

**Resolving the tensions over
the treatment plant's fence:
*Diverse approaches around the world***

**Nutrient Recovery
and Management
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Tension over the fence...



Tension over the fence...



Tension over the fence

- Environmental policy and agriculture...:
 - Acid rain



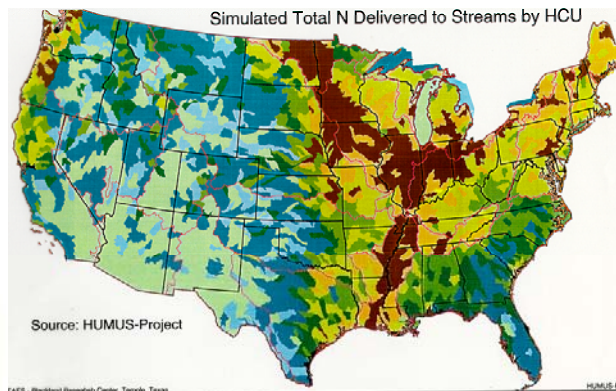
Tension over the fence

- Environmental policy and agriculture...:
 - Acid rain reduced
 - Fertilizer loss minimized as well!



Best management practices

- SWAT model run for N-load to streams



Best management practices

- Contour farming



- Strip cropping



Best management practices

- Buffer strips (5 – 10 – 20 m)



Best management practices

- WEBS: Watershed Evaluation of Beneficial management practices



Agriculture et
Agroalimentaire Canada

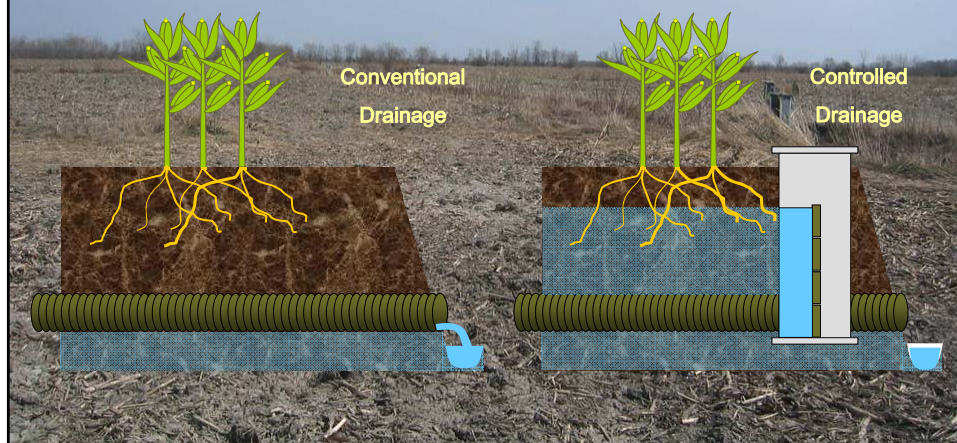
Agriculture and
Agri-Food Canada



Controlled Tile Drainage: South Nation (Canada)

David Lapen, AAFC, Ottawa

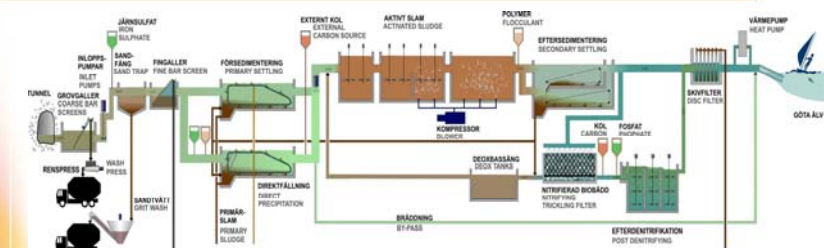
	NH ₄ -N	NO ₃ -N	Total P
Percent Load Reductions	96%	59%	82%



