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Icelandic Met Office

# Experiences with the Norwegian HYMO classification system for rivers/lakes in Iceland

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# Introduction



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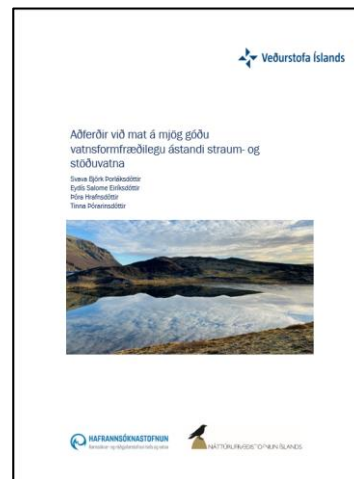
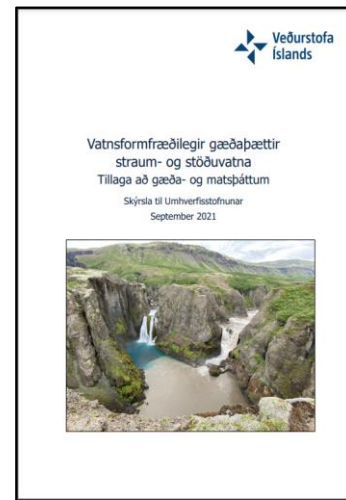
1. Development of methods to assess HYMO condition of rivers and lakes.
2. Testing the methodology in two waterbodies affected by hydropower plant
  - a) River WB.
  - b) Lake WB.
  - c) Further testing.
3. Summary.



# HYMO in Iceland

## What has been done already?

- Norwegian methodology is the basis for the Icelandic method for analyzing HYMO in rivers and lakes.
- Published reports related to HYMO
  - First steps in the assessment of artificial- and HMWB – HYMO changes (2020).
  - HYMO quality elements in rivers and lakes (2021).
  - Methods for assessing high HYMO status in rivers and lakes (2023).
  - Guidance on determining the ecological potential of HMWB (2024).
  - ...and more reports and statements have been made on related topics



# HYMO in Rivers

| Gæðabáttur               | Áhrifabáttur           | Mörk flokka                             |                                                       |                                  |             |              |                             |       |
|--------------------------|------------------------|-----------------------------------------|-------------------------------------------------------|----------------------------------|-------------|--------------|-----------------------------|-------|
|                          |                        | Matsþáttur                              | Mælikvarði á breytingar                               | Náttúrulegt                      | Lítil áhrif | Nokkur áhrif | Mikil áhrif                 |       |
|                          |                        | Einkunnagjöf                            |                                                       | 5                                | 4           | 3            | 2                           | 1     |
| Samfella ár              | A                      | Varnargarðar                            | Hversu stór hluti árinna? (%)                         | <10                              | 10–30       | 30–65        | 65–80                       | >80   |
|                          |                        | Niðurgroftur árinna***                  | Meðaldýpkun farvegarins sem áin hefur grafið sig (m)  |                                  | <0,5        | 0,5–1,0      |                             | >1,5  |
|                          |                        | Stíflur í farvegi                       | Barriereffect (Sandlund o.fl., 2013)                  | <0,2                             | 0,2–0,4     | 0,4–0,6      | 0,6–0,8                     | >0,8  |
|                          | B                      | Uppskipting farvegar                    | Fragmenteringsgrad (Sandlund o.fl., 2013)             | <0,5                             | 0,5–0,65    | 0,65–0,8     | 0,8–0,83                    | >0,83 |
|                          |                        | Lónaáhrif                               | Hlutfall farvegar ofan stíflu undir áhrifum af stíflu | <10                              | 10–30       | 30–50        | 50–80                       | >80   |
|                          |                        | Uppistöðuáhrif                          | Fjarlægð að fyrstu hindrun (km)                       | Engin hindrun                    | >50 km      | 10–50 km     | 2–10 km                     | <2 km |
|                          | C                      | Mannvirki önnur en stíflur *            | Hversu stór hluti árinna er undir áhrifum? (%)        | <5                               | 5–33        | 33–50        | 50–80                       | >80   |
|                          | 5 ➡ Svifabreytingar ** | Hlutfallsleg minnkun svifburs           | <10                                                   | 10–25                            | 25–50       | 50–80        | >80                         |       |
| Vatnúskaþur/Rennishættir | D1                     | Heildarrensli                           | Breyting á heildarrensli (%)                          | <15                              | 15–30       | 30–50        | 50–95                       | >95   |
|                          |                        | Lágrensli sumar                         | 7 daga lágrensli jún–sept (miðað við óbreytt) (%)     | <10                              | 10–20       | 20–40        | 40–60                       | >60   |
|                          |                        | Lágrensli vetur                         | 7 daga lágrensli nóv–mars (miðað við óbreytt) (%)     | <5                               | 5–10        | 10–30        | 30–50                       | >50   |
|                          |                        | Tíðni 1 árs flóða                       | Breyting á endurkomuhlutfalli                         | engin breyting                   |             | 5–10 ár      | sjaldnar en á 10 ára fresti |       |
|                          |                        | Tíðni 10 ára flóða                      | Breyting á endurkomuhlutfalli                         | ekki sjaldnar en á 15 ára fresti |             | 15–30 ár     | sjaldnar en á 30 ára fresti |       |
|                          | D2                     | Skammtíma rennslibreytingar (peaking) * | Hlutföll á milli há- og lágrennsli                    | <1,5                             | 1,5–3       | 3–5          | 5–10                        | >10   |
|                          |                        | Hraði rennslibreytinga *                | Lækkunarhraði (cm/klst.)                              | <5                               | 5–13        | 13–20        | 20–30                       | >30   |

