

Delineation of a Contaminated Site: Snag Airstrip, YT

Prepared by

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As with all reports produced by the Environmental Sciences Group, this report is the product of the collective effort of the entire group, headed by Dr. Ken Reimer. Dawn Pier authored the report which was edited by Marjorie Pine. Pat Fortin managed and organized the data. David Pier prepared the maps and other graphics. Natalie Plato provided assistance with report organization. Deborah Reimer oversaw financial administration of the project and Doug Noonan and Jennifer Kirkland provided logistical support. The field team consisted of Dawn Pier, Natalie Plato, David Pier and Arnie Koroshegyi of the Environmental Sciences Group, and Werner Liebau and Nikki Kroker of Indian and Northern Affairs Canada.

The analytical work was carried out by the Analytical Services Unit (ASU) of Queen's University and the Environmental Sciences Group (ESG) Analytical Laboratory at Royal Military College of Canada, both located in Kingston, Ontario; Axys Analytical Services in Sydney, BC conducted all pesticide analyses, as well as the external check for PCB analyses. The high standards and hard work of these organizations greatly assisted the completion of this project. In particular, we would like to thank Paula Whitley of ASU, Stephen Duffy and Allison Rutter of the ESG lab and Corrine Hamilton of Axys for ensuring the prompt completion and reporting of analyses.

EXECUTIVE SUMMARY

The cleanup of the abandoned World War II military site, Snag Airstrip, was carried out in the summer of 1996, based on the study conducted by the Environmental Sciences Group (ESG) in 1995 and reported in the document *An Environmental Assessment of Snag Airstrip, Yukon Territory*. The cleanup began on 25 June 1996 and continued through to the end of September. It consisted of two phases: the first involved the delineation of contamination in soils and buildings, with the collection and analysis of soil samples and building materials by ESG; the second phase included the excavation of contaminated soils, confirmatory sampling, demolition of building structures, and the appropriate disposal of each category of waste, which was conducted by Lorimer and Associates in conjunction with Hemmera Resource Consultants Ltd. This report summarizes the work conducted by the Environmental Sciences Group as part of the first phase of the Snag Airstrip cleanup. The second phase of work completed by Lorimer and Associates is reported under separate cover.¹ The ESG provided scientific input, managed data and covered the costs of analyses throughout the project.

Field work was conducted from 25 June to 17 July, 1996 and included the collection of 547 samples of various media including 533 soil, six insulation/floor tile, four paint chip and four wood samples. Contaminated soil delineation was conducted in the vicinity of seven buildings or facilities designated as the Tower Building, DOT Barracks Building, Warehouse, Powerhouse, Pump House, Garage and Beacon Site. Seventy-five percent of samples collected were analyzed for at least one contaminant. Soil samples were analyzed for metals in the field using an X-Ray Fluorescence (XRF) field test kit. Polychlorinated biphenyl (PCB) contamination was assessed primarily in a southern laboratory using traditional methods (GC/ECD). Standard quality assurance and quality control measures were followed to ensure data accuracy and precision.

Forty-four percent of samples analyzed contained at least one contaminant at a concentration that exceeded the applicable criteria. Delineation at each of the contaminated areas at Snag Airstrip indicated that a total area of 1010 m² of substrate required excavation: of the total area affected, 645 m² was contaminated above the

¹ Lorimer & Associates and Hemmera Resource Consultants Ltd. 1996. *Snag Airstrip Remediation, Yukon*. Prepared for Indian and Northern Affairs Canada, Action on Waste Program.

Canadian Council of Ministers of the Environment Residential/Parkland Remediation Criteria and required landfilling on site; a 110 m² area of soil contained high concentrations of pesticides or leachate toxic levels of lead, and required double-bagging and removal to a southern disposal facility; and soil over an area of 255 m² was contaminated with PCBs at a concentration exceeding the level regulated under the Canadian Environmental Protection Act and was containerized and shipped to the PCB treatment and disposal facility in Swan Hills, Alberta.

According to recommendations made by ESG, monitoring wells were installed at the base of the Snag Airstrip dump, and the dump was capped with additional fill and regraded to reduce its slope. If water from the dump is monitored regularly, this will provide the information necessary to determine its environmental status.

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GLOSSARY OF TERMS

anthropogenic	=	derived directly or indirectly from human activity
As	=	Arsenic
ASU	=	Analytical Services Unit (Queens University, Kingston, Ont.)
BCMOE	=	British Columbia Ministry of Environment
CCME	=	Canadian Council of Ministers of the Environment
Cd	=	Cadmium
CEPA	=	Canadian Environmental Protection Act
Co	=	Cobalt
Cr	=	Chromium
Cu	=	Copper
DDT	=	Dichlorodiphenyltrichloroethane
DIAND	=	Indian and Northern Affairs Canada
DND	=	Department of National Defence
EC	=	Environment Canada
EPA	=	Environmental Protection Agency (US)
ESG	=	Environmental Sciences Group
FAL	=	Freshwater Aquatic Life
GC	=	Gas Chromatography
GC/ECD	=	Gas Chromatography/Electron Capture Detection
GC/MS	=	Gas Chromatography/Mass Spectroscopy
GNWT	=	Government of the Northwest Territories
Hazmat	=	Hazardous Material
HCB	=	Hexachlorobenzene
HCH	=	Hexachlorocyclohexane
High res	=	High resolution (usually in association with mass spectrometry)
HRGC	=	High Resolution Gas Chromatography
HRMS	=	High Resolution Mass Spectrometry
HS-1	=	NRC Marine Reference Standard
leachate	=	substances (usually in solution) migrating from a more concentrated source.
MENVIQ	=	Ministère de l'Environnement du Québec
Mn	=	Manganese
Mo	=	Molybdenum
NA	=	Not analyzed due to a coeluting interference

GLOSSARY OF TERMS cont'd

NCSCS	=	National Contaminated Sites Classification System
NBS	=	National Bureau of Standards (US)
NCSRP	=	National Contaminated Sites Remediation Program
NDR	=	Not reliably detected
Ni	=	Nickel
NIST	=	National Institute of Standards and Technology
NM	=	Not Measured
NRC	=	National Research Council
NWT	=	Northwest Territories
PAH	=	Polycyclic Aromatic Hydrocarbon
Pb	=	Lead
PCB	=	Polychlorinated Biphenyl
PCDDs		Polychlorinated dibenzodioxins
PCDFs		Polychlorinated dibenzofurans
ppb	=	parts per billion; ng/g, nanograms of substance per gram of soil or sediment sample; $\mu\text{g/L}$, micrograms of substance per litre of aqueous solution.
ppm	=	parts per million; $\mu\text{g/g}$, microgram of substance per gram of soil or sediment sample.
ppt	=	parts per trillion; ng/L in aqueous solutions.
R/P	=	Residential/Parkland
TPH	=	Total Petroleum Hydrocarbons
Zn	=	Zinc

I. INTRODUCTION

Snag Airstrip is an abandoned World War II military site located 30 km by road southeast of the community of Beaver Creek in Yukon Territory (62° 20' N, 140° 29' W, Map I-1). The airstrip was constructed in 1942 as part of the Northwest Staging Route, a series of airstrips forming a flight corridor from Edmonton to Fairbanks. The site consisted of several buildings and a single landing strip. In addition, there was an intermediate range beacon site on the highest point in the vicinity, approximately 7 km northeast of the airstrip. Between 1942 and 1945 the airstrip was administered by the Royal Canadian Air Force. The Department of Transport was given use of the site during this period, and formally took over its administration in 1957. In 1966 Snag Airstrip, along with other airstrips still in operation, was handed over to the territorial government. The property came under the management of Indian and Northern Affairs Canada (DIAND) in 1971, and under their *Arctic Environmental Strategy* Action on Waste program, environmental assessments of facilities associated with the Northwest Staging Route were initiated in 1994. In 1995 the Environmental Sciences Group (ESG), of the Royal Military College of Canada, Kingston, Ontario², undertook an environmental assessment of the facilities associated with Snag Airstrip to determine the contaminant and physical hazard status of the site.³ ESG determined that a number of inorganic and organic contaminants, including polychlorinated biphenyls (PCBs), were present at elevated concentrations in the soil and plants at Snag Airstrip. ESG recommended that cleanup of the site be undertaken, and work commenced the following summer. **This report summarizes the work conducted in June 1996 by ESG as part of the cleanup of Snag Airstrip.**

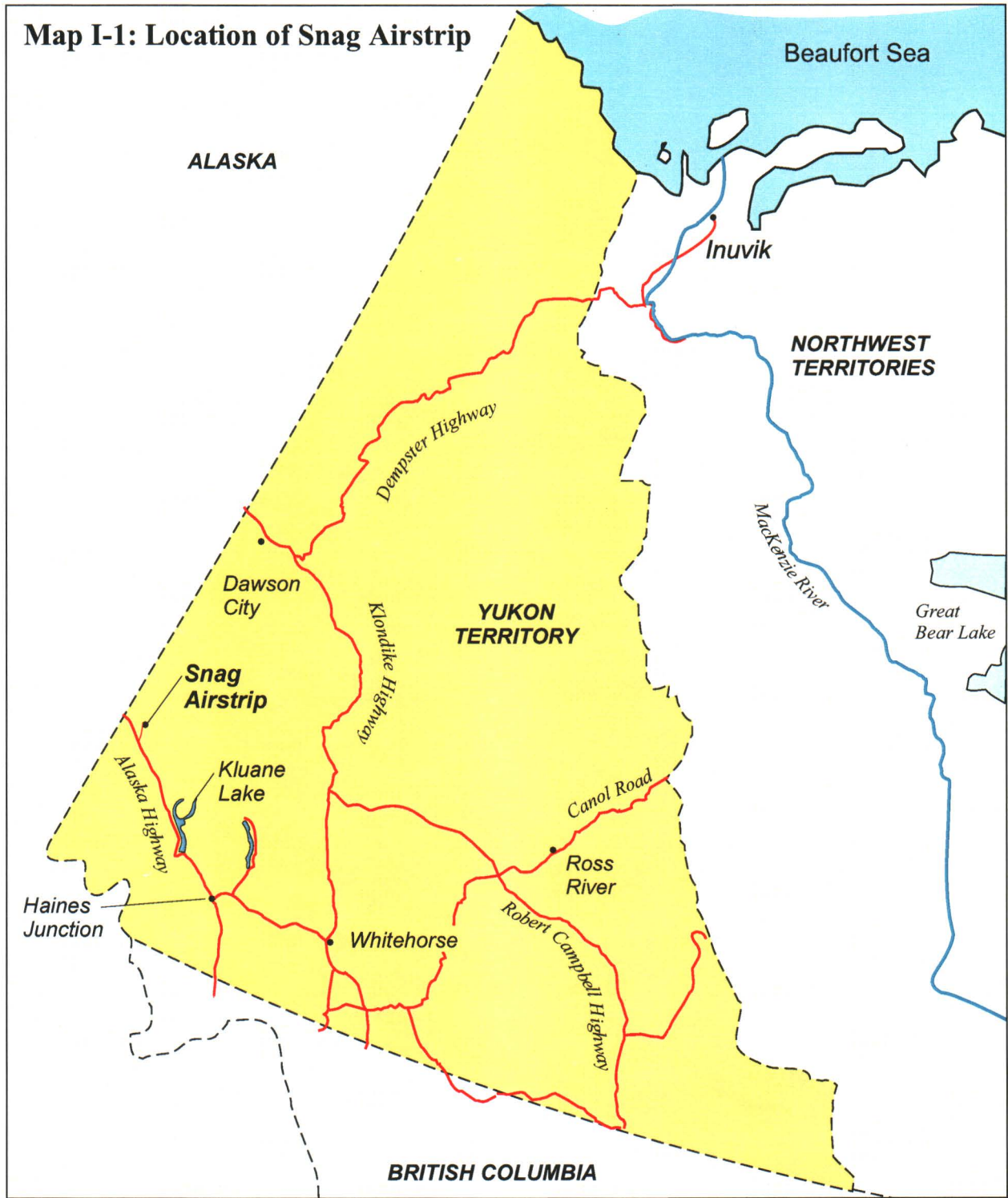
A. Objectives

The objectives of the work described in this report were to delineate the extent of contamination previously detected at Snag Airstrip, and to provide scientific advice during cleanup activities. Field sampling was conducted by ESG from 25 June to 17 July, 1996.

² Formerly of Royal Roads Military College, Victoria, BC.

³ ESG 1996, *An Environmental Assessment of Snag Airstrip, Yukon Territory* Prepared by the Environmental Sciences Group for Indian and Northern Affairs Canada.

Map I-1: Location of Snag Airstrip



II. BACKGROUND

A. Environmental Assessment Results

The scientific investigation of Snag Airstrip was carried out by the Environmental Sciences Group on June 13, 1994 (initial reconnaissance) and from June 28 to July 6, 1995 (detailed site investigation). The environmental assessment of the site addressed visible debris and physical structures, the main site dump, and contaminated soil. An emphasis was made on evaluating the potential for chemical contaminants to enter the foodchain.

The assessment and the corresponding cleanup recommendations proposed for the airstrip were based on requirements as outlined in federal regulations (in particular the Canadian Environmental Protection Act⁴) and on remediation objectives as outlined by the Canadian Council of Ministers of the Environment.^{5,6}

In total, 237 soil samples were collected at Snag Airstrip, 137 of which were assessment soil samples collected in previously uninvestigated areas. The remaining 100 were delineation soil samples, collected for the purpose of defining the extent of contamination identified previously in the 1994 assessment. Thirty-four plant samples were collected, to assess whether contaminants detected in the soil samples were

⁴ *Canada Gazette* (extract), Part II, Vol. 126, No. 19, September 9, 1992. Department of the Environment. Storage of PCB Material Regulations. Ministry of Supply and Services Canada, Queen's Printers for Canada, Ottawa, Ontario.

⁵ Canadian Council of Ministers of the Environment (CCME), 1991a. *Interim Canadian Environmental Quality Criteria for Contaminated Sites*. Prepared by the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites, September 1991.

⁶ Canadian Council of Ministers of the Environment (CCME), 1991b. *Review and Recommendations for Canadian Interim Environmental Quality Criteria for Contaminated Sites*. Scientific Series No. 197. Prepared for CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites by Angus Environmental Limited, 1991.

migrating into the foodchain. In addition, water, barrel, paint chip, wall swab, insulation and oil filter samples were collected from around the site.

Soil samples were screened for polychlorinated biphenyls (PCBs), inorganic elements, polycyclic aromatic hydrocarbons (PAHs), pesticides, and dioxins. Plant, water and paint chip samples were analyzed for inorganic elements and PCBs. Wall swabs were analyzed for PCBs only, and the barrel samples and the oil filter were analyzed for PCBs, total chlorine and the inorganic elements lead, chromium and cadmium. The asbestos content of insulation was also determined.

Table II-1 provides a summary of the results of the environmental assessment conducted by ESG at Snag Airstrip in 1994 and 1995. Forty percent of assessment soil samples collected at Snag Airstrip contained at least one analyte at a concentration exceeding the applicable criterion. Zinc and lead were the most common contaminants detected in these samples. PCBs were also prevalent - 25% of assessment soil samples contained PCBs in excess of the CCME criterion. PCBs were also found in soils in five locations at concentrations above 50 ppm, the level regulated under the *Storage of PCB Material Regulations* arising from the Canadian Environmental Protection Act (CEPA).

Delineation of the following areas to determine the extent of contamination was also undertaken:

- the south side of the Tower Building;
- the east side of the Powerhouse;
- the Pump House basement; and
- the west and south sides of the Warehouse Foundation.

Lead was detected in 87% of these samples and was the most prevalent contaminant exceeding the criteria. Lead was also found to be significantly leachable in soils from near the Warehouse Foundation. The entire extent of contamination at the site was not determined during the 1995 field season. Plant samples collected at Snag Airstrip

contained elevated concentrations of inorganic elements and/or PCBs relative to background plant contaminant levels. In addition to PCBs and metals, pesticides, dioxins and polycyclic aromatic hydrocarbons were detected in soils from Snag Airstrip. Pesticides were the only contaminants not found along with either metals or PCBs.

Table II-1: Summary of Contamination Detected at Snag Airstrip

Area	Contaminants Exceeding the Applicable Criteria ^a	Criteria/Regulation Exceeded	Estimated Total Volume of Soil Affected (m ³)
Tower Building	Pb, Zn, Cu, Cd, PCBs, Pesticides	CCME R/P	65
DOT Barracks Building	PCBs, PCDDs/PCDFs, Zn, Pb, Cu, Ni	CEPA CCME R/P	10 40
Warehouse	Pb, Cu, Zn, Cr, PCBs	LQS ^b CCME R/P	15 55
Powerhouse & Pump House	PCBs, Zn, Pb, Cu, Cd, Ni, Cr	CEPA CCME R/P	20 47
Fire Hall	Zn	CCME R/P	4.5
Garage	PCBs, PCDDs/PCDFs, Pesticides, PAHs, Zn, Pb, Cu, Ni, Cd, Cr	CEPA CCME R/P	4 40
Dump	-	-	-
Septic Field	Cu, Zn, Pesticides	CCME R/P	Manholes to be backfilled
General Site Proximity	Zn	CCME R/P	10
Beacon Site	Zn, Cu, As, Ni	CCME R/P	31

a. Listed in order of degree

b. Leachate Quality Standards

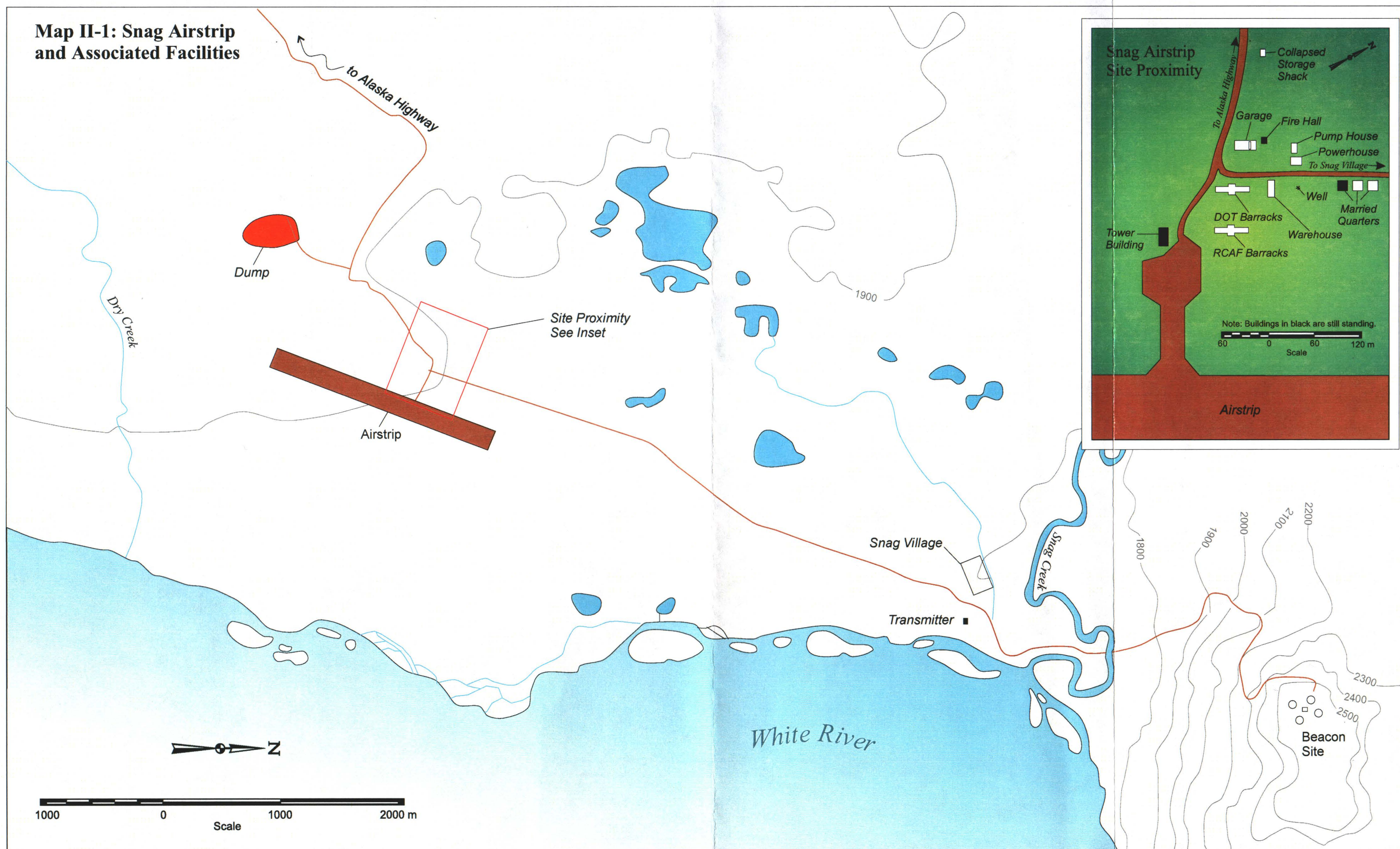
The report presenting the 1994-95 assessment study⁷ recommended a cleanup of Snag Airstrip that would include the following:

- Excavation and containerization of CEPA contaminated soils (that is, soils contaminated with levels of PCBs greater than 50 ppm);
- Excavation and containerization of lead contaminated leachate toxic and pesticide contaminated soils⁸;
- Excavation of CCME R/P contaminated soils and placement in an engineered landfill (either in the South or on site);
- Removal and appropriate burial of all physical structures including buildings and other nonhazardous debris;
- Implementation of erosion control measures and groundwater monitoring at the dump associated with the site;
- Backfilling of any and all manholes, cisterns, wells, oil collection pits and basements; and
- Regrading of all worked areas to encourage revegetation and to avoid slumping and erosion.

⁷ ESG, 1996.

⁸ Recommendations addressing the cleanup of pesticide contaminated soils were included in an Addendum to Chapter V of the ESG environmental assessment report, *An Environmental Assessment of Snag Airstrip, Yukon Territory*.

Map II-1: Snag Airstrip and Associated Facilities



B. Cleanup Criteria

Federal, provincial/territorial and foreign cleanup criteria were used to establish target levels for the remediation of contaminated soil and building materials that would be sufficient to ensure the protection of human health and the environment. The criteria are discussed below, and appear in tables at the end of the chapter.

a) Canadian Council of Ministers (CCME) of the Environment Criteria

Where applicable the Canadian Council of Ministers of the Environment Interim Canadian Environmental Quality Criteria for Contaminated Sites⁹ were applied to the results of analyses for inorganic elements¹⁰, polychlorinated biphenyls, polychlorodibenzodioxins and polychlorodibenzofurans, and polycyclic aromatic hydrocarbons (PAHs). The CCME Interim Canadian Environmental Quality Criteria include Assessment Criteria and Remediation Criteria. Assessment criteria are both approximate background concentrations and approximate analytical detection limits (Table II-2). The CCME Remediation Criteria consist of three tiers - Agricultural (AG), Residential/Parkland (R/P) and Commercial/Industrial (C/I) - which address land use objectives for a site under consideration. Based on the rationale outlined in the CCME report "Review and Recommendations for Canadian Interim Environmental Quality Criteria for Contaminated Sites"¹¹ the Residential/Parkland criteria were applied in the assessment and remediation of Snag Airstrip. This is consistent with the intensity of area use by local First Nations people and the absence of any commercial agricultural activity in the area.

CCME criteria exist for most of the compounds included in the broad screen analysis for polycyclic aromatic hydrocarbons (PAHs, see Table II-3). Polychlorinated dibenzodioxin and dibenzofuran concentrations in soil were also compared to the CCME Residential/Parkland Remediation Criterion. The complete Interim Canadian Environmental Quality Criteria for Contaminated Sites is presented in Annex A at the end

⁹ CCME, 1991b.

¹⁰ Included were copper, nickel, cobalt, cadmium, lead, zinc, chromium, arsenic and mercury.

¹¹ CCME, 1991a.

of this chapter.

In those instances where the CCME criteria did not treat a particular contaminant or types of contaminants, the most stringent provincial/territorial criteria available were applied. In the absence of provincial or territorial criteria, the contaminant concentrations were compared to foreign criteria included in the CCME document *Review and Recommendations for Canadian Interim Environmental Quality Criteria for Contaminated Sites*.¹²

b) Provincial and Territorial Criteria

PAHs not covered by the CCME criteria were compared to the Cleanup Criteria Proposed for British Columbia and presented in italics in Table II-3.

The CCME Interim Remediation Criteria for soil currently do not contain numerical values for most pesticides and their metabolites. Two of the most comprehensive sets of criteria for contaminated soils available in Canada are the British Columbia Ministry of the Environment Proposed Cleanup Criteria, and the Soil and Ground Water Guidelines recommended by the Ministère de l'Environnement du Québec. Both sets of criteria use the three-tiered A, B, C format; soils containing substances in excess of the B level are considered contaminated for residential or recreational use and are therefore analogous to the R/P level of the CCME criteria. The Québec B level and the BCMOE B level both suggest a maximum acceptable total concentration of pesticides and metabolites of 2 ppm (see Table II-4).

The Ontario MOE Leachate Quality Criteria based on Section 4 of Regulation 322/85 and the analogous criteria used by the British Columbia MOE¹³ have been used to assess the degree to which contaminants are susceptible to leaching in water from the soils or paint chips in which they are found (Table II-5).

¹² CCME, 1991b.

¹³ British Columbia Ministry of Environment (BCMOE), 1989. Criteria for Managing Contaminated Sites in British Columbia - DRAFT. Prepared by the Waste Management Program, 21 November 1989.

c) Foreign Criteria

Criteria developed as part of the Soil Cleanup (Interim) Act of The Netherlands' Soil Protection Act incorporate A, B and C levels much like the aforementioned provincial criteria. The Netherlands Cleanup Criteria recommend maximum acceptable levels of 0.5 ppm for each chlorinated pesticide, 1.0 ppm for each nonchlorinated pesticide and 3.0 ppm total pesticides in soil (see Table II-4).

d) Environmental Regulations

Legislation governing the cleanup of Snag Airstrip included the *Storage of PCB Material Regulations* under the Canadian Environmental Protection Act.¹⁴ The *Storage of PCB Material Regulations* governs the amount of PCB material that is in or on a property or a parcel of land; materials containing PCBs at concentrations in excess of 50 ppm must be remedied.

¹⁴ Canada Gazette, 1992.

Table II-2: Some CCME Interim Criteria for Soil and Water^a

	Assessment Criteria		Remediation Criteria
	Soil	Water	Residential/Parkland for Soil
	ppm (µg/g)	ppb	ppm (µg/g)
<i>Inorganic Elements</i>			
Arsenic (As)	5	5	30
Cadmium (Cd)	0.5	1	5
Chromium (Cr)	20	15	250
Cobalt (Co)	10	10	50
Copper (Cu)	30	25	100
Lead (Pb)	25	10	500
Mercury (Hg)	0.1	0.1	2
Nickel (Ni)	20	10	100
Zinc (Zn)	60	50	500
<i>Organic Compounds</i>			
Polychlorinated Biphenyls	0.1	0.1	5
PCDDs/PCDFs ^b	0.00001	--	0.001

- a. This is only a partial list; a complete list may be found in CCME. "Interim Canadian Environmental Quality Criteria for Contaminated Sites" Report CCME EPC-CS34, September 1991.
- b. Polychlorinated dibenzodioxins and dibenzofurans, expressed in 2,3,7,8-tetrachlorinated dibenzodioxin equivalents.

Table II-3: CCME Interim and BC MOE Criteria for Polycyclic Aromatic Hydrocarbons (PAHs) in Soils^{a,b}

Substance	Assessment Criteria	Remediation Criteria		
		Agricultural	Residential/ Parkland	Commercial/ Industrial
ppb or ng/g dry weight				
Naphthalene	100	100	5000	50000
Acenaphthylene	<i>100</i>	<i>10000</i>	<i>10000</i>	<i>100000</i>
Acenaphthene	<i>100</i>	<i>10000</i>	<i>10000</i>	<i>100000</i>
Fluorene	<i>100</i>	<i>10000</i>	<i>10000</i>	<i>100000</i>
Phenanthrene	100	100	5000	50000
Anthracene	<i>100</i>	<i>10000</i>	<i>10000</i>	<i>100000</i>
Fluoranthene	<i>100</i>	<i>10000</i>	<i>10000</i>	<i>100000</i>
Pyrene	100	100	10000	100000
Benz(a)anthracene	100	<i>1000</i>	<i>1000</i>	<i>10000</i>
Chrysene	<i>100</i>	<i>1000</i>	<i>1000</i>	<i>10000</i>
Benzofluoranthenes	<i>100</i>	<i>1000</i>	<i>1000</i>	<i>10000</i>
Benzo(a)pyrene	100	100	1000	10000
Dibenz(a,h)anthracene	100	100	1000	10000
Indeno(1,2,3-c,d)pyrene	100	100	1000	10000
Benzo(ghi)perylene	--	--	--	--

a. Figures in italics are equivalent values from "Criteria for Managing Contaminated Sites in British Columbia", BC MOE); CCME criteria are yet to be established for these particular compounds.

b. No criteria are available for the substances with a -- symbol.

