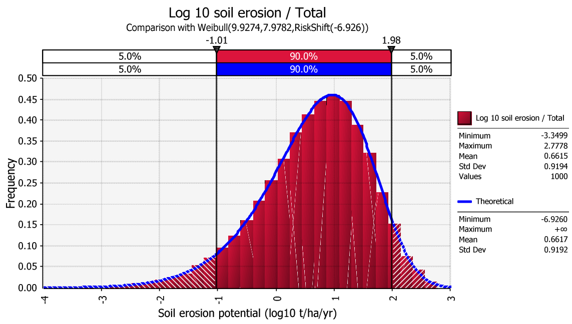
QUANTITATIVE RISK ASSESSMENT FOR LAND APPLICATION OF BIOSOLIDS:

SUMMARY AND ACTION PLAN FOR THE EASTERN AND WESTERN TREATMENT PLANT



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Abbreviations

BSP	Biosolids Stockpile
CLAR	Chemical loading application rate
dw	Dry weight
ETP	Eastern Treatment Plant
LAB	Land Application of Biosolids
NLAR	Nutrient loading application rates
QRA	Quantitative Risk Assessment
QSAR	Quantitative Structure Activity Relationship
WTP	Western Treatment Plant

1 EXECUTIVE SUMMARY

Recent improvements in the quality of biosolids produced at the Eastern and Western Treatment Plant (ETP and WTP), managed by Melbourne Water, have made it compliant with the EPA Victoria Guidelines for Environmental Management Biosolids Land Application(EPA Victoria, 2004) which are currently used to assess if biosolids are suitable for land application. Melbourne Water implemented a Quantitative Risk Assessment for the Land Application of Biosolids (QRALAB) to ensure the risks posed by this practice would be acceptable and in accordance with the guidelines.

An extensive QRALAB has been undertaken for biosolids produced from the ETP (BSP 20, 23 and 38; 1997, 2002 and 2007) and WTP (Recently extracted from the Anaerobic pot and aerated pond; BSP 8, 10 and 11; 2009 and 2010) using a range of state-of-the-science tools and knowledge to assess the risk of a diverse range of inorganic and organic chemicals and a number of other related risks (e.g. perceptions, nano particles). The risk assessment assumed pathogens control is generally compliant with the guidelines and these risks are managed to allow a focus on tens of thousands of chemicals that could enter the sewerage system and other land application related risks.

The primary screening of the literature and comments from a peer review process identified 3905 hazards of interest (i.e. research or experience across the world indicated these hazards could be in biosolids and pose risks to receptors in the receiving environment where biosolids were applied to land). A secondary and then detailed risk assessment was undertaken to logically assess every hazard with increased supportive detail if they progressed through the risk assessment process. The screening and QRA system was designed using techniques currently considered best practice across the world for three different Major Classes of hazards (Class I – Guidelines are available in Australia or internationally; Class II – assessable with Quantitative Structural Activity Relationships (QSAR) and known chemical properties; and Class III – Detailed literature review). These assessments also utilised prioritised exposure pathways and considered general risk characteristics of hazards related to land application of biosolids. Ultimately the QRA provides a risk assessment well beyond any currently available guidelines in the world. It was peer reviewed by a world leading expert in the field who determined it to be a credible approach, and suggested some small improvements that were incorporated into the final QRA.

The QRA determined that:

1. In the short-term (4 years or a single application of biosolids), land application of biosolids was considered low risk providing:
    a. Control measures are adopted as indicated in this report (Section 6.2), most which are considered good practice already by the industry; and

   b. Victoria Guidelines for land application of biosolids are followed (EPA Victoria, 2004).

2. In the longer-term, the QRALAB identified two assessments required to finalise the long-term risk assessment (Helminth Ova (if stock piling is less than 3 years) and BDE (47 and 209, single application of biosolids is low risk)). If these two assessment lead to these hazard being defined as low risk, then land application of biosolids in the long-term should be considered appropriate (low risk) when suitable control measures are practiced as defined below (Section 6.2).

There were several hazards assessed where insufficient data were available to determine a risk. This will always be the case as new chemicals are produced and their toxicity assessed and knowledge accumulates with time. It should therefore be considered good practice to reassess these risks and any new risk identified with in a 5 year time frame; to ensure land application of biosolids from the ETP and WTP remain at acceptable risk levels.

