Application of a Human Health Risk Assessment Software to Support Revitalisation Decisions at Post-industrial Sites

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INSTYTUT EKOLOGII TERENÓW UPRZEMYSŁOWIONYCH KATOWICE

NORISC project – Network Oriented Risk-assessment by In-situ Screening of Contaminated sites

EC 5th Framework Programme for Research, Technical Development and Demonstration Activities

Energy, Environment and Sustainable Development
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Project Co-ordinator – Dr. Barbara Möhlendick, City of Cologne (CGN), Office for European Affairs, Cologne, Germany

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NORISC objectives

- combine and integrate new and existing investigation methods, especially innovative in-situ and on-site techniques

- provide a standard guideline for site characterisation in the form of a decision support software system (DSS)

NORISC objectives

- demonstrate the effectiveness of this investigation approach and developed DSS by conducting field tests

- integrate site investigation with general contaminated site management that includes data management, site assessment, clean-up targeting and development of revitalisation strategy

NORISC Human Health Risk Assessment (HRA) software

- one of the NORISC DSS components
- a tool for site assessors to support conducting site-specific risk assessment in post-industrial sites

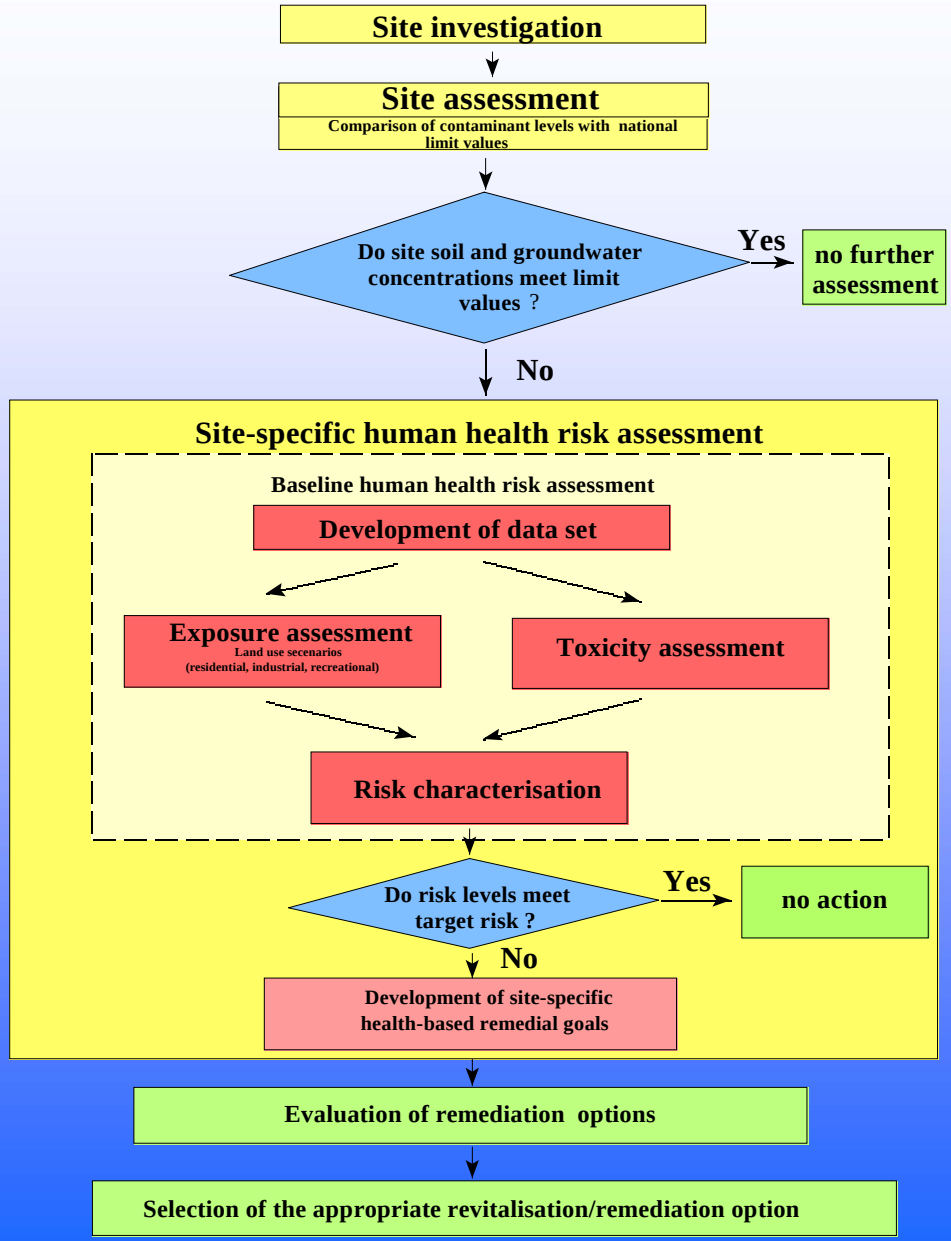
NORISC - HRA software

- for generating information on the level and spatial distribution of human health risks at contaminated sites
- for setting up preliminary Health-Based Remedial Goals (HBRGs)/Risk-Based Concentrations (RBCs)

