Towards Improved Environmental Indicators During the Mining Life Cycle

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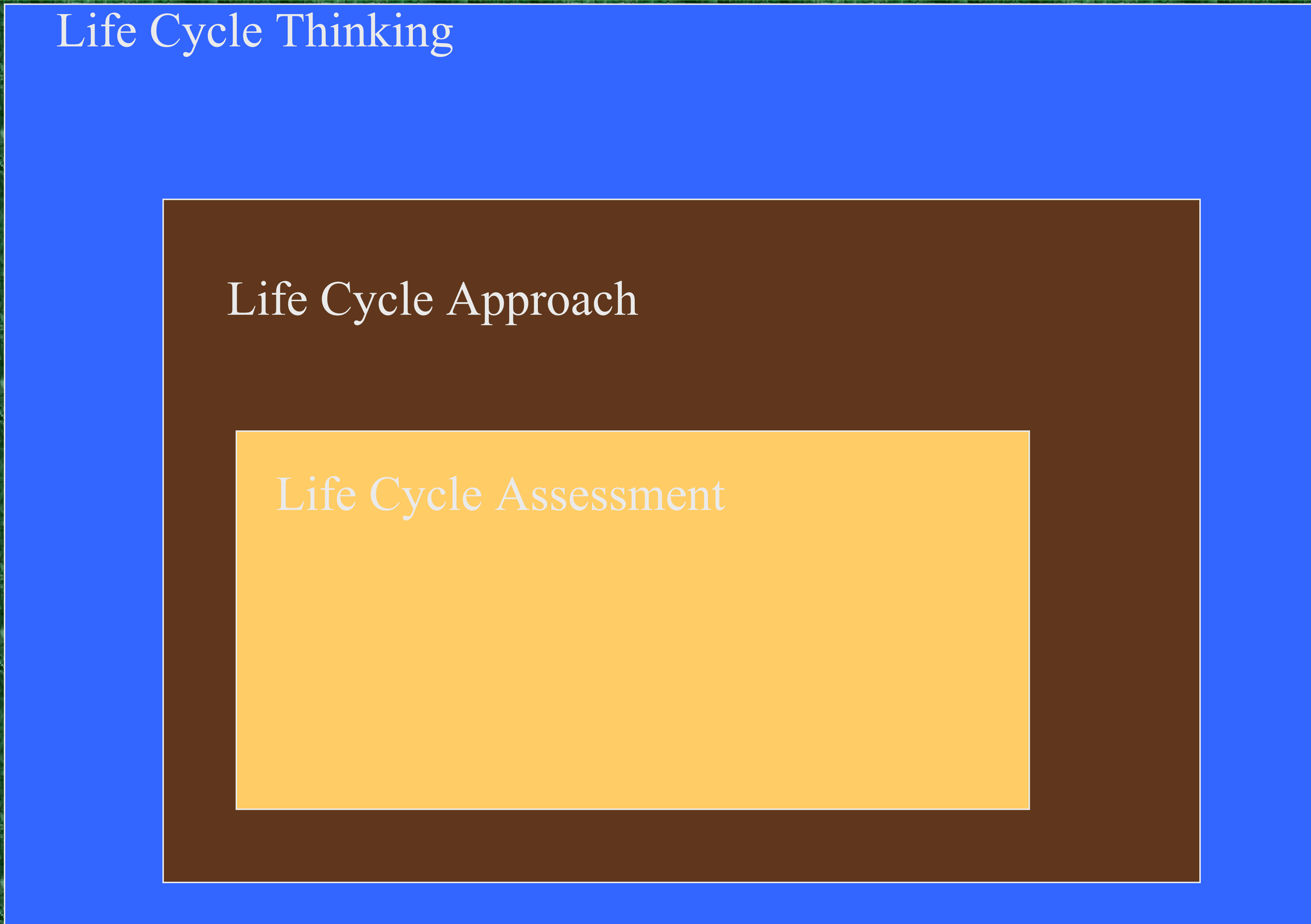
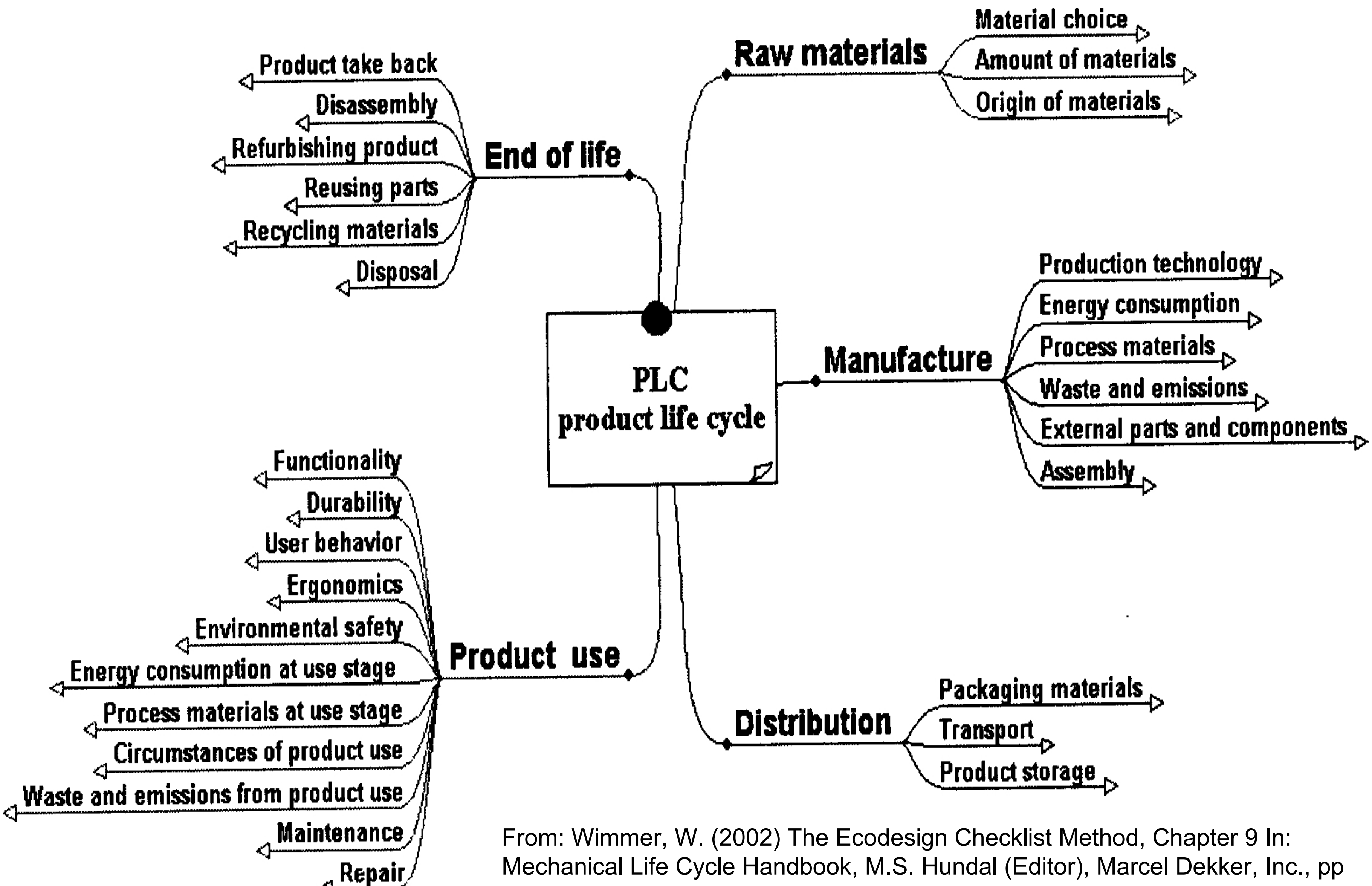
Outline

