

IMPACTS OF MINING AND MINERAL PROCESSING ON WATER RESOURCES IN THE ZAMBEZI, LIMPOPO AND OLIFANTS CATCHMENTS

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WATER ENVIRONMENT &
FORESTRY TECHNOLOGY

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OUTLINE OF PRESENTATION

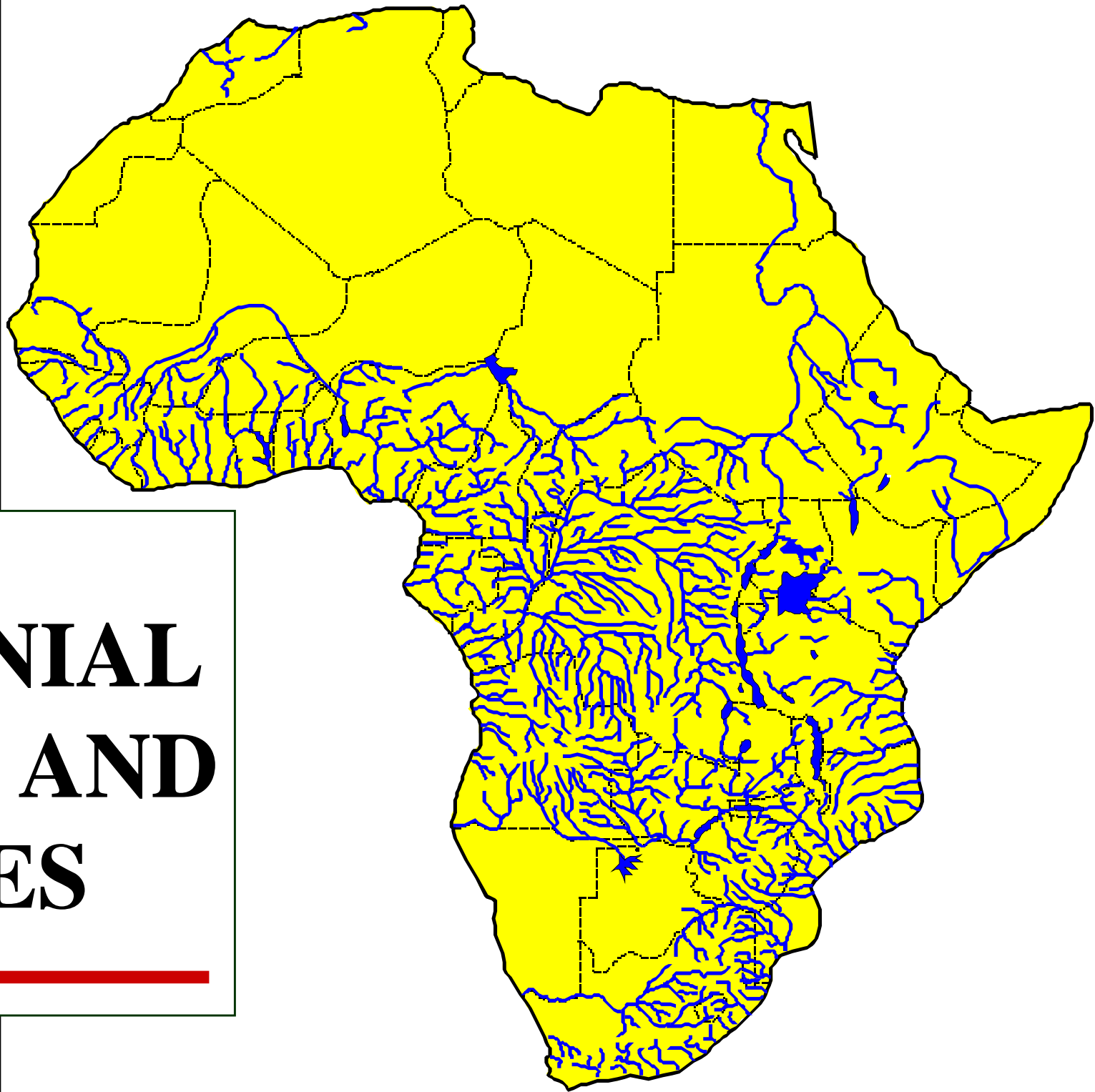
- **Terms of Reference for this study**
- **Brief overview of major findings:**
 - **Availability and vulnerability of water resources in southern Africa**
 - **Extent and variety of mining impacts on water resources and water quality**
 - **Current management approaches to prevent and / or remediate impacts**
- **Recommendations**
- **Future prospects and priorities**

TERMS OF REFERENCE

- **Emphasis on southern Africa**
- **Brief overview of impacts on biophysical environment, then focus on impacts on water resources**
- **Do not assign blame / allege misconduct**
- **Restrict scope to three specific catchments:**
 - **Inventory of mining activities**
 - **Identify types / potential extent of impacts**
 - **Identify management approaches**
- **Recommendations on responsibilities, roles, approaches to minimize impacts**

AVAILABILITY / VULNERABILITY OF WATER RESOURCES

- **Freshwater distributed unevenly across southern Africa, seasonally variable; cyclical changes often unpredictable**
- **Demand for water often centred on areas where water is not easily available**
- **Competing demands for water from different sectors of society**
- **Problems posed by scarce water supplies accentuated by rapid urbanization and contamination of water supplies**



**PERENNIAL
RIVERS AND
LAKES**

EXTENT AND VARIETY OF MINING OPERATIONS

- **Enormous range of minerals and mining processes, at different scales:**
 - **Open-cast mining and quarrying**
 - **Strip mining**
 - **Shallow and deep underground mines**
 - **Riverine alluvial deposits (dry and wet)**
 - **Offshore (marine) mining and dredging**
 - **Beach sands and wind-blown deposits**
 - **Artisan mining (small-scale, often manual)**
- **Multiple phases (prospecting, surveying, ore extraction and milling, smelting and refining, closure and rehabilitation)**

TYPES OF IMPACTS ON BIOPHYSICAL ENVIRONMENT

- **Physical:**

- Water use; stream / river diversions
- De-vegetation and clearing of land
- Erosion and increased siltation
- Salinization; increased dissolved salts

