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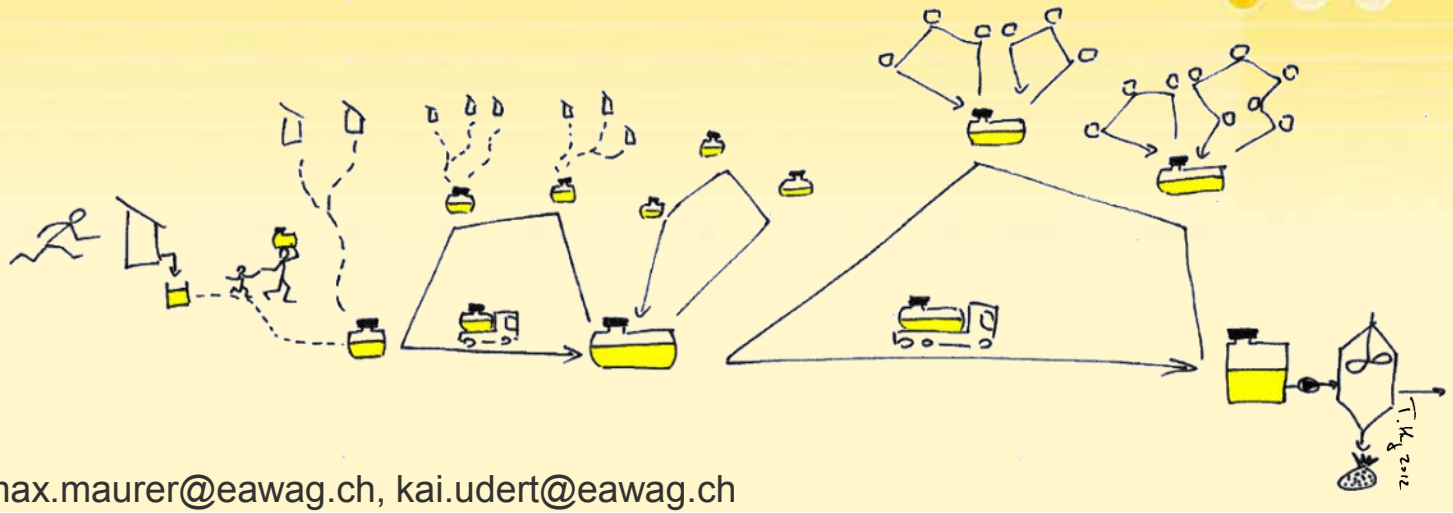
Model-based performance evaluation of the collection of source-separated urine

Thomas Hug, Max Maurer, Kai Udert *(Eawag, Switzerland)*



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DeSaM (Decentralized Sanitation Product Management Model)

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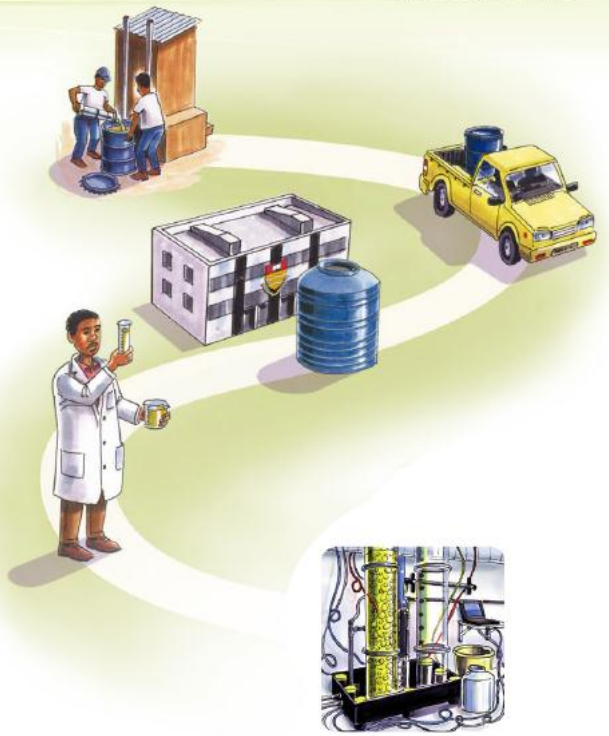
The VUNA project

Promoting sanitation by recovering nutrients from source-separated urine.

- Develop reactor technology
- Manage dispersed urine tanks and reactors
- Explore socio-economic boundaries



Funding and project partners

Funded by the Bill and Melinda Gates Foundation

eawag aquatic research — Swiss Federal Institute of Aquatic Science and Technology

eThekwini Municipality — eThekwini Water and Sanitation

University of KwaZulu-Natal — University of KwaZulu-Natal

ETH — Swiss Federal Institute of Science and Technology Zurich

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Functioning urine *collection* is crucial!

… for nutrient recovery and value production







Photos: Thomas Hug, Kai Udert, Bastian Etter

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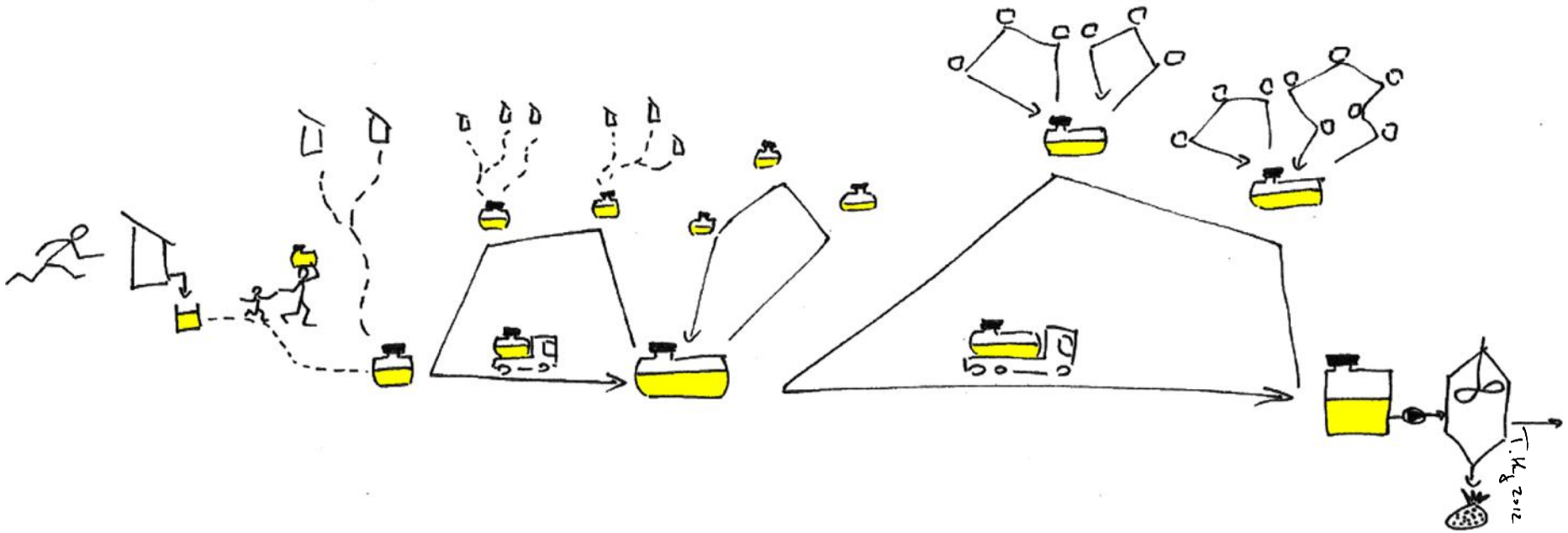

