EVALUATION OF ARSENIC AND LEAD OCCURRING IN SURFICIAL SOILS AT THE MIDDLEPORT ELEMENTARY AND ROY-HART JUNIOR/SENIOR HIGH SCHOOLS

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1.0 INTRODUCTION

In May 1988, URS Consultants, Inc. (URS) was retained by the Royalton-Hartland Central School District to review and evaluate the elevated levels of arsenic and lead found in school ground soils at the Middleport Elementary and adjacent Roy-Hart Junior/Senior High Schools (referred to hereafter as the School property). Specifically, we were provided with and requested to evaluate the following three documents:

- Conestoga - Rovers & Associates. May 1986. Surface Soil Sampling and Analysis Program/Royalton-Hartland and Gasport School Properties/Middleport, N.Y. Prepared for FMC Corporation.

- Conestoga - Rovers & Associates. April 1988. Comprehensive Sampling Program/Royalton-Hartland School Property/Middleport, New York. Prepared for FMC Corporation.

- Meehan, G.M. May 10, 1988. Correspondence from G.M. Meehan of the New York State Department of Health (NYSDOH) to J. Tygert of the New York State Department Environmental Conservation (NYSDEC) regarding Supplemental Royalton-Hartland School Soil

Sampling Program Final Results.

All soil sampling data used in this evaluation is taken from the above three references, and from the following report by the New York State Department of Health:

- NYSDOH. October 1987. Biological Monitoring of Schoolchildren in Middleport, NY, for Arsenic and Lead.

The purpose of our review/evaluation is threefold:

(1) To interpret the sampling/analytical results of previous studies in terms of the level and extent of soil contamination at the Roy-Hart School property;

(2) To perform a limited, independent assessment of health risks associated with this contamination (limited to risks associated with arsenic and lead in surficial soils, under human exposure scenarios considered most relevant at the site); and

(3) If remedial actions appear warranted, to identify and provide budget-level cost estimates for the type of measures which may be appropriate.

This report is organized as follows. Section 2.0 provides our assessment of the adequacy of existing data for the site. Section 3.0 presents our interpretation of this existing data. Section 4.0 contains a limited health risk assessment for human exposure to arsenic and lead in school ground soil, and a general discussion of the meaning and limitations of this risk assessment. Section 5.0 includes a brief discussion and cost estimate of potential remedial measures at the School property.

2.0 ADEQUACY OF EXISTING DATA

From standpoints of both quantity and quality, we feel that existing data is sufficient to evaluate the health risks associated with arsenic and lead in school ground soils.

Data Quantity - Excluding the off-site ditch area, which we understand has already been remediated, there have been over 100 soil samples collected to date from the school grounds. The analytical results for approximately one-quarter of these samples (26 arsenic, 21 lead) are summarized in the Health Department's 1987 biological monitoring report (NYSDOH, October 1987). The remaining sample results (78 arsenic, 78 lead) are included in the most recent report by Conestoga-Rovers & Associates (CRA) for FMC Corporation (CRA, April 1988). Considering the size of the site, we feel that the number of samples collected and the sampling pattern is sufficient to draw reasonable conclusions regarding the levels and extent of arsenic/lead occurrence in school ground soils. (It should be recognized, however, that additional sampling may be required if remedial measures are implemented, on the basis of pre-established cleanup levels, for portions of the site only.)

Data Quality - We have reviewed the field sampling protocols and laboratory analytical procedures described by CRA, and found them to be satisfactory and in general conformance with currently accepted Quality Assurance/Quality Control (QA/QC) standards. Even more important, in our opinion, is the overall consistency of results among the various laboratories analyzing the soil samples, the FMC duplicates and the NYSDOH split samples. It must be recognized that, even under natural conditions, a considerable variation in naturally-occurring metal concentrations can be expected among different soil samples. At the School property, where arsenic and lead levels are elevated, an even greater variation would be expected. Considering this, we feel that the results of different samplers and laboratories are in reasonably close agreement, and that collectively the quality of arsenic/lead soil data is good.

