

Mass transport of contamination released into surface water by landslide



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Aim

- Highlight a hazard not yet recognized
- Show possible implications

AIM

BACKGROUND

INVENTORY

WATER QUALITY
IMPACT

SUMMARY





Göta älv river, SW Sweden

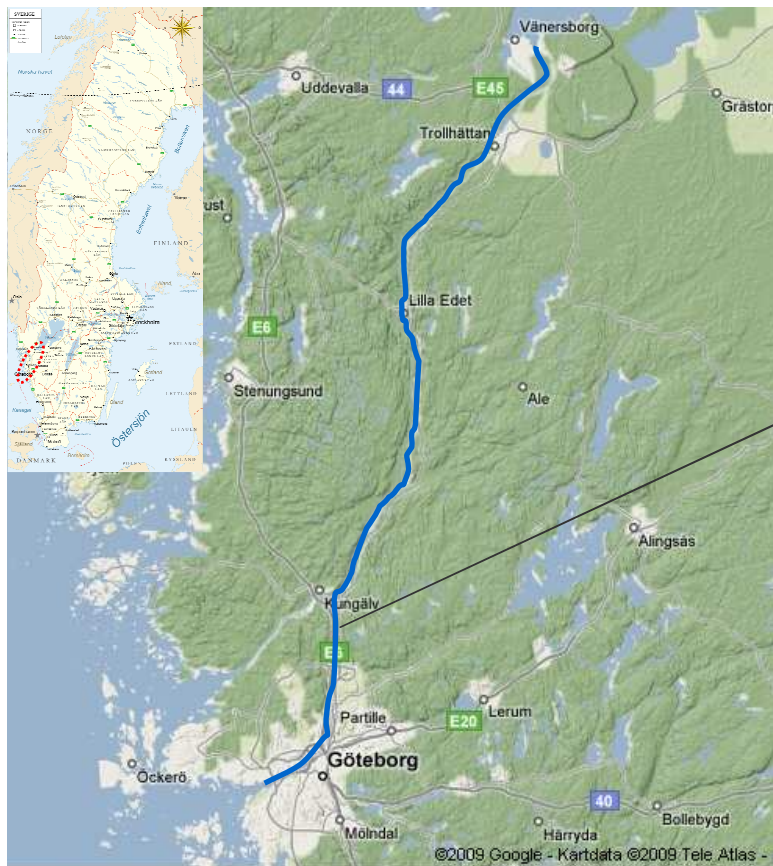


Photo: Gunnel Göransson

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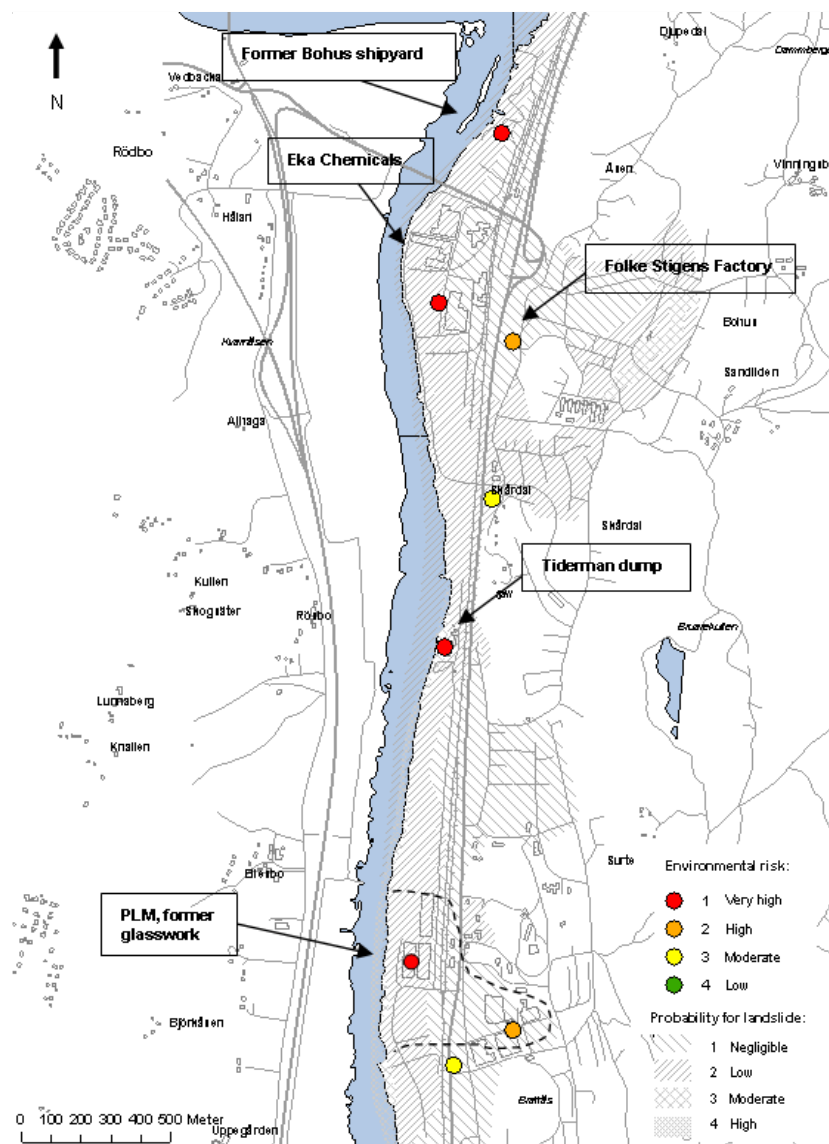
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Contaminated sites at landslide risk?

