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IMPACTS OF COAL-FIRED GENERATING STATIONS AND COAL MINES ACROSS CANADA.

I. THALLIUM AND TRACE METALS IN WATERS

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NWRI Contribution No. 98-140

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by

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MANAGEMENT PERSPECTIVE

This is part of Environment Canada's Action Plan (Conserving Canada's Ecosystems) and Environmental Effects Monitoring Initiatives. It deals with the impacts of coal mining and coal-fired power plants. Are the aqueous surroundings impacted by these operations in term of thallium and trace metals concentrations ?

The sites from Eastern coal-fired electrical generating stations have higher thallium concentrations than the Western and Central counterparts as well as coal mines. Data seem to indicate that it is not the amount but the type of coal used and/or the local geochemical contributions that are amenable to some of the very high Tl concentrations observed in the eastern provinces.

As an extension of the present study, it is recommended that a literature survey be done on the eastern regional geochemistry, geology and toxicology. This will complement our data, and definitive conclusions may be derived as to the sources of thallium and whether they could cause any health problems.

N.B. This Management Perspective is currently being translated into French.

ABSTRACT

A Canada wide survey was undertaken of sites associated with coal mines and coal-fired electrical generating stations. The survey was an extension of previous studies dealing with the determination of thallium (Tl) in selected regions of Canada. Thallium concentrations were generally low except several sites in the eastern generating stations, in spite of the greater coal consumption and production in the western and central regions. Other authors have reported high Tl concentrations in other sites in the Atlantic region. Our data tend to indicate that the coal type (rather than quantity) and/or regional geological contributions are responsible for the high Tl concentrations observed. It is recommended that the toxicological implications of the high levels of this priority pollutant be investigated. It is estimated that the natural background level of total thallium in water may be 0.1 ppt or lower, which is less than that of lead.

N.B. This Abstract is currently being translated into French.

INTRODUCTION

Coal is Canada's most abundant fossil fuel and is important to the Canadian economy in both the steel industry and as a fuel for electricity generation. Coal exports are worth $2 billion[1]. Smith and Carson[2], however, reported that the air emissions from the 415 American coal-burning power plants in highly populated regions form the largest collective source of thallium (Tl) discharge into the atmosphere. Four States around the Great Lakes (including Ohio) along with Texas have the highest coal-fired generating capacity in excess of 15,000 Megawatts of electrical power. Indeed we recently found that the concentration of dissolved Tl in the Great Lakes waters particularly Lake Erie is higher than that of Cd[3]. These two facts led us to suspect that some high Tl concentrations (along with low ones) may be found in the surroundings of coal mines and coal-based power plants, and to undertake this Canada wide survey of such sites.

The toxicity of thallium (Tl) is well known. Recently we have shown that in *Hyalella azteca* (a freshwater amphipod species), Tl is more toxic than Cu, Zn and Ni, slightly more toxic than Pb although less toxic than Cd and Hg[4]. To mammals on the other hand, it has been shown that Tl acute toxicity is the highest among Cu, Zn, Pb, Cd, Hg and Tl[5]. The most famous, recent case of Tl poisoning to humans is the one occuring in China in 1994, where the patient went into a coma and is still recovering from the poisoning[6]. Of course thallium toxicity has been well recognized since its discovery in 1861[7] and USEPA for obvious reasons has listed Tl as a priority metal pollutant along with Pb, Cd and Hg[8].

This report describes the survey and summarizes the impacts of the Canadian coal mines and power plants on the waters of their vicinity. Levels of Tl and other trace metals in waters are given. Comparison with concentrations found in other ecosystems suggests a very low natural baseline level of Tl, probably below 0.1 ppt and about an order of magnitude lower than that of Pb which was reported to be 0.6 ppt in Antarctica ancient ice[9].

MINES AND GENERATING STATIONS IN CANADA

The study was designed to include most principal coal mines (active and abandoned) and coal-burned electrical power plants or generating stations across Canada. Tables 1-3 list respectively by province the generating stations, active mines and abandoned mines, where the samples would be collected. Figures 1 and 2 respectively show the locations of the principal generating stations and coal mines. Alberta and other western provinces have more plants and mines than the eastern and central areas combined. Most of the planned sites were accessible and therefore sampled. The remaining sites were either closed or inaccessible.

The following companies granted us permission to take water and some sediment samples from their sites:

Alberta Power Limited

Cape Breton Development Corporation

Edmonton Power

Luscar Ltd.

Manalta Coal Ltd. / Prairie Coal Ltd. Mines

Manitoba Hydro

NB Coal Limited

New Brunswick Power Corporation

Nova Scotia Power

Ontario Hydro

Quinsam Coal Corporation

SaskPower

Smoky River Coal Limited

TransAlta

The survey is thus far from complete for all Canadian sites.

SAMPLING PROTOCOLS

Most field trips took place in the fall of 1996 although the last samples were not taken until spring 1997.

<u>Basic Protocol</u>:

At each sampling locality (a mine or a generating station), we assume there are at least 3 relevant sampling sites: water intake such as upstream of a river, water discharge after the intake has gone through all necessary processes, and water at the tailing/disposal site such as downstream or pond. Additional samples such as those from settling lagoons, nearby lakes and rivers are also included if available.

Bottle washing:

All containers were washed as follows: rinse with hot tap water and empty well; soak with 30% nitric acid for at least one week; rinse with MQW six times; soak with 0.2% nitric acid (high purity) for a minimum of one week before use. Sub-boiled Seastar acid was used to preserve samples.

Water sampling:

Van Dorn bottles were used whenever possible; if a site was not amenable to the Van Dorn bottle, a “scoop” technique was used, where a "sampling bottle" (250 ml bottle) was scooped to an arm-length depth under water surface. A "sampling bottle" was rinsed three times with actual sample first before it was filled up to top. Followed were standard precautions such as: avoid touching the bottle rim throughout sample collection and handling; tighten bottle caps tightly to avoid cross contamination due to possible leakage during transportation; bag blanks separately from samples; store samples in ice chest immediately; collect sediments last and bag them completely separated from water samples.

Sediment sampling:

Some selected sites were chosen for sediment collection. A mini ponar sampler (1-2L) or an Eckman sampler was used to collect sediment samples. All containers, bags, spoons, and other utensils used were in plastic.

Collection of Blanks and Duplicate Samples:

The following protocol was used to collect blanks and duplicates.

Collection of the Blank Before using Van Dorn bottle: 1) Onsite and just before collecting the first upstream water sample, rinse the Van Dorn bottle very well with 1 litre of ultrapure water poured from the large container (marked MQW) into the marked "intermediate MQW bottle". Collect the last part of the rinsing water into a small bottle marked Blank Before. 2) Then collect the upstream water sample in duplicate, by rinsing then filling two separate small bottles to the rim.

Collection of the Blank After: right after collecting the duplicate upstream samples, rinse the Van Dorn bottle with one litre of ultrapure water and follows the rest of step 1) and label the sample bottle Blank After.

If the "scooping" technique was used (instead of Van Dorn), the collection of the Blank Before/Scoop is as follows: 1) on site and just before collecting the first upstream water sample, rinse and shake well the 250 ml bottle ("sampling bottle") 3 times with about 20-30 ml of ultrapure water each time and save the 4th rinse as blank before; 2) collect the upstream water sample in duplicate, by scooping the 250 ml bottle into an arm-length depth and by rinsing then filling two separate small bottles to the rim.

Collection of the <u>Blank After/Scoop</u> is as follows: right after collecting the duplicate upstream samples, repeat step 1) to obtain the blank after.

If called for, collect surface sediment samples (after water collection) from the same upstream site. Likewise for the discharge and downstream samples, the collection process is repeated as above, but no blank sample should be collected.

<u>Separate bagging</u>:

Samples for blanks, upstream, discharge, downstream, and sediment were to be bagged separately to avoid cross-contamination.

SAMPLE COLLECTION, HANDLING, AND PRESERVATION

We adhered as closely as possible to the planned protocols / sampling strategies of collecting the samples. Interesting sites were encountered and recorded, and some are illustrated in text between the numbered Tables and Figures.

A sample with the marked "u/s" refers to sample collected upstream of a water system such as a river, and "d/s" refers to downstream; "dup1" and "dup2" refer to duplicate sample #1 and duplicate sample #2. Duplicate samples were treated like other samples but not every duplicate sample collected was analyzed as it was deemed unnecessary.

Samples were refrigerated immediately in an ice chest and so maintained through collection and transportation. When in our laboratory, the samples were let settle in a 4°C room overnight or over the weekend. The clear samples i.e. those without visible particulates are preserved by acidifying the whole bottle content to 0.2 % HNO_3. From the samples with visible particulates settled at the bottom of the bottle, twenty milliliters of the clear upper layer was pipetted (called decantate) into a clean container and preserved at 0.2 % HNO_3. The samples with suspended materials were centrifuged and the decantate acidified. With samples in-between, i. e. those which may be cloudy due to suspension or naturally colored due to humic substances, both decantation and centrifugation were performed and acidified accordingly. Samples with high salt content as evidenced by severe signal suppression were diluted 10 times or more until the suppressive effect was manageable.

Saskatchewan samples were kindly provided by Saskatchewan Environment (see acknowledgment), and were handled and treated as other samples.

ANALYTICAL METHODS

Thallium was directly determined by a Laser-Excited Atomic Fluorescence Spectrometric method recently developed[10] where only 3 to 10 μL of samples were used. A 6 kHz repetition rate of a copper vapor laser was used. The 511 nm line was used to optically pump a Rhodamine 575 dye laser. The dye laser output of 554 nm was then frequency-doubled by a second harmonic generator to give the 277 nm. The fluorescence light (353 nm) emitted by the excited atoms was amplified, collected and interpreted. The accuracy and precision of the method have been reported using certified reference materials and spike recoveries. Detection limits of 0.03 ng/L of Tl (0.6 fg) was achieved[10]. Duplicate analysis was carried out for every sample. Thallium results were generated using an *in situ* known addition technique[11]. Samples with very pronounced suppression were diluted until they became analyzable.

