RECENT CHANGES IN CONTAMINANT LEVELS IN THE BOW RIVER FOLLOWING THE INSTALLATION OF A CONTAINMENT SYSTEM AT THE CANADA CREOSOTE SITE

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EXECUTIVE SUMMARY

In November 1989, a liquid mixture of various contaminants including the wood preservatives creosote and pentachlorophenol (PCP) was found seeping into the Bow River adjacent to the abandoned Canada Creosote site in Calgary. A temporary berm was built in the river around the seepage area on November 6-9, 1989, and rebuilt on October 9-19, 1990. Contaminants were removed from the bermed area. A permanent barrier to contaminant flow was installed along the entire shoreline between April 29 and May 3, 1995, and a system designed to prevent the flow of contaminated groundwater to the river around the barrier was operational by February 8, 1996.

Alberta Environmental Protection has intensively monitored the Bow River ecosystem since 1989. This work was designed to determine the distribution of contaminants from the Canada Creosote site in the aquatic ecosystem, to protect domestic water supplies, and to ensure that human consumption of fish was safe. Scans for PCP and for 14 polycyclic aromatic hydrocarbons (PAH) typical of creosote at this site have been conducted. A previous report (Sosiak 1998) evaluated changes in water quality and fish tissue residues in the Bow River after the installation of the second temporary berm in 1990 and immediately after the permanent barrier and ground water treatment system were installed in 1995-96. This report evaluates changes in water quality over the two years since this containment system was installed.

Levels of most PAH compounds and PCP decreased significantly in the Bow River immediately downstream from the Canada Creosote site after the installation of the containment system in 1995-96. Continued low levels of naphthalene ($\leq$0.74 µg/L) and several other compounds at this site probably reflect the scouring and movement of soluble contaminants from the deposit that remains in the bed, or movement from upstream sources. Levels of all compounds were generally low at Stier's Ranch (seven kilometers downstream from Calgary), and at an upstream control site, both before and after the containment system was installed. Naphthalene, benzo(a)pyrene, benzo(a)anthracene and PCP exceeded the CCME water quality guidelines and were detected at both sites downstream from the Canada Creosote site before the containment system was fully-operational (February 8, 1996). As of December 17, 1998, all compounds have since remained below water quality guidelines downstream from this site except for a single benzo(a)anthracene measurement.

The installation of the containment system has significantly reduced the movement of contaminants to the Bow River from the Canada Creosote site and improved water quality in the Bow River since the previous assessment (Sosiak 1998). At current contaminant levels, sampling frequency can be reduced to one sample per season.

ACKNOWLEDGEMENTS

I thank all technical and professional staff of Alberta Environmental Protection who have assisted in the sampling of the Bow River during this program. Bridgette Halbig, Water Sciences Branch, AEP assisted in data compilation and report preparation. Karen Saffran, Water Sciences Branch, tested the data statistically. Review comments on the draft report were provided by Dave Trew and Karen Saffran, Water Sciences Branch.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The former Canada Creosote plant was located beside the Bow River in downtown Calgary, Alberta. The plant used tars, creosote and petroleum oils to preserve wood over about 38 years from 1924 to 1962. Pentachlorophenol (PCP) was also used during the 1950's. Drilling at the site in 1988 by O'Connor Environmental Associates Inc., during the H.E.L.P. (Help Eliminate Landfill Pollution) program, determined that a liquid mixture of creosote, PCP, dioxins and dibenzofurans and other contaminants (DNAPL) was present beneath the former treatment plant.

On November 3, 1989, DNAPL was found seeping into the Bow River from the Canada Creosote site. A temporary berm was built in the river on November 6-9, 1989 to contain contaminants from the seepage area, and to assist DNAPL recovery operations. It was later rebuilt during October 9-19, 1990. A permanent barrier to contaminant flow was installed along the entire shoreline between April 29 and May 3, 1995 and a system designed to treat contaminated groundwater and prevent flow of groundwater to the river around the barrier was fully operational by February 8, 1996. The combined barrier and groundwater system will be called the containment system in this report. Treated groundwater from the groundwater treatment system has been discharged to the City of Calgary sanitary system. AEP has agreed to provide ongoing monitoring of the Bow River water downstream from the containment system until March 31, 2002.

AEP has intensively monitored PCP and 14 polycyclic aromatic hydrocarbons (PAHs) in the Bow River ecosystem since 1989. This work was designed to determine the distribution of contaminants upstream and downstream from the Canada Creosote site, to protect domestic water supplies, and to ensure that fish were safe for human consumption. A previous report (Sosiak 1998) provided a summary and statistical evaluation of water and fish data collected from November 2, 1989 to December 17, 1996. In a February 18, 1998 memorandum from Operations Branch (Southeast Slopes/Prairie Region, AEP), Water Sciences Branch was asked to provide a summary and evaluation of water quality data up to December 31, 1998. Water Sciences Branch has also been asked to review the sampling frequency required for this program.

2.0 MATERIALS AND METHODS

2.1 SAMPLING

Subsurface grab samples of river water were collected in pre-cleaned glass bottles supplied by the analytical laboratory at the locations in Figure 1 during 1989-1998. One site immediately upstream from Canada Creosote, one immediately downstream, and one site further downstream at Stier's Ranch were sampled daily from at least November 6, 1989, after the DNAPL deposit in the Bow River was first discovered, until December 20, 1989. The sampling frequency was then gradually reduced until ongoing monthly sampling began on December 12, 1991. Sampling frequencies are summarized in Table 1. More frequent sampling occurred in April-July 1995 during and after the installation of the permanent barrier. On each sampling occasion, a sample of Type 1 Laboratory water (treated with reverse osmosis and double distilled) was spiked with one or two vials containing a mixture of PAH and PCP in concentrations known only to AEP staff, and submitted "blind" for analysis, as a form of quality assurance.

2.2 CHEMICAL AND DATA ANALYSES

Enviro-Test Laboratories conducted all chemical analyses on water. A list of target PAH compounds and PCP (Table 2) was developed based on the most abundant and important compounds in several detailed gas chromatography/mass spectrometry (GC/MS) scans of DNAPL recovered from the river bed. The carcinogens benzo(a)anthracene and benzo(b)fluoranthene were added to the routine scans after September 20, 1990.

Water samples from 1989-1994 were prepared using a modified version of USEPA extraction method 3510, and method 3520 after January 6, 1995. USEPA detection method 8270 was modified for selected ion monitoring by GC/MS, to provide lower detection limits. Detection limits improved over time with changes in sampling and analytical methods (summary of changes in detection limits in Table 2). Methylphenanthrene, phenanthrene and anthracene were reported as combined measurements, as in Table 2. To monitor analytical method efficiency, water samples were spiked with surrogate compounds.

The statistical significance ($\alpha = 0.10$) of incremental changes (step trends) in the concentration of PAH compounds and PCP when the containment system was installed was tested with the Seasonal Wilcoxon Mann-Whitney test using the statistical package WQHYDRO (Aroner

1994). The decline in median concentration was also estimated using the Seasonal Hodges-Lehmann estimate. The influence of the complete containment system was tested by comparing all available data for the period January 7, 1993 to January 11, 1996 with the period February 21, 1996 to December 17, 1998. To compensate for changes in detection limits and allow statistical testing, data less than the method detection limit were converted to one-half the highest detection limit for the period of analysis.

3.0 RESULTS AND DISCUSSION

All available data for each compound for the period November 2, 1989 to December 17, 1998 are plotted in Figures 2 to 15. Statistically significant changes in median concentration are presented below. There was no significant change in the concentration of other compounds.

Trace levels of naphthalene, methyl and dimethylnaphthalene were sometimes detected at the site upstream from Canada Creosote, both before and after the installation of the containment system. Low levels of PAH compounds can occur in urban runoff (CCME 1995), and probably account for the trace levels found at this upstream site. There were insufficient data from this site to test the statistical significance of changes in concentration after the containment system was installed.

The level of most compounds declined greatly in the Bow River at the station immediately downstream from the Canada Creosote site following the installation of the containment system in 1995-96. There was a significant decrease ($p<0.10$) in the concentration of naphthalene, methylnaphthalene, dimethylnaphthalene, acenaphthene, fluorene, phenanthrene/anthracene, dibenzofuran, PCP and carbazole. These results indicate a dramatic improvement in Bow River water quality since the installation of the containment system. No significant changes occurred at this location in the levels of the remaining compounds ($p\leq0.20$), which were seldom detected both before and after the containment system was installed.

Aside from naphthalene, most compounds were at very low concentrations further downstream at the Stier's Ranch site throughout the sampling period. Although levels of some compounds (naphthalene, methylnaphthalene, phenanthrene/anthracene) appear to have declined at this site after the containment system was installed, these changes were not statistically significant ($p=0.20$).

