CANBERRA TOWN PLANNING

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2/20 CHALLIS STREET DICKSON
CANBERRATOWNPLANNING.COM.AU
ABN 66 131 577 261

18 June 2017

The Assessing Officer
Development Assessment
Environment, Planning and Sustainable Development Directorate – Planning
Dame Pattie Menzies House, Challis Street, Dickson

Document prepared for Kasparek Architects.

Response to Further Information Request DA201731430: Block 22 Section 97 Charnwood:

Peach & Co Childcare Centre

Dear Sir/Madam,

This correspondence has been prepared to provide advice in relation to the Further information requests received from the EPSDD. The advice is prepared on behalf of the Applicant Kasparek Architects.

The Further Information Requests sought advice on a range of matters which we address in turn below:

Further Information request matters as numbered.

The following matters were included in the Further Information Request 1 and is addressed in turn below:

1. ***Proposed Development: Following comments have been received from Education Directorate. Please justify:***
   - ***Anecdotal conversations with current providers in the ACT indicate that there is currently an oversupply of education and care services in the Territory.***

The proposal is supported with a Needs assessment that was prepared Business Geographics Pty Ltd that was submitted with the DA. This assessment indicates that there is capacity in the market for a centre of this size. It should be noted that there is no requirement in the Territory Plan to demonstrate the need for the use at the site and further that the use of Community Use – that include Childcare centre is permissible under the Lease Purpose Clause. This DA only seeks to activate this use by proposal for construction of a building.

2. *Access and Mobility:*

Drawings DO NOT indication Continuous accessible path of travel – on-site pedestrian routes not indicated.
There is no separate pedestrian access from the street to the entry – conflict with vehicles; The Access Report states that the proposal is capable of compliance but

Further information required as the detailed design progresses in particular landscape drawings indicating accessible path of travel to the entrance from the allotment boundary.

Please consider updated Architectural site plan DA04 that now show accessible pedestrian path and lighting detail. The pathways will connect with the street path and will be finally resolved in detail design. A second accessible parking space is now included near centre entry within the carpark.

- ***No details of Door and Doorways provided. It is a mandatory Rule. The Access Report states that the proposal is capable of compliance but***

  Further information required as the detailed design progresses

  Applicant is required to provide further information - notes on the drawings in relation to compliance with the relevant Australian Standards will be considered acceptable.

Please consider the information added to Drawing DA05 that require:" Doorways to be in accordance with Clause 13 of AS1428.1 2009".

- ***One accessible toilet and shower facility provided. The Access Report states that the proposal is capable of compliance but***

  Further information required as the detailed design progresses.

  A performance solution is to be documented with respect to BCA requirement F2.4(a) as accessible sanitary facilities are not provided at 50% of the banks of toilets. As all but one bank of toilets is for use by the children who will be learning how to use the facilities and are likely to require assistance requirement to provide accessible facilities to 50% is not considered appropriate.

  Please justify.

Please refer to updated Access and Mobility Assessment Report. The report now includes a statement in relation to this.

- ***Only one accessible parking space provided. Two required.***

Please consider updated Architectural site plan DA04 that now show a second accessible parking space included near centre entry within the carpark.

3. *Parking – the required parking for the proposed development is:*

Car parking required:

1 space/centre = 1 space

Plus

2 spaces per 15 childcare places for employee parking = 24 spaces for 176 places

plus

visitor parking as follows:

4 spaces for 60-90 childcare places = accordingly, 8 spaces for 176 places is considered reasonable

plus

1 pick-up/set-down bay per 10 childcare places = 18 spaces for 176 places

Total required: 1+24+8+18 = 51 spaces

3% Accessible = 2 spaces out of 51 must be accessible.

Proposed parking is 42 spaces + possible 3 kerbside spaces (depending on if TCCS permits this).

During the pick-up drop-off rush hours, parents often park vehicles on the verge if there is no adequate parking available on site. This is not permitted and not safe. There are no other publicly available parking spaces in the vicinity – please justify the parking shortfall.

Please note that 2 accessible parking spaces are now included near centre entry within the carpark as shown in Architectural site plan DA04.

In relation to the Parking requirement and provision we request that you review the updated advice provided by Graeme Shoobridge Advisory (included in this submission). The advice considers these matters specifically as set out in the report provided.

4. *Signage: Location of the signs has been provided.*
   - ***It is noted that the signs will be illuminated but no size/dimensions, colours, material details provided.***
   - ***The signs are assessed against the incorrect type.***

Please refer to the Signage Plan DA19 and Overall Elevation DA07 that include updated information in relation to the proposed wall signs. In relation to the Signs General Code these signs are:

- Permissible in the CFZ zone (with approval),
- Permitted (with approval) at Ground Level,
- Will be affixed flat to the wall and not protrude by more than 300mm,
- Will be less than 6sqm and/or 20% of the wall are in question,
- May be illuminated and there will be more than one sign per tenancy. Lighting will be in accordance with Australian standard as4282: the control of obtrusive effects of outdoor lighting. In relation to the number of signs proposed please refer to the C4 assessment of the Signs General Code included in the Statement Against Criteria - noting that this is equally applicable to the proposed wall signs.

5. ***Waste enclosure on the boundary: Demonstrate that the sightlines will not be affected due to the location of the waste enclosure.***

We note that there is no concern in relation to sightlines from vehicles entering the site as the waste enclosure does not obstruct visibility to the off-site pedestrian path network. We note that the visibility upon existing the site is not impeded as the driveway is wide enough to be used as a 2-way access road and drivers exciting the site will approach the off-site pedestrian path along the northern part of the driveway; this create a natural sightline zone over the "entry side" of the driveway. AS note has been added to the Site Plan DA04 that indicate that sightlines are to be maintained as per the intended design.

6. ***Solar Access:***

- ***The nursery rooms are very narrow and deep. There are only recessed folding doors facing south-east. Please demonstrate how these rooms will receive adequate natural light and ventilation.***
- ***Similarly one of the toddler rooms will also not receive adequate natural light. Please demonstrate.***
- ***The passage between the nursery and the preschool rooms will not receive any natural light and will have to rely on artificial lighting whole day. Please justify.***

There are no specific solar ingress provisions for non-residential use provided in the applicable zone codes but the proponent have now provided remote operable roof windows (skylights) to allow sunlight ingress and natural ventilation - Please note the inclusion of remote operable roof windows (skylights) as detailed on Drawings DA05 and DA06.

7. ***Tree Removal/ground work within TPZ:***

(a) Tree Protection Unit does not support the removal of regulated trees identified for removal as these trees do not meet Tree Protection Criteria for removal and will need to be considered for removal on Development Grounds.

- ***To consider the removal of trees on Development Grounds, please demonstrate, with various design options, why this particular design option is the best viable option and why removal of these regulated trees is necessary to achieve the best outcome.***
- ***This is required to present the DA to the Major Projects Review Group (MPRG).***

(b) It is also noted that

i) The proposed underground stormwater tank needs to be located outside of the tree protection zone of Tree 17 (Eucalyptus melliodora) and hydrosystem & grated pit will not be supported within the tree protection zone of the same tree (Tree 17 Eucalyptus melliodora) and must be relocated;

ii) The Nappy Change Room located within the tree protection zone of Tree 27 (Eucalyptus bicostata) will need to be constructed using low impact footings (e.g. pier and beam, rebated edge footings or screw in type footings) with a suspended floor within the tree protection zone (dripline + 2 metres). A low impact footing does not cut into the root system except for isolated piers. However, the tree is of poor quality and would likely be supported for removal as the tree meets the criteria 1.1.a (Life expectancy short) as the tree is in decline; and

iii) Excavation for the proposed fencing piers within the tree protection zones (dripline + 2 metres) of regulated trees 8, 17, 21, 22 and 27 shall not exceed 250mm in diameter and excavation for piers shall be undertaken by hand. If roots of a diameter of 100mm are or greater are encountered upon excavation the pier holes are to be relocated either side of the root.

Please provide revised drawings and details of tree management and protection as required.

Please refer to Site Options Analysis DA21 that demonstrate some of the options that was considered in preparing the design as proposed. The design approach sought to balance the building design with site constraints and opportunities such as building presence and frontage/visibility to adjoining roads, privacy, tree quality and the like.

Please consider the new position of the relocated stormwater tank as requested as depicted in Civil Drawing DA-04. We note the proposed conditions around construction methodology and suggest that these are captured as conditions of approval with the Notice of Decision.

8. Strategic Planning - Transport Planning and Social Planning:

(a) Access and Mobility:

i) The ACT Access and Mobility General Code (Rule 2.1 Criteria 3) requires a continuous path of access travel be provided from the property boundary to the entry of the building. This is so the facility can be accessed safety from the street. The proposed development does not include direct pedestrian access to the child care facility from the property boundary, in this case Lhotsky Street.

ii) The car park does not provide an ideal level of pedestrian access to the facility entrance for customers arriving by vehicle and using the car park, given the use of this car park by parents and carers with very young children. Further consideration of safe access from the car park is required. Options to improve safe pedestrian access could potentially include the use of pedestrian foot paths and the use of a pedestrian crossing within the car park.

Please consider updated Architectural site plan DA04 that now show accessible pedestrian path and lighting detail. The pathways will connect with the street path and will be finally resolved in detail design.

(b) Accessible Parking:

i) Accessible parking is required at a rate of 3% rounded up to the nearest whole number. The proposal includes one accessible park. An additional accessible car park is required.

ii) Accessible car parking spaces should not be located adjacent to the turning space. The accessible car park needs to have direct access to the front entry.

iii) The turning circle for the car park should be provided separately at the rear of the car park.

A second accessible parking space is now included near centre entry within the carpark.

(c) Walking and Public Transport Access:

i) The development is located on two large roads (Florey Drive and Lhotsky Street) which place increased importance on safe pathways for pedestrian and cycle access to the site. However, the existing pathway along Lhotsky Street finishes at the entrance to the site. A pathway should be provided to connect the site to the wider pedestrian and cycle network. The pathway should be well lit (see commentary below in Lighting, Safety and Passive Surveillance)

Please consider updated Architectural site plan DA04 that now show accessible pedestrian path and lighting detail. The pathways will connect with the street path and will be finally resolved in detail design. We note that the site is services by pathways on both boundaries and these connect into the wider pedestrian network.

The site will be primarily used by parents dropping children to the centre by private vehicle and/or use of the existing path network that span both site boundaries. The Crown Lease permits the childcare use. If a new pathway is desired by the Territory then this may be installed as capital Government works - it is not a requirement associated with the sale of the land and is not specifically required as a planning consideration in the Territory Plan in the context of this application.

(d) Landscape and shade:

i) If the car park layout was reconfigured to provide islands around the trees it would be possible to retain more trees on site and continue to provide shade.

ii) There is a lack of detail provided on the configuration outdoor play areas. Whilst there is a 40% deep root planting area provided for fall zones for equipment, shade structures and other potential hard stand play areas will likely diminish the area available for deep root planting and permeable landscape.

Noting the Deep Root Planting area shown in green on DA-04 site plan we suggest that a large proportion of the site will remain permeable and free of hard landscaping - especially in the playground areas. We further note that the play area is provided with a large number of mature tress (proposed to be retained), shade structures on pergola elements) and further (new) tree plantings - all of these will provide specific amenity and shade to these play areas. Fall zones are permeable in their construction and will facilitate infiltration of stormwater as will deep-root areas.

We further note that the licencing provisions require a certain amount of shade be provided in play areas and this development is designed to comply with these requirements. If more shade elements are required to obtain a use licence before operation can commence then the Proponent will seek to have the DA amended and provide further elements to meet such provisions.

The carpark design and location is a function of site access, tree retention strategy and building positioning (and parking provision requirements as per the PVAGC). We are seeking the removal of medium quality regulated trees only in favour of retaining a balanced an high amenity development in the context of a number of design options (As demonstrated in the Architectural design documents provided with this submission). We would gladly consider removing a few of the carparking spaces where practicable to retain some of these trees if we the Authority deem this loss of spaces to be acceptable. Out traffic statement included in this submission demonstrate that the site complies and exceed the provisional requirements of the Parking Code and we could easily delete one or two parking spaces if the Authority deem this to be necessary to retain some of the Trees. We would accept such an outcome as a condition of approval if the Authority deem this to be important.

(e) Built form/Materials:

i) The materials are predominately face brick with little use of quality or natural materials. As such there is a lack of high quantity finishes and materials which provides little aesthetic relief and causes problems with high thermal heat gain and glare.

We strongly object to the suggestion that the use of face brick is of little quality and/or use. The design was deliberately and specifically prepared to be in keeping with the site history and play on the interaction with the historical use of fire station, the design quality of that building and the proposed new building. We note the Canberra Times Architecture (https://www.domain.com.au/news/childcare-centre-plans-for-former-charnwood-fire-station-site-revealed-20170512-gw3c5w/) dated 12 May 2017 that sets-out the designer's approach top the building. From this it is clear that the design is generally deliberate including:

- The proposal features a design that "pays homage to the original fire station";

- the red grid feature that formed the former building's distinctive facade will be incorporated into the new design"
- Mr Kasparek said …"the design would also mirror the station's rectangular form and original brickwork. *"We didn't want it to look like an ordinary residential building, we wanted it to look special and different... …You don't often get an opportunity to reference a fire station."*

ii) The shade structures do not provide shade to outdoor areas, play areas and the internal building. Details of shade structures particularly on the western play area and facade should be incorporated into the design.

iii) Metal pergolas are likely to absorb and retain heat making them inappropriate particularly on the western facade.

Shading components are now added to pergola structures – refer to detail on Drawing DA-06 and other site plan and layout drawings.

We do not believe that the proposed metal pergolas will have any heat build-up effect given the small extend of these elements in the context of the building proposed and the addition of shade structure. We suggest retaining this finish as a highly durable implementation in a space that is likely to be heavily impacted upon on the day to day activity at the centre. We view this implementation as an appropriate and low maintenance, highly durable response with no evidence of the impacts suggested in the comment to be a supportable concern- especially given the context of large trees and shade structures being proposed in the design.

(f) Parking:

i) 51 car parking spaces are required as per the Parking and Vehicular Access General Code requirements. The application provides for 42 parking places, including 1 accessible space. The proposal falls short of the requirement of car parks by 9 on site (noting an additional 3 on-street spaces are proposed along Lhotsky Street), Provide evidence/ justification that sufficient parking is available to meet the demands of the proposed facility.

Please refer to the updated advice provided by Graeme Shoobridge Advisory (included in this submission).

9. Health Protection Services:

The HPS supports the EPA's endorsement of the report conducted by AECOM. However, seeks further information regarding the results of the perfluorooctane sulphonate and perfluorooctanoic acid analysis of soil.

We note that the HPS support the EPA endorsement of the AECOM investigation findings and acknowledge the question in relation to the substance listed. It appears that this question is levelled to the EPA as endorsement entity of the report noting that the Lease was sold with this use specifically permitted in the Purpose Clause. There appears to be no evidence that the site is not suitable for the use permitted given this context.

Notwithstanding the proponent will continue his liaison with the EPA during the construction of the proposed building and implement an unexpected discovery protocol in relation to contamination matters through the construction period to provide a framework in which any matters relating to substances such as is listed may be appropriately dealt with if discovered on-site. We will act in accordance with Australian Standards, Best Practice and EPA requirements in this regard.

The request from the Health Protection Services Agency seems to relate to requesting a copy of the test results (laboratory results) that was used in the AECOM assessment presented to the EPA for endorsement. These results were not made available with the sale of the land to the proponent and we do not have a copy of said test results.

The de-contamination works and testing were commissioned by the Territory and endorsed by the EPA prior to the sale of the Lease to the proponent We suggest that the Health Protection Services Agency seek this advice directly from the LDA or EPA as relevant parties in the assessment that relate to the AECOM report. This does not appear to be raised as a matter of concern in the context of the DA and should not be impacting on the assessment of this proposal.

If you have any questions or require anything further, please contact me on [redacted]

Yours Sincerely,

[redacted]
Digitally signed by
Pieter van der Walt
Date: 2017.06.18
16:09:07 +10'00'

[redacted]

ACT Government
Health

MINUTE

This is a good Brief.

SUBJECT: Development Application 201731430-22-97-CHARNWOOD-03

To: Conrad Barr, Executive Director Health Protection Service

From: Radomir Krsteski, A/g Manager Environmental Health

Date: 21 July 2017

Purpose

To provide you with a response to Environment, Planning and Sustainable Development Directorate (EPSDD) following their request for comment regarding a development application for a proposed childcare centre in Charnwood.

