Government of **Western Australia**
Department of **Mines and Petroleum**

EXPLORATION INCENTIVE SCHEME
Economic Impact Study

by
ACIL Allen Consulting




Geological Survey of Western Australia

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ACIL ALLEN CONSULTING

REPORT TO
DEPARTMENT OF MINES AND PETROLEUM

JANUARY 2015

EXPLORATION INCENTIVE SCHEME

ECONOMIC IMPACT STUDY

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Executive summary

In Western Australia the mining sector is the main driver of wealth creation and is a major contributor to state government revenue, providing, through royalty payments, around 22 percent of general government revenue.

Exploration activity is a necessary input into the creation and continued success of the mining sector. Due to the importance of exploration to the long term economic health of the Western Australian economy the state government introduced the Exploration Incentive Scheme (EIS) to support exploration in greenfield areas. Across Australia the need to support greenfield mineral exploration is widely recognised, and all major jurisdictions have implemented programs to support greenfield exploration.

Although major new discoveries are found at increasing depth, the evidence that the value of mineral deposits discovered through exploration is a multiple many times greater than exploration spending is strong; even after discounting to allow for the time it takes to move from a new discovery to an operating mine.

Exploration activity has public good attributes, which means the socially optimal level of exploration activity is greater than the level of exploration activity generated in a pure private market. Furthermore, a pure private market generates too much brownfield exploration and too little greenfield exploration. These issues have long been recognised, and globally, direct government funded geoscience is a standard policy response.

That there is a divergence between the socially optimal level and mix of exploration activity and the level and mix of exploration generated under a pure private market suggests that government action to support exploration in general, and greenfield exploration in particular, could increase community welfare. The typical government response has been to provide some form of exploration incentive to the private sector.

The international evidence, and the evidence from other Australian jurisdictions, all find that there is a strong private sector exploration response following the introduction of exploration incentives. The strength of the response is moderated by general market conditions, as measured by commodity prices, and the extent of successful exploration. When commodity prices are high, and when there have been major discoveries, the extent of the private sector exploration response to incentives is stronger.

For the specific time period that the EIS has operated, detailed statistical modelling found that the long run (three year) cumulative effect of $1M of EIS spending was an increase in exploration expenditure of $19.8M. This estimate is large, but the estimate is consistent with what might be expected based on a review of other published studies, the targeted nature of the EIS program, and market conditions for the sample period.

Care is needed when calculating the net benefits from policy actions. For example, it is necessary to recognise that additional exploration expenditure displaces other expenditure that otherwise would have taken place; and that raising tax revenue to fund any government program also involves costs. Care must also be taken to determine where costs and benefits fall. For example, if the EIS increases the attractiveness of exploration investment in Western Australia relative to other states such that Western Australia attracts additional exploration investment away from other states, this represents a substantial net gain for Western Australia, but the reallocation of funds from other states to Western Australia does not necessarily imply a substantial net gain at the national level.

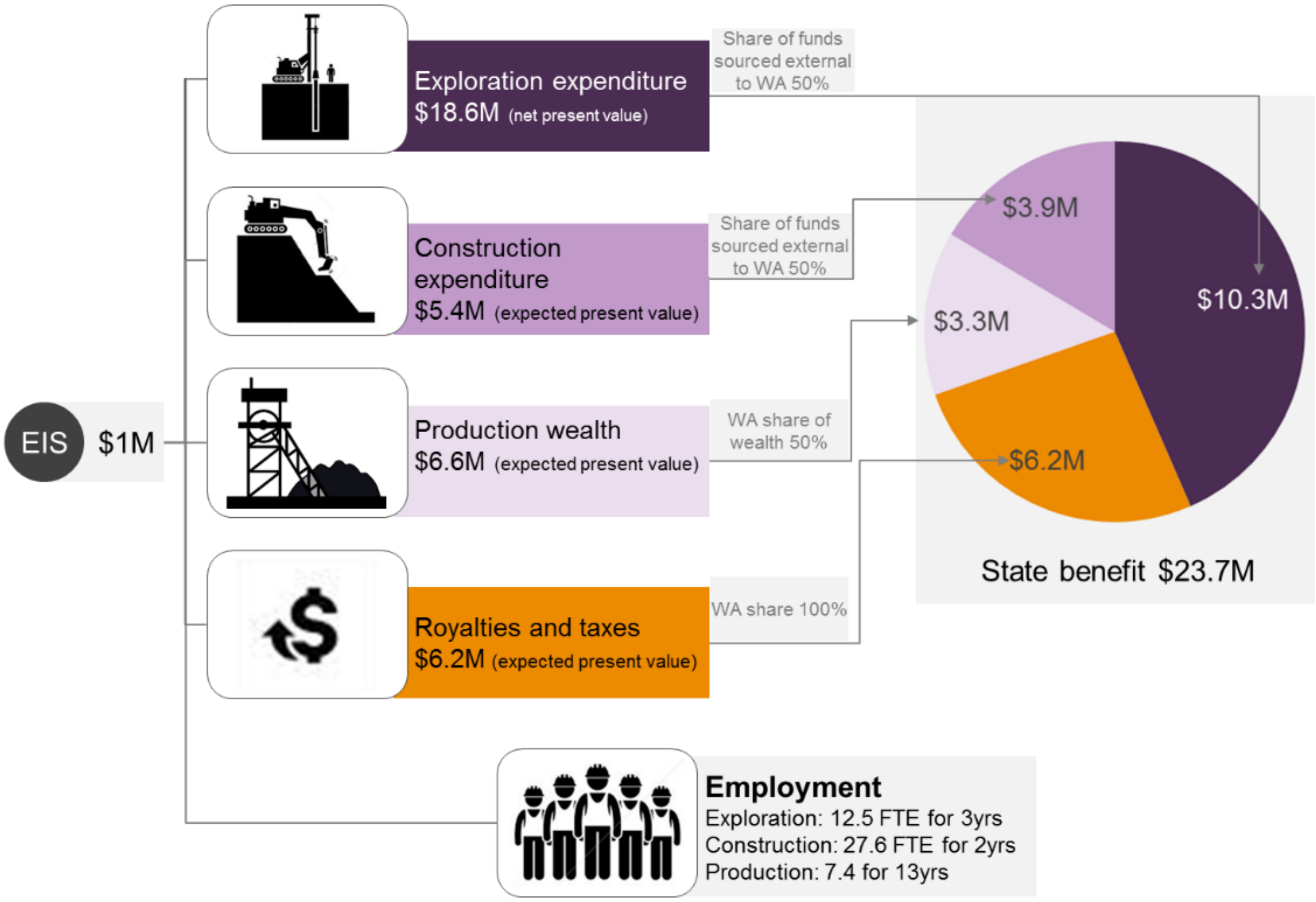
To determine the net benefit of the EIS to Western Australia we consider the source of the additional exploration funds, sector specific multipliers, and the expected value of future mine developments following additional exploration. Where appropriate, future values are discounted to net present value terms. In aggregate, the modelling found that for every $1 million invested in the EIS the long run expected net benefit to the State, in terms of higher GSP, is $23.7 million.

This comprises:

- $10.3M due to additional exploration activity
- $6.2M in additional taxation and royalty revenue
- $3.9M due to additional construction activity
- $3.3M in new net wealth generated by the development of new mines.

The above results, derived from empirical modelling, are large, and the key driver of the result is the strong private sector exploration response to the EIS. For the particular activities of the EIS, and given existing market conditions, such a response is reasonable.

Figure ES 1 **Exploration Incentive Scheme benefit summary**



Source: ACIL Allen

The main transmission channel delivering the large private sector exploration response is new geoscience information. The new pre-competitive geoscience information provided through the EIS opened up, for the first time, significant new areas of the state for exploration. The release of this new pre-competitive geoscience information is non-rival in consumption. This means that each new data release can, and did, stimulate new exploration activity at many firms; hence the large private sector response to the EIS observed in the data.

It should, however, be understood that the results hold only for the range of values observed in the data. So, while the modelling controls for the effect of commodity prices, the results cannot be extrapolated to periods when market prices fall outside the range observed in the study. For example, a consensus view in the literature is that the private sector response to government exploration initiatives is lower when commodity prices are lower.

To explore the effect of high and low prices we conducted sensitivity analysis. For the low price scenario we find that the expected value of an average drilling campaign is negative. When the expected value of a drilling campaign is negative we do not expect rational market participants to fund a drilling campaign that has only an average probability of success. Under a low price scenario only those prospects that have an above average chance of success, which are most likely to be brownfield projects, will attract funding. Overall, with low prices, the private sector exploration response to incentives and new geoscience information will be muted, and as such, the potential benefits that accrue to the state will be low.

Under the high price scenario we find that market conditions make it possible to fund the capital investment needed to develop very large mine projects. As modelled, these projects go on to operate for very long periods of time, and as such, deliver royalty, employment, and net wealth creation benefits to Western Australia for decades.

Key findings

The report key findings are summarised below:

- there are externality issues associated with mineral exploration that result in under investment in grass root exploration. As such, well designed government programs that address these externality issues -- such as the EIS -- can increase community welfare
- for the sample period there was a strong private sector exploration response to the EIS and the additional exploration activity generated net benefits for Western Australia
- the expected combined Western Australian private sector and government sector benefit, in net present value terms, is $23.7M for every $1M invested in the EIS. This finding is consistent with the results reported from other studies
- per $1M invested in the EIS, the expected benefits are:
  - the direct financial impact of the additional exploration activity stimulated by the EIS of $10.3M
  - the employment impact of the additional exploration activity stimulated by the EIS, which is 12.5 FTE positions in minerals exploration for three years
  - the financial impact of the mine site construction phase, which is estimated to be $3.9M
  - the employment impact of the mine site construction phase, which is estimated to result in 27.6 FTE positions for the two year construction phase
  - the share of net private sector wealth that accrues to Western Australians following the successful development of a mine, which is estimated to be $3.3M
  - the employment created during the production phase which is 7.4 FTE for 13 years
  - the net present value of additional government revenue generated by royalty and pay-roll tax payments of $6.2M
- for low price scenarios the expected value of an average drilling campaign is negative. As such, the expected private sector exploration response to incentives under a low price scenario is expected to be modest; as are the benefits that accrue to the state
- for higher price scenarios, market conditions make it possible to fund the development of very large mining projects. These projects operate for long periods, potentially delivering royalty, employment, and net wealth creation benefits to Western Australia for decades. Under the high price scenario the expected net present value of every $1M invested in the EIS is $38.3M.

1 Introduction

This report presents an evaluation of the economic impact of the Exploration Incentive Scheme (EIS). The Exploration Incentive Scheme is a Royalties for Regions initiative that has, as its main objective, the promotion of exploration activity in Western Australia. The EIS program commenced in April 2009, partly in response to the global financial crisis. Specific objectives of the program were to encourage exploration in underexplored areas, reduce the risk for explorers, and provide support to maintain a strong mining sector in Western Australia. The program is managed by the Department of Mines and Petroleum and to date has invested $80M. The Government has committed to funding the scheme to June 2017, by which time total program expenditure will have reached $130M.

Exploration Incentive Scheme

The stated objectives of the Exploration Incentive Scheme include:

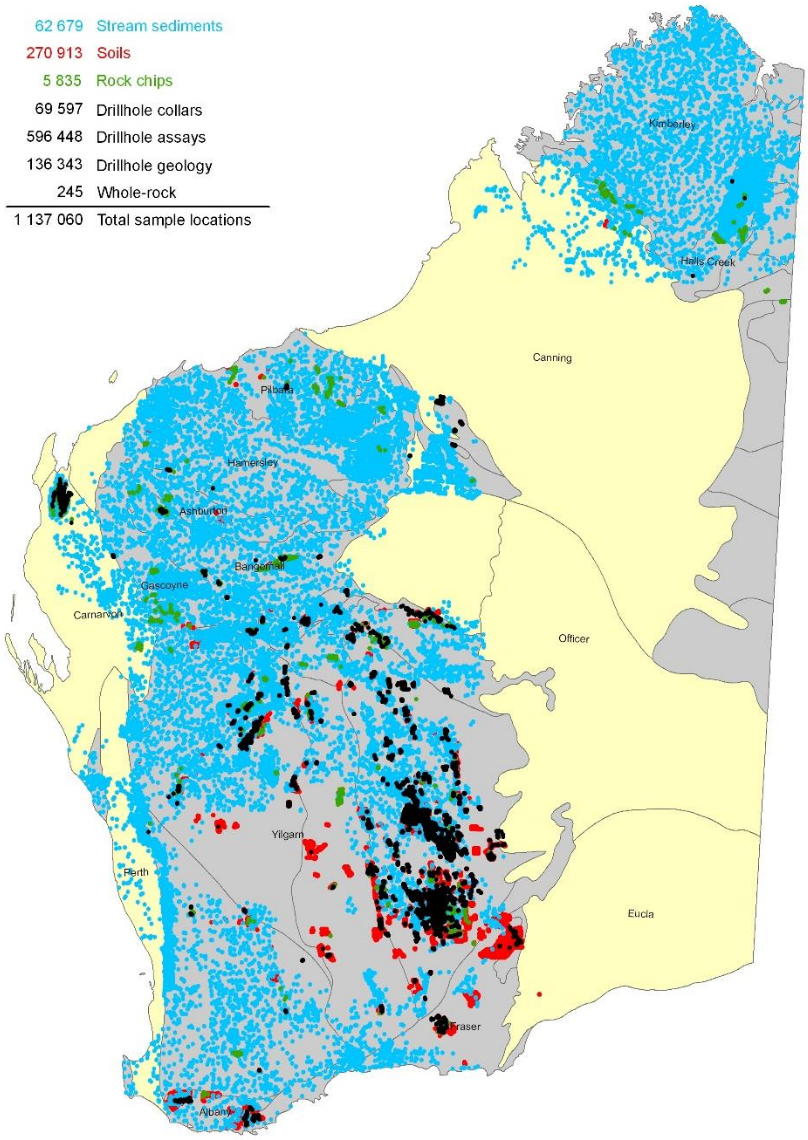
- sending a clear signal to resource investors around the world that Western Australia is serious about attracting exploration investment
- enhancing the take-up of greenfield exploration acreage and hence new mineral discoveries in remote and regional areas
- sustaining the greatly improved international rating of the attractiveness of Western Australia as an investment destination.

To meet these objectives a number of sub-programs were developed as part of the overall EIS program. These sub-programs are explained below.

1. Geophysical and Geochemical Surveys (Funding allocation to date $33.3 million)

   As part of this sub-program, between 2009 and 2013, approximately 3.4M line-km of airborne magnetic and radiometric data was acquired; providing, for the first time, almost complete state coverage with airborne magnetic and radiometric survey data. Other activities under this sub-program have included geochemical and survey work covering the east Wongatha regolith, deep seismic data for the Musgrave, Yilgarn Craton, and Albany-Fraser regions; and pilot AEM surveys.

Figure 1 **State exploration geochemical coverage**



Source: Department of Mines and Petroleum

2. Innovative Drilling Program (Funding allocation to date $26.9 million)

   The innovative drilling co-funding sub-program supports several different types of exploration activity. Co-funding is available, up to a maximum of $150,000, or $200,000 in the case of a deep drill hole, for 50 percent of direct drilling costs. For a 'prospector' application that may involve non-core drilling, co-funding of up to $30,000 is available.

   The application process for funding is highly competitive, and each year there are two calls for funding applications from exploration companies; one around February and another around September. Applications are made via an on-line system where applicants must address a series of criteria which assess the extent of innovation, the soundness of mineral deposit models used to identify target resources, and the potential of the proposed program to advance exploration activity in under explored areas. Applicants are also asked to identify proposed methods of analysis such as assays, geochronology, isotopic analysis, and downhole logging.

   All applications are evaluated by a team of independent exploration geologists, and the evaluation process also determines whether the applications will deliver basic geoscientific information such as age, stratigraphic relationships, structural settings, untested geochemical or geophysical anomalies, depth to geophysical targets or basement, and new mineral commodity potential.

The overall application and grant funding program is also subject to external review.

Figure 2 **Exploration drilling in Western Australia**

Source: Department of Mines and Petroleum

The companies that have received co-funding have been associated with the following discoveries: Hand Pump gold project (Beadell Resources); Tropicana East gold project (Beadell Resources); Lake Mackay uranium project (Toro Energy); Magnus gold project (Alchemy Resources); Yeneena zinc-copper project (Encounter Resources); Speewah vanadium-uranium project (Speewah Metals); Nova nickel-copper project (Sirius Resources).

3. 3D Geological Mapping (Funding allocation to date $13.8 million)

   A wide range of activities have been undertaken as part of this sub-program, including major unconventional energy studies for tight gas and shale gas in the Perth Basin; modelling of the Canning Basin for CO_2 storage potential; and investments in software upgrades. When -- as part of the 2011 Fraser Institute Global Petroleum survey -- detailed information on the quality of the geological survey information in different jurisdictions was released, the Western Australian Petroleum and Geothermal Information Management System (WAPIMS) was ranked in first place, globally.

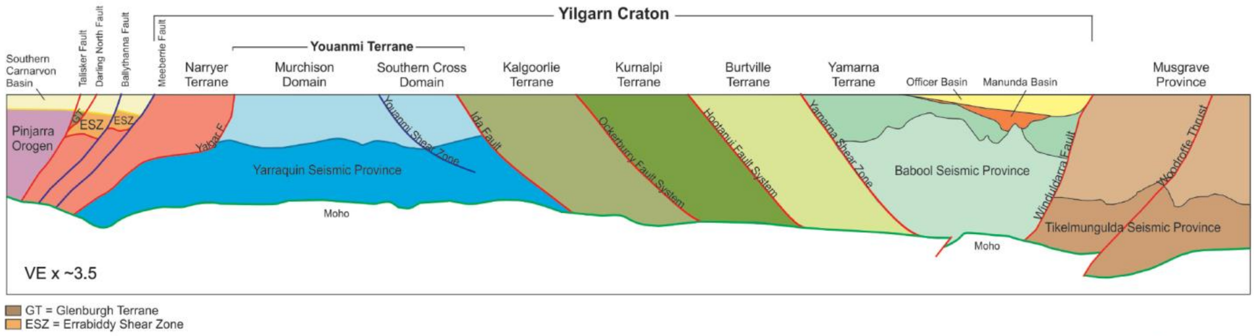
4. Strategic Research with Industry (Funding allocation to date $2.3 million)

   This sub-program has led to the WA Regional Researcher collaboration with CSIRO, and the initiation of new projects through the Minerals and Energy Research Institute of Western Australia, including a biogeochemistry project in the North East Yilgarn.

5. Sustainable Working Relations with Indigenous Communities (Funding allocation to date $2.2 million)

Although there is a whole of government approach for negotiation of land access where native title has been established, a range of other complementary activities have been undertaken as part of this sub-program. These activities have included community engagement to promote awareness about uranium mining, regional heritage studies, and the digitisation of 6,500 existing heritage reports.

Figure 3 **1800 km seismic cross section the Western Australia's crust**



Australian Government Geoscience Australia — Centre for Exploration Targeting — ANSIR National Research Facility for Earth Sounding — Royalties for Regions Exploration Incentive Scheme

Source: Department of Mines and Petroleum

6. Exploration and Environmental Coordination (Funding allocation to date $1.5 million)

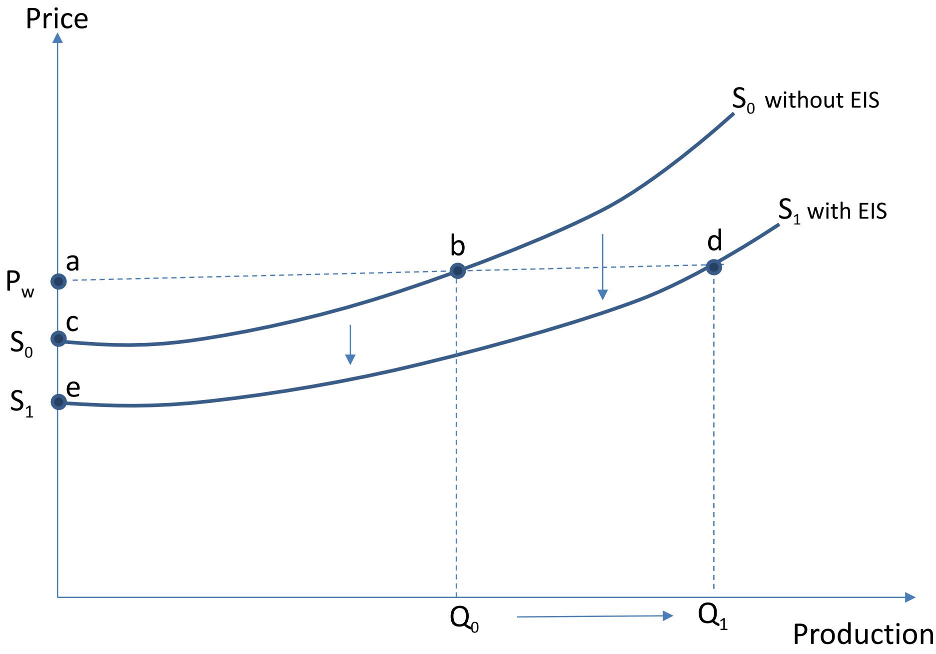
   This program has focused on improving the administrative interactions of private sector exploration companies with government through the use of on-line technology. For example, the implementation of new systems now allows on-line tracking of a wide range of aspects associated with tenement applications, and other administrative processes, such as applications for environmental approval to conduct exploration activities.

Report approach

The purpose of this report is to provide an economic impact assessment of the Exploration Incentive Scheme. Measuring the impact of programs such as the EIS is difficult because it requires an estimate of the increase in the industry economic rent associated with the program (Hogan 2003, p. 37). The concept of economic rent takes into consideration: the full production cost, including mine site rehabilitation; mine development costs; and exploration costs.

At the industry level economic rent is defined as the difference between the long run marginal cost of exploration, development, and extraction (Hogan 2003, p. 35). The EIS works to lower the industry long run marginal cost curve, and hence increase economic rent. Given the simplifying assumption of constant prices (used for illustration purposes only), this increases industry economic rent. In Figure 4 the increase in industry rent can be calculated as the difference between the area defined by *abc*; and the area defined by *ade*; where in the figure S_0 denotes the industry long run marginal cost curve before the program; S_1 denotes the industry long run marginal cost curve following the program; and P_w denotes the world mineral price.