The measurement of pH was randomly made to give an idea of the sample acidity using a Sentron model 2001 pH system. Samples were also selectively analyzed for trace metals, using an ICP-AES system, to give an idea of metal concentration in those samples found to contain high thallium content.

RESULTS AND DISCUSSION

The majority of results for the generating stations in western provinces are low (Table 4). The blanks values for the blanks/before and the blanks/after are low (0 - 6 ppt) and are considered acceptable considering the fact that there were no special precautions taken during field trips which were one or two week long. For example clean room practices such as the use of clean hood, special clothes or gloves were not utilized as it was deemed unnecessary. The results for discharge water, ash lagoon, ash slurry or downstream are higher than other locations but even the highest results – 97 ppt for Long Creek below Boundary Dam Reservoir, or 140-150 ppt for Keephills ash lagoon slurry – are low when compared to the high results of some sites to be discussed below. These low concentrations should not reflect Tl loss even though the samples were not immediately acidified, because thallium in natural waters exists predominantly as monovalent species and as such behave more like potassium species and do not require to be preserved as urgently as divalent species such as mercury, lead and cadmium for example.

Table 5 shows thallium results in western coal mine waters. Samples with brown - black deposit and brown decantate such as those from Highvale and Paintearth mines tend to have higher Tl concentrations than other samples. For sample numbers 37, 38 and 41 (Highvale), centrifugation did not help bring down Tl concentration of the decantates, if anything there was an increase in concentrations. So it appears that decantation (careful pipetting of 20 ml of the solution above the deposit) is fairly representative of the water samples. Also samples from settling pond, pit water, downstream and discharge usually have concentrations (1100 - 1300 ppt) higher than those from upstream's or water intake's (low ppt).

Samples collected from the eastern power plants sites in New Brunswick and Nova Scotia generally contain higher Tl content than the western or central counterparts. For example the ash lagoon discharges of Grand Lake power plant and Trenton power plant contain some 12 ppb and 24 ppb of Tl, respectively, which are much higher than the western discharges (Table 6). The other generating stations such as Belledune, Lingan, Point Aconi and Point Tupper also have elevated concentrations of Tl up to 5 ppb. These levels could be the result of the local geological contribution in the eastern provinces, or the type of coal used. Belledune generating station for example reportedly has been using 75% Columbian coal and 25% Salmon Harbor coal.

Even though the Great Lakes are surrounded by the biggest consumers of coal used in coal - fired generating stations in both USA (Figure 3) and Canada (Table 7), the concentration of Tl in Great Lakes waters[3] are much smaller than those found in waters from the eastern generating stations (Table 6). Also the numerous power plant and mine sites in western and central Canada contain relatively smaller amount of Tl than the eastern counterparts. These two facts tend to indicate that it is not the amount but the type of coal and/or the local geochemical contributions that caused some of the higher Tl concentrations observed in the eastern provinces. Chou and Uthe[12] in 1995 have observed high Tl content in the Belledune Harbor although the source of Tl is obscure, though they suspected the nearby fertilizer plant, the lead smelter as well as the power plant were the sources of thallium. Also Zitko et. al.[13] reported very high Tl concentrations in South Tomogonops River, Little River and South Little River within North Eastern New Brunswick. South Tomogonops and South Little River received discharges from base-metal mining operations. Wong[14] has found some very high Tl content in the regional sediment samples such as those from Upsalquitch Lake.

A study as to the source and toxicology of thallium in the region may be needed. For example a literature search on the geochemical contributions and toxicological data through New Brunswick and Nova Scotia areas should provide additional background information. Combining these with our data, a detailed follow-up study, if called for, can be effectively designed and carried out.

The eastern mines, including the abandoned ones, show some fairly high concentrations (Table 8). Although these results are not as high as those observed in the eastern power plant sites, they may have emanated from the same Tl source as discussed above.

Table 9 shows the results of heavy metals including thallium generated by ICP on selected samples from several mines and power plants. Thallium could not be detected by

ICP due to lack of sensitivity so their results show all "less than values". Likewise, the majority of heavy metals are "less than values" except iron and manganese which show some very high results up to 70 ppm iron and up to 55 ppm for Mn. Also there are some greater than detection limit results for example samples for pit drain (sample 37), settling pond (sample 41), or discharge (sample 87). A detailed interpretation based on so numerous less than values was not attempted.

CONCLUDING REMARKS AND RECOMMENDATION

The sites from eastern coal-fired electrical generating stations have higher thallium concentrations than the western and central counterparts as well as coal mines. Data seem to indicate that it is not the amount but the type of coal and/or the local geochemical contributions that are amenable to some of the very high Tl concentrations observed in the eastern provinces. As an extension of the present study, it is recommended that a brief literature survey on the regional geochemistry, geology and toxicological implications be made, which could prove sufficient to complement our data and to arrive at definitive conclusions as to the sources and health concerns of thallium.

Even though some very high levels of Tl were found in this study, very low ones were also found in these industrial sites (Table 4-6, and Table 8). Comparison of these low level Tl data to those found in other ecosystems such as the Antarctic[15], the Arctic[16], the Great Lakes[3], distilled water[17], suggests a very low natural baseline level of Tl in the neighborhood of 0.1 ppt (probably below 0.1).

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→ Manalta Coal Limited: Bernd Martens and associates;

→ Manitoba Hydro

⇒ NB Coal Limited: Andy Cormier and associates;

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→ Ontario Hydro: Dianne Barker and associates;

→ Prairie Coal Limited samples were collected by Chuck Bosgoed as acknowledged above;

→ Quinsam Coal Corporation: George Vooro and Jack Hann. The samples were collected by Ted Cockett as acknowledged above;

→ SaskPower: Robert Stedwill and associates;

→ Smoky River Limited: Vernon Betts and associates;

→ TransAlta Utilities Corporaton: George Blondeau, Mike Leaist and associates.

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Table 1. List of Generating Stations by province

Alberta	Owner
Sundance	TransAlta Utilities Corporation
Wabamun	"
Keephills	"
Battle River	Alberta Power Ltd.
H. R. Milner	"
Sheerness	" + TransAlta Utilities Corporation
Genesee	Edmonton Power

Ontario	Owner
Nanticoke	Ontario Hydro
Lakeview	"
Lambton	"
Thunder Bay	"
Atikokan	"

Saskatchewan	Owner
Boundary Dam	Saskpower
Poplar River	"
Shand	"

New Brunswick	Owner
Belledune	N. B. Power
Dalhousie	"
Grand Lake	"

Manitoba	Owner
Brandon	Manitoba Hydro
Selkirk	"

Nova Scotia	Owner
Lingan	N. S. Power
Glace Bay	"
Point Alconi	"
Trenton	"
Point Tupper	"

Table 2. List of active coal mines (as of 1994) by province

British Columbia	Owner
Quinsam	Quinsam Coal Corp.
Bullmoose	Teck Corporation
Quintette	Teck Corporation
Fording River	Fording Coal Ltd.
Greenhills	Fording Coal Ltd.
Line Creek	Line Creek Resources Ltd.
Elkview	Teck Corporation
Coal Mountain	Fording Coal Ltd.

Saskatchewan	Owner
Poplar River	Manalta Coal Ltd.
Utility	SaskPower
Boundary Dam	Luscar Ltd.
Costello	Manalta Coal Ltd.
Shand	Luscar Ltd.
Bienfait	Luscar Ltd.

Alberta	Owner
Smokey River	Smokey River Coal Ltd.
Obed	Luscar Ltd.
Highvale	TransAlta Utilities Corporation
Whitewood	TransAlta Utilities Corporation
Luscar	Luscar Ltd.
Gregg River	Manalta Coal Ltd.
Coal Valley	Luscar Ltd.
Genesee	Edmonton Power & Fording Coal Ltd
Vesta	Alberta Power Ltd.
Paintearth	Luscar Ltd.
Montgomery	Manalta Coal Ltd.
Sheerness	Luscar Ltd.

New Brunswick	Owner
N. B. Coal	N. B. Coal Ltd.

Nova Scotia	Owner
Prince	Cape Breton Development Corp
Phalen	Cape Breton Development Corp

Table 3. List of Abandoned Coal Mines (existed in 1970)

British Columbia
East Kootenay

Alberta
Pembina
Caster
Drumhelles - Sheerness
Edmonton
Crowsnest
Mountain Park
Cascade

Saskatchewan
Estevan

Nova Scotia
Sidney - Inverness
Pictou
Cumberland

Table 4. Thallium Concentrations in Waters Collected from Western Generating Stations
(G S = Coal-fired Electrical Generating Sation)

Western GSs	Site / Sample Description	Sample Identificaton	pH	ppt of Tl
Wabamun G S (TransAlta Utility Corporation)	Intake Water (clear)	1 dup1		0.15
	" duplicate	1 dup2		0.61
	Blank before (clear)	2 Blk be		0.9
	Blank after (clear)	2 Blk aft		0.05
	Ash Lagoon Effluent (clear)	3 dup 1		5.87
	" duplicate	3 dup 2		4.57
	Ash slurry (some black deposit, clear decantate), decanted	4 Decanted	8.3	8.44
	" duplicate, centrifuged	4 Centrifuged		11.44
	Discharge Water (clear)	5		2.53
Wabamun Lake	At Wabamun d/s Wabamun GS (clear)	6		1.78
Sundance G S (TransAlta Utility Corporation)	North Saskatchewan River Intake (clear)	7 dup1		2.27
	" duplicate	7 dup2		2.01
	Blank before (clear)	8 Blk be		1.02
	Blank after (clear)	8 Blk aft		0.27
	Pond discharge (clear)	9		5.83
Keephills GS (TransAlta Utility Corporation)	River Make Up (clear)	10 dup1		1.4
	" duplicate	10 dup2		3.29
	Blank (clear)	10 Blk be		0.04
	Cooling Pond Discharge (clear)	11 dup1		4.32
	" duplicate	11 dup2		4.36
	Ash Recirculation Water (clear)	12		8.46
	Ash Lagoon Slurry (some black deposit, clear decantate), decanted	13 dup1 decanted	9.8	140.21
	" duplicate	13 dup2 decanted		150.57
Genesee GS (Edmonton Power)	Intake Water (clear)	14 dup1		7.27
	" duplicate	14 dup2		7.06
	Blank before (clear)	15 Blk be		3.97
	Blank after (clear)	15 Blk aft		1.32
	Discharge Water (clear)	16 dup1		15.14
	" duplicate	16 dup2		12.42
North Saskatchewan River	d/s Keephills and Sundance G.S. (clear)	17 dup1		15.14
H.R. Milner GS (Alberta Power Ltd)	Waste Water - Discharge (visible particulates, clear decantate), decanted	18 dup1 Decantate	6.6	9.25
	Smoky River Intake (clear)	19 dup1		1.15
	Final Discharge (visible particulates, clear light br. decantate), decanted	20 dup1 Decantate	7.6	4.09
	" duplicate	20 dup 2 Decantate		6.9
	" duplicate, centrifuged	20 dup1 Centrifuged		2.26
H.R. Milner GS	Smoky River d/s Discharge (clear)	21		2.69