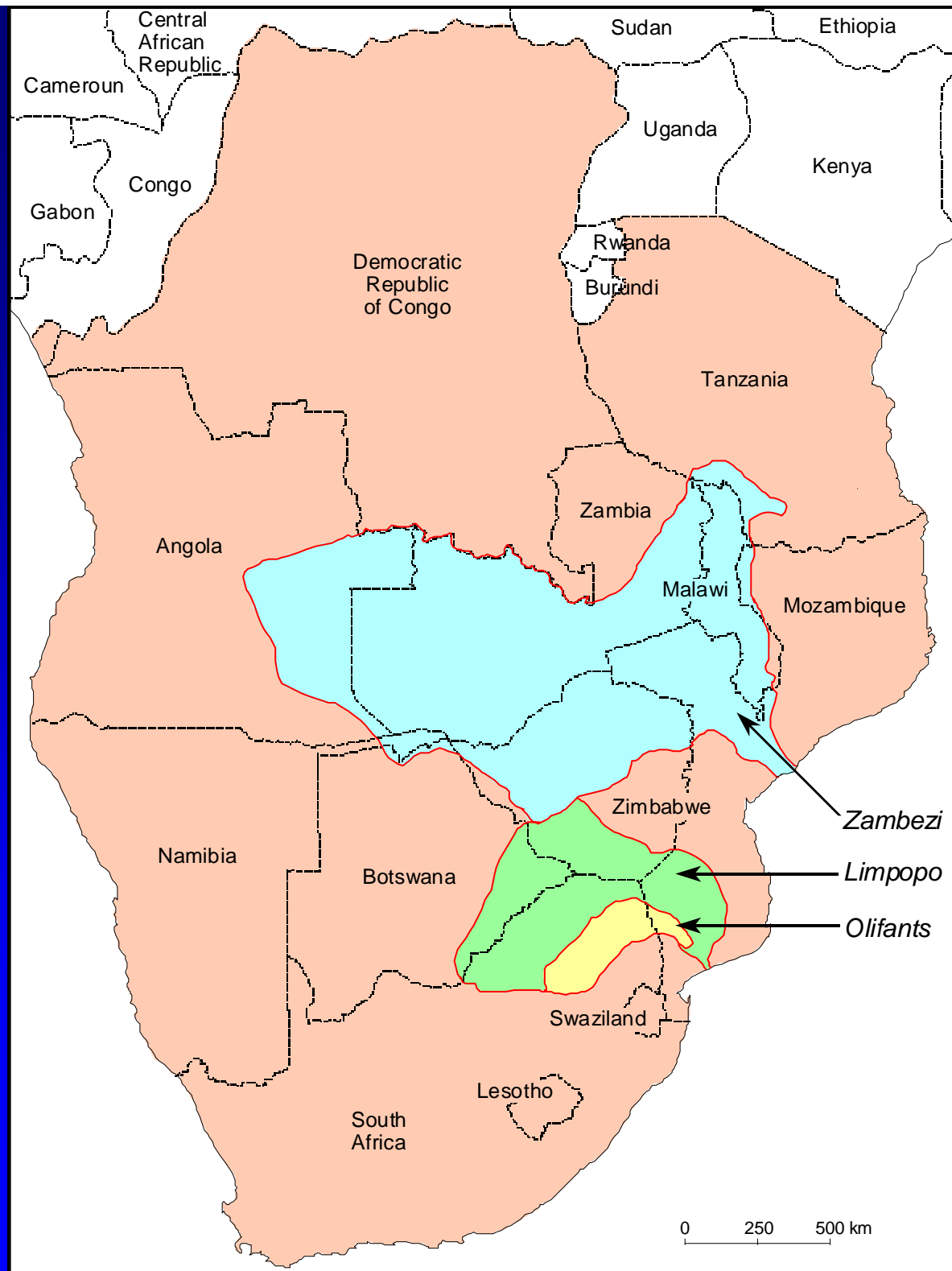
- **Chemical:**

- Acidity / Alkalinity in seepage and wastes
- Radioactivity in seepage
- Arsenic / Mercury / Cyanide / Heavy metals

- **Biological:**

- Loss of species and biodiversity
- Loss / alteration of habitats
- Disruption of ecosystem processes

