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Energy inputs and CO_2 emissions of the nuclear cycle

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23.3.10

Introduction

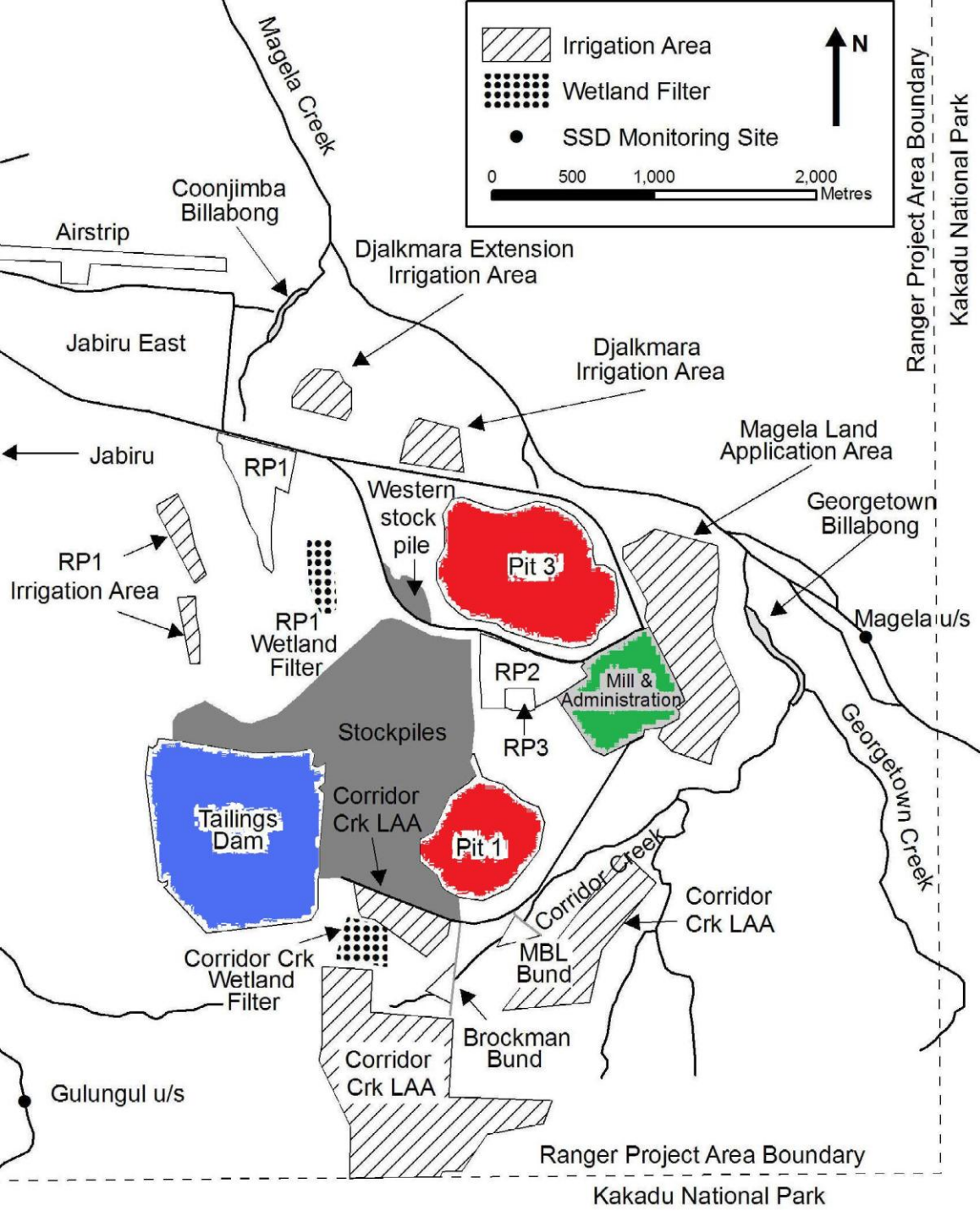
- Nuclear CO2 emissions: 3.5g – 100g per kWh [1], or possibly more?
- For and against: WNA v Storm and Smith
- Uranium mining: insignificant or a major factor?

