INDEPENDENT CONSULTANT REVIEW OF THE CHEMICALS OF CONCERN AND THE STATUS OF LEAD

CITY OF PORT COLBORNE COMMUNITY BASED RISK ASSESSMENT

WATTERS
ENVIRONMENTAL
GROUP INC.

CONFIDENTIAL

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CITY OF PORT COLBORNE
COMMUNITY BASED RISK ASSESSMENT

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1.0 INTRODUCTION

The Port Colborne Community-Based Risk Assessment (CBRA) was initiated by Vale Inco Limited (Inco) to investigate and address any impacts resulting from historical emissions associated with Inco's former nickel refining operation in the City of Port Colborne, Ontario. Inco's consultant, Stantec Limited (formerly Jacques Whitford Environment Limited (JW)), was retained by Inco to conduct studies and assessments on the potential impacts to the natural and agricultural environments of Port Colborne, and on the human health of Port Colborne residents.

As part of the CBRA process, a Public Liaison Committee (PLC) was established comprising interested members of the Community. The PLC was supported by an Independent Consultant that acted as scientific advisors to the Committee. The Independent Consultant also acted as Chair of the Technical Sub-Committee (TSC), which was established to ensure that sound scientific principles were applied throughout all phases of the CBRA and to provide advice to Inco's consultants. The Independent Consultant initially was Beak International (prior to 2004), and Watters Environmental Group Inc. ("Watters Environmental") since that time. The TSC comprised representatives from the Ontario Ministry of the Environment (MOE), Niagara Regional Public Health Department, the City of Port Colborne, Inco and its consultants, and the Independent Consultant.

One of the first tasks of the TSC was to confirm the list of contaminants to be included in the CBRA (referred to as the "Chemicals of Concern" for the CBRA). From the beginning, the TSC members were all aware that any conclusions or decisions reached would have to be based on sound science. Consequently, there were a considerable number of discussions held between members of the TSC concerning the criteria for establishing whether a chemical should be considered a CoC for the CBRA.

Through the various meetings and community open house sessions held, it was unanimously agreed by all participants that a chemical would be identified as a CoC for the CBRA if all of the following three (3) conditions were satisfied:

1. Chemicals that were historically used or generated by the industrial source(s) or its processes, and
2. Chemicals that are present at a community level at concentrations greater than the MOE generic effects-based guidelines, and

3. Chemicals whose presence in soil shows a scientific linkage to the historical operations of that industrial source(s).

The "MOE generic effects-based guidelines" (in Condition 2) refer to the MOE's Table A Guidelines (MOE, 1998).

Inco accepted that nickel, copper, cobalt and arsenic were CoCs for the CBRA.

The Community, PLC and its Independent Consultant were strongly of the view that lead satisfies all the criteria for inclusion as a CoC for the CBRA, although this was not supported by Inco or its consultants.

Criterion	Criterion Met?	Rationale (from Watters Environmental)
Chemicals that were historically used or generated by the industrial source(s) or its processes.	**Yes**	Lead was emitted from the nickel refinery stack primarily between 1918 and 1930 and was also emitted from the lower stack associated with the Precious Metals Refinery, located south of the Nickel refinery stack, between 1987 and 1997.
Chemicals that are present at a community level at concentrations greater than the MOE generic effects-based guidelines.	**Yes**	Concentrations of lead are present in community soils above the MOE Generic Standard of 200 mg/kg.
Chemicals whose presence in soil shows a scientific linkage to the historical operations of that industrial source.	**Yes**	Sampling conducted to the east of the refinery shows a plume downwind of the Precious Metals Refinery.

Lead as a CoC for the CBRA

To address the impasse between Inco and the Community respecting the status of lead as a CoC for the CBRA, Inco directed its consultants to conduct a further review of lead in the community and its use in the Inco refinery. JW produced a draft report, "*Reevaluation of Lead as a Potential Chemical of Concern*" in May 2002. Subsequent drafts were produced in September 2002, January 2003, June 2003 and February 2004. The Independent Consultant expressed concerns with each of these iterations. A Final Report was issued by JW in June 2004, which presented lines of evidence that attempted to demonstrate that Inco was not a primary source of lead in soil in Port Colborne. Attempts were also made to assign responsibility for lead contamination to other sources.

This document is based on a review of the final JW report entitled, "*Re-evaluation of Lead as a Chemical of Concern*" dated June 2004. In this document, Watters Environmental Group refutes the arguments made by JW that lead does not qualify as a CoC, and presents information to support the view that lead should be considered as a CoC for the CBRA.

2.0 BACKGROUND

Since the inception of the CBRA, residents of the Port Colborne community (the "Community") have expressed concern regarding the influence that lead in soil has on the health of the Community, in particular, the health of the young children.

There has been a growing awareness within the scientific and medical communities that lead is more toxic than had been previously recognized and that it is a major environmental health hazard for young children. Extensive literature has shown that lead exposures can result in lowered intelligence, reading and learning disabilities, impaired hearing, reduced attention span, hyperactivity and antisocial behaviour in children. For example, Cranfield et al.(1) concluded, in their study of intellectual impairment in children with blood lead concentrations below 10µg/dl (micrograms per decilitre), that "*blood lead concentrations, even those below 10 µg per decilitre, are inversely associated with children's IQ scores at three and five years of age, and associated declines in IQ are greater at these concentrations than at higher concentrations. These findings suggest that more U.S. children may be adversely affected by environmental lead than previously estimated*".

The United States Environmental Protection Agency (EPA) has issued the statement that, "*Lead can cause a variety of adverse health effects in humans. At relatively low levels of exposure, these effects may include interference with red blood cell chemistry, delays in normal physical and mental development in babies and young children, slight deficits in the attention span, hearing, and learning abilities of children, and slight increases in the blood pressure of some adults. It appears that some of these effects, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold.*"(2)

The World Health Organization expresses similar concerns that lead levels as low as 5 µg/dl can irreversibly impair the development of a child's brain, reducing their IQ. (3)

The growing concern that the effects of lead in young children occur at very low levels of contamination has brought forward the suggestion that the standard for intervention (in the United States) be lowered from 10 µg/dl (blood lead level) to 5µg/dl.(4)

The MOE expressed concern that the current 10 µg/dl Level of Concern should not be interpreted as an acceptable level.(5) They acknowledge that children must be considered the most important receptor in developing environmental quality standards because:

- Children ingest more soil and dust due to hand-to-mouth behaviour, including pica;
- Children are generally in more direct contact with soil and dust;
- Children take in more food and water per unit body weight than adults;
- Absorption of lead is estimated to be as much as 5 – 10 times greater in infants and young children than in adults; and
- Children are more sensitive than adults due to their ongoing neurodevelopment.

There have been a number of studies attempting to determine a relationship between soil lead levels and blood lead levels in children,(6,7,8,9,10,11and12) that suggest the importance of contaminated soils as an exposure source. It has been found that, in many cases, soil abatement has been effective in reducing the body burden of lead in children living in contaminated environments.

3.0 LEAD AS A CHEMICAL OF CONCERN

As noted, to qualify for inclusion as a CoC under the Port Colborne CBRA, a substance must meet three criteria:

- Chemicals that were historically used or generated by the industrial source(s) or its processes, and
- Chemicals that are present at a community level at concentrations greater than the MOE generic effects-based guidelines, and
- Chemicals whose presence in soil shows a scientific linkage to the historical operations of that industrial source(s).

