Analysis of Lead Acid Battery Consumption, Recycling and Disposal in Western Australia

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ANALYSIS OF LEAD ACID BATTERY CONSUMPTION, RECYCLING AND DISPOSAL IN WESTERN AUSTRALIA

PREPARED BY
WARNKEN INDUSTRIAL AND SOCIAL ECOLOGY PTY LTD

FOR

AUSTRALIAN BATTERY RECYCLING INITIATIVE

MAY 2012

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Front cover photos (top to bottom):

Photo 1 – Used Lead Acid Batteries (ULAB) separated at waste transfer station

Photo 2 – New style of ULAB collection bin

Photo 3 – ULAB can be processed into lead ingots and sold into commodity markets

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EXECUTIVE SUMMARY

Lead Acid Batteries (LAB) are integral to the functioning of our economy and support many aspects of modern lifestyles. They provide essential starting, lighting and ignition functions for the national fleet of passenger vehicles and road-based freight trucks, in addition to standby backup power and many other energy storage solutions. A recent study (2010) by the Australian Battery Recycling Initiative (ABRI) provided a comprehensive and detailed assessment of the Australian battery market as an important step in developing a robust plan for battery stewardship implementation.

The ABRI study provided a useful analysis of battery consumption, stocks and arisings at a national level. (Battery **inputs** are the consumption of batteries; **stocks** are those batteries in service within the economy; and **arisings** are batteries that have reached the end of their service life – or are unwanted for any other purpose – and require a resource recovery or waste management solution.) However, there was little detail given at a state level in the ABRI study.

This current study focuses on Western Australia and Used Lead Acid Batteries (ULAB) in order to provide a detailed examination of the likely inputs, stocks and arisings of ULAB in Western Australia, which is the most isolated and yet strongest growing economic region in Australia. The material stocks and flows methodology in the 2010 ABRI study was used to assess the Western Australia market for ULAB in this study. Additionally, the following changes to key assumptions are relevant with regard to the elapsed time since the ABRI study:

– national vehicle fleet increase: 2.47 per cent
– population increase: 1.45 per cent
– GDP increase: 2.28 per cent.

Additionally, although Western Australia makes up only 10.3 per cent of the Australian population, it comprises 14.6 per cent of national GDP and a higher proportion again of mining activity. These factors were taken into account when compiling the WA ULAB model.

A breakdown of the estimated inputs, stocks and arisings of LAB in Western Australia by count is presented in the table below. By definition, all of the data generated by the model with regard to the inputs, stocks and arisings of batteries are estimates – this has been highlighted in table headings in the Executive Summary but has been discontinued in the body text to avoid repetition. Also note that the numbers in the tables may not add up due to rounding.

Table – Estimated Western Australia Lead Acid Battery materials stocks and arisings by count in 2010*

Type	*Inputs*	*Stocks*	*Arisings*
Handheld (Sealed Lead Acid)	185,400	363,700	74,500
Automotive Starting Lighting and Ignition (SLI)	714,000	1,895,700	644,700
Large and Industrial (Lead based)	216,340	622,500	182,900
Mining Sector	46,800	68,500	38,100
Total Units	**1,162,540**	**2,950,400**	**940,200**

* Information in the tables may not total due to rounding

A similar breakdown of the estimated inputs, stocks and flows (waste arisings) of LAB for Western Australia by weight is presented in the table below.

Table – Estimated Western Australia Lead Acid Battery materials stocks and arisings by weight (tonnes) in 2010

Type	*Inputs*	*Stocks*	*Arisings*
Handheld (Sealed Lead Acid)	130	255	52
Automotive Starting Lighting and Ignition (SLI)	10,504	27,891	9,547
Large and Industrial (Lead based)	6,467	21,065	5,332
Mining Sector	2,297	3,220	1,890
Total Weight (kilograms)	**19,398**	**52,431**	**16,821**

ULAB arisings from the Western Australia economy are defined as ULAB that have finished their active service life and now require an end-of-life management solution, such as resource recovery. These estimates of arisings were built on a predictive model based on the amount of LAB inputs and replacement rates as a function of LAB stocks.

From this analysis it was estimated that there were approximately 16,821 tonnes of ULAB arisings in 2010 within Western Australia. Nearly 60 per cent of these arisings were Automotive SLI batteries. Automotive SLI ULAB also have the highest resource recovery rate, owing to their ease of recovery and the underlying value of lead as a commodity. The recovery rate for Automotive SLI ULAB is 61 per cent when formal stockpiling for reprocessing is included.

In terms of the ‘negative’ fate of arisings, if landfill is considered an undesirable management option for batteries, and is grouped with illegal export, rebirth and informal stockpiling (all arguably undesirable from a stewardship perspective), then approximately 34 per cent of all batteries in WA are not being managed in an optimal way.

There is room for improved stewardship amongst LAB including taking action on the eradication of illegal export, improved recovery from remote and regional sites and prevention of batteries entering the urban waste stream and being landfilled. The main challenges for Large and Industrial batteries are improved recovery from remote and regional sites (and in particular from mining sites) and in gaining a better understanding of the standby power sector.

The geographic isolation of remote and regional sites in WA, combined with their distance from reprocessors on the east coast, create an additional challenge for resource recovery especially when the commodity price of lead is low, or when there is a temporary oversupply of ULAB in the Australian market (caused by, for example a reduction in processing capacity as a result of a facility shutdown for maintenance). While this study has not addressed the impacts of cost on ULAB recovery in WA, any reduced price paid for ULAB as a result of market factors will exacerbate the cost impact of geographic isolation. Remoteness and fluctuating market conditions point to the need to firstly gain additional insight into cost impacts on ULAB recovery in WA, and secondly to develop an action framework to support responsible recycling of ULABs in WA.

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FIGURES

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GLOSSARY

ABRI	Australian Battery Recycling Initiative
ABS	Australian Bureau of Statistics
ANZSCC	Australian and New Zealand Standard Commodity Classification
EPR	Extended Producer Responsibility
GDP	Gross Domestic Product
GSP	Gross State Product
HHW	Household Hazardous Waste
KM	Kilometres
LAB	Lead Acid Battery
MSFA	Materials Stocks and Flows Analysis
OH&S	Occupational Health and Safety
SLAB	Sealed Lead Acid Battery
SLI	Automotive Starting Lighting and Ignition
ULAB	Used Lead Acid Battery
WA	Western Australia
WARR	Waste Avoidance and Resource Recovery Regulations

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1 BACKGROUND AND INTRODUCTION

Lead Acid Batteries (LAB) are integral to the functioning of our economy and support many aspects of modern lifestyles. They provide essential starting, lighting and ignition functions for the national fleet of passenger vehicles and road-based freight trucks, in addition to standby backup power and many other energy storage solutions.

A recent study (2010) by the Australian Battery Recycling Initiative (ABRI) provided a comprehensive and detailed assessment of the Australian battery market as an important step in developing a robust plan for battery stewardship implementation. However, there was very little detail given on lead acid batteries at a state level in the ABRI study.

This current report builds on the original 2010 ABRI national battery study by focusing on Western Australia and Lead Acid Batteries (LAB) in order to provide a detailed examination of the likely quantity of inputs, stocks and arisings of Used Lead Acid Batteries (ULAB) in Western Australia.

ABRI is a not-for profit incorporated association of members who seek to maximise resource recovery from batteries. It seeks to divert batteries from landfill and to generate economic benefits from increased recovery and recycling of valuable and finite materials.

1.1 Overview of Report

The structure of this report is presented in Figure 1 overleaf. After this introduction the stocks and flows model is introduced. The range of applications where LAB are used within the WA economy is presented in Section 2. This range includes the major categories of Handheld LAB, Automotive Starting, Lighting and Ignition LAB, Large and Industrial LAB and Mining LAB.

Section 3 then examines Handheld LAB occurrence in businesses and households and data on average battery characteristics to estimate the inputs, stocks and arisings. Section 4 covers Automotive Starting, Lighting and Ignition LAB using data on the different vehicle types in the Western Australia registered vehicle fleet and data on average battery characteristics to estimate the inputs, stocks and arisings.

Section 5 is on Large and Industrial ULAB from marine engine applications; traction and motive power applications; forestry, farming and construction applications; and large stationary standby power applications, while Section 6 looks at ULAB in the Mining sector. Dump trucks, dozers and scrapers, wheel loaders, shovels and ancillary equipment estimates were used, as well as business data, to estimate the inputs, stocks and arisings.

A summary of the arisings by category and weight is presented in Section 7. Consideration is given to Federal and State regulatory settings in Section 8 and their relationship with international obligations, especially in the regulation of hazardous wastes. Finally, conclusions and recommendations are presented in Section 9 with supporting information provided in Appendices.

