LNAPL Extraction Practicability Assessment Tullamarine Closed Landfill

Prepared for:
Transpacific Cleanaway Pty Ltd

March 2015

consider it done

FINAL
LNAPL Extraction Practicability Assessment

Prepared by:
EHS Support

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS

Transpacific	Transpacific Cleanaway Pty Ltd
EHS Support	EHS Support Pty Ltd
LNAPL	Light Non-Aqueous Phase Liquid
SRA	Secondary Risk Assessment
EPA	Environmental Protection Authority
LWMP	Liquid Waste Management Plan
GQMP	Groundwater Quality Management Plan
PAN	Pollution Abatement Notice
IRP	Independent Review Panel
PCB	Polychlorinated Biphenyls
PAH	Polycyclic Aromatic Hydrocarbons
ppm	parts per million
API	American Petroleum Institute
ML	Million Litres
PCMP	Post-Closure Management Plan
TDS	Total Dissolved Solids
mg/L	milligrams per Litre
Pa	Pascal
LFG	Landfill Gas
CH_4	Methane
CO_2	Carbon Dioxide
m^2	Square metres
m/s	metres per second
m/yr	metres per year
kg	kilograms
BTEX	benzene, toluene, ethylbenzene, and xylene
m^3/min	cubic metres per minute
USEPA	United States Environmental Protection Agency
CLU-IN	Contaminated Site Clean Up Information USEPA
ITRC	Interstate Technology & Regulatory Council
Tn	LNAPL transmissivity
kWh	kilowatt-hour
GHG	greenhouse gas
SOx	Sulphur oxides
NOx	Nitrogen oxides
PM	Particulate Matter

EXECUTIVE SUMMARY

Transpacific Cleanaway Pty Ltd (Transpacific) has engaged EHS Support Pty Ltd (EHS Support) to prepare a Light Non-Aqueous Phase Liquid (LNAPL) Extraction Practicability Assessment (LEPA) for the Closed Tullamarine Landfill Site (the Site), located on Western Avenue, Tullamarine, Victoria.

The LEPA comprises an overview of LNAPL Conceptual Site Model, Remediation Technology Evaluation and Review and a Net Benefit Analysis associated with the potential implementation of further LNAPL remediation efforts at the Site.

LNAPL is generally remediated to address the following concerns:

- Combustion risks associated with vapour generated from the LNAPL;
- Direct toxic risks to human health and the environment through contact or ingestion of the LNAPL;
- Indirect toxic risks to human health and the environment through contact, ingestion and inhalation of the constituents of the LNAPL in affected waste and leachate;
- Risks of further and more problematic LNAPL contamination through its continuing movement and spread in the subsurface;
- Impairment of the beneficial use of resources, or aesthetic values whether or not associated with toxic risks;
- Societal and business factors; and
- Intergenerational equity.

LNAPL at Tullamarine Landfill was identified during an upgrade to the leachate extraction system in the mid 2000's. A comprehensive quantitative groundwater risk assessment completed in 2007 determined the risks to human health and environment from the landfill as low, however the assessment identified a number of rehabilitation tasks such as installation of a more comprehensive monitoring network, continued monitoring of the landfill and a requirement to assess the feasibility of extracting LNAPL. Since the 2007 risk assessment was completed, the monitoring network at Tullamarine has been upgraded and now consists of more than 100 groundwater, 14 leachate and 48 landfill gas monitoring locations. A detailed review of groundwater data for the period between 2007 and 2011 indicated the risks to human health and environment from the landfill remained low however an assessment of the feasibility of LNAPL extraction continued to be required. In 2011 the landfill cap was completed and landscaped and so the potential to assess LNAPL extraction feasibility was possible because the leachate extraction wells became accessible. URS designed an extraction system and this was approved by the Independent Review Panel (IRP) in mid 2013. In late 2013, the EPA issued an LNAPL Pollution Abatement Notice (PAN) and this required that an LNAPL extraction trial (or feasibility assessment) be completed and reported on by July 2015. EHS Support was engaged by Transpacific in early 2014 to complete the trial. The field work (baildown testing) was completed by mid 2014 and reported to the IRP and community in September 2014. This report identified that, on a technical basis, LNAPL extraction was not practical. Further assessment, to include other broader aspects, was considered required by the IRP and community and so EHS Support was commissioned by Transpacific to complete the LEPA.

With respect to current and historical investigations, Audits and Independent Reviews, the following assessment and Audit findings provide the framework for remediation drivers for LNAPL in Mounds 1 and 2 at the Tullamarine Site:

- Low long term risks to aquatic ecosystems and primary contact recreation use of Moonee Ponds Creek due to the limited further dissolution potential from LNAPL into groundwater as a result of the landfill cap limiting infiltration potential;
- Low mobility of the LNAPL indicates limited migration potential; and
- The presence of LNAPL necessitates on-going risk management and monitoring and a rigorous assessment of the feasibility for remediation of LNAPL.

Based on the above, particularly in the context of the low inferred mobility of the LNAPL, as reported in the 2007 Audit and consistent with the findings of the LNAPL extraction trials, the remediation drivers for LNAPL within Mounds 1 and 2 can be classified as follows:

- Regulatory drivers to recover LNAPL to the extent practicable;
- Societal and business factors; and
- Intergenerational equity.

Accordingly, the LNAPL remediation goal for the Site was defined as recovery of LNAPL to the extent practicable, noting the composition of the LNAPL and its presence within capped landfill cells (where landfill gas vapours are captured by the landfill gas recovery system and infiltration potential is limited by the landfill cap) functionally eliminates the limited potential for significant further dissolution or vapour concerns. As such, the implemented remediation approach focused on mass removal whilst noting partial mass removal will not materially change the risk profile at the Site.

LNAPL extraction trials conducted in 2014 (utilising the most prospective recovery approach based on Site conditions) demonstrated that Site conditions would not support long-term extraction, and the LNAPL is functionally immobile. Following on from the 2011 remediation technology screening, an updated review of potentially applicable technologies did not reveal any significant advances in LNAPL remediation that could be potentially applicable to the Site.

Based on the trial results, it is considered that LNAPL clean up has been completed to the extent practicable and that the regulatory remediation drivers have essentially been met from a technical perspective, noting that the risks from the LNAPL are considered to be low. However, it is considered that community concerns associated with societal and business factors and intergenerational equity still provide a potential remediation driver. As a means to address community concerns, an assessment was undertaken of the natural mass losses relative to hydraulic recovery and the net benefits (using sustainability principles) of active remedial actions.

Conservative estimates indicate hydraulic recovery would require between 350 and 1,400 years of implementation to extract the estimated recoverable portion of the LNAPL, noting that in reality, the required timeframes would be significantly longer and substantial volumes of LNAPL (recoverable and residual) would remain trapped in the waste due to constraints identified during the extraction trials. In addition, an assessment of natural mass depletion processes was conducted, which indicated that significant LNAPL mass loss relative to the hypothetical conservative continued hydraulic recovery scenario would occur via volatilisation, biodegradation and dissolution. Further, studies undertaken by Kleinfelder indicate the dissolved phase constituents are undergoing natural attenuation and will not pose a risk to down-gradient receptors.

In combination with the limited risk and natural mass losses, active remediation activities can also result in additional impacts to the environment and community, which include odours, greenhouse gas emissions, health and safety, noise and impacts on traffic and traffic safety. A net benefit analysis was conducted and concluded that the benefit to human health of implementing remediation is outweighed by the potential risks to human health and impacts to the environment associated with such remediation implementation. When this balance is placed in context with the absence of drivers for remediation (e.g., risk to human health from the impacts beneath the landfill cap, restoration of a groundwater resource), and consideration of long term societal and business factors and intergenerational equity, the greatest benefit is to not implement remediation.

In conclusion, the LEPA indicates the Tullamarine Landfill LNAPL clean up has been completed to the extent practicable, natural mass losses will continue to occur at appreciable rates and there is no net benefit in terms of implementing further remedial efforts. In the absence of active remediation measures (aside from continued operation of the landfill gas recovery system and maintenance of the landfill cap), the Sites Post Closure Management Plan and in particular the Groundwater Quality Management Plan will serve as the key mechanisms for the assessment of ongoing risks and potential implementation of contingency measures to manage potential risks to health and the environment in the future.

1.0 BACKGROUND

1.1 Introduction

Transpacific Cleanaway Pty Ltd (Transpacific) engaged EHS Support Pty Ltd (EHS Support) to prepare a Light Non-Aqueous Phase Liquid (LNAPL) Extraction Practicability Assessment (LEPA) for the Closed Tullamarine Landfill Site (the Site), located on Western Avenue, Tullamarine, Victoria.

The LEPA comprises an overview of LNAPL Conceptual Site Model, Remediation Technology Evaluation and Review and a Net Benefit Analysis associated with the potential implementation of further remediation efforts at the Site.

The objective of the LEPA was to assess the practicability of further LNAPL extraction within Mound 1 and Mound 2 as recommended in Independent Review Panel – Review of Stage 1 LNAPL Extraction Trial Baildown Testing Letter (Cardno Lane Piper, September 2014).

The LEPA drew from historical investigations and in particular the LNAPL Extraction trials conducted in 2014. In addition, natural mass loss concepts were explored to broadly evaluate likely LNAPL depletion rates as a comparison to hydraulic extraction recovery. Further, net benefit analysis was undertaken to evaluate the potential benefits of remediation in the context of the site's risk profile to provide a holistic approach for the practicability assessments and provide context for non-regulatory and non-technical LNAPL recovery drivers for remediation.

It is noted that the LEPA assesses LNAPL extraction practicability only, with other regulatory mechanisms in place to address Post Closure Management of the Site as a whole.

The approaches utilised throughout the assessment drew from international practices (ITRC, 2009a, b) and Australian standards (CRC CARE, 2010, 2015) regarding LNAPL recoverability as well as appropriate sustainability references and approaches such as SuRF Australia (Nadebaum, 2011) regarding the framework for Assessing the Sustainability of Soil and Groundwater Remediation.

1.2 Regulatory Context and LNAPL Extraction Practicability Assessment Report Objectives

An Environmental Audit (s53V) in relation to risks to and from groundwater of the Tullamarine Closed Landfill was completed in December 2007 (LanePiper, 2007). The 2007 Audit made a number of recommendations for the future management of a range of environmental issues in relation to the Secondary Risk Assessment (SRA) (Golders, 2007a) including the management of LNAPL located within the landfill cells, which forms the focus of this LNAPL Extraction Practicability Assessment.

In 2009, the Environmental Protection Authority (EPA) issued a Pollution Abatement Notice (PAN) for the aftercare management of the Site which, amongst other directives, included the requirement to implement Liquid Waste Management Plan (LWMP) and Groundwater Quality Management Plans (GQMP), noting that these documents were first developed in 2004 and are regularly revised. Transpacific engaged Mr Anthony Lane, an EPA-appointed Environmental Auditor as part of the auditor review under requirement 11 of the PAN in relation to LWMP and GQMP.

In relation to LNAPL within the landfill cells, the LWMP states the following:

- Objective 2: Reduce to the extent practical, the ability of the LNAPL to move out of the landfill cells by reducing its recoverable and/or potentially mobile volume through the identification and implementation of practical extraction technology/system.
- Objective 3: Target areas where LNAPL is most likely recoverable whilst appropriately managing leachate levels.
- Objective 8: Third party review of the LWMP and its implementation to provide assurance that the LWMP is being implemented in accordance with these objectives and that there is no adverse change in the risk to people and the environment posed by the liquids within the landfill cells.

Based on these objectives, the LWMP defined the following actions:

- Action 5: Identify Suitable LNAPL Extraction Method. Identify and Trial a suitable LNAPL extraction technology/system.
- Action 5.1: Transpacific will design, construct and trial a suitable LNAPL extraction technology/system to remove recoverable LNAPL from landfill cells Mounds 1 and 2.
- Action 5.2: Transpacific will conduct a field trial of LNAPL extraction methods on select wells.

LNAPL extraction technologies and approaches were screened against the LWMP objectives with several options identified for potential application at the Site by URS (URS, 2011). An extraction trial program was developed to further assess the applicability of the identified options under Site conditions. The developed program specifically aimed to:

- Assess the effectiveness of selected extraction technologies for the removal of LNAPL from within the landfill waste materials; and
- Evaluate the feasibility and design parameters for full-scale implementation.

A trial extraction system was designed by URS in 2012 and reviewed and approved by the IRP in 2013. The EPA issued an LNAPL PAN 90003661 dated December 2013, which provided the regulatory framework for trial. The system was fabricated during 2014 at which time; the logistics around the waste management were also finalised, including regulatory consents for transport of the LNAPL and destruction of the LNAPL at an incinerator.

The system was procured and fabricated during early 2014, and bail down testing commenced 15 May 2014, and ceased 16 July 2014.

The main objective of the trial was to determine the feasibility of extracting the LNAPL utilizing the identified (potentially suitable and most prospective) extraction methodologies. The Trial outcomes, presented in the EHS Support LNAPL Baildown Testing Report (EHS Support, 2014), concluded that no wells qualified for extended LNAPL extraction given the low derived LNAPL Transmissivity (Tn) values, inability to sustain pumping rates , general inability to draw LNAPL from the waste and very slow LNAPL level recovery. These data and observations showed an inability to support long term extraction and that the LNAPL is effectively immobile within the waste.

These findings were supprted by the independent review panel (Cardno Lane Piper, 2014) which concluded the following:

> *"In the IRP's view, the Stage 1 LNAPL Extraction Trial (Baildown Tests) has been appropriately dessigned, implemented, analysed and reported in accordance with*

current industry standards of practice; it also meets the objectives of the PAN and LWMP and has satisfied the objectives of the IRP. The IRP is of the view that the tested LNAPL extraction method (which is the most prospective method) is not feasible. In order to finally determine the practicability of any further extraction, an LEPA Report should be prepared for submission to EPA, with prior review by the IRP."

In relation to the IRP conclusions and recommendations, the objective of this LEPA is to assess the practicability of further LNAPL extraction within Mound 1 and Mound 2 of the Site using the data collected in the above studies whilst noting that other regulatory mechanisms are in place to address Post Closure Management of the Site as a whole.

1.3 LNAPL Concerns and Remediation Drivers

The objectives for remediating LNAPL vary with the particular setting and circumstances. As presented in CRC Care Technical Report 18 (CRC Care, 2010), the following concerns are associated with the presence of LNAPL:

- Direct explosive risk from the LNAPL;
- Direct toxic risks to human health and the environment through contact or ingestion of the LNAPL;
- Indirect toxic risks to human health and the environment through contact, ingestion and inhalation of the constituents of the LNAPL in affected soil water, groundwater, soil air and other receptors;
- Risks of further and more problematic LNAPL contamination through its continuing movement and spread in the subsurface;
- Impairment of the beneficial use of resources, or aesthetic values whether or not associated with toxic risks;
- Societal and business factors; and
- Intergenerational equity.

Associated with these potential concerns are LNAPL remediation drivers. In broad terms, LNAPL composition drivers are associated with explosive risks, direct contact, ingestion and inhalation risks, dissolved and vapour phase concentrations whilst LNAPL saturation or mass drivers are associated with aesthetic of migration potential risks. These two drivers warrant different remediation strategies which can be divided as follows:

- Strategies that target mass reduction; and
- Strategies that target composition and reductions in concentrations.

From a regulatory point of view, LNAPL recovery to the extent practicable is typically specified and forms the regulatory driver for LNAPL remediation. In the Victorian context, the State Environment Protection Policy, Groundwaters of Victoria, (SEPP GoV) requires that *'Where non-aqueous phase liquid is present in an aquifer, it must be removed unless the Authority (EPA Victoria) is satisfied that there is no unacceptable risk posed to any beneficial use by the non-aqueous phase liquid.'* It is noted however, that the SEPP (GoV), is not directly applicable to the landfill cells where the LNAPL resides, but requires consideration as a potential source of impact to groundwater outside the landfill cells.

The goal of clean up of polluted groundwater is to restore the protection of beneficial uses and where clean up is not practicable, alternate clean up objectives should be derived that reflect clean up to the extent practicable. However, where it considered impracticable to clean up groundwater to restore beneficial uses, there is provision for a consultation process with the Authority.

The determination by the Authority regarding the practicablility of clean up of contaminated groundwater takes into consideration, technical, logistical and financial considerations as outlined in EPA Publication 840.1 *The Clean Up and Management of Polluted Groundwater* (EPA, 2014). Ultimately, the cleanup measures adopted should be "cost-effective and commensurate with the significance of the environmental issues being addressed (including but not limited to consideration of the likelihood of beneficial uses being realised)" (EPA, 2014) which is consistent with the assessment of net benefit.

The Environmental Protection Act, 1970 (the "Act") acknowledges the importance of assessing net benefit, which broadly addresses societal, and business factors as well as intergenerational equity, with the inclusion of the Principle of integration of economic, social and environmental considerations. The Principle includes the following statements:

- Sound environmental practices and procedures should be adopted as a basis for ecologically sustainable development for the benefit of all human beings and the environment.
- This requires the effective integration of economic, social and environmental considerations in decision making processes with the need to improve community well-being and the benefit of future generations.
- The measures adopted should be cost-effective and in proportion to the significance of the environmental problems being addressed.

Sustainability can be considered a driver for remediation in that whether to remediate or not; and if remediation occurs, the nature of remediation, is influenced by the economic, environmental and social elements associated with the remediation activity.

2.0 SITE DESCRIPTION

2.1 Site Description

The Tullamarine Closed Landfill Site is located at Western Avenue in Tullamarine, Victoria, 3043 (**Figure 1**). The landfill began operation in 1972 and ceased waste management operations in 2008. During the operational period, the Site was used for disposal of a wide variety of waste types including solid and liquid scheduled wastes.

A detailed history of the development of the Site can be found in the *Hydrogeological Conceptual Model Version 3* (Golder 2007a); however, a summary of the history is provided below:

- The landfill was established in a former quarry.
- Placement of waste (solid and liquid) began in 1972 at the eastern section of the main quarry hole (Mound 1) and continued westerly (Mound 2).
- During the late 1970s and early 1980s, clay was excavated from north of the quarry, (later becoming Mound 3) to construct a side liner for the upper parts of the landfill.
- Liquid waste disposal at the landfill ceased in 1987.
- An oil recovery plant was built on the south east corner of what is currently Mound 3, accepting oil and oily-water.
- Further excavation and subsequent filling of the Mound 3 area was completed in the 1990s.
- Since the early 2000s, extensive upgrades to the landfill cap have been conducted.
- As part of leachate management onsite, LNAPL that was removed (via total fluids pumps) was re-injected into the landfill via Well 15.
- Mound 3 capping was completed in 2006.
- Waste disposal at the landfill ceased in 2008.
- Final stages of capping of the Mounds 1 and 2 area of the landfill were completed in 2011.

During a leachate characterisation program undertaken in early 2002, the presence of LNAPL in the Tullamarine Landfill was identified. Analysis of samples indicated the LNAPL is predominantly a petroleum hydrocarbon based mixture, with a wide range of organic compounds detected in the samples. The bulk of the mixture is formed of largely aliphatic and aromatic petroleum hydrocarbon oils; however the oils are contaminated with relatively low (but in some cases significant) concentrations of known contaminants such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and phthalates. The LNAPL is less dense than water and therefore, can float on the underlying aqueous leachate layer within the landfill. The PCB concentrations in the LNAPL are generally above the regulatory threshold of 50 parts per million (ppm) for a scheduled waste; thus, the LNAPL requires a higher level of management as per the applicable Australian Waste Regulations.

It has previously been estimated, utilising an American Petroleum Institute (API) modelling program and assumptions of various formation properties, that there may be 20 to 40 million litres (ML) of LNAPL present within the landfill mass, concentrated around the surface of the aqueous phase leachate, as reported in *Report for Tullamarine Landfill – Revised LNAPL Characterisation* (GHD, 2007). A review of the derived volume estimates was conducted in 2011 with the results presented to EPA at the meeting of 6 September 2011. The review utilised the Conceptual Site Model developed by GHD (2007) as a basis for refining LNAPL volumes.

The fundamental method of estimation remained the same; however, it incorporated additional temporal data and refinement of the understanding of the contamination status at the Site.

The potentially recoverable volumes calculated by URS (2011), were estimated between 2 and 12 ML, with a likely range of 4 to 7 ML and a total volume estimate (potentially recoverable and unrecoverable) between 4.5 to 18 ML, with a likely range of 7.5 to 12 ML. While this indicated a significant reduction in potentially recoverable volumes, the calculations confirmed the need to continue to evaluate the feasibility of LNAPL extraction with field trials in accordance with the Post Closure Management Plan (PCMP) (Transpacific, 2012).

2.2 Historical Assessments and Audit Findings

A brief overview of previous assessments and Audit findings in relation to LNAPL are presented below to provide context for this LEPA.

Golders conducted an SRA (2007b) in 2007 to assess the short and long-term risks of leachate and LNAPL impacted groundwater to human health and the environment, with findings summarised below.

The Tullamarine Landfill is a source of contamination due to its operation as a licensed prescribed industrial waste landfill between 1972 and 2008. Sources of groundwater contamination are from the disposal of both liquid and solid waste between 1972 and 1987 and from disposal of solid industrial (prescribed) wastes only between 1987 and 2008.

Groundwater contamination from the landfill has been observed particularly through elevated levels of salinity (total dissolved solids, TDS), with saline groundwater from the landfill evident in down gradient directions (towards the north and south from the landfill cells). Elevated concentrations of inorganic and organic contaminants were found in groundwater down gradient of the landfill, particularly of nitrogen compounds (i.e., ammonia and nitrate) and heavy metals (particularly barium, boron, cobalt, chromium (total), copper, iron, manganese (total), nickel and zinc). A much lower occurrence of elevated (above water quality criteria) of some organic compounds (e.g., PAHs, phthalates, phenols, chlorinated solvents etc.) is evident towards the south east of the landfill.

The following source facilities and media were identified as potential long term sources of continuing impact on groundwater:

- Leachate within the landfill cell.
- Separate Phase Liquid (LNAPL) within and outside the landfill cell.
- Leachate and/or LNAPL contaminated dissolved phase groundwater plumes outside the landfill cell.
- Contaminated groundwater plumes associated with the former Site facilities (i.e., historic leachate evaporation ponds, liquid waste treatment plant and oil recovery plant).

Selective excerpts from extensive conclusions and recommendations in the 2007 Audit (Lane Piper, 2007) of the SRA, consistent with the findings of the 2011 *Environmental Auditor Review of Groundwater Quality Management Plan Implementation & Liquid Waste Management Plan* (Cardno Lane Piper, 2012), with respect to LNAPL are provided below:

Long Term Groundwater Risks

(Lane Piper, 2007, Executive Summary page v): *"Based on the available data and supported by numerical modelling undertaken by the Assessor, the Auditor considers that the installation of a "best practice" landfill cap is likely to significantly reduce the long term flux of dissolved contaminants moving off-Site in groundwater from the premises. The Auditor also notes that the apparently low mobility of the LNAPL suggests that the risk of off-Site movement of LNAPL is low.*

Nevertheless, the Auditor is of the opinion that the presence of LNAPL necessitated on-going risk management and monitoring, and a rigorous assessment of the feasibility for remediation of LNAPL is required. The Auditor notes that remediation of LNAPL is not likely to be fully effective due to the proportion of oil likely to be retained by the solid material in the landfill."

Risk to the Surface Water Environment

(Lane Piper, 2007, Executive Summary page vi): *"The long term risk to the aquatic ecosystem and primary contact recreation use of Moonee Ponds Creek was evaluated by reference to the chemistry of the leachate and groundwater in conjunction with models of groundwater and laboratory testing of LNAPL dissolution into groundwater. This modelling indicates that the long term risk to the aquatic ecosystem and primary contact recreational users of Moonee Ponds Creek is low and not likely to get worse, assuming the aftercare management program, including capping goes to plan. However, the presence of a large volume of LNAPL within the landfill …is an on-going source of contamination of groundwater and must be monitored and managed long-term."*

(Lane Piper, 2007, page 116): *"It should be noted that it would not be possible to remove all of the LNAPL, as significant proportion of the LNAPL will be retained by the waste in the landfill. This will act as an ongoing long term source for dissolved phase contamination in leachate and groundwater, and the risk profile for groundwater would therefore not change significantly in the foreseeable future, even with an aggressive NAPL removal program."*

3.0 LNAPL CONCEPTUAL SITE MODEL

As described earlier, there can be numerous drivers for remediation of LNAPL impacts; however, the rationale and drivers for remediation are driven by Site specific conditions. For this Site, as is evidenced by the Golder Associates (2007a and 2011) technical assessments of groundwater (and verified by the Auditor), the risks to environment and human health are low and as such there are no apparent significant risks associated with the long term management of LNAPL within the landfill.

The properties of the LNAPL define the potential hazards and risks but are also critical to evaluate the potential benefits of further LNAPL extraction in terms of mitigating potential risks and reductions in plume longevity and ultimately restoration of groundwater quality relative to the natural mass losses occurring in the system.

This section provides an overview of key LNAPL Conceptual Site Model Concepts and Assessments with reference to the EHS Support LNAPL Baildown Testing Report (EHS Support, 2014), which details findings from previous assessments.

3.1 LNAPL Source Longevity

LNAPL source longevity for a specific LNAPL constituent is the time over which the constituent will potentially exist in the environment at concentrations of concern.

The longevity of a constituent in groundwater depends on the source zone geometry, the LNAPL saturation within that zone, the mass of constituents within the LNAPL and the partitioning rate from LNAPL into groundwater (a function of its effective solubility). The concentration in groundwater is a function of the composition of the LNAPL (and its effective solubility) and vertical and lateral mixing of groundwater.

Key to understanding LNAPL source longevity is partitioning from LNAPL into vapour and dissolved phases. It is within these secondary phases that mass depletion and potential degradation occurs. With respect to LNAPL and groundwater, the dissolved concentration of an LNAPL constituent in groundwater is the product of its concentration in the LNAPL and the aqueous solubility of the pure LNAPL constituent (Raoult's Law) independent of LNAPL saturation in the pore space. Similarly the effective vapour pressure of a LNAPL source (and therefore its potential mass losses to vapour) can be defined by Raoult's Law.

To further elaborate on LNAPL partitioning, an example, as presented in *ITRC - Evaluating Remedial Technologies for Achieving Project Goals* (ITRC, 2009a), is provided below.

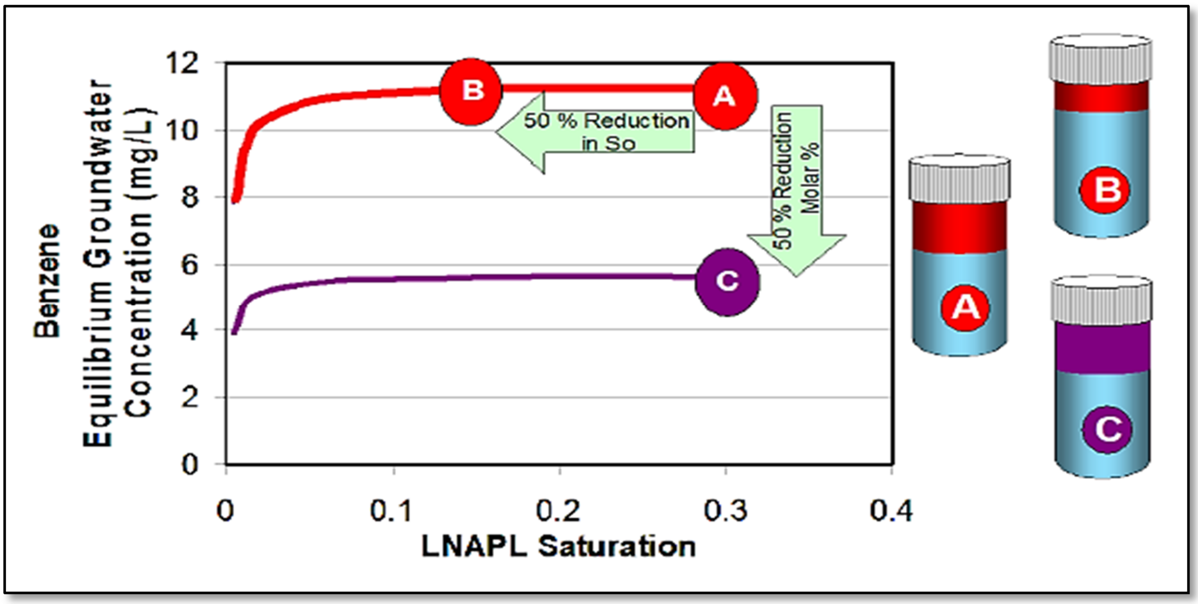


Figure 3-1 Comparison of LNAPL Mass or Saturation (So) Reduction (A to B) and LNAPL Composition Reduction in Constituent Concentration in LNAPL (A to C) on Dissolved Benzene Concentrations in Groundwater (ITRC, 2009a).

If benzene is present in LNAPL at 0.5% by weight (0.62 mole %), its effective solubility (equilibrium groundwater concentration) is approximately 11 milligrams per litre (mg/L) (Scenario A, **Figure 3-1**). If the benzene concentration in the LNAPL were halved to 0.25% even without measurable reduction in LNAPL saturation, the corresponding effective solubility would also be halved to about 5.5 mg/L (Scenario C, **Figure 3-1**).

Alternatively, if the LNAPL saturation were halved with no change in LNAPL composition (e.g., by hydraulic recovery), the dissolved benzene concentration in groundwater would be virtually identical essentially resulting in an unchanged risk profile from the LNAPL. In this case, however, the longevity of groundwater impacts (Scenario B, **Figure 3-1**) would reduce somewhat, as the total mass of benzene would be halved also. Similar relationships exist for other constituents in different pairs of phases, for example, LNAPL and soil gas (vapour pressure and mole fraction), groundwater and soil gas (Henry's Law).

In summary, the composition of LNAPL and not its mass (or saturation level) is the primary control for concentrations and associated potential risks in adjacent phases (groundwater and gas).

Expanding further on the example provided in ITRC (2009a), **Figure 3-2** below conceptually illustrates the effect of partial LNAPL mass removal on the LNAPL constituent concentrations in a monitoring well positioned downgradient of the source area screened completely across the initial thickness of LNAPL impacts. Various cases are presented for conceptual purposes with several assumptions (e.g., plug flow through the source, equilibrium dissolution, no contribution from the unsaturated zone and no biodegradation or other losses). In reality, these conditions are rarely met, but the concepts conveyed regarding the relative significance of LNAPL composition and saturation are considered applicable for contextualisation.

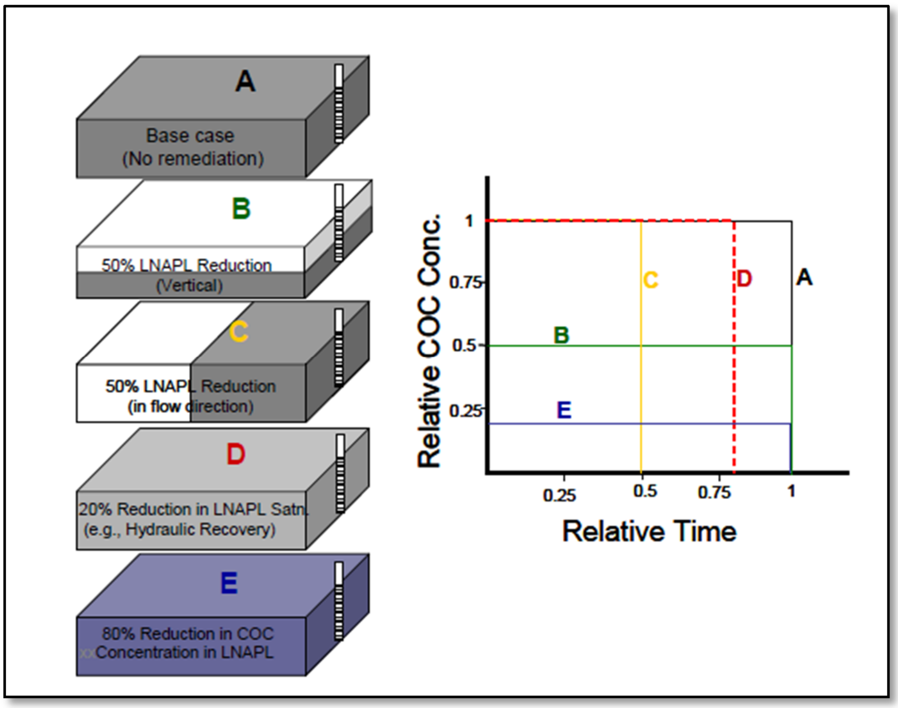


Figure 3-2 Conceptual Effect of Partial Mass Recovery on LNAPL Constituent Plume Concentrations and Longevity in a Monitoring Well Positioned Downgradient from the LNAPL Source.

*Groundwater flow direction is from left to right (ITRC, 2009a).

Case A: In this base case, where no active remediation is performed, the constituent dissolves into the groundwater until it is completely dissipated from the LNAPL. The groundwater constituent concentration and time to total depletion of the constituent in the other cases are normalised to those for Case A. For example, a relative time of 0.5 indicates the constituent will completely dissolve away in one-half the time when compared to the base case. Similarly, a relative concentration of 0.5 indicates the groundwater constituent concentrations in the monitoring well will be one-half of that in the base case.

Case B: In this case, the LNAPL source has been partially cleaned up vertically (e.g., partial excavation or partial hydraulic recovery through a uniformly impacted LNAPL source). Since the well is screened across the entire thickness of the original LNAPL impacts, the constituent concentration in the monitoring well is reduced by one-half due to dilution. However, since the LNAPL source length is not changed, there is no reduction in the longevity of the groundwater impacts nor the risk profile.

Case C: In this case, the LNAPL source has been partially removed in the direction of groundwater flow (e.g., the upgradient one-half of the LNAPL source has been excavated or hydraulically recovered, but the other one-half remains due to lack of access for excavation or inability to extract due to LNAPL immobility). The groundwater constituent concentrations in the monitoring wells are unchanged, but their longevity is reduced by one-half since twice as many source pore volumes are flushed from the source in the same amount of time, resulting in the constituent washing out earlier.

Case D: The theoretical end point of hydraulic recovery is residual saturation. Case D represents a scenario where 20% of the LNAPL is removed (reduced LNAPL saturation) via hydraulic recovery, resulting in a corresponding 20% reduction in time (or pore volumes) for complete dissolution of the constituent.

Case E: In this case, the constituent is preferentially removed from the LNAPL (e.g., via constituent stripping). For simplicity, it is assumed that there is no effect on the other LNAPL constituents and that the change in LNAPL saturation is negligible. Drawing from the earlier discussion on partitioning, there is a proportional decrease in groundwater constituent concentration. However, there is no change in the LNAPL source length or the LNAPL saturation; hence, the time required for complete dissolution of the constituent is unchanged.

In summary, unless all constituents within the LNAPL that are driving risk are removed, the risk profile associated with constituents of concern essentially remains unchanged, although the longevity of the LNAPL may be reduced somewhat.

3.2 Assessment of Source Zone Depletion Potential

A range of mechanisms contribute to the natural depletion of mass from LNAPL. These process can include dissolution of constituents in groundwater, volatilisation of LNAPL constituents in the unsaturated zone and biodegradation of hydrocarbon mass both in the saturated and unsaturated zones. The magnitude of these mass losses can be significant and in many cases natural mass losses can exceed the mass that can be removed via engineering means (active recovery). However, the magnitude of these losses can depend on LNAPL composition and site-specific attributes including the chemical properties of the LNAPL, Site hydrogeology, groundwater geochemistry and the robustness of bacterial processes that facilitate biodegradation.

3.2.1 Source Zone Depletion in the Unsaturated Zone

LNAPL mass in the unsaturated zone (or the waste mass above liquid levels) can be depleted due to volatilisation of hydrocarbon constituents (**Figure 3-3**), following which, vapours can migrate through the unsaturated zone by diffusive (movement of vapours from areas of higher concentrations to areas of lower concentration) and advective processes (movement of vapours driven by pressure gradients).

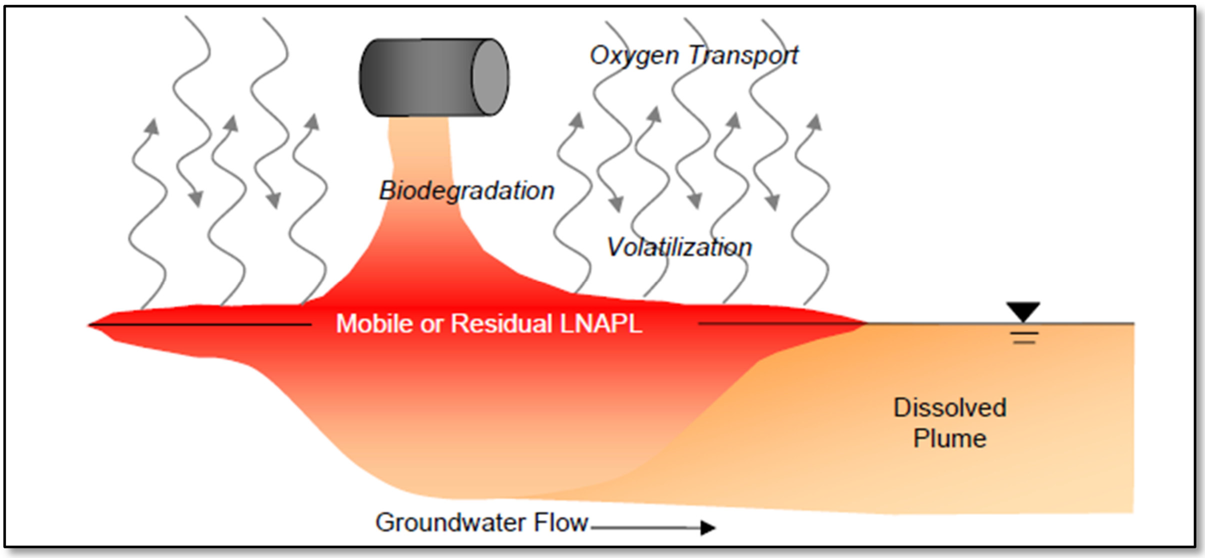


Figure 3-3 Vapour Transport Related Source Zone Depletion Processes in the Unsaturated Zone (ITRC, 2009b).

3.2.1.1 Volatilisation

When LNAPL is in contact with atmosphere gas phase, the constituents within the LNAPL volatilise according to their properties and physical conditions. As vapours migrate away from the LNAPL due to the mass transfer mechanisms described below (diffusion and advection), the system is no longer in equilibrium. To restore equilibrium between the LNAPL and its immediate vapour space, the constituents within the LNAPL volatilise, resulting in mass loss from the LNAPL plume.

The first step whereby volatilisation occurs is relatively rapid; however, the second step of mass transfer can be significantly slower. However, because landfill gas is continually being removed from the waste at the Site, the second step will be more rapid.

The concentration of vapour directly above the LNAPL is estimated using Raoult's Law:

$$C_{Veff} = \frac{P_{Vm} x_i}{P} \times 1{,}000{,}000$$

Where:

- C_{Veff} = effective vapour concentration of component m (ppm_v);
- P_{Vm} = pure vapour pressure of component m (Pascal, Pa);
- x_i = component mole fraction; and
- P = atmospheric pressure (Pa); and
- $1x10^6$ = factor to determine the number of parts in 1 million parts.

Because the rate of removal of each LNAPL constituent by this pathway depends on the constituent vapour pressure (P_{Vm}), gas-phase losses of LNAPL will deplete the LNAPL in its more volatile constituents over time.

3.2.1.2 Biodegradation

Within the landfill, organic matter, including LNAPL, is degraded in a series of steps by microorganisms to produce Landfill Gas (LFG) – a mixture composed primarily of methane (CH_4) and carbon dioxide (CO_2).

The typical composition of LFG from the degradation of putrescible waste is 60% CH_4 and 40% CO_2. In landfills with relatively high infiltration, the typical composition of LFG can be altered such that CH_4 is in the order of 80%. This phenomenon can be explained by the differences in the water solubilities of CH_4 and CO_2. CO_2 has a significantly higher degree of solubility and as such, when the LFG comes in contact with water, the CO_2 is preferentially stripped, resulting in a concentrating effect on the CH_4 within the LFG. This process is typically called water-washing. It is noted that the Tullamarine landfill is not a putrescible waste landfill, however the general concepts discussed are considered relevant, with site specific data utilised in the empirical assessment of mass depletion presented in **Section 3.2.3**.

Whilst biodegradation of dissolved phase hydrocarbon constituents is well documented, the study of degradation of LNAPL is still in its infancy, particularly in relation to LNAPL composition similar to that encountered within Mounds 1 and 2 at the Site. Literature (ITRC, 2009b) documents laboratory and field studies that verified biodegradation of LNAPL under certain circumstances particularly bioactivity occurring at the LNAPL – water interface rather than the LNAPL source centre.

Within the landfill, organic matter (including LNAPL) is typically decomposed in a series of steps to produce biogas– a mixture composed primarily of CH_4 and carbon dioxide CO_2. This occurs primarily through two processes: (a) acetoclastic methanogenesis, where acetate decomposes into CH_4 and CO_2, and (b) CO_2 reduction, where CO_2 and H_2 from decomposition of longer-chain organic acids (mainly propionic [C_3] and butyric [C_4]) combine to form CH_4. Example equations are presented in **Table 3-1** below noting that other common processes like sulphate, manganese and iron reduction may also be occurring.

Table 3-1 Chemical Reaction Sequence

Step	Chemical Reaction	Microbe Class
	Acetoclastic Methanogenesis	
1	$C_6H_{14} + 6H_2O \rightarrow 3C_2H_3O_2 + 8.5H_2$	Acetogens / Syntrophs
2	$C_2H_3O_2 + 0.5H_2 \rightarrow CO_2 + CH_4$	Acetoclastic Methanogens
	CO_2 Reduction	
1 (*e.g.*)	$C_4H_7O_2 + 2H_2O \rightarrow 2CO_2 + 4H_2 + C_2H_3O_2$	
2	$4H_2 + CO_2 \rightarrow CO_2 + 2H_2O$	CO_2 Reducers

Note: regardless of the biological process occurring (methanogenesis of acetate to methane or via the formation of additional H_2 and CO_2), the overall chemical formula is the same. Typically, for every molecule of hexane degraded, 4.75 molecules of CH_4 and 1.25 molecules of CO_2 are generated (i.e., CH_4 to CO_2 ratio of close to 3:1). Provided this process occurs at sufficient rates, it may alter the composition of the LFG within the cells. In comparison, putrescible waste degradation typically results in LFG formation with a CH_4 to CO_2 ratio of 3:2.

The microbes involved in methane production rely, like most organisms, on the presence of various nutrients and other chemical species at suitable and appropriate concentrations, if they are to function efficiently and effectively. It is also important that materials that might be toxic to them are absent or at least relatively inaccessible. The concentrations of trace constituents in the LFG are influenced by the composition of the source they originate from, spatial variability in those sources, the surface areas in contact with LFG, biochemical transformations that may change them into different compounds, and potentially other factors, resulting in spatially and potentially temporally variable concentrations. LFG production is, therefore, a combination of many complex factors that can vary through the body of waste that influence the rate of biogas production and the composition of the LFG generated. However, the composition of biogas, based on site specific data, is relatively consistent at 50 - 60% methane and 40 -50% carbon dioxide, with variable concentrations of minor constituents of LFG including constituents observed in the LNAPL.

3.2.2 Source Zone Depletion in the Saturated Zone

Source zone depletion mechanisms that occur in the saturated zone include dissolution and biodegradation, as discussed in **Section 3.2.1.2**, mass depletion mechanisms, as illustrated in **Figure 3-4** below.

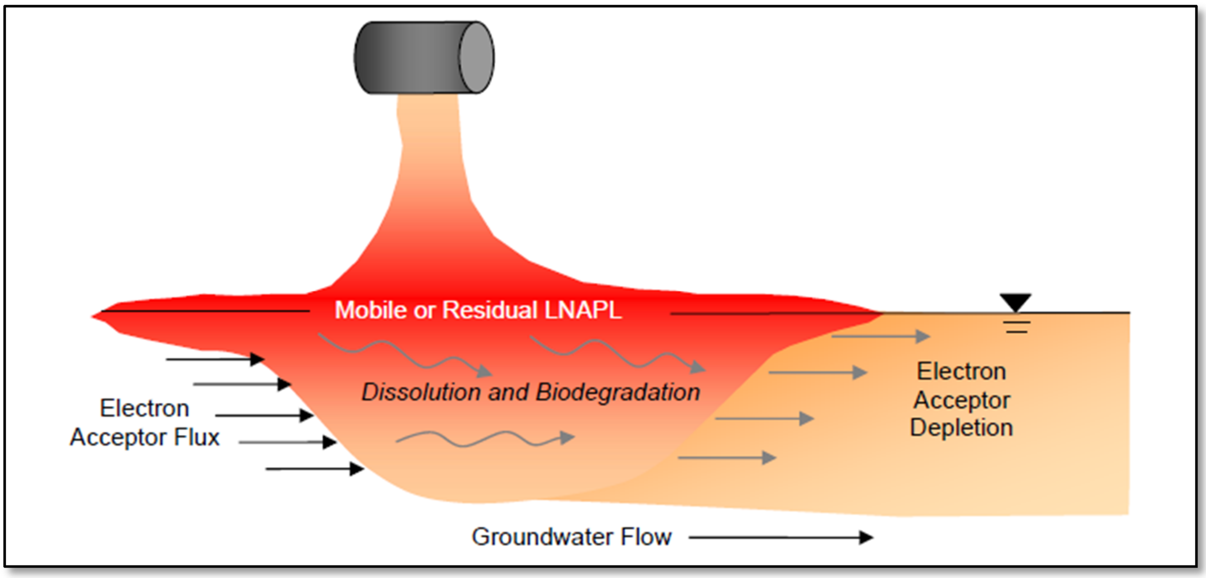


Figure 3-4 Source Zone Depletion Processes in the Saturated Zone (ITRC, 2009b)

3.2.2.1 Dissolution

The rate of depletion is controlled by the solubility of the constituents, availability of electron receptors and the nature of groundwater flow. It is noted that whilst LNAPL mass recovery (e.g., extraction) can result in reducing LNAPL to residual saturation, dissolution continues according to its effective solubility (representing the maximum equilibrium concentration from LNAPL in groundwater). In addition, as the LNAPL weathers, its effective solubility decreases. As dissolution occurs, natural degradation processes serve to reduce dissolved-phase plume mass.

Similar to the vapour phase, the components within the LNAPL must be in continual equilibrium with the groundwater in its immediate contact. As this impacted groundwater migrates away from the LNAPL and is replaced by "fresh" water, or the dissolved phase constituents transport away from the LNAPL, the system will no longer be in equilibrium. To restore equilibrium between the LNAPL and groundwater, the components within the LNAPL continue to dissolve, resulting in mass loss from the LNAPL plume. The mass dissolved is governed by the solubility of each component and its concentration within the LNAPL.

The concentration of dissolved phase in the groundwater in immediate contact with the LNAPL is again estimated using a modified Raoult's Law:

$$C_w = CS$$

Where:

- Cw = effective solubility of component (mg/L);
- C = mole fraction of component present in the LNAPL; and
- S = pure component chemical solubility in water (mg/L).

Because the rate of removal of each LNAPL constituent by this pathway is proportional to the solubility of the constituent, this process will have the effect of depleting the LNAPL of its more soluble constituents over time. As shown in external **Table 1**, the more soluble and volatile constituents of the LNAPL of appreciable concentrations are generally the aromatic compounds (benzene, toluene, ethylbenzene, xylenes, and naphthalene). These compounds have the highest potential impact on human health of the LNAPL constituents and provide conservative estimates of dissolution and volatilisation.

3.2.3 Empirical Assessment of Mass Depletion

An empirical assessment of mass depletion processes inferred to be occurring at the Tullamarine Site was undertaken to assess the likely rate of LNAPL mass loss assuming no hydraulic LNAPL recovery was being implemented.

To estimate the theoretical mass flux from LNAPL to the dissolved phase (leachate), effective solubilities and subsequently the maximum potential dissolved phase concentration values were calculated based on all LNAPL data collected during the trials (Refer to **Appendix A** for laboratory reports of LNAPL samples collected during the trials). Data from minimum, maximum and average results was utilised with calculations performed for C_6 – C_9 and C_{10} – C_{14}, Benzene, Toluene, Ethylbenzene, Xylenes (BTEX) and Naphthalene, noting that the carbon chains greater than C_{14} are unlikely to significantly contribute to dissolution given their low solubilities. To assist in the calculation octane and dodecane were used as a surrogates for C_6 – C_9 and C_{10} –C_{14} providing representative pure phase water solubility values. **Table 1** attached, presents the data utilised, with effective solubility (maximum potential dissolved phase concentration) values for various constituents presented in **Table 3-2** below.

Table 3-2 Effective Solubility Values

Effective Solubility				
		Minimum	Maximum	Average
benzene	mg/L	0.073	1.70	0.39
toluene	mg/L	0.002	0.37	0.11
ethylbenzene	mg/L	0.163	0.66	0.44
m&p xylene	mg/L	0.070	1.57	0.57
o xylene	mg/L	0.011	0.30	0.14
xylene total	mg/L	0.082	1.86	0.71
naphthalene	mg/L	0.004	0.28	0.05
octane	mg/L	0.0003	0.0017	0.0011
dodecane	mg/L	0.0012	0.0014	0.0012

To estimate the approximate magnitude of the maximum flux to the dissolved phase from the LNAPL at the Site, the following assumptions were used:

- The LNAPL mass at the Site is approximately 60,000 square metres (m^2) in area (URS, August 2011);
- The upper 1m of leachate/groundwater is conservatively assumed to be in contact with the LNAPL body above;
- The width of the potential LNAPL source zone is between 200 and 500 m perpendicular to groundwater flow;
- Assumed hydraulic gradient of between 0.005 and 0.05 (approximately based on groundwater contour ranges presented in the Kleinfelder Hydrogeological Assessment (Kleinfelder, 2014);
- Assumed hydraulic conductivity range for waste material of 2.7×10^{-7} to 1.1×10^{-5} metres per second (m/s) (URS, August 2011);
- Assumed effective porosity of waste material of between 25 and 50% (URS, August 2011); and
- Resulting average horizontal seepage velocity of between 0.1 and 70 metres per year (m/yr) and specific discharge of between 0.043 and 17.3 m/yr.

Based on the above assumptions, the following estimates were derived:

Table 3-3 Estimated Magnitude of Flux

			Min Effective Solubility		Max Effective Solubility		Average Effective Solubility	
Length of LNAPL Boundary in direction of GW flow		m	200	500	200	500	200	500
Specific Discharge		m/yr	0.043	17.3	0.043	17.3	0.043	17.3
Volume of Water per Year (Q)		m3/yr	8.6	8650	8.6	8650	8.6	8650
Volume of Water per Year (Q)		L/yr	8,600	8,650,000	8,600	8,650,000	8,600	8,650,000
Constituent	benzene	mg/L	0.073	0.073	1.7	1.7	0.39	0.39
	toluene	mg/L	0.002	0.002	0.37	0.37	0.11	0.11
	ethylbenzene	mg/L	0.163	0.163	0.66	0.66	0.44	0.44
	m&p xylene	mg/L	0.07	0.07	1.57	1.57	0.57	0.57
	o xylene	mg/L	0.011	0.011	0.3	0.3	0.14	0.14
	octane	mg/L	0.0003	0.0003	0.0017	0.0017	0.0011	0.0011
	dodecane	mg/L	0.0012	0.0012	0.0014	0.0014	0.0012	0.0012
	naphthalene	mg/L	0.004	0.004	0.28	0.28	0.05	0.05
Flux to Ground-water per Year	benzene	kg/yr	0.000628	0.631	0.014620	14.705	0.00335	3.37
	toluene	kg/yr	0.000017	0.017	0.003182	3.201	0.00095	0.95
	ethylbenzene	kg/yr	0.001402	1.410	0.005676	5.709	0.00378	3.81
	m&p xylene	kg/yr	0.000602	0.606	0.013502	13.581	0.00490	4.93
	o xylene	kg/yr	0.000095	0.095	0.002580	2.595	0.00120	1.21
	octane	kg/yr	0.000003	0.003	0.000015	0.015	0.00001	0.01
	dodecane	kg/yr	0.000010	0.010	0.000012	0.012	0.00001	0.01
	naphthalene	kg/yr	0.000034	0.035	0.002408	2.422	0.00043	0.43

The constituents assessed indicate that while there is the potential for mass loss via dissolution, it accounts for only a very small portion of the LNAPL mass present.

Assuming, that the upper 1m of leachate/groundwater was in contact with the LNAPL body encompassing 60,000 m^2, in the order of approximately 20 to 275 kilograms (kg) of hydrocarbon mass (primarily comprised of the sum of BTEX and dodecane) would be in solution. Considering that half-lives of the more significant portions of the dissolved mass (primarily BTEX) vary between 50 and 400 days under anaerobic conditions (as derived from methanogenic studies which are considered appropriate for landfill sites (USGS, 2006)) resulting in halving of the mass through the same time period (approximately corresponding up to between 70 and 950 kg/year), and that groundwater flow can potentially transport between 0.003 to 42.2 kg/year (primarily comprised of the sum of BTEX and dodecane), dissolution will continue to occur to maintain equilibrium, contributing to the overall mass depletion. Whilst these are general approximations for illustrative purposes only, it is important to note that these processes occur and contribute to overall mass loss.

In the context of the Site condition, the presence of the landfill cap will serve to limit infiltration and subsequently limit the potential for increased dissolution of the LNAPL into leachate or groundwater. As per the calculations provided above, some dissolution is inferred to occur where LNAPL is in contact with leachate; however studies undertaken by Kleinfelder (in draft and yet to be reviewed as part of the Audit Review of the GQMP and LWMP) indicate that natural degradation processes are occurring in the dissolved phase, thereby controlling potential dissolved phase migration (Kleinfelder, 2015).

Similar calculations were undertaken for the vapour phase (refer to **Table 1** attached) with findings presented in the table below.

Table 3-4 Vapour Phase Findings

Constituents	Pure Phase Equilibrium Pressure (Pa)	Min Vapour Concentration (mg/m3)	Max Vapour Concentration (mg/m3)	Average Vapour Concentration (mg/m3)
Benzene	12553	5.06	117.54	26.68
toluene	3775	1.29	263.72	76.75
ethylbenzene	1267	12.03	48.89	32.54
m&p xylene	1110	7.24	162.14	58.78
o xylene	1110	1.19	30.59	14.65
naphthalene	12	0.02	1.03	0.19
octane	1470	674.48	3471.78	2198.06
dodecane	18	56.41	66.16	56.86

The highest reported vapour concentration provides a general indication of the volatility of the LNAPL and subsequently, the mass that could potentially be depleted due to volatilisation. It is noted that the highest reported vapour concentrations calculated represent the concentrations immediately above the LNAPL with the constituents degrading as they travel through the unsaturated zone and ultimately capture by the LFG System.

As a means of broadly quantifying the rate of LNAPL depletion due to volatilisation within the waste material, data generated from the LFG recovery system and Flare was utilised. The composition of the flare feed was derived from sampling undertaken on 25/3/2013 (URS, 2013). Based on feed influent concentrations of non-methane hydrocarbons (228 milligrams per cubic metre, mg/m^3) at an extraction rate of 5.7 cubic metres per minute (m^3/min) (Mounds 1, 2 and 3) (TPI, 2012 & URS, 2013) approximately 680 kg/year of non-methane hydrocarbons are removed (most likely from the NAPL). Influent BTEX concentrations to the flare are considerably lower than calculated equilibrium concentrations with the flare influent concentrations being 33% (Benzene), 3.4% (Toluene), 12.8% (Ethylbenzene) and 11% (Xylene) of the equilibrium vapour concentrations. The differences in the concentrations could reflect the effects of dilution by biogas (methane + carbon dioxide) production, variability in LNAPL composition, gas drawn from non-LNAPL zones, and other factors including biodegradation of vapours in the unsaturated zone. In addition, the LNAPL sampled could have had the more water-soluble aromatic compounds partially leached out, so that the LNAPL sample composition data are not totally reflective of site-wide LNAPL composition and LNAPL present in other areas has a higher aromatic hydrocarbon content.

Using the same LFG feed data (URS, 2013) approximately 60% and 20% methane and carbon dioxide is present in the gases extracted from the landfill, respectively. At a flare flow rate of 4.0 m^3/min (Mounds 1 and 2) approximately 880,000 and 730,000kg of methane and carbon dioxide is removed from the landfill annually which equates to approximately 660,000 and 200,000 kg of carbon, respectively.

Given the age of the Tullamarine landfill, the decomposition of putrescible waste will be highly advanced and therefore the LNAPL mass will make up a large proportion of the remaining organic mass and source of methane and carbon dioxide being produced within the landfill currently. For comparison, after 30 years, municipal landfills containing putrescible matter typically produce low volumes of methane and carbon dioxide. This is supported by the modelling reported in URS, 2013 and Transpacific 2012, which shows a major decrease in landfill gas production rates over time. On this basis the majority of degradable materials remaining in the landfill are likely associated with residual hydrocarbons in unsaturated and saturated zone fill materials rather than being derived from putrescible waste.

Consistent with the methane production modelling undertaken by SCS Engineers and presented in the Ambient Air and Landfill Gas Management Plan (AALFGMP) (Transpacific, 2012), a reassessment of gas production from potential putrescible matter within Mounds 1 and 2 was undertaken, considering the operational history of these cells. **Appendix D** presents Table 1 from the AALFGMP which provides Landfill Gas Generation Recovery Estimates.

The modelled methane production rates for 2013 are 1,447,000 kg/yr for Mounds 1, 2 and 3. As discussed above, methane production rates (as measured in the influent to the flare and reported in URS, 2013) are approximately 880,000 kg/year for Mounds 1 and 2. To assess potential contributions from Mounds 1 and 2, and ultimately calculate the residual portion of methane produced (above that modelled) that would be potentially sourced from degradation of the LNAPL, the operational history of the site and annual waste quantities as derived from the AALFGMP (Transpacific, 2012) was considered. Mound 3 was utilised from the late 1980s and as such, waste received post late 1980s would primarily be placed in Mound 3. It is noted however, that this approach is considered highly conservative given that methane generation declines over time and consequently methane generation from Mound 3 would be greater than assumed compared to the older Mounds 1 and 2.

The table below provides an overview of proportion of waste from the late 1980s compared to the total cumulative waste disposed at the Site, which is estimated at 3,710,113 tonnes, to provide an estimate of the residual portion of methane that is potentially sourced from LNAPL degradation in mounds 1 and 2. The residual methane, generated from Mounds 1 and 2, considers the proportion of waste generated after Mound 3 operations began and applies the percent contribution of waste mass to the modelled methane generation estimate to conservatively derive methane generation from Mounds 1 and 2 only. The residual is then calculated by subtracting the modelled methane generation for 2013 from the 2013 flare feed data. Given the uncertainty in when operations in Mounds 1 and 2 formally ceased, two scenarios were utilised to cover the period 1988 through 1989, after which the majority of waste was disposed in Mound 3.

