Planning Scheme Amendment C162 – Mt Atkinson and Tarneit Plains, Victoria – Consideration of Landfill Gas Risks

Prepared for:
Victorian Planning Authority

September 2016

consider it done

Expert Witness Report

Prepared by:
EHS Support Pty

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1.0 INTRODUCTION

Following a proposal to the Melbourne Planning Authority (MPA) now the Victorian Planning Authority (VPA) of 16 August 2016, VPA in an email dated 26th August 2016, and purchase order dated 25 August 2016, appointed Mr Kenneth Neil Mival of EHS-Support Pty Ltd to provide Expert Evidence in regard to Planning Scheme Amendment C162 – Mt Atkinson and Tarneit Plains, Victoria in relation to the potential for landfill gas migration risk from the proposed expansion of the Melbourne Regional Landfill. The accompanying brief of instructions provided to this witness is included in **Appendix A** of this report for reference.

From the email request, as well as a prior meeting with VPA on 24 August 2016, it is understood that VPA is assessing the potential impact on land to be developed in accordance with Planning Amendment C162 from the future operations of the Melbourne Regional Landfill where portions of the landfill are proposed to be located up to approximately 100 metres from the Amendment eastern boundary.

In providing this report I have read The Guide to Expert Evidence provided by Planning Panels Victoria and agree to be bound by the terms of the Expert Witness duties as detailed in the Guide and the Provisions of the Civil Procedure Act 2010 relevant to an Expert Witness.

The brief of instructions provided to me by VPA is attached in **Appendix A** of this report, with a copy of the Guide to Expert Evidence.

2.0 DECLARATION OF EXPERT WITNESS

2.1 Report of Expert Witness Pursuant to the Guide to Planning Panels on Expert Evidence.

I Kenneth Neil Mival, Environmental Auditor employed by EHS Support Pty Ltd (EHS), of 55 Forest Road, Flowerdale, Victoria 3717, have been requested by the Victorian Planning Authority (VPA) in regard to the Planning Scheme Amendment C162, to prepare this report in respect of the potential for landfill gas migration from the proposed expansion of the Melbourne Regional Landfill (MRL).

I have read the Guide to Expert Evidence at Planning Panels as provided to me by VPA and agree to be bound by those guidelines.

2.2 Qualifications, Experience and Area of Expertise

I qualified with a Bachelor of Science (Hons) in Geology at Exeter University, Devon England in 1969 and have worked progressively as a geologist, engineering geologist and environmental auditor for the last 47 years.

I have over 45 years of experience in engineering geology and environmental consultancy, the last 23 as an Environmental Auditor appointed by EPA Victoria pursuant to the Environment Protection Act 1970, including management and/or environmental audit of the clean-up of numerous former industrial sites prior to development for sensitive uses, including residential use, and including the auditing of landfills.

I have extensive experience with geotechnical and environmental engineering, including environmental assessments, health risk assessments, contaminated land management, statutory and due diligence audits for many large and small projects (refer to CV attached). My specific areas of expertise relevant to this report includes the provision of consultancy advice and environmental auditor services in regard to landfill management and the auditing of landfills in regard to construction, operation and closure in relation to the BPEM guidelines; the closed landfill guidelines; and the requirements of the Environment Protection Act. This has included the auditing of land proposed for residential developments located within buffer zones in regard to landfill gas migration risk and odour risk from adjacent operating and closed landfills.

My experience has also included audit of many major development projects at Docklands including audits of the clean-up for the former West Melbourne Gasworks; for major road and infrastructure projects; and for the clean-up of major chemical and industrial sites including sewage farms and landfills. As the project manager I supervised the clean-up and disposal of lead contaminated soils and dusts from 63 properties at Suspension Street Ardeer for EPA in the early 1990s. My experience has also included historical research into, and advice on, the likely causes, impacts and costs of contamination by industrial chemicals, and of its remediation including the management of wastes in accordance with EPA regulations, for management decisions, litigation, and audit purposes.

Specific previous project experience relevant to the consideration of landfill gas risks to this proposed amendment includes:

- Audit of the $45m remediation of a large sewage treatment facility in Melbourne's east involving dioxin remediation that also included a 53V audit of the construction of a landfill containment facility to contain the contaminated sludges that included audits of liners; leachate management and gas collection systems;
- 53V Audit of a large landfill site at Springvalley Reserve for landfill gas risks for City of Greater Dandenong as part of the EPA investigation into potentially hazardous landfills following the Brookland Greens evacuation;
- Providing expert advice to EPA regarding landfill gas migration relating to Stevenson's Road Landfill at Cranbourne and its potential impact on the Brookland Greens estate in south east

Melbourne, including informing EPA of the existence of an 'Imminent Environmental Hazard' at the site.

- Provision of consulting advice to the City of Casey in regard to ongoing landfill gas risk post-remediation of the site in 2014;
- Auditing of two large closed landfills (Sunshine and Huletts Road Landfills) for City of Brimbank at Energy Park and Carrington Drive Reserve and ongoing review of landfill gas risk to adjacent properties;
- Auditing of a number of proposed residential sub-divisions within the buffer zone in proximity to the SUEZ Environment (SITA) landfill at Hallam in regard to landfill gas risk and landfill odour that has been a significant ongoing problem with numerous complaints to EPA;
- 53X Audit of Tooronga Village, a former landfill developed for commercial and medium/high density residential use in multiple stages and audit areas and the bulk of the site now being sub-divided for a sports facility for St Kevin's High School;
- The provision of a gas risk assessment for multiple options to construct a Waste Transfer Facility on top of the Fraser Road Landfill at Clayton; and
- Audit of a 20 ha site in South Oakleigh for a property developer that is located on former putrescible waste landfill, and sand quarries filled with clay and silt washings from processing of the sand. This has included review of a site remediation strategy; development designs including vapour barriers and leachate collection wells, and management plans for construction and on-going monitoring of the site (in progress 2013 to current 2016).

More details on my overall experience and qualifications are provided in Section 2.5 below and in my CV included in **Appendix B** of this report.

In preparing this expert report I have been assisted by Dr Tiffany Gourley (Senior Hydrogeologist): Dr Gourley has recent experience working with me on landfill and waste projects, and for this project has assisted me in regard to technical reviews of landfill gas risk management issues, the completion of a preliminary qualitative risk assessment of landfill gas risk in the consideration of proposed buffer distances in relation to the requirements of relevant and proposed guidelines.

Dr Gourley recently undertook, and project managed under my direction a review of the landfill gas risks relating to a proposal to construct a waste transfer facility at Fraser Landfill in Clayton. She has also worked with me in relation to a major review of landfill gas risks on behalf of the City of Casey in relation to Stevenson's Road landfill following completion of the mitigation measures to protect the residents of Brookland Greens Estate in Cranbourne.

Dr Gourley's CV is also included in **Appendix B** for reference.

2.3 Instructions

I have been engaged by VPA Manager Martina Johnson / Director Greenfields, to prepare this witness statement and form an opinion on specific questions relating to this matter. The questions are detailed in **Section 3** of this report and are contained in VPA's briefing document provided on 16 August 2016. A copy of this briefing document is included in **Appendix A** of this report. Subsequent to that instruction, I have also been verbally requested to comment on the potential for odour risk from an operating landfill based on my experience with the Hallam landfill.

In the preparation of this report, I have been directed to a number of documents relating to both the landfill and the proposed amendment available over the internet. I have also referenced a number of other documents that are available through EPA and other publically available records including the audit reports previously prepared by myself that are relevant to these considerations. The documents that have been referenced are listed in **Section 3.2** of this report.

Whilst the bulk of this report has been prepared by myself, I have also utilised the expertise and experience of Dr Gourley to assist me in review of relevant information and to provide me some of the data on which I have based my opinions in this matter and to prepare a preliminary qualitative gas risk assessment to assess suitable buffer distances.

2.4 Declaration

I declare that I have made all inquiries which I believe are desirable and appropriate, and that no matters of significance which I regard as relevant, have to my knowledge been withheld from the Panel.

I declare that all opinions expressed in this report are not subject to any qualifications without which the report may be incomplete or inaccurate.

I declare that I had sufficient research and data and am satisfied that all opinions expressed in this report are conclusive.

Kenneth Neil Mival
Environmental Auditor (Contaminated Land) Victoria

2.5 Summary of Career Experience Kenneth Neil Mival

Qualifications: BSc (Hons) Geology (Exeter UK 1969)

Areas of Experience: Engineering Geology, Instrumentation, Materials, Contaminated Land Management, Environmental Auditing, Landfill auditing.

Career Summary: Kenneth Mival is a Consultant Engineering Geologist with over 45 years of experience in the fields of mining, engineering geology, geotechnical and environmental engineering, and has worked on major projects in these fields in Central and Southern Africa, United Kingdom, Australia, New Zealand, Singapore and Papua New Guinea.

Ken has a wide experience in all aspects of engineering geological investigations, geotechnical instrumentation, and groundwater quality. He has managed many projects involving major infrastructure developments for industry and government including assessment of slope stability, foundations, materials, groundwater, and failure analysis. Projects have included roads, tunnels, harbours, pipelines, landfill permitting, electrical and telephone infrastructure developments, and building basements and foundations. In the last twenty-five years he has also been primarily involved in environmental assessments and audits; the management of contaminated land; and the auditing of construction of landfills and closed landfills.

Ken was accredited by the Environment Protection Authority (EPA) as an Environmental Auditor (Contaminated Land) in 1993. His accreditation has been continuous and remains current in Victoria until November 2020. He has undertaken environmental assessments, health risk assessments, contaminated land management, statutory and due diligence audits for many large and small projects. These include statutory environmental audits for several of the Melbourne Docklands Development Precincts including a $60m remediation of the West Melbourne Gasworks; Victoria Harbour; Yarra's Edge; the Western Link of Melbourne City Link Elevated Freeway; a number of explosives and chemical sites; several landfill sites; and other major due diligence audits for the Commonwealth, and multinationals.

In 2011 he completed the environmental audit for Melbourne Water of the $45m remediation of a large sewage treatment facility in Melbourne's east involving dioxin remediation for continued industrial commercial use, including a 53V audit of the construction of an 8 hectare, 6 celled landfill facility to contain the contaminated sludges. He also recently completed audits for the remediation of the final phases of development in Victoria Harbour, Melbourne Docklands for a developer; a former quarry filled with petroleum hydrocarbon wastes in Sydenham for ongoing use as a car park; other former gasworks sites in Melbourne; and a large former chemical works located adjacent to the Maribyrnong. He also completed Environmental Audits for the Westgate Freeway Upgrade including the management of contaminated soils on the site and previously the City Link Western Link; a large landfill site for landfill gas issues for City of Greater Dandenong; two large closed landfills for City of Brimbank; and provided expert advice to EPA and City of Casey regarding the Cranbourne landfill gas issues.

Ken has also previously developed guidelines for prevention and management of contamination for the Department of Defence, and undertook the Australian part of a worldwide study on the management of contaminated military sites, including explosives manufacturing sites, on behalf of the German Federal EPA. He has also appeared as Expert Witness at VCAT and in court cases relating to: dams; contaminated land management; and two instances of illegal landfills for EPA; and has provided expert opinion on: landfill gas issues; asbestos and PCB contamination; the potential cost for remediation of 75 city sites for continuing port use in a high court dispute; a supreme court action on compensation for land compulsorily purchased for the regional rail project based on the extent and likely cost for remediation; and for claims for variations on unforeseen ground conditions for dams, tunnelling and directional drilling in various jurisdictions.

Most recently he appeared as an Expert Witness in the Supreme Court in relation to coal tar wastes abandoned on the former Richmond Abattoir site purchased by the Metropolitan Fire and Emergency Services Board. He recently also appeared as an expert witness at Planning Panels Victoria in relation to Planning Scheme Amendment C173 that imposed Environmental Audit Overlays on a number of properties in the City of Brimbank Planning Scheme.

Ken is a past Chair of the Victoria Division of the Association of Consulting Engineers Australia (2008/2009) (now Consult Australia) and a committee member from 2004 to 2009. During 2009, Ken was invited to represent ACEA on the Building Commissioner's Bushfire Roundtable. He represented URS on the joint ACEA/Engineers Australia bushfire recovery committee for voluntary engineering support; in waste water studies; and assisted the local Flowerdale recovery committee to establish a temporary recovery village for those displaced by the February 2009 bushfires.

He was a member of EPA's Environmental Audit System Improvement Group (EASIG) from 2010 to 2013, and has been a member of the Victorian Planning and Environmental Law Association since 2001. He remains a member of EPA's Landfill Auditors Reference group and on their Groundwater Committee.

A full professional resume is included in **Appendix B** of this report.

3.0 INFORMATION CONSIDERED BY WITNESS

Whilst no specific documents were provided to the witness except for two overall proposed development plans referenced below (**MPA Figures 1 and 2**), the witness was directed to a number of documents and reports that were located on the web site for the Planning Scheme Amendment to allow him to conduct his review and prepare an Expert Witness statement in accordance with the Planning Panel Guidelines.

The information referenced is documented in Section 3.2 below.

3.1 Questions to Witness by VPA

The questions put to the witness by VPA in the brief supplied, requested that Mr Mival provide expert evidence to the Planning Panel for Planning Scheme Amendment C162 (Mt Atkinson and Tarneit Plains PSP) in relation to landfill gas migration from the proposed Melbourne Regional Landfill expansion.

The VPA requested that the specialist provide expert evidence including, but not limited to:

1) *Potential impact on the precinct from landfill gas migration from the proposed landfill expansion including but not limited to potential impacts on air quality, hydrology, community safety and health?*
2) *Requirements for a proponent within the PSP and within any potential landfill gas migration buffer to ensure compliance with the Best Practice Environmental Management for Siting, Design, Operation and Rehabilitation of Landfills Guidelines?*
3) *The potential implications of a proponent within the PSP having to undertake an environmental audit under Section 53V of the Environment Act 1970 including if possible a cost estimate to undertake the audit and potential mitigation measures?*
4) *The practicalities of undertaking an environmental audit under Section 53V of the Environment Act 1970 in response to a **proposed** landfill cell?*

Further, in discussions with VPA on 26th August, it was requested that in answering question 1 above, that the impact on air quality should also include some comment on the potential for impact from odour due to the waste operations of the landfill.

3.2 Information Considered by the Expert

Documents referenced in the preparation of this expert witness statement include:

- Mt Atkinson (PSP1082) & Tarneit Plains (PSP1085)-Precinct Structure Plan- April 2016 (**PSP 2016**);
- Mt Atkinson (PSP1082) and Tarneit Plains (PSP1085) – Background Report – April 2016 (**PSP BR 2016**);
- MPA plan – Future Urban Structure – Land use Response to the Potential Future Landfill MPA Preferred (**MPA Fig1**) based on Plan 3 from PSP BR 2016 and included as a figure at the end of this witness report
- MPA plan – Future Urban Structure – Land use Response to the Potential Future Landfill – Cleanaway Proposal (**MPA Fig2**) included as a figure at the end of this witness report
- Melbourne Regional Landfill Extension – Planning Permit Application Report – Tract Consultants Ref 0315-0157 PR01_01 dated 19 February 2016 (**Tract 2016**)
- Information to Support Works Approval Application – Proposed Melbourne Regional Landfill (MRL) Extension Ravenhall - Golder Associates Ref 1528407-007-R-Rev0 dated February 2016 (**Golder 2016a**); and including as Appendix H of the Golder Report:

    - Landfill Gas Management Plan, Melbourne Regional Landfill, Ravenhall Vic - Golder Associates Ref 1528407-023-R-Rev0 dated February 2016 (**Golder 2016b**);
- Melbourne Regional Landfill – Hydrogeological Assessment – AECOM ref 60451445.43283857 dated 11 February 2016 (**AECOM 2016**);
- Environmental Audit Report – Energy Park and Carrington Drive Closed Landfills URS Report ref 43295286 dated 7 February 2013 – EPA reference 68897-1 (**URS 2013**)
- Environmental Audit of Risk to the Environment – Section 53V – 18-20 Karoonda Way, Hampton Park – URS Ref 43514169/R001/01 dated 31 July 2015 – EPA Ref 8004695 / 73655-1 (**URS 2015**);

In addition to the documents above that are relevant to the PSP, the MRL or to experience at other sites; this witness considered the advice provided in the following EPA publications and the relevant British Standard that is also referenced by EPA Victoria in relation to developments within buffer zones of landfills:

- EPA 1970 – Environment Protection Act 1970 No 8056 dated 22 Dec 1970 (**EPA 1970**)
- Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills – EPA publication 788.3 dated August 2015 (**EPA 788.3**);
- Closed Landfill Guidelines – EPA publication 1490 dated December 2012 (**EPA 1490**);
- Environmental Auditor (Contaminated Land) Guidelines for Issue of Certificates and Statements of Environmental Audit (EPA publication 759.2 of February 2014 (**EPA 759.2**)
- Draft Guideline* - Assessing Planning Proposals Near Landfills – EPA publication 1625 – June 2016 (**EPA 1625**)
- Draft Guideline* – Landfill Licensing – EPA publication 1619 dated April 2016 (proposed to replace pub 1323.2) (**EPA 1619**);
- British Standard 8485:2015 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (**BS8485**)

Where referenced in this report, the documents are referred to by the short name given in brackets at the end of each title – for example (**PSP 2016**).

Note* - Whilst draft guidelines would not normally be referenced in this context as they may change before finalisation and implementation, in this case – as this report is considering future impacts or restrictions on the planned developments under the amendment, and as they represent current EPA thinking in regard to landfill buffer zones, risks and mitigation measures, it is considered that they are relevant as they indicate restrictions that are likely to be imposed on developments within buffer zones.

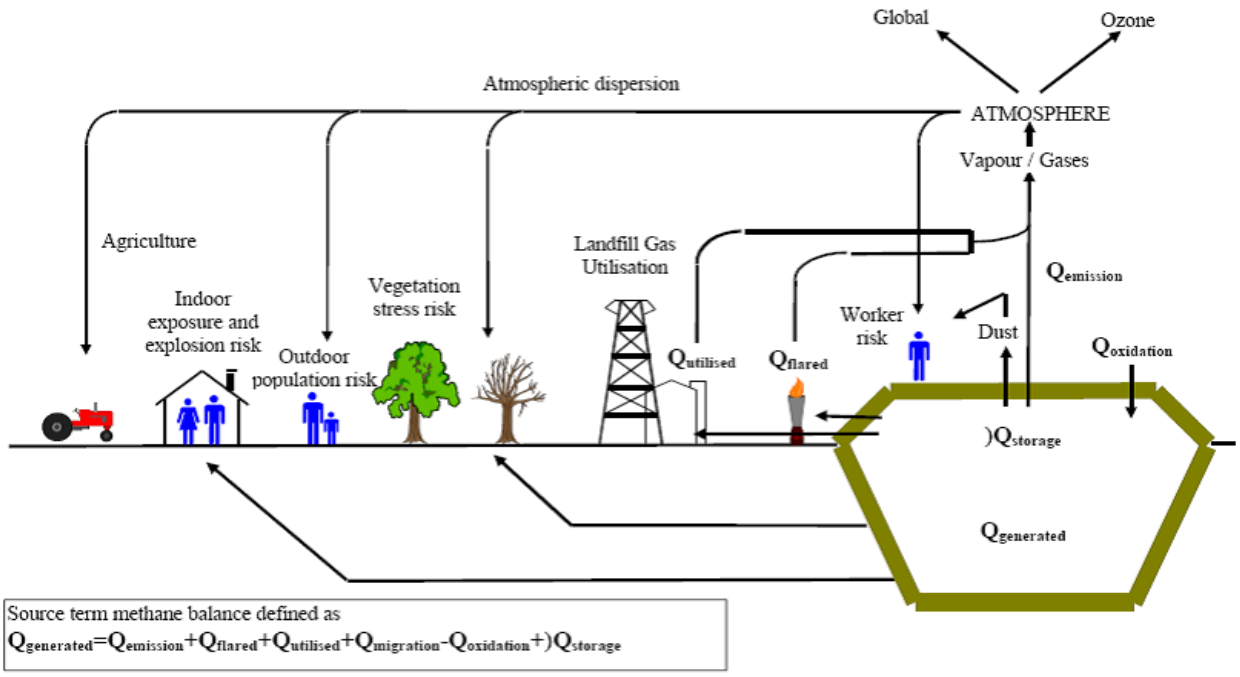
4.0 QUESTION 1 – POTENTIAL IMPACTS FROM LANDFILL GAS MIGRATION

What is the potential impact on the precinct from landfill gas migration from the proposed landfill expansion including but not limited to potential impacts on air quality, hydrology, community safety and health?

4.1 Potential Impacts

The potential impacts from Landfill Gas generation within landfills and migration by various pathways off-site are now well understood, in particular following the experience of the impacts on the surrounding residential properties in the Brookland Greens Estate in Cranbourne, that have subsequently been extensively studied.