Table 4. continued

Western GSs	Site / Sample Description	Sample Identificaton	pH	ppt of Tl
Smoky River	u/s Sheep Creek (clear)	22 dup1		3.17
	" duplicate	22 dup2		2.89
	u/s H.R. Milner G.S. at Hwy. 40 (clear)	23 dup1		1.89
	" duplicate	23 dup2		3.4
	Blank before (clear)	24 Blk be		0.03
	Blank after (clear)	24 Blk aft		0.01
Sheerness GS (Alberta Power Ltd)	Intake Water (visible particulates, clear decantate), decanted	25 dup1 Decantate	7.7	5.13
	Discharge Water (visible particulates, clear decantate), decanted	26 dup1 Decantate	7.3	8.30
	" duplicate, decanted	26 dup2 Decantate		8.65
	" duplicate, centrifuged	26 dup1 Centrifuged		17.54
	" duplicate, centrifuged	26 dup2 Centrifuged		8.41
	Cooling Water Lagoon (clear)	27 dup1		9.47
	" duplicate	27 dup2		6.43
Battle River GS (Alberta Power Ltd)	Battle River u/s (visible particulates, clear decantate), decanted	28 Dup 1 Decantate	7.2	7.87
	" duplicate, decantated	28 Dup 2 Decantate	7.2	7.11
	Intake Water (visible particulates, clear decantate), decanted	29 Dup 1 Decantate	7.3	1.81
	Ash Lagoon - Input (some black deposit, clear decantate), decanted	30 Decantate	7.5	37.86
	Ash Lagoon - Discharge (some dark deposit, clear decantate), decanted	31 Decantate	7.4	18.63
	Discharge Water (visible particulates, clear decantate), decanted	32 Dup 1 Decantate	7.3	6.64
	" duplicate, decanted	32 Dup 2 Decantate	7.3	2.62
	Spillway d/s (visible particulates, clear decantate), decanted	33 Dup 1 Decantate	7.3	14.12
	Battle River d/s (clear)	34 Dup 1		3.53
	" duplicate	34 Dup 2		6.68
	Blank before (clear)	35 Blk be		2.46
	Blank after (clear)	35 Blk aft		5.78
Boundary Dam GS (Saskpower)	Spoil Pond 5-5 (SERM Station no. 72579) (clear)	S9		36.15
	Spoil Pond 32-5 (SERM Station no. 72524) (clear)	S10		30.51
	Long Creek inlet (BDC1 - SERM208)- u/s Boundary Dam Reservoir (clear)	S11		3.12
	Cooling Water inlet (BDC2 - SERM72506) (clear)	S12		21.48
	Cooling Water Discharge Canal: Return to Reservoir (BDC1 - SERM44886) (clear)	S13		24.7
	Long Creek below Boundary Dam Reservoir (BDC3 - SERM235) (clear)	S14		97.45
	u/s Souris River near Boundary Dam GS (clear)	S27		4.48
	", duplicate (clear)	S28		2.98
	", Blank before (clear)	S29 Blk be		0.04
	", Blank after (clear)	S30 Blk aft		0.11
	d/s Souris River @ Nopney's crossing	S26		1.54

Table 4. continued

Western GSs	Site / Sample Description	Sample Identificaton	pH	ppt of Tl
Poplar River GS (Saskpower)	Auxilary Cooling Water (ACW) canal discharging to Cookson Reservoir	S1		0.19
	d/s East Poplar River (SERM 541)	S2		5.21
Shand GS (Zero discharge plant) (Saskpower)	Raw water sample	S15		35.7
Estevan GS (inactive) (Saskpower)	Discharge into drainage ditch no. 7	S16		65.04
	Ash lagoon no. 5 (SE corner)	S17		6.32
Selkirk GS (Manitoba Hydro)	Red River Intake	M1		16.52
	Well Intake	M2		15.67
	Selkirk Discharge	M3		63.90

Notes:

"Decanted" refers to 20ml pipetted from the top of bottle, which has been let settle in the cold room for overnight or longer

"Centrifuged" refers to sample being centrifuged as compared to decanted

"Visible particulates" are particulates at bottom of bottle

d/s = downstream

u/s = upstream

Blk be = Blank before

Blk aft = Blank after

dup 1 = duplicate sample no.1; dup 2 = duplicate sample no. 2

Table 5. Thallium Concentrations in Waters Collected from Western Coal Mines

Western Mines	Site / Sample Description	Sample Identificaton	pH	ppt of Tl
Whitewood Mine (TransAlta Utility Corp)	Pit Water Discharge (some black deposit, clear decantate), decanted	36 Decantate	7.7	6.64
Highvale Mine (Manalta Coal)	Pit 2 Drain (brown deposit, ~ clear dark brown decantate), decanted	37 Decantate	8.3	463.6
	" duplicate, centrifuged	37 Centrifuged		518.5
	Pit 3 (some brown deposit, ~ clear dark brown decantate), decanted	38 Decantate	8.7	106.9
	" duplicate, centrifuged	38 Centrifuged		109.3
	Beaver Creek (clear)	39		2.92
	Pit 3 Settling Pond - Outflow (clear)	40		0.32
	Pit 3 Settling Pond - Inflow (black deposit, clear d br decantate), decanted	41 Decantate	8.5	846.1
	" duplicate, centrifuged	41Centrifuged		1326.2
	Well Water (local groundwater) (vis partics, clear decantate), decanted	42 Decantate	8.0	5.47
Genesee Mine	Mine Drainage (some brown deposit, clear decantate), decanted	43 Dup 1 Decantate	8.1	7.52
Coal Valley Mine Luscar - Sterco (Luscar Ltd)	Tailings Discharge (vis particulates, clear decantate), decanted	44 Dup 1 Decantate	8.2	7.2
	Lovett River Intake (clear)	45 Dup 1		2.82
	" duplicate	45 Dup 2		2.43
	Blank before (clear)	46 Blk be		0.85
	Blank after (clear)	46 Blk aft		0.35
	Coal Creek Impoundment (clear)	47		2.7
	Lovett River d/s (clear)	48 Dup 1		8.64
	" duplicate	48 Dup 2		4.21
	25 ? East mine drain (vis particulates, clear decantate), decanted	49 Decantate	8.3	16.39
	Centre Creek (treated water) (clear)	50		16.59
	Reservoir (well water) (clear)	51		1.74
Gregg River Mine (Manalta Coal)	HI Pit - Plant make up (clear)	52 Dup 1	7.5	16.25
	Plant Site Water Reservoir (clear)	53		63.87
	Refuse = Tailings (Black coal-like deposit, clear decantate !), decanted	54 Dup 1 Decantate	7.6	9.49
	Well Water - tap (clear)	55 Dup 1	7.5	3.67
Cardinal River Mine (Luscar Ltd)	West Jarvis Creek Intake (clear)	56 Dup 1	7.6	4.13
	Blank before (clear)	57 Blk be		0.28
	Blank after (clear)	57 Blk aft		0.07
	Luscar Creek d/s Plant (vis particulates, clear decantate)	58 Dup 1 Decantate	8.2	6.54
	" duplicate, decanted	58 Dup 2 Decantate		5.92
Cardinal River Mine (Luscar Ltd)	Tailings (Black coal-like deposit, clear decantate), decanted	59 Dup 1 Decantate	7.5	17.06
	Well Water (clear)	60 Dup 1	8.0	1.46
	Luscar Creek, d/s Cardinal & Gregg Mines (clear)	61 Dup 1	7.5	3.56
Whitehorse Creek	At Mountain Park (clear)	62 Dup 1	7.6	1.78
	d/s Mountain Park (clear)	63		1.33
	d/s Cadomin (abandoned, but active quarry) (clear)	64		2.39

