

REVISED FINAL REPORT ENDANGERMENT ASSESSMENT NORTH SEA LANDFILL SOUTHAMPTON, NEW YORK

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CDM Federal Programs Corporation

REVISED FINAL REPORT ENDANGERMENT ASSESSMENT NORTH SEA LANDFILL SOUTHAMPTON, NEW YORK 444 44

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Prepared for

U S ENVIRONMENTAL PROTECTION AGENCY Office of Waste Programs Enforcement (Washington, D C 20460

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2 TES5-C02047-FR-BGYL CDM Federal Programs Corporation Robert Goltz (212) 393-9634 Caroline Kwan 3 (212) 264-0151 October 4, 1989 SEA 004 1661

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CDM Federal Programs Corporation

October 4, 1989

Cathy Moyik Regional Project Officer U S Environmental Protection Agency 26 Federal Plaza New York, New York 10278

PROJECT TES V, EPA CONTRACT NO 68-V9-0002

DOCUMENT NO TES5-CO2O47-EP-BGYM

SUBJECT Revised Final Report for EPA Work Assignment CO2047 Endangerment Assessment North Sea Landfill Southampton, New York Document Control No TES5-CO2047-FR-BGYL

Dear Ms Moyik

Please find enclosed the Revised Final Report entitled, "Endangerment Assessment, North Sea Landfill, Southampton, New York", as partial fulfillment of the reporting requirements for this work assignment

If you have any comments regarding this submittal, please contact Pamela Hillis of Versar, Inc at (703) 750-3000 within two weeks from the date of this letter

Sincerely,

CDM Federal Programs Corporation

Robert D Goltz, P E ' TES V Regional Manager

PJP/md

Enclosure

cc Caroline Kwan, EPA Primary Contact, CERCLA Region II Jack Jojokian, EPA Regional Project Officer, EPA, HQ Glenn Hardcastle, EPA HQ Coordinator, CERCLA Region II J Steven Paquette, CDM Federal Programs Corporation, Deputy Program Manager (letter and cover only) Michael P Riley, EPA Contracting Officer (letter only) Pamela Hillis, Versar, Inc (letter only) Document Control, CDM Federal Programs Corporation (2 copies)



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DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service Agency for Toxic Substances and Disease Registry

Memorandum

Date July 5, 1989

From William Nelson

Subject ATSDR's Review of North Sea Municipal Landfill Endangerment Assessment, Southampton, New York

Te Caroline Kwan EPA, Region II

> ATSDR has reviewed the final report of the Endangerment Assessment for the North Sea Landfill. We generally find the report satisfactory, however, I would call to your attention the draft Preliminary Health Assessment for this site dated November 1988. In the Preliminary Assessment ATSDR indicated that a potential human exposure pathway was the inhalation of contaminated air. The Endangerment Assessment was not able to provide information on an exposure evaluation for air due to inadequate data

This potential pathway of exposure should be included in future health evaluations for the site.

Thank you for requesting ATSDR's assistance in the review of this document. If you have any questions please feel free to contact me at Ex. 7662.

cc: George Buynoski, ATSDR/FOB Carol Peterson, EPA Vince Pitruzzello, EPA

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION II

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DATE

TO

SUBJECT North Sea Municipal Landfill Endangerment Assessment: Air Programs Branch Review

FROM Grace Musumeci, Air-Superfund Coordinator from Manual Air Programs Branch, AWM

Caroline Kwan, Project Manager New York/Caribbean Compliance Franch, ERRD

Raymond Werner, Chief A AMM-AP

The Air Programs Branch has reviewed the Endangerment Assessment document for the North Sea Municipal Landfill located in Suffolk County, New York.

Site Background.

The North Sea Landfill is an active municipal landfill, owned and operated by the Town of South Hampton. The landfill was initially constructed in 1963 for the disposal of municipal solid wastes, refuse, debris and septic system wastes Significant features of the site include landfill Cell 1 (inactive, capped, unlined); excavated/filled scavenger lagoons, landfill Cell 2 (soon to be capped and closed); and proposed Cell 3 (soon to be constructed). The scavenger lagoons, which were constructed at the southern portion of the landfill property, served as sludge and leaching pools. The pools accepted septic system wastes from both commercial and residential sources Cell 1 which was filled to capacity and closed in 1985, also receive septic system sludge in the early 1960's in addition to municipal solid wastes

Groundwater studies conducted by Suffolk County Department of Health Services and H2M indicated the presence of elevated levels of iron and manganese in a contaminated plume flowing to the northwest from the landfill area. The RI report confirmed the presence of the leachate plume which consists primarily of ammonia, iron and total organic carbon. The report also identified contaminated soils, sediments, and surface water.

The Endangerment Assessment Report indicated that levels of volatiles and semi-volatiles in the groundwater, soils, sediments, and surface water were minimal and therefore were no included in the actual assessment. Of the inorganics and metal the following were selected to be evaluated: ammonia, arsenic, cadmium, chromium, iron, lead, manganese, nickel. The air pathway was not considered because an air survey during the RI did not identify any volatile organics.

Comments.

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We do not find the endangerment assessment complete because it did not address the potential health impacts associated with particulates that may enter the air. Given that a portion of the site is still active, particulates may be a problem The Superfund Exposure Assessment Manual contains equations for atmospheric contamination in section 2.3. Such equations can be used to predict potential emission rates to the air Equations in Section 3 3, which identify means of analyzing atmospheric fate, should then be used to calculate concentrations from the emission rates. The predicted concentrations can then be used for the risk assessment and comparison to the National Ambient Air Quality Standards for particulate matter (PM_{10}) .

If you have any questions regarding this review, please contact me at extension 9868.



North Sea Landfill Draft Endangerment Assessment

John S. Malleck, Chief Office of Ground Water Management

Carole Peterson, Chief New York/Caribbean Compliance Branch

As requested and in accordance with the Memorandum of Interdivisional Coordination between the Emergency and Remedial Response Division and Water Managament Division (WMD), WMD has reviewed the Draft Endangerment Assessment for North Sea Landfill from the water programs perspective. We offer the following comments:

- WMD recommends that 1,1-dichloroethene be included as an indicator chemical in the endangerment assessment. This contaminant was detected in ground water at concentrations above applicable or relevant and appropriate requirements, as well as in 11 of 12 lagoon sludge boring samples. The endangerment assessment attempts to justify exclusion of 1,1-dichloroethene by stating that all but three of the detections were accompanied by blank contamination. However, considering that there were three unequivocal detections in the lagoon borings, as well as in ground water, there appears to be sufficient justification for including 1,1-dichloroethene as an indicator chemical.
- o Table 2 presents a statistical summary of the sampling data The summary includes the humber of detections of a contaminant in each module, the number of samples analyzed, the minimum and maximum detected concentrations, and arithmetic means. However, for many contaminants which have only one reported detection the table reports different minimum and maximum values, as well as arithmetic means. WMD recommends a close examination of Table 2 to determine the cause of these discrepancies.
- On page 12 the report compares site specific concentrations of metals in soil to values contained in Table 3, Trace Metal Content of Soils. Table 3 presents typical concentrations of metals in soils in terms a "common range" and an "average". The comparison on page 12 does not clearly specify to which values the site specific metal concentrations are being compared. WMD recommends clarifying this discussion.
- o The supplemental ground water sampling results and the findings of the Fish Cove study are forthcoming. It is important to incorporate the results of these activities in

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the Endangerment Assessment to ensure that the conclusions are based on the most surrent information.

o The following corrections should be made to Table 26, Comparison of Estimated Contaminant Concentrations in Fish Cove to Marine Organism Toxicity Criteria (ug/l):

| Contaminant | Marine Acute | Marine Chronic |
|---------------|--------------|----------------|
| Ammonia | \$ | * |
| Arsenic | 69 | 36 |
| Cadmium | 43 | 9.3 |
| Chromíum (VI) | 1100 | 50 |
| Iron | NA | NA |
| Lead | 140 | 5.6 |
| Manganese | NA | NA |
| Nickel | 75 | 6.3 |

 Value is a function of temperature, salinity and pH.
 See attached tables from criteria document (EPA 440/5-88-004, April 1989).

NA No marine organiam toxicity criteria available.

If you have any questions, please call me or Drew Baris of my staff at extension 5635.

cc: G. Pavlou

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- C. Kwan
- R. Hargrove

PC.C:c:\drew\northsea:AB.ebJuly 20, 1989



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY WASHINGTON, D.C. 20460

OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE

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MEMORANDUM.

SUBJECT: Comment on "Final Report Endangerment Assessment" for the North Sea Landfill Site, NY June 29, 1989.

PROM:

Glenn Hardcastle, Environmental Engineer OWPE

TO:

Caroline Kwan, Regional Project Manager ERRD, Region II.

Based on a quick look at the subject document, I have identified one potentially significant problem with the endangerment assessment performed at the site.

In the exposure assessment, the sole receptor point for groundwater is determined to be Fish Cove; humans are not considered receptors for contaminated drinking water due to the fact that the local population is exclusively on public supplied water (page 42). While this appears appropriate to calculate current exposures and risks, this does not appear sufficient to determine the risks associated with the reasonable worst case situation, i.e. that groundwater will be used in the future as a source of drinking mater (Which is the usual Agency assumption where the groundwater has the potential for use as drinking In situations where an aquifer has the potential for use water). as drinking water, MCLs are generally the relevant and appropriate ARAR (with clean-up to more stringent levels a possible necessity if multiple contaminants are present) unless a statutory waiver is exercised. Refer to page 51433 of the Proposed NCP for the Agency's approach for ground-water remediation under Superfund.

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I therefore recommend that exposure thru drinking water be included in the endangerment assessment as a potential route of exposure Also, the endangerment assessment should evaluate the potential for the contaminated groundwater to contaminate the public water supply if groundwater is the source of the public supply.

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cc: Georgia Valaoras Jennifer Haley Mel Hauptman

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1 0 INTRODUCTION

CDM Federal Programs Corporation (FPC) received a work assignment (Contract No 68-01-7331, WA No CO2030) from the U S Environmental Protection Agency (EPA) Region II to conduct an endangerment assessment for the North Sea Landfill site Versar, Inc , under subcontract with CDM FPC prepared this endangerment assessment

1 1 Site Description and History

The North Sea Landfill is an active 131 acre site that has been owned and operated by the Town of Southampton, New York since its construction in 1963 (NYS Permit No 10-83-1374) The site is located north of Southampton and east of the town of North Sea in Suffolk County New York (Figure 1) It is bounded on the North by Old Fish Cove Road and on the West by Major's Path (Figure 2)

Initially, the landfill was used for disposal of refuse, debris, municipal solid wastes, and septic system wastes from residential commercial and industrial sources The site consists of an active waste cell, an inactive cell, and 12 inactive lagoons which have been filled and capped (Figure 2) The inactive cell 1 contains municipal solid wastes as well as septic system sludges that were deposited in the early 1960s The total volume of cell 1 is estimated at 1 3 million cubic yards After reaching capacity in 1985 cell 1 was capped with a 20 milli inch (mil) polyvinylchloride (PVC) membrane and approximately 2 feet of sand The active cell 2 is double-lined and covers about 7 acres

Twelve lagoons (each approximately 50 feet long and 10 feet deep) are located at the southern end of the site The lagoons were constructed in the late 1960s and served as drying beds for septic wastes which were moved to Cell #1 The lagoons are no longer in use and have been filled

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The Suffolk County Department of Health Services (SCDHS) and the Town of Southampton have conducted several studies to characterize the waste in the sludge lagoons and the ground-water quality in the vicinity

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of the North Sea Landfill site In one report it was concluded that based on the analytical results for ground water samples, a leachate plume is migrating from the site toward the Northwest

In 1979, about a dozen private wells located hydrologically downgradient of the landfill were closed by SCDHS In February of 1987 the EPA presented an administrative order on consent to the Town of Southampton The North Sea Landfill site is on the National Priority List (NPL) and the Town of Southampton is the potentially responsible party (PRP) under Section 107 a(1) and (2) of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) The consent order was pursuant to the Superfund Amendments Reauthorization Act (SARA) of 1986 Section 106 A Consent Order was signed by EPA and the Town of Southampton on March 31, 1987 requiring an onsite and offsite remedial investigation (RI) under the supervision of EPA, Region II The Town of Southampton contracted Holzmacher, McLendon & Murrell (H2M) to perform the RI The RI document was completed in April of 1988

1 2 Contaminants Found Onsite

H2M supplied Versar, Inc with the Preliminary Draft Remedial Investigation Report (H2M, April 1988) The report included sample results from the landfill site and nearby Fish Cove During the fall (August-December) of 1987, samples were collected from ground water (rounds 1 and 2) surface water, stream sediment, surficial soil and soil borings (from monitoring well borings and sludge lagoon area borings) Sampling and monitoring well locations are depicted in Figure 3 In addition, Versar, Inc, received sample splits from approximately 53 percent of "the samples collected by H2M

During October (round 1), ground-water samples were collected from the eleven newly installed stainless steel monitoring wells (MW1-A, B, C, MW2, MW3-A, B, C, MW4-A, B, C, MW6-A) located on the landfill site and at Fish Cove from the existing PVC monitoring wells (MW-10, MW-29, MW-30, MW9, UG), the landfill supply well, and from residential wells (104 Fish Cove and 152 Fish Cove) During December (round 2), ground-water samples

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FIGURE 3 NORTH SEA RI STUDY AREA AND SAMPLING LOCATIONS



were collected from the eleven stainless steel wells H2M's samples from the stainless steel wells were analyzed for priority pollutant (PP) volatile organics, PP semivolatile organics PP pesticides/PCBs, PP metals, cyanide, phenols, leachate indicator parameters (i e , ammonia, nitrate, nitrite, iron, manganese), pH, and temperature H2M's samples from PVC wells, the landfill supply well, and the residential wells were analyzed for PP metals, cyanide, phenols, and leachate indicator parameters Versar's samples were analyzed for Target Compound List (TCL) organics and Target Analyte list (TAL), inorganics rather than PP constituents

Surface water samples were collected from six locations on Fish Cove, three were shoreline locations, and the other three were 50 feet from the shoreline stations' thus representing deeper water H2M's samples were analyzed for PP metals and leachate indicator parameters Versar's samples were analyzed for TAL metals and leachate indicator parameters

Surface soil samples were taken from 20 different locations on the landfill site H2M's samples were analyzed for PP semivolatile organics PP metals, and EP Toxicity metals Versar's samples were analyzed for TCL semivolatile organics and TAL metals

Unsaturated soil samples were collected from four borings in the sludge lagoon area The samples were created by compositing split spoon samples that were taken every 5 feet of depth into three zones for each boring The zones were shallow (0-25'), medium (30-50'), and deep (55-75') H2M's samples were analyzed for PP volatile organics, PP semivolatile organics PP PCBs/pesticides, PP metals, phenols, and EP Towicity metals Versar's samples were analyzed for the TCL organics and TAL inorganics rather than PP constituents

Saturated soil samples were collected from borings during drilling of boreholes for stainless steel monitoring wells They were collected from the area at the midpoint of where the well screen would be placed Analyses of H2M's saturated soil samples included PP semivolatile SEA

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organics, PP metals, and EP Toxicity metals Versar's analyses included TCL volatile organics TCL semivolatile organics, and TAL metals

Sediment samples were collected from soil exposed at low tide in Fish Cove at locations coinciding with shallow surface water sampling points H2M's sediment samples were analyzed for PP semivolatile organics PP metals, and EP, Toxicity metals Versar's samples were analyzed for TCL semivolatile organics and TAL metals

All samples collected were analyzed using the following instrumentation gas chromatography/mass spectroscopy (GC/MS) for volatiles, gas chromatography/electron capture (GC/EC) for PCBs, and atomic absorption (AA) and inductively coupled argon plasma (ICP) for metals A list of the compounds or elements detectible by these analytical methods is presented as Table 1 1 Versar's samples were validated according to the U S EPA Functional Guidelines H2M's samples had not undergone data validation

The data was compiled and evaluated to determine the types or classes of contaminants that were identifiable as well as concentrations characterizing the site Table 1 2 presents a summary of constituents detected at the North Sea Landfill site and at Fish Cove (see Section 1 4 Data Handling)

The sample results presented in Table 1 2 have been statistically summarized in order to estimate the distribution frequency of the positively detected constituents identified from the soil and water samples collected from the North Sea Landfill site and nearby Fish Cove Summary statistics presented in Table 1 2 include, for each chemical, the minimum and maximum concentrations, the arithmetic mean, and the number of positive detections along with the number of samples analyzed This information was used as part of the indicator chemical selection process and, therefore, it also appears in Appendix 1 Both methylene chloride and bis(2-ethylhexyl)phthalate were detected often in various media However, the corresponding detection of these compounds in blank samples suggests that their presence was an artifact of sampling, handling, or laboratory procedures, and therefore, not representative of potential contaminants found at or nearby the site

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Phenol

CHEMICALS ANALYZED FOR AT NORTHSEA LANDFILL SITE

TENTATIVELY IDENTIFIED BHAS

VOLATILE ORGANIC COMPOUNDS

Chloronethane Brononethane Vinul Chloride Chloroethane Nethylene Chlorlde Acetone Carbon Disulfide 1, 1-Dichioroethene 1 1-Dichloroethane Trans-1,2-Dichloroethene Chloroforn 1,2-Dichloroethane 2-Butanone 1, 1, 1-Trichloroethane Carbon Tetrachloride Vinul Acetate Bronodichioronethane 1, 1, 2, 2-Tetrachloroethane 1, 2-Di chloropropane Frans-1, 3-Dichloropresene Frichloroethane Dibrowochloronethene 1, 1, 2-Trichloroethane Banzone cls-1, 3-Dichloropropeno 2-Chloroothylvinyl Ether Bronoform 2-Howanone 4-Hothy1-2-Ponteneno Tetrachloroothene Toluene Chierobenzono Ethyl bonzono Sturene Vetal Mulence

PENTATEVELY IDENTIFIED VOCO 60

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1, 1, 2-Trichlorotrifluoro Ethano Hensome Orenachil orena chano

bis (2-Chioroethy1) Ether 2-Chiorophenol 1,3-Dichiorobenzene 1.4-Dichlorobenzene Benzyl Alcohol 1.2-Dichlorobenzene 2-Methylphenol bis (2-Chloroisopropul) Ether 4-Methulphenol N-Nitroso-Di-n-Propulanine Henachlor oe thane Nitrobenzene I sophorone 2-Ni trophenol 2,4-Dimethylphonel Denzoic Acid bis (2-chioroethowy) Methane 2.4-Dichlorophenol 1,2,4-Trichlorobenzene Haphthalene 4-Chioroaniline Henachlorobutadiene 4-Chloro-J-Hethylphemol 2-Nethylphemol Henachi or ocycl opentadione 2,4,6-Trichlorophenol 2,4,5-Trichlorophenol 2-Chloronsphthalone 2-Ni troaniline Binethyl Phthalate Aconsphthylene 9-Nitrosniline Reenaphthene 2,4-Dinitrophenel 4-NI trophonol Dibenzofuran 2,4-Dinitrotoluono 2,6-Dinitrotoluone Dictbyl Phthelate 4-Chlorophonul Phoned Ethor Fluorene 4-Ni tronni i ino 4,6-Dinitro-2-Nothuishonel N-N1 trosodi phonyl ani no 4-Bronophenyl Phenyl Ether Henach1orobenzene Pentach1orophenol Phonenthrono Anthracene D1-N-Butyl Phthelate Fluoranthene Purene Butyl Bonzyl Phthalate 3.3'-Dichlorobenzidins Benze (A)Anthracene bis (2-Ethulhewul) Phthalate Chrusenø D1-N-Octyl Phthelate Benzo (b)Flueranthens Benzo (k) Fluor anthene Benzo (a>Pyrene Indeno (1,2,3-cd) Pyrene Dibenzo(a,h)Anthracone Benzo<g,h,1>Perylene

SEMIVOLATILE ORGANIC COMPOUNDS 4-Hudronu-4-Hethyl-2-Pentanone Acetuldithio Carbonic Acid 3 2-Bepuridine 2-Plnene 3-Hethyl Octane Benzothieno Benzothiophene Hexanedioic Acid, Dioctyl Ester 5-Hethyl-3-Hexyn-2-ol 1-Propananine 4-Hydrony-4-Nethyl-2-Pentanone 2-Nethyl-2-Propanol Molecular Sulfur 3 3°-DHybig-1-Propene Trans-4-Chlorocyclohewanol 2-(2-Butonyethony)-Ethanol 6-Amino-Henanoic Acid 2,6-Diwethul-Heptadecane 2,7,10-Trinethyl-Dodecane 2,6,10,15-Tetranethyl-Heptadecane 2.6.10-Trinethul-Dodecono Nonanole Beld N-Nethyl-N-<1-Onededecyl>-81 yel ne 7,7-Dichloro-Bicycloheptane (1,1 -Biphenyl)-2,2°-Diol 2-Nethyl-2-Ethyl-2-Propensie Acid bis <- Hothyl>-1,2-Bonzenodicarbonylic Acid Dihoptyl-ES-1,2-Bonzenodicarbonylic Acid Diisonomyl-1,2-Bonzenodicarbonylic Acid 9-Nitro-1,2-Bonzenodicarbonylic Acid Caprolactan

PESTICIDES

Mlpha-BHC Deta-BHC Dol ta-BHC Banna-BHC (Lindano) Heptachlor Aldrin Heptechler Epondde Endosul fan 8 Dieldrin 4,4°-DDE Endrin Endogulfan II 4,41-000 Endrin Aldehyde Endosulfan Sulfate 4,4'-001 Rethonychler Endrin Ketone Ch1 ordane Tomaphene

POLYCHLORINATED BIPHENVLS (PC8s)

Aroclor-1016 Aroc1 or-1221 Aroclor-1232 froc1 or-1242 Aroc1 or~ 1248 Arocibr-1254 Aroclor-1260

INDROAMIC HETALS AND CYANIDE

ALUNINUM Anti Honu Arsente Bard un Beryllium Cadnil um Calcium Chront un Cobalt Copper Iron Lead Hagneslun Hanganese Norcury Nickel Potassium Selenium Silver Sodium Thall Lum Tin. Vanadi usi Zinc Cuani do

EP-TOXICITY HETELS

SP-TOX Sreense EP-TOX Barlum EP-TOX Cochium EP-TON Chronium EP-TOX Land EP-TOX Hercury EP-TOX Selentum EP-TON Silver

1

HISCELLANEOUS INDRAMIC COMPOUNDS

Phonols (ug/L in aquocus samples> Romoni a Mitrites Mitrates 11 troto-11 trates Chlorides Total Discolved Solide Total Organic Carbon

SEA 089T 700

| TABLE 2 | CONSTITUENTS | DETECTED AT | NORTH S | EA LANDFILL | SITE |
|---------|--------------|-------------|---------|-------------|------|

•

| | GROUN | DHATER (NOU | ID 1), PPH | Ø HTTS | GROUN | IDMATER (ROUNE | 2) 29 | # H175 | \$ | URFACE WATER, | PPN | Ø MITS | | SUBSOIL, P | M | ø Hit |
|--|-----------------|---------------|-----------------|-----------------|---------|-----------------|-----------------|----------------|------------------|------------------|-----------|---|------------------|---------------|---------|--------------|
| CONSTITUENT | MININE | M NAXIMUN | MENI | I MALYSES | MINIM | m Maximum | NENI (| MALYSES | NINIMIN | MAX (M.M | HEAN | / AMALYSES | S HINIMU | NAXIMUN | PEAN | I ANALY |
| VOLATILE ORGANICS | | | | | | | | | | | | | | | | |
| ACETURE | 0.000 | 0 000 | 0 000 | 0/0 | 0 005 | 0 000 | 0 000 | 2/9 | 0.000 | 0 000 | 000 | 0/0 | 0 000 | 0 000 | 9 000 | 0/0 |
| 2 BUTANONE (MEK) | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | õ/õ | 0 000 | 0 000 | 0 000 | 0/0 | 0 009 | 0 030 | 0 008 | 1/3 |
| 1 1 DICHLOROETHANE | 0 002 | 0 005 | 0 002 | 2 /12 | 0 003 | 0 005 | 0 003 | 1/11 | 0 000 | 0 000 | 0 000 | 0/0 | 8 000 | 0 000 | 0 000 | ōįŏ |
| 1,1-DICHLOROETHERE | 0 005 | 0 016 | 0 003 | 2 /12 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 |
| | 0 005 | 0 005 | 0 003 | 2 /12 | 0 005 | 0 005 | 6 002 | | 0 000 | 0 000 | 0,000 | 0/0 | 0,000 | 0 000 | 0 000 | 0/0 |
| 1 2-DICHLOROETHANE | 0 001 | 0 005 | 0 002 | 2 /12 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 |
| ETHYLBENZENE | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 |
| NETHYLENE CHUCKIDE | 0 000 | 0 000 | 0 000 | 0/0 | 0 002 | 0 015 | 0 005 | 6 /11 1 /11 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 8 000 | 0 000 | 0/0 |
| TOLUENE | 0 001 | 0 006 | 0 002 | ê /iž | 0 002 | 0 005 | 0 002 | š /ii | 0 000 | 0 000 | 0 000 | 0/0 | 8 000 | 0 000 | 0 000 | ů í ě |
| 1 1 1 TRICHLOROETHANE | 0 000 | 0 000 | 0 000 | 0/0 | 0 005 | 0 009 | 0 003 | 1/11 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 9 000 | 0 000 | 0/0 |
| TRICHLORDETHERE | 0 001 | G 007 | 0 002 | 1 /12 | 0 004 | 9 005 | 0 003 | | 0 000 | 9 000 | 0 000 | 0/0 | 0 000 | 000 | 0 000 | 0/0 |
| SENIVOLATILE OREMNICS | 3 000 | 0.000 | 9 000 | | • ••• | | 0 000 | • / • | 0 000 | 0.000 | 6 000 | 9/0 | | 0 000 | 0.000 | w / U |
| BEHZD(B)FLUORANTHENE | 000 0 | 0 000 | 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 600 | 0/0 | 0 000 | 0 000 | 8 000 | 0/0 |
| BERZO(K)FLUORANTHERE | 0 000 | 0 000 | 0 000 | 0/0 | 9 000 | 0 000 | 0000 * 8 000 | 010 | 0 000 | 0000 | 0000 | | 0 000 | 0 000 | 0 000 | 0/0 |
| RENTO A LANTHRACENE | 0 000 | 0 000 | 0 000 | 0/0 | 8 000 | 0 000 | 0 000 | 8/0 | 8 000 | 6 000 | 8 000 | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ | 8 000 | 8 000 | 8 000 | 0/0 |
| BENZO-O-PYRENE | 0 000 | 0 000 | 0 000 | ē/ē | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 010 | 0 000 | 0 000 | 0 000 | ĕ/ŏ |
| BIS(2 ETHYLHEATL)FATTERLATE | 0 010 | 0 240 | 0 056 | 81 /82 | 0 010 | 0 380 | 0 071 | 01 / 11 | 0 000 | 0 000 | 0 000 | 0/0 | 0 044 | 0 700 | 1 336 | 6/7 |
| | 0 000 | 0000 a 000 | 9 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 a/n | 0 000 8 000 | 0 000 | 0 000 | 0/0 | (9 UUU) A AAA | 0 000 | 0 000 | 0/0 |
| INDENOPYREME | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | ŏ/ŏ | 0 000 | 0 000 | 0 000 | õ/õ | 0 000 | 0 000 | 0 000 | 0/0 |
| PHENANTHRENE | 0 009 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 009 | 0 000 | 0 000 | ŏ/ŏ |
| PYRENE OTTING BUTHER OTE | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 8 000 | 0 000 | 0/0 | 0 CCO 0 mag | 0 000 | 0 000 | 0/0 |
| PENTACH OROPHENOL | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 9 000 | 0 000 | 0/0 | 8 000 | 0 000 | 0 000 | 0/0 | 0 260 | 6 000 | A 220 | |
| DIBUTYL PHTHALATE | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 009 | 0/0 | 0 060 | 1 200 | 0 214 | 9 /11 |
| 4 6-01WITRO-2-RETERE | 8 000 | 0000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 9/9 | 0 000 | 0 000 | 0 000 | 0/0 | 6 755 | 8 000 | 0 189 | 8 / 18 |
| BUTYL BENZYL PHTNALATE | 0 005 | 0 024 | 0 006 | 7 /12 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | ĕ/ŏ | 8 000 | 0 000 | 0 000 | 0/0 |
| DI R-OCTYL PHTHALATE | 9 002 | 0 160 | 0 011 | 3 /12 | 0 000 | 0 000 | 9 000 | 0/0 | 0 000 | 0 000 | 0 009 | 0/0 | 0 000 | 0 000 | 0 000 | Ŏ/Ŏ |
| A HIT IN MALE AND A HIT IN MAL | 869 8 | 81 608 | 7 818 | 94 /98 | a 892 | 8 4 70 8 | 8 677 | 9/9 | 0 021 | 8 141 | 6 118 | 4/8 | 968 68 | 9690 66 | 1689 00 | e / a |
| ANTIHONY | 0 000 | 0 000 | 9 000 | 0/0 | 0 000 | 0 000 | 0 000 | õ/õ | 0 000 | 0 000 | 0 000 | õ/õ | 7 00 | 14 90 | 4 29 | ĩ /nĩ |
| ARSENIC | 0 002 | 0 100 | 0 010 | 0 /19 | 0 002 | 0 100 | 0 009 | 6 /11 | 0 000 | 0 000 | 0 000 | 0/0 | 0 80 | 4 50 | 0 97 | 4 /II |
| BARLUN Dervst 1989 | 0 000 | 0 005 | U 140 | ¥ /13 1 /16 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 000 | 0/0 | 8 40 | 84 00 | 31 83 | 3/7 |
| CADMIUM | 0 005 | 0 040 | 0 009 | 15 /19 | 0 005 | 0 020 | 0 005 | 5 /n | 0 003 | 0 010 | 0 004 | Š /1Ž | 0 50 | 1 40 | 0 58 | š /n |
| CALCIUM | 1 750 | 42 000 | 11 010 | 12 /15 | 3 450 | 48 100 | 15 611 | 9/9 | 196 000 | 252 000 | 235 800 | 4/4 | 187 00 | 1670 00 | 475 00 | 4/4 |
| CHRORIUM CORAL I | 8 908 | 0 550 | 0 006 | 36 /19 | 0 001 | 8 720 | 0 319 | | 0,009 | 0 034 | 0 005 | 1/12 | 1 20 | / 00 | 3 45 | 11/11 |
| COPPER | 0 012 | 0 280 | 0 093 | 37 /19 | 0 007 | 0 800 | 0 174 | 10 /11 | 0 007 | 0 030 | 0 013 | ī /1ž | 2 80 | 1i 🖗 | 4 39 | i /11 |
| IRON | - 0 083 | SZ 800 | 16 123 | 19 /19 | 1 350 | 36 700 | 20 612 | n yn | 0 193 | 1 100 | 0 445 | 12 /12 | 1400 00 | 5880 00 | 3932 00 | 4/5 |
| LEAD MACHER THR | 0 004 | 0 185 | 0 035 | 16 /19 | 0 005 | 0 254 | 0 059 | | 0 004 747 000 | 8 050 882 000 | 0 013 | 0 / 12 A / A | 050 161 m | 15 00 | 6 4Z | 10 /11 |
| MANGANESE | 0 006 | 9 600 | 1 505 | 19 /19 | 0 017 | 4 900 | 1 22 | n /n | 0 077 | 0 850 | 0 279 | 12 /12 | 30 80 | 107 00 | 64 47 | 3/3 |
| MERCURY | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 001 | 0 000 | • /ii | 0 200 | 0 200 | 0 110 | 1/11 | 0 00 | 0 00 | 0 00 | 0/0 |
| NICKEL | 0 008 | 0 150 | 0 037 | | 0 023 | 0 150 Al 600 | 91 200 | 7/11 | 206.000 | 274 000 | 9 000 | 1/1 | 145.00 | 1 /0 170 m | 877 60 | 3/11 |
| SELENIUM | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 015 | 0 500 | 9 062 | i /nž | 0 00 | 0 00 | | 0/0 |
| SILVER | 0 005 | 0 010 | 0 005 | 1 /15 | 0 006 | 0 070 | 0 011 | t /n | 0 000 | 0 000 | 0 009 | 0/0 | 1 10 | 19 00 | 1 76 | 2 /11 |
| SODIUM | 0 041 | 54 900 | 21 147 | 15 /15 | 39 500 | EU 200 | 35 433 | 3/9 | 60/0 000 | 000 000 | 0991 250 | 4 / 4 6 / 6 | 300 00 | 472 00 | 242 50 | 3/5 |
| VANADILE | 0 036 | 0 055 | 0 022 | 2 /15 | 0 040 | 0 064 | 0 052 | 2/3 | 0 000 | 0 000 | 0 000 | ō/ŏ | 3 50 | 10 00 | 5 83 | 2/5 |
| 21#C | * *20 | 0 485 | 0 141 | 15 /19 | 0 040 | 0 275 | 0 109 | n Ņi | 0 011 | 0 020 | 0 010 | 8 /18 | 1 90 | 19 70 | 6 01 | 11 /18 |
| | ਮਾਰਵ 10 | 0 000 | 0 000 | 0/0 | 0 0 0 O | G 029 | 0.008 | 2 /11 | 0.000 | 0 000 | 0 009 | e /0 | 9 00 | V QQ | 0 00 | 9/9 |
| 1831 100 | | 0 009 | 002 | 4 /19 | 0 001 | 0 003 | 0 001 | 8 /11 | 000 0 | 000 0 | 0 000 | 0/0 | 0 000 | 9 899 | 0 000 | 0/0 |
| | | 26 400 | 2 740 | 14 /19 | 020 | 44 500 | 4 360 | 7/11 | 0 050 | 2 300 | 0 710 | 12 /12 | 000 0 | 0 000 | 0 000 | 0/0 |
| WINATE-METRITE CHIORITES | 10 200 003 0 | 3 400 | 0 30Z 60 100 | 0 /)7 15 /14 | 9 200 | 112 000 | 26 520 | 1/1 | 12000 000 | 16900 000 | 13660 000 | 1/1 | 0 000 | 0 000 | 0 000 | 0/0 |
| TOTAL DISSOLVED SOL TOS | 10 000 | 20100 000 | 1290 200 | 19 /19 | 60 000 | 46000 000 | 26 520 | n /n | 0 000 | 0 000 | 0 000 | 12 /12 | 0 000 | 0 000 | 0 000 | ŎĬŎ |
| | | | | | | | | | | | | | | | | |

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TABLE 2 CONSTITUENTS DETECTED AT NORTH SEA LANDFILL SITE

| | SI | INFACE SOTI | ., PPN | # HETS | SE | DIHENT PPH | 1 | # HITS | SLUDGE | LAGOON BORT | NGS PPH | / ALTS |
|--|----------------|-------------|------------------|----------------|---------|----------------|-------------|----------|----------------|-------------------|--------------|-------------|
| CONSTITUENT | NINING | A MAXIMUM | HEAN | AMALYSES | MINIMUM | NAXIMIN | HEAN | ANALYSES | NINIM | n haitmin | HEAN | I MINLYSES |
| VOLATILE ORGANICS | | | | | | | | | | | | |
| ACETOME | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 |
| 2 RUTANDE (NEX) | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 002 | 0 000 | 6 000 | 0/0 |
| 1 1 DICHLOROETHANE | Q 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | Ŏ/Ŏ | 0 005 | 0 020 | 0 007 | i /n |
| 1 1 DICHLOROETHENE | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 004 | 0 030 | 0 009 | 10 /12 |
| | 0.000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 6 000 6 004 | 0 000 | 0 000 | 8 / 12 |
| 1 2 DICHLOROETHANE | 0 000 | 0 000 | 0 000 | ŏ/ŏ | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | i/) |
| ETHYLBEHZENE | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 |
| FETHTLERE CHLORIGE | 0 000 | 0 000 | 6 000 | 0/0 | 0 000 | 0 000 | 0.000 | 0/0 | 0 007 | 0 140 | 0 054 | 12 /12 |
| TOLUENE | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 002 | 0 030 | 0 009 | 2 /12 |
| 1 1 1 TRICHLOROETHME | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 |
| IRICALORUE HAENE | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 8 000 | 0/0 |
| SEMIVOLATILE CREATICE | V VVV | • ••• | 9 000 | | | 9.000 | 0.000 | | 0 003 | V U | 0.003 | .,. |
| BENZO(B)FLUORANTHERE | 0 250 | 0 860 | 0 225 | 8 /21 | 000 0 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 000 0 | 0/0 |
| BERZO(K)FLUORANTNERE | 0 110 | 0 860_ | 0 216 | _1 /21 | 6 000 | 0 000 | 0 000 | 0/0, | 0 000 | 8 000 | 0 000 | 0/0 |
| BENZO(A)ANTHRACENE | 0 095 | 0 860 | 0 218 | 1 /21 | 0 000 | 8 000 | 0 000 | - 0/0 | 0 000 | 0 000 | 0 000 | 0/0 |
| BENZO-O PYRENE | 9 110 | 0 860 | 0 210 | 1 /21 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 |
| BIS(2 ETHYLHEAVL)FENHALANE | 0 180 | 9 900 | 2 069 | 10 /11 | 0 240 | 19 000 | 4 4 32 | 3/3 | 0 330 | 7 700 | 3 579 | 18 /18 |
| CHAT SEAL FI INDANTASES | 0 140 | 0 860 | 0 220 | 1 /28 | 0 055 | 0 A70 | 0 157 | 9/9 | 8 000 | 0 000 | 0.000 | 0/0 |
| INDENOPYRENE | 0 078 | 9 860 | 0 216 | ŭ /zi | 0 000 | 0 000 | 0 000 | õíõ | 0 000 | 0 000 | 0 000 | ĕ/ĕ |
| PHENANTRRENE | 0 000 | 0 000 | 0 000 | 0/0 | 0 051 | 0 480 | 0 185 | 1/9 | 0 000 | 0 600 | 0 000 | 0/0 |
| ptreme Disting Bureau Are | 0 140 | 0 860 | 9770 0184 | 8 /28 2 /21 | 8 058 | 8 480 8 000 | 0 000 | 8/3 | 9 000 0 120 | 19 000 11 100 | 0 000 | 0/0 A/19 |
| PENTACHLOROPHEROL | 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 |
| DIBUTYL PHTHALATE | 0 049 | 0 860 | 0 176 | 4 /17 | 0 079 | 0 470 | 0 321 | 8/3 | 0 000 | 6 600 | 0 000 | 0/0 |
| 4 0 UTRITAD-Z-PE INTERNE A RANNOPHERN PHENN CTHER | 8 000 8 000 | 0 000 | 0 VCV 8 600 | 9/D 9/9 | 0 000 | 6 000 | 000 0 | 0/0 | 8 000 6 mm | 0 000 0 000 | 0 000 | 9/5 0/0 |
| BUTYL BENZYL PHTHALATE | 0 170 | 0 860 | 0 221 | 1 /21 | 0 058 | 0 470 | 0 207 | 2/3 | 0 000 | 0 000 | 0 000 | 0/0 |
| DI N-OCTYL PHTHALATE | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 | 0 000 | 0 000 | 0 000 | 0/0 |
| a ************************************ | 897 88 | 61 30 60 | 2381 60 | 6/8 | 367 66 | 788.00 | 469 79 | 3/3 | 1998 68 | £379 6D | 4193 00 | 9 / 9 |
| ANTIMONY | 0 00 | 0 00 | 0 00 | Ŏ/Ŏ | 0 00 | 0 00 | 0 00 | Ö/Ö | 0 00 | 0 00 | 0 00 | ĕ/ĕ |
| ARSENIC | 1 00 | 11 00 | 3 50 | 6 /20 | 0 00 | 0 00 | 0 00 | 0/0 | 1 00 | 31 00 | 12 71 | 8 /18 |
| | 0 00 | 24 00 | 15 30 | 3/0 | 0.00 | 0.00 | 0.00 | 0/0 | 28 /0 | 50 SU 8 00 | 34 62 | 3/J 0/0 |
| CADNIUM | 0 50 | 2 20 | 0 76 | 16 /20 | 1 10 | 1 70 | 0 90 | 3/3 | 0 60 | 2 30 | 0 94 | 7 /12 |
| CALCIUM | 854 00 | 28500 00 | 2014 14 | 1/7 | 0 00 | 0 00 | 9 00 | 0/0 | 412 00 | 1160 00 | 657 50 | 3/3 |
| CHROMIUS | 1 00 | 9 00 | 2 92 | 18 /20 | 1 20 | 34,00 | 7 13 | 3/3 | 5 10 | 16 00 | 10 17 | 82 /82 |
| COPPER | 1 20 | 25 00 | 7 57 | 17 /20 | 1 10 | 19 00 | 6 17 | 2/3 | 5 50 | 35.00 | 10 07 | 97 /19 |
| IRON | 1870 00 | 7190 00 | 3739 00 | 6/6 | 870 00 | 6890 00 | 3270 00 | 3/3 | 6910 00 | 12300 00 | 8720 00 | 3/3 |
| LEAD | 0 50 | 42 00 | 5 38 | 16 /20 | 2 00 | 5 15 | 2 90 | 3/3 | 1 24 | 13 00 | 5 17 | 12 /12 |
| PLAGHES IUN MANCANESE | 346 00 | 112 00 | 2022 80 68 21 | 0/0 | JHZ 00 | 303 00 | 364 00 | 3/3 | 148 00 | 2/10 00 217 00 | 1949 /0 | |
| MERCURY | 0 10 | 1 90 | 0 17 | 7 /20 | 0 05 | 0 00 | 0 07 | 2/3 | 0 05 | 0 10 | 0 05 | i /ni |
| RICKEL | 5 00 | 21 00 | 7 33 | 11 /20 | 0 00 | 0 00 | 0 00 | •/• | 2 73 | 10 10 | 3 60 | \$ /IL |
| PUTASSIUR SELENTIM | 348 00 | 00 00 | 300 00 | 0/0 | 0.00 | 8 00 | 0.00 | 0/0 | 410 00 | 1350.00 | 00 00 | 3/3 |
| SILVER | 3 00 | 3 50 | 0 82 | 1 /20 | 0 00 | 0 00 | 0 00 | ŏ/ŏ | 1 20 | 110 00 | 9 80 | ž /nž |
| SODIUM | 0 00 | 0 00 | 0 00 | 0/0 | 1550 00 | 2360 00 | 2033 00 | 3/3 | 223 00 | 285 00 | 255 50 | 1/3 |
| TRALLIUN WANADIINS | 7 10 | 17 00 | 6 00 | 3/6 | 0 00 | 0 00 | 0.00 | 0/0 | 0.00 | 16 70 | 17 21 | 3/3 |
| 21MC | 3 90 | 33 00 | 11 00 | 20 /20 | 5 40 | 27 00 | 11 50 | 3/3 | 8 40 | 50 00 | 18 55 | 18 /18 |
| | 9 00 | 0 00 | 0 00 | 0/0 | 0 00 | 0 00 | 0 00 | 9/0 | 0 00 | 0 00 | 0 00 | 0/0 |
| 2EV 004 J685 | h 66 | 0 00 | 9 m | | | 8 00 | | 6/6 | 6 666 2 | 6 6362 | 6 cont | e nt |
| | j 00 | 0 00 | 0 00 | ŏį́š | 0 00 | ŏ ÖÖ | 0 00 | ĕ/ē | 0 000 | 6 000 | 6 000 | ĕ/ē |
| NITRATE-WITNITE | | 0 00 | 0 00 | 1/1 | 0 00 | 0 00 | 0 00 | !/! | 0 000 | 0 000 | 0 000 | 1/1 |
| | 0 00 | 000 | 000 | | 0.00 | 0.00 | 0 00 | :/: | 0 000 | 0 000 | 0.000 | 1/1 |
| | | 0.00 | 3 00 | | | ~ ~ | V VV | • • • | | ~ ~~~ | | X / X |