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Relation to faecal sludge management

Collection is crucial for functioning of system
- functionality of toilets
- treatment / nutrient recovery
- collection is expensive

Large number of distributed toilets

Different collection schemes
--> business models and stakeholder interests

Urine diverting toilets
--> management of faecal sludge AND urine

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Functioning urine *collection* is crucial!

… for nutrient recovery and value production

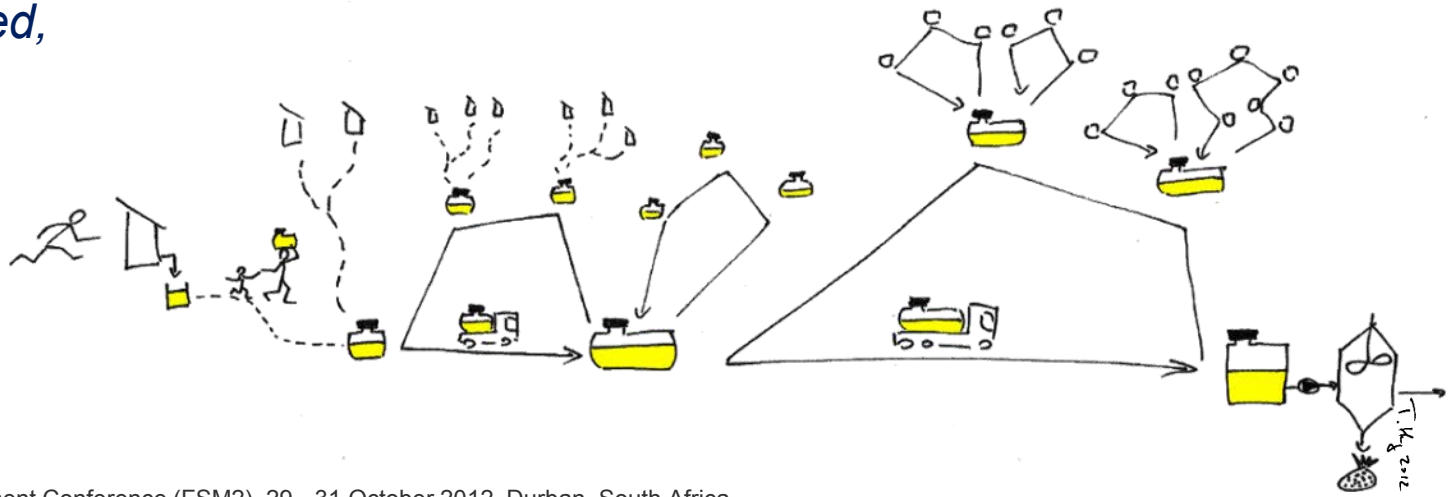
Questions:

- *how much* urine is available for the treatment plant?
- *how reliably* can this amount be delivered?
- *how expensive* is this?

- what factors are the most important, which are negligible?

for…

- volume delivered,
- reliability,
- costs,
- profit,
- environment



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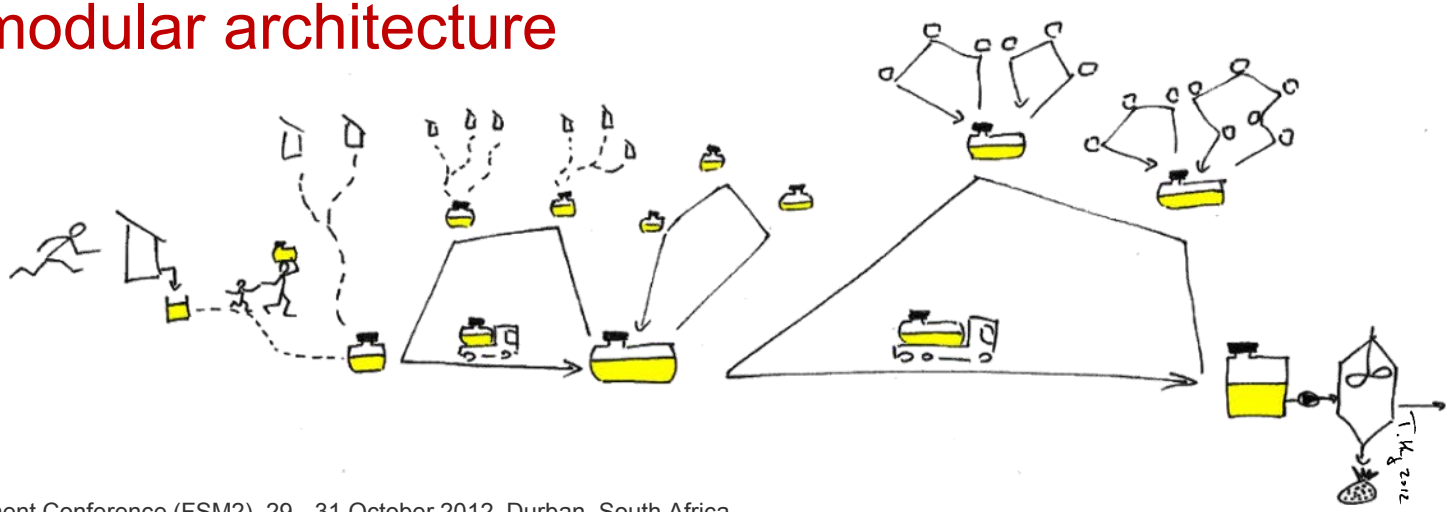
Why modeling urine collection

as tool to answer such questions

to understand system behavior
--> mechanistic model

considering random behavior
--> stochastic model

to analyze different collection schemes and contexts
--> flexible, modular architecture



