TECHNICAL SCOPE OF WORK
COMMUNITY BASED RISK ASSESSMENT PLAN
FOR PORT COLBORNE, ONTARIO

Project No. 33826

Prepared for
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Reviewed by the MOE, Regional Health Department, the PLC, and Beak International Incorporated

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LIST OF ACRONYMS/ABBREVIATIONS

ACRONYMS/ABBREVIATIONS	
Beak	Beak International Incorporated
City	City of Port Colborne
CBRA	Community Based Risk Assessment
CCME	Canadian Council of Ministers of the Environment
CoC	Chemical of Concern
Community.	All potential receptors (human and ecological) within an area of Port Colborne defined by previous MOE studies as having concentrations of CoCs in soil from Inco's historical operations above the MOE generic Table A guideline
CPI	Critical Phytotoxic Index
ERA	Ecological Risk Assessment
HHRA	Human Health Risk Assessment
HI	Hazard Index
ILCR	Incremental Lifetime Cancer Risk
Inco	Inco Limited
Jacques Whitford	Jacques Whitford Environment Limited
MOE	Ministry of the Environment
PLC	Public Liaison Committee
RfD	Reference Dose
RME	Reasonable Maximum Exposure
SSRA	Site Specific Risk Assessment
TSC	Technical Sub-Committee to the PLC
TDI	Tolerable Daily Intake
TSOW	Technical Scope of Work
VECs	Valued Ecological Components

1.0 INTRODUCTION

1.1 Purpose

Inco Limited (Inco) has committed itself to the community of Port Colborne (represented by the Public Liaison Committee, PLC), the City of Port Colborne (The City) and the Ontario Ministry of the Environment (MOE) to conduct a Community Based Risk Assessment (CBRA). This will be conducted for chemicals of concern (CoC) in the Port Colborne area that are elevated as a result of historical emissions from Inco's Refinery. Drawings 1 and 2 show the location and regional topography of the Port Colborne area.

1.2 Background

1.2.1 History of Area

Inco has operated a nickel refinery in the City of Port Colborne since 1918. Historical operations at the refinery released particulate emissions to the environment which caused regional contamination of soil. The MOE has conducted sampling to determine the extent of soil contamination resulting from Inco's operations and has reported on their results and findings (refer to Section 1.2.2).

Inco has acknowledged responsibility for contamination resulting from their operations and is the proponent of the CBRA process, which includes the quantitative assessment of risks for the community as a whole as well as for individual property owners, and includes the removal of identified risks by carrying out remediation on the affected environmental media.

1.2.2 MOE Studies

The MOE (MOE, 2000a) conducted studies of the Port Colborne area in 1998, in particular around the Refinery plant. Soil samples were analyzed for seventeen (17) metals: aluminum, barium, beryllium, calcium, cadmium, cobalt, copper, chromium, iron, magnesium, manganese, molybdenum, nickel, lead, strontium, vanadium, and zinc. The MOE concluded from their sampling that soil concentrations of nickel, copper and cobalt were elevated above MOE effects-based generic soil clean up guidelines and should be considered to be CoCs.

The levels of nickel in soils reported in 1998 were measured at concentrations of up to 5000 ppm, generally with the highest concentrations closest to the Inco stack, and lower concentrations away from the Inco stack. Soil concentrations of copper and cobalt were measured at up to 350 ppm and 150 ppm, respectively. As with nickel, the concentrations of copper and cobalt were found to be highest near where the old Refinery stack was located, and declined further from it. The areas with the concentration of nickel, copper and cobalt exceeding the MOE Table A Generic guidelines as identified from the 1998 data generally occurred in the eastern portions of the City, and agricultural and forested areas to the north and east of the Refinery, an area of approximately 19 km2.

A more detailed phytotoxicology soils investigation of the Port Colborne area by the MOE in 1999 provided more soil chemical data, including arsenic analyses, to the existing data set. The new data increased the estimated areal extent of Table A Guideline exceedances for nickel, copper and cobalt from 19 km2 to 29 km2 (MOE, 2000c). Spatial distributions of these metals in exceedance of the soil guidelines were plotted on maps by the MOE and these are reproduced on Drawings 3 through 5.

The MOE are continually conducting additional soils investigations of the Port Colborne area. This has recently included woodlots where preliminary findings have indicated soil concentrations of nickel above the maximum values found in the MOE 1998 investigation. The results and findings of this investigation and others will be documented by the MOE in due course.

The MOE (1997b) and the Regional Health Department conducted a limited human health risk assessment in 1997 for residents potentially exposed to the metals nickel, copper and cobalt in soils in the area of Port Colborne. The study concluded that there were no adverse health risks associated with exposure of people to these metals. Subsequent to this MOE and the Regional Health Department study, the Health Department revisited the original report in light of the 1998/1999 MOE data and with respect to regional cancer statistics, and its findings which have been published in an updated report (MOE, 2000a) do not refute their earlier findings.

1.2.3 CBRA Process

As the proponent of the CBRA process, Inco is committed to developing a scientifically sound, risk based and practical solution which protects human health and the environment, to resolve the issue of contamination as a result of Inco's operations. Within the MOE's 1997 "Guideline for Use at Contaminated Sites in Ontario", there are several approaches that can be used by a proponent to achieve site restoration. One of these, namely the Site Specific Risk Assessment (SSRA) approach, is being adopted by Inco in the present case. The SSRA is a scientific technique that estimates risks to humans and the natural environment from exposure to chemicals of concern at the site. Because of specific site characteristics, there may exist numerical differences between safe concentrations of chemicals in the site's soil and the MOE generic safe levels. The SSRA is able to derive safe levels of chemicals that give the same level of protection for that site as do the generic levels.

In the Port Colborne issue, it is clear from soil analyses that certain chemicals originating from Inco's operations have been spread over a large area and are not confined to a single site or property. While it might be possible to conduct individual SSRAs on the hundreds of properties within the affected area, the cost of doing such would be prohibitive and the time to accomplish all the assessments, including each being approved by the MOE, would likely be ten years or more. Inco discussed with the MOE whether a community based risk assessment (CBRA) could be done more efficiently. The MOE agreed that the concept of a CBRA approach could be an extension of various SSRAs and Inco therefore has worked toward that end.

The Port Colborne CBRA process being proposed by Inco will:

- assess human health and environmental impacts of chemicals of concern and will develop a scientifically-based model that will calculate Port Colborne-specific soil clean-up guidelines that protect human and environmental health;
- determine remediation options for all environmental media having concentrations above the Port Colborne-specific guidelines and apply remediation actions that will fully protect human and environmental health far into the future.

In addition, the CBRA process will:

- allow for independent verification sampling and testing, and
- ensure that a formal milestone schedule is prepared to allow for community involvement throughout the process.

Inco believes the benefits of conducting a CBRA are:

- that the time required for determining what risks are present and solutions for the entire community is shorter than conducting individual SSRAs;
- that the community will receive safe levels specific to their particular local environmental media;
- that a community-based human health study can be carried out that is more meaningful for the community than doing human health studies for the specific residents of each property;
- that the community as a whole will receive information on property value issues;
- that the risk assessment process will be transparent to the entire community;
- that the risk assessment and remedial actions taken will be consistently applied across the community so that all properties within the community are treated on the same basis;
- that the application of the CBRA model can be carried out using site-specific information and that therefore the CBRA is closely linked to an SSRA; and
- that the CBRA process can also be used to facilitate development approvals in Port Colborne, without requiring application of an SSRA or cleanup to MOE generic effects-based guidelines.

There are two stages envisioned for the CBRA Process. Stage 1 involves the application of technical and scientific information, both from the general scientific literature and Port Colborne, to derive a model to calculate risks from all possible exposures to the chemicals of concern. Once the chemicals of concern have been identified, then Human Health Risk Assessments (HHRAs) and Ecological Risk Assessments (ERAs) will be carried out for each chemical. An HHRA is the evaluation of the probability of adverse health consequences, and the accompanying uncertainties, to humans caused by exposure to a chemical. The evaluation takes into consideration that contaminants may be present simultaneously in several media such as food, air water, soil or dust and that they may reach humans through multiple pathways. A Port Colborne community health study (conducted by independent medical personnel) will provide additional data for the HHRA.

The ERA component of Stage 1 is a process which quantifies risks from a chemical to the environment and its non-human flora and fauna. The results of the HHRA and the ERA will then be integrated into a community-specific risk model. The model will calculate community wide risk-based soil clean-up guidelines using the specific characteristics of Port Colborne's environmental media. Inco has asked Jacques Whitford Environment Limited (Jacques Whitford) to conduct the studies necessary for this first stage. Each part of Stage 1 will have community input. The final results and model derivation will be independently peer-reviewed by outside experts, and the MOE, to assure scientific integrity.

Stage 2 involves application of the model developed in Stage 1 to individual properties. This will only be done with the consent of the property owner. For sites having a concentration of a chemical of concern near or above the Port Colborne community specific risk-based safe guideline for that chemical, soil characteristics from that site will be fed into the community specific risk-based model. The model will determine whether remediation is necessary and what remedial options are possible for the site. Inco will pay for remediation after agreement with the property owner and the MOE. No one will be forced to have their property remediated; nor will the property owner waive any civil or legal rights. The CBRA process has the objective of finding out what risks exist, if any, and determining how to remove such risks in a scientifically acceptable and practical manner. Each property owner will determine whether they want to participate in having the CBRA process applied to their property.

1.2.4 CBRA Participants

Inco is the proponent of the CBRA process and requires input from the Community, the City and the appropriate government agencies regarding conducting the CBRA.

The MOE is the environment government agency responsible for ensuring that Inco and their consultant, Jacques Whitford, conduct the CBRA according to the principles of the SSRA process, as outlined in the MOE (1997a) *Guideline for Use at Contaminated Sites in Ontario*. The Director of the West Central Region of the MOE will make decisions pursuant to the provisions of the *Environmental Protection Act*.

