NORM in TC – overview of the sites and of the radiological data

EMRAS II WG 2 – interim meeting October, 4-7

FANC AFCN

NORM in TC

Sedimentary phosphate ores: typical uranium concentration
1 – 2 Bq/g U-238sec

Ra-226 follows **calcium** in process:

- **CaF_2** sludges;
- **$CaCl_2$** in discharge water;
- **Scales** (sulphate scale $CaSO_4$)

NORM in TC

Before 1990

~ 3 Bq/g Ra-226 in CaF_2 sludges

But $RaCl_2$ in solution in discharge water (20 – 25 Bq/l Ra-226)

$\Rightarrow$ Accumulation of radium in sediments of discharge rivers (Laak and Winterbeek)

Dredging of sediments + flooding $\Rightarrow$ contamination of riverbanks

After 1990 (addition of $BaCl_2$)

Sharp decrease of Ra concentration in discharge water

Increase of Ra concentration in CaF_2 sludges: up to ~ 11Bq/g

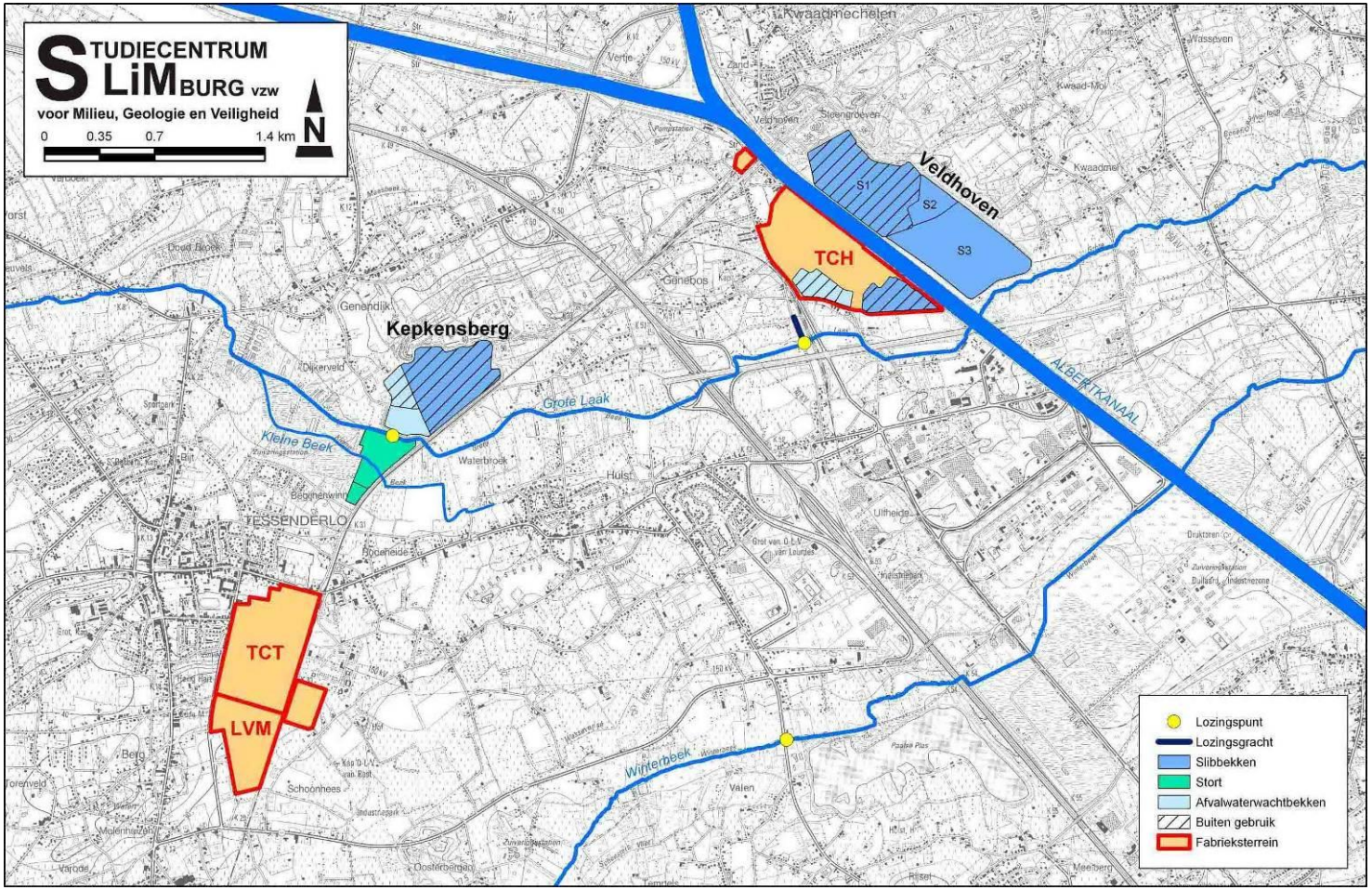
NORM in TC

