Enhancing Our Dandenong Creek

Pollution Prevention Program: Overview of sourcing and management of pollution in the Upper Dandenong Creek Catchment 2010-2018.

Overview Technical Report

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December 2018

Version 1

How to cite this report: Kellar, C., MacMahon, D., Townsend, K., Long, S., Myers, J., Hassell, K., Tillet, B., Allinson, M., & Pettigrove, V., (2018), Enhancing Our Dandenong Creek Catchment Study: Pollution Prevention Program: Overview of sourcing and management of pollution in the Upper Dandenong Creek Catchment 2010-2018. Aquatic Pollution Prevention Partnership, Overview, RMIT University, Victoria, Australia.

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Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type

Printed:	
Last saved:	16 December 2020 02:49 PM
File name:	
File saved location	
Author:	Claudette Kellar, Daniel MacMahon, Kallie Townsend, Sara Long, Jackie Myers, Kathryn Hassell, Bree Tillett, Mayumi Allinson, Vincent Pettigrove
Project manager:	Claudette Kellar
Name of organisation:	Aquatic Pollution Prevention Partnership
Name of project:	Enhancing Our Dandenong Creek: Pollution Prevention Program
Name of document:	Enhancing Our Dandenong Creek Catchment Study: Pollution Prevention Program: Overview of sourcing and management of pollution in the Upper Dandenong Creek Catchment 2010-2018.
Document version:	No. 1
Project number:	738

Overview

Dandenong Creek is a highly urbanised waterway and several modifications have led to a decline in the ecological health of the creek, which include channelisation, modified flows, urban storm water and wastewater discharges, barriers to migration of aquatic life and a lack of streamside vegetation. In the Upper Dandenong Creek Catchment, pollutants were shown to biologically impair aquatic fauna in the creek (Kellar et al. 2014d, Marshall et al. 2010).

In 2010, the Centre for Aquatic Pollution Identification and Management (CAPIM) carried out a study on behalf of Melbourne Water to investigate the effects of wet weather sewer overflow events via an emergency relief structure (ERS) on Dandenong Creek fauna and separate these effects from other sources of pollution within the catchment. The study identified numerous sediment contaminants, including petroleum hydrocarbons, pesticides and metals, which entered at several locations in the Upper Dandenong Catchment and probably affected aquatic fauna across all biological levels. In contrast, there was no evidence that wet weather sewer overflows within the catchment had a major impact on the aquatic ecosystem. As a result, CAPIM did not recommend upgrading the sewerage system as a first priority (Kellar et al. 2011a). Melbourne Water used this study to develop a pilot program for delivering a focused outcomes approach, whereby a 'Triple Bottom Line' assessment was applied to develop the 5-year environmental management program 'Enhancing Our Dandenong Creek (EODC)' for the middle Dandenong Creek corridor.

As part of the EODC program the Pollution Detection and Prevention Project was developed to identify and understand the major sources of point source pollution and to improve water quality and reduce pollution entering Dandenong Creek.

This report aims to provide a synopsis of the key findings undertaken by CAPIM and A3P over the duration of the EODC project.

Aims of the project

The overall aim of the pollution detection and prevention project is to isolate and identify the sources of pollution entering the Upper Dandenong Creek catchment and to recommend and implement follow up actions which may help to reduce the pollution loads, improving the health of Dandenong Creek. The project also monitors and evaluates the success of the pollution prevention measures implemented with the catchment.

Specifically, over 5 years, the project involved:

- Monitoring 10 sites yearly within the Upper Dandenong Catchment for pollutants to establish baseline conditions and assess potential changes from remediation works.
- Carrying out pollution sourcing and tracking in Old Joes, Bungalook, Croydon Main Drain and Heatherdale catchments to isolate the sources of pollutants;
- Monitoring pollutants in Old Joes, Bungalook, Croydon Main Drain and Heatherdale catchments to assess potential changes from remediation works.
- Understanding the effects of synthetic pyrethroids on aquatic fauna;
- Assessing catchment condition of Bungalook and Dandenong Creek Catchments; and
- Investigating the effects of wet weather sewer overflows via an emergency relief structure (ERS) on resident aquatic fauna and separate these effects from other sources of pollution present within the catchment.

Key Findings and Recommendations

Catchment Sediment Monitoring Survey

Ten sites were established in the Upper Dandenong Creek Catchment to understand the spatial distribution of pollutants within the creek (Figure 1). The top fine depositional sediment was collected and analysed them for pollutants including hydrocarbons, metals and synthetic pyrethroids. Since the beginning of the EODC program CAPIM/A3P has collected data at these sites annually (some sites may have multiple samples collected in one year).

To determine trends in pollutant concentrations over time a trends analysis was carried out using a Mann-Kendall test in XLSTAT. Pollutants that were rarely detected were not analysed. For more frequently detected contaminants, data that were below detection limits were given values of half the detection limit prior to analysis. Trends were considered significant when $P < 0.05$.

Overall metals, pesticides and hydrocarbons remained high and unchanged through time at the majority of sites within the Upper Dandenong Creek Catchment. Old Joes Creek remains a significant source of metals entering Dandenong Creek, including silver, lead, nickel, zinc and copper, total petroleum hydrocarbons and the synthetic pyrethroid insecticide bifenthrin. Heatherdale Creek has high concentrations of the synthetic pyrethroids bifenthrin, permethrin and cypermethrin as well as the metals zinc, lead and nickel. Bungalook Creek remains a source of the synthetic pyrethroids permethrin and bifenthrin, as well as the fungicides tebuconazole and propiconazole.