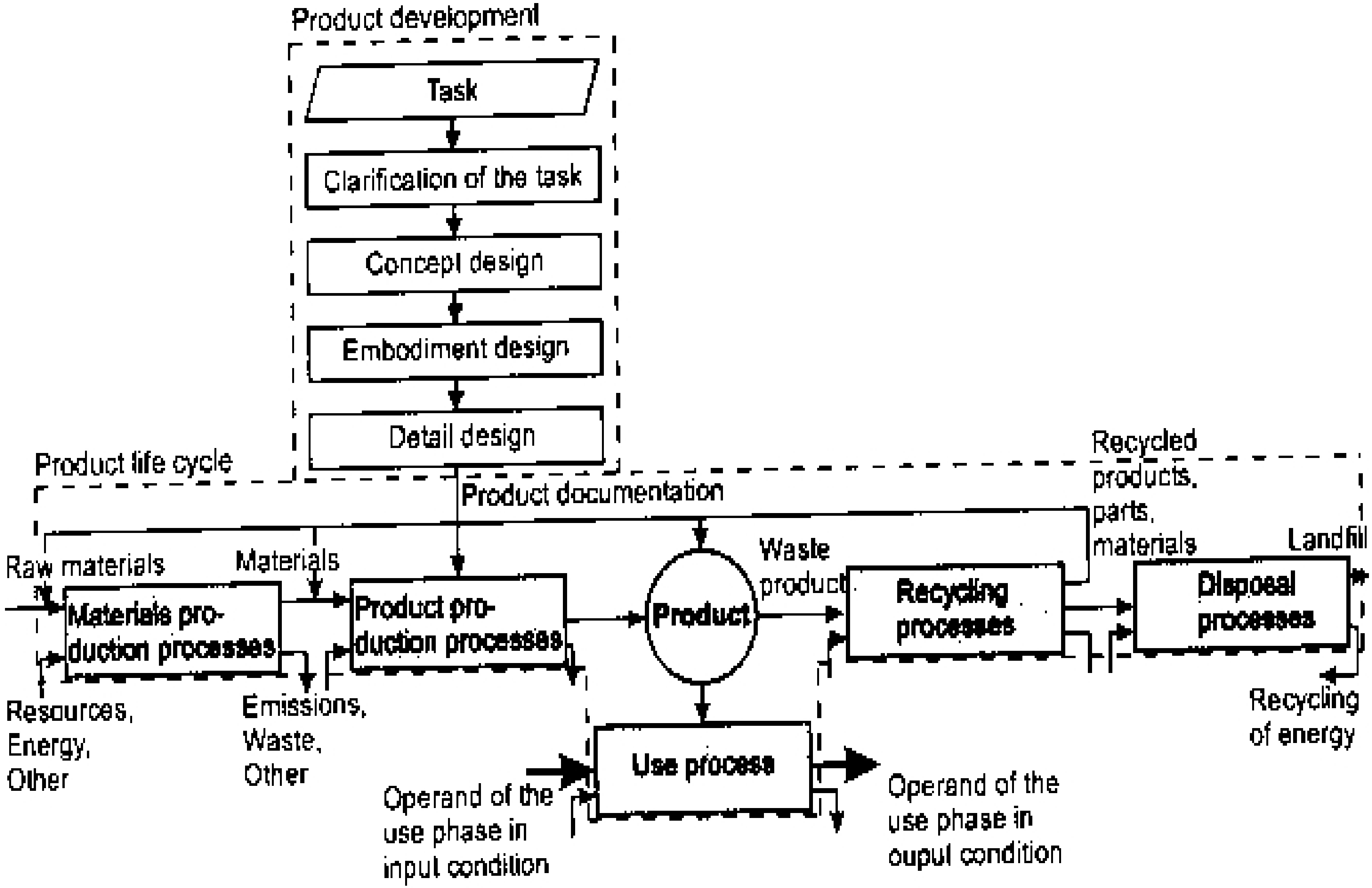
- Dangers of oversimplification
- Scale
- Mining life cycle
- Mine facilities
- Environmental impacts throughout the mine life cycle
- Energy
- Observations