The Public Health Department of the Region of Niagara is the government agency responsible for providing technical input on health issues into the CBRA.

The property owners of Port Colborne can use the findings of the CBRA to their benefit as outlined in Section 1.2.3.

The City supports the CBRA process.

A Public Liaison Committee (PLC) has been established by The City Council to solicit public input; to inform the public; and, to provide input to Inco and to the Director of the MOE respecting the scope of work for and the preparation and conducting of, a proposed CBRA addressing CoC contamination resulting from historical Inco operations in the Port Colborne area. In particular, the PLC is to satisfy the conditions within their terms of reference as follows:

- advise Council of the City on the adequacy of the Terms of Reference for the Committee, and, to make recommendations for changing the "Terms" if necessary,
- receive and review all appropriate information respecting the contamination of lands with CoCs in Port Colborne,
- provide input to the Director (of the MOE) and to Inco respecting the Scope of Work for the CBRA,
- monitor the progress of the CBRA,
- review the findings and recommendations of the CBRA and provide input to Inco and the Director (of the MOE),
- provide input to Inco and the Director on the methods of implementing the recommendations of the CBRA as may be appropriate,
- submit a final report including comments and advice to the Director with respect to the PLC and CBRA processes.

Beak International Incorporated (Beak) is the PLC's independent consultant to provide technical support and advice respecting the CBRA.

Jacques Whitford has been retained by Inco to prepare and implement a Technical Scope of Work (TSOW) for Stage 1 of the CBRA process for Port Colborne. This work is designed to establish a credible basis for the management of the elevated concentrations of CoCs in soils in a manner which is safe and acceptable to all participants, including the residents of Port Colborne, the City, the MOE and Inco.

A Technical Sub-Committee (TSC) of the PLC has been formed with members from the PLC, Beak, the MOE and Jacques Whitford. Representatives of the Public Health Department and Inco are participants at the TSC meetings. This committee is a sub-committee of the PLC and reports its findings to the PLC. The purpose of the TSC is to resolve technical issues throughout the CBRA process. The public has an observational capacity at the TSC meetings.

1.3 Chemicals of Concern (CoC)

According to the MOE, a chemical can only be considered as a CoC for this CBRA if all of the following conditions are found, as follows:

- Chemicals that were historically used or generated in the Inco Refinery or its processes, and
- Chemicals that are present at a community level at concentrations greater than MOE generic effects-based guidelines, and
- Chemicals whose presence in soil shows a scientific link to Inco's operations.

As part of the CBRA an investigation will be conducted to identify the CoCs. However, it should be noted that experience in other parts of the province shows that elevated levels of chemicals may be found that are unrelated to the operations being studied.

2.0 COMMUNITY ASSESSMENT ACTIVITIES

2.1 Technical Scope of Work

The technical scope of work (TSOW) which constitutes Stage 1 of the CBRA process includes:

- an evaluation to confirm that all relevant CoCs have been considered,
- performing a quantitative human health risk assessment (HHRA),
- performing a quantitative ecological risk assessment (ERA), and
- an evaluation of all applicable remediation options.

The HHRA and the ERA components of the TSOW will follow the protocols and principles of the SSRA process, as outlined in the MOE (1997a) *Guideline for Use at Contaminated Sites in Ontario*, the MOE (1996) *Guidance on Site-Specific Risk Assessment for use at Contaminated Sites in Ontario* and the Canadian Council of Ministers of the Environment (CCME, 1996) A Framework for Ecological Risk Assessment: General Guidance.

2.1.1 Confirmation of CoC List

An investigation will be carried out to identify chemicals that should be considered as CoCs for inclusion in Stage 1 of the CBRA. The investigations will include:

- a literature review of historical and current nickel refining,
- review of literature relating to chemical concentrations in Port Colborne soils,
- selection with the PLC via the TSC of a list of potential chemicals for analysis, and
- sampling and analysis of soils, water, air and other environmental media.

2.1.2 Human Health Risk Assessment (HHRA)

A HHRA will be conducted to assess potential risks associated with community exposure to CoCs in areas of Port Colborne. The HHRA is being conducted to address media that were affected as identified in Section 2.1.1. As part of this assessment, site-specific concentrations of CoC will be obtained from soils, surface water, groundwater, sediment and the local food basket. The HHRA will incorporate all of the environmental data available for the areas of potential concern. The method to conduct the HHRA will be based on the MOE (1996a) Guidance document, the US EPA (1989) Risk Assessment Guidance for Superfund and other related documents.

2.1.2.1 HHRA Problem Formulation

The problem formulation step of the HHRA will identify the CoC's, the potential receptors in the community and the potential exposure pathways that will be assessed in the HHRA.

2.1.2.2 HHRA Receptor Identification

Receptors for the HHRA are considered to be people that have the greatest potential exposure to chemicals of concern. People who reside and/or work (including farmers and field workers) in the City of Port Colborne and the surrounding area are considered to be the receptors for the HHRA. Since the soil contamination is present in residential and agricultural areas, infants, toddlers, young children, adolescents and adults will all be considered as receptors for the purposes of the HHRA. For the assessment of both non-carcinogenic and carcinogenic endpoints, the life stage with the greatest exposure to CoCs will be considered to be the most sensitive receptor (e.g., toddlers often receive higher exposures to CoCs than adults).

2.1.2.3 HHRA Exposure Assessment

The HHRA will consider various land uses, including agricultural, residential/parkland, woodlot, and commercial/industrial. In estimating the level of potential exposure of people to the CoCs in each land use scenario, the primary goal will be to identify reasonable maximum exposure (RME) estimates that closely reflect the actual situation for the population in Port Colborne.

A human health risk of a CoC to a human receptor can only occur if there is an operational exposure pathway (Drawing 6). Exposure of human receptors to CoCs may occur via several pathways. These pathways include, but are not limited to: a) soil ingestion; b) dermal contact with soil; c) inhalation of fugitive dust from soils; d) ingestion of water; and e) ingestion of foods. There may be other relevant exposure pathways. Reasonable maximum exposure factors will be used to calculate exposure for people in accordance with the land use. Exposure factors include residence time, incidental soil ingestion rate, inhalation rate, and others. These will be based on Canadian data (Richardson, 1997). US EPA exposure factors (US EPA, 1997) may be used if there are insufficient data available from Canadian sources regarding specific exposure routes.

Site-specific data will be obtained for soils, water, food basket (including garden and purchased food) and air quality. An illustration of potential exposure pathways is illustrated in Drawing 7.

2.1.2.4 HHRA Hazard Assessment

Toxicity reference values (below which potential human health risks are not expected) will be obtained from literature sources. A threshold-based approach will be used for non-carcinogenic chemicals, expressed as tolerable daily intakes (TDI) or Reference Doses (RfD). The RfD is the estimate of lifetime daily exposure to a non-carcinogenic substance for the general human population that appears to be without appreciable risk of deleterious effects. It is expressed as mg chemical/kg body weight/day.

If CoCs are identified to be carcinogens, then potency estimates reflective of carcinogenic potential will be used to assess the risks for these chemicals. A slope factor (SF) is used for assessment of carcinogenic effects of a chemical. The SF is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. It is used to estimate an upper bound probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen.

An attempt will be made to differentiate between different compounds of CoCs in the environment (e.g., metal speciation) that may affect potential toxicity and exposure to the CoCs. The bioavailability of the CoCs will be evaluated for each route of exposure quantified for this assessment based on the available literature. The impact of speciation on CoC exposure, CoC toxicity, and potential chemical interactions will be discussed.

2.1.2.5 HHRA Risk Characterization

Risk characterization is the final stage of a quantitative risk assessment, where the potential health risks from exposure to CoCs are quantified. An estimate of the potential risks from exposure to CoCs in various media will be calculated by comparing the exposure estimate to the toxicity reference dose.

For a non-carcinogen, risk characterization will be expressed as a hazard quotient (HQ), such that HQ = (estimated exposure)/(reference dose). The sum of the individual HQs for each exposure pathway is expressed as a Hazard Index (HI). An HI of greater than one (1.0) represents a potential health concern that should be more closely examined. For carcinogenic chemicals, the incremental lifetime cancer risk (ILCR) will be calculated as the (predicted exposure) x (slope factor). Incremental lifetime cancer risks of more than one in a million represent a potential health concern that should be more closely examined.

The risk characterization will provide information regarding whether the elevated CoC concentrations present at some areas in the Port Colborne area have the potential to cause adverse health effects. Safe, risk-based criteria will be identified for each CoC for different land use areas. The method by which risk-based criteria are calculated is a back-calculation from standard calculations of risk. For instance, the soil concentration of CoC at a site is used as input to identify whether there is a risk at a site. The potential risk is expressed as an HI or ILCR. An acceptable soil concentration at a site may be higher or lower than the current soil

concentration. The acceptable soil concentration is back-calculated using the target risk value (e.g., HI=1) to identify the risk-based criteria. Soil concentrations at or below the risk-based criteria will be protective of the people in different land use areas (e.g., agricultural, residential/parkland, woodlot, and commercial/industrial), based on all potential pathways.

The RBC from the HHRA will be used, together with the RBC from the ERA in derivation of safe CBRA soil clean-up criteria.

2.1.3 Ecological Risk Assessment (ERA)

The ERA will be conducted according to the Canadian Council of Ministers of the Environment (CCME, 1996) framework and the MOE (1996a) Guidance on SSRA. The ERA will be conducted at the same time as the HHRA. In this way, both human and ecological receptors will be considered for the CBRA. Details are provided in the following sections.

2.1.3.1 Receptor Characterization for the ERA

The Receptor Characterization component of the ERA will involve biological assessment of local plants and animals at various levels such as in ecosystems (e.g., a red maple swamp), as ecosystem functions (e.g., nutrient cycling), as a specific community or habitat (e.g., a woodlot), or as a specific species (e.g., robins or local agricultural crops). The objective of the receptor characterization is to identify and characterize local ecosystems potentially at risk from exposure to the CoCs.