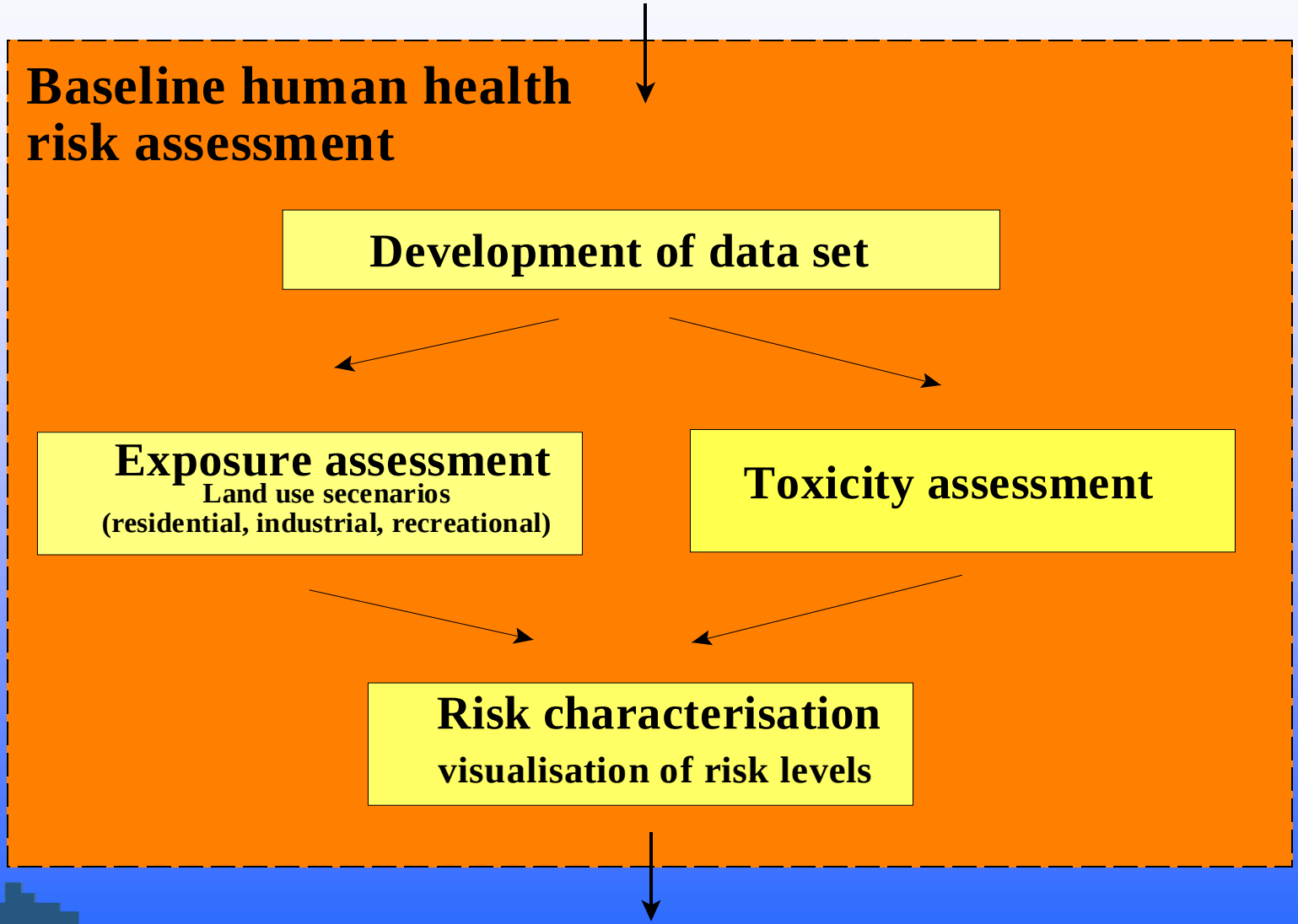
NORISC - HRA software

- based on US EPA site-specific risk assessment procedures
- proposed to be used when national soil and groundwater limit values are exceeded
- serves as a link between site investigation and remediation/revitalisation decision-making

HRA process as an element of the strategy for the revitalisation/remediation of contaminated sites



Site-specific human health risk assessment



Land use categories/Exposure pathways

Exposure pathway	Land use scenario								
	Residential			Industrial/Commercial			Recreational		
	Surface soil	Sub-surface soil	Ground-water	Surface soil	Sub-surface soil	Ground-water	Surface soil	Sub-surface soil	Ground-water
Incidental soil and dust ingestion	✓			✓			✓		
Dermal contact with soil	✓			✓			✓		
Inhalation of fugitive dusts	✓			✓			✓		
Inhalation of volatiles outdoors		✓			✓			✓	
Ingestion of groundwater used as a tap water			✓						
Dermal contact while showering or bathing			✓						
Inhalation of volatiles from groundwater during household use			✓						

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Default exposure parameters

Symbol	Description	Unit	Residential scenario		Industrial/Commercial	Recreational scenario	
			Child	Adult	scenario (Adult)	Child	Adult
EF	Exposure Frequency	days/yr	350	350	225	214	214
ED	Exposure Duration	years	6	24	25	6	24
FC	Soil Fraction Contacted	unitless	1	1	1	0.08	0.08
BW	Body Weight	kg	15	70	70	15	70
IR_o	Ingestion Rate for soil	mg/day	200	100	100	200	100
IR_i	Inhalation Rate for soil	m^3/day	10	20	20	10	20
SA	Skin Surface Area - soil contact	cm^2	2800	5700	3300	2800	5700
AF	Soil-to-skin Adherence Factor	(mg/cm^2 /day)	0.2	0.07	0.2	0.2	0.07
AT (non-carcinogens)	Averaging Time AT=ED*365d/yr	days	2 190	8 760	9 125	2 190	8 760
AT (carcinogens)	Averaging Time	days	25 550	25 550	25 550	25 550	25 550
TR (non-carcinogens)	Target Hazard Quotient	unitless	1	1	1	1	1
TR(carcinogens)	Target Risk for carcinogens	unitless	1E-6	1E-6	1E-6	1E-6	1E-6

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Risk characterisation

- **Non-carcinogenic effects - Hazard Quotient**

  HQ = CDI/RfD

- **Carcinogenic effects**

  Cancer Risk = CDI x CSF

- **Summing Hazard Quotients and Cancer Risks across all chemicals and pathways (Hazard Index, Total Hazard Index, Cancer Risks, Total Cancer Risk)**

Risk characterisation

Calculating HQs, HIs and Cancer Risks as well as Total HI and Total Cancer Risk for relevant receptors (*child, adult*) depending on land use category:

- **for each sampling point concerning soil**

- **as a site value for water-bearing horizon concerning groundwater (if groundwater is planned to be used by residents)**

Default Target Risk levels

Target Hazard Quotient (HQ)/ Hazard Index (HI) = 1

Target Cancer Risk = 1E-06

Development of Risk-Based Concentrations (RBCs)

For contaminants with HQs and Cancer Risks exceeding Target Risk levels

- **Oral/Dermal and inhalation RBCs for carcinogenic and non-carcinogenic substances**
- **Selecting the lowest RBC value as a preliminary remedial goal**

Development of Risk-Based Concentrations (RBCs)

