



LAR og jordforurening – hvordan kan det lade sig gøre?

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ORMUM - MUDP projekt - 2021

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Region Midt
Region Midt

Optimering af risiko- og miljøvurderingerne ved etablering af LAR- løsninger i urbane miljøer **ORMUM**

Klimaløsninger i byen:

Reaktivering af Forureninger



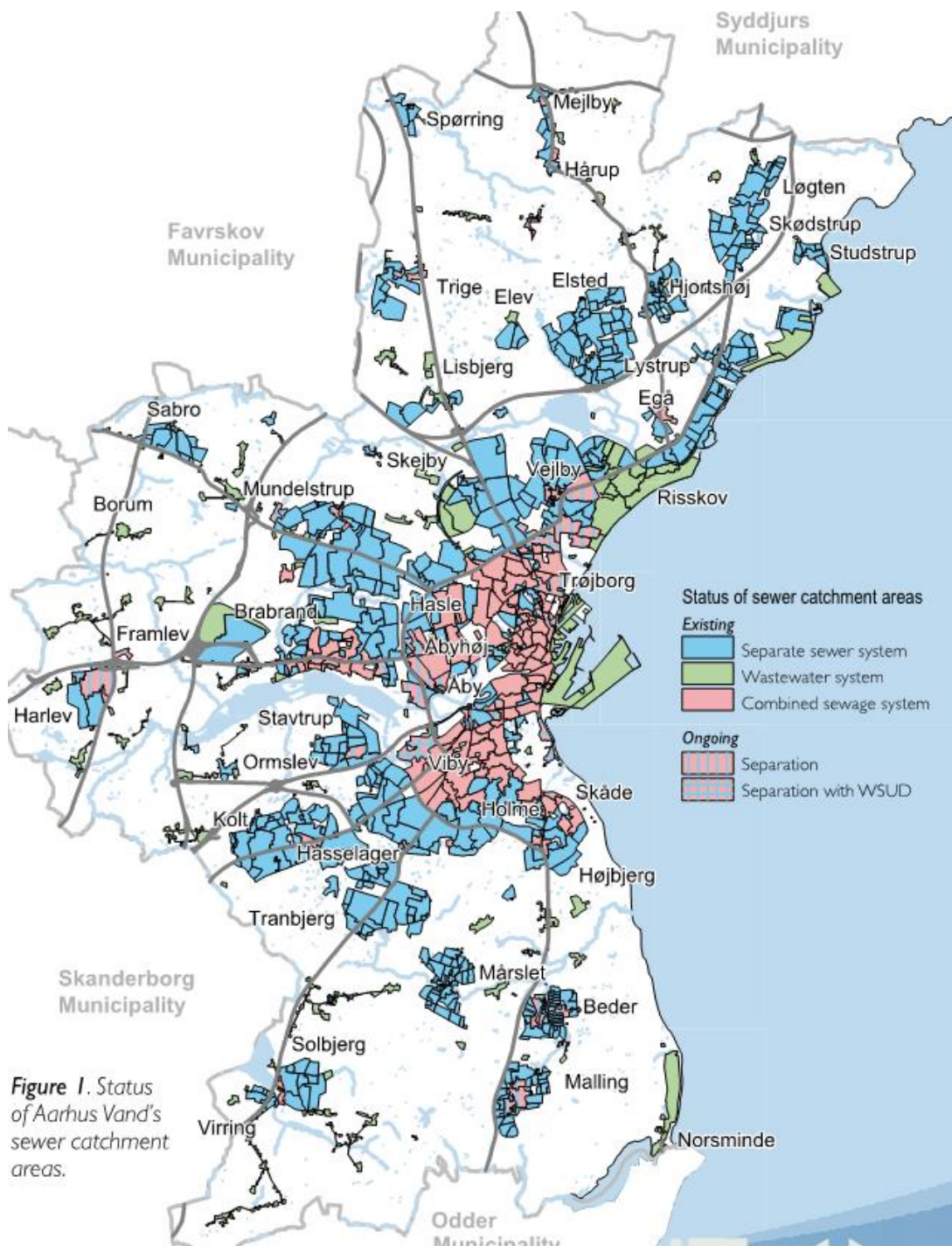


Figure 1. Status of Aarhus Vand's sewer catchment areas.

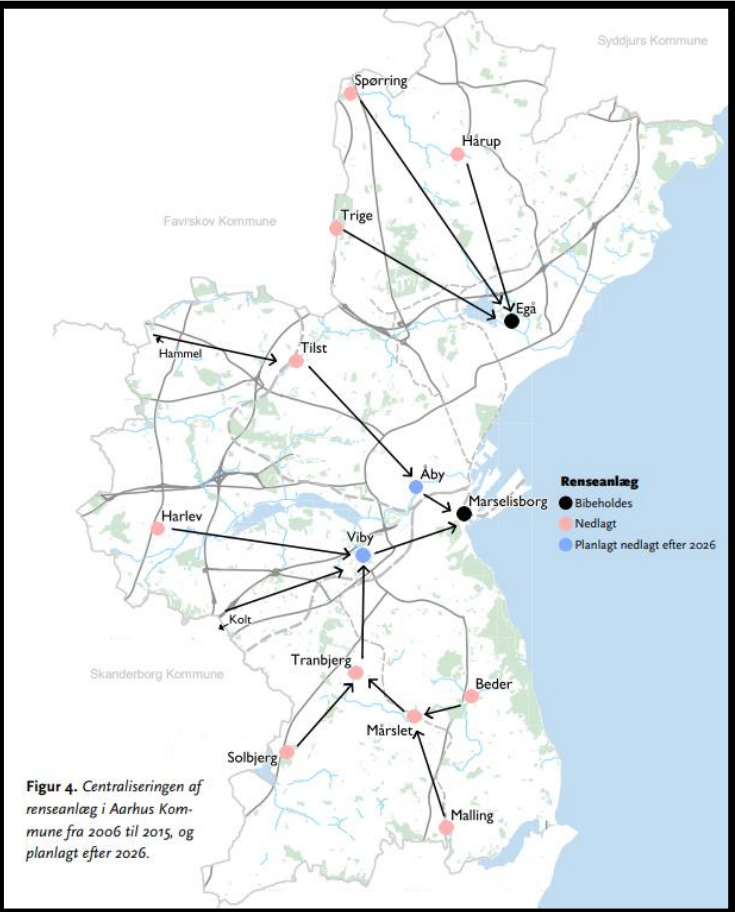
Spildevandsplanen

- Miljøbeskyttelse
 - afledning af regnvand
 - nedsivning af regnvand
 - rensning af spildevand
 - tilslutning til kloakken,
 - dimensionering af kloakken
 - grundvandsbeskyttelse
- Klimatilpasning

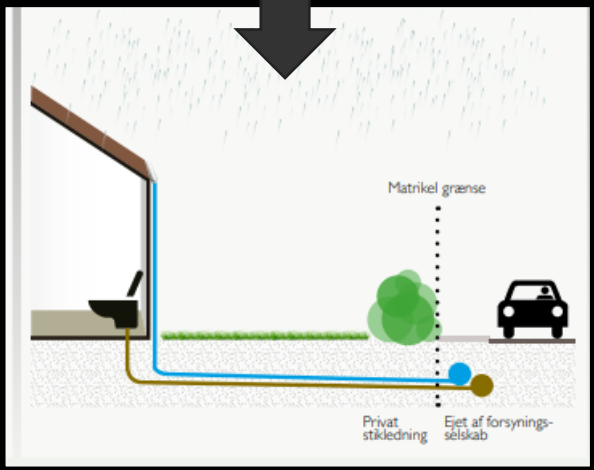
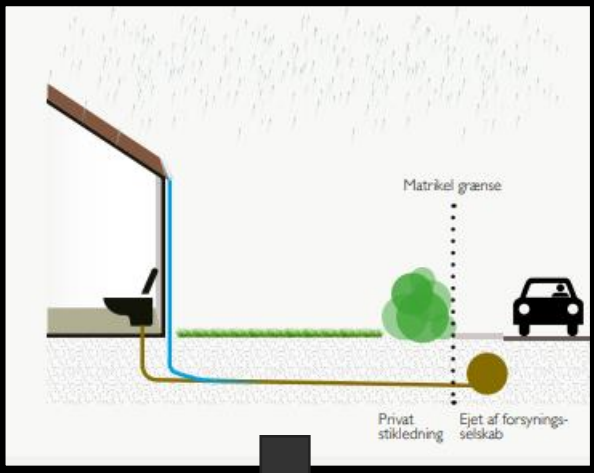


Stormwater & Wastewater management plan

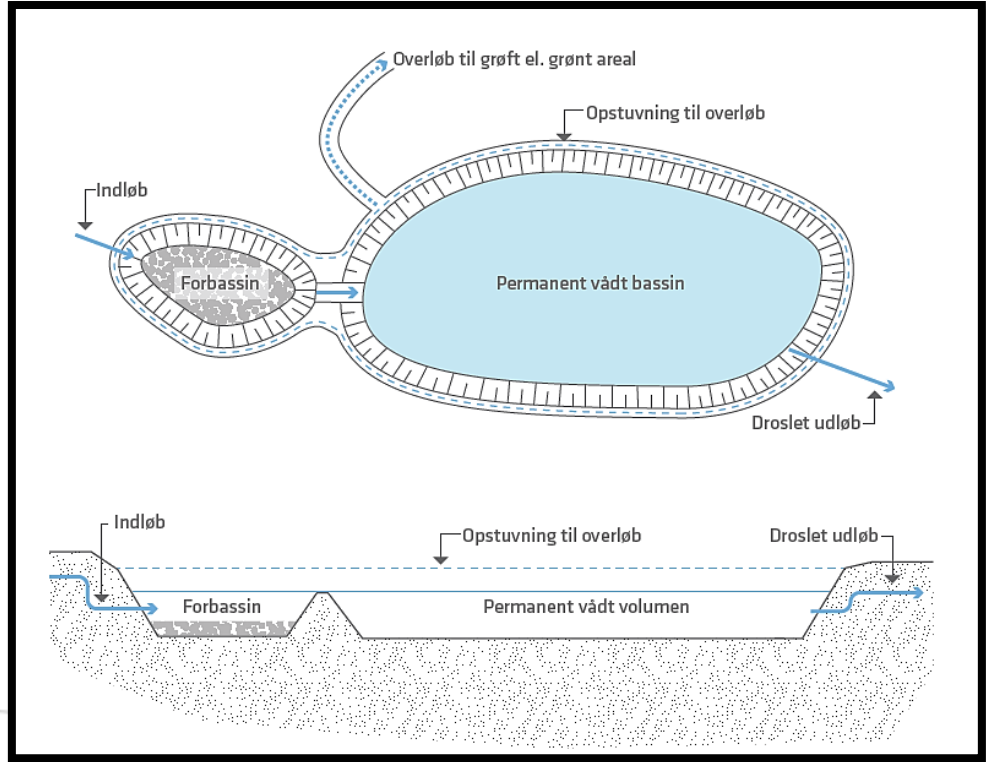
Stepwise centralization of WWTP
- Improved wastewater treatment



100 %
Separation of Sewer
system



Stormwater
management

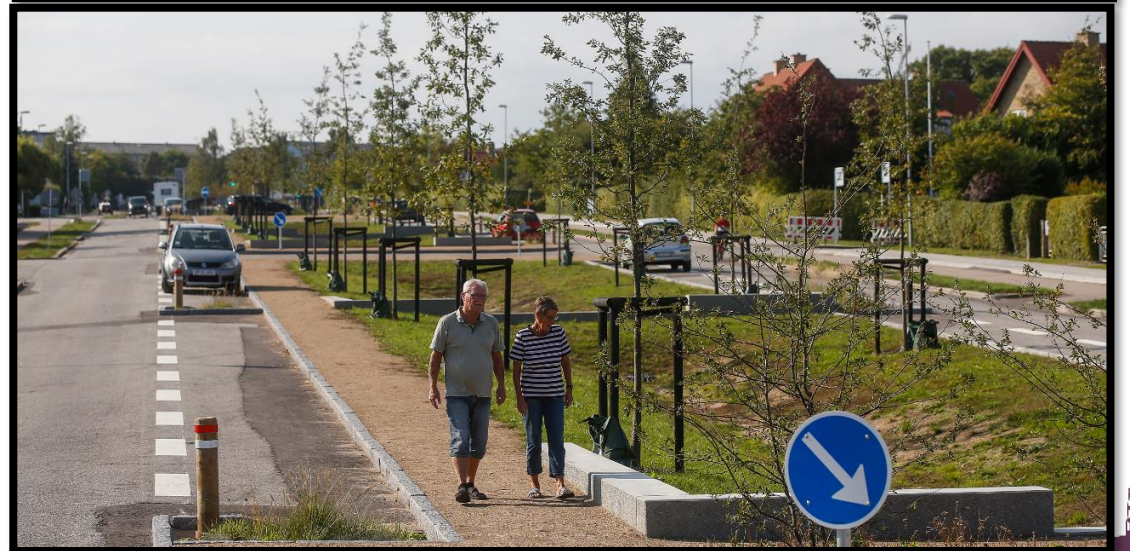
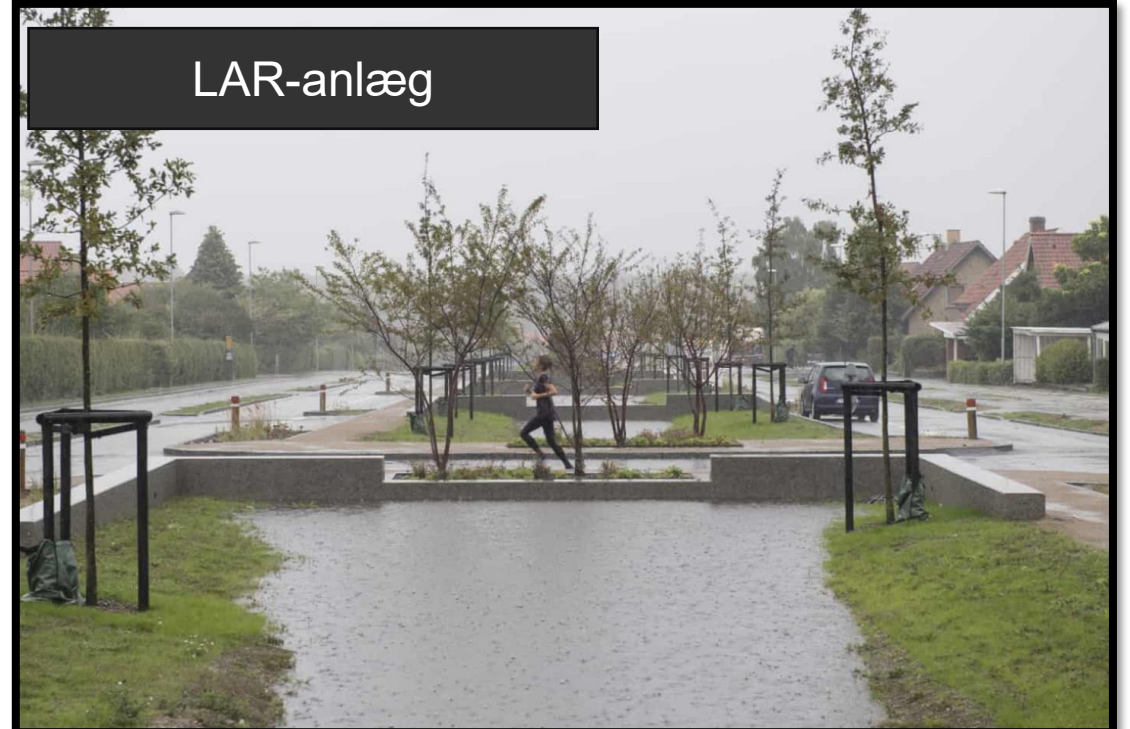