Background

1. EPSDD has requested that comments are received by 24 July 2017.
2. The development application proposes:
    a. demolition of an existing building on the site of a former Fire Brigade Depot
    b. construction of a single storey, 1217 square meter childcare centre (with a proposed capacity of 120 childcare places)
    c. construction of 1157 square meter playground, site works and fencing.
3. The site is located within the CZF – Community Facility Zone - Block 22 Section 97, Charnwood, with an approximate land area of 3601 square meters.
4. The Health Protection Service (HPS) responded to an initial development application on 2 June 2017. A copy of the response is at Attachment A. The HPS sought further information regarding the results of the perfluorooctane sulphonate (PFOS) and perfluorooctanoic acid (PFOA) analysis of soil.
5. A representative of the applicant contacted the HPS on Thursday 15 June 2017 by phone seeking clarification of the HPS request at Attachment A. An email response was provided to the representative on 15 June 2017. A copy is at Attachment B.
6. Information provided in this development application in response to HPS concerns advised that HPS should contact the Environmental Protection Agency or the Land Development Agency to obtain results of the testing. A copy of the results was obtained through the Land Development Agency (LDA), on 10 July 2017. A copy is at Attachment C.
7. The information provided by the LDA included a 2015 report undertaken by AECOM, an engineering consultant in Canberra that provided soil sample results for PFOS and PFOA at three sites in one 5m x 7m area at the periphery of the site (Attachment D). These

results demonstrate the presence of PFOS in all three soil samples tested at levels of 1.06mg/kg, 1.30mg/kg and 1.92mg/kg.

8. AECOM concluded that these levels were below *the USA EPA Region 4 (2009) – Soil Screening Levels for PFOS and PFOA Memorandum* of 6mg/kg and therefore determined that the site is acceptable for future child care land use.

9. The USA EPA Memorandum noted the inherent uncertainties in the degree of protectiveness afforded by the listed screening levels and the document has since been archived by the US EPA.

10. Further, in April 2017, the Australian Government Department of Health published *Health Based Guidance Values for PFAS – For Use in Site Investigations in Australia* which outlines a PFOS tolerable daily intake value of 20ng/kg/day (Attachment E).

11. Young children are particularly at risk for increased exposure to soil contaminants, such as PFOS and PFOA from pica (eating soil), greater hand-to-mouth activity (including crawling) and reduced hygiene (i.e. washing of hands).

12. Preliminary calculations suggest a 10kg child (assuming a two year old) would exceed the PFOS daily tolerance level by consuming just 100mg of soil from the site. A 2006 study conducted in the United States of America found that children aged between 2 and 6 years of age may have an average soil ingestion of 138mg/day of soil, or 193mg/day of soil and dust (Attachment F).

Issues

13. The applicant is advised that additional sampling for PFOS and PFOA must be undertaken to provide a more complete and up-to-date assessment of the site, focusing on areas where children are likely to be exposed to surface soils (including playgrounds and landscaped areas). The results and a map indicating sample sites must be provided to the HPS.

14. The HPS requires that the applicant demonstrate suitable mitigation measures to minimise or eliminate the potential ingestion of PFOS and PFOA by children, who are the most sensitive land use receptors considered in this application.

15. There are no other public health concerns in relation to the proposed development.

ACT Government
Health

MINUTE

Recommendation

16. It is recommended that you sign the letter at Attachment G to EPD.

AGREED/NOT AGREED/NOTED/PLEASE DISCUSS

Conrad Barr
Executive Director, Health Protection Service
24 July 2017

Radomir Krsteski
A/g Manager, Environmental Health
21 July 2017

Action Officer: Keith Rogers
Extension: 51716

A

ACT Government
Health

EPDcustomerservices@act.gov.au

Referral-Health-Development Application – 201731430-22-97-CHARNWOOD-03

Dear Sir/Madam,

Thank you for the documentation received on 12 May 2017 regarding a proposed childcare centre in Charnwood.

The Health Protection Service (HPS) notes that the proposed development will include:

a. demolition of an existing building
b. construction of a single storey, 1217 square meter childcare centre
c. construction of 1157 square meter playground, site works and fencing.

The development proposes construction of a kitchen. The applicant is required to submit a food business registration and fit-out assessment application (with suitably detailed plans) to the HPS for the food business prior to construction. The applicant is advised to contact the HPS for further information.

The HPS supports the Environment Protection Authority's (EPA) endorsement of the report conducted by AECOM Australia Pty Ltd, but seeks further information regarding the results of the perfluorooctane sulphonate and perfluorooctanoic acid analysis of soil.

HPS also supports the EPA's recommendation that a site specific unexpected finds protocol be developed by a suitably qualified environmental consultant and implemented during development works at the site.

There are no other public health concerns in relation to the proposed development.

Please contact Faith Bvirakare on (02) 62059616 if you require any further information.

Yours sincerely

Conrad Barr
Executive Director
Health Protection Service

7 June 2017

B

Bvirakare, Faith (Health)

From: Bvirakare, Faith (Health)
Sent: Thursday, 15 June 2017 11:09 AM
To: [redacted]@peachandco.com.au'
Subject: PFOS & PFOA - AECOM Summary report [SEC=UNCLASSIFIED]
Attachments: AECOM summary report.pdf

Hi [redacted],

Please find attached a copy of the page in the AECOM Investigations and Site Suitability Status report the HPS referred to when they requested further information regarding PFOS & PFOA.

The report notes that analysis for PFOS & PFOA's and other CoPC's was completed by NATA accredited laboratories. The HPS is requesting that copies of the NATA laboratories results be provided to the HPS for their records noting that these compounds are regarded as emerging public health risk.

If you have any questions please do not hesitate to contact myself or our office on 6205 1700.

Kind regards

ACT Government Health
Care Excellence Collaboration Integrity

Faith Bvirakare
Public Health Officer | Environmental Health
Health Protection Service | Population Health Protection & Prevention | ACT Health
25 Mulley Street Holder ACT | Locked Bag 5005 Weston Creek ACT 2611
T 02 6205 9616 | **M** [redacted] | **E** faith.bvirakare@act.gov.au | Website |

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1508057**	Page	: 1 of 11
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Sydney
Contact	: [redacted]	Contact	: Client Services
Address	: LEVEL 2 60 MARCUS CLARKE ST CANBERRA ACT 2600	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: [redacted]@aecom.com	E-mail	: sydney@alsglobal.com
Telephone	: +61 [redacted]	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: 60339175 TASK NO 1 3 CHARNWOOD REMEDIATION	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: 60339175,TASK NO.1.3		
C-O-C number	: ----	Date Samples Received	: 09-APR-2015
Sampler	: RO	Issue Date	: 17-APR-2015
Site	: ----		
		No. of samples received	: 5
Quote number	: EN/004/14	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Descriptive Results
- Surrogate Control Limits

NATA

WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
[redacted]	[redacted]	Newcastle - Asbestos
		Sydney Organics
		Sydney Organics
		Sydney Inorganics

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Work Order	: ES1508057
Client	: AECOM Australia Pty Ltd
Project	: 60339175 TASK NO 1 3 CHARNWOOD REMEDIATION

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero, for 'TEQ 1/2LOR' are treated as half the reported LOR, and for 'TEQ LOR' are treated as being equal to the reported LOR. Note: TEQ 1/2LOR and TEQ LOR will calculate as 0.6mg/Kg and 1.2mg/Kg respectively for samples with non-detects for all of the eight TEQ PAHs.**
- **Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.**
- **EA200 Legend**
- **EA200 'Am' Amosite (brown asbestos)**
- **EA200 'Ch' Chrysotile (white asbestos)**
- **EA200 'Cr' Crocidolite (blue asbestos)**
- **EA200 'Trace' - Asbestos fibres ("Free Fibres") detected by trace analysis per AS4964. The result can be interpreted that the sample contains detectable 'respirable' asbestos fibres**
- **EA200: 'UMF' Unknown Mineral Fibres. "-" indicates fibres detected may or may not be asbestos fibres. Confirmation by alternative techniques is recommended.**
- **EA200: Asbestos Identification Samples were analysed by Polarised Light Microscopy including dispersion staining.**
- **EA200: Negative results for vinyl tiles should be confirmed by an independent analytical technique.**
- **EA200N: ALS laboratory procedures and methods used for the identification and quantitation of asbestos are consistent with AS4964-2004 and the requirements of the 2013 NEPM for Assessment of Site Contamination**
- **EA200N: Asbestos weights and percentages are not covered under the Scope of NATA Accreditation.**
  Weights of Asbestos are based on extracted bulk asbestos, fibre bundles, and/or ACM and do not include respirable fibres (if present)
  The Friable Asbestos weight is calculated from the extracted Fibrous Asbestos and Asbestos Fines as an equivalent weight of 100% Asbestos
  Percentages for Asbestos content in ACM are based on the 2013 NEPM default values.
  All calculations of percentage Asbestos under this method are approximate and should be used as a guide only.
- **PFOS and PFOA results are reported as an aggregate of linear and branched isomers.**

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Work Order : ES1508057
Client : AECOM Australia Pty Ltd
Project : 60339175 TASK NO 1 3 CHARNWOOD REMEDIATION

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	VS01	VS02	VS03	QC102	----
				Client sampling date / time	08-APR-2015 15:00	08-APR-2015 15:00	08-APR-2015 15:00	08-APR-2015 15:00	----
Compound	CAS Number	LOR	Unit		ES1508057-001	ES1508057-002	ES1508057-003	ES1508057-004	----
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		24.0	23.2	23.8	23.6	----
EA200: AS 4964 - 2004 Identification of Asbestos in bulk samples									
Asbestos Detected	1332-21-4	0.1	g/kg		No	No	No	No	----
Asbestos Type	1332-21-4	-	--		-	-	-	-	----
Sample weight (dry)	----	0.01	g		1930	1450	1550	1220	----
APPROVED IDENTIFIER:	----	-	--		G.MORGAN	G.MORGAN	G.MORGAN	G.MORGAN	----
EA200F: Friable Asbestos in Soil (non-NATA)									
Friable Asbestos	1332-21-4	0.0004	g		<0.0004	<0.0004	<0.0004	<0.0004	----
Free Fibres	----	5	Fibres		No	No	No	No	----
Friable Asbestos (as Asbestos in Soil)	1332-21-4	0.001	%		<0.001	<0.001	<0.001	<0.001	----
Weight Used for % Calculation	----	0.0001	kg		1.93	1.45	1.55	1.22	----
EG005T: Total Metals by ICP-AES									
Arsenic	7440-38-2	5	mg/kg		5	6	7	<5	----
Cadmium	7440-43-9	1	mg/kg		1	1	<1	1	----
Chromium	7440-47-3	2	mg/kg		33	36	32	33	----
Copper	7440-50-8	5	mg/kg		10	11	10	11	----
Lead	7439-92-1	5	mg/kg		25	15	13	14	----
Nickel	7440-02-0	2	mg/kg		15	13	13	17	----
Zinc	7440-66-6	5	mg/kg		20	21	19	22	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	----
EP066: Polychlorinated Biphenyls (PCB)									
Total Polychlorinated biphenyls	----	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	----
EP068A: Organochlorine Pesticides (OC)									
alpha-BHC	319-84-6	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Hexachlorobenzene (HCB)	118-74-1	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
beta-BHC	319-85-7	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
gamma-BHC	58-89-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
delta-BHC	319-86-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Heptachlor	76-44-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Aldrin	309-00-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Heptachlor epoxide	1024-57-3	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
^ Total Chlordane (sum)	----	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----

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Work Order	: ES1508057
Client	: AECOM Australia Pty Ltd
Project	: 60339175 TASK NO 1 3 CHARNWOOD REMEDIATION

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)

				Client sample ID	VS01	VS02	VS03	QC102	----
				Client sampling date / time	08-APR-2015 15:00	08-APR-2015 15:00	08-APR-2015 15:00	08-APR-2015 15:00	----
Compound	CAS Number	LOR	Unit		ES1508057-001	ES1508057-002	ES1508057-003	ES1508057-004	----
EP068A: Organochlorine Pesticides (OC) - Continued									
trans-Chlordane	5103-74-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
alpha-Endosulfan	959-98-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
cis-Chlordane	5103-71-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Dieldrin	60-57-1	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
4.4`-DDE	72-55-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Endrin	72-20-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
beta-Endosulfan	33213-65-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
^ Endosulfan (sum)	115-29-7	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
4.4`-DDD	72-54-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Endrin aldehyde	7421-93-4	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Endosulfan sulfate	1031-07-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
4.4`-DDT	50-29-3	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	----
Endrin ketone	53494-70-5	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Methoxychlor	72-43-5	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	----
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
^ Sum of DDD + DDE + DDT	----	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
EP068B: Organophosphorus Pesticides (OP)									
Dichlorvos	62-73-7	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Demeton-S-methyl	919-86-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Monocrotophos	6923-22-4	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	----
Dimethoate	60-51-5	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Diazinon	333-41-5	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Chlorpyrifos-methyl	5598-13-0	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Parathion-methyl	298-00-0	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	----
Malathion	121-75-5	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Fenthion	55-38-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Chlorpyrifos	2921-88-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Parathion	56-38-2	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	----
Pirimphos-ethyl	23505-41-1	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Chlorfenvinphos	470-90-6	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Bromophos-ethyl	4824-78-6	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Fenamiphos	22224-92-6	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Prothiofos	34643-46-4	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----

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Work Order : ES1508057
Client : AECOM Australia Pty Ltd
Project : 60339175 TASK NO 1 3 CHARNWOOD REMEDIATION

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Compound	CAS Number	LOR	Unit	Client sample ID	VS01	VS02	VS03	QC102	----
				Client sampling date / time	08-APR-2015 15:00	08-APR-2015 15:00	08-APR-2015 15:00	08-APR-2015 15:00	----
					ES1508057-001	ES1508057-002	ES1508057-003	ES1508057-004	----
EP068B: Organophosphorus Pesticides (OP) - Continued									
Ethion	563-12-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Carbophenothion	786-19-6	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Azinphos Methyl	86-50-0	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Acenaphthylene	208-96-8	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Acenaphthene	83-32-9	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Fluorene	86-73-7	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Phenanthrene	85-01-8	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Anthracene	120-12-7	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Fluoranthene	206-44-0	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Pyrene	129-00-0	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Benz(a)anthracene	56-55-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Chrysene	218-01-9	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Benzo(k)fluoranthene	207-08-9	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Benzo(a)pyrene	50-32-8	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Indeno(1.2.3.cd)pyrene	193-39-5	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Dibenz(a.h)anthracene	53-70-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Benzo(g.h.i)perylene	191-24-2	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
^ Benzo(a)pyrene TEQ (half LOR)	----	0.5	mg/kg		0.6	0.6	0.6	0.6	----
^ Benzo(a)pyrene TEQ (LOR)	----	0.5	mg/kg		1.2	1.2	1.2	1.2	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	10	mg/kg		<10	<10	<10	<10	----
C10 - C14 Fraction	----	50	mg/kg		<50	<50	<50	<50	----
C15 - C28 Fraction	----	100	mg/kg		<100	<100	<100	<100	----
C29 - C36 Fraction	----	100	mg/kg		<100	<100	<100	<100	----
^ C10 - C36 Fraction (sum)	----	50	mg/kg		<50	<50	<50	<50	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	10	mg/kg		<10	<10	<10	<10	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	10	mg/kg		<10	<10	<10	<10	----

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Work Order	: ES1508057
Client	: AECOM Australia Pty Ltd
Project	: 60339175 TASK NO 1 3 CHARNWOOD REMEDIATION

Quality Control Sample

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Compound	CAS Number	LOR	Unit	Client sample ID	VS01	VS02	VS03	QC102	----
				Client sampling date / time	08-APR-2015 15:00	08-APR-2015 15:00	08-APR-2015 15:00	08-APR-2015 15:00	----
					ES1508057-001	ES1508057-002	ES1508057-003	ES1508057-004	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued									
>C10 - C16 Fraction	>C10_C16	50	mg/kg		<50	<50	<50	<50	----
>C16 - C34 Fraction	----	100	mg/kg		<100	<100	<100	<100	----
>C34 - C40 Fraction	----	100	mg/kg		<100	<100	<100	<100	----
^ >C10 - C40 Fraction (sum)	----	50	mg/kg		<50	<50	<50	<50	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	50	mg/kg		<50	<50	<50	<50	----
EP080: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	----
Toluene	108-88-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Ethylbenzene	100-41-4	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
ortho-Xylene	95-47-6	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
^ Sum of BTEX	----	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	----
^ Total Xylenes	1330-20-7	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Naphthalene	91-20-3	1	mg/kg		<1	<1	<1	<1	----
EP231: Perfluorinated Compounds									
PFOS	1763-23-1	0.0005	mg/kg		1.30	1.06	1.92	1.30	----
PFOA	335-67-1	0.0005	mg/kg		0.0039	0.0043	0.0061	0.0048	----
6:2 Fluorotelomer sulfonate (6:2 FtS)	27619-97-2	0.005	mg/kg		<0.005	<0.005	<0.005	<0.005	----
8:2 Fluorotelomer sulfonate	39108-34-4	0.001	mg/kg		<0.001	<0.001	<0.001	<0.001	----
EP066S: PCB Surrogate									
Decachlorobiphenyl	2051-24-3	0.1	%		103	112	101	97.5	----
EP068S: Organochlorine Pesticide Surrogate									
Dibromo-DDE	21655-73-2	0.1	%		76.2	83.7	78.6	71.1	----
EP068T: Organophosphorus Pesticide Surrogate									
DEF	78-48-8	0.1	%		81.6	61.7	66.2	80.4	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	0.1	%		75.4	74.8	78.5	74.8	----
2-Chlorophenol-D4	93951-73-6	0.1	%		79.2	77.0	81.0	74.2	----
2.4.6-Tribromophenol	118-79-6	0.1	%		82.3	81.8	85.9	71.6	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	0.1	%		99.6	96.9	102	95.5	----

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Work Order	: ES1508057
Client	: AECOM Australia Pty Ltd
Project	: 60339175 TASK NO 1 3 CHARNWOOD REMEDIATION

