FINDINGS OF WATER MONITORING AT FOUR DEMONSTRATION BLANKET BOG SITES

PURPOSE OF WATER MONITORING

The steady increase of the eutrophication of Irish freshwaters since the early 1970s has been identified as the greatest single threat to the quality of the country's rivers and lakes. While it is recognised that diffuse sources from the agricultural sector and point source discharges from industrial and municipal waste treatment facilities are the major contributors to eutrophication, the contribution of the forestry sector to phosphorus input into environmentally sensitive catchment waters has, up to very recently, not been quantified in Ireland.

In particular, there is concern of the potential of forests established on blanket bog to contribute to eutrophication arising from the fact that peat soils have a very low capacity to capture and retain available phosphorus. Although, the forest sector has been proactive in adopting rigorous water protection measures (as outlined for example in Forest Service's Forestry and Water Guidelines & Forest Harvesting and the Environment Guidelines [2000] in minimising and/or avoiding potential nutrient losses from routine forest management practices, there is a need to quantify the efficacy of such restrictions in this project where bog restoration measures on some sites entail the use of larger than normal felling coups, employing non-conventional harvesting techniques, such as felling to waste, and wholesale blocking of forest drains.

WATER MONITORING

Water monitoring was conducted at a four of the project's fourteen study sites (Figure 1), namely, Dromalonhurt and Garrane, Co. Kerry, Emlaghdauroe, Co. Galway and Bellaveeny, Co. Mayo. These properties were selected for monitoring, during site visits in November and December 2002, on the basis of the environmental sensitivity of adjacent rivers/streams. Dromalonhurt and Garrane properties were located within the Carragh River catchment that contains Freshwater Pearl Mussel further downstream. The Emlaghadauroe study site is adjacent to Ballynahinch Lake, an acid sensitive lake in Connemara, Co. Galway. While, Bellaveeney lies within the Owenduff River catchment, one of the most prolific salmon and sea trout fishery in the country.

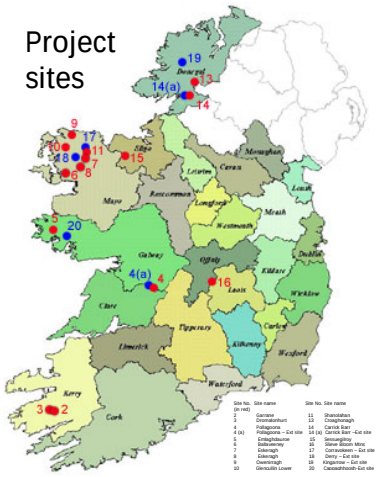

Figure 1. Location of all Blanket Bog project sites.

METHODOLOGY

An autosampler was installed at each of the the study sites, Dromalonhurt, Emlaghdauroe and Bellaveeney in the period March to June 2003. pH measurements were recorded onsite every 30 minutes, while daily composite samples (one sample taken every hour during a 24 hour period) were collected every week to two weeks and dispatched to the Research Laboratory, Newtownmountkennedy, Co. Wicklow for analysis. This continuous monitoring was supplemented by grab sampling conducted approximately every month at locations above and below the study site, before, during and after harvesting and ditch blocking operations. Grab sampling was only conducted at Garrane. All water samples, both from the autosamplers and grab sampling, were analysed for the following elements: colour, total suspended solids [TSS], pH, conductivity, alkalinity, calcium, magnesium, potassium, ammonia, nitrate, soluble reactive phosphorus (otherwise known as ortho-phosphate [Ortho-P]) & total phosphorus [TP].

RESULTS

DROMALONHURT STUDY SITE, CO. KERRY

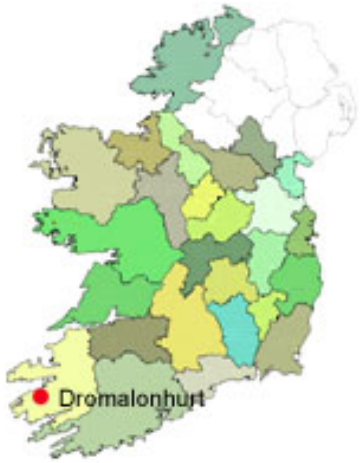

Figure 2. Location of Dromalonhurt study site

As can be seen from the water sample location map (Figure 8), the autosampler at Dromalonhurt (Figure 2 & 3) was sited on a modified 1st order stream on the western boundary of the study site.

The duration of the sampling, harvesting and drain blocking are detailed in Table 1.

The catchment of the small tributary to the autosampler was estimated at 30 ha and contained 20 ha (representing 66% of the catchment) of the 29 ha felled to waste by a harvester in the August/September'03. Much of the harvested material was used as brash mats during the operation. A temporary bridge made from the harvested stems was used to cross the stream, adjacent to where the autosampler was located (see. Figure 6). Drain blocking started as harvesting was nearing completion in October'03 and finished in March'04.

Table 1. Timescale of the various operations at Dromalonhurt

Operations	Duration
Water monitoring	
- Autosampler	19/2/03 to 14/9/07
- Grab sampling	19/2/03 to 13/11/07
Harvesting	~August to Sept.'03
Drain blocking	~Sept.'03 to Mar.'04

Figure 3. Commisioning of the autosampler in February'03.

AUTOSAMPLER RESULTS:
19/2/03 TO 14/9/07

Before operations: (19/2/03 to 31/7/03)

The waters at this site would be characterised as acid sensitive with pH ranging from pH 7.41 in low flow to pH 4.26 in high flow. Buffering capacity is minimal with alkalinity readings consistently <1 mg/l $CaCO_3$ and hardness values in the main <8 mg/l $CaCO_3$.