Table 5. Continued

Western Mines	Site / Sample Description	Sample Identificaton	pH	ppt of Tl
Gregg River	d/s Gregg River Mine (at Hwy 40) (clear)	65		2.59
Obed Mountain Coal (Luscar Ltd)	E. Conveyor Settling Pond (vis particulates, clear decantate), decanted	66 Dup 1 Decantate	8.0	3.61
	Main Tailings Pond (Lower) (vis particulates, clear decantate), decanted	67 Dup 1 Decantate	8.0	0.91
	Reservoir (treated water) (vis particulates, clear decantate), decanted	68 Decantate	8.1	7.97
	Main Tailings Pond (Upper) (dark brown deposit, clear decantate), decanted	69 Dup 1 Decantate	8.0	2.24
	" duplicate, decanted	69 Dup 2 Decantate		2.95
	LSP2 - Coal Storage Drain (for rail shipment) (clear)	70		19.1
Smoky River Coal ((Smoky River Coal)	Sheep Creek u/s Smoky River (clear)	71		2.42
Line Creek Mine (Manalta Coal)	Settling Pond Discharge MSA North Ponds (clear)	72 Dup 1	7.5	5.26
	Line Creek u/s - 0200335 (clear)	73 Dup 1		0.66
	" duplicate	73 Dup 2		0.2
	Blank before	74 Blk be		0
	Blank after	74 Blk aft		0
	South Pit Water (dark brown deposit, clear decantate), decanted	75 Decantate	7.8	217.38
	Line Creek d/s (clear)	76 Dup 1		6.92
	" duplicate	76 Dup 2		5.37
	Wash Water after Thickener (vis particulates, clear decantate), decanted	77 Decantate	7.6	38.54
	Tap Water Not Treated (clear)	78		9.07
Elk River	At Sparwood d/s from four mines (clear)	79 Dup 1	7.6	2.51
Crowsnest Creek	Crowsnest Pass (d/s coal mountain mine) (clear)	80 Dup 1	7.5	9.09
Sheerness Mine (Luscar Ltd)	Pit Water (visible particulates, light decantate), decanted	81 Dup 1 Decantate	8.2	10.58
Montgomery Mine (Manalta Coal)	Pit Water (visible particulates, light decantate), decanted	82 Dup 1 Decantate	7.9	1.84
	Settling Pond Discharge (visible particulates, light decantate), decanted	83 Dup 1 Decantate	7.8	4.55
Carolside Reservoir	d/s mines and G.S.'s (visible particulates, light decantate), decanted	84 Dup 1 Decantate	7.7	4.19
Paintearth Mine (Luscar Ltd)	Surface Runoff Discharge (very brown, brown decantate), decanted	85 Dup 1 Decantate	7.9	811.21
	Section 7 Lake (pit & surface runoff) (d. brown, light brown decantate), decanted	86 Dup 1 Decantate	7.5	63.02
	Impoundment #5 Discharge (black deposit, v. brown decantate), decanted	87 Decantate	7.6	1119.05
	Paintearth Creek d/s (Very brown deposit, light brown decantate), decanted	88 Dup 1 Decantate	7.1	257.33
	Paintearth Creek u/s (Brown deposit, very light brown decantate), decanted	89 Dup 1 Decantate	7.7	35.71
	Blank before	90 Blk be		0.73
	Blank after	90 Blk aft		0.93
Vesta Mine (Manalta Coal)	North Drainage (Brown deposit, very light brown decantate), decanted	91 Dup 1 Decantate	7.6	53.53
	Vesta East - Pond 3 (Brown deposit, clear decantate), decanted	92 Dup 1 Decantate	7.7	51.68

Table 5. Continued

Western Mines	Site / Sample Description	Sample Identificaton	pH	ppt of Tl
Crowsnest River (Chinook coal) (Manalta Coal)	u/s Chinook Coal PlantColeman, Alberta (clear)	93 Dup 1		4.29
	(decommissioned in 1978) (clear)	93 Dup 2		4.72
	Blank before (clear)	94 Blk be		0.14
	Blank after (clear)	94 Blk aft		0.72
	d/s Chinook Coal Plant (clear)	95 Dup 1		3.96
	" duplicate	95 Dup 2		4.72
	d/s Coleman & Frank Slide (clear)	96		5.07
	d/s Leitch Colliery (clear)	97 Dup 1	7.9	2.95
Hell's Gate	Groundwater (clear)	98		2.58
Athabasca River	Hwy. 93 South of Jasper (clear)	99		1.03
Poplar River North Mine (Prairie Coal Ltd.)	Settling Pond NSP1 (clear)	S3		2.81
	u/s East Poplar River (clear)	S4		0.92
	" duplicate	S5		1.19
	East Poplar River - Upstream Blank (clear)	S6 Blk		0
	" duplicate	S7 Blk		0
	East Poplar River - Downstream (clear)	S8		3.79
Utility Mine (Prairie Coal Ltd.	Settling Pond E-4	S18		34.86
	Pond near coal storage pile	S19		6.86
	Dewatering Discharge into BD Reservoir	S20		8.05
Boundary Dam Mine (Estervan Coal Corporation)	Settling Pond / Holding Pond	S23		17.65
Bienfait Mine (Estervan Coal Corporation)	Dewatering Discharge from west side of mine	S24		50.65
	Discharge from Mine areas of section 4-2-6-W2M (V-notch weir)	S25		12.83
Costello Mine Expansion (Prairie Coal Ltd)	Dewatering Discharge from proposed mine	S22		1.26
Old Mac Mine - abandoned	Old Coal Spoil Pond (Old Mac Mine)	S21		0.31
Quinsam Mine (Quinsam Coal Corporation)	Blank before (clear)	Q1 Blk be	4.2	1.13
	Blank after (clear)	Q2 Blk aft	3.2	0.19
	on Quinsam River flowing towards mine (clear)	Q3	6.7	0.14
	" duplicate	Q4	6.8	0.68
	Settling pond (clear)	Q5	7.7	5.69
	" duplicate	Q6	7.7	6.27
	d/s from the mine on Quinsam river before going into the small lake (clear)	Q7	6.7	0.35
	" duplicate	Q8	6.6	0.53
	d/s outlet of the small lake (clear)	Q9	6.8	1.47
	" duplicate	Q10	6.8	1.07

Table 5. Continued

Notes:
"Decanted" refers to 20ml pipetted from the top of bottle, which has been let settle in the cold room for overnight or longer
"Centrifuged" refers to sample being centrifuged as compared to decanted
"Visible particulates" are particulates at bottom of bottle
d/s = downstream
u/s = upstream
Blk be = Blank before
Blk aft = Blank after
dup 1 = duplicate sample no. 1; dup 2 = duplicate sample no. 2

Table 6. Thallium Concentrations in Waters Collected from Eastern and Ontario Generating Stations
(G S = Coal-fired Electrical Generating Sation)

Eastern and Ontario GS	Site / Sample Description	Sample Identificaton	pH	ppt of Tl
*Belldune G.S. (NB Power)	Coal Pile Runoff (Brown - black deposit, clear decantate), decanted	100 Decantate	3.5	744.1
	Equalization Pit (plant waters) (dark deposit, clear decantate), decanted	101 (high salt ?) Decantate	6.4	2376.6
	Treated Discharge (visible particulates, clear decantate), decanted	102 ((high salt ?) Decantate	8.2	4000.5
	Ash Leachate Pond Discharge (clear)	103 ((high salt ?)		5087.1
Grand Lake GS (NB Power)	Ash Lagoon Discharge (clear)	104 Dup 1 (high salt ?)		11989
	" duplicate	104 Dup 2 (high salt ?)		11453
	Lake (visible particulates, clear decantate), decanted	105 Dup 1 Decantate	6.6	159.1
	Intake Water (visible particulates, clear decantate), decanted	106 Dup 1 Decantate	6.8	25.4
	" duplicate, decanted	106 Dup 2 Decantate		23.3
	Blank before (clear)	107 Blk be		3.9
	Blank after (clear)	107 Blk aft		1.27
Lingan GS (NS Power)	Ash Lagoon Return (visible particulates, clear decantate), decanted	108 Dup 1 (high salt ?) Decantate	6.8	4426.1
	Waste Water Discharge to Lagoon (black deposit, clear decantate), decanted	109 Dup 1 Decantate	12.6	885.4
	Pretreatment Waste Water (vis black deposit, clear decantate), decanted	110 Dup 1 (high salt ?) Decantate	7.4	2660.0
	Coal Pile Runoff (visible particulates, clear yellowish decantate), decanted	111 Dup 1 Decantate	2.6	417.5
Point Aconi GS (NS Power)	Ash Leachate Pond Discharge (pH 12) (clear)	112 (high salt ?)		398.1
	Coal Pile Runoff (visible particulates, clear brownish decantate), decanted	113 (high salt ?) Decantate	3.9	569.2
	Waste Water Discharge (Lingan sample #96-150) (clear)	114 Dup 1		558
	Well Water (Intake water) (clear)	115		0.53
Point Tupper GS (NS Power)	Waste Water - pretreatment (visible particulates, clear decantate), decanted	116 Dup 1 Decantate	12.5	33.7
	Coal Berm Runoff Pond (brown - yellow clear, clear decantate), decanted	117 Dup 1 Decantate	2.5	212.1
	Final Wastewater Discharge - treated (clear)	118 Dup 1	8.1	373.6
	Landrie Lake Water (visible particulates, clear decantate), decanted	119 Decantate	6.9	1.94
	Ash Leachate Pond Discharge (clear)	120	4.0	1034.6
Trenton GS (NS Power)	Coal Leachate Pond (visible particulates, clear decantate), decanted	121 Dup 1 (high salt ?) Decantate	7.0	1076.0
	Ash Lagoon Discharge (clear)	122 Dup 2 (high salt ?)	7.2	23605
	Intake Water (treated town water) (clear)	123		0.86
	Pit B Discharge (previously collected by Trenton) (clear)	124		982.0
	Blank after (clear)	125 Blk aft		2.72
Lambton Hydro GS (Ontario Hydro)	Coal Pile Runoff Creek @ Sarnia	300 dup1		55.63
	" duplicate	301dup2		70.29
	Water Intake channel @ Sarnia	302 dup1		3.18
	" duplicate	303 dup2		3.18

Table 6. Continued

Eastern and Ontario GS	Site / Sample Description	Sample Identificaton	pH	ppt of Tl
Lakewiew GS (Ontario Hydro)	Intake Channel @Toronto	304		6.06
	North Coal Runoff Pond	305		112.05
	Blank @Toronto	306 Blk		0.00
	Ash Lagoon Filtration Effluent @Toronto	307		175.26
Nanticoke GS (Ontario Hydro)	Outfall Channel	308		18.15
	Intake Channel	309		11.76
	Ash Lagoon	310		41.47
	Coal Pile Runoff Pond	311		50.07
Antikokan GS (Ontario Hydro)	Intake line	312		1.25
	Discharge/Sn. Lake	313		28.14
Thunder Bay GS (Ontario Hydro)	Intake canal	314		7.16
	Discharge canal	315		14.03
	d/s Mission River	316		9.39

