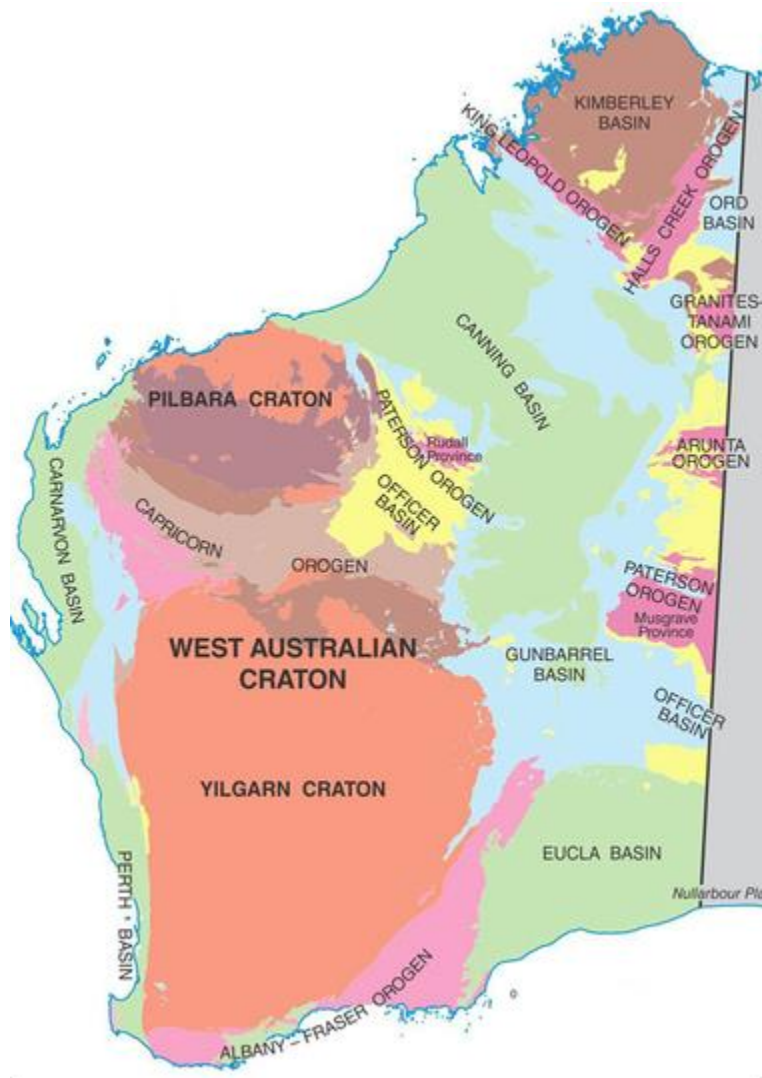




Exploration Incentive Scheme (EIS)



**Report for Department of Mines, Industry
Regulation and Safety
December 2019**

REPORT FOR THE DEPARTMENT OF MINES, INDUSTRY REGULATION AND SAFETY

This publication

This report has been prepared for the Department of Mines, Industry Regulation and Safety. It describes an assessment carried out by Economics Consulting Services into the operation of the Western Australian Government Exploration Incentive Scheme (EIS). This report aims to provide an economic review of the EIS for the two financial years to June 2019. The focus is on the increase in Gross State Product arising from expenditure and investment flowing from the Scheme.

Executive summary

This report has been prepared by Economics Consulting Services for the Department of Mines, Industry Regulation and Safety (DMIRS). The emphasis is on the economic outcomes flowing from investment in the Exploration Incentive Scheme (EIS) for the two financial years ending June 2019. In particular, the aim is to estimate the change in Gross State Product arising from the scheme over these financial years.

The EIS is a Western Australian Government initiative aimed at encouraging mineral and petroleum exploration. It aims to stimulate private sector exploration leading to new mineral and energy discoveries. The program is administered by the Geological Survey of Western Australia (GSWA).

The EIS began in 2009 and has been extended on several occasions with total funding to June 2019 of close to \$150 million (m).

The third phase (EIS 3) was funded by the Royalties to Regions program with some additional funding from the GSWA budget. A key performance indicator was a target of a \$5m increase in Gross State Product (GSP) for each \$1m spent on the program.

This report provides an overview of the program in the 2017-18 and 2018-19 years and an assessment of the economic benefits that have flowed from the investment. The focus on economic outcomes means the report is confined to a review of those activities that might be expected to lead to a short-term increase in exploration activity. Longer-term initiatives such as strategic research, jobs and industry promotions are not included.

The fundamental case for an EIS is that provision of pre-competitive geoscientific data and assistance for innovative drilling in more remote and under-explored areas will lead to an increase in greenfield exploration and discoveries.

The time lag between government geoscience data provision and an increase in private investment is uncertain. Private investment is a function of many factors including commodity prices, access to land and finance and perceptions of policy and regulatory stability. Drawing a direct relationship between government and private expenditure is highly problematic.

The impact of “discoveries” associated with co-funded drilling is more immediate. Discoveries provide the “adrenaline” that excites private investment.

Economic impacts that might be expected from EIS expenditure include increases in:

1. The number of exploration tenements
2. The turnover of exploration tenements
3. Private exploration spend
4. The number of exploration companies
5. Metres drilled
6. Mineral discoveries
7. New explorers attracted to State

There was an increase of 890 Exploration and Prospecting tenements over the two years (9%) from the number at 30 June 2017. Private exploration expenditure was \$584m higher over the two years than if the 2016-17 spend had continued.

The Western Australian share of national exploration expenditure was 61% in the two years compared to an average 57% share over the previous twenty years.

Drilling on brownfields areas in Western Australia has been rising since 2014-15 while there was an even larger rate of increase in greenfields drilling.

In broad terms, GSWA has classified 19 “finds” as successes under the co-funded drilling program. A number of these have been associated with a significant increase in exploration activity in the region of the discovery (Paterson Province, Fraser Range, West Kimberley).

The closest discovery to commercialisation associated with an EIS co-funded program is the rich Bellevue gold mine with an estimated net present value of \$122m. This is a multiple of 5 times the \$20m allocated to the EIS program in the two financial years. When combined with the increase in tenement numbers and exploration investment that could be linked to the program, it provides an economic justification for this program.

There are other discoveries from the co-funded drilling that will add to this value, but they are more difficult to quantify at this early stage.



1. Background

1.1 Introduction

This report has been prepared by Economics Consulting Services (ECS) for the Department of Mines, Industry Regulation and Safety (DMIRS). The emphasis is on the economic outcomes flowing from investment in the Exploration Incentive Scheme (EIS) for the two financial years ending June 2019. This includes an estimate of the change in Gross State Product arising from the scheme over these financial years.

The EIS is a Western Australian Government initiative aimed at encouraging exploration for the sustainability of the State's resources sector. The initiative was designed to stimulate private sector exploration and ultimately lead to new mineral and energy discoveries. The program is administered by the Geological Survey of Western Australia (GSWA).

The initial business case for the EIS was endorsed by the State government in early 2009. It included six programs (EIS 1a) with a total budget of \$80 million (m) over four years:

1. Exploration and Environmental Coordination
2. Innovative Drilling including the Co-funded Drilling Program
3. Geophysical and Geochemical Surveys
4. 3D Geological Mapping
5. Promoting Strategic Research with Industry
6. Sustainable Working Relations with Indigenous Communities

The program was extended in 2013-14 with \$20.6m in funding (EIS 1b). EIS 2 was funded for 3 years at \$10m from Consolidated Revenue. For the last two financial years ending June 2019 EIS 3 was again funded from Royalties for Regions at \$10m a year. Total funding for the program to June 2019 has thus been very close to \$150m.

There have been some program changes over the years although the emphasis remains the same. From 2017, the programs have been:

1. Innovative Drilling
2. Exploration through cover
3. Geophysical surveys
4. 3D Prospectivity mapping
5. Promoting strategic research with industry

1.2 Review approach

This review was conducted in November 2019 and included consultation with Leadership Team members of the Geological Survey. Substantial consideration was given to past reviews of the scheme. Details of members of the ECS review team are included in Appendix 1.

1.3 Terms of Reference

EIS 3 is funded by the Royalties to Regions program (managed by the Department of Primary Industries and Regional Development - DPIRD) and administered by the Geological Survey and Resources Strategy Division, DMIRS.