A reduction of some metal pollution was however observed in Old Joes Creek, where there was a significant decline in cadmium, copper, lead, mercury and zinc concentrations over time in the creek and downstream of its confluence with Dandenong Creek, suggesting that some pollution has been reduced in this waterway (Table 1). However, concentrations of these metals are still above sediment quality guideline (SQG) objectives, indicating they could still cause impacts on aquatic biota.

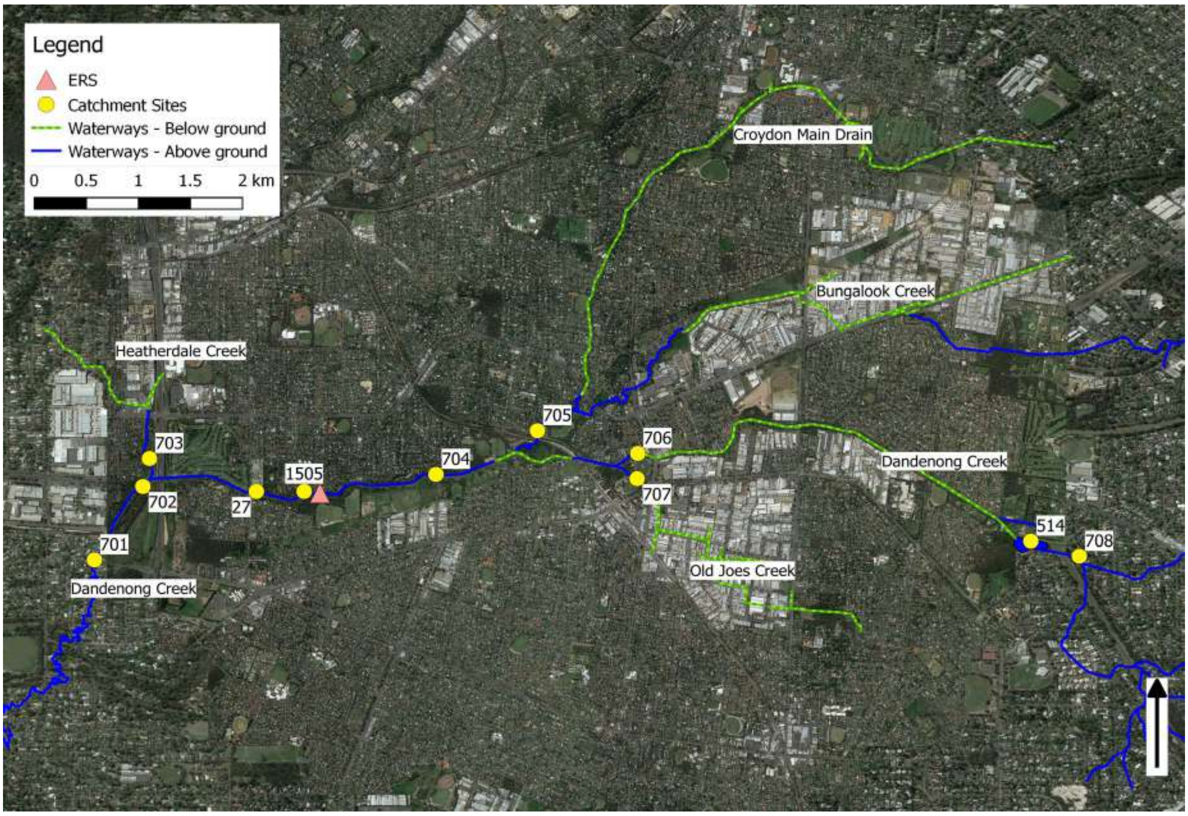

Figure 1. Location of study sites in the Upper Dandenong Creek Catchment

Table 1. Summary of Mann-Kendall Trend analysis for changes in metals, total petroleum hydrocarbons and synthetic pyrethroid concentrations over time and the number of occasions concentrations exceeded trigger values at Old Joes Creek. Significant trends are highlighted bold and italicised. NS = not significant (P > 0.05).

						No. detections above:		
Site	**n**	**Trend direction**	**S**	**P (two-tailed)**	**Kendall's τ**	**High trigger**	**Low trigger**	**No. of Detects**
TPH	5	–	-4	NS	-0.40	5	5	
Silver	21	–	-5	NS	-0.02	21	21	

Cadmium	***21***	↓	***-70***	***0.021***	***-0.39***	***1***	***16***	
Copper	***21***	↓	***-88***	***0.008***	***-0.42***	***1***	***20***	
Lead	***21***	↓	***-100***	***0.002***	***-0.48***	***2***	***21***	
Mercury	***21***	↓	***-69***	***0.037***	***-0.33***	***6***	***19***	
Zinc	***21***	↓	***-95***	***0.004***	***-0.45***	***21***	***21***	
Bifenthrin	6	–	3	NS	0.20			6
Cypermethrin	6	–	-3	NS	-0.23			1
Permethrin	6	–	4	NS	0.28			3

It is clear from the comparisons over time that metals and TPH are still high at many sites and that synthetic pyrethroid pesticides are still a significant threat to the health of Dandenong Creek.

Key Finding:

- While some reduction of some metals have occurred from Old Joes creek, metals, TPH and synthetic pyrethroid pesticides are still a significant threat to the health of Dandenong Creek.