Scales (SO_4 scales) – dissolution and decantation tanks, …

Activity up to ~ 90 Bq/g Ra-226
Dose-rate ~ 10 µSv/h

~ 1 ton/y $\Rightarrow$ disposed on landfill (after homogenization)

Tessenderlo's sites: overview



Tessenderlo's sites: overview

	Area (ha)	Volume (tons - DS)	Years of exploitation
Veldhoven - S1	25	900,000	1963-1986
Veldhoven - S2	4	50,000	(buffer dump) ~1980- today
Veldhoven - S3	26	900,000	1987 - today
Sludge basin - factory premises	5.6	150,000	1931 - 1968
Sludge basin Kepkensberg	19.7	~ 550,000	~ 1946 - 1979
Landfill Spoorwegstraat	2.4	630,000	1942 - 1983 + 1989 – 1996

Veldhoven sludge pond

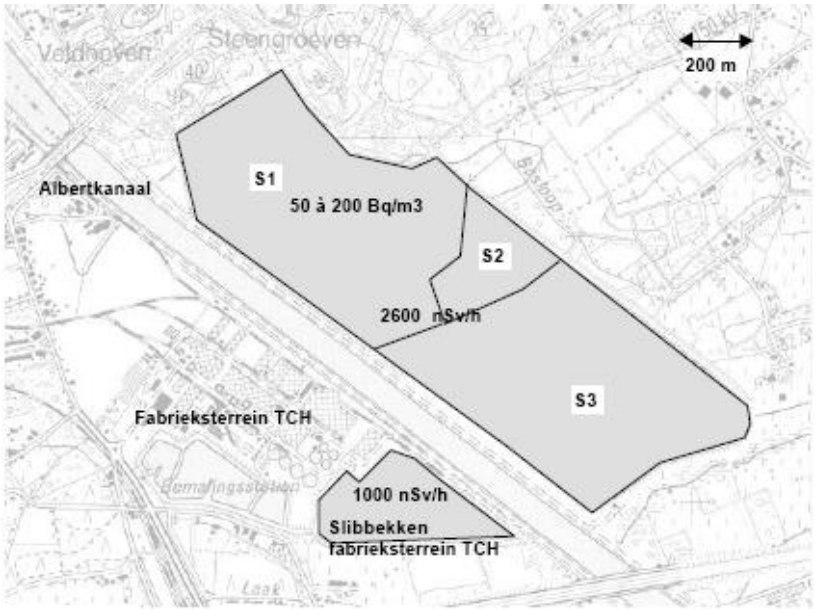
S3, S2 (buffer pond): still in exploitation

Mechanical dewatering of CaF_2 sludges via filter-press

Filter-cake disposed on sludge deposit site

~ 50,000 tons/y CaF_2 + 5,000 t neutralization sludge

(1 ton phosphate ore ⇒ 0.134 ton sludge)