2 BACKGROUND

The quality of biosolids produced at both the Eastern and Western Treatment Plants (ETP and WTP) is managed by Melbourne Water (MW). Due to the implementation of trade waste agreements between trade waste customers and the retail water companies and regulation/bans on many high risk chemicals used prior to 1990 the biosolids currently produced at the ETP and WTP have lower concentrations of many chemicals than those produced in previous years.

Melbourne Water completed a Biosolids Strategy which identified options for pre-treatment and beneficial use of biosolids in agriculture, organic soils, construction materials and energy recovery. Land application of the biosolids is a cornerstone of long-term sustainability and an evaluation of the risks of this practice must be undertaken.

To assess the feasibility of applying biosolids from the ETP to land a series of formal risk assessments have been completed and peer reviewed (Stevens and Wilson, 2009; Stevens, 2010). The recommendations of these risk assessments included further biosolids sampling and analysis at the ETP. A similar study was then carried out for the biosolids at the WTP. A separate study was required as the WTP biosolids can be significantly different than those at the ETP as the WTP catchment contains a significant portion of Melbourne's industry and as such the biosolids are known to have higher levels of some hazards, including heavy metals and some organic chemicals.

A hazard in the context of this report is a substance that is known to have caused harm or that has the potential to cause harm to humans or environment.

This report summaries the findings from the Quantitative Risk Assessments (QRA) for Land Application of Biosolids (LAB) from the ETP and WTP for agricultural or amenity horticultural benefit (Stevens and Magyar, 2013b).

3 INTRODUCTION

This report summarises the findings and actions identified during the quantitative QRALAB from the ETP and WTP, both managed by Melbourne Water. The documents summarized include:

1. ETP – Draft QRALAB with available data (Completed 2009 with sensitivity analysis in 2010; Stevens and Wilson, 2009; Stevens, 2010).
2. ETP – Update QRALAB with additional analytical data and respond to review comments, and any data from the literature (2009 to early 2012).
3. WTP – QRALAB 2012 with sensitivity analysis considering reviewer comments on ETP QRA (Stevens and Magyar, 2013b).
4. Summary action plan for the ETP and WTP (this document).

The process for the QRALAB project relied on each of the four components above to be completed in sequence as the former component informed the next stage (Figure 3-1).

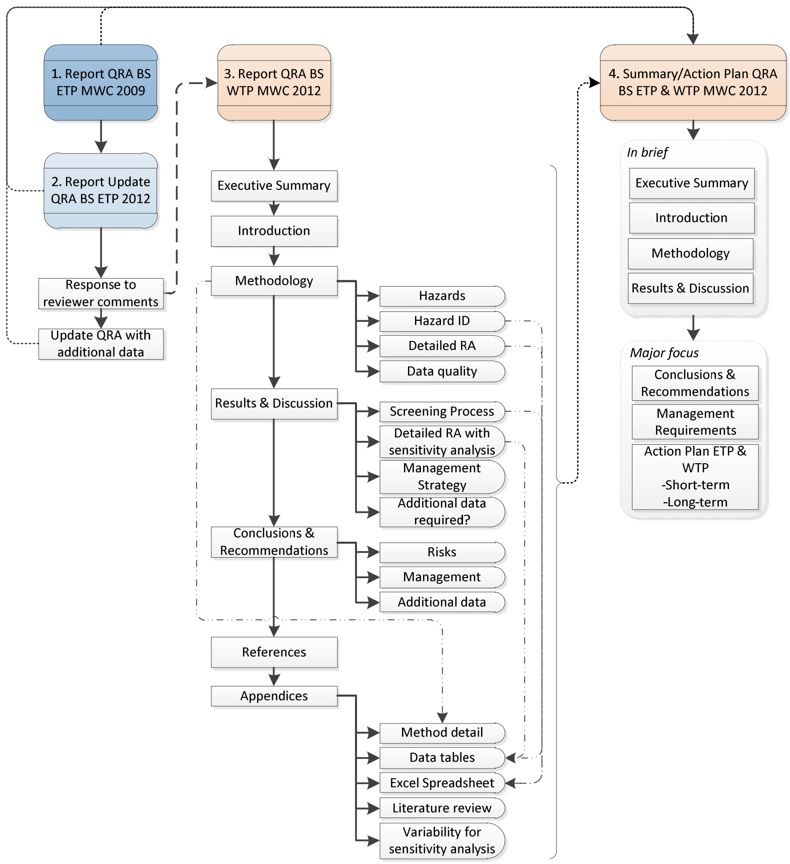

Figure 3-1 Overview of the Quantitative Risk Assessment for Land Application of Biosolids from the ETP and WTP project (QRALAB 2012).