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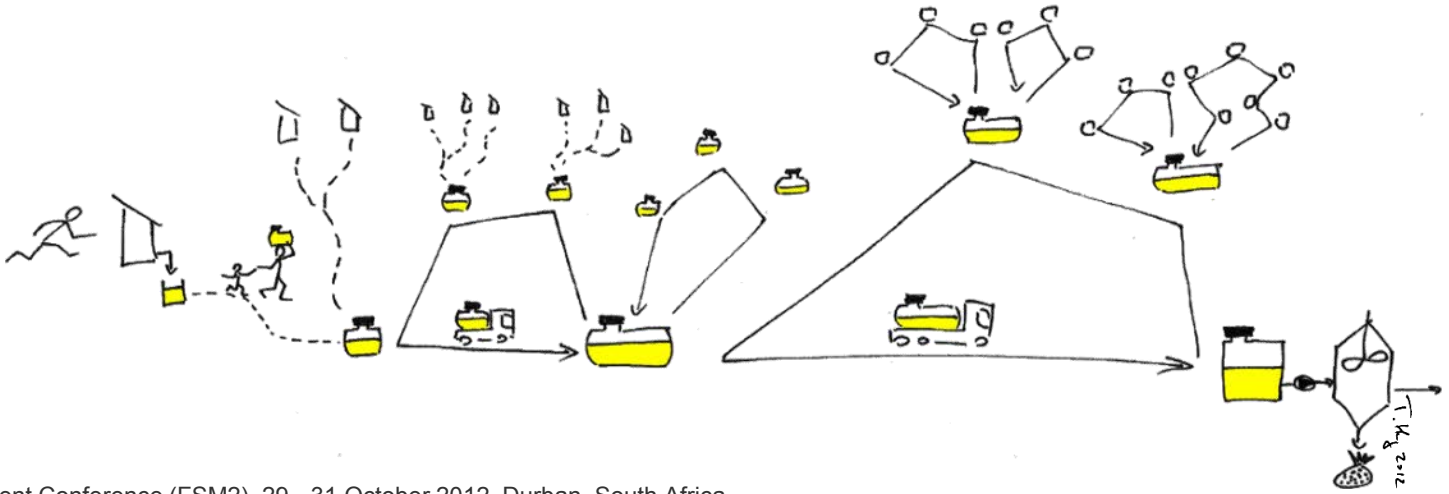
How to model urine collection?

system of connected tanks

--> volumes,

filling and emptying,

reactions…



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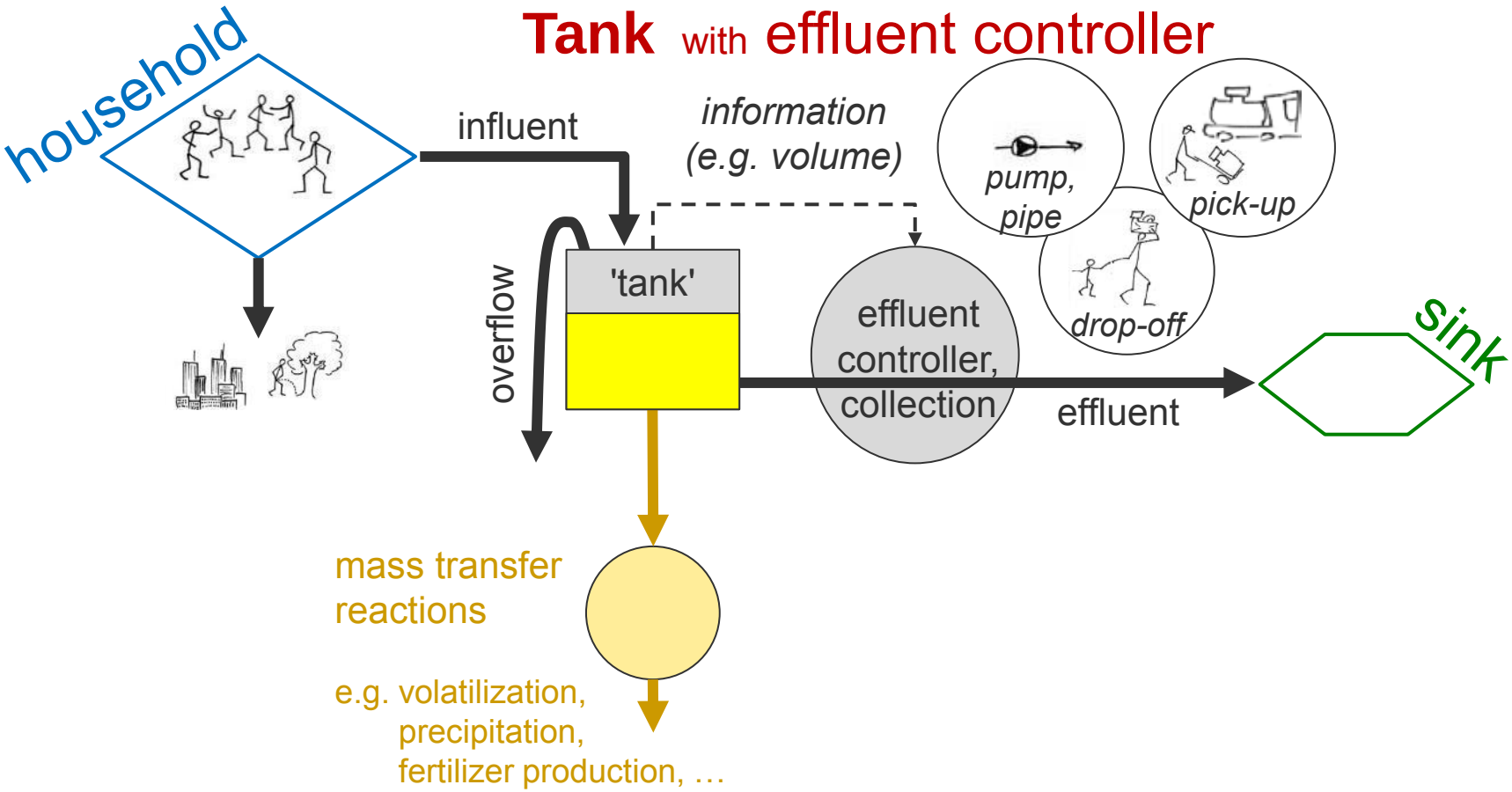
DeSaM
Decentralized Sanitation Product Management Model

--> a flexible system of connected tanks:



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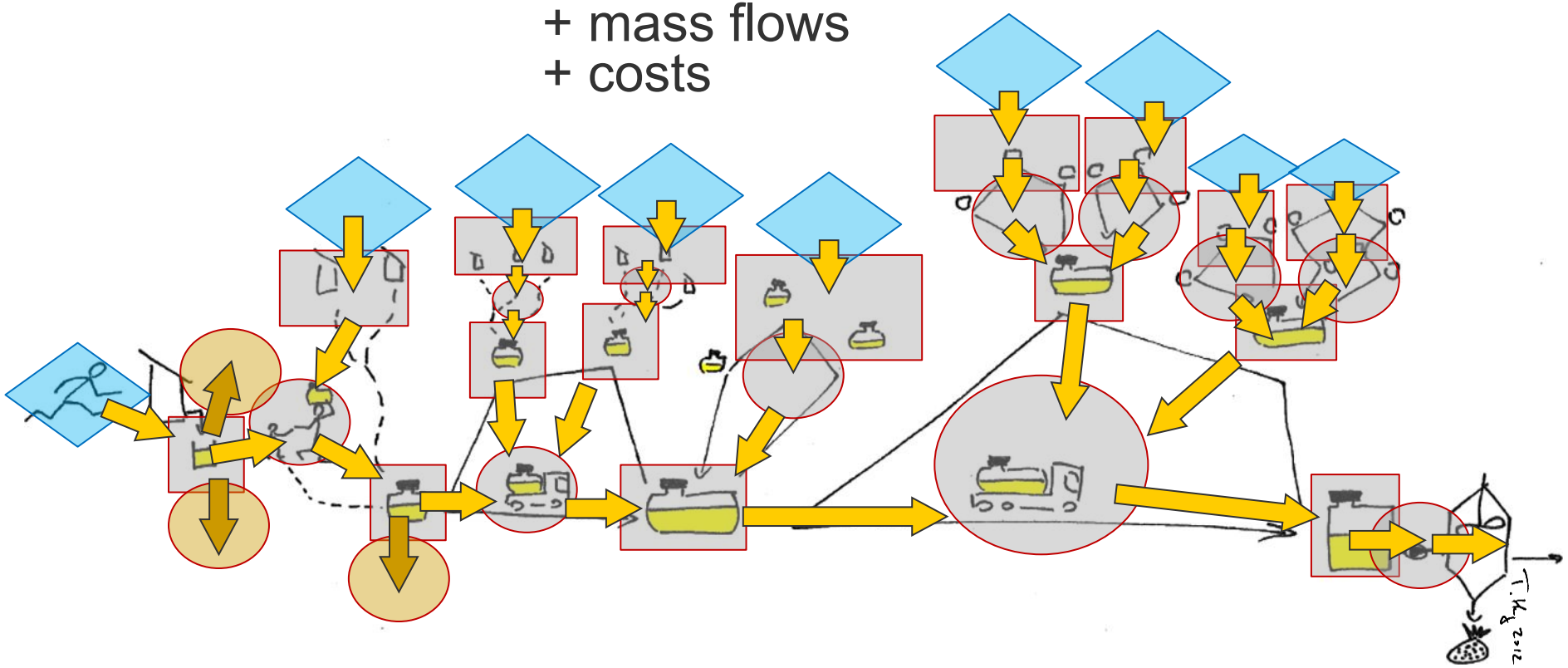
DeSaM

Decentralized Sanitation Product Management Model

stochastic, dynamic, mechanistic

A modular model --> Systems of connected tanks

Simulation order 1. volume flows
+ mass flows
+ costs



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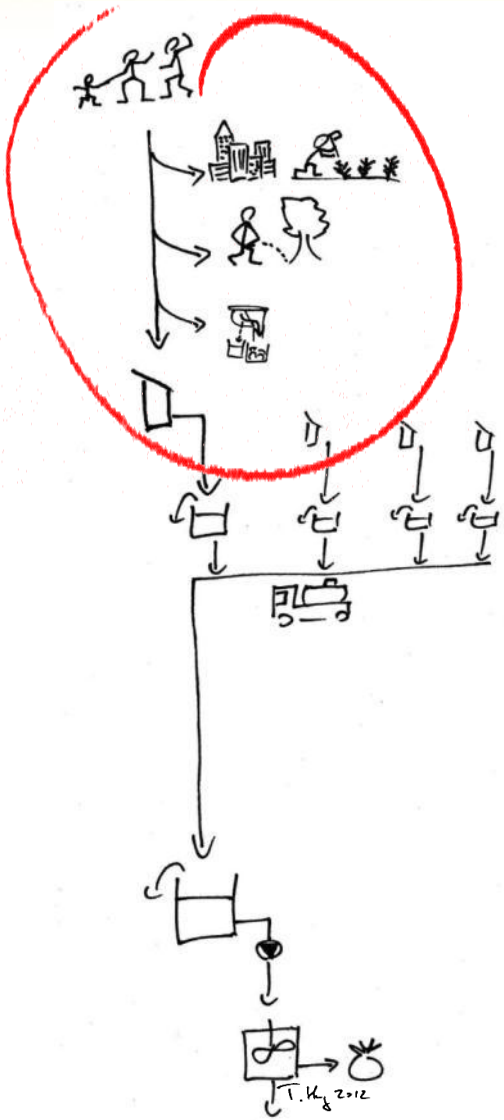
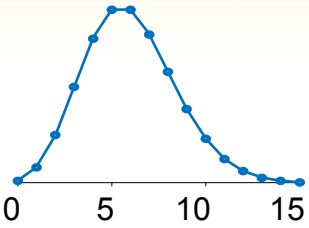
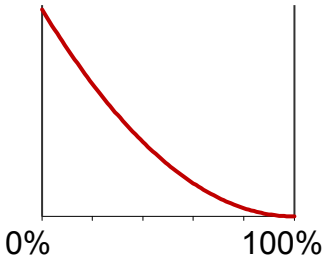
How much urine from a household?