Of 31 potentially contaminated sites:
8 → moderate to high probability for landslide

Of these 8:
5 → high or very high environmental risk

Göta älv river, SW Sweden

Göransson et al. (2009) *J Soils Sediments* 9:33-45

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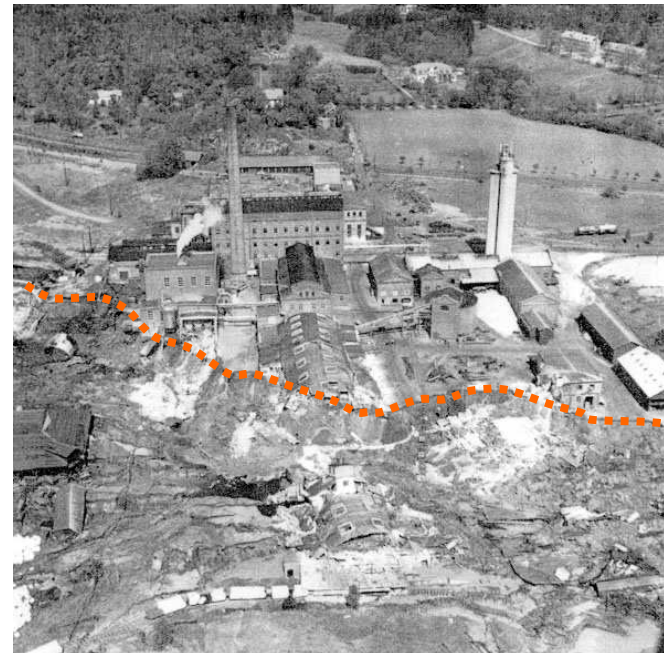
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1957 Göta landslide Göta Sulphite industry (pulp mill)



