National Rivers Authority

Environmental Consultancy Support
Exe/Axe Water Resources

Impact of Reservoir Construction on the Bruckland Stream

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WS/Atkins

WS Atkins Water
a division of WS Atkins Consultants Limited
Curzon House
Southernhay West
Exeter EX1 1JG

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0. SUMMARY

By looking at projected yields, costs and environmental concerns, South West Water Services Ltd (SWWSL) has concluded that the Axe Pumped Storage Scheme provides the optimum resource development for the East Devon area. This scheme involves the construction of a reservoir at Higher Bruckland and the subsequent diversion of the Bruckland Stream.

Two ecological surveys were carried out by SWWSL and the National Rivers Authority – South West Region (NRA) in summer and autumn 1992. Using results from the surveys the main ecological characteristics of the stream were identified. The potential impacts of reservoir construction, the bypass pipeline, flood water release and seepage on the biology of the stream were examined and recommendations for additional data requirements and long term monitoring put forward.

Although the data provided were not extensive, the general picture was one of a clean water stream with reasonable species diversity. It was not possible to accurately predict any changes and more detailed ecological survey work was recommended.

1. INTRODUCTION

The proposed reservoir at Higher Bruckland will have a surface area, when full, of 20ha. The reservoir will be connected to a water treatment works at Whitford by a 4 km long pipeline. The construction of the reservoir will result in approximately 1 km of the Higher Bruckland Stream watercourse being drowned. The stream will be permanently diverted in an underground culvert for a distance of 1 km before rejoining the existing watercourse below the reservoir.

Whilst this report is not concerned with the impact of the proposed reservoir on fisheries in Bruckland Stream, it can be noted that the trout populations are very small. With respect to other uses, including landscape and recreational value, these are considered to be of little importance given the small size of the stream. Water quality in the stream is good and can be classified, based on 1992 data, as Class 1B under the National Water Council (NWC) River Quality Classification System (RQC).

This report is based on survey work carried out in Summer and Autumn 1992 by the NRA[1] and SWWSL[2]. The small amounts of baseline data provided are insufficient for statistical analysis, but identify the main ecological characteristics of the Bruckland Stream along the section which may potentially be affected by the proposed water resources scheme. As the biology of a river is closely linked to environmental factors such as water quality, water depth, flow velocity, substrate, turbulence, water temperature and river bed morphology, it is difficult to isolate the effects of a change in flow.

A reliable prediction of the effects on aquatic biology of the flooding of the upper Bruckland Valley and constructing a reservoir by-pass channel for the Bruckland Stream, would require extensive data acquisition over a longer period than this survey allowed.

However, it is possible to identify which elements of the existing biology of the rivers may change, and assess potential effects that the proposed water resources scheme might have on aquatic biology.

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1 River Axe Water Resources Scheme, Biological Study: Macroinvertebrate Study.

2 Axe Valley Water Resource Scheme: Summer and Autumn 1992 (NRA reference RP-PCA-1328AO-100(01)).

2. EXISTING BIOLOGY

The biological description of the Bruckland Stream has been derived from very limited data from four sampling occasions over the summer and autumn in 1992. One sampling programme was undertaken by SWWSL and the other by the NRA.

2.1 INVERTEBRATES

Upper Bruckland

The upper Bruckland Stream supports a reasonable aquatic invertebrate fauna, with a BMWP of around 120 and an ASPT of 6 (see Table 1). However, it is much less diverse than further downstream though the relatively high value of the ASPT indicates that it is a cleanwater fauna. This was attributed in the NRA survey to the more shaded nature of this site, restricting macrophyte growth, and its lower habitat diversity. The more abundant families recorded are Elmidae (beetles), Hydrobiidae (the gastropod *Potamopyrgus jenkinsi*), Chironomidae, and Gammaridae. In the autumn sample the mayfly family Heptagenidae is better represented. The alderfly *Sialis nigripes* is a notable species (Red Data Book, Category 3) occurring in this reach.

Lower Bruckland

The lower section of the Bruckland Stream supports a more diverse invertebrate fauna with a greater number of species. The BMWP score is between 105 and 161, but the ASPT is slightly lower than that at Upper Bruckland. Samples from this stretch contained larger numbers of individuals than samples from the Upper Bruckland section, apart from the large number of *Potamopyrgus jenkinsi* found in the summer sample at Upper Bruckland.

The nationally uncommon damselfly *Calopteryx virgo* was recorded in the Lower Bruckland as well as the locally rare beetle *Gyrinus urinator.* Notable species may have been under recorded in these studies since not all groups were identified to species level.