Eksempler på Regnvandssystemer

Vådt regnvandsbassin



LAR-anlæg



Kloakadskillelse

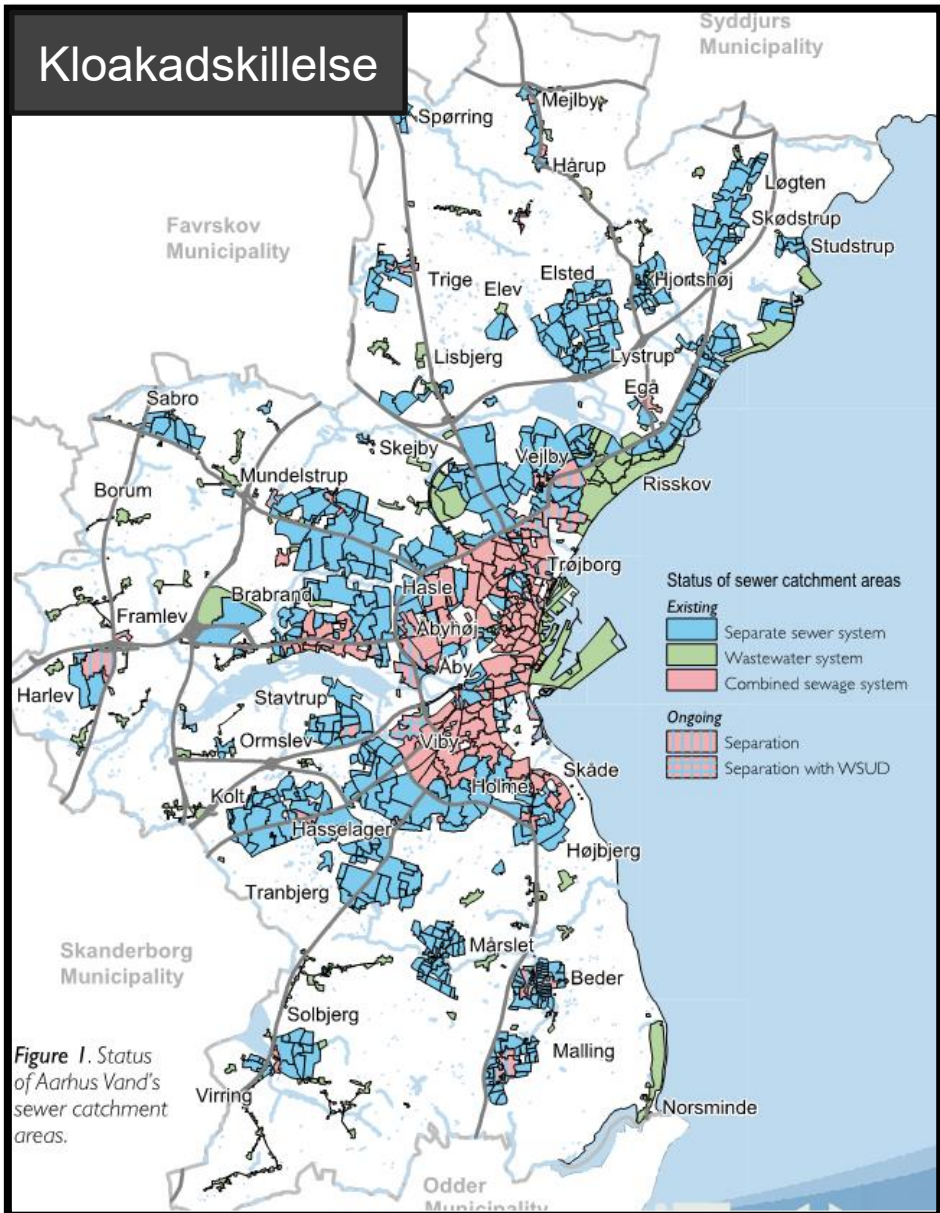
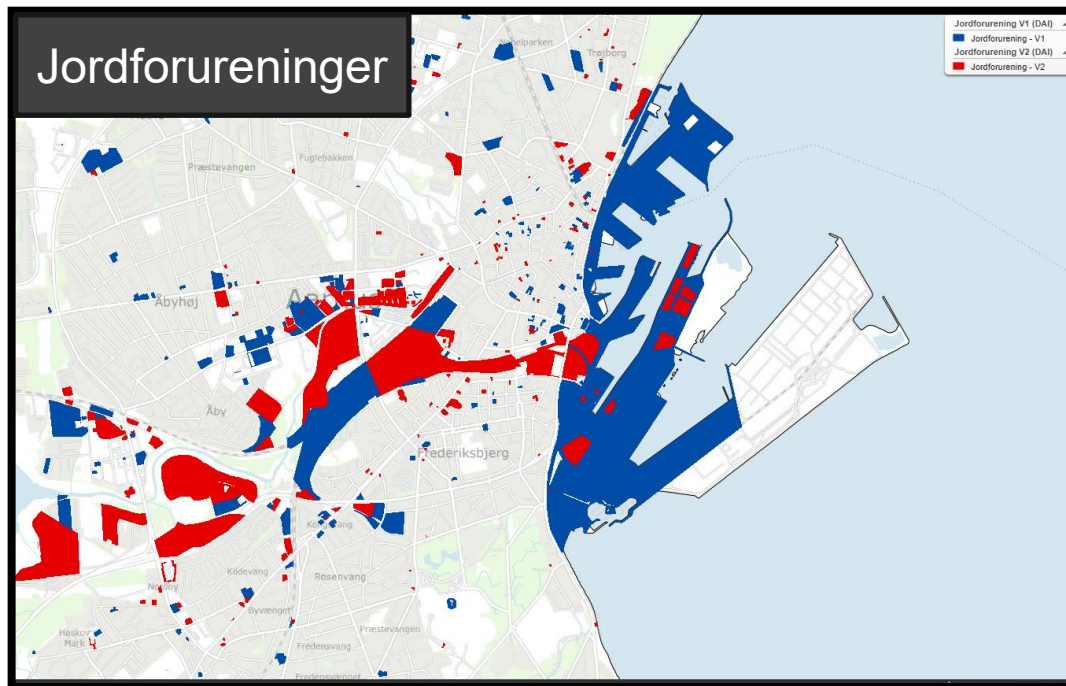


Figure 1. Status of Aarhus Vand's sewer catchment areas.

Jordforureninger



AREALDATA

☐ Kystbeskyttelsesplanlæg

☐ Kronisk erosion

☐ Akut erosion

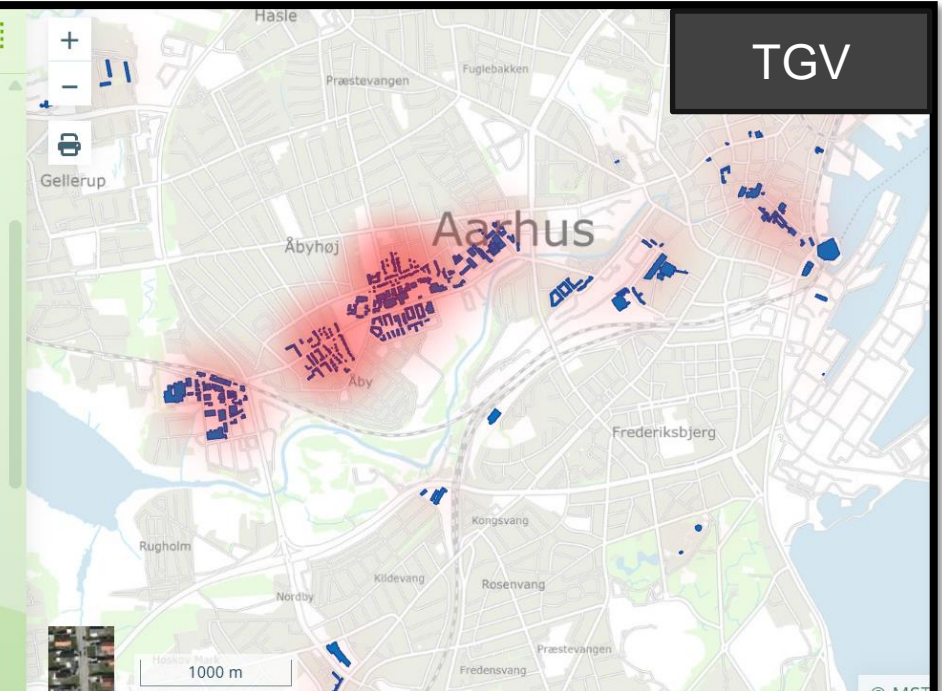
☐ Strømningsveje

Screening af bygninger udsat for terrænnært grundvand

☒ Bygninger der er udsat

☐ Områder med bygninger, der er udsat

☒ Bygninger med < 1 m til det terrænnære grundvand



TGV

Hvad skal vi være opmærksomme på når vi arbejder med LAR-anlæg og nedsivning?



Resultater

Primære leverance:

- en "best practice" som myndighederne kan anvende som procedure ved vurdering af risikoen for reaktivering af forureninger.
- Grundvandssænkninger, Nedsivning, LAR løsninger mv.

Hydrogeologisk modellering

- "Voxel modellering"
- Manuel vs Autogenererede modeller

Proceduren er udviklet og testet på to case områder:

- "Tulip" og "SPARK" grundene i Århus

Projektet har med succes kunnet evaluere risikoen for forureningsspredning i de to case-områder.

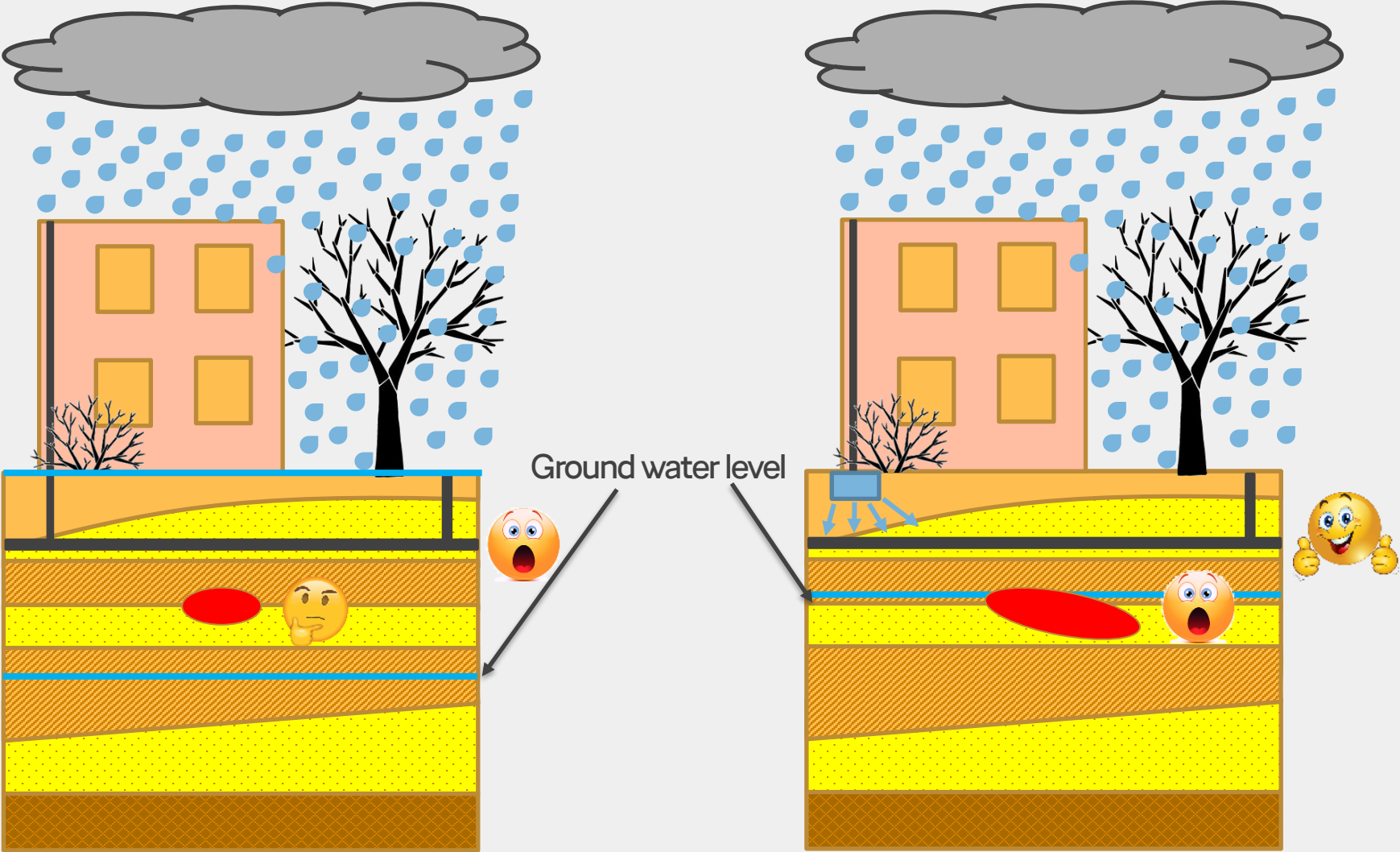


Best practice



Extra winter rain
Overloaded sewers and flooding

Extra winter rain.
Soakaway for roof-water



Screening af potentielle forureningskilder

Typical sources of contamination:

Former industrial use (DK: V1, V2 + locations excluded from mapping)