Method based on site-specific exposure data

$$RBC = C \times \frac{\text{Target Risk}}{\text{Calculated Risk}}$$

C - Chemical concentration in soil or groundwater

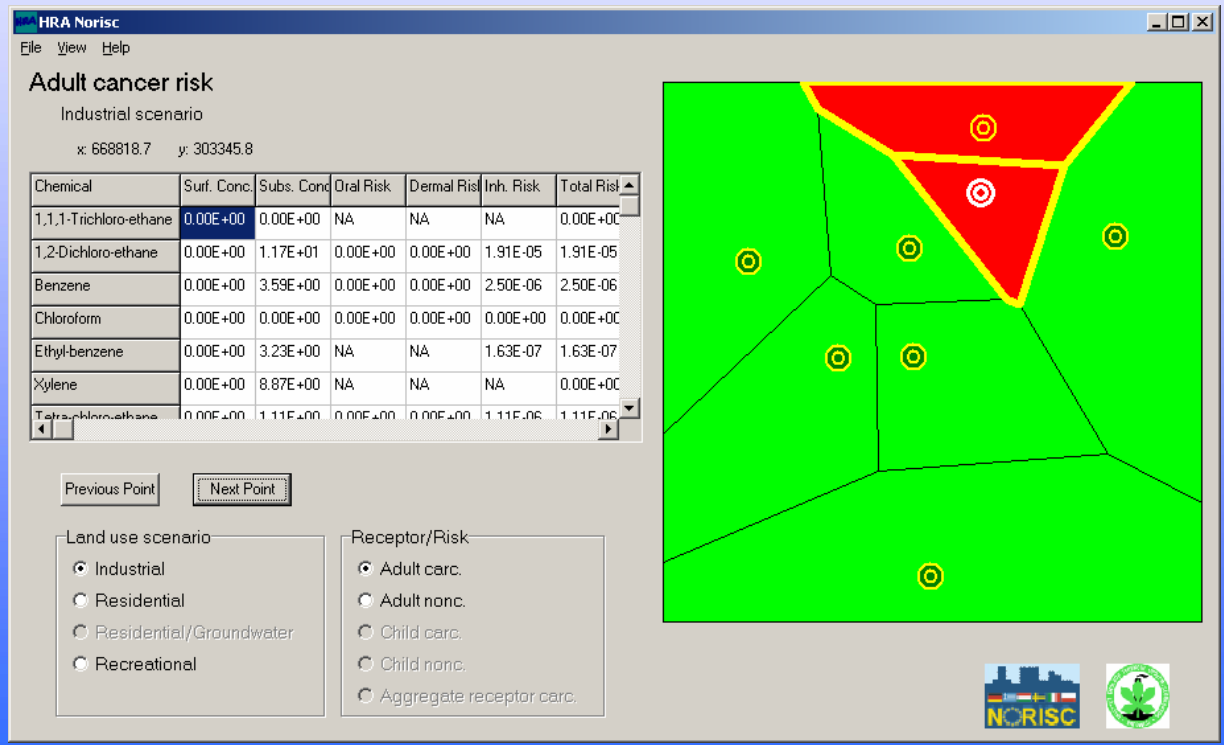
RBC - Risk-Based Concentration (oral/dermal or inhalation)

Visualisation of HRA results (only for soil)

- Presentation of HRA results for each soil sampling point
- Delineation of zones
  - **Risk zones** with Total Cancer Risks and Total HIs below and above Target Risk levels
  - **Remedial zones** with contaminant concentrations exceeding the calculated RBCs

Visualisation of HRA results

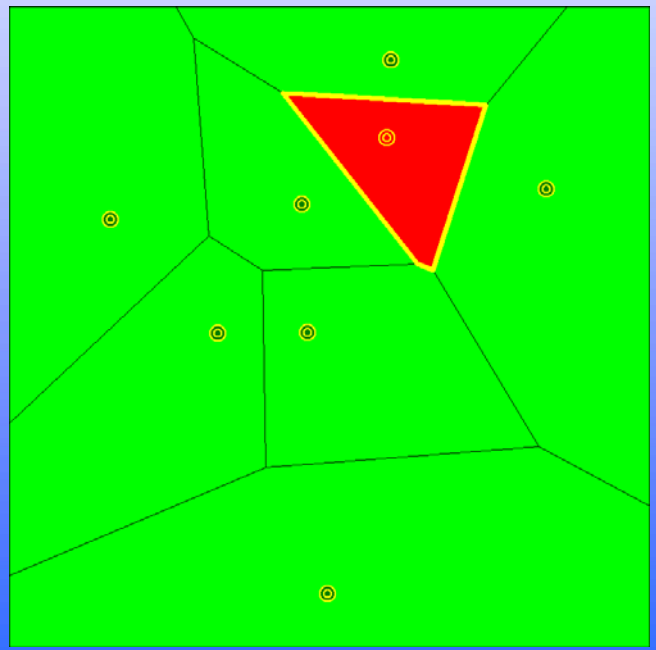
Risk characterisation outputs - an example



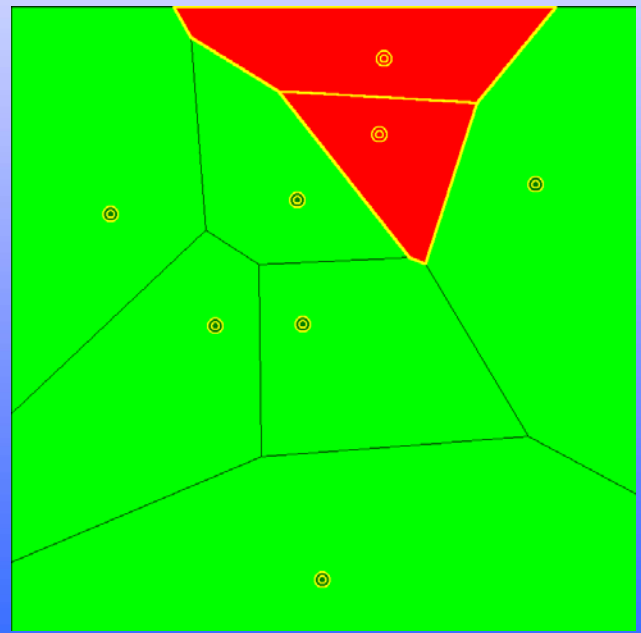
HRA software module report

Summary of HRA outputs - an example

Industrial scenario
Cancer risk zone
(Total CR = 6E-05)

