

CATRINE VOES CAR LICENSE VARIATION

PROPOSAL DOCUMENT with SUPPORTING DATA

1. INTRODUCTION

Catrine Voes is a community hydropower project on the River Ayr, commissioned in 2016 and rated at 250kW, utilising a pair of identical Gilkes Francis turbines.

This document accompanies an application to SEPA from Catrine Community Trust to vary the abstraction conditions within the CAR license for the scheme (ref. CAR/L/1012183).

The current license was issued in 2011 (as a variation to the historic license).

In the context of current guidance and the modest size of the abstraction, the constraints on abstraction within the CAR license appear to be over-precautionary, and are limiting the full potential of the scheme to deliver carbon-free electricity into the local network.

At a time of national urgency to increase local, sustainable energy generation, the balanced measures proposed below would allow a worthwhile increase in hydropower production, but without a significant increase in risk to migratory fish - as will be demonstrated in the accompanying analyses.

2. EXISTING CAR LICENSE

The existing license contains the following conditions:

Condition 3.3

- A minimum Hands-off-Flow (HoF) of 900 litres/sec (the Q83 flow rate).
- A 50:50 flow split above the HoF, divided between hydro-scheme and river.
- Maximum abstraction of 4000 litres/sec (74% of mean river flow).
- A seasonal cap on the abstraction of 2000 litres/sec (i.e. 37% of mean river flow) for the 4 months from Aug to Nov inclusive each year.

Purpose of the condition

- Other than supporting the general ecology of the 850m of deprived reach, the primary driver behind these conditions is to maintain the passability of the watercourse for salmon and sea trout moving upstream.
- This requires adequate water depth, plus sufficient flow over obstacles (principally Anderson's Weir in this case) at the times when salmon and sea trout wish to move (generally Aug to Nov).
- It is also important that migrants are not distracted and potentially delayed by the flow emerging from the turbine outfall, mistaking it for the 'main river'.

However, most hydropower schemes operate successfully across the UK, including on salmonid rivers, with significantly less onerous abstraction conditions i.e.

- lower HoF (Q95 or Q90)
and/or
- more favourable flow split (or no flow split at all)
and/or
- no seasonal cap on peak abstraction

3. IMPLICATIONS FOR ENERGY CAPTURE

The conditions within Clause 3.3 cause a significant reduction in energy generation. The lost energy can be calculated - on average - from the long-term flow duration curve for the River Ayr, and the year-on-year energy capture of the scheme to date.

For example:

- removing the seasonal cap on abstraction would typically allow an energy up-lift of 12%
- reducing the HoF by 33% (down to the Q95 value) would allow a further 6% increase.

The combination of these 2 measures could therefore potentially bring a benefit of 18% to the annual output, equal to roughly 100,000 kWh/year.

This output is equivalent to commissioning a new 25kW hydropower scheme, or the annual electrical consumption of 30 average homes, or displacing the annual CO₂ absorbed by 2000 mature trees.

4. SEPA GUIDANCE (since 2015)

- The most recent guidance on Hydropower abstraction was issued by SEPA in 2015¹.
- Part B “Practicable Mitigation” sets out the measures that are expected to be incorporated into all run-of-river hydropower scheme developments.

4.1 Protection of High Flows (Maximum Abstraction)

- The guidance allows new, larger schemes (i.e. generating >350MWh/year, as applies at Catrine) to apply for abstractions up to 150% of mean river flow.
- For the Ayr at Catrine, where the long-term mean flow is 5.31m³/sec this would be a maximum abstraction of 8.0 m³/sec.
- *The licensed flow at Catrine Voes is 4.0m³/sec, therefore only 50% of the above maximum allowance.*

4.2 Protection of Low Flows (Hands-off-Flow)

- Protection of Low Flows within SEPA Guidance specifies a HoF of Q95 (or Q90 if there is a significant reduction in wetted area between Q90 and Q95).
- *The licensed HoF at Catrine is 900 litres/sec, equal to the Q83 value, which is 150% of the Q95 value of 600 litres/sec.*

4.3 Protection of flows for upstream fish migration and spawning

The scheme must be operated so as to provide suitable flows for fish migration and spawning activity during the periods of the year in which that activity would naturally occur.