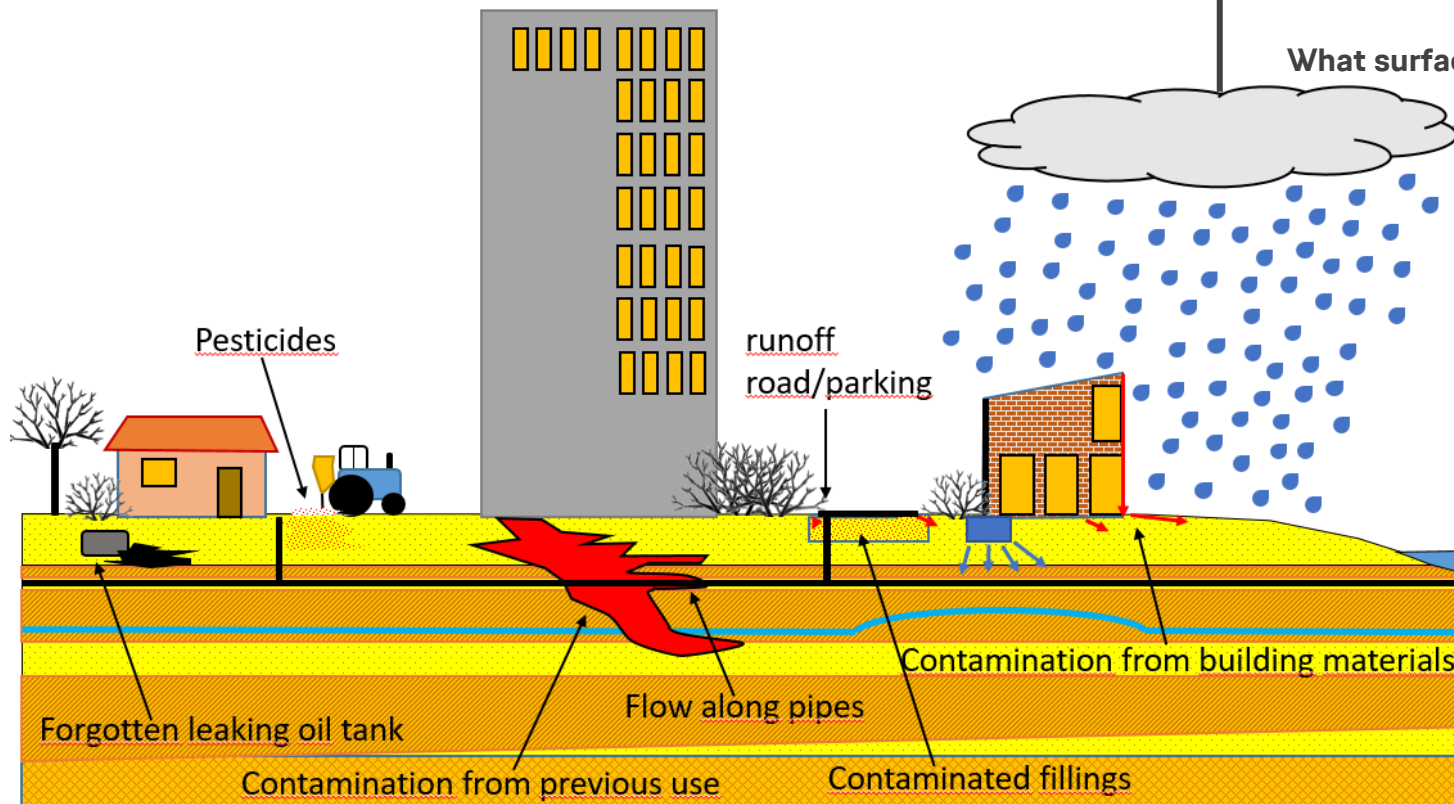
Oiltanks (DK: <https://earkiv.miljoportal.dk/>, BBR and private homes elder than natural gas/district heating)

Pesticides (Field use and washing areas)

Contaminated fill materials

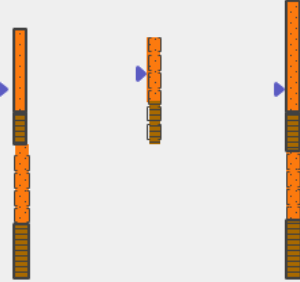
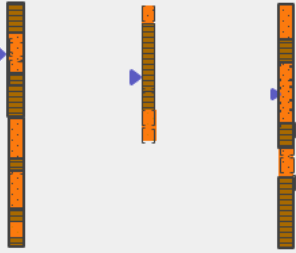
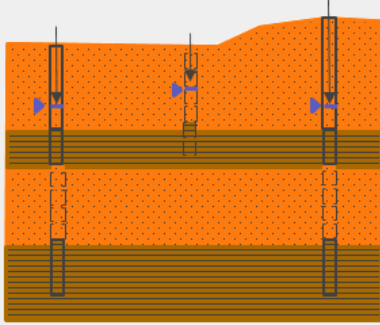
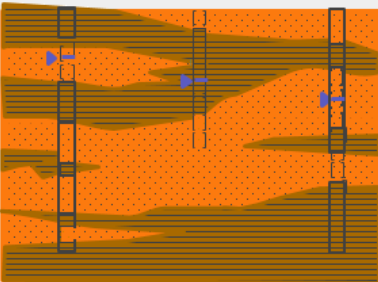
Contamination from building materials (Mainly new buildings)

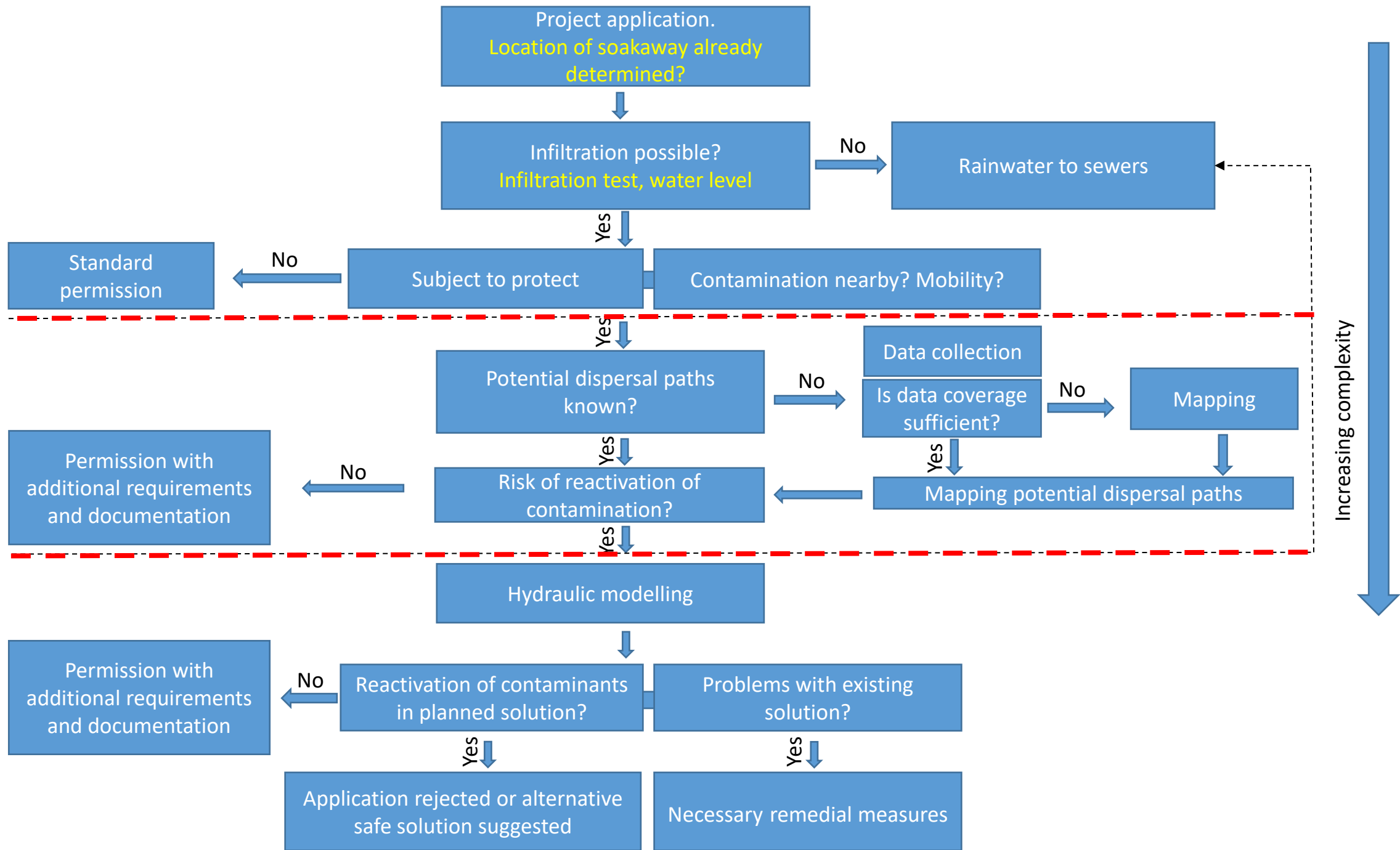
What surfaces does water pass on its way to the soakaway



Compound group	Common sources	Characteristics	Mobility	Soakaways nearby	Notes
Chlorinated solvents (e.g. TCE, PCE and vinylchlorid)	Dry cleaning Plastic companies Metal processing Power plants Car paint shops Car repair shops	Variable solubility Difficult to degrade	High mobility Often developing contamination fans	Infiltration problematic	
Heavy metals	Wood impregnation Car repair shops Metal processing Iron and metal foundries Product retailer etc. Plastic companies Power plants	Low solubility	Relatively low mobility at normal pH values	Mostly unproblematic	Please note that Arsenic may be mobile at common pH (6-8) and chrom (IV) can be mobile in sandy soil. Furthermore, a low pH may increase mobility.
BTEX, Kulbrinter og MTBE	Gas stations Oil tanks Car paint shops Car repair shops Metal processing Product retailer etc. Plastic companies Dry cleaners Heating plants	Old contamination: - mobile compounds degraded - low solubility Recent contamination: - high concentration of mobile compounds - higher solubility – incl. BTEX	Low mobility High mobility Often developing contamination fans	Problematic depending on age/degradation and composition of contaminant Infiltration problematic	Evaluate based on analysis results. Age and mobility may often be evaluated from the amount of BTEX and other small hydrocarbons.
PAH	Gasworks Steep pitches Tar impregnation Car repair shops Product dealers, etc. Heating plants	Generally low solubility Smaller PAH's has greater solubility. High sorption	The smallest PAH's are mobile. The heaviest PAH's are immobile	Potentially problematic depending on composition of contamination	Naphthalen and smaller PAH's needs attension. Sorption depends on soil type and other contaminants present.
Cyanid	Gasworks Salt storage Metallization companies	Typically found as ioncyanides Kinetic release to fluid phase	Deending on type	Potentially problematisk. Avoid infiltration in hotspot area	
Phenoler	Gasworks Wood impregnation Asphalt factories Metal processing Plastic companies Iron and metal foundries	High solubility Degradeable in aerobic conditions	High mobility Sorption depends on the organic content of the soil.	Infiltration problematic	
Pesticider	Machine stations Washing areas Cereal and feed companies	High solubility Varying degradation	Varierende mobilitet og sorption	Infiltration problematic	

Hvornår skal vi anvende Geofysik?

	Area 1	Area 2
Possible boreholes in the area  Clay  Sand  Waterlevel		
One of more possible geological understandings of the area. Sources of information could differ from boreholes		
Geophysical mapping needed?	No	Yes

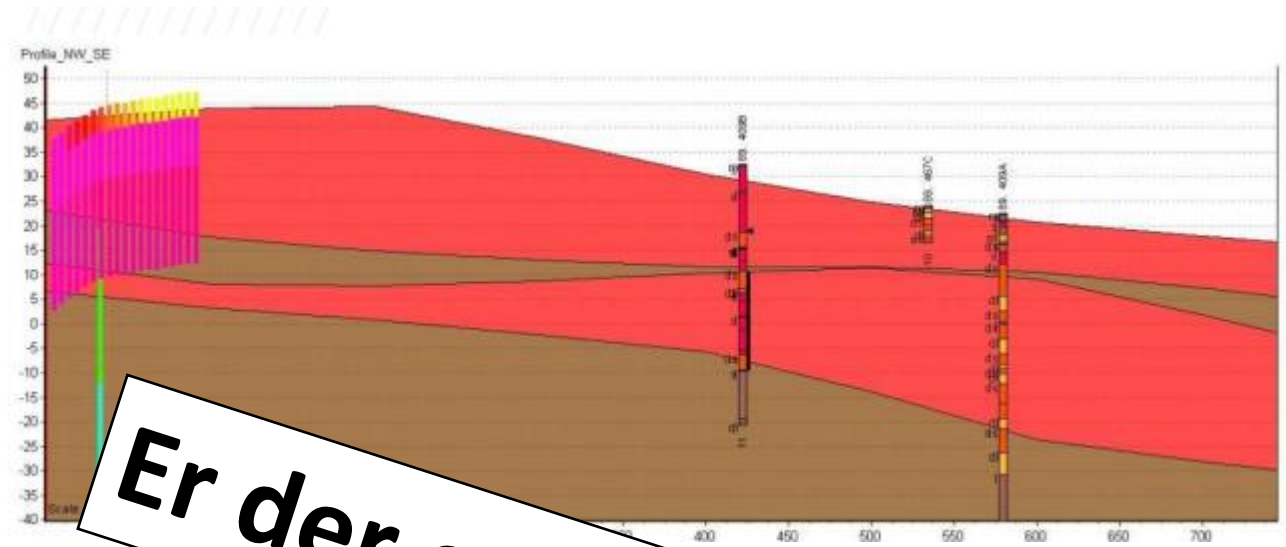


Hydrogeologisk modellering

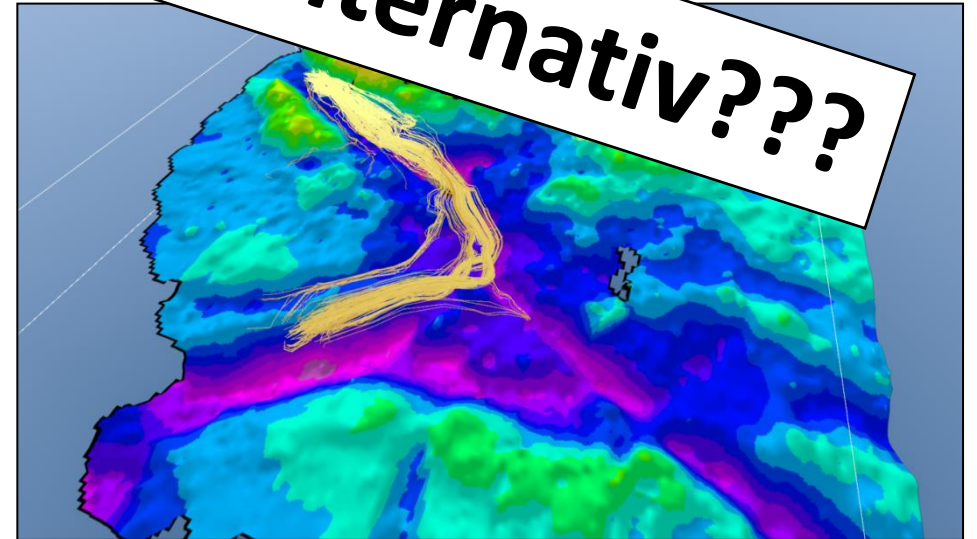


Motivation

1. Hydrologiske modeller kræver detaljeret strukturel input
2. Hydrologiske system responser er komplekse og kræver en høj numerisk opløsning og stor rumlig udbredelse
3. Manual konstruktion af geologisk modeller er subjektiv, tidskrævende og dyrt



Er der et alternativ???