Frankl, P. and F. Rubik (2000) Life Cycle Assessment in Industry and Business, Springer-Verlag, 280 pp.



From: Wimmer, W. (2002) The Ecodesign Checklist Method, Chapter 9 In: Mechanical Life Cycle Handbook, M.S. Hundal (Editor), Marcel Dekker, Inc., pp 199-216



Birkhofer, H. and C. Gruner (2002) Holistic Design for Environment and Market Methodology and Computer Support, Chapter 10 in: Mechanical Life Cycle Handbook, M.S. Hundal (Editor), Marcel Dekker, Inc., pp 217-244

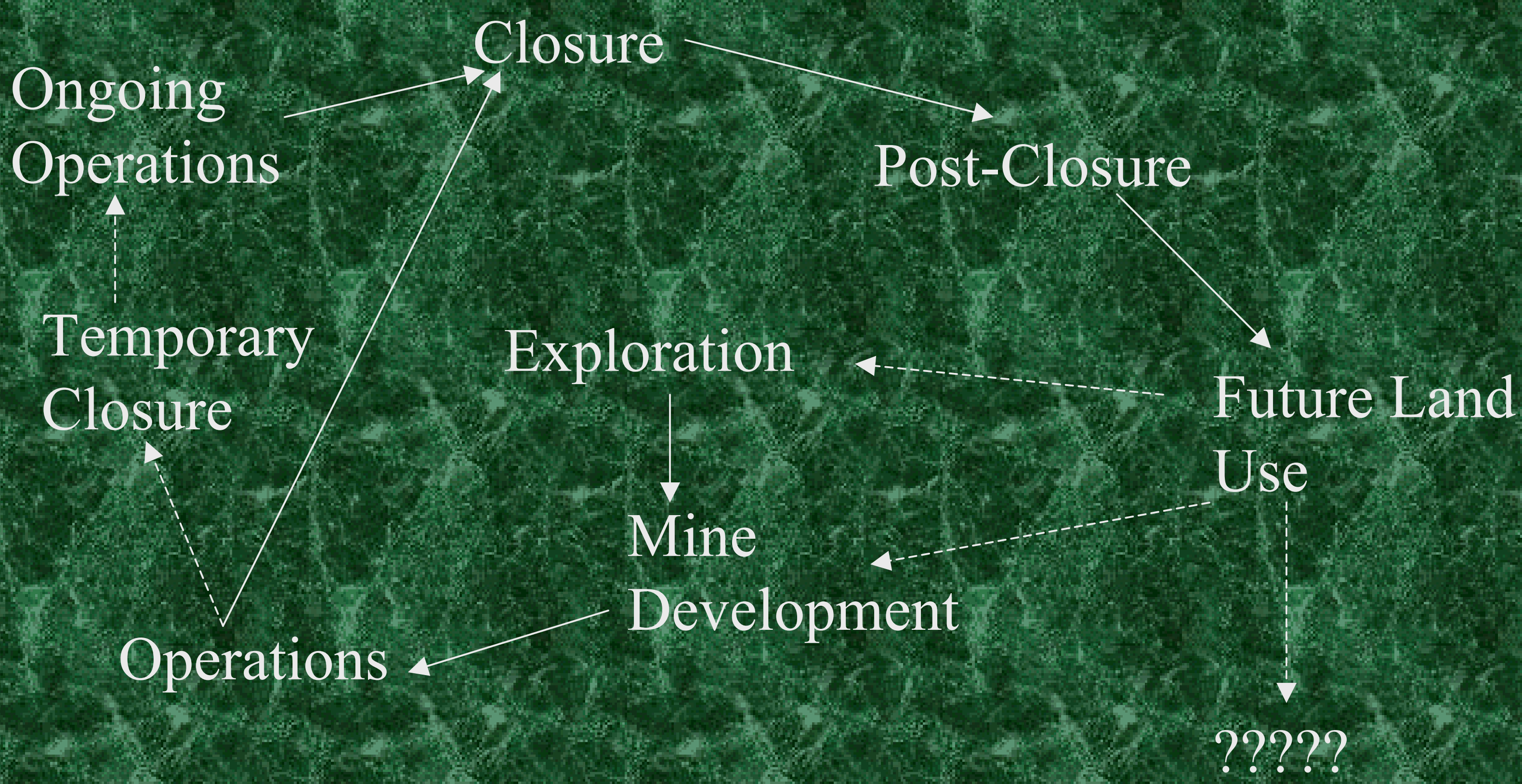
Dangers of Oversimplification

- Extrapolation of selected information can result in incorrect generalizations:
  - For example, presence and assumptions about bio-availability of some constituents
    - Arsenic in some copper ores
    - Selenium in some phosphates
    - Mercury in some gold ores
    - Sulfides in many gold and base metal ores
- Including specifics will increase data collection intensity for LCI's