Mitigation must be designed to provide a flow regime capable of:

- triggering migration;
- enabling fish to pass natural and artificial obstacles in the river;
- providing sufficient time at suitable flows for fish to progress upstream.

This may be achieved by:

- reducing abstraction rates; or
- operating a greater hands-off flow.

¹ Guidance for developers of run-of-river hydropower schemes, Version 2.3, SEPA, November 2015

The analysis below will demonstrate that 2 of the 4 conditions in Clause 3.3 already achieve the conditions needed for protecting salmon migration, namely:

- (a) the relatively low peak abstraction of $4\text{m}^3/\text{sec}$, combined with
- (b) the 50:50 flow split

and therefore the 2 further conditions (the high HoF and the seasonal cap) are unnecessary additional precautions which can be relaxed.

5. PROPOSAL

The requested license changes are to:

1. Reduce the Hands-off-Flow from 900 litres/sec (Q83) to 600 litres/sec (Q95)

Rationale:

- This change would bring the scheme into line with current SEPA guidance.
- Because the scheme is subject to a 50:50 flow-split, the allocated HoF value never occurs in practice because, when the first turbine starts to abstract its minimum ‘start-up’ flow, the license requires that the scheme has to leave in the river a flow equal to: (the HoF) + (the turbine start-up flow).
- The start-up flow for a single turbine is 400 litres/sec, so the minimum flow left in the river when the scheme is abstracting is currently $900 + 400 = 1300$ litres/sec (or Q71).
- By reducing the HoF to 600 litres/sec, this minimum residual flow would reduce to 1000 litres/sec (or Q79) i.e. if the scheme is abstracting, there would never be less than Q79 in the river.
- The standard HoF condition under new SEPA licenses is that the residual flow should rise from Q95 at turbine start-up to Q80 when the river reaches Q30 (roughly mean flow). *In this case – even with the proposed change - the residual flow will already be above Q80 at turbine start-up, then continue to rise with increased abstraction.*
- The deprived reach consists of natural riverbed falling at shallow gradient. The only significant obstacle to migration is Anderson’s Weir, a narrow man-made weir (4.45m wide) roughly 80m downstream of Catrine Weir and fishpass.
- The current minimum residual flow of 1300 litres/sec passing over Anderson’s Weir equates to a depth of 265mm passing over the weir crest, as depicted in Figure 1.
- A flow of 1000 litres/sec will reduce this spill depth by roughly 30mm to 235mm, as depicted in Figure 2.
- As a comparison, the standard depth of spill over each weir crest in the pool-and-weir fishpass adjacent to Catrine Weir is 200mm (shown in Figure 3).
- It is therefore apparent that the proposed modest reduction in HoF will not create an increase in the obstacle imposed by Anderson’s Weir, which will retain a very healthy flow and water depth over the crest, in excess of the overspill depth required for a standard fishpass design.
- The overall effect on the hydrograph within the deprived reach is discussed and depicted in Section 6.

2. Remove the 50% seasonal cap on abstraction (Aug-Nov inclusive)

Rationale:

- The peak abstraction defined in the license is 4000 litres/sec. This is 50% of the maximum abstraction that SEPA would currently permit at this location using current guidance (i.e. 150% of mean flow would be allowed, or 8000 litres/sec).
- If this maximum abstraction had been permitted in the 2011 license, then a seasonal 50% flow cap would only bring the peak abstraction down to the current licensed maximum i.e. the existing peak abstraction is already capped at a modest level of 74% of Q_{mean} .

- The River Ayr is a flashy river which experiences high flow peaks with each rainfall event – typically a few multiples of Q_{mean} . These peaks dwarf the modest hydropower abstraction, and therefore the seasonal cap in abstraction of 37% of Q_{mean} serves little purpose because the flow ‘trigger’ is already so high without it.
- The minor variation in the before/after comparison of the flow in the deprived reach can clearly be seen in the hydrographs presented in Section 6.