STUDY FOCUSSED ON THREE KEY CATCHMENTS IN SADC REGION



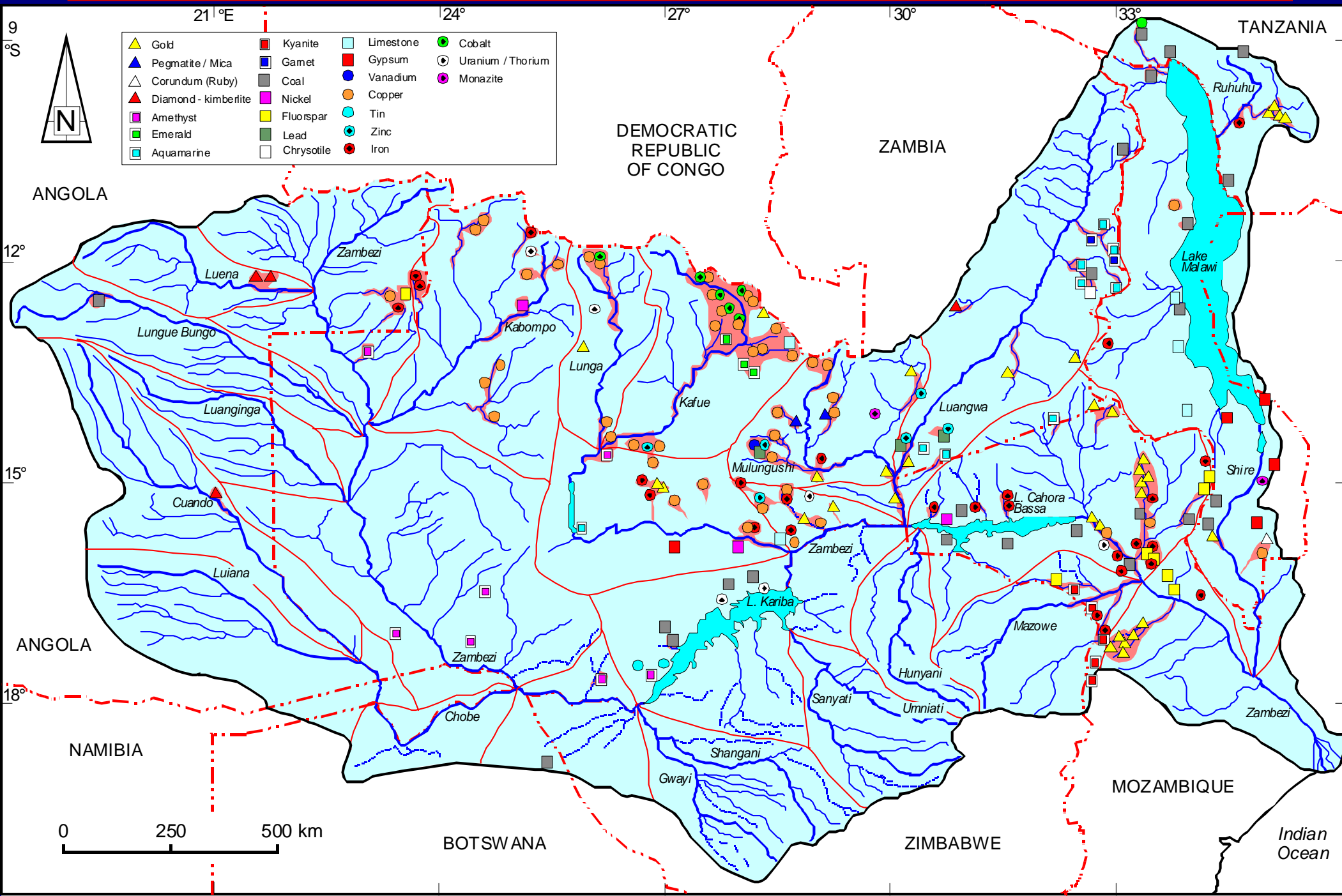
APPROACH ADOPTED

- **Select minimum size of mine for inclusion for each type of commodity**
- **Segment basins into sub-catchments:**
 - **Zambezi = 38; Limpopo = 21; Olifants = 10**
- **For each sub-catchment, details of:**
 - **Hydrology, Geology, Soils, Land use, Water users, Water Management systems (if any), Human impacts on water (excluding mining)**
 - **Details of 66 possible commodities mined, including:**
 - **Name and size of operation; operating, closed or abandoned**
 - **Presence of Alluvial mining, Monitoring systems, Water quality data**
 - **Implications for water quality and quantity management**