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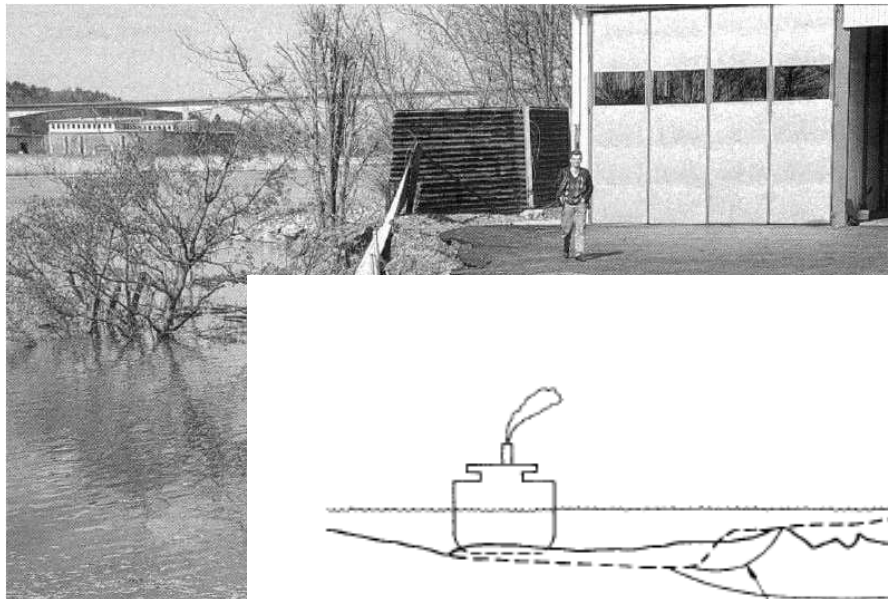
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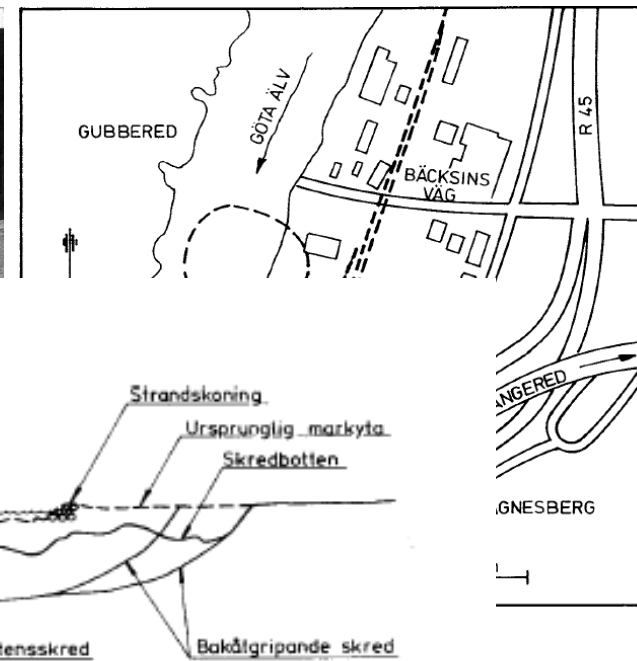
© SOU 1962:48



1993 Agnesberg industrial site



Figur 2.1. Agne:



Figur 2.4. Förmodat skredförlopp.

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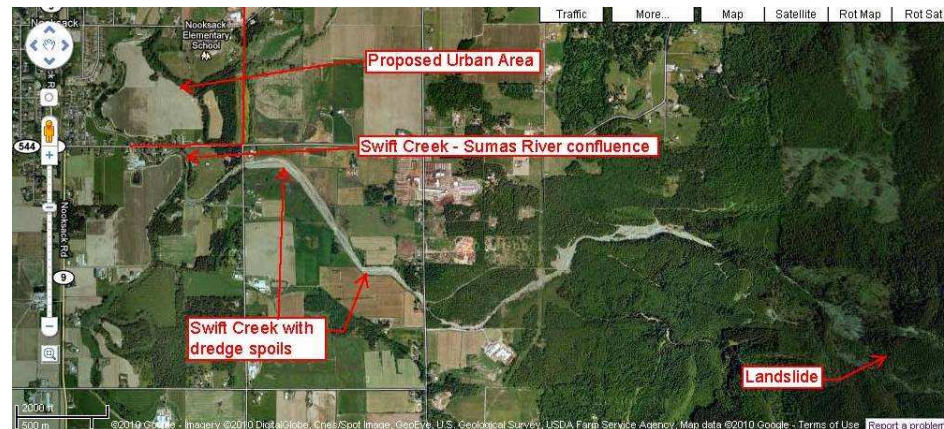
Source: SGI report 45





<http://nwgeology.wordpress.com/the-fieldtrips/virtual-field-trip-to-the-swift-creek-landslide-whatcom-county/>

