

Catchment risk assessment Amlaird WTW



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Summary

- Raw water quality at Amlaird water treatment works (WTW) is generally good. However, raw water colour is consistently high and true colour reached levels of 272 Hazens in 2008, with the works originally designed for a maximum of 244. In 2009-10, apparent colour was generally 230-240 Hazens, but peaked at 400 Hazens following reservoir de-stratification in the autumn. In 2006 there was also a *Cryptosporidium* breach.
- The geology of the Amlaird WTW catchments is dominated by volcanic igneous rocks such as basalt. Basalt is less permeable than sedimentary rocks and when combined with high rainfall produces waterlogged soils with large areas of blanket peat cover. Throughout the catchment the soils are artificially drained.
- The main land uses in the catchment are agriculture (rough moorland grazing and improved grassland), forestry (Whitelee Forest) and the Whitelee Windfarm.
- At Lochgoin Farm around 500 ewes are grazed on improved grassland and on the hill land in the summer. Lambing takes place at Lochgoin Farm in April/May.
- At Myres Hill, in the east of the catchment, around 30 ewes are grazed on rough moorland. This will be increased to 300 ewes in 2010/11.
- At Lochgoin Farm, nitrogen, phosphate and potassium (20:10:10) fertiliser is applied to the improved grassland at an application rate of 190 kg ha⁻¹. The fertiliser applications are applied in the spring. Some manure from the lambing sheds is also stored and spread in these fields.
- 28 wind turbines are also located within the catchment. These form part of the Whitelee Wind Farm, the largest inland wind farm in Europe with a total of 140 turbines.
- Overall, the main risk to water quality appears to be from the number of livestock in the catchment resulting in a moderate to high *Cryptosporidium* risk.
- Other risks to raw water quality include:
 - Diesel use in vehicles and in wind turbines
 - Use and storage of other chemicals on the windfarm
 - Use of organo-phosphate sheep dip at Lochgoin Farm
 - Diesel storage on farm
 - Storage and application of inorganic fertilisers
 - Septic tanks associated with Lochgoin Farm and the 'Scottish Power Renewables' Control Compound

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Amlaird WTW – Catchment risk assessment

1. Introduction

Amlaird Water Treatment Works is supplied with raw water from the Craigendunton and Lochgoin Reservoirs. Lochgoin Reservoir supplements Craigendunton by overflow (in winter months) or by valve (in the summer).

Craigendunton Reservoir (Plate 1) is situated to the north east of Waterside village, approximately 30 km south of Glasgow at 245 m above sea level (asl) and National Grid Reference (NGR) NS525457. Lochgoin Reservoir (NGR NS538476) is located c.2 km to the north east of Craigendunton Reservoir at 260 m asl. Lochgoin (Plate 2) is also supplemented by pipe flow from the Myres Burn in the upper eastern part of the Craigendunton Reservoir catchment at c.270 m asl.

The hydrological catchment is dominated by rough grazing and the Whitelee Windfarm with some forestry close to the Craigendunton Reservoir. Raw water quality at the Amlaird water treatment works (WTW) (NGR NS483444) is generally good and stable. However, colour (associated with dissolved organic carbon) is consistently high and can increase following reservoir de-stratification in the autumn and after heavy rainfall. The treatment process is able to cope with the rapid changes in water colour and turbidity that occur.



Plate 1. View north east from Craigendunton Reservoir dam.

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The Craigendunton reservoir catchment is dominated by low density sheep grazing. Both Craigendunton Reservoir and Lochgoin Reservoir are used as a private trout fishery. However, the fish stock are not supplementary fed and 'ground baiting' of fish (feeding to attract fish to certain areas) is not permitted. Diesel motors are also not permitted on the reservoir.

The remainder of this document focuses on the land and land management within the Amlaird WTW water supply catchments and the raw water quality associated with it.