DMIRS has a Memorandum of Understanding with DPIRD for funding and operation of the Scheme that includes key performance indicators. One of the key indicators is a target of a \$5 million increase in Gross State Product (GSP) for each \$1 million spent on the program.

This report provides an overview of the program in the 2017-18 and 2018-19 years and an assessment of the economic benefits that have flowed from the investment. A focus is the GSP key performance estimate.

1.4 The programs

1.4.1 Sub-programs and funding

The five programs involved 25 sub-programs that are the reporting entities for GSWA. Fifteen of these were funded in 2017-18 and sixteen in 2018-19 (Table 1).

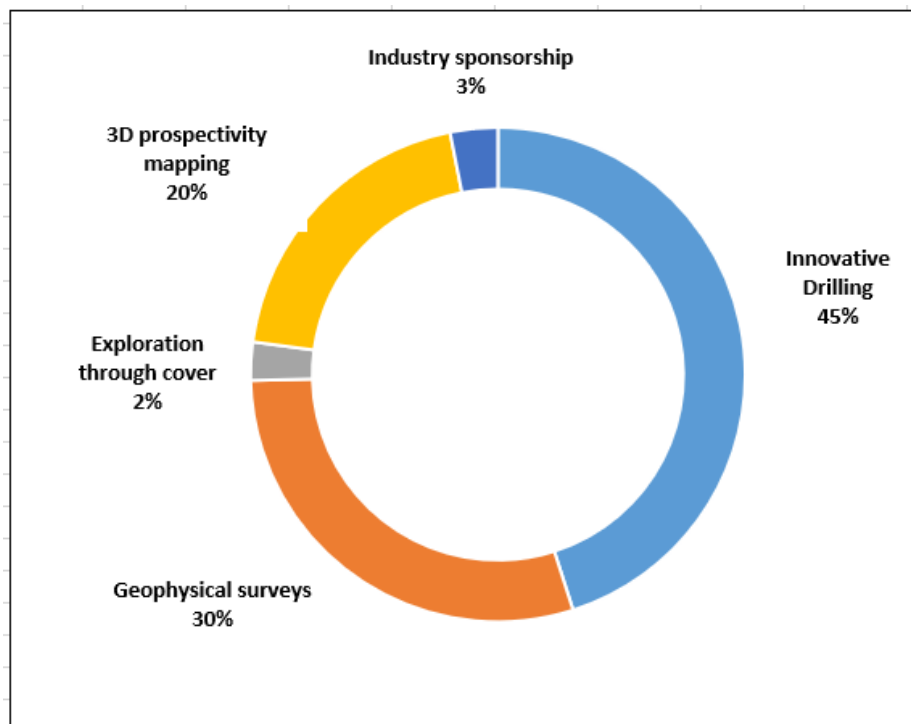
Table 1: Programs (2017-18)

Cost Centre	2017-18	2018-19
3302 Innovative drilling	Co-funded drilling	Co-funded drilling
	Exploration promotion	Exploration promotion
3303 Geophysical surveys	Geophysical surveys	Airborne gravity and electromagnetic surveys
	Seismic and MT surveys	Seismic and MT surveys
	Gravity surveys	
	Yilgarn geochemistry	
	Eastern Goldfields seismic	
3303 Encouraging exploration through cover	MinEx CRC	MinEx CRC
		Drilling decision support
		Depth of the cover and interfaces
		Basement geology and evolution
		Targeting Mineral systems in Covered Terranes
3304 3D Prospectivity & mapping	Geology on-line	Mineral systems
	3D lithosphere visualisation	Petroleum systems
	Mineral systems	WA Geology online
	Mapping geodynamic settings	Exploration data analysis
	Enhanced geochronology and isotope mapping	3D lithospheric visualization
	Petroleum systems	Mapping geodynamic setting
		Enhanced geochronology & isotopic fingerprinting
3305 Research support	MRIWA support	MRIWA support

The sub-program titles change from year to year as the research emphasis shifts but the program codes have remained constant.

Total funding over the two years was \$23.204m with three programs accounting for 95% of the funds (Figure 1). Expenditure was higher than the EIS allocation of \$20m as some additional funding was re-allocated from GSWA operational funds.

Figure 1: Funding in 2017-18 and 2018-19



The MOU on Royalties for Regions funding outlined milestones, performance measures and deliverables. The milestones and performance measures are comprehensive with the outcomes set out in detail in Appendix 2 and summarized here (Table 2).

Given this report's focus on economic outcomes, the summary is confined to those activities that might be expected to lead to a short-term increase in exploration activity. Longer-term initiatives such as strategic research, jobs and industry promotions are not included.

The sections that follow provide more detail on the outcomes of the programs that may provide a short-term increase in economic activity.

Table 2: MOU outcomes with a short to medium term economic impact

Program	Outputs from MOU
Innovative Drilling	Metres drilled
Encouraging exploration through cover	Geochemical data to open file Regolith map Number of stratigraphic holes and data
Geophysical surveys	Line kilometres of survey data Survey points Number of surveys undertaken
3D prospectivity Mapping	Number of reports, maps, data to online geological explanatory notes, datasets and 3D models.

1.4.2 Innovative Drilling

Funding for co-funded government-industry drilling is designed to stimulate geoscience-based, targeted exploration drilling and thus contribute to discovery and economic development in greenfield areas in Western Australia. The emphasis is on projects that promote new exploration concepts and technologies in under-explored areas.

There were 211 offers of financial assistance made to companies that could have involved drilling in the two financial years (Table 2). The continuous nature of the approval and payment process means that payments can be made for holes drilled in the prior half year. For this study, the relevant catalyst for an economic impact is the period of drilling rather than the payment period.

Offers for both calendar years and financial years make it difficult to link activity to a specific financial year given the overlap. Holes drilled in the two financial years could be from offers made in one of five rounds (Table 4). There was a total of 108 projects drilled in the two financial years (Table 3).

Table 3: Co-funded well program

Round	Year	Offered	Drilled
14	2017	42	21
15	2017-18	43	25
16	2018	44	31
17	2018-19	42	30
18	2019	40	1
Total			108

A total of 81,204 metres were drilled in 2017-18 and 127,357 metres in 2018-19 for a combined total of 208,561 metres.