Mining and Milling of Uranium

- Three methods: open pit, underground, ISL
- Different deposit types: unconformity, sandstone etc.
- Ore grade typically <1%
- Major producers: Canada, Australia, Kazakhstan [2]

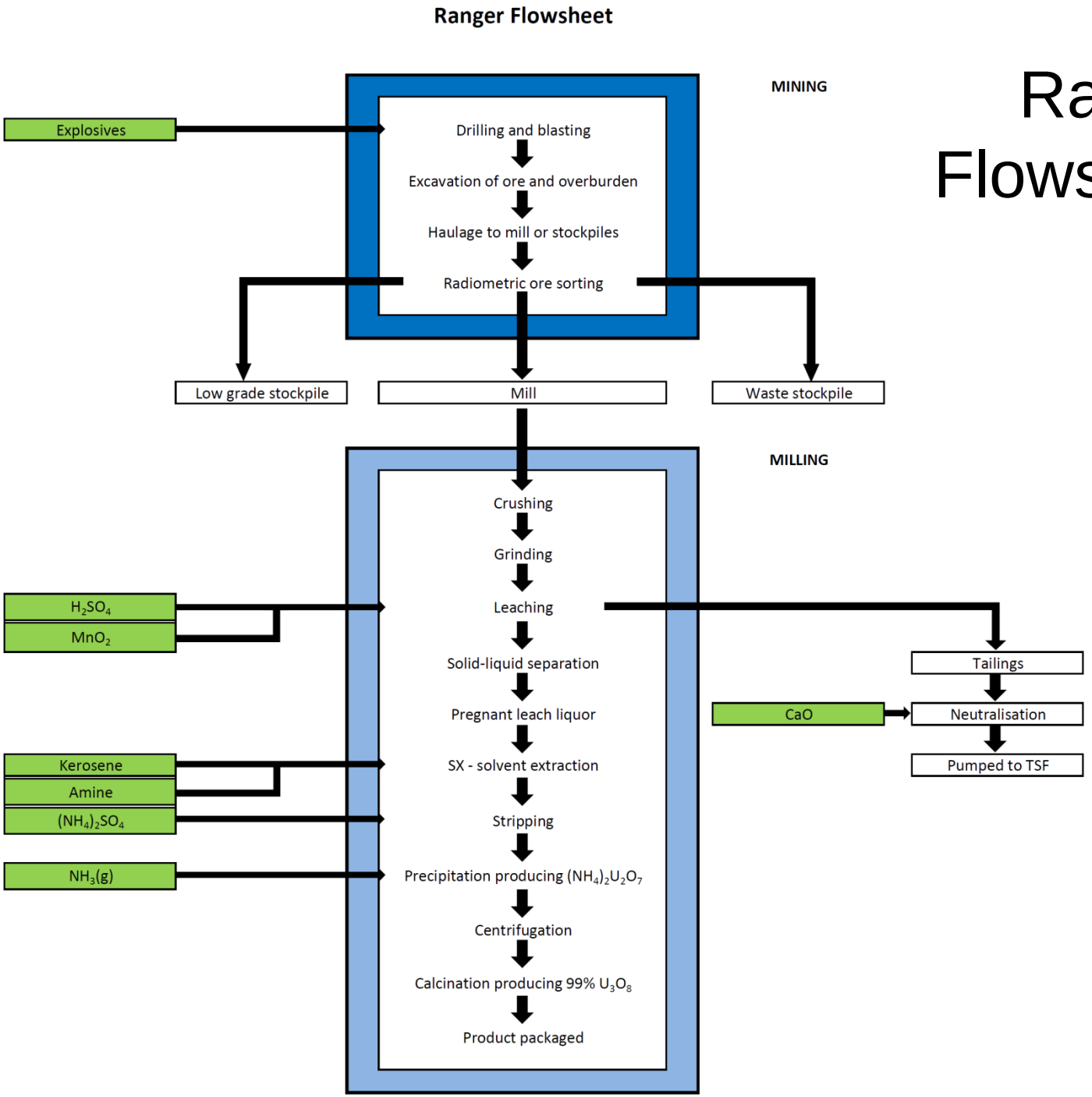
Ranger Mine

- NT, Australia
- 2nd largest by production in the world
- Unconformity deposit
- 5,339 tonnes U_3O_8 in 2008
- Claimed energy use of 273GJ / tonne
- CO_2-eq emissions of 29 tonnes per tonne U_3O_8, but more typically < 20 tonnes [3]



Ranger map: Office of the Supervising Scientist Annual Report 2008-09 [4]
Ranger image: WNA at www.world-nuclear.org/uploadedImages/org/info/Mines_appendices/Ranger2005.jpg

Ranger Flowsheet



Overview of Ranger Process Analysis

Direct inputs / GJ per tonne U_3O_8		Major indirect inputs / GJ per tonne U_3O_8	
Diesel (electricity)	200	Sulphur from crude oil	190
Diesel (other)	20	H_2SO_4	up to 54
		CaO	up to 65
TOTAL:	**220**	**TOTAL:**	**340 - 580**

- 20-25% of emissions due to the production of lime (CaO)

