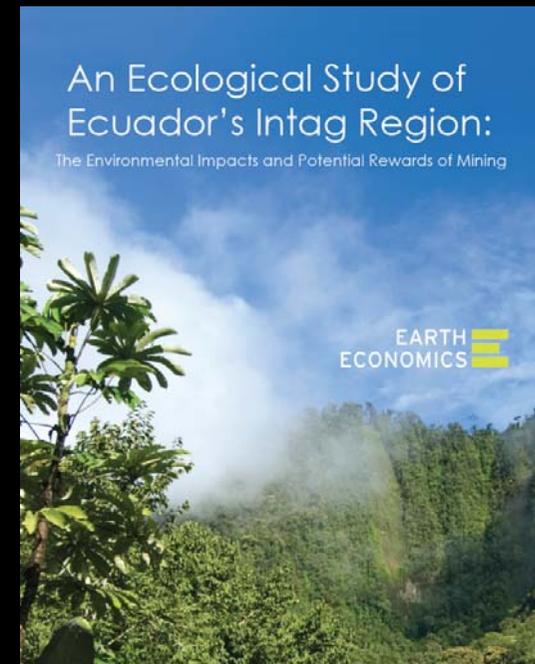
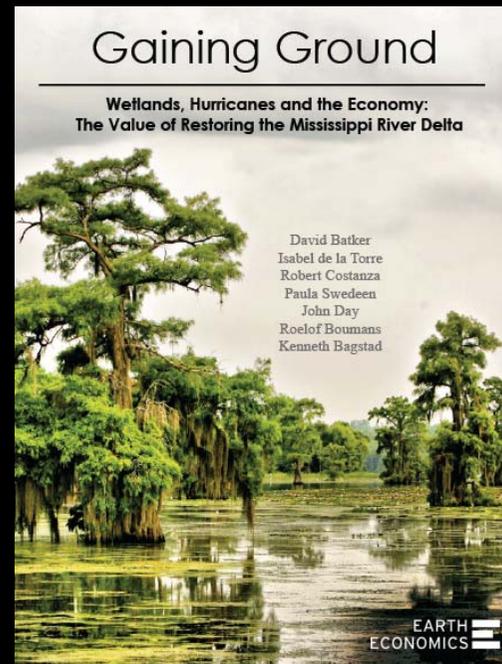
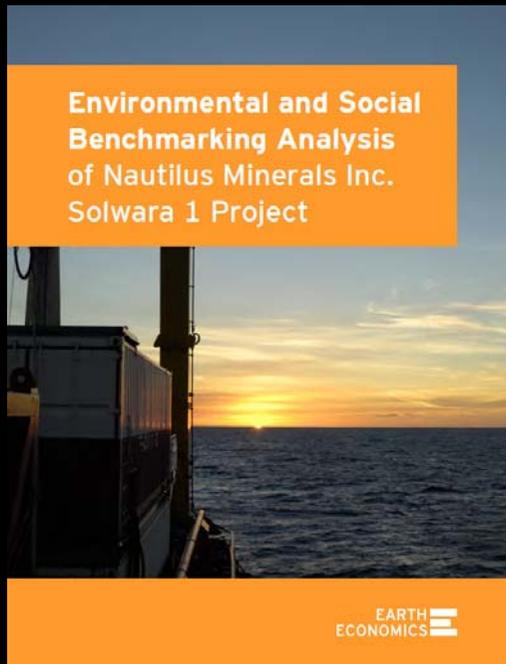


