECEPTORS

Receptors are those at risk from the identified hazards during different stages of the sites development; the following potential receptors were identified in relation to the site:

- Controlled waters;
- Construction workers;
- Final users of the development, and;
- Proposed buildings and structures on site.

8.3 POTENTIAL PATHWAYS

The following potential pathways may exist between the identified contaminative sources and receptors:

- Dermal contact, ingestion and/or inhalation of potentially contaminated soil and/or groundwater;
- Dermal contact, ingestion and/or inhalation of hydrocarbon vapour/ground gas;
- Volatilisation/vapour intrusion into buildings and structures on site;
- Leaching and/or percolation of contaminants to underlying major aquifer, and;
- Run-off of and migration of contaminants to controlled waters.

In addition, there is a potential risk for construction workers during construction and maintenance workers following construction, to be exposed to potential contamination via direct contact, ingestion of soil and/or inhalation of dust.

8.4 CONCEPTUAL SITE MODEL

CLR11 recommends that the Conceptual Site Model should be developed as part of an iterative process. The Conceptual Site Model has therefore been revisited and amended to reflect the increased knowledge and understanding of the site based on the combined results of the intrusive site investigation. The revised Conceptual site model is presented as Table 2 and the pollutant linkages discussed in more detail below.

Table 2: Revised Conceptual Site Model (Potential Pollution Linkages)

Scenario	Source	Pathway	Receptor	Complete Potential Pollution Linkage?	Complete	Risk Rating
Site visitors, site investigation personnel	Potential contaminants within the Made Ground, underlying soils and groundwater	Dermal contact, ingestion and/or inhalation of potentially contaminated ground conditions,	Human Health and controlled waters	<p>General Localised soil contamination from hydrocarbons and complex organic compounds represent a risk to human health and controlled waters.</p> <p>Picketston Area Hydrocarbons particularly PAHs (and potentially PFOS). Further risk assessment of the PFOS and PAHs are required in order to ascertain and mitigate the risk.</p> <p>East Camp Potential residual contamination from the areas of hydrocarbon contamination, which is currently/has been addressed.</p> <p>Castleton Area No potential contaminants of concern have been identified.</p>	Likely	Medium

Scenario	Source	Pathway	Receptor	Complete Potential Pollution Linkage?	Complete	Risk Rating
Excavation and construction workers	Potential contaminants within the Made Ground, underlying soils and groundwater	Dermal contact, ingestion and/or inhalation of potentially contaminated ground/ groundwater conditions.	Human Health	<p>General Localised soil contamination from hydrocarbons and complex organic compounds represent a risk to human health and controlled waters.</p> <p>Picketston Area Hydrocarbons particularly PAHs (And potentially PFOS). Further risk assessment of the PFOS and PAHs are required in order to ascertain and mitigate the risk.</p> <p>East Camp Potential residual contamination from the areas of hydrocarbon contamination, which is currently/has been addressed.</p> <p>Castleton Area No potential contaminants of concern have been identified.</p>	Likely	High

Scenario	Source	Pathway	Receptor	Complete Potential Pollution Linkage?	Complete	Risk Rating
End users of the developed site	Potential contaminants within the Made Ground, underlying soils and groundwater	Dermal contact, ingestion and/or inhalation of potentially contaminated ground/ groundwater conditions.	Human Health	<p>General Localised soil contamination from hydrocarbons and complex organic compounds represent a risk to human health and controlled waters.</p> <p>Picketston Area Hydrocarbons particularly PAHs (And potentially PFOS). Further risk assessment of the PFOS and PAHs are required in order to ascertain and mitigate the risk.</p> <p>East Camp Potential residual contamination from the areas of hydrocarbon contamination, which is currently/has been addressed.</p> <p>Castleton Area No potential contaminants of concern have been identified.</p>	Likely	High

Scenario	Source	Pathway	Receptor	Complete Potential Pollution Linkage?	Complete	Risk Rating
Migration and accumulation of vapours within building/structures. (excluding Radon)	Potential contaminants within the Made Ground, underlying soils and groundwater	Volatilisation/vapour intrusion into buildings and structures on site.	Buildings/structures	<p>General Localised soil contamination from hydrocarbons and complex organic compounds represent a risk to human health and controlled waters.</p> <p>Picketston Area Hydrocarbons particularly PAHs (And potentially PFOS). Further risk assessment of the PFOS and PAHs are required in order to ascertain and mitigate the risk.</p> <p>East Camp Potential residual contamination from the areas of hydrocarbon contamination.</p> <p>Castleton Area No potential contaminants of concern have been identified.</p>	Likely	High

