



13 December 2019

Innovation in Australian battery recycling

New World Metals conference

Late yesterday Lithium Australia NL (ASX: LIT) presented its views on Australian battery recycling at the New World Metals conference in Perth, Western Australia.

The contents of that address, by Lithium Australia managing director Adrian Griffin, are included in this ASX release.

Authorised for release by the Board.

Barry Woodhouse

CFO and Company Secretary

Mobile +61 (0) 438 674 259

Barry.Woodhouse@lithium-au.com

Adrian Griffin

Managing Director

Mobile +61 (0) 418 927 658

Adrian.Griffin@lithium-au.com

About Lithium Australia NL

Lithium Australia aims to ensure an ethical and sustainable supply of energy metals to the battery industry (enhancing energy security in the process) by creating a circular battery economy. The recycling of old lithium-ion batteries to new is intrinsic to this plan. While rationalising its portfolio of lithium projects/alliances, the Company continues with R&D on its proprietary extraction processes for the conversion of *all* lithium silicates (including mine waste), and of unused fines from spodumene processing, to lithium chemicals. From those chemicals, Lithium Australia plans to produce advanced components for the battery industry globally, and for stationary energy storage systems within Australia. By uniting resources and innovation, the Company seeks to vertically integrate lithium recycling, extraction and processing.

Media contacts

Adrian Griffin, Lithium Australia NL

08 6145 0288 | +61 (0) 418 927 658

Kevin Skinner, Field Public Relations

08 8234 9555 | +61 (0) 414 822 631

ACN: 126 129 413

ASX: LIT

Level 1

675 Murray St

West Perth WA 6005

PO Box 1088

West Perth WA 6872

Phone +61 (0) 8 6145 0288

Fax +61 (0) 8 9475 0847

info@lithium-au.com

lithium-au.com



Innovation in Australian battery recycling



ENVIROSTREAM



ASX: LIT

Battery recycling – a modern imperative

- Envirostream Australia Pty Ltd ('Envirostream') is currently 74% owned by Lithium Australia NL (ASX: LIT, 'Lithium Australia').
- Australia's first mixed-battery recycling company, Envirostream has developed safe and innovative management solutions for what is emerging as one of the waste-management industry's biggest challenges.
- Envirostream is at the forefront of innovation in sustainable battery-processing methods. Its Australian facility, designed and built by the team at Envirostream, is based on international best practice.
- As the only company in Australia able to collect, sort, shred and separate the components of spent lithium-ion batteries ('LIBs'), Envirostream recovers cobalt, nickel, lithium and carbon to produce a mixed metal dust ('MMD') as the primary material, as well as scrap steel, copper, aluminum and plastic, which are returned to the manufacturing sector.
- Currently, the MMD is sold to SungEel HiTech Co. Ltd ('SungEel') – one of the world's largest battery recyclers – as feed in the re-birthing of cathode materials for new batteries.





Advanced technology

LITHIUM AUSTRALIA'S LEADING-EDGE TECHNOLOGIES

Lithium Australia has spent more than five years developing innovative extraction technologies for the lithium industry, including for the recovery of lithium from mine waste. Its proprietary processes – which have a common thread, in that the lithium is recovered as a phosphate – are characterised by:

- a lower energy footprint than conventional methods;
- greater control over water balance, and
- the ability to recover lithium from low-grade solutions.

APPLICATION OF TECHNOLOGIES TO RECYCLING

- Research and development for Lithium Australia's SiLeach® and LieNA® processes have led to the ability to recover lithium from various feed sources as lithium phosphate ('LP').
- Employing LP precipitation with its proprietary LP refining technology, Lithium Australia can generate a lithium chemical of very high purity, and of a type in high demand in China, where it sells at a significant premium to the more commonly traded chemicals lithium carbonate and lithium hydroxide.
- Lithium Australia's processing technologies can recover *all* the energy metals in spent LIBs, whereas, typically, conventional LIB recycling focuses on extracting the nickel and cobalt but not the lithium.

Collectively, the recycling capabilities of Lithium Australia and Envirostream will result in a focused business ideally positioned to add value by refining the energy metals from spent LIBs, initially in Australia and then overseas.