The focus will be on defining one or more specific ecological receptors known as Valued Ecological Components (VECs) for more detailed studies. These are receptors that have been determined to be of major local importance.

VECs will be determined from literature review, discussions with the public, and by carrying out field investigations involving flora and fauna present in the Port Colborne area. Potential VECs that may be considered include agricultural and backyard garden crops, domestic and farm animals, local wild animals (e.g., voles, frogs, weasels, worms), and wild and domesticated plants (e.g., red oaks, silver maples). Rare and endangered species will be considered in this assessment. If rare and endangered species are present, they will be identified as VECs, and the ERA will be conducted using surrogate species for which toxicity and behavioral data are available in the literature.

Particular attention will be paid to possible adverse impacts of soil metals on maple trees in the Port Colborne area. Existing maple trees will be evaluated as to variety/cultivar, location, and potential exposures. Selected trees will be evaluated for environmental impacts (disease, insects) from CoCs.

The ERA will also consider phytotoxic effects associated with different land use areas and soil types, with crops and other vegetation as the principal ecological receptors. Other ecological exposure pathways and receptors will also be addressed including: i) aquatic receptors in surface water and ii) fauna that may be exposed to impacted soils. In addition to the selection of VECs based on exposure pathways, where possible, all VECs will be selected for which existing studies and scientific literature have documented bioaccumulation, and sensitivity to concentrations of CoCs.

In summary, VECs for the ERA will be identified based on certain criteria, such as:

- occuring in the study area in sufficient numbers or covers sufficient area to allow for meaningful assessment and analysis of data.
- having a demonstrated and understood pathway for CoC bioaccumulation, and sensitivity to CoCs which have been documented in the literature.
- having a life cycle with duration that will allow for a meaningful assessment of the magnitude of actual and potential exposure to CoC concentrations in the soils of the study area.
- allowing for the relatively easy collection of sufficient samples in a manner which is both systematic and repeatable.
- representing, or being part of, a naturally occurring population/community which has been identified as of concern and/or requiring protection by an ERA.
- being a rare and endangered species.

2.1.3.2 Exposure Assessment for the ERA

The Exposure Assessment component of the ERA will involve detailed assessments of the characteristics, contamination levels and CoC speciation in each of the major soils from the Port Colborne area.

Exposure assessment will be conducted for each CoC identified. The assessment will consider the magnitude, frequency and duration of exposure. Consideration will also be given to potential interactions between biota with respect to food webs. The bioavailability of CoCs will be considered for different areas representing places where varying soil characteristics and CoC speciation exist. Exposure pathways will be considered for each VEC or surrogate, and the most important pathways will be evaluated in detail for the purpose of this assessment. The selection of exposure pathways will be discussed with the TSC, and once consensus is reached, recommendation made to the PLC that exposure pathways are appropriate.

2.1.3.3 Hazard Assessment for the ERA

The hazard assessment component of the ERA will involve determining the toxicity of each CoC to each of the VECs (fauna and flora) in order to define dose-response relationships. Literature-based assessment and/or toxicity tests will be used for the hazard assessment of fauna and flora in the community to define levels of exposure to CoCs that will represent unacceptable risks to identified VECs.

For plants, greenhouse and field test plot experiments will be conducted to establish plant soil metals uptake and phytotoxicity for the CoCs (refer to Section 3). The TSOW will include determinations of bioavailability for each of the CoCs to crops and other plants for a range of soil types typically found in the Port Colborne area. The study will involve experiments to determine plant growth, and the uptake, bioavailability and toxicity of CoCs to plants.

2.1.3.4 Risk Characterization for the ERA

The risk characterization phase of the ERA will be similar to that of the HHRA. The risks for previously identified VECs will be quantified by comparing the exposure of the VEC to the toxicity of the CoCs. Risks will be characterized for the VEC in different soils, and a discussion of uncertainty will be provided based on the exposure and hazard assessment. A hazard quotient of one will be used as the target, where a quotient of less than one is considered to be acceptable and a quotient greater than one implies a potential adverse impact to the VECs.

Discussion of the results in the risk assessment will be thorough and will address issues such as the significance of the levels of the risk found and the uncertainties associated with the assessment. The discussion of uncertainty will include, but not be limited to, the bioavailability of the CoCs in soils. The end product of the ERA will be an empirical model that predicts safe concentrations of CoCs based on relevant soil parameters, such as texture, pH and organic content, for Port Colborne soils. The model will generate safe community risk-based soil cleanup guidelines for the CoCs in Port Colborne.

2.2 Concurrent Studies

Inco is also proposing to undertake concurrent studies that will provide additional information to the Port Colborne community. So far as is possible, the findings from the concurrent studies will be addressed in the detailed report prepared by Jacques Whitford as a result of conducting the TSOW. The concurrent studies include:

1) a health monitoring study, and
2) a socio-economic analysis.

2.2.1 Health Monitoring Study

A health monitoring study will be conducted by an independent group of qualified health science professionals. A separate draft scope of work for this study is currently being developed for presentation, discussion with, and pending satisfactory resolution of issues raised during discussions, approval from the PLC. The results and findings of this health study will be addressed in the HHRA component of the CBRA.

2.2.2 Socio-Economic Analysis

A Socio-Economic Analysis (SEA) will be carried out by independent property valuation specialists to assess economic and social concerns caused by the contamination issue. A separate draft scope of work for this study is currently being developed for presentation, discussion with, and pending satisfactory resolution of issues raised during discussions, approval from the PLC. The SEA will assess whether contamination from the CoCs has affected property values in Port Colborne in relation to the surrounding community over time. The findings of the SEA will be reported in a separate report and considered in the CBRA process.

3.0 SPECIFIC ERA STUDIES

3.1 Overview

As part of the ERA, a number of distinct studies will be carried out. These will include:

- an ecological survey in the Port Colborne area and the selection of VECs,
- sampling of environmental media including soil, water and air,
- greenhouse testing, and
- field test plot programs.

3.1.1 Ecological Survey and the Selection of VECs

Some agricultural crops should be considered as VECs and for these, greenhouse and field testing has already commenced. Due to study timing issues the PLC was not consulted on crop selection; however, all future studies will be discussed with the PLC prior to commencing work. As part of the ERA a field survey of the flora and fauna in the Port Colborne area will be carried out. The purpose of this study is to identify valued ecosystems potentially at risk.

3.1.2 Sampling and Analysis Programs

As part of the ERA, soil sampling will be carried out in the Port Colborne area. Some of this sampling and associated analyses will be carried out in conjunction with other ERA activities (e.g., greenhouse testing) and HHRA activities (e.g., soil sampling also occurring when backyard produce is sampled). During the summer of 2000 an extensive program of soil sampling, collection and analyses was carried out to obtain, prepare, and characterize the soils used during the greenhouse testing program. Due to study timing issues related to crop planting and harvesting, the PLC did not review these studies prior to their commencement. In addition to such support programs, stand alone soil sampling and soil analysis programs will be carried out. In addition to soil sampling carried out by Jacques Whitford, some archived soil samples taken earlier by the MOE will be accessed and further analyzed.

Groundwater and surface water within the community will be sampled and analyzed to determine if the water has been contaminated by CoCs. The sampling will include water wells, and surface water in streams and ditches in the community.

Sampling of ambient air will also be conducted to assess whether air-blown dust (particulate matter) from soil contaminated with CoCs is presenting a potential health risk to residents and workers (including agricultural workers) within the community.

3.1.3 Greenhouse Experiments

Greenhouse testing is proposed using soils obtained from the Port Colborne community to assess the bioavailability and toxicity of CoCs to plants (phytotoxicity) grown in the soils. The greenhouse tests would also assess the applicability of soil amendments to prevent phytotoxicity.

3.1.3.1 Importance of Phyto-Bioavailability Considerations

Bioavailability refers to how much of a chemical that can be taken up from the environment (e.g., soil) by an organism (e.g., a plant). The bioavailability of a chemical can be variable in different matrices (e.g., the bioavailability of CoCs can be lower when adsorbed to soil than dissolved in water). The MOE recognized in their MOE (2000) report that different soil conditions, such as higher soil pH and organic content would result in lower bioavailabilities for plants and therefore lower phytotoxicities of the CoCs.

One or more sets of greenhouse experiments will be conducted to assess bioavailability.

3.1.3.2 Critical Phytotoxic Index of Each CoC

The safe maximum soil concentration of a CoC in this study will be defined as the concentration of the CoC in soil that will not cause losses in plant yield due to phytotoxicity. The critical soil concentration will be determined by measuring the CoC concentration in soil and the concentration of the CoC accumulated in the lowest tissue of a plant grown in the soil where toxicity occurs (MacNicol and Beckett, 1985). The lowest plant tissue (that is the leaves closest to the ground) will be used since metal CoCs are readily accumulated here and the concentrations are not diluted by lower CoC concentrations in the remainder of the plant. The maximum non-phytotoxic plant tissue concentration of a CoC will be used in assessing the effect of soil parameters, such as pH, and CoC bioavailability. The parameters of plant tissue concentration, bioavailable CoC and soil pH will define the critical rating for that plant grown in a particular soil type with a known texture, CoC content, organic matter content and pH.

A bioavailable CoC concentration in soil can be related directly to critical CoC toxicity concentrations in the plant (i.e. the critical phytotoxicity index or CPI). The CPI general relationship is represented by the following equation:

Critical Phytotoxic Index (CPI) = (Concentration of CoC in the plant)/(Concentration of CoC in the soil).

3.1.4 Field Experiments

In addition to the greenhouse experiments, similar outdoor field plot experiments will be conducted. Three existing field sites near Port Colborne will be used: one involving organic soil, and two on mineral clay soils. In addition to the three agricultural crop plants of the greenhouse experiments (field corn, oats and soybeans), sweet corn and radishes will also be grown, as will phytoextracting plants. So far as is practical, experimental parameters (e.g., harvesting times) will be comparable to those for the simultaneous greenhouse experiments. Critical phytotoxicity indices will be determined for the field plot experiments in similar fashion to that described above for the greenhouse experiments. The results from field plot experiments will be combined with the results from the greenhouse experiments to determine safe concentrations of CoCs in soils that are not phytotoxic.