The various potential pathways and receptors of landfill gas migration are best illustrated in the following conceptual model of landfill gas emissions from UK Environment Agency technical paper P271:



From the UK guidance note LFTGN03 *Guidance on the Management of Landfill Gas*, it is considered that the pathways receptors that may be exposed to landfill gas emissions include:

1) Direct release to atmosphere;
2) Sub-surface migration through the ground or along service ducts and/or pipelines etc.;
3) Indirect release to atmosphere, e.g. from sub-surface landfill gas migration then through the atmosphere to receptors; and
4) Direct release of combustion products to atmosphere, e.g. from enclosed flares or engines.

A landfill gas risk assessment would be required that assesses the level of risk in relation to each of these potentially complete pathways. This has already been undertaken by Golder on behalf of the proposed Landfill extension **(Golder 2016 a & b).**

Impacts on air quality would primarily affect residents or the general public with noticeable odours from the landfill gas itself (or from exposure of the putrescible waste materials during operation of the landfill) that would impact on the amenity of those receptors. Landfill gases also include a number of harmful chemicals in trace amounts that could have impacts on health of those regularly exposed to the emissions. Chemicals such as benzene, naphthalene, hydrogen sulphide, ammonia, are common and depending on inputs to the landfill cells, potentially hydrogen cyanide from acidic leachates impacting on metal plating wastes, and a range of other minor volatile chemicals that may be dumped into the wastes by households such as chlorinated solvents.

For example, exposure to even quite low concentrations of hydrogen sulphide will initially cause a rotten eggs odour that would be objectionable to many and generate complaints, but as exposure continues or the concentration increases, the nasal receptors become anaesthetised by the chemical such that it is no longer detected by smell and can eventually reach fatal concentrations. However, the proportion in landfill gas is generally relatively minor in trace amounts and therefore the risks of health impacts are quite low. Exposure over the long term to other chemicals on a regular basis, whilst not initially as severe as for hydrogen sulphide, can produce long term health impacts such as cancer as many are also known carcinogens – for example benzene.

The main potential risk to residents, commercial building occupants and the general public is from the transmission below ground of methane and carbon dioxide generated by methanogenesis in the landfill during its anaerobic phase. They are not odorous, but both are asphyxiants and, whilst carbon dioxide is relatively inert and heavier than air and can settle in basements, methane is explosive in air at between 5% and 15% methane. It is flammable at higher concentrations, and being lighter than air will make its way up through cracks into enclosed spaces within affected properties, where a spark from a water heater or other ignition sources can ignite it.

It was a number of landfill gas explosions in the UK in the 1980s that led to the UK Environment Agency preparing guidelines in relation to buffer zones around active and closed landfills. From their experience, a buffer distance of 500metres was established on the empirical evidence from those events. However, this is based on overall worst case experience and does not take account of differences in geology, climate, landfill design, maintenance and gas management. EPA Victoria has adopted these recommended buffer distances as indicated in the BPEM (**EPA 788.3**) based on the UK experience.

I discuss below some of the lessons learned from Brookland Green's Estate and the exposure to methane from the Stevenson's Road landfill in the City of Casey where some consideration of what should be considered in regard methane migration relating to buffer distances for landfills in Victoria.

4.2 Lessons from Stevenson's Road Landfill

As a conservative measure, the example of the landfill gas migration into the neighboring residential estate of Brookland Greens from Stevenson's Road Closed Landfill (SRCL) in 2008/9 is discussed.

The primary source of LFG to the residential estate was considered to be the former Casey-Frankston Landfill that was unlined, and was known to have had waste depths of up to 31 metres, generating a significant volume of leachate and landfill gas. It was also saturated by a natural spring that flooded the landfill to a certain extent as it was not adequately managed during operation and post closure of the landfill.

In addition, due to perching of the leachate or groundwater on lower-permeability layers of daily cover, a large fraction of the waste was saturated that enhanced gas production. The low permeability layers are considered to have prevented LFG from being adequately captured by the landfill gas collection

system, which in turn caused pressures to build up and gas to migrate laterally into the adjacent geological formations.

The presence of the perched leachate and groundwater was also considered to have hampered the landfill gas extraction system as saturated waste generally terminates the radius of influence of gas extraction wells. Gas that was produced and not extracted or emitted through cover soils was likely to have migrated laterally into adjacent geologic formations that, being primarily sandy from the Tertiary Brighton Group, had significant permeability to gas flow.

The presence of detectable methane at up to 2% within some houses triggered significant concerns by EPA and led ultimately to the evacuation of a number of residents in the worst affected areas. This witness reviewed this information on behalf of EPA and indicated that – in his opinion – the situation represented an 'imminent environmental hazard' as defined in the environmental auditor guidelines (**EPA publication 759.2**).

Following the evacuation, a number of additional studies took place leading to the design of remedial measures to rectify the situation. Enhancements to the leachate and gas collection systems and the installation of a Cement Bentonite Diaphragm Wall following (CBDW) largely addressed the migration of LFG away from SRCL.

LFG that initially migrated into deep unsaturated and porous sediments (e.g. sand and gravel) such as the Werribee Formation beneath the Brighton Group sands and Older Volcanics formation, was thought to have migrated the furthest off-site, being trapped underneath relatively impermeable clays of the Older Volcanics and/or the upper more clay-rich section of the Werribee Formation. This LFG could then reach the surface via diffusion or water-table driven vertical advective transport. Preferential pathways such as fractures in the basalt of the Older Volcanics, or where services penetrated an overlying impermeable barrier, would have also resulted in the vertical migration of LFG to the surface where it impacted the residences.

The LFG main constituents of methane and carbon dioxide, that migrated laterally from the landfill are considered to have travelled distances up of to approximately 700m from the landfill into the neighboring residential estate to the west.

Since 2008, methane and carbon dioxide concentrations for residual LFG in the residential estate have shown a decline consistent with first-order kinetics, which suggests that the process of natural attenuation is occurring. The construction of the cut-off wall has also minimized the flow of methane from the landfill into the formations, and upgrade of the gas collection system so that it is effective, has also contributed to resolving the situation.

The case of LFG migration from SRCL into the neighboring residential estate, is considered by this witness to be a worst case scenario with respect to the proposed extension to the Melbourne Regional Landfill given that the Stevenson's Road landfill was unlined; the wastes became saturated and had multiple layers; the gas extraction system failed; and the underlying geology was conducive for offsite migration of LFG. The fractured rock nature of the Newer Volcanics basalt at the MRL, whilst still potentially permitting flow of gas and leachate through rock fractures, would be significantly less likely to allow rapid transmission of LFG over the distances seen at Brookland Greens, so the 700metres would be considered to be a worst case scenario.

4.3 Measured impacts of landfill gas at Energy Park and Carrington Drive Reserve

Whilst information may be available relating to the existing MRL, in order to assess potential risks relating to landfill gas migration from large unlined landfills within the Newer Volcanics formation that have been in existence for over 40 years, this witness makes reference to a previous audit he undertook for a pair of large closed landfills for City of Brimbank. This information is based on the Environmental

Audit Report – Energy Park and Carrington Drive Closed Landfills (**URS 2013**) prepared by this witness.

There were two main areas of concern for the auditor: the presence of residential properties on the northern flank of the former landfills and in some cases with portions of these properties overlapping onto the wastes placed within the former quarry; and commercial properties grouped around the southern flanks of the landfills.

Both landfills were unlined and accepted large volumes of municipal wastes, but also had a history of co-disposal of industrial wastes including dumping of hydrocarbon wastes into a number of small satellite quarry holes. Whilst it had been capped in the 1980s and a landfill gas extraction system was in place to capture the methane and use it to generate electricity, this had never been particularly successful and at the time of the audit the system was shut down and infrastructure removed, although landfill gas was still being generated.

The audit found that the presence of high levels of LFG remained in bores screened in waste where they were abutting the interface between the former quarry and the residential zone along the north side of the landfills. To the south of the landfills, land on intact basalt was in use for commercial and light industrial operations. In the commercially zoned areas on the south side of the landfill, it was found that there remained some potential risk of migration into properties in those areas from the former landfills.

Most of the monitoring bores installed over a small distance from the landfills in these areas at between 25 and 75 m for the former City of Sunshine landfill, and approximately 25 m for the former Hulett Street landfill, did not show the presence of methane and only modest concentrations of carbon dioxide over background levels. Some significant methane concentrations have been found in the backyards of a number of the residential properties located on the north side of the former landfills at distances of less than 25metres from the landfill boundary. These properties continue to be monitored on a regular basis and gas risk assessments for potential extensions to some of these properties have indicated that mitigation measures are likely to be required as a precaution.

Concentrations of methane were also detected at levels above the BPEM action criteria at a single monitoring location adjacent to a commercial property in between the two former landfills (between 100 and 150m away from a landfill boundary). This does indicate that some LFG migration potentially along preferred pathways has been occurring locally in this southern area and may have migrated elsewhere further than where detected in the one bore.

The elevated levels of carbon dioxide above the action criteria and assumed background concentrations detected in a number of the monitoring bores surrounding the former landfills are also indicative of potential historical LFG migration given that concentrations appear to be lower at a greater distance from the waste mass. The oxidation of historically migrated methane could also be contributing to these elevated concentrations of carbon dioxide, although this may have occurred over some time during operation of the landfills or post capping.

Overall, it was concluded that the whilst the risk to climate systems and ecosystems is ‘medium”, the ongoing generation of methane and migration off-site with the potential to accumulate in buildings close to the site represented a “high” risk to human health in buildings at close proximity to the former landfills.

Despite the presence of methane at significant concentrations exceeding the LEL adjacent to the northern boundary, none of the bores located beyond the residences at a distance of 30 to 40metres from the landfill perimeter recorded methane above the 1% v/v trigger level of the BPEM. Carbon dioxide was present at concentrations up to about 6%v/v and oxygen levels were depleted, indicating that some proportion of landfill gas had probably been present since the landfills were capped.

Whilst soil gas concentrations at the landfill boundary were found to be significant, and were in close proximity to the residences on the northern boundary, this did not appear to have translated to a significant risk to residents in that case. It would appear that the intact nature of the basalt rock is such that very little methane escapes into the surrounding soils. However, due to the relative leakiness of the capping, which allows the escape to atmosphere of the landfill gas, and the reduced flux rate of LFG generation from the landfills, this does not appear to have translated to significant lateral migration within the soils and from there potentially into houses. Improvements to the capping system however, would have to be accompanied by functioning gas collection system to ensure this situation did not change.

Whilst no intervention measure, such as a cut-off wall was considered to be justified in this case to limit gas flow, ongoing monitoring was considered to be required to ensure that no change to the current status occurred whilst gas production at the landfill continues to decline over time, ultimately reducing the risk to negligible levels.

The conclusions that this witness draws from the experience with the Energy Park and Carrington Drive Reserve, is that, whilst the landfills were in excess of 40 years old and had been capped more than 30 years previously, some migration of landfill gas was still occurring within the New Volcanics to up to at least 150metres beyond the landfill boundary. Whilst the landfill was relatively unstructured and unlined, it is not representative of a modern designed landfill, but is instructive as to what may occur if a landfill liner breaks down at the MRL.

4.4 Proposed Cell Structure at MRL

Golder in their report (**Golder 2016 a**) included details of the proposed measures to manage potential LFG risks in section 18.2.6 of their report. They state that the cells in the northern portion are designed with a one kilometre buffer zone to the nearest sensitive receptors, and those in the southern portion with 500metres.

Their main strategy is to design the base liner and capping systems to BPEM standards to minimise the uncontrolled migration of the generated LFG. It is therefore presumably intended to be a composite liner comprising clay and a geofabric liner such as HDPE, along with leachate collection layers within each cell and they state that there will be sacrificial horizontal gas collection piping within the cells as they are filled.

Also, whilst they indicate that some cells will abut the face of the quarry, the majority of the extension will have cell boundaries set back from the face. Golder provide the sketch below indicating how this will operate to manage lateral emissions. However, no detailed designs were reviewed by this witness.

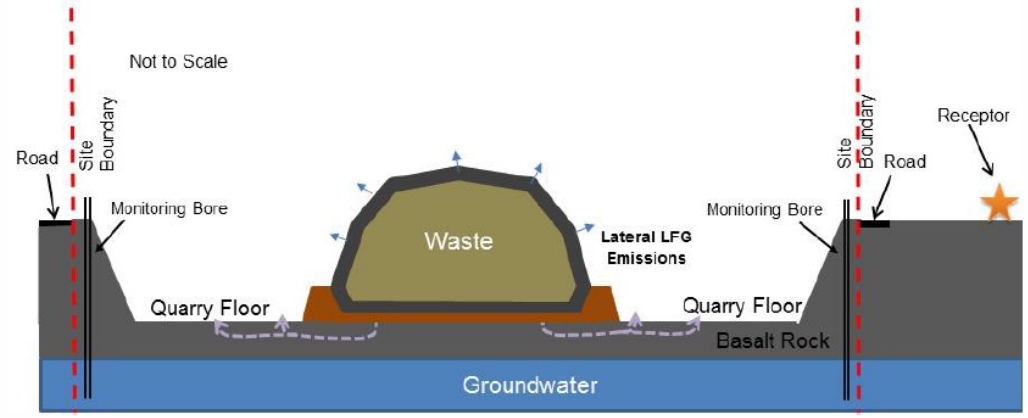


Plate 6: Conceptual model for lateral LFG emissions

Whilst the above design is only conceptual, there are a number of features that are concerning.

Firstly, whilst it would manage the LFG emission such that migration into the surrounding rock is unlikely, there would be a large air gap left around each cell that would considerably reduce the air space available to landfilling. My experience with landfills is that the operator always wants to maximise the air space available to minimise the overall cost per cubic metre of landfill space. So if the above system is adopted, then MRL would need to be held to it by EPA to ensure that there is no later variation to the design to allow the filling up to the side walls of the quarry.

Secondly, there is insufficient detail in the information that was accessed to understand how such a design is to be supported. The sketch provided indicates a landfill cell height of about 15metres. The stability of the compacted municipal waste is a factor in the design and waste slopes should not exceed 1 in 2 and preferably would be flatter than 1 in 3 to maintain stability. Normally, the passive resistance of the rock walls of the former quarry is utilized to provide lateral support to the liner and compacted wastes, and that would minimize the potential for deformation and failure of the liner.

Also as settlement of the waste occurs, there will be distortion of the unsupported sides of the cell, potentially leading to a failure of the liner. That would then release significant quantities of LFG and odours from decomposing wastes at once, with the potential to impact many receptors within the proposed amendment with high concentrations of LFG and accompanying odorous gases.

Even if a cell was constructed in the traditional manner with a side liner against the quarry wall, no landfill has been constructed in Victoria that has existed with composite liners for more than 25 years. Therefore, their longevity and potential for failure over time is untested. From Plate 5 from **Golder 2016a**, the gas production of the landfill is not expected to drop to moderate levels before at least 2080, which is over 60 years from now. Therefore, whatever lining system is used, it will have to last that long and we have no experience of how composite liners will eventually perform over that length of time.

A primary reason for establishment of buffer zones around landfills is to protect potential receptors from the upset condition when the primary system of containment may fail. The rock becomes the secondary containment vessel in that case and would then be no better than an unlined landfill similar to the Energy Park case discussed above.

4.5 Risks to amenity of residents

The physical health of receptors is considered by the LFG risk assessments looking at the potential for penetration of landfill gases into residences from the ground, or that may be carried into ambient air

then into homes. However, one aspect of the impact of operating landfills that has an effect on the mental health of residents or commercial workers in or close to the buffer zones, is the impact of odour.

Whilst odour can be generated from LFG because of the content of odorous trace chemicals – eg H2S; ammonia; naphthalene and the like, during the operational phase of the landfill, the biggest source of complaints about landfill operations received by EPA from residents in proximity to landfills is the odour from tipping and management of the putrescible wastes received by the landfill, the rotting cabbage smell that most people would be familiar with.

This has led to some significant effort by EPA to work with landfill operators to reduce the potential for odour generation. Whilst technically, the landfills are not permitted to allow odour beyond their boundaries, this is difficult to manage.

My experience from the audit of a number of properties around the SUEZ Environment (SITA) landfill at Hallam has indicated that, the worst case is from when light winds (up to 10km per hour) are blowing across the landfill – whether winter or summer – it can move these odours up to considerable distances beyond the boundaries.

Following imposition of the Enforceable Undertaking (EU) by EPA on SITA, there was a dramatic improvement in the complaint history with about an 80% reduction in complaints to EPA about odour from the landfill. Most of these complaints were in the range of up to 1km from the landfill boundaries and were relatively infrequent and short lived. However, whilst it may be feasible to develop residential properties within the 500m to 1km distance from the MRL, it is likely that some odours will occur intermittently within that range and occasionally beyond it.

The primary requirements of the Hallam EU can be summarised as follows:

- Maintain an odour curtain around the boundaries downwind of the working face;
- A significant reduction in cell volume and open areas under active use;
- Undertake aerial infra-red monitoring to detect hotspots on the landfill capping on closed cells that could indicate sources of gas emissions;
- Maintain community updates and open a reporting hotline to report odour, as well as providing access to community representatives to examine the progress with and performance of the odour control measures;

There were also a large number of relatively minor administrative and reporting measures that had to be implemented. A copy of the full EU is included in Appendix C of this witness report for reference.

In considering the question of management of odour and fugitive gas emissions, it is noted that Tract has included a number of measures in Section 3.1 of **Tract 2016** that appear are intended to deal with the potential for odour generation.

Table 5 of Tract – does not take into consideration future land uses within 500metres except the note at the end that states:

> As detailed in section 3.11, whilst BPEM requires a 500m buffer to sensitive uses, a 1km buffer has been provided to the potential future residential communities within the draft Future Urban Structure Plan for the proposed Mt Atkinson PSP. The communities of Caroline Springs, Burnside and Deer Park are each more than 1km from the Extended MRL.

Section 5.4 discusses the potential for air emissions odour and gas in relation to level of complaints about odour from the existing facility which spiked in 2014, possibly due to a heightened awareness of the presence of the landfill and the proposed extension of the MRL.

They indicate that a number of measures are available to minimise odour emissions as follows:

- At the active cell (apart from the active tipping face), by ensuring that an adequate interim cap is in place and that active landfill gas (LFG) capture is installed as soon as possible, using a sacrificial horizontal collection system.
- At completed cells, by having in place an effective final cap, an efficient active LFG gas collection system and an effective monitoring and maintenance program to ensure no significant fugitive emissions. A vegetated cover will also help to reduce the potential for emissions through the surface.
- By minimising the generation of leachate, by ensuring maximum integrity of cells and minimising water infiltration, ensuring that any exposed leachate storage is located well away from sensitive locations, and by monitoring leachate conditions and emissions.
- When undertaking site works, by avoiding disturbance of previously-placed waste, for example when developing or modifying the LFG capture system, when there is a risk that odour emissions will impact on sensitive locations.

■ Landfill management and design plays an important role in determining odour emissions, with the following measures available to minimise emissions from potential sources:
- At the active face, by minimising the area of newly-placed waste that is exposed to the atmosphere on a continuous basis, and ensuring that there is adequate daily cover to minimise emissions.

These are similar to the main measures required by EPA in their enforceable undertaking for the Hallam SITA landfill and were effective in significantly reducing odour complaints. Most odour complaints were from areas close to the boundary of the landfill, but still occur on a regular basis up to 1 km from the landfill boundary, and on occasions with unfavourable weather conditions beyond that distance.

It is therefore necessary that these measures be clearly articulated in the landfill permit and are enforced through regular auditing of their operations.

Tract concludes by stating:

In all cases of identified medium odour risk, current best practice methods are assumed, to apply, however it is expected that as site knowledge progresses and technologies advance, additional proactive measures can be identified, investigated and, if successful, applied to better manage odour risk. Possible measures identified in the report include the opportunity to treat some waste prior to or during placement, odour mitigation by use of neutralising agents and interception of odour plumes.

There was very little in the report on how landfill gas migration might be handled except for reference to implementation of the BPEM requirements, which presumably was the management of the gas by use of liners and gas control and monitoring measures.

5.0 QUESTION 2 - THE REQUIREMENTS FOR PROPONENTS WITHIN THE PSP TO ENSURE COMPLIANCE WITH THE BPEM

What are the requirements for a proponent within the PSP and within any potential landfill gas migration buffer to ensure compliance with the Best Practice Environmental Management for Siting, Design, Operation and Rehabilitation of Landfills Guidelines"?

5.1 Assessing the risks from Potential LFG impacts

The Landfill BPEM advises planning and responsible authorities on buffers for both operating and closed landfills. These buffers have been set to manage potential risks from landfill gas impacts, including the risk of explosion and/or asphyxiation. The table below summarises the default buffer requirements:

Landfill Type	Distance from buildings and structures
Landfill accepting municipal (putrescible) waste	500 m
Landfill accepting solid inert waste	200 m

A landfill buffer of 500 m would therefore be the minimum required for the Melbourne Regional Landfill unless it could be demonstrated that the environment would still be protected and amenity not adversely affected by a reduced buffer distance. However, as this will be a new landfill which is anticipated to only reach its peak gas production in about 2054 (see Plate 5 from Golder 2016a below), it would not be good policy at this stage to consider a buffer reduction. It could also be argued that as a precaution, a buffer of up to a kilometre is necessary due to the very large size of the landfill and the potential for future failure of liners.