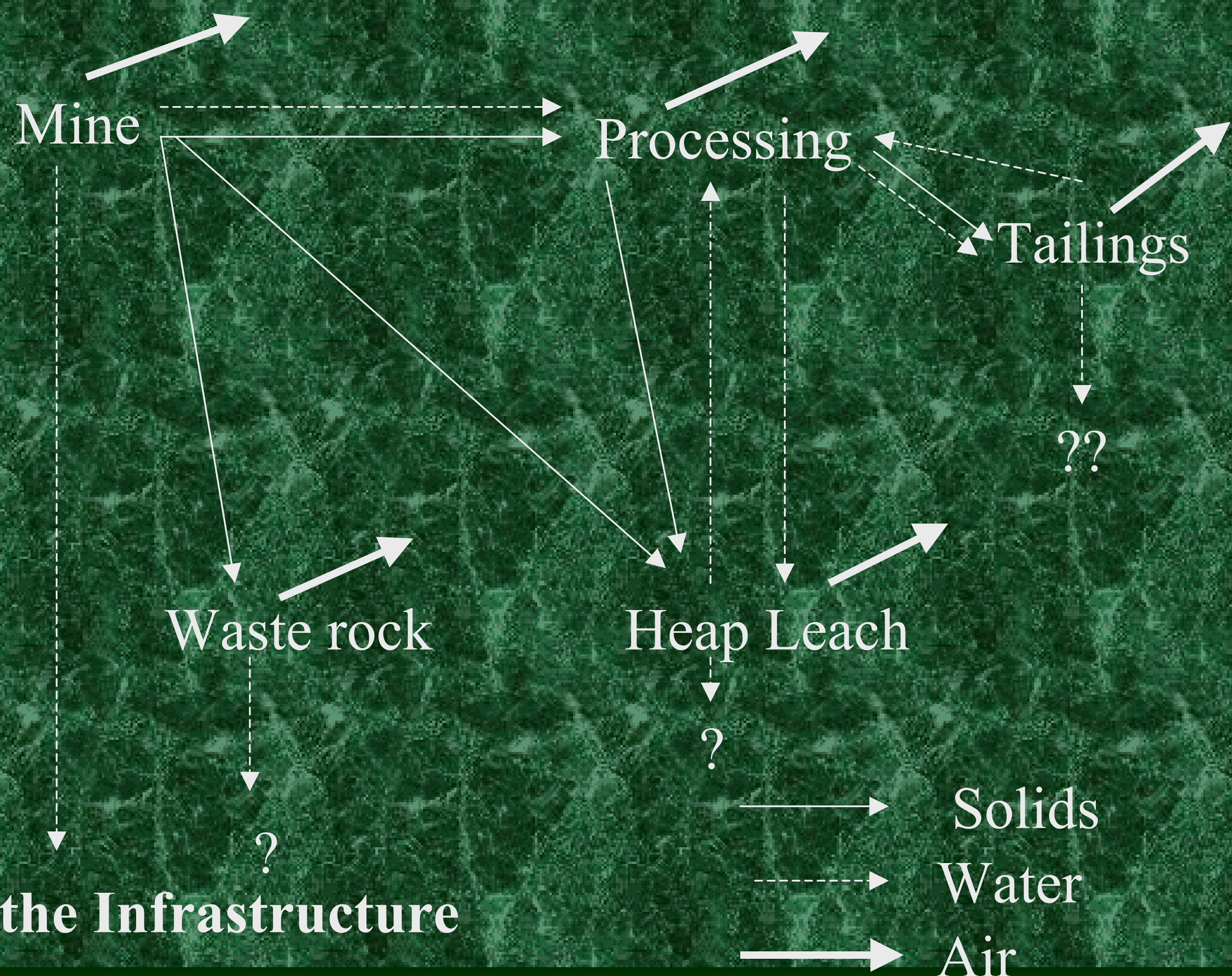
Scale and Technology

- LCA indicators must be developed at the site level, in a few cases at a regional level
- National level indicators for mineral systems:
  - Are being developed in the USA (www.mackay.unr.edu/mlc) and Canada
  - Not all of these are applicable and useful to LCA
- Technological advances can reduce mining impacts

Mining Life Cycle (Spiral?)