Key Recommendation:

- Continue to annually collect sediments from each of these sites to understand the temporal trends of common pollutants within Dandenong creek.

Bungalook Catchment Survey and Pollution Sourcing

Bungalook Catchment Survey

Bungalook Creek has been shown to be a major contributor of pollutants, particularly synthetic pyrethroid pesticides, entering into Dandenong Creek. In 2010 sediment concentrations of bifenthrin and permethrin in Bungalook Creek were at detected at levels known to cause toxicity to aquatic fauna, and may account for the reduced survival of P. antipodarum and the poor physical condition of goldfish in the lower Dandenong Creek sites (Kellar et al. 2014d). Synthetic pyrethroids form constituent ingredients in a range of insecticides, miticides, parasiticides, seed treatments, wood preservatives and household insecticides and are highly toxic to fish and aquatic invertebrates (Holmes et al. 2008, Maul et al. 2008, Phillips et al. 2010, Weston et al. 2009).

In 2014 a catchment survey was carried out in Bungalook Creek whereby seven sites were sampled for sediment chemistry and assessed for toxicology and biological impairment. The study showed Bungalook Creek Catchment was in poor condition with a number of fauna adversely affected by pollutants present within the catchment. At the top of Bungalook Catchment, BNG2, low concentrations of pollutants were detected and no toxicity or biological impairment was observed. An impoverished macroinvertebrate fauna is likely to be due to the poor habitat and lack of riparian vegetation at this site. Across the rest of the sites in Bungalook Catchment a number of pollutants were found that are likely to cause toxicity to the aquatic fauna. The greatest sources of contamination were from Bungalook Retarding Basin (BNG3), the sediment pond (BNG4) and the Retarding Basin in Croydon Main Drain (CMD2). The sediment pond (BNG4) was the most contaminated site within Bungalook Creek with high concentrations of metals (cadmium, chromium, copper, lead, nickel, zinc), hydrocarbons and pesticides (synthetic pyrethroids, particularly permethrin, and fungicides). These pollutants appear to be the main cause of biological impairment, with significant adverse effects detected across a range of fauna (100% mortality of snails, chironomids and amphipods, no fish present apart from mosquitofish). The pollutants found in the sediment pond appear to be present downstream and continue to cause biological impairment up to 2km downstream, at site 705. The Bungalook Retarding Basin (BNG3) also contained high concentrations of some pollutants that caused biological impairment in a number of fauna. While the goldfish collected at this site outwardly appeared fine, elevated biomarkers and some reproductive impairment suggested they were under stress, which is likely to be due to the metals and pesticides, particularly the synthetic pyrethroids, detected at this site. The retarding basin in Croydon Main Drain also contained high concentrations of some pollutants and caused toxicity and biological impairment in some fauna. However, it appears that this retarding basin acts as a sink to trap pollutants, with less pollutants and biological impairment detected downstream.

Key Findings:

- Bungalook Creek Catchment is highly polluted particularly with some metals and the synthetic pyrethroids.
- Many of these pollutants are coming from point sources.
- The sediment pond within Bungalook Creek is highly contaminated particularly with synthetic pyrethroids.

Key Recommendations:

- The sediment pond within Bungalook Creek is cleaned – contaminated sediment is removed from the pond.
- A pollution sourcing program isolating sources of synthetic pyrethroids (and some metals) from Bungalook Creek Retarding Basin and from the sediment pond in Bungalook Creek.
- Conduct laboratory and field experiments to gain a better understanding of the effects of permethrin on aquatic fauna.

MW Actions:

- In 2015 the sediment pond was cleaned out. Further monitoring within Bungalook Creek suggested that a point source of synthetic pyrethroids was still present.

Pollution Sourcing

An initial pilot study was carried out in December 2014, which focussed on the two major inputs into Bungalook Creek sediment pond. The results indicated that the greatest pesticide load was coming from an industrial estate within Turbo Drive. Within this industrial estate suspended passive sampling surveys began in March 2015, October 2015 and January 2016, while the soil survey was completed in June 2016. The passive sampler surveys ran for four weeks except the January 2016 survey which ran for six weeks. Suspended particle samplers (SPS) were deployed into the stormwater network at five sites. Eleven sites were sampled for the soil survey. Soil was collected from concrete driveways at each of these sites and analysed for permethrin. Results indicate that the synthetic pyrethroid, permethrin, is originating from a point source of pollution rather than diffuse pollution. One potential business was identified as potentially causing the elevated permethrin concentrations observed in the soil and water samples.

The EPA Victoria investigated the business and issued a minor works pollution abatement notice (MWPAN) which included ceasing washing of intermediate bulk containers (IBCs) in their driveway and installing bunding inside the building. The works were to be completed by December 2016.

Another passive sampling survey was conducted in April 2017 to see if permethrin concentrations had decreased as a result of the EPA findings. Permethrin concentrations were still high at site 693 even after the EPA issued a MWPAN to the business in the catchment, suggesting that there is still a point source of permethrin. Inspection of the area surrounding the business noticed a grated stormwater pit with a tap and hose nearby, with numerous stains around the grate. It is possible that wash-downs into the stormwater are still occurring at this location. Numerous intermediate bulk containers (IBCs) have also been observed in the carpark at this location, as a temporary storage facility. It is also noted that a permit to use permethrin has been applied for within this area.

