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Drawing excreta flow diagrams and additional fluxes, combined with simulation – the Simba# technical tool

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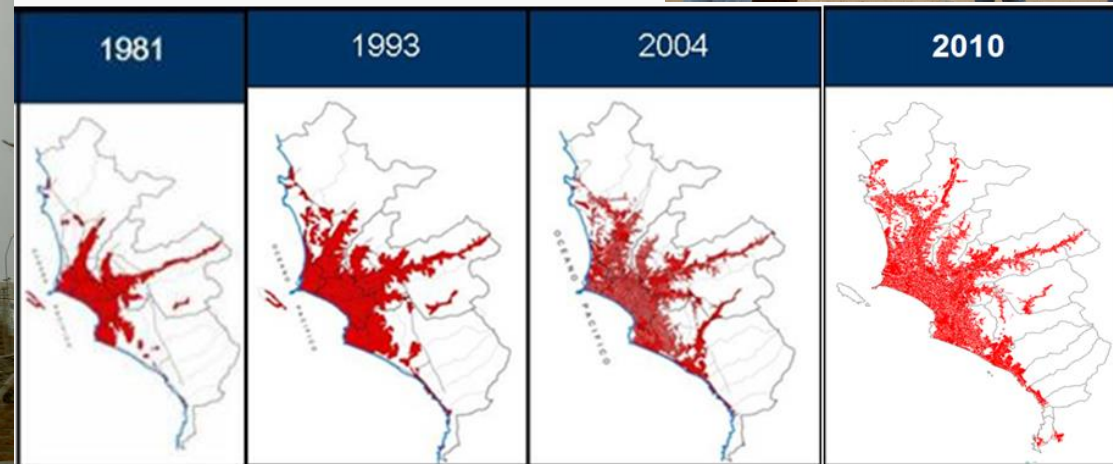
ifak Magdeburg (Flooding June 2013)

A:

Lima/Peru: A city with water challenges

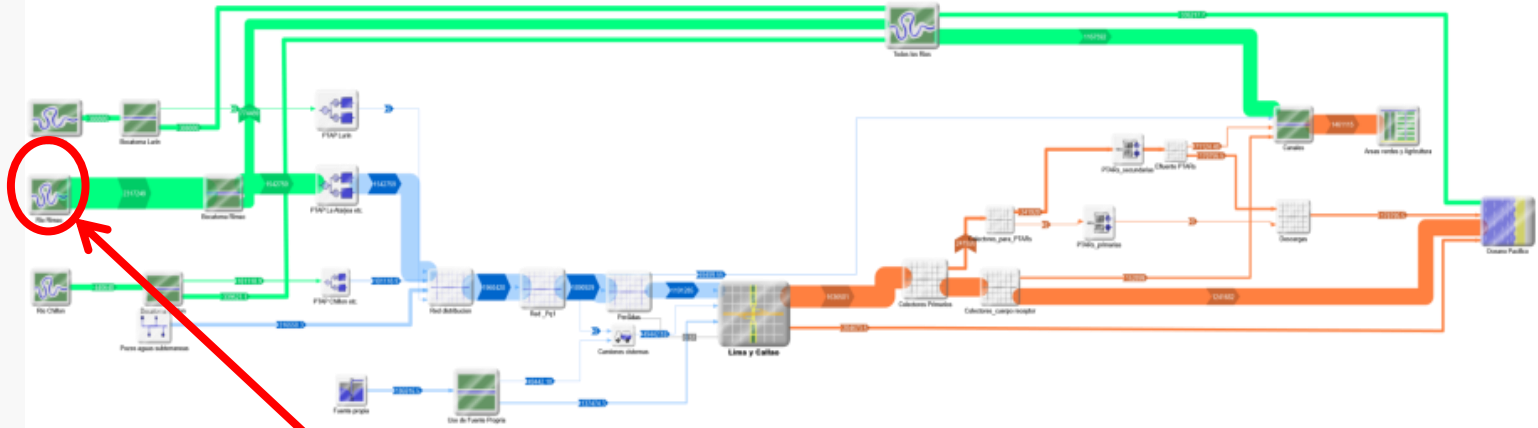
Some characteristics of Lima

- ❑ Second-driest city of the world (Rainfall: 9 mm p.a.)
- ❑ Rivers with trans-Andean tunnels, groundwater
- ❑ Some wastewater reuse (parks, agriculture) – untreated wastewaters
- ❑ Water production: approx. 20 m³/s
- ❑ Main worry of population: Access to water
- ❑ Challenges in administrative framework