Figure 4 **Increase in industry economic rent**



Source: adapted from Hogan (2003)

Although Figure 4 illustrates how, in theory, the change in the economic rent can be measured; in practice deriving this value is difficult. As such, in this report we build a credible story around the impact of the EIS program using evidence from multiple sources.

The first source of evidence is detailed empirical modelling of Western Australian specific exploration expenditure and discovery data. The empirical modelling shows that the EIS has provided substantial net benefits to Western Australia. Next, a series of case studies are presented that show the modelling results are consistent with what we observe in practice. Finally, the results from other studies are presented and compared to the findings of this study. This comparison shows that the findings of this study are consistent with the findings of many other studies.

Combined the weight of evidence provides a compelling case that the EIS program has been a valuable government activity.

2 Background

This chapter provides information on the role of the mining sector in Western Australia and establishes that on average new exploration activity leads to the creation of new private sector and public sector wealth. The externality issues specific to exploration activity are then reviewed, with appropriate government actions to address these externality issues identified.

2.1 Western Australia's mining sector

In Western Australia the mining sector is the industry sector responsible for the greatest contribution to net wealth creation, and in the 2013 financial year the mining industry contributed 29 percent ($71B) of Gross State Product (GSP) (Government of Western Australia, 2014a, p. 2). Mining royalty income for the State Government is significant, and mining royalties currently contribute around $6B, or 22 percent of general government revenue (Government of Western Australia, 2014, p. 88). Over the forward estimates of the current budget, royalty income is forecast to grow at a rate similar to other revenue, but royalty income forecasts rely on many assumptions, and some important variables used to forecast royalty income, such as exchange rates and commodity prices, are volatile.

Given the size of the mining sector a vibrant mining industry is central to the economic prosperity of Western Australia. It has long been recognised that resource abundance alone is not a sufficient condition for the development of a successful resource sector. Rather, developing and maintaining a successful and prosperous resource sector depends on a complex combination of factors, including: technology, social and organisational factors, the legal framework, government policy regarding ownership of resources, and government support for the geological survey function (David and Wright 1997).

2.1.1 Mineral potential of Western Australia

The Fraser Institute *Best Practices Mineral Potential Index* provides a measure of the pure mineral potential of regions based on mining company executives' perceptions of the geology in each region (Fraser 2013, p. 10). Western Australia has consistently ranked highly on this measure, and globally, in 2013, Western Australia was ranked second, behind Alaska. At the top of the rankings the difference between scores is slight and so from year to year there can be some movement in the rankings at the top of the index but little change in the actual index score.

To place the prospectivity of Western Australia in a national context, Table 1 shows index scores for the Australian jurisdictions evaluated in the survey. As can be seen from the detail in the table, Western Australia consistently ranks as the Australian jurisdiction with the geology most favourable for exploration. Over the past five years, the Western Australian index score has been about 30 percent higher than the average for the other Australian jurisdictions in the survey.

Table 1 **Mineral potential of Australian jurisdictions**

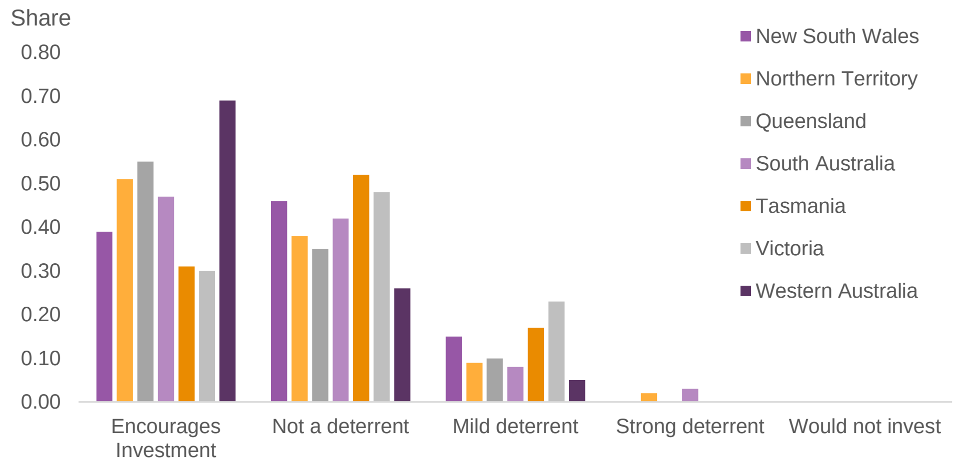
	2009[a]	2010[a]	2011[a]	2012[a]	2013
Western Australia	0.77	0.87	0.83	0.77	0.82
New South Wales	0.62	0.55	0.55	0.49	0.62
Northern Territory	0.83	0.72	0.66	0.68	0.70
Queensland	0.81	0.80	0.75	0.72	0.73
South Australia	0.80	0.73	0.79	0.69	0.68
Tasmania	0.59	0.66	0.47	0.46	0.57
Victoria	0.51	0.42	0.37	0.40	0.53
Average ex WA	0.69	0.65	0.60	0.57	0.64

[a] Financial Years

Source: Fraser Institute (2014)

The index values shown in Table 1 are derived from survey responses. In the survey there are five response options that range from the 'geology encourages investment' through to the 'geology is the defining reason for not investing' in the region. Figure 5 provides a detailed decomposition of the way mining industry executives see the geology potential of different Australian regions. As can be seen from the figure, in the 2013 survey 70 percent of mining executives indicated that the geology in Western Australia encourages investment.

Figure 5 **Mineral potential of Australian regions**



Source: Fraser Institute (2014)

Given Western Australia is a substantial global producer of a number of commodities (Table 2) the view of industry executives is not surprising.

Table 2 **Western Australia: A globally important supplier of minerals**

	WA % of world	WA % of Australia
Iron ore	29.9	97.3
Garnet	15.3	100.0
Zircon	14.7	35.2
Alumina	14.2	63.3
Nickel	12.1	100.0
Limonite	9.0	64.9
Diamonds	6.7	100.0
Rutile	6.7	11.4
LNG	6.4	82.6
Gold	6.1	69.6

Source: Government of Western Australia (2014a)

2.1.2 Exploration expenditure

Consistent with the information on the mineral potential of different regions, Western Australia is the country's most preferred jurisdiction for mineral exploration. As can be seen from the detail in Table 3, Western Australia consistently attracts over half all national exploration expenditure.

Table 3 **Exploration expenditure by state and territory**

	2009	2010	2011	2012	2013	2014
	(%)	(%)	(%)	(%)	(%)	(%)
WA	56	56	54	53	58	57
Qld	16	20	22	25	22	22
SA	10	7	9	8	8	6
NSW	8	6	5	6	6	7
NT	6	6	7	5	4	6
Vic.	3	4	2	2	1	1
Tas.	1	1	1	1	1	1

Note: Financial years
Source: DMP Statistics Digests [available: dmp.wa.gov.au]

2.1.3 Policy setting

In terms of the current investment environment, the Fraser Institute *Current Practices Mineral Potential Index* provides a measure of whether or not a jurisdiction's current policy settings encourage or discourage investment. In 2013, Western Australia ranked first on this measure. Although again it should be emphasised that there are a number of jurisdictions that have a policy structure that is attractive for mining exploration, and so in any one year the rankings can move around at the top of the league table with little change in the underlying policy settings.

Table 4 provides comparative information on the policy setting measure for Australian jurisdictions. Notable features of the information in Table 4 are that Western Australia's policy setting are consistently seen as above average for Australia; perceptions about the policy setting in Western Australia have improved over time; and the gap between Western Australia and the average measure for the rest of Australia has grown.

It is not possible to definitely say that the EIS program was the causal factor in the (0.73 - 0.59)/(0.59) = 24 percent improvement over five years in the policy setting index measure for Western Australia. However, given the nature of the programs undertaken as part of the

EIS, an improvement in mining executives' perception of the policy environment in Western Australia is a reasonable expectation.

Table 4 **Policy setting Australian jurisdictions**

	2009[a]	2010[a]	2011[a]	2012[a]	2013
Western Australia	0.59	0.68	0.64	0.67	0.73
New South Wales	0.48	0.39	0.46	0.42	0.47
Northern Territory	0.66	0.54	0.58	0.65	0.65
Queensland	0.58	0.55	0.51	0.56	0.58
South Australia	0.62	0.56	0.62	0.58	0.60
Tasmania	0.44	0.42	0.37	0.34	0.40
Victoria	0.30	0.35	0.25	0.39	0.42
Average ex WA	0.51	0.47	0.47	0.49	0.52

[a] Financial Years

Source: Fraser Institute (2014)

2.2 Exploration context

Exploration is a necessary step for the successful development of an economically valuable mine. New natural resource deposits can be discovered through exploration activity at the extensive margin, generally referred to as greenfield exploration, or exploration activity at the intensive margin, generally referred to as brownfield exploration. Distinguishing between greenfield and brownfield exploration can be complicated if the issue of depth is considered. For example, while there has been much exploration activity in the Yilgarn region most of this activity has involved drilling to depths of less than 50 metres (Schodde, 2014b). A program of deeper drilling in this area could, therefore, be classified as greenfield exploration.

The Exploration Incentive Scheme is focused on the provision of high quality pre-competitive survey information and lowering the cost of innovative drilling programs through fiscal incentives. The factors that contribute to the rate of new resource discovery identified in Gleb et al. (2009, p. 6) are:

- availability of geological information
- state of technology
- fiscal incentives
- economic feasibility
- government credibility.

As such, the program is aligned with the factors identified as leading to an increase in new discoveries. More generally, Western Australia has been, and continues to be the main source of mineral discoveries in Australia. For example, over half of the major 2013 exploration results highlighted in Geoscience Australia (2014, p. 10-11) relate to Western Australia. As shown in Table 5, over the past five years Western Australia has also dominated the select mineral discoveries profiled in Geoscience Australia (2014, p. 3).

Table 5 **Select Australian mineral discoveries: 2009-2013**

Year	State	Deposit	Commodities	Status
2013	WA	Oxley	Potash	Exploration
2012	WA	Jury-Metcalf	Nickel	Exploration
2012	NSW	Mallee Bull	Copper, Silver, Gold	Exploration
2012	WA	Dampier	Mineral Sands	Exploration
2012	WA	Nova	Nickel, Copper	Development*
2010	SA	Maldorky	Iron Ore	Advanced exploration
2010	NT	Barrow Creek	Phosphorus	Feasibility study
2009	WA	DeGrussa	Copper, Silver, Gold	Operating mine 2011

Note: * Updated to reflect current status
Source: Geoscience Australia (2014)

Junior companies play a major role in exploration and account for between 50 percent and 60 percent of the discovery of new resources (Schodde 2014a). As junior exploration companies, these firms necessarily tend to be focused on exploration at the extensive margin rather than the intensive margin.

That the junior sector plays an important role in discoveries can be seen as an economically efficient allocation of capital. For a junior exploration company the continued remuneration of employees is directly linked to the success or failure of their exploration program. Such a direct link serves to maximise the alignment of incentives between those that have funded an exploration program, and those that are carrying out the exploration.

2.2.1 Drilling to discovery relationship

Drilling and other exploration costs have fluctuated through time. For example Schodde (2013, p. 19) estimates that over the period 2000 to 2012, in real terms, the average per metre drilling cost rose by 88 percent in Canada and 125 percent in Australia. Over the same period the estimated increase in the real average salary for an exploration manager was 83 percent in Canada and 150 percent in Australia. It is therefore necessary to be cautious when looking at the relationship between exploration expenditure and discoveries, as an increase in exploration expenditure may not have been associated with a proportional increase in metres drilled.

For the period 2004 to 2013, the analysis in Schodde (2014b, p. 23) suggests that for Australia there is:

- a moderate size discovery for every 530,000 metres drilled
- a major discovery for every 2.4M metres drilled
- a giant discovery for every 21M metres drilled.

These general relationships can be influenced by the prospectivity of the region. It is also worth noting that there is no uniform definition for defining discovery categories. For example, what is considered a giant discovery in another jurisdiction, may, in Western Australia, be considered merely a large discovery.

2.2.2 Exploration expenditure to discovery relationships

Table 6 provides information on estimated global reserve levels for a range of minerals, oil, and gas in 2000 and 2008. Additionally, the table provides information on the estimated extent of extraction over this period so that it is possible to derive a measure of the extent of new discoveries. The table shows that for most minerals there were substantial additions to reserves over this period.

Table 6 **Mineral and energy reserves 2000-2008**

Mineral	Units	Reserves		Extraction	Imputed discovery	Imputed discovery (%)
		2000	2008	2000-08	2008-08	2008-08
Bauxite	M tn	24,640	25,200	1,480	2,040	8
Copper	M tn	393,500	540,000	128,423	274,923	70
Gold	M toz	45	48	22.9	26	56
Iron	M tn	142,600	162,500	13,115	33,015	23
Lead	M tn	64	79	29	44	69
Nickel	M tn	45,680	67,090	13	21,423	47
Phosphate	M tn	11,500	17,912	1,290	7,702	67
Silver	'000 tn	420	570	175	325	78
Tin	M tn	7,720	6,072	2.5	-1,646	NA
Zinc	M tn	188	182	83	77	41
Oil	B barrel	1,105	1,333	229	457	41
Gas	T m^3	159.00	191	24	56	35

Note: Reserves can be upgraded and downgraded for a variety of reasons in addition to new exploration so that a negative value is possible. For example, in the case of Tin, the collapse in prices in the early 2000s saw previously known reserves struck of the list of known reserves as they became uneconomic.

Source: Gleb et al. (2009)

Valuing mineral discoveries is difficult and there is no universally accepted valuation method. The current rent value method considers the rent value of a unit of resource multiplied by the quantity of resources found, and using the net rent value of resources method, Gleb et al. (2009) compare exploration expenditure and discovery results for non-ferrous metals. A summary of their findings is presented in Table 7 and using this method, globally, the rent value of discoveries is almost 17 times exploration expenditure.

Table 7 **Exploration and discovery relationship**

Period 2005-2008	Exploration	Discovery	Costs/Discovery
	$ B	$ B	(%)
Sub-Saharan Africa	5.9	26	23
Asia-Pacific	4.0	196	2
Europe/Oceania	6.1	57	11
Canada/US	9.6	113	8
South Central America	8.9	183	5
Other	2.5	42	6
World	37.0	617	6

Source: Gleb et al. (2009)

The current rental value method, however, overstates the value of new discoveries as it does not take into account the need to discount the net rent value reflect the fact that extraction will only take place in the future. If the Gleb et al. rent values are first discounted by one half to reflect a low mineral price and hence low resource rent value world; and it was assumed that resource extraction does not start for at least eight years following discovery; then using a discount rate of 5 percent, the net present value of the resource discoveries summarised in Table 5 is still around five times greater than mineral exploration expenditure. Using the same price reduction of one half and applying a discount rate of 15 percent would imply a net present value of new discoveries of 1.6 times exploration expenditure.

The major oil and gas companies of the world are involved in both brownfield and greenfield exploration and can be expected to be at the frontier of efficiency in terms of translating exploration activity to provable reserves. These companies have been able to maintain production reserves with discovery investments equal to about 10 percent of production investment (Gleb et al. 2009, p. 18). Such a ratio in turn implies exploration to resource rent values that are several times greater than the values reported in Table 7.

2.2.3 Junior exploration company analysis

Following the life-cycle of a random sample of Australian mining exploration companies provides an insight into the probability of an exploration company transitioning into a successful producer. Schodde (2014a, p. 28) presents analysis of the history of 100 randomly selected ASX listed junior Australian mineral exploration companies for the period June 2004 to June 2014.

Of the initial 100 exploration company sample, at the end of ten years:

- 52 companies were still listed as exploration active (although 11 had less than $100,000 in cash at hand)
- 10 companies had been acquired by other exploration companies
- 4 companies had switched to oil and gas exploration
- 6 companies had gone into administration without moving to the production stage.

The remaining 28 companies had moved from the junior exploration stage to become mineral producers. This does not mean, however, that all 28 companies went on to become successful mining companies. Specifically, of the 28 companies that transitioned out of the exploration stage:

- 9 subsequently went into administration
- 4 reverted back to exploration company status
- 5 were acquired by other mining companies
- 10 were still in operation as producers.

Acquisition by a larger company is a genuine aspiration for some junior miners, and so over the ten year period, of the initial 100 exploration companies, 15 transformed into operating companies.

In terms of financial performance, over the ten year period, 78 of these companies decreased in value; with 41 falling in value to less than ten percent of their 2004 value. However, a small number of the 100 companies grew substantially in value, and over the ten year period, an equally weighted portfolio of these 100 junior exploration companies delivered a return of $1.60 for every $1 invested. As would be expected, a small number of companies account for most of the total return over this period. Specifically, four companies account for 58 percent of the total portfolio value at the end of ten years, with two companies growing in value by a factor of at least 33.

2.3 Economic perspective

Globally, there has been a long tradition of government provided geological survey services, and there is little disagreement that these activities have been valuable. In the US, going back to at least the 1850s, the provision of reliable government survey work has been identified as a critical element in the successful and rational development of resources that, in turn, led to the rise of the US as a global power. This impact was due to both the pure economic value of the mining industry that the work of the US Geological Survey allowed to flourish, and the role of the US Geological Survey in demonstrating the value of considered research activity.

> The [US Geological Survey] emerged as the leading scientific bureau of the post-Civil War era and was the most productive governmental research agency of the nineteenth century… … The payoff to its early topographical and metallurgical work had a lasting impact on popular appreciation of the practical benefits of scientific research (David and Wright 1997, p. 227).

The economic literature concerning exploration and extraction is substantial, with Cairns (1990) and Krautkraemer (1998) providing comprehensive reviews of most major theory contributions and relevant issues. More recent contributions, such as Cairns (1998), have had a tendency to focus on technical highly theoretical elements of the exploration problem. Here, the intention is not to provide a discussion of this literature, but simply to highlight several key issues relevant to the EIS program and note some of the seminal contributions to the literature.

2.3.1 Exploration activity as research and development

Exploration activity can be characterised as a research and development activity, and there are many studies that have shown the return to government investment in research and development expenditure is very high. Recent critical reviews of past work on the return to research and development, for example Salter and Martin (2001), and Hurley et al. (2014), suggest that the government return to research and development is still high (internal rate of return of around 10%), but not as high as reported in many early studies.

More generally, the return to research and development literature provides a strong evidence base that demonstrates the financial return to government from investment in research and development is high. If exploration activity is characterised as investment in research and development there is a strong case for government investment in exploration.

2.3.2 Exploration activity externalities

The research and development analogy for exploration activity is appropriate, but the issues at stake are not exactly the same, and there are two externality issues that need to be addressed. The first externality issue is due to the exhaustibility of resources. The easiest mineral deposits to find are those that are closest to the surface. As each near surface deposit is found, the chance of finding another near surface deposit falls. This means that the average drilling cost associated with finding each successive deposit increases: deposits will be increasingly found at greater depth, hence greater drilling cost. As, following each discovery, average drilling cost per discovery rises for the industry as a whole, and not just the individual firm, there is a wedge between the social cost of discovery and the private cost of discovery. This cost wedge in turn means that an unregulated market does not deliver the optimal level of exploration activity. That the average depth of deposit discoveries in the Western world has been increasing over time is clear evidence the issue is real (Schodde 2014b). Regulatory practice is suggested as an effective means of addressing this externality issue (Stiglitz 1975, p. 87).

The second externality issue is the information externality. The success or failure of a drilling campaign provides important information about the success or failure of other drilling campaigns in similar regions; where similarity could be defined in terms of geographic distance or mineralisation. This in turn means there is an incentive to wait and not explore until someone else first undertakes a drilling campaign. There have been a number of complex model extensions to the formal exposition of the problem set out in Stiglitz (1975), but the Stiglitz model contains all the essential elements required to gain insights into the public policy implications of the information externality. Specifically, Stiglitz shows that because there are benefits from drilling that accrue to parties external to the individual private firm undertaking the drilling campaign, the socially optimum distance between drill holes is less than the competitive equilibrium solution. To resolve this problem Stiglitz (1975, p. 94) argues for a system of government subsidies/ tax incentives for greenfield drilling far from other drill holes; and a drilling tax for drilling very close to existing drilling activity.

Additionally, from a society point of view, the difference between the social discount rate and the private sector discount rate can result in what would be socially valuable projects not being developed. To understand the issue consider the following simplified example. A resource discovery is made of 100 units, where the resource rent per unit of resource is $10, the resource will not be extracted for eight years, extraction will take place evenly over 5 years, and the resource rent is constant. If a discount rate of 5 percent is selected as the social discount rate the net present value of the wealth created by the discovery is $615. If, however, a discount rate of 15 percent is used to reflect the nature of risky private sector investment, the net present value of the wealth created by the discovery is only $252. For a resource that was not developed for 20 years the respective social and private values would be $342 and $42. In effect this means that there will be a range of projects where the social benefit is greater than development cost that do not proceed.

Taxation also truncates to the upside profits available to exploration, which in turn creates a wedge between the social value of exploration activity and the value to the private sector.

There is also the option value view of exploration activity. This says that we expect technology to lower exploration costs in the future, which in turn raises the option value of delaying exploration today so that the opportunity to explore is available in the future.

In summary, the situation can be described as one where circumstances create a substantial difference between the social value of exploration activity and the private valuation of such activity. This in turn leads to a situation of underinvestment in exploration.

Given there is a divergence between the private and social value of discoveries, a relevant question to consider is the appropriate government response.

While Stiglitz developed a theoretical model to investigate what type of public policy response could be used to address the information exploration externality, Peterson (1975) provides case study evidence to show that the externality issue is real and concludes with a series of public policy recommendations that remain relevant today:

- direct government provision of geophysical studies, or subsidies to the private sector to undertake these studies
- provide tax incentives for greenfield exploration
- use large tenement areas.

Subsequent work, for example Dodds and Bishop (1983) has explored innovative ways of implementing a pure market based approach but have still found that such an approach is unlikely to be the best approach.

It is also notable that the Australia's leading government agency for economic public policy, the Productivity Commission, agrees there are market failure issues in the provision of pre-competitive information for exploration and has concluded that, overall, Australia is well served by our national and state based geoscience providers (Productivity Commission 2013).

2.4 Summary and key findings

2.4.1 Summary

Economic prosperity in Western Australia depends on a successful mining industry. In broad terms, the geology in Western Australia is favourable for further exploration. The policy setting in the state -- which is at least as important as geological factors in ensuring a vibrant mining sector -- is seen in a very positive light by industry. Overall, this suggests that: (i) industry sees the current government policy for mining in Western Australia as appropriate, and (ii) Western Australia is an attractive location for further exploration investment.

