British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

GRoundwater And Soil Pollutants (GRASP)

A screening tool applying soil geochemical data to assess threats to shallow groundwater in Glasgow

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British Geological Survey

William Smith Meeting, London

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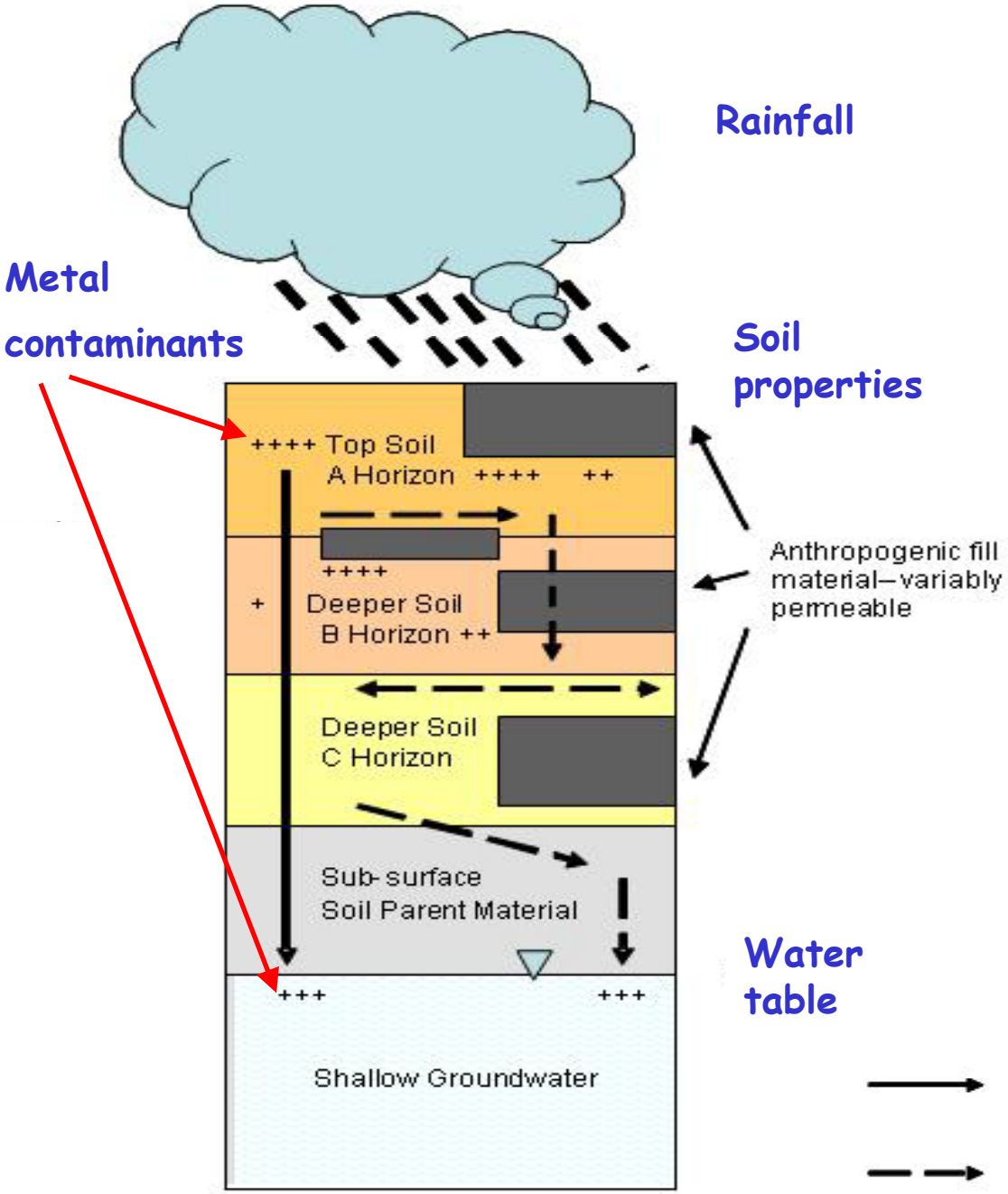
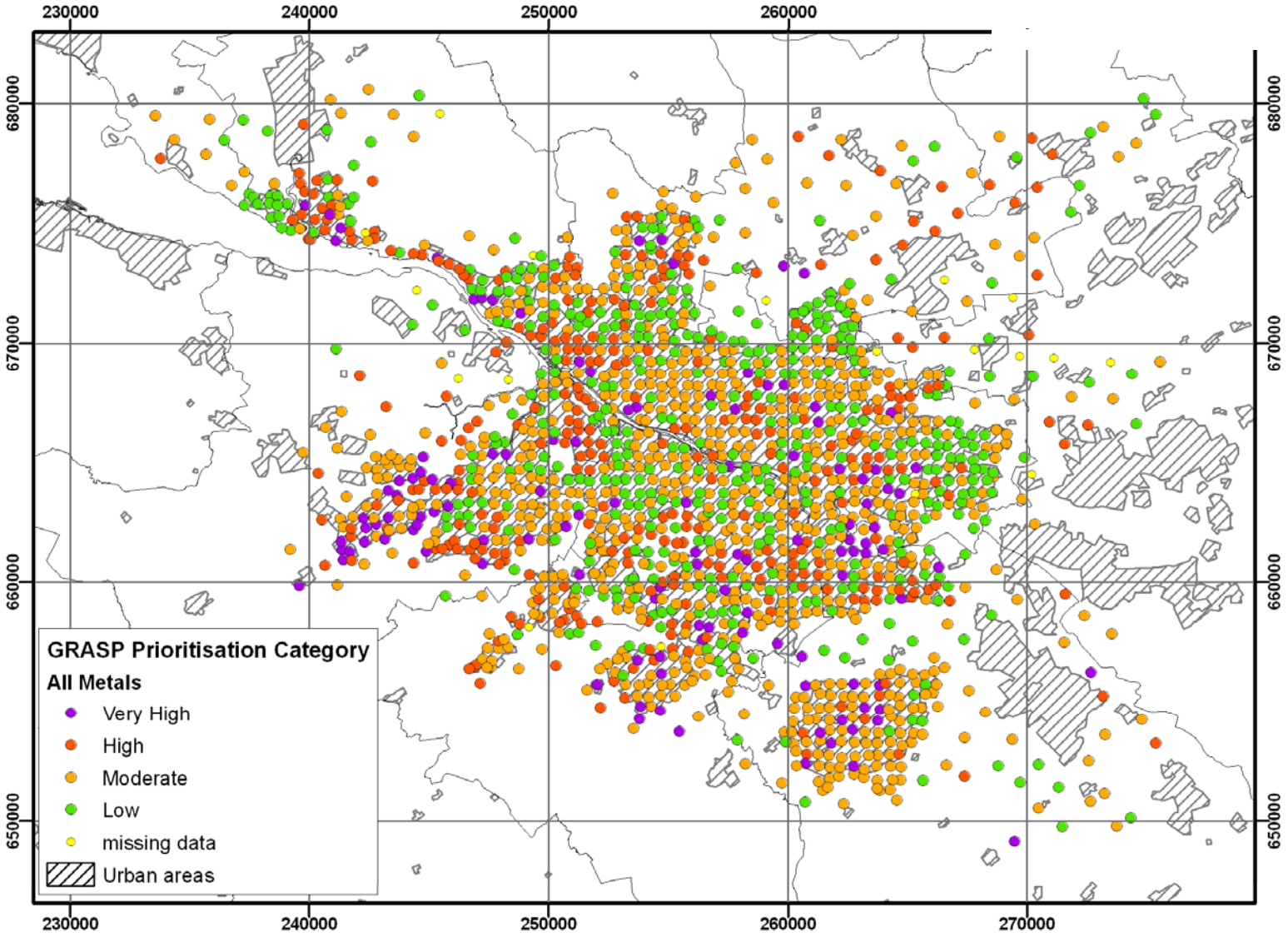