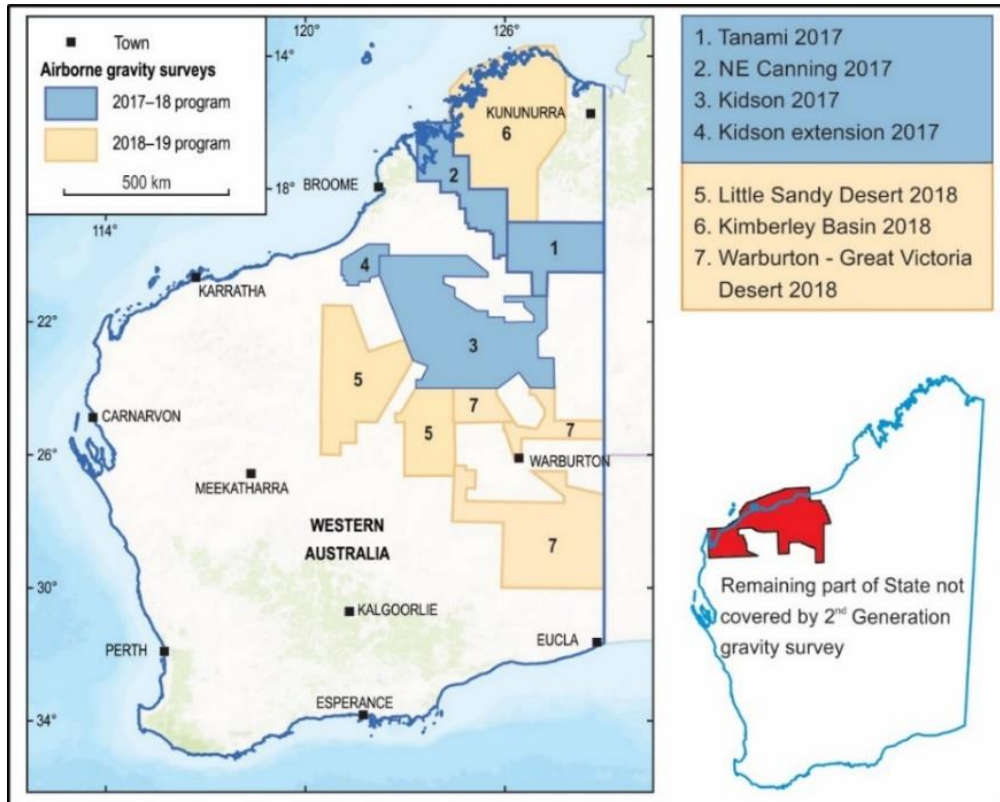
1.4.3 Geophysical Surveys

Regional gravity surveys

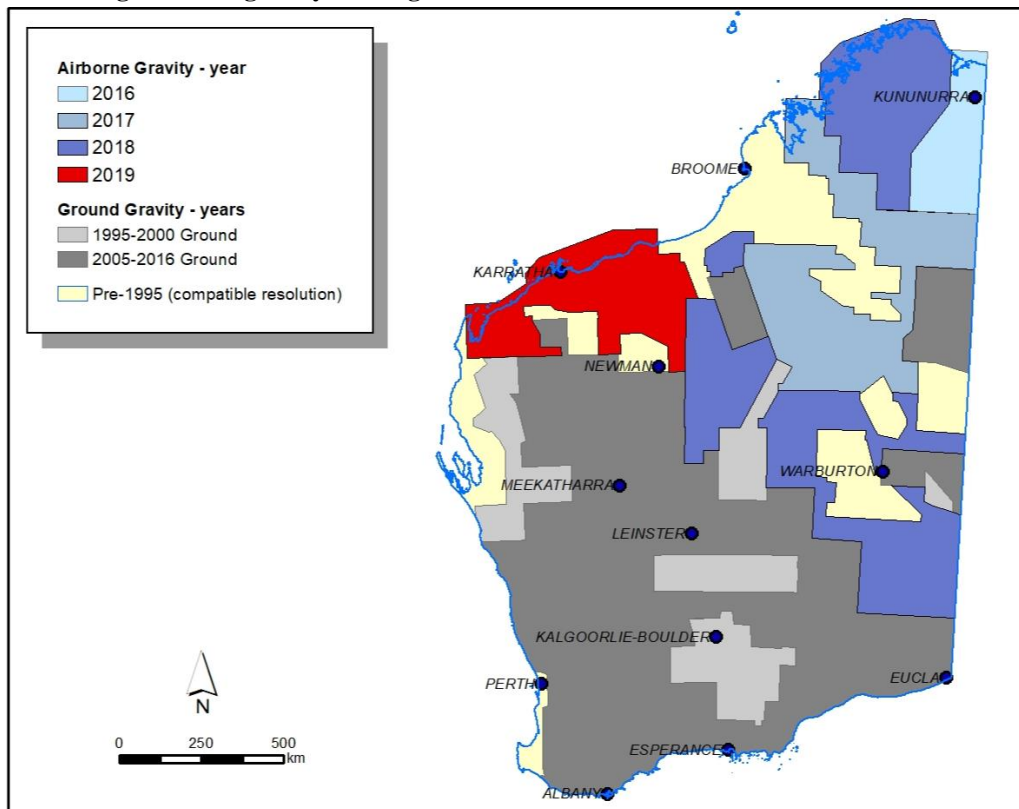
The regional gravity surveys aim to complete regional medium-resolution (<4 km station spacing) gravity coverage of Western Australia by 2020. As ground data acquisition programs were experiencing land access delays in the north and east of the state, the acquisition program shifted to airborne gravity surveys beginning in 2016 with further large survey contracts awarded in 2017–18. The acquisition and processing of the data will often take longer than 12 months therefore reporting of line kilometres and release of final products will be across financial years. The regional gravity surveys were run in collaboration with Geoscience Australia under a National Collaborative Framework Agreement.

Acquisition and processing were completed on all three of the 2018 airborne gravity surveys in six blocks covering large tracts of the Kimberley Basin, and the Little Sandy and Great Victoria Desert areas.

The Pilbara 2019 airborne gravity survey (70,000 kilometres) completed second-generation gravity coverage of the State.

Figure 2: EIS Regional gravity line acquisition and release

Completion of the Pilbara survey allows the second generation of gravity coverage of Western Australia (Figure 3).

Figure 3: Second generation gravity coverage

2D seismic – Kidson Sub-basin

Acquisition and data release was completed for the 872 km of gravity and deep crustal reflection data collected for the Kidson Sub-Basin 2D seismic survey. This project involved a deep seismic line across the Kidson Sub-basin within the Canning Basin and extending west over the Paterson Orogen and the Pilbara Craton. This was a collaborative project with Geoscience Australia with funding from the Commonwealth Northern Australia Exploring for the Future programme (EFTF) and the EIS. The first data release was at the Brisbane APPEA conference in June 2019.

2D seismic – Eastern Goldfields

Data acquisition was completed in March and April 2019 along -305 km of established roads and tracks for the Eastern Goldfields 2D seismic. The seismic acquisition along 7 lines was from Ora Banda, north of Kalgoorlie Boulder to lines near Kambalda.

1.4.4 Encouraging exploration through cover

The EIS is concentrating on the acquisition and interpretation of geophysical data, integrated with geochemical and isotopic analysis of sample material obtained through drilling beneath the cover of soil, sand and sedimentary basins that obscure 80% of Western Australia's economic bedrock. A high priority is to map the distribution, composition, thickness, and age of regolith and paleo-surfaces. A State Regolith map at 1:500,000 was initiated in 2017, with the northern half of the state completed in January 2019. Work on the southern half of the state was 50% completed by the end of this reporting period.

To encourage exploration the EIS contributes to the collection, analysis and online release of data that is essential for explorers and researchers. This includes the release of EIS co-funding reports, geochemical data, geochronological and isotope data (Table 4).

Table 4: EIS sponsored data released (two years)

Data type	Number		
Geochemical – whole rock/trace elements	2,782 analyses		
Regolith geochemistry	637 sample results		
U-Pb Geochronology	184 age dates		
Isotope dating of rocks to investigate crustal evolution and build 4D models	Whole-rock Sm-Nd	Zircon Lu-Hf	Zircon oxygen
	163	134	99
Co-funded drilling reports to open file	128 reports		

The first release of zircon oxygen isotopic data to online applications (GeoVIEW) made GSWA the first survey in the world to generate and release such high-quality isotopic data to the public.

1.4.5 Program 4 – 3D prospectivity mapping

Current mineral systems research includes characterisation of geological settings, metallogeny and alteration footprints of selected mineral system types; development of exploration tools for area and target selection; and direct detection of mineralisation. It encompasses both empirical and conceptual studies, at regional, camp and deposit scales, and is undertaken in-house and via collaborations with State, Federal and international partners, including mineral exploration companies. The work results in the delivery of reports, maps, digital datasets and other products (Table 5).

A new project commenced - Australian Research Centre Linkage Project (3D stochastic geological modelling). This brings together geological surveys and research institutions in Australia, Canada, France, Germany and the UK to fund a new Open Source initiative to build the next generation of 3D geological modelling tools. The project aims to create new knowledge and methods in the field of 3D modelling through the innovative application of mathematical methods, structural geology concepts and cutting-edge probabilistic programming.

Results from the 2014-18 COPA passive seismic array were processed into a lithosphere-scale 3D model of the Capricorn Orogen. Other 3D geo-models released included the East Albany-Fraser Orogen and Lawlers Anticline. The Mineral Systems Atlas development was completed and released as an on-line interactive, GIS-based Atlas. Two major mineral systems, one for komatiitic-based nickel and one for iron-ore formations were also released at the GSWA open day on 22 February 2019.

Table 5. Products released under the EIS

Product type	Number	Description
Data packages	14	USB digital packages with extensive information. E.g. 2017 Canning Basin SEEBASE study, Diamond exploration and prospectivity of Western Australia
Published reports	9	GSWA reports are designed to provide an interpretation on a specific matter which can include specialist input (University and/or Industry collaborations). e.g. Report 177, Crustal and uppermost mantle structure of the west Albany-Fraser Orogen from passive seismic data
Published records	11	GSWA records are designed to deliver information quickly into the public arena. Records deliver raw and/or processed information with minimal interpretation. e.g. Record 2018/3. Regolith geochemistry of the Ngurrurpa area, north-western Western Australia.
Explanatory Notes	236	Open file comprehensive description of lithological and tectonic units within WA. Replacing hardcopy notes, and in digital format, they can be easily updated to provide current information. Linked to online layer in interactive geological map
Posters	23	Conference attendance and verbal presentation. Excluded are the posters produced for GSWA open days.
Maps	2	Regolith component of two 1:250,000 maps sheets – NB from September 2018 the GSWA will no longer produce hard copy maps. More information can be delivered by digital packages, allows for quicker updates and is more cost efficient. Hardcopies will be produced on request and at cost.