Six compounds sampled in this program have pertinent CCME water quality guidelines, namely naphthalene, acenaphthene, fluorene, benzo(a)pyrene, benzo(a)anthracene and PCP (Table 2; CCME 1995, 1999). The guidelines for phenanthrene and anthracene can not be used to evaluate these data because these compounds were not individually quantified. Relatively high levels of naphthalene (≤52.0 µg/L), benzo(a)pyrene (≤0.93 µg/L), benzo(a)anthracene (≤0.16 µg/L) and PCP (≤5.1 µg/L) over these guidelines were sometimes detected downstream from the Canada Creosote site or at Stier's Ranch before the containment system was installed. However, since the installation of the containment system all compounds except benzo(a)anthracene have remained below these guidelines. Benzo(a)pyrene has not been detected at any site since 1995-96, and low levels of PCP (≤0.05 µg/L) have only been detected immediately downstream from the Canada Creosote site. A single benzo(a)anthracene measurement (0.03 µg/L) has since exceeded the guideline at this site.

Although some compounds have remained below detection limits downstream from the Canada Creosote site following the installation of the containment system in 1995-96, low levels of naphthalene (≤0.74 µg/L), benzo(a)anthracene (<0.03 µg/L) and several other compounds have since been detected at this site. These results probably reflect the scouring and movement of soluble contaminants from the deposit that remains in the bed, or movement from upstream sources.

4.0 CONCLUSIONS

1. Levels of most PAH compounds and PCP have declined significantly downstream from the Canada Creosote site and most compounds have remained below water quality guidelines after the containment system was installed in 1995-96.
2. The installation of the containment system has significantly reduced the movement of contaminants to the Bow River from the Canada Creosote site and improved water quality in the Bow River since the previous assessment (Sosiak 1998).
3. Low levels of naphthalene and several other compounds were still detected downstream from the Canada Creosote site after the containment system was installed. These results probably reflect scouring and release of soluble contaminants from the riverbed, and movement from upstream sources.

4. Because the concentration of most contaminants has now decreased to levels below water quality guidelines, the river water can be monitored less frequently. At current contaminant levels, sampling frequency can be reduced to one sample per season.

5.0 LITERATURE CITED

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CCME. 1999. Canadian water quality guidelines for the protection of aquatic life: Summary table. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. 8 p.

Golder Associates Ltd. 1990. Draft report to Alberta Environment HELP project on preliminary risk assessment, Canada Creosote site, Calgary, Alberta. 78 p.

Sosiak, A.J. 1998. Changes in contaminant levels in the Bow River following the installation of a containment system at the Canada Creosote site. Water Sciences Branch, Water Management Division, Alberta Environmental Protection. 27 p.

Table 1. Sampling frequency during monitoring of the Canada Creosote site.

SITE	PERIOD OF DATA (M/D/Y)	SAMPLING FREQUENCY
Bow River u/s Canada Creosote	11/02/89 - 03/30/90	Every other day
	10/03/91 - 11/01/91	Weekly
	08/08/95 - 12/17/98	Monthly
Bow River Immediately d/s Canada Creosote	11/02/89 - 12/29/89	Daily
	01/03/90 - 03/30/90	Every other day
	05/23/90 - 07/26/90	Every other day
	08/02/90 - 12/12/91	Every other day/Weekly
	01/09/92 - 12/07/94	Monthly
	04/07/95 - 07/10/95	Weekly
	08/08/95 - 12/17/98	Monthly
Bow River at Stier's Ranch	11/04/89 - 12/21/89	Daily
	01/03/90 - 10/24/90	Every other day
	11/01/90 - 12/12/91	Weekly
	01/09/92 - 12/07/94	Monthly
	04/07/95 - 07/10/95	Weekly
	08/08/95 - 12/17/98	Monthly

Table 2. Detection limits used in the analyses of water samples.

VARIABLE	GUIDELINES, µg/L (CCME 1995, 1999)	DETECTION LIMIT (µg/L)	D.L. DATES
Naphthalene	1.1 (Freshwater Aquatic Life)	L0.1	11/89 - 08/90
		L0.01	09/90 - 12/98
Methylnaphthalene		L0.1	11/89 - 08/90
		L0.01	09/90 - 12/98
Dimethylnaphthalene		L0.1	11/89 - 08/90
		L0.01	09/90 - 12/98
Acenaphthylene		L0.1	11/89 - 08/90
		L0.01	09/90 - 12/98
Acenaphthene	5.8 (Freshwater Aquatic Life)	L0.1	11/89 - 08/90
		L0.01	09/90 - 12/98
Fluorene	3.0 (Freshwater Aquatic Life)	L0.1	11/89 - 08/90
		L0.01	09/90 - 12/98
Phenanthrene/Anthracene	Phenanthrene, 0.4; Anthracene, 0.012 (Freshwater Aquatic Life)	L0.1	11/89 - 08/90
		L0.01	09/90 - 12/98
Dibenzofuran		L0.1	11/89 - 08/90
		L0.01	09/90 - 12/98
Pentachlorophenol	0.5 (Freshwater Aquatic Life); MAC[a]: 50, AO[a]: 30 (Protection of Community Water Supplies)	L0.1	11/89 - 08/90
		L0.01	09/90 - 12/98
Carbazole		L0.2	11/89 - 08/90
		L0.01	09/90 - 12/98
Methyl Phenanthrene/Anthracene		L0.1	11/89 - 08/90
		L0.01	09/90 - 12/98
Benzo(a)Pyrene	0.015 (Freshwater Aquatic Life); 0.01 (Protection of Community Water Supplies)	L0.01	11/04/89 - 09/20/90
		L0.005	09/27/90 - 08/02/94
		L0.01	09/19/94 - 12/17/98
Benzo(a)Anthracene	0.018 (Freshwater Aquatic Life)	L1.0	1984-1987 (1 sample/yr)
		L0.01	11/04/89 - 09/20/90
		L0.005	09/27/90 - 08/02/94
		L0.01	09/19/94 - 12/17/98
Benzo(b)Fluoranthene		L3.0	10/07/1987 (1 sample)
		L0.01	11/04/89 - 09/20/90
		L0.005	09/27/90 - 08/02/94
		L0.01	09/19/94 - 12/17/98

[a] MAC: maximum acceptable concentration; AO: aesthetic objective

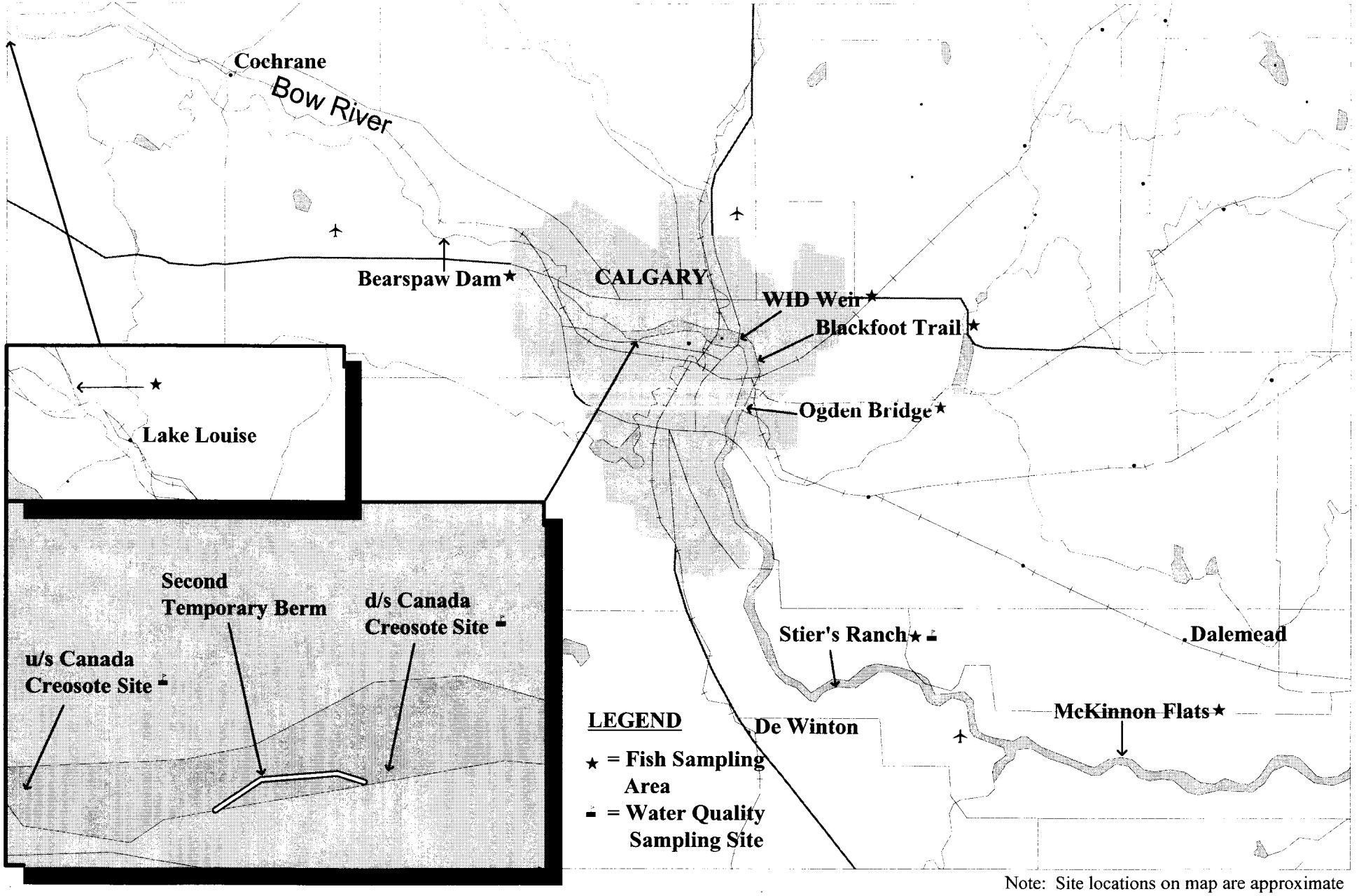

Figure 1. Location of Canada Creosote sampling sites on the Bow River.