Also as noted, Inco acknowledges that lead meets the first two criteria for inclusion as a CoC. They contend that lead does not meet the third criterion for scientific linkage. The following sub-sections present details on these three conditions as related to the consideration of lead as a CoC for the CBRA:

3.1 CHEMICALS THAT WERE HISTORICALLY USED OR GENERATED BY THE INDUSTRIAL SOURCE(S) OR ITS PROCESSES

This criterion has never been in dispute. Since the earliest days of the CBRA, Inco has acknowledged that lead was emitted from the refinery and indicated that, over the life of the operation, 3.5 tonnes were released from the nickel refining operations, mostly between the years 1918 to 1930. In response to questions raised by the Independent Consultant, Inco “discovered” another source of lead and added a further 26.8 tonnes of lead to their emissions inventory, bringing their total disclosed inventory to 30.3 tonnes. The source of the additional lead was reported to be the #2 Research Station Precious Metal Recovery Facility operating between 1987 and 1997. It is not known if there are other sources of lead resulting from the operations carried out at the Inco property.

Inco have acknowledged that this criterion for inclusion as a CoC has been met.

3.2 CHEMICALS THAT ARE PRESENT AT A COMMUNITY LEVEL AT CONCENTRATIONS GREATER THAN THE MOE GENERIC EFFECTS-BASED GUIDELINES

In the introductory section of the Re-evaluation of Lead as a Potential CoC Report, a varying interpretation of the definition of a CoC was presented. Correctly, it was indicated that the definition of "Community Level" has not been specified. In fact, the term "Community" is not defined in the Technical Scope of Work for the CBRA or elsewhere in CBRA Documentation (PLC Minutes, TSC Chairman's Notes, etc). It was then stated that it, "*was understood between the stakeholders during development, to refer to contamination spread over a large percentage of the area of the community. The community area has typically been taken to be 29 square kilometres*." Such an understanding was never reached between the stakeholders (i.e., the reason no actual definition exists); however, throughout the documentation of the CBRA, reference is made to the "East Side Community". This area, of about 5 square kilometres, has approximately 50% of the land area with soil lead concentrations greater than 200 µg/g; typically ranging between 200 µg/g and 400 µg/g.

Following extensive discussions of the above, Inco acknowledged that this criterion for inclusion as a CoC has been met.

3.3 CHEMICALS WHOSE PRESENCE IN SOIL SHOWS A SCIENTIFIC LINKAGE TO THE HISTORICAL OPERATIONS OF THAT INDUSTRIAL SOURCE(S)

Lead is unlike the other CoCs (i.e., nickel, copper, cobalt and arsenic), because there is not just one obvious source of contamination. There are other sources of lead contamination in the Port Colborne area other than the Inco Refinery. Potential sources of lead in the Port Colborne Community include:

- Tetraethyl lead from gasoline;
- Lead from lead-based paints;
- Other domestic sources of lead (old batteries, lead pipe, solder etc.);
- Commercial sources (car body shops etc.);
- Seaway operations;

- Other industrial sources; **and Inco**.

In their Report, *Soil Investigation and Human Health Risk Assessment for the Rodney Street Community, Port Colborne: March 2002,* The MOE observed that "*Even though lead was likely emitted from Inco (lead made up about 10% of a single precipitator dust sample collected in 1978 (MOE 1978a)), the complete lack of a soil lead spatial pattern relative to either Inco or Algoma, suggests that the lead in the soil in the Rodney Street community is associated with general urban and domestic residential sources (lead based exterior paint, disposal of battery and automotive parts, pesticide use, and leaded gasoline)*". The MOE, at the time they drew this conclusion, did not have the benefit of the considerable additional sampling conducted across Port Colborne (including the results from the sampling to the east of the Refinery). Also, they were not aware of the very large, additional source of lead from the comparatively short stack at the #2 Research Station at the south of the Refinery, and the possibility of additional ground-level fugitive emissions.

The situation with lead is made more complicated than with other CoCs because of the other, likely potential sources of lead in addition to the Inco Refinery. JW have suggested that the criterion for scientific linkage includes a consideration of the contribution by Inco to the total amount of lead in the Port Colborne environment. While the MOE declined to suggest what would be considered to be a reasonable contribution to hold Inco responsible for lead contamination, JW offered the opinion that a greater than 25% contribution would be enough to consider lead as meeting the criterion for scientific linkage. Other interested parties to the CBRA may have differing views of what should be regarded as a significant contribution. Certainly, other options present themselves. For example, under U.S. Superfund legislation, any contributor to pollution can be found liable for clean-up costs. An alternative approach to assigning responsibility could be to consider the party that was the greatest single contributor to the pollution to be the responsible party.

Inco emitted approximately 30 tonnes of lead through its stacks and in addition to this there were almost certainly additional fugitive emissions. In the Re-evaluation of Lead as a CoC Report, JW present a number of arguments as to why there is not a scientific linkage between Inco's historical emissions and lead in soils in the community. Reasons were also suggested for deflecting responsibility to other sources. Watters Environmental find none of the arguments to be compelling, and many of them demonstrate misinterpretation of their own data.

4.0 LINES OF EVIDENCE TO ASSESS SCIENTIFIC LINKAGE BETWEEN SOIL LEAD CONCENTRATIONS IN PORT COLBORNE AND THE INCO REFINERY

In the following sections, an evaluation is provided of each of the lines of evidence put forward by JW in its attempt to show that there is no scientific linkage between soil lead in Port Colborne and Inco's operations.

4.1 VERTICAL DISTRIBUTION OF LEAD

JW describe different profiles of lead in soil from the east to the west of the Refinery. To the east of the Refinery they suggest there exists a sharp decline in surficial soil lead levels (0-5 cm), dropping to "background" levels below 10cm while to the west there are high soil lead concentrations at all depth levels; in some cases lead increased with depth and in others remained the same. JW suggest that this variation in the pattern of vertical distribution of lead in the soil columns to the east and west of the refinery "*is another piece of information indicating that most of the lead present in the East Side Community came from source(s) other than atmospheric deposition from the Inco refinery*". We do not believe this assertion is supported by this piece of evidence. The land to the east of the Refinery has been essentially undisturbed while, to the west, soils have been worked and reworked in residential properties for up to 90 years. The different patterns of vertical distribution east and west of the Refinery are what would be expected from the different historical land uses in each respective area.

4.2 SOIL NICKEL TO SOIL LEAD RATIOS

According to JW, the differences in soil Pb to soil Ni ratios are evidence that other sources of lead besides air deposition from the Refinery must have contributed to lead concentrations in the East Side Community. JW found that Ni:Pb ratios in the East Side Community are different from the ratios to the east of the Refinery. JW acknowledged that nickel was emitted from a much taller stack than was the lead and therefore one would not expect soil Ni:Pb ratios to remain constant with increasing distance from the Refinery. However, they contend that, regardless of direction, ratios should be similar.