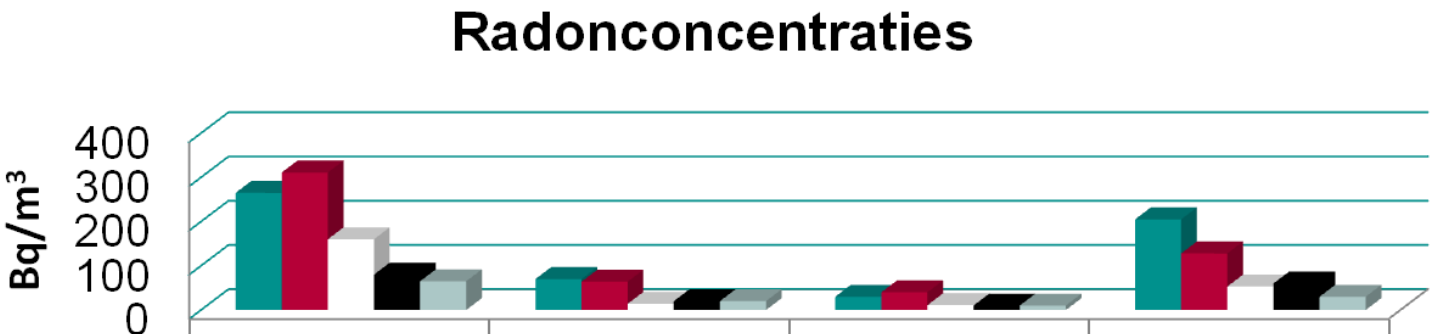


Veldhoven: radiological data

- External dose rate on dumpsite: **max. 2.5 µSv/h**
- Radon monitoring since 1993
- Radon in soil measurements
- Analysis of groundwater

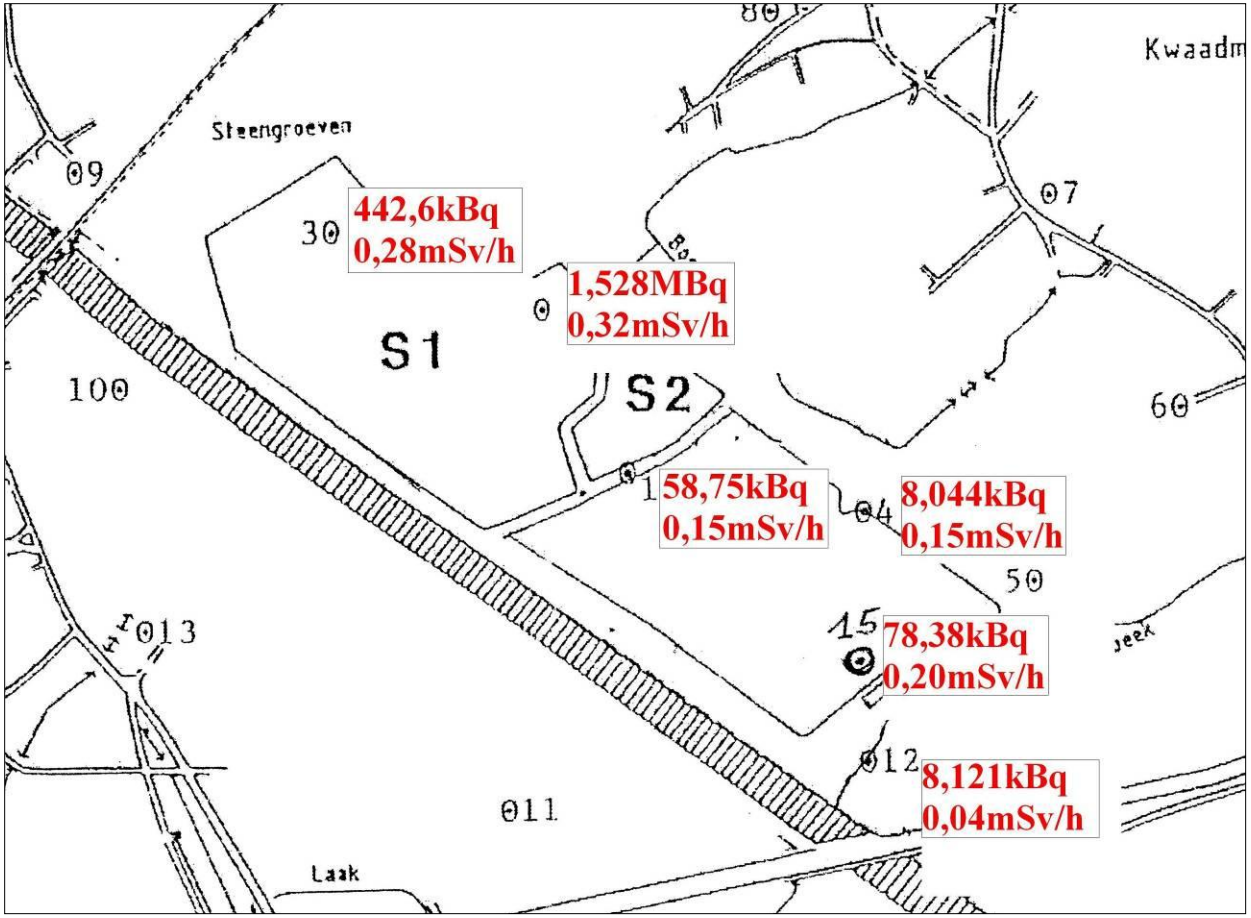
Veldhoven: radiological data

Radon in open air – 14 measurements points on and around Veldhoven(1.5 m high)