Jørgensen et al., 2010

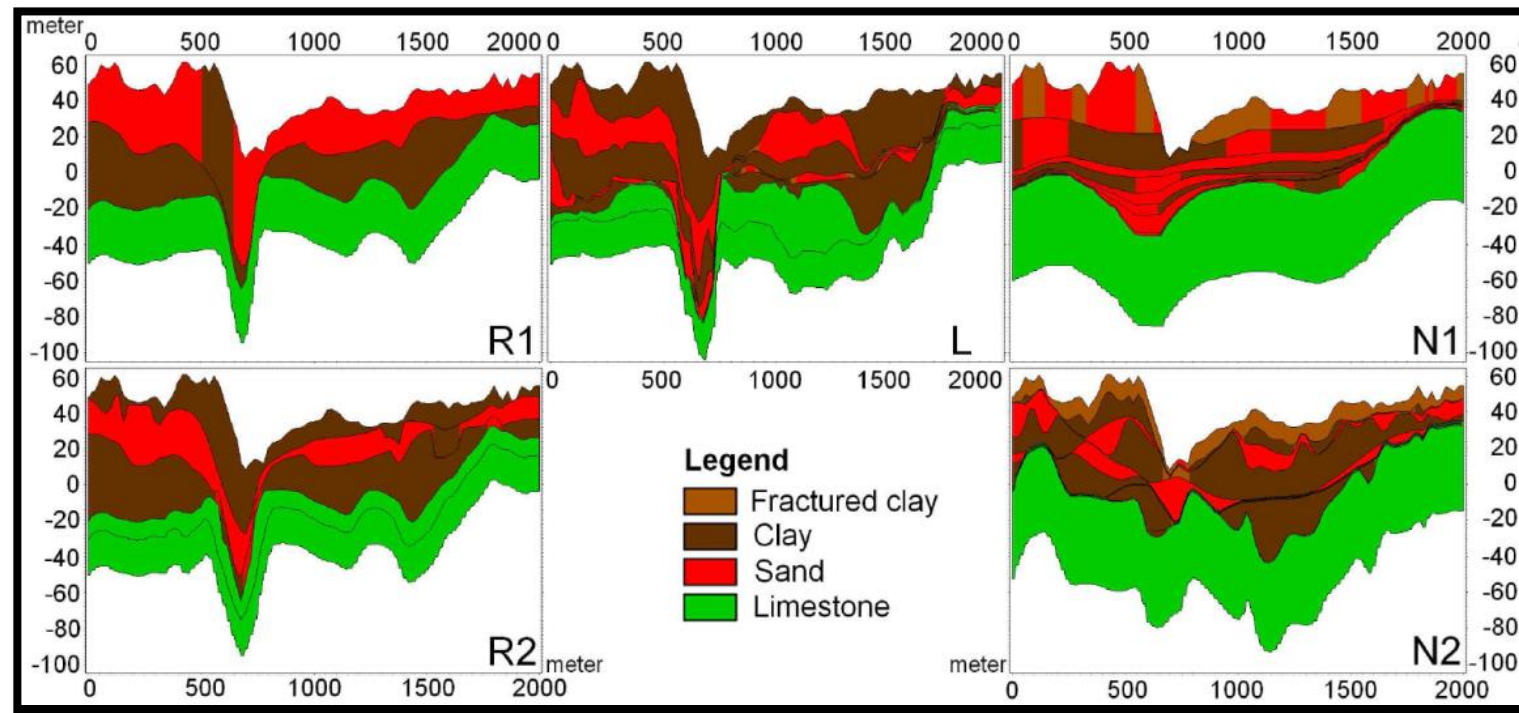
Motivation

MÅL:

- Cost-Effektiv
- Objektiv og reproducerbart
- Kvantificerer den geologiske usikkerhed



Autogenererede 3D hydrogeologiske modeller fra DualEM og boringsbeskrivelser



Seifert, D., et al (2012). Assessment of hydrological model predictive ability given multiple conceptual geological models. WRR vol. 48

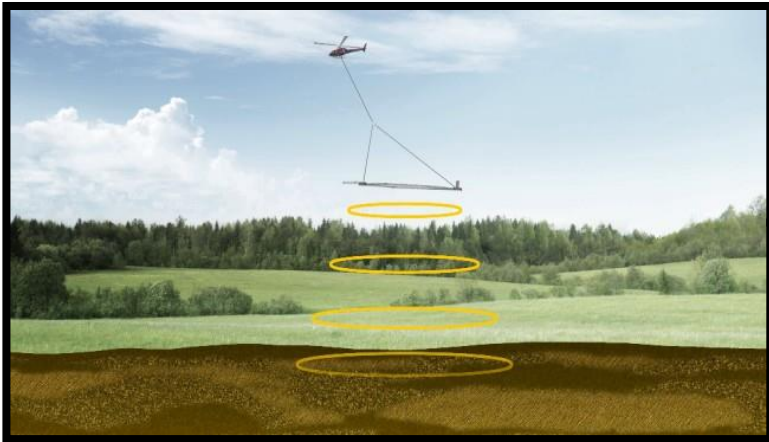
Metode– Geostatistisk modellering

Sequential indicator simulation

- Den stokastiske tilgang gør det muligt at danne mange lige sandsynlige modeller (realiseringer), som kan efterbehandles for at kvantificere den strukturelle usikkerhed
- Geostatistisk simulering er vel accepteret i petroleums industrien som en metode til karakterisering af heterogene reservoirer
- Der findes nu flere eksempler anvendt ifm. grundvandsmodellering



Hard Data



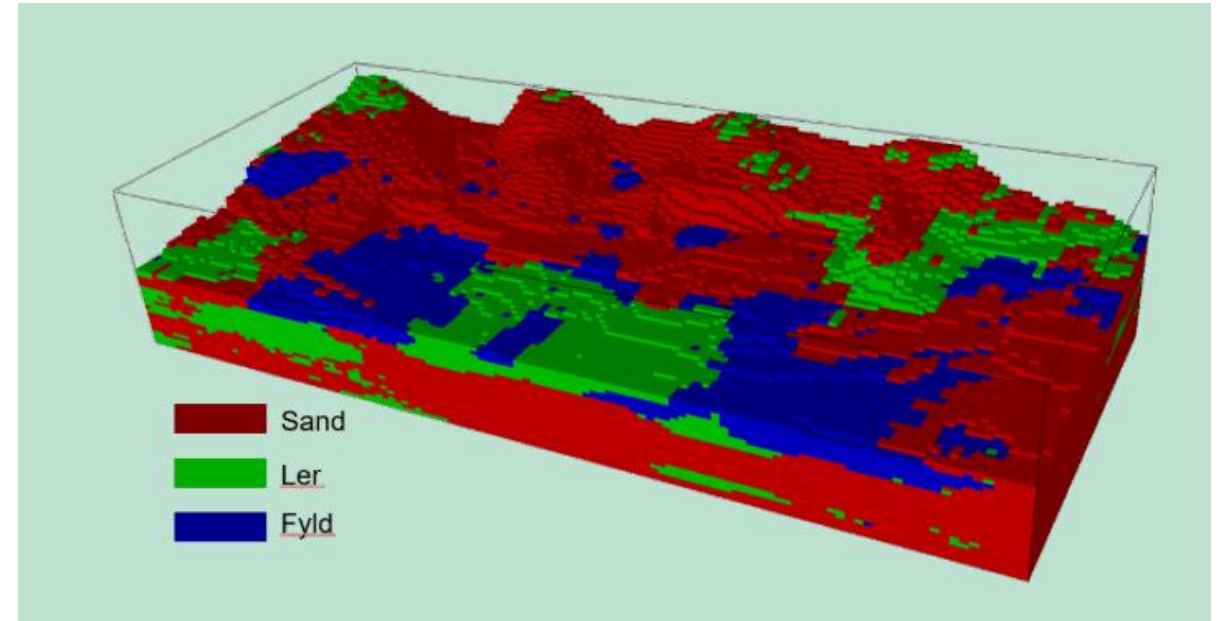
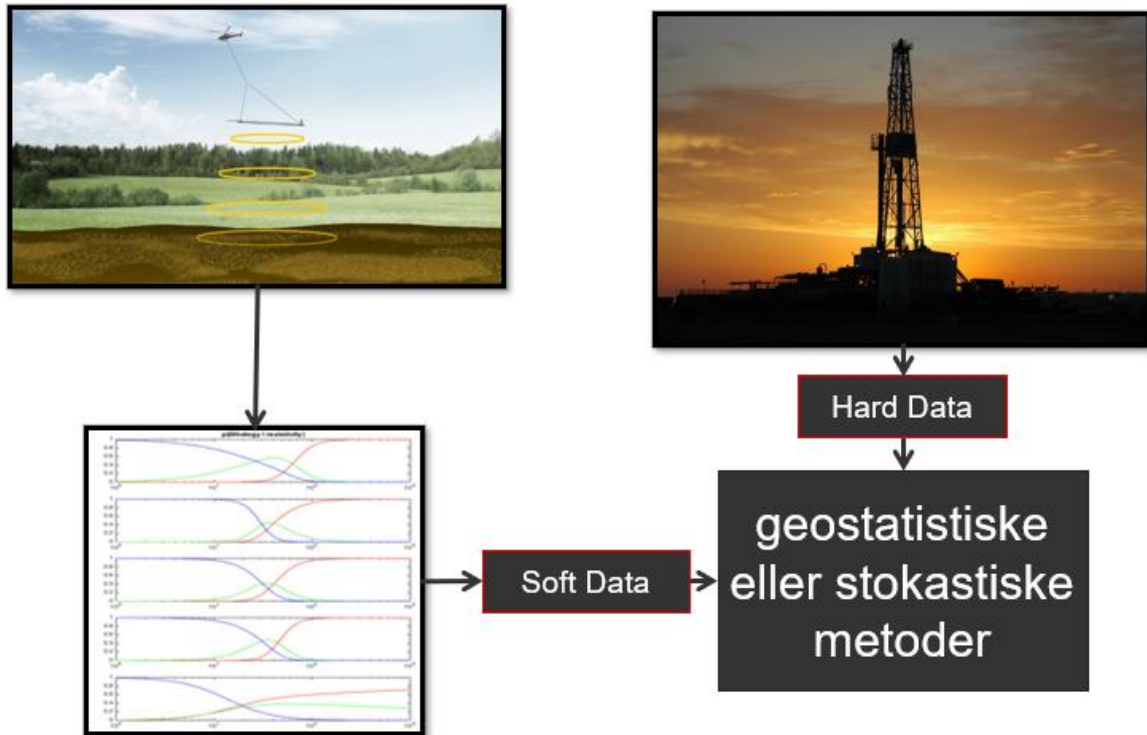
Soft Data

Sequential
indicator
simulation

Hydrogeologisk modellering

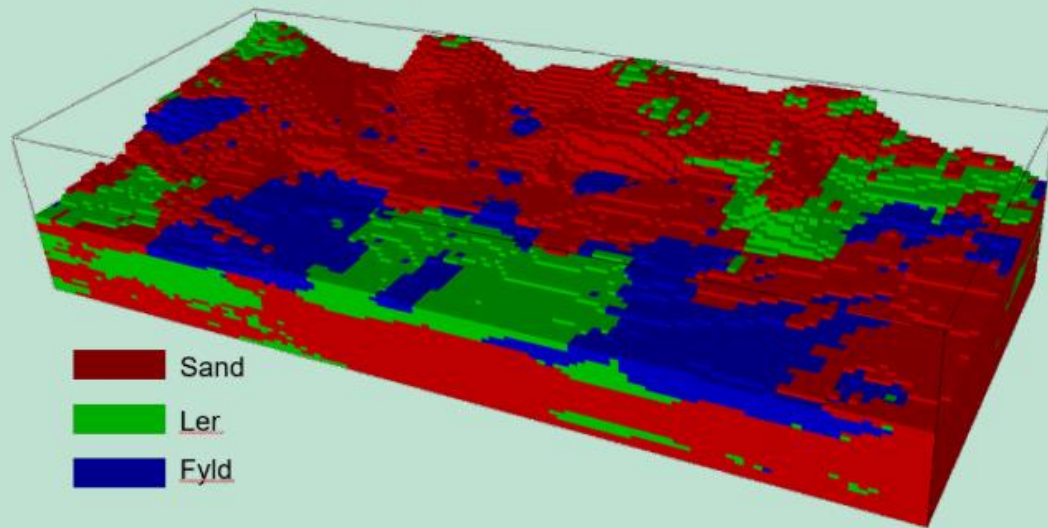
Manuel vs. Autogenererede modeller

Lokalmodel (5 m x 5 m x 1m)

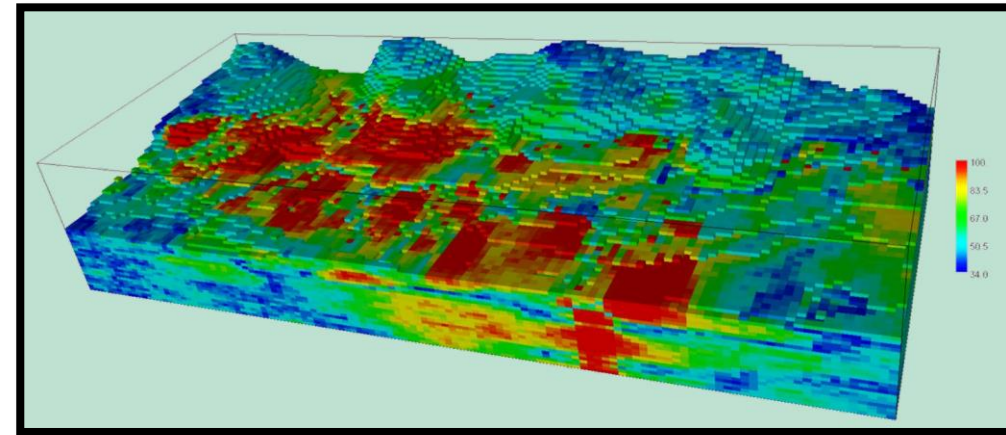


Hydrogeologisk modellering

Manuel vs. Autogenererede modeller



Kvantificering af geologisk usikkerhed
Kvantificering af Hydrologisk usikkerhed



Hydrogeologisk modellering

Manuel vs. Autogenererede modeller

Fordel ved Voxel modeller

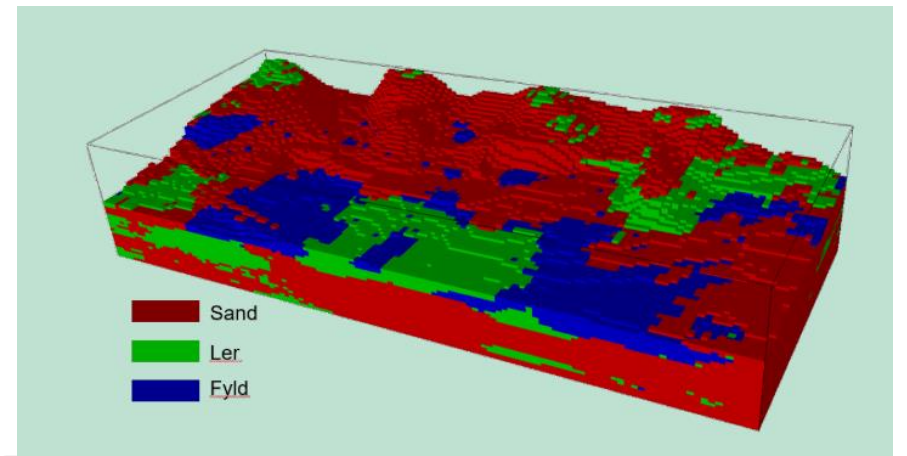
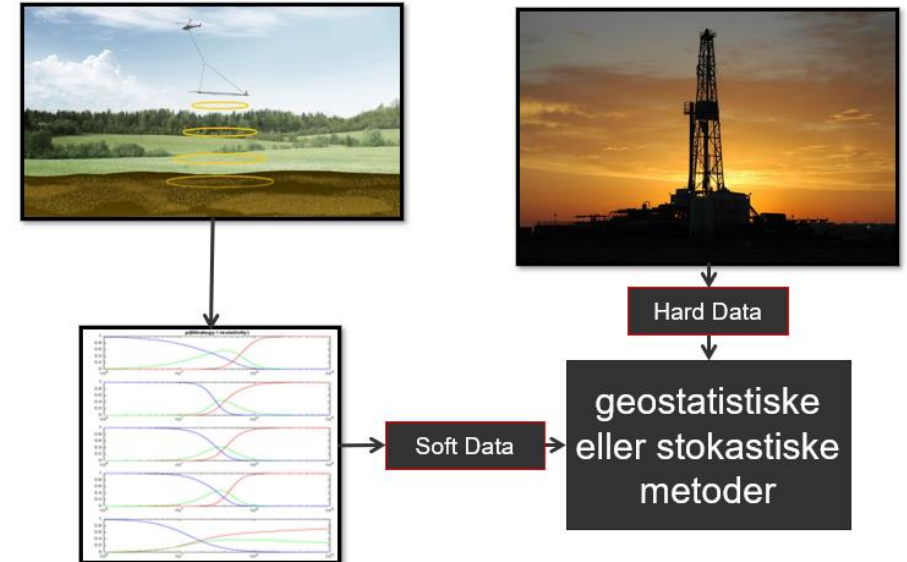
- Indarbejde geologisk heterogenitet

Fordele ved manuelle modeller:

- Lokalt geologisk kendskab kan indarbejdes i de geologiske modeller (Jørgensen 2013).
- Den som udarbejder modellen får opbygget den geologiske forståelse som ligger ud over modellen i forhold til at forstå hvad der sker i området.

