Wheatstone Project

Social Infrastructure

Onslow Water Infrastructure Upgrade Project (OWIUP) – Processing and Disposal of Radionuclides as Solid Waste

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Wheatstone Project

Processing and Disposal of Radionuclides as Solid Waste

WS0-9211-PRO-RPT-WOR-000-00003-000

30 August 2013

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APPENDICES

1 SUMMARY

Process options to remove radium from the Residual Saline Stream (RSS) and produce a solid waste for disposal off site have been identified. The water quality given in the report entitled Design Basis for Water Quality, reference WS0-9211-PRO-BOD-WOR-000-00001-000 has been used for process evaluation.

Lime softening for the removal of calcium and magnesium will remove around 90% of radium and produce 18 m^3 of cake each day when the plant is operating at peak production. The softening approach will also remove iron and manganese. The radioactivity in the RSS will be reduced from 25.6 Bq/L to 2.8 Bq/L and the activity of the cake with 50% w/v dry solids will be 1,364 Bq/kg. Chemical consumption of the process is considerable and the daily consumption of reagents is,

- 3439 kg of commercial premium quality hydrated lime
- 4055 kg of soda ash

An alternative approach is to retain the radium on a non-regenerable ion exchange resin especially formulated for radium removal. The Dowex RSC resin from Dow Chemicals has a reported capacity of 370 Bq/gram of resin. It is possible that $33m^3$ of resin could process the annual water production of the plant. The activity of the exhausted resin will be 370,000 Bq/kg, the resin mass will have an activity of 9.5×10^3 MBq.

The Authority with responsibility for the disposal of radioactive substances in Western Australia is the Radiological Council which is a section within the Department of Public Health. The allowable limit for disposal to a prescribed Class IV landfill site is 250 Bq/kg of solids. Both process options for radium removal produce a waste with significantly higher radioactivity and therefore disposal at a Class IV landfill site is not possible. The only other option is disposal at the Class V intractable waste facility at Mount Walton East which is located 150 km north west of Kalgoorlie. This facility is managed by the Department of Finance and is considered to be a disposal site of last resort. It is not available for continuous receipt of waste; it was last used in 2008 and before that in 2002. Disposal is extremely expensive and essentially requires mobilisation of a mining operation to bury the waste in a controlled manner.

There is no guarantee that the Department of Finance will accept a waste stream and the requirement for storage and management of radioactive waste resides with the Operator producing the waste. The Operator is required to store the waste until such time that it can be accepted at Mount Walton East.

The conclusion of this study was that there is no obvious motivation for removing radionuclides from the RSS on the basis that there is no disposal pathway for continuous disposal of solid waste with a radioactivity in excess of 250 Bq/kg.

2 INTRODUCTION

2.1 Purpose of This Document

The objective of the work is to identify processes for removing radionuclides, iron and manganese from the RSS and quantity the waste solid streams for removal off site to a suitable disposal site.

Operational issues and costs associated with disposal will also be investigated in order to determine the viability generating a solid waste to specifically address the issue of radionuclides in the source water from the Birdrong Aquifer.

2.2 Scope and Limits

The following activities will be undertaken to quantify the solids waste stream and identify management issues associated with its disposal.

- Determine the regulations that relate to acceptance of the solid waste at regulated landfill sites in Western Australia
- Identify a process option to remove iron, manganese and radionuclides
- Identify a process option specifically to remove radionuclides.
- Estimate the approximate operational cost differences between the two process options
- Comment on the potential for a Class IV landfill site located at Onslow to accept the solid waste streams.

2.3 Definitions and Abbreviations

ADWG	Australian Drinking Water Guideline
mg/L	Milligrams per litre
Bq/L	Becqueral per litre
pCi	Picocuries
nCi	Nanocuries
Hz units	Hazen units
NTU	Nephelometric turbidity unit
DS	Dry solids
USEPA	United States Environmental Protection Agency

3 METHODOLOGY

3.1 Method of Approach

The approach focussed on two investigations,

1. Initially to identify the location of landfill sites that could accept the solid waste stream from the treatment process and fully understand the criteria for waste acceptance

2. Identify process options that could produce a solids waste stream that could be accepted at the identified landfill sites.

To enable meaningful discussions with proponents of landfill sites it was initially necessary to quantify the magnitude of radioactivity in the solid waste.

Processes to remove radionuclides were identified from a literature survey and references are given in Chapter 7.

3.2 Quantification of Solid Waste

The mass of solid waste produced each day when the plant is operating at peak production may be determined from knowledge of the incoming flow rate from the Birdrong Aquifer and the water quality. The water quality given in the report entitled Design Basis for Water Quality, reference WS0-9211-PRO-BOD-WOR-000-00001-000 gives the following inlet water quality,

- Radionuclide activity of 10.92 Bq/L, excluding radon, comprising of
  - Radium 226 activity of 2.45 Bq/L
  - Radium 228 activity of 8.35 Bq/L
  - Thorium 228 activity of 0.12 Bq/L
- Iron concentration of 1 mg/L
- Manganese concentration of 0.2 mg/L

At a flow rate of 3755 m^3/day this equates to the following removal quantities per day on the basis of 100% removal,

- Radionuclides 41 $x10^6$ Bq/day
- Iron 7.1 kg/day as $Fe(OH)_3$
- Manganese 1.2 kg/day as MnO_2

4 LANDFILL DISPOSAL

4.1 Western Australian Stakeholders

Several Western Australian government departments and agencies are associated with solid waste disposal in the State. The requirement for landfill sites is documented in,

- Landfill Waste Classification and Waste Definition 1996 (As amended December 2009.)

An excerpt from this document giving definitions and information on the various landfill classes is given in Appendix A. Notable is the absence of any criterion for the activity of radiological material, other than reference to intractable waste at a Class V facility.

From discussion with various government departments regarding disposal of radioactive waste it became evident that the department to which they all deferred was the Department of Public Health, and more specifically the Radiological Council within that department.

The Radiological Council confirmed that the maximum activity for acceptance of radioactive solid waste at a Class IV landfill site is 250 Bq/kg. The only available disposal route for waste having higher levels of activity is to the Class V intractable waste disposal site at Mount Walton East.

4.2 Waste volume for disposal at a prescribed landfill site

The disposal of iron and manganese waste to a prescribed landfill site does not raise any specific issues. The only requirement is that the dewatered waste is spadeable and not in a liquid or slurry form.

This study specifically addresses the disposal of radionuclides, either with or without iron and manganese present, and does raise a potential issue relating to the radiological activity. With reference to the total daily activity in the water from the Birdrong Aquifer stated in Section 3.2, to be below the threshold value of 250 Bq/kg will require that the radionuclides are contained in a mass of 164 tonnes.

Further sampling and analysis might reveal a lower radiological activity in the water from the Birdrong Aquifer and a process to remove radionuclides might not be 100% efficient. However, from the foregoing simple calculation it can be concluded that the solids mass requiring removal off site each day is too great for disposal to a prescribed landfill site.

4.3 Mount Walton East facility

The proponent for the Mount Walton East facility is the Department of Finance and the location of the facility is shown in Figure 4.1. The site is considered by the Department as a site of last resort and a comprehensive submittal is required to determine if a waste qualifies for acceptance. The waste acceptance guideline is given in Appendix B. It is important to appreciate that there is no guarantee that waste can be disposed at Mount Walton East. Acceptance is at the discretion of the Department of Finance.

The facility is not frequently used; it was last used in 2008 and before that in 2002. Disposal involves mobilising a mining operation with all associated infrastructure and camps to construct a deep shaft or open cut to bury the waste in a controlled manner. The method of burial is dictated by the nature of the waste. It is an extremely expensive operation and the cost is passed onto the entity responsible for generating the waste.

The Department of Finance maintains a register of interested parties with radioactive waste and will mobilise a disposal operation at Mount Walton East when the amount of radioactive waste justifies opening the facility. Prior to disposal each producer of radioactive waste is responsible for storing and managing the waste until it can be accepted at Mount Walton East.

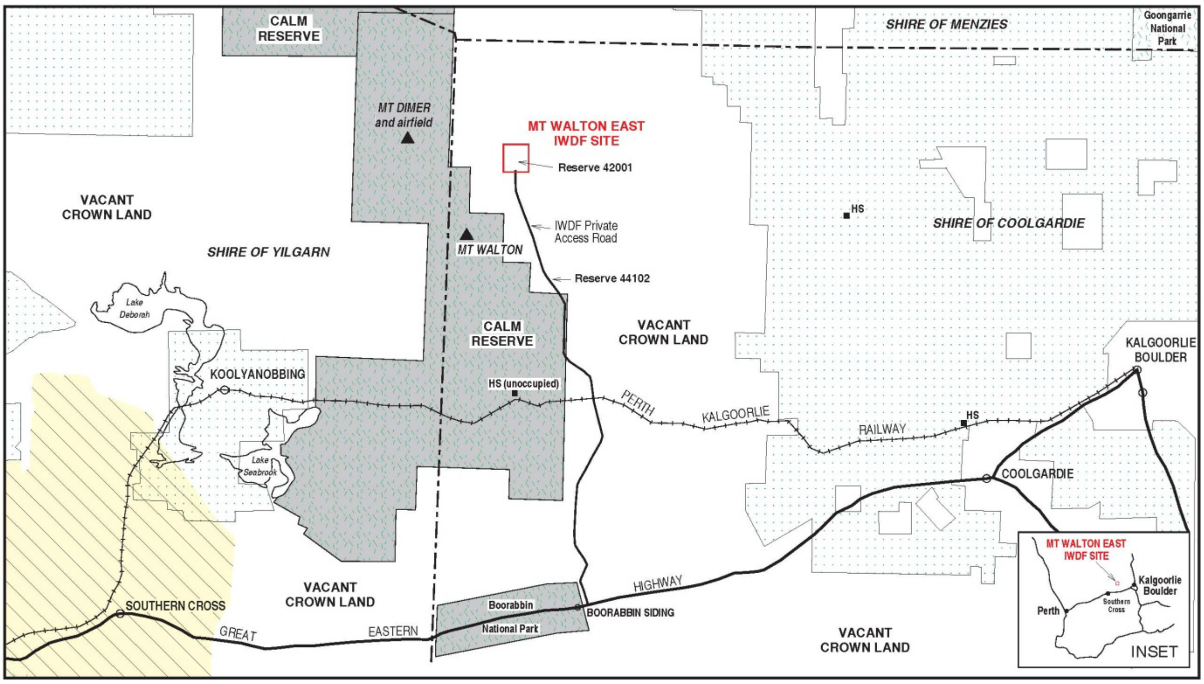

Figure 4-1 Location of Mount Walton East

4.4 Summary of disposal options

It is not practical to dispose of solid waste at landfill sites because of the large volume of inert matter required to achieve the threshold activity of 250 Bq/kg.

It has been assumed that blending on site with inert soil and then burial, as sometimes practiced by large mining operations, is not acceptable. Therefore this leaves Mount Walton East as the only disposal option available; however this option does have its own specific requirements and features, namely

- There is no guarantee that the proponent for the Mount Walton East facility will accept the waste
- Disposal will be an extremely expensive operational cost
- The Water Corporation will have to store the solid waste until it is able to be received at Mount Walton East. This might be for many years of operation.
- Solids waste storage on site would need to be managed in a controlled manner with all the appropriate Management Plans and procedures for addressing the HSE requirements.

5 TREATMENT OPTIONS FOR RADIONUCLIDE REMOVAL

5.1 Process investigations

The treatment process investigated in this study has to result in a solid waste, concentrating the components into a slurry stream or liquid is not acceptable because the stream is not able to be discharged to another facility.

The investigation primarily focussed on radium removal with the objective of,

1. Identifying a process for radium removal with concurrent removal of iron and manganese.

2. Identifying a process solely for radium removal

Processes to remove only iron and manganese were not considered.

The USEPA site provided a comprehensive resource for investigating different approaches and it was concluded that the following processes satisfied the above objectives.

- Lime softening is able to achieve removal of radium as well as iron and manganese, although not all radium is removed. Simple lime softening to remove calcium will achieve approximately 50% to 80% removal of radium, elevating the operating pH to also remove magnesium is able to achieve up to 90% radium removal.

  In the calculations in Section 5.2 it has been assumed that the lime softening process will only remove radium, it will not remove other radionuclides present in the water.

- Ion exchange resins to remove barium and radium have been used in locations such as central Europe to address water polluted with radium. The resin is not regenerated and is discharged as a radioactive solid mass in a suitable contained vessel to meet HSE requirements.

With reference to the initial scope of work, the expectation was that the characteristics of the solid waste and cost of waste disposal of each option would be defined in sufficient detail so enable possible implementation at the FEED stage. However, this was predicated on the basis of constructing a radium removal process for disposal of solid waste to landfill. Discussion in Chapter 4 has highlighted issues in removing radioactive waste from the site on a continuous basis.

The scope has therefore been amended to only give an overview of each of the processes for removing radium and an estimation of the quantity of waste solid produced, there is no requirement to gauge operational costs.

5.2 Lime Softening

Lime softening involves balancing the process chemistry to remove magnesium and calcium as insoluble precipitates. The extent of magnesium removal is dictated by pH; calcium removal requires a stoichiometric balance between calcium and the carbonic species present in the water at the required pH. Removal of magnesium requires operation at a higher pH than that required for calcium, it also consumes more chemicals with increased sludge production.

Although the detailed design of the process train is not required for this report, a lime softening system is a complex process that will involve the following units operations.

- Bulk lime storage
- Milk of lime preparation and dosing system
- Bulk sodium carbonate storage
- Sodium carbonate solution preparation and dosing system
- Reactor clarifier
- Sludge extraction and storage tank
- Dewatering centrifuges
- Cake conveyors
- Cake storage
- Sulphuric acid storage and dosing system to reduce treated water pH

The dewatering system is required in order to produce a spadeable cake suitable for transport off site.

It is possible to incorporate the softening process upstream or downstream of the reverse osmosis system. Upstream and downstream configurations are shown in Figure 5-1 and Figure 5-2 respectively.

Upstream installation will remove a potential scalant from the feed water and enable the reverse osmosis system to operate at a higher recovery without total reliance on anti-scalant. However more comprehensive monitoring and control will be required to minimise the impact of process upsets on the downstream reverse osmosis system. The hydraulic throughput and equipment sizing will be greater than downstream installation.

The advantage of downstream operation is that operation is divorced from the reverse osmosis system and drinking water production is not compromised. Although the hydraulic load is lower, the mass load of ionic species is the same and chemical consumption and the mass of waste solids will not change.

The example below has been based on lime softening downstream of the reverse osmosis system. Relevant feed conditions are given in Table 5-1.