	Op en nabij S1+S2	Op S3	Omgeving slibbekken	punt 11 slibbekken TCH
2006	265	70	30	205
2007	311	64	40	128
2008	160	14	11	53
2009	80	20	10	60
2010	65	20	10	30

Veldhoven: radon in soil measurements



Veldhoven: radiological data

gross alpha measurements in two piezometers

At 10m – from < Detection Limit up to 0.14 Bq/l

At 20m - from < DL up to 0.03 Bq/l

Tessenderlo: site data

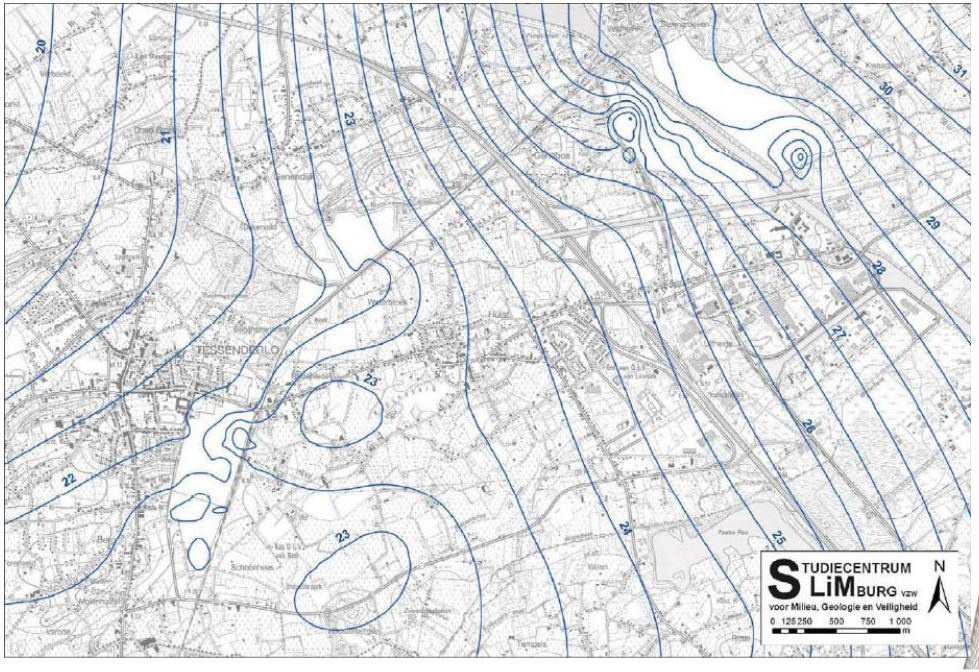
Nature of soil: sandy

Surface waters

Canal + streams ("Bosloop", "Grote Beek", "Kleine Beek", "Winterbeek")

Hydrogeology

- Groundwater: flow towards SW - "Grote / Kleine Beek" as drains
- Piezometric map available



Veldhoven: radiological assessment

EC Report (CARE):

"*Radiation Protection 115: Investigation of a possible basis for a common approach with regard to the restoration of areas affected by lasting radiation exposure as a result of past or old practice or work activity*" (H. Vandenhove et al.)

- Two exposure scenarios:
  - i) **Normal evolution** (farmers residing and working close to the site) => dose of ~ 0.5mSv/y
  - ii) **Intrusion scenario** (living in houses built on site) => 357 mSv/y (radon biggest contributor)

NB: SCK-CEN study (Vanmarcke et al. - 1993) much smaller contribution for Rn (with site-specific data)

=> Intrusion scenario 38 mSv/y – Normal evolution: trivial dose

Veldhoven: radiological assessment

SCK-CEN study – 1993: overview of (some) parameters

Infiltration rate rainwater	0.1 m/y
density	1.5 kg/m3
K_d - sludge	1 m^3/kg
K_d - soil	0.1 m^3/kg
K_d - aquifer	0.1 m^3/kg
Heigth aquifer	30 m
permeability	5000 m/y
Hydraulic gradient	2 10^{-3}
Darcy velocity	10 m/y

