Attenuation of Mining-Related Pollutants in the Hyporheic Zone

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Mine Water Pollution

- Discharges from abandoned mines are a major source of surface and groundwater pollution throughout the world
- Typically highly acidic and rich in metals e.g. iron, manganese, copper, zinc
- Toxic metals plus formation of orange ‘ochre’ have a detrimental effect on aquatic life

- Over last 10 years concerted effort to develop remediation strategies

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Mine Water at the Hyporheic Zone

- Majority of research has focused on treatment of point mine water discharges e.g. from abandoned mine adits and shafts

Groundwater upwelling / contaminated sediment

- Diffuse sources including transfer of polluted groundwater to surface waters (and vice versa) across HZ received far less attention

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Extent of Mine Water at the HZ

- No concerted efforts made to quantify presence of mine water at HZ
- Probably largely due to problem of physically measuring volumes of water transferred across HZ and associated metal loads
- Only information available is anecdotal evidence from catchments previously subject of detailed investigations of mine water pollution
- Examples of mine water pollution arising from HZ in NE England e.g. River Wear, River Tyne

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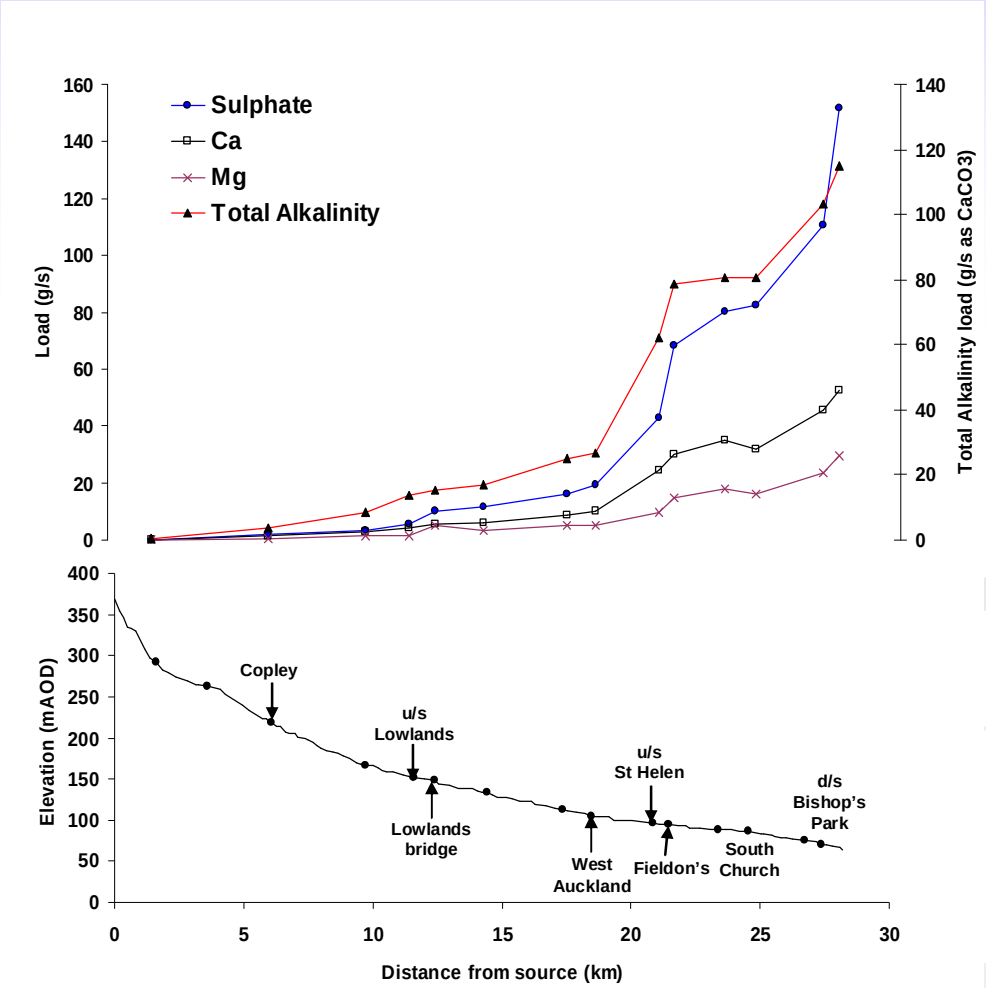
An Example from NE England



The River Gaunless, County Durham – an example of the influence of groundwater inputs on both the chemistry and flow of a river (note that the ordinate of the upper graph is in units of load i.e. concentration x flow)

[From Mayes et al. (2008) *Environmental Pollution*, **151**, 165-175.]