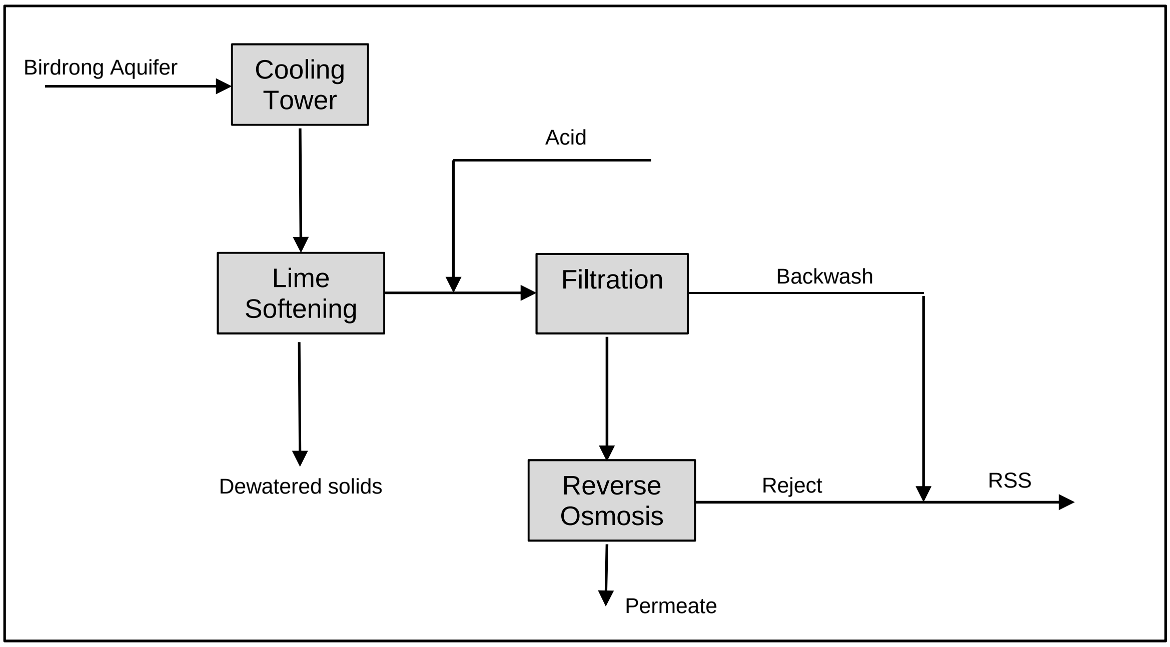

Figure 5-1 Lime Softening Upstream of Reverse Osmosis

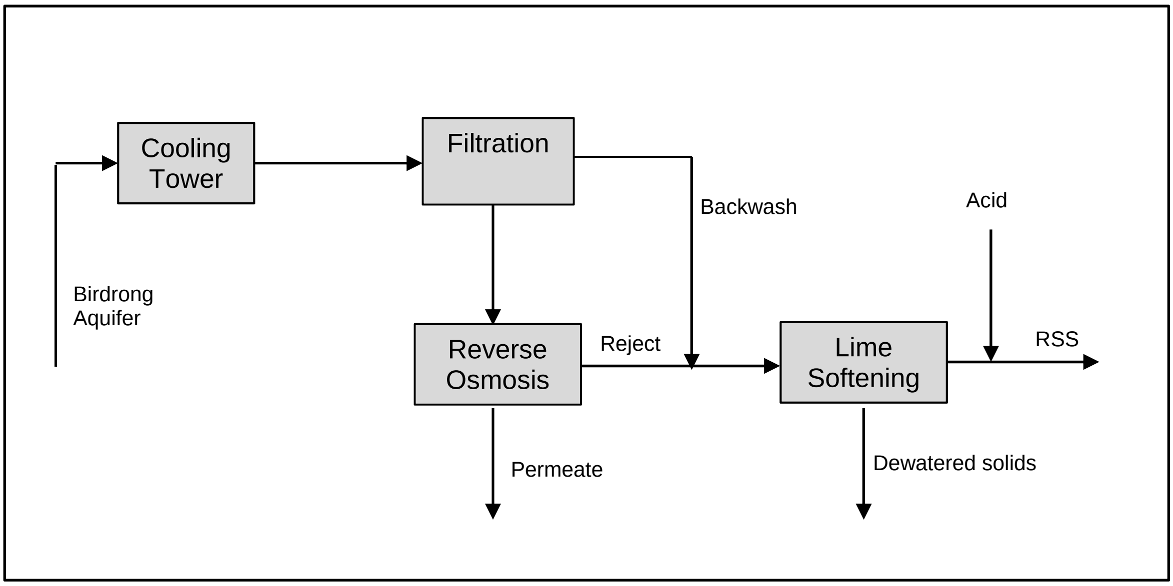

Figure 5-2 Lime Softening Downstream of Reverse Osmosis

Table 5-1 Feed water quality to softening system

	Units	Value
Feed flow	m^3/day	1,594
pH		7.68
Bicarbonate	mg/L	1,277
Calcium	mg/L	752
Magnesium	mg/L	376
Radium	Bq/L	25.4
Radionuclide	Bq/L	25.6

The operating pH and chemical addition is dictated by the required calcium concentration in the treated water; to a lesser extent it is affected by temperature. The process will require the addition of the following chemicals for calcium removal,

- 100% hydrated lime dose rate of 804 mg/L
- Sodium carbonate dose rate of 883 mg/L

The resulting concentration of calcium carbonate produced from the reaction would be 2,966 mg/L. The RSS quality with respect to radionuclides is shown in Table 5-2. The water will be devoid of iron and manganese.

Table 5-2 RSS radionuclide quality for softening process to remove calcium

	Units	50% removal efficiency	80% removal efficiency
Radium	Bq/L	12.8	5.1
Radionuclide	Bq/L	13.0	5.4

The RSS would be in a supersaturated state and require sulphuric acid addition for stabilisation and to achieve a pH more acceptable for discharge.

The mass of calcium carbonate produced from the feed flow of 1,594 m^3/day would be 4,728 kg/day DS. The cake characteristics are given in Table 5-3. It has been assumed that hydrated lime is 91% active, containing 9% inert material. A cake specific gravity of 1500 kg/m^3 has been assumed.

Table 5-3 Cake produced by softening process to remove calcium

	Units	Value
Cake mass	kg/d DS	4,856
Cake dryness	% w/v	50%
Wet cake volume	m^3/d	9.7
Radionuclide activity in cake at 50% removal efficiency	Bq/kg	1,412
Radionuclide activity in cake at 80% removal efficiency	Bq/kg	2,246

If the process is operated to remove magnesium as well as calcium the requirements for chemical addition will increase and the process will operate at a higher pH. The process will require the addition of the following chemicals for calcium and magnesium removal,

- 100% hydrated lime dose rate of 1,963 mg/L
- Sodium carbonate dose rate of 2,544 mg/L

The resulting concentration of insoluble products from the reaction would be

- Calcium carbonate concentration of 4,533 mg/L
- Magnesium hydroxide concentration of 909 mg/L

The RSS quality is shown in Table 5-4. A radium removal efficient of 90% has been considered in this case.

Table 5-4 RSS quality for softening process to remove calcium and magnesium

	Units	Value
Radium	Bq/L	2.6
Radionuclide	Bq/L	2.8

The treated water would be in a supersaturated state and require sulphuric acid addition for stabilisation and to achieve a pH more acceptable for discharge.

The mass of calcium carbonate and magnesium hydroxide produced from the feed flow of 1594 m^3/day would be 8673 kg/day DS. The cake characteristics are given in Table 5-5.

Table 5-5 Cake produced by softening process to remove calcium and magnesium

	Units	Value
Calcium carbonate	kg/d DS	7,225
Magnesium hydroxide	kg/d DS	1,448
Total cake mass, including inerts	kg/d DS	8,983
Cake dryness	% w/v	50%
Wet cake volume	m^3/d	18.0
Radionuclide activity	Bq/kg	1,364

In all cases the radioactivity in the sludge is greater than the regulatory limit for disposal to a landfill site.

The volume of solid waste generated for a lime softening process is considerable and the process will consume appreciable quantities of lime and soda ash. A summary of chemical consumption and waste volume is given in Table 5-6.

Table 5-6 Summary of solids waste production and chemical consumption

	Units	Calcium removal	Calcium and magnesium removal
Solid waste volume	m^3/d	9.7	18.0
Lime consumption	kg/d	1,408	3,439
Soda ash consumption	kg/d	1,408	4,055

The process has been demonstrated to remove radionuclides, however the quantum able to be removed can only be determined from pilot plant trials. It is possible that a calcium removal process might only be able to achieve a level of removal that will produce a RSS with radioactivity comparable to that in the original water from the Birdrong Aquifer. In this case the enhanced process that also removes magnesium would be more appropriate in that it gives more demonstrative removal of radionuclides.

5.3 Ion Exchange

The ion exchange process is based upon a selective retention of barium and radium on a proprietary resin especially formulated for radium removal. A data sheet on such a resin is given in Appendix C.

The high ionic concentration of the water will not affect the exchange ability of the resin. A typical application is removing radium from the saline regenerant stream from a more conventional ion exchange resin that has sodium chloride concentrations as high as 10%.

It is proposed to locate the ion exchange system downstream of the reverse osmosis system where the flow rate is lower and the radionuclides are more concentrated.

Correspondence with Dow who supply the Dowex RSC resin has suggested that the following design values are used,

- Throughput should be between 1 and 3 bed volumes per hour
- Loaded resin can achieve an activity of 7800 nCi/litre of resin, this equates to 370 Bq/gram

The design values will need to be confirmed with pilot plant testing.

The incident radium load is 40 x10^6 Bq/day which equates to 1.09 x10^6 nCi/day. On the basis of a loading capacity of 7800 nCi/L the rate of exhaustion of resin will be 140 L/day.

On the assumption the process will operate at a throughput of 2 BV/hour, the volume of the resin bed will be 33 m^3. At an exhaustion rate of 140 L/day the bed will last 237 days between resin replacement, this has assumed that the plant is operating continuously at a production of 2 ML/day. If an annual production of 444 ML is assumed then a single vessel could process the annual water production from the plant.

The process train will comprise of two vessels in series with the piping configured so that either vessel can be the lead vessel. After an exhausted vessel is removed, the partially loaded second vessel will become the lead vessel for future operation and a fresh vessel located in the now second position.

Handling the high radioactivity of the resin in the vessel will pose HSE concerns and a safer approach might be to dispose of the vessel and the resin so that the vessel is not opened.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Removal of radionuclides by lime softening or ion exchange will reduce the level of activity in the RSS, however the solid waste from these processes will not be acceptable for disposal at a Class IV landfill site in Western Australia. If the Department of Finance will accept the waste at Mount Walton East then there will be a requirement to store the solid waste on site until such a time that it can be accepted.

The quantum of waste generated by the lime softening process is considerable and possibly too large to store and manage on site. Assuming the enhanced process is installed then the annual volume of waste will be around 4,000 m^3, this has assumed an annual water demand from the new plant of 444 ML. Additionally the level of radioactivity associated with this type of waste and the need for Operators to come into contact with the waste will pose HSE issues.

Treatment by ion exchange is a more elegant method of treating the RSS prior to discharge. The resin can be installed in a sacrificial vessel so that plant operators do not need to contact the loaded resin. The volume of waste generated each year will be considerably less than the lime softening approach. Depending upon the annual water demand it might be possible that a single vessel containing 33 m^3 of resin could process all of the RSS produced in a year of operation.

The cost for solid waste disposal has not been determined because there is no available disposal site that is open for continuous acceptance of waste.

From the waste quantities generated from the two process options it could be reasoned that the ion exchange approach would be less expensive option because of the much lower waste quantity, albeit that the waste associated with ion exchange is much more radioactive.

6.2 Recommendations

There is no disposal pathway for continuous disposal of solid waste containing radium with a radioactivity is excess of 250 Bq/kg. On this basis there is no obvious motivation for removing radionuclides from the RSS.

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7 REFERENCES

The following references were used to identify process options for radium removal.

1. US EPA website, Radionuclides Decision Tree, Lime Softening
2. USEPA, Barium and Radium in Water Treatment Plant Wastes, EPA/600/S2-85/006 Mar 1985. Vernon L Snoeyink, Candy K Jongeward, Anthony G Meyers and Sharon K Richter
3. Radium Removal Technologies for Potable Groundwater Systems. Michael Havener
4. Fundamentals of Radium and Uranium Removal from Drinking Water Supplies. Dennis Clifford, University of Houston.
5. Removing radioactive contamination from ion exchange resins used in drinking water treatment. James McMahon and M R Collins. Department of Civil Engineering. University of New Hampshire. 3 April 2007.
6. USEPA, Removal of Barium and Radium from Groundwater, EPA/600/M-86/021 Feb 1987. Vernon L Snoeyink, Carl C Chambers, Candace K Schmidt, Rick F Manner, Anthony G Myers, Julie L Pfeffer, Sharon K Richter, David W Snyder.

APPENDIX A Landfill Waste Classification and Waste Definition

Department of
Environment and Conservation

Our environment, our future

Landfill Waste Classification and

Waste Definitions

1996

(As amended December 2009)

WESTERN AUSTRALIA
DEPARTMENT OF ENVIRONMENT AND CONSERVATION

Landfill Waste Classification and Waste Definitions 1996

(As amended December 2009)

This document provides definitions for the classification of landfills and wastes in Western Australia and supersedes all previous versions and amendments.

Published by the Director General, Department of Environment and Conservation on 17 December 2009 pursuant to items 63, 64, 65 and 66 in Schedule 1, Part 1 of the *Environmental Protection Regulations 1987*.

FOREWORD

This document is intended to provide guidance and criteria to be applied in determining the classification of wastes for acceptance to landfills licensed or registered in Western Australia in accordance with Part V of the *Environmental Protection Act 1986*. More stringent waste acceptance criteria than those listed in this document may be imposed by landfill operators. Similarly, Department of Environment and Conservation (DEC) licence conditions may apply more stringent acceptance criteria as appropriate.

Where additional guidance is required, landfill operators should contact the relevant licensing officer using the contact information provided in the licence. Alternatively, advice may be sought from licensing officers at the following locations:

KWINANA/Peel
Telephone: (08) 9411 1777
Postal Address:
PO Box 454
KWINANA WA 6168

GERALDTON/MidWest
Telephone: (08) 9921 5955
Postal Address:
PO Box 72
GERALDTON WA 6531

ALBANY/South Coast
Telephone: (08) 9842 4500
Postal Address:
120 Albany Highway
ALBANY WA 6330

BUNBURY/Southwest
Telephone: (08) 9725 4300
Postal Address:
PO Box 1693
BUNBURY WA 6231

KALGOORLIE/Goldfields
Telephone: (08) 9080 5555
Postal Address:
PO Box 10173
KALGOORLIE WA 6432

KARRATHA/Pilbara
Telephone: (08) 9182 2000
Postal Address:
PO Box 835
KARRATHA WA 6714

KUNUNURRA/Kimberley
Telephone: (08) 9168 4200
Postal Address:
PO Box 942
KUNUNURRA WA 6742

PERTH/Swan Region
Telephone: (08) 9333 7510
Postal Address:
Swan Region/IR
Locked Bag 104
BENTLEY DELIVERY CENTRE WA 6986

General information on waste and landfill licensing policy can be obtained from the DEC's Environmental Regulation Branch on 6467 5000. Advice on waste management policy can be obtained from the DEC's Waste Management Branch on 6467 5000.

Use of the acceptance criteria in this document for filling of landfills in no way predetermines the future development status of a landfill site following closure. Normal contaminated site management, development, and environmental approval processes still apply to closed landfills.

LANDFILL CLASSES AND THE WASTES THEY ACCEPT

Table 1 below, lists the types and classes of landfill and the types of wastes each class of landfill can accept.

Table 1 Landfill classes and waste types

LANDFILL CLASS	COMMON NAME	WASTE TYPES PERMITTED FOR DISPOSAL
Class I (Prescribed Premises Category 63)	Inert Landfill	• Clean Fill • Type 1 Inert Waste • Contaminated solid wastes meeting waste acceptance criteria specified for Class I landfills (possibly with specific licence conditions) • Type 2 Inert Waste (with specific licence conditions) • Type 3 Inert Waste (subject to DEC approval) • Type 1 Special Waste
Class II (Prescribed Premises Category 64 or 89)	Putrescible Landfill	• Clean Fill • Type 1 Inert Waste • Putrescible Wastes • Contaminated solid waste meeting waste acceptance criteria specified for Class II landfills (possibly with specific licence conditions) • Type 2 Inert Wastes (with specific licence conditions) • Type 1 and Type 2 Special Wastes (for registered sites as approved under the Controlled Waste Regulations)
Class III (Prescribed Premises Category 64)	Putrescible Landfill	• Clean Fill • Type 1 Inert Waste; • Putrescible Wastes; • Contaminated solid waste meeting waste acceptance criteria specified for Class II or Class III landfills (possibly with specific licence conditions) • Type 2 Inert Wastes (with specific licence conditions) • Type 1 and Type 2 Special Wastes
Class IV (Prescribed Premises Category 65)	Secure Landfill	• Clean Fill • Type 1 Inert Waste; • Contaminated solid waste meeting criteria specified for Class II, Class III or Class IV landfills (possibly with specific licence conditions) • Type 2 Inert Wastes (with specific licence conditions) • Type 1 and Type 2 Special Wastes
Class V (Prescribed Premises Category 66)	Intractable Landfill	• Intractable and other wastes in accordance with the approvals for the site.

Note: Materials used for rehabilitation and final landforming (including Class I landfills) need not be wastes, and may include clean fill and soil mixes incorporating mulches, grass sods, peat and biosolids. Rehabilitation of landfills should be conducted primarily with sand and loam to a depth generally not exceeding two metres and may involve the use of neutralised peat or acid sulfate soils or other organic matter to aid soil structure, but not as the main ingredients.

