Environmental Scientific Services

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Wychwood Wild Garden Aquatic Survey

Final report to support the restoration of the ponds

ECRC Research Report Number 173

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Submitted to:

Wychwood Wild Garden

(Shipton-under-Wychwood Wild Garden and Woods Ltd.)

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Cover photo: Basin Pond, Ben Goldsmith

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1. Background

Wychwood Wild Garden (WWG) is an area of woodland and historic garden which once formed part of Shipton Court, but is now managed and owned by the local community. Within the Wild Garden are two ponds, both artificial in creation, but dating back to the 19th century. In addition to the ponds, the water flows north through “The Lifts”, a series of three canals, each with a low cascade to the one below; the final one having a sluice at the northern boundary of the gardens where the water forms a headwater tributary of the River Evenlode.

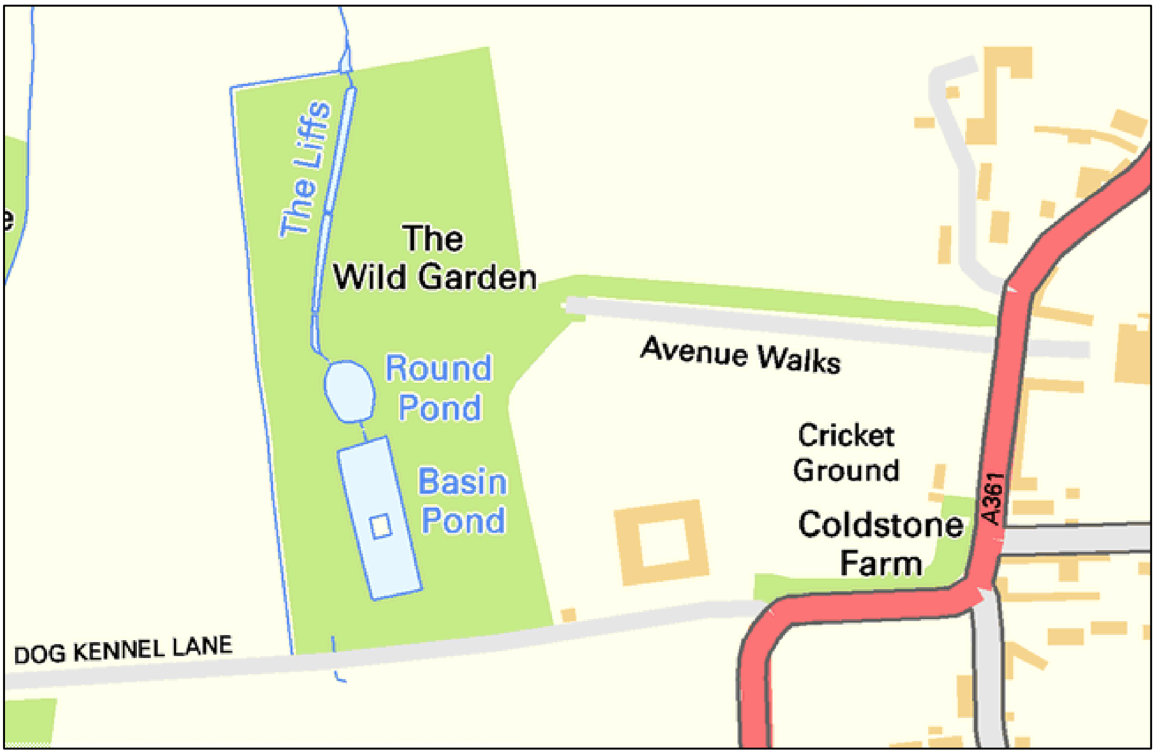

Figure 1. Wychwood Wild Garden (Contains OS Open data © Crown copyright 2016)

Basin Pond is roughly rectangular and measures approximately 85 m long by 30 m wide with a small island (12 x 9 m) in the centre. The edges are generally degraded from their original stone or brick profile and around much of the site have become more naturally graded earth sides. The site is heavily shaded by the encroaching woodland around the margins and the island.

Round Pond is in fact slightly oval in shape measuring approximately 35 m north to south and 25 m east to west. The vertical sides are of stone / brick construction and measures only 80 cm at its deepest point, with much of the water being less than 60 cm deep. The site is heavily shaded to the south by a large Cedar of Lebanon *Cedrus libani* that stands on the earth bank that separates the two ponds.