6. ANALYSIS USING ANNUAL HYDROGRAPHS

Overview

Daily mean flows since 1998 have been obtained from the SEPA gauging station at Catrine, 1 mile downstream of the abstraction. These have been used to plot annual hydrographs and examine the effect on the deprived reach of (a) the hydro abstraction operating as present (b) the change that would occur by the relaxation of the 2 flow constraints, as proposed above.

From the last 25 years:

- 2019 was a typical ‘average’ flow year with a mean flow of 5.6m³/sec.
- 2021 was a typical dry year with a mean flow of 4.5m³/sec
- 2003 was a very dry year with a mean flow of 3.6m³/sec

The 6 graphs from Figure 4 to Figure 9 plot the ‘before’ and ‘after’ situation for each of these 3 years. The green line depicts the flow abstracted by the turbine, which increases at certain river flows in the ‘after’ graph due to the proposed changes, causing the flow in the deprived reach (red line) to reduce commensurately.

Observations

- The hydrographs exhibit high flow peaks, the majority being some multiples of mean flow. Against these peaks, the maximum turbine abstraction of $0.74 \times Q_{\text{mean}}$ is already relatively minor.
- Reducing this to $0.37 \times Q_{\text{mean}}$ has a very small impact on the shape of the graph and hence is unlikely to materially improve the ‘trigger’ effect on salmon movements i.e. this measure is not achieving any significant benefit.
- It can be seen that the proposed reduction in HoF still maintains the minimum river flow above 1000 litres/sec when the turbine is abstracting, as discussed above.

7. MITIGATION AND BENEFITS

- Since commissioning in 2016, the Catrine Community have invested significant time and funds in further improving upstream and downstream passage for adult salmon and smolts. Specifically:
 - i) cutting back the downstream wall at the base of the fishpass, to provide a clear attraction plume down-river plus a straight-on entry into the pass, thereby reducing potential delays and confusion in locating and ascending the pass.
 - ii) adding a 2nd smolt bywash downstream of the Fairburn gates (where smolts had been observed gathering), so accelerating their safe passage downstream.
 - iii) improving the hydraulic performance of the original smolt bywash (bellmouth entry, reduced velocities in the smolt chamber).
- The anticipated energy benefit of the above measures is expected to average 100,000 kWh per year, which equates to 45 tonnes/year of CO₂ no longer emitted from gas-fired power stations.
- This would yield additional revenue of >£25k per annum to re-invest in the community, and future scheme improvements.

- This development will also take another small step towards the Scottish Government’s 2045 Net Zero target, and at no cost to the tax-payer. It is also in line with SEPA’s own climate change commitments².

8. CONCLUSIONS

1. The applicant is requesting a modification to CAR license (ref. CAR/L/1012183), specifically that Table 3.1 within Clause 3.3.1 should now state as follows.

A	B	C	D	E	F
NGR	Name	Period	Maximum Rate litres/sec	Maximum daily volume (m ³)	Hands Off Flow litres/sec
NS 5353 2619	Catrine Weir	All Year	4000	345,600	600

2. Evidence has been provided that these changes are consistent with up-to-date SEPA Guidance (published after the current license was issued) and that salmon migration cannot plausibly be compromised as a result.
3. Additional, specific elements to enhance adult salmon and smolt migration have been provided by the scheme since commissioning.
4. These changes will significantly enhance zero-carbon energy capture from the scheme, in support of Scottish Government targets, and raise revenues for further investment in the local community.