Best Management Practices - Urban



Best Management Practices - WWTP



Outline

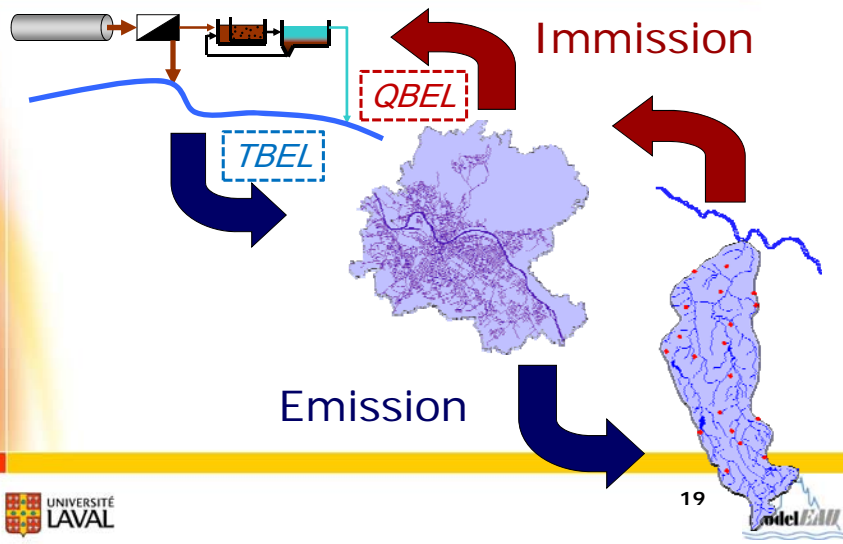
- Tension over the fence / BMPs
- Environmental protection
- Regulatory standards
- Make environmental protection happen
- Conclusions

Environmental protection

- Many things we can do to protect water quality
- How do we go about choosing among them?

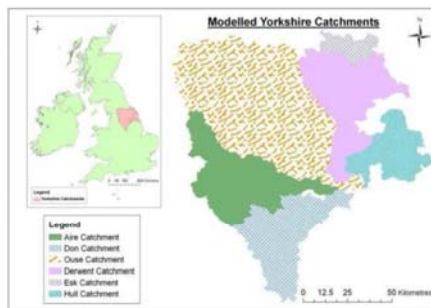


Environmental protection



Tension over the fence - Standards

- Yorkshire (UK):
 - 6 catchments with different rural/urban ratios
- 12,000 km²
- 4 million inhabitants (Leeds, Sheffield, Bradford)
- 3000 km of rivers
 - 79% good chem. status
 - 31% good ecol. status
- 98% of inh. sewered
- 271 WWTPs
- 1.7 G\$ investment (2010-2015)



Crabtree et al. (2010)

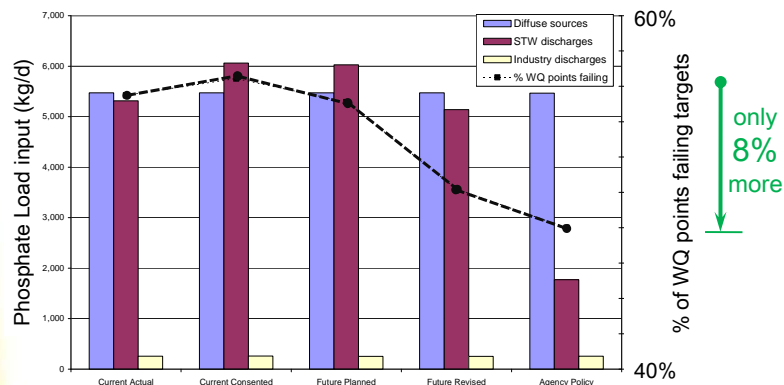
Tension over the fence - Standards

- Yorkshire (UK):
 - 6 catchments with different rural/urban ratios
- SIMCAT WQ modeling study on WWT upgrades
 - 1) As is (2005)
 - 2) 2005 standards in place (AMP3)
 - 3) 2010 standards in place (AMP4)
 - 4) Post-2010 standards to meet river WQ standards
 - 5) Best Available Technology (1-2 mgP/L ...)

Crabtree et al., IWA World Water Congress 2010

Tension over the fence - Standards

- Water quality improvement according to the 5 scenarios:



Bottom line: Look for equitable allocation – fare share !

Outline

- Tension over the fence / BMPs
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- Regulatory standards
 - Principles
 - Questionnaire
 - Comparison
 - Discussion
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- Conclusions

Standards: Principles

- A WWTP effluent standard reflects the requirements in terms of:
 - Quantity
 - Qualityto meet the water quality objectives of a receiving water

B.N. Jacobsen & T. Warn (1999) European Water Management, 6, 25-39

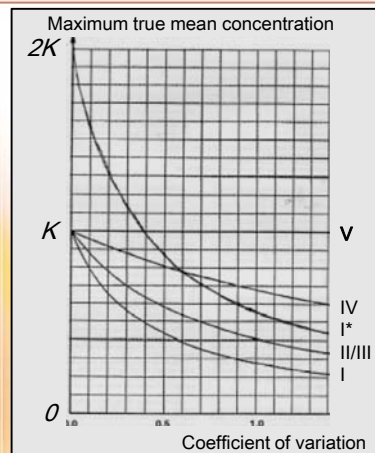
Standards: Principles

- Compliance assessment = evaluation of whether a given WWTP effluent meets the criteria defined in the effluent standard
- Includes:
 - Limit values of the standard
 - Specification of the methods for
 - Sampling (grab, composite)
 - Analysis (APHA, DIN, CEN, ...)
 - Assessment of the data (e.g. rejection, statistics)

