WATER RESEARCH COMMISSION

Water LCA: The impact of energy in SA water infrastructure

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Overview

- what is an Environmental Life Cycle Assessment?
- applicability of LCA results
- comparison of two water production processes
- inclusion of wastewater treatment and water recycling
- inclusion of salinity
- application to a power station
- waste burden shifting
- lessons
- gaps
- way forward

Environmental Life Cycle Assessment - Definition

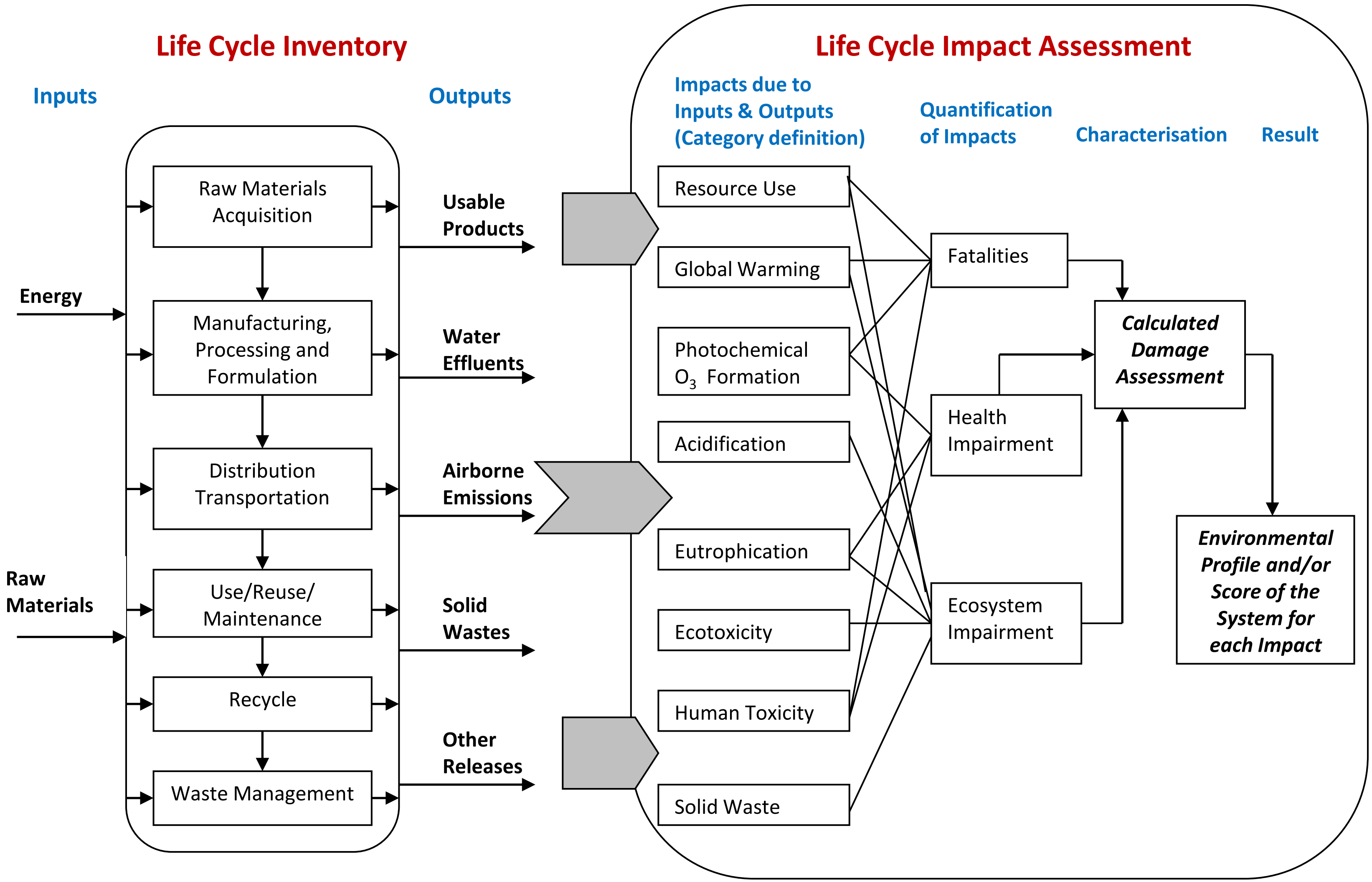
LCA is a technique for assessing the environmental aspects and potential impacts associated with a product by:

- compiling an inventory of inputs and outputs of a system;
- evaluating the impacts associated with those inputs and outputs;
- interpreting the results in relation to the objectives of the study

LCA studies the environmental aspects and potential impacts throughout a product's life (i.e. cradle-to-grave) from raw material acquisition through production, use and disposal. The general categories of environmental impacts needing consideration include resource use, human health and ecological consequences.

SABS and ISO 14040 standard (1997)

Life Cycle Assessment: an overview



Source: modified from SETAC, 1997 and Wenzel et al., 1997

General Applicability

- environmental profile generation
- design for the environment
- product development and improvement
- eco-labelling and environmental claims
- marketing and strategic planning
- environmental reporting
- waste minimisation support
- EIA and SEA support
- ISO 14001 EMS support





Production of Potable Water – Umgeni Wiggins Water Treatment Plant

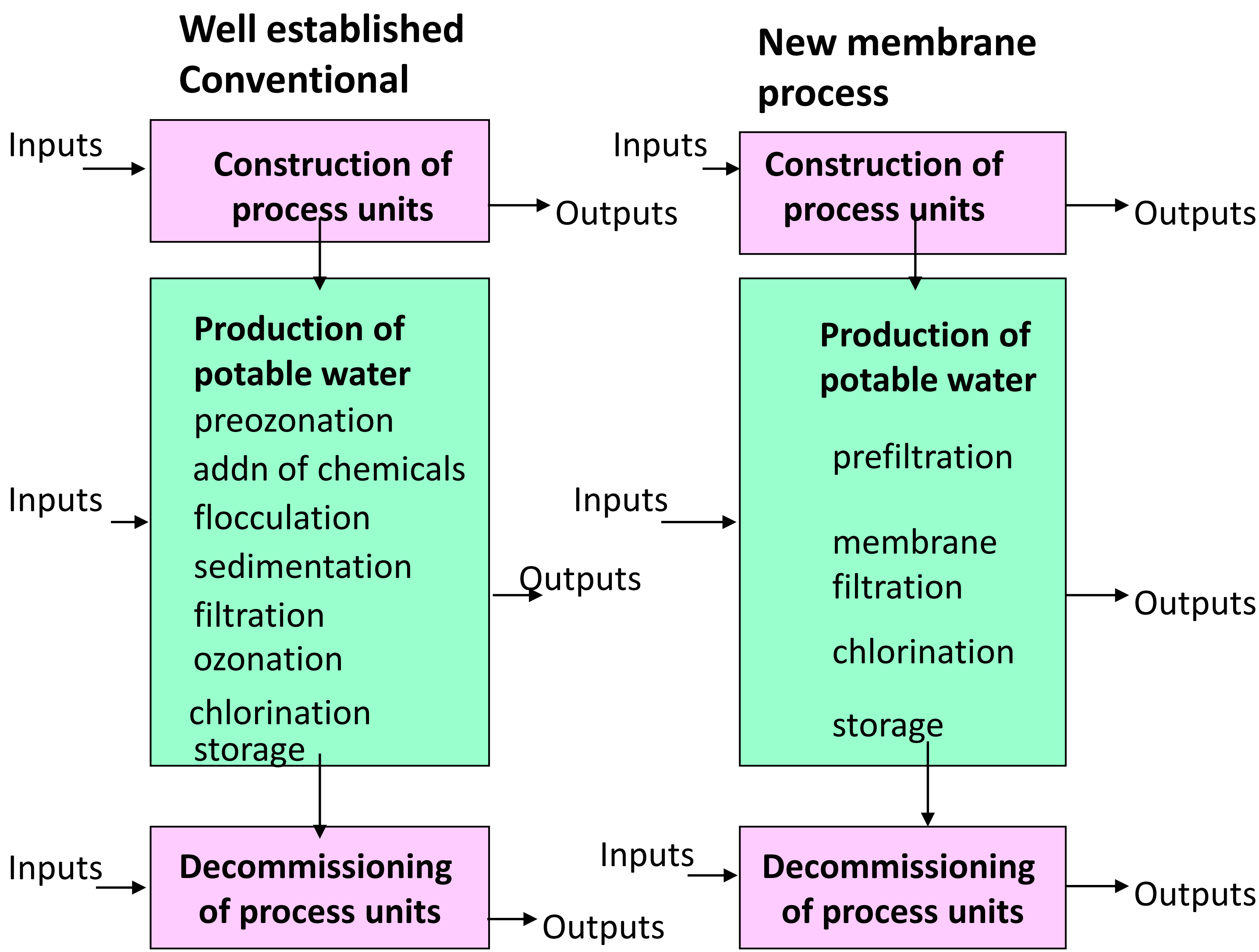
Goal and scope

- generate environmental information on two water treatment processes