TABLE 1

Biotic Indices for Bruckland Stream 1992 (NRA)

Site	BMWP Score		ASPT Score		No. Species	
	Summer	Autumn	Summer	Autumn	Summer	Autumn
Upper Bruckland	120	81	6	5.79	20	14
Lower Bruckland	105	161	5.53	5.55	19	29

2.2 ALGAE

Upper Bruckland

Benthic diatoms are present in the upper Bruckland Stream, but no other algae were recorded in the 1992 survey. This section of the stream is heavily shaded, limiting plant growth.

Lower Bruckland

Cladophora is moderately abundant in the lower Bruckland Stream, and *Vaucheria* and benthic diatoms are also recorded. The community is indicative of moderately eutrophic waters in terms of the cover of filamentous algae and the community of epilithic diatoms. The score for the Generic Diatom Index, which ranges from 1 to 20 (highly polluted to clean), is between 11.3 and 13.5 for the upper and lower reaches (see Table 2).

TABLE 2

Generic Diatom Indices for Bruckland Stream 1992 (SWWSL)

Site	Summer	Winter
Reservoir site	12.9	11.3
Higher Bruckland Farm	12.0	11.7
Haye Farm	11.9	13.5
Lower Bruckland	13.4	12.3

2.3 MACROPHYTES

River corridor survey and transect information is available for one upper and lower reach (recorded August 1992).

The Bruckland Stream is much shallower than the River Axe with a depth of between 5 and 15 cm. The substrate comprises cobble, pebbles and gravel, together with silt trapped by emergent vegetation. The upper Bruckland Stream is heavily shaded where it runs through woodland and this restricts growth of aquatic macrophytes. In more open stretches emergent marginal macrophytes include fool's water-cress (*Apium nodiflorum*), reed canary-grass (*Phalaris arundinacea*), water mint (*Mentha aquatica*), brooklime (*Veronica beccabunga*), floating sweet-grass (*Glyceria fluitans*), and watercress (*Nasturtium officinale*). At the time of the survey the water flowed through a series of meanders past stands of emergent aquatic vegetation. No submerged macrophytes were recorded.

3. POTENTIAL IMPACTS OF RESERVOIR CONSTRUCTION AND BY-PASS PIPELINE

3.1 INVERTEBRATES

Siting of a reservoir in the Bruckland valley is likely to have a significant impact on the lower Bruckland Stream during the construction phase. This could involve temporary flow alterations, increased levels of suspended solids, and risk of pollution from oil or other chemicals on site.

The invertebrate fauna could be adversely affected by three impacts. The main adverse effect on aquatic invertebrate fauna is likely to arise due to the channelling of a large section of the stream within a piped culvert. There would be direct loss of invertebrates during diversion of the stream. The new piped section would result in an entirely new habitat of extremely limited diversity and productivity due to lack of light and oxygen, a smooth substrate, and little or no aquatic macrophyte growth. Upstream of the piped section there may be the possibility of back-up of water and marginal flooding during higher flows, due to a restricted volume of flow through the pipe. In addition, the existing invertebrate fauna upstream of the pipe would in effect be isolated from the rest of the river system. This could reduce the diversity of invertebrate life in the upper Bruckland Stream by inhibiting upstream migration.

The water quality downstream of the piped section is likely to be affected by the scheme. There would be limited aeration in the pipeline itself so there could be reduced oxygen levels in water flowing from the pipe. The rate of flow in the pipe is likely to be sufficient to prevent the problem of deposition in the pipe itself, but this could result in greater deposition in the lower Bruckland Stream. Changes in the aquatic environment in the lower Bruckland Stream are likely to be reflected in changes in the invertebrate communities.

The reservoir itself will take water from the Bruckland Stream catchment area, resulting in lower flows than currently occur in the lower Bruckland Stream. Lower flows result in other changes in the aquatic environment, and could affect invertebrate fauna in the stream below the pipeline.

If the pipe culverting of the Bruckland Stream goes ahead, the lower Bruckland Stream may therefore become slower flowing due to loss of catchment, with a more silty substrate, lower oxygen content, contributing to lower water quality. This could result in reduced diversity of invertebrates, loss of some of the mayfly and caddis larvae species recorded in the 1992 survey, and a potential increase in molluscs, leeches, chironomid larvae, and oligochaete worms.

The reservoir scheme involves construction of a carpark and teashop for visitors. Should any foul sewage facilities be installed it is likely that South West Water plc would wish to apply for a consent to discharge treated effluent to the streams which could further affect the invertebrate fauna in the lower Bruckland Stream. Run off from the car park is likely to carry pollutants (oils, suspended solids) and this should be diverted through silt traps and oil interceptors before final discharge to the watercourses.

3.2 ALGAE

The piped section of the upper Bruckland Stream would not support plant life. Algae, other than benthic diatoms, are not recorded in the upper Bruckland Stream which is heavily shaded, so piping the flow would have limited direct impact on algae.

