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Human Health Risk Assessment

Former Grumman Settling Ponds (Operable Unit 3)
Bethpage, New York

April 2009

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Acronyms

AF	absorption fraction
ALM	Adult Lead Model
AOC	Administrative Order on Consent
AT	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
BaP	benzo(a)pyrene
bgs	below ground surface
BKSF	biokinetic slope factor
BWD	Bethpage Water District
CalEPA	California Environmental Protection Agency
CDC	Center for Disease Control
cm^2	square centimeters
COPC	constituent of potential concern
ED	exposure duration
EF	exposure frequency
EPC	exposure point concentration
FS	feasibility study
GSD	geometric standard deviation
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IR	ingestion rate
IRIS	Integrated Risk Information System
IRM	interim remedial measures

kg	kilogram
KM	Kaplan-Meier
MADEP	Massachusetts Department of Environmental Protection
µg	microgram
µg/dL	micrograms per deciliter
mg/cm^2	milligrams per square centimeters
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/m^3	milligrams per cubic meter
mg/kg-day	milligrams per kilogram of body weight per day
MRL	minimum risk level
NAS	National Academy of Science
NCEA	National Center for Environmental Assessment
NWIRP	Naval Weapons Industrial Reserve Plant
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OU3	Operable Unit 3
PAH	polycyclic aromatic hydrocarbon
Pb	lead
Pb/dL	lead per deciliter
PbB	blood lead level
PCB	polychlorinated biphenyl
PPRTV	provisional peer-reviewed toxicity value
Q-Q	Quantile-Quantile
RBA	relative bioavailability
RfC	reference concentration

RfD	reference dose
RI	remedial investigation
RPD	relative percent difference
RPF	relative potency factor
RSL	regional screening level
SCO	soil cleanup objective
SF	slope factor
SVOC	semivolatile organic compound
UCL	upper confidence level
URF	unit risk factor
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WHO	World Health Organization

1. Introduction

ARCADIS U.S., Inc. (ARCADIS) has prepared this Human Health Risk Assessment (HHRA) on behalf of Northrop Grumman Systems Corporation (Northrop Grumman) for the Former Grumman Settling Ponds, Operable Unit 3 (OU3) Site in Bethpage, New York (hereinafter referred to as Site Area). This HHRA is submitted pursuant to Section II of the July 4, 2005 Administrative Order on Consent (AOC) issued by the New York State Department of Environmental Conservation (NYSDEC) (2005) that required a Remedial Investigation (RI) and Feasibility Study (FS) be conducted for OU3.

For the purposes of this HHRA, the Site Area is divided into the following three sub-areas (Figure 1):

- the southern portion of the Bethpage Community Park (hereinafter referred to as Bethpage Park), which was not subject to soil removal during the Park redevelopment, including the ball field to the southwest, the playground in the south central area, and the pool area to the southeast (see Figure 2)

- the Former Grumman Plant 24 Access Road property (hereinafter referred to as the Access Road), which is located along the southern and western perimeters of the Park

- the residential area along the north side of Sycamore Avenue (hereinafter referred to as the Sycamore Avenue residences), which is bounded to the north by the Former Grumman Plant 24 Access Road Property, to the south by Sycamore Avenue, to the east by Stewart Avenue, and to the west by 11th Street

A baseline risk assessment, which evaluates human health risks in the absence of any remediation, is a normal component of the RI. This HHRA differs slightly from a standard baseline risk assessment in that certain soil remediation scenarios are assumed and those scenarios are factored into the calculation of human health risks. Specifically, the goals of this HHRA are to evaluate potential post-remediation human health risks posed by site-related constituents in soil in the Site Area and to support any remedial action decisions needed to address those risks. Further, the HHRA was completed to provide a site-specific assessment of risk associated with certain portions of the Site Area (i.e. the Bethpage Community Park and the Former Grumman Plant 24 Access Road property as discussed above) because the NYSDEC (2006) SCOs were

developed using standard exposure assumptions that differ from site-specific exposures and conditions in those areas.

Risk assessment, as defined by the National Academy of Sciences (NAS 1983), is the characterization of the probability of potentially adverse health effects resulting from human exposures to environmental hazards. In essence, it is the systematic evaluation of the possible health effects posed by a particular substance or mixture of substances present in one or more environmental media. The framework to quantify such adverse health effects was established by the NAS in 1983 and subsequently adopted by the U.S. Environmental Protection Agency (USEPA).

The four basic components of human health risk assessment, as defined by the NAS (1983), will be conducted to assess whether residual levels of constituents of potential concern (COPCs) in Site Area soils could present a significant potential risk to public health. The four components of risk assessment are:

- Hazard identification – the evaluation of the nature and the extent of potential health hazards associated with exposure to COPCs at the Site Area. The objective of hazard identification is to identify the COPCs and to understand the occurrence and distribution of each in soils.

- Exposure assessment – the identification and evaluation of actual or potential routes of exposures, characterization of exposed populations, and determination, quantification, and evaluation of the extent of exposure to COPCs. The objectives of exposure assessment are to identify potentially exposed populations, to develop exposure scenarios, and to estimate levels of intake of COPCs.

- Dose response assessment – the analysis and interpretation of the relationship between the intake of a COPC and the anticipated incidence of adverse health effects in the exposed population. The objective of dose-response is to identify health-based criteria for noncarcinogenic and carcinogenic effects.

- Risk characterization – the analysis, interpretation and evaluation of the potential incidence of adverse health effects under the various conditions of exposure. The objectives of risk characterization are to estimate potential noncarcinogenic hazards and carcinogenic risks and to identify uncertainties associated with the analysis.

In developing the approach for this HHRA, ARCADIS considered relevant state and federal guidance documents, including, but not limited to, the following:

- *Draft DER-10 Technical Guidance for Site Investigation and Remediation* (NYSDEC 2002)
- *Draft DER-22 Soil Cleanup Guidance* (NYSDEC 2008) (replaces NYSDEC [1994] *Technical and Administrative Guidance Memorandum #4046*)
- *New York State Brownfield Cleanup Program, Development of Soil Cleanup Objectives, Technical Support Document* (NYSDEC 2006)
- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (USEPA 1989a)
- *Guidelines for Exposure Assessment* (USEPA 1992a)
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002a)
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final.* (USEPA 2004)
- *Guidelines for Carcinogen Risk Assessment*; *Final* (USEPA 2005)
- *Exposure Factors Handbook* (USEPA 1997a)

This HHRA is generally presented in the format outlined in the USEPA guidance entitled *Risk Assessment Guidance for Superfund Volume I – Human Health Evaluation Manual, Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments* (USEPA 2001). In addition to the four main HHRA components, Section 2 of this HHRA presents the site characterization, which describes the environmental setting. The hazard identification, including identification of COPCs and media of concern is presented in Section 3, and Section 4 presents the dose response assessment for each of the COPCs. Section 5 provides the exposure assessment including the identification of complete exposure pathways and a description of the specific assumptions and parameters used to quantify exposure. Section 6 presents the quantitative risk and hazard estimates and Section 7 discusses

the sources and degree of the uncertainty associated with those estimates. The results of this quantitative HHRA will be used to help evaluate the residual risks associated with the proposed remedial actions for the Site. Summary and conclusions are presented in Section 7, and Section 8 presents the references cited in this report.

2. Site Characterization

Site characterization presents the site description, site development history, and potential soil remediation scenarios considered in the HHRA.

2.1 Site Description

The Site Area is located adjacent to the former Naval Weapons Industrial Reserve Plant (NWIRP) Facility (NYSDEC Site ID# 1-30-003B) and is bordered by Cherry Avenue Extension/Aerospace Boulevard (which is owned by Northrop Grumman) and commercial properties to the north, Stewart Avenue and Bethpage High School to the east, residential areas to the south, and 901 Stewart Avenue (former Northrop Grumman Plant 24, which is currently unoccupied) to the west. Other unoccupied properties owned by Northrop Grumman, including the McKay Field property, ball fields, and former nursery areas, are also located to the west. Further to the west are the north campus of the Northrop Grumman Facility and the former Occidental Chemical Corporation Polymer Site (Figure 1).

In 1962, the Bethpage Park property was donated by Grumman to the Town of Oyster Bay for exclusive use as parkland. Shortly after Grumman donated the land to the Town, the Town commenced construction and other work on the Park property. The park structures, as they were prior to the town's recent redevelopment, were built by the Town without any Grumman involvement. They included an ice rink, a parking lot, picnic and playground areas, a basketball court, paddleball courts, shuffleboard courts, horseshoe pits, and bicycle rack areas. Prior to the town's redevelopment of the Park for construction of a new ice rink, which commenced in 2005, the Park was open year-round.

Adjoining the Park property to the south and west is the Former Grumman Plant 24 Access Road Property, which is owned by Northrop Grumman. It runs east-to-west along the southern boundary of the Park and north-to-south along the western boundary of the Park. This industrial property is partially paved with asphalt and partially grassed over. While the paved portion is accessible to the public, the grassy

portions are fenced and gated and, as a result, are not publicly accessible. Sycamore Avenue is a Town-owned roadway that is south of the Access Road.

As described above, most of the Site Area has been fully developed and is either parkland (i.e., Bethpage Park) industrial property (i.e., Former Grumman Access Road) or residential properties (i.e., the Sycamore Avenue residences), with paved areas and unpaved areas covered by grass or ornamental landscaping. The recharge basin and portions of the Park perimeter are overgrown.

2.2 Site Activities

In 2005, the Town of Oyster Bay initiated redevelopment of approximately 11 acres of the Bethpage Park. As part of the redevelopment, the Town executed an AOC with the NYSDEC in 2005 for the implementation of an interim remedial measure (IRM) for soils in the construction area. The Town performed an investigation of soil, soil gas, and groundwater in the construction area in 2005 and submitted work plans to NYSDEC recommending excavation and off-site disposal of soil within the construction areas. A number of former features of the Park were demolished and removed in 2006. The Town's IRM soil excavation/disposal was performed from October 2006 to May 2007 and redevelopment was completed in early 2008. The approximate limits of the Town's IRM program are shown in Figure 2. As part of this program, the Town excavated and removed soil from the central, northern, and northeastern portions of the Park to depths between 2 and 20 feet below ground surface (bgs). In these areas, soils that were removed were replaced with clean fill and portions of the area were covered with impermeable materials, such as asphalt. NYSDEC approved the Town IRM on September 17, 2008.