	Volume of waste disposed (tonnes)	% contribution to cumulative waste disposed and landfill gas generation	Methane Generation Estimate from Mounds 1 and 2 only for 2015	Residual
1988 to 2008	1,809,531	51%	741,256	138,744
1989 to 2008	1,571,054	58%	834,265	45,735

On the basis of the estimate, the residual portion of methane that is potentially sourced from LNAPL degradation is between approximately 45,000 and 140,000 kg/year.

Whilst the assessment undertaken was theoretical in nature and represents a simplistic representation of the process likely to be occurring at the Site, its purpose was to illustrate, in broad terms, that LNAPL mass depletion will likely occur (based on the chemistry of the LNAPL) and that dissolution, volatilisation and biodegradation process are likely important degradation mechanisms especially for aliphatic compounds which are easily degraded under anaerobic and fermentation processes.

Whilst actual quantification of the rate of depletion is unable to be accurately calculated, it is considered that the order of magnitude of natural mass depletion will be significant, relative to that achieved by hydraulic extraction over the same time period (350 to 1,400 years as presented in **Section 3.3.3**).

In addition, the potential mass depletion associated with dissolution, degradation and volatilisation is strongly influenced by the composition of the LNAPL, which can vary across the Site. However, the rates of mass losses through these mechanisms are likely to be more constant and will decrease at a slower rate than the expected decline in hydraulic recovery rates which are more constrained by the distribution and availability of recoverable LNAPL.

3.3 Assessment of LNAPL Recoverability

As noted above, natural mass losses from the LNAPL are occurring through a combination of processes with the operation of the landfill gas extraction systems providing additional mass removal from vapour losses. Additional mass removal of LNAPL can be achieved through engineered means, but consistent with the LNAPL Conceptual Site Model, ultimately there are major constraints on the effectiveness of these active remediation methods.

A discussion of the remediation options screening, review of other technologies and LNAPL mobility and recoverability assessments conducted at the Site are provided below.

3.3.1 Remediation Options Screening

URS Australia Pty Ltd (URS) undertook a screening of technologies potentially applicable to the recovery of LNAPL from the Site. The report entitled *Assessment of Tullamarine Closed Landfill LNAPL Extraction Trial Options* (URS, 2011) was submitted for Third Party review in 2011 and endorsed by the IRP in 2012/2013.

The screening drew upon global databases, case studies and company experience to identify technologies (options) that, consistent with the overall program objective, may reduce the ability of LNAPL to move out of the landfill cell by reducing the recoverable and/or mobile volume. The following technologies were assessed:

- In Situ Containment (no LNAPL extraction)
- In Situ Immobilisation (no LNAPL extraction)
- In-situ Chemical Oxidation (no LNAPL extraction)
- Bioremediation (no LNAPL extraction)
- Physical Waste Removal and Disposal by Excavation (no LNAPL extraction)
- Hydraulic LNAPL Extraction
- Thermally Enhanced Hydraulic Extraction
- Chemically Enhanced Hydraulic Extraction
- Pneumatic / Hydraulic Enhanced Hydraulic Extraction
- Vacuum Extraction
- Vacuum Enhanced Hydraulic Extraction
- Thermally Enhanced Hydraulic and Vacuum Extraction

Descriptions of each technology are included in URS *Assessment of Tullamarine Closed Landfill LNAPL Extraction Trial Options*. The technologies were screened against the following criteria:

1. Health, Safety and Environmental impacts / risks;
2. Technical capability to achieve the extraction objectives;
3. Regulatory compliance;
4. Social and community acceptance;
5. Technology availability, development and implementation;
6. Technology implementation and operation issues; and
7. Capital, operating and disposal costs.

The assessment used a "fatal flaws" approach whereby options with low likelihood of achieving one of more of the criteria were rejected. The following options were retained for consideration of field-scale testing:

1. Total fluids (LNAPL/leachate) extraction
2. Downwell skimming (LNAPL)
3. Belt skimming (LNAPL)

To further assess whether pilot testing of the above technologies was practical, LNAPL recovery trials were undertaken (EHS Support, 2014) and these are discussed further below.

3.3.2 Further Review of Technologies

A reassessment of the screening assessment conducted by URS was completed as part of this report. The objectives for remediation used in the original screening remain valid with no material changes in groundwater impacts beneath the Site. In addition, no other changes relating to the project as a whole (for example: changes in regulation, proposed future use of the Site or company aspirations) necessitate modification of the screening framework.

A review of databases, case studies and other literature did not reveal contemporary advances in technologies suitable for the recovery of high viscosity LNAPL.

The following specific sources of information were reviewed:

- United States Environmental Protection Agency (USEPA) Hazardous Waste Cleanup Information (CLU-IN) Website
  - http://www.clu-in.org/
  - 2012 to 2014 issues of *Technology News and Trends*
- USEPA Technology Innovation Program Website (including Federal Remediation Technologies Roundtable)
  - http://www.epa.gov/tio/databases/
  - http://www.frtr.gov/matrix2
- Interstate Technology Regulatory Council (ITRC) – the most relevant document from ITRC is *Evaluating LNAPL Remedial Technologies for Achieving Project Goals* and this has not updated since December 2009.

Recently, the most significant advance in remediation technology is nanomaterials. Pilot trials are underway in North America and Europe, but these are primarily focussed on dissolved contaminants and predominantly chlorinated hydrocarbons. Work is being undertaken using nanomaterials to adsorb oil and assess the remediating potential on LNAPL in the subsurface, however the science is in the early stages and potential benefits and risks are poorly understood. The factors and processes affecting ecotoxicity are complex, and knowledge of the potential impacts of manufactured nanoparticles in the environment on human health is still limited[1]. Nanomaterials are unlikely to be a practical remediation alternative for at least five to ten years and may not be applicable to a Site such as this due to the nature and volume of LNAPL remaining.

Natural Source Zone Depletion was not specifically evaluated in the URS assessment and is a valid approach to LNAPL management providing, as is the case at this Site, intervention to mitigate risk to human health and/or the environment is not required. The ITRC document *Evaluating LNAPL Remedial Technologies for achieving Project Goals* (ITRC, 2009a) describes Natural Source Zone Depletion as natural depletion of LNAPL constituents from the LNAPL body over time by volatilisation, dissolution, absorption and, degradation (LNAPL phase-change remediation). The ITRC document *Evaluating Natural Source Zone Depletion at Sites with LNAPL* (ITRC, 2009b) provides a method to quantify LNAPL mass losses from natural processes. At sites where LNAPL recovery is difficult, the natural mass loss can exceed mass removed by engineered means without the attendant dis-benefits such as greenhouse gas emissions and risk of exposure or accident. A discussion on Natural Source Zone Depletion is presented in **Section 3.2.**

3.3.3 LNAPL Recoverability and Mobility

A comprehensive program of LNAPL recoverability and mobility assessment were conducted at the Site as part of an LNAPL Extraction Trial (EHS Support, 2014). The key metrics utilised to assess potential recoverability and mobility were LNAPL transmissivity (Tn), together with demonstration of the ability to extract from the waste materials in the formation around the well (as compared to solely well storage) and ability to sustain pumping rates. Tn is a measure of the mobility of LNAPL within the subsurface environment and provides a clear indication of potential LNAPL recoverability utilising hydraulic recovery. Tn is derived from the multiplication of saturated thickness (length) and hydraulic conductivity (length/time) is

[1] http://www.nanotechproject.org/inventories/remediation_map/

represented in units of area over time e.g. m^2/day and essentially provides a normalised metric accommodating different LNAPL types and media within which the LNAPL is present.

Based on the trial results, the following conclusions were drawn:

- The Tn metric was not met at any location with only two locations, L1 and L7 reporting Tn in the same order magnitude as the adopted criteria (early time data only). L1 and L7 were noted in the later period or repeated tests to decline in Transmissivityd over time.
- Tn values calculated indicate limited extraction potential and infer that the LNAPL is functionally immobile.
- Extraction from the waste materials in the formation, as compared to in well storage, was only achieved in 8 of 13 wells tested indicating very small well capture radius.
- Of the 8 wells, only L1 yielded appreciable volumes (>50L).
- Extraction on the best yielding well (L1) was sustained for only 398 minutes over 2 events.
- Repeat testing of L1 confirmed low Tn and very low recovery rate.
- Wells exhibited very slow LNAPL level recovery (typically > 1 month).

Based on the assessment provided in EHS Support (2014), no wells qualified for extended LNAPL extraction given the low derived Tn values, inability to sustain pumping rates, general inability to draw LNAPL from the waste and very slow LNAPL level recovery, indicating the inability to support long term extraction and that the LNAPL is functionally immobile.

In order to explore the practicability of LNAPL extraction via hydraulic recovery, extraction rates achieved, together with observed LNAPL rebound to wells, were utilised to conceptually assess the time required to extract the potentially recoverable portions of the LNAPL within the waste material at the Site.

Over the course of the trial, the volume of LNAPL extracted from all targeted wells (less the volume achieved, during the repeat test on L1) was 1,626 L. After approximately four weeks, LNAPL in wells rebounded to approximately 50% of the initial pre-test volume on average. Assuming that LNAPL extraction events occurred on a monthly basis on available wells, it is conservatively assumed that 828 L could be recovered per month continuously (linear). However, this is highly optimistic as removal of LNAPL mass from the formation will lead to reductions in LNAPL transmissivity and corresponding declines in recovery rates. A cumulative recovery curve and LNAPL recovery rates (ITRC, 2009a), shown in red and blue respectively below, illustrates the typical declines in LNAPL recovery rates to be expected, with in many cases major declines in recovery rates observed over very short operational intervals. The graph below illustrates recovery rates declining by at least an order of magnitude within 6 months and a further decline by an order of magnitude shortly thereafter, resulting in a decline of approximately two orders of magnitude in less than a year. In terms of the Tullamarine site, and consistent with the results of the extraction trail, recovery rates would be expected to decline by at least an order of magnitude within the first year corresponding to potential extraction rates of approximately less than 10 L per month.

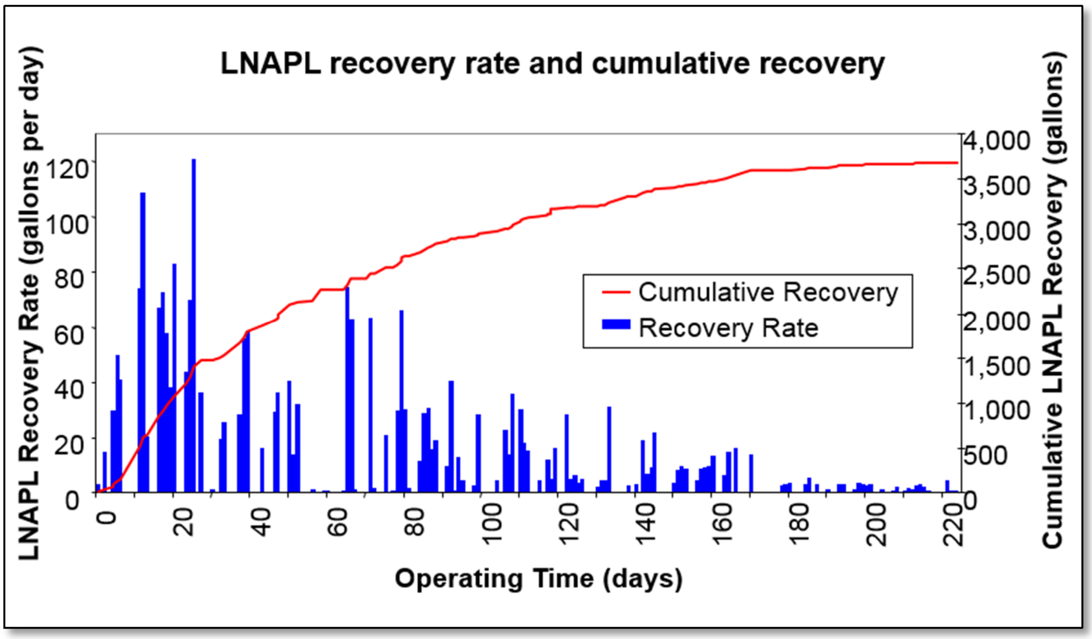


Figure 3-5 LNAPL Recover Rate and Cumulative Recovery

However, for the purposes of exploring the effects of long term recovery, the exaggerated linear potential recovery rate is utilised. In addition, a second scenario is explored whereby it is assumed that 25% rebound of LNAPL occurs, following extraction each month corresponding to approximately 400 L/month, which is still considered to represent at least an order of magnitude higher extraction potential than would be expected based on the results of the extraction trials.

As presented in URS (2011), the total LNAPL volume (mobile and residual) ranges between 4,500 to 18,200 m^3 and is likely to fall between 7,500 to 12,000 m^3. The predicted potentially recoverable portion of the LNAPL (mobile) ranges between 2,000 to 12,000 m^3, with a likely range of 4,000 to 7,000 m^3. Linear extrapolation of the above recovery rates (828 L and 400 L per month) into the total volume of potentially recoverable LNAPL indicates recovery time frames of greater than 350 years. Considering likely lower recovery rates and some asymptotic decline, recovery of all the potentially recoverable LNAPL is more likely to be on the order of greater than 1,400 years with these technologies. For comparison, the conservative calculated natural mass loss depletion rates (lower range estimates utilised) are also included which indicate timeframes in the order of 80 to 140 years, assuming depletion rates are non-limiting.

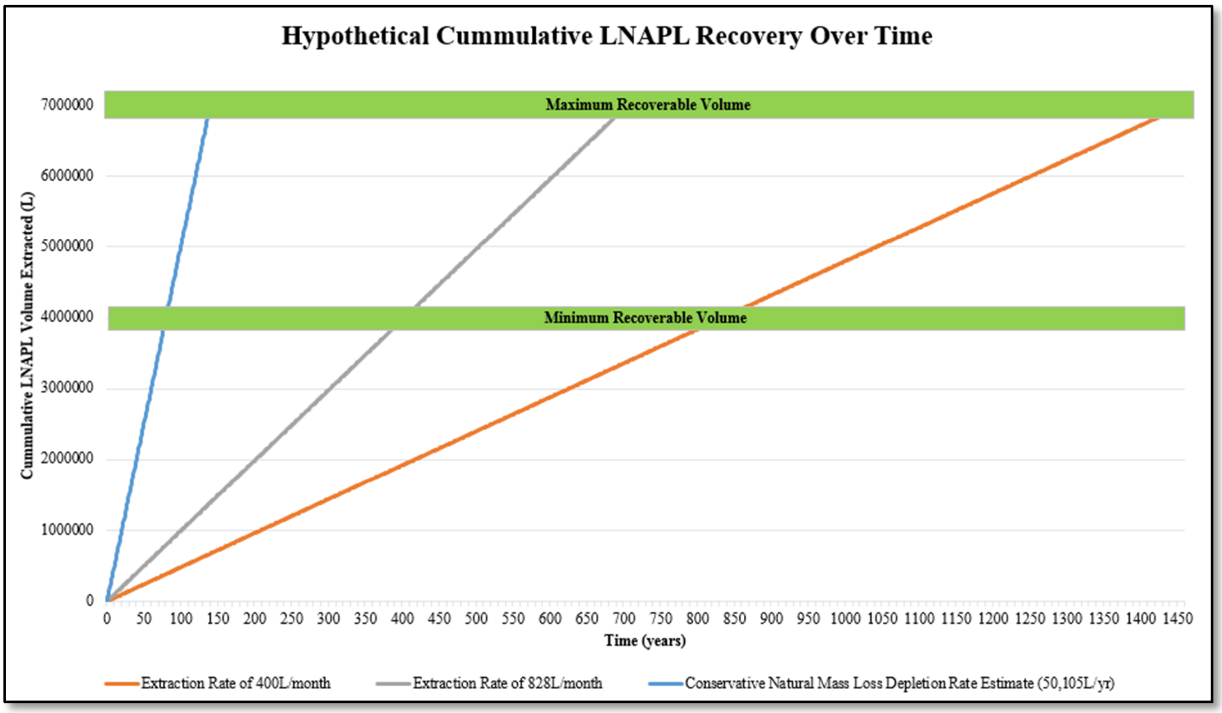


Figure 3-6 Hypothetical Cumulative LNAPL Recovery over Time

As discussed above however, the LNAPL at the Site is considered discontinuous in nature and not readily accessible. With consideration of the total recoverable (mobile) and unrecoverable (residual) LNAPL volumes, a large volume of LNAPL (potentially between 3.5 ML to 5 ML) would remain following extraction timeframes, with prolonged periods of extraction required (in the order of between 350 to 1,400 years) effectively limiting the benefits of such a mass recovery effort, particularly considering potential natural mass loss depletion rates. For illustrative purposes, the amount of LNAPL removed from the Site after ten years would only be between 0.07% and 0.25% of the estimated potential recoverable volume.

As discussed in **Section 2.1.1** (the composition of LNAPL and not its mass (volume or saturation level) is the primary control for concentrations and associated potential risks in adjacent phases (groundwater and gas)) and consistent with the 2007 Audit findings, unless all LNAPL is removed, the risk profile associated with constituents of concern essentially remains unchanged and consequently the benefits of such extensive recovery efforts, as presented above, are not considered justified on the basis of risk.

3.4 LNAPL Conceptual Model Overview

Based on the principles presented in **Appendix A** and assessments presented above, observed LNAPL thickness and lateral and vertical distribution at the Tullamarine Closed Landfill Site are most likely controlled by the following:

- The waste characteristics and hydrogeology of the landfill including key physical properties of the fill material such as grain size and distribution, effective porosity, and lateral continuity;
- The vertical distribution of waste physical properties in the landfill;
- The physical properties of the LNAPL; and
- Fluid saturations in the landfill materials and leachate and residual saturation of LNAPL in the heterogeneous waste material.

The potentially recoverable volumes calculated by URS (August, 2011), estimated to be between 2 to 12 ML, with a likely range of 4 to 7 ML, confirmed the need to evaluate the feasibility of extraction as per the PCMP (Transpacific, 2010 & 2012).

Based on the extraction trials and current and historical LNAPL extent, the LNAPL is considered effectively immobile and unrecoverable with the majority of LNAPL considered residual in nature with limited potential for migration. As presented above and consistent with the 2007 Audit report, remediation of LNAPL is not likely to be fully effective due to the proportion of LNAPL likely to be retained by the solid material in the landfill and the risk profile for groundwater would therefore not change significantly in the foreseeable future, even with an aggressive NAPL removal program.

Degradation of LNAPL is considered to be occurring at an appreciable rate. Based on the assessment of LNAPL mass depletion presented above. The sum of all mass depletion processes considered ranges between approximately 45,100 and 141,600 kg/yr. A simplified overview of likely order of magnitude inferred mass loss depletion rates and associated processes are illustrated below (**Figure 3-7**).

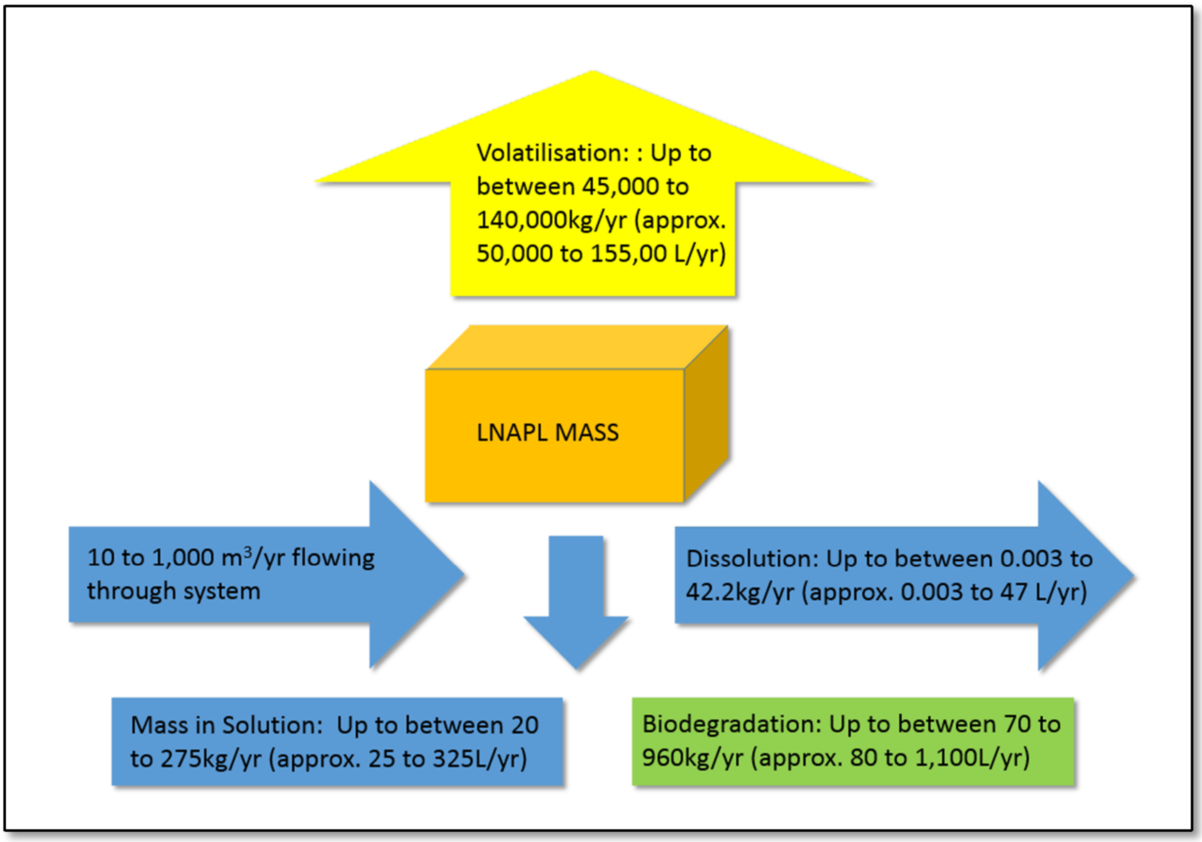


Figure 3-7 Inferred Mass Loss Depletion Rates Overview

In addition, the installation of a landfill cap is considered to significantly reduce the long term flux of dissolved contaminants moving off-Site in groundwater from the premises. Further, assessments undertaken by Kleinfelder (February 2015) indicate that the potential for natural degradation of dissolved phase constituents is occurring further limiting the potential of dissolved phase risks derived from the LNAPL.

With respect to the 2007 Audit findings as presented in **Section 2.2**, the following assessment and Audit findings provide the framework for remediation drivers for LNAPL in Mounds 1 and 2:

- "*that the installation of a "best practice" landfill cap is likely to significantly reduce the long term flux of dissolved contaminants moving off-Site in groundwater from the premises"*;
- *"modelling indicates that the long term risk to the aquatic ecosystem and primary contact recreational users of Moonee Ponds Creek is low and not likely to get worse, assuming the aftercare management program, including capping goes to plan"*;
- *"The Auditor also notes that the apparently low mobility of the LNAPL suggests that the risk of off-Site movement of LNAPL is low"; and*
- "the Auditor is of the opinion that the presence of LNAPL necessitated on-going risk management and monitoring, and a rigorous assessment of the feasibility for remediation of LNAPL is required".

With respect to the presence of LNAPL, it was noted that even after aggressive LNAPL removal, a significant proportion of the LNAPL will be retained by the waste in the landfill, which will act as continuous, long-term source for dissolved phase contamination in leachate and groundwater, and the risk profile for groundwater would therefore not change significantly in the foreseeable future.

Based on the above, particularly in the context of the low inferred mobility of the LNAPL as reported in the 2007 Audit and consistent with the findings of the LNAPL extraction trials (EHS Support, 2014), the remediation drivers for LNAPL within Mounds 1 and 2 can be classified as follows:

- Regulatory drivers to recover LNAPL to the extent practicable and ultimately restore beneficial uses of groundwater;
- Societal and business factors; and
- Intergenerational equity.

Accordingly, the LNAPL remediation goal for the Site was to recover LNAPL to the extent practicable, noting that the composition of the LNAPL and its presence within capped landfill cells (where landfill gas vapours are captured by the landfill gas recovery system and potential infiltration is limited by the landfill cap) functionally eliminate the limited potential for significant further dissolution or vapour concerns. As such, the implemented remediation approach focused on mass removal whilst noting that partial mass removal would not materially change the risk profile at the Site.

Based on the trial results, it is considered that LNAPL clean up has been completed to the extent practicable and that the regulatory remediation drivers have essentially been met from a technical perspective. Logistical constraints have been previously addressed in URS, 2011, from the point of view of screening of applicable technologies and implementability of remedial options at the site, - the outcome of which was the LNAPL extraction trial.

The net benefit analysis presented in **Section 4** and **Appendix B** provides context for societal and business factors as well as intergenerational equity from a sustainability point of view as well as broadly assessing financial considerations, which while important, do not significantly influence the outcomes of the practicability assessment. As per the findings in **Section 4** below, it is considered that intergenerational equity would no longer be considered a driver, given that it has been demonstrated that the potential risks and impacts to humans and the environment, associated with remediation outweigh the benefits associated with remediation.

4.0 NET BENEFIT ANALYSIS

Given that natural processes are already depleting LNAPL mass, the net benefits of LNAPL recovery actions have to be considered in the context of the potential impacts associated with the recovery activities on the environment and broader community. The concept of sustainability is couched in the concept of an action providing some benefit in terms of environmental, social and economic factors. A summary of the Net Benefit Analysis undertaken is presented below, with details provided in **Appendix B**.

Sustainable development was defined by the World Commission on Environment and Development (1987), commonly known as "the Brundtland Commission", as development that "meets the needs of the present generation without compromising the ability of future generations to meet their own needs". Maximising the overall benefit to the community and environment of an activity such as remediation is consistent with this statement.

Soil and groundwater remediation, although designed to remedy contamination and reduce risks to human health and/or the environment, also has the potential to cause environmental, social and economic impacts (SuRF ANZ, Nadebaum, 2011). Whilst there is general agreement as to the overall aspirations, there are a number of definitions provided by the various entities building the frameworks, guidance and tools for sustainable remediation and some of these are shown below. ITRC expands the definition to specifically encompass Green Remediation, thus Green and Sustainable Remediation or GSR. Green remediation is generally considered a necessary subset of Sustainable Remediation.

> *Sustainable remediation can be defined as a balanced decision making process that demonstrates, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than adverse effects (SuRF ANZ, Nadebaum 2011).*
>
> *Sustainable remediation is the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of a balanced decision-making process (SuRF, UK)*
>
> *Sustainable remediation can be defined as a remedy or combination of remedies whose net benefit on human health and the environment is maximized through the judicious use of limited resources (US Sustainable Remediation Forum [SuRF], 2009).*
>
> *GSR is defined as the site-specific use of products, processes, technologies, and procedures that mitigate contaminant risk to receptors while balancing community goals, economic impacts, and net environmental effects. GSR has emerged as a beneficial approach that optimizes all phases of site remediation, from site investigation to project closeout (ITRC, 2011).*
>
> *Sustainable remediation considers a range of environmental issues and community impacts and integrates economic, ecological, and social implications into the consideration of the collateral impacts of investigation and remediation activities (ITRC, 2011).*

A remedy or combination of remedies whose net benefit on human health and the environment is maximized through the judicious use of limited resources (Hadley and Ellis 2009).

Sustainable practices result in clean-ups minimizing the environmental and energy 'footprints' of all actions taken during a project life (EPA 2008b).

Two of the biggest issues facing the world are climate change and diminishing water resources. Climate change is a well-established and wide debate. Water resources is a more recent issue and Sandra Postel in her book *Pillar of Sand* puts the current global water deficit at 160 billion tons per year and rising. Remediation systems can contribute to climate change through generation of greenhouse gases from tailpipe emissions (travelling to and from the Site), electricity generation and hydrocarbon destruction by combustion. Water used during electricity generation is significant with figures ranging from 500 to 2,000 L per 1,000 kilowatt-hour (kWh) common for coal-fired power plants which makes up about two thirds of Victoria's electricity production[2]. As a comparison, the production of grain requires in the order of 500 to 4,000 tons of water to produce 1 ton of grain (Institution of Mechanical Engineers, 2013) and considering even a modest remediation system may use tens of thousands of kWh's per year, the significance of water usage associated with the electricity supply is apparent. When the risks to human health and the environment from impacts remaining in the ground are low and acceptable, the net benefit of a remediation system can be negative for these reasons.

The preservation of intergenerational equity is a key concept when assessing sustainability and net benefit. In a case where contamination may cause long-term health risks or damage to the environment, it may be argued that remediation would preserve intergenerational equity. Where remediation will not decrease the risk or restore amenity (of a groundwater resource for example) or where the risks from impacts are low and acceptable, intergenerational equity is more likely preserved by not implementing remediation because of the impacts associated with the remediation system itself.

To facilitate an assessment of the net benefits of remedial actions a number of remediation scenarios (consistent with the screening process described above) are evaluated in the sections below to determine assess benefits and impacts potentially associated with the proposed activity.

4.1 Regulatory Support for Assessment of Net Benefit

The Environmental Protection Act 1970 (the "Act") acknowledges the importance of assessing net benefit with the inclusion of the Principle of integration of economic, social and environmental considerations. The Principle includes the following statements:

1. Sound environmental practices and procedures should be adopted as a basis for ecologically sustainable development for the benefit of human beings and the environment.
2. This requires the effective integration of economic, social and environmental considerations in decision making processes with the need to improve community well-being and the benefit of future generations.

[2] http://spectrum.ieee.org/energy/environment/how-much-water-does-it-take-to-make-electricity

3. The measures adopted should be cost-effective and in proportion to the significance of the environmental problems being addressed.

In addition, EPA bulletin 840 ("The Clean-up and Management of Polluted Groundwater") states "The clean-up measures adopted shall be cost effective and commensurate with the significance of the environmental issues being addressed including but not limited to consideration of the likelihood of beneficial uses being realised".

There is also considerable flexibility in State and Territory guidance relating to the final outcome of Site remediation methods, in that land can be certified as being suitable for particular land uses subject to certain conditions or controls on land use activities (Nadebaum, 2011).

4.2 Modelled Remediation Scenarios

The primary objective of the landfill gas extraction system is to manage landfill gas (predominantly methane) which will be a key part of Post Closure Management. This is noted here to highlight that continued operation of the landfill gas extraction system is essentially independent of the LNAPL impacts and considered part of the base case for this assessment.

Consistent with the technology screening process described above, the net benefit of skimming using a total fluids pump (the preferred pumping device developed using the URS (2011) screening method and considering the depth and nature of the oil) was modelled. A full total fluids extraction scenario was not modelled as this would require a groundwater treatment system significantly increasing the environmental footprint of a remediation system and hence the more practical and appropriate oil-focused scenarios provides a conservative low carbon footprint assessment. Skimming using belt skimmers is not modelled since the impacts are likely similar to modelled scenario. For the oil focused scenarios, three approaches were modelled:

- Scenario 1 – Recovery from existing wells using portable trailer
- Scenario 2 – Recovery from Existing Wells using a Fixed System
- Scenario 3 – recovery from New Wells using a Fixed System.

Further details on each of these scenarios and details on the evaluation results are provided in **Appendix B**.

4.3 Method to Assess Benefit

Responsible approaches to remediation of groundwater must integrate "sustainability" principles aiming to balance the benefit and dis-benefits to the community and environment of remediation. The assessment of balance should look at a broad range of economic, environmental and social interactions that may include:

- The value and utility of the groundwater resource being protected versus the value of natural resources used or impacted to restore the resource.
- The risk to the environment posed by the impacts remaining in groundwater versus the impacts to the environment from the implementation of a remediation system.
- The risk to human health posed by the impacts remaining in the environment versus the risk of injury and/or detriment to health resulting from the implementation of a remediation system.
- The economic gain from improving the environment against the cost of remediation.

Where possible, net benefit was assessed quantitatively and semi-quantitatively or qualitatively where it was not possible or inappropriate to generate hard numbers. SiteWise™ was used extensively to calculate the footprint of each scenario and this is described below.

The sustainability of remediation options is typically assessed against indicators (e.g. A Framework for Sustainability Indicators at EPA, (USEPA, 2012)). Sustainability assessments of remediation options are also typically assessed against indicators with the various SuRF organisations throughout the world surf adopting similar frameworks (SuRF UK, 2009, and SURF ANZ, Nadebaum 2011). Indicators are generally grouped under the three sustainability headings of environmental, social and economic. The indicators shown in the table are typical of the practice and are considered an appropriate starting point for this assessment. The indicators showing bold are those considered to be most applicable to this assessment. The others are less important and in some cases not considered further. Discussion on the rationale for exclusion is provided in **Appendix B**.

Table 4-1 Indicators

#	Environmental	Social	Economic
1.	**Impacts on air**	**Impacts on human health and safety**	**Direct economic costs and benefits**
2.	Impacts on soil	Ethical and equity considerations	Indirect economic costs and benefits
3.	**Impacts on water**	**Impacts on neighbourhoods or regions**	Employment and capital gain
4.	Impacts on ecology	**Community involvement and satisfaction**	Induced economic benefits
5.	**Use of natural resources and generation of wastes**	Compliance with policy objectives and strategies	Lifespan and project risks
6.	Intrusiveness	Uncertainty and evidence	Project flexibility

4.3.1 SiteWise™ and Calculation of Metrics

SiteWise™ was used to quantify the metrics identified in the sections above. SiteWise™ is an Excel-based lifecycle tool developed jointly by the United States Navy, Army Corps of Engineers, and Battelle. SiteWise™ is currently in a third revision and is used widely used across the world for assessing the footprint of remediation.

The tool provides a baseline assessment of several quantifiable sustainability metrics including: greenhouse gases (GHGs); energy usage; electricity usage from renewable and non-renewable sources; criteria air pollutants that include sulphur oxides (SOx), oxides of nitrogen (NOx), and particulate matter (PM); water usage; resource consumption; and accident risk.

The table below presents an overview of the results of calculations from SiteWise™ for the three remediation scenarios, with details presented in **Appendix B**.

Table 4-2 Overview of the SiteWise™ Calculations Results

Remediation Scenario (10 Year Cycle noting that in excess of 200 years would be required)		Trailer with Existing Wells	Fixed System with Existing Wells	Fixed System with New Wells
Air Impacts				
GHG Emissions	metric ton	95	282	352
Total NOx Emissions	metric ton	0.2	0.7	0.8
Total SOx Emissions	metric ton	0.1	0.4	0.5
Total PM10 Emissions	metric ton	0.02	0.3	0.4
Electricity and Water Impacts				
Electricity	MWH	0	220	220
Water	tonnes	0	424	424
Waste Impacts				
Waste	metric tons	0.8	45	72
Human Health and Safety Impacts				
Accident Risk	Fatality	3.30E-03	9.00E-04	9.30E-04
Accident Risk	Injury	6.80E-01	1.70E-01	1.70E-01
Lost time	Hours	5.4	1.3	1.4
Distance	km	17083	11257	13699
Direct Economic Costs Impacts				
Install	Cost	$48,869	$299,267	$461,647
O&M/yr	Cost	$396,179	$176,834	$176,834
Decom	Cost	$6,000	$42,124	$48,474
Total PV (ten years)	Cost	$2,837,461	$1,583,397	$1,752,127

Appendix B provides further context for these quantities and in summary:

- Implementation of any of the three remediation scenarios will result in emissions to air that are polluting and contribute to global warming. The greenhouse gas emissions are of a magnitude that off-setting with forest requires substantial effort and cost and further use of water to establish and maintain the trees. In comparison, the impacts to air from the LNAPL beneath the Site are insignificant to nil. (It is noted that impacts to air occur from the operation of the landfill gas extraction system but this is the base case and incremental impacts are appropriate to consider for this assessment).
- The electricity use for the fixed system scenarios is equivalent to the annual use of more than 30 average Australian homes.

- Water supply is a major global issue and electricity generation is a significant user. The water use for electricity generation for the fixed systems scenarios is equivalent to amount required to grow about 400 kilograms which could feed around 17 people for a month.
- Implementation of all three remediation scenarios entails significant risk to human health due to the need for extensive driving for installation, operation and maintenance and decommissioning. The risk is primarily connected to driving and operating machinery. Further, not all risks are considered by SiteWise™ most notably the risk to non-workers from transport of oil and solid waste on roads. The risks to human health from the oil impacts beneath the site are low and acceptable. By way of comparison, levels commonly used to determine risk to human health from contaminants are in the order of 10^{-4} and 10^{-6} with NEPM citing 10^{-5} as the default, whereas the risks associated with remediation implementation are significantly higher. For example, considering the human health risk from carcinogens can be defined as the incremental risk of contracting cancer. This does not necessarily imply death whereas the risk of fatality associated with the Trailer scenario is greater than 10^{-3}.

SiteWise™ does not currently assess community or ecological impacts and these are discussed qualitatively within this document and in particular **Appendix B**, with minutes from recent community meetings presented in **Appendix C**.

4.4 Net Benefit Assessment Findings

At this Site, it has been demonstrated that the potential risks and impacts to humans and the environment, associated with remediation outweigh the benefits associated with remediation. In summary:

1. The benefit to human health of implementing remediation is outweighed by the potential risks to human health resulting from driving and exposure to increased traffic, operation of machinery and exposure to hydrocarbons.
2. The benefit to the environment of implementing remediation is outweighed by the environmental impacts including greenhouse gas and air pollutant emissions from electricity generation, combustion of oil waste and air and road transport and potential for a spill during transport oil waste.
3. The implementation of remediation requires the use of precious natural resources including fossil fuels and water.
4. The implementation of remediation requires management of solid and liquid waste.
5. The implementation of remediation would impose a significant financial burden whereas the potential economic gain is negligible.

When this balance is placed in context with the absence of current risks to human health and the surrounding environment, the absence of existing beneficial uses of groundwater, the greatest benefit is to not implement remediation.

It is perhaps useful to compare the findings of this assessment with the broad sustainability factors outlined in **Section 4.3**.

"The risk to the environment posed by the impacts remaining in groundwater versus the impacts to the environment from the implementation of a remediation system".

From an environmental perspective, the key finding is the risk from the LNAPL that a remediation system would attempt to recover, are low and acceptable, whereas remediation itself creates emissions and waste with the potential to cause harm. Greenhouse gas emissions contribute to human health and environmental issues and a remediation system would create not insignificant quantities. Transport and treatment of waste has the potential for environmental impacts from tailpipe emissions and the, albeit low, risk of spill.

"The risk to human health posed by the impacts remaining in the environment versus the risk of injury and/or detriment to health resulting from the implementation of a remediation system".

Implementing remediation has incremental risks to safety primarily relating to accident from road travel. These risks are quantified using SiteWise and placed into context by comparing the risk levels commonly used to assess risk to human health from in-ground contaminants and the low and acceptable risk at this site.

"The economic gain from improving the environment against the cost of remediation". Indicators include direct economic costs and benefits".

Considering engineered recovery of LNAPL to a level that would allow a higher value use of the land is unlikely in the foreseeable long term, there is no realistic or appreciable economic gain from implementing remediation. However, the cost of implementing remediation is significant and this is quantified within the report.

The table below provides a qualitative summary of the assessment from the perspective of the community and surrounds (as compared with impacts upon workers associated with remediation). The benefits of implementing and not implementing remediation are described in terms of values or goals likely to maintain or enhance a happy and healthy human life and preserve the environment. It is noted that parts of this assessment are subjective (e.g., it is possible that a person walking past the Site may feel apprehensive due to the perception of risks from impacts).

Table 4-3 Qualitative Summary of the Assessment

Benefit	Benefit of Implementing Remediation	Benefit of Not Implementing Remediation
Healthy lives free from risk not of our choosing	Nil. Risks to human health from impacts beneath the landfill cap are low and acceptable.	Avoids risk to humans from exposure to machinery, vapours and driving to and from and around the Site. Avoids greenhouse gas and air pollutant emissions. Avoids accident risk due to increased traffic.
Life free of anxiety	Possible benefit to community due to perception that remediation will decrease the risk to health.	Possible benefit due to avoidance of traffic associated with the Site, particularly waste LNAPL transport.

Benefit	Benefit of Implementing Remediation	Benefit of Not Implementing Remediation
Healthy food Preservation of species Preservation of amenity	Nil. Risks to the environment, including Moonee Ponds Creek ecosystem are low and acceptable. Impacts beneath the landfill cap are not currently and unlikely to in the future impact surface water, groundwater or soil used for growing crops or impacting ecological to the point where flora and fauna are detrimentally affected.	Avoids risk of damage to soil and groundwater from oil spill during transport for disposal.
Vibrant life with beautiful surroundings	Negligible	Negligible
Healthy planet	Negligible	Avoid greenhouse gas and air pollutant emissions.
Regional / global high standard of living	Negligible	Negligible

5.0 LNAPL EXTRACTION PRACTICABILITY ASSESSMENT CONCLUSIONS

The LEPA presents an overview of LNAPL Conceptual Site Model, Remediation Evaluation and Review and a Net Benefit Analysis associated with the potential implementation of further LNAPL remediation efforts at the Site.

With respect to current and historical investigations, Audits and Independent Reviews, the following assessment and Audit findings provide the framework for remediation drivers for LNAPL in Mounds 1 and 2 at the Tullamarine Site:

- Low long term risks to aquatic ecosystems and primary contact recreation use of Moonee Ponds Creek due to the limited further dissolution potential from LNAPL into groundwater as a result of the landfill cap limiting infiltration potential;
- Low mobility of the LNAPL indicates limited migration potential; and
- The presence of LNAPL necessitates on-going risk management and monitoring and a rigorous assessment of the feasibility for remediation of LNAPL

Based on the above, particularly in the context of the low inferred mobility of the LNAPL as concluded in the 2007 Audit and consistent with the findings of the LNAPL extraction trials, the remediation drivers for LNAPL within Mounds 1 and 2 can be classified as follows:

- Regulatory drivers to recover LNAPL to the extent practicable;
- Societal and business factors; and
- Intergenerational equity.

Accordingly, the LNAPL remediation goal for the Site was defined as recovery of LNAPL to the extent practicable, noting that the composition of the LNAPL and its presence within capped landfill cells (where LFG vapours are captured by the LFG recovery system and the landfill cap limits the potential for infiltration) functionally eliminates the limited potential for significant further dissolution or vapour concerns. As such, the implemented remediation approach focused on mass removal whilst noting that partial mass removal will not materially change the risk profile at the Site.

LNAPL extraction trials were conducted in 2014 (utilising the most prospective recovery approach based on Site conditions) demonstrated that Site conditions would not support long term extraction and that the LNAPL is functionally immobile. Following on from the 2011 remediation technology screening, an updated review of potentially applicable technologies did not reveal significant advances in LNAPL remediation that could be potentially applicable to the Site.

Based on the trial results, it is considered that LNAPL clean up has been completed to the extent practicable and that the regulatory remediation drivers have essentially been met from a technical perspective. Logistical constraints have been previously addressed in URS, 2011, from the point of view of screening of applicable technologies and implementability of remedial options at the site, - the outcome of which was the LNAPL extraction trial.

As a means to address community concerns, an assessment was undertaken of the natural mass losses relative to hydraulic recovery and the net benefits (using sustainability principles) of active remedial actions.

Conservative estimates indicate that hydraulic recovery would require between 350 and 1,400 years of implementation to extract the estimated recoverable portion of the LNAPL, noting that in reality the required timeframes would be significantly longer and that significant volumes of LNAPL would remain trapped in the formation. In addition, an assessment of natural mass depletion processes was conducted, which indicated that significant LNAPL mass loss relative to the conservative continued hydraulic recovery scenario, would occur via volatilisation, biodegradation and dissolution. Further, studies undertaken by Kleinfelder (2015) (in draft and yet to be reviewed as part of the Audit Review of the GQMP and LWMP) indicate that the dissolved phase constituents are undergoing natural attenuation and will not pose a risk to down-gradient receptors.

In combination with the limited risk and natural mass losses, active remediation activities can also result in additional impacts to the environmental and community which include odours, greenhouse gas emissions, noise and impacts on traffic and traffic safety. A net benefit analysis was conducted and concluded that the benefit to human health of implementing remediation is outweighed by the potential risks to human health, impacts to the environment and a higher intergenerational burden.

When this balance is placed in context with the absence of drivers for remediation (e.g., risk to human health from the impacts beneath the landfill cap, restoration of a groundwater resource), and consideration of long term societal and business factors and intergenerational equity, the greatest benefit is to not implement remediation.

In conclusion, the LEPA indicates the LNAPL clean up has been completed to the extent practicable, natural mass losses will continue to occur at appreciable rates and there is no net benefit in terms of implementing further remedial efforts. In the absence of active remediation measures (aside from continued operation of the landfill gas recovery system and maintenance of the landfill cap as part of the PCMP), the Site's PCMP and in particular the GQMP will serve as the key mechanisms for the assessment of ongoing risks and potential implementation of contingency measures to manage potential risks to health and the environment in the future.

6.0 STATEMENT OF LIMITATIONS

This report is intended for the sole use of Transpacific Cleanaway Pty Ltd. The scope of services performed during this report may not be appropriate to satisfy the needs of other users, and use or re-use of this document or of the findings, conclusions or recommendations presented herein is at the sole risk of said user.

Background information and other data have been furnished to EHS Support Pty Ltd (EHS Support) by Transpacific Cleanaway and/or third parties, which EHS Support has used in preparing this report. EHS Support has relied on this information as furnished, and is neither responsible for nor has confirmed the accuracy of this information. Opinions presented herein apply to the existing and reasonably foreseeable Site conditions at the time of our assessment. They cannot apply to Site changes of which EHS Support is unaware and has not had the opportunity to review. Changes in the condition of this property may occur with time due to natural processes or works of man at the Site or on adjacent properties. Changes in applicable standards may also occur as a result of legislation or the broadening of knowledge. Accordingly, the findings of this report may be invalidated, wholly or in part, by changes beyond our control.

7.0 REFERENCES

Bardos, P, Lazar, A and Willenbrock, N. (2009). *A Review of Published Sustainability Indicator Sets*: "How applicable are they to contaminated land remediation indicator-set development?" SuRF UK, May 2009.

Beckett, G.D. and P. Lundegard. (1997). *Practically Impractical* – The limits of LNAPL recovery and relationship to risk, In: Proceedings of the Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Remediation Conference, Houston, TX, November 12-14, pp. 442-445K, Ground Water Publishing Company.

Cardno Lane Piper. (2012). *Environmental Auditor Review* – Groundwater Quality Management Plan Implementation and Liquid Waste Management Plan, Tullamarine Landfill, Western Avenue Tullamarine, VIC. Cardno Lane Piper Pty Ltd. June 2012.

Cardno Lane Piper. (2014). *Independent Review Panel* – Review of Stage 1 LNAPL Extraction Trial Baildown Testing, Cardno Lane Piper Pty Ltd. September 2014.

Charbeneau, R.J. (2007). *LNAPL Distribution and Recoverability Model* (LDRM) Volume 1: Distribution and Recovery of Petroleum Hydrocarbon Liquids in Porous Media. API Publication Number 4760, American Petroleum Institute, Washington D.C.

CRC Care (2010). *Technical Report 18* – Selecting and Assessing Strategies for Remediating LNAPL in Soils and Aquifers.C,D Johnston, CSIRO Land and Water, September 2010.

EHS Support. (2014). *LNAPL Baildown Testing Report*. EHS Support Pty. September 2014.

EPA (2008a). *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites. Office of Solid Waste and Emergency Response*. www.clu-in.org/download/remed/Green-Remediation-Primer.pdf.

EPA (2008b). *Incorporating Sustainable Practices into Site Remediation. Office of Solid Waste and Emergency Response fact sheet*.

EPA (2014) *EPA Publication 840.1 The Clean Up and Management of Polluted Groundwater*. EPA Victoria, February 2014.

GHD (2007). *Report for Tullamarine Landfill, Revised LNAPL Characterisation*. GHD. October 2007.

Golder (2004). *Groundwater Risk Assessment*, Cleanaway Landfill, Tullamarine, Victoria. Golder Associates Pty Ltd. March 2004.

Golder (2007a). *Hydrogeological Conceptual Model* (Version 3), Cleanaway Landfill, Tullamarine, Victoria. Golder Associates Pty Ltd. September 2007.

Golder (2007b). *Secondary Groundwater Risk Assessment*, Cleanaway Landfill, Tullamarine, Victoria. Golder Associates Pty Ltd. September 2007.

Hadley, P., and P. D. Ellis (2009), eds. 2009. *Sustainable Remediation Forum [SURF] White Paper— Integrating Sustainable Principles, Practices, and Metrics into Remediation Projects*, Remediation Journal 19(3): 5–114.

Higinbotham, J., M. A. Parcher, J. A. Johnson. (2003). "The Importance of Understanding Inherent LNAPL Mobility in Characterizing and Remediating Sites." Proc. Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Remediation, Costa Mesa, CA API/NGWA.

Institute of Mechanical Engineers. (2013). *Global Food Waste Not Want Not*. Institute of Mechanical Engineers January 2013.

ITRC. (2009a). *Evaluating LNAPL Remedial Technologies for Achieving Project Goals*. Washington, D.C.: Interstate Technology & Regulatory Council, LNAPLs Team. www.itrcweb.org. December 2009.

ITRC. (2009b). *Evaluating Natural Source Zone Depletion at Sites with LNAPL*. Washington, D.C.: Interstate Technology & Regulatory Council, LNAPLs Team. www.itrcweb.org. June 2009.

ITRC. (2011). *Technology Overview. Green and Sustainable Remediation:State of the Science and Practice*. Washington, D.C.: The Interstate Technology & Regulatory Council Green and Sustainable Remediation Team. www.itrcweb.org. December 2009.

Kleinfelder, (2014). *Draft Hydrogeological Assessment*, Tullamarine Closed Landfill Western Avenue, Westmeadows, Vic. Klienfelder Australia Pty Ltd, October 2014.

Kleinfelder, (2015). *Draft Leachate Natural Attenuation Assessment*, Tullamarine Closed Landfill Western Avenue, Westmeadows, Vic. Klienfelder Australia Pty Ltd, February 2015.

LanePiper (2007). *Environmental Audit Report* (Secondary Risk Assessment), Tullamarine Landfill, Western Avenue Tullamarine, VIC. LanePiper, December 2007.

Mercer, J.W. and Cohen, R.M. (1990). *A review of immiscible fluids in the subsurface: properties, models, characterisation and remediation*. J. Contaminant Hydrology, 6, 107-162.

Nadebaum, P (2011). *A Framework for Assessing the Sustainability of Soil and Groundwater Remediation*. SuRF Australia, April 2011.

Nadebaum, P, Beck, P (2009). *Cleaning Up Groundwater* – Sustainability and Value Considerations, Ecoforum09, April, Sydney

Parcher, M.A., J.A. Johnson, and J.C. Parker. 1995. *Effects of soil type on separate phase hydrocarbon recovery under fluctuating water conditions.* In: Proceedings of the 1995 Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Remediation Conference, Houston, Texas, Ground Water Publishing Company, pp. 439-451.

Siddique et al. (2007). *Metabolism of BTEX and naphtha compounds to methane in oil sands tailings.* Siddique. T, Fedorak P.M and Mackinnon M.D. Environ Sci Technol. 2007 Apr 1;41 (7):2350-6.

SiteWise™ Version 3. (2013). Batelle Memorial Institute, July 2013.

Sustainable Remediation Forum (SURF), 2009. *Integrating sustainable principles, practices and metrics into remediation projects.* Remediation Journal, 19(3), 5-114. Editors P. Hadley and D. Ellis.

Transpacific (2012). *Post Closure Management Plan* – Ambient Air & Landfill Gas Management Plan, Transpacific Cleanaway Pty Ltd. September 2012.

USEPA (2012). *A Framework For Sustainability Indicators at EPA,* USEPA, October 2012.

USGS (2006). *Description, Properties, and Degradation of Selected Volatile Organic Compounds Detected in Ground Water – A Review of Selected Literature* U.S. Geological Survey, 2006.

URS (2010). *Feasibility Assessment of Tullamarine Closed Landfill LNAPL Disposal Options*. URS Australia Pty Ltd. August 2010.

URS (2011). *Assessment of Tullamarine Closed Landfill LNAPL Extraction Trial Options*. URS Australia Pty Ltd. August 2011.

URS (2012). *Detailed Design Report*, Tullamarine Closed Landfill LNAPL Extraction Trial Detailed Design. URS Australia Pty Ltd. November 2012.

URS (2013). *Landfill Gas Treatment Options Review*. URS Australia Pty Ltd. December 2013.

TABLES

Table 1 Effective Solubility and Effective Vapour Concentrations

LNAPL Samples	Constituent	Unit	Minimum	Maximum	Average
Lab Data	C6-9	mg/kg	3600	79000	32115
	C10-14	mg/kg	38000	190000	104846
	C15-28	mg/kg	110000	420000	283077
	C29-36	mg/kg	71000	260000	189308
	Total	mg/kg	222600	949000	609346
Mass Fraction	C6-9	-	0.0162	0.0832	0.0527
	C10-14	-	0.1707	0.2002	0.1721
	C15-28	-	0.4942	0.4426	0.4646
	C29-36	-	0.3190	0.2740	0.3107
Molecular Weight	C6-9	g/mol	110	110	110
	C10-14	g/mol	170	170	170
	C15-28	g/mol	310	310	310
	C29-36	g/mol	422	422	422
	Total	g/mol	316	316	316
Lab Data	benzene	mg/kg	10	250	54
	toluene	mg/kg	10	2200	611
	ethylbenzene	mg/kg	320	1400	889
	m&p xylene	mg/kg	220	5300	1834
	o xylene	mg/kg	36	1000	457
	naphthalene	mg/kg	57	3900	688
Mass Fraction	benzene	-	0.00001	0.0003	0.0001
	toluene	-	0.0000	0.0022	0.0006
	ethylbenzene	-	0.0003	0.0014	0.0009
	m&p xylene	-	0.0002	0.0053	0.0018
	o xylene	-	0.00004	0.0010	0.0005
	naphthalene	-	0.0001	0.0039	0.0007
Molecular Weight	Benzene	g/mol	78	78	78
	toluene	g/mol	92	92	92
	ethylbenzene	g/mol	106	106	106

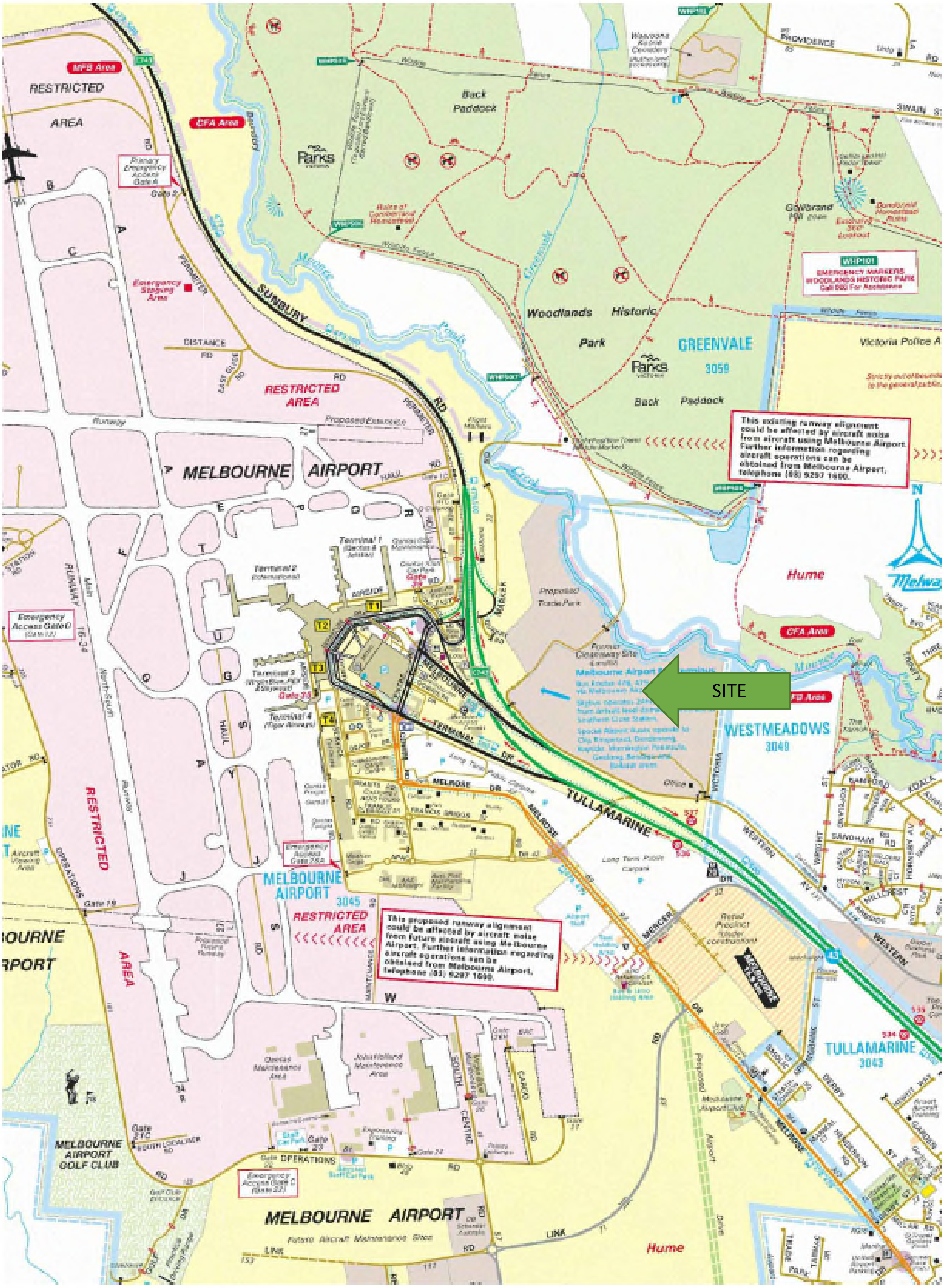
LNAPL Samples	Constituent	Unit	Minimum	Maximum	Average
	m&p xylene	g/mol	106	106	106
	o xylene	g/mol	106	106	106
	naphthalene	g/mol	128	128	128
Mole Fraction	Benzene	-	0.00004	0.0009	0.0002
	toluene	-	0.00003	0.0071	0.0021
	ethylbenzene	-	0.00096	0.0039	0.0026
	m&p xylene	-	0.00066	0.0148	0.0054
	o xylene	-	0.00011	0.0028	0.0013
	naphthalene	-	0.00014	0.0090	0.0017
	C6-9		0.04649	0.2393	0.1515
	C10-14		0.31754	0.3724	0.3201
	C15-28		0.50407	0.4514	0.4739
	C29-36		0.23900	0.2053	0.2328
Pure Phase Water Solubility*	benzene	mg/L	1790	1790	1790
	toluene	mg/L	52.6	52.6	52.6
	ethylbenzene	mg/L	169	169	169
	m&p xylene	mg/L	106	106	106
	o xylene	mg/L	106	106	106
	naphthalene	mg/L	31	31	31
	octane	mg/L	0.007	0.007	0.007
	dodecane	mg/L	0.0037	0.0037	0.0037
Dissolved Phase Concentration (calculated effective solubility)	benzene	mg/L	0.073	1.70	0.39
	toluene	mg/L	0.002	0.37	0.11
	ethylbenzene	mg/L	0.163	0.66	0.44
	m&p xylene	mg/L	0.070	1.57	0.57
	o xylene	mg/L	0.011	0.30	0.14
	xylene total	mg/L	0.082	1.86	0.71
	naphthalene	mg/L	0.004	0.28	0.05
	octane	mg/L	0.0003	0.0017	0.0011
	dodecane	mg/L	0.0012	0.0014	0.0012

LNAPL Samples	Constituent	Unit	Minimum	Maximum	Average
Pure Phase Equilibrium Pressure*	benzene	Pa	12553	12553	12553
	toluene	Pa	3775	3775	3775
	ethylbenzene	Pa	1267	1267	1267
	m&p xylene	Pa	1110	1110	1110
	o xylene	Pa	1110	1110	1110
	naphthalene	Pa	11.6	11.6	11.6
	octane	Pa	1470	1470	1470
	dodecane	Pa	18	18	18
Calculated Maximum Vapour Concentration	benzene	ppm	25.112		
	toluene	ppm	179.276		
	ethylbenzene	ppm	48.493		
	m&p xylene	ppm	65.360		
	o xylene	ppm	12.745		
	naphthalene	ppm	0.257		
	octane	ppm	720.011		
	dodecane	ppm	61.436		
Vapour Concentration	benzene	mg/m^3	16.14	374.97	85.11
	toluene	mg/m^3	4.85	992.30	288.81
	ethylbenzene	mg/m^3	52.14	211.94	141.06
	m&p xylene	mg/m^3	31.40	702.92	254.85
	o xylene	mg/m^3	5.14	132.63	63.51
	naphthalene	mg/m^3	0.09	5.41	1.00
	octane	mg/m^3	3034.46	15619.44	9889.03
	dodecane	mg/m^3	392.21	459.99	395.32

* USEPA, 2014. Regional Screening Levels, Region 9. United States Environmental Protection Agency. http://www.epa.gov/region9/superfund/prg/.