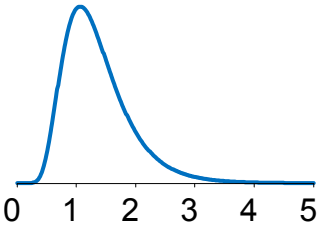




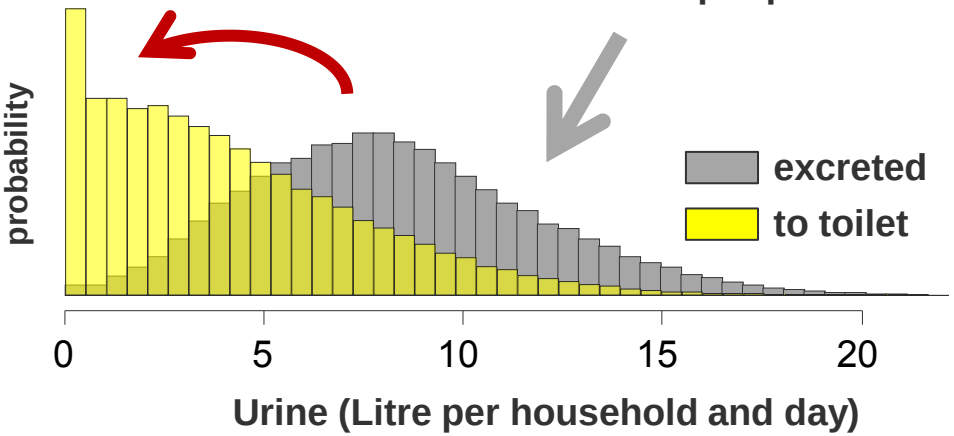
people per household



% of urine to toilet



excretion
litre per person and day



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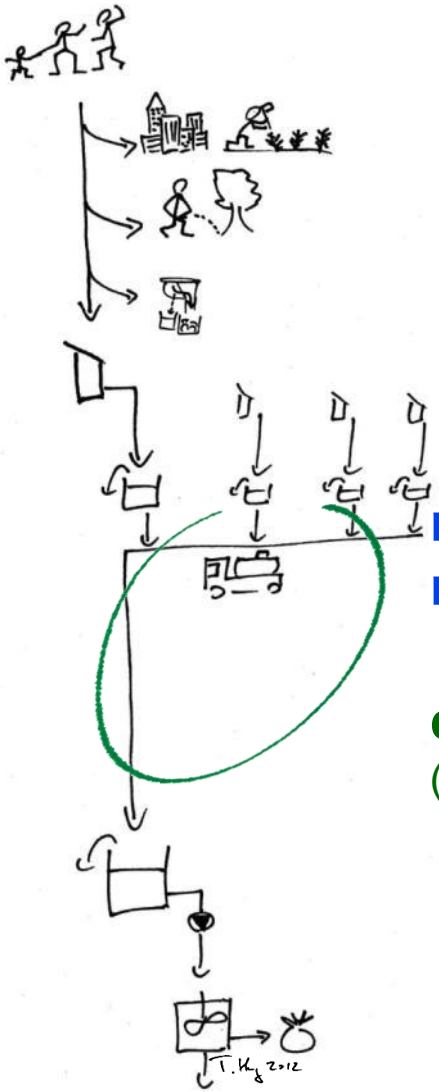
Some selected parameters



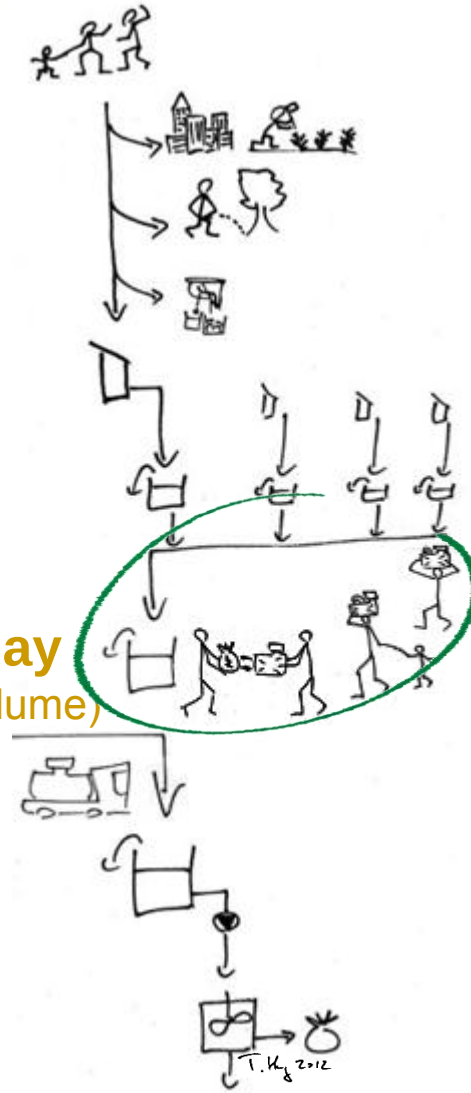
- distances
- topography
- ease of access
- idle time
- …

n tanks per team and day
n teams

collection order
(fix, by level)

How to know which tanks are full?
- online sensors
- people calling
- experience

Probability drop-off today
(depends on volume)



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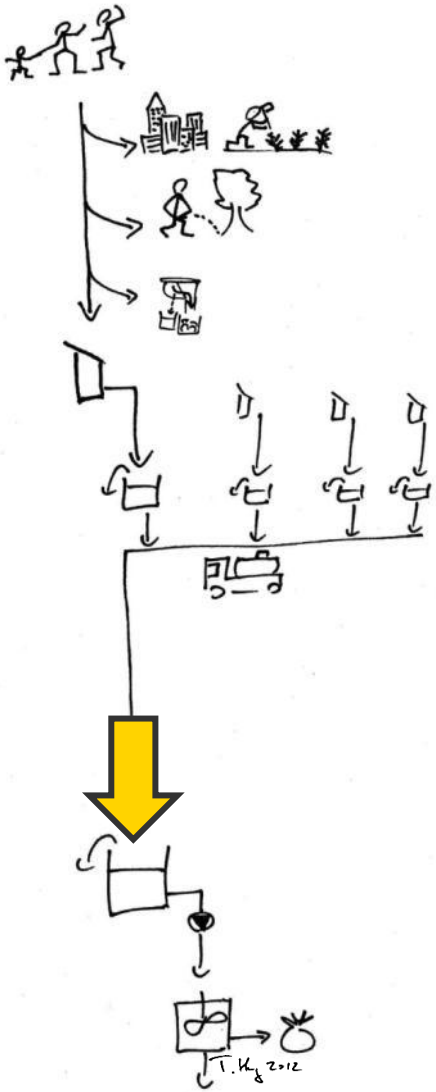
Model results