Chapter

2

2. Exploration and mining

2.1 Introduction

A sustainable mining industry depends on the discovery of new deposits and extensions of existing operations. Except in the cases of iron ore deposits and a limited number of other deposit types mineral exploration is mostly a complex scientific pursuit in a three-dimensional crustal space where there is commonly no surface expression of a mineral system. The difficulty of exploration is commonly further compounded where the hosting rock package is buried deeply beneath younger rocks, and this is more the rule in Western Australia. Mineral exploration is a high-risk activity where discovery is rare.

Depending on the commodity sought, particular rocks and ages are more or less favourable for the occurrence of ore deposits. The regional geology together with previous exploration data and research knowledge helps point the way. The GSWA acquires and produces new regional geoscience data, collects the records of previous exploration and collaborates with research organisations to define genetic models for mineral systems. The regional data acquired by geological survey organisations is known as precompetitive data and may, inter alia, include contemporary geological mapping, regional gravity, deep seismic, airborne electromagnetics, high-resolution airborne magnetics and radiometrics, and scientific research on mineral provinces and mineral systems. Most of this data is in the public domain and readily accessible through the digital information systems and online databases.

The geological history of ore deposits is invariably complex reflecting the structural and chemical influences over hundreds or thousands of millions of years. This makes the work of exploration complex and costly. Exploration is a targeting process which commences with regional geoscience datasets that may allow an explorer to focus on particular and smaller areas that have suitable geology. Generally speaking, the GSWA's precompetitive data allows an explorer to get within the "ballpark" of a potential mineral system reducing exploration risk. The scale and detail of the data is usually insufficient to permit direct ore finding. This is the role of industry and the explorer applies detailed geophysical and geochemical techniques to establish the existence of anomalism in a rock package at depth. Although science and technology are constantly providing smarter techniques and tools, exploration success cannot be guaranteed, and most exploration programs fail to yield an economic ore deposit.

Once an anomalous target is identified then it is usually the time for drilling. This is the most expensive part of an exploration program and usually stretches the financial resources of junior explorers and even mid-caps. Assistance with the EIS co-funded drilling can play an important role in progressing exploration.

Government's provision of precompetitive geoscience data levels the playing field and thus allows junior explorers and mid-cap companies to compete with major companies. This works to the advantage of all in that such data attracts new resource explorers and new investment to Western Australia as well as intensifying the exploration effort by existing explorers.

Government acquisition of this pre-competitive information, as well as having promotional value, addresses market failures including¹:

- positive externalities, whereby the geological knowledge of a new deposit may increase the probability and reduce the costs of the discovery of an analogue
- public provision of geoscientific data, which acts to redress any advantage to a “free rider” deriving from another explorer’s work
- public good, that underpins policy-making decisions
- reduction of risk and uncertainty right across the resources exploration industry, which may prevent exploration activity falling to inefficiently low levels
- harmonising of the data at provincial and continental level
- equality of access to information, and efficiency of data distribution.

¹ House of Representatives Standing Committee on Industry and Resources, Exploring: Australia’s Future – impediments to increasing investment in minerals and petroleum exploration in Australia. Commonwealth of Australia, Canberra, 156pp

Chapter

3

3. EIS Assessment

3.1 Performance measures

The original business case for the EIS identified three key outcomes by which success should be measured:

1. Increased greenfield exploration and hence new mineral discoveries in Western Australia's more remote and regional areas
2. Assistance in maintaining expertise (jobs) and equipment involved in Western Australia's exploration industry during the economic downturn
3. Clear signals to resource investors around the world that Western Australia is serious about attracting exploration investment

The emphasis in this study is the economic impact of the two financial years (2017–18 and 2018–19). The job and investor measures in outcomes 2 and 3 are important but outside the scope of this report.

Economic impacts that might be expected from the EIS expenditure include increases in:

1. The number of exploration tenements
2. The turnover of exploration tenements
3. Private exploration spend
4. The number of exploration companies
5. Metres drilled
6. Mineral discoveries
7. New explorers attracted to State

The time taken for these outcomes to materialise is open to debate. Provision of geoscience information is generally considered a long-term investment to support exploration and mining. Fund raising for greenfields exploration is challenging and government approval processes take time. This creates a lag between data provision and exploration spend.

On the other hand, a significant discovery in a drill hole will create significant interest in the local area potentially leading to new tenements, an increase in tenement turnover and increased local expenditure. The scale of the impact will depend on the discovery, the nature of the companies involved in that region and the commodity. An estimated 50-60% of greenfields exploration is undertaken by junior companies. They are flexible and innovative but rely on

funds from investors willing to chance the high risks involved. Funding takes time to raise and is generally raised for specific purposes and locations – it takes time to divert funds to new locations. On the other hand, larger companies have less funding constraints, but this can be offset by the longer durations needed to obtain corporate approval.

There is some anecdotal evidence that geoscience consultants carrying out work for the geological surveys can attract additional private funding to supplement the government data collection. This means increased private expenditure along with the EIS expenditure.

The net effect is that the time lag between the government geoscience data provision and an increase in private investment is uncertain. It is more likely that there will be a measurable long-term effect while the short-term impact is far less predictable. An example of this lag can be seen in the discovery of the Nova mine operated and owned by Independence Group NL. The GSWA released precompetitive soil geochemical data in 1998 over the region which showed several small geochemical anomalies. Exploration was sparse until the EIS-funded aeromagnetic data released in 2010 and co-funded drilling in 2011–12 attracted private exploration investment. The discovery of Nova followed a year later (2012) and mining started in 2015. The region now has extensive tenement coverage and active exploration by many companies.

Acil Allen² (2015) looked at the short and long-term response of exploration spend to changes in commodity prices. The focus of its study was on long run changes generally defined as three years. The preferred model included prices and exploration expenditure with both being current and lagged for one year. EIS expenditure variables are included in the current period and lagged for two periods. Acil Allen found that although the estimate of the EIS effect was statistically significant, there was considerable uncertainty surrounding the long run impact of the EIS on exploration spend. Different multipliers for private consumption expenditure (the alternative use for EIS funds) and the exploration sector meant that for every \$1 million spent on the EIS, there was a net gain in economic activity of \$2.18m. When discounted back from the three-year gain, the net change was \$2.06m. Further, assuming, conservatively, that half the funds for exploration are sourced from outside Western Australia, the net present value of the induced transfer of spending to Western Australia was \$10.3m for every \$1m spent as part of the EIS program (Acil Allen p26).

Economic modelling indicated that there was a construction expenditure impact (new mines) of \$5.4m, an increase in production wealth of \$6.6m and \$6.2m in royalties and taxation.

The full benefit from the \$1m in EIS expenditure was thus estimated at \$23.7m in net present value.

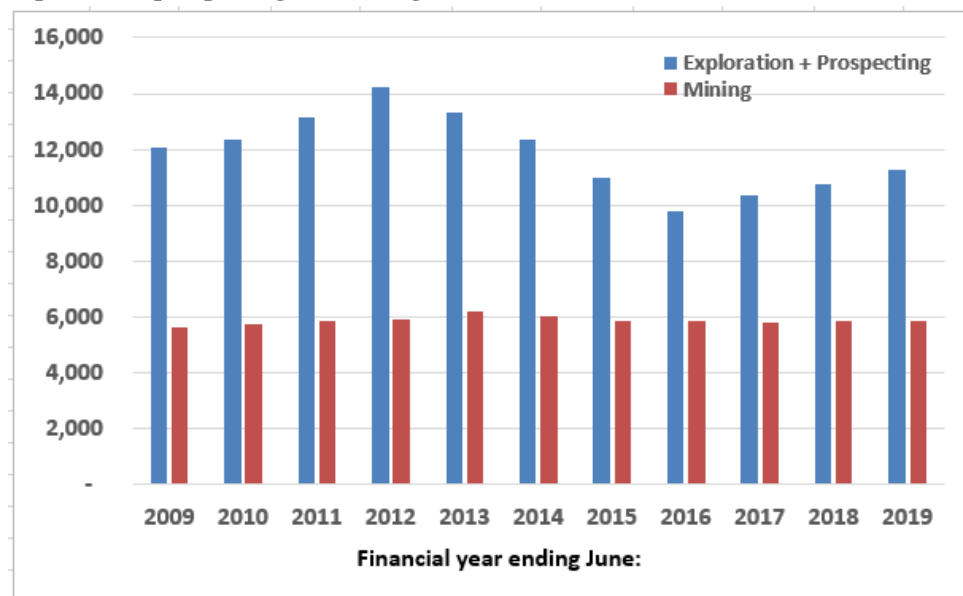
The following sections look at some specific and measurable impacts from the two financial years of EIS expenditure.

