A Zero Waste Framework for a New Minerals Industrial Complex

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Roadmap to a Resource Efficient Europe

As we move towards a genuinely consumption based, sustainable materials management or a "circular economy", where waste becomes a resource, a more efficient use of minerals and metals will result.

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

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The New Minerals Industrial City (MIC)

- **Aluminium Complex**:
  - Alumina Refinery (1.8 Mtpa)
  - Boiler House for Steam Generation (660 t/h)
  - Residue Area / Red Mud Storage (2.0 Mtpa)
  - Aluminium Smelter (0.74 Mtpa) & Rolling Mill (0.25-0.46 Mtpa)
- **Phosphate Complex**:
  - Sulphuric Acid Plant (4.5 Mtpa)
  - Phosphoric Acid Plant (1.52 Mtpa)
  - Ammonia Plant (1.09 Mtpa)
  - Di-Ammonium Phosphate Plant (DAP/MAP Plant) (2.92 Mtpa)
- **Co-Generation Power Plant (2'400 MW)**
- **Desalination Plant (1.025 Mm^3/day)**
- **Workers Accommodation / Village / Recreational Areas**
- **Communal Waste / Sewage Treatment (1'760 m^3/day)**

Waste Streams - Aluminium Complex

Facility	Capacity	Completion Date	Waste Streams
Alumina Refinery	1.8 Mtpa	2014	2.0 Mtpa ARR
Refinery Captive Steam Plant	660 tph (7,300 kPa at 313°C)	2014	230,000 Nm3/h flue gas with 1.0 tph SOx
Aluminium Smelter	0.74 Mtpa	2013	103 t/ph CO2 + Cryolite breakdown products
Rolling Mill	0.46 Mtpa	2013	Wastewater

Waste Streams - Phosphate Complex, Main Power Station & Desalination Plant

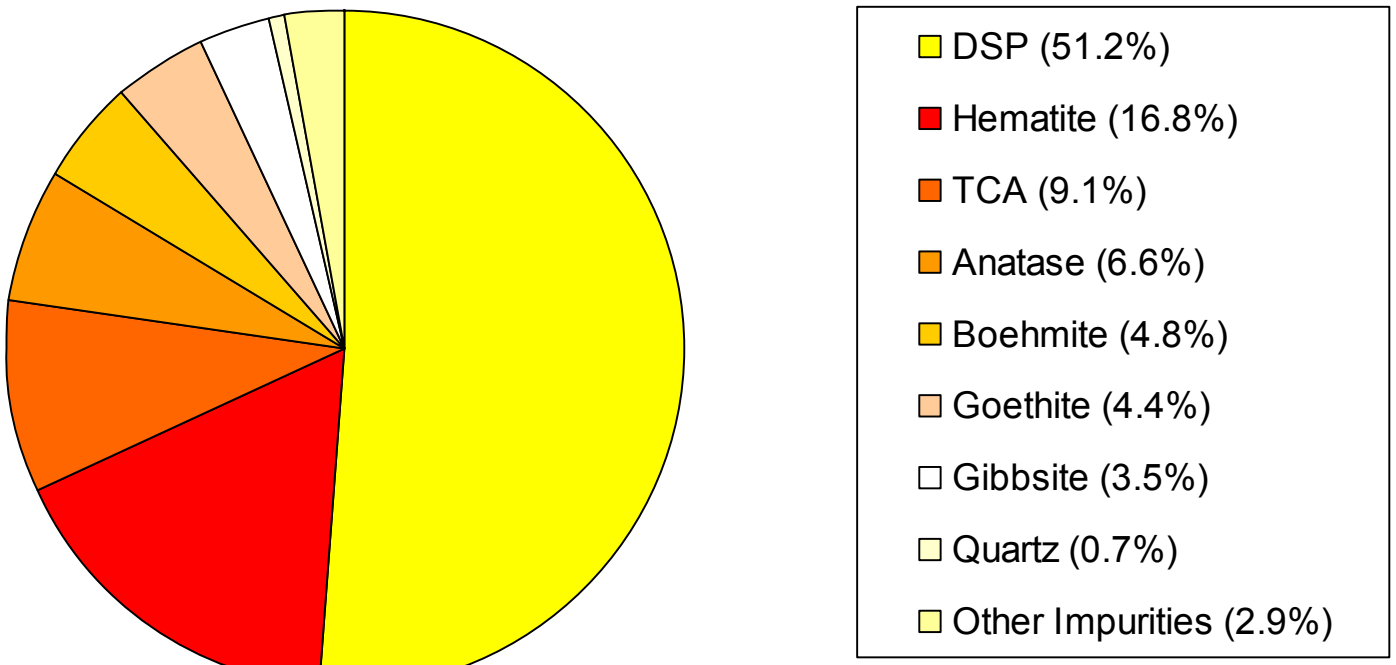
Facility	Capacity	Notes	Waste Streams
Sulphuric Acid Plant	4.5 Mtpa H_2SO_4	Three plants, 4,500 tpd each 240 t/h steam (480°C, 60 bar) per plant	Airborne emissions (e.g., SO_2, H_2SO_4); spent catalyst; ancillary waste
Phosphoric Acid Plant	1.52 Mtpa	Three plants @ 4380 tpd Acid, expandable to 4,800 tpd	21,000 tpd phospho-gypsum; 4,415 tpd highly acidic waste water (internal recycle)
Ammonia Plant	1.09 Mtpa	3,300 tpd plant	Airborne emissions
Diammonium Phosphate Plant	2.92 Mtpa	Four plants @ 8,000 tpd	Returned to phosphoric acid plant
Power Plant	160 MW	Two x Siemens turbines	Airborne emissions
Desalination Plant	40,000 m^3/day	Multi-effect distillation (MED)	60,000 m^3/day saline concentrate