With the redevelopment of the Park, most of the previous features were removed by the Town. Presently, the redeveloped Park contains two swimming pools, offices, and an ice rink on the eastern side, a parking lot in the center, tennis courts and a playground on the north side, a baseball field and stormwater recharge basin on the west side, and a playground to the south. Some areas of the park are fenced and gated, allowing no public access. These areas include the recharge basin and the baseball diamond. Other portions of the Park are publicly accessible. These include the area around the swimming pools, offices, ice rink, parking lot, tennis courts, basketball courts, and the small playground on the south side.

In 2007, a soil gas IRM was proposed for the Site Area. The Soil Gas Interim Remedial Measure 95 Percent Design Report and Design Drawings (ARCADIS 2007) were

approved by the NYSDEC on September 19, 2007 (NYSDEC 2007). ARCADIS completed the soil gas IRM for the Site Area in February 2008. The soil gas IRM was installed along the southern and western boundaries of the Park with the goal of preventing off-site migration of constituents in soil gas. A detailed description of the soil gas IRM is provided in the OM&M Manual (ARCADIS 2009). A history of all soil investigations conducted at the Site Area is provided in the Remedial Investigation for the Site (ARCADIS 2008).

2.3 Soil Remediation Scenarios

For purposes of this HHRA, certain soil remediation activities are assumed for each of the three sub-areas included in the Site Area. Each of these is described below.

Bethpage Park

For the purposes of this HHRA, the upper 2 feet of surface soils in Bethpage Park are assumed to be removed from the areas indicated in Figure 3 and replaced with fill that falls below the NYSDEC restricted residential SCOs. Accordingly, potential risks for receptors exposed to soils in Bethpage Park were evaluated assuming removal of soils from the 0-2 foot depth interval in those areas and no removal of soils deeper than 2 feet.

Access Road

For the purposes of this HHRA, placement of a gravel cover is assumed for the unpaved portions of the Access Road property. This gravel cover would prevent direct contact or indirect contact (i.e., wind-blown dusts) with surface soils during non-invasive activities (e.g., walking).

Sycamore Avenue Residences

For the purposes of this HHRA, soil removal is assumed for any soils in the Sycamore Avenue residential neighborhood that exceed NYSDEC residential SCOs for polychlorinated biphenyls (PCBs). PCBs are the only COPC in soil. Because the State's default residential SCOs are used, it is unnecessary to quantitatively evaluate human health risks in this HHRA for the residential properties.

3. Hazard Identification

The objective of the hazard identification is to identify the media of concern and the COPCs present in those media to understand the nature and extent of each COPC at the Site Area. This information is then used to help develop the potential exposure scenarios to be evaluated and to guide the selection of toxicity criteria for use in this HHRA.

3.1 Media of Concern

The media of potential interest considered in this HHRA were soil, groundwater (including perched water), and soil gas (i.e., indoor air). Exposure to groundwater was determined to not represent a complete pathway because 1) depth to groundwater precludes direct contact and 2) Site Area groundwater is not used as a drinking source or for irrigation. Specifically, groundwater supply wells do not exist in the Site Area. Water for potable use within the Site Area is provided by the Bethpage Water District (BWD). Water from these wells is monitored and treated prior to distribution. Under these conditions, there could be not current or future exposure to Site Area groundwater.

Exposure to COPCs in indoor air via migration from groundwater and/or subsurface soils was recently evaluated in the Sycamore Avenue residential neighborhood by the NYSDEC and the New York State Department of Health (NYSDOH). It was concluded that indoor air did not present a complete exposure pathway for residents (ARCADIS 2005; EA Engineering 2007). As discussed in Section 2.2, an IRM to prevent the migration of soil vapor off-site was completed in early 2008. Likewise, as part of an environmental easement for Bethpage Park, any new building construction will include vapor barriers to mitigate the migration of COPCs from the subsurface environment to indoor air.

Consistent with the above discussions of groundwater and indoor air exposures, the media of concern in the Site Area for this HHRA is limited to soils. As noted above, soils from the Sycamore Avenue residential properties with PCB concentrations greater than SCOs will be removed. Therefore, these soils are not discussed further in this HHRA.

In areas where soil removal activities are assumed, post-removal conditions are evaluated to estimate potential residual risks. In areas where soil removal is not assumed, the HHRA uses existing data to evaluate potential risks. As noted above,

although no soil removal is assumed for the Access Road, the HHRA assumes that a gravel cover will be placed on the unpaved portions of the property to prevent any exposures to individuals engaged in noninvasive activities.

It is assumed that soil remediation for the Bethpage Park will include removal of the upper two feet of exposed (unpaved and uncovered) soils where constituents are present at levels exceeding restricted residential SCOs. It is also assumed that, following removal, excavated areas would be restored to pre-removal grades with soils that do not contain constituent concentrations greater than NYSDEC's restricted residential SCOs.

Because removal of only the upper two feet of soil is assumed , current concentrations of COPCs will remain in subsurface soils (>2 feet) within Bethpage Park. Activities that may involve contact with those deeper soils, such as construction or utility maintenance, installation or repair may present a potential for exposure to those COPCs

3.2 Analytical Data

To ensure the accuracy and validity of the HHRA, it is imperative that the analytical data upon which the HHRA is based are of known and sufficient quality. Therefore, in accordance with USEPA (1989a) guidance, all available data are evaluated with respect to a) analytical methods; b) quantitation limits; c) qualifiers and codes; d) blank sample analytical results; e) background concentrations; f) frequency of detection; and g) essential nutrient qualities.

The analytical data evaluated in this HHRA for Bethpage Park and the Access Road include samples collected by ARCADIS and Dvirka and Bartilucci from 1999 to 2007 (ARCADIS 2008), excluding those areas that were excavated by the Town of Bethpage. Additionally, data from Samples F-7 and F-8 were not included in the Bethpage Park dataset because these samples were collected from the bottom of the recharge basin.

The data used in the HHRA were validated. Results without data qualifiers, plus those values with J and B qualifiers, were treated as detected concentrations at the reported/estimated concentrations. Values qualified with U and UJ were treated as non-detects. Values with R qualifiers, indicating the result was rejected during data validation, were not used in the HHRA. Generally, the soils data evaluated in this HHRA for Bethpage Park included the data from the 2-6 foot depth interval as this is

the depth interval in which most of the Park utilities are located. There are some areas of the Park, however, in which utilities are known to be present in deeper soils (i.e., down to 10 feet). In those areas, soils data from the 2-10 foot depth interval were evaluated. Because a BWD water pipe is present within the Access Road down to an approximate depth of 9.1 feet, soils data from the 0-10 foot depth interval were evaluated in the HHRA.

3.3 Potential Constituents of Concern

All chemicals detected in environmental media of concern (Section 2.1) are defined as COPCs, unless there is a justifiable rationale for their exclusion. Chemicals that meet one or more of the screening criteria are excluded from the list of COPCs and are not evaluated further in this HHRA. As part of the screening, data from Bethpage Park and the Access Road were evaluated separately to identify COPCs.

For the Bethpage Park and Access Road, COPCs are identified by comparing the maximum concentrations of detected constituents from Bethpage Park and the Access Road to the restricted residential SCOs established by NYSDEC (2006). The Restricted Residential SCOs are based on potential exposure of adults and children to soils via ingestion, inhalation of volatiles and particulates, and dermal contact (NYSDEC 2006). SCOs for individual chemicals reflect risk levels that do not exceed a cancer risk of 1×10^{-6} and a hazard index of 1 for non-cancer endpoints (NYSDEC 2006). These SCOs are developed using standard exposure parameters and toxicity values (NYSDEC 2006). Since it is assumed that the 0-2 foot soils in Bethpage Park that exceed the restricted residential SCOs will be removed and replaced with clean fill, the COPC screening for this area of the Site only focuses on data for subsurface soils (>2 feet).

In the event that a constituent did not have an available SCO, the USEPA (2008a) Regional Screening Levels (RSLs) for residential soil were used as a secondary screening source for all areas of the Site. Additionally, if neither a SCO nor a RSL was available, the maximum SCOs for organics (100 mg/kg) and inorganics (10,000 mg/kg) were used to screen the analytical data (NYSDEC 2006).

Appendix A provides a summary of the soils data that were included in the screening evaluation for the Park. Table 2-1 presents the COPC screening for the Park. Table 2-2 presents the COPC screening for the Access Road. Appendix B provides a summary of the soils data that were included in the screening evaluation for the Access Road.

Appendix C provides a summary of the surface soils data (0-2 feet bgs) for Bethpage Park.

The results of the screening analyses for soils are provided in Tables 2-1 and 2-2. The comparison of chemical concentrations to screening criteria is only conducted for detected constituents. A total of 29 constituents, including several volatile organic constituents (VOCs), semi-volatile constituents (SVOCs) (primarily polycyclic aromatic hydrocarbons [PAHs]), PCBs, and metals, are identified as COPCs for Bethpage Park. PCBs, arsenic, cadmium, chromium, and cyanide are identified as COPCs for the Access Road. Potential cancer risks and non-cancer hazards are quantitatively evaluated for these COPCs in Section 5 of this HHRA.

4. Exposure Assessment

Exposure assessment is the process of measuring or estimating the intensity, frequency, and duration of human exposure to chemicals present in the environment. The exposure assessment includes the identification of potentially exposed populations, development of exposure scenarios, analysis of exposure pathways, definition of exposure points, and estimation of exposure point concentrations (EPCs). This information is used to estimate potential dose rates under current and reasonably foreseeable uses of the Site. The dose rate estimates are then combined with the toxicity values identified in the dose-response assessment (Section 5) to estimate the risks associated with current and reasonably foreseeable future exposures as part of the risk characterization (Section 6).

The exposure assessment is a critical component of the site assessment process, as it qualitatively and quantitatively describes the potential contact between people and COPCs in environmental media at the Site. There are two important results of the exposure assessment: exposure profiles and quantitative estimates of exposure. An exposure profile is a narrative description of the exposures that may occur at the Site. The quantification of exposure translates the narrative exposure profile into a series of exposure equations resulting in numerical estimates of dose rates. These numerical estimates are subsequently used in the risk calculations.