Table II-4: List of Criteria for Pesticides

Criteria	Pesticides ^a (ppm)			
	Level A	Level B	Level C	
British Columbia Cleanup Criteria ^b :	Total Pesticides in Soil	0.10	2.0	20
	Total Pesticides in Water	0.00005	0.10	
MENVIQ Soil Guidelines ^c :	Total Pesticides	0.10	2.0	30
Netherlands Soil Guidelines ^d :	Total Pesticides	-	3.0	30
	Individual Chlorinated Pesticides		0.50	5.0
	Individual Nonchlorinated Pesticides		1.0	10

a. Pesticides analyzed include:

Hexachlorobenzene	o,p'-DDE	Mirex
alpha BHC	p,p'-DDE	Heptachlor Epoxide
beta BHC	trans-Nonachlor	alpha-Endosulphan
gamma BHC	cis-Nonachlor	Aldrin
Heptachlor	o,p'-DDD	Dieldrin
Oxychlordane	p,p'-DDD	Endrin
trans-Chlordane	p,p'-DDT	Methoxychlor
cis-Chlordane		

- b. From "Criteria for Managing Contaminated Sites in British Columbia, Ministry of Environment, Waste Management Program, November 1989". Level A represents background levels or achievable detection limits; Level B is the remediation criteria for residential, recreational and agricultural land use; and Level C represents significant soil contamination and is the remediation criterion for commercial or industrial land use.
- c. Ministère de l'Environnement du Québec (MENVIQ), 1988. "Contaminated Sites Rehabilitation Policy". Prepared by the Direction des Substances Dangereuses. Level A indicates background concentrations or analytical detection limits; concentrations between A and B are slightly contaminated. Site investigation is needed if concentrations exceed Level B. Concentrations between B and C are considered to be contaminated; concentration above C indicate serious contamination.
- d. From "Review and Recommendations for Canadian Interim Environmental Quality Criteria for Contaminated sites". The National Contaminated Sites Remediation Program, Scientific Series No.197. The A level marks the boundary between contaminated and uncontaminated soil; B level indicates the relative extent of contamination and potential seriousness of the risk that the contamination might pose; and C level represents the concentration above which a soil was considered to be polluted to such an extent that all potential exposure routes present an intolerable risk to humans or the environment.

Table II-5: Ontario and British Columbia MOE Hazardous (Special^a) Waste Leachate Quality Criteria

Compound	Ontario MOE Criteria (ppm)	BC MOE Criteria (ppm)
Arsenic	5.0	5.0
Barium	100	100
Cadmium	0.5	0.5
Chromium	5.0	5.0
Lead	5.0	5.0
Mercury	0.1	0.1
Selenium	1.0	1.0
Silver	5.0	5.0
Boron	500	500
Cyanide	20	20
Fluoride	240	150
PCBs	0.3	-

- a. Material producing leachate with substances in excess of the BC MOE Criteria are defined as 'special waste' according to these regulations, whereas in Ontario, materials producing leachate containing substances in excess of these criteria are termed 'hazardous waste'.



Annex A: Canadian Council of Ministers of the Environment (CCME) Assessment and Remediation Criteria for Soil and Water

Excerpts from Canadian Council of Ministers of the Environment (1991) Interim Canadian Environmental Quality Criteria for Contaminated Sites. Prepared by the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites, September 1991.

Assessment and Remediation Criteria Tables

Table A-1. Interim Assessment Criteria for Soil and Water

	Soil	Water
General Parameters		
pH	6 to 8	---
conductivity	2 dS/m	---
sodium adsorption ratio	5	---
Inorganic Parameters		
antimony	20 ¹	---
arsenic	5	5
barium	200	50
beryllium	4	---
boron (hot water soluble)	1	---
cadmium	0.5	1
chromium (*6)	2.5	---
chromium (total)	20	15
cobalt	10	10
copper	30	25
cyanide (free)	0.25	40
cyanide (total)	2.5	40
fluoride (total)	200	---
lead	25	10
mercury	0.1	0.1
molybdenum	2	5
nickel	20	10
selenium	1	1

Notes: All values in µg/g dry weight or µg/L unless otherwise stated.

Interim assessment criteria are largely based on ambient or background concentrations for most general and inorganic parameters and on analytical detection limits for most organic parameters.

--- value not established.

See page 7 for numbered footnotes.

Table A-1. Interim Assessment Criteria for Soil and Water (Continued)

	Soil	Water
Inorganic Parameters (cont'd)		
silver	2	5
sulphur (elemental)	250	---
thallium	0.5	---
tin	5	10
vanadium	25	---
zinc	60	50
Monocyclic Aromatic Hydrocarbons		
benzene	0.05	0.5
chlorobenzene	0.1	0.1
1,2-dichlorobenzene	0.1	0.2
1,3-dichlorobenzene	0.1	0.2
1,4-dichlorobenzene	0.1	0.2
ethylbenzene	0.1	0.5
styrene	0.1	0.5
toluene	0.1	0.5
xylene	0.1	0.5
Phenolic Compounds		
non-chlorinated ² (each)	0.1	0.1
chlorophenols ³ (each)	0.05	1.0
Polycyclic Aromatic Hydrocarbons (PAHs)		
benzo(a)anthracene	0.1	0.01
benzo(a)pyrene	0.1	0.01
benzo(b)fluoranthene	0.1	0.01
benzo(k)fluoranthene	0.1	0.01
dibenz(a,h)anthracene	0.1	0.01
indeno(1,2,3-c,d)pyrene	0.1	0.1
naphthalene	0.1	0.2
phenanthrene	0.1	0.2
pyrene	0.1	0.2
Chlorinated Hydrocarbons		
chlorinated aliphatics ⁴ (each)	0.1	0.1
chlorobenzenes ⁵ (each)	0.05	0.3
hexachlorobenzene	0.1	0.1
hexachlorocyclohexane	0.01	---
PCBs ⁶	0.1	0.1
PCDDs and PCDFs ⁷	0.00001	---

Table A-1. Interim Assessment Criteria for Soil and Water (Continued)

	Soil	Water
Miscellaneous Organic Parameters		
non-chlorinated aliphatics (each)	0.3	---
phthalic acid esters (each)	30	---
quinoline	0.1	---
thiophene	0.1	---

Table A-1 footnotes.

¹Set equal to the Agricultural Remediation Criteria value (see Table A-2).

²Non-chlorinated phenolic compounds include

- 2,4-dimethylphenol
- 2,4-dinitrophenol
- 2-methyl 4,6-dinitrophenol
- nitrophenol (2-, 4-)
- phenol
- cresol

³Chlorophenols include

- chlorophenol isomers (ortho, meta, para)
- dichlorophenols (2,6- 2,5- 2,4 3,5- 2,3- 3,4-)
- trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,5- 2,3,4- 3,4,5-)
- tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)
- pentachlorophenol

⁴Aliphatic chlorinated hydrocarbons include

- chloroform
- dichloroethane (1,1- 1,2-), dichloroethene (1,1- 1,2-)
- dichloromethane
- 1,2-dichloropropane, 1,2-dichloropropene (cis and trans)
- 1,1,2,2-tetrachloroethane, tetrachloroethene
- carbon tetrachloride
- trichloroethane (1,1,1- 1,1,2-), trichloroethene

⁵Chlorobenzenes include

- all trichlorobenzene isomers
- all tetrachlorobenzene isomers
- pentachlorobenzene

⁶PCBs include mixtures 1242, 1248, 1254, and 1260.

⁷PCDDs and PCDFs expressed in 2,3,7,8-TCDD equivalents. NATO International Toxicity Equivalency Factors (I-TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Congener	TEF	Congener	TEF
2,3,7,8-T ₄ CDD	1.0	2,3,7,8-T ₄ CDF	0.1
1,2,3,7,8-P ₅ CDD	0.5	2,3,4,7,8-P ₅ CDF	0.5
1,2,3,4,7,8-H ₆ CDD	0.1	1,2,3,7,8-P ₅ CDF	0.05
1,2,3,7,8,9-H ₆ CDD	0.1	1,2,3,4,7,8-H ₆ CDF	0.1
1,2,3,6,7,8-H ₆ CDD	0.1	1,2,3,7,8,9-H ₆ CDF	0.1
1,2,3,4,6,7,8-H ₇ CDD	0.1	1,2,3,6,7,8-H ₆ CDF	0.1
O ₈ CDD	0.001	2,3,4,6,7,8-H ₆ CDF	0.1
		1,2,3,4,6,7,8-H ₇ CDF	0.1
		1,2,3,4,7,8,9-H ₇ CDF	0.01
		O ₈ CDF	0.001

Table A-2. Interim Remediation Criteria for Soil

	Agricultural	Residential/ Parkland	Commercial/ Industrial
General Parameters			
pH	6 to 8	6 to 8	6 to 8
conductivity	2	2	4
sodium adsorption ratio	5	5	12
Inorganic Parameters			
antimony	20	20	40
arsenic	20	30	50
barium	750	500	2000
beryllium	4	4	8
boron (hot water soluble)	2	---	---
cadmium	3	5	20
chromium (*6)	8	8	---
chromium (total)	750	250	800
cobalt	40	50	300
copper	150	100	500
cyanide (free)	0.5	10	100
cyanide (total)	5	50	500
fluoride (total)	200	400	2000
lead	375	500	1000
mercury	0.8	2	10
molybdenum	5	10	40
nickel	150	100	500
selenium	2	3	10
silver	20	20	40
sulphur (elemental)	500	---	---
thallium	1	---	---
tin	5	50	300
vanadium	200	200	---
zinc	600	500	1500

Notes: All values in µg/g dry weight unless otherwise stated.

--- value not established.

See page 10 for numbered footnotes.

Table A-2. Interim Remediation Criteria for Soil (Continued)

	Agricultural	Residential/ Parkland	Commercial/ Industrial
Monocyclic Aromatic Hydrocarbons			
benzene	0.05	0.5	5
chlorobenzene	0.1	1	10
1,2-dichlorobenzene	0.1	1	10
1,3-dichlorobenzene	0.1	1	10
1,4-dichlorobenzene	0.1	1	10
ethylbenzene	0.1	5	50
styrene	0.1	5	50
toluene	0.1	3	30
xylene	0.1	5	50
Phenolic Compounds			
non-chlorinated ² (each)	0.1	1	10
chlorophenols ³ (each)	0.05	0.5	5
Polycyclic Aromatic Hydrocarbons (PAHs)			
benzo(a)anthracene	0.1	1	10
benzo(a)pyrene	0.1	1	10
benzo(b)fluoranthene	0.1	1	10
benzo(k)fluoranthene	0.1	1	10
dibenz(a,h)anthracene	0.1	1	10
indeno(1,2,3-c,d)pyrene	0.1	1	10
naphthalene	0.1	5	50
phenanthrene	0.1	5	50
pyrene	0.1	10	100
Chlorinated Hydrocarbons			
chlorinated aliphatics ⁴ (each)	0.1	5	50
chlorobenzenes ⁵ (each)	0.05	2	10
hexachlorobenzene	0.05	2	10
hexachlorocyclohexane	0.01	---	---
PCBs ⁶	0.5	5	50
PCDDs and PCDFs ⁷	0.00001	0.001	---
Miscellaneous Organic Parameters			
non-chlorinated			
aliphatics (each)	0.3	---	---
phthalic acid esters (each)	30	---	---
quinoline	0.1	---	---
thiophene	0.1	---	---

Table A-2 footnotes.

¹Criteria not recommended for commercial/industrial. One possible recourse is to use the residential/parkland value.

²Non-chlorinated phenolic compounds include

- 2,4-dimethylphenol
- 2,4-dinitrophenol
- 2-methyl 4,6-dinitrophenol
- nitrophenol (2-, 4-)
- phenol
- cresol

³Chlorophenols include

- chlorophenol isomers (ortho, meta, para)
- dichlorophenols (2,6- 2,5- 2,4- 3,5- 2,3- 3,4-)
- trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,5- 2,3,4- 3,4,5-)
- tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)
- pentachlorophenol

⁴Aliphatic chlorinated hydrocarbons include

- chloroform
- dichloroethane (1,1- 1,2-), dichloroethene (1,1- 1,2-)
- dichloromethane
- 1,2-dichloropropane, 1,2-dichloropropene (cis and trans)
- 1,1,2,2-tetrachloroethane, tetrachloroethene
- carbon tetrachloride
- trichloroethane (1,1,1- 1,1,2-), trichloroethene

⁵Chlorobenzenes include

- all trichlorobenzene isomers
- all tetrachlorobenzene isomers
- pentachlorobenzene

⁶PCBs include mixtures 1242, 1248, 1254, and 1260.

⁷PCDDs and PCDFs expressed in 2,3,7,8-TCDD equivalents. NATO International Toxicity Equivalency Factors (I-TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Congener	TEF
2,3,7,8-T ₄ CDD	1.0
1,2,3,7,8-P ₅ CDD	0.5
1,2,3,4,7,8-H ₆ CDD	0.1
1,2,3,7,8,9-H ₆ CDD	0.1
1,2,3,6,7,8-H ₆ CDD	0.1
1,2,3,4,6,7,8-H ₇ CDD	0.1
O ₈ CDD	0.001
2,3,7,8-T ₄ CDF	0.1
2,3,4,7,8-P ₅ CDF	0.5
1,2,3,7,8-P ₅ CDF	0.05
1,2,3,4,7,8-H ₆ CDF	0.1
1,2,3,7,8,9-H ₆ CDF	0.1
1,2,3,6,7,8-H ₆ CDF	0.1
2,3,4,6,7,8-H ₆ CDF	0.1
1,2,3,4,6,7,8-H ₇ CDF	0.1
1,2,3,4,7,8,9-H ₇ CDF	0.01
O ₈ CDF	0.001

Table A-3. Remediation Criteria for Water¹

	Freshwater Aquatic Life ²	Irrigation ^{2,3}	Livestock Watering ²	Drinking Water ^{4,5}
General Parameters				
oxygen, dissolved	5-9.5 mg/L	---	---	---
pH (unitless)	6.5-9.0	---	---	6.5-8.5
total dissolved solids	---	500-3500 mg/L	3000 mg/L	≤500 mg/L ^{6,7}
Inorganic Parameters				
aluminum	5-100 ⁸	5000	5000	---
ammonia	1.37-2.2 mg/L ⁹	---	---	---
antimony	---	---	---	---
arsenic	50	100	500-5000	25 ¹⁰
barium	---	---	---	1000 ¹⁰
beryllium	---	100	100 ¹¹	---
boron (hot water soluble)	---	---	---	---
boron (total)	---	500-6000	5000	5000 ⁶
cadmium	0.2-1.8 ¹²	10	20	5
calcium	---	---	1000 mg/L	---
chloride (total)	---	100-700 mg/L	---	≤250 mg/L
chloride (total residual)	2	---	---	---
chromium (*6)	---	---	---	---
chromium (total)	2-20	100	1000	50
cobalt	---	50	1000	---
copper	2-4 ¹²	200-1000 ¹³	500-5000	≤1000 ⁶
cyanide (free)	5	---	---	---
cyanide (total)	---	---	---	200 ⁶
fluoride (free)	---	---	---	---
fluoride (total)	---	1000	1000-2000	1500 ⁶
iron	300	5000	---	≤300 ¹⁰
lead	1-7 ¹²	200 ¹¹	100	10 ¹⁰
lithium	---	2500	---	---
manganese	---	200	---	≤50 ¹⁰
mercury	0.1	---	3	1
molybdenum	---	10-50	500	---
nickel	25-150 ¹²	200	1000	---
nitrate	---	---	---	45 mg/L ^{10,15}
nitrate and nitrite	---	---	100 mg/L	---
nitrite	0.06 mg/L	---	10 mg/L	4.5 mg/L ^{10,15}

Notes: All values in µg/L unless otherwise stated.

--- value not established.

See pages 15-16 for numbered footnotes.

Table A-3. Remediation Criteria for Water (Continued)

	Freshwater Aquatic Life ²	Irrigation ^{2,3}	Livestock Watering ²	Drinking Water ^{4,5}
Inorganic Parameters (cont'd)				
selenium	1	20-50	50	10
silver	0.1	---	---	---
sodium	---	--- ¹⁶	---	≤200 mg/L ¹⁰
sulphate	---	---	1000 mg/L	≤500 mg/L ¹⁰
sulphur (total)	---	---	---	---
thallium	---	---	---	---
tin	---	---	---	---
uranium	---	10 ¹¹	200	100
vanadium	---	100	100	---
zinc (total)	30 ¹¹	1000-5000 ¹⁷	50 000	≤5000 ¹⁰
Monocyclic Aromatic Hydrocarbons				
benzene	300 ¹¹	---	---	5
ethylbenzene	700 ¹¹	---	---	≤2.4
styrene	---	---	---	---
toluene	300	---	---	≤24
xylenes	---	---	---	≤300
Phenolic Compounds				
non-chlorinated ¹⁸ (each)	---	---	---	---
phenols (total)	1	---	---	---
chlorinated phenols				
monochlorophenol	7	---	---	---
dichlorophenols	0.2	---	---	900 ¹⁹ ; ≤0.3 ¹⁹
trichlorophenols	18	---	---	5 ²⁰ ; ≤2 ²⁰
tetrachlorophenols	1	---	---	100 ²¹ ; ≤1 ²¹
pentachlorophenol	0.5	---	---	60; ≤30
Polycyclic Aromatic Hydrocarbons (PAHs)				
benzo(a)anthracene	---	---	---	---
benzo(a)pyrene	---	---	---	0.01
benzo(b)fluoranthene	---	---	---	---
benzo(k)fluoranthene	---	---	---	---
dibenz(a,h)anthracene	---	---	---	---
indeno(1,2,3-c,d) pyrene	---	---	---	---
naphthalene	---	---	---	---
phenanthrene	---	---	---	---
pyrene	---	---	---	---

Table A-3. Remediation Criteria for Water (Continued)

	Freshwater Aquatic Life ²	Irrigation ^{2,3}	Livestock Watering ²	Drinking Water ^{4,5}
Chlorinated Hydrocarbons				
chlorinated aliphatics				
dichloroethane, 1,2-	100	---	---	5 ^{10,11}
dichloromethane	---	---	---	50
hexachlorobutadiene	0.1	---	---	---
hexachlorocyclohexane isomers	0.01	---	---	---
tetrachloroethylene	260 ¹¹	---	---	---
trichloroethylene	20	---	---	50 ¹⁰
chlorinated benzenes				
monochlorobenzene	15 ¹¹	---	---	80 ¹⁰ ; ≤30 ¹⁰
dichlorobenzene, 1,2-	2.5 ¹¹	---	---	200; ≤3
dichlorobenzene, 1,3-	2.5 ¹¹	---	---	---
dichlorobenzene, 1,4-	4 ¹¹	---	---	5; ≤1
trichlorobenzene, 1,2,3-	0.9 ¹¹	---	---	---
trichlorobenzene, 1,2,4-	0.5 ¹¹	---	---	---
trichlorobenzene, 1,3,5-	0.65 ¹¹	---	---	---
tetrachlorobenzene, 1,2,3,4-	0.1 ¹¹	---	---	---
tetrachlorobenzene, 1,2,3,5-	0.1 ¹¹	---	---	---
tetrachlorobenzene, 1,2,4,5-	0.15 ¹¹	---	---	---
pentachlorobenzene	0.03 ¹¹	---	---	---
hexachlorobenzene	0.0065 ¹¹	---	---	---
PCBs ²²	1 ng/L	---	---	---
PCDDs and PCDFs ²³	---	---	---	---
Halogenated Methanes				
carbon tetrachloride	---	---	---	5
trihalomethanes	---	---	---	350 ⁶
Phthalate Esters				
DBP	4	---	---	---
DEHP	0.6	---	---	---
other phthalate esters	0.2	---	---	---
Pesticides				
aldicarb	---	---	---	9
aldrin and dieldrin	4 ng/L	---	---	0.7 ⁶
atrazine	2	---	---	60 ¹¹
azinphos-methyl	---	---	---	20
bendiocarb	---	---	---	40

Table A-3. Remediation Criteria for Water (Continued)

	Freshwater Aquatic Life ²	Irrigation ^{2,3}	Livestock Watering ²	Drinking Water ^{4,5}
Pesticides (cont'd)				
bromoxynil	---	---	---	5 ¹¹
carbaryl	---	---	---	90
carbofuran	1.75	---	---	90
chlordane	6 ng/L	---	---	7 ⁶
chlorpyrifos	---	---	---	90
cyanazine	2 ¹¹	---	---	10 ¹¹
2,4-D	4	---	---	100 ⁶
DDT	1 ng/L	---	---	30 ^{6,24}
diazinon	---	---	---	20
dicamba	---	---	---	120
diclofop-methyl	---	---	---	9
dimethoate	---	---	---	20 ¹¹
diquat	---	---	---	70
diuron	---	---	---	150
endosulfan	0.02	---	---	---
endrin	2.3 ng/L	---	---	---
glyphosate	65	---	---	280 ¹¹
heptachlor (+ metabolite)	0.01	---	---	3 ⁶
lindane	---	---	---	4 ⁶
malathion	---	---	---	190
methoxychlor	---	---	---	900
metolachlor	---	---	---	50 ¹¹
metribuzin	1	---	---	80
paraquat	---	---	---	10 ¹¹
parathion	---	---	---	50
phorate	---	---	---	2 ¹¹
picloram	29 ¹¹	---	---	190 ^{10,11}
simazine	---	---	---	10 ¹¹
2,4,5-T	---	---	---	280; ≤20
temephos	---	---	---	280 ¹¹
terbufos	---	---	---	1 ¹¹
toxaphene	8 ng/L	---	---	---
triallate	---	---	---	230
trifluralin	---	---	---	45 ^{10,11}

Table A-3. Remediation Criteria for Water (Continued)

	Freshwater Aquatic Life ²	Irrigation ^{2,3}	Livestock Watering ²	Drinking Water ^{4,5}
Radiological Parameters				
¹³⁷ cesium	---	---	---	50 Bq/L ⁶
¹³¹ iodine	---	---	---	10 Bq/L ⁶
²²⁶ radium	---	---	---	1 Bq/L ⁶
⁹⁰ strontium	---	---	---	10 Bq/L ⁶
³ tritium	---	---	---	40 000 Bq/L ⁶

Table A-3 footnotes.

¹ Guidelines for freshwater aquatic life, irrigation, and livestock watering (columns 1, 2, and 3, respectively) are taken from the Canadian Water Quality Guidelines (CWQG) (CCREM 1987). The CWQG also recommends guidelines for recreational uses and several specific industrial uses, which are not included in this table. Guidelines for drinking water (column 4) are taken from the Guidelines for Canadian Drinking Water Quality (GCDWQ) (Health and Welfare Canada 1989).

² Guidelines for heavy metals and trace ions are reported as total concentrations in an unfiltered sample.

³ Applies to all soils; for details on neutral to alkaline soils, refer to CREM (1987).

⁴ Drinking water guidelines are expressed as maximum acceptable concentrations (MAC), and are for unfiltered samples at the point of consumption. Heavy metals and trace ions are expressed as total concentrations (particulate and dissolved) unless otherwise indicated.

⁵ Several parameters also have aesthetic objectives; these are indicated by a "≤" symbol.

⁶ Guideline under review for addition to the GCDWQ or possible changes to the current value. Refer to the latest edition of the GCDWQ.

⁷ The total dissolved solids concentration of 500 mg/L is approximately equal to a conductivity of 1 dS/m.

⁸ Guideline varies with pH, calcium, and dissolved organic carbon concentrations.

⁹ Guideline changes with temperature and pH.

¹⁰ A modification to the previous guideline is proposed. If after one year, no evidence is presented that questions the suitability of this proposal, it will be adopted as the guideline. Refer to the latest edition of the GCDWQ.

¹¹ Tentative water quality guideline/interim drinking water guideline because of insufficient evidence; refer to the latest edition of the CWQG or GCDWQ.

¹² Guideline changes with hardness.

¹³ Guideline varies depending on crop.

¹⁴ Avoid concentrations that stimulate prolific weed growth.

¹⁵ Equivalent to 10.0 mg/L nitrate as nitrogen. Where nitrate and nitrite are determined separately, levels of nitrite should not exceed 4.5 mg/L (1.0 mg/L as nitrogen).

¹⁶ Refer to CREM (1987).

¹⁷ Guideline changes with pH.

Table A-3 footnotes continued.

¹⁸Non-chlorinated phenolic compounds include

- 2,4-dimethylphenol
- 2,4-dinitrophenol
- 2-methyl 4,6-dinitrophenol
- nitrophenol (2-, 4-)
- phenol
- cresol

¹⁹As 2,4-dichlorophenol.

²⁰As 2,4,6-trichlorophenol.

²¹As 2,3,4,6-tetrachlorophenol.

²²Total PCB analysis only for freshwater aquatic life guidelines.

²³Quoted as 2,3,7,8-TCDD equivalents. PCDDs and PCDFs expressed in 2,3,7,8-TCDD equivalents. NATO International Toxicity Equivalency Factors (I-TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Congener	TEF
2,3,7,8-T ₄ CDD	1.0
1,2,3,7,8-P ₅ CDD	0.5
1,2,3,4,7,8-H ₆ CDD	0.1
1,2,3,7,8,9-H ₆ CDD	0.1
1,2,3,6,7,8-H ₆ CDD	0.1
1,2,3,4,6,7,8-H ₇ CDD	0.1
O ₈ CDD	0.001
2,3,7,8-T ₄ CDF	0.1
2,3,4,7,8-P ₅ CDF	0.5
1,2,3,7,8-P ₅ CDF	0.05
1,2,3,4,7,8-H ₆ CDF	0.1
1,2,3,7,8,9-H ₆ CDF	0.1
1,2,3,6,7,8-H ₆ CDF	0.1
2,3,4,6,7,8-H ₆ CDF	0.1
1,2,3,4,6,7,8-H ₇ CDF	0.1
1,2,3,4,7,8,9-H ₇ CDF	0.01
O ₉ CDF	0.001

²⁴Includes DDT metabolites.

III. SITE DELINEATION

Upon arrival at the site in June of 1996, the five member team cordoned off the areas around each building where contamination was detected using yellow caution tape, and posted signs to warn people of the presence of contamination (Photograph III-1). Based on estimates of the total area affected in each location where contamination was detected, grids were set up and delineation soil samples collected at each point along the grid. Topography and large pieces of debris influenced the pattern of the grids in many cases. For quality assurance/quality control purposes duplicate samples were collected at approximately 10% of all sample locations (see Chapter V, Appendix C for details). Test pits were dug to determine the depth of contamination in each area. Sample processing and analyses were conducted in the Indian and Northern Affairs Canada Field Operations Office located in Beaver Creek, YT (Photograph III-2). Delineation soil samples were analyzed for lead, copper and zinc in the field by X-ray fluorescence (XRF) field test kit and for PCBs by both EnviroGard™ Immuno-assay PCB field test kits and traditional laboratory methods (see Appendix A: Methods).¹⁵ Field test kit (both inorganic and PCB) results were confirmed for approximately 10% of samples analyzed. Delineation soil samples requiring analysis for pesticides were sent to a southern laboratory for analysis. Collection of additional delineation soil samples was required in cases where analyses showed that the affected area exceeded the delineated area. Delineation of contaminated areas was conducted in incremental stages so that additional cost associated with over-sampling could be avoided. Maps showing the lateral extent of contamination were produced for the contracted engineer (Lorimer and Associates in conjunction with Hemmera Resource Consultants Ltd.) and construction workers to direct soil excavation activities.

¹⁵ Confirmatory soil samples were analyzed for the full suite of nine inorganic contaminants for which assessment samples were analyzed.



Photograph III-1: Signs and yellow caution tape were used to warn recreational visitors that contamination was present around the buildings at Snag Airstrip.



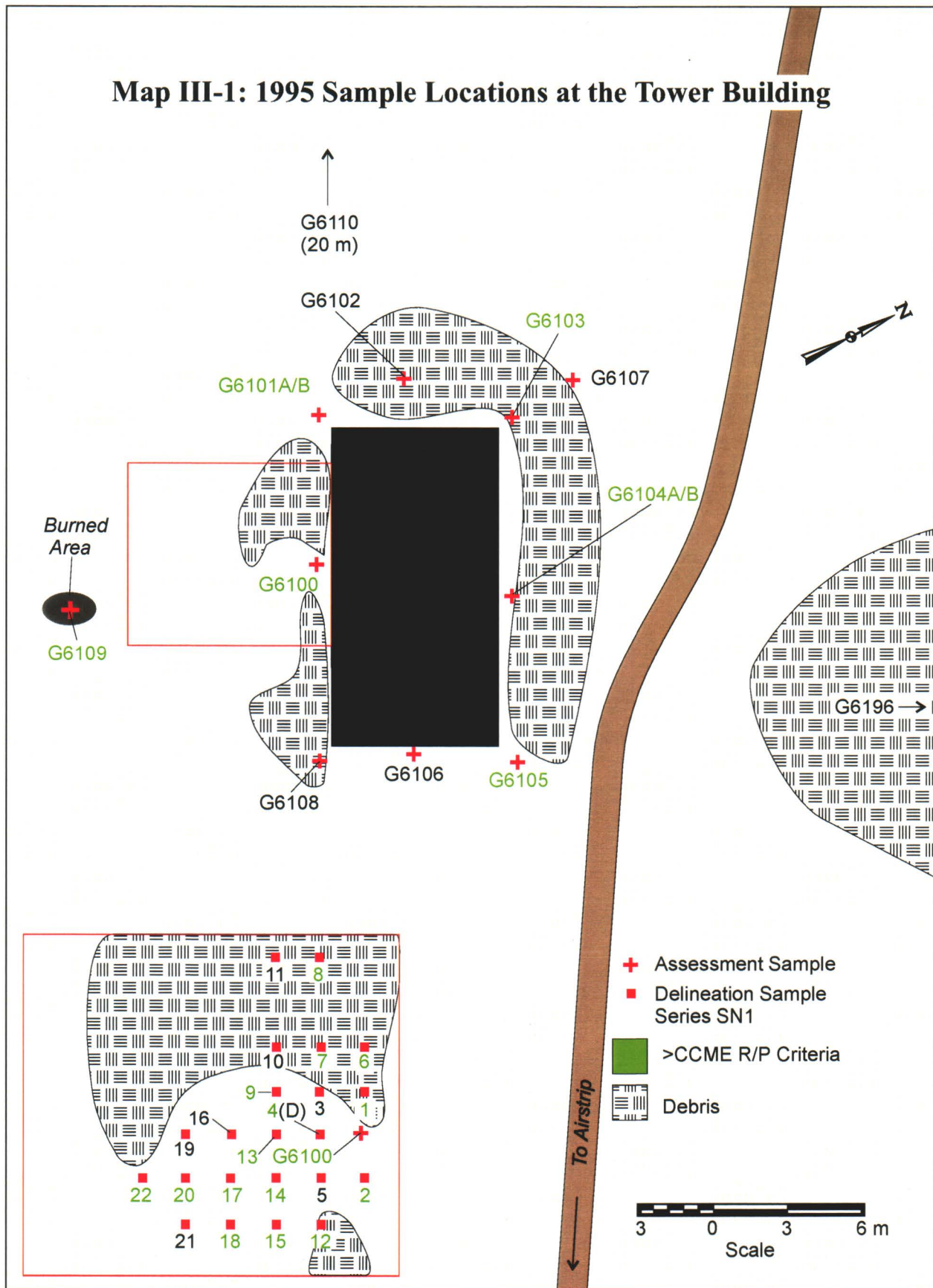
Photograph III-2: Soil samples were homogenized and laid out to dry on laboratory-grade paper towels before they were analyzed.

