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## WATER QUALITY EFFECTS OF TIRE CHIP FILLS PLACED ABOVE THE GROUNDWATER TABLE

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**REFERENCE:** Humphrey, D.N., Katz, L.E., and Blumenthal, M., "Water Quality Effects of Tire Chip Fills Placed Above the Groundwater Table", Testing Soil Mixed with Waste or Recycled Materials, ASTM STP 1275, Mark A. Wasemiller, Keith B. Hoddinott, Eds., American Society for Testing and Materials, 1997.

**ABSTRACT:** Two field trials were constructed to investigate the effect on water quality of tire chip fills placed above the groundwater table. Control wells were used to distinguish the substances naturally present in groundwater from those that leached from tire chips. There was no evidence that tire chips increased the level of substances that have a primary drinking water standard. In addition, there was no evidence that tire chips increased the levels of aluminum, zinc, chloride or sulfate which have secondary (aesthetic) drinking water standards. Under some conditions iron levels may exceed their secondary standard. It is likely that manganese levels will exceed their secondary standard, however, manganese is naturally present in groundwater in many areas. Two sets of samples were tested for organics. Results were below the method detection limit for all compounds.

**KEYWORDS:** tires, tire chips, tire shreds, waste tires, water quality, metals, organics, road construction

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Tire chips are waste tires that have been cut into 25 to 300 mm pieces. They offer the following advantages when used as a fill material: lightweight, low lateral pressure, low thermal conductivity, and free draining. Because of these advantages they have been used on more than 70 road construction projects across the United States. While their

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effect on groundwater quality is thought to be small, there has been little study of the effects for field conditions.

Previous laboratory leaching studies have shown that tire chips are not a hazardous waste. However, low levels of some metals and organic compounds were found in the leachate (Radian, 1989; Minnesota Pollution Control Agency, 1990; Edil and Bosscher, 1992; Ealding, 1992; Downs et al., 1996). This indicated that testing the effects of tire chips on water quality under field conditions was warranted.

A limited field study was performed for the Minnesota Pollution Control Agency (1990). Unfortunately, samples were taken on only one date from open boreholes. This sampling procedure casts doubt on the validity of the results. Edil and Bosscher (1992) installed two pan lysimeters beneath tire chip layers in a test road embankment. The study had no control for sampling an area with no tire chips, so it was not possible to separate the effects of the tire chips from the compounds naturally present in the groundwater.

The objective of the two studies presented herein were to measure the water quality effects of tire chips placed above the water table. The studies include control sections to measure the levels of substances naturally present in the groundwater. A separate study of the effect on water quality of tire chips placed below the groundwater table is ongoing. In this latter study 1.5 tons of tire chips were buried below the water table in glacial till, marine clay, and peat. Preliminary results are given in Downs et al. (1996).

## **RICHMOND FIELD TRIAL**

The purposes of the Richmond Field Trial were to test the use of tire chips as thermal insulation to limit the depth of frost penetration beneath a gravel surfaced road and to measure the effect of tire chips placed above the water table on groundwater quality. The tire chips have reduced the depth of frost penetration by up to 40% and the road surface has remained stable throughout the spring thaw (Humphrey and Eaton, 1995). The thermal resistivity of the tire chips has been found to be approximately eight times greater than a typical granular soil (Humphrey et al., 1997). The site, groundwater monitoring program, and monitoring results are described in the following sections.

### Site and Monitoring Well Descriptions

The test site is located on Dingley Road in the Town of Richmond, Maine. The road follows the northeast shoulder of a broad, flat ridge that trends northwest-southeast. During the summer and fall no standing water or wet areas are evident near the test site. However, during the spring melt, the generally flat topography leads to poor drainage and areas of standing water.

The native soils range from gray silty clay to gray-brown silty gravelly sand. Probes were conducted with a 127-mm diameter power auger. Refusal occurred at depths ranging from 2.7 m to 5.5 m. The general geology of the area suggests that refusal was either glacial till with boulders or bedrock.

The test site is 290 m long and is broken up into five tire chip test sections and one control section. Two different thicknesses of tire chips (152 and 305 mm) were used to

investigate the thickness that is required to provide adequate insulation and three different thicknesses of granular soil (305, 457, and 610 mm) were placed over the tire chips to investigate the thickness needed to provide a stable riding surface. The general layout is shown in Fig. 1.

The tire chips were uniformly graded and had a nominal maximum size of 51 mm. Almost all the tire chips were retained on the No. 4 (4.75 mm) U.S. standard sieve size. They were made from a mixture of steel and glass-belted tires. The tire chips were irregular in shape and many had steel belts protruding from the cut edge of the chip. The tire chips were donated by Pine State Recycling of Nobleboro, Maine. Approximately 20,000 tires were used in this small project, which clearly shows the potential of this application to use large quantities of scrap tires. The gravel fill used over the tire chips was a well graded mixture of sand and gravel with less than 5% passing the No. 200 (0.075 mm) U.S. standard sieve size. Flake calcium chloride was applied to the road surface for dust control.

Groundwater monitoring wells were installed in the shoulder of the road at six locations. Well no. 0+69 is the control well and is located adjacent to the control section, which has no tire chips. Moreover, the control section is located upgradient of the sections with tire chips. The other five wells are adjacent to sections with tire chips. The horizontal distance from the edge of the tire chip fill to the well was between 1 and 2 m. The wells consist of 51-mm diameter Sch. 40 PVC pipe. The pipe was placed in a 127-mm diameter hole and the slotted lower portion was backfilled with concrete sand. Then a 0.3 to 0.6-m thickness of bentonite balls were placed to form an impermeable seal to prevent surface water from reaching the slotted tip. The remainder of the hole was backfilled with native soil. However, no bentonite seal was constructed in well no. 3+42. Well installation is summarized in Table 1. Further details are given in Humphrey and Katz (1995). In the summer and fall, the water table is 0.2 to 2.2 m below the bottom of the tire chip layer. During the spring melt, the water table varies from approximately 0.5 m below the bottom of the tire chip layer in Section A to even with the bottom of the tire chip layer in Section E.