DEFINITIONS

WASTES

Clinical Waste	Waste generated by medical, nursing, dental, veterinary, pharmaceutical or other related activity which is poisonous or infectious; likely to cause injury to public health; or contains human tissue or body parts.
Biosolids	The stabilised organic solids, produced by wastewater treatment processes, which in most cases can be beneficially used (also known as sewage sludge).
Clean fill	Material that will have no harmful effects on the environment and which consists of rocks or soil arising from the excavation of undisturbed material. For material not from a clean excavation, it must be validated to have contaminants below relevant ecological investigation levels (as defined in the document Assessment Levels for Soil, Sediment and Water, Department of Environment, 2003).
Construction and Demolition Waste	Materials in the waste stream which arise from construction, refurbishment or demolition activities.
Controlled waste	Waste types listed in Schedule 1 of *the Environmental Protection (Controlled Waste) Regulations 2004*.
Cytotoxic Waste	Waste consisting of cytotoxic drugs, material contaminated with cytotoxic drugs or residues, or preparations containing cytotoxic material.
Hazardous Waste	Component of the waste stream which by its characteristics poses a threat or risk to public health, safety or the environment (includes substances which are toxic, infectious, mutagenic, carcinogenic, teratogenic, explosive, flammable, corrosive, oxidising and radioactive).
Inert Waste Type 1	Non-hazardous, non-biodegradable (half-life greater than 2 years) wastes containing contaminant concentrations less than Class I landfill acceptance criteria but excluding paper and cardboard (paper and cardboard are bio-degradable materials and are therefore considered as putrescible waste), and materials that require treatment to render them inert (e.g. peat, acid sulfate soils).
Inert Waste Type 2	Waste consisting of stable non-biodegradable organic materials such as tyres and plastics which require special management to reduce the potential for fires.
Inert Waste Type 3	Waste material from DEC licensed secondary waste treatment plants, subject to appropriate assessment and approval of that waste and the specified inert landfill.
Intractable Waste	Waste which is a management problem by virtue of its toxicity or chemical or physical characteristics which make it difficult to dispose of or treat safely, and is not suitable for disposal in Class I, II, III and IV landfill facilities (see Table 2).
Packaged Waste	Waste packed into discrete containers such as 205 L drums or bulka bags so that they meet any requirements under the *Explosives and Dangerous Goods Act 1988* and the *Environmental Protection Act 1986* for packaging, containment and labelling.
Putrescible	Component of the waste stream likely to become putrid.
Poisons	Materials defined as poisons under the *Poisons Act 1964*.

Radioactive	Waste which gives off or is capable of giving off radiant energy in the form of particles or rays, as in alpha, beta and gamma rays at levels exceeding standards defined by the Radiological Council of Western Australia.
Solid	Material that: (a) has an angle of repose of greater than 5 degrees; and (b) does not contain, or is not comprised of, any free liquids; and (c) does not contain, or is not comprised of, any liquids that are capable of being released when the waste is transported; (d) does not become free flowing at or below 60 degrees Celsius or when it is transported; and (e) is generally capable of being moved by a spade at normal temperatures (i.e. is spadeable).
Solid Waste	Waste which meets the definition of a solid.
Special Waste Type 1	Waste which includes asbestos and asbestos cement products.
Special Waste Type 2	Waste consisting of certain types of biomedical waste which are regarded as hazardous but which, with the use of specific management techniques, may be disposed of safely within specified classes of landfill.
Waste	For the purpose of these guidelines waste may mean one or more of the following: • any substance that is discarded, emitted or deposited in the environment in such volume, constituency or manner as to cause an alteration in the environment; • any discarded, rejected, unwanted, surplus or abandoned substance; • any otherwise discarded, rejected, unwanted, surplus or abandoned substance intended for sale or for recycling, reprocessing, recovery, or purification by a separate operation from that which produced the substance; • any substance described in regulations under the *Environmental Protection Act 1986* as waste.

TECHNICAL TERMS

Acceptance Criteria	Refers to the concentration and leachate criteria published in this document (these may be varied for individual landfills in accordance with specific licence conditions).
Biodegradable	Capable of being decomposed by the action of biological processes.
Class I landfill	An un-lined landfill designed to accept inert wastes.
Class II landfill	An un-lined landfill designed to accept putrescible and inert wastes.
Class III landfill	A lined landfill, which may include leachate collection, designed to accept putrescible and inert wastes.
Class IV landfill	A double-lined landfill with leachate collection, designed to accept contaminated soils and sludges (including encapsulated wastes).
Class V landfill	The Mount Walton East Intractable Waste Disposal Facility.
Contaminant	Substance or object in contact or mixed with a material that poses a risk of harm to human health or the environment.
Contaminated Soil	Soil that contains chemical substances or wastes at concentrations above background levels that present, or have the potential to present, a risk of

	harm to human health or the environment.
Disposal	Final stage in the management of the waste stream.
Encapsulation	The process of enclosing a waste within a secure container such as to render it acceptable for long-term disposal.
Flammable	Materials that are readily combustible.
Immobilisation	The process of fixing or locking up contaminants in a waste such as to render it suitable for long-term disposal.
Landfill	A site used for disposal of solid material (i.e. is spadeable) by burial in the ground that is licensed as a landfill under the *Environmental Protection Act 1986*.
Leaching Procedure	Procedures specified in AS 4439.3-1997 Wastes, Sediments and Contaminated Soils - Preparation of leachates - Bottle leaching procedures.
Practical quantitation limit	The lowest concentration that can be reproduced and measured in a laboratory in routine laboratory analyses irrespective of any interference caused by the presence of other substances, such as chemicals, during the analysis. The practical quantitation limit value of any analyte is significantly higher than its detection limit value.
Reuse	Use of a product again for the same or a different purpose without further manufacture.
Spadeable	A physical state of a material where the material behaves sufficiently like a solid (as described above) to be moved by a spade at normal outdoor temperatures.
Storage	Placement of material in one place for more than one day with the intention to relocate, reuse or dispose of the material within a time limit specified before commencement of such storage.
Treatment	Physical, chemical or biological processing of a waste for disposal or reuse.

ABBREVIATIONS

ADGC	Australian Dangerous Goods Code.
ADWG	Australian Drinking Water Guidelines 2004.
ASLP	Australian Standard Leaching Procedures - The procedures specified in AS 4439.3-1997 for assessing the leachability of wastes, sediments and contaminated soils.
I1, I2, I3	Type 1, Type 2 or Type 3 inert waste.
IWDF	Mount Walton East Intractable Waste Disposal Facility (Class V landfill).
NEPM	National Environmental Protection Measure on the Assessment of Site Contamination.
S1, S2, S3	Type 1, Type 2, or Type 3 Special waste.
TCLP	Toxicity Characteristic Leaching Procedure.

For other definitions the reader is referred to the Australian/New Zealand Standard AS/NZS 3831:1998, Waste Management - Glossary of Terms.

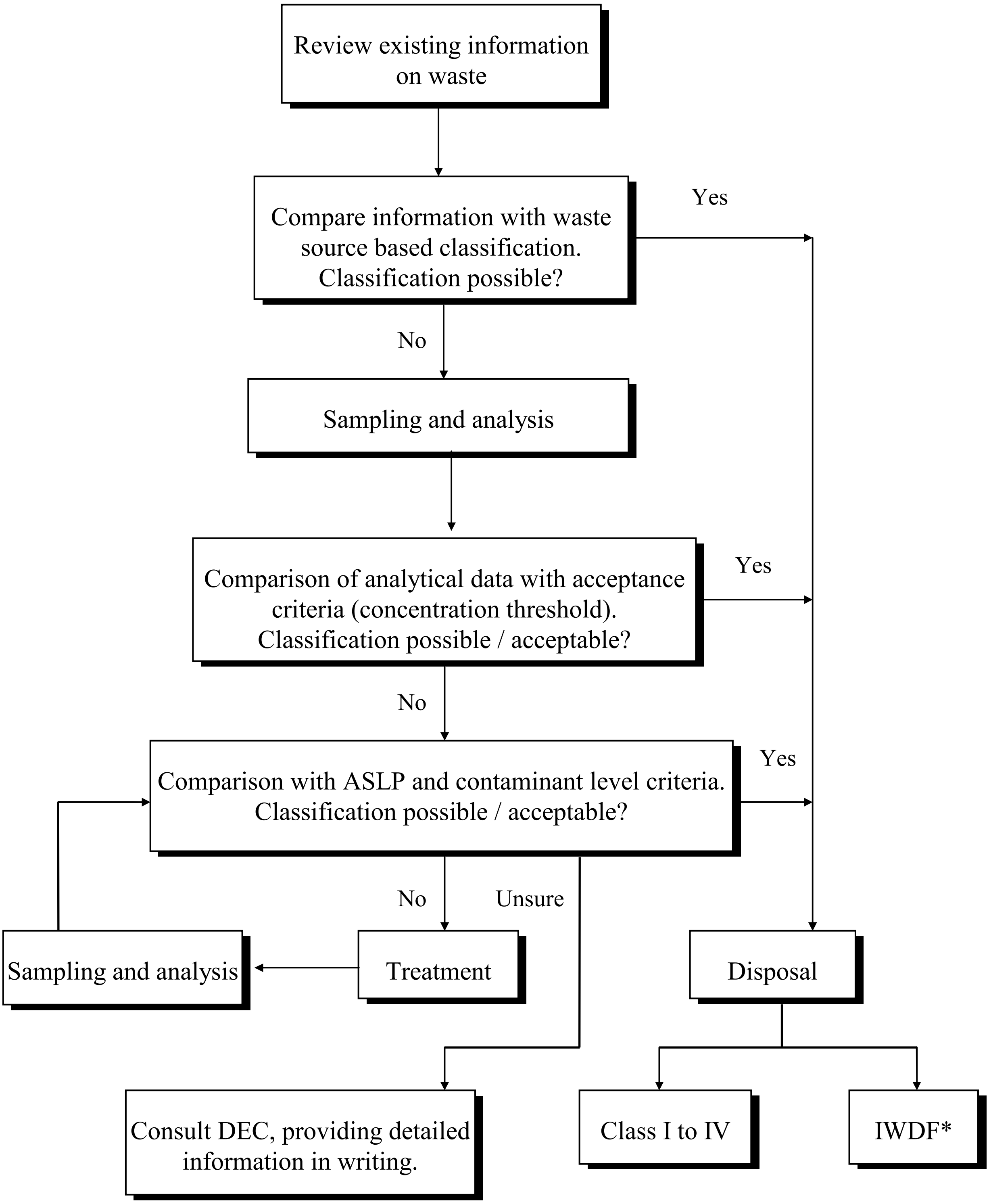
CLASSIFICATION OF WASTE INTO WASTE TYPES AND LANDFILLS

The following process is summarised in Figure 1.

Step 1 Ensure that an assessment needs to be done	The broad classifications used in W A when assessing wastes for landfill disposal are described in Table 1 along with detailed examples of the specific waste types involved. If a waste can be classified according to Table 2, there is no requirement for more detailed assessment.
Step 2 Assess the waste	If the waste cannot be classified in Step 1, based on an assessment of the waste source and characteristics, determine the concentration of relevant contaminants in the waste.
Step 3 Compare total concentration values with CT criteria in Table 3	Compare the contaminant concentrations with the maximum contaminant threshold (CT) values in Table 3 and assign a classification for each contaminant. Provisionally classify the waste according to the highest category assigned to any contaminant. If this classification is satisfactory, dispose of the waste accordingly.
Step 4 Determine contaminant ASLP leachate concentrations	If the classification in step 2 is not acceptable, or any contaminant concentration exceeds the relevant CT value, determine the ASLP leachate concentrations for all relevant contaminants.
Step 5 Compare total and leachate concentrations with CL and ASLP criteria in Table 4	Compare the contaminant ASLP concentrations and total concentrations with the ASLP and concentration limit (CL) values in Table 4. Use Table 5 as a guide to interpretation of the data for each contaminant. Provisionally classify the waste in the highest category assigned to any contaminant. If this classification is satisfactory, dispose of the waste accordingly.
Step 6 Test the immobilised waste against the ASLP criteria in Table 4	If the classification in step 4 is unacceptable, apply some form of immobilisation to the waste, then, after further leachate testing, apply the ASLP criteria only, to determine the appropriate waste classification as set out in step 5. Encapsulated waste need not be further tested, but approval of the encapsulation method must be obtained from the DoE. Note that separate DoE approval is not required for disposal of immobilised waste, but it must be disposed of as follows: • Immobilised or encapsulated Class V waste – to Class IV landfill • Immobilised or encapsulated Class IV waste – to Class III landfill • Immobilised Class III waste – to Class II landfill

For organic and inorganic chemical contaminants not listed in the tables, contact the DEC for assessment/disposal requirements. The DEC should also be consulted about uncertainties in steps 5 and 6 above.

Figure 1 Management of solid waste disposal



* Disposal at the IWDF is only permitted if no alternative is available and is subject to EPA approval.

Table 2 Waste types

Table 2a Clean fill and inert waste

WASTE TYPE	DESCRIPTION
Clean Fill	Material that will have no harmful effects on the environment and which consists of rocks or soil arising from the excavation of undisturbed material.
	Examples: Virgin excavated natural material (e.g. clay, gravel, sand, soil and rock), or such material that is mixed with: • waste that has been excavated from areas that are not contaminated as a result of industrial, commercial, mining or agricultural activities, with manufactured chemicals, and does not contain sulfidic ores or soils (e.g. acid-sulfate soils and peats), or • materials not from a "clean excavation" that have been validated to meet relevant ecological investigation levels.
Inert	Wastes that are largely non-biodegradable, non-flammable and not chemically reactive. Inert wastes are subdivided into three separate classes: • Type 1 - Inert Wastes are as listed below and contain contaminants in concentrations less than the specified criteria. • Type 2 - Wastes consisting of non-biodegradable organic materials such as tyres and plastics, which are flammable and require special management to reduce the potential for fires. • Type 3 - Waste material from DEC licensed secondary waste treatment plants, subject to appropriate assessment and approval of that waste and the specified landfill.
	Examples of Type 1 inert wastes: • Building and demolition waste (e.g. bricks, concrete and associated unavoidable small quantities of paper, plastics, glass, metal and timber[1] that should be recovered), being material resulting from the demolition, erection, construction, refurbishment or alteration of buildings or from the construction, repair or alteration of infrastructure-type development such as roads, bridges, dams, tunnels, railways, and airports, and which is not mixed with any other type of waste (specifically green and food waste), and does not contain any asbestos. • Asphalt waste (e.g. resulting from road construction and waterproofing works). • Biosolids categorised for unrestricted use. • Casting sand (that does not contain leachable components which would require disposal in a higher class of landfill). • Blasting sand or garnet (excluding that used for stripping tributyl tin-containing paints). **Examples of Type 2 inert wastes:** Used, rejected or unwanted tyres (including shredded tyres or tyre pieces).
Notes:	1. Treated timber such as copper chrome arsenate (CCA), high temperature creosote (HTC), pigment emulsified creosote (PEC) and light organic solvent preservative (LSOP) treated timber are to be excluded from the waste.

Table 2b Putrescible waste

<table>
<tr><th>WASTE TYPE</th><th>DESCRIPTION</th></tr>
<tr><td>Putrescible</td><td>Component of the waste stream likely to become putrid - including wastes that contain organic materials such as food wastes or wastes of animal or vegetable origin, which readily bio-degrade within the environment of a landfill.</td></tr>
<tr><td></td><td>Examples:
• Municipal waste, consisting of:
  * household domestic waste that is set aside for kerb-side collection or delivered by the householder directly to the waste facility; or
  * other types of domestic waste (e.g. domestic clean-up, furniture and residential garden waste, grass sods); or
  * local council generated waste (e.g. waste from street sweeping, litter bins and parks); or
  * commercial waste generated from food preparation premises, supermarkets etc).
• Food waste
• Biosolids other than those categorised for unrestricted use.
• Sewage treatment plant grits and screenings.
• Animal manures and carcasses.
• Office and packaging waste (eg paper, cardboard, plastics, wood) that is not mixed with any other type of waste.
• Cleaned pesticide, biocide, herbicide or fungicide containers[2].
• Drained and mechanically crushed oil filters, and rags and oil absorbent materials (not containing free liquids) from automotive workshops.
• Disposable nappies, incontinence pads and sanitary napkins (not otherwise classified as biomedical wastes due to the presence of infectious material).
• Vegetative waste generated from commercial, public and residential sources, agriculture or horticulture.
• Non-chemical waste generated from manufacturing and services (including timber, paper, plastics, thermosets and composites.</td></tr>
<tr><td>Notes:</td><td>2. The cleaning method used should be as good as or better than the triple-rinsing method developed by AVCARE (Phone: (02) 6230 6399, Facsimile: (02) 6230 6355, web site: www.croplifeaustralia.org.au/).
3. Acid sulphate soils may only be accepted at class II, III, or IV landfills if they have been treated to neutralise acid-forming potential in accordance with the Department of Environment and Conservation document Treatment and Management of Acid Sulphate Soils prior to disposal.
Soils being disposed of from areas with known acid-sulfate soil potential should be checked for acidity before disposal.</td></tr>
</table>

Table 2c Hazardous and intractable waste

WASTE TYPE	DESCRIPTION
Hazardous	Component of the waste stream which by its characteristics poses a threat or risk to public health, safety or the environment (includes substances which are toxic, infectious, mutagenic, carcinogenic, teratogenic, explosive, flammable, corrosive, oxidising and radioactive. Hazardous wastes are generally unsuitable for landfill disposal and should only be accepted within landfills after appropriate treatment and/or in accordance with specific licence conditions or with specific, written approval from the Director, Environmental Management Division.