\* Á aðeins við um bergvatnsár. \*\* Á aðeins við um jökulár. \*\*\*Mörk flokka eru tekin óbreytt úr Harby o.fl. (2018).

Tabell 1. Oppsummering av tema, indikatorer for endring og klassegrenser

| Pávirking        | Tema                                            | Indikator for endring                     | Klas                     |             |
|------------------|-------------------------------------------------|-------------------------------------------|--------------------------|-------------|
|                  |                                                 |                                           | Naturlig                 | Litt endret |
| Pá langs av elva | Lateral konnektivitet                           | Løpemetar elv pávirket                    | <5%                      | 5-30%       |
|                  | Flodssikring, forbygning                        | Løpemetar elv pávirket                    | <5%                      | 5-33%       |
|                  | Kantsonevegetasjon                              | Løpemetar elv med høvtere vegetasjon      | <10%                     | 10-33%      |
|                  | Flodskjæring                                    | Gjennomsnittlig senkning av elveløpet (m) | < 0,5m                   |             |
| Pá tvers av elva | Barriere-effekt innen vannforekomsten           | Barriereeffekt etter Sandlund et al.      | <0,2                     | 0,2-0,4     |
|                  | Fragmenteringsgrad innen vannforekomsten        | Fragmenteringsgrad etter Sandlund et al.  | <0,5                     | 0,5-0,65    |
|                  | Oppstuvningseffekt innen vannforekomsten        | Pávirket av oppstuvning fra barrierer     | <10%                     | 10-30%      |
|                  | Fragmentering og barrierer oppstrøms            | Reguleringsgrad                           | <20%                     | 20-50%      |
| I elveleiet      | Tilførsler og fjerning av masser                | Løpemetar elv pávirket                    | <5%                      | 5-33%       |
|                  | Strukturer i elveleiet                          | Løpemetar elv pávirket                    | <5%                      | 5-33%       |
|                  | Elveklasser fra miljødesign                     | Endring i forhold til forventning         | Ingen klasser mangler    |             |
|                  | Substrat og hulrom                              | Endring i skjulklasser                    | Ingen endring            |             |
| Vannføring       | Total vannføring                                | Endring i total vannføring                | <15%                     | 15-30%      |
|                  | Lav vannføring sommer                           | Minste ukemiddel vannføring jun-sep       | <10%                     | 10-20%      |
|                  | Lav vannføring vinter                           | Minste ukemiddel vannføring nov-mar       | <5%                      | 5-10%       |
|                  | Flomstørrelse årsflom                           | Endring av årsflommens gjentakintervall   | Ingen endring            |             |
|                  | Flomstørrelse 10-års flom                       | Endring i frekvens pá ti-års flom uregult | Ikke sjeldnere enn 15 ár |             |
|                  | Korttids vannføringsendring                     | Forholdstall mellom høy og lav vannføring | <1,5                     | 1,5-3       |
|                  | Hastighet pá korttids endring i vannstand       | Senkningshastighet mált i cm/time         | <5                       | 5-13        |
|                  | Tørriagt areal ved korttids endring i vannstand | Endring i vanddekket areal                | <5%                      | 5-10%       |