FIGURES

Figure 1 Site Location Plan



EHS Support *consider it done*	TRANSPACIFIC CLEANWAY PTY LTD	**FIGURE 1** SITE LOCATION MAP	Drawn By: BC
			Date Drawn: 06/2014
			Reviewed By: KS
			Date Reviewed: 06/2014
			Scale: - NTS -
			Plot Date: 06/2014
			Project Number: C00689

APPENDIX A LNAPL ANALYTICAL DATA

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

Chartered Chemists

11-Jul-2014

REPORT NUMBER: M140798R1

Site/Client Ref: LNAPL Trial Sampling Event

Order No: 507127

Transpacific Cleanaway Pty Ltd

Private Bag 5
Tullamarine
VIC 3043
Attention: Kieren McDermott

CERTIFICATE OF ANALYSIS

This report replaces previous report dated 11-Jul-2014

SAMPLES: Two samples were received for analysis

DATE RECEIVED: **19-May-2014**

DATE COMMENCED: **19-May-2014**

METHODS: See Attached Results

RESULTS: Please refer to attached pages for results.

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

REPORTED BY:

Popy Dembalas
Chemist

(I) RESULTS

Report N°: M140798R1

Matrix: LNAPL

Method: MA-82.LNAPL.T001-3 Polychlorinated Biphenyls

Sample units are expressed in mg/kg

	Leeder ID		2014006796	2014006797	2014006798	2014006799
	Client ID		MT2373L7	MT2378L12	MT2373L7	Method
Analyte Name		PQL			DUP	BLANK
MA-82.LNAPL.T0	**Arochlor 1016**	2	nd	nd	nd	nd
	Arochlor 1221	2	nd	nd	nd	nd
	Arochlor 1232	2	nd	nd	nd	nd
	Arochlor 1242	2	53	78	49	nd
	Arochlor 1248	2	nd	nd	nd	nd
	Arochlor 1254	2	nd	nd	nd	nd
	Arochlor 1260	2	nd	18	nd	nd
	Arochlor 1262	2	nd	nd	nd	nd
	Arochlor 1268	2	nd	nd	nd	nd

Matrix: LNAPL

Method: MA-10.OIL.01 Monoaromatic Hydrocarbons

Sample units are expressed in mg/kg

	Leeder ID		2014006796	2014006797	2014006798	2014006799
	Client ID		MT2373L7	MT2378L12	MT2373L7	Method
Analyte Name		PQL			DUP	BLANK
	Benzene	1	43	50	45	nd
	Chlorobenzene	1	27	140	29	nd
	1,2-Dichlorobenzene	1	53	160	57	nd
	1,3-Dichlorobenzene	1	4	8	4	nd
	1,4-Dichlorobenzene	1	47	100	51	nd
	Ethyl Benzene	1	750	1300	810	nd
	Toluene	1	10	1400	11	nd
	m&p-Xylenes	1	310	2000	340	nd
	o-Xylene	1	36	390	39	nd

(I) RESULTS

Report N°: M140798R1

Matrix: LNAPL

Method: MA-72.LNAPL.T001-3 Polycyclic Aromatic Hydrocarbons

Sample units are expressed in mg/L

		Leeder ID	2014006796	2014006797	2014006798	2014006799
		Client ID	MT2373L7	MT2378L12	MT2373L7	Method
Analyte Name		PQL			DUP	BLANK
MA-72.LNAPL.T0	**Naphthalene**	20	420	910	440	nd
	Acenaphthylene	20	nd	nd	nd	nd
	Acenaphthene	20	22	130	23	nd
	Fluorene	20	47	210	47	nd
	Phenanthrene	20	110	630	110	nd
	Anthracene	20	nd	120	nd	nd
	Fluoranthene	20	nd	210	nd	nd
	Pyrene	20	26	260	28	nd
	Benzo(a)anthracene	20	nd	64	nd	nd
	Chrysene	20	nd	62	nd	nd
	Benzo(b)fluoranthene	20	nd	nd	nd	nd
	Benzo(k)fluoranthene	20	nd	nd	nd	nd
	Benzo(a)pyrene	20	nd	nd	nd	nd
	Indeno(123-cd)pyrene	20	nd	nd	nd	nd
	Dibenzo(ah)anthracene	20	nd	nd	nd	nd
	Benzo(ghi)perylene	20	nd	nd	nd	nd
	3-Methyl cholanthrene	20	nd	nd	nd	nd

(I) RESULTS

Report N°: M140798R1

Matrix: LNAPL

Method: MA-30.LNAPL.T1 Total Petroleum Hydrocarbons

Sample units are expressed in mg/kg

	Leeder ID		2014006796	2014006797	2014006798	2014006799
	Client ID		MT2373L7	MT2378L12	MT2373L7	Method
Analyte Name		**PQL**			DUP	BLANK
	C6-C9	20	4900	13000	5500	nd
	C10-C14	20	88000	140000	98000	nd
	C15-C28	50	320000	360000	340000	nd
	C29-C36	50	260000	240000	290000	nd
	Total C6-C36	50	670000	760000	730000	nd

Matrix: LNAPL

Method: MA-1400.LNAPL.T001-3 Metals via ICP-MS

Sample units are expressed in mg/kg

		Leeder ID	2014006796	2014006797	2014006798	2014006799
		Client ID	MT2373L7	MT2378L12	MT2373L7	Method
Analyte Name		PQL			DUP	BLANK
MA-1400.LNAPL.	**Arsenic**	5	nd	nd	nd	nd
	Aluminium	5	70	52	57	nd
	Antimony	5	nd	nd	nd	nd
	Barium	5	8	8	6	nd
	Boron	10	nd	nd	nd	nd
	Cadmium	1	nd	nd	nd	nd
	Chromium	2	51	100	45	nd
	Cobalt	2	nd	nd	nd	nd
	Copper	2	4	9	4	nd
	Total Iron	5	50	110	45	nd
	Lead	5	nd	5	nd	nd
	Total Manganese	5	nd	nd	nd	nd
	Mercury	5	nd	nd	nd	nd
	Molybdenum	5	nd	nd	nd	nd
	Nickel	2	nd	3	nd	nd
	Potassium	5	nd	86	nd	nd
	Selenium	5	nd	nd	nd	nd
	Silver	5	nd	nd	nd	nd
	Sodium	5	57	1000	57	nd
	Thallium	5	nd	nd	nd	nd
	Tin	5	24	7	23	nd
	Vanadium	5	nd	5	nd	nd
	Zinc	5	nd	12	nd	nd

(I) RESULTS

Report N°: M140798R1

Matrix: LNAPL

Method: PC CA.LNAPL.T001-3

Sample units are expressed in g/mL

		Leeder ID	2014006796	2014006797
		Client ID	MT2373L7	MT2378L12
Analyte Name		**PQL**		
	Density @ 30°C (g/mL)		0.89	0.89
	Density @ 25°C (g/mL)		0.90	0.90
	Density @ 40°C (g/mL)		0.89	0.89
ASTM D93 / IP 34	**Flash Point (°C)**		95	100
ASTM D445 / IP	**Viscosity (cSt @ 30°C)**		110	110
ASTM D445 / IP	**Viscosity (cSt @ 25°C)**		140	130
ASTM D445 / IP	**Viscosity (cSt @ 40°C)**		74	79
	LNAPL / Air Surface tension		25	28
	LNAPL / Water Interfacial		11	17

Matrix: LNAPL

Method: MA-82.LNAPL.T001-3 Polychlorinated Biphenyls

Quality Control Results are expressed in Percent Recovery of expected result

Analyte Name		PQL				
		Leeder ID	2014006800	2014006801	2014006802	2014006803
		Client ID	MT2373L7	MT2373L7	Method	Method
			SPIKE	SPIKEDUP	SPIKE	SPIKEDUP
	Arochlor 1260		108	104	80	83

Matrix: LNAPL

Method: MA-10.OIL.01 Monoaromatic Hydrocarbons

Quality Control Results are expressed in Percent Recovery of expected result

Analyte Name		PQL		
		Leeder ID	2014006800	2014006801
		Client ID	MT2373L7	MT2373L7
			SPIKE	SPIKEDUP
	Benzene		U	U
	Chlorobenzene		83	81
	1,2-Dichlorobenzene		80	73
	1,3-Dichlorobenzene		65	61
	1,4-Dichlorobenzene		79	74
	Ethyl Benzene		80	75
	Toluene		U	U
	m&p-Xylenes		90	84
	o-Xylene		U	U

Matrix: LNAPL

Method: MA-72.LNAPL.T001-3 Polycyclic Aromatic Hydrocarbons

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014006800	2014006801	2014006802	2014006803
		Client ID	MT2373L7	MT2373L7	Method	Method
Analyte Name		PQL	SPIKE	SPIKEDUP	SPIKE	SPIKEDUP
	Acenaphthene		101	109	118	110
	Pyrene		U	U	115	111

Matrix: LNAPL

Method: MA-30.LNAPL.T1 Total Petroleum Hydrocarbons

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014006802	2014006803
		Client ID	Method	Method
Analyte Name		PQL	SPIKE	SPIKEDUP
	Total C6-C36		108	113

Matrix: LNAPL

Method: MA-1400.LNAPL.T001-3 Metals via ICP-MS

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014006800	2014006801
		Client ID	MT2373L7	MT2373L7
Analyte Name		**PQL**	SPIKE	SPIKEDUP
MA-1400.LNAPL.	**Arsenic**		98	98
	Aluminium		120	107
	Antimony		105	105
	Barium		102	99
	Boron		94	98
	Cadmium		98	99
	Chromium		100	110
	Cobalt		97	97
	Copper		95	91
	Total Iron		123	121
	Lead		91	90
	Total Manganese		103	104
	Mercury		108	108
	Molybdenum		99	99
	Nickel		100	99
	Potassium		97	102
	Selenium		102	99
	Silver		92	93
	Sodium		U	U
	Thallium		90	90
	Tin		98	96
	Vanadium		90	95
	Zinc		99	96

QUALIFIERS / NOTES FOR REPORTED RESULTS

PQL	Practical Quantitation Limit
is	Insufficient Sample to perform this analysis.
T	Tentative identification based on computer library search of mass spectra.
ND	Not Detected – The analyte was not detected above the reported PQL.
NC	Not calculated, Results below PQL
nr	Not Requested for analysis.
R	Rejected Result – results for this analysis failed QC checks.
SQ	Semi-Quantitative result – quantitation based on a generic response factor for this class of analyte.
IM	Inappropriate method of analysis for this compound
U	Unable to provide Quality Control data – high levels of compounds in sample interfered with analysis of QC results.
UF	Unable to provide Quality Control data- Surrogates failed QCchecks due to sample matrix effects
L	Analyte detected at a level above the linear response of calibration curve.
C1	These compounds co-elute.
C2	These compounds co-elute.
CT	Elevated concentration. Results reported from carbon tube analysis
**	Sample shows non-petroleum hydrocarbon profile

LNAPL.T001-3 SGS Perth Rpt # PG92096

APPENDIX ONE.

CHAIN OF CUSTODY DOCUMENT

KingTech Services : SAMPLE CUSTODY FORM

KTS JOB NO : 131114

CLIENT: Transpacific Cleanaway Pty Ltd

REFERENCE : Schedule 17: May 2014 LNAPL Trial Sampling Event

ORDER NUMBER : see TPI Cleanaway - K. McDermott

Sample ID (Number/Name)	Date	Time	Sample Source (Ground/Surface/Leachate)	Laboratory Analyses to be Performed	Number of Containers	Comments (Preservatives/Site Details/Storage)
MT2373L7	15/05/2014	16:35	LNAPL	See instruction letter.	3+1	Warning - this material must be handled with caution.
MT2378L12	16/05/2014	11:00	LNAPL	Physical properties- density, viscosity, (both at three temperatures), surface tension (air/oil, oil/water), flash point.	3+1	
				PCBs, MAHs, PAHs, TPH, Metals.		

Sampled By (Name and Signature) : Mark Kenna [signature]
Contact No: 041 954 3936

Relinquished By : (Name and Signature) Mark Kenna [signature]
Company: KingTech

Received By : (Name and Signature) James Phillips [signature]
Company: SGS Leeder Consulting

Date and Time 19/05/2014 09:20
19/5/14 9:23

Remarks :

Results To: Kieren McDermott

email: Kieren.McDermott@transpac.com.au

Relinquished By : (Name and Signature)
Company:

Received By : (Name and Signature)
Company:

Date and Time

F_SCF0106

From: Alex Schiavoni [mailto:Alex.Schiavoni@ehs-support.com]
Sent: Tuesday, 13 May 2014 10:14 AM
To: Kieren McDermott; AU.SampleReceipt.Mitcham (Melbourne)
Cc: Mark
Subject: RE: Tullamarine LNAPL Sampling -URGENT QUERIES

Hi Lyndall,

The temperatures required are 20, 30 and 40°C.

Cheers
Alex Schiavoni
Principal Hydrogeologist
EHS Support Pty Ltd
PO Box 5056, Moreland West Victoria, 3055, Australia
Tel: +61 3 8300 0151 Mob: +61 407 863 572
alex.schiavoni@ehs-support.com
www.ehs-support.com

Consider it done.
Work Safe. Live Safe. Stay Safe.

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Tuesday, 13 May 2014 9:47 AM
To: AU.SampleReceipt.Mitcham (Melbourne)
Cc: Mark; Alex Schiavoni
Subject: RE: Tullamarine LNAPL Sampling -URGENT QUERIES

Hi Lyndall

Alex will need to advise on the temperatures he requires for the density and viscosity assessment.

PQLs, will be as per the standard PQLs we have in the agreed schedule lists.

Having said that I doubt if you can achieve PQL in many cases because generally there will be very high concentrations in the samples. PCBs in the leachate will be interesting because their concentrations will be low to negligible yet the leachate will be saturated with other hydrocarbon products potentially creating a lot of noise in the analytical instrument. This might make analysis to PQL for PCBs very difficult. I am mentioning this because SGS might need to modify the way you analyse these samples.

Kieren McDermott | Environmental Specialist | Post Collection
Transpacific Industries Group Ltd
Western Ave Tullamarine Vic | Private Bag 5 Tullamarine VIC 3043
P: + 61 3 9335 8868 (Direct) **| F:** + 61 3 9551 9217 **| M:** + 61 408 996 292

E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

Please consider the environment before printing this email.

From: AU.SampleReceipt.Mitcham (Melbourne) [mailto:AU.SampleReceipt.Mitcham@sgs.com]
Sent: Tuesday, 13 May 2014 9:29 AM
To: Kieren McDermott
Cc: Mark; Alex Schiavoni
Subject: RE: Tullamarine LNAPL Sampling -URGENT QUERIES
Importance: High

Kieren,

Also can you please provide the temperatures you require for density and viscosity?
What PQL do you require for the composition analysis as this determines the bottle size I need to give Mark to use for sampling?
Thanks for your time

Regards,

Lyndall Stevens
Environmental Services
Sample Reception Team Leader

SGS LEEDER CONSULTING
Melbourne Office
Unit 5 /18 Redland Drive
Mitcham VIC 3132,
Australia

Phone +61 (0)3 9874 1988
Fax: +61 (0)3 9874 1933
Email: **lyndall.stevens@sgs.com**
Web: www.au.sgs.com

From: Stevens, Lyndall (Melbourne)
Sent: Tuesday, 13 May 2014 9:03 AM
To: 'Kieren McDermott'
Cc: Mark; Alex Schiavoni
Subject: RE: Tullamarine LNAPL Sampling

Kieren,

As discussed yesterday the analysis listed in Suites 1 & 2 are only suitable for the leachate matrix. We are unable to carry out these parameters on an LNAPL matrix.

Regards,

Lyndall Stevens
Environmental Services
Sample Reception Team Leader

SGS LEEDER CONSULTING
Melbourne Office
Unit 5 /18 Redland Drive
Mitcham VIC 3132,
Australia

Phone +61 (0)3 9874 1988
Fax: +61 (0)3 9874 1933
Email: **lyndall.stevens@sgs.com**
Web: www.au.sgs.com

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Monday, 12 May 2014 5:46 PM
To: Stevens, Lyndall (Melbourne)
Cc: Mark; Alex Schiavoni
Subject: Tullamarine LNAPL Sampling

Lyndall

Apologies for taking so long to get back to you today. Note that we will be sampling no more than 6 locations this round (plus QA samples). Physical properties will be for LNAPL matrix only and composition will be for both LNAPL and leachate matrices. Please note that in terms of reporting levels the samples will have high concentrations and the leachate samples will be saturated / supersaturated and so you will need to prep the laboratory testing equipment accordingly.

I can confirm the following :

	Sample Type	**Analytes**	**Quantities**
		Physical Properties (1 Matrix LNAPL only): -Density at 3 temperatures -Viscosity at 3 temperatures -Surface tension (air/oil)(oil/water)(air water) -Flash point	1 LNAPL sample per well (up to 14 samples in total)
		Composition (LNAPL & Leachate Matrix): -PCB -MAH -PAH -TPH -Metals -Suite 1, plus alkalinity -Suite 2, plus Nitrate	1 LNAPL & 1 Leachate sample per well (up to 14 samples in total)

Kieren McDermott | Environmental Specialist | Post Collection
Transpacific Industries Group Ltd
Western Ave Tullamarine Vic | Private Bag 5 Tullamarine VIC 3043
P: + 61 3 9335 8868 (Direct) **| F:** + 61 3 9551 9217 **| M:** + 61 408 996 292

E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Monday, 7 July 2014 10:13 AM
To: Stevens, Lyndall (Melbourne)
Subject: RE: SGS Leeder Quotation - LNAPL Analysis

Lyndall

Just use this one for all 13 and Nicole will be able to make an adjustment when the invoice arrives.

Kieren McDermott | Environmental Specialist | Post Collection – Vic Landfills
Transpacific Cleanaway
46 Victory Rd | Clarinda VIC 3169
P: + 61 3 9335 8868 (Direct) **|** **M:** + 61 408 996 292

E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

From: Stevens, Lyndall (Melbourne) [mailto:Lyndall.Stevens@sgs.com]
Sent: Monday, 7 July 2014 10:11 AM
To: Kieren McDermott
Subject: RE: SGS Leeder Quotation - LNAPL Analysis
Importance: High

Kieren,
The first job had 2 samples (M140798), the second had 4 (M141125), and the third has 7 (M141256). This totals to 13. Is this PO number able to be used for the 3rd job?

Regards,

Lyndall Stevens
Environmental Services
Sample Reception Team Leader

SGS LEEDER CONSULTING
Melbourne Office
Unit 5 /18 Redland Drive
Mitcham VIC 3132,
Australia

Phone +61 (0)3 9874 1988
Fax: +61 (0)3 9874 1933
Email: **lyndall.stevens@sgs.com**
Web: www.au.sgs.com

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Monday, 7 July 2014 10:01 AM
To: Stevens, Lyndall (Melbourne)
Subject: FW: SGS Leeder Quotation - LNAPL Analysis

Hi Lyndall

Please use PO No 507127 for up to 12 LNAPL samples.

Kieren McDermott | Environmental Specialist | Post Collection – Vic Landfills
Transpacific Cleanaway
46 Victory Rd | Clarinda VIC 3169
P: + 61 3 9335 8868 (Direct) **|** **M:** + 61 408 996 292
E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

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

Chartered Chemists

11-Jul-2014

REPORT NUMBER: M141125

Site/Client Ref: LNAPL Trial Sampling Event

Order No: 507127

Transpacific Cleanaway Pty Ltd

Private Bag 5
Tullamarine
VIC 3043
Attention: Kieren McDermott

CERTIFICATE OF ANALYSIS

SAMPLES: Four samples were received for analysis

DATE RECEIVED: **20-Jun-2014**

DATE COMMENCED: **20-Jun-2014**

METHODS: See Attached Results

RESULTS: Please refer to attached pages for results.

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

REPORTED BY:

Popy Dembalas
Chemist

(I) RESULTS

Report N°: M141125

Matrix: LNAPL

Method: MA-82.LNAPL.T001-3 Polychlorinated Biphenyls

Sample units are expressed in mg/kg

		Leeder ID	2014009728	2014009729	2014009730	2014009731
		Client ID	MT2380L14	MT2367L1	MT2374L8	MT2375L9
Analyte Name		PQL				
MA-82.LNAPL.T0	**Arochlor 1016**	2	nd	nd	nd	nd
	Arochlor 1221	2	nd	nd	nd	nd
	Arochlor 1232	2	nd	nd	nd	nd
	Arochlor 1242	2	26	90	31	56
	Arochlor 1248	2	nd	nd	nd	nd
	Arochlor 1254	2	39	99	28	78
	Arochlor 1260	2	6	37	9	10
	Arochlor 1262	2	nd	nd	nd	nd
	Arochlor 1268	2	nd	nd	nd	nd

Matrix: LNAPL

Method: MA-82.LNAPL.T001-3 Polychlorinated Biphenyls

Sample units are expressed in mg/kg

		Leeder ID	2014009732	2014009733
		Client ID	MT2380L14	Method
Analyte Name		PQL	DUP	BLANK
MA-82.LNAPL.T0	**Arochlor 1016**	2	nd	nd
	Arochlor 1221	2	nd	nd
	Arochlor 1232	2	nd	nd
	Arochlor 1242	2	25	nd
	Arochlor 1248	2	nd	nd
	Arochlor 1254	2	40	nd
	Arochlor 1260	2	5	nd
	Arochlor 1262	2	nd	nd
	Arochlor 1268	2	nd	nd

(I) RESULTS

Report N°: M141125

Matrix: LNAPL

Method: MA-10.OIL.01 Monoaromatic Hydrocarbons

Sample units are expressed in mg/kg

	Leeder ID		2014009728	2014009729	2014009730	2014009731
	Client ID		MT2380L14	MT2367L1	MT2374L8	MT2375L9
Analyte Name		PQL				
	Benzene	1	250	40	62	42
	Chlorobenzene	1	28	71	10	29
	1,2-Dichlorobenzene	1	29	16	140	20
	1,3-Dichlorobenzene	1	2	8	10	7
	1,4-Dichlorobenzene	1	42	59	88	93
	Ethyl Benzene	1	1300	1100	1200	740
	Toluene	1	400	21	1500	290
	m&p-Xylenes	1	2400	1100	2600	1700
	o-Xylene	1	870	85	990	360

Matrix: LNAPL

Method: MA-10.OIL.01 Monoaromatic Hydrocarbons

Sample units are expressed in mg/kg

	Leeder ID		2014009732	2014009733
	Client ID		MT2380L14	Method
Analyte Name		PQL	DUP	BLANK
	Benzene	1	270	nd
	Chlorobenzene	1	30	nd
	1,2-Dichlorobenzene	1	31	nd
	1,3-Dichlorobenzene	1	3	nd
	1,4-Dichlorobenzene	1	43	nd
	Ethyl Benzene	1	1300	nd
	Toluene	1	380	nd
	m&p-Xylenes	1	2400	nd
	o-Xylene	1	870	nd

(I) RESULTS

Report N°: M141125

Matrix: LNAPL

Method: MA-72.LNAPL.T001-3 Polycyclic Aromatic Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014009728	2014009729	2014009730	2014009731
		Client ID	MT2380L14	MT2367L1	MT2374L8	MT2375L9
Analyte Name		PQL				
MA-72.LNAPL.T0	**Naphthalene**	20	360	880	520	310
	Acenaphthylene	20	nd	nd	nd	nd
	Acenaphthene	20	64	150	92	80
	Fluorene	20	66	150	110	80
	Phenanthrene	20	170	560	410	320
	Anthracene	20	29	68	24	63
	Fluoranthene	20	86	250	100	170
	Pyrene	20	100	250	120	140
	Benzo(a)anthracene	20	nd	44	29	43
	Chrysene	20	nd	40	26	38
	Benzo(b)fluoranthene	20	nd	nd	nd	nd
	Benzo(k)fluoranthene	20	nd	nd	nd	nd
	Benzo(a)pyrene	20	nd	nd	nd	nd
	Indeno(123-cd)pyrene	20	nd	nd	nd	nd
	Dibenzo(ah)anthracene	20	nd	nd	nd	nd
	Benzo(ghi)perylene	20	nd	nd	nd	nd
	3-Methyl cholanthrene	20	nd	nd	nd	nd

(I) RESULTS

Report N°: M141125

Matrix: LNAPL

Method: MA-72.LNAPL.T001-3 Polycyclic Aromatic Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014009732	2014009733
		Client ID	MT2380L14	Method
Analyte Name		PQL	DUP	BLANK
MA-72.LNAPL.T0	Naphthalene	20	390	nd
	Acenaphthylene	20	nd	nd
	Acenaphthene	20	66	nd
	Fluorene	20	69	nd
	Phenanthrene	20	170	nd
	Anthracene	20	31	nd
	Fluoranthene	20	99	nd
	Pyrene	20	110	nd
	Benzo(a)anthracene	20	nd	nd
	Chrysene	20	nd	nd
	Benzo(b)fluoranthene	20	nd	nd
	Benzo(k)fluoranthene	20	nd	nd
	Benzo(a)pyrene	20	nd	nd
	Indeno(123-cd)pyrene	20	nd	nd
	Dibenzo(ah)anthracene	20	nd	nd
	Benzo(ghi)perylene	20	nd	nd
	3-Methyl cholanthrene	20	nd	nd

(I) RESULTS

Report N°: M141125

Matrix: LNAPL

Method: MA-30.LNAPL.T1 Total Petroleum Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014009728	2014009729	2014009730	2014009731
		Client ID	MT2380L14	MT2367L1	MT2374L8	MT2375L9
Analyte Name		PQL				
	C6-C9	20	32000	32000	30000	22000
	C10-C14	20	110000	120000	140000	77000
	C15-C28	50	310000	400000	380000	420000
	C29-C36	50	220000	200000	200000	220000
	Total C6-C36	50	670000	760000	750000	730000

Matrix: LNAPL

Method: MA-30.LNAPL.T1 Total Petroleum Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014009732	2014009733
		Client ID	MT2380L14	Method
Analyte Name		PQL	DUP	BLANK
	C6-C9	20	32000	nd
	C10-C14	20	110000	nd
	C15-C28	50	300000	nd
	C29-C36	50	210000	nd
	Total C6-C36	50	650000	nd

(I) RESULTS

Report N°: M141125

Matrix: LNAPL

Method: MA-1400.LNAPL.T001-3 Metals via ICP-MS

Sample units are expressed in mg/kg

		Leeder ID	2014009728	2014009729	2014009730	2014009731
		Client ID	MT2380L14	MT2367L1	MT2374L8	MT2375L9
Analyte Name		**PQL**				
MA-1400.LNAPL.	**Arsenic**	5	nd	nd	nd	nd
	Aluminium	5	59	33	56	28
	Antimony	5	nd	nd	nd	nd
	Barium	5	11	nd	nd	nd
	Boron	10	nd	nd	nd	nd
	Cadmium	1	nd	nd	nd	nd
	Chromium	2	110	60	61	33
	Cobalt	2	nd	nd	nd	nd
	Copper	2	9	8	10	3
	Total Iron	5	200	52	96	93
	Lead	5	5	nd	nd	nd
	Total Manganese	5	nd	nd	nd	nd
	Mercury	5	nd	nd	nd	nd
	Molybdenum	5	nd	nd	nd	nd
	Nickel	2	nd	nd	nd	nd
	Potassium	5	45	27	34	87
	Selenium	5	nd	nd	nd	nd
	Silver	5	nd	nd	nd	nd
	Sodium	5	430	9	230	1400
	Thallium	5	nd	nd	nd	nd
	Tin	5	nd	nd	nd	nd
	Vanadium	5	35	20	20	12
	Zinc	5	14	8	12	nd

(I) RESULTS

Report N°: M141125

Matrix: LNAPL

Method: MA-1400.LNAPL.T001-3 Metals via ICP-MS

Sample units are expressed in mg/kg

		Leeder ID	2014009732	2014009733
		Client ID	MT2380L14	Method
Analyte Name		**PQL**	DUP	BLANK
MA-1400.LNAPL.	**Arsenic**	5	nd	nd
	Aluminium	5	65	nd
	Antimony	5	nd	nd
	Barium	5	12	nd
	Boron	10	nd	nd
	Cadmium	1	nd	nd
	Chromium	2	120	nd
	Cobalt	2	nd	nd
	Copper	2	9	nd
	Total Iron	5	220	nd
	Lead	5	5	nd
	Total Manganese	5	nd	nd
	Mercury	5	nd	nd
	Molybdenum	5	nd	nd
	Nickel	2	nd	nd
	Potassium	5	50	nd
	Selenium	5	nd	nd
	Silver	5	nd	nd
	Sodium	5	460	nd
	Thallium	5	nd	nd
	Tin	5	5	nd
	Vanadium	5	37	nd
	Zinc	5	15	nd

(I) RESULTS

Report N°: M141125

Matrix: LNAPL

Method: PC CA.LNAPL.T001-3

Sample units are expressed in g/mL @ 30 °C

	Leeder ID		2014009728	2014009729	2014009730	2014009731
	Client ID		MT2380L14	MT2367L1	MT2374L8	MT2375L9
Analyte Name		**PQL**				
	Density @ 30°C (g/mL)		0.88	0.89	0.89	0.88
	Density @ 25°C (g/mL)		0.90	0.90	0.90	0.90
	Density @ 40°C (g/mL)		0.87	0.88	0.88	0.88
ASTM D93 / IP 34	**Flash Point (°C)**		95	85	120	95
ASTM D445 / IP	**Viscosity (cSt @ 30°C)**		130	86	140	83
ASTM D445 / IP	**Viscosity (cSt @ 25°C)**		170	110	180	110
ASTM D445 / IP	**Viscosity (cSt @ 40°C)**		87	57	88	55
	LNAPL / Air Surface tension		14	12	21	12
	LNAPL / Water Interfacial		14	20	19	13

(II) QUALITY CONTROL

Report N°: M141125

Matrix: LNAPL

Method: MA-82.LNAPL.T001-3 Polychlorinated Biphenyls

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014009734	2014009735	2014009736	2014009737
		Client ID	MT2380L14	MT2380L14	Method	Method
Analyte Name		PQL	SPIKE	SPIKEDUP	SPIKE	SPIKEDUP
	Arochlor 1260		U	U	75	82

Matrix: LNAPL

Method: MA-10.OIL.01 Monoaromatic Hydrocarbons

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014009734	2014009735	2014009736	2014009737
		Client ID	MT2380L14	MT2380L14	Method	Method
Analyte Name		PQL	SPIKE	SPIKEDUP	SPIKE	SPIKEDUP
	Benzene		U	U	119	120
	Ethyl Benzene		U	U	109	113
	Toluene		U	U	119	116
	m&p-Xylenes		U	U	115	108
	o-Xylene		U	U	123	117

Matrix: LNAPL

Method: MA-72.LNAPL.T001-3 Polycyclic Aromatic Hydrocarbons

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014009734	2014009735	2014009736	2014009737
		Client ID	MT2380L14	MT2380L14	Method	Method
Analyte Name		**PQL**	SPIKE	SPIKEDUP	SPIKE	SPIKEDUP
	Acenaphthene		U	U	97	105
	Pyrene		U	U	106	116

Matrix: LNAPL

Method: MA-30.LNAPL.T1 Total Petroleum Hydrocarbons

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014009736	2014009737
		Client ID	Method	Method
Analyte Name		**PQL**	SPIKE	SPIKEDUP
	Total C6-C36		95	94

(II) QUALITY CONTROL

Report N°: M141125

Matrix: LNAPL

Method: MA-1400.LNAPL.T001-3 Metals via ICP-MS

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014009734	2014009735
		Client ID	MT2380L14	MT2380L14
Analyte Name		**PQL**	SPIKE	SPIKEDUP
MA-1400.LNAPL.	**Arsenic**		103	109
	Aluminium		102	122
	Antimony		105	110
	Barium		104	113
	Boron		113	107
	Cadmium		105	111
	Chromium		91	86
	Cobalt		98	104
	Copper		103	112
	Total Iron		97	95
	Lead		97	105
	Total Manganese		110	116
	Mercury		120	126
	Molybdenum		106	112
	Nickel		112	118
	Potassium		114	121
	Selenium		107	104
	Silver		101	107
	Sodium		122	129
	Thallium		95	101
	Tin		109	115
	Vanadium		101	116
	Zinc		U	U

QUALIFIERS / NOTES FOR REPORTED RESULTS

PQL	Practical Quantitation Limit
is	Insufficient Sample to perform this analysis.
T	Tentative identification based on computer library search of mass spectra.
ND	Not Detected – The analyte was not detected above the reported PQL.
NC	Not calculated, Results below PQL
nr	Not Requested for analysis.
R	Rejected Result – results for this analysis failed QC checks.
SQ	Semi-Quantitative result – quantitation based on a generic response factor for this class of analyte.
IM	Inappropriate method of analysis for this compound
U	Unable to provide Quality Control data – high levels of compounds in sample interfered with analysis of QC results.
UF	Unable to provide Quality Control data- Surrogates failed QCchecks due to sample matrix effects
L	Analyte detected at a level above the linear response of calibration curve.
C1	These compounds co-elute.
C2	These compounds co-elute.
CT	Elevated concentration. Results reported from carbon tube analysis
**	Sample shows non-petroleum hydrocarbon profile

LNAPL.T001-3 SGS Perth Rpt # PG92712

APPENDIX ONE.

CHAIN OF CUSTODY DOCUMENT

KINGTECH SERVICES : SAMPLE CUSTODY FORM

KTS JOB NO : 131114

CLIENT: Transpacific Cleanaway P/L

REFERENCE : Schedule 17: May 2014 LNAPL Trial Sampling Event

ORDER NUMBER : TPI Cleanaway

Sample ID (Number/Name)	Date	Time	Sample Source (Ground/Surface/Leachate)	Laboratory Analyses to be Performed	Number of Containers	Comments (Preservatives/Site Details/Storage)
MT2380 L14	17/06/14		LNAPL	See correspondance	3+1	ice
MT2367 L1	18/06/14		LNAPL	dated Friday 11 April 2014	3+1	ice
MT2374 L8	19/06/14		LNAPL	see Letter	3+1	ice
MT2375 L9	19/06/14		LNAPL	see Letter	3+1	ice

Sampled By (Name and Signature) :	Relinquished By : (Name and Signature)	Received By : (Name and Signature)	Date and Time
Mark Kenna [signature]	Mark Kenna [signature]	Lyndall Stevens [signature]	20/06/2014 13:25
Contact No: 041 954 3936	Company: KingTech	Company: SGS Leeder Consulting	
Remarks :	**Relinquished By : (Name and Signature)**	**Received By : (Name and Signature)**	**Date and Time**
Results To:			
email:	Company:	Company:	

F_SCF0106

From: Alex Schiavoni [mailto:Alex.Schiavoni@ehs-support.com]
Sent: Tuesday, 13 May 2014 10:14 AM
To: Kieren McDermott; AU.SampleReceipt.Mitcham (Melbourne)
Cc: Mark
Subject: RE: Tullamarine LNAPL Sampling -URGENT QUERIES

Hi Lyndall,

The temperatures required are 20, 30 and 40^{o}C.

Cheers
Alex Schiavoni
Principal Hydrogeologist
EHS Support Pty Ltd
PO Box 5056, Moreland West Victoria, 3055, Australia
Tel: +61 3 8300 0151 Mob: +61 407 863 572
alex.schiavoni@ehs-support.com
www.ehs-support.com

Consider it done.
Work Safe. Live Safe. Stay Safe.

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Tuesday, 13 May 2014 9:47 AM
To: AU.SampleReceipt.Mitcham (Melbourne)
Cc: Mark; Alex Schiavoni
Subject: RE: Tullamarine LNAPL Sampling -URGENT QUERIES

Hi Lyndall

Alex will need to advise on the temperatures he requires for the density and viscosity assessment.

PQLs, will be as per the standard PQLs we have in the agreed schedule lists.

Having said that I doubt if you can achieve PQL in many cases because generally there will be very high concentrations in the samples. PCBs in the leachate will be interesting because their concentrations will be low to negligible yet the leachate will be saturated with other hydrocarbon products potentially creating a lot of noise in the analytical instrument. This might make analysis to PQL for PCBs very difficult. I am mentioning this because SGS might need to modify the way you analyse these samples.

Kieren McDermott | Environmental Specialist | Post Collection
Transpacific Industries Group Ltd
Western Ave Tullamarine Vic | Private Bag 5 Tullamarine VIC 3043
P: + 61 3 9335 8868 (Direct) **| F:** + 61 3 9551 9217 **| M:** + 61 408 996 292

E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

Please consider the environment before printing this email.

From: AU.SampleReceipt.Mitcham (Melbourne) [mailto:AU.SampleReceipt.Mitcham@sgs.com]
Sent: Tuesday, 13 May 2014 9:29 AM
To: Kieren McDermott
Cc: Mark; Alex Schiavoni
Subject: RE: Tullamarine LNAPL Sampling -URGENT QUERIES
Importance: High

Kieren,

Also can you please provide the temperatures you require for density and viscosity?
What PQL do you require for the composition analysis as this determines the bottle size I need to give Mark to use for sampling?
Thanks for your time

Regards,

Lyndall Stevens
Environmental Services
Sample Reception Team Leader

SGS LEEDER CONSULTING
Melbourne Office
Unit 5 /18 Redland Drive
Mitcham VIC 3132,
Australia

Phone +61 (0)3 9874 1988
Fax: +61 (0)3 9874 1933
Email: **lyndall.stevens@sgs.com**
Web: www.au.sgs.com

From: Stevens, Lyndall (Melbourne)
Sent: Tuesday, 13 May 2014 9:03 AM
To: 'Kieren McDermott'
Cc: Mark; Alex Schiavoni
Subject: RE: Tullamarine LNAPL Sampling

Kieren,

As discussed yesterday the analysis listed in Suites 1 & 2 are only suitable for the leachate matrix. We are unable to carry out these parameters on an LNAPL matrix.

Regards,

Lyndall Stevens
Environmental Services
Sample Reception Team Leader

SGS LEEDER CONSULTING
Melbourne Office
Unit 5 /18 Redland Drive
Mitcham VIC 3132,
Australia

Phone +61 (0)3 9874 1988
Fax: +61 (0)3 9874 1933
Email: **lyndall.stevens@sgs.com**
Web: www.au.sgs.com

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Monday, 12 May 2014 5:46 PM
To: Stevens, Lyndall (Melbourne)
Cc: Mark; Alex Schiavoni
Subject: Tullamarine LNAPL Sampling

Lyndall

Apologies for taking so long to get back to you today. Note that we will be sampling no more than 6 locations this round (plus QA samples). Physical properties will be for LNAPL matrix only and composition will be for both LNAPL and leachate matrices. Please note that in terms of reporting levels the samples will have high concentrations and the leachate samples will be saturated / supersaturated and so you will need to prep the laboratory testing equipment accordingly.

I can confirm the following :

	Sample Type	Analytes	Quantities
		Physical Properties (1 Matrix LNAPL only): -Density at 3 temperatures -Viscosity at 3 temperatures -Surface tension (air/oil)(oil/water)(air water) -Flash point	1 LNAPL sample per well (up to 14 samples in total)
		Composition (LNAPL & Leachate Matrix): -PCB -MAH -PAH -TPH -Metals -Suite 1, plus alkalinity -Suite 2, plus Nitrate	1 LNAPL & 1 Leachate sample per well (up to 14 samples in total)

Kieren McDermott | Environmental Specialist | Post Collection
Transpacific Industries Group Ltd
Western Ave Tullamarine Vic | Private Bag 5 Tullamarine VIC 3043
P: + 61 3 9335 8868 (Direct) | **F:** + 61 3 9551 9217 | **M:** + 61 408 996 292

E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Monday, 7 July 2014 10:13 AM
To: Stevens, Lyndall (Melbourne)
Subject: RE: SGS Leeder Quotation - LNAPL Analysis

Lyndall

Just use this one for all 13 and Nicole will be able to make an adjustment when the invoice arrives.

Kieren McDermott | Environmental Specialist | Post Collection – Vic Landfills
Transpacific Cleanaway
46 Victory Rd | Clarinda VIC 3169
P: + 61 3 9335 8868 (Direct) | **M:** + 61 408 996 292

E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

From: Stevens, Lyndall (Melbourne) [mailto:Lyndall.Stevens@sgs.com]
Sent: Monday, 7 July 2014 10:11 AM
To: Kieren McDermott
Subject: RE: SGS Leeder Quotation - LNAPL Analysis
Importance: High

Kieren,
The first job had 2 samples (M140798), the second had 4 (M141125), and the third has 7 (M141256). This totals to 13. Is this PO number able to be used for the 3rd job?

Regards,

Lyndall Stevens
Environmental Services
Sample Reception Team Leader

SGS Leeder Consulting
Melbourne Office
Unit 5 /18 Redland Drive
Mitcham VIC 3132,
Australia

Phone +61 (0)3 9874 1988
Fax: +61 (0)3 9874 1933
Email: **lyndall.stevens@sgs.com**
Web: www.au.sgs.com

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Monday, 7 July 2014 10:01 AM
To: Stevens, Lyndall (Melbourne)
Subject: FW: SGS Leeder Quotation - LNAPL Analysis

Hi Lyndall

Please use PO No 507127 for up to 12 LNAPL samples.

Kieren McDermott | Environmental Specialist | Post Collection – Vic Landfills
Transpacific Cleanaway
46 Victory Rd | Clarinda VIC 3169
P: + 61 3 9335 8868 (Direct) | **M:** + 61 408 996 292
E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

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

Chartered Chemists

REPORT NUMBER: M141256

21-Jul-2014

Site/Client Ref: LNAPL Trial Sampling Event

Order No: 507127

Transpacific Cleanaway Pty Ltd

Private Bag 5
Tullamarine
VIC 3043
Attention: Kieren McDermott

CERTIFICATE OF ANALYSIS

SAMPLES: Seven samples were received for analysis

DATE RECEIVED: **4-Jul-2014**

DATE COMMENCED: **7-Jul-2014**

METHODS: See Attached Results

RESULTS: Please refer to attached pages for results.

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

REPORTED BY:

Popy Dembalas
Chemist

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-82.LNAPL.T001-3 Polychlorinated Biphenyls

Sample units are expressed in mg/kg

		Leeder ID	2014010742	2014010743	2014010744	2014010745
		Client ID	MT2379L13	MT2370L4	MT2377L11	MT2368L2
Analyte Name		PQL				
MA-82.LNAPL.T0	**Arochlor 1016**	2	nd	nd	nd	nd
	Arochlor 1221	2	nd	nd	nd	nd
	Arochlor 1232	2	nd	nd	nd	nd
	Arochlor 1242	2	46	29	nd	44
	Arochlor 1248	2	nd	nd	nd	nd
	Arochlor 1254	2	45	18	19	44
	Arochlor 1260	2	9	2	2	8
	Arochlor 1262	2	nd	nd	nd	nd
	Arochlor 1268	2	nd	nd	nd	nd

Matrix: LNAPL

Method: MA-82.LNAPL.T001-3 Polychlorinated Biphenyls

Sample units are expressed in mg/kg

		Leeder ID	2014010746	2014010747	2014010748	2014010749
		Client ID	MT2369L3	MT2381QA1	MT2371L5	MT2379L13
Analyte Name		PQL				DUP
MA-82.LNAPL.T0	**Arochlor 1016**	2	nd	nd	nd	nd
	Arochlor 1221	2	nd	nd	nd	nd
	Arochlor 1232	2	nd	nd	nd	nd
	Arochlor 1242	2	35	28	4	39
	Arochlor 1248	2	nd	nd	nd	nd
	Arochlor 1254	2	40	39	6	38
	Arochlor 1260	2	6	5	nd	8
	Arochlor 1262	2	nd	nd	nd	nd
	Arochlor 1268	2	nd	nd	nd	nd

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-82.LNAPL.T001-3 Polychlorinated Biphenyls

Sample units are expressed in mg/kg

		Leeder ID	2014010750
		Client ID	Method
Analyte Name		PQL	BLANK
MA-82.LNAPL.T0	**Arochlor 1016**	2	nd
	Arochlor 1221	2	nd
	Arochlor 1232	2	nd
	Arochlor 1242	2	nd
	Arochlor 1248	2	nd
	Arochlor 1254	2	nd
	Arochlor 1260	2	nd
	Arochlor 1262	2	nd
	Arochlor 1268	2	nd

Matrix: LNAPL

Method: MA-10.OIL.01 Monoaromatic Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014010742	2014010743	2014010744	2014010745
		Client ID	MT2379L13	MT2370L4	MT2377L11	MT2368L2
Analyte Name		PQL				
	Benzene	1	30	47	40	15
	Chlorobenzene	1	25	18	110	23
	1,2-Dichlorobenzene	1	19	42	61	36
	1,3-Dichlorobenzene	1	5	2	8	5
	1,4-Dichlorobenzene	1	80	180	1700	78
	Ethyl Benzene	1	660	820	1200	400
	Toluene	1	170	380	2200	210
	m&p-Xylenes	1	1600	980	5300	510
	o-Xylene	1	560	330	1000	210

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-10.OIL.01 Monoaromatic Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014010746	2014010747	2014010748	2014010749
		Client ID	MT2369L3	MT2381QA1	MT2371L5	MT2379L13
Analyte Name		**PQL**				DUP
	Benzene	1	56	59	10	34
	Chlorobenzene	1	270	310	5	25
	1,2-Dichlorobenzene	1	150	160	25	19
	1,3-Dichlorobenzene	1	8	10	1	5
	1,4-Dichlorobenzene	1	95	110	41	83
	Ethyl Benzene	1	1400	1500	320	720
	Toluene	1	1100	1200	180	170
	m&p-Xylenes	1	4400	3400	720	1700
	o-Xylene	1	710	1000	280	590

Matrix: LNAPL

Method: MA-10.OIL.01 Monoaromatic Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014010750
		Client ID	Method
Analyte Name		**PQL**	BLANK
	Benzene	1	nd
	Chlorobenzene	1	nd
	1,2-Dichlorobenzene	1	nd
	1,3-Dichlorobenzene	1	nd
	1,4-Dichlorobenzene	1	nd
	Ethyl Benzene	1	nd
	Toluene	1	nd
	m&p-Xylenes	1	nd
	o-Xylene	1	nd

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-72.LNAPL.T001-3 Polycyclic Aromatic Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014010742	2014010743	2014010744	2014010745
		Client ID	MT2379L13	MT2370L4	MT2377L11	MT2368L2
Analyte Name		PQL				
MA-72.LNAPL.T0	**Naphthalene**	20	270	180	460	3900
	Acenaphthylene	20	nd	nd	nd	88
	Acenaphthene	20	140	60	71	160
	Fluorene	20	100	61	87	240
	Phenanthrene	20	200	120	190	960
	Anthracene	20	46	28	36	210
	Fluoranthene	20	84	39	39	370
	Pyrene	20	110	69	69	600
	Benzo(a)anthracene	20	24	nd	nd	110
	Chrysene	20	nd	nd	nd	70
	Benzo(b)fluoranthene	20	nd	nd	nd	38
	Benzo(k)fluoranthene	20	nd	nd	nd	nd
	Benzo(a)pyrene	20	nd	nd	nd	68
	Indeno(123-cd)pyrene	20	nd	nd	nd	40
	Dibenzo(ah)anthracene	20	nd	nd	nd	22
	Benzo(ghi)perylene	20	nd	nd	nd	64
	3-Methyl cholanthrene	20	nd	nd	nd	nd

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-72.LNAPL.T001-3 Polycyclic Aromatic Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014010746	2014010747	2014010748	2014010749
		Client ID	MT2369L3	MT2381QA1	MT2371L5	MT2379L13
Analyte Name		PQL				DUP
MA-72.LNAPL.T0	**Naphthalene**	20	470	500	210	280
	Acenaphthylene	20	nd	nd	nd	nd
	Acenaphthene	20	50	55	40	140
	Fluorene	20	94	120	84	120
	Phenanthrene	20	190	210	140	200
	Anthracene	20	35	30	22	56
	Fluoranthene	20	34	34	26	86
	Pyrene	20	47	42	43	130
	Benzo(a)anthracene	20	nd	nd	nd	22
	Chrysene	20	nd	nd	nd	nd
	Benzo(b)fluoranthene	20	nd	nd	nd	nd
	Benzo(k)fluoranthene	20	nd	nd	nd	nd
	Benzo(a)pyrene	20	nd	nd	nd	nd
	Indeno(123-cd)pyrene	20	nd	nd	nd	nd
	Dibenzo(ah)anthracene	20	nd	nd	nd	nd
	Benzo(ghi)perylene	20	nd	nd	nd	nd
	3-Methyl cholanthrene	20	nd	nd	nd	nd

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-72.LNAPL.T001-3 Polycyclic Aromatic Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014010750
		Client ID	Method
Analyte Name		**PQL**	BLANK
MA-72.LNAPL.T0	**Naphthalene**	20	nd
	Acenaphthylene	20	nd
	Acenaphthene	20	nd
	Fluorene	20	nd
	Phenanthrene	20	nd
	Anthracene	20	nd
	Fluoranthene	20	nd
	Pyrene	20	nd
	Benzo(a)anthracene	20	nd
	Chrysene	20	nd
	Benzo(b)fluoranthene	20	nd
	Benzo(k)fluoranthene	20	nd
	Benzo(a)pyrene	20	nd
	Indeno(123-cd)pyrene	20	nd
	Dibenzo(ah)anthracene	20	nd
	Benzo(ghi)perylene	20	nd
	3-Methyl cholanthrene	20	nd

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-30.LNAPL.T1 Total Petroleum Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014010742	2014010743	2014010744	2014010745
		Client ID	MT2379L13	MT2370L4	MT2377L11	MT2368L2
Analyte Name		PQL				
	C6-C9	20	49000	42000	44000	44000
	C10-C14	20	120000	92000	87000	120000
	C15-C28	50	290000	250000	180000	280000
	C29-C36	50	200000	210000	140000	210000
	Total C6-C36	50	660000	590000	450000	650000

Matrix: LNAPL

Method: MA-30.LNAPL.T1 Total Petroleum Hydrocarbons

Sample units are expressed in mg/kg

		Leeder ID	2014010746	2014010747	2014010748	2014010749
		Client ID	MT2369L3	MT2381QA1	MT2371L5	MT2379L13
Analyte Name		PQL				DUP
	C6-C9	20	79000	85000	22000	51000
	C10-C14	20	190000	210000	41000	120000
	C15-C28	50	230000	260000	110000	270000
	C29-C36	50	170000	190000	71000	190000
	Total C6-C36	50	670000	740000	240000	630000

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-30.LNAPL.T1 Total Petroleum Hydrocarbons

Sample units are expressed in mg/kg

	Leeder ID		2014010750
	Client ID		Method
Analyte Name		**PQL**	BLANK
	C6-C9	20	nd
	C10-C14	20	nd
	C15-C28	50	nd
	C29-C36	50	nd
	Total C6-C36	50	nd

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-1400.LNAPL.T001-3 Metals via ICP-MS

Sample units are expressed in mg/kg

		Leeder ID	2014010742	2014010743	2014010744	2014010745
		Client ID	MT2379L13	MT2370L4	MT2377L11	MT2368L2
Analyte Name		PQL				
MA-1400.LNAPL.	**Arsenic**	5	nd	nd	nd	nd
	Aluminium	5	52	60	39	29
	Antimony	5	nd	nd	nd	nd
	Barium	5	5	5	nd	nd
	Boron	10	nd	nd	nd	nd
	Cadmium	1	nd	nd	nd	nd
	Chromium	2	180	80	45	54
	Cobalt	2	nd	nd	nd	nd
	Copper	2	7	4	9	5
	Total Iron	5	160	60	96	62
	Lead	5	nd	nd	6	nd
	Total Manganese	5	nd	nd	nd	nd
	Mercury	5	nd	nd	nd	nd
	Molybdenum	5	nd	nd	nd	nd
	Nickel	2	nd	nd	nd	nd
	Potassium	5	nd	nd	nd	nd
	Selenium	5	nd	nd	nd	nd
	Silver	5	nd	nd	nd	nd
	Sodium	5	nd	8	64	5
	Thallium	5	nd	nd	nd	nd
	Tin	5	nd	nd	nd	nd
	Vanadium	5	59	30	18	20
	Zinc	5	16	nd	10	7

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-1400.LNAPL.T001-3 Metals via ICP-MS

Sample units are expressed in mg/kg

		Leeder ID	2014010746	2014010747	2014010748	2014010749
		Client ID	MT2369L3	MT2381QA1	MT2371L5	MT2379L13
Analyte Name		PQL				DUP
MA-1400.LNAPL.	**Arsenic**	5	nd	nd	nd	nd
	Aluminium	5	26	29	120	55
	Antimony	5	nd	nd	nd	nd
	Barium	5	5	5	47	nd
	Boron	10	nd	nd	14	nd
	Cadmium	1	nd	nd	nd	nd
	Chromium	2	66	78	250	190
	Cobalt	2	nd	nd	nd	nd
	Copper	2	4	5	5	6
	Total Iron	5	59	72	620	160
	Lead	5	nd	nd	14	nd
	Total Manganese	5	nd	nd	9	nd
	Mercury	5	nd	nd	nd	nd
	Molybdenum	5	nd	nd	nd	nd
	Nickel	2	nd	nd	5	nd
	Potassium	5	nd	nd	120	nd
	Selenium	5	nd	nd	nd	nd
	Silver	5	nd	nd	nd	nd
	Sodium	5	nd	nd	3300	nd
	Thallium	5	nd	nd	nd	nd
	Tin	5	nd	nd	5	nd
	Vanadium	5	24	27	79	61
	Zinc	5	8	8	20	16

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: MA-1400.LNAPL.T001-3 Metals via ICP-MS

Sample units are expressed in mg/kg

		Leeder ID	2014010750
		Client ID	Method
Analyte Name		PQL	BLANK
MA-1400.LNAPL.	**Arsenic**	5	nd
	Aluminium	5	nd
	Antimony	5	nd
	Barium	5	nd
	Boron	10	nd
	Cadmium	1	nd
	Chromium	2	nd
	Cobalt	2	nd
	Copper	2	nd
	Total Iron	5	nd
	Lead	5	nd
	Total Manganese	5	nd
	Mercury	5	nd
	Molybdenum	5	nd
	Nickel	2	nd
	Potassium	5	nd
	Selenium	5	nd
	Silver	5	nd
	Sodium	5	nd
	Thallium	5	nd
	Tin	5	nd
	Vanadium	5	nd
	Zinc	5	nd

(I) RESULTS

Report N°: M141256

Matrix: LNAPL

Method: PC CA.LNAPL.T001-3

Sample units are expressed in g/mL @ 20 °C

		Leeder ID	2014010742	2014010743	2014010744	2014010745
		Client ID	MT2379L13	MT2370L4	MT2377L11	MT2368L2
Analyte Name		PQL				
	Density @ 20°C (g/mL)		0.90	0.88	0.90	0.90
	Density @ 30°C (g/mL)		0.88	0.88	0.89	0.89
	Density @ 40°C (g/mL)		0.88	0.87	0.88	0.89
ASTM D93 / IP 34	Flash Point (°C)		85±5	95±5	85±5	105±5
ASTM D445 / IP	Viscosity (cSt @ 20°C)		260	690	160	190
ASTM D445 / IP	Viscosity (cSt @ 30°C)		150	380	98	110
ASTM D445 / IP	Viscosity (cSt @ 40°C)		100	240	67	74
	LNAPL / Air Surface tension		28	28	27	29
	LNAPL / Leachate Interfacial		23	18	15	21

Matrix: LNAPL

Method: PC CA.LNAPL.T001-3

Sample units are expressed in g/mL @ 20 °C

		Leeder ID	2014010746	2014010747	2014010748
		Client ID	MT2369L3	MT2381QA1	MT2371L5
Analyte Name		PQL			
	Density @ 20°C (g/mL)		0.89	0.89	0.98
	Density @ 30°C (g/mL)		0.88	0.88	0.95
	Density @ 40°C (g/mL)		0.88	0.88	0.92
ASTM D93 / IP 34	Flash Point (°C)		75±5	75±5	--
ASTM D445 / IP	Viscosity (cSt @ 20°C)		120	100	760
ASTM D445 / IP	Viscosity (cSt @ 30°C)		66	67	220
ASTM D445 / IP	Viscosity (cSt @ 40°C)		46	46	150
	LNAPL / Air Surface tension		28	28	28
	LNAPL / Leachate Interfacial		21	20	21

Matrix: LNAPL

Method: MA-82.LNAPL.T001-3 Polychlorinated Biphenyls

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014010751	2014010752
		Client ID	MT2379L13	MT2379L13
Analyte Name		PQL	SPIKE	SPIKEDUP
	Arochlor 1260		74	69

Matrix: LNAPL

Method: MA-10.OIL.01 Monoaromatic Hydrocarbons

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014010753	2014010754
		Client ID	Method	Method
Analyte Name		PQL	SPIKE	SPIKEDUP
	Benzene		110	102
	Ethyl Benzene		114	94
	Toluene		113	112
	m&p-Xylenes		109	116
	o-Xylene		111	119

Matrix: LNAPL

Method: MA-72.LNAPL.T001-3 Polycyclic Aromatic Hydrocarbons

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014010753	2014010754
		Client ID	Method	Method
Analyte Name		PQL	SPIKE	SPIKEDUP
	Acenaphthene		115	106
	Pyrene		114	113

Matrix: LNAPL

Method: MA-30.LNAPL.T1 Total Petroleum Hydrocarbons

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014010753	2014010754
		Client ID	Method	Method
Analyte Name		PQL	SPIKE	SPIKEDUP
	Total C6-C36		98	95

Matrix: LNAPL

Method: MA-1400.LNAPL.T001-3 Metals via ICP-MS

Quality Control Results are expressed in Percent Recovery of expected result

		Leeder ID	2014010751	2014010752
		Client ID	MT2379L13	MT2379L13
Analyte Name		**PQL**	SPIKE	SPIKEDUP
MA-1400.LNAPL.	**Arsenic**		99	97
	Aluminium		104	97
	Antimony		101	98
	Barium		103	99
	Boron		107	113
	Cadmium		99	97
	Chromium		70	75
	Cobalt		100	96
	Copper		98	94
	Total Iron		109	107
	Lead		103	98
	Total Manganese		104	101
	Mercury		115	109
	Molybdenum		100	97
	Nickel		100	96
	Potassium		119	116
	Selenium		96	90
	Silver		100	98
	Sodium		126	118
	Thallium		103	99
	Tin		104	101
	Vanadium		91	93
	Zinc		105	109

QUALIFIERS / NOTES FOR REPORTED RESULTS

PQL	Practical Quantitation Limit
is	Insufficient Sample to perform this analysis.
T	Tentative identification based on computer library search of mass spectra.
ND	Not Detected – The analyte was not detected above the reported PQL.
NC	Not calculated, Results below PQL
nr	Not Requested for analysis.
R	Rejected Result – results for this analysis failed QC checks.
SQ	Semi-Quantitative result – quantitation based on a generic response factor for this class of analyte.
IM	Inappropriate method of analysis for this compound
U	Unable to provide Quality Control data – high levels of compounds in sample interfered with analysis of QC results.
UF	Unable to provide Quality Control data- Surrogates failed QCchecks due to sample matrix effects
L	Analyte detected at a level above the linear response of calibration curve.
C1	These compounds co-elute.
C2	These compounds co-elute.
CT	Elevated concentration. Results reported from carbon tube analysis
**	Sample shows non-petroleum hydrocarbon profile

APPENDIX ONE.