# Environmental Impacts of Offshore Mining Compared to Conventional Land Mining

David Batker

Earth Economics Executive Director

November 28, 2016



# The Environmental Impacts of Terrestrial Mining are Costly and Rising



# 2015 Samarco Iron Ore Mine Tailings Spill in Brazil



November 5, 2015



# Holden Mine Tailings, \$200 million in 2015

Photo: Rio Tinto

Gravity is a tough,  
persistent opponent



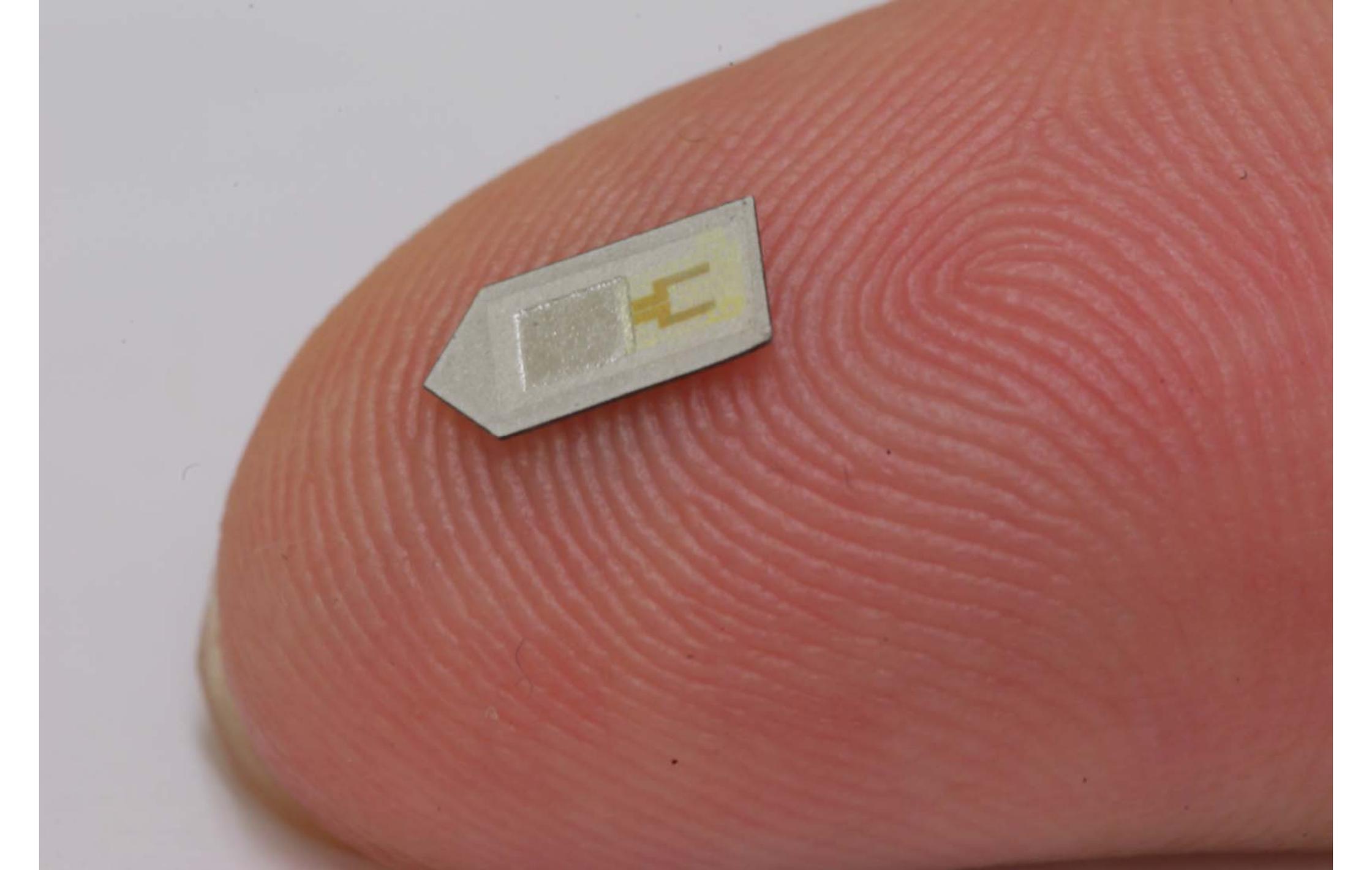


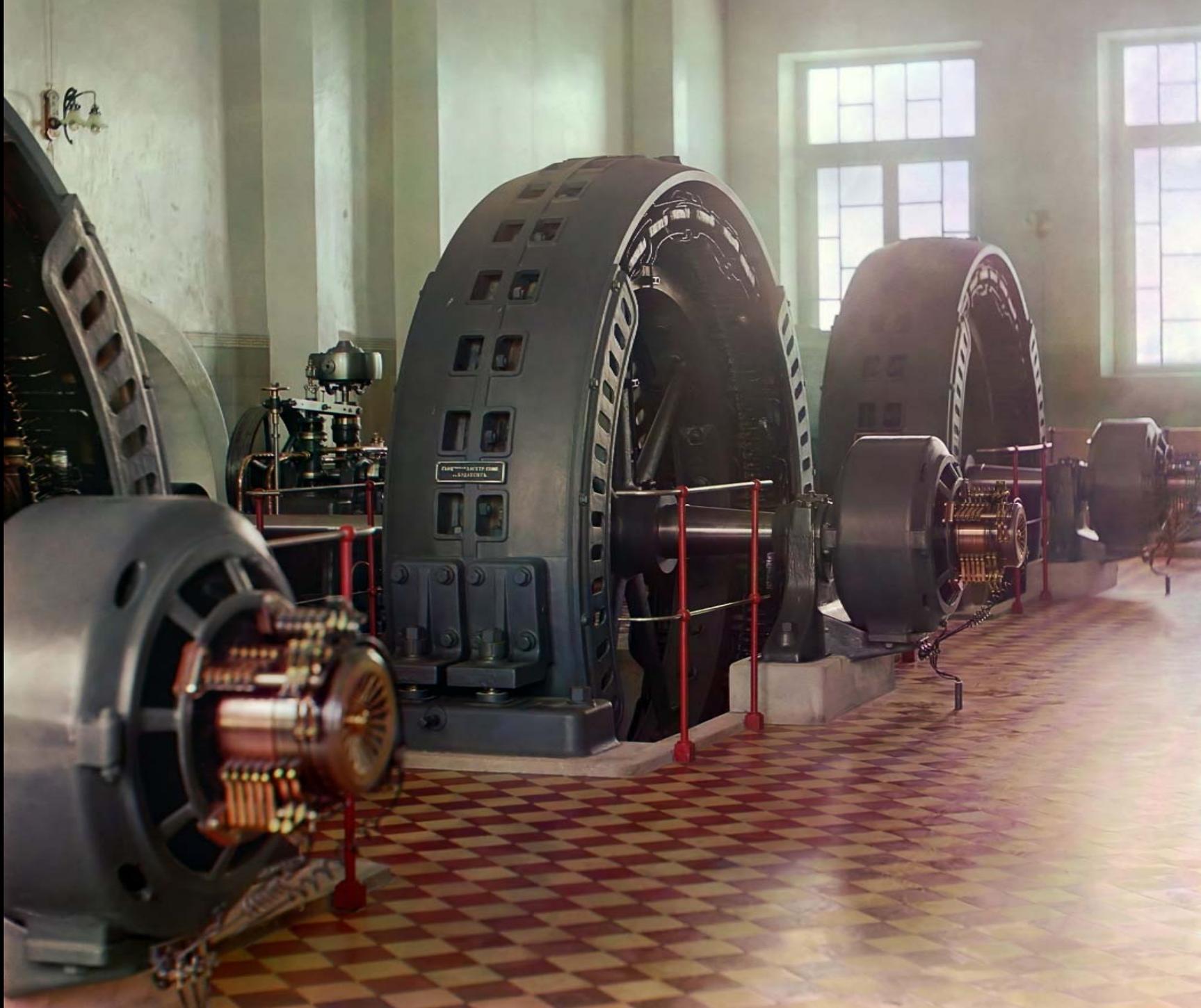
# Loss of Natural Capital



How do we measure  
the environmental  
and social impacts of  
mining?