Key Findings:

- A point source of the synthetic pyrethroid insecticide, permethrin, was determined to be arising from a point source in the Bayswater Industrial Estate.
- One business was identified as the potential cause of elevated permethrin concentrations observed in the soil and water samples.

Key Recommendations:

- The information was passed on to EPA for further investigation and enforcement.
- A continued monitoring of this area should be carried out to ensure there has been a reduction of permethrin entering Bungalook Creek.

MW/EPA Actions:

- In 2016 EPA Victoria visited the business and issued a MWPAN, which included installing bunding and ceasing washing of IBCs in the carpark.

Croydon Main Drain Pollution Sourcing

In 2014 an initial investigation to identify if metals were high within Croydon Main Drain, a sub-catchment of Bungalook catchment was conducted. A total of 4 sites were sampled over four weeks within the stormwater drains of Croydon Main Drain using the suspended particle samplers. Overall metal concentrations found within Croydon Main Drain were of low concern, compared to other pollutant sources within the catchment. No further sourcing was carried out for the rest of the program.

During the catchment survey of Dandenong Creek in 2017/2018 consistently high concentrations of ammonia were observed in Bungalook Creek. In 2018 the ammonia source was tracked through the creek to Croydon Main Drain, through the stormwater drainage network and isolated to a 400m stretch near the Dorset Golf Course. In collaboration with Maroondah Council the source of ammonia was leaching from an old landfill into a stormwater drain within Dorset Golf course. Maroondah Council fixed the leak by capping the area and will investigate a longer term solution to the problem. Ammonia was tested again in January 2019 was still found to be coming from the stormwater network below the Golf course, suggesting the leachate has found another area to infiltrate the stormwater network. It is recommended that Maroondah Council continue to investigate and fix the problem.

Key Findings:

- Initial investigations monitoring pollution in Croydon Main Drain suggested there was low concentrations of pollutants compared to other tributaries of Dandenong Creek.
- In 2017/2018 high concentrations of ammonia was observed in Bungalook Creek and was traced back to Croydon Main Drain with a leachate from an old landfill site infiltrating the stormwater drain on the Dorset Road Golf Course.

Key Recommendations:

- Monitor Croydon Main Drain to determine sources of pollution entering into Bungalook Creek and Dandenong Creek.
- Continue to monitor the ammonia within Croydon Main Drain.
- Maroondah Council investigate the high concentrations of ammonia still observed near the Dorset Road Golf Course.

MW/Maroondah Council Actions:

- In 2018 Maroondah Council engaged a consultant to provide recommendations as to how to manage the leachate from the Dorset Golf Course into the stormwater drain. As a result capping was done to the leaking area to prevent ammonia from entering into the stormwater drain.

Old Joes Pollution Sourcing

Old Joes Creek has been shown to be a major contributor of pollutants, particularly metals, hydrocarbons and synthetic pyrethroid pesticides, entering into Dandenong Creek (Kellar et al. 2014d). A pollution sourcing program in Old Joes Catchment commenced in 2013-2014, where a number of drains and sites within the Bayswater industrial catchment were sampled over a 4 week period using sediment passive samplers to measure the concentrations of metals and hydrocarbons. The purpose of this investigation was to identify sub-catchments within the Old Joes Creek industrial catchment responsible for discharging toxicants into Dandenong Creek and to identify potential businesses that were likely to be responsible for the discharges. Silver, zinc, lead, copper, hydrocarbons (TPH), cadmium and nickel were investigated.

A total of five sub-catchments were identified as sources of pollution within the Old Joes Catchment. At each of these sub-catchments, high concentrations of several metal pollutants were detected and are of high concern. The highest areas of concern were on Holloway Drive and upstream of Jersey Road. It was recommended that a pit located on Holloway Drive within the drainage network be cleaned out to reduce silver, zinc, cadmium, copper and nickel, monitoring and enforcement to occur surrounding a business in Holloway Drive and education programs commence in the area. Knox Council cleaned the pit out in 2014 and subsequent sampling still showed high concentrations of metals within the drainage network indicating the pollution was still an issue and cleaning the pit has not resulted in a reduction in metals downstream of the pit.

A stormwater pollution prevention behaviour change program (led by Melbourne Water and BehaviourWorks Australia), was implemented in 2015 within the Old Joes industrial estate. Alongside this work a number of drain signs highlighting system monitoring and connection of drainage network to local waterways and ecosystems were placed within the Old Industrial Estate. Passive sampling across a number of drains and sites within the Industrial estate was conducted ‘before’ and ‘after’ the behaviour change program. The pre and post sampling of the Old Joes Industrial Catchment show significant areas of pollution that contain high concentrations of a number of metals and pose an extreme risk to the environment. These areas continue to be around Holloway Drive, 53 Jersey Road and 23-25 Power Road. The metals of concern include lead, zinc, silver, copper, chromium and cadmium. For the majority of metals there was no reduction in concentrations after the Behaviour

Change Program (post sampling compared to pre sampling and background sampling concentrations) at any of the sites or within Old Joes Creek at site 707. However, it does appear that lead, zinc, copper and cadmium concentrations have within the creek at site 707 indicating the program may have led to a reduction of these metals. It was concluded that a number of factors limited the effectiveness of the behaviour change program in providing a significant decrease in waterway pollution. These factors varied from turnover of tenants, business willingness to participate and some already undertaking best practice within their property. Behaviour change does not rectify the potential legacy issues within the catchment such as contaminated land and infrastructure failures within drainage assets.