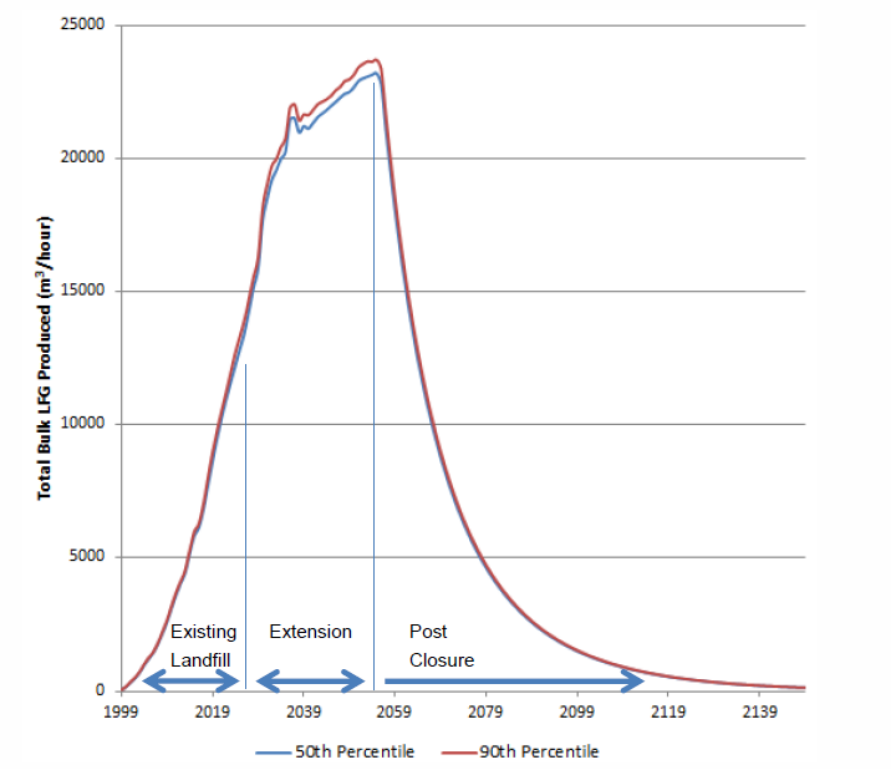


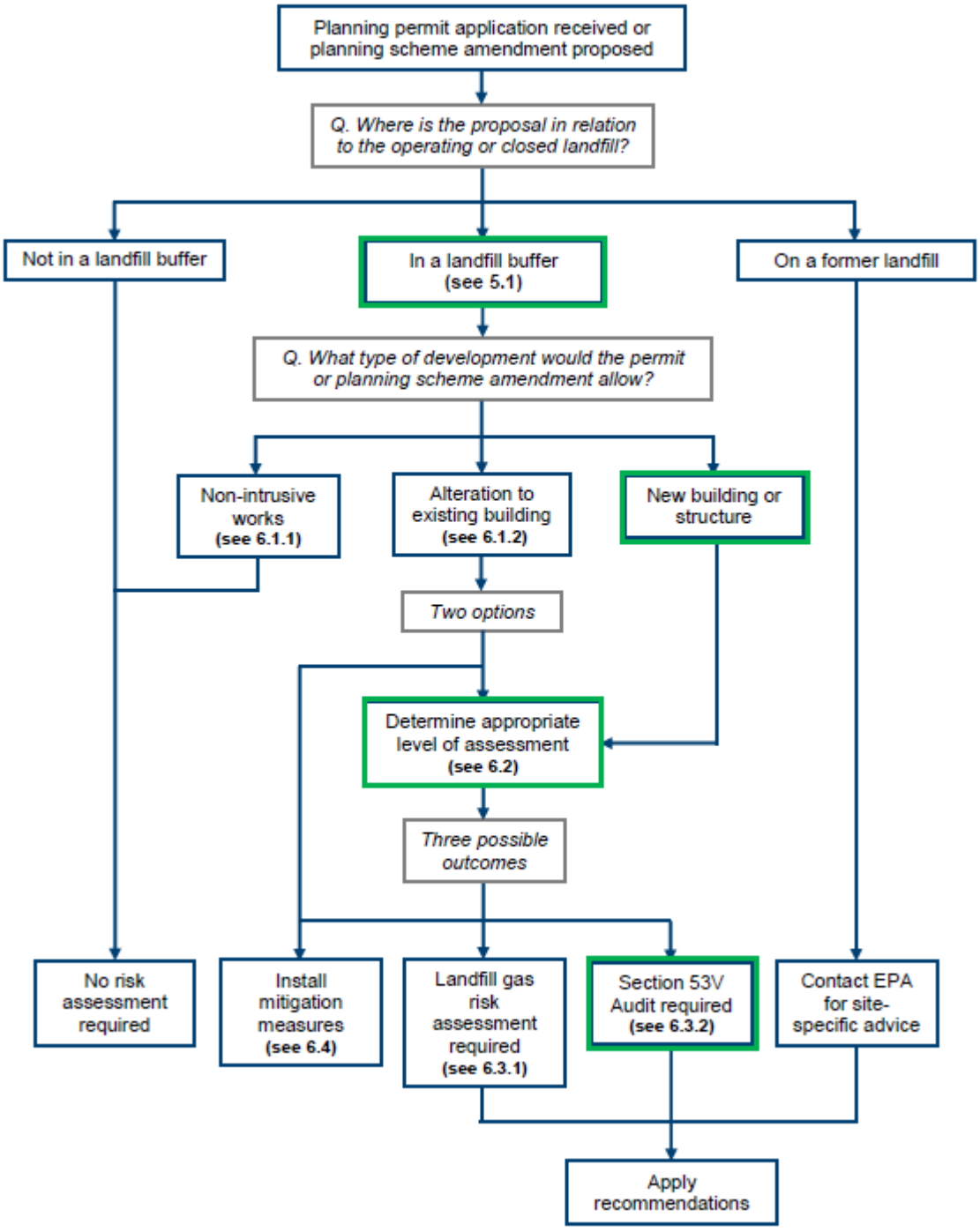
Plate 5: Estimate of Total Bulk Landfill Gas Produced

The EPA also recently released draft guidelines for assessing planning proposals near landfills (**EPA 1625)**. Guidance is provided regarding the recommended approach to assessing planning proposals near landfills and assessing the risk of landfill gas impacts.

The Landfill BPEM generally recommends a section 53V Audit be completed to assess the risk of landfill gas migration impacting on a proposed development within the landfill buffer. However, depending on the type of landfill and proposed development, that level of assessment may not be necessary. However, in accordance with the draft guidance provided in EPA Publication 1625, a staged approach is illustrated to indicate how potential landfill gas impacts would need to be assessed if development was proposed within the landfill buffer zone of 500m.

An overview of the recommended approach (from EPA Publication 1625) is provided in the flow chart below taken from the draft guideline.

The outcomes relevant for a proposed development within the 500 m buffer zone of the proposed extension to the Melbourne Regional Landfill are highlighted in green in the flow chart and discussed further below.



With the implementation of the draft guideline, the following steps would need to be taken in accordance with the approach detailed above, to determine that appropriate level of assessment required for LFG impacts.

STEP 1: Assign a Proposal Score

As a precautionary approach, it would be assumed that there is the potential for some properties to have below ground structures such as a basement or a lift shaft for multi-storey blocks.

Proposal Score = 3

STEP 2: Assign a Landfill Score

A review of available information indicates that:

- The size of the proposed landfill is expected to be greater than 5,000,000 m^3. [1]

  Score = 5

- The predominant type of waste disposed in the landfill is expected to be putrescible.

  Score = 5

- Assumed to be an operating landfill at the time of development.

  Score = 5

STEP 3: Calculate an Overall Score

The Overall Score = Proposal Score x Landfill Score (landfill size + type + age) = 3 x (5 + 5 + 5) = **45**

STEP 4: Determine the Level of Assessment Required

According to Table 5 of Draft EPA Publication 1625, the level of assessment required for a Score of 45, is a section 53V Audit.

Given the large size of the Melbourne Regional Landfill Extension and that it is likely to be operational throughout the time of development, a more rigorous level of assessment for any planning permit application or proposed planning scheme amendment is therefore required.

Even if it were assumed that there would be no below ground structures as part of the proposed developments (i.e. Proposal Score = 2), the Overall Score would equal 30, which would still require a 53V Audit to assess the risk of landfill gas impacts.

A 53V Audit may take several months to prepare, with the cost for such a report and Auditor involvement, generally within the range of $12,000 to $30,000 depending on the size of the plot and complexity of the proposed developments.

From this analysis, it would appear that any developments within 500 metres of the landfill boundary would have to comply with the requirement to undertake an audit under section 53V of the Environment Protection Act. This is confirmed by the preliminary qualitative risk assessment conducted for this report (**see Appendix D**) which indicates that protective measures would be required within 500 metres of the landfill as a precaution against future failure of the liner.

Depending on when the audit is completed, it may also require the installation of landfill gas bores to examine the potential presence of LFG. A recent investigation for the same reasons in the same Newer Volcanics Formation for a small hotel style development, was estimated to cost approximately $20,000 for the installation of 6 bores and the gas monitoring, and up to $5,000 for a landfill gas risk assessment. This does not include the 53V audit.

[11] AECOM (2016). Hydrogeological Assessment - Melbourne Regional Landfill. Prepared by AECOM for Landfill Operations Pty Ltd in February 2016.

6.0 QUESTION 3 - THE IMPLICATIONS OF UNDERTAKING A 53V AUDIT AND COSTS OF MITIGATION MEASURES

What are the potential implications of a proponent within the PSP having to undertake an environmental audit under Section 53V of the Environment Act 1970 including if possible a cost estimate to undertake the audit and potential mitigation measures?

6.1 Potential mitigation measures

Depending on the outcome of a 53V Audit and whether a LFG migration risk exists at the audited site, the following mitigation measures summarised in the draft EPA guideline (**EPA 1625**) may be recommended by the Auditor:

- Passive Mitigation Measures:
  - Building floor construction with concrete slabs and gas-resistant membranes;
  - Underfloor venting using beam and block suspended floor or raft concrete foundations;
  - Sealed joints and service entry points; or
  - In-ground vertical venting wells to create a preferential pathway for gas to escape before reaching a building.
- Active Mitigation Measures:
  - Extraction from the ground; or
  - Maintaining a positive pressure of air to prevent gas from entering under or within a building.

British Standard **BS8485:2015** presents a large volume of information on the potential entry of LFG into buildings and the range of mitigation measures that could address them. Figure 2 of the Standard included below illustrates the potential entry points of gases that may need management.

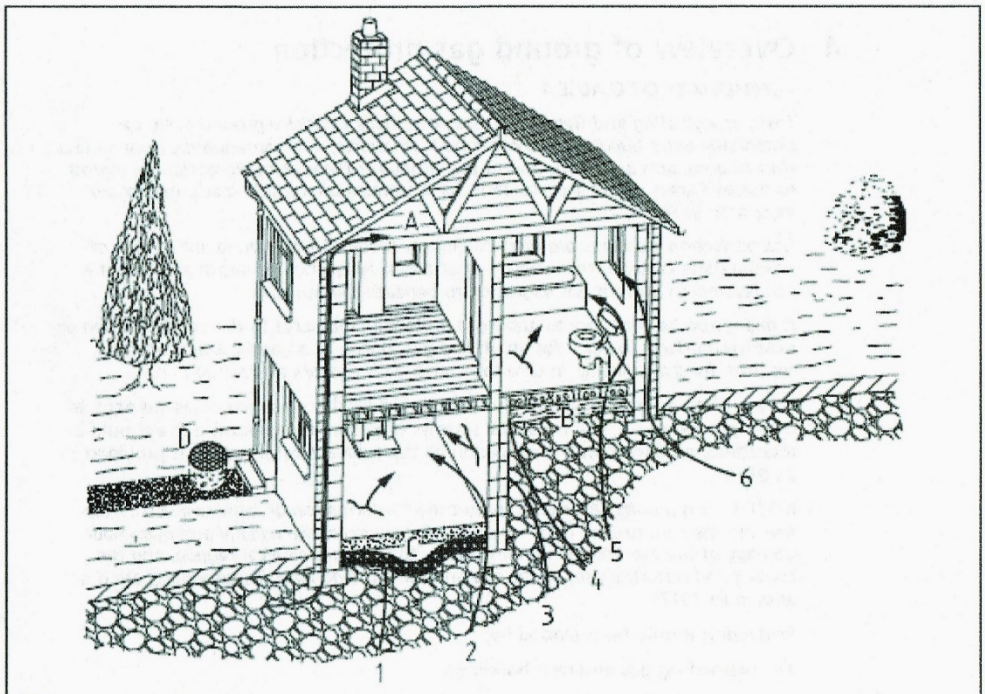
As indicated in the draft guideline (**EPA 1625**), mitigation measures can be quite simple – no more than raising a building off the ground to allow an air gap that can be flushed by the direction of wind under the building, or by the inclusion of a ventilation system that uses wind speed on a whirligig on the top of the pipe to pull air out from under the floor slab. This would not add significant costs to the construction of a building if it is built into the original design, along with the requirement to seal joints and service entry points.

The entry of LFG into a club adjacent to the Energy Park landfill was found to be coming through a sewer entry point into the building. This was resolved by sealing the entry point and also providing better ventilation to the rooms affected by accumulation of gases.

The addition of gas resistant membranes can vary enormously in cost depending on the complexity of the building. Penetrations of the membrane would need to be avoided or sealed to reduce any potential leakage. For small commercial propoerties, building on an engineered raft would avoid the requirement for deep footings that would all have to be sealed.

BS 8485:2015 BRITISH STANDARD

Figure 2 **Key ground gas ingress routes and accumulation areas within unprotected conventional residential buildings**



Key

1 Through cracks and openings in solid concrete ground slabs if present due to shrinkage and curing
2 Through construction joints and openings at wall-foundation interface with ground slab if not sealed
3 Through cracks in walls below ground level
4 Through numerous gaps and openings in suspended block and beam floors or timber floors
5 Through gaps around service pipes and ducts or within the ducts
6 Through cavity walls

A Roof voids
B Beneath suspended floors
C Within settlement voids below floor slab
D Drains and soakaways (or similar voids)

NOTE This Figure is Figure 3 from CIRIA Report 149 [5] reproduced with the kind permission of CIRIA.

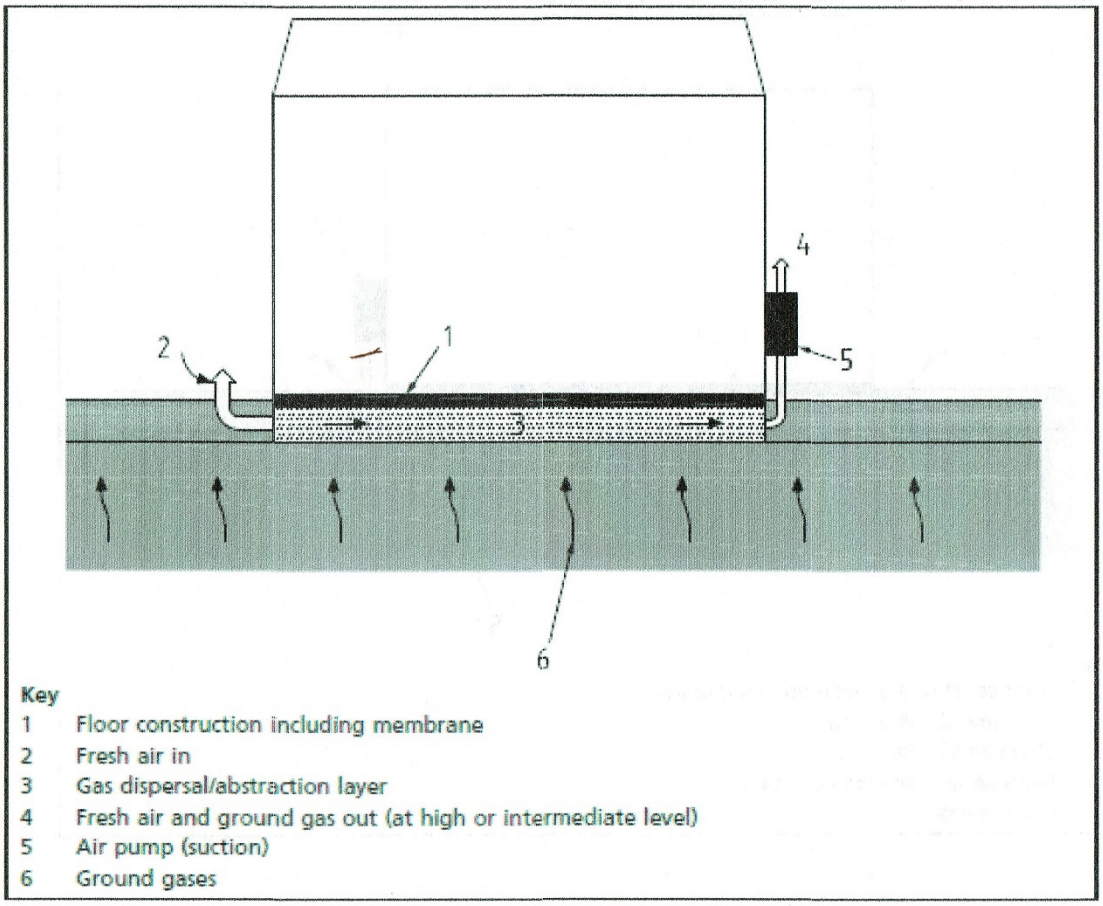
For large buildings with many footings and service entry points, constructing a gas proof membrane is not simple. A recent project for a commercial multistorey building on about 2,400m^2 had an active extraction system and HDPE membrane installed below the slab. However, the membrane had about 90 penetration points which all had to be sealed. Final costs were in the region of $300,000 to $500,000 (in the regions of about $150 to $200 per m^2 and a seven-month delay on the construction schedule. This was due to solvent vapours in the ground rather than LFG, but illustrates the upper ends of costs if there is a severe ground gas problem below a large building.

The construction of in ground vertical venting wells in the underlying basalt to intercept migrating LFG would be problematical and costly due to the nature of the hard fractured rock at this site. There is also the danger of missing the one or more significant preferential pathways if the bores are not sited directly onto the fractures. So it is not practical to intercept migrating LFG once it has penetrated the landfill liner and entered the basalt fractures.

Maintaining a positive pressure in a building to keep LFG from accumulating is feasible in a commercial building with ventilation requirements, however would be onerous for small developments with many openings. The British Standard provides several examples of methods to exclude the entry of LFG from simple passive systems to active removal of any accumulated vapour within a permeable layer below the building slab. See Figure B5 from the BS8485 below.

BRITISH STANDARD BS 8485:2015

Figure B.5 Typical active suction system with floor slab below ground level



Key
1 Floor construction including membrane
2 Fresh air in
3 Gas dispersal/abstraction layer
4 Fresh air and ground gas out (at high or intermediate level)
5 Air pump (suction)
6 Ground gases

The cost of such a system would still be relatively modest in comparison to the overall cost of construction of the building and could be set up to be a passive system first as a precaution in areas where LFG migration may occur later after the building is constructed. Such a system if imposed by an auditor or EPA before construction may have ultimately been successful at allowing continued occupation of the dwellings at Brookland Greens, but the opportunity was missed as the risks were not recognised by the developer.

As indicated above, a compulsory 53V Audit for developments in landfill buffer zones may take several months to prepare, and with costs in the range of $12,000 to $30,000 depending on the size of the plot and complexity of the proposed developments. If landfill gas bores are also needed to complete a gas risk assessment, then another 10,000 to 25,000 is likely for a modest home site.

7.0 QUESTION 4 – THE PRACTICALITIES OF UNDERTAKING A 53V AUDIT IN RESPONSE TO A PROPOSED LANDFILL CELL

What are the practicalities of undertaking an environmental audit under Section 53V of the Environment Act 1970 in response to a proposed landfill cell?

To undertake a Section 53V Audit on land that may at some time in the future be impacted by landfill gas or other pollutants, would have significant difficulties as all assessments would be speculative and theoretical until the landfill cell has been completed. Also, as landfill gas generation would not have peaked for a number of years after construction of the cell, it would not be possible to measure the extent of any such impacts.

The assessment for a 53V audit would therefore have to be based on modelling of the potential gas migration through the soils and rocks below the development site, and through comparison with similar operations in the same formations that may be impacted by other landfill cells. As a result, any recommendations that come out of such an audit would have to be precautionary and therefore also would likely be heavily conservative to allow for potential worst case scenarios.

As the most cost effective construction of mitigation measures that may be needed some years or decades into the future, would be at the time of construction of any residential properties or industrial commercial buildings, this would need to be taken into consideration for every building within the buffer zone, and possibly beyond, to comply with possible future needs highlighted by guidance as indicated in Section 6 above.

It is feasible to undertake a theoretical risk assessment that examines the generation rates of landfill gas in other parts of MRL by testing flow rates within gas management bores; then apply those rates to likely rock mass permeabilities at the PSP and estimate the potential distances that LFG could migrate should the landfill liners fail, but it would remain theoretical until such time that a failure occurred. This witness has undertaken a preliminary gas risk assessment that is included in **Appendix D** to indicate the likely impact of LFG migration if the liners were to fail, based on the information currently available in relation to the MRL.