Risk assessors most often apply point estimates of key exposure characteristics in calculating dose rate. This practice requires that variability within the population under study be reduced to a single value for each exposure parameter. If conservative upper-bound estimates are utilized for these single point values, multiplying these values together in the risk assessment often results in overestimation of dose rate and risk

(USEPA 1992a). The magnitude of the overestimation in dose rate or risk increases with each additional input parameter that has been overestimated.

The initial step in evaluating potential human exposure is the identification of potentially complete exposure pathways, which per regulatory guidance (NYSDEC 2002), must contain the following five elements: 1) constituent source, 2) constituent release and transport mechanisms, 3) point of exposure, 4) route of exposure and 5) receptor population. Exposure pathways without even one of these elements are considered incomplete and do not require further evaluation (NYSDEC 2002). Potential receptors and associated exposure pathways are summarized in Table 1-1 of this HHRA and discussed below for Bethpage Park and the Access Road.

4.1 Exposure Scenarios

The exposure scenarios that are evaluated in this HHRA differ among the different locations within the Site Area and are based on current and potential future uses of each location. The scenarios for each location are discussed below.

4.1.1 Bethpage Park

As discussed previously, the current and future uses of Bethpage Park are primarily recreational. Bethpage Park is used by residents of the surrounding areas for a variety of purposes, including playgrounds, basketball courts, tennis courts, swimming pools and an ice rink. In addition, there are expected to be some full-time office workers at some of the park facilities (e.g., ice rink).

Recreational users and office workers at Bethpage Park could come into contact with surface soils in the park during their activities. It is expected that recreational users, who would include both children and adults, would have the higher potential for exposure to those soils than would office workers, due to the fact that they could be regularly engaged in a number of outdoor activities there. However, as discussed in Section 1.1 of this HHRA, it is assumed that the upper two feet of soils in Bethpage Park that exceed the restricted residential SCOs are removed. Because it is assumed that there will be no COPCs in the 0-2 foot soils in Bethpage Park after that removal is complete, potential exposure to surface soils for recreational users is incomplete and is not evaluated further in this HHRA.

Underground utilities are present in portions of Bethpage Park. Utility workers may be involved in the replacement, repair or maintenance of those utilities and may be

exposed to both surface and subsurface soils during such activities. In most areas of the park, utilities are present in the 0-6 foot depth interval. In some specific areas, utilities were historically placed in deeper soils at a depth of 8 or 9 feet bgs. Thus, potential exposure to adult utility workers is evaluated using data from the 0-6 foot soil depth for most of the park, and using soil data from the 0-10 foot depth interval in those areas of the park where it is known that utility depths are below 6 feet.

Construction workers may be involved in the repair and/or alteration of existing buildings or the construction of new buildings or features in the park. Future construction is expected to be slab-on-grade construction and therefore, would not be expected to extend beyond a depth of 6 feet. Thus, potential exposures of adult construction workers to surface and subsurface soils are evaluated in this HHRA.

4.1.2 Access Road

Much of the Access Road area is fenced to prohibit public access. While paved areas are publicly accessible, the presence of pavement prevents direct contact with soils in this area. Based on current knowledge, the paved portion of the Access Road is sometimes used for walking. The remaining grassy areas of the Access Road property are not accessible to the public and the placement of a gravel cover over areas of exposed soil is expected to effectively control potential exposures. Thus, recreational exposures to soils in the Access Road area are not evaluated in this HHRA.

The BWD water pipe crosses the Access Road area and as such, it is possible that utility work could take place in this area in the future. The BWD water pipe extends down to a depth of 9.1 feet. Therefore, soils data from 0-10 feet bgs are used in the HHRA to evaluate potential exposures of adult utility workers to surface and subsurface soils in this area. Because this area is relatively small, future construction in this area of the Site is unlikely.

4.2 Exposure Point Concentrations

Discrete EPCs were developed for each portion of the Site Area. For Bethpage Park, EPCs for the utility worker and construction worker scenarios were developed by combining the existing data for subsurface soils (>2 feet) with the assumed post-removal data for the 0-2 foot depth interval. Subsurface soils data for the utility worker included data for the 2 to 6 foot depth interval as well as data from several sampling locations where utility easements were identified up to 10 feet in depth (i.e., samples B-60, TP-1, G-5-SB, P-3 through P-16, and B-28). Subsurface soils data for the

construction worker included data for the 2-6 foot depth interval only. Bethpage Park soils exceeding the NYSDEC Restricted Residential SCOs are assumed to be removed and the exact post-removal concentrations of individual constituents in the 0-2 foot depth interval cannot be predicted, therefore, the concentration of each COPC was conservatively assumed to be equivalent to the residential SCO for that constituent for the 0-2 foot depth interval.

All soils data (0-10 feet bgs) were used for the utility worker scenario for the Access Road. Because the BWD water pipe is located at approximately 9 feet bgs and because any new utilities in the Access Road would likely be placed within the 0-6 foot depth interval, the EPCs included data for the 0-10 foot depth interval.

Prior to EPC calculations, duplicate field samples were paired with their parent samples using the following methodology (USEPA 1992b; 2002c):

- If both the parent and duplicate values were non-detect, the maximum reporting limit was used as a single representative result.

- If both the parent and duplicate values were detects and neither value was greater than five times the reporting limit, the maximum value of the pair was used as a single representative result.

- If both the parent and duplicate values were detects and one or both of the values was greater than five times the reporting limit, the relative percent difference (RPD) was evaluated. If the RPD was greater than 100 percent, the maximum value was used as a single representative result. If the RPD was less than 100 percent, the arithmetic mean of the two values was used as a single representative result.

EPCs (e.g., 95 percent Upper Confidence Levels [UCLs]) were derived from existing data using the USEPA (2007a) ProUCL Software (Version 4.0). ProUCL statistical software was used to calculate the UCL of the unknown population arithmetic mean (USEPA 2007a). The rationale for calculating the UCL term followed the procedures outlined in the ProUCL's User's Guide. Each data set was tested for normality using the Shapiro-Wilk W Test statistic with accompanying Quantile-Quantile (Q-Q) plots. Each data set was also tested for the gamma distribution using the Anderson-Darling and Kolmogorov-Smirnov Empirical Distribution Functions test statistics with accompanying Q-Q plots.

Based on the distribution of the data set, a recommended UCL calculation procedure was followed. In instances where the recommended UCL exceeded the maximum detected concentration, the maximum concentration was used as the EPC consistent with USEPA (2007a) guidance.

For data sets with non-detect observations occurring at multiple detection limits, the Kaplan-Meier (KM) estimate method was used. The KM estimate method adjusts for censoring by calculating an estimate of standard error of the mean, which then can be used to calculate a UCL for various methods (e.g., normal approximations, percentile bootstrap, Chebyshev inequality) (USEPA 2007a).

EPCs are presented in Tables 3-1 through 3-3. Analytical data that were used to calculate EPCs are provided in Appendices A and B.

4.3 Exposure Pathways

Potential receptors considered in this HHRA included utility workers and construction workers. Potential routes of exposure associated with site-related soils are discussed below for each receptor group.

4.3.1 Utility Worker

Utility workers are defined as adult workers engaged in short-term intrusive activities to maintain, repair, or replace utility pipes. Utility workers are assumed to have future exposures to surface and subsurface soils at Bethpage Park and the Access Road through direct contact (ingestion and dermal contact) and through inhalation of dusts and vapors.

4.3.2 Construction Workers

Construction workers are defined as adult workers engaged in short-term intrusive activities associated with building construction. Construction workers are assumed to have exposures to surface and subsurface soils at Bethpage Park through direct contact (ingestion and dermal contact) and through inhalation of dusts and vapors.

4.4 Exposure Factors

This HHRA used exposure factors that reflect conditions at the Site Area consistent with current scientific and regulatory policy. While some exposure factors are USEPA

default values, others are site-specific values that more accurately reflect exposures at the Site Area. The goal of this HHRA is to evaluate potential scenarios that represent reasonable maximum exposures that may be experienced by the identified receptor groups. The specific exposure factors used to quantify potential risks and hazards for the receptors/pathways identified previously are presented in Table 4-1.

4.4.1 Intake Equations

Intakes (i.e., average daily doses) for the ingestion and dermal contact exposure pathways for all constituents are expressed in milligrams per kilogram of body weight per day (mg/kg-day) and were calculated using the EPC and applying the exposure factors that account for ingestion rates, dermal surface areas, dermal adherence factors, absorption rates, exposure frequencies, exposure durations, body weights, and averaging time.

Intakes for the inhalation exposure pathways are expressed in milligrams per cubic meter (mg/m^3) and were calculated using the EPC and applying the exposure factors that account for exposure time, exposure frequency, exposure duration, and averaging time. The intake equations used in this HHRA for ingestion, dermal contact, and inhalation for the utility and construction workers are presented in Table 4-1.

The exposure factors used in this HHRA are discussed below and summarized in Table 4-1.

4.4.2 Soil Ingestion Rates

Upper-bound estimates of soil ingestion rates were used for the utility worker and construction worker.

For the utility and construction worker scenarios, it is reasonable to assume that because of the intensity of intrusive activities and the dust generated by them, soil ingestion may be higher for these individuals than expected for other adult activities. USEPA (2002a) recommends the use of an upper-bound soil ingestion rate of 330 mg/day based on the results of the study by Stanek, Calabrese et al. (1997). However, as discussed below, that soil ingestion rate is not likely to be representative of actual, daily adult soil ingestion.

As discussed in USEPA's *Exposure Factors Handbook* (1997a), adults are not expected to have the same intentional mouthing behaviors as young children. As a

result, soil ingestion for adults generally results from soil or dust that adheres to the skin surface of the hands and is incidentally ingested if individuals place their unwashed hands or materials contacted by their hands (such as food or cigarettes) into their mouths during the day. Thus, soil ingestion by adults is likely to be a function of the amount of soil that adheres to their hands during the day.