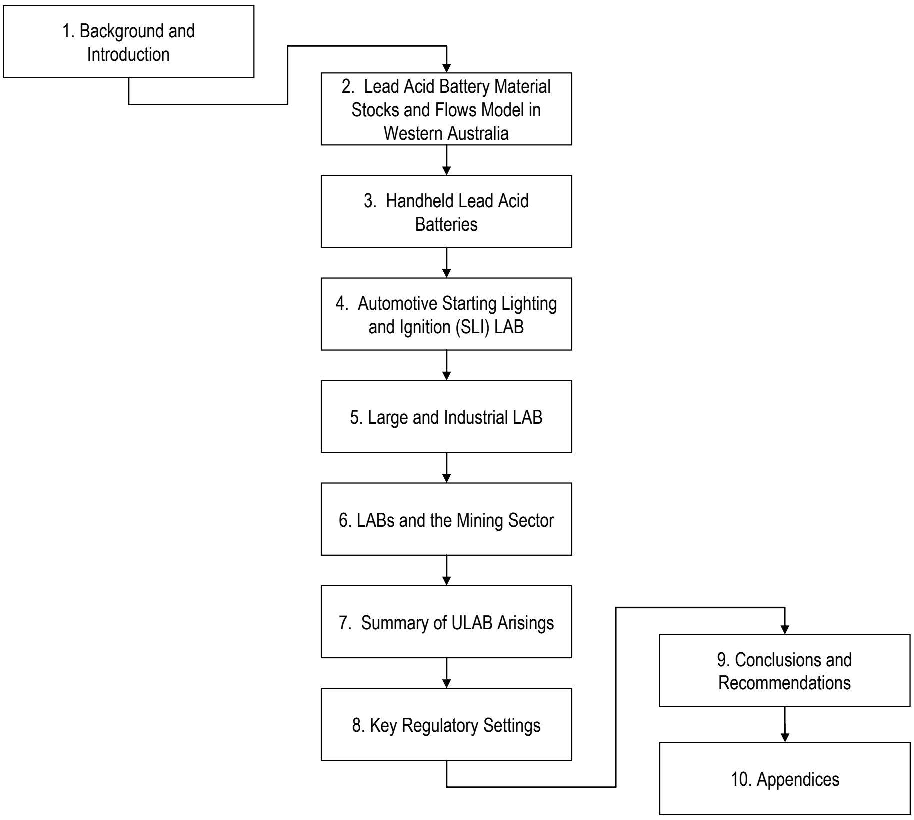

Figure 1 – Structure of report

2 LEAD ACID BATTERY MATERIAL STOCKS AND FLOWS MODEL IN WESTERN AUSTRALIA

In 2010 the Australian Battery Recycling Initiative published a comprehensive and detailed assessment of the Australian battery market as an important step in developing a robust plan for battery stewardship implementation. The report 'Analysis of Battery Consumption, Recycling and Disposal in Australia'[1] provided useful insight into the materials stocks and flows of all battery types across Australia, including LAB.

The analysis within this report builds on the original ABRI study to provide an assessment of the Western Australian market for ULAB. As such, it draws on the ABRI study for a number of assumptions. The decision to follow this approach was to ensure that the analysis in the report is, where relevant, consistent with the ABRI study, as the ABRI studiy had been through an extensive industry review. However, in translating the assumptions, consideration was given to whether these assumptions could be made more relevant to the Western Australian context. All assumptions are listed and justification provided for those that differ from the ABRI study.

This section provides an overview of the underlying methodology for this assessment. Note that the focus of this report is on the amount of lead acid batteries that are consumed, recycled and disposed in WA. The costs of collection and processing, and the impact of WA's remoteness on costs and on responsible recycling is beyond the scope of this study.

2.1 Materials Stocks and Flows Model

A material stocks and flows model of LAB inputs, stocks and arisings within Western Australia was prepared for this study as shown in Figure 2 below. LAB inputs are the **consumption** of batteries; **stocks** are those batteries in active service within the economy; and **arisings** are ULAB that have reached the end of their service life (or are unwanted for any other purpose) and require a resource recovery or waste management solution.

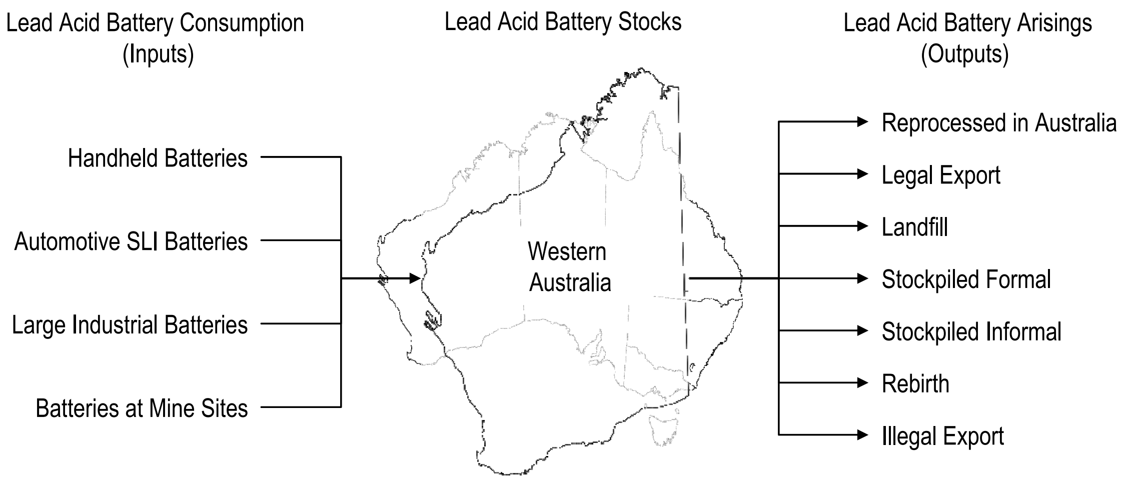

Figure 2 – Overview of stocks and flows model

[1] Warnken ISE, 2010, 'Analysis of Battery Consumption, Recycling and Disposal in Australia', Australian Battery Recycling Initiative, accessed at http://www.batteryrecycling.org.au/wp-content/uploads/2011/06/Battery-consumption-recycling-and-disposal-in-Australia_Executive-Summary.pdf, October 2011.

The model is an estimated mass balance of current LAB usage in Western Australia. By definition, all of the data generated by the model with regard to the inputs, stocks and arisings of batteries are estimates – this has been highlighted in table headings in the Executive Summary but has been discontinued in the body text to avoid repetition. Also note that the numbers in the tables may not add up due to rounding.

Data are reported on both a count and weight basis. LAB are by nature significantly heavier than other battery types. This means that relatively low numbers of LAB can comprise a significant amount of lead-based material by weight.

Although this Western Australian assessment relies on the ABRI methodology, other information was obtained from several sources and from differing years, including:

- Australian Bureau of Statistics
- battery-based studies
- battery manufacturers and importers
- resource recovery companies
- industry reports
- state and federal government
- industry participants
- battery recycling programs
- other reports on waste generation, resource recovery and stewardship in Australia.

The report also benefited from a round of comments from ABRI members. (A draft report was distributed to ABRI members early in 2012). This version of the report for ABRI publication incorporates comments provided by ABRI members.

It is again highlighted that, in the absence of any direct quantitative data, the figures are based on informed estimates regarding deployment of LAB. Further information on the methodology within this study is provided in Appendix 1.

There are three main LAB types, as defined by a combination of size and application. These LAB types include:

- Handheld batteries
- Automotive Starting Lighting and Ignition (SLI) batteries that are used in registered on-road vehicles
- Large and Industrial batteries (essentially greater than 1 kg) that are used in non-registered or off-road engine applications, for example, agriculture, in addition to batteries used for traction and motive, and standby power.

An additional sub-category of Large and Industrial has also been differentiated for the purposes of this study. Specific attention to the arisings of Large and Industrial batteries in mining applications has been paid, with the inclusion of Mining LAB as a separate category for analysis.

Note that the main focus of the study has been on the Automotive SLI and Large and Industrial LAB, in addition to Mining LAB, as these comprise the majority of battery flows. The flows of Handhelds are relatively small.

2.2 Handheld LAB

The category of Handheld Sealed Lead Acid Batteries (SLAB) refers to those used in emergency lighting and standby power applications, typically with a weight of less than 1 kg. It is recognised that the majority of handheld devices make use of batteries with alternative chemistries, which are outside the scope of this study.

It is noted that the weight of handheld batteries (<1kg) is arbitrary, and serves to draw a boundary around 'small' batteries that are portable, easy to install, remove and replace, and thus have the potential to arise in collection schemes for household collections schemes. For example, informal analysis undertaken by ABRI has identified that SLAB weighing approximately 2 kilograms were collected in a WA household collection scheme.[2] The implications of a heavier average 'handheld' LAB are discussed in Section 3.

2.3 Automotive Starting Lighting and Ignition (SLI) LAB

Automotive Starting, Lighting and Ignition (SLI) batteries are a dominant sub-category within the total stocks and flows of batteries in Australia. Automotive SLI Batteries excludes the categories of Handheld (<1 kg) SLAB and Industrial (>1 kg) SLAB), which are covered elsewhere.

As highlighted in the ABRI study there are four main channels for Automotive SLIs to enter the market:

- 'do-it-yourself' where the battery is bought directly from a retailer. This channel has approximately one third (35 per cent) of Automotive SLI batteries
- 'do-it-for-me' change over at a service centre, with a similar proportion to the direct battery replacement channel, at 25 per cent of Automotive SLI battery inputs
- embedded in a new car sale, either locally produced or imported. Based on estimates of new vehicle sales in Australia, approximately 20 per cent of Automotive SLI battery inputs are in new vehicles, with the majority of these (approximately 85 per cent) imported
- direct battery replacement, for example through roadside replacement programs, with approximately 20 per cent of the inputs through the direct replacement channel.

[2] *Helen Lewis, ABRI Chief Executive, 2012, Personal Communication.*

2.4 Large and Industrial LAB

Large and Industrial batteries includes those batteries used in non-automotive applications and is the stream that was expected to give rise to the largest volumes of LAB. Common uses of Large and Industrial LAB include:

- marine engine applications
- traction and motive power applications, such as golf carts, mobility scooters, small forklifts, large materials handling units, hybrid vehicles and electric vehicles
- forestry, farming and construction applications, for those vehicles with engines (such as excavators, front-end loaders, dozers, graders, tractors, harvesters, trucks, feller-bunchers). It also includes those on compressors and gensets
- large stationary standby power applications.