4 METHODOLOGY

4.1 THE QUANTITATIVE RISK ASSESSMENT FOR LAND APPLICATION OF BIOSOLIDS (QRALAB) PROCESS

The risk assessment used a three stage approach (Figure 4-1) to quickly focus resources on hazards of potential high risk combined with three classes of hazards:

- **Class I** – guideline available
- **Class II** - conformed to Quantitative Structural Activity Relationships (QSAR) assessment (Class I hazards included if possible)
- **Class III** - does not conform to QSAR assessment.

The three stages of the risk assessment were:

- **Primary Screening** – determined the hazards that are currently of a concern and potential found in biosolids (Class I (34)+ Class II (3474) + Class III (397) = 3905)
- **Secondary Screening** – determined the hazards identified in the Primary Screening that were likely to be found in biosolids and had the potential to cause detrimental impacts to humans or the environment (34 +713+105 = 852) using modelled and some measured data.
- **Detailed Risk Assessment (DRA)** - assessed in detail all hazards promoted to this level from the secondary screening to determine the actual risk posed, using measured data predominantly (modelled data was used were measured data could not be located. In some cases there were insufficient data available to determine the risk posed. In many cases, where there was sufficient data, a hazard quotient (HQ) was used to assess the risk:

$$HazardQuotient(HQ) = \frac{Substance(mg/kg)}{Guideline(mg/kg)} \; or \; \frac{PEC}{PNEC}$$

Where PEC = Predicted environmental concentration, PNEC=Predicted no effect concentration

A risk matrix was also used in some cases to designate a low, medium, high and extreme risk which was defined by likelihood and impact.

The risk assessment undertaken in the document provides compliance with current Victorian Guidelines (EPA Victoria, 2004). The techniques used also provide as much insight as possible into any foreseeable risks as to guidelines that may be developed or substances that may be of concern now or in the immediate future.