Co-Generation Power Plant	2,400 MW	1,350 MW Aluminium Smelter 1,050 MW Domestic Consumption	Airborne emissions
Main Desalination Plant	1.025 Mm^3/day	25,000 m^3/day Aluminium Complex 1.0 Mm^3/day Domestic Consumption	1.6 Mm^3/day saline concentrate (Brines)

Main Waste Streams

- Alumina Refinery Residue (ARR): → 2.0 Mtpa (~ 5,500 tpd)
- Wastewaters (Brines) from Desalination Plants
  - 1.6 Mm^3/day of Brines from Main Desalination Plant (30% RO / 70% MED)
  - 60,000 m^3/day from Phosphate Complex Desalination Plant (100% MED)
- SOx, NOx and CO2 Emissions from:
  - Refinery Boiler House (230,000 Nm^3/h Flue Gas with ~ 24 t SOx/day)
  - Sulphuric Acid Plant (~ 26 t SO2/day)
  - Power Station(s)
  - Ammonia Plant
- Phospho-gypsum: ~ 21,000 t/day
- Acidic waste streams from phosphoric acid production
- Wastewaters resulting from MAP/DAP production
- General Effluent, Sewage & Communal Waste (~ 1,760 m^3/day)

Estimated Mineralogical Composition of Alumina Refinery Residue (ARR)



