



**Record of determination of Contaminated Land at
Zone A - Rear Garden, Boxwood
Shore Road, Tain**

Our Reference: RC-GSW-1002

National Grid Reference: 277855, 882443

Part IIA of the Environmental Protection Act 1990



June 2020

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1. INTRODUCTION

A site investigation of a former gasworks and gasworks manager's house at Shore Road, Tain has been carried out to determine whether the land meets the statutory definition of contaminated land. This report provides a written Record of Determination that land at Zone A - Rear Garden, Boxwood, Shore Road, Tain, NGR: 277855, 882443 is Contaminated Land.

Powers and duties with respect to land contamination were conferred on Local Authorities when the Contaminated Land Regime came into force with the Contaminated Land (Scotland) Regulations 2000. The legislative basis for the regime is contained in Part IIA of the Environmental Protection Act 1990 (inserted by section 57 of the Environment Act 1995). The Regulations were accompanied by a Scottish Executive Circular, 1/2000, which contained statutory guidance on the implementation of the Regime. The Regime has since been updated by The Contaminated Land (Scotland) Regulations 2005 (Scottish Statutory Instrument 2005 No.658) and publication of Statutory Guidance Edition 2 (paper SE/2006/44).

The above legislation provides the following definition of contaminated land:

“Contaminated land” is any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that –

(a) significant harm is being caused or there is a significant possibility of such harm being caused;

or

(b) significant pollution of the water environment is being caused or there is a significant possibility of such pollution being caused.

In October 2001, The Highland Council published a *Contaminated Land Inspection Strategy*. Following review, an updated Strategy was published in August 2009. These strategies describe how sites within Highland were prioritised for inspection based on their previous and current use. Those sites perceived to be most at risk, and therefore prioritised for inspection, were sites which include residential properties on areas previously used as gasworks, landfills and other high risk industrial land uses.

Once the Local Authority considers that a site is contaminated land, and wishes to identify it as such, a written record of determination is required, as set out in paragraph B53 of Annex 3 to the Statutory Guidance for contaminated land. Paragraph B53 sets out the following list of requirements for the written record:

(a) a description of the particular significant pollutant linkage, identifying all three components of pollutant, pathway and receptor;

(b) a summary of the evidence upon which the determination is based;

- (c) a summary of the relevant assessment of this evidence; and
- (d) a summary of the way in which the authority considers that the requirements of the guidance in this Part and in Chapter A of the guidance have been satisfied.

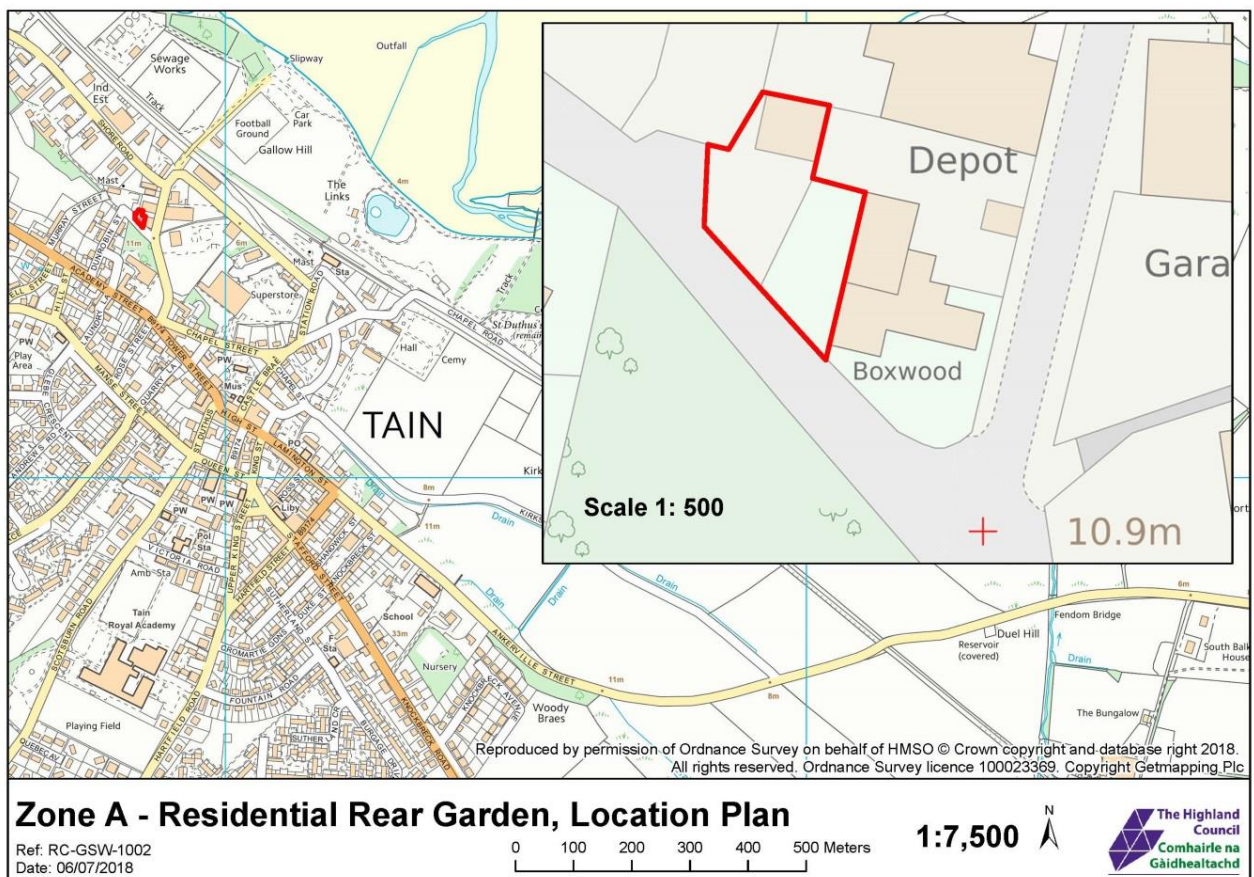
The following report provides a written document which records that The Highland Council has determined that land at Zone A – rear garden, Boxwood, Shore Road, Tain, is contaminated land as defined by Part IIA of the Environmental Protection Act 1990 (as amended by The Contaminated Land (Scotland) Regulations 2005).