Water quality was considered to be of a high standard in the period prior to the start of operations. As can be seen in Figures 4 and 5., both the median and maximum and concentrations for TSS, Ortho-P and TP were well within the EPA critical threshold limits indicated by the appropriately coloured horizontal lines for each parameter.

It should be noted that this colour scheme demonstrating the critical limit for each parameter is the same for all figures in this report, the red line is applicable to TSS (at 25 mg/l on the right hand scale), the yellow line for Ortho-P and the blue line for TP (at 20 µg/l P and 62 µg/l P respectively on the left hand side scale).

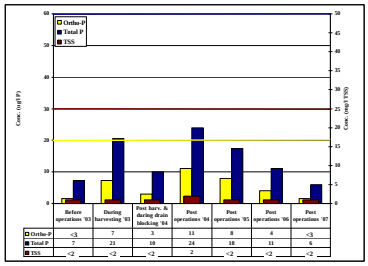

Figure 4. Median concentrations of TSS, Ortho-P and TP determined at the autosampler at Dromalonhurt during the various stages of operations in the period February'03 to September'07.

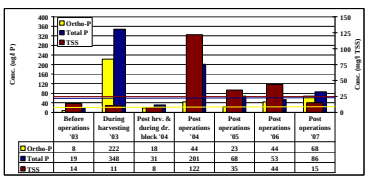

Figure 5. Maximum concentrations of TSS, Ortho-P and TP determined at the autosampler at Dromalonhurt during the various stages of operations in the period February'03 to September'07

The concentration of nitrogen measured as nitrate and ammonia was on the whole exceedingly low throughout the monitoring period and in the case of nitrate never exceeded 0.5 mg/l N-NO_3 and normally fluctuated between 0.02 to 0.04 mg/l N-NO_3

- *During harvesting: (1/8/03 to 30/9/03)*

During early August to late September'03, when harvesting of the property was taking place, an increase in the median and maximum concentrations of P was noted. The maximum concentrations determined for Ortho-P and TP, in particular, showed the sharpest increase and exceeded the acceptable threshold limit for either form of phosphorus by 6 to 11 times. The highest concentrations of P primarily occurred over a two weeks period in mid-August and again in late August to early September and then quickly reverted to negligible levels. This increase corresponded with elevated levels of ammonia over a three day period in early September with the highest concentration detected during the study at 1.06 mg/l $N\text{-}NH_3$.

Total suspended solids did not increase during harvesting operations. Indeed, the maximum concentration detected was actually less than that recorded before the start of operations.

Figure 6. Harvesting at Dromalonhurt using a temporary bridge made from log and brash to facilitate the harvester crossing the stream.

- *Post harvesting & ongoing drain blocking: (1/10/03 to 31/3/04)*

With the completion of harvesting and the commencement of drain blocking, P levels returned immediately to pre-operations levels, the one exception was a sample taken on the 8/11/03 where concentrations of 18 and 31 µg/l P were obtained for Ortho-P and TP respectively.

- *Post operations: (1/4/04 to 14/9/07)*

In 2004, after all operations had ceased, a general but not overly significant increase in P levels was noted in the results, particularly in the period April to October'04. In comparison to pre-operation levels, the median concentration of Ortho-P and TP from April to December'04 increased from <3 to 7 to 11 and 24 µg/l P respectively. A marginal decrease in both forms of P was noted in 2005, with a further decline noted in 2006. During the last year of monitoring in 2007, P levels had returned to that observed prior to the commencement of bog restoration operations at the study site four years previously.

While sediment loss was not a major feature at this site, the highest concentration of 122 mg/l for the entire monitoring study was detected in early October'04. This was a once off result with median concentration for this post operations period of 2 mg/l declining to <2 mg/l in subsequent years.

GRAB SAMPLING RESULTS:
19/2/03 TO 13/11/07

Grab sampling took place at four locations above, within and downstream of the study site and at two locations on the Caragh River, above and below the confluence of the monitored tributary with the main channel.

Sampling took place every month with the exception of the months of May to July'03 inclusive when harvesting operations were awaited at the site.

Figure 7 Taking the first water sample at sample point No. 5 (beside the autosampler) in February'03.

- *Natural watercourse above the forest property (sample point No. 4)*

Elevated levels of TP and TSS were a periodic feature of the results at this sample point. It is believed that a mixture of background factors and sampling errors were the primary influences of water quality at this