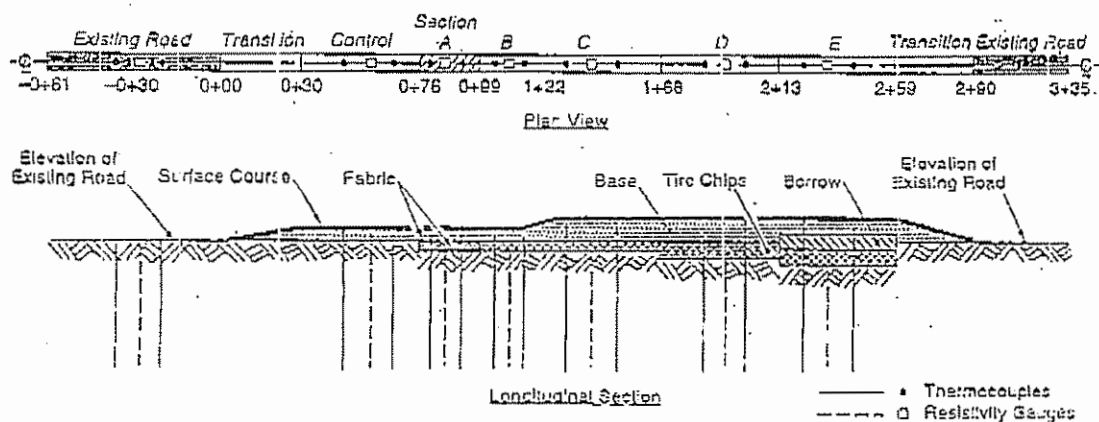


FIG. 1—Plan view and longitudinal section of the Richmond Field Trial.

TABLE 1—Summary of well installation at Richmond Field Trial.

Well no.	Elev. of top of sand backfill (m)	Elev. of bottom of sand backfill (m)	Elev. of bottom of adjacent tire chip layer (m)
0+69	12.17	11.47	Not applicable
3+00	10.95	10.22	13.16
3+42	Not recorded	10.09	13.03
6+19	7.23	6.47	13.03
6+77	8.58	7.88	11.97
8+32	9.85	8.60	11.41

Note: Elevations are referenced to an arbitrary site datum.

### Sampling and Testing Procedures

Water samples were obtained with a 1-liter capacity high density polyethylene (HDPE) bailer. Just prior to sampling, approximately three wells volumes were bailed from the well, then the samples were taken from the groundwater that recharged the well. The following sample types were taken from each well: leachate filtered through a 0.3-micron filter and preserved with nitric acid (1.5-ml/L) as appropriate for determination of dissolved metals (Ciesceri, et al., 1989); leachate unfiltered and preserved with nitric acid (1.5-ml/L); and unfiltered leachate with no acid. Samples were stored in HDPE bottles and were refrigerated to minimize degradation of sample quality. In addition, on two dates samples were taken for biological oxygen demand (BOD<sub>5</sub>) determination.

The samples were tested for the substances listed in Table 2. Samples for metals analysis except for lead and selenium were prepared in accordance with EPA Method 200.7 (Inductively Coupled Plasma - Atomic Emission Spectrometric Method for Trace Element Analysis) (EPA, 1991). The metals were then measured with a Thermo Jarrell Ash Model 975 Plasma Atomcomp Inductively Coupled Plasma Emission Spectrometer. Samples for lead and selenium were prepared in accordance with EPA Method 200.9 (Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic

TABLE 2—List of substances tested for in study.

Aluminum (Al)**	Magnesium (Mg)
Barium (Ba)*	Manganese (Mn)**
Cadmium (Cd)*	Selenium (Se)*
Calcium (Ca)	Sodium (Na)
Copper (Cu)*	Zinc (Zn)**
Chromium (Cr)*	Chloride (Cl)**
Iron (Fe)**	Sulfate (SO <sub>4</sub> )**
Lead (Pb)	

\*Has primary drinking water standard

\*\* Has secondary drinking water standard

Absorption Spectrometry) (EPA, 1991). The tests were carried out in accordance with EPA Method 7421 Lead (Atomic Absorption, Furnace Technique) and EPA Method 7740 Selenium (Atomic Absorption, Furnace Technique) (EPA, 1987). Chloride and sulfate were measured in accordance with EPA Method 300.0 (Determination of Inorganic Anions by Ion Chromatography) (EPA, 1983). Water quality index tests such as pH, alkalinity, BOD<sub>5</sub>, chemical oxygen demand (COD), conductivity, total dissolved solids, and hardness were also performed.

For most substances, tests were performed on both acid preserved filtered and acid preserved unfiltered samples. The unfiltered samples generally contained some fine grained soil that imparted a slight turbidity to the water. Since most of the inorganic substances that were of interest are present in small amounts in soil, it would not be representative to compare the results from unfiltered samples to drinking water standards. This recognizes that wells for drinking water are designed to prevent any significant amount of particulate matter from entering the well. Thus, results from unfiltered samples provide supplementary information only and were not compared to drinking water standards.

## Results

Results for filtered samples are given in Table 3. Results for unfiltered samples and water quality index tests are given in Humphrey and Katz (1995). Results for filtered and unfiltered samples were generally similar, except that the concentration of aluminum (Al), iron (Fe), and manganese (Mn) were higher in the unfiltered samples. However, the unfiltered concentrations of these substances were about the same in the control well and the five wells adjacent to the tire chip sections. Since these substances are present in Maine soils (Downs et al., 1996), the higher concentrations are most likely due to the presence of suspended soil particles in the unfiltered samples.