In 2016 targeted drain surveys were conducted to investigate potential sewer cross connections. Water samples were collected at eight sites and analysed for ammonia, E. coli and Bacteroides spp.. No contamination from Bacteroides spp. were detected surrounding Holloway Drive. There are some moderate-high levels of E. coli and Bacteroides spp. contamination at Jersey Road. This site contains low-moderate contamination Bacteroides spp. from human sources. These results indicate that there are potentially collapsed sewers within this area. As a result in 2017 MW carried out CCTV works within this area and found a number of illegal connections, blockages and failed infrastructure. The focus has then shifted to enforcement and an ‘end of pipeline’ solution, essentially diverting all dry weather flow into the sewer system for removal and treatment.

Potential land contamination issues were identified along Holloway Drive. In 2016 soil samples were collected along all nature strips along Holloway Drive. High concentrations of silver, cadmium and zinc (Category C prescribed waste) were detected in the top layer of soil at a number of nature strips on between 35 and 41 Holloway Drive. As a result MW and Knox Council removed the top layer of soil along several nature strips along Holloway Drive. In 2018 and 2019 soil concentrations have remained low along these nature strips however remains high outside one business. It is recommended that EPA collects soil samples within this property and remediation of soils may need to take place on this property.

In 2018 and 2019 a number of actions were carried by EPA, MW, Knox and CAPIM/A3P within the Industrial Estate including sourcing of foaming events, 130 storm water drain signs highlighting system monitoring and connection of drainage network to local waterways and ecosystems, pollution blitzes and development of trialling new water quality monitoring technology within the industrial estate.

Key Findings:

- A number of sub catchments within the Old Joes Industrial Estate are responsible for high concentrations of metals, with the most significant around Holloway Drive and Jersey Road.

- The behaviour change program may have helped to reduce some metals (lead, zinc, cadmium) but overall there was little change in concentrations of metals entering Old Joes Creek and it continues to be a point source of pollution into Dandenong Creek.
- Poor infrastructure, potential cross connections and illegal connections are a problem within this industrial estate.
- There still appears to be contaminated land surrounding one business within Holloway Drive that may be responsible for high concentrations of some metals.

Key Recommendations:

- Continue to monitor key sub catchments within the Old Joes Industrial Estate.
- Regular enforcement blitzes
- Investigation of an ‘end of pipe’ solution
- Investigation of online treatment of metals coming from the Old Joes Industrial Estate

MW/EPA/Know/SEW Actions:

- In 2014 Knox Council cleaned out a pit within the stormwater drainage network in Holloway Drive.
- In 2015 a Behaviour Change Program led by MW and BehaviourWorks Australia was established and carried out. As part of this program stormwater drains were labelled to highlight connection of drainage network to local waterways and ecosystems and EPA carried out inspections.
- In 2017 MW carried out CCTV footage along some of the stormwater drains.
- In 2017 MW and Knox Council removed contaminated soil along nature strips along Holloway Drive.
- In 2018 MW let a co-ordinated pollution blitz (Knox Council, EPA, SEW) within the Old Joes Industrial Estate.

Heatherdale Pollution Sourcing

Since 2014, monitoring of pollution in the catchment sediment monitoring survey has detected high concentrations of synthetic pyrethroids, especially cypermethrin, within in Heatherdale Creek. Cypermethrin is an insecticide that has very rarely been detected in Victorian waterways. In 2016, CAPIM conducted an initial investigation to identify the potential sources of synthetic pyrethroids, particularly cypermethrin within the Heatherdale Drain catchment. This investigation involved collecting sediment samples from four sites in March 2016. No clear source of synthetic pyrethroids were detected and further investigation was recommended (Kellar et al. 2016). As a result, two additional surveys were conducted to isolate the source of the synthetic pyrethroids: the first in

December 2016 and the second in February 2017. These follow up surveys relied mainly on sediment passive samplers as the drainage network was almost entirely underground; however, sediment grab samples were also taken at key sites in the catchment where possible. Although sporadic, very high concentrations of cypermethrin were detected within the stormwater network and the point source was narrowed down to a small industrial estate on the Maroondah Highway in Mitcham.

In 2018 further work was carried out to see if cypermethrin was still entering into Heatherdale creek and to further isolate the source of cypermethrin within drains surrounding the Industrial Estate. Suspended passive samplers and sediment grab samples were collected over four weeks between February and May 2018. Cypermethrin was still detected and having an impact on Heatherdale Creek, with possible effects downstream in Dandenong Creek. The most likely source of cypermethrin is from a drain or premises along Monomeith Drive and Cochrane Street. Dust and soil samples around these areas were collected and analysed for synthetic pyrethroids. Further samples need to be collected to determine the source.

Key Findings:

- High concentrations of synthetic pyrethroids, in particular cypermethrin, have been detected in Heatherdale Creek.
- The occurrence of cypermethrin appears to be sporadic and arising from a small industrial estate on the Maroondah Highway in Mitcham.

Key Recommendations:

- Continue to monitor cypermethrin concentrations around this industrial estate
- A visit to a potential business that uses these chemicals to understand if they are the source.

Faecal Sourcing in the Dandenong Creek Catchment: with a focus on Liverpool Road Retarding Basin

In the Liverpool Road Retarding Basin (LRB) several biological effects in a number of organisms were observed in 2010 in the health of the Upper Dandenong Creek Catchment Study (Kellar et al. 2011a). These effects indicated that endocrine disrupting chemicals (EDCs) may have been present; as such, they were identified as a priority chemical group for further investigations. Sewer spills are one potential source of EDCs. Newly developed rapid assessment techniques for tracking microbial contamination to aid in identifying sources of faecal contamination, including sewer spills were subsequently utilised in the Upper Dandenong Creek Catchment.