CHAIN OF CUSTODY DOCUMENT

KINGTECH SERVICES : SAMPLE CUSTODY FORM

KTS JOB NO : 131114

CLIENT: Transpacific Cleanaway Pty Ltd

REFERENCE : Schedule 17: May 2014 LNAPL Trial Sampling Event

ORDER NUMBER : see TPI Cleanaway - K. McDermott

Sample ID (Number/Name)	Date	Time	Sample Source (Ground/Surface/Leachate)	Laboratory Analyses to be Performed	Number of Containers	Comments (Preservatives/Site Details/Storage)
MT2379L13	3/07/2014		LNAPL	See instruction letter.	3+1	Warning - this material must be handled with caution.
MT2370L4	3/07/2014		LNAPL	Physical properties- density, viscosity, (both at three temperatures),	3+1	ice
MT 2377L11	2/07/2014		LNAPL	surface tension (air/oil, oil/water), flash point.	3+1	ice
MT2368L2	30/06/2014		LNAPL		3+1	ice
MT2369L3	2/07/2014		LNAPL	PCBs, MAHs, PAHs, TPH, Metals.	3+1	ice
MT2381QA1	2/07/2014		LNAPL		3+1	ice
MT 2371L5	1/07/2014		LNAPL		3+1	ice

Sampled By (Name and Signature) : Mark Kenna [signature]
Contact No: 041 954 3936

Relinquished By : (Name and Signature) Mark Kenna [signature]
Company: KingTech

Received By : (Name and Signature) [signature] Lyndall Stevens
Company: SGS Leeder Consulting

Date and Time 04/07/2014 16:00 4/7/14 16:00

Remarks :

Results To: Kieren McDermott

email: Kieren.McDermott@transpac.com.au

Relinquished By : (Name and Signature)
Company:

Received By : (Name and Signature)
Company:

Date and Time

F_SCF0106

From: Alex Schiavoni [mailto:Alex.Schiavoni@ehs-support.com]
Sent: Tuesday, 13 May 2014 10:14 AM
To: Kieren McDermott; AU.SampleReceipt.Mitcham (Melbourne)
Cc: Mark
Subject: RE: Tullamarine LNAPL Sampling -URGENT QUERIES

Hi Lyndall,

The temperatures required are 20, 30 and 40^{o}C.

Cheers
Alex Schiavoni
Principal Hydrogeologist
EHS Support Pty Ltd
PO Box 5056, Moreland West Victoria, 3055, Australia
Tel: +61 3 8300 0151 Mob: +61 407 863 572
alex.schiavoni@ehs-support.com
www.ehs-support.com

Consider it done.
Work Safe. Live Safe. Stay Safe.

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Tuesday, 13 May 2014 9:47 AM
To: AU.SampleReceipt.Mitcham (Melbourne)
Cc: Mark; Alex Schiavoni
Subject: RE: Tullamarine LNAPL Sampling -URGENT QUERIES

Hi Lyndall

Alex will need to advise on the temperatures he requires for the density and viscosity assessment.

PQLs, will be as per the standard PQLs we have in the agreed schedule lists.

Having said that I doubt if you can achieve PQL in many cases because generally there will be very high concentrations in the samples. PCBs in the leachate will be interesting because their concentrations will be low to negligible yet the leachate will be saturated with other hydrocarbon products potentially creating a lot of noise in the analytical instrument. This might make analysis to PQL for PCBs very difficult. I am mentioning this because SGS might need to modify the way you analyse these samples.

Kieren McDermott | Environmental Specialist | Post Collection
Transpacific Industries Group Ltd
Western Ave Tullamarine Vic | Private Bag 5 Tullamarine VIC 3043
P: + 61 3 9335 8868 (Direct) **| F:** + 61 3 9551 9217 **| M:** + 61 408 996 292

E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

Please consider the environment before printing this email.

From: AU.SampleReceipt.Mitcham (Melbourne) [mailto:AU.SampleReceipt.Mitcham@sgs.com]
Sent: Tuesday, 13 May 2014 9:29 AM
To: Kieren McDermott
Cc: Mark; Alex Schiavoni
Subject: RE: Tullamarine LNAPL Sampling -URGENT QUERIES
Importance: High

Kieren,

Also can you please provide the temperatures you require for density and viscosity?
What PQL do you require for the composition analysis as this determines the bottle size I need to give Mark to use for sampling?
Thanks for your time

Regards,

Lyndall Stevens
Environmental Services
Sample Reception Team Leader

SGS LEEDER CONSULTING
Melbourne Office
Unit 5 /18 Redland Drive
Mitcham VIC 3132,
Australia

Phone +61 (0)3 9874 1988
Fax: +61 (0)3 9874 1933
Email: **lyndall.stevens@sgs.com**
Web: www.au.sgs.com

From: Stevens, Lyndall (Melbourne)
Sent: Tuesday, 13 May 2014 9:03 AM
To: 'Kieren McDermott'
Cc: Mark; Alex Schiavoni
Subject: RE: Tullamarine LNAPL Sampling

Kieren,

As discussed yesterday the analysis listed in Suites 1 & 2 are only suitable for the leachate matrix. We are unable to carry out these parameters on an LNAPL matrix.

Regards,

Lyndall Stevens
Environmental Services
Sample Reception Team Leader

SGS LEEDER CONSULTING
Melbourne Office
Unit 5 /18 Redland Drive
Mitcham VIC 3132,
Australia

Phone +61 (0)3 9874 1988
Fax: +61 (0)3 9874 1933
Email: **lyndall.stevens@sgs.com**
Web: www.au.sgs.com

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Monday, 12 May 2014 5:46 PM
To: Stevens, Lyndall (Melbourne)
Cc: Mark; Alex Schiavoni
Subject: Tullamarine LNAPL Sampling

Lyndall

Apologies for taking so long to get back to you today. Note that we will be sampling no more than 6 locations this round (plus QA samples). Physical properties will be for LNAPL matrix only and composition will be for both LNAPL and leachate matrices. Please note that in terms of reporting levels the samples will have high concentrations and the leachate samples will be saturated / supersaturated and so you will need to prep the laboratory testing equipment accordingly.

I can confirm the following :

	Sample Type	Analytes	Quantities
		Physical Properties (1 Matrix LNAPL only): -Density at 3 temperatures -Viscosity at 3 temperatures -Surface tension (air/oil)(oil/water)(air water) -Flash point	1 LNAPL sample per well (up to 14 samples in total)
		Composition (LNAPL & Leachate Matrix): -PCB -MAH -PAH -TPH -Metals -Suite 1, plus alkalinity -Suite 2, plus Nitrate	1 LNAPL & 1 Leachate sample per well (up to 14 samples in total)

Kieren McDermott | Environmental Specialist | Post Collection
Transpacific Industries Group Ltd
Western Ave Tullamarine Vic | Private Bag 5 Tullamarine VIC 3043
P: + 61 3 9335 8868 (Direct) | **F:** + 61 3 9551 9217 | **M:** + 61 408 996 292

E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Monday, 7 July 2014 10:13 AM
To: Stevens, Lyndall (Melbourne)
Subject: RE: SGS Leeder Quotation - LNAPL Analysis

Lyndall

Just use this one for all 13 and Nicole will be able to make an adjustment when the invoice arrives.

Kieren McDermott | Environmental Specialist | Post Collection – Vic Landfills
Transpacific Cleanaway
46 Victory Rd | Clarinda VIC 3169
P: + 61 3 9335 8868 (Direct) | **M:** + 61 408 996 292

E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

From: Stevens, Lyndall (Melbourne) [mailto:Lyndall.Stevens@sgs.com]
Sent: Monday, 7 July 2014 10:11 AM
To: Kieren McDermott
Subject: RE: SGS Leeder Quotation - LNAPL Analysis
Importance: High

Kieren,
The first job had 2 samples (M140798), the second had 4 (M141125), and the third has 7 (M141256). This totals to 13. Is this PO number able to be used for the 3rd job?

Regards,

Lyndall Stevens
Environmental Services
Sample Reception Team Leader

SGS LEEDER CONSULTING
Melbourne Office
Unit 5 /18 Redland Drive
Mitcham VIC 3132,
Australia

Phone +61 (0)3 9874 1988
Fax: +61 (0)3 9874 1933
Email: **lyndall.stevens@sgs.com**
Web: www.au.sgs.com

From: Kieren McDermott [mailto:Kieren.McDermott@transpac.com.au]
Sent: Monday, 7 July 2014 10:01 AM
To: Stevens, Lyndall (Melbourne)
Subject: FW: SGS Leeder Quotation - LNAPL Analysis

Hi Lyndall

Please use PO No 507127 for up to 12 LNAPL samples.

Kieren McDermott | Environmental Specialist | Post Collection – Vic Landfills
Transpacific Cleanaway
46 Victory Rd | Clarinda VIC 3169
P: + 61 3 9335 8868 (Direct) | **M:** + 61 408 996 292
E: Kieren.McDermott@transpac.com.au | www.transpacific.com.au

APPENDIX B NET BENEFIT ANALYSIS

APPENDIX B NET BENEFIT ANALYSIS

B.1 Net Benefit Analysis

Sustainable development was defined by the World Commission on Environment and Development (1987), commonly known as "the Brundtland Commission", as development that "meets the needs of the present generation without compromising the ability of future generations to meet their own needs". Maximising the overall benefit to the community and environment of an activity such as remediation is consistent with this statement.

Soil and groundwater remediation, although designed to remedy contamination and reduce risks to human health and/or the environment, also has the potential to cause environmental, social and economic impacts (SURF ANZ, Nadebaum 2011). Whilst there is general agreement as to the overall aspirations, there are a number of definitions provided by the various entities building the frameworks, guidance and tools for sustainable remediation and some of these are shown below. ITRC expands the definition to specifically encompass Green Remediation, thus Green and Sustainable Remediation or GSR. Green remediation is typically considered a necessary subset of Sustainable Remediation.

> *Sustainable remediation can be defined as a balanced decision making process that demonstrates, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than adverse effects* (SuRF ANZ, Nadebaum 2011).

> *Sustainable remediation is the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of a balanced decision-making process* (SURF, UK).

> *Sustainable remediation can be defined as a remedy or combination of remedies whose net benefit on human health and the environment is maximized through the judicious use of limited resources* (US Sustainable Remediation Forum [SURF], 2009).

> *GSR is defined as the site-specific use of products, processes, technologies, and procedures that mitigate contaminant risk to receptors while balancing community goals, economic impacts, and net environmental effects. GSR has emerged as a beneficial approach that optimizes all phases of site remediation, from site investigation to project closeout* (ITRC, 2011).

> *Sustainable remediation considers a range of environmental issues and community impacts and integrates economic, ecological, and social implications into the consideration of the collateral impacts of investigation and remediation activities* (ITRC, 2011).

> *A remedy or combination of remedies whose net benefit on human health and the environment is maximized through the judicious use of limited resources* (Hadley and Ellis 2009).

> *Sustainable practices result in clean-ups minimizing the environmental and energy 'footprints' of all actions taken during a project life* (EPA 2008b).

Two of the biggest issues facing the world are climate change and diminishing water resources. Climate change is a well-established and wide debate. Water resources is a more recent issue and Sandra Postel in her book *Pillar of Sand* puts the current global water deficit at 160 billion tons per year and rising. Remediation systems can contribute to climate change through generation of greenhouse gases from tailpipe emissions (travelling to and from the site), electricity generation and hydrocarbon destruction by combustion. Water used during electricity generation is significant with figures ranging from 500 to 2,000 litres per 1,000 kWh common for coal-fired power plants, which makes up about two thirds of Victoria's electricity production[1]. The production of grain requires in the order of 500 to 4,000 tons of water to produce 1 ton of grain (Institution of Mechanical Engineers, 2013) and considering even a modest remediation system may use 10's of thousands of kWh's per year, the significance of water usage associated with the electricity supply is apparent. When the risks to human health and the environment from impacts remaining in the ground are low and acceptable, the net benefit of a remediation system can be negative for these reasons.

The preservation of intergenerational equity is a key concept when assessing sustainability and net benefit. In a case where contamination may cause long-term health risks or damage to the environment, it may be argued that remediation is required to preserve intergenerational equity. Where remediation will not decrease the risk or restore amenity (of a groundwater resource for example) or where the risks from impacts are low and acceptable, intergenerational equity is more likely preserved by not implementing remediation due to the impacts associated with the remediation system itself.

B.2 Regulatory Support for Assessment of Net Benefit

The Environmental Protection Act, 1970 (the "Act") acknowledges the importance of assessing net benefit with the inclusion of the Principle of integration of economic, social and environmental considerations. The Principle includes the following statements:

- Sound environmental practices and procedures should be adopted as a basis for ecologically sustainable development for the benefit of all human beings and the environment.
- This requires the effective integration of economic, social and environmental considerations in decision making processes with the need to improve community well-being and the benefit of future generations.
- The measures adopted should be cost-effective and in proportion to the significance of the environmental problems being addressed.

In addition, EPA bulletin 840 ("The Clean-up and Management of Polluted Groundwater") states "The clean-up measures adopted shall be cost effective and commensurate with the significance of the environmental issues being addressed including but not limited to consideration of the likelihood of beneficial uses being realised".

There is also considerable flexibility in State and Territory guidance relating to the final outcome of site remediation methods, in that land can be certified as being suitable for particular land uses subject to certain conditions or controls on land use activities (Nadebaum, 2011).

B.3 Technical Challenges for Remediation

It is well documented (e.g. ITRC, 2009a) that reduction in LNAPL thickness rarely reduces risk. Reduction in LNAPL thickness will not affect the magnitude of flux to vapour or groundwater[2]. It may reduce the length of time LNAPL will partition into these phases but the reduction in time is unlikely to be significant when considered in the overall remediation timeframe. Only complete removal of LNAPL may reduce flux to vapour or groundwater but even then, residual LNAPL (no longer mobile) is likely to produce similar concentrations to vapour and groundwater.

[1] http://spectrum.ieee.org/energy/environment/how-much-water-does-it-take-to-make-electricity

[2] Reduction in LNAPL thickness as a result of excavation may result in decreased dissolved phase concentrations since the residual LNAPL is removed. Residual LNAPL is not removed by pumping.

Complete removal of LNAPL from beneath this Site is challenging to the point of impracticable primarily due to the high viscosity and low volatile content of the LNAPL. Further complicating recovery is the depth to the LNAPL at greater than 20 metres below ground surface within the contents of the landfill.

Baildown testing undertaken in May 2014 assessed the mobility and recoverability of the LNAPL beneath the Site by pumping each well and allowing recovery. The tests and results were reported in EHS Support, September 2014 and concluded no wells qualified for extended LNAPL extraction given the low derived transmissivity values, inability to sustain pumping rates, general inability to draw LNAPL from the waste and very slow LNAPL level recovery. The LNAPL was found to be functionally immobile. The IRP (Cardno LanePiper, 2014) agreed with the opinion that the most prospective recovery technology (hydraulic recovery) was not practical for further implementation at the Site.

It is noted that even recovery at the upper end flowrate (see **Section 2.6.3**), the amount of LNAPL removed from the Site after ten years would only be between 0.14% and 0.25%[3] of the estimated recoverable volume.

B.4 Modelled Remediation Scenarios

The primary objective of the landfill gas extraction system is to manage landfill gas (predominantly methane) which will be a key part of Post Closure Management. This is noted here to highlight that continued operation of the landfill gas extraction system is essentially independent of the LNAPL impacts and considered part of the base case for this assessment.

A review of recent advances in remediation did not result in a change to the screening undertaken by URS from an engineered solution perspective. The net benefit of scenarios focused on skimming using a total fluids pump (the preferred pumping device considering the depth and nature of the LNAPL and proven during baildown testing) are modelled. A full total fluids extraction scenario would require a groundwater treatment system significantly increasing the environmental footprint of a remediation system and hence the more practical and appropriate LNAPL-focused scenarios provide a conservative assessment. Skimming using belt skimmers is not modelled since the impacts are likely similar to modelled scenario. For the LNAPL-focused scenarios, three approaches were modelled and these are discussed below.

B.4.1 Scenario 1 – Recovery from Existing Wells using Portable Trailer

This is an extension of the baildown testing approach whereby a portable recovery system is used to recover LNAPL from wells. The approach is defined:

1. Portable recovery system consisting a storage tank, off-gas emissions mitigation, down-well pump and controls mounted to a trailer. The Transpacific owned trailer used during the recovery testing is suitable and therefore costs for refurbishing only are included.
2. Installation / commissioning works consisting of refurbishing the existing trailer and maintaining the wellheads.
3. Recovery occurs from the existing landfill gas extraction wells.
4. A recovery event occurs once per month throughout the year for ten years. Ten years is used as a reasonable duration for such a project after which re-assessment would likely be undertaken.
5. The trailer is towed by a four-wheel drive vehicle from well to well.

[3] The estimate of total recoverable LNAPL is between 4 million and 7 million litres.

6. A portable bund is installed at each well site and the trailer is located within the bund.
7. The pump hoses are connected to a rotating drum on the trailer and the pump and hoses are unfurled from the drum at each site to allow the pump to travel down the well.
8. The pump and hoses travel through a well head specially designed to allow ready installation and retrieval and minimise the egress of vapour.
9. A hose is connected from a port on the landfill gas extraction pipe to each well to allow a small vacuum to be applied to the storage tank preventing vapour egress. In the event of a landfill gas extraction system stoppage, vapours from the tank are directed to the back-up offgas treatment system (activated carbon drums) on the trailer.
10. Extraction occurs for approximately eight hours at each well.
11. Wells are not decommissioned as they are continued to be used for landfill gas mitigation.
12. Recovered LNAPL is transported to Sterihealth for thermal destruction.
13. The volume of recovered LNAPL is based upon the bail down testing and assumes approximately 830 L would be recovered every month (see below for further explanation of this assumption).

B.4.2 Scenario 2 – Recovery from Existing Wells using Fixed System

This scenario uses the existing eleven (11) landfill wells for recovery to a fixed system. The approach is defined:

1. Fixed recovery system consisting piping from the landfill wells to a process equipment area located off the landfill cap.
2. Recovery occurs from the existing landfill gas extraction wells using a dedicated air operated pump within each well.
3. Fixed piping transports compressed air from the process equipment to the down well pumps and LNAPL product from the pumps to the storage tank.
4. Process equipment consists of a larger (than the trailer scenario) capacity storage tank, off-gas mitigation, air compressor and concrete bund for the storage tank.
5. Installation / commissioning works are more significant than the trailer scenario and includes manufacture and installation of specially designed wellheads, installation of piping between the wells and process equipment, fabrication and installation of a storage tank, fabrication and installation of a compressed air skid and construction of a concrete bund to house the storage tank.
6. Recovery is continuous aside from unplanned downtime (for example power failure) and maintenance events.
7. Operation and maintenance events occur monthly for 10 years.
8. Wells are not decommissioned as they are continued to be used for landfill gas mitigation.
9. Recovered LNAPL transported to Sterihealth for thermal destruction.
10. The volume of recovered LNAPL is based upon the bail down testing and assumes approximately 830 L would be recovered every month (see below for further explanation of this assumption).

B.4.3 Scenario 3 – Recovery from New Wells using Fixed System

This scenario entails the installation of new recovery wells and extraction using a fixed system (as for Scenario 2). This approach is unlikely to be practicable considering the challenges associated with piercing the landfill cap. However it is included to demonstrate the additional impacts associated with drilling new wells. The approach is defined:

1. Installation of eleven (11) recovery wells to approximately 32 m below ground surface, noting that to reasonably target all the LNAPL present would likely require an order of magnitude increase in required wells. The depth includes 20 metres to the leachate and a 12 metre screen.

2. Disposal off-site of the drilling spoil.
3. Fixed recovery system consisting piping from the new wells to a process equipment area located off the landfill cap.
4. Recovery occurs from new wells using a dedicated air operated pump within each well.
5. Fixed piping transports compressed air from the process equipment to the down well pumps and LNAPL product from the pumps to the storage tank.
6. Process equipment consists of a larger (than the trailer scenario) capacity storage tank, off-gas mitigation, air compressor and concrete bund for the storage tank.
7. Installation / commissioning works is more significant than the trailer scenario and includes drilling of the new wells, manufacture and installation of specially designed wellheads, installation of piping between the wells and process equipment, fabrication and installation of a storage tank, fabrication and installation of a compressed air skid and construction of a concrete bund to house the storage tank.
8. Recovery is continuous aside from unplanned downtime (for example power failure) and maintenance events.
9. Operation and maintenance events occur monthly for 10 years.
10. Wells are decommissioned using concrete to seal the landfill cap.
11. Recovered LNAPL transported to Sterihealth for thermal destruction.
12. The volume of recovered LNAPL is based upon the bail down testing and assumes approximately 830 L would be recovered every month (see below for further explanation of this assumption).

LNAPL Recovery Assumption

The assumption for the volume of LNAPL recovered each month is based on the results of recovery testing (EHS Support, 2014). Approximately 1,660 L of LNAPL was recovered during the testing from the eleven wells and 50% recovery in LNAPL volume in wells was observed after 4 weeks. In the longer term, recovery would be anticipated to reduce further as LNAPL depletes within the formation, however for the purposes of this assessment it is a reasonable to assume recovery remains constant at approximately 830 L per month (50% of the initial recovered volume).

The volume of LNAPL recovered during each scenario is assumed to be the same since it is likely the test volume represents a maximum volume due to depletion of LNAPL around each well and subsequent lowering of mobility.

B.5 Method to Assess Benefit

B.5.1 Context

With respect to contaminated groundwater and removal of LNAPL, it is recognised it is it not technically feasible or responsible to clean-up at any cost, especially in complex geologies. Responsible approaches to remediation of groundwater must integrate “sustainability” principles aiming to balance the benefit and dis-benefits to the community and environment of remediation. The assessment of balance should look at a broad range of economic, environmental and social interactions that may include:

- The value and utility of the groundwater resource being protected versus the value of natural resources used or impacted to restore the resource.
- The risk to the environment posed by the impacts remaining in groundwater versus the impacts to the environment from the implementation of a remediation system.
- The risk to human health posed by the impacts remaining in the environment versus the risk of injury and/or detriment to health resulting from the implementation of a remediation system.
- The economic gain from improving the environment against the cost of remediation.

Remediation sustainability assessments are in their infancy and there is no comprehensive method currently available. Frameworks and tools are being prepared and some are in limited use (e.g. SuRF UK). The framework used for this assessment is appropriate for the objectives and scale of this project and this is discussed further below.

B.5.2 Boundaries

Considering the nature of the impacts; type of remediation contemplated; and the setting and use of the Site, this assessment can be constrained to the Site; roads and facilities outside the Site that would be used for supply and waste transport; and the local community potentially affected by the wider and historical issues associated with the landfill.

Considering the purpose of the assessment is to provide support to impracticability arguments (as opposed to a stand-alone assessment for its own sake), it is focused on assessing environmental sustainability with economic and social sustainability limited to the immediate costs and risks of remediation implementation. In many cases, a qualitative assessment is appropriate.

Examples illustrating the drawing of the boundaries include:

- The strength of community concern is highest at a community level.
- Transport related impacts associated with materials such as PVC piping or the raw materials for PVC piping that is not imported into the country specifically for the project are not counted. Road travel from the local supplier to the site is counted.
- Impacts associated with transport of, for example nitrogen and activated carbon are calculated from the local supplier and not the initial manufacturer which may be overseas.
- Impacts associated with equipment imported specifically for the project (e.g. down well pumps) are counted. However, for air transport for example, the impacts are calculated on a mass basis, i.e. only the impacts associated with the mass of the specific equipment are included.
- Impacts associated with waste are those directly attributable to installation (e.g. impacted soil resulting from drilling of new wells), operation (e.g. depleted activated carbon and recovered LNAPL) and decommissioning (e.g. concrete rubble from bund demolition, used piping) of the system. Waste associated with off-site manufacturing and electricity generation for example are outside the boundary.
- The accident risk from using equipment (e.g. drilling rig) is calculated for operators and not surrounding users.
- The accident risk to drivers other than those associated with the project and to pedestrians is not included.
- The accident risk to workers at off-Site facilities (e.g. power stations and manufacturing plants) is not included.

B.5.3 Sustainability Indicators and Metrics

Where possible, net benefit was assessed quantitatively and semi-quantitatively or qualitatively where it was not possible or inappropriate to generate hard numbers. SiteWise™ was used extensively to calculate the footprint of each scenario and this is described below.

The sustainability of remediation options is typically assessed against indicators. Indicators are generally grouped under the three sustainability headings of environmental, social and economic. The SuRF UK indicators shown in the table are typical of the practice and are considered an appropriate starting point for this assessment.

#	Environmental	Social	Economic
1.	Impacts on air	Impacts on human health and safety	Direct economic costs and benefits
2.	Impacts on soil	Ethical and equity considerations	Indirect economic costs and benefits
3.	Impacts on water	Impacts on neighbourhoods or regions	Employment and capital gain
4.	Impacts on ecology	Community involvement and satisfaction	Induced economic benefits
5.	Use of natural resources and generation of wastes	Compliance with policy objectives and strategies	Lifespan and project risks
6.	Intrusiveness	Uncertainty and evidence	Project flexibility

The indicators showing bold are those considered to be most applicable to this assessment. The others are less important and in some cases not considered any further for the following reasons:

- Impacts on soil – the focus of remediation in this case is groundwater and more specifically leachate and LNAPL. Remediation will not have any benefit to soil and is discussed only qualitatively from the point of view of the possibility of accidental soil impact from implementation of the remediation system.
- Impacts on ecology – considering the nature of the impacts and Site setting, the focus of this remediation is unlikely to provide positive benefit or negatively affect the ecology of the Site and surrounds. It is possible that implementation of the remediation system could disturb soil ecology in the surface layers of the landfill cap but this is unlikely to be of any significance.
- Intrusiveness – the remediation system would be contained within an operating landfill site and construction and operation is unlikely to seriously affect the aesthetic values around the Site.
- Ethical and equity considerations – the ethical side of this indicator is typically not focused on general community issues or regulatory compliance. Ethical issues are typically broader / bigger picture in nature, for example there was debate about the sustainability of biofuel production which has strong ethical content related to possible impacts on poorer countries (Surf UK, 2009). Equity typically considers issues of access related to affordability, disability, gender, ethnic or cultural background. Ethical and equity considerations are typically more relevant to development type projects and are not considered further here. It is stressed that community concerns with remediation of the Site are discussed in other social indicators within this report.
- Compliance with Policy Objectives and Strategies – compliance with regulation is a non-negotiable for remediation, however this indicator is focused on the extent to which remediation aligns with broader policy and initiatives. This is more applicable to large-scale development projects and not a significant indicator for this assessment. The possibility of future regulation change that may affect the outcomes of this assessment is considered unlikely.
- Uncertainty and evidence – this indicator is concerned with the quality of information feeding into a sustainability assessment and the veracity of conclusions leading to decisions. It is typically used also to assess, for each remedy proposed, the certainty of achieving objectives. Since this assessment is focused on assessing the net benefit of remedies and not intent on using the assessment for selection, this indicator is not considered further.
- Indirect economic costs and benefits - this indicator typically assesses costs not directly borne by the project or organisations undertaking the remediation project. For example a large remediation project might require construction of additional infrastructure funded by the State. In such cases, groups other than the immediate project stakeholders may be affected. Indirect economic costs and benefits also refers to the general economic performance of the area. This indicator is not considered further since, from an economic perspective, the remediation project is unlikely to have significant impact beyond the immediate stakeholders.

- Employment and capital gain - whilst the implementation of a remediation system at the Site would engage contractors and vendors, the project is relatively small and will not impact upon employment within the immediate area of the Site, State or the country. Since the area of remediation is unlikely to be developed in the short to medium term, capital gain is unlikely
- Induced economic benefits - considering the small scope and nature of the project, induced economic benefits of significance to warrant discussion within this assessment are unlikely.
- Lifespan and project risks and project flexibility - these indicators are typically related to the longevity of the project and how well remediation can adapt to change that may challenge or improve the sustainability of the initial solution. Similarly to the indicators above, this is typically more relevant to large-scale development projects and assessment of the sustainability factors associated with longer-term development of the landfill site cannot realistically be contemplated at this stage. The scenarios assessed within this project are relatively minor with respect to permanency and can be adjusted to foreseeable changes at the Site. Project risk includes issues such as the reliability of project/technologies; technology status and maturity; issues of due diligence; taking decisions that affect the susceptibility of an activity to environmental hazards (Surf UK, 2009) predominantly natural disasters or extreme conditions. Considering the small-scale and well established technologies and nature of the Site, project risks are likely to be related to system design and implementation rather than big picture issues.

It is noted development may occur in the longer term and at this time the bigger picture indicators above may become relevant. It could be argued perhaps that action now could influence factors such as the range of development that could occur, however near to complete removal of LNAPL would be required and this is impracticable as discussed above and in other documents.

The retained indicators that this assessment focuses on are shown in the table below.

#	Environmental	Social	Economic
1.	Impacts on air	Impacts on human health and safety	Direct economic costs and benefits
2.	Impacts on water	Impacts on neighbourhoods or regions	
3.	Use of natural resources and generation of wastes	Community involvement and satisfaction	

The retained indicators and metrics used to assess each indicator are defined below.

B.5.3.1 Impacts on air

At a broad-scale this indicator includes air-quality, climate change and ozone-depleting substances. This assessment focuses on carbon dioxide and the contribution remediation adds to the greenhouse gas load and priority air pollutants including nitrous oxides, sulphurous oxides and particulates. To allow quantitative assessment of impact to air, the following metrics are calculated using SiteWise™:

- Mass of carbon dioxide - resulting from electricity generation, air and road transport, manufacture of materials and combustion in the high temperature incinerator.
- Mass of nitrous oxides - resulting primarily from the combustion of hydrocarbons and to a lesser degree electricity generation, air and road transport and manufacture of materials.
- Mass of sulphurous oxides - resulting from electricity generation, air and road transport and manufacture of materials, and combustion in the high temperature incinerator.
- Mass of particulates - resulting from electricity generation, air and road transport and manufacture of materials, and combustion in the high temperature incinerator.

In this assessment, the environmental impacts of the above are discussed semi-quantitatively. For example, the mass of carbon dioxide generated is compared to the area of trees required to sequester this quantity and the equivalent amount of cars that would need to be taken off the road to make the emissions neutral.

B.5.3.2 Impacts on water

This indicator includes discussion on the benefit remediation may bring to groundwater. Considering the nature of the Site and remediation scenarios, the likelihood of remediation impacting surface water is unlikely although the possibility of an accident occurring during waste transport is discussed qualitatively.

B.5.3.3 Resource use and Waste

The resource use indicator includes the depletion of natural resources such as water (note this is separate from impacts to water); fossil fuels (for transport, electricity generation, waste destruction and as a raw material to construction materials such as PVC piping); and raw materials for construction (e.g. limestone for cement added to sand and water for concrete, steel for storage tanks, structures and pipes). To allow quantitative assessment of resource use, the following metrics are calculated using SiteWise™:

- Total energy used (mmBTU converted to MJ). The total energy used is a headline indicator of the intensity of remediation and includes, for example, energy embodied in fuels used to power vehicles, operate equipment and generate electricity and to treat wastewater.
- Water consumption (gallons converted to litres). The water consumption quantified is primarily that used associated with generation of electricity.
- Electricity use (MWh). Calculated as a headline quantity to calculate emissions and water consumption associated with power generation. Also used in a semi-quantitative discussion to show equivalent uses for power (e.g., electricity to homes).

The waste indicator accounts for impacts associated with construction, operation and maintenance and decommissioning of the remediation system. To allow quantitative assessment of waste, the following metrics are calculated using SiteWise™:

- Landfill space used (reported as a mass (metric tons)).

B.5.3.4 Impacts on Human Health and Safety

This indicator accounts for the potential increase risk of accident and injury due to the remediation. The impacts on health and safety of populations not involved in construction, operation and decommissioning of the system is discussed qualitatively. The increase in risk to workers associated with remediation (e.g. a driller, pipe fitter or waste truck driver) are assessed quantitatively in SiteWise™ through calculation of:

- Accident risk fatality (unitless) – SiteWise™ uses inputs including distance travelled in vehicles and hours of operation of equipment to calculate the incremental risk of fatality from remediation.
- Accident risk injury (unitless) – SiteWise™ uses inputs including distance travelled in vehicles and hours of operation of equipment to calculate the incremental risk of injury from remediation.
- Lost hours due to injury (hours) - SiteWise™ uses inputs including distance travelled in vehicles and hours of operation of equipment to calculate statistical lost time due to injury.

B.5.3.5 Impacts on Neighbourhoods or Regions

This indicator accounts for impacts such as increased traffic on roads (e.g. due to waste transport during operation of the system) and noise (e.g. during drilling of wells or due to an operating air compressor). The nature of the remediation scenarios is unlikely to have a wider impact on the region. This assessment reports the total kilometres on roads for each scenario and qualitatively discusses impacts to neighbourhoods. Other impacts such as noise are unlikely to be significant considering the nature of the Site and these are only briefly discussed.

B.5.3.6 Community Involvement and Satisfaction

This indicator assesses the degree of meaningful engagement with and input from the community. The satisfaction aspect is used to assess how satisfied the community is with the remedy upon completion and is more applicable to large scale development projects. For this Site, there is significant community attention and meetings are held regularly. Consequently, this important indicator is discussed qualitatively with reference to feedback from the community.

B.5.3.7 Direct Economic Costs and Benefits

Life-cycle cost – an estimate of the total cost for the remediation system including installation/commissioning, operation and maintenance and decommissioning. Costs associated with the remediation system but not directly the implementation (for example regulatory engagement, community meetings) are excluded.

Remediation at this Site is unlikely to bring any tangible economic benefits.

B.5.4 SiteWise™ and Calculation of Metrics

SiteWise™ was used to quantify the metrics identified in the sections above. SiteWise™ is an Excel-based lifecycle tool developed jointly by the United States Navy, Army Corps of Engineers, and Battelle. SiteWise™ is currently in a third revision and is used widely used across the world for assessing the footprint of remediation.

The tool is a series of excel sheets and provides a detailed baseline assessment of several quantifiable sustainability metrics including: greenhouse gases (GHGs); energy usage; electricity usage from renewable and non-renewable sources; criteria air pollutants that include sulphur oxides (SOx), oxides of nitrogen (NOx), and particulate matter (PM); water usage; resource consumption; and accident risk.

The assessment is carried out using a building block approach where every remedial alternative is first broken down into modules that can represent generic components of an alternative or mimic the remedial phases in remedial actions. For this Site, the modules are used to represent the various phases of a remediation system - installation/commissioning, operation and maintenance and decommissioning. Once broken down into various modules, the footprint of each module is calculated individually. The different footprints are then combined to estimate the overall footprint of the remedial alternative. This building block approach reduces redundancy in the sustainability evaluation and facilitates the identification of specific activities that have the greatest environmental footprint.

SiteWise™ does not currently assess community or ecological impacts and these are discussed qualitatively within this document.

SiteWise™ allows calculation of a state specific electricity profile by identifying the mix of electricity generating technologies. The approximate mix of technologies in Victoria in Victoria is shown in the table below and this was used in the SiteWise™ calculations.

Electricity Generation Technology	Proportion of Supply in Victoria
Coal	66%
Oil	0%
Hydroelectric	7%
Natural Gas	20%
Biomass	1%
Nuclear	0%
Wind	5%
Solar	1%
Geothermal	0%
Total	**100%**

The outputs reported from SiteWise are for 10 years of operation. Inputs and assumptions used for SiteWise™ are included in the table in **Appendix B1**.

B.5.5 Further Quantitation of Metrics

Some of the metrics are perhaps not particularly useful by themselves other than to compare between remediation scenarios. For example it may be argued that all other things being equal a technology that has higher carbon dioxide emissions has an overall lower net benefit due to perceived impacts to the environment and human health. Further context may be provided by calculating quantities more readily evaluated for contribution to net benefit. In this assessment the following calculations are undertaken:

- Greenhouse gas emissions – greenhouse gas emissions are placed in context by calculating:
- The area of forest required to sequester the yearly remediation emissions. This is calculated using a value derived from the Sustainable Remediation Tool (U.S Air Force, 2010) and assumes 0.2 hectares of forest can sequester 1 tonne of carbon dioxide each year.
- The number of cars to which the emissions from remediation are equivalent. A number of values for car emissions are available and an appropriate number for Australia is 5 tonnes per year.
- Electricity use – electricity use is placed in context by calculating:
- The number of residential Victorian homes the electricity use represents. This is calculated using information from the Australian government website4 that states the average Australia household uses an average of 6,617 kWh of electricity per year.
- Water use – water use is placed in context by calculating:
- The number of people that could be fed from the grain produced using the equivalent amount of water. This is calculated using the rule of thumb of 1000 tons of water to produce 1 ton of grain and 25 kg of grain per capita per month.
- Accident risk – accident risk is placed in context by comparing the calculated values to the risk levels commonly used to assess human health risk from contamination. The recommended (NEPC 2010 and supported by enHealth 2012) acceptable incremental lifetime risk of

[4] http://energymadeeasy.gov.au/bill-benchmark/results/3660/4

developing cancer arising from exposure to single or multiple carcinogens is 1 in 100,000 (10-5).

B.6 Net Benefit Assessment

The following sections discuss the performance of each scenario against each of the retained indicators. Where metrics were calculated these are reported quantitatively. The key results summarised below.

B.6.1 Relative Contribution of Phases

For these remediation scenarios, in general the greatest impacts occur during the operation and maintenance phase primarily because this occurs over the longest time interval; is when most of the road travel occurs; is when the majority of recovered LNAPL disposal occurs; and, for the Fixed System scenarios, is when the majority of electricity use occurs. The impacts associated with the installation of new wells is significant.

B.6.2 Impacts on Air

The table below shows the results of calculations from SiteWise™ for the three scenarios. The range of each metric is:

- Greenhouse gas emissions – minimum of 95 metric tons to maximum of 352 metric tons
- Total NOx – minimum of 0.2 metric tons to maximum of 0.8 metric tons
- Total SOx – minimum of 0.1 metric tons to maximum of 0.5 metric tons
- Total PM10 – minimum of 0.02 metric tons to maximum of 0.4 metric tons

The highest emissions are from the *Fixed System with New Wells* scenario primarily because of the additional emissions associated with transport and manufacture of materials for the installation of the new wells.

Remediation Scenario	GHG Emissions (metric ton)	Total NOx Emissions (metric ton)	Total SOx Emissions (metric ton)	Total PM10 Emissions (metric ton)
Trailer with Existing Wells	95	0.2	0.1	0.02
Fixed System with Existing Wells	282	0.7	0.4	0.3
Fixed System with New Wells	352	0.8	0.5	0.4

The table below shows the greenhouse gas emissions placed in context as discussed in the section above.

Remediation Scenario	GHG Emissions (metric ton)	Forest (hectare)	Cars
Trailer with Existing Wells	95	19	22
Fixed System with Existing Wells	282	56	64
Fixed System with New Wells	352	70	80

Implementation of any of the three remediation scenarios will result in emissions to air that are polluting and contribute to global warming. The greenhouse gas emissions are of a magnitude that off-setting with forest requires substantial effort and cost and further use of water to establish and maintain the trees. The emissions are equivalent to between 22 and 80 cars. In comparison, the impacts to air from the LNAPL beneath the Site are insignificant to nil. (It is noted that impacts to air occur from the operation of the landfill gas extraction system but this is the base case and incremental impacts are appropriate to consider for this assessment).

B.6.3 Impacts on Water

No quantifiable metrics are calculated for this indicator. Implementation of any of three remediation scenarios is unlikely to cause detrimental impact to groundwater or surface water since there are no discharges to water (for example from a water treatment plant) and no chemicals injected into groundwater. There is a low possibility surface water or groundwater outside the remediation area could be impacted by a spill during transport of the LNAPL to the disposal facility or breach from the fixed system storage tank.

Impacts to water from the Site operations are well understood and whilst the objective of remediation would be to improve groundwater conditions (primarily though the removal of LNAPL), as discussed above, the technical challenges are such that any appreciable improvement is unlikely. Further, the existing LNAPL impacts are not currently and are unlikely to impact groundwater off-site or surface water.

B.6.4 Natural Resources and Waste

Electricity and Water

The table below shows the results of calculations from SiteWise™ for the three scenarios and the context for the metrics as discussed above.

Remediation Scenario	Electricity (MWH)	Homes	Water (tonnes)	Grain (tonnes)	People (per month)
Trailer with Existing Wells	0	0	0	0	0
Fixed System with Existing Wells	220	33	424	0.4	17
Fixed System with New Wells	220	33	424	0.4	17

The table above illustrates the impact electricity use can have on the footprint of a project with the use for the fixed system scenarios equivalent to the annual use of more than 30 average Australian homes. Water supply is a major global issue and electricity generation is a significant user. The water use for electricity generation for the fixed systems scenarios is equivalent to amount required to grow about 400 kilograms which could feed around 17 people for a month.

Groundwater

A key consideration when assessing the net benefit of remediation is the value of the groundwater resource. In many cases contamination has removed the benefit to the community and State of the groundwater resource. In these cases an assessment of the value of the groundwater resource versus the cost of remediation is often useful. For this Site, beneficial use of groundwater is precluded due to the designated land use and evaluation of the value of the groundwater resource is not considered relevant given that observed groundwater impacts are typically unrelated to the LNAPL specifically.

Waste

The table below shows the results of calculations from SiteWise™ for the three scenarios.

Remediation Scenario	Waste (metric tons)
Trailer with Existing Wells	0.8
Fixed System with Existing Wells	45
Fixed System with New Wells	72

The waste is solid waste to landfill including soil from drilling of new wells for the Fixed System with New Wells scenario; depleted activated carbon; consumables (e.g. gloves and bailers); and concrete rubble and piping resulting from decommissioning.

The recovered LNAPL is not reported in the table above as it is assumed treated by thermal destruction. In this case, the impacts are in electricity use and air emissions.

B.6.5 Human Health and Safety

The table below shows the results of calculations from SiteWise™ for the three scenarios.

Remediation Scenario	Accident Risk (Fatality)	Accident Risk (Injury)	Lost time (hours)	Distance (km)
Trailer with Existing Wells	3.3E-03	6.8E-01	5.4	17083
Fixed System with Existing Wells	9.0E-04	1.7E-01	1.3	11257
Fixed System with New Wells	9.3E-04	1.7E-01	1.4	13699

Implementation of all three remediation scenarios entails significant risk to human health due to the need for extensive driving for installation, operation and maintenance and decommissioning. The risk is primarily connected to driving and operating machinery. Further, not all risks are considered by SiteWise™ most notably the risk to non-workers from transport of LNAPL and solid waste on roads.

The risks to human health from the LNAPL impacts beneath the site are low and acceptable. By way of comparison, levels commonly used to determine risk to human health from contaminants are in the order of 10^{-4} and 10^{-6} with NEPM citing 10^{-5} as the default, whereas the risks associated with remediation implementation are significantly higher. For example, considering the human health risk from carcinogens can be defined as the incremental risk of contracting cancer. This does not necessarily imply death whereas the risk of fatality associated with the Trailer scenario is greater than 10^{-3}.

B.6.6 Neighbourhoods

Considering the setting of this Site, impacts such as noise and unsightliness are not likely to be significant. Trucking LNAPL from this high-profile Site however, may heighten community concern.

B.6.7 Community Involvement and Satisfaction

The Site is high-profile with much community scrutiny. Community concern is mostly connected to historical operation of the Site and fear of the contamination beneath the Site. The importance of maintaining open lines of communication with the community and obtaining their support for the environmental management of the Site is well understood.

B.6.8 Direct Economic Costs and Benefits

The table below summarises the costs per phase and total present costs over ten years of operation for each scenario (noting that in reality that extraction would be required for a minimum 200 years based on the LNAPL recovery assessment). The costs are based on the scenarios detailed in **Section B4** and specific quantity assumptions are contained in the table in **Appendix B1**.

Remediation Scenarios	Install	O&M/yr	Decom	Total PV (10 years)
Trailer with Existing Wells	$ 48,869	$ 396,179	$ 6,000	$ 2,837,461
Fixed System with Existing Wells	$ 299,267	$ 176,834	$42,124	$ 1,583,397
Fixed System with New Wells	$ 461,647	$ 176,834	$ 48,474	$ 1,752,127

The costs are significant with the highest cost being the Trailer scenario primarily due to the intensity of field activities during the operating period. Whilst removal of LNAPL to the point where groundwater beneficial uses could be restored (requiring complete removal of mobile LNAPL at a minimum) is impracticable, it is perhaps informative to project the cost of complete removal at the optimistic recovery rate used for this assessment. In today’s terms, the cost would be in the order of $70 million to $120 million.

Considering the relatively small scale and simple (e.g. no development is occurring) nature of remediation at this Site, a comprehensive quantitative analysis of financial benefits and dis-benefits of implementing remediation versus not implementing remediation is unlikely to add value to this assessment.

A quantitative assessment would typical aim to calculate the benefit cost ratio to compare the financial benefit of implementing or not implementing remediation to the cost of implementing or not implementing. Ratios larger than one imply benefits of implementing or not implementing are larger than the costs. As an example, a financial benefit of implementing remediation might be a decrease in the time require to monitor the site. However considering the unlikeliness of achieving LNAPL removal and restoring groundwater to the point where a significant reduction in time may occur, this is unlikely to be significant compared to the cost of remediating. Further, a financial benefit from not implementing remediation may be avoidance of additional maintenance cost associated with increased stress on the landfill cap due to additional vehicle movements. For this Site, the benefits of not implementing remediation are likely to exceed the costs whereas the costs of implementing remediation are likely to exceed the benefits.

B.6.9 Relative Contribution of Activities

A number of additional sub-scenarios were run for the *Fixed System with New Wells* scenario to gain a sense for the main contributors to each calculated value. The additional scenarios were:

- No air travel – removal of transport of equipment (down-well pumps in this case) by air. The impact is primarily a reduction in greenhouse gas emissions. Since the amount of air travel is small for the scenarios, the overall impact is relatively minor with a change in the order of 1%. However, the decrease in the mass of greenhouse gas emissions is in the order of 4 tonnes which is significant considering the small amount of air travel. SiteWise™ uses a carbon dioxide emissions factor for air cargo of 1.4 kg CO_2 per ton-mile. The same factor for road transport is orders of magnitude lower.

- No activated carbon – removal of activated carbon used to mitigate offgas emissions from the storage tank. This scenario removes the impacts associated with manufacture, local transport and disposal of the carbon. The result is a reduction of approximately 29 metric tons (or 8%) of greenhouse gas and a slight reduction in accident risk due to reduced road travel.
- No concrete – removal of the concrete used to construct the equipment pad and bund for the Fixed System scenarios. The impact is relatively minor since the amount of concrete is small.
- No electricity – removal of the electricity used to power equipment for the Fixed System scenarios. This has the largest impact with reductions close to 195 metric tonnes (or 55%) for greenhouse gas emissions. The reduction of greenhouse gas emissions and NOx and SOx was in the order of 60% and close to 90% for particulates. The reduction in water is over 420 kilolitres which is 100% since SiteWise™ includes water only for electricity generation.
- No road travel – removal of road transport impacts air emissions and accident risk and results in a reduction in greenhouse gas emissions of 12 tonnes (3%) and risk of injury by 17%.
- No high temperature incinerator– removal of the thermal destruction for recovered LNAPL primarily affects air emissions with a reduction of 1 tonnes (<1%) in greenhouse gas emissions and 84% reduction in NOx.
- No waste – removal of transport and disposal of waste include solid (e.g. activated carbon) and liquid (recovered LNAPL) has a similar effect to the removal of high temperature incineration reflecting the relative predominance of the recovered LNAPL in the waste.
- No workers – removal of workers on-site (without removing road transport) affects the accident risk with a reduction of 82% risk of injury.

It is acknowledged that changes to metrics will be different between remediation scenarios, however the exercise provides insight into which activities have the greatest affect from a net benefit perspective. In this case, the following broad conclusions are drawn:

1. For these remediation scenarios, the total distance of equipment transported by air is relatively small. However, the relative contribution to greenhouse gas emissions is significant and suggests minimization of air transport would provide a strong contribution to the overall net benefit of a project. It could also be argued that reducing air transport would benefit social indicators by influencing a “buy local” strategy supporting local enterprise.
2. Electricity generation is a major contributor to impacts to air and water use. The immediate conclusion may be to move toward renewable technologies, however the life-cycle impacts to air and water use of these technologies is not necessarily clear cut and assessment is beyond the scope of this project. Further, the additional financial cost of implementing renewable technology must be considered.
3. Reduction in road travel will reduce greenhouse gas emissions though not as significantly as reduction in electricity use.
4. It is self-evident that reduction in road transport and operation of machinery will decrease the accident risk.

B.7 Discussion

The work reported in this report and preceding work referenced throughout the report demonstrates for this Site:

- Risks to human health and the environment posed by LNAPL remaining beneath the landfill cap are low and acceptable and the risk profile is unlikely to materially change over time;
- LNAPL is functional immobile and not migrating;
- The recoverability of LNAPL is impracticable and even large-scale recovery (which is not possible in any case due to the presence of the landfill cap) is unlikely to significantly reduce the mass in a reasonable timeframe;
- Active remediation is unlikely to significantly reduce the time for restoration of groundwater beneficial uses;

- If active remediation were undertaken there would be significant negative impacts including greenhouse gas emissions and real safety risk to personnel from potential exposure to pressurised remediation equipment and liquid and vapour phase hydrocarbons;
- Natural degradation of petroleum hydrocarbons is occurring;
- Recovery to the point where a long-term benefit such as reduction in the time the landfill impacts persist or conditions are changed to allow or increase the value of development is unlikely; and
- There is no real benefit to the community or environment from further recovery.

Considering the absence of risk to human health and the environment from the LNAPL beneath the Site, the only significant driver for LNAPL remediation is the perceived risk to human health by the community noting that regulation allows robust arguments focusing on impracticability to select natural remediation over engineered for the restoration of groundwater beneficial uses.

This assessment modelled remediation scenarios deemed most suitable from screening to determine the dis-benefits or negative impacts of implementation. Aside from the significant financial burden, remediation would cause impacts to air including greenhouse gas emissions and pollutants, use natural resources including fossil fuels and water, produce waste, increase traffic on local roads and present significant risks of injury. Remediation would also stress the landfill cap due to increase vehicle movements particularly with the Trailer scenario.

It is perhaps useful to compare the findings of this assessment with the broad sustainability factors outlined in **Section B5.1**.

"The risk to the environment posed by the impacts remaining in groundwater versus the impacts to the environment from the implementation of a remediation system".

From an environmental perspective, the key finding is the risk from the LNAPL that a remediation system would attempt to recover, are low and acceptable, whereas remediation itself creates emissions and waste with the potential to cause harm. Greenhouse gas emissions contribute to human health and environmental issues and a remediation system would create not insignificant quantities. Transport and treatment of waste has the potential for environmental impacts from tailpipe emissions and the, albeit low, risk of spill.

"The risk to human health posed by the impacts remaining in the environment versus the risk of injury and/or detriment to health resulting from the implementation of a remediation system".

Implementing remediation has incremental risks to safety primarily relating to accident from road travel. These risks are quantified using SiteWise and placed into context by comparing the risk levels commonly used to assess risk to human health from in-ground contaminants and the low and acceptable risk at this site.

"The economic gain from improving the environment against the cost of remediation". Indicators include direct economic costs and benefits".

Considering engineered recovery of LNAPL to a level that would allow a higher value use of the land is unlikely in the foreseeable long term, there is no realistic or appreciable economic gain from implementing remediation. However, the cost of implementing remediation is significant and this is quantified within the report.

The table below provides a qualitative summary of the assessment from the perspective of the community and surrounds (as compared with impacts upon workers associated with remediation). The benefits of implementing and not implementing remediation are described in terms of values or goals likely to maintain or enhance a happy and healthy human life and preserve the environment. It is noted that parts of this assessment are subjective (e.g. it is possible that a person walking past the Site may feel apprehensive due to the perception of risks from impacts).

Benefit	Benefit of Implementing Remediation	Benefit of Not Implementing Remediation
Healthy lives free from risk not of our choosing	Nil. Risks to human health from impacts beneath the landfill cap are low and acceptable.	Avoids risk to humans from exposure to machinery, vapours and driving to and from and around the Site. Avoids greenhouse gas and air pollutant emissions. Avoids accident risk due to increased traffic.
Life free of anxiety	Possible benefit to community due to perception that remediation will decrease the risk to health.	Possible benefit due to avoidance of traffic associated with the Site, particularly waste LNAPL transport.
Healthy food Preservation of species Preservation of amenity	Nil. Impacts beneath the landfill cap are not currently and unlikely to in the future impact surface water, groundwater or soil used for growing crops or impacting ecological to the point where flora and fauna are detrimentally affected.	Avoids risk of damage to soil and groundwater from LNAPL spill during transport for disposal.
Vibrant life with beautiful surroundings	Negligible	Negligible
Healthy planet	Negligible	Avoid greenhouse gas and air pollutant emissions.
Regional / global high standard of living	Negligible	Negligible

B.8 Conclusions

At this Site, it is demonstrated the potential risks and costs to humans and the environment of implementing remediation are outweighed by the benefits of not implementing remediation. In summary:

1. The benefit to human health of implementing remediation is outweighed by the potential risks to human health resulting from driving and exposure to increased traffic, operation of machinery and exposure to hydrocarbons.
2. The benefit to the environment of implementing remediation is outweighed by the environmental impacts including greenhouse gas and air pollutant emissions from electricity generation, combustion of LNAPL waste and air and road transport and potential for a spill during transport LNAPL waste.
3. The implementation of remediation requires the use of precious natural resources including fossil fuels and water.
4. The implementation of remediation requires management of solid and liquid waste.

When this balance is placed in context with the absence of drivers for remediation (e.g. risk to human health from the impacts beneath the landfill cap, restoration of a groundwater resource), other than community concern, the greatest benefit is to not implement remediation. From a bigger picture perspective, not implementing remediation avoids contribution to climate change and diminishing water supplies.