Notes:
* Belledune GS uses 75% Columbian coal and 25% Salmon Harbor Mine coal
"Decanted" refers to 20ml pipetted from the top of bottle, which has been let settle in the cold room for overnight or longer
"Visible particulates" are particulates at bottom of bottle
Blk be = Blank before
Blk aft = Blank after
(high salt ?) = probably the sample contains high salt content as it has to be diluted numerous times to be analyzable.
Particulates in decantate may result in very high results if decantate is not diluted; filtration or digestion may be needed for more accurate results if dilution is not done.
dup 1 = duplicate sample no.1; dup 2 = duplicate sample no. 2

Table 7. Canadian Coal-based Electrical Generation Capacity, megawatts

G Stations	Owner	Total Capacity, MW
Sundance	TransAlta Utilities Corp.	1987
Wabamun	TransAlta Utilities Corp.	569
Keephills	TransAlta Utilities Corp.	754
Battle River	Alberta Power Ltd.	735
H. R. Milner	Alberta Power Ltd.	140
Sheerness	Alberta Power Ltd. and TransAlta Utilities Corp.	766
Genesee	Edmonton Power	400
Boundary Dam	SaskPower	875
Poplar River	SaskPower	592
Shand	SaskPower	272
Brandon	Manitoba Hydro	237
Selkirk	Manitoba Hydro	132
Thunder Bay	Ontario Hydro	423
Nanticoke	Ontario Hydro	**4096**
Lakeview	Ontario Hydro	**2400**
Lambton	Ontario Hydro	**2040**
Atikokan	Ontario Hydro	230
Belledune	N. B. Power	440
Dalhousie	N. B. Power	286
Grand Lake	N. B. Power	82
Lingan	Nova Scotia Power	602
Glace Bay	Nova Scotia Power	116
Trenton	Nova Scotia Power	350
Point Aconi	Nova Scotia Power	165
Point Tupper	Nova Scotia Power	150

7,~~090~~ 459 MW

9,189 MW

2,191 MW

Table 8. Thallium Concentrations in Waters Collected from Eastern Coal Mines

Eastern Mines	Site / Sample Description	Sample Identificaton	pH	ppt of Tl
8200 Salmon Harbour Mine (NB Coal)	Pit Water (visible particulates, clear decantate), decanted	126 Dup 1 Decantate	8.1	53.25
	" duplicate, decanted	126 Dup 2 Decantate		35.15
	Lagoon Discharge (visible particulates, clear decantate), decanted	127 Dup 1 Decantate	7.4	9.33
	" duplicate, decanted	127 Dup 2 Decantate		6.55
	Lake Water (visible particulates, clear decantate), decanted	128 Dup 1 Decantate	7.3	7.72
	" duplicate, decanted	128 Dup 2 Decantate		7.43
	Blank before (clear)	129 Blk be		2.19
	Blank after (clear)	129 Blk aft		4.22
Phalen Colliery, NS (Cape Breton Developmt Corp)	Mine Water Discharge (high Na) (brown clear decantate), decanted	130 Dup 1 (high salt ?) Decantate	7.0	424.0
	Town Water (from tap at security) (clear)	131 Dup 1	7.1	4.13
	Surface Runoff Brook (visible particulates, clear decantate), decanted	132 Decantate	4.8	169.2
Victoria Junction Coal Preparation Plant, NS (Cape Breton Developmt Corp)	V.J. Tailings Basin Old Final Discharge KL1 (clear)	133 Dup 1	7.2	18.93
	V.J. Tailings Basin KL3 (clear)	134 Dup 1	7.6	1.47
	V.J. Final Discharge WWT3 (treated water) (clear)	135 Dup 1	6.9	121.1
	North and South Process Wells (for wash & town w) (clear)	136		0.64
	Surface water Pond WWT1 (brown, clear brown decantate), decanted	137 Decantate		404.3
Prince Colliery, NS (Cape Breton Developmt Corp)	Process Water (reservoir and well comnined) (clear)	138 Dup 1	8.1	1.95
	Mine Discharge and Coal Pile Runoff (light clear decantate), decanted	139 Dup 1 (high salt ?)	2.8	698.3
	Treated Lagoon Discharge (clear)	140 Dup 2 (high salt ?)	6.4	565.0
	d/s Discharge (clear)	141 Dup 1 (high salt ?)		552.5
	" duplicate	141 Dup 2 (high salt ?)		514.0
	Blank before (clear)	142 Blk be		2.77
	Blank after (clear)	142 Blk aft		2.86
Abandoned coal mines*:				
Gardiner Mine	Mine Discharge (clear brown decantate)	143 Dup 1	7.0	0.15
Pioneer Coal	at Sydney Airport	H1		100.9
"	" duplicate	H2		107.2
Brogan Brothers	at Pt. Aconi 5th seep	H3		83.8
"	at Pt. Aconi 11th seep	H4		76.5
Prince	at Edwards Pond	H5		660.6
"	" duplicate	H6		718.5

Notes:
"Decanted" refers to 20ml pipetted from the top of bottle, which has been let settle in the cold room for overnight or longer
"Centrifuged" refers to sample being centrifuged as compared to decanted
"Visible particulates" are particulates at bottom of bottle
d/s = downstream

Table 8. Continued

u/s = upstream
Blk be = Blank before
Blk aft = Blank after
(high salt ?) = probably the sample contains high salt content as it has to be diluted numerous times to be analyzable.
Particulates in decantate may result in very high results if decantate is not diluted; filtration or digestion may be needed for more accurate results if dilution is not done.
dup 1 = duplicate sample no.1; dup 2 = duplicate sample no. 2
* Samples H1 - H6 were thankfully subsampled by Mr. Henry Wong

Table 9. Trace Metal Concentrations (by ICP), mg/L, in Waters from Generating Sation and Mine Sites

GS and Mine	*Site / Sample Description	Sample Identificat	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Tl	Zn
Boundary Dam GS	Spoil Pond 5-5	S9	<.034	<.009	<.009	<0.01	1.46	0.067	<.020	<.025	<0.126	<.009
	Spoil Pond 32-5	S10	<.034	<.009	<.009	<0.01	0.507	0.02	<.020	<.025	<0.126	<.009
	Long Creek inlet	S11	<.034	<.009	<.009	<0.01	0.384	0.029	<.020	<.025	<0.126	<.009
	Cooling Water inlet	S12	<.034	0.012	<.009	<0.01	0.509	0.03	<.020	<.025	<0.126	<.009
	Cooling Water Discharge Canal	S13	<.034	<.009	<.009	<0.01	0.232	0.121	<.020	<.025	<0.126	<.009
	Long Creek below Boundary Dam	S14	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	d/s Souris River @ Nopney's	S26	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	u/s Souris River near Boundary	S27	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	", duplicate (clear)	S28	<.034	<.009	<.009	<0.01	0.017	<.002	<.020	<.025	<0.126	<.009
Keephills GS	River Make Up (clear)	10 dup1	<.034	0.014	<.009	<0.01	0.022	<.002	<.020	<.025	<0.126	<.009
	Cooling Pond Discharge (clear)	11 dup1	<.034	<.009	<.009	<0.01	<0.012	0.017	<.020	<.025	<0.126	<.009
	Ash Lagoon Slurry	13 dup1 decanted	<.034	<.009	0.491	<0.01	1.29	0.014	<.020	<.025	<0.126	<.009
	" duplicate	13 dup2 decanted	<.034	<.009	0.496	<0.01	1.39	0.009	<.020	<.025	<0.126	<.009
	Ash Lagoon Slurry	13 dup1 centrifuged	<.034	<.009	0.49	<0.01	0.242	<.002	<.020	<.025	<0.126	<.009
	" duplicate	13 dup2 centrifuged	<.034	<.009	0.491	<0.01	0.611	<.002	<.020	<.025	<0.126	<.009
Battle River GS	Battle River u/s	28 Dup 1 Decantate	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	Intake Water	29 Dup 1 Decantate	<.034	0.013	<.009	<0.01	<0.012	<.002	0.022	0.037	<0.126	<.009
	Ash Lagoon - Discharge	31 Decantate	<.034	0.012	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	Discharge Water	32 Dup 1 Decantate	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	Spillway d/s	33 Dup 1 Decantate	<.034	<.009	<.009	<0.01	0.047	0.013	<.020	<.025	<0.126	<.009
	Battle River d/s (clear)	34 Dup 1	<.034	<.009	<.009	<0.01	0.42	0.008	0.04	<.025	<0.126	<.009
	Blank before (clear)	35 Blk be	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	Blank after (clear)	35 Blk aft	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
Highvale Mine	Pit 2 Drain	37 Decantate	0.065	0.061	0.271	0.078	64.84	0.159	0.12	<.025	<0.126	0.62
	" duplicate, centrifuged	37 Centrifuged	<.034	0.03	0.244	0.065	69.95	0.149	0.113	<.025	<0.126	0.372
	Pit 3	38 Decantate	<.034	<.009	<.009	<0.01	2.63	<.002	<.020	0.045	<0.126	0.024
	" duplicate, centrifuged	38 Centrifuged	<.034	<.009	<.009	<0.01	2.11	<.002	<.020	0.04	<0.126	0.013
	Beaver Creek (clear)	39	<.034	<.009	<.009	<0.01	0.213	<.002	<.020	0.035	<0.126	<.009
	Pit 3 Settling Pond - Outflow	40	<.034	0.011	<.009	<0.01	<0.012	<.002	<.020	0.041	<0.126	<.009
	Pit 3 Settling Pond - Inflow	41 Decantate	<.034	0.025	0.03	0.073	40.28	0.281	0.093	<.025	<0.126	0.529
	" duplicate, centrifuged	41Centrifuged	<.034	0.019	0.026	0.069	35.87	0.266	0.095	<.025	<0.126	0.558
	Well Water (local groundwater)	42 Decantate	<.034	0.014	0.037	0.014	19.74	0.059	0.051	<.025	<0.126	1.8