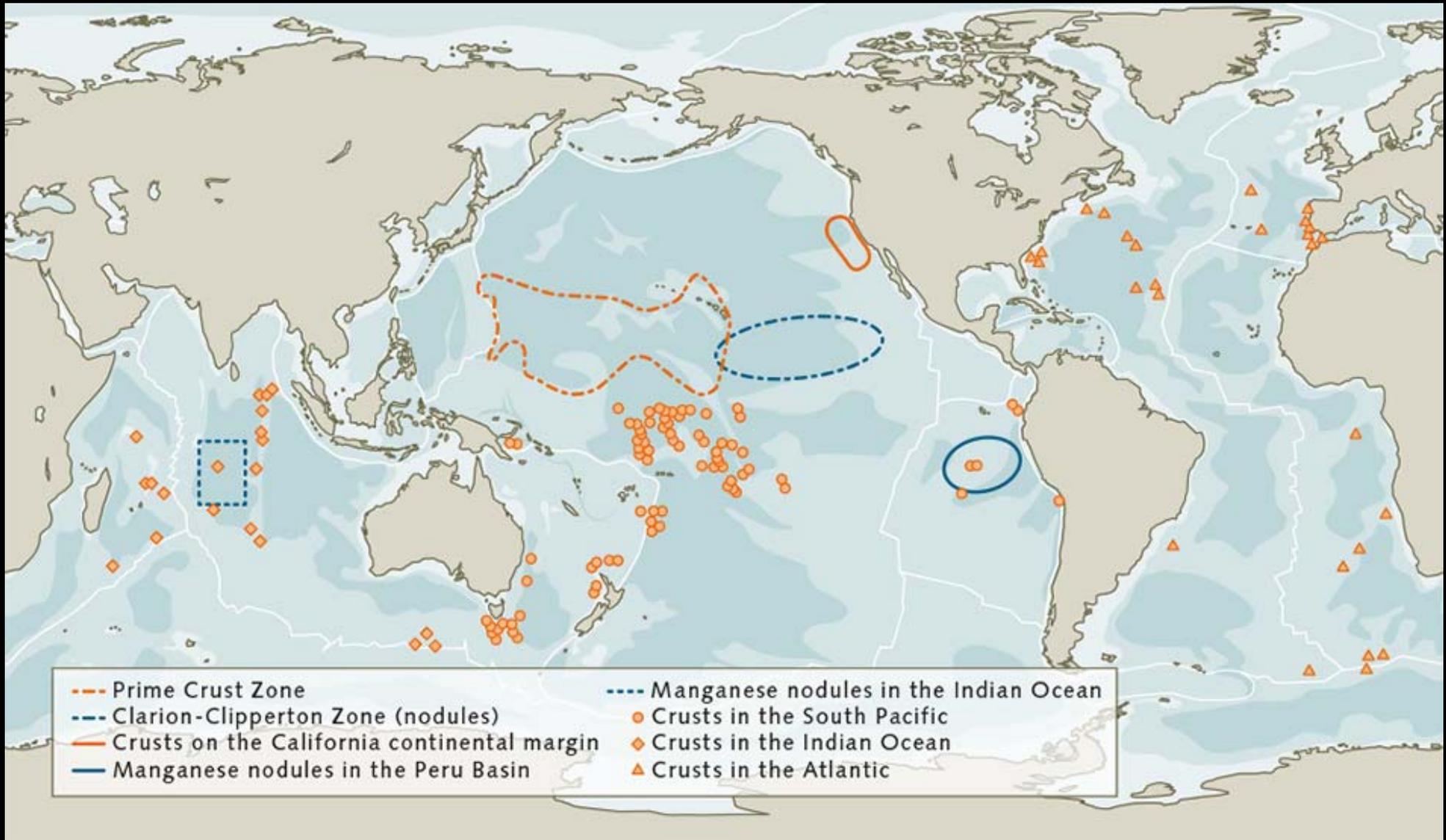




# Cobalt Mining and Child Labor



# Cobalt and Other Metal Rich Crusts

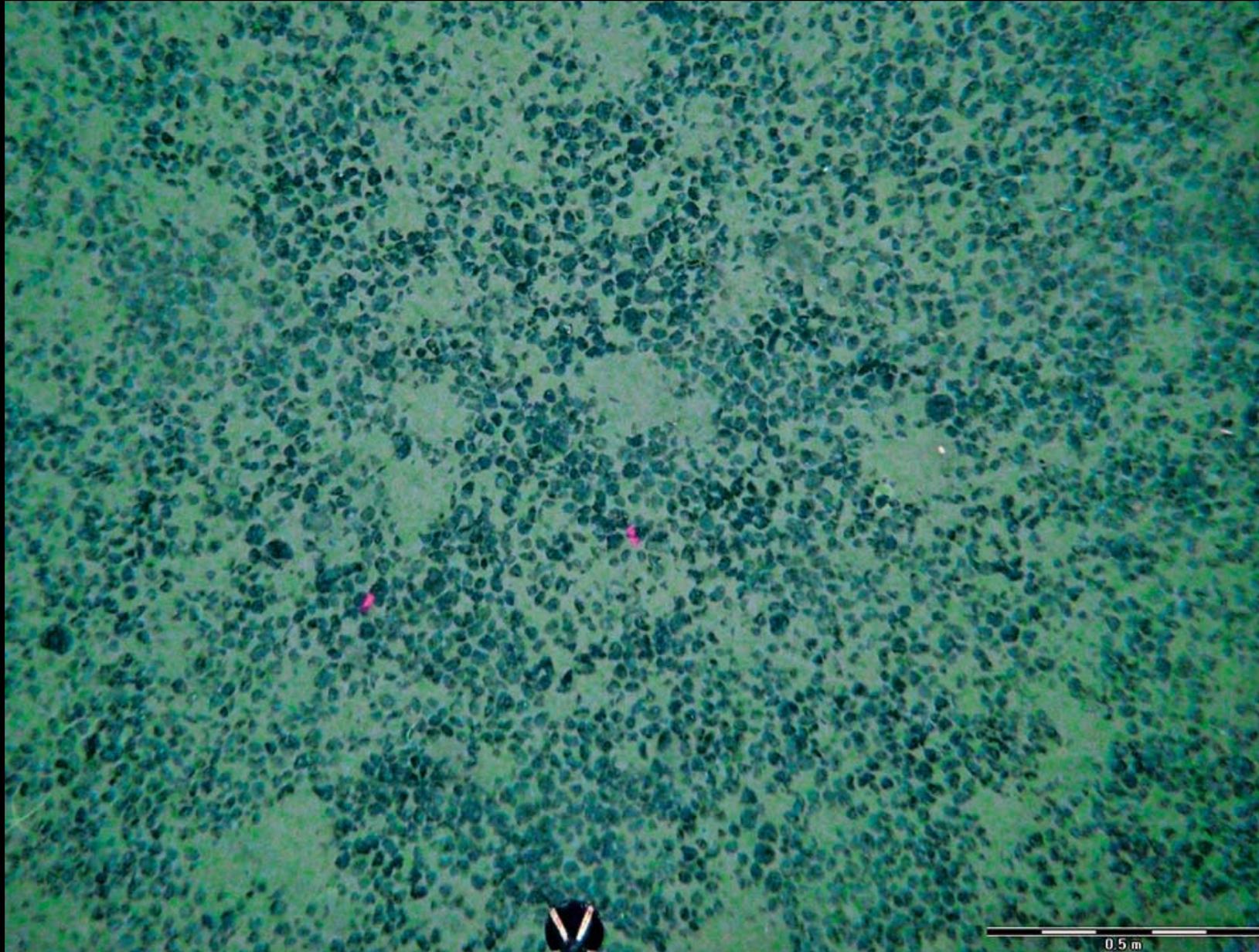


World Ocean Review

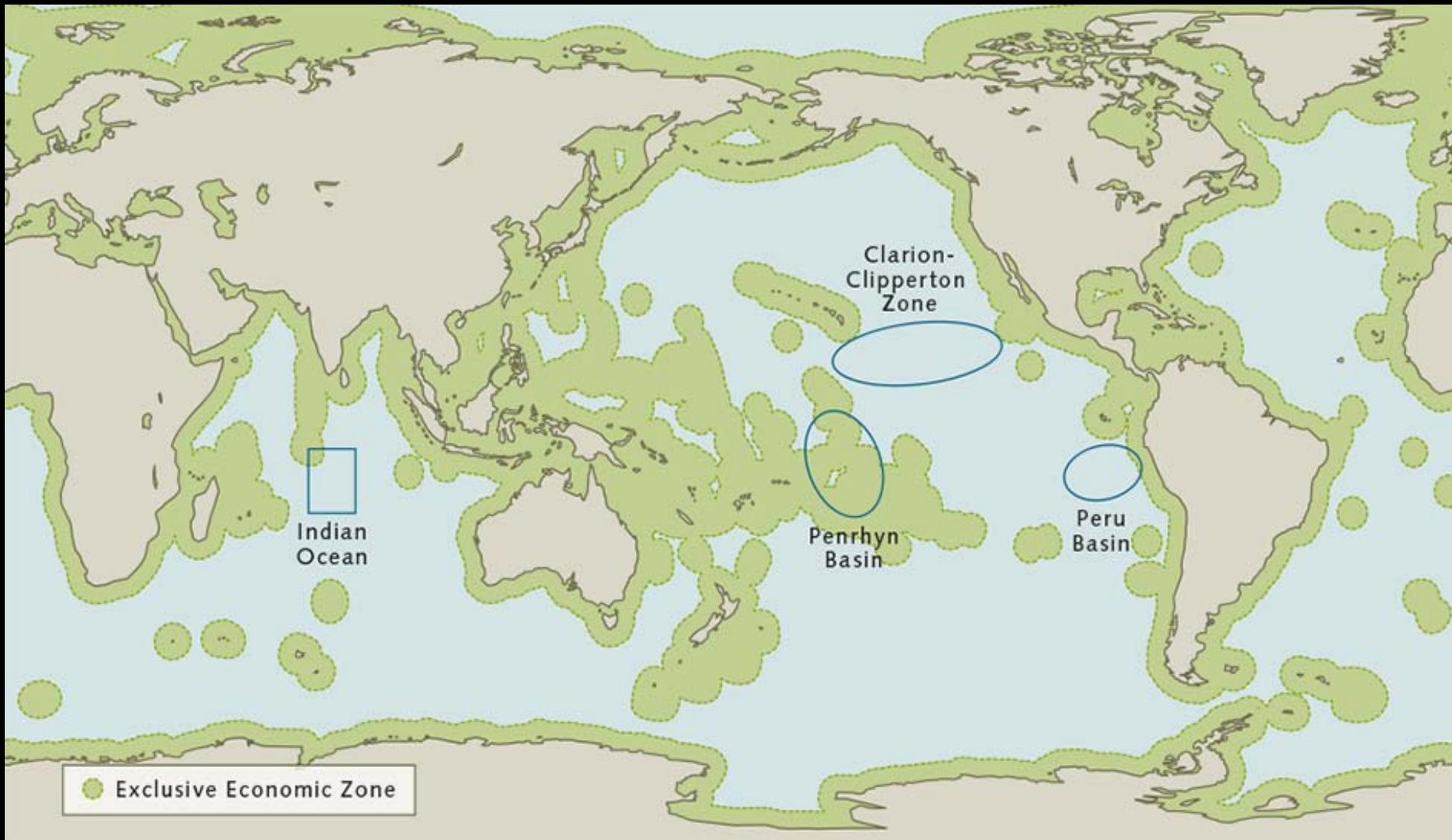
# Mamatwan Manganese Mine, South Africa



# Polymetallic