- identify improvement potential for processes
- compare environmental burdens of conventional and membrane treatment methods

Functional unit

- 1 000 kg water at the quality stipulated by Umgeni Water

Conventional and New Membrane Water Treatment Processes



Friedricks 2002

Comparison of Environmental profiles

Category	Conventional	%*	Membrane	%*	Units
global warming	1.8E-1	94	2.9E-1	99	kg CO_2-Equiv
ozone depletion	3.6E-9	89	9.5E-10	88	kg R11-Equiv.
acidification	1.2E-3	93	1.8E-3	98	kg SO_2-Equiv.
Nutrient enrichment	7.3E-5	89	5.7E-5	97	kg PO_4 – Equiv
photochemical	1.5E-5	84	4.9E-6	83	kg Ethene-Equiv
aquatic ecotoxicity	2.7E-3	98	2.1E-4	92	kg DCB-Equiv.
human toxicity	4.1E-3	81	1.8E-3	89	kg DCB-Equiv.

* Percentage from the Operation Stage

Friedricks 2002

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Not too different

* Percentage from the Operation Stage

Overall Materials and Energy Used per Kilolitre of Water

STAGE	INDICATOR			
	Mass (kg)		Energy (MJ)	
	Conventional Method	Membrane Method	Conventional Method	Membrane Method
Construction	0.051	0.03	0.08	0.05
Operation	2.70	2.50	2.06	2.59
Decommission	0.0002	0.0004	0.0015	0.0036