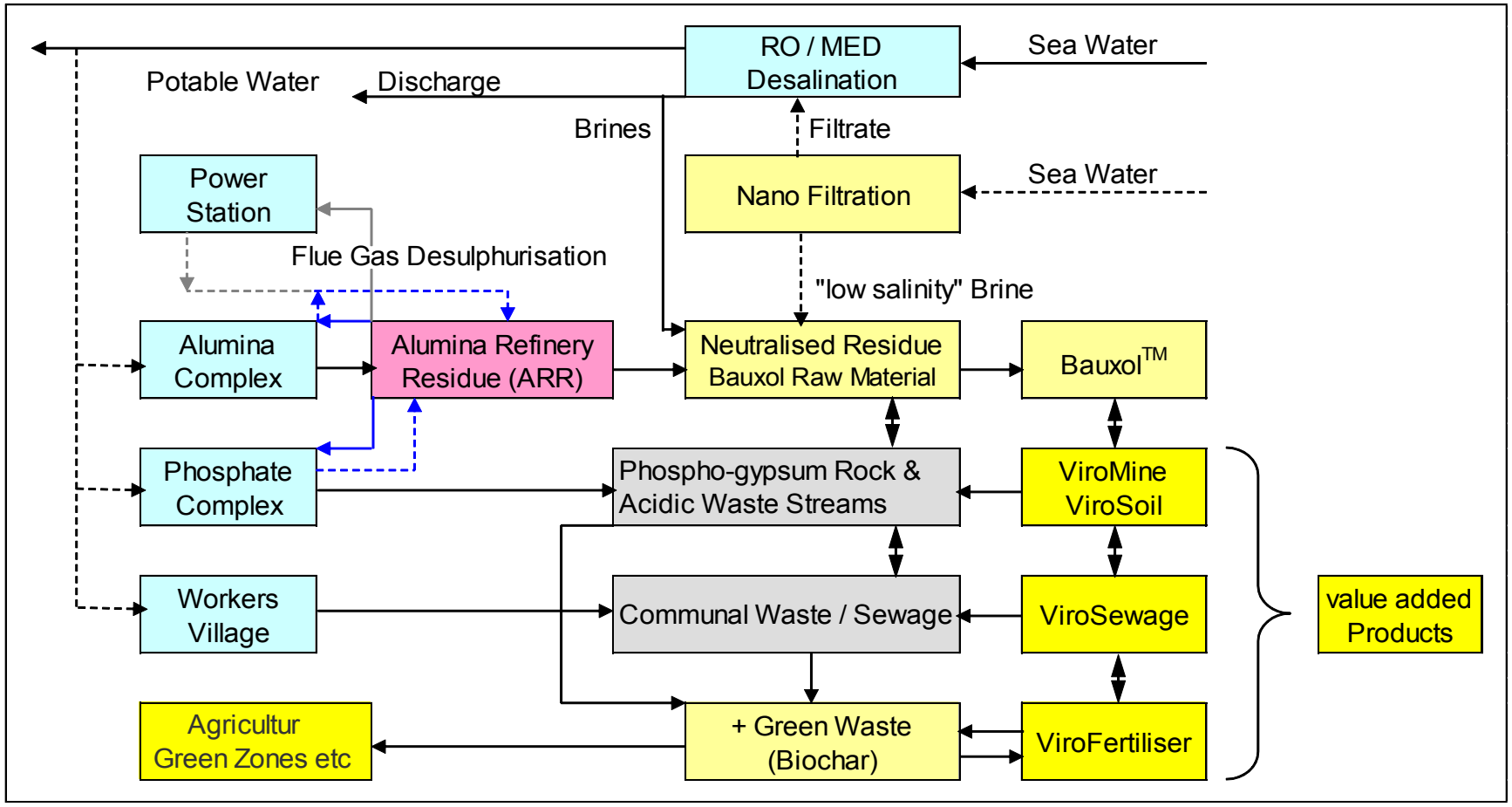
Beneficial Properties of DSP and Neutralisation Products (Hydrotalcite)

- Large Acid Neutralisation Capacity
  - Acidic Mine Tailings and Waste Waters
  - Flue Gas Adsorption (SOx, NOx)
  - Acidic Sulphate Soils
- Removal of Heavy Metals
  - Waste Water and industrial Solid Waste:
  - Remediation of contaminated Soil and Sites