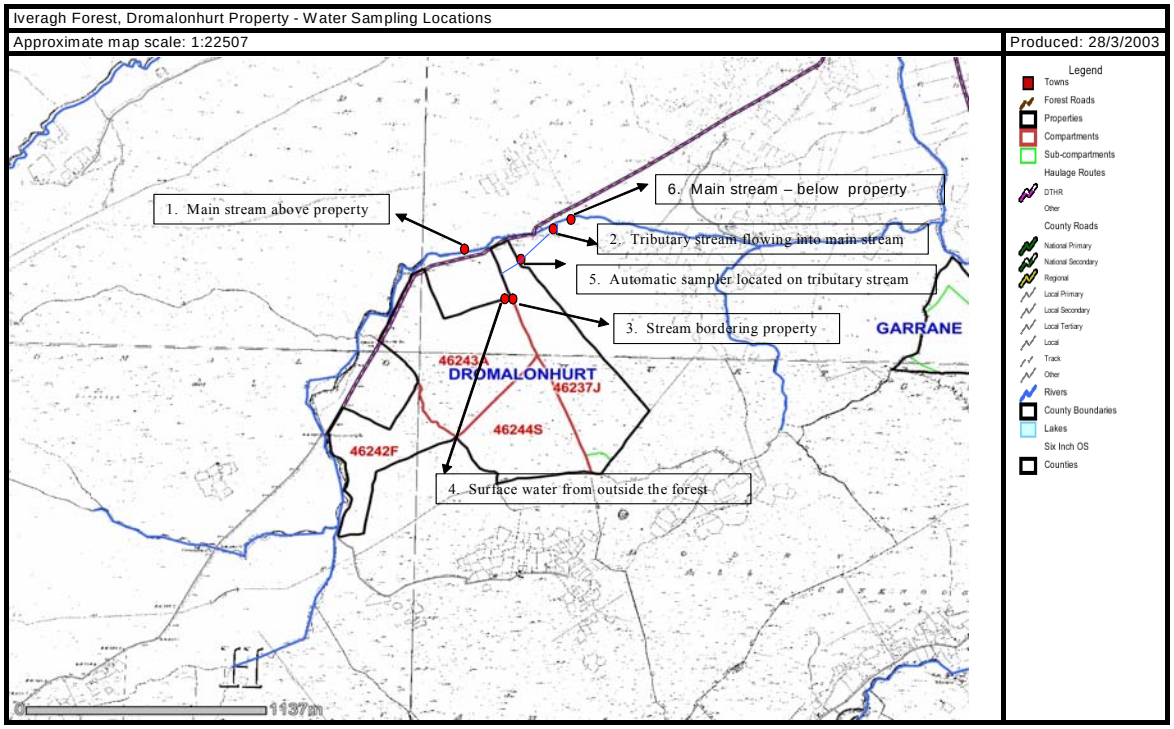

Figure 8. Water sampling locations at Dromalonhurt study site.

location. The latter issue arose as this watercourse was subject to very low flow on occasion and the sampler when endeavouring to take a water sample was more than likely picking up stream sediments rather than sampling the slowly moving surface water.

- *Tributary stream (sample points No. 2, 3, and 5)*

Samples were taken from the midst of the operations area (No. 3), at the property boundary (No. 5) where the autosampler was located and at the confluence point of the tributary with the River Caragh (No. 2).

After the commencement of harvesting, a significant increase in TSS, TP and to a lesser extent Ortho-P was immediately apparent in the results at No. 3. These elevated levels continued more or less for a year and then decreased significantly from November'04 onwards. For the remainder of the study, apart from the odd spike in TSS, especially in the sampling of the 3/8/05 (40 mg/l) and 11/10/07 (84 mg/l), the bulk of the results were less than the detection limit for TSS (<2 mg/l).

Further downstream, at sample point No. 5, adjacent to the autosampler (Figure 7), the impacts were significantly less evident than at No. 3. The levels of TSS, Ortho-P and Total P were either not detected or detected at low concentrations. The only exception was the sampling of the 2/9/03 where elevated levels of TSS, Ortho-P and TP noted at sample point No.3 was equally reflected, although to a lesser extent, at No. 5.

Another interesting feature of the results was the elevated levels of TSS and TP at sample point No. 2, located at the confluence of the tributary with the main river channel in comparison to further upstream at the property boundary and where the autosampler was sited (No.5). As can be seen in Figure 9, the difference in results between the two sampling points was highly significant. For example in the period after harvesting was completed but drain blocking was still ongoing in '04, the average concentration of TSS and TP was 385 mg/l and 426 µg/l P respectively at the tributary outlet (No. 2) in comparison to the corresponding figures at the property boundary further upstream (No. 5) of <2 mg/l and 18 µg/l P.

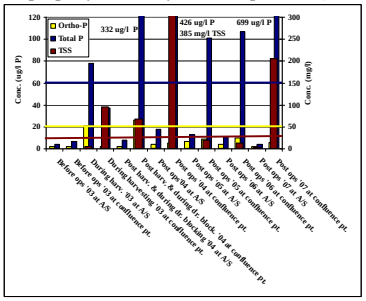

Figure 9. Mean concentrations of TSS, Ortho-P and TP determined at sample point No. 5 (at the property boundary) and at No. 2 (at confluence with the River Caragh) for comparison at the various stages of operations at Dromalonhurt.

The cause(s) for such a difference in the findings at these two points is uncertain but most probably due to stream bank erosion between the forest property boundary and the tributary outlet.

- *River Caragh (Sample points No. 1 and No. 6)*

A comparison of the results above (No. 1) and below (No. 6) where the tributary meets the main river showed that these waters were of a highly quality with TSS, Ortho-P and TP well within critical threshold limits applicable to such waters. TP in general was slightly higher above the confluence point than further downstream with the exception of '06 where a once off TP concentration of 429 µg/l P was determined at No. 6 in October'06 skewed the average for the year upwards (see Figure 10). The cause for such a result was unclear because phosphorus, if detected at all, was present at trace levels at both the upstream sample point (No.1) and at the tributary outlet (No.2) in samples taken on the same date.

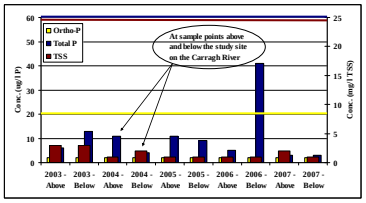

Figure 10. Mean concentrations of TSS, Ortho-P and TP determined above (No. 1) and below (No. 2) where the tributary meets the Caragh River for the years '03 to '07

GARRANE STUDY SITE, CO. KERRY

Figure 11. Location of Garrane study site.

Garrane is located a few kilometres upstream of Dromonalhurt in the Caragh River catchment (Figure 11). Grab sampling at this property was initiated in mid February '03 and was conducted at monthly intervals. Sample points were selected on watercourses above and below the forest property and above and below the confluence with the adjacent Carragh River (see Figure 12). Sampling was initially conducted at five sample points, increasing to six in October'04. This additional point (No.6) was to determine the water quality of a hill side watercourse flowing along the boundary of the forest property which was overlooked when

setting up the initial grab sampling scheme in '03.