Nodules



# Four areas of greatest interest for nodules



# Seafloor Massive Sulfides



North Su, active subsea volcano

# Framework for Evaluating Mining

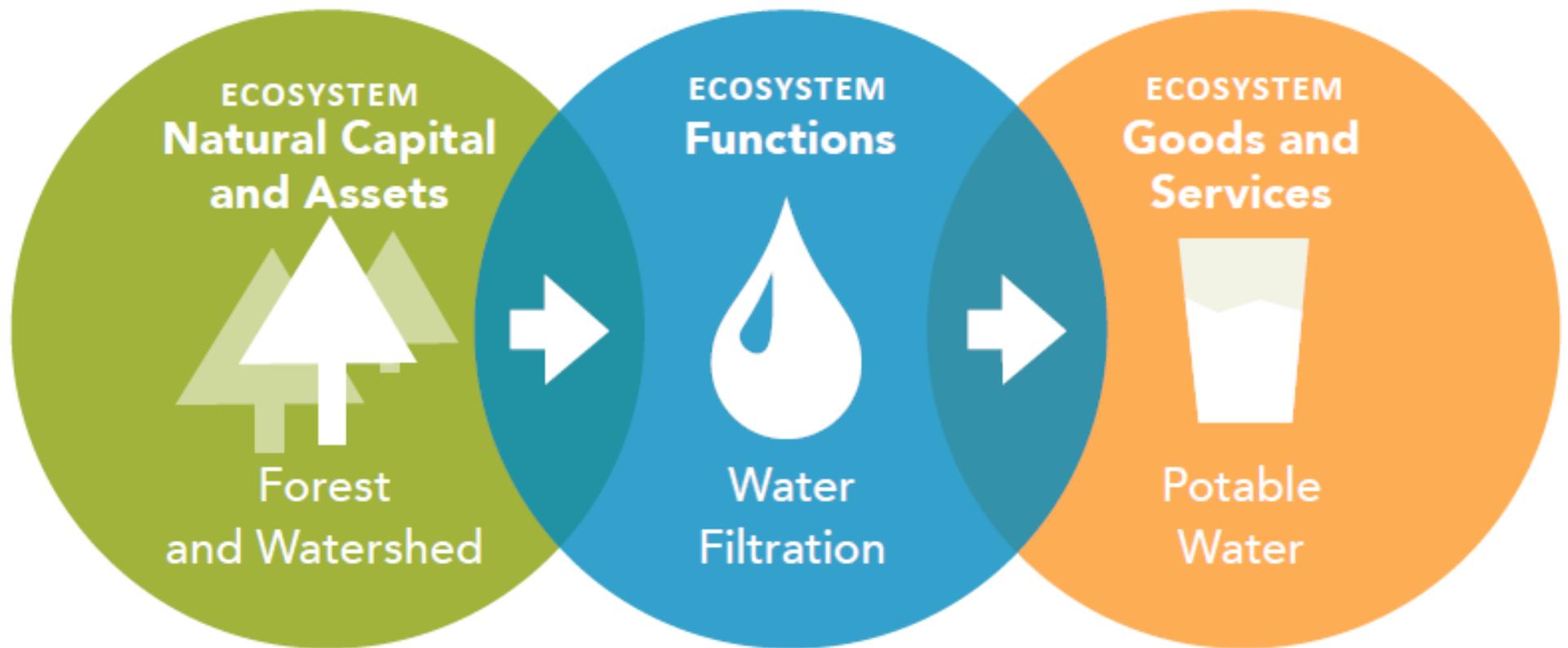
Who's Interested?  
Investors, Lenders, Insurers,  
Reinsurers, Guarantors