Swift creek landslide, Suma River, USA Asbestos containing rock



http://washingtonlandscape.blogspot.com/2010_07_01_archive.html

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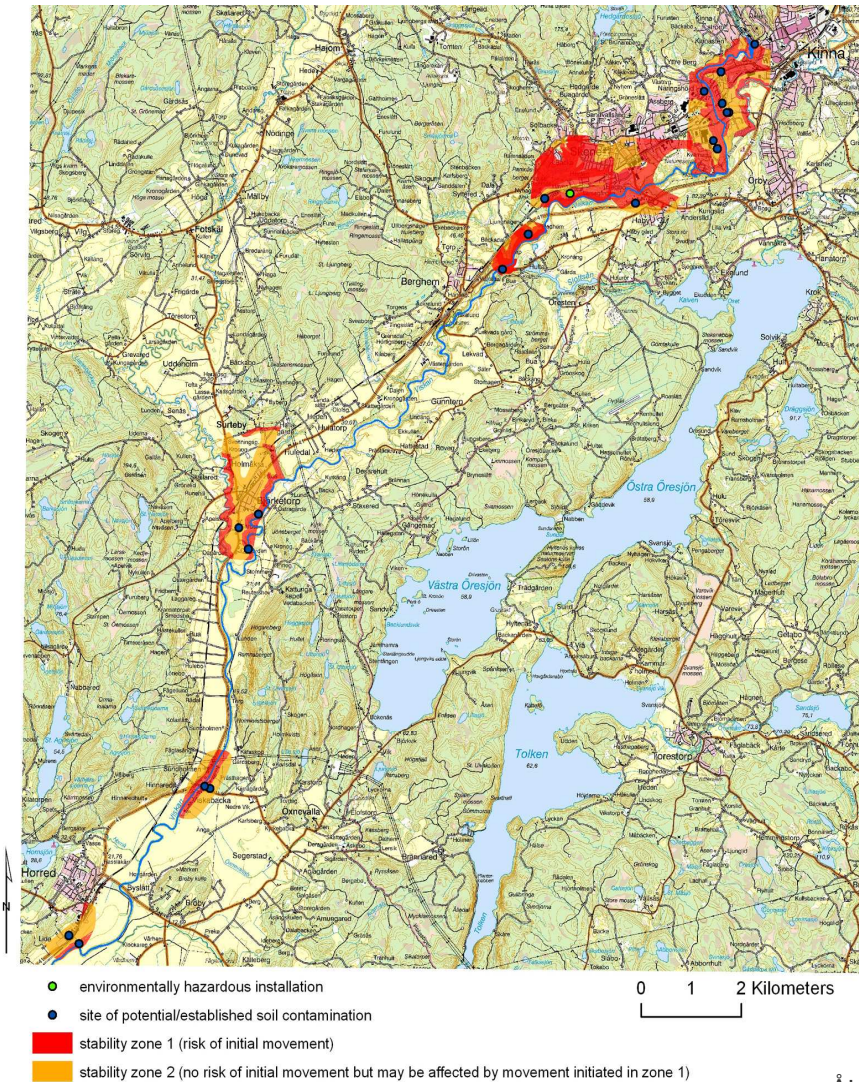
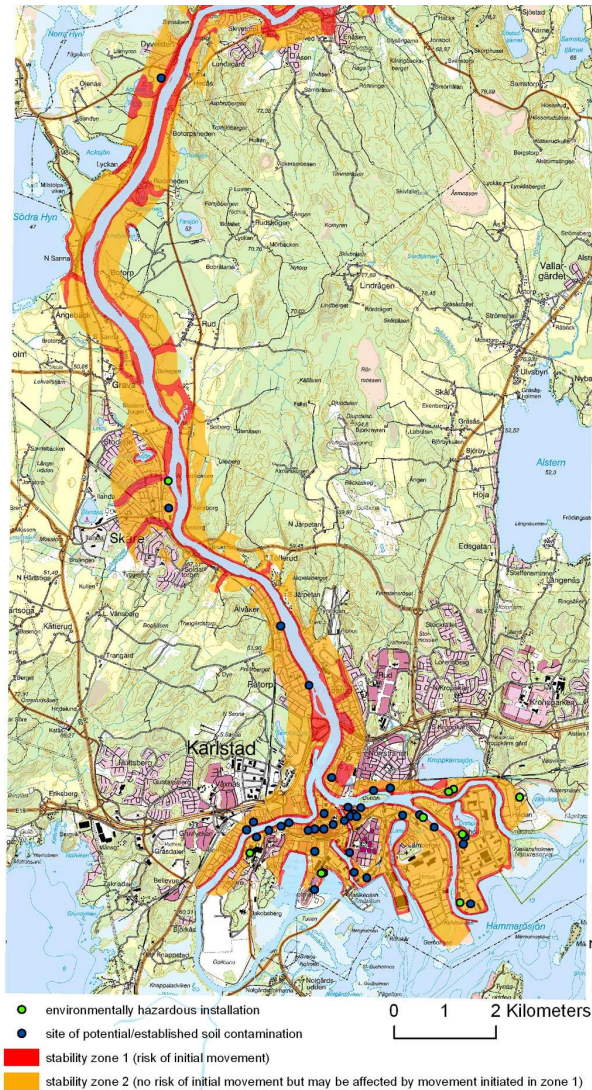
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Åkesson, 2010