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Not counting methylene chloride a total of 11 volatile organic compounds were found in water samples The highest frequency of detection was recorded for toluene which had 13 detections out of 23 analyses (three of the detections were accompanied by blank contamination)

The highest detected concentration of a volatile organic compound in water samples (excluding methylene chloride) was for 1,1-dichloroethene (16 ppb in ground-water sampling round 1) Maximum concentrations for other volatile organic compounds were less than 10 ppb Arithmetic averages of chemical concentrations were 5 ppb or less for all volatile organic compounds except methylene chloride (9 ppb in ground-water sampling round 1) and acetone (6 ppb in ground-water sampling round 2)

In soils, nine volatile organic compounds were detected, one of which was methylene chloride which again consistently showed blank contamination Although 1,1-dichloroethene was prevalent in sludge samples (10 detections in 12 analyses), all but two of the detections were accompanied by blank contamination The two detections of 1,1-dichloroethene were relatively low (11 ppb and 8 ppb) and both were found in subsurface samples from sludge boring #4 Not counting methylene chloride or 1,1-dichloroethene, the volatile organic compounds were not prevalent in soil samples collected from or nearby the North Sea Landfill site The next highest prevalence was for chloroform with 3 detections in 12 samples followed by toluene with 2 detections in 12 samples The remaining detected volatile organic compounds were each found in only one sample

Detections of semivolatile organic compounds in water samples were also accompanied by blank contamination Compounds detected without blank contamination are limited to ground-water sampling round 1 and are bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, and di-n-octyl phthalate each with only 1, 3, and 3 non-blank contaminated detections respectively One compound, di-n-octyl phthalate, was detected at 160 ppb

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In soils, 18 semivolatile organic compounds were detected, the most prevalent of which [bis(2-ethylhexyl)phthalate], was accompanied by blank contamination in all of its 31 detections Next most detected was diethylphthalate, found in 17 of 44 samples, followed by dibutyl phthalate found in 9 of 31 samples It should be noted that the number of detections counted for a compound includes only the non-rejected samples from matrix specific sample rounds which contain above-detection-limit or estimated detection concentrations So in soils, diethyl phthalate was analyzed for in more than 44 samples, but was only found 17 times above detection limits or at estimated values in one or more sampling rounds containing a total of 44 analyses (not including rejected analyses) For a more thorough explanation of data handling procedures, see Section 1 4 Maximum concentrations reported for semivolatile compounds detected in soils reflect detection limits for one or more samples in the matrix category rather than highest actual or estimated detection So, although 6.000 ppb is recorded as the maximum concentration for pentachlorophenol in subsoil, its highest actual or estimated detection is an estimated In general semivolatile organic compounds are not value of 3 000 ppb prevalent in soils and concentrations used for risk analysis may be inaccurate but are conservative representations of actual concentrations detected

Inorganic elements are very prevalent at and nearby the North Sea Landfill site in water and in soil samples Reported soil concentrations of many inorganic elements are high compared to reported concentrations of volatile and semivolatile compounds, but the iorganic concentrations are within the limits typically found in soils in the United States (Table 1 3) Of the 20 inorganic metals detected in soils, 3 were generally found at concentrations below the maximum concentration specified as the common range in Table 13 (i e , aluminum, barium, and vandium), and 2 were found at concentrations above the maximum concentration (i e , cadmium and iron) Five metals (i e . antimony. arsenic, magnesium, mercury, and silver) had one or two detected concentrations that exceeded the maximum concentration of Table 1 3 The remaining concentrations of inorganic metals were within the specified limits

SEA 004 1684

| METAL | COMMON RANGE (ppm) | AVERAGE (ppm) | | | |
|-----------|-----------------------|------------------|--|--|--|
| Aluminum | 10 000-300,000 | 71 000 | | | |
| Antimony | 2-10 | | | | |
| Arsenic | 1-50 | 5 | | | |
| Barium | 100-3,000 | 430 | | | |
| Beryllıum | 0 1-40 | 6 | | | |
| Cadnium | 0 01-0 7 | 06 | | | |
| Calcium | Variable | | | | |
| Chromium | 1-1,000 | 100 | | | |
| Cobalt | 1-40 | 8 | | | |
| Copper | 2-100 | 30 | | | |
| Iron | 10-4,000 | 200 | | | |
| Lead | 2-200 | 10 | | | |
| Magnesium | 600-6,000 | 5,000 | | | |
| Manganese | 20 3 00 0 | 600 | | | |
| Mercury | 0 01-0 3 | 0 03 | | | |
| Nickel | 5-500 | 40 | | | |
| Potassium | Variable | | | | |
| Selenium | 0 01-2 | 03 | | | |
| Silver | 0 01-5 | 0 05 | | | |
| Sodium | Variable | | | | |
| Thallium | | | | | |
| Vanadium | 20 500 | 100 | | | |
| Zinc | 10-300 | 50 | | | |

TABLE 1 3TRACE METAL CONTENT OF SOILS

From U S EPA Hazardous Waste Land Treatment SW-874

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Concentrations of inorganic elements in water depend on characteristics of the water, characteristics of the soil, and the conditions under which contact is made (e g , pH, amount of inorganics in the soil, intimacy of contact) So, in general, the concentrations of metals in water vary greatly from site to site Therefore, the concentrations of metals found in waters at and nearby the North Sea Landfill site should not be compared to a "normal", mon-site specific range of concentrations

1 3 <u>Selection of Indicator Chemicals</u>

This endangerment assessment focuses on selected site contaminants that have been identified through a screening process The contaminants selected represent chemicals posing the most significant risk of adverse effect to human health or the environment These "indicator" chemicals are selected based on the following properties intrinsic toxicity, quantity present (includes @nvironmental concentrations and prevalence at the site) and properties affecting the chemical's mobility in the environment (and therefore, potentially critical exposure routes) (Life Systems, 1985)

The selection process for the North Sea Landfill site identified seven metals and one inorganic compound upon which this endangerment assessment will be based The seven metals are arsenic, cadmium, chromium, iron lead, manganese, and nickel Ammonia was identified as an inorganic compound of interest Full documentation supporting these selections as indicator chemicals is provided in Appendix 1

The indicator chemical selection process focused on inorganic metals This is supported by the fact that the North Sea Landfill site is operated as a landfill (the type of site where metals contamination is common) and because the remedial investigation (RI) for the site also identified several metals as potential contaminants of concern

Two of the metals identified in the RI were iron and manganese Further study of the analysis results showed that the applicable standards or criteria for iron, manganese, cadmium chromium, and lead have been exceeded Based on their high concentrations and prevalence at the site (as evidenced by their frequency of occurrences as shown in

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Table 1 2), their high toxicity (as indicated by their high rankings in the indicator chemical selection process), and the previous concern expressed over them these five metals were chosen to be indicator chemicals Arsenic, nickel, and ammonia were also chosen due to their concentrations, prevalence, and toxicity

Several chemicals ranked higher in the toxicity-based selection process than the chemicals that were chosen However, their high rankings were based on sometimes as few as one detection out of many samples Such was the case for selenium Other chemicals that were discounted due to lack of prevalence or low toxicity include all of the identified volatile organics and semivolatile organics The semivolatile organic compound 1,1-dichloroethene was not chosen as an indicator chemical despite two detections in sludge lagoon boring #4 This decision was based on many factors including its low prevalence (two detections in all of the samples) low concentrations found (11 ppb and 8 ppb) and the knowledge that exposure to subsurface soil in the sludge lagoon area is not an exposure pathway of concern as identified in Section 3 2 of this report Silver ranked above the selected chemicals in the scoring procedures, however, it showed-up at concentrations above detection limits in only 8 out of 70 samples, therefore, it was not chosen as an indicator chemical

Although bis(2-ethylhexyl)phthalate did show prevalence, it was present as a blank contaminant at levels which significantly diminished the relative toxicity of the sample concentrations

Although, at the concentrations found at the North Sea Landfill site ammonia is not generally considered a high toxicity concern to humans when compared to other chemicals, its toxicity to fish and other aquatic life merits consideration Therefore, ammonia was chosen as an indicator chemical

14 Data Handling

Analytical results of samples collected at and nearby the North Sea Landfill site were used in the indicator chemical selection process SEA 004 1687

according to set rules Each data point representing the concentration of a specific chemical from a specific sample was considered along with its associated laboratory footnotes (or data qualifiers) Data points whose qualifiers indicated that the data was rejected for any reason were not included in calculations Calculations for each chemical included determination of high, low, and arithmetic mean High concentrations were determined by examining the data for a chemical and choosing the highest non-rejected concentration Determination of low concentrations however, required some data manipulation

For any given data point whose qualifier indicates that it is a detection limit that is being reported, and not an actual concentration found some means of dealing with the possibility of the respective chemical being present in a sample below detection limits had to be used The convention adopted for the calculations presented in this report was to consider detection limit qualified data points to be one-half of their reported value It is expected that this convention results in a reasonably conservative report of possible site contamination for risk assessment purposes This procedure was employed prior to determining the low and arithmetic mean concentration for each chemical in each sampling round

In order to incorporate all of the sampling data available for the site and since split samples or duplicate samples were collected and analyzed for approximately 50 percent of the samples collected, the split and duplicate sample results were averaged before inclusion with the regular sample results This practice provided for a more complete and accurate data set by often providing legitimate data to replace rejected data points and by either canceling-out or reinforcing extreme chemical detections

It is noted here that certain compounds may have seemingly inaccurate summary statistics (i e, ground water round 1 results for trans-1,2-dichloroethene) (see Table 1 2) For this compound, the contract detection limit was 5 ppb (0 005 ppm) Since the only positive

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detection of trans-1 2-dichloroethene was 4 ppb the summary statistics list the minimum at 4 ppb and the maximum at 5 ppb For the mean calculation, all detection limit values of 5 ppb were considered to be 2 5 ppb, which when averaged with the single detection of 4 ppb resulted in a mean of slightly higher than 2 5 ppb, or 3ppb when rounded Thus, the mean is not within the minimum to maximum range, but it does represent the reasonable worst case average This situation occurs with several other chemicals, and this explanation is provided to avoid confusion



2 0 ENVIRONMENTAL FATE AND TRANSPORT MECHANISMS EVALUATION

The purpose of this section is to establish the expected environmental fate and transport mechanisms of each indicator chemical at the North Sea Landfill site The nature and extent of contamination which has, or had the potential for offsite migration are governed by the site's environmental setting (e g geology and soil, topography and drainage, climate, hydrogeology) and the characteristics of the wastes found at the site (i e , concentrations, and chemical and physical properties) Release mechanisms identified through this qualitative evaluation will be further quantified to assess potential human and environmental exposures All analyses in the following section are based on present site conditions without any further remediation

2 1 Site Characteristics

The North Sea Landfill is located on the South Fork of Long Island (Figure 4) which lies in the Atlantic Coastal Plain physiographic province of the United States The topographic features of the South Fork are a result of the Wisconsin ice advance, the last major glacial stage of the Pleistocene glacial epoch Approximately 10,000 years ago the Wisconsin ice sheet advanced to the central portion of Suffolk County and stopped, leaving behind the Ronkonkoma Moraine, a ridge of mixed glacial sediments trending east-west (Levin 1983) As the glacier melted, meltwater flowed seaward down the southern and northern sides of the Ronkonkoma Moraine carrying large volumes of sand and gravel The mixed sand and gravel was deposited on either side of the Moraine in outwash plains sloping gently seaward (deLaguna, 1948) Elevations for the South Fork range from approximately 400 feet above sea level to sea The North Sea Landfill is located on the northern slope of the level terminal Moraine (Figure 4) at an elevation between 50 and 100 feet above sea level (Figure 5)

Site characteristics that influence environmental fate and transport mechanisms of the contaminants at the North Sea Landfill site are presented in the following subsections Site characteristics include

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geology and soils topography and surface drainage, hydrogeology and climatology

2 1 1 Ceology and Soils

The North Sea Landfill area and Suffolk County in general are covered by unconsolidated Quaternary-aged sediments deposited during the Wisconsin glacial stage and subsequently reworked by recent sedimentation and erosion These glacial deposits overlie water-bearing Cretaceous sediments which rest directly on the bedrock floor of Long Island (deLaguna 1948) The bedrock surface dips gradually to the southeast (Figure 4) and ranges in depth from 400 to 2 200 feet below sea level throughout Suffolk County (USDA 1975) Depth to bedrock at the landfill area is estimated at approximately 1,200 feet below sea level (H2M, As the stratigraphic column in Figure 6 indicates bedrock is 1987) composed of Pre-Cambrian schist and gneiss with some occurrences of granodiorite Additional information regarding bedrock in Suffolk County is minimal due to the lack of wells or borings extending into bedrock, where well yields are poor and may likely encounter saltwater (deLaguna, 1948)

The Cretaceous sediments are divided into the Raritan and Magothy Formations (Figures 4 and 6) The Raritan Formation, the deepest aquifer in Suffolk County, lies directly on the bedrock surface and is composed of two members - the lower Lloyd sand member and the upper clay member Both members are continuous throughout the county, and range in thickness from approximately 150 feet to over 300 feet for each member The Lloyd sand consists of clean, medium to coarse, subangular quartz grains interbedded with coarse sand and gravel fine sandy clay, clayey sand, and very thin layers of clay The clay member of the Raritan formation is composed of light and dark gray laminated silty and solid clays with thin interbedded sandy layers The sandy layers assist downward movement of water through the clay member and into the Lloyd sand (deLaguna. 1948) The Magothy Formation rests conformably upon the Raritan clay member and is composed of alternating water-bearing zones of coarse

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FIGURE 6 Stratigraphic Column of Geologic and Hydrogeologic Units in the North Sea Landfill Site Area (Adapted From H2M, 1987) SEA

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angular sand and gravel interbedded with layers of fine clayey sands, fine sands silts and solid clays Sands in the Magothy are comprised mostly of gray, brown, and yellow quartz grains with small amounts of dark heavy minerals and particles of lignite and pyrite (delaguna, 1948)

The remaining unconsolidated Quaternary sediments comprise the Upper Glacial sediments a 200- to 300-foot layer of mixed till, terminal moraine and outwash deposits of the Wisconsin stage These deposits include a wide variety of material such as beds of fine to coarse stratified sand and gravel, tills consisting of mixtures of clay and boulders, fresh water lake deposits of silt and clay, and heterogeneous mixtures of quartz, biotite, muscovite, and feldspar rock fragments (deLaguna 1948) The upper glacial sediments at the landfill area are composed of a stratified draft sheet of outwash deposits from Ronkonkoma Moraine, capped by a thin veneer (10-30 feet) of late Wisconsin age till The Upper Glacial sediments are highly permeable (except in (H2M 1988) localized zones of clayey till deposits) and support a continuous unconfined water table Most of the wells on Long Island are screened in this zone (deLaguna 1948)

Surficial soils on the landfill property are composed of the made land series, a mixture of trash and nonsoil landfill material mixed with graded and excavated sand and loamy sand The surrounding soils are composed predominantly of the Plymouth-Carver Association soils formed from stratified glacial sand and gravel typical of steep moraines and outwash plains These soils develop a dark grayish-brown loam surface layer, about 4 inches thick, followed by substrata of yellowish-brown loamy sand and loose, gravelly coarse sand, to a depth of approximately 5 feet Plymouth-Carver soils are very permeable and are usually dry (USDA, 1975)

2 1 2 Topography and Surface Drainage

Very few perental streams or rivers are found in Suffolk County due to the high permeability and infiltration rate of the glacial soils and sediments Based on values of total average annual precipitation for the SEA 004 1695

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county (45 inches) minus losses due to recharge infiltration (21 3 inches) and evapotranspiration (23 inches), available runoff amounts to less than 1-inch of the total water budget (H2M 1987)

Fish Cove (Figure 5), the closest surface water body to the landfill, is an estuarine pond which receives most of its recharge from ground-water underflow (Fetler 1971) The cove also receives daily salt water influx via a tidal inlet connected to North Sea Harbor, which is in turn connected to the Little Peconic Bay estuary An intertidal marsh of approximately 45 000 square feet (H2M 1987) surrounds much of the Fish Cove shoreline

Very few fresh water ponds or lakes exist near the landfill area with the exception of small isolated basins (Figure 5) that are recharged by direct precipitation and ground-water underflow These lakes are probably formed on isolated deposits of low permeability glacial silt and clay (deLaguna, 1948)

2 1 3 <u>Hydrogeology</u>

Nearly all supplies of water for domestic and municipal use in Suffolk County are drawn from ground-water wells (USDA, 1975) As discussed in Section 2 1 2, 21 3 inches of the total average annual rainfall of 45 inches is recharged directly to the ground-water system Under these conditions county-wide ground-water recharge amounts to about 350 billion gallons of water annually (USDA, 1975) In the South Fork region where glacial moraine deposits are thickest, much of the ground-water supply is contained in the Pleistocene Upper Glacial The Magothy Formation and Lloyd Sand member of the Raritan sediments Formation also provide good well yields In the North Sea area, wells need only penetrate the Upper Glacial aquifer to obtain adequate yields for domestic use (deLaguna, 1948) The three aquifers - Lloyd Sand, Magothy, and Upper Glacial - are considered separate not only lithologically, but in terms of their water-bearing properties as well The Lloyd Sand member is separated from the Magothy Formation by the relatively impermeable Raritan Clay member The Magothy, though not

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considered a confined aquifer, is hydrologically distinct from the Upper Glacial aquifer due to the occurrence of interbedded clay layers near the contacts of both formations (deLaguna, 1948) A zone of low permeability silt and clay has also been identified in the Upper Glacial aquifer at a depth of 80 to 100 feet below sea level (H2M, 1988) which may restrict or control vertical ground-water flow between the Upper Glacial and the Magothy aquifers

- Regionally shallow ground-water flow in the South Fork is most effected by topographical features, such as the Ronkonkoma Moraine The moraine acts as a ground-water divide (Figure 7), causing the water table north of the divide to flow toward Peconic Bay, and the water table south of the divide to flow toward the Atlantic Ocean Water table flow at the landfill situated north of the divide follows the regional pattern and discharges locally to Fish Cove (H2M, 1987 H2M, 1988) Hydraulic conductivity for the Upper Glacial aquifer is variable ranging from 167 feet per day to 42 feet per day (Fetter, 1971 H2M, 1988) Based on water level measurements taken from wells installed for the RI (H2M 1988) the water table elevation ranges from 7 to 10 feet above sea level at the landfill and gradually approaches sea level toward Fish Cove where ground-water from the landfill area eventually discharges

214 Climatology

Climatic features of greatest interest for this endangerment assessment include temperature precipitation, wind speed, and wind direction These climatic features may play an important role in influencing contaminant fate and transport mechanisms, and hence exposure at the North Sea Landfill site

The climate of Suffolk County is humid-continental (USDA, 1975) Weather is affected by both continental and maritime influences Air masses affecting the county usually originate over land areas in North America, however, the county's proximity to the ocean helps to reduce diurnal and annual temperature ranges and increases the amount of precipitation

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Average temperatures for Suffolk County (Table 2 1) range from an average daily maximum for the year of 61°F (16 1°C) to an average daily minimum for the year of 44°F (6 7°C) July has the highest average daily maximum temperature 83°F (28 3°C), and January has the lowest average daily minimum temperature, 24°F (-4 4°C)

Annual precipitation in Suffolk County averages 43 4 inches (110 2 cm) per year and is generally uniform throughout the year (Table 2 1) The wettest months are March, August, November, and December, while the dry periods occur during June, September, and October Average annual snowfall for the county is 26 inches (66 cm), although accumulations of 40 inches (101 6 cm) or more have been noted in some winters

Information on wind speed and direction was available from the National Weather Service station in Islip New York Although the National Weather Service did not have site specific wind data for the North Sea Landfill area, site conditions at Islip generally represent the elevation and topography for the North Sea Landfill site Wind directions are predominantly from the north with average speeds of National Weather Service wind data is augmented by 8 7 miles per hour wind data collected during H2M's remedial investigation (H2M, 1988) Daily wind speeds and directions were measured at the landfill from September 22 to October 17, 1987, and compiled in a wind rose diagram, shown in Figure 8 Predominant wind directions were out of the west. north, and northwest Predominant wind speed was in the range of 5 5 miles per hour to 10 0 miles per hour

2 2 <u>Site Contaminants</u>

Environmental fate and transport mechanisms for the contaminants of concern at the North Sea Landfill site are presented in the following sections Fate and transport mechanisms of selected contaminants will provide information on the expected exposure routes possible at the site

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TABLE 2 1 Temperature and Precipitation Data for Suffolk County, New York (From USDA, 1975)

| | Lemperature | | | | Precipitation | | | | |
|--|------------------|---|---|---|--|--|---|--|---|
| Manth | Average | Average | 7 years in 10 |) will have— | Average | 3 yean will h | s in 10 sve— | Sac | den |
| | daily maximum | daily Tainum | Maximum temperature equal to or higher than— | Minimum temperature equal to or lower than | monthly total | More than— | Less than— | Average monthly total | 4 years in 10 will have more than— |
| anuary February March May June July July September Decober November Vear | ° | ° F 24 25 31 39 49 58 64 64 57 48 38 28 44 | ◦ ₽ 51 61 74 81 90 90 87 84 79 66 57 92 | | ૭ ೫ ૧૦ ૭ ૮ ೫ ೫ ೫ ૫ ૫ ૭ ૧ ૫ ઝે જે | 89076508708855 444844555 444844555 40 | 8409091463196 222291463196 222991463196 2296 | Am. 7 7 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | AD. 7 (9)2 (9)2 (9)2 (9)2 (9)2 (9)2 (9)2 7 28 |

⁶ Tracs. ⁹ One year in 10 will have more.



FIGURE 8 Wind Rose Diagram



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2 2 1 <u>Ammonia</u>

Ammonia (NH₃) enters the environment as discharges from a wide variety of industrial processes and cleaning operations that use ammonia or ammonia salts Ammonia also results from the decomposition of organic material and may be a natural constituent of certain ground-waters (U S EPA 1973)

In water, the dissociation of ammonia to its positively charged ammonium ion is controlled by the pH of the water In acidic waters the compound exists almost entirely in its ionized form However, in alkaline water the amount of unionized ammonia becomes significant Since it is the unionized ammonia compound that is toxic, the pH of its containing solution is very important (U S EPA 1973) Nitrogen is a limiting nutrient for microbial growth in most water, and ammonia is used by microbes through reductive ?animation to synthesize proteins when ambient ammonia concentrations are higher than normal (Atlas 1984)

2 2 2 Arsenic

Though a rare element arsenic (As) is ubiquitous in the earth's crust and occurs in hundreds of minerals, often with sulfur With four possible oxidation states 3- 0 3+, and 5+ arsenic's speciation is both complex and important in determining its fate Interconversions of the 3+ and 5+ states and organic ?complexation have the greatest impact of any transformations (Clement, 1985) Arsenic is generally very mobile in the environment The chemical form of arsenic and the properties of the surrounding medium determine the degree of mobility of the metal

When atmospheric deposition, runoff from soils, and industrial discharge send arsenic into aqueous environments, it tends to cycle through the water column, sediments, and biota Arsenate (As^{5+}) is generally the dominant species in aquatic systems, but biological activities may produce arsenite (As^{3+}), methylated arsenicals (As^{3-}), and the highly volatile methyl arsenics (AsH_3) (U S EPA, 1984a) Most salts and compounds of arsenic are soluble in water (U S DHHS, 1985)

Ambient pH and Eh (redox potential) conditions determine the prevailing form of the metal and thus influence its fate (U S EPA, 1979) Adsorption and desorption to sediments dominate the aquatic cycling process Iron concentration affects aqueous arsenic sorption, and coprecipitation with hydrous owides of iron is a prevalent process expected at the North Sea Landfill site (U S EPA, 1979) Transport in solution to ocean sediments is the major sink for arsenic in water Volatilization of arsenic or methylarsenics through biotransformations and highly reducing conditions is also an important mobilization process (Clement, 1985) Due to arsenic's high towicity, bioaccumulation is not an important fate in aqueous media and is significant only in lower trophic levels (U S EPA, 1979)

On land and in the atmosphere arsenic is also quite mobile In the air arsenic trioxide (As_2O_3) is the dominant species Arsenic particles remain in the atmosphere for only a short period before continuing to cycle through the environment Wet or dry deposition removes arsenic from the air The properties of the soil determine the fate of arsenic on land Sandy soils without much organic matter do not sorb arsenic well nor retard its leachability Arsenic will mobilize into the ground-water from soils with low sorptive capacity (U S EPA, 1984a) As with aquatic blota, bloaccumulation of toxic arsenic by terrestrial organisms contributes little to its transport and fate

2 2 3 <u>Cadmium</u>

Cadmium (Cd) is found in very low concentrations (usually >l ppm) in most rocks, as well as in coal and petroleum and often in combination with zinc Geologic deposits of cadmium can serve as sources to ground water and surface water, especially when in contact with soft, acidic waters It is introduced into the environment from mining and smelting operations and industrial operations including electroplating, reprocessing cadmium scrap, and incinerating cadmium containing plastics The remaining cadmium emissions are from fossil fuel use, fertilizer application and sewage sludge disposal Landfill leachates

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are also an important source of cadmium in the environment (Federal Register, 1985)

Cadmium appears in nature in the zero valence state (in metals and alloys) and most often in the divalent state (in compounds) Cadmium may form both organic and inorganic complexes

At least some of the total cadmium in waters near the North Sea Landfill site is expected to exist as the divalent cadmium ion Relative to other heavy metals cadmium is very mobile in aquatic environments, although certain forms are insoluble in water and therefore less mobile (U S EPA 1979) Hydrated cations and organic or inorganic complexes account for the cadmium that remains in solution The principal fate of any cadmium migrating offsite in aquatic media however, is sedimentation via sorption by clays or organic matter following organic ?complexation especially with humic acids (Clement, 1985) Cadmium concentrations in sediments are generally at least an order of magnitude greater than those in the ambient water (U S EPA 1979) The speciation of the cadmium ion and the degree to which the water is polluted, control the fate of the The divalent metal cation predominates in acidic and metal approximately neutral waters Higher pH yields complexes with carbonate and hydroxide ions Hydrated divalent cation is common in unpolluted water, and organically complexed cadmium is found in polluted water (U S EPA. 1979)

Though investigations have been limited, cadmium transport in soil appears to be a slow process Cadmium sorption in soil is strong and correlates well with the organic content of the ground (U S EPA, 1979) After adsorption however, cadmium may desorb from the soil and remobilize, often as a result of a decrease in pH below seven or an increase in salinity (U S EPA 1984b)

Dust and fumes containing cadmium reside in the atmosphere Chemical interaction usually results in speciation rather than decomposition The removal mechanism of these particles occurs through wet and dry deposition (U S EPA, 1984b)

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Organisms at all levels of the food chain accumulate cadmium often by the replacement of zinc in metabolic functions Bioaccumulation or bioconcentration factors (the ratio of the concentration in the organism to the concentration in the surrounding water, abbreviated BCF) in aquatic biota generally range from 1,000 to 3 000 but may reach several hundred thousand (U S EPA, 1979)

Terrestrial plants do not significantly deplete cadmium concentrations in soils by absorption through their roots However, concentrations of cadmium in plants may be elevated sufficiently to cause potential exposure to humans and animals through ingestion (Clement 1985)

224 Chromium

Chromium (Cr) generally appears in nature in either a trivalent (Cr^{3+}) or hexavalent (Cr^{6+}) oxidation state Other valences are relatively unstable and therefore do not contribute significantly to total concentration of chromium in the environment The speciation dominates the fate of the metal Hexavalent chromium is very water soluble and remains very mobile On the other hand, for trivalent chromium precipitation and adsorption are important processes

Hexavalent chromium, a strong oxidizing agent, forms stable complex anions, such as chromate $(CrO_4^{2^-})$ and dichromate $(Cr_2O_7^{2^-})$ The high solubility of these anions is responsible for their great mobility in aquatic environments (Clement, 1985) When reduced to the trivalent state, chromium is usually hydrolized and precipitated as chromium hydroxide $(Cr(OH)_3)$ (U S EPA, 1979), the expected principal fate of chromium at the North Sea Landfill site Trivalent chromium may also adsorb on sediments or be consumed by aquatic and marine biota Ambient conditions such as pH, hardness, and the types of other compounds present influence the oxidation state formed in aquatic environments (Clement 1985) Thus, conditions favorable to the trivalent state will lead to precipitation, adsorption, and bioaccumulation while soluble forms of chromium will accumulate in aquatic settings favorable to Cr^{6+} formation

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Trivalent chromium accounts for nearly all the chromium present in soils and sediments Trivalent chromium is strongly adsorbed onto clays and organic soils Soil components, with the exception of activated carbon do not readily adsorb hexavalent chromium, which remains soluble and mobile in ground-water and surface water (U S EPA, 1979) Little hexavalent chromium is leached from soil instead it quickly reduces to the trivalent state especially in soils of high organic content (Clement, 1985) This is substantiated by surface and ground-water samples analyzed for hexavalent chromium which showed no detectable levels of chromium above 10 mg/l (U S EPA 1987a, b)

Chromium occurs in the atmosphere as particulate matter This dust may spread miles from its source depending on particle size and density before returning to the ground via fallout or precipitation (Clement, 1985)

Chromium may pass through the food chain especially by accumulation in aquatic and marine biota,¹ whose chromium levels are usually much higher than in the surrounding water though lower than chromium levels in sediments This indicates that the food chain is a greater source of chromium for aquatic life than is direct uptake from seawater (U S EPA 1979) On land, plants tendito retain chromium in their roots and rarely translocate it to their leaves This in turn, limits the availability of chromium to terrestrial animals

2 2 5 <u>Iron</u>

The predominant sources of iron (Fe) in the atmosphere are natural processes including continental dust created by wind erosion of weathering mineral deposits, volcanic gas and dust, and forest fires Processes that remove iron from the atmosphere are wet and dry deposition (U S EPA, 1984e)

In aquatic media iron can undergo chemical reactions including precipitation, speciation, oxidation-reduction, and chelation, photochemical reactions including photoaquation, photosensitization and

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photoredox microbial interactions resulting in oxidation, reduction and precipitation, and sorptive interactions These reactions may depend on available light, pH oxidation potential of the body of water, microorganism type and concentrations, and nature of sorptive species In most bodies of water, iron is expected to be present largely in the form of suspended particles and sediments although small amounts of dissolved iron may occur as Fe(II) or Fe(III) ions, and inorganic and organic complexes of both Fe(II) and Fe(III) The residence time of iron in aquatic media has been estimated to be greater than 140 years (U S EPA, 1984e)

In soils iron is present as Fe(III) unless the soil is oxygen deficient (flooded or rich in organic matter) where it occurs more often The fate of iron compounds in soil is primarily determined by as Fe(11) chemical and microbiological reactions in soils and the capacity of soils to sorb iron-organic complexes In most soils, iron is not mobile, however small amounts of iron are transported through soil in the form of colloidal ferric oxyhydroxides, and in solution as iron-organic chelates formed under peptizing action of dissolved organic compounds Soll pH is one of the most important regulators of iron mobility with lower pH favoring mobility The mobility of iron in soils is such that it is not likely to leach from soil into ground-water under most conditions Exceptions are coal mine drainage areas and waste burial sites where iron may leach into ground-water Iron is circulated from soil to air and to surface waters by wind blown dusts and surface water runoff (U S EPA, 1984)

226 <u>Lead</u>

Lead (Pb), is a naturally occurring heavy metal and can pass through soils, aquatic environments, the atmosphere, and the food chain The species (oxidation states) of lead formed and their associated solubilities are important in determining lead's environmental mobility

Metallic lead is stable in dry air however, in moist air, it quickly forms lead monoxide, which in turn combines with carbon dioxide SEA 004 1707

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to produce lead carbonate In general, the chemical properties of inorganic lead compounds are similar to those of the alkaline earth metals The nitrate chlorate and acetate salts are water soluble the chloride is slightly soluble, and the sulfate, carbonate, chromate, phosphate and sulfide are insoluble The aromate, carbonate, nitrate, sulfide, and phosphate are soluble in acid, and the chloride is slightly soluble in acıd Lead forms stable tetraalkyl compounds with organic ligands, for example tetramethyl tetraethyl tetrapropyl, and tetrabutyl They are soluble in many organic solvents but are insoluble compounds in water The tetraorganolead compounds decompose to lead metal and free organic radicals at elevated temperatures or in the presence of light In the presence of oxygen, the thermal decomposition of tetraethyl lead produces lead oxide rather than the free metal Lead also forms stable metal complexes with polydentate chelating agents for example penicillamine or ethylene diaminetetra acetic acid (EDTA) (ATSDR, 1988b)

The primary mechanisms controlling the distribution of lead in the environment appears to be sorption Soils readily adsorb lead at a pH above 5 but soils tend to desorb lead as pH becomes more acidic Consequently, lead exhibits greater mobility in acidic waters and tends to accumulate in sediments under neutral or alkaline conditions Surface waters near North Sea Landfill are approximately neutral The observed sorption method varies with soil conditions (Clement, 1985) Because studies show that only 0 6 percent to 1 6 percent of the total lead in soils should be leachable runoff of suspended particles, rather than the leaching of soluble lead, should be the dominant migration pathway for contaminants in soils at the site (Penwak et al., 1980)

In the atmosphere, lead exists primarily in the particulate form Upon release to the atmosphere (mostly from fuel combustion), lead particles are dispersed transformed by physical and/or chemical processes, and ultimately removed from the atmosphere by wet or dry deposition The average residence time of lead particles in the atmosphere is expected to range between 7 and 30 days (ATSDR, 1988b)

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In the aquitic environment speciation of the lead influences its fate The divalent form (Pb²⁺) is the stable ionic species of lead hydroxide, carbonate, sulfide, and more rarely sulfate may act as solubility controls in its precipitation Tetraalkyl leads may also form by a combination of chemical/biological alkylation of inorganic lead compounds under appropriate conditions The amount of lead that remains in solution depends upon the pH of the water and the dissolved salt content (ATSDR, 1988b)

The accumulation of lead in most soils is primarily a function of the rate of deposition from the atmosphere Most lead is retained strongly in soil, and very little is transported into surface water or ground-water The fate of lead in soil is affected by processes which are dependent on such factors as soil pH, organic content of soil, the presence of inorganic colloids and iron oxides ion exchange characteristics and the amount of lead in the soil (ATSDR, 1988b)

Bioaccumulation of lead occurs in a variety of organisms, though lead concentrations tend to decrease with increasing trophic level or distance from the primary source in the food chain (U S EPA, 1979) Except for some shellfish (e g, mussels), lead does not appear to bioaccumulate significantly in most fish (ATSDR, 1988b)

2 2 7 Manganese

Although manganese (Mn) can exist in all valence states from -3 to +7 the inorganic chemistry of manganese is dominated by compounds in the +2 +4 and +7 oxidation states The principal sources of manganese in the atmosphere are natural processes including continental dust, volcanic gas and dust, and forest fires, while the main anthropogenic sources are industrial emissions and combustion of fossil fuels Atmospheric fate of manganese is determined by tropospheric chemical reactions and physical removal processes while aquatic fate may be controlled by its ability to undergo chemical and microbial reactions - as in the case for manganese in soil (U S EPA 1985a)

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In the air, manganese may undergo photochemical and thermal reactions which result in speciation, but these reactions may not be directly responsible for its removal from the atmosphere Manganese may be removed from the air through dry fallout or wet precipitation It has been estimated that the atmospheric residence time for manganese due to such physical removal process is approximately 7 days (U S EPA 1985a)

The fate of manganese in aquatic systems may be determined by its ability to undergo chemical and microbiological reactions In most natural aquatic systems manganese is expected to be present predominantly in the suspended particulates and sediments as MnO2 or Mn₃0₄ A small amount of manganese ion may remain as soluble The maximum concentration of soluble Mn⁺² may be limited by Mn^{+2} the solubility product of MnCO₂ and under certain reducing conditions, by the MnS solubility product The concentration of soluble chelated manganese in aquatic systems is likely to be less than soluble free Thus although manganese may undergo speciation through manganese lons chemical and microbiological reactions in systems it may persist in aquatic systems for a long period By analogy with aquatic iron, the residence time of aquatic manganese may be a few hundred years (U S EPA 1985a)

The BCF for manganese in a species of edible fish (striped bass) has been reported to be less than 10 Also, significant bioaccumulation of manganese may not occur with organisms of high trophic level (U S EPA, 1985a)

Both chemical and microbiological interactions may cause speciation of manganese in soils soil pH and oxidation-reduction potential of soil may influence the speciation process It has been suggested that in acid water-logged soils, manganese passes freely into solution and may leach into ground water Also, manganese can be leached readily from waste burial sites and from other natural soils into ground-water (U S EPA, 1985a)

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2 2 8 Nickel

A relatively mobile heavy metal, nickel (Ni) commonly occurs in the elemental and divalent states Sorption processes and plant uptake may limit its mobility somewhat Photolysis, volatilization, and biotransformation do not play important roles in the environmental transport and fate of nickel at the North Sea Landfill site (Clement, 1985)