The entire forest block of 18 ha was felled to waste between April to September'03. After a period of nearly a year, drain blocking took place on the site between March and August'04 (see Table 2. below).

Table 2. Timescale of the various operations at Garrane.

Operations	Duration
Water monitoring	
- Grab sampling	18/2/03 to 13/11/07
Harvesting	~April to Sept.'03
Drain blocking	~March to Aug.'04

GRAB SAMPLING RESULTS:
18/2/03 TO 13/11/07

- *Watercourses adjacent to the forest property (Sample points 1-3 & 6)*

A note worthy feature of the results at these sample points was the periodic high levels of TSS, Ortho-P and TP observed at No.1 and No. 6. relative to the other sample locations. On occasion TSS and TP concentrations exceeded critical limits by between 1 to 4 times acceptable levels for either parameter. In July and August'07, TP concentrations increased to an unprecedented 1,525 and 1,283 µg/l P at No. 6 and 1 respectively. As both points would be considered to lie outside the forest operations area, other site factors were at play to contribute to these results.

Further investigation uncovered that the site was subject to periodic flooding resulting in increased over land flow from the nearby hill magnifying background erosion pressures at sample points No. 1 and No. 6 as well as potential mixing of surfaces waters from both adjacent pasture land and felled area.

- *Watercourses adjacent to the forest property (Sample points 4 & 5)*

To estimate the impact of bog restoration measures on the main river channel, the Caragh River was sampled above (No. 4) and

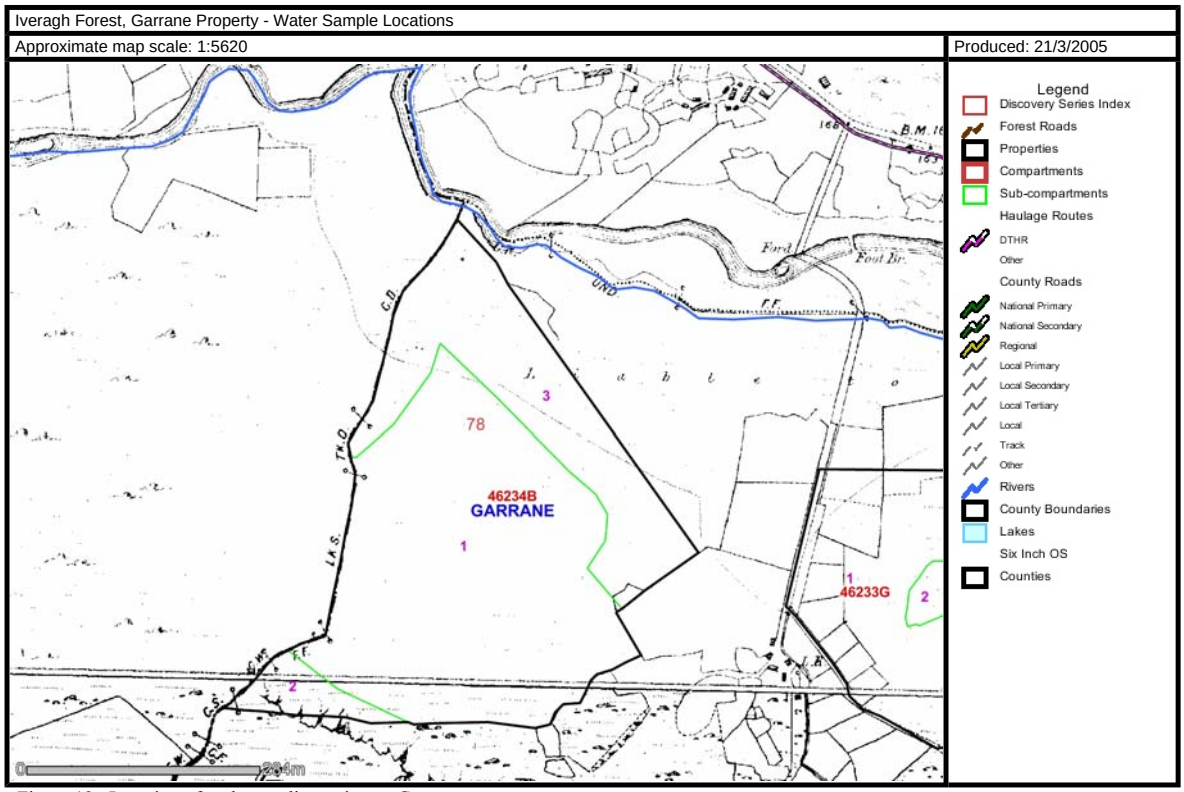

Figure 12. Location of grab sampling points at Garrane

below (No. 5) the confluence of the watercourses from Garrane property. Overall, water quality, as shown in Figure13, was of a high standard with little difference between the sample points for the main parameters tested.

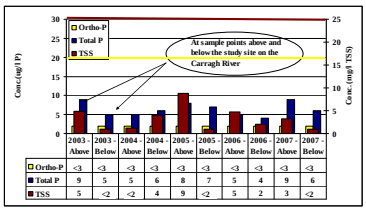

Figure 13. Mean concentrations of TSS, Ortho-P and TP determined above (No. 4) and below (No. 5) where the watercourses in Garrane property converge with the Caragh River for the years '03 to '07.

A comparison of the maximum concentrations observed at these points (Figure 14) would strongly suggest that backround erosion pressures upstream of the property, as indicated by higher levels of TSS and TP, had a greater impact on water quality of the main river than harvesting operations at Garrane.