The first group of substances in Table 3 have a primary drinking water standard indicating that they pose a known or suspected health risk. This includes barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), and selenium (Se). These substances were present in trace amounts or were below the detection levels. Filtered sample results for cadmium (Cd), lead (Pb), and selenium (Se) were below detection levels for all wells on all three sampling dates. It should be noted that for the first two sampling dates the detection limit for lead (Pb) was above its drinking water standard due to testing difficulties. This problem was corrected prior to the third sampling date. The significant result is that for substances that were detected, the concentrations were below applicable drinking water standards. This can be seen for the chromium (Cr) results which are plotted in Fig. 2. Chromium (Cr) levels were consistently higher in the control well than the wells adjacent to the tire chip sections. This suggests that trace levels of chromium (Cr) are naturally present in the soil and illustrates the importance of having a control well when assessing the effect of tire chips on water quality.

The second group of substances in Table 3 has secondary drinking water standards indicating that they are of aesthetic concern. This includes: aluminum (Al), iron (Fe), manganese (Mn), zinc (Zn), chloride (Cl<sup>-</sup>), and sulfate (SO<sub>4</sub>). The results were below the applicable standard except for manganese (Mn). As shown in Fig. 3, for some sampling dates the manganese concentration was above the secondary standard in the control well

TABLE 3—Water quality results on filtered samples for Richmond Field Trial.

Well No.	Date	Concentrations with primary limit (mg/L)								Concentrations with secondary limit (mg/L)								Conc. with no limit (mg/L)		
		Ba	Cd	Cr	Cu	Pb	Se	Al	Fe	Mn	Zn	Cl-	SO4	Solids	Ca	Mg	Hard.	Na		
R.A.L.		2	0.005	0.1	1.3	0.015	0.05	0.2	<0.1	<0.1	0.145	<0.01	3.17	55.3	500	N.A.	N.A.	N.A.		
0+69	12/23/93	<0.01	<0.005	0.015	<0.01	<0.057	N.D.	<0.1	<0.1	0.145	<0.01	3.17	55.3	N.D.	59.9	12.4	N.D.	30.3		
0+69	5/24/94	0.023	<0.005	0.033	0.005	<0.057	N.D.	<0.2	<0.03	0.022	<0.005	122.0	57.3	N.D.	76.2	15.0	N.D.	30.0		
0+69	1/18/95	0.030	N.D.	0.011	0.005	<0.005	N.D.	<0.015	<0.1	0.003	0.010	148.0	22.3	430	76.1	15.1	252	32.1		
3+00	12/23/93	<0.01	<0.005	<0.01	<0.01	<0.057	N.D.	<0.1	<0.1	0.021	<0.01	135.9	13.2	N.D.	63.4	15.4	N.D.	24.2		
3+00	5/24/94	0.045	<0.005	0.009	<0.005	<0.057	N.D.	<0.2	<0.01	0.008	<0.005	123.9	12.7	N.D.	54.6	13.4	N.D.	23.0		
3+00	1/18/95	0.028	N.D.	<0.002	<0.004	<0.005	N.D.	<0.015	<0.1	<0.002	<0.003	50.2	12.5	210	27.5	6.6	96	16.0		
3+42	12/23/93	<0.01	<0.005	<0.01	<0.01	<0.057	N.D.	0.176	<0.1	0.091	<0.01	5.6	11.8	N.D.	6.4	1.7	N.D.	7.9		
3+42	5/24/94	0.005	<0.005	0.005	<0.005	<0.057	N.D.	<0.2	0.040	0.057	<0.005	12.0	4.1	N.D.	9.1	2.3	N.D.	7.8		
3+42	1/18/95																			
6+19	12/23/93	<0.01	<0.005	<0.01	<0.01	<0.057	N.D.	<0.1	<0.1	0.294	<0.01	5.8	8.2	N.D.	21.8	2.0	N.D.	7.1		
6+19	5/24/94	0.007	<0.005	0.005	0.005	<0.057	N.D.	<0.2	<0.01	0.042	<0.005	5.0	3.1	N.D.	20.6	1.7	N.D.	6.2		
6+19	1/18/95	0.008	N.D.	<0.002	<0.004	<0.005	N.D.	<0.045	<0.1	0.006	<0.003	2.2	4.0	80	20.6	1.7	58	5.8		
6+77	12/23/93	<0.01	<0.005	<0.01	<0.01	<0.057	N.D.	<0.1	<0.1	0.252	<0.01	3.7	15.8	N.D.	19.9	1.6	N.D.	10.3		
6+77	5/24/94	<0.005	<0.005	0.005	<0.005	<0.057	N.D.	<0.2	<0.01	0.090	<0.005	2.8	5.0	N.D.	12.0	1.3	N.D.	7.7		
6+77	1/18/95	0.004	N.D.	0.002	<0.004	<0.005	N.D.	<0.015	<0.1	0.009	<0.003	1.6	4.8	40	17.6	1.2	49	8.1		
8+32	12/23/93	<0.01	<0.005	<0.01	<0.01	<0.057	N.D.	<0.1	<0.1	<0.01	<0.01	109.4	7.1	N.D.	78.4	12.8	N.D.	14.5		
8+32	5/24/94	0.023	<0.005	0.011	<0.005	<0.057	N.D.	<0.2	<0.01	0.015	<0.005	170.3	4.0	N.D.	105.0	18.3	N.D.	15.0		
8+32	1/18/95	0.024	<0.005	0.005	<0.004	<0.005	N.D.	<0.015	<0.1	0.005	0.004	144.0	12.4	490	84.1	16.4	278	19.2		

D.L.	12/23/93	0.01	0.005	0.01	0.01	0.057	N.D.	0.1	0.1	0.01	0.01	0.04	2.71	N.D.	1	1	N.D.	1
D.L.	5/24/94	0.005	0.005	0.005	0.005	0.057	N.D.	0.2	0.01	0.001	0.005	0.64	2.71	N.D.	1	0.2	M.D.	2
D.L.	1/18/95	0.001	0.005	0.002	0.004	0.005	0.001	0.015	0.1	0.002	0.003	0.05	0.05	1	0.1	0.1	0.562	0.5