GRASP:

Predicting threats to shallow groundwater quality from the downward leaching of soil metal contaminants

GRASP Output



Glasgow, UK

- Scotland's largest city
- **Issues:**
  - Industrial legacy of **contamination**
  - Urban **regeneration** & **development** – local authorities, Scottish Enterprise, Scottish Govt.
  - Water body **qualitative status** - Scottish Environment Protection Agency
- Extensive recent geoscience/geochemical **research**

Why GRASP?

- **City-wide** scale
- Addresses threats to groundwater (contaminant **pathway**)
- **First-pass** screening
- Uses available data from:
  - high quality **geochemical soil survey**
  - national-scale **groundwater** datasets

BGS Clyde Urban Super Project

Onshore sediment and soil geochemistry surveys

Estuarine geophysical and sediment geochemistry surveys

Digital data compilation of borehole records.

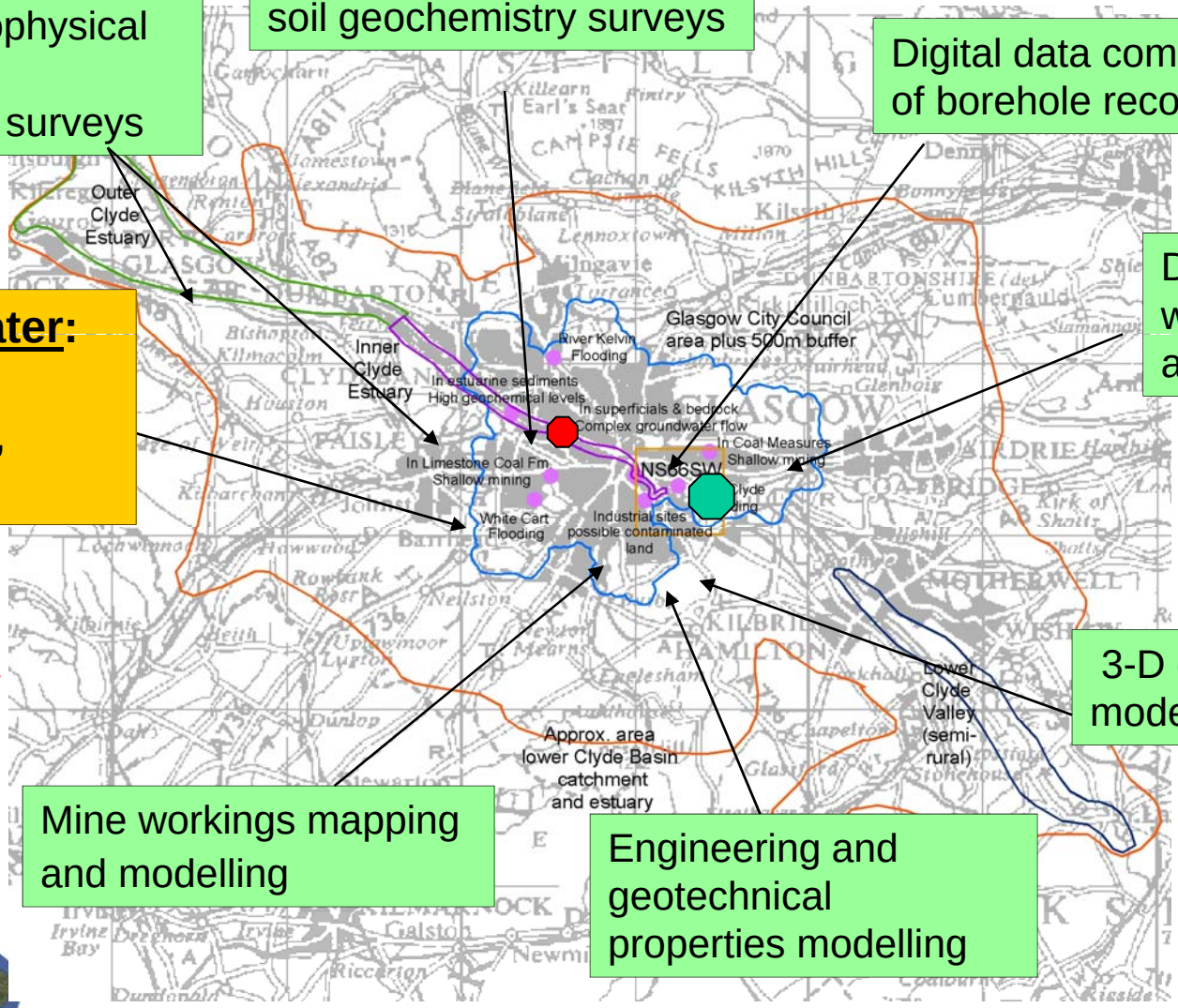
Data exchange with local authorities

Groundwater: GRASP, monitoring, modelling

3-D geological modelling

Mine workings mapping and modelling

Engineering and geotechnical properties modelling



GRASP Methodology

Step 1: Attenuation properties of unsaturated soil & Quaternary deposits

Step 2: Climatic water balance

Step 3: Depth to groundwater

BS-ISO soil leaching model **validated for 10 metals**

- Al
- As
- Cd
- Cr
- Cu
- Fe
- Mn
- Ni
- Pb
- Zn

Step 4: Measured metal concentrations in soil for each of 10 metals

Step 5: Combined GRASP prioritisation assessment for all 10 metals

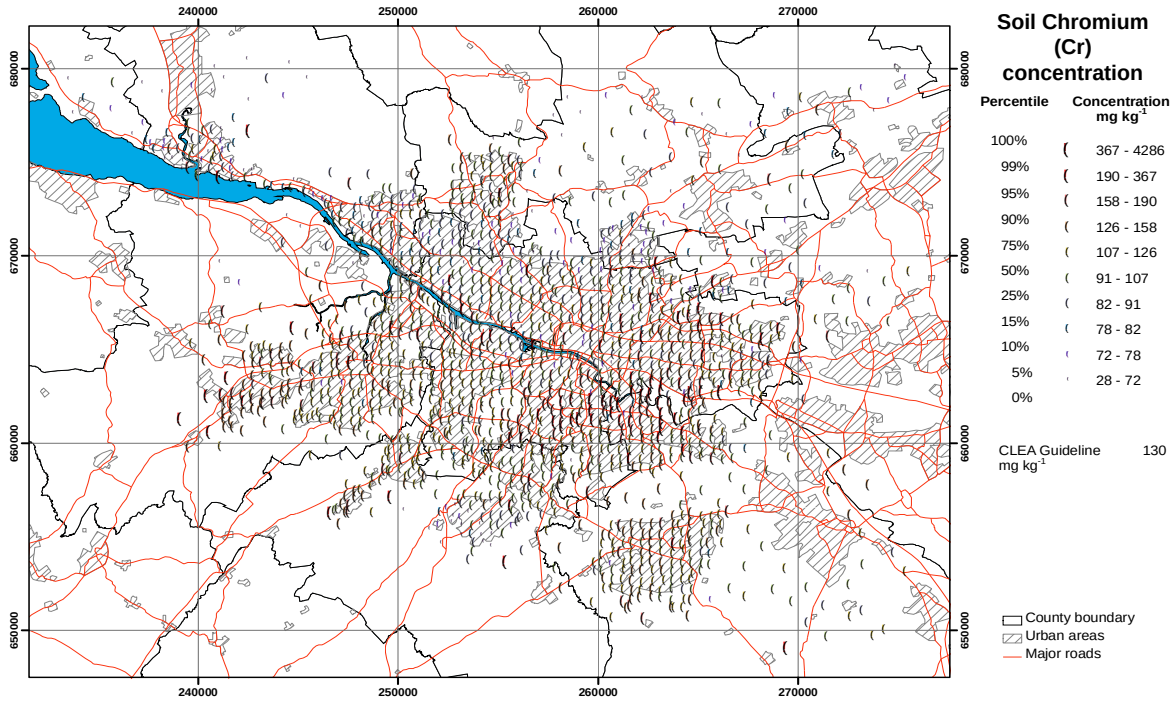
GRASP additional factors

Input data (i): Soil Geochemistry

(BGS Geochemical Baseline Survey of the Environment: G-BASE)

