Surficial Sediment Plume Study - 1997

Red River, Manitoba

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Executive Summary

Polycyclic aromatic hydrocarbon (PAH) contamination was discovered in sediments of the Red River in the vicinity of the Disraeli Bridge in March, 1994. The contamination was linked to PAH contamination in soils and groundwater on the adjacent site of a former manufactured gas plant which is now owned by Centra Gas Manitoba Inc. This report presents the results of a study conducted in September-October 1997 to monitor the change in areal extent of the contaminated sediments over time. The base situation, against which the 1997 survey results are compared, is the extent of contamination documented in September-October 1995. The contamination assessment utilized the visual/olfactory NC/TC/VC protocol used in the preceding studies.

The 1997 survey results indicate the area of PAH contaminated surficial sediments has increased by about a factor of 2.2 since 1995, from 3,800 m^2 to 8,400 m^2, primarily due to an approximately 300 m extension in the downstream margin of the plume. The increase in size of the surficial sediment PAH contamination zone has several possible causes. PAH loading to the river via groundwater seepage may have increased, due to higher PAH concentrations in the groundwater or higher groundwater seepage rates. The flood flows in spring 1997 may also have increased river bed scour, thereby distributing previously contaminated sediments farther downstream. These factors may be operating individually or in some combination. A continuation of the monitoring program to 1998 is recommended to assess the persistence of this recent increase in plume area.

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Acknowledgments

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1.0 Introduction

Polycyclic aromatic hydrocarbon (PAH) contamination was discovered in sediments of the Red River in the vicinity of the Disraeli Bridge in March, 1994 (CH2M Hill 1995). The contamination was linked to PAH contamination in soils and groundwater on the adjacent site of a former manufactured gas plant which is now owned by Centra Gas Manitoba Inc. Subsequent studies were undertaken in 1994, 1995, and 1996 to examine the extent of the PAH plume in the river and to determine the effects of the contamination on aquatic biota. In 1995, the plume of visible contamination in surficial river sediments was found to begin approximately 22 m upstream of the bridge, extending approximately 135 m downstream, and from 30 to 50 m into the river channel from the winter waterline on the south side of the river (Figure 1). The contamination has had a measurable, but minor, impact on zoobenthos abundance and there is no indication of any adverse effects on fish or fish habitat (Agassiz North 1996).

The only major uncertainty related to the contaminated sediments is the stability of the zone of contamination. Studies to date indicate the plume is not expanding in size, and may be decreasing (Agassiz North 1996 and 1997). This report presents the results of a study conducted in September and October 1997 to monitor the change in areal extent of the contaminated sediments over time. The base situation, against which the 1997 survey results are compared, is the extent of contamination documented in September-October 1995 (Agassiz North 1996).

2.0 Methods

The sediment contamination survey involved the collection of sediment samples along a series of transects located within and adjacent to the known area of contamination. The shoreline was staked at 25 m intervals, beginning at the 25 m marker used in the 1995 survey and continuing 625 m downstream to the 650 m marker. Sediment samples were taken at about 10 m intervals along each transect, beginning about 10 m offshore. Transect locations and sampling points are shown on Figure 2. Sampling was carried out between 9 September 1997 and 21 October 1997.

A stainless steel Wildco Ekman dredge (0.023 m^2 sampling area) was used to collect the sediment samples. A visual/tactile substrate assessment was conducted on each sample while in the dredge. The contents of each dredge sample were then transferred to a plastic pan for a visual/olfactory evaluation of contamination. The substrate assessment involved classification of the surface and sub-surface sediment as clay, silt, sand, or gravel, along with notation of sediment colour. The contamination assessment followed the NC/TC/VC protocol used in the previous studies (CH2M Hill 1995, Agassiz North 1996 and 1997).

Water depth was measured at each sample location using an Eagle Model 7200 depth sounder. Distance off shore was determined using either a Ranging model TLR75 coincidence range-finder, or a Bushnell Yardage Pro 400 laser range-finder.