Plate 2. View north east across Lochgoin Reservoir

2. Raw water quality issues

Amlaird WTW (Figure 1) feeds the towns of North Kilmarnock, Fenwick, Kilmaurs, Galston, Greenholm, and Darvel. It also supplements Stewarton. The average flow rate of the works is 14 Ml day^{-1} and supplies a population of approximately 34,800. The raw water source is from Craigendunton Reservoir approximately 4 km to the east of the works and Lochgoin Reservoir approximately 2 km north east of Craigendunton. The works is a conventional two stage works employing ferric sulphate coagulation, dissolved air flotation and rapid gravity filtration with intermediate lime dosing prior to the rapid gravity filters enabling manganese removal within the filters. Intermediate chlorine is added for disinfection, lime for final pH correction and orthophosphoric acid is dosed for plumbosolvency control. The works supplies one service reservoir (Hillfarm SR) and supplements one other (Williamshaw SR).

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Figure 1. Location map of Amlaird WTW and water supply catchment (the catchment map does not indicate recent felling activity or the location of 28 wind turbines)

Raw water quality at Amlaird WTW is generally good. However, raw water colour is consistently high and true colour reached levels of 272 Hazens in 2008, with the works originally designed for a maximum of 244. In 2009-10, apparent colour was generally 230-240 Hazens, but peaked at 400 Hazens following reservoir de-stratification in the autumn. Wet summers have resulted in peaks of high colour observed considerably earlier in July following heavy rainfall. High colour is then sustained for as long as the weather remains wet, normally until the first autumn frosts.

A Scottish Water Incident Report in August 2008 reported that increases in colour co-incident with windfarm construction within the Amlaird water supply catchment. The report intimated that windfarm construction may have had an effect on raw water quality, although this was not conclusive.

Turbidity also increases following heavy rain, but is normally within the range 1–3 Nephelometric Turbidity Units (NTU). The WTW is normally able to cope with the temporary deterioration in raw water quality and can still produce final water of acceptable clarity.

Algal blooms are occasionally observed in the summer, but do not cause significant problems for the water treatment works.

Soluble manganese concentrations are high in the summer and following reservoir de-stratification in the autumn, but lime dosing prior to the rapid gravity filters enables manganese removal within the rapid gravity filters (RGF's).

Cryptosporidium is occasionally present in the raw water as a consequence of the number of sheep and lambs within the water supply catchments. The

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treatment process is normally able to cope with occasional high *Cryptosporidium* counts.

3. Causes of high water colour and turbidity

There have been several hypotheses for increased water colour and dissolved organic carbon (DOC) concentrations in streams and rivers. These include:

- Increasing air temperature (Freeman *et al.*, 2001)
- changes in land management (Worrall & Burt, 2007)
- changes in pH, both increases and decreases (Krug and Frink, 1983; Bouchard, 1997; Greive, 1990a, b; Kullberg and Petersen, 1987)
- Change in the amount and nature of flow (Tranvik and Jansson, 2002)
- Nutrient enrichment (Harriman *et al.*, 1998)
- Increasing atmospheric CO₂ (Freeman *et al.*, 2004)
- Severe summer drought (Worrall *et al.*, 2004)
- Decrease in acidic deposition (Evans *et al.*, 2005; Clark *et al.*, 2005)

In the UK, Mitchell and McDonald (1995) identified primary diffuse sources of colour as areas of extensive peat with slopes <5° and high drainage densities. Heather burning and moorland gripping were identified as land management practices likely to increase water discolouration. The Craigendunton reservoir catchment does have some of these characteristics with gentle slopes dominated by drained peaty soils, heather moorland and rushes.

4. Amlaird catchment

4.1 Geology, geomorphology, soils and vegetation

The geology of the Amlaird catchment is dominated by volcanic igneous rocks such as basalt. Basalt is less permeable than sedimentary rocks and when combined with high rainfall produces waterlogged soils with large areas of blanket peat cover.

Soils in the Amlaird catchment range from improved organo-mineral soils around Lochgoin Farm to genuine peaty podzol and peat soils on Flow Moss and Drumduff Hill. The catchment is mainly flat to gently sloping with extensive areas of heather moorland and peat bog (Plate 3). Soils vary from genuine peat soils which range from 1m to 7m deep to organo-mineral soils with peaty top layers.