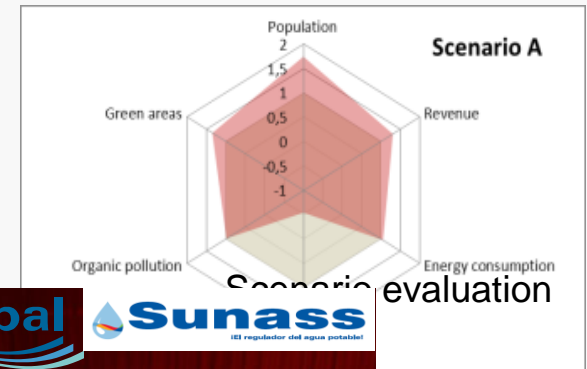
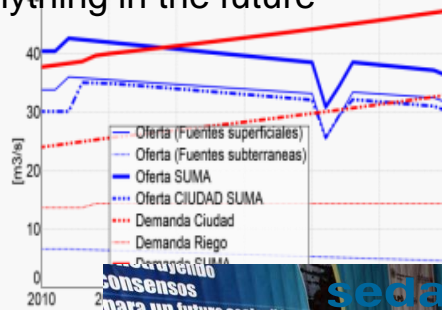
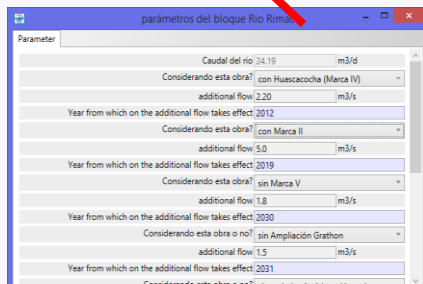


Present population: 9 million

A: Lima: Modelling for stakeholder participation



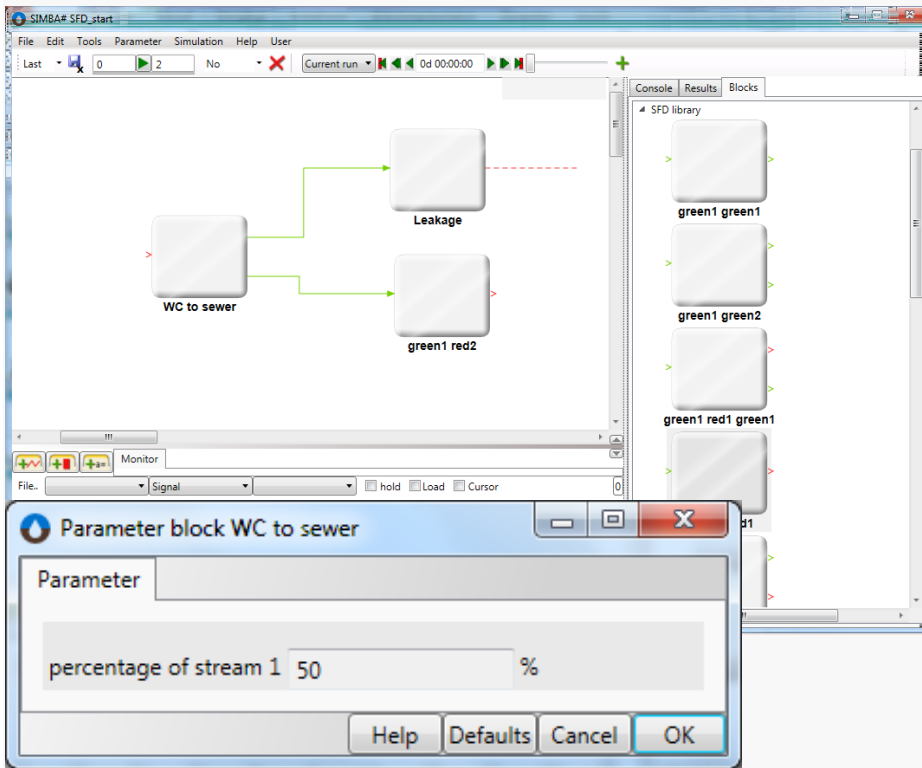
Scenario Zero: Not doing anything in the future