2. THE SITE

The site is located at Shore Road, Tain, within Highland Council Ward No. 8: Tain and Easter Ross. The site is currently occupied by the residential rear garden of one private property known as Boxwood.

Site Address: Rear garden, Boxwood, Shore Road, Tain, IV19 1EH
Area: approximately 320m²
NGR: 277855:882443
Current Use: Residential rear garden, driveway and garage/outbuilding

The site was previously used as part of the operational gas works, and a site location plan is provided below:



NOTE: The front garden, the residential building known as Boxwood, and the commercial land which also occupy the former gasworks (Council reference RC-GSW-1002) were investigated at the same time as Zone A. However these zones are **not** the subject of this report, and their evidence is documented separately. **The residential front garden and building known as Boxwood are NOT considered to be contaminated land.**

3. DESCRIPTION OF SIGNIFICANT POLLUTANT LINKAGE

A pollutant linkage is defined in the Statutory Guidance as a linkage between a Contaminant and a Receptor, by means of a Pathway. All types of receptors detailed in Table A of the Statutory Guidance, and the Water Environment, were considered in conceptualising the site. The following potential pollutant linkages were investigated at the site:

Table 1 - Description of Linkages Investigated

Potential Source	Potential Pathway		Potential Receptor
Contaminants in soil associated with the former use of the site as a gasworks or made ground: Cd (cadmium), Cr (chromium), Cu (copper), Pb (lead), Hg (mercury), V (vanadium), Zn (zinc), As (arsenic), Free and Total CN (cyanide), S (sulphur), S ₂ (sulphide), SO ₄ ²⁻ (sulphate), NH ₃ (ammoniacal nitrogen), asbestos, pH, TPH (total petroleum hydrocarbon), VOC (volatile organic compounds including BTEX - benzene-toluene-ethylbenzene-xylenes), PAH (polycyclic aromatic hydrocarbons) and speciated phenol; Or soil leachate : Cd, Cr, Cu, Pb, Hg, V, Zn, As, CN, NH ₃ , and PAH.	Dermal	Direct contact with outdoor soil or indoor dust	Current and Future Residents or Property including water pipes
	Oral	Ingestion of outdoor soils or indoor dust Ingestion of home-grown produce	
	Inhalation	Inhalation of vapours from soils (outdoor and indoor) Inhalation of outdoor and indoor dust	
	Leachate	Leaching of contaminants into groundwater or surface water, either directly or via migration	Water Environment or Ecosystem
Contaminants in groundwater associated with the former use of the site as a gasworks yard: Cd, Cr, Cu, Pb, Hg, V, Zn, As, S, S ₂ , SO ₄ ²⁻ , CN, NH ₃ , pH, TPH, PAH, VOC and spec phenols, with B, Ni, Se. Or light non aqueous phase liquid LNAPL associated with groundwater surface or dense non aqueous phase liquid DNAPL on bedrock	Inhalation	Inhalation of vapours	Current and Future Residents
	Migration	Into surface water, either directly or via migration through groundwater	Water Environment or Ecosystem

Following investigation, Zone A, the residential rear garden Boxwood, Shore Road, Tain is determined to be Contaminated Land on the basis of **significant possibility of significant harm to human health**. The following significant pollutant linkages are present:

Table 2 - Description of Significant Pollutant Linkages

Source	Pathway		Receptor
Benzo(a)pyrene in soil	Inhalation	Inhalation of outdoor and indoor dust	Current and Future Residents
Benzo(a)pyrene in soil	Oral	Ingestion of outdoor soils or indoor dust Ingestion of home-grown produce*	Current and Future Residents

- Note that home-grown produce is not being produced on the site at the time of the assessment but has been included within assessment of the oral exposure pathway

4. SUMMARY OF EVIDENCE UPON WHICH THE DECISION IS BASED

The rear garden, Boxwood, Shore Road in Tain was subject to the completion of the following reports:

- RC-GSW-1002 Tain Gasworks Phase I Desk Study, The Highland Council, May 2005.
- RC-GSW-1002 Tain Gasworks Phase I Desk Study, The Highland Council, Revised November 2006.
- RC-GSW-1002 Tain Gasworks Site Investigation Interpretative Report, IKM, December 2008, v2.
- RC-GSW-1002 Tain Gasworks Additional Works Addendum Report, IKM, September 2009, v2.
- RC-GSW-1002 Tain Gasworks Site Investigation Strategy for Supplementary Works, ERS, March 2011, Issue 3.
- RC-GSW-1002 Tain Gasworks Water Environment Risk Assessment, ERS, July 2012, Issue 4.