The overall passage of atmospheric nickel may be characterized as a short-lived transport process Various chemical forms of nickel appear in the atmosphere as dust and fumes but any chemical interactions of nickel usually result in its conversion to nickel oxide (U S EPA, 1985b) The length of stay in the atmosphere of nickel particulates before removal by wet or dry deposition depends on particle size and density The average half-life in air is much longer for smaller particles allowing greater transport distances The average residence time for nickel in the air is 7 days

Nickel usually occurs in the divalent oxidation state in aqueous media and has a great affinity for organic liquids, hydrous, iron, and manganese ovides Most of the common aquatic organic liquids of nickel are soluble in water and support the metal's high mobility However, sorption and coprecipitation involving hydrous iron and manganese oxides moderately limit nickel mobility, especially at high pH (U S EPA, 1979) Another factor that regulates the mobility of nickel in aqueous media is the degree of pollution Nonpolluted water favors sorption and precipitation, while polluted waters provide organic groups needed for the formation of soluble nickel compounds (Clement, 1985) Both precipitated and soluble nickel are expected in surface waters near the North Sea Landfill site Bioaccumulation of nickel by aquatic organisms is limited and in general most nickel introduced to rivers and streams eventually settles in ocean basins (U S EPA, 1979)

Analogous to aqueous media the composition of the soil exerts a dominating effect on the fate of nickel in terrestrial settings Soil

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high in iron and manganese oxides (expected at the North Sea Landfill site) sorbs nickel significantly and impedes its movement The metal remains mobile in ground-water with a high organic content (U S EPA, 1985b) Plants may take up some nickel, while other plants identified as nickel accumulating plants extract great amounts of nickel from soil Nickel is reasonably mobile in low pH and cation exchange capacity mineral soils but less mobile in basic mineral soils and soils with high organic content Nickel present in dump sites will have higher mobility under acid rain conditions and will be more likely to contaminate underlying aquifers (ATSDR 1987b)

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3 0 EXPOSURE EVALUATION

This section presents an evaluation of existing routes of exposures to humans and other potential receptors (fish and wildlife) as well as routes that may reasonably be expected to occur in the future Releases from the North Sea Landfill site were identified through a contaminant release screening process (Section 2 2) Specific routes through which exposures may occur will be identified through an environmental fate screening process to qualitatively assess all releases from the site, and the anticipated ranges of ambient concentrations at affected points distant from the site (U S EPA, 1986a)

The contaminant release information (Section 3 1) presents a summary of the operational activities and waste handling practices employed at the North Sea Landfill site that contributed to the contamination of the site This information was used to identify all actual or potential routes of exposure (Section 3 2), to characterize the populations exposed (Section 3 3) and qualify as possible the extent of exposure (Section 3 4) These objectives have been achieved through a chemical analysis of soil samples collected at the site, and an evaluation of the site's environmental setting This evaluation is based on a "no action remedial response "

3 1 Source and Mechanism of Contaminant Release

Contaminants at the North Sea Landfill site can potentially be released into the environment from the following sources (1) buried waste in landfill cells 1 and 2, (2) buried waste and contaminated soil in the septic sludge lagoon area, and (3) road salt storage piles

Waste material was placed in landfill cell 1 and in a series of 12 scavenger sludge lagoons during the 1960's Landfill cell 1 was closed in 1985 This cell received septic system sludges from the scavenger lagoons and municipal solid wastes The 12 sludge lagoons are presently filled and are not 'active It is estimated that these lagoons received a total of 11 million gallons of septic wastes (H2M, 1988)

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The remaining active landfill cell 2 currently accepts 80 000 tons of municipal waste annually Upon reaching capacity the Town of Southampton will close the remaining active cell (H2M, 1988)

The key release mechanism of site contaminants is via precipitation and infiltration to ground-water at the source areas Contaminants from landfill cell 1 travel via the ground-water environmental transport medium northwest from the source to discharge (locally) at Fish Cove It is not known at this time how far contaminants from the other two sources have traveled but it can be expected that their plumes run parallel to the cell 1 plume and have the same receptor areas (H2M, 1988)

The key receptors of site contaminants are downgradient ground water and surface water at Fish Cove, and these two media compose the primary risk media Surficial soils at or near the suspected source areas are secondary risk areas Air surveys during the remedial investigation did not identify specific volatile organics, therefore, exposure due to inhalation of volatile organic compounds was not included as part of this exposure assessment

3 2₄ <u>Routes of Exposure</u>

Based on the contaminant release screening process and the environmental fate and transport characteristics for the selected indicator chemicals described earlier, the following potential exposure routes were identified

- 1 Dermal exposures during swimming, boating, and fishing to indicator chemicals released to Fish Cove, dermal exposure from direct contact with contaminated soils at the site
- 2 Ingestion exposures through direct contact with contaminated surface soils
- 3 Ingestion exposure from consuming contaminated fish and shellfish caught from Fish Cove and inadvertent ingestion of contaminated water during swimming and other water-related activities

organisms the cove supports are considered ecological receptors, and the cove must meet the water quality standards for human health The North Sea Landfill site boundary is approximately 1,700 to 3,000 feet from the cove so the transport distance is relatively long Pollutant information from hydraulically upgradient wells was included in this assessment because those wells also contained detectable concentrations of the selected indicator chemicals The study was designed to ensure that all potential contaminant sources be included so that any potential health risks would be identified

The Soil Contamination Evaluation Methodology (SOCEM) (CH2M Hill, 1985) was used to characterize the impact that contaminated ground water below the North Sea Landfill site may have on Fish Cove Versar has used actual ground-water monitoring results to estimate contaminant concentrations reaching Fish Cove The model assumes the following

- steady state conditions,
- continuous source of contaminants,
- constant source concentration
- no retardation of contaminants
- no losses or decay mechanisms (degradation, volatilization),
- no longitudinal dispersion,
- no diffusion and
- no precipitation recharge

These assumptions will produce a conservative estimate of potential offsite contaminant concentrations The numbers can be viewed essentially as a "worst-case" situation since they do not allow for important loss mechanisms Exposure levels computed from these numbers will therefore be biased high This conservative approach is taken to ensure that the potential human or environmental health risks will be identified, and that selected remedial alternatives will be protective

The codified version of SOCEM used in this endangerment assessment was based on the EPA Vertical and Horizontal Spread (VHS) model (50 FR 7882), adapted from an equation presented by Domenico and Palciauskas

4 Inhalation exposures from breathing fugitive dust emissions from the site

Although ground water is not used for drinking water in the area of the North Sea Landfill, the contaminated aquifer has the potential for such use Therefore, exposures due to consumption of contaminated ground water will also be evaluated

Each exposure route was assessed through an environmental fate screening process Environmental concentrations were estimated for each of the affected media ground water surface water biota, and soil Concentrations were estimated using predictive equations or models that rely (to the extent possible) on site-specific information Contaminants released to ground water are expected to be discharged into Fish Cove Concentrations entering the estuary from this pathway were also estimated using a computer model

Exposure to contaminants from ingestion of fish is highly speculative Estimates of edible tissue concentrations are based on estimated contaminant concentrations in Fish Cove and estimated bioconcentration factors

Ground Water

Migration of contaminants through soil and into ground-water was a pathway identified in Section 2.0 The principal concern of exposure stems from the discharge of contaminated water into Fish Cove from ground water below the site All homes in the affected area are currently connected to a public water supply for drinking showering, and cooking (H2M 1988) however, barring site-related contamination, the aquifer may potentially be used for drinking water purposes

Once the contaminants have entered the ground-water below the site, they are transported with ground-water flow to potential receptor points In the ground water flow system at the North Sea Landfill site the ground water below the site flows north-westward to Fish Cove For an exposure evaluation, the cove is considered a receptor point The

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(1982) The SOCEM version of their equation is given by

 $C_{gw} = C_{o} * erf[Z/(2(d*X)^{0.5})] * erf[1/(4(d*X)^{0.5})]$

Where

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C_{gw} - Contaminant concentration at the ground-water receptor, in this case Fish Cove,

- C₀ = Initial ground-water contaminant concentration at the source in this case concentrations in monitoring wells,
- d = Aquifer transverse dispersivity,
 - Distance to receptor in the direction of ground water flow,
 - Width of contaminated zone at the waste boundary (measured perpendicular to the direction of ground water flow)
- Z = Thickness of the contaminated zone at the waste boundary (measured downward from the ground-water table) and
- erf(f) = The error function of any function (f)

The developers of SOCEM (CH2M Hill, 1985) intended that the method be used to evaluate the effect that alternate remedial options may have on reducing contaminant concentrations at the receptor They suggest that it be used as a straight forward, simplified procedure to characterize the threat that contaminated soil may pose to ground water at Superfund sites even though they do not suggest a way of estimating one of the most critical input values to the SOCEM model, the initial source concentration in ground water from contaminated soil To reduce uncertainty associated with generated ground water concentration values from soil concentration values, the ground-water exposure assessment relies on the ground water monitoring data and not soils concentration In such an approach, each monitoring well with constituent data concentration C, acts as a source of contaminated ground water that will be transported to Fish Cove

If each location where samples were taken is treated as a source of contamination and the concentration of constituents at all depths and at each location are summed, the contribution of contamination introduced to Fish Cove can be calculated using the VHS model or SOCEM Table 3 1 shows constituent concentrations entering the cove from wells at the site

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TABLE 3 1CONTAMINANT CONCENTRATION TO FISH COVETHROUGH GROUND WATER SEEPAGE FROM NORTH SEA LANDFILL SITE
(DETERMINED B) SOCEM)

| Constituent | Wells at Landfill and Near Fish Cove | |
|-------------|---|---|
| Ammonia | 23 l mg/l | |
| Arsenic | 25 7 ug/l | |
| Cadmium | 19 2 ug/l | |
| Chromium | 256 ug/l | |
| Iron | 642 mg/l | |
| Lead | 76 6 ug/l | |
| Manganese | 6 020 ug/l | |
| Nickel | 133 ug/l | 1 |

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and for wells near Fish Cove Source areas for wells at the landfill are 350 feet wide (1), which is approximately 1/10 of the length of the site measured perpendicular to the direction of ground-water flow Source areas for wells near Fish Cove are 175 feet wide (1), which is approximately 1/9 of the length of the shore of the cove adjacent to the monitoring wells The penetration depth of the contamination (Z) was determined for shallow wells by subtracting the depth to water from the total depth of the well For intermediate and deep wells, Z is the distance from the bottom of the adjacent shallow or intermediate well to the bottom of each intermediate or deep well respectively SOCEM was used to calculate concentrations of contaminated water released to Fish Cove for each constituent identified at each sampling location and totaled for all indicator chemicals from each sampling location (see Appendix 2 Attachment E)

For the ground-water ingestion exposure pathway, data from monitoring wells near residences are used The concentrations found in these wells (MW 4 MW 10, MW 29, MW 30, and Mahoney Residence) are higher than those predicted by SOCEM for concentrations entering Fish Cove In order to create the most conservative exposure scenario concentrations found in the near-residence wells were used These concentrations are

| Chemical | Concentration (µg/L) | Location | |
|-----------|-------------------------|--------------|--|
| Ammonia | 21 700 | MW 30 | |
| Arsenic | 16 05 | MW - 4 | |
| Cadmıum | 6 20 | MW-29, MW-30 | |
| Chromium | 102 | MW-4 | |
| Iron | 39 650 | MW - 30 | |
| Lead | 26 | MW-4 | |
| Manganese | 4,610 | MW-30 | |
| Nickel | 48 8 | MW - 4 | |

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Surface Water

Two distinct exposure routes were identified related to contaminants that migrate to Fish Cove Direct contact (dermal) exposures may occur to humans who may use the cove for recreation Direct contact exposures will also occur to any aquatic biota that inhabit Fish Cove Inhalation exposures may additionally occur while swimming, though this particular route is expected to be minor and will not be further evaluated Ingestion exposures to individuals consuming fish and shellfish from the cove will be considered separately

Contaminants are generally sorbed onto soil particles at the soil surface or they exist in a dissolved state around soil particles During rainfall events or snowmelt these soil particles become entrained through erosion and conveyed by runoff streams from the North Sea Landfill site into storm sewers or by direct overland flow into Fish The 20 62 hectare site is located in a contoured area with slopes Cove ranging from 3 percent to 35 percent (USDA 1975) A stormwater collection system was installed on the site which collects runoff from the landfill and directs stormwater to a recharge basin at the western edge of the site (H2M 1988a) No naturally-occurring standing water bodies exist on the landfill property No significant streams exist onsite and storm precipitation follows transient drainage paths (H2M. 1988b)

Releases via overland flow of contaminants from the North Sea Landfill site were estimated using the Modified Universal Soil Loss Equation (MUSLE) and sorption partition coefficients for each compound (Haith 1980, Mills et al , 1982, [cited in U S EPA, 1988]) This equation provides an estimate of the amount of soil eroded during a single storm event of a given intensity, while sorption coefficients allow prediction of the amounts of contaminants that will be conveyed in the runoff in suspended form (as sediment) or in dissolved form The equation presented by Mills is given by

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 $Y(S)_E = a(V_r - q_p)^{0.56} KLSCP$

| Where | $Y(S)_{F}$ | 🛥 sediment yıeld, (metric tons) |
|-------|------------|---|
| | a | - conversion constant, (11 8 metric) |
| | Vr | - volume of runoff, (m ³) |
| | 9 2 | - peak flow rate, (m ³ /sec) |
| | ĸ | soil erosion factor, (tons/acre/R unit) |
| | L | slope-length factor (dimensionless) |
| | S | slope steepness factor, (dimensionless) |
| | С | cover factor (dimensionless, 0 75 for North Sea Landfill site). and |
| | P | erosion control practice factor (dimensionless 1 0 for no erosion control) |

The supporting calculation for $Y(S)_E$ is provided in Appendix 2 as Attachment A Substituting these values

$$Y(S)_E = (11 \ 8)[(257 \ 8)(0 \ 118)]^0 \ 5^6(0 \ 17)(0 \ 83)(0 \ 75)(1 \ 0)$$

= 8 46 metric tons of sediment/two-inch storm event

To estimate the partitioning of contaminants between solid and dissolved phases during a runoff event, a simple mass balance approach can be used Partitioning of the contaminant is dependent on its sorption partition coefficient, K_d and the soil bulk density and available water capacity (Haith 1980) The amounts adsorbed and dissolved can be estimated as

$$S_s = [1/(1 + \Theta_c/K_d\beta)] C_{soil}A$$

and

$$D_s = [1/(1 + K_d \beta / \Theta_c)] C_{soil}A$$

| Where | S | 🛥 sorbed substance quantity, (kg) |
|-------|-------------------|--|
| | D | m dissolved substance quantity, (kg) |
| | ອັ | available water capacity of top centimeter of |
| | • | soil, (dimensionless) |
| | Ka | sorption partition coefficient, (cm ³ /g) |
| | βີ | ∞ soil bulk density, (g/cm ³) |
| | C _{soil} | - contaminant concentration in soil, (kg/ha), and |
| | A | - contaminated area (ha) |

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To compute the amount of sorbed and dissolved contaminant loads to Fish Cove, Haith (1980) proposes the following

$$PX_1 = [Y(S)_E / 100 \beta] S_s$$

and

$$PQ_i = [Qr/R_r] D_s$$

Where

PX₁ = sorbed contaminant loss per event, (kg)
PQ₁ = dissolved contaminant loss per event (kg)
Qr = total storm runoff depth (cm), and
R_t = total storm rainfall, (cm)

Table 3 2 presents the estimated partitioning of each indicator chemical into the sorbed and dissolved phases and the expected short-term contaminant loads to Fish Cove

Contaminant Loading to Fish Cove

After calculating the amount of sorbed and dissolved contaminants in surface waters leaving the site and considering the contribution from ground water flow the contaminant loading to the receiving water body is calculated as

Total loading = loading from ground water + loading from surface water Because Fish Cove is an estuary tidal fluctuations act as a flushing mechanism to remove contaminants from the cove Mills et al (1982) outlines methods for calculating pollutant concentrations in estuaries, but these methods require knowledge of the ratio of fresh water to sea water at different points from the head to the mouth of the estuary Since this information is not available for Fish Cove, an alternate method for determining the ground water contaminant contribution to Fish Cove was developed

The Estuary Pollutant Concentration (EPCON) model was developed (Lackey, 1989) to provide a reasonably conservative estimate of pollutant concentration in an estuary (Fish Cove) from a continuous pollution

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| | °c | K _d (cm ³ /g) | p (g′cm ²) | C _{soil} (kg/ha) | Area (ha) | s (kg) | D _s (kg) | PX ; (ka) | PQ ₁ (ka) | Tota 1 (kg) | |
|-----------|------|--|---------------------------|------------------------------|--------------|-----------|------------------------|--------------|-------------------------|----------------|---|
| Armon i a | 0 04 | 0 51 | 1 55 | 0 | 20 61 | 0 | 0 | 0 | 0 | 0 | |
| Arsenic | 0 04 | 4 71 | 1 55 | 0 555 | 20 61 | 11 37 | 0 062 | 0 030 | 0 0015 | 0 032 | |
| Cacinium | 0_04 | 2 46 | 1 55 | 0 118 | 20 61 | 2 40 | 0 025 | 0 0063 | 0 00062 | 0 007 | - |
| Chromium | 0 04 | 284 3 | 1 55 | 0 453 | 20 61 | 9 33 | 0 001 | 0 025 | 0 00002 | 0 025 | |
| Iron | 0 04 | 54 6 | 1 55 | 579 5 | 20 61 | 11940 | 5 64 | o1 64 | 0 139 | 31 8 | |
| Lead | 0 04 | 99 48 | 1 55 | 0 834 | 20 61 | 17 2 | 0 004 | 0 046 | 0 00011 | 0 046 | |
| Manganese | 0 04 | 148 4 | 1 55 | 10 57 | 20 61 | 218 | 0 038 | 0 577 | 0 00093 | 0 58 | |
| #icke1 | 0 04 | 54 6 | 1 55 | 1 14 | 20 61 | 23 11 | 0 011 | 0 062 | 0 00027 | 0 062 | |

Table 3 c Calculation of Sorbed and Dissolved Contaminant Loads to Fish Cove from Surface Water Runoff

References for and calculation of numbers in this table appear in Attachment A of Appendix 2

source (in this case, contaminated ground-water migrating from North Sea Landfill) EPCON uses the following equations

$$C_{1} = (C_{1}Q_{1}T)/V_{L}$$

and

$$c_2 = (c_1 v_L + c_1 Q_1 T) / v_H$$

, Where

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- ere C₁ = contaminant concentration in estuary after time period T at low tide C₂ = contaminant concentration after second time period T
 - at high tide
 - C₁ concentration of contaminant entering estuary
 - Q_1 = flow rate of contaminant entering estuary
 - T = time between tidal fluctuations
 - V_{L} = volume of estuary at low tide
 - $V_{\rm H}^{\rm L}$ = volume of estuary at high tide

The assumptions the EPCON model makes are

- 1 constant inflow of contaminants ($C_i = \text{constant}, Q_i = \text{constant}$)
- 2 perfect mixing of contaminants in estuary
- 3 instantaneous tidal fluctuation after time T, and therefore constant estuary volumes at low and high tides
- 4 volume contribution by ground-water or surface water is negligible
- 5 only contaminant removal mechanism is dilution and tidal flow

The contaminant concentrations after the initial tides are calculated using

$$C_{x+1} = (C_x V_H - C_x V_D + C_1 Q_1 T) / V_L$$

and

$$C_{x+2} = (C_{x+1}V_L + C_1Q_1T)/V_H$$

Where λ, V_D

 λ , λ +1, x+2 $rac{-}{r}$ counters for sequential time periods $V_{\rm D}$ $rac{-}{r}$ volume difference between tides $(V_{\rm H} - V_{\rm L})$

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By using an iterative process to model the concentration changes as the system approaches steady state the maximum concentrations for high and low tides can be determined

This model will give conservative estimates of pollutant concentrations for the estuary as a whole due to assumptions 2 and 5 However the concentrations at any point in the estuary may not be accurately modeled due to the perfect mixing assumption Concentrations at pollutant sources (at the head of the estuary) may be under estimated while those at the mouth of the estuary may be overestimated

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The results of EPCON modeling for Fish Cove appear in Table 3 3, while the actual model appears as Attachment B to Appendix 2 In order to provide a worst-case estimate of total contamination in Fish Cove, the EPCON results for low tide were used to represent the ground-water contribution

The contamination contribution to Fish Cove from surface water runoff was calculated using the Modified Universal Soil Loss Equation (MUSLE)(Williams 1975 as cited in U S EPA, 1988) In order to provide a worst case estimate of surface runoff contaminant contribution to Fish Cove a severe storm of 2-inches of precipitation in 2-hours was used in the modeling equations Resulting concentrations of contaminants in Fish Cove are the sum of surface water runoff and ground-water migration contributions The individual contributions of ground-water and surface water runoff as well as the total contaminant concentrations in Fish Cove appear in Table 3.4 Supporting calculations for the values in Table 3.4 appear in Attachment B of Appendix 2

<u>Biota</u>

Information obtained from the Town of Southampton indicated that Fish Cove is classified as Class B, which is suitable for recreational activities (e g fishing, shellfishing, boating, swimming) However, these waters are not suitable for drinking or food preparation Because of these recreational activities, potential ingestion or dermal exposure may occur

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Since recreational and commercial fishing are a regular occurrence at Fish Cove, cumulative exposure to the contaminants of concern from eating potentially contaminated fish or shellfish may be of significance

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| | Concentration Reaching | Resulting Cor | centration_1 | n Fish Cove ⁽²⁾ |
|-----------|--|---------------|--------------|----------------------------|
| | Fish Cove from Ground Water ⁽¹⁾ | Low Tide | , | High Tide |
| | (Fy/L) | | | (µg/1) ⁽³⁾ |
| Amnon 1a | 23 118 | 1 050 | | 666 |
| Arsenic | 25 7 | 1 18 | 1 | 0 74 |
| Cadmium | 19 2 | 0 88 | | D |
| Chromium | 256 | 11 7 | t | 0 55 |
| Iron | 64 160 | 2 943 | ١ | 74 |
| Lead | 76 6 | 3 51 | 1 | 1 81d |
| Manganese | 6 015 | 276 | | 2 2 |
| Nickel | 133 | 6 12 | | 17 3 |

Table 3 3 Estimate of Pollutant Concentrations in Fish Cove from Ground Water Migration

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(1)From results of SOCEM modeling for all available wells
(2)From results of EPCON modeling
(3)Used for chronic exposure for ingestion of surface water

| | Concentration (low tide) Du Ground-Water | a in Estuary no to (µg/1) ⁽¹⁾ | Contribu Surfe (k) | ution from ce Water g) ⁽²⁾ | Haximum Conce Estuary (| ntration in µg/l) ⁽³⁾ |
|----------------|--|--|--------------------------|---|----------------------------|-------------------------------------|
| âmmon 1 a F | 1060 | | 0 | | 1060 | |
| Arsenic | 1 16 | 3 | 0 | 032 | 1 | 7 |
| Cadmaum | 0 88 | 3 | O | 007 | 1 | 0 |
| Chromsum | 11 7 | | O | 025 | 12 | 1 |
| Iron | 2943 | | 31 | 8 | 3436 | |
| Lead | 3 51 | | O | 046 | 4 | 2 |
| Manganese | 276 | · | D | 58 | 285 | |
| Bickel | 6 12 | 2 | O | 062 | 7 | 1 |

Table 3 4 Total Loading to Estuary from Ground Water and Surface Water

(1) From EPCON modeling (2) From MUSLE modeling

(3) Calculated as sum of ground-water and surface water contributions Used for subchronic exposure for ingestion of surface water i

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A quantitative assessment of the fate of each indicator chemical (except ammonia) from hard and soft clams collected from Fish Cove was conducted by NiSDEC (1985) Clam tissue concentrations identified for each chemical parameter are as follows 0 18 ppm arsenic, 0 23 ppm cadmium, 0 70 ppm chromium, -150 ppm iron, 0 90 ppm lead, 23 ppm manganese, and 1 0 ppm nickel (NiSDEC, 1985) Values related to ambient chemical contaminant concentrations in surface water and a bioconcentration factor (BCF) - which describes the ratio of aquatic amimal tissue contaminant concentration to water contaminant concentration (U S EPA, 1988) are estimated in Appendix 2, Attachment C

Estimating contaminant concentrations in terrestrial animal tissue or in plant species cannot be reliably determined on available data

<u>Soll</u>

Direct contact with contaminated soils at North Sea Landfill site may lead to exposure to metals primarily through accidental ingestion Oral exposures may occur from inadvertent transfer of contaminated soil from fingers and hands to the mouths of children and young adults trespassing onto the site or by poor hygiene habits of site workers Oral exposures are expected to be minor since the main entrance to the site is fenced and secure from unauthorized entry However, remote areas of the site have only natural boundaries that may be accessible by trespassers The exposure scenario developed for this study, however, does assume free access to the site by neighborhood children and adults for exploring or playing over the contaminated soil

Mean contaminant concentrations in surface soil samples (12 to 18 inches) were used to calculate direct contact exposures (Table 3 5) Each sample result was given-equal weight in the determination of mean contaminant concentration

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| Table 3 5 |
|---------------------------------------|
| Concentrations of Indicator Chemicals |
| in Surface Soil Samples Collected at |
| North Sea Landfill Site (mg/kg) |

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| Contaminant | Minii | ກບກ | Max | LMUM | Arithmet | tic Mean |
|-------------|-------|------------|------|------|----------|----------|
| Ammonia | • | | - | | - | |
| Arsenic | 1 (| 0 | 11 | 0 | 3 | 58 |
| Cadmium | 0 | 5 | 2 | 2 | 0 | 76 |
| Chromium | 1 | 0 | 9 | 0 | 2 | 92 |
| Iron | 1870 | 0 | 7190 | 0 | 3739 | 0 |
| Lead | 0 | 5 | 42 | 0 | 5 | 38 |
| Manganese | 23 | 0 | 135 | 0 | 68 | 21 |
| Nıckel | 5 | 0 1 | 21 | 0 | 7 | 33 |

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Wind transported dust may be an inhalation hazard at the North Sea Based on laboratory analysis of samples collected from Landfill site the ground surface at the landfill, soils onsite are contaminated by metals The major exposure pathway for these metals is expected to be as The fugitive dust is released into the air windblown, or fugitive, dust through vehicular traffic The landfill is presently still in use and during the peak season (summertime), more than a thousand vehicles per day may drive on and off the site

In order to assess the contaminant concentrations present onsite due to fugitive dust emissions, details about site usage were acquired Map and site observations and interviews with site personnel provided most of the information necessary to estimate the rate of dust generation The fugitive dust emission calculations require information about mass fraction of contaminant in particulate emissions vehicle-kilometers per hour travelled onsite percent of silt in the road surfaces, vehicle speed, weight and number of wheels, and the number of days per year with at least 0 245 mm (0 01 inches) of precipitation Two sets of data were used to evaluate dust emissions at the North Sea Landfill site In one scenario conservative emission rate estimates were derived from information gathered at the site These high estimates were used for calculation of sub-chronic risk The other scenario involved average values for many of the parameters rather than maximum values The chronic risk evaluation, based on these data, more realistically approximate the long term effects of inhalation of fugitive dust at the Attachment F of Appendix 2 contains details about the terms and site equations used to assess fugitive dust emissions and downwind concentrations of contaminants in both scenarios

The emission rate calculation for the first (conservative) scenario is as follows

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$$Q_{10} = [\alpha E_{10} Vk]$$
 (GRI, 1988)

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Where

| | Q ₁₀ <i>α</i> Ε | - emission rate of particles 10 microns and smaller (mg/hr) - mass fraction of contaminant in particulate emissions, |
|-----|----------------------------------|---|
| and | -10 Vk | an emission factor, vehicle-kilometers travelled onsite in one hour, totaled across all vehicles |

The mass fraction of contaminant in particulate emissions, α , was approximated using the maximum contaminant concentrations in surface soils acquired from the site investigation Maximum values were used for a conservative estimate of subchronic exposure These values are found in Table 3 5 of this report

According to site personnel, daily vehicular traffic onsite varies from a winter low of about 450 vehicles to a summertime high of 1,200 vehicles (Gilbride 1989) To provide the most conservative estimate of contaminant concentration, the number of vehicles used in this evaluation was chosen to be 1 200 The vehicle-kilometers travelled onsite, Vk, was estimated using an average vehicle speed of 15 km/hr and 0 6096 km as the average distance travelled onsite Given an average 8-hour day of landfill usage the average vehicle-kilometers travelled onsite was determined to be 91 44

The emission factor, E_{10} used herein differs slightly from the one used in the SEAM (U S EPA, 1988), which is based on data from heavier equipment (up to 142 metric tons as opposed to a maximum of 26 tons) The emission factor was calculated as follows

 $E_{10} = 0.85 (s/10) (S/24)^8 (W/7)^{0.3} (W/6)^{1.2} ((365-p)/365)$ (GRI, 1988) Where

| E ₁₀ | emission factor for an unpaved road per vehicle-kilometer of travel (kg), |
|-----------------|---|
| S | = percent silt in road surface $(0 < s < 100)$, |
| S | - mean vehicle speed (km/hr), |
| W | - mean vehicle weight (metric tons, Mg), |
| W | - mean number of wheels (unitless), |
| P | mumber of days per year with at least 0 254 mm (0 01 inches) of precipitation (unitless) |

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The exact percentage of silt present in the road surface was not determined in the site investigation This figure can be estimated from the dominant soil type in the vicinity Most of the soils in the area of the landfill are loamy sand (USDA, 1975), which, by definition, contain between 0 and 30 percent silt (AGI, 1982) Thirty percent was chosen as the most conservative value

The vehicles vary in weight and number of wheels Approximately 1,100 of the vehicles using the landfill on August 6, 1989 were cars and light trucks (Gilbride, 1989) These privately owned four-wheeled vehicles carry minor amounts of garbage and weigh approximately 2 metric The remaining 100 vehicles using the site are either 6-, 10tons each or 18 wheeled trucks and/or tractor trailers, which weigh between 10 tons and 40 tons The average number of wheels for trucks used in the calculations was chosen to be 10 and the average weight was estimated to be 20 metric tons Additionally, 3 large four-wheeled earth-moving vehicles are used by the landfill staff to redistribute and bury the These vehicles weigh approximately 40 tons each solid waste The overall average number of wheels for vehicular usage of the landfill was determined to be 4 5 and the average vehicle weight was calculated as 3 51 metric tons

Because site specific information was unavailable, the number of days with at least 0 245 mm (0 01 inches) of precipitation was determined from Figure 2-3 of the Superfund Exposure Assessment Manual (U S EPA, 1988) The site is between the 120 and 140 day contours so 130 was chosen as a reasonable estimate

For the second (more realistic) scenario the following value were changed to evaluate a long-term or chronic risk

In the vehicle-kilometer per hour calculation, an annual number of 825 vehicles per day was chosen instead of the more conservative number of 1,200 vehicles This annual average reflects the winter and summer traffic variability The vehicle speed onsite was lowered from 15 kilometers to 10 kilometers to account for vehicles stopping or walting

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in line to dump refuse These changes yielded an average vehicle-kilometer per hour of 62 87

The mean contaminant concentration in surface soils was chosen instead of the maximum value to represent long-term conditions These values are found in Table 3 5 of this report

The percentage of silt on the road surface was conservatively estimated as 30 percent in the first (conservative) scenario For the more realistic case an average value of 15 percent was used

The estimates of average weight and number of wheels are not likely to change with the season The ratio of commercial travel to private vehicles is presumed to remain the same in winter as it is in summer

Fugitive dust emission rates from short-term and long-term vehicular traffic at the North Sea Landfill are presented in Table F-1 of Appendix 2 Attachment F

The airborne pollutants at the North Sea Landfill site are expected to have the most impact on individuals working at the landfill In order to evaluate the contaminant concentrations onsite, a model designed for short distances should be used The EPA's Graphical Exposure Modelling System (GEMS) uses Gaussian dispersion algorithms that are invalid when used for distances less than 100 meters (U S EPA, 1988) An alternative to the approach used by GEMS Atmospheric Modelling System (GAMS) is by considering simple conservation of mass in the dispersion of contaminated particles A near field box model, which is accurate at short downwind less than 100 meters), was selected because it is distances (1 e applicable to scenarios where the receptor is onsite or very nearby (Pasquill, 1975 and Horst, 1979 as cited in GRI, 1988)

The equations for the near field box model are presented below

C = Q/(H W u)

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(GRI, 1988)

Where

- C = concentration of contaminant in ambient air onsite $(\mu g/m^3)$
- Q = emission rate of contaminant ($\mu g/s$)
- H = downwind height of box (m),
- W = width of box (m),

and u = average wind speed through the box (m/s)

The emission rates and predicted concentrations for the chemicals of interest were calculated as described above and are found in Table F-1 of Appendix 2

The downwind height of the box H is estimated using a specific relationship between the length and height of the box As seen in Table F-2 of Attachment F, Appendix 2 (Pasquill, 1975 and Horst, 1979 as cited in GRI 1988), a box height of 1 4 m, which roughly corresponds to the human breathing zone, provides a distance from source to receptor of 10 m These values allow evaluation of the onsite risks associated with chemical contaminants in the breathing zone A less conservative evaluation of what a worker might be exposed to during 30 years onsite would involve inhaling dust at a variety of locations and distances from the source To provide a concentration comparable with that variability a distance from receptor to source of 50 meters was chosen The box height that corresponds to that distance is 3 8 from Table F-2 of Appendix 2, Attachment F

Average wind speed through the box, u, is estimated with the following equation

$$u = 0.22$$
 (v) $ln(2.5 H)$ (GRI, 1988)

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Where

v = the average annual wind velocity at the site This value was determined from the National Weather Service station in Islip, New York The average wind speed wa 8 7 miles per hour (3 75 m/s)

The resulting concentrations of contaminants in the air for the short-term and long-term exposures are presented in Table 3 6

TABLE 3 6CONTAMINANT CONCENTRATION IN AMBIENT AIR THROUGH DUST GENERATIONFROM VEHICLE TRAFFIC AT NORTH SEA LANDFILL SITE

| | | Concen | tration $(\mu g/I)$ | m ³) |
|-------------|------|-------------|---------------------|------------------|
| Constituent | Mean | (long-term) | Maximum | (short-term) |
| Arsenic | 2 | 08E-02 | 1 | 25E+00 |
| Cadmıum | 4 | 41E-03 | 2 | 51E-01 |
| Chromium | 1 | 70E-02 | 1 | 02E+00 |
| Iron | 2 | 17E+01 | 8 | 16E+02 |
| Lead | 3 | 12E-02 | 4 | 78E+00 |
| Manganese | 3 | 96E-01 | 1 | 53E+01 |
| Nickel | 4 | 26E-02 | 2 | 39E+0 0 |

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3 3 Populations Exposed

A quantitative analysis of exposed populations was completed to determine the likelihood of receptor contact with environmental contaminant data presented in Section 3.2 Exposed population screening involved an examination of each of the exposure pathways listed in Table 3.7

Identification and enumeration of exposed human populations was derived from 1980 census data compiled by the U S Department of Commerce Census information for 1980 indicate that the total population for North Sea is 1,163 Information was obtained to provide age and sex data on potentially exposed populations near the North Sea Landfill Females (all age groups) comprise 53 percent (617) of the population Child bearing age groups, conservatively figured at 15 to 54 years of age comprise 29 percent (338) of the population The total population of elderly age 65 years and over, was 14 percent (162) The median age for all age groups is 40 years (USDOC, 1988)

Dermal Exposure

Chemical contaminants released to Fish Cove are expected to lead to dermal exposures to individuals using the surface water for recreational purposes Fish Cove is classified by New York State as Class B waters Recreational exposures may result from many activities, primarily swimming boating and fishing (Whitmyre, 1987) Dermal absorption of chemical contaminants contained in Fish Cove sediment samples may also occur Inadvertent ingestion of surface water may also occur during recreational activities

In order to enumerate the potentially exposed populations (dermal route), a national average of individuals who use natural bodies of water (includes oceans, rivers, lakes, coves) was used to provide a conservative estimate Based on data from the Bureau of Outdoor Recreation, 34 percent of the total population swims outdoors in natural

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Table 3 7Potential Release Mechanisms at North Sea Landfill Site

| Process | Media Affected | Time Frame |
|---------------------|---------------------------------------|------------|
| Surface runoff | Surface water, soils, ground-water | Episodic |
| Leachate generation | Soils, ground-water, surface water | Continuous |
| Dust generation | Air | Episodic |



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surface water bodies (USDOI, 1973) Using this percentage estimate then approximately 395 individuals (34 percent of 1,163) may potentially be dermally exposed to the chemical contaminants of concern at Fish Cove Dermal exposure through direct contact will be minimal

Ingestion Exposure

Individuals who swim in Fish Cove may be subject to ingestion exposures to contaminants Ingestion of contaminated water while swimming is inadvertent It has been estimated that up to 50 milliliters of surface water may be accidentally ingested during each hour of swimming (Whitmyre et al, 1987)

Since no data exist that could be used to quantify the populations potentially exposed via this route, the same assumption as the previous example was used in enumerating these populations Therefore up to 395 individuals (34 percent of 1,163) may be potentially exposed to contaminated surface water via the oral route

Presently the Town of North Sea receives its water from the Town of Southampton's public water supply

Ingestion exposures are also expected through the inadvertent ingestion of contaminated soil adhering to fingers and hands of individuals directly contacting soils or sediment

Populations Exposed by Biota Route

Individuals who eat fish and shellfish that are caught from Fish Cove may be potentially exposed to the contaminants that may accumulate in edible portions of fish and shellfish

According to the National Marine Fisheries Service some of the species of fish and shellfish migrating into Fish Cove from North Sea Harbor and Little Peconic Bay may include eels, flounder, porgies, sea bass, whiting clams, mussels, oysters, and scallops

Using the same example for enumerating the population of individuals ingesting fish and shellfish from Fish Cove, up to 395 individuals

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(34 percent of 1,163) may potentially be exposed to contaminants after ingesting fish and shellfish from Fish Cove

Populations Exposed by Direct Contact

Neighborhood children or young adults trespassing onto the site may be potentially exposed by direct contact (ingestion) to contaminants in the soil Exposures assume that one-third of the population of 0 to 19 year olds (male and female) living in North Sea may visit the site to play The 1980 census data enumerate a total of 353 persons in the 0 to 19-year-old age group (USDOC, 1988) One-third of this total, 118, is therefore the number of persons assumed to be potentially exposed by this route Exposures are assumed to occur five times a year for 5 years (based on professional estimate on rate of occurrence) during an average 70-year lifetime

Populations Exposed by Inhalation of Dust

Individuals depositing refuse at the North Sea Landfill will be potentially exposed by inhalation of fugitive dust generated through vehicular traffic onsite Additionally, trespassers to the site will be exposed by inhalation All of these individuals will be exposed for short periods of time

The greatest exposed population includes landfill workers who remain on the site for extended periods These individuals will be breathing contaminated dust particles emitted from the landfill Exposures for these workers are assumed to last 8 hours per day, 5 days per week, 48 weeks per year, and 30 years out of a 70-year lifetime

3 4 Extent of Exposure

The final step in the exposure assessment is the calculation of dose incurred Exposure to the contaminants released from the North Sea Landfill site considers collectively each of the various routes the receptor may be exposed to these toxic substances, the frequency and duration of exposure, and the amount of contaminated material (concentrations) present

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Exposure estimates contained in this report are based on an average adult body mass of 70 kilograms (20 kilograms for children) and an assumed 70-year lifespan (U S EPA, 1988)

Toxic effects of dermally adsorbed contaminants is assumed to have identical toxic effects as oral exposures This assumption is made because U S EPA has not developed toxicity values for contaminants via the dermal route

Dermal Exposures

Dermal exposure to inorganics (metals) generally occurs when these contaminants are present in elemental (pure) form or when organically (methylated) bound Fate analysis indicates that these forms will not be present in significant quantities, but rather as complexed inorganics (e g , carbonates, hydroxides) Most metals exhibit a high affinity for particulate matter therefore minimizing their availability for transport across the skin barrier, or the contaminants will precipitate in an aqueous medium

In order for contaminants to be absorbed through the skin via direct contact, a substance must pass through epidermal cells, the cells of the sweat or sebaceous glands, or hair follicles Most substances pass through epidermal cells Chemicals must then pass through a series of other cellular layers Absorption through the various skin layers is dependent on chemical polarity solubility, and molecular weight (Casarett, 1986)