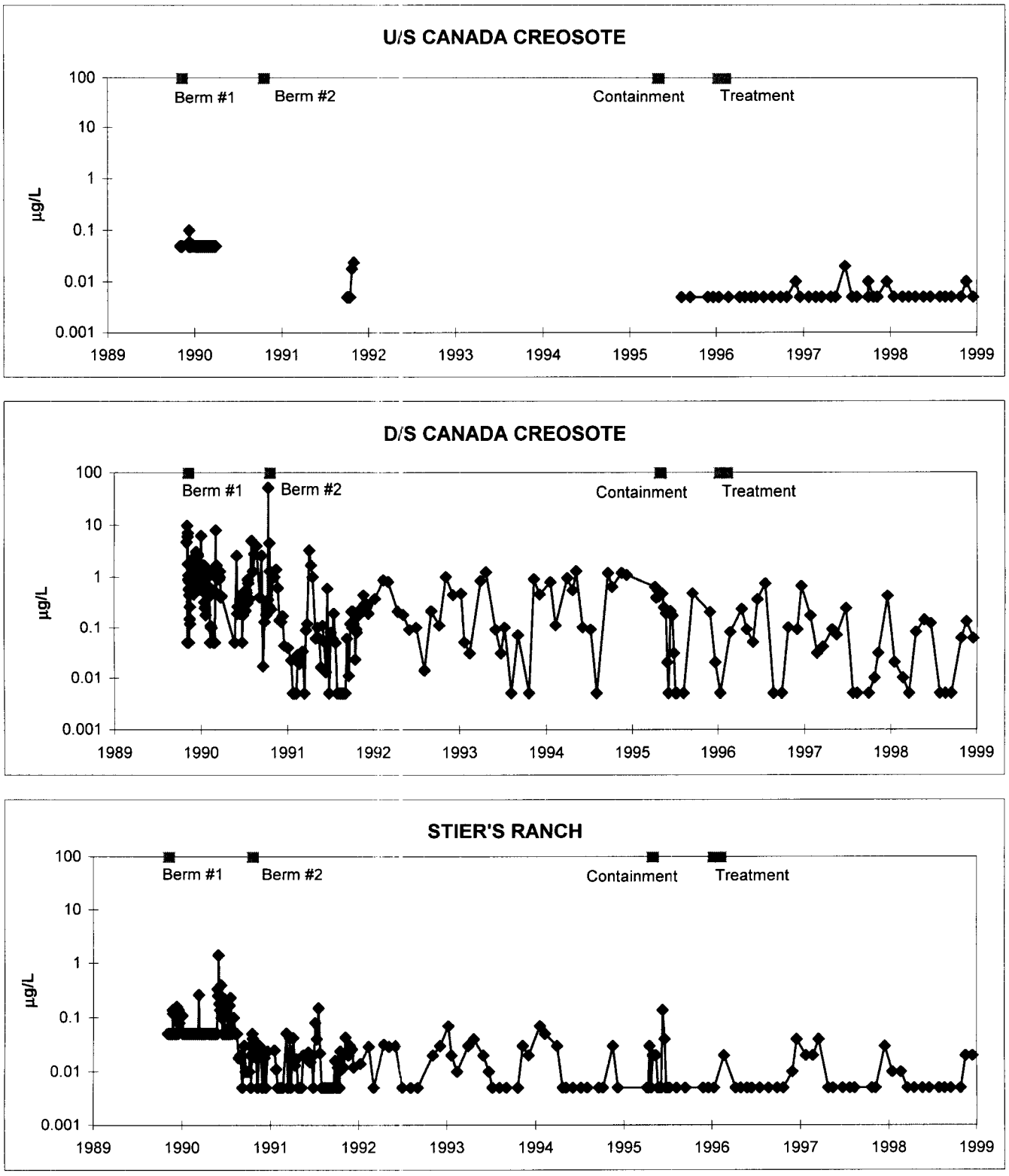

Figure 2. Concentrations of naphthalene at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

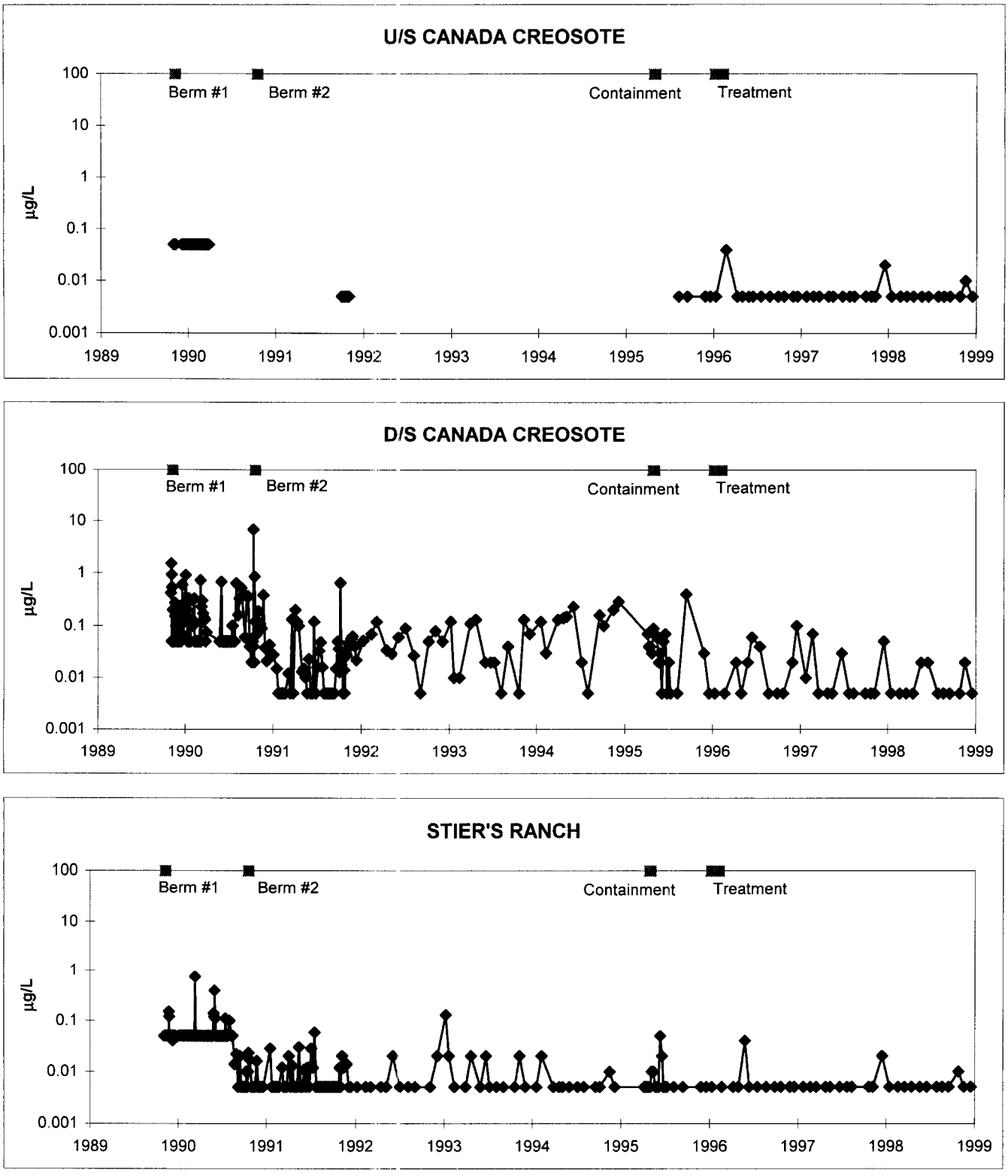

Figure 3. Concentrations of methylnaphthalene at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