www.lima-water.de

Adoption of Action Plan „Lima 2040“

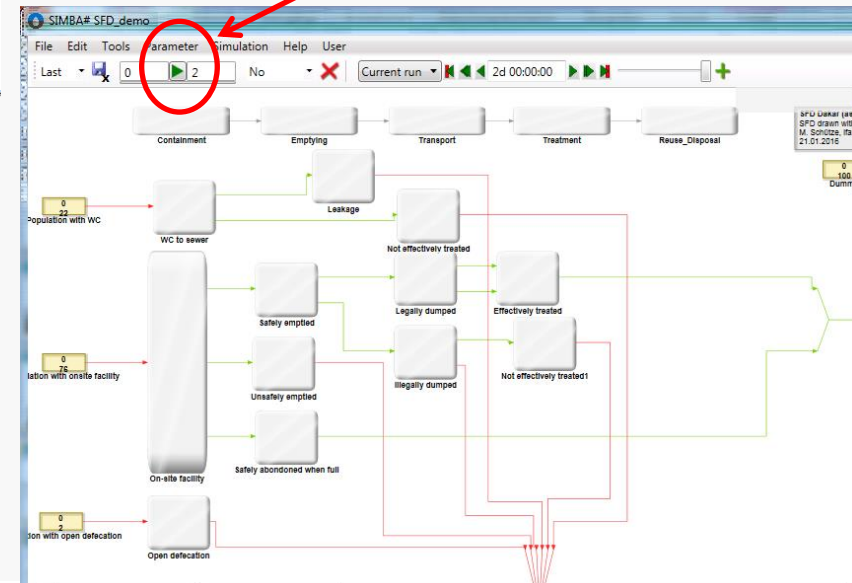
B: Drawing an SFD



2. Connecting blocks

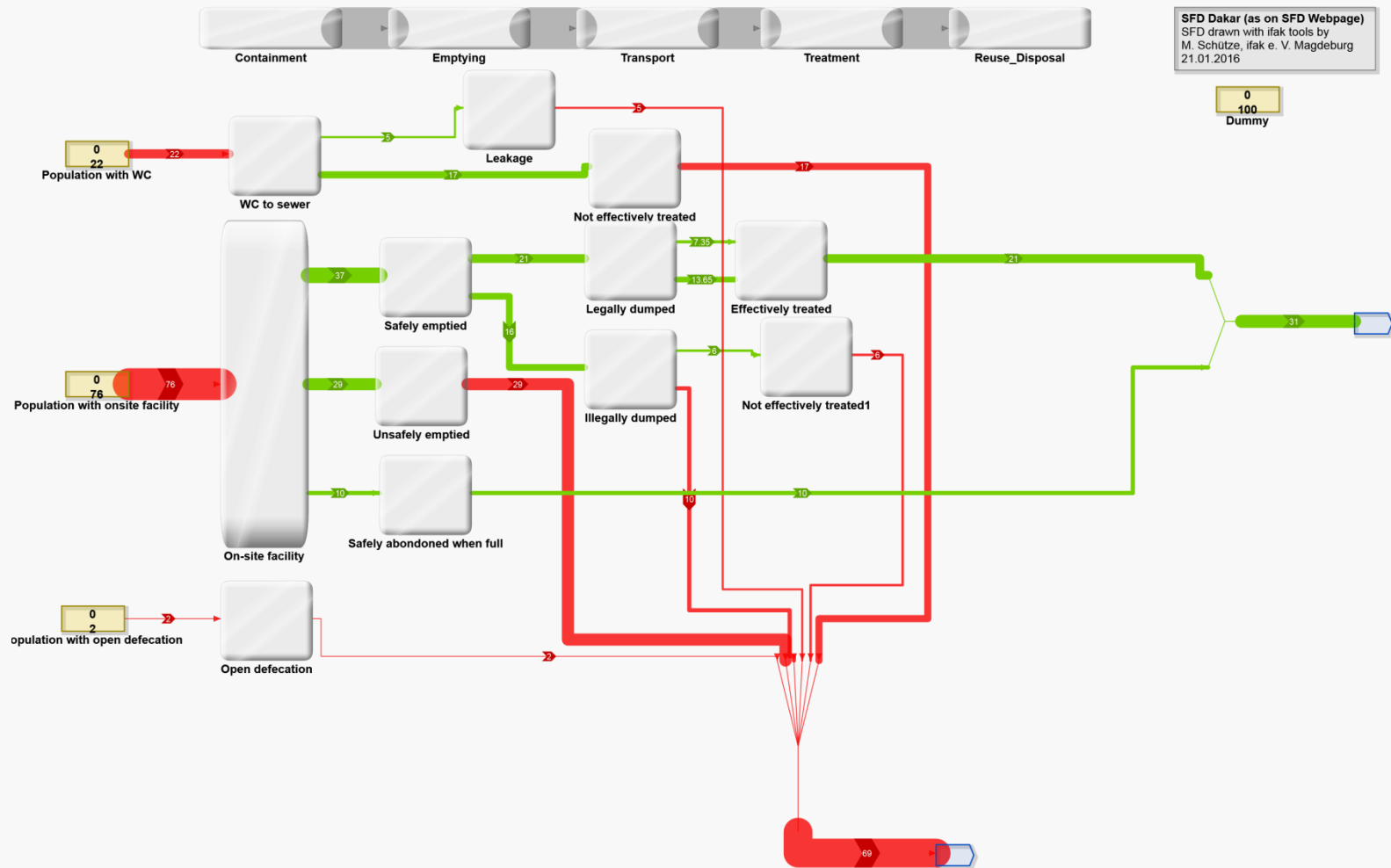
1. Setting up of blocks

3. Start “simulation”
(calculation)



B: Drawing an SFD

4. Result: SFD Dakar (as on SFD Webpage)




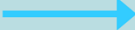

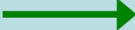


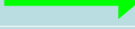

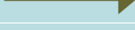

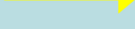


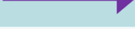


- Are the following of interest?
 - Time series (future developments/scenarios)
 - Spatial distribution (e.g. city districts)
 - Particular substances (e.g. nutrients)
 - Calculation of additional criteria (e.g. costs, GHG)
 - Individual technologies?
- Who are the users?
 - Visualisation, assistance of strategic planning
 - NOT: detailed modelling
 - (for that: other tools, modules – of same simulator)
 - Scripts to assist/automate model building and application process

New and alternative sanitation systems (NASS): System visualisation

■ Concept:

□ Consideration of resource fluxes

Input/Output	Colour used	Input/Output	Colour used
Anal Cleansing water		Faeces	
Black water		Flush water	
Biogas		Faecal Sludge	
Brown water		Organics	
Compost/ Ecohumus		Stored Urine	
Dried Faeces		Treated Sludge	
Dry cleansing Materials		Urine	
Effluent		Excreta	

Adapted from: Tilley *et al.* (2008)

□ Sanitation chain: User interface - Collect/Storage/Treatment – Conveyance - (Semi)centralised treatment - Use/Disposal

□ Block-based composition of systems



New and alternative sanitation systems (NASS): System visualisation

■ User Parameter dialogue

Input Resource fluxes:

Urine

Faeces

Flush and anal cleansing water



Output Resource fluxes:

Black water

Parameter block Cistern flush toilet

Parameter		
Type of toilet	Cistern flush toilet	
Lifetime	10	years
Energy consumption (Vacuum toilet only)	4	kWh/cap/year
Number of times the small flush water quantity is used	4	number/cap/d
Number of times the full flush water quantity is used	3	number/cap/d
Flush water quantity for the small flush	3	l/flush
Flush water quantity for the full flush	6	l/flush
Anal cleansing water demand per cleansing per person	0	litre/cleansing
Average number of household served by one unit	1	

Help Apply Cancel OK

New and alternative sanitation systems (NASS): System visualisation

Definition of modules

Converter Model NASS_2OptionsFlushToilet_PopdataVialnport

File Edit View Check

Converter Model
NASS_2OptionsFlushToilet_PopdataVialnport
Autor: ?
Description: ?
State Id: ?? (Algebraic)

Available flow definitions:
Signal asm3m influent BiogasGasInfo BiogasReactorInfo Digestion
asm1hsg asm3biopm gas gasm cost_energy AW BAW BG BL BW C
insieg02d
WP DW

Global: E =?= Local:E
Global: Pathogen =?= Local:Res
Global: E =?= Local:E
Global: capex =?= Local:capex
Global: opex =?= Local:opex
Global: Profits =?= Local:Profits
Global: Balance =?= Local:Balance

Available resource fluxes

Inputs:

ur
urn
u0p
u0k
u0c
u0b
u0cod
u0e
u0res
u0g

fa
n
p
k
c
bod
cod
e
rez
q

used/flush water
un
up
uk
ue
ubod
ucod
ue
upc
ua

Variables:
 $P0 = Population$
 $H = \frac{Population}{\max(1, A \cdot person)}$

State Variables:
 $TotalFlushWater = f(TotalFlushWater) = (NFlushSmallQ \cdot SmallQ + NFlushBigQ \cdot BigQ) \cdot 0.001 \cdot P0$

Auxiliary variables

State variables

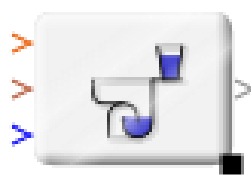
Calculation of output as a function of

- input
- parameters
- states

Evaluation functions, e.g.

- Costs
- Energy

Cistern flush toilet



Static evaluation items:

Dynamic evaluation items:

Capacity functions:

Equations:

$$N = \frac{urn \cdot u0q + n \cdot q + un \cdot ug}{u0q + q + ug}$$

$$p = \frac{u0p \cdot u0q + p \cdot q + up \cdot ug}{u0q + q + ug}$$

$$K = 0$$

$$C = 0$$

$$BOD = \frac{u0bod \cdot u0q + bod \cdot q + ubod \cdot ug}{u0q + q + ug}$$

$$COD = \frac{u0cod \cdot u0q + cod \cdot q + ucod \cdot ug}{u0q + q + ug}$$

$$E = if(toilettype == 4, Powercon \cdot \frac{P0}{365}, 0)$$

$$Res = \frac{u0res \cdot u0q + res \cdot q + upathogen \cdot ug}{u0q + q + ug}$$

$$Q = u0q + q + ug$$

$$ycosts$$

$$yE = -1 \cdot E$$

$$capex = if(toilettype == 1, 150 \cdot \frac{H}{N0}, if(toilettype == 4, 150 \cdot \frac{H}{N0}, if(toilettype == 2, 150 \cdot \frac{H}{N0}, if(toilettype == 3, 150 \cdot \frac{H}{N0}, 0)))$$