Most of the contaminants addressed in this report (i e, arsenic, cadmum, chromium, iron, lead, manganese, and nickel) are generally sorbed onto sediment particles and are not expected to be highly available for uptake through the skin

Versar calculated the risks associated with exposure for individuals who may swim or play in contaminated areas (Versar, 1986)

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Dermal exposures due to direct contact with contaminated surface water and sediments were determined based on the concentration of the

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indicator chemical in the surface water the extent of contact, and the duration of contact with each contaminant Annual exposures (dosage incurred over a one-year period) is based on a national average of 7 occurrences or events per year (USDOI, 1973) Dermal exposures, presented in Table 3 8, were computed using the following equation

DEX = D x A x C x Flux

Where DEX = Estimated dermal exposure per event (µg/event)
D = duration of exposure event (hours/event)
A = skin surface area available for contact, (18 150 cm²
is an adult average)
C = contaminant concentration in water, (µg/l), and
Flux = flux rate of water across skin or dermal permeation
rate, (0 5 µg/cm²/hour)

Dermal exposure due to direct contact with contaminated soil or sediment can be calculated as

| Where | DEX | | Dermal exposure (mg/event) |
|-------|-----|----|--|
| | WF | 60 | Weight fraction of chemical substance in soil or |
| | | | sediment (unitless) |
| | A | - | Skin surface area exposed per event (cm ² /event) |
| | DA | | Dust adherence (mg/cm ²) |

Dermal exposures assume that the average skin surface area of an adult is $1,175 \text{ cm}^2$ and dust adherence is 1.45 mg/cm^2 (Versar, 1986) The dose incurred through dermal exposure is computed by multiplying the frequency of events (7 events per year) and dividing by 365 days per year and assuming an average adult weight of 70 kilograms (Table 3 9)

Ingestion Exposure

Ingestion exposures occurring to individuals swimming in Fish Cove were based on estimated estuary concentrations of each of the indicator chemicals, the expected ingestion rate, and the duration and frequency of swimming in the estuary Table 3 10 presents the intakes from inadvertent ingestion of surface water Ingestion exposures were computed as follows

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TABLE 3 8 INTAKE FROM DERMAL ABSORPTION OF CHEMICALS IN SURFACE WATER VIA DIRECT CONTACT (SUBCHRONIC AND CHRONIC)

| CHEMICAL | Short-term Water Conc (ug/1) | Long-term Water Conc (ug/1) | Skin Surface (cm2) | Duration of Exposure (hours/event) | Dermal Permeation rate (ug/cm2 hr) | Subchronic TWA Dose** (mg/kg day) | Chronic TWA Dose*** (mg/kg day) |
|-----------|------------------------------------|-----------------------------------|--------------------------|--|--|---|---------------------------------------|
| Ammonia | 1 06 E+03 | 6 66E+02 | 18150 | 26 | 0 5 | 2 78E-05 | 1 23E-06 |
| Arsenic | 1 68 B+00 | 7.40E-01 | 18130 | 26 | 0 3 | 4 40 8- 08 | 1 37 E-0 9 |
| Cadnium | 1 00B+00 | S 53B-01 | 18150 | 26 | 0 5 | 2 62B-08 | 1 02E-09 |
| Chromium | 1 218+01 | 7 37 8+0 0 | 18150 | *26 | | 3.178-07 | 1 36E-08 |
| Iron | 3 44 8 +03 | 1 858+03 | 18150 | 26 | 0 5 | 9 01B-03 | 3 428-06 |
| lead | 4 20B+00 | 2 21 8+00 | 18150 | 26 | 0 5 | 1.108-07 | 4 08 E-0 9 |
| Manganese | 2 858+02 | 1 73E+02 | 18150 | 26 | 0.5 | 7.4 78-06 | 3 20B-07 |
| Nickel | 7.10 6+0 0 | 3 85E+00 | 18150 | 26 | 0.5 | 1.86B-07 | 7 10E-09 |

 Exposure - permeation rate x conc x skin area x duration
 Based on 7 events in 90 days
 Based on 7 events per year and 20 years of exposure over 70 year lifespan Notes: *

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| | CHEMICAL | Maximu Concen (mg | m Soil tration /kg) | Mean Concer (m | n Soil ntration g/kg) | Skin Area (cm2) | Adh (mg | erance /cm2) | Subcl TWA (mg/l | hronic Dose * kg day) | Chi TWA I (mg/l | ronic Dose ** (g day) |
|---|-----------|-------------------------|---------------------------|----------------------|-----------------------------|-----------------------|------------|-----------------|-------------------------|-----------------------------|-----------------------|-----------------------------|
| | Amonia | 0 | 00E+00 | 0 | 00 E +00 | 1 17E+03 | 1 | 45E+00 | 0 | 00E+00 | 0 | 008+00 |
| | Arsenic | 8 | 70 E +00 | 3 | 58 6 +00 | 1 17E+03 | 1 | 45E+00 | 1 | 65E-05 | 4 | 77 8 -07 |
| | Cadmium | 2 | 20 B +00 | 9 | 60 E- 01 | 1 17E+03 | 1 | 45 E+00 | L aj | 16 E-06 | 1 | 01 8-07 |
| | Chromium | 9 | 008+00 | 2 | 92 8 +00 | 1 17E+03 | 1 | 4 52+00 | 1 | 70E-05 | 3 | 89 2 -07 |
| | Iron | 7 | 19 2+03 | 3 | 74 E +03 | 1 17 E+03 | 1 | 45 E+ 00 | 1 | 36E-02 | 4 | 99 8 -04 |
| 0 | Lead | 6 | 208+01 | 5 | 38B+00 | 1 17 8+03 | 1 | 45e+00 | 7 | 95E-05 | 7 | 18 e -07 |
| - | Mangenese | 1 | 358402 | 6 | 828+01 | 1 178403 | 1 | 45 E +00 | 2 | 36 e-0 4 | 9. | 10E-06 |
| | Nickel | 2 | 108401 | 7 | . 33 8 +00 | 1.17B+03 | 1 | 45 E +00 | 3 | 98E-05 | 9 | 78 B-0 7 |

TABLE 3 9 INTAKE FROM DERMAL ABSORPTION OF CHEMICALS IN SURFACE SOIL VIA DIRECT CONTACT (SUBCHRONIC AND CHRONIC)

Notes: * Based on 7 days of exposure over 90 days ** Based on 7 events per year for 20 years over 70 year lifespan

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| CHEMICAL | Maximum * concentration (mg/l) | Mean ** concentration (mg/1) | fluman Intake (1/hr) | Exposure Duration (hours/event) | Body Weight (adult) (kg) | Subchronic Daily Intake (mg/kg day)# | Chronic Daily Intake (mg/kg day)## |
|-----------|--------------------------------------|------------------------------------|----------------------------|---------------------------------------|--------------------------------|--|--|
| Annonia | 1 06E+00 | 6 66 E -01 | 0 05 | 26 | 70 | 1 53 E-0 4 | 6 78E-06 |
| Arsenic | 1 68 8-03 | 7 40 5 -04 | 0 05 | 26 | 70 | 2 43E-07 | 7 53E-09 |
| Cadmium | 1 00B-03 | 5 53 8- 04 | 0 03 | 26 | 70 | 1 44B-07 | 3 63E-09 |
| Chronium | 1 218-02 | 7 37 E-0 3 | 0 05 | 9 E | 70 | 1 75 E-06 | 7 49 8-0 8 |
| Iron | 3 44 8 400 | 1 852400 | 0 05 | 26 | 70 | 4 96E-0 4 | 1 88E-03 |
| Lead | 4 20B-03 | 2 21 E -03 | 0 05 | 26 | 70 | 6 07 E-0 7 | 2 25E-08 |
| Manganese | 2 85B-01 | 1 73 E-0 1 | 0 03 | 26 | 70 | 4 12 E-0 5 | 1.76E-06 |
| Nickel | 7.10 8-0 3 | 3.858-03 | 0 05 | 26 | 70 | 1 03B-06 | 3.91E-08 |

TABLE 3 10 INTAKES FROM INADVERTENT INGESTION OF SURFACE WATER

Notes: * Using results of EPCON and MUSLE modeling for concentrations at low tide. ** Using results of EPCON modeling for concentrations at high tide, excluding surface runoff contribution (MUSLE) # Based on 7 events in 90 days ## Based on 7 events per year for 20 years over a lifetime (70 yrs)

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 $GEX = G \times D \times C \times \frac{1 \text{ liter}}{1,000 \text{ ml}}$

Where

| GEX | | estimated ingestion exposure per event (mg/event) |
|-----|------------|---|
| G | 6 3 | ingestion rate of surface water (ml/hr) |
| D | 6 3 | duration of exposure event (hours/event) |
| С | - | contaminant concentration in water (mg/liter) |

Ingestion exposures to individuals eating fish and shellfish caught from Fish Cove were based on a person consuming 124 grams of fish per day (average, nonevent based) This estimate was derived for persons whom fish constitute a major portion of their diet (USDA, 1980) Concentration of each of the indicator chemicals in fish tissue (assumed to be derived at equilibrium from skeletal muscle) were computed using chemical specific bioconcentration factors (BCF)(U S EPA, 1986) and the estimated estuary concentrations of each indicator chemical (see Table 3 4) Estimated tissue concentrations in fish are presented in Appendix 2 Attachment C Ingestion exposures presented in Table 3 11 were computed by simply multiplying the ingestion rate with the contaminant concentration in fish tissue

Ingestion exposures to individuals potentially coming into direct contact with contaminated soils at the North Sea Landfill site were computed assuming an average child/young adult (0 to 19 years) model The exposure scenario assumes free access to a barren site, and that all soil contaminants adhering to fingers and hands will be consumed This exposure route is event-based, meaning exposure rate is dependent on the number of visits an individual will make to the site Since no information exists to estimate this rate, Versar conservatively estimated that the site would be visited five times per year for 5 years over an average 70-year lifetime Table 3 12 presents the ingestion exposures via direct contact, GEX_{DC}, computed as follows

$GEX_{DC} = WF_i \times A \setminus DA$

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Where WF₁ = weight fraction of contaminant i, (dimensionless) A = skin surface area (cm²) and DA = dust adherence factor, (mg/cm²)

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TABLE 3 11

INTAKE FROM INGESTION OF CONTAMINATED FISH * **EXPOSURE POINT: Fish Cove**

| | CHEMICAL | Bio- concentration factor | Human Intake Factor (TWA) (kg fish/kg day) | Maximum ** concentration (mg/l) | Subchronic Daily Intake (mg/kg day) | Mean *** concentration (mg/l) | Chronic Daily Intake (mg/kg day) |
|------|-----------|---------------------------------|--|---------------------------------------|---|-------------------------------------|--|
| | Amnonia | 0 | 0 00009 | 1 06E+00 | 0 00E+00 | 6 66E-01 | 0 00E+00 |
| | Arsenic | 44 | 0 00009 | 1 68E-03 | 6 65E-06 | 7 40 E -04 | 2 93 E- 06 |
| | Cadmium | 81 | 0 00009 | 1 00B-03 | 7 29 8 -06 | S 53E-04 | 4 03 B-0 6 |
| | Chromium | 16 | 0 00009 | 1 21 5-0 2 | 1 74 B-0 5 | 7 37B-03 | 1 06E-05 |
| | Iron | 1 | 0 00009 | 3~44 B +00 | 3 09B-04 | 1 85 E+0 0 | 1 662-04 |
| | Lead | 49 | 0 00009 | 4 205-03 | 1 858-05 | 2 21 E-0 3 | 9 74E-06 |
| - 7% | Manganese | 1 | 0.00009 | 2 85E-01 | 2 57B-05 | 1.73 E-0 1 | 1 56E-03 |
| | Nickel | 47 | 0 00009 | 7 1 0E-03 | 3 OOE-05 | 3 85 8-0 3 | 1 63B-05 |

 Calculations according to SPHEM
 Using results of EPCON and MUSLE modeling for concentrations at low tide
 Using results of EPCON modeling for concentrations at high tide, excluding surface water runoff contribution (MUSLE) Notes: +

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Table 3 12 INTAKE FROM SURFACE SOIL INGESTION VIA DIRECT CONTACT (SUBCHRONIC AND CHRONIC)

| CREMICAL | Maximum Concentration (mg/kg) | Mean Concentration (mg/kg) | Skin Area (cm2) | Adherance Factor (mg/cm2) | Body Weight (Child) (kg)* | Subchronic TWA Dose** (mg/kg day) | Chronic TWA Dose*** (mg/kg day) |
|-----------|-------------------------------------|----------------------------------|--------------------|---------------------------------|---------------------------------|---|---------------------------------------|
| Amnonia | 0 00 8 +00 | 0 00E+00 | 709 | 1 45 | 10 | 0 00E+00 | 0 00E400 |
| Arsenic | 8 70 8+00 | 3 58 E+ 00 | 709 | 1 45 | 10 | 4 97 E -05 | 3 60E-07 |
| Cadmium | 2 20 E+00 | 7.60E-01 | 709 | 145 | 10 | 1 26 8-0 5 | 7 648-08 |
| Chronium | 9_00E+00 | 2 92E+00 | 709 | 145 | 10 | 5 14 8-0 5 | 2 94 E-0 7 |
| iron | 7.1 96+0 3 | 3 74 E+ 03 | 709 | 1 45 | 10 | 4.11 8-0 2 | 3.76 E -04 |
| Lesd | 4 20 8+01 | 3 38 e +00 | 709 | 145 | 10 | 2.40 E-0 4 | 5 41 E-0 7 |
| Manganese | 1.358402 | 6 828+01 | 709 | 1 45 | 10 | 7.712-04 | 6 86 E -06 |
| Nickel | 2.1 08401 | 7 33B+00 | 709 | 145 | 10 | 1.208-04 | 7.37 E-0 7 |

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Notes: *

From Exposure Factors Handbook
 ## Based on 5 events in 90 days
 ### Based on 5 events per year and 5 years of exposure over 70 year lifespan

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Average skin surface area (both hands) was computed at 709 cm² Dust adherence was derived from commercial potting soil having a comparable loamy texture of 1 45 mg/cm² References and supporting calculations are presented as Appendix 2, Attachment D

Inhalation Exposure

Inhalation exposures to onsite workers were based on concentrations of chemicals in dust emitted from surface soil at the site, standard human inhalation rates, an 8-hour work day and a 5-day work week Dust inhalation exposures were calculated as

$$DI = C \times V \times \underline{D} \times \underline{5} \text{ days } \times \underline{1} \times \underline{1} \text{ mg}$$

$$24i \quad 7 \text{ days} \quad 70 \quad 1,000 \ \mu g$$

Where

DI = estimated inhalation exposure (mg/kg/day), C = concentration of chemical in air as dust $(\mu g/m^3)$, V = volume of air inhaled per day (m^3) , and D = duration of exposure per day (hr)

The fourth term in the equation for DI represents the fraction of days of exposure per week and the fifth term is the standard adult body weight in kilograms A conversion factor changes the units of C to (mg/m^3) For chronic exposure additional terms are introduced into the DI equation to account for the fraction of each work year that exposure occurs and the fraction of a lifetime over which one works Recall that the consideration that dust will not be emitted on rainy days is already taken into account by the models which predict the airborne concentrations C Table 3 1/3 calculates exposures to airborne dust

| TABLE | 3 | 13 |
|-------|---|----|
|-------|---|----|

CALCULATION OF EXPOSURES DUE TO FUGITIVE DUST INHALATION

| ~~~~~~~~~~ | | | | | | |
|------------|-------------------------------|------------------------------|--------------------------------|----------------------------------|---|---------------------------------------|
| CHEMICAL | Air Conc (Mean) (ug/m3) | Air Conc (Max) (ug/m3) | Exposure Volume (m3/day) | Exposure Duration (hr/day) | Subchronic Exposure * (mg/kg/day) | Chronic Exposure ** (mg/kg/day) |
| Ammonia | 0 00E+00 | 0 00E+00 | 22 4 | 8 | 0 00E+00 | 0 00E+00 |
| Arsenic | 2 08E-02 | 1 25E+00 | 22 4 | 8 | 9 52E-05 | 6 27 E -07 |
| Cadmium | 4 41B-03 | 2 51E-01 | 22 4 | 8 | 1 91E-05 | 1 33E-07 |
| Chromium | 1 70E-02 | 1 02E+00 | 22 4 | 8 | 7 77E-05 | 5 12E-07 |
| Iron | 2 1 78+01 | 8 16E+02 | 22 4 | 8 | 6 22B-02 | 6 54E-04 |
| Lead | 3 1 28-02 | 4 78 E +00 | 22 4 | 8 | 3 64 E -04 | 9 40E-07 |
| Manganese | 3 96 8 -01 | 1 53E+01 | 22 4 | 8 | 1 17 E-03 | 1 19 E-0 5 |
| Nickel | 4 26 8- 02 | 2 39 E +00 | 22 4 | 8 | 1 82 8-0 4 | 1 28E-06 |

Notes: * Based on 8-hr work day and 5-day work week ** Based on 8-hr work day, 5-day work week, a 48 week work year and a 30 year work lifetime

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4 0 TOXICITY ASSESSMENT

The objective of this toxicity assessment is to describe the nature and extent of potential health and environmental hazards that may be associated with the selected indicator chemicals at the North Sea Landfill site through the exposure routes identified in Section 3 0 of this report This section contains information on pharmacokinetics, human health effects, environmental toxicity and dose-response assessments for the contaminants of concern

In the pharmacokinetic sections, the absorption, distribution metabolism and excretion of particular chemicals are discussed Under human health effects the various human side effects from exposure to a chemical will be listed These effects may include toxicity, carcinogenicity mutagenicity and teratogenicity The environmental toxicity sections will focus on aquatic toxicity and will provide chemical concentrations known to be toxic to certain aquatic plant and The dose-response sections will discuss the correlation between anımals a particular dose of chemical and the response in the exposed These sections will also include several human health individual criteria such as carcinogenic potency values, and the chemical concentrations associated with specific cancer risk levels

Throughout this section, various environmental and toxicological criteria are listed for the selected chemicals These criteria are divided into several categories such as carcinogenic potency and acute aquatic toxicity For clarification of the significance of these criteria the different categories are defined below

EPA developed Water Quality Criteria to help protect human health and aquatic life Human health criteria include toxicity and carcinogenicity protection factors For carcinogens EPA established concentrations corresponding to several incremental lifetime cancer risk levels (i e , 1E-05, 1E-06, and 1E-07) A risk of 1E-05, for example, indicates a probability of one additional case of cancer for every 100,000 people exposed (Federal Register, 1980)

Aquatic life criteria are divided into acute and chronic values for both freshwater and saltwater environments The values are based on research data for plants and animals occupying various trophic levels A trophic level is a hierachical stratum of a food web characterized by organisms that are the same number of steps removed from the primary producers Acute values are maximum concentrations allowed at any time, and chronic values are maximum 24-hour average concentrations EPA developed this two-number criteria to describe the highest average ambient water concentration that will produce a suitable water quality while restricting the extent and duration of the excursions over that average to harmless levels (Federal Register, 1980)

Maximum Contaminant Levels (MCLs) are standards established under the Safe Drinking Water Act and represent the allowable concentrations in public water systems In general, MCLs are based on lifetime exposure (70 years) to the contaminant of concern for a 70 kilogram adult who consumes 2 liters of water per day In addition to health factors, EPA's development of MCLs also considered the technological and economic feasibility of removing the contaminant from the water supply (U S EPA, 1986)

EPA is also developing maximum contaminant level goals (MCLGs) Unlike MCLs, the MCLGs are entirely health based They are, therefore, always less than or equal to MCLs

Carcinogenic potency values are frequently used to help compare the carcinogenic effects among various chemicals These values are also used to determine risks to individuals The potency values (or unit risks) are upper 95 percent confidence limits on the slope of the dose-response curve Assuming low-dose linearity, the potency value represents the excess lifetime risk due to a continuous lifetime exposure of one unit of carcinogen concentration A generalized dose-response curve is shown in Figure 9 For inhalation and ingestion, typical exposure units are milligrams per kilogram of body weight per day Table 4 1 and 4 2 lists the carcinogenic potency factors and other toxicity values for the selected chemicals at the North Sea Landfill site (U S EPA, 1986)

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FIGURE 9 DIAGRAM OF DOSE-RESPONSE RELATIONSHIP

| Chemical | | Subchronic Acceptable Intake ical (mg/kg/day) | | Carcinogenic Potency Factor (mg/kg/day) | |
|----------|------------------------|--|-------------------------------------|---|--|
| 1 | Ammonia | NA | NA | NC | |
| 2 | Arsenic | 1 00E-03 | NA | 1 80E+08(A) ¹ | |
| 3 | Cadmium | NA | 1 00E-03 (food) 5 00E-04 (water) | NA | |
| 4 | Chromium (III) (VI) | 1 4E+01 2 5E-02 | 1 00E+00 5 00E-03 | NC NA | |
| 5 | Iron | NA | 8 57E-03 | NC | |
| 6 | Lead | NA | 1 4E-03 | NC | |
| 7 | Manganese | 5 00E-01 | 2 00E-01 | NC | |
| 8 | Nıckel | 2 OOE-02 | 2 00E-02 | NA | |

TABLE 4 1CRITICAL TOXICITY VALUES FOR INGESTION ROUTEFOR INDICATOR CHEMICALS AT NORTH SEA LANDFILL SITE

NOTES NA - Not available NC - Noncarcinogenic

1 - Letter in parentheses represents EPA Weight of Evidence classification

Cadmium has 2 AIC values, one for food and one for water

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TABLE 4 2

CRITICAL TOXICITY VALUES FOR INHALATION ROUTE FOR INDICATOR CHEMICALS AT NORTH SEA LANDFILL

| *** | | | |
|-----------|--------------------|--------------------|---|
| CHEMICAL | AIS (mg/kg/day) | AIC (mg/kg/day) | Carcinogenic Potency Factor 1/(mg/kg/day) |
| Ammonia | INHALATION NA | na | nc |
| Arsenic | NA | NA | 1 50 E+ 01 |
| Cadmium | NA | AK | 6 10E+00 |
| Chromium | NA | 5 10E-03 (+3 |) 4 10E+01 (+6) |
| Iron | NA | 8 60E-03 | NC |
| Lead | NA | 4 30E-04 | nc |
| Manganese | 3 OOE-02 | 3 00E-02 | NC |
| Nıckel | na | na | 1 19E+00 |
| | | | |



Notes NA - Not Available NC - Noncarcinogenic

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EPA has also developed acceptable intakes for noncarcinogens These values are expressed in units of milligrams per kilogram of body weight per day The Acceptable Intake for Subchronic Exposure (AIS) is the highest human intake of a chemical that does not cause adverse effects when exposure is short term (i e , for an interval which does not constitute a significant portion of the life span) (U S EPA, 1986a) The Acceptable Intake for Chronic Exposure (AIC) is the highest human intake of a chemical that does not cause adverse effects when exposure is long term (i e , for a lifetime) (U S EPA 1986a) The AIS and AIC for the selected chemicals are listed in Table 4 1

41 Ammonia

Human Health Effects

Ammonia can affect the human body if it is inhaled or if it comes in contact with the eyes or skin It may also affect the body if it is swallowed (NIOSH, 1981)

Ammonia is a severe irritant of the eyes, respiratory track, and It may cause burning and tearing of the eyes, runny nose, skin coughing chest pain, cessation of respiration, and death It may cause severe breathing difficulties which may be delayed in onset Exposure of the eyes to high gas concentrations may produce temporary blindness and Exposure of the skin to high concentrations of the severe eye damage gas may cause burning and blistering of the skin Contact with liquid ammonia may produce severe eye and skin burns Contact of the eyes, nose, throat and skin with solutions of ammonia may produce severe Repeated exposure to ammonia gas may cause chronic irritation of burns the eyes and upper respirator tract (NIOSH, 1981)

Ammonia and ammonium hydroxide injure cells directly by caustic action and causes extremely painful irritation of all mucous membranes Ingestion of ammonia causes severe pain in the mouth, chest, and abdomen with coughing, vomiting and shock-like collapse Gastric or espohageal perforation may occur later with exacerbation of abdominal pain, fever, and abdominal rigidity Lung irritation and pulomary edema may appear after 12 to 24 hours delay (Dreisbach, 1977)

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Environmental Toxicity

Ammonia consumes oxygen as a result of its biochemical oxidation to nitrite and nitrate and studies have found that a decrease in the dissolved oxygen concentration increased the toxicity of unionized ammonia to several species of freshwater fishes Gill hyperplasia, liver and blood pathology extensive necrotic changes tissue disintegration and death have all been documented results of ammonia exposure to fish EPA has recommended that ammonia concentrations not exceed 5% of the 96-hour LC_{50} of the most sensitive important species in the locality, or a maximum of 0 02 mg/l (EPA 1973)

Dose Response

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The fatal dose of ammonium hydroxide by ingestion is about 30 ml (1 ounce) of a 25 percent concentration

4 2 Arsenic

Pharmacokinetics

In mice approximately 90 percent of orally administered trivalent arsenic (As^{3+}) or pentavalent arsenic (As^{5+}) was absorbed through the gastrointestinal tract (Casarett 1986) In humans, up to 95 percent of administered inorganic arsenic is absorbed (U S EPA, 1984a) Following absorption into the blood arsenic was rapidly and widely distributed to all body tissues The highest percentage of arsenic was found in the liver and kidney (Clayton, 1981)

Arsenic is excreted primarily in urine The biological half-life of ingested inorganic arsenic is about 10 hours, and the half-life of methylated arsenic in humans is about 30 hours Arsenic is also excreted through desquamation of skin and in sweat (Casarett, 1986)

Results of studies indicate that placental transfer of arsenic is possible (Casarett 1986)

Human Health Effects

Arsenic poisoning produces a variety of effects in humans Acute poisoning of humans who have ingested as little as 130 mg of arsenic has been reported Acute poisoning is characterized by nausea vomiting diarrhea abdominal pain and severe gastrointestinal damage

Chronic arsenic poisoning is associated with digestive and nervous system problems liver damage and kidney problems Dermal effects of chronic toxicity include hyperkeratosis and arsenical melanosis Mucous membrane effects of chronic toxicity include irritation of the nose and pharynx Arsenic is a recognized carcinogen of the skin, lungs and liver It is a cumulative poison in mammals although a small amount is considered essential for normal life (Clayton, 1981)

Environmental Tolicity

A few cases of arsenic poisoning of domestic animals have been reported The poisoning caused hyperemia and edema of the gastrointestinal tract, hemorrhage of cardiac serosal surfaces and peritoneum and pulmonary congestion and edema

Inorganic forms of arsenic seem to be much more toxic to aquatic organisms than organic forms Arsenic trioxide is acutely toxic to adult freshwater animals at a concentration as low as $812 \ \mu g/l$ A level as low as 40 $\mu g/l$ can be toxic to the early life stages of aquatic organisms (Clement, 1985) Acute toxicity to saltwater fish occurs at 15 mg/l Some saltwater invertebrates are affected at much lower levels (Clement, 1985)

Dose-Response

Two studies on humans present useful dose-response information (Mizuta et al 1956, Tay and Seah, 1975, cited in ATSDR, 1987a) Tay and Seah (1975) investigated 74 individuals who had ingested

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arsenic-containing antiasthmatic herbal preparations for periods ranging from less than 6 months (intermittent ingestion) to 15 years Doses were estimated to be 2 5 mg of arsenic per day as arsenic oxide (trivalent arsenic) or 10 3 mg of arsenic per day as arsenic sulfides The following systems of the individuals were affected cutaneous (91 9 percent) neurological (51 3 percent) gastrointestinal (23 percent) hematological (23 percent) and renal and other (19 percent), 5 4 percent of the patients had internal malignancies

In the study by Tay and Seah the major effects in more than 10 percent of the subjects were generalized hyperpigmentation (arsenic melanosis) hyperkeratosis of palms and soles "raindrop" depigmentations palmar and plantar hyperhidrosis, multiple arsenical keratoses sensorimotor polyneuropathy fine finger tremors, persistent chronic headache lethargy weakness and insomnia psychosis gastritis or gastroenteritis mild iron deficiency anemia as a result of toxic marrow suppression and transient albuminuria without azotemia The internal malignancies consisted of two squamous-cell carcinomas of the lungs one squamous-cell carcinoma of the gall bladder, and one hemangiosarcoma of the liver Mizuta et al (1956) observed similar neurological effects in people who consumed approximately 3 mg of arsenic per day in contaminated soy sauce for 2 to 3 weeks (ATSDR 1987a)

Other investigators have indicated that airborne arsenic compounds are associated with skin lesions, cardiovascular and respiratory effects, and peripheral neuropathy, but no adequate exposure information is available for any of the studies (U S EPA, 1984a)

Chronic toxicity caused by arsenic ingestion was studied by Tseng (cited in ATSDR 1987a) Tseng (1977) investigated the relationship between blackfoot disease, a peripheral circulatory disease characterized by gangrene of the extremities and the arsenic concentration in drinking water of residents of the southwest coast of Taiwan A total of 40,421 individuals in 37 villages were included in the study Arsenic concentrations ranged from 0 001 mg/l to 1 82 mg/l The overall

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prevalence rate for blackfoot disease was 8 9/1,000, with a positive correlation between the prevalence rate and arsenic concentration and duration of intake This study established a NOAEL of 0 001-0 017 mg/l for blackfoot disease

Numerous arsenic compounds particularly trivalent inorganics have been associated with lung and skin carcinomas in humans In two studies investigators surveyed 40,421 residents of Taiwan who consumed artesian well water containing 0 01 mg/l to 1 8 mg/l for arsenic for 45 years to 60 years A dose-response relationship (Table 4 3) was established between the prevalence of skin cancer and arsenic consumption, which was based on arsenic concentrations in different wells and length of exposure (age) The overall incidence of skin cancer was 10 6/1,000, the maximum incidence was 209 6/1 000 in males over 70 years of age (U S EPA 1984a)

4 3 <u>Cadmium</u>

<u>Pharmacokinetics</u>

In humans both the respiratory and gastrointestinal tracts absorb cadmium The rate of gastrointestinal absorption is about 5 percent to 8 percent This rate is affected by dietary factors Diets that are low in calcium Vitamin D, protein zinc, iron, and copper significantly increase cadmium absorption in the gastrointestinal tract A deficiency in ascorbic acid has been shown to increase cadmium toxicity (U S EPA, 1984b)

In blood cadmuum binds, to red blood cells and high-molecular-weight proteins in plasma The blood cadmuum level in adults without excessive exposure is usually less than 1 μ g/dl (Casarett, 1986)

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The liver and kidneys contain approximately 5 percent to 75 percent of the body burden of cadmium The half-life of cadmium in the body is at least several years and may be as long as 30 years With continued retention, cadmium progressively accumulates in soft tissues (especially the kidney) until about age 50 when levels begin to slowly decline (Casarett 1986)

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| | Age (years) | | |
|----------------------|---------------|---------------|---------------------|
| Exposure Range (ppm) | 20-39 (30) | 40-59 (50) | <u>≥</u> 60 (70) |
| 0-0 29 | 0 0013 | 0 0065 | 0 0481 |
| 0 030-0 59 | 0 0043 | 0 0477 | 0 1634 |
| 0 6 | 0 0224 | 0 983 | 0 2553 |

TABLE 4 3DOSE-RESPONSE RELATIONSHIPS BETWEEN PREVALENCE OF
SKIN CANCER AND ARSENIC CONSUMPTION BY AGE

Source ATSDR, Toxicology Profile for Arsenic (1987a)

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The placenta may be a partial barrier to maternal cadmium but the fetus may become exposed with increased maternal exposure (Casarett, 1986)

Cadmium is excreted in both urine and feces In individuals of industrially exposed populations, much more cadmium is excreted in urine than in feces (Clayton 1981)

Human Health Effects

An ingestion dose of 15-30 mg (1/1 000 oz) of metal or soluble compounds may cause increased salivation, choking, vomiting, abdominal pain, anemia, kidney malfunction, diarrhea, and persistent desire to Symptoms may occur within 15 30 minutes after ingestion micturate (NYSDOH 1984)

Studies indicate that there is an increased incidence of prostatic cancer and possible kidney and respiratory cancer in workers who are exposed to airborne cadmium Cadmium causes birth defects in rats, mice, and hamsters whether or not it does so in humans is not known (NYSDOH, 1984)

Cadmium toxicity also affect calcium metabolism Persons with severe cadmuum nephropathy may develop kidney stones and excrete excess Corresponding skeletal changes include bone pain, osteomalacia calcium and osteoporosis (Casarett, 1986)

The International Agency for Research on Cancer has placed cadmium and certain cadmium compounds in Group 2B This group consists of substances for which there is limited evidence of carcinogenicity in humans, sufficient evidence of carcinogenicity in animals, and inadequate evidence of activity in short, term tests This classification is based on exposure to cadmium by inhalation Inhalation of cadmium dust Brief exposures to high cadmiun primarily affects the respiratory tract concentrations may be fatal No evidence has been found linking ingestion of cadmium with carcinogenicity in animals or humans (Federal Register 1985)

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Cadmium is an animal teratogen and reproductive toxin but this has not been adequately supported in a human model Evidence concerning the mutagenicity of cadmium in animals is equivocal (U S EPA 1984b)

Environmental Toxicity

Research data indicates that fish reproduction may be affected by cadmium in slightly to moderately polluted waters (Clement, 1985) Freshwater fish and invertebrates have acute 50-percent lethal concentration dose (LC_{50}) values ranging from $100-1000\mu g/l$ Salmonids are much more sensitive than other freshwater fish species (U S EPA 1980b) Bioconcentration factors are generally less than 1 000 but can reach 10 000 for some freshwater fish species Saltwater species are generally 10 times more tolerant to the acute effects of cadmium (Clement 1985)

A study was conducted on white-tailed deer to determine liver cadmium concentrations (Stansley 1988) Liver cadmium concentrations in 86 deer ranged from 0 07-23 2 ug/g dry weight The mean concentration was 4 02 ug/g Cadmium was found to accumulate in the livers of older Significant differences in liver cadmium concentration were anımals observed in deer from different areas in the study Deer from three of the areas surveyed had concentrations that were higher than those reported in the literature for normal populations Four deer had unusually high liver cadmium concentrations (19 0-23 2 ug/g) that suggest exposure to highly contaminated environments Concentrations in some animals raise concerns about the health of the animals and also about the health of people who consume deer liver (Stansley, 1988)

Dose-Response

Some of the effects of low doses of cadmuum on humans are shown in Table 4 4 EPA has calculated a temporary adjusted acceptable daily intake (AADI) for cadmuum of 0 018 mg/l These calculations used the

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| | | TABLE 4 | 4 | | |
|-------|---------|----------|------|-----|---------|
| HUMAN | CHRONIC | TOXICITY | DATA | FOR | CADMIUM |

| Form of Cd | Route of Exposure | Cd Dose | Length of Exposure | Effects |
|----------------------------|----------------------|--------------|--------------------|--|
| Not reported ¹² | Oral | 228 ug/d | Lifetime | Itai-Itai disease tubular proteinuria |
| Not reported ¹ | Oral | 250-350 ug/d | 30 yr | Renal dysfunction |

¹Friberg et al (1974) cited in U S EPA (1984b) ²U S EPA (1980b) cited in U S EPA (1984b)



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value of 200 μ g/g for the critical (threshold) concentration of cadmium in the renal cortex resulting in renal dysfunction, and a lowest observed adverse effects level (LOAEL) value of 0 352 mg Cd/day The LOAEL value was derived by assuming that 4 5 percent of the daily oral dose was absorbed and 0 01 percent per day of the total body burden was excreted The AADI was developed using an uncertainty factor of 10 and assuming of 2 1/day of water were consumed

The current MCL for cadmium is 0 01 mg/l This level was based on the critical concentration of cadmium in the renal cortex $(200\mu g/g)$ 5-percent gastrointestinal absorption, rapid excretion of 10 percent of the absorbed dose, and 0 05-percent daily excretion of the total body burden

The National Academy of Sciences and the World Health Organization (WHO) have determined a guideline of 0 005 mg/l cadmium EPA is proposing that 0 005 mg Cd/l be the recommended maximum contaminant level (RMCL) or maximum contaminants level goal

4 4 <u>Chromium</u>

<u>Pharmacokinetics</u>

Chromium exists at several oxidation states within a variety of compounds Pharmacokinetic properties vary with chromium species and with the chromium compound and its solubility Hexavalent chromium (Cr^{6+}) is of most concern for humans from a toxicological standpoint Humans absorb approximately 2'1 percent of ingested hexavalent chromium (Donaldson [1966] cited in U S EPA, 1984c)

In a study by Baetjer (1959), 200 g of sodium chromate and potassium dichromate (chromate salts) were injected into the tracheas of guinea pigs After 24 hours, 13 percent of the dose had been eliminated in the urine, 11 percent remained in the lungs, 8 percent remaining the the red blood cells, 1 percent remained in the plasma and about 4 and 3 percent remaining the the liver and kidneys, respectively After 140 days, chromium was still present in the lungs and spleen but decreased to very

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low levels in all other tissues The amount of chromium in the spleen peaked at 30 days because of the uptake of disintegrating chromium-bearing red blood cells (cited in Clayton 1981)

In the same study Baetjer (1959) investigated the metabolism of chromium chloride and the results were not the same as those for chromate salts Chromium in this compound is at a valence of 3+ After 24 hours 6 percent had been excreted in urine, 45 percent of the dose was in the lungs and only trace amounts remained in other tissue Blood plasma contained greater amounts of chromium than the blood cells

In rats fed low levels (0 45 to 11 ppm) of hexavalent chromium, the highest amounts of chromium were found in the spleen thin bones, the kidney, and the liver No differences between sexes were seen Rats fed 25 ppm trivalent chromium (Cr^{3+}) retained about 1/5 to 1/10 the amount of hexavalent chromium retained earlier (MacKenzie [1958] cited in Clayton [1981])

In the general human population tissue concentrations of chromium (total) are as high as 7 g/kg in the lungs and lower levels occur in the liver and kidneys (Schroeder [1962] cited in Casarett [1986]) Blood chromium concentrations are between 20 μ g/l and 30 μ g/l in people without an excess exposure to chromium. The chromium in blood is evenly distributed between erythrocytes and plasma. Occupational exposure to chromium correlates with increases in chromium in red blood cells. In persons without excess exposure, chromium is excreted in urine at a rate usually less than 10 micrograms per day (μ g/day) (Underwood [1977] cited in Casarett [1986])

Biliary excretion also removes chromium from blood In the liver chromium is excreted in bile, which subsequently passes to the small intestines The ratio of the concentration of chromium in the bile to that in plasma is less than one (Casarett, 1986)

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Human Health Effects

The main acute effect of chromium ingestion is acute renal tubular necrosis (Langard [1979] as cited in Casarett [1986]) In a fatal case of chromium poisoning from chromic acid crystals, the person's kidneys developed extensive lesions especially of the convoluted tubules The blood had elevated levels of urea inorganic phosphates amino acids and creatinine (Major [1922] cited in Clayton [1981])

Chronic exposure to hexavalent chromium can cause inflammation of the nasal mucosa, ulceration and performation of the nasal septum, liver and kidney damage and internal hemorrhage (Federal Register 1985 Clement, 1985) Hexavalent chromium in the form of chromic acid can cause dermatitis and ulceration of the skin (Federal Register, 1985)

Studies on individuals who work at chrome production and chrome pigment facilities have shown an association between chromium exposure and cancer of the respiratory tract (Norseth [1981] cited in Casarett [1986]) It is not clear whether chromium compounds cause cancer at sites other than the respiratory tract however, a slight increase in cancer of the gastrointestinal tract has been reported (Casarett 1986)

The IARC has classified chromium and certain chromium compounds in Group 1 For Group 1 substances there is sufficient evidence of carcinogenicity in humans and animals This classification is based on inhaled hexavalent chromium

Environmental Toxicity

No information could be found concerning the toxic effects of chromium on wild life and domestic animals

Chromium is an essential nutrient that accumulates in aquatic and marine blota to levels much greater than levels in ambient water Concentrations of chromium in biota, however, are usually less than levels in sediments (U S EPA, 1979)

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Other experiments have shown that chromium can pass through the food chain and that other metals accumulated by benthic species may enhance chromium mobilization through biota (Patrick [1976] cited in U S EPA [1979]) According to U S EPA (1979), bioconcentration factors for chromium range from 70 (in fish muscle) to 4,000 (in freshwater plants)