Established battery recovery network



EXPANDING THE RECYCLING BUSINESS

- Lithium Australia's equity contributions have enabled Envirostream to finalise the construction and commissioning of its expanded, 3,000 tonnes per annum ('tpa') plant in Melbourne – designed to cater for the growing need and impetus for battery recycling.
- Currently, Envirostream is the only Australian company recycling spent LIBs to recover all the energy metals they contain.
- The MMD that Envirostream produces from the spent LIBs it collects is exported for further refining.
- Envirostream has the exclusive Australian right to supply MMD to SungEel in South Korea.

COMBINED EXPERTISE

By providing Envirostream with access to its proprietary extraction technologies, Lithium Australia offers the former significant leverage for its battery recycling business. And, as that business grows to critical mass (about 2000 tpa of battery feed material), the addition of in-house refining capacity should further improve financial returns.

Sources and recovery of energy metals

CURRENT ENVIROSTREAM BUSINESS – CONSUMER ELECTRONICS

The electrode-active materials currently recovered as MMD (dominated by cobalt) by Envirostream equate to approximately 30% of the processed battery mass (MMD composition shown at right).

LIB MMD analysis – % wt			
Co	Ni	Mn	Li
24.9%	3.0%	1.6%	3.7%

FUTURE ENVIROSTREAM BUSINESS – ELECTRIC VEHICLES

As the larger battery packs in electric vehicles ('EVs') approach end of life, they also need to be recycled. The dominant LIB chemistry in these packs is nickel-cobalt-manganese ('NCM') of the '622' type (lithium + 6 parts nickel + 2 parts cobalt + 2 parts manganese). Further, the packs contain a lower proportion of MMD (pack mass being dominated by the container, structural elements, and electrical components such as busbars, etc.). Generally, there is around 30% MMD by mass. Approximately 55% of that MMD is cathode-active material of the composition and value shown at left.

Typical NCM 622 composition			
	% wt	Metal price (AU\$/t)	Value/t battery (AU\$)
Ni	38	22000	920
Co	13	50000	720
Mn	12	225	3
Li ₃ PO ₄	15	14000	230
Total value			1873

The remaining MMD content consists of graphite (from the battery anode) and minor metals resulting from comminution of the current collectors (copper and aluminium), plus iron from cell casings and structural elements of the battery pack. Thus, the value of the MMD per tonne of batteries processed is around AU\$1,900 (at Nov 19). Most of the operating costs incurred in recovering the MMD from the batteries is covered by the sale of the other separated components (copper, aluminium, steel and plastic).

Stockpiles of toxic spent batteries growing

USED BATTERY TRENDS

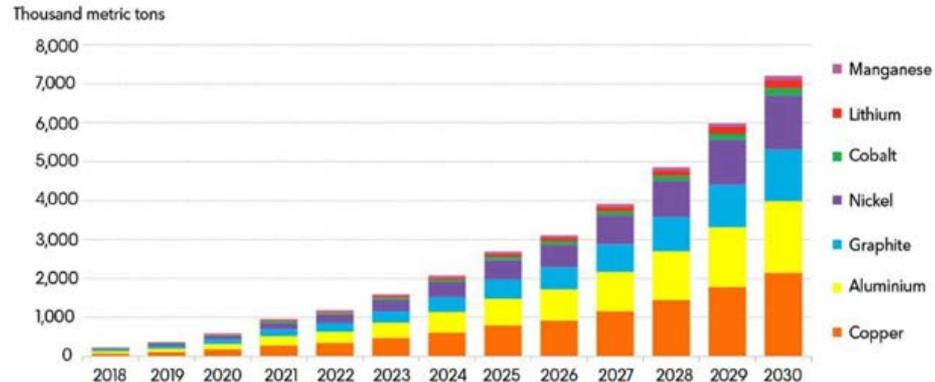
- Currently only 9% of LIBs are recycled globally, and in Australia the recycling rate is less than 3%.
- It is anticipated that the volume of spent batteries worldwide will grow to 7,000,000 tpa in the next 10 years.
- At present, battery recycling involves mostly surplus consumer electronics containing lithium-cobalt oxide ('LCO') LIBs, but the trend is towards recycling of end-of-life EV batteries, in which, as noted, the dominant LIB chemistry is now NCM of the 622 type.

BATTERY CONSUMPTION

Currently, about half of LIB demand (which is rising at around 18% per annum) can be attributed to the growing popularity of EVs.