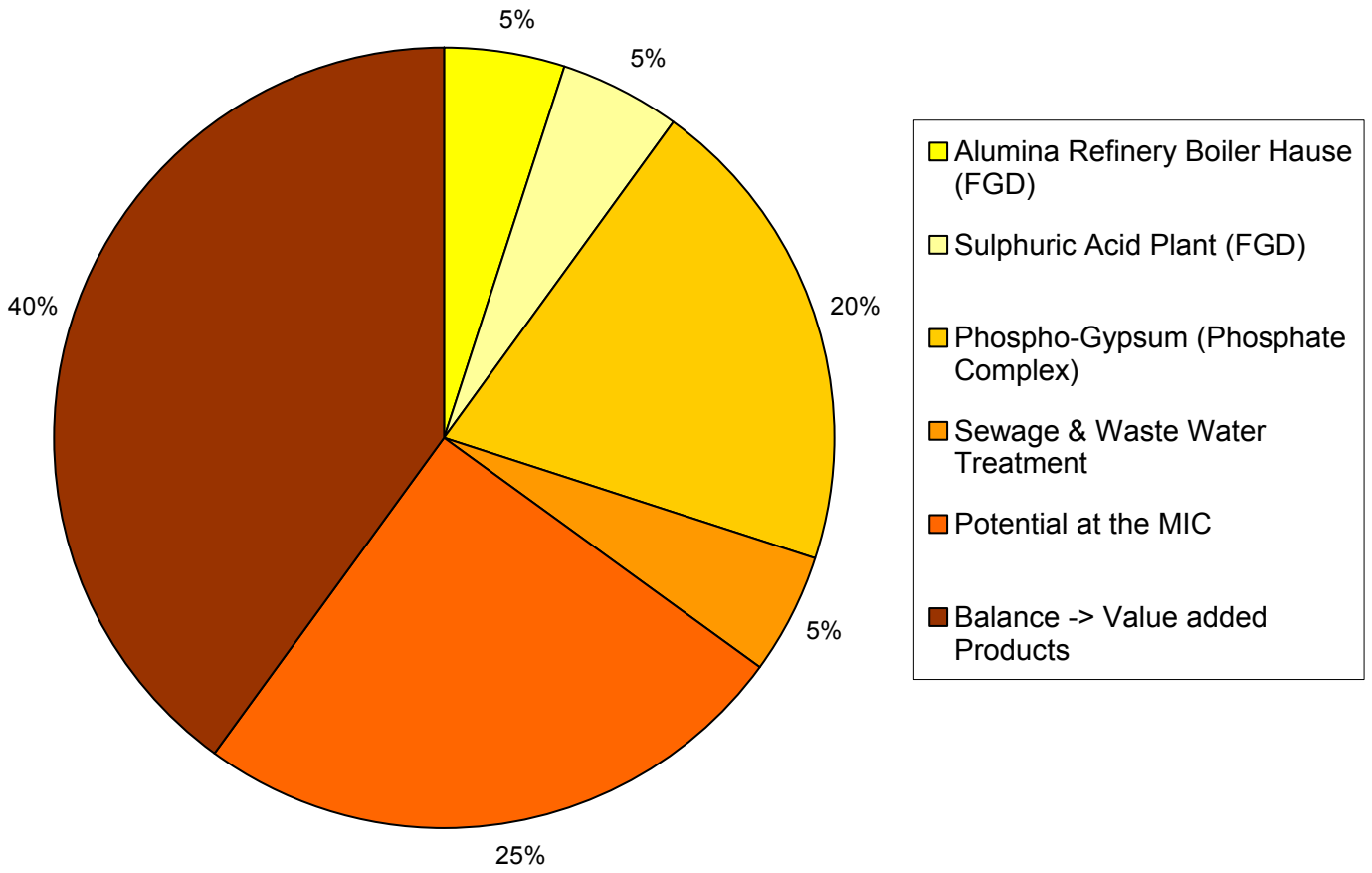
  → stable Landfill
- Absorption of Phosphate
  - Waste Waters
  - Sewage Effluent and Treatment of Biosolids