4.0 EVALUATION AND MODEL APPLICATION

4.1 Derivation of Community Risk-Based Soil Cleanup Guidelines from the HHRA and ERA

A matrix will be developed for community risk-based soil clean-up guidelines for each CoC for various land uses and soil types. For each combination of soil type and land use, the most sensitive of the HHRA- and the ERA- derived community risk-based soil clean-up guidelines developed during the TSOW, will be proposed for any soil remediation in the Port Colborne area.

4.2 Analysis of Applicable Soil Remedial Options

The purpose of the remedial actions will be to mitigate any unacceptable risk to human health or the environment. Remedial option(s) will be selected based on site specific conditions. At present, the preferred remedial option for each soil type and for each land use is unknown.

An analysis of potential remedial options for the Port Colborne area will be done. The following remedial options will be assessed in terms of their value based on the following criteria: practicality, impact on HHRA, impact on ERA, feasibility, permanency, public input and cost. This analysis will include remedial options potentially applicable for the Port Colborne area, such as:

Contaminant Removal

1. phytoextraction,
2. "remove and replace"
3. soil washing
4. a combination of 1), 2) and/or 3)

Risk Management

1. encapsulation
2. capping
3. fencing
4. phytostabilization
5. a combination of 1), 2), 3) and/or 4)

Phytoextraction is the use of special plants that take up soil CoCs into their tissues. These plants can then be harvested and ashed, with residue being recycled to a metals refinery or disposed of at an approved facility. Several crops are usually required to reduce soil CoC concentrations sufficiently.

Remove and replace is the excavation, the haulage and disposal of contaminated soil to local MOE-approved landfill sites and replacement with clean soil.

Soil Washing is the process of washing CoCs out of the impacted soil. This would involve excavation of the contaminated soil, processing the soil at a washing facility and returning the cleaned soil to the excavated sites.

Phytostabilization involves the immobilization of soil contaminants by amending soils with materials such as pH adjustment agents, diminishing the availability of contaminants to plants and inhibiting their leaching.

4.3 Water Remediation Options

Potential options will be analyzed for addressing contamination of surface water and groundwater, including potable and non-potable sources. These options include:

1. Treatment of water to below applicable standards, objectives or guidelines (e.g., potable water guidelines, provincial water quality objectives, etc.);
2. Contaminant source mitigation, including removal, isolation, contaminant migration controls, or other controls; and,
3. Alternate supply.

5.0 SUMMARY

In summary, a TSOW consisting of a human health and ecological risk assessment will be carried out for receptors potentially exposed to CoCs in soils, water, air and other environmental media. The human health and ecological risk assessments will use reasonable maximum exposure estimates. These will be used to determine the potential risks to human and ecological receptors.

The TSOW will establish the soil concentrations of the CoCs that are safe for the intended land use in Port Colborne. The TSOW will ensure that the levels of CoCs in soil, water, air and other environmental media will be safe for people that reside and work in the Port Colborne area as well as for ecological receptors that may inhabit or frequent the area.

Remedial options will be proposed to reduce unacceptable exposures to the CoCs, based on site-specific data. The findings will be thoroughly discussed, an interpretation of the findings provided, and the limitations of the study documented. The results of the TSOW, with proposed remedial recommendations, will be communicated to the community, the PLC and other participants.

6.0 REFERENCES

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US EPA 1999. Integrated Risk Information System database. United States Environmental Protection Agency, Cincinnati, OH. http://www.epa.gov/iris/index.html . Last updated 08/11/99.

0 1km 2km 3km

SCALE 1:50000

NOTE: MAP OBTAINED FROM THE SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES.

1988 PORT COLBORNE AERIAL PHOTOGRAPH

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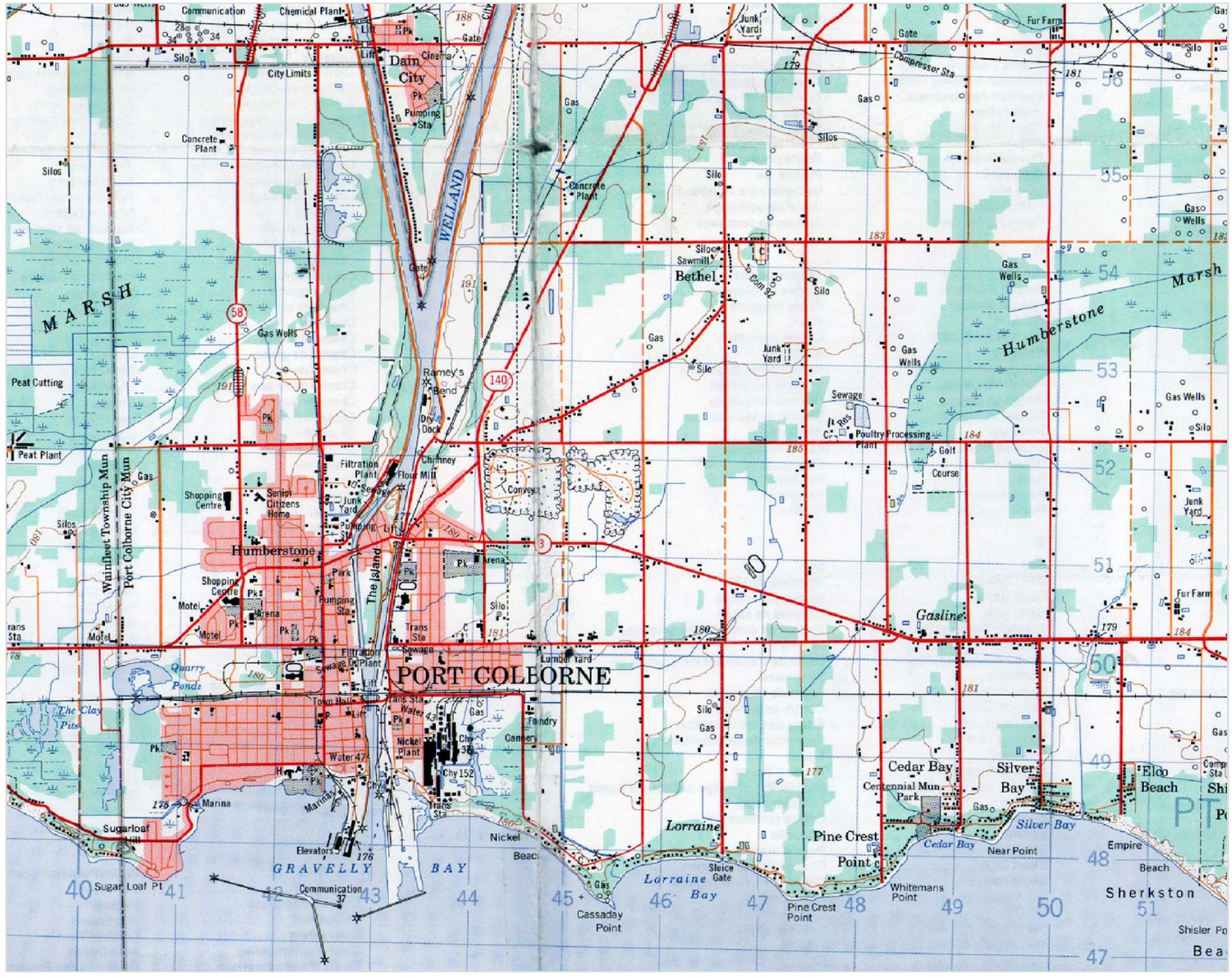
Date:	Dwn. by:	Appd.:	
00/11/27	BJC	KW	

Jacques Whitford



LEGEND

- RESIDENTIAL
- INDUSTRIAL
- AGRICULTURAL

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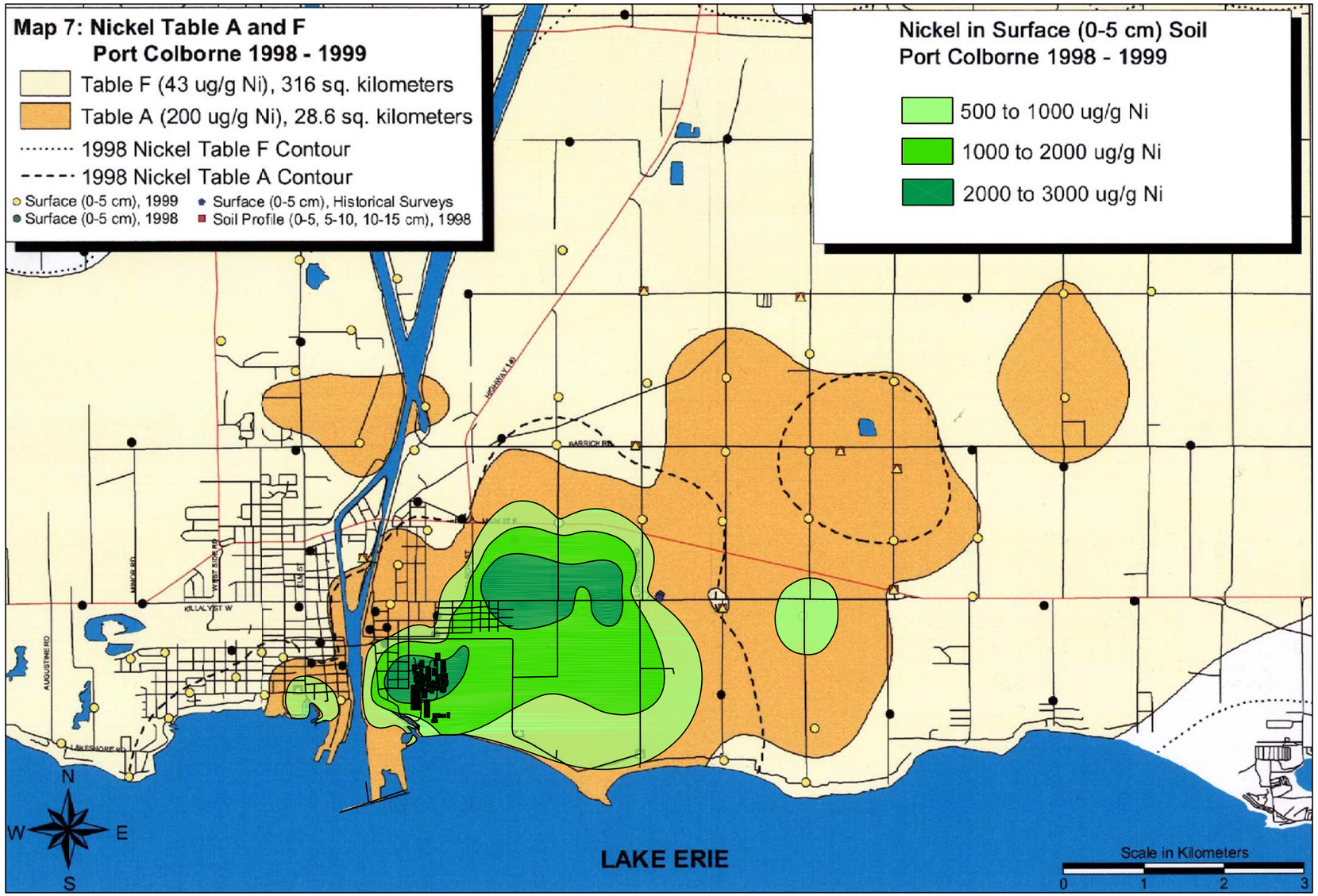
SCALE 1:50000