NOTES: R.A.L. = regulatory allowable limit

D.L. = detection limit

M.D. = not determined

N.A. = not applicable

Hard. = hardness expressed in mg/L as CaCO3

☐ = average of results of two tests

Well no. 3+42 destroyed prior to 1/18/95 sampling date

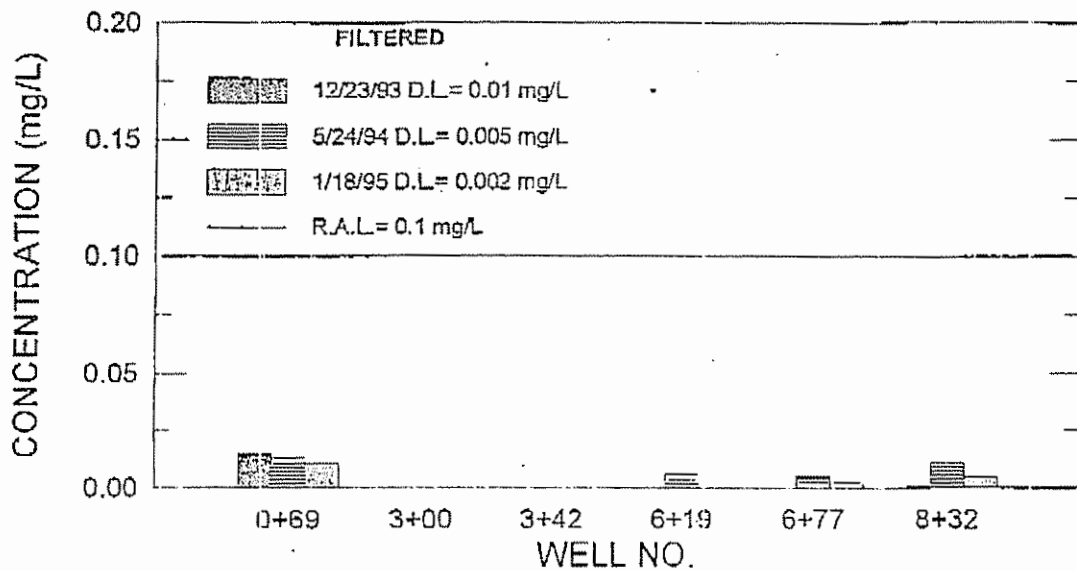


FIG. 2—Filtered chromium (Cr) concentrations on Richmond Field Trial.

(no. 0+69) and three of the wells adjacent to tire chip sections (nos. 3+42, 6+19, and 6+77). However, it appears that manganese is present in the natural groundwater since levels above the standard were detected in the control well. Dissolved solids, which have a secondary drinking water standard, were measured on the third sampling date. The result was 460 mg/L for the control well and ranged from 70 to 460 mg/L for the wells adjacent to tire chip sections. These levels are below the applicable standard.

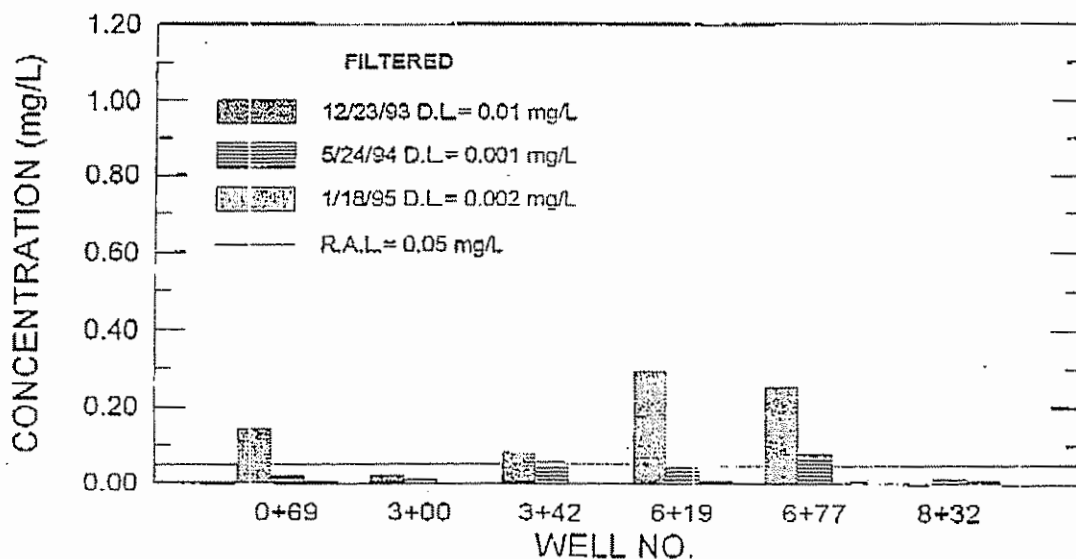


FIG. 3—Filtered manganese (Mn) concentration on Richmond Field Trial.

The third group of substances in Table 3 and water quality index test results given in Humphrey and Katz (1995) have no drinking water standards. This includes: calcium (Ca), magnesium (Mg), sodium (Na), conductivity, hardness, alkalinity, pH, BOD<sub>5</sub>, and chemical oxygen demand (COD). The levels of calcium and magnesium indicate that the water is hard as confirmed by the hardness results. The levels of sodium as well as chloride are higher in well nos. 0+69, 3+00, and 8+32. A possible source is road salt (NaCl) used for deicing in the winter. Calcium chloride (CaCl<sub>2</sub>) used for dust control in the summer could contribute to Cl<sup>-</sup> as well as the higher calcium levels measured in these same three wells. The BOD<sub>5</sub> and COD were low (less than 7 and 50 mg/L, respectively) and are acceptable for drinking water. It is difficult to measure BOD<sub>5</sub>'s as low as obtained from this study. The results have an accuracy sufficient only to indicate that the BOD<sub>5</sub> is very low.