The Massachusetts Department of Environmental Protection (MADEP 2002) recognized this fact and re-evaluated available soil ingestion data to determine an appropriate "enhanced" soil ingestion rate to be used for the evaluation of intensive soil activities for adults, such as utility and construction work. Their analysis was based on updated information about rates of soil adherence to the hands of individuals engaged in more intensive soil contact activities. Based on its review of the literature, MADEP (2002) concluded that an upper bound soil ingestion rate of 100 mg/day was appropriate for these types of activities. This analysis, combined with the conclusions reported by the authors of the soil ingestion study upon which USEPA's recommended value is based (Stanek, Calabrese et al. 1997; Calabrese 2003), indicates that the default value recommended by USEPA (2002a) is not representative. For that reason, an upper-bound soil ingestion rate of 100 mg/day is used to evaluate exposure through soil ingestion for both the construction and utility worker scenarios.

4.4.3 Fraction Soil Ingested

For all scenarios, it was assumed that Site media account for 100 percent of potential exposures. This is a conservative approach for the utility and construction worker scenarios since this does not account for exposures outside of the Site during non-working hours that may dilute daily intakes.

4.4.4 Exposed Dermal Surface Areas and Adherence Factors

To evaluate potential dermal exposures for utility and construction workers at Bethpage Park and the Access Road, the USEPA (2004) default surface area (3,300 cm^2) was used for both receptors. The USEPA (2004) recommended adherence factor for a commercial/industrial worker (0.2 mg/cm^2) is based on the 50^{th} percentile for utility workers. Therefore, the dermal adherence factors for the utility worker (0.2 mg/cm^2) and the construction worker (0.10 mg/cm^2) used in this HHRA represent the geometric means for these receptors from USEPA (2004).

4.4.5 Dermal Absorption Factors

The dermal absorption factors used in this HHRA are chemical-specific and were taken from USEPA (2004). Consistent with USEPA (2004) guidance, a default dermal absorption factor of 10 percent was used for SVOCs lacking chemical-specific factors. However, no default dermal absorption factors are available for VOCs or inorganics. Therefore, consistent with USEPA (2004) guidance, COPCs lacking a chemical-specific dermal absorption factor were not quantitatively evaluated for the dermal pathway.

4.4.6 Exposure Frequencies

For the utility worker, it was assumed that utility work would be of limited frequency (3 days per year for Bethpage Park and 3 days per year for the Access Road) based on the relative size of the Site and the number of utilities present. For the construction worker, an exposure frequency of 60 days per year was assumed based on the current understanding regarding future development plans for Bethpage Park.

4.4.7 Exposure Durations

The exposure duration for the utility worker (25 years) represents the USEPA (2002a; 2004) default. For the construction worker, an exposure duration of 1 year was assumed since construction projects at Bethpage Park are expected to last no longer than 1 year.

4.4.8 Exposure Time

For the inhalation pathway, the exposure time represents the length of time the receptor may be exposed, i.e., the length of time spent participating in an activity that could lead to exposure. For both the utility and construction workers, it was assumed that the exposure time consists of a standard 8-hour workday.

4.4.9 Body Weights

The body weight used for the utility worker and construction worker (70 kg) represents the USEPA (1989a; 2002a; 2004) default.

4.4.10 Volatilization Factors

Table 4-2 presents the chemical-specific factors used to calculate the volatilization factors for VOCs identified as COPCs. The volatilization factor and particulate emission factor were used to calculate intakes for the inhalation pathway as shown in Table 4-1.

4.5 Evaluation of Lead

Lead was identified as a COPC for Bethpage Park. NYSDEC (2006) provides a cancer toxicity value for lead for both the oral and inhalation exposure routes, (i.e., a SF and URF), but does not provide non-cancer toxicity values for lead. Therefore, potential cancer risks due to lead for utility and construction workers were quantitatively evaluated using the standard intake equations and applying the NYSDEC-recommended toxicity values. In addition, potential Site risks due to lead were evaluated with the USEPA (2003b) Adult Lead Model (ALM), which allows a quantification of lead risks based on biokinetics. This method allows the use of region-specific parameters (Northeast baseline blood levels) to quantify Site risks. Specifically, the ALM is used to evaluate lead risks for non-residential scenarios where the receptor of concern is the fetus of an adult worker. In this HHRA, the ALM was used to quantify potential lead risks for the construction worker exposed to soils at Bethpage Park. Because USEPA (2007b) does not recommend the use of the ALM for exposures less than 90 days because blood lead levels don't reach quasi steady state until that time, the utility worker was not evaluated with the ALM. Rather, the utility worker will have less exposure than the construction worker so the construction worker also serves as a surrogate in the ALM for evaluating lead risks for the utility worker.

Because lead is ubiquitous in the environment, predicted blood lead levels (PbB) associated with exposure to site-related sources of lead are added to an assumed age-specific baseline PbB that also reflects exposure to non-site-related lead sources. Potential health risks associated with lead exposure are evaluated by comparing the estimated PbB to the target PbB of 10 µg/dL (Centers for Disease Control [CDC], 1991). The target PbB is based on potentially adverse neurological effects in children (CDC 1991). Therefore, lead risk is evaluated based on the probability that PbB among a receptor population will exceed 10 •g/dL. This is sometimes referred to as the "P10 statistic." Consistent with USEPA guidance (USEPA 2003b), this lead evaluation focuses on determining if P10 equals or exceeds 5 percent, which is equivalent to calculating the 95th percentile of the probability distribution of PbB among a receptor population.

The following equation is used in the ALM to estimate quasi-steady state PbBs:

$$PbB_{GM} = PbB_0 + \frac{PbSxBKSFxIRxAFxEF}{AT}$$

where:

PbB_{GM} = geometric mean (50th percentile) of the lognormal distribution of PbBs in adult workers

PbB_0 = baseline PbB due to exposure to non-site-related sources of lead (µg/dL)

PbS = soil lead concentration (mg/kg)

BKSF = biokinetic slope factor (µg/dL per µg/day)

IR = soil ingestion rate (g/day)

AF = gastrointestinal absorption fraction for lead in soil (unitless)

EF = exposure frequency (days/year)

AT = averaging time (years)

USEPA assumes a linear relationship between PbB in the adult woman and the fetus. Therefore, the geometric mean PbB in the fetus is equal to PbB_{GM} multiplied by a constant, R (0.9).

Table 4-3 presents the exposure variables used in the ALM to evaluate lead risks for the construction worker at Bethpage Park. The exposure variables are briefly discussed below.

Baseline Blood Lead Concentration (PbB_0)

The baseline PbB is intended to represent the best estimate of a reasonable central value of PbB in women of child-bearing age who are not exposed to lead-contaminated non-residential soil or dust from the Site. USEPA (2003b) recommends a range of baseline concentrations (1.7 to 2.2 µg/dL) based on national survey data for women from different demographic groups defined by geographic region, ethnicity, and race. A baseline value of 1.9 µg/dL was used in the ALM, which represents non-Hispanic white populations from the Northeast Region (USEPA 2002b).

Geometric Standard Deviation (GSD)

USEPA recommends a range of GSDs that may be used in the ALM model, depending on site-specific demographics and the characteristics of the receptor population (USEPA 2003b). Higher GSD values imply greater variability in PbBs and will result in a higher probability of exceeding the target PbB of 10 µg/dL. A GSD of 2.01 was used in this lead evaluation to reflect a non-Hispanic white population from the Northeast (USEPA 2002b).

Biokinetic Slope Factor (BKSF)

The BKSF represents the increase in typical adult PbB due to average daily lead uptake. USEPA (2003b) recommends a default value of 0.4 µg Pb/dL blood per µg Pb absorbed/day for the BKSF. This value is based on empirical data on the relationship between tap water lead concentrations and PbBs for a sample group of adult males. This default value is used for in the ALM.

Soil Ingestion Rate (IR_S)

Consistent with USEPA (2007b) guidance, a soil ingestion rate of 100 mg/day is used to evaluate potential risks for the construction worker. This value represents the central tendency ingestion rate for soil contact-intensive adult scenarios (USEPA 2007b). This value is also consistent with the soil ingestion rate used in the standard intake equations in the HHRA for the construction worker.

Exposure Frequency (EF) and Averaging Time (AT)

The exposure frequency used for the construction worker in the ALM reflects 12 weeks (3 months) of exposure and assumes 5 days per week of exposure (i.e., 5 days/week x 12 weeks = 60 days/year). So as not to dilute the exposures over the entire year, the averaging time is based on the exposure frequency (i.e., 7 days/week x 12 weeks/year = 84 days/year).

Lead Absorption Fraction (AF)

The default value for lead absorption (0.12) is used in the ALM. This value is based on experimental studies of the bioavailability of ingested lead in adults with considerations for the following three major sources of variability: 1) effect of food on lead bioavailability; 2) nonlinearity in PbB; and 3) effect of lead form and particle size on

bioavailability. The value assumes the a relative bioavailability (RBA) of 0.6 for lead in site-related media as compared to soluble lead, and also assumes an absorption fraction of 0.2 for soluble lead. Thus the final AF is 0.12 (i.e. AF = 0.6 x 0.2 = 0.12).

Fetal/Maternal Blood Lead Concentration ($R_{fetal/maternal}$)

A fetal/maternal blood lead ratio of 0.9 is used for adult receptors, which is the default value recommended by USEPA (2003b) based on studies that have explored the relationship between umbilical cord and maternal PbBs.

Exposure Point Concentration

As recommended by USEPA (2003b; 2007b), the EPC used in the ALM represents the arithmetic mean of Site Area data for surface and subsurface soils. Consistent with the EPC methodology described in Section 3.2, surface soil lead concentrations for Bethpage Park were replaced with the NYSDEC Restricted Residential SCO prior to calculation of the EPC assuming that soils with concentrations greater than the SCOs will be removed.

Results of the lead evaluation are discussed below in the risk characterization.

5. Dose Response Assessment

The dose response assessment identifies the potential effects that are associated with exposure to a given chemical. The USEPA's guidance evaluates two types of toxic effects: carcinogenic effects and non-carcinogenic effects. To quantify carcinogenic effects, the USEPA has derived slope factors (SFs) for those chemicals found to cause a dose-related, statistically significant increase in tumor incidence in an exposed population relative to the incidence of tumors observed in an unexposed population. These dose-related incidence rates are usually determined in a laboratory study. SFs are typically developed based on oral toxicity studies and are reported as risk per dose in units of $(mg/kg\text{-}day)^{-1}$. The SFs are used to quantify the potential risk of cancer associated with a given exposure. Unit risk factors (URFs) are based on inhalation studies and are reported in units of $(mg/m^3)^{-1}$. The oral/dermal SFs, including weight-of-evidence classifications, for carcinogenic COPCs are presented in Table 6-1. Table 6-2 presents the URFs for carcinogenic COPCs.