Standards: Principles

- Six assessment approaches
 - 1) Each sample should comply
 - 2) A certain % of the samples (e.g. 95%)
 - 3) A variable number of samples (depending on number of samples taken)
 - 4) The average of the samples
 - 5) The average of the samples + standard deviation
 - 6) The average percentage of pollution reduction
- How do they compare? e.g. 1) is most stringent

Standards: Principles



- Translation key between assessment methods for the same standard K
- Maximum true mean effluent concentration
- Under certain assumptions



Jacobsen & Wam (1999)

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Standards: Questionnaire



Standards: Questionnaire

- Questionnaire (32 of my friends - 18 countries)
- Response from 16 of my friends - 12 countries
- Questions:
 - What variables are considered
 - What limit values are used
 - What compliance assessment method is applied
 - Where do these regulations originate from

Standards: UK – Yorkshire Water

- | | |
|--|--|
| <ul style="list-style-type: none">▪ Standards<ul style="list-style-type: none">▪ NH_4: 5 mgN/L
For EU sensitive areas▪ NO_3: 50 mg NO_3/L (WHO)▪ PO_4: 1-2 mgP/L▪ Origin:<ul style="list-style-type: none">▪ EU UWWT/Habitats/Fresh Water Fish/WFD directives▪ MC SIMCAT WQ simulations of recipient to set standard | <ul style="list-style-type: none">▪ Compliance testing<ul style="list-style-type: none">▪ NH_4:<ul style="list-style-type: none">• 95%ile compliance• Grab samples• 12 to 365 samples/yr▪ Comments:<ul style="list-style-type: none">▪ Prosecution only if there has been a <u>resulting</u> WQ deterioration |
|--|--|

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Standards comparison

- Standards:
 - P_{tot} : 0.07 – 10 mgP/L (developing/developed nations)
(sensitive/non-sensitive areas)
 - N_{tot} : 3 – 60 mgN/L
 - NH_4 : 2 – 20 mgN/L
 - NO_x : 1.5 – 15 mgN/L
 - NO_2 : 0.3 mgN/L (Switzerland)

Standards comparison

- Compliance testing:
 - Not specified (developing & emerging countries)
 - Grab versus daily composite sampling ($\times 0.85$)
 - Number of samples (intervals):
 - 2hr
 - Daily
 - Weekly (every 6 days to capture weekend effects)
 - Monthly
 - Averaging over week, 3 months, year
 - No exceedance vs. %ile exceedance (50-80-90-95%)

Standards comparison

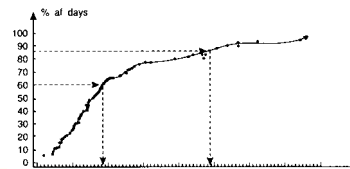
- Origin of standard:
 - Sensitive versus non-sensitive areas
 - Based on water quality uses *QBEL*
 - WQ simulations
 - Dilution with reference flow (Q90)
 - Best available technologies *TBEL*
 - National law, local permitting body
 - Negotiations between discharger – permit writer
 - EU UWWT directive

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Discussion: Standards principles

- “No exceedance” or “percentile” standards?
 - No exceedance: easy to administer
 - There is always a risk to fail to comply
 - The more you monitor, the higher the risk of failing = counter-productive!
 - Statistical analysis has become feasible at the plant
 - Proposal:
 - Long-term effects: 50 %ile
 - Short-term effects: 95 %ile



Discussion: Standards principles

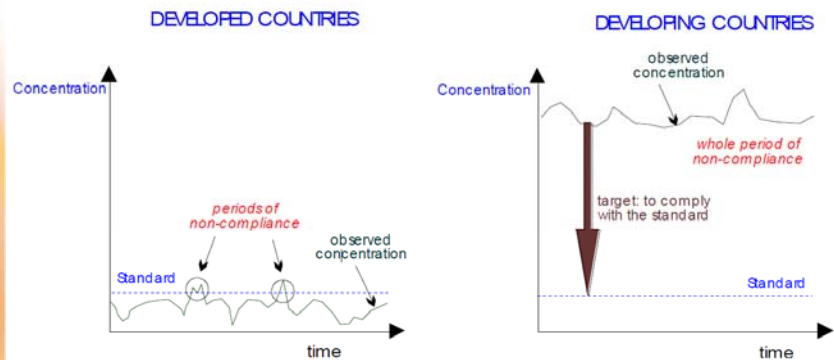
- What are standards for?
- Reminder: A WWTP effluent standard reflects the requirements in terms of:
 - Quantity
 - Qualityto meet the water quality objectives of a receiving water