A. Tower Building

The Tower Building, located at the south end of the site approximately 100 m northwest of the airstrip, functioned as a communications and administration building during the operation of the airstrip (Map II-1, Photograph III-3). A different structure stood at this site at one time, and one of its functions was that of radio tower: hence the name of the present structure. The Tower Building was partially demolished in early 1995, and as a result the area around the building was littered with wood, pressboard, glass, paint chips sheet metal and piping. In 1995, ESG collected 13 assessment and 23 delineation soil samples from around the Tower Building - six of the assessment soil samples and 15 of the delineation soil samples contained inorganic contaminants including lead, zinc, and copper at concentrations exceeding the CCME Residential/Parkland (R/P) Remediation Criteria (Map III-1). PCBs and pesticides were also found at concentrations exceeding the applicable remediation criteria in one sample that also contained metals above the criteria.

Ninety delineation soil samples, including 5 field duplicates and one sample collected at depth, were collected in either a 3 m x 2 m, or a 2 m x 2 m grid around the Tower Building in 1996. Of those samples, 52 were analyzed on site by XRF test kit for lead, copper and zinc, and 20 were found to contain at least one of these contaminants at concentrations exceeding the CCME R/P Criteria. Map III-2 illustrates where delineation soil samples were collected during the 1996 ESG field program and the extent of contaminated areas as determined by field analyses. The total area of soil with contaminant concentrations exceeding the CCME R/P Remediation Criteria was determined to be approximately 200 m².

Map III-1: 1995 Sample Locations at the Tower Building





Photograph III-3: The Tower Building as it appeared in July 1995, before the start of remediation activities in June 1996.

B. DOT Barracks Building

The DOT Barracks Building, located in the southern half of the site 50 m north of the Tower Building, contained a kitchen and living quarters for several personnel (Map II-1, Photograph III-4). All that remained of this building was a concrete foundation with basement, a large concrete chimney and some rectangular concrete supports. The area around the Barracks Building was littered with metallic debris, and there was a layer of moss and debris on the floor of the basement. In 1995, ESG collected 14 assessment soil samples - from around the DOT Building. Six of these samples including a field duplicate contained several inorganic contaminants at concentrations exceeding the CCME Residential/Parkland (R/P) Remediation Criteria, and dioxins were detected at elevated concentrations in the moss and debris collected from the floor of the basement. In addition, PCBs were present at a level exceeding that regulated by the Canadian Environmental Protection Act (CEPA, Map III-3).

Forty-three delineation soil samples including four field duplicates were collected in the Barracks area in 1996 (Photograph III-5). The thin layer of moss on the basement floor was not delineated but estimated to be uniformly contaminated with PCBs at a concentration exceeding 50 ppm. Of the delineation soil samples collected around the foundation, 40 (93%) were analyzed on site by XRF test kit for lead, copper and zinc, and 13 were found to contain at least one of these contaminants at concentrations exceeding the CCME R/P Criteria. Map III-3 illustrates where delineation soil samples were collected during the 1996 ESG field program, and the extent of contaminated areas as determined by field analyses. Contamination was confined to the immediate area of the building, including a narrow trench that ran between the concrete supports to the northeast. Debris and moss covering an area of approximately 45 m² contained PCBs at concentrations above 50 ppm, and in another area of approximately 75 m² soil contained metals at concentrations above the CCME R/P Remediation Criteria.

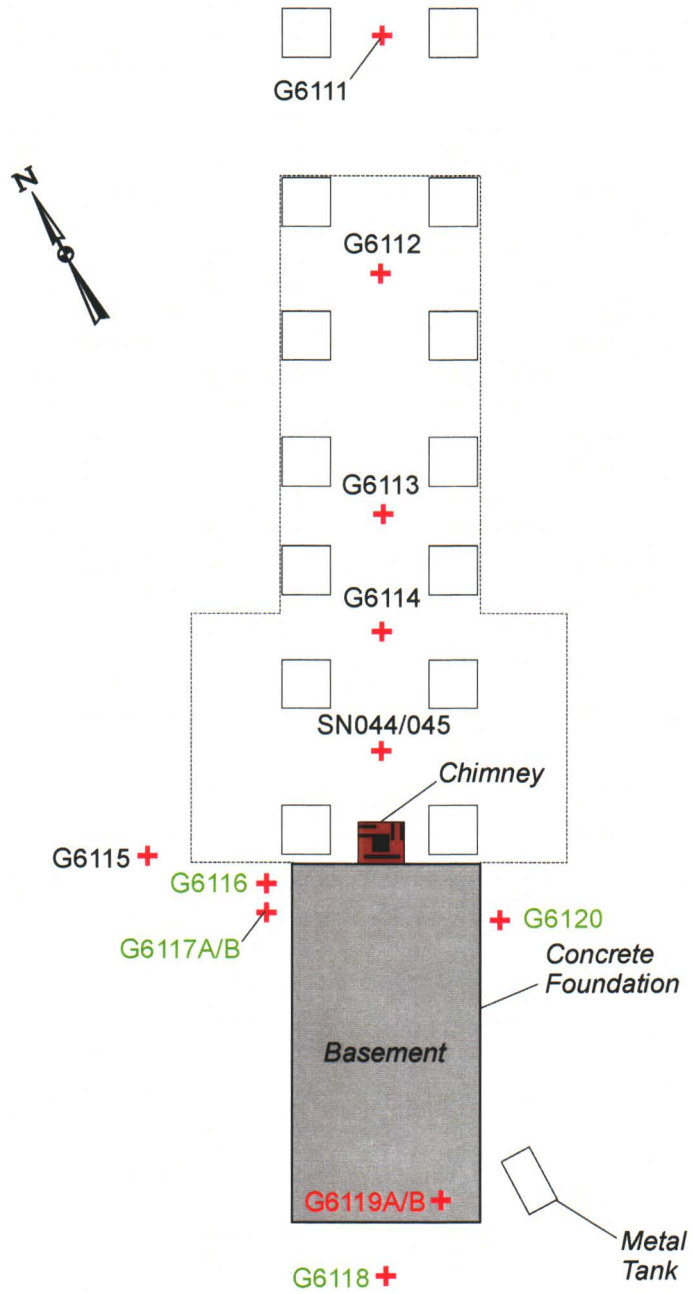


Photograph III-4: The DOT Barracks Building remains as they appeared in 1995.



Photograph III-5: Delineation of the south side of the DOT Barracks Building - sample locations are indicated by the arrows.

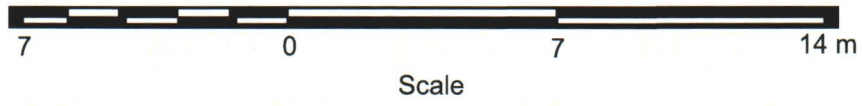
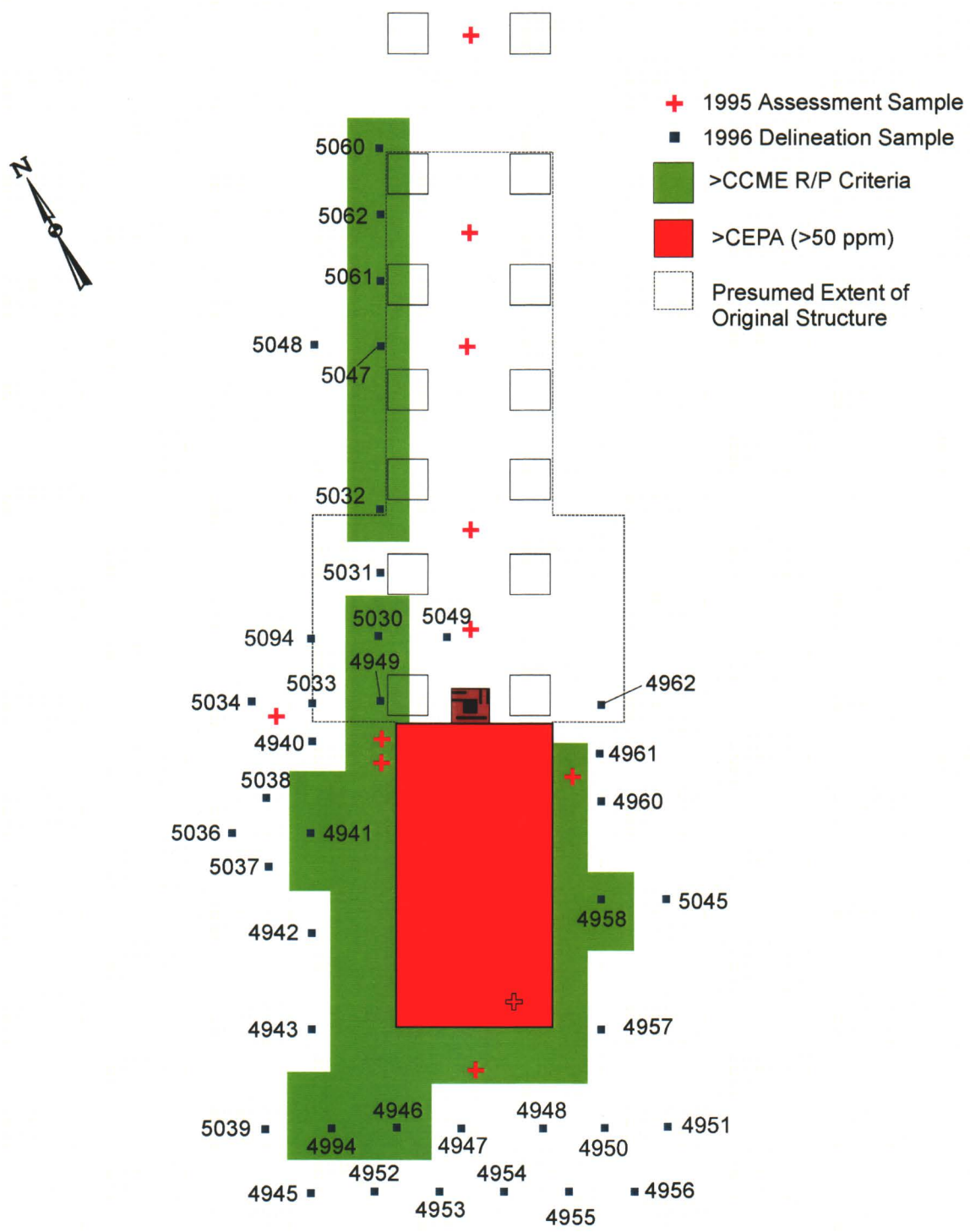
Map III-3: 1995 Sample Locations at the DOT Barracks



- + Assessment Sample
- >CCME R/P Criteria
- >CEPA (>50 ppm)
- Presumed Extent of Original Structure



Map III-4: 1996 Delineation Sample Locations at the DOT Barracks



C. Warehouse

The Warehouse was located between the DOT Barracks Building and the Married Quarters on the east side of the Snag Road (see Map II-1, Photograph III-6). All that remained of the Warehouse was its foundation and a wooden staircase running off its northwest end. A painted wooden pallet/platform, some transformer plates and a transformer case made up the bulk of debris in the immediate area of the warehouse. In addition, some grey powder with a metallic appearance was scattered over the foundation surface.

In total, eight assessment soil samples were collected around the Warehouse in 1994 and 1995 (Map III-5). Six of these contained at least one contaminant at concentrations exceeding the applicable criteria. Contaminants exceeding the criteria included lead, zinc, copper, chromium and pesticides - soil from the west side of the foundation (G6121) leached lead at concentrations classified as hazardous according to the British Columbia MOE Leachate Criteria. During the 1995 assessment conducted by ESG, 43 delineation soil samples were collected from three different locations around the warehouse where it had been determined that one or more metals exceeded the CCME R/P Criteria: 21 delineation soil samples were collected in a grid around assessment soil sample G6121, collected off the west side of the Warehouse Foundation and containing elevated concentrations of copper, zinc and particularly, lead; 11 delineation soil samples were collected around assessment soil sample G6123 at the south end of the foundation containing elevated levels of copper and zinc; and finally, copper and lead contamination detected in assessment soil sample SN046 taken in a pile of transformer plates south of the foundation was delineated with 11 soil samples.

An additional 136 delineation samples, including nine field duplicates and two test pits were collected around the Warehouse Foundation in 1996 (Map III-6, Photograph III-7). Of these additional delineation soil samples, 81 (60%) were analyzed on site by XRF test kit for lead, copper and zinc, and 44 (32%) were found to contain at least one of these contaminants at concentrations exceeding the CCME R/P Criteria. Thirty-nine delineation soil samples, including three duplicates and two samples taken at depth (30-40 cm), were collected around assessment soil sample G6126 which contained elevated concentrations of the pesticide chlordane and its metabolites. Fifteen (38%) of these samples including the depth samples were analyzed in a southern laboratory for 22 pesticides, and eight (53%) contained one or more pesticide compounds at a concentration exceeding the Netherlands Level B Criteria for individual chlorinated pesticides. Map III-6

illustrates the contaminated areas as defined by field analyses. Contamination at the Warehouse was primarily confined to the immediate area of the building, and consisted of both hazardous lead toxic and pesticide-contaminated soils along the southwest and southeast ends of the foundation (110 m²), as well as nonhazardous CCME R/P contaminated soils along the northwest and northeast sides (80 m²).

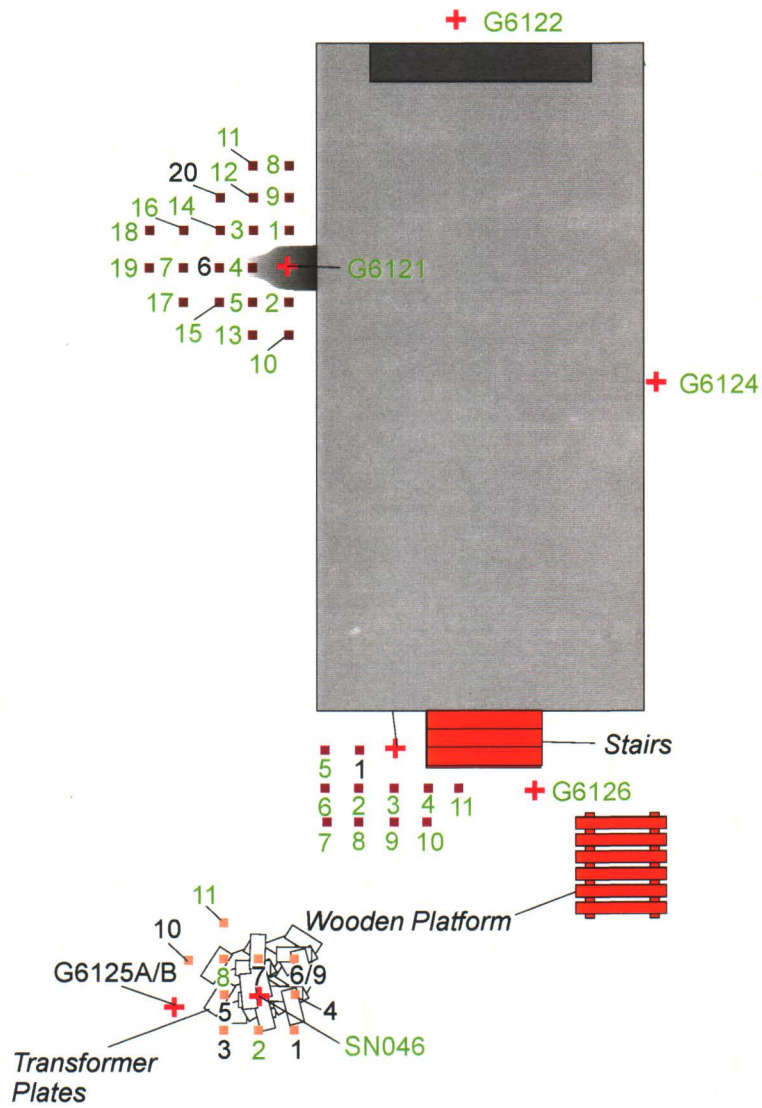


Photograph III-6: The Warehouse Foundation as it appeared prior to cleanup.



Photograph III-7: Delineation of the perimeter of the Warehouse Foundation.

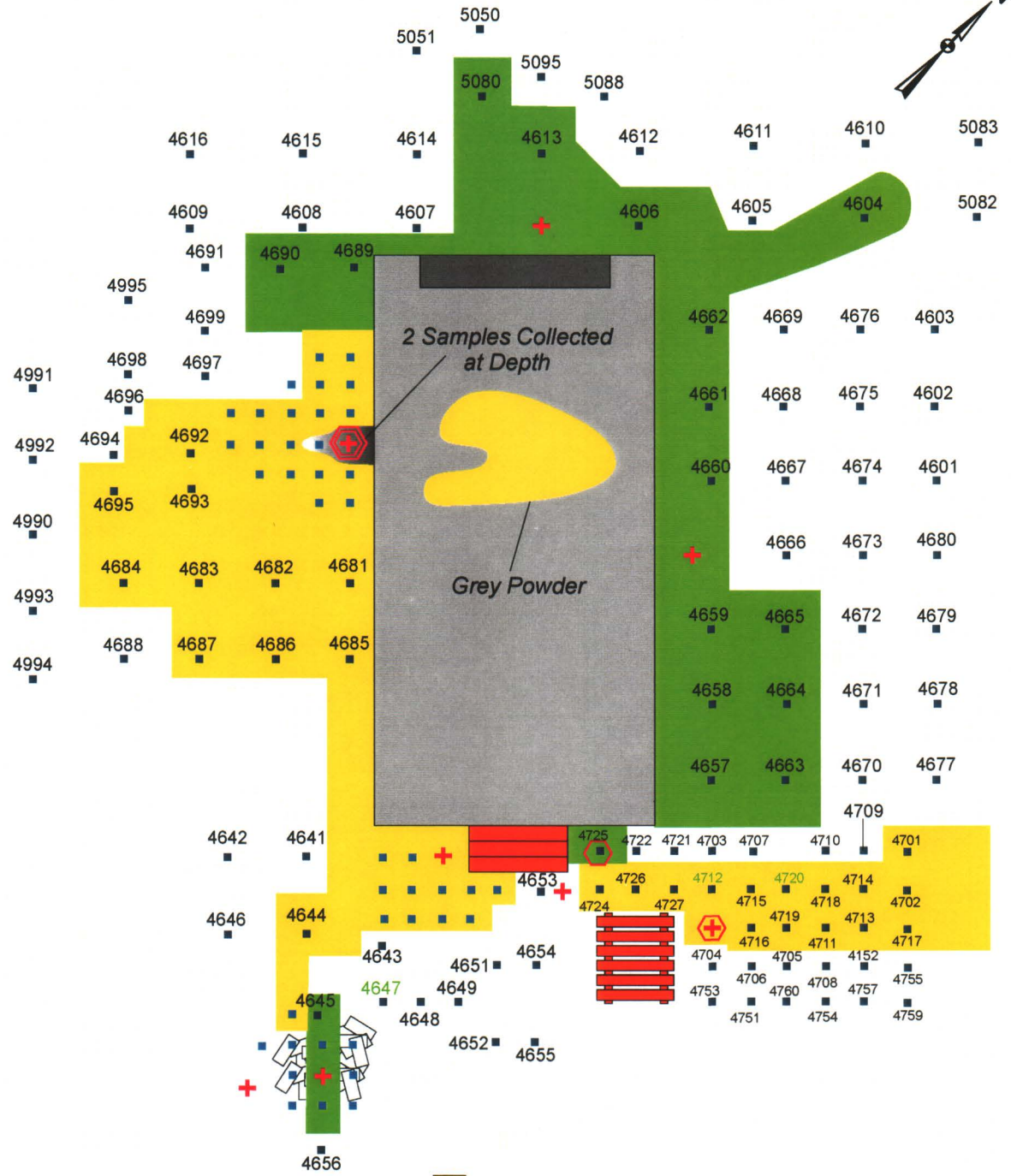
Map III-5: 1995 Sample Locations at the Warehouse



- + Assessment Sample
- Delineation Sample Series SN22
- Delineation Sample Series SN24
- Delineation Sample Series SN39
- >CCME R/P Criteria
- Stain



Map III-6: 1996 Delineation Sample Locations at the Warehouse



- + 1995 Assessment Sample
- 1995 Delineation Sample
- 1996 Delineation Sample Series
- Leachate Toxic/Pesticides
- >CCME R/P Criteria
- Stain
- Test Pit



D. Powerhouse and Pump House

The Powerhouse, and Pump House to the west of it, were located together at the north end of the site on the west side of Snag Road across from the Warehouse (see Map II-1). All that remained of the Powerhouse was the foundation and a large concrete chimney which lay across it. The Powerhouse Foundation was darkly stained by an oily substance, and littered with building materials such as pressboard, insulation, sheet metal and crumbled concrete (Photograph III-8). The Pump House consisted of a basement and a ground-level floor with a cistern attached off its western end (Photograph III-9).

A total of 31 assessment soil samples were collected around the Powerhouse and Pump House in 1994 and 1995 (Map III-7). Twenty-five of the assessment soil samples collected in this area contained at least one contaminant at concentrations exceeding the CCME R/P Remediation Criteria - of these, 11 contained PCBs at concentrations greater than 50 ppm. Materials containing more than 50 ppm PCBs are regulated under the Canadian Environmental Protection Act (CEPA). In addition to PCBs, other contaminants present at concentrations exceeding the CCME R/P criteria included zinc, lead, copper, cadmium, chromium, dioxins and pesticides.

During the 1995 assessment conducted by ESG, 33 delineation soil samples were collected at the Powerhouse and Pump House: 25 of these samples were collected at the east end of the Powerhouse Foundation to delineate PCB contamination found in assessment soil sample SN047 (5 ppm); the remaining eight samples were taken from the Pump House basement to delineate PCBs found in assessment soil sample SN049 (>50 ppm).

An additional 184 delineation samples, including 13 field duplicates and five test pits were collected around the Powerhouse and Pump House foundations in 1996 (Map III-8). Of these additional delineation soil samples, 30 (16%) were analyzed on site by XRF test kit for lead, copper and zinc, and 118 (64%) were analyzed for PCBs [92 by standard laboratory procedures (GC/ECD), 15 by test kit and 12 by both methods]. Out of the 184 delineation soil samples collected, 70 (38%) contained at least one contaminant above the applicable criteria: 35 of these contained PCB concentrations over the CCME R/P Remediation Criterion, and 12 contained more than 50 ppm PCBs, a CEPA violation. Map III-8 illustrates the extent of contamination at the Powerhouse and Pump House. CEPA-contaminated soils were confined to the Pump House basement, the north and east sides of the Powerhouse Foundation, and the debris on the surface of the foundation (total

area affected: 45 m²). CCME R/P contaminated soil was present on all four sides of the Powerhouse, but was constrained by topography to the east side of the Pump House (total area affected: 190 m²).

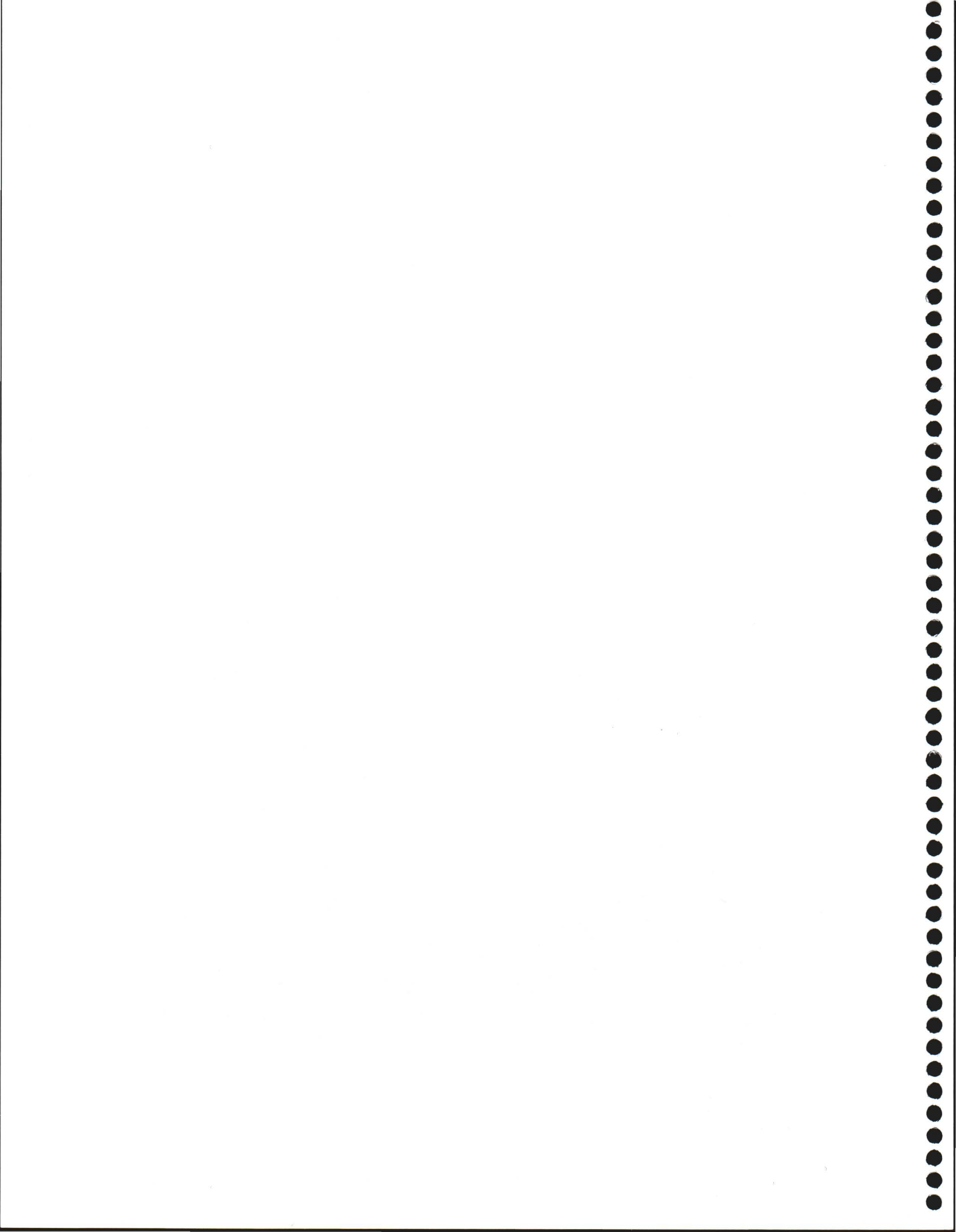
After completing the delineation sampling at the site, the ESG field team began containerizing the debris that was contaminated with PCBs above 50 ppm from the surface of the Powerhouse Foundation (Photograph III-11). Fourteen barrels were filled.



Photograph III-8: The Powerhouse and Pump House Foundations as they appeared in 1996 before their cleanup.



Photograph III-9: A close-up of the Pump House Foundation prior to cleanup.

