Living Water

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Living Water Capabilities

Living Water, founded in 1989 by Jane Shields and David Shields, is a pioneering and innovative company applying ecological principles to solve a range of water and waste problems associated with households, communities, developments, landfill, agriculture, vineyards and industry.

Our approach begins with water and waste minimisation, resource management and recycling and our treatment systems recreate pond, wetland, soil and woodland ecologies, selected and designed to meet the unique requirements of each project.

We have developed techniques to treat effluent and wastes with a high organic loading (e.g. distilleries, vineyards, farms, cosmetic industry) and those with a high hydrocarbon content (e.g. oil industry, road gully tankers, contaminated soil and sludges).

The aim of our work is to transform contaminated water and waste into usable resources using a combination of natural processes. Any material that cannot be reused or recycled is incorporated into the food web where it can enhance biodiversity.

Living Water has carried out consultancy, water and waste management work and the design and implementation of a range of ecological systems for a number of clients including British Petroleum plc, AMEC Services plc, The Body Shop International plc, GEHE plc, Tayside Contracts, Electro Furnace Products Ltd., EWOS Ltd., BSW Timber plc, The National Trust (England and Wales), The National Trust for Scotland, NEXFOR, William Grant & Sons and other distilleries, industries, regional and city councils, water authorities, architects, engineers, developers and householders. A complete client list is provided at the end of this document.

Living Water works in a broad range of areas:

1. **Ecological water and waste treatment**

2. **Bioremediation and phytoremediation of contaminated soils and sludges**

3. **Surface water management and treatment**

4. **Capture and recycling of roof water**

5. **Integrated strategies, watershed and catchment management**

6. **Treatment of vineyard effluent and waste**

7. **Management of surface water and treatment of run-off from vineyards**

8. **Development of new applications of the ‘rhizoid regeneration’ technique for monitoring pesticides and herbicides in vineyards**

9. **Biodiversity enhancement and functional landscaping**

We will now discuss each area in more detail.

1. Ecological water and waste treatment

In designing a system we work with a basic principle that in nature there is no waste, because the waste of one organism is food for another. Inherent within this are concepts of nutrient balancing, carrying capacity, completing and linking cycles and the food web.

We distinguish between a *biological treatment system* (using bacteria) which creates a sludge (unconsumed nutrient) and an *ecological system* which utilises a much wider range of flora and fauna (bacteria, microorganisms, invertebrates, fungi and plants) that consume nutrients and thus minimise sludge production. By providing the correct balance and mixture of flora and fauna it is possible to support creatures higher up the food chain, i.e. fish, birds, amphibians and mammals. The more complex the food web, the greater the efficiency, effectiveness and flexibility of the treatment system.

Each system is a unique design according to the particular characteristics of the pollutant (liquid or solid) and the context in which it is produced or discharged.

Steps include:

- Environmental audit.
- Management of the process to reduce the volume or toxicity of all end products.
- Management of water (process water, roof water, surface water).
- Assessment of the chemical composition and concentration of the effluent or waste product.
- Assessment of volume, flow rates, discharge rates and other relevant information on the timing or dynamics of feeds and waste products.
- Determination of potential resources that can be created using the waste products.
- Site assessment (level survey, climatic factors, available area, location in context with the wider community and landscape).
- Choosing and designing the biological and ecological system(s) required for the treatment and transformation of the effluent and waste into a resource.
- Appropriate sizing of the treatment system.
- Drawing up of detailed drawings and specifications.
- Liaison with project team and official bodies.
- Project management (we can act as the main contractor).
- Site management.
- Compliance with Health & Safety requirements.
- Supervision and commissioning of the construction process.
- Maintenance and aftercare.
- Landscaping and habitat creation.

We offer our clients a complete service from integrated management and design through to implementation and landscaping. An environmental audit and up front management steps are required because this is a necessary part of the design solution.

The implementation of water and waste minimisation measures has given our industrial clients a commercial payback on treatment systems of between one and two years.

Our treatment systems are considered best practice, owing to our integrated approach. They achieve excellent standards and are accepted by the Environment Agencies as one of the best available wastewater treatment industry options. Wherever possible we discharge via land and trees (functional landscaping) instead of to water so that discharge is to an appropriate ecological system.

2. Bioremediation and phytoremediation of contaminated soils and sludges

We use, and are continuing to develop, natural remediation techniques (bioremediation and phytoremediation) and composting processes that improve the quality of materials including:

- Gully sludge (arisings from road gullies including hydrocarbons, oils, chemicals heavy metals, salt, grit, soil).
- Pipeline piggings (pigwax).
- Tank bottom sludges.
- Contaminated straw and hay from filters.
- Waste from petrol interceptors, catch pits and settlement tanks.
- Contaminated soil (containing hydrocarbons, jet fuel, acid mine drainage).

