Update on trends in water quality in the sub-catchments of the upper Lunan Water

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Monitoring effort in the Lunan Water by James Hutton Institute for 2007-present has focused on regular water chemistry samples and stage recording at 5 main stations (see Figure 1), with several other stations having a shorter record). Data from 2007-2011 for these stations along with the longer term (from 1981) SEPA data for samples at the main catchment outlet hydrometric station at Kirkton Mill, were analysed for trends in concentrations and loads, in a 2014 paper (Dunn et al., 2014). This report provides a brief update for data to 2018, using (1) the same methodology and (2) a Generalised Additive Model (GAM) with spline terms for the trend, the effect of discharge, and a cyclic spline for the seasonal effect (Dupas et al., 2018). Analysis of linear trends are summarised in Table 1. The GAM fits to the data are shown in figure 2.

The results show a decline in NO_3N in all sub-catchments. Most of this decline is from 2007 to 2015, after which concentrations are stable or in some cases have increased again. There was no significant trend in flow over the same period. The $\log_{10}(PO_4P)$ results show a significant upward linear trend for Westerton and Murton sites. The clearest indication of upward trends in PO_4P is since 2015.

In Dunn et al. (2014) the only direct relationship between land use and water quality that could be identified based on annual data was a positive link between arable cropping and nitrate concentrations. At the sub-catchment scale some temporal changes in land use and management explained short-term trends in nitrate but not in SRP. Lags in the system were identified due to soil adsorption, in-stream processing and groundwater transport making the identification of cause and effect problematic. The outworking of these lags has more opportunity to take effect in this longer term dataset, but consideration of this process is counteracted by the change in direction of several of the trends since 2015.

Table 1. Linear trends in NO_3N and $\log_{10}(PO_4P)$ for sub-catchments of upper Lunan Water and Lemno Water (Hatton) after adjusting for seasonal and discharge effects.

Site	Stream	Area (km^2)	Determinand	Trend	p-value
Hatton	Lemno Burn	7.23	NO_3N	-0.399	<0.001
Westerton	Balgavies Burn	7.01	NO_3N	-0.059	0.080
Wemyss	Baldardo Burn	3.49	NO_3N	-0.129	0.042
Murton	Burnside Burn	7.83	NO_3N	-0.095	0.003
Newmills	Newmills Burn	1.22	NO_3N	-0.147	0.003
Hatton	Lemno Burn	7.23	$\log_{10}(PO_4P)$	0.010	0.119
Westerton	Balgavies Burn	7.01	$\log_{10}(PO_4P)$	0.048	<0.001
Wemyss	Baldardo Burn	3.49	$\log_{10}(PO_4P)$	0.012	0.246
Murton	Burnside Burn	7.83	$\log_{10}(PO_4P)$	0.033	0.003
Newmills	Newmills Burn	1.22	$\log_{10}(PO_4P)$	0.010	0.223
Westerton	Balgavies Burn	7.01	Discharge	-0.001	0.950

Dunn, S.M.; Sample, J.; Potts, J.; Abel, C.; Taylor, C.; Cook, Y.; Napier, F.; Vinten, A.J.A. (2014) Recent trends in water quality in an agricultural catchment in Eastern Scotland: elucidating the roles of hydrology and land use., Environmental Science: Processes and Impact, 16, 1659-1675.

Dupas, R.; Tittel, J.; Jordan, P.; Musolff, A.; Rode, M (2018). Non-domestic phosphorus release in rivers during low-flow: Mechanisms and implications for sources identification. Journal of Hydrology, 560, 141-149.