Rapport

Forslag til metode for klassifisering av hydromorfologisk tilstand i norske elver



Rapport

Hydromorfologisk klassifisering av elver og økologisk relevans - testing av metode



Rapport

HyMo 1.0 - Hydromorfologisk klassifisering av vannforekomster i elver og innsjøer



Harby et al. (2018; 2020, 2023)

# HYMO in Lakes

| Gæðabáttur             | Matsþáttur                                         | Mælikvarði                                                                                                                                    | Mörk flokka      |             |                                            |                                      |               |
|------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------|--------------------------------------------|--------------------------------------|---------------|
|                        |                                                    |                                                                                                                                               | Mjög gott ástand | Gott ástand | Ekki viðunandi ástand                      | Slakt ástand                         | Lélegt ástand |
|                        | Einkunn                                            |                                                                                                                                               | 5                | 4           | 3                                          | 2                                    | 1             |
| Vatnúsúskapur          | Árlegt innrennsli                                  | Breyting á árlegu innrennsli miðað við óraskaðar aðstæður (%)                                                                                 | <5               | 5–20        | 20–50                                      | 50–90                                | >90           |
|                        | Breytingar á vatnsstöðu                            | Munur á hæstu og lægstu stýrðu vatnsstöðu (HRWL - LRWL) (m)                                                                                   | <2               | 2–3         | 3–10                                       | 10–50                                | >50           |
|                        | Heildar rúmmálsbreytingar                          | Hlutfallsleg breyting á rúmmáli vatns borið saman við náttúrulegar aðstæður (%)                                                               | <5               | 5–10        | 10–30                                      | 30–70                                | >70           |
|                        | Viðstöðutími <sup>1</sup>                          | Hlutfallsleg breyting á viðstöðutíma vatns miðað við náttúrulegar aðstæður (%)                                                                | <5               | 5–20        | 20–50                                      | 50–100                               | >100          |
|                        | Vatnsstöðubreytingar við hæstu vatnsstöðu          | Hlutfallsleg breyting á hæstu vatnsstöðu gefin sem mismunur milli náttúrulegrar vatnsstöðu og raunverulegrar vatnsstöðu á viðkomandi degi (%) | <5               | 5–10        | 10–30                                      | 30–70                                | >70           |
|                        | Vatnsstöðubreytingar við lægstu vatnsstöðu         | Hlutfallsleg breyting lægstu vatnsstöðu gefin sem mismunur milli náttúlegrar vatnsstöðu og raunverulegrar vatnsstöðu á viðkomandi viku (%)    | <5               | 5–10        | 10–30                                      | 30–70                                | >70           |
| Formfræði <sup>2</sup> | Flatarmál sem fer á þurt                           | Flatarmál sem fer á þurt miðað við lægstu og hæstu stöðu, mælt lárétt (%)                                                                     | <5               | 5–10        | 10–40                                      | 40–90                                | >90           |
|                        | Fjörusvæði sem fara á þurt (littoral zone)         | Hlutfall fjörusvæðis sem verður fyrir áhrifum að vatnsstöðu/rennslistjórnun. Lárétt mæling (%)                                                | <5               | 5–10        | 10–40                                      | 40–90                                | >90           |
| Samfella <sup>3</sup>  | Hindranir ofan til á vatnsviði sem hindra setferla | Hlutfall svæða ofar í vatnsviði sem lokast vegna manngerðra hindrana miðað við aðstæður án inngripa (encroachment) (%)                        | <5               | 5–10        | 10–50                                      | 50–90                                | >90           |
|                        | Aukning á svifaur                                  | Aukning á svifaur vegna tilfærslu jökuláa                                                                                                     | Engin aukning    |             | Gruggugu vatni veitt í minna gruggugt vatn | Gruggugu jökulvatni veitt í bergvatn |               |