Mine Facilities: Solids and Water Flows and Releases to the Air



Remember the Infrastructure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Environmental Impacts – Area of Disturbance

Mine Life-Cycle Stage	Normal Operations	Failures – probability of release
Exploration	Low	Low
Development	Increasing	Increasing
Operations	Highest	Highest
Closure	Reducing	Reducing
Post-Closure	Very Low	Very Low?


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LCA Approaches to Land Use

- Sliwka, et al*:
  - Land use = land requirement x duration ($y.m^2/t$)
- Chapter 2: Impact assessment of resources and land use:
  - Land use = area x duration of use
  - Transformation impact = (change in) quality x area
  - Occupation impact = quality x area x time

(note that "quality can be expressed in various indicators for flora, fauna, soil surface or structure or may be quantitatively different for each indicator")

* Sliwka, P., et al (2001) A Global Environmental Impact Assessment for Bauxite Mining – Land Use and Soil Erosion, Proc. Of Light Metals, TMS, New Orleans, pp. 85-90.

Environmental Impacts – Water Management

Mine Life-Cycle Stage	**Supply/ Consumption**	**Potential Water Quality Impacts**
Exploration	Low	Low
Development	Increasing	Increasing to High
Operations	Highest	Highest
Closure	Reducing	High
Post-Closure	Very Low	High to low?

Water Quality Impacts

- Process chemicals:
  - Cyanide
  - Sulfuric acid
  - Organics
  - Others
- Geologic characteristics of rock:
  - Acid drainage
  - Metal leaching

Sources of Water Quality Impacts

Source	Life Cycle Stage	Long-term Issue
Process Chemicals	Operations to Post-Closure	Yes to maybe
Geologic Characteristics of Rock	Exploration to post-closure	Definitely when it occurs

Energy

Life Cycle Stage	Activities	Types of Energy
Exploration	Airborne surveys, land surveys, drilling, assays, interpretation	Fuel, electricity
Development	Environmental studies, design, procurement, construction	Fuel, electricity
Operations	Blasting, transport, processing, refinement, water management, etc.	Explosives, fuel, electricity