This reasoning might have some merit if the emission sources of lead and nickel were immediately adjacent; however, they are not. The stack, which was historically the main source of nickel emissions, is half a kilometre north of the #2 Research Station (i.e., the identified source of most of the lead emissions). The relative distribution of Ni and Pb with ratios varying with direction is exactly what one would expect to see with two sources with this distance of separation. This is demonstrated in Figures 1 and 2 below. Figure 1 is an idealized view of lead and nickel being emitted from the same point source and shows that, as JW postulate, it may be possible to expect that ratios could remain fairly consistent in all directions (although different stack heights and physical characteristics of lead (i.e., melting point and density) make even this improbable). Figure 2 shows that the argument brought forth by JW has no merit in reality. The stacks from which most of the lead and nickel were emitted are not only of different heights but are also separated by about half a kilometre. Within the scale being considered for impacts on the East Side Community, there will be very significant differences in ratios depending on direction and distance from the Refinery.

JW's argument that lower soil Ni:Pb ratios in the East Side Community than those to the east of the Refinery could not be the consequence of aerial deposition from the Refinery is without merit and provides no evidence of a lack of scientific linkage.

Figure 1 represents Nickel: Lead Ratios from an idealized Single Point Source.

As JW postulate, it is possible to conceive that ratios might remain constant in all directions from the source.

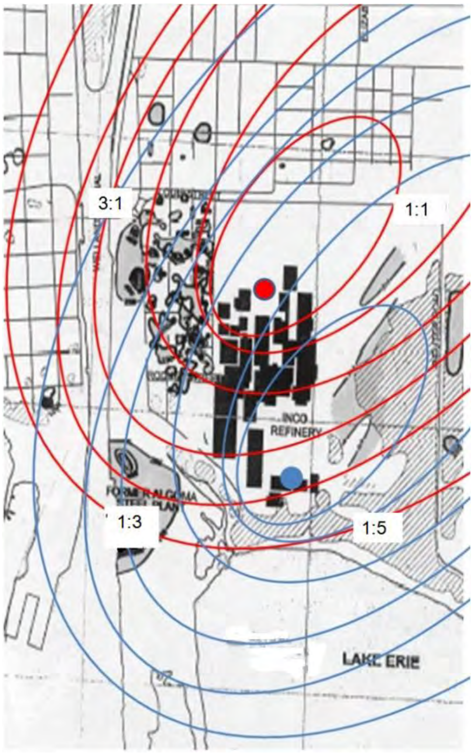

Figure 2 represents Nickel: Lead Ratios from separate sources approximately half a kilometre apart (the actual situation that existed).

It shows that ratios will vary depending on the direction and distance from the Refinery.

4.3 SOURCES OF LEAD AT INCO

In the initial Lead as a CoC report dated January 3, 2003, JW reported that the total lead emissions from the Refinery were approximately three tonnes over the life of the Refinery. We know that significant quantities of lead were emitted from the Inco stack, based on the MOE's Rodney Street Report (MOE, Report SDB-010-3511, 2001). Inco's stack dust analysis showed levels of 10.5%, or 105,000 ppm lead.

Continuing concerns expressed by the Independent Consultant regarding the quality of the January 2003 Lead as a CoC Report resulted in Inco instructing its consultants to prepare a revised report, which was issued in July 2003. In this revision, JW reported that another source of lead had been discovered, which added 26.8 tonnes to their estimate of emissions from the Refinery. This new source of lead was the precious metals recovery unit located in the #2 Research Station, where a by-product from Copper Cliff refinery containing 1 – 12% lead (average 7%) was treated in a top-blown rotary converter to extract precious metals. Emissions from the process (including lead) were passed through an air cleaning system comprising a venturi scrubber and an absorption tower. Average lead emissions from the #2 Research Station were reported to be approximately 2 tonnes per year.

The Independent Consultant had an opportunity to review the new report on Lead as a CoC and concluded that the report did not have sufficiently robust studies to support JW's position that lead was not a CoC for the CBRA (specifically, there was not sufficient evidence to support the contention that there was no scientific linkage).

Inco inquired about what evidence would be regarded as satisfactory to the Independent Consultant in order to settle the question of scientific linkage. Two things were requested: a proper mass-balance accounting for material processed through the #2 Research Station and additional sampling of soils to the east of the Refinery.

The mass-balance accounting for material processed through the #2 Research Station is inadequate and generalized, not allowing for any meaningful conclusions to be drawn. JW contend that the mass-balance account provides affirmation of the amount of lead emitted from the stack (26.8 tonnes of lead), but it does not account for any fugitive emissions. It has been emphasized that much care was taken to avoid the loss of material at the front end of the process because of the content of precious metal in the feed; however, little information is available about how downstream waste and product was handled and/or stored. The mass-balance table provided by JW indicates that 44.3 tonnes of lead remained in products and by-products. Lead in the waste was present in the form of lead carbonate, which was either sent to landfill or sold as a by-product. No information regarding the handling of the wastes is provided but presumably, being of little or no commercial value, the same care was not taken as it was with the raw material. One of the biggest environmental problems facing the minerals industry is fugitive dust from material stockpiles or railcars. So, depending on the way in which the waste material was handled, there is the potential for quite high wind-blown dust loadings.

Scrubber solids were collected in a settling pond and periodically removed to an asphalt ore-pad before shipment by truck to Sudbury. Depending on whether dry beaches were allowed to develop in the ponds and whether the material on the ore-pad was allowed to dry, there was also the potential for fugitive lead emissions from these sources.

4.4 AIR DISPERSION MODELING

JW assert that it is more appropriate to convert soil: mass ratios (µg/g) of soil contaminants to mass per volume (µg/cm^3) when assessing the extent of contaminant distribution from point source emissions, such as refineries. No further explanation is provided for this departure from the standard approach of evaluating µg/g soil, and no justification for the use of the approach is provided. The only allusion of the use of such an approach ever being employed is an internet reference to an obscure study of soils in “upland” areas of the United Kingdom.

The concept of “normalizing” the lead concentrations measured in soils collected in the open spaces and in the woodlot directly east of the Inco property was initially raised in Section 3.2.2 of the Re-assessment of Lead as a CoC report. However, this concept is not founded on an accepted scientific principle or procedure. There are no relevant references provided, likely because there are no scientifically accurate papers reporting studies that rely on such a concept.

JW suggest the following on page 23 of their report: “*To distinguish differences in soil lead distribution both west, north and east of the Inco Refinery as a result of historical atmospheric particulate deposition from the Refinery, regardless of an open space setting or a woodlot setting then any comparison would require all soils in the collective soil metal database to be of a uniform bulk density*”. This is scientifically incorrect. Scientists have been comparing metal concentrations in soil based on mass-to-mass ratios for many years, with no need for the introduction of a soil density factor or further “correction” of the results.

The CBRA document, “Soil/Sediment Sampling and Analysis Protocol, 2003”, makes no mention of a density factor and if a density correction is required, then every soil result for the CBRA would have to be similarly corrected to account for density.

JW assigns bulk density values based on **averaged** data for samples that were analyzed. Instead of providing actual data, they provide a table showing six soil types, with “assigned”, “average” bulk density values. They also assume that such an approach, even if it had been scientifically justified (it is not), would be mathematically valid. Without knowing the range of values, the statistical significance of the values, and the standard deviation associated with the averages, the “assigned Bulk Density” values are meaningless.