  → “slow release” Fertiliser
- Moisture Retention

Overview – Zero Waste Framework



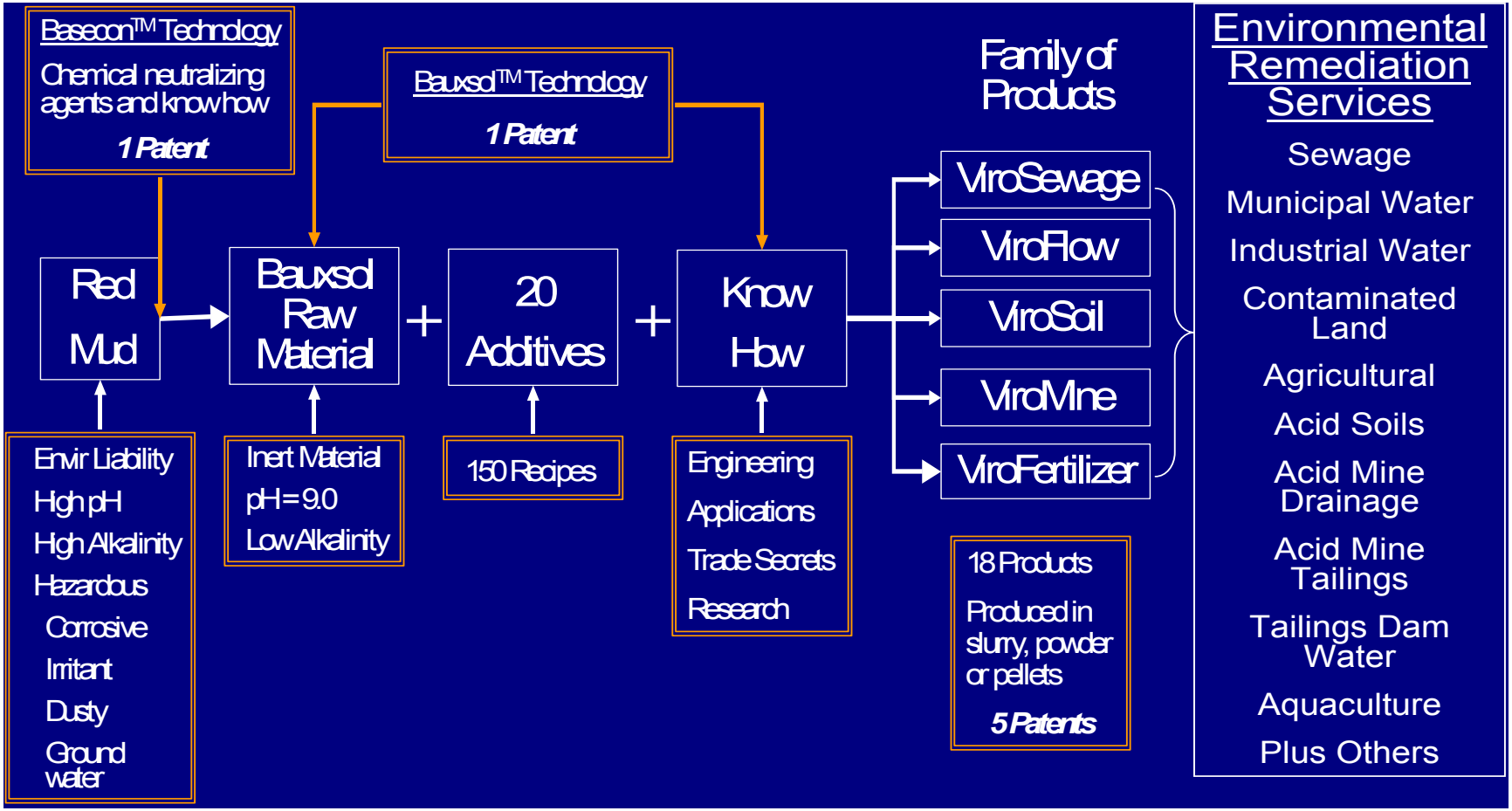
Estimation of ARR Usage



ARR Residue Management Comparison

Current Proposal / Industry Standard	Hatch / Virotec Proposal
• Dry Stacking of Red Mud (caustic) • Natural Evaporation, no Lake Water return • long Term Storage (Liability)	• Seatwater (Brine) Neutralisation • Drying Ponds → Bauxol™ • on-site usage to treat other Waste Streams • all Wastes to be combined → Agriculture & Soil Beneficiation
• Residue is Hazardous	• Residue is begnin, handling/transport ok
• Capital Costs approx A$200M	• Capital Costs < A$100M • potential to sell Value added Product (Profit)