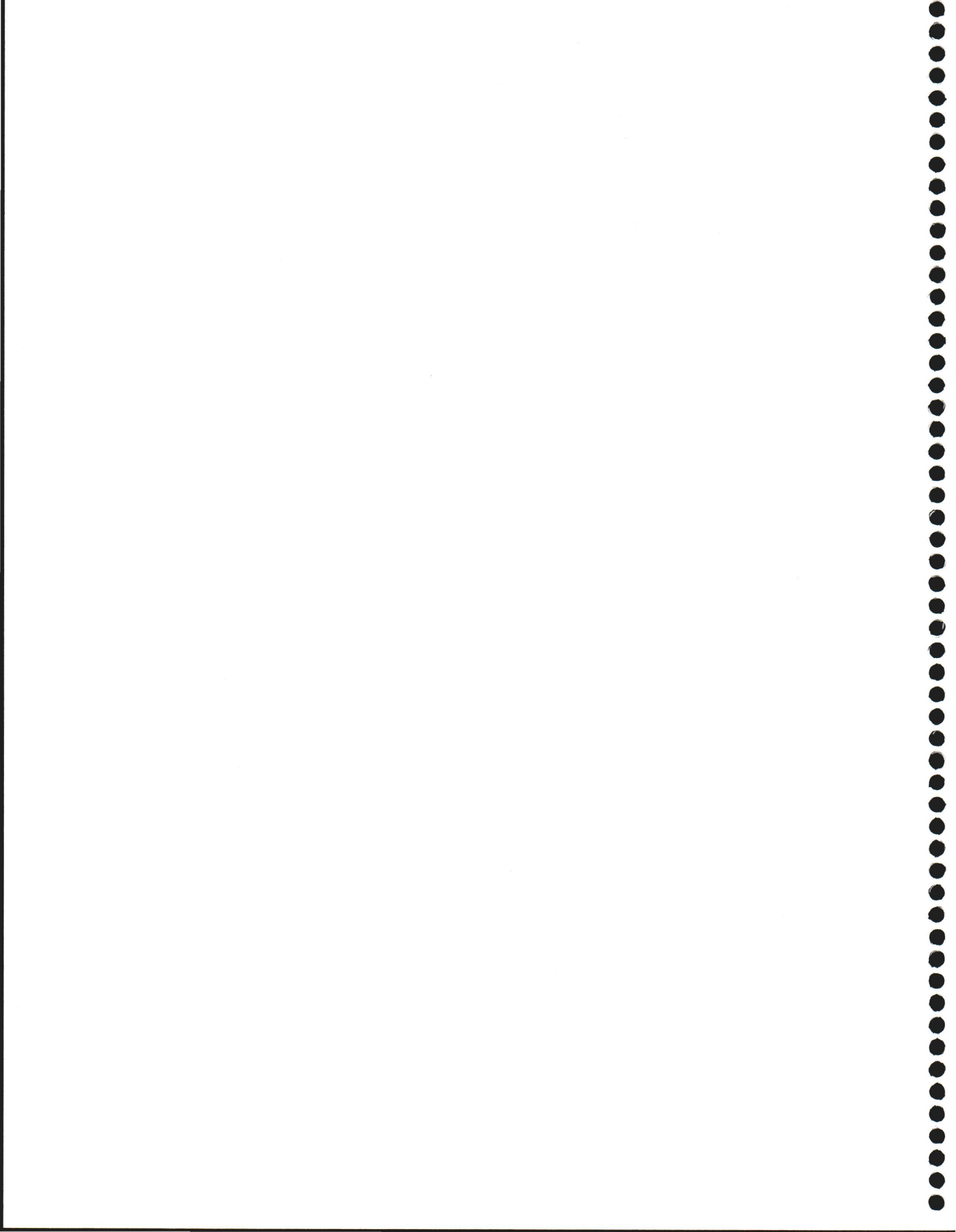




Photograph III-10: Delineation sample markers along the edge of the Powerhouse Foundation where soil was collected to determine the extent of PCB and metal contamination.

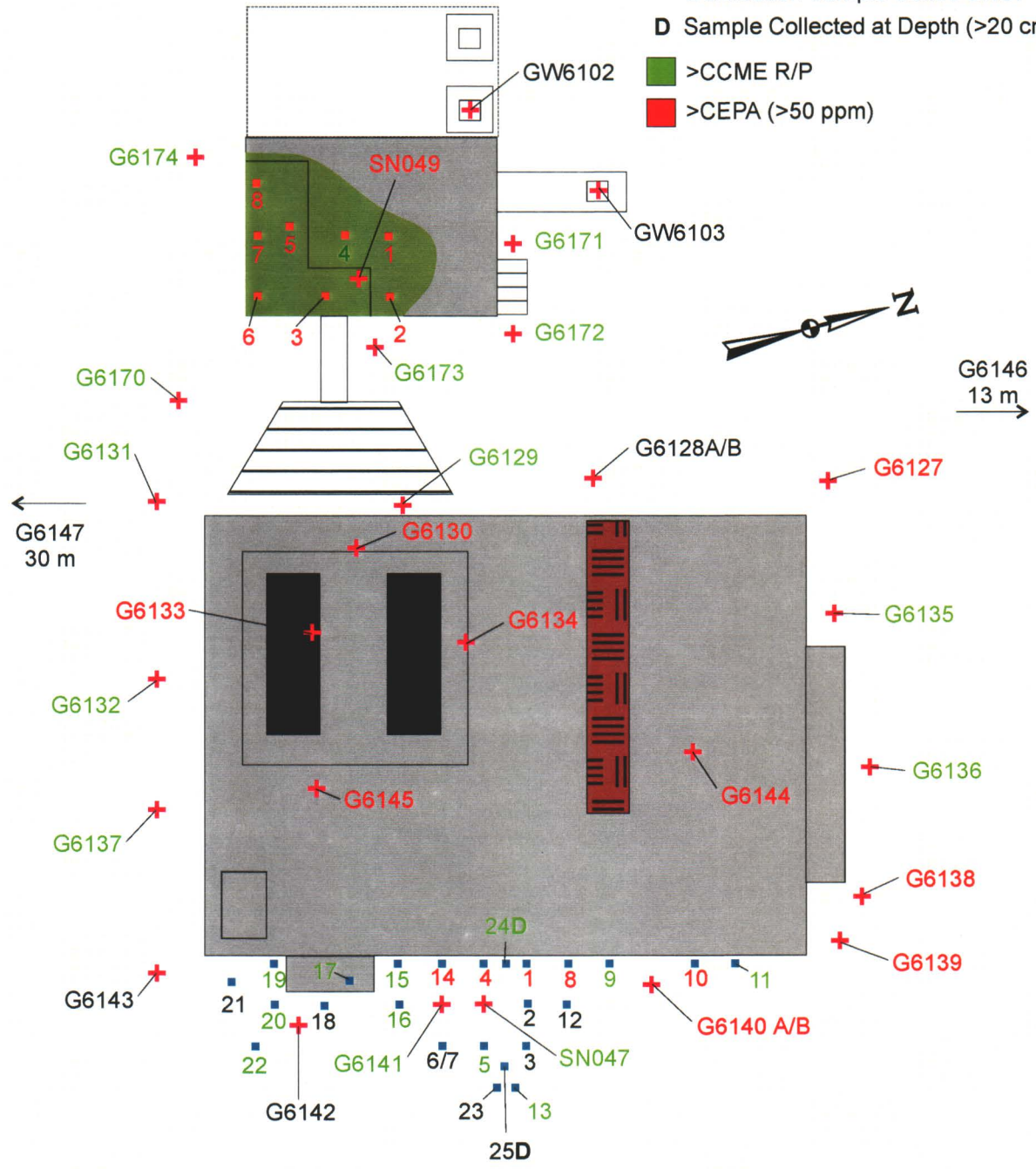


Photograph III-11: Removal of PCB-contaminated surface debris from the Powerhouse Foundation was completed by the ESG field team.



Map III-7: 1995 Sample Locations at the Powerhouse and Pump House Foundations

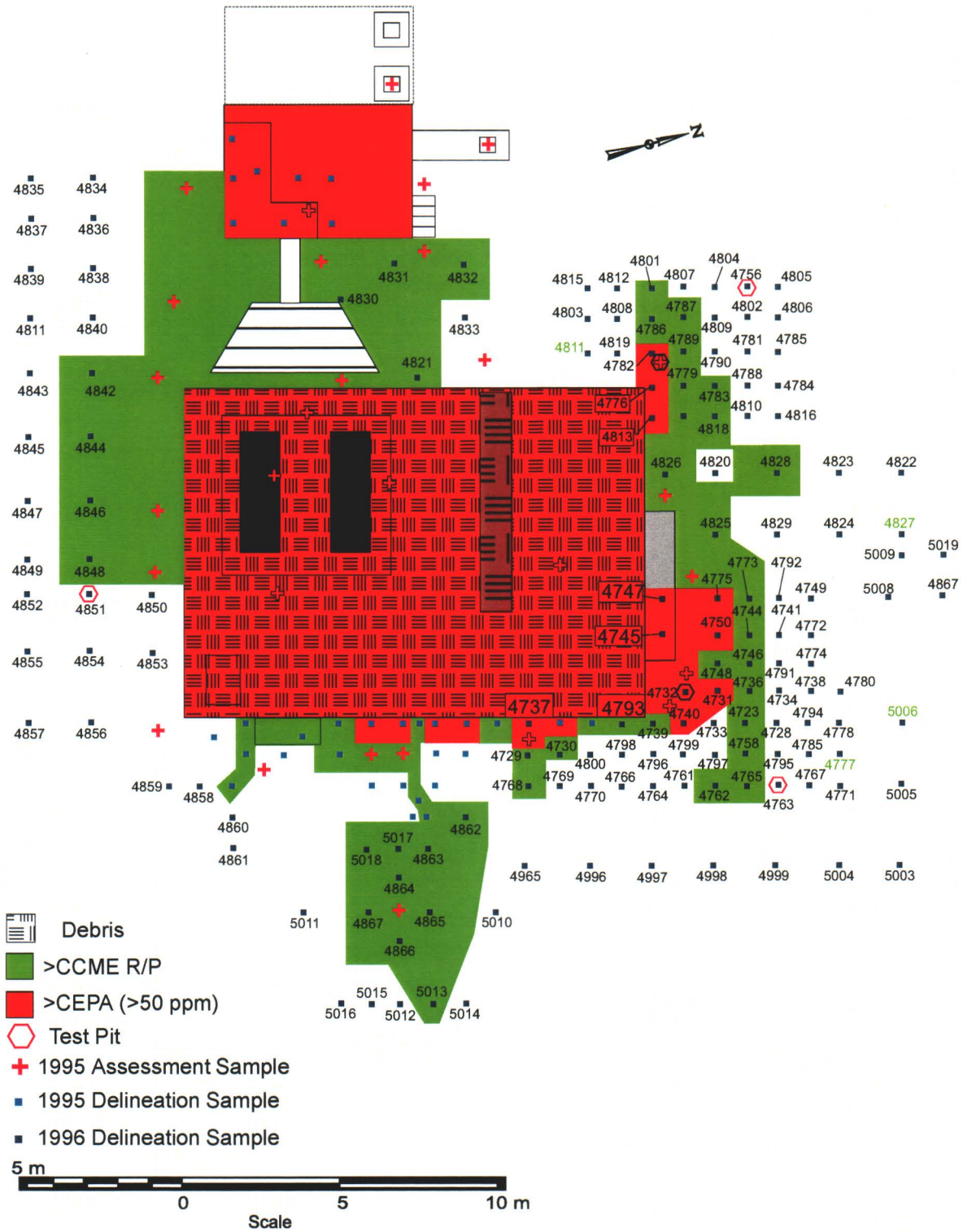
- + Assessment Sample
- Delineation Sample Series SN33
- Delineation Sample Series SNCP
- D** Sample Collected at Depth (>20 cm)
- >CCME R/P
- >CEPA (>50 ppm)



OIL 1 +++ G6185



Map III-8: 1996 Delineation Sample Locations at the Powerhouse and Pump House Foundations





E. Garage and Fire Hall

The Fire Hall was one of three buildings still standing at Snag Airstrip during the 1994-5 assessment. It was located on the western side of the site immediately north of the Garage Foundation (Map II-1). The Garage had been next to the Fire Hall, north of the main access road and west of Snag Village Road, but all that remained was its foundation (Photograph III-12).

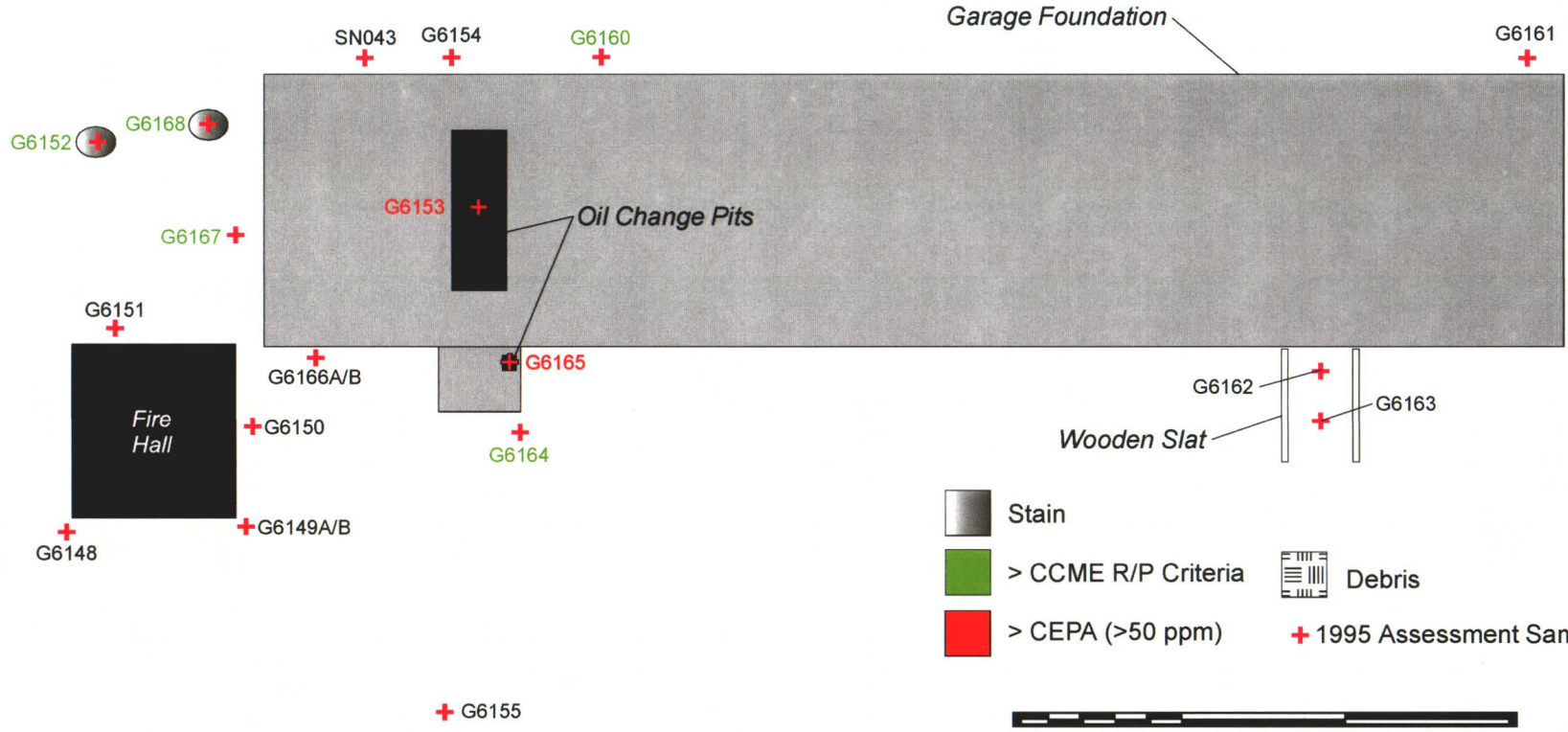
There was a small amount of scattered debris consisting of wood, metal scrap and other building materials. A total of 20 assessment soil samples were collected around the Fire Hall and the Garage Foundation (Map III-9). Seven of these contained at least one contaminant at concentrations exceeding the CCME R/P Remediation Criteria - of these, two from the Garage Foundation contained over 50 ppm PCBs. In addition to PCBs, other contaminants found at concentrations exceeding the CCME R/P criteria included zinc, lead, copper, cadmium, chromium, dioxins, pesticides and polycyclic aromatic hydrocarbons (PAHs). No dioxin, pesticide or PAH contamination was detected above the criteria except in one sample from the large oil change pit in the Garage Foundation which also contained over 50 ppm PCBs.

As part of the 1996 field program, 25 delineation soil samples, including two field duplicates and two test pit samples, were collected around the Garage Foundation and near the Fire Hall (Map III-10). Delineation of the two oil change pits containing debris contaminated with PCBs above 50 ppm was not necessary as the pits were bordered by concrete walls. Nor were three visibly stained areas (G6152, G6157 and an unsampled stain beside G6152) delineated, as the extent of contamination was defined by the stain. Twenty-two (88%) delineation soil samples were analyzed for copper, lead and zinc by XRF test kit. Of these, eight (36%) contained at least one contaminant at concentrations exceeding the applicable criteria. Map III-10 illustrates the extent of contamination defined around the Garage Foundation and the Fire Hall. Small patches of CCME contaminated soil were defined along the northern half of the Garage Foundation (total area affected: 30 m²).



Photograph III-12: The Garage Foundation and Fire Hall, viewed from the air prior to cleanup in 1996.

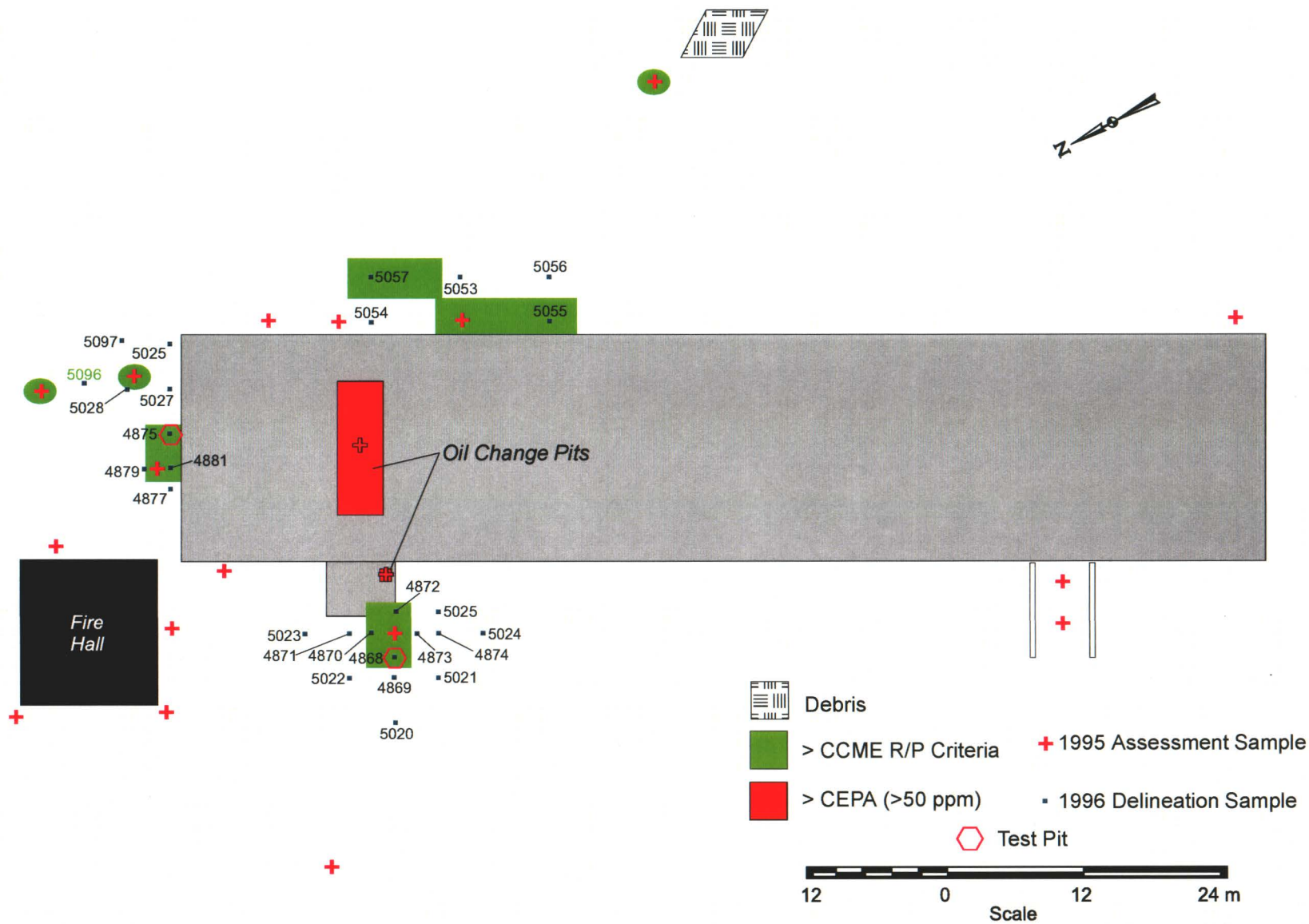
Map III-9: 1995 Sample Locations at the Garage and Fire Hall










- Stain
- > CCME R/P Criteria
- > CEPA (>50 ppm)
- Debris
- 1995 Assessment Sample



Map III-10: 1996 Delineation Sample Locations at the Garage and Fire Hall



 Debris
 > CCME R/P Criteria
 > CEPA (>50 ppm)
 1995 Assessment Sample
 1996 Delineation Sample
 Test Pit


 12 0 12 24 m
 Scale

F. Married Quarters

The Married Quarters had been located in three log cabins with painted interiors, each containing numerous rooms, situated at the north end of the site approximately 50 m east of the Powerhouse (Map III-11, Photograph III-13). Only one cabin remained at the time of the ESG site assessment. There was evidence of a septic field running northeast away from the building where most of the assessment samples had been collected. Debris in the area included metal scrap, wood and wire. Six assessment soil samples were collected in the vicinity of the Married Quarters and the septic field during the 1995 ESG study. Of these, only one sample (G6104), collected at the bottom of a manhole that was part of the septic system, contained a contaminant at elevated concentrations (copper and zinc). Delineation and excavation of the thin layer of contaminated debris in the septic system was not attempted because the enclosed space constituted a health hazard to field workers. Instead it was recommended by ESG that the septic system be thoroughly back-filled with granular material to remove the physical hazard of the holes as well as to reduce the potential for contaminant migration.

Prior to commencement of the Snag Airstrip cleanup, a request had been made by the local White River First Nations Band that ownership of either the Fire Hall or the Married Quarters be transferred to them. Therefore it was necessary during the cleanup to ensure that the Married Quarters was clean from both an environmental and human health perspective. Three samples of paint and two of wood from the interior of the building were therefore collected for inorganic and PCB analysis (Figure III-1, Photograph III-14). Although all the paint chip samples contained elevated concentrations of lead, copper, zinc and PCBs, the results were comparable to those obtained for paint from the Tower Building, and it was determined in the 1995 study that these contaminants did not leach from the paint. The wood samples taken from the interior of the Married Quarters both contained elevated concentrations of lead and zinc. Previously insulation from the building was found not to contain asbestos (<0.5%). Based on the paint chip results the recommendation was made that all painted surfaces and interior walls be removed from the building and placed in the containment cell before transferring ownership (Photograph III-15, Photograph III-16).

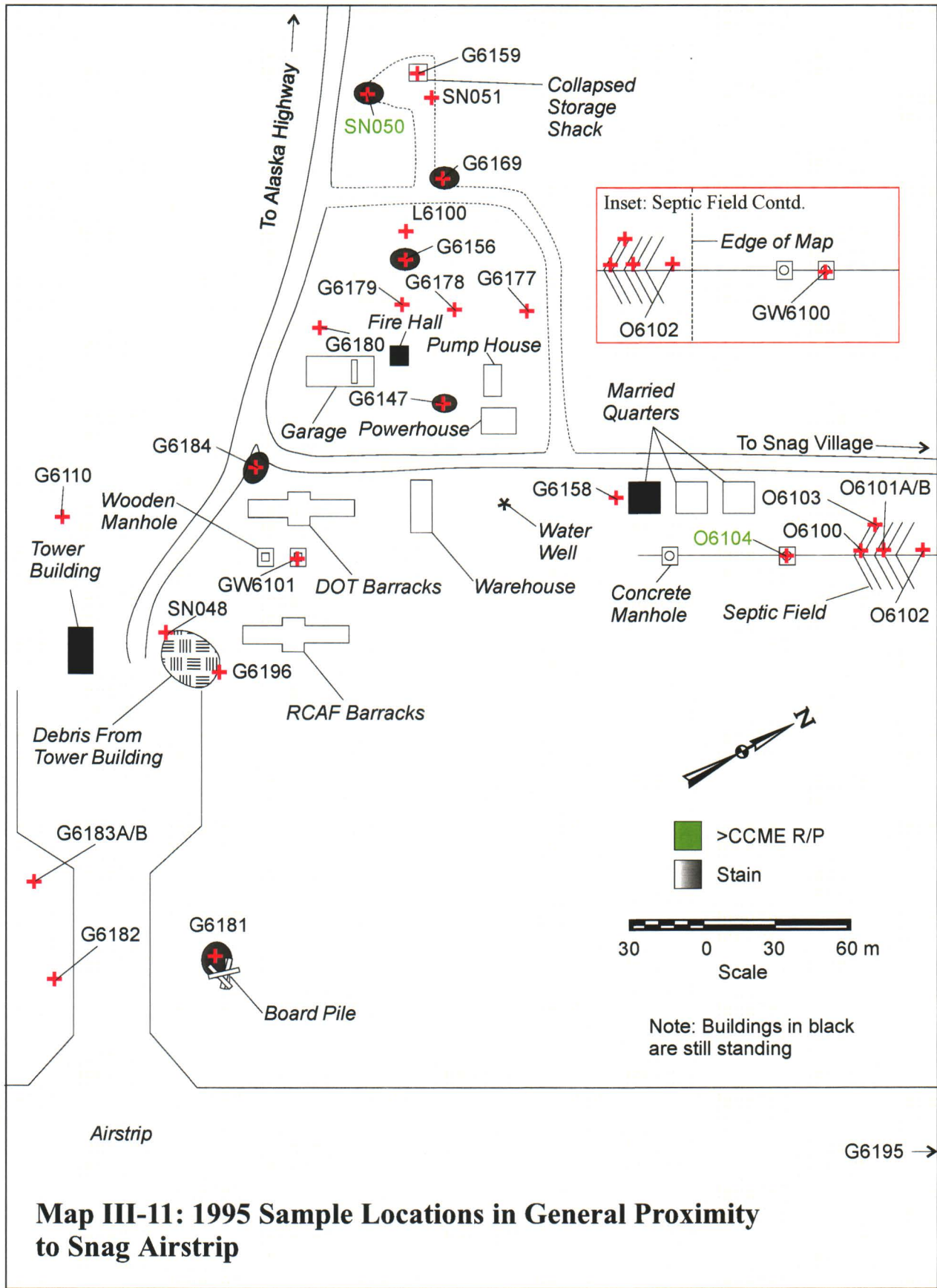
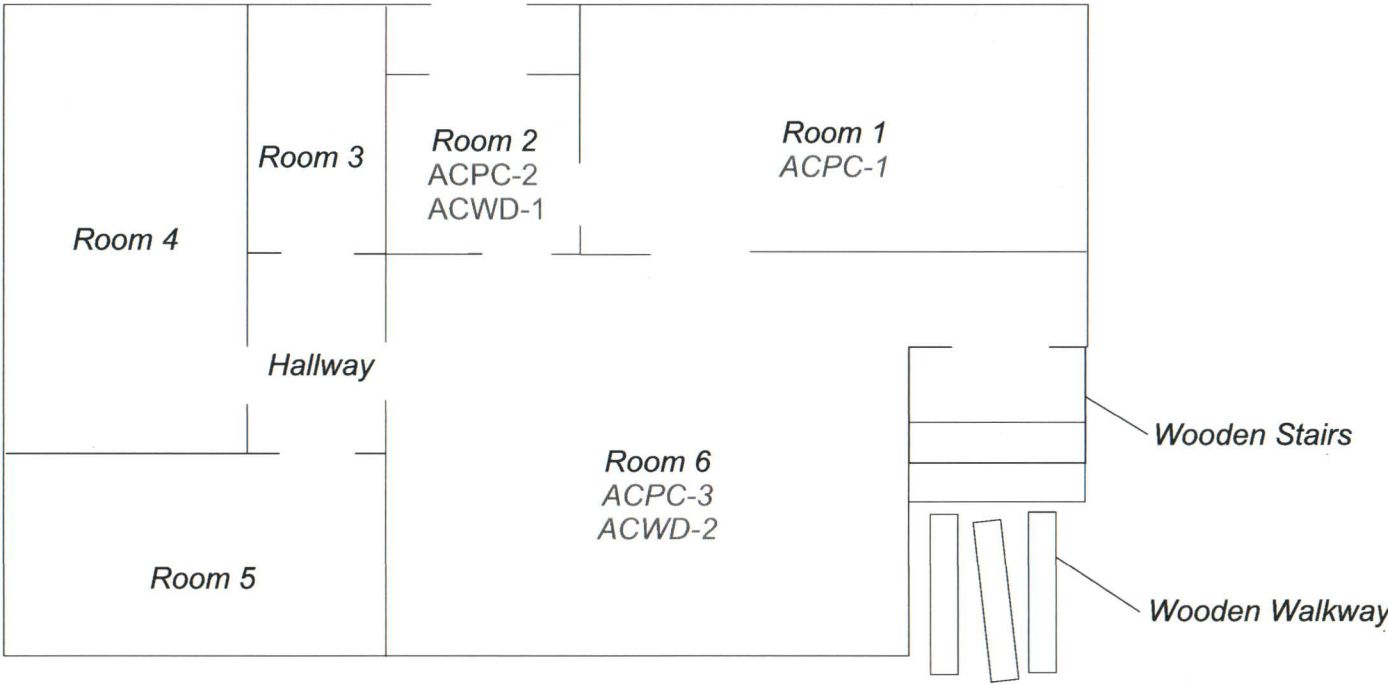


Figure III-1: Paint Chip and Wood Sample Locations in the Married Quarters





Photograph III-13: The Married Quarters as they appeared prior to cleanup in 1996.