Despite the obvious scientific concerns with using this approach, JW applies these values to the actual lead values, with the result that the actual soil-lead concentrations provided by the laboratory are effectively halved.

The ISC Prime model employed to predict the distribution and concentrations of lead provided a reasonable agreement between the predicted and observed soil distribution of nickel. However, there is a very poor correlation between predicted soil levels and the actual results obtained in the field measurement of lead. Samples taken by JW in 2003 to the East of the Refinery (NE of the primary point source of emission of lead) show a plume of lead in soil greater than 200 µg/g and with concentrations ranging up to 340 µg/g. In the same area the model predicts concentrations of around 4 - 8 $\mu g/cm^3$, (presumably about 8 – 16 µg/g if one applied JW’s density corrections).

The ISC Prime model does not consider lakeshore wind effects and this was identified as a weakness of the air dispersion model in the RWDI peer review of the air dispersion model. The peer reviewer’s concern is that “*a shore-line site could be expected to experience lower mixing heights than one further inland, which would bring a plume to ground sooner (and in higher concentrations) than would be predicted by a model such as ISC*”. JW claim to have addressed this concern in their response to the peer reviewer but in fact just say, “*this effect is not expected to substantially affect the model predictions, and was approximately accounted for in the method used to develop the meteorological data set*”. An additional concern is that the Inco weather station from which wind direction and velocity data were gathered is situated 1.4 km from the lakeshore and is shielded from it by the bulk of the Refinery. Given the strong influence of lakeshore winds along the shores of Lake Ontario, this throws doubt on the applicability of the wind rose used to predict lead dispersion from the south end of the Refinery.

The ISC Prime model predicts a weak plume of lead to the E and ESE of the Refinery, (not E and NE, as reported by JW). The actual data from the additional sampling conducted in 2003 shows quite a well defined plume trending to the NE, as would be expected.

JW offer no comment in their report on the considerable disparity between actual and calculated concentrations and distribution of soil lead and, throughout the rest of the report, they accept the ISC Prime numbers as being correct.

4.5 SENSITIVITY ANALYSIS

In an attempt to strengthen the validity of the results of dispersion modeling, JW carried out a "sensitivity analysis". JW deemed this necessary because of the "*scarcity of historical operations and emissions data for the PNCR*".

The sensitivity analysis, employing factors of two and three times the reported emissions of lead adds little useful information because the ISC Prime model is unable to predict lead concentrations with any accuracy.

JW used this information to attempt to quantify the percentage contribution of Inco's emissions to the total lead burden in the East Side Community. In doing this, they used a maximum soil concentration of 1,350 µg/g. This concentration represents a localized point source of lead; something buried, and is not representative of the general lead concentrations across the East Side Community. This use of an outlier result distorts any attempt to estimate a realistic contribution by Inco.

4.6 PEER REVIEW OF AIR DISPERSION MODELING

Inco retained RWDI Consultants to peer review the Air Dispersion section of the Reevaluation of Lead as a Potential Chemical of Concern Report, prepared by JW. The review started with a weak endorsement of the study which hinged on the proviso that the data supplied was complete and correct, "*if the missing information and details about air quality assessment are shown to support the text in the report, and based on the assumption that the information provided in the report pertaining to the emission sources of lead, soil concentrations and densities is correct, we concur with the conclusion that high lead levels measured in the east Side Community do not appear to be as a result of historical air emissions of lead from Inco*." As discussed above, the data on soil concentrations to the NE of the Refinery provided by JW is neither complete nor correct and no credence can be placed in the ISC Prime prediction for East Side Community results.

The ISC Prime model predicts lead concentrations in the East Side Community of 2 - 4 µg/cm^3 over the lifetime of the facility. Given the inability of the model to predict the actual results to the NE of the refinery, the air dispersion modeling results cannot be used to determine scientific linkage.

4.7 LEAD SAMPLING TO THE EAST OF THE REFINERY

Reference has been made to additional sampling of soils that was conducted by JW to the east of the Refinery in September 2003. Twenty four samples were taken in a 3 x 8 grid pattern directly to the east of the Refinery and at an equivalent distance from the Refinery as the East Side Community (Figure 3).

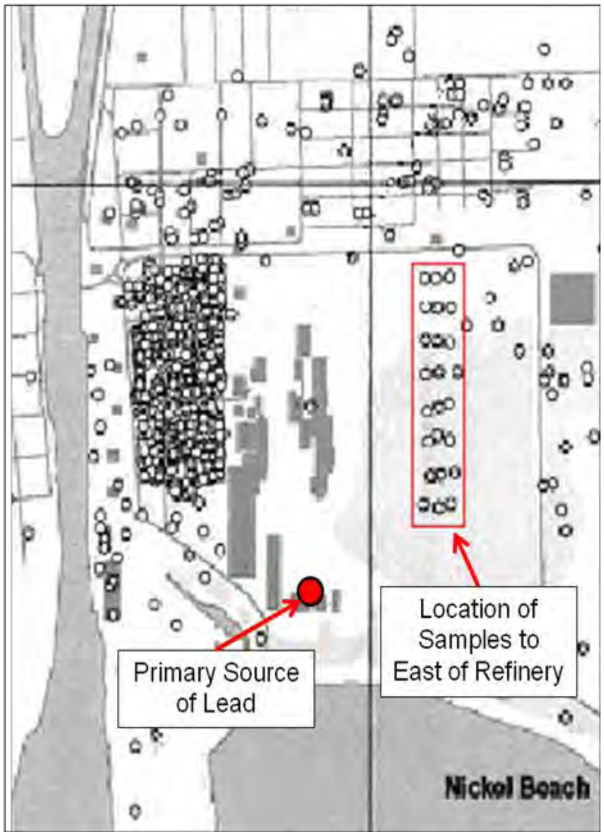

Figure 3. Additional samples were taken to the East of the Refinery and the same distance from Research Laboratory 2 as the East Side Community, specifically to test whether there is scientific linkage.

These samples were taken with the explicit purpose of testing whether a scientific linkage exists for lead as a CoC. The sampling program was agreed to at a meeting between Inco and the Independent Consultant in response to the Consultant's concern with the draft *Re-evaluation of Lead as a COC* Report. It was agreed that if sampling to the east of the Refinery demonstrated similar concentrations and a similar pattern of distribution as was found in soils in the East Side Community, then this would be compelling evidence of a scientific linkage.

Nowhere in the final *Re-evaluation of Lead as a COC* Report are these data presented. The reason for the omission of this data is not understood. The Independent Consultant has plotted the data from the 2003 sampling and it is presented in Figure 4.

The data, when plotted, demonstrates the following:

1. Concentrations of lead in soil over half the area sampled in excess of the MOE Standard of 200 µg/g
2. A maximum lead in soil concentration of 344 µg/g
3. A plume trending NE, directly downwind from the primary source of lead emission, the stack at #2 Research Station.
4. A similar (but not identical) pattern of distribution of lead to the east and west of the Refinery. Differences in the pattern of distribution are attributed to:
   - Higher density of sampling in the East Side Community compared with the area to the east of the Refinery;
   - Artefacts associated with computer-drawn isopleths to the west compared with hand drawn contours to the east;
   - Reworking of soils and addition of new material in the yards of homes in the East side Community. The area to the east of the Refinery is relatively untouched;
   - Local variations due to wind direction and buildings; and
   - Additional sources of lead in the East Side Community including additional airborne sources, such as leaded gasoline and point source "hot-spots" attributable to buried lead (batteries, wheel balance weights, lead pipe etc).

