WAIPA MILL GROUNDWATER REMEDIATION: A SUCCESS STORY

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Introduction

In New Zealand, chemical treatment of Pinus radiata for temporary and long term preservation is an established and often necessary practice. Pentachlorophenol (PCP) was the chemical of choice and was used for an extended period of time (30-40 years) by the NZ timber industry before being withdrawn in the late 1980's. It was largely used in the water soluble form, sodium pentachlorophenate (Na-PCP) as an anti-sapstain fungicide for the temporary surface protection of sawn timber and was often used in conjunction with boron. This was the case at the Waipa Mill. PCP as pentachlorophenol was also but less widely used with oil as the carrier, for the permanent protection of timber. This (oil/pressure) treatment called the "reuping" process was used extensively at Waipa for treating poles and railway sleepers until closure in 1984.

The PCP used contained undesirable contaminants formed as unwanted by-products during manufacture. These included other chlorinated phenols, dioxins and furans.

Unfortunately during the decades of PCP use it was not appreciated the environmental hazard that PCP and the associated contaminants posed. Consequently poor handling practices by today's standards were common-place, in particular drippage of PCP–containing solutions to ground resulting in contaminated soil. PCP in the water soluble, ionised form, is relatively mobile in the soil profile hence can contaminate groundwater directly and is exacerbated by the flushing effect of rainfall on the soil surface. In the case of Waipa, the light volcanic soils are highly porous and the groundwater in the PCP handling areas was less than 3 metres below ground level. As a consequence of this, significant PCP contamination of groundwater has occurred.

In 1991 the full extent of the PCP contamination at Waipa was investigated in a study commissioned by the Ministry of the Environment and the Department of Health on behalf of the National Task Group (NTG) which was established to investigate contamination caused by the use of timber treatment chemicals. Whilst significant soil contamination was identified in the study it was the groundwater contamination that posed the greatest and most immediate environmental threat since it was mobile and moving off-site into the wider environment.

To mitigate these effects, a groundwater remediation system was designed and built. It was commissioned in 1994 and has run continuously since that time.

This paper does not address the issue of soil contamination but focuses specifically on groundwater. The paper describes the system installed, looks at the effectiveness of the initiative after 11 years operation, and discusses future plans.

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The situation in 1993

The NTG study had identified the PCP contaminated groundwater plumes and determined that the groundwater flow was in the direction on the Waipa Stream which formed the Southern boundary of the site as shown in diagram 1. The PCP concentration in the Waipa Stream downstream of the site was consistently measured at about 40 mg/m^3 (ppb) whereas above the site it was less than the detection limit (which was 1 ppb at that time). PCP had reached Lake Rotorua where it was detected in trout and lake bed sediments.

An estimate of the total mass load of PCP entering the Waipa Stream was calculated as follows:

Groundwater discharge upstream of the main stormwater drain outfall	200 kg/yr
Main stormwater (SW) drain flow (groundwater infiltration)	220 kg/yr
Main SW drain trench flow (leakage via drain fill material)	145 kg/yr
Groundwater flow downstream of the main SW drain outfall	10 kg/yr
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	575 kg/yr

The remediation proposal

The remediation system was designed to remove at least 80% of the PCP load that was entering the Waipa Stream. The remediation process consisted of three main components:

1. Groundwater interception

Strategically located shallow interception trenches where laid to intercept the majority of contaminated groundwater flow. The trenches were designed to intercept only the upper 0.5 to 1.0 metre of groundwater since the contamination was mainly concentrated in the upper layer of groundwater, especially where the PCP was associated with oil.

In total about 700 m of trenches using impervious plastic sheeting and slotted PVC pipe were constructed between 2.5 and 3.5 metres deep and 900 mm wide, draining to a single pump station.