The water supply to the ponds is a small spring rising just to the south of the gardens where it flows under Dog Kennel Lane and into the southwest corner of Basin Pond. From the basin pond, there is a shallow channel through with the water passes down into the Round Pond, from which it exits north, under the path into the uppermost canal of The Lifts.

The ponds have suffered from years of neglect prior to 2010. The surrounding woodland has encroached around the ponds resulting in tree roots damaging the edges in places, and sediments have accumulated resulting in the sites becoming very shallow; neither pond being more than 50-60 cm deep throughout most of the basin.

As part of the continued management of the gardens, some improvement work has already been done on the Ponds to shore up the banks and remove trees that were damaging the stonework edges. More extensive restoration work was conducted on The Lifts, with clearance of the channels and restoration and stabilisation of the banks using geo-textile matting. Wychwood Wild Garden now wishes to undertake further restoration of the ponds, including further remedial work to the edges of the Round Pond and partial de-silting in order to deepen the ponds. The aim of the work will be to restore the ponds back towards their former appearance and structure. In so doing it is hoped to improve the aesthetic value of the ponds while also ensuring they provide good habitat for the wildlife that inhabits the gardens.

ENSIS was engaged by WWG to undertake a programme of works to inform the planned management. This included an assessment of the current ecological quality of the ponds and provision of chemical analysis of the pond sediments to ensure the necessary legal compliance was met for on-site disposal of the dredged material.

1.1. Project aims

- Undertake a water quality survey of the ponds and canals;
- Undertake an ecological quality appraisal of the ponds;
- Collect and analyse sediment cores from both ponds;
- Present management recommendations to enhance the ecological quality of the site.

2. Methods

2.1. Water quality samples

Water samples were collected on 24th February from four points: the spring, the Basin Pond, the Round Pond and at the north end of The Lifts where the water flows out of the garden.

In addition, an extra sample was taken from the water that issues from a pipe that appears to come from under Dog Kennel Lane and flows into the south side of the culvert. The purpose of this additional sample was to ensure this was natural in origin, rather than a leaking main or drainage water.

Water samples were sent by overnight courier to the National Laboratory Service (UKAS accredited) laboratories and analysed for a standard range of water quality variables (Table 1).

Table 1 List of determinands analysed for water quality

Determinand	Unit	Limit of detection
pH	pH	0.05
Conductivity @ 20C	µS/cm	10.0
Suspended Solids	mg/l	1.0
Total Alkalinity	mg/l	5.0
Orthophosphate, reactive as P	µg/l	1.0
Total Phosphorus (TP)	µg/l	3.0
Total oxidised Nitrogen as N	mg/l	0.005
Nitrate Nitrogen as N	mg/l	0.005
Nitrite Nitrogen as N	mg/l	0.001

2.2. Sediment sampling and analysis

Sediment samples were collected from the Round Pond and the Basin Pond using a modified Livingstone corer. Each core was extruded on site and thoroughly mixed before subsampling into sample pots. Samples were sent by overnight courier to the National Laboratory Service (UKAS accredited) laboratories and analysed for a suite of chemical parameters that present potential for toxicity or environmental damage if found at high concentrations. These include heavy metals (e.g. cadmium, lead, mercury) and a wide range of hydrocarbons.

A further subsample was taken from each core and analysed at UCL for water and organic content.

Approximate coring locations were:

Basin Pond: SP2733517459
Round Pond: SP2732217507

In addition to the core samples, an estimate of the soft sediment depth was made throughout the two ponds by using a 3 m metal pole (30 mm diameter) to probe the silts to a point where the resistance exceeded gentle pushing. From experience this gives a good estimate of the sediment depth that overly the basal clay lining of artificial ponds.

2.3. Macroinvertbrate sampling

A combined sample was taken from each pond using a 3 minute net sampling technique to disturb and sweep the representative habitats found within each pond, with sample time allocated to the proportion of each habitat present.

Samples were field-assessed, with any larger invertebrates identified, counted and returned to the site. The remaining sample was preserved using 75% de-natured alcohol and the invertebrates sorted and identified to family level in the laboratory.

2.4. Ecological survey

Survey timing was outside the normal period for aquatic and wetland plants, which normally takes place between June and September. We were however able to assess the species present in February inclusive of some of the marginal vegetation remaining from the previous year. An overall habitat assessment was made based on expert judgement.