Overview results residential scenario

External exposure	2 mSv/y
Inhalation dust	0.002 mSv/y
Consumption vegetables grown in garden	1.6 mSv/y
Inhalation radon - indoor	34 mSv/y
Inhalation radon - outdoor	0.29 mSv/y
TOTAL	38 mSv/y

Sludge pond on factory premises

~ 310,000 m^3 CaF_2 sludges

Remediation foreseen ⇒ disposal on Veldhoven sludge deposit site

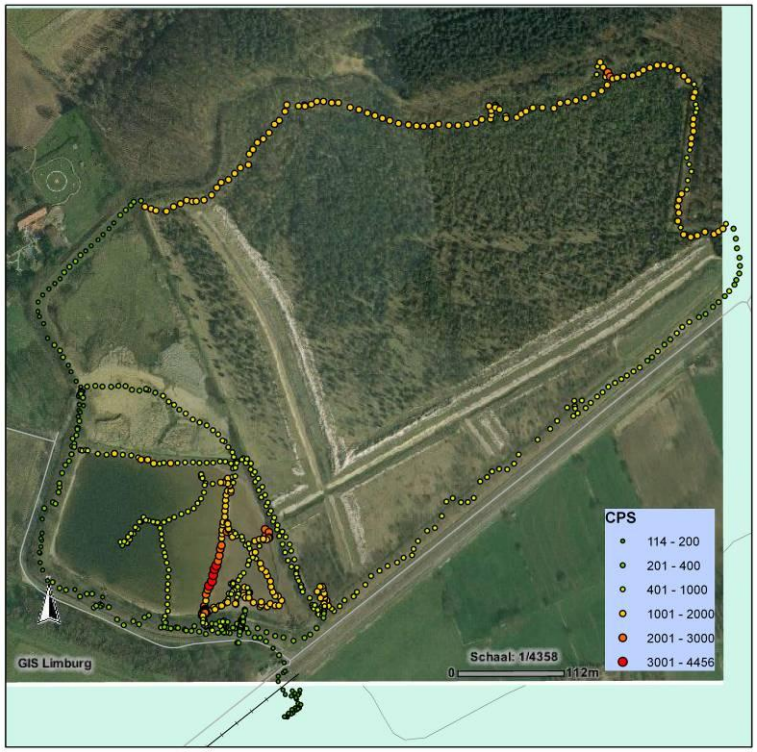
Groundwater - max. 50 mBq/l Ra-226

Sludge pond Kepkensberg

Sludge basin + buffer basin for waste water discharge

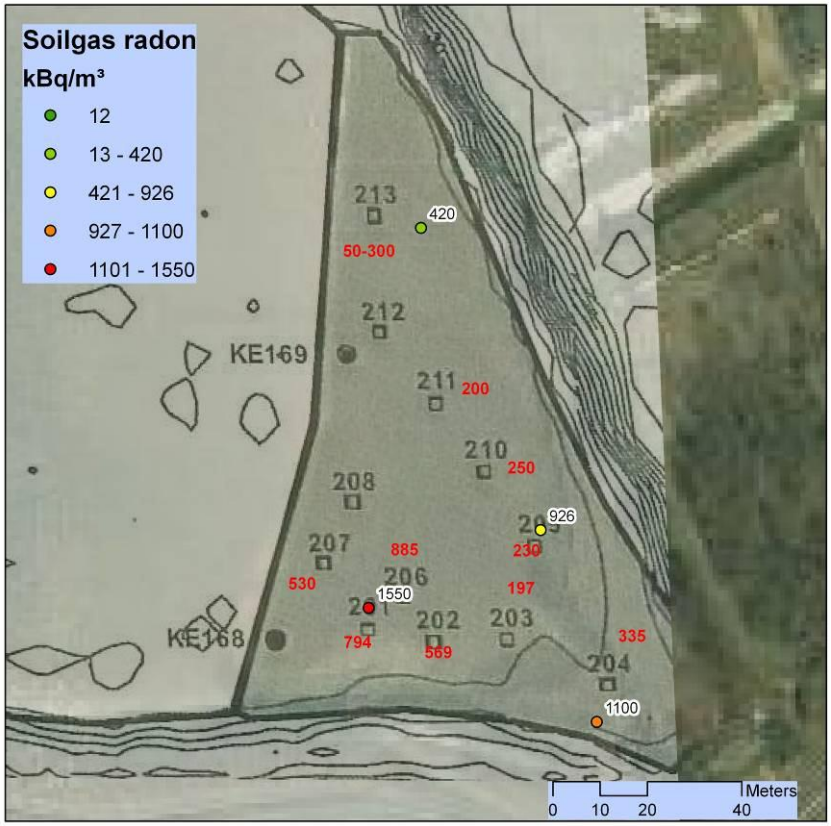
~ 550,000 T CaF_2 sludge – not operational since 1979