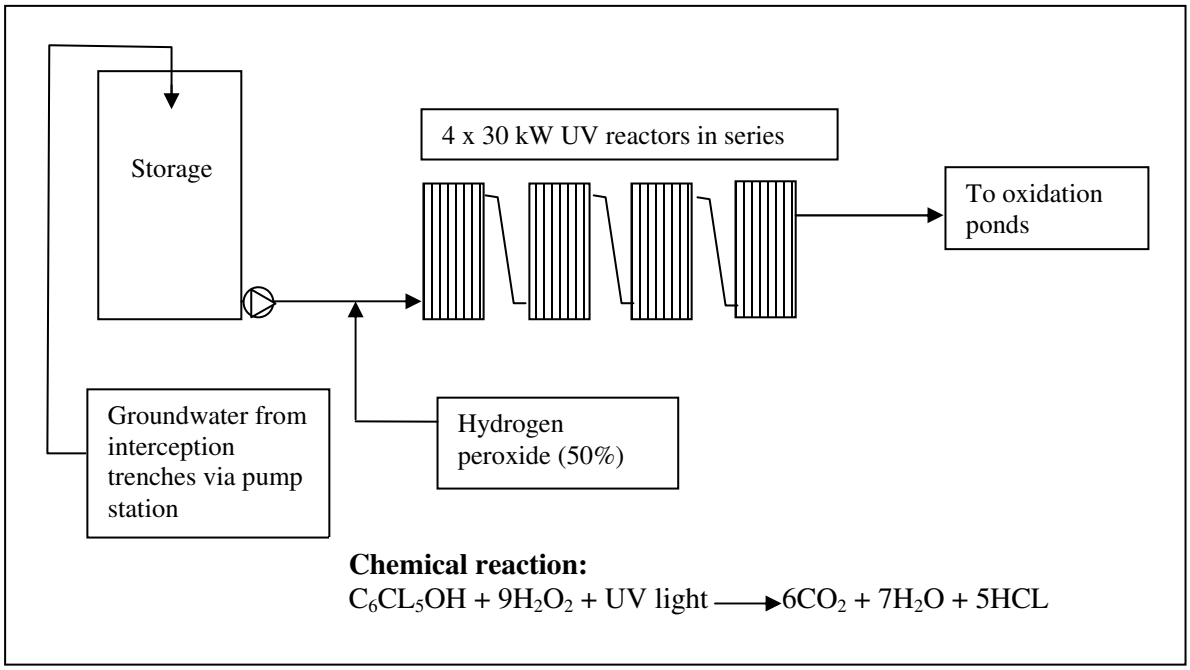
An important aspect of the interception project was to minimise contaminated groundwater infiltration into stormwater drains. This was achieved by sealing or replacing affected sections of the drains. Groundwater leakage to the stream via the more permeable drain backfill material was mitigated by grouting the interception drain around the main stormwater drain.
The rate of groundwater draining to the Waipa Stream in the interception drain zone was estimated to be between 20 and 100 m^3 /day.

2. Groundwater treatment

Chemical treatment of the intercepted groundwater using the Rayox® process was chosen for this step. Hydrogen peroxide in the presence of ultraviolet light destroys the PCP in a series of chemical reactions, ultimately reducing it to harmless carbon dioxide, water and hydrochloric acid. The plant was designed to run automatically with minimal operator input and had the

capacity to treat 500 m^3/day of groundwater with a PCP concentration of 4000 ppb using four 30 kW UV light reactors in series. Refer to diagram 2 for a schematic drawing of the plant.

Diagram 2: A schematic plan of the Rayox® plant



3. Discharge via the wastewater system

The treated groundwater is discharged to the existing oxidation pond sewage treatment system where it is ultimately discharged to the adjacent forest, land disposal system.

The remediation system required a resource consent for the abstraction of groundwater and changes to the existing effluent discharge consent to allow for a greater volume of wastewater to be irrigated and a maximum PCP concentration of 10 ppb. Both consents called for comprehensive monitoring to be undertaken to demonstrate the efficiency of the system as a whole in reducing the PCP load on the Waipa Stream.