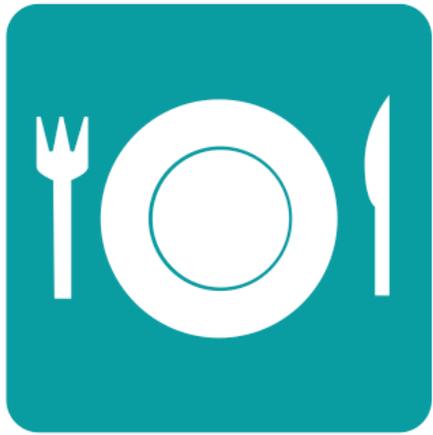


# Uniting Environmental and Financial Analysis



# Natural Capital and Ecosystem Services





# Food Production





# Goods

Food

Water Supply

Minerals

Medicine

Fiber

Fuel

Carbon



# Services

Flood Risk Reduction

Gas & Climate Stability

Water Quality

Fire Risk Reduction

Soil Erosion Control

Sediment Transport

Natural Pest and Disease Control

Soil Formation

Water Flow and Temperature Regulation



# Supporting Functions

Pollination

Biodiversity and Habitat

Nutrient Cycling

Net Primary Production



# Cultural Functions

Aesthetic

Recreation

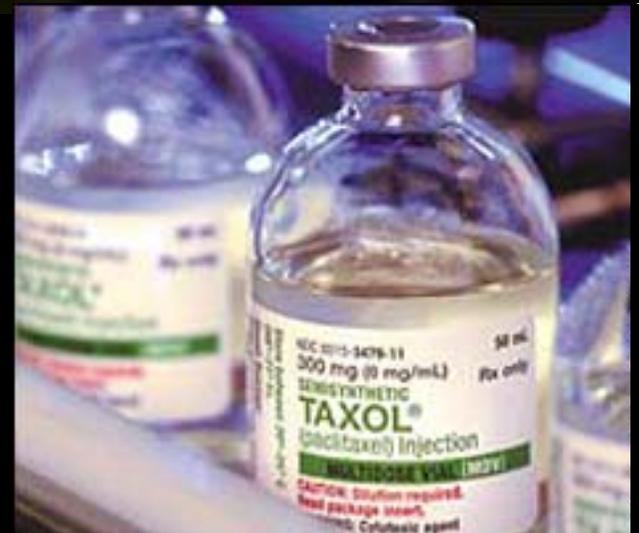
Cultural Values

Spiritual & historic

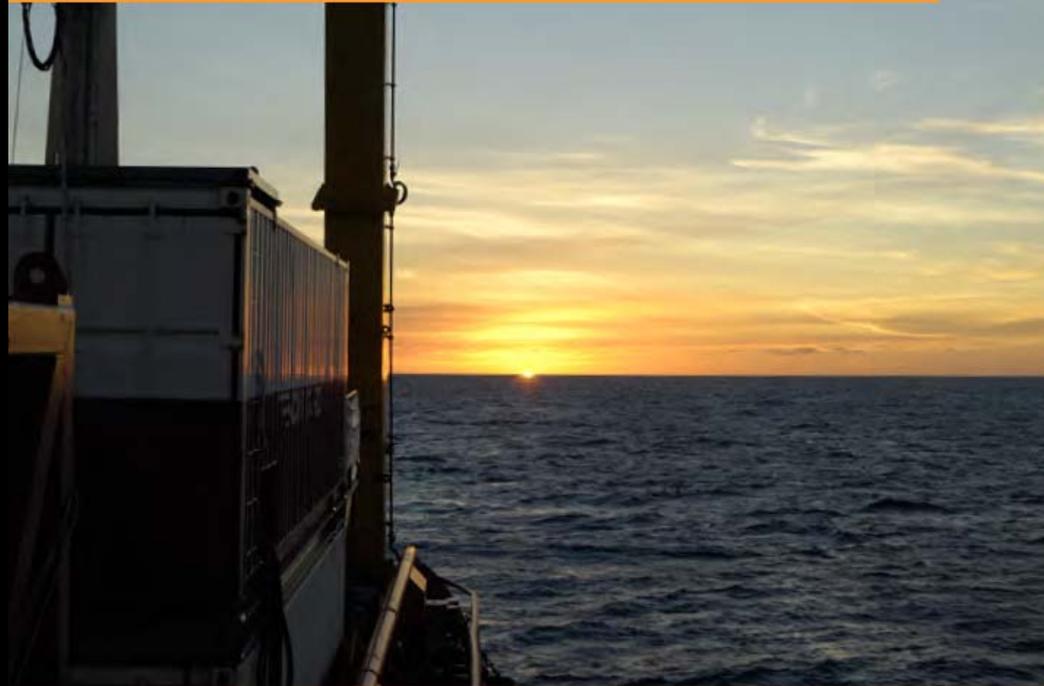
Science & education



Medicine



**Environmental and Social  
Benchmarking Analysis  
of Nautilus Minerals Inc.  
Solwara 1 Project**



EARTH  
ECONOMICS 

# Report Outline

- Intro, history, demand/supply
- Copper Recycling & Substitution (Analysis I)
- State of Knowledge of the Bismarck Seabed
- Identification of Impacts (Analysis II)
- Quantification of Impacts (Analysis III)
- Monetization of Impacts (Analysis IV)
- Concentration & Smelting
- Conclusions & Recommendations