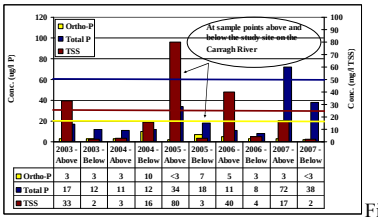

Figure 14. Maximum concentrations of TSS, Ortho-P and TP determined above (No. 4) and below (No. 5) where the watercourses in Garrane property converge with the Caragh River for the years '03 to '07

BELLAVEENEY STUDY SITE,
CO. MAYO

Figure 15. Location of Bellaveeney study site

The autosampler was located on the headwaters of a tributary of the Owenduff River, and just upstream of the confluence with an adjacent moorland tributary at the eastern property boundary (see Figures 15 & 16).

Due to the distance of the sample point from the nearest forest road, a Muskeg was used to transport all the equipment required to the monitoring site (Figure 17, 18 & 19). Water sampling started at Bellaveeney on the 26th June '03 and stopped and equipment removed on the 29/11/07.

Bellaveeney had the second largest catchment of the three automated sampling sites at 152 ha but the largest felling coup at 85 ha (equating to 56% of the catchment). The trees were felled manually to waste in between November'03 to July'04 (see Table 3) and the site then windrowed. Once harvesting was finished, drain blocking commenced and was completed in December'04.

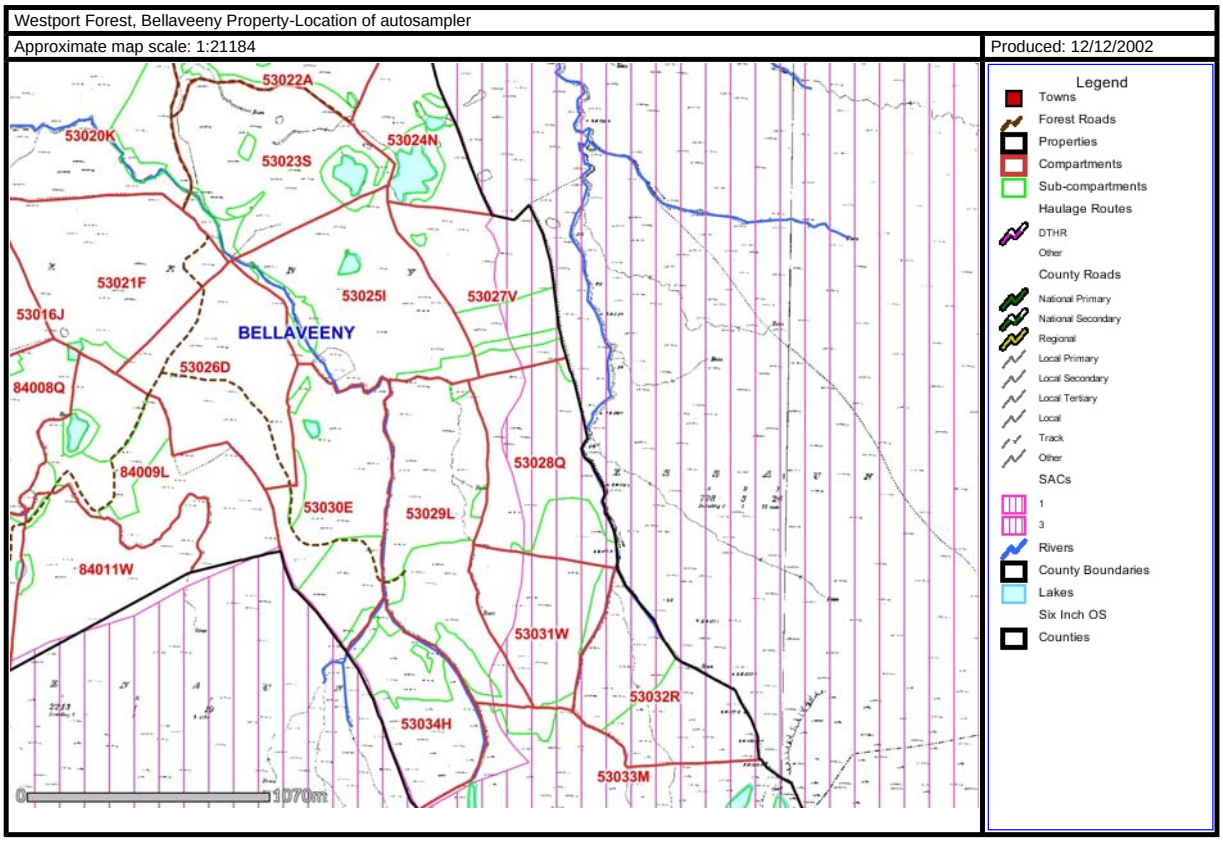

Figure 16. Location of autosampler at Bellaveeney

Table 3. Timescale of the various operations at Bellaveeney

Operations	Duration
Water monitoring	
- Autosampler	26/6/03 to 29/11/07
Harvesting	~Nov.'03 to July'04
Drain blocking	~July to December'04

AUTOSAMPLER RESULTS:
26/6/03 TO 29/11/07

- *Before operations: (26/6/03 to 28/10/03)*

The monitored waters at Bellaveeney would be characterised as acid sensitive with pH ranging from approximately pH 7.50 in low flow to pH 5.00 in high flow. Buffering capacity is minimal with alkalinity readings consistently <1 mg/l $CaCO_3$ and hardness values in and around 10 mg/l $CaCO_3$.

Water quality was of an exceedingly high quality prior to the start of operations. Both forms of P were either not detected or detected at trace concentrations (Figure 16 and 20).