Exploration discovery rates in Australia over the past decade have been such that for every million metres drilled there were, on average, 1.9 moderate discoveries, 0.4 large discoveries, and 0.05 giant discoveries. Due to the geology, policy settings, and the infrastructure base in Western Australia, these average rates understate the expected discovery rate and quantum of minerals expected to be discovered in Western Australia following exploration activity.

On average, global information shows that exploration expenditure leads to the creation of new wealth. In the Australian context analysis of the performance of junior mining companies confirmed this result. Specifically, analysis of a representative sample of 100 ASX listed junior mining companies indicated that over a ten year period every $1 invested in exploration companies generated a return of $1.60 in value. The average return was however highly skewed, with two of the 100 sample companies growing in value by at least a factor of 33.

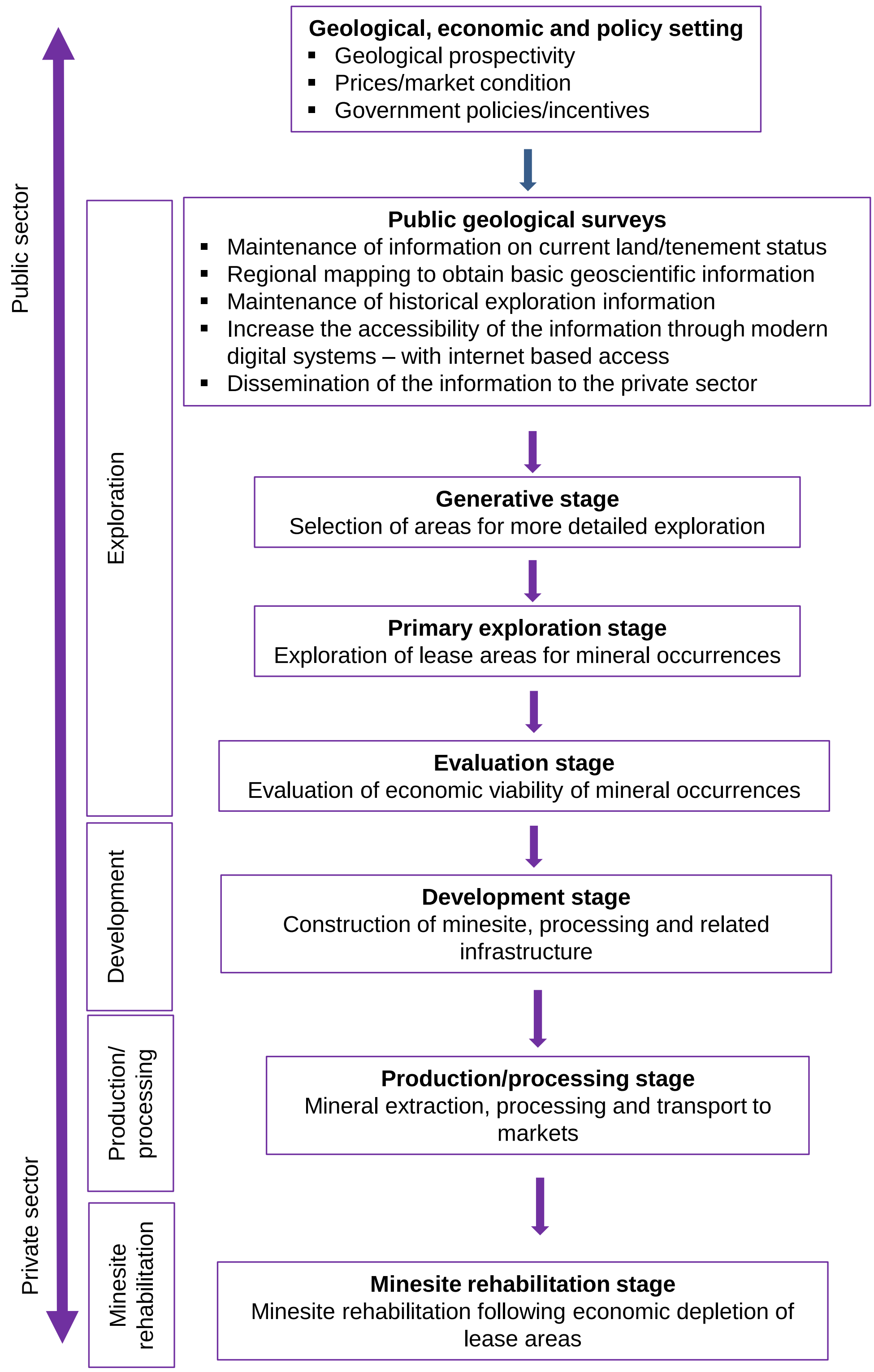
Overall it is clear that:

- exploration activity leads to new discoveries, and due to geology and institutional factors exploration in Western Australia is likely to be especially prospective
- a proportion of exploration companies transition from exploration to production, and a small proportion of companies increase in value significantly
- the net value created through discoveries is substantially greater than exploration expenditure.

The economic history literature has specifically acknowledged the positive contribution of the government geological survey function to economic wealth creation. In the modern economics literature the theory of exploration, and the role of externalities in exploration have been studied extensively. The economic theory literature finds that there is a role for government to play in the exploration sector. The key roles of government are found to be the provision of pre-competitive geoscience information, encouragement of greenfield exploration, and discouraging additional drilling near existing finds. The validity of these solutions has continually been probed, and recent reviews of the state of play in the exploration sector find nothing to challenge the long established findings.

Figure 6 provides an overall flow chart that identifies those stages in the process of supporting the mining sector where there is a role for government.

Figure 6 **Flow diagram of greenfield mine development process**



Source: Adapted from Hogan (2003)

2.4.2 Key findings

Exploration activity is characterised by market failure issues that result in under investment in grass roots exploration. As such, well designed government initiatives that address these externality issues -- such as the EIS -- can increase community welfare.

3 EIS expenditure benefits

There are several reasons to think that the Exploration Incentive Scheme would result in a strong private sector exploration response. First, the new pre-competitive geoscience information provided through airborne surveys conducted by GSWA, and funded through the EIS, opened up, for the first time, significant new areas of the state for exploration. The release of this new pre-competitive geoscience information is non-rival in consumption. This means that each new data release can, and did, stimulate new exploration activity at many firms. Second, receipt of co-funding for drilling can be seen as a quality marker that allows firms to raise additional private sector funds for new exploration. Third, institutions in Western Australia are very supportive of exploration and mine development. Fourth, the geology in Western Australia is very prospective for mineral exploration.

If the EIS stimulates additional exploration spending this additional spending can create additional benefits for Western Australia. In this chapter we explain the approach used to estimate what we are referring to as the Stage 1 benefits of the EIS. There are several elements to deriving these benefits.

First, the EIS involves switching expenditure from general consumption activity to exploration activity. If the economic multiplier associated with exploration activity is greater than the multiplier associated with general private sector consumption, then this reallocation of spending will result in a net economic gain.

Second, the EIS can stimulate additional private sector exploration activity. If the funding for this additional exploration activity is sourced from within Western Australia the marginal difference between the economic impact of general consumption spending and exploration spending represents a net gain to economic activity in Western Australia. If the funding for additional exploration activity is sourced from outside Western Australia, the full value of this induced spending represents a net gain to economic activity in Western Australia.

This chapter sets out the approach used to estimate the private sector exploration response to the EIS, explains how the various industry sector multipliers are estimated, and calculates the net benefits to the state.

3.1 Modelling approach for induced exploration

From the available literature, the most flexible models used to estimate the relationship between government incentive programs to encourage exploration and the private sector exploration response appear to be Autoregressive Distributed Lag (ADL) models and Error Correction Mechanism (ECM) models . Both modelling approaches require time series data and can estimate both short-run and long run relationships. As it is possible to take an ADL model and write it as an ECM model and vice versa, here the focus is on the ADL representation of the model representation.

ADL models were originally developed in the 1960s, and interest in ADL type models was revived in the 1990s as techniques emerged to estimate long run relationships with non-stationary time series data. The ADL model can be difficult to interpret, so it is worth explaining the approach as a combination of two underlying sub-models that have a more natural interpretation. Here the sub-models are explained informally, but a formal explanation is also provided in an appendix. The explanation presented here uses the response to market conditions (prices) to motivate the discussion, but the formal exposition of the model presented in the appendix derives key results for the case of the EIS multiplier.

3.1.1 Partial adjustment model

The first sub-model to consider is the partial adjustment model, and in the context of exploration activity the model can be understood as follows.

Consider a firm engaged in exploration. When commodity prices change it is unlikely the firm will respond immediately; rather, it is more likely the firm will wait to see if the price change looks like a permanent price change or transitory price change. However, even if a firm wanted to adjust immediately, it is unlikely the firm would be able to. For example, it takes time to research the most prospective sites. It takes time to obtain management and board level approval for a specific exploration program. It takes time to source the equipment needed for a drilling program and then get the equipment on site, etc.

The aggregate effect of these practical frictions to business operations is that in response to a mineral price increase in the current time period there will be only a partial adjustment in exploration activity towards the intended ultimate target level of activity in the current time period. With this characterisation of the market there is then a very real problem in assessing the impact of price and government policy changes. What is required for policy evaluation is a measure of the long-run exploration expenditure response; what is observed every period is the short-run exploration expenditure response. As explained in the appendix, the partial adjustment framework provides a mechanism that makes it possible to retrieve the long-run effect based on actual data observations.

3.1.2 Distributed lag model

The second sub-model to consider is the distributed lag model. The distributed lag model says that there can be a delay in responses to a change in the operating environment today. In the context of exploration activity and price changes, the model says what happen today, in terms of price changes, matters, but because we have a slow moving process, what happened in the past also matters for what happens today. The motivation is similar to that outlined for the partial adjustment model. If there is a commodity price increase in 2012, then that increase is important for what happens in 2012, but the increase is also important for what happens in 2013, and subsequent years.

To see why this is the case, consider an example where commodity prices increase substantially in 2012. In the immediate period the price increase might encourage some existing exploration companies to increase or extend their current exploration programs, so there is an exploration expenditure response in 2012 from a commodity price increase in 2012. The increase may, however, also encourage someone to start a new exploration company, where the company only becomes operational in 2013. The price change in 2012 therefore has a modest immediate period effect on exploration expenditure, and a second additional effect on exploration expenditure in 2013, and potentially 2014. As with the partial adjustment model, the distributed lag model allows the long-run effect to be derived from observable data. The specific process for achieving this is described in the appendix.

3.1.3 The autoregressive distributed lag model

With an understanding of the relevant sub-models, and the motivation for the way these models are estimated, it become possible to consider the ADL model. The ADL model is very flexible and incorporates both the partial adjustment model and the distributed lag model within the one overarching framework. The specific way the partial adjustment model and the distributed lag model are combined into an ADL model is described in the appendix.

3.1.4 Technical issues

Non-stationary data

Non-stationary data is a situation where the mean value of the data series varies through time. The issue can result in what is known as the spurious regression problem. Note, however, that the traditional ADL model is still valid for trend stationary data, and the modelling approach has been shown to generate consistent estimates of long-run effects with a mix of I(1) and I(0) regressors (Pesaran and Shin 1999). The method does however require that no regressor is I(2).

For all data series, there is no evidence any regressor is I(2). The models estimated meet the remaining technical requirements for estimation as outlined by Pesaran and Shin (1999), and for the models considered there is no evidence that the error process violates the classical model assumption.

Note, however, that we still proceed with caution and allow for a trend term in the model. Specifically, in this case a quadratic trend term was found to be appropriate. The cost of this approach is in terms of estimate precision. The introduction of a trend term necessarily introduces additional multicolinearity into the model such that standard errors are inflated. However, the failure to include a trend term will result in an incorrect estimate of the EIS effect.

Multicolinearity

Although use of a trend term causes multicolinearity problems, it is the use of lags in models that generally introduces the greatest multicolinearity problems. The extent of the issue can be investigated by calculating what are called variance inflation factors (VIF). In this instance, based on the VIF measure, multicolinarity is found to be a problem for the statistical model. In terms of interpreting model outputs, this problem means that traditional t-statistics, which are used for testing the significance of individual variables are overly conservative. The problem is most acute when trying to determine short run impacts.

One approach to dealing with this problem is to impose structure on the model to ensure the short run impacts behave in a manner consistent with theory. However, from a policy perspective it is the long run response that is important not the short run effect. Given there are now delta method implementations available to derive standard errors for long run impacts, in this instance our preferred approach is to not impose structure on the short run impacts but to just focus on estimating the long run impact and the associated standard error for the long run impact.

3.2 Empirical model

In section 3.1 a very simplified specification was used to illustrate the model structure: the only variable considered in the discussion was price. The actual model estimated considers a full range of relevant factors. These factors are explained below.

3.2.1 Model design

The factors considered in the empirical model are:

- market structure
- private sector exploration spending
- commodity prices
- underlying data trends

- Exploration Incentive Scheme expenditure
- geoscience expenditure
- discovery impacts.

This is a more comprehensive list of factors than considered in the models reviewed in section 7.2, but by considering these factors we mitigate against the possibility of finding a spurious relationship between variables. The Akaike Information Criterion (AIC) measure is used to select between different models where the dependent variable is the same. For models where the dependent variable is not the same, it is difficult to settle on a clear selection criteria. Here the approach is to select the model with the easiest interpretation as the preferred model, but present the results from alternative functional form specifications to show that functional form changes do not have a material impact on the estimated relationships.

Market structure

In the model we allow for a dynamic structure where responses are not immediate but there is business friction such that it takes time for a full response to changes in market conditions to be realised. This is achieved by allowing for lags of both the explanatory variables and the dependent variable in the model. We focus on long run effects, which in this instance means the cumulative effect after three years. For policy discussions it is the long run impact that is the appropriate measure.

Private sector exploration spending

The dependent variable in the model is private sector exploration spending. The data used is the publicly available ABS exploration data for Western Australia.

Market conditions and commodity prices

We include in the model prices and lagged prices for iron ore, copper, gold, and nickel. Specifically, we include the current price and one year lagged Australian dollar prices so that we allow for a dynamic adjustment process to changes in market conditions. For consistency, both the price series and exchange rate values have been sourced from the London Metal Exchange.

Underlying data trends

To mitigate against spurious regression we include a trend term. Selection between a linear trend and a quadratic trend was based on empirical criteria, and this indicated a quadratic time trend was appropriate.

Expenditure type

As the review is of the EIS program, the EIS specific expenditure has been separated from general geoscience program expenditure. This financial information has been provided by the Department of Mines and Petroleum.

When considering the lag structure, convention is to include all lags up the final lag. For example, let E_t denoted EIS expenditure at time *t*, and assume that it was thought appropriate to include EIS expenditure at time *t-2* in the model. If E_{t-2}, is considered in the model, E_{t-1}, and E_t are also included in the model. For co-funded drilling the traditional approach of including all lags seems appropriate. In the case of more general geoscience work, initially it was not clear that the traditional approach was appropriate. However, discussions with industry suggest that when undertaking activities such as large scale regional airborne surveys, the firms undertaking this work will actively market their services at the time of the survey to induce exploration firms with tenements in the area to commission more granular work over their tenement areas. So, while investment in geoscience is generally an investment in a long term research and development service, this activity also has the ability to stimulate additional exploration activity in the current period. This suggests that for both types of EIS expenditure, all lags up to the final lag should be included in the model. For completeness we also empirically test alternative model assumptions.

Discovery impacts

Independent of market conditions, discoveries will trigger an increase in exploration activity. We control for this effect through the use of the SNL discoveries database and include discoveries as an explanatory variable. We count as a discovery all new discoveries in the SNL database, and any increase in the resource if there has been no change in the resource for at least five years. This is an important element in the model. In the Canadian context the impact of exploration incentives reported in Khindanova (2012) is much lower (although still substantial) than that reported in Synergies (2009), where the key difference between the studies appears to be that Khindanova introduces a control for discoveries.

3.2.2 Summary regression model results

A summary of the key modelling results is presented in Table 8. For all models except Model 2 the estimated effect is statistically significant at the 95 percent confidence level. For Model 2 the effect is statistically significant at the 90 percent confidence level. The model preferred on: (i) theory grounds; (ii) empirical model selection criteria; and (iii) ease of interpretation is highlighted in bold.

Table 8 **Summary modelling results**

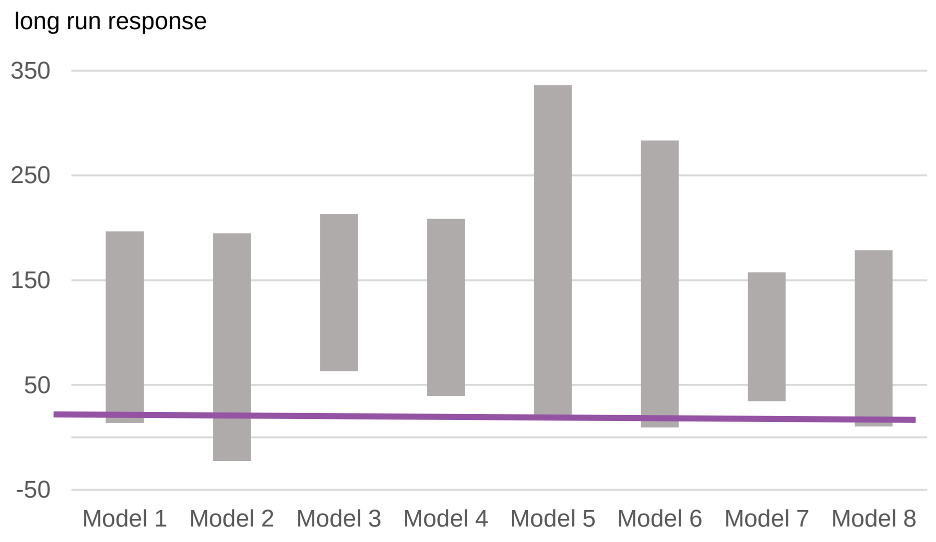
No.	Prices (periods)	Exploration (period and transformation)	Trend	Existing budget (period)	EIS (period)	EIS impact	Std error	AIC
1	current, one lag	levels, one period lag	quadratic	current, one lag	current, one lag	105	38.7	289
2	current, one lag	log, one period lag	quadratic	current, one lag	current, one lag	0.099	0.055	-28
3	current, one lag	levels, one period lag	quadratic	two lags	two lags	138	31.7	255
4	current, one lag	log, one period lag	quadratic	two lags	two lags	0.148	0.041	-56
5	**current, one lag**	**levels, one period lag**	**quadratic**	**current, two lags**	**current, two lags**	**178**	**61.5**	**250**
6	current, one lag	log, one period lag	quadratic	current, two lags	current, two lags	0.166	0.060	-54
7	current, one lag	Levels	quadratic	current, two lags	current, two lags	96.0	25.1	271
8	current, one lag	Log	quadratic	current, two lags	current, two lags	0.113	0.041	-36

Note: All models have been estimated using the open source software platform R. Data and estimation code are available on request. For the AIC, lower values are preferred. Note, however, that AIC values are not comparable across models where there is a transformation of the dependent variable.
Source: ACIL Allen

As mentioned earlier, although the estimate of the EIS impact is statistically significant, there is substantial uncertainty surrounding the long run impact of the program on exploration spending. One way of illustrating the extent of the uncertainty is to show the 95 percent confidence interval for the estimated long run impact from each version of the model. For the models that have been estimated with a log transformation of the dependent variable, the conversion back to dollar value equivalents has been performed using the mean level of exploration spending during the period of the EIS program and the suggested correction of Kennedy (1981). These uncertainty bands are shown in Figure 7.

When estimates are relatively precise it makes sense to use the point estimate as the best guess value. When there is significant uncertainty surrounding an estimate there is a risk that such an approach may lead to an overestimate of the impact. To mitigate against such a possibility, here our approach is to use the 95 percent confidence interval lower bound from the preferred model (shown as the purple line in Figure 7). Using this approach the estimated long run effect of $1M of EIS spending is an increase in exploration expenditure of $19.8M.

Figure 7 **Long run EIS impact on private sector exploration spending**



Source: ACIL Allen

This finding is consistent with the results for the evaluation of the PACE program reported in Economic Consulting Services (2014), and substantially less than the result report in ACIL Tasman (2010). In terms of the results reviewed in Duke (2010), the result is towards the top end of the range of observed values. Although, as some of the schemes evaluated in Duke were general tax credit schemes and the EIS has been a much more focused program, at a minimum it should be expected that the EIS response would be above the average response for the studies reviewed in Duke.

A relatively strong response to the government program is also consistent with industry observations that Western Australia is a highly prospective location for exploration, and also a location with excellent institutions that support the mining sector.

A final caveat to the result is that, as with all regression modelling exercises, the relationship estimated holds only for the sample data period.

3.3 Direct impact

The above discussion makes the case that the EIS stimulated additional private sector exploration spending. This change in the allocation of spending can stimulate economic activity.

The EIS is funded from royalties that are collected from operating mines[1] So, the EIS transfers a fraction of the (pre-tax) revenue of operating mines to resource exploration.

[1] http://www.dmp.wa.gov.au/7743.aspx [available 21 December 2014]

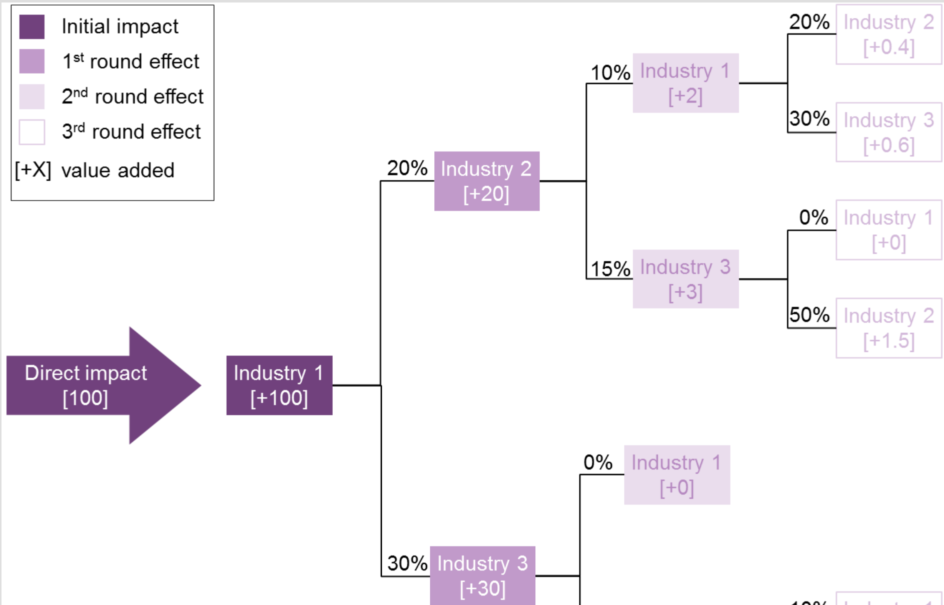
Assuming this fraction of the total royalty payment does not render a mine unviable, the associated payments reduce the affected mines' profitability, and thus, ultimately incomes. Based on this logic, the EIS replaces private consumption with resource exploration expenditure. In this setting, the direct impact of the EIS can be estimated as the difference between the economic multiplier associated with private consumption and the multiplier associated with resource exploration, net of any deadweight loss due to the imposition of the royalty.