3. Monitoring Results

3.1. Water quality

The results presented in Table 2 are typical of spring fed surface waters in the Shipton area (Geology of alkaline bedrock formations from the Jurassic period). With the exception of nitrate, these data are excellent and show the site to benefit from very high water quality. The high nitrate is typical of ground water in the area and not therefore something that can be reduced. In terms of the ecology of the site, it almost certainly promotes the nuisance growths of the filamentous algae seen in the ponds. Anything less than 10 µg/l of total phosphorus is excellent and below 20 µg/l – very good. With high nitrogen in the water it is important that phosphorus remains low; this should be no problem while the spring remains the main water supply to the ponds.

Table 2 Water quality in Wychwood Wild Gardens

Determinand	Unit	Spring	Unknown Pipe	Basin Pond	Round Pond	Canal end
pH	pH	7.4	7.48	7.97	7.93	7.94
Conductivity @ 20C	µS/cm	556	550	541	547	547
Suspended Solids	mg/l	< 1.0	< 1.0	1.2	1.5	2.1
Total Alkalinity	mg/l	284	282	262	256	254
Orthophosphate, reactive as P	µg/l	7.7	7.9	5.7	5.4	7
Total Phosphorus (TP)	µg/l	10.3	13.7	8.1	9.1	9.4
Nitrate Nitrogen as N	mg/l	12.1	12.1	11.5	11.3	10.9
Nitrite Nitrogen as N	mg/l	<0.001	<0.001	0.005	0.005	0.007

Suspended solids show the water to carry very little particulate matter, with the very slightly higher value at the end of the canal likely to be a result of the instability of the canal banks following the restoration works. Anything less than 3 mg/l is excellent.

It is also very encouraging to note that the “unknown” pipe that issues into the spring has very similar chemical composition to the spring water. This is strong evidence to suggest it is another outlet from the same groundwater source and not from road drainage or a burst water main that would be characterised by elevated levels of suspended solids in the case of the former and higher phosphorus if the latter.

Although not particularly relevant to the Gardens, the levels of nitrate in the spring water is very close to the “safe” standards issues under law for UK drinking water (set at 50 mg/l as NO_3 or 11.3 mg/l as N). This no-doubt reflects the rich agricultural land surrounding the Gardens, but as you will notice, the levels are already declining by the time the water leaves the site and measurements taken by ENSIS in the River Evenlode in the past suggest it to be down to approximate half (5-7 mg/l) in the river.

3.2. Sediment quality

The results of the sediment toxicity testing showed no cause for concern. The official wording from the testing Laboratory was as follows:

> *The sample did not breach thresholds from the hazardous waste regulations for any of the parameters that were determined.*
>
> *The sample did not breach Waste Acceptance Criteria thresholds from the Environment Agency*
>
> *Waste Sampling and Testing for Disposal to Landfill EBPRI 11507B: March 2013 for any of the parameters that were determined.*
>
> *HAZARDOUS WASTE LANDFILL criteria: None*
>
> *STABLE NON-REACTIVE HAZARDOUS WASTE in NON-HAZARDOUS LANDFILL criteria: None*
>
> *INERT WASTE LANDFILL criteria: None*

The sediments can therefore be considered as non-hazardous and may be disposed of on site under the exemption licence as applied for.

3.3. Sediment volume

Basin Pond

Based on a series of depth probes conducted throughout the Basin Pond, the soft sediments ranged from 70-80 cm in depth in the open water areas. Below the soft sediment was a layer of more consolidated material comprising of clay and gravels which is assumed to be the original base of the pond. Sediment depth around the pond edges was harder to determine accurately due to the denuded banks and vegetation growth (mainly yellow flag iris and sedges), and in places there was no soft sediment. The distinction between basal clays and coarse material (mainly in-washed soils and gravel) could not therefore be made. Table 3 gives a summary of the sediment depth and estimates of total sediment volume (wet and dry).