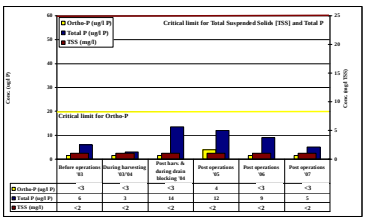

Figure 16. Median concentrations of TSS, Ortho-P and TP determined at the autosampler at Bellaveeney during the various stages of operations in the period June'03 to November'07.

Figure 17. Using a Muskeg to transport material to the monitoring point at Bellaveeney.

Figure 18. Setting up the autosampler at Bellaveeney in June'03.

Figure 19. Autosampler in operation prior to the commencement of harvesting operations at Bellaveeney.

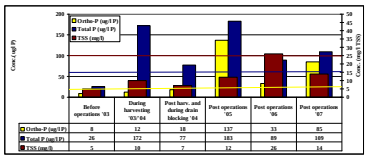

Figure 20. Maximum concentrations of TSS, Ortho-P and TP determined at the autosampler at Bellaveeney during the various stages of operations in the period June'03 to November'07.

- *During harvesting and drain blocking: (1/11/03 to 31/12/04)*

Overall, mean water quality did not change during harvesting and actually improved somewhat as TP concentrations declined in comparison to pre-harvesting levels (i.e. from 6 µg/l P [before operations '03] to 3 µg/l P [during harvesting '03/'04]). However, a sharp increase in the maximum values of TP and to a much lesser extent Ortho-P and TSS was noted in this period (Figure 20). A once off daily concentration for TP of 172 µg/l P was determined in late July'04 but in general daily TP values never exceeded that observed prior to the start of operations.

After harvesting and during drain blocking, average TP values began to slowly increase and at a mean concentration of 14 µg/l P was more than twice that observed at that start of monitoring. That been said, the TP values were well within the indicative critical value of 62 µg/l P for TP. In regard, to Ortho-P, daily values became more erratic but average values were comparable to that observed before harvesting. TSS concentrations increased marginally in this period but to a lesser extent than that of TP and Ortho-P.

Finally, the levels of ammonia and nitrate remained the same throughout the four year study period and showed no impact from site activities at Bellaveeney.

- *Post operations: (1/1/05 to 29/11/07)*

The first year after operations ceased on site, irregular once off spikes of phosphorus, particularly as TP, occurred which were not a feature of the results prior to the commencement of harvesting in November'03. The frequency of these spikes abated in '06 and water quality from that date was comparable to before bog restoration measures commenced at Bellaveeney.

Figure 20. Servicing the autosampler at high flow at Bellaveeney.

EMLAGHDAUROE DEMONSTRATION SITE, CO. GALWAY

Figure 21. Location of Emlaghdauroe study site.

The autosampler is situated on a tributary, which drains Emlaghdauroe Property, and flows into Ballnahinch Lake. For security reasons the autosampler was located downstream of Emlaghdauroe Bridge on the main Clifden to Galway road (N59) (Figure 21 & 22).