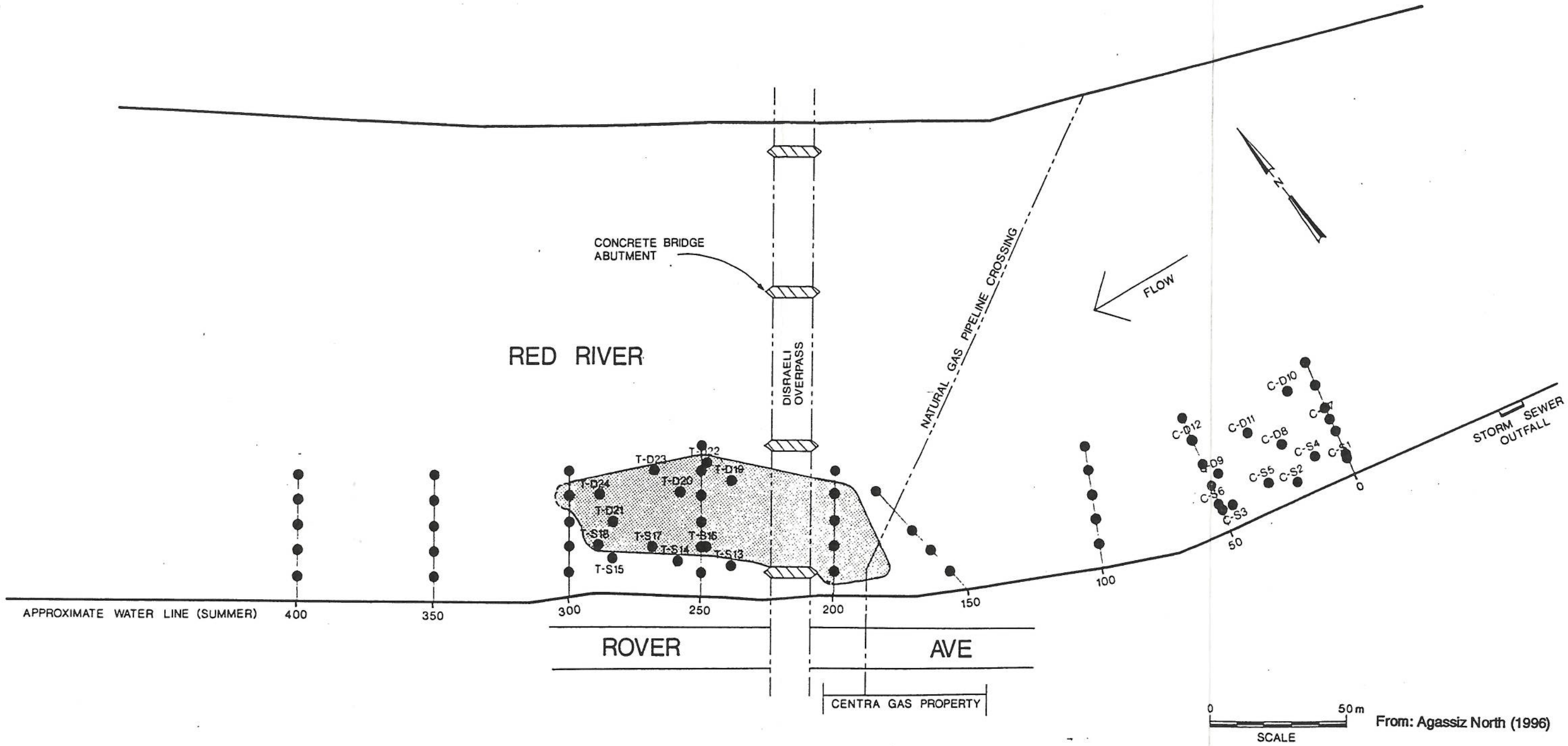

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Figure 1
Estimated Extent of Sediments with Visible PAH Tar Residues
September - October 1995

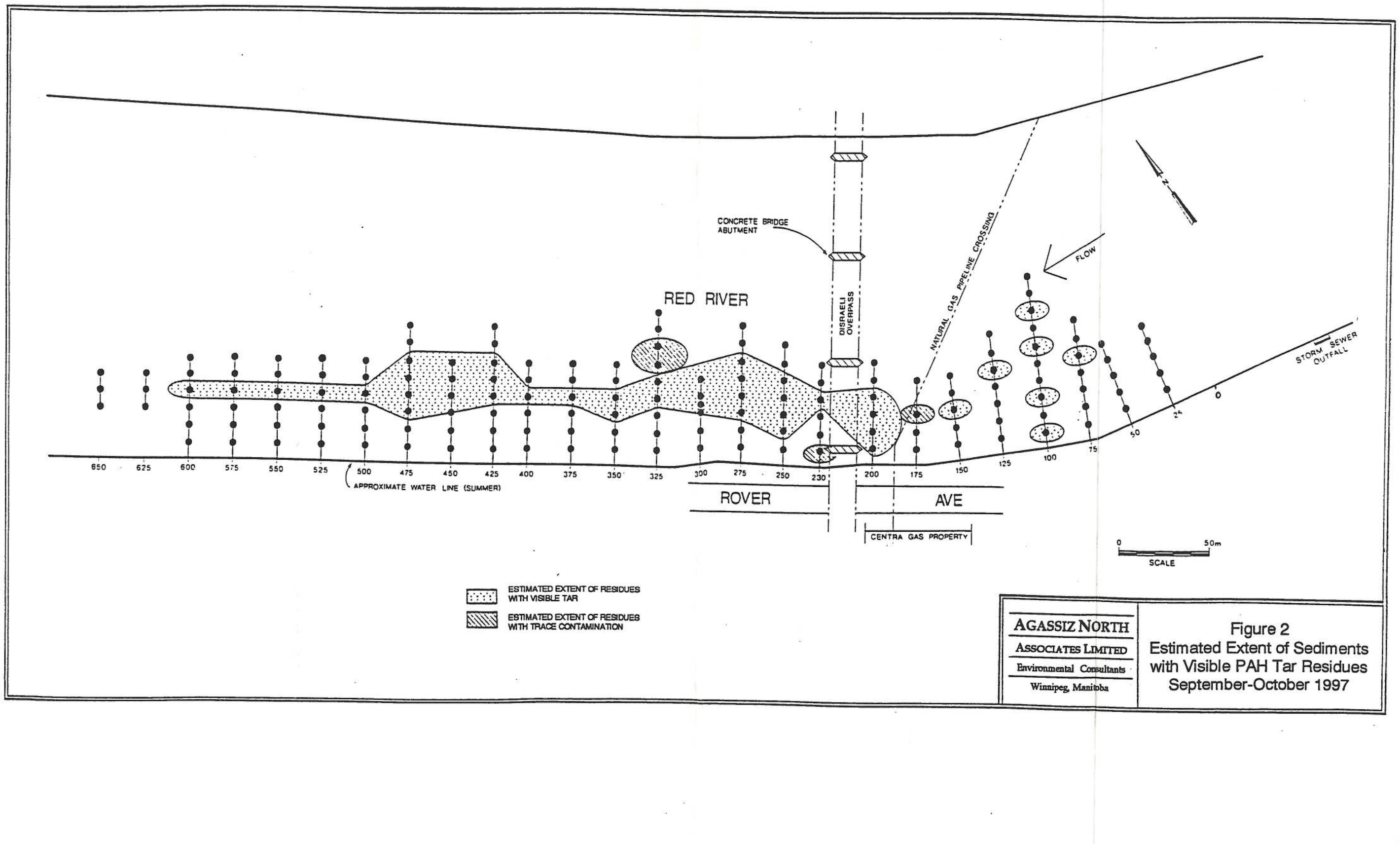

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Figure 2
Estimated Extent of Sediments with Visible PAH Tar Residues
September-October 1997

3.0 Results

The near-surface river sediments consisted primarily (i.e., at 157 of the 187 stations at which sampling was attempted) of layered sediments. At these locations, the uppermost layer consisted of brown silty-clay ranging from 1cm to more than 11 cm in thickness (Table 1). The silty-clay was typically underlain by a grey to grey-black clay layer ranging from 1 cm to 15 cm in thickness. Granular materials (sand and gravel) generally occurred beneath this clay layer, although the sampling depth did not include this granular layer in all cases.

Hard bottom materials, either granular or hardpan, replaced these layered sediments within 10 m of shore on the 75, 100, and 125 m transects, 18 to 37 m offshore on the 200 m transect, at 46 m on the 230 m transect, at 56 m on the 250 m transect, 18 to 27 m offshore on the 275 m transect, 27 to 46 m offshore on the 300 m transect, at 27 m on the 325 m transect, and at 55 m on the 450 m transect. No samples could be collected from the sites where hard bottom materials occurred (Table 1).

The primary zone of visually detectable PAH contamination (i.e., tarry material) originated at the 200 m transect, where the tars were evident from 9 to 37 m offshore, and extended 400 m downstream, covering an area of approximately 8,400 m^2 (Table 1, Figure 2). Between the 200 m and 475 m markers, the plume varied between 10m and 40 m in width. Plume width was a consistent 10 m between the 475 m and 600 m markers.