NOTE: Reports commissioned by the Council exclusively for other areas of the former gasworks reference RC-GSW-1002 have not been listed here.

The site was prioritised for inspection in 2005 in accordance with the Councils' statutory duty under Part IIA of the Environmental Protection Act 1990. The site has been prioritised due to a residential property with a private garden being located in part on a former gasworks.

The Phase I Site Investigation collated information from a variety of sources which date Zone A as part of the operational gasworks from 1839 to 1965. Scottish Gas plans from 1950 records a "Chimney", "Tar Tank" and "Tar Well" within the rear garden area. The stone and slate two storey residential property which was the Gas Managers house previously had a small garden area to the front (south) of the property. Following closure of the gasworks, the residential property incorporated some of the former gasworks land to the west of the house as garden ground (Zone A). The remainder of the gasworks site was sold and now forms commercial businesses, including a coal yard, and a garage/disused car storage yard.

The Site Investigation Interpretative Report, Dec 2008 recorded that IKM undertook the first intrusive site investigations of the whole former gasworks area (0.3 ha) between January and February 2007 in accordance with British Standards BS10175:2001 (which has since been superseded by BS10175:2011+A2:2017) and BS5390:1999.

The investigation location sampling density within Zone A equated to approximately 12m centres. The whole 0.3hectare gasworks investigation comprised of the locations and sampling detailed below: (items in **BOLD** were located within **Zone A**):

- Fifteen onsite boreholes (BH1 to BH15) drilled to a maximum 5.0mbgl (metres below ground level) of which 14 were installed as gas and groundwater monitoring wells. **(Zone A: three boreholes BH5, BH6 and BH7 with monitoring wells)**
- Two locations were completed as trial pits excavated to 1.0 mbgl in the current residential garden areas. **(Zone A: one trial pit TP1)**
- Two rounds of groundwater monitoring with an oil-water interface probe and sample collection between the 24th-30th January 2007 and 6th-7th February 2007. All wells in Zone A were found to be dry or held an insufficient volume to sample.
- Soil and soil leachate analysis for the contaminants of concern (COC) as listed in Table 1 in Section 3. **(Zone A: samples from BH5, BH6, BH7 and TP1)**
- Fifteen rounds of soil gas monitoring **(Zone A: three installed boreholes BH5, BH6 and BH7)**
- Rising head test in two boreholes.

Overall the investigation found made ground to be present to a maximum depth of 2.3mbgl across the site **(Zone A: 1.6 mbgl)** predominately consisting of reworked natural materials (sands, gravels, silts and clays) over SAND with occasional GRAVEL at depth. Visual and olfactory evidence of contamination was recorded in 6 excavations consisting of a hydrocarbon odour or tar pitch stain **(Zone A: BH5 solid tar/pitch, strong heavy end hydrocarbon odours between 0-0.6mbgl)**.

The Additional Works Addendum Report, September 2009 recorded that IKM undertook further intrusive site investigations in October to December 2008 in accordance with British Standards BS10175:2001 (which has since been superseded by BS10175:2011+A2:2017) and BS5390:1999.

The investigation location density within Zone A now equated to a sampling density of approximately 7 to 8m centres. The supplementary investigation of the whole 0.3 ha site comprised of the locations and sampling detailed below: (items in **BOLD** were located within **Zone A**):

- Eight hand auger boreholes (SB1 to SB8) to a maximum of 0.5mbgl. **(Zone A: two hand auger boreholes SB6 and SB7)**
- Five onsite boreholes (BH16 to BH20) were drilled to a maximum 4.0mbgl, of which all were installed as gas and groundwater monitoring wells. (Zone A: no additional wells).
- One offsite borehole (BH21) located 35m down suspected groundwater hydraulic gradient of the gasworks as a whole, drilled to 3.8mbgl and installed as a gas and groundwater monitoring well.

- Two rounds of groundwater monitoring with an oil-water interface probe and sample collection on the 13th-14th November 2008 and 27th November 2008. All wells in Zone A were found to be dry or held an insufficient volume to sample.
- Soil, soil leachate and groundwater analysis was undertaken for the reduced list of contaminants of concern (COC), identified at the end of the first phase of site works.
- Three rounds of soil gas monitoring from all accessible locations and bulk gas composition sampling from BH10, BH12 and BH17. **(Zone A: three installed boreholes BH5, BH6 and BH7)**
- Naphthalene vapour monitoring from all boreholes surrounding the residential property BH7 to BH10. Zone A: not risk assessed – residential indoor air assessed for Zone B and reported separately.

The Water Environment Risk Assessment Report, July 2012, details the supplementary work undertaken by ERS in March 2011 in accordance with British Standards BS10175:2011 (which has since been superseded by BS10175:2011+A2:2017) and BS5390:1999. The supplementary investigation of the whole 0.3 ha site comprised of the sampling detailed below, none of which were in Zone A

- Groundwater monitoring in all installed locations with an oil-water interface probe for LNAPL, and DNAPL at the well base; and groundwater sample collection on the 16th-18th March 2011.