WASTE TYPE	DESCRIPTION
	Examples: • Wastes that meet the criteria for assessment as dangerous goods under the *Australian Code of Practice for the Transport of Dangerous Goods by Road and Rail*, and categorised as one of the following: explosives; gases (compressed, liquefied or dissolved under pressure); flammable liquids; substances liable to spontaneous combustion (excluding organic waste, and all physical forms of carbon such as activated carbon and graphite); substances which on contact with water emit flammable gases; oxidising agents and organic peroxides; toxic substances; corrosive substances. • Biomedical and related wastes. • Pharmaceuticals and poisons, being waste generated by activities carried out for business or other commercial purposes and that consists of pharmaceutical or other chemical substances specified as poisons in the *Standard for the Uniform Scheduling of Drugs and Poisons No. 13 (1998)*. • Quarantine waste.
Intractable	Waste that is a management problem by virtue of its toxicity or chemical or physical characteristics which make it difficult to dispose of or treat safely and is not suitable for disposal in a Class I, II, III or IV landfill. Provided there is no practical alternative destruction or treatment technology, these are disposed of in Class V facilities[4].
	Examples: • Radioactive wastes (disposal must be approved by the Radiological Council of Western Australia). • Significantly contaminated soils, industrial sludges, some spent catalyst wastes.
Notes:	4. The Mount Walton East Intractable Waste Disposal Facility is currently the only available Class V disposal site in Western Australia. Before disposal to the facility is approved, it is necessary to demonstrate to the Environmental Protection Authority that there are no practically available destruction, disposal or management technologies in Australia such that the site is maintained as a facility of last resort.

Table 2d Special waste

WASTE TYPE	DESCRIPTION
Special	Includes asbestos wastes and certain types of biomedical wastes that are regarded as hazardous but which, with special management techniques, may be disposed of safely within specified classes of landfill. • Type 1 Special Waste - Asbestos Wastes • Type 2 Special Waste – Biomedical Wastes
	Examples of Type 1 Special Waste: • Stabilised asbestos waste in bonded matrix (e.g. asbestos cement sheeting). • Asbestos fibre and dust waste (e.g. dust resulting from the removal of thermal or acoustic insulating materials or from processes involving asbestos material, and dust from ventilation collection systems). **Examples of Type 2 Special Waste:** • Biomedical waste which does not require incineration and which is approved for supervised burial.

Table 3 Contaminant threshold (CT) values for waste not requiring a leach test

Contaminant[1]	**Maximum Values of Total Concentration for Classification Without the Requirements to Assess Leachability**[2,3]			
	CT1 (mg/kg) Class I	**CT2 (mg/kg) Class II**	**CT3 (mg/kg) Class III**	**CT4 (mg/kg) Class IV**
Metals				
Arsenic	14	14	140	1,400
Beryllium	2	2	20	200
Cadmium	0.4	0.4	4	40
Chromium (Hexavalent)	10	10	100	1,000
Lead	2	2	20	200
Mercury	0.2	0.2	2	20
Molybdenum	10	10	100	1,000
Nickel	4	4	40	400
Selenium	2	2	20	200
Silver	20	20	200	2,000
Other Inorganic Species				
Cyanide (amenable)[4]	7	7	70	700
Cyanide (total)	16	16	160	1,600
Fluoride	300	300	3,000	30,000
Non-Chlorinated Organics				
Benzene	0.2	0.2	2	20
Cresols (total)	400	400	4,000	40,000
2,4-D	0.02	0.02	0.2	2
Ethylbenzene	60	60	600	6,000
Petroleum hydrocarbons	N/A	N/A	N/A	N/A
Phenol (total, non-halogenated)	28.8	28.8	288	2880
Polycyclic aromatic hydrocarbons (total)	N/A	N/A	N/A	N/A
Styrene (vinyl benzene)	6	6	60	600
Toluene	160	160	1,600	16,000
Xylenes (total)	120	120	1,200	12,000
Chlorinated Organics[5]				
Organochlorine pesticides, polychlorinated biphenyls etc.	N/A	N/A	N/A	N/A
Other metals[6]	**% by weight**	**% by weight**	**% by weight**	**% by weight**
Aluminium , barium, boron, cobalt, copper, manganese, vanadium and zinc	5	5	10	20

Notes:
1. For organic and inorganic chemical contaminants not listed in Table 3 contact the DEC for assessment / disposal advice.
2. Contaminant Threshold (CT) values based on 2004 Australian Drinking Water Guidelines (20 x ASLP criteria – uncorrected for practical quantitation limit).
3. N/A means no Contaminant Threshold applicable, however, the criteria in Table 4 apply.
4. Analysis for cyanide (amenable) is the established method to assess the potentially leachable cyanide. Other methods may be considered by DEC if it can be demonstrated that these methods yield the same information.
5. OCP scheduled wastes, polycyclic aromatic hydrocarbons and polychlorinated biphenyls are assessed by using concentration criteria (CL values - Table 4). No leaching analysis is required.
6. For waste containing significant quantities of these metals preference should be given to recovery and recycling rather than disposal.

Table 4 Leachable concentration (ASLP[1]) and concentration limit (CL[2]) values for waste classification

Contaminant	Leachable Concentration ASLP1 (mg/L) Class I	Concentration Limit CL1 (mg/kg) Class I	Leachable Concentration ASLP2 (mg/L) Class II	Concentration Limit CL2 (mg/kg) Class II	Leachable Concentration ASLP3 (mg/L) Class III	Concentration Limit CL3 (mg/kg) Class III	Leachable Concentration ASLP4 (mg/L) Class IV	Concentration Limit CL4 (mg/kg) Class IV
Metals								
Arsenic[3]	0.5	500	0.5	500	5	5,000	50	20,000
Beryllium[3,4]	0.1	100	0.1	100	1	1,000	10	4,000
Cadmium[3]	0.1	100	0.1	100	1	1,000	10	4,000
Chromium (hexavalent)	0.5	500	0.5	500	5	5,000	50	2,000
Lead	0.1	1,500	0.1	1500	1	15,000	10	60,000
Mercury	0.01	75	0.01	75	0.1	750	1	3,000
Molybdenum[4,5]	0.5	1,000	0.5	1,000	5	10,000	50	40,000
Nickel	0.2	3,000	0.2	3000	2	30,000	20	120,000
Selenium[3,5]	0.5	50	0.5	50	5	500	50	2,000
Silver[5]	1	180	1	180	10	1,800	100	7,200
Aluminium, barium, boron, cobalt, copper, manganese, vanadium and zinc	N/A	5% by weight	N/A	5% by weight	N/A	10% by weight	N/A	20% by weight
Other Inorganic Species								
Cyanide (amenable)[4]	0.35	1,250	0.35	1,250	3.5	12,500	35	50,000
Cyanide (total)	0.8	2,500	0.8	2,500	8	25,000	80	100,000
Fluoride[5]	15	10,000	15	10,000	150	100,000	1500	400,000
Non-Chlorinated Organics								
Benzene	0.01	18	0.01	18	0.1	180	1	720
Cresol (total)[4,5]	20	7,200	20	7,200	200	72,000	2,000	288,000
Ethylbenzene[5]	3	1080	3	1080	30	10,800	300	NA

Contaminant	Leachable Concentration ASLP1 (mg/L) Class I	Concentration Limit CL1 (mg/kg) Class I	Leachable Concentration ASLP2 (mg/L) Class II	Concentration Limit CL2 (mg/kg) Class II	Leachable Concentration ASLP3 (mg/L) Class III	Concentration Limit CL3 (mg/kg) Class III	Leachable Concentration ASLP4 (mg/L) Class IV	Concentration Limit CL4 (mg/kg) Class IV
C_6-C_9 petroleum hydrocarbons[6]	N/A	2,800	N/A	2,800	N/A	28,000	N/A	112,000
C_{16}-C_{35} petroleum hydrocarbons (aromatics)	N/A	450	N/A	450	N/A	4,500	N/A	18,000
C_{10}->C_{35} petroleum hydrocarbons (aliphatics)	N/A	28,000	N/A	28,000	N/A	280,000	N/A	N/A
Phenols (total, non-chlorinated)	1.44	42,500	1.44	42,500	14.4	425,000	144	N/A
PAHs (total)	N/A	100	N/A	100	N/A	1,000	N/A	4,000
Benzo(a)pyrene	0.0001	5	0.0001	5	0.001	50	0.01	200
Styrene[,5]	0.3	108	0.3	108	3	1,080	30	4,320
Toluene[5]	8	518	8	518	80	5,180	800	NA
Xylenes (total)[5]	6	1800	6	1800	60	18,000	600	NA
Chlorinated Organics								
2,4-D[5]	0.3	360	0.3	360	3	1,440	30	5,760
OCP scheduled wastes[8]	N/A	50	N/A	50	N/A	50	N/A	50
Other solvents	N/A	50	N/A	50	N/A	500	N/A	2,000
Polychlorinated biphenyls[9]	N/A	50	N/A	50	N/A	50	N/A	50

Notes:

1. ASLP values determined as follows: Class I = 10 x Australian Drinking Water Health Guideline (ADWG) value; Class II = Class I; Class III = 10 x Class I; Class IV = 100 x Class I.
2. CL values determined as follows: Class I = Contaminated Sites Management Series assessment levels for soil (HIL F) for commercial/industrial land; Class II = Class I; Class III = 10 x Class I; Class IV = 40 x Class I.

3. ASLP1 and ASLP2 values = practical quantitation limit instead of figure derived from ADWG.
4. ASLP values derived from *Waste Classification Guidelines Part 1 Classifying Waste (NSW Department of Environment and Climate Change, 2008 revised 2009*) (Class I = SCC1). This value may be divided by 10 to take into account the sandy WA coastal plain soils". (Class I = SCC1)
5. CL values derived from Environmental Guidelines: Assessment, Classification & Management of Liquid & Non-liquid Wastes (NSW EPA, 1999) (Class I = SCC1)
6. CL values = one tenth limit for C_{15}->C_{35} limits consistent with previous Landfill Waste Classifications and Waste Definitions 1996.
7. Applies to soil contaminated with organochlorine pesticides consistent with Organochlorine Pesticides Waste Management Plan (ANZECC, 1999).
8. CL values consistent with Organochlorine Pesticides Waste Management Plan (ANZECC, 1999). Note that waste containing < 50 mg/kg is not classified as scheduled wastes for the purposes of this plan.
9. CL values consistent with Polychlorinated Biphenyls Management Plan (ANZECC, 1996).

N/A No applicable value, please contact DEC for clarification on a case by case basis

Notes:

Table 5 Summary of criteria for chemical contaminants in waste classification

Landfill Class	Acceptance Criteria[1,2,3,4,5]	Comments
Inert (Class I)		
	1. Concentration ≤ CT1	ASLP test not required.
	2. ASLP ≤ ASLP1 and concentration > CT1, ≤ CL1	Leaching Solution to be used is water.
	3. ASLP ≤ ASLP1 and concentration > CL1	After immobilisation[6].
Putrescible (Class II)		
	1. Concentration ≤ CT2	ASLP test not required.
	2. ASLP ≤ ASLP2 and concentration > CT2, ≤ CL2	ASLP required
	3. ASLP ≤ ASLP2 and concentration > CL2	After immobilisation[6.].
Putrescible (Class III)		
	1. Concentration ≤ CT3	ASLP test not required.
	2. ASLP ≤ASLP3 and concentration > CT3, ≤ CL3	ASLP required
	3. ASLP ≤ ASLP3 and concentration >CL3	After immobilisation[6] or encapsulation.
Secure (Class IV)		
	1. Concentration ≤ CT4	ASLP test not required.
	2. ASLP ≤ ASLP4 and concentration > CT4, ≤ CL4	ASLP required. Leaching solution to be specified in site licence.
	3. ASLP ≤ ASLP4 and concentration > CL4	After immobilisation[6] or encapsulation.
Intractable (Class V)[7]		
	1. ASLP > ASLP4	Store or treat waste as appropriate.
	2. ASLP ≤ ASLP4 and concentration > CL4	Store or treat waste as appropriate.

Notes:
1. The values CT1- 4 refer to concentration threshold criteria specified in Table 3.
2. The values ASLP1 - 4 refer to leachability criteria (ASLP) specified in Table 4.
3. The values CL1-4 refer to the concentration limit (CL) values specified in Table 4.
4. The acceptance criteria specified in Tables 3 and 4 apply to each toxic contaminant present in the waste.
5. The ASLP and concentration values refer to the test values determined on the basis of sampling and analysis in accordance with DoE approved sampling procedures (typically the mean of the sample distribution plus 1 standard deviation).
6. In certain cases, DEC will require specific conditions, such as the segregation of immobilised waste from all other types of waste in a monofill or a monocell, in order to achieve a greater margin of safety against possible failure of the immobilisation in the future.
7. Disposal of wastes to the Mount Walton East Intractable Waste Facility is subject to approval by the Environmental Protection Authority.

SAMPLING SOLID WASTE AND INTERPRETATION OF RESULTS

Assessment of Bulk Waste Stockpiles

This section outlines the recommended sampling strategy to be employed in assessing waste composition where other information is not available. Alternative sampling strategies (e.g. core sampling, composite sampling) may be employed where these provide equivalent levels of information to enable the appropriate class of landfill to be determined. Equally, for industrial process wastes, information may be available which precludes the necessity for detailed testing of wastes once they have been stockpiled or packaged (i.e. where the characteristics of the waste are not likely to change once stockpiled or packaged), or for repeated testing of well-characterised wastes..

Documentation that should be made available to a landfill operator to verify that waste has been assessed in accordance with the following guidelines should include:
- A description of the sampling methodology - showing that it is consistent with these guidelines.
- Copies of original laboratory analysis data - showing that samples have been analysed by an appropriately accredited laboratory, using appropriate methods and detection limits, and that data has not been used selectively.
- Where appropriate, information showing that a waste is of consistent quality such that it does not require ongoing high-frequency testing.

Bulk Waste Categories

Bulk wastes (>5 m^3) occur in a wide variety of combinations and configurations, both in-situ and a stockpiles. The following rules have been derived primarily for use on stockpile wastes, but the same statistical treatment can be applied to in-situ soils provided the soil is segregated into broadly homogeneous blocks, with each block sampled as a separate “stockpile”.

Where this approach is inappropriate, suitable sampling methodologies that can be used are outlined in the following publications:
- National Environmental Protection Measure on the Assessment of Site Contamination. Guideline 2. Data Collection, Sample Design and Reporting. December 1999.
- Australian Standard AS 4482.1—1997, Guide to the Sampling and Investigation of Potentially Contaminated Soil. Part 1: Non-volatile and Semi-volatile Compounds.
-

The primary approach is used to categorise waste based on quantities using the following classifications:
1. Minor quantities - less than 100 m^3;
2. Medium quantities - more than 100 m^3 and less than 5,000 m^3; and
3. Large quantities - more than 5,000 m^3.

With respect to information about wastes, the determination of whether or not there is reliable and representative process data should be determined in consultation with DEC. Typically this will apply to a fixed process from which the variations of concentrations of contaminants in the waste are likely to be relatively small and the expected contaminant concentrations easily meet the relevant acceptance criteria.

Minor Quantities (<100 m^3)

Approach
The steps in the management of minor quantities are shown in Figure 2.

Samples
If reliable and representative information is available from process data then only one confirmatory sample may be required (qualitative assessment). Typically this will apply to a fixed process from which the variations of concentrations of contaminants in the waste are likely to be relatively small and the expected contaminant concentrations easily meet the relevant acceptance criteria. Otherwise, three samples are required (quantitative assessment).

The sample locations should be biased towards locations where there is visual and/or olfactory evidence of contamination (judgemental sampling).

The waste owner also has the option of assessment according to the procedures for medium quantities using four or more samples.

Comparison with Criteria
The results of the analyses are compared with the relevant landfill acceptance criteria value(s) or the relevant reuse acceptance criteria value(s) (CT or CL as appropriate). If all results for a contaminant are below the relevant criteria value(s) the material can be disposed of or reused as appropriate.

If one or more of the results are above the criterion value for a contaminant, but the value of the mean plus one standard deviation of the test results is below the relevant criterion, then the material can be disposed of or reused as appropriate.

However, if the results do not satisfy either of these conditions, the available options are:
- disposal of the waste to the appropriate class of landfill;
- treatment of material so that it is suitable for disposal to a lower class of landfill or reuse; or
- more detailed assessment using six samples as described for medium quantities.

Medium quantities (100 m^3 to 5,000 m^3) and large quantities (>5,000 m^3)

Approach
The steps in management of medium quantities are shown on the decision diagram presented as Figure 3, while that for large quantities is shown in Figure 4. The assessment may be undertaken by either a qualitative or quantitative approach depending on the available in formation on contaminant concentrations. The number of samples is, however, based mainly on the volume of waste.

Samples
For medium quantities, if reliable and representative information is available from process data then six confirmatory samples are required, regardless of the volume (qualitative assessment

Note that sampling conducted to characterise waste for disposal will generally not provide adequate information for contaminated sites assessment purposes.