Chromium does not accumulate in plants used for human food or animal feed (Clement 1985) Chromium in plants is found primarily in the roots Trivalent inorganic chromium does not readily accumulated through food chains but organic chromium compounds may have much high bioconcentration rates (Clement, 1985)

Dose-Response

The current provisional AADI for chromium is 0 17 mg/l The study used to develop this value involved feeding rats up to 25 mg/l hexavalent chromium (Cr^{6+}) for 1 year (MacKenzie [1958] cited in Federal Register [1985]) To determine the provisional AADI, the following data were used a NOAEL of 2 41 mg/kg/day, an uncertainty factor of 500, and a water consumption rate of 2 liters/day

The present MCL for total chromium is 0 05 mg/l EPA is proposing an RMCL of 0 12 mg/l for total chromium based upon the provisional AADI of 0 17 mg/l and human exposure data (0 01 mg/day via the diet)

4 5 <u>Iron</u>

Pharmacokinetics

Iron is contained in the body of various forms, principally as hemoglobin Normal blood contains about 15 g of hemoglobin/100 ml and each gram of hemoglobin contains 3 4 mg of iron It may be calculated then that the total normal blood volume contains about 2 6 g of iron and each milliliter of blood contains 0 5 mg (Goth and Shore, 1978)

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In addition to hemoglobin iron is contained in ferritin the storage form for iron in the tissues, and in the serum attached to the carrier substance the globulin transferring Minute quantities are also present in the cytochrome enzymes and myoglobin of muscle Quantitatively hemoglobin and ferritin contain the bulk of the iron in the body, amounting to a total of about 4 g to 5 g Minute quantities are excreted into the feces and the urinary loss of iron is even less (Goth and Shore, 1978)

Human Health Effects

Iron is an essential element in plants and animals However the ingestion of excess amounts of iron produces toxic effects primarily associated with gastrointestinal irritation Severe poisoning may cause gastrointestinal bleeding, pneumonitis, convulsions and hepatic toxicity Chronic ingestion of excess iron may lead to hemosiderosis or hemochromatosis

Environmental Toxicity

Iron is an essential nutrient in plants and animals and most of the intake of iron by animals is through food There is no evidence that iron accumulates in the food chain to unacceptable levels

Dose-Response

No acceptable intake quantity levels have been established for either chronic or subchronic exposure to iron for either of the two exposure pathways of concern at the North Sea Landfill site (oral and dermal) This is primarily due to lack of information for deriving acceptable exposure values The ACGIH has set TWA TLU's and STEL's for soluble iron salts at 1 mg/m^3 and 2 mg/m^3 , respectively to protect from skin irritation The drinking water quality criterion for iron is 0 3 mg/L (U S EPA 1984e)

4 6 <u>Lead</u>

<u>Pharmacokinetics</u>

In humans lead is absorbed primarily through the gastrointestinal and respiratory tracts Several factors influence the gastrointestinal absorption of lead the most important of which are age and nutrition Adults absorb 5 percent to 15 percent of ingested lead and usually retain less than 5 percent of the absorbed lead More lead can be absorbed by children than by adults In one study an average net absorption of 41 5 percent, with 31 8 percent net retention, was found for infants on regular diets High mineral diets inhibit the absorption of lead, while diets that are low in calcium or iron enhance lead absorption (Casarett, 1986)

Human red blood cells contain more than 90 percent of the lead in blood Lead in red blood cells is associated primarily with the cell membrane and hemoglobin (Casarett, 1986) The level of blood lead is affected by inhalation and ingestion, and is a good indicator of recent lead exposure

The total body burden of lead may be divided into at least two kinetic pools which have different ranges of turnover The skeleton is the largest pool and has the slowest turnover rate (approximately 20-year half-life) The other kinetic pool is soft tissue (e g kidneys lungs and central nervous system) The rate of turnover in soft tissue depends on the organ that is involved (Casarett, 1986)

Lead easily traverses the placenta The concentration of lead in the cord correlates with but is slightly lower than the maternal blood level During pregnancy, material blood lead concentrations decrease This suggests that material lead is transferred to the fetus or is excreted (Casarett 1986) In adults, lead is excreted primarily through the kidneys

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Human Health Effects

Many lead compounds are sufficiently soluble in body fluids to be toxic Exposure of humans or experimental animals to lead can result in

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toxic effects in the brain and central nervous system, the peripheral nervous system the kidneys, and the hematopoletic system Chronic exposure to inorganic lead by ingestion or inhalation can cause lead encephalopathy and severe cases can result in permanent brain damage Lead poisoning may cause peripheral neuropathy in adults and children. and permanent learning disabilities that are clinically undetectable in children may be caused by exposure to relatively low levels Short-term exposure to lead can cause reversible kidney damage, but prolonged exposure at high concentrations may result in progressive kidney damage and possibly kidney failure Anemia due to inhibition of hemoglobin synthesis and a reduction in the life span of circulating red blood cells is an early manifestation of lead poisoning Several studies with experimental animals suggest that lead may interfere with various aspects of the immune response (Clement, 1985)

Environmental Toxicity

Although lead is known to occur in the tissue of many free-living wild animals including birds mammals fishes and invertebrates, reports of poisoning usually involve waterfowl There is evidence that lead at concentrations occasionally found near roadsides and smelters, can eliminate or reduce populations of bacteria and fungi on leaf surfaces and in soil Many of these microorganisms play key roles in the decomposer food chain (Clement, 1985)

Cases of lead poisoning have been reported for a variety of domestic animals, including cattle, horses dogs, and cats Several types of anthropogenic sources are cited as the source of lead in these reports Because of their curiosity and their indiscriminate eating habits, cattle experience the greatest incidence of lead toxicity among domestic animals (Clement 1985)

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Bioaccumulation of lead has been demonstrated for a variety of organisms Bioconcentration factors ranging from 42 for young brook trout to 1 700 for a snail have been reported For shellfish, bioconcentration factors ranging from 17 5 for the Quahog clam to 2,570

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for the blue mussel have also been reported There is no evidence that lead is biomagnified in the food web, however

Based upon available information fish accumulate very little lead in edible tissues, however, oysters and mussels are capable of accumulating high levels of lead Decreasing pH increases the availability of divalent lead the principal form accumulated by aquatic animals (U S EPA 1979)

Dose-Response

At blood lead levels of approximately 10 μ g/dl to 15 μ g/dl, indications of the following problems begin heme synthesis impairment in many different organ systems increasing degrees of pyrimidine metabolism interference altered nervous system activity, and interference of Vitamin D metabolism (Federal Register 1985)

A summary of the lowest blood lead levels associated with observed biological effects in various populations is shown in Table 4 5 Table 4 6 summarizes the blood lead levels associated with "no observed biological effects" in different populations

The current maximum containment level (MCL) for lead is 0 05 mg/l This MCL is based upon an estimate that this level in drinking water would contribute 25 percent to 33 percent of the lead normally ingested by a child and 33 percent of that normally ingested in food for an adult

The National Academy of Sciences has stated that the present drinking water standard of 0 05 mg/l may not provide a sufficient margin of safety especially for fetuses and young growing children, when other sources of environmental exposure to lead are considered (Federal Register 1985)

EPA is proposing a recommended maximum contaminant level or maximum contaminant level goal (MCLG) of 0 02 mg/l based upon the effects of lead on infants as a sensitive part of the population

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TABLE 4 5 SUMMARY OF LOWEST BLOOD LEAD LEVELS ASSOCIATED WITH OBSERVED BIOLOGICAL EFFECTS IN VARIOUS POPULATION GROUPS

| LOEL (µg Pb/dl 1n Blood) | Effect | Affected Population Group |
|--------------------------------|--|------------------------------|
| 10 | Aminolevulinic acid dehydratase (ALAD) inhibition | Children and adults |
| 15-20 | Erythrocyte protoporphyrin elevation | Women and children |
| 15-20 | CNS electrophysicological deficits | Children |
| 25-30 | Erythrocyte protoporphyrin elevation | Adult males |
| 40 | Increased urinary aminolevulinic acid (ALA) excretion | Children and adults |
| 40 | Anemia | Children |
| 40 | Coproporphyrin elevation | Children and adults |
| 50 | Anemia | Adults |
| 50-60 | Cognitive (CNS) deficits | Children |
| 50 60 | Peripheral neuropathies | Children and adults |
| 80-100 | Encephalopathic symptoms | Children |
| 100-120 | Encephalopathic symptoms | Adults |

Source USEPA (1984d)

| NOEL (µg Pb/dl in Blood) | Effect | Affected Population Group |
|--------------------------------|--------------------------------|------------------------------|
| 10 | Electrophysicological deficits | Children |
| 10 | Erythrocyte ALAD inhibition | Children and adults |
| 20-25 | FEP | Children |
| 20 30 | FEP | Adult females |
| 25-30 | FEP | Adult males |
| 30 | Cognitive deficits neuropathy | Children |
| 30-40 | Erythocyte ATPase inhibition | General |
| 40 | ALA excretion in urine | Children and adults |
| 40 | CP excretion in urine | Adults |
| 40 | Anemia | Children |
| 40 50 | Peripheral neuropathy | Adults |
| 50 | Anemia | Adults |
| 50-60 | Minimal brain dysfunction | Children |
| 60 70 | Minimal brain dysfunction | Adults |
| 60-70 | Encephalopathy | Children |
| 80 | Encephalopathy | Adults |

TABLE 4 6 NOELS IN TERMS OF BLOOD LEAD LEVELS

Source USEPA (1984d)

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4 7 <u>Manganese</u>

<u>Pharmacokinetics</u>

For daily manganese intake ranges from 2 mg to 9 mg, gastrointestinal absorption is less than 5 percent It is transported in plasma bound to a β_1 -globulin, thought to be transferrin, and is widely distributed in the body Manganese concentrates in mitochondria so that tissues rich in these organelles have the highest concentrations of manganese including pancreas, liver, kidney and intestines Biologic half-life in the body is 37 days. It readily crosses the blood-brain barrier and half-time in the brain is longer than in the whole body (Casarett 1986)

Manganese is eliminated in the bile and is reabsorbed in the intestine but the principal route of excretion is with feces This system apparently involves the liver auxiliary gastrointestinal mechanisms for excreting excess manganese and perhaps the adrenal cortex This regulating mechanism plus the tendency for extremely large doses of manganese salts to cause gastrointestinal irritation, accounts for the lack of systemic toxicity following oral administration or dermal application (Casarett 1986)

Human Health Effects

In humans manganese dusts and compounds have relatively low oral and dermal toxicity but they can cause a variety of toxic effects after inhalation exposure Acute exposure to very high concentrations can cause manganese pneumonitis increased susceptibility to respiratory disease, and pathologic changes including epithelial necrosis and mononuclear proliferation Chronic manganese poisoning is more common, but generally occurs only among persons occupationally exposed to manganese compounds Degenerative changes in the central nervous system are the major toxic effects Early symptoms include emotional changes, followed by a masklike face, retropulsion or propulsion, and a

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Parkinson's-like syndrome Liver changes are also frequently seen Individuals with an iron deficiency may be more susceptible to chronic poisoning (Clement, 1985)

Environmental Toxicity

Duplication of human exposure symptoms in experimental animals has only been partially successful In rabbits exposed by inhalation to manganese dust, manganese pneumonitis did not develop, but fibrotic change in the lungs were observed Central nervous system effects characteristic of chronic exposure in humans have only been reproduced in monkeys (Clement, 1985)

Dose Response

The acceptable daily intake of manganese from subchronic exposure (AIS) for oral exposure routes is 0 53 mg/kg/day The corresponding acceptable daily intake for chronic exposure (AIC) is 0 22 mg/kg/day (U S EPA, 1986) The U S EPA has set the freshwater criterion at 0 05 mg/l based on the organoleptic threshold for manganese, and the marine water criterion at 0 1 mg/l to protect consumers of seafood (U S EPA, 1985)

4 8 Nickel

Pharmacokinetics

Human and animal studies indicate that 1 percent to 10 percent of dietary nickel is absorbed (ATSDR, 1987b) Nickel solutions penetrate human skin and depending on type of nickel compound in solution and application conditions, up to 77 percent of the nickel can be absorbed Distribution of nickel occurs in humans in the nasal mucosa and lungs following inhalation and in the blood following oral exposure In animals, nickel was found in the lungs and kidneys following inhalation in the kidneys lungs liver heart, testes and central nervous system following oral exposure, and in various tissues following dermal exposure (ATSDR, 1987b)

Once absorbed, nickel binds to a number of serum biomolecular components A number of disease states and physicological stresses (i e myocardial infarction) have been reported to alter the metabolism of nickel in man and animals (ATSDR, 1987b)

Nickel is removed from the body in urine feces hair, and perspiration The half life of nickel in nasal mucosa has been estimated at 3 5 years, and at 100 hours in blood serum EPA conducted that age-dependent accumulation of nickel in soft tissue appears to occur only in the lungs (ATSDR, 1987b)

Human Health Effects

Dermal exposure to nickel is associated with contact dermatitis and effects only those sensitive to nickel (<15% of the human population) Oral and inhalation exposure to nickel has effects on the immune system the kidney and hematological and hematopoietic systems (ATSDR, 1987b)

Some nickel compounds associated with nickel refinery dust are classified as known human carcinogens via the inhalation exposure route Other data suggest that nickel and compounds may be mutagenic and elastogenic processes which are thought to be related to carcinogenesis

Environmental Toxicity

Values for LD₅₀ have been established for several nickel compounds via oral exposure ranging from hundreds to thousands of mg Ni/kg Acute exposures to nickel have been shown to effect the immune system and immune system components Nickel has also been shown to impair renal function Hematological effects and hematopoietic effects as well as decreased body weight have been observed in animals treated orally with nickel compounds Exposure of animals to nickel salts is associated with delayed fetal development and increase resorptions Genotoxicity and carcinogenicity have also been found as the result of nickel treatment in animals (ATSDR, 1987b)

The toxicity of nickel for freshwater organisms depends on the water's hardness nickel tends to be more toxic in softer water (Clement, 1985) Acute values for exposure to a variety of nickel salts, expressed as nickel, range from $50\mu g/1$ for <u>Daphnia magna</u> (a freshwater brachiopod) to 46 200 $\mu g/1$ for banded killifish at comparable hardness levels Chronic values range from 14 8 $\mu g/1$ for <u>Daphnia</u> magna in soft water to 530 $\mu g/1$ for the fathead minnow in hard water (Clement 1985) Residue data for the fathead minnow indicate a bioconcentration factor of 61 Freshwater algae experience reduced growth at nickel concentrations as low as 100 $\mu g/1$ (Clement 1985)

Acute values for saltwater species range from 152 μ g/l for mysid shrimp to 350 000 μ g/l for the mummichog (a killifish) A chronic value of 92 7 μ g Ni/l has been reported for mysid shrimp Bioconcentration factors ranging from 299 to 416 have been reported for oysters and mussels (Clement 1985) The growth of saltwater algae is reduced at nickel concentrations as low as 1 000 μ g/l

Dose-Response

For drinking water EPA advises that the following concentrations are probably associated with minimal risk 1 mg Ni/l for 10 days for children 3 5 mg Ni/l for 10 days for adults and 0 35 mg/Ni/l for lifetime exposure of adults Figure 10 shows dose-response information for nickel ingestion (ATSDR, 1987b)

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FIGURE 10 HEALTH EFFECTS FROM INGESTING NICKEL



5 0 RISK EVALUATION

51 <u>Human Health</u>

The objective of this risk evaluation is to integrate information in the exposure evaluation (Section 3 0) and the toxicity evaluation (Section 4 0) in order to evaluate potential or actual human health risks associated with the North Sea Landfill site Risk refers to the probability of injury disease or death resulting from exposure to the chemicals identified in this study Risk values are generally expressed in scientific notation An individual lifetime risk of one in 10,000 is represented as 1×10^{-4} or 1E-04

Impacts of noncarcinogenic chemicals on human health are evaluated by comparing projected or estimated intakes and reference levels for the chemicals of concern A reference level represents an acceptable exposure level at which there will be no observable adverse effect or the lowest observable adverse effect on human health The impact of carcinogenic chemicals is assessed by comparing calculated risks and target risks for known or suspected carcinogens Target risks for carcinogens generally range from 1E-04 to 1E-07

A summary of the subchronic daily intakes (SDIs) and chronic daily intakes (CDIs) is presented as Tables 5-1 and 5-2 Total SDI and CDI are calculated for both the oral exposure pathway and the inhalation exposure These totals are compared to acceptable levels and carcinogenic pathway potencies to obtain total hazard indices and carcinogenic risks for the By using the total SDIs and CDIs, the overall site risk is overall site assuming that individuals will be exposed to each and every of the exposure pathways simultaneously This scenario may be realized if a person lives near the landfill and drinks contaminated ground water, eats contaminated fish caught from Fish Cove, contacts and inadvertently ingests surface water from Fish Cove contacts and inadvertently ingests surface soil at the landfill, and inhales dust at the landfill It is expected that one or more of the individual pathways will dominate the total risk while the remaining pathways will produce insignificant risk

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| CHEMICAL | Ground Water SDI | Surface Water SDI | Fish Ingestion SDI | Soil Ingestion SDI | Dermal Absorption SDI | Total Oral SDI | Dust Inhalation SDI | Total Inhalation SDI |
|-----------|------------------------|-------------------------|--------------------------|--------------------------|-----------------------------|----------------------|---------------------------|----------------------------|
| Amnonia | 6 20 E -01 | 1 53B-04 | 0 00E+00 | 0 00E+00 | 2 78E-05 | 6 20E-01 | 0 00E+00 | 0 00E+00 |
| Arsenic | 4 59E-04 | 2 43 E-0 7 | 6 65E-06 | 4 97 E -05 | 4 40 E-08 | 5 15B-04 | 9 52E-05 | 9 52E-05 |
| Cadmium | 1 77 8-0 4 | 1.44 8-0 7 | 7 29E-06 | 1 26E-05 | 2 62 5-08 | 1 97 8 -04 | 1 91 B- 05 | 1 91B-05 |
| Chromium | 2 91E-03 | 1 75 E-06 | 1 74E-05 | 5 14E-05 | 3 1 75-0 7 | 2 99 8- 03 | 7 778-05 | 7 77E-05 |
| Iron | 1.13 5+00 | 4 96 e-0 4 | 3 09E-04 | 4 11 8-02 | 9 01E-05 | 1 178+00 | 6 22E-02 | 6 22E-02 |
| Lead | 7.43 8-0 4 | 6 07 E-0 7 | 1 85E-05 | 2 40E-04 | 1 10E-07 | 1 00E-03 | 3 64E-04 | 3 64E-04 |
| Manganese | 1 32E-01 | 4 128-05 | 2 57E-05 | 7 71E-04 | 7 47 8-0 6 | 1 33B-01 | 1.17 8-0 3 | 1.17E-03 |
| Nickel | 1. 39E-0 3 | 1 03E-06 | 3 OOB-05 | 1 20B-04 | 1 86E-07 | 1 55B~03 | 1.82E-04 | 1 82 8-0 4 |

TABLE 5 1 SUBCHRONIC HUMAN INTAKE LEVELS (mg/kg/day)

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| . | | | - | | | . | | | |
|----------|------|-------|---|------|------|----------|------|------|------|
| | | _ | | | | | | | |

| | 1 | TABLE 5 | 2 | |
|---------|-------|---------|--------|-------------|
| CHRONIC | HUMAN | INTAKE | LEVELS | (mg/kg/day) |

| CHEMICAL | Ground Water CDI | Surface Water CDI | Fish Ingestion CDI | Soil Ingestion CDI | Dermal Absorption CDI | Total Oral CDI | Dust Inhalation CDI | Total Inhalation CDI |
|-----------|------------------------|-------------------------|--------------------------|--------------------------|-----------------------------|----------------------|---------------------------|----------------------------|
| Ammonia | 1 05E-01 | 6 78E-06 | 0 00E+00 | 0 00E+00 | 1 23E-06 | 1 05E-01 | 0 00E+00 | 0 00E+00 |
| Arsenic | 1 41E-04 | 7 53B-09 | 2 93E-06 | 3 60E-07 | 1 37 E- 09 | 1 45B-04 | 6 27 E -07 | 6 27 E -07 |
| Cadmium | 1 11E-04 | 5 63E-09 | 4 03E-06 | 7 64 E -08 | 1 02E-09 | 1 15E-04 | 1 33E-07 | 1 33E-07 |
| Chromium | 1 27E-03 | 7 49 B -08 | 1 06E-05 | 2 94E-07 | 1 36E-08 | 1 28 B -03 | 5 12E-07 | 5 12E-07 |
| Iron | 2 98 E-0 1 | 1 88E-05 | 1 66E-04 | 3 76E-04 | 3 42E-06 | 2 99E-01 | 6 54E-04 | 6 54 E -04 |
| Lead | 3 61B-0 4 | 2 25E-08 | 9 74 E- 06 | 5 41E-07 | 4 08E-09 | 3 71 B -04 | 9 40 E-0 7 | 9 40E-07 |
| Manganese | 2 81E-02 | 1 76E-06 | 1 56B-05 | 6 86E-06 | 3 20E-07 | 2 81B-02 | 1 19E-05 | 1 19E-05 |
| Nickel | 7 20E-04 | 3 91E-08 | 1 63E-05 | 7 37E-07 | 7 10E-09 | 7 37 8 -04 | 1 28E-06 | 1 28E-06 |

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Noncarcinogenic Effects

Versar evaluated the noncarcinogenic effects of exposures to the indicator chemicals via both the oral route and the inhalation route Any potential health effects are identified by computing hazard indices derived from subchronic and chronic intake levels The hazard index is a simple means of comparing intake levels (SDIs and CDIs) to acceptable intake levels acceptable intake for subchronic exposure (AIS) and acceptable intake for chronic exposure (AIC) The hazard index is computed as follows

> Hazard Index = $\frac{DI_1}{AI_1} + \frac{DI_2}{AI_2} + \frac{DI_n}{AI_n}$ Where DI = subchronic or chronic daily intake (mg/kg/day) Where AI_n = subchronic or chronic acceptable intake level (mg/kg/day)

The assumption that the combined effects of the chemicals will be additive may not be accurate Actual effects may be multiplicative or may not be related at all However it is generally agreed that if the hazard index is less than one, deleterious health effects are unlikely If the hazard index is greater than one, then the individual effects of each chemical should be considered to determine the liklihood of ill effects

Hazard indices for total oral and total inhalation exposures for the North Sea Landfill site are presented in Tables 5 3 and 5 4 Both hazard indices for subchronic exposure are less than one, as is the hazard index for chronic inhalation The hazard index for chronic oral exposure, however, is greater than one The major contributor to this exceedance is the CDI AIC ratio for iron at 34 9 This high ratio results primarily from the high iron intake in the ground-water ingestion exposure pathway Since ground-water ingestion is not a currently completed exposure pathway because no private wells are used for drinking water

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| | Inhalation | | ORAL | | | |
|-----------|-------------------|----------|----------|-----------|----------|--|
| CHEMICAL | SDI AIS | SDI AIS | SDI | AIS | SDI:AIS | |
| Ammonia | 0 00E+00 NA | NA. | 6 20E-01 | NA | NA | |
| Arsenic | 9 52E-05 NA | NA | 5 15E-04 | 0 001 | 5 15E-01 | |
| Cadmium | 1 91E-05 NA | NA | 1 97E-04 | NA | NA | |
| Chromium | 7 77E-05 NA | NA | 2 99E-03 | 14 | 2 13E-04 | |
| Iron | 6 22E-02 NA | na | 1 17E+00 | na | na | |
| Lead | 3 64B-04 NA | na | 1 00E-03 | NA | na | |
| Manganese | 1 17E-03 3 00E-02 | 3 89E-02 | 1 33E-01 | 0 5 | 2 65E-01 | |
| Nickel | 182E-04 NA | NA | 1 55E-03 | 0 02 | 7 73E-02 | |
| | Hazard Index: | 3 89E-02 | Hazaro | Index: | 8 58E-01 | |
| | | ****** | | ********* | | |

TABLE 5 3CALCULATION OF SUBCHRONIC HAZARD INDEXNORTH SEA LANDFILL SITE

Notes: NA - Not available or not applicable

| | | Inhalation | | · · · · · · · · · · · · · · · · · · · | ORAL | | |
|-----------|----------|------------|----------|---------------------------------------|----------|-------------|--------|
| | CDI | AIC | CDI:AIC | CDI | AIC | CDI:AIC | |
| Ammonia | 0 00E+00 | NA | NA | 1 05E-01 | NA | NA | |
| Arsenic | 6 27E-07 | NA | NA | 1 45E-04 | NA | NA | |
| Cadmium | 1 33E-07 | NA | NA | 4 11E-06 | 1 00E-03 | 4 11E-03 (f | iood)* |
| Chromium | 5 12E-07 | 5 10E-03 | 1 OOE-04 | 1 28E-03 | 1 00E+00 | 1 28E-03 | acerj |
| Iron | 6 54E-04 | 8 60E-03 | 7 61E-02 | 2 99E-01 | 8 57E-03 | 3 49E+01 | |
| Lead | 9 40E-07 | 4 30E-04 | 2 19E-03 | 3 71E-04 | 1 40E-03 | 2 65E-01 | |
| Manganese | 1 19E-05 | 3 00E-02 | 3 98E-04 | 2 81E-02 | 2 00E-01 | 1 40E-01 | |
| Nickel | 1 28E-06 | NA | NA | 7 37E-04 | 2 00E-02 | 3 69E-02 | |
| | Hazar | d Index: | 7 87E-02 | Hazar | d Inder: | 3 56E+01 | |

TABLE 5 4 CALCULATION OF CHRONIC HAZARD INDEX NORTH SEA LANDFILL SITE

Notes: NA - Not available or not applicable * Cadmium has AIC values for food and water Food CDI is total of fish and soil ingestion, and water CDI is total of the remaining intakes

₽8LT ₽00 SEA consumption it is prudent to consider what the hazard index would be without including ground-water ingestion as a pathway Tables 5 5 and 5 6 show such a calculation Not including intakes from ground water, all hazard indices are less than one, supporting the premise that the high hazard index calculated for the total oral and total inhalation pathways is due to the ground-water ingestion pathway

Carcinogenic Effects

For potential carcinogens risks are estimated by the probability of increased cancer incidence A carcinogenic potency factor represents the upper 95 percent confidence limit of the probability of response per unit intake of the contaminant over a lifetime, and converts estimated intakes directly to incremental risk (U S EPA, 1986) Because all inputs into the exposure assessments are conservatively based, the resulting risks identified for the North Sea Landfill Site represent upper-bound risk estimates, and may over estimate the actual risk from exposures to the indicator chemicals studied Additional data would be required to derive a statistically valid estimate of error in the exposure and risk calculations

The carcinogenic risk via exposure pathways for the North Sea Landfill were calculated as

Risk = CDI x CPF

Where CDI = chronic daily intakes (mg/kg/day) CPF = carcinogenic potency factor (mg/kg/day)

Of the eight indicator chemicals for the North Sea Landfill site, cadmium, chromium, and nickel are recognized as potential carcinogens via the inhalation pathway only, and arsenic is recognized as a carcinogen via both inhalation and oral pathways

Table 5 7 shows the calculation of the total upper-bound carcinogenic risk for exposure to the indicator chemicals The total is 2 93E-04 Removing the contribution to this risk from the ground water ingestion scenario only reduces the risk to 3 87E-05 (Table 5 8) The

| CHEMICAL Ammonia 0 | CD1 | AIC NA | CDI:AIC | CDI | AIC | CDI:AIC |
|-----------------------|------------------|----------------------|----------------------|----------------------|----------------------|--------------------------------------|
| Ammonia O | 00E+00 | NA | 57A | | | |
| | | | NA | 8 01E-06 | NA | NA |
| Arsenic 6 | 5 27E-07 | NA | NA | 3 30E-06 | NA | NA |
| Cadmium 1 | . 33E-07 | NA T tot of | NA 8. 007. 04 | 4 11E-06 6 65E-09 | 1 00E-03 5 00E-04 | 4 11E-03 (food)* 1 33E-05 (water) |
| Chromium 5 Iron 6 | 12E-07 54E-04 | 5 108-03 8 60E-03 | 1 00E-04 7 61E-02 | 1 10E-05 5 65E-04 | 1 00E+00 8 57E-03 | 1 10E-05 6 59E-02 |
| Lead 9 | 40E-07 | 4 30E-04 | 2 19E-03 | 1 03E-05 | 1 408-03 | 7 36E-03 |
| Manganese 1 | . 19E-05 | 3 00E-02 | 3 98E-04 | 2 46E-05 | 2 00E-01 | 1 23E-04 |
| Nickel 1 | 28E-06 | NA | NA | 1 70E-05 | 2 00E-02 | 8 52E-04 |
| | Hazaro | i Index: | 7 87E-02 | Hazaro | l Index: | 7 84E-02 |
| ~ | | | **** | | | |

TABLE 5 6CALCULATION OF CHRONIC HAZARD INDEX(NOT INCLUDING INTAKES FROM GROUND WATER)

otes: NA - Not available or not applicable * Cadmium has AIC values for food and water Food CDI is total of fish and soil ingestion, and water CDI is total of the remaining intakes

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TABLE 5 7

RISK ESTIMATES FOR CARCINOGENS

| CHEMICAL | Exposure Route | CDI (mg/kg day) | Carcinogenic Potency Factor 1/(mg/kg day) | Route- Specific Risk | Total Chemical-specific Risk |
|--|-------------------|--------------------|---|----------------------------|------------------------------------|
| 0 - - - - - - - - - | **************** | | | | |
| Ammonia | Oral | 1 05E-01 | U | U | Ŭ |
| | Inhalation | 0 00E+00 | U | U | |
| Arsenic | Oral | 1 45E-04 | 1 80E+00 | 2 61E-04 | 2 70E-04 |
| | Inhalation | 6 27E-07 | 1 50E+01 | 9 40E-06 | |
| Cadmium | Oral * | 1 15E-04 | U | U | 8 11E-07 |
| | Inhalation | 1 33E-07 | 6 10E+00 | 8 11E-07 | |
| Chromium | Oral | 1 28E-03 | U | U | 2 10E-05 |
| | Inhalation | 5 12E-07 | 4 10E+01 | 2 10E-05 | |
| Iron | Oral | 2 99E-01 | U | U | ប |
| | Inhalation | 6 54E-04 | U | U | |
| Lead | Oral | 3-71E-04 | ប | U | ប |
| | Inhalation | 9 40E-07 | U | U | |
| Manganese | Oral | 2 81E-02 | Ū | Ū | ប |
| | Inhalation | 1 19E-05 | บิ | Ū | |
| Nickel | Oral | 7 37E-04 | ប | Ŭ | 1 53E-06 |
| | Inhalation | 1 28E-06 | 1 19E+00 | 1 53E-06 | |
| | | | Total Upper B | ound Risk = | 2 93E-04 |
| | | | | | |

Notes: U Unavailable or not applicable * Oral CDI for cadmium is total of food and water CDIs

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| CHEMICAL | Exposure Route | CDI (mg/kg day) | Carcinogenic Potency Factor 1/(mg/kg day) | Route- Specific Risk | Total Chemical-specific Risk |
|-----------|-------------------|--------------------|---|----------------------------|------------------------------------|
| Ammonia | Oral | 8 01E-06 | NA | NA | NA |
| | Inhalation | 0 00E+00 | NA | NA | |
| Arsenic | Oral | 3 30E-06 | 1 80E+00 | 5 948-06 | 1 53E-0 |
| | Inhalation | 6 27E-07 | 1 50E+01 | 9 40E-06 | |
| Cadmium | Oral * | 4 12E-06 | NA | NA | 8 11E-07 |
| | Inhalation | 1 33E-07 | 6 10E+00 | 8 11E-07 | |
| Chromium | Oral | 1 10E-05 | NA | NA | 2 10E-03 |
| | Inhalation | 5 12E-07 | 4 10E+01 | 2 10E-05 | |
| Iron | Oral | 5 65E-04 | NA | NA | na |
| - | Inhalation | б 54Е-04 | NA | NA | |
| Lead | Oral | 1 03E-05 | NA | NA | na |
| | Inhalation | 9 40E-07 | NA | NA | |
| Manganese | Oral | 2 46E-05 | NA | NA | na |
| - | Inhalation | 1 19E-05 | NA | NA | |
| Nickel | Oral | 1 70E-05 | NA | NA | 1 53E-00 |
| | Inhalation | 1 28E-06 | 1 19E+00 | 1 53E-06 | |
| | | | Total Upper Bound | d Risk = | 3 87E-0: |

TABLE 5 8 RISK ESTIMATES FOR CARCINOGENS (NOT INCLUDING INTAKES FROM GROUND WATER)

Notes: NA - Not available or not applicable * Oral CDI for cadmium is total of food and water CDIs

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| | TABLE 5 9 | |
|------------|---|--|
| COMPARISON | OF ESTIMATED CONTAMINANT CONCENTRATIONS | |
| | IN FISH COVE TO | |
| MARINE | ORGANISM TOXICITY CRITERIA (μ g/1) | |

| Contaminant | Subchronic Concentrations in Fish Cove | Marıne Organism Acute Toxıcıty | Marine Organism Chronic Acute Concentrations Toxicity in Fish Cove | |
|------------------------|--|---|---|------------|
| Ammonia | 1 06 mg/l | 0 4 mg/l* | 1 06 mg/l | 0 01 mg/l |
| Arsenic (trivalent) | 17 | 69 | 1 18 | 36 |
| Cadmium | 1 0 | 43 | 0 88 | 93 |
| Chromium (VI) | 12 1 | 1 100 | 11 7 | 50 |
| Iron | 3 4 mg/l | 0 300 mg/1* | 2 9 mg/l | 0 05 mg/1* |
| Lead | 4 2 | 140 | 3 51 | 56 |
| Manganese | 0 28 mg/l | 0 1 mg/1* | 0 28 mg/l | 0 02 mg/1* |
| Nıckel | 7 086 | 140 | 6 12 | 71 |

Reference Guidance on Remedial Action for Contaminated Ground Water at Superfund sites Final Review Draft, August 1988

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Migratory or resident blota in the areas surrounding the North Sea Landfill are not expected to be impacted from the site contamination Vegetative covers at the landfill will minimize any erosional losses to the estuary during large storm events

The New York State Department of Environmental Conversation has identified the following rare threatened and endangered species for the North Sea area

- 1 Least tern and piping plover, bird species listed under state law as endangered These birds utilize the open sandy beach near Towd Point North Sea Harbor
- 2 Bushy Rockrose (<u>Helianthemum dumosum</u>) Hairy Woodrush (<u>Luzula</u> <u>multiflora</u>) and <u>Lespedeza stueri</u> are rare plants identified near Conscience Point Also, this site includes a rare plant community known as "Maritime Grassland"
- 3 Hessel's Hairstreak (<u>Mitoura Lessel</u>) is a rare butterfly known to occur in the white cedar swamp habitat in this area

According to NYSDEC site-specific or comprehensive surveys for plant and animal occurrences have not been conducted (Scheibel, 1988)

The areas mentioned above (see Figure 1) are not presently impacted from any contaminants migrating from the North Sea Landfill site

Information regarding wildlife species in this area was unavailable during the compilation of this report

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6 0 CONCLUSIONS

Contaminant screening was performed on analytical results from H2M's samples and Versar's samples The contaminant screening process identified eight indicator chemicals The indicator chemicals used in this Endangerment Assessment were ammonia, arsenic cadmium, chromium iron lead manganese and nickel These compounds or elements were selected because of their toxicological properties, potentially critical exposure routes and higher concentrations present in comparison to other contaminants

Environmental fate and transport mechanisms were evaluated for each of the indicator chemicals based on an assessment of the site's environmental setting and the chemical, physical, and biological properties of each contaminant Predominant transport mechanisms identified include movement through soils (percolation) to ground-water and thence to Fish Cove and surface runoff of contaminants to Fish Cove

Some of the contaminants evaluated were sorbed to an appreciable extent by sediment particles, which tend to immobilize each of the elements Some of the elements exhibit greater solubility in water (hexavalent chromium and nickel), but their solubilities are controlled by the ambient pH and oxidation/reduction potential

Exposed populations generally include residents of North Sea, New York and site workers (identified in Section 3 3) In addition, individuals who may play, swim, or wade in Fish Cove near or topographically downgradient from the North Sea Landfill site would be at a higher health risk because of the potential exposure by direct contact with contaminated surface water, soils, or sediment Recreational uses of Fish Cove include swimming, wading, fishing, and boating Populations potentially exposed include recreational users of Fish Cove and neighborhood children venturing (trespassing) onto the site

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Seven exposure routes were identified (1) ingestion of contaminated surface water during recreational use of Fish Cove

(2) ingestion of contaminated fish and shellfish (3) ingestion of contaminated soil (4) direct contact (dermal) exposure to contaminated surface water during recreational use of Fish Cove, (5) direct contact (dermal) exposure of contaminated soil, (6) ingestion of ground water, and (7) inhalation of dust from the site

Total body burden rates were computed based on all potential exposure routes using an average body mass of 70 kilograms (adult) or 20 kilograms (child) and an average 70 year lifetime It was assumed that dermal exposures (e g , swimming and wading) would occur in 20 out of the 70-year average lifetime ingestion exposures (fishing) would occur in 40 out of an average 70-year lifetime (Whitmyre, et al , 1987) and inhalation exposures will occur in a 30 year working lifetime

Estimated time weighted average doses for the indicator chemicals varied considerably The lowest subchronic intake was for cadmium via dermal adsorption at 2 62E-08 mg/kg/day, while the highest was for iron via ground water ingestion at 1 13 mg/kg/day These same chemicals and exposure routes generated the lowest and highest chronic exposures at 1 02 E-09 and 2 98E 01 mg/kg/day respectively The ground-water ingestion pathway contributed the most to the body burden via oral exposure while dust inhalation was the only contributor to body burden via inhalation

Toxicity profiles were developed for each of the indicator chemicals based on current U S EPA accepted health effects documents Toxicological evaluation included pharmacokinetics, human and environmental health effects, and a dose-response assessment Toxicity information is dependent to a large extent on animal models upon which any potential adverse human health effects must be extrapolated

Risk characterization included an assessment of risk associated with exposures to noncarcinogens and carcinogens Noncarcinogenic risks were assessed using a hazard index computed from expected daily intake levels (subchronic and chronic) and reference levels (representing acceptable intakes) Hazard indices were less than one for all scenarios considered

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except for chronic oral exposure which had a hazard index of 35 6, due almost entirely to the CDI/AIC ratio for iron consumption via ground water ingestion When ground water ingestion was not included, all hazard indices were less than one These low chronic and subchronic hazard indices indicate a low liklihood of adverse human health impacts The one high hazard index indicates that chronic consumption of ground water may pose a health threat

Potential carcinogenic risks were computed by multiplying chronic (long term) intake levels with respective carcinogenic potency factors The cumulative upper bound risk for all carcinogens was 2 93E-04 This was derived predominantly from oral exposures, with a minor contribution from inhalation exposures This value is within the range of 10^{-4} to 10^{-7} , the range for which cleanup actions have been initiated under CERCLA

Upon evaluation of all available information on the site and the most recent analytical data collected from the site, potential threat to human health exists This conclusion is based on an evaluation of the site history and operations, the overall environmental setting, and on recent chemical analyses Chemical releases from North Sea Landfill site are also expected to result in environmental impacts to Fish Cove