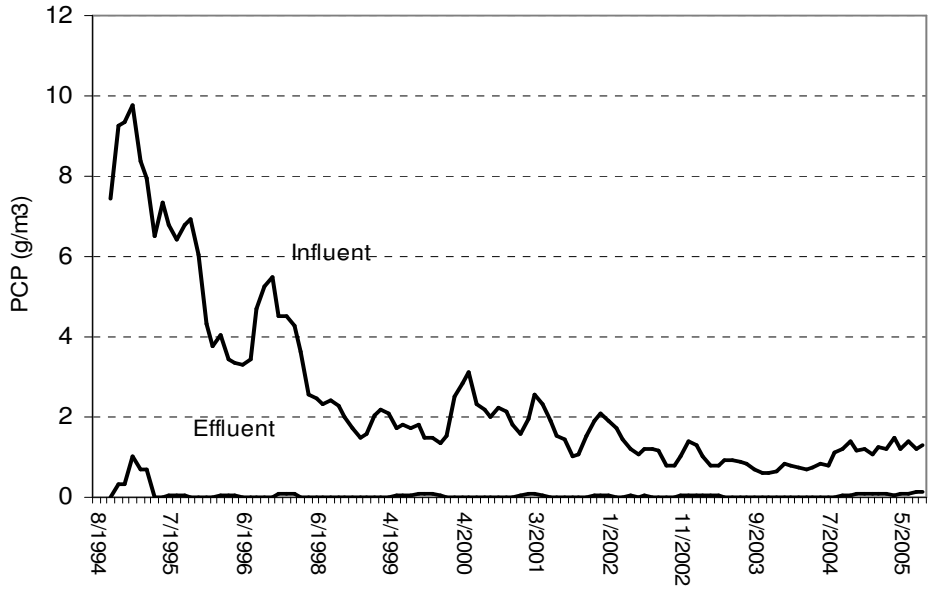
The remediation system was commissioned in August 1994 and has run continuously (24/7) since that time. The Rayox plant initial throughput was set at 14 m^3/hour (336 m^3/day) which set the abstraction rate. The total capital cost of the system including the interception drains was approximately $1.0 million. The annual operating cost of the plant was about $200,000 with the main costs being UV lamp replacement, hydrogen peroxide and electricity. Operationally the system has performed extremely well with few problems encountered.

Review of implemented proposal after 11 years operation

Rayox plant

The plant has typically achieved in excess of 99.8% destruction of PCP in the in-coming groundwater (influent). This is graphically shown in Figure 1. The treated groundwater (effluent) PCP concentration has typically been significantly less than 10 ppb. A steady decline in the influent PCP concentration indicates that groundwater contamination from the site is diminishing and is being successfully remediated.

Figure 1: Rayox plant influent and effluent PCP concentrations



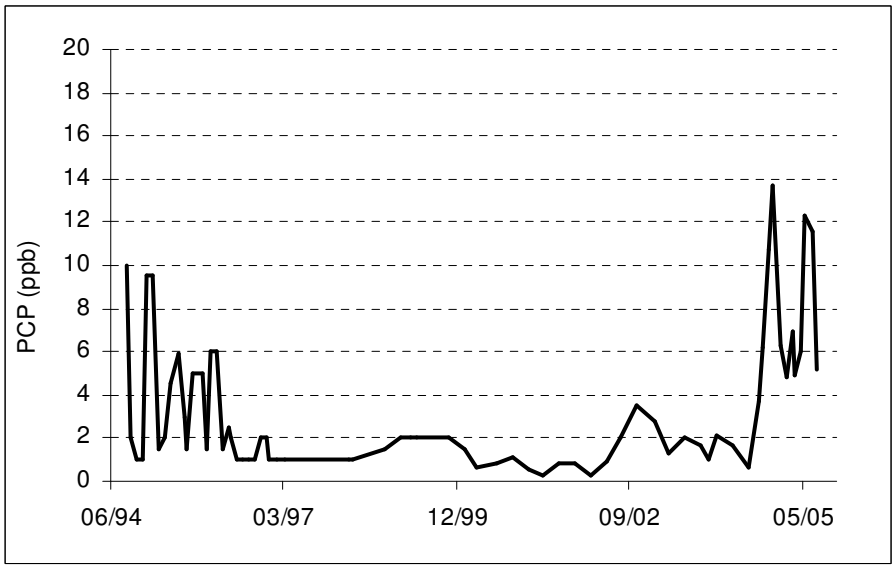
As the PCP concentration has declined the Rayox plant flow rate has been decreased from 14 to 6 m^3/hr and the number of UV lamps in operation reduced from 4 to 1. This has resulted in significant cost savings with only minimal impact on the effluent. Currently the Rayox plant is removing about 61 kg/year of PCP. In 1994/5 the removal was about 735 kg. Thus after 11 years operation the annual PCP mass load from the interception drains has dropped by more than 75%, taking into account the change in abstraction rates.

Wastewater disposal

The amended, then later renewed wastewater consent allowed for up to 10 ppb of PCP in the wastewater effluent. As can be seen in Figure 2, this has been for the most part successfully achieved.

In addition to wastewater effluent monitoring, groundwater, surface water and soil monitoring is required as part of the consent conditions. These monitoring data have consistently shown no detectable PCP, even when using ultra-low detection methods. Dioxin testing on the land disposal system soil samples has shown only background levels.