The tarry materials in the contaminated zone typically occurred in the clay or granular layers beneath the surface layer of silty-clay. Visual evidence of contamination was seldom found in the surface layer of the sediments (Table 1).

Trace evidence of PAH contamination (i.e., an odour of "mothballs" but no visual evidence of tars) was found adjacent to the primary zone of visual PAH contamination at the 27 m station on the 175 m transect, at the 9 m station on the 230 m transect, and at the 55 m and 67 m stations on the 325 m transect (Table 1, Figure 2). Although trace contamination also was recorded at the 46 m stations on both the 275 m and 425 m transects (Table 1), these locations were mapped as visually contaminated on Figure 2, which was more consistent with the prevalence of tars in these areas.

Isolated pockets of visual contamination also were found upstream of the primary zone, on the 75 m, 100 m, 125 m, and 150 m transects (Table 1, Figure 2). The contamination at these locations differed from that in the primary zone in that it occurred in the form of one to several small droplets in each sample and none had a distinct PAH odour.

Table 1. Description of sediments and evidence of PAH contamination in the Red River near the Disraeli Bridge. Transects were sampled between 9 September and 21 October 1997. Evidence of contamination codes are defined as: NC (no contamination); VC (visual contamination, indicated by the presence of tar and of PAH odour); and TC (trace contamination, indicated by detection of PAH odour but no visual evidence of tar).

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
25 m	9	1.5	Brown oxidized silty clay (about 4 cm deep) over 5 cm of silty grey clay over gravel, some black reduced organic matter; fresh smell	NC
	18	3.4	Brown oxidized silty clay (about 4 cm deep) over 3 cm of black clay over sand and gravel; fresh smell	NC
	27	5.5	Brown oxidized silty clay (about 3 cm deep) over 4 cm of clay over sand and gravel; fresh smell	NC
	37	6.1	Brown oxidized silty clay (about 4 cm deep) over sand and gravel, some black reduced organic matter subsurface; fresh smell	NC
	46	6.4	Brown oxidized silty clay (about 8 cm deep), some black reduced organic matter subsurface; fresh smell	NC
		5.8	Brown oxidized silty clay (about 8 cm deep) over sand and one large rock; fresh smell	NC
50 m	9	1.8	Brown oxidized silty clay (about 5 cm deep) over 3 cm of clay slurry over gravel; fresh smell	NC
	18	3.4	Brown oxidized silty clay (about 4 cm deep) over 3 cm of grey clay sand and gravel, some black reduced organic matter subsurface; fresh smell	NC
	27	5.5	Brown oxidized silty clay (about 3 cm deep) over sand and gravel; fresh smell	NC
	37	5.5	Thin layer of brown oxidized silty grey clay over gravel; fresh smell	NC
		5.8	Brown oxidized silty clay (about 4 cm deep) over gravel and sand, some black reduced organic matter; fresh smell	NC
	46	5.5	Brown oxidized silty clay (about 11 cm deep) over sand, some black reduced organic matter subsurface; fresh smell	NC
75 m	9	2.1	Rocky bottom	No Sample
	18	3.4	Brown oxidized silty clay (about 3 cm deep) over 3 cm of grey clay and gravel; fresh smell	NC
	27	5.5	Brown oxidized silty clay (about 3 cm deep) over 3 cm of grey clay; fresh smell	NC
	37	5.5	Brown oxidized silty clay (about 6 cm deep) over gravel; fresh smell	NC
	46	5.5	Small sample, brown oxidized silty clay over sand; small tar spots with oil slicks, fresh smell	VC

Table 1. Continued.

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
75 m Cont.	55	6.1	Brown oxidized silty clay (about 5 cm deep), rocky bottom, some black reduced organic matter; fresh smell	NC
	64	6.1	Brown oxidized silty clay (about 10 cm deep) over 1 cm of sand, some black reduced organic matter subsurface; fresh smell	NC
100 m	9	1.8	Rocky bottom (small sample); brown oxidized silty clay over gravel; fresh smell	NC
		1.5	Brown oxidized silty clay (about 4 cm deep) mixed with gravel over 3 cm of sandy clay and gravel; small tar spots and oil slicks, fresh smell	VC
	18	3.1	Thin layer of brown oxidized silty clay over gravel; fresh smell	NC
	27	4.6	Brown oxidized silty clay (about 5 cm deep) over 3 cm of clay over sand, some black reduced organic matter subsurface; multiple tar spots, fresh smell	VC
	37	5.2	Brown oxidized silty clay (about 3 cm deep) over gravel, some black reduced organic matter subsurface, fingernail clam; fresh smell	NC
	46	5.2	Brown oxidized silty clay (about 9 cm deep) over 3 cm of sand, some black reduced organic matter subsurface; fresh smell	NC
	55	5.5	Brown oxidized silty clay (about 5 cm deep) over sand, one large rock; 1 spot of tar and oil slick, fresh smell	VC
	64	5.2	Brown oxidized sandy silty clay (about 5 cm deep) over 5 cm of sandy clay over 1 cm of sand; fresh smell	NC
	73	5.5	Brown oxidized sandy silty clay (about 5 cm deep) over 3 cm of sand; several spots of tar and oil slicks, no smell	VC
	82	5.8	Brown oxidized sandy silty clay (about 4 cm deep) over sand, some black reduced organic matter and black clay subsurface, 4 fingernail calms; fresh smell	NC
	91	5.8	Rocks, woody debris and sand	NC
		5.8	Brown oxidized silty clay (about 4 cm deep) over gravel, some black reduced organic matter; fresh smell	NC
125 m	9	1.2	Hard bottom	No Sample
	18	3.4	Brown oxidized silty clay (about 3 cm deep) over gravel, some black reduced organic matter subsurface; fresh odour	NC
	27	4.6	Thin layer of brown oxidized silty clay over sand and gravel, slab of marble; fresh smell	NC

Table 1. Continued.