To quantify non-carcinogenic effects, the USEPA has derived oral reference doses (RfDs) in units of mg/kg-day that represent a threshold of toxicity. RfDs are intended to

represent “an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime” (USEPA 1989a). Reference concentrations (RfCs) were derived for the inhalation pathway and are presented in units of mg/m^3. Table 5-1 presents oral/dermal RfDs for noncarcinogenic COPCs. Table 5-2 presents the RfCs for noncarcinogenic COPCs.

The oral SFs and RfDs described above were used to evaluate both ingestion and dermal contact exposure routes. Because most oral toxicity values are based on an administered dose, these toxicity values were sometimes adjusted (expressed as an absorbed dose) when evaluating dermal exposure scenarios. The USEPA requires this adjustment only when the gastrointestinal absorption of a compound is less than 50 percent (USEPA 2004).

Toxicity data presented were preferentially selected from the USEPA Integrated Risk Information System (IRIS) on-line database (USEPA 2008b). The toxicity data from NYSDEC (2006) were used as a secondary source if no toxicity data were available in IRIS. The NYSDEC (2006) selected their toxicity data from various sources, including the USEPA, Agency for Toxic Substances and Disease Registry (ATSDR), World Health Organization (WHO), Health Canada, NYSDOH, and California EPA (CalEPA). If toxicity data were not available from IRIS or NYSDEC (2006), values were selected according to the USEPA (2003a) toxicity hierarchy, which includes the Provisional Peer-Reviewed Toxicity Values (PPRTVs) provided by the USEPA National Center for Environmental Assessment (NCEA), ATSDR minimum risk levels (MRLs), CalEPA values, and the USEPA (1997b) Health Effects Assessment Summary Tables (HEAST).

For the carcinogenic PAHs, for which no specific toxicity information is provided, relative potency factors (RPFs) recommended by USEPA (1993) were used. The compound-specific RPF is multiplied by the SF for benzo(a)pyrene (BaP) to derive a toxicity factor for those constituents, based on their assumed potency relative to BaP.

Surrogate toxicity data were used when chemical-specific values were unavailable. Specifically, for RfDs, the value for mercuric sulfide was used for mercury, Aroclor 1254 was used for total PCBs, and thallium sulfate was used for thallium. For RfCs, the value for elemental mercury was used for mercury and thallium sulfate was used for thallium. The SF and URF for PCBs represent the values for high risk PCBs.

When available, subchronic toxicity data were used to evaluate potential non-cancer hazards for the construction worker. When only one toxicity value was available (i.e., chronic or subchronic), the same value was used to evaluate both chronic and subchronic exposures.

6. Risk Characterization

The risk characterization integrates the results of the data evaluation, toxicity assessment, and exposure assessment to evaluate potential risks associated with exposure to site-related constituents in Site Area soils. Consistent with the USEPA (1989a) guidance, the potential for carcinogenic risks and non-carcinogenic health hazards are evaluated separately.

Tables 7-1 through 7-3 and Tables 9-1 through 9-3 present the cancer and non-cancer intakes, as well as the cancer risks and non-cancer hazards, respectively. The RAGS Part D Table 8 series are not presented as part of this HHRA because radiation risks are not of concern for the Site.

6.1 Non-Carcinogenic Health Hazards

Quantitative estimates for noncancer effects are called hazard quotients (HQs). The HQ is the ratio of the estimated average daily dose or exposure intake and the appropriate noncancer toxicity value (RfD), as presented below for oral and inhalation exposures.

$$HQ = \frac{E_{oral}}{RfD}$$

where:

E = exposure intake (mg/kg-day)

RfD = reference dose (mg/kg-day)

$$HQ = \frac{E_{inhalation}}{RfC}$$

where:

E = Exposure intake (mg/m^3)

RfC = Reference Concentration (mg/m^3)

The Hazard Index (HI) is used to characterize potential non-carcinogenic health hazards associated with exposure to multiple chemicals. This approach assumes that sub-threshold chronic exposures to multiple chemicals are additive. However, HQs should only be summed for constituents with the same target organ. The USEPA target HI is 1; therefore, exposures with a cumulative HI or target-organ HI of less than 1 are presumed not to pose unacceptable health hazards. An HQ/HI value greater than 1 indicates that a calculated exposure is greater than the RfD for a given constituent; however, it does not reflect the probability of an adverse effect, nor does it necessarily imply that adverse health effects will occur (USEPA 1989a). Although cumulative HIs are presented in the risk characterization, the target-organ HIs are the true indicators of whether a group of chemicals presents an unacceptable health hazard. Tables 7-1 through 7-3 present cumulative HIs, while Tables 9-1 through 9-3 present target organ-specific HIs.

The HI for the oral and dermal exposure pathways is calculated as follows:

$$HI = \frac{E1}{RfD1} + \frac{E2}{RfD2} + \mathrm{K} + \frac{Ei}{RfDi}$$

where:

HI = Hazard Index

$$\frac{E}{RfD} = HQ$$

where:

Ei = Exposure intake for the ith chemical (mg/kg-day)

RfDi = RfD for the ith chemical (mg/kg-day)

The HI for the inhalation exposure pathway is calculated as follows:

$$HI = \frac{E1}{RfC1} + \frac{E2}{RfC2} + \mathrm{K} + \frac{Ei}{RfCi}$$

where:

HI = Hazard Index

$$\frac{E}{RfC} = HQ$$

where:

Ei = exposure intake for the ith chemical (mg/m^3)

RfCi = RfC for the ith chemical

Non-carcinogenic health hazards for each area of the Site are discussed separately below.

6.1.1 Bethpage Park

Potentially complete exposure pathways for Bethpage Park included exposure of utility workers and construction workers to surface and subsurface soils via ingestion, dermal contact, and inhalation. The target organ-specific HIs for the utility worker and construction worker at the Bethpage Park were below the USEPA target of 1. Tables 7-1 and 9-1 present the HIs for the utility worker. Tables 7-3 and 9-3 present the HIs for the construction worker.

Lead was identified as a COPC for Bethpage Park. The USEPA (2003b) ALM was used to evaluate potential lead risks for receptors exposed to soils at Bethpage Park in the absence of noncancer toxicity values. Because blood lead levels do not reach quasi-steady state until 90 days, use of the ALM was not appropriate to evaluate potential lead risks for the utility worker. Therefore, the ALM was only used to evaluate potential lead risks for the construction worker.

Table 7-4 presents the ALM modeling results for the construction worker exposed to surface and subsurface soils at Bethpage Park. The ALM predicts that exposure of construction workers to surface and subsurface soils at Bethpage Park will result in a P10 less than 5 percent (i.e., less than 5 percent of fetal PbBs will be greater than the target of 10 µg/dL). Since the utility worker is expected to have less exposure than the construction worker, it can be assumed that the P10 for the utility worker would also be less than 5 percent.

6.1.2 Access Road

Potentially complete exposure pathways for the Access Road included exposure of utility workers to surface and subsurface soils via ingestion, dermal contact, and

inhalation. The target organ-specific HIs for the utility worker were below the USEPA target of 1. Tables 7-2 and 9-2 present the HIs for the utility worker.

6.2 Carcinogenic Risk

Carcinogenic risk is expressed as a probability of developing cancer over the course of a lifetime as a result of a given level of exposure (USEPA 1989a) (also referred to as "excess cancer risk"). Tables 7-1 through 7-3 and Tables 9-1 through 9-3 present cancer risks for individual COPCs for each exposure pathway and receptor. As stated previously, the RAGS Part D Table 8 series is not presented as part of this HHRA because radiation risks are not of concern for the Site.

Quantitative estimates for carcinogenic effects are obtained by calculating the excess lifetime cancer risk. Cancer risk, which is equal to the product of the estimated dose and the cancer toxicity value, is estimated for each known, probable or possible carcinogenic COPC in each medium. For a given chemical, carcinogenic risk for the oral and dermal exposure routes is calculated as follows:

$$Risk = ExSF$$

where:

E = exposure intake (mg/kg-day)

SF = slope factor $(mg/kg\text{-}day)^{-1}$

For a given chemical, carcinogenic risk for the inhalation exposure route is calculated as follows:

$$Risk = ExURF$$

where:

E = exposure intake (mg/m^3)

URF = unit risk factor $(mg/m^3)^{-1}$

Cancer risks reflect the increased risk, above that experienced by the general population, which may result from the selected exposure scenarios. The risk estimates are considered upper bound estimates of risk. It is very likely that the true risks are less than those predicted and may, in fact, be essentially zero. Current regulatory

methodology conservatively assumes that cancer risks can be summed across routes of exposure, media, and COPCs to derive the cumulative cancer risk (USEPA 1989a).

When evaluating potential individual cancer risks, USEPA has established an acceptable risk range of 1 in 1,000,000 (1×10^{-6}) to 1 in 10,000 (1×10^{-4}) (USEPA 1990). In establishing this range, USEPA accepted the policy that a risk range, rather than a single risk value, adequately protects public health (55 Federal Register 8716). The National Contingency Plan states that "for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 1×10^{-4} to 1×10^{-6}" (USEPA 2003c).

Carcinogenic risks for each area of the Site are discussed separately below.

6.2.1 Bethpage Park

Potentially complete exposure pathways for Bethpage Park included exposure of utility workers and construction workers to surface and subsurface soils via ingestion, dermal contact, and inhalation. The total cancer risk for the utility worker is 2×10^{-6} which is on the low end of USEPA's target risk management range. The total cancer risk for the construction worker is 1×10^{-6}. Tables 7-1 and 9-1 present the cancer risks for the utility worker. Tables 7-3 and 9-3 present the cancer risks for the construction worker.