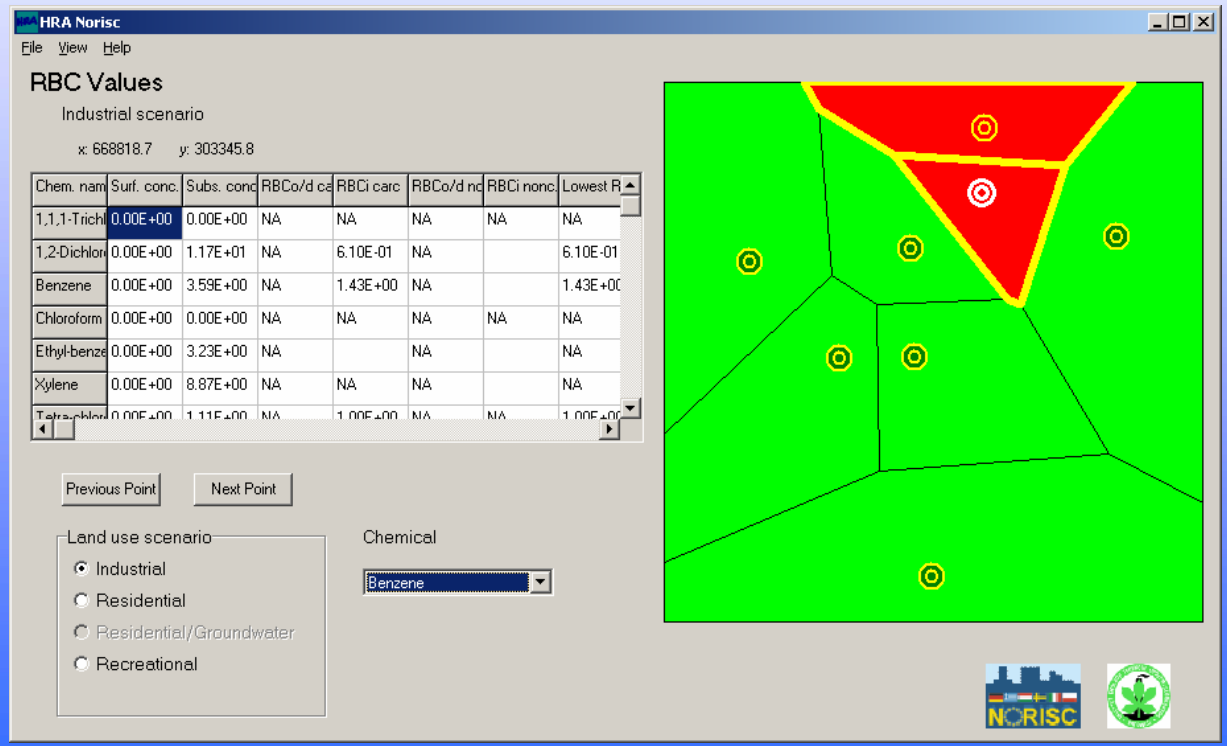


Residential scenario
Cancer risk zone
(Total CR = 2E-04)



Visualisation of HRA results

Analysis of RBC values - an example



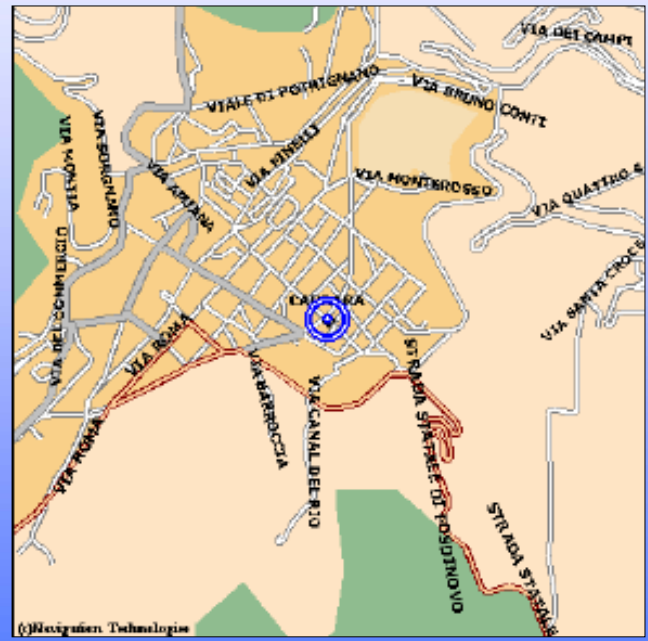
Application of HRA software

NORISC test sites

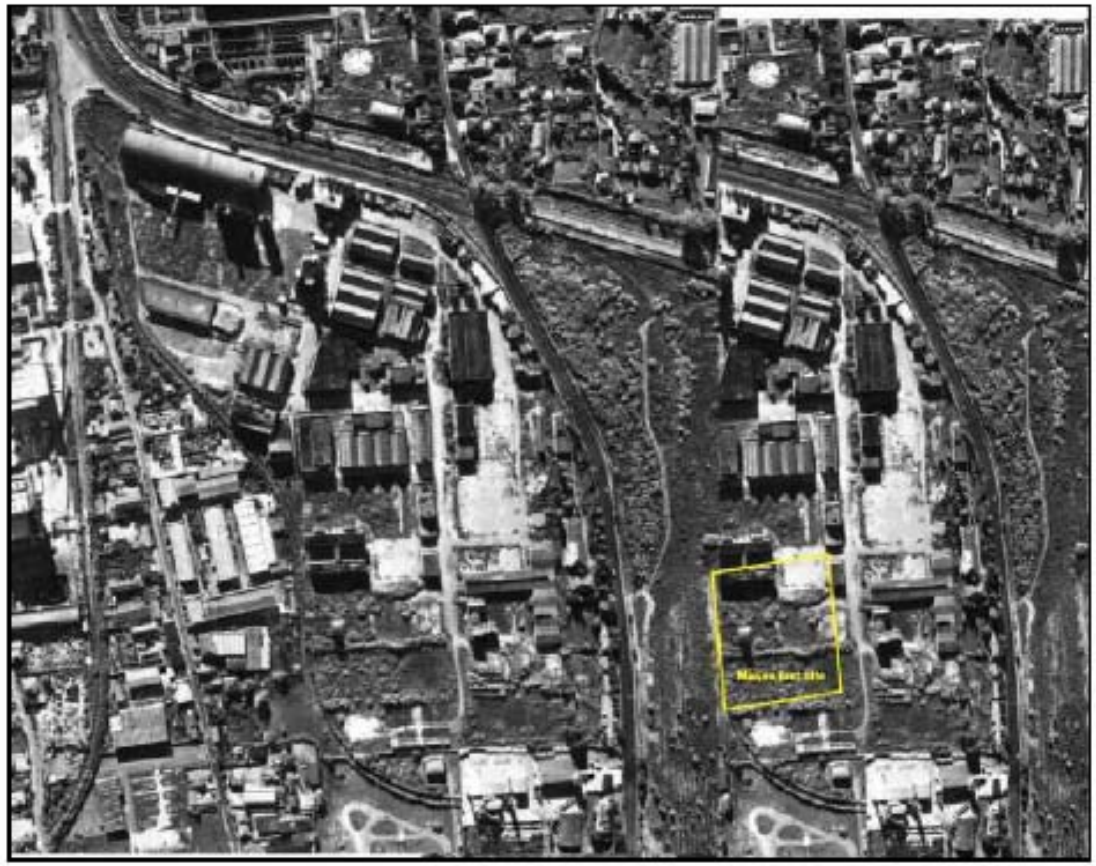
- Balassagyarmat site, Hungary - former petroleum filling station
- Massa site, Italy - former chemical factory, manufactured agrochemical products