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Attenuation at the HZ

- Biogeochemical processes within the HZ can impact the fate and transport of mining-derived pollutants
- HZ can act to attenuate / mobilise metal pollutants by e.g. precipitation and adsorption processes and dissolution
- Attenuation / release of metals is dependent upon redox conditions
- Represents a mixing zone where high pH and high DO in surface waters meet low pH and low DO in groundwater

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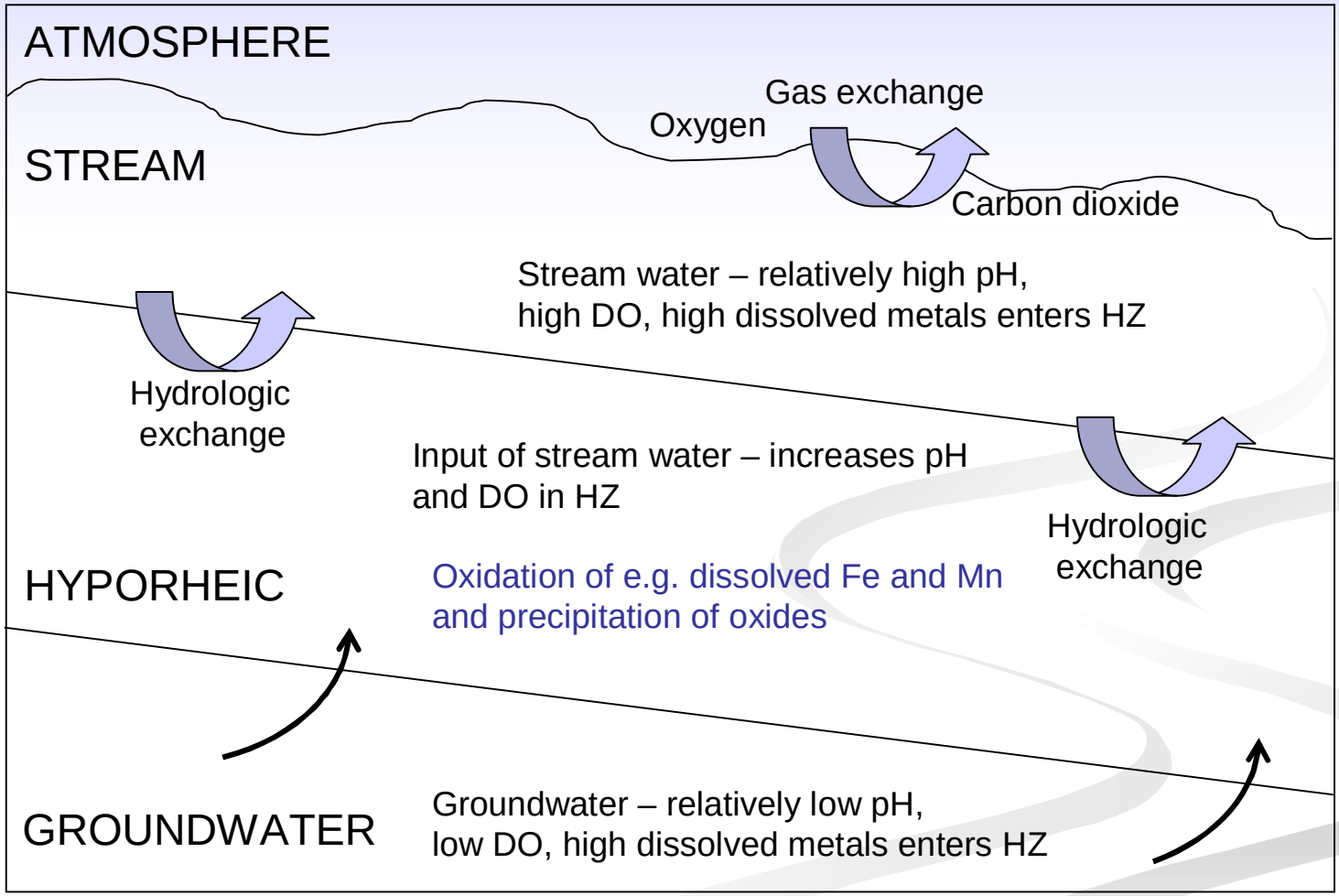
HZ as a Mixing Zone



(Modified from Harvey & Fuller (1998))

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Metal Attenuation / Release

- Input of stream water to HZ raises pH and DO concentration, stimulates bacterial activity, enhances Fe and Mn oxidation
- Form Fe and Mn oxide precipitates
- Other metals, e.g. Zn, As, Cu, U co-precipitated or adsorbed
- Respiration by micro-organisms and oxidative degradation of organic matter may lead to reducing conditions
- Dissolution of Fe and Mn oxides and associated metals