Table 9. Continued

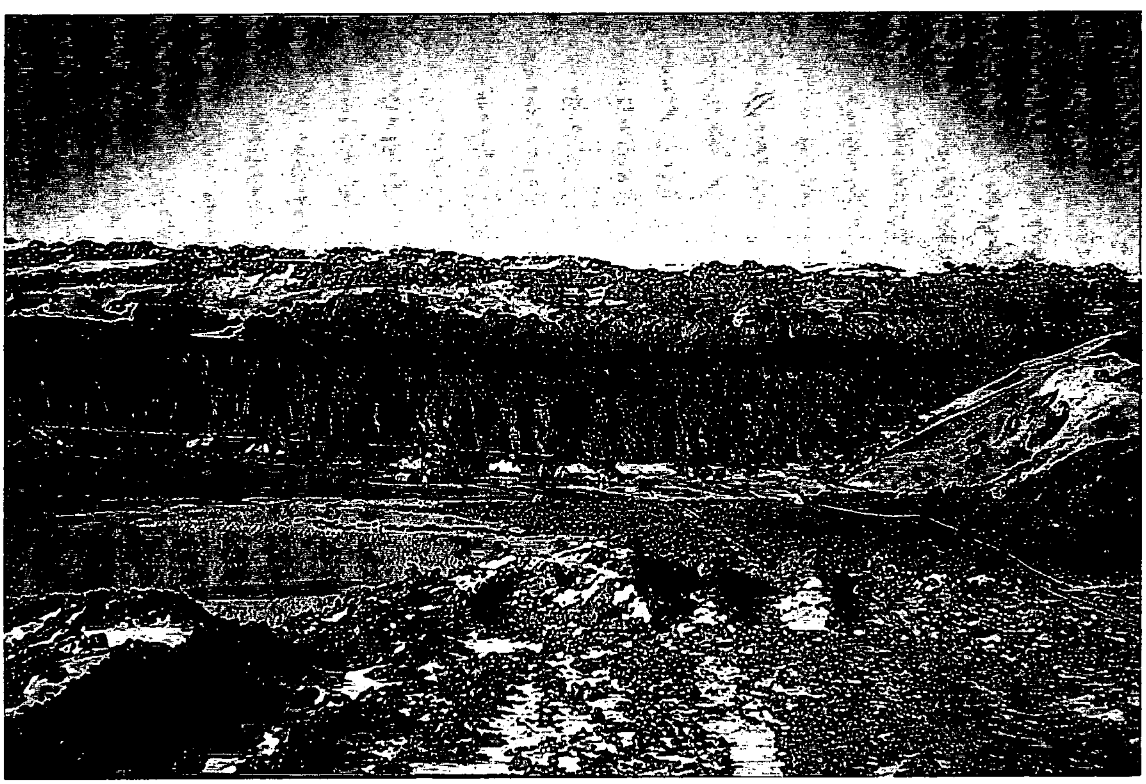
GS and Mine	*Site / Sample Description	Sample Identificat	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Tl	Zn
Line Creek Mine	Settling Pond Discharge MSA	72 Dup 1	<.034	<.009	0.015	<0.01	12.88	0.022	<.020	<.025	<0.126	0.209
	Line Creek u/s - 0200335 (clear)	73 Dup 1	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	Blank after	74 Blk aft	<.034	<.009	<.009	<0.01	<0.012	<.002	0.029	<.025	<0.126	<.009
	South Pit Water	75 Decantate	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	Line Creek d/s (clear)	76 Dup 1	<.034	<.009	<.009	<0.01	<0.012	<.002	0.024	<.025	<0.126	<.009
	Wash Water after Thickener	77 Decantate	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	Tap Water Not Treated (clear)	78	<.034	<.009	<.009	1.27	<0.012	<.002	0.031	<.025	<0.126	<.009
Paintearth Mine	Surface Runoff Discharge	85 Dup 1 Decantate	<.034	<.009	<.009	<0.01	9.46	0.126	0.02	<.025	<0.126	0.231
	Section 7 Lake (pit surface runoff)	86 Dup 1 Decantate	<.034	<.009	<.009	<0.01	0.71	<.002	0.13	<.025	<0.126	<.009
	Impoundment #5 Discharge	87 Decantate	<.034	0.041	0.237	0.076	122	0.304	0.025	<.025	<0.126	0.63
	Paintearth Creek d/s	88 Dup 1 Decantate	<.034	<.009	<.009	<0.01	6.64	0.018	<.020	<.025	<0.126	0.094
	Paintearth Creek u/s	89 Dup 1 Decantate	<.034	<.009	<.009	<0.01	1.46	0	<.020	<.025	<0.126	<.009
	Blank after	90 Blk aft	<.034	<.009	<.009	<0.01	<0.012	0	<.020	<.025	<0.126	<.009
Belldune G.S.	Coal Pile Runoff	100 Decantate	<.034	0.15	<.009	0.064	0.615	14.33	0.346	<.025	<0.126	0.596
	Equalization Pit	101 (high salt ?)	<.034	0.052	<.009	<0.01	<0.012	55.45	0.17	<.025	<0.126	<.009
		101 10x dilution	<.034	0.012	<.009	<0.01	<0.012	6.04	0.029	<.025	<0.126	<.009
	Treated Discharge	102 ((high salt ?)	<.034	0.031	0.015	<0.01	<0.012	73.3	0.117	<.025	<0.126	<.009
		102 10x dilution	<.034	<.009	<.009	<0.01	0.088	7	<.020	<.025	<0.126	<.009
	Ash Leachate Pond Discharge	103 ((high salt ?)	<.034	<.009	0.308	<0.01	0.109	0.003	<.020	<.025	<0.126	<.009
		103 ((high salt ?)	<.034	<.009	0.034	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
Grand Lake GS	Ash Lagoon Discharge (clear)	104 Dup 1 (high salt ?)	<.034	<.009	<.009	<0.01	1.04	0.598	<.020	<.025	<0.126	<.009
		104 Dup 1 10x dilution	<.034	<.009	<.009	<0.01	0.062	0.066	<.020	<.025	<0.126	<.009
	Lake	105 Dup 1 Decantate	<.034	<.009	<.009	<0.01	0.126	0.003	<.020	<.025	<0.126	<.009
	Intake Water	106 Dup 1 Decantate	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
Lingan GS	Ash Lagoon Return	108 Dup 1 (high salt ?)	<.034	<.009	<.009	<0.01	0.23	0.007	<.020	<.025	<0.126	<.009
		108 Dup 1 10x dilution	<.034	<.009	<.009	<0.01	<0.012	1.95	<.020	<.025	<0.126	<.009
	Waste Water Discharge to Lagoon	109 Dup 1 Decantate	<.034	<.009	<.009	<0.01	<0.012	0.227	<.020	<.025	<0.126	<.009
	Pretreatment Waste Water	110 Dup 2 (high salt ?)	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
		110 Dup 2 10x dilution	<.034	<.009	<.009	<0.01	<0.012	0.063	<.020	<.025	<0.126	<.009
	Coal Pile Runoff	111 Dup 2 Decantate	<.034	0.038	<.009	0.018	71.94	3.81	0.084	<.025	<0.126	0.087