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Client sample ID	VS01	VS02	VS03	QC102	----
				Client sampling date / time	08-APR-2015 15:00	08-APR-2015 15:00	08-APR-2015 15:00	08-APR-2015 15:00	----
					ES1508057-001	ES1508057-002	ES1508057-003	ES1508057-004	----
EP075(SIM)T: PAH Surrogates - Continued									
Anthracene-d10	1719-06-8	0.1	%		96.0	94.2	99.9	94.0	----
4-Terphenyl-d14	1718-51-0	0.1	%		96.2	94.3	99.7	93.2	----
EP080S: TPH(V)/BTEX Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		102	102	102	98.4	----
Toluene-D8	2037-26-5	0.1	%		93.7	93.2	95.8	92.5	----
4-Bromofluorobenzene	460-00-4	0.1	%		95.5	90.6	95.0	90.3	----

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Work Order : ES1508057
Client : AECOM Australia Pty Ltd
Project : 60339175 TASK NO 1 3 CHARNWOOD REMEDIATION

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID: QC300	----	----	----	----
				Client sampling date / time: 08-APR-2015 15:00	---	---	---	---
				ES1508057-005	----	----	----	----
EG020T: Total Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	---	---	---	---
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	---	---	---	---
Chromium	7440-47-3	0.001	mg/L	<0.001	---	---	---	---
Copper	7440-50-8	0.001	mg/L	<0.001	---	---	---	---
Lead	7439-92-1	0.001	mg/L	<0.001	---	---	---	---
Nickel	7440-02-0	0.001	mg/L	<0.001	---	---	---	---
Zinc	7440-66-6	0.005	mg/L	<0.005	---	---	---	---
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	---	---	---	---
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	---	---	---	---
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	---	---	---	---
Acenaphthene	83-32-9	1.0	µg/L	<1.0	---	---	---	---
Fluorene	86-73-7	1.0	µg/L	<1.0	---	---	---	---
Phenanthrene	85-01-8	1.0	µg/L	<1.0	---	---	---	---
Anthracene	120-12-7	1.0	µg/L	<1.0	---	---	---	---
Fluoranthene	206-44-0	1.0	µg/L	<1.0	---	---	---	---
Pyrene	129-00-0	1.0	µg/L	<1.0	---	---	---	---
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	---	---	---	---
Chrysene	218-01-9	1.0	µg/L	<1.0	---	---	---	---
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	---	---	---	---
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	---	---	---	---
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	---	---	---	---
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	---	---	---	---
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	---	---	---	---
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	---	---	---	---
^ Sum of polycyclic aromatic hydrocarbons	---	0.5	µg/L	<0.5	---	---	---	---
^ Benzo(a)pyrene TEQ (zero)	---	0.5	µg/L	<0.5	---	---	---	---
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	---	20	µg/L	<20	---	---	---	---
C10 - C14 Fraction	---	50	µg/L	<50	---	---	---	---
C15 - C28 Fraction	---	100	µg/L	<100	---	---	---	---
C29 - C36 Fraction	---	50	µg/L	<50	---	---	---	---

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Work Order	: ES1508057
Client	: AECOM Australia Pty Ltd
Project	: 60339175 TASK NO 1 3 CHARNWOOD REMEDIATION

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID: QC300	---	---	---	---
				Client sampling date / time: 08-APR-2015 15:00	---	---	---	---
				ES1508057-005	---	---	---	---
EP080/071: Total Petroleum Hydrocarbons - Continued								
C10 - C36 Fraction (sum)	---	50	µg/L	<50	---	---	---	---
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	---	---	---	---
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	---	---	---	---
>C10 - C16 Fraction	>C10_C16	100	µg/L	<100	---	---	---	---
>C16 - C34 Fraction	---	100	µg/L	<100	---	---	---	---
>C34 - C40 Fraction	---	100	µg/L	<100	---	---	---	---
>C10 - C40 Fraction (sum)	---	100	µg/L	<100	---	---	---	---
>C10 - C16 Fraction minus Naphthalene (F2)	---	100	µg/L	<100	---	---	---	---
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	---	---	---	---
Toluene	108-88-3	2	µg/L	<2	---	---	---	---
Ethylbenzene	100-41-4	2	µg/L	<2	---	---	---	---
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	---	---	---	---
ortho-Xylene	95-47-6	2	µg/L	<2	---	---	---	---
Total Xylenes	1330-20-7	2	µg/L	<2	---	---	---	---
Sum of BTEX	---	1	µg/L	<1	---	---	---	---
Naphthalene	91-20-3	5	µg/L	<5	---	---	---	---
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.1	%	25.5	---	---	---	---
2-Chlorophenol-D4	93951-73-6	0.1	%	57.6	---	---	---	---
2.4.6-Tribromophenol	118-79-6	0.1	%	49.1	---	---	---	---
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	58.9	---	---	---	---
Anthracene-d10	1719-06-8	0.1	%	87.5	---	---	---	---
4-Terphenyl-d14	1718-51-0	0.1	%	84.9	---	---	---	---
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	83.5	---	---	---	---
Toluene-D8	2037-26-5	0.1	%	99.6	---	---	---	---
4-Bromofluorobenzene	460-00-4	0.1	%	93.6	---	---	---	---

Analytical Results

Descriptive Results

Sub-Matrix: **SOIL**

Method: Compound	Client sample ID - Client sampling date / time	Analytical Results
EA200: AS 4964 - 2004 Identification of Asbestos in bulk samples		
EA200: Description	VS01 - 08-APR-2015 15:00	Mid orange clay soil.
EA200: Description	VS02 - 08-APR-2015 15:00	Mid orange clay soil.
EA200: Description	VS03 - 08-APR-2015 15:00	Mid orange clay soil.
EA200: Description	QC102 - 08-APR-2015 15:00	Mid orange clay soil.

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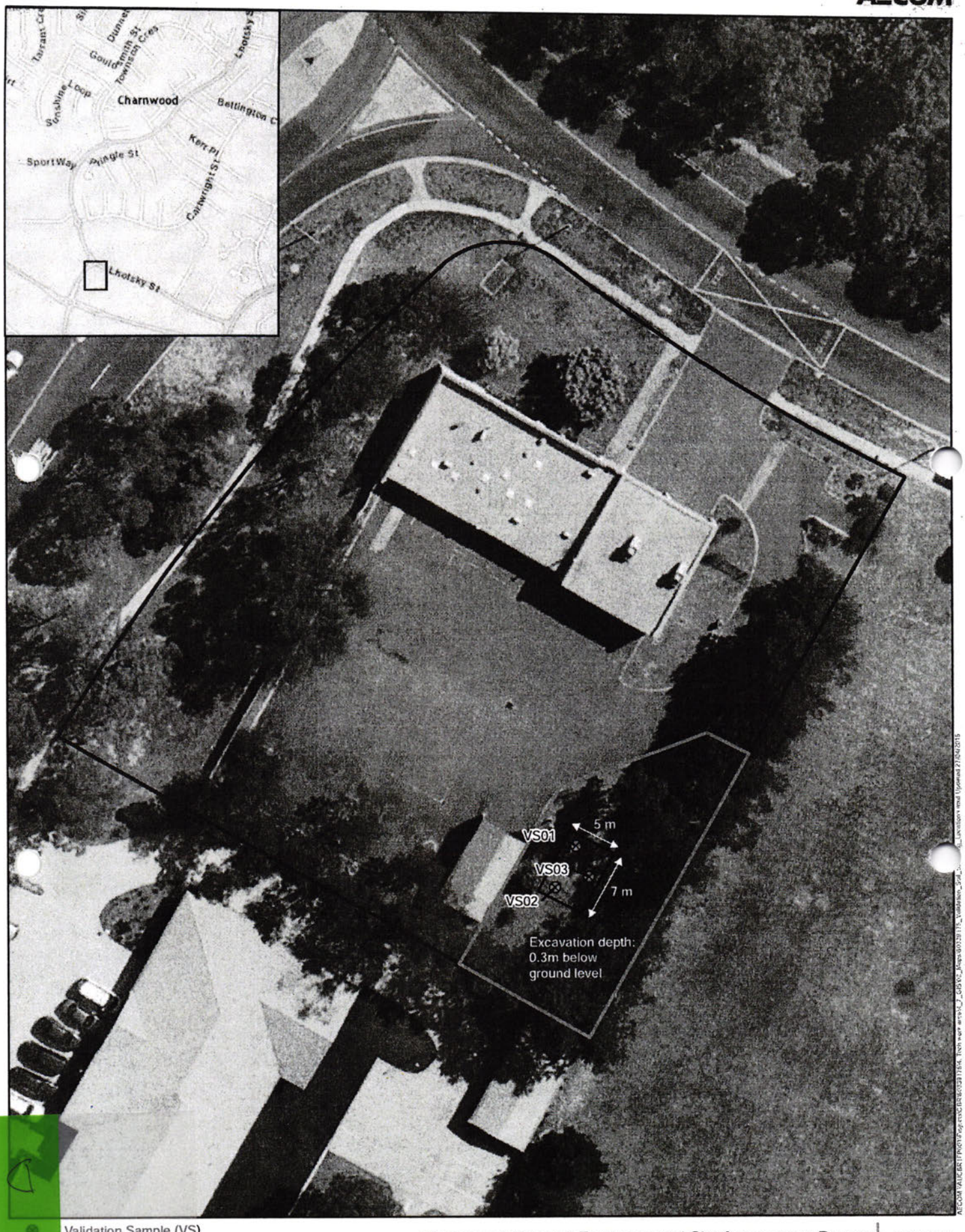
Work Order	: ES1508057
Client	: AECOM Australia Pty Ltd
Project	: 60339175 TASK NO 1 3 CHARNWOOD REMEDIATION

Surrogate Control Limits

Sub-Matrix: SOIL		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP066S: PCB Surrogate			
Decachlorobiphenyl	2051-24-3	39	149
EP068S: Organochlorine Pesticide Surrogate			
Dibromo-DDE	21655-73-2	49	147
EP068T: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	35	143
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	63	123
2-Chlorophenol-D4	93951-73-6	66	122
2.4.6-Tribromophenol	118-79-6	40	138
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	70	122
Anthracene-d10	1719-06-8	66	128
4-Terphenyl-d14	1718-51-0	65	129
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	72.8	133.2
Toluene-D8	2037-26-5	73.9	132.1
4-Bromofluorobenzene	460-00-4	71.6	130.0

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10.0	44
2-Chlorophenol-D4	93951-73-6	14	94
2.4.6-Tribromophenol	118-79-6	17	125
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	20	104
Anthracene-d10	1719-06-8	27.4	113
4-Terphenyl-d14	1718-51-0	32	112
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	71	137
Toluene-D8	2037-26-5	79	131
4-Bromofluorobenzene	460-00-4	70	128

AECOM



Validation Sample (VS)

TP05 Excavated Area

AEC 04 - Potential uncontrolled fill

Site Location

Charnwood Phase 2 Environmental Site Assessment Report
Validation Soil Sampling Locations

APR 2015
60339175

0 5 10 20 m

N

Fig. 1

Australian Government
Department of Health

E

Health Based Guidance Values for PFAS
FOR USE IN SITE INVESTIGATIONS IN AUSTRALIA

In June 2016, the Department of Health commissioned Food Standards Australia New Zealand (FSANZ) to develop final health based guidance values for perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS), which belong to a group of chemicals known as per- and poly-fluoroalkyl substances (PFAS).

The Department of Health has received FSANZ's *Hazard Assessment Report—PFOS, PFOA and PFHxS* with its recommendations for Australia's final health based guidance values.

The final health based guidance values will be used consistently in undertaking human health risk assessments across Australia. The recommended health based guidance values have replaced the Environmental Health Standing Committee's (enHealth) interim human health reference values.

The final health based guidance values are protective of human health; are a precautionary measure for use when conducting site investigations; and are to assist in providing advice to affected communities on how to minimise exposure to PFAS.

What is a health based guidance value?

Health based guidance values indicate the amount of a chemical in food or drinking water that a person can consume on a regular basis over a lifetime without any significant risk to health. Health based guidance values can be expressed as a tolerable monthly intake (TMI), a tolerable weekly intake (TWI) or a tolerable daily intake (TDI). The choice of whether a TMI, TWI or TDI is set depends on the nature of the chemical.

Health based guidance values are used by organisations and government agencies to investigate and assess potential human health risks.

Final health based guidance values for use in site investigations in Australia

FSANZ has recommended final health based guidance values for PFOS and PFOA in the form of a tolerable daily intake. A tolerable daily intake is a level of daily oral exposure over a lifetime that is considered to be without significant health risk for humans.

Based on FSANZ's recommended tolerable daily intake, the Department of Health has calculated revised drinking water quality and recreational water quality values for use in site investigations in Australia.

To determine the drinking and recreational water quality values for site investigations across Australia, the Department of Health used the final tolerable daily intakes for PFOS and PFOA and the methodology described in Chapter 6.3.3 of the National Health and Medical Research Council's *Australian Drinking Water Guidelines*. This approach is consistent with the one used by enHealth in developing the interim values in 2016.

The health based guidance values for use in site investigations in Australia are:

Toxicity reference value	PFOS/PFHxS		PFOA	
	ng	*µg*	*ng*	*µg*
Tolerable daily intake (*ng* or *µg* / *kg bw/day*)	**20**	**0.02**	**160**	**0.16**
Drinking water quality value (*ng* or *µg* /L)	**70**	**0.07**	**560**	**0.56**
Recreational water quality value (*ng* or *µg* /L)	**700**	**0.7**	**5,600**	**5.6**

Note: bw = body weight, ng = nanograms, µg = micrograms

How did FSANZ determine the health based guidance values?

The tolerable daily intake for PFOS and PFOA are derived from the results of toxicity studies in laboratory animals. FSANZ concluded that the current available epidemiological data on human health is not suitable to support the derivation of tolerable daily intake levels for PFOS and PFOA.

A pharmacokinetic modelling approach was used to extrapolate data for humans, noting that animal physiology is not the same as human.

For PFHxS, FSANZ concluded that there was not enough toxicological and epidemiological information to justify establishing a tolerable daily intake. However, as a precaution, and for the purposes of site investigations, the PFOS tolerable daily intake should apply to PFHxS. In practice, this means that the level of PFHxS exposure should be added to the level of PFOS exposure; and this combined level be compared to the tolerable daily intake for PFOS.

The tolerable daily intakes include conservative assumptions to ensure the protection of public health.

FSANZ's report and recommended health based guidance values have been nationally and internationally peer reviewed.

How will the final health based guidance values impact communities affected by PFAS contamination?

Commonwealth agencies and other organisations that conduct site investigations for PFAS contamination can use the health based guidance values to assist in assessing human health risk. Agencies or organisations that have recently conducted human health risk assessments for PFAS contamination may review their assessments and advice based on the final health based guidance values.

Advice on reducing exposure to PFAS will vary with each location so you should follow the most current advice provided by your state or territory government, and if available, the human health risk assessment for your area conducted by the investigating agency.

Further information

For further information regarding health based guidance values and the Department of Health's response to PFAS contamination, please visit the Department of Health website (health.gov.au/pfas)

Alternatively you can contact the Department of Health by phone on 1800 941 180 or by email: health.PFAS@health.gov.au

F

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Children's Behavior and Physiology and How It Affects Exposure to Environmental Contaminants

Jacqueline Moya, Cynthia F. Bearer and Ruth A. Etzel

Pediatrics 2004;113;996-1006
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Children's Behavior and Physiology and How It Affects Exposure to Environmental Contaminants

Jacqueline Moya, BS*; Cynthia F. Bearer, MD, PhD‡; and Ruth A. Etzel, MD, PhD§

ABSTRACT. Infant, child, and adolescent exposures to environmental toxicants are different from those of adults because of differences in behavior and physiology. Because of these differences, there is the potential for quantitatively different exposures at various stages of development. Pediatricians are well aware of these behavioral and physiologic differences from a clinical standpoint—namely, food and water intake, soil ingestion, mouthing behavior, inhalation physiology, and activity level—as they relate to the ratio of these parameters between the adult and the child when considering weight and surface area. Pediatricians recognized the importance of pica as a cause of lead poisoning, the noxious effect of second-hand smoke, and the greater propensity for addiction during the adolescent years. For determining the differences in impact of many environmental toxicants between adults and children, research is needed to document where and whether these differences result in deleterious effects. *Pediatrics* **2004;113: 996–1006;** ***children, behaviors, exposure, food intake, water intake, soil intake, inhalation rates, soil adherence.***

ABBREVIATIONS. EPA, Environmental Protection Agency; USDA, US Department of Agriculture; CSFII, Continuing Survey of Food Intakes by Individuals.

It is a child's job to explore his environment. The exploratory behaviors of childhood are the principal ways that children learn. The normal behavioral development of a child will also influence his or her environmental exposures. Children are naturally curious and active. Infants learn about objects by mouthing them (hand-to-mouth behaviors). Toddlers learn by venturing out of doors and testing their physical prowess. As children become adolescents, they gain more and more freedom from parental authority. They learn by trying new things (eg, smoking). Although they are at a stage of development at which physical strength and stamina are at a peak, they are continuing to acquire abstract thinking.[1] Therefore, they may not consider cause and effect, particularly delayed effects, in the same way as adults do. They may place themselves in situations with greater risk as a result of this lack of perception. Although there are tremendous benefits to the exploratory learning that occurs during childhood, it obviously has its risks.