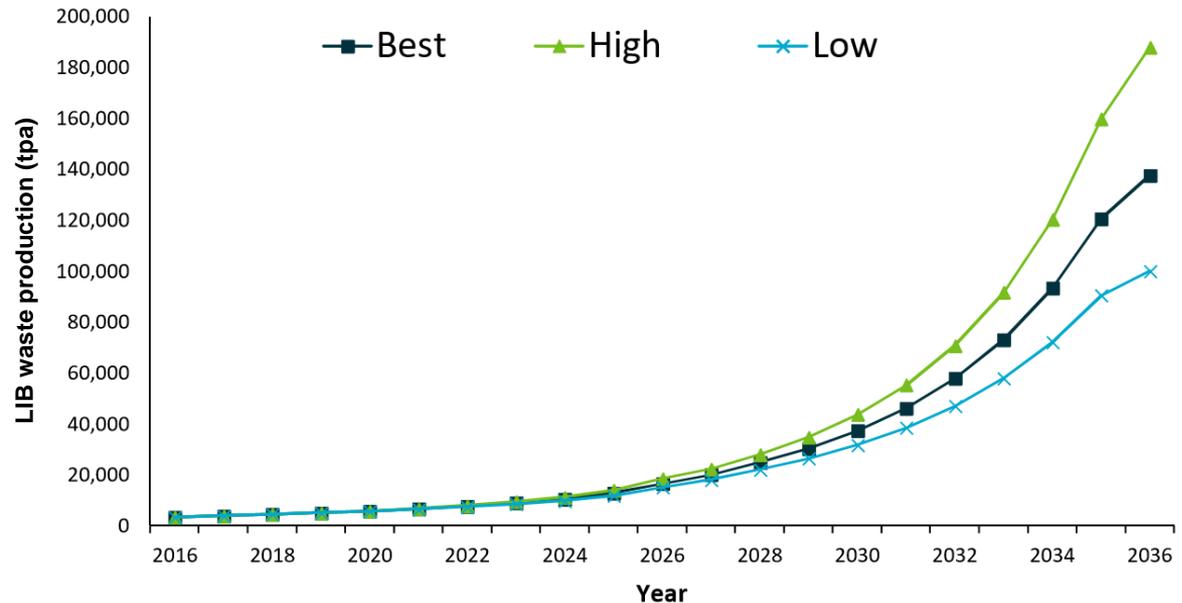
In 2018, Bloomberg estimated the metal consumption involved (and ultimately available for recycling) as shown in the graph at right.

Metals and materials demand from LIB packs in passenger EVs



LIB recycling market – Australia

- Currently in Australia, about 4,000 tonnes of spent LIBs annually are available for recycling.
- In the absence of adequate recycling, the disposal of LIBs to landfill in Australia alone is likely to exceed 150,000 tpa by 2036.¹
- Therefore, in Australia the potential value of the contained metal in spent LIBs could be up to AU\$3 billion per annum by 2036.¹



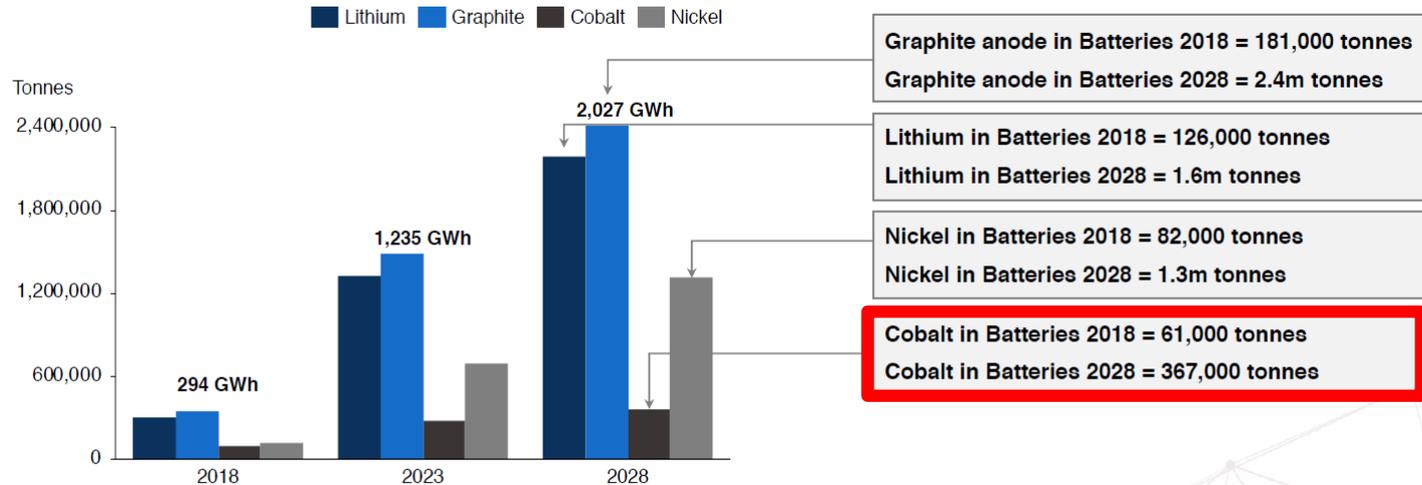
Projected Australian LIB waste 2016 – 2036
(modified from Randell et al, 2016).