Multipliers can be estimated by tracing an economic shock through an input-output table (Australian Bureau of Statistics, 2013). An input-output table provides a summary of the transactions occurring within an economy. Specifically, an input-output table shows, for a given industry, the industries it purchase from, and the industries to which it sells. Box 1 presents a simple example illustrating this approach.

Box 1 **Input-output table analysis**

The illustration depicts how an impact is traced through a simple economy with three industries (1, 2, and 3). The initial impact occurs in Industry 1 where an additional 100 units of value are added to its output. In order to generate this additional output, Industry 1 requires additional inputs from Industry 2 and Industry 3. Therefore, Industry 2 and 3 increase their output as well. This in turn requires input from Industry 1 and 3, and Industry 1 and 2 respectively, which increase their output to satisfy this additional demand, and so on. The impacts grow smaller with each iteration and ultimately converge to zero.

Figure 8 **Input-output trace through analysis summary**



Total impact	
Industry 1	103.5
Industry 2	36.9
Industry 3	35.85

Source: Source: ACIL Allen Consulting

Using the input-output analysis approach, ACIL Allen has estimated a multiplier of 2.01 for resource exploration activity and a multiplier of 1.90 for private consumption. These findings align with those in a Reserve Bank of Australia discussion paper which quantifies the links from demand for Australia's natural resources to activity in other domestic industries using the structural relationships embedded in input-output tables. Specifically, Rayner and Bishop (2013) use the 2008-09 version of the ABS input-output table and estimate the resource extraction sector multiplier to be 1.74 excluding imports, and 2.16 including imports.[2] Rayner and Bishop assume imports contribute 13 percent to the output of the resource extraction sector and only 1.6 percent to the exploration and mining support services sub-industry, which is the relevant sub-category for a discussion of the exploration sector multiplier. This in turn suggests an implied exploration sector multiplier slightly below 2.16, which is consistent with the value estimated by ACIL Allen of 2.01.

For the EIS this means that for every $1M spent by DMP on exploration, additional economic activity worth $1.01M, through flow-on effects is generated. The same amount spent as private consumption would have generated flow on effects of $900,000.[3] In other words, by redirecting funds, for every $1M the EIS directed away from private consumption spending the net gain in economic activity was $110,000.

However, in any program evaluation the distortion created when the funds raised for the program must be considered as part of the program cost. Raising funds for programs such as the EIS and geological surveys is no different (Hogan 2003, p. 40). If we assume the deadweight loss associated with raising the funds was equal to 10 percent of the funds raised, then the deadweight loss effect completely offsets the gain identified above.

In the long run, the EIS is, however, estimated to stimulate a further 19.8 dollars of exploration activity for each dollar of EIS spending. It is reasonable to assume that these funds were redirected away from private consumption. Applying the same multiplier values for exploration and private consumption, the redirection of spending away from private consumption to exploration activity generates an economic benefit equal to the induced exploration spending multiplied by the difference in the private sector consumption multiplier and the exploration sector multiplier. So, for each $1M in EIS spending, the net gain can be calculated as $1M × 19.8 × (2.01 – 1.90) = $2.18M, and this value can be thought of as the net economic gain attributable to the reallocation of funds towards exploration activity.

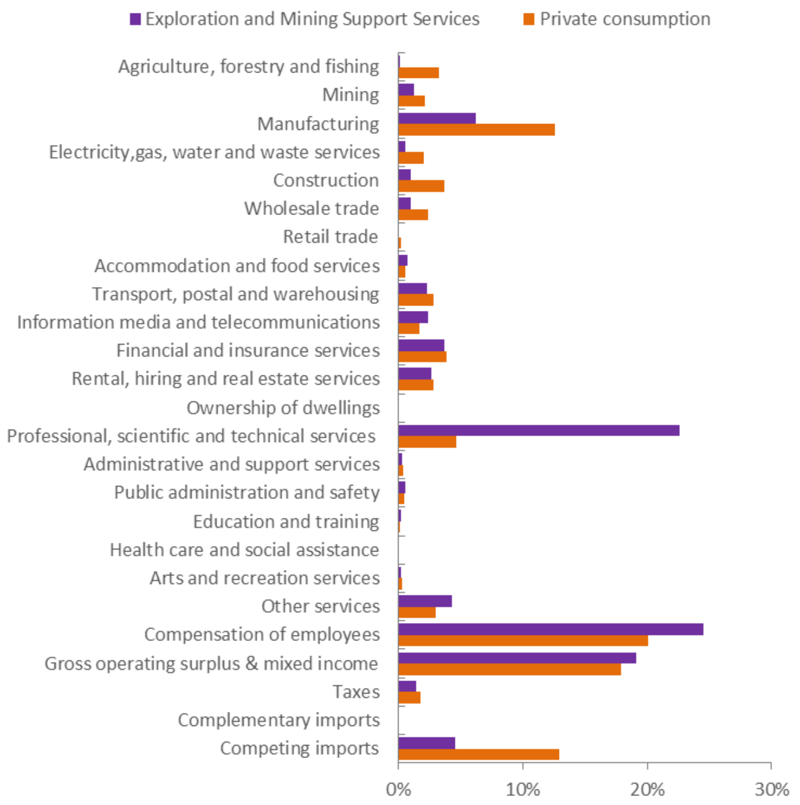
As this increase takes place over three years, discounting makes little difference to the result, but reduces the net benefit calculation to $2.06M.

On an industry basis, professional, scientific and technical services benefit most from the flow on effects. Manufacturing, in contrast, would be better off if the funds were spent on private consumption. Figure 9 shows the break-down of the effect by industry.

[2] The paper defines the resource extraction sector as an aggregation of the coal mining, oil & gas extraction, iron ore mining, non-ferrous metal ore mining, non-metallic mineral mining and quarrying, exploration and other mining support services, iron and steel manufacturing and basic non-ferrous metal manufacturing sub-industries.

[3] For estimating the consumption multiplier, the initial spend is allocated to the industries found in the input-output table using a typical (basket) of good(s) sold by each industry and the expenditure weights from the consumer price index (Australian Bureau of Statistics, 2011).

Figure 9 **Relative impact by industry**



Source: ACIL Allen modelling based on ABS data (Catalogue 5209.0.55.001: Australian National Accounts: Input-Output Tables, 2013)

A final relevant question to consider is the source of the funds directed towards exploration. If the funds were entirely sourced within Western Australia, then the above analysis is an accurate reflection of the direct economic impact of redirecting expenditure away from private consumption to exploration. If, however, funds are sourced from outside Western Australia, it is possible to classify these funds as a net gain for Western Australia. This net gain to Western Australia is a transfer from other regions in Australia and overseas.

The majority of funds sourced for exploration come from outside Western Australia, and so the net gain estimate of $2.06M for every $1M invested actually represents the lower bound of net benefits. 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 is $9.35M for every $1M spent as part of the EIS program.

3.4 Summary and key findings

3.4.1 Summary

Using a transparent methodology, an estimate was obtained of the new private sector exploration spending stimulated by the EIS. Although a statistically significant effect was found, there is considerable uncertainty regarding the true response value. Inspired by the approach taken in the peer reviewed literature, eg Scott et al. (2002), we address this issue by taking the 95 percent lower bound confidence interval of our estimate. This results in an estimate of private sector responsiveness consistent with what others have found (discussed in section 7.2).

Multiplier values were then derived for private consumption expenditure and the exploration sector. For funds sourced from within Western Australia, only the net difference between these two values, not the full exploration sector multiplier, was used to calculate the net economic benefit from the program. Further, the deadweight loss created by the government raising revenue for the EIS through royalty payments was subtracted from the benefit calculation.

The effect of exploration funds raised outside of Western Australia was then considered. If the interest of the program evaluation is the benefit to Western Australia, then this transfer can be counted as a net gain.

3.4.2 Key findings

For the sample period, we find that in the long run there was a strong private sector exploration response to the Exploration Incentive Scheme.

Using conservative assumptions, for every $1M invested in the EIS, the net present value of the additional benefit delivered to the state was $10.3M.

4 Induced mineral extraction

The previous chapter discussed the benefits of the EIS in terms of the reallocation of funds away from private consumption to exploration activity, and the transfer of investment funds from other jurisdictions to Western Australia. In section 2.2 it was established that there is a direct relationship between exploration activity and the discovery of resources. In this chapter Western Australian specific data is used to explore the expected value of induced exploration activity in terms of increased mineral discoveries that go on to be developed as successful mines.

4.1 Methodology

The benefits that are derived from the successful establishment of a mine we refer to as stage 2 benefits. The stage 2 benefits are modelled as the result of a binary event. Any co-funded drilling campaign can lead to a commercial discovery (triggering a very high payoff) or not (a payoff of 0). The probability of any given drilling campaign leading to a commercial discovery is low. As the EIS was implemented only five years ago, it would not be appropriate to draw inferences based just on the actual drill results associated with the program. The absence of a commercial discovery would not imply that the EIS has no stage 2 benefits. Conversely, if a major discovery was made in the last five years it would not necessarily mean that another major discovery should be expected in the next five years.

In order to address this problem the assessment of the stage 2 benefits uses an expected value approach. In such a framework the average outcome of an event is estimated rather than the result of a single draw. For the binary outcome case, a risk neutral person will engage in an activity if there is a non-negative expected payoff. For a risk averse person there will be some projects with a positive expected value that they reject.

The development of a mineral resource can be understood as a process which requires positive exploration expenditure for a potentially large payoff. The cost of exploration expenditure is certain; the potential payoff uncertain. For an exploration program to be undertaken the expected payoff from the program (which could be far into the future) must be greater than the exploration cost.

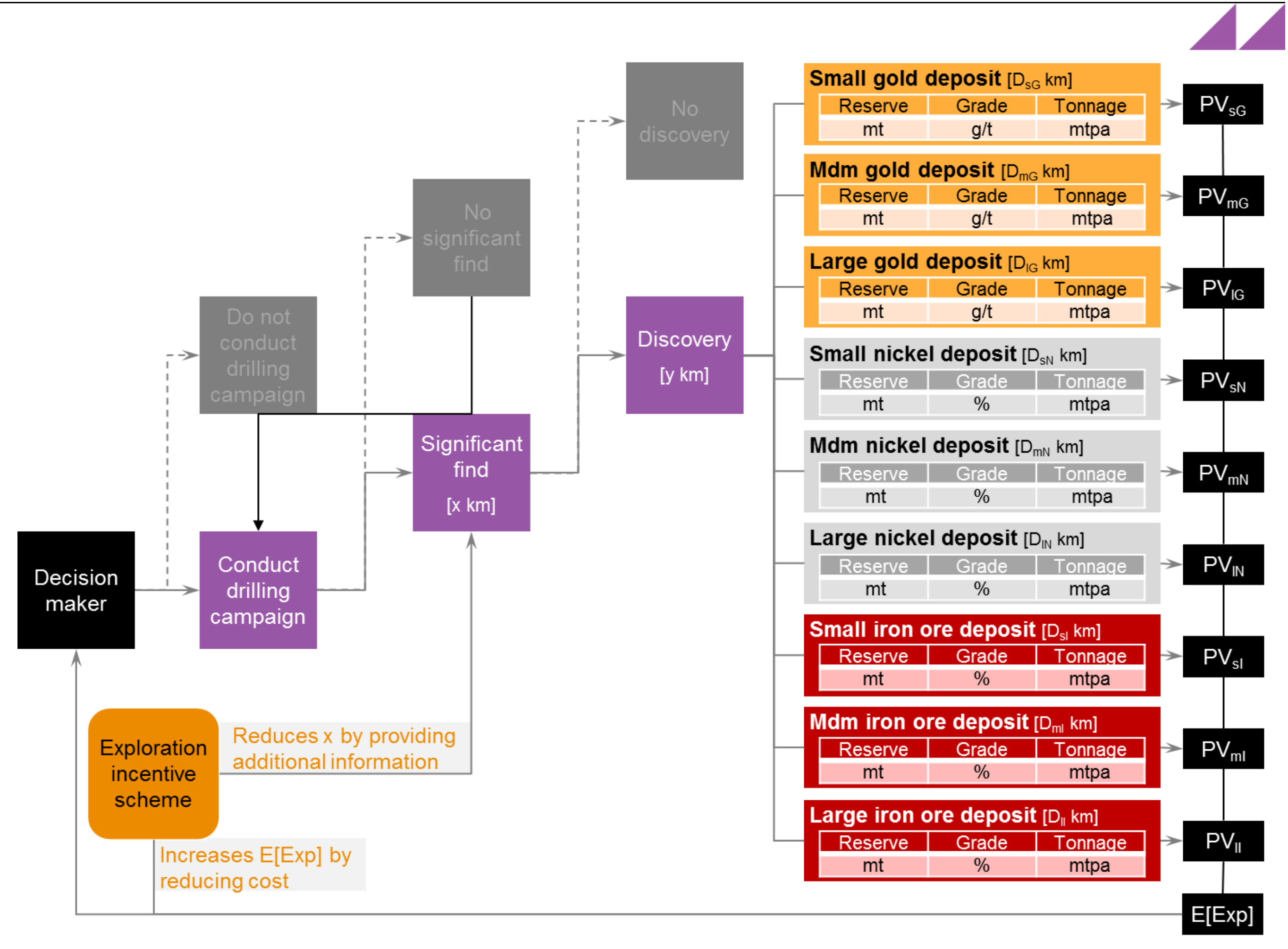
In the spirit of the model described above, Figure 10 illustrates the development of a resource. A decision maker (black box) embarks on a drilling campaign if the expected payoff is positive. This decision can be influenced by a policy measure such as the EIS (orange box) as it increases the probability of a find by providing better (geological) information and reduces the cost of the drilling campaign through co-funding.

Once embarked upon, a drilling campaign leads to a significant find every x kilometres. Detailed analysis of the drilling results and potentially further drilling can turn a certain share of finds into a discovery. Further research is required to assess the commercial potential of the discovery. In this context the subset of discoveries which show commercial potential are referred to as deposits. This means that the (ex-ante) probability of finding a deposit D_{iM} can be expressed as:

$$D_{iM} = D_{SF} \cdot p(Disc \mid SF)^{-1} \cdot p(R_i^M \mid Disc)^{-1}, \qquad (1)$$

where M denotes the respective mineral and i the size of the (representative) deposit; D_{SF} denotes the average distance to be drilled until a significant find is made; $p(Disc \mid SF)$ denotes the conditional probability that this significant find turns out to be a discovery; and $p(R_i^M \mid Disc)$ denotes the conditional probability that the discovery shows commercial potential.

Figure 10 **Methodology flow**



In Western Australia the most common deposits are gold, nickel and iron. Over the last 35 years 96 percent of the discoveries with commercial potential were associated with one of these three minerals (see section 4.2 for details). In light of this, and in order to keep the analysis tractable, the assessment of the stage 2 benefits is limited to gold, nickel, and iron ore. As a practical matter, this approach means that we capture slightly less than all the expected benefits. This in turn can be viewed as a conservative approach to estimating program benefits.

For each mineral three representative deposits, which are defined by reserve size, grade, and production tonnage are considered. For each case a financial model has been developed to estimate the present value of the mine's revenue (PV).[4]

[4] Although the financial models developed are relatively simple, in reality models with a more detailed decomposition of costs add little extra insight as essentially such models just further split out fixed and variable costs into their component parts before subsequently re-aggregating these costs for the return calculations.

In this setting the expected value of the exploration program -- denoted $E\left[Exp\right]$ -- for an exploration campaign drilling D metres is the sum of the nine PVs weighted by the average drilled distance required to discover the associated deposit iM. Formally, this relationship can be written as:

$$E\left[Exp\right]=\left(\sum_{i=1}^{3}\sum_{M=1}^{3}PV_{iM}\cdot D_{iM}^{-1}\right)\cdot D-D\cdot C'. \qquad (2)$$

The first part of the expression represents the expected payoff to the campaign, which is calculated as the expected payoff per metre drilled (term inside the brackets) multiplied by distance drilled $\left(D\right)$ of the assessed exploration program. The second part of the expression represents the expected cost; again with D denoting the distance to be drilled in the exploration campaign and C' denoting the all-inclusive per unit (metre) drilling cost to the decision maker. A rational decision maker will only conduct a drilling campaign with an expected payoff larger than zero. Co-funding drilling and/ or better geoscience information can reduce the cost of the drilling campaign and thus increase its expected value.

The following three sections derive and discuss the parameters of equation (2), but the intuition of equation (2) has important implications for the results derived in section 3.3. Equation (2) says that if the expected payoff from exploration without any incentive is sufficiently low, even with an incentive program, the expected payoff could still be negative. That in turn implies that it is theoretically possible for an incentive program to result in no additional private sector response. In reality, price movements for minerals are not perfectly correlated, and the characteristics of each drilling campaign vary so the zero response scenario is unlikely. It is however likely that under a low price scenario the extent of private sector exploration stimulated by programs like the EIS would be much lower than the response found for the sample period of this study.

4.2 Estimating the probability of a commercial discovery

Essential inputs into the model, for each of the nine representative mines are the metres drilled for each significant find, and the metres drilled for each significant find that ultimately transitions into a discovery. To obtain this information the SNL Metals & Mining database was used, and the specific steps in the process are explained below.

Between 1 January 2012 and 19 November 2014 there were 40,187 mineral exploration holes drilled in Western Australia. The combined distance drilled was four million metres and this drilling resulted in 3,500 significant intervals. This means that in the past three years a significant interval was found every 1,140 metres.

For the period 1980 to 2013, the SNL database reports the (annual) reserve and production history of 1,196 named mineral deposits in Western Australia. This dataset can be used to estimate the number of new discoveries with commercial potential and the discovered quantity of the (primary) commodity. The dataset shows that reserve sizes often increase over a number of years. Since, by definition, stage 2 impacts are only triggered by new discoveries, the data set was filtered for initial discoveries. In this context a new discovery is defined as an increase in the reported reserve if it has not increased in the previous five years. The total discovered quantity was estimated by adding any subsequently discovered reserve to the initial discovery.

This methodology identified five new discoveries in 2012 and 2013. In these two years 2,841 significant intervals were found which means that about one in every 570 significant intervals led to a new discovery, or that on average, a discovery is made about every 650,000 metres. In total the analysis identified 314 new discoveries with an aggregate reserve of 26 billion tonnes. Of these discoveries -- with an aggregate reserve of 25 billion tonnes -- 192 were gold discoveries, 53 were iron ore discoveries, and 39 were nickel discoveries. The sizes of the discovered reserves vary significantly and not all discoveries show commercial potential.

Representative mines were developed with reference to actual operations in Western Australia. For example, the smallest currently operating Western Australian gold mines produce about two tonnes of gold per annum. Assuming a minimum required mine life of five years, this means that at the average reserve grade of the analysed sample, which is 3 g/t, the smallest reserve size with commercial potential is four million tonnes. Medium gold mines such as Agnew or Sunrise Dam produce approximately seven tonnes of gold per annum. Assuming a minimum life of 10 years for this type of mine, and an average reserve grade of 2.4 g/t, the minimum reserve size of a medium mine is 30 million tonnes. Using similar logic it was possible to determine the attributes for all nine representative mines. A summary of the key attributes for each mine is presented in Table 9, and in the final column of the table the number of economically viable mines in each category is identified. In total, only 116 of the 314 new discoveries are economically viable new discoveries.

Table 9 **Stylised deposits: characteristics**

Deposit type	Minimum life	Reserve minimum/average	Average grade	Economic new discoveries
	Years	Million tonnes	Units	Count
Gold small	5	4 / 9	3.0 g/t	53
Gold medium	10	30 / 52	2.4 g/t	15
Gold large	15	100 / 429	1.6 g/t	4
Nickel small	5	2.5 / 8	1.7%	14
Nickel medium	10	15 / 25	1.3%	3
Nickel large	15	100 / 171	0.8%	3
Iron ore small	5	100 / 312	49.1%	13
Iron ore medium	10	800 / 951	46.4%	7
Iron ore large	15	1,500 / 2,459	60.4%	4

Source: ACIL Allen analysis of SNL Metals and Mining Database

The number of metres required to be drilled in order to find one specific representative deposit D_{iM} can be calculated by applying the share of a specific type of deposit of the total new discoveries $p\left(R_i^M \mid Disc\right)$ to the average number of drilled metres required to make a new discovery. The estimates obtained by working through this process are presented in Table 10. As can be seen from the detail, the most common discovery during the sample period was the small gold mine category.

Table 10 **Stylised deposits: required drilling**

Deposit type	Economic new discoveries	$p(R_{iM}\|Disc)$	D_{iM}
	Count	Percent	Million metres
Gold small	53	16.9	3.83
Gold medium	15	4.8	13.56
Gold large	4	1.3	50.86
Nickel small	14	4.5	14.53
Nickel medium	3	1.0	67.81
Nickel large	3	1.0	67.84
Iron ore small	13	4.1	15.65
Iron ore medium	7	2.2	29.06
Iron ore large	4	1.3	50.86
Any	**116**	**36.9**	**1.73**

Source: ACIL Allen analysis of SNL Metals and Mining Database

Although the relationships shown in Table 10 suggest drilling rates greater than those reported in Schodde (2014b) the values used here are based on Western Australian specific data. The definition of size is also different between the two studies and the large mine category in the Schodde (2014b) classification more closely matches what we define in this report as a medium mine. The difference in the size classification is due to the focus on the Western Australian specific data, where very large discoveries are possible.