This approach can also be misleading if escaping LFG found a preferred pathway such as large interlinked fractures; a more permeable layer such as scoria that can occur within the lava flows that made up the Newer Volcanics and are present at the MRL. This is therefore not considered to be a practical way of limiting the risk of LFG migration into buildings to be constructed on the PSP by reducing the buffer distances.

8.0 CONCLUSIONS ON BUFFER ZONES

It is concluded that the first line of defence for developments on the PSP would be to establish and maintain substantial buffers between the landfill boundary and potential developments – including commercial and industrial buildings. Based on the BPEM this should be a minimum of 500 metres to ensure that in the event of failure of the landfill liner, the secondary containment of the geological formation would be capable of limiting the spread of LFG to occupied buildings.

This is also based on the experience with old closed landfills in similar geology at Energy Park in City of Brimbank where migration of landfill gas was identified at 150 metres from the nearest landfill boundary, despite there being a record of low flux rates of LFG such that generation of electricity was not feasible.

It is considered that 500 metres is justified as a minimum buffer to any occupied building given the very large nature of the MRL extension which rates at a high risk based on the EPA draft Guideline 1625, and is likely to generate very high flow rates of LFG for up to 60 years. It would also assist in limiting the impact of potential release of LFG and odorous emissions from the site due to placing of putrescible wastes. Whilst the preliminary qualitative gas risk assessment undertaken for this study indicates that a buffer zone of 100 metres may be acceptable for commercial/industrial buildings, this would not remove the need to implement some precautionary mitigation measures given the long period of LFG generation and the size of the proposed landfill extension.

Similarly, it is considered that a buffer zone of 1 kilometre to the nearest residential properties should be maintained from the nearest operating landfill cells based on the experience with odour complaints and the enforceable undertaking at the SUEZ Environment Landfill at Hallam. This would also substantially reduce the risk of LFG penetration into residential buildings where mitigation costs to prevent entry of LFG would be a significant proportion of the construction costs.

Site specific gas risk assessments would likely indicate that the potential for penetration of buildings by LFG is minimal at that distance from the landfill, given that in the worst case scenario of Stevenson's Road Landfill and Brooklands Green, whilst the LFG reached approximately 700 metres from the boundary of the landfill cell, the geology at the MRL is less conducive to transmission of the LFG; the cells will be lined rather than unlined; placement of the waste would be better controlled being under the scrutiny of an annual audit; and LFG will also be required to be properly managed at the MRL rather than the system that failed at Stevenson's Road.

It is considered that the preferred option in the Figure supplied by VPA (**VPA Fig 1**) would meet the above conclusions in regard to the landfill gas risks. It would not eliminate all risks, particularly the potential for occasional odour spread into the PSP when there are light south easterly or easterly winds. However, this can also be limited to some extent by the imposition of restrictions on operating areas within the cells, similar to those imposed in the Enforceable Undertaking on the Hallam landfill, so that the minimum area of waste is exposed at any one time, and that measures are taken in adverse conditions to manage operations to limit the generation of odour.

9.0 LIMITATIONS

EHS Support Pty Ltd (EHS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of the Victorian Planning Authority (VPA), their legal representatives, the Planning Panel for Amendment C162 and only those third parties who have been authorised in writing by EHS Support to rely on this Report.

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

It is prepared in accordance with the scope of work and for the purpose outlined in EHS proposal reference P160809 dated 16 August 2016, and the VPA Purchase Order 6258 dated 25 August 2016.

Where this Report indicates that information has been provided to EHS by third parties, EHS has made no independent verification of this information except as expressly stated in the Report. EHS assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared between 26 August 2016 and 2 September 2016 and is based on the information examined at the time of preparation as detailed in this report. EHS disclaims responsibility for any changes that may have occurred or information that may become available after this time.

This Report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This Report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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10.0 REFERENCES

The following publications have been directly or indirectly considered in the preparation of this report:

BS 8485:2015 - Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings June 2015;

EPA 1970 – Environment Protection Act 1970 No 8056 dated 22 Dec 1970;

EPA, 2012 - Environment Protection Authority (Victoria) Publication 1490 - Closed Landfill Guidelines – dated December 2012;

EPA, 2014 - Environment Protection Authority (Victoria) Publication No. 759.2: Environmental Auditor (Contaminated Land) Guidelines for Issue of Certificates and Statements of Environmental Audit;

EPA 2015, Environment Protection Authority (Victoria) Publication No 788.3; Best Practice Environmental Management on Siting, Design, Operation and Rehabilitation of Landfills, August 2015;

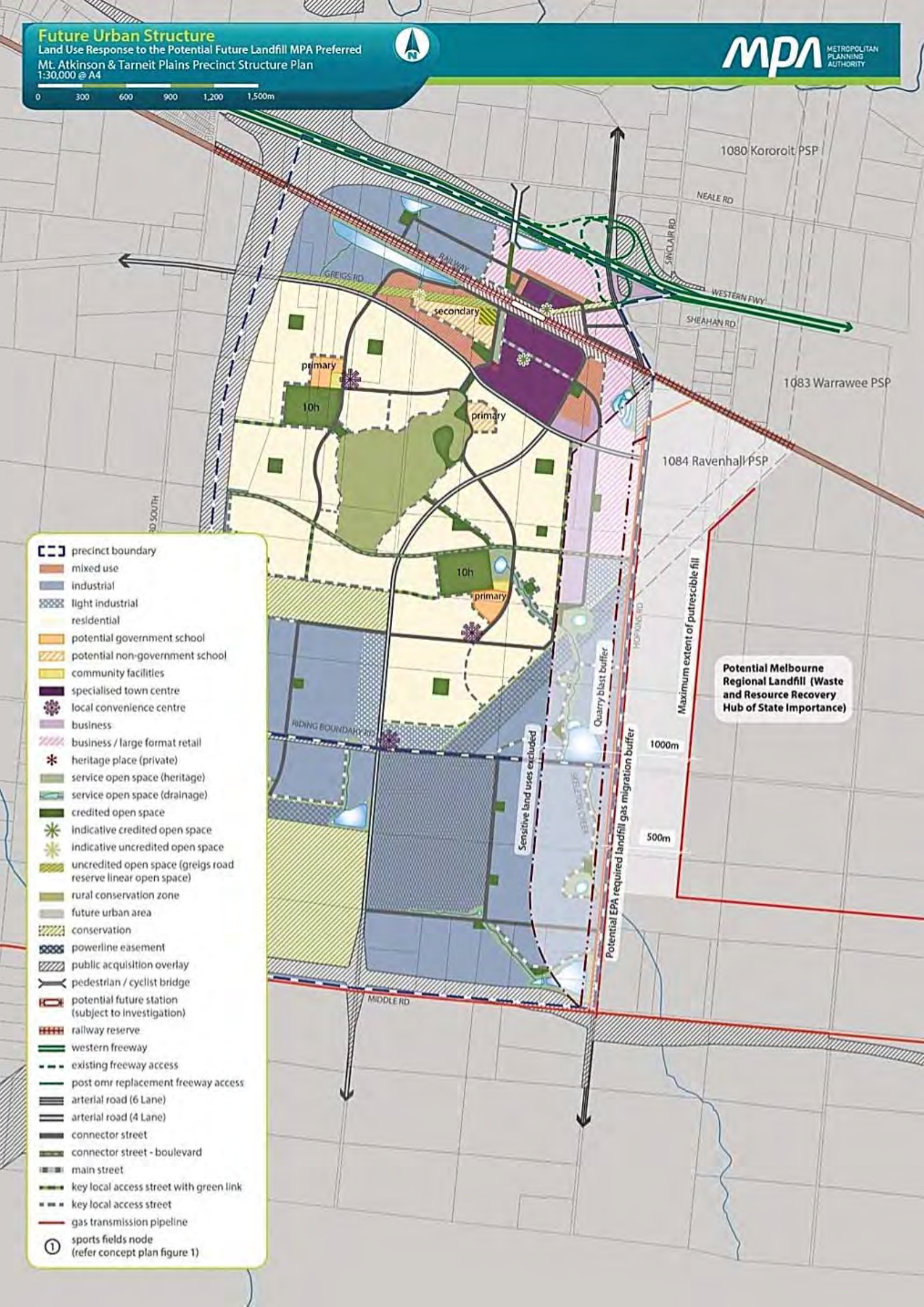
EPA 2016, Environment Protection Authority (Victoria) Publication No 1619 Draft Guideline - Landfill Licensing (proposed to replace publication 1323.2);

EPA 2016, Environment Protection Authority (Victoria) Publication No 1625 Draft Guideline - Assessing Planning Proposals Near Landfills;

SEPP 2003, State Environmental Protection Policy - Variation to State Environment Protection Policy (Waters of Victoria), Victorian Government Gazette No. S107.

SEPP 2002, State Environmental Protection Policy - Prevention and Management of Contaminated Land, State Government of Victoria, No S95, Gazette 4 June 2002 as varied by Variation to the State Environment Protection Policy (Prevention and Management of Contamination of Land) No. G39, Gazette 26 September 2013.

FIGURES


Future Urban Structure
Land Use Response to the Potential Future Landfill MPA Preferred
Mt. Atkinson & Tarneit Plains Precinct Structure Plan
1:30,000 @ A4
0 300 600 900 1,200 1,500m
MPA METROPOLITAN PLANNING AUTHORITY
1080 Kororoit PSP
1083 Warrawee PSP
1084 Ravenhall PSP
NEALE RD
SINCLAIR RD
WESTERN FWY
SHEAHAN RD
GREIGS RD
RAILWAY
secondary
primary
10h
HOPKINS RD
RIDING BOUNDARY RD
MIDDLE RD
Quarry blast buffer
Potential EPA required landfill gas migration buffer
Sensitive land uses excluded
Maximum extent of putrescible fill
1000m
500m
Potential Melbourne Regional Landfill (Waste and Resource Recovery Hub of State Importance)
precinct boundary
mixed use
industrial
light industrial
residential
potential government school
potential non-government school
community facilities
specialised town centre
local convenience centre
business
business / large format retail
heritage place (private)
service open space (heritage)
service open space (drainage)
credited open space
indicative credited open space
indicative uncredited open space
uncredited open space (greigs road reserve linear open space)
rural conservation zone
future urban area
conservation
powerline easement
public acquisition overlay
pedestrian / cyclist bridge
potential future station (subject to investigation)
railway reserve
western freeway
existing freeway access
post omr replacement freeway access
arterial road (6 Lane)
arterial road (4 Lane)
connector street
connector street - boulevard
main street
key local access street with green link
key local access street
gas transmission pipeline
sports fields node (refer concept plan figure 1)

Future Urban Structure

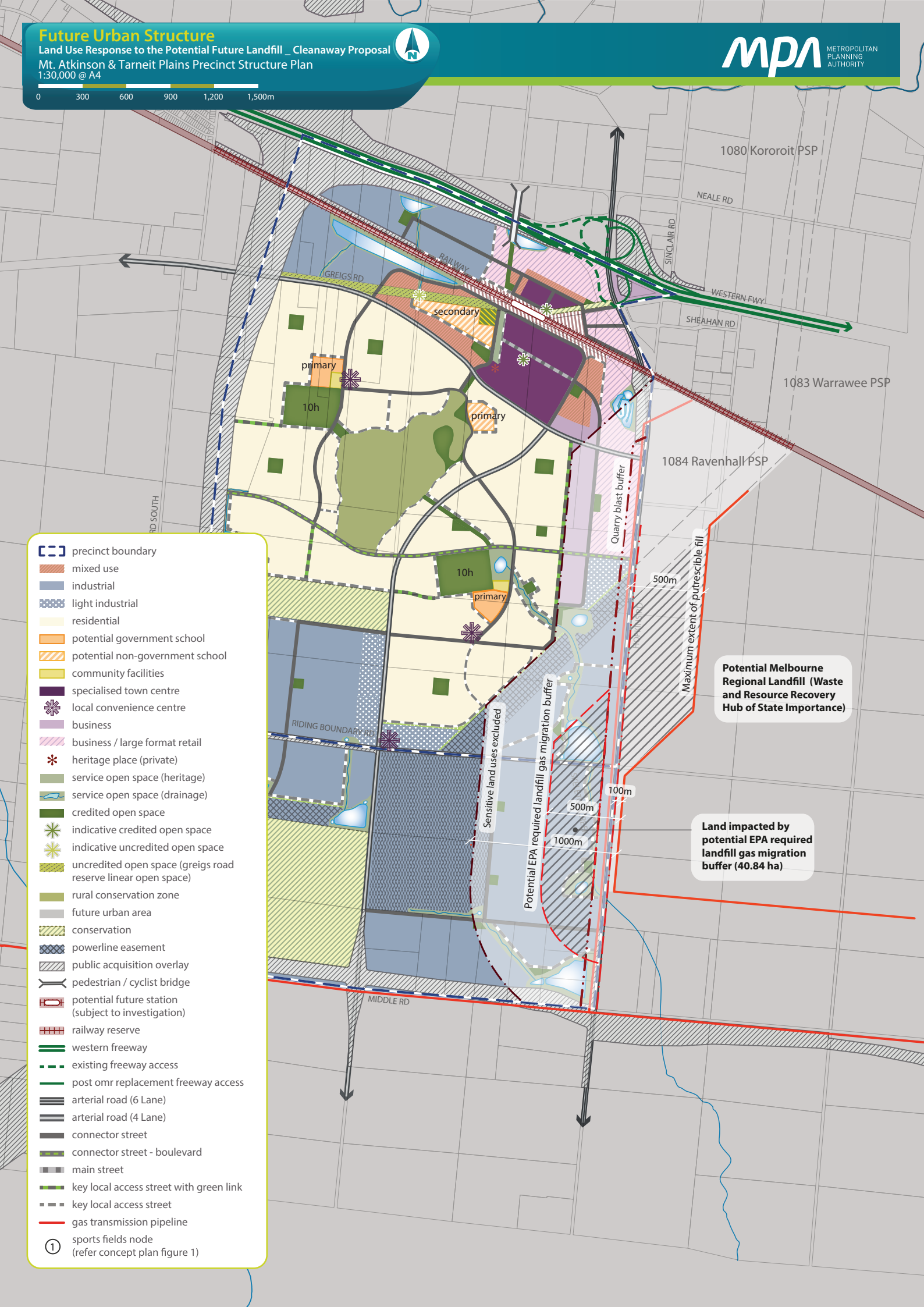
Land Use Response to the Potential Future Landfill _ Cleanaway Proposal

Mt. Atkinson & Tarneit Plains Precinct Structure Plan

1:30,000 @ A4

0 300 600 900 1,200 1,500m

METROPOLITAN PLANNING AUTHORITY



APPENDIX A LETTER OF INSTRUCTION & PLANNING PANEL GUIDELINES

Brief

Please provide a cost proposal to provide expert evidence to the Planning Panel for Planning Scheme Amendment C162 (Mt Atkinson and Tarneit Plains PSP) in relation to landfill gas migration from the proposed Melbourne Regional Landfill expansion.

The MPA would like the specialist to provide expert evidence including but not limited to:

- Potential impact on the precinct from landfill gas migration from the proposed landfill expansion including but not limited to potential impacts on air quality, hydrology, community safety and health.
- Requirements for a proponent within the PSP and within any potential landfill gas migration buffer to ensure compliance with the Best Practice Environmental Management for Siting, Design, Operation and Rehabilitation of Landfills Guidelines.
- The potential implications of a proponent within the PSP having to undertake an environmental audit under Section 53V of the *Environment Act 1970* including if possible a cost estimate to undertake the audit and potential mitigation measures
- The practicalities of undertaking an environmental audit under Section 53V of the *Environment Act 1970* in response to a **proposed** landfill cell

Your proposal should provide a lump sum for the project and a breakdown of hourly rates for staff involved.

Qualification

It should be noted that the Planning Permit Application and Works Approval Application for the landfill will be considered separately by a second planning panel following the planning panel for Planning Scheme Amendment C162. This expert evidence should not focus on the merits, extent or need of the landfill, but on the potential impact on the precinct from landfill gas migration and on the requirements for a proponent within the PSP and within any potential landfill gas migration buffer to ensure compliance with the Best Practice Environmental Management for Siting, Design, Operation and Rehabilitation of Landfills Guidelines. The expert evidence provided for C162 will be tabled and/or referred to by the MPA in its submission to the second planning panel.

Deliverables

- A statement of expert evidence (date for circulation will be confirmed by panel at the directions hearing on the 9th of August). The statement should include:
    - Qualifications and experience
    - Expertise to make the statement
    - Instructions received
    - Any particular comments regarding the PSP and the landfill expansion Planning Permit Application and Works Approval Application
    - Declaration
    - Findings and opinions

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Australia
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Facsimile: 03 9651 9623

- Availability to present at the planning panel in support of the statement and respond to any questions from the panel or other parties as required at the planning panel between the 12 and 23 of September (the exact dates required will be clarified when the panel provided further direction).
- Availability to confer with other landfill gas migration experts prior to, during and after the C162 planning panel hearing, if required.

Circulation of Expert Reports

Expert witness reports must be submitted five working days prior to the commencement of the Hearing, or another date directed by the Panel. An earlier date will be specified for more complex reports.

Parties must identify at the Directions Hearing, the evidence (if any) they will be calling at the Public Hearing.

Copies of witnesses' reports or statements must be circulated in accordance with Directions made at the Directions Hearing. If no specific directions are made, six copies of their reports or statements must be given to the Panel Coordinator at least five working days before the Hearing. Copies will be given to the Panel and to other parties as directed. Other people may obtain electronic copies by contacting the Panel Co-ordinator at Planning Panels Victoria (PPV) on 8392 6397.

A soft copy of reports should be provided as follows:

- as an unlocked 'pdf' or Microsoft Word format to PPV; and
- as a 'pdf' to the Planning Authority suitable for uploading in its website.

Before the Hearing, copies of witnesses' reports or statements will normally be available for perusal by submitters at the offices of the Planning Authority and PPV.

Expert's Duty to the Panel

An expert witness has a paramount duty to the Panel and not to the party retaining the expert.

An expert witness has an overriding duty to assist the Panel on matters relevant to the expert's expertise.

An expert witness is not an advocate for a party to a proceeding.

Content and form of Expert's Report

The report of an expert must include the following:

- the name and address of the expert;
- the expert's qualifications and experience;
- a statement identifying the expert's area of expertise to make the report;
- a statement identifying any other significant contributors to the report and where necessary outlining their expertise;
- all instructions that define the scope of the report (original and supplementary and whether in writing or oral); and
- the identity of the person who carried out any tests or experiments upon which the expert has relied on and the qualifications of that person.

Where an expert has prepared a report that has been used to inform the preparation of an amendment or proposal, the expert should not provide a revised version of that report. The expert should provide a brief report that includes:

- an unambiguous reference to the report, or reports that the expert relies upon;
- a statement identifying the role that the expert had in preparing or overseeing the exhibited report(s);

- a statement to the effect that the expert adopts the exhibited report and identifying:
    - any departure of the expert from the finding or opinions expressed in the exhibited report;
    - any questions falling outside the expert's expertise;
    - any key assumptions made in preparing the report; and
    - whether the exhibited report is incomplete or inaccurate in any respect.

Where a report has not been used to prepare an amendment or proposal, the report should include:

- the facts, matters and all assumptions upon which the report proceeds;
- reference to those documents and other materials the expert has been instructed to consider or take into account in preparing his or her report, and the literature or other material used in making the report;
- a summary of the opinion or opinions of the expert;
- a statement identifying any provisional opinions that are not fully researched for any reason (identifying the reason why such opinions have not been or cannot be fully researched); and
- a statement setting out:
    - any questions falling outside the expert's expertise, and
    - whether the report is incomplete or inaccurate in any respect.

The expert must declare at the end of the report:

'I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.'

Privacy

Expert witnesses need to be aware of their obligations under the *Information Privacy Act 2000*. Particularly when using personal information contained in submissions they have received as a third party.

Copies of witnesses' reports are usually posted on the Planning Authorities website. Where possible, the report of an expert should not refer to any individual submitter by name and if necessary, submitters should be referred to by submission number.

For more information on Privacy refer to the separate PPV **Guide to Privacy at Planning Panels Victoria.**

Where the expert changes his or her opinion on a material matter

An expert witness who changes an opinion on a material matter on the basis of another expert's report or for any other reason must communicate that change of opinion in writing to the party retaining the expert and that party must file with the Panel, notice of such change of opinion as soon as practicable.

Such a document must specify reasons why his or her opinion has changed.

Where the Panel directs expert witnesses to meet

Expert witnesses retained by parties are encouraged to meet to narrow any points of difference between them and to identify any remaining points of difference. The Panel may also direct that they meet.

If expert witnesses meet they must each set out in writing by a document filed with the Panel any agreed points and all remaining points of difference.

If any expert witness directed by the Panel to meet with any other expert is instructed not to reach agreement in respect of points of difference, the fact of such instructions must be reported in writing to the Panel by the expert witness.