2.5 Mining LAB

As identified above, Large and Industrial LAB also includes those used in mining applications, a sector which is given special consideration due to the prominent role, and hence likely volume of battery arisings, associated with this sector. Applications are mostly for vehicles, including:

- dump trucks
- dozers and scrapers
- wheel loaders
- shovels.

As well as a significant component being ancillary stationary equipment such as gensets, lighting and other uses.

3 HANDHELD LEAD ACID BATTERIES

The category of Handheld Sealed Lead Acid Batteries (SLAB) refers to those used in emergency lighting and standby power applications, typically with a weight of less than 1 kg. It is recognised that the majority of handheld devices make use of batteries with alternative chemistries and hence are outside the scope of this study.

Australian Bureau of Statistics reports were consulted to find the number of businesses[3] of various sizes and households[4] in Western Australia in 2009. The estimated average numbers of SLAB in use in businesses of different sizes and in households are based on the same assumptions in the ABRI study, as shown in Table 1 below.

Table 1 – Occurrence of SLAB in businesses in 2009 and households in 2010

Large (>100 employees)	50	/business
Small-medium (5–100 employees)	5	/business
Micro (<5 employees)	0.1	/business
Households	0.1	/household

The previous ABRI assessment also provided an estimated average Handheld SLAB mass of 0.7 kg, an attrition rate for batteries of 20.5 per cent of existing stock and additional inputs of new batteries as 10 per cent of existing stock.

Inputs of small Handheld SLAB arise from replacement of failed batteries in the existing stock and from sales of batteries for first-time applications, for example during the electrical fitting of a new building. The numbers of businesses in 2009 were multiplied by a factor of 1.042, based on the average growth in GDP in WA of 4.2 per cent over the past three years, to provide an estimate for 2010 because more recent data was unavailable. Existing stock was calculated by multiplying the number of businesses and households by the occurrence rates given in Table 1. It was assumed that essentially all end-of-life batteries were replaced, so that the total input of SLAB was calculated as 30.5 per cent of the existing stock. This was converted to mass using the average battery mass of 0.700 kg, as suggested in the ABRI study.

Multiplying the existing stock by the attrition rate of 20.5 per cent provided the number of batteries arising as waste in 2010. The results of the analysis are shown in Table 2. This analysis shows that handheld SLAB contribute a relatively minor amount of ULAB arisings, with only 52 tonnes of ULAB arisings from this source in 2010. This suggests that Handheld SLAB are not a materially significant source of ULAB arisings.

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[3] *Australian Bureau of Statistics, 2011, 'Counts of Australian Businesses, Including Entries and Exits', Jun 2007 to Jun 2009', accessed at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun%202007%20to%20Jun%202009?OpenDocument, October 2011.*

[4] *Australian Bureau of Statistics, 2010, 'Australian Demographic Statistics, June Quarter 2010', accessed at http://www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/40946B5F0164658CCA2577FF0011CB14/$File/31010_jun%202010.pdf, October 2011.*

Table 2 – Summary of Handheld SLAB inputs, stocks and arisings in Western Australia, 2010

Description	*Inputs*		*Stocks*		*Arisings*	
	Number of batteries	*Weight of batteries (tonnes)*	*Number of batteries*	*Weight of batteries (tonnes)*	*Number of batteries*	*Weight of batteries (tonnes)*
Large business (>100 employees)	44,500	31	87,300	61	17,900	13
Small-medium business (5–100 employees)	87,600	61	171,800	120	35,200	25
Micro business (<5 employees)	9,500	7	18,600	13	3,800	3
Households	43,800	31	86,000	60	17,600	12
Total	**185,400**	**130**	**363,700**	**255**	**74,500**	**52**

It is noted that the above estimates use an average SLAB weight of 0.7 kilograms and that recent information provided by ABRI suggests that the average could be higher, with SLAB weights of approximately 2 kilograms found in WA household battery collections. Assuming for the sake of example, that the average weight of a handheld SLAB was 2 kilograms, then the total arisings for handheld SLAB in WA would increase to 149 tonnes.

However, as the following sections will show, even with a higher average weigh, handheld SLAB would still remain less than one per cent of the total arisings. For the purposes of this report, the original average of 0.7 kilograms has been used. It is recommended that a revised average be developed for use in future updates of battery studies where a comparison of battery types with the handheld category is required.

4 AUTOMOTIVE STARTING LIGHTING AND IGNITION (SLI) LAB

Lead Acid Batteries (LAB) are widely used in automobiles to provide power for electrical systems and in these applications are often termed 'starter, lights and ignition' batteries or SLI. This section begins by describing the methodology used for determining stocks and flows of this category of battery, and is followed by the results of the model outputs.

4.1 Methodology

Calculation of the inputs, stocks and arisings of Automotive SLI batteries in Western Australia was carried out on the basis of vehicle sales, fleet sizes, and fleet attrition rates for these vehicles in WA. Further details are provided in the following sections.

4.1.1 Data Sources

Vehicle fleet data drawn from the Australian Bureau of Statistics Motor Vehicle Census[5] for the years 2008 to 2010 are shown in Table 3. Even though WA has only 10.3 per cent of the national population, it has 11.8 per cent of the national registered vehicle fleet.

Table 3 – Western Australia registered vehicle fleet (vehicle units)

	2008	*2009*	*2010*
Passenger	1,295,136	1,345,494	1,369,133
Campervans	7,396	7,535	7,611
Light commercial	283,319	299,638	308,516
Light rigid truck	11,079	11,984	12,438
Heavy rigid truck	45,248	47,340	48,352
Articulated truck	11,111	11,944	12,229
Non-freight trucks	4,182	4,360	4,470
Buses	12,098	13,007	13,418
Motorcycles	77,010	87,044	93,901

Vehicle sales data for WA are shown in Table 4. WA motorcycle sales figures were only available for 2008 and 2009, so these were extrapolated in proportion to passenger vehicle sales to provide a figure for 2010. Similarly to the national fleet, WA accounted for more than its per capita share of new vehicle sales, accounting for 11.3 per cent of national sales.

[5] *Australian Bureau of Statistics, 2009 and 2011,'Motor Vehicle Census', Australian Bureau of Statistics, accessed at http://www.abs.gov.au, October 2011.*

Table 4 – WA vehicle sales data (vehicle units)[6]			
Category	*2008*	*2009*	*2010*
Passenger	90,869	77,937	93,843
Light commercial/truck	20,856	19,122	20,089
Heavy trucks	4,002	2,862	3,153
Buses	927	419	368
Motorcycles	13,148	14,975	14,757
Passenger	90,869	77,937	93,843
Totals	116,243	100,249	117,453

* 2010 figure extrapolated in proportion to passenger vehicle sales in the above Table.

The main characteristics of batteries from an 'arisings' perspective include the replacement rate, average weight of the battery in kilograms and the number of batteries installed per vehicle. These key characteristics for the WA fleet of vehicles are shown in Table 5.

Table 5 – Data on average battery characteristics			
Category	*Replacement Rate*	*Average Weight (kg)*	*Batteries per Vehicle*
Motorcycle	24%	3	1
Passenger vehicle	31%	14.3	1
Light commercial	29%	15.7	1
Rigid trucks	36%	23	1
Articulated trucks	35%	31.6	2
Non-Freight trucks	36%	31.6	1
Buses	37%	31.6	2

4.1.2 Inputs Methodology

The two different vehicle classification systems used in the data sources above were converted into a single classification consisting of passenger, light commercial/truck, heavy truck, buses and motorcycles. This was done with consideration of the definitions in the original sources, avoiding overlap as far as possible. In this way vehicle fleet, national sales and battery characteristic data were all converted to this basis, with weighted averages applied where necessary.

[6] *Department of Innovation, Industry, Science and Research, 1998-2010, 'Key Automotive Statistics', Department of Innovation, Industry, Science and Research, accessed at http://www.innovation.gov.au/Industry/Automotive/Statistics/Pages/default.aspx, October 2011.*

Replacement battery inputs were calculated by multiplying the number of registered vehicles in 2010 by the replacement rate and other relevant parameter values in Table 5. WA vehicle sales were determined from ABS data,[7] although allocation to the different vehicle classes was done on the basis of national sales.

The number and weight of batteries entering Western Australia through new vehicle sales was calculated using vehicle sales data and the battery characteristics.

4.1.3 Stocks Methodology

Automotive SLI battery stocks are simply the number of batteries currently in use in vehicles. This was calculated as the product of registered vehicles in the fleet and the battery characteristics presented above in Table 5, for each vehicle class.

4.1.4 Arisings Methodology

Battery arisings come about through battery failure, which results in replacement, or through vehicle attrition, when the vehicle is deregistered and scrapped whether as a result of accident or age.

Battery arisings through replacement are equal to battery inputs for replacement, for which the calculation was discussed above.

Vehicle attrition in year i was calculated as:

$$\textit{vehicles scrapped}_i = \textit{registered vehicles}_i + \textit{vehicle sales}_i - \textit{registered vehicles}_{i+1}$$

Because data was not available for 2011, the number of vehicles scrapped in the course of 2010 was calculated by using average attrition rates from 2008 and 2009 for each vehicle class, expressed as a percentage of the fleet size for that vehicle class. This rate, multiplied by the vehicle fleet data for 2010 and by the relevant battery characteristics given above in Table 5, provided the Automotive SLI battery arisings from vehicle attrition in 2010 (see Table 10 for more information)..