Water samples were collected to identify and isolate potential sources of faecal contamination in and around the Liverpool Road Retarding Basin using *Escherichia coli*, *Bacteroides* spp., and ammonia as indicators in April 2016 (Kellar et al., 2016). Samples were also taken from the main tributaries of Dandenong Creek and Dandenong Creek downstream Liverpool Road Retarding Basin. Overall, faecal contamination within LRB and upstream within Dandenong and Dobsons Creek was low (low *E. coli* and *Bacteroides* spp.), apart from the first sampling season at the inlet of LRB, which contained high levels of *E. coli*. The likely source of this was dogs and ruminants. The results suggest that sewer spills (from septic tanks) were not responsible for presented contamination within LRB. There was however moderate levels of human faecal contamination, identified by *E. coli* and *Bacteroides* spp., in

Bungalook and Old Joes Creeks suggesting that sewer spills and failed sewer infrastructure may exist within these catchments.

In 2017, further sampling around LRB during wetter conditions were carried out to establish sources of faecal contamination and to confirm the presence of estrogenic EDCs within the area. The majority of high-moderate faecal contamination found in the LRB during wet conditions came from dogs. Human sources were detected within the LRB and in Dandenong Creek, suggesting there may be some septic tank leaks occurring within the area. Estrogens in the LRB may sometimes occur at concentrations that will affect fauna by causing endocrine disruption.

Key Findings:

- Overall faecal contamination within LRB and upstream within Dandenong Creek and Dobsons Lane was overall which is likely to be due to dogs and ruminants.
- Human sources of faecal contamination and the presence of the synthetic estrogen within the LRB suggests that there may be some septic tank leakages within the area.

Key Recommendations:

- Include faecal contamination and estrogen monitoring in the yearly catchment monitoring program to understand the effects of these contaminants in the Upper Dandenong Creek Catchment.

Understanding the effects of synthetic pyrethroids on aquatic fauna

Previous studies have indicated that synthetic pyrethroids (SPs) are being detected within Dandenong Creek at increasingly elevated concentrations (Kellar et al. 2011b, Kellar et al. 2014a, Kellar et al. 2014b). Moreover, elevated SPs are increasingly becoming an issue in other urban catchments around Melbourne (Kellar et al. 2014c). Currently, there are no sediment or water quality guideline values for SPs in Australia, as there are for other pollutants such as heavy metals, organochlorine pesticides and polycyclic aromatic hydrocarbons (PAHs) (ANZECC/ARMCANZ 2000). In 2015 the effects of permethrin and in 2016 the effects of cypermethrin on aquatic invertebrates were investigated using laboratory and field-based experiments.

The results from the permethrin experiments have shown that permethrin concentration detected in the sediment within Dandenong Creek and Bungalook Creek and cypermethrin concentrations detected in the sediment within Heatherdale Creek are at levels that are likely to adversely affect local biota. This was seen by a reduction in survival, growth, reproduction and changes in biomarker responses in larvae from laboratory and field-based experiments.

Key Findings:

- Permethrin and Cypermethrin concentrations detected in the Upper Dandenong Creek catchment are at levels likely to adversely affect the local biota.

Key Recommendations:

- Synthetic pyrethroids should be continued to be monitored in the catchment survey and toxicity testing should occur on the sediments to understand the effects of these chemicals on the biota.

Investigating the effects of wet weather sewer overflows via an emergency relief structure (ERS) on resident aquatic fauna and separate these effects from other sources of pollution present within the catchment.

In 2017/2018 a study investigating the effects of wet weather sewer overflows on resident fauna and separating these effects from other sources of pollution present within the catchment was undertaken.

To achieve these aims a multiple lines of evidence approach was used, which included the following:

1) Catchment Condition:

   - Sediment and water chemistry – analysis of pesticides, petroleum hydrocarbons, nutrients, heavy metals, *E. coli*, *Bacteroides* spp., total steroidal estrogens, sewage related pharmaceuticals.
   - Toxicology – chironomid (*Chironomus tepperi*) and amphipod (*Austrochiltonia subtenuis*) sediment toxicity tests.
   - Aquatic fauna impairment: macroinvertebrate community assessment; impairment to an alga (*Scendesmus* spp.), an invertebrate (the mud snail *Potamopyrgus antipodarum*) and a long-lived fish (the goldfish *Carassius auratus*).

2) Potential Wet Weather Sewer Overflow Effects:

   - Sediment and water chemistry – detection of sewage related compounds – pharmaceuticals and personal care products (e.g. caffeine, artificial sweeteners, triclosan).
   - Specific bioassays to assess exposure to endocrine disrupting chemicals (EDCs) in an invertebrate (the mud snail *Potamopyrgus antipodarum*) and a long-lived fish (the goldfish *Carassius auratus*).