Alternatively the number of samples depends on the volume of waste according to the following schedule:

Volume (m^3)	**Number of Samples**
100 to 200	4
200 to 500	6
500 to 1,000	8
1,000 to 2,000	11
2,000 to 3,000	15
3,000 to 4,000	18
4,000 to 5,000	20
5,000 to 10,000	24
> 10,000	24 plus 4 for each additional 10,000 m^3

Sample locations should be biased towards locations where there is visual and/or olfactory evidence of contamination (judgemental sampling). Procedures for selection of random samples are described by the AS4482.2- 1999 Guide to the Sampling and Investigation of Potentially Contaminated Soil Part 2 : Volatile Substances.

Comparison with criteria
The results of the analyses are compared with the relevant landfill acceptance criteria values or the relevant reuse acceptance criteria value(s).

If all results for a contaminant are below the relevant criteria value(s) the material can be disposed of or reused as appropriate.

If one or more of the results are above the criterion for a contaminant, but the value of the mean plus one standard deviation of the test results is below the relevant criterion, then the material can be disposed of or reused as appropriate.

However, if the results do not satisfy either of these criteria, the options available are:
- disposal of the material to the appropriate class of landfill;
- treatment of material so that it is suitable for disposal to a lower class of landfill or reuse; or
- more detailed assessment using the procedures described for large quantities.

Packaged Wastes

Typically packaged waste is contained in 205 L drums. This guideline applies to all containers up to 5 m^3 in capacity.

The most common situations relevant to packaged wastes are:

Case 1. Source or composition of the wastes not known;

Case 2. Source of waste is known (for example, waste from a particular process for which there is information available on the process and the likely composition of the waste) but there is no analytical data available on the actual contents of the containers; and

Case 3. Source of waste is known and reliable analytical information is available on the waste composition (for example, a continuing process for which it can be shown that there is little variation in the composition of the waste owing to the nature of the process).

The following section presents the minimum sampling requirements for packaged wastes and the corresponding methods for comparison with acceptance criteria.

Case 1. No knowledge of source or composition

If neither the source nor the composition of a packaged waste is known, at least the following sampling frequency is required (see Figure 5):

Number of Containers	Sampling Requirements	Value to be compared with waste classification criteria
1 to 3	• Three per container. • One top third, one middle third, and one bottom third from each container.	Mean of sample analyses.
more than 3	• Three containers selected randomly and sampled as for 1 to 3 containers above. • One sample from each other container, with depth selected randomly.	Mean of analyses plus one standard deviation.

Case 2. Source known, likely composition known, no analytical data on packaged waste.

For the second category, samples shall be taken according to the following schedule:

Number of Containers	**Sampling Requirements**	**Value to be compared with waste classification criteria**
1 to 3	• One per container. • Sampling depth selected randomly.	All analyses to be below criteria.
3 to 6	• Three containers selected randomly and one sample taken from each at a depth selected randomly. • One sample from one of the remaining containers, with container and depth selected randomly.	
> 6	• Three containers selected randomly and one sample taken from each at a depth selected randomly. • One sample from each set of three (or part thereof) remaining containers, with containers and depths selected randomly.	

Case 3. Source known, analytical data available on process.

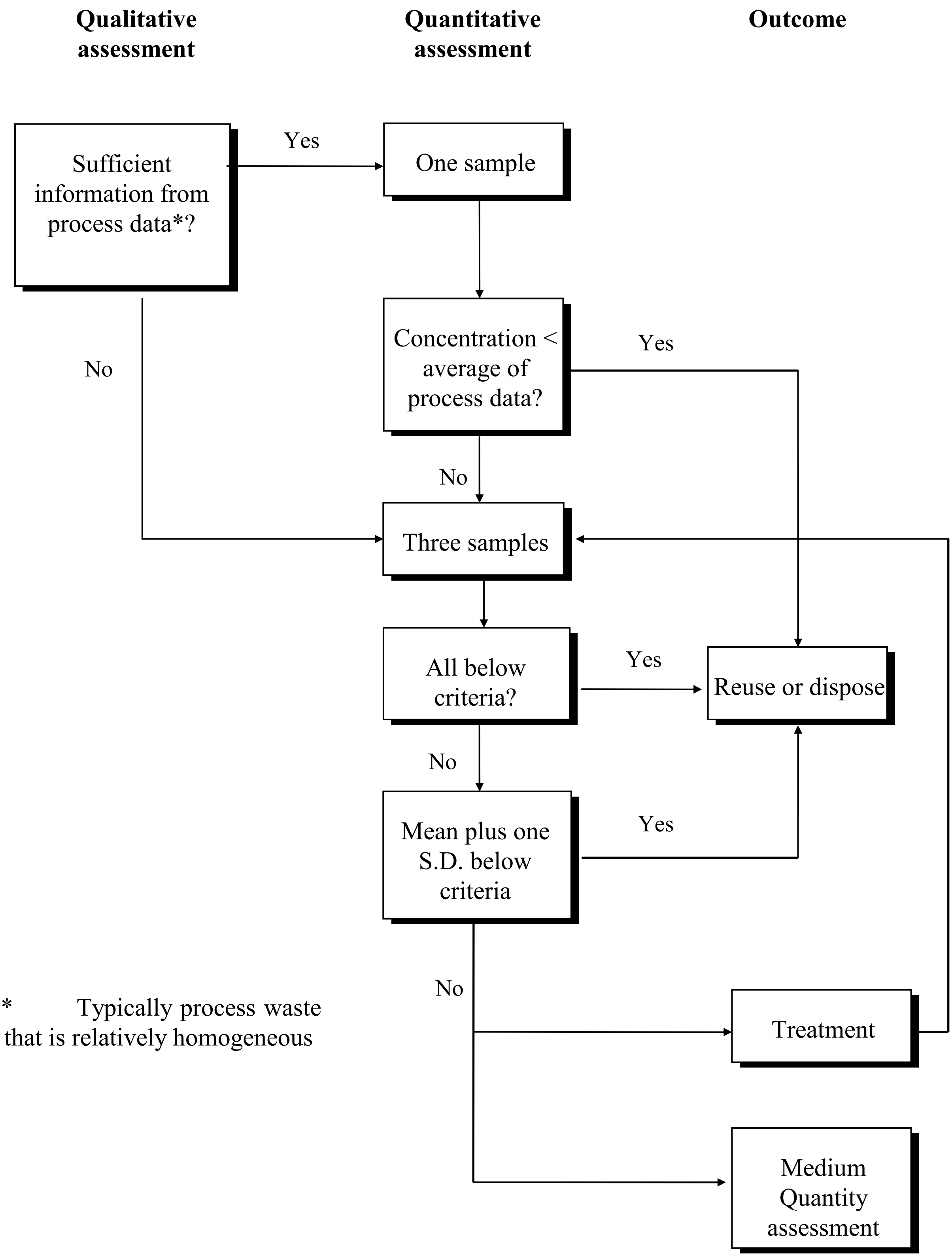
The third category addresses specific situations where there is a high level of knowledge of the waste producing processes such that only relatively low levels of waste sampling may be required.

The level of sampling will depend mainly on the:
- type and levels of contaminants;
- number of containers;
- type and reliability of the process;
- level of management and technical control on the process; and
- toxicity of contaminants involved.

In such situations the analytical data can be compared with the relevant landfill criteria to determine the appropriate landfill class.

ASSESSMENT OF MINOR QUANTITIES (<100 m^3)

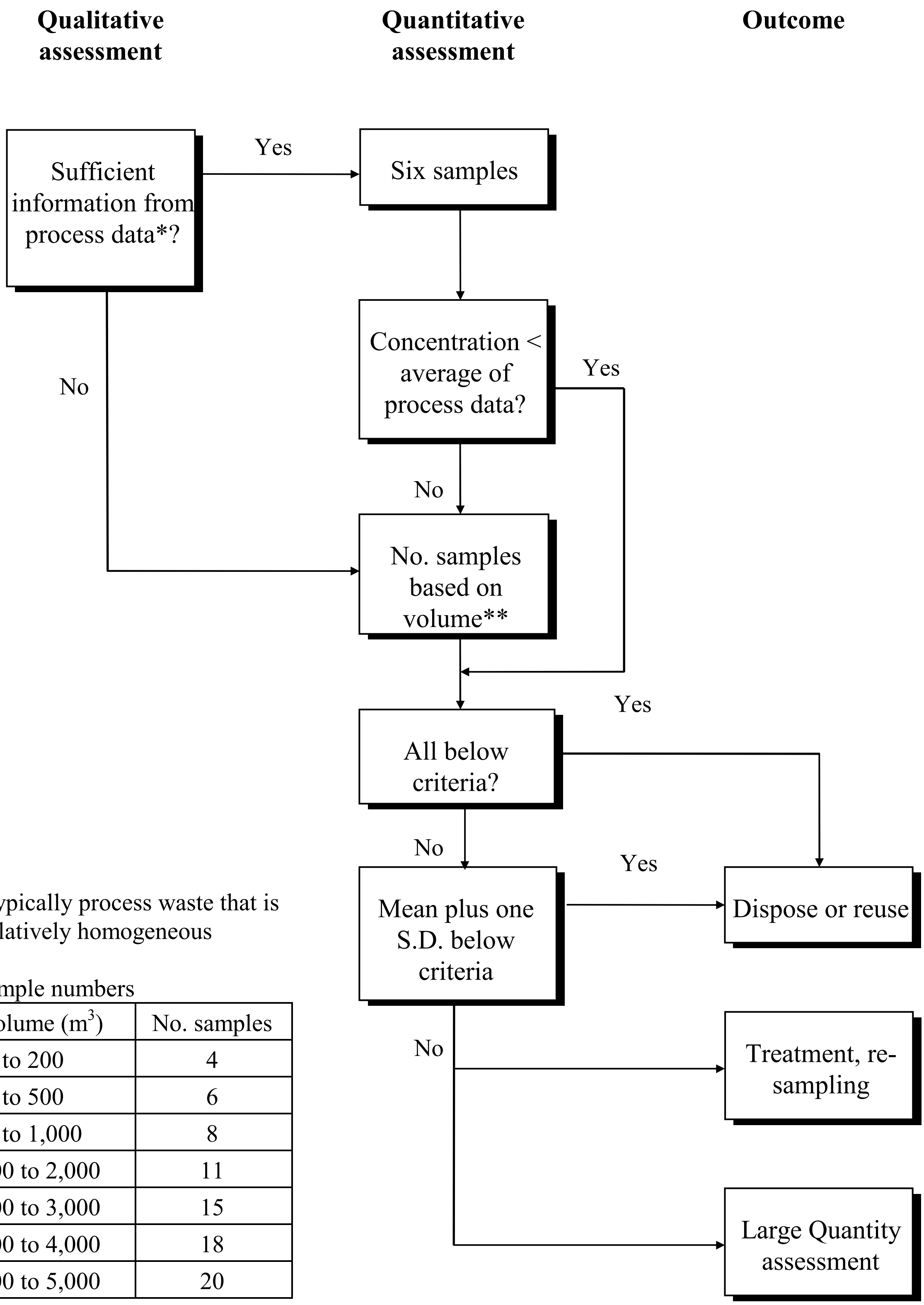
Figure 2



* Typically process waste that is relatively homogeneous

Figure 3

ASSESSMENT OF MEDIUM QUANTITIES (>100 m^3, <5,000m^3)



* Typically process waste that is relatively homogeneous

**Sample numbers

Volume (m^3)	No. samples
100 to 200	4
200 to 500	6
500 to 1,000	8
1,000 to 2,000	11
2,000 to 3,000	15
3,000 to 4,000	18
4,000 to 5,000	20

Figure 4

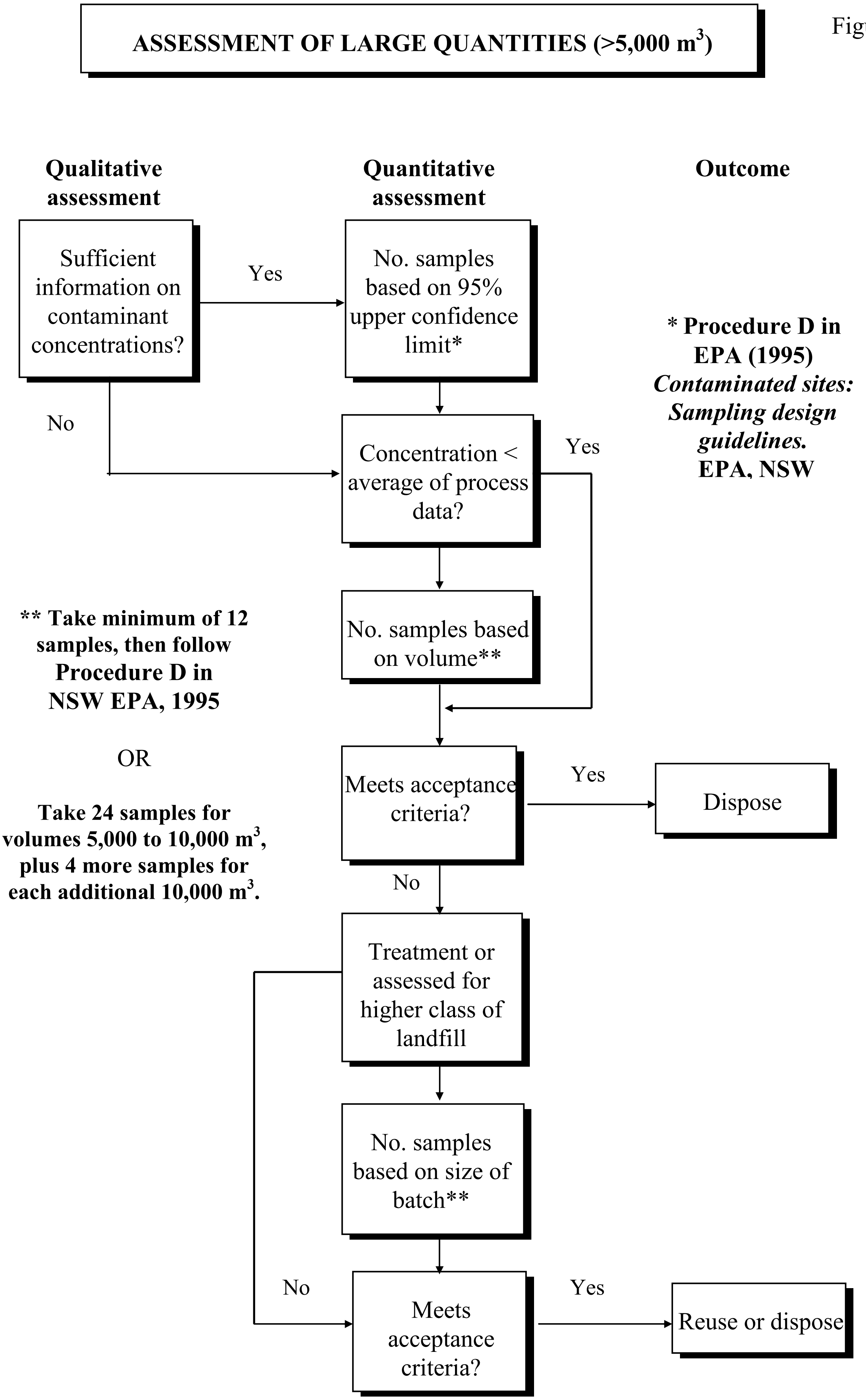
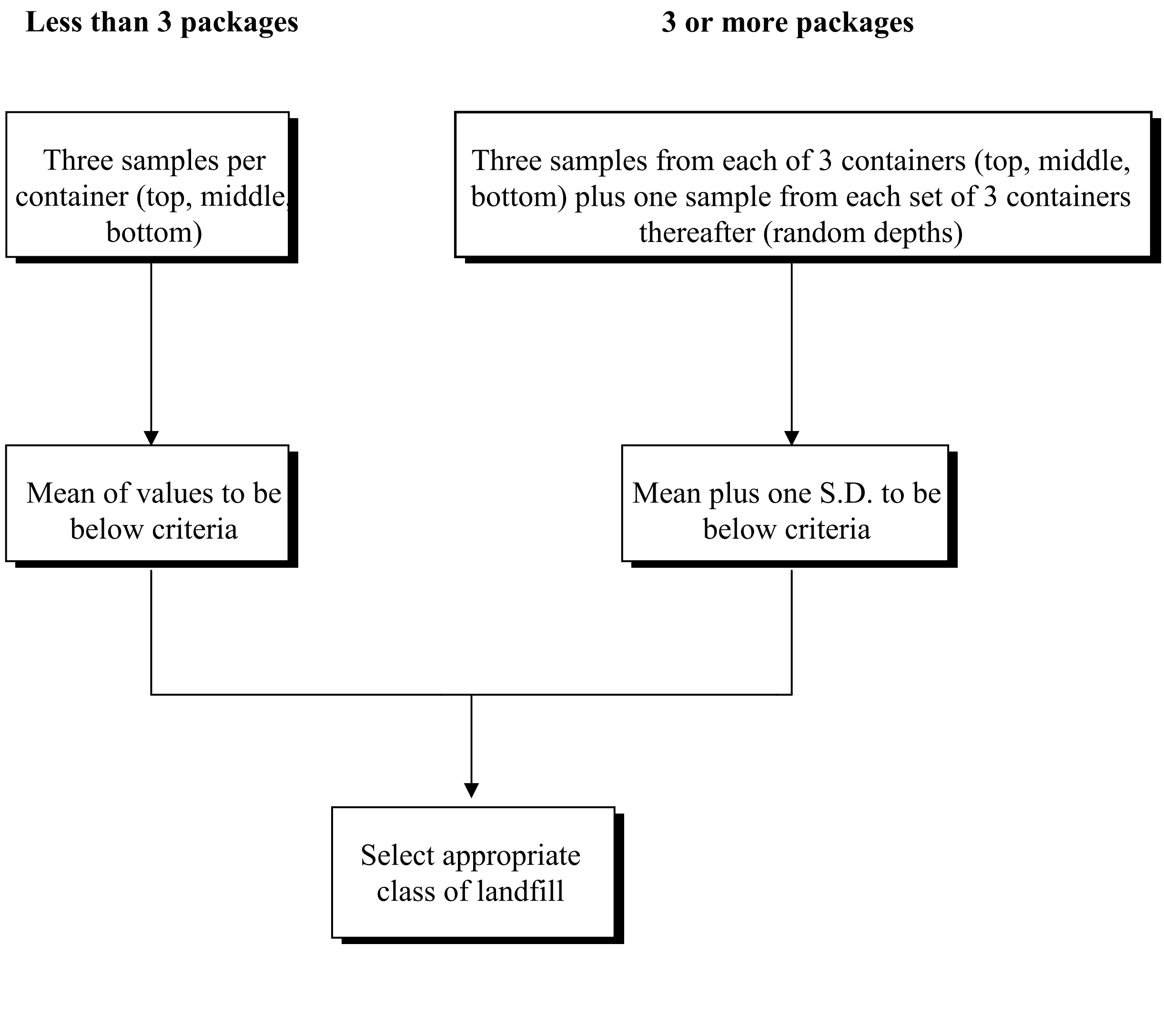