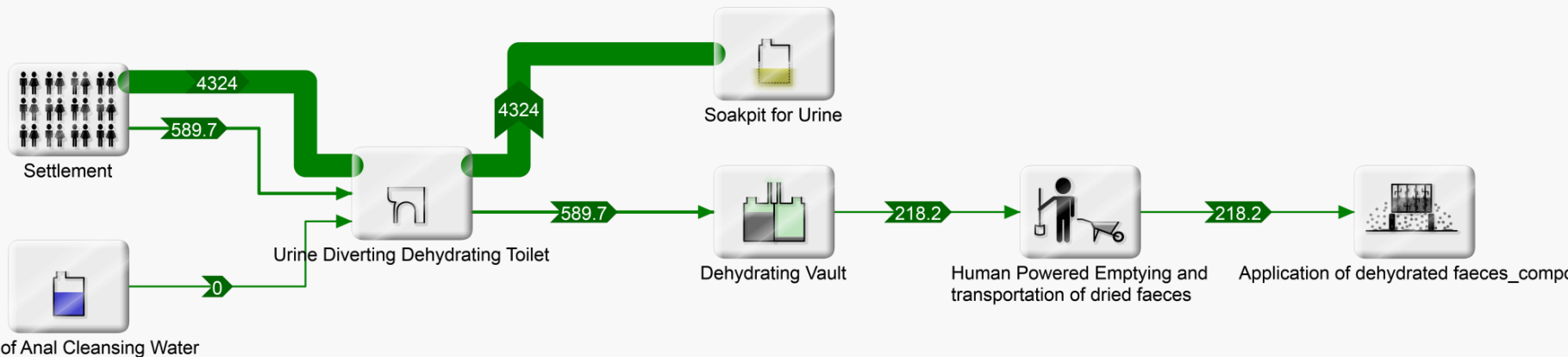
$$opex = 0$$

$$Profits = 0$$

$$Balance = 0$$

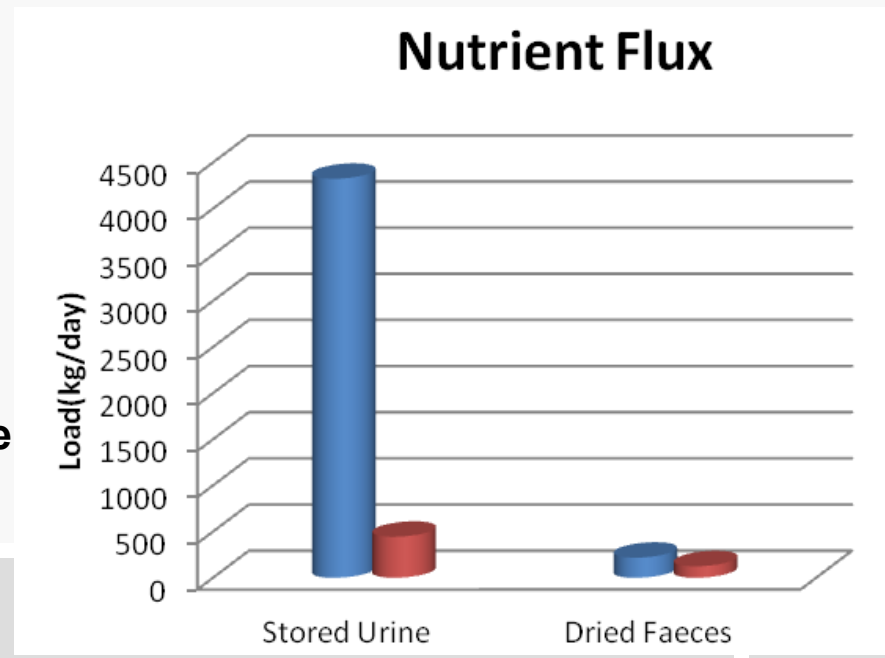
$$Cc0 = if(toilettype == 1, 150 \cdot \frac{H}{N0}, if(toilettype == 4, 150 \cdot \frac{H}{N0}, if(toilettype == 2, 150 \cdot \frac{H}{N0}, if(toilettype == 3, 150 \cdot \frac{H}{N0}, 0)))$$