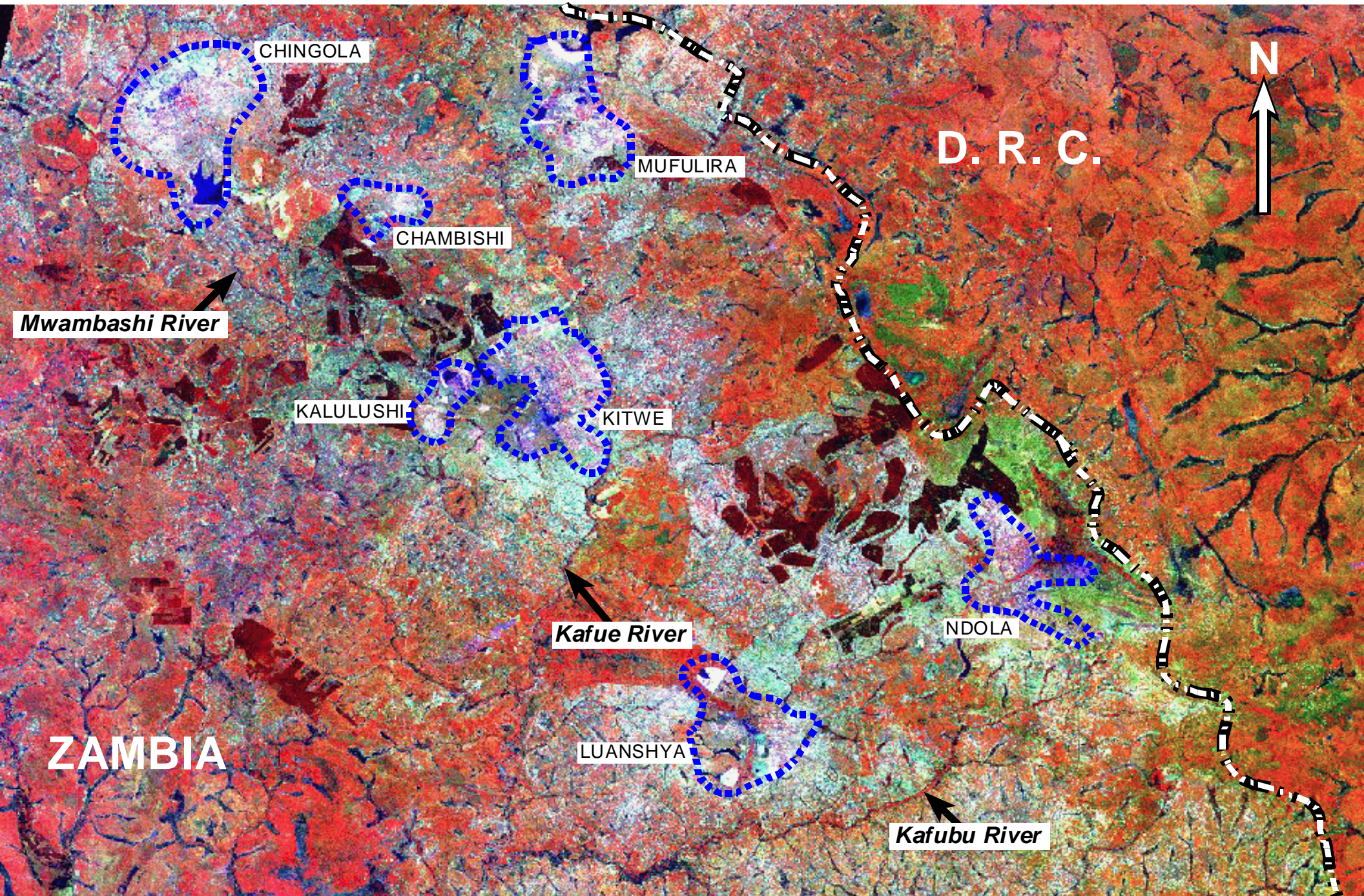
THE CURRENT REALITY

- **Over 6,000 mining operations listed for Zimbabwe; Reduced to approx. 600 on minimum size criteria**
- **Over 1,900 mines in Limpopo and Olifants basins, plus 1,700 abandoned mines; Active mines reduced to 265 on minimum size criteria**
- **Lack of spatially-controlled data**
- **Availability of data, information, maps**
- **Sheer scale of the problem**

IMPACTS ON WATER QUALITY



ZAMBIAN COPPERBELT



ZIMBABWE – PRECIOUS METAL MINES

Precious metals
Au, Ag, PGE's

100 km

Zambezi

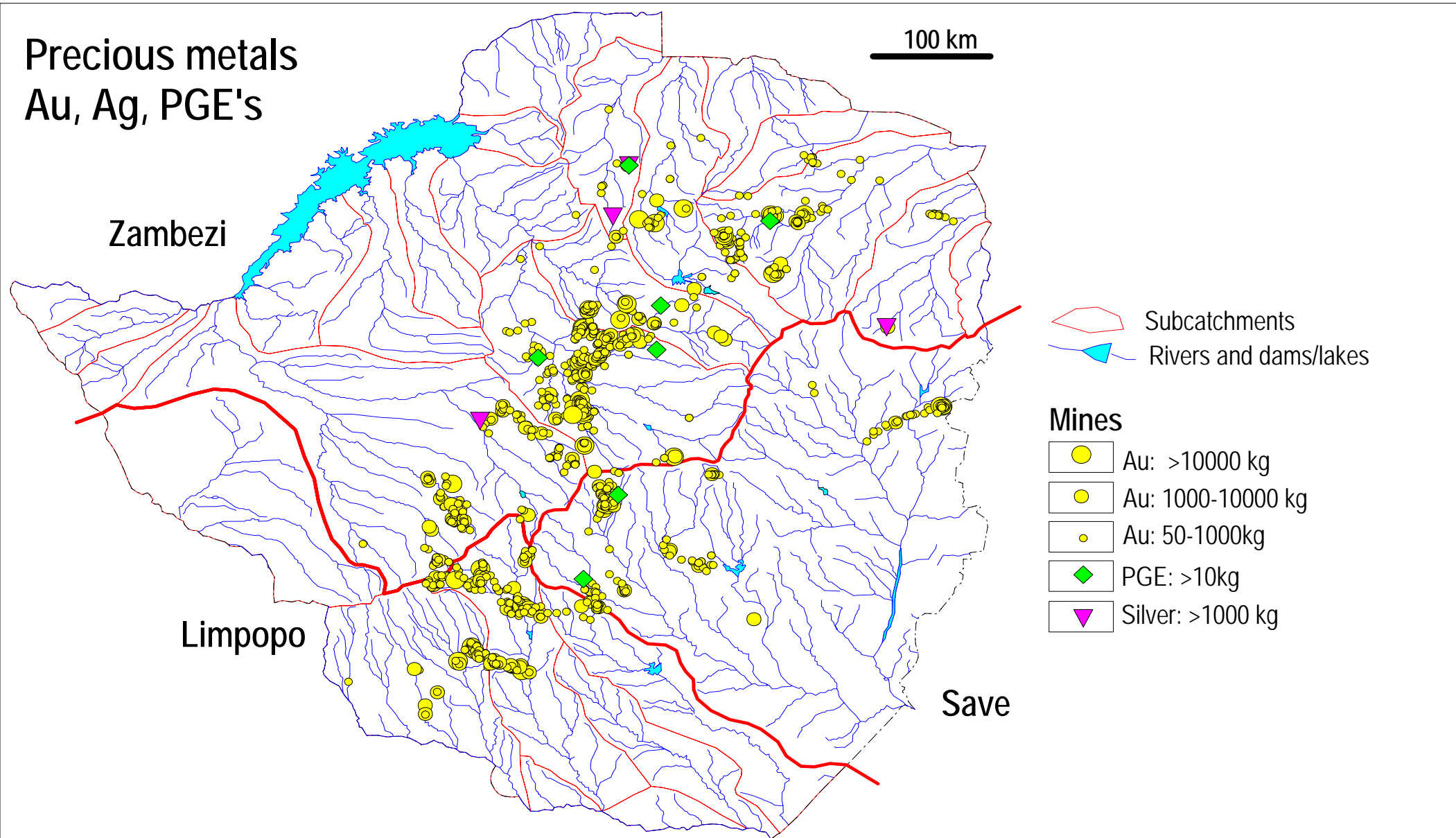
Limpopo

Save

Subcatchments
Rivers and dams/lakes

Mines

- Au: >10000 kg
- Au: 1000-10000 kg
- Au: 50-1000kg
- PGE: >10kg
- Silver: >1000 kg