4.3 Value of a deposit

The value of a deposit is estimated using a simple model assessing the cash flows generated by a representative mine exploiting this deposit type. A stylised mine is described by assumptions specifying its reserve, key production parameters, construction timing, and the relevant commodity price. These assumptions are translated into a simple (monthly) cash flow model which calculates the NPV of each stylised mine based on its specific capital and operating expenditure, revenue from mineral sales, wage cost, and royalty payments.

The model assumes a real discount rate of 12 percent for private enterprise revenues and costs, and a real discount rate of 4 percent for government revenues. The assumed pay-roll tax rate is 5.5 percent, the royalty rate for gold and nickel is set at 2.5 percent, and the royalty rate for iron ore is set at 7.5 percent. The impact of alternative assumptions are considered as part of the sensitivity analysis.

Reserve

The reserve is defined by the stylised deposits described above. Specifically, the reserve is defined as the average reserve size and grade identified for the nine stylised deposits described in Table 9 above. So, for example, the assumed reserve size for a small gold mine is 9M tonnes, at a reserve grade of 3.0g/t.

Production assumptions

The production assumptions for each of the representative mines are based on information in the Raw Materials Database for matching benchmark mines that have a similar reserve size. The production assumptions specify operating expenditure, employment, annual production tonnage, and life of mine. The labour cost information, which enters the model in terms of a per FTE value, is sourced from ABS catalogue 6302: Average weekly earnings Australia: table 17 average weekly cash earnings by industry. The production assumptions are summarised in Table 11 below.

In the case of gold mines, both the small and medium mines are assumed to be underground mines, whereas the large gold mine is assumed to be an open cut gold project. For the nickel projects, both the small and medium mines are assumed to be sulphide nickel projects. The large nickel mine is assumed to be a nickel laterite project. The chemical process of separating the mineral from the rock is less complex for nickel sulphide mines and this is reflected in the operating expense assumptions. The size, grade, and operating expenses for a medium nickel mine reflect the Nova-Bollinger project. All iron ore mines are assumed to be hematite mines.

Table 11 **Stylised mine: production assumptions**

Mine type	OPEX	Employment	Production	Life
	AUD / unit	FTE / cost per FTE	Million tonnes p a	years
Gold small	$850 per oz	250 / $132,000	1.0	10
Gold medium	$1,000 per oz	500 / $132,000	5.0	10
Gold large	$1,120 per oz	750 / $132,000	30.0	15
Nickel small	$10,000 per t	100 / $132,000	0.5	15
Nickel medium	$8,000 per t	225 / $132,000	1.5	15
Nickel large	$18,000 per t	390 / $132,000	3.0	55
Iron ore small	$60 per t	200 / $132,000	10.0	30
Iron ore medium	$55 per t	450 / $132,000	30.0	30
Iron ore large	$46 per t	900 / $132,000	60.0	40

Source: ACIL Allen analysis of SNL Metals and Mining Database

Construction assumptions

Construction assumptions use the same set of benchmark mines as the production assumptions, but the data is sourced from company reports, the Deloitte Access Investment Monitor, and confidential data held by ACIL Allen. Construction assumptions specify capital expenditure, the time required from exploration campaign to mine construction, construction time, and production ramp up profile. The assumptions are summarised in Table 12 below.

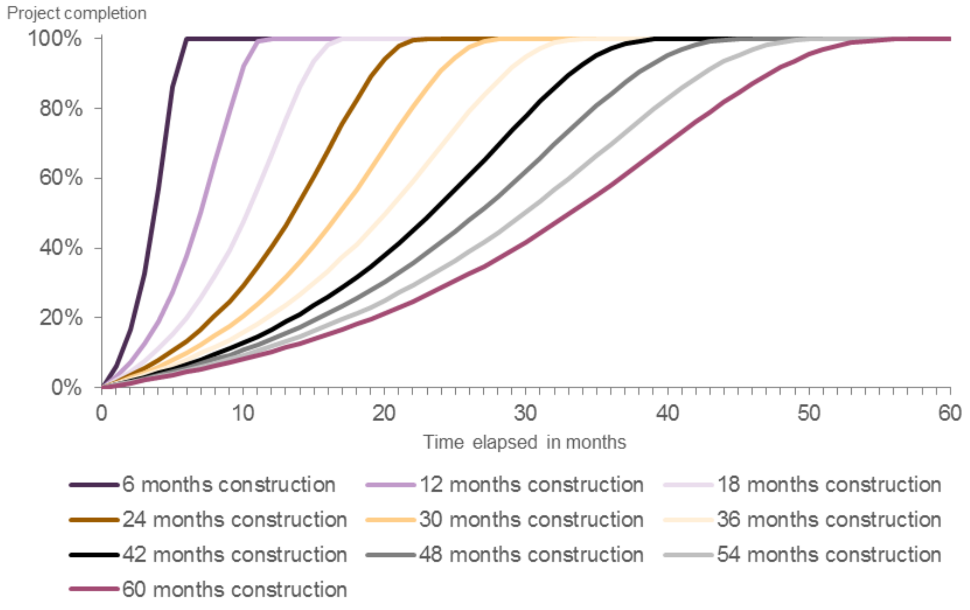
Table 12 **Stylised mine: timing assumptions**

Mine type	CAPEX	Time to construction start	Construction time	Ramp up time
	AUD million	Years	Years	Years
Gold small	80	2	0.5	0.5
Gold medium	800	5	1.5	0.5
Gold large	3,500	10	2.5	1.0
Nickel small	80	2	1.0	0.5
Nickel medium	500	5	1.5	1.0
Nickel large	2,000	10	4.0	2.0
Iron ore small	500	5	1.5	1.5
Iron ore medium	5,000	7	3.0	2.0
Iron ore large	10,000	10	5.0	3.0

Source: Company reports, Deloitte Access Investment Monitor and ACIL Allen intelligence

The construction spend follows an inverted log-normal distribution with the mean at half the construction time (see Figure 11). This function has proven to reliably describe the typical construction spend as it has a slow ramp up, a distinct peak, and a steep decline. The analysis assumes a linear ramp up.

Figure 11 **Construction spend assumptions**



Source: ACIL Allen modelling

Commodity prices

The three modelled price scenarios are summarised in Table 13. The price scenarios were provided by the Department of Mines and Petroleum. Here we focus on the results for the mid price scenario, with a discussion of the high and low price scenarios considered as part of the sensitivity analysis.

Table 13 **Price scenario assumptions**

Commodity	Nickel	Gold	Iron Ore (@62%)
	AUD per tonne	AUD per oz	AUD per tonne
Low	15,000	1,200	65
Mid	20,000	1,400	95
High	35,000	1,600	125

Source: Department of Mines and Petroleum

Decision rule

A key decision rule applied in the modelling process is that if a representative mine shows a negative NPV for a certain price scenario it is assumed the mine does not go ahead, and the mine is therefore excluded from any further analysis. For example, under the mid price scenario, and given the assumptions about the nature of each mine, we find that the expected value of the representative large gold mine, large nickel mine, and medium iron ore mine are such that they do not provide a commercial rate of return.

4.4 Summary and key findings

The EIS stimulated additional private sector exploration. In this chapter an expected value framework has been used to estimate the value of this additional exploration spending on future mine development. The modelling found that on an expected value basis, the stimulated exploration activity will lead to the discovery of additional resources that can be developed into commercial mines. In order to quantify the value creation attributable to the

EIS, a metric was developed which expresses the value of a mine per metre required to be drilled for discovering the associated deposit.

Value of stylised mines

The value of the future mines was estimated by analysing the cash flows associated with the commercialisation of nine representative deposits. Stylised mines were described by assumptions specifying their reserve, key production parameters, construction cost, and the relevant commodity price. Table 14 summarises the key parameters.

Table 14 **Stylised mine: Wealth created**

Mine type	CAPEX	Production	Life	PV of revenue	PV of CAPEX	PV OPEX	NPV
	AUD million	Million tonnes p a	Years	AUD million	AUD million	AUD million	AUD million
Gold small	80	1.0	10	594	52	360	181
Gold medium	800	5.0	10	1,550	394	1,107	49
Gold large	3,500	30.0	15	3,492	894	2,801	not viable
Nickel small	80	0.5	15	738	58	369	312
Nickel medium	500	1.5	15	1,163	246	465	451
Nickel large	2,000	3.0	55	640	468	576	not viable
Iron ore small	500	10.0	30	2,577	246	2,053	277
Iron ore medium	5,000	30.0	30	4,662	1,775	3,609	not viable
Iron ore large	10,000	60.0	40	6,440	2,206	3,202	1,032

Source: ACIL Allen analysis of SNL Metals and Mining Database

In addition to the wealth created from each stylised mine, the metres required to be drilled for discovering each representative deposit was also estimated. The expected value of exploration attributable to the EIS is estimated by applying the probability of discovering a (viable) deposit to the present value of its revenue.

Expected value of exploration

The expected value of a drilling campaign was defined as the sum of the nine NPVs weighted by the average drilled distance required to discover the associated deposit less the cost of the drilling campaign:

$$E\left[Exp\right]=\left(\sum_{i=1}^{3}\sum_{M=1}^{3}PV_{iM}\cdot D_{iM}^{-1}\right)\cdot D-\left(D\cdot C'\right). \qquad (3)$$

The total distance drilled triggered by the EIS (D) can be estimated using the regression analysis results presented in section 3.2. Specifically, the regression analysis found a long term multiplier of 19.8 for the EIS, which means that an annual payment of $1M triggers total exploration expenditure of $19.8M, which is spread over three years. ACIL Allen analysis of ABS catalogue 8412 found the three year average cost of drilling per metre for a new deposit (i.e. C') to be $382 per metre. This means that drilling expenditure of $19.8M translates to approximately 51,700 drilled metres.

The expected present value of the wealth created through a representative drilling campaign stimulated by $1M of EIS spending, less the cost of the drilling program, is $6.6M. This figure represents the value of the campaign to the decision maker, net of all costs and taxes. In the following chapter this value is decomposed into a range of private sector and government components in order to estimate the campaign's economic impact.

5 Benefits to Western Australia

This chapter combines the findings of chapters 3 and 4 in order to quantify the benefits to Western Australia triggered by the EIS. The first section outlines the approach to deriving the benefits and presents the results. The second section presents sensitivity testing results.

5.1 Benefit summary

The net present value of the total expected financial benefits generated by the exploration activity stimulated by $1M in EIS spending is $23.7M.

The expected benefits to Western Australia comprise:

- the direct financial and employment impact of the new exploration activity stimulated by the EIS
- the (expected) impact of new mine developments consisting of:
  - the financial and employment impact of the mine construction phase
  - the net wealth created through mining, which is represented by the net present value of the new mines net of all costs; and the associated employment benefit
  - the additional government revenue generated by royalty and pay-roll tax payments.

The underlying assumptions and resulting benefits, by component, are described in Table 15. Because the modelled expenditure is $1M, the final column in Table 15 can be interpreted as a benefit cost ratio. As can be seen by reading down the table, the single biggest impact channel is the direct extra exploration activity stimulated by the program.

A key element in Table 15 is the distinction between funds sourced from within Western Australia and funds sourced external to Western Australia. Consider the first row of Table 15. For the present value of total induced drilling expenditure of $18.6M, the calculation assumes that 50 percent of the funds are external to Western Australia. For drilling expenditure and construction expenditure this assumption increases the benefit calculation. However, for the wealth created for Western Australians, the assumption works in the opposite direction: if 50 percent of the funds for exploration and construction are sourced from outside Western Australia, 50 percent of the net private sector wealth created with each new mine is then assumed to flow back to the providers of the initial funds.

If it was assumed that 100 percent of the funds for new exploration were sourced from within Western Australia, and that as such, 100 percent of the private sector wealth generated from new mines also went to Western Australians, the overall benefit cost ratio would fall from 23.7 to 21.1

Table 15 **Net present value of benefits to Western Australia**

	WA share	State impact	Expenditure of modelled campaign	Benefits of modelled campaign
Unit	Share	Multiplier	Million	Million
Drilling expenditure	50%	0.11	$18.6	$10.3
Construction expenditure	50%	0.43	$5.4	$3.9
Wealth created	50%	0.10	$6.6	$3.3
Royalties (net of EIS)	100%	1.00	$5.8	$5.8
Pay-roll tax	100%	1.00	$0.4	$0.4
Total			$36.8	$23.7

Source: ACIL Allen modelling

Each element of the return identified in Table 15 is explained in further detail below.

5.1.1 Drilling expenditure benefits

As discussed in section 3.3, the EIS transfers a fraction of the (pre-tax) revenue of operating mines to resource exploration and thus ultimately replaces private consumption with resource exploration expenditure. In this setting, the direct impact of the EIS can be estimated as the difference between the economic multiplier associated with private consumption and the multiplier associated with resource exploration, net of any deadweight loss due to the imposition of the royalty. Section 3.3 found a difference of 0.11 between the minerals exploration and the consumption multiplier. For funds sourced external to Western Australia these funds represent a net economic stimulus to the Western Australian economy. Using a discount rate of 12 percent the total benefit is estimated to be $10.3M.

In addition to monetary effects, the EIS generates employment. Analysis of the input-output table revealed that approximately 25 percent of total exploration expenditure is employee compensation (see section 3.3). This means that of the undiscounted $19.8M spent under the modelled drilling campaign $4.95M is paid to employees. This spending takes place over three years.

According to the ABS (catalogue 6302: Average weekly earnings Australia: table 17 average weekly cash earnings by industry) average full time ordinary time earnings in the mining industry in May 2014 were $2,552 per week or about $132,000 per annum. Assuming that the wages in the mineral exploration sector align with this industry average, compensation of employees of $1.7M per annum ($4.95 million / 3 years) translates to 12.5 full time equivalent (FTE) positions.

This means that every $1M spent under the EIS generates 12.5 FTE positions in minerals exploration for three years.

5.1.2 Construction phase benefits

A similar logic applies to the impact of the construction phase. The capital expenditure of a mining development is funded by a mix of internally raised equity and debt. As raising equity reduces company profits, and the debt funding of one party requires the investment (savings) of another party, both courses of action ultimately replace consumption with construction expenditure. For the share of locally sourced funds, the impact of the EIS can therefore be approximated as the difference between the construction sector multiplier and the general consumption multiplier developed in section 3.3.[5] The ACIL Allen estimate of

[5] The difference of the two multipliers is likely to be the lower bound of the construction impact as it assumes that no additional funds enter the state economy, i.e. only WA residents fund the construction cost.

the economic multiplier of the construction industry is 2.33, so the multiplier difference is 0.43. For the externally sourced funds the impact is the present value of the construction value.

For $1M of EIS payments, the present value of the expected construction expenditure is $5.4M. Applying the multipliers derived above, this translates to a state benefit of $3.9M.

The expected undiscounted construction expenditure associated with $1M of EIS payments is $14.7M, which is spent over a 17 month period. Analysis of the input-output table found that approximately 20 percent of total construction expenditure is employee compensation. This means that $2.9M is paid to employees per annum, for 17 months, or $2.1M per annum.

According to ABS data (catalogue 6302: Average weekly earnings Australia: table 17 average weekly cash earnings by industry) average full time ordinary time earnings in the construction industry in May 2014 were $1,465 per week or about $76,000 per annum. So, for the construction industry, employee compensation of $2.1M per annum translates to 27.6 full time equivalent (FTE) positions. This means that for every $1M spent under the EIS, 27.6 FTE positions are created in the construction industry for 17 months.

5.1.3 Private sector wealth

Exploration activity is not an end product. Individuals fund exploration activity because it can lead to the development of a successful mine that generates significant new wealth. Here, the wealth created by a new mine is calculated as the net present value of the mine. As future revenue is discounted with this approach it is a much more conservative approach than the resource rent valuation approach. Additionally, and consistent with the treatment of exploration expenditure, only half the private sector value created is attributed to Western Australia. Applying the same 12 percent discount rate, this benefit is estimated to be $3.3M.

The representative mine operates for 12 years and 8 months. Based on the employment assumptions presented in Table 11, $1M of EIS payments create 7.4 FTE positions. This means that every $1M spent under the EIS generates 7.4 FTE positions in the mineral extraction industry that last for 12 years and 8 months.

5.1.4 Government revenue

The analysis assumes that (in the long term) the exploration triggered by the EIS induces additional mineral extraction which would not have happened without the EIS program. Therefore, all royalty and pay-roll tax payments (net of the initial incentive payment) made by the representative mines defined in chapter 4 are interpreted as financial benefits of the scheme.

Royalty payments were estimated by applying the relevant rate (2.5 percent for gold and nickel, and 7.5 percent for iron ore) to the undiscounted revenue of the nine representative mines. The net present value of the royalty payments was calculated by applying the assumed government discount rate of 4 percent to the resulting revenue flow and the net present value of expected royalty income for every $1M invested in the EIS is $5.8M.

Pay-roll tax was only estimated for the production phase of the representative mine and for every $1M invested in the EIS the net present value of expected pay-roll tax income is $0.4M.

5.2 Sensitivity testing

The above results are based on the central value assumptions described in chapter 4.

The two assumptions that have the greatest impact on the results are the price assumption and the discount rate assumption. The impact of variation in these two setting is explored below.

5.2.1 Prices

The nine representative mines were analysed under three price scenarios and Table 16 shows the expected net present value for each mine type under each price scenario. As can be seen, under the low price scenario, six of the nine representative mines are not viable. Under the high price scenario all mines are viable.

Table 16 **Value of deposit by price scenario**

Mine type	Mid price	Low Price	High price
Net NPV	$ million	$ million	$ million
Gold small	181.4	96.5	266.2
Gold medium	48.7	Not viable	270.0
Gold large	Not viable	Not viable	295.3
Nickel small	311.5	126.9	865.4
Nickel medium	451.3	160.6	1,323.3
Nickel large	Not viable	Not viable	76.3
Iron ore small	277.5	Not viable	1,091.2
Iron ore medium	Not viable	Not viable	751.6
Iron ore large	1,032.1	Not viable	3,065.9

Source: ACIL Allen modelling

The low price scenario has significant implications when considering average values, as for a representative drilling campaign the probability of finding a deposit that is commercially viable is greatly reduced. When we apply the same decision structure as outlined in chapter 4, we find that the expected value of a representative drilling campaign is negative. A summary of the findings for the mid, high and low price scenario are presented in Table 17.

Table 17 **Decision maker's value of deposit by price scenario**

	Mid price	Low Price	High price
	$ million	$ million	$ million
Net value of deposits	27.1	8.9	44.1
Incurred drilling cost	18.8	18.8	18.8
E[Exp]	8.3	-9.9	25.3

Source: ACIL Allen modelling

The table demonstrates that the modelled exploration campaign would only be undertaken under the mid and high price scenario. The decision maker can expect a return of $8.3M or 44 percent under the mid price scenario and one of $25.3 or almost 135 percent under the high price scenario.

For the low price scenario the expected value to the company is less than the cost of the drilling campaign, so no drilling campaign takes place. This result is in part due to the model reflecting averages and expected values. Under the low price scenario there are still a number of mine developments that would be viable, for example small gold mines, so we would expect that some drilling campaigns with above average prospects would still take place under the low price scenario. Such prospects are typically brownfield prospects.

This analysis demonstrates that the modelled exploration campaign would only be undertaken under the mid and high price scenario. This means that the benefit to Western Australia under the low price scenario is zero. The scenario represents an outcome where prices are so low, for all commodities, simultaneously, that incentives do not stimulate new exploration activity.

The result is a reminder that the modelling results hold for the sample period only. At the initial stage of the modelling process the driving factor is a large private sector response to the EIS program. Such a response is only possible if exploration companies are able to raise new funds for exploration. If all commodity prices are seriously depressed, government incentives may not be enough to allow new funds for greenfield exploration to be raised. Funds for prospects that are likely to have a below average drilling requirement, such as brownfield exploration, are, however, still likely to be funded.

Returning to the specifics of the model structure, the specific logic of the model is that investors do not provide funds when the expected value of a project is negative. Unless the EIS stimulates exploration activity that would not otherwise be undertaken there are no net benefits to the program.

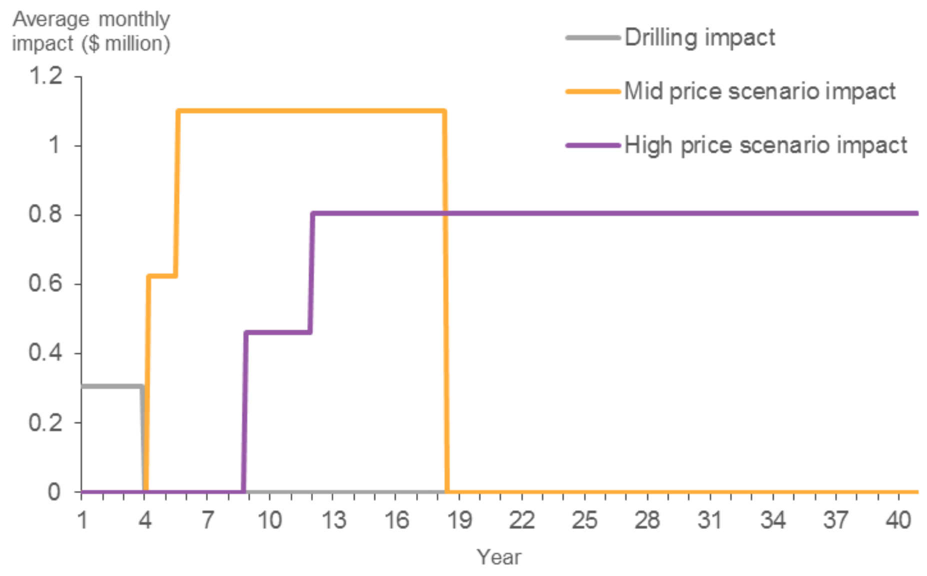
Table 18 **Benefits to Western Australia by price scenario**

	Mid price	Low Price	High price
Unit	$ million	$ million	$ million
Drilling expenditure	$10.3	0	$10.3
Construction expenditure	$3.9	0	$5.8
Wealth created	$3.3	0	$11.3
Royalties (net of EIS payment)	$5.8	0	$10.3
Pay-roll tax	$0.4	0	$0.5
Total	**$23.7**	**0**	$38.3

Source: ACIL Allen modelling

The structure of the payoff to the state also changes under each price scenario, and because future values are discounted, the net present value calculations mask some of this variation. Under the high price scenario it is larger projects that are developed, and these projects start later, but have a much longer life. This effect is illustrated in Figure 12 and Figure 13 that show the different profile of benefits under the high and mid price scenarios. As can be seen, the main difference between the mid and the high price scenarios is that under the high price scenarios mines with very long lives (and hence substantial initial capital expenditure costs) are established.