Many factors influence children's health. These factors include genetic background, physiology, nutrition, age, lifestyle, and so forth. Parental exposures that occur before conception can also threaten the health of the fetus either because the maternal or paternal reproductive organs are affected or because chemicals can be stored in the body and excreted during pregnancy. The purpose of this article, however, is to describe the normal childhood behaviors at various life stages and illustrate the ways in which these behaviors and physiologies put them at risk of exposure to environmental contaminants.

BEHAVIORS AND PHYSIOLOGIC NEEDS AT VARIOUS LIFE STAGES

Exposure to an environmental agent is the first step in the sequence of environmentally related health effects. Exposures differ with developmental stage because the environments of fetuses, children, and adolescents are different from those of adults. On a body weight basis, children breathe more air, drink more water, and consume more of certain foods than adults. Children develop in spurts and, at times, discontinuously. For this reason, children's behavioral stages are better defined as a continuum rather than fixed age categories. There is no consistent way to define these age categories. Sometimes the categories selected are driven by the amount of data available. Experts at an Environmental Protection Agency (EPA)-sponsored workshop suggested a set of age categories that may be used while more specific data are developed.[2] Table 1 summarizes the proposed age categories and the behavioral characteristics associated with the different routes of exposure that were proposed.

This article presents data on breast milk intake, water intake, food consumption, soil intake rates, mouthing behavior, inhalation rates, soil adherence factors, and time spent in various activities. Much of the data presented was extracted from the EPA Interim Final Child-Specific Exposure Factors Handbook.[3] A literature search was conducted to identify other relevant data.

From the *US Environmental Protection Agency, National Center for Environmental Assessment, Office of Research and Development, Washington, DC; ‡Department of Pediatrics and Neurosciences, Case Western Reserve University, School of Medicine, Cleveland, Ohio; and §George Washington University, School of Public Health and Health Services, Washington, DC.
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Reprint requests to (J.M.) US Environmental Protection Agency (8623D), 1200 Pennsylvania Ave, Washington, DC 20460. E-mail: moya.jacqueline@epa.gov
The views expressed in this paper are those of the authors and do not necessarily reflect the views or policies of the US Environmental Protection Agency or the US Department of Health and Human Services.

TABLE 1. Behaviors at Various Stages of Childhood

Age Group	Behaviors Relevant to Oral and Dermal Exposure	Behaviors Relevant to Inhalation Exposure
Birth through 2 mo	Breast and bottle feeding. Hand-to-mouth activities.	Time spent sleeping/sedentary.
3 through 5 mo	Solid food may be introduced. Contact with surfaces increases. Object/hand-to-mouth activities increase.	Breathing zone close to the floor. Children spend time in day care.
6 through 11 mo	Food consumption expands. Children's floor mobility increases (surface contact). Children are increasingly likely to mouth nonfood items.	Because children become more mobile and their breathing zone is close to the floor, they may generate and be exposed to dust clouds that contain particulate matter. Children spend time in day care.
12 through 23 mo	Children consume full range of foods. They participate in increased play activities, are extremely curious, and exercise immature judgment. Breast and bottle feeding may cease.	Children walk upright, run, and climb. They occupy a wider variety of breathing zones and engage in more vigorous activities. Children spend time in day care (or preschool/early education).
2 through 5 y	Hand-to-mouth activities begin to moderate.	Occupancy of outdoor spaces increases.
6 through 10 y	There is decreased oral contact with hands and objects as well as decreased dermal contact with surfaces.	Children spend time in school environments and begin playing sports.
11 through 15 y	Smokeless tobacco use may begin. There is an increased rate of food consumption.	Increased independence (more time out of home). Workplace exposure can begin. May begin cigarette smoking.
16 through 20 y	High rate of food consumption begins.	Independent driving begins. Expanded work opportunities. Smoking may begin.

Adapted from USEPA.[2]

EXPOSURE DATA RELEVANT TO CHILDREN'S BEHAVIOR AND PHYSIOLOGY

Breast Milk Intake

The diets of many newborns are limited to breast milk. The American Academy of Pediatrics advocates breastfeeding as the optimal form of nutrition for infants.[4] Epidemiologic research shows that breast milk and breastfeeding of infants provide advantages with regard to general health, growth, and development while significantly decreasing risk for a large number of acute and chronic diseases.[4]

Breast milk, however, can be a potential source of exposure to toxic chemicals for nursing infants. This is especially true because breastfed infants are at the top of the food chain.[5] Certain chemicals can accumulate in the mother's fatty tissue and may be transferred to an infant during breastfeeding. Studies of breast milk have shown the presence of chlorinated organic contaminants such as polychlorinated biphenyls and dioxins.[6–8] Breast milk contains fat in which these chemicals tend to accumulate.[6] Estimating exposure via this route requires information about the amount of breast milk intake. Average breast milk intake rates range from 427 mL/day to 765 mL/day for children <1 year of age.[9–14] Upper percentile values range from 900 mL/day to 1059 mL/day. Information on the fat content of breast milk may also be necessary to assess exposure when chemical concentrations are indexed to lipid content. Lipid content in breast milk is approximately 4%.[11–16] Although some mothers breastfeed beyond 12 months, data on the prevalence of this behavior or the amount consumed by the child are not currently available.

Food Intake

Toxic chemicals may enter the food supply as a result of environmental contamination. The consumption of a wide variety of foods minimizes the chance of eating large amounts of a particular food that may be contaminated. However, a child's eating habits differ from those of an adult in the choices of food and amounts of a particular food item eaten. As another example, food neophobia, initial reluctance to eat new foods, is a normal behavior among young children. Children with neophobia had a higher intake of saturated fat and less food variety than children without food neophobia.[17]

Also, for many foods, the intake per unit body weight is greater for children than adults. The diet of children contains more milk products and more fruits and vegetables per unit body weight than adults. The primary source of food consumption data are the US Department of Agriculture's (USDA's) Nationwide Food Consumption Survey and the USDA Continuing Survey of Food Intakes by Individuals (CSFII). Analysis of these data shows that, for example, the average consumption of apples for children between birth and 5 months of age is 19 g/kg/day (consumers only). Because the data were broken out by specific age groups and infants at birth are not likely to eat apples, the average apple consumption will probably be higher if one only looks at a finer age group (eg, 3 to 5 months of age). Adults older than 20 years consume approximately 2 g/kg/day of apples (consumers only). When the level of exposure of children to Alar was calculated using a child's daily consumption of apples and apple products, an unacceptable level of risk for cancer was found.[18] This section summarizes food intake data obtained from an EPA analysis of the most recent USDA CSFII (1994–1996). Although data from the 1998 CSFII survey are available, analysis of these data has not been conducted. Table 2 summarizes the per capita consumption of the major food groups. Data for adults older than 20 years are also included for comparison purposes. Definitions of the major food groups can be found in Appendix 1. Table 3 focuses on individual food items that at least 10% of the children in the survey reported having eaten. It is

TABLE 2. Per Capita Intake of the Major Food Groups (g/kg/day as Consumed)

Population Group	Unweighted No. of Observations	% Consuming	Mean	SE	P5	P25	P50	P75	P95	P100
Fruits (age; y)										
<1	359	56.8%	13.2	1.1	0	0	7.6	22.7	41.2	110.2
1–2	1,356	85.5%	19.3	0.52	0	6.4	15.5	27.5	53.9	125.3
3–5	1,435	79.0%	11	0.34	0	2.3	8.1	16.3	32.7	105.2
6–11	1,432	71.2%	5.4	0.2	0	0	3.4	7.9	18	44.6
12–19	1,398	60.7%	2.8	0.13	0	0	1.4	4.1	11	32.2
>20	9,323	69.7%	2.4	0.07	0	0.22	1.5	3.5	8.1	39.9
Vegetables (age; y)										
<1	359	50.1%	6.9	0.72	0	0	2.3	12.2	24.1	102.6
1–2	1,356	95.4%	9.5	0.21	0.57	4.5	8	12.6	23.3	83.3
3–5	1,435	92.7%	7.3	0.16	0	3.4	6.2	9.7	18.3	45.5
6–11	1,432	93.2%	5.4	0.12	0	2.5	4.3	7.1	13.5	52.3
12–19	1,398	97.9%	4	0.09	0.63	2.1	3.4	5.1	9.3	42.4
>20	9,323	97.7%	4.1	0.06	0.64	2.2	3.6	5.4	9.1	31.9
Grains (age; y)										
<1	359	64.9%	4.1	0.42	0	0	1.6	5.4	20.2	40.1
1–2	1,356	95.6%	11.2	0.2	1.7	6.4	9.8	14.3	24.7	48
3–5	1,435	93.1%	10.3	0.2	0	6.3	9.2	13.1	21.1	120.9
6–11	1,432	93.4%	7.2	0.12	0	4.3	6.7	9.4	15.6	36.3
12–19	1,398	98.2%	4.4	0.08	1.1	2.5	3.8	5.5	9.7	34.6
>20	9,323	98.0%	3.3	0.04	0.69	1.8	2.9	4.3	7.5	23.2
Meats (age; y)										
<1	359	32.3%	1.1	0.2	0	0	0	1.4	5.9	12.4
1–2	1,356	94.0%	4.4	0.09	0	1.9	3.8	6.2	10.2	24.4
3–5	1,435	92.2%	4.1	0.08	0	2.1	3.8	5.6	9.4	20.7
6–11	1,432	92.4%	2.9	0.06	0	1.4	2.5	4	6.8	17.6
12–19	1,398	97.3%	2.2	0.05	0.27	1.1	1.9	2.8	4.9	26.8
>20	9,323	96.4%	1.7	0.02	0.16	0.88	1.5	2.2	3.8	12
Fish (age; y)										
<1	359	20.9%	0.11	0.05	0	0	0	0	0.53	4.7
1–2	1,356	58.2%	0.37	0.04	0	0	0.08	0.29	1.8	14.4
3–5	1,435	56.4%	0.32	0.03	0	0	0.07	0.25	1.7	9.6
6–11	1,432	57.5%	0.26	0.03	0	0	0.06	0.18	1.3	6.7
12–19	1,398	62.9%	0.2	0.02	0	0	0.06	0.17	1.1	5.4
>20	9,232	68.3%	0.24	0.01	0	0	0.06	0.18	1.2	8.1
Dairy products (age; y)										
<1	359	83.6%	111.4	4.9	0	63.9	102.2	158.6	235.3	576.3
1–2	1,356	95.7%	37.5	0.78	0.41	17.8	31.8	51.4	90.2	182.8
3–5	1,435	92.9%	20.9	0.4	0	10.2	18.7	29.2	48.8	89.7
6–11	1,432	93.3%	13.9	0.28	0	6.4	12.4	19.3	33.5	80.8
12–19	1,398	96.9%	6.2	0.16	0.17	1.8	4.5	8.8	17.8	38
>20	9,323	96.4%	3.3	0.07	0.08	0.82	2.4	4.7	9.8	37.8

SE indicates standard error; P, percentile of the distribution. Based on EPA's analyses of the 1994–1996 CSFII.[3]

important to note that the CSFII survey is conducted over a period of 2 nonconsecutive days and is based on a 24-hour recall. Therefore, these estimates of intake may not reflect long-term consumption patterns.

Tap Water Intake

Microbiologic and chemical contaminants can enter water supplies. Tap water may be a source of human exposure to these contaminants. The source of the pollution can be the result of human activity or naturally occurring chemicals. Contaminants may enter water sources by seeping through the soil to the ground water or entering streams as surface runoff. For instance, fertilizers and pesticides used in agricultural sites can migrate in the runoff from crops and contaminate sources of drinking water. Waste disposal sites can contaminate sources of drinking water through surface runoff or through infiltration to the ground water. In addition, animal wastes may be carried to lakes and streams by rainfall runoff or snow melt.

Consumption of drinking water may vary depending on levels of physical activity and changes in temperature and humidity. On a body weight basis, children drink more water than adults. For instance, the mean consumption rate of tap water by adults 20 years old and older is approximately 17 mL/kg/day. Tap water intake for children younger than 6 months is approximately 88 mL/kg/day. Table 4 presents tap water intake for various age groups. These values are based on consumers only and represent plain water directly ingested by the individual and indirect water that was added to foods and beverages during final preparation at home or by local food service establishments (eg, school cafeterias, restaurants).[19] For this reason, these values exclude infants who are completely breastfed and infants who drink ready-to-use formula and are not consuming any tap water. Indirect water does not include water that was added by the manufacturer during processing of a food or water that is intrinsic in food.

TABLE 3. Per Capita Intake of Individual Food (g/kg/day as Consumed)[3]

Population Group (Age; Years)	Apples			Bananas			Carrots			Corn			Cucumbers		
	% Consuming	Mean	SE	% Consuming	Mean	SE	% Consuming	Mean	SE	% Consuming	Mean	SE	% Consuming	Mean	SE
0–5 mo	24.3%	4.7	1.7	8.0%	0.38	0.33	7.9%	0.68	0.7	0.0%	0	0	0.0%	0	0
6–12 mo	64.4%	9.7	1.2	39.2%	2	0.52	18.5%	0.67	0.35	8.4%	0.35	0.51	0.2%	0	0.02
<1	43.1%	7	0.98	22.6%	1.2	0.34	12.9%	0.68	0.35	3.9%	0.16	0.36	0.1%	0	0.01
1–2	55.0%	8	0.45	34.7%	1.7	0.14	14.7%	0.34	0.18	17.6%	0.46	0.1	6.9%	0.09	0.05
3–5	47.2%	4.1	0.27	21.0%	0.71	0.1	15.2%	0.18	0.04	18.6%	0.43	0.07	11.6%	0.13	0.06
6–11	34.7%	1.4	0.14	15.4%	0.35	0.07	19.4%	0.15	0.03	20.8%	0.32	0.05	15.0%	0.12	0.04
12–19	21.3%	0.58	0.09	9.5%	0.12	0.04	12.9%	0.06	0.02	12.9%	0.14	0.04	15.6%	0.09	0.04
>20	22.2%	0.38	0.04	26.1%	0.28	0.02	20.0%	0.09	0.01	14.7%	0.12	0.04	20.0%	0.07	0.01
	Lettuce			Onions			Peaches			Pears			Peas		
0–5 mo	0.0%	0	0	0.0%	0	0	5.3%	0.28	0.45	12.9%	0.93	0.67	7.3%	0.28	0.39
6–12 mo	0.0%	0	0	0.5%	0.01	0.2	23.3%	1.5	0.58	25.9%	1.8	0.71	20.9%	0.97	0.46
<1	0.0%	0	0	0.3%	0.01	0.14	13.7%	0.86	0.39	19.0%	1.4	0.49	13.7%	0.6	0.31
1–2	12.4%	0.11	0.04	3.9%	0.02	0.02	9.7%	0.45	0.15	9.0%	0.39	0.16	12.0%	0.26	0.07
3–5	19.8%	0.17	0.03	4.8%	0.02	0.02	6.5%	0.25	0.12	4.7%	0.18	0.11	10.1%	0.16	0.05
6–11	24.7%	0.18	0.03	6.5%	0.03	0.02	5.5%	0.13	0.08	5.1%	0.11	0.07	8.4%	0.11	0.05
12–19	35.9%	0.18	0.02	13.5%	0.04	0.02	4.5%	0.06	0.05	1.8%	0.02	0.04	5.5%	0.06	0.04
>20	42.0%	0.07	0.01	23.4%	0.06	0.01	7.3%	0.08	0.03	4.7%	0.06	0.03	11.6%	0.11	0.03
	Snap Beans			Tomatoes			White Potatoes			Breads			Breakfast Foods (Grains)		
0–5 mo	5.1%	0.26	0.43	4.6%	0.16	0.36	7.4%	0.12	0.19	0.9%	0.1	0.08	0.0%	0	0
6–12 mo	26.7%	1	0.36	66.2%	0.93	0.12	62.1%	1	0.21	30.2%	0.53	0.16	4.2%	0.1	0.24
<1	15.2%	0.62	0.27	33.5%	0.52	0.12	33.0%	0.54	0.15	14.6%	0.26	0.11	1.7%	0.05	0.16
1–2	20.1%	0.49	0.09	88.9%	2.1	0.08	77.3%	2.2	0.1	77.2%	2	0.06	20.4%	0.43	0.07
3–5	15.6%	0.24	0.05	88.3%	1.7	0.06	78.2%	2	0.09	86.5%	2.3	0.05	20.8%	0.39	0.06
6–11	12.0%	0.16	0.06	90.2%	1.2	0.04	79.2%	1.5	0.06	87.1%	1.7	0.04	23.7%	0.37	0.05
12–19	7.9%	0.06	0.02	95.1%	1	0.03	84.9%	1.2	0.05	86.2%	1.1	0.03	13.0%	0.13	0.03
>20	15.8%	0.12	0.02	90.7%	0.82	0.02	83.0%	0.89	0.02	89.9%	0.94	0.02	9.6%	0.07	0.02
	Baby Cereals			Cereals (Cooked)			Cereals (Ready-to-Eat)			Pasta			Rice		
0–5 mo	40.8%	0.83	0.24	0.9%	.05	.54	0.0%	0	0	0.0%	0	0	0.2%	0.01	0.24
6–12 mo	67.8%	2.5	0.45	16.6%	1.9	1.2	19.9%	0.13	0.07	7.5%	0.14	0.22	9.2%	0.35	0.42
<1	53.4%	1.6	0.27	8.3%	0.93	0.82	9.3%	0.06	0.05	3.5%	0.07	0.15	4.4%	0.17	0.28
1–2	6.2%	0.16	0.1	18.4%	1.6	0.29	64.9%	0.97	0.04	16.0%	0.8	0.15	19.2%	0.91	0.17
3–5	0.3%	0	0.06	16.0%	1.3	0.28	69.8%	1.1	0.04	12.8%	0.55	0.13	17.0%	0.8	0.18
6–11	0.1%	0	0	8.7%	0.47	0.17	64.0%	0.79	0.03	13.4%	0.49	0.12	15.8%	0.49	0.1
12–19	0.0%	0	0	5.6%	0.16	0.09	45.7%	0.36	0.02	11.7%	0.26	0.09	17.1%	0.46	0.11
>20	0.0%	0	0	14.1%	0.32	0.01	36.7%	0.2	0.01	12.2%	0.22	0.04	17.0%	0.34	0.06
	Snacks (Grains)			Sweets (Grains)			Beef								
0–5 mo	1.0%	0.02	0.11	2.5%	0.01	0.04	5.3%	0.07	0.1						
6–12 mo	29.0%	0.27	0.08	23.0%	0.32	0.14	66.6%	1	0.15						
<1	14.1%	0.14	0.06	12.1%	0.16	0.1	34.0%	0.51	0.11						
1–2	58.1%	0.74	0.04	53.2%	1.2	0.07	88.9%	1.4	0.05						
3–5	56.7%	0.7	0.04	62.1%	1.3	0.06	86.7%	1.3	0.04						
6–11	51.3%	0.46	0.03	64.2%	1.2	0.06	88.7%	1.1	0.04						
12–19	45.0%	0.29	0.02	54.3%	0.62	0.03	93.3%	0.92	0.03						
>20	40.0%	0.14	0	52.9%	0.48	0.02	86.8%	0.66	0.01						
	Pork			Poultry			Eggs								
0–5 mo	4.6%	0.01	0.01	4.6%	0.03	0.05	5.5%	0.02	0.07						
6–12 mo	68.5%	0.19	0.04	70.6%	0.72	0.15	66.6%	0.84	0.21						
<1	34.6%	0.09	0.03	35.5%	0.35	0.1	34.1%	0.41	0.14						
1–2	86.6%	0.4	0.03	89.9%	1.4	0.05	88.6%	1.2	0.06						
3–5	84.4%	0.38	0.02	89.0%	1.3	0.05	84.8%	0.7	0.04						
6–11	85.9%	0.27	0.02	88.5%	0.83	0.03	86.1%	0.4	0.03						
12–19	90.9%	0.21	0.01	94.1%	0.62	0.02	91.6%	0.29	0.02						
>20	86.0%	0.2	0.01	87.9%	0.48	0.01	85.9%	0.28	0.01						