² Climate Change Commitment Statement, <https://www.sepa.org.uk/media/369292/climate-change-commitment-statement.pdf>

Figure 1 : 265mm over Anderson's Weir



Figure 2 : 240mm over Anderson's Weir



Figure 3 : 200mm passing over the crests of the fishpass



Figure 4 : CATRINE VOES 2019 (MEAN YEAR) – STATUS QUO

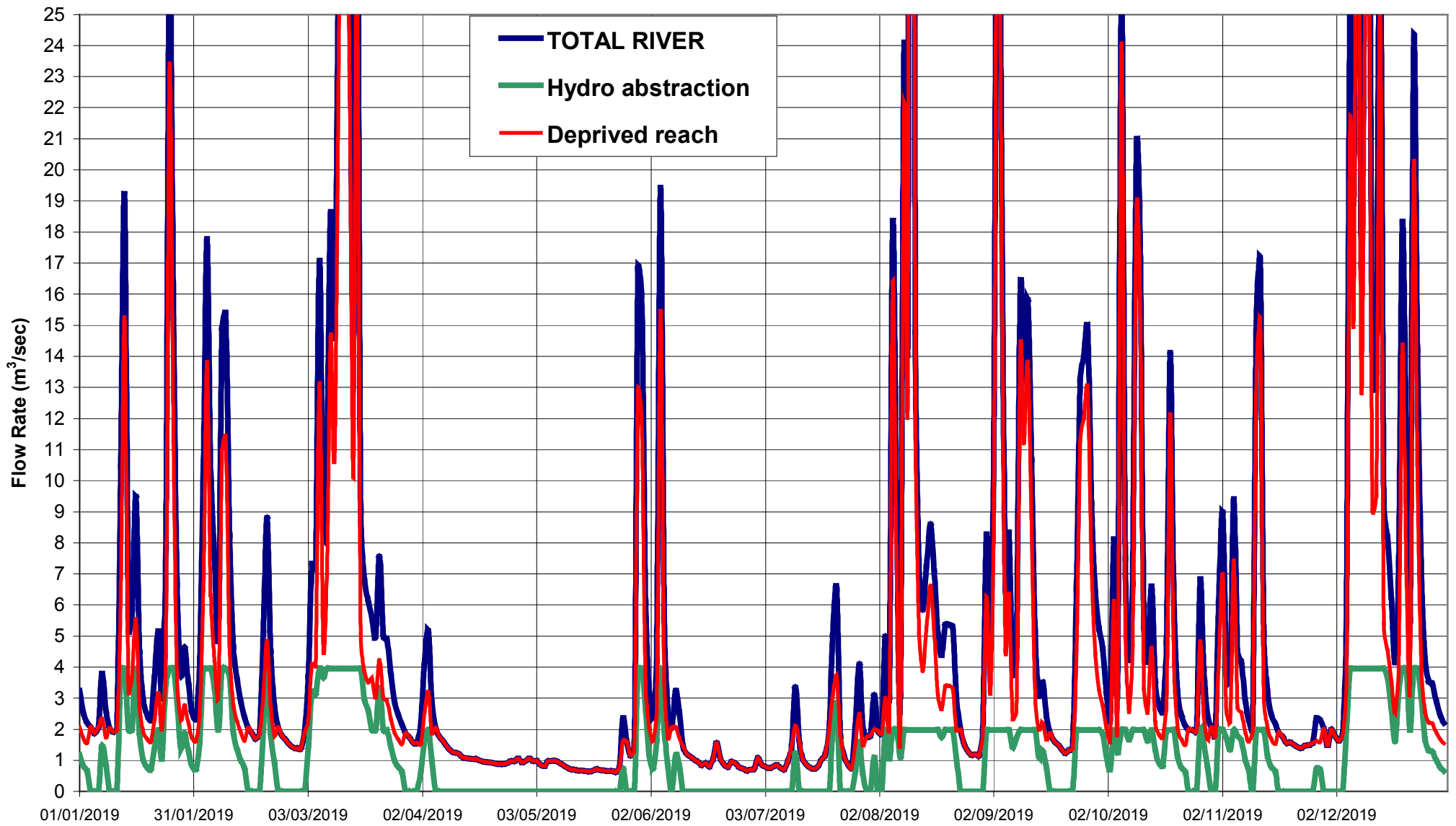


Figure 5 : CATRINE VOES 2019 (MEAN YEAR) - AUTUMN CAP REMOVED and LOWER HoF (Q95)