It is noted that for buses, the data gave rise to negative attrition rates, which is by definition not possible. Actual sales data was likely higher than that which was calculated based on national averages. As such, bus sales data was scaled to give positive attrition rate and sales of other vehicles adjusted in proportion accordingly.

4.2 **Automotive SLI LAB Inputs**

Automotive batteries enter Western Australia primarily as separately sold replacement batteries or within new vehicles. Estimated inflows through these pathways are presented in Table 6 and Table 7 respectively.

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[7] *ABS, 2011, '9314.0 - Sales of New Motor Vehicles, Australia, Dec 2010', Australian Bureau of Statistics, Canberra, accessed at http://www.abs.gov.au/AUSSTATS/abs@.nsf/allprimarymainfeatures/5E52BF4D517C8C2FCA2578380010CF54?opendocument, October 2011.*

Table 6 – Breakdown of replacement Automotive SLI inputs 2010

Vehicle type	*No. of batteries*	*Proportion count*	*Ave weight (kg)*	*Total weight (tonnes)*	*Proportion weight*
Passenger	426,800	73%	14.3	6,103	70%
Light commercial/truck	89,500	15%	15.7	1,405	16%
Heavy trucks	32,200	6%	24.9	799	9%
Buses	9,900	2%	31.6	314	4%
Motorcycles	22,500	4%	3.0	68	1%
Total	**580,900**	**100%**		**8,688**	**100%**

Table 7 – Breakdown of Automotive SLI inputs in new vehicle sales 2010

Vehicle type	*No. of batteries*	*Proportion count*	*Ave weight (kg)*	*Total weight (kg)*	*Proportion weight*
Passenger	93,800	71%	14.3	1,342	74%
Light commercial/truck	20,100	15%	15.7	315	17%
Heavy trucks	3,700	3%	24.9	91	5%
Buses	700	1%	31.6	23	1%
Motorcycles	14,800	11%	3.0	44	2%
Total	**133,100**	**100%**		**1,816**	**100%**

4.3 Automotive SLI LAB Stocks

Considerable numbers of Automotive SLI batteries reside within the existing fleet of registered vehicles in Western Australia. These stocks are summarised in Table 8.

Table 8 – Breakdown of Automotive SLI stocks 2010

Vehicle type	*No. of batteries*	*Proportion count*	*Ave weight (kg)*	*Total weight (tonnes)*	*Proportion weight*
Passenger	1,376,700	74%	14.3	19,687	72%
Light commercial/truck	308,500	16%	15.7	4,844	18%
Heavy trucks	77,500	4%	24.9	1,926	7%
Buses	13,400	1%	31.6	424	2%
Motorcycles	93,900	5%	3.0	282	1%
Total	**1,870,068**	**100%**		**27,163**	**100%**

4.4 Automotive SLI LAB Arisings

Batteries become available for recycling or disposal either when the battery fails and is replaced or when the vehicle it services is deregistered and scrapped. This assumes that one new battery replaces one ULAB and also that that vehicles are decommissioned with their batteries intact within the vehicle. Replacement rates were applied to the registered vehicle fleet to determine arisings from replacement (equal to the inputs for replacement shown in Table 6), while vehicle attrition was calculated as the difference between vehicle sales and change in fleet. The breakdown of results is given in Table 9 and Table 10.

Table 9 – Breakdown of replaced Automotive SLI arisings 2010

Vehicle type	*No. of batteries*	*Proportion count*	*Ave weight (kg)*	*Total weight (tonnes)*	*Proportion weight*
Passenger	426,800	73%	14.3	6,103	70%
Light commercial/truck	89,500	15%	15.7	1,405	16%
Heavy trucks	32,200	6%	24.9	799	9%
Buses	9,900	2%	31.6	314	4%
Motorcycles	22,500	4%	3.0	68	1%
Total	**580,900**	**100%**		**8,688**	**100%**

Table 10 – Breakdown of Automotive SLI arisings due to vehicle attrition 2010

Vehicle type	*No. of batteries*	*Proportion count*	*Ave weight (kg)*	*Total weight (tonnes)*	*Proportion weight*
Passenger	49,100	77%	14.3	702	82%
Light commercial/truck	7,800	12%	15.7	122	14%
Heavy trucks	500	1%	24.9	14	2%
Buses	10	0%	31.6	1	0.1%
Motorcycles	6,300	10%	3.0	19	2%
Total	**63,710**	**100%**		**859**	**100%**

4.5 Summary of Results – Automotive SLI LAB

A summary of the overall SLI inputs, stocks and arisings, by unit and by mass, in Western Australia is presented in Table 11. This shows that approximately 9,500 tonnes of ULAB from SLI sources were generated in 2010.

Table 11 – Summary of 2010 Automotive SLI data

	Units	*Mass (tonnes)*
Battery inputs (SLI LAB)	714,000	10,504
Battery stocks (SLI LAB)	1,895,700	27,891
Battery arisings (SLI ULAB)	644,700	9,547

5 LARGE AND INDUSTRIAL ULAB

As identified in Section 2.3, this category of batteries includes the following:

- marine engine applications
- traction and motive power applications, such as golf carts, mobility scooters, small forklifts and large materials handling units
- forestry, farming and construction applications, for those vehicles with engines (such as excavators, front-end loaders, dozers, graders, tractors, harvesters, trucks, feller-bunchers). It also includes those on compressors and gensets
- large stationary standby power applications.

Each of these categories is considered in turn below. Mining applications are considered in the following section.

5.1 Marine Engine Applications

Consolidated data on boat registrations for Australia as a whole, as well as for WA, is not readily available in the public domain. In order to estimate the national boat fleet, the approach taken in the ABRI study was to use data that was available for NSW and QLD and extrapolate according to the population. On this basis, a national fleet of non-sail boats of 716,100 was estimated. It is suggested that the number of boats that would be found in WA is proportional to WA's share of population (10.18 per cent in 2010), suggesting a fleet size of 72,920 non-sail boats. Although it may be argued that economic growth could have lead to higher boat sales in WA as would be the case for cars, typically the turnaround on boat purchases is relatively slow, and hence this is not expected to have a significant impact.

Other assumptions made in calculating the stocks, inputs and arisings for this category include the following, all extracted from the ABRI study:

- average life – 3 years
- average weight – 21.8 kg (based on a range of 15.1 kg to 30 kg)
- 1 battery per vehicle
- replacement rate = 37 per cent.

The key assumption that differed from the ABRI study is that new sales of boats was estimated as 5 per cent of the fleet as opposed to 3.6 per cent. This alteration is made to account for the growing prosperity in the state.

Based on this data, the model was used to calculate the results as number and weight of batteries for stocks, inputs and arisings shown in Table 12.

Table 12 – Results for marine engine applications in WA 2010

Description	*Inputs*	*Stocks*	*Arisings*
Number of batteries	30,600	72,900	27,000
Weight of batteries (tonnes)	668	1,590	588

5.2 Traction and Motive Power Applications

As identified above, this category includes a variety of equipment, each group of which is treated somewhat differently. Assumptions made to obtain the estimates for golf carts and mobility scooters are as follows:

- WA has approximately 150 golf courses[8]
- an average of 25 golf carts is estimated to be associated with each club. This formula estimates a fleet of 3,750 golf carts in WA
- batteries used in golf carts weigh between 10.5 kg and 33 kg, with an average of 22.6 kg, which was the average weight used in this study. Six batteries are used per cart with an average life of five years, with the assumption of a greater service life than SLI batteries due to a lower frequency of use in this application. Furthermore, inputs were assumed to be 10 per cent of the fleet. These assumptions are in line with that used in the ABRI study
- given no alternative data being available for mobility equipment, it is assumed that the population of mobility equipment is equivalent to the number of golf carts. The remainder of assumptions are consistent with those used for golf carts, except that mobility equipment uses two batteries instead of six.

In terms of materials handling equipment, it is recognised that a large range of equipment exists. As such, for the purposes of this study, two nominal classes of equipment were identified, once again in line with the ABRI study:

- Materials Handling – Small: In this category, battery weights range from 10.5 kg to 33 kg, with an average weight of 22.6 kg used in this study. Two batteries, with an average life of five years, were assumed for each equipment item
- Materials Handling – Large: For this study, large materials handling forklifts have been assumed to utilise an average 24-volt array weighing 300 kg, with an average life of 5 years (each battery is assumed to have a 5 hour run time with 1,500 cycles of charge and recharge, giving an average of 30 hours run time per week).[9]

To estimate stocks, inputs and arisings in this category, it was assumed that all manufacturing businesses that were also employers would utilise such equipment, with the number of pieces of equipment proportional to the number of employees, as shown in Table 13. The table also shows

[8] See for example, http://www.golfselect.com.au/armchair/courseList.aspx?state=WA.

[9] Such vehicles use a battery that comprises an array of 2-volt cells that are either 158 mm wide (British Standard), or 198 mm wide (German standard). The height and thickness of each cell varies, with weights ranging from 20 kg to 50 kg. Some 36-volt batteries that weigh one tonne are quite common and special application batteries for mine sites can contain 56 cells and weigh nearly 3 tonnes (ABRI Report).

the number of businesses in the different employee categories as taken from ABS data.[10] It is noted that the latest ABS data is for June 2009, so the data was scaled assuming a growth of 4.2 per cent to estimate 2010 data.