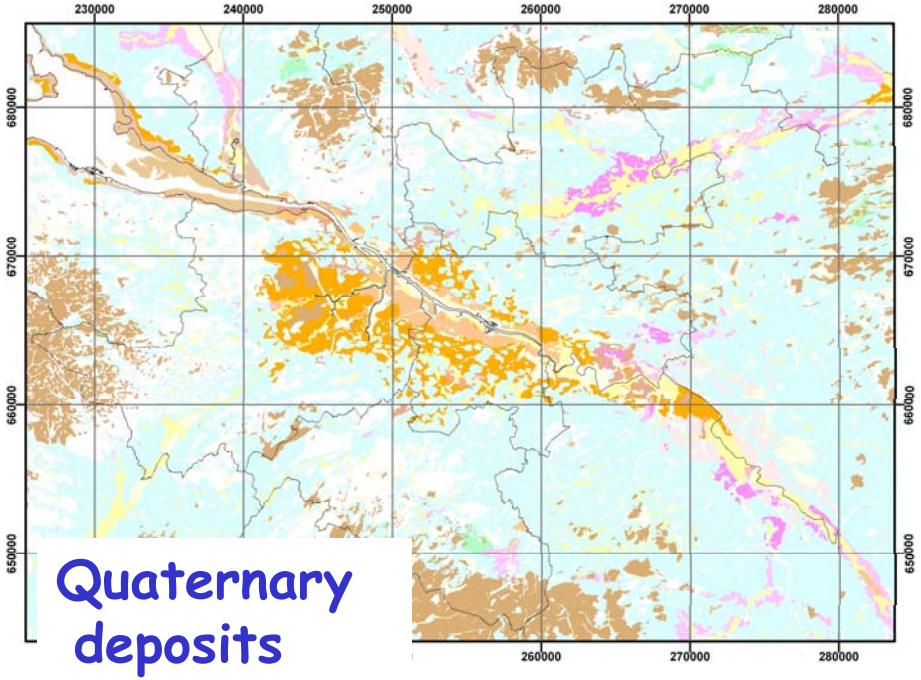
- Soil chemistry at **0.2 m** and **0.5 m** depths for **1622** sites.

- Total concentrations of 46 **elements** + **pH** + **Loss On Ignition** + **soil texture** + **colour**.

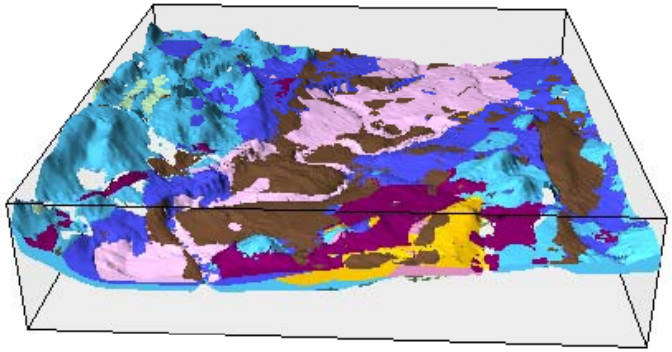


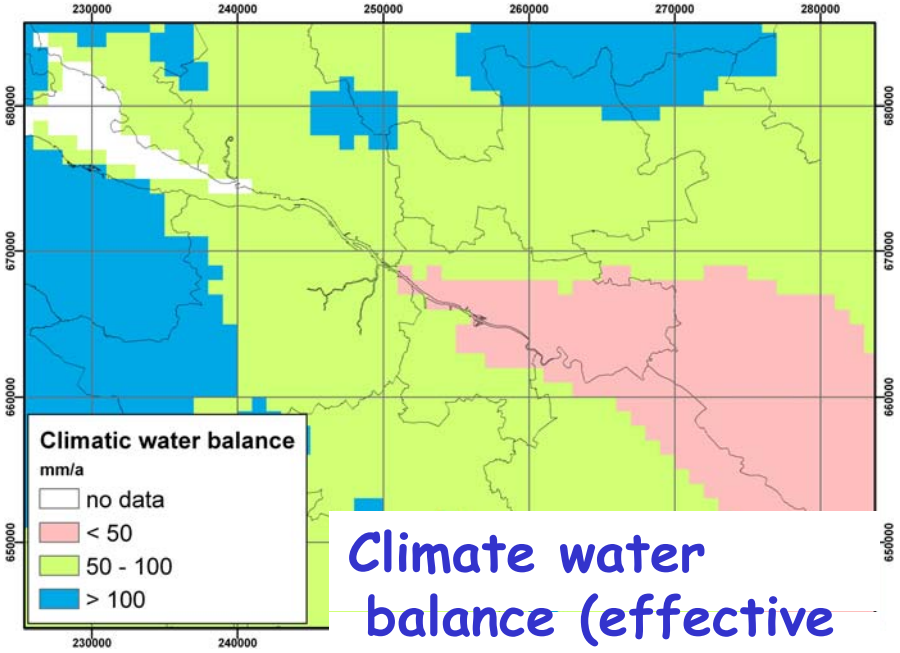
E.g. Cr concentration in soils

Input data (ii)