| No  | Parameter                                                  | Unit       | Metric for                                                                               |
|-----|------------------------------------------------------------|------------|------------------------------------------------------------------------------------------|
| 100 | Change in annual inflow                                    | %          | Change in annual inflow conditions, expressed as                                         |
| 101 | Upstream barriers affecting sediment processes             | %          | Percentage of upstream blocked due to man-made river without e                           |
| 200 | Water level changes                                        | Meter      | Highest regulated water regulated water                                                  |
| 201 | Total volume change                                        | %          | Change in volume of lake conditions, in                                                  |
| 202 | Change in retention time                                   | %          | Change in retention time natural conditions                                              |
| 203 | Change in date of filling                                  | Days       | No. of days changed state the date in the                                                |
| 204 | Change in date of emptying                                 | Days       | No. of days changed in state to the date in the                                          |
| 205 | Water level change at filling date                         | %          | Relative deviation at filling between natural water level at this date, divided          |
| 206 | Water level change at emptying date                        | %          | Relative deviation at emptying between natural water level at this date, divided         |
| 207 | Short term water level variations (days)                   | Meter/day  | Water level changes, given in meter                                                      |
| 208 | Short term water level variations (weeks)                  | Meter/week | Water level changes, given in meters                                                     |
| 210 | Dewatered areas                                            | %          | Dewatered areas due to low water levels at lowest level compared to highest level (mean) |
| 211 | Relative lake level fluctuation                            | %          | Relative water level variation divided by LRWL                                           |
| 212 | Dewatered littoral zone versus total littoral zone (ratio) | %          | Percentage of the littoral regulation (measured)                                         |
| 213 | Loss in lateral connectivity along the shoreline           | %          | Percentage of the shoreline embankments or other types                                   |
| 214 | Riparian zone changes                                      | %          | Percentage of riparian shoreline affected by alterations                                 |
| 220 | Change in substrate qualities                              | %          | Changes in extent of a                                                                   |

Bakken et. al., 2018, 2019

## Report

### Outlining a hydromorphological classification system for lakes

Data availability, modelling tools and comparable assessment approaches

Author(s)  
Tor Heston Bakken, Lennart Hagen Schindler & Jule Christmann (SINTEF)  
Knut Alnbjørn & Andre Gimsøy Alnes (NTNU)



## Report

### Testing and evaluation of a HYMO classification system for lakes and reservoirs

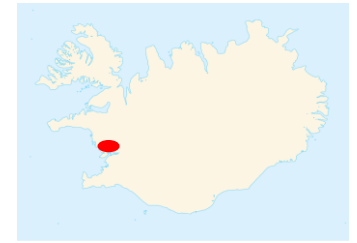
Proposed new and modified hydromorphological (HYMO) classification system

Author(s)  
Tor Heston Bakken, Valerie Beck, Lennart Hagen Schindler & Jule Christmann (SINTEF),  
Jan-Erik Thorsen & Markus Lindholm (NIVA), Åge Skarland (UO-LFI)



# Testing the HYMO method

## River Andakílsá and Lake Skorradalssvatn



- Both WB affected by hydroelectric power plant
  - Started in 1947.
  - 8 MW.
  - Originally designed to meet the electricity needs of surrounding communities.
  - Now mainly used when energy need is high.



Photo: <https://skessuhorn.is>

# River Andakílsá and Lake Skorradalsvatn



## Skorradalsvatn

Length: 16 km

Mean depth: 22,5 m

Max depth: 48 m

Dam height: 1,2 m

## Andakílsá

## Andakílsá

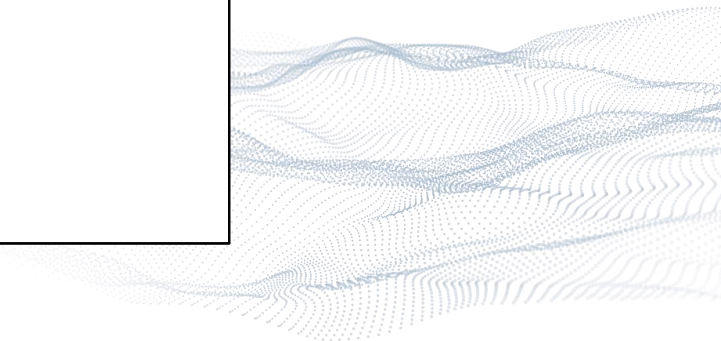
Length: 9,5 km

Avg. annual discharge: 10,2 m<sup>3</sup>/s

# Testing – River HYMO classification

|                                                        | A (along the river) | B (across/barrier) | C (in the river) | D1 (hydrology) | D2 (hydrology - rapid changes) |
|--------------------------------------------------------|---------------------|--------------------|------------------|----------------|--------------------------------|
| $((A+B+C)/3 + D2) * 1/2$                               | 5                   | 4,5                | 5                | 5              | 2                              |
| $((A+B+C)/3 + (D1+D2)/2) * 1/2$                        | 5                   | 4,5                | 5                | 5              | 2                              |
| $(A+B+C+D)/4$                                          | 5                   | 4,5                | 5                | 5              | 2                              |
| Parameter with lowest score<br>(one out all out)       | 5                   | 4,5                | 5                | 5              | 2                              |
| Quality element with lowest<br>score (one out all out) | 5                   | 4,5                | 5                | 5              | 2                              |