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APPENDIX 1 SELECTION OF INDICATOR CHEMICALS

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TABLE 1 SCORING FOR REDICATOR CHEMICAL SELECTION: CONCENTRATIONS (PPH) IN VARIOUS AEDIA AND Not VALUES

| | | M | M | 80 | GROUNDMATER ROUND 1 | | | GROUNDMATER ROUND 2 | | |
|---|--|---|----------|--|--|---|--|---|--|--|
| CIENICAL | CAS EO | Coc (Bg/1) | | AULIAUA | MALIAM | MEAN | SURDAY. | HINDAM MADRIN | | |
| VOLATILE ORGANICS | | | | | | | | | | |
| ACETONE BENZENE 2-BUTANOME (MEK) 1 1-DICHLOROETHAME 1 1-DICHLOROETHEME CHLOROECHAME 2-DICHLOROETHAME ETHYLENE CHLORIDE TTMLENE CHLORIDE TTMLENE CHLORIDE TTMLENE 1 1 1-TRICHLOROETHAME TRICHLOROETHEME TRICHLOROETHEME | 67-64-1 71-43-2 76-03-3 75-35-4 540-39-0 67-65-3 107-06-2 100-41-4 75-09-2 127 18-4 106-80-3 71 55-6 71-01-6 | 2 2 30 0 85 0 14 0 100 2 300 0 150 0 150 0 155 0 155 0 155 0 | | © 010 © 000 | 6 010 6 000 8 005 8 00000 8 000 8 000 8 000 8 000 8 000 8 000 8 000 8 000 8 000 8 00 | 6 605 6 000 6 000 | 6 8050 6 6000 6 6000 6 6000 8 6050 8 6050 8 6000 8 6000 | 6 0100 6 0050 6 0050 6 0050 6 0050 6 0050 8 0050 8 0050 8 0050 8 0000 8 0150 8 0000 8 0050 | 6 9057 6 0025 6 0000 6 0025 6 00025 6 0025 6 0025 6 0024 8 0000 6 0028 6 0028 6 0028 6 0028 6 0028 6 0028 | |
| SENIVOLATILE ORGANICS | 1330-80-7 | 269.0 | | 0.033 | 0.030 | 0 .899 | 0.0000 | 6.5000 | 9.833C | |
| BERZO(B)FLUCRANTHENE BERZO(K)FLUCRANTHENE BERZO(K)FLUCRANTHENE BERZO(A)ANTHRACENE BERZO(A)ANTHRACENE BIS(2 ETHYLHEXYL)PHTHALATE DIS(2 ETHYLHEXYL)PHTHALATE GIRYSENE FLUCRANTHENE FILORANTHENE PIETHYL PHTHALATE PERENE DIETHYL PHTHALATE DIBUTYL PHTHALATE GIBUTYL PHTHALATE BUTYL BERZYL PHTHALATE BUTYL BERZYL PHTHALATE BUTYL BERZYL PHTHALATE | 205-99-2 207-08 9 191 24 2 56-55-3 117-81 7 218-01-9 206 44-0 193-39 5 85-01-8 129-00-0 84-86-2 87-86-5 84-74-2 534-52 1 MA 84. | 550000 0 550000 0 180000 0 550000 0 5500000 0 170000 0 38000 0 14000 0 14000 0 14000 0 14000 0 142 0 53000 0 142 0 53000 0 840 | 建筑 化基化化化 | 0 6000 0 0000 0 <t< td=""><td>0 000 0 000</td><td>© 600 © 600 ©</td><td>8.2000 8 0000 8 0000</td><td>8.8000 8.0000 8.0000 8.0000 8.0000 8.2000 8.0000 9.2200 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000</td><td>\$ 6000 6 0000 6 0000 0 0000 0 00000000</td></t<> | 0 000 | © 600 © | 8.2000 8 0000 8 0000 | 8.8000 8.0000 8.0000 8.0000 8.0000 8.2000 8.0000 9.2200 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 8.0000 | \$ 6000 6 0000 6 0000 0 0000 0 00000000 | |
| INDREANICS | | | | | | | | | | |
| ALUMINUM ALUMINUM ARSENIC BARIUM GARIUM CADMIUM CALCIUM CORONIUM COBALT COPPER IRON LEAD INGRESSIUM MAGANESE MAGANESE MAGANESE MAGANESE MAGANESE SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM SILVER SIDIUM | BA 7440-35-0 7440-39-3 7440-43-9 BA 7440-47-3 7440-47-3 7440-47-3 7440-47-4 7440-47-4 7440-47-3 15438 31-0 7439-92-1 RA 7439-96-5 7439 97-6 7440-02-0 NA 7782-49-2 7440-22-0 RA 7440-22-0 7440-22-0 7440-22-0 7440-22-0 7440-22-0 | 194 194 194 194 194 194 194 194 194 194 | | © \$729 6 \$000 6 \$000 0 \$000 <td>51 600 8 500 8 584 8 805 6 040 8 550 8 550 8</td> <td>7.818 9 000 9 010 9 046 9 002 9 009 11 818 9 006 9 093 16 029 9 093 16 029 9 093 16 029 9 035 6 039 9 035 6 039 9 035 6 039 9 035 6 039 9 035 6 039 9 035 8 000 9 035 6 039 9 035 8 000 9 037 6 037 6 000 9 037 6 000 9 037 6 000 9 000 9 037 6 000 9 0000 9 000 9 0000 9 0000 9 0000 9 0000 9 0000 9 0000 9 0000000000</td> <td>6 6220 6 0005 6 0015 6 0095 6 0000 6 0050 3 4500 8 0070 8 0070 8 0052 4 6500 9 0052 4 6500 8 0052 8 0002 8 0002 8 0000 8 00000000</td> <td>14 7000 6 1000 6 1000 6 2550 6 0200 6 0200 6 0190 8 8000 6 0190 8 8000 6 0190 8 8000 6 013 6 1500 6 0001 6 0000 6 0700 8 2500 6 0700 6 0640 9 2760 6 0259</td> <td>£ 0770 8 0000 8 0093 9 1261 8 0000 9 0055 15 6110 9 0094 8 1744 80 6120 9 0094 8 1744 80 6120 9 0094 8 1744 80 6120 9 0094 8 1010 1 2320 9 0094 8 1010 1 2320 9 0094 8 1010 1 2000 9 0094 8 1010 9 0094 8 10094 8 1009 9 0094 8 10094 8 1009 9 0094 8 10094 8 10094 8 0094 8 10094 8 10094 8 0094 8 10094 8 10094 8 0094 8 0094 8 10094 8 10094 8 0094 8 10094 8 10094 8 0094 8 10094 8 10094 8 0094 8 0094 8 10094 8 0094 8 10094 8 10094 8 0094 8 10094 8 0094 8 0094 8 10094 8 0094 8 0094 8 10094 8 10094 8 0094 8 10094 8 0094 8 10094 8 0094 8 10094 8 1000 8 0094 8 1000 8 1000 8 0094 8 1000 8 0094 8 1000 8 0094 8 1000 8 0094 8 1000 8 0094 8 1000 8 0094 8 0094 8 0094 8 1000 8 0094 8 0000 8 00000 8 00000 8 00000 8 00000 8 00000 8 00000 8 00000 8 00000 8 000000 8 0000000000</td> | 51 600 8 500 8 584 8 805 6 040 8 550 8 | 7.818 9 000 9 010 9 046 9 002 9 009 11 818 9 006 9 093 16 029 9 093 16 029 9 093 16 029 9 035 6 039 9 035 6 039 9 035 6 039 9 035 6 039 9 035 6 039 9 035 8 000 9 035 6 039 9 035 8 000 9 037 6 037 6 000 9 037 6 000 9 037 6 000 9 000 9 037 6 000 9 0000 9 000 9 0000 9 0000 9 0000 9 0000 9 0000 9 0000 9 0000000000 | 6 6220 6 0005 6 0015 6 0095 6 0000 6 0050 3 4500 8 0070 8 0070 8 0052 4 6500 9 0052 4 6500 8 0052 8 0002 8 0002 8 0000 8 00000000 | 14 7000 6 1000 6 1000 6 2550 6 0200 6 0200 6 0190 8 8000 6 0190 8 8000 6 0190 8 8000 6 013 6 1500 6 0001 6 0000 6 0700 8 2500 6 0700 6 0640 9 2760 6 0259 | £ 0770 8 0000 8 0093 9 1261 8 0000 9 0055 15 6110 9 0094 8 1744 80 6120 9 0094 8 1744 80 6120 9 0094 8 1744 80 6120 9 0094 8 1010 1 2320 9 0094 8 1010 1 2320 9 0094 8 1010 1 2000 9 0094 8 1010 9 0094 8 10094 8 1009 9 0094 8 10094 8 1009 9 0094 8 10094 8 10094 8 0094 8 10094 8 10094 8 0094 8 10094 8 10094 8 0094 8 0094 8 10094 8 10094 8 0094 8 10094 8 10094 8 0094 8 10094 8 10094 8 0094 8 0094 8 10094 8 0094 8 10094 8 10094 8 0094 8 10094 8 0094 8 0094 8 10094 8 0094 8 0094 8 10094 8 10094 8 0094 8 10094 8 0094 8 10094 8 0094 8 10094 8 1000 8 0094 8 1000 8 1000 8 0094 8 1000 8 0094 8 1000 8 0094 8 1000 8 0094 8 1000 8 0094 8 1000 8 0094 8 0094 8 0094 8 1000 8 0094 8 0000 8 00000 8 00000 8 00000 8 00000 8 00000 8 00000 8 00000 8 00000 8 000000 8 0000000000 | |
| NISCELLANEOUS CHEMICALS | 104_02 0 | 6 0 <i>1</i> | | 8 691 | a aaa | 6 609 | 6 6 41A | 0 0000 | 8 8897 | |
| APPONIA NITRATE NITRITE CHLORIDES TOTAL DISSOLVED SOLIDS TOTAL ORGANIC CARBON | 7654-41-7 84 84 84 84 | 83 1 MA MA MA MA | Ĺ | 0 020 0 230 14 000 50 000 | 85 400 1 400 169 000 80400 000 51 699 | 2 740 0 302 60 100 1230 200 5 040 | 6 0200 0 1000 9 7000 60 0000 1 8000 | 44 5000 16 0000 112 0000 46000 000 84 0000 | 4 3600 1 4790 35 5200 35 5200 7_3100 | |

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| CREMICAL | Miniman | MALIAIPH | haith | KINIMP | | un (sean | FURIDA | n majai | n qean | |
| VOLATILE OREANICS | | | | | | | | | | |
| ACETONE BENZENE 2-BUTANONE (MEX) 3 3-DICHLOROETHANE | 0 000 0 000 0 000 0 000 | 8 680 8 000 8 000 8 000 | 0 000 0 000 0 000 0 000 | 0 600 0 600 6 607 9 600 | 8.000 8 000 8 000 8 000 | 0 000 0 000 0 008 0 000 | 8 000 8 000 8 000 8 000 | 0.000 0 000 0 000 0 000 | 0 000 0 000 0 000 | |
| TRANS 1 2 DICHLOROETHENE CHLOROFORH 1 2 DICHLOROETHANE ETHYLBENZENE | 8 000 8 000 8 000 8 000 8 000 | 0 000 0 000 0 000 0 000 0 000 | 0 000 0 000 0 000 0 000 0 000 | 8 800 8 800 8 800 8 800 8 800 | 8 000 8 000 8 000 8 000 | 8 000 8 000 8 000 8 000 | 8 000 8 000 8 000 | 8 000 8 000 8 000 8 000 | 8 000 8 000 8 000 8 000 | |
| NETHYLENE CHLORIDE TETRACHLOROETHENE TOLUENE 1 1 1 TRICHLOROETHANE TRICH OROETHENE | 6 000 6 000 8 000 9 000 | 8 000 8 000 8 000 -9 000 | 0 000 0 000 0 000 0 000 0 000 | 6 602 6 602 9 600 8 600 8 600 | 0.047 0.030 0 000 0 000 | 015 0003 0000 0000 | 0 000 0 000 0 000 0 000 0 000 | 6 000 8 000 8 000 8 000 | 8 000 8 000 8 000 8 000 | |
| ATCHEORES THERE | 8 900 | 8 660 | 0.600 | 6.690 | 8.000 | 8.099 | 8.000 | 8 .000 | 0.000 | |
| SENIVOLATILE ORGANICS | | | | | | | | | | |
| BERIZO(B)FLUCRANTHENE BERIZO(K)FLUCRANTHENE BERIZO(K)FLUCRANTHENE BERIZO(A)ANTHRACENE BERIZO(A)ANTHRACENE BERIZO(A)ANTHRACENE BLIZO(A)ANTHENE FLUCRANTHENE | 0 000 0 000 | 000 000 000 000 000 000 000 000 000 00 | 003 8 005 8 003 8 000 8 0000 8 0000 8 000 8 0000 8 00000000 | 8 600 8 600 8 600 8 600 8 600 8 600 8 600 8 600 | 8 000 8 000 8 000 8 000 8 000 8 700 8 700 8 000 8 000 | 0000 0000 0000 0000 0000 0000 0000 0000 0000 | <pre>8 250 9 110 9 057 8 095 8 110 8 180 9 180 9 140</pre> | 6.860 6.860 6.860 6.860 6.860 9 900 8.860 8.860 8.860 | © 225 © 216 © 218 © 218 © 210 2 068 © 220 © 220 | |
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| A-BROMOPHENYL PHENYL ETHER BUTYL BENZYL PHTHALATE DI-N-OCTYL PNTHALATE | 8 000 8 000 8 000 | 0 000 0 000 0 000 0 000 | 0 600 0 600 0 600 | 0 800 0 800 0 800 | 3 000 9 000 9 000 | 3 257 8 800 8 800 | 9 000 9 170 9.000 | 0 000 0 860 0.000 | 0 000 0 221 0 000 | |
| INGREANICS | | | | | | | | | | |
| ALUNINUM ANTIHONY ARSENIC BARIUH BERYLLIUH CADIUH CALCIUH CORONIUH CORALT COPPER IRON LEAD WGKESSIUM MAGANESSI HARGANESSI HERCURY NICKL POTASSIUM | 6 023 6 000 6 000 9 000 6 003 196 000 8 009 8 009 8 000 8 000 8 000 8 000 9 000 9 000 2 000 2 0 000 2 0 000 8 015 | 6 143 8 000 8 000 9 000 6 010 8 2 000 0 031 1 100 9 050 9 850 9 850 9 00020 9 850 9 00020 9 00020 9 000 8 500 9 00020 9 000 9 0000 9 000 9 000 9 000 9 000 9 0000 9 00000 9 0000 9 00000 9 00000 9 00000 9 00000 9 000000 9 0000000000 | 6 119 6 600 6 600 6 600 6 600 6 605 6 603 6 603 6 613 6 613 6 613 6 613 6 613 6 613 6 779 6 60010 6 600 741 250 8 832 | 302 00 7 80 8 .00 8 .00 9 80 1 30 1 30 2 .20 1 70 2 .20 1 90 2 .50 1 91 9 10 1 9 10 10 10 10 10 10 10 10 10 10 10 10 10 | 3020 00 14 90 4.50 84 00 0 00 1 45 8070 00 1 40 5380 00 11 40 5380 00 1200 00 14 00 1200 00 14 00 14 00 10 00 14 90 14 90 10 7 80 10 7 80 10 7 80 10 7 80 10 7 80 10 7 80 10 90 10 90 100 | 1602 90 4 29 6 57 11 83 9 09 6 58 475 00 6 58 475 00 445 500 5 42 533 15 6 4 47 9 07 3 17 522 60 6 07 3 20 | 487 00 1 00 6 10 6 50 154 00 154 00 3 20 187 00 148 00 9 10 5 00 3 44 00 3 40 00 | 6130 00 6 00 11 00 8 00 2 20 8 00 9 00 9 00 9 00 9 00 9 00 9 00 9 00 9 00 135 00 135 00 135 00 135 00 135 00 8 00 21 00 13 00 14 00 9 0 9 | 2391 60 9 60 3 54 12 50 9 60 6 76 7 57 5 79 60 5 .38 5 .39 5 . | |
| SILVER SODIUM TMALLIUM ZINC CYANIDE | 6 000 6070 000 0 000 0 000 0 011 0 000 | 0 000 8030 000 8 000 0 000 9 020 8 020 8 020 | 6 000 (3791 220 6 000 6 000 6 010 0.009 | 1 10 160 60 0 60 3 50 1 50 6.69 | 19 00 472 00 6 00 18 00 19 70 8.09 |) 75 242 50 0.00 \$.83 8.01 0.00 | 1.60 8 80 9 90 7 10 3 90 8.69 | 3.50 0 00 0 00 12 00 33 00 0.69 | 0 82 0 60 0 63 5 68 235 55 8 69 | |
| NUSCELLAREOUS CHEMICALS PHENOLS AMMONIA NITRATE NITRITE CHLORIDES TOTAL DISSOLVED SOLIDS TOTAL ORGANIC CARBON | 6 000 6 050 0 100 12000 000 6 000 6 030 | 0 000 2 300 0 400 1,6900 000 8 000 0 939 | 0 620 6 710 6 150 150 150 000 0 600 0 600 | 6 .630 6 .000 6 .000 6 .000 6 .000 6 .000 6 .000 6 .000 6 .000 | 9 600 9 600 9 600 9 600 9 600 9 600 | 6.000 9.000 6 000 6 000 6 000 6 000 8 000 8 000 | 8 00 8 00 9 00 9 00 9 00 8 00 | 8 80 8 80 8 80 8 80 8 80 8 80 8 80 8 80 | 8 00 8 00 8 00 8 00 8 00 8 00 | |

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| CHEPIICAL | MINIMA | MILM | n cean | MEDAP | and the second sec | n (tean |
| VOLATILE ORGANICS | | | | | | |
| ACETONE BENZENE 2-BUTANONE (MEX) 1DICHLOROETHANE 1 1-DICHLOROETHANE 1 1-DICHLOROETHANE TANS-1 2-DICHLOROETHANE CHLOROFORM 1 2-DICHLOROETHANE ETWYLBENZENE METHYLENE CHLORIDE TETRACH.OROETHANE TOLUENE 1 1 TRICHLOROETHANE TICHLOROETHANE TICHLOROETHANE TYLENES SENIVOLATILE ORGANICS | 6 600 6 000 8 000 6 000 | 6 600 8 | 6 600 6 6000 6 6000 6 6000 6 6000 6 6000 6 6000 6 600000000 | 6 800 6 802 6 805 6 805 6 805 6 805 6 805 6 805 6 805 6 805 6 805 8 805 8 805 800 805 800 800 800 800 800 80 | 6 000 6 010 6 020 6 020 6 020 6 020 6 000 6 00000000 | 6 630 6 008 8 009 6 007 6 009 6 009 6 009 6 000 0 005 6 000 0 008 6 000 0 009 0 000 0 009 0 000 0 000000 |
| BERIZO(B)FLUCRANTHENE BERIZO(K)FLUCRANTHENE BERIZOFENYLENE BERIZO-O-O PYRENE BIS(2 ETHILHEXTL)PHTMALATE CHRYSENE FLUCKANTHENE PHENANTHENE PHENANTHENE PHENANTHENE PRENE DIETHYL PHTMALATE OIETHYL PHTMALATE OIETHYL PHTMALATE G-DINITRO-2-HETHYLPHENOL G-BOUTYL PHTMALATE DI H-DETYL PHTMALATE DI H-DETYL PHTMALATE DI H-DETYL PHTMALATE | 8 800 6 000 6 000 8 000 8 240 6 000 8 055 6 000 8 055 6 000 8 051 8 000 8 000 8 000 8 000 8 000 8 000 8 000 8 000 8 000 8 000 | a 600 6 600 6 600 8 600 9 600 9 600 9 600 9 600 9 450 8 450 8 450 8 600 8 600 8 510 8 600 8 600 | 6 600 6 600 6 600 6 600 4 432 6 157 6 157 6 155 6 125 6 125 6 125 6 125 6 200 6 200 7 200 7 200 7 200 7 200 7 200 7 200 7 200 7 200 7 200 7 200 7 200 700 7 | 9 500 9 5000 9 5000 9 500 9 500 9 500 9 500 9 500 9 500 9 50 | 0 000 | 6.000 6.000 6.000 6.000 3.529 6.0000 6.0000 6.0000 6.0000 6.0000 6.0000 6.0000 6.0000 6.00000 6.0000 6.0000 6.0000 6.0000 6.00000000 |
| INDREANICS ALUMINUM ANTINONY ARSENIC BARIUM BERYLLIUM CAUCIUM CALCIUM CONDUM CONDUM CONDUM LEAD MAGAGESIUM MANGAGESIUM MANGAGESIUM MANGAGESE MERCURY HICKEL POTASSIUM SILVER SCDIUM TMALLIUM VANADIUM ZINC CTARIDE | 307 00 0 00 1 90 0 00 1 10 108 00 1 20 0 00 3 30 870 00 342 00 342 00 351 00 3550 00 3550 00 6 00 5 40 6 80 | 785 00 6 00 6 00 1 70 1 33 00 1 9 00 0 000 | | 1000 60 6 00 1 00 25 70 6 60 6 60 6 50 6 50 7 7 8 50 6 50 6 50 7 8 50 6 50 6 50 7 8 50 6 50 6 50 7 8 50 6 50 6 50 7 8 50 8 5 | 6376 60 6 60 31 60 50 60 2 30 1100 60 32 60 33 60 34 60 35 60 32 60 32 60 33 60 34 60 35 60 36 60 36 60 36 60 36 60 36 60 36 60 37 60 38 60 39 60 36 60 37 60 38 60 39 60 | 4150.00 0 00 12 71 34.52 0 94 0 94 10 95 10 |
| HISCELLANEOUS CHEMICALS HIENOLS ANHONIA NITRATE RITRITE CHLORIDES TOTAL DISSOLVED SOLEDS TOTAL ORGANIC CARBON | 6 00 6 00 6 00 6 00 5 00 8 00 | 9 00 9 00 9 00 9 00 9 00 9 00 | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 0 6001 0 6000 0 6000 0 6000 0 6000 0 6000 0 6000 | 6 6353 6 6000 8 6000 8 6000 8 6000 8 6355 | 0.0001 0 0000 0 0000 0 0000 0 0000 0 0000 0 0000 0 0000 |

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NOTES NA - NOT AVAILABLE OR NOT APPLICABLE N CHEMICAL HAS ONE OF THE TEM HIGHEST KOC VALUES L - CHEMICAL HAS ONE OF THE TEM HIGHEST KOC VALUES CAS NO AND KOC FOR PHENOLS ARE FROM DATA FOR PHENOL ZERO ENTRY INDICATES THAT ANALYSIS WAS NOT PERFORMED CHEMICAL WAS NOT DETECTED OR BATA WAS REJECTED SOURCE CONCENTRATIONS BASED ON AMALYTICAL RESULTS FROM 1987 REMEDIAL INVESTIGATION CAS NO AND KOC FROM SUPERFUND PUBLIC NEALTH EVALUATION HARVAL (USEPA, 1839)

SEA 004 1802

TABLE 2 SCORING FOR THEDICATOR CHEMICAL SELECTION CRAL TOXICITY LIFERATION

| | | E | DELACIED | EAIC | 6 | PRCINGENIC | | | |
|---|---|--|---|--|---|--|---|--|--|
| GENICAL | TOXIC | GATINS VALUE | ยล าย (ชาต) | EDIL (STR) | EPA CATAGORY | WATER (WTC) | SOIL (sĩc) | | |
| VOLATILE ORGANICS | (0) | (B) | (i/c;) | (09/09) | (c) | (1/08) | (tg/eg) | | |
| ACETONE BENZENE 2-BUTANCNE 1 J-DICHLOROETNANE 1 J-DICHLOROETNANE TRANS 1 2-DICHLOROETNENE CHLOROFORM 1 2-DICHLOROETNANE ETNYLENE CHLOROETNANE TYTYLENE CHLOROETNANE TTHACHLOROETNENE 1 J 1-TRICHLOROETNENE TRILENE 1 J 1-TRICHLOROETNENE TRILENE STLENES | un un nun nun nun nu | 04 50 7 7 5 84 10 7 7 84 10 7 7 85 7 | EA 2 71E-01 7 75E-03 2 84E-02 3 71E-01 5 88E-02 6 88E-02 6 88E-02 9 80E-02 9 80E-03 9 80E-03 9 80E-03 7 33E-04 1 05E+00 1-05E+00 1-05E+00 | EX S 05E-05 S 87E-05 S 87E-05 S 05E-05 S 05E-05 S 05E-05 S 05E-07 | a a a a a a a a a a a a a a a a a a a | (BA 7712-03 BA BA 8.4 8.4 8.4 8.4 8.4 8.4 8.4 8.4 8.4 8.4 | BA 3 BSE-07 BA BA BA BA BA BA 2.211-05 BA BA 3.365-07 BA BA 2.145-05 BA BA BA | | |
| SERVICATILE GREATICS EXERCIC(S)FLUCRANTHENE • BERIZO(S)FLUCRANTHENE • BERIZO(S)FLUCRANTHENE • BERIZO(A)ATTHEACENE BERIZO(A)ATTHEACENE BERIZO(A)ATTHEACENE BIS(2 ETHYLHEXYL)PHTHALATE GURYSENE FLUCRANTHENE • FLUCRANTHENE • PIEDANTHENE • PIEDANTHENE • PIEDANTHENE • PIEDANTHENE • DIETHYL PHTHALATE SIGNODPHENGL DIBUTYL PHTHALATE 4 6-DINITRO-2-HETHYL PHENOL 4-BROHOPHENYL PHTHALATE * BUTYL BENYL PHTHALATE * | 한자지 않는 것 같은 것 같 | BAAAA SAAAAAA JA SAAAAAA JA SAAAAAAA | 2 70E+01 2 76E+01 2 76E+01 2 76E+01 2 76E+01 2 76E+01 2 76E+01 2 76E+01 2 76E+01 2 76E+01 2 76E+00 3 81E-02 6 93E+00 8 76E+01 8 76E+00 8 87E+00 8 8 | 1.23F-03 1 23F-03 1 23F-03 1.23F-03 1.23F-03 1.23F-03 1.23F-03 1.23F-03 1.23F-03 1.23F-04 1.25F- | 82 9 44 2 2 2 2 2 4 4 4 4 4 4 4 4 4 4 4 4 | 4.557+00 4 555+00 5 811-01 4 555+00 5 715-04 4 555+00 4 555+00 4 555+00 4 555+00 8 4 555+00 8 4 555+00 8 8 4 555+00 8 8 555+00 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | 2 255-04 2 255-04 3 255-04 3 255-04 3 255-04 3 2 255-04 2 255-0 | | |
| INDREANTICS ALUFINIM ANTINOMY ARSENIC BARIUM GARNUM CAURIUM CAURIUM CAURIUM COBALT COPPER IRON LEAD MGRESTUM MURGNESSE HERCURY HICKEL POTASSIUM SELENIUM SELENIUM SELENIUM SELENIUM SELENIUM SELENIUM SELENIUM SELENIUM SULVER SUDIUM TMALLIUM | ᄣᇨᄣᇨᇨᇨᄣᇔᄣᇔᄣᄣᄣᄣᄣᄣᄣᄣᄣᄣ | logoaloaaasaasaa taalo 2000 logoaloaasaasaasaasaasaasaasaasaasaasaasaasaas | 4.295+00 1.005+01 4.085+000 13.455+000 14.455+000 10.4 10.4 10.55+0000 10.55+0000 10.55+0000 10.55+0000 10.55+00000 10.5 | 2 17E-04 9 001-04 2 045-04 8 045-04 8 04 8 04 8 04 8 04 8 05 8 05 8 05 8 05 8 05 8 05 8 05 8 05 | | 84 6.077 + 000 88A 88A 88A 88A 88A 88A 88A 88A 88A 88 | 2 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 | | |
| NESCELLAREOUS CHEMICALS PHENCLS ANOCHIA NITRATE-HITRITE CHLORIDES TOTAL DISSOLVED SOLIDS TOTAL ORGANIC CARBON NOTES (a) HC + RONCARCINOGEN PC + | BE BE BA BA BA BA BA | D B BA BA BA BA BA BA BA | 1 002-01 5 235+60 (AA (BA (BA (BA) (BA) (BA) (BA) (BA) (B | 6 025-03 3 61E-04 64 64 64 64 64 64 64 64 64 64 64 64 64 | BA BA BA BA CA ENT DATA FO | en Ch Ch Ch Ch Ch SCOR LISE | 63A 63A 63A 63A 63A 63A | | |

(b) RATING VALUE IS FOR SEVERITY OF EFFECT FOR HONCARCINGERS RANGING FROM 1 (LOM) TO 10 (HIGH)
 (c) EPA CATEGORY IS A QUALITATIVE WEIGHT OF EVIDENCE DESIGNATION FOR POTENTIAL CARCINGGENS RANGING FROM A (SUFFICIENT EVIDENCE OF CARCINGERIGITY) TO 8 (NO EVIDENCE)
 NO - NOT AVAILABLE OR NOT APPLICABLE
 • TOXICITY CONSTANTS BASED ON BENZO(A)PTREME
 • TOXICITY CONSTANTS BASED ON BENZO(A)PTREME
 • TOXICITY CONSTANTS FOR NETWICHE CHLORIDE ARE BASED ON METHYL CHLORIDE NOMCAR INGENIC TOXICITY CONSTANTS FOR PENTACHLOROPHENGL ARE BASED ON 4 6-DINITRO-Z-METHYLPHENGL CARCINGERIC TOXICITY CONSTANTS FOR PENTACHLOROPHENGL ARE BASED ON 2 4 6-TRICHCROPHENGL AND CARCINGENIC TOXICITY CONSTANTS FOR PENTACHLOROPHENGL BASED ON 2 4 6-TRICHCROPHENGL MONCARCINGENIC TOXICITY CONSTANTS FOR PENTACHLOROPHENGL BASED ON 2 4 6-TRICHCROPHENGL MONCARCINGENIC TOXICITY CONSTANTS FOR PENTACHLOROPHENGL BASED ON 2 4 6-TRICHCROPHENGL MONCARCINGENIC TOXICITY CONSTANTS FOR BENZO(A)ANTHRACENE BASED ON BEAZO(A)PTREME

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TABLE 3 SCORING FOR INDICATOR CHEMICAL SELECTION: CALCULATION OF CT AND IS VALUES FOR CARCINGENIC EFFECTS

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| CHENICAL | GROUN MAX | D WATER | (RI) CT NEAM | GROUN HAX | D WATER | (R2 HEAI |) CT | SURFACE MAX | WATER CI HEAN | r I | SURFACE MAX | SOIL C | 17 V1 | IS NAK | NALUE NEAN | TENTATI NAX | VE RANK MEAN | EPA CATEGORY |
|----------------------------|--------------|-----------|-----------------|----------------|---------|-------------|----------|---|------------------|--|------------------|----------|------------|------------------|------------------|----------------|-----------------|-----------------|
| VOLATILE ORGANICS | 00 - | | | | •• | • | • | • • | | •0 | *** * | | | • • | | | • | • • |
| BENZENE | | • | • | 3 86E- | 05 L | 17E | 05 | ٥ | | ٠ | 0 | | 9 | 3 865 05 | 1 776-05 | 17 | 16 | A |
| 1 1 DICHLOROETHERE | 1 97E- | 03 3 | 912-04 | | | | | | | 0 | • | | | 1 97E 03 | 3 91E 04 | 1 | 2 | _C |
| CHLOROFORM | 2 DIE | 04 1 | 406-04 | 8 81E | | ЭÆ | 04 | | | | • | | • | 2 81E 04 | 1 40E 04 | 4 | 4 | 82 |
| 1 Z-DICHLOROE THANE | 2 9.2 | | 4/2-04 | A | | - | | | | | | | 4 | 295.04 | 1 47E D4 | | 3 | 82 |
| TETRACH COULTING | 8 906 | NJ 2 | A75.06 | 9 001 | NG 1 | 3/12 | 05 | ő | | | | | | 1 000 00 | 2 J4L U3 | 10 | 83 | 38 |
| TRICH ORDETHERE | 3 ODE- | 05 | 06E-05 | 8 146 | 05 1 | ΩĘ. | 05 | 9 | | 0 | • | | • | 3 OOE OS | 1 096-05 | 90 13 | 17 | 82 |
| SENIVOLATILE ORGANICS | | | | | | | | | | | | | | | | | | |
| BEN70(A)FLUORANTHERE | | 9 | 0 | | 0 | | 0 | 0 | | 0 | 1 955-04 | S 14 | 65 | 1 955-04 | S 14E 05 | 9 | ß | 60 |
| BENZO(K)FLUORANTHERE | | ø | ۲ | | 0 | | 0 | 0 | | 0 | 1 96E 04 | 4 988 | -05 | 1 96E 04 | 4 98E 05 | Ğ | Ğ | ñ |
| BENZOPERYLENE | | 0 | | | 0 | | 9 | 6 | | • | 3 96E D4 | 4 926 | 63 | 1 96E 04 | 4 92E 05 | AĂ | 12 | RA |
| BENZO(A)ANTHRACERE | | 0 | ø | | 0 | | ٥ | 0 | | 0 | 8 508-05 | 6 19 | 06 | 2 502-05 | G 33E 06 | 10 | 19 | 92 |
| GENZO(A)PYRENE | | 0 | ٥ | | 0 | | 9 | o | | ø | 8 96E 04 ~ | 4 988 | 03 | 1 96E 04 | 4 98E 05 | 12 | ÎØ | 62 |
| BIS(2 ETHYLHEAVE)PHTHALATE | 1 976- | 64 9 | 176-05 | 0 1 76- | 64 6 | OTE | -05 | 0 | | 0 | 8 65E 07 | <u> </u> | 68 | 2 17E 04 | 9 OBE 05 | S | 13 | GŽ |
| CHRYSERE | | 0 | 0 | | Ċ. | | ٥ | ٥ | | 0 |) 96E 04 | § 02E | 05 |) 95E 04 | § 02E-09 | Ņ | 6 | 62 |
| FLUORANTHERE | | 0 | ø | | 0 | | 0 | 0 | | 0 | 8 96E 0 8 | § 018 | 65 | 1 96E 04 | 5 O1E OS | 0 | .0 | ria. |
| IDE NOP YRE WE | | 0 | 0 | | 0 | | 0 | 0 | | 0 | 8 965 09 | 4 93 | 0 5 | 1 985 08 | 4 9 32-05 | 10 | 80 | C |
| PHERAATURERE | | 0 | 6 | | 0 | | 0 | 0 | | 0 | • | |) | 0 | 0 | | • | (BA |
| PYREME | | 0 | 0 | | 0 | | 0 | 0 | | 0 | 0 032-09 | 9 OR | -63 | 1 632-64 | 9 o1e-09 | 19 | 0 | ria. |
| PENTACREDERDITERIOL | 0.000 | ~ ^ | 9 | | 0 | | 0 | 0 | | 0 | 0 | | 0 | 0 | 0 | | | Ū, |
| SUTAL BERTAL PHIRELAVE | 1 1996- | 69) A | 600 - FE | | 0 | | 0 | 0 | | 0 | 8 705-65 | 0 073 | -69 | 1 1012-693 | J 678-69 | 50 | 60 | (IA |
| OB-B-OCIAL PRINKLAIR | V 848- | 05 (| 4415-1039 | | 0 | | U | 0 | | ° 1 | 0 | | æ | 0 14 E-05 | 6 442-05 | 14 | 10 | ea. |
| INDREASTICS | | | | | | | | | | | | | | | | | | |
| | 0.089 | | 0.00 80 | 1 083 | <u></u> | | ~ | ~ | | • | 0.000.00 | 0 000 | | 0 000 00 | A | • | • | • |
| 19(35WIC | 0.0008- | -06 (j | 643-66 | | 98 J | 102 | -98 | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ | | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ | K X 25 - 60 | 1 816 | -07 | 4 9/12-01 | C 102-03 | H | Я | _# |
| Benter Burg | | 00 | 00 | | 66 | | 00 | 66 | | 66 | 60 | | 00 | ~ | 00 00 | | | 89 |
| EB FEST | | 00 | 00 | | 00 | | 00 | 60 | | 00 | 66 | | 00 | 66 | 00 | | | A A |
| An Caracter P | | | | | | | | | | | | | | | | | | 6 |

EDVES: • • CT VALUE NAS EDT CALCULATED BECAUSE CONSCIEND UNA GOT DETECTED OR NOT ANALYZED •• • CT VALUE NAS EDT CALCULATED BECAUSE TORICLIVY CONSTANTS ARE ROT AVAILABLE ER • ROT AVAILABLE OR NOT APPLICABLE