Process Analysis Results

	Energy use / GJ per tonne U	CO_2 emissions / g per kWh
Process analysis	562 – 800	0.75 – 1.18
Process analysis + indirect inputs	645 – 883	0.89 – 1.32
Storm and Smith	1080	1.75
WNA / ERA	325	0.54*

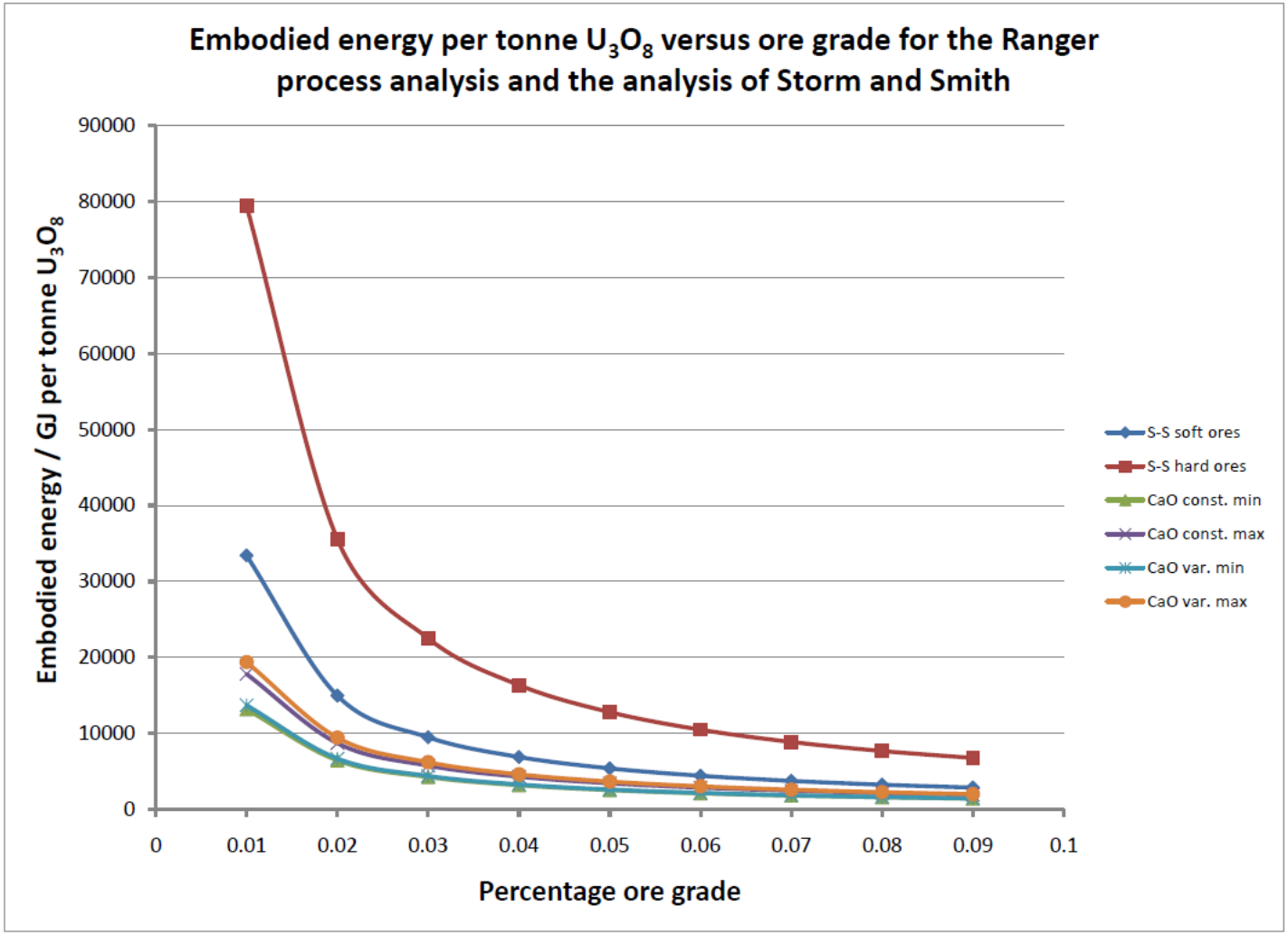
* 20 tonnes CO_2-eq per tonne U_3O_8

Extrapolation of Ranger Flowsheet

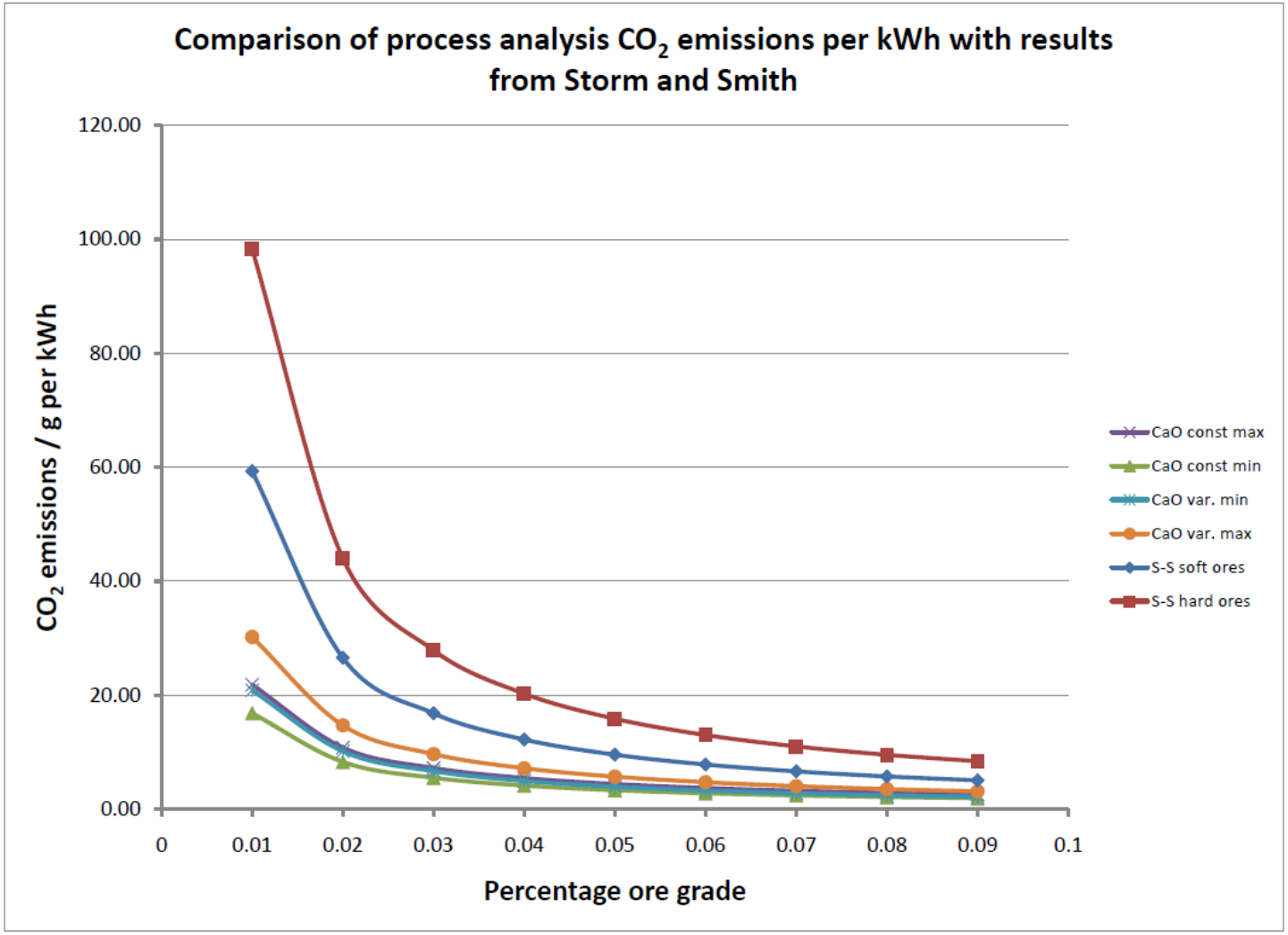
- Effect of ore grade on energy inputs and CO_2 emissions a controversial topic

- Ranger flowsheet extrapolated to lower ore grades

Extrapolation Results



Extrapolation Results (cont.)



Analysis

- Limited to similar ores and gangue
- Most common process and deposit type though
- Heavily dependent on yield – little empirical data to determine this
- May suggest that ore grades < 0.01% become significantly energy intensive using open pit mining

Conclusions

- One of the two front end processes of the nuclear cycle studied
- Results lie between arguments of pro- and anti- nuclear camps, as was expected
- Very low grade ores may be of little value using open pit technique

References

1. Fthenakis, V.M and Kim, H.C, (2007) ‘Greenhouse-gas emissions from solar electric- and nuclear power: A life-cycle study’, Energy Policy 35 pp2549-2557.
2. OECD, IAEA (2008) ‘Uranium 2007: Resources, Production and Demand’, OECD Publishing
3. ERA, (2009) ‘Annual Report 2008’ and ‘Sustainable Development Report 2008’ [online] Available at: www.energyres.com.au/media/38_reports_and_publications.asp
4. Supervising Scientist (2009). Annual Report 2008–2009. Supervising Scientist, Darwin. [online] Available at: www.environment.gov.au/ssd/about/corporatedocs.html