Products & Services Value Chain



-ve Value | Low Value | High Value

Working Together SAFELY

VIROTEC

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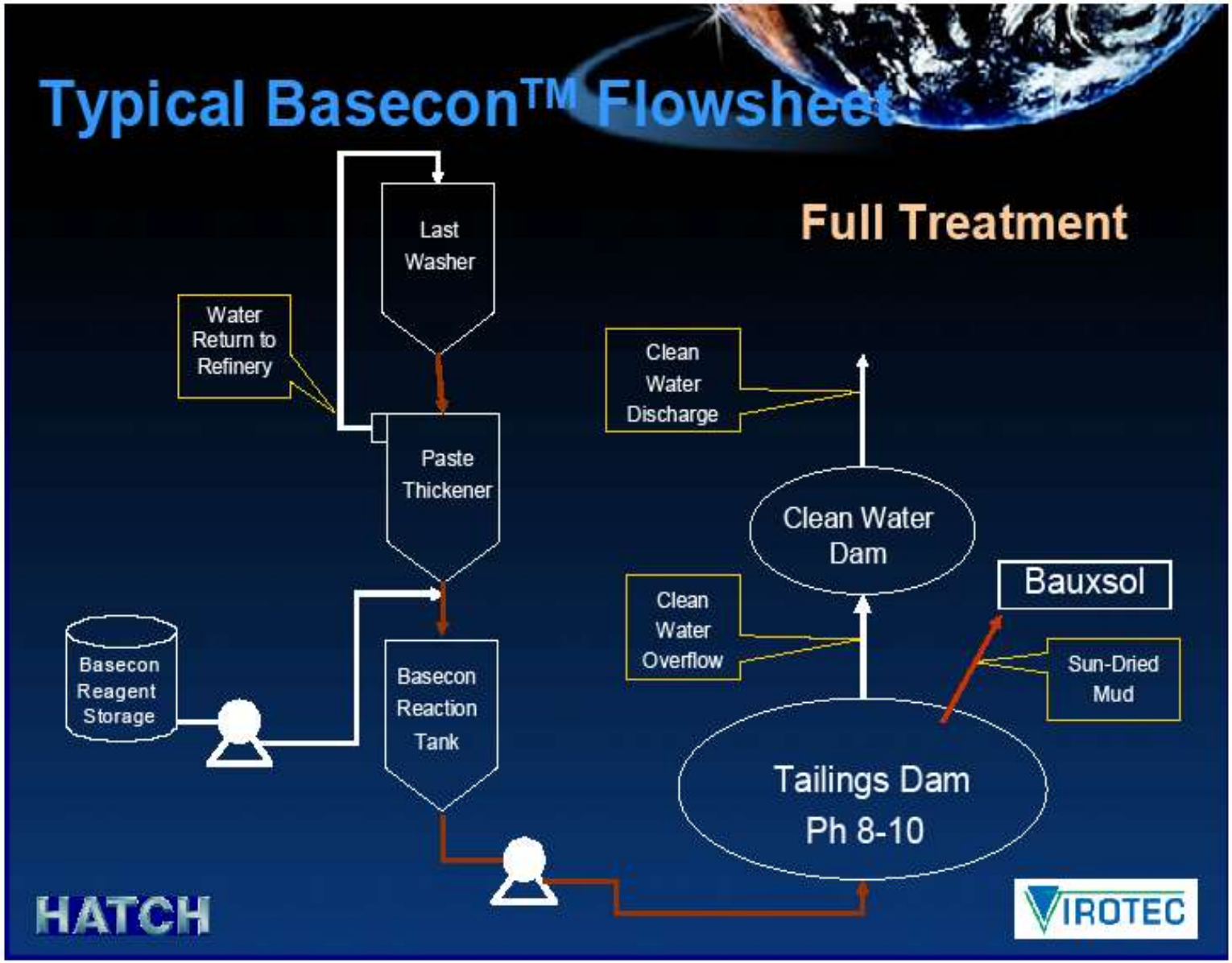