SITE PLAN SHOWING REGIONAL TOPOGRAPHY

PORT COLBORNE, ONTARIO

Job No.:	Dwg. No.:	
33826	2	Jacques Whitford
Date: 00/11/27	Dwn. by: CBD BJC	Appd.: EV

33826-2



NOTE: MAP OBTAINED FROM MOE REPORT "PHYTOTOXICOLOGY TECHNICAL MEMORANDUM" PHYTOTOXICOLOGY SOIL INVESTIGATION INCO–PORT COLBORNE (1999)

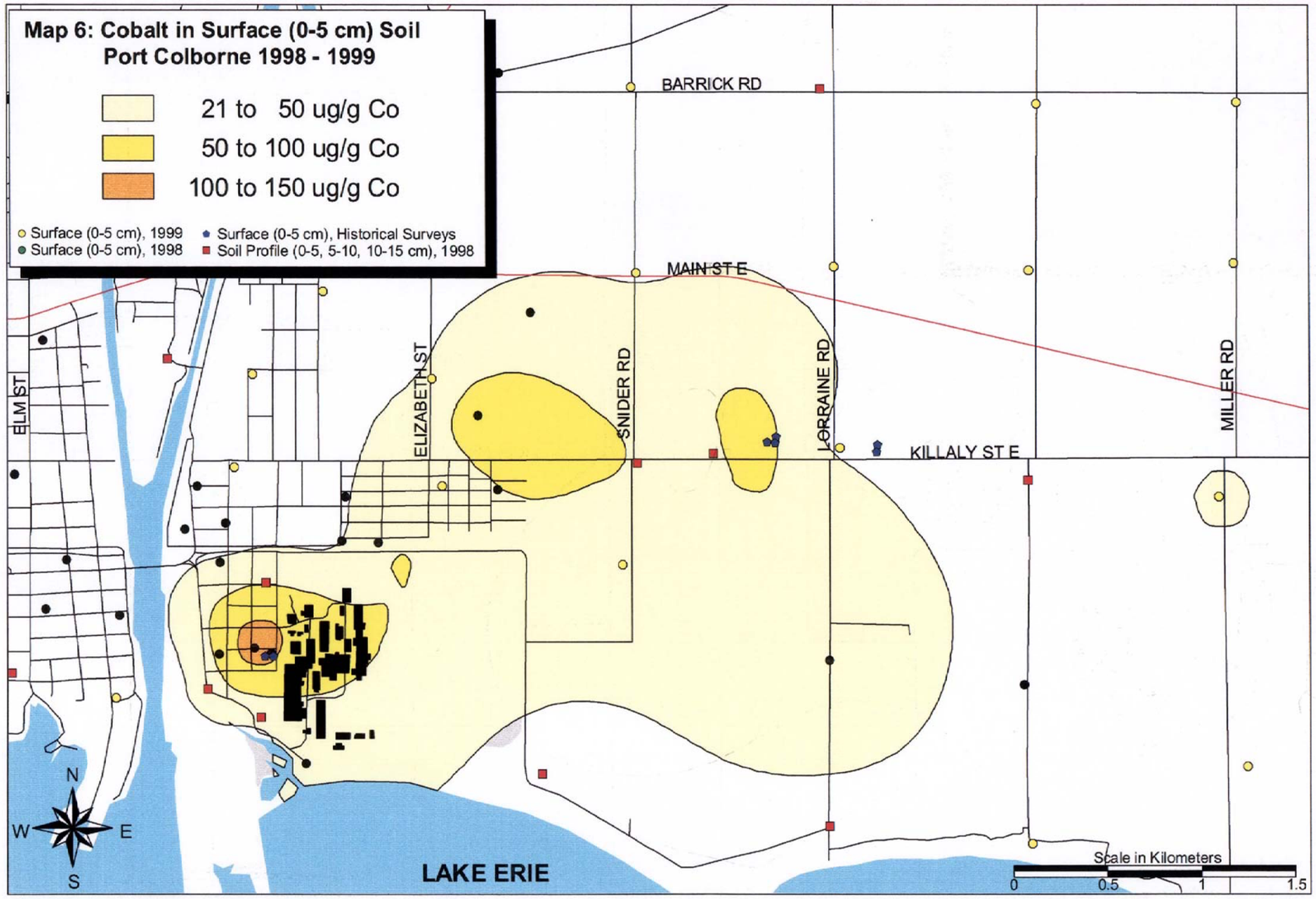
SITE PLAN SHOWING NICKEL CONCENTRATIONS IN SURFACE SOIL

PORT COLBORNE, ONTARIO

Job No.:	Dwg. No.:	
33826	3	
Date: 00/12/04	Dwn. by: LMV BJC	Appd.: KW

Jacques Whitford

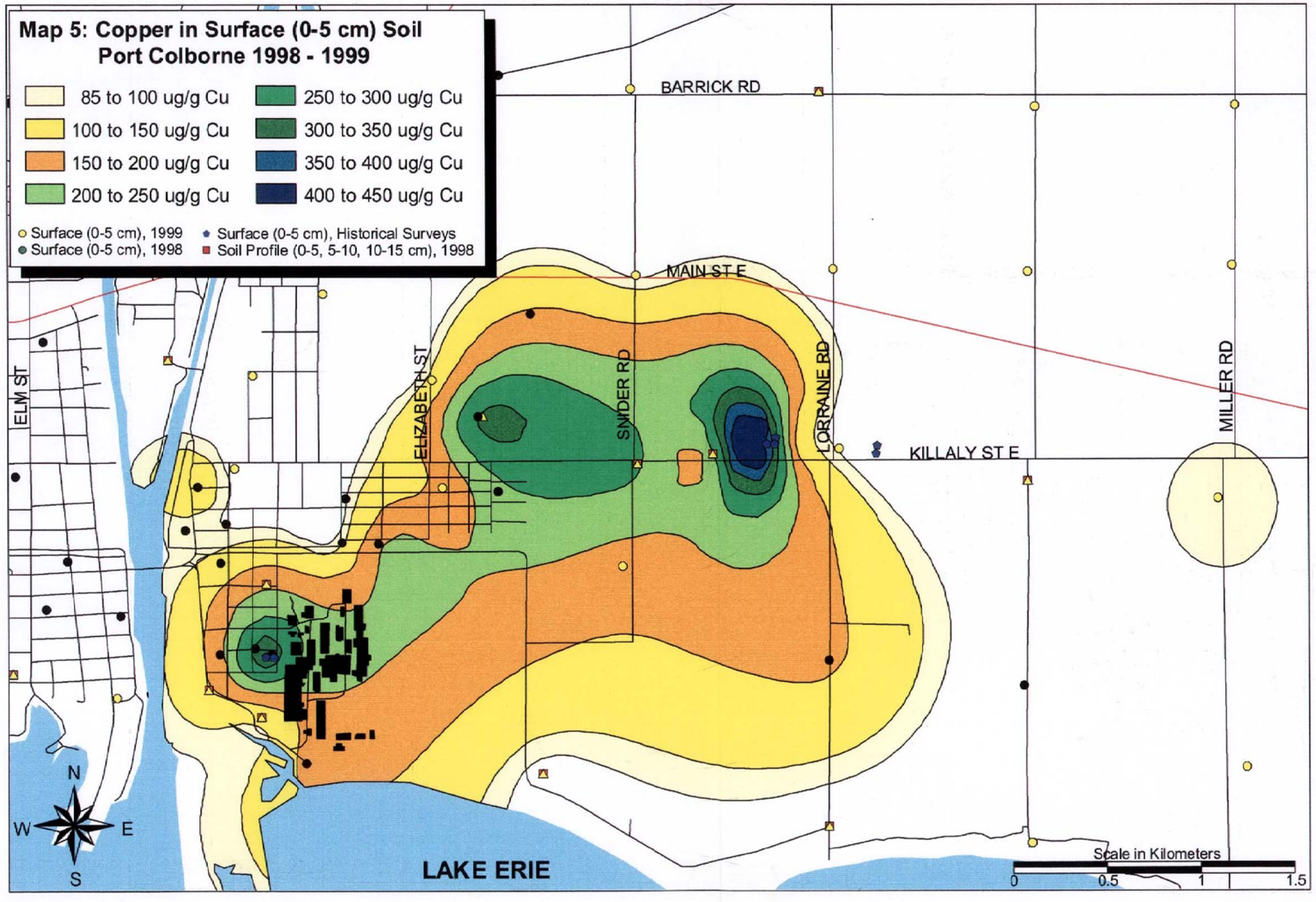
33826-3



NOTE: MAP OBTAINED FROM MOE REPORT "PHYTOTOXICOLOGY TECHNICAL MEMORANDUM" PHYTOTOXICOLOGY SOIL INVESTIGATION INCO-PORT COLBORNE (1999)