The MOE, in their 2002 Report on Soil Contamination in the Rodney Street Community, observed that it was evident from the contaminant contour maps that soil contamination for a number of contaminants in the Rodney Street community tended to be patchy. They attributed this to property landscaping or redevelopment over time and observed that, "*Landscaping need not be elaborate to substantially alter the surface soil (top few cm) contaminant levels. Simply filling low spots in a lawn with topsoil or re-sodding can add enough clean soil to dilute the residual surficial contamination. The contamination status of undisturbed/unlandscaped properties would remain relatively unchanged in the years since the sources closed, to create the soil contamination patchwork pattern that was observed across the Rodney Street community*".

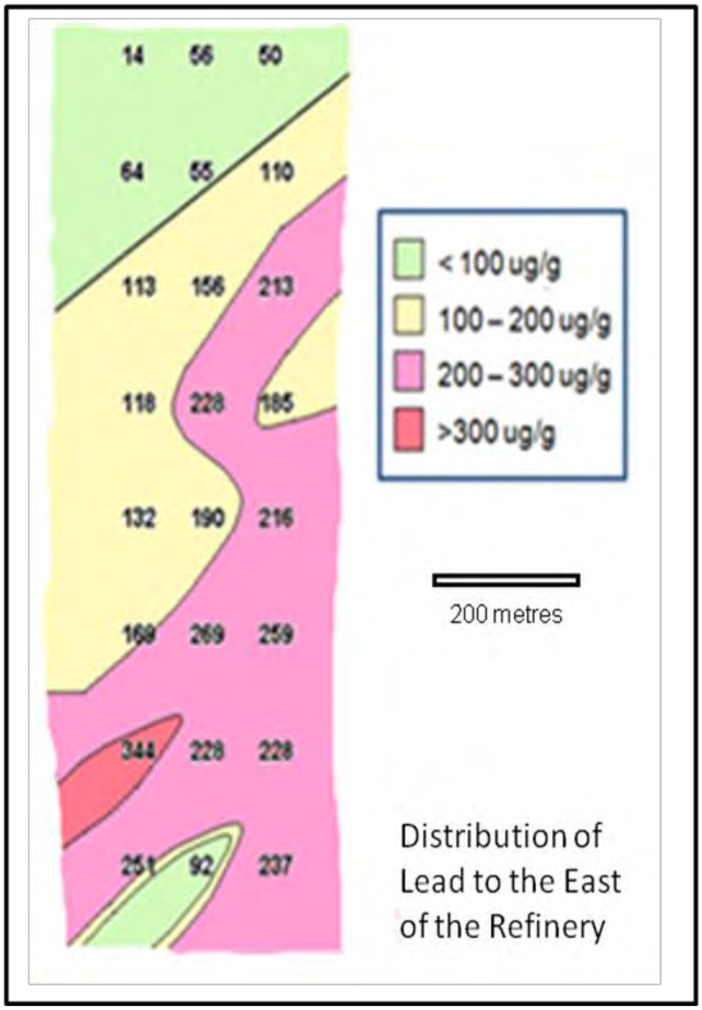

Figure 4. The additional samples show soil concentrations above the MOE Guideline and a plume trending downwind from #2 Research Station 2. [Located 500 metres to the SW of the grid pattern]

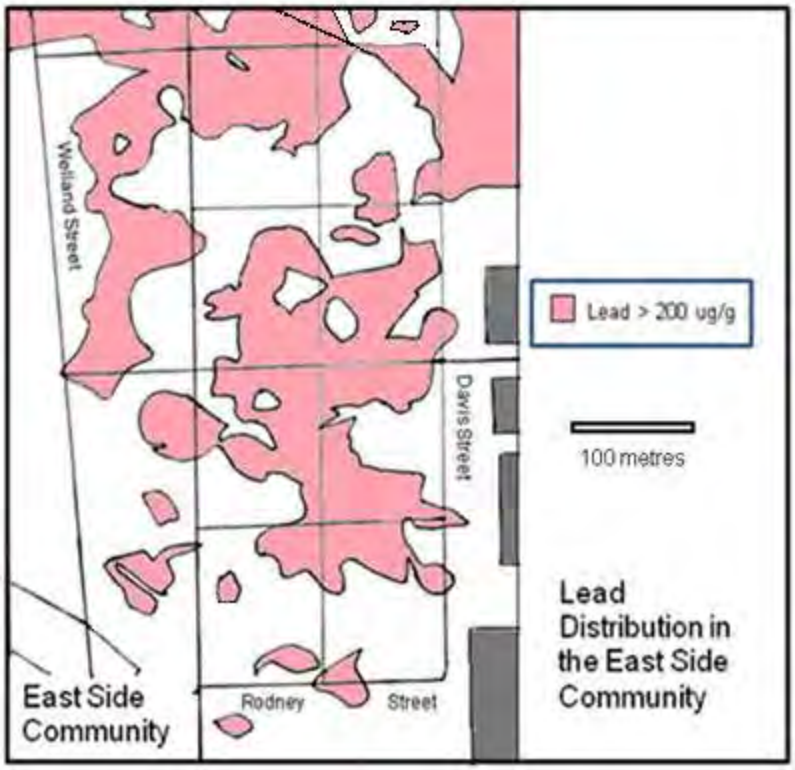

Figure 5. Pattern of lead distribution to the west of the Refinery shows similar concentrations and the patchy distribution as seen to the east.
[Corner of Rodney Street and Davis Street is 500m NW of #2 Research Station]

From Re-evaluation of Lead as a Chemical of Concern Report - Fig. 3.3

4.8 BACKGROUND CONCENTRATIONS OF LEAD IN SOIL

Background concentration is defined as the ambient concentration of a chemical in the soil, groundwater, air or sediment that is representative or typical of the conditions in urban or rural setting. Background concentrations are established by the MOE and are presented in Table F of Appendix A of the Guideline for Use at Contaminated Sites in Ontario. These background criteria were developed from an Ontario-wide sampling program at rural and urban parks unaffected by local sources of pollution.

The Guideline criteria are organized by two land use types; agricultural and all other land uses, which includes parkland, residential, industrial and commercial use. The background level of lead for agricultural use is 55 µg/g and for all other land uses is 120 µg/g. The “all other uses” background level considers not just natural sources of a contaminant (from the weathering of country rock for example) but also anthropogenic sources, substances present in the environment as a result of human activities. These will include, for lead in residential areas, sources such as leaded gasoline etc., but exclude clearly defined single sources of lead (such as refinery stack emissions).

JW reported that "average" soil lead concentrations outside the soil nickel plume in Port Colborne were 33 µg/g, with maximum concentrations outside the plume of 98 µg/g. These numbers accord well with MOE Typical Ranges for Lead and it has been assumed that the "natural" background concentrations in the East Side Community are 33 µg/g. This number is not representative of the natural background, but is the general area concentration, unaffected by any local source. Lead does not naturally occur in any great concentration in the rocks of the Port Colborne area and the background levels will be the result of aerial deposition from sources, potentially a great distance from the Niagara Peninsula, as well as more local sources such as burning fossil fuels, leaded gasoline, etc.