Water quality monitoring for the project continued for 28 months after construction. Since the native soils would be expected to have some sorptive capacity, it is possible that the elapsed time may have been insufficient for potential contaminants to migrate from the tire chip layer to the wells even though the wells were located only 1 to 2 m away from the tire chips. Thus, it can be concluded from this project only that no significant levels of inorganic contaminants migrated from the tire chips to the wells in the first 28 months after construction. The North Yarmouth Project discussed in the next section was designed to eliminate the uncertainty imposed by the sorptive capacity of the soil between the tire chips and the sampling point.

## NORTH YARMOUTH FIELD TRIAL

The purposes of the North Yarmouth Field Trial were to measure the effect of a compressible tire chip layer on asphaltic concrete pavement performance and to carry out long term monitoring of the effect of tire chips placed above the water table on groundwater quality. To date there has been no difference in pavement performance for sections underlain by tire chips compared to the control section. Further details are given in Nickels (1995), and Humphrey and Nickels (1997). The site, groundwater monitoring program, and monitoring results are described in the following sections.

### Site and Monitoring Well Descriptions

The North Yarmouth Field Trial is located on Route 231, a secondary highway in North Yarmouth, Maine. It consists of four 33-m long sections each with a 0.61-m thick tire chip layer. The tire chip layer was covered with a total thickness of between 0.76 m and 1.37 m of granular soil prior to paving. The pavement was 0.13 m thick. In addition, two sizes of tire chips were used (passing a 75-mm sieve and passing a 305-mm sieve) to investigate the effect of soil cover thickness and tire chip size on pavement deflection. Approximately 100,000 tires were used in this test project. In addition, there was a 33-m long control section designed according to Maine Department of Transportation standards with conventional soil fill.

Two seepage collection basins were installed beneath sections with tire chips passing the 75-mm sieve to collect samples for water quality testing. The seepage



collection basins were 3-m by 3-m in plan and were lined with a HDPE geomembrane. A drain in the center of the liner lead to a collection tube located along the side of the embankment as shown in Fig. 4. The design was similar to that used by Edil and Bosscher (1992). The basin projected beyond the edge of the pavement so that runoff from the pavement and from the embankment sideslope could infiltrate into the basin. With this design, there is no opportunity for substances leached from the tire chips to be sorbed onto the soil prior to sampling, an advantage over the monitoring wells used at the Richmond Field Trial. The basins were located directly below the tire chip layer. One basin (Section C) was overlain by 0.61-m of tire chips followed by 1.37-m of granular soil and the other (Section D) was overlain by 0.61-m of tire chips followed by 0.72-m of granular soil. A third seepage collection basin was installed in the control section. It was overlain by 0.72-m of granular soil. In the subsequent sections, this basin is referred to as the 'Control'. Further details are given in Nickels (1995), and Humphrey and Nickels (1997).

#### Sampling and Testing Procedures

Quarterly samples have been taken since January, 1994. Eleven sets of samples have been taken to date. For the period January, 1994, through September, 1995, samples were taken from the water that accumulated in the collection tube since the previous sampling period. On each sampling date the tubes were full and it was apparent that water had been flowing out of each tube's overflow pipe. After sampling, the tube was bailed dry in preparation for the next sampling period. This procedure raised the concern that sediments could accumulate in the bottom of the tube. For this reason, the sampling procedure was changed starting with the December, 1995, sample. From this date onward, the tubes were bailed dry two to three weeks prior to the desired sampling date. Samples were subsequently taken from the water that had accumulated over this short period. Prior to sampling, the water in the tube was agitated. Samples were obtained with a 1-liter capacity high density polyethylene (HDPE) bailer.

The sample types and testing procedures for inorganic compounds and water quality index tests were the same as were used for the Richmond Field Trial. On selected sampling dates, samples were also taken for BOD<sub>5</sub> determination. In addition, on December 28, 1995, and April 5, 1996 samples were taken for volatile organic compounds (VOC's) and semivolatile organic compounds (SVOC's). The containers used for the

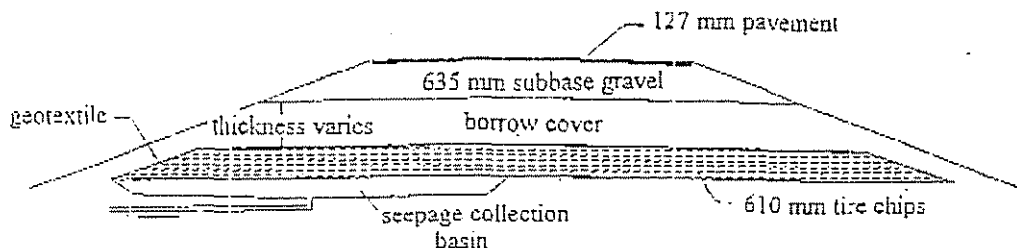


FIG. 4—Typical cross section of North Yarmouth Field Trial.

VOC samples were clear 40 mL borosilicate glass vials with polypropylene closures and Teflon faced silicone septa. The samples were preserved by adding 4 drops of ultrapure hydrochloric (HCl) to each vial before collecting the samples. Leachate from the bailer was placed directly in the vial with no sample preparation. The VOC samples were tested in accordance with EPA Method 8260 (Determination of Volatile Organics by Purge-and-Trap Capillary Column GC/MS). SVOC samples were collected in 1 L amber borosilicate glass bottles with polypropylene closures with Teflon liners. Leachate from the bailer was placed directly in the bottles with no sample preparation. The SVOC samples were tested in accordance with EPA Method 8270 (Determination of Semivolatile Organics by Capillary Column GC/MS). Further details of the testing procedure are given in Humphrey and Katz (1996).