3.0 DATA INTERPRETATION

3.1 Arsenic and Lead Levels in School Ground Soils

In a previous study (NYSDOH, October 1987), the New York State Department of Health divided the School grounds into three areas (see Figure 1): Area 1 is behind the elementary school and extends to about 100 feet from the railroad tracks; Area 2 is behind the high school; and Area 3 is the strip of land behind the bleachers south of the football field. (A fourth area identified by NYSDOH, which includes the off-site ditches along the railroad tracks, is not addressed in this report.) Within these three areas, arsenic and lead concentrations were highest in Area 3, intermediate in Area 2, and lowest in Area 1. Although different subdivisions of the school grounds are possible, we find this one to be quite useful, in that it provides a reasonable basis for distinguishing between areas which exhibit a clear, albeit gradational, trend in arsenic and lead concentration values. As part of our study, we have updated the NYSDOH statistical analyses of arsenic and lead in these three areas (NYSDOH, October 1987) to include results of the most recent soil sampling by Conestoga-Rovers & Associates (CRA, April 1988). The results are summarized in Table 1.

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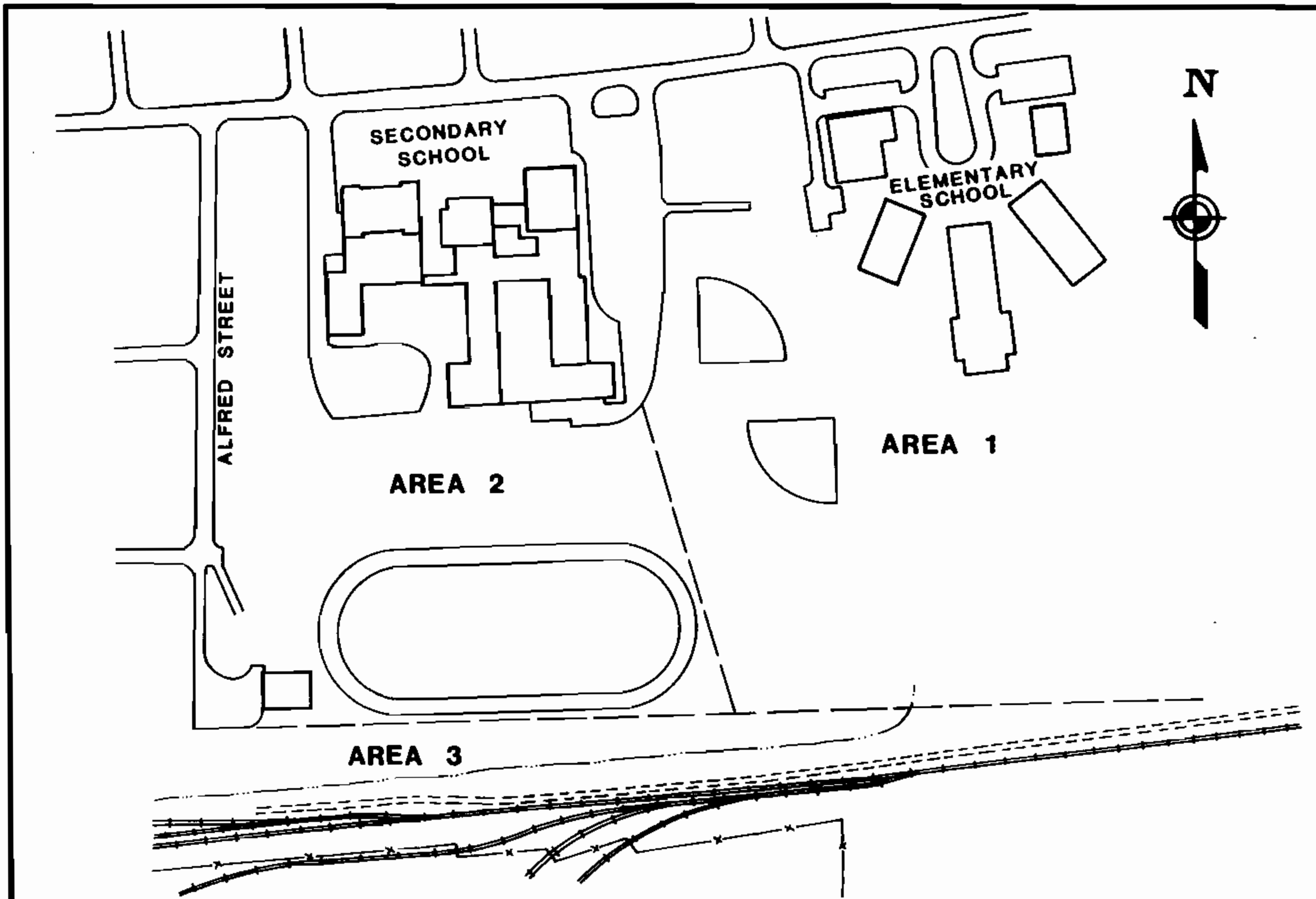