The plant communities found in the Amlaird catchment include heather moorland, sphagnum mosses and cotton grass on the wetter blanket bog areas, acid grasslands, bracken beds, moorland scrub, wet flushes and improved grassland. Lower areas adjacent to burns and flushes are dominated by rushes (*Juncus spp.*), cotton grass, mosses and sphagnum bog. The lower western half of the catchment is dominated by rough moorland grasses (Plate 4), while the higher eastern end is dominated by Common heather (*Calluna vulgaris*) and Bilberry (*Vaccinium myrtillus*). Approximately

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40 hectares of improved grassland surrounds the farm buildings at Lochgoin Farm, just over half of which is in the water supply catchment.



Plate 3. View west from Drumduff Hill (eastern end of catchment – 350 m asl) towards the Craigendunton Reservoir and Lochgoin Farm.

4.2 Land use

The Amlaird catchment is dominated by rough grazing and colonised by heather (blanket bog). There are c.150 ha of commercial forestry on the southern edge of the catchment to the east of Craigendunton Reservoir, either side of the Birk Burn and between Hareshaw Hill and Rough Hill. The catchment is popular with walkers and the Dam and Reservoir are occasionally used for fishing.

There a number of tracks used to access forestry and the 28 wind turbines within the catchment. These form part of the Whitelee Wind Farm, the largest wind farm in Europe with a total of 140 turbines.

Table 1. Land use in Amlaird WTW catchment.

Catchment	Land use						
	Rough grazing	Forestry	Maintenance vehicles	Boating	Walking	Fishing	Other
Amlaird WTW	✓	✓	✓	x	✓	✓	Wind Farm



Plate 4. View east south east from Lochgoin Reservoir dam towards Flow Moss.

5. Land management

5.1 Agriculture

The western end of the catchment is managed by Mr J Barr of Lochgoin Farm, while the eastern end, around Myres Hill, is managed by Mr R Chambers. The majority of the catchment is used for low intensity sheep grazing. Silage is baled and stored within the catchment. Fertiliser and manure are applied to the improved grassland at Lochgoin Farm, but no herbicides have been applied for a number of years.

Lambing takes place in the catchment so the catchment has a medium to high *Cryptosporidium* risk. Sheep are also dipped in the catchment at Lochgoin Farm.

Table 2 summarises the land management activities in the Amlaird WTW catchment.

Table 2. Agricultural activity in the Amlaird WTW catchment.

Catchment	Agricultural activity							
	Low intensity sheep grazing	Low intensity cattle grazing	Fertiliser storage or spreading	Pesticide storage and use	Manure storage or spreading	Silage storage	Sheep dipping	In-bye (enclosed) grassland
Amlaird WTW	✓	x	✓	x	✓	✓	✓	✓



Plate 5. Improved grassland at Lochgoin Farm.

5.1.1 Lochgoin Farm

At Lochgoin farm, approximately 500 ewes are grazed on rough moorland grazing and c.40 ha of improved grassland (Plate 5). Lambing takes place in sheds at the farmstead in April and May. Manure is spread to the improved grassland surrounding the farm. Young hogs (ewes that have not yet lambed) and older ewes are grazed on the rough moorland grazing in the summer. There are a few large open drains on the open moorland, but there has been no recent drainage and none is planned.

Nitrogen, phosphate and potassium (20:10:10) fertiliser is applied to the improved grassland in the spring at an application rate of 190 kg ha⁻¹. There is a fertiliser store and a covered silage store at Lochgoin Farm. Herbicide has not been applied to the grassland for a number of years and none is planned.

Sheep are treated with an organo-phosphate sheep dip at Lochgoin Farm. Sheep are retained on a hardstanding area for a few hours before they are returned to the grassland.

The farm has a septic tank and diesel is also stored on farm.

5.1.2 Myres Hill

Mr R Chambers grazes around 20 ewes on the rough moorland grazing at Myres Hill. In 2010, now that the wind turbines have been established, numbers will soon be increased to c.300 ewes.

There is no improved grassland and no usage or storage of fertiliser, pesticide or sheep dip. Diesel is used in agricultural vehicles, but is not stored within the catchment.

5.2 Forestry

Nisbet (2001) stated that the major water quality concerns associated with commercial forestry are increased turbidity and sedimentation due to the soil disturbance accompanying cultivation, drainage, road construction and harvesting operations; and the enhanced capture of acid deposition by forest canopies resulting in further acidification of surface waters.