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
125 m Cont.	37	5.5	Brown oxidized silty clay (about 4 cm deep) over gravel, some black reduced organic matter; fresh smell	NC
	46	5.2	Brown oxidized silty clay (about 8 cm deep) over sand, some black reduced organic matter subsurface; fresh odour	NC
		5.2	Brown oxidized silty clay (about 4 cm deep) over grey clay, some black reduced organic matter subsurface; 2 small spots of tar in sediments, fresh odour	VC
	55	5.2	Brown oxidized silty clay (about 4 cm deep) over gravel, some black reduced organic matter subsurface; fresh smell	NC
		5.2	Brown oxidized silty clay (about 6 cm deep) over thin layer of sand, black reduced organic matter subsurface, with twigs; fresh smell	NC
	64	5.5	Brown oxidized silty clay (about 9 cm deep) over 1 cm of sand, some black reduced organic matter subsurface; fresh smell	NC
150 m	9	1.8	Brown oxidized silty clay (about 6 cm deep) over gravel; fresh smell	NC
	18	3.3	Brown oxidized silty clay (about 1 cm deep) over sand and gravel; fresh smell	NC
	27	4.6	Brown oxidized silty clay (about 3 cm deep) over gravel, some black reduced organic matter subsurface; small oil slicks, piece of tar gravel substance, faint PAH odour	VC
	37	5.5	Brown oxidized silty clay (about 9 cm deep), some black reduced organic matter; fresh smell	NC
	46	5.2	Brown oxidized silty clay (about 3 cm deep) over sand; fresh smell	NC
		5.5	Brown oxidized silty clay (about 6 cm deep) over 8 cm of clay, black reduced organic matter subsurface; fresh smell	NC
175 m	9	1.2	Thin layer of brown oxidized silty clay over gravel and sand, some black reduced organic matter; fresh smell	NC
	18	3.0	Brown oxidized silty clay (about 3 cm deep) over gravel; fresh smell	NC
		2.7	Twigs, sand and gravel	NC
	27	3.7	Brown oxidized silty clay (about 5 cm deep) over sand/gravel; faint PAH odour	TC
	37	5.2	Crosses gas line; no sample	No Sample
	46	5.2	Brown oxidized silty clay (about 3 cm deep) over 1 cm of sand; one clam shell with gravel; fresh smell	NC

Table 1. Continued.

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
175 m Cont.		5.5	Brown oxidized silty clay (about 1 cm deep) over rocks/sand, large clam and rocks plus 2 fingernail clams; fresh smell	NC
200 m	9	1.8	Hard bottom; sample contained gravel and large chunk of sandy tar; PAH odour	VC
	18	4.0	Hard bottom; very rocky	No Sample
		3.7	Hard bottom; very rocky	No Sample
	27	4.9	Brown oxidized silty clay (about 3 cm deep) over sandy tar and gravel; PAH odour	VC
	37	4.9	Hard bottom; sample included rock, wire and sandy tar	VC
	37	5.2	Brown oxidized silty clay (about 3 cm deep) over 5 cm of grey clay; PAH odour; tar present in clay	VC
	46	6.4	Brown oxidized silty clay (about 9 cm deep), some black reduced organic matter subsurface with some rust; fresh smell	NC
	55	5.2	Brown oxidized silty clay (about 7 cm deep) over 5 cm of grey silty clay, one large rock; no odour	NC
230 m	9	1.8	Brown oxidized silty clay (about 9 cm deep) over gravel, thin layer of clay; faint PAH odour	TC
	18	4.0	Hard grey clay (about 3 cm deep) over gravel and sand; fresh smell	NC
	27	4.3	Brown oxidized silty clay (about 3 cm deep) over sand/gravel; fresh smell	NC
	36	4.9	Brown oxidized silty clay (about 3 cm deep) over gravel and twigs; small pieces of soft tar, PAH odour	VC
	46	5.2	Hard bottom, dredge picked up several rocks	NC
	55	5.5	Brown oxidized silty clay (about 9 cm deep) over 3 cm of sand; fresh smell	NC
250 m	9	1.8	Brown oxidized silty clay (about 4 cm deep) and plant matter over 3 cm of clay slurry; fresh smell	NC
	18	3.0	Small sample, tar evident in clay, oil slick and PAH odour	VC
		3.0	Thin brown oxidized silty clay over gravel; soft tar present, some tar on gravel, faint PAH odour	VC
	27	4.3	Brown oxidized silty clay (about 3 cm deep) over gravel; soft tar on gravel, PAH odour in gravel	VC

Table 1. Continued.

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
250 m Cont.	37	4.9	Brown oxidized silty clay (about 4 cm deep) over tar and clay; tar evident throughout sample, oil slick, PAH odour	VC
	46	5.5	Brown oxidized silty clay (about 4 cm deep) over tar and sand; tar on dredge, oil slick in water, strong PAH odour	VC
	56	6.7	Hard bottom, small sample; thin layer of brown oxidized silty clay over sand and gravel; fresh smell	NC
		6.7	Hard bottom, sand and gravel with clam shell fragments; no smell	NC
	64	6.4	Brown oxidized silty clay (about 6 cm deep) over 1 cm of sand, some black reduced organic matter subsurface; fresh smell	NC
275 m	9	0.9	Brown oxidized silty clay (about 1 cm deep) over 6 cm of grey clay; fresh smell	NC
	18	2.4	Hard bottom, thin layer of brown oxidized silty clay over gravel and some glass; fresh smell	NC
	27	3.0	Hard bottom; 1 cm of brown oxidized silty clay over gravel; sandy tar with PAH odour	VC
	37	4.9	Lost sample, however some soft tar remained in dredge, PAH odour	VC
		4.6	Brown oxidized silty clay (about 1 cm deep) over 1 cm of black clay and gravel; strong PAH odour	TC
	46	6.4	Brown oxidized silty clay (about 1 cm deep) over 1 cm of sand; PAH odour	TC
	55	6.4	Brown oxidized silty clay (about 10 cm deep) over 6 cm of clay; tar present; oil slick in basin, strong PAH odour	VC
	64	7.0	Brown oxidized silty clay (about 9 cm deep) over 3 cm sand, fingernail clams; fresh smell	NC
	73	6.4	Brown oxidized silty clay (about 6 cm deep) over 6 cm of grey clay; fresh smell	NC
300 m	9	0.6	Brown oxidized silty clay (about 10 cm deep), some black reduced organic material. twigs throughout sample; fresh smell	NC
	18	2.1	Brown oxidized silty clay (about 2.5 cm deep) over gravel. Fresh smell.	NC
	27	3.4	Hard bottom, gravels	NC
	27	3.0	Hard bottom, found rocks, clam shell and a nail incased in cement	NC
	27	2.7	Hard bottom	No Sample
	32	4.0	Hard bottom, picked up a cinder block	NC
	37	4.6	Hard bottom	No Sample

Table 1. Continued.