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TABLE 4 SCORING FOR INDICATOR CHEMICAL SELECTION CALCULATION OF CT AND IS VALUES FOR HORCARCINGEENIC EFFECTS

| NUTLY BEAULT NUTLY BEAULT NUTLY BEAULT ATTRACT Status | CIFUICAL | GROUIDHA Max | TER (R1) CT MEAN | GROUNDMA MAI | TER (R2) CT | SERFAC | E MATER ET | 901 (211 | L CT MEAN | IS MAX | VALUE MEAN | TENT | ATIVE | raik Mean |
|--|--|-----------------|------------------------------------|-----------------------|----------------------|----------------|------------------------|--------------------|----------------------|------------------------|--|-----------------|-------|--------------|
| NUMBER S. SEC. 44 S. SEC. 45 S. SEC. 45< | VELATILE ORGANICS | | 000 | C0110000000 | | 000000000 | | 000000000 | | | | 0000 | | 0090 |
| BATTAN C <td>ACTINE</td> <td>•</td> <td>•</td> <td>Ø</td> <td>0</td> <td>ø</td> <td>0</td> <td>1 0</td> <td>0</td> <td>0</td> <td>0</td> <td></td> <td></td> <td></td> | ACTINE | • | • | Ø | 0 | ø | 0 | 1 0 | 0 | 0 | 0 | | | |
| Latistics Latistics <thlatistics< th=""> Latistics <thlatistics< th=""> Latistics <thlatistics< th=""> <thlatistics< th=""> <thlat< td=""><td>BENZEHE</td><td>Ū</td><td>8</td><td>8.655-04</td><td>8 932-94</td><td>0</td><td>0</td><td>•</td><td>•</td><td>8.555-04</td><td>3.935-04</td><td>25</td><td></td><td>25</td></thlat<></thlatistics<></thlatistics<></thlatistics<></thlatistics<> | BENZEHE | Ū | 8 | 8.655-04 | 8 932-94 | 0 | 0 | • | • | 8.555-04 | 3.935-04 | 25 | | 25 |
| Lider.SETTLAT. | 2-BUTANURE 1 1-DICHLOROETHANE | 1 295-04 | 6 40E-05 | 1 296-04 | 6.552-05 | 0 | 0 | • | | 1 291-04 | 6 505-05 | 23 | | 28 |
| Coll Discrete Control | 1 1-DICHLOROETKENE TRANS-1 2-DICH ORDETWENE | 5 946-03 | 1 185-03 | 0 | 1 315-04 | ° . | 0 | 6 6 | 0 0 | 5 94E-03 2.64E-04 | 1 185-03 | 14 97 | | 14 97 |
| 140 | CHLOROFORM | 0 | | 0 | 00000 | 0 | 0 | 0 | 0 | 0 | 00000 | e / | | ~ |
| MITTALE 2 59:-65 3 33:33 MICH AND LEGADETINAL | 1 2-DICHLOROETHANE Ethylibenzene | 8 80E-05 | 4.25E-05 | 0 0 | 0 | 0 | 0 | 9 9 | 8 | 4 .87(4) 0 | 4.255-05 | 29 | | 8 |
| Internal 1 (1) (1) (1) (1) (1) (1) (1) (1) (1) (1 | HETHYLENE CHLORIDE | 2 395-05 | 7 95E-06 | 1 38E-05 | 4 64E-05 | 0 | 0 | 0 | 6 | 2.386-65 | 7 955-06 | 22 | | 22 |
| I.I.T.T.TUCK.NET.NAME I.I.T.TUCK.NET.NAME I.I.T.TUCK.NET.NAME <td>TETRACHLORGE I HERE</td> <td>3 125-05</td> <td>2 081-05 1 29E-05</td> <td>2 601-05</td> <td>2 /12-05 1 26E-05</td> <td>0</td> <td>ő</td> <td>0</td> <td>ø</td> <td>3 122-05</td> <td>Z 712-05</td> <td>31</td> <td></td> <td>31</td> | TETRACHLORGE I HERE | 3 125-05 | 2 081-05 1 29E-05 | 2 601-05 | 2 /12-05 1 26E-05 | 0 | ő | 0 | ø | 3 122-05 | Z 712-05 | 31 | | 31 |
| Martine J. Served J. Served <thj. served<="" th=""> <thj. served<="" th=""> <thj.< td=""><td>1 1 1 TRICHLOROETHANE</td><td>en. 320 C</td><td>9 605-03</td><td>6 60E-06</td><td>2 236-05</td><td>0</td><td>0 0</td><td>0 0</td><td>10 13</td><td>6 60E-06</td><td>2 236-06</td><td>33</td><td></td><td>33</td></thj.<></thj.></thj.> | 1 1 1 TRICHLOROETHANE | en. 320 C | 9 605-03 | 6 60E-06 | 2 236-05 | 0 | 0 0 | 0 0 | 10 13 | 6 60E-06 | 2 236-06 | 33 | | 33 |
| SUTURE VITLE GRANTES EXCOMPLETE EXCOMPLE | RILENES | * | 2 002-03 0 | 8 535-A3 | 6 696 °YJ | 0 | 0 | 0 | 0 | (| 6 •005 ~43 | 64 | | 29 |
| DESCRIPTION | SENIVOLATILE ORGANICS | | | | | | | | | | | | | |
| BEZERYLINE BEZERYLINE BEZERYLINE EXCOMPTINE | BENZO(&)FLUCRANTHENE | • | • | 0 | 0 | 0 | Q | 1 145-03 | 3 005-04 | 1 142-03 | 2 00E-04 | 18 | | 16 |
| BLUE NUMBER 1141-01 <td>BENZO(K)FLUCRANTHENE</td> <td>•</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>1 145-03</td> <td>8 905-04</td> <td>1 146-03</td> <td>2 905-04</td> <td>17</td> <td></td> <td>21</td> | BENZO(K)FLUCRANTHENE | • | 0 | 0 | 0 | 0 | 0 | 1 145-03 | 8 905-04 | 1 146-03 | 2 905-04 | 17 | | 21 |
| EXERCIC/INFIGUE EXERCIC I Add-01 Z.ADG-04 I Add-01 Z.ADG-04 I Add-01 Z.DOG-04 I I I Add-01 Z.DOG-04 I I I Add-01 Z.DOG-04 I I I I I I I I I I I I I I I I I I I | BENZO(A)ANTHRACENE | • | • | | õ | e | õ | 1 142-03 | 2.89E-04 | 1 142-03 | 2 8/2-04 2 89E-04 | 15 | | 22 |
| Distriction Distriction 1 142-01 2 002-04 22 13 Distriction 1 142-01 2 002-04 23 14 Pristriction 1 142-01 2 002-04 23 14 Pristriction 1 142-01 2 002-04 23 14 Pristriction 1 142-01 2 002-04 2 002-04 23 20 Distriction 1 012-04 2 002-04 | BENZO (A) PYRENE | • | 19 10 | 9 19 | 0 | 0 | 0 | 1 145-03 | 8.905-04 | 1 146-03 | 2 905-04 | 19 | | 30 |
| RINGAMERE READWREATE READWRE | DRYSENE | • | | 6 | 6 | ¢ | 0 | 1 142-03 | 2 93E-04 | 1 148-03 | 2.93E-04 | 22 | | 87 |
| ATELENTINE ATELENT ATELENTIC | FLUCRARTHERE | • | 9 9 | 0 9 | 0 | 0 | 0 0 | 1 145-03 | 2 92E-04 9 885-04 | 1 145-03 | 8 925-04 9 885-04 | 21 36 | | 19 23 |
| Printeri Instruct, Minutation 1 <th1< td=""><td>PHENANTHRENE</td><td>•</td><td>4</td><td>0</td><td>^ 0</td><td>¢</td><td>ø</td><td>6 496~900</td><td>0</td><td>8 146-43 0</td><td>6.005-W</td><td></td><td></td><td>6</td></th1<> | PHENANTHRENE | • | 4 | 0 | ^ 0 | ¢ | ø | 6 49 6~9 00 | 0 | 8 146-43 0 | 6.005-W | | | 6 |
| DETERMINENCI • <t< td=""><td>PYRENE RITETAN BUTHALATT</td><td>9 9</td><td>6</td><td>0 0</td><td>0</td><td>0</td><td>0 0</td><td>1 14E-03</td><td>2 925-04 9 A75-00</td><td>1 142-03</td><td>2 925-04 9 475-09</td><td>23 M</td><td></td><td>18 M</td></t<> | PYRENE RITETAN BUTHALATT | 9 9 | 6 | 0 0 | 0 | 0 | 0 0 | 1 14E-03 | 2 925-04 9 A75-00 | 1 142-03 | 2 925-04 9 475-09 | 23 M | | 18 M |
| BILLING MYNULATE 4-GOURDOCTE, MYNULATE 4-GOURDOCTE, MYNULATE 4-GOURDOCTE, MYNULATE 4-GOURDOCTE, MYNULATE 4-GOURDOCTE, MYNULATE 1005-001 1805-01 1805-00 1677-01 0 9005-03 1.225-03 1.816-06 1.867-01 4 6 MATINON ATTONY ATTON | PENTACHLOROPHENOL | • | | | Ð | 0 | 0 | 0.000-000 | 6 47 6 49 6 | 8 | 04416-41 | | | ~ |
| Laborentin Permit Permit Principal Construction Distriction Distri | BIBUTYL PHTHALATE | 3 816-04 | 1 916-04 | 9 9 | 6 0 | 6 0 | 0 0 | 1.635-96 | 3 .345-0 7 | 3.835-04 | 1 91E-04 | 85 | | 35 |
| BUTT, BEXT, WITHLAITE BUTT, WITHLAITE BUTT, BUTHLAITE BUTT, BUTHLAITE BUTT, BUTHLAITE BUTT, BUTHLAITE BUTT, BUTHLAITE BUTT, BUTHLAITE BUTT, BUTHLAITE BUTT, BUTHLAITE | 4-BRONDPHERYL PHERYL ETHER | ٠ | | 0 | ø | 0 | 0 | 0 | 0 | 0 | Û | | | |
| DERMEMICS ALTRINUM ANTIDUMY I BOF-000 1 BSE-01 1 BOF-001 1 BSE-01 1 BOF-001 1 BSE-01 0 < | BUTYL BERZYL PHTHALATE BI-B-OCTYL PHTHALATE | | 0 | 0 0 | 0 | 0 0 | 0 | 0 | Ø | 0 | 0 4 | | | |
| Automatical Autom | INTRANICS | | | | | | | | | | | | | |
| ANTINONY ANTINO | ALIPLINUM | ٠ | 10 | 8 | o | 0 | o | ø | ø | 0 | Ø | | | |
| Martini 1 OK 100 1 Set -01 1 Add +00 1 Met -01 - 4 BET -01 2 Add +01 1 Add +01 - 4 BET -01 2 Add +01 3 J BERTINI 1 761 -01 3 B44 -02 8 B01 -02 2 Add +02 4 BET -01 3 B44 -02 8 B01 -02 2 Add +02 4 BET -01 3 B44 -02 9 B01 -01 3 B44 -02 3 B44 -02 <td>ANTIMONY</td> <td>9</td> <td>¢ 1.895-01</td> <td>0</td> <td>0 1 875-01</td> <td>0</td> <td>0 0</td> <td>0 8 685.89</td> <td>9 9 992 99</td> <td>0</td> <td>0 9 867 -81</td> <td>A</td> <td></td> <td>a</td> | ANTIMONY | 9 | ¢ 1.895-01 | 0 | 0 1 875-01 | 0 | 0 0 | 0 8 685.89 | 9 9 992 99 | 0 | 0 9 867 -81 | A | | a |
| BETHLINK 1 784-01 3 644-02 8 904-02 2 435-62 4 055-62 4 915-64 1.685-64 1 785-61 3.665-02 9 9 CAUCIUM CORNIUM CORNIUM Corner Corner Corner Corner Corner 1 785-61 3.685-62 9 9 9 9 CORNIUM Corner Corner Corner Corner Corner 1 655-62 8 775-61 8 975-64 8 775-61 3.685-62 9 9 9 CORNIUM Corner 1 645-61 3 145-62 8 716-61 2 146-62 9 146-62 1 335-63 8 975-64 8 775-61 1 255-61 7 7 DEC 1 645-61 3 145-62 8 976-62 9 146-63 1 795-63 1 557-64 2 575-64 2 575-61 5 256-61 6 55 MARCESINM MARCESINM Corner 7 356-61 2 605-61 6 5 5 255-61 6 435-61 2 605-61 6 5 SILERIN Corner 7 365-61 3 665-62 1 665-62 2 657-65 5 255-61 5 657-62 2 764-60 2 575-62 1 665-62 <td>BARIUM</td> <td>2 385+00</td> <td>5 968-01</td> <td>1 462+00</td> <td>§ 14E-01</td> <td>0</td> <td>0</td> <td>4 905-03</td> <td>8.638-03</td> <td>2 39E+00</td> <td>8 99E-01</td> <td>j</td> <td></td> <td>3</td> | BARIUM | 2 385+00 | 5 968-01 | 1 462+00 | § 14E-01 | 0 | 0 | 4 905-03 | 8.638-03 | 2 39E+00 | 8 99E-01 | j | | 3 |
| CHUICH 7 ME-01 3 CHUCL 0 CHUCL | SERVILIUN CADMIUM | 1 785-01 | * • | 0 \$0~300 8 | 0 66761. 0 | 0 4 /162_09 | 0 9675_09 | 0 A 915_84 | 0 Ma_200. 1 | 0 1 985-01 | 9 9 855-09 | a | | ø |
| CHRONIUM COMPTR COMPT COMPTR C | CALCIUM | 4 1 /05-01 | 9 0 ~ 5~ 0 6 | 0 0 0 0 0 | 8 498 498 | 0 035-96 | 8 078-06 O | 0 | 0 | 0 196-91 | 0 | | | |
| COPPER 2 00 -01 6 655-02 5 715-01 1 255-01 2 145-02 9 185-03 8 035-04 2.705-04 5 725-01 1.255-01 7 IEAD 1 655-01 3 145-02 2 275-01 8 246-02 0 407-02 1 195-03 1 055-04 2.575-02 7.815-03 1.255-01 7 7 MAGNESSE • • 2 395-02 7 355-03 3 085-03 3.045-03 1.552-04 2.575-02 7.815-03 11 11 MAGNESSE • • 2 395-01 8 075-01 8 075-03 1.652-04 2.575-02 7.815-03 11 11 11 MAGNESSE • • 2 395-01 8 075-01 8 075-03 1.652-04 2.575-02 7.815-03 11 11 11 MICALE • • 8 075-01 8 075-01 8 075-03 1.652-04 2.575-02 7.815-03 11 11 11 Stoclar • • • • • • • • <td>ORONIUM CORAL T</td> <td></td> <td>0 0</td> <td>•</td> <td>0</td> <td>0 0</td> <td>0</td> <td>0</td> <td>6</td> <td>0 0</td> <td>6 6</td> <td></td> <td></td> <td></td> | ORONIUM CORAL T | | 0 0 | • | 0 | 0 0 | 0 | 0 | 6 | 0 0 | 6 6 | | | |
| IEAD 1 645-01 3 14E-02 2 27E-01 8 24E-02 6 47E-02 1 18E-02 1 18E-02 8.40E-03 1.55E-04 8.55E-04 8.55E-01 8.40E-03 8.4 | COPPER | 2 005-01 | 6 655-02 | 5 71E-01 | 1 25E-01 | 8 146-92 | 0 18E-03 | 8 9 35-0 4 | 2.705-04 | \$ 725-01 | 1.255-01 | 1 | | 7 |
| NUMERISIUM 1 00 00 000 0 000 00 | JRON LEAD | * 1 65F-01 | 9 3 145-07 | 9 9 976-01 | 6 8 245-02 | ። የጨቆሻል ል | 1 195-49 | 0 1.075-03 | 9 2.405-04 | ອ 2. 296 -01 | 6 5.967-07 | ß | | 8 |
| NUCLANESE NECCURY NECCURY NECCURY NECCURY NECCURY NECCURY NECCURY NECCURY NECCURY NECCURY NECCURY NOTAL DISSOLVED SOLIDS 9 10E-04 1 94E-04 3 00E-04 7 27E-05 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | MAGNESTUM | 9 | 0 0 0 0 | 8 | 0 | 0 | 0 | 0 | 9 | 9-9-9-603 9- | 0 | Ŭ | | Ũ |
| BIOCLI 6 395-01 1 545-01 6 395-01 2 075-01 0 000 00 0 0000 0 0000 0 000 | MANGARESE MERCURY | | 8 | 2 391 -02 | 7 355-03 | 1 ML-00 | 1.045.03 | 1 792-01 | 1.825-04 | 2.575-02 | 7.E1E-03 | 11 | | 81 |
| NOTASSIUN 0 005+00 < | SIDEL | 6 39E-01 | 1 56E-01 | 6 39[-0] | 8 075-01 | | | 4 672-03 | 1.662-03 | 6 43E-01 | 8 095-01 | 6 | | 5 |
| STILVER 2 00E-01 1 0E-01 1 40E+00 2 24E-01 0 | SELENTIN | 0 006+00 | 0 006+00 | | 0 | 6 225461 | 6.678+00 | 8 | 6 | § 255E+0) | 6 675+60 | 2 | | 2 |
| SUDIUM 7 & 55 = -03 3 14E - 03 9 15E - 03 7 44E - 03 0 | SILVER | 2 002-01 | 1 05E-01 | 1 405+00 | 8 245-9) | 0 | 0 | 3 865-63 | 8.892-04 | 1 405+00 | 8.252-01 | Š | | ā |
| NAMO 7 & & E = -03 3 & 1 & E = -03 9 & 1 & E = -03 7 & 4 & E = -03 1 & E = -03 7 & 4 & E = -03 1 & E & E & E & E & E & E & E & E & E & | THALLIUM - | | • | 0 | 0 | 0 | õ | 0 | œ | 0 | 0 | 6 | | ` |
| ZIK 3 ZQE-02 1 SIE-02 2 P3E-02 1 SIE-02 8 Sec-02 8 Sec-03 3 ZZE-03 3 ZZE-03 3 ZZE-03 3 ZZE-03 3 ZZE-03 1 SIE-04 1 SIE-04 1 OI 10 NISCELLANEOUS CHEMICALS | MULONAN | 7 \$62-03 | 3 14E-03 | 8 15£-03 | 7 445-03 | 0 | 0 6 898 80 | 8 572-05 | 4.34E-05 | 9 24E-03 | 7 445-03 | 2 | 70 | 12 |
| NISCELLANEOUS CHEMICALS | CYANDE | 3 205-02 | 1 916-02 | 2 835~02 | હ 1 શિદ્ય નઉડ | ୦ ୫.୧୫୧~୫୨ | ୁ ଅର େକ୍ରର ଜ | \$ 185 ≪94 | ₹ 202 ∝03 | 9 <u>87</u> 8-98 | 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 8 | SE | 10 |
| 9 10E-04 1 94E-04 3 00E-04 7 27E-03 0 0 9 10E-06 1 94E-04 2 0 25 AWONIA 1 66E+02 1 72E+01 2 79E+02 2 74E+01 0 1 HITRATE-RITRITE • | MISCELLANEOUS CHEMICALS | | | | | | | | | | | | Þ | ŀ |
| AMMONIA 1 66E+002 3 79E+012 8 79E+022 8 74E+01 0 1 NITRATE-RITRITE 0 0 0 0 0 0 0 1 1 ChildRides 0 0 0 0 0 0 0 0 1 | PHENOLS | 9 105-04 | 1 945-04 | 3 00E-04 | 7 87E-05 | 0 | 0 | 0 | 0 | 9 10E-04 | 1 945-04 | 8 | 0 | 8 |
| TOTAL DISSOLVED SOLIDS • • • • • • • • • • • • • • • • • • • | APPONIA HITRATE ANTERITE | 1 66E+02 | 1 72E+01 | 8 79€ 402 | 8 765001 | 1 642401 | 6 63 5 489 | 0 0 | 0 0 | 8 795+02 | 8 74E+01 | 1 | 50 | 1 |
| TOTAL DISSULVED SOLUTS • • • • • • • • • • • • • • • • • • • | CHLORIDES | | • | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | 1 |
| | TUTAL DISSOLVED SOLIDS | • | 6 | 0 0 | e 0 | 0 0 | 0 | 0 0 | 0 | 0 | ବ ପ | | فببرا | |
| | | | - | | | - | | | | | - | | ω | I |
| NOTES •• NO ST SINCE COMPOUND WAS NOT AMALYZED FOR OR SINCE NO TOXICITY CONSTANTS WERE AVAILABLE | | ALL CALLOR | HUT ANALYZED | FOR OR STU | | | s were avar | ATLE | | | | | 05 | |

NOTES • • NO ET SINCE COMPOUND WAS NOT AWALYZED FOR OR SINCE NO TOXICITY CONSTANTS MERE AVAILABLE

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TABLE 5 SCOTING FOR INDICATOR CHEMICAL SELECTION EVALUATION OF EXPOSURE FACTORS AND FINAL CHEMICAL SELECTION

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| | MEAN IS VALUES | | RANK MATER | | TER VAFOR WEDRY S LA LITY(0) FRESSURE(0) CONSTANT(0 | CEDRY S LAH | Rec | MALF-LIFE (8) | | | 80 |
|---|---|--|--|--|--|--|--|--|---|---|-----------|
| CHENTLAC. | PC | 85 | PE 02 | (03/1) | (CEHA) | ensited (G) | (89/1) | 20IL | AIR | 8 | (8) |
| WELATILE ORGANICS | | | | | L | | 1-01 | | | | |
| BENZENE 1 J-DICHLOROETHENE CHLOROFORM 1 2-DICHLOROETHANE METTYLENE CHLORIDE TETRACHLOROETHENE TEICHLOROETHENE SEMUYOLATILE ORGANICS | 1 77E-05 3 91E-04 1 40E 04 1 42E-04 8 34E-05 8 50E-05 3 09E-05 | 3 932-04 1 865-03 4 265-05 7 955-06 2 715-05 8 695-03 | 17 20 2 18 3 ° 85 94 14 91 17 17 | \$750 0000 \$50 0000 8300 0000 8300 0000 83000 0000 \$50 0000 \$50 0000 \$50 0000 | 9 522+09 1 525+02 1 515+02 6 405+01 3 625+02 1 785+01 5 795+01 | 0 00554000 0 00431000 0 00237000 0 00207200 0 00203000 0 02590000 0 00910000 | 83 0 30 0 31 0 34 0 8.8 284 0 125 0 | 6 6 6 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | 8 म म म म म म म म म म म म म म म म म म म | 1-6 1-6 0.1-10 0 171 1-5 1-20 1-20 | |
| BENZO(B)FLUCROANTHENE BENZO(K)FLUCROANTHENE BENZO(K)FLUCROANTHENE BENZOPERYLENE BIS(2 ETHYLHEXYL)PHTHALATE DIS(2 ETHYLHEXYL)PHTHALATE DISTERE FLUCROANTHENE FLUCROANTHENE PHRENE | \$ 14E-05 4 98E-05 4 98E-05 4 92E-05 4 98E-05 5 02E-05 5 01E-05 4 93E-05 5 01E-05 5 01E-05 | 3 005-04 2 905-04 2 905-04 8 875-04 2 935-04 2 935-04 2 935-04 2 885-04 2 925-04 | § 21 0 25 10 8 12 29 13 6 22 24 1 27 1 27 7 23 | 0 0140 0 0043 0 0012 0 0012 0 0013 0 0013 0 0013 0 2050 U U 0 1233 | 5 602 -07 5 105 -07 9 1 035 10 9 6 305 -09 5 505 -05 9 8 505 -05 | 6 00001190 6 0000155 6 00000155 6 0000005 8 6 00000105 9 00000546 U 0 00000546 | 850000 0 850000 0 8500000 0 9500000 0 900000 0 7300 0 9 93000 0 | 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | 5.51 9 9 9 5.51 9 9 9 9 0.2-2 9 | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | |
| INCREANICS | | | | | | | | | | | |
| ARSENIC BARIUH GADAIUH CHICHIUH CHICHIUH CHICHIUH ERCH ERCH BECKURY HICKEL SELENIUM SILVER VANADIUH ZINC | 6 14E-02 0 | 1 86E-01 5 99E-01 3 86E-02 0 1 25E-01 5 26E-02 0 7 51E-03 2 09E 01 6 47E-00 2 25E-01 7 48E-03 1 63E-02 | 1 9 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | 8 8 9 9 9 9 9 9 9 9 9 9 9 9 | 6 6 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 | ea Baar Beerer Bear Bear Baar Baar Baar | 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 | 866666666666666666 | 4.8-20 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | PERS PERS U U U PERS U PERS U U U U U PERS | • • • • • |
| NISCELLANEOUS CHEMICALS | | | | | | | Ø | | | | |
| NHO RIA | | 8 745+01 | 9 | £30000 0000 | 7 695+03 | 0 00032100 | 81 | | Ø | a | ¢ |
| NUTES: (a) SOURCE FOR CHEMIC (b) INDICATOR CHEMIC • NOT CALCULATEL • NOT CALCULATEL • UMAYAILABLE • A SOURCE (USEPA L • LOWER LIMIT OF • PERS ENVIRONMENTALL | CAL PROPERTIES CAL SELECTIONS DUE TO UNAVA 1986) LISTS HALF LIFE Y PERSISTENT | is superfun Ilability of As not avail | o public : Toxicity Able | NEALTH EVALUATI BATA | or hakulal (88 | epa, 1095) | | | | | |

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APPENDIX 2 SUPPORTING CALCULATIONS

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ATTACHMENT A SURFACE RUNOFF CONTAMINATION ANALYSIS

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Releases by overland flow of contaminants from source areas at North Sea Landfill is estimated using the Modified Universal Soil Loss Equation (MUSLE) and sorption partition coefficients derived from each compound's octanol-water partition coefficient K_{OW} (Haith, 1980, Mills, et al , 1982) The MUSLE allows estimation of the amount of surface soil eroded in a storm event of given intensity while sorption coefficients allow the projection of the amounts of contaminant carried along with the soil and the amount carried in dissolved form

Soil loss calculation The modified universal soil loss equation is (Mills et al 1982)

$$Y(S)_{E} = a (V_r q_p)^{0.56} KLSCP$$

Where

| Y(S) _E | - sediment yield (metric tons) |
|-------------------|--|
| a | conversion constant (11 8 metric) |
| vr | □ volume of runoff (m ³) |
| 9 _D | = peak flow rate (m ³ /sec) |
| K | <pre>> soil erodibility factor (tons/acre/runoff)</pre> |
| L | = slope length factor (dimensionless) |
| S | slope-steepness factor (dimensionless) |
| С | - cover factor (dimensionless 1 0 for bare soil) |
| P | - erosion control practice factor (dimensionless, |
| | 1 0 for uncontrolled waste site) |

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Volume of runoff (V_r) $V_r = aAQ_r$ - conversion constant (100 metric) Where а Α - contaminated area, (ha) acre = 2 218 750 ft² (from R I map) x (2 296 x 10 5 ft^2 x (0 4047 ha/acre) = 20 62 ha - depth of rungff (cm) Qr $= (R_{t} - 0.2S_{w})^{2}/(R_{t} + 0.8S_{w})$ - total storm rainfall (cm) Rt = 5 08 cm (2-inch storm) S_w - water retention factor (cm) $= (1000/CN \ 10)a$ CN = curve number (dimensionless) - 59 (Versar 1988 Table 3-4) a = conversion constant (2 54 metric) (1000/CN-10)2 59 æ - 17 65 cm $= [5 \ 08 \ cm - 0 \ 2(17 \ 65 \ cm)]^2 / [5 \ 08 \ cm + 0 \ 8(17 \ 65 \ cm)]$ Qr - 0 125 cm - 100 (20 62 ha)(0 125 cm) - 257 8 m³ V_r

Peak Flow Rate

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$$q_{p} = \frac{aAR_{t}Q_{r}}{T_{r}(R_{t} - 0.2S_{w})}$$

Where T_r = peak storm duration (hours), assume 2 hours a = conversion factor, 0 028 metric

 $q_{p} = \frac{(0.028)(20.62ha)(5.08cm)'(0.125cm)}{(2 hr)[5.08cm - 0.2(17.65cm)]}$ = 0.118 m³/sec

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Soil Erodibility Factor

K = 0 17

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Slope Length and Slope Steepness Factors

LS = 50-foot elevation difference over 1,500-foot slope length (average of four slope lengths onsite) (750 + 1,000 + 2,000 + 2,250)1/4) (USGS TOPO Map)

= 0 83 (Versar 1988, Figure 2-6)

Cover Factor

C = 0 75 (Versar 1988 Table 2-4)

Erosion Control Practice Factor

P = 1 0 (Versar 1988)

Soil Loss Calculation

 $Y(S)_{E} = (11 \ 8)[(257 \ 8m^{3})(0 \ 118m^{3}/sec)]^{0.56} (0 \ 17)(0 \ 83)(0 \ 75)(1)$

= 8 46 metric tons/event

The following equations were used to predict the degree of soil/water partitioning for given compounds once storm event soil loss has been calculated

Dissolved/sorbed contaminant loading calculation (Versar, 1988, p 2-41)

 $S_s = [1/(1 + \theta_c/K_d\beta)] C_{soil} A$

 $D_s = [1/(1 + (K_d\beta)/\theta_c)] C_{soil} A$

| Where | S | 🛥 sorbed substance quantity, (kg) |
|-------|-------------------|---|
| | D | dissolved substance quantity (kg) |
| | ອີ | - available water capacity of the top cm of soil, |
| | - | (dimensioniess) |
| | ^k d | sorption partition coefficient (cm ² /g) |
| | β | ∝ soil bulk density (g/cm²) |
| | C _{soil} | soil substance concentration (kg/ha-cm) |
| | A | - contaminated area (ha-cm) |
| | | |

Available Water Capacity

 $\theta_c = 0.04$ cm available water/cm soil (dimensionless) (Pennock 1986)

Sorption Partition Coefficient

| <u>Chemical</u> | <u>К</u> (с | m ³ /g) | |
|-----------------|-------------|--------------------|--------|
| Ammonia | 0 31 | (See bel | ow) |
| Arsenic | 4 71 | (Dragun, | 1987)* |
| Cadmium | 2 46 | (Dragun | 1987) |
| Chromium | 284 | (Dragun | 1987) |
| Iron | 54 6 | (Dragun | 1987) |
| Lead | 99 5 | (Dragun | 1987) |
| Manganese | 148 | (Dragun | 1987) |
| Nickel | 54 6 | (estimat | ed) |

 K_d for ammonia was calculated from $K_{oc} = K_d/soil$ organic carbon content (Lyman et al. 1982) using $K_{oc} = 3.1 \text{ mg/l}$ (U.S. EPA. 1986), and assuming a soil organic carbon content of 1%

*Dragun 1987 Table 4 2 Represents an average K_d value for As (III) and As (V)

Soil Bull Density

Sand has a bulk density, $\beta = 1.55 \text{ g/cm}^3$ (Hausenbuiller, 1978) Based on the descriptions of soils found in the area of the North Sea Landfill Site (Carver and Plymouth Sands) in the soil survey for the area, the bulk density for sand is appropriate (USDA 1975)

Soil Substance Concentration

| | Average Concentration found in Surface Soils (mg/k (from Table 1-2) | :g) |
|-----------|--|--------|
| Ammonia | ο | |
| Arsenic | 3 58 | \sim |
| Cadmium | 0 76 | |
| Chromium | 2 92 | S. F. |
| Iron | 3740 | Ā |
| Lead | 5 38 | ł |
| Manganese | 68 2 | 0 |
| Nickel | 7 33 |)4 |
| | | 1811 |

For a soil with a bulk density of 1 55 g/cm³ a volume of soil one hectare (10 000 m²) by one centimeter has a weight of 155,000 kg/ha as shown below

| ha | x 10,000 $\frac{m^2}{m}$: | $x \frac{(100 \text{ cm})^2}{m^2} x$ | l cm x 1. | ⁵⁵ g 1 1 ³ 1, | <u>kg</u> 000 g | 155,000 kg/ha |
|----|----------------------------|--------------------------------------|-----------|--|--------------------|-----------------------|
| | The soil con | taminant concer | ntrations | are as i | ollows | |
| | Average soil | conc (mg/kg) | x 155,000 | 0 kg/ha w | : 1 x 10 | -6 kg/mg |
| | Ammonia | 0 mg/kg x | 155,000 1 | kg/ha x 1 | × 10 ⁻⁶ | kg/mg = |
| | Arsenic | 3 58 mg/kg x | 155 000 1 | kg/ha x 1 | $\times 10^{-6}$ | $kg/mg \approx 0.555$ |
| | Cadmium | 0 76 mg/kg x | 155,000 1 | kg/ha x 1 | $\times 10^{-6}$ | kg/mg = 0.118 |
| | Chromium | 2 92 mg/kg x | 155 000 1 | kg/ha x 1 | × 10 ⁻⁶ | kg/mg = 0.453 |
| | Iron | 3740 mg/kg x | 155 000 1 | kg/ha x 1 | × 10 ⁻⁶ | kg/mg = 579 |
| | Lead | 5 38 mg/kg x | 155,000 1 | kg/ha x 1 | $x 10^{-6}$ | kg/mg = 0.834 |
| | Manganese | 68 2 mg/kg x | 155,000 1 | kg/ha x 1 | × 10 ⁻⁶ | kg/mg = 10.6 |
| | Nıckel | 7 33 mg/kg x | 155,000 1 | kg/ha x 1 | x 10 ⁻⁶ | kg/mg = 1 14 |

Calculation of Sorbed/Dissolved Substance Quantity

 $S_s = [1/(1 + 0.04/K_d \times 1.55)] C_{soil} A$

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 $D_s = [1/(1 + (K_d \times 1 55)/0 04)] C_{soil} A$

| | K _d (cm ³ /g) | C _{soil} (kg/ha) | A (ha) | S_ (kg) | D _s (kg) |
|-----------|-------------------------------------|---------------------------|--------|---------|---------------------|
| Ammonia | 0 31 | | 20 61 | | |
| Arsenic | 4 71 | 0 555 | 20 61 | 11 37 | 0 062 |
| Cadmium | 2 46 | 0 118 | 20 61 | 24 | 0 025 |
| Chromium | 284 | 0 453 | 20 61 | 9 33 | 0 001 |
| Iron | 54 6 | 579 | 20 61 | 11,900 | 5 64 |
| Lead | 9 9 5 | 0 834 | 20 61 | 17 18 | 0 004 |
| Manganese | 148 | 10 6 | 20 61 | 217 9 | 0 038 |
| Nickel | 54 6 | 1 14 | 20 61 | 23 40 | 0 011 |

Loading to Estuary from Surface Water

Total Loading = $P\lambda i + PQi$ $P\lambda i = [\lambda(S)_E / aA\beta]S_S$ $PQi = [Q_r/R_t] D_S$

Where PX_i = sorbed substance loss per event, (kg) PQ_i = dissolved substance loss per event, (kg) a = constant (100, metric) SEA 004 1812

and as calculated before

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| Y(S)E | | 8 47 metric tons |
|----------------|-------------|-----------------------|
| A | 6 | 20 61 ha |
| β | 6 28 | 1.55 g/cm^3 |
| Q _r | œ | 0 125 cm |
| Rr | | 5 08 cm |

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| Chemical | S _s (kg) | D _s (kg) | PX ₁ (kg) | PQ _i (kg) | Total (kg) |
|-----------|------------------------|------------------------|-------------------------|-------------------------|---------------|
| Алтопіа | 0 | 0 | 0 | 0 | 0 |
| Arsenic | 11 37 | 0 062 | 0 030 | 0 0015 | 0 032 |
| Cadmium | 24 | 0 025 | 0 0063 | 0 00062 | 0 007 |
| Chromium | 9 33 | 0 001 | 0 025 | 0 00002 | 0 025 |
| Iron | 11940 O | 5 64 | 31 64 | 0 139 | 31 8 |
| Lead | 17 18 | 0 004 | 0 046 | 0 00011 | 0 046 |
| Manganese | 217 8 | 0 038 | 0 577 | 0 00093 | 0 58 |
| Nickel | 23 4 | 0 011 | 0 062 | 0 00027 | 0 062 |

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ATTACHMENT B CALCULATION OF CONTAMINANT CONCENTRATIONS IN FISH COVE

The Estuary Pollutant Concentration Calculation (EPCON) model uses the following equations to determine a steady state (maximum in the case of no initial pollution) pollutant concentration in an idealized estuary with a constant pollutant input

 $c_{1} = (c_{1}Q_{1}T)/V_{L},$ $c_{2} = (c_{1}V_{L} + c_{1}Q_{1}T)/V_{H},$ $c_{3} = (c_{2}V_{H} - c_{2}V_{D} + c_{1}Q_{1}T)/V_{L},$ $c_{4} = (c_{3}V_{L} + c_{1}Q_{1}T)/V_{H},$

| Where | $C_{1,2}$ | 4 = subsequent pollutant concentrations in estuary Odd |
|-------|-----------|--|
| | | numbers are low tide concentrations, even numbers are |
| | | high tide concentrations |
| | С, | - pollutant input concentration to estuary |
| | Q, | pollutant input flow rate |
| | T | 🛥 time between tides |
| | V- | - solume of estuary at low tide |

 v_L = volume of estuary at low tide v_H = volume of estuary at high tide

= volume difference $(V_{H} - V_{L})$

For this application of the EPCON model, C_i values were obtained as results of SOCEM modeling, of ground-water contaminant migration (see Attachment E)

| <u>Pollutant</u> | C |
|------------------|----------------|
| Ammonia | 23 l mg/l |
| Arsenic | 25 7 µg/L |
| Cadmium | $19 2 \mu g/L$ |
| Chromium | 25 6 µg/L |
| Iron | 64,156 µg/L |
| Lead | 76 6 µg/L |
| Manganese | 6,020 µg/L |
| Nickel | 133 µg/L |

Pollutant input flow rate was calculated as follows

 $Q_1 = A - V$

Where A = cross section area of contaminated water plume leaving site = $60' \times 3,500' = 210,000 \text{ fr}^2$ V = 135 ft/year (H₂M, 1988) so Q₁ = (210 000 ft²)(135 ft/yr) = 2 835 $\times 10^7 \text{ ft}^3/\text{year}$

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converting to liters/hr

 $(2 835 \times 10^7 \text{ ft}^3/\text{yr})(1 \text{ yr}/365 \text{ days})(1 \text{ day}/24 \text{ hrs})(28 316847 \text{ liters/ft}^3)$

Q = 91 642 liters/hr

Time between tides was assumed to be 12 hours, T = 12

The volume of the estuary was calculated as follows

V = A d

Where A = area and d = average depth

The area of the estuary was determined from a $1^{\alpha} = 350'$ scale map appearing in the remedial investigation report (H₂M, 1988) Manual determination of the area using a grid placed over the map gave an area of 1 034 000 ft² while a computerized digitizer gave a value of 1 036 000 ft² The value of 1 036 000 ft² was chosen for use in calculations The average depth of the estuary was stated as 3-4 feet (H₂M 1988) so 3 1/2 feet was used The USGS quadrangle map for the area states that mean tidal fluctuation is 2 6 feet The high tide and low tide volumes (V_H and V_L respectively) are then

$$V_{\rm H} = (1\ 0.36\ 0.00\ {\rm ft}^2) \pm (3\ 1/2 \pm \frac{2.6}{2})$$

= 4 972 800 ft³

and $V_L = (1,036\ 000\ ft^2) * (3\ 1/2 - \frac{2.6}{2})$ = 2.279 200 ft³

conversion to liters (28 3168 1/ft³) yields

and $V_{\rm H} = 1.408 \times 10^8$ liters $V_{\rm I} = 6.454 \times 10^7$ liters

Using the above values gives C_1 through C_4 , for arsenic, the calculation is

 $C_{1} = (25\ 665\ x\ 91\ 642\ x\ 12)/6\ 454\ x\ 10^{7} = 0\ 4375$ $C_{2} = (0\ 4373\ x\ 6\ 454\ x\ 10^{7}\ \div\ 25\ 665\ x\ 91,642\ x\ 12)/1\ 408\ x\ 10^{8} = 0\ 4009$ $C_{3} = 0\ 4009\ x\ 1\ 408\ x\ 10^{8}\ -\ 0\ 4009\ x\ 7\ 63\ x\ 10^{7}\ \div\ 25\ 665\ x$ $g_{1} = (0\ 8384\ x\ 6\ 454\ x\ 10^{7}\ \div\ 25\ 665\ x\ 91,642\ x\ 12)/1\ 408\ x\ 10^{8}\ =\ 0\ 5843$

For subsequent tidal fluxuations the lst calculated concentration (C_4) is used as input for calculation of the following concentration The EPCON model stops calculating subsequent concentrations after conveyance to the ten thousandth unit of concentration Table 1 is an example of arsenic concentrations in Fish Cove as calculated by the EPCON model The numbers under the c3 heading represent arsenic concentrations in Fish Cove from the first low tide to the low tide at which a steady state of arsenic input and washout is achieved The c4 column is the corresponding high tide concentrations Table 2 is the EPCON results using the SOCEM modeling results for all available wells as input parameters

Total loading to the estuary is calculated as

$$(C_{gw} \times V + M_{sw})/V = C_E$$

Where C_{gw} = concentration of pollutant in estuary from ground water V^{gw} = volume of estuary low tide value gives conservative results M_{gw} = mass of pollutant in estuary from surface water runoff C_E = resulting pollutant concentration in estuary

For arsenic contamination in Fish Cove the calculation is

$$C_{E} = \frac{(1 \ 77 \ \mu g/1 \ x \ 6 \ 45 \ x \ 10^{7} \ 1) + (0 \ 0317 \ kg \ x \ 1 \ x \ 10^{9} \ \mu g/kg)}{6 \ 45 \ x \ 10^{7} \ 1}$$

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 $-1668 \mu g/L$

Table 3 shows the C_E values for the eight indicator chemicals

TABLE 1LOW AND HIGH TIDE CONCENTRATIONS OFARSENIC IN FISH COVE FROM FIRST LOW TIDE TOSTEADY STATE CONCENTRATION AS CALCULATED BY THE EPCON MODEL

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| c3 (µg/l) | c4 (μg/l) |
|-----------|-----------|
| 8381581 | 5843325 |
| 1 02174 | 668431 |
| 1 105839 | 7069561 |
| 1 144364 | 7246045 |
| 1 162013 | 732689 |
| 1 170097 | 7363925 |
| 1 173801 | 7380891 |
| 1 175497 | 7388663 |
| 1 176274 | 7392223 |
| 1 17663 | 7393854 |
| 1 176793 | 7394601 |
| 1 176868 | 7394943 |
| 1 176902 | 73951 |
| 1 176918 | 7395171 |

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TABLE 2 RESULTS OF EPCON MODELING

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| <u>Contamin int</u> | Low Tide Conc. | <u>High Tide Conc.</u> |
|---------------------|----------------|------------------------|
| Ammonia | 1 060421 mg/1 | 0 6663356 mg/l |
| Arsenic | 1 176902 ug/l | 0 73951 ug/l |
| Cadmium | 0 8804379 ug/l | 0 5532301 ug/l |
| Chromium | 11 72142 ug/l | 7 365164 ug/l |
| Iron | 2943 189 ug/l | 1849 349 ug/l |
| Lead | 3 514146 ug/l | 2 208124 ug/l |
| Manganese | 275 9508 ug/l | 173 3934 ug/l |
| Nickel | 6 119606 ug/l | 3 845259 ug/l |

TABLE 3 TOTAL LOADING TO ESTUAR) FROM GROUND WATER AND SURFACE WATER*

| Arsenic Cadmium Chromium Iron Lead Manganese | Concentration in estuary (low tide) from ground water (ug/L) | Contribution from Surface | Maximum Concentration (CE) in Estuary (ug/l) |
|---|---|----------------------------------|---|
| Arsenic | 1 18 | 0 0317 | 17 |
| Cadmıum | 0 880 | 0 0070 | 10 |
| Chromium | 11 7 | 0 0247 | 12 1 |
| Iren | 2943 000 | 31 78 | 3,436 |
| Lead | 3 514 | 0 0456 | 4 2 |
| Manganese | 276 000 | 0 578 | 285 |
| Nickel | 6 120 | 0 0623 | 71 |
| Ammonia | 1060 | 0 0000 | 1060 |
| | | | |

*Only low tide concentrations are used in order to provide a conservative estimate of estuary pollution, high tide concentrations not used

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ATTACHMENT C BIOCONCENTRATION FACTORS

Principle reference Lyman et al , and EPA 1986

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 C_E = Maximum Concentration in Estuary (Fish Cove)

 $BCF = \frac{10 \text{ organism (wet weight)}}{\text{Mean concentration of chemical in water}}$

Where BCF = bioconcentration factor

Assume contaminants are at equilibrium with fish tissue

Concentration of Chemical in Fish Tissue = $C_E \times BCF$

| Contaminant | $C_E^{1}(mg/g)$ | Fish BCF ² | Fish Tissue Concentration (mg/g) | | | | |
|-------------|-----------------|-----------------------|-------------------------------------|--|--|--|--|
| Ammonia | 1 06 E-03 | 0 | 0 | | | | |
| Arsenic | 1 68 E-06 | 44 | 7 34 E-05 | | | | |
| Cadmium | 988E07 | 81 | 8 00 E-05 | | | | |
| Chromium | 1 21 E-05 | 16 | 1 94 E-04 | | | | |
| Iron | 3 44 E-03 | - | | | | | |
| Lead | 4 22 E-06 | 49 | 2 07 E-04 | | | | |
| Manganese | 2 85 E-04 | - | | | | | |
| Nickel | 7 09 E-06 | 47 | 3 33 E-04 | | | | |