### Inorganic Results

Detailed test results are given in Humphrey and Katz (1996). Substances with a primary drinking water standard were present in trace amounts or were below the detection limit. The level of cadmium (Cd) in the control section for the April 1995 sample and in Section D for the June, 1995 sample slightly exceeded the regulatory allowable limit (RAL). However, for all other sampling dates the levels were below the test method detection limit. It is believed that the two samples that exceeded the RAL are due to testing inaccuracies as no cadmium was detected on the other sampling dates. For all other substances with primary drinking water standards, the levels were well below the applicable RAL. The results on filtered samples for barium (Ba), chromium (Cr), and lead (Pb) are shown in Figs. 5, 6, and 7, respectively. All three substances are present in the control well, indicating that they are naturally present in the soil. However, there is no significant difference between the levels found in the two tire chip sections and the control section. This indicates that for the conditions found at this test site, there is no evidence that tire chips tend to increase the levels of these compounds for the 2.5 years that have been monitored to date.

For substances with a secondary drinking water standard, aluminum (Al), iron (Fe), manganese (Mn), and zinc (Zn) are plotted versus date in Figs. 8 through 11. All three substances are naturally present in the soil, however, there is no evidence that tire chips increased the levels of aluminum (Al) or zinc (Zn). In fact, the zinc levels are generally higher in the control section than the two tire chip sections. For most sampling dates, the iron (Fe) levels in the tire chip and control sections are about the same. However, on a few sampling dates the iron levels in the tire chip sections are higher than in the control section and the level exceeds the secondary RAL. The total iron levels were consistently higher in the tire chip sections, indicating that under the right conditions of solubility, tire chips could increase the iron levels present in groundwater. On almost all sampling dates the levels of manganese (Mn) are higher in the tire chip sections than in the control section. The levels in tire chip Section D generally exceed the RAL by more than a factor of 10. On the most recent sampling date (June 1996) a very high level of manganese was found in Section C. The much lower levels found on all previous sampling dates suggests that this may be an anomaly. The levels of chlorine (Cl<sup>-</sup>) are plotted in Fig. 12. It is seen that high levels are present in all wells for samples taken in April. This is most likely due to infiltration from road salt. There was no evidence that

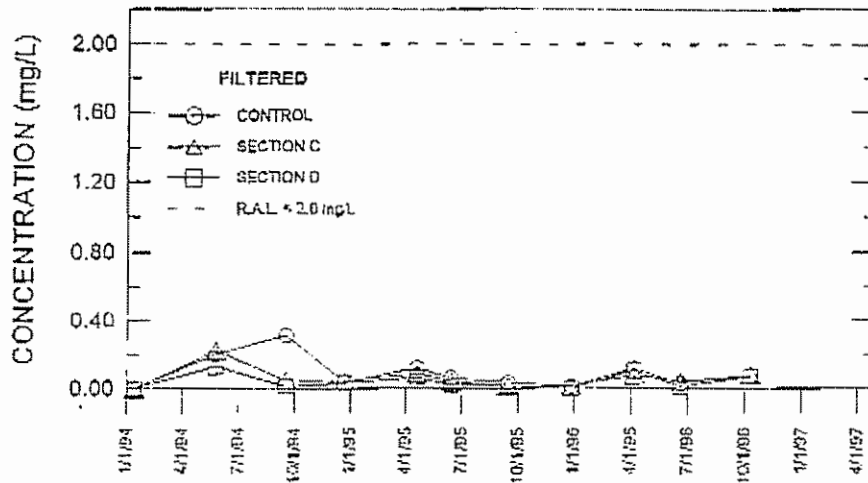


FIG. 5—Filtered barium (Ba) concentrations for North Yarmouth Field Trial.

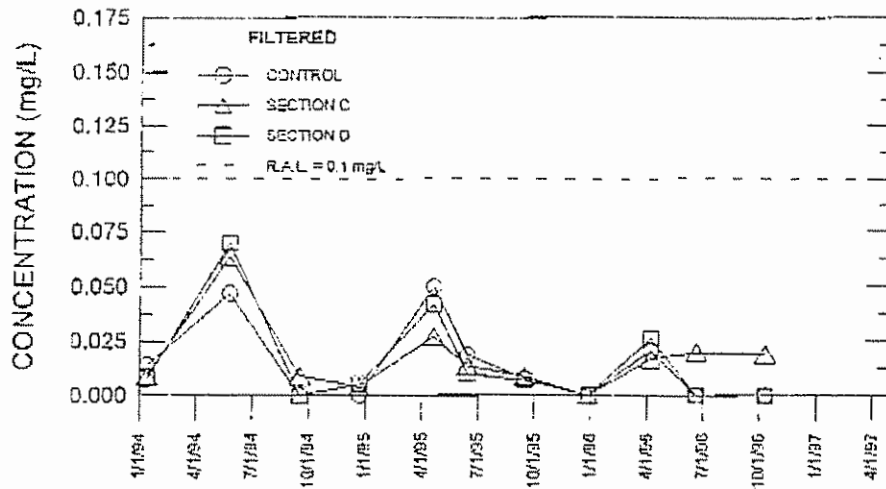


FIG. 6—Filtered chromium (Cr) concentration for North Yarmouth Field Trial.