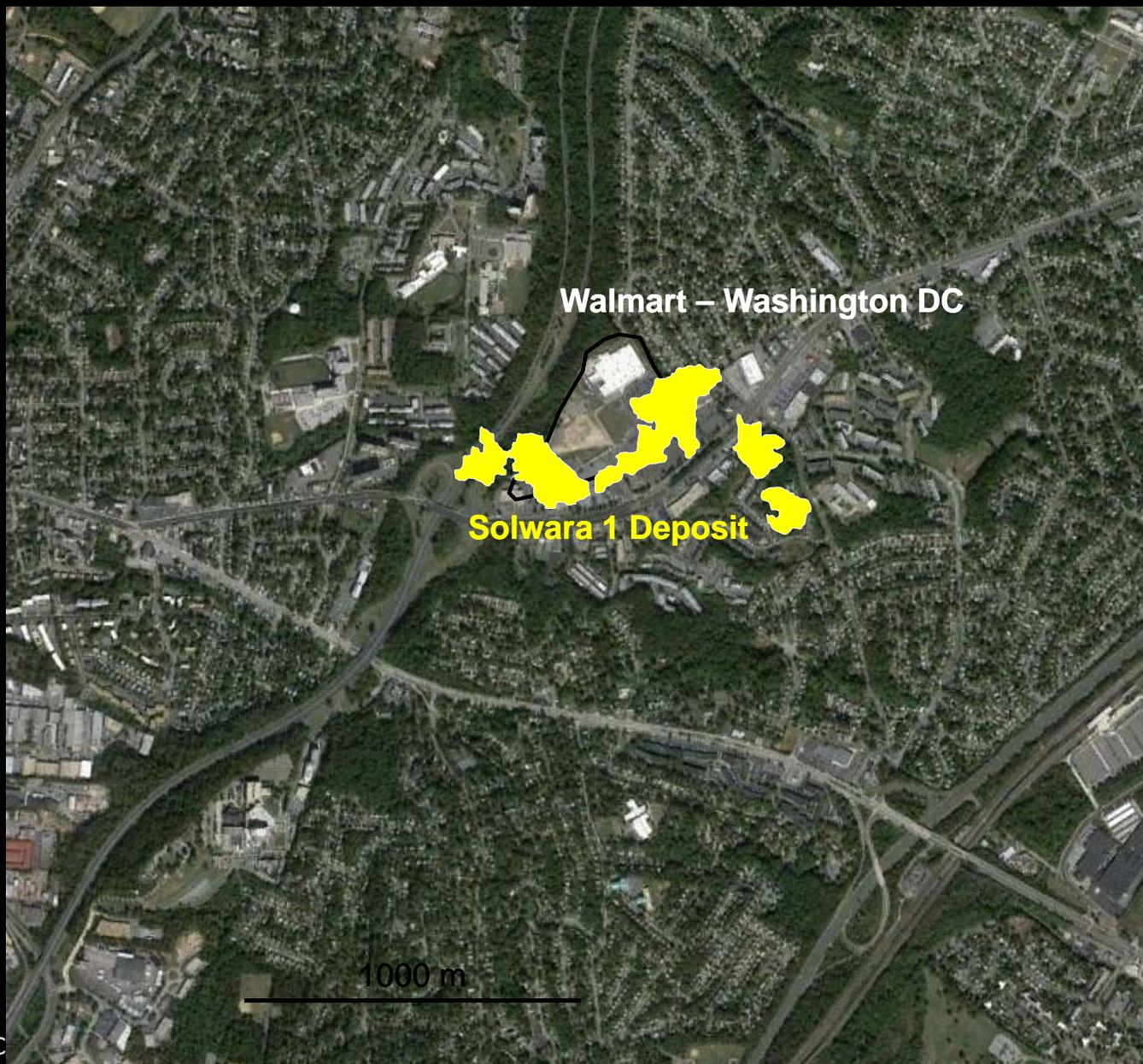


# Identification of Impacts

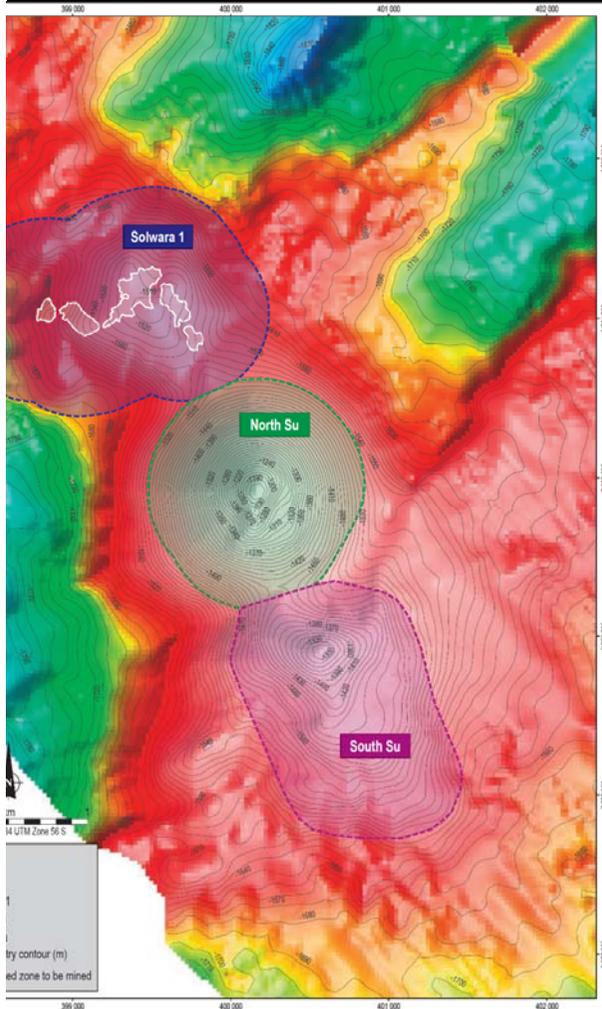
# Solwara 1 Project Location



# Solwara 1 Project Scale - Shopping Centre



# Site State of Knowledge is Strong



- 35+ independently published academic articles related to Solwara 1.
- May be the best studied 14 hectares of seabed on Earth.
- Vent systems in the Solwara 1 mine area exhibit dramatic disturbance, with vents naturally turning on and off with variations in volcanic activity.
- Studies indicate that the mine site could recover relatively quickly following disturbance, if adequate hard substrates and larval recruits are available.
- South Su reserve area will mitigate impacts on biodiversity.

# Solwara 1 Comparison Sites



▲ Bingham Canyon: Tailings Pond (above) and Mine (below)



▲ Solwara 1 Mine Site, with Tongjing Refinery area\* (square)