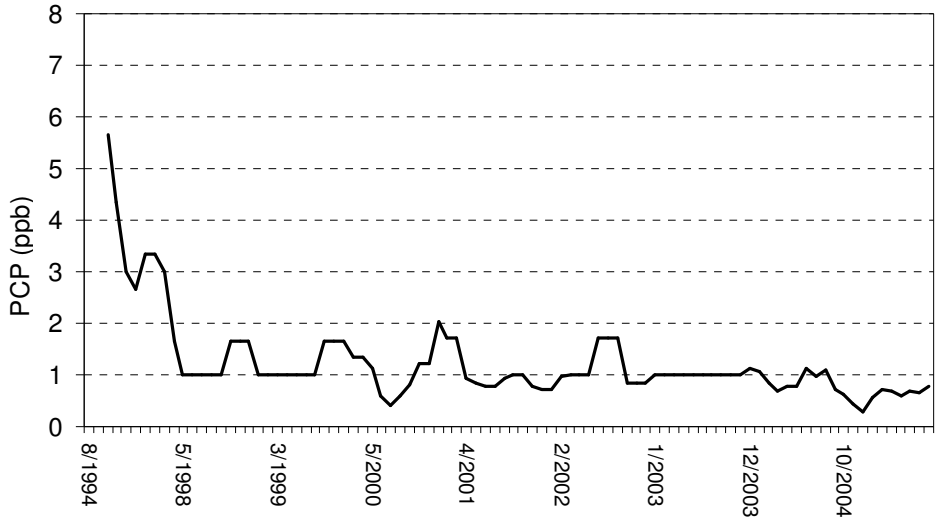
Figure 2: Wastewater effluent PCP concentrations



Impact of groundwater remediation project on the Waipa Stream

Almost immediately following commissioning in August 1994 the PCP concentration in the Waipa Stream dropped from about 40 ppb to below 10 ppb where it has remained ever since, as shown in Figure 3. Typically it is now below 0.3 ppb which is less than 1% of the original PCP concentration measured in the stream. Importantly, this is significantly less ($1/10^{th}$) than the ANZECC 2000 guidelines PCP trigger value for 99% protection of species, set at 3.6 ppb. Dioxin results have typically been at background levels.

Figure 3: Waipa Stream PCP concentrations downstream of the site



Using low level analysis techniques, the current concentration is typically about 0.2 ppb. The mass of PCP discharging to the Waipa Stream from the site based on this figure is about 3 kg per year which is less than 0.5% of the 575 kg/yr of PCP estimated to be entering the stream in 1993.

Future Plans

Given that the amount of PCP collected is declining with time, investigations have been made to determine whether natural photo-chemical oxidation processes that take place in the oxidation ponds are an alternative to running the Rayox plant. NIWA was commissioned to investigate this possibility and undertook a comprehensive experimental programme over the 2005 autumn period. Their findings were that up to 97% removal of the current PCP load could be expected. This level of removal would reduce in the winter to 62% because of the lower levels of sunlight (insolation) received by the oxidation ponds.

PCP removal using natural processes in the oxidation ponds is a desirable objective since it will allow the closure of the Rayox plant and consequently significant cost savings. This will be a win for the environment in that the energy for PCP removal will now come from the sun (for free) and the cost savings can be allocated to other environmental initiatives.

On the basis of this work it is proposed that groundwater will be pumped directly to the oxidation ponds at a flow rate (about 50 m^3/day) sufficient to achieve adequate PCP destruction in the ponds whilst still providing the same level of protection of the Waipa Stream.

Conclusion

The installation of a groundwater interception and remediation system at the Waipa Mill in 1994 was an absolute necessity since significant amounts of PCP were moving off-site in the groundwater and contaminating the wider environment. The system installed has more than achieved the design objective of reducing the load of PCP entering the Waipa Stream by 80%, and in doing so has decontaminated the stream and curtailed any off-site effects. Contaminant levels in groundwater discharging from the site are progressively reducing with time due to a flushing effect. After 11 years of successful Rayox plant operation and significantly lower amounts of PCP being recovered, natural degradation in the oxidation ponds is seen as an obvious and environmentally-friendly way forward. What was originally an environmental nightmare has now become a success story on how to deal with it.

Diagram 1: Aerial photo of the Waipa Mill showing a diagram of the groundwater remediation system