Generally

Parties to a proceeding must ensure that any expert retained by them to provide a report for use in the proceeding is aware of the contents of this direction, at the time of such retainer.

Form of Report

Written material presented at the Hearing should be in the following form:

- Two-hole punched.
- Stapled, not bound.
- Photographs or other visual material should be presented in binders in A4 or A3 format, not on large boards. This makes the material easier to transport and file.

Further Information

Further information about Planning Panels Victoria can be found on the department's website:

http://www.dtpli.vic.gov.au/planning/panels-and-committees

APPENDIX B QUALIFICATIONS

EHS Support
consider it done

PROFESSIONAL PROFILE

"A vital ingredient of success is not knowing that what you're attempting can't be done" – Terry Pratchett

KEN MIVAL

ENVIRONMENTAL AUDITOR, CONTAMINATED LAND

KEN.MIVAL@EHS-SUPPORT.COM • TEL: 0408 060 045 • HAZELDENE VICTORIA, AUSTRALIA

EXPERTISE

- Landfill Construction Auditing & Verification
- Environmental Auditing
- Expert Witness
- Engineering Geology
- Environmental Site Assessment
- Contaminated Land & Groundwater Management and Remediation
- Project Management and Direction

EDUCATION

Bachelor of Science (HONS), Geology, University of Exeter, 1966-1969

CERTIFICATIONS AND TRAINING

Environmental Auditor, Accredited by EPA Victoria, 1993-Current

Ken Mival is an EPA accredited Environmental Auditor (Contaminated Land) with over 45 years' experience in geology, engineering geology, environmental engineering and auditing, throughout Africa, UK, NZ, Singapore, PNG, and Australia. Over the past 25 years Ken has primarily focused on auditing and management of contaminated land. He has undertaken environmental audits for many large urban and iconic developments; large chemical and manufacturing plants; clean-up of dioxins; and landfill construction and landfill gas sites.

Ken has performed over 200 statutory environmental audits and due diligence and regulatory compliance audits for property transfers, factory shut downs, closed landfills and for operational landfills and clean-up of former industrial sites for residential and commercial developments. He has provided expert evidence to VCAT, Planning Panels Victoria, and the Magistrates, High and Supreme Courts, in several jurisdictions on: dam failure; contaminated land; illegal landfills; landfill gas risk; and the cost of remediation of, and responsibility for, contaminated land. Additionally, Ken has provided expert advice to EPA on landfill gas risks; human health risks, and risks to large animals relating to arsenic and mercury contamination from mining; and on clean-up criteria for dioxins.

He has taken part in numerous workshops and studies with EPA Victoria on improvements to the Victorian regulations and guidelines with regard to contaminated land management; groundwater and waste. Ken currently represents EHS Support at the Landfill Auditors Workshops (held quarterly) and on their Groundwater committee.

He is widely published and has contributed extensively to the regulatory environmental framework in Victoria and presented many papers and articles for books, conferences, and seminars on engineering geology, contaminated land clean-up, bushfire impacts and disaster planning.

Together with the consultants to Melbourne Water, Ken in his auditor capacity won the Consult Australia Engineering Excellence Gold Award in 2011 (Environmental Category) for the clean-up of Dioxins at the 180 hectare Dandenong Sewage Treatment Plant.

Key Experience

Landfill Auditing Experience

Landfill Construction Audits – Cosgrove Landfill – City of Shepparton

Lead Auditor

Currently (2016) undertaking a 53V audit of the construction of the sideliner for the Cosgrove Landfill. This project includes the review of changes to design to fit the former quarry metrics, approved as major variation by EPA.

Bowser landfill – City of Wangaratta

Auditor

Currently (2016) undertaking a 53V audit of the construction of the base liner for the Bowser Landfill. This includes a designed multilayered liner with HDPE, GCL and clay layers, as well as leachate collection. This has also included the review and approval of minor variations to the design and review and approval of CQA testing data.

Closed Landfill Audits & verifications – Oakleigh South

Lead Auditor

Serves as the lead auditor of 20 hectares of former sand quarries and landfills at Oakleigh South including gas risk and leachate management for proposed residential development (2013 to present – ongoing).

Energy Park

Auditor

Audit of Energy Park former landfill in regard to landfill gas risk, leachate management and verification of aftercare management plan and hydrogeological assessment for City of Brimbank.

Landfill at Sydenham

Lead Auditor

Ken undertook the audit of this former landfill with hydrocarbon wastes (from 2000 to 2014), with clean-up to extent practicable completed in 2012 and 53X audit completed February 2014.

Multiple Landfill Sites

Audit Verification

Provided verification of hydrogeological assessments and aftercare management plans for several closed landfills at Reg Harris Reserve, Rowans Road, and Springvalley for Cities of Greater Dandenong and Kingston.

Heller St North - Melbourne

Auditor

Conducted a closed landfill audit of the Quarry and Municipal Landfill site at the Heller St North Melbourne for residential development (2008-2010).

Former Brick Quarry – East Melbourne

Auditor

Audit of closed landfill in former brick quarry at Tooronga, East Melbourne (2008 to 2011) and ongoing assessment of landfill gas risk for future residential developments (2013 – 2015) and recently included car parking and sports field development.

Former Landfill Site – 16 Leigh St Footscray

Audit & Health Risk Assessment

Following identification of long-term contamination by the EPA, Ken conducted an audit of this closed landfill filled with foundry waste products. A health risk assessment was also conducted for surrounding residents (2012 – 2014).

Landfill at Clayton

Lead Auditor

Ken undertook the audit of this former landfill including a landfill gas risk assessment to provide advice to SUEZ Environment (TPI) on a proposed waste transfer facility to be located on top of the former landfill.

Environmental Auditing Experience

Melbourne Docklands – Multiple Audits

Auditor

Ken started auditing the former Docklands areas for the Docklands Authority in 1997, including the 63m clean-up of the former West Melbourne Gasworks completed in 2005. He has also completed audits for all developments within the 30 hectare Victoria Harbour Precinct; the Yarra's Edge Precinct and for much of the infrastructure up to 2014.

Melbourne Water – Dandenong Treatment Plant

Auditor

Ken conducted an Environmental Audit under Section 53X of the EP Act of the Melbourne Water 193ha former Dandenong Treatment Plant, that included the establishment of criteria for remediation of Dioxins Remediation; then went on to complete audits for the residential area then the industrial zones from 2007 to 2011, plus a 53V Audit of construction of this 6 cell landfill as "CALM" repository for containment of dioxin wastes (2008/10). This included review of design and audit of construction of: leachate system; landfill gas management; cell base linings and cap construction.

Fisherman's Bend – Multiple Audits

Auditor

With the re-zoning of Fisherman's Bend into "Capital City Zones" Ken has been providing advice to EPA on what worked with Docklands and also undertaking audits of two major properties. The first for a twin tower high rise on Lorimer St for Little Projects, now under construction, and the second ongoing audit for over 300 townhouse lots on the former Symex Oleo Chemical site. This included approval of designs for vapour and odour management capping and the use of "Liquid Boot" inside a heritage building for 6 apartments. Stage 1 audit was completed in 2015 and Stage 2 is currently in progress.

Braybrook Carpet Manufacturer

Auditor

Ken is undertaking a 53X audit of a former carpet manufacturing site that is under notice from EPA due to PCE pollution in groundwater. Multiple groundwater wells have identified the areas impacted and client is exploring remediation options. Likely to continue to 2017/18.

Industrial Sites – 53V Audits – Orica, Yarraville

Auditor

Ken started auditing the 150yr old former ICI chemical factory site at Yarraville in 2000, completing an audit in 2005 followed by independent auditor review of on-going groundwater monitoring, assessment of organic chemical areas and work plans for a large scale clean up planned to occur in 2016/17. Contaminants included a large range of chlorinated organics, metals, aniline and monocyclic aromatics.

Fisherman's Bend – Symex Plant Closure

Auditor

Prior to the demolition and audit for over 300 townhouse lots on the former Symex Oleo Chemical site. Ken undertook a section 53V audit to provide EPA with confidence that the site did not remain a significant source of pollution. This permitted the EPA to close the original scheduled premises license and the client to sell the site.

Infrastructure Audits and Geotechnical

With his combined geotechnical engineering and accredited auditor experience has Ken has undertaken audits and geotechnical reviews of several large scale infrastructure projects on behalf of the contractors or clients. These have included:

- Audit of Western Link of Melbourne City Link Project, Victoria (1995-1997) the construction of 17 km of freeway and elevated road that is the main gateway to Melbourne;
- Audit for VicRoads of the Westgate Freeway Upgrade (2008/10) that included additional interchanges, road widening, and the reuse of soils in noise mounds;
- Audit of Docklands infrastructure that included a major by-pass (Wurundjeri Way) and storm water and cabling infrastructure.
- Review of tunnel condition of 8.5km of brick lined tunnels in CBD for Telstra and advice on remedial requirements.
- Advice to Utility company on removal of infrastructure from Yarra River prior to dredging 2007/2009.
- Confidential Project June 2004 – Probabilistic Cost Analysis for, and Feasibility of, Construction of Major Infrastructure Project valued at >$50 Billion, Victoria.
- Geological & geotechnical review, preliminary design and costing, and functional design for relocation of utilities under Yarra River by Horizontal Directional Drilling 2003 to 2006.
- Engineering Geological and Environmental Dredging Risk Review for power and communication cables beneath Yarra River 2003 prior to channel deepening for Port of Melbourne.

Expert witness

Ken has provided expert evidence to several jurisdictions including in Victoria: VCAT, Planning Panels Victoria, and the Magistrates, High and Supreme Courts, contaminated land; illegal landfills; landfill gas risk; the cost of remediation of, and responsibility for, contaminated land; and unforeseen ground conditions. Additionally, he has provided expert reports on engineering geological and geotechnical issues including failure of dams and engineering structures in South Africa.

Richmond Tar Pit – Supreme Court Victoria 2015

Lead Auditor

Ken was engaged in 2013 as an expert witness in the Victorian Supreme Court on the origin, hazards and impacts from Coal Tar wastes discovered during construction of a training facility on behalf of MFESB in 2005. Judgement given in December 2015 in favour of MFESB concluded that the former Council was liable for the clean-up costs related to abandonment of the former tar pit and wastes that it contained.

Other expert witness roles

Lead Expert

- Ken has also been engaged as an expert witness on a number of occasions, examples in Victoria include for:
- Multiple sites impacted by TCE vapour (2015).
- Planning Panel on suitability of sub-divisions St Albans.
- Asbestos contamination delaying office building for SE Water (2015).
- Impact of contamination on land value on former tannery Maribyrnong, Vic (2013).
- Expert Review of data to identify source of PCB contamination for litigation (2012).
- Planning Panel on Lang development adjacent to former landfill.
- Review of Management Plan and expert witness for illegal landfill (Greenvale) for EPA prosecution.
- High Court action on costs of contamination at 75 sites Port of Melbourne.
- VCAT on demolition and remediation of contaminated slipway site Williamstown.
- Review of Asbestos Contamination for Litigation at Defense Site Broadmeadows, Vic.

Previous Experience

Ken has more than 20 years of previous experience as a geologist and engineering geologist in direction of, and as principal investigator for geological and engineering geological investigations, instrumentation and monitoring, field studies and teaching primarily in South & Central Africa and UK.

Publications and Presentations

K Mival – 1984 - Assistance to Editor (ABA Brink) on one chapter in "*Engineering Geology of Southern Africa Vol IV – The Quaternary"*.

K Mival 1998 - A paper on a "Scheme for the rapid assessment of the structural integrity of lined tunnels" to the XI Australian tunnelling conference.

K Mival -1996 - Author of the Australian chapter of the study on "*International Experience and Expertise in Registration, Investigation, Assessment, and Clean-up of Contaminated Military Sites*." published by German Federal EPA.

Ken has also presented and had published various scientific papers and articles locally and internationally on aspects of land reclamation; on clean-up of sites contaminated with heavy metals; risk based approaches to soil remediation; ground improvement; geology of cities; instrumentation & monitoring; penetration testing; slope stability; blasting trials for stabilisation of undermined ground, and aspects of climate change.

Environmental Papers

Gorman J, Mival K, Wright J, and Howell M, - 2002 "Developing risk-based screening guidelines for dioxin management at a Melbourne Sewage Treatment Plant" Paper e20500a Enviro 02 Melbourne April 2002 (re-published in Water Science & Technology Journal, Vol 47 No 10 pp 1-7 by IWA publishing 2003).

Mival K, 2004 - "All that's Green is not Clean - Lessons from the Risk Based Management of a Gasworks Clean-up" Paper e4095, to Enviro 04 Sydney, March 2004.

Mival K, Pump W, Dixon G 2006 "From Wasteland to Green Parkland – The Clean-up of the West Melbourne Gasworks" presented to MGP06, Reading UK April 2006.

Mival K, 2011 "The Challenges for an Environmental Auditor of Dioxin Remediation on a Former Sewage Treatment Plant Site" presented to Ecoforum – Sydney March 2011 - also presented to ACLCA Adelaide 2013.

Mival K; - 2016 – presented on "Land use Planning and Controls" for ALGA Seminar on Vapour and Gas Mitigation.

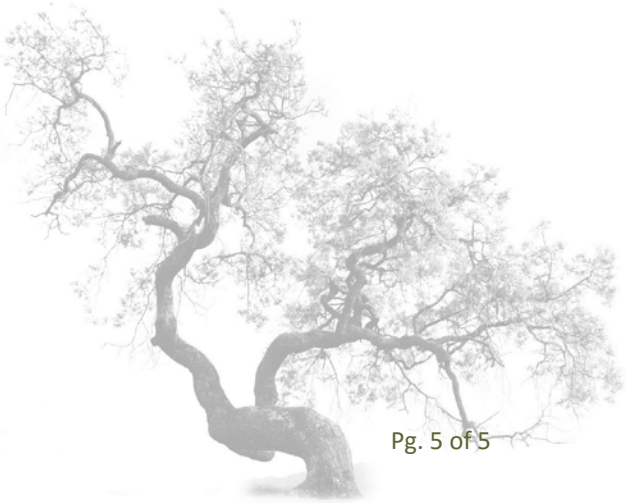
Others

K Mival - 2009 - Presentation – "Living in a Bushfire Zone – Planning; Decisions; Actions" to VPELA Seminar June 2009.

K Mival – 2011- Presentation "Impact on land, groundwater and community and recovery from the 2009 Victorian Bushfires" to ALGA April 2011.

K Mival – 2014 - Presentation "Costs of Rebuilding in Bushfire Zones" to VPELA 2014.

K Mival – 2015 - Article "Re-assessing the Disappearance of the Clippership *Guiding Star"* – published in The Great Circle – the biannual peer-reviewed journal of the Australian Association of Maritime History, Volume 37 No 2 pages 16-39.



EHS Support consider it done

PROFESSIONAL PROFILE

Quote to Live By:
"When we strive to become better than we are, everything around us becomes better too."
-Paulo Coelho

TIFFANY GOURLEY, PHD

PROJECT/ SENIOR HYDROGEOLOGIST
TIFFANY.GOURLEY@EHS-SUPPORT.COM • TEL: [+61 421 354 807] • [MELBOURNE, VICTORIA]

EXPERTISE

- Geology
- Hydrogeology
- Contaminated Land Assessment

EDUCATION

- Doctor of Philosophy (PhD) Geology, University of Melbourne, 2005
- Bachelor of Science with First Class Honours, Geology, University of Melbourne, 2000
- Bachelor of Science, Earth Sciences, University of Melbourne, 1999

CERTIFICATION AND TRAINING

- Managed Aquifer Recharge, Melbourne, Australia, 2011 (National Centre for Groundwater Research and Training, 2-day Specialist Course)
- Advances in Aquifer Testing for Improved Site Characterisation, Melbourne, Australia, 2010 (Midwest Geosciences Group, 3-day Specialist Course)
- Maritime Security Identification Card (MSIC) Induction, (Expiry 2015)
- WorkCover OH&S Construction Induction, 2009
- St John's Ambulance Senior First Aid Training, 2007 with ongoing refresher training (Expiry 2016)
- Introduction to Monitored Natural Attenuation and Enhanced Bioremediation, Melbourne, Australia, 2007 (ACLCA, 1-day Short course)
- Soil and Groundwater Pollution 2007 – Characterisation, Remediation and Risk Management, Melbourne, Australia (Centre for Groundwater Studies, 5-day Specialist course)
- One- and Two-day Four Wheel Drive Vehicle training courses (One-day course conducted by RAC Driving Centre in WA in 2011 and two-day course conducted by Motor School in QLD in 2011)
- One Day Intelligent Car course. Conducted by DECA Training in Melbourne, Australia, 2007
- OSHA 40 hours Health and Safety Training, 2006

Dr Tiffany Gourley is a Senior Hydrogeologist with a PhD in Geology and over nine years' consultancy experience in both Australia and Canada, predominantly focused in hydrogeological and contaminated site assessment. Her consultancy experience includes management, coordination, supervision, design and reporting of environmental investigations including the assessment of groundwater source protection and supply, construction dewatering, groundwater chemistry, managed aquifer recharge, landfill gas and leachate, acid waste sulphate soils, groundwater-surface water interaction, groundwater impact assessment (e.g. those due to dewatering, managed water injection, land development and climate change) and contaminant fate and transport.

Tiffany has been a member of a number of multidisciplinary teams working for various industry sectors including Defence, government, construction, property, petroleum and transport. As a result, she has gained extensive experience in soil and groundwater investigation, project planning and management, health and safety, field and laboratory QA/QC procedures and database management. Tiffany has also been involved in the preparation of a number of conceptual site models for complex hydrogeological sites and has completed field work and reporting for several sites subject to statutory Environmental Audit.

Key Experience

Contaminated Land Experience

Tiffany has conducted numerous soil and groundwater contaminations assessments that have included Phase I and Phase II ESAs through to complex Conceptual Site Models for a wide range of land use in Victoria, New South Wales and Queensland, Australia. She is also highly experienced in preparing environmental monitoring and management plans to meet regulatory guidelines.

Risk Identification And Soil Contamination Assessments, Kew And Aspendale, Victoria, 2016

Project Manager

Project management, field work and reporting for two risk identification and soil contamination assessments along the proposed route of gas main renewal projects in both Kew and Aspendale.

Salt Cake Cell Remediation Plan, Maryvale Mill, Victoria, 2015

Project Manager

Tiffany provided project management and technical input for the preparation of a remediation plan required for excess salt cake (a by-product of the paper manufacturing process) that was landfilled in a number of cells adjacent to a paper mill site.

Hydrogeological Assessment, Rowan/Spring Road Closed Landfill, Victoria, 2014-2015

Preparation of a Hydrogeological Assessment, including a Conceptual Hydrogeological Model, for a closed landfill site in south eastern Victoria. Requested as part of the Post Closure Pollution Abatement Notice (PCPAN) process by EPA.

Groundwater Monitoring Review And Landfill Gas Risk Assessment, Maryvale Mill, Gippsland, Victoria, 2013 – 2014

Project Manager

Project management and technical input into the preparation of a Groundwater Monitoring Review and Landfill Gas Risk Assessment for a complex paper mill and landfill site. Included optimisation of the groundwater and leachate bore network, identification of key contaminant trigger levels and the drilling and monitoring of soil gas bores.

Aftercare Management Plan (AMP), Landfill Gas Investigation And Remediation, Rowan/Spring Road Closed Landfill, Victoria, 2014

Project Manager

Preparation of an AMP (as part of PCPAN process) following an in-depth investigation of the potential risk posed by landfill gas migrating from a closed landfill. The design and implementation of remedial works were required to mitigate concentrations of soil gas exceeding Best Practice Guidelines in close proximity to sensitive receptors.

Conceptual Site Model, Stevensons Road Closed Landfill, Cranbourne, Victoria, 2013

Preparation of a revised conceptual site model for the historical migration of landfill gas into offsite areas driven by a complex hydrogeological regime. This project included both technical input and project management skills for a series of four deliverables including the revised Conceptual Site Model, Risk Assessment, Assessment of Clean Up Technologies and Clean Up Plan.

Annual Report And Trade Waste Agreement Application, Heatherton Park Former Landfill, Clayton, Victoria, 2012

Preparation of a review of groundwater, leachate, surface water and stormwater monitoring conducted at a rehabilitated landfill site in Clayton, and an application to the local water regulator for discharge of leachate to sewer.

Annual Report, Argyle Avenue Former Landfill, Chelsea, Victoria, 2011

Preparation of an annual review of groundwater and surface water monitoring conducted at a rehabilitated landfill site in Chelsea.

Groundwater Management Plan (GMP), Fitzroy Gasworks, Victoria, 2011

Preparation of a GMP for a gasworks site with contamination to soil and groundwater. Required as part of the completion of a 53V Audit for the site

Annual Reporting, Carisbrook Landfill, Victoria, 2010 – 2011

Compilation of an annual review for the bi-annual monitoring of surface water and groundwater, to assess current or possible future impacts of the site on nearby potential receptors.

Various Soil, Groundwater And Hydrogeological Reporting, South Morang Rail Extension Project, Victoria Australia, 2010

Completion of various reporting tasks for soil and groundwater investigations conducted along the Brownfield and Greenfield alignments of the planned rail extension.