² Acil Allen; 2015. Exploration Incentive Scheme, Economic Impact Study

3.1.1. Tenement numbers

The number of exploration tenements is a measure of investor confidence in the future of the sector. It also correlated to private investment as there are costs associated with the application and compliance requirements. The two financial years under review both saw an increase in exploration and prospecting tenement numbers – an increase of 890 tenements over the two years (9%) from the number at 30 June 2017. There was no significant change in the number of mining leases.

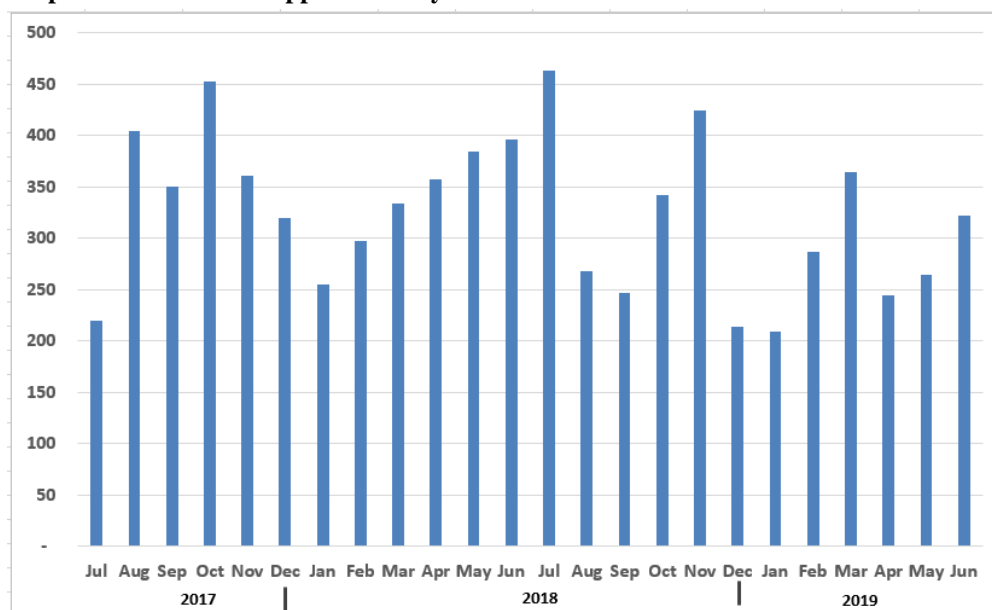
Figure 4: Exploration, prospecting and mining tenement numbers



3.1.2. Tenement turnover

Monthly exploration applications varied significantly over the two years from a low of around 200 to a high of about 450 (Figure 5). There seems to be some suggestion of a cycle with high application months followed by two or three low months.

Figure 5: Exploration tenement applications by month

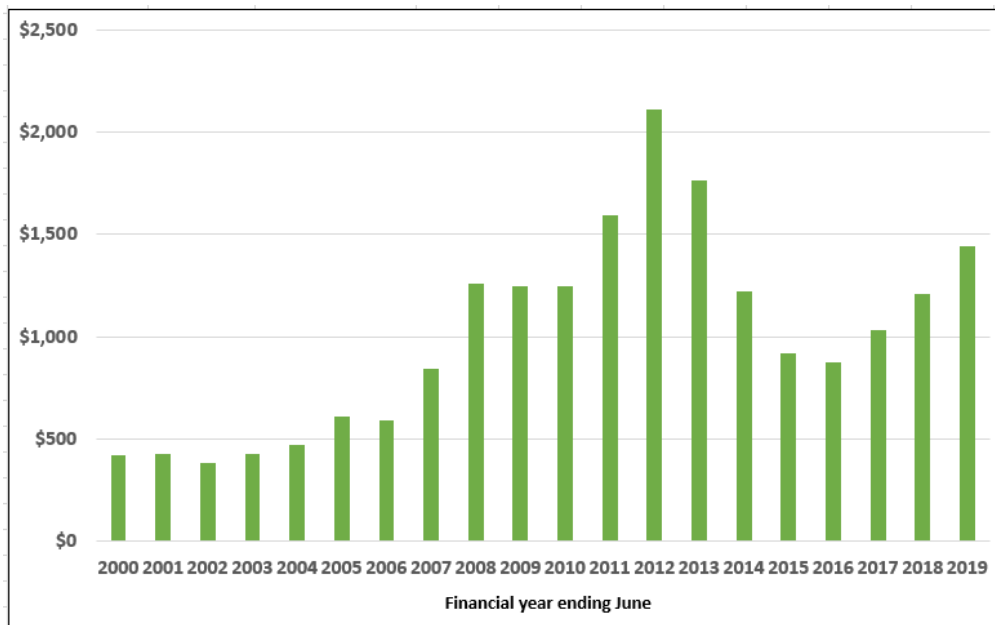


3.1.3. Exploration investment

Mineral exploration expenditure in Western Australia reached a peak of \$2,110m in 2011-12 (Figure 6). It fell after that to a low in 2014-15 before gradually picking up again to \$1,400m in 2018-19. Expenditure in the first half of 2019 suggests a further rise in 2019-20.

Expenditure in the two financial years under review was \$2,640m. This compared with \$1,028m in 2016-17 or \$584m more than if the 2016-17 spend had continued.

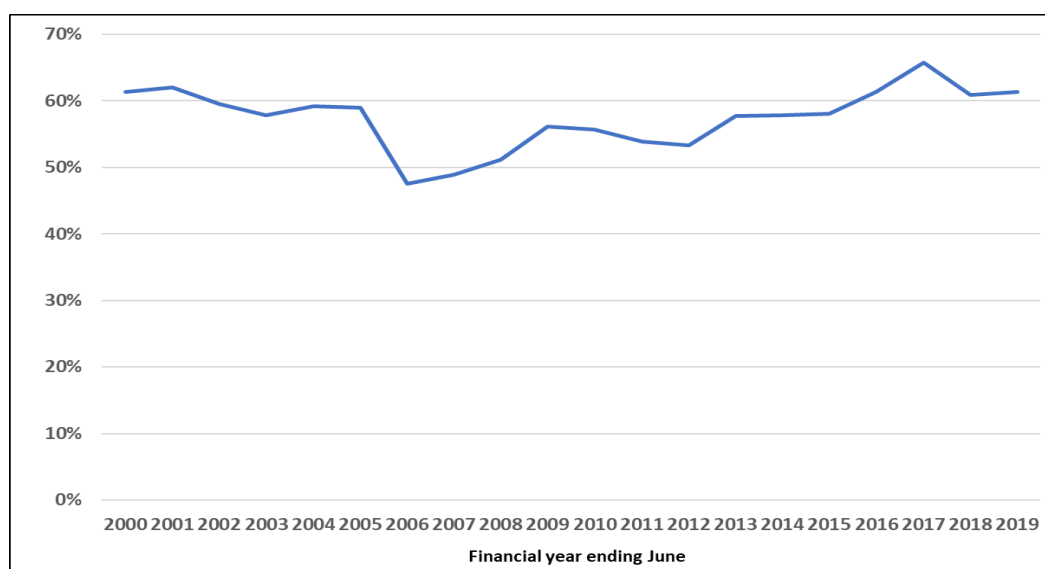
Figure 6: Mineral exploration expenditure – the last (\$m)



Source: Australian Bureau of Statistics, 2011

The Western Australian share of national expenditure has varied from a low of 49% to a high of 66% with an average of 57% in the last twenty financial years (Figure 7). Expenditure in the two study years averaged \$1,320m and represented 61% of the Australian total. The next highest state was Queensland with less than one quarter of the WA expenditure.