NYSDEC (2006) recommends a cancer slope factor and unit risk factor for lead. These toxicity values were developed by CalEPA and adopted by the NYSDEC. These toxicity values were used to quantify potential cancer risks for workers exposed to lead in soils at Bethpage Park. Lead risks for the utility worker are 1×10^{-8}, and lead risks for the construction worker are 7×10^{-9}, both of which are well below 1×10^{-6}.

6.2.2 Access Road

Potentially complete exposure pathways for the Access Road included exposure of utility workers to surface and subsurface soils via ingestion, dermal contact, and inhalation. The total cancer risk for the utility worker is 2×10^{-6}, which is on the low end of USEPA's target risk management range. Tables 7-2 and 9-2 present the cancer risks for the utility worker.

6.3 Summary

The following table presents a summary of total risks and hazards for each receptor (also shown in Table 9-4):

Receptor	Exposure Point	Total Cancer Risk	Hazard Index
Utility Worker	Bethpage Park	2×10^{-6}	0.1
Utility Worker	Access Road	2×10^{-6}	0.07
Construction Worker	Bethpage Park	1×10^{-6}	<1.0*

* All organ-specific HI's were found to be less than the target HI of 1.0.

Given the soil remedial actions described in this HHRA:

- The organ-specific HIs for all receptors and exposure points are below the USEPA target HI of 1
- Total cancer risks for all receptors and exposure points are on the low end of the acceptable risk range.

7. Uncertainty Analysis

There are various sources of uncertainty inherent in the risk assessment process. These include uncertainties associated with exposure parameters and toxicity factors for which conservative assumptions are typically used so as not to underestimate risk. The objective of an uncertainty analysis is to present key information regarding assumptions and uncertainties in the risk assessment process in order to place the quantitative risk estimates in proper perspective (USEPA 1989a).

7.1 Exposure Factors

Sources of uncertainty in this HHRA include exposure factors, such as area use factors, exposure durations, and exposure frequencies. The following provides a discussion of the individual exposure factors that may lend uncertainty to this HHRA.

Site soils were assumed to represent 100 percent of potential exposure (i.e., FI = 1) for the utility worker and construction worker, which is conservative given that this does not account for exposures outside of the Site during non-working hours. It is likely that these receptors may be exposed to off-site soils that would have lower COPC concentrations, which would essentially dilute the exposure point concentration and subsequent intakes. Using an area use factor of 1 to estimate potential risks is a conservative approach, indicating risks are unlikely to be higher and may actually be much lower than the risk estimates presented in this HHRA.

The exposure duration for the utility worker (i.e., 25 years) represents that for an outdoor worker. USEPA (2002a) defines an outdoor worker as a long-term receptor exposed during the work day who is a full-time employee of the company operating on-site and who spends most of the workday conducting maintenance activities outdoors. The utility worker evaluated in this HHRA represents an individual who would be involved in intermittent utility maintenance, repair, and/or placement, and not necessarily someone who is employed at the Park or Access Road on a full-time basis. Therefore, assuming that the same individual would be working on utilities at the Site over a 25-year period is highly conservative.

7.2 Toxicity Values

As discussed in Section 3, the toxicity values used to quantify potential risks and hazards were primarily taken from the USEPA IRIS on-line database. However, IRIS did not contain toxicity values for several of the COPCs. In this instance, the NYSDEC-recommended toxicity values were used in the HHRA. If neither IRIS nor NYSDEC (2006) contained toxicity values for a particular COPC, alternate resources were used (e.g., PPRTVs, HEAST, CalEPA).

Many of the toxicity values used in this HHRA are based on older animal studies. As with the case of non-cancer toxicity values, the application of uncertainty and modifying factors (sometimes also referred to as safety factors) in the development of these toxicity values indicates there is a certain amount of uncertainty associated with these values, usually due to the fact that these values are based on animal studies rather than epidemiological studies. Further, some toxicity values that are based on epidemiological studies rely on route-to-route extrapolation. Both cancer and non-cancer toxicity values build in a “margin of safety” (USEPA 2008c). Therefore, the toxicity values themselves may be overly conservative. The use of conservative toxicity values along with conservative exposure factors results in conservative estimates of

potential risks. Therefore, it is unlikely that the estimated risks in this HHRA are reflective of actual risks.

7.3 Dermal Absorption Factor for PCBs

A dermal absorption factor of 14 percent for uptake of PCBs from soil was used in this HHRA. The dermal absorption factor is presented in the USEPA (2004) *Dermal Risk Assessment Guidance* and is based on a study by Wester, Maibach et al. (1993) of rhesus monkeys dermally exposed to PCB-contaminated soil (Aroclors 1242 and 1254). In this study, the PCB-contaminated soil was applied to the skin of rhesus monkeys for a 24-hour period. Absorption of PCBs was determined by urinary and fecal excretion over a 5-week period. The amount of PCBs excreted following dermal exposure was compared to the amount excreted following an intravenous administration (assumed to represent 100 percent absorption). Although the study provided interesting information on the kinetics of dermal absorption of PCBs in rhesus monkeys, there is a significant level of uncertainty associated with extrapolating these results to the general population. Wester, Maibach et al. (1993) allowed the PCB-containing soil to remain in contact with the skin of the rhesus monkeys for 24 hours, a period much greater than would be expected to occur as a result of occupational, residential, or recreational exposure. Lastly, the soil/PCB matrix used by Wester, Maibach et al. (1993) was unweathered and contained relatively little organic carbon – a mixture that is not typically representative of environmental conditions. Given that the presence of organic carbon reduces the bioavailability of lipophilic compounds such as PCBs (Umbriet, Hesse et al. 1986; Shu, Teitelbaum et al. 1988; USEPA 1989b) and weathered organic constituents frequently exhibit reduced bioavailability (Loehr and Webster 1996), the 14 percent dermal absorption factor observed in the Wester, Maibach et al. (1993) study likely overestimates the availability of environmental PCBs.

Empirical evidence of the uncertainty (and overestimation) associated with using the 14 percent absorption factor can be found in the analysis of the dermal absorption of Aroclor 1260 in the rhesus monkey (Mayes, Brown et al. 2001). The results of this analysis demonstrated that 4 percent of the dermally applied dose was absorbed following either a 12-hour or 24-hour exposure period. Based on this information, it is likely that the dermal absorption factor for humans would be lower than 14 percent. By using 14 percent as the dermal absorption factor to quantify potential dermal exposures, risks and hazards associated with dermal contact with PCBs in soils are likely to be overestimated.

8. Summary and Conclusions

Several VOCs, SVOCs (primarily PAHs), PCBs, and metals were identified as COPCs and quantitatively evaluated for Bethpage Park. PCBs, arsenic, cadmium, and chromium were identified as COPCs that were quantitatively evaluated for the Access Road. Potentially complete exposure pathways that were quantitatively evaluated as part of this HHRA included exposure of utility workers and construction workers to soils at Bethpage Park and exposure of utility workers to soils within the Access Road. Potential soil exposure routes included ingestion, dermal contact, and inhalation of volatiles and particulates.

Results of this HHRA indicate that cancer risks for utility workers and construction workers are on the low end of USEPA's risk management range of 1×10^{-4} to 1×10^{-6}. The results of this HHRA indicate the non-cancer risks for utility workers and construction workers are less than 1.

As discussed previously, as with any risk assessment, there are uncertainties associated with the risk and hazard estimates presented in this HHRA. Some of the exposure factors used in this HHRA are site-specific, but still conservative, and as such, potential risks and hazards may be overestimated.

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Table 1-1. Summary of Exposure Pathways
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Location	Receptor Population	Receptor Age	Exposure Route	Pathway Complete?	Rationale
Current/Future	Soil	Surface Soil	Surface Soil	Bethpage Park	Trespasser	Adolescent	Dermal Ingestion Inhalation	No No No	Surface soils with concentrations greater than restricted residential SCOs will be removed.
					Recreator	Adult	Dermal Ingestion Inhalation	No No No	Surface soils with concentrations greater than restricted residential SCOs will be removed.
						Child	Dermal Ingestion Inhalation	No No No	Surface soils with concentrations greater than restricted residential SCOs will be removed.
					Site Worker	Adult	Dermal Ingestion Inhalation	No No No	Surface soils with concentrations greater than restricted residential SCOs will be removed.
				Plant 24 Access Road	Trespasser	Adolescent	Dermal Ingestion Inhalation	No No No	Surface soils with capped with a gravel cover, which will preclude direct contact exposures.
					Recreator (a)	Adult	Dermal Ingestion Inhalation	No No No	Surface soils with capped with a gravel cover, which will preclude direct contact exposures.
	Groundwater	Groundwater	Groundwater	Bethpage Park	Recreator	Adult	Dermal Ingestion Inhalation	No No No	Depth to groundwater precludes direct contact. Site groundwater is not used as a drinking source.
						Child	Dermal Ingestion Inhalation	No No No	Depth to groundwater precludes direct contact. Site groundwater is not used as a drinking source.
					Construction Worker	Adult	Dermal Ingestion Inhalation	No No No	Depth to groundwater precludes direct contact. Site groundwater is not used as a drinking source.
				Plant 24 Access Road	Trespasser	Adolescent	Dermal Ingestion Inhalation	No No No	Depth to groundwater precludes direct contact. Site groundwater is not used as a drinking source.
					Utility Worker	Adult	Dermal Ingestion Inhalation	No No No	Depth to groundwater precludes direct contact. Site groundwater is not used as a drinking source.
					Recreator (a)	Adult	Dermal Ingestion Inhalation	No No No	Depth to groundwater precludes direct contact. Site groundwater is not used as a drinking source.
	Soil/Groundwater	Indoor Air	Indoor Air	Bethpage Park	Recreator	Adult	Inhalation	No	An IRM is in place to address soil gas. Current buildings have vapor barriers. Future buildings will be constructed with vapor barriers.
						Child	Inhalation	No	An IRM is in place to address soil gas. Current buildings have vapor barriers. Future buildings will be constructed with vapor barriers.
					Site Worker	Adult	Inhalation	No	An IRM is in place to address soil gas. Current buildings have vapor barriers. Future buildings will be constructed with vapor barriers.