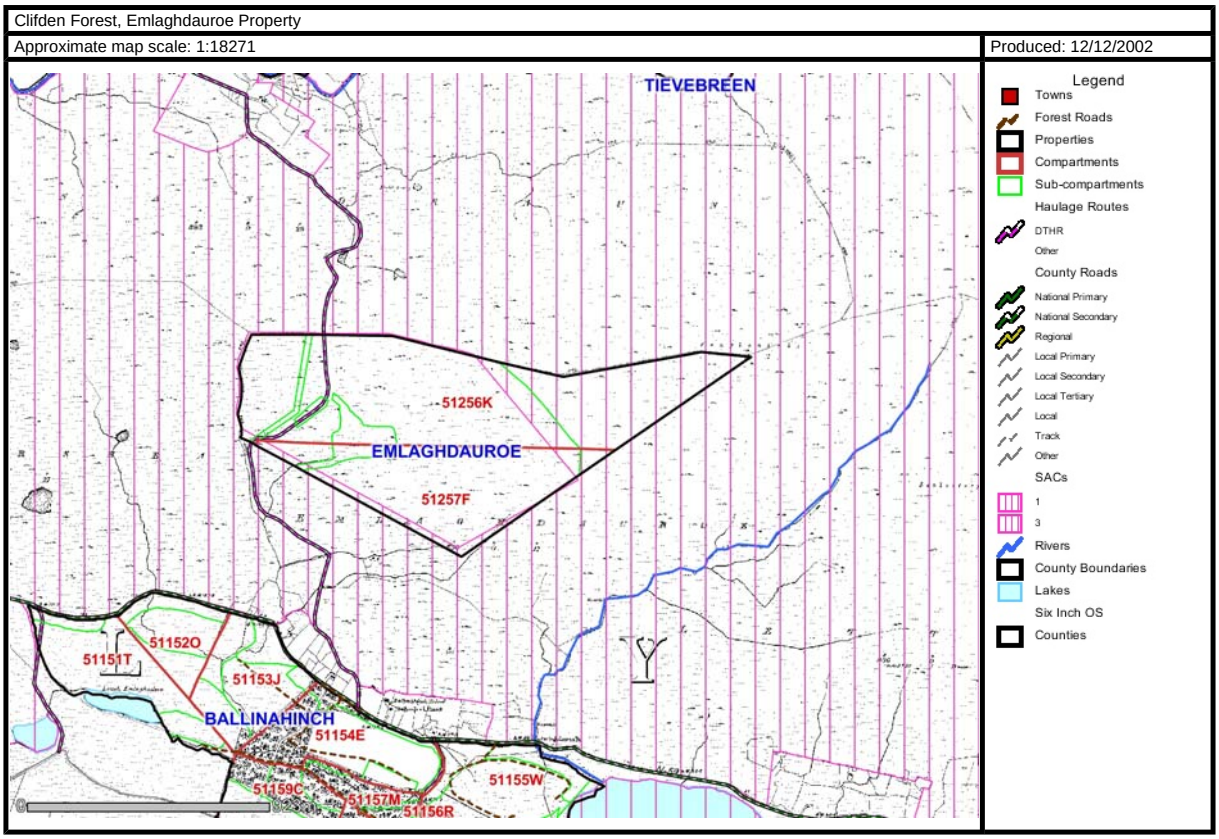

Figure 22. Location of autosampler and grab sample point at Emlaghdauroe

Emlaghdauroe had the largest catchment of the three automated sites at 170 ha. Unlike, the other sites, most of the 70 ha (equating to 41% of the total catchment) was commercially felled between April'03 to June'04 (Table 4.) resulting in less harvest residue remaining on site.

Sampling started at Emlaghduaroe in April'03 just as harvesting started. At the same time, Galway Co. Council carried out a significant drainage and road surfacing of the N59, including Emalaghdauroe Bridge, resulting in significant runoff from the roadside drains during high flow conditions into the tributary, upstream of the inlet to the autosampler.

Table 4. Timescale of the various operations at Emlaghdauroe

Operations	Duration
Water monitoring	
- Autosampler	3/4/03 to 16/11/07
- Grab sampling	11/8/04 to 7/11/07
Harvesting	~April'03 to June'04
Drain blocking	~June'03 to Dec.'04

AUTOSAMPLER RESULTS:
3/4/03 TO 6/11/07

- *Before operations*

There is no baseline or pre-operation monitoring at this site as harvesting had commenced when the autosampler was set up in April'03.

The waters at the sampled tributary are acid sensitive with pH values varying in the range of pH 5.05 to 7.92. Alkalinity values were very low and were on average <6.00 mg/l $CaCO_3$. Hardness values fluctuated somewhat but were on average 14-15 mg/l $CaCO_3$.

- *During harvesting, drain blocking and road resurfacing: (3/4/03 to 31/12/03)*

An initial significant increase in TP levels (in comparison to Ortho-P) followed shortly by TSS was observed within two months of sampling starting at Emlaghdauroe. The highest concentrations were recorded between June to September'03, peaking in mid August. The maximum concentration for TP and TSS occurred on the 20/8/03, where levels exceeded the appropriate EPA critical limit by five to six times respectively (Figure 23).

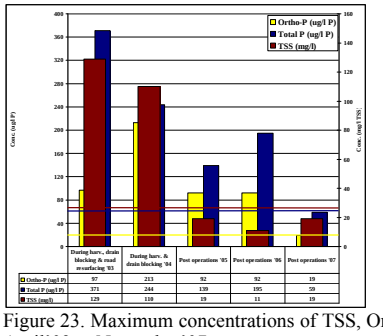

Figure 23. Maximum concentrations of TSS, Ortho-P and TP determined at the autosampler at Emlaghdauroe during the various stages of operations in the period April'03 to November'07

Ortho-P levels were slower to increase than TP and TSS and it wasn't until November'03 to February '04 that concentrations were consistently greater than the

acceptable threshold limit of 20 µg/l P was observed, peaking in December'03.

In general, water quality at Emlaghdauroe in '03 with the exception of TP, was satisfactory as both Ortho-P and TSS were for the most part present at negligible concentrations (Figure 24).

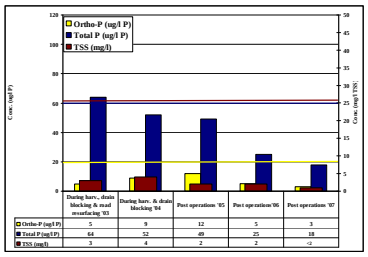

Figure 24. Median concentrations of TSS, Ortho-P and TP determined at the autosampler at Emlaghdauroe during the various stages of operations in the period April'03 to November'07

The presence of significant concentrations of other nutrients such as ammonia and nitrate was not a feature at this site and with the rare exception, daily concentrations never exceeded 0.20 mg/l N-NH_3 and 0.10 mg/l N-NO_3 respectively.

- *During harvesting, drain blocking and road resurfacing: (1/4/04 to 31/12/04)*

During the second year of operations, Ortho-P and TP concentrations decreased somewhat for most of the Spring and Summer'04 but spiked again in early November'04, where concentrations of 213 and 244 µg/l P were detected respectively in high stream flow on the 2/11/04.

Sediment loss was not overly apparent in '04. Only on three days out of 235 days where the autosampler was operational were concentrations recorded that exceeded the critical limit of 25 mg/l.

- *Post operations (5/1/05 to 6/11/07)*

There was a cross the board improvement in water quality for all tested paremeters from '05 onwards. By 2006, average levels of TSS, Ortho-P and TP were at or less than the critical limit for the respective parameters. In 2007, further decreases were noted and maximum concentrations for the aforementioned parameters never exceeded tolerable levels. Water quality at that stage was the best since monitoring began.

GRAB SAMPLING RESULTS:
11/8/04 TO 29/12/04

In an attempt to determine the impact on the tributary from the bog restoration measures, while excluding that of road re-resurfacing, fortnightly grab sampling was started in August'04 upstream of the road and bridge on a watercourse draining the property at sample point No. 1 (Figure 22).

- *Watercourse draining Emlaghdauroe Property (Sample point No. 1)*

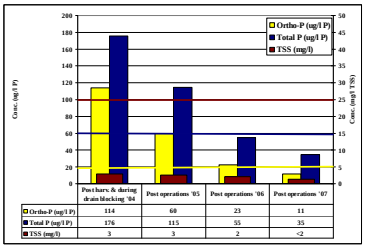

Figure 25. Mean concentrations of TSS, Ortho-P and TP determined on the watercourse draining from Emlaghdauroe at sample point No. 1 in the years '04 to '07.