ZIMBABWE – INDUSTRIAL MINERAL MINES

Industrial Minerals

100 km

Subcatchments
Rivers and dams/lakes

Zambezi

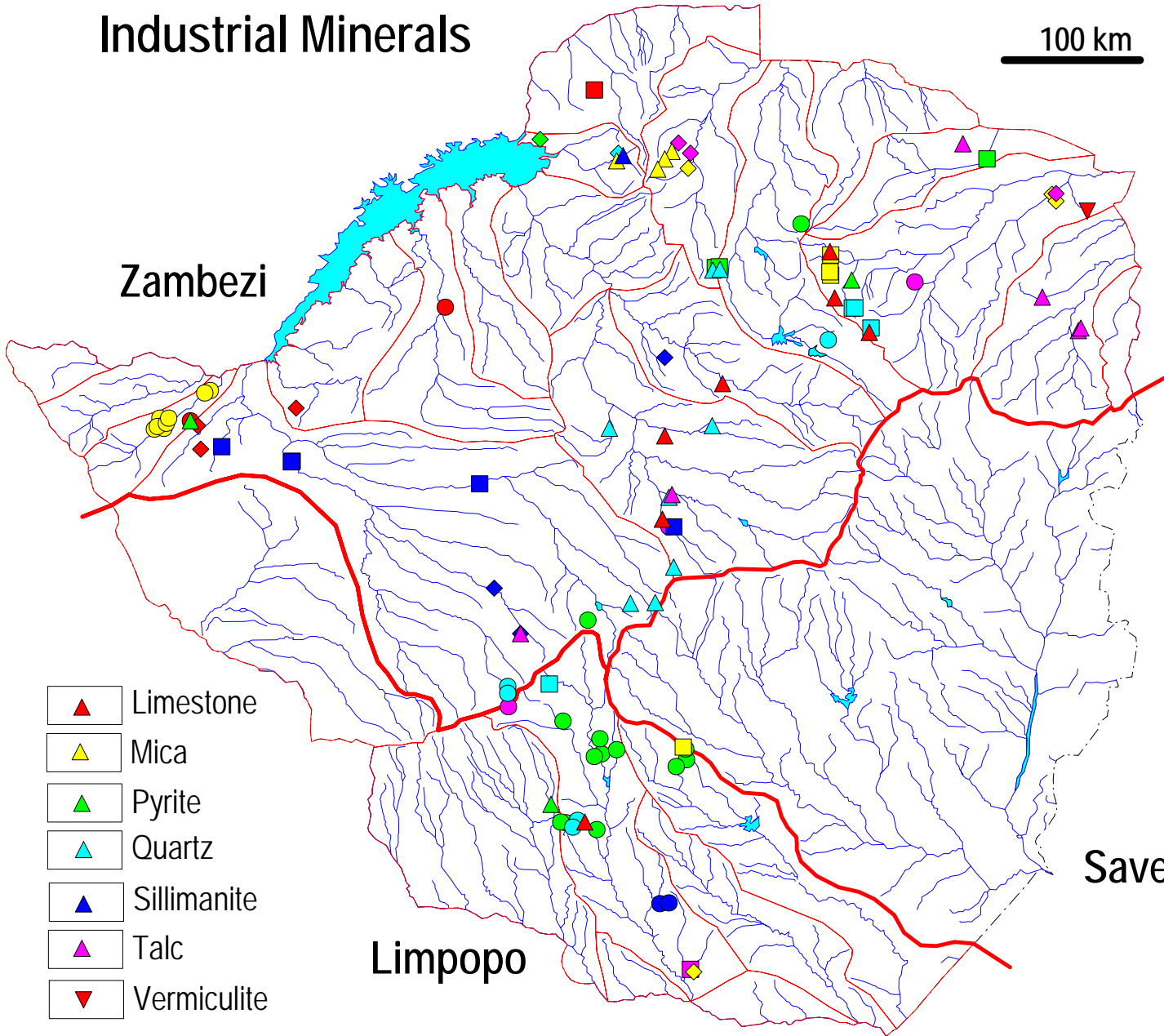
Limpopo

Mines

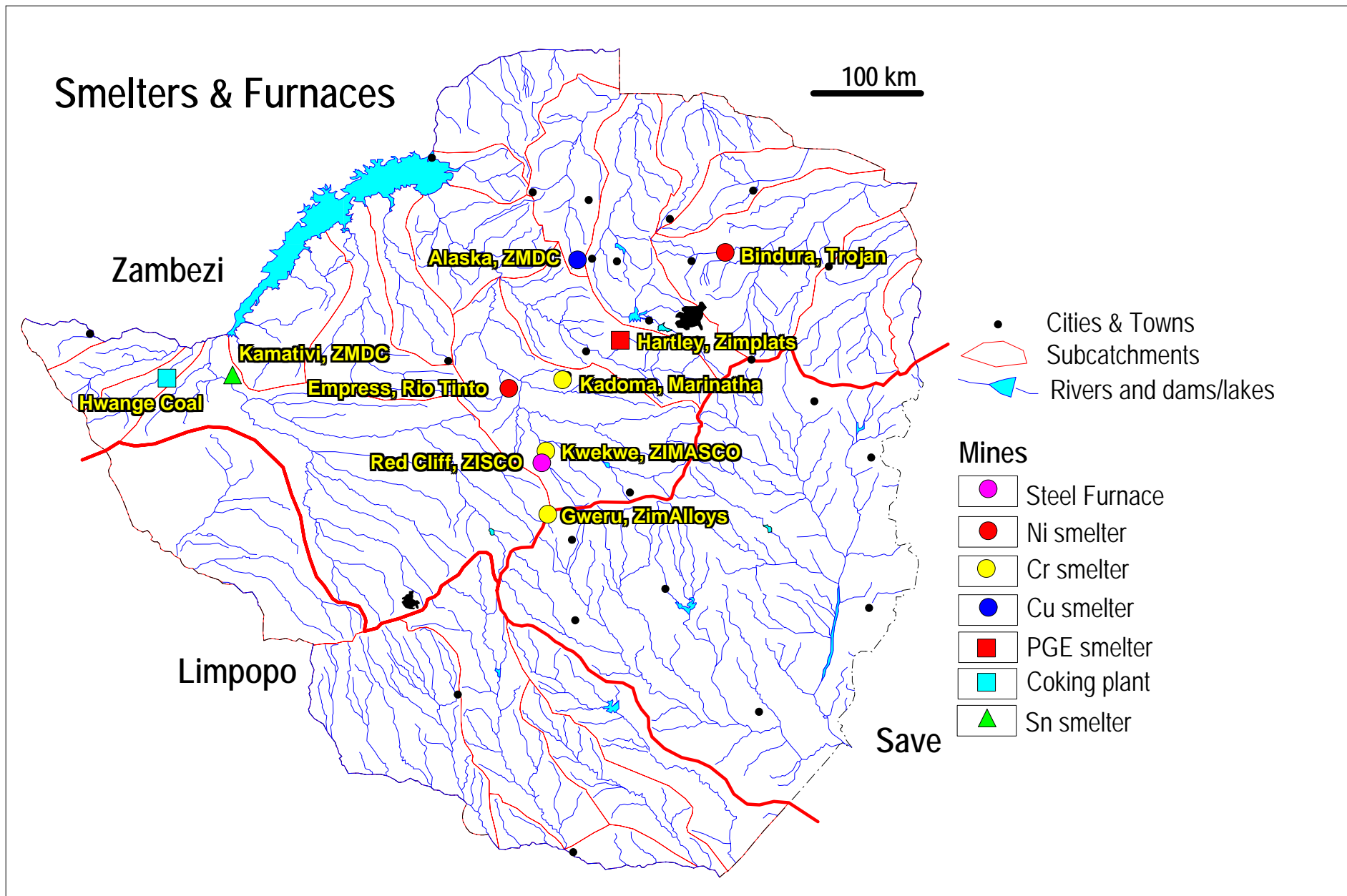
- ▲ Limestone
- ▲ Mica
- ▲ Pyrite
- ▲ Quartz
- ▲ Sillimanite
- ▲ Talc
- ▼ Vermiculite