| Litakvarði<br>ástandsmats | Einkunn     | Ástand                |
|---------------------------|-------------|-----------------------|
|                           | 5,00 – 4,21 | Mjög gott ástand      |
|                           | 4,20 – 3,41 | Gott ástand           |
|                           | 3,40 – 2,61 | Ekki viðunandi ástand |
|                           | 2,60 – 1,81 | Slakt ástand          |
|                           | 1,80 – 1,00 | Lélegt ástand         |

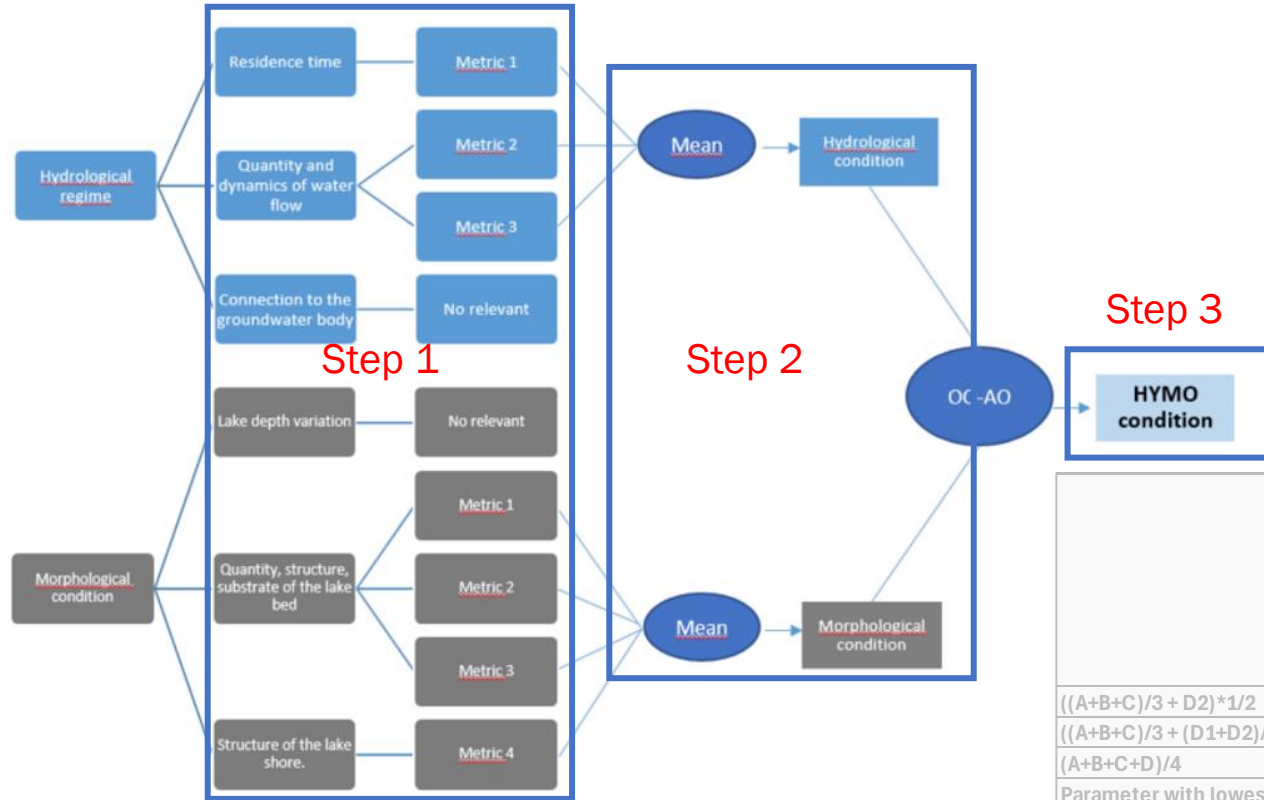


# Testing – River HYMO classification

|                                                        | A (along the river) | B (across/barrier) | C (in the river) | D1 (hydrology) | D2 (hydrology - rapid changes) | Continuity average | Morphology average | Hydrology average | Final score |
|--------------------------------------------------------|---------------------|--------------------|------------------|----------------|--------------------------------|--------------------|--------------------|-------------------|-------------|
| $((A+B+C)/3 + D2) * 1/2$                               | 5                   | 4,5                | 5                | 5              | 2                              | 4,7                | 5                  | 3,5               | 3,42        |
| $((A+B+C)/3 + (D1+D2)/2) * 1/2$                        | 5                   | 4,5                | 5                | 5              | 2                              | 4,7                | 5                  | 3,5               | 4,17        |
| $(A+B+C+D)/4$                                          | 5                   | 4,5                | 5                | 5              | 2                              | 4,7                | 5                  | 3,5               | 4,50        |
| Parameter with lowest score<br>(one out all out)       | 5                   | 4,5                | 5                | 5              | 2                              | 4,7                | 5                  | 3,5               | 1,00        |
| Quality element with lowest<br>score (one out all out) | 5                   | 4,5                | 5                | 5              | 2                              | 4,7                | 5                  | 3,5               | 3,50        |

| Litakvarði<br>ástandsmats | Einkunn     | Ástand                |
|---------------------------|-------------|-----------------------|
|                           | 5,00 – 4,21 | Mjög gott ástand      |
|                           | 4,20 – 3,41 | Gott ástand           |
|                           | 3,40 – 2,61 | Ekki viðunandi ástand |
|                           | 2,60 – 1,81 | Slakt ástand          |
|                           | 1,80 – 1,00 | Lélegt ástand         |

# Testing – River HYMO classification



|                                                            | A (along the river) | B (across/barrier) | C (in the river) | D1 (hydrology) | D2 (hydrology - rapid changes) | Continuity average | Morphology average | Hydrology average | Final score |