Massa test site

AGRICOLTURA S.p.a.i.l. site;
15 ha industrial area
of Avenza-Carrara;
north-western part of Tuscany



Massa test site



Aerial photo;
investigated area (1.2 ha) marked in yellow

Massa test site

Massa test site

Chemicals of Potential Concern

- Arsenic
- Chromium
- Cobalt
- Copper
- Mercury
- Manganese
- Nickel
- Lead
- Zinc
- Aldrin
- DDT

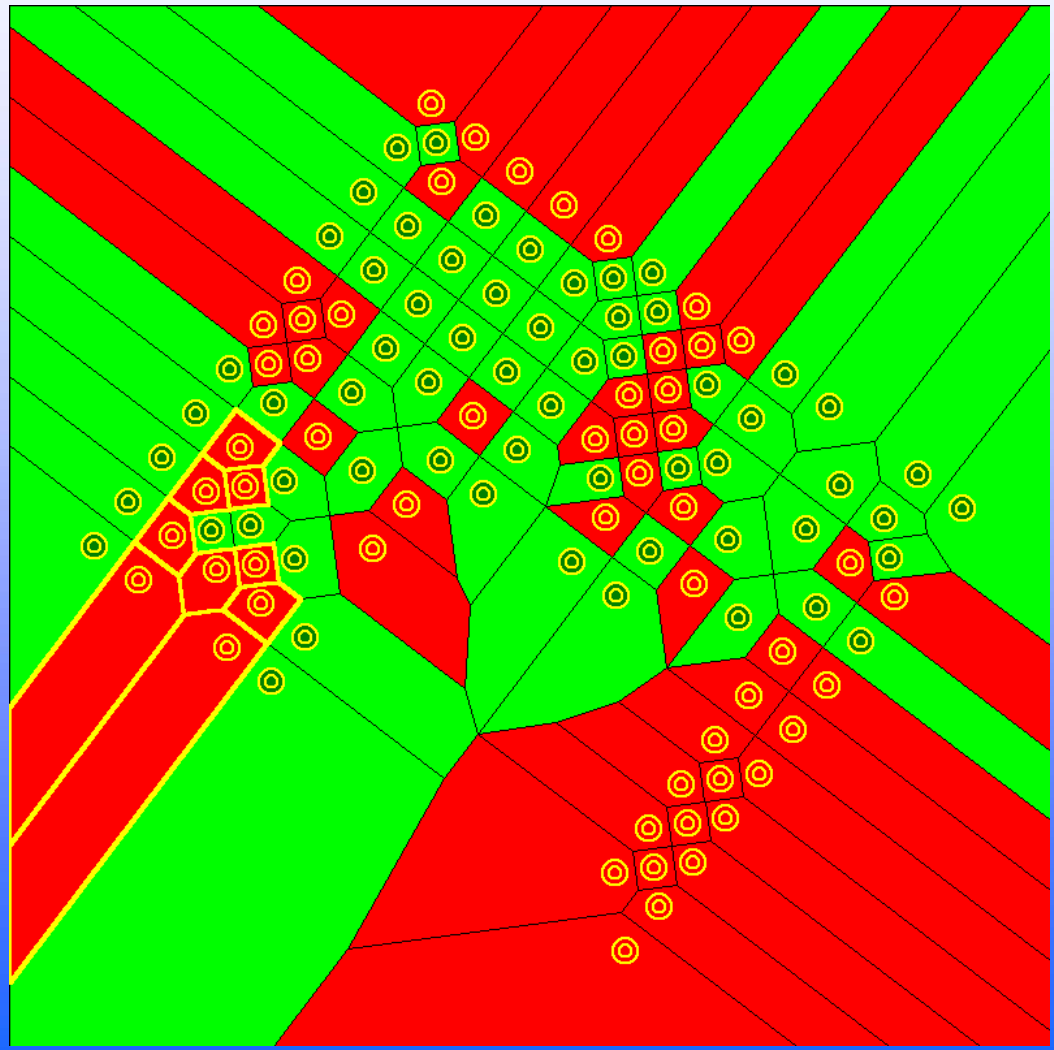
Massa test site – HRA results

10 non-cancer risk zones (total HIs > 1)

1 cancer risk zone (total CR > 1E-06)