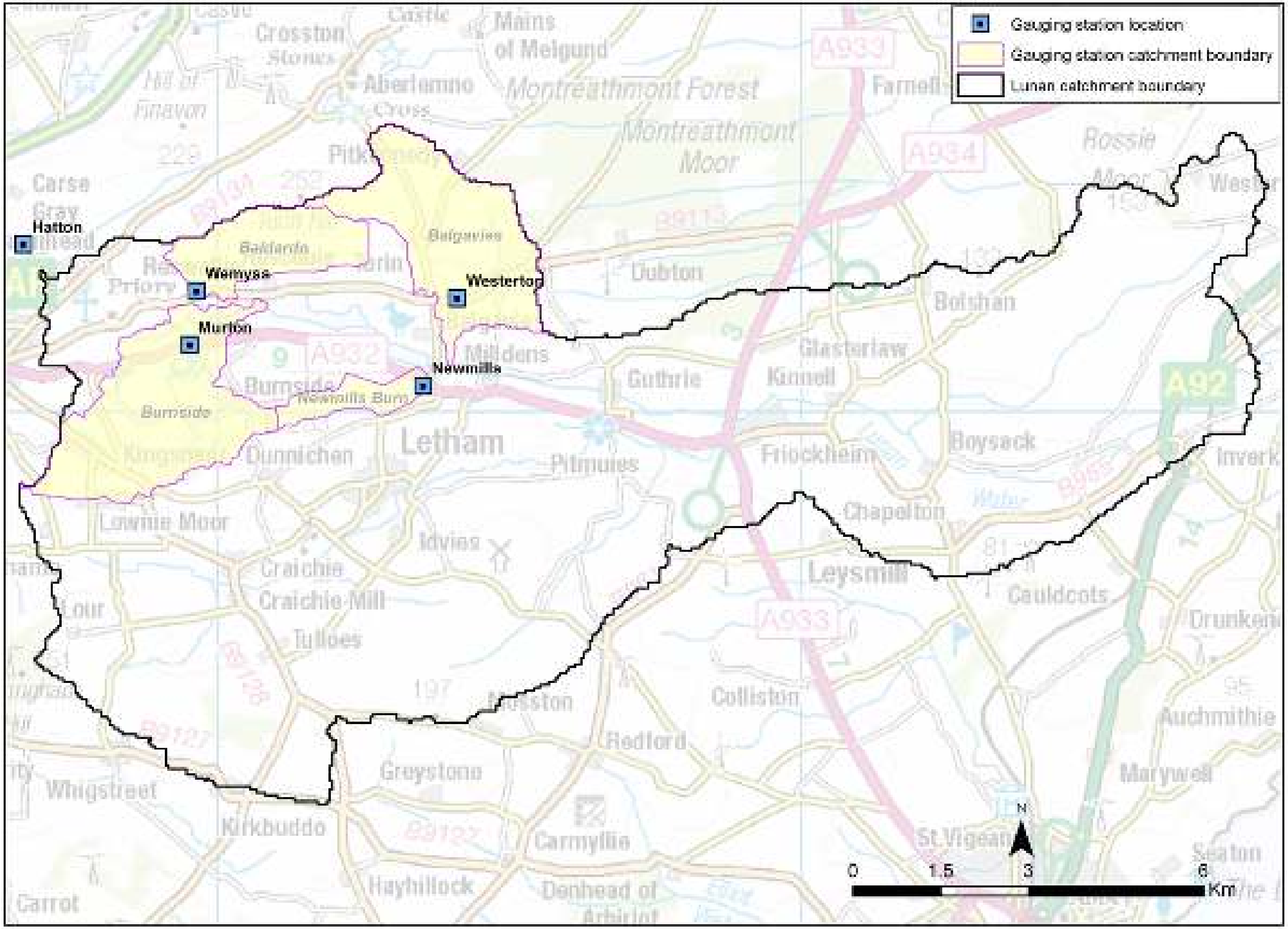

Figure 1. Sub-catchments of the upper Lunan Water where chemical and flow monitoring have taken place since 2007.