APPENDIX B1: TABLE OF QUANTITY ASSUMPTIONS

Item	Units	All	Trailer	Fixed	New Wells	Justification / Source
General						
O&M period	years	10				Reasonable period of time to operate system
Working day	hours	10				Standard
LNAPL Recovery						
Liquid flowrate (averages)	litres per hour	1.5				Baildown testing (EHS Support, 2014)
Liquid volume for waste (totals)	litres per month	828				Baildown testing (EHS Support, 2014)
LNAPL density	kilograms per litre	0.85				Measurements of LNAPL
Trailer Bund (portable)						
Width	metres		4			Sufficient to capture contents of trailer storage tank
Length	metres		10			Sufficient to capture contents of trailer storage tank
Area of bund (for SiteWise input)	square feet		431			Calculated from above and using conversion shown below
Thickness of bund (for SiteWise input)	feet		0.02			Calculated from above and using conversion shown below
Storage Tank						
Capacity	litres		1636	4545	4545	
Empty frequency per event	months		1.0	4.0	4.0	
Storage Tank Bund (fixed system)						
Width of bund wall	metres		N/A	4	4	Based on volume required to hold to meet regulations
Length of bund wall	metres		N/A	7	7	Based on volume required to hold to meet regulations
Height of bund wall	metres		N/A	0.3	0.3	Based on volume required to hold to meet regulations
Thickness of bund wall	metres		N/A	0.2	0.2	Standard thickness
Thickness of bund floor	metres		N/A	0.2	0.2	Standard thickness
Concrete volume	cubic metres		N/A	6.9	6.9	Calculated from above
Concrete density	tonnes per cubic metre		N/A	2.4	2.4	Engineering toolbox
Concrete mass	tonnes		N/A	16.6	16.6	Calculated from above
Held volume	litres		N/A	8400	8400	Calculated from above
Multiplier over stored volume	dimensionless		N/A	1.7	1.7	Check on suitability of size
Area of bund (for SiteWise input)	square feet		N/A	372	372	Calculated from above and using conversion shown below
Thickness of bund (for SiteWise input)	feet		N/A	0.66	0.66	Calculated from above and using conversion shown below
Process Equipment Foundation						
Width of foundation	metres			4	4	Based on volume required to hold to meet regulations
Length of foundation	metres			8	8	Based on volume required to hold to meet regulations
Height of foundation	metres			0.2	0.2	Based on volume required to hold to meet regulations
Concrete volume	cubic metres			6.4	6.4	Calculated from above
Concrete density	tonnes per cubic metre			2.4	2.4	Engineering toolbox
Concrete mass	tonnes			15.4	15.4	Calculated from above
Area of bund (For SiteWise input)	square feet			32	32	Calculated from above and using conversion shown below
Thickness of bund (for SiteWise input)	feet			0.66	0.66	Calculated from above and using conversion shown below
Machinery and equipment						
Capacity	tonnes	28.0				Standard
Average speed	kilometres per hour	45.0				Estimation based on local roads
Loading / unloading time (each)	hours	1				Experience estimate
Drilling speed	metres per hour				4	Experience estimate
Density of soil	tonnes per cubic metre				1.5	Engineering toolbox
Nitrogen						

Item	Units	All	Trailer	Fixed	New Wells	Justification / Source
Bottle size			G			Standard size
Mass in bottle	kilograms		8.5			Supplier reference
Mass in 6 pack of G-size bottles	kilograms		51			Supplier reference
	tonnes		0.051			Calculated from above
Molecular weight	grammes per mole		28			Engineering toolbox
Consumption by one pump (AP4-High vis)	litres per minute		42			EHS Support Design (2014)
	kilograms per hour		3.0			Calculated from above
Rates (processing)	-					
High temperature incinerator	tonnes LNAPL per hour	10				Estimate as proprietary information (Sterihealth)
Electrical (commissioning)	-					
Equipment rating	kW		N/A	5	5	Air compressor
Hours operating per month	hours		N/A	20	20	Half day for five days of commissioning
Consumption	kWh		N/A	100	100	Calculated from above
Electrical (operation and maintenance)	-					
Equipment rating	kW		N/A	5	5	Air compressor
Hours operating per month	hours		N/A	366	366	Operating each day within month for half the time
Consumption	kWh		N/A	1830	1830	Calculated from above
Distances	-					
Flight one-way Los Angeles to Melbourne	kilometres	13000				Google Earth
Local labour one-way to site	kilometres	20				Estimate
Local / int. del to site equipment one-way to site	kilometres	20				Estimate
Crane one-way to site	kilometres	20				Estimate
Carbon supply one-way to site	kilometres	20				Estimate
Landfill (e.g. carbon) disposal one-way to site	kilometres	20				Estimate
Incinerator one way	kilometres	20				Estimate
Nitrogen one-way to site	kilometres		20			Estimate
Fuel supply one-way to site	kilometres	20				Estimate
Average between wells	kilometres	0.1				Site maps
Costs	-		Cost (A$)			
Well casing - 250 mm PVC	per 6 metre length			$ 300	$ 300	Experience estimate
Well screen - 250 mm PVC	per 6 metre length			$ 1,000	$ 1,000	Experience estimate
Wellheads	assembly			$ 1,000	$ 1,000	EMS
Piping - 10 mm LNAPL and air hose	metres per roll		$ 80			Experience estimate
Piping - 13 mm LNAPL and air hose	metres per roll		$ 100			Experience estimate
Piping - 25 mm LNAPL and air hose	metres per roll		$ 200			Experience estimate
Piping - 32mm LNAPL and air hose	metres per roll		$ 350			Experience estimate
Piping - 25 mm HDPE/UPP	metres per roll			$ 300		Experience estimate
Piping - 32 mm HDPE/UPP	metres per roll			$ 500		Experience estimate
Recovery Trailer - refurbish	lump		$ 20,000			EMS

Item	Units	All	Trailer	Fixed	New Wells	Justification / Source
Pump - downwell	item	$ 5,000				QED
Pump - spares	item	$ 300				QED
Portable bund	item	$ 5,000				Vendor
Air compressor (5 kW)	item			$ 5,000	$ 5,000	Experience estimate
Storage tank (5,000 L)	item			$ 15,000	$ 15,000	Experience estimate
Offgas system	item			$ 5,000	$ 5,000	Experience estimate
Carbon drum - offgas (replace)	item	$ 2,000	$ 2,000			Experience estimate
Instrumentation	lump			$ 10,000	$ 10,000	Experience estimate
Switch replacement	item	$ 200				Experience estimate
Delivery cost of assembled skids	lump			$ 5,000	$ 5,000	Experience estimate
Fixed bund	item			$ 20,000	$ 20,000	Experience estimate
Pipe and fittings (process equipment)	lump			$ 20,000	$ 20,000	Experience estimate
Skids	lump			$ 15,000	$ 15,000	Experience estimate
Electrical (fixed system)	lump			$ 15,000	$ 15,000	Experience estimate
Nitrogen six pack	lump		$ 300			Experience estimate
Activated carbon (supply)	kilogram	$ 4.00	$ 4.00			InSite Remediation
Electrical supply	kilowatt hour			$ 0.12	$ 0.12	Experience estimate
Fuel for generator (delivered)	litre	$ 1.50				InSite Remediation
LNAPL analytical	sample	$ 300.00				Experience estimate
Labour - field	hour	$ 100				Experience estimate
Electrician	hour			$ 150	$ 150	Experience estimate
Design engineer	hour	$ 200	$ 200			Experience estimate
Vehicle	day	$ 200	$ 200			Experience estimate
PID/FID/LEL	day	$ 50	$ 50			Experience estimate
PPE	day	$ 50	$ 50			Experience estimate
Generator	day	$ 60				Experience estimate
Crane	day			$ 1,600	$ 1,600	Experience estimate
Rockbreaker	day			$ 1,500	$ 1,500	Experience estimate
Truck for rubble	hour			$ 140	$ 140	Experience estimate

Item	Units	All	Trailer	Fixed	New Wells	Justification / Source
Drill rig daily	day			$ 5,000	$ 5,000	Experience estimate
Concrete for decom wells	tonne delivered			$ 100	$ 100	Experience estimate
Landfill rubble gate fee	tonne	$ 200.00				Experience estimate
Landfill soil disposal	tonne				$ 300.00	Experience estimate
Activated carbon (dispose)	kilogram disposed	$ 6.00				Experience estimate
LNAPL dispose	kilogram treated	$ 5.50				Sterihealth
LNAPL transport	load	$ 700.00				Sterihealth
Consumable solid waste	kilogram	$ 2.00				Based on $200 per 100 kilogram drum
Masses	-					
Well casing - 250 mm PVC	kilograms per metre				5	Estimate
Well screen - 250 mm PVC	kilograms per metre				4.5	Estimate
Wellheads	kilograms			2	2	Estimate
Piping - 10 mm LNAPL and air hose	kilograms per metre	0.2				PB Series Swagelok
Piping - 13 mm LNAPL and air hose	kilograms per metre	0.2				PB Series Swagelok
Piping - 25 mm LNAPL and air hose	kilograms per metre	0.49				PB Series Swagelok
Piping - 32mm LNAPL and air hose	kilograms per metre			0.7	0.7	Estimate
Piping - 25 mm HDPE/UPP	kilograms per metre			1	1	Estimate
Piping - 32 mm HDPE/UPP	kilograms per metre			1.5	1.5	Estimate
Pump - downwell	kilograms	7.8				QED
Pump - spares	kilograms	0.1				Estimate
Portable bund	kilograms		30			Estimate
Air compressor (5 kW)	kilograms			50		Estimate
Storage tank (5,000 L)	kilograms			1200		Estimate
Offgas system	kilograms			400		Estimate
Carbon drum - offgas (replace)	kilograms	20				Estimate
Instrumentation	kilograms			50		Estimate
Switch replacement	kilograms	0.1				Estimate
Pipe and fittings (process equipment)	lump			200	200	Estimate
Skids	lump			250	250	Estimate
Electrical (fixed system)	lump			200	200	Estimate
Conversions	-					
Distance - kilometres to miles	km/mile	1.609				Unit convertor
Mass - kilograms to pounds	lb/kg	2.2				Unit convertor
Area - square metres to square feet	ft2/m2	10.764				Unit convertor
Length - millimetres to inches	in/mm	0.0394				Unit convertor
Length - metres to feet	ft/m	3.281				Unit convertor
Volume - gallons (US vol) to litres	l/gal	3.79				Unit convertor
Energy - MJ to mmBTU	MJ/mmBTU	1055				Unit convertor
Power - kW to hp	kW/hp			0.746	0.746	Unit convertor
-	-					

APPENDIX B2: SITE WISE INPUTS AND OUTPUTS

SITE INFORMATION	
User Name and Date	Kevin Simpson
Site Name	TPI Tullamarine
Remedial Alternative Name	Trailer existing wells
Alternative File Name	Trailer ex wells
Choose electricity profile	CUST

To Custom

Do you want to reload a previously saved remedial alternative in the SiteWise input sheet?

Yes

Refresh List

Reset all input values on all worksheets to default

Reset All Values on All Sheets

-= Status =-

Done Loading!

This worksheet allows the user to define material production, transportation, equipment use, and residual handling variables for the remedial alternative

Yellow cells	require the user to choose an input from a drop down menu
White cells	require the user to type in a value

BASELINE INFORMATION

COMPONENT 1 DURATION AND COST	Entire Site
Input duration of the component (unit time)	1
Input component cost per unit time ($)	48869

MATERIAL PRODUCTION

WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Choose specific casing material schedule from drop down menu	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC
Choose well diameter (in) from drop down menu	10	1/8	1/8	1/8	1/8	1/8
Input total quantity of Sand (kg)						
Input total quantity of Gravel (kg)						
Input total quantity of Bentonite (kg)						
Input total quantity of Typical Cement (kg)						
Input total quantity of General Concrete (kg)						
Input total quantity of Steel (kg)						

TREATMENT CHEMICALS & MATERIALS	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input number of injection points						
Choose material type from drop down menu	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide
Input amount of material injected at each point (pounds dry mass)						
Input number of injections per injection point						

TREATMENT MEDIA	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input weight of media used (lbs)	110					
Choose media type from drop down menu	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC

CONSTRUCTION MATERIALS	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material type from drop down menu	HDPE Liner	General Concrete	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner
Input area of material (ft2)	431					
Input depth of material (ft)	0.02					

WELL DECOMMISSIONING	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Input well diameter (in)						
Choose material from drop down menu	General Concrete	Soil	Soil	Soil	Soil	Soil

BULK MATERIAL QUANTITIES	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material from drop down menu	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid
Choose units of material quantity from drop down menu	pounds	pounds	pounds	pounds	pounds	pounds

Input material quantity						

TRANSPORTATION

PERSONNEL TRANSPORTATION - ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose vehicle type from drop down menu*	Cars	Cars	Cars	Cars	Cars	Cars
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input distance traveled per trip (miles)	12.4	12.4	12.4	12.4	12.4	12.4
Input number of trips taken	2	2	2	2	19	2
Input number of travelers	2	3	2	1	2	4
Input estimated vehicular fuel economy (mi/gal) (Input only if known for the vehicle selected, otherwise a default will be used by the tool)						

*For vehicle type 'Other' please enter values in Table 2b in the Look Up Table tab.

PERSONNEL TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input number of travelers						
Input number of flights taken						

PERSONNEL TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Choose vehicle type from drop down menu	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail
Input distance traveled (miles)						
Input number of trips taken						
Input number of travelers						

EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Account for an empty return trip?	No	No	No	No	No	No
Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).	12					
Input weight of equipment transported per truck load (tons)	0.01					

EQUIPMENT TRANSPORTATION - SHARED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of equipment transported (tons)						

EQUIPMENT TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)	8,080					
Input weight of equipment transported (tons)	0.01					

EQUIPMENT TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of load (tons)						

EQUIPMENT TRANSPORTATION - WATER	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (mile)						
Input weight of load (tons)						

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Dozer	Dozer	Dozer	Dozer	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)						
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

DRILLING	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Input number of drilling locations	0					
Choose drilling method from drop down menu	Hollow Stem Auger	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push
Input time spent drilling at each location (hr)						
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel

TRENCHING	Trencher 1	Trencher 2	Trencher 3	Trencher 4	Trencher 5	Trencher 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input operating hours (hr)						

For each pump, select only one of the three methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused pump columns or unused methods

PUMP OPERATION	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - ELECTRICAL USAGE IS KNOWN						
Input pump electrical usage (KWh)	0	0	0	0	0	0
Method 2 - PUMP HEAD IS KNOWN						
Input flow rate (gpm)	0	0	0	0	0	0
Input total head (ft)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Pump efficiency (default already present, user override possible)	0.6	0.6	0.6	0.6	0.6	0.6
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Input specific gravity (default already present, user override possible)	1	1	1	1	1	1
Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input pump horsepower (hp)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Percent of max speed for pump motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Pump load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input pump load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

DIESEL AND GASOLINE PUMPS	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1
Equipment operating hours (hrs)						

Input estimated fuel consumption rate (gal/hr) (Input only if known for the pump selected, otherwise a default will be used by the tool)						

For each type of equipment, select only one of the methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused equipment columns or unused methods

BLOWER, COMPRESSOR, MIXER, AND OTHER EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose type of equipment from drop down	Blower	Blower	Blower	Blower	Blower	Blower
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input equipment horsepower (hp)	0	0	0	0	0	0
Input number of equipments operating	0	0	0	0	0	0
Input operating time for each equipment (hrs)	0	0	0	0	0	0
Percent of max speed for motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Equipment load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input equipment load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Equipment motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Method 2 - ELECTRICAL USAGE IS KNOWN						
Input equipment electrical usage, if known (kWh)	0	0	0	0	0	0
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Diesel	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	3 to 6	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)	44					

AGRICULTURAL EQUIPMENT	Tillage Tractor 1	Tillage Tractor 2	Tillage Tractor 3	Tillage Tractor 4	Tillage Tractor 5	Tillage Tractor 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area to till (acre)						
Choose soil condition from drop down menu	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil
Choose soil type from drop down menu	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil
Input time available (work days)						
Input depth of tillage (in)						

CAPPING EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose stabilization equipment type from drop down menu	Roller	Roller	Roller	Roller	Roller	Roller
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area (ft2)						
Input time available (work days)						

MIXING EQUIPMENT	Mixer 1	Mixer 2	Mixer 3	Mixer 4	Mixer 5	Mixer 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input volume (yd3)						
Input production rate (yd3/hr)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the mixer selected, otherwise a default will be used by the tool)						

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)						
Input operating hours (hr)						

OTHER FUELED EQUIPMENT	Fuel 1	Fuel 2	Fuel 3	Fuel 4	Fuel 5	Fuel 6
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input volume (scf for Natural gas, gallons for all others)						

OPERATOR LABOR	Occupation 1	Occupation 2	Occupation 3	Occupation 4	Occupation 5	Occupation 6
Choose occupation from drop-down menu	Construction laborers	entific and technical serv	Construction laborers	Construction laborers	Construction laborers	Construction laborers
Input total time worked onsite (hours)	96.0	16.0				

LABORATORY ANALYSIS	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Analysis 6
Input dollars spent on laboratory analysis ($)	3,300.00					

OTHER KNOWN ONSITE ACTIVITIES	Entire Site
Input energy usage (MMBTU)	
Water consumption (gallon)	
Input CO2 emission (metric ton)	
Input N2O emission (metric ton CO2 e)	
Input CH4 emission (metric ton CO2 e)	
Input NOx emission (metric ton)	
Input SOx emission (metric ton)	
Input PM10 emission (metric ton)	
Input fatality risk	
Input injury risk	

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)			0.0			
Choose fuel used from drop down menu	Diesel	Gasoline	Diesel	Diesel	Diesel	Gasoline
Input total number of trips			2.0			
Input number of miles per trip			12.4			

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)			0.1			
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

THERMAL/CATALYTIC OXIDIZERS*	Oxidizer 1	Oxidizer 2	Oxidizer 3	Oxidizer 4	Oxidizer 5	Oxidizer 6
Choose oxidizer type from drop down menu	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas

Input waste gas flow rate (scfm)						
Input time running (hours)						
Input waste gas inlet temperature (F)						
Input contaminant concentration (ppmV)						

*(Electric blowers are included in the analysis)

RESOURCE CONSUMPTION

WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)						

ONSITE LAND AND WATER RESOURCE CONSUMPTION	Entire Site 1	Entire Site 2	Entire Site 3	Entire Site 4	Entire Site 5	Entire Site 6
Input volume of topsoil brought to site (cubic yards)						
Input volume of groundwater or surface water lost (gal)						

This worksheet allows the user to define material production, transportation, equipment use, and residual handling variables for the remedial alternative

Yellow cells	require the user to choose an input from a drop down menu
White cells	require the user to type in a value

BASELINE INFORMATION

COMPONENT 2 DURATION AND COST	Entire Site
Input duration of the component (unit time)	10
Input component cost per unit time ($)	396179

MATERIAL PRODUCTION

WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Choose specific casing material schedule from drop down menu	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC
Choose well diameter (in) from drop down menu	1/8	1/8	1/8	1/8	1/8	1/8
Input total quantity of Sand (kg)						
Input total quantity of Gravel (kg)						
Input total quantity of Bentonite (kg)						
Input total quantity of Typical Cement (kg)						
Input total quantity of General Concrete (kg)						
Input total quantity of Steel (kg)						

TREATMENT CHEMICALS & MATERIALS	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input number of injection points						
Choose material type from drop down menu	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide
Input amount of material injected at each point (pounds dry mass)						
Input number of injections per injection point						

TREATMENT MEDIA	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input weight of media used (lbs)	1,320					
Choose media type from drop down menu	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC

CONSTRUCTION MATERIALS	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material type from drop down menu	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner
Input area of material (ft2)						
Input depth of material (ft)						

WELL DECOMMISSIONING	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Input well diameter (in)						
Choose material from drop down menu	Soil	Soil	Soil	Soil	Soil	Soil

BULK MATERIAL QUANTITIES	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material from drop down menu	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid
Choose units of material quantity from drop down menu	pounds	pounds	pounds	pounds	pounds	pounds

Input material quantity						

TRANSPORTATION

PERSONNEL TRANSPORTATION - ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose vehicle type from drop down menu*	Cars	Cars	Cars	Cars	Cars	Cars
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input distance traveled per trip (miles)	12.4	12.4	12.4	12.4	12.4	12.4
Input number of trips taken	2	8	4	24	24	24
Input number of travelers	1	1	1	1	1	1
Input estimated vehicular fuel economy (mi/gal) (Input only if known for the vehicle selected, otherwise a default will be used by the tool)						

*For vehicle type 'Other' please enter values in Table 2b in the Look Up Table tab.

PERSONNEL TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input number of travelers						
Input number of flights taken						

PERSONNEL TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Choose vehicle type from drop down menu	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail
Input distance traveled (miles)						
Input number of trips taken						
Input number of travelers						

EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Account for an empty return trip?	No	No	No	No	No	No
Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).						
Input weight of equipment transported per truck load (tons)						

EQUIPMENT TRANSPORTATION - SHARED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)	12					
Input weight of equipment transported (tons)	0.1					

EQUIPMENT TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)	8,080	8,080				
Input weight of equipment transported (tons)	0.0004	0.01				

EQUIPMENT TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of load (tons)						

EQUIPMENT TRANSPORTATION - WATER	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (mile)						
Input weight of load (tons)						

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Dozer	Dozer	Dozer	Dozer	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)						
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

DRILLING	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Input number of drilling locations						
Choose drilling method from drop down menu	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push
Input time spent drilling at each location (hr)						
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel

TRENCHING	Trencher 1	Trencher 2	Trencher 3	Trencher 4	Trencher 5	Trencher 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input operating hours (hr)						

For each pump, select only one of the three methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused pump columns or unused methods

PUMP OPERATION	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - ELECTRICAL USAGE IS KNOWN						
Input pump electrical usage (KWh)	0	0	0	0	0	0
Method 2 - PUMP HEAD IS KNOWN						
Input flow rate (gpm)	0	0	0	0	0	0
Input total head (ft)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Pump efficiency (default already present, user override possible)	0.6	0.6	0.6	0.6	0.6	0.6
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Input specific gravity (default already present, user override possible)	1	1	1	1	1	1
Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input pump horsepower (hp)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Percent of max speed for pump motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Pump load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input pump load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

DIESEL AND GASOLINE PUMPS	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1
Equipment operating hours (hrs)						

Input estimated fuel consumption rate (gal/hr) (Input only if known for the pump selected, otherwise a default will be used by the tool)						

For each type of equipment, select only one of the methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused equipment columns or unused methods

BLOWER, COMPRESSOR, MIXER, AND OTHER EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose type of equipment from drop down	Blower	Blower	Blower	Blower	Blower	Blower
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input equipment horsepower (hp)	0	0	0	0	0	0
Input number of equipments operating	0	0	0	0	0	0
Input operating time for each equipment (hrs)	0	0	0	0	0	0
Percent of max speed for motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Equipment load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input equipment load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Equipment motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Method 2 - ELECTRICAL USAGE IS KNOWN						
Input equipment electrical usage, if known (kWh)	0	0	0	0	0	0
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)						

AGRICULTURAL EQUIPMENT	Tillage Tractor 1	Tillage Tractor 2	Tillage Tractor 3	Tillage Tractor 4	Tillage Tractor 5	Tillage Tractor 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area to till (acre)						
Choose soil condition from drop down menu	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil
Choose soil type from drop down menu	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil
Input time available (work days)						
Input depth of tillage (in)						

CAPPING EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose stabilization equipment type from drop down menu	Roller	Roller	Roller	Roller	Roller	Roller
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area (ft2)						
Input time available (work days)						

MIXING EQUIPMENT	Mixer 1	Mixer 2	Mixer 3	Mixer 4	Mixer 5	Mixer 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input volume (yd3)						
Input production rate (yd3/hr)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the mixer selected, otherwise a default will be used by the tool)						

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)						
Input operating hours (hr)						

OTHER FUELED EQUIPMENT	Fuel 1	Fuel 2	Fuel 3	Fuel 4	Fuel 5	Fuel 6
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input volume (scf for Natural gas, gallons for all others)						

OPERATOR LABOR	Occupation 1	Occupation 2	Occupation 3	Occupation 4	Occupation 5	Occupation 6
Choose occupation from drop-down menu	Construction laborers	entific and technical serv	Construction laborers	Construction laborers	Construction laborers	Construction laborers
Input total time worked onsite (hours)	2665.0					

LABORATORY ANALYSIS	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Analysis 6
Input dollars spent on laboratory analysis ($)	7,200.00					

OTHER KNOWN ONSITE ACTIVITIES	Entire Site
Input energy usage (MMBTU)	
Water consumption (gallon)	
Input CO2 emission (metric ton)	
Input N2O emission (metric ton CO2 e)	
Input CH4 emission (metric ton CO2 e)	
Input NOx emission (metric ton)	
Input SOx emission (metric ton)	
Input PM10 emission (metric ton)	
Input fatality risk	
Input injury risk	

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)			0.0	0.7		
Choose fuel used from drop down menu	Gasoline	Gasoline	Diesel	Gasoline	Diesel	Gasoline
Input total number of trips			24.0	24.0		
Input number of miles per trip			12.4	12.4		

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)			0.0			
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

THERMAL/CATALYTIC OXIDIZERS*	Oxidizer 1	Oxidizer 2	Oxidizer 3	Oxidizer 4	Oxidizer 5	Oxidizer 6
Choose oxidizer type from drop down menu	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas

Input waste gas flow rate (scfm)				1000		
Input time running (hours)				1		
Input waste gas inlet temperature (F)				65		
Input contaminant concentration (ppmV)				100		

*(Electric blowers are included in the analysis)

RESOURCE CONSUMPTION

WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)						

ONSITE LAND AND WATER RESOURCE CONSUMPTION	Entire Site 1	Entire Site 2	Entire Site 3	Entire Site 4	Entire Site 5	Entire Site 6
Input volume of topsoil brought to site (cubic yards)						
Input volume of groundwater or surface water lost (gal)						

This worksheet allows the user to define material production, transportation, equipment use, and residual handling variables for the remedial alternative

Yellow cells require the user to choose an input from a drop down menu

White cells require the user to type in a value

BASELINE INFORMATION

COMPONENT 3 DURATION AND COST	Entire Site
Input duration of the component (unit time)	1
Input component cost per unit time ($)	6000

MATERIAL PRODUCTION

WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Choose specific casing material schedule from drop down menu	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC
Choose well diameter (in) from drop down menu	1/8	1/8	1/8	1/8	1/8	1/8
Input total quantity of Sand (kg)						
Input total quantity of Gravel (kg)						
Input total quantity of Bentonite (kg)						
Input total quantity of Typical Cement (kg)						
Input total quantity of General Concrete (kg)						
Input total quantity of Steel (kg)						

TREATMENT CHEMICALS & MATERIALS	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input number of injection points						
Choose material type from drop down menu	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide
Input amount of material injected at each point (pounds dry mass)						
Input number of injections per injection point						

TREATMENT MEDIA	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input weight of media used (lbs)						
Choose media type from drop down menu	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC

CONSTRUCTION MATERIALS	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material type from drop down menu	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner
Input area of material (ft2)						
Input depth of material (ft)						

WELL DECOMMISSIONING	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Input well diameter (in)						
Choose material from drop down menu	Soil	Soil	Soil	Soil	Soil	Soil

BULK MATERIAL QUANTITIES	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material from drop down menu	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid
Choose units of material quantity from drop down menu	pounds	pounds	pounds	pounds	pounds	pounds

Input material quantity						

TRANSPORTATION

PERSONNEL TRANSPORTATION - ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose vehicle type from drop down menu*	Cars	Cars	Cars	Cars	Cars	Cars
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input distance traveled per trip (miles)	12.4	12.4	12.4			
Input number of trips taken	2	7	4			
Input number of travelers	1	2	1			
Input estimated vehicular fuel economy (mi/gal) (Input only if known for the vehicle selected, otherwise a default will be used by the tool)						

*For vehicle type 'Other' please enter values in Table 2b in the Look Up Table tab.

PERSONNEL TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input number of travelers						
Input number of flights taken						

PERSONNEL TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Choose vehicle type from drop down menu	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail
Input distance traveled (miles)						
Input number of trips taken						
Input number of travelers						

EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Account for an empty return trip?	No	No	No	No	No	No
Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).						
Input weight of equipment transported per truck load (tons)						

EQUIPMENT TRANSPORTATION - SHARED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of equipment transported (tons)						

EQUIPMENT TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of equipment transported (tons)						

EQUIPMENT TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of load (tons)						

EQUIPMENT TRANSPORTATION - WATER	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (mile)						
Input weight of load (tons)						

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Dozer	Dozer	Dozer	Dozer	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)						
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

DRILLING	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Input number of drilling locations						
Choose drilling method from drop down menu	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push
Input time spent drilling at each location (hr)						
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel

TRENCHING	Trencher 1	Trencher 2	Trencher 3	Trencher 4	Trencher 5	Trencher 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input operating hours (hr)						

For each pump, select only one of the three methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused pump columns or unused methods

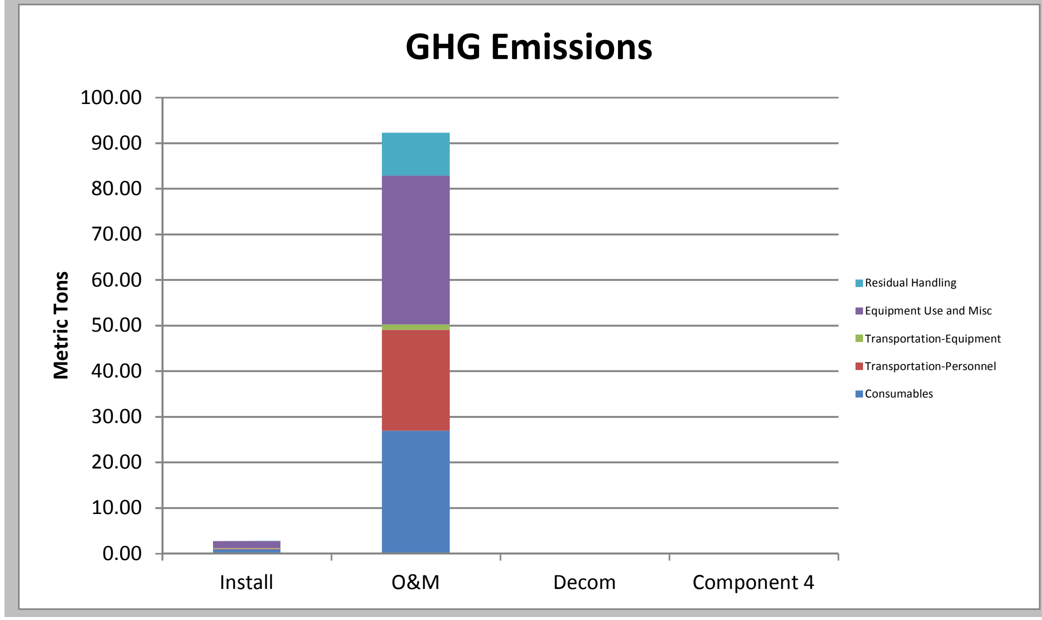
PUMP OPERATION	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - ELECTRICAL USAGE IS KNOWN						
Input pump electrical usage (KWh)	0	0	0	0	0	0
Method 2 - PUMP HEAD IS KNOWN						
Input flow rate (gpm)	0	0	0	0	0	0
Input total head (ft)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Pump efficiency (default already present, user override possible)	0.6	0.6	0.6	0.6	0.6	0.6
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Input specific gravity (default already present, user override possible)	1	1	1	1	1	1
Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input pump horsepower (hp)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Percent of max speed for pump motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Pump load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input pump load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

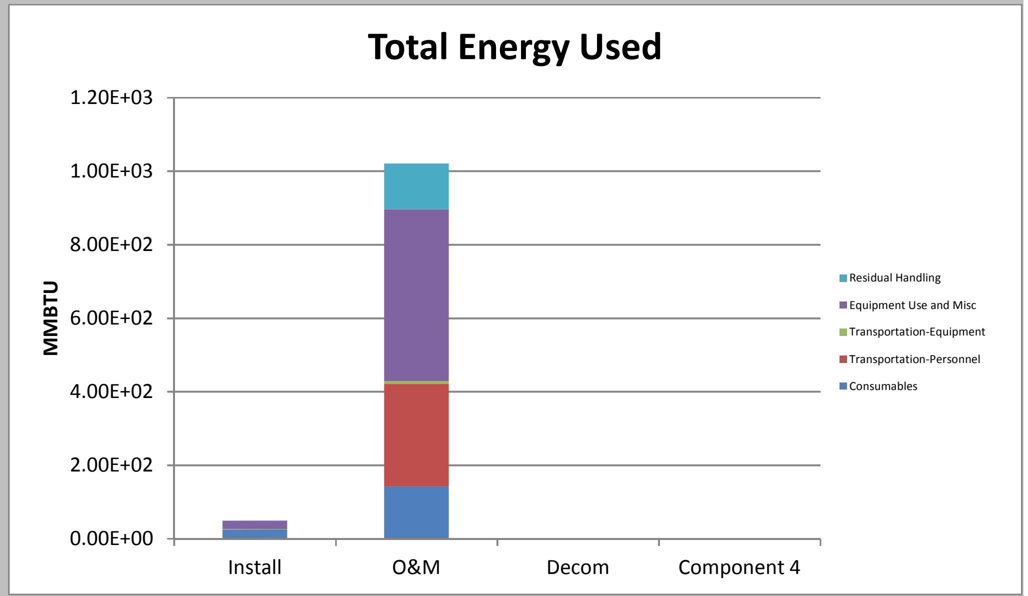
DIESEL AND GASOLINE PUMPS	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1
Equipment operating hours (hrs)						

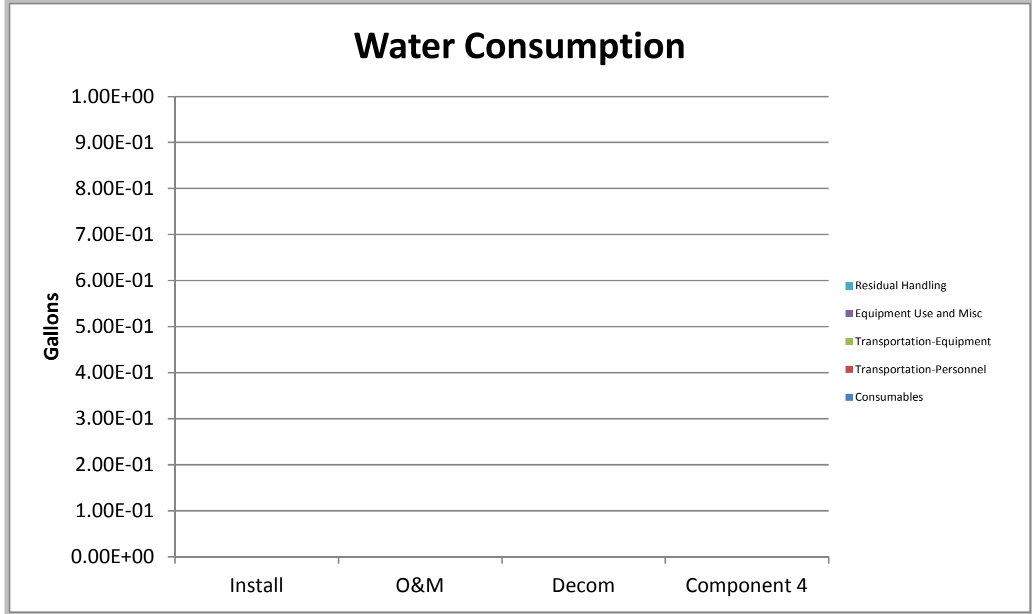
Sustainable Remediation - Environmental Footprint Summary
Trailer ex wells

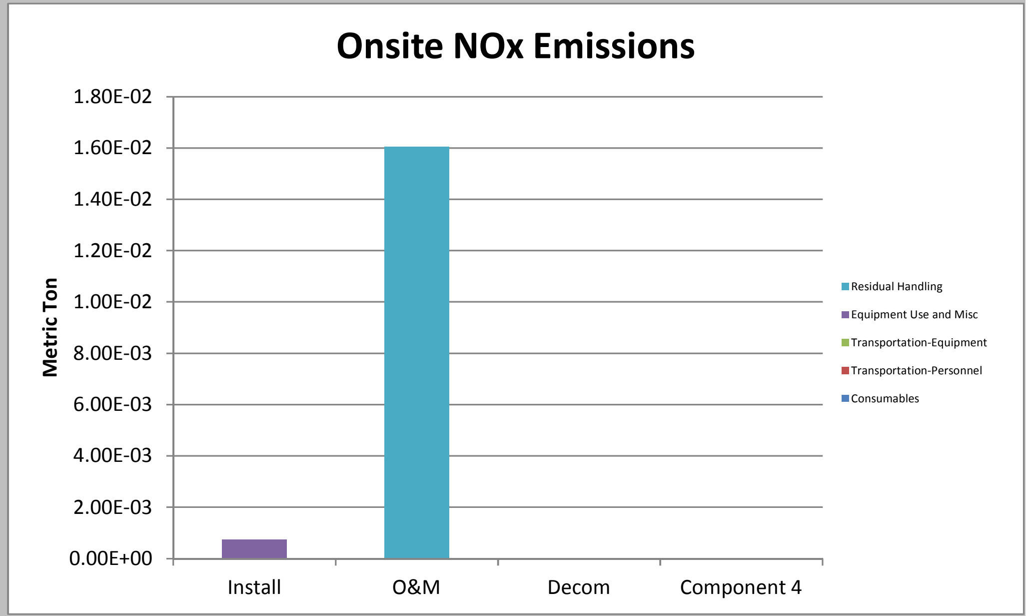
Phase	Activities	GHG Emissions (metric ton)	Total Energy Used (MMBTU)	Water Consumption (gallons)	Electricity Usage (MWH)	Onsite NOx Emissions (metric ton)	Onsite SOx Emissions (metric ton)	Onsite PM10 Emissions (metric ton)	Total NOx Emissions (metric ton)
Install	Consumables	0.93	2.4E+01	NA	NA	NA	NA	NA	1.5E-03
	Transportation-Personnel	0.14	1.7E+00	NA	NA	NA	NA	NA	5.1E-05
	Transportation-Equipment	0.13	1.0E+00	NA	NA	NA	NA	NA	3.5E-04
	Equipment Use and Misc	1.57	2.2E+01	0.0E+00	0.0E+00	7.5E-04	8.3E-05	9.1E-05	8.0E-03
	Residual Handling	0.04	4.7E-01	NA	NA	0.0E+00	0.0E+00	0.0E+00	1.4E-05
	Sub-Total	2.80	4.98E+01	0.00E+00	0.00E+00	7.47E-04	8.31E-05	9.14E-05	9.84E-03
O&M	Consumables	26.94	1.4E+02	NA	NA	NA	NA	NA	5.4E-05
	Transportation-Personnel	22.16	2.8E+02	NA	NA	NA	NA	NA	8.2E-03
	Transportation-Equipment	1.16	8.1E+00	NA	NA	NA	NA	NA	3.6E-03
	Equipment Use and Misc	32.66	4.7E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.6E-01
	Residual Handling	9.42	1.2E+02	NA	NA	1.6E-02	3.6E-06	7.4E-05	2.1E-02
	Sub-Total	92.34	1.02E+03	0.00E+00	0.00E+00	1.61E-02	3.59E-06	7.40E-05	1.89E-01
Decom	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Personnel	0.06	7.7E-01	NA	NA	NA	NA	NA	2.3E-05
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.04	5.7E-01	NA	NA	0.0E+00	0.0E+00	0.0E+00	3.6E-05
	Sub-Total	0.10	1.34E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.91E-05
Component 4	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Personnel	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total		**9.5E+01**	**1.1E+03**	**0.0E+00**	**0.0E+00**	**1.7E-02**	**8.7E-05**	**1.7E-04**	**2.0E-01**

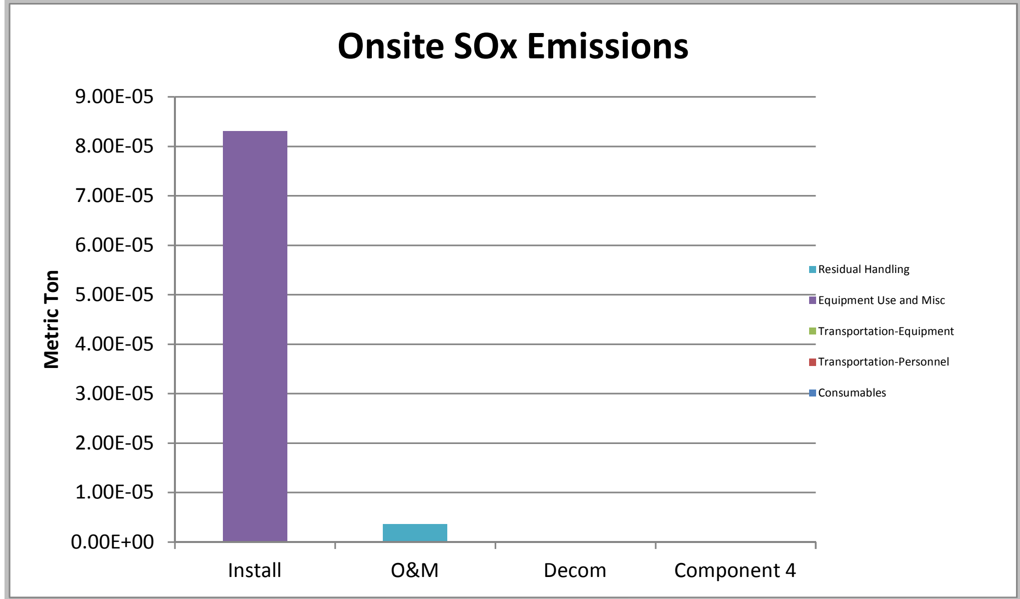
Remedial Alternative Phase	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Topsoil Consumption	Costing	Lost Hours - Injury	Percent electricity from renewable sources	Total Cost with Footprint Reduction
	tons	tons	cubic yards	$		%	
Install	5.0E-02	0.0E+00	0.0E+00	48,869	2.2E-02	0.0%	$4,016,659
O&M	3.5E-01	0.0E+00	0.0E+00	3,961,790	5.4E+00	0.0%	
Decom	4.0E-01	0.0E+00	0.0E+00	6,000	8.4E-03	0.0%	
Component 4	0.0E+00	0.0E+00	0.0E+00	0	0.0E+00	0.0%	
Total	**8.0E-01**	**0.0E+00**	**0.0E+00**	**$4,016,659**	**5.4E+00**	**0.0%**	

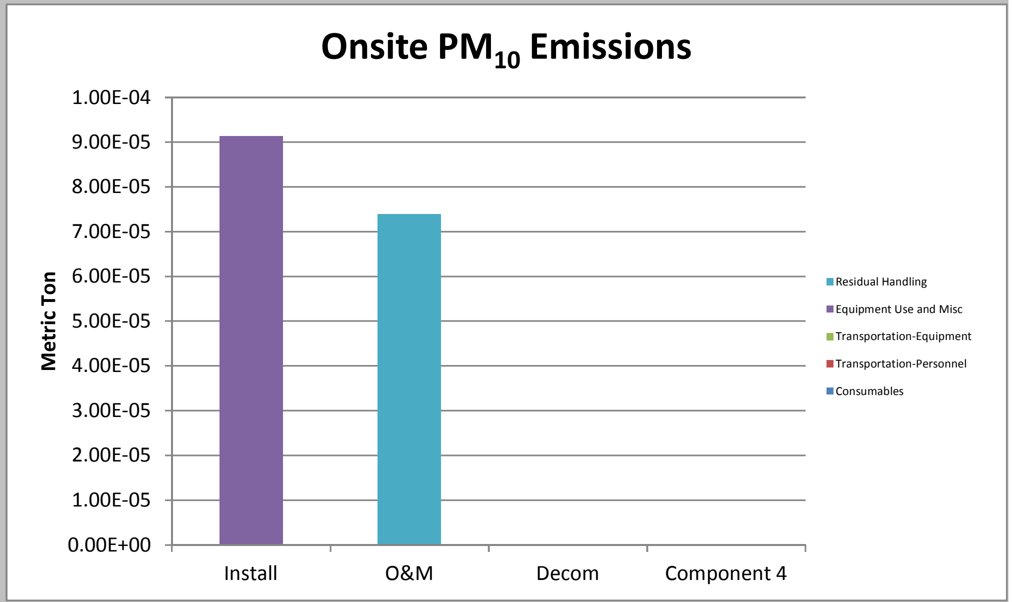

GHG Emissions
Metric Tons
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

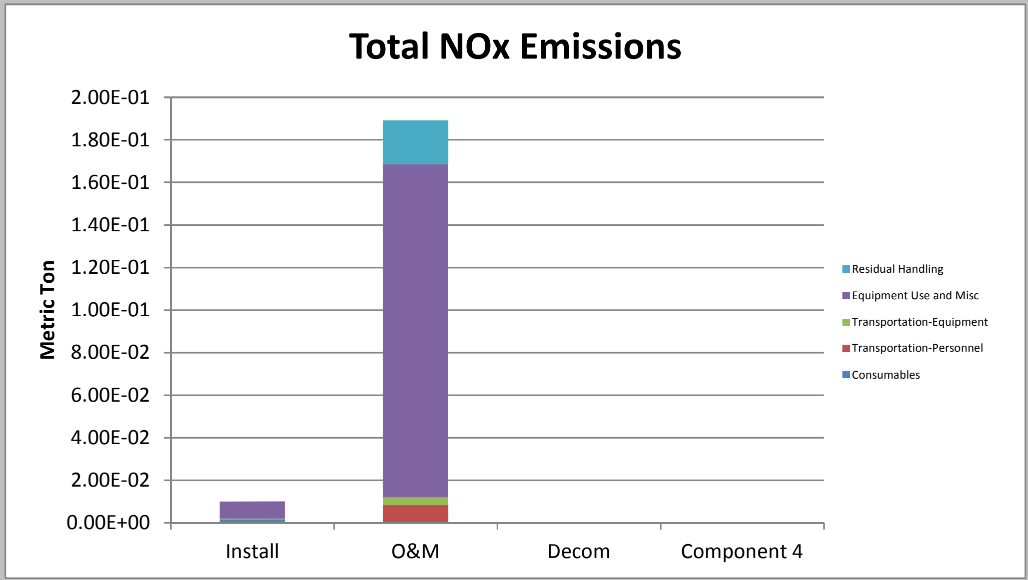

Total Energy Used
MMBTU
1.20E+03
1.00E+03
8.00E+02
6.00E+02
4.00E+02
2.00E+02
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

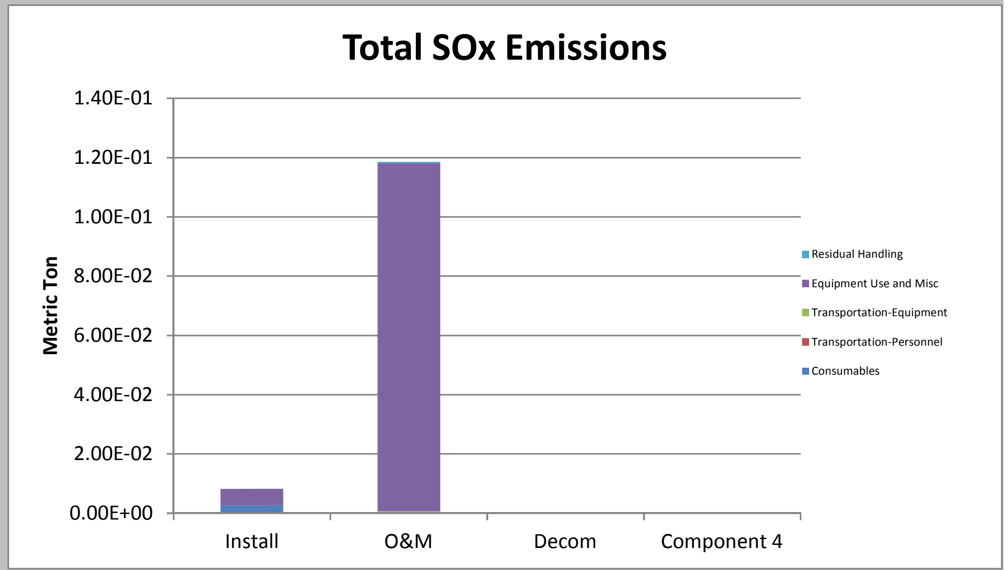

Water Consumption
Gallons
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

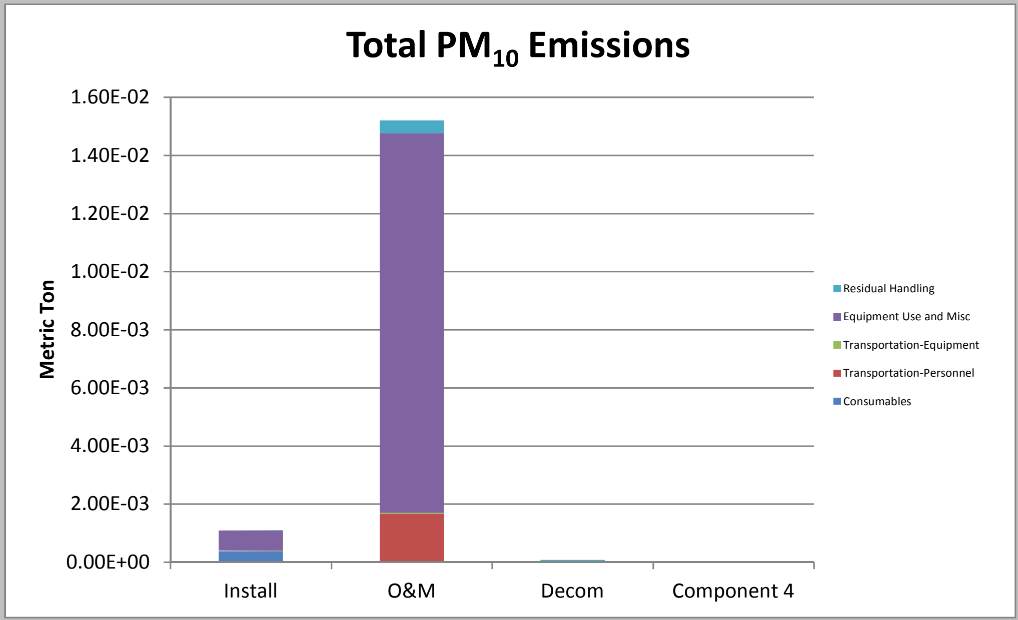

Onsite NOx Emissions
Metric Ton
1.80E-02
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

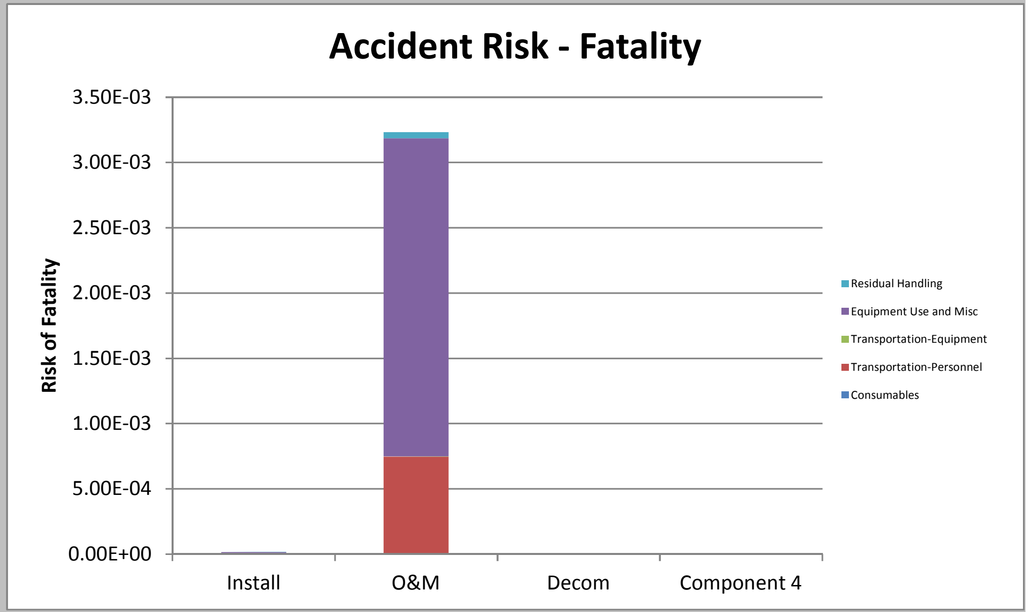

Onsite SOx Emissions
Metric Ton
9.00E-05
8.00E-05
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

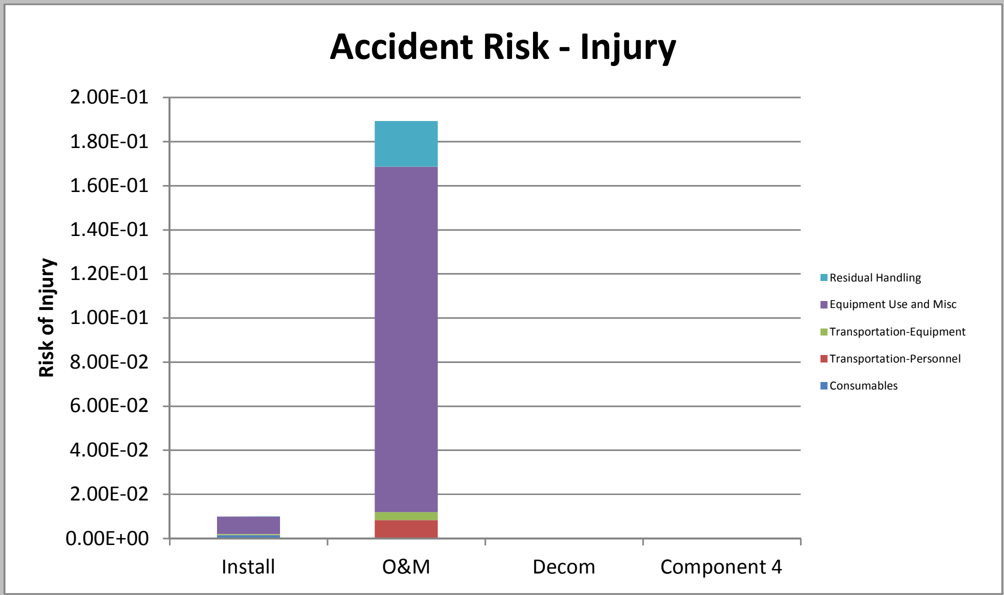

Onsite PM10 Emissions
Metric Ton
1.00E-04
9.00E-05
8.00E-05
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

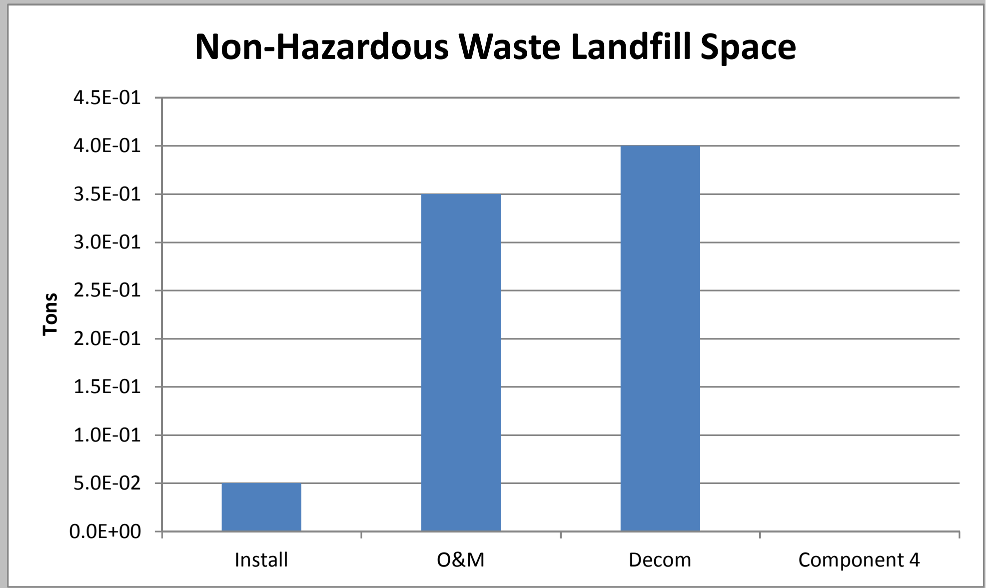

Total NOx Emissions
Metric Ton
2.00E-01
1.80E-01
1.60E-01
1.40E-01
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

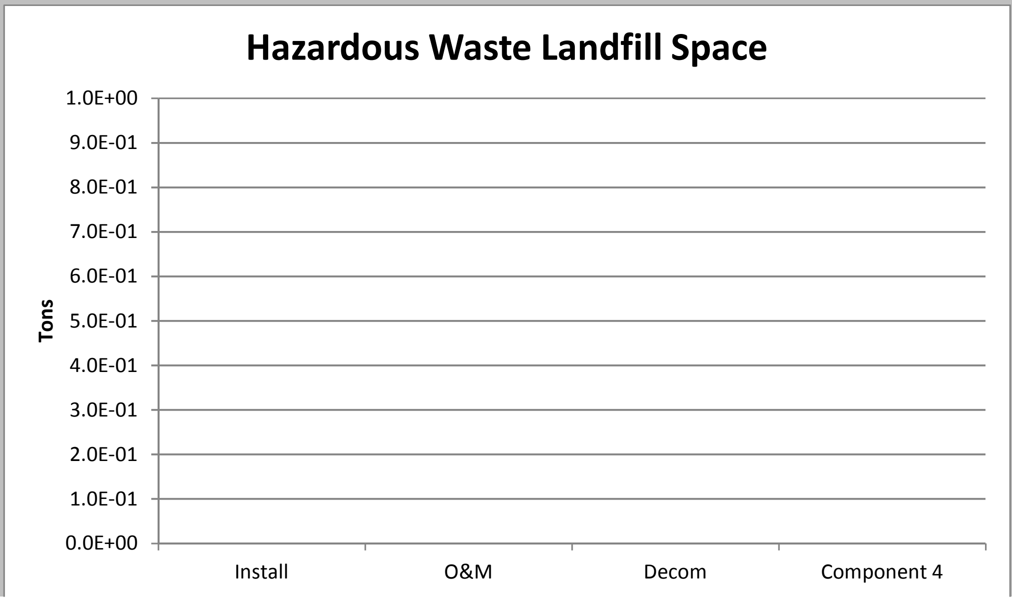

Total SOx Emissions
Metric Ton
1.40E-01
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

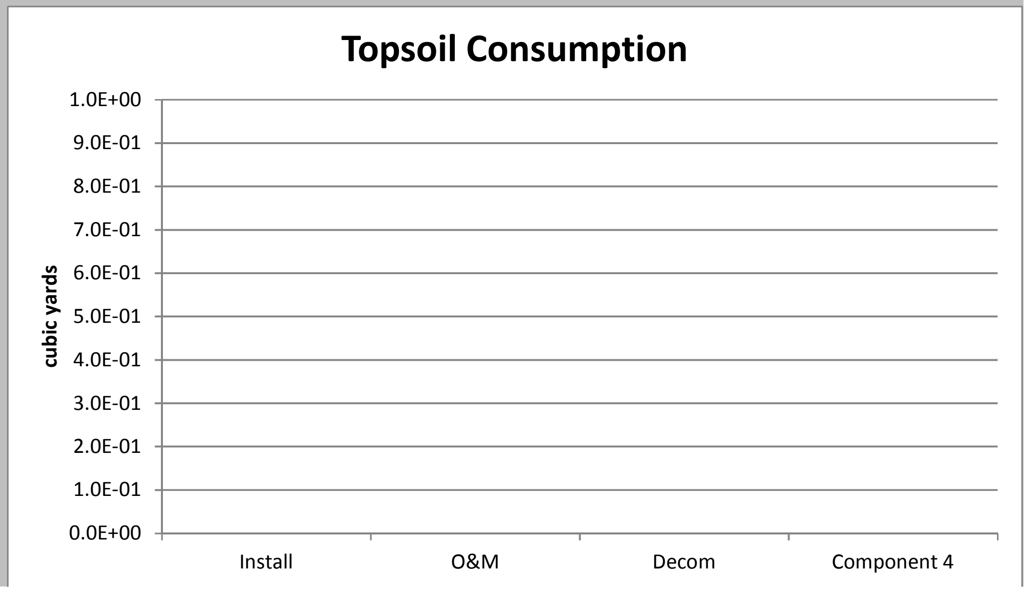

Total PM_{10} Emissions
Metric Ton
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Fatality
Risk of Fatality
3.50E-03
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Injury
Risk of Injury
2.00E-01
1.80E-01
1.60E-01
1.40E-01
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Non-Hazardous Waste Landfill Space
Tons
4.5E-01
4.0E-01
3.5E-01
3.0E-01
2.5E-01
2.0E-01
1.5E-01
1.0E-01
5.0E-02
0.0E+00
Install
O&M
Decom
Component 4


Hazardous Waste Landfill Space
Tons
1.0E+00
9.0E-01
8.0E-01
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Install
O&M
Decom
Component 4


Topsoil Consumption
cubic yards
1.0E+00
9.0E-01
8.0E-01
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Install
O&M
Decom
Component 4

SITE INFORMATION	
User Name and Date	Kevin Simpson
Site Name	TPI Tullamarine
Remedial Alternative Name	Fixed existing wells
Alternative File Name	Fixed ex wells
Choose electricity profile	CUST

To Custom

Do you want to reload a previously saved remedial alternative in the SiteWise input sheet?

Yes

Refresh List

Reset all input values on all worksheets to default

Reset All Values on All Sheets

-= Status =-

Done Loading!

