Public safety and Monitoring requirements

Recommendations by COWI

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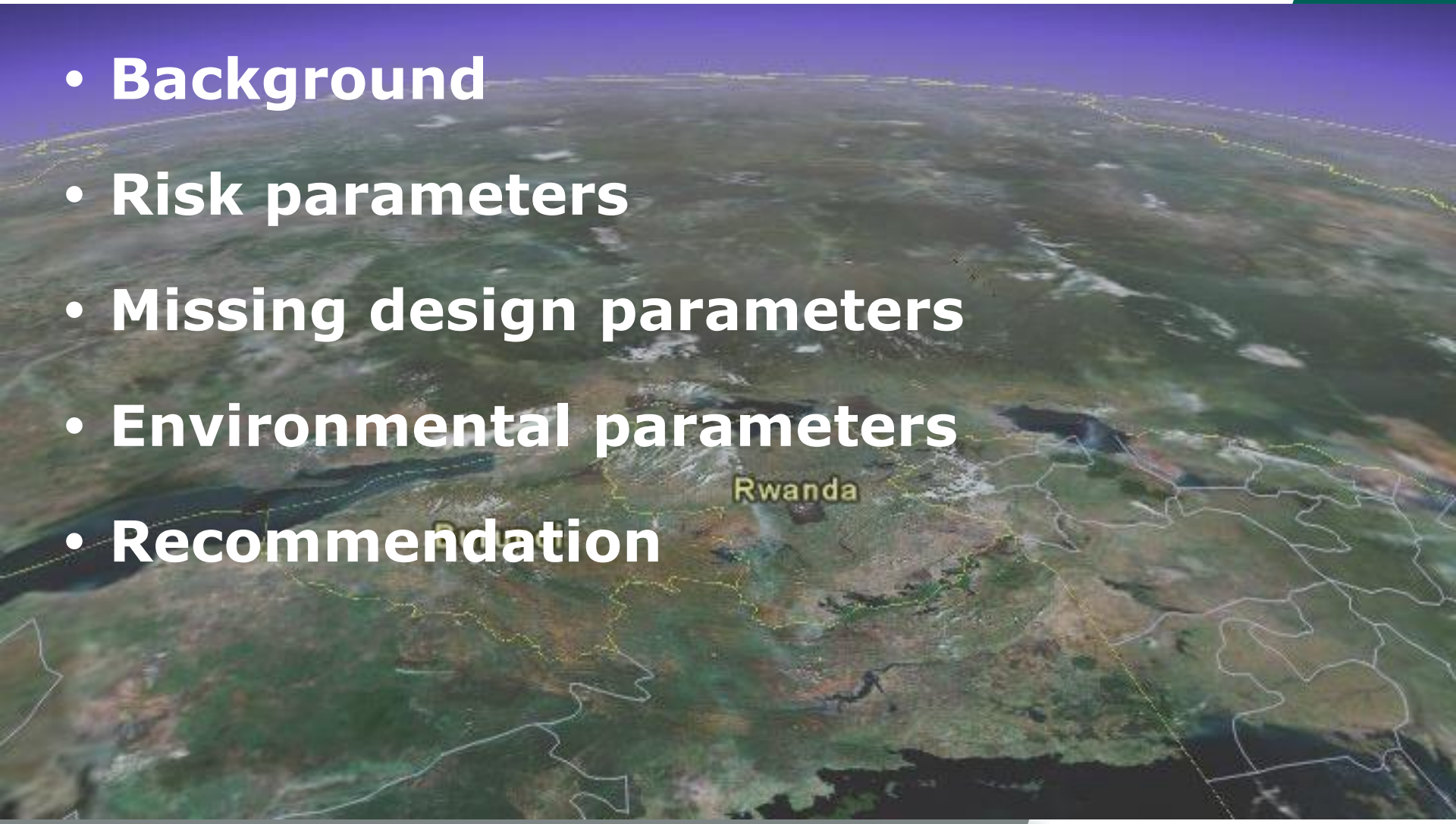
Content



- Background
- Risk parameters
- Missing design parameters
- Environmental parameters
- Recommendation

Background - suggestions

Monitoring suggestions:

- **Conference in Gisenyi, March 2007**
- **Advice from NCEA, Feb. 2008**
  (mainly environmental approach)
- **'Methane from Lake Kivu - how to extract the gas and avert the dangers', May 2009**
  (Mainly risk approach, finding missing risk data and design data plus environmental impact)
- **Start with defining goals**

Background - Why do we monitor?

Monitoring is required to:
(financing priority order)

- **Verify risk parameters**
  (status of gradients the lake plus parameters that may be influenced by extraction activities)
- **Provide missing design data**
  (to get concessionaires started)
- **Verify environment parameters**
  (the ones that may be influenced by extraction activities)
- **Investigate issues of general interest**

Background - who does it?