Table 3 Summary of the sediment volumes – Basin Pond
Surface area is based on OS 1:2500 mapping

Surface area - pond	2584 m^2
Surface area - island	114 m^2
Surface area - total	2470 m^2
Minimum sediment depth	0 cm
Maximum recorded sediment depth	80 cm
Estimated mean sediment depth	65 cm
Estimated volume of sediment – wet	1605.5 m^3
Percent dry weight of sediment	24.3%
Estimated volume of sediment – dry	390.1 m^3
Estimated volume of sediment – 40 % water	546.2 m^3

Round Pond

The soft sediments ranged from 50-85 cm in depth in the open water areas, below which was a layer of more consolidated material comprising of clay and gravels which is assumed to be the original base of the pond. The deepest sediments were in the centre of the pond, but was typically only 50-60 cm throughout much of the open water areas. Sediment depth around the pond edges was variable, with no soft sediment present on the south side around the inflow; instead this area comprised mainly of gravel and coarser materials, presumably washed in and sorted during periods of disturbance or high flow. The remaining margins included a mix of material fine and coarser materials within 1 m of the stone banks, grading to finer and less consolidated material 2-3 m from shore. The depth of sediment in these areas was difficult to accurately determine, but in most areas there was clay (presumed to be the pond base) at 30 – 40 cm below the sediment surface. Table 4 gives a summary of the sediment depth and estimates of total sediment volume (wet and dry).

Table 4 Summary of the sediment volumes – Round Pond

Surface area is based on OS 1:2500 mapping

Surface area - pond	722 m^2
Minimum sediment depth	0 cm
Maximum recorded sediment depth	85 cm
Estimated mean sediment depth	60 cm
Estimated volume of sediment – wet	433.2 m^3
Percent dry weight of sediment	23.2%
Estimated volume of sediment – dry	100.5 m^3
Estimated volume of sediment – 40 % water	140.7 m^3

Given that the proposed dredging of Round Pond will be limited by the 4 m reach of the excavator, the volume of removed sediment is given in Table 5 for differing removal depth scenarios.

Table 5 Summary of the sediment volumes for a 4 m strip around Round Pond

Surface area is based on OS 1:2500 mapping

Surface area - pond	722 m^2
Surface area of a 4 m band from pond edge	330.5 m^2
Estimated mean sediment depth within this area	35 cm
Percent dry weight of sediment	23.2%

	Cubic meters (m^3)		
	Wet	Dry	40 % water
Estimated volume of sediment after 20 cm removed	66.1	15.3	21.5
Estimated volume of sediment after 25 cm removed	82.6	19.2	26.8
Estimated volume of sediment after 30 cm removed	99.1	23.0	32.2
Estimated volume of sediment after 35 cm removed	115.7	26.8	37.6
Estimated volume of sediment after 40 cm removed	132.2	30.7	42.9
Estimated volume of sediment after 45 cm removed	148.7	34.5	48.3
Estimated volume of sediment after 50 cm removed	165.2	38.3	53.7
Estimated volume of sediment after 60 cm removed	198.3	46.0	64.4
Estimated volume of sediment after 70 cm removed	231.3	53.7	75.1
Estimated volume of sediment after 80 cm removed	264.4	61.3	85.9

The sediments from both ponds contain approximately 75% water (Basin Pond 75.7% and Round Pond 76.8%). During disposal of the sediments on site, it can be expected that the original volume of sediment removed will reduce significantly as it dries. While unlikely to reduce by 75% in volume under natural de-watering, a conservative estimate would be for it to reduce in total volume by at least 50% over a period of 2-3 months, and ultimately up to 60% given that the soils and geology of that areas are free draining and aided by uptake of water by the trees.

3.4. Macro-invertebrates

The invertebrate assemblages of both ponds were very similar and dominated by high numbers of freshwater shrimp (*Gammaridae*) and hoglice (*Asellidae*) which reflects the high levels of leaf litter in the ponds. Overall the assemblage was surprisingly species poor, which possible reflects the timing of the survey rather than habitat quality. Water snails, and a few caddisfly larvae are worth of note, but otherwise very few other invertebrates were recorded. A full list of taxa recorded is given in Table 6.

We would recommend a follow-up survey is carried out in summer to detect taxa that may have been dormant in the cooler winter months.