5. SUMMARY OF RELEVANT ASSESSMENT OF THE EVIDENCE

The factual investigation information (detailed previously) from the site has been assessed and interpreted in the following reports:

- RC-GSW-1002 Tain Gasworks Site Investigation Interpretative Report, IKM, December 2008, v2.
- RC-GSW-1002 Tain Gasworks Additional Works Addendum Report, IKM, September 2009, v2.
- RC-GSW-1002 Tain Gasworks B(a)P Margin of Exposure Risk Assessment, IKM, September 2010, Letter Report
- RC-GSW-1002 Tain Gasworks Water Environment Risk Assessment, ERS, July 2012, Issue 4.
- RC-GSW-1002 Tain Gasworks Data Review and Revised Human Health Risk Assessment Report, ERS, April 2016, Issue 3.
- Dose Response Roadmaps Report for Benzo(a)Pyrene found at the Former Gasworks Shore Road, Tain (County of Ross-shire, Scotland) relating to Part IIA assessments for Zones A and C. LQM, November 2017
- Comment on the Dose Response Roadmaps Report for Shore Road, Tain, by Land Quality Management Ltd for The Highland Council. Health Protection Scotland, March 2018.

5.1. Summary of Assessment of Evidence that there is Significant Possibility of Significant Harm to Human Health (SPOSH)

Soil Contaminant Source

To assess the risk to human health (HH) from contaminants of concern (COC) in soil associated with the previous use of the site, generic assessment criteria (GAC) derived using the joint Department of Environment, Food, and Rural Affairs (DEFRA) & The Environment Agency (EA) Contaminated Land Exposure Assessment (CLEA) software model, or an alternate model amended to UK exposure assumptions, or the best commercially available laboratory limit of detection were used in line with best practice at the time of the reports. These GAC were compared to the COC concentrations in representative soil samples from the site investigation.

The first soil HH risk assessment was reported in December 2008 by IKM. The assessment criteria (AC) used were the DEFRA/EA published Soil Guideline Values (SGVs); and values derived using the software Risk Integrated Software for Clean-ups (RISC) version 4.0, published by Groundwater Software.com, which was amended to UK derived residential receptor and exposure parameters, following the framework in the DEFRA/EA Contaminated Land Report CLR publication series.

The Inhalation of dust pathway is not included within the RISC model, therefore site specific assessment criteria were derived using the UK model CLEA v1.0 for three substances to represent substances with low volatility from the metals, hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAHs) - Zinc, TPH aromatic C16-21 and Benzo(a)pyrene. The CLEA derived values were then integrated with the RISC values to create the overall site specific assessment criteria (SSAC).

The ingestion of soil attached to vegetables pathway is also not included in RISC 4.0. To account for this 25mg/day was added to the CLEA default ingestion rate of 100mg/day, based on Contaminated Land Report CLR10 soil loading and vegetable ingestion rates.

Toxicological data was sourced using the hierarchy of sources cited in CLR9. For PAHs to address uncertainty in assumptive mechanism of toxic action, both Toxic Equivalency Factors (TEFs) methodology, and Benzo(a)pyrene as a marker compound methodology was undertaken.

Initially the site maximum values were compared directly with the AC, then a statistics package to derive site UCL (upper confidence limit of the arithmetic mean) values for comparison against the AC for all substances with a max concentration above the AC. The software package ProUCL V4.0.01, published by the USEPA (2006) was used to calculate the UCLs. Outlier tests and Q-Q plots were undertaken prior to the UCL calculations, and outliers were also considered against the AC. Limits of detection (LOD) were used in the calculations where soil results were recorded as less than LOD.

Table 3 presents the results of the IKM 2008 residential area assessment. This was an evaluation of ALL residential area samples which included what was to become Zone B, the former manager's house and front garden (BH8, BH9 and TP2) and Zone A the current residential rear garden (BH05, BH6, BH7, TP1).

Table 3 – IKM, 2008, HHRA Residential with plant uptake comparison against AC-2008

Substance	SSAC-2008 (mg/kg)	Max onsite 2008 (mg/kg)	Outlier (if any)	UCL 2008 (mg/kg)	Further assessment required?
Arsenic	20 (SGV)	24	BH07 S1	4 exc outlier 12 inc outlier	NO UCL < AC-2008 except YES - OUTLIER
Benzo(a)pyrene	1.38 integrated SSAC	360	n	190 or 311 B(a)P TEQ	YES UCL > AC-2008
Naphthalene	248 integrated SSAC	2000	n	746	YES UCL > AC-2008
TPH aromatic C16-21	108 direct contact SSAC	2000	n	1052	YES UCL > AC-2008
TPH aromatic C21-35	3472 direct contact	6500	n	4512	YES UCL > AC-2008

Prior to concluding the 2008 HHRA IKM discussed splitting the residential area into two zones based on their former use, as the soil results especially for hydrocarbons appeared elevated in the western portion (rear residential garden and driveway BH5, BH6, BH7 and TP1) in comparison to the eastern portion (front garden BH8, BH9 and TP2). IKM concluded there was insufficient data at present for a robust evaluation if the data were divided.

Overall IKM recommended further assessment for shallow soil Naphthalene, Benzo(a)pyrene, TPH aromatic C16-21, TPH aromatic C21-35 and the Arsenic outlier in the residential area.

The Council commissioned the further site works as detailed in Section 4, and the IKM soil HH risk assessment was updated as detailed in the Addendum Report, September 2009.

Between the IKM initial report (2008) and the addendum report (2009); DEFRA, the Scottish Government and EA updated the UK approach for assessing risk to human health and published a new CLEA model Version 1.04 and supporting science reports (SR2 -SR4). Therefore, substances found elevated above the original AC-2008, were assessed further using newly derived CLEA 1.04 assessment criteria (AC-2009).