Key observations from some Swedish slides

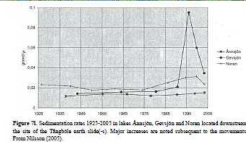
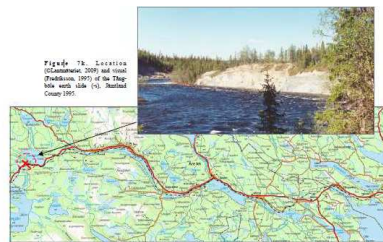


Figure 7c. Sedimentation rate (1971-2001) in lakes Åsby, Götta and Yara, located downstream the site of the Tångböle landslide. Major increases are noted subsequent to the landslide. From Nilsson (2005).



Figure 7d. Location (©Landsmålscentral, 2009) and visual (Persson, 2007) of the Yara landslide, Östergötland County, 2007.

Name (yr)	Type	Material	Size	Geography / Geology	Key observations
Tångböle (1995)	Earth slide/fall	Clay, silt	~200 000 m ³	30-40 m high, steep, clayey-silty, forested river bank in sparsely populated region	- Widespread and long-term increases in levels of turbidity and rates of downstream sedimentation - Local hydrogeological disturbances including signs of pollution
Öd 1 (2002)	Earth fall	Silt/fine sand	~31 000 m ³	40-45 m high, steep, silty, cultivated river bank in sparsely populated region	- Influence/-s) of ice on river upon time of movement - Major forces involved at time of movement - Long-term (permanent) damming and associated alterations of flow- and erosion patterns
Trossnäs (1996)	Rotational earth slide	Clay (sand, silt)	~100 000 m ³	Clayey, forested, relatively flat stretch of river in a relatively developed and densely populated region	- Extensive up- and downstream damming - Rates of erosion and sediment transport - Downstream alterations in colour, temperature, visibility
Yara (2007)	Earth slide	Fills, clay	~1 200 m ²	Industrial site within clayey harbour area in densely populated region	- Damming - Permanent shoreline displacement - Short- and long-term release of contaminants from displaced masses
Göta (1957)	Rotational earth slide	Clay	~370 000 m ²	Industrial site along relatively steep, clayey river bank within densely populated area	- Evolution of movement - Extensive onshore soil subsidence and offshore damming - Up- and downstream surging
Agnesberg (1993)	Rotational earth slide	Clay	~9 600 m ²	Industrial site along seemingly flat, clayey river bank within densely populated area	- Importance of sub aquatic topography - Evolution of movement - Sediment transport capacity and processes