- Asbestos
- Aventurine
- Baryte
- Calcite
- Clay
- Coal
- Cordierite
- Corundum
- Dolomite
- Feldspar
- Fireclay
- Flintclay
- ◆ Fluorite
- ◆ Garnet
- ◆ Glitterstone
- ◆ Graphite
- ◆ Kaolin
- ◆ Kyanite

Save



ZIMBABWE – SMELTERS AND FURNACES



ZIMBABWE – ALLUVIAL GOLD AND ARTISAN CHROME MINING

Alluvial Au and small-scale Cr mines

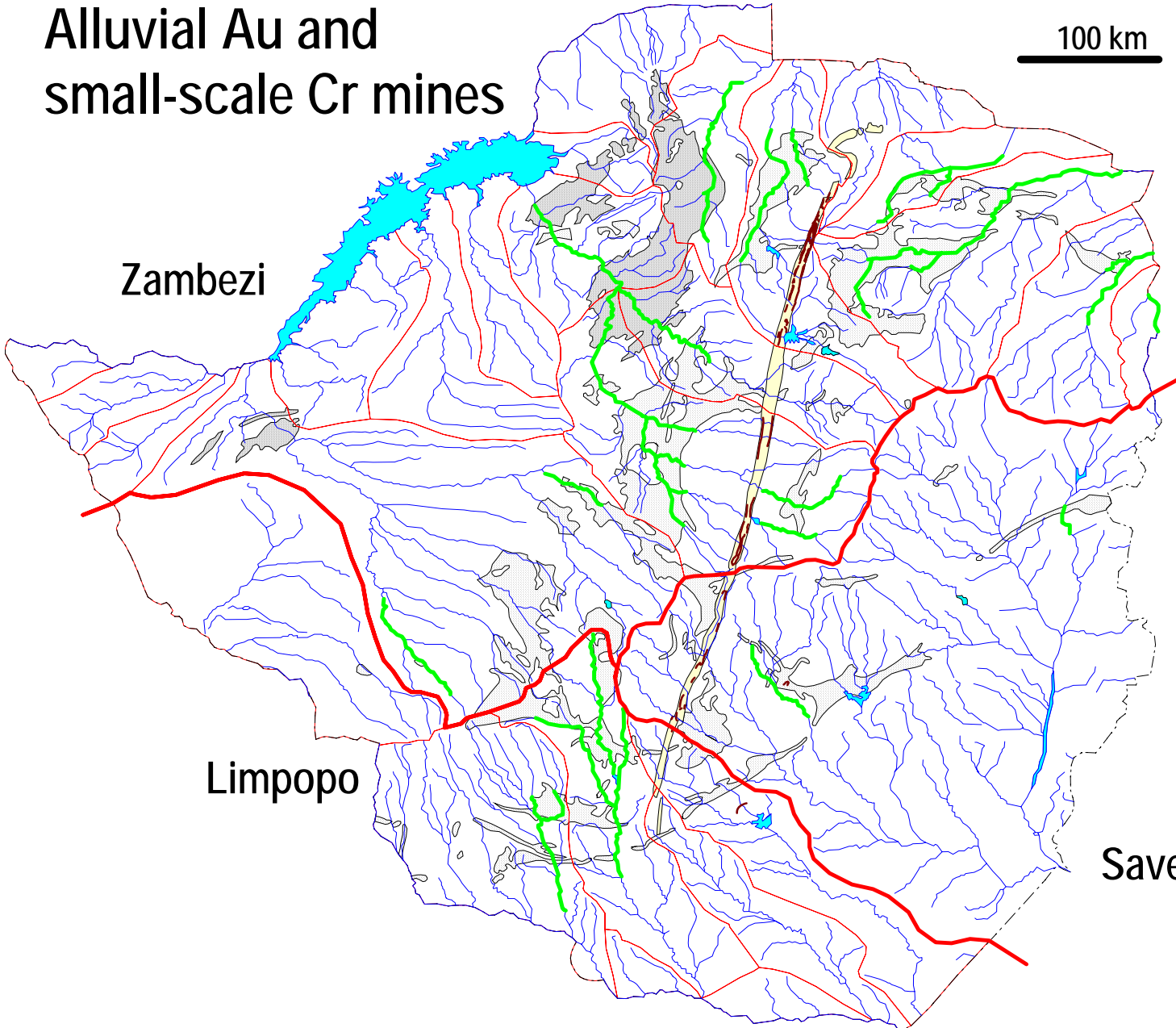
100 km

Zambezi

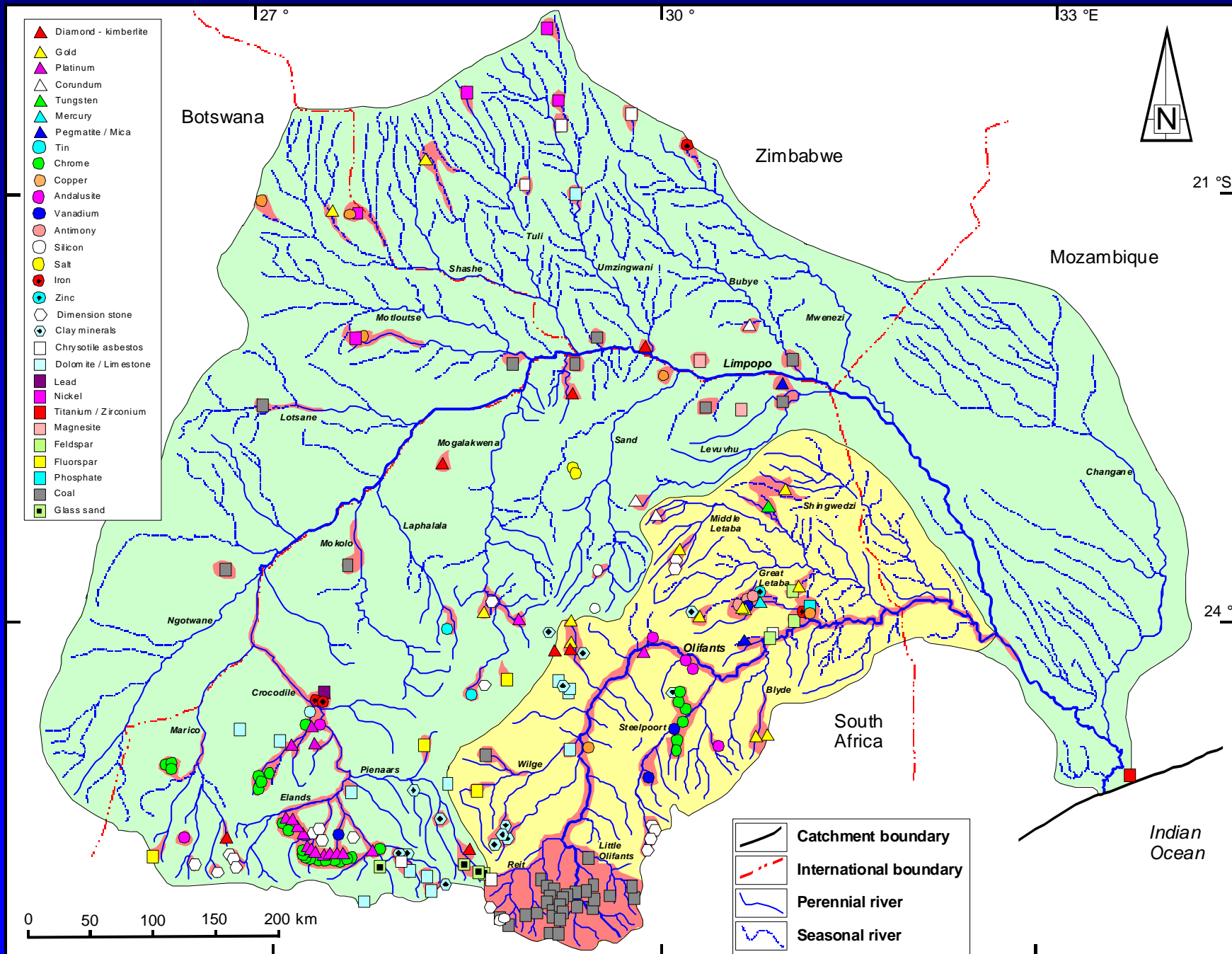
Limpopo

Save

- Subcatchments
- Rivers and dams/lakes
- Small scale & alluvial mining**
 - River segments with extensive alluvial mining
 - Numerous small-scale Cr workings
- Great Dyke
- Archaean greenstone
- Proterozoic Piriwiri Phyllite



IMPACTS ON WATER QUALITY



TYPICAL IMPACTS ON WATER RESOURCES (1)

- **Need for process water – demand on local and regional water resources**
- **Discharge of effluents and seepage from solid waste / tailings dams contaminates surface and ground waters**
- **Alteration of ground water flows by pollution control activities**
- **Alteration of river channels and flows**
- **Erosion of unprotected surfaces - increased sediment loads in streams**
- **Contamination from explosives residues**

TYPICAL IMPACTS ON WATER RESOURCES (2)

- Atmospheric emissions (metal vapours, fumes, gases and dusts) enter aquatic environment – transferred / transformed
- Wind-blown dusts from unprotected tailings and waste rock dumps enter aquatic environment
- Discharge and spillage of chemicals used in metal extraction process (e.g. cyanide)