Conceptual Site Model, Former Defence Site (Fire Training Area), Point Cook, Victoria, 2009

Prepared the Conceptual Site Model for a complex hydrogeological and contaminated soil and groundwater site at Pont Cook, Victoria.

Groundwater Study, Former Defence Site (Weapons Range), Salt Ash, Victoria, 2009

BIOSCREEN Modelling to simulate natural attenuation of dissolved hydrocarbons in groundwater as part of a Validation Report and remediation works.

Site Remediation, Preston, Victoria, 2007

Field and technical work as part of CUTEP (Clean Up To Extent Practicable) report preparation for a chlorinated solvent contaminated site undergoing remediation. Involved assessment of natural attenuation occurring at the site.

Phase I And II ESA, Mt Macedon, Victoria, 2007

Examined an area of land for potential environmental issues before redevelopment to an outdoors childcare facility.

Environmental Site Assessment For Audit, Yarraville, Victoria, 2007

Conducted field and report preparation for an assessment of soil and groundwater contamination of an area of land previously used a fertilizer manufacturing facility, and contaminated with heavy metals, PCBs and PAHs.

Environmental Site Assessment For Audit, Cranbourne Sewage Treatment Plant, Victoria, 2007

Detailed assessment of soil and groundwater quality, aquifer characterisation and geochemical analysis of groundwater for a large parcel of land under proposed redevelopment to residential land use.

Validation Report, Hoppers Crossing, Victoria, 2007

Fieldwork and report preparation for the removal of contaminated soil and underground storage tanks associated with a petroleum facility.

Geology and Hydrogeology Experience

Tiffany has managed a wide range of hydrogeological projects for a range of industry sectors. Projects include the areas of groundwater resource protection, groundwater quality and quantity assessment, surface water/ groundwater interaction, hydrogeochemistry and stratigraphic correlation. Her involvement has included both field and technical input with supervision and management of junior staff and contractors, liaison with council and municipal staff and collaboration with other geologists, hydrogeologists and engineers.

Hydrogeological Assessment, Officer, 2016

Project Manager

Project management, field work and reporting for a hydrogeological impact assessment of a proposed land re-development site in Officer, VIC.

Managed Aquifer Recharge (MAR) Project, EPIC Park in Canberra, 2013 – 2015

Project management and technical input into the drilling of a deep injection bore at the site, a MAR trial (involving injection and extraction) and subsequent hydrogeological assessment of the MAR potential (for treated stormwater) in the Flemington Road area of Canberra, ACT.

Groundwater Impact Assessment, Big Hill Enhanced Development Project, Stawell, Victoria, 2013

A review of the hydrogeology relevant to Big Hill, in particular the potential impact to groundwater resources over the life of the open pit mine project.

Groundwater Supply Bore Installation, Narrabri, New South Wales, 2013

Field works and site supervisory role for the installation of a groundwater supply bore installed to around 200 m into the Pilliga Sandstone.

Hipwell Rd Dewatering Scheme, Gunbower Forest, Victoria, 2013

Spear point design and WinFlow modelling for a groundwater dewatering scheme required for the safe construction of a weir.

Hydrogeology Investigation Of Pools On Kangeenarina Creek, Pilbara, Western Australia, 2013

Field works including the installation of monitoring and pumping bores and an aquifer pumping test, to ultimately meet the environmental water provisions for conservation of the groundwater dependent pools of Kangeenarina Creek, which lies adjacent to a proposed iron ore mine.

Hermitage Dam Injection Bore Rehabilitation, Roma, Queensland, 2012

Field works and site supervisory role for the rehabilitation of an injection bore related to a Managed Aquifer Recharge scheme in Queensland. The purpose of field works was to increase the injection capacity of the bore.

Geological Storage Options For Saline Effluent, Queensland, 2011-2012

Two desktop hydrogeological assessments (for two separate coal seam gas fields) to determine the technical feasibility of long term geological storage via deep well injection, of saline effluent produced from coal seam gas activities, into fractured rock aquifers beneath the Bowen Basin in Queensland. Included the siting of prospective injection and monitoring wells, a preliminary impact assessment and the preparation of a monitoring plan.

Groundwater Monitoring And Supply Bore Installation, Pilbara, Western Australia, 2012

Field works including the drilling and installation of monitoring bores and a groundwater supply bore, into bedrock and the overlying alluvial/ colluvial valley fill deposits, with a subsequent aquifer pumping test.

Tier 3 Hydrogeological Assessment, Mallacoota, Victoria, 2011

Aquifer testing and impact assessment in accordance with SRW guidelines to assess the suitability of an increase in groundwater allocation volume for urban water supply to the township of Mallacoota.

Managed Aquifer Recharge (MAR) Feasibility Assessment, Mallacoota, Victoria, 2011

A preliminary assessment of the feasibility of MAR techniques to address potential future declines water availability for urban water supply, including aquifer storage and potential decreasing streamflow in the Betka River.

Hydrogeologcial Assessment, Albury Former Gasworks, Victoria, 2011

Aquifer testing and analysis to provide quantitative information regarding the hydraulic properties of the underlying aquifer. Included capture-zone analysis and preliminary well-field design for a proposed P&T system to capture contaminated groundwater.

Groundwater Inundation Study, Portland, Victoria, 2010

An assessment of the risk posed to coastal assets due to changes in the groundwater system as a result of sea level rise and climate change.

Hydrogeological Investigation, Berth 6, Yarraville Victoria, 2010

Preparation of a Conceptual Site Model for a contaminated site with a complex hydrogeological flow regime. Field and technical evaluation of the underlying geology, groundwater quality and the hydraulic interaction of groundwater with adjacent surface-water in the Yarra River.

Hydrogeological Study, Stephenson's Road Landfill, Cranbourne, Victoria, 2009

Preparation of detailed geological cross-sections using both sedimentological and geophysical data. Field and technical evaluation of aquifer tests and a census of groundwater bores in the region. Technical review and reporting of hydrogeological conditions at the Site.

Hydrogeological And Dewatering Study, West Don Lands, Ontario, Canada, 2009

Assessment of dewatering requirements for a Storm Water Servicing Project for the West Don Lands development, a 32-hectare brownfield site proposed for a mixed use redevelopment under Risk Assessment.

Environmental Assessment, Proposed Eglinton Crosstown Light Rail Transit, Toronto, Ontario, Canada, 2008-2009

Evaluation of hydrogeological conditions and potential impact to groundwater resources due to a proposed light rail transit.

Hydrogeological Investigation, Proposed Highway 28 Realignment And Rehabilitation, Lakefield, Ontario, Canada, 2008

Investigation to determine the potential impacts to surface and groundwater supported natural features, due to the proposed construction activities of the Highway 28 Realignment.

Infiltration Study, Forest Hill Rd, Toronto, Ontario, Canada, 2008

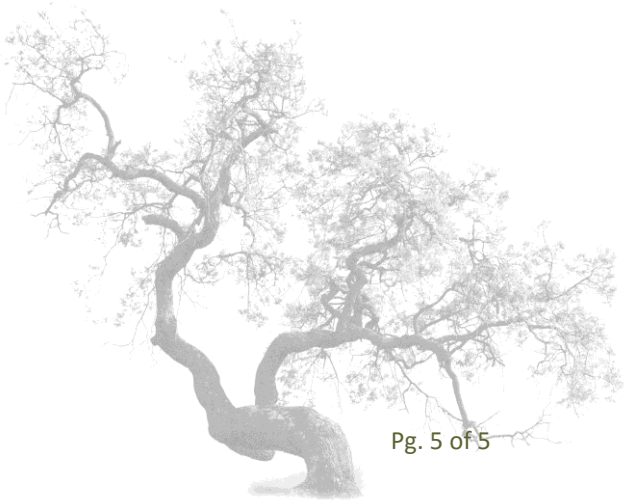
Study to determine the potential for infiltration and infiltration structure design options in a residential setting.

Hydrogeological Study, Mayfield West Community Lands, Ontario, Canada, 2008

Evaluation of hydrogeological conditions at the site, that included an assessment of groundwater and surface water interaction, and preparation of a final report for a large development site that was proposed to be subdivided.

Hydrogeological Study, Tremaine Rd, City Of Burlington, Ontario, Canada, 2008

Evaluation of hydrogeological data, water balance analysis for the site and preparation of final text to be included as part of the 'Tremaine Subwatershed Study'.



APPENDIX C ENFORCEABLE UNDERTAKING APPLIED TO SITA LANDFILL - HALLAM

ENFORCEABLE UNDERTAKING

Environment Protection Act 1970 (Vic)

Section 67D

The commitments in this undertaking are offered to the Environment Protection Authority (EPA) by:

SITA Australia Pty Ltd (ACN 002 902 650)

1. DEFINITIONS

In addition to terms defined elsewhere in this undertaking, the following definitions are used:

Auditor means an independent auditor appointed under section 53S of the *Environment Protection Act 1970 (Vic)*

EPA means the Environment Protection Authority

the Act means the *Environment Protection Act 1970* (Vic)

Company means SITA Australia Pty Ltd (ACN 002 902 650)

Licence means EPA Licence number ES33144

Local affected community means the residents of Cranbourne North, Cranbourne, Narre Warren, Lyndale, Lynbrook, Hampton Park, Hallam, Narre Warren South and Lyndhurst.

Premises means the landfill located at 274 Hallam Road, HAMPTON PARK

Undertaking means Enforceable Undertaking made pursuant to section 67D of the *Environment Protection Act 1970 (Vic)*

2. BACKGROUND

2.1 EPA's role

The EPA is a statutory body created by the Act, which has primary responsibility for the administration and enforcement of that Act.

2.2 Details of conduct / incident

During the period April to August 2011 the EPA received a number of community reports about offensive odours in the residential areas surrounding the Premises. EPA officers visited the Premises and identified their concerns regarding the source of fugitive odour emissions from the Premises.

2.3 Alleged Contraventions

The EPA alleges the following:

By the discharge beyond the boundaries of the Premises of odours offensive to the senses of human beings on the following dates: 14 April 2011, 6, 9 17 and 29 May 2011, 28 June 2011 and 22 August 2011, the Company breached condition 1.13 of its Licence in contravention of section 27(2) of the Act.

3. KEY OBJECTIVES OF THIS UNDERTAKING

This Undertaking is a binding agreement that aims to:

- Deliver benefits beyond compliance;
- Deliver benefits to the environment and to local communities that have been affected by the alleged contravention;
- Improve the Company's environmental performance by implementing systemic changes that will reduce the likelihood of a similar incident occurring in the future.

4. UNDERTAKINGS

Under section 67D of the Act, the Company has offered, and the EPA has agreed to accept as an alternative to taking Court proceedings, the following undertakings.

4.1 The Company undertakes to operate the Odour Curtain System (or any similar system as may be proposed by SITA and approved by EPA) around the boundaries of operating cells downwind of prevailing winds for the purpose of reducing odours.

4.2 The Company undertakes to operate in accordance with the cell volume and lifespan spreadsheet attached as Appendix A, as validated through the approval of each cell by EPA. The Company undertakes to notify EPA of any significant change to the Company's business model which could affect cell volume and lifespan. At the conclusion of this Undertaking, Appendix A will form part of the licence.

4.3 The Company undertakes to agree to a licence amendment to include conditions which address the matters listed in Appendix B to the agreement.

4.4 The Company undertakes to carry out a six monthly aerial infra red monitoring program to detect hotspots on the landfill cap which would indicate gas emissions. The results of such monitoring programs shall be reported to EPA within 7 days of the results being known.

4.5 The Company undertakes to update the local community on a quarterly basis, via a Community Update Fact Sheet, on the actions being pursued in this Undertaking. The updates will be distributed via email to the local affected community, including the Hallam Road Community Reference Group (**CRG**), and shall be posted on SITA's Website. A copy of each such Community Update Fact Sheet shall be provided to the EPA.

4.6 The Company undertakes to operate the SITA Environmental Report Hotline (or any similar reporting service as may be proposed by SITA and approved by EPA) for use by the local affected community. The SITA Environmental Hotline is a Freecall number

available for use by the community on a 24h/7 days per week basis, should they wish to report any concerns or make any enquiry regarding the Premises.

4.7 The Company undertakes to use all reasonable endeavours to obtain local council approval to display a poster in key local affected community hub locations such as shopping centres, community notice boards, childcare centres, community halls and council offices. The Community Contact Poster will provide details of SITA's Environmental Report Hotline and SITA's contact details. No less than 20 posters must have been put on display by 30 November 2012.

4.8 The Company undertakes to facilitate the Hallam Road CRG including by holding meetings of no less frequency than once every 3 months. Members of the CRG shall be informed of this Undertaking no later than one month after it has been signed by both the Company and the EPA. The Company shall report on progress with the Undertakings as a standing agenda item at each CRG meeting until the completion of the Undertaking.

4.9 The Company undertakes to offer to CRG members a guided site tour of the Premises, following a safety induction, twice per year; the first such tour to take place no later than 30 November 2012. Each tour shall include a briefing by the Company on the progress of the works to be carried out pursuant to this Undertaking and CRG members will be able to comment on, and ask questions in relation to, the progress of the works and the performance of the odour-control systems at the Premises.

4.10 The Company undertakes to offer to host one meeting per year of the Waste Management Association of Australia - Victorian Landfills division, to include a site tour of the Premises and a presentation of the actions taken pursuant to this Undertaking. The presentation will particularly focus on the lessons learnt from the alleged contravention and the actions taken to address this through this Undertaking. SITA will initiate the invitation for the first meeting to be held by 28 February 2013.

4.11 The Company undertakes to make a monetary contribution of $100,000 (excluding GST) to a local environment project for the restoration or enhancement of the environment in a public place or for the public benefit, within 60 days of the date of this Undertaking. The nature of the project will be determined in consultation with the local affected community, the EPA and the local council.

4.12 The Company undertakes to provide the Solicitor to the EPA with proof of the payment of the project [s] listed in clause 4.11 within 7 days of the payment of $100,000.

4.13 The Company undertakes not to refer to the payment referred to clause 4.11 without reference to this Undertaking.

4.14 The Company undertakes to address concerns raised by the community about potential health impacts from the Premises by funding an independent research study into the effects of odour and landfill gas from the Premises as identified in Appendix C to this agreement or otherwise agreed by EPA. Such a study will incorporate the results from air analysis undertaken by EPA Victoria in 2012. The study will be completed by 31 March 2013 and will be presented to the CRG and be made available on EPA's website.

4.15 The Company undertakes to implement by 31 March 2013 a landscaping plan to screen the Premises along the South Gippsland Highway boundary, such screening to be comprised of multiple rows of plantings.

4.16 The Company undertakes to engage, at its own cost, an EPA appointed Auditor. The Auditor will examine the content of this Undertaking and will review the Company's compliance with its terms. The Company must ensure that the Auditor provides written advice to the EPA that the Company has complied with the undertakings in clauses 4.1-4.15 of Part 4 of this Undertaking by no later than 31 December 2013.

4.17 The Company undertakes to supply all documents and information reasonably requested by the EPA from time to time for the purpose of assessing the Company's compliance with the terms of this Undertaking.

4.18 The Company undertakes that it will pay the costs of its compliance with this Undertaking. The Company has estimated the cost of compliance with this Undertaking to be no less than $800,000.

5. ACKNOWLEDGMENTS

5.1 The Company acknowledges that the EPA:

(a) may issue a media release on execution of this Undertaking referring to its terms and to the concerns of EPA which led to its execution;

(b) may from time to time publicly refer to this Undertaking; and

(c) will make this Undertaking available for public inspection on a register of undertakings, in accordance with section 67G of the Act and that this Undertaking will remain on the register upon completion of all undertakings contained within.

5.2 Further, the Company acknowledges that:

(a) as provided in section 67D(4) of the Act, EPA's acceptance of this Undertaking means that proceedings may not be brought by EPA against the Company for the offences constituted by the contraventions alleged in clause 2.3 of this Undertaking;

(b) as provided in section 67D(5) of the Act, if the Company withdraws this Undertaking before it has been fulfilled, proceedings may be brought for the offences constituted by the contravention alleged in clause 2.3 of this Undertaking;

(c) EPA's acceptance of this Undertaking does not affect EPA's power to bring proceedings against the Company, to issue penalty infringement notices or instigate any other enforcement action against the Company in relation to any subsequent contravention or alleged contravention of the Act that is not the subject of this Undertaking, whether or not the subsequent contravention or alleged contravention involves a provision of the Act that is referred to in clause 2.3 of this Undertaking;

(d) this undertaking in no way derogates from the rights and remedies available to any other person or entity arising from any conduct described in this Undertaking or arising from subsequent conduct.

5.3 The Company acknowledges that it has offered an Undertaking in the terms set out above.

5.4 The Company acknowledges that this Undertaking has no operative force until accepted and signed by EPA, and the Company and EPA acknowledge that the date of the Undertaking is the date on which it is accepted and signed by EPA.

6. STATEMENT OF REGRET

6.1 The Company regrets that the community may have been adversely impacted by the emission of offensive odours beyond the boundary of the Premises on or about the period from April 2011 to August 2011.

7. ASSURANCE ABOUT FUTURE BEHAVIOUR

7.1 By completing each of the undertakings set out above, the Company is committed to ceasing the alleged conduct referred to in clause 2.3 and not recommencing that conduct.

8. EFFECT OF NON-COMPLIANCE

8.1 The Company acknowledges that failure to comply with this Undertaking may result in the EPA seeking to enforce the Undertaking in the Magistrates' Court.

8.2 Consistent with section 67D of the Act EPA may consent to a variation of this undertaking.

9. TERMINATION OF ENFORCEABLE UNDERTAKING

9.1 This Undertaking will terminate 3 years from the date the Undertaking is signed. All undertakings contained within this Undertaking must be completed by the termination date.

Executed in accordance with section 127(1) of the *Corporations Act 2001 (Cth)* by SITA Australia Pty Ltd :)

..... Director

..... ~~Director~~/Company Secretary

Accepted by the Environment Protection Authority under section 67D of the Environment Protection Act 1970 by its CEO and Deputy Chairman:

.....

MATTHEW VINCENT

Acting CEO of the Environment Protection Authority:

[date] 21/9/12

APPENDIX A

Hallam Road Landfill, Cell Volume & Lifespan

Cell Number	Total Cell Volume	Time to Fill Cell	Time to Fill Cell	Cumulative Time	Projected Filling Period for each Cell	
Fill Sequence	(m^3)	Months	Years	Years	Start Month	End Month
8						June 2012
9A	676,000	14.3	1.2	1.2	June 2012	Aug 2013
9B	359,185	8.0	0.7	1.9	Aug 2013	Apr 2014
14A	232,601	5.2	0.4	2.3	Apr 2014	Oct 2014
10A	416,613	9.3	0.8	3.1	Oct 2014	Jun 2015
10B	422,144	9.4	0.8	3.9	Jun 2015	April 2016
11A	302,079	6.8	0.6	4.5	April 2016	Oct 2016

Assumptions

monthly airspace consumption (m^3) incl. daily cover	44,680
monthly tonnage received (t)	37,234
daily cover airspace consumption (monthly)	7,447
compaction density (t/m^3)	0.75
daily cover as a % of waste volume received (%)	0.15

APPENDIX B

The matters to be addressed in conditions of an amended licence include:

1. The Company will operate in accordance with a site Landfill Gas Management Plan, as approved by EPA.

2. The Company will limit the tipping face of each cell to 600m2 and must only operate one tipping face at any one time.

3. The Company will progressively cover all deposited waste other than the operational tipping face with a minimum of 300mm of clay soil, such that only the operational tipping face is exposed at any one time.

4. The Company will effectively strip back cover soils prior to the next lift of waste to prevent perched leachate levels.

5. The Company will store cover soils around the operational cell for immediate use when required.

APPENDIX C

SITA Australia P/L - Health Study Proposal

The Restorative Justice Conference held on 2 August 2012 gave an opportunity for discussion about impacts from the Hallam Rd Landfill. Some participants expressed concern at the level of odour experienced in the community, and questioned whether there were health risks associated with this.

In response to such concerns, SITA Australia will provide funding for the following projects:

Independent Literature Review
Involving current scientific knowledge on air quality and related potential health impacts of air emissions from putrescible landfills including:

(a) Characterise the compounds typically emitted from putrescible landfills into air and where possible at what levels measured.
(b) Review studies and summarise the health impacts of living near putrescible landfills (i.e. from population studies etc)
(c) Review effects/health impacts including well-being from malodour generated from putrescible landfills.

This work has been scoped by EPA and the Department of Health and will be conducted by RMIT
The cost for the literature review is to be no more $20,000.

Air Sampling
Continuation of air sampling and analysis, in areas adjacent to the Hallam Rd Landfill with particular focus on compounds that contain sulphur which are typically odorous and are known to be emitted from landfills

The cost of air sampling is to be no more than $15,000.