Friedricks 2002

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Summary of Results

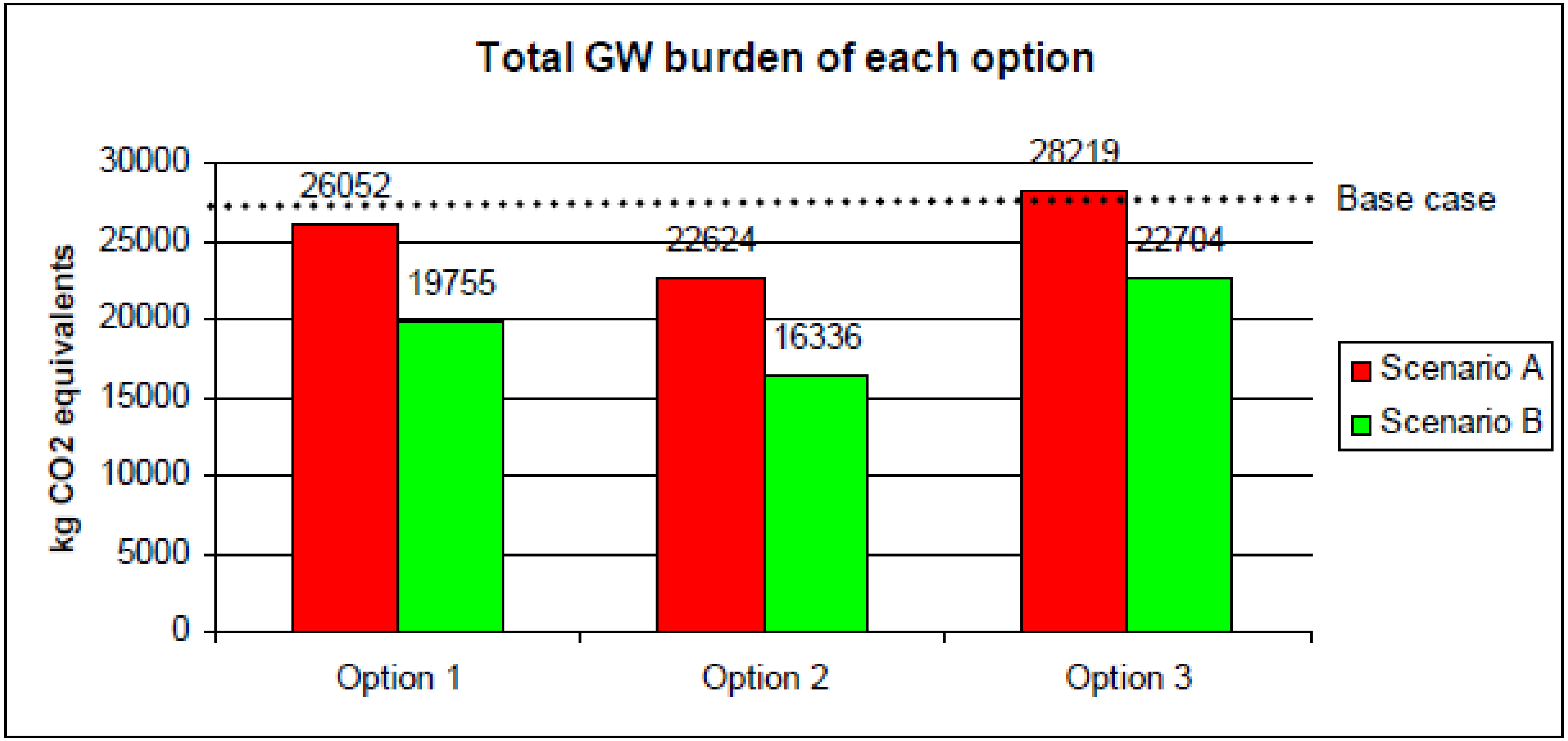
- The most significant life stage in terms of environmental impacts is the operation stage
- The majority of the environmental impacts are traced to electricity production
- Ozonation and sludge treatment have the highest environmental burdens for the conventional technology
- Pumping and the design of the plant have the highest contribution towards environmental burdens for the membrane technology
- The two technologies are comparable from an environmental point of view

However the membrane process is an emerging process while the conventional process is well established

Recommendations for Water Production

- for environmental improvement
  - increase electricity efficiency
  - optimisation of ozonation (conventional method)
  - efficiency of pumping and the design of the plant (membrane method)
- for further LCA research
  - develop LCA impact categories for salination and water consumption (i.e. water shortage)
  - extend the study by including more details and more areas of the water cycle

Options for the Provision of Water to 200 000 New Domestic Consumers in Durban



Option	Description
1	sweat the assets
2	recycle treated wastewater to industry
3	new construction (dam, waterworks, sewage works)