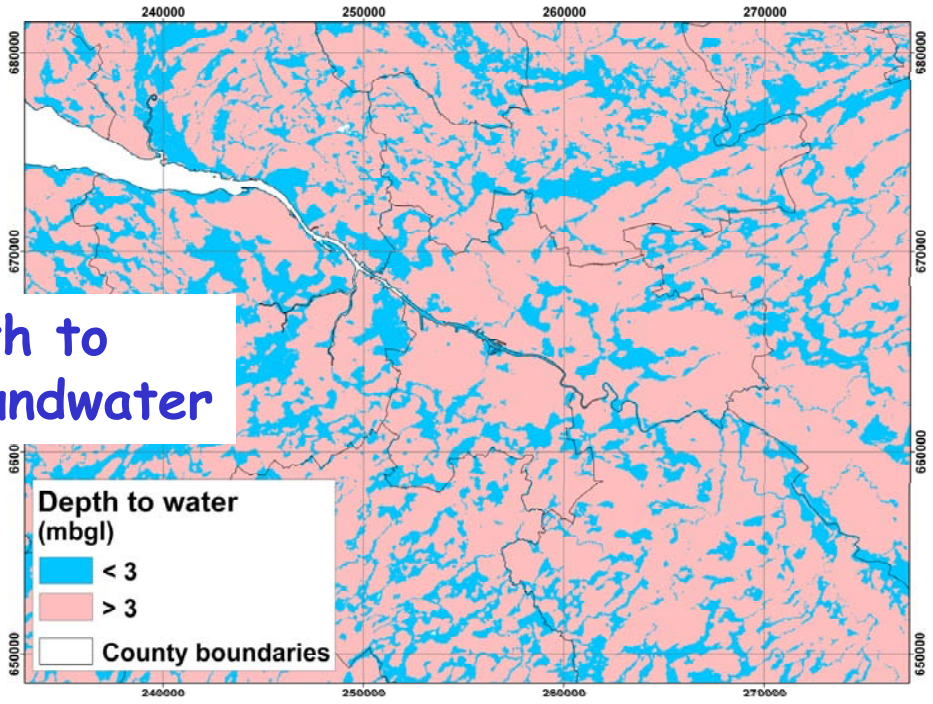


Quaternary deposits





Climate water balance (effective rainfall)



Depth to groundwater

Steps 1 – 3: Soil Leaching Model

(BS-ISO 15175:2004)

top soil → pH + organic carbon + clay + sesqui-oxides

+

sub soil + Quaternary → unsaturated → organic carbon + clay

+

effective rainfall

+

depth to groundwater

Metal	Relative Binding Force b_{ij} for given pH-range									
	2.5 to 2.7	> 2.7 to 3.2	> 3.2 to 3.7	> 3.7 to 4.2	> 4.2 to 4.7	> 4.7 to 5.2	> 5.2 to 5.7	> 5.7 to 6.2	> 6.2 to 6.7	> 6.7 to 8.0
Cd	0.0	0.5	1.0	1.5	2.0	2.5	3.5	4.0	4.5	5.0
Mn	0.0	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	5.0
Ni	0.0	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	5.0
Co	0.0	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	5.0
Zn	0.0	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	5.0
Al	1.0	1.5	2.0	3.0	3.5	4.5	5.0	5.0	5.0	5.0
Cu	1.0	1.5	2.0	3.0	3.5	4.5	5.0	5.0	5.0	5.0
Cr(III)	1.0	1.5	2.0	3.0	3.5					
Pb	1.0	2.0	3.0	4.0	5.0					
Hg	1.0	2.0	3.0	4.0	5.0					
Fe(III)	1.5	2.5	3.5	5.0	5.0					