Figure 12 **Economic benefit per $1M (undiscounted) over time by scenario**



Source: ACIL Allen modelling

Figure 13 **Generated employment per $1M over time by scenario**

Source: ACIL Allen modelling

5.2.2 Discount rate

There is no absolute correct discount rate assumption, and reasonable people can disagree about what is the most appropriate rate to apply. In the base case we use a real discount rate of 12 percent for the private sector benefits. As there is a substantial lag between when exploration costs are incurred, and when a mine enters production, the discount rate assumption is important. The lower the discount rate the greater the benefit. Although Table 19 considers a wide range of discount rates it is likely that most people would agree a real discount rate of between 10 percent and 14 percent is appropriate for private sector calculations. Within this range of values the core conclusions remain unchanged: under a universal low price scenario for all commodities future returns are so low that the expected payoff to grass roots exploration is always less than the discounted expected return, and we find no net benefit for the program; under the mid and high price scenarios the return to the EIS is always substantial.

Table 19 **Sensitivity to private discount rate assumptions**

	Low price	Mid price	High
Discount rate	Total state benefit per $1M of EIS payments in $M		
6%	$19.6	$59.8	$79.5
8%	$0.0	$40.0	$59.8
10%	$0.0	$28.6	$47.0
12%	$0.0	$23.7	$38.3
14%	$0.0	$20.2	$31.6
16%	$0.0	$0.0	$24.2

Source: ACIL Allen modelling

5.3 Summary and key findings

The expected combined community and government benefit, in net present value terms, is $24.6M for every $1M invested in the EIS. This finding is consistent with the results reported from other studies.

For every $1M invested in the EIS, the expected benefits comprise:

- the direct financial impact of the additional exploration activity stimulated by the EIS of $10.3M
- the employment impact of the additional exploration activity stimulated by the EIS, which is 12.5 FTE positions in minerals exploration for three years
- the financial impact of the mine site construction phase, which is estimated to be $3.9M
- the employment impact of the mine site construction phase, which is estimated to result in 27.6 FTE positions for the two year construction phase
- the share of net private sector wealth that accrues to Western Australians following the successful development of a mine, which is estimated to be $3.3M
- the employment created during the production phase which is 7.4 FTE for 13 years
- the net present value of additional government revenue generated by royalty and pay-roll tax payments of $6.2M.

For low price scenarios the expected value of an average drilling campaign is negative. As such, the expected private sector exploration response to incentives under a low price scenario is expected to be modest; as are the benefits that accrue to the state

For higher price scenarios, market conditions make it possible to fund the development of very large mining projects. These projects operate for long periods; potentially delivering royalty, employment, and net wealth creation benefits to Western Australia for decades. Under the high price scenario the expected net present value of every $1M invested in the EIS is $38.3M.

6 Case studies

The following case studies are not meant to be a comprehensive description of all exploration activity stimulated by the EIS. Rather, the case studies are presented as evidence to demonstrate that the impact values derived from the empirical modelling are reasonable. Each case study is relevant to a different element of the empirical modelling.

The EIS program included a significant geoscience element. The first case study demonstrates that pre-competitive geoscience provided through EIS has directly resulted in the creation of new private sector exploration companies with an active exploration program that definitely would not exist without the work completed as part of the EIS. The case study also shows that a substantial proportion of the funds raised to establish the company are external to Australia; hence a significant proportion of new exportation expenditure can be counted as a net gain to economic activity in Western Australia.

The second case study focuses on the way accessing co-funding for a drilling program allows junior exploration companies to raise additional funds from the private sector for new grass roots exploration. The case study demonstrates that, at least for the junior exploration sector, the EIS is not just displacing planned private sector funding for an existing drilling program, but is assisting companies to raise a significant multiple of the co-funding amount in new private sector money that is then invested in grass roots exploration. The case study provides evidence to support the finding of a high exploration multiplier for the EIS.

The third case study focuses on examining the implications for wealth creation and royalty income for the state when a specific project transitions from exploration to production. The case study relates to an exploration company that received co-funding for their drilling program, and also made use of GSWA data to inform their exploration program. This case study demonstrates that the values derived as part of the stage 2 impacts are reasonable and appropriate.

6.1 Enterprise Uranium: From pre-compensative geoscience to an ASX listed company

In December 2012 Enterprise Uranium Limited listed on the ASX after raising $5.1M in funds for grass roots uranium exploration activity in Western Australia. Several of the prospects (see Figure 15) that formed the basis of the portfolio of projects at the time of listing were identified as a direct result of past and recent GSWA work and the recent EIS program. The role of the EIS and earlier GSWA pre-competitive geoscience work was made clear at the time the company listed:

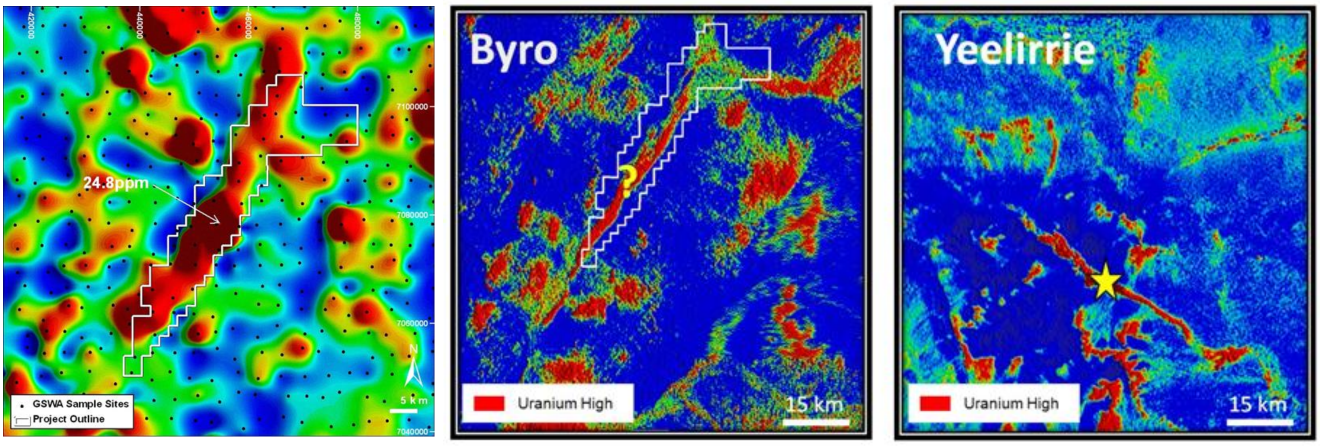
> The uranium targets in the Perenjori area were identified by the Company from airborne survey data recently flown by the Geological Survey of Western Australia (GSWA) under the Royalties for Regions program.
>
> Using this GSWA data and other proprietary data, Enterprise has assembled a strong portfolio of projects at Byro, Yalgoo, Peranbye, Ponton and Harris Lake, covering a total area of 5,931km2. These areas cover airborne uranium anomalies located over present day lake systems which have historically had little or no previous uranium exploration (Enterprise Uranium 20 December 2012).

The projects forming the basis of the company at the time of listing, the relationship to government pre-competitive geoscience, the additional private sector exploration investment prior to listing, and the planned exploration activity are all outlined below.

Byro project

Located 250km Northeast of Geraldton, the Byro prospect is in an under explored area. The airborne magnetic and radiometric surveys flown by GSWA in 2008, and region wide soil sampling at approximately 4km intervals, also conducted by GSWA, allowed for the identification of a uranium anomaly that has similar features to known other high yield uranium deposits (see Figure 14). The prospectivity of the deposit was then further defined by private sector exploration investment including: high resolution airborne magnetic and radiometric surveys in 2011 and airborne electro magnetic surveys in 2012.

Figure 14 **Pre-competitive science can lead to the identification of promising targets**



Source: Enterprise Uranium Ltd Prospectus; ASX announcement Enterprise Metals Limited 20 January 2010

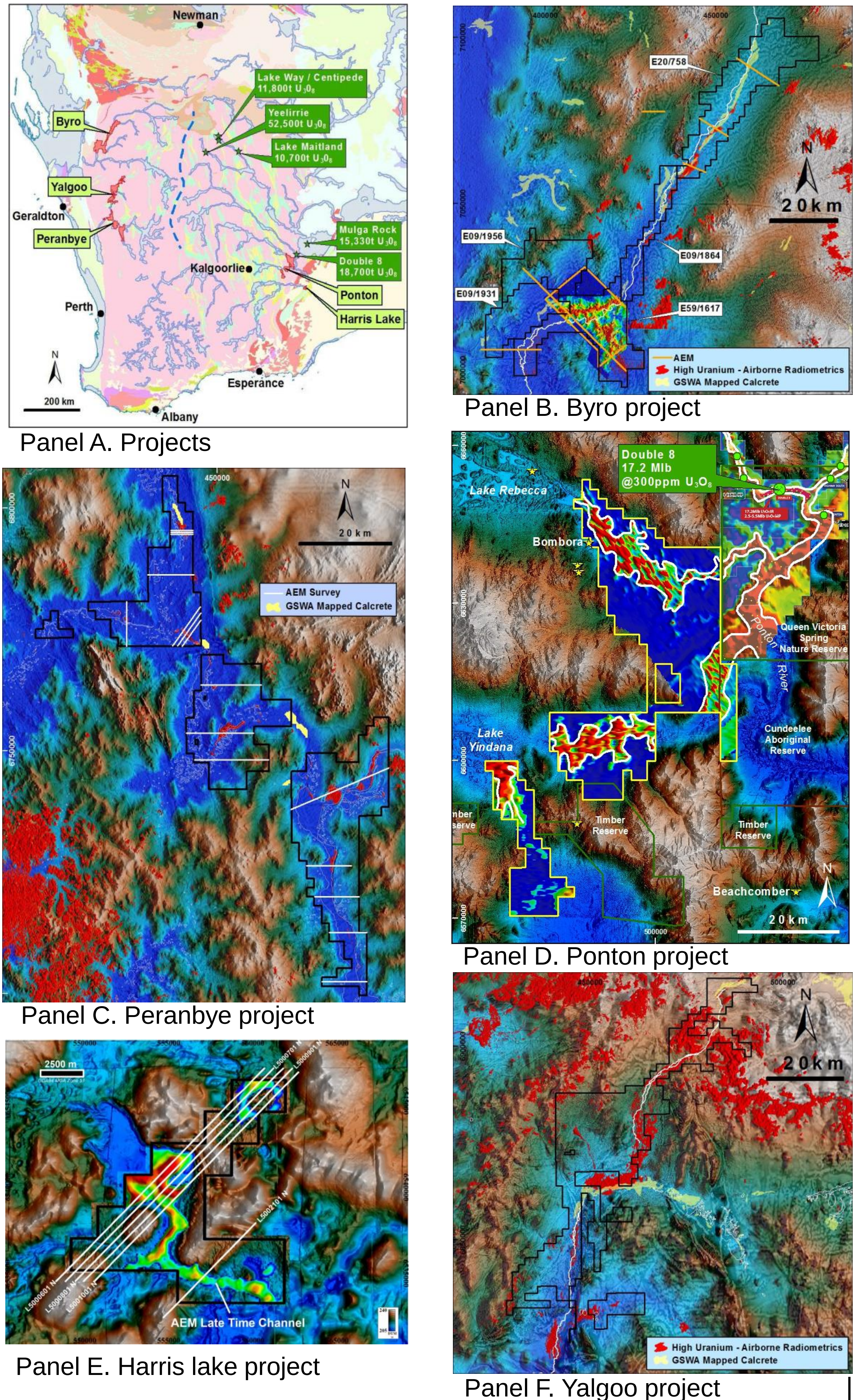
Table 20 **Bryro project exploration expenditure**

Byro project	Year1 Low	Year2 Low	Year1 High	Year2 High
Expenditure item	$	$	$	$
Native title and stakeholder management	45,000	45,000	45,000	45,000
Geological activities and interpretations	15,000	15,000	15,000	40,000
Geophysical activities and interpretations	-	-	80,000	80,000
Drilling activities and assaying	124,000	124,000	120,000	430,000
Direct project administration costs	18,000	18,000	18,000	58,000
Total	202,000	202,000	278,000	653,000

Note: The low case represents expenditure based only on existing tenements. The high case represents exploration expenditure under the assumption all additional tenement applications lodged are approved at the end of one year.

Source: Enterprise Uranium Ltd Prospectus

Figure 15 **Enterprise Uranium Limited Projects**



Panel A. Projects

Panel B. Byro project

Panel C. Peranbye project

Panel D. Ponton project

Panel E. Harris lake project

Panel F. Yalgoo project

Source: Enterprise Uranium Ltd Prospectus

Yalgoo project

The Yalgoo project is a deposit that has been identified through private sector exploration activity on airborne magnetic and radiometric surveys and drilling, combined with GSWA information on Calcrete deposits. For this prospect it is the combination of pre-competitive geoscience and private sector initiative and exploration investment that developed the project to the point that it could be included as a prospect at the time of the IPO.

Table 21 **Yalgoo project exploration expenditure**

Yalgoo project	Year1 Low	Year2 Low	Year1 High	Year2 High
Expenditure item	$	$	$	$
Native title and stakeholder management	55,000	50,000	55,000	50,000
Geological activities and interpretations	35,000	20,000	35,000	20,000
Geophysical activities and interpretations	-	5,000	-	50,000
Drilling activities and assaying	190,000	160,000	190,000	285,000
Direct project administration costs	28,000	28,000	28,000	41,000
Total	308,000	263,000	308,000	446,000

Note: The low case represents expenditure based only on existing tenements. The high case represents exploration expenditure under the assumption all additional tenement applications lodged are approved at the end of one year.
Source: Enterprise Uranium Ltd Prospectus

Peranbye project

The initial potential of the Peranbye project was identified following the release of the airborne magnetic and radiometric surveys of GSWA in 2012. The genuine potential of the prospect was then established through private sector exploration work including airborne and ground radiometric surveys, and bulk soil sampling.

Table 22 **Peranbye project exploration expenditure**

Peranbye project	Year1 Low	Year2 Low	Year1 High	Year2 High
Expenditure item	$	$	$	$
Native title and stakeholder management	50,000	50,000	50,000	50,000
Geological activities and interpretations	25,000	15,000	25,000	25,000
Geophysical activities and interpretations	-	50,000	-	50,000
Drilling activities and assaying	175,000	135,000	175,000	315,000
Direct project administration costs	25,000	25,000	25,000	44,000
Total	275,000	275,000	275,000	484,000

Note: The low case represents expenditure based only on existing tenements. The high case represents exploration expenditure under the assumption all additional tenement applications lodged are approved at the end of one year.
Source: Enterprise Uranium Ltd Prospectus

Ponton project

The identification of the potential of the Ponton prospect followed a similar pattern to that of other prospects. Following the release of airborne magnetic and radiometric airborne survey information private sector explorers were able to conduct a targeted airborne electro magnetic survey to better identify the resource.

Table 23 **Peranbye project exploration expenditure**

Ponton project	Year1 Low	Year2 Low	Year1 High	Year2 High
Expenditure item	$	$	$	$
Native title and stakeholder management	55,000	-	55,000	-
Geological activities and interpretations	30,000	20,000	30,000	20,000
Geophysical activities and interpretations	-	70,000	-	70,000
Drilling activities and assaying	290,000	285,000	290,000	285,000
Direct project administration costs	37,000	37,000	37,000	37,000
Total	412,000	412,000	412,000	412,000

Note: The low case represents expenditure based only on existing tenements. The high case represents exploration expenditure under the assumption all additional tenement applications lodged are approved at the end of one year.
Source: Enterprise Uranium Ltd Prospectus

Lake Harris project

The Lake Harris project has been identified through private sector exploration investment in terms of high resolution airborne magnetic and radiometric surveys, and airborne electro magnetic surveys. The prospect has the same characteristics in terms of a plausible process that might result in the accumulation of a uranium deposit as the other prospects.

Table 24 **Lake Harris project exploration expenditure**

Lake Harris project	Year1 Low	Year2 Low	Year1 High	Year2 High
Expenditure item	$	$	$	$
Native title and stakeholder management	50,000	50,000	50,000	50,000
Geological activities and interpretations	15,000	15,000	15,000	15,000
Geophysical activities and interpretations	-	-	-	-
Drilling activities and assaying	120,000	120,000	120,000	120,000
Direct project administration costs	18,000	18,000	18,000	18,000
Total	203,000	203,000	203,000	203,000

Note: The low case represents expenditure based only on existing tenements. The high case represents exploration expenditure under the assumption all additional tenement applications lodged are approved at the end of one year.
Source: Enterprise Uranium Ltd Prospectus

Ownership structure

At the time of listing a significant proportion of the funds raised were from overseas companies. For example, a brief examination of significant shareholders at the time of listing identified two holdings, representing 32 percent of the issued stock, as Hong Kong registered investment companies. The shareholder registry investigation did not aim to identify all non-Western Australian subscribers to the share issue. Rather, the investigation was simply to show that it is reasonable to assume a significant proportion of funds raised for new exploration are sourced from outside Western Australia.

6.1.2 Summary

Information provided through airborne surveys as part of the EIS has made it possible for private sector exploration companies to identify prospective anomalies. Private sector initiative, exploration knowledge, and new thinking has then been used to take this information and identify potential resources in areas that were previously under explored. For this one company, the total new exploration expenditure approved for the first two years following listing was $1.8M if no new tenement applications were approved; and $3.7M if all new tenement applications were approved.

In this case study geoscience should be seen as the catalyst for new exploration activity, but geoscience is not the only factor. A complex set of interrelated factors, including: the skill base in Western Australia; IT developments that allow manipulation of large data sets; institutions and governance in Western Australia that support exploration; and market conditions also play a role.

It should also be highlighted that the geoscience information provided through the EIS is non rival in consumption so that we should expect this pattern of private sector initiative based on EIS funded geoscience to be repeated many times over across the state. In turn that means it is possible for programs such as the EIS to stimulate a very significant increase in private sector exploration spending.

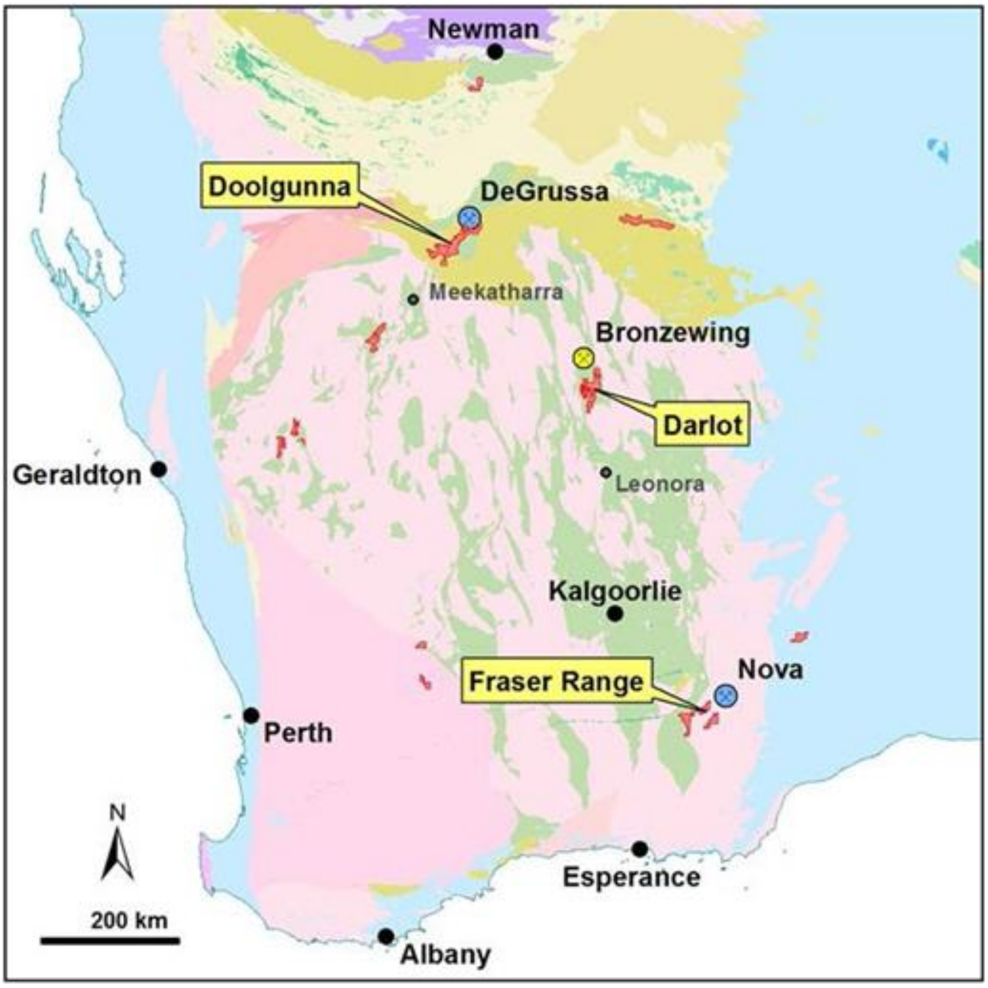
6.2 Why the EIS multiplier is so high

The core empirical results found a relatively high exploration multiplier for the EIS. The focus of this case study is on highlighting drilling co-funding announcements to subsequent capital raisings by a junior exploration company. Projects that receive co-funding under the EIS must be evaluated by an expert panel. This conveys some level of information to the market that although the drilling program may be a grass roots drilling program, within the context of such programs, the proposed project has been well thought through. For example, following the most recent round of co-founding the Antipa Minerals 9 December 2014 announcement of success in gaining co-funding included the following passage:

> Antipa would like to acknowledge the ongoing support provided by the WA Government through its EIS programme for the Company's exploration programmes. Since listing the Company has successfully applied for four WA Government EIS co-funded drilling grants. The EIS co-funded drilling programme preferentially funds high quality, technical and economically based projects that promote new exploration concepts and are assessed by a panel on the basis of geoscientific and exploration targeting merit.