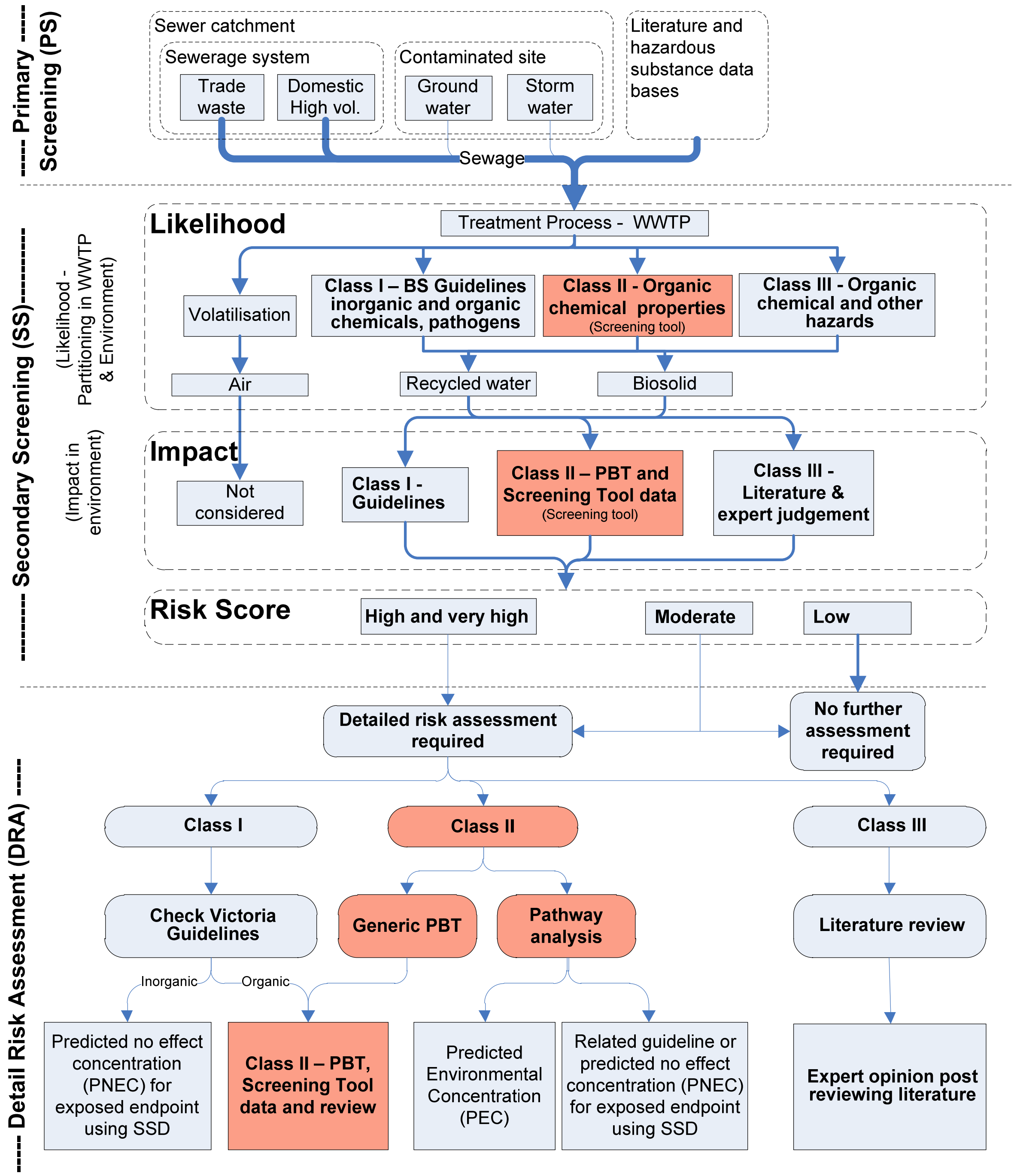

Figure 4-1 **Overview of risk assessment process with number of Class I, II and III hazards on the right hand side for each step through the risk assessment.**

4.2 Update of QRALAB from the ETP 2012

The update of the QRALAB 2009 was completed by:

1. Assessment of peer-review comments, documentation of interpretation of peer-review comment.
2. Incorporation of relevant modifications from the peer-review to the QRALAB process of 2009 for use in the ETP QRALAB update
3. Using additional analysis undertaken as identified in the 2009 report (Stevens and Wilson, 2009) for the QRALAB ETP 2012 update.
4. Reviewing the literature for additional hazards that may have been identified since the 2009 ETP QRALAB.

4.3 QRALAB from the WTP 2012

The WTP QRALAB was completed by:

1. Using the revised risk assessment process developed during the ETP QRALAB 2009 and 2012 (Section 4.2)
2. Reviewing the literature for additional hazards that may have been identified since the 2009 ETP QRALAB
3. Considering analytical data available from both the ETP and WTP biosolids and identifying high risk hazards that required their concentration in biosolids to be determined immediately to complete the risk assessment. In most cases biosolid samples were taken and analysed during the WTP QRALAB so the risk posed by a specific hazard could be finalized.

The QRA used the process detailed in Section 4.1 and the results of the QRA process and major finding are discussed in Section 5.2.

4.4 Sensitivity analysis of QRALAB ETP and WTP 2012

A sensitivity analysis was detailed extensively in 2009 and an identical sensitivity analysis was also undertaken for the QRALAB 2012 for ETP and WTP. The sensitivity analysis considered a range of key variables that would influence the risk assessed. The findings of the sensitivity analysis are discussed in Section 5.3.