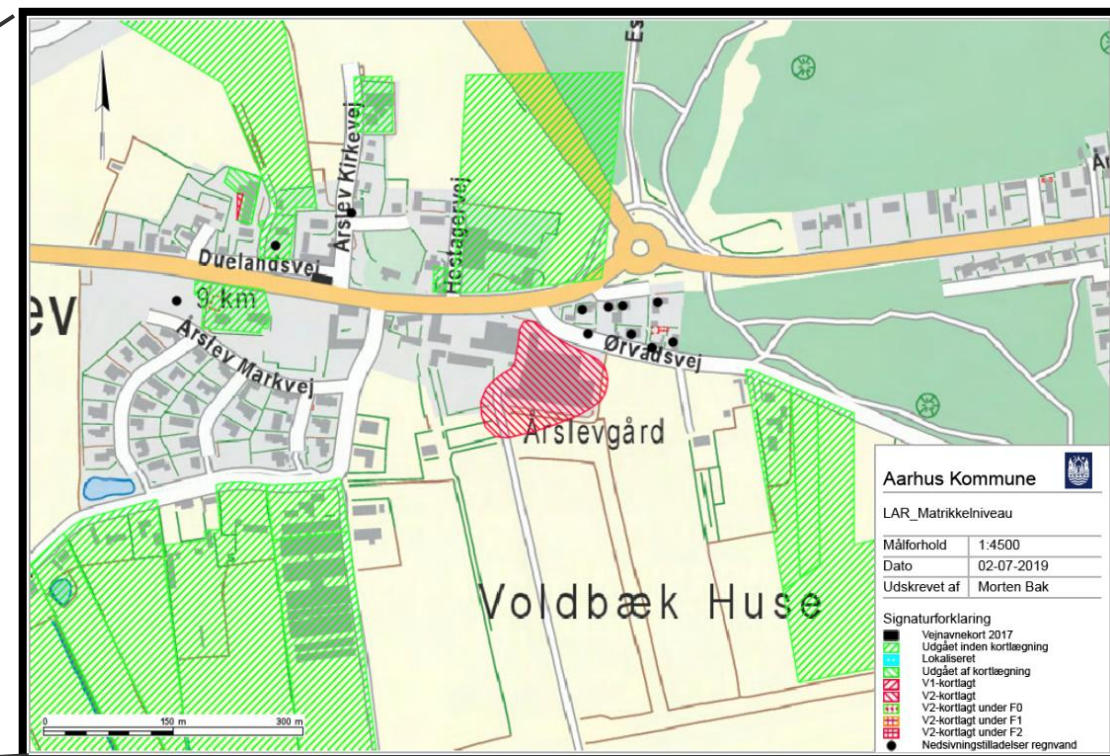
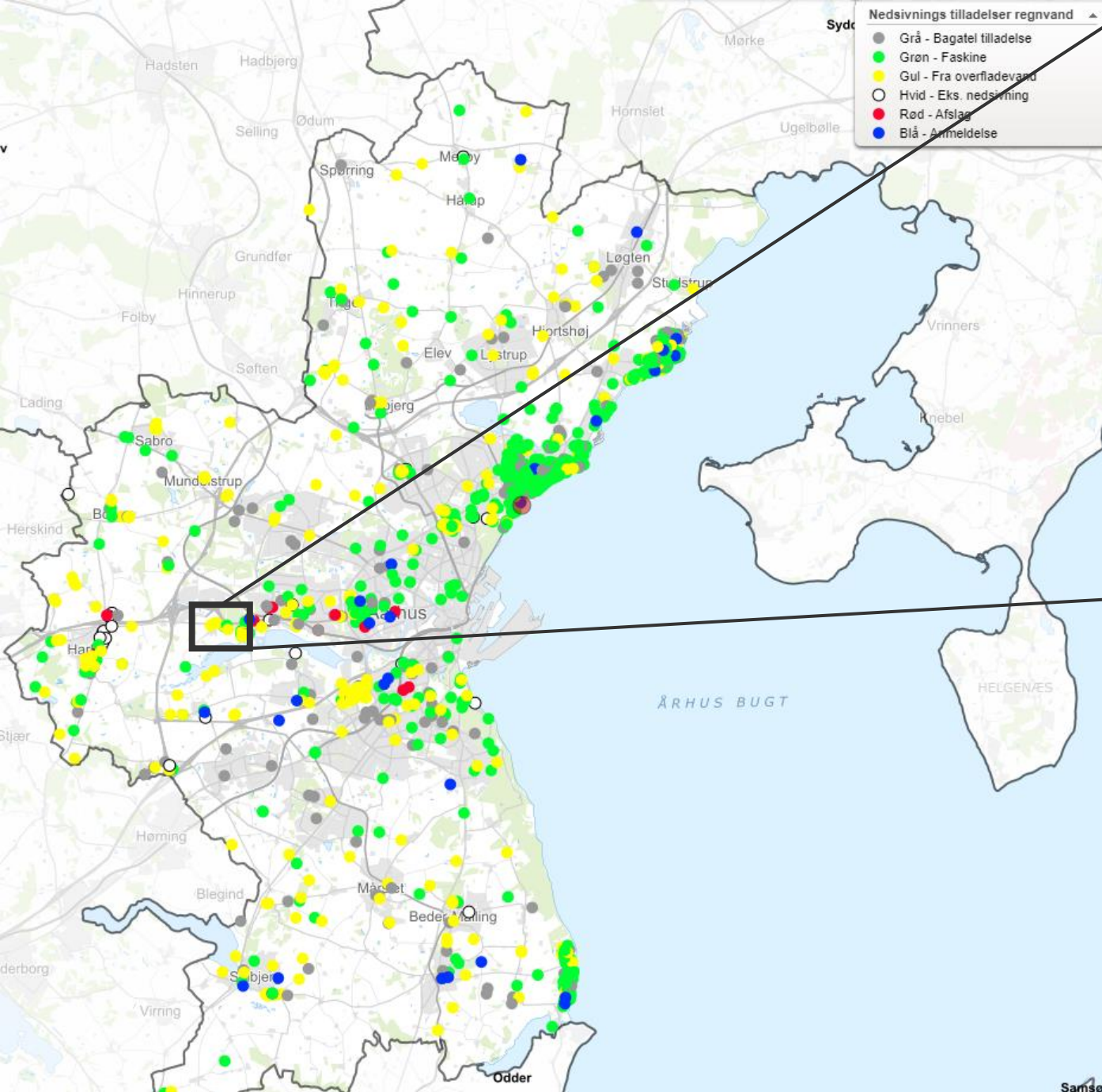
Fordele ved de geostatistiske metoder:

- De er hurtige og dermed billige
- Reproducerbare med veldokumenterede arbejdsgange. Subjektiviteten er fjernet.
- Løbende ajourføring er mulig



CASES





Mobilisering af forurening

Flyveaske under erhversbyggeri

→ Immobile tungmetaller

- Ingen eller lav risiko for mobilisering

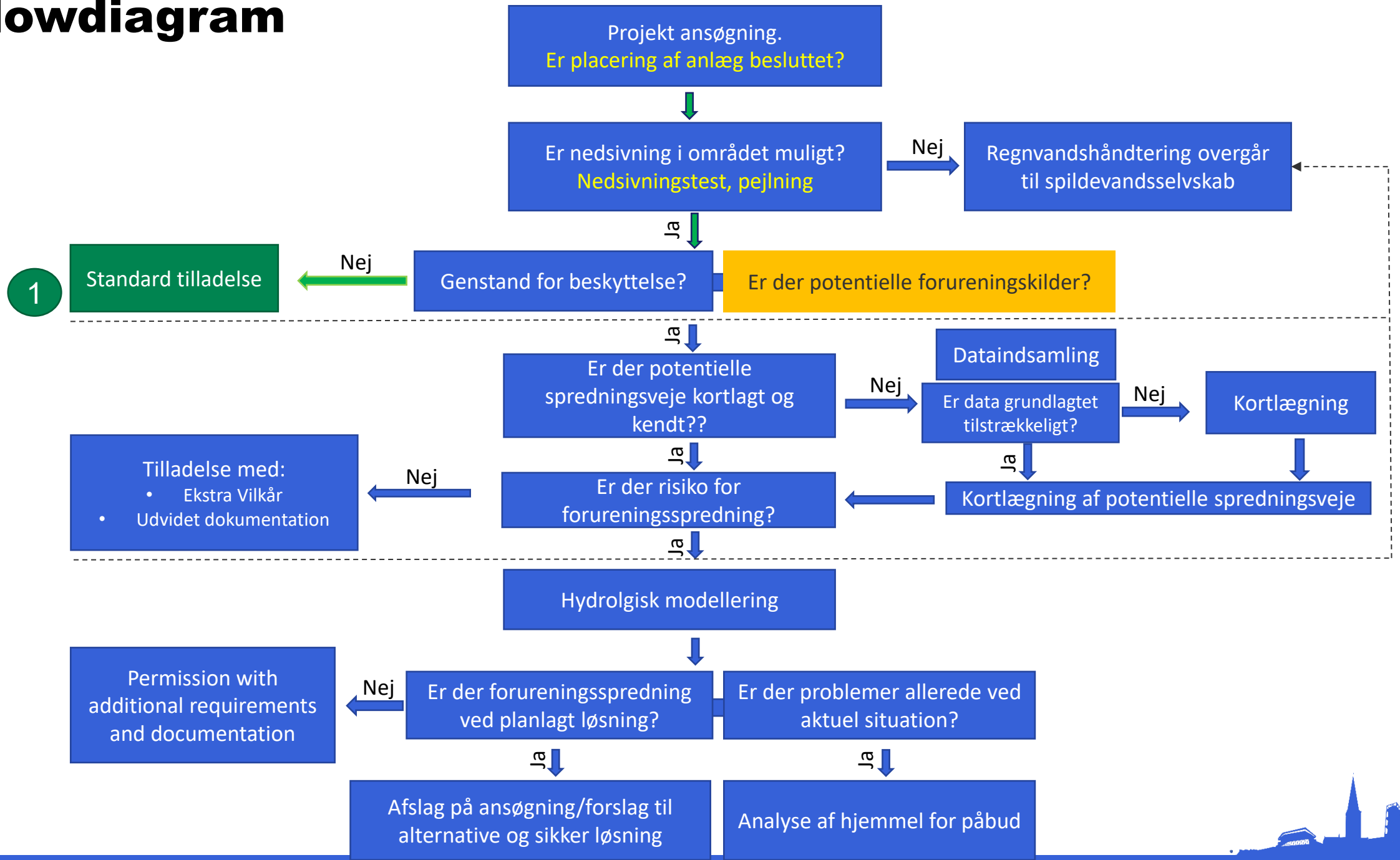
Grundvandssårbarhed:

- Gul-område

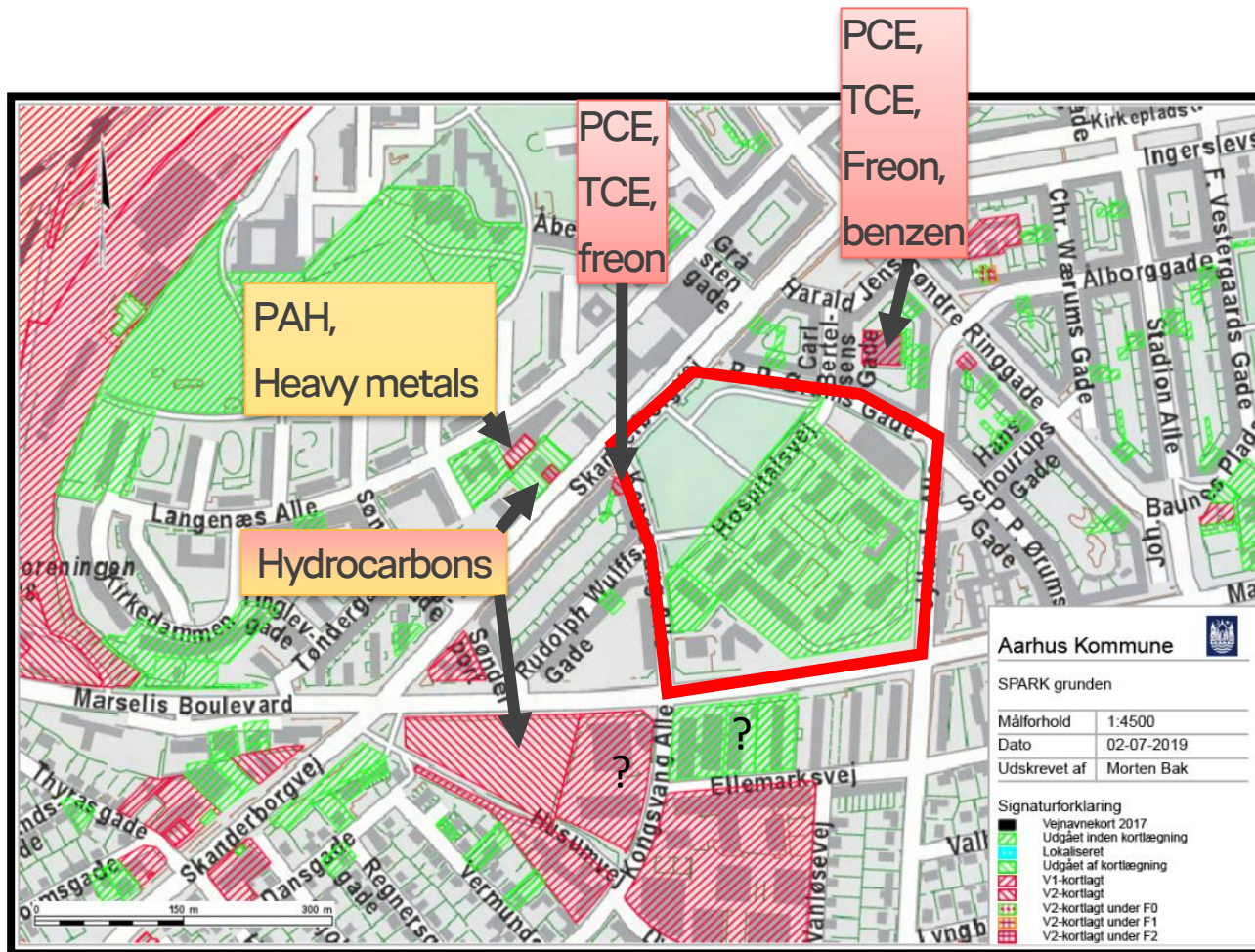


Flowdiagram

Stigende Komplexitet

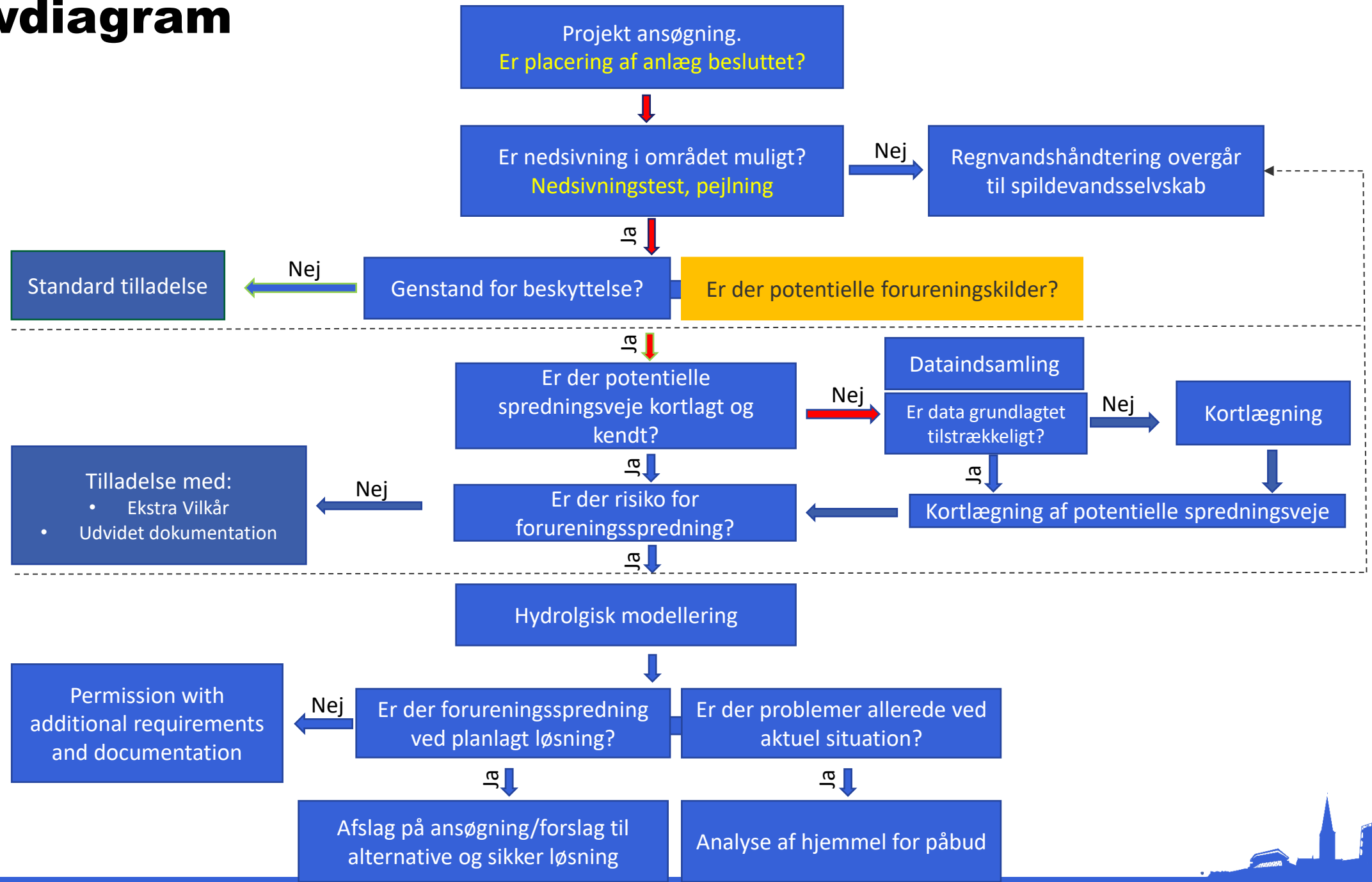


SPARK : Aarhus



Flowdiagram

Stigende Komplexitet

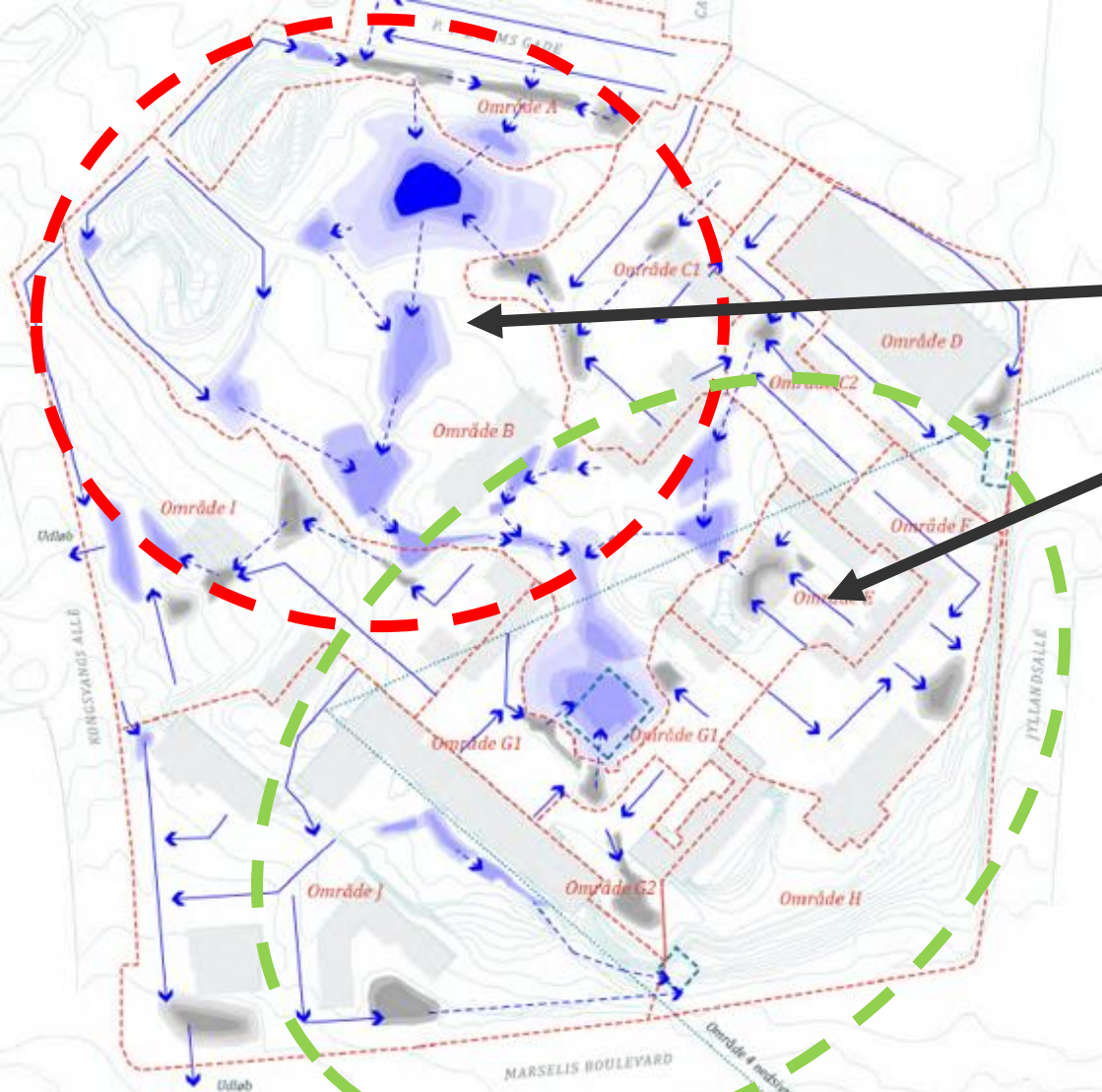




Boring nr	XUTM32EUR EF89	YUTM32EU REF89	Kote (m)	GVS m u.t. 24-06-2016	GVS kote (m o.h.) 24-06-2016	GVS m u.t. 06-07-2016	GVS kote (m o.h.) 06-07-2016
Bor01	573853,70	6222358,56	20,55	2,85	17,70	2,84	17,72
Bor02	573883,14	6222438,55	20,70	2,96	17,75	2,96	17,75
Bor03	573950,40	6222382,58	20,31	2,70	17,60	2,69	17,62
Bor04	573901,17	6222319,93	20,39	4,31	16,08	4,31	16,09
Bor05	573794,20	6222323,01	17,82	2,42	15,41	1,70	16,13
Bor06	573728,84	6222402,70	18,80	2,14	16,66	1,54	17,27
Bor07	573715,58	6222445,85	19,51	4,95	14,56	3,80	15,71
Bor08	573759,91	6222536,44	21,54	2,42	19,12	1,48	20,06
Bor09	573797,94	6222511,31	20,89	4,90	16,00	3,42	17,48
Bor10	573737,09	6222500,63	20,86	4,62	16,25	2,57	18,30



Regnvandshåndteringsplan



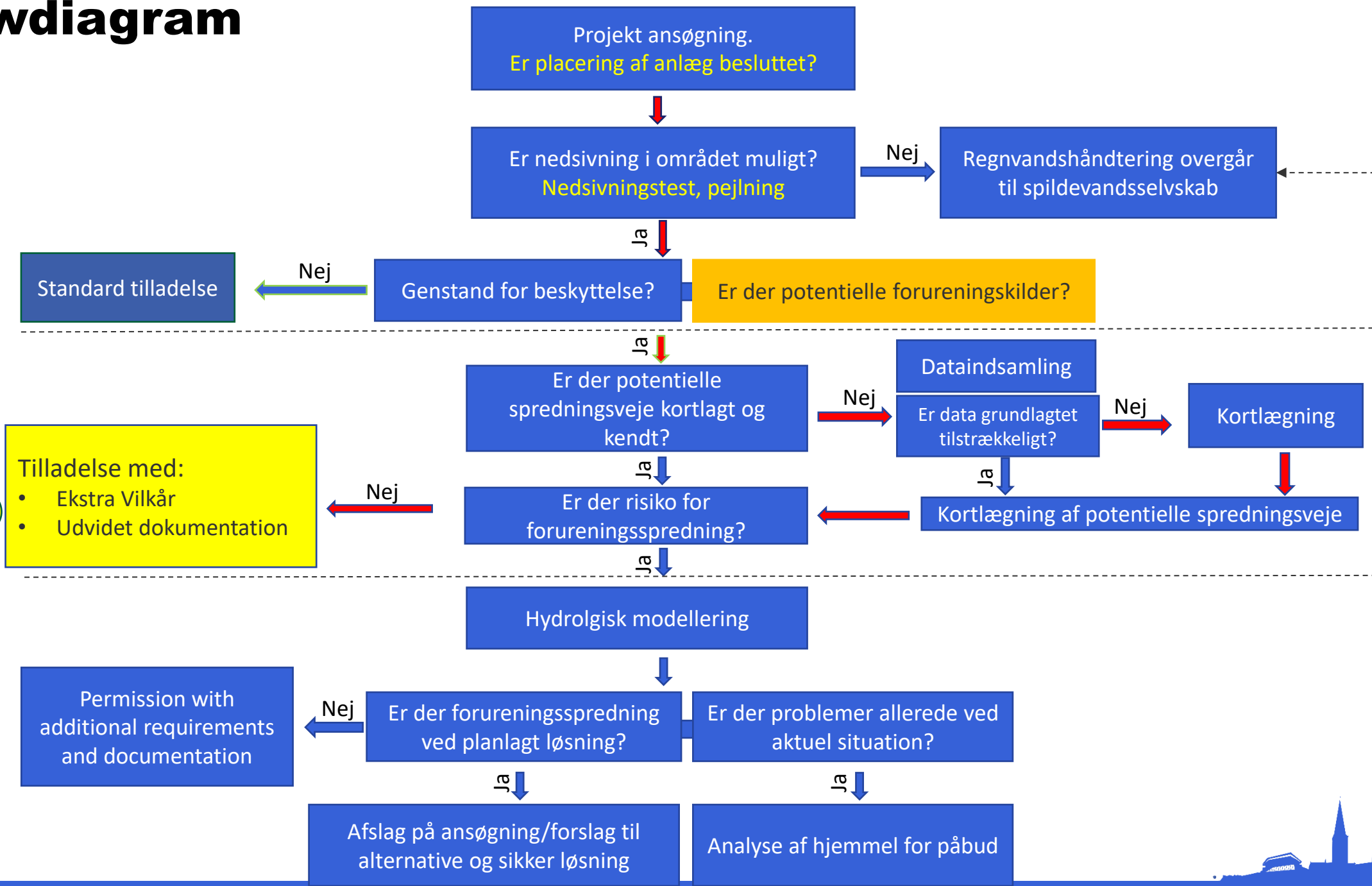
- Afledning i det nordlige område til det sydlige områder
- Nedsivning i der sydlige område
- Nedsivning fra terræn (Filterjord)

- Forsinkelsesbæde uden rensning, dobbelt programmeret - regnbed og aktivitet.
- Forsinkelsesbæde med filtermuld til rensning af vejvand
- Underjordisk faskine
- Grænse område 4, nedsivning
- Permanent vand
- Strømning i åben grøft