Master monitoring list, updating and priorities by:

- **Bilateral Competent Authority**
  (assistance from international group of experts)

Actual monitoring by:

- **Bilateral monitoring institute**
  (local bilateral staff carrying out as much as possible)
- **Assistance from international experts**
  (Complicated monitoring tasks plus QA of BMI work)

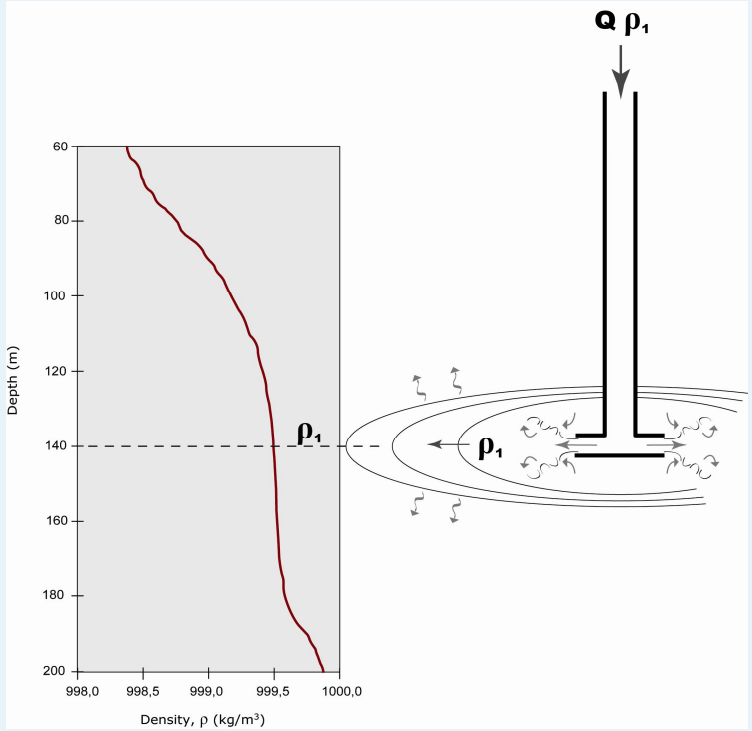
Master Monitoring List -Risk data

1 Lens spreading after re-injection

- **The lens contains degassed water and shall be distributed over the entire Lake in order to avoid pockets of water with high gas content. We need to know horizontal spreading through investigating:**
- **Horizontal background mixing at -200 m, -280 m & -320 m**

With first possible extraction facilities:

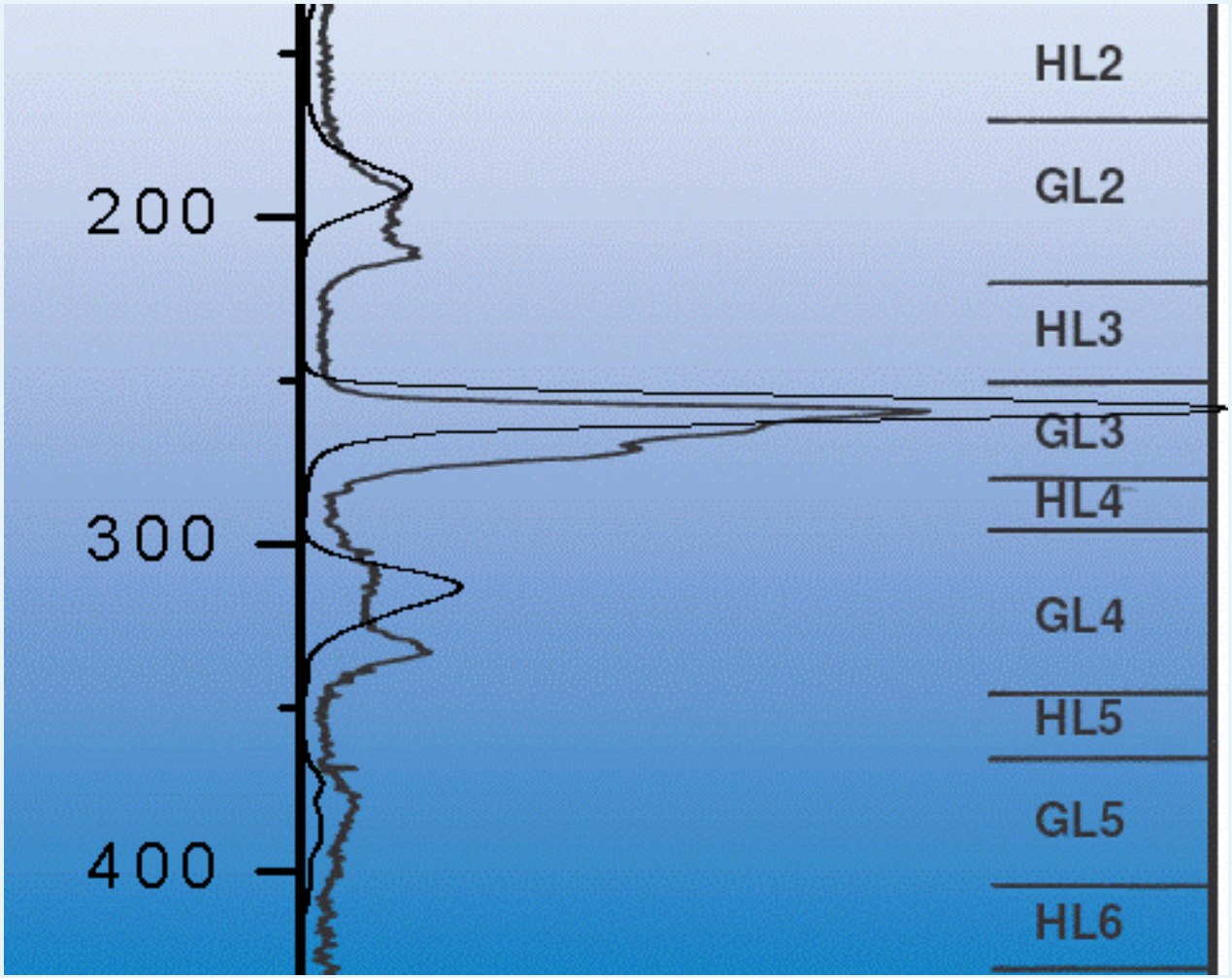
- **Velocity of spreading**
- **Dimensions of lens or about**