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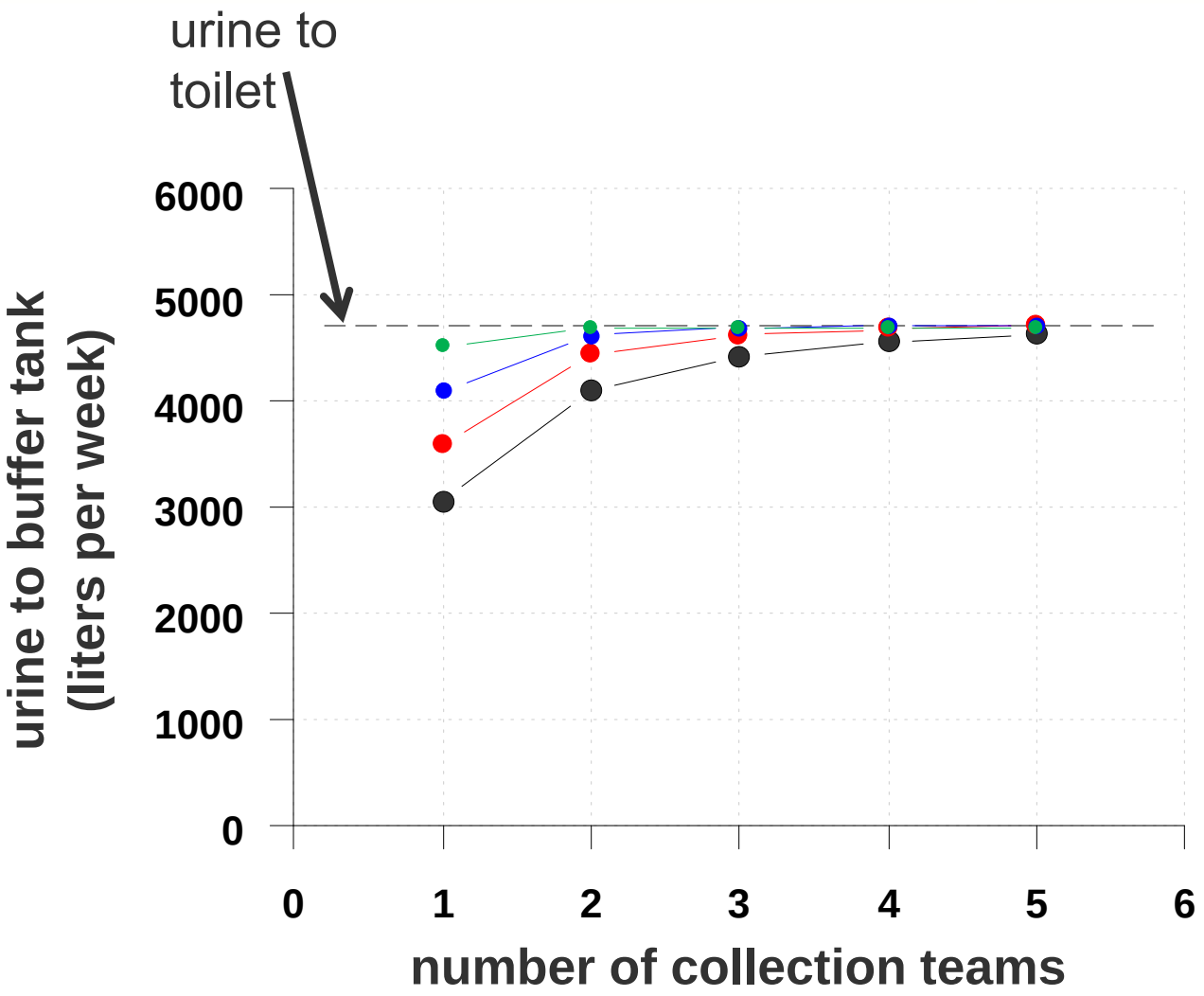

500 households

50 tanks per team per day

volume toilet tank	working days per week	collection order
20 L	5	fixed
20 L	**7**	fixed
40 L	5	fixed
20 L	5	**by level**

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Model results

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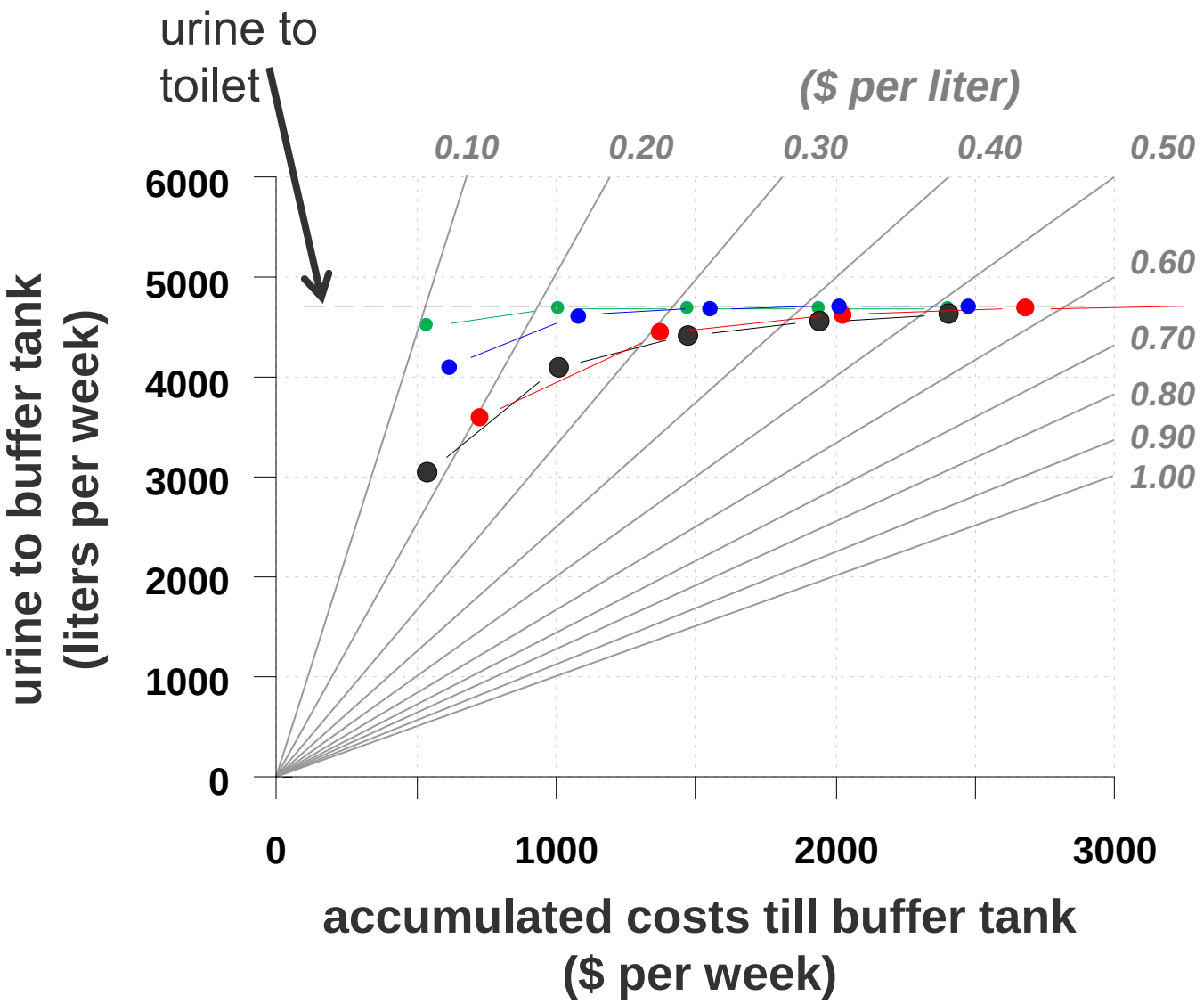