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MIDDLEPORT SCHOOL PROPERTY

FIGURE 1

TABLE 1

Arsenic and Lead Levels in School Ground Soils

Compound	Area	No. Samples	Minimum Concen. (ppm)	Maximum Concen. (ppm)	Average Concen. (ppm)
Arsenic	1	56	2.9	115	31
	2	36	5.9	228	41
	3	12	40	560	156
Lead	1	53	0.4	200	59
	2	34	5.9	340	84
	3	12	63	423	230

Notes: (1) ppm = parts per million.
(2) Average concentration = Arithmetic mean.
(3) Area locations shown on Fig. 1.

The trend in arsenic and lead concentrations (lowest in Area 1 to highest in Area 3) is evident from Table 1. Also apparent from this table is the large range in concentration values which, as previously mentioned, reflects a magnification of the natural variation in soil concentrations of these elements. It should be noted, for reasons discussed later, that concentrations of arsenic and lead have been averaged among all samples within each subarea, without regard to whether these samples were collected from grass or dirt areas. If such a distinction were to be made, the concentration of arsenic and lead in soil samples from areas presently in dirt would be markedly less than that in samples from presently grassed areas.

3.2 Concentration of Arsenic and Lead in Natural Soils

It is important to recognize that both arsenic and lead occur naturally in soils, and that some degree of human exposure to these elements via soil contact is virtually unavoidable. Potential exposure may be even greater in agricultural areas, due to past and/or present usage of farm products (e.g., insecticides, herbicides) containing these elements. In order to establish typical "background" values for arsenic and lead in soils, a number of sources were reviewed, and are summarized below.

- The United States Geological Survey has conducted an extensive soil sampling and analysis program to determine the natural concentrations of earth elements throughout the United States (Shacklette and Boerngen, 1984). In this study, reported average concentrations of arsenic and lead were 7.2 ppm and 19 ppm, respectively, for the conterminous United States; 7.4 ppm and 17 ppm, respectively, for the Eastern United States.

- URS has performed remedial investigations for six Superfund sites in New York State. As part of these investigations, off-site surficial soil samples have been collected and analyzed to establish background conditions. At no site has arsenic occurred at a background concentration higher than 10 ppm, nor lead at a concentration higher than 25 ppm. At an ongoing study for a site located in Niagara County, background concentrations of arsenic and lead measured by URS to date are 3.8 ppm and 23 ppm, respectively.

- As part of the National Soils Monitoring Program, pesticide residues in cropland and noncropland soil throughout the United States are regularly monitored and reported. (Wiersma et.al., 1972) reported that, for cropland soil samples analyzed across the United States, the average arsenic concentration was 6.43 ppm (range of 0.25 to 107.45 ppm). Within New York State alone, the average arsenic concentration reported was 9.38 ppm (range of 1.24 to 43.90 ppm). A similar study in a later year (Carey et.al., 1978) indicated an average nationwide concentration of arsenic in cropland soils equal to 5.92 ppm (0.09 ppm to 180.42 ppm range), and an average New York State arsenic concentration of 11.62 ppm (0.41 ppm to 180.42 ppm range).