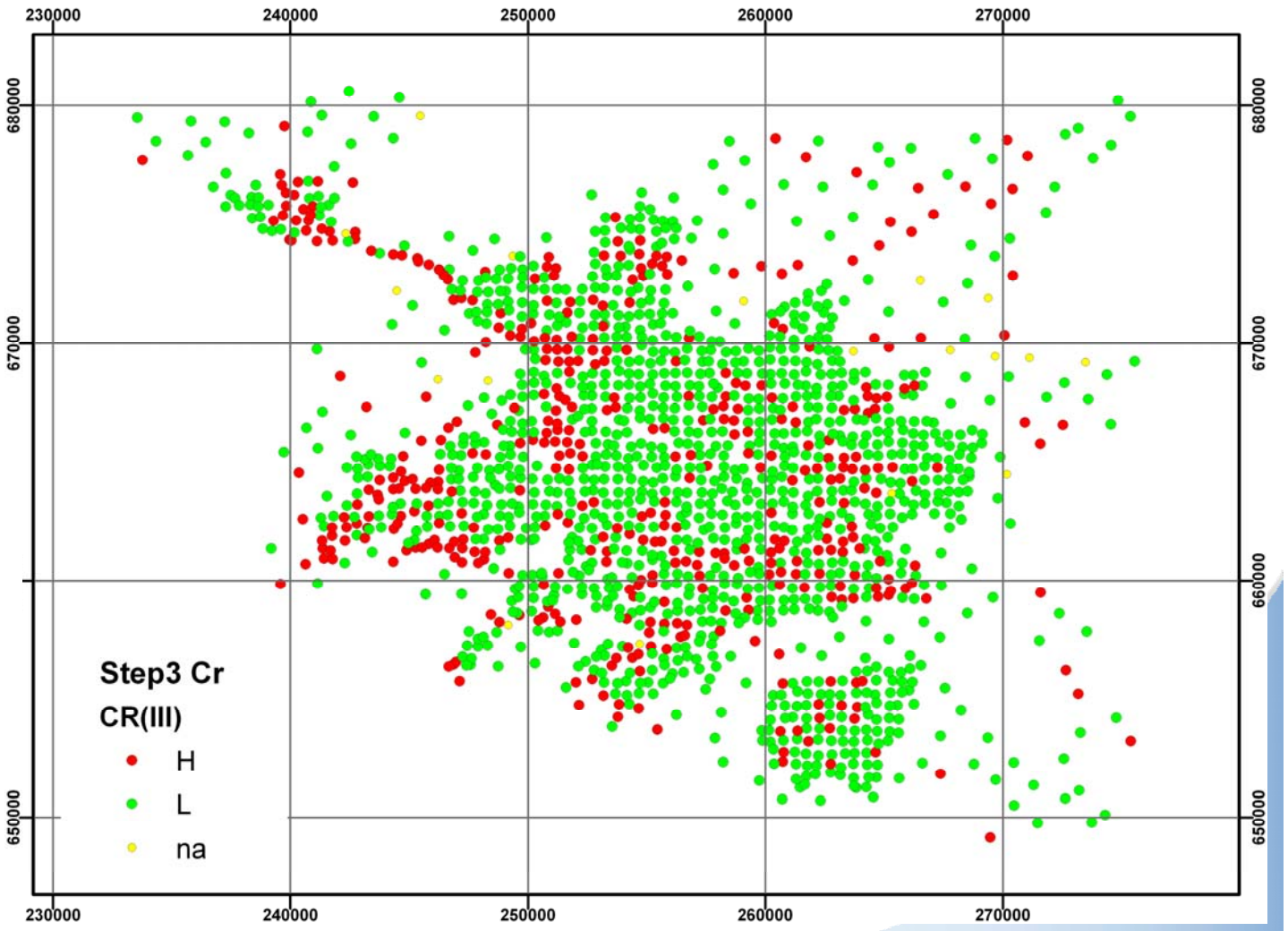
E.g. of look-up table for pH

Al As Cd Cr Cu Fe Mn Ni Pb Zn

End Step 3: Leaching Potential Maps

For each of 10 metals

E.g.
Cr leaching
potential map



Step 4: Incorporating soil metal concentrations