By reading the details in ASX company announcements the following pattern emerges for one company that has received EIS funding. In June 2009 Enterprise Metals had cash at bank of $1M. In the previous quarter exploration spending had been around $700,000, and in the forthcoming quarter planned exploration spending was also $700,000. The exploration budget of the company was therefore almost exhausted. In June 2009 the company also announced that it was successful in the first round of applications for drilling co-funding of up to $110,000 for the Doolguna project. In July 2009 the company raised $2.3M from the market for additional exploration work. Since this time the company has gone on to conduct significant exploration activity around the Doolguna project; including Versatile Time Domain Electromagnetic airborne survey work, as well as investing in a range of other exploration projects. Some of these projects continue to be seen as attractive prospects and the 2014 company AGM presentation notes the company had a market capitalisation of $10.6M.[6]

Figure 16 **Location of company prospects**



Source: ASX announcement Enterprise Metals Limited 8 December 2014

That the company was able to raise additional funds for exploration just after the announcement of a successful co-funding for drilling application does not mean that co-funding for drilling was a causal factor in the successful capital raising. The example does, however, illustrate, that a high multiplier for the EIS program is plausible. EIS funding can do more than just leverage an existing program of drilling or displace existing private sector exploration. It can serve as a quality signal that can help junior explorers to raise funds. In doing so, the EIS can support a high exploration multiplier.

6.3 Sirius Resources: The long run value of a mine

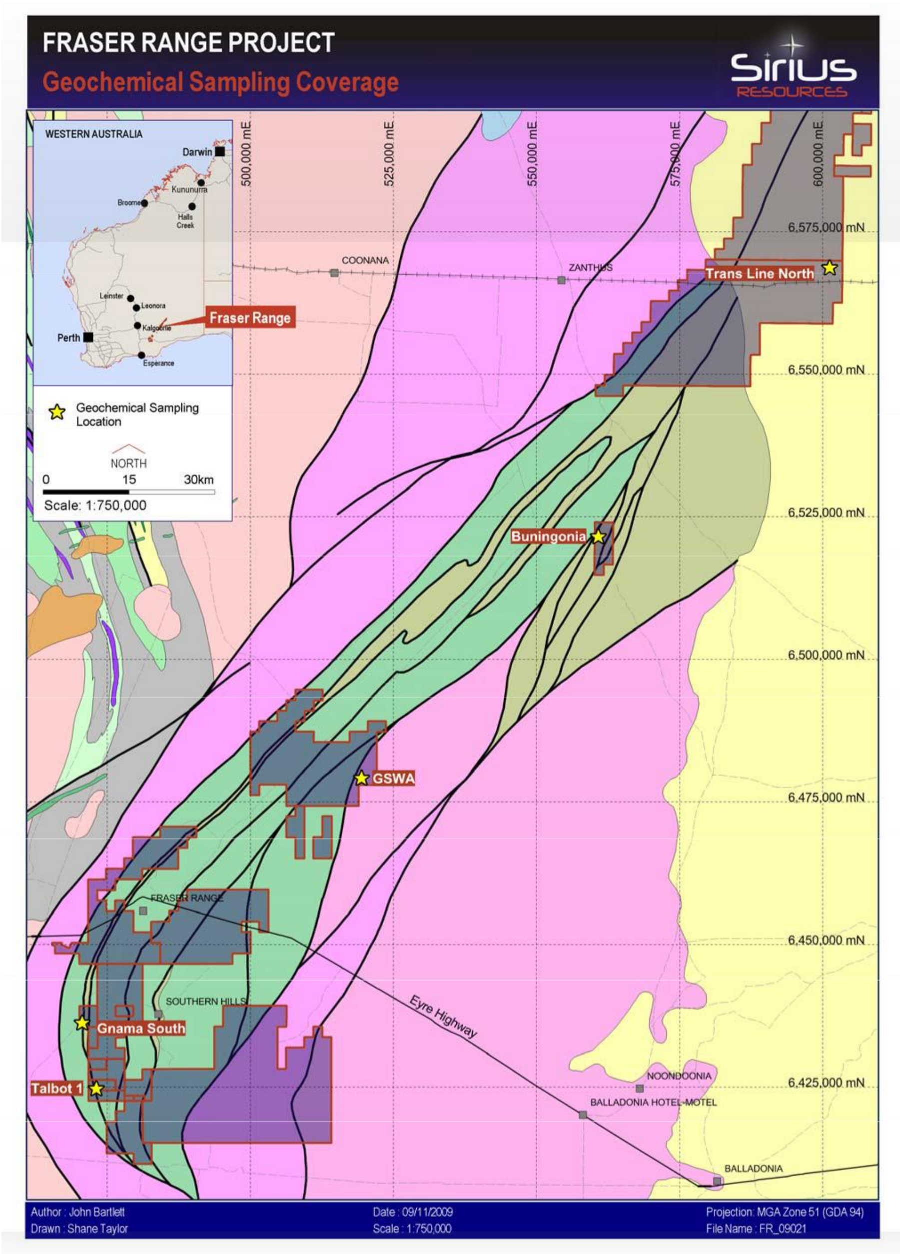
The empirical modelling does not assume that the EIS is above average in stimulating productive exploration investment. The modelling just assumes that the EIS program has stimulated exploration investment and that based on average probabilities this will lead to new developments that create value for the state. This is a conservative position. New and

[6] All ASX announcement material and company presentations are available at http://enterprisemetals.com.au/investor-information/asx-announcements/ [accessed 10 December 2014]

historical geoscience information allows explorers to be more selective in the prospects they target, and hence become more effective.

This final case study explores the value to the state when an exploration company transitions from junior explorer status to a viable mineral production company. The Sirius Resource Fraser Range Nickle project made use of data from various sources, including historical data from the 1960s, and GSWA geophysics and soil sample information (see Figure 17). In addition, the company also received an EIS co-funding grant for its initial drilling program (see Appendix B). For these reasons, tracking the growth in value for this specific company and likely benefits to Western Australia seems appropriate.

Figure 17 **GSWA work combined with private sector expertise, investment and expertise identifies deposits of high economic value**



Source: ASX announcement Sirius Resources Limited 20 January 2010.

Company history

Company details as described in the Annual General Meeting presentation, November 2009:

— the company has a market capitalisation $13M and is actively working in under explored and unexplored areas for large deposits. The focus of exploration is on Western Australia, a location known for producing world class resource discoveries that can be developed into low cost mines.

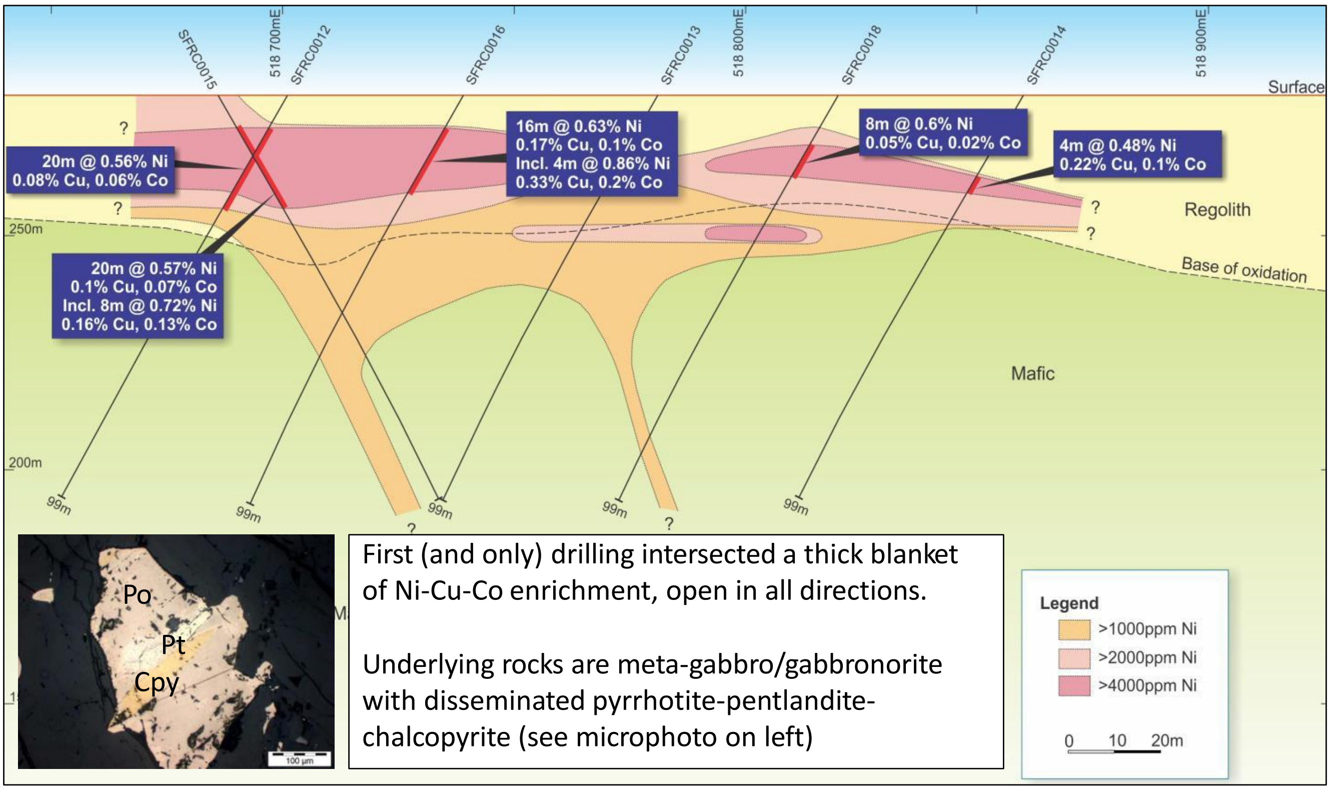
Company details as described in a presentation to the Brisbane Mining 2010 Conference, October 2010:

— the company has an experienced exploration team and $11M in funds to undertake drilling in highly prospective, yet under explored areas.

Company details as described in a presentation to the London Mines and Money Conference, December 2011:

— the company has a market capitalisation of $13M. A range of prospects are being progressed. Initial drilling at the Fraser range project has found nickel, copper, and cobalt enriched material and "a "stratigraphic" diamond drilling hole (co-funded by the WA government exploration incentive scheme) is underway".

Figure 18 **Drilling to identify a valuable resource for Western Australia**



Source: Sirius Resources NL at the Mines and Money conference, London Limited December 2011

Company details as described in a presentation to the Australian Resources Conference, November 2012

— the company market capitalisation has risen to $623M from a value of $84.5M in June 2012. For the Nova-Bollinger deposit discovery, the discovery hole was "the last roll of the dice". Since the initial discovery extensive work has been undertaken to define the resource (90 holes) and this work has not identified any major mineral issues.

Company details as described in Annual General Meeting presentation, November 2014:

- the company market capitalisation is $770M (fully diluted), and the Nova-Bollinger mineral resource looks to be able to support a 10 year mine project with cash operating costs in the lowest quarter of global nickel producers. Once operating the scale of the project is such that it will represent a top 15 global producer and the expected net cash flow from the project is $2.8B, using reasonable assumptions. Additional prospects continue to be developed.

Company status as described in the Annual General Meeting presentation, November 2014:

- the company market capitalisation is $1.2B, and the definitive feasibility study for the project has been completed. Access arrangements with the traditional owner have been finalised and preferred tenders for major mine construction works identified. Construction is expected to start in late January 2015 with the first concentrate production expected in late 2016. The company continues to explore and there are still additional target electro magnetic conductor targets to be drilled.

The above details illustrate that in Western Australia the increase in private sector wealth when an exploration company transitions from an explorer to a company moving into the extraction and production stage is extraordinary. In this case study example the company market capitalisation increased from $13M in 2009 to $1.2B in 2014; an almost 100 fold increase in value. The case study also illustrates that companies of this nature do continue to invest in additional exploration activity once they have found a substantial deposit, and this commitment to continued exploration provides long term benefits to the Western Australian community.

Implied values

ACIL Allen has modelled the value to the state of this project, where we use the Department of Mines and Petroleum provided mid price scenario and apply a real discount rate of 12 percent to the private sector return and a 4 percent discount rate for royalty income. The values we use in the model are either ACIL Allen derived values or details obtained from publicly available company reports. Based on these calculations we arrive at a NPV for the development of $1.23B, which roughly accords with the market valuation of the company. The similarity between the ACIL Allen derived NPV for the project and the market value for the company should provide some level of confidence regarding the ACIL Allen royalty income forecast. From a state revenue perspective, we find that the NPV of just the royalty income from this one project is $107M.

Table 25 **Sirius resources value**

Variable	Value	Unit	Source
Construction start	1/03/2015	Date	FS p. 10
Capital expenditure	473	Million dollars	FS p. 8
Construction time	36	Months	FS p. 6
Ramp up	6	Months	ACIL Allen
Planned mining reserve	14.2	Million tonnes	FS p. 5
Capacity	1.5	Mtpa	FS p. 6
Life	10	Years	ACIL Allen
Key nickel values			
Nickel grade	2	per cent	FS p. 5
Mined nickel	285	Kt	FS p. 5
Expected annual nickel production	26	Kt	FS p. 8
Key copper values			
Copper grade	2	per cent	FS p. 5
Mined copper	118	Kt	FS p. 5
Expected annual copper production	11.5		FS p. 8
Key cobalt values			
Cobalt grade	2	per cent	FS p. 5
Mined cobalt	10	kt	FS p. 5
Expected annual cobalt production	0.85	kt	FS p. 8
Operating expenditure values			
OPEX material mined	124.64	AUD/tonne	FS p. 9
OPEX at target production	186.96	$ million p.a.	ACIL Allen
Key values			
Project NPV	1.23	$ billion	ACIL Allen
Royalty income NPV	106.75	$ million	ACIL Allen

Note: FS = ASX Announcement: Definitive Feasibility Study indicates Nova is a goer, July 2014

6.3.2 Summary

The empirical modelling used expected value relationships to derive estimates of the value to the state from the additional exploration activity stimulated by the EIS. This case study has highlighted that in Western Australia exploration activity has the potential to lead to resource discoveries that are globally significant, and that such discoveries create significant private sector and public benefits.

6.4 Case study summary

The main results in this report are based on empirical modelling. However, the report seeks to draw on multiple sources of information to substantiate the findings presented. The empirical modelling found that the EIS program stimulated significant new private sector exploration expenditure and that exploration expenditure leads to new mines that create significant value. Additionally, the empirical modelling assumed that not all private sector funds raised for exploration in Western Australia are sourced from within the state.

The case study information is presented as part of the overall evidence base and the case study information is consistent with the empirical modelling results.

7 Other studies

If, as argued above, there is a compelling case for government action to support exploration activity, it is reasonable to expect that we would observe governments taking such action. It is therefore reasonable to ask: (i) what evidence is there that governments behave in a manner consistent with long established economic propositions, and (ii) what evidence is there that government actions have been successful in stimulating exploration activity.

To answer these two questions the current policy settings of Australian jurisdictions were reviewed, and a literature search was conducted to identify relevant government program evaluation reports.

7.1 Programs in Australia

Through Geoscience Australia, the Commonwealth Government has a substantial commitment to the provision of pre-competitive scientific information. Select relevant deliverables for Geoscience Australia, detailed in Department of Industry's 2013/14 Annual Report, include:

- the provision of pre-competitive minerals and petroleum information
- promotion of a prospectus of Australia's resources and energy endowment
- provision of advice on current and potential mineral and energy resources
- provision of technical assessments to support environmental assessment for projects.

In addition to the traditional survey functions provided by state geological survey agencies the states and territories of Australia also have significant targeted programs that are aimed at assisting the exploration industry:

Northern Territory – Creating Opportunities for Resource Exploration is a $23.8M investment for the period 2014-18 that is being co-ordinated by the Northern Territory Geological Survey. The program focus is on providing pre-competitive science to stimulate exploration activity.[7]

South Australia – The Plan for Accelerating Exploration (PACE) initiative, was started in 2004 as a $22.5M 5-year program. The program was subsequently extended to 2009 with a further $8.4M investment. For the period 2010-14 a further $10.2M has been allocated to the PACE 2020 program and for the 2013-18 period an additional $8M has been allocated to the PACE frontiers program focusing on pre-competitive data.[8]

Queensland – The Future Resources Program includes $7.5M for geoscience; $9.0M for the Mt Isa geophysics initiative; $3.0M for collaborative drilling; $5.0M to extend the sample core library; $1.0 for a specific project at Cape York; and $1.5M for seismic work.[9]

[7] Available www.core.nt.gov.au/about.html [accessed 5 December 2014

[8] Available www.pir.sa.gov.au/minerals/initiatives/pace [accessed 5 December 2014]

[9] Available www.dnrm.qld.gov.au/our-department/policies-initiatives/mining-resources/future-resources-program [accessed 5 December 2014]

New South Wales – the New Frontiers program was launched in 2006 and covers a range of activities that support exploration, including a drilling co-funding program, extension of library core services, and pre-competitive survey information.[10]

Victoria – in response to the *Inquiry into greenfields mineral exploration and project development* report, the Victorian government developed an action plan to support exploration activity. Specific actions included delivery of new pre-competitive geoscience and a drilling co-funding program. Prior to the change of government in November 2014 the delivery of new pre-competitive geoscience action was underway, and the co-funding program had been added to the forward works program.[11]

Tasmania – In 2011 the Tasmanian government introduced the Western Tasmanian Geoscience imitative. As detailed in Geoscience Australia (2014), projects within this initiative include the mapping of four 1:25,000 map sheets, new LiDAR work, and additional gravity and airborne magnetic surveys.

As the above list of targeted programs demonstrates, all Australia's jurisdictions have a focus on not just standard geosurvey work, but have established specific targeted programs to support greenfield exploration. At a minimum, this suggests Australian governments perceive such programs as valuable.

7.2 Evidence of effects

In terms of independent verification of program effects it could be argued that the peer reviewed literature should be given the highest weight. Government agencies such as Treasury departments, ABARES, World Bank, and the IMF, have exacting internal review processes that are at least equal to the peer review process, and so reports from such agencies should also be weighted highly. Books published by long standing publishers should also be seen as high quality sources. Working papers from research institutes and universities are generally produced by independent researchers that do not receive funding for their work and so should be considered unbiased reports; but these papers have not necessarily been subject to the same critical review process as other publications and so should receive less weight. In the case of commissioned reports, because there is necessarily a commercial aspect to the work, it is appropriate to take a cautious approach to the interpretation of results. Studies based on Australian data are also more relevant than international studies.

7.2.1 Peer reviewed studies

One directly relevant Australian paper -- Scott et al. (2002) -- and one international paper -- Khindanova (2012) -- were identified in the peer reviewed literature.

Scott et al. (2002) evaluate the return to Queensland Geological Survey actions to improve data quality. In their cost effectiveness calculations they consider only the benefits that accrue to the state, and not those benefits that accrue to private exploration companies. For the most plausible scenario considered -- which considers as a return to the state only royalty income plus a fraction of the economic rent from new mines that is allocated to within state exploration -- Scott et al. find an IRR of 76 percent for the data quality improvement

[10] Available www.pir.sa.gov.au/minerals/initiatives/pace [accessed 5 December 2014]

[11] Available ww.energyandresources.vic.gov.au/earth-resources/industry-and-investment/news-and-publications/victorian-government-plan-for-the-earth-resources-sector [accessed 5 December 2014]

program, or expressed alternatively, a cost benefit ratio of 6.2. Note that the IRR value is approximately seven time greater than the return to general R&D investment cited earlier.

Drilling co-funding programs can also be characterised as a production subsidy that supports new exploration investment. If characterised this way, drilling co-funding programs might be seen as closer to programs such as general exploration tax incentive schemes that lower the effective cost of funding exploration activity. Tax incentive schemes of various kinds have been implemented in other jurisdictions and analysis of such programs suggests that subsidies of this kind result in a strong exploration response.

Khindanova (2012) considers the extent of exploration activity generated by the introduction of the Minerals Exploration Depletion Allowance (MEDA), which was in operation for the period 1983-97. Controlling for both effect of prices and the new discovery effect, Khindanova (2012. p. 85) found that the MEDA program was associated with a (exp(0.48)-1)×100 = 62 percent increase in exploration activity by junior explorers. There was no response from major companies to the tax incentive program.

One additional peer reviewed paper, with a focus on geoscience information in general, rather than exploration specific geoscience, was also identified. The paper provides a review of existing studies into the value of geoscience information and the paper concludes that: "The results from previous research indicate that significant economic benefits are attached to the use of geological information" (Haggquist and Soderhold 2015, p. 99).

7.2.2 Government agency literature

In a comprehensive review of exploration issues, Hogan (2003) does not undertake a formal cost benefit assessment, but based on the weight of evidence concludes that in Australia it is highly likely geoscience expenditure has more than paid for itself.

Canadian Department of Finance research found that the deductibility introduced as part of Canada's Flow Through Share Scheme (similar to Australia's Franking credit system) altered the incentives for exploration such that for every $1 in lost tax revenue the incremental gain in mining exploration activity was $3 (Department of Finance 1994). It was, however, noted that once tax incentives become a decision criteria for investors this can lead to lower quality exploration, as investor incentives may not be aligned with exploration incentives.

7.2.3 Other literature

Synergies (2009) investigated the impact of various Canadian exploration incentive schemes. The three incentives schemes considered are: the Flow Through Share Scheme (FTS) that allows individual investors income tax deductibility for new expenditures of the corporation, which is a long standing policy; the MEDA; and a tax incentive scheme that operated as both the Investment Tax Credit for Exploration (ITCE) scheme and the Mineral Exploration Tax Credit (METC) scheme, that allows a 15 percent deduction for expenditures on what is referred to as grass roots exploration spending (since 2000).

Controlling for the effect of mineral prices and lags in the adjustment process, Synergies (2009, p. 65) found that the MEDA, the TIS, and the FTS resulted in increases of, respectively, 315 percent, 137 percent, and 79 percent, in junior exploration company expenditure. Given the significant role of junior companies in the exploration sector these programs resulted in substantial new exploration expenditure.

KPMG (2013) used a Computable General Equilibrium model to investigate the impact of the Commonwealth Government providing a Mineral Exploration Tax Credit scheme that would allow exploration company losses for greenfield exploration to be passed back to

Australian resident shareholders. The analysis assumes that a 1.0 percent fall in exploration costs results in a 1.5 percent increase in exploration activity. KPMG (2013, p.11) estimate that the tax credit would lower the cost of greenfield exploration activity by 19.5 percent, and hence lead to a 28 percent increase in exploration activity. Evaluated in 2012-13, this exploration activity is estimated to equal $142M in new greenfield exploration, with a cost to government in terms of lost tax revenue of $133M. In terms of the additional mining activity that flows from additional exploration due to the tax credit scheme, three scenarios are considered:

- each additional $1 in exploration activity results in no additional mining return
- each additional $1 spent on exploration results in an additional $1 return in the mining sector
- each additional $1 spent on exploration results in an additional $2 return in the mining sector.