3.3 Comparison of School Ground with Natural Soils

Based upon the foregoing discussion, we conclude that arsenic and lead concentrations in School ground soils are significantly elevated above levels which occur naturally in soils. Comparison of school values with nationwide averages for these elements in naturally-occurring soils (Shacklette and Boerngen, 1984) indicates that arsenic occurs at concentrations ranging from approximately 4 to 20 times its natural value, and lead at concentrations ranging from approximately 3 to 12 times its natural value. Because of substantial variations in the natural occurrence of these earth elements, and the absence of local background soil samples, the above ranges must be qualified as descriptive only. Even so, they clearly demonstrate the elevated concentrations of arsenic and lead in school ground soils.

Furthermore, the concentration of arsenic at the School property significantly exceeds its typical value in cropland soils, nationwide or in New York State, as indicated by data from the National Soils Monitoring Program. We do not have comparative data for arsenic in orchard soils alone, but understand that typical concentrations may be higher than in general cropland soils. However, from a risk characterization standpoint, we feel that "typical" arsenic concentrations in agricultural soils--whether general cropland or orchard--are largely irrelevant, since the exposure of school children to agricultural soils on a school ground is not at issue.

4.0 RISK CHARACTERIZATION

The human health risk posed by arsenic and lead in school ground soils has been calculated using procedures in the Superfund Public Health Evaluation Manual (USEPA, 1986). Both arsenic and lead are toxic and can cause a variety of acute and chronic health effects in humans. In addition, arsenic has been classified by the United States Environmental Protection Agency (USEPA) as a Group A human carcinogen (i.e., a chemical for which there exists sufficient evidence to support a cause-and-effect relationship between exposure and cancer). This evidence consists primarily of several studies linking arsenic with several forms of skin cancer. Although there is also evidence of an association between arsenic ingestion and an elevated risk of cancer of various internal organs, this association is not well understood at present (USEPA, 1987).

Two types of potential health effects are considered in this assessment: toxic (noncarcinogenic) and carcinogenic. Evaluation of each type of effect requires an identification of exposure pathways and an estimation of chemical intakes. In the following subsections, human intakes of arsenic and lead from school ground soils are estimated, noncarcinogenic and potential carcinogenic effects of these chemicals are calculated, and the meaning of these calculations is discussed from a human health risk perspective.

4.1 Human Intake

The exposure pathway of primary concern at the School property is soil ingestion. Exposure to contaminants via ingested soil can occur by inadvertent consumption of soil on hands or food items, mouthing of objects, swallowing of soil during recreational activities or consumption of non-food items (primarily of concern for younger children). Because of the site's location and usage, unrestrained and frequent access to soil contaminants is a reasonable assumption. In estimating a lifetime average daily intake (LADI) of soil from the school grounds, the following scenario was assumed:

> A child (age 5 to 18), with an average body weight of 38 kilograms (kg), would be exposed to the soil 5 days per week, 40 weeks per year, for 13 years; and an adult (age 18 to 70), with an average body weigh of 70 kg, would be exposed to the soil 1 day per week, 40 weeks per year, for 52 years. During each exposure, 100 milligrams (mg) of soil would be ingested and fully absorbed.

The lifetime average daily intake of soil from the school grounds is calculated to be 3.84 E-07 kg/kg/day. It is important to recognize, however, that the exposure assumptions on which this LADI value are based are quite conservative, i.e., tend to overestimate exposure. They involve much more individual contact with school ground soils than any particular individual is likely to incur. Furthermore, the human intake calculation assumes that individuals using the school grounds will be exposed to bare earth, which is not the condition (at least at the present time) over large grassed portions of the school property. Nevertheless, these assumptions are considered to be reasonable in the sense that they represent a potential (albeit unlikely) exposure scenario, and that they are consistent with general risk assessment methodology, which is inherently--and intentionally--conservative so as to avoid underestimation of human health risks.