¹Randell et al, 2016.

LIB cell production capacity forecast to rise to 2027 GWh by 2028 (up from 1550 GWh in Jan 2019) – 99 plants tracked.

The impact on raw materials is profound.

Assuming a 100% utilization rate, these are the numbers...



Graphite anode in Batteries 2018 = 181,000 tonnes
Graphite anode in Batteries 2028 = 2.4m tonnes

Lithium in Batteries 2018 = 126,000 tonnes
Lithium in Batteries 2028 = 1.6m tonnes

Nickel in Batteries 2018 = 82,000 tonnes
Nickel in Batteries 2028 = 1.3m tonnes

Cobalt in Batteries 2018 = 61,000 tonnes
Cobalt in Batteries 2028 = 367,000 tonnes

Note: The data in this chart does not constitute a forecast, and assumes 100% utilization rates. Benchmark's forecast numbers are available via a separate subscription, please contact info@benchmarkminerals.com for further information
 Source: Benchmark Mineral Intelligence

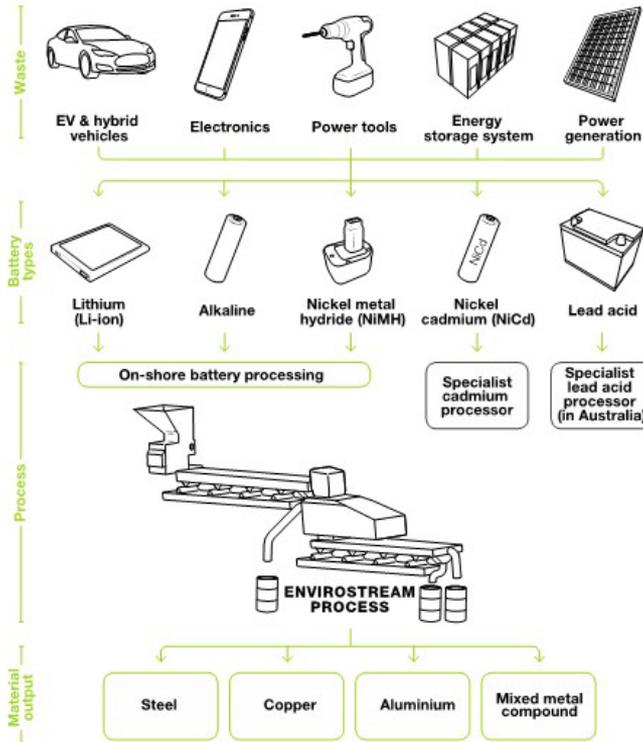


Cobalt deficit



© Benchmark Mineral Intelligence 2019

Battery recycling business model



AUSTRALIA – THE CASE FOR DEVELOPMENT

During FY19, Envirostream generated \$1.3 million in revenue from the recycling of 149 tonnes of spent LIBs. Envirostream's newly expanded Melbourne plant can recycle up to 3,000 tpa of spent LIBs.

POTENTIAL CLIENTS

As noted, Envirostream recovers cobalt, nickel, lithium and carbon to produce MMD as the primary material and source of revenue, as well as scrap steel, copper, aluminum and plastic, which are returned to the manufacturing sector.

The MMD, which is used as input material in the manufacture of cathodes for new batteries, is sold to SungEel in South Korea.

Products refined from spent LIBs by the Envirostream/Lithium Australia alliance will include a commercially tradeable mixed sulphide containing nickel and cobalt, as well as high-purity LP for sale into the battery industry.