ASSESSMENT OF LARGE QUANTITIES (>5,000 m3)
Qualitative assessment
Quantitative assessment
Outcome
Sufficient information on contaminant concentrations?
Yes
No. samples based on 95% upper confidence limit*
* Procedure D in EPA (1995) Contaminated sites: Sampling design guidelines. EPA, NSW
No
Concentration < average of process data?
Yes
** Take minimum of 12 samples, then follow Procedure D in NSW EPA, 1995
No. samples based on volume**
OR
Take 24 samples for volumes 5,000 to 10,000 m3, plus 4 more samples for each additional 10,000 m3.
Meets acceptance criteria?
Yes
Dispose
No
Treatment or assessed for higher class of landfill
No. samples based on size of batch**
No
Meets acceptance criteria?
Yes
Reuse or dispose

Figure 5

MANAGEMENT OF PACKAGED SOLID WASTE

CASE 1

Source of waste unknown
No analytical data on waste



APPENDIX B Waste Acceptance Guidelines for Mount Walton East

Government of **Western Australia**
Department of **Finance**
Building Management and Works

DISPOSAL OF RADIOACTIVE WASTE AT THE INTRACTABLE WASTE DISPOSAL FACILITY, MT WALTON EAST

WASTE ACCEPTANCE GUIDELINES AND WASTE ACCEPTANCE PROFORMA

July 2012

REVISION 7

1. GUIDE TO ACCEPTANCE OF WASTE AT THE IWDF

The acceptance of waste for disposal at the Intractable Waste Disposal Facility (IWDF) is dependent upon compliance with waste acceptance criteria and the approval of operational procedures by the Environmental Protection Authority (EPA) and the Radiological Council. This document outlines the waste acceptance criteria and introduces the Waste Acceptance Proforma. The Waste Acceptance Proforma must be completed by waste owners to enable an assessment of waste suitability for disposal at the IWDF.

The IWDF waste **acceptance criteria** details the properties and characteristics that deem wastes **unsuitable** for disposal at the IWDF. As such, wastes that are in the following categories are **<u>not acceptable</u>** for disposal at the IWDF:

- Waste for which there are alternative, readily available, and practicable, reuse, recycling, treatment, destruction or disposal options in Australia.
- Waste generated outside Western Australia.
- Liquids.
- Explosive materials.
- Highly flammable materials.
- Highly reactive materials.
- Gases.
- Materials that decompose.
- Category S radioactive material.

These criteria are further defined and discussed in *Notes to the Waste Acceptance Proforma*.

Waste that is proposed for disposal at the IWDF must be packaged in accordance with the IWDF packaging requirements. Details of the packaging requirements are contained within the *Notes to the Waste Acceptance Proforma.* Preliminary information on packaging is required at this stage; however, further details will be requested at a later stage.

To allow an assessment of the suitability of your waste for disposal at the IWDF, please complete the *Waste Acceptance Proforma*. If the Department of Finance, Building Management and Works (BMW) is not satisfied that the waste proposed for disposal is in compliance with the acceptance criteria the waste will not be accepted for transport at the IWDF. BMW approval will be subject to the requirements of the Environmental Protection Authority.

Further information and/or an electronic version of the proforma can be obtained by contacting:

Randall Haigh
IWDF Project Manager
Department of Finance, Building Management and Works
Locked Bag 44
Cloisters Square, WA 6850

Phone: 08 6551 1867

Email: randall.haigh@finance.wa.gov.au

Attachments

- Location map of the IWDF
- Flowchart detailing the stages of preparation and planning involved in a disposal operation and the roles of the BMW and waste owners
- Waste Acceptance Proforma
- Notes to the Waste Acceptance Proforma
- References
- Glossary

WASTE ACCEPTANCE PROFORMA

DETAILS OF RADIOACTIVE WASTE PROPOSED FOR DISPOSAL AT THE INTRACTABLE WASTE DISPOSAL FACILITY

NB: Notes to assist with the completion of the proforma are attached

BMW REFERENCE NUMBER:

WASTE DETAILS

1.0 CLIENT (WASTE OWNER) DETAILS

Client's Name:	
Address:	
Tel:	Fax:
Radiation Safety Officer:	
Tel:	Fax:
After hours contact number:	
Email:	

2.0 PRESENT LOCATION OF WASTE

2.1 Address:
2.2 Location at Site:
2.3 Contact Person at address:

3.0 WASTE DESCRIPTION

3.1 Source/material description:

3.2 Radioisotope(s):	3.3 Half-life:
3.4 Types of radiation emitted: alpha☐ beta ☐ gamma ☐ neutron ☐	
3.5 Current date:	3.6 Current activity:
3.7 Physical form: solid ☐ liquid ☐ gas ☐ sealed ☐ unsealed ☐	
3.8 Is it special form radioactive material Yes ☐ No ☐	
Special form certificate no:	
Expiry date of special form certificate:	
3.9 Volume of source/material for disposal (may need to include container and/or shielding):	
3.10 Length of time source/material used/registered or possessed in WA:	
3.11 Purpose/use of source/material:	
3.12 Chemical Analysis of waste attached: Yes ☐ No ☐ Not Applicable ☐	
3.13 Has a Disposal Permit been issued by the Radiological Council Yes ☐ No ☐ If yes, please attach.	

if relevant:

3.14 Manufacturer:	3.15 Serial no.:
3.16 Manufactured date:	3.17 Initial activity:
3.18 Radiological Council Registration No.:	

4.0 RADIOLOGICAL ASSESSMENT

TABLE 1

Radioisotope	Near-Surface Disposal Code[a] Category B activity conc (Bq kg^{-1})	Near-Surface Disposal Code[a] Max activity in 500 kg drum (GBq)	Transport Code[b] A_1[c] (GBq)	Transport Code[b] A_2[d] (GBq)
^{60}Co	10^8	50	400	400
^{137}Cs	10^8	50	2,000	600
^{226}Ra	5×10^5	0.25	200	3
^{241}Am	10^7	5	1,000	1

[a] Code of Practice for the Near-Surface Disposal of Radioactive Waste in Australia (1992).
[b] Code of Practice for the Safe Transport of Radioactive Material (2008).
[c] Maximum activity of special form radioactive material permitted in a Type A package.
[d] Maximum activity of radioactive material, other than special form radioactive material, permitted in a Type A package.

TABLE 2

Radioisotope	Activity (GBq)	Volume (L)	Activity fraction of 200L drum	Volume fraction of 60L drum Actual	Volume fraction of 60L drum Practical[a]

[a] A 50% packing factor is to be assumed, i.e., actual volume divided by 0.5.

4.1 Assigned fraction of a disposal unit (activity fraction in a 200L drum, or practical volume fraction in a 60L drum, whichever is the largest):	
4.2 Is a leakage test required? Yes ☐ No ☐	
4.3 Is a contamination test required? Yes ☐ No ☐	
4.4 Assessment made by:	Date:
4.5 Verified by IWDF RSO: Yes ☐ No ☐	Date:

5.0 PACKAGING AND WASTE QUANTITY

5.1 Current packaging (type):
5.2 Waste Package Weight and Volume/dimensions:
5.3 Total Consignment Weight:
5.4 If repackaging is required, describe how this may affect quantities of waste:

6.0 ALTERNATIVES TO DISPOSAL AT IWDF

NOTE: Supporting information regarding alternatives must be attached.

6.1 Return to supplier:	Applicable ☐ Not Applicable ☐
Discussion:	
6.2 Transfer to new user:	Applicable ☐ Not Applicable ☐
Discussion:	
6.3 Transfer to re-processor:	Applicable ☐ Not Applicable ☐
Discussion:	
6.4 Disposal at Class IV landfill:	Applicable ☐ Not Applicable ☐
Discussion:	
6.5 Supporting documentation attached :	Yes ☐No ☐
6.6 Disposal at IWDF is the only currently available method for dealing with the waste:	**Yes ☐No ☐**

7.0 COMPATIBILITY WITH IWDF WASTE ACCEPTANCE CRITERIA

	Yes	No
7.1 Free liquid or sludge (with potential for separation of free liquid) present:	☐	☐
If yes, please describe:		
7.2 Explosive:	☐	☐
If yes, please describe:		
7.3 Highly flammable:	☐	☐
If yes, please describe:		
7.4 Highly reactive:	☐	☐
If yes, please describe:		
7.5 Gaseous (or greater than 5% volume gas):	☐	☐
If yes, please describe:		
7.6 Decomposable material:	☐	☐
If yes, please describe:		
7.7 Category S radioactive waste:	☐	☐
If yes, please describe:		
7.8 Waste Compatible (all "No" answers above)?	☐	☐
7.9 If "No", how will non-compatibility be addressed?		

8.0 OTHER DETAILS

8.1 Any additional comments:

9.0 ATTACHMENTS

A. Technical (Chemical) Description of your Waste	Yes ☐ No ☐
B. Information on Alternatives to Disposal at Mt Walton IWDF	Yes ☐ No ☐

I certify that all sections of the Waste Acceptance Proforma have been completed (unless not applicable). I understand that should any section of the Proforma be incomplete, no further consideration of the waste for disposal at the IWDF can be made by the Department of Finance, Building Management and Works.

Completed by Authorised Client Representative:	
Name:	**Position:**
Signature:	**Date:**

NOTES TO THE WASTE ACCEPTANCE PROFORMA

1.0 CLIENT (WASTE OWNER) DETAILS

Insert details of the current owner of the waste (waste owner) and key personnel.

2.0 PRESENT LOCATION OF WASTE

Insert details of the location of the waste. It must be noted if the waste is to be transferred to another location prior to transport to the IWDF.

3.0 WASTE DESCRIPTION

3.1 Provide details of the source/ material (e.g. Soil moisture gauge, contaminated metal etc.).

3.2 Detail the radioisotopes.

3.3 Detail the half- life

3.4 Detail the types of radiation emitted i.e. alpha beta gamma neutron.

3.5, 3.6 Detail current activity with date reference.

3.7 Provide details of the physical form of the wastes material, i.e. solid, liquid, gas and if it is sealed or unsealed.

3.8 Is the waste is a special form radioactive material? If so provide further detail including the special form material certificate and its expiry date.

3.9 Detail the current volume of the waste including its current container or shielding.

3.10 Detail the length of time the source was used in Western Australia.

3.11 Describe the purpose of the source and what its uses were in Western Australia.

3.12 Where applicable chemical analysis of the waste must accompany the Proforma submitted (i.e. if the waste is a contaminated soil, sediment or residue, etc). Representative analyses of samples from the waste consignment are to be taken according to a proposed sampling and analysis program by the waste owner, which also meets the requirements of the *Landfill Waste Classifications and Waste Definitions 1996 (as amended December 2009)* (DEC, 2009).

Analyses are to be reported for:

- The dominant intractable (i.e. radioactive or other) component(s) as total weight % (or mg/kg) or the activity concentration in Bq/kg, for every sample.

- The general chemical composition of the waste (including moisture content), for representative (e.g. selected or composite) samples.

The number of analyses required will be assessed by the BMW on a case by case basis, based on the variability in the waste consignment as indicated by information supplied by the waste owner and the process(es) by which the waste was generated. It is likely that a minimum of 10% of waste packages will require sampling and analysis. Additional guidance for the sampling of solid waste is provided *in Landfill Waste Classifications and Waste Definitions 1996 (as amended December 2009)* (DEC, 2009), although the BMW requirements may exceed those defined in this document.

In situations where chemical characterisation data are already available (e.g. standard operational analysis or where the waste material comprises raw products, which have original, clearly identifiable labels providing chemical component data), additional sampling may not be necessary, upon agreement with the BMW. However, additional sampling and analysis must be undertaken if any waste material is not clearly identifiable.

This information shall be presented as a *Technical (Chemical) Description* of the waste, which is to be attached to the submitted Proforma (Attachment A).

3.13 Prior to the disposal of radioactive waste at the IWDF a *Disposal Certificate/Permit* must be issued by the Radiological Council. If a certificate has been issued please attached a copy to the proforma. If you have not applied for a certificate one must be applied for as soon as possible.

3.14 Where available/relevant please provide the name of the manufacturer and date of manufacture of the source/material.

3.15 Where available/relevant please provide the serial number of the source.

3.16, 3.17 Where available/relevant please provide the initial activity of the source.

3.18 Where available/relevant please provide the Radiological Council registration number.

4.0 RADIOLOGICAL ASSESSMENT

The key parameters of the common radioisotopes considered for burial at the IWDF are listed in Table 1. Data for other radioisotopes should be added as required.

In Table 2, the relevant radioisotopes for each source/material should be listed and then the previous listed activity and volume on page one of the proforma should be inserted. The generally adopted method of disposal of radioactive wastes is to cement the waste into a 60L drum and then concrete the 60L drum within a 200L drum. A disposal unit can be regarded as having a volume of 60L and a weight of 500kg. Based upon such a disposal unit, the activity fraction and volume fraction of a disposal unit can be calculated for each radioisotope, and the fractions summed for the overall disposal unit. In arriving at the volume fraction, a 50% packing factor is assumed, i.e., actual volume divided by 0.5.

The double containment method of packing the radioactive source/material should ensure that there are no potential problems of leakage and contamination. However, these parameters are questioned as an extra check on the condition of the waste during the assessment procedure.

5.0 PACKAGING AND WASTE QUANTITY

5.1 Provide details of the current packaging of the waste (if any).

5.2 To satisfy IWDF packaging requirements the packaging should fulfil packaging and transport criteria, as outlined in the Packaging and Transport Guidelines (a copy of which can be obtained from the BMW).

5.3 Provide details of waste package weight and dimensions.

5.4 Please estimate the percentage increase in volume if the waste packaging is to change.

6.0 ALTERNATIVES TO DISPOSAL AT IWDF

Please provide details on alternatives that have been adopted to avoid the disposal of radioactive waste at the IWDF. Each alternative **must** be addressed. Particular detail needs to be provided on the treatment options that have been investigated. Supporting documentation must be attached.

The disposal of waste at the IWDF is regarded as an option of last resort. Thus, in order for waste to be accepted at the IWDF, **it must be proven that there are no alternative, readily available, and practicable, reuse, recycling, treatment, and destruction or disposal options in Australia**.

The current alternatives to disposal for radioactive waste at the IWDF are:

- Return to supplier;
- Sale to a new user;
- Transfer to reprocessor;
- Disposal at lower class landfills.