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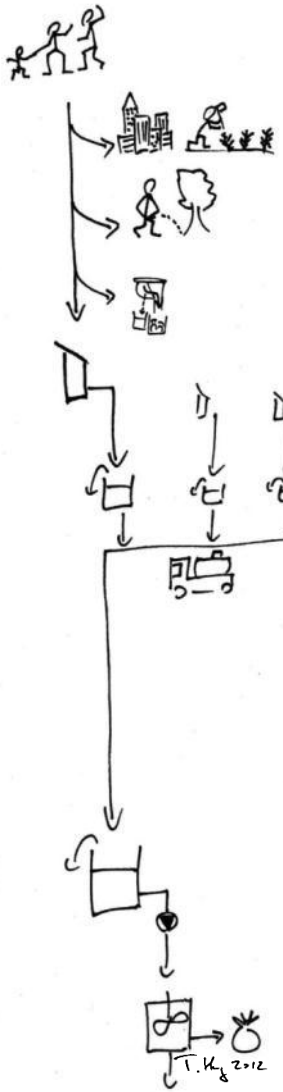
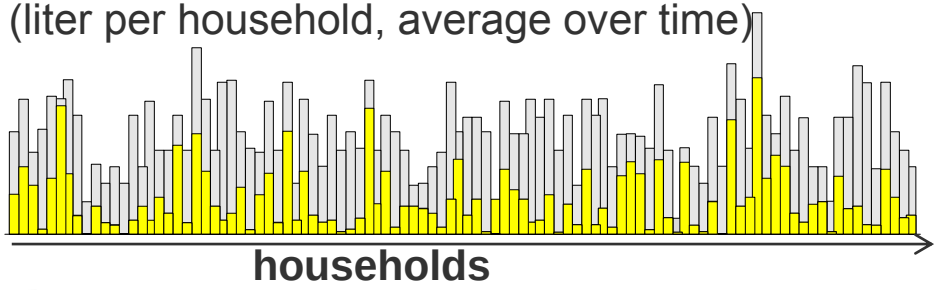
Model results: dynamic behaviour



households and toilet tanks

(liter per household, average over time)



urine not to toilets

urine to toilets

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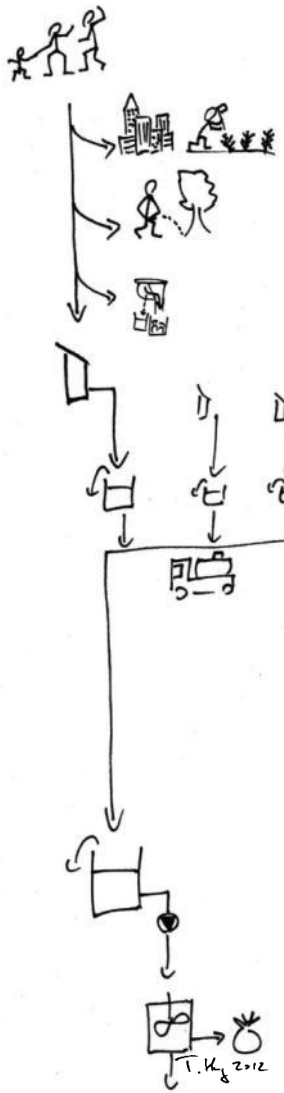
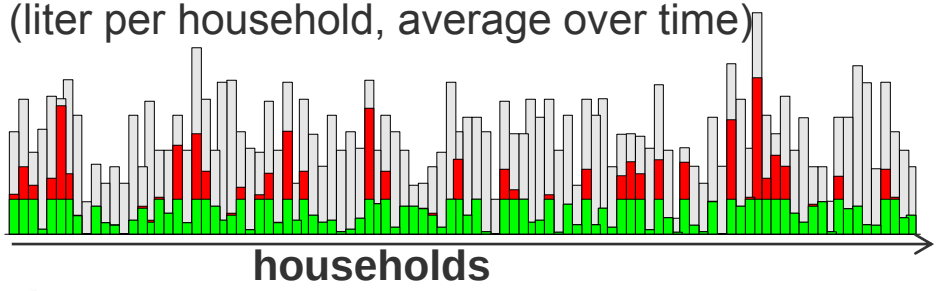
Model results: dynamic behaviour

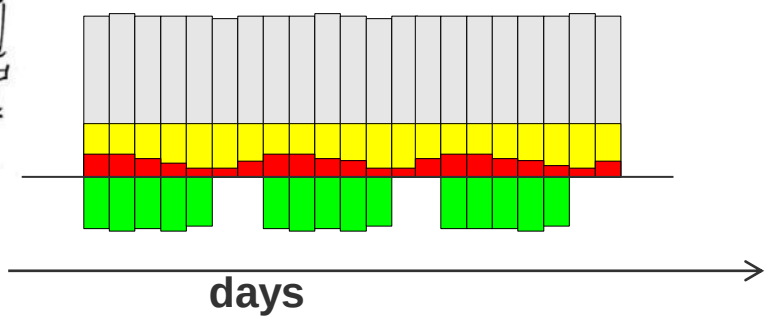


households and toilet tanks

(liter per household, average over time)



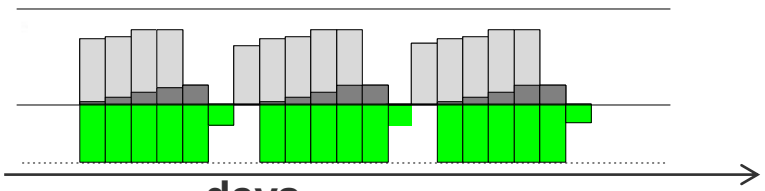
(liter per day, average of toilets)



collection order: "fixed"

- urine not to toilets
- urine to toilets
- overflow toilets
- urine collected

buffer tank (liter per day)



- overflow buffer
- volume variation in tank
- urine to treatment

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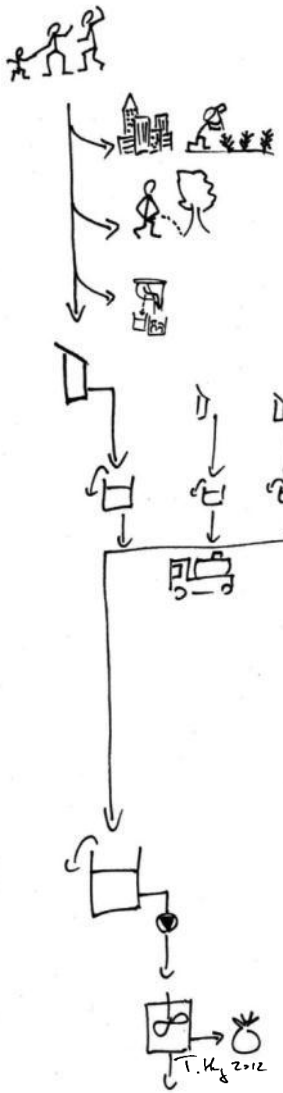
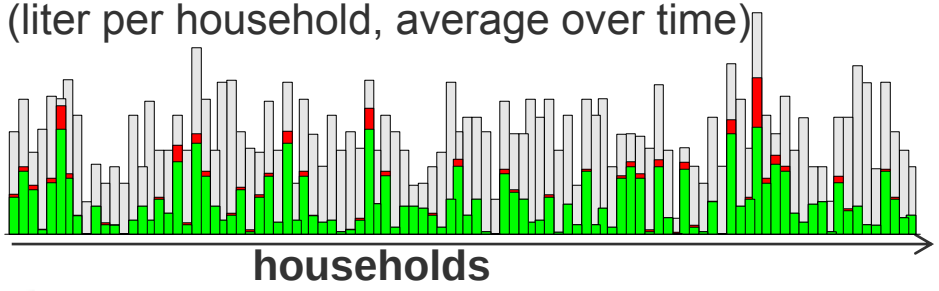
Model results: dynamic behaviour