These recycled materials will improve the sustainability of the battery industry, help establish conflict-free supply chains and reduce the environmental impact of mining for new resources.



Battery collection network

Envirostream is planning a national collection roll-out, with the collection network expanded Australia-wide, as well as into New Zealand.

Through partnerships with Bunnings, Officeworks, LG Chem, Milwaukee and Battery World, among others, an additional 50 collection points have been added to those previously established by Envirostream.

Retailers and producers pay for delivery of the spent batteries to Envirostream's Melbourne plant.

Envirostream also has collection arrangements with the Australian, Victorian, NSW and WA governments.





Enhancing recycled product

SUCCESSFUL REFINING

Recently, Lithium Australia produced high-quality LP ($> 99.9\% \text{Li}_3\text{PO}_4$) from Envirostream-produced MMD at the Australian Nuclear Science and Technology Organisation ('ANSTO') in New South Wales.

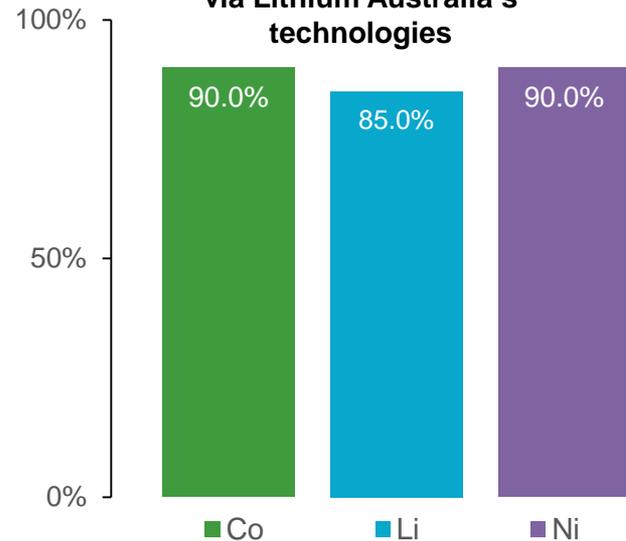
Lithium-ferro-phosphate ('LFP') battery cathode material was then synthesised from the LP at the VPSC Ltd cathode powder pilot plant in Brisbane (VSPC Ltd is a 100%-owned subsidiary of Lithium Australia). LIB coin cells were subsequently manufactured by VSPC Ltd using this LFP material, then tested. Test results indicated cell performance was comparable to that of similar LIB cells manufactured using commercial-grade lithium carbonate.

Base metals were also recovered as mixed sulphides – a high-value intermediate product – from the MMD produced by Envirostream.

THE COMBINED BUSINESS

Lithium Australia will provide the processing technology required for Envirostream to transition from a collection and separation entity to an integrated business able to further refine the MMD and produce higher-value products.

Process metal recoveries
via Lithium Australia's
technologies



Overall process recoveries.

Metal recovery at pilot scale



Process technologies developed by Lithium Australia for the recovery of LP have been extensively tested at pilot scale by ANSTO.

The processes developed specifically to recover energy metals from spent LIBs have focused on:

- best environmental practice;
- maintaining a low energy footprint, and
- producing products in high demand.

Lithium Australia's technology for the recovery and refining of lithium products from spent LIBs is covered by international patent applications, some PCT's have recently been granted.



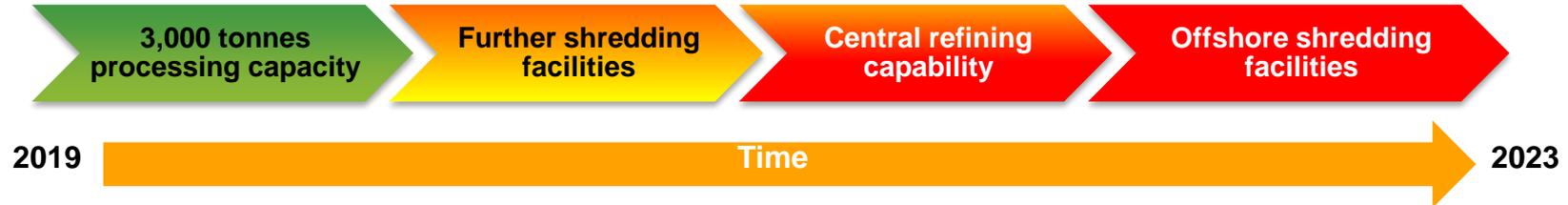
Development plan

Lithium Australia and Envirostream have worked together to commission a new production line in Melbourne for the shredding and separation of materials from spent LIBs. The expanded plant can process around 3,000 tonnes of battery feed annually.