Waste that is acceptable at Class I, II, III or IV landfills will not be accepted for disposal at the IWDF, which is a Class V landfill. Acceptance criteria for Class I, II, III and IV landfills are given in *Landfill Waste Classifications and Waste Definitions 1996 (as amended December 2009)* (DEC, 2009).

7.0 COMPATIBILITY WITH WASTE ACCEPTANCE CRITERIA

Using the description below as a guide please assess the properties of your waste against the Waste Acceptance Criteria.

Waste types **not acceptable** for disposal at the IWDF, are listed below.

7.1 **Liquids – Not Accepted**. Liquids (except in very small volumes) are unacceptable for burial at the IWDF since it is assumed that they will ultimately escape from their containers and seep into the surrounding clay formation that acts to confine the waste. While this would not result in off-site contamination, if the volume of liquid is significant, the loss of volume could potentially cause slumping and cracking in the capping structure and result in rainwater infiltration into the waste cell.

Appropriate measures must therefore be implemented by the waste owner to prevent the presence of any **free liquid** within the waste or within the containers. Proposed measures should be approved by the BMW **BEFORE** being implemented to ensure that the outcome satisfies the requirements of the IWDF operators.

Sludge must have any **free liquid** removed prior to transport and should have sufficient absorbent material added to the container to absorb any liquid that may be separated during transport to the IWDF. Conservative quantities of absorbent material (e.g. 30-40% of waste volume) may have to be added to waste packages containing sludge waste unless specific vibration testing is undertaken to determine the potential for liquid separation (tests may include laboratory vibration table testing or transport trials).

7.2 **Explosive materials – Not Accepted**. The following classes of materials, as defined by *The Australian Code for the Transport of Dangerous Goods by Road and Rail* (2007) are not accepted at the IWDF:

- *Class 1.1 – substances and articles that have a mass explosion hazard*. A mass explosion is one that affects almost the entire load virtually instantaneously.
- *Class 1.2 – substances and articles that have a projection hazard but not a mass explosion hazard.*
- *Class 1.3 – substances and articles that have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard*. This includes substances and articles that give rise to considerable radiant heat, or that burn one after another, producing minor blast or projection effects or both. (*The*

Australian Code for the Transport of Dangerous Goods by Road and Rail, 2007, Volume 1).

Materials that are not themselves explosive but which have the potential to form or generate an explosive atmosphere of gas or vapour may not be suitable for disposal at the IWDF. This would depend on several factors such as the rapidity of vapour or gas generation and the reactions involved. For example, soil contaminated with a mixture of DDT and toluene has been accepted for disposal.

7.3 **Highly flammable materials – Not Accepted**. *The Australian Code for the Transport of Dangerous Goods by Road and Rail* (2007) defines flammable solids in the following manner:

1. *flammable solids* comprise:

   - solids that, under conditions encountered in transport, are readily combustible or may cause or contribute to fire through friction;

   - self-reactive and related substances that are liable to undergo a strongly exothermic reaction; and

   - desensitised explosives that may explode if not diluted sufficiently;

2. *substances liable to spontaneous combustion* comprises substances that are liable to spontaneous heating under normal conditions encountered in transport, or to heating up in contact with air, and being then liable to catch fire;

3. *substances that, in contact with water, emit flammable gases* comprises substances that, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities (*The Australian Code for the Transport of Dangerous Goods by Road and Rail*, 2007).

Some substances that are flammable, such as wood and synthetic materials (e.g. contaminated PPE), may be acceptable for burial if they require an open flame and oxygen for combustion since they will be buried in an environment essentially devoid of both these characteristics.

7.4 **Highly reactive materials – Not Accepted**. The following classes of materials, as defined in *The Australian Code for the Transport of Dangerous Goods by Road and Rail* (2007), are not accepted:

- *Class 5 - Oxidising Substances*. Substances that, while in themselves not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other materials.

- *Class 8 - Corrosive substances*. Substances that, by chemical action, will cause severe damage when in contact with living tissue, or, in the case of leakage, will materially damage or even destroy, other goods or the means of transport; and may cause other hazards (*The Australian Code for the Transport of Dangerous Goods by Road and Rail*, 2007).

For waste disposal operations at the IWDF involving the co-disposal of more than one type of waste, the BMW will consider the compatibility of the waste consignments and reserves the right to exclude a particular waste consignment from a specific disposal trench on this basis.

Verification of the corrosive or oxidising nature of the material may be required, by a combination of chemical (pH) and other corrosivity testing (see below).

7.5 **Gases – Not Accepted**. "Gases" are defined, for the purposes of *The Australian Code for the Transport of Dangerous Goods by Road and Rail* (2007), as substances that at 50°C have a vapour pressure greater than 300kPa; or completely gaseous at 20°C and a standard pressure of 101.3kPa.

Gases are therefore precisely defined and will not be accepted at the IWDF for disposal. However, uncompressed gas comprising less than 5% of the waste volume (or as otherwise specified by the BMW that is deemed to be satisfactorily contained may be considered for acceptance.

Compressed gases will not be accepted for disposal.

7.6 **Materials that may decompose – Not Accepted**. Materials that are likely to decompose and produce combustible hazardous gases or wastes that decompose and become compressible are not suitable for burial at the IWDF, since any significant volume reduction could compromise the integrity of a capping system. In addition, gases generated within a waste cell have the potential to create subsurface pathways, which could provide a route for subsequent rainwater ingress to the cell. Such materials include organic, domestic wastes.

7.7 **Category S radioactive material – Not Accepted.** The *Code of Practice for the Near Surface Disposal of Radioactive Waste in Australia (1992)* states that Category S radioactive material is unacceptable for near-surface disposal and shall be retained in storage until an alternative disposal method is available. Such storage is not available at the IWDF.

According to the *Code of Practice for the Near Surface Disposal of Radioactive Waste in Australia (1992)* defines Category S material as follows:

- *Category S* – covers waste that does not meet the specifications of Categories A, B or C. Typically this category will comprise sealed sources, gauges or bulk waste which contains radionuclides at higher concentrations than are allowable under Categories A, B or C.

Separate Guidelines for Chemical Waste Acceptance, further definitions and requirements related to chemical waste disposal at the IWDF are available from the BMW.

7.8 Please provide details on how non-compatibilities will be addressed.

8.0 OTHER DETAILS

Any further details, which the waste owner may wish to provide or comment upon such as special handling requirements of the waste.

REFERENCES

Australian Radiation Protection and Nuclear Safety Agency (2008) *Code of Practice for the Safe Transport of Radioactive Material*. Radiation Protection Series No. 2.

Department of Environment and Conservation (2009) *Landfill Waste Classifications and Waste Definitions 1996 (as amended December 2009).*

Department of Treasury and Finance (2010) *Chemical Waste Acceptance Guidelines - Disposal of Waste at the Intractable Waste Disposal Facility, Mt Walton East.*, Department of Finance, July 2011.

Ministerial Statement No 562 (2001) *Statement to Amend Conditions Applying to Proposals (Pursuant to the Provisions of Section 46 of the Environmental Protection Act, 1986) Intractable Waste Disposal Facility, Mt Walton East, Shire of Coolgardie*, Published on 1 February 2001.

National Health and Medical Research Council (Australia) (1993) *Code of Practice for the Near Surface Disposal of Radioactive Waste in Australia (1992)*. Radiation Health Series No.35. Australian Government Publishing Service, Canberra.

National Transport Commission (2007) *The Australian Code for the Transport of Dangerous Goods by Road and Rail*. 7th Edition.

GLOSSARY

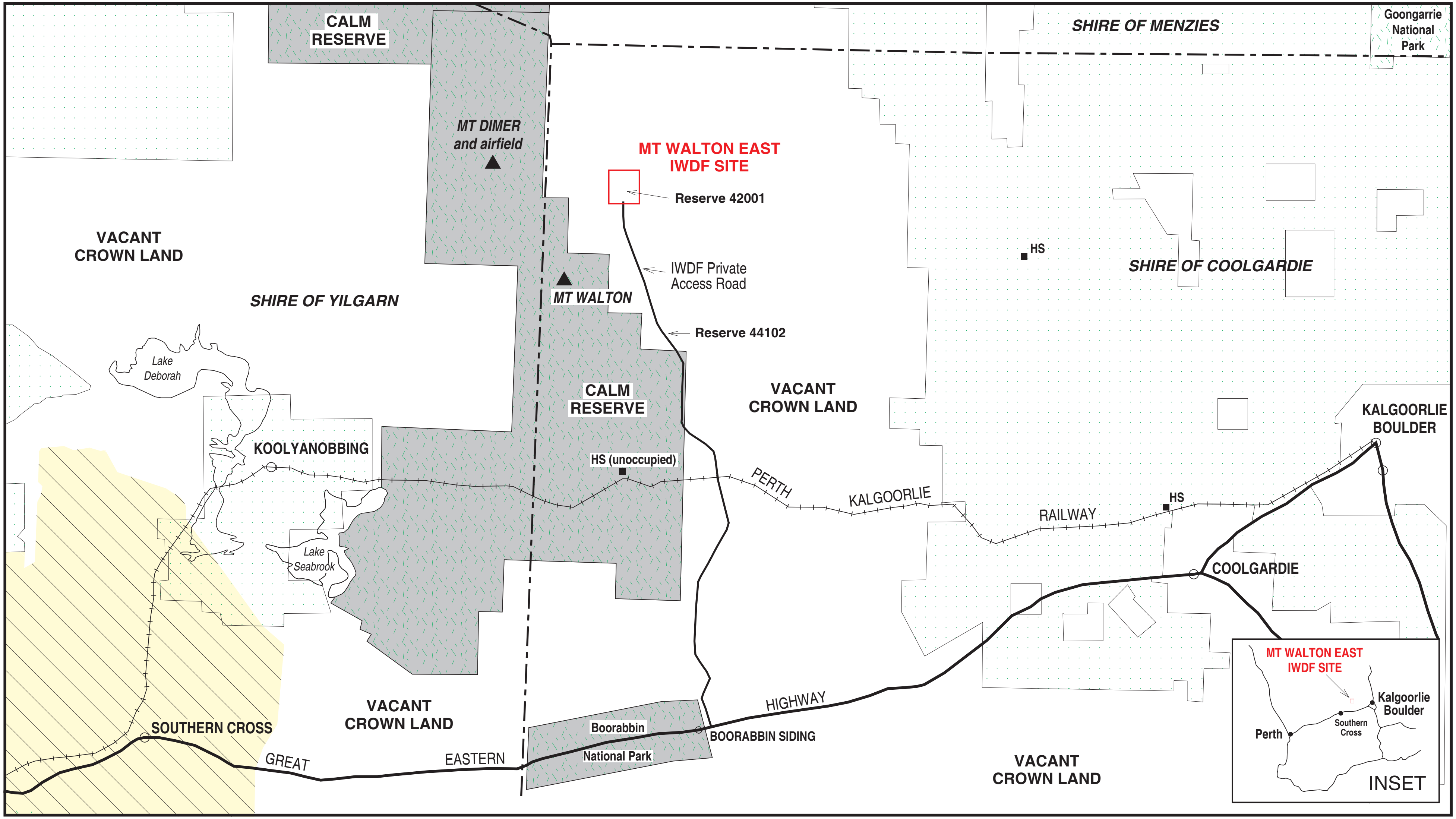
Acceptance Criteria	Criteria which describe the properties and characteristics of waste and packaging, which must be complied with in order for waste to be accepted for disposal at the IWDF
BMW	Department of Finance, Building Management and Works - operates the IWDF site
Client	Any natural person, body or corporation who proposes to dispose of intractable waste at the IWDF as part of a specific waste disposal operation (waste owner)
DEC	Department of Environment and Conservation (Western Australia)
Double Containment	A system of waste containment used during transport that provides both a primary and secondary level of protection against spillage of the waste in the event of a traffic accident
EMP	Environmental Management Program
Guideline	Documents which give guidance on aspects such as waste acceptance for disposal, waste packaging, transport of waste to the IWDF
HSP	Health & Safety Plan (for the IWDF)
Intractable Waste	Waste that is a management problem by virtue of its toxicity or chemical or physical characteristics which make it difficult to dispose or treat safely and is not suitable for disposal in Class I, II, III or IV landfill facilities (*Landfill Waste Classifications and Waste Definitions 1996 (as amended December 2009)*, Western Australia: Department of Environment and Conservation 2009).
IWDF	Intractable Waste Disposal Facility, located at Mt Walton East, Western Australia
Low level radioactive waste	Waste that conforms to the *Code of Practice for the Near Surface Disposal of Radioactive Waste in Australia (1992)*
Packaging	Primary form of containment for the waste

OEWP	Operation Environmental and Waste Acceptance Procedures (procedures for the environmental management of a specific disposal operation at the IWDF)
OHSERP	Operation Health & Safety and Emergency Response Procedures (procedures for the health & safety and emergency response of a specific disposal operation at the IWDF)
OTP	Operation Transport Procedures (procedures for the transport of wastes related to a specific disposal operation at the IWDF)
PPE	Personal Protective Equipment
RHS	Radiation Health Section, of the Health Department of Western Australia
Special Form	Radioactive material that meets the requirements of paragraphs 239, 502(f), 602, 603 and 604 of the *Code of Practice for the Safe Transport of Radioactive Material, 2008 edition* (Radiation Protection Series, Publication No.2)
Transporter	Any natural person, body or corporation who has possession of intractable waste and is transporting it for disposal at the IWDF.
Waste Owner	Any natural person, body or corporation, including an authorised delegate, who may be the original waste producer, or may have subsequently assumed ownership of waste, who proposes to dispose of their waste at the IWDF.
Waste Package	The waste and any packaging that will be disposed at the IWDF (disposal unit).

UNITS/ABBREVIATIONS

L	litre
m	metre
mg/kg	milligram per kilogram (10^{-3}g/kg).

G:\work\ENVI\PERT\00729AA\Community Liaison\ENVIPERT00729AA-Community Liaison-F01.dgn



LEGEND

- Shire Boundary
- HS Homestead
- Pastoral Leasehold Areas
- CALM Reserve / National Park
- Freehold Farmland

kilometres

0 10 20 30 40 50

SCALE 1 : 1 000

SOURCE: DAMES AND MOORE, 1998

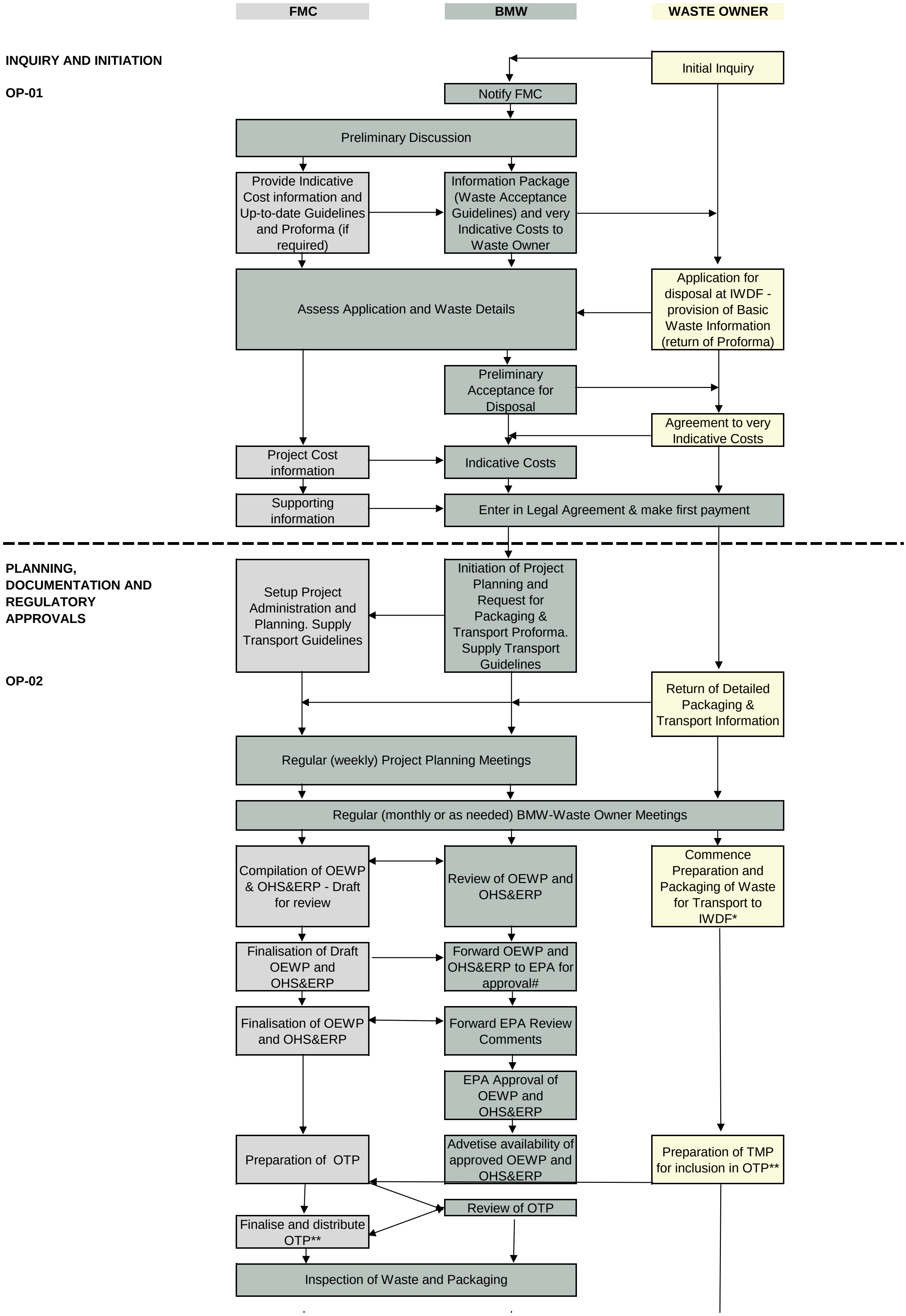
Government of **Western Australia**
Department of **Finance**