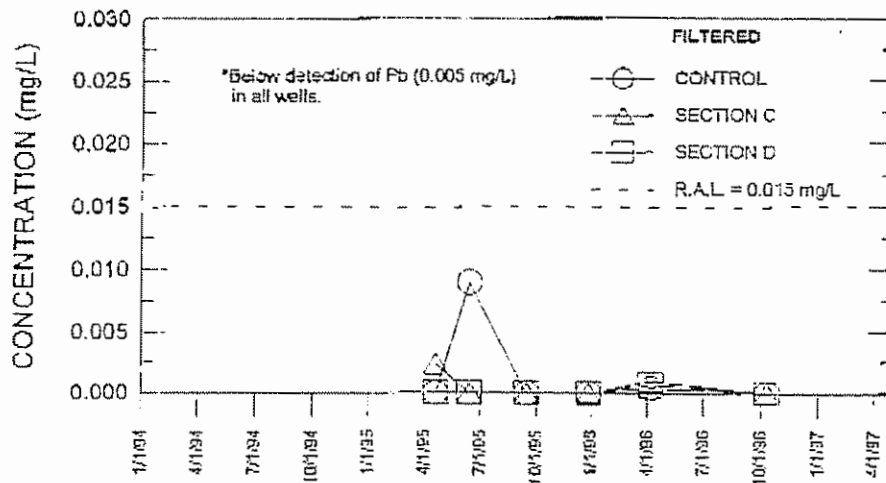


FIG. 7—Filtered lead (Pb) concentrations on North Yarmouth Field Trial.

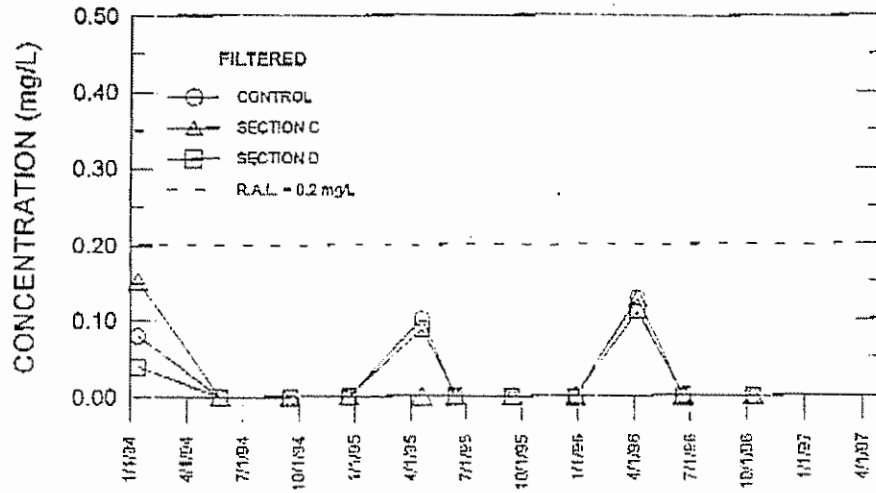


FIG. 8—Filtered aluminum (Al) concentrations for North Yarmouth Field Trial.

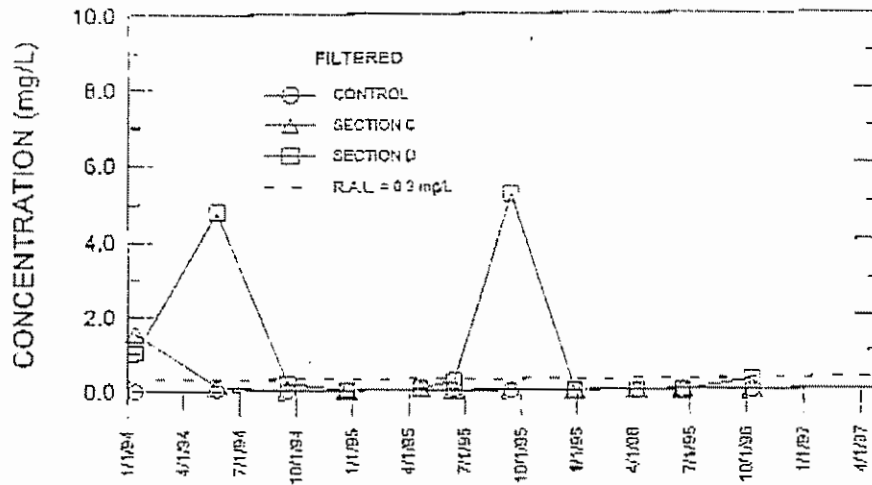


FIG. 9—Filtered iron (Fe) concentration for North Yarmouth Field Trial.

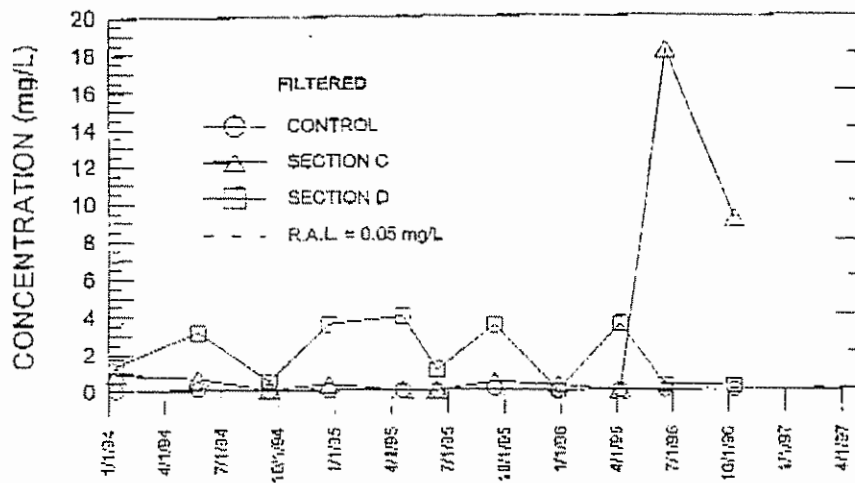


FIG. 10—Filtered manganese (Mn) concentrations on North Yarmouth Field Trial.