Will be reopened in the framework of remediation Winterbeek / Laak



Kepkensberg: radon in soil

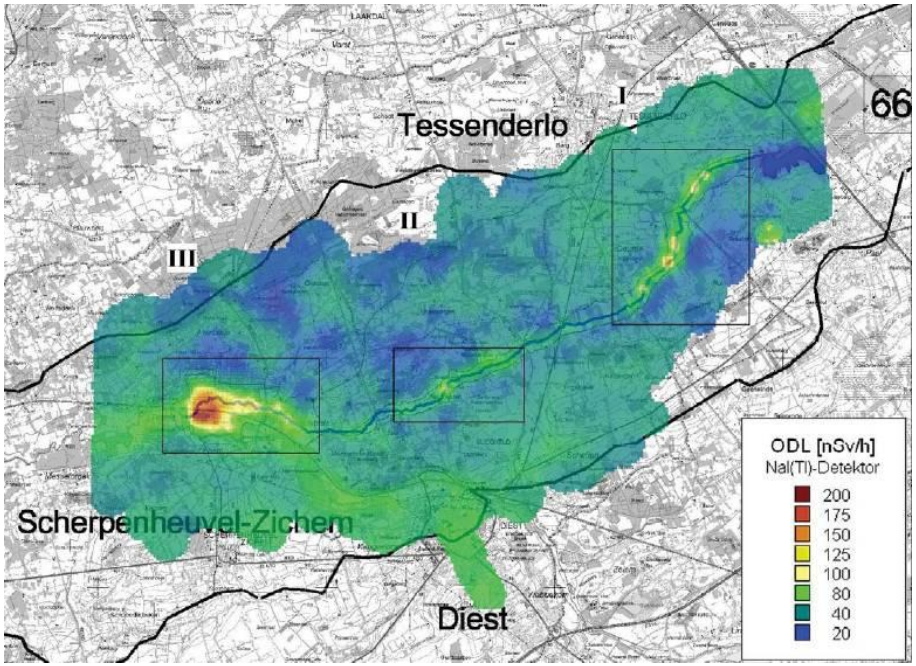
Radon in soil between 420 and 1550 kBq/m^3



Laak and Winterbeek streams

Dredging of sediments + flooding area: contamination of large areas with Ra-226

- Several measurements campaigns performed
- Aerial gamma-spectrometry (helicopter) over Winterbeek (in collaboration with BfS - 2004): contour of Ra contamination around Winterbeek



Laak and Winterbeek streams

Measurements campaign SCK-CEN of dose-rate (2007):

Dose-rate (nSv/h)	Winterbeek	Grote Laak
> 150	59 ha	7.8 ha
> 200	41 ha	4.15 ha
> 300	20 ha	1.4 ha
> 500	6 ha	0.2 ha

Laak and Winterbeek streams

Activity concentration Ra-226 on the banks of Winterbeek:

	Left bank (Bq/kg)	Right bank (Bq/kg)
Average on whole study area	1330	810
Range	8 - 8600	15 - 3700
Average on river side	3800	2000

Laak and Winterbeek streams

Radon measurements campaign in dwellings < 100 m from banks (**53** houses):

#	Average (Bq/m^3)	Median (Bq/m^3)	Range (Bq/m^3)
53	42	38	19 - 134
Percentage distribution			
< 20 Bq/m^3	20 – 39 Bq/m^3	40 – 59 Bq/m^3	> 60 Bq/m^3
2%	55%	37%	6%

Laak and Winterbeek: correlation Ra - Cd

Measurements campaign of SCK-CEN (2007) showed a **correlation** between **dose-rate** and **cadmium** concentration

⇒ Use of dose-rate as **tracer** for heavy metals contamination (facilitates delimitation of contour of contamination) ;

- Laak: areas with dose-rate > 150 nSv/h include **75 %** of samples with Cd > 6 mg/kg (ds)
- Winterbeek : areas with dose-rate > 150 nSv/h include **90 %** of samples with Cd > 6 mg/kg (ds)

⇒ 6 mg/kg Cd ~ 150 nSv/h …