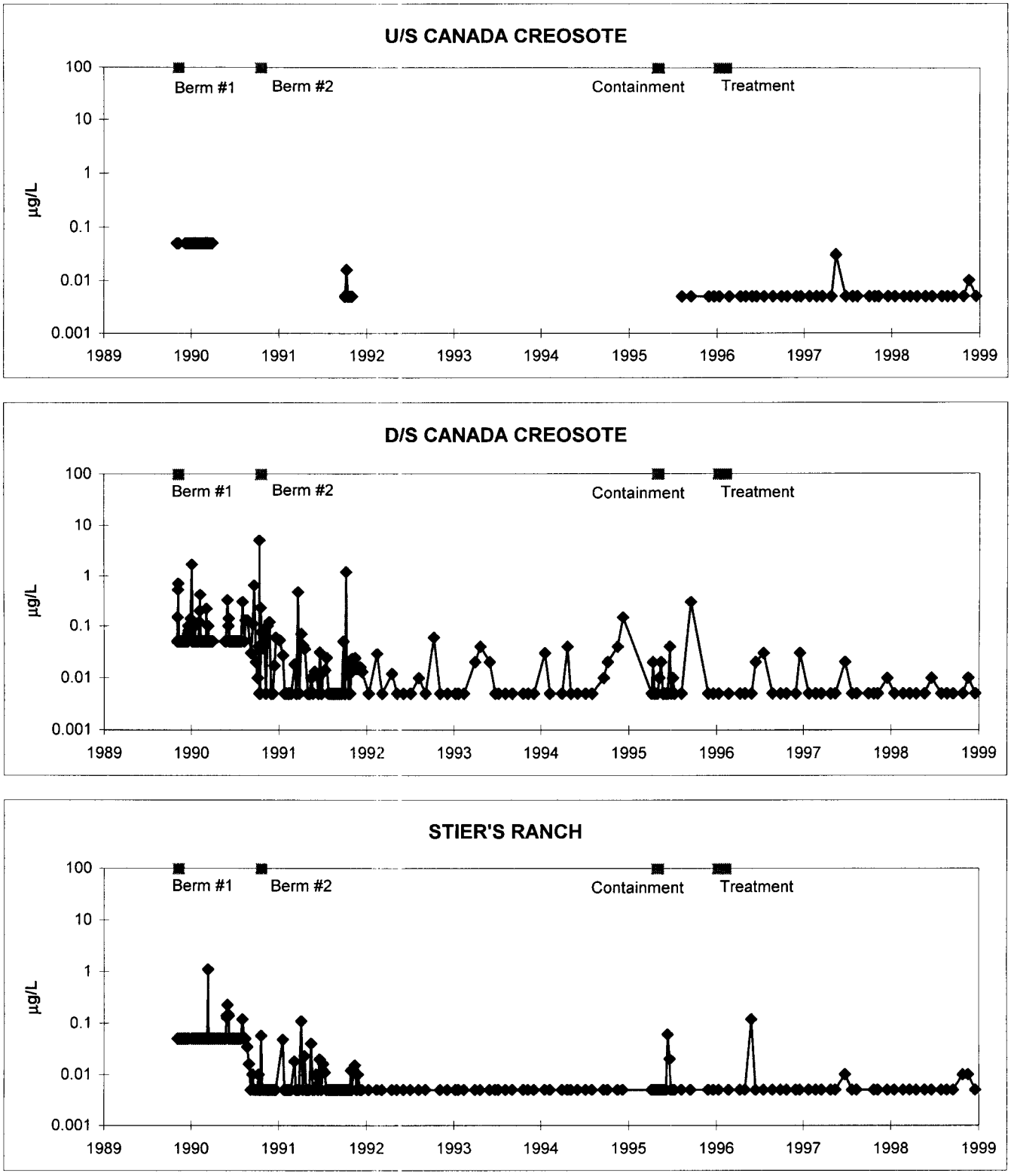

Figure 4. Concentrations of dimethylnaphthalene at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

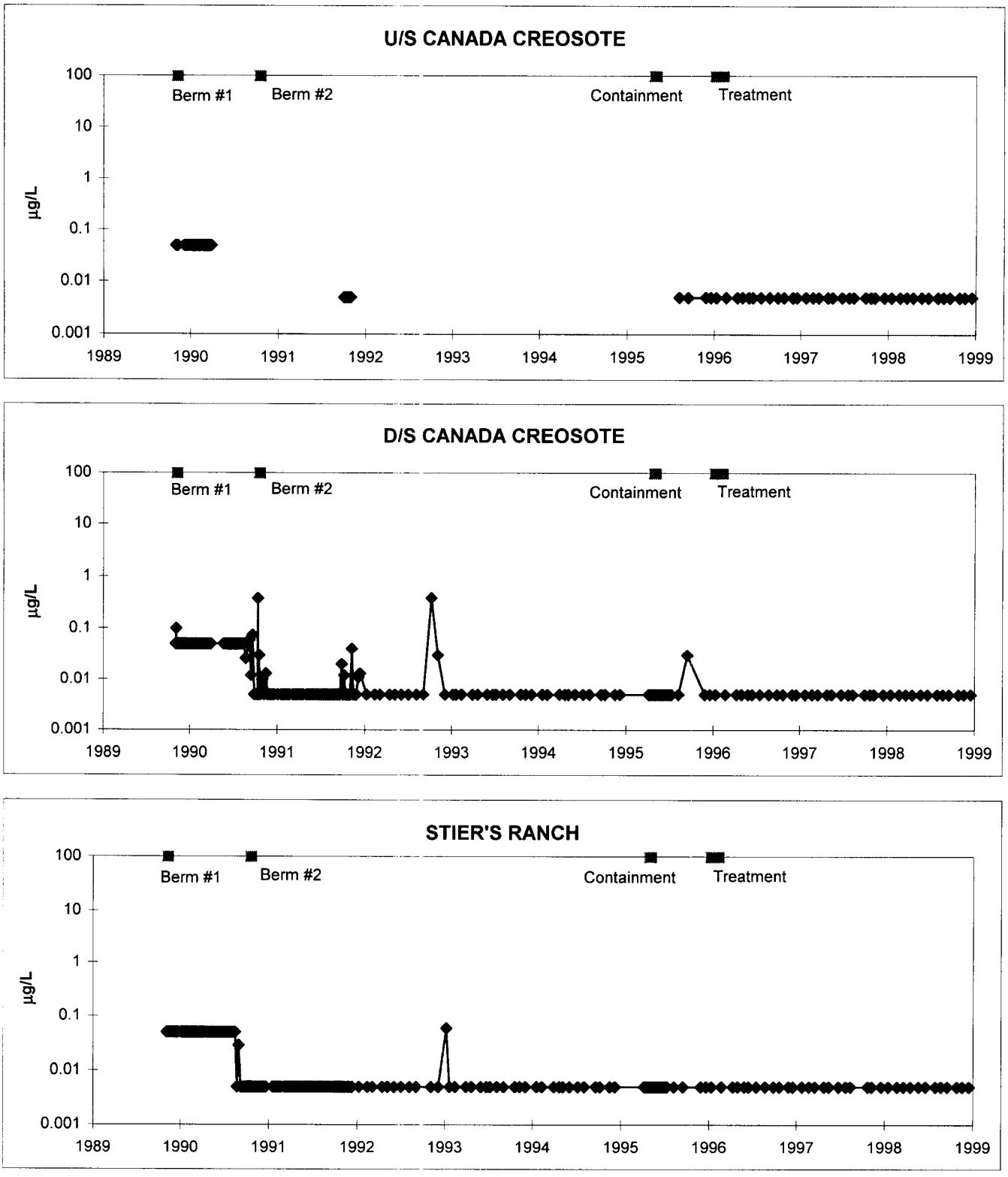

Figure 5. Concentrations of acenaphthylene at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