3.3 MACROPHYTES

Construction of a reservoir in the upper Bruckland valley, and diversion of the existing stream to the south of the reservoir via a piped culvert, would result in extensive loss of wildlife habitat due to inundation. The section of the Bruckland stream from immediately below Bulmoor Coppice SSSI to 200m upstream of Higher Bruckland Farm is heavily shaded by mature overhanging trees, mainly oak, ash, willow, alder, hazel and holly. Although this shading limits the amount of aquatic macrophyte growth, the associated damp woodland ground flora is of some interest, and contains some ancient woodland indicators. A list of some species found along this section during a November field visit is given in Appendix A. Species found growing in or near the water include fool's water cress (*Apium nodiflorum*), opposite-leaved saxifrage (*Chrysosplenium oppositifolium*), water mint (*Mentha aquatica*), brooklime (*Veronica beccabunga*), yellow flag (*Iris pseudacorus*), and water figwort (*Scrophularia aquatica*). The mature trees and stream form a wide wildlife corridor particularly where a tributory enters the stream, linked up with Bulmoor Coppice SSSI, and is of ecological importance although the aquatic macrophytes themselves are of little interest. There were numerous birds noted in this woodland belt including tits, bullfinch, chaffinch, wren, little owl, and wagtails.

The proposed piped section of the Bruckland Stream would not support any macrophytes due to the lack of light and suitable substrate. It could also cause back-up of water and flooding at the upstream end of the pipe during high flows, and this would affect Bulmoor Coppice SSSI.

4. POTENTIAL IMPACTS OF FLOOD WATER RELEASE AND SEEPAGE

4.1 INVERTEBRATES

Additional flow down the lower Bruckland Stream due to flood water release following periods of heavy rainfall is unlikely to have a significant effect on the downstream freshwater invertebrate ecology, as this is already adapted to spate flows. However the additional water is likely to contain high concentrations of suspended solids, which could result in increased silt deposition as the flow subsides. Slight seepage of reservoir water to the Bruckland Stream is not expected to adversely affect aquatic invertebrates, but as there are no water quality or flow records for this watercourse, and the quality of the reservoir water has not been predicted, it is not possible to assess this impact satisfactorily.

4.2 ALGAE

It is not anticipated that additional flow in the lower Bruckland Stream following periods of heavy rainfall would have significant effects on algae, unless any species are transferred to the watercourse from the reservoir. Seepage of water from the reservoir is not expected to have a significant effect, but as mentioned in section 4.1 there are insufficient data on water quality to assess this. It is possible that the reservoir waters may be more eutrophic than the Bruckland Stream, in which case seepage could result in additional algal growth in the lower Bruckland Stream.

4.3 MACROPHYTES

Flood water release and seepage from the reservoir into the Bruckland Stream is not expected to have a significant affect on macrophytic vegetation, unless it results in substantial changes in water quality in the stream, or increased silt deposition in the channel.

5. RECOMMENDATIONS AND CONCLUSIONS

The complex inter-relationships that exist between environmental factors such as water flow velocity, turbulence, water quality, substrate characteristics, wetted bed area and water depth, and associated biological characteristics render the accurate prediction of impacts caused by changes in any particular environmental factor extremely difficult. The amount of comparable data presently available is inadequate to attempt any accurate assessment of the impacts associated with reservoir construction and diversion of the Bruckland Stream.

In order to provide a more detailed data base further survey work will be necessary, including detailed measurements of water depth, flow velocity, turbidity, water temperature, channel morphology and substrate characteristics, and water quality. At the same time ecological characteristics of certain stretches of the stream should also be recorded in detail, including macrophytes, algae, aquatic invertebrates, fish and adjacent marginal flora and fauna, in order to relate these biological characteristics directly to other measured environmental conditions. This data would establish the existing environmental conditions and enable future monitoring to be related directly to this baseline information.

Plans for long-term monitoring of environmental conditions in the Bruckland Stream need to be drawn up at an early stage, before implementation of the scheme. Monitoring of the long term effects of the reservoir construction on the stream are necessary to provide a fuller understanding of the proposed development on the River Axe and its catchment generally. This would enable environmental changes as a result of construction activities and operation of the scheme to be detected, and suitable amelioration options discussed and implemented before any irreversible damage is done should any adverse impact be identified.

A preferable option to the culverting of the Bruckland Stream would be to channelise the stream through an open culvert. Although the colonizing invertebrate population would be limited initially by the smooth substrate and lack of aquatic macrophytes, there would be potential for gradual development of a more interesting fauna than would be possible in a closed pipe. An open channel would permit positive measures for habitat improvement. Actual excavation of the reservoir would result in loss of invertebrates due to physical removal or to downstream displacement of dislodged invertebrates. Colonization of the culverted section following construction would depend on the substrate characteristics, rate of flow, and rate of vegetation colonization.