Table 9. Continued

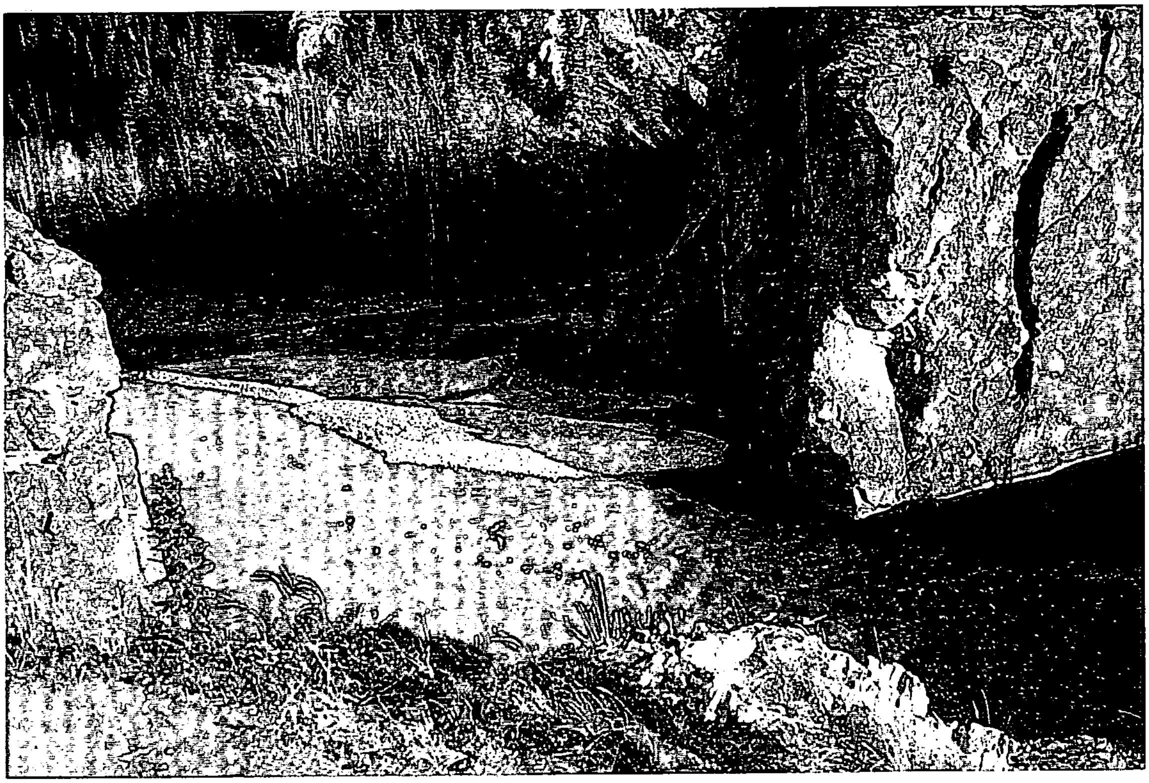
GS and Mine	*Site / Sample Description	Sample Identificat	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Tl	Zn
Trenton GS	Coal Leachate Pond	121 Dup 1 (high salt ?)	<.034	<.009	<.009	<.01	<.012	0.854	<.020	<.025	<0.126	<.009
	Ash Lagoon Discharge (clear)	122 Dup 1 (high salt ?)	<.034	<.009	<.009	<0.01	0.393	0.068	<.020	<.025	<0.126	<.009
		122 Dup1 10x dilution	<.034	<.009	<.009	<0.01	0.016	0.003	<.020	<.025	<0.126	<.009
	Intake Water (treated town water)	123	<.034	<.009	<.009	<0.01	0.121	0.029	<.020	<.025	<0.126	<.009
	Pit B Discharge	124	<.034	<.009	<.009	<0.01	0.088	0.024	<.020	<.025	<0.126	<.009
8200 Salmon Harbour Mine	Lake Water	128 Dup 1 Decantate	<.034	<.009	<.009	<0.01	0.384	<.002	<.020	<.025	<0.126	<.009
Phalen Colliery	Mine Water Discharge	130 Dup 1 (high salt ?)	<.034	<.009	<.009	<0.01	<0.012	1.44	<.020	<.025	<0.126	<.009
		130 Dup1 100x dilution	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	Town Water (from tap at security)	131 Dup 1	<.034	<.009	<.009	<0.01	<0.012	<.002	<.020	<.025	<0.126	<.009
	Surface Runoff Brook	132 Decantate	<.034	<.009	<.009	<0.01	0.096	0.684	<.020	<.025	<0.126	<.009
Prince Colliery	Process Water	138 Dup 1	<.034	<.009	<.009	<0.01	<0.012	0.013	<.020	<.025	<0.126	<.009
	Mine Discharge and Runoff	139 Dup 1 (high salt ?)	<.034	0.033	<.009	<0.01	2.56	1.07	0.054	<.025	<0.126	<.009
		139 Dup1 100x dilution	<.034	<.009	<.009	<0.01	<.012	0.01	<.020	<.025	<0.126	<.009
	Treated Lagoon Discharge (clear)	140 Dup 2 (high salt ?)	<.034	<.009	<.009	<0.01	<0.012	0.26	<.020	<.025	<0.126	<.009
		140 Dup2 10x dilution	<.034	<.009	<.009	<0.01	<0.012	0.023	<.020	<.025	<0.126	<.009
	d/s Discharge (clear)	141 Dup 1 (high salt ?)	<.034	<.009	<.009	<0.01	0.021	0.248	<.020	<.025	<0.126	<.009
		141 Dup1 10x dilution	<.034	<.009	<.009	<0.01	<0.012	0.021	<.020	<.025	<0.126	<.009