Flowdiagram

Stigende Komplexitet

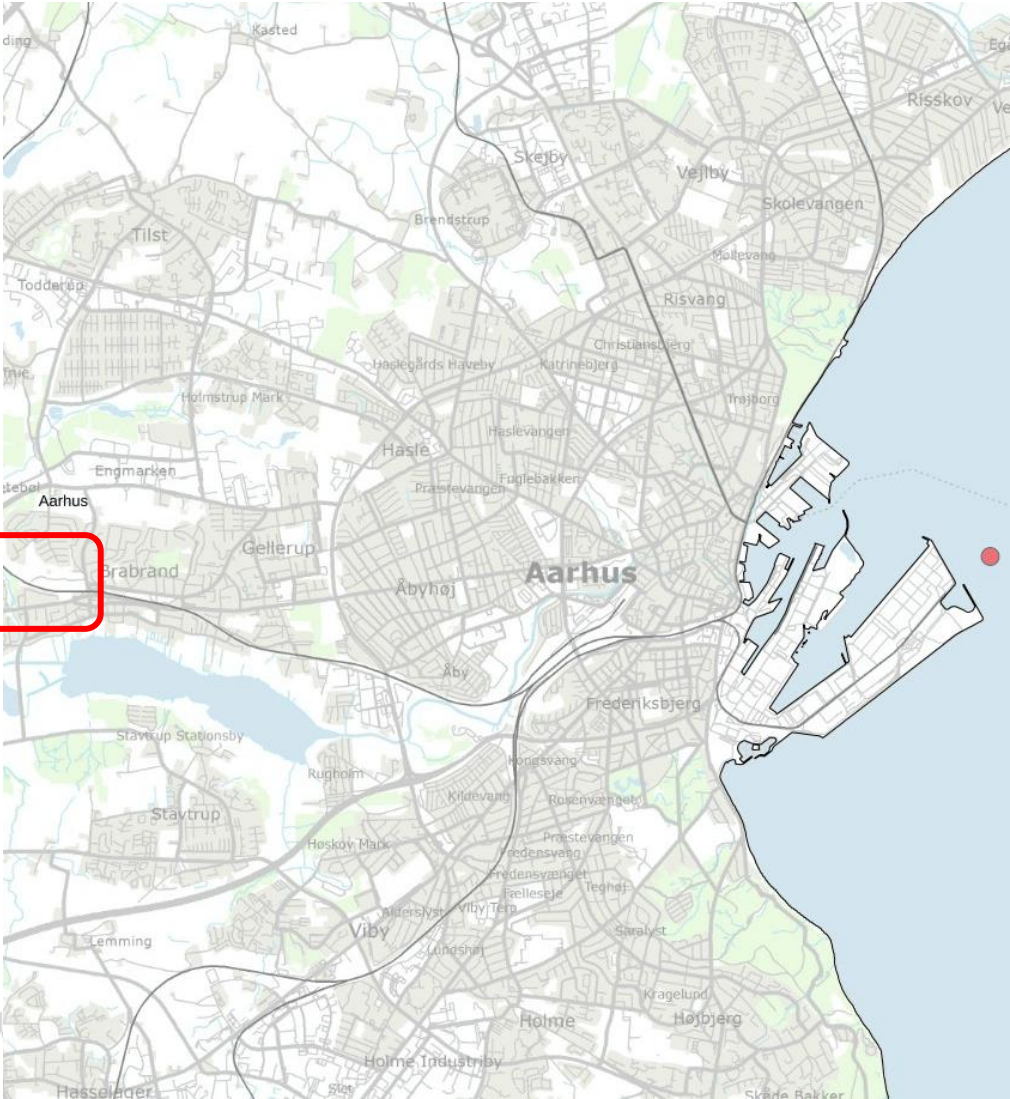


CASE: TULIP –

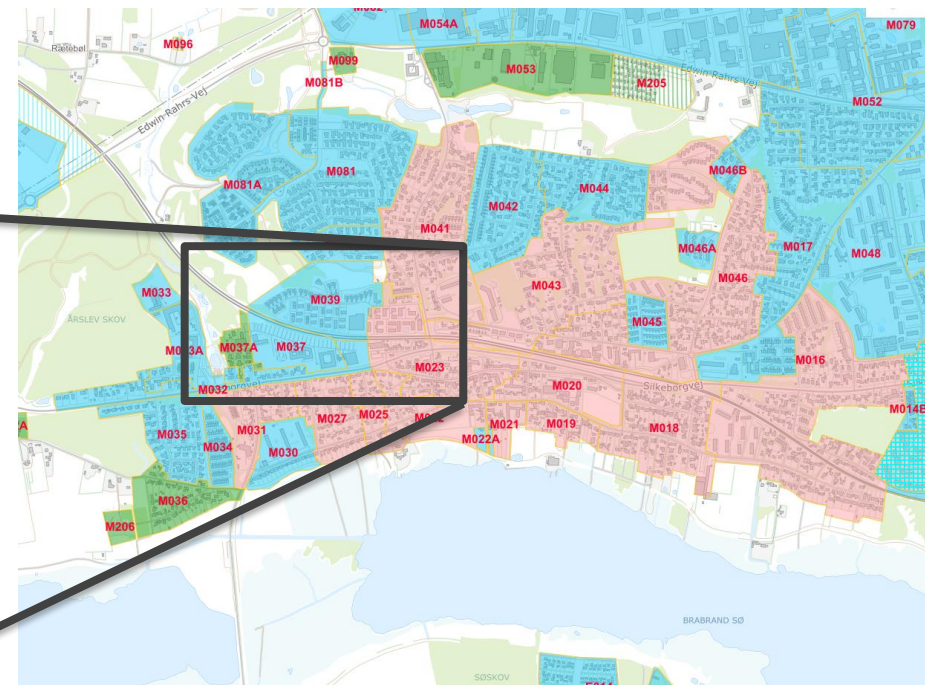
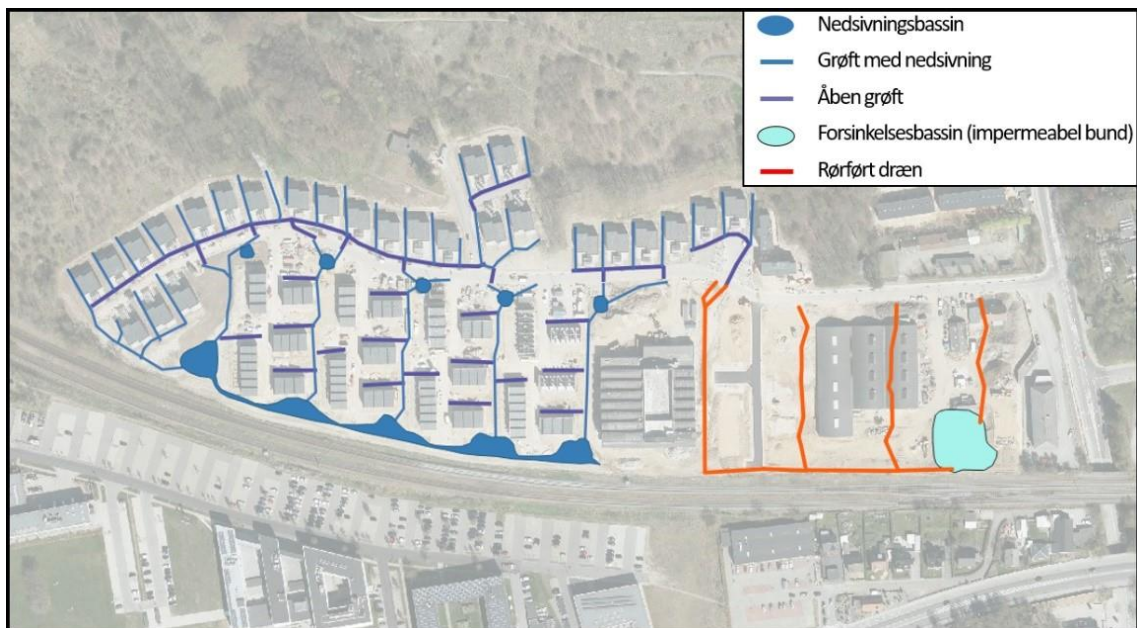
Regnvandshåndteringsplan



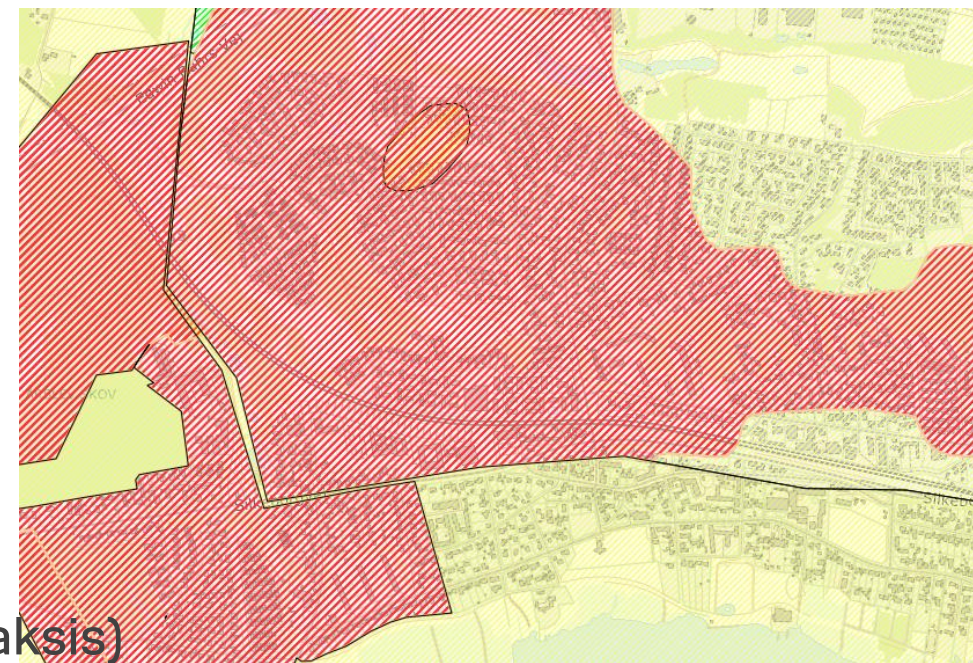
Ref: NIRAS



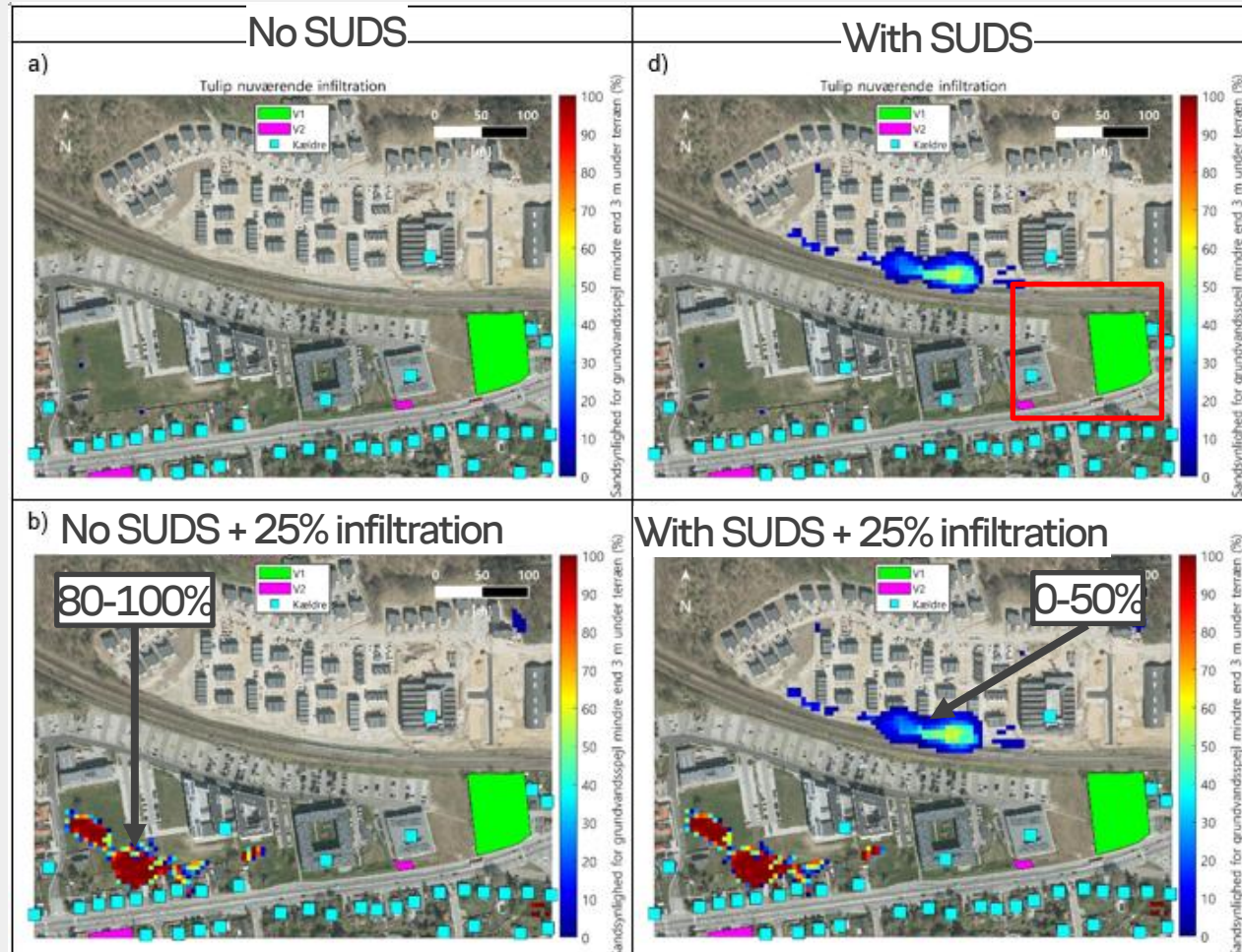
Pilot projekt - ORMUM



- Udfordring med at afledning som følge af jernbane
- Nedsivning af delområde af Lokalplan område?
- Ikke Håndhæve tilslutningspligt
- Ingen udtræden → for kompleks for privat
- Forsyning står med et nedsivningsanlæg (ikke standard praksis)



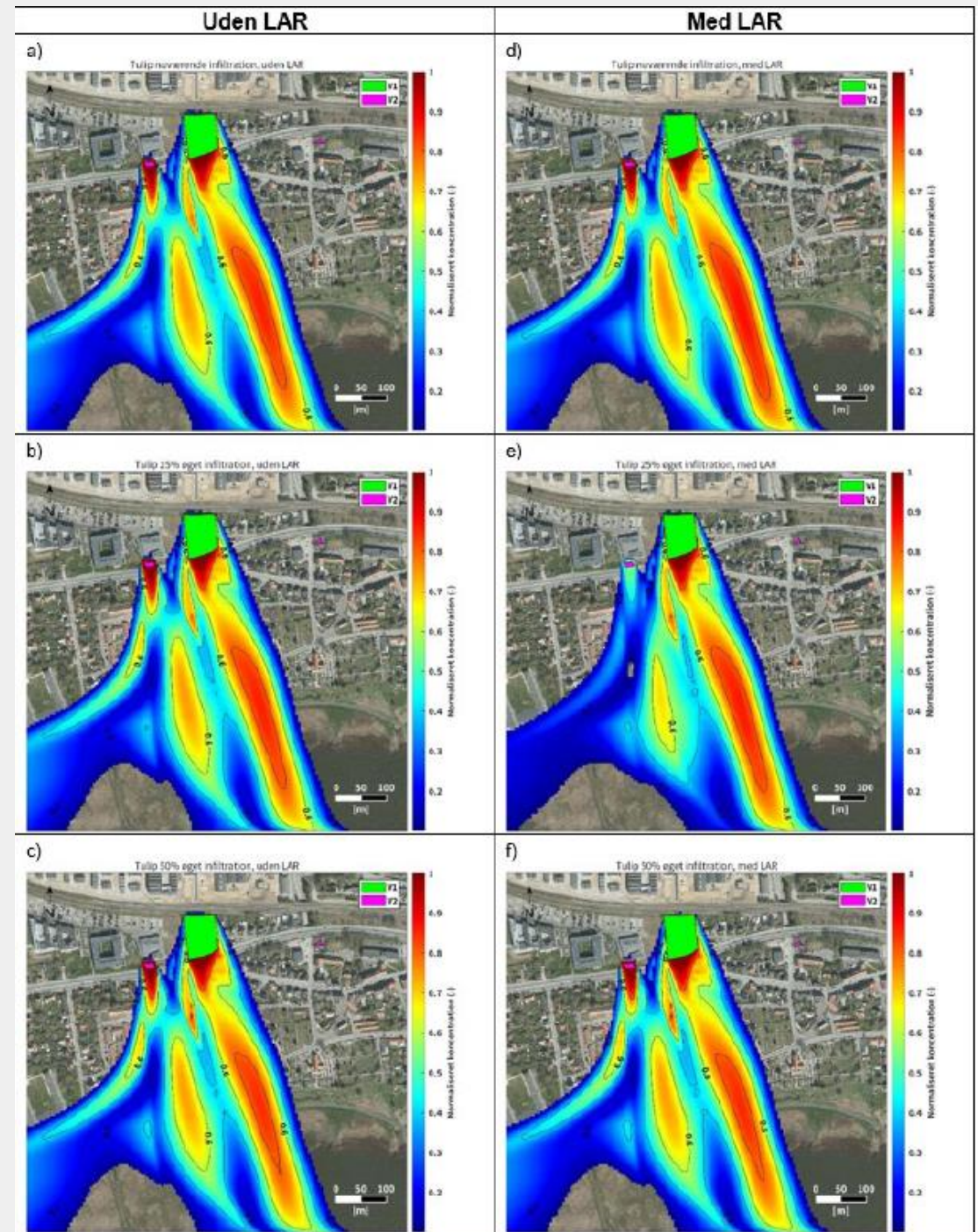
Probability of groundwater less than 3 m below terrain