Discussion: Standards principles

- What are standards for?
- Should we regulate average (e.g. yearly av.) or extreme values (%iles of daily values)?
 - Extremes for:
 - Oxygen, NH_4 , toxics
 - Hygiene
 - Aesthetics
 - Average for:
 - Eutrophication
 - Bioaccumulation

Discussion: Developed/ing nations

- Problems are quite different:



von Sperling (2007)



Standard setting should be different

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Discussion: Developed/ing nations

- Regulations in developing nations should:
 - Focus on stepwise implementation
 - Migrate stepwisely to improved effluent quality
 - Follow population growth (urbanization)
 - Not try to copy developed nations' regulations



Outline

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Making it happen: By what means?

- Enforcing
- Public humiliation – blacklisting
- Benchmarking (“peer review”)
- Financial mechanisms
- Be creative: try to find BMPs that give benefits
(e.g. acid rain, tile drainage control, resource recovery?)

Making it happen: Financial means

- Denmark (1994)

- NH_4 :

$C_{\text{discharge}}: 1.5 \text{ mgN/L}$

$\Delta\alpha = 4 \text{ € /kg N}$

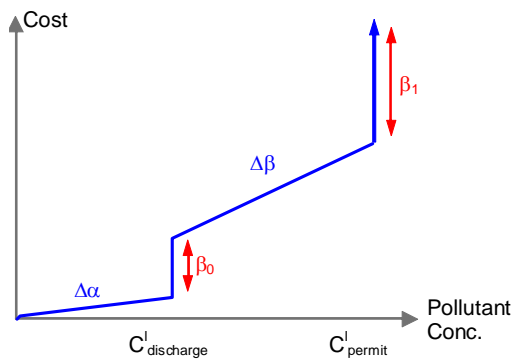
$\Delta\beta = 12 \text{ € /kg N}$

- NO_3 :

$C_{\text{discharge}}: 8.0 \text{ mgN/L}$

$\Delta\alpha = 2.5 \text{ € /kg N}$

$\Delta\beta = 7.5 \text{ € /kg N}$



Vanrolleghem et al. (1996), WST, 34(3-4), 159-171

Making it happen: Financial means

- Flanders - Belgium:

$$\text{Fine} = \text{Unitfine} \cdot (k_{\text{organic}} \cdot N_{\text{organic}} + k_{\text{metals}} \cdot N_{\text{metals}} + k_{\text{nutrients}} \cdot N_{\text{nutrients}} + N_{\text{heat}})$$

- Switzerland:

WWTP owner pays effluent load fee to fund:

- 0.05 \$/m³
- 0.70 \$/kg COD
- 4.00 \$/kg NH₄-N
- 1.00 \$/kg NO₃-N
- 30.00 \$/kg P_{tot}

Upgrading applications to fund (instead of subsidies)

Outline

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Conclusions

- There is tension over the fence
- Rural vs. urban pollution (diffuse vs. point pollution)
 - Look from receiving water perspective (integrator)
 - Bang for your buck (see UK study)
 - Look for equilibrium – fare share of pollution control
- Regulatory standards should reflect this
- River basin management plans

Conclusions

- Consensus on variables to consider
 - P_{tot} , N_{tot} , NH_4 , NO_x
- Diversity of:
 - Standards
 - Analytical methods
 - Compliance testing approaches

Conclusions

- Compliance assessment should :
 - Differentiate between impacts:
 - Long-term (Eutrophication, Bioaccumulation)
 - Short-term (Oxygen, Ammonia, Hygiene, Aesthetics)
 - Long-term → averages, 50thile over a year
 - Short-term → 80-95 thile on daily values
- “No exceedance” policy is counter-productive because it punishes the one that monitors frequently
- Statistics to work with %ile approaches are available

Conclusions

- Developing/Emerging vs. Developed nations
 - Road-map of standards for gradual improvement
 - Coping with urbanization (population growth)
 - Catching up with large back-log in terms of WQ
 - Don't copy regulations from developed nations

Conclusions

- How to make it happen?
- Several mechanisms
 - Enforcing
 - Public humiliation – blacklisting
 - Benchmarking (“peer review”)
 - Financial mechanisms
 - Be creative: try to find BMPs that give other benefits



Thank you:

- Friends around the world (questionnaire)
- Marc Neumann, postdoc at modelEAU
- IWA/WEF DOUTgroup
- NSERC Collaborative R&D Grant
- Canada Research Chair in Water Quality Modeling



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