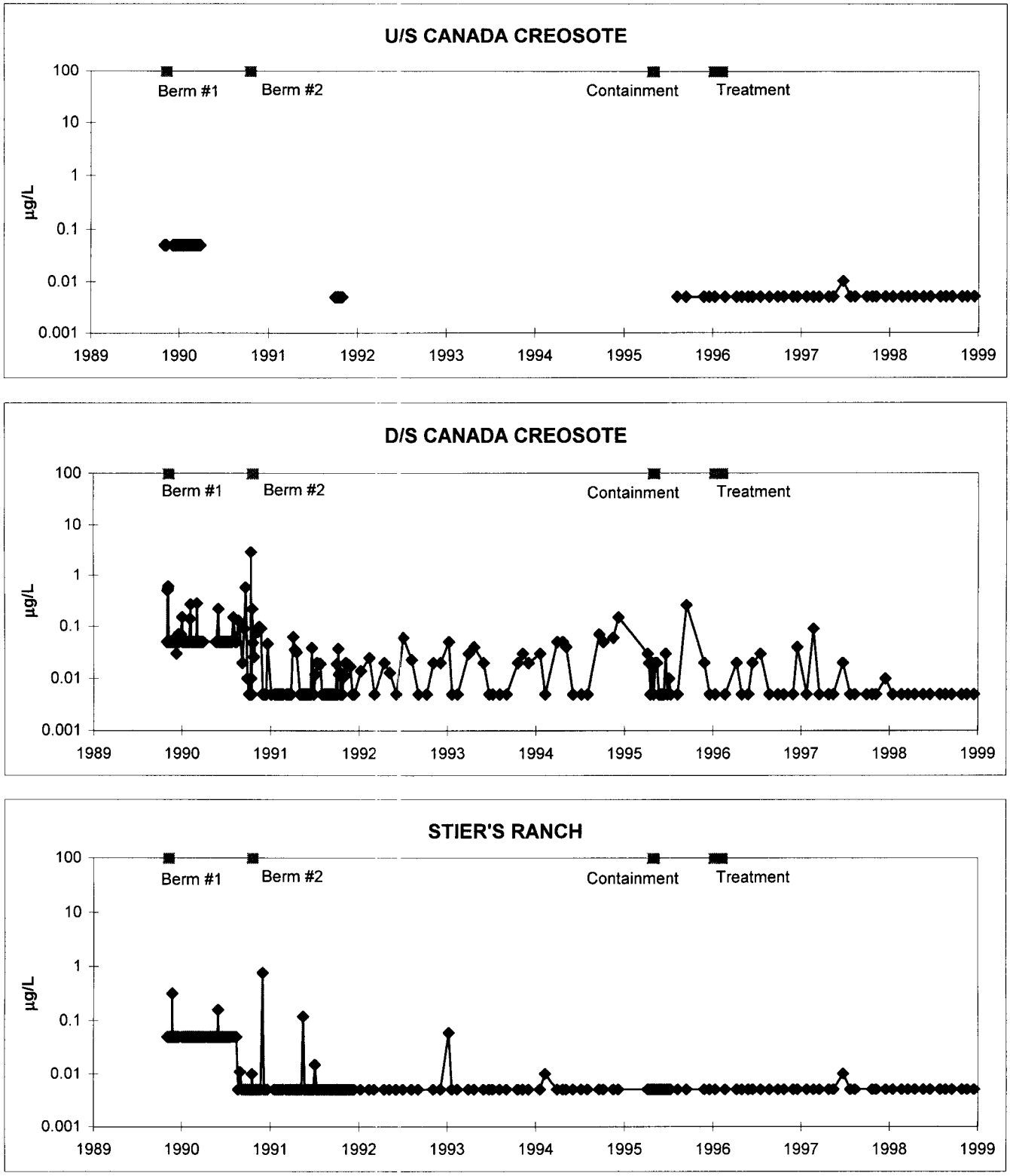

Figure 6. Concentrations of acenaphthene at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

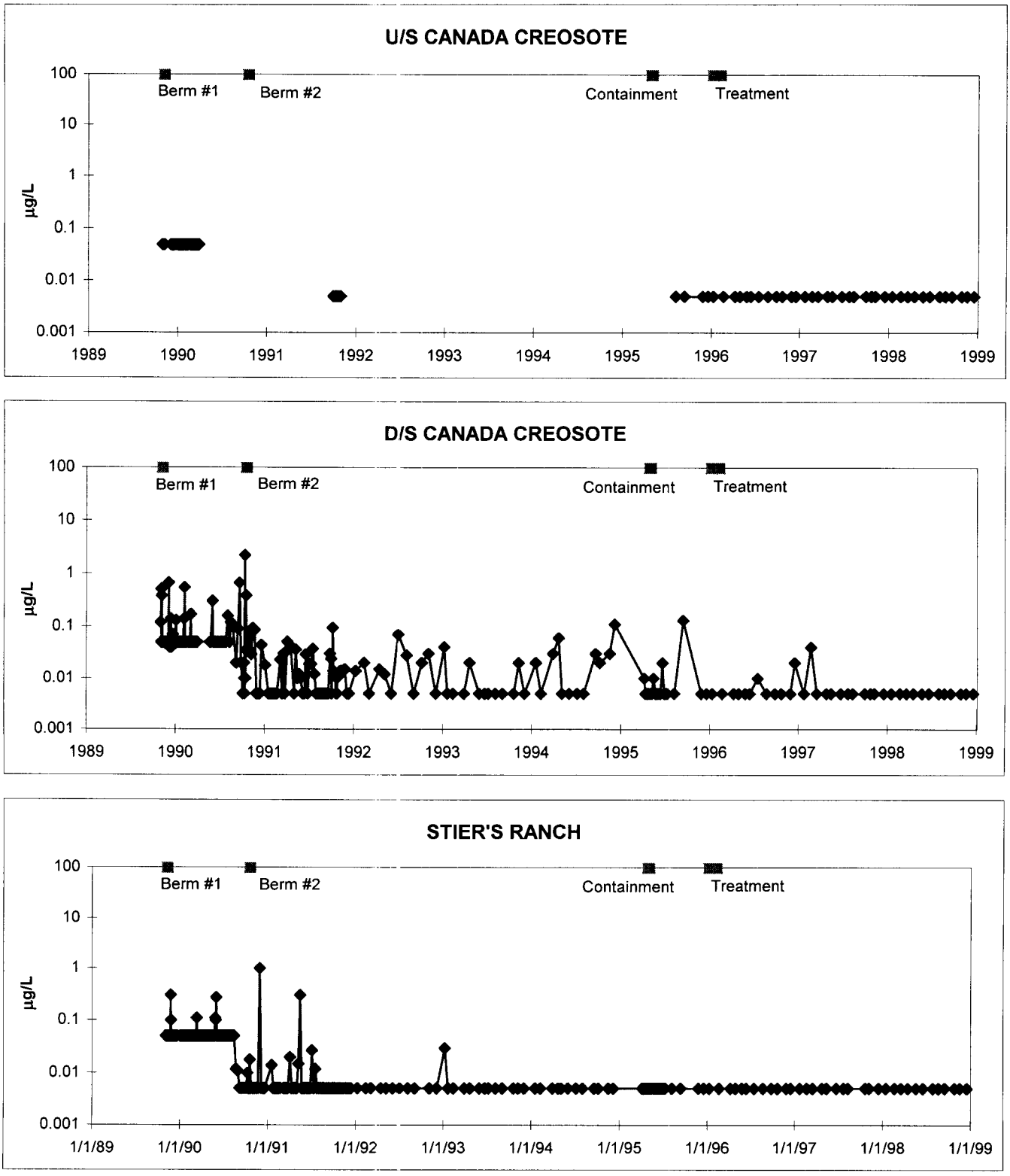

Figure 7. Concentrations of fluorene at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

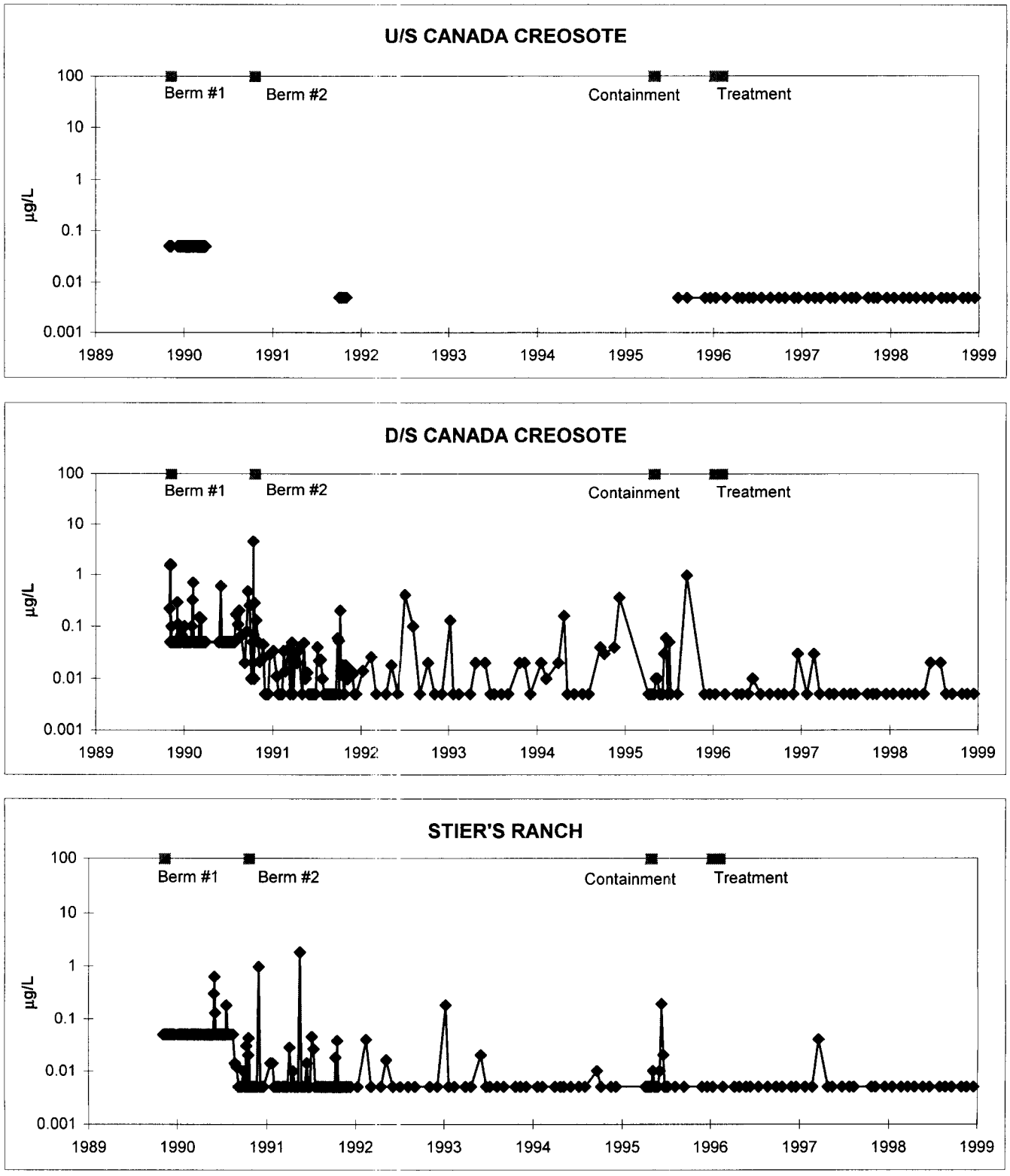

Figure 8. Concentrations of phenanthrene/anthracene at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