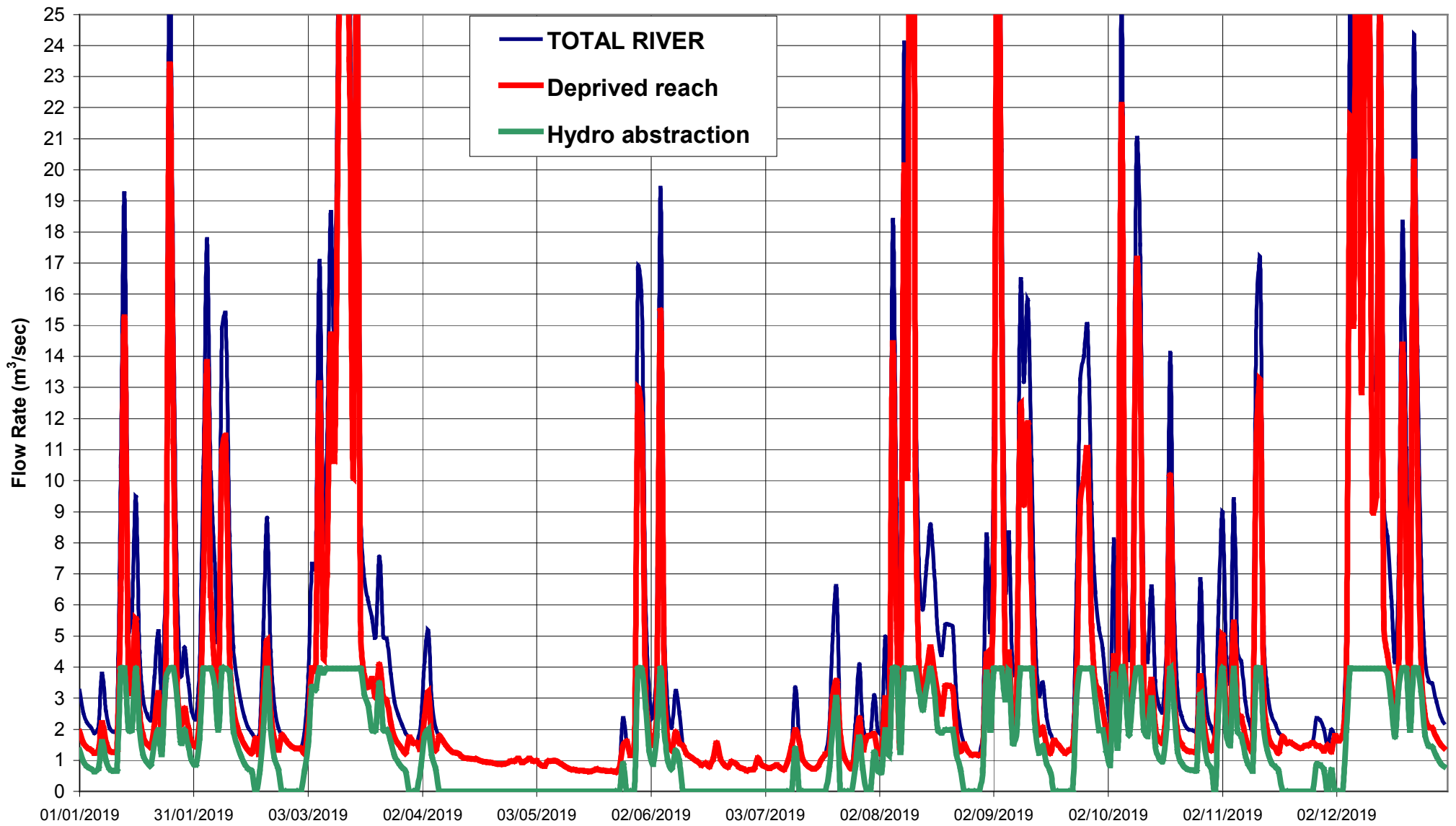


Figure 6 : CATRINE VOES 2021 (DRY YEAR) – STATUS QUO