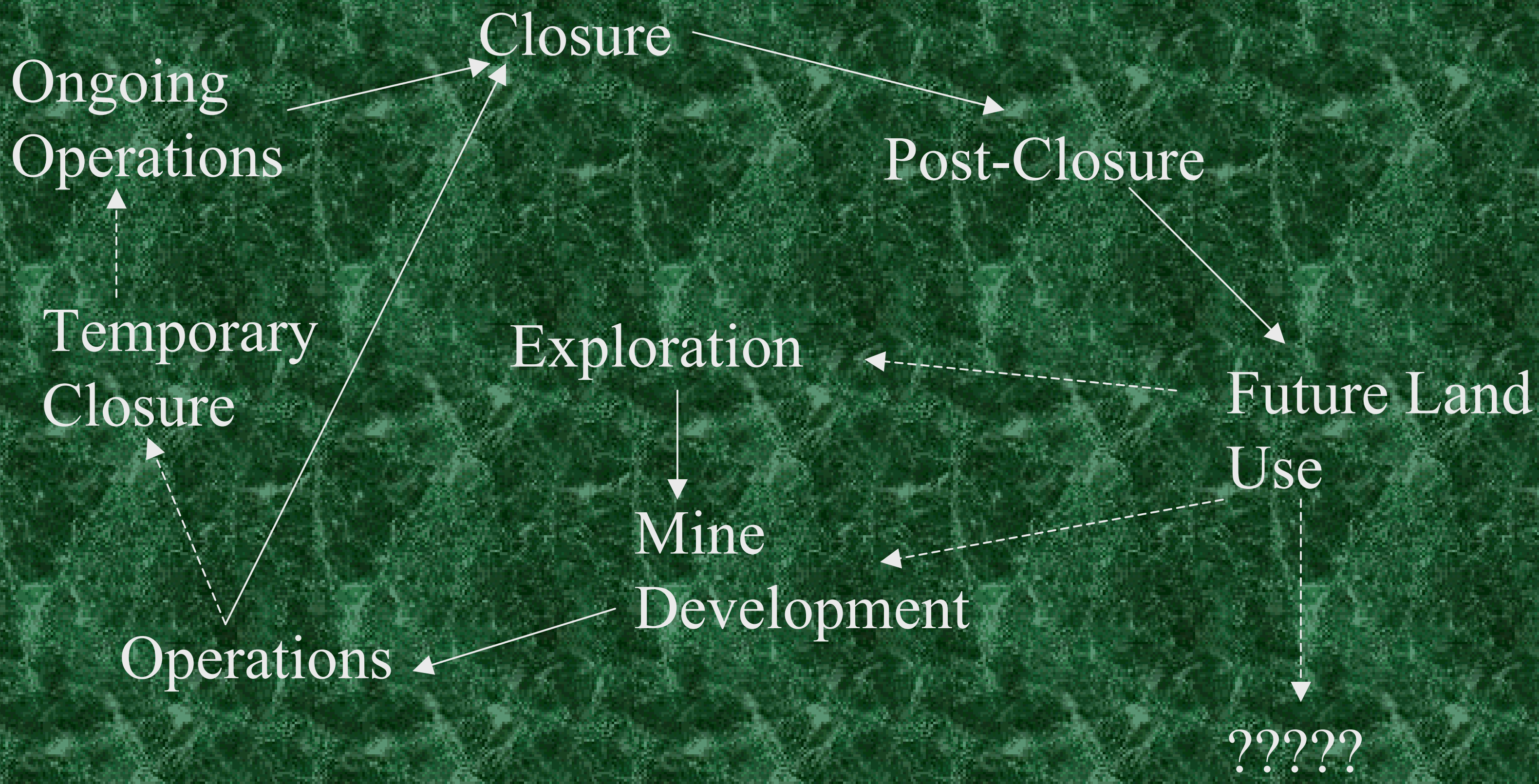
Energy (2)

Life Cycle Stage	**Activities**	**Types of Energy**
Closure	Demolition, regrading, reclamation, water management	Fuel, electricity
Post-closure	Monitoring, treatment, etc.	Fuel, electricity

Observations (1)

- For a specific metal at a snapshot in time:
  - Not all mines are at the same stage in their life cycle – there are different impacts to area of disturbance, water consumption, etc.

Mining Life Cycle (Spiral?)



Observations (1)

- For a specific metal at a snapshot in time:
  - Not all mines are at the same stage in their life cycle – there are different impacts to area of disturbance, water consumption, etc.
  - Therefore: total impact is an integration of impacts from all mines at all their different life cycle stages such as exploration, development, operations, closure, etc.
  - Similarly for energy use

Observations (2)

- Transformation in practice:
  - Open pit mine: natural vegetation to open pit (void) to lake (water quality?)
  - Waste rock: natural vegetation to new land form to new land productivity (higher or lower than before), stable surface
  - Tailings: natural vegetation to new land form to new land productivity, less stable surface initially
- Period for ‘completing’ the transformation cycle is dependent on many factors, e.g. ore body, site physical and climatic conditions, etc.

Observations (3)

- The ‘R’ word:
  - Reclamation
  - Rehabilitation
  - Remediation
  - Restoration
  - Renaturation
- Topsoil can be salvaged if sufficiently developed and then used for ‘R’ – very little loss to fertility, etc. before and after mining
- Use native species for ‘R’ – may influence the time it takes for ‘success’ or ‘completion’

Observations (4)

- Site specific conditions make it difficult to generalize, especially when a metal/material is mined in a wide range of climatic and physical conditions (e.g. copper from the Atacama dessert and Indonesia)
- What considerations for:
  - Abandoned/orphaned mines?
  - Alternative long-term land use: renewable energy generation (e.g. wind), etc.

Closing Comments

- The concepts of impact assessment for metal mining was presented using Life Cycle Thinking – further work required to operationalize
- Average values for land use and other environmental impacts from mineral extraction can be misleading; it may under- or over-estimate the true impacts
- Not all mines are at the same stage in their life-cycle; LCI must integrate impacts over the various stages
- Site specific evaluations are necessary to obtain accurate LCI