Ideally the new channel alignment should copy the existing channel characteristics as closely as possible to enable recolonization by a similar invertebrate assemblage. Sediment from the existing channel could be transferred to the culvert to speed up natural colonization of the new channel.

The new channel could potentially develop a more interesting aquatic invertebrate fauna than exists in the heavily shaded stretches of the upper Bruckland Steam, depending on the methods of design and construction used.

Should the stream be diverted into an open culvert, a more abundant and diverse algal community is likely to develop, including species already found in the downstream section (*Vaucheria* and *Cladophora*).

Careful construction of an open culvert bypass would enable fairly rapid colonization of aquatic plants provided that suitable substrate is present. The open nature of a new culvert could enable greater aquatic vegetation growth than in the shaded upper Bruckland Stream, and hence greater invertebrate productivity. It might be expected to be colonized by similar species to those present in the lower Bruckland Stream, depending on the flow velocity and substrate.

APPENDIX

Field Visit : 14.11.92 / 15.11.92

Bruckland Stream

A358 Roadbridge - Steep sided bank with improved pasture either side. Muddy cattle/stock watering areas. No interesting aquatics.

Musbury House - Large boulders and gravel. Nettles and grasses on banks. No submerged species.

Lower Bruckland Farm - Stream passes along hedgerow with ivy, ferns, mosses. Patches of *Apium nodiflorum.*

Haye Farm - West of roadbridge stream flows through sheep-grazed pasture with sloping grassy banks - only supports *Apium nodiflorum* and rushes (*Juncus* sp); east of bridge the stream is heavily shaded by mature dense hedgerow trees to the south. Much organic debris in stream. No submerged or emergent species seen.

Higher Bruckland Farm - Less than 1m wide; fairly rapid flow. Clipped hedge with many willows on one side. Much algae, ferns including harts' tongue fern, *Epilobium hirsutum*, and *Juncus* sp, *Iris pseudacorus*. Some patches of froth - possibly farm pollution.

Downstream of spring, vegetation on north bank has been cut. There is a new flow gauge? V-notch weir? and water level.

NGR 286935 to 288937 - Shaded in deeply cut valley with trees either side - mature oak, hazel, ash, alder, elder, willow, holly, ivy, brambles, and field maple. Few aquatics recorded, but interesting riverside flora with many bryophytes, ferns and woodland species, and lichen. River bed with stones, gravel, and silt. Banks become steeper and higher upstream.

Liverworts	-	*Marchantia* sp
Mosses	-	Numerous species
Ferns	-	Harts tongue fern (*Asplenium scolopendium*)
		Soft shield fern (*Polystichum setiforum*)
Higher plants		
Square stalked willow herb	-	*Epilobium tetragonum*
Burdock	-	*Arctium pubens*
Opposite-leaved saxifrage	-	*Chrysosplenium oppositifolium*
Wood avens	-	*Geum urbanum*
Hogweed	-	*Heraclium sphondylium*
Bedstraw	-	*Galium* sp
Greater stitchwort	-	*Stellaria holostea*
Wavy bittercress	-	*Cardamine flexuosa*
Wild rose	-	*Rosa* sp
Foxglove	-	*Digitalis purpurea*
Enchanter's nightshade	-	*Circaea lutetiana*
Yellow flag	-	*Iris pseudacorus*
Dog's mercury	-	*Mercurialis perennis*
Primrose	-	*Primula vulgaris*

Ivy	-	*Hedera helix*
Lungwort	-	*Pulmonaria officinalis*
Bastard balm	-	*Melittis melissophyllum*
Lesser periwinkle	-	*Vinca minor*
Water figwort	-	*Scrophularia aquatica*
Hemlock water dropwort	-	*Oenanthe crocata*
Pendulous sedge	-	*Carex pendula*
Soft rush	-	*Juncus effusus*
Jointed rush	-	*Juncus articulatus*
Fool's water cress	-	*Apium nodiflorum*
Square stalked St John's wort	-	*Hypericum tetrapterum*

Conservation Value - Mature woodland trees and streams form good wildlife corridor. Many damp woodland plants, some indicators of ancient woodland. Linked with Bulmoor Coppice SSSI upstream. Important ecological unit.

NGR 288937 to 294938

As above, but more open areas with pasture.

Additional plant species :

Wood spurge	-	*Euphorbia amygdaloides*
Water mint	-	*Mentha aquatica*
Brooklime	-	*Veronica beccabunga*
Violet	-	*Viola riviniana*
Ground ivy	-	*Glechoma hederacea*

More willow and alder along this stretch, plus holly.

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