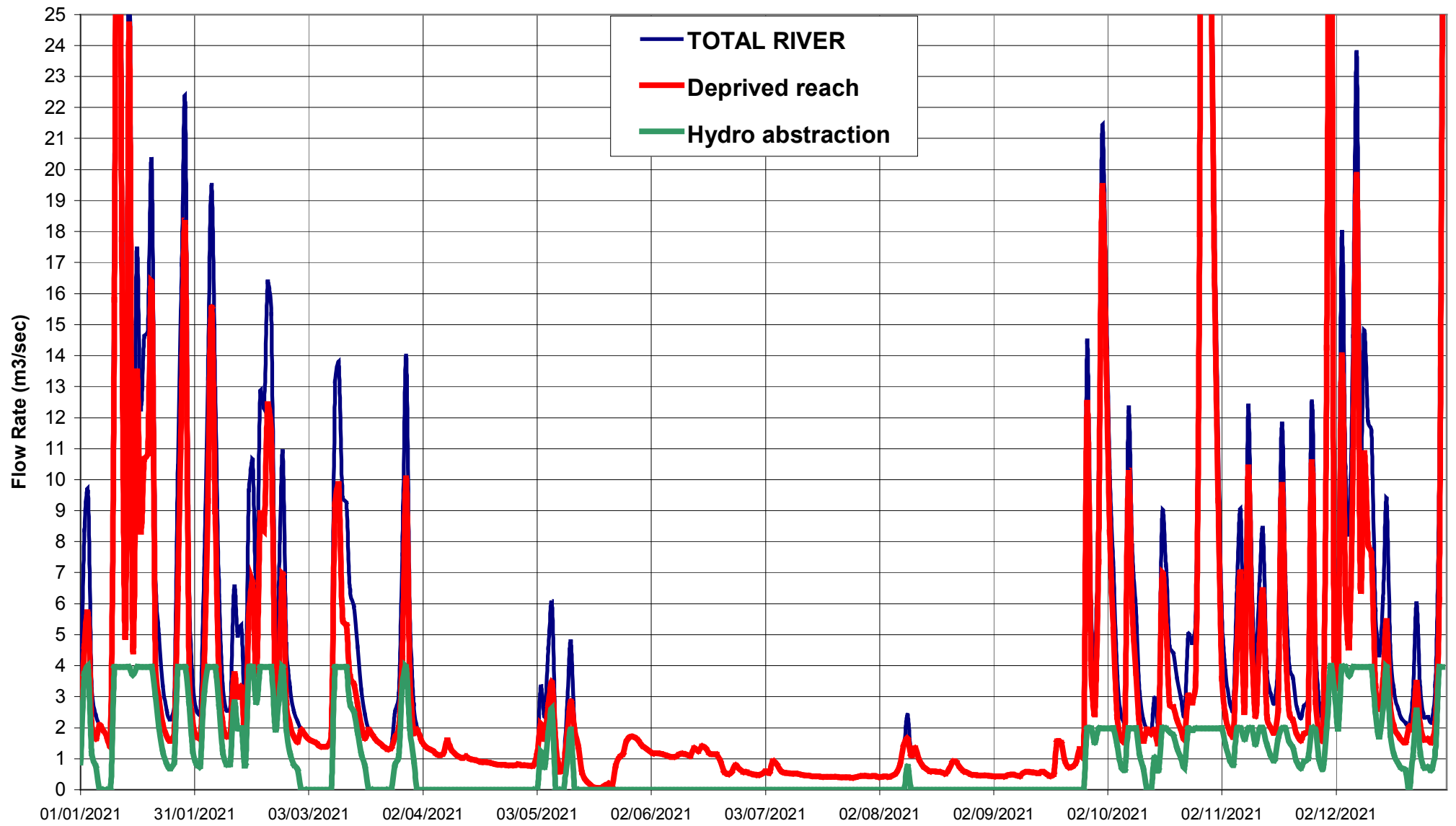


Figure 7 : CATRINE VOES 2021 (DRY YEAR) - AUTUMN CAP REMOVED and LOWER HoF (Q95)