- Release of potentially harmful substances such as radio-nuclides and metals into the aquatic environment

TYPICAL IMPACTS ON WATER RESOURCES (3)

- **Acid rock drainage and associated water quality problems in receiving waters:**
 - Lower pH values – altered chemical equilibria
 - Increased metal concentrations – potential toxicity to aquatic organisms and human users
 - Increased total dissolved salts – salinization problems for agriculture and sensitive users
 - Unsightly / toxic precipitates in streams
 - Increased sediment loads – loss of habitat
 - Increased water treatment costs to other users
 - Corrosion problems in distribution systems

CURRENT MANAGEMENT APPROACHES (1)

- Industry plays leadership role in development of new pollution prevention technologies and rehabilitation methods
- Partnership approach with governments to design and implement new legislation
- Implement international standards of practice (e.g. ISO 14000+ certification)
- Reduce water consumption and minimize wastes and emissions (e.g. via EMPR)
- Information sharing within industry

CURRENT MANAGEMENT APPROACHES (2)

- Dramatic reduction in water use through new tailings management approaches**
- Successful re-vegetation and stabilization of tailings and mined dune sands**
- Re-working of tailings deposits for economic minerals**
- Experimental use of wetlands as “low maintenance systems” to neutralize acid rock drainage**
- Improved smelter efficiencies**

RECOMMENDATIONS (1)