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Table 1-1. Summary of Exposure Pathways
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Future	Soil	Surface and Subsurface Soil	Surface and Subsurface Soil	Bethpage Park	Utility Worker	Adult	Dermal Ingestion Inhalation	Yes Yes Yes	Utility workers may be exposed to surface and subsurface soils (0-6 feet bgs) during maintenance activities. Surface soils (0-2 feet bgs) with concentrations greater than SCOs will be removed.
					Construction Worker	Adult	Dermal Ingestion Inhalation	Yes Yes Yes	Construction workers may be exposed to surface and subsurface soils (0-6 feet bgs) during intrusive activities. Surface soils (0-2 feet bgs) with concentrations greater than SCOs will be removed.
				Plant 24 Access Road	Utility Worker	Adult	Dermal Ingestion Inhalation	Yes Yes Yes	Utility workers may be exposed to subsurface soils (0-10 feet bgs) during maintenance activities.

Notes:
This table identifies exposure pathways that are considered in the human health risk assessment.
Surface soils are defined as 0-2 feet bgs.
Subsurface soils are defined as 0-10 feet bgs in the Access Road and 0-6 feet bgs for Bethpage Park, with the exception of select utility locations within the Park that extend down to 10 feet bgs.
(a) Recreator includes walkers and joggers.
bgs – below ground surface
Child – Individual aged 0-6 years
Construction Worker – Individual who may be involved in intrusive construction activities.
Current – Exposure scenarios that may exist based on current site conditions
Future – Exposure scenarios that may exist in the future based on site redevelopment, etc.
IRM – Interim remedial measure
SCO – Soil cleanup objective
Utility Worker – Individual who may be involved in utility maintenance work

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Table 2-1. Occurrence, Distribution and Selection of COPCs – Bethpage Park Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Soil, 2-6 feet [1]
Exposure Point: Bethpage Park

Chemical Name	Minimum Detected Value (mg/kg)	Maximum Detected Value (a) (mg/kg)	Location of Maximum Detected Value	Frequency of Detection	Range of SQLs (mg/kg)	Screening Level (mg/kg)	Screening Level Reference	COPC?	Rationale
Volatile Organic Compounds									
1,1,1-Trichloroethane	0.003	0.013	TP-08	4 / 64	0.00037 - 0.056	100	SCO	no	BSV
1,1,2-Trichloroethane	0.012	4	TP-02A	2 / 64	0.0007 - 0.056	1	RSL	YES	ASV
1,1-Dichloroethane	0.0014	0.24	TP-08	16 / 64	0.00032 - 0.056	26	SCO	no	BSV
1,1-Dichloroethene	0.0062	0.8	TP-02A	2 / 64	0.0015 - 0.056	100	SCO	no	BSV
1,2,4-Trimethylbenzene	0.0071	0.035	B-42	2 / 6	0.00035 - 0.00036	52	SCO	no	BSV
1,2-Dichlorobenzene	0.005	16	TP-02A	11 / 78	0.0004 - 71	2000	RSL	no	BSV
1,2-Dichloroethane	0.0031	0.067	TP-08	3 / 64	0.0004 - 0.056	3	SCO	no	BSV
1,2-Dichloroethene	0.006	0.006	B-67	1 / 24	0.00072 - 0.056	100	SCO	no	BSV
1,2-Dichloropropane	0.057	0.057	TP-08	2 / 64	0.00062 - 0.056	1	RSL	no	BSV
1,3,5-Trimethylbenzene	0.0032	0.039	B-42	2 / 4	0.00028 - 0.00029	52	SCO	no	BSV
1,4-Dichlorobenzene	0.012	2.4	TP-02A	7 / 78	0.00037 - 0.74	13	SCO	no	BSV
2-Butanone	0.005	0.065	B-56	16 / 64	0.0015 - 0.27	100	SCO	no	BSV
Acetone	0.005	0.99	TP-01	41 / 64	0.0018 - 0.054	100	SCO	no	BSV
Benzene	0.008	1.1	TP-02A	4 / 64	0.00035 - 0.056	5	SCO	no	BSV
Benzene, 1-methylethyl-	0.001	0.13	B-60	7 / 22	0.00033 - 0.011	100	SCO	no	BSV
Carbon disulfide	0.001	0.002	B-62	3 / 64	0.0022 - 0.27	670	RSL	no	BSV
Chlorobenzene	0.13	0.46	TP-01	2 / 64	0.00038 - 0.056	100	SCO	no	BSV
Chloroethane	0.006	0.0064	TP-07	2 / 64	0.0026 - 0.056	15000	RSL	no	BSV
cis-1,2-Dichloroethene	0.001	1300	TP-02A	39 / 63	0.0005 - 0.011	100	SCO	YES	ASV
cis-1,3-Dichloropropene	0.0075	0.0075	TP-02A	1 / 64	0.0004 - 0.056	2	RSL	no	BSV
Cumene	0.0056	0.0056	B-42	1 / 4	0.00029 - 0.0003	2200	RSL	no	BSV
Ethylbenzene	0.0008	220	TP-02A	19 / 64	0.00069 - 0.027	41	SCO	YES	ASV
Isopropylbenzene	0.002	2.2	TP-02A	14 / 32	0.00032 - 0.011	100	SCO	no	BSV
Methylene chloride	0.0009	0.016	B-24	25 / 64	0.00086 - 0.056	11	RSL	no	BSV
Tetrachloroethene	0.001	4.8	TP-02A	5 / 64	0.00066 - 0.056	19	SCO	no	BSV
Toluene	0.001	8200	TP-02A	40 / 64	0.00034 - 0.027	100	SCO	YES	ASV
trans-1,2-Dichloroethene	0.0006	0.12	TP-08	8 / 39	0.00069 - 0.77	100	SCO	no	BSV
trans-1,3-Dichloropropene	0.0003	0.0003	TP-07	1 / 62	0.00029 - 0.056	2	RSL	no	BSV
Trichloroethylene	0.0014	8200	TP-02A	37 / 64	0.00038 - 0.056	21	SCO	YES	ASV
Trichlorotrifluoroethane (freon 113)	0.0008	0.001	VP-28	2 / 35	0.004 - 0.056	100	SCO	no	BSV
Vinyl chloride	0.0013	0.27	TP-02A	20 / 64	0.00091 - 0.056	1	SCO	no	BSV
Xylene (total)	0.0006	120	TP-02A	26 / 56	0.001 - 0.011	100	SCO	YES	ASV
Xylene-o	0.0036	0.11	I-3-SB	8 / 18	0.00048 - 0.0057	100	SCO	no	BSV
Xylenes - m,p	0.002	0.088	I-3-SB	6 / 14	0.005 - 0.027	100	SCO	no	BSV

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Table 2-1. Occurrence, Distribution and Selection of COPCs – Bethpage Park Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Soil, 2-6 feet [1]
Exposure Point: Bethpage Park

Chemical Name	Minimum Detected Value (mg/kg)	Maximum Detected Value (a) (mg/kg)	Location of Maximum Detected Value	Frequency of Detection	Range of SQLs (mg/kg)	Screening Level (mg/kg)	Screening Level Reference	COPC?	Rationale
Semivolatile Organic Compounds									
2,4-Dimethylphenol	0.084	21	TP-02A	4 / 38	0.055 - 1.2	1200	RSL	no	BSV
2-Methylnaphthalene	0.041	81	TP-02A	40 / 53	0.045 - 0.36	310	RSL	no	BSV
2-Methylphenol	0.041	0.61	TP-08	3 / 39	0.063 - 1.7	100	SCO	no	BSV
2-Phenylbutane	0.0041	0.006	B-42	2 / 4	0.00048 - 0.00049	100	SCO	no	BSV
4-Methylphenol	0.05	16	TP-02A	11 / 39	0.055 - 1.2	100	SCO	no	BSV
Benzyl butyl phthalate	3	3	TP-08	1 / 39	0.051 - 1.3	12000	RSL	no	BSV
Biphenyl	0.066	0.49	B-17	3 / 8	0.33 - 1.2	3900	RSL	no	BSV
Bis(2-chloroethyl)ether	1.1	1.1	TP-21	1 / 39	0.047 - 1.3	0.19	RSL	YES	ASV
Bis(2-ethylhexyl)phthalate	0.056	1500	TP-01	32 / 39	0.051 - 0.77	35	RSL	YES	ASV
Carbazole	0.045	4.7	O9	23 / 39	0.058 - 0.88	24	RSL	no	BSV
Dibenzofuran	0.037	5.1	O9	35 / 53	0.033 - 0.51	100	SCO	no	BSV
Diethyl phthalate	1.8	1.8	O9	1 / 39	0.048 - 1.3	49000	RSL	no	BSV
di-n-Butylphthalate	0.045	13	TP-02A	10 / 39	0.048 - 1.2	6100	RSL	no	BSV
di-n-Octyl phthalate	0.015	0.015	B-70	1 / 39	0.04 - 1.2	100	NA	no	BSV
Hexachloro-1,3-butadiene	0.087	0.087	TP-13	1 / 39	0.057 - 1.5	6	RSL	no	BSV
Isophorone	0.54	0.54	TP-21	1 / 39	0.035 - 1.2	510	RSL	no	BSV
Methylcylohexane	0.001	0.8	B-60	11 / 27	0.004 - 0.011	3400	NA	no	BSV
Phenol	0.05	2.1	TP-08	5 / 39	0.047 - 1.3	100	SCO	no	BSV
Polycyclic Aromatic Hydrocarbons									
Acenaphthene	0.041	31	TP-09	38 / 52	0.035 - 0.54	100	SCO	no	BSV
Acenaphthylene	0.04	1.5	O9	6 / 53	0.035 - 1.2	100	SCO	no	BSV
Anthracene	0.053	8.5	O9	36 / 53	0.057 - 1.5	100	SCO	no	BSV
Benzo(a)anthracene	0.059	17	O9	45 / 53	0.061 - 1.6	1	SCO	YES	ASV
Benzo(a)pyrene	0.042	16	O9	45 / 53	0.048 - 1.3	1	SCO	YES	ASV
Benzo(b)fluoranthene	0.064	21	O9	46 / 53	0.065 - 1.7	1	SCO	YES	ASV
Benzo(g,h,ii)perylene	0.042	2.9	O9	40 / 53	0.084 - 2.2	100	SCO	no	BSV
Benzo(k)fluoranthene	0.047	6.5	O9	42 / 53	0.045 - 1.2	4	SCO	YES	ASV
Chrysene	0.073	17	O9	46 / 53	0.06 - 1.6	4	SCO	YES	ASV
Dibenzo(a,h)anthracene	0.044	1.7	O9	34 / 53	0.068 - 1.8	0.33	SCO	YES	ASV
Fluoranthene	0.11	41	O9	47 / 53	0.047 - 0.082	100	SCO	no	BSV
Fluorene	0.044	10	O9	40 / 53	0.036 - 0.55	100	SCO	no	BSV
Indeno(1,2,3-cd)pyrene	0.088	4.4	O9	38 / 53	0.07 - 1.9	1	SCO	YES	ASV
Naphthalene	0.036	68	TP-02A	39 / 53	0.042 - 1.2	100	SCO	no	BSV
Perylene	0.82	0.82	B-28	1 / 1	NA - NA	100	NA	no	BSV
Phenanthrene	0.056	35	O9	48 / 53	0.044 - 0.047	100	SCO	no	BSV
Pyrene	0.099	35	O9	47 / 53	0.049 - 0.086	100	SCO	no	BSV