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
300 m Cont.	46	6.1	Hard bottom	No Sample
325 m	9	1.5	Brown oxidized silty clay (about 15 cm deep); fresh smell	NC
	18	2.7	Brown oxidized silty clay (about 4 cm deep) over grey sandy clay and gravel; fresh smell	NC
	27	3.7	Hard bottom	No Sample
	37	4.9	Brown oxidized silty clay (about 5 cm deep) over 5 cm sandy clay over gravel, and 2 clam shells; faint PAH odour in clay, small clumps of tar	VC
	46	6.4	Brown oxidized silty clay (about 8 cm deep) over 4 cm of grey clay over 3 cm of sandy gravel, some black reduced organic matter subsurface; PAH odour, with oil slick in sample and blackish tar present in gravel	VC
	55	7.0	Brown oxidized silty clay (about 6 cm deep) over 1 cm grey clay over sand and gravel; PAH odour in clay and sand, no tar evident	TC
	64	6.7	Brown oxidized silty clay (about 9 cm deep) over 1 cm of sand; faint PAH odour in sand	TC
	73	6.7	Brown oxidized silty clay (about 8 cm deep) over sand, one large clam plus many fingernail clams, black reduced organic matter subsurface; fresh smell	NC
	82	6.4	Brown oxidized silty clay (about 10 cm deep) over 3 cm of sand, black reduced organic matter, fingernail clams; fresh smell	NC
350 m	9	0.9	Brown oxidized silty clay (about 10 cm deep) some black reduced organic matter over 4 cm of silty sandy clay with twigs; fresh smell	NC
	18	0.9	Brown oxidized silty clay (about 4 cm deep) over some black reduced organic matter over 13 cm of silty sandy clay; fresh smell	NC
	27	4.6	Brown oxidized silty clay (about 4 cm deep), some black reduced organic matter over gravel; fresh smell; one brick with black stain on one side with PAH odour; tar present on some gravel	VC
	37	6.1	Brown oxidized silty clay (about 5 cm deep) with black reduced organic matter; fresh smell, small pieces of tar found in clay and on gravel	VC
	47	5.8	Brown oxidized silty clay (about 9 cm deep) over 3 cm of silty grey clay, some black reduced organic matter; fresh smell	NC
	56	6.4	Brown oxidized silty clay (about 9 cm deep) over 1 cm of grey clay over sand	NC

Table 1. Continued.

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
375 m	9	1.2	Brown oxidized silty clay (about 10 cm deep) over 8 cm grey clay, some black reduced organic matter and twigs; fresh smell	NC
	18	2.7	Brown oxidized silty clay (about 6 cm deep) over 13 cm silty grey clay; fresh smell	NC
	27	4.9	Brown oxidized silty clay (about 8 cm deep) over 4 cm grey sandy clay over small stones; fresh smell	NC
	37	5.5	Brown oxidized silty clay (about 4 cm deep) over 6 cm of silty clay; oil slick in sample, thin layer of gritty tar found in sample; PAH odour	VC
	37	5.5	Brown oxidized silty clay (about 4 cm deep) over 4 cm of grey sandy clay; sandy tar found in sample; faint PAH odour	VC
	46	6.1	Brown oxidized silty clay (about 9 cm deep) over 3 cm silty grey clay; fresh smell	NC
	55	6.4	Brown oxidized silty clay (about 8 cm deep) over 5 cm silty grey clay; fresh smell	NC
400 m	9	1.2	Brown oxidized silty clay (about 14 cm deep) over 1 cm grey clay, some black reduced organic matter subsurface; fresh smell	NC
	18	2.4	Brown oxidized silty clay (about 8 cm deep) over 5 cm clay slurry; fresh smell	NC
	27	4.9	Brown oxidized silty clay (about 3 cm deep) over small to large rocks, some black reduced organic matter subsurface, some concrete pieces; fresh smell	NC
	37	5.8	Brown oxidized silty clay (about 9 cm deep) over 3 cm of grey clay; 1 black spot in clay (PAH odour); faint PAH odour in clay	VC
	46	5.8	Brown oxidized silty clay (about 4 cm deep) over 9 cm silty grey clay, some black reduced organic matter subsurface; fresh smell	NC
	55	5.8	Brown oxidized silty clay (about 10 cm deep), some black reduced organic matter , some rust stains subsurface; fresh smell	NC
425 m	9	0.9	Brown oxidized silty clay (about 11 cm deep) over 13 cm clay slurry; fresh smell	NC
	18	3.1	Brown oxidized silty clay (about 5 cm deep) over 14 cm silty grey clay, some black reduced organic matter subsurface; fresh smell	NC
	27	4.9	Brown oxidized silty clay (about 10 cm deep) over 9 cm silty sandy clay; fresh smell	NC
	37	5.2	Brown oxidized silty clay (about 8 cm deep) over 1 cm of sand mixed with tar; fresh smell	VC
	46	5.5	Brown oxidized silty clay (about 3 cm deep) over 4 cm sandy clay; faint PAH odour in the clay	TC

Table 1. Continued.

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
425 m Cont.	55	6.1	Brown oxidized silty clay (about 8 cm deep) over 4 cm sandy silty clay; very faint PAH odour from clay	TC
	55	6.4	Brown oxidized silty clay (about 1 cm deep) over gravel; three pieces of tar (2 soft, 1 hard)	VC
	64	6.1	Brown oxidized silty clay (about 9 cm deep) over gravel, black reduced organic matter subsurface; fresh smell	NC
	73	6.1	Brown oxidized silty clay (about 4 cm deep) over 5 cm of silty clay over gravel and sand, black reduced organic matter and rust stains subsurface, several pieces of coal; fresh smell	NC
450 m	9	1.2	Brown oxidized silty clay (about 6 cm deep) over 8 cm clay slurry mixed with leaves and twigs; fresh smell	NC
	18	3.4	Brown oxidized silty clay (about 3 cm deep) some black reduced organic matter over 11 cm of clay; fresh smell	NC
	27	5.2	Brown oxidized silty clay (about 4 cm deep) over 5 cm silty sandy clay mixed with twigs; fresh smell	NC
	37	5.2	Brown oxidized silty clay (about 5 cm deep) over 1 cm of sand, some black organic reduced matter; fresh smell	NC
	46	5.2	Brown oxidized silty clay (about 5 cm deep) over some black reduced organic matter with sand and gravel; fresh smell	NC
	55	5.5	Hard bottom, brown oxidized silty clay (about 1 cm deep) over sand and gravel; fresh smell	NC
	55	5.5	Hard bottom, (rock in dredge)	No Sample
	55	5.8	Hard bottom, (rock in dredge)	No Sample
475 m	9	1.2	Brown oxidized silty clay (about 11 cm deep) over 3 cm of clay slurry mixed with small twigs over gravel; fresh smell	NC
	18	3.7	Brown oxidized silty clay (about 11 cm deep) over 4 cm of grey clay; fresh smell	NC
	27	5.5	Brown oxidized silty clay (about 3 cm deep) over gravel; faint PAH odour, one small rock covered with tar	VC
	37	5.5	Brown oxidized silty clay (about 1 cm deep) over 4 cm of sand; fresh smell	NC

Table 1. Continued.