Figure 7: WA exploration expenditure share



3.1.4. Exploration companies

There are no published statistics on exploration companies. Public companies listed on the Australian Stock Exchange are classified in the “materials” category which includes manufacturing and other enterprises. There are around 670 companies in this category. The two largest are BHP and Rio Tinto and the top ten include six mining companies. One measure of company activity would be new listings, but this is not published by category.

It is reasonable to assume that exploration expenditure is closely linked to the number of companies and this will include private companies as well as publicly listed ones. Given the paucity of information, the number of companies is not considered further in this study.

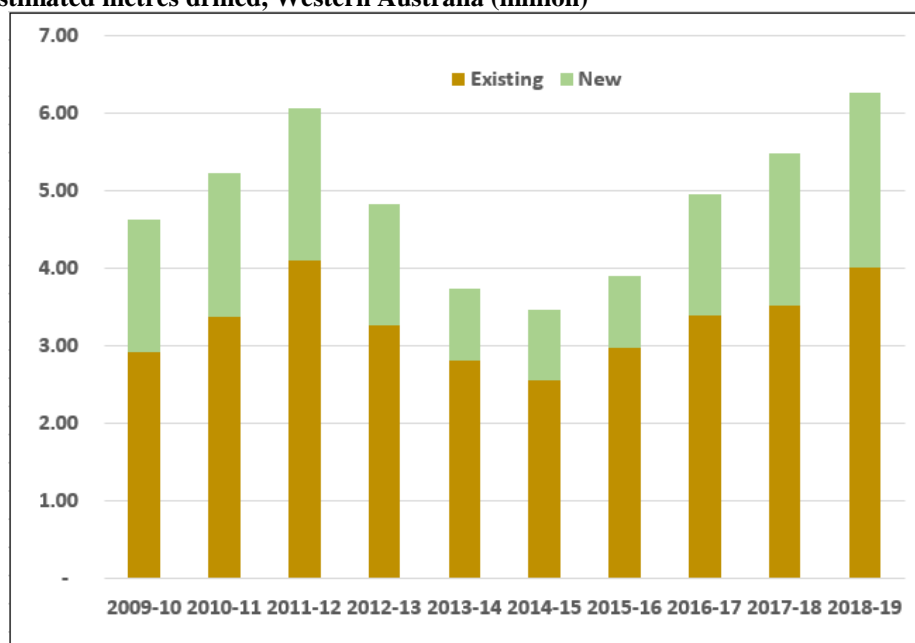
3.1.5. Metres drilled

Metres drilled under the co-funded drilling program for the two financial years totalled 208,561 metres. Unfortunately, there is no data available on metres drilled in Western Australia against which to compare this total. ABS surveys companies and records expenditure and metres drilled for Australia but does not segregate drilling on a state basis. DMIRS receives returns from mining and exploration companies that include details on drilling, and this has been recorded electronically since 2015-16. However, at this stage lodgement of electronic reports is still only at 70% providing an incomplete dataset on which to determine metres drilled.

One way of estimating metres drilled is to multiply the Western Australia share of exploration expenditure by the metres drilled for Australia. Drilling costs are possibly higher in states such as Victoria with significant land access and environmental controls, but the Victorian share of exploration is low and hence the distortion may not be great.

Drilling on brownfields areas (*existing* in Figure 8) has been rising since 2014-15 while there was an even larger rate of increase in greenfields drilling (*new* in Figure 8).

Figure 8: Estimated metres drilled, Western Australia (million)



The co-funded amount drilled in the two financial years represents 5% of the estimated metres drilled in Western Australia over this period. It is possibly too early to say whether the co-funded results will influence new greenfields drilling in future years, but the trend is certainly upwards.

3.1.6. Discoveries

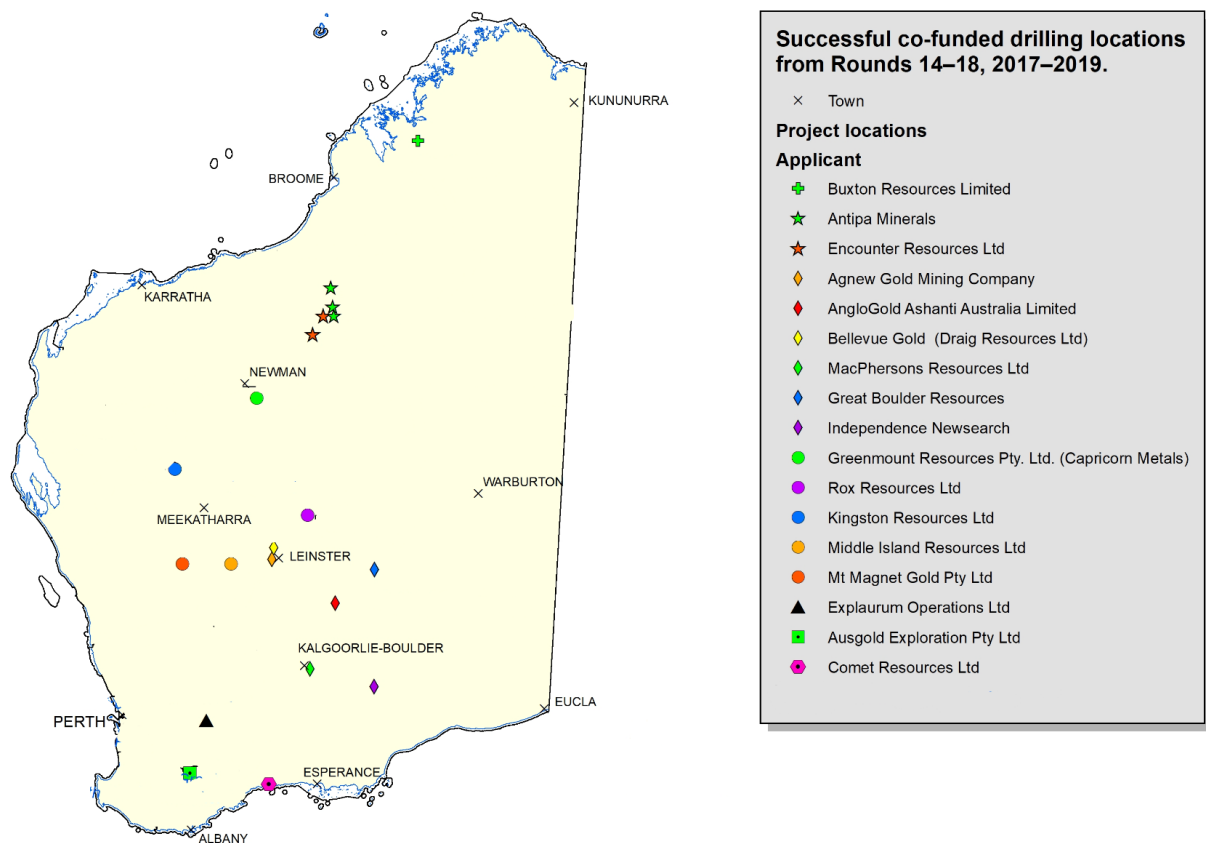
Measuring success in drilling is a subjective exercise. A major discovery in a new area might be regarded as standard in an old and established mining area. A discovery with high grade intercepts will still depend on the size of the resource while information that disproves a geological model may be just as important in the long term as one that demonstrates support. GSWA uses a broad approach to describing success (Table 6).

Table 6: Discoveries under the co-funded drilling program

Round						
14	Agnew Gold (Au)	Encounter Resources (Cu/Au)	Middle Island Resources (Au)	Antipa Minerals (Cu/Au)	Mt Magnetic Morning Star (Au)	
15	Bellevue Gold (Au)	Buxton Resources (Au)	Comet Resources (graphite)	Great Boulder Yamarna (Au)	Greenmount Karlawinda (Au)	MacPhersons Boorara (Au)
16	IGO Andromeda (Cu/Zn)	Explaurum (Au)	Rox Resources (Ni)	Kingston Livingstone (Au)		
17	Anglo Gold Southern Shear (Au)	Antipa Chicken Ranch (Au)	Ausgold Exploration (Au)			
18	Bellevue Gold (Au)					

The broad distribution of discoveries over the State demonstrates the diversity of mineral types and focus on remote areas (Figure 9).