Based on EPA's analyses of the 1994–1996 CSFII.[3]

TABLE 4. Estimate of Direct and Indirect Community Water Ingestion, Consumers Only[19]

Age, Years	Sample Size	Mean	Water Intake, Percentile (mL/kg/day)				
			5th	25th	50th	75th	95th
<0.5	106	88	5*	27	85	131	204*
0.5–0.9	128	56	3*	14	52	83	127*
1–3	1548	26	2	9	20	35	68
4–6	1025	23	2	9	18	31	65
7–10	820	16	1	6	12	22	39
11–14	736	13	1	5	10	17	36
15–19	771	12	1	4	9	16	32

Source of Data: 1994–1996 USDA CSFII.
* Sample size was insufficient for minimum reporting requirements according to "Third Report on Nutritional Monitoring in the U.S. (1994-96)."

Soil Intake

Children often put their hands, toys, and other objects in their mouths during normal exploration of their environment. This hand-to-mouth or object-to-mouth behavior may result in the ingestion of soil and dust. This behavior may present a risk to children when the soil and dust are contaminated. Children with "pica"—the habitual eating of nonfood objects—are at even greater risk as they may consume larger amounts of soil per day. To set soil cleanup standards, health officials need data on the amount of soil expected to be ingested by a child. Soil intake studies of young children have been conducted using methods that measure trace elements in feces and soil that are believed to be poorly absorbed in the gut. These measurements are used to estimate the amount of soil ingested over a specified time period by doing a mass balance using the measured amounts of tracer elements found in the various media. Soil ingestion studies conducted thus far included children between 2 and 6 years of age. Although children younger than 2 years are of concern because they are more likely to display hand-to-mouth behavior, data for this age group do not exist. Likewise, data do not exist for children older than 6 years. In addition, these studies have not been able to differentiate successfully between ingestion of soil and ingestion of dust. Children with pica may exhibit unusually high levels of soil ingestion. Data on ingestion rates by children with pica are very limited, and the behavior is considered to be relatively uncommon.

Children's mean soil ingestion values ranged from 39 mg/day to 271 mg/day with an average of 138 mg/day for soil ingestion and 193 mg/day for soil and dust ingestion.[20–25] Upper percentile values ranged from 104 mg/day to 1432 mg/day with an average of 358 mg/day for soil and 790 mg/day for soil and dust combined.[20–25] Limitations of these data do not permit the derivation of a distribution of soil intake rates by children. Individuals were not studied for sufficient periods of time to get a good estimate of long-term behavior. In addition, inconsistencies among tracers and input/output misalignment errors indicate a fundamental problem with the methods currently used to estimate soil intake rates.

Mouthing Behavior

Young children, during normal exploration of their environment, mouth objects or their fingers.[26] Children play close to the ground and are constantly licking their fingers or mouthing toys or objects. This mouthing behavior may result in exposure to toxic chemicals in the environment. For example, pesticide residues that have been transferred from treated surfaces to the hands or objects may be mouthed by children. This route of exposure may exceed other ingestion routes (eg, food, pica, drinking water, breast milk) and dermal exposure because nondietary ingestion may result in higher ingestion rates of contaminated material.[27] In addition, because young children spend a lot of time indoors, contaminants that are deposited on surfaces in the home may be a concern. Mouthing behavior is intermittent and nonuniform, which makes it difficult to measure and model.[28] For this reason, data on mouthing behavior are limited.

Some researchers express mouthing behavior in terms of frequency of occurrence (eg, contacts/hour, contacts/min). Others express mouthing behavior as a rate in units of minutes per hour of mouthing time. Four studies have examined mouthing behavior in children (Table 5).

Inhalation Rates

Infants and young children have a higher resting metabolic rate and rate of oxygen consumption per unit body weight than adults because they have a larger surface per unit body weight and because they are growing rapidly. Therefore, their exposure to any air pollutant may be greater. An additional consideration is the smaller lung surface area/kg in the early stages of development. Thus, the higher amount of inspired air will affect a relatively smaller area of lung tissue.

Although oxygen consumption is a physiologic factor, it is affected by the level of activity. The oxygen consumption of a resting infant aged between 1 week and 1 year is 7 mL/kg body weight per minute. The rate for an adult under the same conditions is 3 to 5 mL/kg/min.[29] Thus, on a body weight basis, the volume of air passing through the lungs of a resting infant is twice that of a resting adult under the same conditions, and therefore twice as much of any chemical in the atmosphere could reach the lungs of an infant. In addition to an increased need for oxygen relative to their size, children have narrower airways than those of adults. Thus, irritation caused by air pollution that would produce only a

TABLE 5. Summary of Mouthing Behavior Data

Age	No. of Children	Mouthing Frequency/Time	Reference
3–6 mo	5	1 min/d	Groot et al[26]
6–12 mo	14	44 min/d	
12–18 mo	12	16 min/d	
18–36 mo	11	9 min/d	
2–6 y		9.5 contacts/h (hand to mouth)	Reed et al[47]
	30	16.3 contacts/h (object to mouth)	
2.5–4.2 y	4	9 contacts/h	Zartarian[28]
10–60	92	55 min/d	US EPA[3]
<24	30	76 ± 5 contacts/h	
>24	56	38 ± 3 contacts/h	

slight response in an adult can result in potentially significant obstruction in the airways of a young child. In addition, they often spend more time engaged in vigorous activities than adults.[30] Table 6 summarizes studies conducted in California. Layton[31] calculated breathing rates on the basis of oxygen consumption associated with energy expenditures. Energy expenditures were obtained from data collected in the USDA 1977–1978 food consumption survey. Table 7 summarizes inhalation rate data for various age categories. These data represent average values for the US population.

Soil Adherence

Children may be involved in several activities that may put them in contact with soil and dust. In addition to the ingestion and inhalation of soil and dust particles, children may be exposed to soil and dust through the dermal route. Soil can adhere to the skin, and contaminants found in soil can penetrate the dermal barrier. Although soil adherence itself is not a behavior, studies show that soil adherence is highly dependent on the type of activity[3,32–35] (see Table 8). Soil adherence is expressed in units of milligrams of

TABLE 6. Summary of Inhalation Rate Studies Conducted in California

Age Group	Location	Activity Level	Inhalation Rate				
			Mean (m^3/h)	50th (m^3/h)	99th (m^3/h)	Average Daily (m^3/day)	Study
Healthy		Slow	0.84		1.98		Linn et al[48]
Elementary school		Medium	0.96				
		Fast	1.14				
		Mean	0.90				
High school		Slow	0.78		2.22		
		Medium	1.14				
		Fast	1.62				
		Mean	0.84				
Asthmatics		Slow	1.2		2.40		
Elementary and high school		Medium	1.2				
		Fast	1.5				
		Mean	1.2				
10–12 y	Indoor	Slow	0.84	0.78	2.34*	21.4† (mean)	Spier et al[49]
		Medium	0.96	0.84	2.58*	19.3† (50th)	
		Fast	1.02	0.84	3.42*	64† (99.9th)	
	Outdoor	Slow	0.96	0.78	4.32*		
		Medium	1.08	0.96	3.36*		
		Fast	1.14	0.96	3.60*		
13–17 y	Indoor	Slow	0.78	0.72	3.24*	19.9† (mean)	
		Medium	0.96	0.84	4.02*	18.2† (50th)	
		Fast	1.26	1.08	6.84*	85.5† (99.9th)	
	Outdoor	Slow	0.96	0.90	5.28*		
		Medium	1.26	1.08	5.70*		
		Fast	1.44	1.02	5.94*		
3–5.9 y		Resting	0.37				Adams[50]
		Sedentary	0.40				
		Light	0.65				
6–12.9 y		Resting	0.45				
		Sedentary	0.47				
		Light	0.95				
		Moderate	1.74				
		Heavy	2.23				
<12 y						0.452‡	OEHHA[51]
						0.581*§	

* 99.9th percentile.
† Calculated using data on hours spent at each activity and inhalation rates for each activity type.
‡ m^3/kg/day.
§ High end.

TABLE 7. Summary of Mean Daily and Activity-Specific Inhalation Rates

Population	Mean*
Daily	
Infants	
<1 y	4.5 m³/day (0.54 m³/kg/day)
Children	
1–2 y	6.8 m³/day (0.56 m³/kg/day)
3–5 y	8.3 m³/day (0.48 m³/kg/day)
6–8 y	10 m³/day (0.40 m³/kg/day)
9–11 y	
Boys	14 m³/day (0.39 m³/kg/day)
Girls	13 m³/day (0.35 m³/kg/day)
12–14 y	
Boys	15 m³/day (0.28 m³/kg/day)
Girls	12 m³/day (0.22 m³/kg/day)
15–18 y	
Boys	17 m³/day (0.24 m³/kg/day)
Girls	12 m³/day (0.20 m³/kg/day)
Activity specific	
Children (18 y and under)	
Rest	0.3 m³/h
Sedentary activities	0.4 m³/h
Light activities	1.0 m³/h
Moderate activities	1.2 m³/h
Heavy activities	1.9 m³/h

Source: Layton.[31]
* Converted to body weight basis using data from US EPA.[3]

soil divided by surface area of the skin exposed. Experiments to determine soil loadings have been conducted on children engaged in various physical activities. These activities can be grouped into some general classes of low, moderate, or high soil contact. In general, the hands have the highest soil loadings. Likewise, activities involving high soil contact with wet soil result in high soil loadings. Exposure to environmental contaminants may be reduced by handwashing after active play outdoors.

Activity Factors

When considering exposures, one must look at the exposures of an individual over the course of time. Children move through several environments during the course of a day: going to school, going to child care, going to play, and sleeping. What is needed is a sum total of all of the exposures and/or an idea of the total exposure, but we are usually not able to put monitors on children to measure their total exposure. Usually our estimates of exposure are from retrospective estimates.

Understanding children's activity patterns and time spent in various microenvironments is important to understand exposure to potentially harmful environmental pollutants. Microenvironment is defined as the location that the child occupies (eg, indoors, outdoors, home, school). The physical location of children changes as they grow. The newborn frequently spends more time in a single environment for prolonged periods of time (eg, a crib) rather than in several different environments. Infants and toddlers are frequently placed on the floor, carpet, or grass. Therefore, they may have much more exposure to chemicals associated with these surfaces, such as formaldehyde and volatile organic chemicals from synthetic carpet and pesticide residues from flea bombs.[36,37] In addition, the breathing zone for an adult is typically 4 to 6 feet above the floor. However, for a child, it will be closer to the floor and dependent on the height and mobility of the child. Within lower breathing zones, chemicals that are heavier

TABLE 8. Geometric Mean and Geometric Standard Deviations of Soil Adherence by Activity and Body Region

Activity	*N*	Postactivity Dermal Soil Loadings (mg/cm²)*				
		Hands	Arms	Legs	Faces	Feet
Indoor						
Tae Kwon Do	7	0.0063	0.0019	0.0020		0.0022
		(1.9)	(4.1)	(2.0)		(2.1)
Indoor kids no. 1	4	0.0073	0.0042	0.0041		0.012
		(1.9)	(1.9)	(2.3)		(1.4)
Indoor kids no. 2	6	0.014	0.0041	0.0031		0.0091
		(1.5)	(2.0)	(1.5)		(1.7)
Daycare kids no. 1a	6	0.11	0.026	0.030		0.079
		(1.9)	(1.9)	(1.7)		(2.4)
Daycare kids no. 1b	6	0.15	0.031	0.023		0.13
		(2.1)	(1.8)	(1.2)		(1.4)
Daycare kids no. 2	5	0.073	0.023	0.011		0.044
		(1.6)	(1.4)	(1.4)		(1.3)
Daycare kids no. 3	4	0.036	0.012	0.014		0.0053
		(1.3)	(1.2)	(3.0)		(5.1)
Outdoor						
Soccer no. 1	8	0.11	0.011	0.031	0.012	
		(1.8)	(2.0)	(3.8)	(1.5)	
Gardeners no. 1	8	0.20	0.050	0.072	0.058	0.17
		(1.9)	(2.1)	—	(1.6)	—
Archeologists	7	0.14	0.041	0.028	0.050	0.24
		(1.3)	(1.9)	(4.1)	(1.8)	(1.4)
Kids-in-mud no. 1	6	35	11	36		24
		(2.3)	(6.1)	(2.0)		(3.6)
Kids-in-mud no. 2	6	58	11	9.5		6.7
		(2.3)	(3.8)	(2.3)		(12.4)

Sources: Kissel et al,[34] Holmes et al.[35]
* Geometric means (first row) and geometric standard deviation (second row in parentheses).

TABLE 9. Summary of Mean Time Spent Indoors and Outdoors From Several Studies

Age (Years)	Time Indoors (Hours/Day)	Time Outdoors (Hours/Day)*	Population	Study
3–5	19	2.8	US population; children were studied during school months (n = 922)	Timmer et al[52]
6–8	20	2.2		
9–11	20	1.8		
12–14	20	1.8		
15–17	19	1.9		
12 and older	21 (national)	1.2 (national)	Children in California were studied (n = 1762) and compared with national data (n = 2762)	Robinson and Thomas[53]
	21 (California)	1.4 (California)		
0–2	20	4	Children in California were studied (n = 1200)	Wiley[54]
3–5	18.8	5.2		
6–8	19.7	4.4		
9–11	19.9	4.1		
1–4	—	6	US population (n = 1789)	Tsang and Kleipeis[55]
5–11	—	6		
12–17	—	5		

* Mean of weekday and weekend rounded up to 2 significant figures.

than air, such as mercury vapor, may concentrate.[38] This is 1 factor that may have accounted for a case of acrodynia in a Michigan child who was exposed to mercury vapor from latex house paint.[39]

Preambulatory children also may experience sustained exposure to noxious agents because they cannot remove themselves from their environment. An example is the infant who is badly sunburned as a result of the inability to protect him- or herself. It has been shown that the risk of skin cancer is most closely related to the amount of sun damage that the skin sustains during the first 18 years of life.[40]

Certain activities and behaviors specific to children place them at higher risk of exposure to certain environmental agents.[41] An activity or time spent will vary on the basis of culture, hobbies, location, gender, age, and personal preferences. It is difficult to collect/record accurately data on a child's activity patterns.[42] Because children engage in more contact activities than adults, a much wider distribution of activities needs to be considered when assessing exposure.[42] Behavioral patterns and preferred activities result in different exposures for children in different developmental stages.[41]

This section summarizes information on various activities, length of time spent performing these activities, and locations and length of time spent by individuals within those various microenvironments. We focus on those activities that are deemed the most important in assessing children's exposures. Young children spend most of their time indoors at home.[3] Because infants and toddlers spend a significant amount of time in the house, they may use only 1 source of tap water. Information about the amount of time spent indoors is necessary to assess exposures related to indoor air environments. Older children spend a significant part of their lives at school. Schools are frequently near highways (auto emissions and lead), under power lines (electromagnetic fields), or on old industrial sites (benzene, arsenic). Schools made frequent use of asbestos as a building material and commonly use pesticides for ground and building management.[43] Because child care facilities range from private homes to institutional facilities and the environments of child care facilities are less regulated than schools, little is known about these physical environments.