This worksheet allows the user to define material production, transportation, equipment use, and residual handling variables for the remedial alternative

Yellow cells require the user to choose an input from a drop down menu

White cells require the user to type in a value

BASELINE INFORMATION

COMPONENT 1 DURATION AND COST	Entire Site
Input duration of the component (unit time)	1
Input component cost per unit time ($)	299267

MATERIAL PRODUCTION

WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Choose specific casing material schedule from drop down menu	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC
Choose well diameter (in) from drop down menu	10	1/8	1/8	1/8	1/8	1/8
Input total quantity of Sand (kg)						
Input total quantity of Gravel (kg)						
Input total quantity of Bentonite (kg)						
Input total quantity of Typical Cement (kg)						
Input total quantity of General Concrete (kg)						
Input total quantity of Steel (kg)						

TREATMENT CHEMICALS & MATERIALS	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input number of injection points						
Choose material type from drop down menu	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide
Input amount of material injected at each point (pounds dry mass)						
Input number of injections per injection point						

TREATMENT MEDIA	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input weight of media used (lbs)	110					
Choose media type from drop down menu	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC

CONSTRUCTION MATERIALS	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material type from drop down menu	HDPE Liner	General Concrete	General Concrete	HDPE Liner	HDPE Liner	HDPE Liner
Input area of material (ft2)	431	372	32			
Input depth of material (ft)	0.02	0.66	0.66			

WELL DECOMMISSIONING	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Input well diameter (in)						
Choose material from drop down menu	General Concrete	Soil	Soil	Soil	Soil	Soil

BULK MATERIAL QUANTITIES	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material from drop down menu	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid
Choose units of material quantity from drop down menu	pounds	pounds	pounds	pounds	pounds	pounds
Input material quantity						

TRANSPORTATION

PERSONNEL TRANSPORTATION - ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose vehicle type from drop down menu*	Cars	Cars	Cars	Cars	Cars	Cars
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input distance traveled per trip (miles)	12.4	12.4	12.4	12.4	12.4	12.4
Input number of trips taken	2	2	2	2	2	4
Input number of travelers	1	9	2	2	2	1
Input estimated vehicular fuel economy (mi/gal) (Input only if known for the vehicle selected, otherwise a default will be used by the tool)						

*For vehicle type 'Other' please enter values in Table 2b in the Look Up Table tab.

PERSONNEL TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input number of travelers						
Input number of flights taken						

PERSONNEL TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Choose vehicle type from drop down menu	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail
Input distance traveled (miles)						
Input number of trips taken						
Input number of travelers						

EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Account for an empty return trip?	No	No	No	No	No	No
Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).	12					
Input weight of equipment transported per truck load (tons)	5.70					

EQUIPMENT TRANSPORTATION - SHARED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of equipment transported (tons)						

EQUIPMENT TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)	8,080					
Input weight of equipment transported (tons)	0.09					

EQUIPMENT TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of load (tons)						

EQUIPMENT TRANSPORTATION - WATER	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (mile)						
Input weight of load (tons)						

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Dozer	Dozer	Dozer	Dozer	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)						
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

DRILLING	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Input number of drilling locations	0					
Choose drilling method from drop down menu	Hollow Stem Auger	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push
Input time spent drilling at each location (hr)						
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
TRENCHING	**Trencher 1**	**Trencher 2**	**Trencher 3**	**Trencher 4**	**Trencher 5**	**Trencher 6**
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input operating hours (hr)						
For each pump, select only one of the three methods to calculate energy and GHG emissions Enter "0" for all user input values for unused pump columns or unused methods						
PUMP OPERATION	**Pump 1**	**Pump 2**	**Pump 3**	**Pump 4**	**Pump 5**	**Pump 6**
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - ELECTRICAL USAGE IS KNOWN						
Input pump electrical usage (KWh)	0	0	0	0	0	0
Method 2 - PUMP HEAD IS KNOWN						
Input flow rate (gpm)	0	0	0	0	0	0
Input total head (ft)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Pump efficiency (default already present, user override possible)	0.6	0.6	0.6	0.6	0.6	0.6
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Input specific gravity (default already present, user override possible)	1	1	1	1	1	1
Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input pump horsepower (hp)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Percent of max speed for pump motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Pump load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input pump load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST
DIESEL AND GASOLINE PUMPS	**Pump 1**	**Pump 2**	**Pump 3**	**Pump 4**	**Pump 5**	**Pump 6**
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1
Equipment operating hours (hrs)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the pump selected, otherwise a default will be used by the tool)						
For each type of equipment, select only one of the methods to calculate energy and GHG emissions Enter "0" for all user input values for unused equipment columns or unused methods						
BLOWER, COMPRESSOR, MIXER, AND OTHER EQUIPMENT	**Equipment 1**	**Equipment 2**	**Equipment 3**	**Equipment 4**	**Equipment 5**	**Equipment 6**
Choose type of equipment from drop down	Blower	Blower	Blower	Blower	Blower	Blower
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input equipment horsepower (hp)	0	0	0	0	0	0

Input number of equipments operating	0	0	0	0	0	0
Input operating time for each equipment (hrs)	0	0	0	0	0	0
Percent of max speed for motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Equipment load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input equipment load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Equipment motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Method 2 - ELECTRICAL USAGE IS KNOWN						
Input equipment electrical usage, if known (kWh)	100	0	0	0	0	0
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Diesel	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	3 to 6	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)	44					

AGRICULTURAL EQUIPMENT	Tillage Tractor 1	Tillage Tractor 2	Tillage Tractor 3	Tillage Tractor 4	Tillage Tractor 5	Tillage Tractor 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area to till (acre)						
Choose soil condition from drop down menu	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil
Choose soil type from drop down menu	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil
Input time available (work days)						
Input depth of tillage (in)						

CAPPING EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose stabilization equipment type from drop down menu	Roller	Roller	Roller	Roller	Roller	Roller
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area (ft2)						
Input time available (work days)						

MIXING EQUIPMENT	Mixer 1	Mixer 2	Mixer 3	Mixer 4	Mixer 5	Mixer 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input volume (yd3)						
Input production rate (yd3/hr)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the mixer selected, otherwise a default will be used by the tool)						

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)						
Input operating hours (hr)						

OTHER FUELED EQUIPMENT	Fuel 1	Fuel 2	Fuel 3	Fuel 4	Fuel 5	Fuel 6
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input volume (scf for Natural gas, gallons for all others)						

OPERATOR LABOR	Occupation 1	Occupation 2	Occupation 3	Occupation 4	Occupation 5	Occupation 6
Choose occupation from drop-down menu	Construction laborers	ntific and technical serv	Construction laborers	Construction laborers	Construction laborers	Construction laborers
Input total time worked onsite (hours)	260.0	160.0				

LABORATORY ANALYSIS	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Analysis 6
Input dollars spent on laboratory analysis ($)	3,300.00					

OTHER KNOWN ONSITE ACTIVITIES	Entire Site
Input energy usage (MMBTU)	
Water consumption (gallon)	
Input CO2 emission (metric ton)	
Input N2O emission (metric ton CO2 e)	
Input CH4 emission (metric ton CO2 e)	
Input NOx emission (metric ton)	
Input SOx emission (metric ton)	
Input PM10 emission (metric ton)	
Input fatality risk	
Input injury risk	

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)			0.0			
Choose fuel used from drop down menu	Diesel	Gasoline	Diesel	Diesel	Diesel	Gasoline
Input total number of trips			2.0			
Input number of miles per trip			12.4			

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)			0.1			
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

THERMAL/CATALYTIC OXIDIZERS*	Oxidizer 1	Oxidizer 2	Oxidizer 3	Oxidizer 4	Oxidizer 5	Oxidizer 6
Choose oxidizer type from drop down menu	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input waste gas flow rate (scfm)						
Input time running (hours)						
Input waste gas inlet temperature (F)						
Input contaminant concentration (ppmV)						

*(Electric blowers are included in the analysis)

RESOURCE CONSUMPTION

WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)						

ONSITE LAND AND WATER RESOURCE CONSUMPTION	Entire Site 1	Entire Site 2	Entire Site 3	Entire Site 4	Entire Site 5	Entire Site 6
Input volume of topsoil brought to site (cubic yards)						
Input volume of groundwater or surface water lost (gal)						

This worksheet allows the user to define material production, transportation, equipment use, and residual handling variables for the remedial alternative

Yellow cells	require the user to choose an input from a drop down menu
White cells	require the user to type in a value

BASELINE INFORMATION

COMPONENT 2 DURATION AND COST	Entire Site
Input duration of the component (unit time)	10
Input component cost per unit time ($)	176834

MATERIAL PRODUCTION

WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Choose specific casing material schedule from drop down menu	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC
Choose well diameter (in) from drop down menu	1/8	1/8	1/8	1/8	1/8	1/8
Input total quantity of Sand (kg)						
Input total quantity of Gravel (kg)						
Input total quantity of Bentonite (kg)						
Input total quantity of Typical Cement (kg)						
Input total quantity of General Concrete (kg)						
Input total quantity of Steel (kg)						

TREATMENT CHEMICALS & MATERIALS	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input number of injection points						
Choose material type from drop down menu	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide
Input amount of material injected at each point (pounds dry mass)						
Input number of injections per injection point						

TREATMENT MEDIA	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input weight of media used (lbs)	1,320					
Choose media type from drop down menu	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC

CONSTRUCTION MATERIALS	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material type from drop down menu	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner
Input area of material (ft2)						
Input depth of material (ft)						

WELL DECOMMISSIONING	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Input well diameter (in)						
Choose material from drop down menu	Soil	Soil	Soil	Soil	Soil	Soil

BULK MATERIAL QUANTITIES	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material from drop down menu	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid
Choose units of material quantity from drop down menu	pounds	pounds	pounds	pounds	pounds	pounds
Input material quantity						

TRANSPORTATION

PERSONNEL TRANSPORTATION - ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose vehicle type from drop down menu*	Cars	Cars	Cars	Cars	Cars	Cars
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input distance traveled per trip (miles)	12.4	12.4	12.4	12.4	12.4	12.4
Input number of trips taken	2	6	4	24	24	4.37
Input number of travelers	1	1	1	1	1	1
Input estimated vehicular fuel economy (mi/gal) (Input only if known for the vehicle selected, otherwise a default will be used by the tool)						

*For vehicle type 'Other' please enter values in Table 2b in the Look Up Table tab.

PERSONNEL TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input number of travelers						
Input number of flights taken						

PERSONNEL TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Choose vehicle type from drop down menu	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail
Input distance traveled (miles)						
Input number of trips taken						
Input number of travelers						

EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Account for an empty return trip?	No	No	No	No	No	No
Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).						
Input weight of equipment transported per truck load (tons)						

EQUIPMENT TRANSPORTATION - SHARED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)	12					
Input weight of equipment transported (tons)	0.1					

EQUIPMENT TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)	8,080	8,080				
Input weight of equipment transported (tons)	0.005	0.02				

EQUIPMENT TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of load (tons)						

EQUIPMENT TRANSPORTATION - WATER	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (mile)						
Input weight of load (tons)						

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Dozer	Dozer	Dozer	Dozer	Dozer	Dozer
Choose fuel type from drop menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)						
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

DRILLING	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Input number of drilling locations						
Choose drilling method from drop down menu	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push
Input time spent drilling at each location (hr)						
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel

TRENCHING	Trencher 1	Trencher 2	Trencher 3	Trencher 4	Trencher 5	Trencher 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input operating hours (hr)						

For each pump, select only one of the three methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused pump columns or unused methods

PUMP OPERATION	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - ELECTRICAL USAGE IS KNOWN						
Input pump electrical usage (KWh)	0	0	0	0	0	0
Method 2 - PUMP HEAD IS KNOWN						
Input flow rate (gpm)	0	0	0	0	0	0
Input total head (ft)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Pump efficiency (default already present, user override possible)	0.6	0.6	0.6	0.6	0.6	0.6
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Input specific gravity (default already present, user override possible)	1	1	1	1	1	1
Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input pump horsepower (hp)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Percent of max speed for pump motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Pump load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input pump load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

DIESEL AND GASOLINE PUMPS	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1
Equipment operating hours (hrs)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the pump selected, otherwise a default will be used by the tool)						

For each type of equipment, select only one of the methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused equipment columns or unused methods

BLOWER, COMPRESSOR, MIXER, AND OTHER EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose type of equipment from drop down	Blower	Blower	Blower	Blower	Blower	Blower
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input equipment horsepower (hp)	0	0	0	0	0	0

Input number of equipments operating	0	0	0	0	0	0
Input operating time for each equipment (hrs)	0	0	0	0	0	0
Percent of max speed for motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Equipment load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input equipment load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Equipment motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Method 2 - ELECTRICAL USAGE IS KNOWN						
Input equipment electrical usage, if known (kWh)	21960	0	0	0	0	0
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)						

AGRICULTURAL EQUIPMENT	Tillage Tractor 1	Tillage Tractor 2	Tillage Tractor 3	Tillage Tractor 4	Tillage Tractor 5	Tillage Tractor 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area to till (acre)						
Choose soil condition from drop down menu	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil
Choose soil type from drop down menu	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil
Input time available (work days)						
Input depth of tillage (in)						

CAPPING EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose stabilization equipment type from drop down menu	Roller	Roller	Roller	Roller	Roller	Roller
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area (ft2)						
Input time available (work days)						

MIXING EQUIPMENT	Mixer 1	Mixer 2	Mixer 3	Mixer 4	Mixer 5	Mixer 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input volume (yd3)						
Input production rate (yd3/hr)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the mixer selected, otherwise a default will be used by the tool)						

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)						
Input operating hours (hr)						

OTHER FUELED EQUIPMENT	Fuel 1	Fuel 2	Fuel 3	Fuel 4	Fuel 5	Fuel 6
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input volume (scf for Natural gas, gallons for all others)						

OPERATOR LABOR	Occupation 1	Occupation 2	Occupation 3	Occupation 4	Occupation 5	Occupation 6
Choose occupation from drop-down menu	Construction laborers	entific and technical serv	Construction laborers	Construction laborers	Construction laborers	Construction laborers
Input total time worked onsite (hours)	520.0	96.0				

LABORATORY ANALYSIS	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Analysis 6
Input dollars spent on laboratory analysis ($)	7,200.00					

OTHER KNOWN ONSITE ACTIVITIES	Entire Site
Input energy usage (MMBTU)	
Water consumption (gallon)	
Input CO2 emission (metric ton)	
Input N2O emission (metric ton CO2 e)	
Input CH4 emission (metric ton CO2 e)	
Input NOx emission (metric ton)	
Input SOx emission (metric ton)	
Input PM10 emission (metric ton)	
Input fatality risk	
Input injury risk	

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)			0.0	1.9		
Choose fuel used from drop down menu	Gasoline	Gasoline	Diesel	Gasoline	Diesel	Gasoline
Input total number of trips			24.0	4.4		
Input number of miles per trip			12.4	12.4		

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)			0.0			
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

THERMAL/CATALYTIC OXIDIZERS*	Oxidizer 1	Oxidizer 2	Oxidizer 3	Oxidizer 4	Oxidizer 5	Oxidizer 6
Choose oxidizer type from drop down menu	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input waste gas flow rate (scfm)				1000		
Input time running (hours)				1		
Input waste gas inlet temperature (F)				65		
Input contaminant concentration (ppmV)				100		

*(Electric blowers are included in the analysis)

RESOURCE CONSUMPTION

WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)						

ONSITE LAND AND WATER RESOURCE CONSUMPTION	Entire Site 1	Entire Site 2	Entire Site 3	Entire Site 4	Entire Site 5	Entire Site 6
Input volume of topsoil brought to site (cubic yards)						
Input volume of groundwater or surface water lost (gal)						

This worksheet allows the user to define material production, transportation, equipment use, and residual handling variables for the remedial alternative

Yellow cells	require the user to choose an input from a drop down menu
White cells	require the user to type in a value

BASELINE INFORMATION

COMPONENT 3 DURATION AND COST	Entire Site
Input duration of the component (unit time)	1
Input component cost per unit time ($)	42124

MATERIAL PRODUCTION

WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Choose specific casing material schedule from drop down menu	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC
Choose well diameter (in) from drop down menu	1/8	1/8	1/8	1/8	1/8	1/8
Input total quantity of Sand (kg)						
Input total quantity of Gravel (kg)						
Input total quantity of Bentonite (kg)						
Input total quantity of Typical Cement (kg)						
Input total quantity of General Concrete (kg)						
Input total quantity of Steel (kg)						

TREATMENT CHEMICALS & MATERIALS	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input number of injection points						
Choose material type from drop down menu	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide
Input amount of material injected at each point (pounds dry mass)						
Input number of injections per injection point						

TREATMENT MEDIA	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input weight of media used (lbs)						
Choose media type from drop down menu	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC

CONSTRUCTION MATERIALS	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material type from drop down menu	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner
Input area of material (ft2)						
Input depth of material (ft)						

WELL DECOMMISSIONING	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Input well diameter (in)						
Choose material from drop down menu	Soil	Soil	Soil	Soil	Soil	Soil

BULK MATERIAL QUANTITIES	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material from drop down menu	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid
Choose units of material quantity from drop down menu	pounds	pounds	pounds	pounds	pounds	pounds
Input material quantity						

TRANSPORTATION

PERSONNEL TRANSPORTATION - ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose vehicle type from drop down menu*	Cars	Cars	Cars	Cars	Cars	Cars
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input distance traveled per trip (miles)	12.4	12.4	12.4	12.4		
Input number of trips taken	4	24	8	4		
Input number of travelers	1	2	1	1		
Input estimated vehicular fuel economy (mi/gal) (Input only if known for the vehicle selected, otherwise a default will be used by the tool)						

*For vehicle type 'Other' please enter values in Table 2b in the Look Up Table tab.

PERSONNEL TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input number of travelers						
Input number of flights taken						

PERSONNEL TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Choose vehicle type from drop down menu	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail
Input distance traveled (miles)						
Input number of trips taken						
Input number of travelers						

EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Account for an empty return trip?	No	No	No	No	No	No
Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).						
Input weight of equipment transported per truck load (tons)						

EQUIPMENT TRANSPORTATION - SHARED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of equipment transported (tons)						

EQUIPMENT TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of equipment transported (tons)						

EQUIPMENT TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of load (tons)						

EQUIPMENT TRANSPORTATION - WATER	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (mile)						
Input weight of load (tons)						

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Dozer	Dozer	Dozer	Dozer	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)						
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

DRILLING	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Input number of drilling locations						
Choose drilling method from drop down menu	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push
Input time spent drilling at each location (hr)						
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel

TRENCHING	Trencher 1	Trencher 2	Trencher 3	Trencher 4	Trencher 5	Trencher 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input operating hours (hr)						

For each pump, select only one of the three methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused pump columns or unused methods

PUMP OPERATION	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - ELECTRICAL USAGE IS KNOWN						
Input pump electrical usage (KWh)	0	0	0	0	0	0
Method 2 - PUMP HEAD IS KNOWN						
Input flow rate (gpm)	0	0	0	0	0	0
Input total head (ft)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Pump efficiency (default already present, user override possible)	0.6	0.6	0.6	0.6	0.6	0.6
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Input specific gravity (default already present, user override possible)	1	1	1	1	1	1
Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input pump horsepower (hp)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Percent of max speed for pump motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Pump load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input pump load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

DIESEL AND GASOLINE PUMPS	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1
Equipment operating hours (hrs)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the pump selected, otherwise a default will be used by the tool)						

For each type of equipment, select only one of the methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused equipment columns or unused methods

BLOWER, COMPRESSOR, MIXER, AND OTHER EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose type of equipment from drop down	Blower	Blower	Blower	Blower	Blower	Blower
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input equipment horsepower (hp)	0	0	0	0	0	0

Input number of equipments operating	0	0	0	0	0	0
Input operating time for each equipment (hrs)	0	0	0	0	0	0
Percent of max speed for motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Equipment load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input equipment load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Equipment motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Method 2 - ELECTRICAL USAGE IS KNOWN						
Input equipment electrical usage, if known (kWh)	0	0	0	0	0	0
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)						

AGRICULTURAL EQUIPMENT	Tillage Tractor 1	Tillage Tractor 2	Tillage Tractor 3	Tillage Tractor 4	Tillage Tractor 5	Tillage Tractor 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area to till (acre)						
Choose soil condition from drop down menu	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil
Choose soil type from drop down menu	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil
Input time available (work days)						
Input depth of tillage (in)						

CAPPING EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose stabilization equipment type from drop down menu	Roller	Roller	Roller	Roller	Roller	Roller
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area (ft2)						
Input time available (work days)						

MIXING EQUIPMENT	Mixer 1	Mixer 2	Mixer 3	Mixer 4	Mixer 5	Mixer 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input volume (yd3)						
Input production rate (yd3/hr)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the mixer selected, otherwise a default will be used by the tool)						

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)						
Input operating hours (hr)						

OTHER FUELED EQUIPMENT	Fuel 1	Fuel 2	Fuel 3	Fuel 4	Fuel 5	Fuel 6
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input volume (scf for Natural gas, gallons for all others)						

OPERATOR LABOR	Occupation 1	Occupation 2	Occupation 3	Occupation 4	Occupation 5	Occupation 6
Choose occupation from drop-down menu	Construction laborers	ntific and technical serv	Construction laborers	Construction laborers	Construction laborers	Construction laborers
Input total time worked onsite (hours)	207.0					

LABORATORY ANALYSIS	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Analysis 6
Input dollars spent on laboratory analysis ($)						

OTHER KNOWN ONSITE ACTIVITIES	Entire Site
Input energy usage (MMBTU)	
Water consumption (gallon)	
Input CO2 emission (metric ton)	
Input N2O emission (metric ton CO2 e)	
Input CH4 emission (metric ton CO2 e)	
Input NOx emission (metric ton)	
Input SOx emission (metric ton)	
Input PM10 emission (metric ton)	
Input fatality risk	
Input injury risk	

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)			11.0			
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input total number of trips			4.0			
Input number of miles per trip			12.4			

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)			45.0			
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

THERMAL/CATALYTIC OXIDIZERS*	Oxidizer 1	Oxidizer 2	Oxidizer 3	Oxidizer 4	Oxidizer 5	Oxidizer 6
Choose oxidizer type from drop down menu	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input waste gas flow rate (scfm)						
Input time running (hours)						
Input waste gas inlet temperature (F)						
Input contaminant concentration (ppmV)						

*(Electric blowers are included in the analysis)

RESOURCE CONSUMPTION

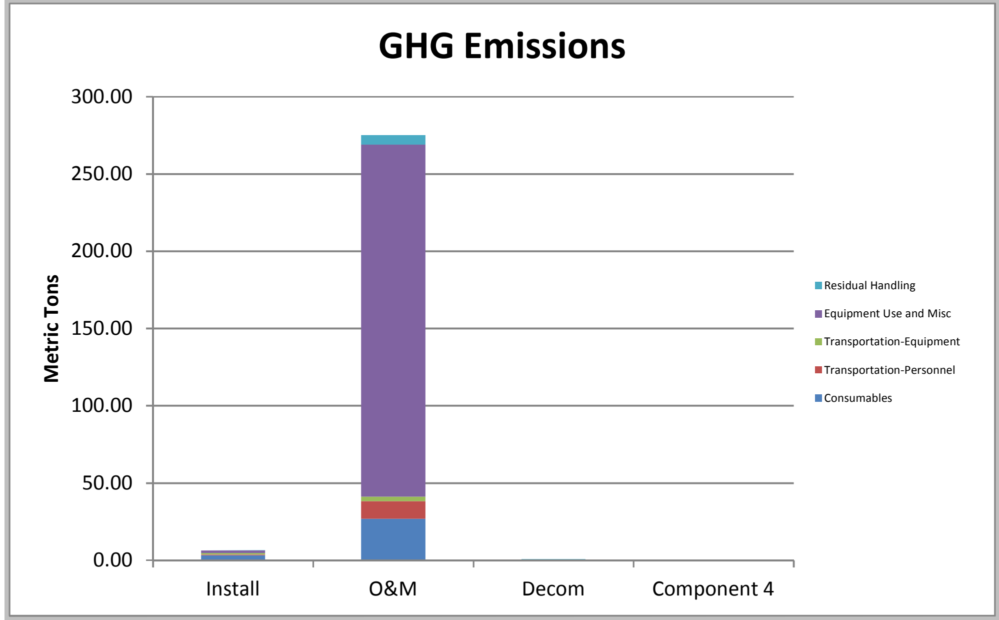
WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)						

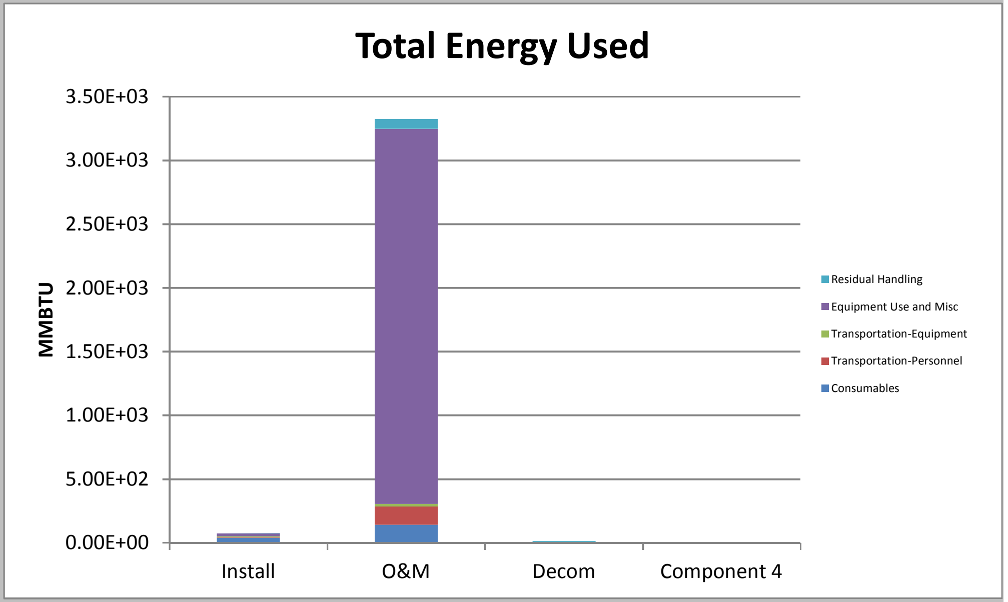
ONSITE LAND AND WATER RESOURCE CONSUMPTION	Entire Site 1	Entire Site 2	Entire Site 3	Entire Site 4	Entire Site 5	Entire Site 6
Input volume of topsoil brought to site (cubic yards)						
Input volume of groundwater or surface water lost (gal)						

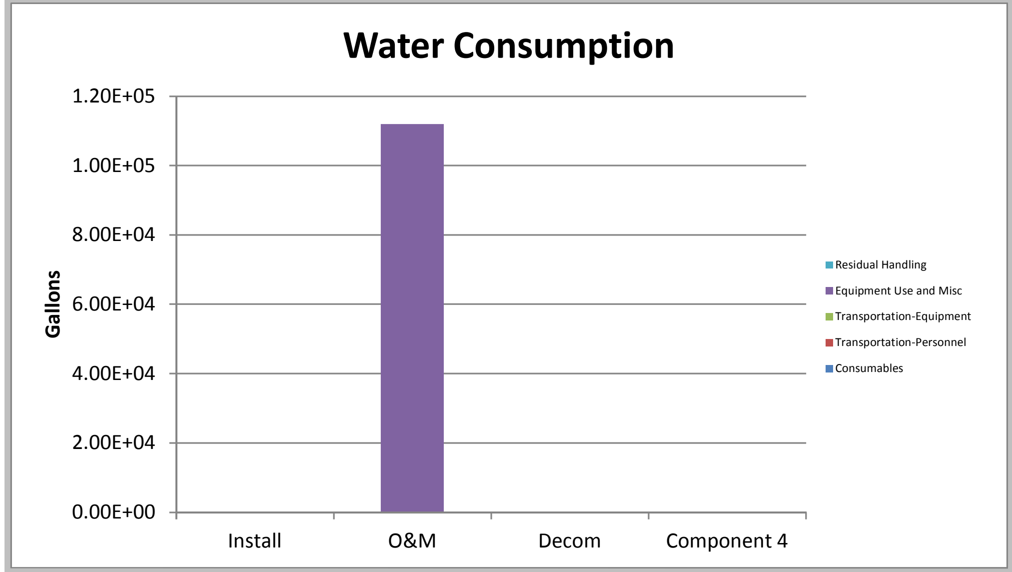
Sustainable Remediation - Environmental Footprint Summary
Fixed ex wells

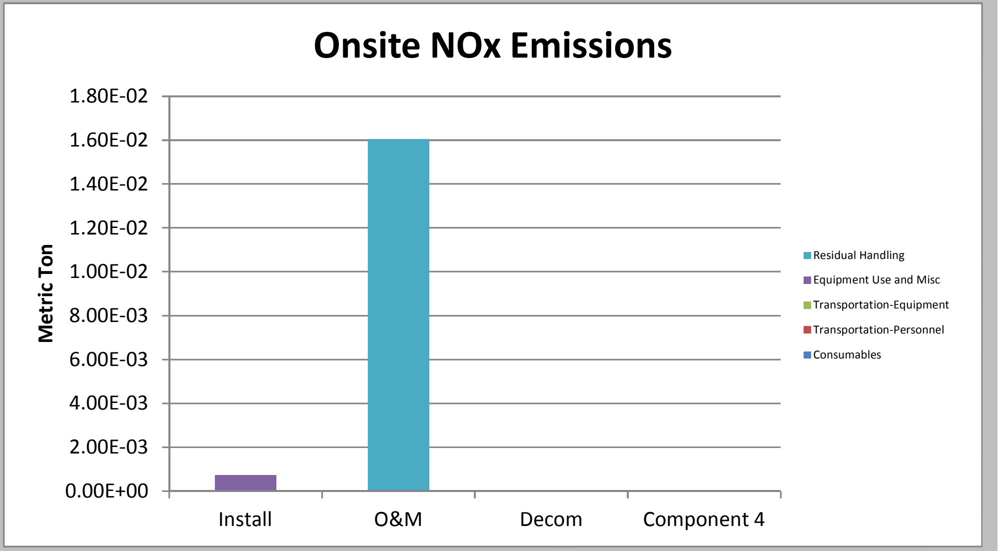
Phase	Activities	GHG Emissions (metric ton)	Total Energy Used (MMBTU)	Water Consumption (gallons)	Electricity Usage (MWH)	Onsite NOx Emissions (metric ton)	Onsite SOx Emissions (metric ton)	Onsite PM10 Emissions (metric ton)	Total NOx Emissions (metric ton)
Install	Consumables	3.26	4.0E+01	NA	NA	NA	NA	NA	6.1E-03
	Transportation-Personnel	0.35	4.4E+00	NA	NA	NA	NA	NA	1.3E-04
	Transportation-Equipment	1.02	7.2E+00	NA	NA	NA	NA	NA	3.1E-03
	Equipment Use and Misc	1.66	2.3E+01	5.1E+01	1.0E-01	7.5E-04	8.3E-05	9.1E-05	8.2E-03
	Residual Handling	0.04	4.7E-01	NA	NA	0.0E+00	0.0E+00	0.0E+00	1.5E-05
	Sub-Total	6.32	7.59E+01	5.10E+01	1.00E-01	7.47E-04	8.31E-05	9.14E-05	1.76E-02
O&M	Consumables	26.94	1.4E+02	NA	NA	NA	NA	NA	5.4E-05
	Transportation-Personnel	11.45	1.4E+02	NA	NA	NA	NA	NA	4.2E-03
	Transportation-Equipment	2.78	1.9E+01	NA	NA	NA	NA	NA	8.6E-03
	Equipment Use and Misc	227.89	2.9E+03	1.1E+05	2.2E+02	0.0E+00	0.0E+00	0.0E+00	6.7E-01
	Residual Handling	6.06	7.9E+01	NA	NA	1.6E-02	3.6E-06	7.4E-05	2.0E-02
	Sub-Total	275.13	3.32E+03	1.12E+05	2.20E+02	1.61E-02	3.59E-06	7.40E-05	7.00E-01
Decom	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Personnel	0.19	2.4E+00	NA	NA	NA	NA	NA	7.0E-05
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.59	1.2E+01	NA	NA	0.0E+00	0.0E+00	0.0E+00	2.9E-03
	Sub-Total	0.78	1.46E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.95E-03
Component 4	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Personnel	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total		**2.8E+02**	**3.4E+03**	**1.1E+05**	**2.2E+02**	**1.7E-02**	**8.7E-05**	**1.7E-04**	**7.2E-01**

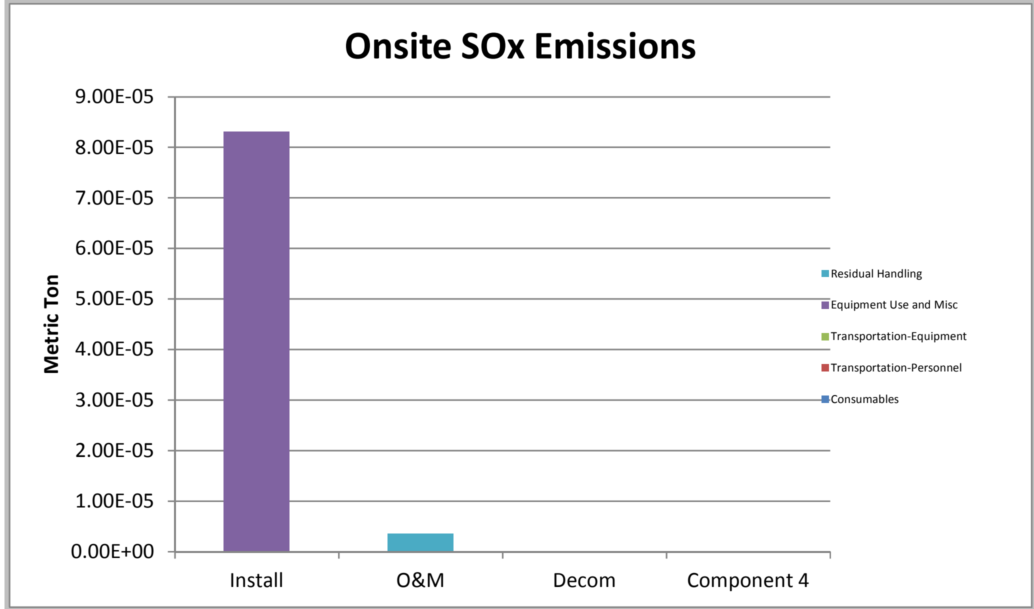
Remedial Alternative Phase	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Topsoil Consumption	Costing	Lost Hours - Injury	Percent electricity from renewable sources	Total Cost with Footprint Reduction
	tons	tons	cubic yards	$		%	
Install	7.0E-02	0.0E+00	0.0E+00	299,267	6.5E-02	14.0%	$2,109,731
O&M	3.5E-01	0.0E+00	0.0E+00	1,768,340	1.2E+00	14.0%	
Decom	4.5E+01	0.0E+00	0.0E+00	42,124	4.2E-02	0.0%	
Component 4	0.0E+00	0.0E+00	0.0E+00	0	0.0E+00	0.0%	
Total	**4.5E+01**	**0.0E+00**	**0.0E+00**	**$2,109,731**	**1.3E+00**	**7.0%**	

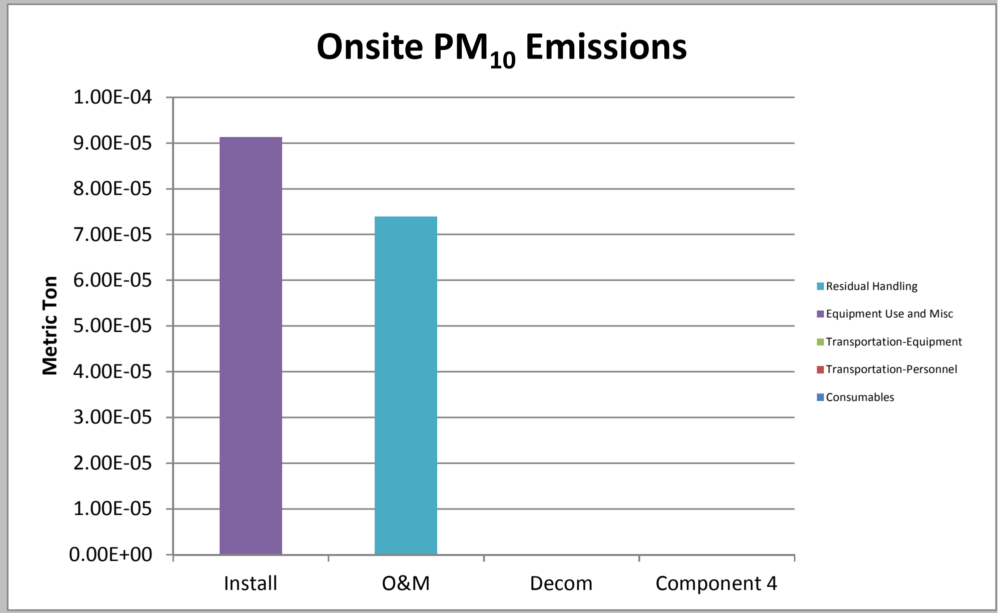

GHG Emissions
Metric Tons
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

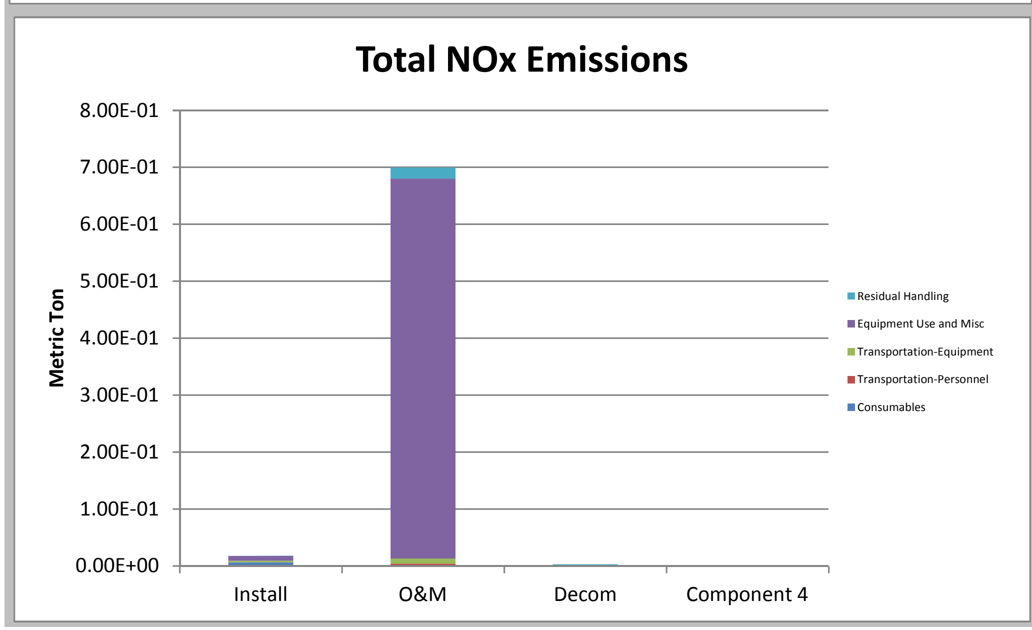

Total Energy Used
MMBTU
3.50E+03
3.00E+03
2.50E+03
2.00E+03
1.50E+03
1.00E+03
5.00E+02
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

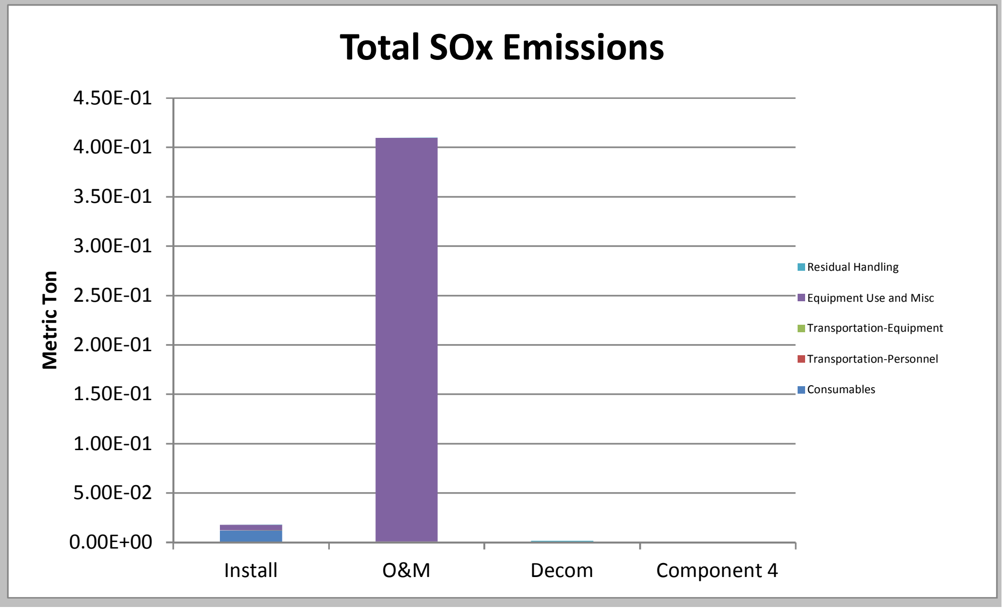

Water Consumption
Gallons
1.20E+05
1.00E+05
8.00E+04
6.00E+04
4.00E+04
2.00E+04
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

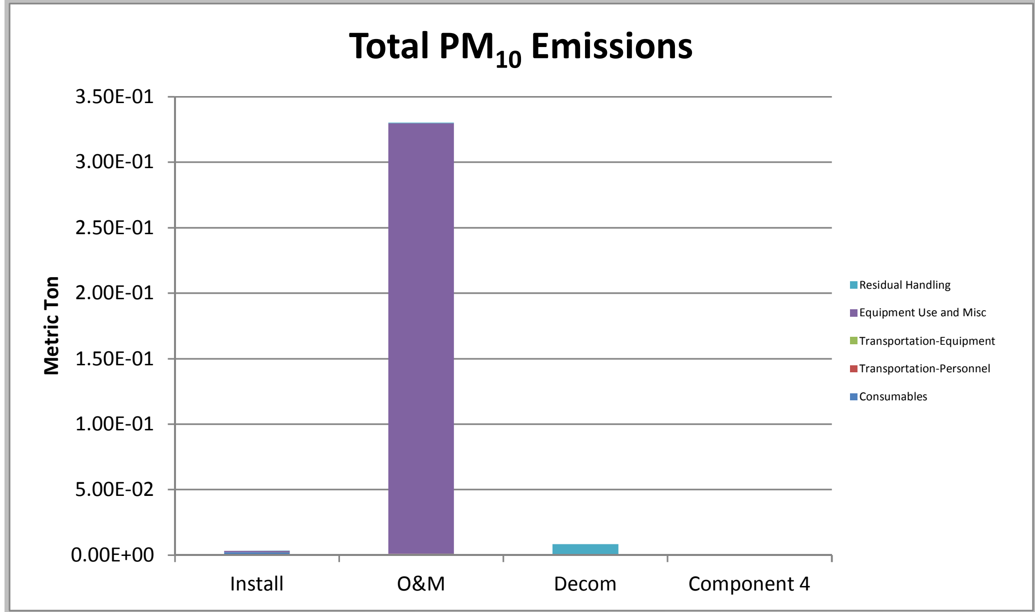

Onsite NOx Emissions
Metric Ton
1.80E-02
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

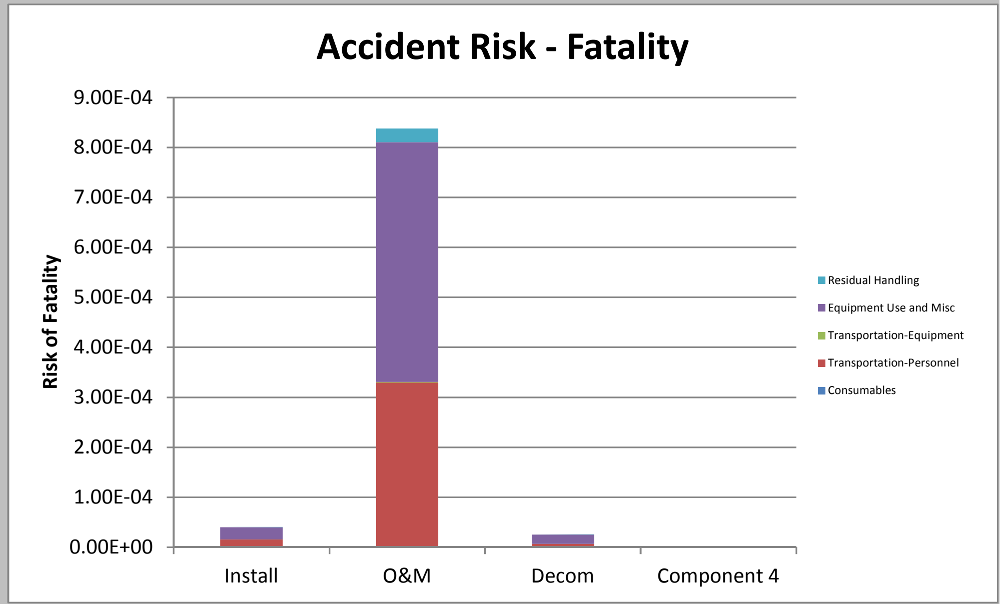

Onsite SOx Emissions
Metric Ton
9.00E-05
8.00E-05
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

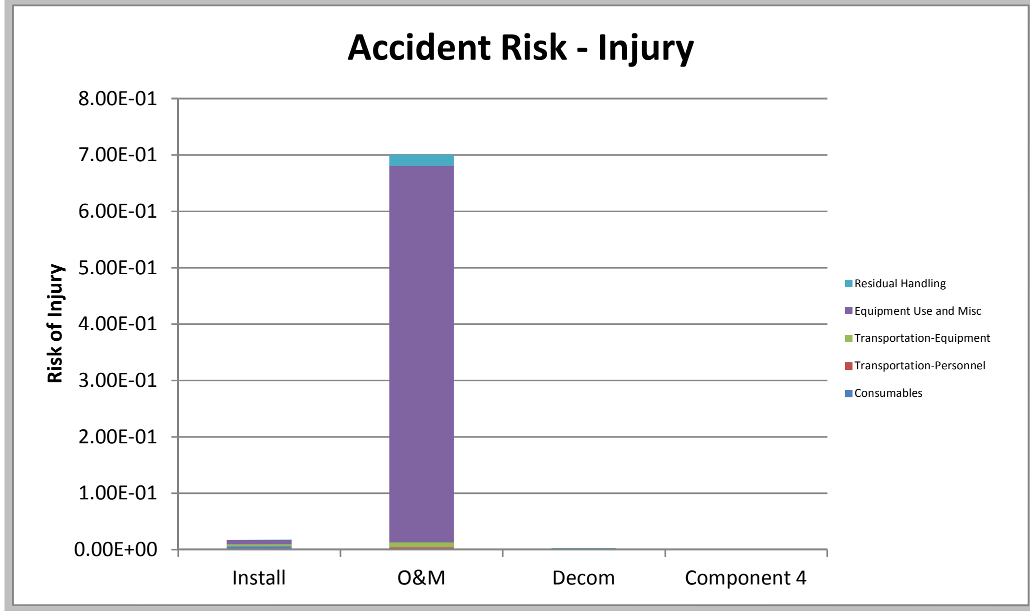

Onsite PM_{10} Emissions
Metric Ton
1.00E-04
9.00E-05
8.00E-05
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

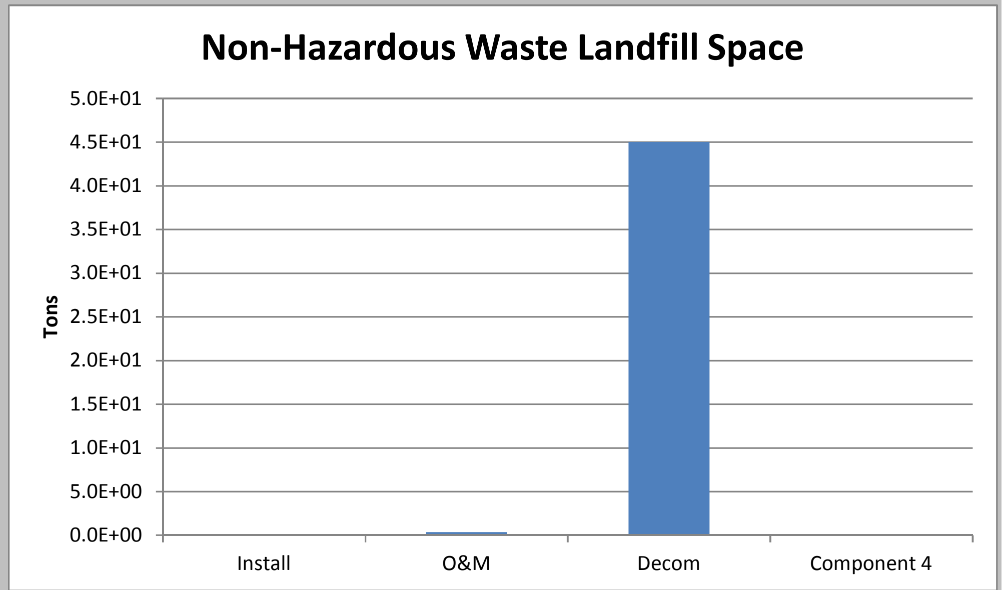

Total NOx Emissions
Metric Ton
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

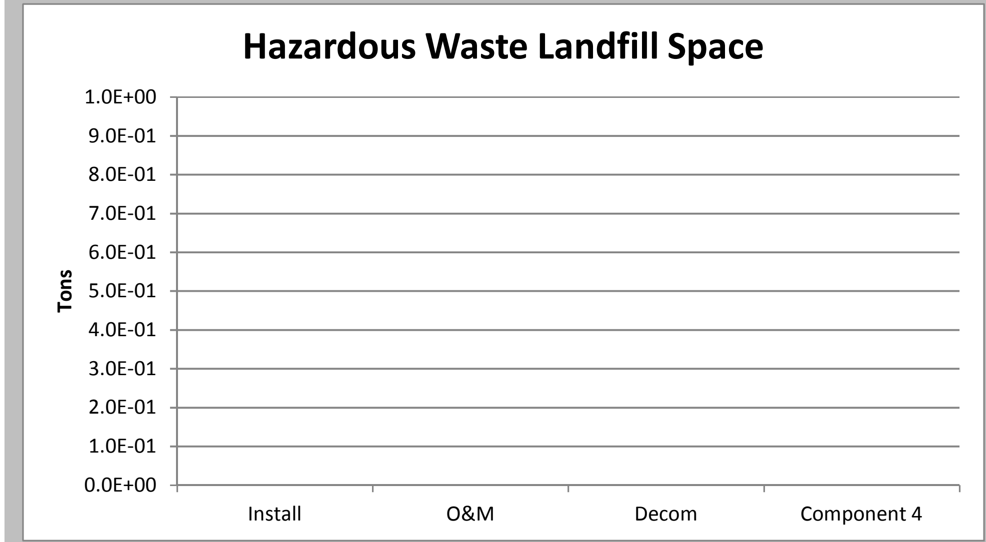

Total SOx Emissions
Metric Ton
4.50E-01
4.00E-01
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

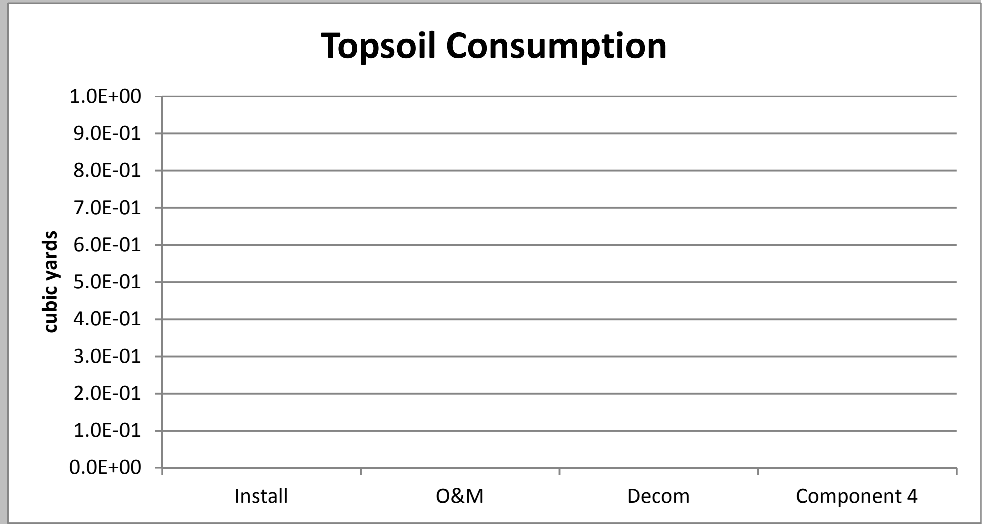

Total PM10 Emissions
Metric Ton
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Fatality
Risk of Fatality
9.00E-04
8.00E-04
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Injury
Risk of Injury
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Non-Hazardous Waste Landfill Space
Tons
5.0E+01
4.5E+01
4.0E+01
3.5E+01
3.0E+01
2.5E+01
2.0E+01
1.5E+01
1.0E+01
5.0E+00
0.0E+00
Install
O&M
Decom
Component 4


Hazardous Waste Landfill Space
Tons
1.0E+00
9.0E-01
8.0E-01
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Install
O&M
Decom
Component 4


Topsoil Consumption
cubic yards
1.0E+00
9.0E-01
8.0E-01
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Install
O&M
Decom
Component 4

SITE INFORMATION	
User Name and Date	Kevin Simpson
Site Name	TPI Tullamarine
Remedial Alternative Name	Fixed existing wells
Alternative File Name	Fixed ex wells
Choose electricity profile	CUST

To Custom

Do you want to reload a previously saved remedial alternative in the SiteWise input sheet?

Yes

Refresh List

Reset all input values on all worksheets to default

Reset All Values on All Sheets

-= Status =-

Done Loading!

This worksheet allows the user to define material production, transportation, equipment use, and residual handling variables for the remedial alternative

Yellow cells	require the user to choose an input from a drop down menu
White cells	require the user to type in a value

BASELINE INFORMATION

COMPONENT 1 DURATION AND COST	Entire Site
Input duration of the component (unit time)	1
Input component cost per unit time ($)	299267

MATERIAL PRODUCTION

WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Choose specific casing material schedule from drop down menu	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC
Choose well diameter (in) from drop down menu	10	1/8	1/8	1/8	1/8	1/8
Input total quantity of Sand (kg)						
Input total quantity of Gravel (kg)						
Input total quantity of Bentonite (kg)						
Input total quantity of Typical Cement (kg)						
Input total quantity of General Concrete (kg)						
Input total quantity of Steel (kg)						

TREATMENT CHEMICALS & MATERIALS	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input number of injection points						
Choose material type from drop down menu	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide
Input amount of material injected at each point (pounds dry mass)						
Input number of injections per injection point						

TREATMENT MEDIA	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input weight of media used (lbs)	110					
Choose media type from drop down menu	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC

CONSTRUCTION MATERIALS	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material type from drop down menu	HDPE Liner	General Concrete	General Concrete	HDPE Liner	HDPE Liner	HDPE Liner
Input area of material (ft2)	431	372	32			
Input depth of material (ft)	0.02	0.66	0.66			

WELL DECOMMISSIONING	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Input well diameter (in)						
Choose material from drop down menu	General Concrete	Soil	Soil	Soil	Soil	Soil

BULK MATERIAL QUANTITIES	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material from drop down menu	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid
Choose units of material quantity from drop down menu	pounds	pounds	pounds	pounds	pounds	pounds
Input material quantity						

TRANSPORTATION

PERSONNEL TRANSPORTATION - ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose vehicle type from drop down menu*	Cars	Cars	Cars	Cars	Cars	Cars
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input distance traveled per trip (miles)	12.4	12.4	12.4	12.4	12.4	12.4
Input number of trips taken	2	2	2	2	2	4
Input number of travelers	1	9	2	2	2	1
Input estimated vehicular fuel economy (mi/gal) (Input only if known for the vehicle selected, otherwise a default will be used by the tool)						

*For vehicle type 'Other' please enter values in Table 2b in the Look Up Table tab.