Forestry should be considered as a land-use whose management practices are very infrequent and spatially diverse. For example, unlike agriculture, most interventions posing a diffuse pollution risk such as cultivation, drainage, fertilisation, thinning and harvesting occur only once in a 40-60 year cycle for conifer plantations and even less frequent, or absent for broadleaved woodland. Such practices could have affected relatively large areas of a catchment during the period of extensive upland conifer afforestation that characterised the 1960's and 70's. This is no longer the case following the policy changes introduced during the 1990's. The drive for planting to move 'down the hill', involve smaller areas and more native woodland, and for existing forests to be redesigned to create a greater diversity in age, species choice and structure, have significantly reduced the diffuse pollution threat.

Even more significant was the introduction of the Forests & Water Guidelines in 1988, which has driven the development of best management practice to protect the freshwater environment within forests. The guidelines are now in their fourth edition and therefore have been tried, tested and adapted over a period of 20 years to ensure that the correct set of measures are in place. Although detailed testing has been limited to a relatively small number of sites, those selected provide a robust evaluation by focusing on very sensitive catchments and involving large-scale operations beyond that normally practised. The studies were conducted in close partnership with water regulators and water companies and the results published in both peer-reviewed (e.g. Nisbet, 2001; Nisbet *et al.*, 2002) and grey literature.

Adherence to the Forests & Water Guidelines is a pre-requisite for the UK woodland assurance scheme, and is a condition for issuing of felling licences and the award of planting grants. The Forestry Commission considers that levels of implementation are generally very high (90-100%).

5.2.1 Forestry Commission Scotland

Amlaird WTW water supply catchment is part of Whitelee Forest, which is managed by Scottish Lowlands Forest District. Until 2005, forestry occupied over 250 ha in the south central part of the water supply catchment. Around 65 ha were cleared in 2005-06 for the installation of five wind turbines and to reduce the amount of shelter.

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Forestry now occupies c.150 ha to the east of Craigendunton Reservoir, either side of the Birk Burn and between Hareshaw Hill and Rough Hill. The area to the north of Birk Burn is due for felling in 2009-10, while the area to the south is planned for 2011-12 and 2015-19. There is also a small area close to the Birk Burn tributaries, which is due for re-stocking in 2011-12. All felling and re-stocking activities are carried out in line with the 'Forests and Water Guidelines' (2003).

Fertiliser is not used on re-stocking areas as costs are prohibitive. Pesticide use is minimal with possible use of 'Roundup probiactive' (Glyphosate) for spot spray weed control. Trees used for re-planting are electrodyn treated at the source nursery with Alpha 6ED - a cypermethrin based insecticide. There is no prophylactic post-planting application of cypermethrin.

5.3 Whitelee Windfarm

Whitelee Windfarm covers an area of approximately 55 km². The generating plant consists of 140 'Siemens Wind Power' 2.3 MW turbines with a total output of 322 MW. The windfarm also consists of an associated infrastructure including 140 externally housed transformers, underground high voltage (HV) and communication cables and a Control Compound, which is the permanent work location for both Scottish Power Renewables Operations and Siemens Service (UK). The Control Compound is on the western edge of the Amlaird WTW water supply catchment, south west of Lochgoin Reservoir. The compound contains the Scottish Power Renewables Control Building including workshop/stores and an external lay down area for component storage. The area is enclosed with a fenced perimeter and includes car parking for all operational and service staff. There is also a septic tank and associated reed bed located to the rear of the Control Compound adjacent to the spine access road.

There are 28 wind turbines within the Amlaird WTW water supply catchment. These are served by a number of access roads. Each turbine uses approximately 800 l of oil and approximately 500 litres of antifreeze liquid. The turbine hub area is sealed, but not banded so if a leak develops in the hydraulic system (for example) it is likely that hydraulic oil will escape into the wider environment. There are spill response plans in place for all hydrocarbons and other chemicals used or stored within the catchment. These are detailed in the Scottish Power Renewables Whitelee Operational Site Environmental Plan, which includes details of monitoring and Environmental Incident Response Procedures. Vehicle Spill Kits are located within the workshop/store and carried in every site vehicle. Turbine Spill Kits are located within the workshop/store and at a number of specified turbines within the water supply catchment. The Spill Response Flowchart includes an instruction to report spills to Scottish Water on 0845 601 8855.