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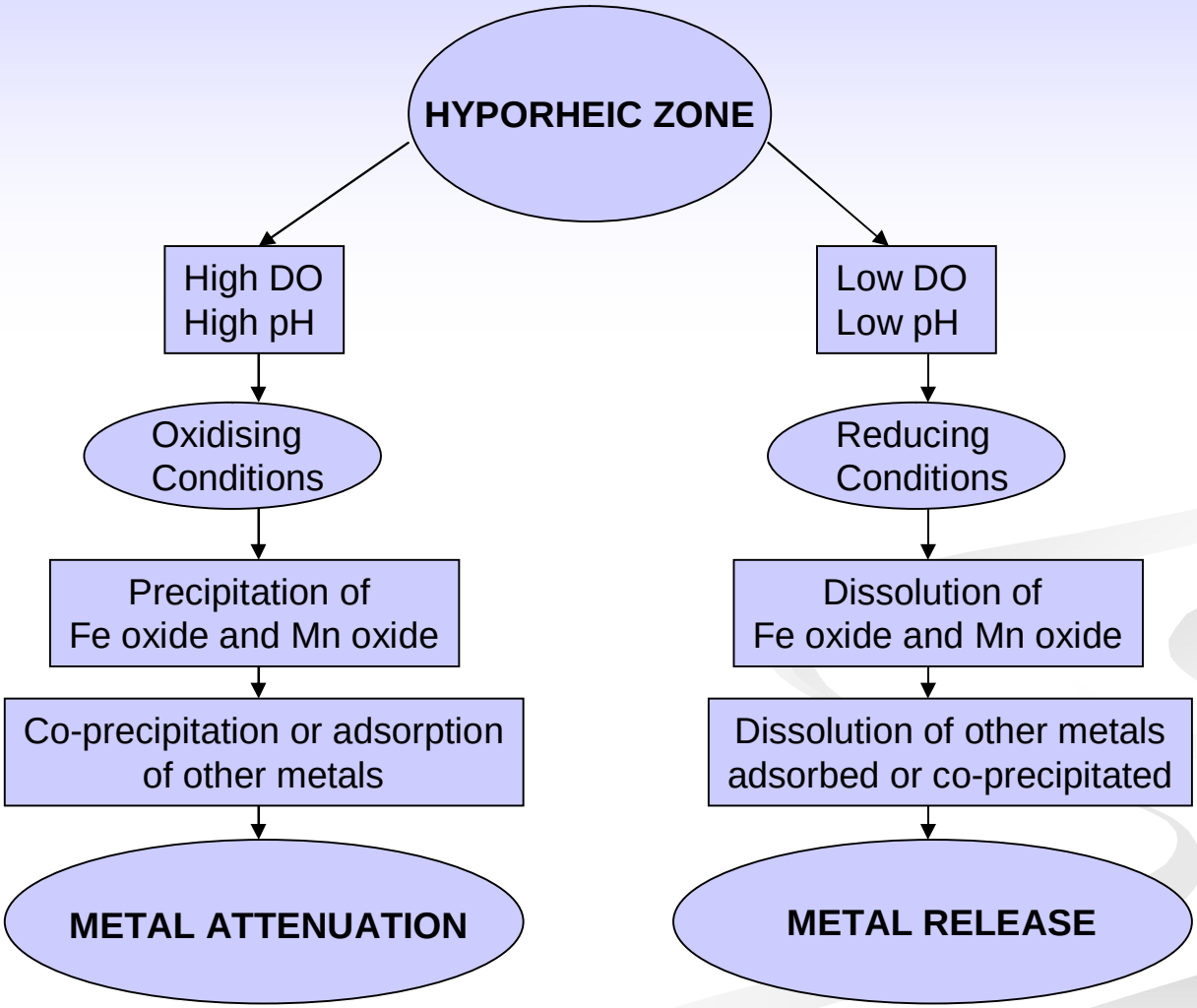
Attenuation or Release?



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Literature Gaps

- Limited published information on fate of mine pollutants as they pass through HZ
- Difficulty in accessing HZ to retrieve sediment samples
- Although most studies concluded that surface and groundwater interact and that zone plays major role in storing and attenuating metals – little progress in fully understanding dynamics
- Need further understanding of flow and solute transport in HZ

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Modelling Studies

- Very few modelling studies undertaken on fate of pollutants in HZ
- Ren & Packman (2004) developed theoretical model to predict role of colloids in advective transport of contaminants between streams and subsurface
- Younger et al. (1993) – 3D model to simulate solute transport in stream – aquifer systems
- Broshears et al. (1996) simulated transport and geochemical processes in water column at sediment – water interface of stream affected by acid mine drainage

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Summary

- HZ recognised as important biogeochemical interface between surface water and groundwater but there has been little focus on its role in attenuating and / or mobilising metal pollutants
- Existing literature suggests that HZ may be an important sink for metal pollutants but no detailed understanding of how processes vary temporally and spatially
- Redox conditions play an important role in governing metal attenuation or mobilisation
- Need greater understanding of flow / solute transport
- Need for modelling studies to determine both flow / solute transport and fate of pollutants

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Questions

- How important is the HZ in governing overall loading of metal contaminants to rivers and how does it affect the proportions of mine water pollution arising as point sources or diffuse sources?
- What are the key biogeochemical processes, and associated rates, that result in attenuation of metals in HZ?
- What is the most appropriate, and accurate, method for monitoring the HZ?
- Is it feasible to resolve the scale-dependence of these biogeochemical processes so that we can understand the role of the HZ in mine water-affected freshwaters for entire catchments?

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Reference

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