As can be seen in Figure 25, phosphorus losses were significant in 2004 but have steady declined in the intervening years. Of particular note was how consistent the losses appeared over time with little variation between the samplings. A comparison of mean and maximum P concentrations, shown in Figure 25 and 26 indicate very similar values and patterns throughout the three years monitoring was conducted.

By 2006, the average levels of both Ortho-P and TP were at or less than the critical limits for either parameter and decreased further in 2007 to negligible concentrations.

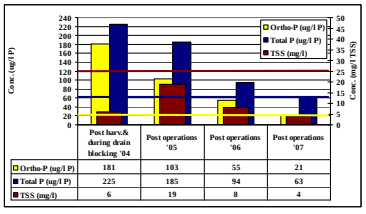

Figure 26. Maximum concentrations of TSS, Ortho-P and TP determined on the watercourse draining from Emlaghdauroe at sample point No. 1 in the years '04 to '07.

Finally, the silt loss was not significant at this sample point, which was reflected in the consistently low concentrations detected throughout the monitoring period.

CONCLUSIONS

- The impact of bog restoration measures varied great between the four monitoring sites. Surprising, Bellaveeney, which had the largest felled area resulted in the least effect on water quality.
- What minimal impacts where observed in Ballaveeney, primarily related to periodic spikes in daily concentrations of Ortho-P and TP. These sharp changes in daily concentrations, considered to be related to the nutrient losses from the decomposing harvest residue, decreased in time and two years after felling were very infrequent.
- The large intact well vegetated buffer zone (~20 to 50 m in width) adjacent to the tributary at Bellaveeney was considered to have played a major role in minimising the impact of harvesting at this site. The buffer zone ensured that:

- The critical threshold for total suspended solids of 25 mg/l was never exceeded
- The limits for Ortho-P (20 µg/l P) and TP (62 µg/l P) were exceeded on only 7 and 8 days respectively of the 287 days the autosampler was operation in '05, the most significant year an effect on water quality was observed.

- Where significant impacts on water quality were observed, such as Dromalonhurt and Emlaghdauroe, they varied from being of short duration in the case of the former to more prolonged in the case of the later.
- In regard to Dromalonhurt, notwithstanding the large increases in Ortho-P and TP for two weeks during harvesting period, overall water quality was considered highly satisfactory throughout the study period, bearing in mind the lack of a vegetated buffer zone and felled tress on either side of the tributary bank.
  - Only one sample, out of the 206 daily samples taken in the post-harvesting '04 period, exceeded the critical limit for TSS of 25 mg/l. The median concentration in this period was <2 mg/l. Therefore, leading one to conclude that silt loss was not a significant issue arising from the harvesting of the property
  - A marginal increase in both Ortho-P and TP, due to mineralisation of the harvest residue, was noted in 2004 and 2005 in comparison to that pertaining prior to bog restoration operations and by 2005, two years after operations were completed, Ortho-P exceeded the tolerable threshold of 20 µg/l P on only five out of 300 daily samples taken in that year. The median concentration during this sampling period was 8 µg/l P.
  - Four years after the completion of bog restoration measures at Dromalonhurt, water quality at the autosampler sampling point was highly comparable to before the start of operations.
  - Apart from the impacts of the bog restoration measures on the tributary's water quality, the results from the grab sampling indicated periodic but highly significant bank erosion between the forest property, where the autosampler was located, and the outflow to the River Caragh.
- The water results at Garrane were confounded by the regular flooding of the site, resulting in inexplicably large concentrations of suspended solids and phosphorus at sampling locations considered outside the harvested area.
- That been said the results from the Caragh River both at Dromalonhurt and Garrane indicated that natural erosion pressures in the headwaters of the river was a greater determinant on the river's water quality than bog restoration operations conducted at both sites.

- Finally, it was impossible to distinguish the impacts from the felling at Emlaghdauroe from that of the resurfacing of the nearby road at the point where the autosampler was located.

- Grab sampling of a natural watercourse draining this property did show consistently high P losses (both Ortho-P and TP) immediately after harvesting and continued to do so for at least another two years afterwards. The presence of high Ortho-P and TP in the absence of TSS would strongly suggest that the decomposition of the brash on this steep property was contributing to the chronic phosphorus losses.

- Finally, the difference in nature of impacts and duration as that observed at Emlaghdauroe, Co. Galway and Dromalonhurt, Co. Kerry is not readily explicable and will require further site investigation

ACKNOWLEDGEMENTS

There are many who should be thanked for their assistance and support in ensuring this these monitoring studies were undertaken but the following must receive particular mention:

- My colleague, Dr. Richard McCarthy, (now retired), who set up the water monitoring network with me at the Life Demonstration sites in 2002/2003.
- District and Site Managers; Con O'Shea (Dromalonhurt and Garrane), John Kelly (Emlaghdauroe) and Seamus O' Connor (Bellaveeney).
- The dedicated team of samplers at each site, who maintained and serviced the autosamplers and took grab samples in all weather conditions throughout the year; William Mangan (Dromalonhurt and Garrane), John Kelly (Emlaghdauroe) and Philip Irwin (Bellaveeney).
- The laboratory staff in ensuring that the water analysis was completed in a timely and efficient manner.
- Dr. Florence Renou, who assisted in the data compilation and statistical analysis of the water monitoring test data.
- Finally and most importantly of all, the EU Life Nature Funding Programme.

Philip O'Dea
4/6/08.