¹Assume water density is 1000g/liter ²USEPA, 1986

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ATTACHMENT D CALCULATIONS OF INGESTION TO CONTAMINATED SOILS VIA DIRECT CONTACT

The ingestion exposure from direct contact to contaminated soils was calculated using the following equation

 $GEX_{DC} = WF_1 \times A \times DA$

Where GEX_{DC} - estimated ingestion exposure from direct contact to contaminated soils per event (mg/event)

- WF, = contaminant weight fraction in soil (dimensionless)
- A = available skin surface for direct contact per event (cm²/event)

DA = dust adherence factor (mg/cm^2)

Contaminant Weight Fraction

Mean contaminant concentrations in surface soil samples were used to calculate the contaminant weight fraction in soil The mean contaminant concentrations in ppm (mg/kg) are converted to a weight fraction by multiplying by 10^{-6}

| Contaminant | Min | mum Maxımum | | | Arithme | etic Mean |
|-------------|------|-------------|------|---|---------|-----------|
| Ammon 1 a | • | • | | | | |
| Arsenic | 1 | 0 | 8 | 7 | 3 | 58 |
| Cadmium | ō | 5 | 2 | 2 | õ | 76 |
| Chromium | 1 | 0 | 34 | - | 2 | 92 |
| Iron | 1870 | 0 | 7190 | 0 | 3739 | 0 |
| Lead | 0 | 5 | 42 | 0 | 5 | 38 |
| Manganese | 23 | 0 | 135 | 0 | 68 | 21 |
| Nickel | 5 | 0 | 21 | 0 | 7 | 33 |

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cm2

9 400

<u>18,150</u> 27,550

¹Concentiations in mg/kg

<u>Skin Surface Area (Versar, 1988)</u>

| • | Average | child | male | and | female, | 3-12 | years | |
|---|---------|-------|------|-----|---------|------|-------|--|
| • | Average | adult | male | and | female | | - | |

-Average child/young adult 0-19 years assume average child + adult = 27,550 + 2 = 13,775

-Assume hands only contribute to direct contact (ingestion)

Hands (both) comprise 5 15% of total body area (Versar 1988)

 $13,775 \ge 0.0515 = 709 \text{ cm}^2$

Dust Adherence Factor (Versar, 1988)

Commercial Potting Soil (loamy mix) = 1 45 mg/cm²

Short Term Ingestion Exposure

| | | | | GEX |
|-------------|----------|-------------------------|----------------------------|------------|
| | WF, | A | DA | DC |
| Contaminant | 1 | <u>(cm²)</u> | <u>(mg/cm²)</u> | (mg/event) |
| Arsenic | 3 58E-06 | 709 | 1 45 | 3 68E-03 |
| Cadmıum | 7 6E-07 | 709 | 1 45 | 7 81E-04 |
| Chromium | 2 92E-06 | 709 | 1 45 | 3 OOE O3 |
| Iron | 3 74E-03 | 709 | 1 45 | 3 845 |
| Lead | 5 38E-06 | 709 | 1 45 | 5 53E-03 |
| Manganese | 6 82E 05 | 709 | 1 45 | 0 0701 |
| Nickel | 7 33E 06 | 709 | 1 45 | 7 54E-03 |
| | * | | | |

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Long Term is simply 10% of Short Term

Time Weighted Average Dose. d

Assume - exposures are event based

100% of contaminant adhering to hands is ingested
events occur at the rate of five times per

year

 $\mathbf{d} = \operatorname{GEX}_{\operatorname{DC}} \times \mathbf{C}$

Where d = time weighted average dose (mg/kg/day)

c = conversion (events/kg/day)

$$c = f \times \frac{1}{bw} \times \frac{5 \text{ years}}{70 \text{ years}} \times \frac{1 \text{ year}}{365 \text{ days}}$$

f = frequency of exposure (events/year) = 5

bw = body weight of child/young adult = 45 kg

Average body weight adult (male and female)70 kgAverage body weight child20 kgAverage body weight child/young adult = (70 + 20)/2 = 45 kg

 $c = 5 \times \frac{1}{45} \times \frac{5 \text{ years}}{70 \text{ years}} \times \frac{1}{365 \text{ days}} = 2 174 \times 10^{-5} \text{ events/kg/day}$

Short Term Time Weighted Average Dose

| <u>Contaminant</u> | GEX DC (mg/event) | C (events/kg/day) | Time Weighted Average Dose (mg/kg/day) |
|--------------------|-------------------------|------------------------|--|
| Arsenic | 3 68E-03 | $2 174 \times 10^{-5}$ | 8 00E-08 |
| Cadmium | 7 81E 04 | $2 174 \times 10^{-5}$ | 1 70E 08 |
| Chromium | 3 OOE-03 | $2 174 \times 10^{-5}$ | 6 52E-08 |
| Iron | 3 845 | $2 174 \times 10^{-5}$ | 8 36E-05 |
| Lead | 5 53E 03 | $2 174 \times 10^{-5}$ | 1 20E-07 |
| Manganese | 0 0701 | $2 174 \times 10^{-5}$ | 1 52E-06 |
| Nickel | 7 54E-03 | $2 174 \times 10^{-5}$ | 1 64E-07 |

Long Term is simply 10% of Short Term

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ATTACHMENT E CONCENTRATIONS OF EACH INDICATOR CHEMICAL RELEASED TO FISH COVE AS DETERMINED BY SOCEM

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TOTAL ANNONIA TO FISH COVE FROM HELLS

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| | | Co | of | | | | | | | Cç | P# 20 | |
|--------------|-------|---------|--------------|------|------|------|-------|-----|----|------|--------------|--------|
| | | We | 11 | X | | A | đ | 2 | 2 | Fist | Cove | |
| WELL | | (829 | j/L) | (f1 | t) (| ft) | (ft) | (ft | :) | (E | 평/L) | |
| MM1-A | ANHON | IA C |) 13 | 33(| 00 | 350 | 14 | 20 | 00 | 0 | 00297 | |
| MH1-B | | 0 | 01 | 33(| 00 | 350 | 14 | 40 | 00 | 0 | 00063 | |
| MH1-C | | 0 | 01 (| 33(| 00 | 350 | 14 | 60 | 00 | 0 | 00094 | |
| NH2 | | C | 26 | 20! | 50 | 350 | 14 | 20 | 00 | 0 | 00907 | |
| MK3-A | | Q | 26 | 14 | 50 | 350 | 14 | 20 | 00 | 0 | 01252 | |
| MW3-B | | 31 | 95 | 14 | 50 | 350 | 14 | 40 | 00 | 3 | 09141 | |
| MK3-C | | 0 | 02 | 14 | 50 | 350 | 14 | 60 | 00 | 0 | 00310 | |
| MH4-A | | 1 | 29 |) 2 | 25 | 175 | 14 | 20 | 00 | 0 | 71050 | |
| MH4-B | | 2 | 48 | | 25 | 175 | 14 | 40 | 60 | 2 | 15415 | |
| MM4-C | | 0 | 80 (| 1 | 25 | 175 | 14 | 60 | 60 | 0 | 07562 | |
| PEN 6 | | 0 |) 19 | 320 |)0 | 350 | 34 | 20 | 00 | 0 | 00447 | |
| NH9 | | 1 | 50 | 40 | 00 | 175 | 14 | 20 | 00 | 0 | 13303 | |
| UG | | 0 | 04 | 30! | 50 | 350 | 14 | 20 | 00 | 0 | 00098 | |
| LANDFILL | | 0 |) 29 | 170 |)0 | 350 | 14 | 20 | 00 | 0 | 01223 | |
| MAHONEY | | 0 | 02 | : 1! | 50 | 175 | 14 | 20 | 00 | 0 | 00349 | |
| FISH COVE | RD | 2 | : 9 0 |) 4! | 50 | 175 | 14 | 20 | 00 | 0 | 23143 | |
| MH-10 | | 0 | 02 | 20 | 00 | 175 | 14 | 20 | 00 | 0 | 00279 | |
| MW-29 | | C |) 02 | 20 |)0 | 175 | 14 | 20 | 00 | 0 | 00279 | |
| NH-30 | | 21 | 70 |) 1 | 10 | 175 | 14 | 20 | 00 | 16 | 66564 | |
| | TOTAL | APPONIA | TO | FISH | COVE | FROM | WELLS | 5 | 0 | 8 | 3 118 | (@g/L) |

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TOTAL ARSENIC TO FISH COVE FROM HELLS

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| | | Co of | | | | - | 01 HQJ | |
|-----------|-----------|------------|-------------|-------------|--------------|----------------|-----------|--------|
| | | We]] | X | Y | đ | Z | Fish Cove | |
| MELL | | (ug/L) | (ft) | (ft) | (ft) | (ft) | (vg/L) | |
| MM1-A | ARSENIC | 27 05 | 3300 | 350 | 14 | 20 60 | 0 61754 | |
| MW1-8 | | 4 175 | 3300 | 350 | 14 | 40 CO | 0 19022 | |
| MH1-C | | 4 525 | 3300 | 350 | 14 | 60 00 | 0 30813 | |
| M6/2 | | 27 5 | 2050 | 350 | 14 | 20 00 | 0 97858 | |
| MA-A | | 6 05 | 1450 | 350 | 14 | 20 00 | 0 29413 | |
| MV3_B | | 11 275 | 1450 | 350 | 14 | An an | 1 09094 | |
| MV3_C | | 15 0125 | 1450 | 350 | 1.6 | 60 03 | \$ 16120 | |
| NL/A_A | | 16 05 | 25 | 175 | 1.4 1.4 | 20 00 | R 82412 | |
| MUA_D | | R 475 | 25 | 175 | 14 | 20 00 20 00 | 1 01842 | |
| | | 1 725 | 25 | 175 | 19 19 | 60 00 60 A0 | 8 94473 | |
| | | 3 323 | 3200 | 6/4 1860 | 1949 1947 | 90 00 | A 69775 | |
| | | 3 323 | 3200 | 196 | ନୁ ଜୁନ | 80 00 80 00 | 8 88283 | |
| | | - 3 00 | 900 | 719 | ମ କ ଅକ | 80 80 | 0 07255 | |
| Ub | | 2 30 | 3030 | 330 | 14 | 20 00 | 0 17633 | |
| LANDFILL | | 2 95 | 1/00 | 350 | 14 | 20 00 | 0 12443 | |
| MANUNET | | 2 95 | 150 | 175 |]4 | <u>50 00</u> | 0 20040 | |
| FISH COVE | RD | 5 00 | 450 | 175 | 34 | 20 00 | 0 39901 | |
| MW-10 | | 2 95 | 20 0 | 175 | 14 | 20 00 | 0 47103 | |
| MW-29 | | 295 | 200 | 175 | 14 | 20 00 | 0 47103 | |
| MH-30 | | 295 | 10 | 175 | 14 | 20 00 | 2 26561 | |
| | TOTAL ARS | SENIC TO F | ISH CO | ve fro | N WELL | S 0 | 25 655 | (ug/L) |

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TOTAL CHRONIUM TO FISH COVE FROM HELLS

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| | | Co o | f | | | | | | | G | 74 20 | |
|--------------|-------|----------|----|------|------|------|-------|----|----|------|--------------|--------|
| | | Wel | 1 | X | Y | | đ | 2 | 2 | Fisi | í Cove | |
| WELL | | (ug/ | L) | (ft) | (* | 2) (| ft) | (? | t) | (1 | ⊮g/L) | |
| m 1-A | CHROM | IUM 65 | 25 | 3300 |) 34 | 50 | 14 | 20 | 60 | 1 | 48963 | |
| MW1-B | | 40 | 25 | 3300 |) 3! | 50 | 14 | 40 | 00 | 1 | 83381 | |
| MW1-C | | 102 | 5 | 3300 |) 🧕 | 50 | 14 | 60 | 00 | 6 | 97980 | |
| MH2 | | 16 | 35 | 2050 |) 3 | 50 | 14 | 20 | 00 | 58 | 18117 | |
| MN3-A | | 46 | 5 | 1450 |) 🧕 | 50 | 14 | 20 | 00 | 2 | 26070 | |
| MW3-B | | 10 | 75 | 1450 |) 3 | 50 | 14 | 40 | 00 | ĺ | 04015 | |
| MK3-C | | 45 1 | 25 | 1450 |) 34 | 50 | 14 | 60 | 00 | 6 | 49619 | |
| MW4-A | | 1 | 02 | 25 | 5 17 | 15 | 14 | 20 | 00 | 55 | 07855 | |
| MW4-B | | 73 | 75 | 25 | 5 17 | 75 | 14 | 40 | 60 | 64 | 06002 | |
| MW4-C | | 16 1 | 65 | 25 | 5 17 | 15 | 14 | 60 | 00 | 15 | 77279 | |
| MW6 | | 83 | 25 | 3200 |) 34 | 50 | 14 | 20 | 60 | 1 | 95568 | |
| 9W9 | | 30 | 00 | 400 |) 17 | 75 | 14 | 20 | 00 | 2 | 65052 | |
| UG | | 6 | 95 | 3050 |) 34 | 50 | 14 | 20 | 00 | 0 | 17092 | |
| LANDFILL | | 11 | 95 | 1700 |) 3! | 50 | 14 | 20 | 00 | 0 | 50407 | |
| MAHONEY | | 6 | 85 | 150 |) 17 | /5 | 14 | 20 | 00 | 1 | 36648 | |
| FISH COVE | RD | 10 | 00 | 450 |) 17 | 15 | 14 | 20 | 00 | 0 | 79803 | |
| MW-10 | | 37 | 00 | 200 |) 17 | /5 | 14 | 20 | 00 | 5 | 90788 | |
| MH-29 | | 50 | 00 | 200 |) 17 | 75 | 14 | 20 | 00 | 7 | 98362 | |
| MH-30 | | 26 | 00 | 10 |) 17 | 15 | 14 | 20 | 00 | 19 | 96805 | |
| | TOTAL | CHROMIUM | TÖ | FISH | COVE | FROP | I WEL | LS | ¢ | 2 | 55 509 | (ug/L) |

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TOTAL MANGANESE TO FISH COVE FROM HELLS

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| | | Cod | of | | | | | | Cg. | 1 to |
|-------------|-----------|------|-----|------|---------------|------------|-----------|----|-----------|-------------|
| | | He | 11 | X | Y | đ | 2 | 2 | Fish | Cove |
| WELL | | (ug, | /L) | (ft) | (ft) | (ft) | (?1 | :) | (ហ្ | g/L) |
| MH1-A | MANGANESE | 772 | 00 | 3300 | 350 | 14 | 20 | 00 | 17 | 6245 |
| MW1-B | | 416 | 00 | 3300 | 350 | 14 | 40 | 00 | 18 | 9532 |
| MM1-C | | 889 | 50 | 3300 | 350 | 14 | 60 | 00 | 60 | 5710 |
| Mk2 | | 7250 | 00 | 2050 | 350 | 10 | 20 | 60 | 257 | 9899 |
| MM3-A | | 349 | 00 | 1450 | 350 | 14 | 20 | 00 | 16 | 9674 |
| MM3-B | | 4472 | 50 | 1450 | 350 | 14 | 40 | 60 | 432 | 7493 |
| MH3-C | | 806 | 00 | 1450 | 350 | 14 | ßÕ | 00 | 116 | 0317 |
| MM4-A | | 872 | 00 | 25 | 175 | 14 | žŏ | õõ | 879 | 4166 |
| MH4-B | | 838 | 75 | 25 | 175 | 14 | <u>ao</u> | 00 | 728 | 5470 |
| MH4-C | | 46 | 25 | 25 | 175 | 18 | 60 | 00 | 85 | 1279 |
| MM/5 | | 1185 | 00 | 3200 | 350 | 14 | 20 | 60 | 27 | 8519 |
| MN9 | | 870 | 00 | 400 | 175 | 14 | 20 | 00 | 77 | 1551 |
| NG + | | R | 05 | 3050 | 350 | 14 | 20 | 00 | â | 1980 |
| LANDFILL | | 50 | 50 | 1700 | 350 | 14 | 20 | õõ | ž | 1302 |
| MAHONEY | | 10 | 00 | 150 | 175 | 14 | 20 | 00 | 9 | 7902 |
| FISH MOVE R | n | 1400 | 00 | 450 | 175 | 14 | 20 | 00 | าาา้ | 7241 |
| MW_10 | | 436 | 00 | 200 | 175 | 14 | จิ๊ก | ññ | ŝ | 6172 |
| MU_20 | | 52 | 00 | 200 | 175 | 8-9 9.A | 20 | 20 | وي اھ | 3030 |
| MJ. 20 | | 4610 | 00 | 10 | 475 | 84 14 | 6V 9A | 60 | 9 8846 | A802 |
| - 30 | | 4010 | 00 | 10 | \$ 1 9 | 40 | 69 | 99 | 9946 | -9096 |

TOTAL MANGANESE TO FISH COVE FROM WELLS - 6015 237 (wg/L)

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TOTAL LEAD TO FISH COVE FROM WELLS (as determined by SOCEM)

*

| WellXYGZFish CoveWELL(ug/L)(ft)(ft)(ft)(ft)(ug/L)WH1-ALEAD41 0033003501440 009 27157WH1-B203 5033003501440 009 27157MW1-C31 5033003501460 002 14501MW2219 5020503501420 007 81087MW3-A39 2514503501420 001 90822NW3-B82914503501460 0080188MW3-C406014503501460 005 84477MW4-A2600251751440 009 42533MM4-B630251751460 0015MH4-C1590251751460 0015MH4-B630251751420 000 67573MH6287532003501420 000 97552UG22830503501420 000 5195LANDFILL501751420 005 19163FISH COVE RD10004501751420 0097803NW-106532001751420 001 04186MH23532001751420 003 09121 | |
|---|--------|
| WELL (ug/L) (ft) (ft) (ft) (ft) (ug/L) MW1-A LEAD 41 00 3300 350 34 20 00 0 93601 MW1-B 203 50 3300 350 14 40 00 9 27157 MW1-C 31 50 3300 350 14 60 00 2 14501 MW2 219 50 2050 350 14 20 00 7 81087 MW3-A 39 25 1450 350 14 40 00 9 80188 MW3-B 8 29 1450 350 14 40 00 9 80188 MW3-C 40 60 1450 350 14 60 00 5 84477 MM4-A 26 00 25 175 14 40 00 5 47225 MH4-C 15 90 25 175 14 60 00 15 51422 WH6 28 75 3200 350 14 20 00 0 97552 <th></th> | |
| HH1-A LEAD 41 00 3300 350 14 20 00 93601 HH1-B 203 50 3300 350 14 40 00 9 27157 HH1-C 31 50 3300 350 14 60 00 2 14501 HW2 219 50 2050 350 14 20 00 7 81087 HW3-A 39 25 1450 350 14 20 00 7 81087 HW3-A 39 25 1450 350 14 40 00 80182 HW3-B 8 29 1450 350 14 60 05 84477 MW4-A 26 00 25 175 14 40 00 5 14225 HW4-C 15 90 25 175 14 60 00 15 5 1422 H | |
| NM1-B 203 50 3300 350 14 40 00 9 27157 NM1-C 31 50 3300 350 14 60 00 2 14501 MW2 219 50 2050 350 14 20 00 7 81087 MW3-A 39 25 1450 350 14 20 00 9 8022 NW3-A 39 25 1450 350 14 40 00 0 80188 MW3-C 40 60 1450 350 14 40 00 5 84477 MW4-A 26 00 25 175 14 40 00 5 47225 MW4-B 6 30 25 175 14 40 00 5 5 1422 MH4-C 15 90 25 175 14 40 00 9 95 14 20 00 0 95 1422 MH4-C 15 <td< td=""><td></td></td<> | |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | |
| MN2 219 50 2050 350 14 20 00 7 81087 MN3-A 39 25 1450 350 14 20 00 7 81087 MN3-A 39 25 1450 350 14 20 00 1 90822 MN3-B 8 29 1450 350 14 40 00 0 80188 MN3-C 40 60 1450 350 14 60 0 5 84477 MN4-A 26 00 25 175 14 40 00 5 84477 MH4-B 6 30 25 175 14 40 00 5 47225 MH4-C 15 90 25 175 14 40 00 5 547225 MH4-C 15 90 25 175 14 20 00 0 97552 UG 28 3050 350 14 20 00 0 2595 <td></td> | |
| HN3-A 39 25 1450 350 14 20 00 1 90822 NN3-B 8 29 1450 350 14 40 00 0 80188 NN3-B 8 29 1450 350 14 40 00 0 80188 NN3-C 40 60 1450 350 14 60 00 5 84477 MN4-A 26 00 25 175 14 20 00 14 29453 MM4-B 6 30 25 175 14 40 00 5 5 1422 NH6 28 75 3200 350 14 20 00 0 65595 LANDFILL 503 1700 350 14 20 00 0 95595 LANDFILL 503 150 175 14 20 00 0 95595 LANDFILL 503 150 175 14 20 00 97803 <t< td=""><td></td></t<> | |
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| MN9 11 00 400 175 14 20 00 0 97552 UG 2 28 3050 350 14 20 00 0 05595 LANDFILL 5 03 1700 350 14 20 00 0 0 21196 MAHONEY 26 03 150 175 14 20 00 0 79803 FISH COVE RD 10 00 450 175 14 20 00 0 79803 NW-10 6 53 200 175 14 20 00 1 04186 MN-29 3 53 200 175 14 20 00 0 56285 MN-30 4 03 10 175 14 20 00 3 09121 | |
| UG 2 28 3050 350 14 20 00 0 05595 LANDFILL 5 03 1700 350 14 20 00 0 21196 MAHONEY + 26 03 150 175 14 20 00 0 21196 MAHONEY + 26 03 150 175 14 20 00 0 79803 FISH COVE RD 10 00 450 175 14 20 00 104186 MW-29 3 53 200 175 14 20 00 0 56285 MW-30 4 03 10 175 14 20 00 3 09121 | |
| LANDFILL 5 03 1700 350 14 20 00 0 21196 MAHONEY 26 03 150 175 14 20 00 5 19163 FISH COVE RD 10 00 450 175 14 20 00 0 79803 MN-10 6 53 200 175 14 20 00 10 04186 MN-29 3 53 200 175 14 20 00 0 56285 MN-30 4 03 10 175 14 20 00 3 09121 | |
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| MW-30 4 03 10 175 14 20 00 3 09121 | |
| | |
| TOTAL LEAD TO FISH COVE FROM WELLS 🗢 76 604 | (ug/L) |

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| Length of Side of Box, x (m) | Box Height, H _b (m) | |
|---------------------------------|-----------------------------------|--|
| 10 | 1 4 | |
| 20 | 2 1 | |
| 30 | 27 | |
| 40 | 33 | |
| 50 | 38 | |
| 60 | 4 3 | |
| 70 | 48 | |
| 80 | 53 | |
| 90 | 5 8 | |
| 100 | 62 | |

TABLE F-2 PLUME HEIGHTS USED IN NEAR FIELD BOX MODEL

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Reference GRI 1988 derived from work by Pasquill 1975 and Horst 1979

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TOTAL IRON TO FISH COVE FROM WELLS (as determined by SOCEM)

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| | | Co of | | | | | Cgw to | |
|-----------|-------|--------------|---------|---------|------|-------|-----------|----------|
| | | Well | X | Y | d | Z | Fish Cove | 9 |
| WELL | | (ug/L) | (ft) | (ft) | (ft) | (ft) | (ug/L) | |
| MW1-A | IRON | 14500 | 3300 | 350 | 14 | 20 00 | 331 03 | 3 |
| MW1-B | | 12578 | 3300 | 350 | 14 | 40 00 | 573 04 | 4 |
| MW1-C | | 14675 | 3300 | 350 | 14 | 60 00 | 999 30 | 0 |
| MW2 | | 47050 | 2050 | 350 | 14 | 20 00 | 1674 2 | 7 |
| MW3-A | | 24900 | 1450 | 350 | 14 | 20 00 | 1210 5 | 7 |
| MW3-B | | 32950 | 1450 | 350 | 14 | 40 00 | 3188 1 | 7 |
| MW3-C | | 39218 | 1450 | 350 | 14 | 60 00 | 5645 7 | 5 |
| MW4-A | | 23975 | 25 | 175 | 14 | 20 00 | 13181 2 | ĩ |
| MW4-B | | 2128 | 25 | 175 | 14 | 40 00 | 1847 9 | 7 |
| MW4-C | | 1849 | 25 | 175 | 14 | 60 00 | 1804 3 | D |
| MH6 | | 19000 | 3200 | 350 | 14 | 20 00 | 446 5 | 7 |
| MW9 | | 5090 | 400 | 175 | 14 | 20 00 | 451 4 | 0 |
| UG | | 150 | 3050 | 350 | 14 | 20 00 | 3 6 | 9 |
| LANDFILL | | 200 | 1700 | 350 | 14 | 20 00 | 8 4 | 9 |
| MAHONEY | | 1160 | 150 | 175 | 14 | 20 00 | 231 4 | Ĵ \ |
| FISH COVE | RD | 17700 | 450 | 175 | 14 | 20 00 | 1412 5 | l l |
| MW-10 | | 3595 | 200 | 175 | 14 | 20 00 | 574 0 | 2 |
| HW-29 | | 760 | 200 | 175 | 14 | 20 00 | 121 3 | 5 |
| MW-30 | | 39650 | 10 | 175 | 14 | 20 00 | 30451 2 | 8 |
| | TOTAL | IRON TO FISH | COVE FI | ROM WEL | LS | • | 64156 20 | 5 (ug/L) |

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TOTAL CADMIUM TO FISH COVE FROM WELLS (as determined by SOCEM)

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| | | Co of | | | | | Caw to | |
|-----------|--------|--------------|--------|----------|--------|---------------|-----------|--------|
| | | Well | X | Y | đ | Z | Fish Cove | |
| WELL | | (ug/L) | (ft) | (ft) | (ft) | (ft) | (ug/L) | |
| MW1-A | CADMIL | JM 81 | 3300 | 350 | 14 | 20 0 0 | 0 18492 | |
| MW1-8 | | 6 175 | 3300 | 350 | 14 | 40 00 | 0 28134 | |
| MW1-C | | 7 475 | 3300 | 350 | 14 | 60 00 | 0 50901 | |
| HW2 | | 30 | 2050 | 350 | 14 | 20 00 | 1 06754 | |
| MH3-A | | 6 8 5 | 1450 | 350 | 14 | 20 00 | 0 33303 | |
| MW3-B | | 4 35 | 1450 | 350 | 14 | 40 00 | 0 42090 | |
| MW3-C | | 5 85 | 1450 | 350 | 14 | 60 00 | 0 98613 | |
| NW4-A | | 31 | 25 | 175 | 14 | 20 00 | 1 70435 | |
| MW4-B | | 2 475 | 25 | 175 | 14 | 40 00 | 2 14981 | |
| MW4-C | | 31 | 25 | 175 | 14 | 60 00 | 3 02479 | |
| MW6 | | 13 125 | 3200 | 350 | 14 | 20 00 | 0 30849 | |
| MW9 | | 10 00 | 400 | 175 | 14 | 20 00 | 0 88684 | |
| UG | | 6 20 | 3050 | 350 | 14 | 20 00 | 0 15248 | |
| LANDFILL | | 2 45 | 1700 | 350 | 14 | 20 00 | 0 10334 | |
| MAHONEY | | 3 70 | 150 | 175 | 14 | 20 00 | 0 73810 | |
| FISH COVE | RD | 2 50 | 450 | 175 | 14 | 20 00 | 0 19951 | |
| MW-10 | | 2 45 | 200 | 175 | 14 | 20 00 | 0 39120 | |
| NW-29 | | 6 20 | 200 | 175 | 14 | 20 00 | 0 98997 | |
| NW-30 | | 6 20 | 10 | 175 | 14 | 20 00 | 4 76161 | |
| | TOTAL | CADMIUM TO F | ISH CO | ove from | I WELL | S = | 19 193 | (ug/L) |

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TOTAL NICKEL TO FISH COVE FROM WELLS

| | | Co d | วร์ | | | | | | Cç | ja 20 | |
|-----------|--------------|------------|------|---------|------|-------|-----|----|------|--------------|---------|
| | | We | 11 | X | Y | đ | - 2 | 2 | Fist | Cove | |
| WELL | | (ug, | ′L) | (ft) | (ft) | (ft) | (fí | :) | (L | ıg/L) | |
| MW1-A | NICKE | L 33 | 00 | 3300 | 350 | 14 | 20 | 00 | 0 | 75338 | |
| MW1-B | | 33 | 25 | 3300 | 350 | 14 | 40 | 00 | 1 | 51489 | |
| MW1-C | | 6 8 | 13 | 3300 | 350 | 14 | 60 | 00 | 4 | 63901 | |
| MH2 | | 150 | 00 | 2050 | 350 | 14 | 20 | 00 | 5 | 33772 | |
| MW3-A | | 25 | 50 | 1450 | 350 | 14 | 20 | 00 | 1 | 23974 | |
| MX3-B | | 50 | 75 | 1450 | 350 | 14 | 40 | 00 | Ą | 91046 | |
| MW3-C | | 48 | 80 | 1450 | 350 | 14 | 60 | 00 | 2 | 02525 | |
| 164-A | | 48 | 88 | 25 | 175 | 14 | 20 | 00 | 26 | 87097 | |
| 1W4-B | | 33 | 50 | 25 | 175 | 14 | 40 | ŐŐ | 29 | 09845 | |
| 16/4-C | | 26 | 42 | 25 | 175 | 14 | 60 | 00 | 25 | 77410 | |
| MW6 | | 35 | 50 | 3200 | 350 | 14 | 20 | 00 | Õ | 83438 | |
| NH9 | | 20 | 00 | 400 | 175 | 14 | 20 | ĎŌ | ī | 77368 | |
| UG | | 15 | 00 | 3050 | 350 | 14 | 20 | ŐÕ | ŏ | 36889 | |
| LANDFILL | | 15 | 50 | 1700 | 350 | 14 | 20 | 00 | ŏ | 65381 | |
| MAHONEY | | 12 | 05 | 150 | 175 | 14 | 20 | õõ | ž | 40381 | |
| FISH COVE | RD | 20 | 00 | 450 | 175 | 14 | 20 | ÕÕ | ĩ | 59606 | |
| MW-10 | | 12 | 05 | 200 | 175 | 14 | 20 | ŐĎ | ĩ | 92405 | |
| W-29 | | 27 | 50 | 200 | 175 | 14 | 20 | õõ | Ä | 39099 | |
| MH-30 | | 16 | 00 | 10 | 175 | 14 | 20 | 00 | 12 | 28803 | |
| | TOTAL | NTCKEL TO |) FT | SH COVE | FROM | WFILS | | 0 | 98 | 3 308 | (un/i) |
| | TAINE | NIGNEL II | | | raun | MEFES | | 0 | 60 | 19 920 | 19815 |

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ATTACHMENT F FUGITIVE DUST CONCENTRATIONS

Vehicle Induced Dust Emission Rate

Emission rates for contaminated airborne particles at the North Sea Landfill were evaluated in two scenarios short-term and long-term These two scenarios were used to estimate subchronic vs chronic risks at Two sets of data were utilized in the evaluation of dust the site emissions at the North Sea site In one scenario conservative emission rate estimates were derived from information gathered at the site These high estimates were used for calculation of sub-chronic risk The other scenario involved average values for many of the parameters rather than The chronic risk evaluation based on these data more maximum values realistically approximates the long term effects of inhalation of The emission rate calculation is as follows fugitive dust at the site

$$Q_{10} = [\alpha E_{10} Vk]$$
 (GRI 1988)

Where

Q₁₀ = emission rate of particles 10 microns and smaller (mg/hr)
 α mass fraction of contaminant in particulate emissions
 E₁₀ = an emission factor,
 and Vk = vehicle-kilometers travelled onsite in one hour, totalled across all vehicles

The mass fraction of contaminant in particulate emissions, α for short term risk evaluation was approximated using the maximum soil concentration of contaminants in surface soils collected onsite These values are found in Table 3 5 of this report

The vehicle-kilometers per hour, Vk, for the more conservative short term risk estimation was estimated based on site observations map observations and interviews with site personnel The number of vehicles onsite ranges from 450 in the winter to 1,200 in the summer (Gilbridge 1989) To evaluate a worst case the higher number was chosen The average distance travelled onsite was estimated as 0 6096 km from the site map and site observations An average day of landfill usage is approximately 8 hours These values were used to provide a value of 91 44 vehicle-kilometers per hour

The emission factor used herein differs slightly from the one used in the SEAM (U S EPA 1988) which is based on data for heavier equipment (up to 142 metric tons as opposed to a maximum of 26 metric SEA 004 1834

tons) The emission factor was calculated as follows

$$E_{10} = 0.85 (s/10) (S/24)^8 (W/7)^{0.3} (w/6)^{1.2} ((365-P)/365) (GRI 1988)$$

Where

| E ₁₀ | m emission factor for an unpaved road per vehicle-kilometer of travel (kg), |
|-----------------|---|
| S | <pre>= percent silt in road surface (0 < s < 100)</pre> |
| S | • mean vehicle speed (km/hr) |
| W | - mean vehicle weight (metric tons, Mg) |
| W | <pre>mean number of wheels (unitless),</pre> |
| P | mumber of days per year with at least 0 254 mm (0 01") of precipitation (unitless) |
| | |

Site specific information on the percent of silt in the road was not available The dominant soil types in the area and available fill material are composed primarily of loamy sand (USDA 1975) Based on the United States Department of Agriculture Soil Conservation Service (USDA-SCS) textual classification scheme for soils, the silt content would likely be between 0 and 30 percent (AGI, 1982) Thirty percent was chosen to provide a conservative emission rate for the short term exposure estimate

The mean vehicle speed on the site was estimated from site observations and telephone interviews with site personnel According to site personnel the vehicle speed ranges from 0 to 15 kilometers per hour (Gilbride 1989) Again, in an effort to provide the most conservative estimate of emissions 15 km/hr was used for mean vehicle speed

Mean vehicle weight was estimated from information provided by site personnel (Gilbride, 1989) According to Mr Gilbride, 1,200 vehicles used the landfill on August 6, 1989 Approximately 100 of these were commercial trucks the rest being private cars and small pickup trucks Additional vehicles onsite are large earth moving devices operated by the landfill Three of these are present and they weight approximately 40 tons each The 1 100 cars and light trucks approximated at 2 metric tons each, 100 commercial garbage trucks approximated at 20 metric tons each, and 3 earth movers at 40 metric tons each provide an average weight of 3 51 metric tons

The mean number of wheels traveling onsite was derived using corresponding information from the vehicle weight data Given these figures, the 1,100 cars and light trucks with 4 wheels each, the 100 commercial garbage trucks with 10 wheels each, and the 3 earth movers with 4 wheels each provide an average of 4 5 wheels per vehicle

The number of days annually with at least 0 254 mm (0 01") of precipitation was estimated from Figure 2-3 of the SEAM (EPA, 1988) The site is between the 120 and 140 day contours so 130 days was chosen as a reasonable estimate Emission rates for short term exposure estimates are found in Table F-1 SEA 004 1835

| | SOIL CONCENTRATION | | | | | EMISSION | res | AIR CONCENTRATION | | | | |
|-----------|--------------------|----|--------------|----|-----------------------|----------|-----------|-------------------|------------------------------------|--------|-----------------------------------|--------|
| CHEMICAL | MEAN (ppm) | | MAX (ppm) | | SHORT TERM (mg/hr) | | LOI (1 | NG TERM ng/hr) | SHORT TERM (µg/m ³) | | LONG TERM (µg/m ³) | |
| Arsenic | 3 | 58 | 11 | 0 | 5 | 28E+01 | 6 | 53E+02 | 2 | 08E-02 | 1 | 25E+00 |
| Cadmium | 0 | 76 | 2 | 20 | 1 | 12E+01 | 1 | 31E+02 | 4 | 41E-03 | 2 | 51E 01 |
| Chromium | 2 | 92 | 9 | 00 | 4 | 31E+01 | 5 | 34E+02 | 1 | 70E-02 | 1 | 02E+00 |
| Iron | 3,739 | 00 | 7,190 | 00 | 5 | 51E+04 | 4 | 27E+05 | 2 | 17E+01 | 8 | 16E+02 |
| Lead | 5 | 38 | 42 | 00 | 7 | 93E+01 | 2 | 49E+03 | 3 | 12E 02 | 4 | 78E+00 |
| Manganese | 68 | 21 | 135 | 00 | 1 | 01E+03 | 8 | 01E+03 | 3 | 96E-01 | 1 | 53E+01 |
| Nıckel | 7 | 33 | 21 | 00 | 1 | 08E+02 | 1 | 25E+03 | 4 | 26E-02 | 2 | 39E+00 |

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TABLE F 1CONTAMINANT CONCENTRATIONS AND EMISSION RATES FOR FUGITIVE DUST

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For the second (more realistic) scenario, the following values were changed to evaluate a long term or chronic risk

In the vehicle kilometer per hour calculation, an annual number of 825 vehicles per day was chosen instead of the more conservative number of 1 200 vehicles This annual average reflects the winter and summer traffic variability The vehicle speed onsite was lowered from 15 kilometers to 10 kilometers to account for vehicles stopping or waiting in line to dump refuse These changes yielded an average vehicle-kilometers per hour of 62 87

The mean contaminant concentration in surface soils was chosen instead of the maximum value to represent long term conditions These values are found in Table 3 5 of this report

The percentage of silt on the road surface was conservatively estimated at 30 percent in the first (conservative) scenario For the more realistic case an average value of 15 percent was used

The estimates of average weight and number of wheels are not likely to change with the season The ratio of commercial trucks to private vehicles is presumed to remain the same in winter as it is in summer

Emission rates for long term exposure estimates are found in Table F 1

Fugitive Dust Concentrations

Because the area of concern for arborne pollution is actually on the site rather than several kilometers downwind the EPA's Graphical Exposure Modeling System (GEMS) is invalid The Gaussian dispersion model used in GEMS Atmospheric Modelling System is invalid for evaluation of contaminants at locations less than 100 meters from the source area The concentration of airborne particulates onsite was instead calculated using a near field box model contained in the Gas Research Institute's Management of Manufactured Gas Plant Sites manual (GRI, 1988) The near field box model is accurate at short downwind distances (i e , less than 100 meters) and is therefore applicable to scenarios where the receptor is onsite or very near the site (Pasquill, 1975 and Horst, 1979 as cited in GRI 1988) The box model 'results directly from simple conservation of mass considerations (GRI, 1988)

The equations and assumptions used to derive the concentration of contaminant in ambient air onsite are as follows

[']C = Q/(H ₩ u)

(GRI 1988)

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Where

C = concentration of contaminant in ambient air onsite $(\mu g/m^3)$

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- Q = emission rate of contaminant ($\mu g/s$)
- H = downwind height of box (m)
- W = width of box (m),
- and u = average wind speed through the box (m/s)

The emission rates and predicted concentrations for the chemicals of interest are found in Table F-1

The downwind height of the box H is estimated using a specific relationship between the length and height of the box As seen in Table F-2 (Pasquill, 1975 and Horst, 1979 as cited in GRI, 1988), a box/ height of 1 4 m which approximates the height of the human breathing zone provides a distance (from source to receptor) of 10 m These values allow evaluation of the onsite risks associated with chemical contaminants in the breathing zone

A less conservative evaluation of what a worker might be exposed to during 30 years onsite would involve inhaling dust at a variety of locations and distances from the source To provide a concentration comparable with that variability a distance from receptor to source of 50 meters was chosen The box height that corresponds to that distance is 3 8m from Table F-2

The crosswind dimension of the area W of dust generation was determined to be 100 m from site and map observations This is also a conservative estimate the actual area for dust generation may be greater which would yield greater dispersion and therefore lower concentrations

Average wind speed through the box u is estimated with the following equation

$$u = 0.22$$
 (v) $ln(2.5 H)$ (GRI 1988)

Where

v = the average annual wind velocity at the site This value was determined from the National Weather Service station in Islip New York The average wind speed was 8 7 miles per hour (3 75 m/s)