Table 13 – Estimated national fleet electric fork lift equipment in 2010

Employee Range	*1–4*	*5–19*	*20–49*	*50–99*	*100–199*	*200+*
Number of businesses within range (2010)	2,385	1,994	785	294	81	66
Number of small materials handling items per business	1	2	4	8	16	16
Estimated number of small materials handling items	2,385	3,988	3,140	2,352	1,296	1,056
Number of large materials handling items per business	1	2	2	4	8	8
Estimated number of large materials handling items	2,385	3,988	1,570	1,176	648	528

Based on the assumptions above, the model was used to calculate the stocks, inputs and arisings for the Traction and Motive Power Application category shown in Table 14.

Table 14 – Summary of results for traction and motive power applications in WA 2010

	Inputs		*Stocks*		*Arisings*	
Description	*Number of batteries*	*Weight of batteries (tonnes)*	*Number of batteries*	*Weight of batteries (tonnes)*	*Number of batteries*	*Weight of batteries (tonnes)*
Golf carts and mobility equipment	5,100	115	20,300	458	4,100	92
Small materials handling equipment	6,400	145	25,600	578	5,100	116
Large materials handling equipment	nd	695	nd	2,780	nd	556
Total	**11,500**	**955**	**45,900**	**3,816**	**9,200**	**764**

* nd = no data on number of batteries in the large materials handling equipment category, due to the approach used for the calculation

5.3 Industry, Construction, Forestry, Agriculture and Large Stationary Standby

Direct industry information for industry, construction, agriculture and large stationary lead acid batteries was not readily available. As such, a similar approach was used to that for Materials Handling Equipment in which the number of businesses falling into various employee categories

[10] *ABS, 2009, 'Counts of Australian Businesses, Including Entries and Exits, Jun 2007 to Jun 2009', accessed at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun%202007%20to%20Jun%202009?OpenDocument, October 2011.*

was determined and assumptions made about the number of pieces of equipment that each size of business would use. An alternative approach was used for Large stationary standby due to the lack of data in this category.

5.3.1 Methodology: Industry

This category includes small, gas-operated forklifts and materials handling equipment, as well as internal combustion forklifts. For this category, it was assumed that every business in WA that was an employer held one each of these pieces of equipment. According to the ABS statistics,[11] there were 5,377 such businesses in 2009. Scaling at 4.2 per cent, the average growth in GDP in WA over the past three years, gave 5,605 businesses in 2010. Assumptions used here, based on the ABRI report, were that the average battery weight is 9.1 kg for small forklifts and 31.6 kg, the input 10 per cent of the stock and the replacement rate 36 per cent.

5.3.2 Methodology: Earth Moving, Construction and Landfill

In order to estimate stocks, inputs and arisings in this category, it was assumed that the category of 'construction' as included in ABS data[12] would act as a suitable proxy for the remainder of the category.[13] A further assumption was that all construction businesses that were also employers would utilise such equipment, with the number of pieces of equipment being proportional to the number of employees, as shown in Table 15. The table also shows the number of businesses in the different employee categories from data obtained from the ABS. It was noted that the latest ABS data was for June 2009, so the data was scaled to 2010 assuming a growth of 4.2 per cent.

Table 15 – Estimated number of each vehicle type per business

Employee Range	*1–4*	*5–19*	*20–49*	*50–99*	*100–199*	*200+*
Number of businesses within range (2010)	7,086	2,453	564	150	68	56
Number of each vehicle items per business	1	2	4	8	16	16
Estimated number of small materials handling items	7,086	4,906	2,256	1,200	1,088	896
Total Vehicle Fleet Factor	**17,432**					

Six types of equipment were included in this category as shown in Table 16 below, along with the weights of the different types of batteries used in each vehicle. The total number and mass of batteries was calculated assuming that there were 22,489 vehicles of each type shown in Table 16. Other assumptions, apart from the battery weight, included inputs being 10 per cent of the fleet, a replacement rate of 60.6 per cent and one battery per vehicle.

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[11] *ABS, 2009, 'Counts of Australian Businesses, Including Entries and Exits, Jun 2007 to Jun 2009', accessed at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun%202007%20to%20Jun%202009?OpenDocument, October 2011.*

[12] *ABS, 2009, 'Counts of Australian Businesses, Including Entries and Exits, Jun 2007 to Jun 2009', accessed at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun%202007%20to%20Jun%202009?OpenDocument, October 2011.*

[13] *It is noted, however, that the ABS data aggregates both construction and construction trade services. In order to dissagregate these, it was assumed that the national split between these two categories holds in WA. This split was 22.5 per cent of the total were services in 2006, as derived from ABS, 2007, '8165.0 - Counts of Australian Businesses, Including Entries and Exits, Jun 2003 to Jun 2007', Australian Bureau of Statistics, Canberra, accessed at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun%202003%20to%20Jun%202007?OpenDocument, August 2010.*

Table 16 – Estimated number of each vehicle type per business

Vehicle type	Weight of battery (kg)
Excavators	27.9
Front-end loaders	27.9
Dozers	27.9
Graders	27.9
Compressors and gensets	19.4
Bobcats (small items)	9.1

5.3.3 Methodology: Forestry

The forestry sector in WA is relatively small, with one estimate suggesting that in 2005/06 there were 11 industrial forest growers and 69 wood and paper processors.[14] Escalating at 4.2 per cent gave a total of 94 companies in 2010. The assumption was made here that these companies fell within the 20–49 employee category, and as per the ABRI report, utilised 16 feller-bunchers and 16 chippers each, giving rise to a fleet of 1,376 of each of these pieces of equipment. The assumptions made to calculate the stocks and flows for this category included that each piece of equipment had one battery, with an average life of 2 years, an average weight of 27.9 kg, inputs being 10 per cent of the fleet and a replacement rate of 60.6 per cent.

5.3.4 Methodology: Agriculture

The approach taken in Agriculture was similar to that described for Earth Moving, Construction and Landfill. The number of businesses in different employee groupings was determined from the ABS data and adjusted to 2011 data. It was noted that the ABS data grouped Agriculture, Forestry and Fishing together. The number of businesses in the Forestry sector was removed as per the figures presented in the previous section. In terms of fisheries, WA Department of Fisheries states that there are 35 commercial fisheries and 15 under management.[15] These were also excluded – once again from the 20–49 employee category.

Further assumptions made to calculate the stocks and flows for this category included that each vehicle had one battery, with an average life of 2 years, an average weight of 27.9 kg, inputs being 10 per cent of the fleet and a replacement rate of 60.6 per cent. Three vehicle types were included here, which were multiplied by the fleet factor to get the overall number of vehicles, being tractors, harvesters and trench diggers.

Using these assumptions, the fleet factor was calculated as shown in Table 17.

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[14] Schirmer, J, 2008, 'Forestry, Jobs and Spending: Forest Industry Employment And Expenditure In Western Australia, 2005–06', accessed at http://www.crcforestry.com.au/downloads/WA-Forestry_download_part1.pdf, October 2011.

[15] WA Department of Fisheries, undated, 'Commercial Fishing', WA Department of Fisheries, Perth, accessed at http://www.fish.wa.gov.au/sec/com/index.php, October 2010.

Table 17 – Estimated number of each vehicle type per business in agricultural applications

Employee Range	*1–4*	*5–19*	*20–49*	*50–99*	*100–199*	*200+*
Number of businesses within range (2011)	4,781	2,018	295	114	40	9
Number of each vehicle items per business	1	4	16	32	64	64
Estimated number of small materials handling items	4,781	8,072	4,720	3,648	2,560	576
Total Vehicle Fleet Factor	**24,357**					

5.3.5 Methodology: Large Stationary Standby

Large Stationary Power applications include those for stand-by power, photovoltaics, wind power and large scale uninterruptible power supplies (rather than those used in commercial applications). This category of batteries has the least available information which can be used to determine the prevalence in WA. In the ABRI study, use was made of estimates from the United Kingdom, and scaled according to population. For this current study, the results from the ABRI study were used, and once again scaled for WA's population. Furthermore, a nominal growth of 7 per cent was applied to the ABRI figures to account for the high growth in the WA economy.

5.3.6 Summary of Results

Using the data and assumptions presented above, the results shown in Table 18 for the stocks and flows of the Industry, Construction, Forestry, Agriculture and Large stationary standby category could be estimated.

Table 18 – Summary of results for Industry, Construction, Forestry, Agriculture and Large Stationary Standby in WA 2010

	Inputs		*Stocks*		*Arisings*	
Description	*Number of batteries*	*Weight of batteries (tonnes)*	*Number of batteries*	*Weight of batteries (tonnes)*	*Number of batteries*	*Weight of batteries (tonnes)*
Industrial premises	4,600	93	11,200	228	4,000	82
Earth-moving, Demolition and Construction	68,610	1,602	104,600	2,442	63,400	1,480
Forestry	1,980	55	3,000	84	1,800	51
Agriculture	52,350	1,460	79,800	2,227	48,400	1,349
Large Stationary Standby	46,700	1,634	305,100	10,678	29,100	1,018
Total	**174,240**	**4,844**	**503,700**	**15,659**	**146,700**	**3,980**

6 ULAB AND THE MINING SECTOR

The mining sector plays a major role in the Western Australian and national economy, a role which is continuing to grow. This sector is also a significant consumer of Lead Acid Battery (LAB) products. As such, there is merit in exploring this sector separately from the remaining applications both in terms of contribution to battery arisings currently and moving in to the future. An assessment is also provided here of the logistics challenges for resource recovery, given the uniqueness of the sector.

6.1 Approach

The approach used in the ABRI study was used to guide calculation of the estimates of the ULAB arisings in the mining sector in WA. In that study, it was suggested that the fleet of equipment included:

- dump trucks
- dozers and scrapers
- wheel loaders
- shovels
- ancillary equipment such as gensets and lighting.