INTRACTABLE WASTE DISPOSAL FACILITY
MT WALTON EAST, WESTERN AUSTRALIA

REGIONAL LOCATION OF IWDF

Figure 1

Intractable Waste Disposal Facility - Mt Walton East
Waste Disposal Operation
Typical Sequence of Activities



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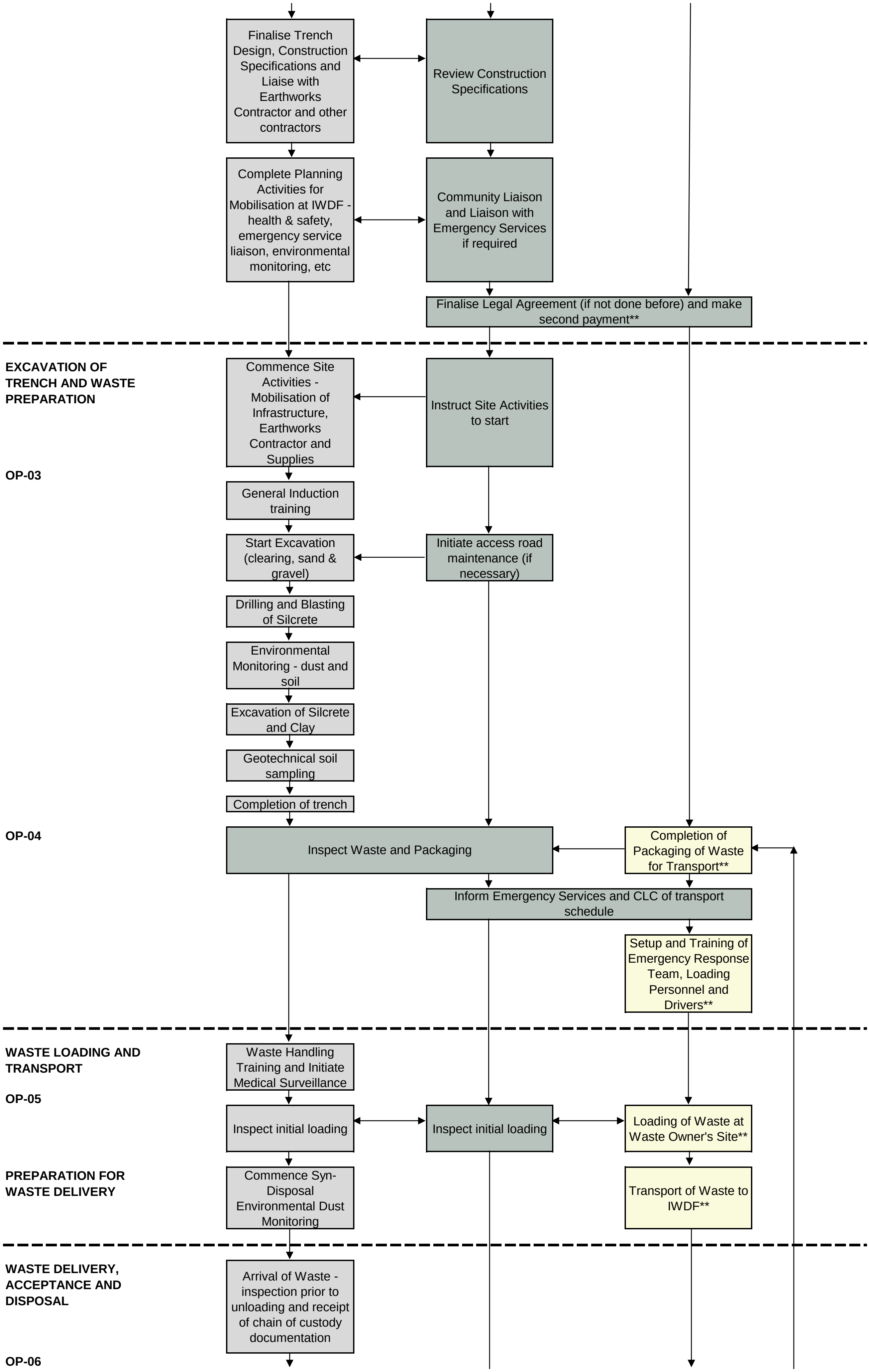
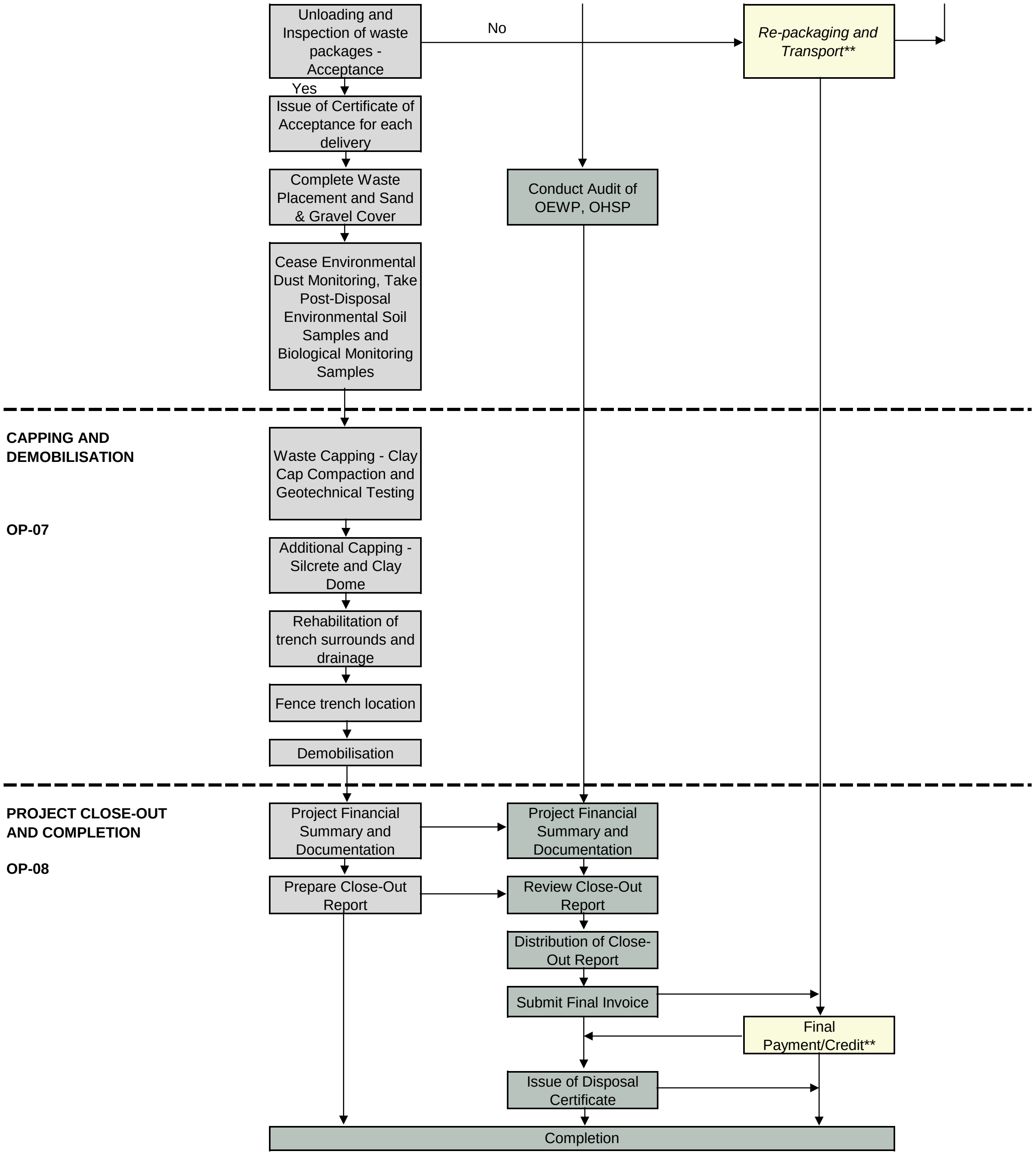

Finalise Trench Design, Construction Specifications and Liaise with Earthworks Contractor and other contractors
Review Construction Specifications
Complete Planning Activities for Mobilisation at IWDF - health & safety, emergency service liaison, environmental monitoring, etc
Community Liaison and Liaison with Emergency Services if required
Finalise Legal Agreement (if not done before) and make second payment**
EXCAVATION OF TRENCH AND WASTE PREPARATION
OP-03
Commence Site Activities - Mobilisation of Infrastructure, Earthworks Contractor and Supplies
Instruct Site Activities to start
General Induction training
Start Excavation (clearing, sand & gravel)
Initiate access road maintenance (if necessary)
Drilling and Blasting of Silcrete
Environmental Monitoring - dust and soil
Excavation of Silcrete and Clay
Geotechnical soil sampling
Completion of trench
OP-04
Inspect Waste and Packaging
Completion of Packaging of Waste for Transport**
Inform Emergency Services and CLC of transport schedule
Setup and Training of Emergency Response Team, Loading Personnel and Drivers**
WASTE LOADING AND TRANSPORT
OP-05
Waste Handling Training and Initiate Medical Surveillance
Inspect initial loading
Inspect initial loading
Loading of Waste at Waste Owner's Site**
PREPARATION FOR WASTE DELIVERY
Commence Syn-Disposal Environmental Dust Monitoring
Transport of Waste to IWDF**
WASTE DELIVERY, ACCEPTANCE AND DISPOSAL
Arrival of Waste - inspection prior to unloading and receipt of chain of custody documentation
OP-06



Notes:

*	Packaging is undertaken by BMW for small consignments of radioactive wastes stored at Radiation Health Section Store
**	Transport of small consigments of chemical waste may be undertaken by BMW with a one-off payment to be completed subsequent to packaging, but prior to transport
#	Approval from the Radiological Council is required if radioactive waste
BMW	Department of Finance, Building Management & Works
CLC	Community Liaison Committee for the Intractable Waste Disposal Facility, Mt Walton East
EPA	Environmental Protection Authority
FMC	Facility Management Contractor
OWEP	Operation Environmental and Waste Acceptance Procedures
OTP	Operation Transport Procedures
OHS&ERP	Operation Health & Safety and Emergency Response Procedures

APPENDIX C Dowex RSC Data Sheet

Remove Radium Efficiently with DOWEX™ Radium Selective Complexer Resin

The Challenge – Removing Radium without Generating Undesirable Waste

Radium is a radioactive element that occurs naturally in trace amounts in rocks, soils and some groundwater. Surface water is usually low in radium, but groundwater can contain significant amounts of radium due to local geology. The U.S. Environmental Protection Agency has set a maximum contaminant level (MCL) for radium in public water supplies of 5 picoCuries per liter (pCi/L).

The uranium mining industry is also concerned about radium where it is a by-product of solution mining. This is dealt with by direct barium precipitation techniques, but these processes take up a lot of space and generate large quantities of sludge that must be further treated.

The Solution – DOWEX™ Radium Selective Complexer Resin

Why Selective Removal of Radium is Better than Unselective

Radium and barium can be unselectively removed from groundwater through standard cation exchange resins, using several different regeneration cycles, but these processes change the composition of the water hardness components and produce undesirable wastes that contain radium.

DOWEX™ Radium Selective Complexer (RSC) resin was developed to meet the growing need for selective removal of radium and barium from groundwater, without generating sludge or undesirable waste.

DOWEX RSC resin is a barium salt complexed in an ion exchange matrix. Water soluble radium and barium react with the DOWEX RSC resin, forming an insoluble complex for excellent, cost-effective removal.

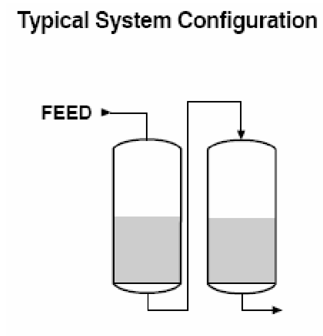
DOWEX RSC is certified by NSF under NSF/ANSI Std. 61 for Municipal Drinking Water System Components. For more information on this certification, see the NSF web site at www.nsf.org.

Typical System Configuration

A double-pass bed configuration, as shown in Figure 1, will allow the DOWEX RSC resin in the lead bed to be completely loaded before change-out, resulting in higher system efficiency. A typical system configuration is designed for a throughput of 10 gpm/square foot of bed. Bed depths of DOWEX RSC resin are a minimum of three feet. Prefiltration for particulate removal may be necessary, depending on the groundwater quality.

Form No. 177-01675-0209

Figure 1. Double-pass system configuration



A typical loading capacity might be 10 to 20 nanocuries/gram (11,000 to 22,000 nanocuries/liter). This means that a single bed volume of DOWEX™ RSC resin may be capable of treating millions of bed volumes of water before exhaustion.

DOWEX RSC resin is not regenerated like an ion exchanger. The radium-loaded DOWEX RSC resin can be conveniently disposed of with an accredited radioactive waste disposal company. However, DOWEX RSC generates only a fraction of the volume of waste that would be produced by classical barium precipitation.

Typical Physical Properties[1]

Physical form	Spheres
Total exchange capacity	0.65 meq/mL (min.)
Water retention capacity	65 - 75%
Packing density**	49 lb/cu ft 780 g/L
True density	1.18 - 1.25 g/cc
Estimated capacity	10 - 20 nanocuries/gram
Particle size analysis	
Through 40 mesh, max.	8%
Through 50 mesh, max.	1%

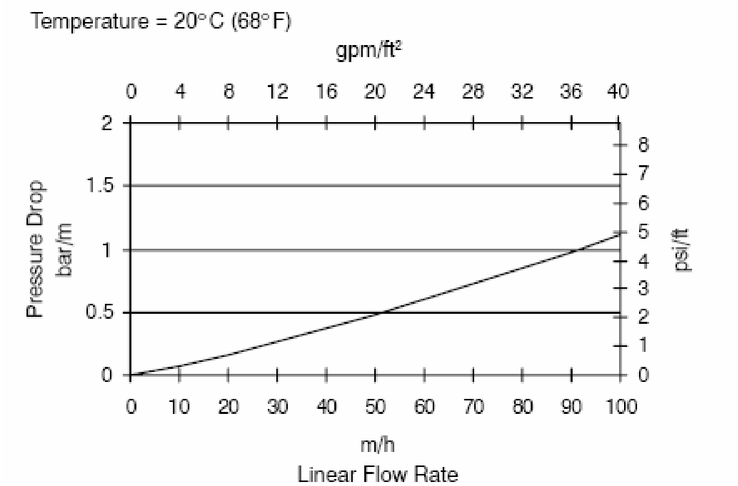
[1] Typical properties, not to be considered sales specifications.

General Design Criteria

1. Throughput of 10 gpm/square foot of bed.
2. Bed depth should be at least three feet deep.
3. Tanks and piping may be steel, lined or unlined, as per normal corrosion criteria.
4. Piping system should be designed to permit backwashing.
5. Tank size should allow 75-100% bed expansion during backwash.
6. Prefiltration for particulate matter is necessary.
7. Double tank system will allow DOWEX RSC resin in the lead tank to be completely loaded before change-out.

** As per the backwashed and settled density of the resin, determined by ASTM D-2187.

Figure 2. Pressure drop data



For other temperatures use:

$P_T = P_{20°C}$ (0.026T$_{°C}$ + 0.48), where P ≡ bar/m

$P_T = P_{68°F}$ (0.014T$_{°F}$ + 0.05), where P ≡ psi/ft

References

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Mangelson, K. A. and Lauch, R. P. "Removing and Disposing of Radium From Well Water." Jour. AWWA, June 1990.

DOWEX™ Ion Exchange Resins
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