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
475 m Cont.	37	5.8	Brown oxidized silty clay (about 1 cm deep) over gravel, piece of brick with one side covered in tar, one piece of tar mixed with sand; fresh smell	VC
	46	4.9	Plant material	NC
	46	4.9	Brown oxidized silty clay (about 3 cm deep) with sand over gravel, some black reduced organic matter; fresh smell	NC
	46	4.9	Brown oxidized silty clay (about 1 cm deep) mixed with sand (hard bottom); fresh smell	NC
	55	4.9	Brown oxidized silty clay (about 4 cm deep) over gravel, 2 clam shells; small clumps of soft black tar, faint PAH odour	VC
	64	4.6	Brown oxidized silty clay (about 3 cm deep) over 2 cm of black reduced organic matter mixed with gravel and one clam; fresh smell	NC
	73	5.2	Brown oxidized silty clay (about 3 cm deep) over 3 cm of silty grey clay over sand, black reduced organic matter subsurface; fresh smell	NC
500 m	9	1.5	Brown oxidized silty clay (about 8 cm deep) mixed with twigs and leaves; fresh smell	NC
	18	4.3	Brown oxidized silty clay (about 9 cm deep) over 10 cm of grey clay, some black reduced organic matter subsurface; fresh smell	NC
	27	5.8	Brown oxidized silty clay (about 3 cm deep) over 4 cm of grey clay and gravel; fresh smell	NC
	37	6.1	Very small sample, small pieces of clay with soft tar; strong PAH odour	VC
	46	5.8	Brown oxidized sandy silty clay (about 5 cm deep) over sand, some black reduced organic matter, two clams; fresh smell	NC
		5.8	Brown oxidized silty clay (about 5 cm deep) over 3 cm of sand, some black reduced organic matter; fresh smell	NC
	55	4.9	Brown oxidized silty clay (about 8 cm deep) over gravel over sand, one small clam; fresh smell	NC
525 m	9	1.2	Brown oxidized silty clay (about 10 cm deep) over gravel and twigs with some sand; fresh smell	NC
	18	3.7	Brown oxidized silty clay (about 10 cm deep) over 9 cm of grey clay; fresh smell	NC
	27	5.8	Brown oxidized silty clay (about 5 cm deep) over 15 cm of grey clay, some black reduced organic matter subsurface; fresh smell	NC

Table 1. Continued.

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
525 m Cont.	37	5.8	Brown oxidized silty clay (about 6 cm deep) over gravel, some black reduced organic matter subsurface; PAH odour in brown oxidized silty clay, soft tar on rocks	VC
	46	6.1	Brown oxidized silty clay (about 9 cm deep) over 3 cm of sand; fresh smell	NC
	55	5.2	Brown oxidized silty clay (about 9 cm deep) over sand and gravel, one clam; fresh smell	NC
550 m	9	1.5	Brown oxidized silty clay (about 5 cm deep) over 6 cm of clay slurry, some black reduced organic matter and leaves subsurface; fresh smell	NC
	18	3.7	Brown oxidized silty clay (about 9 cm deep) over 9 cm of grey clay, some black reduced organic matter subsurface; fresh smell	NC
	27	5.2	Brown oxidized silty clay (about 9 cm deep) over 11 cm of clay slurry; fresh smell	NC
	37	6.1	Brown oxidized silty clay (about 10 cm deep) over 3 cm of gravel and clay, some black reduced organic matter subsurface; tar present with oil slicks, strong PAH odour	VC
	46	6.4	Brown oxidized silty clay (about 10 cm deep) over gravel and twigs, some black reduced organic matter subsurface; fresh smell	NC
	55	6.1	Brown oxidized silty clay (about 14 cm deep) over 4 cm of grey clay over sand and gravel; fresh smell	NC
575 m	9	0.9	Brown oxidized silty clay (about 9 cm deep) over gravel and twigs; fresh smell	NC
	18	3.7	Brown oxidized silty clay (about 9 cm deep) over 10 cm of grey clay; fresh smell	NC
	27	4.9	Brown oxidized silty clay (about 6 cm deep) over 5 cm of sandy clay, some black reduced organic matter subsurface; fresh smell	NC
	37	5.2	Brown oxidized silty clay (about 6 cm deep) over grey 3 cm of clay and gravel, one clam shell; soft tar in clay, strong PAH odour	VC
	46	5.8	Brown oxidized silty clay (about 15 cm deep) over 1 cm of sand, some black reduced organic matter subsurface; fresh smell	NC
	55	5.8	Brown oxidized silty clay (about 10 cm deep) over 9 cm of sandy clay, some black reduced organic matter; fresh smell	NC
600 m	9	0.9	Brown oxidized silty clay (about 9 cm deep) over 6 cm of clay slurry; fresh smell	NC
	18	2.7	Brown oxidized silty clay (about 5 cm deep) over 11 cm silty clay with twigs; fresh smell	NC

Table 1. Continued.

Transect	Distance from Shore (m)	Water Depth (m)	Sediment Description	Evidence of Contamination
600 m Cont.	27	4.6	Brown oxidized silty clay (about 8 cm deep) over 8 cm of grey clay, some black reduced organic matter subsurface; fresh smell	NC
	37	5.5	Brown oxidized silty clay (about 5 cm deep) over 5 cm of grey clay and gravel; soft tar in clay, strong PAH odour	VC
	46	5.8	Brown oxidized silty clay (about 10 cm deep) over 6 cm of sandy clay, some black reduced organic matter subsurface; fresh smell	NC
	55	5.8	Brown oxidized silty clay (about 11 cm deep) over 10 cm of sandy clay; fresh smell	NC
625 m	27	4.6	Brown oxidized silty clay (about 9 cm deep) over 10 cm of silty clay, some black reduced organic matter subsurface, one large rock; fresh smell	NC
	37	5.2	Brown oxidized silty clay (about 9 cm deep) over 13 cm of silty clay; fresh smell	NC
	46	5.8	Brown oxidized silty clay (about 8 cm deep) over 3 cm of clay over gravel, some black reduced organic matter subsurface, one piece of black sandy rock; fresh smell	NC
650 m	27	4.3	Brown oxidized silty clay (about 6 cm deep) over 8 cm of grey clay, some black reduced organic matter subsurface; fresh smell	NC
	37	5.5	Brown oxidized silty clay (about 9 cm deep) over 4 cm of grey clay; fresh smell	NC
		5.5	Brown oxidized silty clay (about 6 cm deep) over thin layer of grey clay (hard bottom); fresh smell	NC
	46	6.1	Brown oxidized silty clay (about 9 cm deep) over 4 cm of grey clay, some black reduced organic matter subsurface; fresh smell	NC

4.0 Discussion

The 1997 contamination survey results indicate the zone of near-surface sediments with visible tars is substantially larger than found in 1994, 1995, or 1996 (Figures 1, 2, 3, and 4). The primary zone of visually detectable contamination begins at about the same location as in the earlier surveys, but the plume extends about 5 m farther offshore and 300 m farther downstream than previously recorded. The primary zone of visual contamination in 1997, at about 8,400 m^2, was 2.2 times larger than in 1995, when the area was about 3,800 m^2, and 4.1 times larger than in 1996, when the area was about 2,040 m^2.