5 Results and Discussion

5.1 Updated QRALAB ETP 2012

A stand-alone amendment to the original QRALAB from the ETP document (Stevens and Wilson, 2009) was drafted to include:

1. The amendment also addressed improvements and recommendations of the Peer Review undertaken of the ETP QRALAB. The main points raised by the peer review were:
    I. The Australian and International pollution inventories should be assessed and included if relevant.
    II. Where possible, chemicals should be assessed directly from experimental evidence at the tertiary screening levels.
    III. Chemicals that have regulated and recommended guideline concentrations in the Victorian Guidelines (EPA Victoria, 2004) should have a full QRA performed on them to assess their risks to health and the environment. An expert opinion on the levels set in these regulations should be documented in relation to concentrations that actually pose a risk.
    IV. The risk posed by Di-ethylhexyl-phthalate (DEHP) should be reviewed and taken through a detailed risk assessment.
    V. High salinity / sodium adsorption ratio (SAR) / conductivity / exchangeable Sodium Percentage (ESP) risks found in Melbourne Water biosolids should be developed further to indicate what sorts of risks these levels pose to plant growth.

When Australian and International Pollution Inventories were assessed with the recent literature (2009 to early 2012 predominantly and some earlier literature to ensure hazards where not missed). This review identified 641 new hazards. The new hazards were assessed for ETP and WTP concurrently during the WTP QRALAB 2012. Ultimately none of the additional 641 hazards were considered a risk for LAB in Australia. Many of these hazards could be screened out after reviewing the literature as:

1. Many of these hazards were already banned for production and use in many countries and therefore not found in biosolids produced from recently produced sewage.
2. They were obscure petro-chemicals which were very unlikely to enter sewerage systems (as they are no longer produced or used) and if they did it would at very low concentrations.
3. They were identified from aquatic risk databases and the likelihood of exposure to aquatic systems through land application with appropriate control measure was low, especially as many were as described in point 1.

Responses to the peer review were:

1. Hazards from many relevant pollutant inventories where already included in the 2009 report (QRALAB from the ETP):
    a. All the hazards identified in the Australian National Pollution Inventory (www.npi.gov.au/) were already assessed.
    b. All hazards in the Environment Agency for England and Wales Pollution Inventory substances - (Environment Agency, 2012) were already assessed
    c. European Directive 76/769/EEC[A] (European Commission, 1976) lists 1108 chemicals banned for use in Europe, many of these were already assessed. However, 221 were added that had not been assessed, even though there was no logic for why they would be found in Australian sewage influent. No additional hazards added were considered above a low risk.
2. Where possible experimental data has always been given preference in the QRA at the detailed risk assessment level and at lower screening levels where databases were available.
3. Thirteen guidelines values were verified using the QRA risk procedures, where there was sufficient data, and found to be similar. There was no obvious challenge to current guidelines identified. This process was complicated by the guideline value not usually identifying the specific pathway or endpoint protected. Therefore comparative guidelines would need to be checked for every end point the guideline could be protecting (animals, fish, microbes, worms, plants, etc.).
4. The risk posed by Di-ethylhexyl-phthalate (DEHP) was reviewed. The secondary screening of the QRA process determined it to be low risk in the context of land application of biosolids from the ETP at agronomic rates.
5. Additional analysis of ETP stockpile for ESP confirmed that certain parts of the Biosolids Stock Pile (BSP) had high ESPs (26 to 34%), however, the average BSP ESP <20%. Biosolids stockpile should be well mixed on use to ensure the average ESP applied to soil is <20%. The biosolids production systems should be checked to determine if modification can be made to ensure the ESP is < 20%. Application of biosolids to soils with high to very high cation exchange capacity, or calcium amendment added to soil, will also minimise the risks of detrimental impacts from the sodic levels of biosolids.

The original ETP QRALAB report was modified to refer to the amendment to ensure the two documents were linked.

[A] http://ec.europa.eu/enterprise/policies/european-standards/documents/harmonised-standards-legislation/list-references/dangerous-substances/index_en.htm.

5.2 QRALAB ETP AND WTP 2012

The risk assessment identified that land application of biosolids (Stockpiles 20, 23 and 38 at the ETP and BSP 10, 11 and 12 at WTP) in controlled rural production systems and controlled urban applications will be low risk if:

1. Control measures and restrictions identified in the Victorian Guidelines are practiced, including specifically:
    a. One application of biosolids in a five year period.
    b. An application rate of 20 t dw/ha/5 years or less t/ha (depending on the Nutrient Loading Application Rate - NLAR) is adopted and is determined prior to application.
    c. Contaminant Loading Application Rates (CLAR) indicate no more than 9 applications of biosolids (from recently produced sludge from the ETP or WTP) to any one site (Biosolids stockpiles should be checked before application to land).
    d. Consider soil background concentrations for application sites in the calculation of the CLAR. Typical concentrations used in this reported are listed in Table 4.6 (Stevens and Magyar, 2013b).
    e. All other requirements of the Victorian Guidelines (EPA Victoria, 2004).
2. Additional control measures in this report are also practiced.
    a. Wear protective equipment to prevent dust inhalation while working with biosolids.