The collection of additional soil samples allowed further statistical interrogation using the newly published Chartered Institute of Environmental Health CIEH/CL:AIRE, *Comparing Soil Contamination Data With A Critical Concentration*, May 2008 and the companion ESI Contaminated Land Statistics Calculator. The soils from Zone A were interrogated separately from the residential front garden, Zone B, as the former use of the areas was different. Zone A represented the rear garden area, the driveway and garage/outbuilding associated with the dwelling. This part of the site was previously part of the operational gasworks. Zone B represented the dwelling and front garden; this part of the site always appeared from plans to be residential.

All non-detects were recorded at the limit of detection (LOD). Outliers were removed from the 95% confidence limit (95% CL) calculation, only if they were demonstrably the result of an error or there was evidence of more than one soil population.

Under Part IIA the CIEH/CL:AIRE statistical test compares the 95th Lower Confidence Limit (95% LCL) of the true population mean (μ) with the critical concentration (cc). The Part IIA Null Hypothesis should be:

...that the level of contamination in the land of interest is the same as or lower than the critical concentration;

There are three options should $\mu > cc$, where the cc is deemed and appropriate measure of unacceptable risk.

1. If the evidence suggests that the probability against the Null Hypothesis being true is >95% the regulator should reject the Null Hypothesis with a high degree of confidence that they have an immediate and robust basis for determination;
2. If the evidence suggests that the probability against the Null Hypothesis being true is <51% the regulator should not reject the Null Hypothesis, and not

determine the land as contaminated land as it is unlikely that the land would meet the definition of contaminated land;

3. The third option is the evidence suggests the probability against the Null Hypothesis being true is < 95% but greater than 51%, the regulator can still reject the Null Hypothesis and proceed to determination on a 'balance of probabilities' basis, although the determination will be based on a (statistically) lower degree of confidence than 95%.

Table 4 contains the outcome of the IKM 2009 statistical assessment of the Zone A contaminants of concern.

Table 4 – IKM, 2009, HHRA Zone A Tier 3 comparison against AC-2009

Substance	AC-2009 (mg/kg)	Maximum Zone A (mg/kg)	Outlier excluded (if any)	Mean (mg/kg)	Lower Confidence Limit (mg/kg)	Evidence Against Null Hypothesis
Arsenic	19.5	38	n	13.4	6	8%
Benzo(a) pyrene	1.06	150	BH5	49.4	21.2	99%
Naphthalene	4.73	23	BH5	4.74	<0	50%
TPH aromatic C16-C21	1200	730	BH5	186	71.7	0%
TPH aromatic C21-35	2290	4400	n	1439	660	4%

The mean concentration of benzo(a)pyrene was noted to exceed the critical concentration (SSAC-2009) and the level of evidence against the Null hypothesis being true is greater than 95%. IKM concluded the Null hypothesis should be rejected, and that benzo(a)pyrene represents a significant possibility of significant harm (SPOSH) to human health under Part IIA. IKM concluded that remedial measures should be considered such as capping.

All the other contaminants of concern assessed were NOT considered to represent a significant possibility of significant harm.

Following receipt of IKM 2009 report, The Highland Council acted and, with the agreement of the owner/occupier of the site, paved the majority of the bare soil in the rear garden area (approximately 60m²) in December 2009 in order to prevent direct contact with the soil. Hygiene guidance to the owner/occupier was also issued to advise that gloves should be worn when gardening, and children should not be allowed to dig/play in the soil.

However, The Highland Council did not consider that the Assessment Criteria used in the IKM assessment as analogous to significant possibility of significant harm because the criteria is based on a "minimal" health criteria value. This means that soil with concentrations of benzo(a)pyrene below the assessment criteria have "minimal risk" but does not necessarily mean that soils with concentrations above the assessment criteria pose an "unacceptable risk" defined in the legislation as significant possibility of significant harm. The Scottish Government has not provided Local Authorities with health criteria values for benzo(a)pyrene which would allow calculation of "unacceptable" risk in the context of Part IIA of the Environmental Protection Act 1990.

The Council commissioned IKM to undertake an alternate Margin of Exposure (MOE) methodology evaluation of the risk to HH for the whole gasworks (RC-GSW-1002) from Benzo(a)Pyrene, to gain multiple lines of evidence, and support determination of the soils as meeting the definition of contaminated land, if necessary.

The MOE is defined as the ratio of an estimated exposure level to the exposure level which produces a defined response in toxicological tests, for example the BMDL₁₀, is a benchmark dose which yields a 10% increased experimental risk of tumour development. (e.g 10% increase in liver tumours in rats)

The IKM 2010 Benzo(a)Pyrene MOE values calculated for Zone A, using a lower 95th percentile average daily exposure value (ADE) soil concentration and three literature sourced BMDL₁₀ values, from the Health Protection Agency (HPA), the European Food Safety Authority (EFSA) and Joint FAO/WHO Expert Committee of Food Additives (JECFA), is summarised in Table 5 below.

Table 5 - IKM, 2010, Benzo(a)pyrene Zone B Margin of Exposure calculated values

Substance	BMDL ₁₀ (HPS)	MOE	BMDL ₁₀ (EFSA)	MOE	BMDL ₁₀ (JECFA)	MOE
Benzo(a)pyrene	0.07	952	0.1	1360	0.23	3128

The EFSA Scientific Committee considered a margin if exposure of 10,000 or higher “would be of low concern from a public health point of view and might reasonably be considered as a low priority for risk management actions.” The COC indicated a MOE of >10,000 to 100, 000 was unlikely to be of concern; and at the time of writing Health Protection Scotland (HPS) advised the Council that the HPA endorsed use of a BMDL₁₀ range of 0.07 – 0.1 mg/kg BW/day in relation to Benzo(a)pyrene.