Table 6 Aquatic invertebrates recorded from Wychwood Wild Gardens

Group	Common name	Family	Round Pond	Basin Pond
Water bugs (Hemiptera)	Water boatman	Corixidae	3	
Mayflies (Ephemeroptera)	Pond olive	Baetidae		1
Caddis Flies (Trchoptera)	Cased-caddis larvae	Trichoptera	12	18
True-Flies (Diptera)	Non-biting midge larvae	Chironomidae	12	20
	Cranefly larvae	Tipulidae	1	
Beetles (Coleoptera)	Beetle Larvae	Haliplidae		1
Crustaceans	Hoglice	Asellidae	212	80
	Freshwater shrimp	Gammaridae	560	960
Leeches (Hirundea)	Leeches	Glossiphonidae	4	
Molluscs	Ramshorn snails	Planorbidae	20	25
	Pond snails	Lymnaeidae	2	3
Flatworms (Platyhelminthes)	Turbellaria	Planariidae	1	3
	Number of Taxa		**10**	**9**

3.5. Ecological survey

Basin Pond

The open water of the Basin Pond is dominated by growths of an aquatic moss – willow moss *Fontinalis antipyretica*. Also present is ivy-leaved duckweed *Lemna trisulca*; mainly at low density. This submerged aquatic assemblage provides good potential habitat for invertebrates. Two small growths of a starwort *Callitriche* sp. were recoded. No other submerged species were recorded.

The south end of the pond has quite extensive beds of sedge (Greater pond sedge *Carex riparia*) and there are beds of yellow flag iris *Iris pseudacorus* along the sides of the pond with evidence of water mint *Mentha aquatica*, brooklime *Veronica beccabunga* and common willowherb *Epilobium hirsutum* also present.

These beds of marginal and emergent species, particularly where extensive, provide very good habitat for invertebrates and birds and we would recommend that they be left to enhance the ecological potential of the Basin Pond.

Round Pond

The Round Pond is similar to Basin Pond in that it has dense growths of willow moss *Fontinalis antipyretica* with ivy-leaved duckweed *Lemna trisulca* locally frequent in much of the open water. The site also benefits from a good-sized bed of water lilies *Nymphaea* sp. lying roughly centre of the pond. Given the probability that these were planted in the pond, we are uncertain if these are the native white water lily *N. alba,* or a cultivated variety. Either way they bring interest to the site from both a habitat and aesthetic perspective. The lilies rely on their robust tuber-like rhizomes to over-winter and proliferate. During restoration works, these should tolerate the disturbance providing they are not allowed to dry out completely.

There was little marginal or emergent vegetation present in February. We noted small areas with brooklime *Veronica beccabunga* and a starwort *Callitriche* sp.

Overall the presence of any submerged plant species should be considered to be good. The willow moss provides good habitat and the marginal vegetation in the Basin Pond and Water Lilies in the Round Pond give further benefits by providing good structure to habitat within the sites. A summer survey would be required to establish a more comprehensive species list or the plants.

4. Comments and Recommendations

The water chemistry data show the ponds to benefit from high quality waters. Nitrate levels are however high and therefore this may restrict the growth of some plant species in the sites which are intolerant of high nitrogen (e.g. stoneworts *Chara* spp.). The majority of aquatic species will be unaffected and greater depth provided by dredging may potentially benefit some species by reducing physical disturbance. We would recommend that nature be left to take its course rather than any planting of aquatic plants. If there is no evidence of any new species in the ponds three years after restoration, you may wish to consider careful selection and introduction of native plant species.

Sediments in both ponds breach no thresholds for hazardous substances and may therefore be safely removed to adjacent land under the terms of the EA exemption for sediment disposal. We estimate that after de-watering, the sediment should reduce in volume by at least 50% of its original wet volume.

Shading from the surrounding trees is likely to be the main inhibitor to aquatic plant growth as well as contributing to the large amounts of leaf litter to the ponds (and hence sediment accumulation). We would support the selective thinning of bankside trees to allow more light to reach the ponds. This would be more easily achieved for the Basin Pond than the Round Pond; the latter being shaded mainly by the Cedar of Lebanon.

Direct shading from the southeast, south and particularly western side of the Basin Pond could be alleviated if trees were cut back to approximately 10 m from the pond edge. This distance may be less to the south of the pond where the angle of incident sunlight will be higher. Clearance need not be of all trees, but removal of approximately 75% of the cover in these areas would greatly increase the incident light required by aquatic plants. Specimen trees, and those with high aesthetic value (e.g. the weeping willow), would be best left to maintain the visual appeal of the site. Removal of the overhanging trees on the island may also help to reduce leaf litter. A reduction of shading would also facilitate the growth of marginal and emergent vegetation and potentially result in the increased species richness of the margins which are currently dominated by shade tolerant species such as pond sedge and yellow flag iris.

At the Round Pond, the Cedar of Lebanon takes much of the sunlight from the water. Removal, or thinning of trees to the southeast and west of the site to 10 m from the edge, would nonetheless improve the quality of light to the pond and help to reduce leaf litter.