Master Monitoring List -Risk data

2Lifting of gradients is imprecisely known

- **Precise CTD profiles needed, satellite level determination.**
- **5 locations in 2010, 2015, 2020 and 2030**



Master Monitoring List -Risk data

3 Rate of gas accumulation is poorly known in RZ and PRZ of main basin:

- **Information required for forecasts of methane production, especially in the PRZ, but also in the RZ.**
- **Information required for verification of operator's restratification goals (control of carbon dioxide)**
- **Information required for better understanding of continuous/rhapsodic nature of carbon dioxide accumulation.**

Master Monitoring List -Risk data

4 Small IZ eruptions

- **Collect statistical information**
- **Prepare risk map for protection of operators and fishermen**

Master Monitoring List -Risk data

5 Rate of gas accumulation is not known in intermediate zone of:
- main basin &
- Ishungu basin

- **Information required for forecasts**
- **Information required for finding solutions**

Possible solutions must be studied:

- **Venting plants?**
- **Dilution of IZ with biozone water?**
  (most probable but it probably hurts environmentally)

Master Monitoring List -Risk data

6 Rate of gas accumulation is not known in separate basins of Kalehe and Kabuno Bay

- **Kabuno bay is likely to be the closes to an eruption and methane extraction seems excluded.**
- **Information is required for finding solutions after a careful study of how to get the carbon dioxide out without producing an unacceptable future situation.**
- **We must not repeat the same mistake as was intended for the main basin.**
- **Kalehe seems to have a life of its own and may pose a future risk, monitoring of development required.**

Master Monitoring List -Risk data

7 Our knowledge of the eruption triggers is not sufficient:

The following limits to gas saturation have been proposed in order to prevent unbearable surprises, based on evaluation, but is it good enough?

- **Maximum 60 % saturation before action is taken.**
- **Long-term goal: to come below 40 % saturation everywhere.**

A risk study should be made

Master Monitoring List -Risk data

8 Regular CTD monitoring in order to:

- **Verify development in the lake, general checking for surprise developments**
- **Verify operation of extraction facilities and in particular re-stratification of plumes of re-injected water**

9 Extraordinary CTD monitoring in case of lava inflow

- **Immediate verification of density structure in the lake in case of new lava inflows**

Master Monitoring List - Design data

10 Wind data missing/inaccurate:

- **Spurious errors in high range of existing wind data makes it impossible to find the maximum design criterion. Instrumental errors to be found and corrected.**
- **Wind data over water are missing. Goma observatory to make a fifth weather station on the KP barge**

11 Wave height statistics missing

- **Establish monitoring station on KP barge**

Master Monitoring List - Design data

12 Data for underwater currents are missing:

- **Important for design reasons, calculating forces on underwater structures.**
- **Important for understanding possible additional spreading mechanisms for degassed water in the depths.**
- **First gather 1 month statistical data at the following depths: 10 m, 20 m, 60 m, 200 m, 290 m, and 330 m, then also at 30 m, 40 m and 50 m**
- **Then expand same levels to cover 6 months statistical data.**