SITE PLAN SHOWING COBALT CONCENTRATIONS IN SURFACE SOIL PORT COLBORNE, ONTARIO	Job No.: 33826	Dwg. No.: 4	Jacques Whitford
	Date: 00/12/04	Dwn. by: BJC BJC	Appd.: KW

33826-5



NOTE: MAP OBTAINED FROM MOE REPORT "PHYTOTOXICOLOGY TECHNICAL MEMORANDUM" PHYTOTOXICOLOGY SOIL INVESTIGATION INCO–PORT COLBORNE (1999)

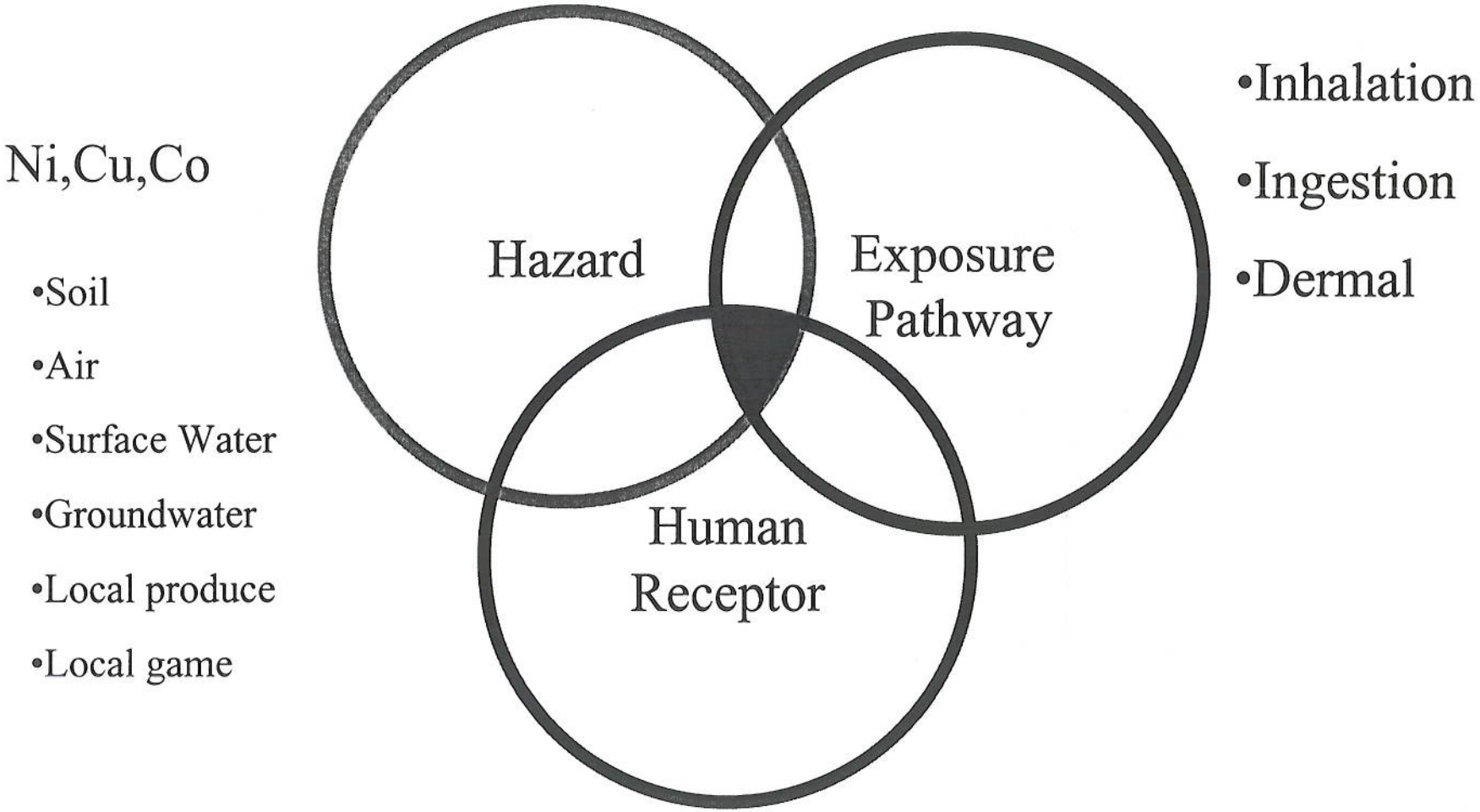
SITE PLAN SHOWING COPPER CONCENTRATIONS IN SURFACE SOIL
PORT COLBORNE, ONTARIO

Job No.:	Dwg. No.:	
33826	5	
Date: 00/12/04	Dwn. by: BJC BJC	Appd.: KW

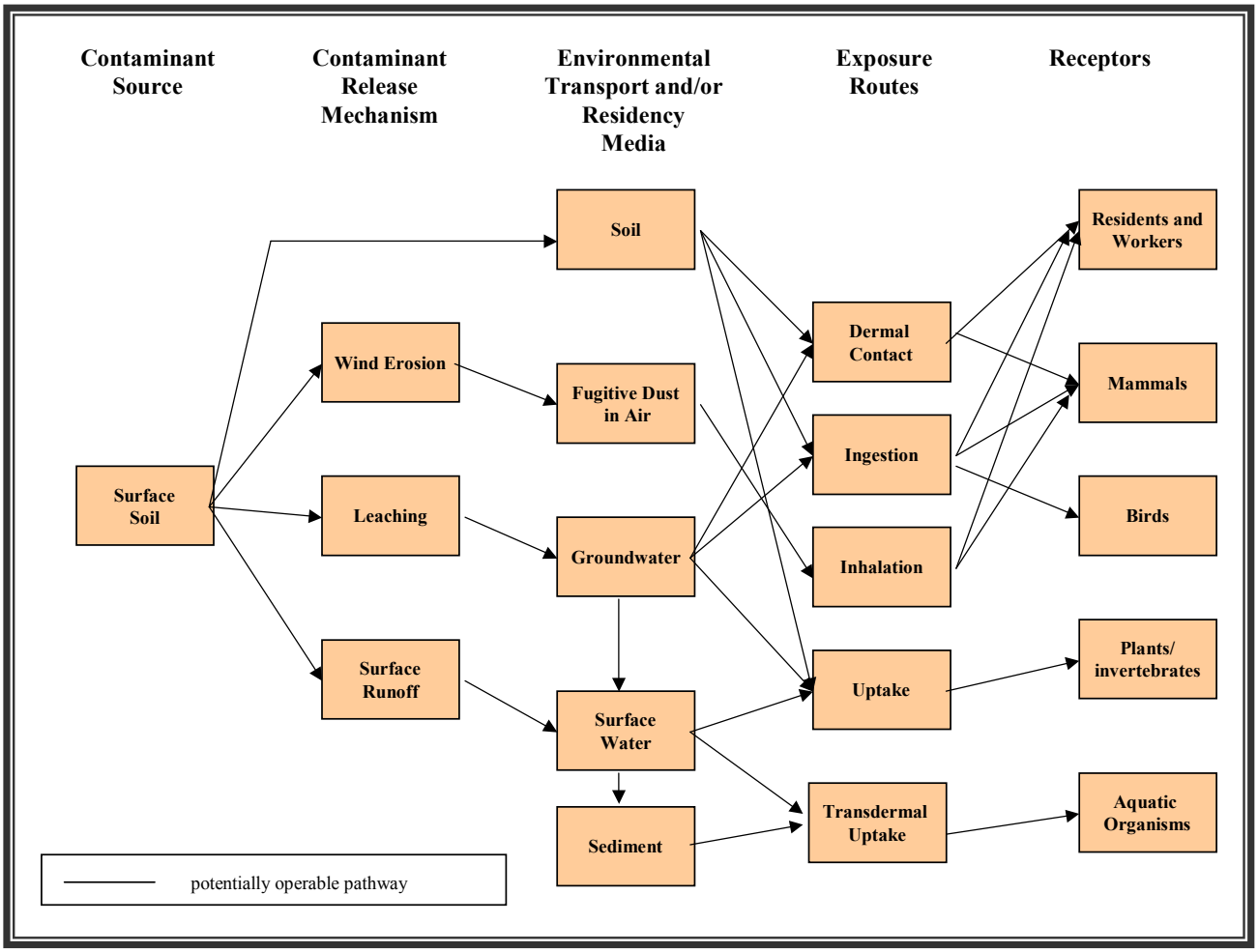
Jacques Whitford

33826-4

Figure 6. Three Requirements for a Health Risk: a) a hazard, b)an exposure pathway and c) a human receptor.



Drawing 7: Conceptual Model for Human and Ecological Receptors at Port Colborne



APPENDICES

APPENDIX I

RECEPTOR CHARACTERISTICS FOR HHRA

Receptor characteristics will be selected based on site-specific data and information from the Canadian Council of Ministers of the Environment (CCME) document, *A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines* (1996) and *Compendium of Canadian Human Exposure Factors for Risk Assessment* Richardson (1997). If additional information is required that is not available from Canadian sources, further information will be obtained from the *"Exposure Factors Handbook"* US EPA (1997). As discussed in the main text, the exposure assessment for the HHRA will provide a conservative estimate of reasonable maximum exposure for people living and working in the community.