4.2 Noncarcinogenic Health Effects

The potential for toxic (noncarcinogenic) effects was evaluated using a hazard index approach (USEPA, 1986), which involves an identification of projected intakes for arsenic and lead, a comparison of these intakes with acceptable chronic intakes, and a summation of projected versus acceptable intake ratios to yield a single hazard index value for the site. Chemical intake is equal to soil intake (LADI) multiplied by concentration of the chemical in soil, and has been calculated for the range of arsenic and lead concentrations found in Areas 1, 2 and 3 (Table 1). Acceptable chronic intakes (AIC's) for arsenic and lead were established as follows:

- For arsenic, there is no published AIC value (USEPA, 1984). A value was calculated by multiplying the current New York State groundwater standard for arsenic (0.025 mg/liter) times a typical human water consumption value (2 liters/day), and dividing the result by a typical adult human body weight (70 kg). The resulting AIC value for arsenic is 7.14 E-04 mg/kg/day.

- For lead, the published AIC value (USEPA, 1986) is 1.40 E-03 mg/kg/day (oral route).

Applying the hazard index approach to even the highest measured concentrations of arsenic and lead at the school property (560 ppm and 423 ppm, respectively) yields a combined hazard index (0.450) which is less than unity. It is concluded from this that arsenic and lead pose no long-term toxic health threat to persons using the school property.

4.3 Potential Carcinogenic Health Effects

The carcinogenic risk associated with arsenic in school ground soils has been calculated using current USEPA risk assessment guidelines (USEPA, 1986). This methodology involves use of a carcinogenic potency factor (CPF) which, for arsenic, has a value of 1.50 E+01 $(mg/kg/day)^{-1}$. Multiplying this CPF times the estimated intake of arsenic (lifetime average daily intake of soil X arsenic concentration in soil) yields an incremental lifetime cancer risk. For Area 1 (average arsenic concentration = 31 ppm), the calculated incremental lifetime cancer risk is 1.8 E-04; for Area 3 (average arsenic concentration = 156 ppm), the calculated incremental lifetime cancer risk is 9.0 E-04. (A risk of 1.0 E-04 indicates a probability of one additional case of cancer for every 10,000 people exposed.)

4.4 Discussion of Risks

Based upon the foregoing evaluation, we conclude that arsenic and lead pose no long-term toxic health treat at the School property, but that the incremental carcinogenic risk from lifetime exposure to arsenic (via human ingestion) is significant. In all three areas of the site (Figure 1), the calculated carcinogenic risk exceeds USEPA's "allowable risk range" for Superfund sites of 1.0E-04 to 1.0E-07 (USEPA, 1988). Although the calculated values of incremental carcinogenic risk are a matter of concern, they must also be qualified as follows:

(1) The USEPA risk model used to calculate carcinogenic risk is very conservative, and probably overestimates actual risk considerably. Inherent in the model are numerous assumptions (e.g., low-dose linearity) which contribute to this overall conservatism. Likewise, as previously discussed, the exposure assumptions used to calculate human intake are quite conservative. For these reasons, it is recommended that this risk assessment not be construed as presenting an absolute risk to human populations, but rather as a conservative analysis intended to indicate the potential for adverse impacts, and to serve as a benchmark for comparison with environmental risks at other sites where soil contamination is present.

(2) Arsenic occurs naturally in soils at concentrations which, using the USEPA model, produce measurable carcinogenic risks. For example, under the exposure scenario utilized in this report and with a "natural" soil arsenic concentration of 7.5 ppm, the model would indicate an incremental carcinogenic risk of 4.3 E-05. This "background" risk associated

with naturally-occurring arsenic in soils, as well as in some human food items, must be accounted for in any risk management decision regarding the impact of arsenic in school ground soils.

(3) Recent studies by USEPA suggest that estimates of risk resulting from ingestion of inorganic arsenic may, in the future, be revised downward to reflect a number of factors, including the fact that only a small fraction of arsenic-induced skin cancers are fatal (USEPA, 1987).