Issue	Recommendation	Responsibility
Minimize demands for water	<ul style="list-style-type: none">• Implement cost-effective water management systems• Design and operate tailings dams to minimize water use and water losses	<ul style="list-style-type: none">• All mining operators• Consulting Engineers• Relevant Government Departments <p>Timescale: 5-10 years</p>
Harmonize legislation within SADC	<ul style="list-style-type: none">• Ensure relevant pieces of legislation are congruent in each country, without unnecessary inconsistencies or duplication	<ul style="list-style-type: none">• Relevant Government Departments• All mining operators <p>Timescale: 3-5 years</p>

RECOMMENDATIONS (2)

Issue	Recommendation	Responsibility
Improved Stakeholder participation in decision making	<ul style="list-style-type: none">● Ensure full participation of Stakeholders in all relevant decisions	<ul style="list-style-type: none">● All mining operators● All Stakeholders● Relevant Government Departments <p>Timescale: 2-3 years</p>
Reduce impacts of small-scale / artisan miners	<ul style="list-style-type: none">● Provide cost-effective and efficient technologies to small-scale miners● Reduce use of mercury	<ul style="list-style-type: none">● Mining R&D organizations● Relevant Government Departments <p>Timescale: 5-10 years</p>

RECOMMENDATIONS (3)

Issue	Recommendation	Responsibility
Control and reduce releases of potentially toxic metals from mines and mineral processing operations	<ul style="list-style-type: none">• Eliminate chrome and vanadium from seepage• Provide alternatives to mercury for concentrating gold• Treat effluents from mines in Greenstone areas• Improve collection and treatment of seepage at Zambian copper mines• Reduce seepage from lead and zinc mines	<ul style="list-style-type: none">• All chrome and vanadium mines and smelters• Mining R&D groups• Relevant Government Departments• Greenstone mines• Copper mines• Lead and zinc mines• Consulting Engineers <p>Timescale: 2-10 years</p>

RECOMMENDATIONS (4)

Issue	Recommendation	Responsibility
<p>Control acid mine drainage in Olifants basin</p>	<ul style="list-style-type: none"> ● COALTECH 2020 project should be fully supported by all Stakeholders ● Coal mines should combine forces to minimize costs 	<ul style="list-style-type: none"> ● Each mining company ● Relevant Government Departments ● Local Authorities ● Water use associations <p>Timescale: Continuous</p>
<p>Control acid mine drainage in Zambian Copperbelt</p>	<ul style="list-style-type: none"> ● Reduce acidic seepage from tailings dams ● Relocate improperly-sited tailings dams 	<ul style="list-style-type: none"> ● Each mining company operating on Zambian Copperbelt ● Consulting Engineers <p>Timescale: 5-10 years</p>

RECOMMENDATIONS (5)

Issue	Recommendation	Responsibility
Control acid mine drainage and linked arsenic problems	<ul style="list-style-type: none">• Pay strict attention to reducing acidic seepage and treat effluents to reduce arsenic concentrations	<ul style="list-style-type: none">• Mines in Giyani and Murchison Greenstone belts• Mines in Zimbabwe Greenstone belts• All arsenic mines <p>Timescale: 5-10 years</p>
Control cyanide at gold mines	<ul style="list-style-type: none">• All gold mines should implement the cyanide handling directives developed by the R. S. A. Chamber of Mines	<ul style="list-style-type: none">• All gold mines• Consulting Engineers• All Depts of Mineral & Energy Affairs <p>Timescale: 3-5 years</p>

RECOMMENDATIONS (6)

Issue	Recommendation	Responsibility
<p>Control and reduce high salinity seepage</p>	<ul style="list-style-type: none"> ● Design and implement effective seepage control systems and effluent treatment systems 	<ul style="list-style-type: none"> ● Coal mine operators ● Gold mine operators ● Depts of Mineral & Energy Affairs ● Depts of Water Affairs <p>Timescale: 3-5 years</p>
<p>Control releases of suspended solids</p>	<ul style="list-style-type: none"> ● Implement effective runoff control systems ● Minimize loss / washoff of tailings ● Reduce alluvial gold mining impacts 	<ul style="list-style-type: none"> ● All mine operators ● Relevant Government Departments ● Artisan / small-scale mining associations <p>Timescale: 5-10 years</p>

RECOMMENDATIONS (7)

Issue	Recommendation	Responsibility
Availability of treatment technologies for specific effluents of concern	<ul style="list-style-type: none">• Continue research into improved effluent treatment technologies and processes• Publicize available manuals on treatment technologies• Exchange technical information between mine operators and mining R&D organizations• Ensure wider application of treatment technologies for effluents of concern	<ul style="list-style-type: none">• Water Research Commission• All mining operators• Relevant Government Departments, espec. Water Affairs• Mining R&D groups• Consulting Engineers <p>Timescale: 3-5 years</p>

RECOMMENDATIONS (8)

Issue	Recommendation	Responsibility
Implement effective environmental management systems on all mining operations	<ul style="list-style-type: none">● Publicize benefits of effective environmental management systems● Expand training initiatives in environmental management● Enhance/ improve current EMPR initiatives● Implement appropriate management systems (e.g. ISO 14000+ series) on all operating mines	<ul style="list-style-type: none">● All mining operations● Relevant Government Departments● Certification and training authorities (e.g. SABS)● All mining R&D organizations <p>Timescale: 2-3 years</p>

FUTURE PROSPECTS

- Greater government control over formal and “informal” mining operations and “ownership” of mineral / water resources
- Tighter legislation to protect water resources and prevent contamination; difficult to obtain “new” water supplies
- Increased public involvement in decisions around environmental issues; emphasis on equitable sharing of costs and benefits
- More emphasis on regional approaches to “water security” and economic development, also poverty reduction

PRIORITIES FOR PREVENTION AND REMEDIATION

- All mining practices and processes must comply with appropriate statutory and legal requirements, as well as with best industry practice – management systems**
- Minimize waste and eliminate emissions**
- Prevent / minimize acid rock drainage**
- Clean-up existing problem areas**
- Assist small-scale mining operations to improve operating methods / standards**