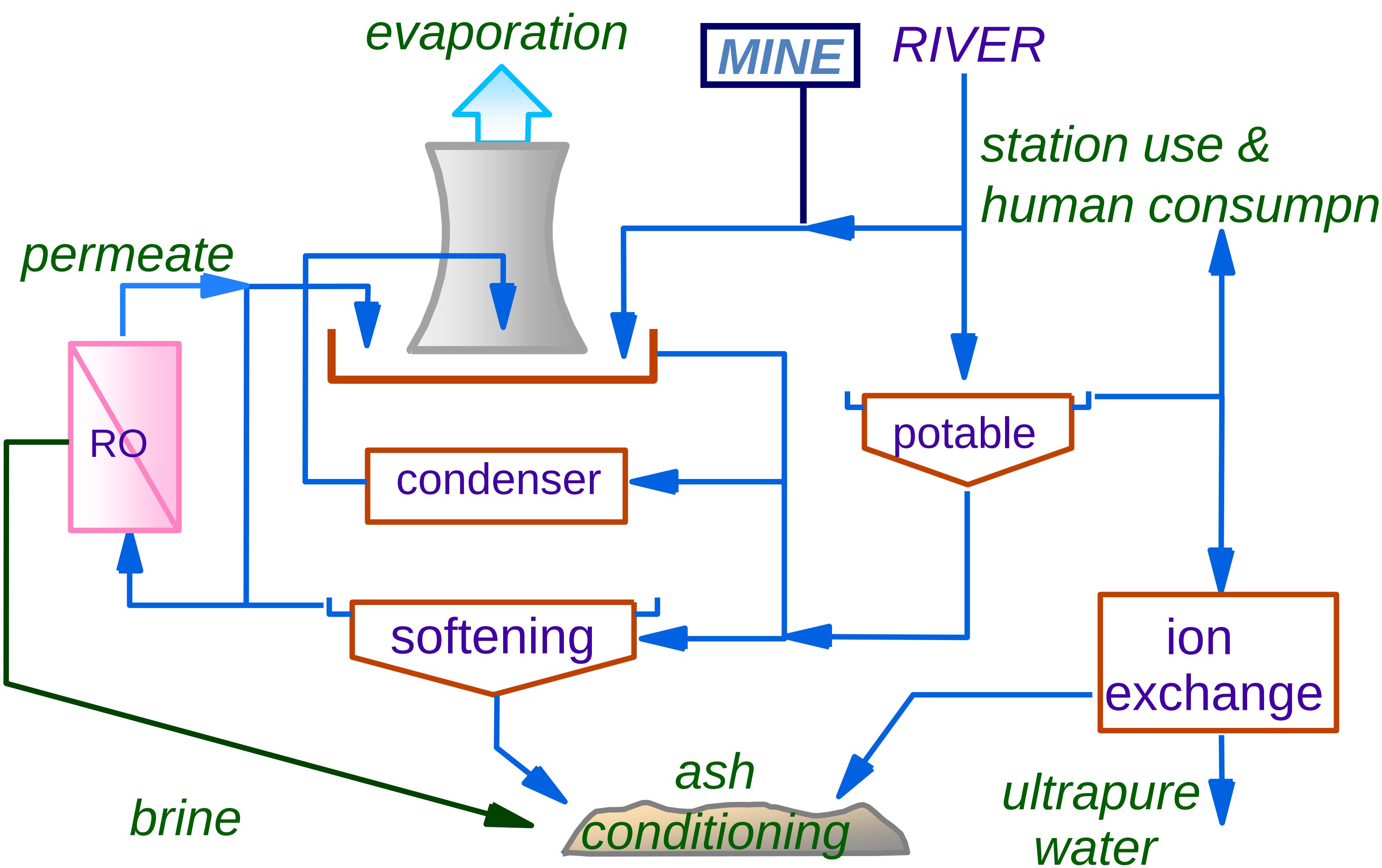
scenario A – waterborn sewage
scenario B – dry on-site sanitation

S Pillay 2006

Summary of Results (for Durban)

- electricity consumption per kL is a metric for environmental burden
- wastewater treatment has the highest burden (activated sludge)
- dry on-site sanitation has the lowest environmental burden
- water recycling to a lower class (industry) user is to be encouraged