Receptors in the area include agricultural workers, residents and commercial/industrial workers. Conservative receptor characteristics will be used for each exposure scenario. The characteristics used for each of the receptors will be as specific to the Port Colborne area as reasonably possible, based on site-specific information, the available literature and consultation with the PLC.

Some of the assumptions proposed for use in the HHRA are outlined below:

- Residents in the town and surrounding agricultural area will conservatively be assumed to reside in the area all year, for an exposure frequency of 365 days/year with no provisions for time spent away from the site on vacation;
- Workers will be conservatively assumed to work 8 hours/day for 260 days/year, based on a 5 day work week, with no adjustment made for vacation time that would reduce exposure;
- The exposure frequency will be adjusted to account for days with snow cover and frozen ground, since direct contact with soils is negligible during the winter months in Port Colborne. On average, it will be assumed that there is no direct contact with soils from late December through the end of February due to snow cover and frozen ground (Canadian Climate Normals), which is conservatively assumed to be 2 out of 12 months of the year. Therefore, the exposure frequency of 365 days/year to soils at the site will be adjusted by a factor of 0.84;
- A conservative estimate of daily exposure will be used for people in residential and in an agricultural setting. The time spent at a site will be determined following discussions with the public;
- A conservative estimate of the length of time a person may reside at one site is 30 years. It is possible that a person may reside in one house or one area for 70 years, however this is not typical of the population. Similarly, a 30-year exposure duration is not typical of the North American population. The typical length of time an adult may reside at one residence is assumed to be 9 years (US EPA, 1997). However, it is expected that people in small towns have a longer residency time than the average population, since there is less mobility in these areas than in large urban populations. Accordingly for the HHRA, a conservative exposure duration of 30 years will be used;

- Air intake rates (e.g., inhalation rate) will be based on values suggested by the CCME (1996). These will be provided for each age range in the CBRA, and include a rate of 23 m^3/day for an adult;
- Soil intake rates for the receptor age groups will be based on data suggested by Canadian regulators (CCME, 1996) will be used to estimate exposure. The CCME (1996) suggests soil intake values of 80 mg/day for toddlers and 20 mg/day for other age groups.
- The dermal bioavailability for each chemical of concern will be based on the most current scientific literature.

The above assumptions will be reviewed and discussed at an appropriate TSC meeting to ensure that the assumptions represent community specific characteristics. Once consensus is reached the TSC will recommend that the PLC endorse the use of these assumptions.

As mentioned in the main text, potential exposure to CoCs may occur via several exposure pathways. The significance of each of these pathways will be assessed following a review of all data available. Receptor characteristics will be provided for each operable exposure pathway. An example of some calculations that may be used for the exposure assessment are provided in Appendix II.

APPENDIX II

EQUATIONS FOR HHRA EXPOSURE ESTIMATES

Exposure of human receptors to CoC may occur via several pathways. Currently, these pathways are known to include: a) soil ingestion; b) dermal contact with soil; and c) inhalation of fugitive dust from soils. Additionally, there may be other relevant exposure pathways, including but not limited to, drinking water for residents with groundwater wells, dermal contact with water, consumption of non-local dietary sources, local produce, local game or local fish. The operable exposure pathways will be determined following analysis of environmental data from the site.

The potential for adverse health effects from chemicals increases with increasing exposure. Exposure from each of the operable exposure pathways will be considered in the HHRA. If certain exposure pathways are found to be minimal or inapplicable, then these will not be further considered for quantitative assessments under the HHRA. Selection of operable exposure pathways will be decided upon following discussions with the public.

CoC concentrations in media (eg., soils) retained for quantitative evaluation under the HHRA will be assessed using the 95th percentile concentrations in each of the areas of potential environmental concern to be considered in the assessment. This will provide an estimate of the upper bound exposure for residents in each area. Additionally, exposure to the 95th upper confidence limit of the mean will be estimated to provide information relevant for typical exposures in each area.

Particulate samples have been obtained from the site. Since these were obtained at one point in time, JWEL also proposes that fugitive dust modeling be conducted to assess the concentrations of CoCs in ambient air resulting from windblown dust. The potential sources will be mainly due to wind erosion of exposed contaminated soil, agricultural operations, and vehicle traffic (that may introduce CoC-contaminated particulates deposited on roadways back into the atmosphere). This will be conducted for the residential and agricultural scenarios separately, since increased levels of dust are expected from agricultural tilling and larger areas of unvegetated land certain times of the year. Modeled concentrations for CoCs in air will be used for the exposure assessment. For the purpose of modeling concentrations of fugitive dust in air, the contaminated area in the vicinity of Port Colborne will be subdivided into a number of chemical concentration zones. Chemical emission rates from each zone due to wind erosion will be conservatively estimated from available empirical data and relationships (US EPA (1995) and Cowherd (1983)). Using these emissions data, annual-average ground level CoC concentrations at receptors located in Port Colborne and surrounding areas will be estimated using the US EPA Fugitive Dust Model (FDM). FDM was designed to model particulate dispersion from area sources accounting for plume depletion and tilting due to gravitational settling of the particulate matter in the plume. Meteorological data from the nearest station will be used with FDM to generate the estimates for predicted annual-average ambient concentrations of CoCs adsorbed to particulates. The modeled results for PM10 concentrations in air will be compared against annual average PM10 concentrations for a rural area for the purpose of model validation.

For the HHRA, exposure estimates will be calculated for all pathways and expressed as mg chemical/kg body weight/day for each exposure pathway retained for assessment. Examples of some of the equations to determine exposure estimates are given below. Separate exposure assessments will be conducted for each of the areas of potential environmental concern that will be evaluated based on soil chemistry data.

Soil Ingestion:

$$DR_{SI} = \frac{IR_{SI} \times C_S \times BIO_{SI} \times ET \times EF \times ED}{BW \times AT \times CF} \quad \text{Equation 1}$$

Where:
DR_{SI} = estimated dose from soil ingestion of chemical (mg/kg bw/day)
IR_{SI} = soil ingestion rate (kg/day)
C_S = chemical concentration in soil (mg/kg, or ppm)
BIO_{SI} = bioavailability factor via ingestion of soil (unitless)
ET = exposure time (hours/day / 24 hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (yr)
CF = conversion factor (365 days/yr)

Dermal Contact with Soil:

$$DR_{DC} = \frac{SA \times SDAF \times C_S \times BIO_{DC} \times ET \times EF \times ED}{BW \times AT \times CF} \quad \text{Equation 2}$$

Where:
DR_{DC} = dose rate from dermal contact with chemical in soil (mg/kg bw/day)
SA = surface area of body available for dermal contact (m^2)
SDAF = soil dust adherence factor (kg/m^2-day)
C_S = chemical concentration in soil (mg/kg, or ppm)
BIO_{DC} = bioavailability of chemical via dermal contact (unitless)
ET = exposure time (hours/day / 24 hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (yr)
CF = conversion factor (days/yr)

Inhalation of Fugitive Dust from Soil:

$$DR_{IH} = \frac{IR \times C_A \times BIO_{FD} \times ET \times EF \times ED}{BW \times AT \times CF_1 \times CF_2} \quad \text{Equation 3}$$

Where:
DR_{IH} = dose rate from inhalation of chemical of airborne particles (mg/kg bw/day)
IR = inhalation rate (m^3/hour)
C_A = chemical concentration in air ($\mu g/ m^3$)
BIO_{FD} = bioavailability of chemical via fugitive dust inhalation (unitless)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (yr)
CF_1 = conversion factor (days/yr)
CF_2 = conversion factor (1000 μg/mg)

Ingestion of Local Produce:

$$DR_{PR} = \frac{IR_{PR} \times C_{PR} \times BIO_{PR} \times EF \times ED}{BW \times AT \times CF} \quad \text{Equation 4}$$

Where:
DR_{PR} = dose rate of chemical from local produce (mg/kg bw/day)
IR_{PR} = ingestion rate of local produce (kg/day)
C_{PR} = chemical concentration in local produce (mg/kg, or ppm)
BIO_{PR} = bioavailability of chemical via ingestion of produce (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (yr)
CF = conversion factor (days/yr)

Ingestion of Local Game:

$$DR_{GA} = \frac{IR_{GA} \times C_{GA} \times BIO_{GA} \times EF \times ED}{BW \times AT \times CF} \quad \text{Equation 5}$$

Where:
DR_{GA} = dose rate of chemical from ingestion of local game (mg/kg bw/day)
IR_{GA} = ingestion rate of local game (kg/day)
C_{GA} = chemical concentration in local game (mg/kg, or ppm)
BIO_{GA} = bioavailability of chemical via ingestion of edible tissue of game (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (yr)
CF = conversion factor (days/yr)

Ingestion of Drinking Water:

$$DR_{DW} = \frac{IR_{DW} \times C_{DW} \times BIO_{DW} \times EF \times ED}{BW \times AT \times CF} \quad \text{Equation 6}$$

Where:
DR_{DW} = dose rate of chemical from ingestion of drinking water (mg/kg bw/day)
IR_{DW} = ingestion rate of drinking water (L/day)
C_{DW} = chemical concentration in drinking water (mg/L)
BIO_{DW} = bioavailability of chemical via ingestion of drinking water (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (yr)
CF = conversion factor (days/yr)

Ingestion of Local Fish:

$$DR_F = \frac{IR_F \times C_F \times BIO_F \times EF \times ED}{BW \times AT \times CF} \quad \text{Equation 7}$$

Where:
DR_F = dose rate of chemical from ingestion of local fish (mg/kg bw/day)
IR_F = ingestion rate of local fish (kg/day)
C_F = chemical concentration in edible tissue of local fish (mg/kg, or ppm)
BIO_F = bioavailability of chemical via ingestion of local fish (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (yr)
CF = conversion factor (days/yr)

Dermal Contact with Surface Water While Swimming:

$$DR_{SW} = \frac{SA \times Kp \times C_{Sw} \times BIO_{SW} \times ET \times EF \times ED \times CF}{BW \times AT \times CF} \quad \text{Equation 8}$$

Where:
DR_{SW} = dose rate from dermal contact with chemical in water while swimming (mg/kg bw/day)
SA = surface area of body available for dermal contact (cm^2)
Kp = chemical permeability constant (cm/hr)
C_{Sw} = chemical concentration in surface water (mg/L)
BIO_{SW} = bioavailability of chemical via dermal contact with water while swimming (unitless)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
CF = conversion factor (L/cm^3)
BW = body weight (kg)
AT = averaging time (yr)
CF = conversion factor (days/yr)

APPENDIX III

TOXICITY REFERENCE VALUES FOR IDENTIFIED CoC IN HHRA

The following is a discussion on toxicity reference values for copper, cobalt and nickel. If other CoCs are identified to be included within this CBRA, then these will also be reviewed for toxicity reference values.