The concentration of 33 µg/g seems reasonable as a general background level and consequently it is necessary to identify an additional source, or sources of lead to account for the bulk of the lead deposited in soil. Concentrations of lead range between 200 µg/g and 400 µg/g over half the land area of the East Side Community. The obvious primary source of the lead is the Inco Refinery. The measured high soil lead concentrations proximal to the Refinery to the east and west and rapidly declining with distance from the Refinery support this view. As previously discussed, it is acknowledged that there are other sources of lead contributing to the overall soil burden, including localized pockets where concentrations are very high.

4.9 EMPIRICAL AND STATISTICAL EVALUATION

JW seek to test whether there is a linkage between soil lead and the Inco Refinery through a number of statistical approaches. Unfortunately, the central tenets of the hypotheses chosen to test are flawed. JW contend that, if Inco was the principal source of lead in the East Side Community, soil lead concentrations would be higher to the NE of the Refinery. This may be true if Inco was the **only** source, but it is clear that there are other sources of lead, both airborne and point source contamination to the west of the Refinery. In fact, soil lead concentrations are similar to the NE and NW of the primary point source (with the exception of the scattered "hotspots" in the East Side Community).

Another perspective on why concentrations of lead are elevated to the NW compared with the NE of the Refinery comes from Chaney and Mielke (13) who, among others, assert that the (lead) particles, *"waft through the city and adhere to surfaces they come in contact with."* These particulates may then be washed down into the surrounding soil. Areas with large surfaces would, by this hypothesis, attract more of these small particles. This suggests that elevated soil-lead concentration at an urban residence's foundation may not strictly be a function of lead-based paint. In the Port Colborne context, to the NE of the point source from the Refinery there is open ground, while to the NW are the buildings making up the community against which particles of lead would impact.

JW also hypothesize that the ratio of lead to other CoCs should be similar both within and outside the East Side Community if there was a scientific linkage. As previously discussed, this rationale is confusing. Ratios would only be expected to be the same if the point of emission of lead and the other CoCs was one and the same. In fact, they are not, and are separated by half a kilometre.

Regression modeling was carried out to attempt to quantify Inco's contribution. The relationships between lead and the other CoCs to the east of the Refinery were used in order to attempt to predict concentrations to the west. JW concluded from the regression analysis that Inco contributed 54.5 µg/g lead (uncorrected for background). Subtracting an assigned value of 33 µg/g, leaves a calculated contribution 21.5 µg/g, or 11% of average soil lead loading of 201µg/g across the East Side Community. JW also calculated the contribution from the Refinery by applying regression analysis to the maximum value for soil lead concentrations in the East Side Community and maximum background level (98 µg/g). This provides a calculated Inco contribution of 40.5 µg/g. This is the number that JW have used in their later discussion assigning contribution by Inco to soil-lead contamination relative to a maximum soil concentration of 1,350 µg/g.

The regression modeling line of evidence is premised on lead concentrations relative to the other CoCs being constant to the east and west of the Refinery. As lead is emitted from a different primary source than the other CoCs, this premise is problematic.

JW have compared their suggested contribution of lead from Inco and other sources with the highest lead values in the community (they use 1,350 µg/g). In our opinion, this is inappropriate. The high concentrations are highly localized and represent single point sources close to the sampling locations (i.e., a buried battery). Concentrations should more appropriately be compared with high levels attributable to non-point source contributions.

4.10 ALGOMA AS A SOURCE OF LEAD

The Algoma steel plant is an insignificant contributor to soil lead concentrations in the East Side Community.

In soil lead distribution maps prepared by JW, a significant zone of high soil lead levels is shown centered on the Algoma plant. This is nothing more than an artefact of the contour drawing software employed in the CBRA studies. The high concentration (3,000 µg/g) is almost certainly a point source, probably buried lead material. None of the samples adjacent to the high value are above 200 µg/g (the nearest sample is 150 metres from the point source). There is no evidence of a lead plume from the Algoma site and no reason to assume that Algoma was a significant contributor to soil lead contamination.

Algoma operated two blast furnaces and a sinter plant, with the raw materials being iron ore, waste iron oxides, limestone and coke; none of which would be expected to produce significant lead emissions. The list of major historical emitters of lead to the Canadian environment presented in Section 4.7 of the Re-evaluation of Lead Report does not include a single iron or steel works, all of the listed emitters are non-ferrous, base-metal facilities.

To assign a contribution of lead from Algoma, JW refer to the U.S. EPA AP-42 emissions factors for grey iron foundries from which they assume that 0.5% of total emissions from Algoma would be lead. This is based on the U.S. EPA reporting less than 1% lead from similar facilities. 1% is the lowest cut-off point in the EPA data-base of emissions but JW capriciously assigned half the lowest reporting level to estimate Algoma emissions. There is no scientific basis for this.

4.11 OTHER INDUSTRIAL/COMMERCIAL SOURCES

JW present a list of commercial enterprises including rail yards, scrap yards, machine shops automobile repair shops, drycleaners, etc. Each of these is cited as a “likely” source of lead released to the environment. In our opinion, the assertions are pure conjecture. No references are provided to support these claims and no rationales for their inclusion as a source of lead is provided. Particularly, there is no understanding as to why a dry-cleaning shop, an iron foundry or an OPG power transformer would be considered as a contributor of lead to the environment. Other “likely” sources such as automobile repair shops could more reasonably be expected to be contributors of local point sources of lead, e.g., from spilt solder or wheel balance weights dropped on the ground. They cannot be used to explain the widespread contamination ranging from 200 to 400 µg/g across half the area of the East Side Community.

4.12 OTHER COMMUNITY SOURCES OF LEAD

Although various other sources of lead are suggested, (such as lead-glazed pottery and batteries), two major sources of lead are cited, leaded gasoline and lead-based paint. JW reference the work of Howard Meikle and present his observations that, "*In general, larger, older cities have more lead contamination than smaller, older cities. Inner city areas with heavy traffic congestion have higher soil lead levels than outer lying residential or suburban areas. Soils near building foundations and streets typically have more lead than soils or yard areas*".

Gasoline

Port Colborne clearly fits into the grouping of "smaller" cities referred to by Meikle and does not suffer particular traffic congestion. Two main E-W traffic routes traverse the East Side Community, Killaly Street and Main Street. There is no reason to assume that emissions from traffic would be greater east of the canal than they are to the west. The main route to Welland West Side Road is to the west of the canal. Consequently, the contribution of leaded gasoline to soil loadings should be much the same across communities east and west of the canal. We can therefore assume that the contribution from gasoline is something less than the average lead in soil concentration of 33 µg/g, outside of the Inco plume.