Notes on some of these discoveries follow to demonstrate the impact on exploration. A detailed case study is used for the Bellevue discovery in Round 15 as this is the most advanced commercially thus providing a financial model for assessment.

Figure 9: Mineral discoveries**3.1.6.1 Antipa Minayri-Waca deposit**

Antipa announced a maiden resource at the Minayri-Waca deposit in November 2017 following drilling supported by Round 14. This deposit is in a poorly explored area north of the Telfer mine in the Great Sandy Desert known as the Paterson Province. After December 2017, Rio Tinto increased the area they held for exploration in the area from an interest in 2,335 km² to 11,036 km² while FMG increased acreage from zero to 5,300 km². Antipa announced new discoveries in 2019 partly in response to a second co-funded drilling program in Round 17. The Rio Tinto expansion was due to the successful discovery of the Winu deposit that the company found, and the broader regional excitement created by the Antipa discoveries. The Paterson Province is now extensively covered in exploration tenements.

3.1.6.2 Buxton Resources Double Magic

The Double Magic discovery of nickel including the flagship Merlin prospect has increased interest in the poorly explored West Kimberley region. IGO subsequently formed a joint venture with Buxton to explore for nickel-copper in the broader region. IGO acquired \$4 million in Buxton shares and the right to earn 70% of Merlin/Double Magic by spending an additional \$8 million on exploration. This joint venture brings a large nickel company into the region to join a junior explorer.

A substantial exploration program is planned for 2020 and Buxton has increased the area held for exploration.

3.1.6.3 Comet Resources graphite

Comet Resources received EIS funding for graphite exploration drilling in 2017. Drilling commenced in December of that year. A new high-grade deposit was announced at the Springdale deposit in March 2018 and a maiden resource in December 2018. The company has now proven up a promising graphite project at Hopetoun on the WA south coast. Metallurgical test work has been completed and the company is engaging with off-take partners.

3.1.6.4 Explaurum

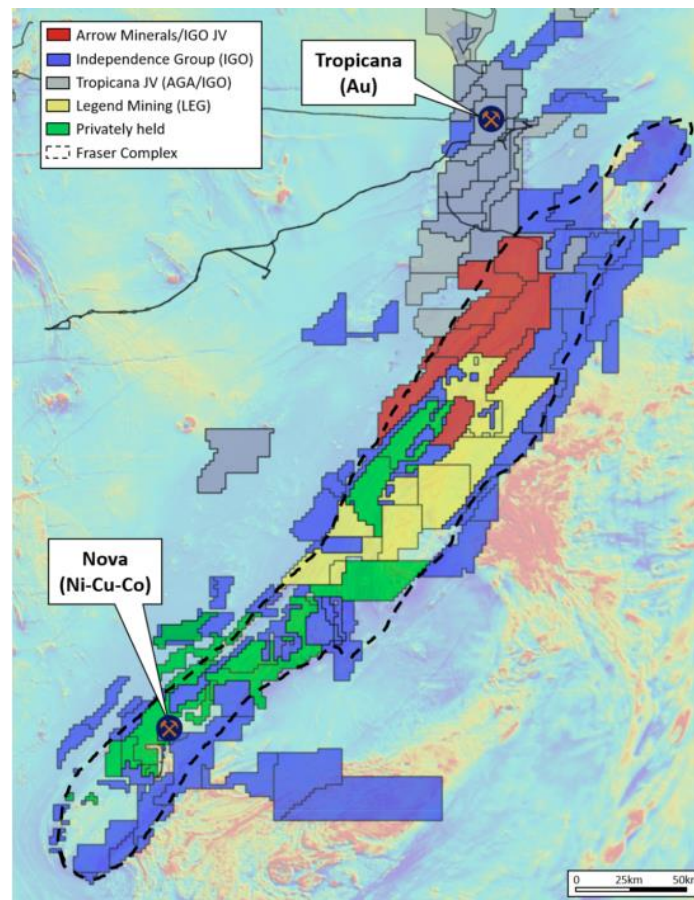
The Tampia Hill gold deposits near Narambeen in the Wheatbelt of Western Australia were first discovered by BHP in 1987. Numerous companies operated small mines over the years with Explaurum taking over from Auzex Exploration in 2015. Co-funded exploration drilling in 2018 found promising grades in all three holes. A feasibility study subsequently completed found the Tampia Hill project could produce 100,000 ounces of gold for five or six years with a pre-tax net present value of \$156 million and a 70% internal rate of return.

The project attracted larger companies and Ramelius Resources gained ownership through the takeover of Explaurum Limited in February 2019. The ore will be mined and trucked to the Ramelius Resources Edna May plant for processing. A decision to proceed with mining is expected in early 2020.

3.1.6.5 IGO Andromeda

A co-funded program by IGO intersected zinc-bearing sulphides in metasedimentary rocks and identified the Andromeda nickel orebody. This marked a change of focus in the area, which previously concentrated on the mafic rocks where the Nova-Bollinger nickel-copper-cobalt deposit is located. IGO subsequently intensified exploration in the Fraser Range. An adjacent tenement holder stated that “IGO is spending \$30 million in Fraser Range, Mark Creasy has been spending \$10 million and we’ve been spending \$4 million³. An indication of the exploration excitement in the Fraser Range resulting from the initial Nova discovery and subsequent Andromeda can be seen from the exploration tenement map (Figure 9).

³ <https://www.proactiveinvestors.com.au/companies/news/310127/igo-s-andromeda-discovery-also-a-wildcard-for-legend-minings-fraser-range-project-10127.html>

Figure 9: Fraser Range exploration tenement holdings**3.1.6.6 Bellevue Gold mine**

Gold was mined at the Bellevue lode for over 100 years through to 1997 when the operation shut down. About 800,000 ounces of gold were produced largely from narrow underground veins. The geology is complex, and the ore had many processing challenges leading to frequent changes of ownership and production disruptions. Copper and silver were found in the gold with the copper creating early ore-processing difficulties. Ore recovered was generally high in grade with the average over the mine life a significant 15g/t.

The mine site was partially rehabilitated in the late 1970s and little remained of the previous operations other than some pit workings, an old roaster and a chimney.

A co-funded drill hole in Round 15 located gold mineralisation on the other side of a critical fault zone. A second co-funded hole in Round 18 intersected deeper and significant mineralisation. This discovery and higher gold prices (in Australian dollars) have made the company an ASX success story and it is now in the S&P/ASX 300 Index.

The new resource of 1.8mt has an average grade of 11g/t which is very high by Australian standards. The company has eight drill rigs on site to prove up the resource to allow a definitive feasibility study to be completed. Mineralisation remains open to the north, south and at depth, and additional new lodes have been identified to the east and west. This study assumes there will be further success with a project based on reserves of 2mt grading 10g/t.

The discovery will be mined. This study estimates the net value of the gold in present day terms as **\$122m** using the assumptions summarized in Table 7. The notes provide justification for the key assumptions.

The net value of output from the Bellevue mine discounted to present day values provides a multiple of 5 times the \$20m allocated to the EIS program in the two financial years. When combined with the increase in tenement numbers and exploration investment that could be linked to the program, it provides an economic justification for this program. There are other discoveries from the co-funded drilling that will add to this value, but they are more difficult to quantify at this early stage.