    Together 1 and 2 above should be considered best practice.

3. Additional analysis is undertaken and concentrations are below low risk guidelines derived in this report, including:
    a. If stockpiling of biosolids will be less than three years, one Class I hazard (Helminth) requires additional information to finalise the risk assessment. To comply with guidelines all Class I hazards should have a low risk HQ at the DRA level. Helminth ova were considered to pose a moderate risk as there was insufficient analytical or treatment process data to determine if they were low risk if stockpiled for less than three years (Three year stockpiling without recontamination will satisfy the Long-term storage T1 treatment if digested sludge is dewatered to >10% w/w solids and stored for > 3 years). If stockpiling is less than three years
        i. Analytical data for helminth ova numbers in biosolids or validation of the treatment process temperature are required. Without these data on site control measures will be required that prevent grazing on the application site until a three month period over summer has passed. Grazing of dairy cows should not be allowed.
    b. Three Class II hazards require assessment:

i. Short Chain Chlorinated Paraffins (SCCP) was analysed and estimated at 20 mg/kg (worse case; analysis was completed but due to analytical difficulties could only give an indication of highest concentration that there may be), indicating this is a moderate risk, where a watching brief is required. It is most likely that concentrations are below the 1 mg/kg low risk concentration and degradation in soil is sufficient. After 2 applications of biosolids (10 years) the risk assessment should be revised consulting literature and new analytical data.
ii. Two Class II hazards (BDE209 (001163-19-5) and BDE47 (005436-43-1)) require their typical degradation half-lives in soils (typical of where biosolids will be applied to land) to be determined to finalise the risk assessment. Half-lives of less than 5 years should be considered low risk. Note: half-lives may be second order with a component that will not degrade due to strong adsorption to soil and this should be considered during analysis of half-lives. This data should not pose a significant risk for a single application of biosolids, however, should be acquired for repeat application.

4. No Class III hazards required analysis during the QRA process, however, fourteen required a watching brief (i.e. are substances of concern, however, there is insufficient data available to determine the current risk posed).

Use of the biosolids for uncontrolled uses (potting mixes or compost) will require dilution of biosolids with other raw material used in these processes to produce a C1 chemical grading or they will need to be used for controlled, well documented, uses (EPA Victoria, 2004).

During the QRA process a number of hazards were identified as high risk using best estimates for concentrations potentially in the biosolids. Analysis was required to determine if this risk was real for the biosolids produced at the ETP or WTP. Analysis was completed during the risk assessment and in all, except two (BDE47 and BDE209), cases the risk was defined as low. In many cases the chemicals were determined to be below the detection limit requested that would be considered a low risk concentration. These observations highlight the robust nature of both WWTPs in degrading many chemical hazards or the management of chemicals entering the sewage systems.

Heavy metals concentrations in influent are now at concentrations at the WTP that will limit total applications at general agronomic rates, based on N and P (Approximately 20t dw/ha), to no more the 9 applications per site.

The risks from 4 hazards described above as requiring additional analysis are:

1. Helminths - The type of helminth that are of concern in biosolids are:
    a. Ascaris (human-human infection) causing helminthiasis in human, which if untreated can lead to malnourishment and intestinal blockages.
    b. Taenia saginata (human-cattle-human infection) causing human tapeworm infections and a risk to health and trade of beef cattle due to beef measles (Cysticercus bovis); and
    c. Taenia solium (human-pigs-human infection) can affect the health of pigs, but can cause a human nerocycticercosis infection which is generally accepted to refer to cysts in the parenchyma of the brain. It presents with seizures and, less commonly, headaches.
2. SCCP – Also referred to as Short Chain Polychlorinated n-alkanes (PCA) are used in a wide range of industrial applications (flame retardants, plasticisers, sealants, paint, additives in metal working fluids). SCCP are classified as persistent and having a high potential for bioaccumulation. PCAs are classified as toxic to aquatic organisms and carcinogenic to rats and mice, and possible to humans.
3. BDE 209 (001163-19-5) is a brominated fire retardant (BFR) being phased out in Australia it is potential highly toxic to surface waters and a chronic reference dose for human consumption has been set. BDE47 (005436-43-1) – BFR and breakdown product of related longer chain BFRs. Very persistent in soil and is highly toxic to soil biota and humans. Impacts of BDEs are potentially thyroid hormone disruption, neurodevelopmental effects and, for some congeners, cancer. Many of these potential impacts are currently being assessed.