Once again, the number of pieces of each type of equipment was assumed to be dependent on the number of employees in the business. ABS[16] provides the number of businesses in each employee category for 2009 for the WA mining sector which, in accordance with the ANZIC 2006 code, includes Oil and Gas Extraction.[17]

To scale the number of businesses from 2009 to 2010, consideration had to be given to the growth in production output between these years. Growth in value to the economy was not considered a suitable proxy due to the change in value of the Australian dollar and the fluctuation in commodity prices. Production outputs for individual commodities varied significantly between these years – from 1 per cent for alumina to 25 per cent for gold.[18] As such, increases in production outputs were not considered to be useful as an indication of growth of the industry, giving the resolution of data used here.

Increases in total employee numbers were thus selected as an alternative indicator of growth in the industry. In 2010 there were 85,163 employees in the sector, up from 75,609 in 2009, representing a 12.64 per cent increase.[19] This increase was used to scale the 2009 business numbers to 2010. The resulting number of businesses that fell into each employee category, along with the number of

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[16] *ABS, 2009, 'Counts of Australian Businesses, Including Entries and Exits, Jun 2007 to Jun 2009', accessed at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun%202007%20to%20Jun%202009?OpenDocument, October 2011.*

[17] *Tthe ABS data aggregates mining services with mining activities. In order to dissagregate these, it was assumed that the national split between these two categories holds in WA. This split was 41.5 per cent of the total in 2006 were services, as derived from ABS, 2007, '8165.0 - Counts of Australian Businesses, Including Entries and Exits, Jun 2003 to Jun 2007', Australian Bureau of Statistics, Canberra, accessed at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun%202003%20to%20Jun%202007?OpenDocument, August 2010.*

[18] *Western Australia Department of Mines and Petroleum, 2011, 'Western Australian Mineral and Petroleum Statistics Digest 201', accessed at http://www.dmp.wa.gov.au/documents/Statistics_Digest_2009-10.pdf, October 2011.*

[19] *Western Australia Department of Mines and Petroleum, 2011, 'Western Australian Mineral and Petroleum Statistics Digest 201', accessed at http://www.dmp.wa.gov.au/documents/Statistics_Digest_2009-10.pdf, October 2011.*

each of the different types of vehicles for each category used to calculate the 'fleet factor', is shown in Table 19 below.

Table 19 – Summary of business count data for Mining in 2010

	Employee Numbers					
	1–4	*5–19*	*20–49*	*50–99*	*100–199*	*200+*
Number of employees (2010)	427	243	93	36	32	42
Plant items per business	1	2	4	8	16	32
Estimated fleet of equipment	427	486	372	285	506	1349
Total estimated fleet factor	**3,425**					

It was thus estimated that that there was a fleet factor of 3,425 for each piece of the above equipment items. The one exception was ancillary equipment, including lighting, generation sets and other small pieces of plant and equipment. It was estimated that four times as much of this equipment was used when compared to other larger plant.

Other key assumptions used to estimate the stocks and flows of LAB in the mining industry include that:

- dump trucks, dozers, wheel loaders and shovels using the largest sized battery of 53.9 kg, an average of 4 per vehicle and a life of 2 years
- ancillary equipment with an average weight of 19.4 kg, a life span of 3 years and 1 battery used per piece of equipment
- inputs were estimated at 12.64 per cent of the total fleet, in line with the growth in employment in the mining sector in the state as described previously.

A summary of the data used in the calculations, including the average life in years, average weight in kg, batteries per vehicle, fleet size and replacement rate, are presented in Table 20.

Table 20 – Summary of data on mining equipment

Category	*Average Life (yrs)*	*Average Weight (kg)*	*Batteries per Vehicle*	*Fleet Size*	*Replacement Rate*
Dump trucks	2	53.9	4	3,425	60.6%
Dozers and scrapers	2	53.9	4	3,425	60.6%
Wheel loaders	2	53.9	4	3,425	60.6%
Shovels	2	53.9	4	3,425	60.6%
Ancillary equipment (eg gensets, lighting etc.)	3	19.4	1	13,700	36.0%

Using these assumptions, the stocks and flows of LAB in the mining sector can be estimated, with the results presented in Table 21.

Table 21 – Summary of stocks and flows of ULAB from the Mining sector in WA 2010

	Inputs		*Stocks*		*Arisings*	
Description	*Number of batteries*	*Weight of batteries (tonnes)*	*Number of batteries*	*Weight of batteries (tonnes)*	*Number of batteries*	*Weight of batteries (tonnes)*
Mining sector ULABs	46,800	2,297	68,500	3,220	38,100	1,890

In interpreting these numbers against the estimates provided in the ABRI study, it is important to note that WA had 36.6 per cent of the total mining businesses in Australia in 2009.[20] Hence the estimated arisings are significantly higher than if estimated on a population or GDP contribution or similar basis.

[20] *ABS, 2009, 'Counts of Australian Businesses, Including Entries and Exits, Jun 2007 to Jun 2009', accessed at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun%202007%20to%20Jun%202009?OpenDocument, October 2011. Note that this percentage includes mining services as these could not be disaggregated from the data set.*

7 SUMMARY OF ULAB ARISINGS

The previous sections detailed the methodology for and results of the stocks and flows analysis of lead acid batteries in Australia. A summary of ULAB arisings is presented in Table 22, which gives a concise indication of the stream which could potentially be available for recovery.

Table 22 – Summary of ULAB arisings in WA 2010

Category	*Mass (tonnes)*
Handheld SLAB	52
Automotive SLIs	9,547
Marine	588
Golf, mobility and forklifts	764
Industry, earth moving, demolition and construction	2,962
Large Stationary Standby	1,018
Mining	1,890
Total WA arisings	**16,821**

There is also merit in providing some indication of the fate of LAB. The original ABRI report suggested an indicative split of the streams to different fates. The end-of-life outcomes considered in that report that are applicable for ULAB were:

- reprocessed in Australia
- landfill
- stockpiled formal, in warehouses and at industrial facilities according to relevant legislation for battery storage in bulk
- stockpiled informal, for example left embedded in plant and equipment to accumulate around the farm, barn or mine site
- rebirthing, which is the inappropriate re-branding of an end-of-life battery for resale
- illegal export, which although is likely to be for reprocessing, nevertheless carries all of the risks of potentially hazardous materials being processed at unlicensed facilities.

In order to estimate the relevant proportions attributable to the potential end-of-life fate of ULAB, consideration must be given to the geographic isolation of WA and in particular, to the mine sites that contribute a significant amount of ULAB arisings. The 'mine site' factor of 36.6 per cent has been used as a factor to increase the non-recovery outcomes. For example, 36.6 per cent of all national stockpiling, rebirthing, illegal export, and landfill of ULAB has been estimated to occur in WA.[21] It is highlighted that while the use of the mine site factor affects the estimates related to the fate of ULAB arisings, it does not affect the quantum calculation of total ULAB arisings in WA.

[21] *The exception here is Handheld SLAB, which has been adjusted proportionally to the total ULAB WA arising estimate of 52 tonnes.*

The resulting split of arising according to end destination, along with the likely implications for the various WA arisings, is shown in Table 23 below.

Table 23 – Fate of Western Australian battery arisings by category and weight (tonnes) in 2010

Fate of Arisings	*Handheld*	*Automotive SLI*	*Large and Industrial (inc mining)*	*Total Weight*	*Total Proportion*
Reprocessed in Australia	5[22]	4,347	4,540	8,8892	53%
Landfill	25	732	381	1,138	7%
Stockpiled Formal	1	1,449	747	2,197	13%
Stockpiled Informal	21	604	311	936	6%
Rebirth	-	483	247	730	4%
Illegal Export	-	1,932	996	2,928	17%
Totals	**52**	**9,547**	**7,222**	**16,821**	**100%**

On this basis it is estimated that only 53 per cent of WA ULAB arisings are reprocessed in Australia. Of the remainder it is estimated that approximately 34 per cent of all batteries in WA are not being managed in an optimal way. This represents:

- 1,138 tonnes of batteries disposed of to landfill (7 per cent of total arisings)
- 936 tonnes of batteries stockpiled informally, for example left to accumulate in the farm, barn or mine site (6 per cent)
- 730 tonnes of batteries being 'rebirthed', which means they are inappropriately re-branded for resale with no quality control or assurance (4 per cent)
- 2,298 tonnes of illegal export, which although is likely to be for reprocessing, nevertheless carries all of the risks of hazardous materials being processed at unlicensed facilities (17 per cent).

[22] The Western Australia Local Government Authority operates a Household Hazardous Waste trial collection service, which includes the collection of handheld batteries from drop off points around the Perth Metropolitan region. 4,611.1 kilograms of sealed lead acid batteries were collected through this trial in 2010 and sent to the eastern seaboard for processing. Source: Eastern Metropolitan Regional Council cited by ABRI (unpublished) 2012.. Note that the implied recycling rate of 10% could be lower if the average weight of a SLAB unit is heavier than 0.7 kilograms.

8 KEY REGULATORY SETTINGS

The key regulatory settings affecting the use, movement and disposal of ULAB can be divided between Federal and State jurisdictions. Federal Regulations and Guidelines cover ULAB because they are classified internationally as hazardous waste. The 'National Waste Policy: Less Waste, More Resources' also covers ULAB, with further direction given under the *Product Stewardship Act 2011 (Cth)*. ULAB are also classified as hazardous waste in Western Australia, as set out under Western Australian Regulations and Guidelines. This section reviews the relevant policies, regulations and acts, and their relationship with international obligations.