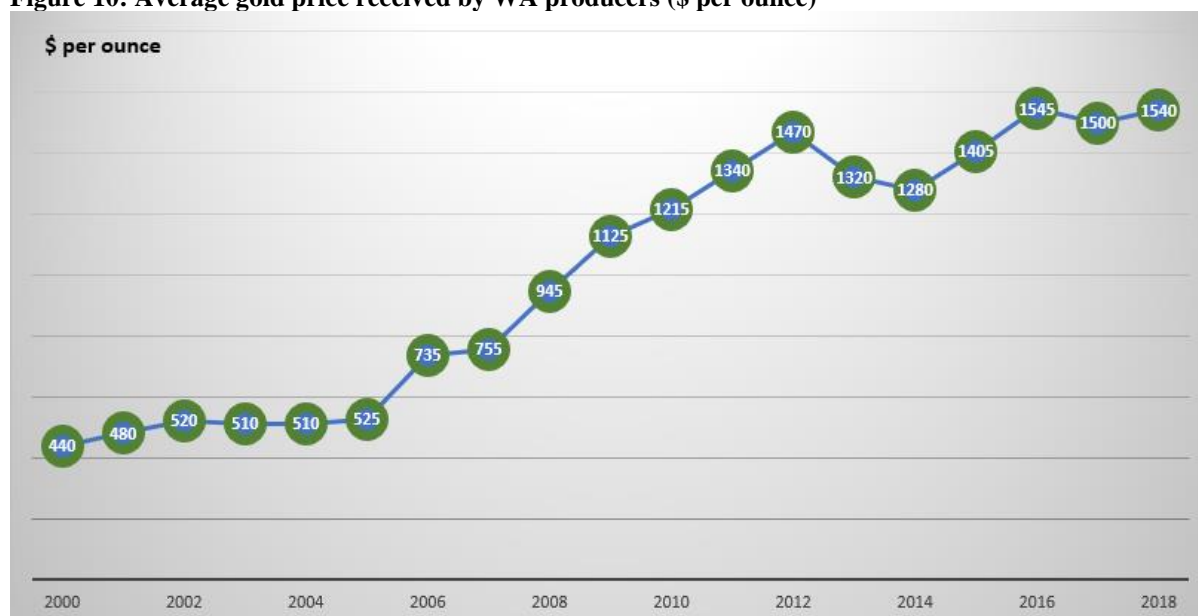
Table 7: Financial model assumptions

Parameter	Benchmark	Totals (rounded)
Gold reserves	2 mt grading 10g/t	
Recovery	94%	
Processing	350,000 tonnes a year	
Mine life	6 years	
Output schedule	Start in 3 years, finish in year 9	
Output	Average 112,000 ounces a year	671,400 ounces
Capital cost	\$180/oz	\$121m
Operating cost	\$900/oz	\$604m
Net revenue		\$282m
Net present value	10% discount rate	\$122m

Gold price

Average prices received by Western Australian producers have steadily increased from 2000 and following a slump in 2014 have now risen to record highs (Figure 10). This study assumes a long-term price of A\$1,500 an ounce.

Figure 10: Average gold price received by WA producers (\$ per ounce)



Cost of gold production.

PCF Capital Group released a report in May 2019 with details on the all-in sustaining costs (AISC) for Australian and New Zealand gold operations⁴. AISCs are the costs attributed to production at operating mines. They don't include the costs of building a plant and establishing the infrastructure required to bring a mine into production, commonly referred to as upfront capital expenditure (CAPEX).

AISC costs vary widely with such factors as the grade, open cut or underground extraction, by-product credits, location, and scale of operation.

The average AISC was A\$1,255/oz with the lowest cost producers below A\$500 and the highest cost ones over A\$1,500. This study uses the average of A\$900 given the high grade.

Capital costs vary a great deal with location, scale and metallurgical complexity. This study applies a capital cost of \$180 per ounce of reserves slightly higher than the recently commissioned Gruyere mine which has a capital cost of \$620m and reserves of 3.5m ounces (\$177/oz).

Production

It will take at least two more years to bring the mine into production and this study assumes a more conservative three years.

⁴ <https://finfeed.com/investor-101/australias-gold-mines-by-production-grades-and-costs-part-1/>

Chapter

4

4. Findings

1. The EIS involved funding of \$23.4m over the two financial years to June 2019.
2. 95% of this expenditure was on three programs – innovative drilling, geophysical surveys and 3D prospectivity mapping.
3. 108 projects were drilled with government co-funding achieving 208,500 metres.
4. Second generation gravity survey coverage was completed for the whole state.
5. 2D seismic surveys were completed for the Kidson Sub-Basin and the Eastern Goldfields
6. The 1:500,000 Regolith map was completed for the northern half of the State.
7. Geoscience data released included 2,782 geochemical samples, 637 regolith geochemistry samples, 184 age dates, 396 isotope analyses and 128 drilling reports.
8. The release of zircon oxygen isotopic data to online applications made GSWA the first survey in the world to generate and release such high-quality isotopic data to the public.
9. Results from the 2014-18 COPA passive seismic array were processed into a lithosphere-scale 3D model of the Capricorn Orogen.
10. A new open source 3D stochastic geological model was commenced involving geological surveys and research institutions in Australia, Canada, France, Germany and the UK.
11. Two 3D geo-models were released –East Albany-Fraser Orogen and Lawlers Anticline.
12. The Mineral Systems Atlas was completed and released as an on-line interactive, GIS-Atlas.
13. 295 products were released including data packages, published reports and maps.
14. The two financial years under review both saw an increase in exploration and prospecting tenement numbers – an increase of 890 tenements over the two years (9%) from the number at 30 June 2017.
15. Private exploration expenditure in the financial years was \$2,640 m. This compared with \$1,028 m in 2016-17 or \$584 m more than if the 2016-17 spend had continued.
16. Western Australian has seen an average 57% share of national private exploration spend over the last twenty years. Expenditure in the two study years increased to 61%.
17. Drilling on brownfields areas in Western Australia has been rising since 2014-15 while there was an even larger rate of increase in greenfields drilling.
18. Measuring success in drilling is a subjective exercise. In broad terms, GSWA has classified 19 “finds” as successes under the co-funded drilling program.
19. The discovery of the rich Bellevue gold mine is a commercial success. It will almost certainly be developed and the net present benefit to the State is estimated at \$122m.

20. The net value of the benefit from the Bellevue mine provides a multiple of 5 times the \$20m allocated to the EIS program in the two financial years.
21. When combined with the increase in tenement numbers and exploration investment that could be linked to the program, it provides an economic justification for this program.
22. There are other discoveries from the co-funded drilling that will add to this value, but they are more difficult to quantify at this early stage.
23. The time lag between government geoscience data provision and an increase in private investment is uncertain. Private investment is a function of many factors including commodity prices, access to land and finance and perceptions of policy and regulatory stability. Drawing a direct relationship between government and private expenditure is highly problematic.
24. Given the long-term nature of the exploration and mining cycle, it is more likely that there will be a measurable long-term effect than a demonstrable short-term impact. This relationship deserves further investigation.

Appendix 1: Study team

Murray Meaton AM

Murray Meaton is Managing Director of Economic Consulting Services Pty Ltd (ECS). Murray has completed over 800 consulting assignments for a wide range of government agencies, private corporations and industry associations. Private sector clients have included Wesfarmers, Woodside Energy, CSBP, WMC, CRA, and the Chamber of Minerals and Energy. Government sector clients have included the Department of Water, Office of Water Regulation, Water Corporation, Department of Agriculture and Food, Departments of Fisheries and Education, the Office of Gas Regulation, Department of Industry and Technology, Department of Industry and Resources Development, and Department of Commerce and Trade.

Projects have included feasibility studies, economic impact studies, and financial evaluations, government submissions, forecasting studies, corporate planning facilitation workshops, and reviews of government legislation. Murray has worked in all regions of Western Australia and is very familiar with the economies and development issues facing regional areas, including the south west of the State.

Prior to joining the private sector, Murray spent 25 years with the State and Commonwealth governments. Appointments included the Departments of Agriculture, Minerals and Energy, Treasury, and the Commonwealth Department of Primary Industry.

Lindsay Gilligan PSM

Lindsay was formerly Director of the Geological Survey of New South Wales. His career has focused on the geology of mineral resources and fostering mineral exploration and discovery of NSW and he has over 40 years' experience as a geologist. Lindsay has extensive experience in government geoscience. He has published widely on aspects of mineral deposits. Whilst Director he led the NSW State Government's highly successful *New Frontiers* exploration initiative. He has actively promoted mineral exploration investment in New South Wales both nationally and internationally.

Lindsay has a broad network across the exploration industry, government and research organisations, as well as internationally in both government and industry and has a high public profile in the minerals industry. He was non-executive Chairman of Thomson Resources Ltd, a NSW-based junior explorer, from 2009 to 2019. He was a director from 2010 to 2018 on the governing body of the Deep Exploration Technologies Cooperative Research Centre (DET CRC). In 2019, he was appointed to the board of the newly formed Mineral Exploration Cooperative Research Centre (MinEx CRC) which is arguably the largest mineral exploration research organisation in the world. He has also consulted to Commonwealth and State agencies on government geoscience issues.

Lindsay was awarded the Public Service Medal in the 2008 Queen's Birthday Honours and, in the same year, was also awarded the *Australian Mining* magazine's "Most Outstanding Contribution to Australian Mining" Award.