Paint

The recognition of the health consequences of low levels of lead contamination on children's health has resulted in quite a considerable amount of research into the sources of contamination. In the 1970's, the assumed source of contamination was lead-based house paint. A study in Baltimore, Maryland, raised questions about that assumption. Soil around Baltimore's inner-city buildings, predominantly unpainted brick, exhibited the highest amounts of lead, and soils outside of the inner city, where buildings were commonly constructed with lead-based paint on wood siding, contained comparatively low amounts of lead, suggesting that lead-based house paint could not account for the observed pattern of soil lead (Mielke et al. 1983). A similar pattern was also found in Ottawa, Canada (Ericson and Mishra 1990). Studies in other U.S. cities (as well as Oslo, Norway, and Ibadan, Nigeria), exhibited the same distance decay characteristic initially identified in garden soils of Baltimore and support the idea that lead-based house paint was not the sole source contributing to these observed differences(5). However, JW contend that lead-based paint is the primary source of lead in soils in Port Colborne.

JW cite studies reviewed in a literature review conducted by the Battelle Memorial Institute (*Sources of Lead in Soil – A literature Review*) (13) that stated that samples collected near the foundations of residences had higher lead concentrations than samples collected at more remote locations. This is demonstrated in the HUD National Lead Survey, (14) involving 762 samples, that reported that the geometric mean soil-lead concentrations for samples collected at the drip-line of dwellings was 72 ppm (geometric standard deviation: 5.37), compared to 47 ppm (GSD: 4.14) for samples collected at remote locations (but still on the property).

The sampling protocol established by the MOE and used in the soils contamination study in 2000, required that soil samples were not collected within one metre of driveways, walkways, building structures, fences and debris to reduce the likelihood of encountering local residential sources of contamination (e.g., driveway spills, eroded paint from painted surfaces). Therefore samples taken for the CBRA should be fairly representative of lead deposition in the area and the influence from possible sources such as lead paint should be diminished.

To test the contention that the primary source of lead was from paint from older homes in the East Side Community, JW submitted six paint chip samples for examination under a scanning electron microscope. All of the chips came from soil with lead concentrations above 200 µg/g.

In the one sample taken from soil in the East Side Community lead was found in just one chip of paint out of six. In a sample taken 4.2 km to the NW, two chips out of ten contained lead and a sample 1.1 km north yielded one out of eight (i.e., a range of 12 – 20%).This would suggest that lead based paints are not predominantly used on houses in Port Colborne. Based on these three samples, JW speculate on the age of houses, on the locations from where they were taken, and developments in paint technology of the paints used on the houses without actually taking forward our understanding of the contribution of lead-based paint to lead-soil concentrations.

JW suggest that the typical preparation of soils employed in the CBRA studies, which involved sieving through a 2mm mesh before analysis, results in the underestimation of any contribution from lead-based paint chips greater than 2mm. In actual fact, the soils preparation protocol calls for disaggregation of samples with a mortar and pestle before screening through a 2 mm sieve. This would presumably result in most paint chips being ground to a size where they will pass through the mesh (the paint chips from the East Side Community analysed by electron microscopy actually have an average diameter of 2mm (1.12 – 3 mm) and 11 of the 16 samples (i.e., 70%) would have passed a 2mm mesh). However, to confirm their assumption that chips and their contribution to lead loadings were being under-sampled, JW ground “portions” of greater than 2mm fractions of the soil samples and submitted them for analysis.

They found 4,090 µg/g lead in the East Side sample and 133 µg/g and 567 µg/g lead in the other samples. It is not clear how representative these samples were; however, as the laboratory reports that the samples submitted were so small that the laboratory had to adjust its Estimated Quantitation Limit and there was insufficient material available for HCl digest. The laboratory was unable to measure precision because samples were insufficient to recover a matrix spike.

Lighthouses

Lighthouses along the British Columbia coast were looked at as a source for supporting information that lead from Port Colborne homes is a primary source of soil-lead in the community. JW hoped to find a leaded paint signature in soils around the lighthouses that would provide proof that lead in soil in Port Colborne also derived from lead-based paint. They reported that they found that signature in a strong lead: barium: zinc relationship and that the relationship also presented itself in East Side Community Soils. To test this assertion, we looked at lead: barium ratios of the mean levels of data from the B.C. lighthouses (Figure 6) and found this to be correct. There is a strong relationship, a consistent 6:1 lead: barium ratio, however, we do not see the same relationship in the soil data presented in Table 7.6 of the Re-assessment of Lead as a CoC Report. Soil lead: soil barium ratios vary between 2:1 to 4:1. Accepting that lighthouses in B.C have some relevance to homes in Port Colborne, rather than supporting JW's view that lead-based paint is the major contributor to lead in soil, the lighthouse data would suggest that, in fact, it is not.

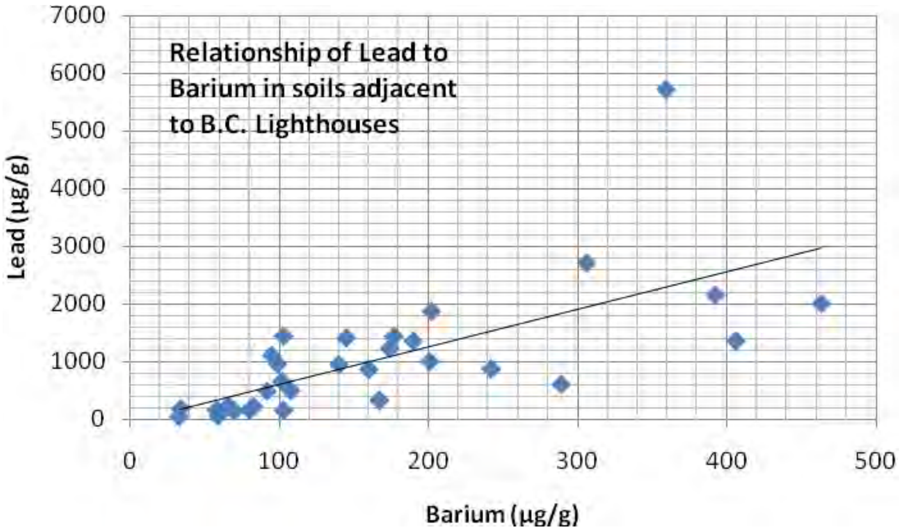

Figure 6. Lead and Barium demonstrate a consistent 6:1 ratio in soils adjacent to lighthouses in British Columbia.
[Data from Appendix K of Re-evaluation of Lead as a CoC Report]

While there is no doubt that lead-based paint must contribute some of the soil-lead concentrations in the East Side Community, the studies carried out by JW on the chemical make-up of a few paint chips do not allow any accurate estimation of the level of contribution. It seems likely that paint may account for elevation of soil concentrations along the foundations of some houses but it is less likely that paint is a major contributor to the soil lead concentrations measured across the East Side Community.

5.0 DISCUSSION

JW acknowledge that Conditions 1 and 2 are met for designating lead as a CoC but express confusion respecting what level of contribution of lead from Inco would satisfy the criterion for scientific linkage required by Condition 3. They suggest that this would rely on “professional judgment”. They invoke a circular argument that scientific linkage would be predicated on the MOE feeling that Inco contributed sufficient contamination to justify issuing a control order.