Were the Council to adopt the EFSA approach that a MOE of >10,000 is of low concern to public health as the departure point to define acceptable from unacceptable risk, a BMDL₁₀ value greater than that advised for use by the HPS would need to be utilised in the evaluation. IKM concluded based on their MOE assessment that the need for further risk management for Zone A may be warranted.

In 2011 the Scottish Government (SG) commissioned the Institute of Occupational Medicine (IOM) to undertake a review of methods to assess risk from contaminated land. Reporting in 2012 IOM suggested the development of a benchmarking dose/MOE approach as a basis for defining ‘unacceptable intake’ would offer a real improvement to the assessment status quo, provided a centrally held resource of BMDs was available to local authorities.

A further IOM Pilot Study of the use of benchmark doses in assessing risk to human health from contaminated land was commissioned and to date has reported directly to the SG Contaminated Land Advisory Group (CLAG) only. As of April 2016, CLAG peer review comments have been forwarded to IOM, and the Final Report publication remains pending.

Looking for guidance on the definition of 'unacceptable risk' within the rest of the UK following the revision of the Contaminated Land Statutory Guidance for England in 2012, DEFRA commissioned the 'category 4 screening levels' C4SL research project (SP1010) reviewing exposure and toxicology for 6 substances, where category 4 refers to the categorisation system in English Statutory Guidance for acceptably low risk. The DEFRA project was published in 2014 and included benzo(a)pyrene CAT 4 criteria for a residential with home grown produce uptake, ranging from 2.4mg/kg to 5.0mg/kg. Were Zone A, the rear garden of Boxwood, regulated in England, the Benzo(a)Pyrene concentration levels in soils would be above the CAT 4 screening level.

The divergence in national guidance and specifically the debate in the contaminated land practitioner community regarding what constitutes 'unacceptable risk' for benzo(a)pyrene has resulted in the Council deferring the determination of whether Zone A (or any other part) of the former gasworks in Tain presents a significant possibility of significant harm (SPOSH) to human health and whether the land meets the legal definition of 'contaminated land'.

Published in January 2015, the consultancy Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) developed a peer review project to derive assessment criteria for six exposure land uses and three soil types to provide up to date GAC for 35 substances including benzo(a)pyrene. The GACs incorporate more recent toxicological data and updated exposure information as per the DEFRA C4SL project however did not incorporate additional risk exposure levels or reference the English categorisation classification as rejected by the SG. The LQM/CIEH values are described as 'suitable for use levels' abbreviated to S4UL and designed to assess generic risk to human health from new planning developments on brownfield land.

To document changes in guidance since 2010, the Council commissioned a data review and revised human health risk assessment of the whole Tain gasworks site in 2015, as reported in the ERS Tain Gasworks Data Review and Revised Human Health Risk Assessment Report, April 2016.

Overall ERS concluded the site works undertaken were in line with current practice and guidance; and the Zone A dataset was considered sufficiently robust for an updated risk assessment. ERS completed their assessment in line with current UK guidance. Utilising the available UK Soil Guideline Values (SGV); the LQM/CIEH generic assessment criteria (GAC) updated in 2015 and termed S4ULs (suitable for use levels) developed using the contaminated land exposure assessment CLEA model v1.06; and the CL:AIRE, Environmental Industries Commission (EIC) joint publication of 35 GAC; or in the absence of a GAC the commercially available limit of detection LOD was used for initial comparison.

The COC from the representative soil samples which had some samples elevated when compared to residential with home-grown produce were subject to statistical analysis using the Chartered Institute of Environmental Health CIEH Statistics software package, 2008. For several chemicals, an outlier at BH5 was recorded; once this was removed from the dataset, two contaminants, benzo(a)pyrene and

dibenzo(ah)anthracene were considered by ERS to present significant possibility of significant harm, see Table 6:

Table 6 – ERS 2016, HHRA (Zone A) statistical comparison against LQM S4UL

Substance	GAC S4UL (mg/kg)	Mean (mg/kg)	LCL of true mean (mg/kg)	Upper bound % against NULL	Further action	Lower bound % against NULL	Further action
Benzo(a)pyrene (outlier not removed)	2.7	77.64	59.6	98%	Yes	85%	Yes
Dibenzo(a,h) Anthracene (normal distribution)	0.28	6.85	3.12	99%			

Although IKM and ERS both presented Reports with their opinion that the rear garden represented significant possibility of significant harm to human health, The Highland Council still considered that the assessment criteria used indicated the site was above a minimal risk, but could not judge whether it was sufficiently above the “minimal” risk level to be considered “unacceptable”.

In July 2017, The Highland Council commissioned the consultancy Land Quality Management Ltd (LQM) to undertake a review of Zone A using the joint LQM/CIEH Dose Response Roadmap (DRR) approach. This involves using meta-analysis of toxicological and epidemiological studies in humans and animals to produce a visual indication of the contaminant dose-response relationship using the USEPA scale ranging from 0 (no effect) to 10 (death). The contaminant Average Daily Exposure for each pathway (oral, dermal and inhalation) are displayed on charts along with the various outputs from peer-reviewed toxicological/epidemiological studies. In this way, the DRR provides a scientific basis for determining if site specific estimates of average daily exposure are likely to result in significant harm, or pose a significant possibility of significant harm. The DRR were undertaken for benzo(a)pyrene as a surrogate marker for all PAH as this contaminant has the most robust scientific studies.