Photograph III-14: The interior of the Married Quarters had been vandalized over the years prior to the cleanup.



Photograph III-15: The exterior of the Married Quarters after all interior materials with painted surfaces were removed.



Photograph III-16: The interior of the Married Quarters following the removal of all interior materials with painted surfaces.

G. Beacon Site

The Beacon Site was located approximately 7.5 km northeast of Snag Airstrip proper (see Map II-1). The remains of a road from Snag Airstrip ascends the hill to the site, which is marked by the charred remains of the building and its contents, a single downed telegraph pole and some dismantled wooden antenna towers (Photograph III-17). The site is only accessible by helicopter, or on foot if the Snag Creek is passable. Some wood, metal scrap and other building materials constituting a small amount of debris were found in the area. A total of eight assessment soil samples, including one field duplicate, were collected at the Beacon Site in 1995 (Map III-12). Metals were the only contaminants that were found to be in excess of the CCME R/P Remediation Criteria - three of the assessment soil samples (G6186A/B and G6187), including the field duplicate, contained elevated concentrations of copper, nickel, zinc and/or arsenic. In addition, paint chip samples collected from the dismantled antenna towers contained elevated concentrations of lead, zinc, chromium and cobalt. None of these metals leached from the medium in which they were found.

As part of the 1996 field program, 55 delineation soil samples including five field duplicates and one test pit sample were collected in the area of G6186 and G6187 (Map III-13, Photograph III-18). A total of 37 (67%) delineation soil samples from the Beacon Site were analyzed for copper, lead and zinc by XRF test kit. Of the delineation soil samples analyzed, only four (11%) contained one of these metals at a concentration exceeding the applicable criteria. As shown in Map III-13, contamination at the Beacon Site was confined to the area of the building remains (total area affected: 70 m²).

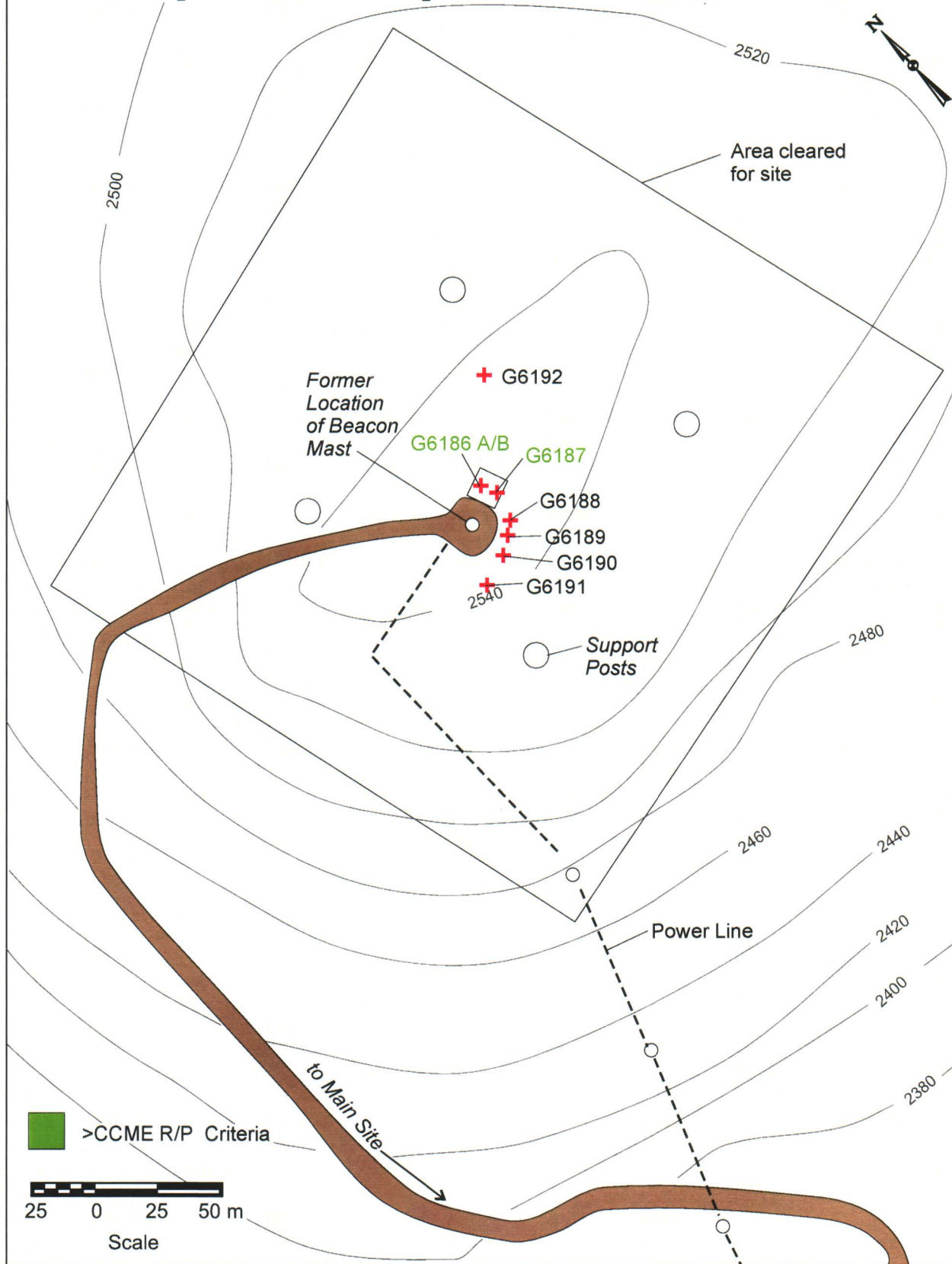


Photograph III-17: The location of the building at the Beacon Site, viewed from the air prior to cleanup in 1996.

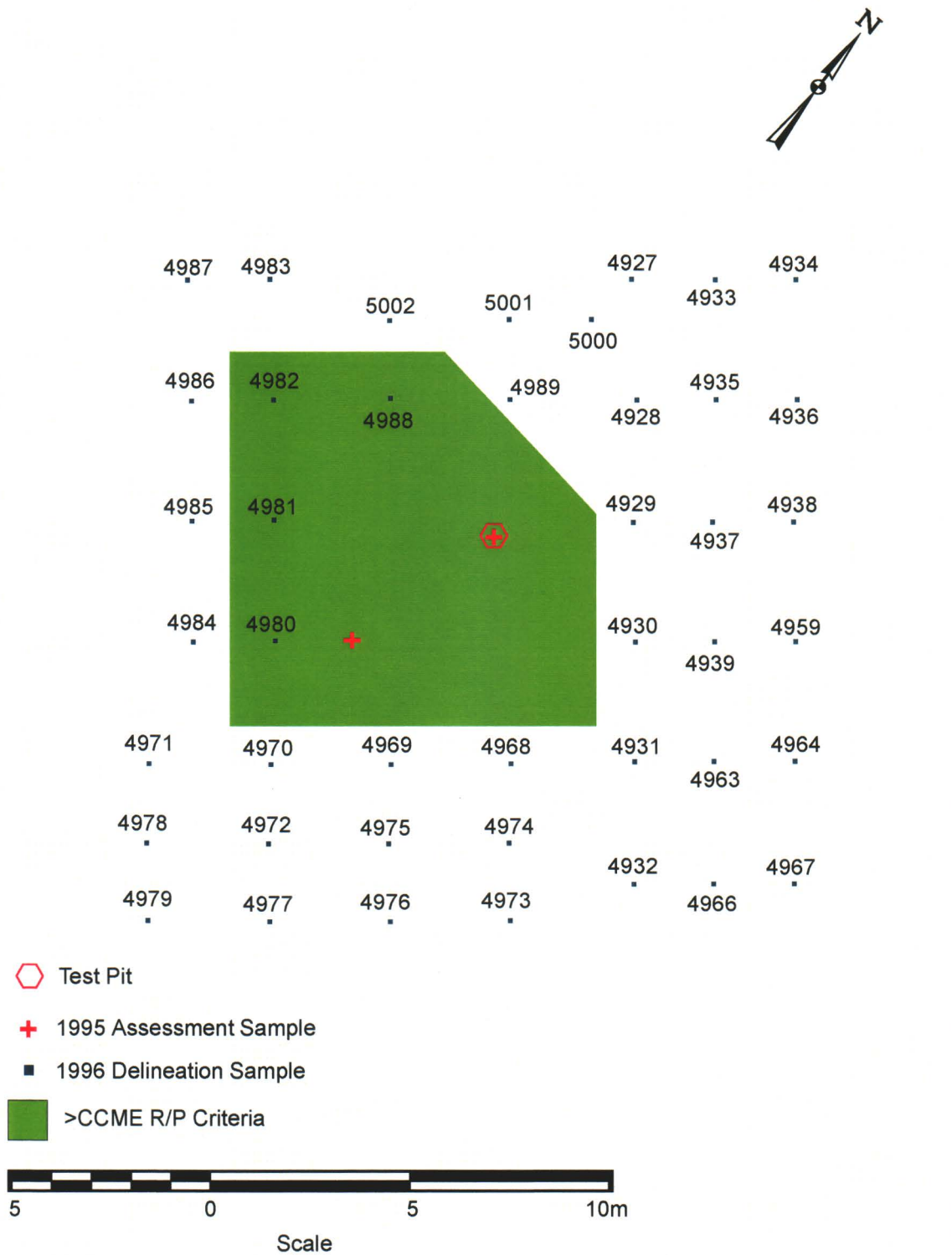


Photograph III-18: Delineation at the Beacon Site.

Map III-12: 1995 Sample Locations at the Beacon Site



Map III-13: 1996 Delineation Sample Locations at the Beacon Site



IV. SUMMARY

A. Background

In the summer of 1994 and 1995, the Environmental Sciences Group conducted an environmental assessment of Snag Airstrip, Yukon Territory. The World War II military site functioned as part of the Northwest Staging Route in the 1940s, and after the war, continued to operate as an airstrip until it was eventually closed in 1966. The assessment at Snag Airstrip was commissioned by Indian and Northern Affairs Canada of Whitehorse YT, under their *Arctic Environmental Strategy* Action on Waste program.

The results of the ESG assessment indicated that soil at Snag Airstrip was contaminated extensively with metals and polychlorinated biphenyls (PCBs) and, to a lesser extent, with pesticides, dioxins and polycyclic aromatic hydrocarbons. PCBs were detected at elevated concentrations in three different areas of the site. The contamination was shown to be exerting a significant impact on the local plant life, and there was a concern that it could be transferred up the foodchain. ESG recommended that the contaminated soils be excavated and placed in a secure landfill designed to contain contaminated materials,¹⁶ and these recommendations were carried out the following summer. Snag Airstrip is the second site on the Northwest Staging Route to be assessed and cleaned up - the cleanup of Aishihik Airstrip was completed a year earlier, in the summer of 1995.

B. Sampling Program

Field work was conducted at Snag Airstrip from 25 June to 17 July, 1996. In all, 547 samples of various media were collected. Although paint chip and wood samples were collected during the 1995 environmental assessment, additional samples were collected from the only two buildings on site still standing, the Fire Hall and Married Quarters, to determine which of these buildings would be more suitable for transfer to the White River First Nation. Samples of insulation and floor tiles from the Married Quarters were collected for the same reason, and were also collected from the Fire Hall to ensure worker safety during its demolition. The number and type of samples collected during the 1996 field program are outlined in Table IV-1.

¹⁶ ESG, 1996.

In total, 533 delineation soil samples were collected in a grid pattern in areas of previously detected contamination (as part of 1994 and 1995 ESG studies). A breakdown of the number of delineation samples by area is presented in Table IV-2, and the samples are indicated on the appropriate maps in Chapter III.

Table IV-1: Sample Breakdown for Snag Airstrip Cleanup

Sample Type	Number of Samples Collected
Delineation Soil	533
Paint Chip	4
Wood	4
Insulation/Floor Tiles	6
Total Samples	547

Table IV-2 Delineation Soil Sample Breakdown

Area Requiring Delineation	Number of Delineation Samples Collected
Tower Building	90
DOT Barracks Building	43
Warehouse	136
Powerhouse and Pump House	184
Garage	25
Beacon Site	55
Total Delineation Soil Samples	533

C. Analytical Program

Delineation soil samples were analyzed for the compound or element that had originally prompted the delineation - 75% of all samples collected, including soil, paint, wood, and insulation and floor tiles, were analyzed for at least one contaminant. Metal contamination in soils was delineated using copper, lead and/or zinc as indicators, as these elements could be analyzed in the field using an XRF field test kit. Analysis of confirmatory samples collected by Lorimer and Associates in conjunction with Hemmera

Resource Consultants Ltd. included all contaminants detected above the applicable criteria in each particular area.¹⁷ XRF results were confirmed in a southern laboratory by standard laboratory Atomic Absorption techniques for 9% of samples (details appear in Chapter V, Appendix C). PCB contamination was delineated using both the EnviroGard™ Immunoassay PCB field test kits (28 samples) and standard laboratory methods (103 samples). PCB field test kit results were confirmed by standard laboratory methods for 39% of samples analyzed. Twelve delineation soil samples were analyzed for both PCBs and metals. An external laboratory check of PCB results obtained by standard laboratory methods was conducted for 9% of samples analyzed in the laboratory. PCB and metal concentrations were determined in paint chips and wood from the Fire Hall and Married Quarters. The asbestos content of insulation and floor tiles from these two buildings was also determined. A summary of the overall analytical program is given in Table IV-3.

Table IV-3: Analytical Program by Type of Analysis

Type of Analysis	Number of Samples Analyzed
<i>Soil:</i>	
Inorganic Elements ^a by XRF	266
Inorganic Elements ^a by AA	24
PCBs ^b by Test Kit	28
PCBs ^b by GC/ECD	103
Pesticides ^c	15
<i>Paint Chip & Wood:</i>	
Inorganic Elements ^a by AA	8
PCBs ^b by GC/ECD	8
<i>Insulation & Floor Tiles:</i>	
Asbestos	7
Totals	459

- a. Including copper, nickel, cobalt, cadmium, lead, zinc, chromium and arsenic.
- b. Polychlorinated biphenyls
- c. Includes a suite of 22 compounds.

¹⁷ Lorimer & Associates and Hemmera Resource Consultants Ltd. 1997.

D. Results

A summary of the results from the analysis of delineation soil samples for each area of the site appears in Table IV-4.

Delineation at each of the contaminated areas at Snag Airstrip indicated that an area of 1010 m² was contaminated above an applicable criteria. The greatest number of delineation soil samples were collected around the Powerhouse and Pump House (184 samples). These samples required delineation for PCBs, lead, zinc and copper. Soil around this area was primarily contaminated with PCBs at levels above the CCME R/P Remediation Criterion of 5 ppm, but some areas, in particular the surface of the Powerhouse foundation, were contaminated with over 50 ppm PCBs, the level regulated under the Canadian Environmental Protection Act. The maximum concentration of PCBs detected at the Powerhouse and Pump House was 4000 ppm. The total area requiring excavation was greater than for any of the other contaminated areas at Snag Airstrip and was estimated at 390 m².

The Tower Building exhibited a unique pattern of contamination in comparison to other building areas. In addition to contamination that was found in the immediate area of the building, a long plume of metal contamination extended out from its west side for approximately 20 m. Zinc and copper were the most prevalent contaminants in delineation soil samples and were detected at a maximum concentration of 2000 and 1160 ppm, respectively. A total area of approximately 200 m² was contaminated above the CCME R/P Remediation Criteria for zinc and copper.

Contamination detected at the Warehouse included leachate toxic lead-contaminated soil, pesticide-contaminated soil, and soil contaminated above the CCME R/P Remediation Criteria. The maximum concentration of lead detected in a delineation soil sample collected in 1996 was 21,500 ppm. A delineation soil sample collected in 1995 in this area contained 370,000 ppm lead. The maximum concentration of a single pesticide detected in one of the delineation soil samples from the 1996 field season was 1,100 ppm for the compound *trans*-chlordane, detected in one of the samples taken from a 40 cm deep test pit. The total area of soil at the Warehouse affected by leachate toxic lead and pesticide contamination was 110 m², while an area 80 m² contained metals at levels above the CCME R/P Criteria.

The remaining three areas where contamination required delineation were not as badly affected as the three areas discussed above; contamination in these areas was

considerably more patchy and constituted only 23% of the total area affected at Snag Airstrip. At the Beacon Site the only area of contamination was the former location of the building, where ash and debris from the building were all that remained. Several small patches of inorganic contamination were delineated along the edge of the Garage Foundation; the total area affected was 30 m². The contamination representing the greatest concentration and potential concern was the CEPA level PCB contamination detected in the two oil change pits at the Garage. Neither of these areas warranted delineation because the contents were contained within the concrete foundation. However, the presence of the concrete pits made the excavation phase of the cleanup more difficult than it would have been otherwise (Yasmin Nazami, personal communication). Finally, a small amount of metal contamination was delineated around the DOT Barracks Building foundation and extending to the northeast along the former location of part of this building. The total area affected above the CCME R/P Remediation Criterion was 75 m². PCB contamination exceeding 50 ppm was limited to the thin layer of moss and debris in the basement of the DOT Barracks Building, an area of 45 m².

Table IV-4: Summary of Delineation Work Conducted as Part of 1996 Cleanup of Snag Airstrip

Location	Contaminants Delineated	Other Contaminants	Samples Collected	Samples Analyzed	Samples Affected	Area Requiring Excavation (m ²)
Tower Building	Pb, Zn, Cu	Cd, PCBs, Pesticides	90	52	20	200
DOT Barracks Building	Zn, Pb, Cu	PCBs, PCDDs/PCDFs, Ni	43	40	13	120 ^a
Warehouse	Pb, Cu, Zn, Pesticides	Cr, PCBs	130	91	52	190 ^b
Powerhouse & Pump House	PCBs, Zn, Pb, Cu	Cd, Ni, Cr	184	136	70	390 ^c
Garage & Fire Hall	Zn, Pb, Cu	PCBs, Dioxins, Pesticides, PAHs, Ni, Cd, Cr	25	22	8	40 ^d
Beacon Site	Zn, Cu	As, Ni	55	37	4	70
TOTALS			527	378	167	1010

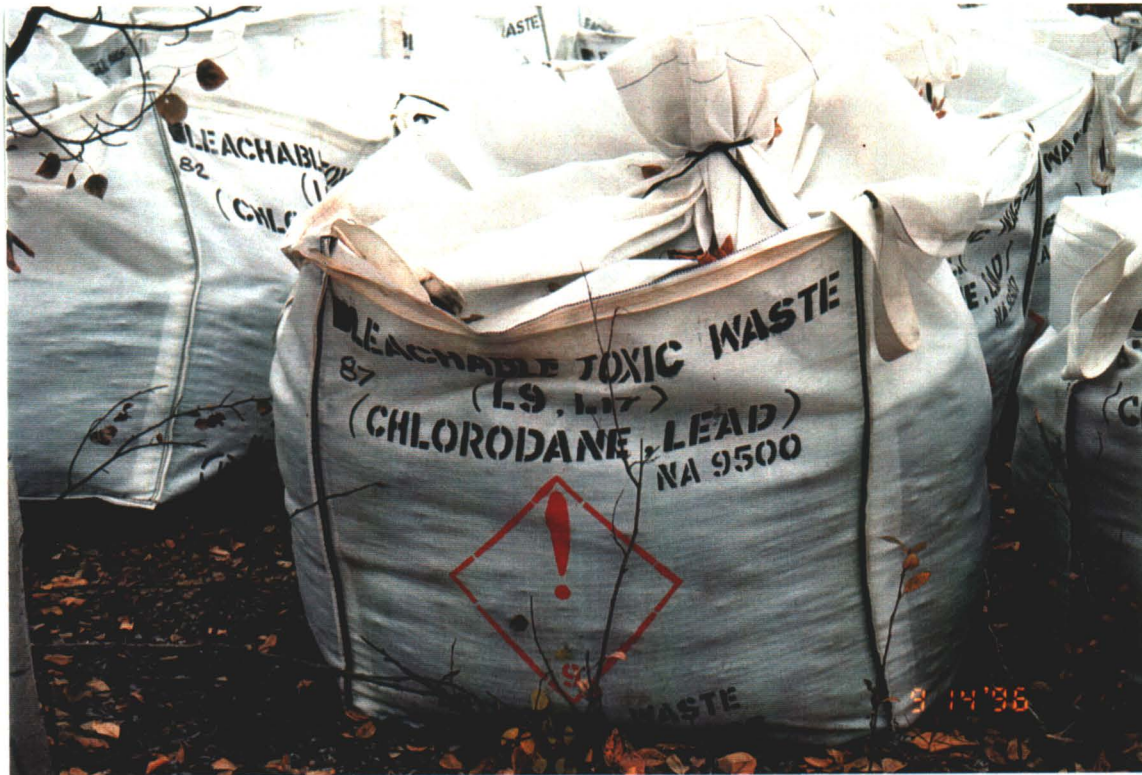
- a. Including 75 m² of CCME R/P contaminated soil and 45 m² of CEPA contaminated soil or substrate.
- b. Including 110 m² leachate toxic or pesticide contaminated soil and 80 m² CCME R/P contaminated soil.
- c. Including 190 m² CCME R/P contaminated soil and 200 m² of CEPA contaminated soil or substrate.
- d. Including 30 m² CCME R/P contaminated soil and 10 m² of CEPA contaminated soil or substrate.

E. Conclusions

The cleanup at Snag Airstrip was completed in two-phases: the first phase involved the delineation of contaminated areas through the collection and analysis of many soil samples both at surface and at depth; the second entailed the excavation of contaminated soil based on the results of delineation, confirmatory sampling, demolition of buildings and foundations (where required), and the proper disposal of each category of waste. This second phase of work was completed in July, August and September of 1996 by Lorimer and Associates in conjunction with Hemmera Resource Consultants Ltd.¹⁸ ESG, although not continuously on site, acted as the scientific advisor for the project, and assumed responsibility for all sample analyses conducted in southern laboratories.

In September of 1996, ESG revisited Snag Airstrip to assess the results of the cleanup, which was close to completion. All the contaminated soil had been excavated and either placed in barrels (CEPA-contaminated soil), double-bagged (leachate toxic and pesticide contaminated soil) or placed in a containment cell south of the former location of the Tower Building (Photograph IV-1, Photograph IV-2). The soils in barrels and bags were still awaiting transport off site at the time of the ESG visit. No evidence of the buildings remained except for their cleaned foundations (Photograph IV-3), and no evidence of the Tower Building remained at all (Photograph IV-4). The Married Quarters remained in place, but all interior painted structures, insulation and floor tiles had been removed (see Photograph III-16). The dump had been thoroughly regraded, effectively reducing its slope and therefore the potential for erosion. In addition, three monitoring wells had been installed at the base of the slope (Photograph IV-5). Finally, a small dump that was discovered during a search by the contractor for granular material was visited, and notes taken on its location and disposition. This dump contained barrels, building materials, metal scrap and domestic debris (Photograph IV-6).

¹⁸ Lorimer and Associates and Hemmera Resource Consultants Ltd., 1997.



Photograph IV-1: Double-bagged leachate toxic and/or pesticide-contaminated soil at Snag Airstrip awaiting transport to a southern disposal facility.



Photograph IV-2: The containment cell for CCME contaminated soil was constructed in a concealed location behind and south of the former location of the Tower Building.



Photograph IV-3: The DOT Barracks Building basement following containerization of debris and moss contaminated with PCBs and dioxins. In addition, a portion of the foundation was later containerized because high levels of PCB contamination were detected in the cement.



Photograph IV-4: The former location of the Tower Building was used to store barrels containing soil contaminated with CEPA PCBs.



Photograph IV-5: The Snag Airstrip Dump, after the application of additional fill and regrading, and the installation of monitoring wells.



Photograph IV-6: Debris in a small dump located on the north side of the Alaska Highway access road just west of the main dump.

V. APPENDICES

APPENDIX A. METHODS

A. Sampling

1. *Delineation*

All work at the site was done following the site specific Health and Safety Plan prepared by Phoenix OHC, Inc. (see Annex A this Appendix). On arrival at the site, the team members cordoned off all known contaminated areas. In order to define the lateral extent of a contaminated area, a grid was laid out, and samples were collected at chosen coordinates. Soil samples were generally restricted to the upper 10 cm and were collected using plastic scoops and placed in Whirl Pak™ bags. To determine the depth of contamination, test pits were dug and samples collected at specific intervals. Sample locations were marked using nails with tag numbers and red flagging tape attached.

Soil samples were kept at ambient temperatures. The samples were shipped by guaranteed air freight to labs at Queen's University, Kingston, Ontario (for all analyses except pesticides) and in Sidney, British Columbia (for pesticide analyses only). Upon receipt in the laboratory, the samples were kept at approximately 4°C (inorganics) or below freezing (organics) while awaiting analysis.

2. *Samples for Asbestos Analysis*

Samples of insulation and floor tile were collected from several areas. The samples were stored in polyethylene bags which were sealed, labeled and shipped to the laboratory for asbestos analysis.

3. *Paint Chip and Wood Sample Collection*

Samples of paint chips and wood were collected from the Fire Hall and Married Quarters, using a steel blade knife. The samples were stored in polyethylene bags which were sealed, labeled and shipped to the laboratory for inorganic and PCB analysis.

4. Chain of Custody

A rigorous chain of custody was maintained for sample control. Chain-of-custody forms were filled out and checked for each sample before shipment from the North, and the contents of shipments were verified upon receipt in the laboratory. The relevant documentation is available on request.

5. Quality Assurance/Quality Control (QA/QC)

At least one soil field duplicate sample was collected from each delineated area and for approximately 10% of all samples collected. The soil to be sampled was homogenized in the field and split into two bags which were labeled with consecutive numbers.

QA/QC procedures were carried out by means of the standard techniques of blind replicates and spiked samples. A detailed discussion is given in Appendix C.

B. Laboratory Analysis of Inorganic Elements

1. Atomic Absorption

Analyses were conducted by the Analytical Services Unit, Queen's University, Kingston, Ontario.

a) Soil Samples

Samples were air-dried and ground to a fine powder with a mortar and pestle. Large stones were removed as they would not be expected to contain any anthropogenic environmental contaminants. Approximately 0.5 g of powdered sample was heated with 2 mL of nitric acid and 6 mL of hydrochloric acid overnight so that the volume was reduced to 1-2 mL. This solution was then made up to 25 mL with distilled, deionized water and analyzed by atomic absorption spectrophotometry (AAS). Although not all metals may be brought into solution by this procedure (some may be locked into silicate minerals), metals that are released are considered to be of greater environmental significance than are true total metals. Concentrations of the following eight elements were measured: arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), nickel (Ni), and zinc (Zn). Samples were analyzed in batches of up to 36, which comprised up to 28 samples, 2 blanks, 4 duplicates and 2 samples of reference material (NRC MESS-1).

b) Insulation Materials

Asbestos content of bulk material was determined by polarized light microscopy dispersion staining. Analysis was carried out at the Occupational Health and Safety Resource Centre, University of Western Ontario, London, Ontario.

C. Laboratory Analysis of Pesticides and Polychlorinated Biphenyls

1. Analysis by GC/ECD and GC/MS for soil samples

Analysis for pesticides (and PCBs for external QA/QC check) were conducted by Axys Analytical Services Ltd. of Sidney, B.C. Each sample was clearly labeled and locked in a secure frozen storage area before analysis.

a) Summary

Samples for PCB and/or pesticide analysis were spiked with the surrogate standard (2,4,5,6-tetrachloro-m-xylene, PCB 209 and d₄-alpha endosulphan) prior to analysis by gas chromatography with electron capture detection (GC/ECD); for gas chromatography with mass spectrometry (GC/MS), the samples were spiked with ¹³C labeled surrogate standard (PCB 101, PCB 180, PCB 209, gamma-BHC, Mirex, p,p'-DDE, p,p'-DDT and d₄-alpha endosulphan). Sediments were extracted with a solvent on a shaker table. Tissues were ground with sodium sulphate, packed in a glass chromatographic column and eluted with solvent. Water was liquid/liquid extracted with dichloromethane. Sample extracts were separated into three fractions on a Florisil column. The first fraction was also analyzed for PCBs as Aroclors, PCB congeners and chlorinated pesticides by GC/ECD or GC/MS. The second and third fractions were analyzed for chlorinated pesticides by GC/ECD.

b) Extraction Methods

(1) Soils

Soil samples were thoroughly homogenized and a subsample of each taken for the determination of wet weight/dry weight ratio.

Each wet sediment sample (10 - 15 g), to which an aliquot of surrogate standard had been added, was extracted once with 80 mL of 1:1 dichloromethane/methanol by shaking on a shaker table for 30 minutes. The extraction procedure was repeated using 80

mL of dichloromethane. The extracts were combined, washed with solvent-extracted water, dried over anhydrous sodium sulphate and concentrated by Kuderna-Danish¹⁹ techniques. After the addition of activated copper to remove sulphur, the extract was separated on a Florisil column.

c) Sample Cleanup and Separation

(1) Cleanup for GC/ECD

The extract was quantitatively transferred to a Florisil column and eluted with three solvent systems consisting of hexane (Fraction-1), 85:15 dichloromethane/hexane (Fraction-2) and 50:50 dichloromethane/hexane (Fraction-3).

An aliquot of surrogate standard was added to each Fraction-2 to allow quantification, since the surrogate standard added at the beginning of the procedure eluted into Fraction-1 and Fraction-3. Each fraction was concentrated, transferred to a microvial, and an aliquot of recovery standard (4,4'-dibromooctafluorobiphenyl and PCB 204 to Fraction-1 and Fraction-2 and ¹³C-PCB 153 to Fraction-3) was added prior to analysis by GC/ECD.