Example: eThekweni (Durban)/South Africa



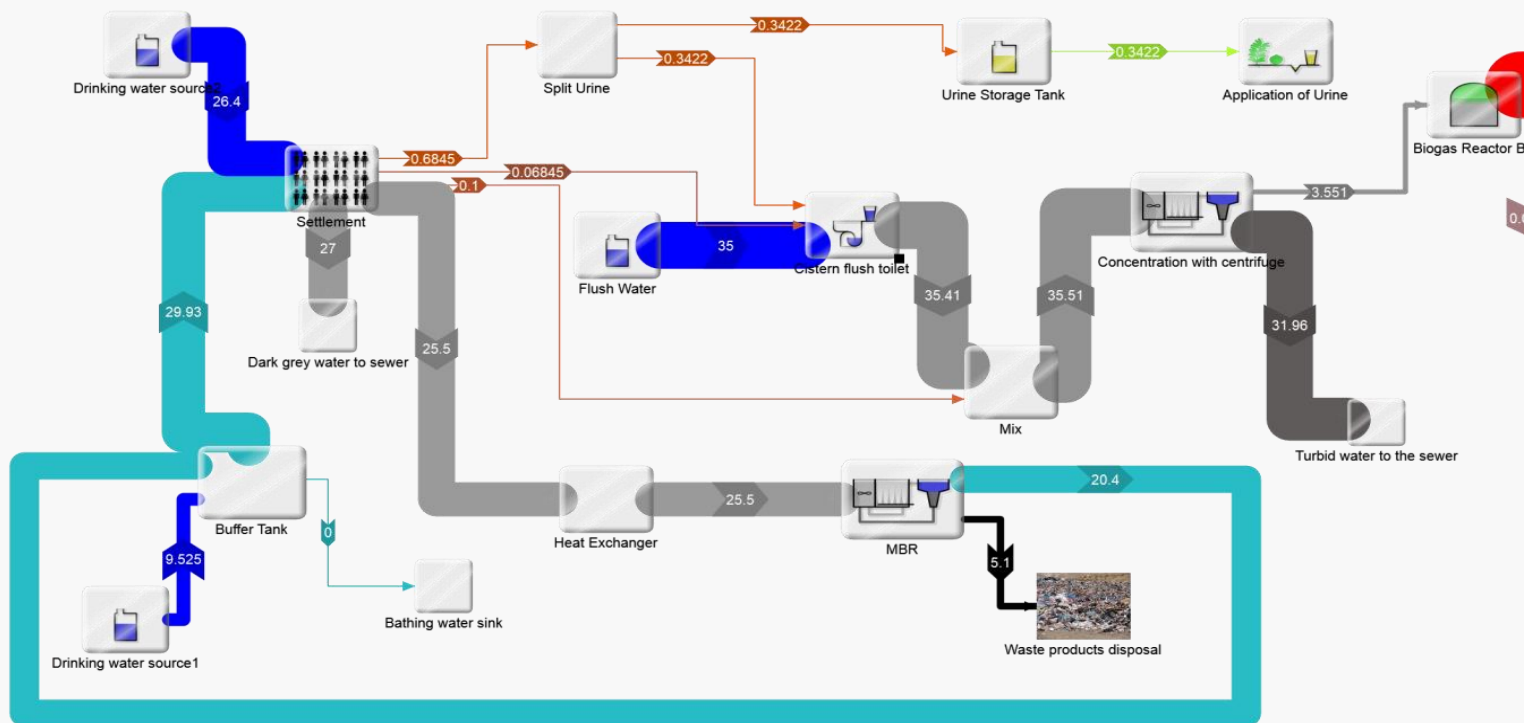
Simulation of N fluxes (kg/day)

Daily load (kg/day) for Scenario "A" (Blue cone = Nitrogen; Red cone = Phosphorus)



New and alternative sanitation systems (NASS): Potential scenarios (von Horn *et al.*, 2013)

- NASS-Option 2: Environmentally-friendly hotel
 - Separation of urine, used as fertiliser
 - Greywater treated for reuse
 - Blackwater composted or used for biogas production



Drawing excreta flow diagrams + simulation: Conclusion

■ Summary

- Combinations of SFD with simulation possible
- Some specifications and then go ahead! The tools are there!

■ Related projects

- “LiWa – Lima Water”
- NewSan (with UCL London)
- nidA200
- Sampsons
- Rapid Planning
- ifak preparatory research



New and alternative sanitation systems (NASS): Summary



Bureaucratic
hindrances

Thank you!

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