To date we have focussed mainly on hydrocarbon rich sludges and soil from the oil industry and from companies maintaining road gullies. We have successfully treated their effluents and contaminated water.

Our objective is to utilise bioremediation and composting techniques to recycle various materials currently specified as special waste into a useful soil product. Special waste can only be disposed of in designated landfill sites and is a very expensive option. In the case of contaminated soils we treat material so it can support native vegetation and a healthy ecology.

In the case of gully sludge, we have been able to transform it into British and European agricultural grade compost supporting earthworms and a range of healthy soil microorganisms. It is then ready for use in the reinstatement of road verges, capping landfills and other landscaping applications. By mixing it with subsoils that were also considered a waste product we have created a high quality topsoil substitute. This company saves approximately £25,000 per year in tipping levies, landfill charges and transport, and also receives an income when the final product is sold.

Most of the remediation carried out for oil companies are for in situ clean-up operations and all materials are transformed and utilised on site for landscaping and increasing biodiversity.

3. Surface water management and treatment

In the UK treatment of surface water arising from new developments is a requirement set by the Environment Agencies in order to prevent contamination of water bodies.

We have developed a range of designs using wetland habitats that can capture, treat, ameliorate, attenuate and store storm events yet are able to provide enough water year round to endure dry periods. It can be safely discharged to a water body or used for irrigation and habitat creation.

Other measures that are also used for the attenuation of surface water include: porous pavement, filter drains and Hydrobrakes™. (The latter reduces discharges to a lower, constant rate.)

In some areas that have sewage works receiving a combined surface and foul water mix, surface water treatment systems can be essential to prevent flooding of the sewers and can be used as part of an integrated strategy for flood prevention.

Living Water has designed systems for use in both treatment and flood prevention. We have also treated contaminated roof and surface water that is subsequently recycled to the factory at a rate of 13 m^3 per hour year round.

4. Capture and recycling of roof water

Providing the roof materials are suitable and the building is located in an unpolluted area, roof water is a relatively uncontaminated resource. This water can be captured, filtered and recycled for use in buildings. In Europe the majority of captured roof water is used for flushing toilets, washing and irrigation. Uncontaminated roof water treated with an UV filter or equivalent can be used as drinking water.

As fresh water becomes scarcer the use of roof water for drinking is increasing. We recommend the use of low flush toilets, taps, showers and appliances in order to reduce water requirements so that the captured roof water can meet a greater proportion of demand.

5. Integrated strategies, watershed and catchment management

Our approach focusses on the elimination of pollution problems at source. Each problem requires one or more solutions. For factories, a site strategy may be sufficient as the source of the problem is localised. However, when diffuse pollution, e.g., run-off from farmland, affects a river or lake, it is necessary to identify the sources of pollution in the catchment area.[1] On a larger scale, e.g., when an estuary or sea becomes polluted, it is necessary to assess the entire watershed.[2]

To develop an integrated strategy for a site, catchment or watershed the methodology is similar, consisting of identifying each source of pollution and its solution. Although working at a catchment or watershed level is necessary to improve water quality, conflicting points of view and lack of co-operation often make it difficult in practice.

Most of our work with watershed management has been carried out in developing countries (Costa Rica, Tanzania, Kenya, Uganda [Lake Victoria] and Fiji). Catchment and watershed issues can be more difficult, time consuming and complex especially when politics between several countries are involved. However, when a watershed management plan is implemented correctly success is possible and remediation can therefore be worth the effort over a number of years. An example is described below.

When several coastal communities in Fiji complained of 'dead water' and reduced fish stocks due to the death of coral reefs, Living Water was asked by a Fijian NGO to identify the problems and provide solutions. We implemented a watershed management strategy to deal with a range of problems including run-off from sugar cane farming, animal husbandry, clear cutting of forests, soil erosion, sewage, rubbish, and removal of mangroves, all of which had been found to contribute to coral reef death. The solutions were identified, and pilot treatment system projects completed. Successful treatment includes involvement and education of the community. Local people have been trained and a number of solutions have been developed and implemented.

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[1] The area from which rainfall drains to a river or lake.
[2] The area from which rainfall drains to an estuary or sea.