Plans to recover manganese, zinc and potassium from alkaline batteries are also being evaluated, with extraction trials ongoing. Negotiations are currently underway with various producers to utilise this material as a trace-element supplement in fertilisers.

To optimise efficiency, Envirostream plans to establish more shredding and separation facilities in Sydney and Brisbane, as well as in Auckland, New Zealand.

Once the Australian/New Zealand market reaches the required volume, refining facilities will also be established to improve cashflow and profitability and expand the customer base.





Key personnel – Envirostream

Adrian Griffin

(Non-executive Chairman)

Mr Griffin has more than 40 years' experience in the mining and processing industries – in project identification, development and financing, as well as oversight of integrated mining and processing facilities. A founding director of Northern Minerals (the first heavy-rare-earths producer outside China), he has particular expertise in processing technologies. Mr Griffin is currently identifying unconventional sources of lithium (including mine waste) and developing the technology to process them as well as more conventional feed stocks such as spodumene. As managing director of Lithium Australia, he is also focused on the downstream production of LIB components, and the recycling of battery/ e-waste to recover the energy metals they contain. In so doing, Mr Griffin has been positioning Lithium Australia as a vertically integrated producer of lithium processing technology, a manufacturer of battery components and a developer of battery-recycling technology, the aim being to cover all facets of the lithium value chain.

Andrew Mackenzie

(Founder and Managing Director of Envirostream)

Mr Mackenzie, who founded Envirostream in 2017, has been a leader in the scrap metal and battery recycling arena since 2007 and has a significant network in the battery industry, including retailers, wholesalers, battery producers and recyclers. President of the Australian Battery Recycling Initiative (ABRI) in 2018, he has been on the executive since 2017. Previous to his involvement in recycling, Mr Mckenzie designed and built machinery for a wide range of manufacturing companies. He is passionate about closing the loop on battery recycling for a more sustainable society.

Andrew Skalski

(Non-executive Director (proposed))

Mr Skalski is a project development professional with 36 years' experience in the mining/minerals resource industry. He has extensive operational, corporate and project development experience, working for national and international companies, and has managed the development of projects for the production of gold, copper, magnetite, phosphate and lithium in Australia, New Zealand, West and South Africa, Indonesia and Germany. Currently, Mr Skalski heads up the development of critical battery metal processing and recovery technology at Lithium Australia.



Why invest in battery recycling?

- Envirostream is a first-mover business with a strong and established network for the collection and recycling of spent LIBs Australia-wide.
- Currently, Envirostream is the only Australian company recovering MMD from spent LIBs.
- Lithium Australia's technology reduces the number of process steps required to manufacture cathode powder for LIBs using MMD produced by Envirostream.
- Burgeoning amounts of spent LIBs are creating a disposal problem globally – a problem that, collectively, Lithium Australia and Envirostream view as a real opportunity on several fronts.
- With its battery recycling business, the Envirostream/Lithium Australia alliance will create an ethical and sustainable supply of battery materials while reducing negative impacts on the environment.
- There is strong traction from both governments and producers/retailers for an Australian stewardship programme to support battery recycling.
- **Collectively, the assets of Lithium Australia and Envirostream can create a battery recycling business ideally positioned to dominate the collection, refining and re-birthing of energy metals in Australia.**

Envirostream Australia information



Adrian Griffin
(nominated non-executive chairman)

Exploration, production, mine management and processing technology.



Andrew Mackenzie
(managing director)

Founding director and shareholder of Envirostream Australia. Andrew is an engineer with over 20 years' experience and was instrumental in the design and development of Envirostream's plant with the vision of increasing the low battery recycling rate in Australia through continuous, onshore innovation.



Andrew Skalski
(proposed non-executive director)

Project development professional with 36 years' experience in the mining/minerals industry, has extensive operational, corporate and project development experience working for national and international companies.

For more information on the collection of spent batteries, please contact

Email: info@envirostream.com.au

Phone: **1800 727 274**

Web: envirostream.com.au

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