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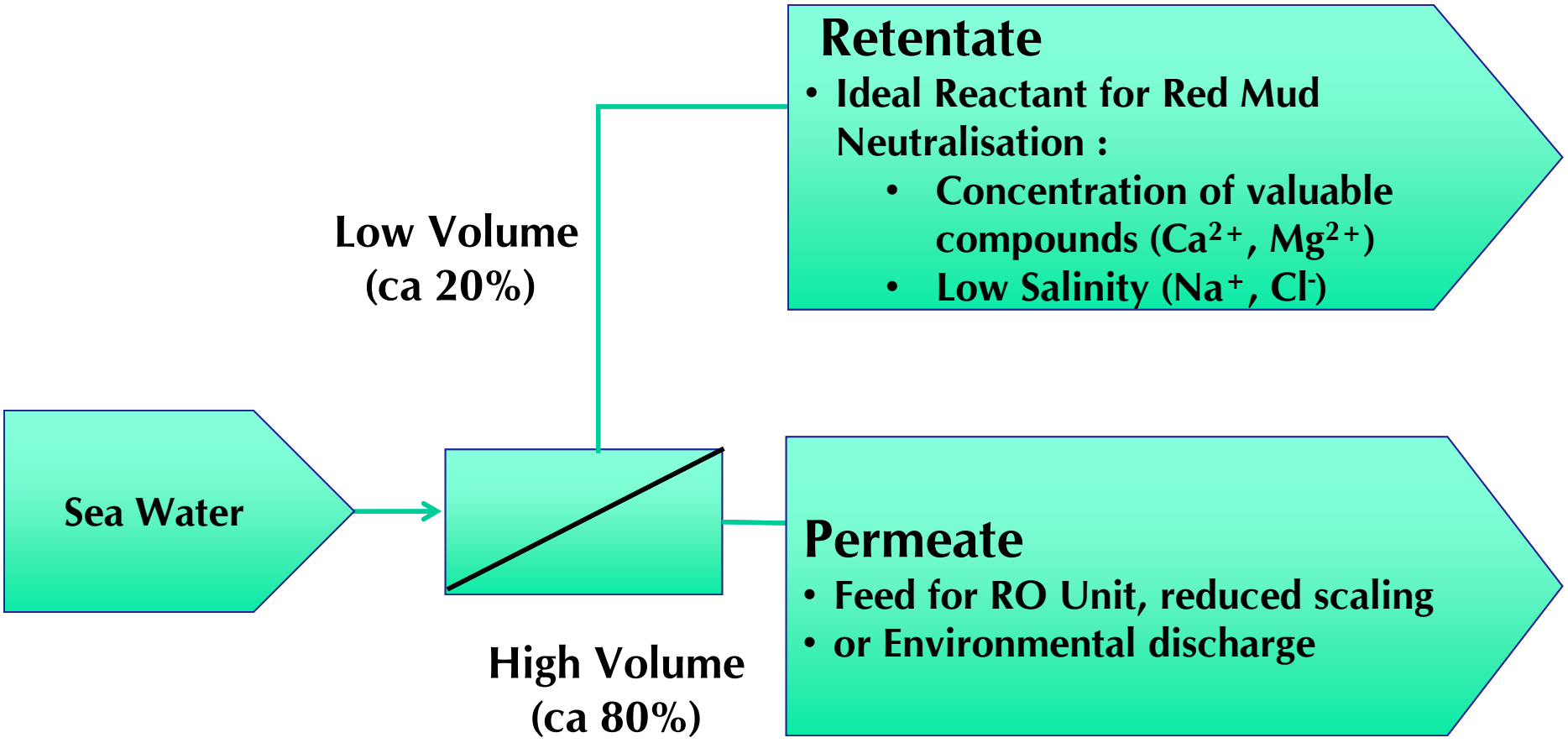
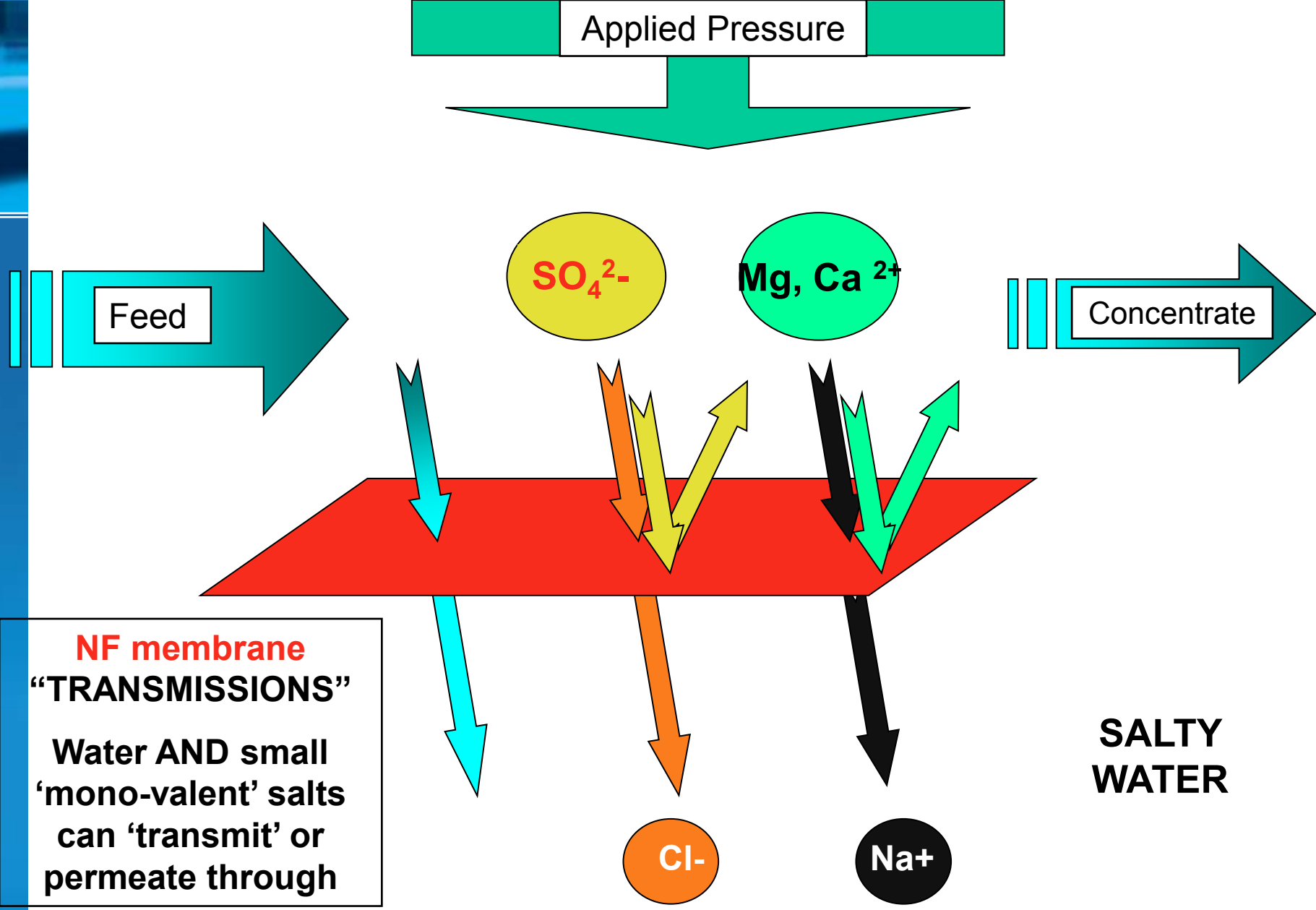
Virotec - Value Added Product
(other uses of Bauxol Raw Material (BRM))