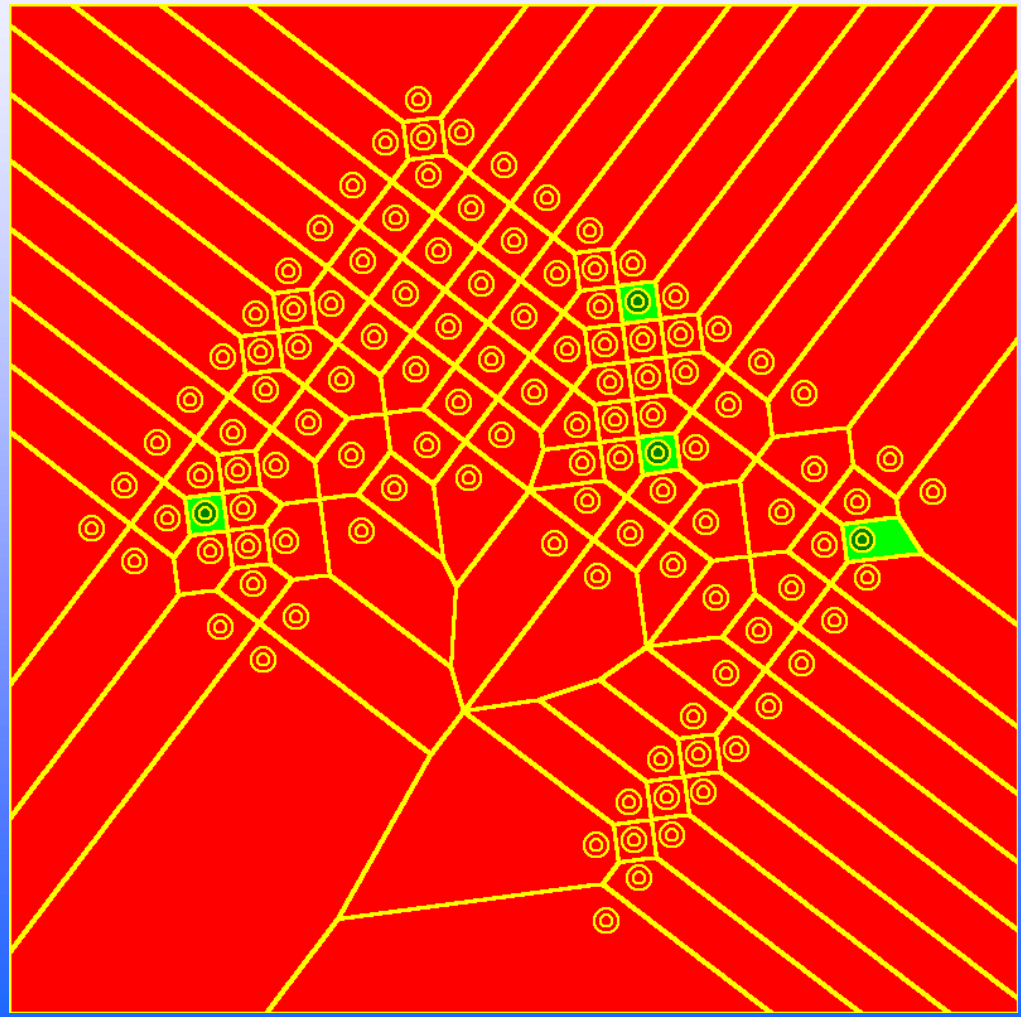
Massa test site – HRA results

Non-cancer risk zones



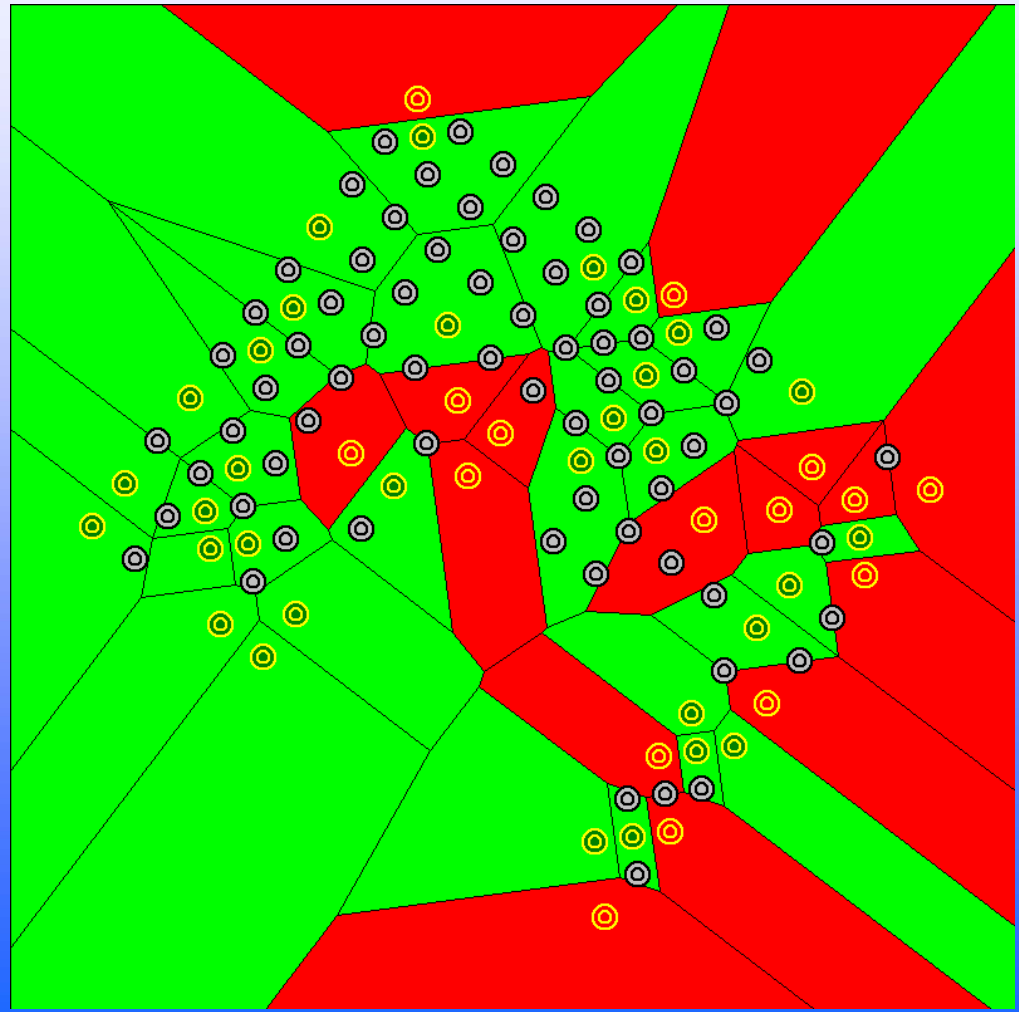
Massa test site – HRA results

Cancer risk zone



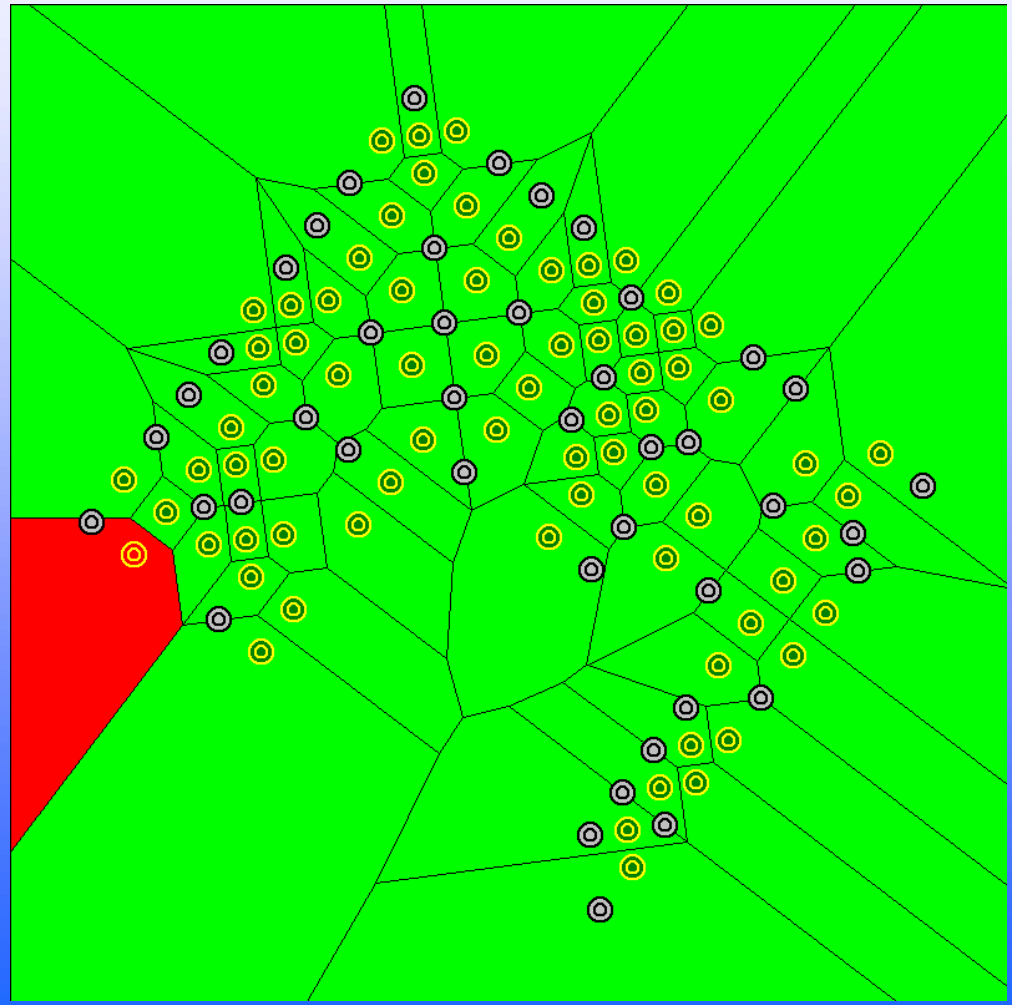
Massa test site – HRA results

Remedial zone - Aldrin



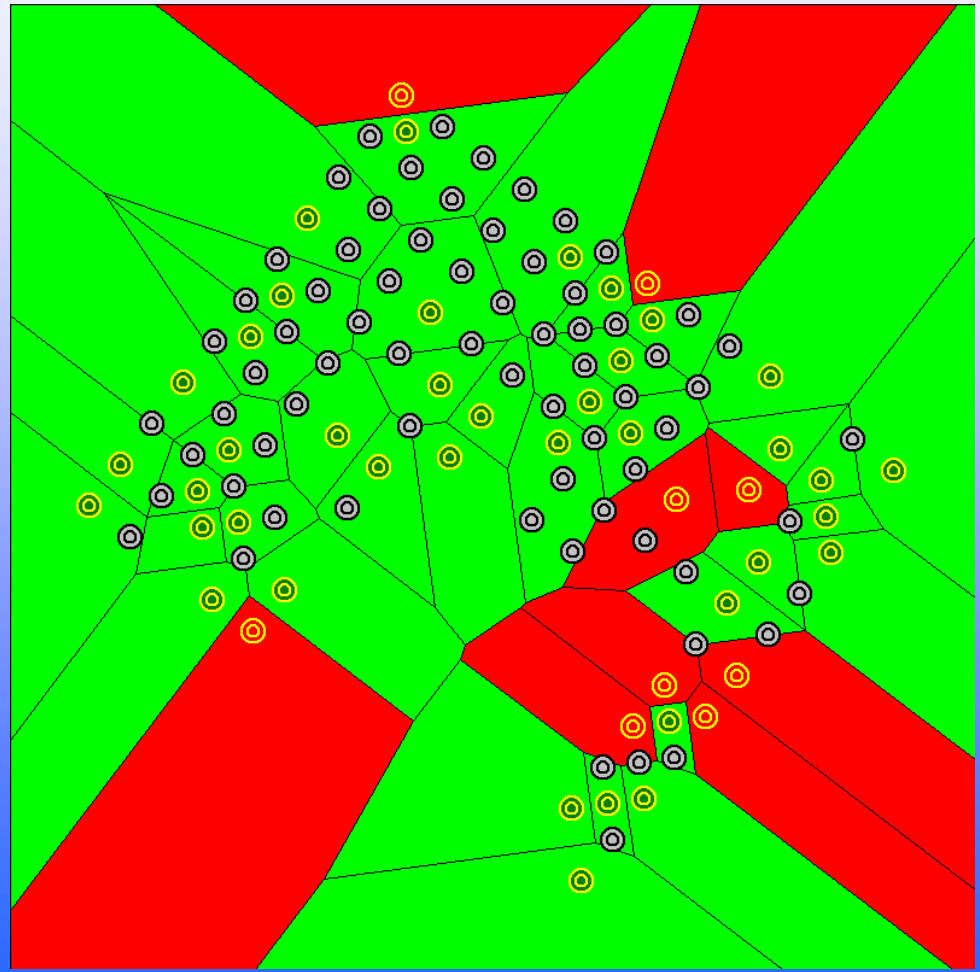