5.3.1 Windfarm construction and water colour

Windfarm construction has co-incided with an increase in raw water colour at Amlaird and other Scottish Water treatment works. However, the link between

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an increase in apparent colour and windfarm construction was inconclusive at Amlaird.

Between 2006 and 2010, the University of Glasgow have monitored dissolved organic carbon (DOC), soluble reactive phosphorus (SRP) and nitrate outputs from the larger Dunton Water catchment (which includes the Amlaird water supply catchment). DOC showed seasonality with maxima in the late summer/autumn, but while an increase in SRP was observed, DOC appeared to be unaffected by windfarm construction activities. The lack of increase in DOC between June 2006 and March 2010 appears to indicate either little impact of windfarm construction or downstream attenuation (Murray *et al.*, 2010). In other words, the fact that construction activities did not appear to affect DOC in the Dunton Water catchment (which includes a large area downstream of the Amlaird WTW catchment) does not mean that water colour in the Amlaird WTW catchment has not been affected. Continued monitoring should indicate whether felling planned for 2011 in the lower Dunton Water catchment will have an impact on DOC and SRP.

6. Conclusions

Raw water quality at Amlaird WTW is generally good. However, raw water colour is consistently high and true colour reached levels of 272 Hazens in 2008, with the works originally designed for a maximum of 244. In 2009-10, apparent colour was generally 230-240 Hazens, but has peaked at 400 Hazens following heavy rainfall and following reservoir de-stratification in the autumn.

Turbidity also increases following heavy rain, but is normally within the range 1–3 Nephelometric Turbidity Units (NTU). The WTW is normally able to cope with the temporary deterioration in raw water quality and can still produce final water of acceptable clarity.

Table 3 summarises the main water quality risks within the Amlaird WTW catchment.

Livestock numbers within the catchment mean that the *Cryptosporidium* risk is moderate to high.

Despite fertiliser and manure storage within the catchment, the risk from fertiliser and manures is low. Pesticide usage in the catchment is limited to the very occasional use of glyphosate for weed control in forestry re-stocking areas. Re-stocking is planned for a small area on the southern edge of the catchment in 2011-12.

Although no problems have arisen to date from the 28 wind turbines located within the catchment the risk of oil leaks and spillages should be monitored. The risk is reduced by the fact that Scottish Power Renewables have introduced 'Environmental Incident Response Procedures' and 'Spill Response Plans' that are reviewed on an annual basis (or earlier, if required).

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Table 3. Risks to raw water quality in the Amlaird WTW catchment.

Risk	Source	Pathway	Magnitude of Risk	Risk management
<i>Cryptosporidium</i>	Livestock	Surface and Sub-surface flows	Moderate to High	Fence off watercourses
Water colour and turbidity	Heavy rainfall, artificially drained peat soils	Run-off and soil erosion	High	Follow PEPFAA code* to minimise soil erosion and run-off
Veterinary medicine/ insecticide – Organophosphate	Sheep dipping	Leaks from dipper tanks, and from dipped sheep if they have access to rough grazing within hours of dipping	Moderate	<ul style="list-style-type: none"> • Follow PEPFAA code* for sheep dipping and flock management • Follow Sheep Dipping Code of Practice for Scottish Farmers, Crofters and Contractors – Groundwater Regulations 1998 • Follow best practice guidelines
Nutrients	Fertiliser and slurry applications	Drainage, soil erosion	Low	Follow SAC Technical notes or RB209 for application rates and PEPFAA
Insecticide - Cypermethrin	control spruce weevil in forestry	Direct spray, spray drift, run-off	Low	<ul style="list-style-type: none"> • Use of buffer strips along watercourses • Do not apply near watercourses • Do not apply during wet weather • Follow best practice guidelines
Oil and other chemicals	Windfarm	Leaks and spillages from vehicles, wind turbines and stores; oil in surface run-off or groundwater	Low	Monitor risk and follow correct procedure in response to any leaks

* Prevention of Environmental Pollution From Agricultural Activity.

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