Fraction-1 was analyzed by GC/ECD for PCBs as Aroclors, PCB congeners, and mildly polar chlorinated pesticides.

Fraction-2 was analyzed by GC/ECD for moderately polar chlorinated pesticides.

Fraction-3 was analyzed by GC/ECD for the most polar chlorinated pesticides.

(2) Cleanup for GC/MS

The extract was quantitatively transferred to a Florisil column, which was eluted with hexane followed by 85:15 dichloromethane/hexane. The eluates were combined (Fraction-1). The column was eluted with 50/50 dichloromethane/hexane (Fraction-2). Each fraction was concentrated, transferred to a microvial and spiked with an aliquot of recovery standard (¹³C-PCB 153) prior to instrumental analysis.

¹⁹ Soxhlet Extraction EPA method 3540B, Sections 4.3, 7.6-7.11.1 (Revised Nov. 1992)

Fraction-1 was analyzed by GC/MS for PCBs as Aroclors, PCB congeners, and nonpolar and moderately polar chlorinated pesticides.

Fraction-2 was analyzed by GC/ECD for the most polar chlorinated pesticides.

d) Instrumental Analysis

(1) GC/ECD Analysis

Each fraction was analyzed for pesticides by using an HP 5830A gas chromatograph equipped with a ^{63}Ni electron capture detector (GC/ECD), a 60 m DB-5 column (0.25 mm i.d. x 0.1 μm film thickness) and HP 3392 integrator. Fraction-1 was simultaneously analyzed for PCBs as Aroclors and PCB congeners. Chromatographic conditions were as follows - Initial temp: 100°C; Injection: splitless, 1 min; Initial time: 2 min; Ramp: 10°C /min to 150°C, 3°C/min to 300°C; Final time: 5 min. Column conditions were: Carrier gas, helium; Pressure, 21 psi; Flow rate, 60 mL/min; and Split ratio, 15:1.

The instrument was calibrated daily using a solvent blank and standards of Aroclor 1242, Aroclor 1254 and Aroclor 1260. For each Aroclor, the sum of the areas of three characteristic peaks was used to calculate its response factor against the internal standard. The area of the same three peaks was used to determine the concentration of each Aroclor in the sample.

All values reported in the tables are in parts per billion (ppb) (ng/g) on a dry weight basis for soil samples and on a wet weight basis for plant samples. Procedural blank information is given in Appendix B; the levels obtained demonstrated no blank interferences with the sample results.

PCBs were also quantified as individual congeners by calibrating the GC/ECD response with four well-characterized mixtures of 51 congeners (total) obtained from the National Research Council (NRC), Halifax, NS. Aroclor mixtures of known composition were used for some congeners not present in the NRC mixtures.

(2) Low Resolution GC/MS

Fraction-1 was analyzed for PCB congeners, Aroclors and nonpolar and moderately polar chlorinated pesticides using a Finnigan INCOS 50 mass spectrometer equipped with a Varian 3400 GC, a CTC autosampler and a DG 10 data system running INCOS 50 (Rev 9) software. Chromatographic separation of pesticides was achieved with

a 60 m DB-5 column (0.25 mm i.d. and 0.10 μm film thickness). The mass spectrometer was operated in the electron impact (EI) mode at unit mass resolution in the multiple ion detection (MID) mode acquiring two characteristic ions for each target analyte and surrogate standard.

2. *Analysis by GC/ECD for Soil and Paint Samples*

Analyses were conducted by the Environmental Sciences Group Analytical Laboratory, located at the Royal Military College in Kingston, Ontario. Each sample arrived in an appropriate container, clearly labeled and was stored at low temperatures in a secured area before and after analysis.

a) Summary

Samples were spiked with decachlorobiphenyl (DCBP), a surrogate standard, prior to analysis by gas chromatography (GC) with electron capture detection (ECD). Soil and paint were extracted with dichloromethane, using soxhlet apparatus. Extracts were concentrated using a rotary evaporator and the solvent was exchanged to hexane before cleanup of the sample, by passing the hexane containing the PCBs through a Florisil column.

b) Extraction Method

(1) Soils & Paints

All samples were thoroughly homogenized before sampling for the analysis. Soil samples were subsampled for the determination of wet/dry weight ratio.

Accurately weighed wet soil (15 g) and paint (1 g) to which DCBP, sodium sulphate (40 g) and Ottawa sand (20 g) were added, were extracted by soxhlet for 4 hours at 4-6 cycles per hour using 250 mL of dichloromethane. The extract was then concentrated by rotary evaporation to approximately 1 mL, 5 mL of hexane was added and again evaporated to 1 mL. This was repeated twice more, resulting in 1 mL of hexane solvent, which was then applied to a Florisil column for cleanup. The column was thoroughly rinsed with hexane and the eluant containing the PCBs was diluted to 10.0 mL.

c) Instrumental Analysis

(1) GC/ECD Analysis

Each sample was analyzed using an HP 5890 Series II Plus gas chromatograph equipped with a ^{63}Ni electron capture detector (GC/ECD), a SPBTM-1 fused silica capillary column (30 m, 0.25 mm ID x 0.25 μm film thickness) and the HPChem station software. The chromatographic conditions were as follows: Sample volume - 2 μL , splitless injection, initial temperature - 100°C for 2 min; ramp - 10°C/min to 150°C, 5°C/min to 300°C; final time 5 min. Carrier gas used was helium at a flow rate of 20 mL/min. Nitrogen was used as a makeup gas for the ECD.

All values were reported as parts per million (ppm) ($\mu\text{g/g}$) on a dry weight basis which were reported as $\mu\text{g}/100\text{ cm}^2$ PCB.

D. Analysis of Polyaromatic Hydrocarbons (PAHs) in Soil

1. Analysis by GC/MS

Analyses for PAHs were conducted by the Environmental Sciences Group Analytical Laboratory at Royal Military College in Kingston, Ontario. Each sample was in an appropriate container, clearly labeled and stored at low temperatures in a secured area before and after analysis.

a) Summary

Samples were spiked with a Surrogate standard (a mixture of the deuterated PAHs: naphthalene, phenanthrene, anthracene, and benzo(a)anthracene) prior to extraction and analysis by gas chromatography (GC) with mass selective detection (MS). Soil and sediment samples were extracted with dichloromethane using an ultra-sonic bath. Extracts were concentrated using the EPA recommended Kuderna-Danish method and the solvent was exchanged prior to cleanup through a laboratory prepared silica-gel column.

b) Extraction Method

Samples were thoroughly homogenized before analysis. Soil and sediment samples were subsampled for determination of the wet/dry weight ratio.

Accurately weighed wet soil samples (12 g), to which the surrogate standard (1 mL), sodium sulphate (40 g) and Ottawa sand (20 g) were added, were extracted by ultrasound using three separate portions of 75 mL of dichloromethane for 10 minutes each. The extract, including the solvent used for rinsing (totaling 250 mL) was collected in the Kuderna-Danish apparatus. The volume was then reduced to near 1 mL and exchanged with 2 mL of cyclohexane. This was then applied to a laboratory-prepared activated silica-gel (Grade 923, 100-200 mesh) column for cleanup. The column was rinsed with hexanes (7 mL), and this portion of the eluant was discarded before collecting the dichloromethane fraction (25 mL). In some cases extracts were applied to an LC-Si - Supelco column containing silica gel for cleanup and diluted to 10 mL. In either case a GC vial (2 mL) was filled by measuring 960 μL of the sample solution and 40 μL of an internal standard and submitted for analysis by GC/MS.

c) Instrumental Analysis

Each sample was analyzed using an HP 5890 Series II Plus - GC equipped with an HP 5972 Mass selective detector, a PTETM - 5 fused silica capillary column (30 m, 0.25 mm ID x 0.25 μm film thickness) and the HPChem station software. The chromatographic conditions were as follows: Sample volume 1 μL , splitless injection, initial temperature - 70°C for 5 min; ramp 12°C/min to 130 °C, 5°C/min to 260°C, final time 27 min. The carrier gas used was high purity helium with a column flow rate of 1 mL/min. The mass selective detector was used in the selective ion monitor mode for the following ions: Mass/Charge ratio (m/z) 128, 136, 152, 166, 172, 178, 188, 202, 228, 240, 252, 276, 278, representing each of the 16 PAHs, 4 surrogates and the internal standard used in the analysis.

For each set of samples analyzed, a six point calibration curve (0, 20, 50, 100, 250, and 500 ppb) was prepared for each of the 16 PAHs analyzed. Concentrations of PAHs in samples were determined by comparing sample responses with calibration curves. The surrogate and internal standards were used to account for the efficiency of extraction and analysis.

E. Field Analysis

1. Inorganic Elements Analysis by X-ray Fluorescence

A TN Technologies, Inc. Spectrace 9000 Field Portable X-Ray Fluorescence Analyzer (FPXRF) was used for all field analysis of inorganic elements, and also at the

Environmental Sciences Group Analytical Laboratory, Royal Military College of Canada and at the Analytical Services Unit, Queen's University both located in Kingston, Ontario. The FPXRF was equipped with a high resolution solid state (mercuric iodide) detector and fundamental parameters quantitative analysis software. Fundamental parameters quantitative analysis involved measuring all major elements present and compensating for the effects of the interferences on one another by computer calculations. This allowed for a good estimate of inorganic element concentrations regardless of the soil matrix type, removing the need for multiples of the same standard prepared with different matrices. Pure elements or standard reference materials were used for calibration standards.

The FPXRF used three radioactive sources for X-ray generation; sources and acquisition times used for analysis are given in Table II-1. As recommended by the manufacturer, the operation of the instrument was monitored periodically with pure element and teflon standards during analysis.

Table V-1: Count Times for FPXRF Sources

Source	Analysis Measurement Time (sec)		
	Calibration	Short (Pb & Zn)	Extended (Cu)
Fe-55	50	100	200
Cd-109	50	300	700
Am-241	50	50	50
Total Time	150	450	950

The soil samples were analyzed as follows. Subsamples were spread out on absorbent paper towels and allowed to air dry. Large stones and pebbles were removed and the sample ground with a mortar and pestle. The ground sample was placed in the sample cup and covered with a Mylar film and ring. The filled sample cup was inverted (Mylar side down), tapped gently to settle and compact the contents, placed on the probe and analyzed.

The detection limit was defined as the analyte concentration which gave a signal equal to the blank plus two standard deviations of the blank. The limit of detection for each element was determined by using the standard deviations of analyte samples which gave concentrations close to the blank. A lower detection limit was obtained for copper when a longer count time was used.

Table V-2: Detection Limits for the Determination of Copper, Lead and Zinc by FPXRF

Element	Detection Limits (ppm or µg/g)	
	Short Measurement Time	Extended Measurement Time
Copper	50	30
Lead	20	20
Zinc	30	20

2. *Polychlorinated Biphenyl (PCB) Field Analysis*

The method was carried out according to the manufacturer's instructions with a few minor modifications. A subsample was spread out on absorbent paper towels and allowed to air dry. Then a 5 g portion was weighed and extracted with 5 mL methanol; in some cases more methanol was added until a liquid phase was present. The soil-methanol mixture was filtered and an aliquot of the extract used for subsequent analysis. Aliquots of 25 ml were used and the colour intensity recorded on a portable photometer. When more than 5 mL of methanol was used, an appropriate dilution factor was applied.

Field analyses of polychlorinated biphenyls (PCBs) were performed with Millipore EnviroGard™ PCB Test Kits. These utilize the enzyme-linked immunoabsorbent assay (ELISA) technique which is based on antibodies that are specifically designed to bind to PCB molecules. These antibodies are bonded onto the inside of polystyrene test tubes. The sample is added, along with excess enzyme-conjugate, which competes with PCB molecules in the sample for the available binding sites on the antibodies. The higher the concentration of PCBs in the sample, the less conjugate will be bound to the antibody. After incubation, the test tubes are washed thoroughly with water, leaving only the bound conjugate and bound PCB molecules in the tube. Enzyme substrate and chromogen are then added, which react with the bound conjugate - but not the bound PCB - to form a blue solution. After a timed interval for colour development, a reagent is added to stop the reaction, turning the solution yellow. The colour intensity of the product is directly proportional to bound enzyme-substrate, and inversely proportional to the PCB concentration in the original sample in the test tube. Aroclor 1260, 1254 or 1248 standards were used for calibration, rather than the Aroclor 1248 standards supplied by the manufacturer. These were prepared by dilution of a 200 ppm standard supplied by Supelco. Quantification was performed using a spectrophotometer.

Since the samples are extracted for only two minutes and no correction is made for incomplete extraction efficiency, results obtained by this method are generally multiplied by a suitable factor, determined by comparison with laboratory data, before interpretation.

**ANNEX A: HEALTH AND SAFETY PLAN FOR ADVISORY PERSONNEL: SNAG
AIRSTRIP CLEANUP, YUKON**

**REVISED INTERIM HEALTH AND SAFETY PLAN
FOR ADVISORY PERSONNEL**

SNAG AIRSTRIP CLEANUP, YUKON

Summer, 1996

Phoenix OHC, Inc.





REVISED INTERIM HEALTH AND SAFETY PLAN FOR ADVISORY PERSONNEL

SNAG AIRSTRIP CLEANUP, YUKON

PREPARED BY: Tom Beardall, MHS, CIH, ROH
ON: 1996.06.14

AS REQUESTED BY: Environmental Sciences Group at RMC
REFERENCE NO.: 4673

1. APPLICATION

- 1.1 This plan **applies** to the Environmental Sciences Group (ESG) team, as defined in the Snag Airstrip Implementation Plan, who will be on-site during the Snag Airstrip Cleanup as scientific advisors and for the purposes of observation, sampling, analysis, inspection and quality control. These personnel may also be involved with minor manual labour and with solvent extraction of PCB contaminated concrete.
- 1.2 This plan **does not apply** to the contractor and contractor's employees.
- 1.3 This plan **does not apply** to any confined space entry (including manholes, pits, etc.), entry into buildings where the structural integrity has been compromised, operation of heavy machinery (including backhoe, forklift truck, jack hammer, etc.), handling of asbestos-containing material, paint removal, heavy labour, and any other activities not mentioned in subsection 2.2.
- 1.4 This plan **does not apply** to sites or activities other than to the cleanup at Snag Airstrip, Yukon, as delineated.
- 1.5 This plan represents interim guidelines which will need to be reconciled with the contractor's health and safety plan, to ensure that there are no inconsistencies that may, for example, lead to a disregard for necessary procedures and protective measures by either party. Similarly, one individual will need to be designated as Site Safety Officer with overall responsibility for health and safety on site, to ensure a consistent approach to such matters.

2. SCOPE OF WORK

- 2.1 The cleanup project to be undertaken by the contractor involves: removal and disposal of contaminated soil and debris; demolition and disposal of buildings and other structures; possible Varsol extraction of PCB contaminated concrete; closure/covering of structures including manholes, wells, pits and basements; and closure of an existing landfill.
- 2.2 The advisory aspects of the project, to which this health and safety plan applies, include: delineation sampling and field analysis of materials prior to removal/excavation or decontamination; confirmatory sampling and field analysis of materials after removal/excavation or decontamination, staging activities such as sampling/analysis of collected materials and labelling of containers; observation of the cleanup activities; participation in minor cleanup activities (light shovelling, loose debris collection) and participation in Varsol extraction of PCB-contaminated concrete foundations (if necessary).
- 2.3 Soils sampled from the site have been determined analytically to contain up to 3.2% lead, 0.4% PCB and 0.1% total pesticides (largely Chlordane and DDT). Paint chips have been determined analytically to contain up to 22.0% lead and 0.002% PCB. Soil and paint also contain varying concentrations of other elements; see the Snag Airstrip Environmental Assessment for detailed results.

3. DEFINITIONS

- 3.1 ACGIH®: American Conference of Governmental Industrial Hygienists
- 3.2 CEPA: Canadian Environmental Protection Act
- 3.3 COSHR: Canada Occupational Safety and Health Regulations under the Canada Labour Code, Part II.
- 3.4 CSA: Canadian Standards Association
- 3.5 DDT: Dichlorodiphenyltrichloroethane
- 3.6 ESG: Environmental Sciences Group, Royal Military College
- 3.7 Hydrocarbon absorbent material: e.g. Oclansorb™ or equivalent
- 3.8 MSDS: Material Safety Data Sheet
- 3.9 NIOSH: National Institute for Occupational Safety and Health (in the U.S.A.)
- 3.10 PCB: Polychlorinated Biphenyl (aka chlorodiphenyl)
- 3.11 Qualified person: "In respect of a specified duty, a person who, because of his knowledge, training and experience, is qualified to perform that duty safely and properly" (COSHR)
- 3.12 Transition Zone: The zone between the contaminated work area and the uncontaminated areas
- 3.13 TLV®: Threshold Limit Value. ACGIH's occupational exposure limits
- 3.14 Waste load-out area: A temporary staging area for waste filled containers to allow for the organization of wastes and decontamination of their outer surfaces (if necessary) prior to transport to the site's waste staging area, or to the final destination.

4. ASSUMPTIONS AND BACKGROUND

- 4.1 This plan was prepared based on information provided by ESG about the site and anticipated work procedures (some of which have yet to be determined), including a Draft Environmental Assessment of the Snag Airstrip, and Addenda, dated 11 April 1996, as well as information provided by UMA Engineering Ltd, including their Draft Conceptual Design Report for the Snag Airstrip Cleanup. The author of this present health and safety plan has not personally surveyed the site. Furthermore, it is assumed that the types and levels of identified contaminants represent the degree of risk offered by this site. It is outside the scope of work of this author to comment on other contaminants that might be present.
- 4.2 The greatest hazards with respect to the site appear to be "construction project" related and include the use of heavy demolition/excavation equipment, the presence of a partially toppled building and the presence of confined spaces, such as manholes, wells and pits. Entry into confined spaces is not scheduled, and must be prohibited. These will be filled and covered over by the contractor. Similarly, entry into buildings that are not structurally sound, must be prohibited. The contractor must also be responsible for minimizing other risks to the advisory group associated with construction projects, as would typically be done for observers/visitors to a construction site.
- 4.3 From an inhalation exposure perspective this is a **low hazard site**, not consistent with the term "hazardous waste site", as it would be applied, for example, to an industrial waste disposal area with drums and other containers of known and unknown chemical agents. During the project, the highest chemical exposure hazards are anticipated to be associated with:
- a) Varsol™ during the extraction of PCBs from concrete,
 - b) naturally occurring silica, if high airborne dust concentrations are generated during soil excavation,
 - c) lead, if high airborne dust concentrations are generated during the excavation of lead contaminated soil,

It is, however, unlikely that high dust levels (e.g. 10 to 100 mg/m³) will be created and maintained for extended periods; Varsol extraction would be conducted outdoors, reducing the risk.

- 4.4 Airborne pesticides resulting from soil excavation would be mainly in particulate form. Consequently, the dust filtering respiratory protection, intended to reduce lead and silica exposures, would also provide protection against pesticides.
- 4.5 The term "hazardous" used in the environmental sense (e.g. in an environmental assessment) should not, necessarily, be extrapolated to indicate "hazardous" from an occupational exposure perspective. For example, the contaminant levels found **in the soil** at the Snag Airstrip, are not the anticipated **airborne levels** to which the cleanup workers will be exposed. As well, environmental criteria (e.g. 50

ppm PCB in soil; CEPA) are very different from, and not directly comparable to, occupational exposure limits for workers, (e.g. 0.5 to 1.0 mg/m³ PCB in air; 1995-96 TLVs[®], see s. 4.6)

- 4.6 The same Occupational Exposure Limits (OELs) have been adopted in the Yukon Territory as in federal jurisdictions for lead, PCB, DDT and Chlordane (excepting the different short term limit for chlordane -- 1.5 mg/m³ in the Yukon, rather than 2 mg/m³, as in federal jurisdictions). These are also the 1985-1986 Threshold Limit Values (TLVs[®]) published by the ACGIH. Although the statutory limits have not been updated since that time, the ACGIH updates the TLVs[®] on an annual basis. Statutory limits and current TLVs[®] are shown in Table 1, below:

Table 1. Occupational Exposure Limits

Chemical Agent	Statutory Limits (mg/m ³)		1995-96 TLVs [®] (mg/m ³)	
	TWA	STEL	TWA	STEL
Lead, inorg. dust & fume	0.15	0.45	0.05, A3	-
PCB (42% chlorine)	1(skin)	2	1 (skin)	-
PCB (54% chlorine)	0.5 (skin)	1	0.5 (skin)	-
DDT	1	3	1	-
Chlordane	0.5 (skin)	1.5 or 2*	0.5 (skin)	-

TWA: Time-Weighted Average (8 hour work day and 40 hour work week limit)

STEL: Short Term Exposure Limit (15 minute limit)

Where a short term limit does not exist, exposures must not exceed 3 times the TWA for any 30 minute period or 5 times the TWA for any period of time.

* 1.5 mg/m³ in Yukon Territory jurisdictions, and 2 mg/m³ in federal jurisdictions
(skin) denotes significant quantities can be absorbed through intact skin

- 4.7 A soil excavation activity may generate airborne dust exposures in the <1 to 10 mg/m³ range, with occasional peaks above 100 mg/m³. Considering the **maximum concentrations** of lead, PCB, and total pesticides found in soil samples, it would appear that airborne lead levels could, at times, be twice the statutory limit and more than 5 times the current TLV[®] over that time interval. There may also be occasional peaks more than five times higher than the short term exposure limit of 0.45 mg/m³ (and more than 10 times higher than the current TLV[®] excursion limit of 0.25 mg/m³). In contrast, airborne PCB and pesticide levels would not be anticipated to exceed occupational exposure limits.

Of course, incorporating both worst-case soil concentrations with worst-case airborne dust concentrations should result in the prediction of unlikely events. For example, if the **average** concentrations of lead, PCBs and pesticides determined

from **all** of the soil samples were used in the predictions of airborne concentrations, then the potential exposure levels would be at least an order of magnitude lower.

- 4.8 Considering the worst-case scenarios described for airborne lead during soil excavation (s. 4.7), a disposable dust respirator with a protection factor of at least 5 would "almost" be sufficient from a statutory limit perspective, even for heavy labourers directly involved with excavation. Under the actual, anticipated conditions (i.e. not considering continuous, compounding, worst-case scenarios), a disposable dust respirator should be sufficient, even from a health standpoint, especially where coupled with "common sense" approaches such as avoidance of "dust clouds".

5. GENERAL REQUIREMENTS AND TRAINING

- 5.1 All work is to be conducted in strict compliance with the relevant legal requirements of the applicable jurisdiction(s), including the Canada Occupational Safety and Health Regulations under the Canada Labour Code, Part II.
- 5.2 Prior to the start of work, all team members should read this plan, be informed of the hazards of the work and work area, and be trained in the proper care, use and limitations of their personal protective equipment.

6. MEDICAL SURVEILLANCE PROGRAM

- 6.1 Advisory personnel intend to be present in the contaminated work areas and to participate in various cleanup activities (e.g. shovelling of contaminated soil). Consequently, they should have pre- and post-placement medical examinations. In addition to a medical history and general examination, the person's fitness for use of air purifying respirators should be established, and blood lead and PCB levels determined.

7. EMERGENCY RESPONSE AND MEDICAL EMERGENCY PROCEDURES

- 7.1 Emergency response and medical emergency procedures must be established by the contractor, prior to commencement of the project. Advisory personnel will need to familiarize themselves with and abide by the procedures (e.g. from the contractor's site safety plan).

8. HYGIENE AND PERSONAL PROTECTIVE EQUIPMENT (GENERAL)

- 8.1 Anyone entering a contaminated work area must be wearing the personal protective equipment assigned for the particular phase of remediation (see specific section).
- 8.2 There will be no eating, drinking or smoking inside the contaminated work areas and workers will wash-up prior to eating, drinking or smoking, away from these areas.
- 8.3 The contaminated work areas will be exited into a transition area (e.g. a 6 mil polyethylene drop sheet on the ground adjacent to the work area). The exiting sequence will consist of the following:
 - a) disposable protective clothing, and disposable dust respirators or respirator cartridges will be removed and disposed in waste receptacles,
 - b) non-contaminated protective clothing intended for reuse will be stored,
 - c) protective eye wear and reusable respirators will be cleaned and stored in sealed containers,
 - d) personnel will wash exposed skin surfaces (e.g their hands and face).

9. PROJECT SET-UP

- 9.1 This is primarily a construction project with an environmental abatement component. Control of worker/visitor exposures should be achievable with a minimum of protective equipment and procedures. Those responsible for the project may incorporate more rigorous components/procedures for the prevention of environmental cross-contamination (e.g. multiple exclusion and contamination reduction zones, etc.).
- 9.2 The project set-up will be the responsibility of the contractor. Its form will depend on such variables as the types of activities and the distances between different work areas. It should include:
 - a) living quarters (if on site) and support areas (operations centre, equipment and supply centre, etc.) located upwind (if possible), and outside of the contaminated areas,
 - b) transition areas with waste receptacles for disposal of contaminated clothing, wash-up facilities, storage containers for personal protective equipment, a portable eye-wash and a first aid kit.
 - c) warning signs (e.g. "Health and Safety Hazard, Keep Out") posted at the approaches to the contaminated work areas,
 - d) waste load-out areas for intermediate storage of waste containers, allowing for a systematic cleanup, as well as cleaning of the external container surfaces if necessary, prior to the transport of waste containers,
 - e) waste staging area for longer term storage, additional testing, classification, labelling, etc, prior to transport to the ultimate destination.

10. OBSERVATION OF DEMOLITION AND EXCAVATION ACTIVITIES

10.1 Advisory personnel may be present during demolition of buildings, structures and facilities and during soil excavation for the purposes of inspection, sample collection, waste classification, etc. They will be maintained at a safe distance from the demolition. These personnel may also participate with collection of light waste and debris and hand shovelling of soil.

10.1.1 The following **personal protective equipment**, intended to minimize head, foot and eye injury during demolition and excavation activities, as well as exposures to lead and silica containing dust, must be worn:

- a) hard hat (CSA approved),
- b) safety boots (green patch, CSA approved),
- c) safety glasses or impact resistant goggles (CSA approved)
- d) disposable full body coveralls (e.g. Tyvek®, or Saranex®-coated) with hood,
- e) and, if there is likely to be significant dust generation, then a NIOSH approved dust/mist respirator (e.g. single-use 3M 8710 or equivalent or reusable half-mask with dust/mist cartridges)

10.1.2 Advisory personnel will adhere to the safety practices established for the demolition and excavation activities, and stand clear of heavy equipment and buildings/structures lacking adequate structural integrity or being demolished.

11. CONFIRMATORY SAMPLING FROM SOIL EXCAVATIONS

11.1 Entry in soil excavations may be necessary for the purpose of confirmatory sampling. Soil contamination has been assumed to extend to a depth of 0.5 metres; however, delineation testing may indicate otherwise.

11.1.1 The **personal protective equipment** assigned in subsection 10.1.1 will also apply to excavation entry, except for confined space entry (see below), which may require additional protective equipment.

11.1.2 If an excavation to be entered is more than 1.2 metres (4 ft) deep, then a qualified person, will need to determine if the excavation is or is likely to become a **confined space**, as defined in Part XI of COSHR.

If it is not a confined space, then proceed with subsection 11.1.3.

If it is a confined space then a qualified person must assess the confined space and ensure compliance with all sections of Part XI of COSHR (pertaining to confined spaces), before proceeding.

- 11.1.3 Consult with the excavation crew supervisor prior to entry into an excavation or trench.
- 11.1.4 Ensure that another person remains above ground, observing the team member in the excavation.
- 11.1.5 If a team member is to put their head below ground level inside an excavation then:
 - a) they are to wear a body harness with a rope attached and tended by the above ground person (to facilitate rapid extrication, if necessary), and
 - b) a person trained in artificial respiration is to remain above ground during the excavation entry.
- 11.1.6 If there may be explosive gas present and the activity in the excavation may provide a source of ignition, then:
 - a) prior to entry into the excavation, the levels of oxygen, and explosive gases need to be evaluated by a qualified person using direct reading instruments, calibrated that day. Excavation entry and presence in the excavation would only be permitted if the level of oxygen exceeded 19.5%, the LEL was less than 10% of the lower explosive limit for methane and the excavation was free from other hazards to the occupant while present in the excavation, as verified by the qualified person, and
 - b) a person trained in artificial respiration is to remain above ground during the excavation entry.
- 11.1.7 Personnel are not to enter an excavation or trench that is more than 1.2 metres (4 ft) deep and whose sides are steeper than a 45° angle unless the walls of the excavation or trench have been supported by shoring or bracing.
- 11.1.8 Entry into an excavation or trench that is more than 1.2 metres (4 ft) deep will require the use of a ladder.
- 11.1.9 Personnel will adhere to the other safety practices established for the excavation activities

12. SAMPLE ANALYSIS

12.1 Field analysis of PCBs involves the use of 5 millilitre aliquots of methanol.

12.1.1 The following **personal protective equipment**, intended to minimize minor skin exposure to methanol and splashes to the eyes, must be worn:

- a) disposable chemical protective gloves (polyvinyl chloride or polyethylene),
- b) chemical-splash resistant goggles.