Pollution from petroleum hydrocarbons, pesticides, nutrients and metals were still present at several locations within the Upper Dandenong Creek catchment at concentrations likely to cause impairment for a range of taxa (algae, macroinvertebrate communities, chironomids, amphipods, mud snails and fish). Point sources of pollution (metals, pesticides, nutrients) were consistently coming from Old Joes

Creek, Bungalook Creek and Heatherdale Creek. Toxicity (identified in laboratory-based toxicity tests) and biological impairment were consistently shown throughout the Upper Dandenong Creek Catchment, with impairment worse at point sources of pollution (i.e. Old Joes Creek and Bungalook Creek). Reproductive changes in mud snails from several sites throughout the catchment also indicated that endocrine disruption may be occurring, although further investigation is required to clarify those findings. In contrast, there was no evidence that wet weather sewer overflows within the catchment had a major impact on the aquatic ecosystem (Table 2).

A summary of the major stressors and their impacts on values, their sources to the creeks, the contributions of wet weather sewer overflows and priorities are outlined in Table 3. The major stressors that impact ecosystem and social values were from pollutants entering in the catchment through urban and industrial runoff. Hence, we recommend that priority management actions should continue to focus on reducing pollutants in the Upper Dandenong Creek Catchment rather than upgrading the sewer infrastructure to comply with wet weather sewer overflow spills.

Table 2: Summary of weight of evidence approach – inference based on the sediment quality triad (modified from Chapman 2002)

		Reference		Upstream of the ERS		Downstream of the ERS	
		Dandenong Creek (708,514)	**Old Joes Creek (707)**	**Dandenong Creek (706, 704)**	**Bungalook Creek (705)**	**Heatherdale Creek (703)**	**Dandenong Creek (1505, 702, 701)**
Pollutants	Nutrients (water)	High	High	High	High	High	High
	Pathogens (water)	Low level: dog, ruminant	Low level: human	Low level: **human**, dog, ruminant	Low level: dog, ruminant	Low level: dog, ruminant	Low level: dog, ruminant
	Estrogens (water)	Moderate-High levels	Low levels	High levels	High levels	Low levels	Low levels
	Herbicides (water)	Low: simazine, atrazine, diuron	Low: simazine, atrazine, diuron	Low: simazine, atrazine, diuron	Low: simazine, atrazine, diuron	Low: simazine, atrazine, diuron	Low: simazine, atrazine, diuron
	Metals (sediment)	Low	High: **Cd**, **Cu**, **Pb**, **Ni**, **Ag**, **Zn**	High: Cu, Pb, Ni, Ag, Zn	High: Cu, Pb, Zn	High: Cu, Pb, Zn	High: Cu, Pb, Ag, Zn
	Pesticides (sediment)	Low	High: **synthetic pyrethroids**, **organochlorines**	High: **synthetic pyrethroids**, organochlorines	High: **synthetic pyrethroids**, **fungicides**, **organochlorines**	High: **synthetic pyrethroids** organochlorines	High: synthetic pyrethroids, organochlorines
	Hydrocarbons (sediment)	Low	High	High	High	High	High
Summary of Effect		**+**	**++**	**++**	**++**	**+**	**++**
Toxicity							
C. tepperi	Survival	Not Impacted	Impacted	Impacted	Impacted	Not Impacted	Not Impacted
	Growth & Emergence	Not Impacted	Impacted	Impacted	Impacted	Not Impacted	Not Impacted
	TIE Growth		Organics & Metals	Organics & Metals	Organics & Metals	Organics & Metals	Organics & Metals
A. subtenuis	Survival	Not Impacted	Impacted	Impacted	Impacted	Impacted	Impacted
Summary of Effect		**-**	**++**	**++**	**++**	**+**	**+**
Species Alterations							
Macroinvertebrates*	Indices	High: most meet SEPP	Low: all fail SEPP	Low: all fail SEPP	Low: all fail SEPP		Low: all fail SEPP
Microalgal assay	Inhibition	Not affected	Not affected	Not affected	Not affected		Not affected
P. antipodarum	Survival	Not reduced	Reduced	Reduced at 704	Not reduced		Reduced
C. auratus	Morphological			High % Lesions			High % Lesions
	Physiological						
	Biochemical			Induced stress response			Induced stress response

		Reference		Upstream of the ERS		Downstream of the ERS	
		Dandenong Creek (708,514)	**Old Joes Creek (707)**	**Dandenong Creek (706, 704)**	**Bungalook Creek (705)**	**Heatherdale Creek (703)**	**Dandenong Creek (1505, 702, 701)**
Summary of Effect		**-**	**-**	**++**	**+**		**++**
Sewage Effects							
Sewage related contaminants		caffeine, venlafaxine, carbamazepine, EE2 detected	*Bacteroides* spp. – human sources; caffeine, carbamazepine, EE2 detected;	*Bacteroides* spp. – human sources; caffeine, venlafaxine, carbamazepine, EE2 detected	caffeine, venlafaxine, carbamazepine, EE2 detected and total estrogen	caffeine, venlafaxine, carbamazepine, EE2 detected	caffeine, venlafaxine, carbamazepine, EE2 detected
Endocrine Disruption							
C. auratus	Vitellogenin			Not elevated in males			Not elevated in males
	Histopathological			Capable of reproducing			Capable of reproducing
				No tissue damage			No tissue damage
P. antipodarum	Survival	Reduced during overflow event		Significantly reduced during overflow event			Significantly reduced during overflow event
	Reproduction (resident population)		Low				Low at ERS site (1505)
Summary of Effect		**-**	**+**	**+**			**+**
Overall Assessment		Potential adverse effects predicted due to: low level of contamination. No biological impacts detected	Significant adverse effects predicted due to: elevated pollutants (particularly metals). two or more toxicological endpoints reduced; reduced macroinvertebrate fauna	Significant adverse effects predicted due to: elevated pollutants (metals, hydrocarbons and pesticides); two or more toxicological endpoints reduced; reduced macroinvertebrate fauna; reduced fitness of goldfish. No sign of endocrine disruption	Significant adverse effects predicted due to: elevated synthetic pyrethroids (organic pollutants); two or more toxicological endpoints reduced; significant reduction in mud snail survival; reduced macroinvertebrate fauna	Potential adverse effects predicted due to: elevated pollutants (synthetic pyrethroids and metals)	Significant adverse effects predicted due to: elevated synthetic pyrethroids (and some metals); two or more toxicological endpoints reduced; reduction in mud snail survival; reduced macroinvertebrate fauna; reduced fitness of goldfish. No sign of endocrine disruption due to ERS spills