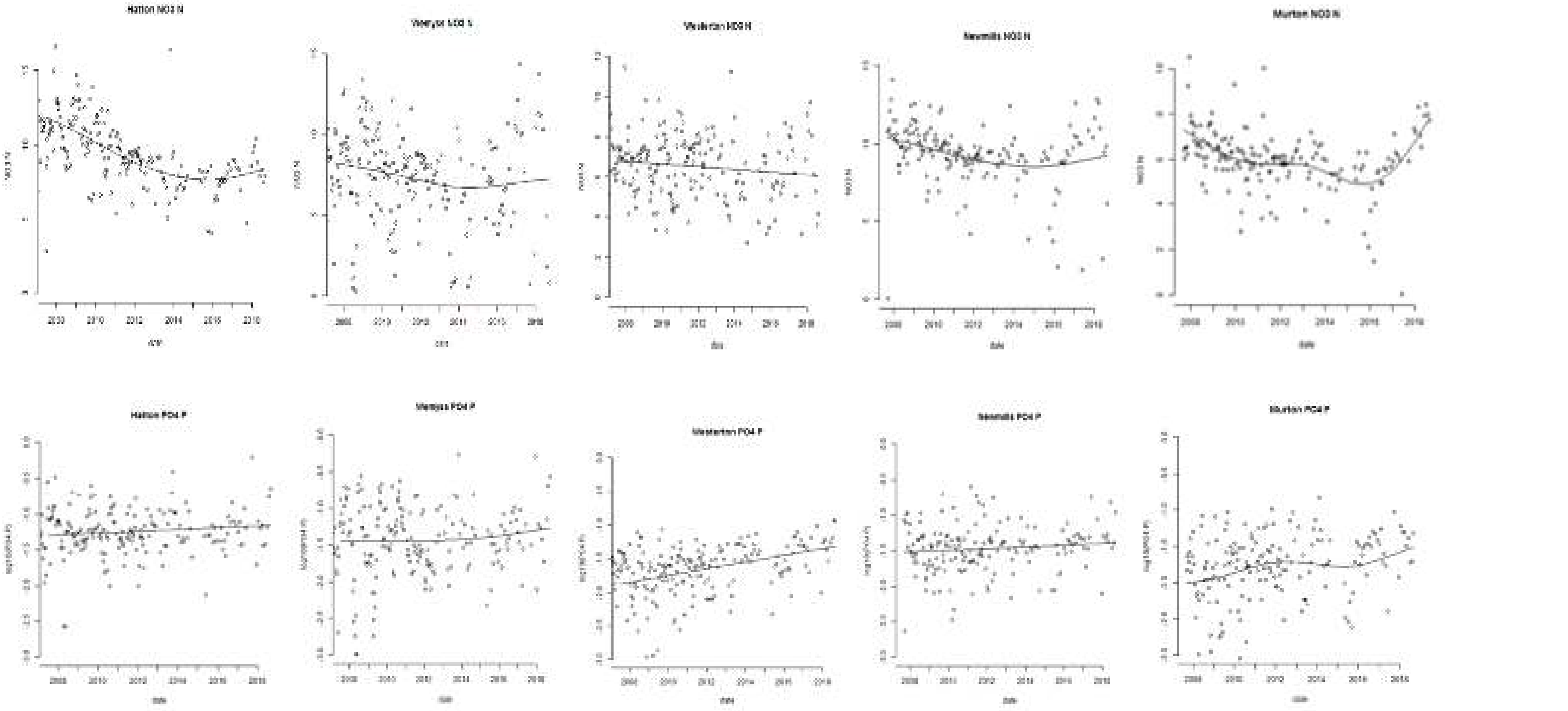

Figure 2. Line shows the trend in concentrations of NO_3N and $log_{10}(PO_4P)$ in regular samples at 5 sub-catchments in the upper Lunan Water from General Additiive Model (GAM) that includes seasonal and discharge effects. The points show the original data.

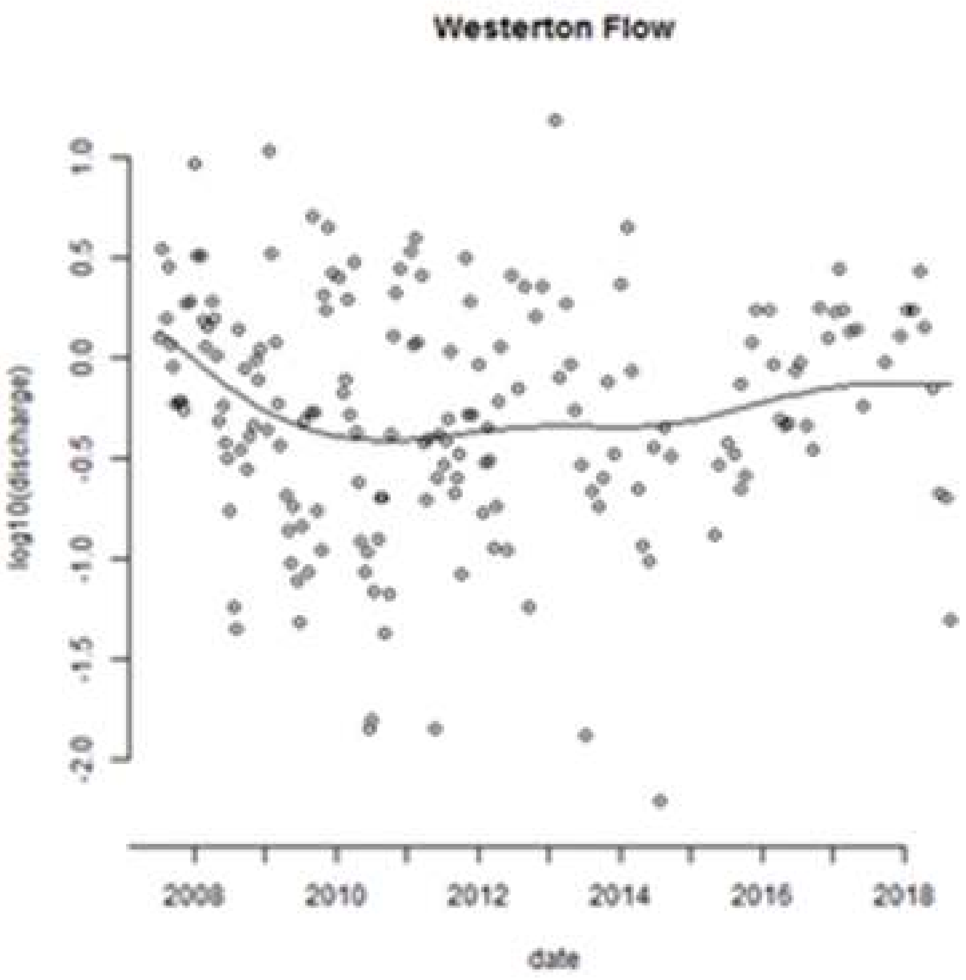

Figure 3. Trend in discharge from a GAM that also includes seasonal effects for the Westerton site, 2007-2018. Circles represent the original data.