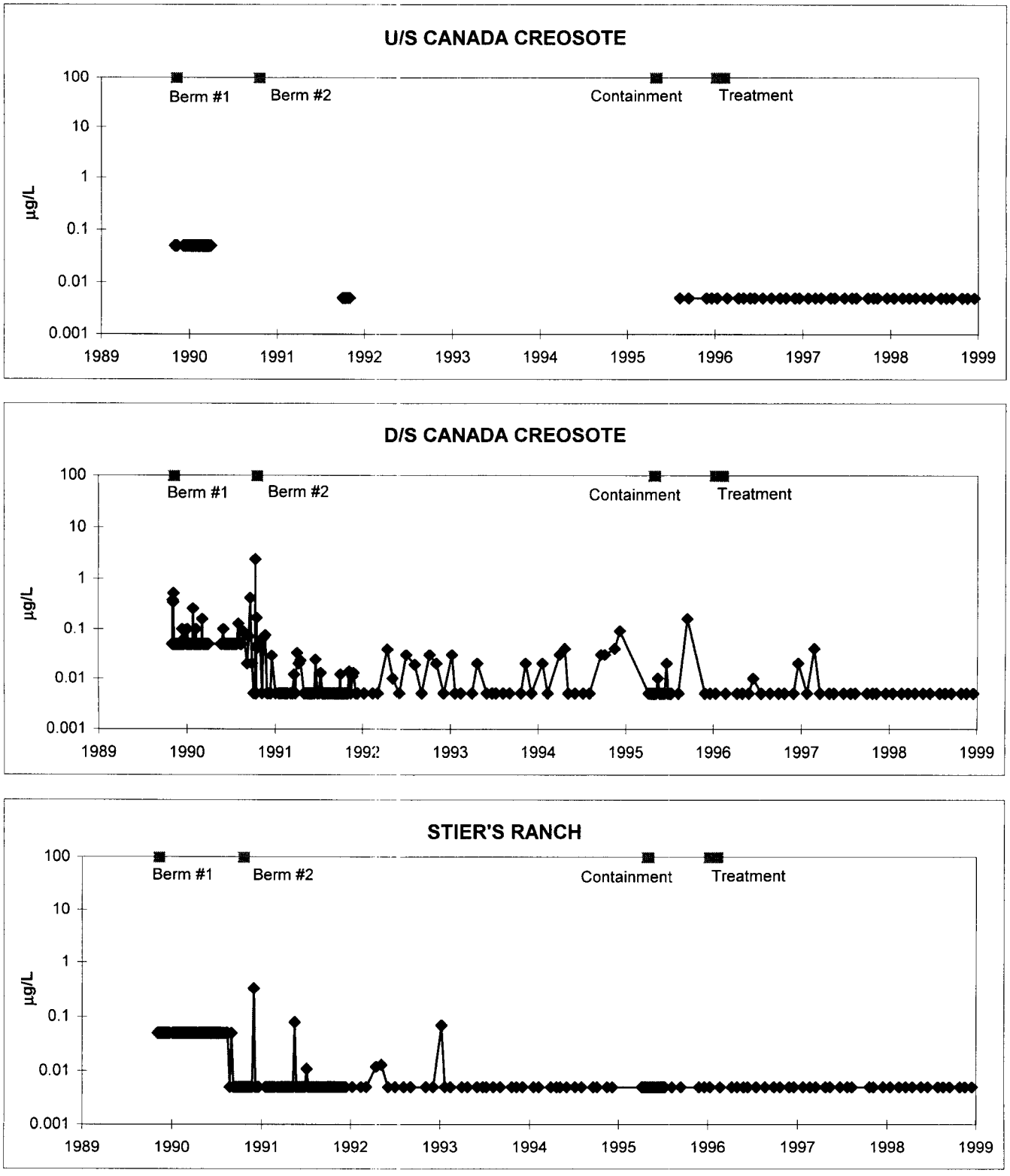

Figure 9. Concentrations of dibenzofuran at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

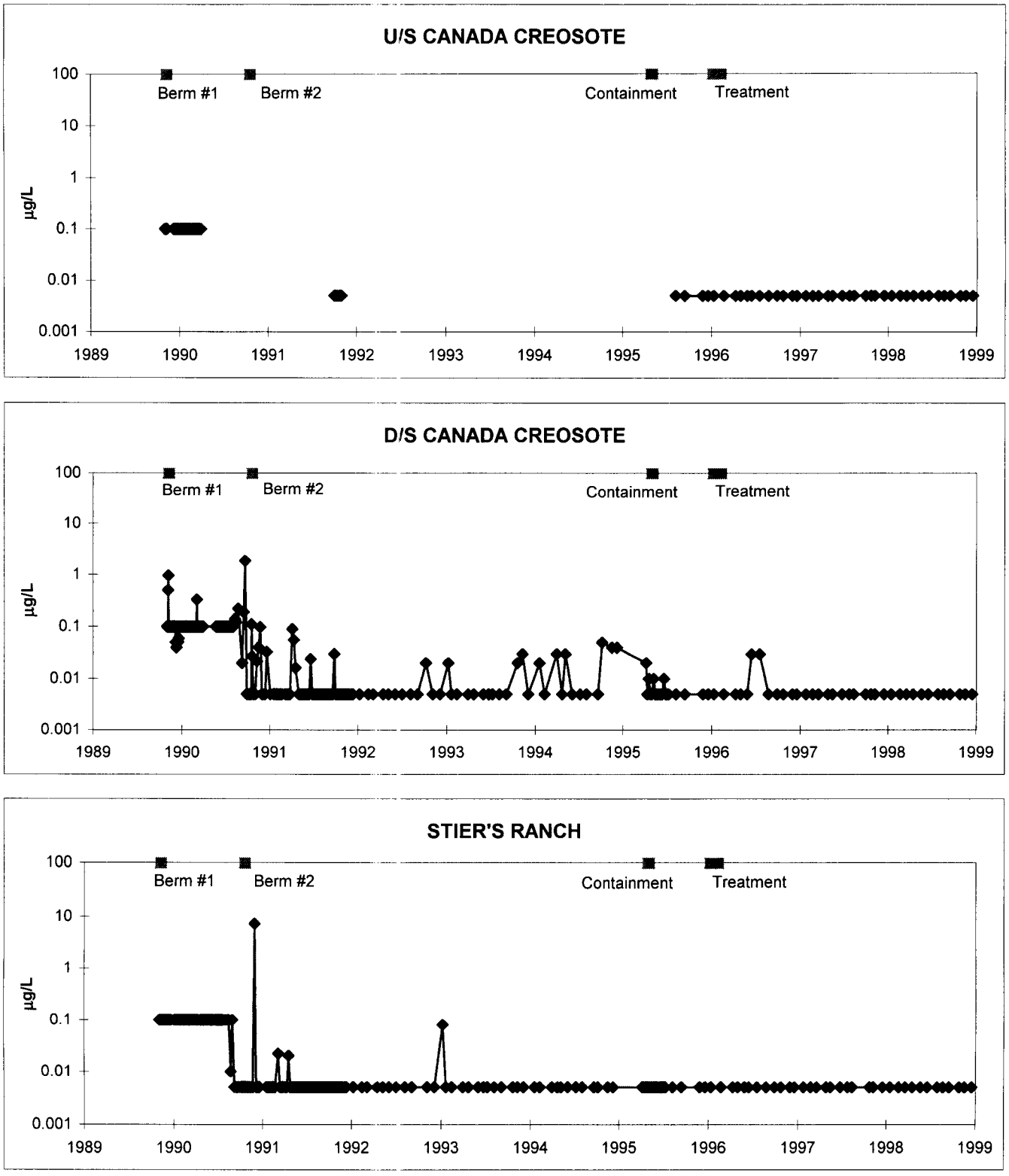

Figure 10. Concentrations of carbazole at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