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Åkesson, 2010



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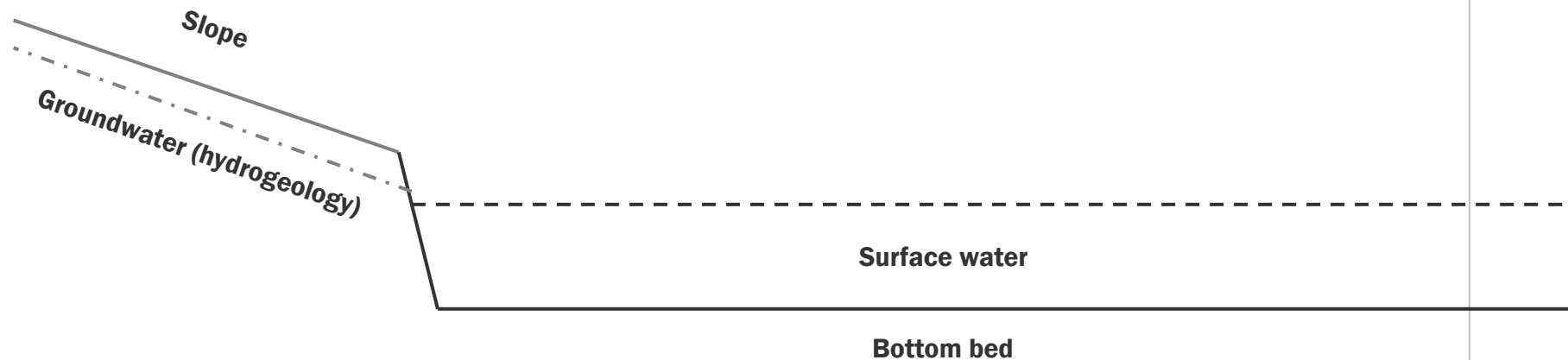
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- Initiate zone (head & flowing part)
- Cracking, movement
- Disturbed soil

- Run-out zone (deposition)
- Potential for damming
- Stirred soil/sediment

- 2:nd Run-out zone (deposition of susp. mtl / erosion, flow, deposition of bottom sed.)
- Potential for flooding
- Mixing of soil, sediment, water, contaminants