|------------------------------------------------------------|---------------------|--------------------|------------------|----------------|--------------------------------|--------------------|--------------------|-------------------|-------------|
| $((A+B+C)/3 + D2) * 1/2$                                   | 5                   | 4,5                | 5                | 5              | 2                              | 4,7                | 5                  | 3,5               | 3,42        |
| $((A+B+C)/3 + (D1+D2)/2) * 1/2$                            | 5                   | 4,5                | 5                | 5              | 2                              | 4,7                | 5                  | 3,5               | 4,17        |
| $(A+B+C+D)/4$                                              | 5                   | 4,5                | 5                | 5              | 2                              | 4,7                | 5                  | 3,5               | 4,50        |
| Parameter with lowest score (one out all out)              | 5                   | 4,5                | 5                | 5              | 2                              | 4,7                | 5                  | 3,5               | 1,00        |
| <b>Quality element with lowest score (one out all out)</b> | <b>5</b>            | <b>4,5</b>         | <b>5</b>         | <b>5</b>       | <b>2</b>                       | <b>4,7</b>         | <b>5</b>           | <b>3,5</b>        | <b>3,50</b> |

# Testing – Skorradalvatn HYMO classification

The number of parameters behind each category/quality element is different (5 for hydrology, 2 for morphology)

Differences between suggested method and other calculations where parameters have equal weight are similar = Good status

Results for HYMO-condition are in line with biological condition



|                                                        | Hydrology average | Morphology average | Final |
|--------------------------------------------------------|-------------------|--------------------|-------|
| $H \cdot 0,75 + M \cdot 0,25$                          | 4,4               | 3                  | 4,05  |
| $(H+M)/2$ (equal weight)                               | 4,4               | 3                  | 3,7   |
| All parameters (equal weight)                          | 4,4               | 3                  | 4     |
| Parameter with lowest score<br>(one out all out)       | 4,4               | 3                  | 3     |
| Quality element with lowest<br>score (one out all out) | 4,4               | 3                  | 3     |

# Further testing of the HYMO methods

## River- and lake WB tested

Overall results indicate that the method captures, in most cases, all major changes that HYMO conditions have been exposed to