The November 2017 LQM Report found that for the inhalation exposure pathway for benzo(a)pyrene in soil, the predicted average daily exposure for 5 out of 11 samples of surface soils in Zone A plot at levels that are at or above doses that have resulted in a 20% lung tumour incidence in humans. LQM pointed out the uncertainties in the inhalation toxicological database such as the occupational study on which the assessment was based was adult males in a working environment (aluminium smelter) where the exact concentration of benzo(a)pyrene they were exposed to was unknown. The bioaccessibility of benzo(a)pyrene was not considered and is assumed in the DRR to be 100% which is conservative (reliable bioaccessibility tests for benzo(a)pyrene are not currently available).

It was LQM’s opinion that the concentrations of benzo(a)pyrene onsite are likely to represent significant possibility of significant harm to human health via the inhalation exposure pathway; however, LQM noted that the presence of paving slabs over the majority of the site represented an effective barrier which, if extended to cover the remaining soft-standing, would break the source-pathway-receptor pollutant linkage.

LQM advised that the Highland Council should consider invoking “institutional control” over the rear garden to ensure soils in the rear garden are prevented from being penetrated, removed or reworked. If institutional control were not possible, LQM advise that The Highland Council consider determining the rear garden as Contaminated Land.

LQM did not consider the benzo(a)pyrene in soil to represent significant possibility of significant harm by the oral or dermal exposure routes.

The Highland Council contacted Health Protection Scotland (HPS) for advice on whether the average daily exposure from benzo(a)pyrene in soils in the rear garden represents an unacceptable risk to health without action to prevent exposure (by covering or remediating the soil). HPS agreed with LQM that the risk from inhalation of benzo(a)pyrene in soils is likely to present an unacceptable intake and hence to pose a significant possibility of significant harm. Furthermore, HPS considered that the increased risk of benzo(a)pyrene from oral exposure may also constitute a significant possibility of significant harm. HPS concluded that Zone A should be determined as Contaminated Land and recommended that action is required to mitigate the risk posed to residents at the site.

Groundwater contaminant source

To assess the volatile risk to human health from the contaminants of concern (COC) in the groundwater associated with the previous use of the site, appropriate scenario site specific assessment criteria (SSAC) derived by IKM in 2008 using the RISC software version 4.0 (as previously detailed). These SSAC were compared to the COC concentrations in groundwater encountered across the whole site.

None of the concentrations of chemicals detected in groundwater across the entire site exceeds the respective SSAC, and IKM concluded these chemicals do not present a significant possibility of significant harm to human health.

NOTE: Abstraction of groundwater for use as a drinking water supply or the potential for direct contact with groundwater linkages were both ruled out on the basis of the urban location and the depth to groundwater being greater than 1.0m.

SUMMARY

In summary, two consultants, IKM and ERS, have reported that concentrations of benzo(a)pyrene in soil in Zone A are above levels which are considered to pose a “minimal” risk to human health. LQM have reported that concentrations of benzo(a)pyrene in soil are at or above concentrations which are associated with a 20% incidence of lung cancer tumours in occupational studies of aluminium smelter workers. LQM and HPS report that, without action to break the exposure pathway, the average daily exposure of benzo(a)pyrene in soils at Zone A represents significant possibility of significant harm to human health via inhalation exposure route. HPS also considers that the average daily exposure of benzo(a)pyrene in soils at Zone A may constitute a significant possibility of significant harm via the oral exposure route.

5.2. Summary of Assessment of Evidence that there is No Significant Possibility of Significant Pollution of the Water Environment (SPWE)

To assess the site wide risk to the water environment from all contaminant of concern (COC) in the soils associated with the previous use of the gasworks site, representative soil and groundwater samples were collected from the onsite locations and analysed for the COC.

Data collected from the groundwater sampling rounds was used to model the groundwater flow and undertake a hydraulic gradient calculation for the area.

In December 2008 IKM compared the onsite information against then appropriate drinking and environmental water quality standards, and modelled impact to the surface water receptor, the Dornoch Firth located an estimated 350m downgradient from the site.

In September 2009 IKM undertook a second water environment risk assessment utilising the additional data from the newly installed offsite down gradient assessment borehole (BH21) which provided a comparison to modelled compliance point values.

The 2009 IKM evaluation was provided to SEPA for consultation and advice on the seven measures of significance as detailed in the Statutory Guidance. SEPA highlighted a number of areas of concern with the assessment.

Following publication of the SEPA Position Statement WAT-PS-10-01, Version 2.1 document, ERS were commissioned to update the water environment assessment to meet 2011 relevant statutory water quality standards.

GROUNDWATER RECEPTOR

ERS concluded Ammoniacal Nitrogen, Benzo(a)pyrene and 4 PAHs were an onsite potential source, however only the PAHs were recorded at the offsite compliance monitoring borehole (BH21).

An elevated soil leachate result for PAH was reported from one soil taken from BH5 within Zone A. However, the main area of soil leachate samples with elevated PAH were taken from the Commercial Yard (Zone C) to the north of the site, and it is therefore considered by The Highland Council unlikely that the area of Zone A by itself would represent significant possibility of significant pollution of the water environment.