For these three scenarios the net long run annual position for Commonwealth tax revenue is -$72M, $106M, and $286M.

Duke (2010) reports estimates from 19 studies, including several from Australia, that look at the extent of new exploration expenditure stimulated by government exploration initiative programs. Across these studies the mean increase in private sector exploration for each dollar of government investment is 6.2. The maximum response value reported is a $19 increase in private sector exploration for every dollar of government stimulus.

The impact of the Northern Territory Exploration Attraction Programs 1999-2007 is reviewed in ACIL Tasman (2007). The report does not formally model the program impact, but works though the economic implications assuming the program resulted in a five percent increase in exploration expenditure and a five percent increase in mineral production.

The South Australian Plan for Accelerating Exploration (PACE) is evaluated in Economic Consulting Services (2014). The review concludes that the ratio of exploration expenditure stimulated by the program was at least $20 of private exploration expenditure for every $1 spent on the program. The report then focuses on the revenue value of mining projects stimulated by the program rather than the rent value or the discounted net present value of these induced projects.

Three separate analyses are presented in ACIL Tasman (2010). In the first, which is specific to NSW, the reported findings suggest a one percent increase in pre-competitive geoscience expenditure results in a 0.37 percent increase in private sector exploration expenditure. In the second model the effect of co-funding drilling and pre-competitive science are estimated separately for four Australian States. The reported findings are that a one percent increase in pre-competitive geoscience expenditure result in a 0.21 percent increase in private sector exploration expenditure; and a one percent increase in drilling co-funding expenditure results in a 0.24 percent increase in private sector exploration expenditure. In the third analysis the relationship between mineral production (excluding coal) and exploration expenditure in NSW is estimated and the results suggest that a one percent increase in private sector exploration expenditure is associated with 0.27 percent increase in the real value on non-coal mineral production. Converting the elasticity values to dollar values, ACIL Tasman (2010, p. 39) report that in the long run, for a one dollar increase in pre-competitive geoscience there is a long run increase in private sector exploration expenditure of $41 dollars; and for a one dollar increase in a combination of pre-competitive geoscience and drilling co-founding there is $78 increase in private sector exploration spending. To support these very high values case study information is presented.

7.3 Summary

The evidence base that government investment in initiatives such as co-funded drilling programs and the provision of geoscience information results in a strong private sector exploration response is convincing.

The analysis of the Canadian experience is robust. If there is a production subsidy there is a strong exploration response from junior exploration companies. The quality of the exploration response may however be below average as some investors may focus on the tax deductibility issue.

The evaluation process for the drilling co-funding program is notable in this regard. In direct contrast to general tax incentive schemes that may result in lower than average exploration activity, the evaluation process to secure co-funding ensures that above average exploration companies secure the production subsidy. The EIS program should, therefore, be more effective than general tax credit type schemes.

In the existing literature the return to government from investments to support exploration has been estimated using a variety of approaches. The most convincing, and also the most relevant example of calculating the return to government from investment in programs such as the EIS is the Scott et al. study of the return to the Queensland community from investments in geoscience. This study found a cost benefit ratio of 6.2, which is very high, despite the study being undertaken at a time when commodity prices were not high.

Overall, the externality issues associated with exploration appear to be widely recognised. All major Australian jurisdictions are involved in the provision of pre-competitive geoscience information, and in addition, all also have targeted programs to support greenfield exploration. There have been many studies that show exploration incentive schemes such as drilling co-funding or special tax deduction allowances generate substantial new private sector exploration expenditure. Studies that have gone on to estimate the return to government, not just the extent of private sector exploration stimulated, are more limited, but the studies that have been conducted suggest a high return to government from geoscience and exploration incentive programs.

8 Conclusions

This report has provided an economic impact assessment of the Exploration Incentive Scheme managed by the Department of Mines and Petroleum.

Overview and context

In Western Australia the mining sector is the main driver of wealth creation. The sector is also a major contributor to state government revenue, and through royalty tax payments provides around 22 percent of general government revenue.

Exploration activity is a necessary input into the creation and continued success of the mining sector. Although major new discoveries are found at increasing depth, the evidence that the value of mineral and energy deposits discovered through exploration is a multiple many time greater than exploration spending is strong; even after discounting to allow for the time it takes to move from new discovery to an operating mine.

Externality issues in exploration

If exploration activity was a pure private good there would be no role for government other than in terms of environmental regulation. Exploration activity is not, however, a pure private good, and there are substantial spillovers from private sector exploration. The existence of spillovers means that the socially optimal level of exploration activity is greater than the level of exploration activity generated in a pure private market. This issue has long been recognised, and globally, direct government funded geoscience is a standard government policy response.

The nature of the exploration spillovers are such that the mix of exploration activity generated by a pure private market, in terms of greenfield exploration relative to brownfield exploration, is different to the socially optimal mix of exploration activity. Specifically, a pure private market generates too much brownfield exploration and too little greenfield exploration.

That there is a divergence between the socially optimal level and mix of exploration activity and the level and mix of exploration generated under a pure private market suggests at least the possibility that government action to support exploration in general, and greenfield exploration in particular, could raise community welfare.

Across Australia the need to support greenfield exploration is widely recognised, and all major jurisdictions have implemented programs to support greenfield exploration. In Western Australia a specific initiative to support exploration in greenfield areas is the Exploration Incentive Scheme.

Private sector response to the EIS

The international evidence, and the evidence from other Australian jurisdictions, all find that there is a strong private sector exploration response following the introduction of exploration incentives. The strength of the response is moderated by general market conditions, as measured by commodity prices, and the extent of successful exploration. When commodity prices are high, and when there have been major discoveries, the extent of the private sector exploration response to incentives is stronger.

For the sample period, we find that in the long run, defined as three years, there was a strong private sector exploration response to the Exploration Incentive Scheme. Given:

1. the program resulted in the release of significant new airborne magnetic and radiometric data that opened up new areas for exploration
2. that receipt of co-funding for drilling can be seen as a quality marker that allows firms to raise additional private funds for exploration
3. institutions in Western Australia are very supportive of exploration and mine development
4. the geology in Western Australia is very prospective for mineral exploration
5. the co-funding program is targeted rather than a general tax incentive program,

a strong private sector exploration response was expected.

Stage 1 benefits

Additional exploration expenditure in Western Australia generates benefits. For funds allocated to exploration from within Western Australia the benefit is the difference between the general consumption multiplier and the exploration industry multiplier. For funds raised from outside Western Australia these funds represent a pure net gain for the Western Australian community. Under the assumption that 50 percent of the exploration expenditure stimulated by the program was raised from outside Western Australia, we find that in net present value terms the long run benefit to the state (extra GSP) is $10.3M for every $1M invested in the EIS.

Stage 2 benefits

Using an expected value approach, the impact of the additional exploration expenditure stimulated by the program was investigated. The model was calibrated to Western Australian specific data, where mineral discoveries tend to be larger than average. Due to the long lead time between a given drilling campaign and the development of a mine all values were discounted. For the private sector a real discount rate of 12 percent was used. For the government sector a real discount rate of 4 percent was used.

In expected net present value terms, for every $1M invested in the EIS we find that the benefit to the state (extra GSP) is $13.4M. This comprises $6.2M in additional taxation and royalty revenue, $3.9M due to additional construction activity, and $3.3M in new net wealth generated by the development of new mines.

Total benefit

The effects are additive, so that for every $1M invested in the EIS the long run expected net benefit to the state is $23.7M.

Sensitivity analysis

To explore the effect of high and low prices we conduct sensitivity analysis. For the low price scenario we find that the expected value of an average drilling campaign is negative. When the expected value of a drilling campaign is negative we do not expect rational market participants to fund a drilling campaign that has only the average probability of success. Under a low price scenario only those prospects that have an above average chance of success, which are most likely to be brownfield projects, will attract funding. Overall, the private sector exploration response to incentives and new geoscience information will be muted, and as such, the potential benefits that accrue to the state will be low.

Under the high price scenario we find that market conditions make it possible to fund the capital investment needed to develop very large mine projects. These projects go on to operate for very long periods of time, and as such, deliver royalty, employment, and net wealth creation benefits to Western Australia for decades. Under the high price scenario the expected net present value of every $1M invested in the EIS is $38.3M.

Appendix A Modelling approach

A (trend stationary) Autoregressive Distributed Lag (ADL) model was used to estimate the extent of induced private sector exploration activity due to the EIS. The ADL model can be difficult to interpret, so it is worth explaining the approach as a combination of two underlying sub-models that have a more natural interpretation: the partial adjustment model and the distributed lag model. In some of the literature cited in section 7.2, the modelling approach is not clearly explained, and it can be hard to understand the modelling choices made. Such work is open to the criticism that the final model selected was the result of an ad-hoc search process that sought to find the largest possible response.

The explanation presented below is based on a simplified model specification, but it places the subsequent empirical work on solid theoretical grounds.

A.1 Partial adjustment model

The first sub-model to consider is the partial adjustment model, and in the context of estimating the relationship between government expenditure on the EIS and private sector exploration activity, the model can be understood as follows.

Start by considering a standard business operation. In any business there are many operational frictions that mean it takes time to respond to changes in market conditions. In the case of exploration activity this means that the contemporaneous period response to a change in market conditions is unlikely to be the complete final response. For example, in response to an increase in the commodity price level the firm may want to increase exploration activity, but it takes time to raise funds, organise the drilling program, etc.

This thinking leads to a model that says the current period response is only a partial response to the change in conditions; the full long run response will not take place for several periods. The most common approach to operationalising this assumption is to assume that the adjustment process towards the target level of exploration activity depends on the difference between the unobservable target level for exploration activity in the current period and the observable actual level of exploration activity in the previous period.

In its simplest form we would have the following expression for the theoretical unobservable relationship between the target level of exploration activity and government EIS expenditure:

$$Q_t^* = a + bE_t + e_t. \tag{4}$$

In the above expression Q_t^* denotes the target level of exploration at time *t*, given government EIS expenditure E_t, *a* and *b* are parameters to be estimated, and e_t is a zero mean random error term that accounts for the various small random shocks that are always present in the system, but not explicitly accounted for in the model. As it is the theoretical target exploration activity we do not actually observe Q_t^*, rather, what we observe is Q_t, the actual level of exploration activity in each time period.

Assuming the adjustment process depends on the difference between the level of exploration activity in the previous period and the target level of activity in this period gives the formal expression:

$$Q_t - Q_{t-1} = \gamma[Q_t^* - Q_{t-1}], \tag{5}$$

where γ is the speed of adjustment parameter. The above expression say that the observed change in exploration activity is proportional to the difference between the level of exploration in the previous period and the target level of exploration activity this period.

Values for γ are bounded by zero, which implies no adjustment, and one, which implies complete adjustment. That γ will lie somewhere between no adjustment and complete adjustment is the result that gives rise to the name "partial adjustment model". This relationship can also be seen by rearranging equation (5) as:

$$Q_t = Q_t^*\gamma + Q_{t-1}[1-\gamma], \tag{6}$$

which says that the level of exploration activity we observe today is a weighted average of the level of exploration activity in the previous period, and the optimal level of activity we would like to undertake today.

To obtain a model completely in terms of observable information note that equation (6) can also be written as:

$$Q_t^* = \frac{Q_t}{\gamma} - \frac{Q_{t-1}}{\gamma} - Q_{t-1}. \tag{7}$$

The right hand side of equation (7) can then be used to replace the left hand side of equation (4) to give:

$$\frac{Q_t}{\gamma} - \frac{Q_{t-1}}{\gamma} - Q_{t-1} = a + bE_t + e_t. \tag{8}$$

Following simplification, the expression collapses to:

$$Q_t = \gamma a + \gamma bE_t + (1-\gamma)Q_{t-1} + \gamma e_t. \tag{9}$$

The term γb in equation (9) then describes the short-run effect of government EIS expenditure on private sector exploration activity. As, in the long-run, we move from one equilibrium point to another, to find the long-run effect we substitute into equation (9) long-run equilibrium values. Using Q' and E' to denote long-run equilibrium values this substitution first gives:

$$Q' = \gamma a + \gamma bE' + (1-\gamma)Q', \tag{10}$$

which can then be rearranged to give:

$$Q' = a + bE'. \tag{11}$$

Equation (11) says that the long-run impact of government EIS expenditure on private sector exploration activity is given by the b term.

So, for the partial adjustment model the underlying model estimated is:

$$Q_t = \gamma a + \gamma bE_t + (1-\gamma)Q_{t-1} + \gamma e_t, \tag{12}$$

and the actual model regression output (estimated via least squares) is of the form:

$$Q_t = \alpha + \beta_1 E_t + \beta_2 Q_{t-1} + e_t'. \tag{13}$$

Long-run and short run impacts are then determined via a process of matching terms between the theoretical model (equation (12)) and the estimated model output (equation (13)). Through this matching process it can be seen that we have $\beta_1 = \gamma b$, so that in the estimated regression model the β_1 parameter gives the short-run impact of EIS investment on exploration investment. Further, as the short run estimate is derived directly via the regression model, the standard error associated with the β_1 estimate provides a clear measure of the uncertainty associated with the estimated short-run effect.

As b gives the long-run impact, through matching the estimated model output to the theoretical model output the long-run impact can be found as: $b = \gamma b/\gamma = \beta_1/1 - \beta_2$. That is, the long-run impact is found from the estimated regression model as the ratio of the β_1 term and one minus the β_2 term. The variance of the ratio of two normally distributed random variables is not defined. An accurate measure of the uncertainty surrounding the estimated long-run effect can however be obtained via the delta method approximation.

The interpretation of the effects depends on whether or not transformations have been applied to the data. If no transformations have been applied to the data then the marginal effect can be read directly from the model output. If a log transformation has been used for private sector exploration expenditure, the effects have an interpretation as approximate percentage changes. When the above model is estimated using the log of private sector exploration expenditure and the log of government EIS expenditure, the parameter values have an interpretation as the short-run and long-run own-price elasticity.[12]

A.2 Distributed lag model

The second sub-model to consider is the distributed lag model. The distributed lag model says that there can be a delay in responses to a change in the operating environment. In the context of the government EIS, the model says what happens today, in terms of the EIS, matters, but because we have a slow moving process, what happened in the past also matters for what happens today. The motivation is similar to that outlined for the partial adjustment model.

Using the same notation as for the partial adjustment model, the distributed lag model implies a model of the form:

$$Q_t = a + bE_t + cE_{t-1} + e_t. \qquad (14)$$

If it was thought appropriate, the model could also include $E_{t-2}, E_{t-3}, \dots, E_{t-k}$ as additional explanatory variables. For illustration purposes, here the discussion is restricted to a single period lagged effect.

In equation (14) the b term describes the current period, or short-run impact, and the c term describes the delayed impact. Similar to the partial adjustment model, the total impact, or long-run impact, is found by substituting equilibrium values into equation (14) to give:

$$Q' = a + (b + c)E'. \qquad (15)$$

The long-run effect is therefore the sum of the terms on the current and past EIS expenditure variables. As with the partial adjustment model, the interpretation of the estimates depends on whether or not log transformations have been applied to the raw data. As the short-run impact is estimated directly, the estimate of the parameter standard error provides a measure of the uncertainty surrounding the estimate. For the long-run impact a measure of estimate uncertainty can be derived using the delta method.

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12 The partial adjustment model can be criticised as a backward looking model. It might reasonably be argued that exploration companies are forward looking. Such a framework is known as the rational expectation model. However, from a statistical point of view the rational expectations model and the partial adjustment model are statistically equivalent. This means that as an empirical matter it does not matter whether one thinks people are forward looking or backward looking, the empirical model estimated takes the same form.

A.3 Autoregressive distributed lag model

With an understanding of the relevant sub-models, and the motivation for the way these models are estimated, it becomes possible to consider the ADL model. The specific ADL model presented here is known as an ADL(1,1) model, and based on the literature review implementations of this kind of model appear to be the most flexible model that has been considered as a way to estimate the impact of government actions, such as incentive programs or tax changes on private sector exploration.[13] The ADL(1,1) model may be thought of as a model that combines the distributed lag model and the partial adjustment model, and is specified as:

$$Q_t = \alpha + \beta_1 E_t + \beta_2 E_{t-1} + \beta_3 Q_{t-1} + e_t. \quad (16)$$

As the model combines the partial adjustment model and the distributed lag model the short-run and long-run effects are derived by working through the same steps. Specifically, in equation (16) the short-run effect is given by β_1, and the long-run effect is found by substituting long-run equilibrium values into equation (16) to give:

$$Q' = \alpha + (\beta_1 + \beta_2)E' + \beta_3 Q', \quad (17)$$

which, after grouping common terms and rearranging gives:

$$Q' = \frac{\alpha}{(1-\beta_3)} + \frac{(\beta_1 + \beta_2)}{(1-\beta_3)} E'. \quad (18)$$

As the term $(\beta_1 + \beta_2)/(1-\beta_3)$ describes the equilibrium change in the level of private sector exploration activity following a change in the EIS it describes the long-run impact. Although the expression looks complex, note the expression is simply a composite of the way the long-run effect is derived in both of the sub-models described.

[13] In at least once case an Error Correction Model (ECM) format was used, but as it is possible to derive the ADL format from the ECM format, here such models are treated as part of the same general model class.

Appendix B Co-funding grants 2011-12

Table B1 **Round 5 Co-funded Exploration Drilling 2011-12 Successful Projects**

	Applicant Name	Drilling Project Title	Target Commodities
1	Anglo American Exploration (Australia) Pty Ltd	Musgraves Project - Roquefort Prospect	Ni; Cu; PGE's
2	Anglo American Exploration (Australia) Pty Ltd	Musgraves Project - Latitude Hill Prospect	Ni; Cu; PGE's
3	Atlas Iron Ltd	Limestone Creek – Buried Brockman Formation.	Fe
4	Atlas Iron Ltd	McCameys North – Boolgeeda Formation Stratigraphic Diamond Hole	Fe
5	Atlas Iron Ltd	Jigalong: Marra Mamba Stratigraphy or Manganese Subgroup?	Fe
6	Atlas Iron Ltd	Weelarrana: Buried Hamersley Stratigraphy	Fe
7	Aurora Minerals Limited	Glenburgh	Au; Cu; U
8	Ausprey Resources Pty Ltd	Wallal Banded Iron Formation	Fe
9	Australia Minerals & Mining Group Ltd	Bencubbin Project	Fe
10	Beadell Resources Ltd	Pleiades Lakes	Au
11	Beadell Resources Ltd	Hercules	Au
12	Cazaly Rources Ltd	Earaheedy Manganese	Mn
13	Chrysalis Resources	Pioneer Gold Project - Norseman	Au
14	Chrysalis Resources Ltd	Doolgunna West	Au & Cu
15	Dragon Energy Ltd	Lee Steere Project- Spriggs Pool Prospect	Fe, Mn
16	Echo Resources Limited	Lucius Target	Au
17	Empire Resources Ltd	Constantine Project	Pt; Pd; Ni; Cu
18	Empire Resources Ltd	Wynne	Cu; Pb; Zn; W
19	Enterprise Metals Limited	Burgess Drilling Project	Ni, Cu, PGE
20	Fortescue Metals Group	Horatio-Boolgeeda Evaluation	Fe
21	Galaxy Resources Ltd	Mt Cattlin	Lithium/Tantalum
22	Gold Road Resources Ltd	Golden Sands	Au
23	Gold Road Resources Ltd	Dorothy Hills	Au
24	Green Rock Energy	Collie Geothermal Drilling	Geothermal
25	Hancock Prospecting Pty Ltd	Fortescue Valley Stratigraphic Drilling	Fe
26	Independence Group NL	Duketon Nickel JV	Ni, Cu, Pt, Pd

	Applicant Name	Drilling Project Title	Target Commodities
27	La Mancha Resources Australia Ltd	Frog's Leg Offset	Au
28	Laconia Resouces Ltd	Barramine Project	Cu; Pb; Zn; Au
29	Matsa Resources Limited	Mt Henry Gold/Magnetite Project (MH)	Au, Fe
30	McVerde Minerals Pty Ltd	Pithara	Au
31	New Standard Onshore Pty Ltd	Lawford #1 Well, Laurel Project	Gas and Oil
32	Northern Star Resources Limited	Underground navigation drilling: Testing the continuation of mineralization (Voyager 3) down plunge, Paulsens Gold Mine, Wyloo Dome, Ashburton Region	Au
33	Oroya Mining Limited	Talc Lake Nickel Project	Ni; Cu-Au
34	Rubianna Resources Ltd	Murchison	Au, Cu, Pb, Zn
35	Salisbury Resources Limited	Starion Gold Project	Au
36	Sirius Resources NL	Ram Well Anomaly, Youanmi Igneous Complex	Cu, Ni, Co, PGE's
37	Sirius Resources NL	Symons Hill Ni-Cu Anomaly	Ni; Cu; PGE
38	Speewah Metals Ltd	Speewah zoned, epithermal fluorite-barite-Cu±Au mineralised veins and the associated potassic-alteration systems	Cu, Au, F,
39	TPL Corporation Limited	Lightjack Hill Drilling	Coal
40	Traka Resources Limited	Mt Short	Cu, Pb, Zn
41	Traka Resources Limited	Jameson Project	Ni, Cu
42	UXA Resources Ltd	Myroodah West	U
43	Ventnor Resources Limited	Warrawanda	Ni
44	West Peak Iron Limited	Santy Well	Au, base metals
45	CoxsRocks Pty Ltd	Edjidina	Au
46	Greg Jorgensen	Reptile Shear	Au
47	Harold Dowling	Orrinda South Project	Au
48	Mr Christopher Potts	Great Hope Gold Mine	Au
49	Mr Ladislav Stanko	Mt Edwards, M15/34, Widgiemooltha WA	Au (Ag)
50	Stuart Hooper	Copperfield Northwest	Au
51	Sulphide Resources Pty Ltd	Kat Gap	Au
52	Sulphide Resources Pty Ltd	Tropicana East	Au
53	Wild Side Pty Ltd & Westover Holdings Pty Ltd	Eucla West Project	Mineral Sands

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