▲ Prominent Hill Mine

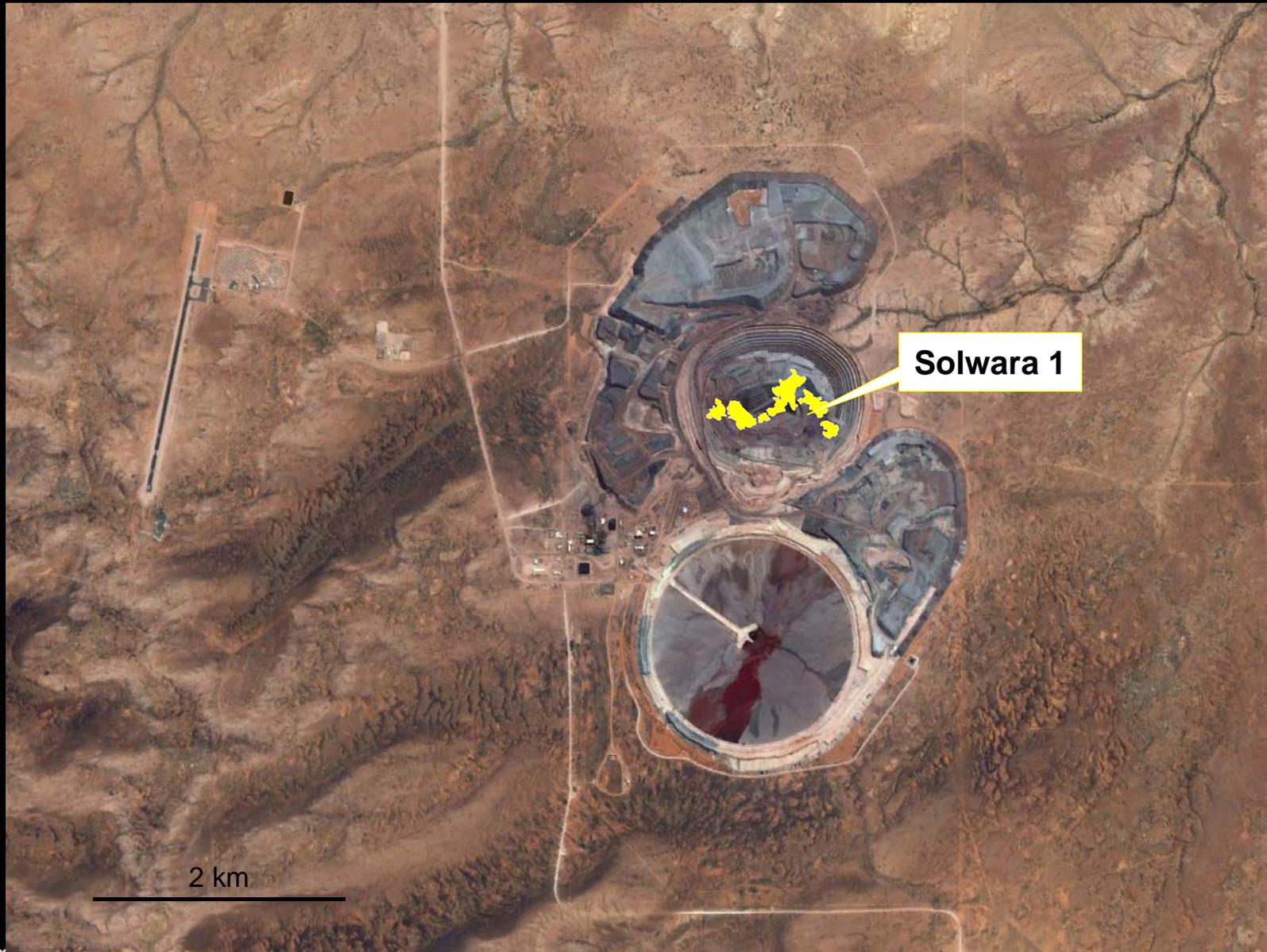


▲ Proposed Intag Mine\*

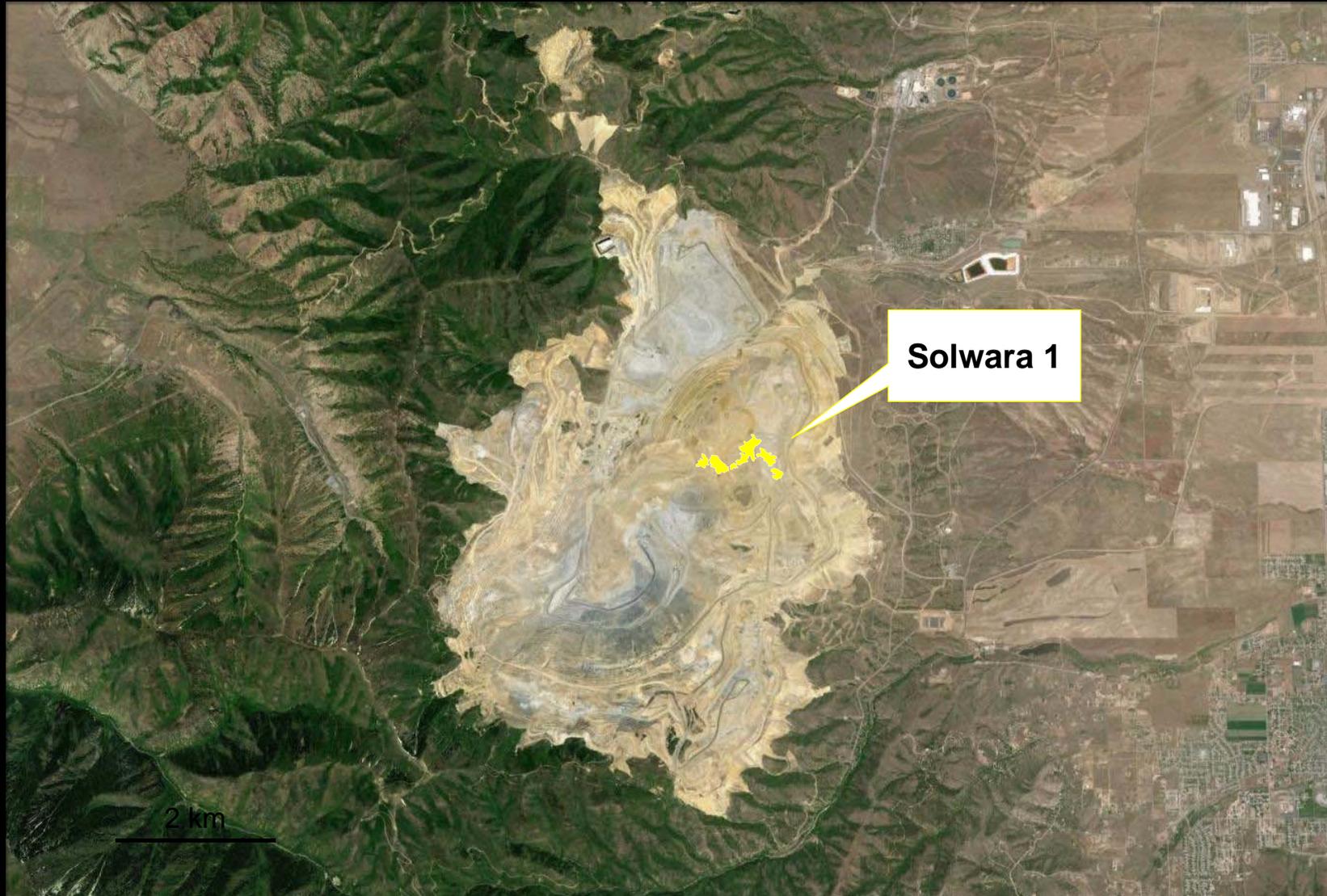


▲ JFK Airport, New York City  
(for size comparison)

# Prominent Hill, South Australia

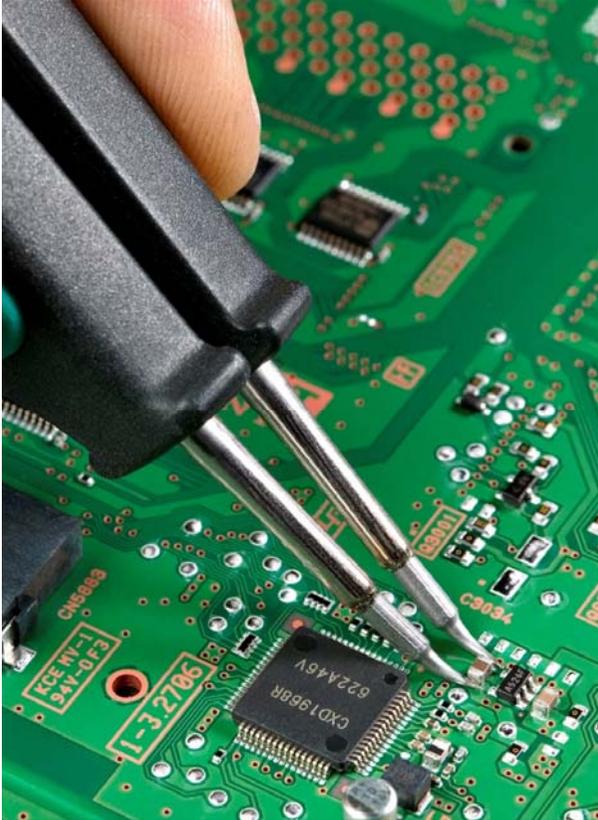


# Bingham Canyon, Utah



Ecosystem Service	Level of Impact (0 = lowest, 3 = highest)			
	Solwara 1	Prominent Hill	Bingham Canyon	Intag
<b>Provisioning Services</b>				
Food	0	1	3	3
Medicinal Resources	0	1	1	3
Ornamental Resources	0	0	0	1
Energy & Raw Materials	3	3	3	3
Water Supply	0	1	3	3
<b>Regulating Services</b>				
Biological Control	1	3	2	2
Climate Stability	1	1	2	3
Air Quality	1	0	1	1
Moderation of Extreme Events	0	1	3	3
Pollination	0	1	1	3
Soil Formation	0	3	3	3
Soil Retention	0	3	3	3
Waste Treatment	1	2	3	3
Water Regulation	0	1	3	3
<b>Supporting Services</b>				
Habitat & Nursery	2	2	3	3
Nutrient Cycling	1	2	3	2
Genetic Resources	1	3	3	3
<b>Cultural Services</b>				
Natural Beauty	1	1	3	2
Cultural and Artistic Information	0	1	2	3
Recreation and Tourism	0	0	3	3
Science and Education	1	3	1	2
Spiritual and Historic	0	3	1	3

# Conclusions



- Solwara 1 mine involves fewer potential impacts than comparison sites, ranked across the 22 categories of natural capital accounting.
- People will not be displaced by the Solwara 1 deep seabed copper mine.
- **Not Impacted by Solwara 1:**
  - Food production, fresh water supply, disaster risk reduction, pollination, soil formation, erosion, freshwater regulation, recreation, historic & cultural values.
- **Impacted by Solwara 1:**
  - Raw materials, biological control, climate stability, air quality, waste treatment, habitat and nursery, nutrient cycling, biodiversity, genetic resource values, science and education.