SURFACE WATER RECEPTOR

ERS concluded 5 PAHs were a potential source onsite and found at the offsite compliance monitoring borehole (BH21).

An elevated soil leachate result for PAH was reported from one soil taken from BH5 within Zone A. However, the main area of soil leachate samples with elevated PAH were taken from the Commercial Yard (Zone C) to the north of the site, and it is therefore considered by The Highland Council unlikely that the area of Zone A by itself would represent significant possibility of significant pollution of the water environment.

6. SUMMARY OF STATUTORY REQUIREMENTS WHICH HAVE BEEN SATISFIED

In determining that land at Zone A –Rear Garden, Boxwood, Shore Road, Tain is contaminated land, as defined by Part IIA of the Environmental Protection Act 1990, The Highland Council has taken into account the guidance contained within Chapter A and Chapter B of Annex 3 of the Environmental Protection Act 1990: Part IIA Contaminated Land - Statutory Guidance: Edition 2, June 2006.

Chapter A, paragraph A12 of the Statutory Guidance states that the first step for the local authority is to satisfy itself that “*a contaminant, a pathway, and a receptor have been identified with respect to that land*”. Following on from this, the local authority must satisfy itself that both:

- a) *such a pollutant linkage exists in respect of a piece of land; and*
- b) *that the pollutant linkage:*
 - (i) *is resulting in significant harm being caused to the receptor in the pollutant linkage,*
 - (ii) *presents a significant possibility of significant harm being caused to that receptor,*
 - (iii) *is resulting in the significant pollution of the water environment which constitutes the receptor, or*
 - (iv) *is likely to result in a significant possibility of such pollution being caused.*

Chapter B, Paragraph 45 of the Statutory Guidance states that the local authority should determine that land is contaminated land on the basis that there is a significant possibility of significant harm being caused where “*it has carried out a scientific and technical assessment of the risks arising from the pollutant linkage, according to relevant, appropriate, authoritative and scientifically based guidance on such risk assessments; that the assessments shows that there is a significant possibility of significant harm being caused; and that there are no suitable and sufficient risk management arrangements in place to prevent such harm*”.

Highland Council is satisfied that the Statutory Guidance has been followed in that:

- Sufficient soil sampling has been undertaken at the site to allow measurement of any contaminants of concern;
- The investigation carried out has been scientific and technically sound, according to relevant, appropriate, authoritative and scientifically based available guidance and was designed in accordance with British Standard BS10175:2011+A2:2017 Investigation of potentially contaminated sites – Code of Practice.

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- The risk assessment was carried out following non-statutory guidance from the Environment Agency and the Chartered Institute of Environmental Health,
 - The risk management arrangements in place at the site are not suitably robust to ensure protection from areas of soft landscaping which are uncovered, furthermore there is no current legal requirement on the owner/occupier to keep the current paving in place.

The Highland Council is satisfied that the assessment undertaken is considered sufficient to allow determination that there is significant possibility of significant harm (SPOSH) to human health from benzo(a)pyrene in shallow soils within Zone A from inhalation and oral exposure.

The Highland Council is satisfied that the assessment undertaken is considered sufficient to allow determination that there is no significant pollution of the water environment (SPWE), or the significant possibility of SPWE through the various pathways examined as outlined in Section 3 of this report.

It is therefore concluded by The Highland Council that Zone A - Rear Garden, Boxwood, Shore Road, Tain, NGR: 277855:882443 is determined to be contaminated land as defined under Part IIA of the Environmental Protection Act 1990 (as amended by The Contaminated Land (Scotland) Regulations 2005).

REFERENCES

British Standards BS 10175: 2011+A1:2013, Code of practice for investigation of potentially contaminated sites, British Standards Institution

British Standards BS 5930: 1999+A2:2010, Code of practice for site investigations, British Standards Institution

The Contaminated Land (Scotland) Regulations 2000 (Scottish Statutory Instrument 2000 No. 178)

The Contaminated Land (Scotland) Regulations 2005 (Scottish Statutory Instrument 2005 No. 658)

Contaminated Land Inspection Strategy, Highland Council 2001

Contaminated Land Inspection Strategy, Highland Council 2009

The Environmental Protection Act 1990

Environmental Protection Act 1990: Part IIA Contaminated Land - Statutory Guidance: Edition 2

Scottish Environment Protection Agency (SEPA). June 2011. Position Statement WAT-PS-10-01, Version 2.1. Assigning Groundwater Assessment Criteria for Pollutant Inputs. SEPA

Environment Agency, Human Health Toxicological Assessment of Contaminants in Soil, SC050021/SR2

RC-GSW-1002, The Highland Council commissioned Reports from IKM, ERS and LQM as detailed in Section 4

Institute of Occupational Medicine (IOM). November 2012, Review of Methods to assess risk to human health from contaminated land, Ref 611-00497.

Land Quality Management and Chartered Institute of Environmental Health "The LQM/CIEH S4ULs for Human Health Risk Assessment", 2015

Land Quality Management and Chartered Institute of Environmental Health "Generic Assessment Criteria for Human Health Risk Assessment" 2nd Edition, 2009

Chartered Institute of Environmental Health and CL:AIRE "Guidance on Comparing Soil Contamination Data with a Critical Concentration", May 2008

Statistics Calculator (Version 2) ESI Ltd, 2011

HPS Comment on the Dose Response Roadmaps Report for Shore Road, Tain, by Land Quality Management Ltd for The Highland Council. March 2018