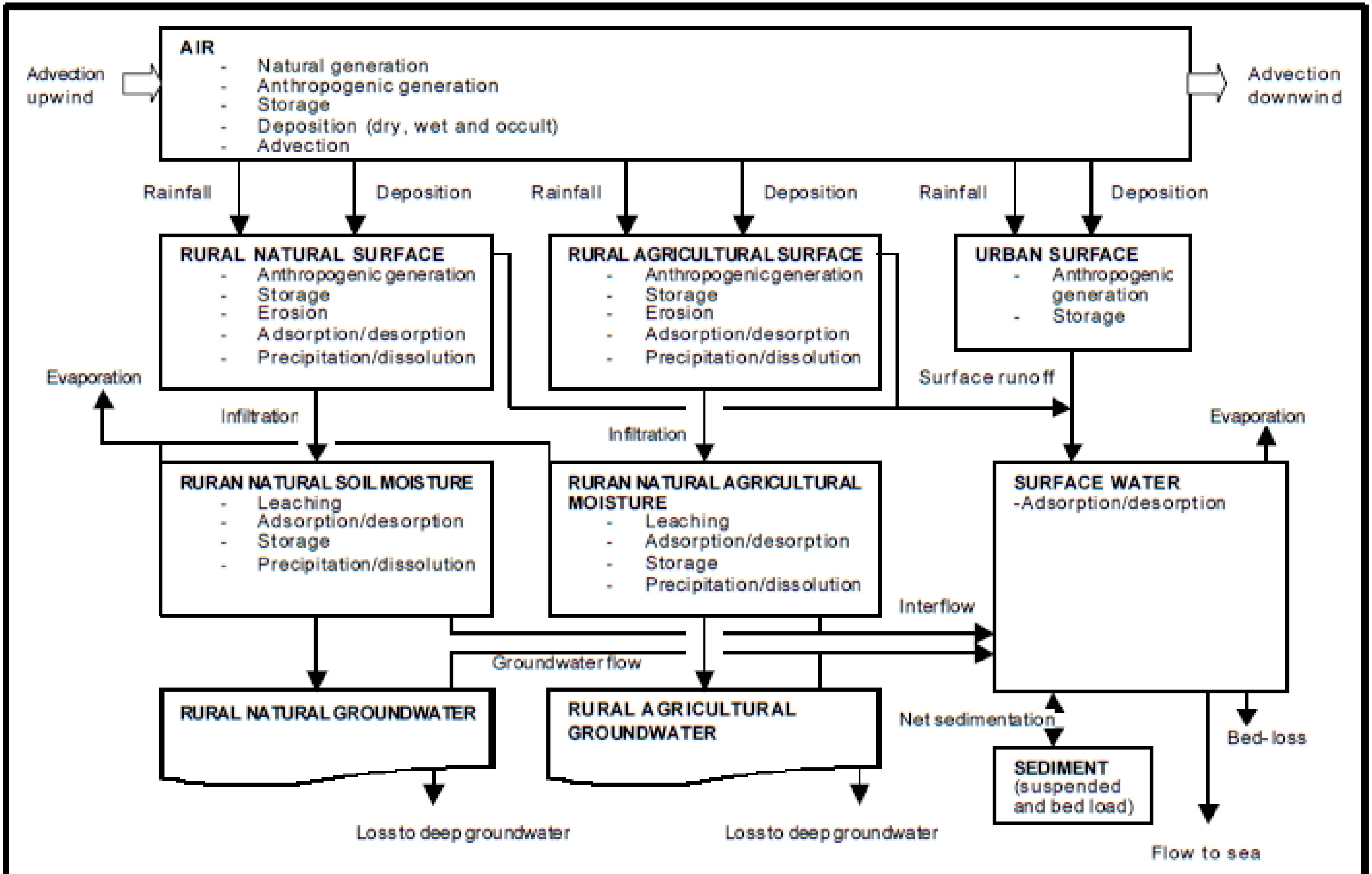
Letabo Power Station



Letabo Power Station

- where to put the salts
- analysed using LCA thinking + water pinch
- permit was on or off (permit / prohibit) to discharge mine water to the river
- mine water could be used *at a cost*
- LCA thinking guided the modelling

Conceptual Model for the Fate of Salts



A Leske 2004

Salinity Potential for Release in Different Compartments

Initial release compartment	Total salinity potential (kg TDS equ./kg)
Atmosphere	0.013
River	0.16
Rural natural surface	0.03
Rural agricultural surface	1.00

A Leske 2004

irrigation with saline effluent is a controlled activity

Regional Analysis of Desalination

- reverse (RO) osmosis desalination using electricity does not shift salt from one region to another
- ion exchange (only) is preferable to RO
  BUT
  RO is preferable to ion exchange + flocculation

Ras and von Blottnitz (2011)

Lessons

- limited number of detailed LCA assessments are necessary
- LCA *thinking* can be guided by detailed assessments
- burden during operational phase is much greater than during construction or decommissioning phase
- electricity consumption is a good indicator for environmental burden
- much of the past policy is consistent with recent LCA thinking

Gaps

- encourage LCA thinking
- low penetration into policy making processes and debates
  - sanitation policies
  - acid mine drainage option analysis
  - water cascade / reuse / augmentation decisions
  - industrial effluent discharge permiting

The Way Forward

- analysis of complex system problems
- identify high impact activities
- tool to guide research priorities
- guide improvement trajectories