Master Monitoring Li

Statistical data from KP barge

10 **Wind data**

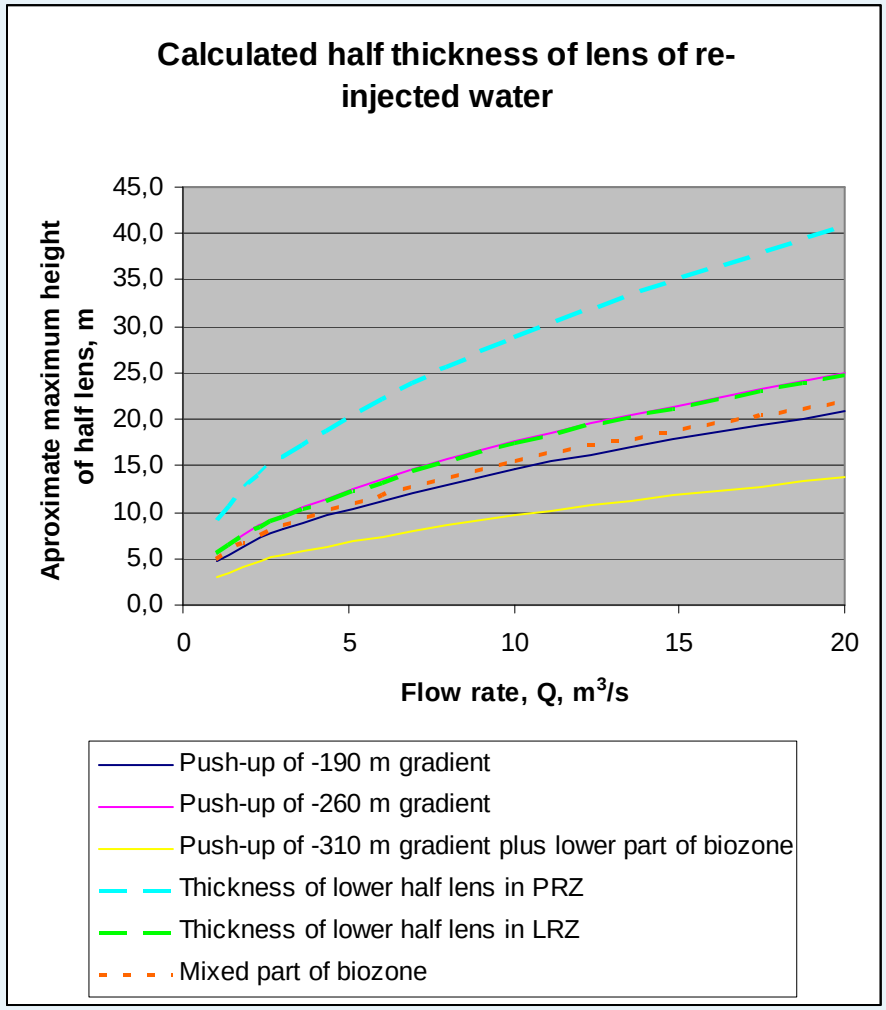
11 **Wave height**

12 **Currents at different depths**

Master Monitoring List - Design data

13 Short-circuiting

- **Theoretical calculation results require verification in order to be able to decide on maximum size for gas extraction facilities in the URZ**
- **This is of general interest to all designers and should therefore be part of the publically financed programme**



Master Monitoring List - Environmental Data

14 Baseline environmental data are missing:

- **Yearly variations in primary production as well as in phytoplankton and zooplankton composition in central northern basin**
- **If funds suffice: same study in Kalehe and Ishungu basins**
- **Endemic ciclid diversity and distribution in the entire lake**

Assumption: Natasha Pasche thesis will provide enough P data for interpretation of plankton study

Master Monitoring List - Environmental Data

15 Baseline data on thickness of anoxic zone insufficient:

- **Yearly variations in thickness of anoxic zone to be monitored by monthly profiles in northern basin**

  Reason: in theory, the expansion in thickness may set a limit to maximum desirable as extraction

- **Continue measurements in vicinity of new extraction facilities in order to follow the development of this parameter as gas production picks up with more and more facilities.**

Master Monitoring List – Environmental Data

16 Data on upwelling missing:

We do not know well enough the slow upwelling of water due to inflow of denser water to the deeper parts of the lake. This parameter is important for understanding the phosphorous balance.

- **Regularly measure salts in Ruzizi River and obtain flow data from power station. Over time, this is expected to allow an accurate estimate of the slow upwelling**

Master Monitoring List - Recommendation

- **What to do?**
- **Discuss this list now and ask for comments**

  Cost priorities are suggested. Time priorities are implied but not discussed, it might somewhat change the order of priorities as presented here
- **Submit list to other well known scientists for comments**
- **Receive comments and update the list (in the main document)**
- **THEN it may serve as a very useful tool for the Bilateral Competent Authority as a check list for what monitoring to give priority.**