Despite the above qualifications, we feel that the elevated levels of arsenic and lead in school ground soils pose an increased potential health risk for persons using the property, and that remedial action is warranted to mitigate this risk. Notwithstanding current scientific debate regarding its health effects, arsenic is an acknowledged human carcinogen. Furthermore, whatever level of exposure school users might have to this elements via natural soils or diet, that level is undoubtedly increased by the significantly elevated concentrations of arsenic in school ground soils. Finally, although absolute levels of risk are difficult to quantify, we feel, based upon our firm's experience at other sites, that the levels of arsenic in soil at the Roy-Hart school are high enough to require remedial action, by current environmental regulatory standards, at even remote or relatively unused sites. In our opinion, the fact that this contamination occurs at a school property increases the need for a cautious approach and the justification for remedial action.

While we recommend that remedial action be taken to reduce human exposure to soil contaminants, we do not feel that the present situation poses an emergency condition or that usage of the school grounds must be curtailed pending remediation. The incremental carcinogenic risk for arsenic which was calculated previously, and forms the basis for our recommendation, results from a lifetime exposure to soil contaminants. Over any short period of time (e.g., the upcoming fall/winter season), even the highly conservative degree of human exposure assumed in our evaluation would produce only minimal incremental health risk. Therefore, we would recommend that remedial action be taken in a considered manner, at the earliest practical time (e.g., during the next construction season), but that until then no action be taken to limit usage of the school grounds, except for maintenance of the temporary fence which is now being used to prevent access to the area behind the bleachers (Area 3).

5.0 POTENTIAL REMEDIAL MEASURES

The calculated health risk presented in the previous section results entirely from direct human contact (via ingestion) with arsenic-contaminated surficial soil at the School property. Two alternate methods for addressing--and essentially eliminating-- this risk are:

- Alternative A - Excavate and replace surficial soil: It is assumed, for purposes of costing this alternative, that contaminated soil would be excavated to a depth of 12 inches, trucked to and disposed of at the FMC plant adjacent to the school, and replaced with 12 inches of clean topsoil. Existing facilities (e.g., track, bleachers) would have to be removed and replaced in areas where they were disturbed by excavation. The school grounds would have to be immediately re-landscaped.

- Alternative B - Place clean soil cap over existing soil surface: For this alternative, it is assumed that a 12-inch cap of clean topsoil would be placed over the existing soil at the school grounds. As with Alternative A, replacement of existing facilities and re-landscaping would be required in all disturbed areas.

The cost of each alternative is dependent upon the area over which it is applied. Table 2 provides preliminary, budget-level cost estimates for these alternatives by site area (Figure 1). Determination of how large an area must be remediated requires the establishment of an "acceptable" risk value, or (alternately stated) an "acceptable" level of arsenic and lead in school grounds. In all three areas of the site, the soil concentrations of these elements are elevated (Table 1), producing risks in excess of those which would result from exposure to naturally occurring arsenic and lead in soil. Although it is beyond the scope of this report to establish acceptable risk values, we would suggest that concentrations of arsenic and lead above those occurring in natural soils be tolerated only if it can be proven that such concentrations do not pose an unacceptable incremental risk. Applying this standard would probably require remediation of all three site areas or, with further sampling/analysis, at least portions of all three areas.

Because both potentially applicable remedial alternatives require earthwork and immediate re-landscaping at the completion of earthwork activities, we do not feel that either should be commenced prior to the next full construction season

TABLE 2

Preliminary Cost Estimate for Potential Remedial Alternatives

	Implemented in Area	Estimated Cost
Alt. A - Excavate and Replace	1	$ 800,000
	2	530,000
	3	200,000
	1, 2 & 3	1,530,000
Alt. B - Cover	1	$ 600,000
	2	420,000
	3	80,000
	1, 2 & 3	1,100,000

Notes: (1) Cost estimates are budget-level only.

(2) Costs include full construction, but not engineering, legal or administrative expenses.

(i.e., spring/summer). Since the site does not, in our opinion, pose an emergency or short-term health risk, this timing constraint should not effect present school ground usage.

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