In order to assess whether the elevated lead concentrations in soils in the East Side Community could be linked to the historical operations of Inco JW summarize nine lines of evidence. These are presented in Table 8.1 of the Report. We have also considered the lines of evidence presented, but draw different conclusions (See Table 1 below)

Table 1: Summary of Lines of Evidence

Line of Evidence		Report Section	Independent Consultant’s Findings
1	Predominant wind direction	5.2.2	The predominant wind is to the NE and blows 14% of the time. The East Side Community bears NW to NNW from the point of emission of lead (not west as reported by JW) and blows 3 – 4% of the time (not 1.3%). It is not known what influence any shoreline effect may have on the local wind distribution compared with that measured at the station north of the Refinery.

Table 1: Summary of Lines of Evidence (Continued)

Line of Evidence		Report Section	Independent Consultant's Findings
2	Observed lateral soil lead distribution	3.2.2	JW contend that there is "no visible pattern apparent downwind of Inco". However, the additional samples taken to test the hypothesis that there is scientific linkage clearly shows a plume of lead directly downwind of the primary source of lead. JW chose not to present or plot this data.
3	Observed vertical soil lead distribution	3.3	The different vertical patterns are what one would expect when comparing undisturbed soils to the east of the Refinery with domestic plots that will have been worked by homeowners in the East Side Community.
4	Observed soil nickel: lead ratios	3.4 6.3.1	JW find that different Pb:Ni ratios in different directions from the Refinery is evidence that there is not scientific linkage. This finding is predicated on the false premise that the sources of lead and nickel are the same. They are not. The pattern of varying Pb:Ni ratios is what one would expect from two sources separated by half a kilometer.
5	Predicted soil lead contribution from Inco Refinery emissions using air dispersion modeling	5.4 8.2.5	The air dispersion model for lead is flawed. Predicted lead levels from the model are two orders of magnitude below measured concentrations. JW estimate that Inco's contribution to soil contamination in the East Side Community is 0.3%. This is based on considerably underestimated data from the air dispersion model and using a "point source" hot spot for the "maximum concentration" (1350 µg/g). 0.3% is a gross underestimated actual contribution

Table 1: Summary of Lines of Evidence (Continued)

Line of Evidence		Report Section	Independent Consultant's Findings
6	Predicted soil lead contribution from Inco Refinery emissions using regression modeling	6.3.4.	JW predict a contribution of 11% of the average soil lead loading of 201µg/g across the East Side Community. (40.5 µg/g, or 20% in Section 8.2.3). This depends on the theory that relationships of lead to other CoCs east of the Refinery would be the same as those to the west, and does not consider possible fugitive emissions from storage pads.
7	Historical review of East Side Community	7.1	The historical review provides no insight into relative contribution but is merely a speculative overview of "possible" sources of lead.
8	Literature review of domestic sources of lead found in urban communities in North America	8	The literature review is not sufficiently comprehensive or sufficiently analysed to provide clarity on relative contributions of lead.
9	SEM analysis of soil from East Side Community	7.3	This adds nothing to our understanding of relative contributions of lead to soil. It does show that, as expected, chips of lead-based paint contain high levels of lead.
10	Pattern of distribution of lead in soil east of the Refinery similar to pattern in East Side Community	NEW	At the request of the Independent Consultant, Inco undertook additional sampling to the east of the Refinery. The purpose of these samples was to test the hypothesis of scientific linkage. Although the results are not presented or plotted in the Re-assessment of Lead as a CoC Report, they provide compelling evidence of a plume of lead downwind of the Refinery and consequently substantial proof of a scientific linkage.

JW attempted to assign the relative contribution of lead in soil from various sources. Based primarily on the Air Distribution Modeling results (which we discredit) and a maximum concentration of lead in soil of 1,350 µg/g (which we believe to be inappropriate), JW suggest that Inco's contribution to the East Side Community soil lead pollution is 2 to 3%. They proceed to try and account for the remaining 97% from other sources. Candidates proposed are Natural Background, the Algoma Steel Plant, other industrial sources and domestic sources.

Their estimates, and our comments, are presented in Table 2.

Table 2: Comments on Sources of Contribution of Lead to Soil in Port Colborne

JW Assessment	Independent Consultant's Comments
Natural Background JW suggest a "natural background" level of 33 µg/g.	While this is not truly "natural background" and includes lead from possibly distal, non-point sources as well as more local sources, we accept that it is a reasonable number to use as a general background concentration for the study.
Algoma JW assign a 30 µg/g loading to Algoma's operations.	There is no reason to believe Algoma is a significant source of lead. JW's rationale for this is fundamentally flawed and is not borne out by the data collected in the CBRA.

Table 2: Comments on Sources of Contribution of Lead to Soil in Port Colborne (Continued)

JW Assessment	Independent Consultant's Comments
Inco JW invoke the regression analysis results to assign a 40.5 µg/g contribution to Inco. This is stated to be "only 3%" of the maximum measured soil concentration. Oddly, this number is dropped to 2% by averaging results from the regression model and the air dispersion model.	The regression modeling depends on the premise that a similar relationship between lead and the other CoCs exists to the east and west of the Refinery. As the sources are separated by distance and are emitted from stacks of considerably different heights, this premise is problematic. It is not appropriate to consider contribution in terms of a % age of a maximum concentration (which is clearly a localized point source, unrelated to aerial deposition). In Section 6.3.4., JW relate a contribution to an average concentration (201 µg/g). This is more logical. The concept of averaging the air dispersion results and the regression modeling results is not justified – particularly as the air dispersion analysis is discredited, bearing no relationship to actual, measured concentrations.
Domestic Sources JW postulate, based on "a detailed literature review" of other North American communities and light houses on the Pacific Coast, that other sources of lead exist within the East Side Community. To establish relative contribution they employed a "mass balance" approach. This yields an assigned contribution of 95% from community sources.	The literature review is not "detailed" but is sparse and selective. Despite all the effort to consider other sources of lead, and particularly lead-based paint, the mass balance approach consists of extracting the assigned contributions from Algoma, Inco and general background and assuming the rest of the bucket comes from community sources.

6.0 CONCLUSIONS

JW conclude that, "*plausible explanations for the localized, randomly-scattered areas of soil lead exceedences as high as 1,350 µg/g at the 0 to 5 cm depth observed within the East Side Community neighbourhood were provided through a mass balance approach on the relative contributions by all sources*".

There are two general ways by which lead has been introduced into soils in the community. Localized high concentration "hot spots" including JW's reported maximum of 1,350 µg/g are most likely the result of buried lead objects in the soil (batteries, piping wheel balance weights etc.). These "hot spots" are underlain by a general swathe of soil concentrations around 200-400 µg/g across the East Side Community, the result of aerial deposition. Inco was, in all probability the major, single contributor to this contamination.

JW's conclusion respecting Condition 3 in the Re-evaluation of Lead as a CoC Report is "***No***. *(i.e., there is no significant scientific linkage of soil lead to the Inco Refinery*"). However,

Condition 3 actually is, "*Chemicals whose presence in soil shows a scientific linkage to the historical operations of that industrial source(s)*". There is no mention of "significant". Either way, the information that JW have presented in their report and the data from the east of the Refinery, that they have chosen not to discuss, indicates that there is a scientific linkage between lead in soil in Port Colborne and the operations of the Inco Refinery, and that the linkage is significant.

In Conclusion, in the opinion of the Independent Consultant, lead meets the criteria for inclusion as a CoC for the purposes of the Port Colborne CBRA.

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