Simulation of contaminations spreading - FEFLOW

25% increase of precipitation

50 % increase of precipitation

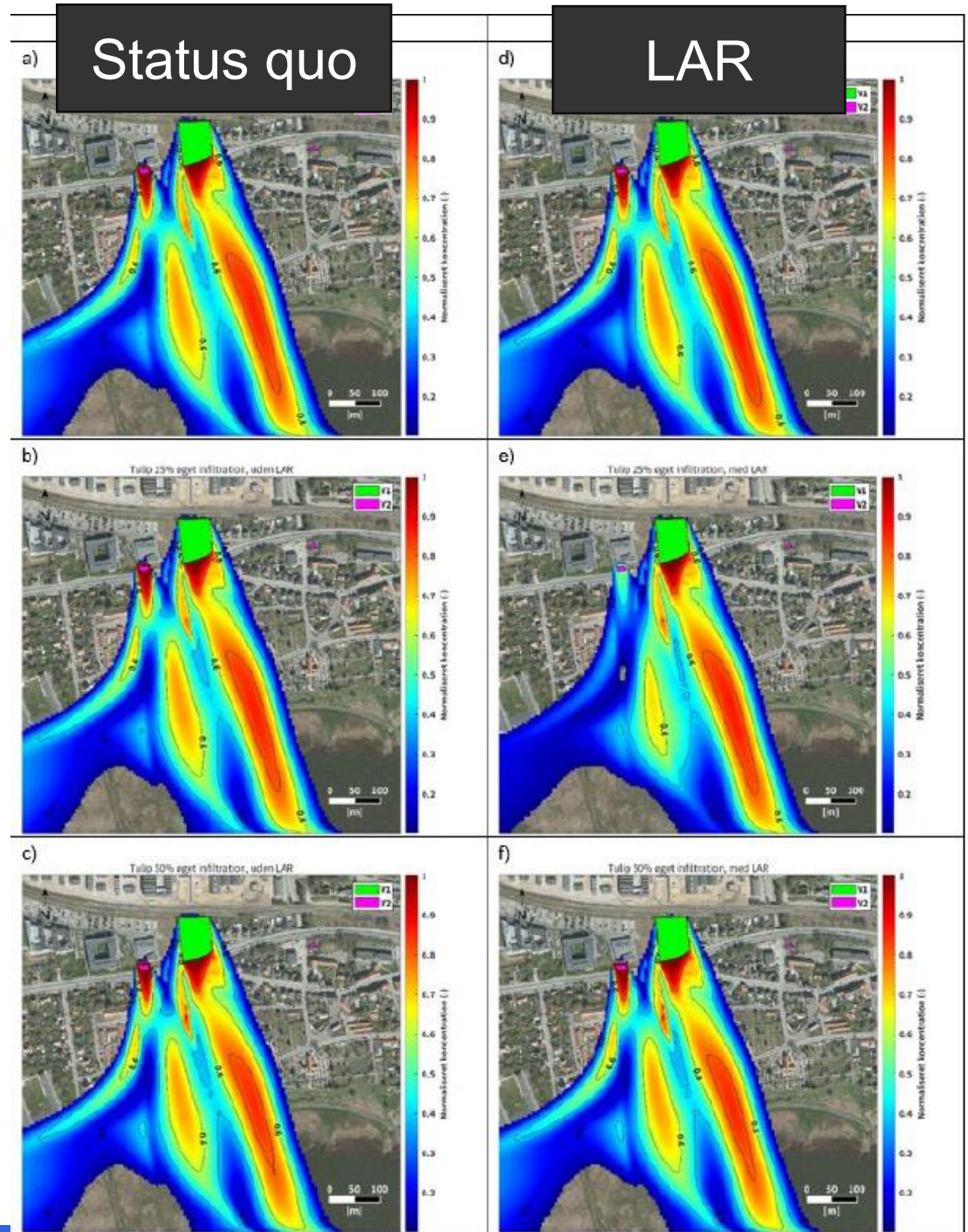


Simulation of contaminations spreading - FEFLOW

25% increase of precipitation

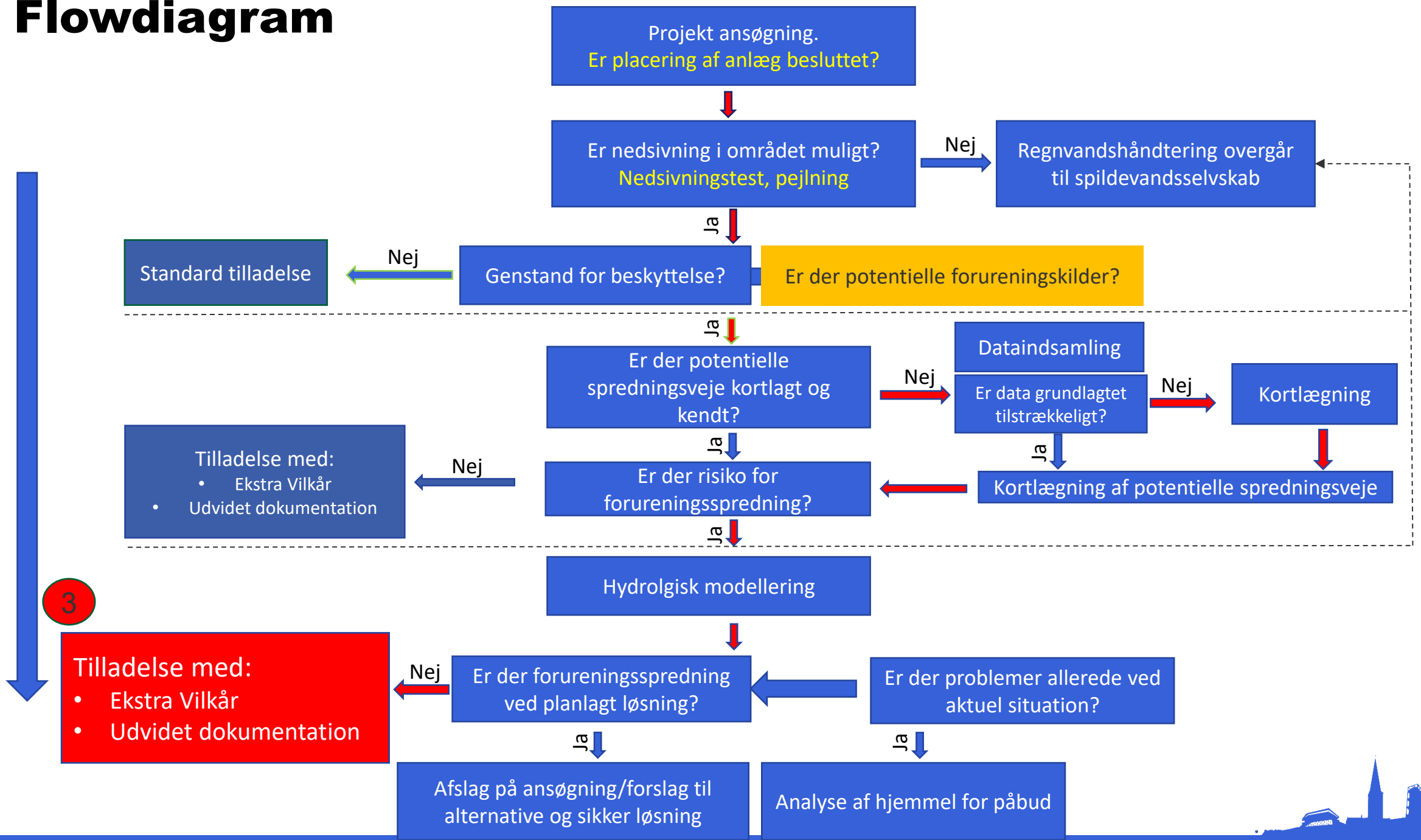
Ingen væsentlig ændringer!!!

50 % increase of precipitation



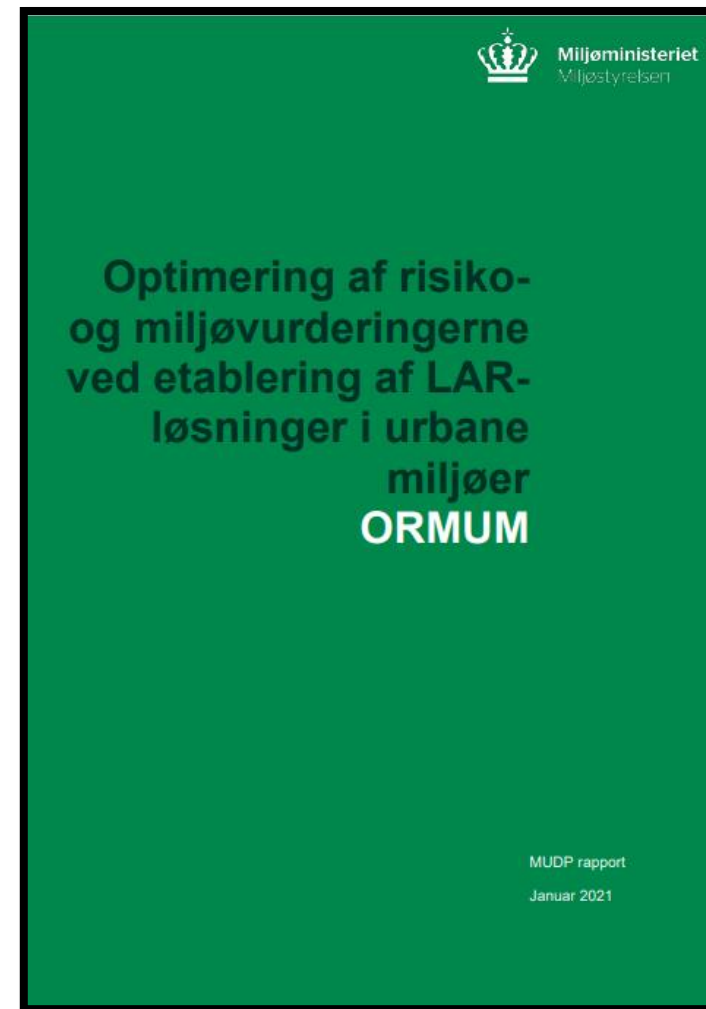
Flowdiagram

Stigende Komplexitet



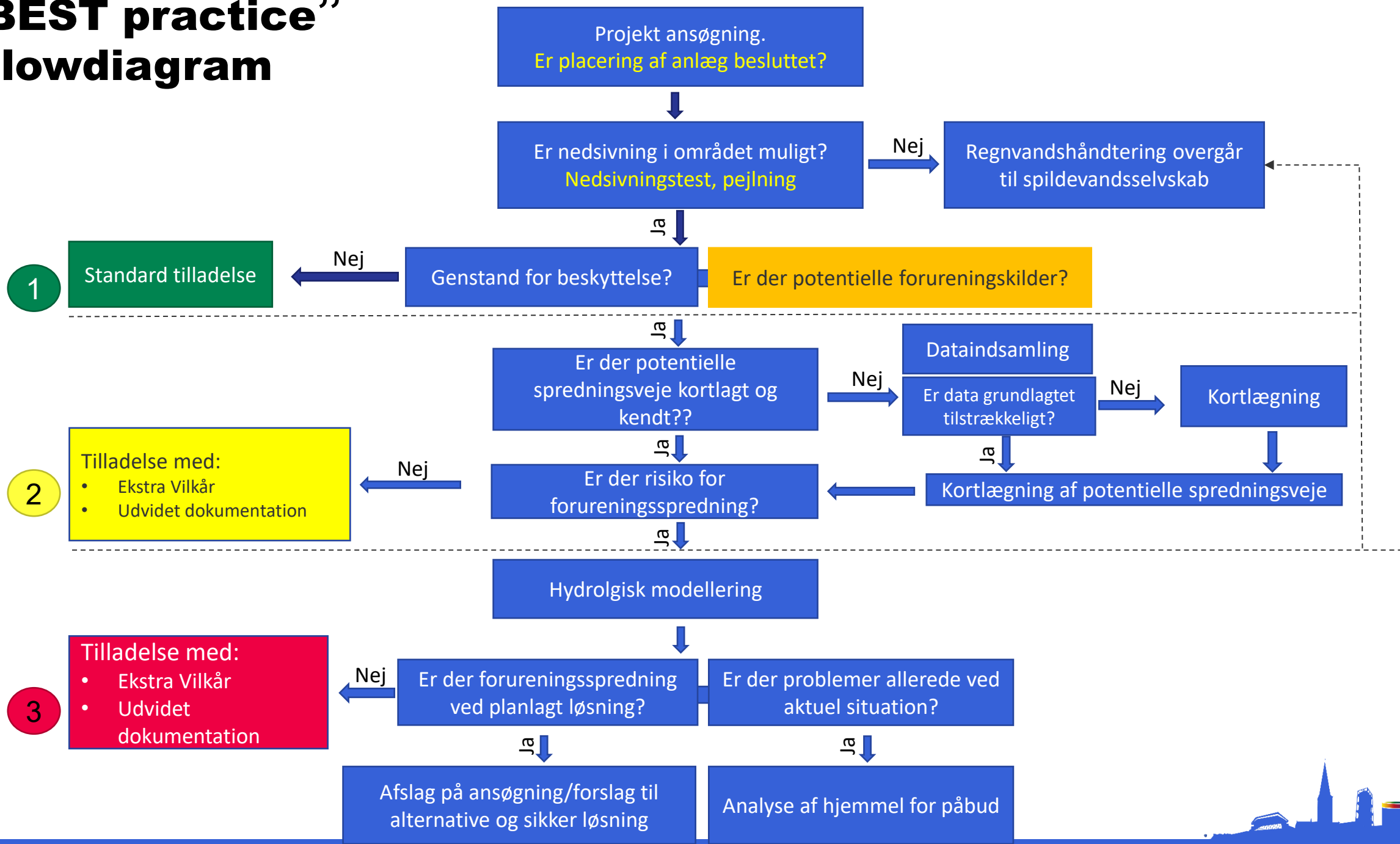
Opsamling:

Hvad skal vi være opmærksomme på når vi arbejder med LAR-anlæg og nedsivning?



"BEST practice" Flowdiagram

Stigende Komplexitet



A landscape photograph featuring a small, calm pond in the foreground, surrounded by several large, smooth, greyish-brown rocks. The water reflects the surrounding greenery and the sky. The background consists of a grassy field and a modern building with large windows and a dark facade. The text "Sprøgsmål?" is overlaid in the center of the image.

Sprøgsmål?