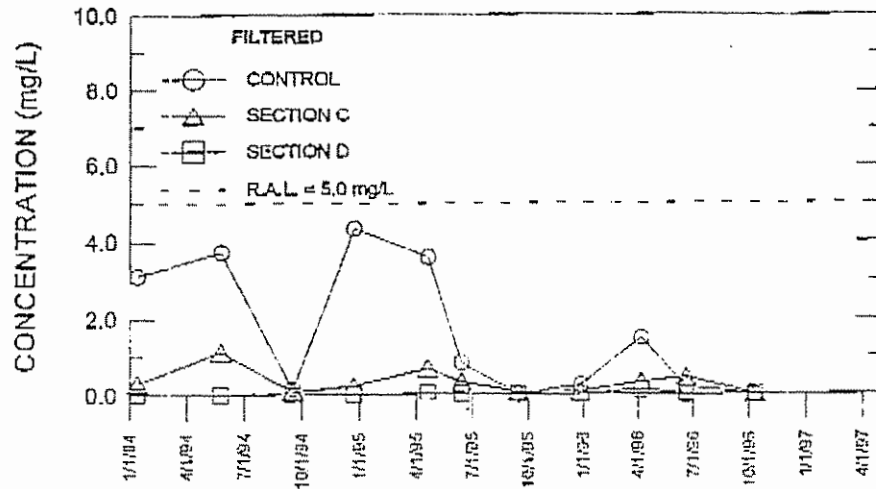


FIG. 11—Filtered zinc (Zn) concentrations on North Yarmouth Field Trial.

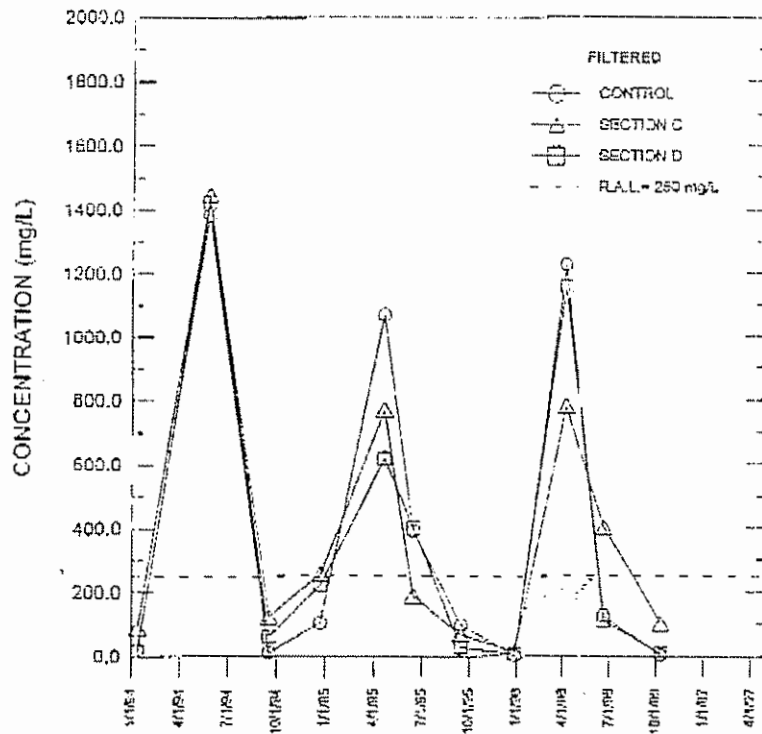


FIG. 12—Filtered chloride (Cl-) concentrations on North Yarmouth Field Trial.

tire chips increase the concentration of sulfate (SO<sub>4</sub>), total solids, calcium (Ca), magnesium (Mg), or sodium (Na). BOD<sub>5</sub> and COD levels have consistently been low and there is no evidence that tire chips increase their levels

Organic Results

Samples taken on December 28, 1995, and April 5, 1996, were tested for volatile and semi-volatile organics. On both sampling dates the levels for all compounds were

below the test method detection limits. The negligible levels of VOC's are supported by results of a laboratory leaching study by Downs et al. (1996). In this study, tire chips and tire chip/soil mixtures were placed in a glass reactor, the reactor was filled with water, and then sealed for 10 months. Six VOC's were above the detection limit but the concentrations were less than 5 ppb. This is an important check on the results of the field study since the design of the seepage collection basins and sampling tubes leaves open the possibility that VOC's volatilized from the leachate prior to sampling. Downs et al. (1996) also found one positively identified SVOC (aniline), with a concentration ranging from 25 to 48 ppb and five tentatively identified SVOC's with estimated concentrations between 200 and 600 ppb. In contrast, no SVOC's were detected in the samples from the North Yarmouth field site. A separate field study of tire chips placed below the groundwater table is ongoing (Downs et al., 1996).

## CONCLUSIONS

1. Most of the inorganic substances that can potentially leach from tires are naturally present at low levels in groundwater. This includes aluminum (Al), barium (Ba), chromium (Cr), iron (Fe), lead (Pb), manganese (Mn), and zinc (Zn). Thus, it is critical that control wells be used to measure the natural background levels of these substances. This would allow any changes in level caused by the tire chips to be separated from background levels.
2. No evidence was found that tire chips increased the concentration of substances that have a primary drinking water standard including: barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), and selenium (Se).
3. No evidence was found that tire chips increased the concentration of the following substances which have a secondary drinking water standard: aluminum (Al), chloride (Cl<sup>-</sup>), sulfate (SO<sub>4</sub>), and zinc (Zn). There was some evidence that tire chips could increase the levels of iron (Fe) and exceed the secondary drinking water standard under some conditions.
4. Tire chips increase the levels of manganese (Mn) which has a secondary drinking water standard. It is likely that the levels will exceed this standard. However, manganese is of aesthetic concern only and it is naturally present in groundwater in many areas. Further study would be required to determine how far manganese that has leached from tire chips would migrate from a tire chip fill.
5. No detectable levels of organics were measured in two sets of samples taken from the North Yarmouth Field Trial.

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