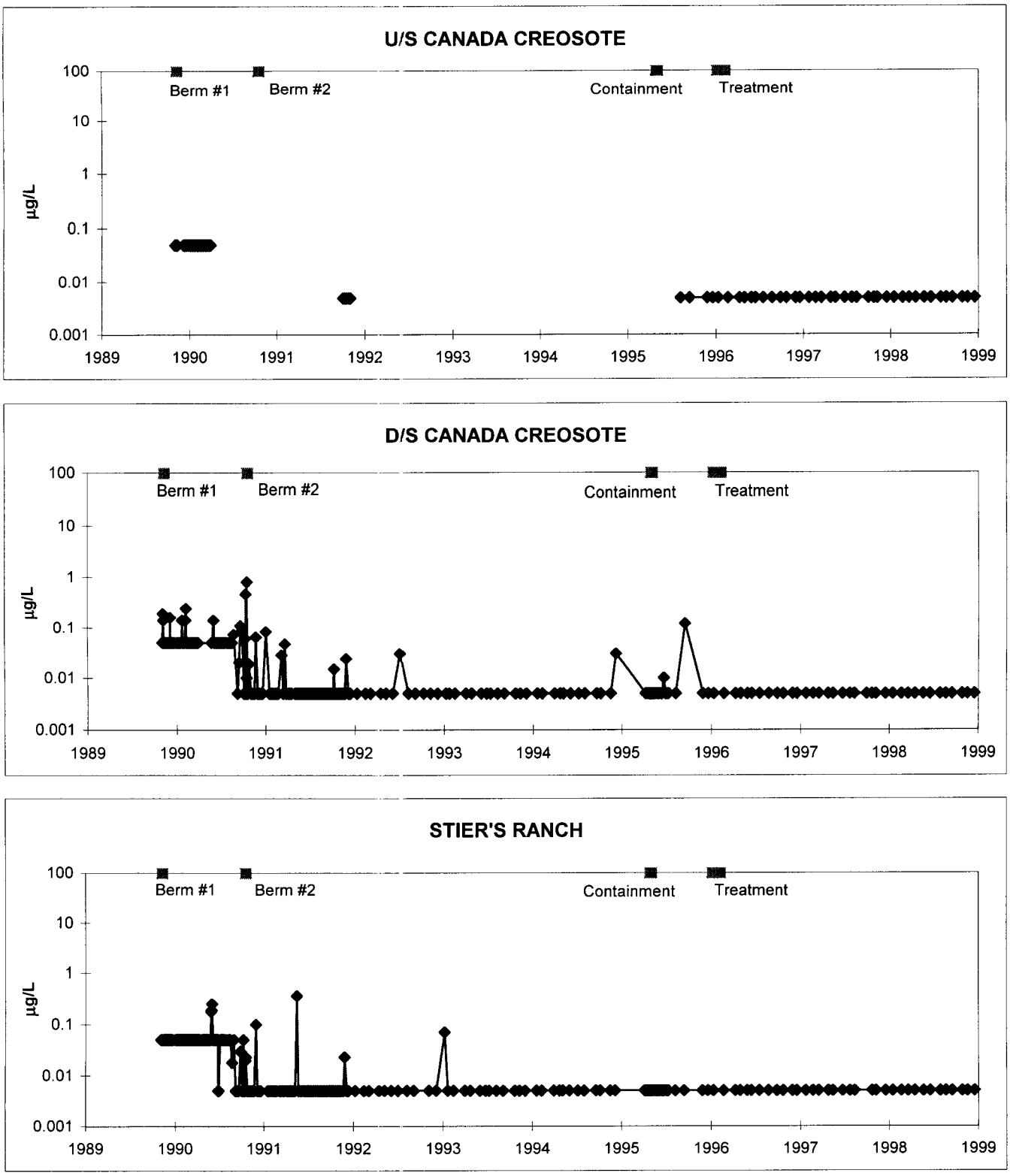

Figure 11. Concentrations of methylphenanthrene/anthracene at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

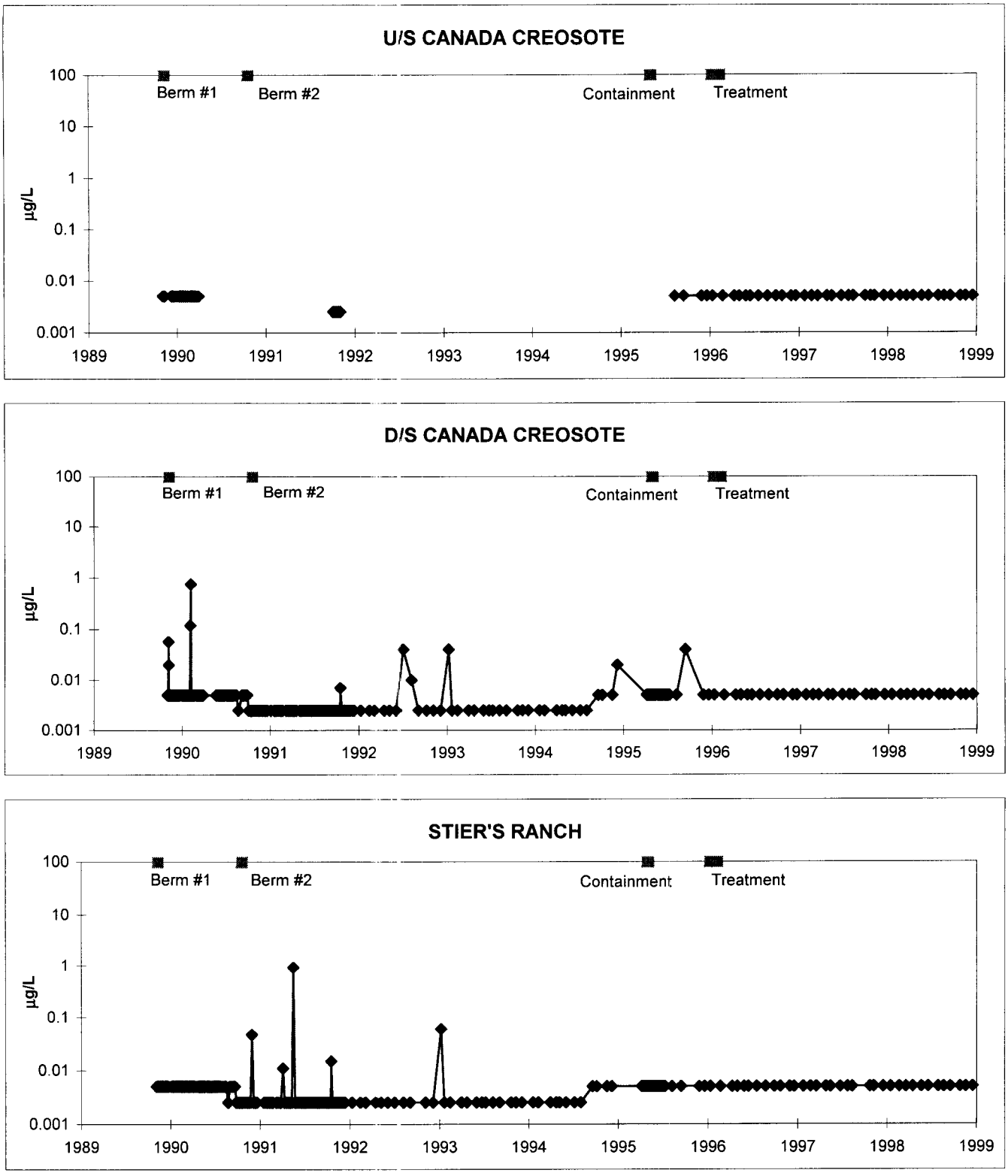

Figure 12. Concentrations of benzo(a)pyrene at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.

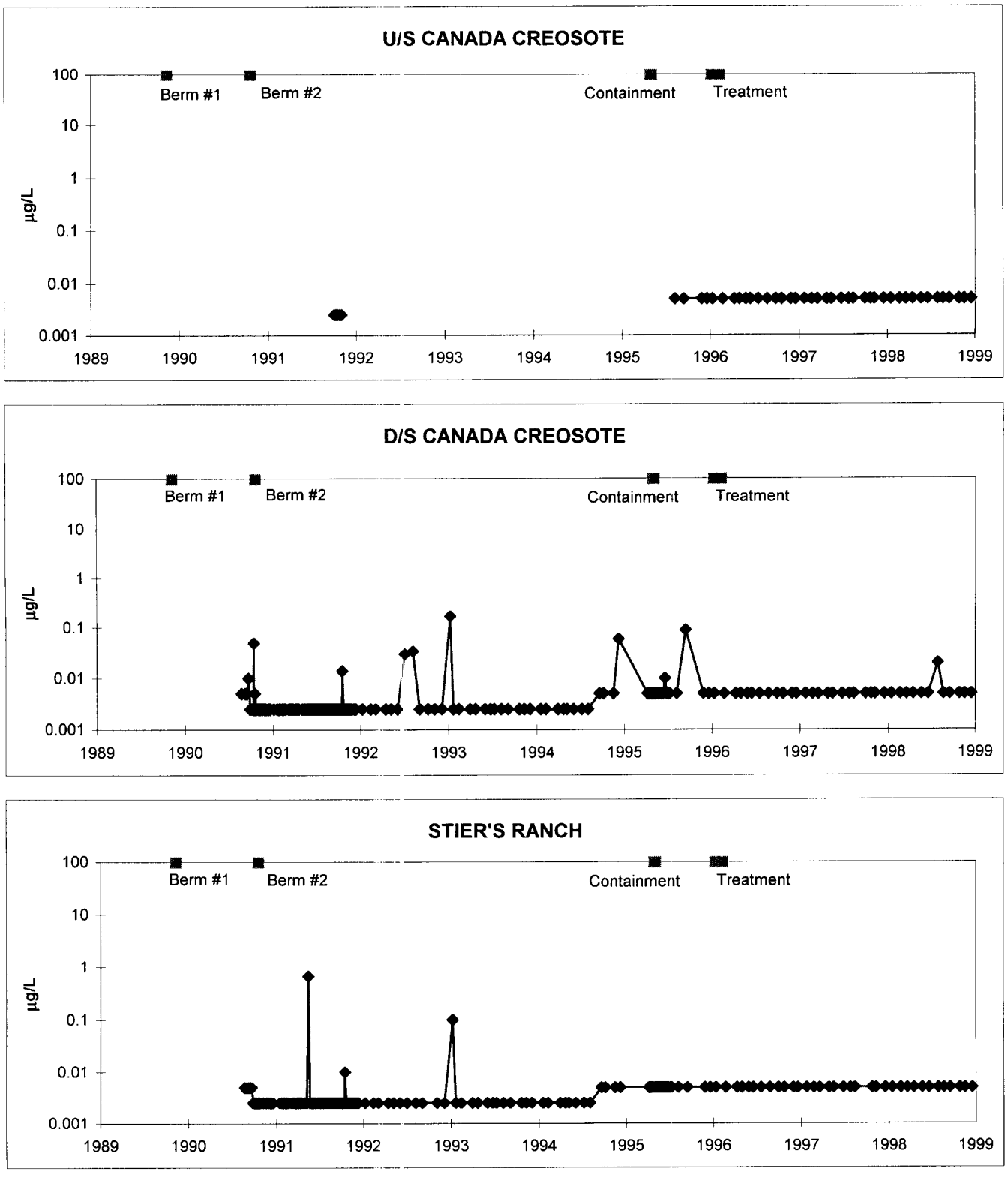

Figure 13. Concentrations of benzo(b)fluoranthene at three sites on the Bow River, August, 1990 to December, 1998. Note: logarithmic scale used.