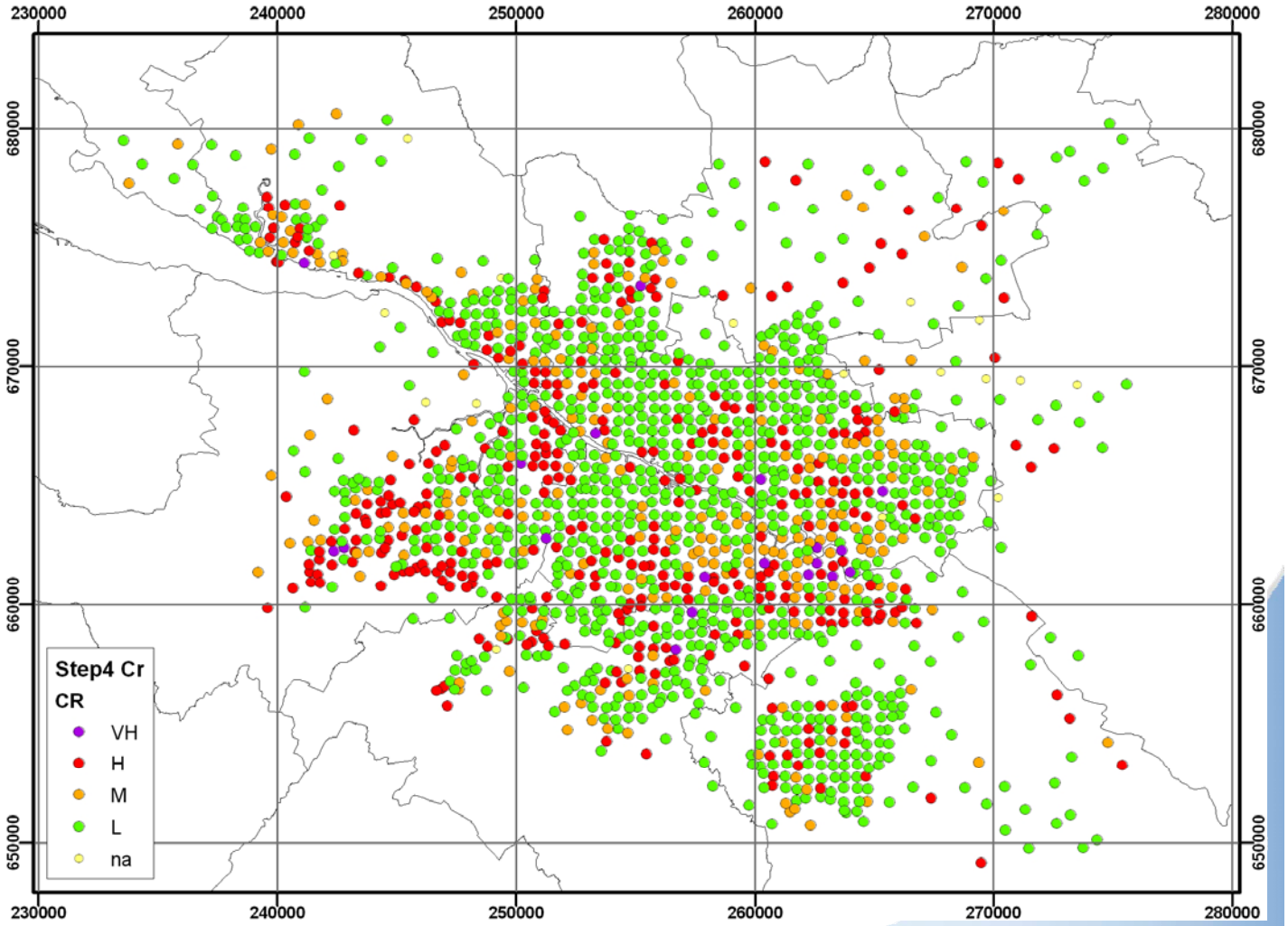
		G-BASE Metal Concentration Category (percentiles)		
		0-25 % (L)	25-90 % (M)	90-100 % (H)
GRASP Metal Leaching Potential Category (Step 3)	H	M	H	VH
	M	L	M	H
	L	L	L	M