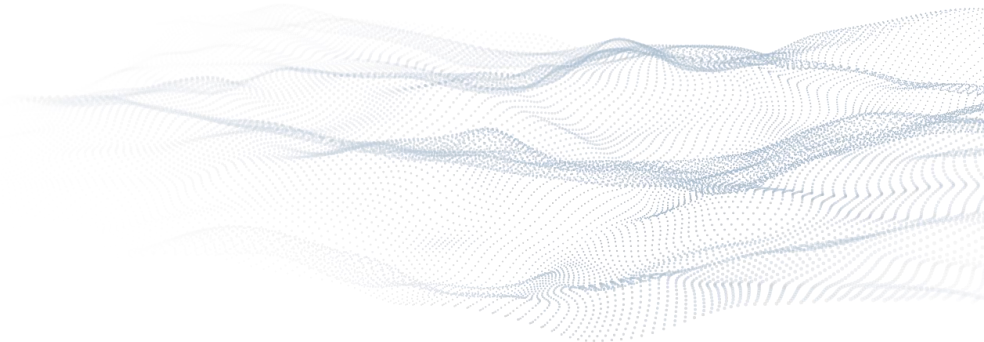
BUT...because of limitation in number of quality elements and parameters used the results might not be as accurate as it could be.

For lakes: Score changed when number of quality elements was increased from two to three in modified water bodies, but those that were natural did not change

| Einkunn                    |                                 |                  |               |               |                     |                         |                 |                         |
|----------------------------|---------------------------------|------------------|---------------|---------------|---------------------|-------------------------|-----------------|-------------------------|
| Vatnshlot                  | Vatnshlotanr.                   | A. Langsnið      | B. Þversnið   | C. Í farvegi  | D1. Rennslis-hættir | E. Svifaur              | Heildar-einkunn | Litakvarði ástands-mats |
| Þjórsá                     | 103-663-R                       | 5,0              | 4,25          | 4,0           | 4,8                 | 2,0                     | 4,31            |                         |
| Einkunn                    |                                 |                  |               |               |                     |                         |                 |                         |
| Vatnshlot                  | Vatnshlotanr.                   | A. Vatnsbúskapur | B.* Formfræði | C.** Samfella | Heildar-einkunn     | Litakvarði ástands-mats |                 |                         |
| Jökulsá Fljótsd            | Lagarfljót                      | 102-1857-L       | 3,67          | 5,00          | 3,00                | 3,50                    |                 |                         |
| Jökulsá Fljótsd            | Þórisvatn                       | 103-2162-L       | 2,83          | 2,50          | 3,00                | 2,88                    |                 |                         |
| Jökulsá Fljótsd            | Þingvallavatn                   | 104-2232-L       | 5,00          | 5,00          | 5,00                | 5,00                    |                 |                         |
| Jökulsá Fljótsd            | Kelduárlón                      | 102-2452-L       | 2,33          | 3,50          | 3,00                | 2,50                    |                 |                         |
| Jökulsá Fljótsd            | Þiðriksvallavatn                | 101-1028-L       | 3,33          | 3,00          | 5,00                | 3,25                    |                 |                         |
| Jökulsá Fljótsd            | Stífluvatn                      | 101-1386-L       | 2,50          | 4,00          | 5,00                | 2,88                    |                 |                         |
| Jökulsá Fljótsd            | Haukadalsvatn                   | 101-647-L        | 5,00          | 5,00          | 5,00                | 5,00                    |                 |                         |
| Blanda                     | Mývatn                          | 102-1448-L       | 5,00          | 5,00          | 5,00                | 5,00                    |                 |                         |
| Holtsá                     | Reyðarvatn                      | 104-358-L        | 5,00          | 5,00          | 5,00                | 5,00                    |                 |                         |
| Eyjafja                    | *Aðeins notað fyrir bergvötn.   |                  |               |               |                     |                         |                 |                         |
| Marka                      | **Aðeins notað fyrir jökulvötn. |                  |               |               |                     |                         |                 |                         |
| Tungufljót í Biskupstungum | 103-833-R                       | 5,0              | 4,0           | 5,0           | 5,0                 | *                       | 4,83            |                         |

# Summary

- Methods for assessing hydromorphological changes are based on Norwegian methods
- Parameters chosen to capture hydromorphological changes expected in Iceland
- Testing shows that these methods captures all major HYMO changes in rivers and lakes
- However, adding quality elements and appropriate parameters might increase accuracy in the classification





**Thank You**