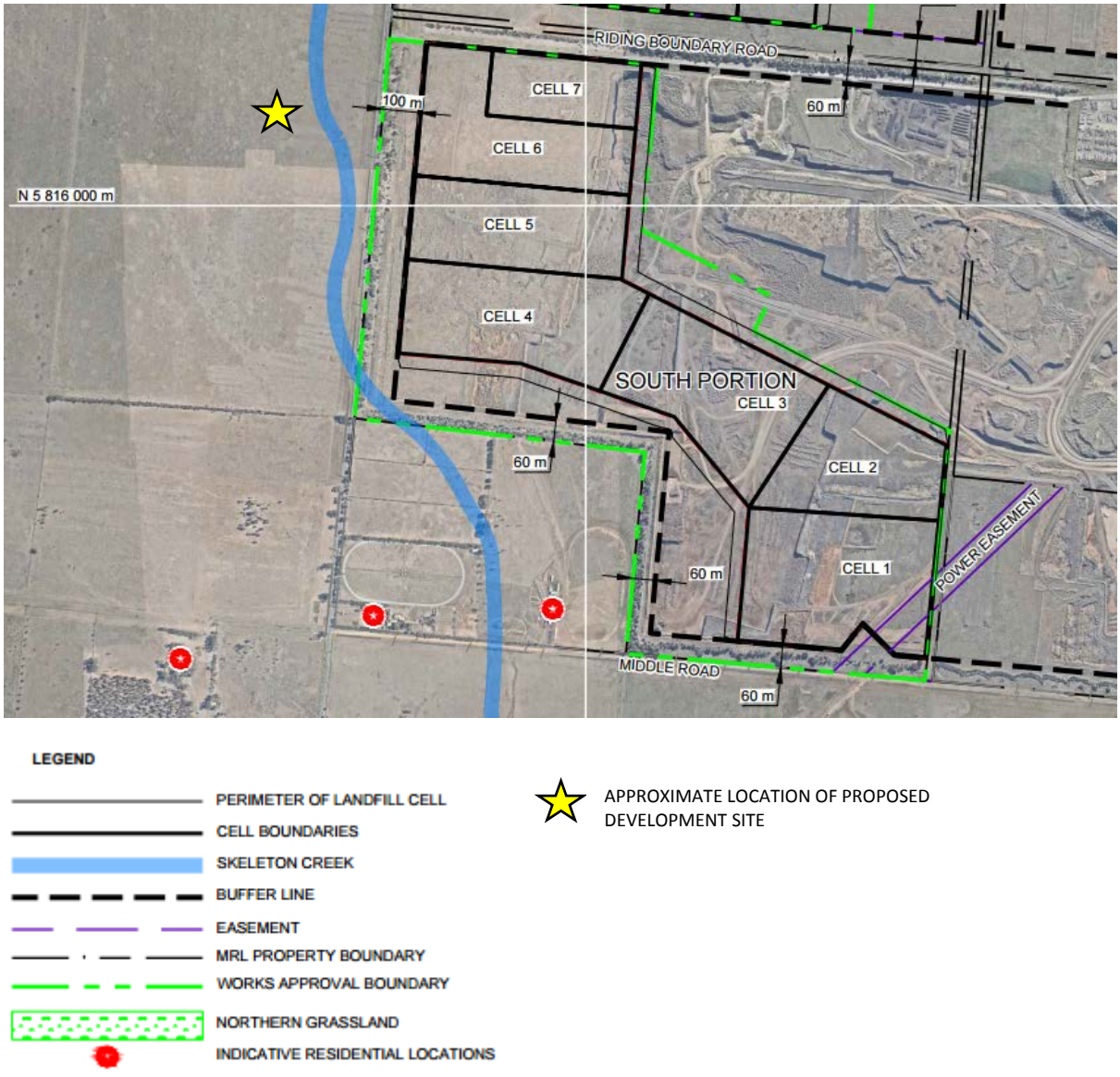
Independent Review
In order to link these separate pieces of work together, an independent review of the literature review and the air sampling will be conducted by CSIRO air experts.
The cost of the independent expert review is to be no more than $5000

APPENDIX D PRELIMINARY QUALITATIVE RISK ASSESSMENT

PRELIMINARY QUALITATIVE LANDFILL GAS RISK ASSESSMENT:

To evaluate the potential risk posed by LFG (particularly methane) to human health in nearby development sites (such as the Mt Atkinson & Tarneit Plains Precinct) within the 500 m buffer zone of the proposed extension to the Melbourne Regional Landfill, and the possibility of other residential properties within the buffer zone now or in the future, a preliminary qualitative landfill gas risk assessment (LFGRA) was conducted based upon a review of publically available information and prior experience regarding development sites in close proximity to former landfills. This is not intended to be a detailed LFGRA, rather a brief review of available information and assessment of potential risk.

The location of a proposed development area, within the 500 m buffer zone of the proposed extension to the Melbourne Regional Landfill, can be seen in the figure below (Source: Golder, 2016):



It can be seen that the proposed development site considered in this LFGRA would lie around 450 m to the west of the southern portion of the proposed landfill extension (in particular Cell 6), within the proposed Mt Atkinson & Tarneit Plains Precinct and that proposed commercial developments and existing residential properties would also be located within that distance.

The EPA Victoria Landfill Licensing Guidelines (EPA Publication 1323.2) dated August 2011 provide a framework for LFG risk assessments. These guidelines refer to the 'Guidance on the Management of Landfill Gas, UK Environment Agency Publication, LFTGN 03' (UK EA, 2004). The CIRIA 665 methodology, *'Assessing risks posed by ground gases to buildings' (revised)'* (Wilson et al., 2007) and British Standard (BS 8485:2015) "*Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'*, have also been referred to in preparing this risk assessment.

The following assumptions are integral to this assessment of LFG risk:

- The proposed development (the 'site') is located just within the 500 m buffer zone of the landfill, with no planned below ground structures such as a basement or lift shaft;
- That existing residential properties may also remain located within the buffer zone;
- That the landfill is now closed and past its peak LFG generation phase (i.e. 50 years since waste was last placed);
- The landfill is situated above the shallow water table;
- That the landfill was constructed to BPEM standards, with a basal and side liner, a suitable cap, leachate collection system and gas extraction system; and
- That the lining of the landfill has been compromised in some way (e.g. lining failure 50 years post construction) allowing LFG to migrate into the adjacent geologic media.

SITE SETTING:

Information regarding the site setting has largely been taken from the AECOM (2016) Hydrogeological Assessment report that was prepared for Landfill Operations Pty Ltd in February 2016.

Landscape and Topography:

The site is located on the Western Volcanic Plains, a geomorphological feature that has developed on the Newer Volcanics basalt and extends for 15,000 km^2 from north and west of Melbourne almost to the South Australian border.

Basalt has been quarried from the site since the 1960s and extraction is expected to continue for the life of the resource.

The topography of the site is assumed to be relatively flat and at an elevation of around 75 m AHD. The rehabilitated surface of the proposed extension to the Melbourne Regional Landfill is expected to lie higher than the site.

Geology:

Review of the Geological Survey of Victoria, 1974; Melbourne Mapsheet (1:63,360) and deep drilling in close proximity to the Melbourne Regional Landfill, indicates that the site is likely to be located on Quaternary aged Newer Volcanics consisting primarily of basalt, scoria and agglomerate with intervening weathered horizons and paleosols.

In the vicinity of the Melbourne Regional Landfill, the weathered regolith (soil horizon) is usually 1 to 2m thick with fresh basalt occurring at shallow depth. Drilling and quarrying on the site has indicated that the individual basalt flows are generally 10 to 20m thick and often separated by paleosols suggesting significant time has elapsed between eruption cycles which has allowed time for development of mature drainage patterns, weathering and soils.

Drilling in the south east corner of the Melbourne Regional Landfill site has indicated that basalt of the Newer Volcanics is 56 m thick in this area, with sandstone and siltstone of the Brighton Group occurring between 56 and 70m depth, overlying Fyansford Formation clays and ligneous clays with some sandy clay and clayey sand occurring between 70 and 141m depth (AECOM, 2016).

Hydrogeology:

The closest surface water receptor is likely to be Skeleton Creek, with land subject to inundation as defined by the Melton Planning Scheme (dated September 2014), located approximately 100 to the west of the landfill cells in the southern area of the proposed landfill extension (Golders, 2016). The Current Mt. Atkinson & Tarneit Plains Precinct Structure Plan indicates that Skeleton Creek will be incorporated into the design of the precinct and will traverse the eastern boundary of the site.

Groundwater monitoring at the Melbourne Regional Landfill site in the vicinity of the proposed extension, indicates that the water table is likely to be around 25 m below ground surface (m bgs) in the vicinity of the site. The landfill is positioned in the upper basalt layer which reportedly has a low hydraulic conductivity (~0.1 to 0.5 m/day) (AECOM, 2016). The water table is to be located a minimum of 2 metres vertically below the deposited waste at its closest point.

Document Review:

AECOM (2016). *Hydrogeological Assessment* report that was prepared for Landfill Operations Pty Ltd in February 2016.

In 2016 AECOM prepared a Hydrogeological Assessment for Landfill Operations Pty Ltd, regarding the existing and propose extension of the Melbourne Regional Landfill in Ravenhall. Relevant information used to prepare this LFGRA is summarised below.

Basalt rock has been quarried from the site by Boral since the 1960s and in November 1997 a Works Approval (WA31723) was issued to Boral in for the construction of a putrescible landfill within the quarry void and the original Licence to allow waste disposal activities to commence in Cell A of the Stage 1 area was issued in December 1998. The Stage 1 area, consisting of two cells, was completed in late August 2001 and filling of the Stage 2 cells began in September 2001. Currently filling is being carried out in Cell 2M of Stage 2.

The design of the landfill cells within the quarry has changed over the duration of the life of the landfill in response to changing EPA standards, as expressed in the Landfill BPEM that was originally released in October 2001 and revised in September 2010, October 2014 and August 2015. The existing cells (Cell 1A to 2M) have both a liner and capping system in place.

The proposed landfill extension (North and South Portions: Cells 1-16) has an estimated cell volume of 53 million m^3 and a cell area of approximately 210 hectares, with filling to commence around 2026.

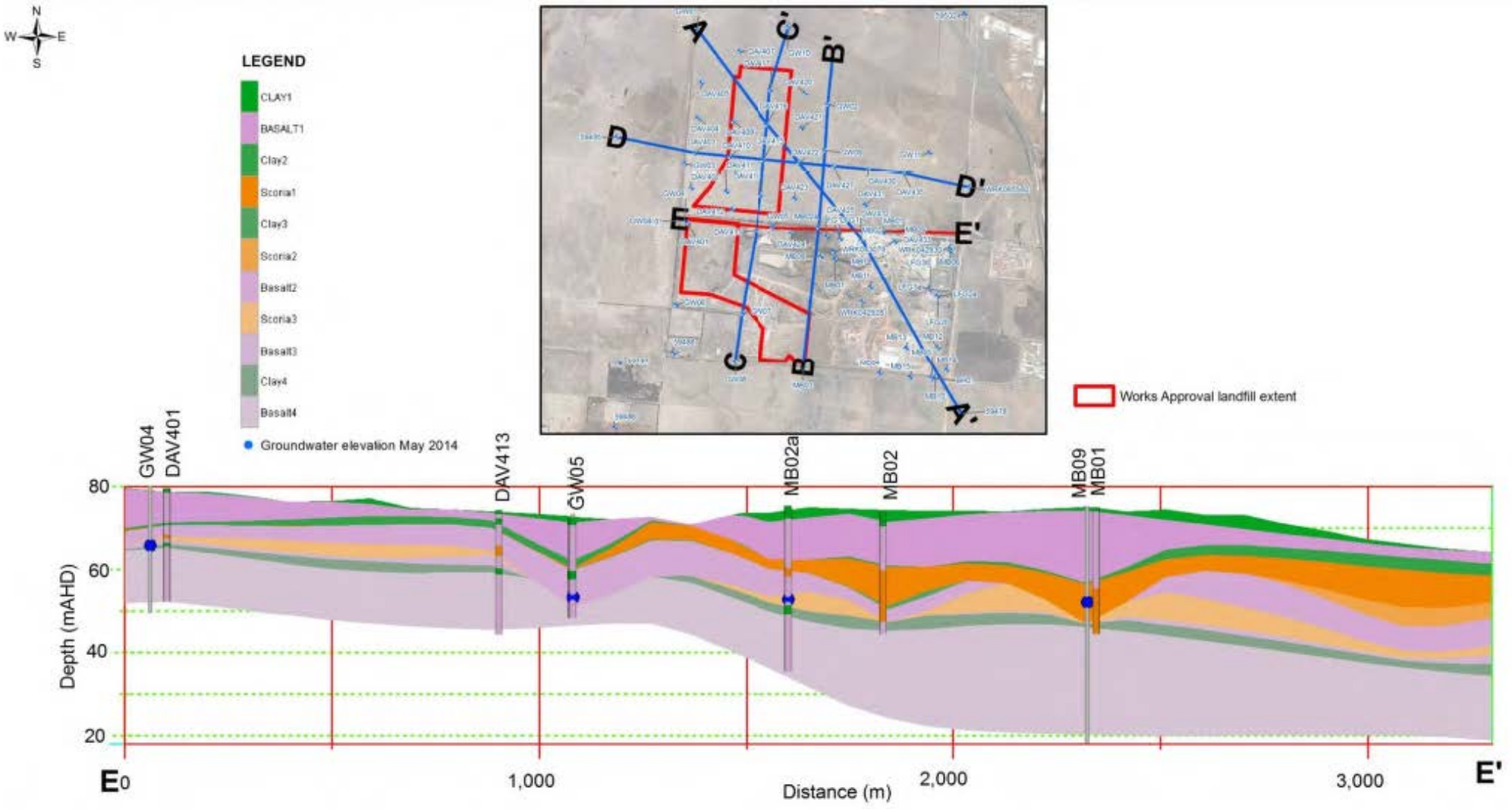
The Hydrogeological Assessment confirmed that the current landfill operation at the Melbourne Regional Landfill has not adversely impacted on the beneficial uses of groundwater, and that the proposed extension will conform with current BPEM Groundwater Management requirements to protect the beneficial uses of groundwater.

The landfill is situated on basalt of the Newer Volcanics, which is a Quaternary age geological unit comprising olivine basalt of variable rock quality with intervening layers of scoria and scoriaceous basalts and with intervening weathered horizons which comprise clay layers and paleosols. The degree of fracturing in the basalt sequence determines its hydraulic characteristics. Drilling as part of a deep groundwater investigation has identified at least 4 basalt flows, intermittently separated by clay

and scoria layers. A clay and topsoil layer overlies weathered basalt of the Newer Volcanics to a maximum depth of 5.5 m in the area of the investigation.

Pumping tests and bailing tests carried out on the site boreholes indicated that the upper basalt layers are more massive and exhibited a low hydraulic conductivity (0.1 to 0.5 m/day) whereas the lowest of the four flows exhibited a high degree of fracturing with a hydraulic conductivity of 5 – 10 m/day. Quarrying has been developed in the topmost competent rock of the topmost basalt layer and above the regional water table level.

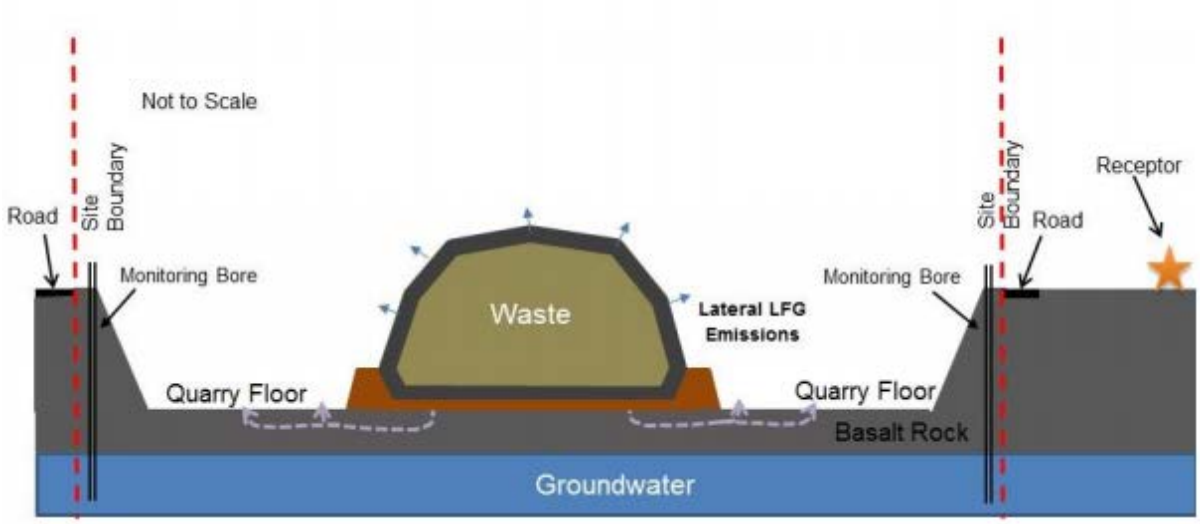
East to west orientated cross section (E-E') illustrates the interlayering of basalt flows, scoria and clay soils in the vicinity of the proposed extension to the Melbourne Regional Landfill. In the vicinity of GW04, the depth to groundwater was measured as approximately 26.5 m bgs in 2014.


N
W
E
S
LEGEND
CLAY1
BASALT1
Clay2
Scoria1
Clay3
Scoria2
Basalt2
Scoria3
Basalt3
Clay4
Basalt4
Groundwater elevation May 2014
A
A'
B
B'
C
C'
D
D'
E
E'
Works Approval landfill extent
GW04
DAV401
DAV413
GW05
MB02a
MB02
MB09
MB01
80
60
40
20
Depth (mAHD)
E0
1,000
2,000
3,000
E'
Distance (m)

Golder Associates (2016). ***Information to Support Works Approval Application – Proposed Melbourne Regional Landfill (MRL) Extension, Ravenhall*****. Prepared for Landfill Operations Pty Ltd in February 2016.**

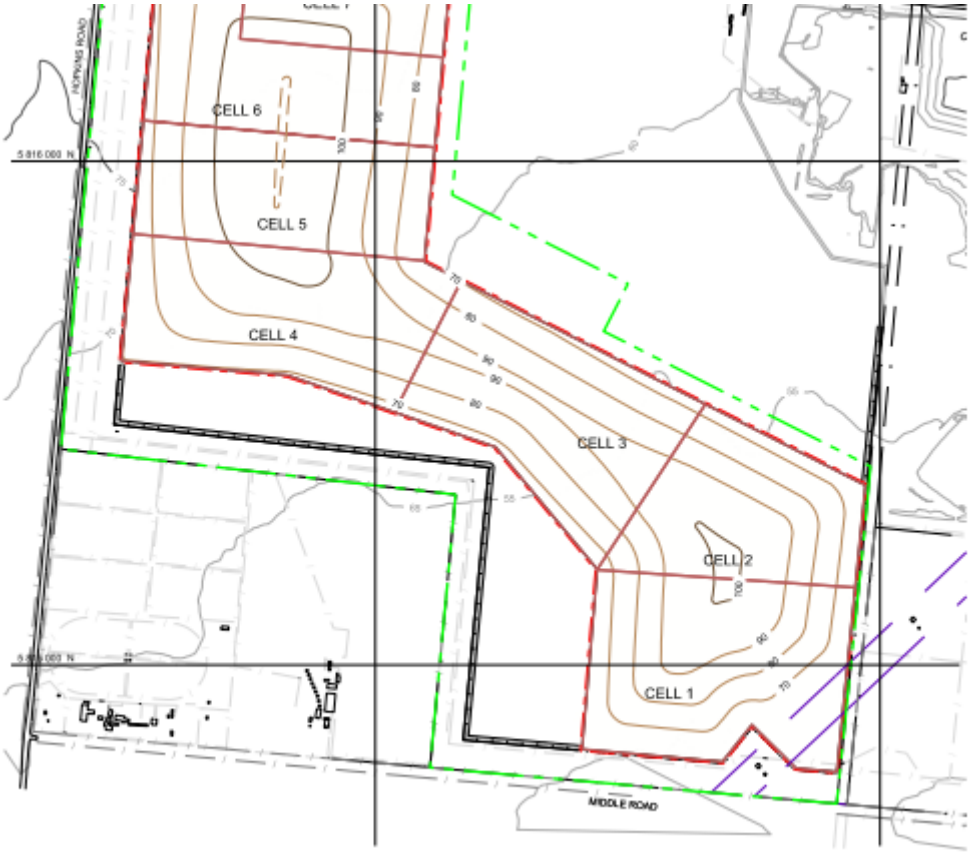
Golder were commissioned by Landfill Operations Pty Ltd to prepare a report in support of a Works Approval from the EPA. Relevant information used to prepare this LFGRA is summarised below.

A conceptual model for lateral LFG emissions was presented as illustrated below:



According to this report, for the majority of the proposed Extension the cell boundary is proposed to be set back from the quarry face as illustrated above. If this were the case, then the risk of lateral migration would therefore be reduced under these conditions. This is attributed to the expected ~10 m vertical height difference between the boundary surface and the quarry floor, the large horizontal gap between the edge of the waste and the perimeter rock face, and the confining nature of the water table in regards to the lateral flow path as illustrated above.