5.3 Sensitivity analysis summary

The sensitivity analysis considered a range of variables related to hazard in biosolids and their movement in the environment when applied to land, and ultimately exposure to a specific receptor (micro, animal or plant). Variables could be chemical, environmental or receptor based and included: Partitioning coefficients and degradation rates; years between application of biosolids, soil depth, organic carbon content, leaching rate, root density, air and water volumes, soil erosion rates and several factors influence this; and soil, plant and water ingestion rates, plant milk and beef ingestion rates, human body weight of children and adults, inhalation volumes.

Some of the findings from the sensitivity analysis which apply for LAB from the ETP and WTP are summarized below.

5.3.1 Control measures

The sensitivity analysis and updated risk assessment has confirmed the value of several onsite control measures recommended by the Victorian Guidelines (EPA Victoria, 2004). Recommended control measures for biosolids that should be managed and maintained onsite during and after application are:

- Sites of application should be in areas where movement of any solids (soil/biosolids) from the site into surface water is minimal (factors considered in the Revised Universal Soil Loss Equation (RUSLE) can define this as listed below).
- Buffer distances (well vegetated) from water ways should also be used as per the Victoria Guidelines to minimise any movement into waterways.
- Soil types (permeability, pH, groundwater depth) should fit into the slight to moderate category defined by the Victoria Biosolids Guidelines (EPA Victoria, 2004).
- Biosolids should be incorporated as soon as possible after application to a depth of at least 10 cm.
- At least 2 years between each application (5 would be ideal) will help minimise any build-up of organic substances in the soil.

RUSLE factors used for onsite controls should be:

- slope < 5% (flat long slopes preferred)
- Good soil management that minimises soil erosion (e.g. minimum tillage systems)
- Good conservation practice with lots of preventive measures to stop erosion
- Avoid application in high rainfall and erositivity index areas (Sheridan and Rosewell, 2003)

5.3.2 Improvements to the treatment process

The sensitivity analyses indicated that for some hazards retention in the stockpile could provide time for substances to degrade and lower inherent risks. This may be useful for some substances with moderate half-lives (120 to 180 days). However, the sensitivity analysis also highlighted that for substances with longer half-lives (>360 days) this may be of no benefit in reducing the concentration of organic substances.

Maximising both the time in the anaerobic digester and drying times are also beneficial for removal of certain hazards, however, can impact fertilizer values (Nitrogen).

5.3.3 Types of land application uses considered low risk

Low risk land uses recommend limited grazing by cattle with a focus on dryland cropping or farming systems where biosolids can easily be incorporated as part of a tillage system that minimise erosion (minimum tillage). For example, biosolids could be incorporated when offset disking is used to incorporate stubble.

Landscape or roadside uses are not recommended unless applied to low slopes and erosion control is possible.

5.3.4 *How safe is it to use?*

In the short-term, if control measures are practiced, land application of biosolids to low risk sites can be practiced at low risk to humans and the environment with respect to acute or chronic impacts on living organisms in the terrestrial and aquatic environments.

However, in the longer-term (BDE209 (001163-19-5) and BDE47 (005436-43-1)) concentrations in the ETP and WTP biosolids could lead to human reference doses (RfDs) being exceeded through ingestion of plant, milk and beef. BDE209 is also known to be very persistent in the environment, leading to contamination of soils with repeated applications at sites, increasing risks to surface water where it is considered relatively toxic.

If BDE209 (001163-19-5) and BDE47 (005436-43-1) concentrations can be reduced via source control and/or degradation of these hazards in the soils where they are applied is determined to be a half-life of less than 5 years (equal to any repeat application cycle), then longer-term land application of biosolids should be considered low to moderate risk (acceptable in terms of the Melbourne Water Risk Matrix).