8.1 Federal Regulations and Guidelines

ULAB are classified internationally as a hazardous waste. As such, their export and import are regulated under the Federal Hazardous Waste *(Regulation of Exports and Imports) Act 1989 (Cth)* to ensure environmentally sound handling, treatment, recycling and disposal of hazardous wastes.[23] The Act came into effect to ensue Australian compliance with obligations under the 'Basel Convention on the Control of the Transboundary Movements of Hazardous Wastes and their Disposal,' commonly referred to as the Basel Convention. The specific obligations that the Act addresses under the Basel Convention are:

- to control the export and import of hazardous and other wastes (i.e. household wastes or incinerator residues)
- to minimise the movement and generation of hazardous and other wastes and ensure environmentally safe disposal of hazardous wastes.[24]

The classification of hazardous waste under the Federal Hazardous Waste Act also aligns with the Basel Convention. Wastes listed in Annex I of the Basel Convention are considered hazardous. Wastes may also be considered hazardous if they exhibit one or more of the hazardous characteristics listed in Annex III (flammable, explosive, poisonous, infectious, corrosive, toxic and ecotoxic). The classification of wastes under Annex I is quite broad (for example, category Y31 Lead; lead compounds). More detailed categorisation of hazardous wastes is given in Annex VIII (also known as list A). Wastes in this Annex will belong to a category listed under Annex I, but also display a number of the hazardous categories defined in Annex III. Annex IX (also known as list B) lists wastes that are not required to be covered under the Convention in that they either do not fall under a category contained in Annex I, or they typically lack hazardous characteristics.

ULAB waste streams listed in Annex VIII (list A) include:

- A1160 – waste lead acid batteries, whole or crushed
- A1170 – unsorted waste batteries excluding mixtures of only list B batteries

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[23] *Australian Commonwealth Government, 2009, 'Hazardous Waste (Regulation of Exports and Imports) Act 1989', accessed at http://www.environment.gov.au/settlements/chemicals/hazardous-waste/guide.html, November 2011*

[24] *Australian Commonwealth Government, 2008, 'Information Paper No 3. Australian Guide to Exporting and Importing Hazardous Waste: Applying for a Permit', October 2008 / Fourth edition, accessed at http://www.environment.gov.au/settlements/chemicals/hazardous-waste/publications/pubs/permits.pdf, November 2011*

- A1180 – waste electrical and electronic assemblies or scrap containing components such as accumulators and other batteries included on list A.

Exporting ULAB for treatment and recycling is theoretically permitted by the Federal Government to avoid unsafe disposal such as landfilling or incineration. However, this need for export would only arise if there were insufficient reprocessing capacity in Australia to reprocess all ULAB arisings. This is not the case as was set forward in the ABRI 2010 study which identified 143,000 tonnes of ULAB processing capacity and approximately 122,500 tonnes of ULAB arisings .

8.2 National Waste Policy

The other key policy at national level that affects ULAB is the 'National Waste Policy: Less Waste, More Resources'.[25] The policy's broad objectives are to minimise waste generation and increase resource recovery. Two of the six key directions (and 2 of 16 strategies) under the National Waste Policy and associated implementation plan pertain to ULAB:[26]

- 'Taking responsibility: Shared responsibility for reducing the environmental, health and safety footprint of manufactured goods and materials across the manufacture-supply consumption chain and at end of life. Strategy 1: To establish a national framework underpinned by legislation to support voluntary, co-regulatory and regulatory product stewardship and extended producer responsibility schemes to provide for the impacts of a product being responsibly managed during and at end of life
- Reducing Hazard and Risk: Potentially hazardous content of wastes is reduced and waste recovery, handling and disposal is consistent, safe and accountable. Strategy 12: To ensure that: our international obligations are met; hazardous materials entering the waste stream are reduced; transboundary movement of hazardous waste is effectively, efficiently and legally undertaken within Australia and complies with international requirements; product stewardship is adopted to provide for the impacts of a product with potentially hazardous materials being responsibly managed during and at the end of life; and facilities are available to handle and dispose of hazardous substances that become waste in an environmentally sound manner.'

At this stage, there are no specific initiatives under Strategy 12 that relate to battery resource recovery. In addition, no federally operated or assisted programs with implications for battery resource recovery were identified and no direct funding is provided to State Governments or organisations to operate battery recycling programs. It is likely that battery recycling could be facilitated under Strategy 1, which includes an initiative related to e-waste product stewardship.

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[25] Department of Environment, Water, Heritage and the Arts, 2009, 'National Waste Policy: Less Waste, More Resources', Environment Protection and Heritage Council, Adelaide, accessed at http://www.ephc.gov.au/sites/default/files/WasteMgt_Rpt__National_Waste_Policy_Framework_Less_waste_more_resources_PRINT_ver_200911.pdf, November 2011.

[26] Department of Environment, Water, Heritage and the Arts, 2009, 'National Waste Policy: Less Waste, More Resources Implementation Plan', Environment Protection and Heritage Council, Adelaide, accessed at http://www.ephc.gov.au/sites/default/files/WasteMgt__National_Waste_Policy_Implementation_Plan_Final_201007.pdf, November 2011.

8.3 Product Stewardship Act

It is likely that battery recycling could be facilitated under Strategy 1 of the National Waste Policy. Under this key direction of the National Waste Policy the *Product Stewardship Act 2011 (Cth)* came into effect in August 2011.[27] The Act aims to promote the recovery and recycling of valuable materials from products. The Act is flexible in that it allows for a product or material specific approach to be developed as appropriate. Thus, products may be regulated in voluntary accreditation schemes; co-regulatory schemes co-ordinated by industry and regulated by Government; and mandatory schemes that contain legal requirements such as product labelling, or a deposit at end-of-life.[28] The first products to be regulated under the Act are televisions and computers, through the National Television and Computer Product Stewardship Scheme.[29] Future product stewardship schemes that have been planned under this Act are packaging, tyres and mercury containing lights. However, the legislation allows for materials and products to be added 'as the need arises'.[30] Lead acid batteries could thus fall under this legislation in the future.

8.4 Western Australia Regulations and Guidelines

In line with Federal regulations, ULAB are also classified as hazardous waste in Western Australia.[31] Western Australia also applies the schedule of waste from the National Environmental Protection Measure (Movement of Controlled Waste between State and Territories). Batteries are identified under Western Australia's Draft II Waste Strategy for Western Australia as a household hazardous waste and also a 'problem waste' that needs to be prioritised for product stewardship schemes.[32] The Waste Authority established under the *Waste Avoidance and Resource Recovery (WARR) Regulations 2008 (WA)* is the body responsible for implementing extended producer responsibility (EPR) schemes in Western Australia.

No comprehensive management strategy for the disposal or recovery of household hazardous waste currently operates in Western Australia.[33] However, the Household Hazardous Waste Program ran from 2008–2010 and held temporary collection days for recovering HHW including batteries.[34] An outcome of this program was the establishment of permanent collection facilities with additional funding set aside for new permanent facilities for the next 4-year HHW program.[35]

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[27] *Australian Government, 2011, 'National Product Stewardship Legislation', Department of Sustainability, Environment, Water, Population and Communities, accessed at http://www.environment.gov.au/settlements/waste/product-stewardship/index.html, November 2011.*

[28] *Australian Government, 2011, 'National Waste Policy Fact Sheet: Product Stewardship Act 2011', Department of Sustainability, Environment, Water, Population and Communities, accessed at http://www.environment.gov.au/wastepolicy/publications/pubs/fs-product-stewardship-act.pdf, November 2011.*

[29] *Australian Government, 2011, 'Product Stewardship (Television and Computers) Regulations 2011', Exposure Draft, accessed at http://www.environment.gov.au/settlements/waste/ewaste/publications/pubs/regulations-exposure-draft.pdf, November 2011.*

[30] *Australian Government, 2011, 'National Waste Policy Fact Sheet: Product Stewardship Act 2011', Department of Sustainability, Environment, Water, Population and Communities, accessed at http://www.environment.gov.au/wastepolicy/publications/pubs/fs-product-stewardship-act.pdf, November 2011.*

[31] *WA Government, 2004, 'Environmental Protection (Controlled Waste) Regulations 2004', WA Government, Perth, accessed at http://www.austlii.edu.au/au/legis/wa/consol_reg/epwr2004575.txt/cgi-bin/download.cgi/download/au/legis/wa/consol_reg/epwr2004575.txt, June 2010.*

[32] *WAWA, 2010, 'Draft II Waste Strategy for Western Australia', West Australian Waste Authority, Perth, accessed at http://www.zerowastewa.com.au/documents/waste_strategy_draft2_mar2010.pdf, September 2010.*

[33] *WAWA, 2010, 'Draft II Waste Strategy for Western Australia', West Australian Waste Authority, Perth, accessed at http://www.zerowastewa.com.au/documents/waste_strategy_draft2_mar2010.pdf, November 2011.*

[34] *Zero Waste Western Australia, 2010, 'Household Hazardous Waste Program, Program Summary and Forecasts for 2010–2011', accessed at htp://www.zerowastewa.com.au/documents/HHWC/HHW_proj_summ_2010-11.pdf, November 2011.*

[35] *Western Australia Waste Authority, 2011, 'Waste Authority Annual Report 2010/2011', accessed at http://www.zerowastewa.com.au/documents/WAuth_annual_report_1011.pdf, November 2011.*

9 CONCLUSIONS AND RECOMMENDATIONS

Lead Acid Battery (LAB) inputs refer to the consumption of LAB; stocks are those LAB in service within the economy; and arisings are LAB that have reached the end of their active service life (or are unwanted for any other purpose) and require a resource recovery or waste management solution. The materials stocks and flows model built for this study presents a breakdown of information on batteries according to:

- Handheld sealed lead acid batteries of less than 1 kg
- Automotive Starting Lighting and Ignition (SLI) batteries that are used in registered on-road vehicles and that use lead acid chemistry
- Large and Industrial lead acid batteries (essentially greater than 1 kg) that are used in non-registered or off-road engine applications, for example, agriculture, in addition to LAB used for motive and standby power
- Mine site lead acid batteries, to allow specific examination of the potential impact of mining relevant to the 'two speed' economy in Australia.