# Quantification of Impacts

# Quantified Impacts: Solwara 1 vs. Comparison Mines

	Measure	Annual Cu Production	Total Cu Production	Freshwater Use	Energy Use	CO <sub>2</sub> Emissions	Mineral Waste	Area of Disturbance
	Unit	Metric tons	Metric tons	Liters per metric ton of Cu produced	MWh per metric ton of Cu produced	Metric tons of CO <sub>2</sub> per metric ton of Cu produced	Metric tons of tailings & waste rock per metric ton of Cu produced	Square meters per metric ton of Cu produced
<i>COMPARISON MINES</i>	<i>IMPACT TYPE</i>							
<b>Solwara 1 (proposed) Total</b> <sup>46,48</sup>	Mine + Refinery	<b>77,760</b> <sup>86</sup>	<b>127,186</b> <sup>87</sup>	<b>0</b>	<b>4.0</b>	<b>3.6</b>	<b>1.9</b>	<b>5.4</b>
<i>Solwara 1 Mine</i>	<i>Mine</i>			<i>0</i>	<i>4.0</i>	<i>3.6</i>	<i>1.9</i>	<i>1.1</i>
<i>Tongling Refinery</i>	<i>Refinery</i>			<i>Data not available</i>	<i>Data not available</i>	<i>Data not available</i>	<i>0</i>	<i>4.3</i>
<b>Prominent Hill Total</b>	Mine + Refinery	<b>73,362</b> <sup>89</sup>	<b>2,046,000</b> <sup>89</sup>	<b>83,831</b> <sup>90</sup>	<b>15.3</b> <sup>91</sup>	<b>5.4</b> <sup>92</sup>	<b>36.3</b> <sup>93</sup>	<b>7.2</b> <sup>94</sup>
<b>Bingham Canyon Total</b>	Mine + Refinery + Smelter	<b>194,000</b> <sup>95</sup>	<b>19,000,000</b> <sup>96</sup>	<b>21,041</b> <sup>97</sup>	<b>24.8</b> <sup>98</sup>	<b>7.7</b> <sup>99</sup>	<b>11.5</b> <sup>100</sup>	<b>5.4</b> <sup>101</sup>
<b>Intag (proposed) Total</b>	Mine	<b>484,437</b> <sup>102</sup>	<b>9,906,472</b> <sup>103</sup>	<i>Data not available</i>	<i>Data not available</i>	<i>Data not available</i>	<b>11.5</b> <sup>104</sup>	<b>5.4</b> <sup>105</sup>

Downslope impacts and liabilities are not present

Social impacts not present

Fresh water impacts not present





# Monetization of Impacts

# Bingham Canyon Ecosystem Service Impacts

	Developed, Open Space/M-low Density	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrub	Grasslands	Pasture/Hay	Cultivated	Woody Wetlands	Emergent Herbaceous Wetland
Ecosystem Service	Value (\$/hectare/year)									
Food			\$78	\$39		\$90		\$22,560		\$877
Medicinal Resources										
Ornamental Resources										
Energy and Raw Materials		\$48	\$10	\$29				\$356		
Water Supply										
Biological Control										
Climate Stability										
Air Quality	\$579	\$670	\$410	\$540				\$251		
Moderation of Extreme Events	\$319		\$1,682	\$841					\$18,270	\$7,694
Pollination										
Soil Formation										
Soil Retention			\$2	\$1		\$18	\$15	\$325		
Waste Treatment			\$516	\$258					\$14,064	\$38,684
Water Regulation	\$1,083					\$4		\$121	\$2,644	\$6,503
Habitat & Nursery			\$9,496	\$4,748	\$828	\$87	\$12	\$736	\$35,791	\$14,688
Nutrient Cycling										
Genetic Resources										
Natural Beauty	\$57,805	\$1,217		\$609			\$13	\$217	\$17,683	\$15,559
Cultural and Artistic Information										
Recreation and Tourism		\$742	\$15,922	\$8,332	\$481	\$285		\$68	\$18,646	\$13,121
Science and Education										
Spiritual and Historic										
<b>Total</b>	<b>\$59,785</b>	<b>\$2,678</b>	<b>\$28,116</b>	<b>\$15,397</b>	<b>\$1,309</b>	<b>\$484</b>	<b>\$40</b>	<b>\$24,634</b>	<b>\$107,097</b>	<b>\$97,126</b>

Land Cover Type	Area (hectares)	Value (\$/hectare/year)	Value of Impacts to Ecosystem Services (\$/year)
Open Water	4	\$0	\$0
Developed, Open Space	129	\$59,785	\$7,697,270
Developed, Low Intensity	205	\$59,785	\$12,262,929
Developed, Medium Intensity	183	\$0	\$0
Developed, High Intensity	49	\$0	\$0
Barren	179	\$0	\$0
Deciduous Forest	242	\$2,678	\$648,584
Evergreen Forest	524	\$28,116	\$14,724,095
Mixed Forest	1	\$15,397	\$12,282
Shrub/Scrub	838	\$1,309	\$1,096,636
Grassland/Herbaceous	242	\$484	\$117,206
Pasture/Hay	302	\$40	\$12,153
Cultivated Crops	96	\$24,634	\$2,364,458
Woody Wetlands	27	\$107,097	\$2,862,971
Emergent Herbaceous Wetlands	11	\$97,126	\$1,066,274
<b>Total</b>	<b>3,031</b>		<b>\$42,864,859</b>

# Summary of Ecosystem Service Impacts

Mine	Annual Value of Ecosystem Service Impacts	Net Present Value of Ecosystem Service Impacts	Total Copper Production for Lifetime of Mine (metric tons)	Relative Impact on Ecosystem Services per Ton of Copper Produced
Solwara 1 (proposed)	\$24,724	\$605,871	127,186	1.0
Prominent Hill	\$1,919,065	\$47,026,675	2,000,000	4.9
Bingham Canyon	\$42,864,859	\$1,050,403,319	17,000,000	13.0
Intag (proposed)	\$8,797,585	\$215,584,802	9,906,472	4.6

# Framework for Evaluating Mining

Who's Interested?  
Investors, Lenders, Insurers,  
Reinsurers, Guarantors



# Thank You

[dbatker@eartheconomics.org](mailto:dbatker@eartheconomics.org)