* For detailed description, seeTables 4 -7

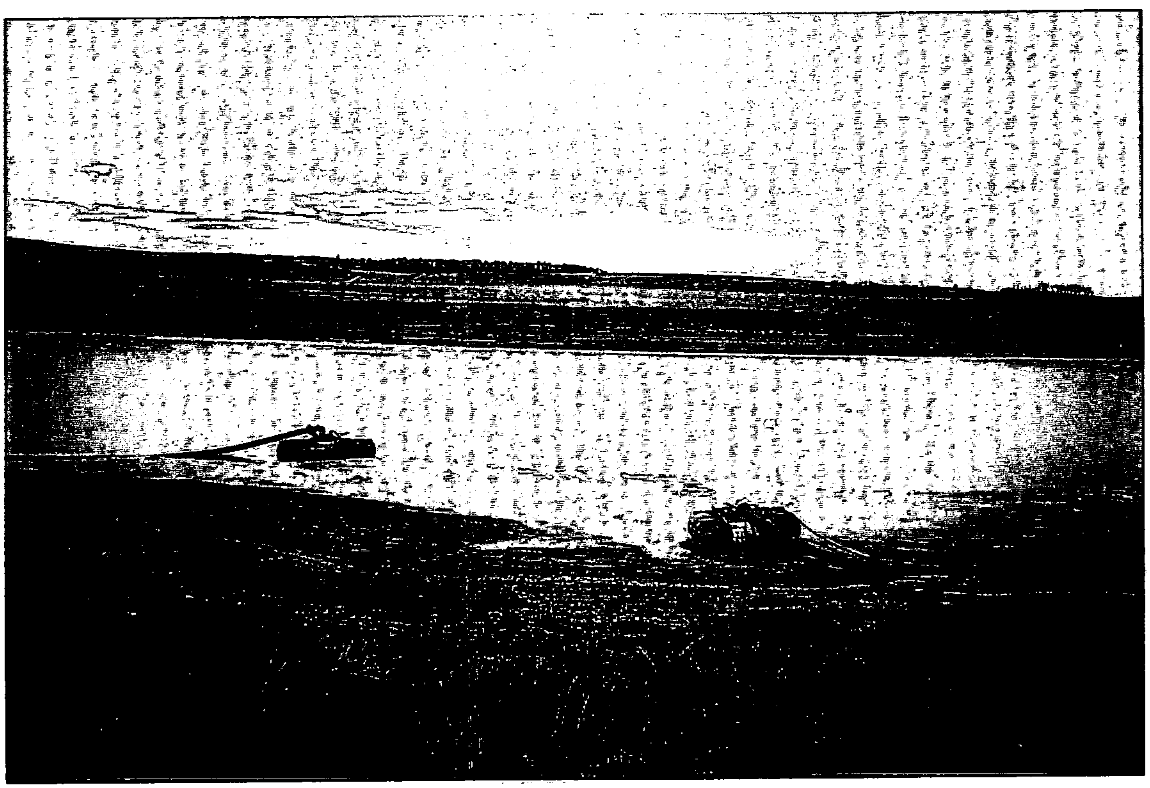
Cardinal River Mine



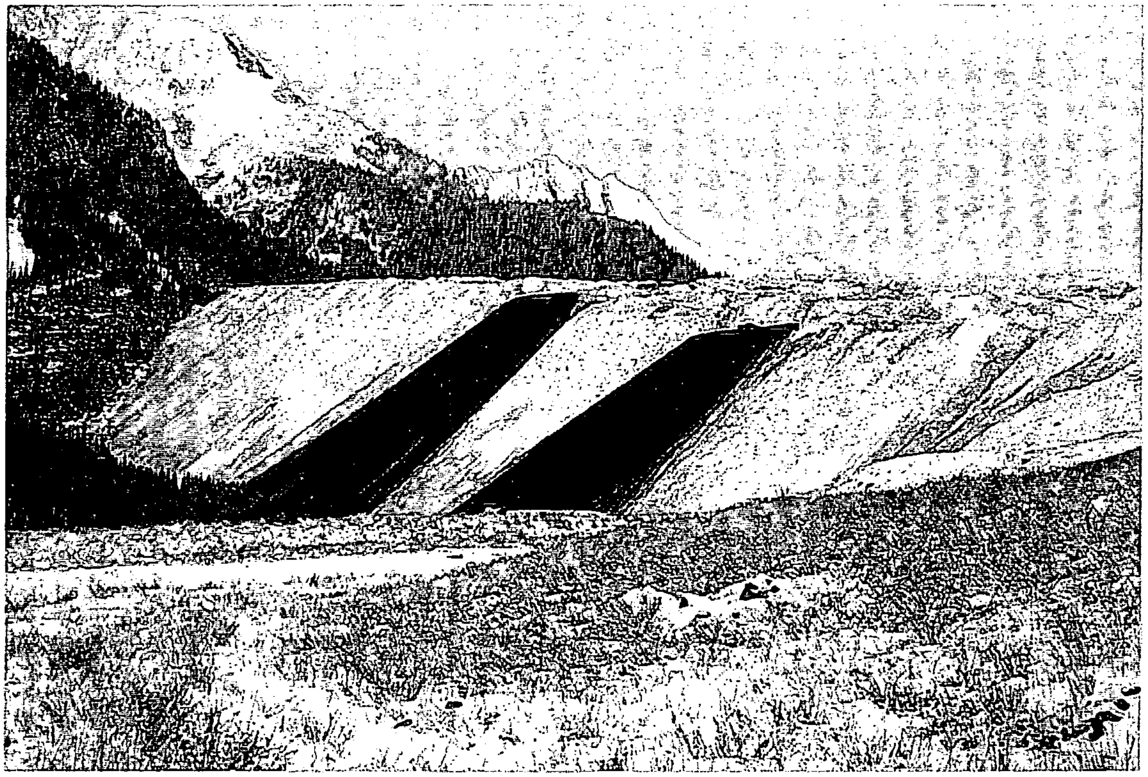
Sheerness Mine: Pit water



Hell's Gate, Alberta



Highvale Mine: Pit 3 Settling pond

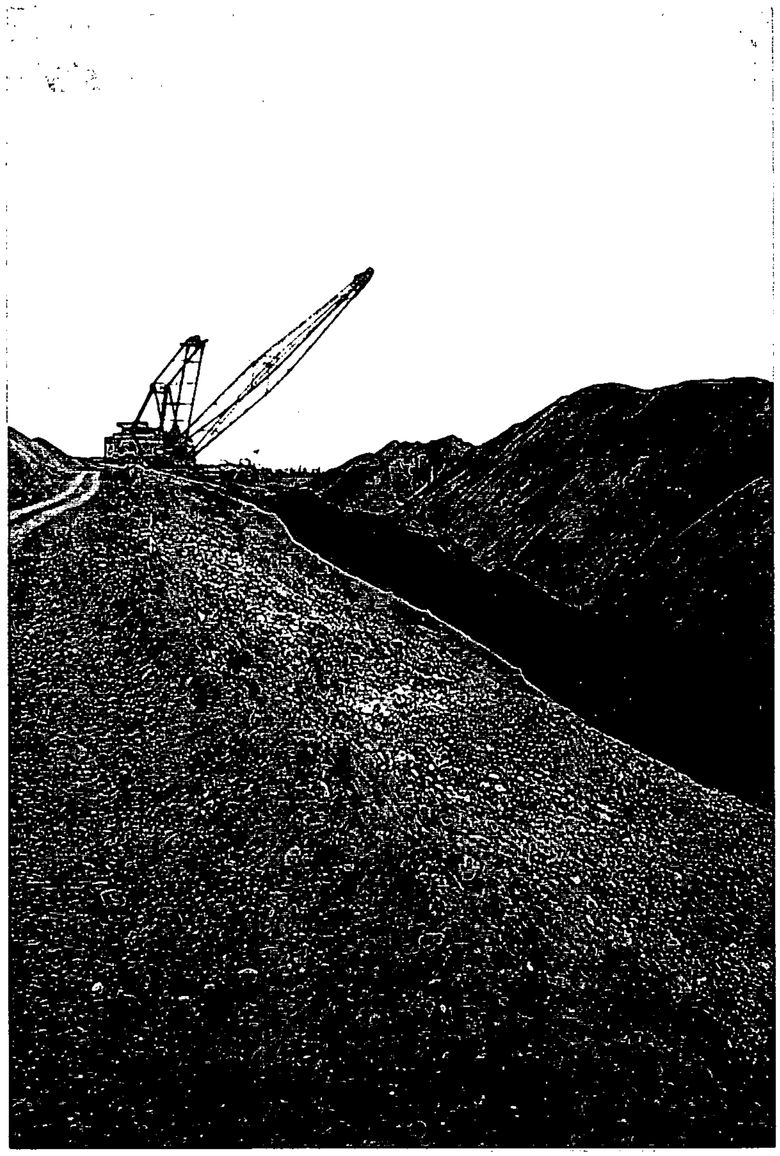


Line Creek Mine: Dump area

Gregg River Mine: H I pit

Battle River Generating Station: Cooling pond

H.R. Milner Generating Station and Smokey River Coal



Whitewood Mine (Wabamun, Alberta)

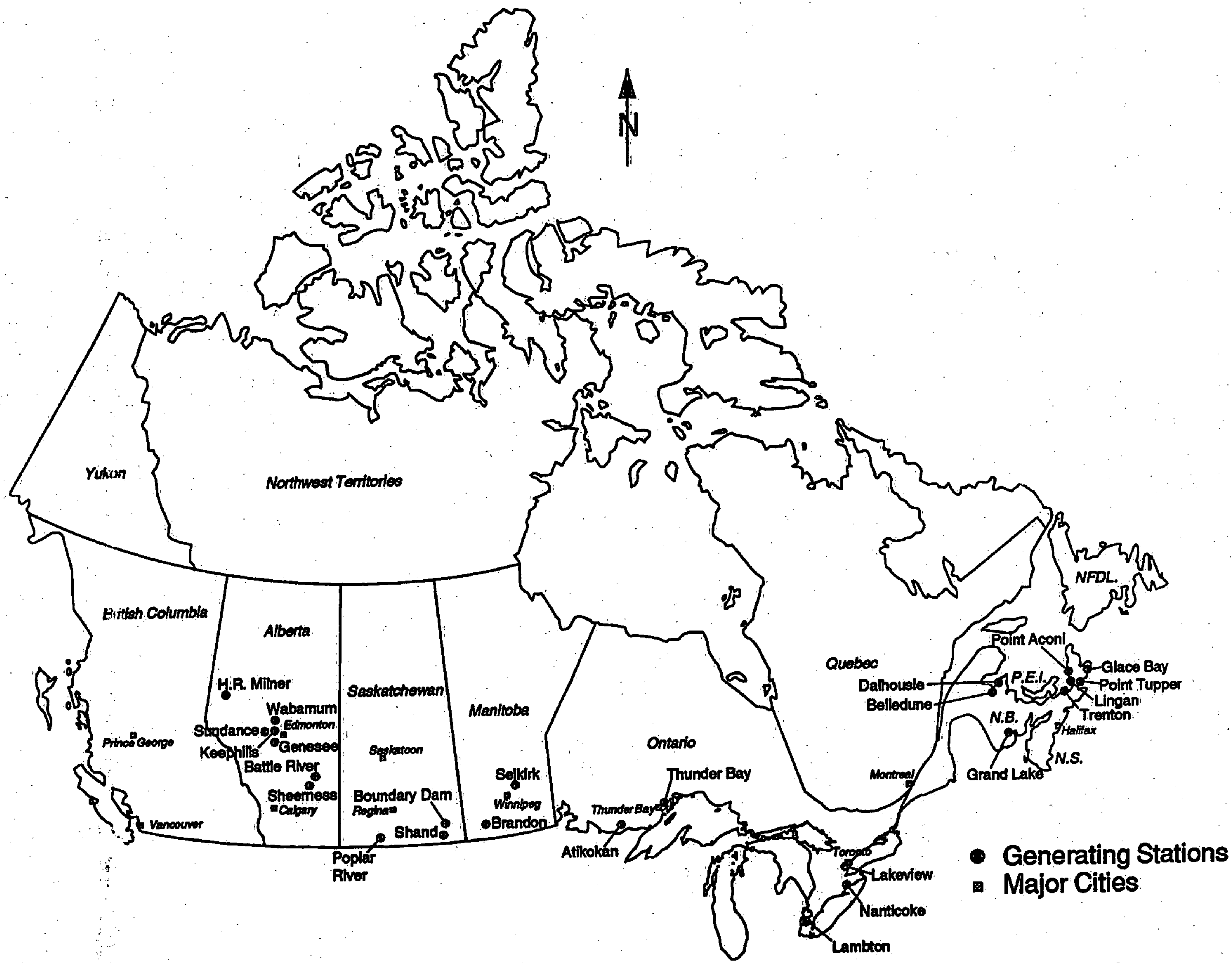
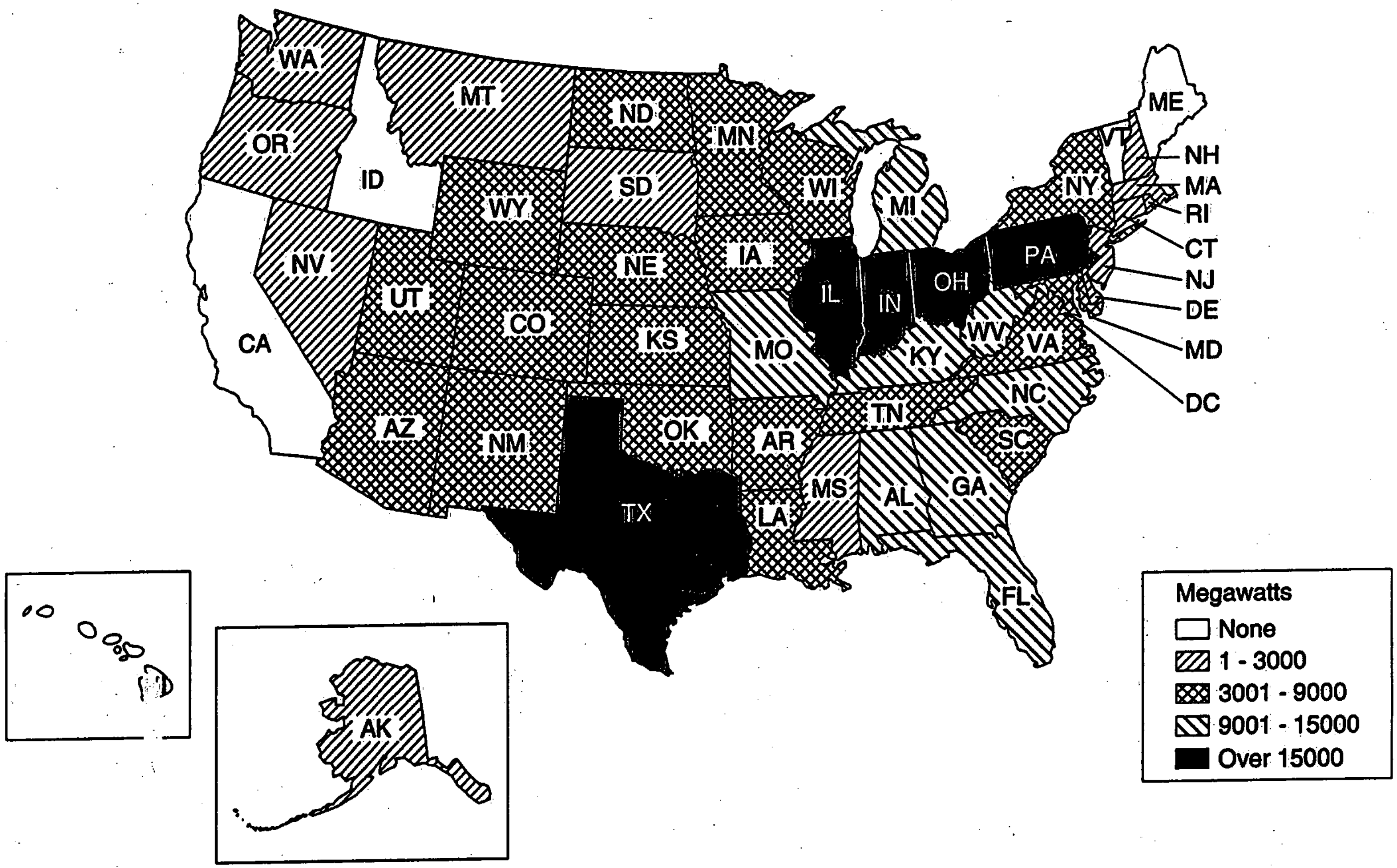


Figure 1. Coal-fired Electrical Generating Stations in Canada

Figure 2. Principal Coal Mines in Canada

Figure 3. Coal-Fired Generating Capacity by State in USA (as of December 31, 1993)



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