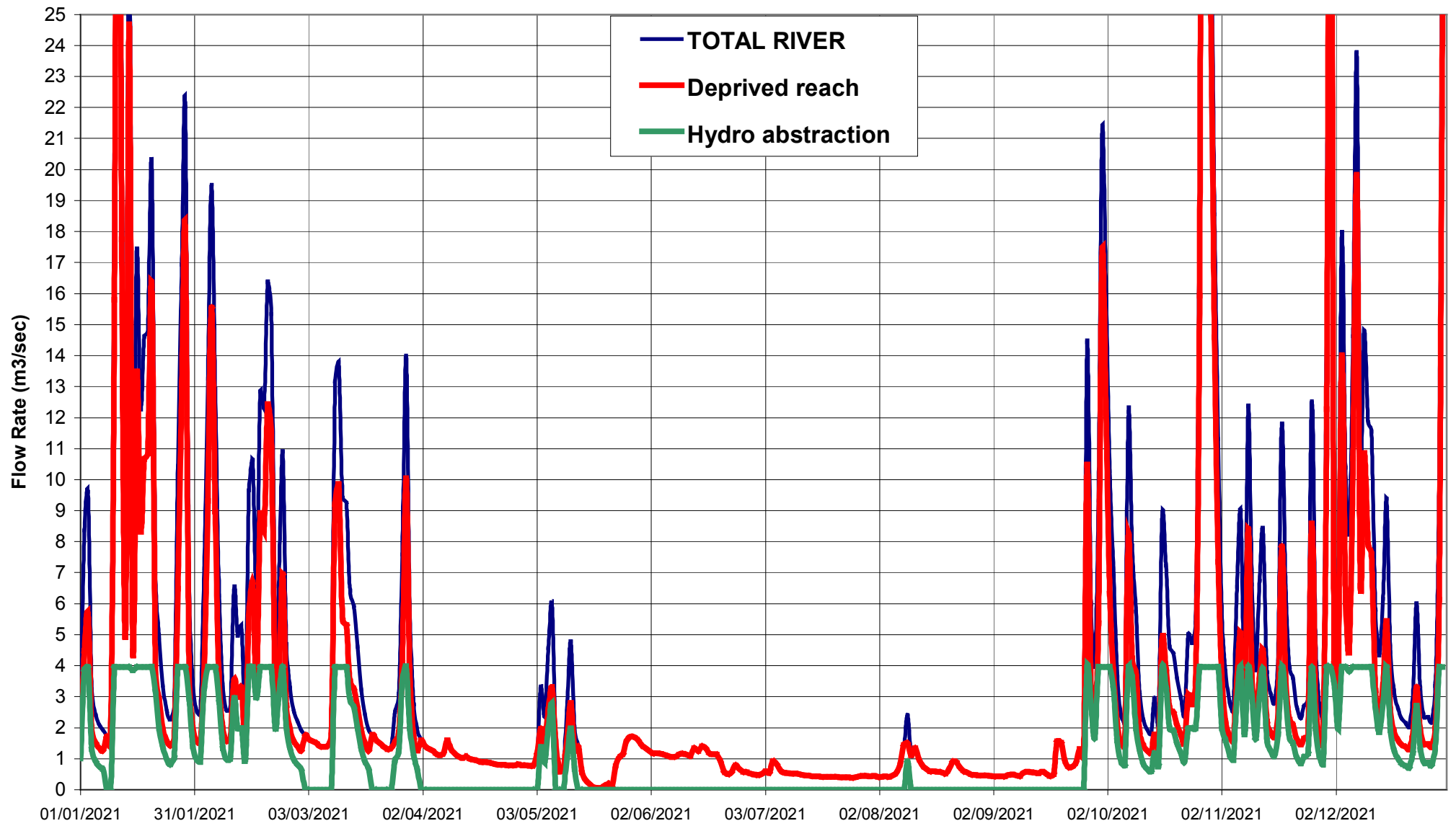


Figure 8 : CATRINE VOES 2003 (VERY DRY YEAR) – STATUS QUO