Massa test site – HRA results

Remedial zone - Cobalt



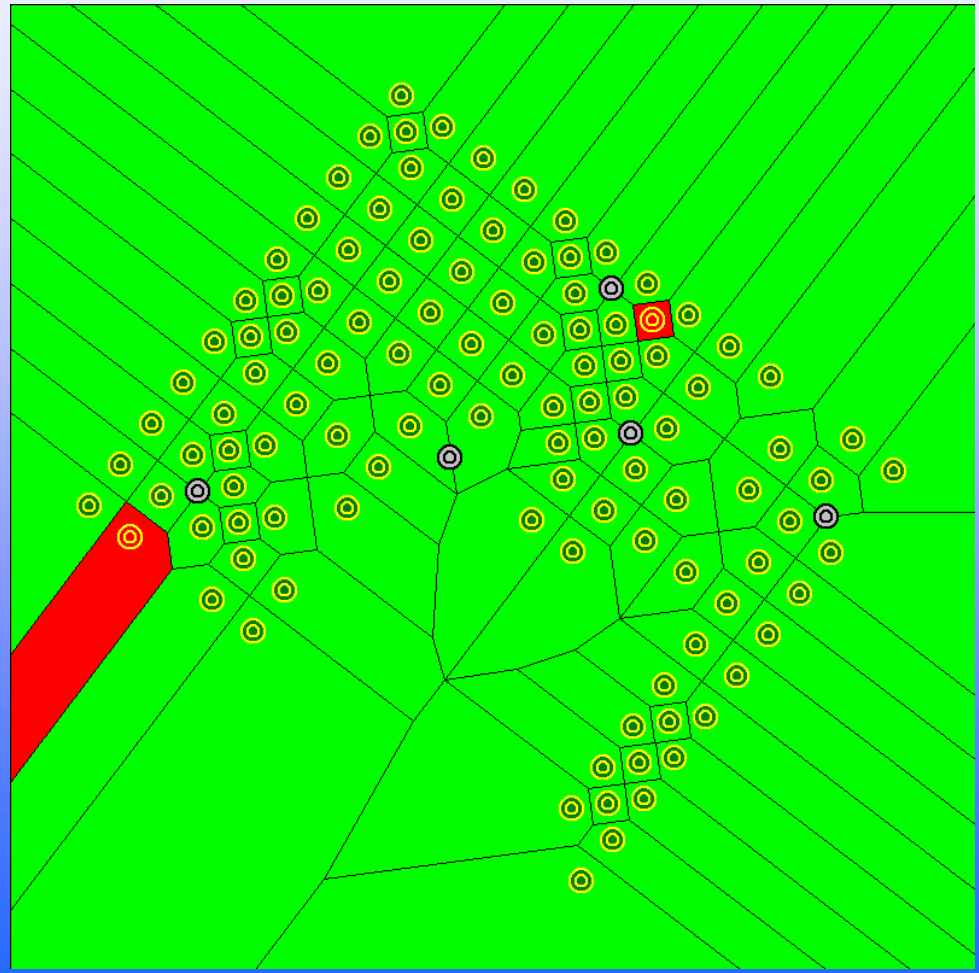
Massa test site – HRA results

Remedial zone - DDT



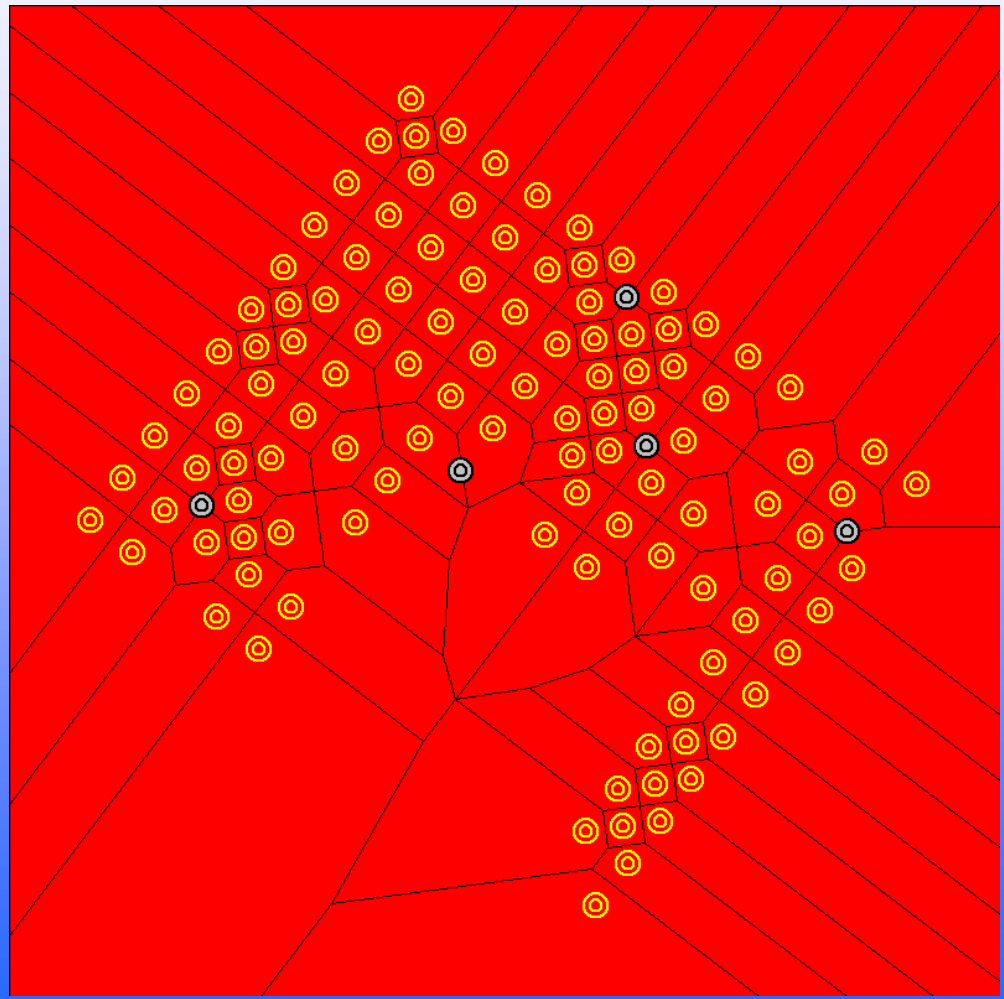
Massa test site – HRA results

Remedial zone - Manganese



Massa test site – HRA results

Remedial zone – Arsenic (dominant substance)



Application of the HRA results

- for designing and conducting remediation/revitalisation of post-industrial sites
- for setting up remedial/revitalisation options
- for facilitating other risk management decisions at the post-industrial sites

  (e.g., in city planning – considering different land use options)