6. Treatment of wine effluent and waste

In 1995 we were invited by a French environmental consultant to help develop an ecological solution to wine effluent. This was urgently needed because traditional practices and conventional technology were not sufficient to meet European (EU) legislation for water quality. Given our experience with treating the effluent from the whisky industry and having studied the effluent and practices in a number of vineyards we decided to seek European funding to develop a solution for vineyard effluent.

We received an EU grant for our project ”Ecological Treatment and Transformation of Effluent from the Drinks Industry into a Resource for Re-use, Irrigation and Land Reclamation”. This involved studying whisky and wine production processes in Scotland, Ireland, France, Greece and Portugal for a period of one year to develop the solutions required.

This successful project led to an experimental treatment system being installed in Chateau La Chapelle-Maillard, an organic (biodynamic) vineyard in the Bordeaux region of France. This system consists of a straw filter to remove solid material, three constructed wetlands in series and a planted soakaway. This system has been monitored by Centre Technique Interprofessionnel de la Vigne et du Vin (ITV) located in Epernay, France.

Wine effluent is the result of cleaning the vats and machinery used in the vinification process. While not an obvious pollutant, such effluent contains sufficient sugars, alcohols and tartaric acid to constitute an oxygen sink and hence a danger to the environment if discharged without treatment. There are three distinct processes in the production of wine and each produces its own pollutants.

To indicate the amount of pollution, or *loading*, we will use the concept of chemical oxygen demand, COD (the oxygen required to decompose a given sample through chemical oxidation). The biochemical oxygen demand, BOD_5, (the oxygen required to decompose a sample biologically over 5 days) in vineyard effluent is typically 50% of COD.

<u>Grape Juice Extraction (grape harvest) and Pressing:</u> During this process stalks and leaves are removed and the crushed grapes are stored in vats to begin fermenting. Wine effluent is a result of washing the equipment and consists mainly of skins, yeasts and sugars. Crushed grapes are pressed to extract the juice and solids are sent for distillation. The effluent is a result of washing equipment and consists mainly of products of fermentation. The COD is approximately 9,900 mg/l.

<u>Racking</u>: During racking wine is decanted and the remaining liquor and sediment has a COD of 5,300 mg/l.

<u>Removal of Tartrates</u>: Loading due to crystals of tartaric salts (‘soda’) that accumulate on the walls of the vats is expressed as BOD_5. A range is expressed below:

35 kg soda = 42,500 mg/l BOD_5. pH = 12.05
25 kg soda = 84,670 mg/l BOD_5. pH = 11.60

Over three years the experimental wetland treatment system has achieved an average removal of 40 g COD / m^2 / day with a peak removal of 130 g COD / m^2 / day. The system also consistently raised the pH. A wetland employing recirculation of effluent showed improved efficiency: it was regularly able to remove 80g COD / m^2/ day, implying an even higher peak removal.

Our system has provided excellent results for this vineyard. We have continued to improve our understanding of how these systems should be sized to give consistent results for a range of wine effluents and other waste water with high organic loading.

We are presently working in partnership with ITV, building two pilot systems near their laboratory to monitor and study the dynamics of the wetland system during the treatment of wine effluent. We are also investigating the uptake mechanisms and effectiveness of pesticide and herbicide removal by wetland plants. Two vineyards have expressed an interest in having a full-scale experimental treatment system designed by ourselves and monitored by ITV. These experiences will enable us to develop and fine-tune our treatment system and ensure its effectiveness for champagne, white and red wine effluent.

7. Management of surface water and treatment of run-off from vineyards

Frost is another problem highlighted by ITV on our visit to the Champagne region in France, which is at the northern limit of wine growing. During March and April pesticides, herbicides and fertilisers, if required, are sprayed onto the vines. Frosts also occur at this time of year, so water is sprayed onto the vines in order to prevent them from freezing. Subsequently this water, now contaminated with pesticides, herbicides and fertilisers, washes soil into a nearby watercourse. The residual pesticide or herbicide from bulk containers and from washing down of spraying machines, conducted either on the vineyard or in the wine production area, poses an additional problem.

Up front management of surface water on the vineyard itself is difficult because of the intensity of farming and the proximity of the vines.

A Champagne vineyard owner has asked Living Water to install a system to treat this contaminated run-off, which flows into the Seine River. ITV will survey the land, perform run-off calculations for soil and water and estimate concentrations of contaminants. These data will form the basis of our design.

During the pilot projects designed by Living Water treatment of pesticides and herbicides in a wetland system will be studied to provide a framework for the design of the full scale treatment system.