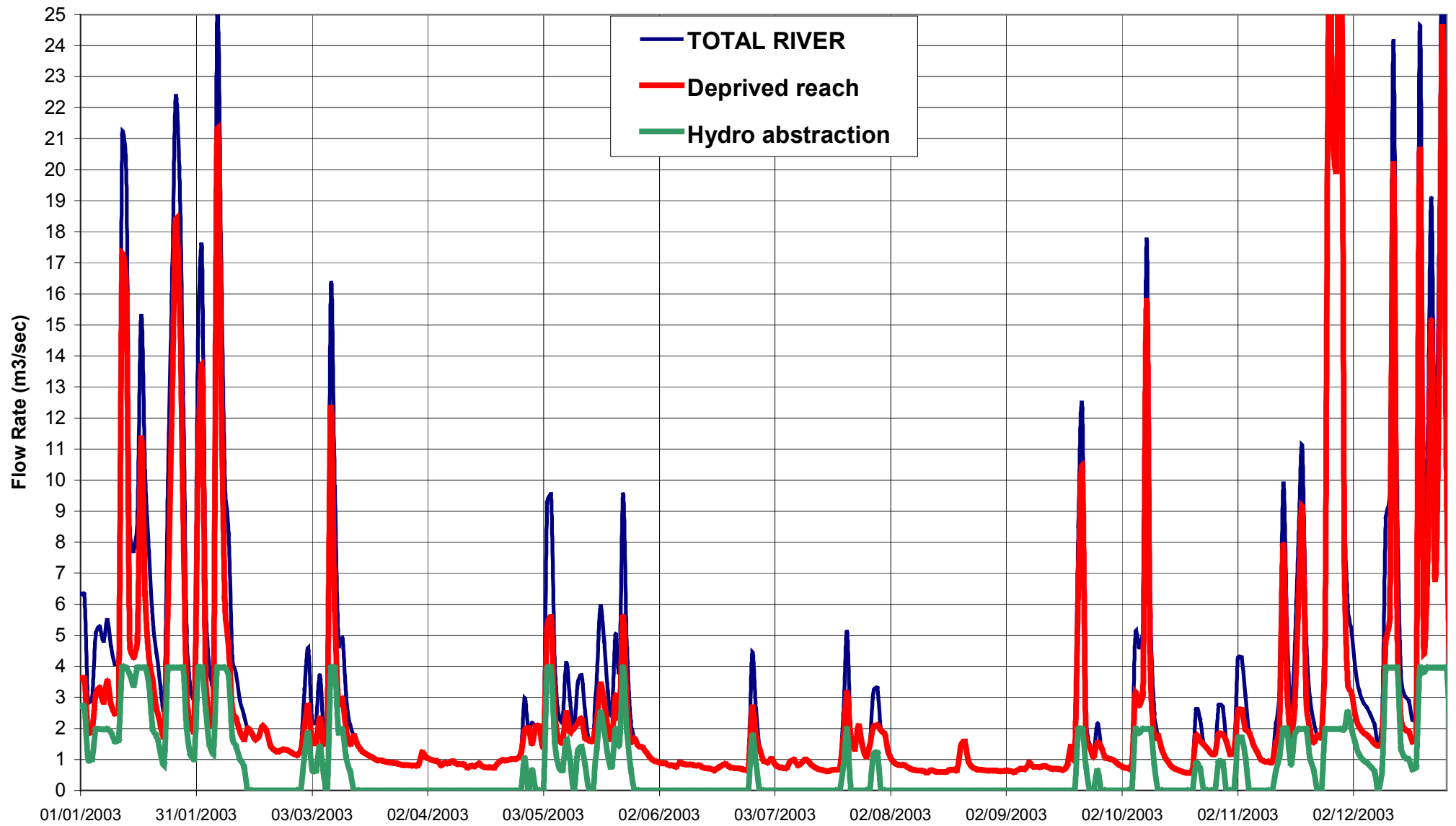


Figure 9 : CATRINE VOES 2003 (VERY DRY YEAR) - AUTUMN CAP REMOVED and LOWER HoF (Q95)