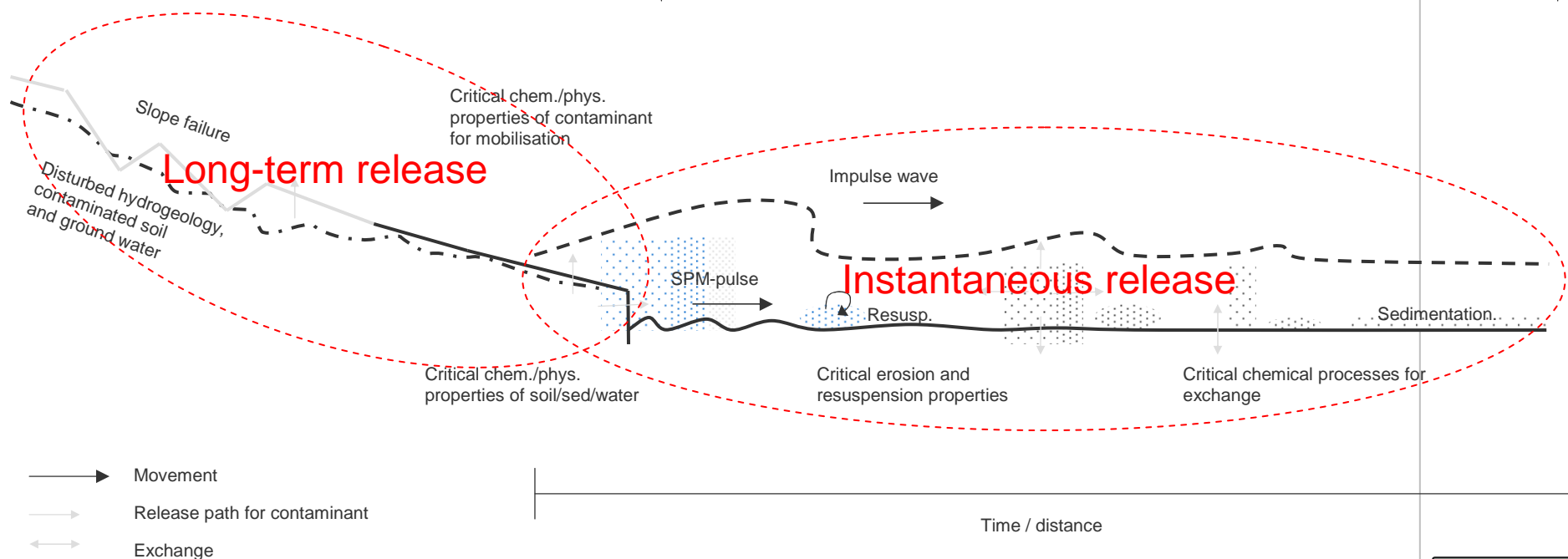
Critical slope properties

Critical slide properties for wave generation

Critical transportation processes for contaminant

Critical hydrodynamic Properties

Critical sedimentation properties of SPM



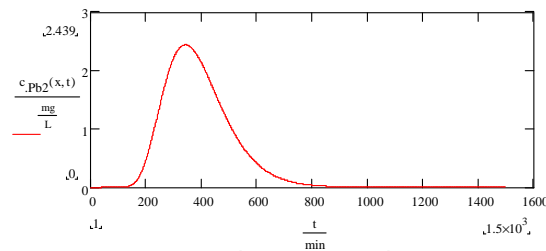
Göransson et al. (2009) *J Soils Sediments* 9:33-45



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Tot 585 ton Pb in soil → assume 1% release

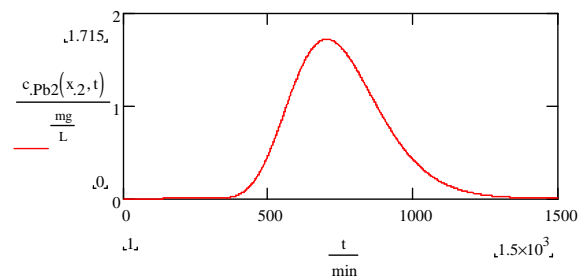


Freshwater intake (10 km):

Time peak: ca 6 h

Time pulse passage: ca 12 h

Cons. peak: 2,4 mg/l

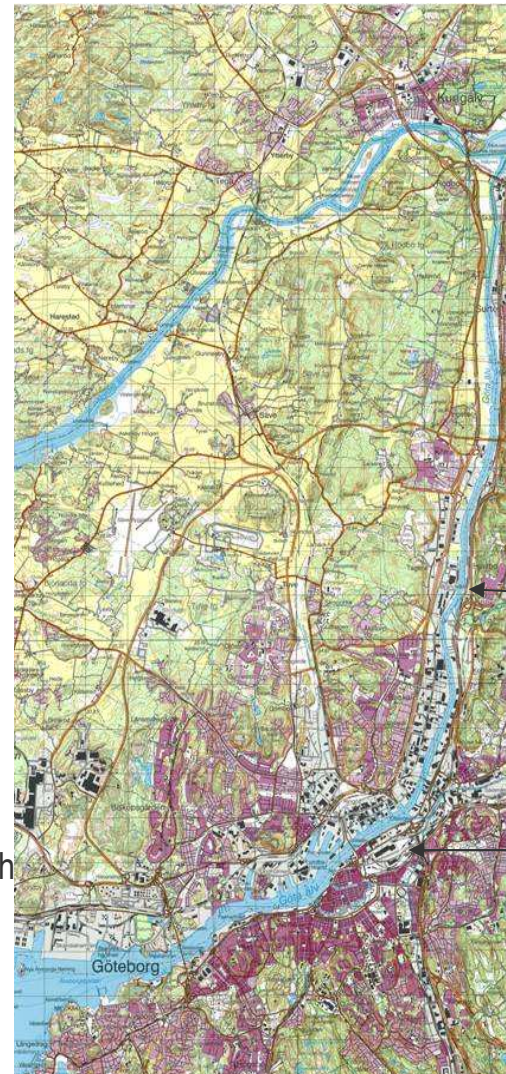


Göteborg C (20 km):