Combination matrix

End Step 4: Prioritisation Ranking Maps

For each of 10 metals

E.g. Cr prioritisation ranking map

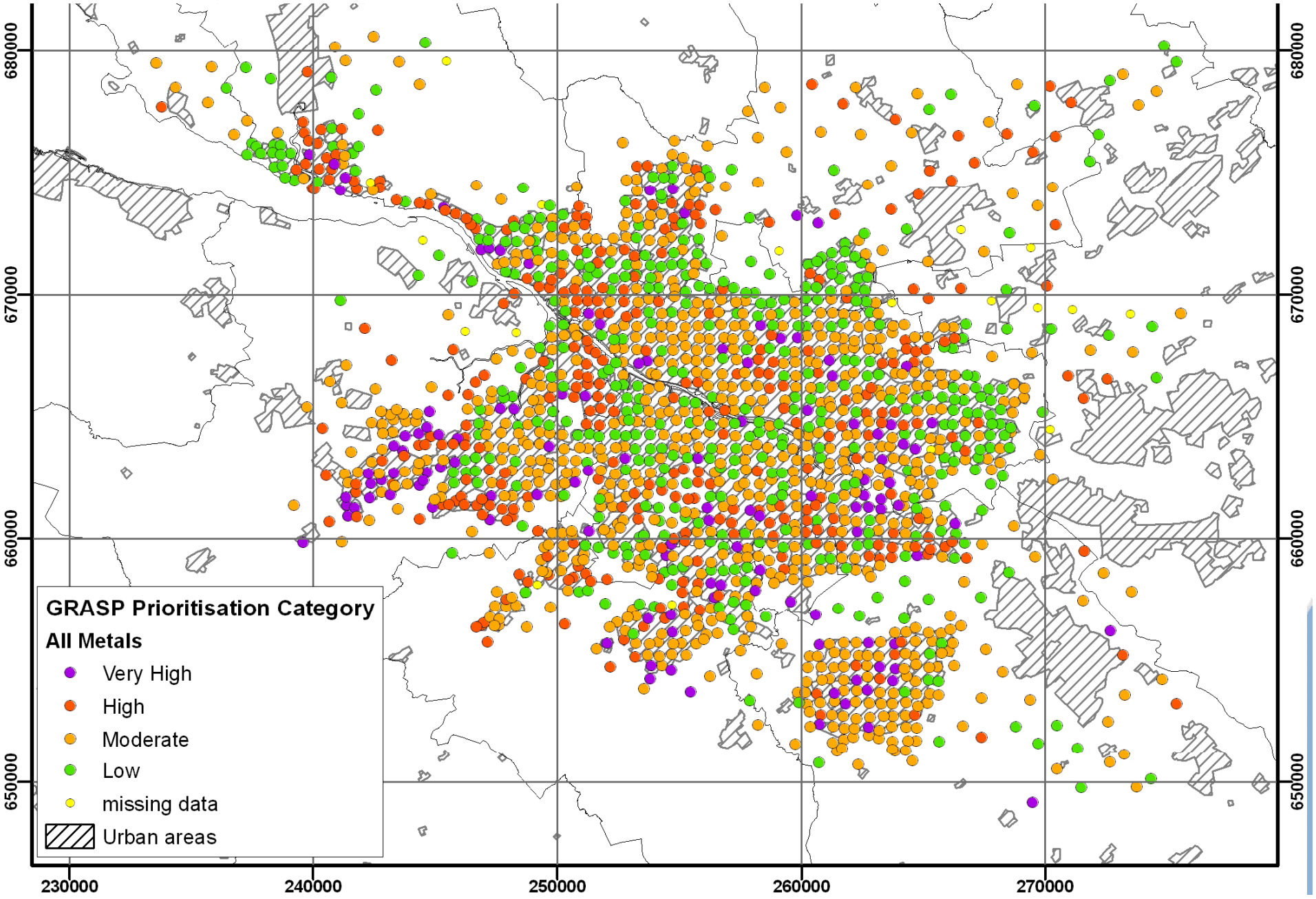


Step 5: Combined prioritisation ranking

Precautionary: combined category at a site determined by the **highest** ranking for any metal at that site

Individual Metal Rankings (Step 4)	Combined GRASP Priority Category (Step 5)
All 10 are Low	Low
One or more is Moderate, the rest Low	Moderate
One or more is High, the rest Low or Moderate	High
One or more is Very High, the rest Low, Moderate or High	Very High