++ significant adverse effects predicted; + potential adverse effects predicted; - No adverse effects predicted. Bold indicates the source of the pollutants *Macroinvertebrate Indices are described and measured against the EPA Victoria SEPP Guidelines (2004).

Key Recommendations:

- Continue pollution sourcing programs - to identify the sources of pollution and to reduce their presence within the Upper Dandenong Creek Catchment. Information from these programs will drive either EPA/Compliance/enforcement, education or infrastructure works.
  Priority areas include:
  - Bungalook Creek – pesticides, metals, dissolved oxygen;
  - Croydon Main Drain – metals, pesticides, ammonia;
  - Dandenong Creek at King Street – metals and pesticides;
  - Stormwater Drain in Dandenong Creek near the ERS site.
- Continued monitoring of the health of the catchment (chemically and biologically) to understand temporal or spatial changes in pollution.
- Intensive monitoring of wet weather overflow spills to gain a better understanding of the impacts of the sewer spills.
- Intensive monitoring of event based pollution to understand patterns and regular types of event-based pollution occurring in the catchment.

Table 3: Identified stressors and impacts on values within the Upper Dandenong Creek Catchment

Potential stressors		Impacts on values	Catchment sources	Contributions from wet weather sewer overflows		Contribution from other sources	
				Priority	Confidence	Priority	Confidence
Pollution	Nutrients	Ecosystem Value: nuisance plant growth – loss of flora and fauna	Agriculture, urban runoff, stormwater, septic tanks, wet weather sewer overflows	Low-Moderate	Low – limited data	High – observed high nutrients throughout the catchment	High
	Pathogens	Ecosystem Value: loss of macroinvertebrates and fish diversity	Urban runoff, rural runoff, septic tanks, failing infrastructure, wet weather sewer overflows	Low-Moderate	Low – limited data	Moderate – some evidence of pathogens present within the catchment	High
	Heavy metals	Ecosystem Value: low macroinvertebrate diversity	Urban runoff, roads, stormwater, industry	Low	Moderate	High – observed high metals throughout the catchment	High
	Hydrocarbons	Ecosystem Value: low macroinvertebrate diversity, anaerobic sediments	Urban runoff, roads, vehicles, stormwater, industry	Low	Moderate	High – observed high hydrocarbons throughout the catchment	High
	Pesticides	Ecosystem Value: loss of flora (algae) and fauna (macroinvertebrates and fish)	Urban runoff, rural runoff, industry	Low	Moderate	High – observed high pesticides throughout the catchment	High
	Endocrine disrupting chemicals (EDCs)	Ecosystem Value: low fish diversity and impaired reproduction Potential impacts on other biota (frogs)	Urban runoff, industry, wet weather sewer overflows	Low-Moderate	Low – limited data	Moderate – some endocrine disrupting chemicals observed within the catchment	Moderate
	Pharmaceuticals and Personal Care Products (PPCPs)	Ecosystem Value: low fish diversity and impaired reproduction Potential impacts on other biota (frogs)	Urban runoff, low residential areas—septic tanks, wet weather sewer overflows	Low-Moderate	Low-Moderate	Moderate – some PPCPs observed within the catchment	Low-Moderate
	Litter	Social Value: reduced amenity Ecosystem Value: low macroinvertebrate diversity	Urban, industrial estates, stormwater, wet weather sewer overflows	Moderate	Moderate	High – evidence of litter frequently observed within the catchment	Moderate
Stream Hydrology	Water harvesting	Social Value: reduced amenity Ecosystem Value: low flora and fauna diversity	Agricultural offtakes	Nil		Nil	

Potential stressors		Impacts on values	Catchment sources	Contributions from wet weather sewer overflows		Contribution from other sources	
				Priority	Confidence	Priority	Confidence
	Urban runoff	Ecosystem Value: low flora and fauna diversity	Urban	Nil		High – many stormwater drains discharge in the catchment	High
	Industrial runoff	Social Value: reduced amenity Ecosystem Value: low macroinvertebrate diversity, reduced fish habitat	Industrial Estates	Nil		High – many industrial drains discharge in the catchment	High
	Rural runoff	Ecosystem Value: reduced macroinvertebrate and fish habitat	Upper Dandenong Creek Catchment	Nil		Moderate	High
Physical habitat	Riparian Habitat	Ecosystem Value: low flora and fauna diversity, reduced habitat quality	All	Nil		Moderate	High
	Stream banks	Social Value: reduced amenity	All	Nil		Moderate	High
	Stream bed and instream barriers	Ecosystem Value: low flora and fauna diversity, reduced fish movement		Nil		Moderate	High

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