1.0 COPPER

Copper is a micro-nutrient and an essential element in the diet. The oral RfD for copper to be used for the purpose of the HHRA will be the provisional tolerable daily intake (PTDI) of copper provided by Health Canada. In children, an "adequate and safe" concentration of copper in the diet was estimated to be 0.05 to 0.1 mg/kg-day (Health and Welfare Canada, 1990). The lower end of this range, 0.05 mg/kg-day, will be used as the oral RfD for the purpose of this assessment.

No data are available in the literature reviewed for the current assessment to calculate toxicity reference values for inhalation and dermal exposure. For this reason, the oral RfD will be used for the inhalation and dermal routes of exposure.

The bioavailability of copper to human receptors for each exposure route of interest will be determined from available literature. Speciation data will be used for this assessment, where applicable.

References

CCME. 1999. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health: Copper. Canadian Council of Ministers of the Environment. Winnipeg, MN, Canada.

Health and Welfare Canada. 1990. Nutrition recommendations – The report of the Scientific Review Committee – 1990. Cat. No. H49-42/1990E. Supply and Services Canada. Cited In: CCME, 1999.

2.0 COBALT

The US EPA (1999) provides an oral RfD of 6E-2 mg/kg-day for cobalt. This value is based on the upper range of the average intake of cobalt in the diet for children. The range of cobalt in the diet will be used for guidance for the purpose of this assessment, with consideration given to the oral RfD provided by the US EPA (1992). No toxicity reference values for cobalt are available from Health Canada or the MOE. Dermatitis has been associated with exposure to cobalt and there are interrelationships between cobalt and nickel sensitization (US EPA, 1992). These data will be considered in this assessment.

References:

US EPA. 1992. Oral Toxicity Assessment for Cobalt. Memorandum from Kenneth A. Poirier to Roxy Barnett. United States Environmental Protection Agency. Office of Research and Development. Environmental Criteria and Assessment Office. Cincinnati, OH.

US EPA. 1999. Region 9 Preliminary Remediation Goals (PRGs) 1999. San Fransisco, CA.

3.0 NICKEL

As with copper, nickel is an essential micro-nutrient. However, elevated dosages may cause problems. The oral reference dose for nickel (soluble salts) is 2E-2 mg/kg-day (US EPA, 1999) based on decreased body weight and organ weights in rats exposed to nickel in food for two years (Ambrose et al., 1976). Nickel was administered in the diet as nickel sulfate hexahydrate in this study. The NOAEL from this study was 5 mg/kg-day, and an uncertainty factor of 300 was applied to the NOAEL to account for inter- and intra-species variabilities as well as inadequate data from reproduction studies.

Nickel refinery dust has been shown to be a respiratory carcinogenic in several occupationally exposed populations, with endpoints of lung and nasal tumors. A slope factor of 0.8 (mg/kg-day) -1 may be used for the assessment of nickel (as nickel refinery dust) carcinogenicity via inhalation exposure. The inhalation slope factor was derived from epidemiological studies of humans following occupational exposure. Occupational exposure to nickel refinery dust in dusty areas of a refinery areas where calcining, leaching and sintering were carried out in Port Colborne, Ontario has been claimed to result in an increased incidence of lung and nasal cancer in men (Roberts et al., 1983). One measurement of nickel refinery flue dust from Port Colborne, Ontario showed that it was comprised of 20% nickel sulfate, 59% nickel subsulfide and 6.3% nickel oxide (US EPA, 1999). The unit risk for nickel refinery dust was 4.8E-4 (µg/m3)-1. It is noted that the unit risk for nickel subsulfide was 2.4E-4 (µg/m3)-1 that can be expressed as a slope factor of 1.7 (mg/kg-day)-1. A factor of 2 can be applied to the nickel subsulfide unit risk estimate to obtain the estimate for nickel refinery dust, assuming a composition of 50% nickel subsulfide in nickel refinery dust (US EPA, 1999).

The actual forms of nickel in the Port Colborne soils are unknown but is believed that they may be in amorphous states. Appropriate chemical analyses of these soils will be attempted to determine their composition. The toxicity assessment will incorporate information from the chemical analyses.

The bioavailability of nickel to human receptors for each exposure route of interest will be determined from available literature. Speciation data will be used for this assessment, where applicable.

References

Ambrose, A.M., Larson, D.S, Borzelleca, J.R. and Hennigar, G.R. 1976. Long term toxicologic assessment of nickel in rats and dogs. J Food Sci Technol 13:181-87. Cited In: US EPA, 1999.

Roberts, R.S., Julian, J.A., Muir, D.C.F. and Shannon, H. 1983. Cancer mortality associated with nickel sintering. Occupational Health Faculty of Health Sciences. McMaster University Hamilton, Ontario, Canada. Presented at the IARC Nickel symposium, March 1983, Lyon, France. Cited In: US EPA, 1999.

US EPA. 1999. Integrated Risk Information System. IRIS Database On-Line Search. U.S. Environmental Protection Agency, Cincinnati, OH.

APPENDIX IV

RISK CHARACTERIZATION FOR HHRA

Risk characterization is the final stage of a quantitative risk assessment, where the health risks from exposure to CoCs at a site, or the community of Port Colborne in this situation are quantified. An estimate of the potential risks from exposure to CoCs in various media will be calculated by comparing the exposure estimate to the toxicity reference dose.

For a threshold-acting chemical, risk characterization will be expressed as a hazard quotient (HQ), such that HQ = (estimated exposure)/(reference dose). The sum of the individual HQs for each exposure pathway is expressed as a Hazard Index (HI). A risk estimate of greater than one represents a health concern that should be more closely examined. For non-threshold acting chemicals, the incremental lifetime cancer risk (ILCR) will be calculated as the (predicted exposure) x (slope factor). Incremental lifetime cancer risks of more than one in a million represent a potential health concern that should be more closely examined.

As part of the risk characterization, risks associated with exposure to CoCs in the Port Colborne area will be compared to risks associated with background exposures (identified from literature sources). This aspect will be addressed in more detail under the HHRA.

The risk characterization phase of the HHRA will assess whether the elevated CoC concentrations present at some areas in the Port Colborne area have the potential to cause adverse health risks. The magnitude of risk from exposure to CoCs in soils will be compared to the risk from background exposure. Discussion of the results in the assessment will be thorough and will address issues such as the significance of the levels of the risk found, implications from the comparison to the background levels, the uncertainties associated with the assessment. The goal will be to provide a balanced, factual and thorough interpretation of the findings. Residents living in areas with different concentrations of CoCs and different soil types (resulting in different CoC bioavailabilities) will have different levels of risk associated with elevated CoCs in soils of their area. This will be communicated under the HHRA.

APPENDIX V

DEFINITION OF TERMS

- **Hazard Identification** – The identification of the environmental hazards (e.g., chemicals of concern) that may pose a health risk. The chemical hazards at the site are identified based on the results of data reviewed and field investigations, as well as an understanding of the toxicology of the chemicals of concern (CoCs);
- **Receptor Identification** – The identification of the receptors that may be exposed to the CoCs. For the human health risk assessment, residents of the area will be considered, including infants, toddlers, adolescents and adults. For ecological risk assessment, valued ecological components (VECs) will be considered to be the most sensitive receptors. For the purpose of this assessment, plants (e.g., crops) have been identified as one VEC. Other VECs, such as terrestrial animals, soil dwelling organisms, avian species and aquatic species, will be evaluated as part of the environmental risk assessment;
- **Exposure Assessment** – A qualitative or quantitative evaluation of the degree to which the receptors will be exposed to the CoCs. For the exposure assessment, all potential exposure pathways are identified for each CoC-receptor combination. From this list, a qualitative assessment of the likelihood of exposure is made for each pathway. Those pathways with the highest likelihood of exposure (and thus with the highest likelihood to contribute a health risk) are carried forward for further quantitative analysis. This is done for each of the human and ecological receptors selected for the purpose of this assessment;
- **Toxicity Assessment** – Toxicity reference values will be obtained for the CoCs. The reference dose (RfD) is the estimate of lifetime daily exposure to a noncarcinogenic substance for the general human population that appears to be without appreciable risk of deleterious effects. It is expressed as mg chemical/kg body weight/day. The slope factor (SF) is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime, expressed as $(mg/kg\ body\ weight\ /day)^{-1}$. It is used to estimate an upper bound probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. For ecological receptors, the toxicity reference values will be selected based on the literature for test species that are related as closely as possible to the VEC selected;
- **Risk Characterization** – A qualitative or quantitative assessment of the actual health risk of each hazard to each receptor, based on the degree of exposure. The potential of adverse effects for human and ecological receptors are assessed by comparing the potential exposure with the toxicity of each CoC. The quantification of health risks is calculated for the identified pathways using generally accepted exposure scenarios and appropriate predictive models, where appropriate. The risk characterization can determine if the existing chemical concentrations cause an unacceptable risk to human health or it can determine the concentration of the CoCs which would cause the risk; and
- **Uncertainty Assessment** – A qualitative or quantitative assessment of the uncertainty associated with the risk estimation. Uncertainty is associated with a number of components of the HHRA, including the exposure estimate, the toxicity reference value, and the assumed bioavailability of the CoCs from the exposure matrix