The increase in area of contamination cannot be attributed to variation in survey methods or time of sampling. The same methods were employed in sample collection and contamination assessment, the same locations were sampled, the same personnel conducted the assessments, and the surveys were conducted at about the same time of year; September 9 to October 21 in 1997, October 16-18 in 1996, and September 11 to October 10 in 1995. It must, therefore, be concluded that an increase in the areal extent of contamination in the surficial sediments has occurred.

The change in size of the surficial sediment PAH contamination plume has several possible causes. The loading of PAH to the river via groundwater seepage may have increased, due to higher PAH concentrations in the groundwater or higher groundwater seepage rates. The spring flood flows may also have increased river bed scour, thereby distributing previously contaminated sediments farther downstream. These factors may be operating individually or in some combination. A materials balance would be required to assess the relative importance of these mechanisms.

It is unlikely that the increase in downstream extent was a result of the erosion of overlying, uncontaminated sediments, to expose previously deposited PAH contamination. Deeper samples (typically to 1 m depth and several up to 3.3 m in depth) taken by CH2M Hill in March, 1994, did not find evidence of visual contamination beyond about 330 m (CH2M Hill 1995). The prevalence of fine-grained surficial sediments between the 375 m and 600 m markers (Table 1) also suggests the area in which the plume expansion has occurred is a depositional, rather than a scour, zone.

The 1997 survey also found isolated pockets of tarry material extending 125 m upstream of the main area of contamination (Figure 2). It is unclear at present whether these deposits originated from the Centra Gas property or from some other upstream source(s). The Centra Gas property is not the only documented source of PAH contamination to the Red River, and there are many other potential sources, including docks and piers constructed of creosote-treated timbers and storm sewer outfalls which may carry PAH's leached from utility poles or in surface runoff from contaminated sites (Agassiz North 1996, Garrod and Sonmor 1995). The very different qualities of these upstream deposits (spotty distribution, small tar droplet size, and lack of a distinct PAH odour) all suggest the material has dispersed from upstream rather than originating from the adjacent riverbank properties.