6 Conclusions and Recommendations

6.1 Summary

In total 3905 hazards were assessed though the risk assessment process.

In the short-term (4 years or a single application of biosolids), land application of biosolids was considered low risk providing:

- Control measures are adopted as indicated in this report (Section 6.2)
- Victoria Guidelines for land application of biosolids are followed (EPA Victoria, 2004).

In the longer-term, the QRALAB identified two assessments required to finalise the long-term risk assessment:

- Firstly, if less than three years stockpiling will be practiced in the future, analysis of helminth ova is required to determine if helminth in biosolids are low risk, or alternatively, practice onsite control measures of restricting cattle access until 3 months of summer have passed (EPA Victoria, 2004).
- Secondly, determine half-lives for BDE47 and BDE209 in soils typical of where biosolids would be applied. This can be done after one application of biosolids as it is the longer-term build-up of these hazards which are of concern (i.e. repeat applications).

If these two assessment lead to these hazard being defined as low risk, then land application of biosolids in the long-term should be considered appropriate (low risk) when suitable control measures are practiced as defined below (Section 6.2).

The risk assessment should be updated every 5 years to allow for one update within each application of biosolids to ensure the risks continue to be considered low. In the future, as control measures for release of chemicals of concern in to the environment continue to improve nationally and internationally, and historical risk assessment support it, the time between reviews could possibly be increased.

Development and validation of fugacity models (Stevens, 2015a) to estimate organic chemical removal through the ETP and WTP highlighted the increased error when using low half-lives (<75 days) over long periods (≥ 2 years). However, a 3 year stock piling of biosolids during the production and treatment process minimizes any impact on the overall fugacity approach used in the QRA. Where possible measured half-lives should always be used.

6.2 Management Requirements

During the QRALAB the sensitivity analysis identified specific components of the land application of biosolids that lowered the risk through various pathways to specific environmental receptors. Interestingly, in all cases these components were also covered in the Victorian Guidelines (EPA Victoria, 2004). The sensitivity analysis support the recommendation in these guidelines identified some of the more important best practices from it. Management requirements that are crucial to ensure land application of biosolids remains low risk are:

a. One application of biosolids in a five year period
b. An application rate of 20 t dw/ha/5years** or less t/ha (depending on the Nutrient Loading Application Rate - NLAR) is adopted and is determined prior to application.
c. Contaminant Loading Application Rates (CLAR) indicate no more than 9 applications to the one site should be applied. (WTP and ETP biosolids assuming a 20 t dw/ha application rate). The NLAR and CLAR will need to be calculated prior to any land application as nitrogen concentration can change significantly during storage.
d. Consider soil background concentrations for application sites in the calculation of the CLAR.
e. Wear protective equipment to prevent dust inhalation while working with biosolids.
f. All other requirements of the Victorian Guidelines

**Additional assessment in 2015 (Stevens, 2015b) indicated that:

- Biosolids application rates limits were
  - If 25 mg/kg dw BDE-209 in the biosolids:
    - 55 t/ha – single application
    - 44 t/ha – continual application once every 5 years
    - Algorithms were derived for both to determine the maximum BDE-209 limited rate, given application rate and frequency and the BDE-209 concentration of the biosolids.
  - Considering all priority Class II organic chemicals in Biosolids from the ETP and WTP (Stevens and Magyar, 2013a, 2013b) indicated that:
    - for ETP biosolids:
      - 55 t/ha dw every 5 years, based on Heptachlor and Aldrin detection limits (DQ indicates that limited data at the detection limit was used for the HQ estimate)
    - for WTP biosolids:
      - 44 t/ha dw every 5 years based on BDE209 concentrations, if BDE209 concentrations

decrease below 20 mg/kg dw, then the limiting rate will be

- 55 t dw/ha every 5 years, based on Heptachlor and Aldrin measured concentrations

The application rates limits summarised above should always be considered with relative state and national guideline values for other contaminant they may contain.

Other recent risk assessments indicated that alternative uses of biosolids with higher application rates (e.g. 100% biosolid layer capped with a soil layer), where there are potentially higher exposures, can impose additional management requirements (Stevens, 2015b).

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