Adolescents not only have a new school environment but also begin to self-determine physical environments, often misjudging or ignoring the risks to themselves.[44] In addition, many adolescents have part-time jobs that place them in physical environments that may be hazardous as a result of occupational exposures.[45]

Other activities, such as time spent showering, bathing, swimming, and playing in grass or gravel, may also be important. Because young children tend to take baths rather than showers and bathing generally takes more time than showering, their exposure may be higher because the duration may be longer. Swimming may be another source of dermal, inhalation, and ingestion exposures. Water may be inadvertently swallowed during swimming. Children may be exposed to chemicals found in swimming pools or contaminants found in water bodies.

A comprehensive list of activities, locations, and length of time spent on these activities is available.[3] Several studies have been conducted to obtain data on children's time use. Most of these studies have been done using time diary methods. Tables 9 and 10 provide a summary of a selected group of activities in which children are engaged. Activities can vary significantly with differences in age.

DATA GAPS AND CONCLUSIONS

Although much information is available in the published literature and there has been a recent increased emphasis on children's environmental research, large data gaps still exist. For example, fetal exposure may occur through maternal exposure to environmental chemicals as substances cross the placenta.[46] Exposure factors data related to fetal exposures are limited. Other areas in which research related to childhood exposures is needed are[3]

- Breast milk consumption and the incidence and duration of breastfeeding

TABLE 10. Summary of Data on Activity Factors

Type	Value			Study
Time indoors	At residence			
	Age, y	Mean, h	95th percentile, h	Tsang and Klepeis[55]
	1–4	20	24	
	5–11	17	24	
	12–17	16	23	
	Total time indoors			
	Ages	Mean, h*		Timmer et al[52]
	3–5	19		
	6–8	20		
	9–11	20		
	12–14	20		
	15–17	19		
Time outdoors	At residence			
	Age, y	Mean, h	95th percentile, h	Tsang and Klepeis[55]
	1–4	3	9	
	5–11	3	8	
	12–17	2	8	
	Total time outdoors			
	Ages, y	Mean, h†		Timmer et al[52]
	3–5	3		
	6–8	2		
	9–11	2		
	12–14	2		
	15–17	2		
Time in school	Age, y	Mean, min/day		Timmer et al[52]
	3–5	137		
	6–8	292		
	9–11	315		
	12–14	344		
	15–17	314		
Taking showers	10 min/day shower duration			Tsang and Klepeis[55]
	1 shower event/day			Tsang and Klepeis[55]
	20 min/day bath duration			
Swimming	1 event/month			Tsang and Klepeis[55]
	60 min/event			
Playing on sand or gravel	60 min/day			Tsang and Klepeis[55]
Playing on grass	60 min/day			Tsang and Klepeis[55]

* Mean of weekday and weekend rounded up to 2 significant figures.
† Mean of weekday and weekend rounded up to 1 significant figure.

- Children's food handling practices that might exacerbate exposure
- Fish intake among children, particularly recreational and subsistence populations
- Consumption of ethnic foods by children. The term "ethnic" here refers to foods pertaining to a group of people recognized as a class on the basis of certain distinctive characteristics such as religion, language, ancestry, culture, or national origin.
- Better estimates of soil intake rates, particularly at the upper percentiles. Research is also needed to refine the methods to calculate soil intake rates and to better understand the relative contribution of soil versus dust ingestion.
- Nondietary ingestion and dermal exposure factors, such as the microenvironments in which children spend time and the types of materials with which they come in contact, as well as information on the rate at which they come in contact with contaminated surfaces, the fraction of the contaminants that are transferred to skin and object surfaces, and the amount of the object/skin entering the mouth
- Better soil adherence rates for additional activities involving children
- Frequency and duration of use and kinds of consumer products used by children
- Derivation of new surface areas based on newer body weight data
- Inhalation rates that are specific to children's activities and overall 24-hour breathing rates
- Biomarkers of exposure need to be developed to improve estimates of exposure
- Methods to extrapolate from short-term to long-term or chronic exposures
- Studies that link exposures to specific health outcomes

Children's physiology and behavior during various life stages may put them at higher risk from environmental exposures. On a body weight basis, children breathe more air, drink more water, and consume more of certain foods than adults. Children also engage in activities that may put them in contact with contaminants in the environment (eg, crawling, mouthing behavior). Understanding these differences between adults and children is important when assessing environmental health risks to children.

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Appendix 1. Food Definitions for the Major Food Groups[3]

Food Product	Food Codes	
Total dairy	Milk and milk products; milk and milk drinks; cream and cream substitutes; milk desserts, sauces, and gravies; cheeses	Includes regular fluid milk, human milk, imitation milk products, yogurt, milk-based meal replacements, and infant formulas. Also includes the average portion of grain mixtures (13.48%) and the average portion of meat mixtures (5.56%) made up by dairy. Includes soy-based milk or formula.
Total meats	Meat, type not specified; beef; pork; lamb, veal, game, carcass meat; poultry; organ meats, sausages, lunchmeats, meat spreads	Also includes the average portion of grain mixtures (7.87%) and the average portion of meat mixtures (31.11%) made up by meats.
Total fish	Fish, all types	Also includes the average portion of meat mixtures (4.44%) made up by fish.
Total grains	Flour, breads, tortillas, sweets, snacks, breakfast foods, pasta, cooked cereals and rice, ready-to-eat and baby cereals	Also includes the average portion of grain mixtures (31.46%) and the average portion of meat mixtures (13.33%) made up by grain.
Total fruits	Fruits, citrus fruits and juices, dried fruits, other fruits, fruits/juices and nectar, fruit/juices baby food	Includes baby foods.
Total vegetables	Vegetables (all forms), white potatoes and Puerto Rican starchy, dark green vegetables, deep yellow vegetables, tomatoes and tomato mixtures, other vegetables, veg. and mixtures/baby food, veg. with meat mixtures, beans/legumes, soybeans, bean dinners and soups, meatless items, soyburgers	Includes baby foods; mixtures, mostly vegetables; does not include nuts and seeds. Also includes the average portion of grain mixtures (25.84%) and the average portion of meat mixtures (30.00%) made up by vegetables.

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Children's Behavior and Physiology and How It Affects Exposure to Environmental Contaminants

Jacqueline Moya, Cynthia F. Bearer and Ruth A. Etzel

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AECOM

AECOM Australia Pty Ltd
Level 2
60 Marcus Clarke Street
Canberra ACT 2600
Australia
www.aecom.com

+61 2 6201 3000 tel
+61 2 6201 3099 fax
ABN 20 093 846 925

30 April 2015

Lucia Carson
Land Development Agency
Level 7 TransACT House
470 Northbourne Avenue
Dickson ACT 2602

Dear Lucia

Excavated Soils | Block 6, Section 97, Former West Belconnen Fire Station, Charnwood, ACT | Validation Letter

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was engaged by the Land Development Agency (LDA) to prepare this report to validate the completion of remediation works undertaken at the property identified as Block 6, Section 97 Charnwood, ACT.

The property is proposed to be developed from a former fire station to a childcare centre. A Stage 2 Environmental Site Assessment (AECOM, 2015) identified one sample (TP05_0.0-0.1) which exceeded investigation criteria for TRH C10-C16 (Less Naphthalene) (190 mg/kg) and indicates a potential risk in surface soils to the proposed future land use. As such, remedial actions were recommended to remove the impacted soils.

In addition, aqueous film forming foam (AFFF), used during firefighting training previously at the Site, was also analysed for as part of this validation exercise.

Recommendations from AECOM (2015) proposed remedial actions via targeted excavation, removal and validation of the surface soils in AEC04 adjacent to sample location TP05 to remove the potentially unacceptable risk to human health within the childcare land use scenario.

2.0 Objectives

The objectives of the works were to:

- Excavate TRH-impacted soils around TP05.
- Assess the remaining soils and validate whether the remediation excavation is suitable for the proposed future childcare centre land use.

3.0 Scope of Works

In order to achieve the objectives, the following scope of works were completed:

- Excavation of TP05 (dimensions of 7 m X L 5 m W x 0.3 m D) and removal to a pre-prepared stockpile area.
- Collection of 3 soil validation samples (VS01 to VS03) from the excavation base plus two quality control / quality assurance (QA/QC) samples, QC102 and QC202.
- Laboratory analysis of the soil samples for contaminants of potential concern (CoPC) identified during AECOM (2015):
  - Total recoverable hydrocarbons (TRH).
  - Benzene, toluene, ethylbenzene, xylenes (BTEX).
  - Heavy metals.
  - Polycyclic aromatic hydrocarbons (PAHs) including naphthalene.
  - Polychlorinated biphenyls (PCBs).
  - Organochlorine and organophosphorous pesticides (OCPs and OPPs).
  - Asbestos.
  - AFFF compounds perfluorooctane sulphonate (PFOS) and perfluorooctanoic acid (PFOA).

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- All analysis was completed by National Association of Testing Authority (NATA) accredited laboratories.

- Prepare of this soil validation letter report.

4.0 Site Identification

The site is identified as:

Table 1 Site Identification Details

Consideration	Details
Site Owner	Land Development Agency
Site Occupier	Formerly ESA/ACT Fire and Rescue
Site Address & Legal Description	35 Lhotsky Street Block 6, Section 97 Charnwood
Zoning	TSZ2- Services
Geographical Coordinates	35°12'15.4"S 149°01'42.2"E
Site Elevation (m AHD)	572.7
Site Area (approximate)	3638 m²

The findings of AECOM (2015) developed a conceptual site model (CSM) identifying the sources of CoPC, potential receptors (humans and the environment) and potential transport mechanisms. One AEC (AEC04) posed a potentially unacceptable risk to human health for the proposed future childcare land use – that is, surface soils associated with test pit TP05.

Table 2 Transport Mechanisms, Potential for Exposure and Recommended Mitigations

Transport Mechanism	Details	Potential for Exposure	Recommended Mitigation
Direct contact, ingestion of impacted soils and contaminant vapour inhalation by future Site users.	Volatile contaminants exist in surface soils.	Isolated to the surface - as demonstrated with vertical and lateral samples reporting no exceedances- and able to be mitigated and reduced to not pose an unacceptable on-going risk during the design and construction phase of the childcare centre.	Bulk removal of the existing topsoils to a depth below TP05_0.0-0.1, off-Site disposal of the impacted material and importation of clean fill to replace.

TP05 is located within AEC04 (refer to **Figure 1** in **Appendix A**).

5.0 Site Validation Criteria

Based on the development of the preliminary CSM in AECOM (2015) for the Site, the following validation acceptance criteria (VAC) are considered appropriate to the works

Given the future childcare centre land use of the Site, the following hierarchy of screening criteria will be adopted.

During demolition and construction of the childcare centre, protection of human health and the environment should be addressed by a Construction Environmental Management Plan endorsed by the ACT EPA.

As the Site will change to childcare centre land use with minimal plant life, an assessment of potential on-Site ecological risks from soils is not considered applicable for further investigation.

As the childcare centre is the most sensitive land use receptor, risks future commercial and intrusive maintenance workers (i.e. less sensitive land use scenarios) are considered covered within the assessment.

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- National Environment Protection Measure (NEPM), Assessment of Site Contamination (ASC) (National Environment Protection Council [NEPC], 1999 as amended (2013): Schedule B1. Soil Health Investigation Levels (HILs) and Health Screening Levels (HSLs) for vapour intrusion (ASC NEPM), specifically:
  - HIL A (Childcare centre).
  - Vapour intrusion –Soil HSL A (Childcare centre) – Sand.
- Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) Technical Report No.10 - HSLs for direct contact to soil. (Friebel, E. and Nadebaum, P., 2011):
  - Direct Contact –HSL A (Childcare centre).
- United States Environmental Protection Agency (US EPA) (January, 2015) - Regional Screening Levels (RSLs) – Residential Soil (US EPA, 2015).
- US EPA Region 4 (2009) – Soil Screening Levels for PFOS and PFOA.

The resultant VAC, Childcare user adult and child – (contamination at) 0 to 1 m below ground surface (bgs), will be used as the screening criteria based on the receptor (childcare centre user adult and child) and depth to contamination. The screening criteria are summarised in **Table 3** below.

Table 3 Soil Assessment Validation Criteria for Key Contaminants

Chemical Name	ASC NEPM – Childcare Centre – HIL A (mg/kg)
Soil HIL A (Childcare Centre)	
Lead	300
Total PAHs	300
Benzo(a)pyrene TEQ	3
Total PCBs	1
OCP/OPPs	Refer to footnote (a)
Vapour Intrusion – Soil HSL A (Childcare centre) – Sand - 0 to <1.0 m	
Naphthalene	3
TRH F1 C_6-C_{10} (Less BTEX)	45
TRH F2 >C_{10}-C_{16} (Less naphthalene)	110
Benzene	0.5
Toluene	160
Ethylbenzene	55
Xylenes	40
US EPA Regional Screening Levels (RSLs) – Residential Soil	
OCPs/OPPs	Refer to footnote (b)
VOCs	Refer to footnote (c)
sVOCs	Refer to footnote (d)
US EPA Region 4 – Soil Screening Levels for PFOA and PFOS	
PFOS	6 mg/kg
PFOA	16 mg/kg

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CW Commercial Worker
IMW Intrusive Maintenance Worker – assume direct contact with soils
NL No Limit
NA Not Applicable
TEQ Carcinogenic PAHs assessed as the concentration multiplied by their potency relative to benzo(a)pyrene.
(a) OCPs and OPPs will be assessed based upon individual criterion per analyte as per ASC NEPM HIL A.
(b) Individual OCPs and OPPs without a criterion in ASC NEPM HIL A will be obtained from USEPA RSL – Residential Soils.
(c) Individual VOCs without a criterion in ASC NEPM HIL A will be obtained from USEPA RSL – Residential Soils.
(d) Individual sVOCs without a criterion in ASC NEPM HIL A will be obtained from USEPA RSL – Residential Soils.

5.1 Asbestos Assessment Criteria

The current assessment criteria endorsed by the NSW EPA to evaluate asbestos is soil is based on the ASC NEPM.

AECOM notes that the asbestos criteria in the ASC NEPM are sourced from the Western Australia Department of Health (WA DoH) (2009) *Guidelines for the Assessment, Remediation and Management of Asbestos – Contaminated Sites in Western Australia*.

The guideline emphasises that the assessment and management of asbestos contamination should take into account the condition of the asbestos materials and the potential for damage and resulting release of asbestos fibres.

Table 4 Asbestos Assessment Criteria

Land Use	Asbestos Group	% w/w asbestos
Residential (child care centres)	ACM	0.01
All land uses	FA and AF[1]	0.001
All forms of asbestos	No visible or free fibre asbestos in surface soil	

w/w = weight for weight of asbestos in soil
1) Not applicable for free fibres.

6.0 Methodology

The fieldwork methodology for AECOM activities only (collection of soil samples for laboratory analysis) is summarised in **Table 5** below.

All soil samples were collected directly by hand using disposable nitrile gloves and placed into laboratory prepared 125mL soil jars with minimal headspace to reduce the potential for volatile loss. Soils were assessed for the presence of olfactory indicators of contamination (staining or odour) and logged at the time of sampling. The samples were then placed into an eski with crushed ice and transported to the NATA-accredited laboratory ALS Environmental, Smithfield, Sydney, for analysis under chain of custody (COC) conditions.

Table 5 Soil Sampling Methodology

Activity	Details
Soil Sampling	Following excavation and scraping of soils at TP05 (dimensions of 7 m X 5 m), three validation soil samples were collected from 0.3 m bgs at the base only. Note, due to the shallow depth of the excavation, samples from the walls were not considered practicable and that the soils were appropriately represented by those obtained from the base.
Field Screening for VOCs	Soil subsamples were collected from each sample location and were placed in snap-lock plastic bags and the headspace in the bag was screened for volatile organic compounds (VOC) using a calibrated phot-ionisation detector (PID) equipped with a 10.6 eV lamp.
Soil Logging	Soil logging was generally in accordance with the Unified Soil Classification System (USCS) and the AECOM documented standard field procedures.
Decontamination	A new pair of disposable nitrile gloves was used to collect each soil sample. Non-disposable equipment was utilised during the works and a rinsate sample was

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Activity	Details
	taken. Decontamination of the hand trowel during stockpile soil validation sampling was undertaken using a phosphate free detergent (Decon 90) solution followed by a comprehensive and thorough double rinse with de-ionised water.
Field QA/QC Samples	The following quality assurance and quality control samples were collected during the sampling program: - Intra-laboratory duplicates at a rate of 1 per 20 primary samples. - Inter-laboratory duplicates at a rate of 1 per 20 primary samples. - Rinsate blank at a rate of 1 per day of soil sampling.