Scenario	Source	Pathway	Receptor	Complete Potential Pollution Linkage?	Complete	Risk Rating
Migration and accumulation of vapours within building/structures (excluding Radon)	Potentially contaminated soils and/or groundwater underlying the site.	Inhalation of hydrocarbon vapours/ground gas	Human Health	<p>General Localised soil contamination from hydrocarbons and complex organic compounds represent a risk to human health and controlled waters.</p> <p>Picketston Area Hydrocarbons particularly PAHs (And potentially PFOS). Further risk assessment of the PFOS and PAHs are required in order to ascertain and mitigate the risk.</p> <p>East Camp Potential residual contamination from the areas of hydrocarbon contamination, which is currently/has been addressed.</p> <p>Castleton Area No potential contaminants of concern have been identified.</p>	Likely	High
Migration and accumulation of Radon within building/structures	Local geology	Intrusion into buildings and structures on site.	Human Health of final site users	Radon has been identified as potentially a significant risk at the site and is subject to a second body of work and will not be expanded upon here	Likely	High

Scenario	Source	Pathway	Receptor	Complete Potential Pollution Linkage?	Complete	Risk Rating
Migration of contaminants from underlying ground to the major aquifer pre-development	TPH, PAH and VOC impaction identified	Leaching and or percolation to underlying strata.	Groundwater Major Aquifer	<p>General Localised soil contamination from hydrocarbons and complex organic compounds represent a risk to human health and controlled waters.</p> <p>Picketston Area Hydrocarbons particularly PAHs (And potentially PFOS). Further risk assessment of the PFOS and PAHs are required in order to ascertain and mitigate the risk.</p> <p>East Camp Potential residual contamination from the areas of hydrocarbon contamination, which is currently/has been addressed.</p> <p>Castleton Area No potential contaminants of concern have been identified.</p>	n/a	n/a
Migration of contaminants from underlying ground to minor aquifer during development				See above.		

Scenario	Source	Pathway	Receptor	Complete Potential Pollution Linkage?	Complete	Risk Rating
Migration of contaminants from underlying ground to minor aquifer post - development				See above.		
Impacted groundwater abstraction and use				See above.		
Impact to local ecosystems	Underlying ground conditions and on-site land use.	Direct contact inc: inhalation, dermal contact and ingestion.	Surface water bodies	The stream surrounding the site could be impacted from surface water runoff of contaminated soils	Yes	Medium
Future on-site buildings and/or structures impacted by local ground conditions	Potential Made Ground and geochemistry of underlying soils and groundwater. e.g. Sulphur, sulphate, sulphide, pH etc (BRE 365)	Direct contact and/or leaching (inc sulphate, pH) leading to impact on building and/or structures on site.	Buildings/ structures and materials	There is the potential for damage to buried concrete and this needs further consideration and assessment in line with BRE 365.	Unlikely	Low
Flora and Fauna	Phytotoxins	Direct contact within soils	Plants	Both TP15 and TP20 within the Picketston area of the site contain elevated copper concentrations.		

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 SOILS

The contamination within the near surface soils identified within both Picketston and East Camp potentially represents a potential risk to human health and the environment. The main contaminants of concern are as follows:

- Total Petroleum Hydrocarbons;
- Polycyclic Aromatic Hydrocarbons, and;
- Perfluorooctane Sulphonate.

The site investigation did not reveal the presence of any radioactive materials.

9.1.1 Picketston Summary

The assessment of the near surface soils, particularly the Made Ground needs further consideration in respect to the potential risk from Perfluorooctane Sulphonate, Polycyclic Aromatic Hydrocarbons and Total Petroleum Hydrocarbons.

9.1.2 East Camp

The assessment of the near surface soils, particularly the Made Ground needs further consideration in respect to the potential risk from both Polycyclic Aromatic Hydrocarbons and Total Petroleum Hydrocarbons.

9.1.3 Castleton

This area does not represent a significant risk to human health and the environment and requires no further consideration.

9.2 GROUNDWATERS

The aquifer beneath St Athan contains the following contaminants of concern, which require further assessment through the production of an appropriate DQRA which addresses the risk to both ecological and human health receptors.

- Total Petroleum Hydrocarbons;
- Polycyclic Aromatic Hydrocarbons;

9.3 RECOMMENDATION

A review of the soil contamination identified on the Picketston area and East Camp indicates that the hydrocarbon contamination is predominantly non-volatile. It is therefore recommended that as part of the design and construction process a combined earthworks and remediation strategy is developed and a Materials Management Plan is produced in line with the CL:AIRE Definition of Waste:

Industry Code of Practice to optimise the re-use of materials and minimise off site disposal.

10. LIMITATIONS AND UNCERTAINTIES

This report has been prepared by Pell Frischmann with all reasonable skill, care and diligence, and taking account of manpower and resources devoted to it by agreement with the client.

The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true representative data with respect to site conditions. Should additional information become available which may influence the opinions expressed in this report, Pell Frischmann reserves the right to review such information and, if warranted, to alter the opinions accordingly.

This report has been prepared solely for the use of Metrix, and may not be relied upon by other parties without written consent from Pell Frischmann.

Pell Frischmann disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.