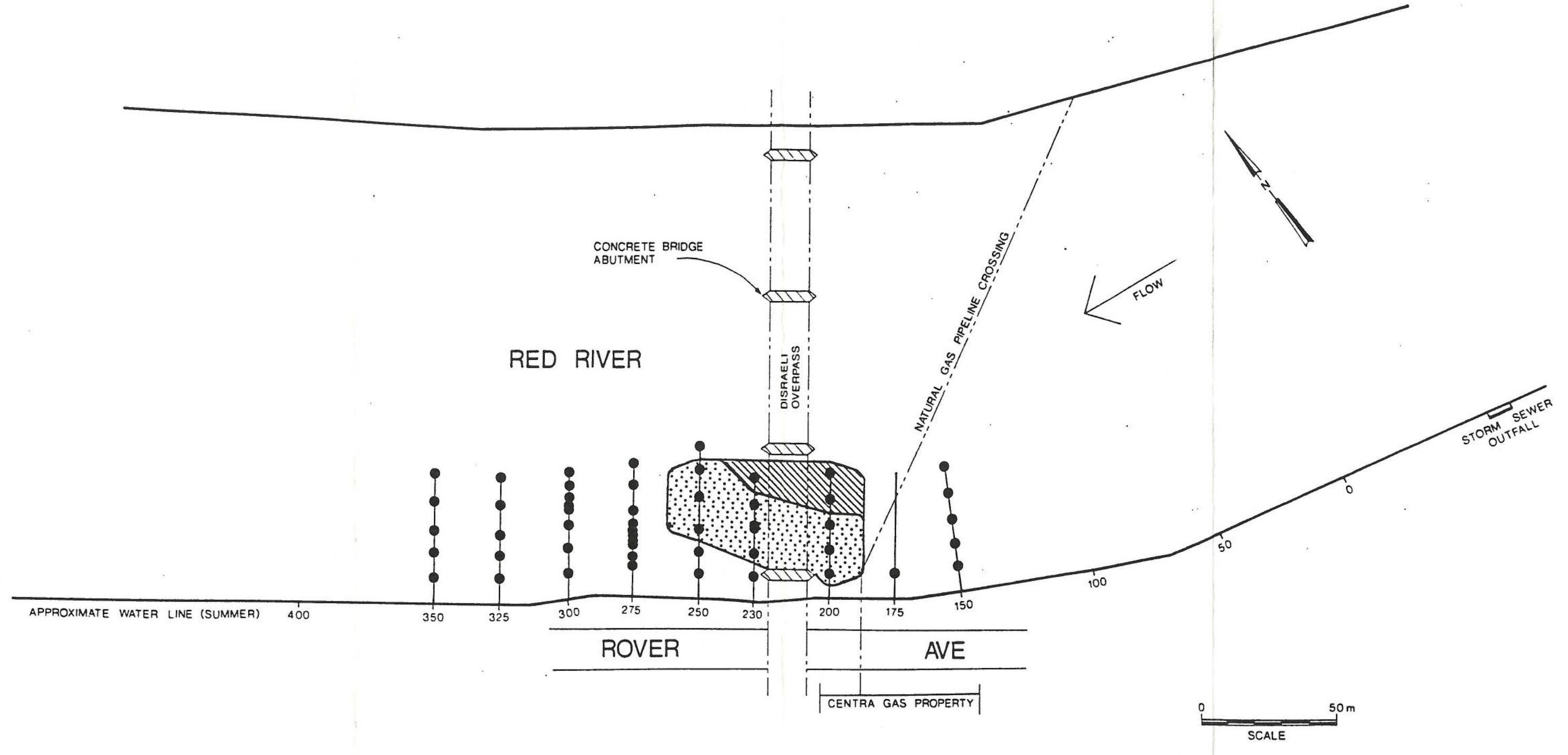

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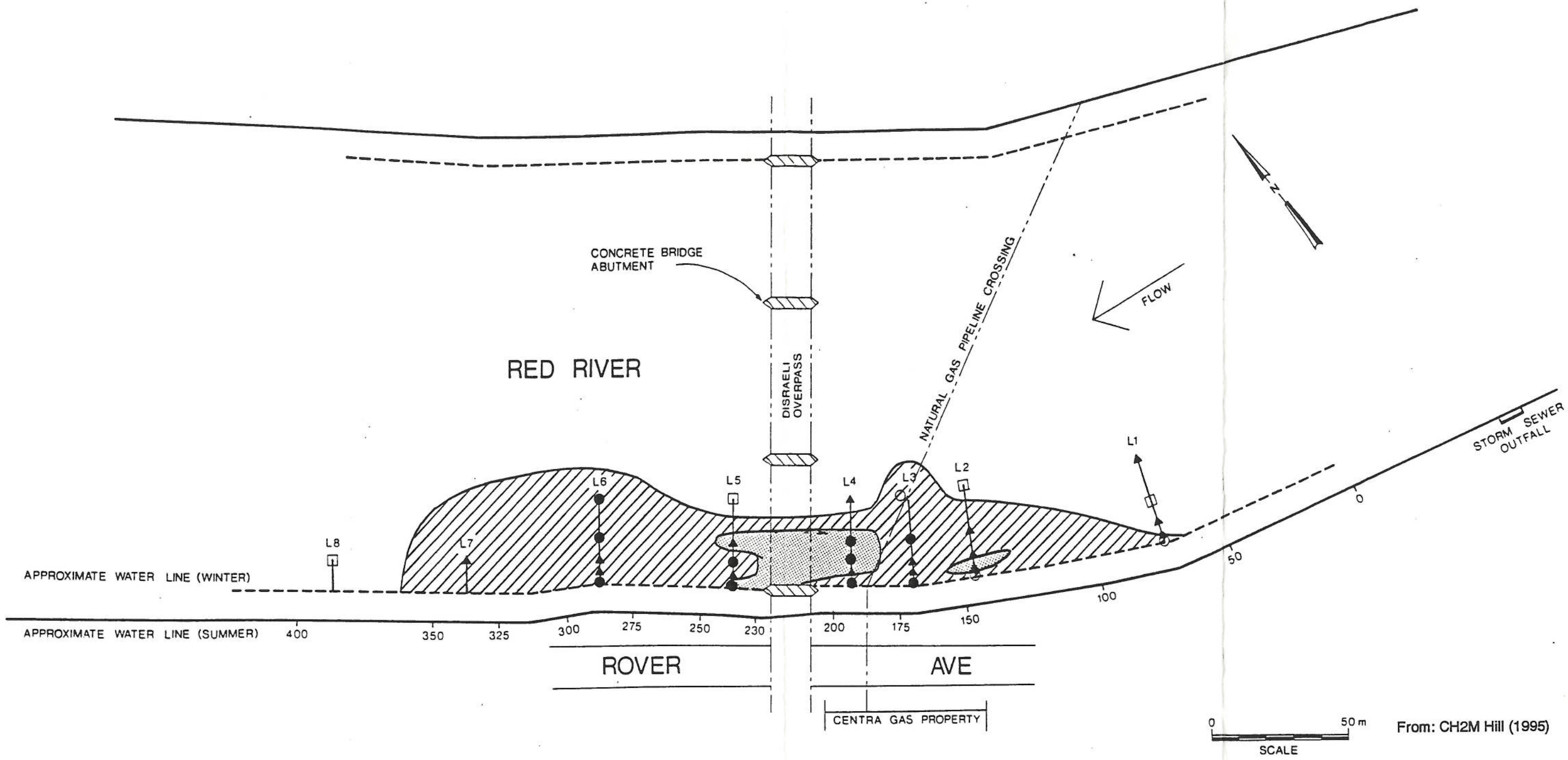
Figure 3
Estimated Extent of Sediments
with Visible PAH Tar Residues
October 1996



From: CH2M Hill (1995)

ESTIMATED EXTENTOF RESIDUES WITH STRONG ODOURS AND/OR VISIBLE TAR

ESTIMATED EXTENT OF PAHs > BACKGROUND CONCENTRATIONS

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Figure 4
Estimated Extent of Sediments
Containing PAH Tar Residues
March 1994

After four years of plume monitoring, the past three using the same methods, it is apparent that the area of surficial sediment PAH contamination is dynamic and can fluctuate substantially from year to year. The factors affecting these fluctuations are not entirely understood, but the considerable increase in plume area in 1997, coincident with the extreme river flows and levels that occurred in spring 1997, suggest year to year variations in river flows are involved in some way.

The role of temporal variations in PAH loading from the Centra Gas site in the sediment plume fluctuations should become more clear over the next few years. In 1996, Centra Gas commissioned a pilot study of the potential for minimizing the movement of PAH contamination off their Sutherland Avenue property. Results to date indicate that bioremediation techniques can be used effectively to reduce PAH concentrations in groundwater on the site (H. Pankratz, Agra Earth & Environmental Limited, Winnipeg, MB, pers. comm.). The bioremediation treatment process being tested involves increasing the dissolved oxygen concentration in the groundwater through the installation of oxygen release compounds. The increased oxygen promotes the activity of naturally occurring micro-organisms that break down the contaminants, thereby reducing concentrations in the groundwater.

Based on the success of the pilot study, Centra Gas has committed to implementing a large scale bioremediation program in 1998 (A. Galarnyk, Centra Gas Manitoba Inc., Winnipeg, MB, pers. comm.), subject to approval by Manitoba Environment. This program will likely involve installation of a row of air sparging wells along the Rover Avenue boundary of the site to increase the dissolved oxygen concentration in the groundwater (H. Pankratz, Agra Earth & Environmental Limited, Winnipeg, MB, pers. comm.). These wells, called a sparging fence, will intercept the groundwater as it flows off the Centra Gas site, treating the contamination as it flows past and reducing PAH loading to the Red River. This should eventually result in a reduction of the PAH contamination pool in the river, although a number of years may be required before any beneficial effects can be measured.

5.0 Conclusions and Recommendations

The 1997 survey results indicate the area of PAH contaminated surficial sediments has increased by about a factor of 2.2 since 1995. The increase is due primarily to extension of the downstream margin of the plume. Possible causes of the increase in area of contamination include an increase in PAH loading to the river via groundwater seepage and the distribution of previously contaminated sediments farther downstream by flood flows in spring 1997. These factors may be operating individually or in some combination. Additional plume monitoring should be planned for 1998 to assess the persistence of this recent increase in plume area.

6.0 References

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