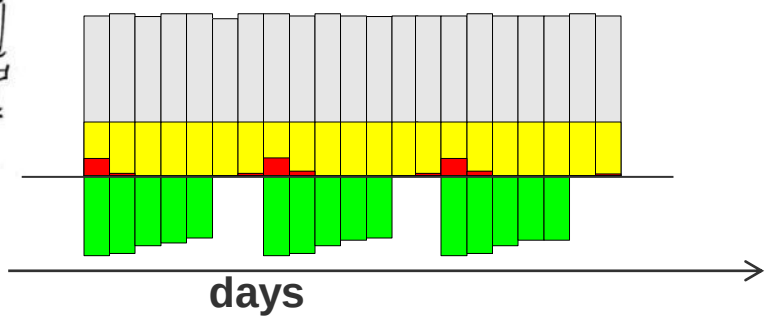
households and toilet tanks

(liter per household, average over time)



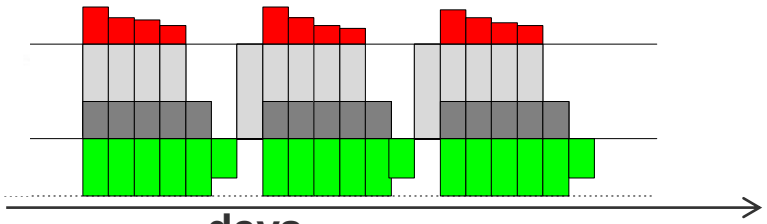
collection order: "by level"

(liter per day, average of toilets)



- urine not to toilets
- urine to toilets
- overflow toilets
- urine collected

buffer tank (liter per day)



- overflow buffer
- volume variation in tank
- urine to treatment

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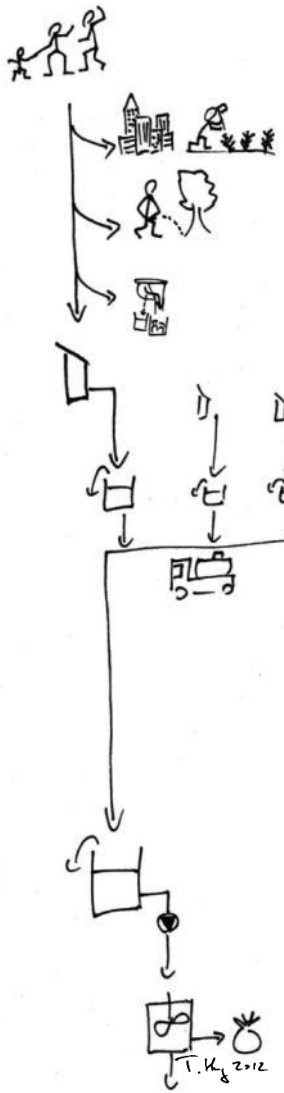
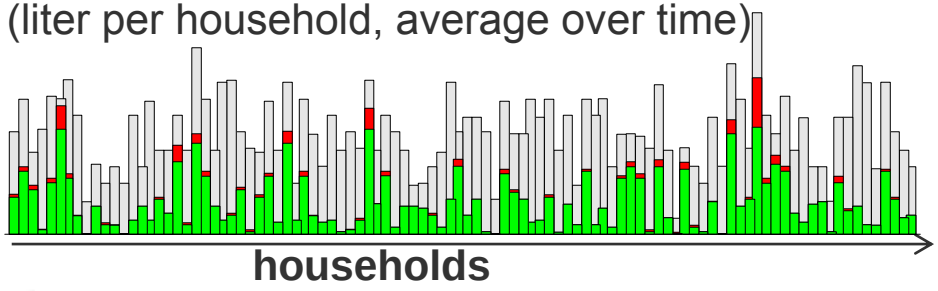
Model results: dynamic behaviour

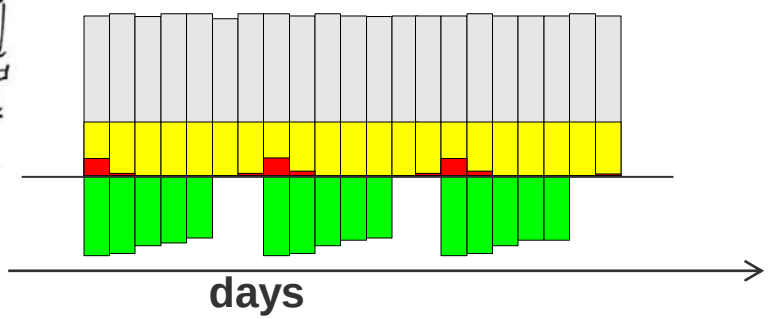


households and toilet tanks

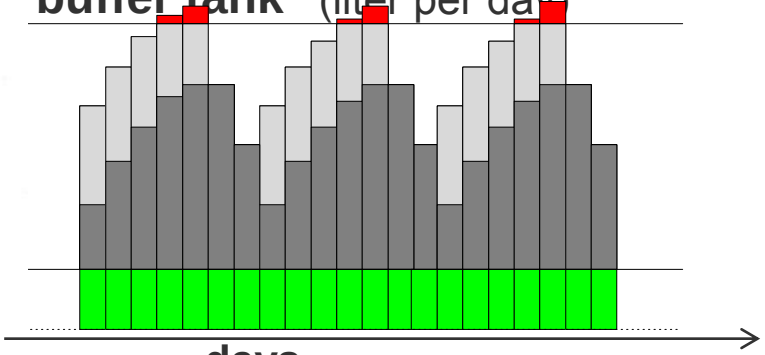
(liter per household, average over time)



(liter per day, average of toilets)



buffer tank (liter per day)



collection order: "by level"

original plant capacity

larger buffer tank

- urine not to toilets
- urine to toilets
- overflow toilets
- urine collected

- overflow buffer
- volume variation in tank
- urine to treatment

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Summary

Collection is crucial for treatment and nutrient recovery
--> how much urine and nutrients for what costs

Model to understand system behavior
--> mechanistic, stochastic, dynamic

DeSaM, a modular model
--> different system layouts
--> volume flows, mass flows, costs
--> local knowledge needed

Outlook:
- application in eThekwini/Durban
- tool for development of business model
- further model development