12.1.2 Other standard laboratory safety practices will also be followed.

13. DECONTAMINATION OF OUTDOOR CONCRETE FOUNDATIONS

13.1 The cleanup of loose debris from the foundations, washing of the foundations with Varsol, absorbing of washings with hydrocarbon absorbent material and disposal of debris and contaminated materials in designated containers will be conducted with the following stipulations:

13.1.1 The following **personal protective equipment**, intended to minimize skin absorption of PCBs and solvent effects from Varsol, must be worn:

- a) disposable full body Saranex[®]-coated (or equivalent) coveralls with a hood (if Varsol washing is to be "on hands and knees" or otherwise potentially result in contact with skin/clothing),
- b) nitrile or Silvershield[®] gloves (disposable "surgical-type" glove coverings over the Silver Shields, used to improve dexterity, is optional)
- c) safety boots (CSA approved) with disposable Saranex[®] (or equivalent) boot covers (to minimize solvent transfer of PCBs),
- d) chemical-splash resistant goggles.

13.1.2 Protect the surrounding area with plastic drop sheets and hydrocarbon absorbent material.

13.1.3 Remove litter and debris prior to the clean-up/decontamination activities.

13.1.4 By means of a PCB field test kit, verify the need for decontamination of concrete.

13.1.5 Wash the concrete with Varsol

- 13.1.6 Absorb the washings with hydrocarbon absorbent material and dispose in appropriate waste receptacle
- 13.1.7 By means of a PCB field test kit, confirm the effectiveness of the decontamination procedure, and repeat the decontamination if necessary.
- 13.1.8 Fold up plastic drop sheets in a manner that contains any residual material left on the surface and dispose in the appropriate waste receptacle.

14. DECONTAMINATION OF INDOOR CONCRETE FOUNDATIONS

14.1 The cleanup of loose debris from the indoor foundations, washing of the foundations with Varsol, absorbing of washings with hydrocarbon absorbent material and disposal of debris and contaminated materials in designated containers will be conducted with the following stipulations:

- 14.1.1 Decontamination will only be conducted indoors if the building is structural sound and effective ventilation can be achieved either by natural cross-drafting through openings to the outdoors and/or by portable fans. However, it is imperative that solvent vapour explosivity be precluded (e.g. by using a solvent such as Varsol with a flash point well above ambient temperature) and by ensuring that no source of ignition (e.g. fan motor) is present where there is any significant accumulation of solvent vapour. Where the effectiveness of the ventilation is questionable, air monitoring for the solvent, by a qualified person, will be necessary during the solvent washing activities (e.g. by means of an appropriate detector tube system or calibrated monitor).
- 14.1.2 The federal statutory limits for Varsol (referenced as Stoddard Solvent) include an 8 hour TWA of 100 ppm (535 mg/m³) and a 15 minute STEL of 200 ppm (1,050 mg/m³). The lower explosive limit for Stoddard Solvent is approximately 1.1% and its upper explosive limit is approximately 6%.
- 14.1.3 A qualified person, familiar with the site and intended activities, will need to determine if the indoor area is or is likely to become a **confined space**, as defined in Part XI of COSHR. If it is not a confined space, then proceed with subsection 14.1.4. If it is a confined space then either:
 - a) a qualified person must assess the confined space and ensure compliance with all sections of Part XI of COSHR (pertaining to confined spaces), or

- b) the location must be altered (in a safe manner) such that it is no longer a confined space (e.g. remove the roof, or create additional and appropriate means of egress, etc.).

14.1.4 Prior to commencing the work, ensure that the building will not be disturbed by the contractor's activities (i.e. demolition/excavation equipment to be kept clear of the area) by:

- a) notifying the contractor's supervisor, and
- b) posting clearly visible signs at all approaches to the building (e.g. "Personnel At Work, Keep Clear" and "Health and Safety Hazard, Keep Out").

The Site Safety Officer will need to judge the necessity for posting personnel outside the building in order to monitor activities indoors (i.e. "buddy system") and outdoors (i.e. monitoring heavy equipment traffic).

14.1.5 The following **personal protective equipment**, intended to minimize skin absorption of PCBs and solvent effects from Varsol (e.g. inhalation and skin and eye contact), must be worn:

- a) a half-face respirator with organic vapour cartridges and dust/mist prefilter (NIOSH approved),
- b) disposable full body Saranex[®]-coated (or equivalent) coveralls with a hood (if Varsol washing is to be "on hands and knees" or otherwise potentially result in contact with skin/clothing),
- c) nitrile or Silvershield[®] gloves (disposable "surgical-type" glove coverings over the Silver Shields, used to improve dexterity, is optional)
- d) safety boots (CSA approved) with disposable Saranex[®] (or equivalent) boot covers (to minimize solvent transfer of PCBs),
- e) chemical-splash resistant goggles.

14.1.6 Conduct the cleanup and decontamination activities according to subsections 13.1.2 to 13.1.8, inclusive.

APPENDIX B. DATA

Table V-3: Inorganic Element and PCB Results for Delineation Soils

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>1. Tower Building</i>							
96-10283	4617		53	61	91		
96-10284	4618		27	46	113		
96-10285	4619		61	44	140		
96-10286	4620	duplicate	76	176	376		
96-10287	4620	duplicate	72	260	410		
96-10288	4621		69	180	290		
96-10289	4622						
96-10290	4623		<30	100	170		
96-10291	4624						
96-10292	4625		30	47	120		
96-10293	4626						
96-10294	4627		448	454	632		
96-10295	4628						
96-10296	4629		309	766	589		
96-10297	4630	duplicate					
96-10298	4630	duplicate					
96-10299	4631						
96-10300	4632		64	51	150		
96-10301	4633						
96-10302	4634		230	200	340		
96-10303	4635	XRF long	82	340	500		
96-10304	4636						
96-10305	4637	duplicate	340	660	680		
96-10306	4637	duplicate	600	820	980		
96-10307	4638	XRF long	78	200	200		
96-10308	4639		40	39	180		
96-10309	4880		<30	36	160		
96-10310	4882		<30	320	250		
96-10311	4883	duplicate	82	220	180		
96-10312	4883	duplicate	45	190	190		
96-10313	4884						
96-10314	4885		60	200	200		
96-10315	4886		<30	95	140		
96-10316	4887						
96-10317	4650						
96-10318	4899						
96-10319	4897						
96-10320	4895						
96-10321	4893						
96-10322	4890		54	<20	120		
96-10323	4888						
96-10324	4889	duplicate					
96-10325	4889	duplicate					
96-10326	4891						
96-10327	4894		63	<20	97		
96-10328	4896						
96-10329	4898	XRF long	39	39	130		
<i><=less than the detection limit indicated</i>							

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>1. Tower Building cont'd</i>							
96-10330	4892						
96-10331	4640						
96-10332	4900		75	120	140		
96-10333	4901						
96-10334	4902		58	84	130		
96-10335	4903						
96-10336	4904		38	120	190		
96-10337	4905						
96-10338	4906		63	114	113	<0.5	
96-10339	4907						
96-10340	4908		41	240	170		
96-10341	4909		61	450	360	<0.5	
96-10342	4910		<30	730	260		
96-10343	4911		<30	<20	93		
96-10344	4912						
96-10345	4913						
96-10346	4914		38	95	150		
96-10347	4915		59	54	200		
96-10348	4916	XRF long	73	110	130		
96-10349	4917		<30	33	150		
96-10350	4918		<30	21	130		
96-10351	4919						
96-10352	4920		<30	26	150		
96-10353	4921						
96-10354	4923	XRF long	<30	40	140		
96-10355	4922		<30	99	150		
96-10356	4925						
96-10357	4924		48	110	200		
96-10358	4926	XRF long	<30	470	370		
96-10359	4884	30-40cm	32	43	120		
96-10498	5040		280	430	840		
96-10499	5041		250	490	800		
96-10500	5042		240	490	800		
96-10501	5043		360	560	1080		
96-10502	5044		220	590	2000		
96-10518	5085		35	<20	95		
96-10519	4700		1160	1040	1360		
96-10520	5086		460	580	860		
96-10521	4878		<30	25	160		
96-10522	5084	XRF long	93	63	230		
96-10523	5081		330	360	470		
96-10524	5089		170	200	400		
96-10525	5087		140	130	420		

<=less than the detection limit indicated

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>2. Barracks Building</i>							
96-10360	4949		78	187	7520		
96-10361	4940	duplicate	<30	29	190		
96-10362	4940	duplicate	56	25	170		
96-10363	4941		65	190	620		
96-10364	4942	XRF long	43	27	224		
96-10365	4943		<30	100	410		
96-10366	4944		34	350	1340		
96-10367	4945		53	<20	100		
96-10368	4946		160	540	9740		
96-10369	4947		<30	160	190		
96-10370	4948						
96-10371	4950		39	47	210		
96-10372	4951						
96-10373	4952		<30	110	390		
96-10374	4953		<30	70	680		
96-10375	4954		67	280	430		
96-10376	4955		<30	41	180		
96-10377	4956		<30	36	120		
96-10378	4957		38	140	320		
96-10379	4958		96	440	1180		
96-10380	4960		53	<20	100		
96-10381	4961	duplicate	<30	160	320		
96-10382	4961	duplicate	<30	200	330		
96-10383	4962		32	120	280		
96-10483	5032		61	320	840		
96-10484	5031		47	240	420		
96-10485	5032		48	200	710		
96-10486	5033		<30	97	280		
96-10487	5034		<30	<20	94		
96-10488	5038		<30	<20	94		
96-10489	5037		<30	270	330		
96-10490	5036	duplicate	41.5	<20	115		
96-10491	5036	duplicate	<30	<20	110		
96-10492	5039		67	25	190		
96-10503	5045	duplicate	<30	69	160		
96-10504	5045	duplicate	50	90	350		
96-10505	5047		84	139	2240		
96-10506	5048		<30	71	450		
96-10507	5049		<30	180	36		
96-10508	5094		46	33	140		
96-10526	5061		100	79	700		
96-10527	5062		<30	430	1140		
96-10528	5060		63	3100	4980		
<i><=less than the detection limit indicated</i>							

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>3. Warehouse</i>							
96-10000	4725						
96-10001	4755						
96-10002	4721						
96-10003	4703						
96-10004	4707						
96-10005	4710						
96-10006	4709						
96-10007	4701						
96-10008	4714						
96-10009	4702						
96-10010	4718						
96-10011	4720						
96-10012	4715						
96-10013	4712						
96-10014	4727						
96-10015	4726						
96-10016	4724						
96-10017	4716						
96-10018	4719						
96-10019	4711						
96-10020	4713						
96-10021	4717						
96-10022	4715						
96-10023	4752						
96-10024	4708						
96-10025	4705						
96-10026	4706						
96-10027	4704	duplicate					
96-10034	4704	duplicate					
96-10028	4753						
96-10029	4751	duplicate					
96-10035	4751	duplicate					
96-10030	4760						
96-10031	4754	duplicate					
96-10036	4754	duplicate					
96-10032	4757						
96-10033	4759						
96-10133	4725	30-40cm					
96-10134	ESG27	30-40cm					
96-10204	4681						
96-10205	4682						
96-10206	4683						
96-10207	4684		30	1840	78		
96-10208	4685		640	1060	340		
96-10209	4686	XRF long	130	93	84		
96-10210	4687		140	670	160		
96-10211	4688		31	190	140		

<=less than the detection limit indicated

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD
(ppm)							
<i>2. Warehouse cont'd</i>							
96-10212	4689	duplicate	370	1960	1380		
96-10213	4689	duplicate	609	3437	1559		
96-10214	4690	XRF long	80	77	78		
96-10214D		XRF long	75	74	100		
96-10215	4691		<30	140	170		
96-10216	4692		260	20500	230		
96-10217	4693		30	21500	170		
96-10218	4694	XRF long	<30	330	140		
96-10219	4695		150	620	170		
96-10220	4699		63	150	320		
96-10221	4697						
96-10222	4698		<30	430	270		
96-10223	4696		96	960	140		
96-10224	ESG22	30-40cm	370	1100	620		
96-10225	4642	XRF long	69	100	110		
96-10226	4646		<30	70	86		
96-10227	4641		220	250	120		
96-10228	4644	XRF long	120	220	140		
96-10229	4645	XRF long	140	89	130		
96-10230	4647		160	560	240		
96-10231	4648		54	6240	1420		
96-10232	4649	XRF long	52	66	130		
96-10233	4651	XRF long	47	200	170		
96-10234	4652		<30	<20	67		
96-10234D			<30	<20	65		
96-10235	4653	XRF long	110	470	270		
		XRF long	88	450	290		
96-10236	4654						
96-10237	4655		<30	160	91		
96-10238	4656		42	33	130		
96-10239	4657		210	1060	150		
96-10240	4658						
96-10241	4659						
96-10242	4660		720	3580	680		
96-10243	4661		220	700	180		
96-10244	4662	XRF long	118	375	155		
96-10245	4663	XRF long	130	300	280		
96-10246	4664		160	500	140		
96-10247	4665	XRF long	110	240	140		
96-10248	4666		53	98	94		
96-10249	4667						
96-10250	4668		<30	230	170		
96-10251	4669	XRF long	75	30	63		
96-10252	4670	duplicate/ long	76	360	140		
96-10253	4670	duplicate	87	555	164		
96-10254	4671	XRF long	110	340	120		
96-10255	4672		<30	220	170		
96-10256	4673						

<=less than the detection limit indicated

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>2. Warehouse cont'd</i>							
96-10257	4674	XRF long	76	420	150		
96-10258	4675						
96-10259	4676	XRF long	80	150	110		
96-10260	4677						
96-10261	4678	duplicate	41	240	160		
96-10262	4678	duplicate	110	406	145		
96-10263	4679						
96-10264	4680		<30	72	100		
96-10265	4601						
96-10266	4602		<30	80	120		
96-10267	4603						
96-10268	4604	XRF long	90	240	150		
96-10269	4605						
96-10270	4606	duplicate					
96-10271	4606	duplicate					
96-10272	4607						
96-10273	4608						
96-10274	4609		<30	88	110		
96-10275	4610		33	100	91		
96-10276	4611						
96-10277	4612		65	280	180		
96-10278	4613		55	600	200		
96-10279	4614		<30	320	200		
96-10280	4615	duplicate	63	32	75		
96-10281	4615	duplicate	81	19	119		
96-10282	4616		<30	52	110		
96-10439	4643						
96-10482	ESG22	60-70cm	290	330	320		
96-10493	5088		63	91	130		
96-10494	5095		53	69	97		
96-10495	5080		120	820	330		
96-10496	5082		<30	120	110		
96-10497	5083						
96-10509	5050		46	54	110		
96-10510	5051		24	40	110		
96-10511	5055		150	290	440		
96-10512	5054	XRF long	75	280	310		
96-10513	5056		60	270	290		
96-10514	5053	XRF long	64	190	180		
96-10515	5057	XRF long	78	180	240		
96-10516	5096	XRF long	53	60	164		
96-10517	5097		53	73	160		
96-10433	4991	duplicate	68	55	143		
96-10434	4991	duplicate					
96-10435	4992		<30	100	130		
96-10436	4990		58	<20	100		
96-10437	4993		<30	63	60.5		
96-10438	4994		<30	130	78		

<=less than the detection limit indicated

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>4. Powerhouse and Pump House</i>							
96-10037	4737						
96-10038	4729						18
96-10039	4768						6.0
96-10040	4769						
96-10041	4730	duplicate					39
96-10042	4730	duplicate					32
96-10043	4793						
96-10044	4798						
96-10045	4770						<1.0
96-10046	4800						
96-10047	4739						23
96-10048	4796						
96-10049	4766						
96-10050	4764						3.0
96-10051	4761						
96-10052	4740						138
96-10053	4799						4.0
96-10054	4762						19
96-10055	4797	duplicate					3.0
96-10056	4797	duplicate					5.0
96-10057	4733						22
96-10058	4731						100
96-10059	4743						765
96-10060	4732						1500
96-10061	4742						2200
96-10062	4745						2900
96-10063	4747						4000
96-10064	4775						53
96-10065	4750						56
96-10066	4748						44
96-10067	4736						28
96-10068	4723	duplicate					5.0
96-10069	4723	duplicate					13
96-10070	4794						<1.0
96-10071	4778						
96-10072	4735						
96-10073	4777						6.0
96-10074	4771						
96-10075	4767						<1.0
96-10076	4763						
96-10077	4765						
96-10078	4758						20
96-10079	4795						
96-10080	4728						<1.0
96-10081	4728						3.0
96-10082	4780						2.0
96-10083	4738						

<=less than the detection limit indicated

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>4. Powerhouse and Pump House cont'd</i>							
96-10084	4734						1.0
96-10085	4746						7.0
96-10086	4791						2.0
96-10087	4774						
96-10088	4772						<1.0
96-10089	4741						
96-10090	4749						<1.0
96-10091	4749						<1.0
96-10092	4792						<1.0
96-10093	4773						21
96-10094	4744						11
96-10095	4776						260
96-10096	4779						35
96-10097	4783						35
96-10098	4788						4.0
96-10099	4784						
96-10100	4782						40
96-10101	4782						80
96-10102	4789						39
96-10103	4790						<1.0
96-10104	4781						
96-10105	4785						1.0
96-10106	4813						728
96-10107	4814						16
96-10108	4818						7.0
96-10109	4810						2.0
96-10110	4816	duplicate					2.0
96-10111	4816	duplicate					6.0
96-10112	4805						<1.0
96-10113	4756						<1.0
96-10114	4804						
96-10115	4807						12
96-10116	4801						7.0
96-10117	4812						8.0
96-10118	4815						2.0
96-10119	4803						
96-10120	4808						
96-10121	4786	duplicate					11
96-10122	4786	duplicate					12
96-10123	4787						9.0
96-10124	4809						3.0
96-10125	4802						
96-10126	4806						
96-10127	4811						18
96-10128	4819						5.0
96-10129	ESG40	30-40cm					<1.0
96-10130	4763	30-40cm					<1.0
96-10131	ESG28	30-40cm					<1.0
96-10132	4756	30-40cm					<1.0

<=less than the detection limit indicated

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>4. Powerhouse and Pump House cont'd</i>							
96-10135	4825						15
96-10136	4829						<1.0
96-10137	4824						<1.0
96-10138	4827	XRF long	36	180	410	3.4	
96-10139	4826	XRF long	73	71.5	260	8.2	
96-10140	4820	duplicate					<1.0
96-10141	4820	duplicate					1.0
96-10142	4828						13
96-10143	4823						<1.0
96-10144	4822	XRF long	36	110	270	<0.5	
96-10145	4821					8.6	
96-10146	4830					0.7	
96-10147	4833						
96-10148	4831						
96-10149	4832	XRF long	150	59	580		
96-10150	4834	duplicate					<1.0
96-10151	4834	duplicate				<0.5	<1.0
96-10152	4835						
96-10153	4836						
96-10154	4837						
96-10155	4838						
96-10156	4839						
96-10157	4840					<0.5	
96-10158	4841						
96-10159	4842	duplicate					
96-10160	4842	duplicate					
96-10161	4843						
96-10162	4844						
96-10163	4845					<0.5	
96-10164	4846						
96-10165	4847						
96-10166	4850	duplicate				2.2	14
96-10168	4850	duplicate				0.5	<1.0
96-10167	4849						
96-10169	4851						
96-10170	4852		<30	<20	100	<0.5	
96-10171	4853	duplicate				0.8	
96-10172	4853	duplicate					2.2
96-10173	4854						
96-10174	4855		<30	<20	130	<0.5	
96-10175	4856						
96-10176	4857					<0.5	
96-10177	4851	30-40cm					
96-10178	4858						
96-10179	4859						<1.0
96-10180	4860						
96-10181	4861		<30	77	<20	<0.5	
96-10182	4862		97	1040	3760		

<=less than the detection limit indicated

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>4. Powerhouse and Pump House</i>							
96-10183	4863	duplicate	390	51	130		
96-10184	4863	duplicate	290	44	150		
96-10185	4864		160	63	150		
96-10187	4865		180	480	1320		
96-10188	4866		34	75	740		
96-10189	4867		210	160	1100		
96-10440	4965		48	89	210	<0.5	<1.0
96-10441	4996						<1.0
96-10442	4997					<0.5	2.0
96-10443	4997						<1.0
96-10444	4998						4.0
96-10445	4999					<0.5	<1.0
96-10446	5004						<1.0
96-10447	5003					<0.5	<1.0
96-10448	5005						<1.0
96-10449	5006					<0.5	7.0
96-10450	5007	duplicate				<0.5	<1.0
96-10451	5007	duplicate					<1.0
96-10452	5008						
96-10453	5009					<0.5	
96-10454	5011		85	<20	130		
96-10455	5010		32	46	160		
96-10456	5016		61	<20	150	<0.5	<1.0
96-10457	5015	XRF long	55	<20	100		
96-10458	5012		44	160	260		<1.0
96-10459	5013		99	330	3220	<0.5	
96-10460	5014	duplicate	140	30	89		<1.0
96-10461	5014	duplicate	<30	31	63		<1.0
96-10462	5017		200	42	210		
96-10463	5018	XRF long	110	81	160		
96-10464	4817					<0.5	
96-10465	4876						<1.0
96-10466	5019					<0.5	<1.0
96-10467	5090		<30	330	300		
96-10468	5093		180	330	510		
96-10469	5091	XRF long	53	50	140		
96-10470	5092		270	320	700		
96-10471	5092		200	370	820		
<i>5. Garage Foundation and Fire Hall</i>							
96-10186	4868		52	160	490		
96-10190	4869		32	<20	130		
96-10191	4870	duplicate	<30	110	250		
96-10192	4870	duplicate	<30	49	190		
96-10193	4871						
96-10194	4872		83	720	1320		
<i><=less than the detection limit indicated</i>							

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>5. Garage cont'd</i>							
96-10195	4873		<30	220	160		
96-10196	4874						
96-10197	4868	30-40cm					
96-10198	4868	white substance	<30	<20	150		
96-10199	4877	XRF long	49	100	440		
96-10200	4879		51	82	150		
96-10201	4875		<30	820	820		
96-10202	4881		89	660	1440		
96-10203	4875	20-30cm/ XRF long	72	180	190		
96-10472	5023		<30	<20	180		
96-10473	5024	XRF long	<30	<20	130		
96-10474	5022	XRF long	69	20	370		
96-10475	5021		32	28	140		
96-10476	5020	XRF long	77	<20	140		
96-10477	5025		<30	45	130		
96-10478	5027		58	160	170		
96-10479	5028		33	66	230		
96-10480	5025	duplicate	65	320	390		
96-10481	5025	duplicate	54	270	390		
<i>6. Beacon Site</i>							
96-10384	4927						
96-10385	4933						
96-10386	4934		<30	32	<20		
96-10387	4928		45	<20	100		
96-10388	4935						
96-10389	4936		65	<20	120		
96-10390	4929	duplicate	100	40	110		
96-10391	4929	duplicate	<30	49	160		
96-10392	4937						
96-10393	4938						
96-10394	4930		80	120	230		
96-10395	4939						
96-10396	4959		<30	<20	110		
96-10397	4931		51	42	110		
			34	29	140		
96-10398	4963						
96-10399	4964	duplicate					
96-10400	4964	duplicate					
96-10401	4932						
96-10402	4966						
96-10403	4967		44	72	220		
96-10404	4968		130	150	530		
<i><=less than the detection limit indicated</i>							

Table V-3: Inorganic Element and PCB Results for Delineation Soils cont'd

Sample #	Tag #	Details	Cu	Pb	Zn	PCBs by Test Kit	PCBs by GC/ECD (RMC)
(ppm)							
<i>6 Beacon Site cont'd</i>							
96-10405	4974						
96-10406	4973		<30	53	100		
96-10407	4969		150	70	290		
96-10408	4975						
96-10409	4976	duplicate	59	248	164		
96-10410	4976	duplicate	90	135	153		
96-10411	4970		<30	290	520		
96-10412	4972						
96-10413	4977		53	360	330		
96-10414	4971		<30	120	230		
96-10415	4978						
96-10416	4979	XRF long	<30	120	160		
96-10417	4980		73	1120	1020		
96-10418	4984		41	49	140		
96-10419	4981		42	39	150		
96-10420	4985		<30	110	67		
96-10421	4982		77	620	130		
96-10422	4986	duplicate	52	118	114		
96-10423	4986	duplicate	56	97	74		
96-10424	4983						
96-10425	4987	XRF long	44	50	120		
96-10426	4988		<30	1340	150		
96-10427	4989		49	110	200		
96-10428	5002		30	22	110		
96-10429	5001						
96-10430	5000	duplicate	<30	<20	140		
96-10431	5000	duplicate	40	<20	78		
96-10432	ESG109	30-40cm	54	48	180		
<i><=less than the detection limit indicated</i>							

Table V-4: Pesticide Results for Delineation Soils

Sample Tag #	96-10001 4722	96-10003 4703	96-10005 4710	96-10006 4709	96-10007 4701	duplicate 4701
Sample Wt. (dry)	5.00g	5.22g	5.95g	4.80g	4.88g	4.79g
% moisture	3.5	3.9	2.8	6.2	8.1	9.6
concentration in ppb (ng/g)						
Compound						
Hexachlorobenzene	NDR(5.2)	NDR(5.7)	5.2	6.2	<5.0	<4.3
alpha BHC	<9.5	<5.2	<7.1	<14	<9.0	<9.7
beta BHC	<15	<8.3	<11	<23	<14	<15
gamma BHC	<14	<7.7	<10	<21	<13	<14
Heptachlor	<30	<19	<13	<33	<22	<23
Aldrin	<8.2	<5.3	<5.7	<9.1	<8.0	<6.3
Oxychlorthane	<38	<38	<18	<58	NDR(55)	58
trans-Chlordane	130	88	8.4	120	620	710
cis-Chlordane	130	86	12	120	650	720
o,p'-DDE	<5.8	<2.3	<2.1	<4.4	<3.4	<2.6
p,p'-DDE	43	34	NDR(13)	27	23	22
trans-Nonachlor	66	45	<4.5	36	360	390
cis-Nonachlor	23	25	<3.9	10	130	140
o,p'-DDD	<5.0	<3.6	<2.6	<5.7	<2.9	<3.3
p,p'-DDD	<5.2	<3.8	<2.7	<5.9	<3.0	<3.4
p,p'-DDT	85	64	<4.0	54	54	51
Mirex	<4.7	<3.3	<2.9	<5.7	<4.0	<4.1
Heptachlor Epoxide	14	4.9	23	63	42	49
alpha-Endosulphan	<1.4	<1.5	<1.1	<1.9	<2.9	<2.3
Dieldrin	<2.3	<2.3	<1.8	<2.6	<3.2	<3.1
Endrin	<4.6	<4.5	<3.6	<4.8	<6.3	<5.9
Methoxychlor	<11	<11	<8.8	<12	<17	<16

** calibration range exceeded. Concentrations could be greater than those reported here.*

Table V-4: Pesticide Results for Delineation Soils cont'd

Sample	96-10008	96-10011	96-10013	96-10016	96-10020	96-10025
Tag #	4714	4720	4712	4724	4713	4705
Sample Wt. (dry)	5.04g	4.62g	5.30g	4.90g	3.81g	5.07g
% moisture	9.0	9.7	5.4	4.7	25	9
concentration in ppb (ng/g)						
Compound						
Hexachlorobenzene	NDR(8.6)	<5.3	<6.5	NDR(5.4)	<6.1	<5.1
alpha BHC	<12	<26	<36	<10	<19	<27
beta BHC	<19	<45	<62	<16	<31	<47
gamma BHC	<18	<37	<51	<15	<28	<39
Heptachlor	160000	<27	<43	110000	62	<35
Aldrin	<10	<14	<22	<10	<9.3	<18
Oxychlorane	NDR(1100)	100	<87	NDR(570)	76	<71
trans-Chlordane	950000	1300	600	330000	670	18
cis-Chlordane	660000	1400	700	270000	670	15
o,p'-DDE	NDR(93)	<3.4	<5.6	NDR(44)	<5.0	<4.6
p,p'-DDE	180	130	54	120	52	29
trans-Nonachlor	170000	890	390	78000	370	11
cis-Nonachlor	27000	260	140	18000	110	<9.2
o,p'-DDD	NDR(280)	<5.0	<7.9	NDR(120)	<7.5	<6.4
p,p'-DDD	NDR(270)	<5.6	<8.8	NDR(130)	<7.8	<7.2
p,p'-DDT	3100	500	220	NDR(1700)	150	99
Mirex	<6.0	<8.3	<11	<6.5	<8.3	<7.5
Heptachlor Epoxide	1300	250	130	770	170	10
alpha-Endosulphan	<39	<3.2	<1.9	<13	<2.9	<2.2
Dieldrin	<37	<5.3	<3.3	<14	<4.1	<3.7
Endrin	<72	<8.1	<5.0	<26	<8.0	<5.4
Methoxychlor	<200	<12	<12	<71	<20	<14

* calibration range exceeded. Concentrations could be greater than those reported here.

Table V-4: Pesticide Results for Delineation Soils cont'd

Sample	96-10027	96-10030	96-10133	96-10134
Tag #	4704	4760	4725 30-40 cm	Tag 27 30-40 cm
Sample Wt. (dry)	4.99g	4.92g	5.25g	4.95g
% moisture	8.9	10	4.4	12
concentration in ppb (ng/g)				
Compound				
Hexachlorobenzene	<5.6	<5.0	<5.5	6.9
alpha BHC	<32	<25	<30	<22
beta BHC	<55	<43	<50	<38
gamma BHC	<46	<36	<42	<31
Heptachlor	<43	<34	740	730000
Aldrin	<22	<17	<18	<15
Oxychlorane	<88	<68	<74	NDR(2000)
trans-Chlordane	<10	<8.1	600	1100000*
cis-Chlordane	<12	<9.2	390	760000*
o,p'-DDE	<5.5	<4.4	<4.8	<3.4
p,p'-DDE	14	16	9.4	NDR(41)
trans-Nonachlor	<13	<9.8	160	170000
cis-Nonachlor	<11	<8.9	<9.6	19000
o,p'-DDD	<8.0	<6.2	<6.7	<5.6
p,p'-DDD	<8.9	<6.9	<7.5	NDR(280)
p,p'-DDT	28	24	<9.8	2300
Mirex	<9.4	<7.8	<9.2	<7.7
Heptachlor Epoxide	NDR(3.8)	<2.3	690	NDR(1400)
alpha-Endosulphan	<2.0	<1.4	<1.7	<28
Dieldrin	<3.0	<2.2	<2.8	<39
Endrin	<4.6	<3.2	<4.2	<60
Methoxychlor	<11	<8.1	<10	<140

* calibration range exceeded. Concentrations could be greater than those reported here.