Time peak: ca 11,5 h

Time pulse passage: ca 16 h

Cons. peak: 1,7 mg/l



Former
shipyard

Freshwater
intake

Göteborg C

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Figur 2.1. Agnesbergskredet 1993-04-14. (Foto: Sven Liedberg, CTH)

Agnesberg industrial site

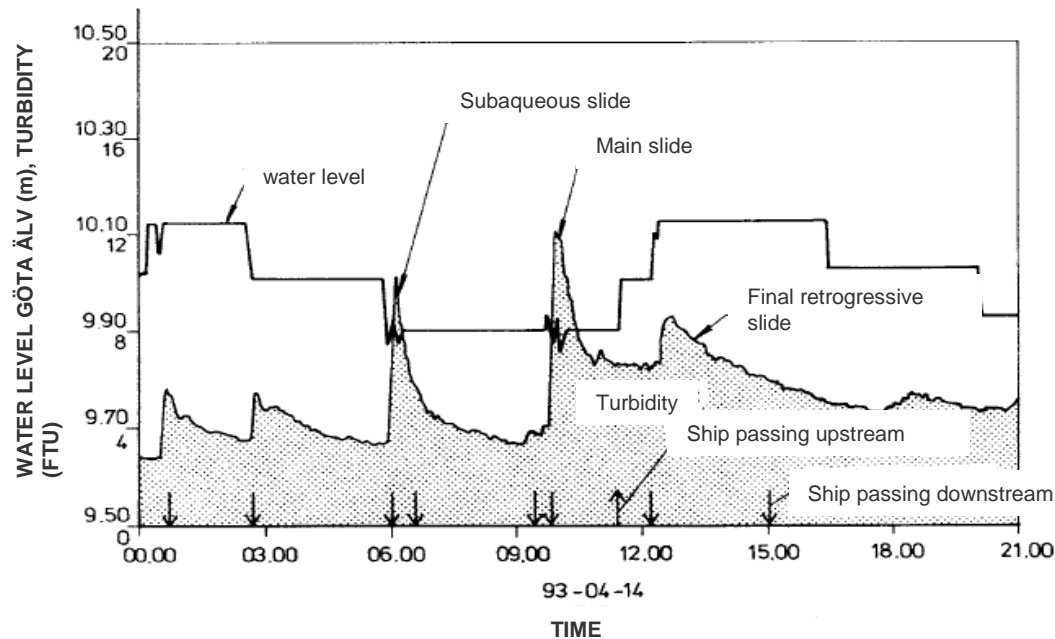
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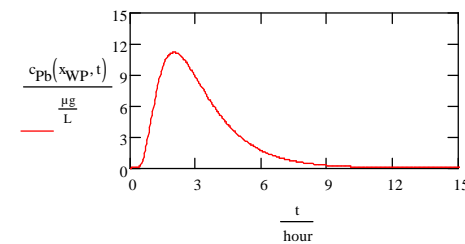
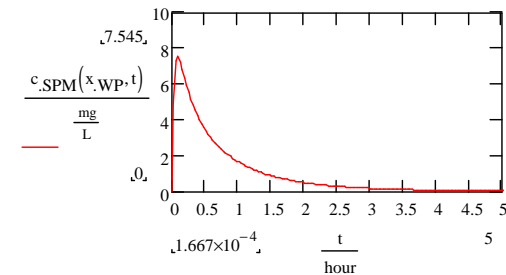
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Source: SGI report 45





Deviation from ADE

- Deposition occurs and its velocity depends on sediment concentration. This may give a skewed concentration distribution (long tail).
- There is a reversible or irreversible sediment exchange with e.g. stagnant or slow moving water masses. If the exchange is irreversible (depending on concentration gradient), it gives strong effect and a skewed tail.
- In cases where the hydrodynamic dispersion is very limited, the above mentioned processes give a strong impact on the shape of the distribution.

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In summary

- Most likely not only a Swedish phenomena ...
- Has large impact on sediment dynamics
- May have large impact on water quality
- Needs to be included in river basin management and risk assessments

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Thank you!