7.0 Quality Assurance and Quality Control

An assessment of field and laboratory QAQC data was conducted and the results are summarised below.

7.1 Field QA/QC

A review of the AECOM field QA/QC is summarised below:

- Use of AECOM standard procedures for soil sampling.
- Use of a new pair of disposable nitrile gloves for each soil sample collection event.
- Use of calibrated equipment.
- Decontamination of the hand trowel for breaking the surface of the soil using a phosphate free detergent (Decon 90) and comprehensive rinse with distilled water and air drying between sample collection events.
- Use of laboratory prepared and supplied sampling containers appropriate for each CoPC investigated.
- Use of appropriate sample Chain of Custody (COC) documentation. Copies of the COCs are included in the laboratory reports (**Appendix C**).
- Analysis of field duplicate samples at a rate of one per ten primary samples (requirement one per twenty primary samples).
- Analysis of inter-laboratory (split) field duplicate samples at a rate of approximately 1 per 20 primary samples (requirement one per twenty primary samples).
- The relative percentage difference (RPD) of the primary and duplicated sample results to be less than 50%.

7.2 Laboratory QA/QC

A review of the laboratory QAQC is summarised below:

- Samples were collected in appropriate sample containers, transported in chilled sealed containers with appropriate COC documentation.
- Laboratory LORs were below the assessment criteria.
- All laboratory duplicate and triplicate samples reported RPDs within acceptable DQI ranges and analyte-specific acceptance criteria except for PFOS which was 66% for VS02 and QC202. Both samples were below the criteria and a higher than 50% RPD could either be the result of inter-laboratory duplicate analysis and/or is typical of heterogeneous material.

7.3 Data Validation and Usability

A review of the laboratory QA/QC data completed by AECOM is presented in **Appendix C**. This indicated that the results met the acceptance criteria for the analyses conducted.

The data validation procedure employed in the assessment of the field and laboratory QA/QC data indicated that the reported analytical results are representative of soil conditions at the sample locations tested and that the overall quality of the analytical data produced is acceptably reliable for the purpose of this project.

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8.0 Results

8.1 Soil Conditions

Based on previous test pit advancement and observations in AECOM (2015) the soils within AEC04 to comprise:

- Topsoil: 0.0 to 0.2 m bgs.
- Sand: 0.2 to 0.5 m bgs.
- Clay: 0.5 to 1.4 m bgs.

The excavation base comprised red sandy clay: high plasticity, moist and soft. Soil samples collected from the base of the excavation contained no staining and no odour. No other obvious signs of contamination were noted.

Photoionisation detector (PID) sample readings from the excavation ranged from 0.7 (VS02) to 1.2 (VS01). These readings were considered not significant in concentration to indicate remaining TRH impacts exist.

8.2 Analytical Results

A total of 3 primary samples (VS01 to VS03), one duplicate (QC102) and one triplicate (QC202) soil validation samples were collected from the excavation.

Soil analytical results were compared to the site assessment criteria 0-1 m bgs and reported no exceedances of the VAC. Analytical soil data is presented in **Table T1** in **Appendix B**.

9.0 Discussion

A total of 3 primary soil samples and 2 QA/QC samples were collected for validation purposes from the excavation base.

Laboratory analysis reported concentrations of all CoPCs less than the screening criteria for the land use scenario of a childcare centre.

The EPA Region 4 calculated a residential soil screening level of 6 mg/kg for PFOS and 16 mg/kg for PFOA (EPA Region 4 2009). All results, included in **Appendix C**, returned for AFFF (PFOS and PFOA) readings below the threshold outlined in the Emerging Contaminants Fact Sheet – PFOS and PFOA provided by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO). The results are reported to be below the threshold levels for the proposed land-use (childcare centre).

Based on field observations made during validation works and laboratory analysis of collected validation samples, AECOM considers that the soils within an area 5 m x 7 m to a depth of 0.3 m bgs associated with TP05/AEC04 has been appropriately validated and that no unacceptable risks exist to human health from concentrations of TRH C_{10}-C_{16} (less naphthalene).

10.0 Summary and Conclusions

AECOM was engaged by the LDA to prepare this letter report to document the excavation of TP05 and validate the remediation works associated with removing TRH impacts in surface soils around TP05/AEC04. The objective of the works was to excavate TRH-impacted soils around TP05, assess the remaining soils and validate whether the remediation excavation is suitable for the proposed future childcare centre land use.

AECOM considers that validation of the TP05/AEC04 excavation was completed to a standard acceptable for the proposed future child care land use.

11.0 References

1) AECOM Australia Pty Ltd (2015) *Former Charnwood Fire Station: Stage 2 Environmental Site Assessment Report.*
2) AECOM Australia Pty Ltd (2014) *ESDD Charnwood: Stage 1 Environmental Assessment*, issued 18 November 2014.
3) AECOM Australia Pty Ltd (2014) *UPSS Validation Report – Former West Belconnen Fire Station, Belconnen, ACT*, issued 18 November 2014.
4) National Environmental Protection Council (1999). *National Environmental Protection Measure (Assessment of Site Contamination) (ASC NEPM)*, as amended May 2013.

AECOM

Yours sincerely

[redacted]

[redacted]@aecom.com

Direct Dial: +61 2[redacted]
Direct Fax: +61 2 6201 3099

[redacted]@aecom.com

Mobile: +61[redacted]
Direct Dial: +61 2[redacted]

encl: Appendix A - Figure
Appendix B - Table
Appendix C - Laboratory Certificates
Appendix D - Calibration Records
Appendix E - Site Photographs

ANALYTICAL REPORT

WORLD RECOGNISED ACCREDITATION

CLIENT DETAILS		LABORATORY DETAILS	
Contact	[redacted]	Manager	[redacted]
Client	AECOM Australia Pty Ltd	Laboratory	SGS Alexandria Environmental
Address	Level 2, 60 Marcus Clarke Street ACT 2600	Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	02 6201 3000	Telephone	+61 2 [redacted]
Facsimile	02 6201 3099	Facsimile	+61 2 8594 0499
Email	[redacted]@aecom.com	Email	au.environmental.sydney@sgs.com
Project	**60339175,Task 1.3- Charnwood Remediation**	SGS Reference	SE138091 R0
Order Number	**60339175,Task 1.3**	Report Number	0000108649
Samples	1	Date Reported	28 Apr 2015
		Date Received	10 Apr 2015

COMMENTS

Accredited for compliance with ISO/IEC 17025. NATA accredited laboratory 2562(4354).

PFOA/PFOS - subcontracted to SGS Leeder Consulting, 4 - 5, 18 Redland Drive Mitcham VIC, NATA Accreditation Number 14429.

No respirable fibres detected in all samples using trace analysis technique.

Asbestos analysed by Approved Identifier Yusuf Kuthpudin.

SIGNATORIES

[redacted]

SGS LEEDER CONSULTING

A.B.N. 44 000 964 278
3 - 5, 18 Redland Drive
Mitcham, Vic, 3132
Telephone: (03) 9874 1988
Fax: (03) 9874 1933

Chartered Chemists

28-Apr-2015

REPORT NUMBER: M150782

Site/Client Ref: SE138091

AECOM Canberra

Level 2
60 Marcus Clarke Street
Canberra
Australian Capital Territory 2600
Attention: Ryan O'Leary

CERTIFICATE OF ANALYSIS

SAMPLES:	One sample was received for analysis
DATE RECEIVED:	**13-Apr-2015**
DATE COMMENCED:	**13-Apr-2015**
METHODS:	See Attached Results
RESULTS:	Please refer to attached pages for results.

Note: Results are based on samples as received at SGS Leeder Consulting's laboratories

REPORTED BY:

[redacted]

[redacted]

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory Number: 14429

Accredited for compliance
with ISO/IEC 17025.

SGS LEEDER CONSULTING

(I) RESULTS

Report N°: M150782

Matrix: Soil

Method: MA_1523.SL.01

Sample units are expressed in mg/kg on a dry weight basis unless otherwise stated

	Leeder ID	2015008387	2015008388
	Client ID	SE138091.001 QC202	Method
	Sampled Date	8/04/2015	
Analyte Name	PQL		Blank
oorooctane sulfonate	0.01	2.1	nd
luorooctanoic Acid	0.01	nd	nd

2000 mg 1 kg

10 kg child - TDI ~~PFOS~~ 0.2 mg.

2 mg / 1000 g

x mg / 100 g.

= 0.2 mg. / day.

SGS LEEDER CONSULTING

(II) QUALITY CONTROL

Report N°: M150782

Matrix: Soil

Method: MA_1523.SL.01

Quality Control Results are expressed in Percent Recovery of expected result

	Leeder ID	2015008389	2015008390
	Client ID	Method	Method
	Sampled Date		
Analyte Name	**PQL**	Spike	Spike Dup
Perfluorooctane sulfonate		85	96
Perfluorooctanoic Acid		99	93

SGS LEEDER CONSULTING

Report N°: M150782

QUALIFIERS / NOTES FOR REPORTED RESULTS

PQL	Practical Quantitation Limit
nd	Not Detected – The analyte was not detected above the reported PQL.
is	Insufficient Sample to perform this analysis.
T	Tentative identification based on computer library search of mass spectra.
NC	Not calculated and/or Results below PQL
NV	No Vacuum, Canister received above standard atmospheric pressure
nr	Not Requested for analysis.
R	Rejected Result – results for this analysis failed QC checks.
SQ	Semi-Quantitative result – quantitation based on a generic response factor for this class of analyte.
IM	Inappropriate method of analysis for this compound
U	Unable to provide Quality Control data – high levels of compounds in sample interfered with analysis of QC results.
UF	Unable to provide Quality Control data- Surrogates failed QC checks due to sample matrix effects
L	Analyte detected at a level above the linear response of calibration curve.
E	Estimated result. NATA accreditation does not cover estimated results.
C1	These compounds co-elute.
--	Parameter Not Determined
CT	Elevated concentration. Results reported from carbon tube analysis
**	Sample shows non-petroleum hydrocarbon profile

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 4

61 Forsyth Street
Atlanta, Georgia 30303

MEMORANDUM

DATE: **November 20, 2009**

SUBJECT: Soil Screening Levels for Perfluorooctanaoic Acid (PFOA) and Perfluorooctyl Sulfonate (PFOS)

FROM: [redacted]
Technical Services Section
Superfund Division
US EPA Region 4

TO: [redacted]
Superfund Division
US EPA Region 4

[redacted]
Water Protection Division
US EPA Region 4

Perfluorooctanaoic Acid (PFOA) and Perfluorooctyl Sulfonate (PFOS) have been found at two sites in EPA Region 4. PFOA and PFOS were both detected in surface soils and groundwater including private drinking water wells at these two sites. As there are no toxicity values for PFOA or PFOS available in EPA's Integrated Risk Information System or as Provisional Peer Reviewed Toxicity Values (PPRTVs), Region 4 requested EPA's Office of Superfund Remediation and Technology Innovation (OSRTI) and the Office of Emergency Management (OEM) to recommend toxicity values for PFOA and PFOS.

In response, OSRTI and OEM provided a memorandum dated October 28, 2009, to EPA Region 4's Superfund Division which recommended toxicity values for PFOA and PFOS (see Attachment). The memorandum made the following recommendations regarding interim oral non-cancer reference dose (RfD) values for PFOA and PFOS.

Perflurooctanaoic Acid (PFOA) Sub-chronic RfD = 2E-4 mg/kg-day

Perfluorooctyl Sulfonate (PFOS) Sub-chronic RfD= 8E-5 mg/kg-day

The sub-chronic RfDs presented above may be used in the Superfund program's risk-based Regional Screening Level (RSL) calculator to derive screening levels for surface soils and other media, as appropriate. Using the RSL calculator, a **residential soil screening level** for PFOA of **16 mg/kg** (16,000 ug/kg) and for PFOS of **6 mg/kg** (6,000 ug/kg) was derived. The RSL calculator is available at:

http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

The exposure assumptions used in the calculator are protective of children over a six (6) year exposure period which is the most protective screening level for residential surface soil exposures.

It should be noted there are uncertainties in the degree of protectiveness provided by these screening levels. Some of these uncertainties include the lack of a long-term (lifetime exposure period) RfD for PFOA and PFOS, and the lack of sub-chronic or lifetime exposure RfD's for other perfluorochemicals known to be present in the soils.

The recommendations in this memorandum may be modified as the state of the science evolves with respect to deriving toxicity values and determining protective concentrations of PFOA and PFOS, or other perfluorochemicals. Such changes may include the availability of an IRIS or a PPRTV assessment, other more credible toxicity values than those available in 2009, and/or the promulgation of a Safe Drinking Water Act Maximum Contaminant Level by EPA's Office of Water.

Please contact me at 404-562-8771 if you have any questions.

Attachment

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

OCT 28 2009

MEMORANDUM

SUBJECT: The Toxicity of Perfluorooctanic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS)

FROM: [redacted]
Office of Emergency Management (OEM)
Office of Solid Waste and Emergency Response (OSWER)
[redacted]
Office of Superfund Remediation and Technology Innovation (OSRTI)
Office of Solid Waste and Emergency Response (OSWER)

TO: [redacted]
Technical Services Section
Superfund Division
US EPA Region 4

Background

PFOA and PFOS have been found at sites in EPA Region 4 and in other regions. As a result, Region 4 has asked the Headquarter's Office of Superfund Remediation and Technology Innovation (OSRTI) and the Office of Emergency Management (OEM) to recommend toxicity values.

On December 5, 2003, OSRTI released guidance (OSWER Directive 9285.7-53) establishing a three-tiered hierarchy of human health toxicity values. Tier 1 is EPA's Integrated Risk Information System (IRIS). Tier 2 is the provisional peer reviewed toxicity values (PPRTVs) completed for the EPA Superfund Program by the EPA Superfund Health Risk Technical Health Risk Support Center. Tier 3 are toxicity values from other credible sources such as other federal or State agencies. Three sources of Tier 3 toxicity values were identified in

2003, but OSRTI also stated that additional Tier 3 sources may exist, and that additional Tier 3 sources may be identified in the future. As there are no toxicity values for PFOA or PFOS available in IRIS or as PPRTVs, this memorandum constitutes a Tier 3 consultation and recommends Tier 3 toxicity values for PFOA and PFOS.

Process

OSRTI and OEM consulted with several EPA program offices to discuss the use of the EPA Office of Water (OW) provisional health advisories as Tier 3 toxicity values. After weighing input from these offices, we make the following recommendations regarding the OW advisory and the interim oral non-cancer toxicity values for PFOA and PFOS.

Recommendations

On January 8, 2009 OW completed and released Provisional Health Advisories for PFOA and PFOS (See Attachment 1). Prior to the release of this assessment, OW invited, received and considered internal and external peer review comments on the then draft assessment. Although derived using methods that differ from the Superfund program's risk-based approaches, OSRTI and OEM find the OW provisional drinking water advisories of 0.4 µg/l for PFOA and 0.2 µg/l for PFOS credible as protective health-based concentrations for these contaminants in drinking water.

Because the OW provisional health advisories address only water consumption, oral reference dose values (RfDs), which can be used to address oral exposure to other media such as soil, were not developed. However, the methodology used by OW in deriving its provisional health advisories can also be used to derive subchronic RfD values for PFOA and PFOS, as shown below:

- **Perflurooctanoic Acid (PFOA)**

  For PFOA, the OW provisional health advisory relies on data from a sub-chronic study in mice (Lau, et al 2006) to derive a Benchmark Dose Level ($BMDL_{10}$) of 0.46 mg/kg-day[1]. When calculating toxicity values such as an RfD, a BMDL or a No Observed Adverse Effect Level (NOAEL) can be used to derive an RfD. In deriving an RfD for PFOA, certain numerical factors are applied to the BMDL to account for differences in the metabolism and sensitivity among test animals and humans to the effects of PFOA. Using the numerical factors presented in OW's provisional health advisory, a subchronic RfD can be developed, as follows:

[1] EPA toxicity assessments, including Integrated Risk Informaiton System (IRIS) assessments, using BML modeling in the derivation of an RfD typically use the 10% response level from the BML modeling ($BMDL_{10}$) to derive an RfD.