PERSONNEL TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input number of travelers						
Input number of flights taken						

PERSONNEL TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Choose vehicle type from drop down menu	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail
Input distance traveled (miles)						
Input number of trips taken						
Input number of travelers						

EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Account for an empty return trip?	No	No	No	No	No	No
Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).	12					
Input weight of equipment transported per truck load (tons)	5.70					

EQUIPMENT TRANSPORTATION - SHARED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of equipment transported (tons)						

EQUIPMENT TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)	8,080					
Input weight of equipment transported (tons)	0.09					

EQUIPMENT TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of load (tons)						

EQUIPMENT TRANSPORTATION - WATER	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (mile)						
Input weight of load (tons)						

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Dozer	Dozer	Dozer	Dozer	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)						
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

DRILLING	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Input number of drilling locations	0					
Choose drilling method from drop down menu	Hollow Stem Auger	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push
Input time spent drilling at each location (hr)						
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel

TRENCHING	Trencher 1	Trencher 2	Trencher 3	Trencher 4	Trencher 5	Trencher 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input operating hours (hr)						

For each pump, select only one of the three methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused pump columns or unused methods

PUMP OPERATION	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - ELECTRICAL USAGE IS KNOWN						
Input pump electrical usage (KWh)	0	0	0	0	0	0
Method 2 - PUMP HEAD IS KNOWN						
Input flow rate (gpm)	0	0	0	0	0	0
Input total head (ft)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Pump efficiency (default already present, user override possible)	0.6	0.6	0.6	0.6	0.6	0.6
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Input specific gravity (default already present, user override possible)	1	1	1	1	1	1
Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input pump horsepower (hp)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Percent of max speed for pump motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Pump load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input pump load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

DIESEL AND GASOLINE PUMPS	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1
Equipment operating hours (hrs)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the pump selected, otherwise a default will be used by the tool)						

For each type of equipment, select only one of the methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused equipment columns or unused methods

BLOWER, COMPRESSOR, MIXER, AND OTHER EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose type of equipment from drop down	Blower	Blower	Blower	Blower	Blower	Blower
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input equipment horsepower (hp)	0	0	0	0	0	0

	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Input number of equipments operating	0	0	0	0	0	0
Input operating time for each equipment (hrs)	0	0	0	0	0	0
Percent of max speed for motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Equipment load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input equipment load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Equipment motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Method 2 - ELECTRICAL USAGE IS KNOWN						
Input equipment electrical usage, if known (kWh)	100	0	0	0	0	0
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Diesel	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	3 to 6	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)	44					

AGRICULTURAL EQUIPMENT	Tillage Tractor 1	Tillage Tractor 2	Tillage Tractor 3	Tillage Tractor 4	Tillage Tractor 5	Tillage Tractor 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area to till (acre)						
Choose soil condition from drop down menu	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil
Choose soil type from drop down menu	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil
Input time available (work days)						
Input depth of tillage (in)						

CAPPING EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose stabilization equipment type from drop down menu	Roller	Roller	Roller	Roller	Roller	Roller
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area (ft2)						
Input time available (work days)						

MIXING EQUIPMENT	Mixer 1	Mixer 2	Mixer 3	Mixer 4	Mixer 5	Mixer 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input volume (yd3)						
Input production rate (yd3/hr)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the mixer selected, otherwise a default will be used by the tool)						

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)						
Input operating hours (hr)						

OTHER FUELED EQUIPMENT	Fuel 1	Fuel 2	Fuel 3	Fuel 4	Fuel 5	Fuel 6
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input volume (scf for Natural gas, gallons for all others)						

OPERATOR LABOR	Occupation 1	Occupation 2	Occupation 3	Occupation 4	Occupation 5	Occupation 6
Choose occupation from drop-down menu	Construction laborers	entific and technical serv	Construction laborers	Construction laborers	Construction laborers	Construction laborers
Input total time worked onsite (hours)	260.0	160.0				

LABORATORY ANALYSIS	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Analysis 6
Input dollars spent on laboratory analysis ($)	3,300.00					

OTHER KNOWN ONSITE ACTIVITIES	Entire Site
Input energy usage (MMBTU)	
Water consumption (gallon)	
Input CO2 emission (metric ton)	
Input N2O emission (metric ton CO2 e)	
Input CH4 emission (metric ton CO2 e)	
Input NOx emission (metric ton)	
Input SOx emission (metric ton)	
Input PM10 emission (metric ton)	
Input fatality risk	
Input injury risk	

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)			0.0			
Choose fuel used from drop down menu	Diesel	Gasoline	Diesel	Diesel	Diesel	Gasoline
Input total number of trips			2.0			
Input number of miles per trip			12.4			

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)			0.1			
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

THERMAL/CATALYTIC OXIDIZERS*	Oxidizer 1	Oxidizer 2	Oxidizer 3	Oxidizer 4	Oxidizer 5	Oxidizer 6
Choose oxidizer type from drop down menu	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input waste gas flow rate (scfm)						
Input time running (hours)						
Input waste gas inlet temperature (F)						
Input contaminant concentration (ppmV)						

*(Electric blowers are included in the analysis)

RESOURCE CONSUMPTION

WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)						

ONSITE LAND AND WATER RESOURCE CONSUMPTION	Entire Site 1	Entire Site 2	Entire Site 3	Entire Site 4	Entire Site 5	Entire Site 6
Input volume of topsoil brought to site (cubic yards)						
Input volume of groundwater or surface water lost (gal)						

This worksheet allows the user to define material production, transportation, equipment use, and residual handling variables for the remedial alternative

Yellow cells require the user to choose an input from a drop down menu

White cells require the user to type in a value

BASELINE INFORMATION

COMPONENT 2 DURATION AND COST	Entire Site
Input duration of the component (unit time)	10
Input component cost per unit time ($)	176834

MATERIAL PRODUCTION

WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Choose specific casing material schedule from drop down menu	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC
Choose well diameter (in) from drop down menu	1/8	1/8	1/8	1/8	1/8	1/8
Input total quantity of Sand (kg)						
Input total quantity of Gravel (kg)						
Input total quantity of Bentonite (kg)						
Input total quantity of Typical Cement (kg)						
Input total quantity of General Concrete (kg)						
Input total quantity of Steel (kg)						

TREATMENT CHEMICALS & MATERIALS	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input number of injection points						
Choose material type from drop down menu	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide
Input amount of material injected at each point (pounds dry mass)						
Input number of injections per injection point						

TREATMENT MEDIA	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input weight of media used (lbs)	1,320					
Choose media type from drop down menu	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC

CONSTRUCTION MATERIALS	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material type from drop down menu	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner
Input area of material (ft2)						
Input depth of material (ft)						

WELL DECOMMISSIONING	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Input well diameter (in)						
Choose material from drop down menu	Soil	Soil	Soil	Soil	Soil	Soil

BULK MATERIAL QUANTITIES	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material from drop down menu	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid
Choose units of material quantity from drop down menu	pounds	pounds	pounds	pounds	pounds	pounds
Input material quantity						

TRANSPORTATION

PERSONNEL TRANSPORTATION - ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose vehicle type from drop down menu*	Cars	Cars	Cars	Cars	Cars	Cars
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input distance traveled per trip (miles)	12.4	12.4	12.4	12.4	12.4	12.4
Input number of trips taken	2	6	4	24	24	4.37
Input number of travelers	1	1	1	1	1	1
Input estimated vehicular fuel economy (mi/gal) (Input only if known for the vehicle selected, otherwise a default will be used by the tool)						

*For vehicle type 'Other' please enter values in Table 2b in the Look Up Table tab.

PERSONNEL TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input number of travelers						
Input number of flights taken						

PERSONNEL TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Choose vehicle type from drop down menu	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail
Input distance traveled (miles)						
Input number of trips taken						
Input number of travelers						

EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Account for an empty return trip?	No	No	No	No	No	No
Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).						
Input weight of equipment transported per truck load (tons)						

EQUIPMENT TRANSPORTATION - SHARED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)	12					
Input weight of equipment transported (tons)	0.1					

EQUIPMENT TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)	8,080	8,080				
Input weight of equipment transported (tons)	0.005	0.02				

EQUIPMENT TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of load (tons)						

EQUIPMENT TRANSPORTATION - WATER	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (mile)						
Input weight of load (tons)						

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Dozer	Dozer	Dozer	Dozer	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)						
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

DRILLING	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Input number of drilling locations						
Choose drilling method from drop down menu	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push
Input time spent drilling at each location (hr)						
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel

TRENCHING	Trencher 1	Trencher 2	Trencher 3	Trencher 4	Trencher 5	Trencher 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input operating hours (hr)						

For each pump, select only one of the three methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused pump columns or unused methods

PUMP OPERATION	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - ELECTRICAL USAGE IS KNOWN						
Input pump electrical usage (KWh)	0	0	0	0	0	0
Method 2 - PUMP HEAD IS KNOWN						
Input flow rate (gpm)	0	0	0	0	0	0
Input total head (ft)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Pump efficiency (default already present, user override possible)	0.6	0.6	0.6	0.6	0.6	0.6
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Input specific gravity (default already present, user override possible)	1	1	1	1	1	1
Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input pump horsepower (hp)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Percent of max speed for pump motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Pump load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input pump load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

DIESEL AND GASOLINE PUMPS	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1
Equipment operating hours (hrs)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the pump selected, otherwise a default will be used by the tool)						

For each type of equipment, select only one of the methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused equipment columns or unused methods

BLOWER, COMPRESSOR, MIXER, AND OTHER EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose type of equipment from drop down	Blower	Blower	Blower	Blower	Blower	Blower
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input equipment horsepower (hp)	0	0	0	0	0	0

Input number of equipments operating	0	0	0	0	0	0
Input operating time for each equipment (hrs)	0	0	0	0	0	0
Percent of max speed for motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Equipment load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input equipment load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Equipment motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Method 2 - ELECTRICAL USAGE IS KNOWN						
Input equipment electrical usage, if known (kWh)	21960	0	0	0	0	0
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)						

AGRICULTURAL EQUIPMENT	Tillage Tractor 1	Tillage Tractor 2	Tillage Tractor 3	Tillage Tractor 4	Tillage Tractor 5	Tillage Tractor 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area to till (acre)						
Choose soil condition from drop down menu	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil
Choose soil type from drop down menu	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil
Input time available (work days)						
Input depth of tillage (in)						

CAPPING EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose stabilization equipment type from drop down menu	Roller	Roller	Roller	Roller	Roller	Roller
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area (ft2)						
Input time available (work days)						

MIXING EQUIPMENT	Mixer 1	Mixer 2	Mixer 3	Mixer 4	Mixer 5	Mixer 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input volume (yd3)						
Input production rate (yd3/hr)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the mixer selected, otherwise a default will be used by the tool)						

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)						
Input operating hours (hr)						

OTHER FUELED EQUIPMENT	Fuel 1	Fuel 2	Fuel 3	Fuel 4	Fuel 5	Fuel 6
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input volume (scf for Natural gas, gallons for all others)						

OPERATOR LABOR	Occupation 1	Occupation 2	Occupation 3	Occupation 4	Occupation 5	Occupation 6
Choose occupation from drop-down menu	Construction laborers	entific and technical serv	Construction laborers	Construction laborers	Construction laborers	Construction laborers
Input total time worked onsite (hours)	520.0	96.0				

LABORATORY ANALYSIS	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Analysis 6
Input dollars spent on laboratory analysis ($)	7,200.00					

OTHER KNOWN ONSITE ACTIVITIES	Entire Site
Input energy usage (MMBTU)	
Water consumption (gallon)	
Input CO2 emission (metric ton)	
Input N2O emission (metric ton CO2 e)	
Input CH4 emission (metric ton CO2 e)	
Input NOx emission (metric ton)	
Input SOx emission (metric ton)	
Input PM10 emission (metric ton)	
Input fatality risk	
Input injury risk	

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)			0.0	1.9		
Choose fuel used from drop down menu	Gasoline	Gasoline	Diesel	Gasoline	Diesel	Gasoline
Input total number of trips			24.0	4.4		
Input number of miles per trip			12.4	12.4		

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)			0.0			
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

THERMAL/CATALYTIC OXIDIZERS*	Oxidizer 1	Oxidizer 2	Oxidizer 3	Oxidizer 4	Oxidizer 5	Oxidizer 6
Choose oxidizer type from drop down menu	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input waste gas flow rate (scfm)				1000		
Input time running (hours)				1		
Input waste gas inlet temperature (F)				65		
Input contaminant concentration (ppmV)				100		

*(Electric blowers are included in the analysis)

RESOURCE CONSUMPTION

WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)						

ONSITE LAND AND WATER RESOURCE CONSUMPTION	Entire Site 1	Entire Site 2	Entire Site 3	Entire Site 4	Entire Site 5	Entire Site 6
Input volume of topsoil brought to site (cubic yards)						
Input volume of groundwater or surface water lost (gal)						

This worksheet allows the user to define material production, transportation, equipment use, and residual handling variables for the remedial alternative

Yellow cells	require the user to choose an input from a drop down menu
White cells	require the user to type in a value

BASELINE INFORMATION

COMPONENT 3 DURATION AND COST	Entire Site
Input duration of the component (unit time)	1
Input component cost per unit time ($)	42124

MATERIAL PRODUCTION

WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Choose specific casing material schedule from drop down menu	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC
Choose well diameter (in) from drop down menu	1/8	1/8	1/8	1/8	1/8	1/8
Input total quantity of Sand (kg)						
Input total quantity of Gravel (kg)						
Input total quantity of Bentonite (kg)						
Input total quantity of Typical Cement (kg)						
Input total quantity of General Concrete (kg)						
Input total quantity of Steel (kg)						

TREATMENT CHEMICALS & MATERIALS	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input number of injection points						
Choose material type from drop down menu	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide	Hydrogen Peroxide
Input amount of material injected at each point (pounds dry mass)						
Input number of injections per injection point						

TREATMENT MEDIA	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Input weight of media used (lbs)						
Choose media type from drop down menu	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC	Virgin GAC

CONSTRUCTION MATERIALS	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material type from drop down menu	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner	HDPE Liner
Input area of material (ft2)						
Input depth of material (ft)						

WELL DECOMMISSIONING	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5	Well Type 6
Input number of wells						
Input depth of wells (ft)						
Input well diameter (in)						
Choose material from drop down menu	Soil	Soil	Soil	Soil	Soil	Soil

BULK MATERIAL QUANTITIES	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6
Choose material from drop down menu	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid	Acetic Acid
Choose units of material quantity from drop down menu	pounds	pounds	pounds	pounds	pounds	pounds
Input material quantity						

TRANSPORTATION

PERSONNEL TRANSPORTATION - ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose vehicle type from drop down menu*	Cars	Cars	Cars	Cars	Cars	Cars
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input distance traveled per trip (miles)	12.4	12.4	12.4	12.4		
Input number of trips taken	4	24	8	4		
Input number of travelers	1	2	1	1		
Input estimated vehicular fuel economy (mi/gal) (Input only if known for the vehicle selected, otherwise a default will be used by the tool)						

*For vehicle type 'Other' please enter values in Table 2b in the Look Up Table tab.

PERSONNEL TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input number of travelers						
Input number of flights taken						

PERSONNEL TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Choose vehicle type from drop down menu	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail	Intercity rail
Input distance traveled (miles)						
Input number of trips taken						
Input number of travelers						

EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Account for an empty return trip?	No	No	No	No	No	No
Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).						
Input weight of equipment transported per truck load (tons)						

EQUIPMENT TRANSPORTATION - SHARED LOAD ROAD	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of equipment transported (tons)						

EQUIPMENT TRANSPORTATION - AIR	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of equipment transported (tons)						

EQUIPMENT TRANSPORTATION - RAIL	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (miles)						
Input weight of load (tons)						

EQUIPMENT TRANSPORTATION - WATER	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Input distance traveled (mile)						
Input weight of load (tons)						

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Dozer	Dozer	Dozer	Dozer	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)						
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

DRILLING	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Input number of drilling locations						
Choose drilling method from drop down menu	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push	Direct Push
Input time spent drilling at each location (hr)						
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel

TRENCHING	Trencher 1	Trencher 2	Trencher 3	Trencher 4	Trencher 5	Trencher 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input operating hours (hr)						

For each pump, select only one of the three methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused pump columns or unused methods

PUMP OPERATION	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - ELECTRICAL USAGE IS KNOWN						
Input pump electrical usage (KWh)	0	0	0	0	0	0
Method 2 - PUMP HEAD IS KNOWN						
Input flow rate (gpm)	0	0	0	0	0	0
Input total head (ft)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Pump efficiency (default already present, user override possible)	0.6	0.6	0.6	0.6	0.6	0.6
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Input specific gravity (default already present, user override possible)	1	1	1	1	1	1
Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input pump horsepower (hp)	0	0	0	0	0	0
Input number of pumps operating	0	0	0	0	0	0
Input operating time for each pump (hrs)	0	0	0	0	0	0
Percent of max speed for pump motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Pump load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input pump load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Pump motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

DIESEL AND GASOLINE PUMPS	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1	2-Stroke: 0 to 1
Equipment operating hours (hrs)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the pump selected, otherwise a default will be used by the tool)						

For each type of equipment, select only one of the methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused equipment columns or unused methods

BLOWER, COMPRESSOR, MIXER, AND OTHER EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose type of equipment from drop down	Blower	Blower	Blower	Blower	Blower	Blower
Choose method from drop down	Method 1	Method 1	Method 1	Method 1	Method 1	Method 1
Method 1 - NAME PLATE SPECIFICATIONS ARE KNOWN						
Input equipment horsepower (hp)	0	0	0	0	0	0

Input number of equipments operating	0	0	0	0	0	0
Input operating time for each equipment (hrs)	0	0	0	0	0	0
Percent of max speed for motor (Optional input for variable speed motor)	100%	100%	100%	100%	100%	100%
Equipment load if max motor speed draws full nameplate horsepower	1	1	1	1	1	1
Input equipment load (default already present, user override possible, consider above value)	0.85	0.85	0.85	0.85	0.85	0.85
Equipment motor efficiency (default already present, user override possible)	0.85	0.85	0.85	0.85	0.85	0.85
Method 2 - ELECTRICAL USAGE IS KNOWN						
Input equipment electrical usage, if known (kWh)	0	0	0	0	0	0
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST
GENERATORS	**Generator 1**	**Generator 2**	**Generator 3**	**Generator 4**	**Generator 5**	**Generator 6**
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)						
AGRICULTURAL EQUIPMENT	**Tillage Tractor 1**	**Tillage Tractor 2**	**Tillage Tractor 3**	**Tillage Tractor 4**	**Tillage Tractor 5**	**Tillage Tractor 6**
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area to till (acre)						
Choose soil condition from drop down menu	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil	Firm untilled soil
Choose soil type from drop down menu	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil	Clay Soil
Input time available (work days)						
Input depth of tillage (in)						
CAPPING EQUIPMENT	**Equipment 1**	**Equipment 2**	**Equipment 3**	**Equipment 4**	**Equipment 5**	**Equipment 6**
Choose stabilization equipment type from drop down menu	Roller	Roller	Roller	Roller	Roller	Roller
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input area (ft2)						
Input time available (work days)						
MIXING EQUIPMENT	**Mixer 1**	**Mixer 2**	**Mixer 3**	**Mixer 4**	**Mixer 5**	**Mixer 6**
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3
Input volume (yd3)						
Input production rate (yd3/hr)						
Input estimated fuel consumption rate (gal/hr) (Input only if known for the mixer selected, otherwise a default will be used by the tool)						
INTERNAL COMBUSTION ENGINES	**Engine 1**	**Engine 2**	**Engine 3**	**Engine 4**	**Engine 5**	**Engine 6**
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)						
Input operating hours (hr)						
OTHER FUELED EQUIPMENT	**Fuel 1**	**Fuel 2**	**Fuel 3**	**Fuel 4**	**Fuel 5**	**Fuel 6**
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input volume (scf for Natural gas, gallons for all others)						
OPERATOR LABOR	**Occupation 1**	**Occupation 2**	**Occupation 3**	**Occupation 4**	**Occupation 5**	**Occupation 6**
Choose occupation from drop-down menu	Construction laborers	ntific and technical serv	Construction laborers	Construction laborers	Construction laborers	Construction laborers
Input total time worked onsite (hours)	207.0					

LABORATORY ANALYSIS	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Analysis 6
Input dollars spent on laboratory analysis ($)						

OTHER KNOWN ONSITE ACTIVITIES	Entire Site
Input energy usage (MMBTU)	
Water consumption (gallon)	
Input CO2 emission (metric ton)	
Input N2O emission (metric ton CO2 e)	
Input CH4 emission (metric ton CO2 e)	
Input NOx emission (metric ton)	
Input SOx emission (metric ton)	
Input PM10 emission (metric ton)	
Input fatality risk	
Input injury risk	

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)			11.0			
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input total number of trips			4.0			
Input number of miles per trip			12.4			

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)			45.0			
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	CUST	CUST	CUST	CUST	CUST	CUST

THERMAL/CATALYTIC OXIDIZERS*	Oxidizer 1	Oxidizer 2	Oxidizer 3	Oxidizer 4	Oxidizer 5	Oxidizer 6
Choose oxidizer type from drop down menu	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer	Simple Thermal Oxidizer
Choose fuel type from drop down menu	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Input waste gas flow rate (scfm)						
Input time running (hours)						
Input waste gas inlet temperature (F)						
Input contaminant concentration (ppmV)						

*(Electric blowers are included in the analysis)

RESOURCE CONSUMPTION

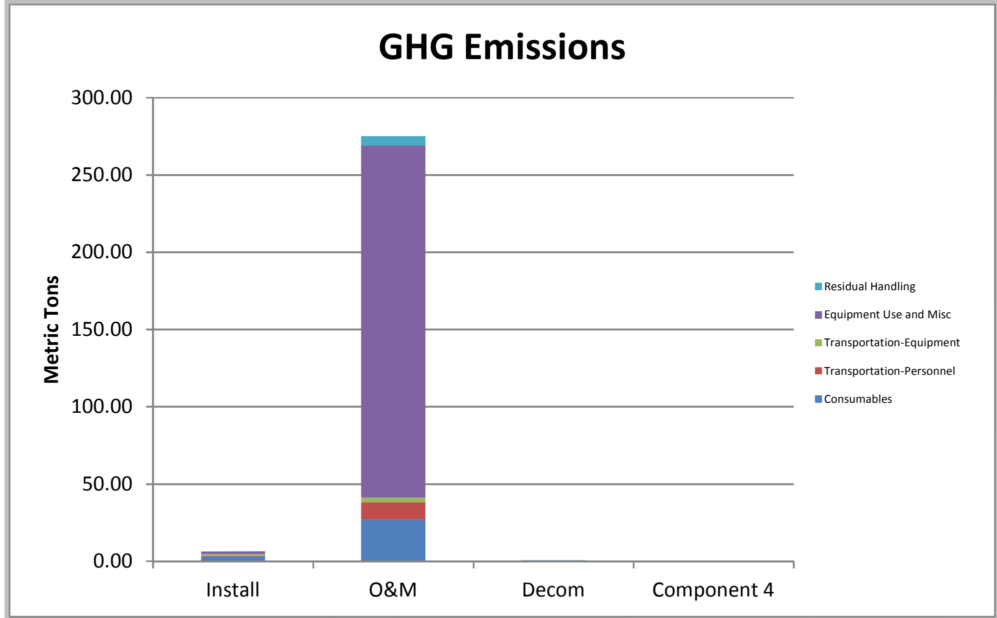
WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)						

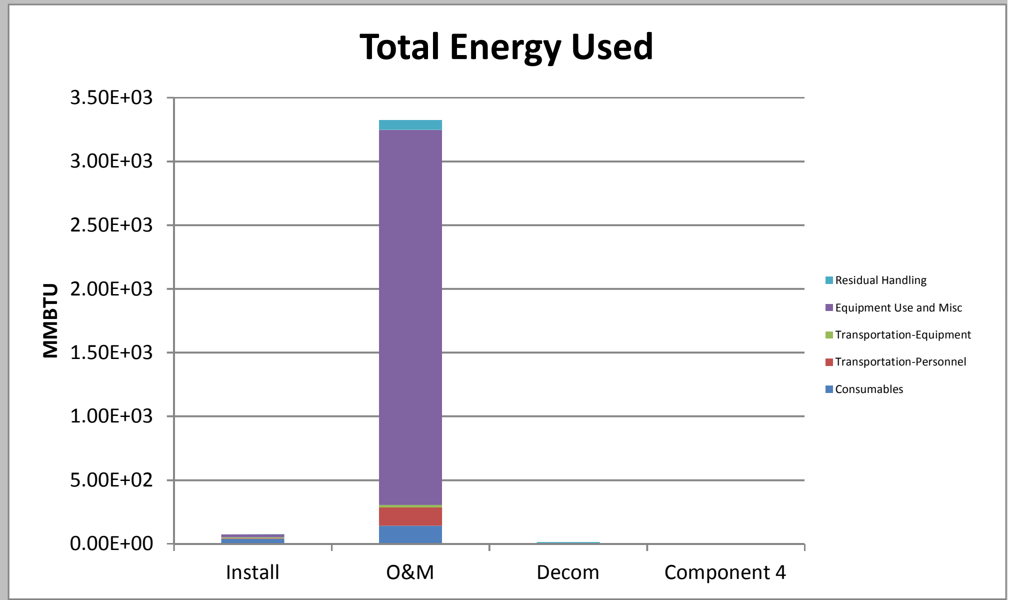
ONSITE LAND AND WATER RESOURCE CONSUMPTION	Entire Site 1	Entire Site 2	Entire Site 3	Entire Site 4	Entire Site 5	Entire Site 6
Input volume of topsoil brought to site (cubic yards)						
Input volume of groundwater or surface water lost (gal)						

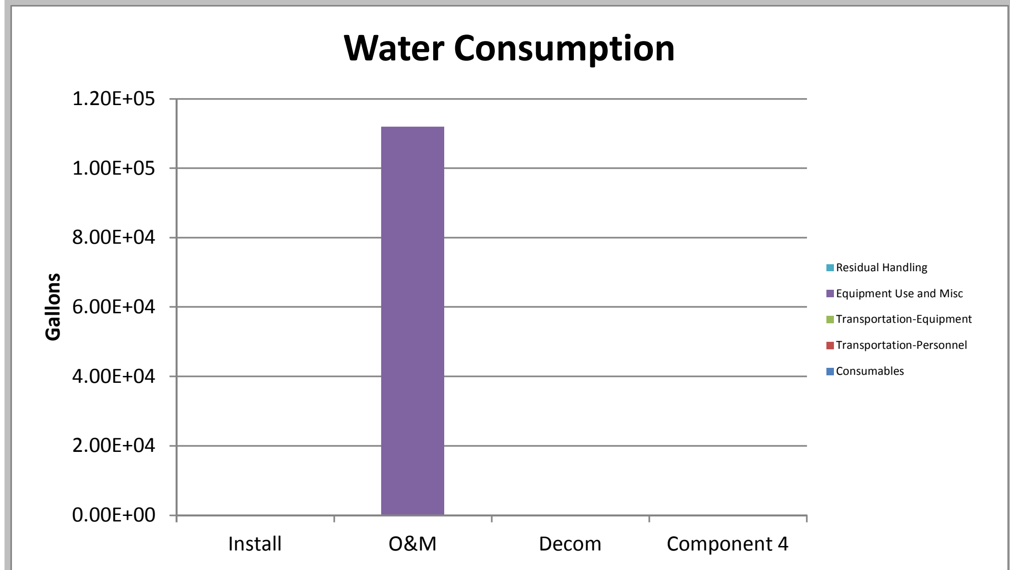
Sustainable Remediation - Environmental Footprint Summary
Fixed ex wells

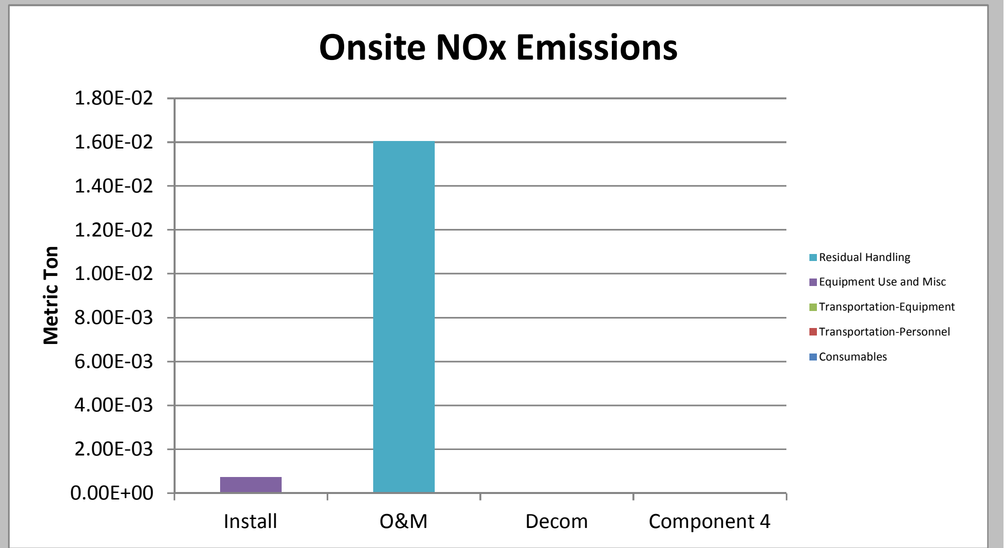
Phase	Activities	GHG Emissions (metric ton)	Total Energy Used (MMBTU)	Water Consumption (gallons)	Electricity Usage (MWH)	Onsite NOx Emissions (metric ton)	Onsite SOx Emissions (metric ton)	Onsite PM10 Emissions (metric ton)	Total NOx Emissions (metric ton)
Install	Consumables	3.26	4.0E+01	NA	NA	NA	NA	NA	6.1E-03
	Transportation-Personnel	0.35	4.4E+00	NA	NA	NA	NA	NA	1.3E-04
	Transportation-Equipment	1.02	7.2E+00	NA	NA	NA	NA	NA	3.1E-03
	Equipment Use and Misc	1.66	2.3E+01	5.1E+01	1.0E-01	7.5E-04	8.3E-05	9.1E-05	8.2E-03
	Residual Handling	0.04	4.7E-01	NA	NA	0.0E+00	0.0E+00	0.0E+00	1.5E-05
	Sub-Total	6.32	7.59E+01	5.10E+01	1.00E-01	7.47E-04	8.31E-05	9.14E-05	1.76E-02
O&M	Consumables	26.94	1.4E+02	NA	NA	NA	NA	NA	5.4E-05
	Transportation-Personnel	11.45	1.4E+02	NA	NA	NA	NA	NA	4.2E-03
	Transportation-Equipment	2.78	1.9E+01	NA	NA	NA	NA	NA	8.6E-03
	Equipment Use and Misc	227.89	2.9E+03	1.1E+05	2.2E+02	0.0E+00	0.0E+00	0.0E+00	6.7E-01
	Residual Handling	6.06	7.9E+01	NA	NA	1.6E-02	3.6E-06	7.4E-05	2.0E-02
	Sub-Total	275.13	3.32E+03	1.12E+05	2.20E+02	1.61E-02	3.59E-06	7.40E-05	7.00E-01
Decom	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Personnel	0.19	2.4E+00	NA	NA	NA	NA	NA	7.0E-05
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.59	1.2E+01	NA	NA	0.0E+00	0.0E+00	0.0E+00	2.9E-03
	Sub-Total	0.78	1.46E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.95E-03
Component 4	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Personnel	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total		**2.8E+02**	**3.4E+03**	**1.1E+05**	**2.2E+02**	**1.7E-02**	**8.7E-05**	**1.7E-04**	**7.2E-01**

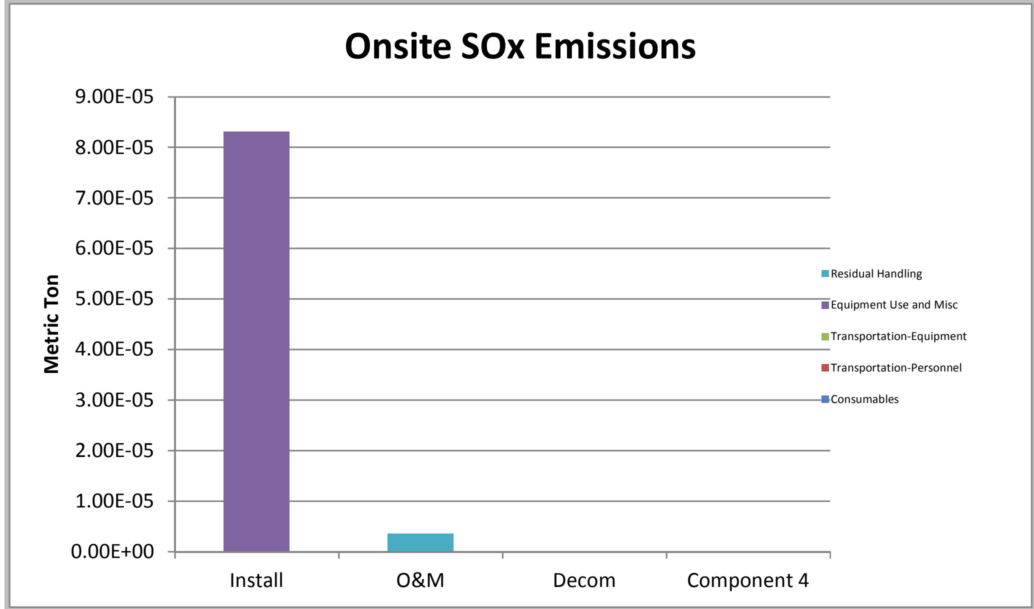
Remedial Alternative Phase	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Topsoil Consumption	Costing	Lost Hours - Injury	Percent electricity from renewable sources	Total Cost with Footprint Reduction
	tons	tons	cubic yards	$		%	
Install	7.0E-02	0.0E+00	0.0E+00	299,267	6.5E-02	14.0%	$2,109,731
O&M	3.5E-01	0.0E+00	0.0E+00	1,768,340	1.2E+00	14.0%	
Decom	4.5E+01	0.0E+00	0.0E+00	42,124	4.2E-02	0.0%	
Component 4	0.0E+00	0.0E+00	0.0E+00	0	0.0E+00	0.0%	
Total	**4.5E+01**	**0.0E+00**	**0.0E+00**	**$2,109,731**	**1.3E+00**	**7.0%**	

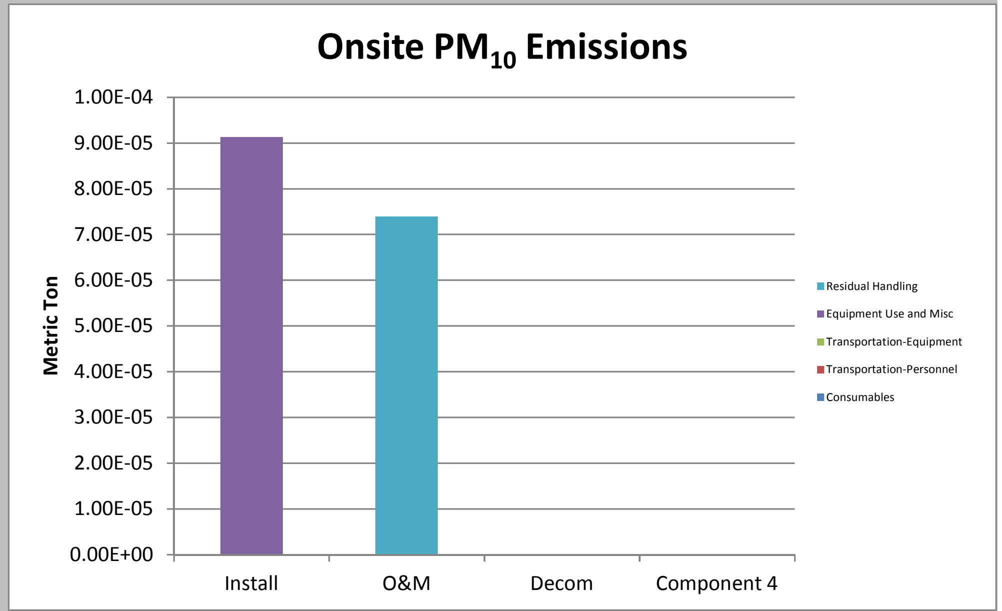

GHG Emissions
Metric Tons
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

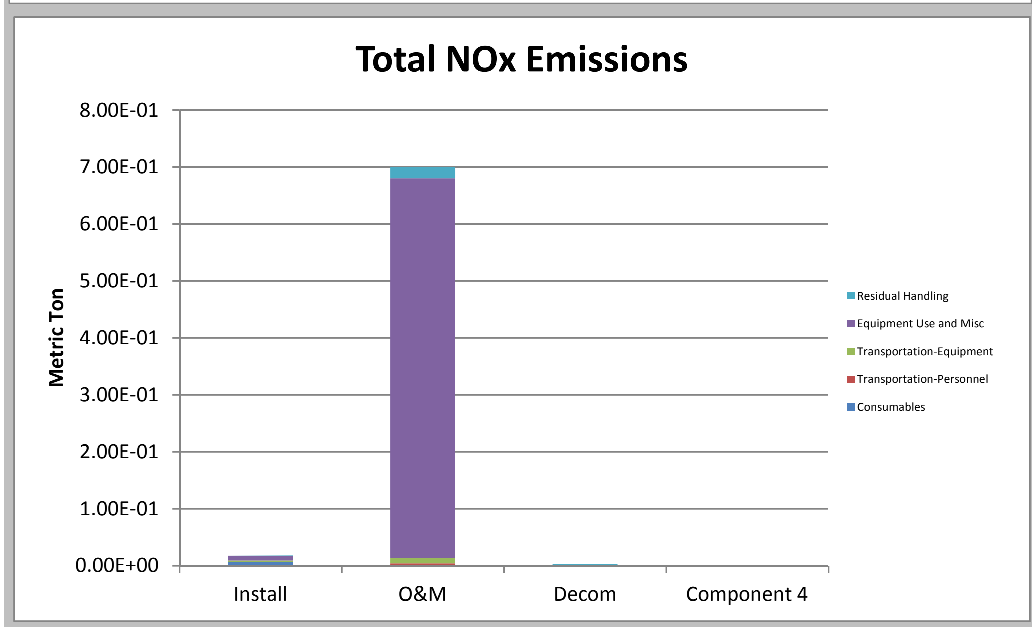

Total Energy Used
MMBTU
3.50E+03
3.00E+03
2.50E+03
2.00E+03
1.50E+03
1.00E+03
5.00E+02
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

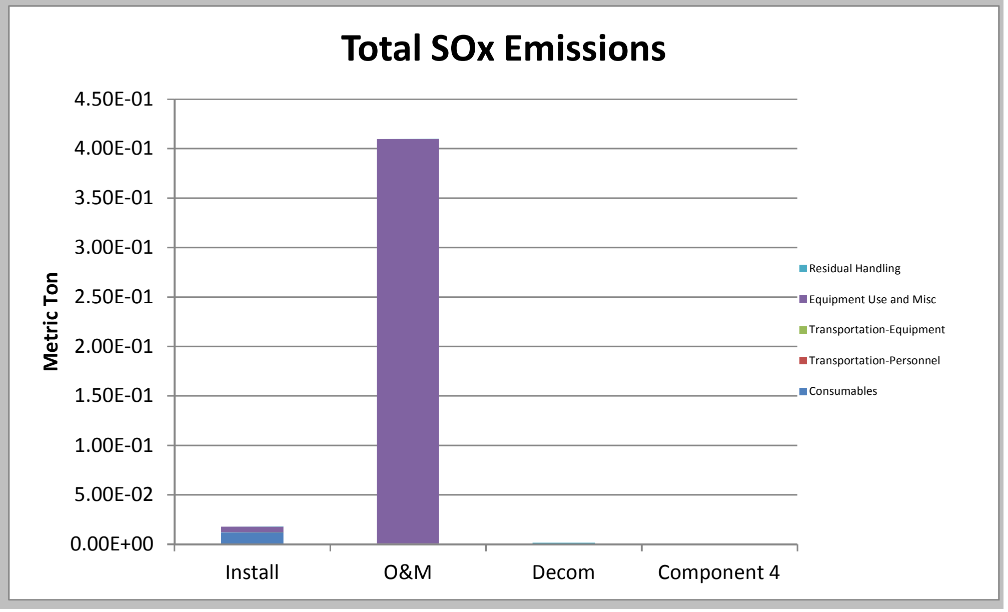

Water Consumption
Gallons
1.20E+05
1.00E+05
8.00E+04
6.00E+04
4.00E+04
2.00E+04
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

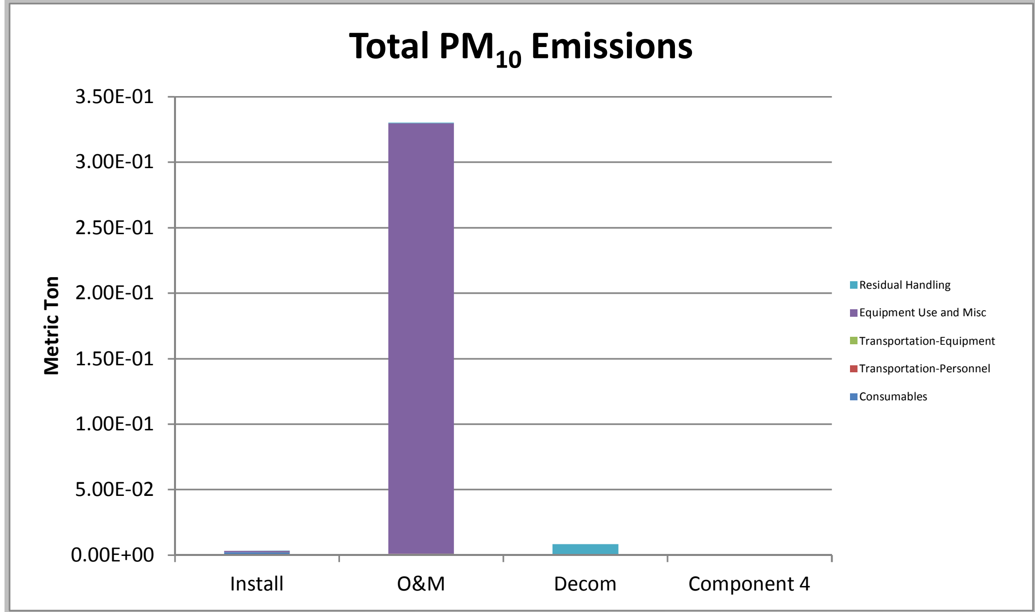

Onsite NOx Emissions
Metric Ton
1.80E-02
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

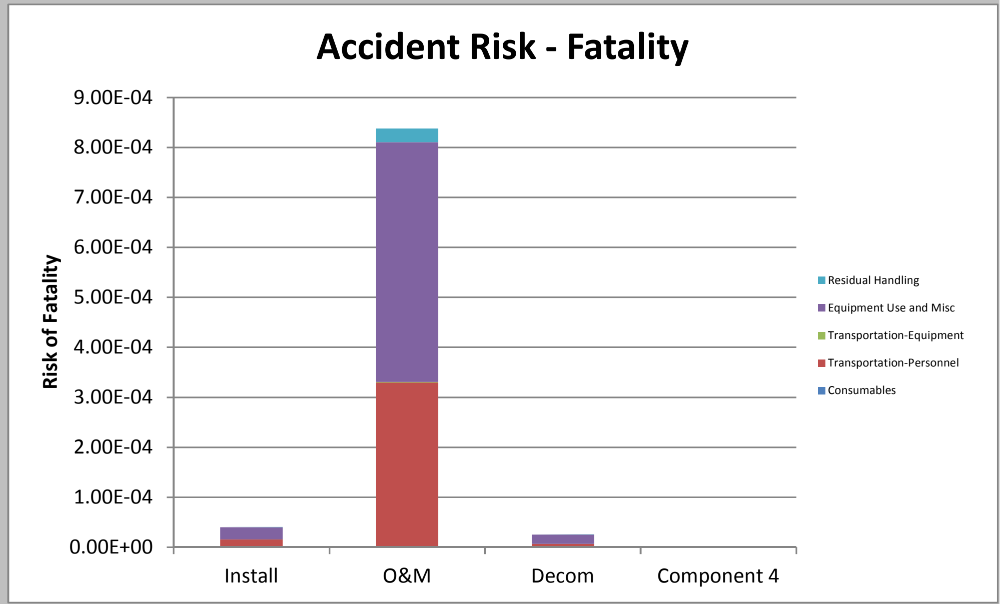

Onsite SOx Emissions
Metric Ton
9.00E-05
8.00E-05
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

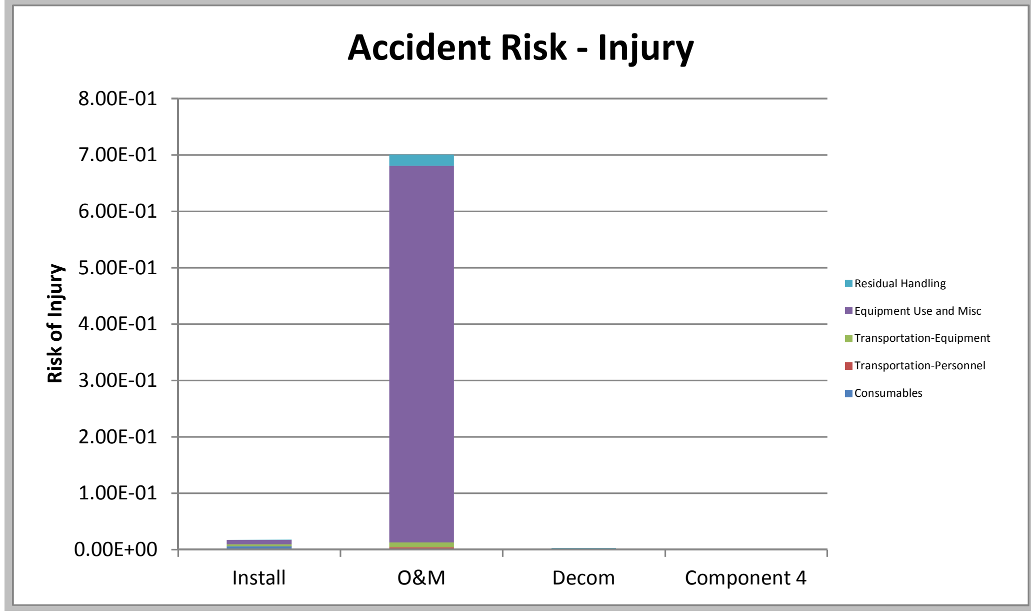

Onsite PM_{10} Emissions
Metric Ton
1.00E-04
9.00E-05
8.00E-05
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

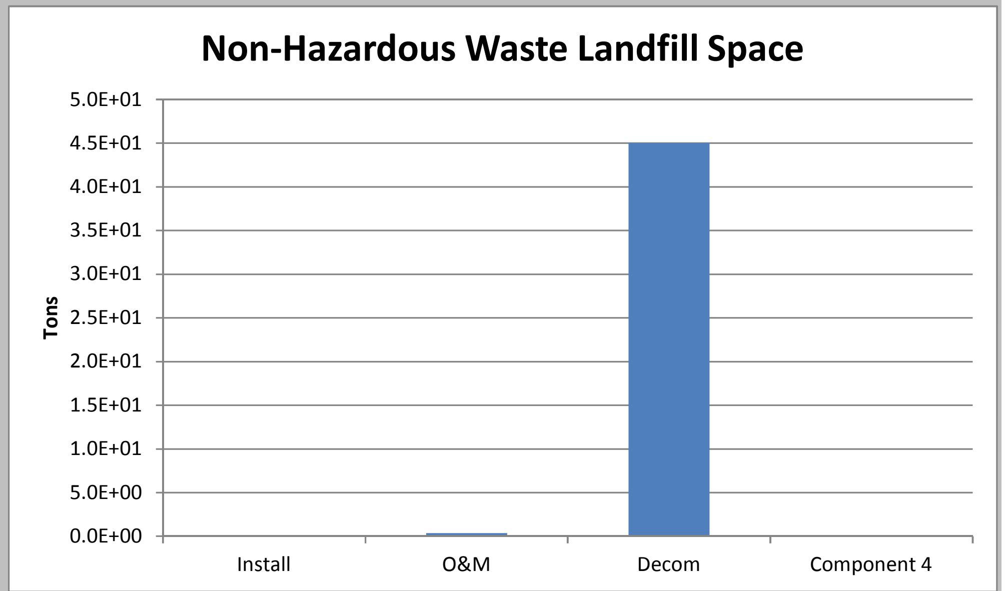

Total NOx Emissions
Metric Ton
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

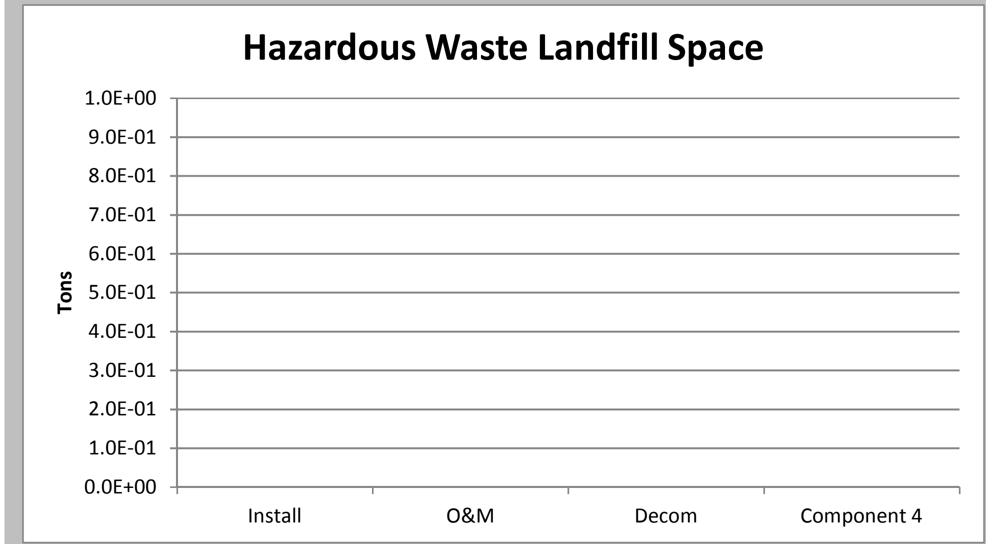

Total SOx Emissions
Metric Ton
4.50E-01
4.00E-01
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

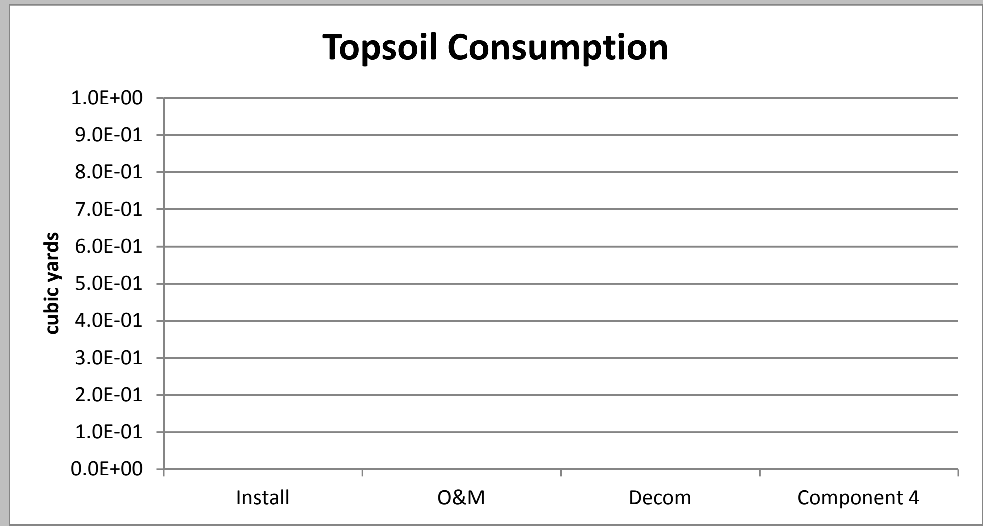

Total PM10 Emissions
Metric Ton
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Fatality
Risk of Fatality
9.00E-04
8.00E-04
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Injury
Risk of Injury
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Install
O&M
Decom
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Non-Hazardous Waste Landfill Space
Tons
5.0E+01
4.5E+01
4.0E+01
3.5E+01
3.0E+01
2.5E+01
2.0E+01
1.5E+01
1.0E+01
5.0E+00
0.0E+00
Install
O&M
Decom
Component 4


Hazardous Waste Landfill Space
Tons
1.0E+00
9.0E-01
8.0E-01
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Install
O&M
Decom
Component 4


Topsoil Consumption
cubic yards
1.0E+00
9.0E-01
8.0E-01
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Install
O&M
Decom
Component 4

APPENDIX C TULLAMARINE LANDFILL COMMUNITY CONSULTATION GROUP MEETING MINUTES (SEPTEMBER AND NOVEMBER 2014) AND REVIEWS

TLCCG
Tullamarine Landfill
Community Consultation Group

TULLAMARINE LANDFILL COMMUNITY MEETING

10 September, 2014 **6:30pm for 7:00 – 8:40 pm**

Level 8, Mantra Hotel, Cnr Melrose Drive & Trade Park Drive, Tullamarine

---

Attendees
Community: Cr Helen Patsikatheodoru, Helen van den Berg, Jos van den Berg, Frank Rivoli, Sam Cetrola, Graeme Hodgson, Prue Hicks, Peter Barbetti, Russell Nilsson, Ovi Clements, Julie Law

EPA: Jeremy Settle (Senior Environment Protection Officer, EPA Victoria), Stephen Lansdell (Manager – Specialist Regulatory Services, EPA Victoria)

Transpacific: Clete Elms (Regional Manager Vic Post Collections), Kieren McDermott (Environment Specialist), Olga Ghiri (Stakeholder and Community Liaison), Alan O'Brien (Environment and Technical Manager, Transpacific)

Guests: Alex Schiavoni, (EHS support), Anthony Lane, (Cardno Lane Piper), Garry Jewel (community), Pam Munro (community)

Observers (TPI): Melinda Lizza – Business Development Manager, Julian Howard – Environment Specialist, Megan Taylor – Head of Reputation and Engagement, James O'Loan – External Affairs

Apologies received: Kim Westcombe, Kaylene Wilson, Lolita Gunning, Alistair Nairn (Advisor - Community & Environmental Partners, EPA Victoria)

Facilitator - Jen Lilburn
Note taker – Andrea Mason

TLCCG
Tullamarine Landfill
Community Consultation Group

Meeting Purpose:

- To provide an update on progress towards rehabilitation of the landfill site and rezoning of the buffer land

Agenda Items and Actions from meeting

Welcome, Jen Lilburn Confirm meeting purpose and agenda, confirm meeting conduct
Progress on actions from last meeting
Summary of LNAPL trial fieldwork and results, Alex Schivoni (EHS support)
TPI Update and next steps, Kieren McDermott (TPI)
Independent review of findings, Anthony Lane (Cardno Lane Piper)
TPI Site Tours Update, Olga Ghiri (TPI) ***Action 100914_1:*** *Olga to update the community on the rezoning process and will let the community know when there is a Council consultation period.*
Questions

About these notes

Notes were taken and produced by Andrea Mason. Presenters were given the opportunity to review the notes relating to their item to ensure the discussion was accurately summarised, and that it details best available knowledge at the time of the meeting. Additional comments received after the meeting have been highlighted as such.

These notes will be posted on the Tullamarine Community Information page on Transpacific's website http://www.transpacific.com.au/content/tullamarine.aspx and will be available to the general public. Meeting participants should advise Andrea Mason or Jen Lilburn if they would like their name removed from this public document.

The intent of these meeting notes is to promote open communication between Transpacific, local government, community and the EPA. They are not to be used in a manner that compromises this objective.

Item 1. Welcome, Jen Lilburn

Jen Lilburn (Convenor) welcomed everyone to the forum including new community members and observers from Transpacific staff. Jen explained her role as independent convenor and confirmed that the meeting conduct guidelines had the group's continued support.

The LNAPL Baildown Testing Report and summary were tabled at the meeting and will be available on the Transpacific website from 11 September, 2014.
As there had been no lead time for the community to read this report, it was agreed that TPI would allow questions to be raised after the meeting and at the November meeting.

Item 2. Progress on actions from May 28 2014

Action 280813_3: *Harry to draft a definition and a set of expectations around the 'engagement' processes between the community, TPI and EPA.* ***Action to be removed***

Action 280813_4: *Harry van Moorst to provide TPI with a request for access to relevant supporting documents.* ***Action to be removed***

Action 260214_1: *Cr Helen Patsikatheodoru, Hume City Council to ask Hume CC if it wishes to be involved in the LNAPL trial monitoring.* ***Complete*** Cr Helen noted that that she had raised the matter with Council who did not take up the offer. As the trial is now finished the Council reserves the right to reassess if there are any new developments.

Action 280514_1: *Olga to update TPI website with final meeting notes from February and March.* ***Complete***
Action 280514_2: *Meeting participants will have one week from the distribution of the draft meeting notes to make comment before the meeting notes are considered finalized and the draft watermark removed. This final version is then to be posted to the TPI website.* ***Complete***

Item 3. Summary of Light Non-Aqueous Phase Liquid (LNAPL) trial fieldwork and results, Alex Schivoni (EHS support)

These notes should be read in conjunction with Alex's presentation and summary report, which can be seen in full in Attachment 1.

Kieran introduced Alex who is a principal hydrogeologist and remediation engineer with extensive experience in the petroleum industry including oil refineries and service stations in Australia, US and Europe.

Alex reported on the LNAPL recovery system design, extraction trial methodology and trial results for the baildown tests undertaken by EHS Support at 13 wells at the Tullamarine closed landfill from 15th May to 16th July 2014. In particular, he explained the methodology and rationale for the key measurements used – the thickness of the LNAPL, pumping rates and its Transmissivity (T) i.e. the rate that LNAPL levels recover in the well after extraction.

The process was reviewed by the Independent Review Panel. Stringent safety and quality assurance measures were undertaken and there were no incidents of vapour or liquid losses. The LNAPL was safely transported and destroyed by the waste receiver.

The data analysis showed that key metrics including the Transmissivity metric (potential LNAPL recovery rate) together with inability to extract from the formation or sustain pumping rates were not met at any location and there was very slow LNAPL recovery to wells (typically > 1 month).

On the basis that no metric was met, EHS Support concluded that the progression to longer term trials is not practical or achievable.

Item 4. TPI Update and next steps, Kieren McDermott (TPI)

These notes should be read in conjunction with Kieren's presentation, which can be seen in full in Attachment 2. The disclaimer at the rear of the presentation document should be noted.

Kieren confirmed that the EHS Support report has shown that the LNAPL fluid extraction is not feasible and that the LNAPL is effectively immobile. Hydraulic containment and skimming techniques have been discounted and other technologies pose a risk to remobilising the LNAPL or damaging the integrity of the landfill cap. Kieren showed an example from the US to illustrate that biodegradation alone will reduce the LNAPL at a similar rate to that of extraction and biodegradation together – supporting the decision to discontinue the extraction at Tullamarine.

The next steps include:

- offering an opportunity for community members to ask questions and seek clarification,
- making the reports available on the community web site,
- extending a period of 6 to 8 weeks from the 15th Sept when the community can ask questions / comment on the reports, and
- offering another opportunity to ask questions at the November meeting
- Proposal for site visits on Thursday 23rd and Saturday 25th October, 2014 (to enhance the community's understanding of the landfill which may assist with question preparation).

TPI also proposes to make EHS and the Independent Review Panel available for questioning. To facilitate this, TPI will organise a meeting during the consultation period so that the community can formulate questions to our experts.

Question: Is it possible to speed up the biodegradation process by introducing more microbes?

Response (Alex, EHS): Where there is a large volume of product the microbial bugs will eat away at the edges. The bugs have been there for a long time and are bred through natural selection to work best in the environment they live. So if you try to increase the numbers of microbes by altering the environment, such as by increasing temperature or moisture, it is possible to adversely change the environment they have got used to over many years and this can have a detrimental effect and actually kill the best performing bugs. Microbes need time to adapt to the environment – it is difficult to manufacture the right balance to get perfect conditions for them, particularly in a mixed waste environment.

Question: Is there any risk of the microbes becoming super bugs with the potential to carry diseases or become a risk to the public?

Response (Kieren, TPI): No. The microbes require a specific underground environment such as an anaerobic (no oxygen) environment to survive and so would die if exposed to oxygen in the near surface environment.

Question: Was the temperature of the landfill measured during the trial? What effect did the cool winter temperature have and would there have been a change if the trial was undertaken in summer?

Response (Alex, EHS): The temperature in the landfill and wells is relatively constant despite the season and is currently around 40 ^{0}C.

Question: If the LNAPL can't be pumped out of the landfill, is there still a risk to the groundwater from it dissolving in the water and what is being done to protect the groundwater?

Response (Kieren, TPI): The risk assessments undertaken in 2007 indicated that the risks to groundwater are low. The network of 100 bores is showing some contamination levels but these are below thresholds for risks to the environment and human health. The findings show that the LNAPL is degrading and therefore the plume will stabilise and reduce over time. Because the landfill is capped the water table won't rise, the leachate level is anticipated to drop slightly and the LNAPL will remain in the waste.

Response (Alex, EHS): Given the length of time the LNAPL has been present, the more soluble components of the LNAPL will have already dissolved and the rate of contribution to leachate will have declined significantly over time.

Question: Has the community already been harmed from exposure in the past and is the potential to cause harm now reduced?

Response (Kieren, TPI): The risks have been demonstrated as being below thresholds for risks to the environment and human health low therefore the risk of harm is also low.

Question: How long does it take for the LNAPL to become carbon black and what are the risks from this? Can the process be accelerated?

Response (Kieren, TPI): It will take approximately 50 years for the LNAPL to turn into something like carbon black which is an inert material i.e. a substance that is stable and reacts very little with the environment and therefore does not pose a risk to the environment.