One further advantage of opening up the ponds to more sunlight would be to improve the habitat for dragonflies. Adult dragonflies actively seek sunny areas to both bask and also as breeding territories. The combination of woodland roosts and open areas of water is ideal for many species, including two notable specialist woodland pond species, the downy emerald dragonfly and brilliant emerald dragonfly, the larvae of which also utilize leaf litter for cover. A sunny woodland pond with a diverse array of marginal and aquatic plants is ideal dragonfly and damselfly habitat.

5. Supplementary information

Table 7 Sediment toxicity test results

Analyte	***Units***	**Round Pond**	**Basin Pond**
Cyanide : Free : Dry Wt as CN	mg/kg	<5	<3
Cyanide : Total : Dry Wt as CN	mg/kg	<5	3.71
Phenols : Monohydric : Dry Wt	mg/kg	<10	<6
Sulphide : Dry Wt	mg/kg	605	129
pH : Solid sample	pH Units	7.41	7.5
Arsenic : Dry Wt	mg/kg	5.78	5.4
Barium : Dry Wt	mg/kg	38.4	24.6
Cadmium : Dry Wt	mg/kg	0.24	0.247
Chromium : Dry Wt	mg/kg	16.6	11.2
Copper : Dry Wt	mg/kg	11.8	8.53
Lead : Dry Wt	mg/kg	18.2	14.3
Mercury : Dry Wt	mg/kg	<1	<1
Nickel : Dry Wt	mg/kg	10.9	6.87
Zinc : Dry Wt	mg/kg	78.4	59.2
Hydrocarbons >C10 - C40 (Total) : Dry Wt	mg/kg	<200	<200
Acenaphthene : Dry Wt	ug/kg	<15	<20

Analyte	*Units*	Round Pond	Basin Pond
Acenaphthylene : Dry Wt	ug/kg	<20	<20
Anthanthrene : Dry Wt	ug/kg	57.6	101
Anthracene : Dry Wt	ug/kg	<20	23
Benzo (b + k) fluoranthene : Dry Wt	ug/kg	559	691
Benzo(a)anthracene : Dry Wt	ug/kg	149	205
Benzo(a)pyrene : Dry Wt	ug/kg	217	281
Benzo(b)fluoranthene : Dry Wt	ug/kg	421	525
Benzo(e)pyrene : Dry Wt	ug/kg	204	249
Benzo(ghi)perylene : Dry Wt	ug/kg	243	266
Benzo(k)fluoranthene : Dry Wt	ug/kg	138	167
Chrysene : Dry Wt	ug/kg	236	314
Coronene : Dry Wt	ug/kg	70	72.7
Cyclopenta(cd)pyrene : Dry Wt	ug/kg	<10	<10
Dibenzo(ah)anthracene : Dry Wt	ug/kg	46.7	61.9
Fluoranthene : Dry Wt	ug/kg	386	550
Fluorene : Dry Wt	ug/kg	15.8	18.8
Indeno(1,2,3-cd)pyrene : Dry Wt	ug/kg	276	292
Naphthalene : Dry Wt	ug/kg	16	19.1
Perylene : Dry Wt	ug/kg	71.8	84.4
Phenanthrene : Dry Wt	ug/kg	93.4	143
Pyrene : Dry Wt	ug/kg	317	458
PCB - 028 : Dry Wt	ug/kg	<2	<2
PCB - 052 : Dry Wt	ug/kg	<1	<1
PCB - 101 : Dry Wt	ug/kg	<2	<2
PCB - 118 : Dry Wt	ug/kg	<2	<2
PCB - 138 : Dry Wt	ug/kg	<1	<1
PCB - 153 : Dry Wt	ug/kg	<1	<1
PCB - 180 : Dry Wt	ug/kg	<1	<1
Hydrocarbons >C5 - C10 : Dry Wt	mg/kg	<20	<10
1,2-Dimethylbenzene : Dry Wt :- {o-Xylene}	ug/kg	<5	<3
Benzene : Dry Wt	ug/kg	<5	<3
Dimethylbenzene : Sum of (1,3- 1,4-) : Dry Wt	ug/kg	<10	<6
Ethylbenzene : Dry Wt	ug/kg	<2	<2
Toluene : Dry Wt :- {Methylbenzene}	ug/kg	<10	<9
Toxicity rating		0	0

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