Table V-5: Inorganic Element and PCB Results for Paint Chips and Wood

Sample	Cu	Ni	Co	Cd	Pb	Zn	Cr	As	PCBs by GC/ECD	Description
FHPC-1	10.5	<5.0	10.0	<1.0	800	560	140	0.16		Fire Hall: light blue paint from wall board
FHWD-1	4.4	<5.0	<5.0	<1.0	<10	80	<20	<0.2		Fire Hall: wood from doorway - painted red
FHWD-2	1100	<5.0	<5.0	1.3	449	640	38	1.8		Fire Hall: wood from floor - painted red
ACPC-1	3.9	<5.0	102	<1.0	960	4300	47	<0.2	19	Married Quarters: White paint over beige from Room #1
ACPC-2	<3.0	45	54	<1.0	700	1160	144	0.44	10	Married Quarters: Blue paint from Room #2
ACPC-3	<3.0	<5.0	24	<1.0	880	5720	125	<0.2	19	Married Quarters: White paint over green from Room #6
ACWD-1	4.1	<5.0	23	1.5	560	2960	73	<0.2		Married Quarters: Wood from floor of Room #2 - painted blue
ACWD-2	<3.0	<5.0	15.1	<1.0	499	5380	50	<0.2		Married Quarters: Wood from Room #6 - painted white

Table V-6: Building Material Asbestos Results

Sample	Asbestos Content	Location
SNASB-5	1-5% chrysotile	Fire Hall exterior white siding
SNASB-6	asbestos not detected	Fire Hall insulation
ACASB-1	asbestos not detected	Married Quarters floor tile from Room #1
ACASB-2	asbestos not detected	Married Quarters insulation from ceiling in Room #6
ACASB-3	asbestos not detected	Married Quarters floor tile from Room #6
ACASB-4	asbestos not detected	Married Quarters insulation from Room #4
ACASB-5	asbestos not detected	Married Quarters floor tile from Room #2

APPENDIX C: QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

An internal quality assurance/quality control program was implemented to allow the monitoring of data quality on an ongoing basis. All samples were given sequential, numerical codings before submission to the analytical firms; these codings masked any information concerning site location, sample type or possible concentration of the sample. Aspects of the QA/QC program and the results are discussed below.

A. QA/QC for Field Testing

1. *Inorganic Elements*

a) Field Analyses

For field measurements, the operation of the Field Portable X-ray Fluorescence Analyzer (FPXRF) was monitored with pure metal and Teflon standards in accordance with the manufacturer's instructions. As recommended by the manufacturer, analyses were only performed upon obtaining manganese and cobalt intensities of <0.003 when pure iron was used as the standard, and gave a result of $>96\%$ iron content. Precision and reproducibility of the data was reviewed by analyzing 17 samples in duplicate. The average relative standard deviation or coefficient of variation expressed as a percentage for all replicate soil was good for copper (19%) and zinc (14.3%) and acceptable for lead (28%, Table V-7).

Precision and reproducibility of XRF results was monitored by submitting 17 field duplicates (two samples collected from the same location) blind to the XRF technician. Good reproducibility as achieved as indicated by average relative standard deviations of 18.7% for copper and 14.3% for both lead and zinc.

b) Comparison of Field and Laboratory Results

Twenty-four samples analyzed by FPXRF in the field were reanalyzed in the ASU laboratory by using atomic absorption spectroscopy (AAS) - the results are presented in Table V-9. Average relative standard deviations were 30% for copper, 38% for lead and 15.8% for zinc. These results are acceptable for the purposes of delineation.

2. PCB Analysis

a) Field Analyses

PCB field test kits were used to arrive at a rough estimate of PCB soil concentrations, as it was shown previously that due to the organic nature of the substrate the kits did not produce accurate results.²⁰ Only 28 soil samples were analyzed by PCB test kit, as compared to 103 samples that were analyzed by gas chromatography with electron capture detector (GC/ECD) in a southern laboratory. Analysis by test kit was done in batches of no more than 20 samples, including one blank and a range of standards between 0 and 10 ppm. For QA/QC purposes at least one of the standards was run at the beginning and again at the end of the run. Sample concentrations were interpolated from a standard curve, and if necessary, samples were diluted so as to have PCB concentrations within the range of the PCB standards.

b) Comparison of Field and Laboratory Results

Eleven soil samples were reanalyzed in the ESG laboratory by GC/ECD. In 63% of cases PCB test kit results correctly categorized PCB concentrations in the soil samples in terms of the applicable criteria.

B. QA/QC for Inorganic Analysis - Queen's University Analytical Services Unit (ASU)

1. Accuracy

Accuracy was monitored internally by ASU using two replicates of NRC Canada Marine Reference Sediment MESS-2 (Table V-11). These were run concurrently with sample batches throughout the analytical program. Good agreement with the certified values was obtained for all elements, with the exception of chromium and lead. Results for these elements were consistently low relative to the certified values, but this discrepancy is attributed to differences in the digestion methods.

²⁰ ESG, 1996.

2. Precision/Repeatability

Internal monitoring of precision was carried out by ASU through the use of analytical replicates. Three soil samples and 1 paint chip sample were analyzed in duplicate and one soil sample was analyzed in quadruplicate (Table V-12). Average relative standard deviations for nickel (10.5%), cobalt (7.5%), lead (9.8%), zinc (8.2%), chromium (10.4%) and arsenic (5.1%) in the soil replicates were less than 20% indicating good to excellent analytical precision for soil analysis. Copper was slightly higher but well within acceptable levels at 22%. All cadmium results were below the level of detection. The Relative Standard Deviations for the paint chip analytical duplicates were all within acceptable standards.

C. QA/QC for Analysis of PCBs in Soil - ESG Laboratory, RMC, Kingston, Ontario

The QA/QC protocol for PCBs calls for analyses to be carried out in batches of no more than 20 samples. Each batch must include one analytical duplicate and a procedural blank. Each batch is treated as a separate unit: samples within the same batch must be worked up and analyzed continuously, and the QA/QC data considered with respect to each batch.

1. Accuracy

Internally all samples were spiked with an aliquot of decachlorobiphenyl (DCBP), a surrogate standard, prior to analysis by gas chromatography (GC) with electron capture detection (ECD), in order to measure recovery of PCBs. The method was calibrated using known standards of Aroclor 1260 and 1254. Each batch was monitored internally by running blank soil samples. Eight blank samples were analyzed in total, and their results are shown in Table V-13. Accuracy was monitored externally by reanalyzing nine samples at the Axys laboratory (Table V-14). For those samples in which PCBs were detected by the ESG lab (detection limits of 0.5 or 1.0), accuracy of results as compared to the Axys results were within the acceptable range (<30%) for only two samples. Results from the two laboratories led to the same categorization of contaminated soil in 67% of the samples, even though the values did not agree closely. In the remaining 33% of samples RMC values were higher than Axys values. Hence, using RMC values, a larger volume of soil was excavated than would have been, based on Axys values. The discrepancies

between the results from the two labs can be attributed to the great heterogeneity of the samples which consisted of roots, pebbles and soil.

2. Precision/Repeatability

Precision was monitored externally by ESG using seven pairs of soil sample field duplicates which were homogenized in the field during collection and submitted blind to the laboratory for analysis. Results for these field duplicates are presented in Table V-16. The average relative standard deviation was 38% and individual relative standard deviations ranged from 0% to 71%. The three sample pairs that exceeded the acceptable range of <30% relative standard deviation were particularly heterogeneous in their makeup.

Precision was also monitored internally using ten soil analytical replicates (Table V-16). The average relative standard deviation for these duplicates indicated good precision (20%) was obtained overall, but individual relative standard deviations ranged 0% to 41% indicating precision obtained with this method was sample dependent. Again, the heterogeneity of the substrate at Snag Airstrip made reproduction of results difficult.

D. QA/QC for PCB Analysis - Axy's Analytical Services Ltd., Sydney, BC

The QA/QC protocol used by Axy's for PCBs consisted of the batch method, in which samples were worked up in batches with associated quality control samples. A single batch (nine samples) was run for the purposes of conducting an external check of the PCB results from the RMC laboratory. This batch also included one QA/QC sample (certified or internal spiked reference material), one analytical duplicate and a procedural blank. Each batch analyzed at Axy's was carried through sample workup, instrumentation and interpretation as a unit, and the sample results interpreted in relation to the associated QA/QC results. The results of the PCB QA/QC program for Axy's Analytical are discussed below.

1. Accuracy

Axy's monitored the accuracy of PCB analysis of soils (for Aroclors 1242, 1254 and 1260) internally using spiked soil reference materials (Table V-17). Good agreement was found between determined and expected values for all three Aroclors (within 16% of the expected value), indicating that analytical accuracy was good.

Interferences for PCB analysis as Aroclors were monitored internally using a single soil blank (Table V-18). The soil analytical blank showed no detectable Aroclors.

2. Precision/Repeatability

Precision was monitored internally by Axys, through the use of one soil analytical replicate (Table V-19). The relative standard deviation, or coefficient of variation (standard deviation divided by the mean), for this sample was 72%, indicating poor correlation between these duplicates; the discrepancy of these results were attributed to the heterogeneity of the sample.

E. QA/QC for Chlorinated Pesticides - Axys Analytical Services Ltd (Axys)

1. Accuracy

The accuracy of pesticide analysis was monitored internally by Axys using a spiked reference material which was analyzed for the single batch of soil for which these analyses were requested during the delineation phase of the project (Table V-20). Recoveries for most of the chlorinated pesticides were within 20% of the spiked value, indicating good analytical accuracy.

Interferences were also checked internally through the use of two analytical blanks (Table V-21). Most of the pesticide concentrations were below the detection limits and those that were detected were at very low concentrations (<14 ppb).

2. Precision/Repeatability

Precision for pesticide analysis was monitored internally by Axys through the analysis of a soil sample in duplicate (Table V-22). The majority of compounds analyzed in the soil samples were below detection limits. The seven compounds that were quantifiable had relative standard deviations ranging between 3.1% and 11%, indicating that very good to excellent precision was obtained using the methods applied.

Table V-7: Concentrations of Metals in Duplicate Analyses of Soil Samples by FPXRF

Sample #	Tag #	Cu	Pb	Zn
ppm (ug/g)				
96-10336	4904	61	73	200
96-10336D		<30	160	180
Std Dev		-	62	14.1
Rel Std Dev		-	53	7.4
96-10346	4914	42	130	150
96-10346D		33	60	140
Std Dev		6.4	49	7.1
Rel Std Dev		17	52	4.9
96-10381	4961	<30	180	480
96-10381D		<30	160	320
Std Dev		-	14.1	113
Rel Std Dev		-	8.3	28
96-10490	5036	68	<20	100
96-10490D		<30	<20	130
Std Dev		-	-	21
Rel Std Dev		-	-	18.4
96-10222	4698	<30	540	330
96-10222D		29	320	210
Std Dev		-	156	85
Rel Std Dev		-	36	31
96-10235	4653	110	470	270
96-10235		88	450	290
Std Dev		15.6	14.1	14.1
Rel Std Dev		15.7	3.1	5.1

Table V-7: Concentrations of Metals in Duplicate Analyses of Soil Samples by FPXRF cont'd

Sample #	Tag #	Cu	Pb	Zn
ppm (ug/g)				
96-10239	4657	200	860	140
96-10239D		210	1260	160
Std Dev		7.1	283	14.1
Rel Std Dev		3.4	27	9.4
96-10244	4662	94	300	160
96-10244D		73	390	170
Std Dev		14.8	64	7.1
Rel Std Dev		17.8	18.4	4.3
96-10510	5051	<30	27	130
96-10510D		33	53	91
Std Dev		-	18.4	28
Rel Std Dev		-	46	25
96-10457	5015	31	29	76
96-10457D		37	<20	110
Std Dev		4.2	-	24
Rel Std Dev		12.5	-	26
96-10186	4868	48	190	480
96-10186D		56	130	490
Std Dev		5.7	42	7.1
Rel Std Dev		10.9	27	1.5
96-10474	5022	120	260	440
96-10474D		120	230	450
Std Dev		0	21	7.1
Rel Std Dev		0	8.7	1.6

Table V-7: Concentrations of Metals in Duplicate Analyses of Soil Samples by FPXRF cont'd

Sample #	Tag #	Cu	Pb	Zn
ppm (ug/g)				
96-10417	4980	53	1080	980
96-10417D		93	1180	1080
Std Dev		28	71	71
Rel Std Dev		39	6.3	6.9
96-10437		<30	100	35
96-10437		<30	26	86
Std Dev		-	52	36
Rel Std Dev		-	83	60
10287	4620	45	251	435
10287D	4620	99	265	389
Std Dev		38	9.9	33
Rel Std Dev		53	3.8	7.9
10423	4986	54	107	68
10423 D	4986	57	87	79
10423	4986	56	97	74
Std Dev		1.5	10	5.5
Rel Std Dev		2.7	10.3	7.5
10332D		96	120	140
10332		53	111	131
Std Dev		30	6.4	6.4
Rel Std Dev		41	5.5	4.7
Average Rel Std Dev		19	28	14.3
Std Dev		± 16.7	± 25	± 14.9

Table V-8: Inorganic Element Results for Field Duplicates Analyzed by FPXRF

Sample #	Tag #	ppm (ug/g)		
		Cu	Pb	Zn
96-10286	4620	76	176	376
96-10287	4620	72	260	410
Std Dev		2.8	59	24
Rel Std Dev		3.8	27	6.1
96-10305	4637	340	660	680
96-10306	4637	600	820	980
Std Dev		184	113	212
Rel Std Dev		39	15.3	26
96-10311	4883	82	220	180
96-10312	4883	45	190	190
Std Dev		26	21	7.1
Rel Std Dev		41	10.3	3.8
96-10381	4961	<30	170	400
96-10382	4961	<30	200	330
Std Dev		-	21	49
Rel Std Dev		-	11.5	13.6
96-10490	5036	68	<20	115
96-10491	5036	<30	<20	110
Std Dev		-	-	3.5
Rel Std Dev		-	-	3.1
96-10503	5045	<30	69	160
96-10504	5045	50	90	350
Std Dev		-	14.8	134
Rel Std Dev		-	18.7	53

Table V-8: Inorganic Element Results for Field Duplicates Analyzed by FPXRF cont'd

Sample #	Tag #	Cu	Pb	Zn
ppm (ug/g)				
96-10183	4863	390	51	130
96-10184	4863	290	44	150
Std Dev		71	4.9	14.1
Rel Std Dev		21	10.4	10.1
96-10191	4870	<30	110	250
96-10192	4870	<30	49	190
Std Dev		-	43	42
Rel Std Dev		-	54	19.3
96-10480	5025	65	320	390
96-10481	5025	54	270	390
Std Dev		7.8	35	0
Rel Std Dev		13.1	12	0
96-10390	4929	100	40	110
96-10391	4929	<30	49	160
Std Dev		-	6.4	35
Rel Std Dev		-	14.3	26
96-10430	5000	<30	<20	140
96-10431	5000	40	<20	78
Std Dev		-	-	44
Rel Std Dev		-	-	40
96-10460	5014	140	30	89
96-10461	5014	<30	31	63
Std Dev		-	0.71	18.4
Rel Std Dev		-	2.3	24

Table V-8: Inorganic Element Results for Field Duplicates Analyzed by FPXRF cont'd

Sample #	Tag #	Cu	Pb	Zn
96-10212	4689	370	1960	1380
96-10213	4689	600	3440	1560
Std Dev		169	1040	127
Rel Std Dev		35	39	8.6
96-10252	4670	78	375	130
96-10253	4670	87	560	164
Std Dev		6.7	127	24
Rel Std Dev		8.2	27	16.4
96-10261	4678	41	240	160
96-10262	4678	110	406	145
Std Dev		49	117	10.6
Rel Std Dev		65	36	7
96-10280	4615	63	32	75
96-10281	4615	81	18.5	119
Std Dev		12.7	9.2	31
Rel Std Dev		17.7	37	32
96-10483	5032	61	320	840
96-10485	5032	48	200	710
Std Dev		9.2	85	92
Rel Std Dev		16.9	33	11.9
Average Rel Std Dev		26	23	17.7
Std Dev		± 18.7	± 14.3	± 14.3

Table V-9: Concentrations of Cu, Pb, and Zn in Soils Analyzed by FPXRF and AA

Sample	XRF Cu	AA Cu	Cu			XRF Pb	AA Pb	Pb		
			Rel Std	Dev	Rel Std			Dev	Rel Std	Dev
	XRF Zn	AA Zn	Zn			Rel Std	Dev	Zn		
			Rel Std	Dev	Rel Std			Dev	Rel Std	Dev
96-10139	73	59	14.8		72	308	88	260	373	25
96-10144	36	103	68		110	132	13	270	250	5.4
96-10149	150	328	53		59	129	53	580	450	17.9
96-10181	<30	41	-		77	22	78	<20	82	-
96-10183	390	298	18.8		51	92	41	130	135	2.6
96-10188	34	57	35		75	100	20	740	700	4.4
96-10194	83	65	17.5		720	1880	63	1320	2040	30
96-10202	89	109	14.4		660	450	27	1440	760	43
96-10216	260	108	58		20500	35360	38	230	125	42
96-10233	49	69	24		203	342	36	173	187	5.5
96-10278	55	101	42		600	840	24	200	212	4.1
96-10302	230	268	10.8		200	417	50	340	200	37
96-10342	<30	39	-		740	800	6.1	260	260	0.02
96-10417	73	214	70		1120	1080	2.7	1020	1180	10.1
96-10428	30	34	7.8		22	49	54	110	93	11.7
96-10440	48	41	10.3		89	86	2.5	210	285	21
96-10457	59	64	6.4		<20	119	-	96	128	20
96-10469	56	47	12		47	41	10.7	153	159	2.7
96-10474	72	92	16.9		49	317	104	390	418	4.9
96-10484	47	7.3	103		240	270	8.4	420	520	14.4
96-10487	<30	36	-		<20	<10	-	94	116	15.1
96-10518	35	57	34		<20	142	-	95	117	14.4
96-10519	1160	1120	2.6		1040	1200	10.3	1360	1420	3.3
96-10528	63	56	8.7		3100	8120	63	4980	7620	30
Average Rel Std Dev			30				38			15.8
Std Dev			± 27				± 30			± 13.2

Table V-10: Comparison of PCBs Analyzed by Test Kits and GC/ECD

Sample #	Tag #	PCBs by GC/ECD (RMC)	PCBs by Test Kit	Agreement
		ppm		
96-10151	4834	<1.0	<0.5	yes
96-10166	4850	14	2.2	
96-10168	4850	<1.0	0.5	
96-10440	4965	<1.0	<0.5	yes
96-10442	4997	2.0	<0.5	
96-10445	4999	<1.0	<0.5	yes
96-10447	5003	<1.0	<0.5	yes
96-10449	5006	7.0	<0.5	
96-10450	5007	<1.0	<0.5	yes
96-10456	5016	<1.0	<0.5	yes
96-10466	5019	<1.0	<0.5	yes

Table V-11: Summary of Inorganic Element Analysis Results for Soil Internal Standards

Element	MESS-2	
	Certified Value ppm ($\mu\text{g/g}$)	Mean (n=2)
Cu	39.3 \pm 2.0	37 \pm 1.1
Ni	49.3 \pm 1.8	45 \pm 0.92
Co	13.8 \pm 1.4	12.5 \pm 0.7
Cd	0.24 \pm 0.01	<1.0
Pb	21.9 \pm 1.2	14.2 \pm 2.8
Zn	172 \pm 16	182 \pm 0.58
Cr	106 \pm 8	52 \pm 3.6
As	20.7 \pm 0.8	18 \pm 1.1

Table V-12: Inorganic Element Results for Soil and Paint Chip Analytical Replicates

Sample	Cu	Ni	Co	Cd	Pb	Zn	Cr	As
SOIL								
96-10144	145	31	13.9	<1.0	136	256	62	5.5
96-10144	61	30	13.9	<1.0	128	245	54	5.6
96-10144	61	33	14.3	<1.0	129	227	59	4.6
96-10144	62	35	14.3	<1.0	129	230	61	5.4
Std Dev	42	2.2	0.23	-	3.7	13.5	3.6	0.46
Rel Std Dev	51	6.9	1.6	-	2.8	5.6	6	8.7
96-10233	63	31	14	<1.0	283	163	62	6.6
96-10233	76	44	17.9	<1.0	400	210	87	7
Std Dev	9.2	9.2	2.8	-	83	33	17.7	0.28
Rel Std Dev	13.2	25	17.3	-	24	17.8	24	4.2
96-10474	92	34	15.7	<1.0	312	421	110	5.9
96-10474	91	34	14.9	<1.0	322	415	108	6.1
Std Dev	0.71	0	0.57	-	7.1	4.2	1.4	0.14
Rel Std Dev	0.77	0	3.7	-	2.2	1	1.3	2.4
Average Rel								
	22	10.5	7.5	-	9.8	8.2	10.4	5.1
Std Dev								
Std Dev	± 26	± 12.6	± 8.5	-	± 12.5	± 8.7	± 11.8	± 3.3
PAINT CHIPS								
ACPC-2	4.0	37	56	<1.0	700	1260	140	0.37
ACPC-2	<3.0	53	51	<1.0	700	1060	148	0.52
Std Dev	-	11.3	3.5	-	0	141	5.7	0.11
Rel Std Dev	-	25	6.6	-	0	12.2	3.9	24

Table V-13: Analytical Blanks for PCBs at RMC Lab

Date	blank concentration
	ug/g
Jul-01	<0.5
Jul-03	<0.5
Jul-09	<0.5
Jul-17	<0.5
Jul-24	<0.5
Aug-5	<0.5
Aug-30	<0.5
Sep-04	<0.5

Table V-14: PCB GC/ECD Results for Samples Analyzed at RMC and Axy's Analytical

Sample #	Tag #	PCBs by Axy's	PCBs by RMC	Std Dev	Rel Std Dev
		ppm	ppm		
96-10056	4797	3.8	5.0	0.8	19.3
96-10065	4750	162	56	75.0	68.8
96-10068	4723	8	5.0	2.1	32.6
96-10106	4813	890	728	114.6	14.2
96-10135	4825	4.9	15	7.1	71.8
96-10137	4824	0.9	<1.0	-	-
96-10142	4828	3	13	7.1	88.4
96-10449	5006	1.5	7.0	3.9	91.5
96-10460	5014	0.03	<1.0	-	-
Average Rel Std Dev					55
Std Dev					± 33

Table V-15: PCB GC/ECD Results for Soil Field Duplicates Analyzed at RMC

Sample #	Tag #	PCBs (ppm)
96-10041	4730	39
96-10042	4730	32
Std Dev		4.9
Rel Std Dev		14
96-10055	4797	3
96-10056	4797	5
Std Dev		1.4
Rel Std Dev		35
96-10068	4723	5
96-10069	4723	13
Std Dev		5.7
Rel Std Dev		63
96-10110	4816	2
96-10111	4816	6
Std Dev		2.8
Rel Std Dev		71
96-10121	4786	11
96-10122	4786	12
Std Dev		0.7
Rel Std Dev		6.1
96-10450	5007	<1.0
96-10451	5007	<1.0
Std Dev		-
Rel Std Dev		-

Table V-15: PCB GC/ECD Results for Soil Field
 Duplicates Analyzed at RMC cont'd

Sample #	Tag #	PCBs (ppm)
96-10460	5014	<1.0
96-10461	5014	<1.0
Std Dev		-
Rel Std Dev		-
Average Rel Std Dev		38
Std Dev		± 29

Table V-16: PCB GC/ECD Results for Soil Analytical
 Replicates at RMC

Sample	Value #1	Value #2	Average	Std Dev	Rel Std Dev
	ug/g				
96-10129	<0.5	<0.5	<0.5	-	-
96-10109	2.2	4.0	3.1	1.3	41
96-10127	16	21	19	3.5	19
96-10466	0.6	0.5	0.6	0.1	13
96-10059	638	677	658	28	4.2
96-10128	4.1	7.4	5.8	2.3	41
96-10143	0.5	0.7	0.6	0.1	24
96-10598	<0.5	<0.5	<0.5	-	-
96-10580	81	107	94	18	20
96-10588	230	230	230	0	0
Average Rel.					20.3
Std Dev					
Std Dev					± 15.1

Table V-20: Determination by Axys Analytical of Internal Spiked Reference Material for Pesticides in Soils

Sample		CL-S-SPM 574	
Concentration in ng/g			
COMPOUNDS	Determined	Certified	% Recovery
Hexachlorobenzene	630	560	113
alpha BHC	510	560	91
beta BHC	790	820	96
gamma BHC	590	540	109
Heptachlor	600	580	103
Aldrin	400	360	111
Oxychlordane	710	640	111
trans-Chlordane	380	320	119
cis-Chlordane	530	480	110
o,p'-DDE	760	570	133
p,p'-DDE	670	540	124
trans-Nonachlor	450	410	110
cis-Nonachlor	290	300	97
o,p'-DDD	580	560	104
p,p'-DDD	600	620	97
p,p'-DDT	680	620	110
Mirex	530	540	98
Heptachlor Epoxide	530	400	133
alpha-Endosulphan	410	400	103
Dieldrin	710	520	137
Endrin	1200	1100	109
Methoxychlor	2400	2500	96

Table V-17: Determination of PCB Aroclors in Internal Spiked Reference Material for Soils by Axys Analytical

	Aroclor 1242			Aroclor 1254			Aroclor 1260		
	Deter	Expected	Recovery	Deter	Expected	Recovery	Deter	Expected	Recovery
	(%)			(%)			(%)		
	ppb or ng/g								
CLS-SPM 723	46	52	88	41	48	85	41	49	84

Table V-18: Analytical Blanks for PCB Aroclors by Axys Analytical

Sample I.D.	Aroclor 1242	Aroclor 1254	Aroclor 1260	Total Aroclor
SOILS	Concentration in ppb (ng/g)			
CLS-BLK 1043	<0.43	<0.45	<0.11	

Table V-19: PCB Aroclor Results for Analytical Replicates by Axys

Sample #	Aroclor 1242	Aroclor 1254	Aroclor 1260	Aroclor Total	Std Dev	Rel Std Dev
	ppb (ng/g)					
96-10135	<30	5800	1000	6800	3200	72
	<17	1900	320	2220		

**Table V-21: Analytical Blanks for Pesticides in Soils
by Axys Analytical**

COMPOUNDS	SOIL	
	CL-S-BLK 834	CL-S-BLK 823
	Concentration in ng/g	
HCB	4.9	<5.7
alpha BHC	<14	<24
beta BHC	<22	<41
gamma BHC	<21	<34
Heptachlor	<24	<29
Aldrin	<8.3	<14
Oxychlordane	<28	<58
trans-Chlordane	<8.9	<6.9
cis-Chlordane	<9.5	<7.9
o,p'-DDE	<3.8	<3.6
p,p'-DDE	NDR(14)	NDR(6.4)
trans-Nonachlor	<9.2	<8.4
cis-Nonachlor	<8.0	<7.6
o,p'-DDD	<5.2	<5.3
p,p'-DDD	<5.4	<5.9
p,p'-DDT	<7.4	<6.6
Mirex	5.3	<7.3
Heptachlor Epoxide	<2.4	<3.0
alpha-Endosulphan	<2.1	<1.9
Dieldrin	<3.2	<3.1
Endrin	<6.3	<4.5
Methoxychlor	<16	<11

NDR = Peak detected but did not meet quantification
criteria

Table V-22: Analytical Replicate Results for Pesticides in Soil by Axys Analytical

Sample Tag #	96-10007	duplicate	Std Dev	Rel Std Dev
	4701	4701		
concentration in ng/g				
Compound				
Hexachlorobenzene	<5.0	<4.3	-	-
alpha BHC	<9.0	<9.7	-	-
beta BHC	<14	<15	-	-
gamma BHC	<13	<14	-	-
Heptachlor	<22	<23	-	-
Aldrin	<8.0	<6.3	-	-
Oxychlordane	NDR(55)	58	-	-
trans-Chlordane	620	710	64	9.6
cis-Chlordane	650	720	49	7.2
o,p'-DDE	<3.4	<2.6	-	-
p,p'-DDE	23	22	0.7	3.1
trans-Nonachlor	360	390	21	5.7
cis-Nonachlor	130	140	7.1	5.2
o,p'-DDD	<2.9	<3.3	-	-
p,p'-DDD	<3.0	<3.4	-	-
p,p'-DDT	54	51	2.1	4.0
Mirex	<4.0	<4.1	-	-
Heptachlor Epoxide	42	49	4.9	11
alpha-Endosulphan	<2.9	<2.3	-	-
Dieldrin	<3.2	<3.1	-	-
Endrin	<6.3	<5.9	-	-
Methoxychlor	<17	<16	-	-