8. Development of new applications of the ‘rhizoid regeneration’ technique for monitoring pesticides and herbicides in vineyards

Jane Shields developed a ‘rhizoid regeneration’ technique during post-graduate research at Heriot-Watt University, Edinburgh. The aim of the original research was to develop an effective treatment system for the marine environment using algae. However, there was no effective method for assessment of the contaminants in the water without using marine animals in a LD_{50} test (the concentration of a substance required to kill 50% of the organisms). This is a crude measurement and Jane wanted to find an alternative to animal experimentation.

Methods with multicellular algae used dead material or staining, both ineffective and crude. All the available methods focussed on the concentrations required to kill a certain type of organism. Her thesis became the development of this technique.

Algae form the first link in many food webs, oxygenate the water and are important in the cycling of dissolved organic and inorganic substances. Toxins accumulated by algae may be passed up the whole food web, and if stored rather than metabolised may be concentrated and have effects at higher trophic levels.

For this reason the focus was on the development of a sensitive technique that could detect the first signs of stress in algal populations, which required the algae to remain alive. Another difficulty to overcome was the variability and steepness of physio-chemical gradients in estuarine water, the continuous and frequently unpredictable oscillations of salinity and dissolved and particulate matter in the water. It was also necessary for the technique to not be affected by reproduction.

The genus Enteromorpha (Chlorophyta, Ulvales), a green tubular parenchymatous alga, was chosen as it has a wide geographical distribution (both northern and southern hemispheres, well know nutrient requirements, small genetic and phenotypic variation, good taxonomic characterisation of the strains, a high growth rate and ease of handling. The habitat ranges from fresh water to seawater but it is more common in estuarine and coastal habitats.

One of the most precarious stages in the life history of a marine benthic organism is the colonisation of new substrata, for which highly specialised processes of settlement and early growth have developed. In Enteromorpha, a primary rhizoid develops which penetrates a substrate on structures being colonised and other rhizoids soon follow the point of entry. Secondary rhizoid regeneration occurs in nature when the alga is removed from the substrate by either predation or wave action and must reattach.

The technique is based on the secondary rhizoid regeneration process that can be simulated by cutting 5 mm off the basal end of the algal filament which removes the specialised cells that grow rhizoids. This technique has proved to be extremely sensitive as the algal filaments must be in good health in order to regenerate the specialised cells and produce rhizoids. Assessment is based on the number of algal filaments that have regenerated in a given substance or natural waters and the density and number of the rhizoids which is a finer indicator of the degree of stress on the organism.

This technique has been used to assess water quality along an estuary by studying different algal populations located in different parts of an estuary in combination with testing samples along an estuary tested against a base population used as a control, using standard statistical analysis. It has also been shown to be effective in testing particular contaminants at known concentrations, e.g. copper, biocide and salinity.

ITV in France has asked Jane Shields to see if the rhizoid regeneration technique can be developed to monitor pesticides and herbicides. Of the hundreds in use there are specific tests for a few only, so it is virtually impossible to understand the full impact of these contaminants in the soil or water. Analysis is made even more difficult by the fact that most agrochemicals are used in mixtures.

We are starting to work on the development of the rhizoid regeneration test for this purpose. Initial funding is expected from ITV.

9. Biodiversity enhancement and functional landscaping

Biodiversity includes bacteria, invertebrates, microorganisms, insects, fungi, plants, animals that are essential for a healthy ecology and functioning of the major life cycles. Enhancement of biodiversity requires the creation of the infrastructure or habitat on and in which the ecological food web can develop and the inhabitants can survive.

Life does not exist in isolation. Therefore in order to improve biodiversity, it is essential not only to improve the immediate environment but to place the habitat in its wider context. On a larger scale it is preferable to create wildlife corridors that link different habitats, enabling various species to move uninhibited from one area to another, widening their range and thus their viability as a species. Land animals such as deer, badger, fox and hedgehogs all benefit from wildlife corridors linking woodlands, agricultural land, hedgerows and wild areas.

Biodiversity can also be increased through the improvement of the quality of water, soil and air and the decrease of noise and traffic.

All components of a Living Water treatment system are multifunctional. We specialise in creating aquatic, wetland, meadow and woodland habitats with native species that treat as well as increase biodiversity. These environments can also be used to ameliorate, capture, treat and reuse roof and surface water and to provide a park for use by the public. Willows or other trees used in soakaways can also be used for crafts or as biomass for energy production.

We feel it is important to integrate the system into the surroundings and wherever possible, to provide a landscape structure as a solid base upon which the appropriate succession can establish itself.

Landscaping is also used to prevent ingress of surface water, grass, weeds and leaf matter into the treatment system and can be incorporated into developments to create wildlife corridors.