Response (Alex, EHS): From experience with industrial sites around the world where there have been historic spills and LNAPL is present on shallow groundwater, the LNAPL volume diminishes quickly with fresh products (i.e. recent spills) but then the rate of these mass losses slows over time. In this case at Tullamarine Landfill the product is not fresh, has low solubility and the degradation rate is slowing down. Acceleration of degradation processes used in the industry is generally used on fresh spills such as at service stations when it is still effective. It is not suitable for this situation.

Item 5. Independent review of findings, Anthony Lane (Cardno Lane Piper)

These notes should be read in conjunction with Anthony's presentation, which can be seen in full in Attachment 3.

Anthony provided an overview of the timeline and process undertaken by the Independent Review Panel (IRP) appointed in 2013 to monitor all stages of the LNAPL Extraction Trial. The trial and the appointment of the IRP were undertaken as part of the Liquid Waste Management Plan (LWMP) and the subsequent Post Closure Pollution Abatement Notice (PCPAN) issued by the EPA.

The objectives of the IRP were to conduct independent expert peer review of LNAPL extraction trials to:

- ensure that the trial meets the objectives of the LWMP,
- provide assurances to stakeholders on the technical rigor of the trial, and
- to ensure best industry practice used in LNAPL extraction trial.

The IRP team included four highly qualified experts in this field:

- Anthony P. Lane – Senior Principal / EPA Environmental Auditor
- Peter Gringinger – Principal Hydrogeologist / Auditor Expert Support Team Member (approved by EPA)
- Dr Joseph E. O'Connell – Senior Principal Engineer, Cardno ERI, California
- Prof Randall J. Charbeneau – Jewel McAlister Smith Professor in Engineering, University of Austin, Texas

The summary of IRP review findings for LNAPL removal feasibility is that:

- The IRP agrees with the findings of the trial that this extraction method (which was previously determined to be the most appropriate method), is not a feasible method of extracting LNAPL at this site.
- The IRP is of the view that LNAPL within Tullamarine Landfill is effectively immobile within the waste.
- An LNAPL Extraction Practicability Assessment (addressing all relevant methods) should be prepared, with prior review by the IRP.
- Subject to the outcome of the LNAPL Extraction Practicability Assessment, a decision should be made on the need for the Stage 2 LNAPL Extraction Trials.

Question: Has the EPA reviewed the draft LNAPL Baildown Testing Report? Is the EPA acknowledging the findings and recommendations of the trial?
Response (Jeremy, EPA): The EPA has reviewed the draft LNAPL Baildown Testing Report and is comfortable that the results show the technology being used at this stage is not going to yield viable extraction volumes.

Question: Who appointed the Independent Review Panel?
Response (Anthony, CLP): EPA instructed TPI to appoint an IRP. Anthony Lane put the team together at the request of TPI and the EPA approved the proposed team.

Question: The LNAPL and polychlorinated biphenyls (PCB) are still present in the landfill. What is being done to address these risks to the community?
Response (Alex, EHS): EHS Support was engaged to investigate the technical aspects of removing the LNAPL but the risks associated were dealt with separately.
Response (Kieren, TPI): TPI has engaged Kleinfelder to undertake two reports – one for the technical review of the ground and surface water and the other for the leachate. These reviews will review the last three years of data and show long terms trends in surface water and groundwater. They are being undertaken now and will then be reviewed by the auditor. It is hoped that these will be available by the November meeting. These reports will add to the risk assessments of 2007 and the more recent bore monitoring and will address the question of the risks to the community.

Question: Why have the consultants being used changed from URS to EHS? Did URS submit any reports?
Response (Alex, EHS): Alex used to work with URS then came to EHS recently.
Response (Kieren, TPI): The reason for the change was because the consultants offer different expertise. URS are design engineers and were required in the design stages of the trial. EHS are remediation engineers and were engaged for the implementation of the trial. URS did not submit any other reports.

Question: What evidence is there that the 60 million litres (ML) of LNAPL in the ground becomes inert and safe when it changes to carbon black? Can you confirm that without extracting and testing it from the site?
Response (Alex, EHS): The recoverable volume of LNAPL is estimated to be approx. 7ML total based on our trials and the URS model.
Response (Kieren, TPI): The science is based on other world experience that shows carbon black is inert and safe.

Question: Why isn't TPI attempting to extract as much of the 7ML of LNAPL as possible - even if it is slow and 'not practicable', to reduce the volume and speed up the biodegradation process?
Response (Kieren, TPI): The trial showed that for most of the bore holes only a few litres were extracted over 2 months which is extremely low.
Response (Alex, EHS): The revised recoverable volumes are probably even more conservative than estimated and significantly less if pumping is used. To continue the extraction at these rates would require the storage tanks to stay above ground on the landfill for longer increasing the risks of leakage or spills. One of the criteria for the process was to avoid storage of LNAPL on site.
Response (Kieren, TPI): EHS will be undertaking further assessments as part of the practicability assessment to look at other technologies that may be used and will assess the LNAPL mass losses. TPI could consider testing to see if the LNAPL is turning into inert material and measure the microbial activity in the site.

Question: Why wasn't the trial undertaken over 12 months to monitor changes over different seasons and temperatures?
Response (Alex, EHS): The temperature within the waste material at depth remains relatively constant. Temperature data collected during routine monitoring will be evaluated in the EHS practicability assessment.

Question: Can the wells (particularly well L1) be assessed periodically e.g. over 1 - 2 years to see if there are any changes to the state of the LNAPL and if there are any changes in transmissivity and viscosity given that there are possibly some drums of LNAPL still in the landfill that may not have corroded and spilt yet?
Response (Alex, EHS): During the trial well L1 was retested after 1 month, which was considered enough time to re- measure the transmissivity. The second test showed a significant decline in pumping rates.
Response (Kieren, TPI): Based on the available LNAPL science available the rate will continue to decrease.

Question: Is the LNAPL science based on deeper oil wells and is it relevant to the shallow landfill at Tullamarine? What difference does the depth make to the extraction rates?
Response (Alex, EHS): The reference material and techniques used were based on shallow extractions such as leaking pipes at oil refineries at 5 – 10 metres. Extraction at shallow depths is more straight-forward than the deeper oil wells.

Question: Has any testing been done to determine if there are any microbes onsite and how many do you need for successful biodegradation?
Response (Alex, EHS): Petroleum hydrocarbons degrade naturally. The EHS Support studies have focussed on the hydrogeological aspects of the trial. We have not measured the microbial activity however this aspect will be considered as part of the practicability assessment.

Item 6. TPI Site Tours Update, Olga Ghiri (TPI)

Transpacific invited TLCCG participants to attend the **Tullamarine Landfill site tours** proposed for **Thursday 23rd October or Saturday 25th October, 10am -11am followed by lunch.**
The invitation is open to this group as a priority and other community members but they must RSVP to Olga as each tour will have limited numbers. TPI will consider hosting more days if there is a need. The purpose of the tours is to show the landfill site and to allow further time for discussion regarding any issues that may have arisen from the LNAPL Baildown Testing Report.

A Q&A information sheet regarding the baildown tests was distributed and further questions or feedback were welcomed. This Q&A is also available from the TPI website.

Question: Is TPI aware of the motorbikes driving around on the buffer zone?
Response (Kieren, TPI): TPI has increased security to discourage the motorbikes. We are also aware of cars being dumped on neighbouring properties.

Question: Will there be any updates on the new rezoning proposal?
Response (Olga, TPI): TPI is meeting with Hume City Council this month to lodge a new application for a Comprehensive Development Zone which will provide council with better controls and monitoring of traffic management and bore monitoring. Objections will be sought by HumeCC.

Action 100914_1: *Olga to update the community on the rezoning process and will let the community know when there is a Council consultation period.*

Meeting closed 8.40pm

After the meeting several questions were submitted to TPI for a response. These can be seen in Appendix 1 below.

TLCCG
Tullamarine Landfill
Community Consultation Group

Appendix 1. Questions raised by Graeme Hodgson following the TLCCG meeting 10 September 2014, regarding the findings of the LNAPL trial program. Responses by TPI.

Q. What was the outcome of the destruction trials at the Laverton facility?

Sterihealth have confirmed the destruction was successful in that all LNAPL was completely destroyed in their high temperature incinerator.

Q. How many litres were destroyed?

A total of 2,111 litres of LNAPL extracted from the leachate wells was destroyed at the Sterihealth facility.

Q. What was the composition of the LNAPL from each of the wells?

The LNAPL composition is presented in *Table 1* on the last page.

Q. Was the LNAPL from each of the wells destroyed separately?

No. The LNAPL was combined into a single 1,000 litre double skinned tank and so the LNAPL from the wells was combined.

Q. If so, what difficulties in the destruction process did the different compositions (if any) pose and how were they overcome?

No difficulties were encountered with destruction of the LNAPL.

Q. Will the proposed LNAPL Extraction Practicability Assessment include methods of lowering the viscosity of the LNAPL so that it can be readily extracted?

Yes. The methods for lowering viscosity such as introducing heat, solvents and moisture have already been reviewed as part of a technology options assessment completed by URS in 2011. These were discounted due to potential impact to cap integrity and potential to mobilise contamination.

As a final check EHS will, as part of their practicability assessment, revisit the URS assessment in the light of the results from the trial and also in the light of the potential for any new technologies that might have been developed and approved by international regulatory bodies and the EPA since 2011.

Q. What was the viscosity of the LNAPL extracted from each well? In addition to the technical details please explain it in comparison to light sewing machine oil through to axle grease.

The LNAPL viscosities are presented in the *Table 2* below, together with a comparison with natural oil product.

Table 2 : LNAPL Viscosity and description relative to natural oil product

	LNAPL Viscosity at 20°C (cSt)	Natural Product Description
L1	>110	More viscous than olive oil
L2	190	
L3	120	
L4	690	More viscous than glycerine
L5	760	
L6	>160	More viscous than olive oil
L7	>140	
L8	>180	
L9	>110	
L10	>1,000	More viscous than castor oil
L11	160	More viscous than olive oil
L12	>130	
L13	260	
L14	>170	
Relative viscosities : Water / Fuel = 1 cSt @ 20 degrees		
Heating Oil = 10 cSt @ 20 degrees		
Olive Oil = 100 cSt @ 20 degrees		
Glycerine = 600 cSt@ 20 degrees		
Castor Oil = 1,000 cSt@ 20 degrees		
Honey = 10,000 cSt @ 20 degrees		
Molasses = 50,000 cSt @ 20 degrees		
Source	http://www.engineersedge.com/fluid_flow/fluid_data.htm	

Table 1 : Percentage Composition of LNAPL (Main Constituents % w/w)

Leachate Well	Total Petroleum Hydrocarbon* (%)	Benzene (%)	Naphthalene (%)	Cr (%)	Pb (%)	Hg(%)	Ni (%)	HACs (%)	PCBs (%)	BaP (%)	PAH Total (%)
L1	76.0%	0.004%	0.88%	0.006%	nd	nd	nd	0.015%	0.023%	nd	0.151%
L2	65.0%	0.002%	3.90%	0.005%	nd	nd	nd	0.014%	0.010%	0.007%	0.304%
L3	67.0%	0.006%	0.47%	0.007%	nd	nd	nd	0.052%	0.008%	nd	0.045%
L4	59.0%	0.005%	0.18%	0.008%	nd	nd	nd	0.024%	0.005%	nd	0.038%
L5	24.0%	0.001%	0.21%	0.025%	0.001%	nd	0.001%	0.007%	0.001%	nd	0.036%
L7	67.0%	0.004%	nd	0.005%	nd	nd	nd	0.013%	0.005%	nd	0.000%
L8	75.0%	0.006%	0.52%	0.006%	nd	nd	nd	0.025%	0.007%	nd	0.091%
L9	73.0%	0.004%	0.31%	0.003%	nd	nd	nd	0.015%	0.014%	nd	0.093%
L10	31.0%	0.002%	0.06%	0.008%	nd	nd	nd	0.008%	0.002%	nd	0.003%
L11	45.0%	0.004%	0.46%	0.005%	0.001%	nd	nd	0.188%	0.002%	nd	0.049%
L12	76.0%	0.005%	nd	0.010%	0.001%	nd	0.000%	0.041%	0.010%	nd	0.000%
L13	66.0%	0.003%	0.27%	0.018%	nd	nd	nd	0.013%	0.010%	nd	0.070%
L14	67.0%	0.025%	0.36%	0.011%	0.001%	nd	nd	0.010%	0.007%	nd	0.052%
Notes :											
BaP = benzo a pyrene											
Cr = chromium											

HAC = halogenated aromatic compounds (total of 1,2 dichlorobenezene, 1,3 dichlorobenezene 1,4 dichlorobenezene, chlorobenzene)
Hg = Mercury
nd = not detected
Ni = nickel
PAH = poly aromatic hydrocarbons
Pb = lead
PCBs = poly chlorinated byphenyls
*Total Petroleum Hydrocarbons = petroleum oils with carbon chains C6 to C36
w/w = weight for weight

TULLAMARINE LANDFILL COMMUNITY MEETING

26 Nov, 2014 **6:30pm for 7:00 – 8:30 pm**

Mantra Hotel, Cnr Melrose Drive & Trade Park Drive, Tullamarine

---

Attendees

Community: Kim Westcombe, Julie Law, Helen van den Berg, Jos van den Berg, Graeme Hodgson, Russell Nilsson, Ovi Clements, Frank Rivoli, Harry van Moorst

EPA: Jeremy Settle (Senior Environment Protection Officer, EPA Victoria), Alistair Nairn (Advisor - Community & Environmental Partners)

Transpacific: Clete Elms (Regional Manager Vic Post Collections), Kieren McDermott (Environment Specialist), Olga Ghiri (Stakeholder and Community Relations Manager), Alan O'Brien (Environment and Technical Manager), Bruno Pronesti (Finance Business Partner)

Guests: Alex Schiavoni, (EHS support), Anthony Lane, (Cardno Lane Piper)

Apologies received: Peter Barbetti, Sam Cetrola, Cr Helen Patsikatheodoru, Lolita Gunning, Prue Hicks, Kaylene Wilson, Jeremy Hearne

Facilitator - Jen Lilburn
Note taker – Andrea Mason

About these notes

Notes were taken and produced by Andrea Mason. Presenters were given the opportunity to review the notes relating to their item to ensure the discussion was accurately summarised, and that it details best available knowledge at the time of the meeting. Additional comments received after the meeting have been highlighted as such.

These notes will be posted on the Tullamarine Community Information page on Transpacific's website http://www.transpacific.com.au/content/tullamarine.aspx and will be available to the general public. Meeting participants should advise Andrea Mason or Jen Lilburn if they would like their name removed from this public document.

The intent of these meeting notes is to promote open communication between Transpacific, local government, community and the EPA. They are not to be used in a manner that compromises this objective.

TLCCG
Tullamarine Landfill
Community Consultation Group

Meeting Purpose:

- To provide an update on progress towards rehabilitation of the landfill site and rezoning of the buffer land

Agenda Items and Actions from meeting

Arrival, Catch up, Light Refreshments
Welcome, Jen Lilburn Apologies, Confirm meeting purpose and agenda, confirm meeting conduct Progress on actions ***Action 100914_1:*** *Olga to update the community on the rezoning process and will let the community know when there is a Council consultation period.* There has been no further development but Olga will provide an update when appropriate.
Clarity of Ground Rules, Clete Elms ***Action 261114_1:*** *Helen and Clete to discuss Helen's role on community radio.* ***Action 261114_2:*** *Helen, Harry, Graeme and Olga to review the TTTDAG website and Facebook and update information as appropriate.* ***Action 261114_3:*** *Andrea to supply the TLCCG purpose to Graeme for the TTTDAG website.*
Feedback on the Field Trip, Julie Law and Graeme Hodgson
Update on progress of Tullamarine tasks and LNAPL report, Kieren McDermott
Questions regarding LNAPL destruction ***Action 261114_4:*** *Olga to set up a technical meeting regarding the Practicability Assessment during February 2015.*
Buffer land rezoning update, Olga Ghiri ***Action 100914_1:*** *Olga to update the community on the rezoning process and will let the community know when there is a Council consultation period.* ***Action 261114_5:*** *Olga to advise TPI of the frustrations the community is experiencing regarding this process of simultaneously addressing the rezoning applications and issues associated with LNAPL destruction. The community requests that the LNAPL issues be addressed before the rezoning process is continued.*
The year (and a half) in review
Date and locations of 2015 meetings

Item 1. Welcome, Jen Lilburn

Jen Lilburn (Convenor) welcomed everyone to the forum. Jen explained her role as independent convenor and confirmed that the meeting conduct guidelines had the group's continued support.

Action 100914_1: *Olga to update the community on the rezoning process and will let the community know when there is a Council consultation period.*
There has been no further development but Olga will provide an update when appropriate.

Item 2. Clarity of Ground Rules, Clete Elms (TPI)

Clete spoke of the ongoing commitment from Transpacific to the purpose of TLCCG and the agreed meeting conduct. He stressed that TPI has undertaken to provide information and engage with the community in a transparent and cooperative manner in the past 12 months.

He expressed his concern that outside the TLCCG meetings, there are examples where information from this forum has been misrepresented, not referred to, or where other information that lacks the integrity of that offered in this forum has been used.

He commented that this situation undermines the relationship that this forum has been fostering.

Discussion that followed included:

- Confirmation that any incidents of misrepresentation occurring were not intentional.
- The community reserves the right to make comment on issues where there is still disagreement.
- Clete is not trying to stifle TLCCG members from speaking publicly – but wanted to ensure that factual, current information is used.
- The TTTDAG website and Facebook currently contains some historical information that should be reviewed.
- The capacity for updating information on the community platforms is limited by their IT skills.
- Outdated images being used can be replaced by new images supplied from TPI.
- A stronger message to the public highlighting the progress being made through the TLCCG forum and the availability of the meeting notes to the public would be beneficial.
- Add the TLCCG forum purpose to the TTTDAG website with links to the meeting notes.

It was agreed that the ground rules are still relevant for the TLCCG forum and that TPI and the community are still committed to these.

Action 261114_1: *Helen and Clete to discuss the recent community radio interview.*

Action 261114_2: *Helen, Harry, Graeme and Olga to review the TTTDAG website and Facebook and update information as appropriate.*

Action 261114_3: *Andrea to supply the TLCCG purpose to Graeme for the TTTDAG website.*

Item 3. Feedback on the Landfill Field Trip, Julie Law and Graeme Hodgson (community)

Julie and Graeme provided very positive reports following a recent tour of the landfill hosted by Kieren. They commented on:

- The marked improvement since a previous trip 15 years ago when chemical odours were intolerable and the creek was full of dumped material. .
- How the grassed areas of the landfill cap are well established, irrigated and lush.
- The improvement to the amenity and environment on the north face of the quarry as the revegetation has established with good survival rates – will look really good in 20 years.

- The excellent species list used in the revegetation and the improvement to the creek.
- Thank you to Kieren for explaining the operations of the treatment plants, the gas collection point, the flare and for answering any questions readily.
- There were no visible cracks in the landfill surface cap.
- There is enough gas being generated to run the flare in the long term.

Question: Will the flare remain on site in the long term?
Response (Kieren, TPI): Yes

Question: Is the 900^{o}C exit temperature of the flare sufficient to destroy the gases?
Response (Clete, TPI): It is but further stack testing will confirm the results.
Kieren reconfirmed that TPI has an open door policy and can organise a further landfill site tour on request.

Item 4. Update on progress of Tullamarine tasks and LNAPL report, Kieren McDermott (TPI)
These notes should be read in conjunction with Kieren's presentation which can be seen in full in Attachment 1 and the US EPA fact sheet Attachment 2. The disclaimer at the rear of the presentation document should be noted.

Kieren gave an overview of the progress to date on the Post Closure Management Plan for the Tullamarine landfill, key dates for 2015 and planned tasks.

> Light Non-Aqueous Phase Liquid (LNAPL) Trial Practicability Assessment (March 2015)

> Groundwater technical review (March 2015)

> Groundwater management plan update (March 2015)

> Landfill Gas Audit (September 2015)

> Stormwater Connection (Construction to Commence Summer 2014/15)

> Landfill maintenance (mainly mowing - ongoing)

> Ongoing monitoring (landfill gas, groundwater)

> Consultation (workshop & questions Nov 26 2014)

> Special meeting with EHS Support & Anthony Lane (mid February 2015)

> Practicability Assessment Report (Issued March 2015)

> The Practicability Assessment Report will include consultation process and responses to questions from community.

<u>Community questions and feedback timetable</u>

- > Mid Nov — Round 1 Questions received
- > 26 November — Questions and Responses tabled at TLCCG forum
- > 5 December — Round 2 Questions deadline
- > End January — TPI to supply responses to Round 2 questions
- > 13 February — Round 3 Questions deadline
- > March 25 — TPI to supply responses to Round 3 questions at TLCCG forum
- > March 31 — TPI/EHS report to EPA due then review by Panel

Kieren included information to help address some of the questions that have been raised by the community, including why the LNAPL extraction is so difficult and considered to be not feasible, the expected processes for the biodegradation of the LNAPL and its conversion to something like black carbon.

He also gave a summary of the technology options that had been reviewed for the LNAPL extraction and the suite of technologies that are currently employed at the landfill including the landfill cap, hydraulic control, gas collection and emissions flaring, groundwater and landfill gas monitoring plus natural attenuation.

<u>LNAPL, biodegradation and natural attenuation processes</u>

Kieren explained that the mobility of the LNAPL will have decreased significantly since it was last injected into the landfill 27 years ago. Biodegradation alone is almost as effective as coupling it with extraction, however further extraction has the potential to cause greater harm because of the potential exposure to workers involved with extracting the LNAPL together with inherent risks associated with the transport of the LNAPL to destruction facilities.

Monitored natural attenuation is a term used in the US EPA document to describe the use of natural processes for remediation. At Tullamarine this includes anaerobic biodegradation, the sorption or binding of the LNAPL to clay particles and the gas collection system. The biodegradation occurs over time with the LNAPL binding to the clay particles, increasing the rate of decay around the edges of the plume and making it more difficult to extract.

The current polychlorinated biphenyl chemical (PCB) levels in the LNAPL (25 m below ground surface) are on average 100mg/kg. PCBs have a degradation half-life of 9 years and the concentration would be expected to degrade to below soil guideline levels (50 mg/kg) within 10 – 20 years in the anaerobic (no oxygen) conditions in the soil.

LNAPL at Tullamarine is more complex than a “standard petroleum site”. Overall, the reliance on natural degradation process is not considered an ideal nor the preferred method (preference would ideally be for techniques that worked more rapidly) to address LNAPL. However, in light of the trial results, which indicate the impracticability of LNAPL recovery and lack of available alternate and more practical approaches, the use of natural degradation under monitored conditions presents an opportunity for safe, low risk, mass reduction over time. The positive side of relying on natural degradation is that the approach does not require manual handling and consequently results in significant risk reduction regarding potential exposures (for workers and community alike) and risks of uncontrolled releases to the environment.

More technical detail will be provided by Alex Schiavoni (EHS Support) in his Practicability Assessment Report to the auditor. It was noted that the questions from the community will be used to further inform this report.

Item 5. Questions regarding LNAPL destruction from the community.

All questions submitted to TPI before December 5 from the Terminate Tulla Toxic Dump Action Group (TTTDAG), Western Region Environment Centre (WREC) and the community will be addressed in the Round 2 response from TPI by the end of January 2015. This will be distributed at that time.

Question: According to the US EPA fact sheet referenced in your presentation it states that "*Natural attenuation is not expected to remediate NAPL*". Why didn't you quote this in your presentation as part of the whole story?

Response (Alex, EHS): The US EPA fact sheet was written in 1999. Whilst the key definitions and concepts presented in the document are still considered accurate, the understanding of LNAPL behaviour has advanced significantly specifically in relation to natural source zone depletion (specifically that LNAPL constituents naturally depleted from the LNAPL body over time by volatilization, dissolution, absorption and, degradation). More recent guidance documents are available, in particular - [(Interstate Technology & Regulatory Council). 2009. *Evaluating Natural Source Zone Depletion at Sites with LNAPL*. LNAPL-1. Washington, D.C.: Interstate Technology & Regulatory Council, LNAPLs Team. www.itrcweb.org.] which specifically addresses the degradation of LNAPL. EHS Support considers that source zone depletion of LNAPL is relevant for the site and will explore the concepts in the Practicability Assessment Report.

Response (Kieren, TPI): The remediation approach being undertaken is not ideal but the trials have shown that we can't easily extract the LNAPL. However, we are not just relying on attenuation but have other technologies being utilised such as the vacuum applied to the landfill to operate the flare and the landfill cap. The vacuum assists by helping to evaporate lighter compounds in the LNAPL (via the movement of air across the LNAPL) and the cap assists by reducing the amount of infiltration through the waste, reducing the leachate levels and risk of migration towards the creek.

Question, Jen: How do you explain the disparity in information regarding the treatment of the LNAPL from TPI and the US EPA document?

Response (Alex, EHS): TPI information includes references to more recent documents than the US EPA fact sheet and in particular the document referenced above. The process is now relatively well understood. The rates of degradation are slower in LNAPL than in a dissolved phase with biodegradation primarily occurring at the edges of LNAPL rather than the plume centre. It is considered that source zone depletion of LNAPL is relevant for the site.

Comment: **Some of the references are older than 10 years. It would be helpful if the publication date was quoted to prevent further confusion.**

Comment, Jen: There is still a need to explain the latest research to provide assurance to the community that decisions are based on the latest information available.

Response (Alex, EHS): The Practicability Assessment Report will present the latest understandings and provide robust answers to why we think it will work.

Question: If the biodegradation only works on the edges of the LNAPL mound, what happens to the thicker part and what will make it disappear?

Response (Alex, EHS): Degradation of the LNAPL will start at the edges and work its way to the thicker parts of the LNAPL over time. The LNAPL at Tullamarine is partially submerged and not continuous across the entire landfill which means there is an increased surface area for microbes. We still need to quantify the time required for this process to be successful.

Question: Can you explain the difference in the rate of degradation by the microbes given that the LNAPL on this site is stale and contaminated? Why do you think it will be eaten by the microbes and what happens in the future if they fail? Monitoring will be essential as there are still so many unknowns and it is a unique site. It must be stabilised to convince the community that it is safe.

Response (Alex, EHS): Degradation of the LNAPL will occur in both fresh and weathered LNAPL but the difference relates to its rate of degradation – weathered is degraded much more slowly. There is literature and practical evidence available that indicates microbial degradation will serve to reduce the LNAPL mass. Monitoring for natural attenuation is critical and is being and will continue to be undertaken as part of the longer term management measures.

Response (Kieren, TPI): TPI reviews the monitoring every 3 years through its technical review and is committed to this in the foreseeable future. There will be an update at the next TLCCG meeting.

Response (Alex, EHS): The breakdown of the contaminated LNAPL on this site is more complex than normal LNAPL and more research is required to show what the process will look like. Biodegradation is not the only process being used at the site. This information will be included in the EHS Support report.

Amendment to draft notes received from Graham:

The community does not accept that the LNAPL should be allowed to remain in the dump in the hope it will eventually biodegrade. It is imperative that the LNAPL be removed no matter how small the quantity or the length of time it takes. Every litre removed is one less litre that can enter the groundwater.

Question: What impact does the gas extraction have on the LNAPL?

Response (Alex, EHS): The gas removal reduces the more volatile components of the LNAPL which typically are the more soluble components leaving the LNAPL in a more passive form which assists the process overall. This occurs via the passing of air over the LNAPL which occurs during gas extraction.

Question: The LNAPL report showed that the L1 well refilled quite quickly. Why can't you continue to extract from L1 for as long as possible to reduce the amount of LNAPL and speed up the biodegradation process?

Response (Alex, EHS): The LNAPL trial showed that there is limited opportunity to recover a reasonable portion of the LNAPL and it is not feasible to remove every drop. Residual unrecoverable LNAPL will remain consistent with worldwide experience at LNAPL sites. There is also the potential risk of decreasing the stability of the LNAPL if more action is taken by more active methods which serve to mobilise the LNAPL (for example surfactant flushing and similar technologies). Whilst some technologies can mobilise the LNAPL, the clear risk is associated with uncontrolled migration which is not currently occurring at the site with the LNAPL effectively contained. Further research is required to evaluate if the process can be accelerated and if it can improve the time period. This information will be included in the EHS Support report.

Question: Is there any new information or research into new technologies for best practice across the world?

Response (Alex, EHS): The technology assessment was undertaken in 2011 but technology is constantly changing so we will be revisiting this to look for any technology improvements as part of the Practicability Assessment Report.

Response (Clete, TPI): TPI will endeavour to provide answers to explain the degradation processes regarding the LNAPL mound and the surface area of the edges of the LNAPL, the estimated time required and the risks of undertaking any further extractions.

Question: I don't believe that the data shows the LNAPL to be immobile as stated in the documents provided. In the LNAPL trial an 80% recovery rate was measured. Why isn't a 30% recovery rate enough for extraction particularly from well L1?

Response (Alex, EHS): To clarify, 80% recovery relates simply to both the minimum requirement of LNAPL extraction from a well for test initiation as well as the 80% return of LNAPL of wells to signify the end of the test. In essence, the 80% reflects trial operational parameters that were set to ensure that the tests were conducted appropriately and to enable accurate data analysis. It is not the reason that extraction is not considered feasible. The reason why extraction is not considered reasonable is because (i) transmissivity values (the rate of inflow into the well) calculated where below thresholds used internationally, (ii) the volumes extracted were very low and in fact in all wells except L1 yielded less than 50 litres and mostly represented volumes of LNAPL stored in the well rather than the surrounding formation and so indicate very little movement of LNAPL into the extraction wells, (iii) the volume was fully removed from the wells within 2 hrs and (iv) removing relatively small volumes appears to have relatively little benefit and does not serve to change apparent risk profiles yet potentially exposes workers (and the community) to the LNAPL.

Question: The assumptions underpinning the transmissivity scoring in the LNAPL report do not appear to be supported. TPI has not shown that the LNAPL is totally immobile and some community members believe that the LNAPL could be extracted from L1. Why has TPI ruled out all other options than biodegradation?

Question (Jen): Is it the intention of the report or a perception of the report that other options have been ruled out?

Response (Alex, EHS): The term biodegradation was not used in the report, but has been discussed in the responses to the questions posed. The report essentially only indicated that the extraction option available did not prove to be feasible. Biodegradation was not chosen as a method but as it is already happening it is providing a service where other options have proven to be not viable and warrants consideration. The trial report itself was focussed on the outcomes of the trial only and did not provide commentary on suitability of other options. It is the role of the Practicability Assessment Report to address these issues in the context of the trial outcomes.

Question: How much extraction of LNAPL could be done if attempted?

Response (Alex, EHS): We believe that the method used in the LNAPL trial using the three elements of assessment, transmissivity, the ability to pump and the sustained LNAPL pumping rates, didn't show that it is feasible to undertake further extractions. EHS Support believes that the trial showed that we have approached the point of practicability with only volumes stored in wells essentially available for extraction, representing an insignificant percentage of apparent LNAPL volumes within the landfill.

TPI Response post meeting: All leachate sumps except one yielded less than 50 litres during the trial. The trial has effectively demonstrated that on average less than 50 litres per sump could be extracted per pumping event.

Question: Can you define practicability - at what point do the overseas studies indicate that it is viable or not? There is a big difference between the Tullamarine site and overseas sites. Other non-scientific factors need to be taken into account other than transmissivity, such as the size of the contamination, economic viability and socioeconomic values of the community.

Response (Alex, EHS): The information used is based on many international studies and universally accepted standards. Transmissivity when used as a metric normalises the differences/complexities between different sites and as such is considered a suitable metric for essentially any site based solely on technical practicability. It is important to note that transmissivity was not the only metric utilised to assess practicability. Other considerations, such as socioeconomic values of the community become important from the point of view of net benefit analysis, which is being undertaken as part of the Practicability Assessment. In the context of the net benefit analysis, the values of the community are considered to be very important and will be weighted accordingly.

Response (Anthony, Cardno): It is important that there is an agreed goal and set of parameters established to help make decisions. Any remediation project should have goals relating to protecting the environment and community health as a minimum. An assessment of unacceptable risks should be undertaken and a decision to proceed should be made if it is possible to do so. For this site the guidelines are based around the cleaning of the groundwater contamination to the extent that is practicable.

Question: Is there a need to rethink what is practicable? Shouldn't the community have a right to take part in that judgement? Can we be involved in preparation of the Practicability Report?

Response (Alex, EHS): The Practicability Assessment Report will undertake a net benefit analysis of whether the LNAPL can be removed and any consequences. A robust assessment will take into account many factors including community concerns, economic factors, potential impacts on the environment and potential risks. The draft report will address as many questions as possible in the early stages before it is released to the community for comment. It is important to note that the Trial Report was focused only on technical practicability which is based on accepted scientific principals and experience drawn from remediation projects across the world.

Comments: It would be beneficial if TPI and the community can continue to work together to have input and discussions. It would also be beneficial to produce reports that have community input and use language that is more community friendly to increase the level of understanding in the future.

Response (Clete, TPI): TPI is happy to answer technical questions outside this forum and has committed to answering the questions from the community according to the agreed timetable. Further discussions may take place once the questions have been answered in February.

Action 261114_4: *Olga to set up a technical meeting regarding the Practicability Assessment during February 2015.*

Question: What is the role of the EPA as regulator in informing the community of the processes that they expect to happen and what they think is acceptable. How can the EPA involve the community in discussions with TPI?

Response (Alistair, EPA): The EPA will get the Practicability Report when it is completed and then review it. Discussions with the community that help everyone understand their concerns and formulate a clear and appropriate response will be beneficial. The EPA will then make a final decision. It is reasonable for the EPA to provide their rationale regarding any decisions related to the outcomes of the report to the community. This information can then be used by the community to ask more questions of TPI if necessary.

Response (Jeremy, EPA): The EPA must work within the legislative framework of the EP Act, SEPPs (State Environmental Protection Policy) and regulations. Any assessment of the report will take into account issues such as any ongoing risks to the environment or community but can only go as far as the legislation allows.

Item 6. Buffer land rezoning update, Olga Ghiri (TPI)

Olga provided an information sheet (see **Attachment 3**) regarding the rezoning application by TPI for the buffer land.

The application is still being assessed by Hume City Council and not yet available for public comment. It is expected that there will be 28 days for comment.

Action 100914_1: *Olga to update the community on the rezoning process and will let the community know when there is a Council consultation period.*

Comment: The community is finding it very stressful to address the buffer land issue when the issue regarding the degradation of the LNAPL is still not resolved. The representatives at the TLCCG forum are under a lot of pressure to supply answers and hope to their relevant communities who are still not assured of their safety in the future.

Action 261114_5: *Olga to advise TPI of the frustrations the community is experiencing regarding this process of simultaneously addressing the rezoning applications and issues associated with LNAPL destruction. The community requests that the LNAPL issues be addressed before the rezoning process is continued.*

Comment: It is a general concern that the Tullamarine buffer land will lost from the community as industry development progresses. This has happened before in the area and there is little open space left. The rezoning should be attached to the final outcomes.

Item 7. The year (and a half) in review (Jen)

Jen postponed the review questions and will provide an online survey instead to gauge how participants are feeling with regard to the success of the TLCCG forum.

She did ask everyone: ***"How worthwhile are these meetings?"***

Comment: Tonight's discussion laid the foundation for where we can go next year. We appreciate the professional advice from TPI and others received at the meetings. The community still has some concerns but now has more of an understanding. Working together in making decisions is much more beneficial. Both parties are now listening to each other and TPI is accepting input from the community which we appreciate.

It was agreed that there is a role for this group next year.

Item 8. Date and locations of 2015 meetings

A discussion on the frequency of meetings for 2015 included:

- Frequency needs to reflect key events or actions happening on the site
- Ensuring the meetings are often enough that corporate memory isn't lost
- There are key reports due to be finalised in March 2015
- There is a focussed, technical meeting scheduled in February 2015
- The Post Closure PAN report is due in the middle of the year.

The next meeting is scheduled for March 25 2015.

Meeting closed: 9pm

The attachments will be available on the Transpacific website,
http://www.transpacific.com.au/content/community-meetings.aspx?navId=289

Attachment 1. Kieren McDermott TPI presentation

Attachment 2. US EPA Fact sheet

Attachment 3. Rezoning Fact sheet

TLCCG
Tullamarine Landfill Community Consultation Group

***OUR PURPOSE:** to foster collaboration between the community, Transpacific and EPA Victoria, and ensure community concerns and aspirations regarding the closed Tullamarine Landfill and adjoining land form part of the decision making process.*

NOVEMBER 2014 MEETING SNAPSHOTS

Principles for the conduct of our meetings were discussed and confirmed.

TLCCG members who had taken part in the recent field trip of the Landfill site reported on their experience. They stated that the site in general, and in particular the environment on the north face of the landfill, was significantly improved since their last visit some years before.

Kieren McDermott (Transpacific Environment Specialist) gave an overview of the progress to date on the Post Closure Management Plan for the landfill, key dates for 2015 and planned tasks:

- Stormwater Connection (Construction to Commence Summer 2014/15)
- Light Non-Aqueous Phase Liquid (LNAPL) Trial Practicability Assessment (March 2015)
- Groundwater technical review (March 2015)
- Groundwater management plan update (March 2015)
- Landfill Gas Audit (September 2015)
- Landfill maintenance (mainly mowing - ongoing)
- Ongoing monitoring (landfill gas, groundwater)
- Practicability Assessment Report (Issued March 2015)

The purpose of the Practicability Assessment Report is to report on the trial extraction of LNAPL, and advise whether it is practical to attempt to remove all of the LNAPL from below the landfill. The report will be presented to EPA Victoria, and will include a summary of the consultation process and responses to all questions received from the community.

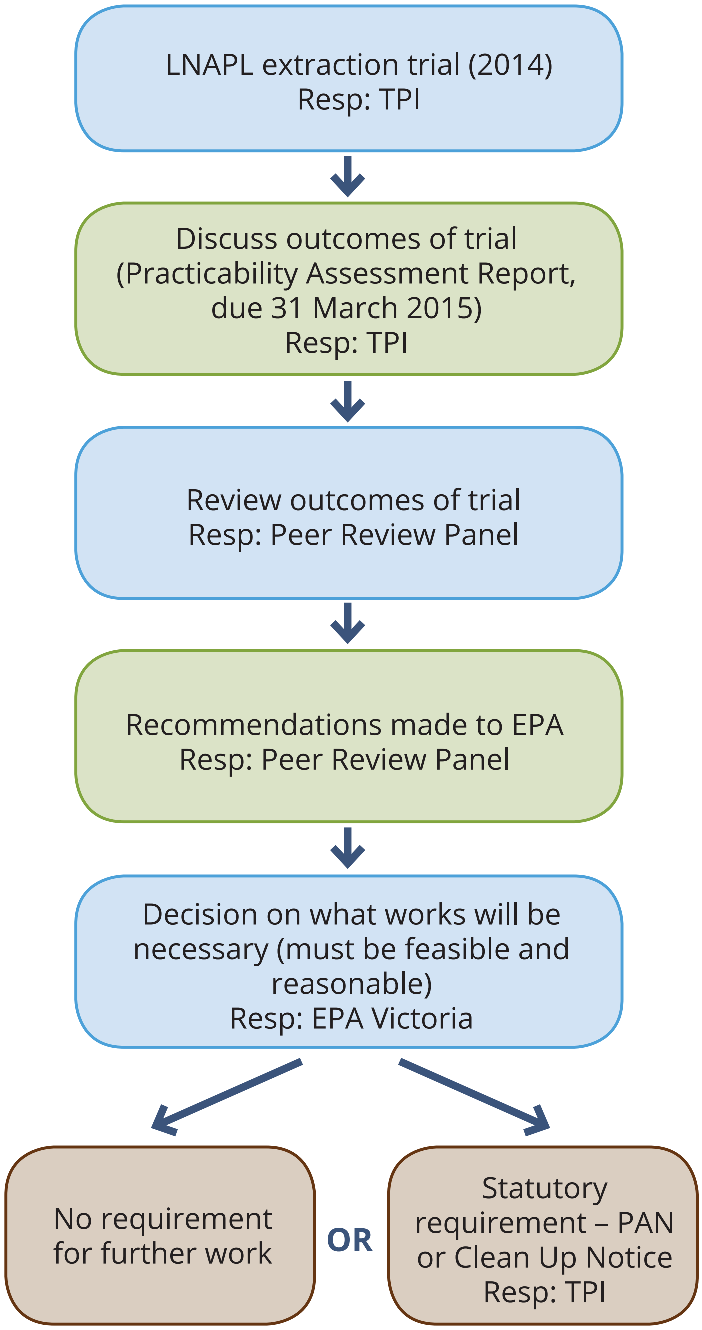
Some members of TLCCG expressed concern about the preliminary findings that it is not practicable to continue with LNAPL extraction. TPI and consultants EHS Support advised that the LNAPL is too viscous for extraction, and that it will break down via microbes over the next 50 years. This will be supported by extraction of gases, which will reduce the volatile components of the LNAPL. Community members reiterated that all of the LNAPL should be removed.

Community members stated that it would be beneficial if TPI and the community can continue to work together to have input and discussions. It would also be beneficial to produce reports that have community input and use language that is more community friendly to increase the level of understanding in the future.

Community questions are informing the Practicability Assessment Report, and the following timeline for TLCCG input was discussed:

- Mid Nov — Round 1 Questions received
- 26 November — Questions and Responses tabled at TLCCG forum
- 5 December — Round 2 Questions deadline
- End January — TPI to supply responses to Round 2 questions
- 13 February — Round 3 Questions deadline
- 19 February — Special (technical) TLCCG meeting with EHS Support & Anthony Lane
- 25 March — TPI to supply responses to Round 3 questions at TLCCG forum
- 31 March — TPI/EHS report to EPA due then review by Panel

Trial LNAPL extraction process



Olga Ghiri (Transpacific Stakeholder and Community Relations Manager) gave an update on the rezoning application by TPI for the buffer land. She said that it is still being assessed by Hume City Council and not yet available for public comment. It is expected that there will be 28 days for comment.

Community members expressed significant concern about the timing of the application, and that it should occur after the issues associated with LNAPL extraction/degradation are resolved. Olga committed to take these comments back to TPI.

NEXT MEETINGS:

19 February 2015 - Focussed, technical meeting regarding LNAPL

25 March 2015 – Next TLCCG meeting

See the meeting notes at www.transpacific.com.au/content/tullamarine.aspx for a full account of discussions at the meeting.

TLCCG is supported by Transpacific in order to support good communication and relations with the community.

TLCCG 2014: THE YEAR IN REVIEW

TLCCG
Tullamarine Landfill Community Consultation Group

OUR PURPOSE: *to foster collaboration between the community, Transpacific and EPA Victoria, and ensure community concerns and aspirations regarding the closed Tullamarine Landfill and adjoining land form part of the decision making process.*

2014

November 2014 marked the end of the first full year of TLCCG (in its current form). It is worthwhile reviewing what happened this year.

In February TLCCG participants agreed on the following goals:

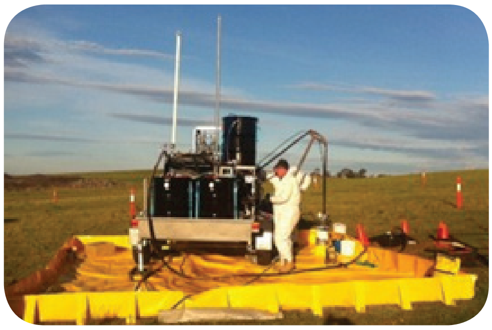
the landfill will be stabilised and safe, with ongoing monitoring to ensure that it poses no risk to the community,

open space will be established, with a return of land to the community,

transparent and information will be shared between the community and Transpacific.

There were also some areas of difference between the aspirations of the community and those of Transpacific; these were based around the potential for rezoning and commercial development on the adjacent buffer land.

LNAPL extraction



After much discussion and careful planning, the trial extraction of Light Non-Aqueous Phase Liquid (LNAPL) commenced in May 2014, involving 14 wells across the site. Controls and monitoring were put in place to protect the community against escaping gases, spillage and noise, and the entire process was approved and monitored by an Independent Review Panel on behalf of EPA Victoria. Extracted leachate was destroyed offsite.

Kieren McDermott (Transpacific) advised TLCCG members of the proposed extraction process in February, and provided a progress update in May.

In September the results of the LNAPL extraction trial were discussed by consultant Alex Schiavoni (EHS Support). Alex advised that the leachate was extremely slow to extract, and replacement of LNAPL into the wells for further extraction was also very slow. It was concluded that further extraction was neither practical nor achievable. He added that the LNAPL will decompose over time due to microbes.

Kieren reiterated earlier advice that testing of 100 bores across the site had shown some groundwater contamination due to LNAPL, but that this was at levels below thresholds for risks to the environment and human health.

Alex also attended the November meeting to further discuss the findings and to answer additional community questions. It was agreed at the November meeting that the final report being prepared by Alex will be issued to the group and there will be another question and answer meeting in February 2015.

Some community members of TLCCG remain convinced that further extraction should be undertaken.

Gas Flare

A new 9m high gas flare was designed and installed in May 2014, in order to destroy the gas generated by the landfill, including vapours emitted by the subsurface LNAPL.

The flare will be operated and monitored for many years, until it ceases to have a positive environmental impact. Transpacific advised TLCCG members of the proposed design at the February meeting, and provided an update on the construction in May.

Buffer Land

In February 2014 the Environmental Auditor reviewed and issued a statement on the four studies that have been completed regarding the use of the buffer land adjoining the landfill site. The statement allowed for commercial land use providing there is access to the groundwater bore holes and the groundwater must be tested before being used in the future. This report was discussed with TLCCG members at a special meeting in March 2014, involving the Environmental Auditor.

The application for rezoning of the buffer land was publicly exhibited by Council. It was abandoned by Council in April 2014 after Transpacific sought to withdraw the application due to unresolved issues associated with rezoning.

In November 2014 Olga Ghiri (Transpacific) advised that an amended application for rezoning was with Council. Community members requested that the application be postponed until after issues associated with LNAPL extraction had been resolved.

Post Closure Pollution Abatement Notice (PCPAN)

In February 2014 Alistair Nairn and Jeremy Settle (EPA Victoria) explained a new template for PCPANs statewide. In May TLCCG members provided extensive input for the application of the new PCPAN to Tullamarine Landfill.

Landfill Site Tours

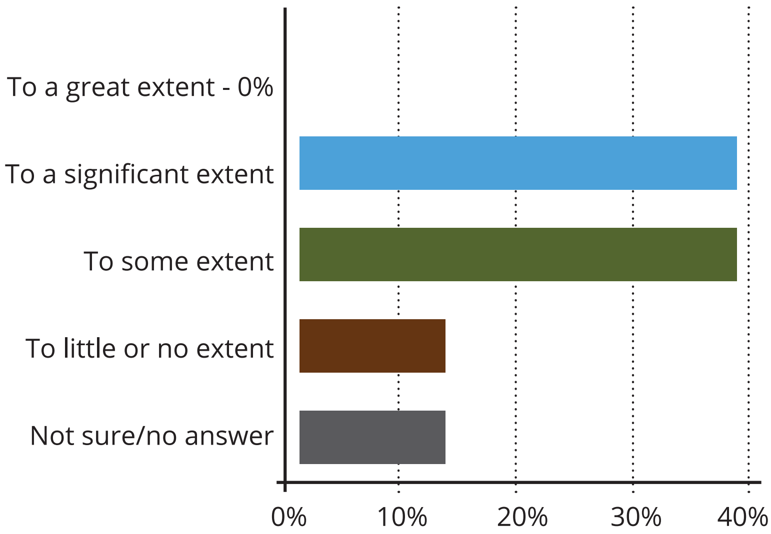
Two community members of TLCCG took part in a tour of the landfill during October 2014. Both reported that it was a valuable experience; Kieren extended the offer to other TLCCG members for future tours upon request.

Feedback from TLCCG participants

After the November 2014 meeting, TLCCG community participants were asked several questions about the forum and management of the landfill site in general. Questions and responses included:

> *"I am face to face with people involved with the landfill, I can raise my questions and concerns with the owners/operators and the authorities. And I want to be heard, because I'm there for the right reasons, OUR PROTECTION. I'm sick and tired of the lies and incompetence and safety risks we have had to put up with in the past, and possibly in the future."*

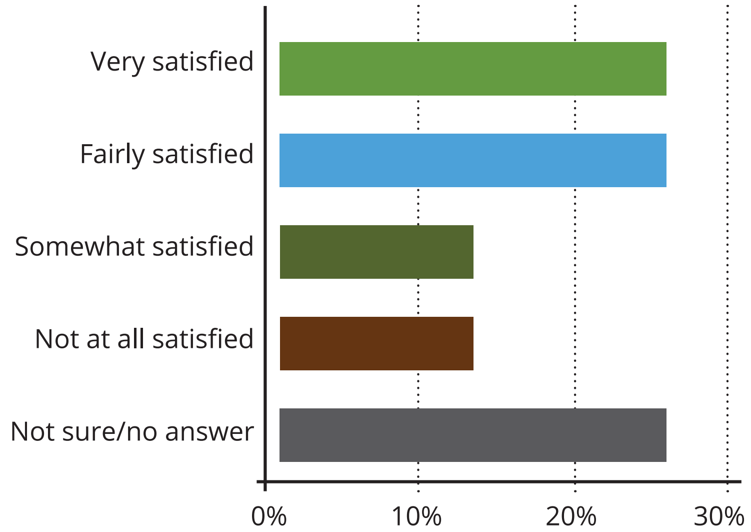
To what extent do you think that Transpacific listens to community concerns and feedback about the landfill's rehabilitation?



> *"I believe the group are discussing issues, trusting each other, not being experts and lecturing the others. TPI are now taking us along with progress, consideration of the social issues are being given equal consideration against the monetary decision. We relied on EPA for support in regulation and supervision, we were disappointed earlier on, but I feel we are getting a better understanding of their position and they are being more open. I feel this has been a great year for group and really believe we can now work together next year to progress forward together without doubting each other. Clete I feel is playing a leading role behind the scenes. Kieren has been a great addition to the group."*

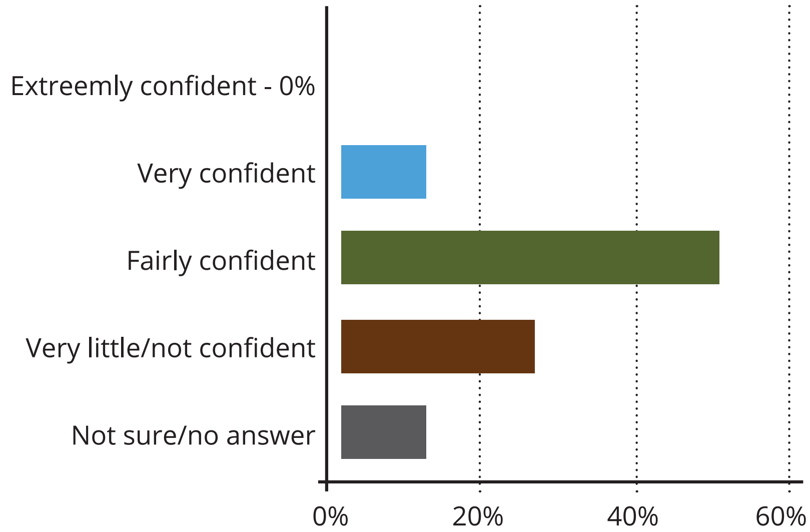
"It is disappointing to see Transpacific reneg on the original agreement the community had from Brambles to develop the buffer land/land fill into recreational area to pay back to the community for the pollution the landfill created in the area - attending these meetings provides me with what I hope is accurate information to be able to present an informed objection to the rezoning of the buffer."

How satisfied are you with Transpacific's management of the LNAPL extraction trial?



"The community was given the same reports as those received by the other parties including the regulatory authorities. And the community was given the opportunity, and still are able, to ask specific questions re the LNAPL trial. It could not be more open than that."

Are you confident that Transpacific is managing the site appropriately?



APPENDIX D SCS ENGINEERS LANDFILL GAS GENERATION AND RECOVERY ESTIMATE (AMBIENT AIR AND LANDFILL GAS MANAGEMENT PLAN (AALFGMP) (TRANSPACIFIC, 2012))

Table 1
LANDFILL GAS GENERATION AND RECOVERY ESTIMATE
Project:
File No:
Date: 26-Mar-12

	Waste Data		LFG Generation Estimate				LFG Recovery Estimate					Actual LFG Recovery		Green House Gas Emissions			
Year	Annual Waste Quantity	Cumulative Waste Disposed	Estimated CH_4 Flow	Estimated LFG Flow	Estimated LFG Flow	Estimated LFG Flow	Estimated LFG System Coverage	Estimated Well Collection Efficiency	Estimated Overall LFG Efficiency	Projected LFG Recovery Rate	Projected LFG Recovery Rate	Actual LFG Recovery Rate	Actual LFG Recovery Rate	Gross Annual Methane Generation	Recovered Methane Per Year	Oxidation Factor	Net Annual Methane Emissions
	(tonnes)	(tonnes)	(m^3/yr)	(m^3/yr)	(m^3/hr)	(GJ/hr)	(%)	(%)	(%)	(m^3/hr)	(GJ/hr)	(m^3/hr)	(GJ/hr)	(tonnes/yr)	(tonnes/yr)		(tonnes/yr)
1972	96,240	96,240	0	0	0	0						0	0.0	0	0	0.1	0
1973	96,240	192,480	395,805	791,611	90	2						0	0.0	269	0	0.1	242
1974	96,240	288,720	757,544	1,515,088	173	3						0	0.0	514	0	0.1	463
1975	96,240	384,960	1,088,149	2,176,297	248	5						0	0.0	738	0	0.1	664
1976	96,240	481,200	1,390,298	2,780,596	317	6						0	0.0	943	0	0.1	849
1977	125,564	606,764	1,666,442	3,332,884	380	7						0	0.0	1,131	0	0.1	1,017
1978	134,200	740,964	2,039,419	4,078,839	466	9						0	0.0	1,384	0	0.1	1,245
1979	159,425	900,389	2,415,812	4,831,624	552	10						0	0.0	1,639	0	0.1	1,475
1980	164,344	1,064,733	2,863,552	5,727,103	654	12						0	0.0	1,943	0	0.1	1,748
1981	96,792	1,161,525	3,292,985	6,585,970	752	14						0	0.0	2,234	0	0.1	2,011
1982	116,149	1,277,674	3,407,637	6,815,275	778	14						0	0.0	2,312	0	0.1	2,081
1983	102,128	1,379,802	3,592,031	7,184,062	820	15						0	0.0	2,437	0	0.1	2,193
1984	98,000	1,477,802	3,702,890	7,405,780	845	16						0	0.0	2,512	0	0.1	2,261
1985	123,650	1,601,452	3,787,230	7,574,460	865	16						0	0.0	2,569	0	0.1	2,312
1986	169,634	1,771,086	3,969,802	7,939,604	906	17						0	0.0	2,693	0	0.1	2,424
1987	165,653	1,936,739	4,325,778	8,651,556	988	18						0	0.0	2,935	0	0.1	2,641
1988	202,050	2,138,789	4,271,779	8,543,557	975	18						0	0.0	2,898	0	0.1	2,608
1989	238,477	2,377,266	4,307,282	8,614,565	983	18						0	0.0	2,922	0	0.1	2,630
1990	299,309	2,676,575	4,427,336	8,854,672	1,011	19						0	0.0	3,004	0	0.1	2,703
1991	288,265	2,964,840	4,674,148	9,348,295	1,067	20						0	0.0	3,171	0	0.1	2,854
1992	134,860	3,099,700	4,903,378	9,806,755	1,119	21						0	0.0	3,326	0	0.1	2,994
1993	14,213	3,113,913	4,841,011	9,682,023	1,105	20						0	0.0	3,284	0	0.1	2,956
1994	41,306	3,155,219	4,560,382	9,120,764	1,041	19						0	0.0	3,094	0	0.1	2,784
1995	74,230	3,229,449	4,352,984	8,705,968	994	18						0	0.0	2,953	0	0.1	2,658
1996	102,861	3,332,310	4,226,276	8,452,552	965	18						0	0.0	2,867	0	0.1	2,580
1997	60,157	3,392,467	4,168,045	8,336,090	952	18						0	0.0	2,828	0	0.1	2,545
1998	78,649	3,471,116	4,037,799	8,075,598	922	17						0	0.0	2,739	0	0.1	2,465
1999	46,717	3,517,833	3,955,287	7,910,574	903	17						0	0.0	2,683	0	0.1	2,415
2000	62,171	3,580,004	3,821,133	7,642,265	872	16						0	0.0	2,592	0	0.1	2,333
2001	60,351	3,640,355	3,727,860	7,455,719	851	16						0	0.0	2,529	0	0.1	2,276
2002	53,103	3,693,458	3,640,161	7,280,322	831	15						0	0.0	2,469	0	0.1	2,223
2003	3,222	3,696,680	3,546,922	7,093,845	810	15						0	0.0	2,406	0	0.1	2,166
2004	1,866	3,698,546	3,366,012	6,732,024	768	14						0	0.0	2,284	0	0.1	2,055
2005	2,219	3,700,765	3,193,723	6,387,446	729	13						0	0.0	2,167	0	0.1	1,950
2006	2,422	3,703,187	3,032,646	6,065,291	692	13						0	0.0	2,057	0	0.1	1,852
2007	2,292	3,705,479	2,881,727	5,763,453	658	12						0	0.0	1,955	0	0.1	1,759
2008	4,634	3,710,113	2,739,631	5,479,262	625	12						0	0.0	1,859	0	0.1	1,673
2009	0	3,710,113	2,610,491	5,220,982	596	11						0	0.0	1,771	0	0.1	1,594
2010	0	3,710,113	2,480,146	4,960,292	566	10						0	0.0	1,683	0	0.1	1,514
2011	0	3,710,113	2,357,320	4,714,641	538	10	90	46	41	223	4	225	4.2	1,599	662	0.1	843
2012	0	3,710,113	2,241,512	4,483,024	512	9	90	45	41	207	4	209	3.9	1,521	616	0.1	814
2013	0	3,710,113	2,132,257	4,264,514	487	9	90	45	41	197	4		0.0	1,447	586	0.1	775
2014	0	3,710,113	2,029,125	4,058,249	463	9	90	45	41	188	3		0.0	1,377	558	0.1	737
2015	0	3,710,113	1,931,717	3,863,433	441	8	90	45	41	179	3		0.0	1,310	531	0.1	702
2016	0	3,710,113	1,839,664	3,679,328	420	8	90	45	41	170	3		0.0	1,248	505	0.1	668
2017	0	3,710,113	1,752,624	3,505,248	400	7	90	45	41	162	3		0.0	1,189	482	0.1	637
2018	0	3,710,113	1,670,280	3,340,561	381	7	90	45	41	154	3		0.0	1,133	459	0.1	607
2019	0	3,710,113	1,592,338	3,184,676	364	7	90	45	41	147	3		0.0	1,080	437	0.1	578
2020	0	3,710,113	1,518,523	3,037,046	347	6	90	45	41	140	3		0.0	1,030	417	0.1	552
2021	0	3,710,113	1,448,582	2,897,163	331	6	90	45	41	134	2		0.0	983	398	0.1	526
2022	0	3,710,113	1,382,278	2,764,556	316	6	90	45	41	128	2		0.0	938	380	0.1	502