However, pre-settlement top of waste contour plans indicate that waste will be deposited on the landfill liner adjacent to the rock face along the western boundary of the southern Portion of the extension, as shown in the clipping of a figure taken from the report below:

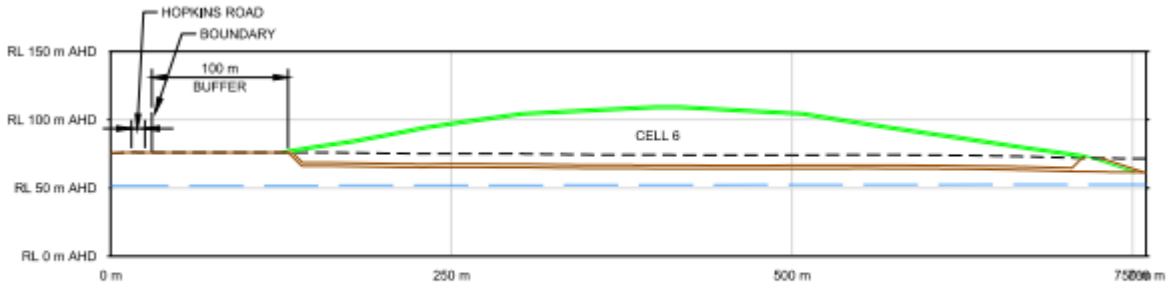


SOUTH PORTION - PRE-SETTLEMENT TOP OF WASTE PLAN
SCALE 1:10,000

APPROXIMATE LOCATION OF PROPOSED DEVELOPMENT SITE

Under these conditions, the risk of lateral off-site LFG migration via the adjacent geologic media could be higher. For this reason, the scenario where waste is deposited on the liner directly adjacent to the rock face has been assumed for further assessment of the potential risks posed by LFG.

Pre-settlement waste contours and cross-sections through the southern portion of the proposed extension (see Section B below) indicate that waste could be placed as high as 30 -50 m within the quarry pit.



SCALE 1:5,000 B 20 NORTH-SOUTH LONG SECTION (SOUTH PORTION)

SUMMARY OF LANDFILL DETAILS:

A summary of collated information relating to the existing and proposed extension to the Melbourne Regional Landfill is provided in the table below:

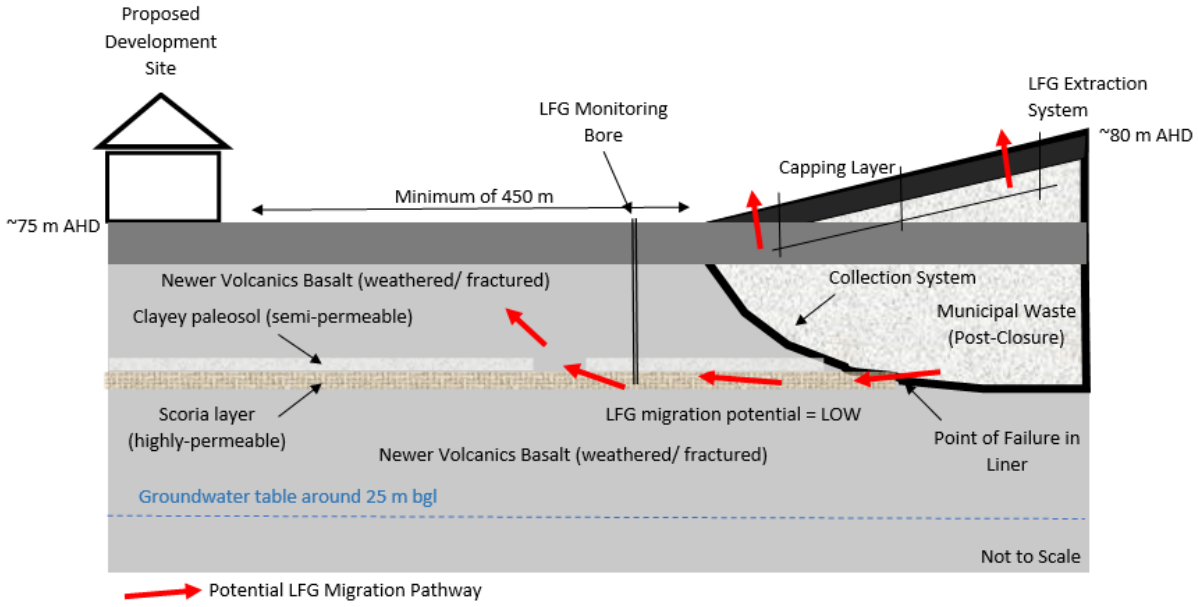
Melbourne Regional Landfill Area	Information	
Existing: (Stage 1 – 4C: Cells 1A to 2M)	Distance from Site:	~2,500 m
	Landfilling Status:	Operational
	Landfilling Type:	Municipal
	Area (m^2):	133,000 m^2
	Volume of waste received:	N/A
	Max. depth of waste:	N/A
	Landfill liner present?:	Yes
	Landfill leachate collection system present?:	Yes
	Landfill cap present?:	Yes for closed cells
	LFG extraction system operational?	Yes
	Regular monitoring of perimeter soil gas bores?	Yes
Proposed Extension: (North and South Portions: Cells 1 -16)	Distance from Site:	~450 m
	Landfilling Status:	Proposed
	Landfilling Type:	Municipal
	Area:	210,000 m^2
	Volume of waste received:	Assumed 53 Million m^3
	Max. depth of waste:	Assumed 50m
	Landfill liner present*?:	Assumed Yes
	Landfill leachate collection system present*?:	Assumed Yes
	Landfill cap present*?:	Assumed Yes
	LFG extraction system operational?	Assumed Yes
	Regular monitoring of perimeter soil gas bores?	Assumed Yes

Notes: * BPEM compliant

CONCEPTUAL SITE MODEL:

A Conceptual Site Model (CSM) was developed to identify potential sources of landfill gas, likely pathways of gas migration, potential receptors and the possible associated hazards. It is based upon the characteristics of the landfill and the available information at the time of review.

The figure below provides a preliminary illustration of the CSM for any proposed residential or commercial development within the 500 m buffer of the Melbourne Regional Landfill proposed extension, based upon the currently available information reviewed.



Potential Gas Sources:

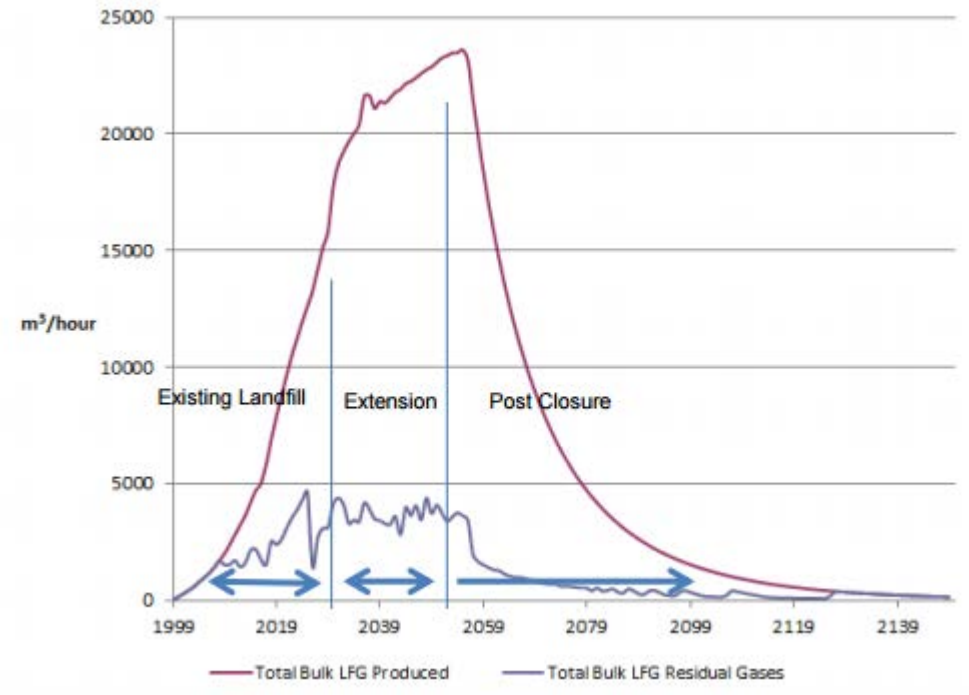
The proposed development would lie within 500 m of a large municipal landfill, which is expected to produce a significant quantities of landfill gas over its lifetime.

Methane and carbon dioxide, as well as many other trace gases (hydrogen sulphide, hydrogen cyanide, carbon monoxide, ammonia and hydrogen) are collectively referred to as landfill gas. Landfill gas is generated by bacterial decomposition (i.e. when natural bacteria break down organic material in the waste), volatilization (i.e. when organic compounds in the waste change from a solid or liquid into the vapour phase) or other chemical reactions occurring within the waste mass.

Gas generation, in particular methane and carbon dioxide, occurs at widely varying rates depending on:

- The age of the waste - given the correct conditions, peak methane and carbon dioxide generation will occur within the first decade or so of landfill closure.
- Waste composition - to generate large volumes of methane and carbon dioxide, a large mass of easily degradable organic matter is required (e.g. domestic landfill sites).
- Landfill capping - capping will restrict the rate of rainfall infiltration and thus moisture content, lowering the potential for gas generation.
- Physical conditions in the soil - including pH, temperature, presence of oxygen, moisture and microorganism content.

A landfill gas simulation model, GasSim V2.5 (GasSim) was used to model the potential LFG generation for the Extension. Waste mix types permitted to be received by the extension were assumed to remain similar for the future extension (Cells 1 to 16) when compared to the existing Landfill (Golder, 2016). An estimate of the total bulk landfill gas produced from both the existing and proposed extension of the Melbourne Regional Landfill can be observed in the figure below (Source: Golder, 2016). The peak LFG production rate is in the order of 24,000 m^3 per hour.



As part of this LFGRA we are assuming that failure of the lining has occurred some 50 years after it was constructed (i.e. around the year 2075 assuming that construction is completed by 2025). Prior to 2075, the risk of offs-site landfill gas migration is considered to be low assuming that a BPEM compliant liner and capping along with a gas extraction system would be in place and operating effectively.

As can be seen in the figure above, by 2075 the landfill would have passed its peak phase of LFG generation with a decreased potential to generate gas (around 80% less than its peak). Furthermore, in considering the case of liner failure, the volume of LFG that could potentially escape into the adjacent geologic media is considered to be very low when compared to unlined landfills such as Energy Park and Carrington Drive Closed Landfills in St Albans and Stevenson's Road Closed Landfill in Cranbourne, Victoria.

Potential Pathways:

Gas migration is primarily driven by pressure differentials (advective flow) and/or diffusive flow (concentration differentials). Migration can also be driven by the buoyancy of the gases. Advective flow is driven by rapid differential pressure changes caused by phenomena such as passing weather systems, changing groundwater levels or rapid release of pressure built up by a gas barrier. The permeability of the surrounding media restricts the ability of LFG to migrate.

The extent and rate of gas migration depends on three key factors:

1. Gas generation rates (driven by a pressure or concentration gradient);
2. Presence of a preferential pathway; and
3. The buoyancy of the gas mixture.

Given that the landfill extension is proposed to have a BPEM compliant liner, leachate collection system and capping, potential pathways for LFG migration from the landfill are restricted.

Assuming that the liner of the landfill becomes compromised (e.g. 50 years post construction) and LFG permitted to escape, based on the surrounding geology there is a potential flow path for landfill gas migration via fractured rock pathways as well as unsaturated layers of highly permeable scoria

beneath and adjacent to the landfill. However, given the presence of clayey and impermeable paleosol layers and that the surficial soils are likely to consist largely of clays, the off-site migration of landfill gas is likely to be relatively restricted.

The potential transport pathways for LFG migration considered in this assessment include:

- Migration though the landfill cap and leachate extraction and gas collection points into ambient air;
- Migration through the landfill liner into subsurface geology into buildings;
- Migration through the landfill liner into subsurface geology into services into buildings; and
- Migration through the landfill liner into subsurface geology into near-surface soils.

Each of these combinations was evaluated for the likelihood of its occurrence and the severity of its potential consequences.

Volatilisation of dissolved LFG is not considered to be a significant transport process given the expected depth to groundwater at the site, and that vertical transport of the LFG constituents would occur via diffusion which is a relatively slow process.

Emissions into the air are not expected to represent fluxes that would support hazardous concentrations of LFG constituents, Thus, concern is limited to amenity. Due to the wide-open nature of the site and dispersion, some level of air emissions can occur without harm to amenity. Odour complaints from nearby residents, which are confirmed to originate from the landfill would be evidence for unacceptable atmospheric emissions from the landfill. Control of the LFG and maintenance of the cap can mitigate atmospheric emissions.

Receptors and Hazards:

For this assessment, the main potential receptors are considered to include:

- Construction workers and on-site employees/ contractors present during the construction/ maintenance of the proposed building/s; and
- Eventual users of the proposed building/s.

Hazards posed to the receptors by migration of landfill gas to the site potentially include:

- Effects on human health (e.g. explosion, fire);
- Effects on human health (e.g. asphyxiation, toxicity, odour); and
- Damage to buildings (e.g. explosion).

Potential LFG Migration:

Given that LFG monitoring data for the Melbourne Regional Landfill was unavailable at the time of this assessment, LFG data from the URS (2013) *'Environmental Audit Report - Energy Park and Carrington Drive Closed Landfills – EPA Reference 68897-1'* was considered. These former landfills are situated approximately 10 km to the north east of the site and were constructed within a similar geological setting. However, the landfills are unlined, with no leachate collection or disposal system and no BPEM compliant cap to restrict the off-site migration of LFG and leachate.

The absence of detectable methane in bores and in underground services outside of the waste mass, indicated that for methane, migration was not occurring to any significant distance from the landfill. This relates to bores installed over a small distance from the landfills in these areas at between 25 and 75 m for the former City of Sunshine landfill, and approximately 25 m for the former Hulett Street landfill.

Some minor concentrations of methane were inferred to be escaping through either dissolution from leachate or lateral migration to where carbon dioxide was detected in the soil gas bores at levels slightly above background (~6%v/v), but at a relatively slow rate such that any methane had sufficient time to dissipate to atmosphere or oxidise to carbon dioxide rather than accumulate to concentrations above 1% v/v methane. Given the proximity of residences to the landfill, this does not appear to have translated into a significant risk to residents.

Concentrations of methane were, however, detected at levels above the action criteria at a single monitoring location adjacent to a commercial property in between the two former landfills (between 100 and 150 m away from a landfill boundary). This indicated that some LFG migration, potentially along preferred pathways, was occurring in this area.

This is considered to be a relatively similar model for likely behaviour of gas migration at the MRL in the event of failure of the liner.

RISK ASSESSMENT:

The CSM has identified a potential source-pathway-receptor linkage, with potential hazards including an effect on human health and damage to proposed buildings and/or structures via an explosion due to an accumulation of gas under or within the building.

To evaluate the risks, an assessment of likelihood and consequences was performed based on Guidance on the Management of Landfill Gas (UK EA, 2004). It is noted that this varies in detail from the assessment matrix presented in EPA Publication 1321.2 but the general approach is the same.

The Likelihood of an occurrence and the Consequences were then assessed, and the combination of the two used to compute a score for the associated risk.

The table below presents likelihoods of events for use in the risk assessment from UK EA guidance (2004); they range from extremely unlikely to probable.

Categories of Likelihood:

LEVEL	CATEGORY	RANGE
1	Extremely Unlikely	Conditions are theoretically possible, but are unheard of in the landfill industry
2	Very Unlikely	Conditions are rarely encountered in the landfill industry
3	Unlikely	Conditions are encountered several times in the landfill industry, however it is reasonable to assume that these conditions will not present themselves onsite
4	Somewhat unlikely	Conditions are assumed to present themselves onsite during the lifetime of the landfill
5	Fairly probable	Conditions are assumed to present themselves onsite several times during the lifetime of the landfill
6	Probable	Conditions are assumed to present themselves onsite

The severity of consequences for each potential event was evaluated and each was given a score. The table below presents descriptions of severity and the score assigned to it that is predominantly based on the UK EA guidance (2004).

Qualitative Categories of Severity:

LEVEL	DESCRIPTOR	DESCRIPTION
1	Minor	No health impacts Nuisance on site only No off site complaint
2	Noticeable	Noticeable nuisance off-site e.g. discernible odours, loose rubbish Minor breach of permitted emission limits, but no environmental harm One or two complaints from the public
3	Significant	Sustained nuisance, e.g. strong offensive odours First aid required Numerous public complaints
4	Severe	Large environmental release or incident which directly affects offsite receptors Hospital treatment required Public warning and off-site emergency plan invoked
5	Major	Major evacuation of local population (residents) Permanent disabling injuries sustained or fatality Serious toxic effect on beneficial or protected species Widespread but not persistent damage to land
6	Catastrophic	Substantial offsite impacts to broader environment, long-term environmental damage, extensive clean-up required Complete failure of environmental protection controls Site shutdown

The Likelihood and Severity scores are then multiplied by each other to obtain a risk score. The table below is from the UK EA guidance (2004) and it shows the scores associated with various Likelihood/ Severity combinations. Each potential scenario was addressed using this approach.

Severity - Likelihood Matrix:

		SEVERITY OF CONSEQUENCES					
		1. Minor	2. Noticeable	3. Significant	4. Severe	5. Major	6. Catastrophic
LIKELIHOOD	1. Extremely unlikely	1	2	3	4	5	6
	2. Very unlikely	2	4	6	8	10	12
	3. Unlikely	3	6	9	12	15	18
	4. Somewhat unlikely	4	8	12	16	20	24
	5. Fairly possible	5	10	15	20	25	30
	6. Probable	6	12	18	24	30	36

The classification of the score calculated with the risk was performed in accordance with UK EA (2004) guidance using the table below.

Risk Evaluation:

MAGNITUDE OF RISK	SCORE
Insignificant	6 or less
Acceptable	8 to 12
Unacceptable	15 or more

Summary of Risk Associated with Landfill Gas at the Site (Scenario: Proposed development site around 450 m from landfill cell):

Using the Severity and Likelihood scores above, we can arrive at a risk score for each potential exposure scenario.

The potential severity of LFG migration into near-surface soils and any cap or infrastructure emissions, is considered to be lower than that of LFG migration into buildings where human health impacts are more likely.

The LFG migration pathways identified in this LFGRA have rarely been realised or encountered in the landfill industry, however, cases are known (e.g. Stevenson's Road Closed Landfill in Cranbourne, Victoria). With a BPEM compliant liner, leachate collection system and capping in place as proposed for the extension to the Melbourne Regional Landfill, the likelihood of these pathways being realised is considered to be even less.

The table below summarises the Severity and Likelihood scores and lists the Risk Score computed from them:

PROCESS	SEVERITY	LIKELIHOOD	RISK SCORE
Geology → Buildings	5	2	10
Geology → Services → Buildings	5	2	10
Geology → Soils	3	2	6
Cap and Infrastructure Emissions	3	2	6

The scores range from 6 to 10. On this basis, the risk ratings are considered low and acceptable for proposed development site evaluated.

This is primarily due to the BPEM compliant buffer zones, liner, leachate collection system, landfill gas extraction system and capping that is proposed for the landfill. The regular monitoring of perimeter landfill gas bores and surface emissions that is proposed, will also mitigate any potential risks from LFG migration from the landfill.

Considering the scenario where a commercial/ industrial site was proposed within 100 m of the site, the likelihood of each potential event occurring would be higher and unacceptable risks are likely to be identified. Additional mitigation measures would be required to address any unacceptable risks. Further assessment, incorporating LFG monitoring data from the existing Melbourne Regional Landfill, would be required to accurately assess the potential risk to human health under this scenario.

REFERENCES:

AECOM, 2016. Hydrogeological Assessment report that was prepared for Landfill Operations Pty Ltd in February 2016.

British Standard (BS 8485:2007) “Code of practice for the characterisation and remediation from ground gas in affected developments’ 2007.

EPA, 2010. Licence Assessment Guidelines- EPA Publication 1321.1, EPA Victoria.

EPA, 2011. Landfill Licensing Guidelines- EPA Publication 1323.2, EPA Victoria.

EPA, 2015. Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills. EPA Publication 788.3, August 2015. Environment Protection Authority.

Geological Survey of Victoria, “Melbourne Map Sheet”, 1: 63,360 scale, Government Printer 1974.

Golder Associates, 2016. Information to Support Works Approval Application – Proposed Melbourne Regional Landfill (MRL) Extension, Ravenhall. Prepared for Landfill Operations Pty Ltd in February 2016.

UK EPA, 2004. Guidance on the Management of Landfill Gas, UK Environment Agency Publication LFTGN 03, September 2004.

URS, 2016. Environmental Audit Report. Energy Park and Carrington Drive Closed Landfills. EPA Reference 68897-1. Prepared for City of Brimbank in February 2013.

Wilson, S., Oliver, S., Mallett, H., Hutchings, H. and Card, G, 2007. Assessing risks posed by hazardous ground gases to buildings. CIRIA C655 publication, prepared in London 2007.