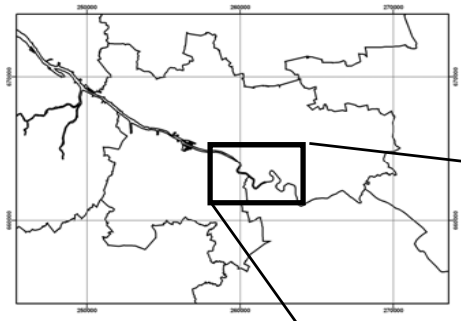
End Step 5: GRASP Prioritisation Map

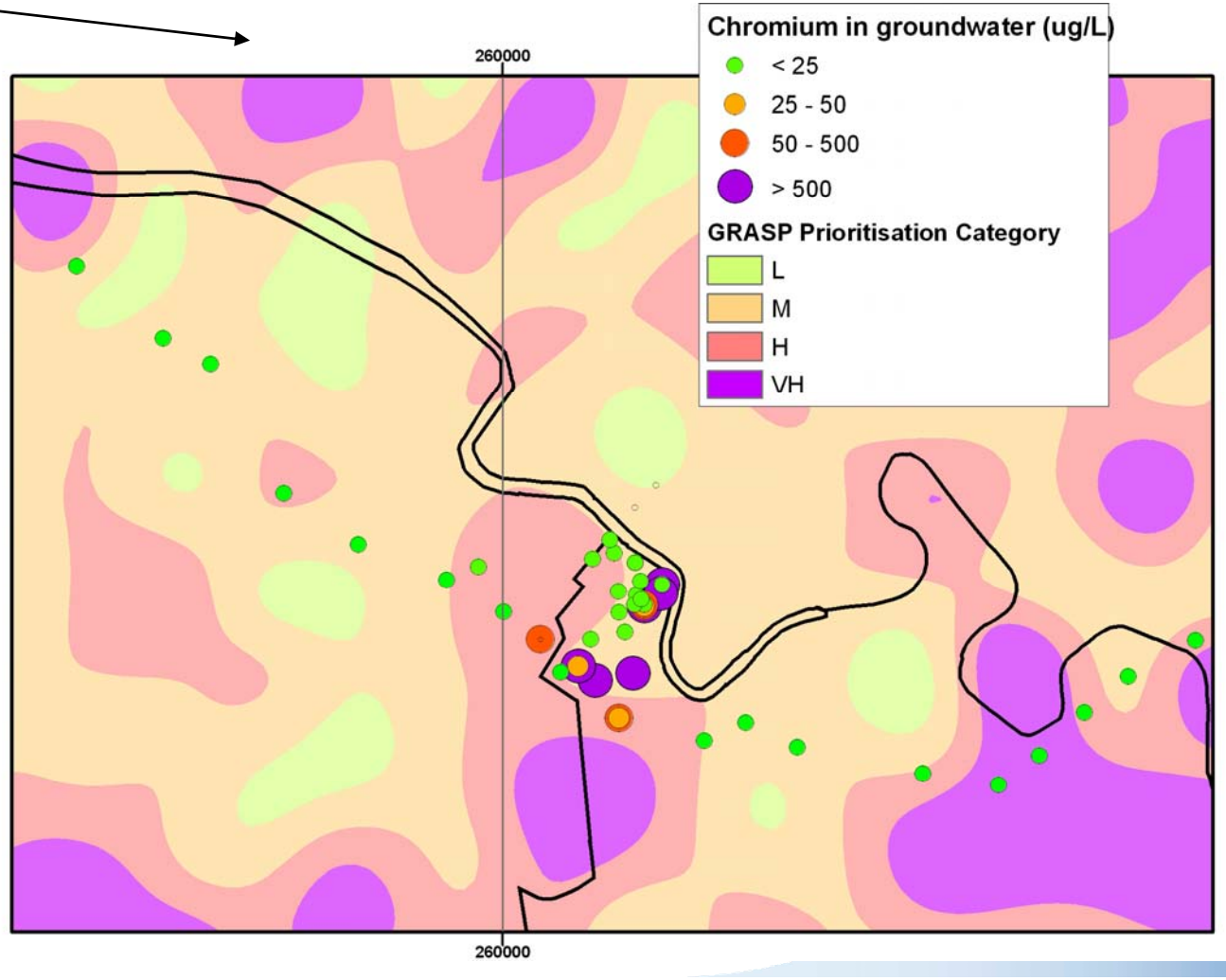


Initial interpretation of GRASP outputs

- Highlights **key areas at greatest threat** of metals leaching to shallow groundwater
- Main controls on **Very High priority** sites are **metal concentration** and **depth to groundwater**
- Main control on **High priority** sites is **depth to groundwater**
- Many highlighted areas coincide with known **industrial areas**

Limited available groundwater quality data for validation



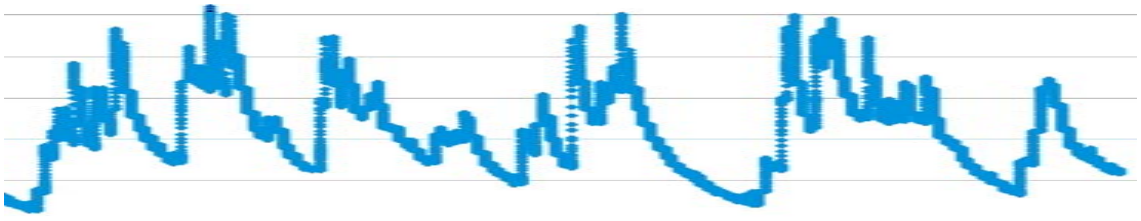


Initial validation: **partial match.**

Does this reflect the complex groundwater system?

Future work (i)

- Improve GRASP with better data from groundwater **monitoring**:
  - better **groundwater level** data to improve GRASP's predictions
  - more **groundwater quality** data for validation
- Use GRASP to **steer** monitoring: target areas at greatest threat



Future work (ii)

- Develop better understanding of pollutant **migration** and **attenuation** at a **city scale**:
  - Incorporate **groundwater flow** mechanisms by numerical groundwater **modelling**
  - Investigate the point at which metal **attenuation capacity** in soils is exceeded, e.g. using CEC &/or Kd values

Future work (iii)

- Apply to specific issues e.g.

- UK:
  - **Ecosystem health** (urban surface waters)
  - Sustainable Urban Drainage (**SUDS**)
  - **Climate change** impacts

- Internationally:
  - **Drinking water quality** & human health in industrialising cities

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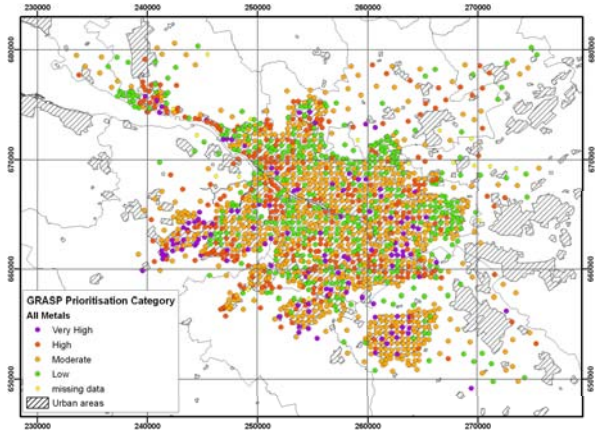

Thankyou

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