Lead Acid Battery Consumption (Inputs) in 2010

Western Australians consume nearly 1.2 million lead acid batteries each year, weighing over 19,000 tonnes. This represents approximately 14.5 per cent of the estimated 133,615 tonnes of national lead acid battery consumption, even through WA accounts for only 10.3 per cent of the population. These LAB inputs comprise approximately (with rounding):

- 185,400 Handheld SLAB weighing 130 tonnes
- 714,000 Automotive SLI batteries weighing 10,504 tonnes
- 216,300 Large and Industrial batteries weighing 6,467 tonnes
- 46,800 Mining batteries weighing 2,297 tonnes.

Lead Acid Battery Stocks in 2010

Stocks of batteries are defined as batteries in active service life. Estimates of battery stocks thus rely on estimates of the WA 'fleet' of products that use batteries. On this basis it was estimated that approximately 3 million lead acid batteries are in service in WA, weighing over 52,000 tonnes. These totals comprise (with rounding):

- 363,700 Handheld SLAB weighing 255 tonnes
- 1,895,700 Automotive SLI batteries weighing 27,891 tonnes
- 622,500 Large and Industrial batteries weighing 21,065 tonnes
- 68,500 Mining batteries weighing 3,220 tonnes.

Lead Acid Battery Arisings in 2010

Battery arisings are the batteries that reach the end of their service life each year. It is estimated that over 900,000 batteries present as an end-of-life management issue in WA, weighing 16,821 tonnes.

Battery arisings comprise (with rounding):

- 74,600 Handheld batteries weighing 52 tonnes
- 644,700 Automotive SLI batteries weighing 9,547 tonnes.
- 182,900 Large and Industrial batteries weighing 5,332 tonnes
- 38,100 Mining batteries weighing 1,890 tonnes.

Fate of Battery Arisings in 2010

If landfill is considered an undesirable management option for batteries, and is grouped with illegal export, rebirth and informal stockpiling (all arguably undesirable from a stewardship perspective), then approximately 34 per cent of all batteries in WA are not being managed in an optimal way. This represents:

- 1,138 tonnes of batteries disposed of to landfill (7 per cent of total arisings)
- 936 tonnes of batteries stockpiled informally, for example left to accumulate in the farm, barn or mine site (6 per cent)
- 730 tonnes of batteries being 'rebirthed', which means they are inappropriately re-branded for resale with no quality control or assurance (4 per cent)
- 2,298 tonnes of illegal export, which although is likely to be for reprocessing, nevertheless carries all of the risks of hazardous materials being processed at unlicensed facilities (17 per cent).

Challenges for Battery Resource Recovery

Automotive SLI batteries have the highest resource recovery rate of LAB battery types, owing to their size and the value of lead as a commodity. The recovery rate is 61 per cent when including formal stockpiling for reprocessing is included. There is room for improved stewardship amongst LAB including taking action on the eradication of illegal export, improved recovery from remote and regional sites and prevention of batteries entering the urban waste stream and being landfilled.

The main challenges for Large and Industrial batteries are improved recovery from remote and regional sites and gaining a better understanding of the standby power sector.

Mining represents a particular challenge with respect to recovery of ULAB. Despite representing a significant proportion of the arisings, it is estimated that recovery rates are very low from mining sites because of their geographic isolation, which contributes to the cost of recovery.

Recommendations

The geographic isolation of remote and regional sites in WA, combined with their distance from reprocessors on the east coast, create challenges for responsible resource recovery especially when the commodity price of lead is low, or when there is a temporary oversupply of ULAB in the Australian market (caused by, for example a reduction in processing capacity as a result of a facility shutdown for maintenance).

While this study has not addressed the impacts of cost on ULAB recovery in WA, any reduced price paid for ULAB as a result of market factors will exacerbate the cost impact of geographic isolation.

Remoteness and fluctuating market conditions point to the need to firstly gain additional insight into cost impacts on ULAB recovery in WA, and secondly to develop an action framework to support responsible recycling of ULABs in WA.

With regard to lead acid batteries in WA (and also nationally), it is recommended that additional work be undertaken in the following areas:

- improved assessment of average weights for use in materials stocks and flows models. This could be achieved through a formal sampling program amongst trials and also reprocessors in Australia
- study into the impact of commodity price and collection cost on ULAB recovery rates, and in particular, costs of recovery from remote sites in WA. This would provide insight in to the level of support required to mitigate against remoteness acting as a barrier to improved stewardship
- replication of the WA study in other states and territories to provide a 'bottom-up' cross reference model to the original ABRI top down study that was undertaken on a national basis.

10 APPENDICES

10.1 Appendix 1 – Assumptions and Limitations of Study Approach

The original 2010 ABRI study entitled 'Analysis of Battery Consumption, Recycling and Disposal in Australia' provided the foundation for the classification of battery types, and the methodology for the material stocks and flows analysis. The ABRI study identified three main LAB types, as defined by a combination of size and application. These LAB types include:

- Handheld batteries (less than 1 kg)
- Automotive Starting Lighting and Ignition (SLI) batteries that are used in registered on-road vehicles
- Large and Industrial batteries (essentially greater than 1 kg) that are used in non-registered or off-road engine applications, for example, agriculture, in addition to batteries used for traction and motive, and standby power.

A specific focus of this study has also been the arisings of Large and Industrial batteries in mining applications. Thus 'Mining LAB' as an additional sub-category of Large and Industrial batteries has also been included for the purposes of this study.

Note that the main focus of the study has been on the Automotive SLI and Large and Industrial LAB, in addition to Mining LAB, as these comprise the majority of battery flows. The flows of Handhelds are relatively small. Table 24 below provides an overview of the approach taken in this study, as compared to the original 2010 ABRI study.

Table 24 – Summary of battery data sources and confidence levels

Inputs	*Stocks*	*Arisings*	*Overall Confidence*
	Handheld Batteries		
As per ABRI 2010 study based on WA Stock estimates	As per ABRI 2010 study and adjusted to WA business count and household count	As per ABRI 2010 study based on WA Stock estimates	N/A – the overall flow of SLAB is low (less than 0.5% of arisings) and therefore immaterial
	Automotive SLI Batteries		
As per ABRI 2010 study and adjusted to WA market based on ABS published data, industry data and calculations	As per ABRI 2010 study and adjusted to WA on basis of ABS published data, industry data and calculations	As per ABRI 2010 study - calculated on inputs and stocks in combination with life span	High - good data on fleet size and reasonable data on LAB requirements
	Large and Industrial Batteries		
As per ABRI 2010 study using ABS published data, industry data, similar international studies, calculations and extrapolations, in addition to adjusting to WA on basis of stocks	As per ABRI 2010 study and adjusted to WA on basis of per business use rates with ABS published data on industry size and count. Other proportional comparisons such as population, GDP and economic growth were also used	As per ABRI 2010 study - calculated on stocks in combination with estimated life span	Low to Medium – relies on modelling and assumptions for inputs, stocks and arisings

Table 24 – Summary of battery data sources and confidence levels

Inputs	*Stocks*	*Arisings*	*Overall Confidence*
	Large and Industrial Batteries - Mining		
As per ABRI 2010 study using ABS published data, industry data, similar international studies, calculations and extrapolations, in addition to adjusting to WA on basis of stocks	As per ABRI 2010 study and adjusted to WA on basis of per business use rates with ABS published data on industry size and count, incorporating growth factors on increased employment	As per ABRI 2010 study - calculated on stocks in combination with estimated life span	Low to Medium – relies on modelling and assumptions for inputs, stocks and arisings. Note that WA had 36.6%t of total mining businesses in Australia in 2009

In order to estimate the relevant proportions attributable to the potential end-of-life fate of ULAB in WA, consideration was given to the geographic isolation of WA and in particular, to the mine sites that contribute a significant amount of ULAB arisings.

The 'mine site' factor of 36.6 per cent has been used as a factor to increase the non-recovery outcomes. For example, 36.6 per cent of all national stockpiling, rebirthing, illegal export, and landfill of ULAB has been estimated to occur in WA. The exception here is Handheld SLAB, which has been adjusted proportionally to the total ULAB WA arising estimate of 52 tonnes. Table 25 below presents a comparison of the national fate of ULAB arisings as compared to the estimated WA proportions to highlight the implications of the WA approach.

Table 25 – Proportional comparison of the fate of National and WA ULAB arisings (tonnes basis)

Fate of Arisings	*National Proportion*	*WA Proportion*
Reprocessed in Australia	82%	53%
Landfill	3%	7%
Stockpiled Formal	5%	13%
Stockpiled Informal	2%	6%
Rebirth	2%	4%
Illegal Export	7%	17%
Totals	**100%**	**100%**

It is highlighted that while the use of the mine site factor affects the estimates related to the fate of ULAB arisings, it does not affect the quantum calculation of total ULAB arisings in WA.