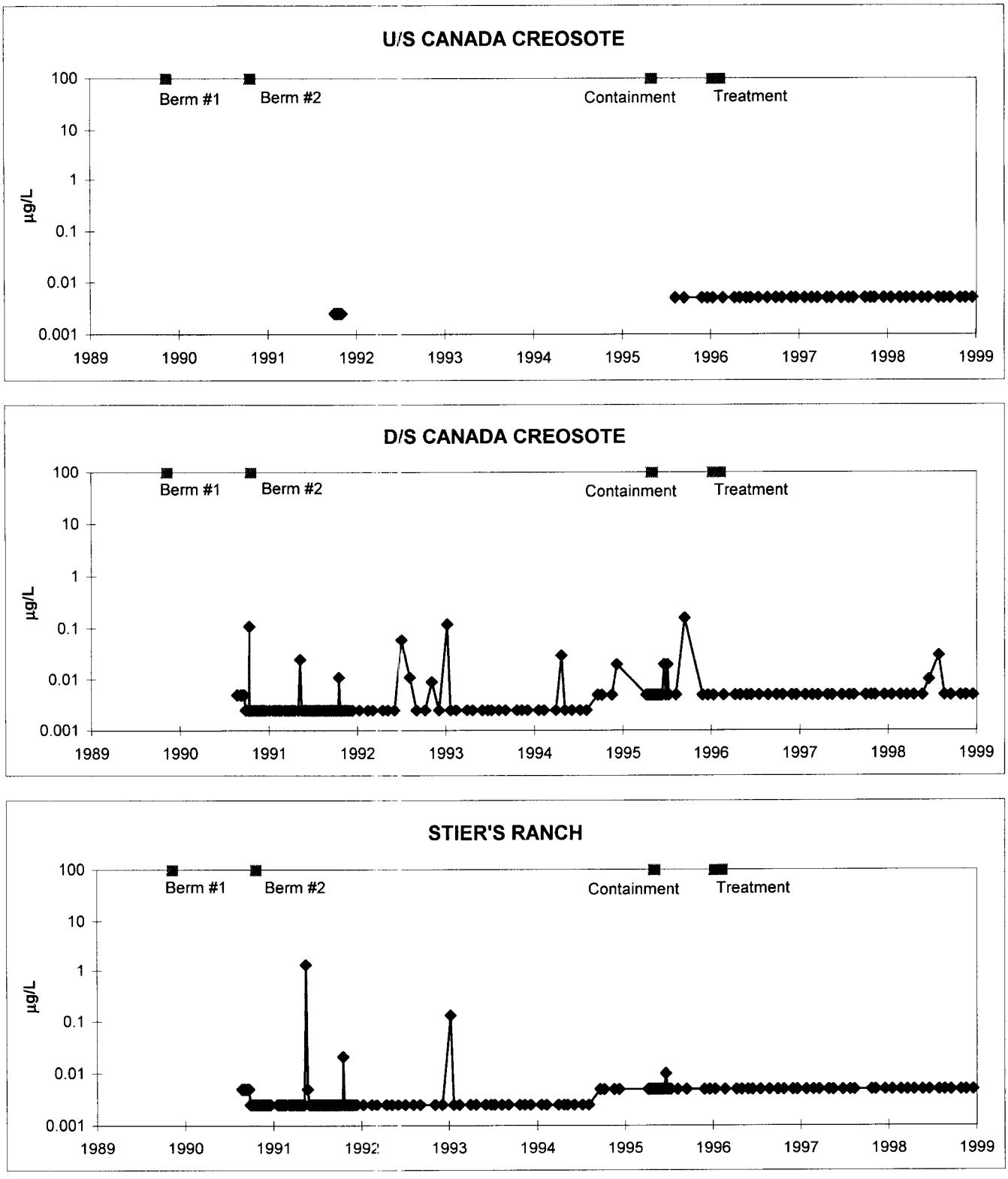

Figure 14. Concentrations of benzo(a)anthracene at three sites on the Bow River, August, 1990 to December, 1998. Note: logarithmic scale used.

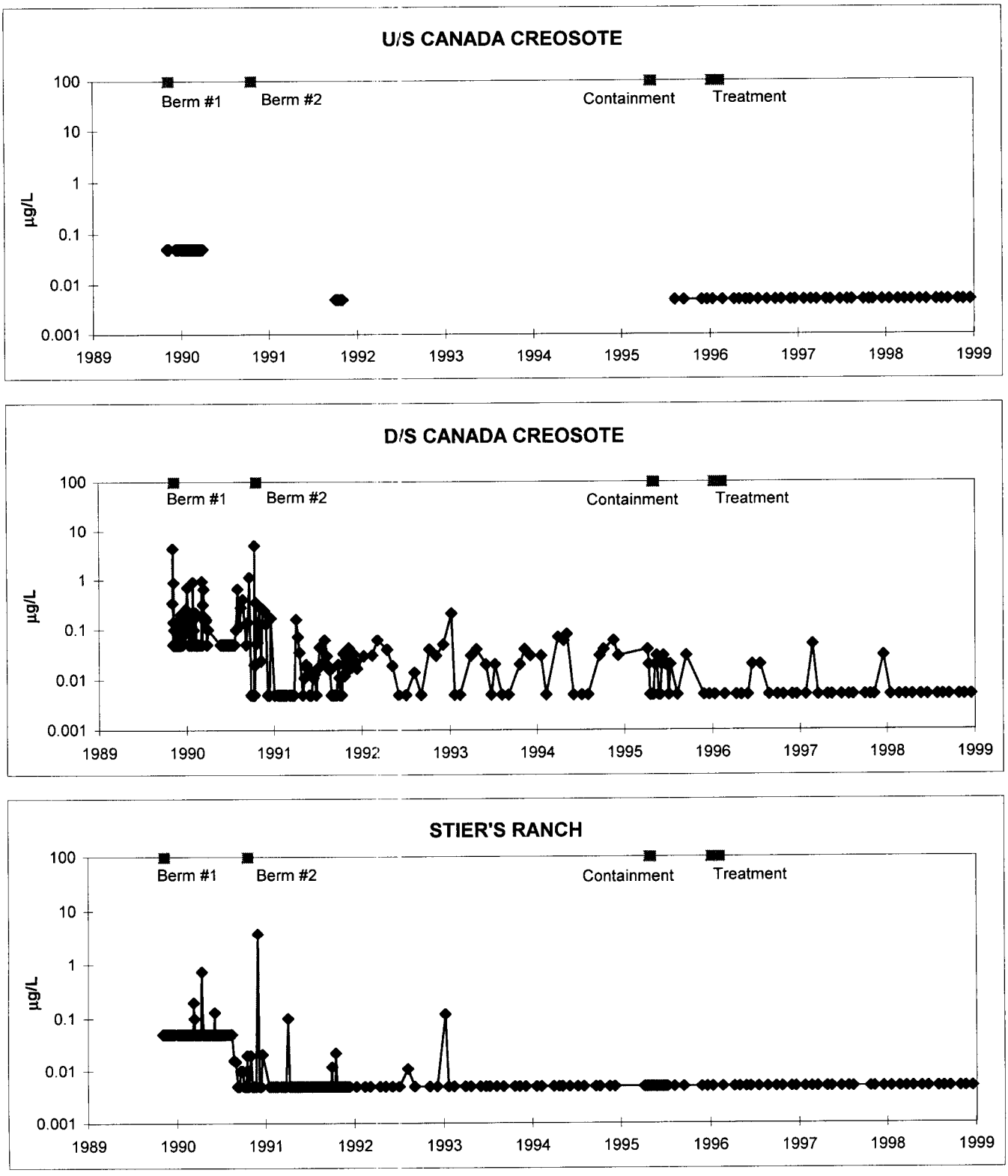

Figure 15. Concentrations of pentachlorophenol at three sites on the Bow River, November, 1989 to December, 1998. Note: logarithmic scale used.