Track Record of successful Applications in Saudi Arabia alone:

- **Ash treatment from Desal & Oil burning Power Stations**
- **Sewage Waste Treatment**
  - Briman Lake
  - Jeddah
- **Composting Dairy Waste**
  - Al-Hofuf
- **New Project "Greening the Desert", combining waste streams of:**
  - Neutralised Alumina Refinery Residue,
  - Green Waste (& other sources of carbon),
  - Neutralised Phospho-gypsum,
  - Treated Sewage and Biosolids (& other sources of phosphorous and nitrogen)
  - Balance of Nutrients etc. as required (→ Agriculture / Green Areas)

NF Membrane Application (Hatch Prov. Patent)





NF membrane
"TRANSMISSIONS"

Water AND small 'mono-valent' salts can 'transmit' or permeate through

SALTY WATER

HATCH - Current ARR / Residue Projects

- **Greenfields Residue Storage Areas:**
  - Earthworks, Liner Systems, Liquor Recovery (Underdrains and Decants), Mud Distribution and Dust Suppression Systems
- **Conversions from Wet-Lakes to Dry Stacking Areas:**
  - Wick Drains to aid consolidation and limit increasing Basal Pore Pressures
  - Intermediate Level Drainage Layer with Liners and Underdrains to reduce recharge of lower Layers
- **Composite lined Cooling Pond**
- **Double-lined Oxalate Storage Ponds**
- **Operational Support:**
  - Stability Analyses
  - Seepage Assessments
  - Dam Break Studies

Conclusion – “Don’t waste your Waste!”

- **Ensure that ARR is neutralised:**
  - ARR is a highly corrosive, hazardous material (Basel Convention, Art 1, Para 1a, Classification #B2110)
  - Transboundary Movement is tightly controlled
- **Brines are ideal Reactants to neutralise ARR**
  - Kinetics are accelerated (Equipment Size/Capex ↓)
- **Neutralised ARR = Bauxol Raw Material (BRM)**
  - Inert and safe Raw Material
  - Bauxsol is approved as non-hazardous, non-toxic and benign. BRM can be transported and handled as bulk material:
    - ✓ USA Environmental Protection Agency (Nov 2004)
    - ✓ United Kingdom Environmental Agency (Oct 2004)
    - ✓ Australian State & Federal Agencies:
      - Queensland EPA 2003
      - National Industrial Chemicals Notification & Assessment 2003
      - Environment Australia 2006
      - Tasmanian Primary Industries, Water and Environment 2005

Thank You !

Figure 1 : An Australian Turf Farm just after residue has been spread.
The poor quality sand can be seen to the right of the photograph

Figure 2 : Rolls of Turf being harvested from the same Turf Farm the following year

Figure 3 : Good Plant Root Penetration Exploiting the Improved Water Holding Capacity of Sands Amended with very high rates of red mud Residue

Figure 4 : Red Mud Residue being added as a Slurry to a 1500 ML Dam containing Water Polluted with High Levels of Toxic Metals

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Figure: Similar contaminated mine waters after treatment with red mud residue and lime. Lime treatment (left) leaves behind large volumes of sludges which are difficult to deal with – red mud (right) residues leave behind sediments which can be used for farming.

Figure: Treated waste water, now within the standards for drinking water, being discharged

Figure: Sediment remaining after water treatment with red mud residue

Figure: Plant growth on sulphidic mine tailings after toxic waste water was treated with neutralised residue