Subchronic RfD = $(BMDL_{10}) / UF_H * (UF_A = UF_{pharmacodynamic} * UF_{pharmacokinetic})$
= (0.46 mg/kg-day) / 10 * (3 * 81)
= **2E-4 mg/kg-day**

UF_H = a factor of 10 to account for variations in the dose-response (i.e., sensitivity) among humans to the effects of PFOS

UF_A= a factor to account for differences in the metabolism of PFOA in mice vs. humans
- $UF_{pharmacodynamic}$ = a factor of 3 to account for variations in the dose-response among mice to the effects of PFOA
- $UF_{pharmacokinetic}$ = a factor of 81[2] to account for differences in the rate of clearance of PFOA in mice vs. humans

- **Perfluorooctane Sulfonate (PFOS)**

For PFOS, the OW provisional health advisory relies on data from a sub-chronic study in monkeys (Seacat, et al. 2002) to derive a NOAEL of 0.03 mg/kg-day. As with PFOA, certain numerical factors are applied to the NOAEL to account for differences in the metabolism and sensitivity among test animals and humans to the effects of PFOS. Using the numerical factors presented in OW's provisional health advisory, a subchronic RfD can be developed, as follows:

Subchronic RfD = $(NOAEL) / UF_H * (UF_A = UF_{pharmacodynamic} * UF_{pharmacokinetic})$

= 0.03 mg/kg-day / 10 * (3 * 13)
= **8E-5 mg/kg-day**

UF_H = a factor of 10 to account for variations in the dose-response (i.e., sensitivity) among humans to the effects of PFOS
UF_A= a factor to account for differences in the metabolism of PFOS in monkeys vs. humans
- $UF_{pharmacodynamic}$ = a factor of 3 to account for variations in the dose-response among monkeys to the effects of PFOS
- $UF_{pharmacokinetic}$ = a factor of 13[3] to account for differences in the rate of clearance of PFOS in monkeys vs. humans

Currently, OEM has not established removal action levels for PFOA or PFOS as the basis for considering alternate water supplies, nor have these contaminants been addressed in the Regional Screening Levels for Chemical Contaminants at Superfund Sites. However, the Tier 3 sub-chronic RfDs presented in this memorandum may be used in the Superfund program's risk-based equations to derive Removal Action Levels and/or Screening Levels for water and other media, as appropriate.

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[2] See Attachment 1, page 4 for additional details about this UF.
[3] See Attachment 1, pages 4 and 5 for additional details about this UF.

Please be aware that the recommendations made in this memorandum may be modified by OSRTI and OEM as the state of the science evolves with respect to deriving toxicity values and determining protective concentrations of PFOA and PFOS. Such changes may include the availability of an IRIS or a PPRTV assessment and/or the promulgation of a Safe Drinking Water Act Maximum Contaminant Level by OW.

Questions related to the use of this memorandum and its recommendations may be directed to Dave Crawford (703-603-8891) and to Janine Dinan (202-564-8737) in OEM.

Attachment 1

January 8, 2009

Provisional Health Advisories for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS)

1. Introduction

EPA recently concluded limited testing of agricultural sites in Alabama where sewage sludge was applied from a local wastewater treatment plant that receives wastewater from numerous industrial sources, including facilities that manufacture and use perfluorooctanoic acid (PFOA) and other perfluorinated chemicals (PFCs). The results from this limited testing indicated elevated levels of PFCs in the sludge and the soil that received the sludge. As a result, EPA has conducted sampling of public drinking water. The levels of PFOA and perfluorooctane sulfonate (PFOS) recently analyzed in community water systems in Lawrence and Morgan Counties are all lower than 0.04 ppb. Based on its current understanding, EPA believes these levels are not of concern and residents may rely upon public water systems. EPA will soon begin groundwater and surface water sampling to determine if PFOA or PFOS has migrated into any private drinking water supplies and ponds in the affected area.

The Office of Water (OW) has developed Provisional Health Advisory values[1] for PFOA and PFOS to assess potential risk from exposure to these chemicals through drinking water. Other PFCs have been found at this site. However, information on the toxicity of PFCs other than PFOS and PFOA is limited and therefore no attempt is made at the present time to develop Provisional Health Advisory values for these other PFCs.

2. Summary of Data for PFOA

Epidemiological studies of exposure to PFOA and adverse health outcomes in humans are inconclusive at present.

Several animal toxicological studies have been conducted using PFOA. These include subchronic, developmental/reproductive, and chronic toxicity/carcinogenicity studies in several animal species, in both sexes. An evaluation of these studies was conducted by the European Food Safety Authority (EFSA) and no-observed-adverse-effect level (NOAEL), lowest-observed-adverse-effect level (LOAEL), and critical endpoints identified (EFSA, 2008).

Among these studies, a recent and well conducted developmental toxicity study in mice was selected by the Office of Water (OW) as the critical study for the derivation of the

[1] Provisional Health Advisory values are developed to provide information in response to an urgent or rapidly developing situation. They reflect reasonable, health-based hazard concentrations above which action should be taken to reduce exposure to unregulated contaminants in drinking water. They will be updated as additional information becomes available and can be evaluated.

Provisional Health Advisory for PFOA (Lau et al., 2006). In this study, CD-1 mice were given the ammonium salt of PFOA by oral gavage from gestational day (GD) 1 to 17 at doses of 0, 1, 3, 5, 10, 20 or 40 mg/kg/day. Significant increase in the incidence of full-litter resorption occurred at 5 mg/kg/day and higher doses. Weight gain in dams that carried pregnancy to term was significantly lower in the 20-mg/kg/day group. At GD 18, some dams were sacrificed for maternal and fetal examinations (group A), and the rest were treated once more with PFOA and allowed to give birth (group B). Postnatal survival, growth, and development of the offspring were monitored. PFOA induced enlarged liver in group A dams at all dosages, but did not alter the number of implantations. The percent of live fetuses was lower only in the 20-mg/kg/day group (74 vs. 94% in controls), and fetal weight was also significantly lower in this group. However, no significant increase in malformations was noted in any treatment group. The incidence of live birth in group B mice was significantly lowered by PFOA: ca. 70% for the 10- and 20-mg/kg/day groups compared to 96% for controls. Postnatal survival was severely compromised at 10 or 20 mg/kg/day, and moderately so at 5 mg/kg/day. Dose-dependent growth deficits were detected in all PFOA-treated litters except the 1-mg/kg/day group. Significant delays in eye-opening (up to 2–3 days) were noted at 5 mg/kg/day and higher dosages. Accelerated sexual maturation was observed in male offspring, but not in females. These data indicate maternal and developmental toxicity of PFOA in the mouse, leading to early pregnancy loss, compromised postnatal survival, delays in general growth and development, and sex-specific alterations in pubertal maturation (Lau et al., 2006).

Toxicity endpoints identified in the Lau et al. (2006) study included a number of developmental landmarks: neonatal eye opening, neonatal survival and body weight at weaning, reduced phalangeal ossification at term, live fetus weight at term, maternal liver weight at term, and maternal weight gains during pregnancy. The most sensitive endpoint was for increased maternal liver weight at term. This endpoint for liver effects was identified in a number of other studies described in EFSA (2008).

Benchmark dose (BMD_{10}) and the 95% lower bound on the BMD ($BMDL_{10}$) were calculated for these toxicity endpoints by the EFSA on the basis of raw data provided by the principal author (Lau, personal communication, November 18, 2008). The lowest $BMDL_{10}$ in the Lau et al. (2006) study was 0.46 mg/kg/day for increase in maternal liver weight at term. This value was used as the point of departure for the derivation of the Provisional Health Advisory value for PFOA. It should be noted that liver effects were also reported in studies in rats and monkeys. $BMDL_{10}$ values for increased liver weight in studies in mice and rats ranged from 0.29 to 0.74 mg/kg/day (EFSA, 2008). The $BMDL_{10}$ for Lau et al. (2006) was in the middle of this range.

3. Summary of Data for PFOS

Epidemiological studies of exposure to PFOS and adverse health outcomes in humans are inconclusive at present.

Several animal toxicological studies have been conducted with PFOS. These include subchronic, developmental/reproductive, and chronic toxicity/carcinogenicity studies in several animal species, in both sexes. An evaluation of these studies was conducted by the EFSA (2008) and NOAEL, LOAEL and critical endpoints identified.

The subchronic toxicity study in Cynomolgus monkeys (Seacat et al., 2002) was selected by the OW as the critical study for the derivation of the Provisional Health Advisory value for PFOS. In the study by Seacat et al. (2002), groups of male and female monkeys received orally potassium PFOS at doses of 0, 0.03, 0.15 or 0.75 mg/kg/day for 183 days. Compound-related mortality in 2 of 6 male monkeys, decreased body weights, increased liver weights, lowered serum total cholesterol, lowered triiodothyronine (T_3) concentration, and lowered estradiol levels were seen at the highest dose tested. At 0.15 mg/kg/day, increased levels of thyroid-stimulating hormone (TSH) in males, reduced total T_3 levels in males and females, and reduced levels of high-density lipoproteins (HDL) in females were seen. A NOAEL of 0.03 mg/kg/day was identified in this study.

4. Calculation of Provisional Health Advisories for PFOA and PFOS

The general equation for the derivation of a Provisional Health Advisory is:

$$\frac{(\text{NOAEL or } BMDL_{10}) \times BW \times RSC}{UF \times \text{Extrapolation Factor} \times \text{Water intake}}$$

Where BW = body weight; RSC = relative source contribution; UF = uncertainty factors

The OW is using the exposure scenario of a 10-kg child consuming 1 L/day of drinking water to calculate the Provisional Health Advisories for PFOA and PFOS. This population subgroup was used because children, who consume more drinking water on a body weight basis than adults, have a higher exposure on a body weight basis than adults. The selection of children's exposure parameters will help to ensure that this Provisional Health Advisory is protective of sensitive populations potentially exposed. A default relative source contribution (RSC) of 20% was used to allow for exposure from other sources such as food, dust and soil. The relevant period of exposure for the Health Advisory is a short-term exposure. This time period is consistent with the toxicity data used for PFOA and PFOS, both of which rely upon subchronic data. The value should be protective of all population subgroup and lifestages.

Data derived extrapolation factors for toxicokinetics were developed to better approximate internal doses for PFOA and PFOS. This step was deemed important because of the marked differences in retention time among humans and the test species in which toxicological data were collected. Available data for PFOA from female mice indicate a half-life of 17 days and from humans, a half-life of 3.8 years (1387 days). Critically, measures of internal exposure should be used as the basis for interspecies extrapolation; the assessment is somewhat complicated by the lack of area under the curve (AUC) or clearance (CL) data. However, the one-compartment model foundation

is useful to convert half-life data to clearance data, assuming steady-state has been reached (Equation 1).

$$\text{Half-life} = (\ln 2 \text{ or } 0.693) \times \text{Volume of Distribution} / \text{CL} \quad (1)$$

The volume of distribution of 198 $\pm$ 69 ml/kg has been estimated in female monkeys (Butenhoff et al., 2004). Olsen et al. (2007) summarized other findings on PFOS and PFOA as indicating primarily an extracellular distribution volume. Olsen et al. (2007) also cited other reports that these agents were highly bound to plasma proteins in rats, monkeys and humans. Together, these data support using the same volume of distribution for rodents and humans, based on the findings (198 ml/kg) in monkeys.

The mouse half-life of 17 days converts:
CL = (0.693 x 198 ml/kg) / 17 days = 8.07 ml/kg/day

The human half-life of 1387 days converts:
CL = (0.693 x 198 ml/kg) / 1387 days = 0.10 ml/kg/day

Calculating the toxicokinetic portion of the interspecies on the basis of plasma CL would be:

CL animal / CL human = 8.07 ml/kg/day / 0.10 ml/kg/day = 80.7

The total interspecies correction derived from using a 3X for toxicodynamics and 81X for toxicokinetics is 243X.

To calculate the Provisional Health Advisory for PFOA, a default intraspecies uncertainty factor of 10 was applied to the $BMDL_{10}$ of 0.46 mg/kg/day to account for variation in susceptibility within the human population. A default uncertainty factor of 3 was used for toxicodynamic differences between animals and humans.

The following Provisional Health Advisory is obtained:

$$\text{PFOA Provisional Health Advisory} = \frac{0.46 \times 1000 \times 10 \times 0.2}{10 \times 3 \times 81 \times 1} = 0.4\ \mu g/L$$

Similarly, a data-derived extrapolation factor was developed for PFOS. The half-lives of PFOS in humans and in male and female monkeys were estimated by Lau et al., (2007) to be 5.4 years and 150 days, respectively.

The monkey half-life of 150 days converts:
CL = (0.693 x 198 ml/kg) / 150 days = 0.915 ml/kg/day

The human half-life of 1971 days converts:
CL = (0.693 x 198 ml/kg) / 1971 days = 0.07 ml/kg/day

Calculating the toxicokinetic portion of the interspecies on the basis of plasma clearance would be:

CL animal / CL human = 0.915 ml/kg/day / 0.07 ml/kg/day = 13.1

The total interspecies correction derived from using a 3X for toxicodynamics and 13X for toxicokinetics is 39X.

To calculate the Provisional Health Advisory for PFOS, a default intraspecies uncertainty factor of 10 was applied to the NOAEL of 0.03 mg/kg/day to account for variation in susceptibility within the human population. A default uncertainty factor of 3 was used for toxicodynamic differences between animals and humans.

The following value is obtained:

$$\text{PFOS Provisional Health Advisory} = \frac{0.03 \times 1000 \times 10 \times 0.2}{10 \times 3 \times 13 \times 1} = 0.2\ \mu g/L$$

REFERENCES

Butenhoff JL, Kennedy GL Jr, Hinderliter PM et al. (2004). Pharmacokinetics of perfluorooctanoate in cynomolgus monkeys. Toxicol Sci. 82:394-406.

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Lau C, Thibodeaux JR, Hanson RG et al. (2006). Effects of perfluorooctanoic acid exposure during pregnancy in the mouse. Toxicol. Sci. 90 (2) 510-518.

Lau C, Anitole K, Hodes C et al. (2007). Perfluoroalkyl acids: A review of monitoring and toxicological findings. Toxicol. Sci. 99 (2) 366-394.

Olsen GW, Burris JM, Ehresman DJ et al. (2007). Half-life of serum elimination of perfluorooctanesulfonate, perfluorohexanesulfonate, and perfluorooctanoate in retired fluorochemical production workers. Environ Health Perspect. 115: 1298–1305.

Seacat AM, Thomford PJ, Hansen KJ et al. (2002). Subchronic toxicity studies on perfluorooctanesulfonate potassium salt in Cynomolgus monkeys. Toxicol. Sci. 68, 249-264.

FOOD STANDARDS
Australia New Zealand
Te Mana Kounga Kai – Ahitereiria me Aotearoa

Summary of Consolidated Report

Perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) belong to a group of compounds referred to as per- and poly-fluoroalkylated (PFAS) substances.

The use of these chemicals in firefighting foams has led to contamination in some Australian locations.

The Australian Department of Health asked Food Standards Australia New Zealand (FSANZ) to review interim health based guidance values (HBGVs) for PFOS and PFOA developed by the Environmental Health Standing Committee (enHealth)[1]—a subcommittee of the Australian Health Protection Principal Committee. FSANZ also reviewed PFHxS, providing advice about potential dietary risks associated with food and considered risk management options.

FSANZ looked at comprehensive international assessments on the health effects of PFAS and recommended tolerable daily intakes (TDIs) of 20 ng/kg bw/day for PFOS and 160 ng/kg bw/day for PFOA.[2] There was not enough information to establish a TDI for PFHxS.

There is very little data on the occurrence of these compounds in the general food supply so it not possible to calculate dietary exposure for the general Australian population. However, based on the data that is available and a literature review, dietary exposure to PFOS, PFOA and PFHxS from the general food supply is likely to be low.

People consuming certain foods sourced from or near contaminated sites may reach the TDI for PFOS and PFOS/PFHxS combined when they consume their usual amounts of that food but not for PFOA. Foods that result in the greatest potential exposure include cattle meat, rabbit meat, milk, offal and some vegetables. However, there are data limitations, so FSANZ's conclusions are highly conservative. It is also extremely unlikely that the specific foods consumed (e.g. milk and milk products) over a period would all be sourced locally from a contaminated site.

FSANZ considered a range of regulatory and non-regulatory options in parallel with at-site risk management measures by other commonwealth and state and territory jurisdictions to manage and potentially reduce dietary exposure of PFAS.

Whilst there are insufficient data to recommend a regulatory approach and set maximum limits in the Food Standards Code, FSANZ proposed trigger points for investigation for PFOS + PFHxS combined and PFOA. These trigger points could be employed by state and territory food jurisdictions when analysing PFAS in foods to identify when further investigation of a food may be required. For example, when levels of PFAS in analysed foods exceed specific values (trigger points) further investigations or risk management action may be required but this would be dependent on the relevant jurisdiction and the specific issues at the particular site.

10 kg child = 200ng/day ! for PFOS

1600 ng/day for PFOA

1 Enhealth adopted the 2008 European Food Safety Authority (EFSA) human health reference values for two PFAS chemicals, perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) and set interim Health Based Guidance Values (HBGVs).

2 These values are lower than the EFSA TDIs of 150 and 1,500 ng/kg bw/day, respectively.

FOOD STANDARDS
Australia New Zealand
Te Mana Kounga Kai – Ahitereiria me Aotearoa

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10 kg child = 200ng/day ! for PFOS

1600 ng/day for PFOA

1 Enhealth adopted the 2008 European Food Safety Authority (EFSA) human health reference values for two PFAS chemicals, perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) and set interim Health Based Guidance Values (HBGVs).

2 These values are lower than the EFSA TDIs of 150 and 1,500 ng/kg bw/day, respectively.

1 µg = .001 mg

.02 µg / 10kg/day

.2 µg / day

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cont

2.1 mg / 1000g

2100.0

2100.0 µg / 1000 g

2.1 µg / 1 g

.21 µg / .1 g sol

.21 µg / 100 mg sol.

FOOD STANDARDS
Australia New Zealand
Te Mana Kounga Kai – Ahitereiria me Aotearoa

Summary of Consolidated Report