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Table 2-1. Occurrence, Distribution and Selection of COPCs – Bethpage Park Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Soil, 2-6 feet [1]
Exposure Point: Bethpage Park

Chemical Name	Minimum Detected Value (mg/kg)	Maximum Detected Value (a) (mg/kg)	Location of Maximum Detected Value	Frequency of Detection	Range of SQLs (mg/kg)	Screening Level (mg/kg)	Screening Level Reference	COPC?	Rationale
Polychlorinated Biphenyls									
Total PCBs	0.076	880	P-31	139 / 191	NA - 0.067	1	SCO	YES	ASV
Metals									
Aluminum (fume or dust) (b)	849	110000	TP-01	26 / 26	NA - NA	77000	RSL	YES	ASV
Antimony	0.69	1180	TP-08N	20 / 26	0.57 - 3	31	RSL	YES	ASV
Arsenic	0.39	1110	TP-08N	138 / 139	0.79 - 0.79	16	SCO	YES	ASV
Barium	2.5	5470	P-5	139 / 139	NA - NA	400	SCO	YES	ASV
Beryllium	0.13	24	TP-21	24 / 26	0.45 - 0.47	72	SCO	no	BSV
Cadmium	0.04	480	TP-01	147 / 162	0.03 - 0.7	4	SCO	YES	ASV
Calcium metal	43	86300	TP-08N	25 / 26	22 - 22	NA	NA	no	NSV
Chromium - soluble	1.1	124000	P-5	176 / 176	NA - NA	180	SCO	YES	ASV
Chromium (hexavalent compounds)	6.28	560	B-18	5 / 41	1.1 - 11	110	SCO	YES	ASV
Cobalt	1.4	9980	TP-08	26 / 26	NA - NA	10000	SCO	no	BSV
Copper	1.8	4100	TP-01	26 / 26	NA - NA	270	SCO	YES	ASV
Iron	3130	42700	TP-08	26 / 26	NA - NA	10000	SCO	YES	ASV
Lead	0.61	2000	TP-21	143 / 143	NA - NA	400	SCO	YES	ASV
Magnesium	148	2600	TP-06	26 / 26	NA - NA	10000	SCO	no	BSV
Manganese	42.1	393	TP-08	26 / 26	NA - NA	2000	SCO	no	BSV
Mercury	0.01	19	P-5	101/ 139	0.029 - 0.1	1	SCO	YES	ASV
Nickel	1.7	230	TP-01	26 / 26	NA - NA	310	SCO	no	BSV
Potassium	94.2	2770	TP-08	26 / 26	NA - NA	10000	SCO	no	BSV
Selenium	0.38	14	TP-01	54 / 139	0.1 - 9	180	SCO	no	BSV
Silver	0.12	26	TP-01	78 / 139	0.14 - 2	180	SCO	no	BSV
Sodium	4.9	2790	TP-08N	22 / 26	27 - 32	NA	NA	no	ENUT
Thallium	0.1	17	TP-21	9 / 26	0.54 - 3	5	RSL	YES	ASV
Vanadium (fume or dust)	2.1	93.4	TP-08	24 / 26	0.033 - 2	390	RSL	no	BSV
Zinc	3.1	29200	TP-08	26 / 26	NA - NA	10000	SCO	YES	ASV

Notes:
[1] Also includes select samples from deeper utility easements up to 10 feet in depth (samples G-5-B, P-3 through P-16, B-28, B-60, and TP-1).
(a) Maximum detected concentrations were compared to screening levels to identify COPCs.
(b) The maximum concentration was detected at 10 feet bgs. Therefore, aluminum is retained as a COPC for the utility worker, but not for the construction worker who is only exposed to 0-6 foot soils. The maximum concentration for the 0-6 foot soils is 15,000 mg/kg.
ASV – Above screening value
BSV – Below screening value
COPC – Chemical of potential concern
ENUT – Essential nutrient
mg/kg – Milligrams per kilogram
NA – Not available
RSL – USEPA regional screening level for residential soil
SCO – NYSDEC restricted residential soil cleanup objective
SQL – Sample quantitation limit

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Table 2-2. Occurrence, Distribution and Selection of COPCs – Access Road Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Soil, 0-10 feet
Exposure Point: Access Road

Chemical Name	Minimum Detected Value (mg/kg)	Maximum Detected Value (a) (mg/kg)	Location of Maximum Detected Value	Frequency of Detection	Range of SQLs (mg/kg)	Screening Level (mg/kg)	Screening Level Reference	COPC?	Rationale
Volatile Organic Compounds									
1,1-Dichloroethene	0.018	0.021	B-46	2 / 5	0.0017 - 0.006	100	SCO	no	BSV
1,2,4-Trimethylbenzene	20	30	B-46	2 / 3	0.00036 - 0.00036	52	SCO	no	BSV
1,2-Dichloroethane	0.0037	0.0037	B-46	1 / 5	0.00082 - 0.006	3	SCO	no	BSV
1,2-Dichloroethene	0.027	0.061	B-46	2 / 5	0.00074 - 0.006	100	SCO	no	BSV
1,3,5-Trimethylbenzene	0.67	10	B-46	2 / 3	0.00029 - 0.00029	52	SCO	no	BSV
Acetone	0.01	0.13	B-46	3 / 7	0.0019 - 0.006	100	SCO	no	BSV
Benzene	0.0018	0.0018	B-46	1 / 5	0.00038 - 0.006	5	SCO	no	BSV
Benzene, 1-methylethyl-	0.22	0.22	B-46	1 / 5	0.00032 - 0.006	100	SCO	no	BSV
Carbon disulfide	0.003	0.0058	B-46	2 / 5	0.0024 - 0.006	670	RSL	no	BSV
cis-1,2-Dichloroethene	0.003	38	B-46	5 / 7	0.00053 - 0.00053	100	SCO	no	BSV
Cumene	0.24	3.6	B-46	2 / 3	0.0003 - 0.0003	2200	RSL	no	BSV
Ethylbenzene	2.2	4	B-46	2 / 5	0.00075 - 0.006	41	SCO	no	BSV
Methylene chloride	0.001	0.0044	B-46	4 / 7	0.00092 - 0.006	11	RSL	no	BSV
p-Xylene	7.5	13	B-46	2 / 3	0.00074 - 0.00074	100	SCO	no	BSV
Tetrachloroethene	0.023	0.034	B-46	3 / 7	0.00072 - 0.006	19	SCO	no	BSV
Toluene	0.001	0.93	B-46	6 / 7	0.00036 - 0.00036	100	SCO	no	BSV
Trichloroethylene	0.012	0.064	B-46	5 / 7	0.0004 - 0.0004	21	SCO	no	BSV
Xylene (total)	0.004	21	B-46	4 / 6	0.0011 - 0.005	100	SCO	no	BSV
Xylene-o	4.7	7.5	B-46	2 / 3	0.00049 - 0.00049	100	SCO	no	BSV
Semivolatile Organic Compounds									
2-Methylnaphthalene	0.28	0.87	B-46	2 / 5	0.048 - 0.4	310	RSL	no	BSV
2-Phenylbutane	5.3	7.4	B-46	2 / 3	0.00049 - 0.00049	100	SCO	no	BSV
Bis(2-ethylhexyl)phthalate	0.13	6	VP-09	4 / 4	NA - NA	35	RSL	no	BSV
n-Butylbenzene	9.8	13	B-46	2 / 3	0.00061 - 0.00061	100	SCO	no	BSV
n-Propylbenzene	4.9	7.7	B-46	2 / 3	0.00071 - 0.00071	100	SCO	no	BSV
Polycyclic Aromatic Hydrocarbons									
Anthracene	0.11	0.11	B-46	1 / 5	0.06 - 1.8	100	SCO	no	BSV
Benzo(a)anthracene	0.044	0.29	B-65	3 / 5	0.067 - 0.085	1	SCO	no	BSV
Benzo(a)pyrene	0.11	0.19	B-65	2 / 5	0.054 - 0.4	1	SCO	no	BSV
Benzo(b)fluoranthene	0.17	0.2	B-65	2 / 5	0.071 - 0.4	1	SCO	no	BSV
Benzo(k)fluoranthene	0.083	0.083	B-46	1 / 5	0.05 - 1.8	4	SCO	no	BSV
Chrysene	0.13	0.32	B-65	3 / 5	0.066 - 0.4	4	SCO	no	BSV
Fuoranthene	0.058	0.51	B-65	3 / 5	0.052 - 0.066	100	SCO	no	BSV
Fluorene	0.097	0.097	B-46	1 / 5	0.038 - 1.8	100	SCO	no	BSV
Naphthalene	0.15	1.3	B-46	3 / 5	0.047 - 0.4	100	SCO	no	BSV
Phenanthrene	0.045	0.53	B-46	4 / 5	0.049 - 0.049	100	SCO	no	BSV
Pyrene	0.059	0.44	B-65	4 / 5	0.055 - 0.055	100	SCO	no	BSV

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Table 2-2. Occurrence, Distribution and Selection of COPCs – Access Road Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Soil, 0-10 feet
Exposure Point: Access Road

Chemical Name	Minimum Detected Value (mg/kg)	Maximum Detected Value (a) (mg/kg)	Location of Maximum Detected Value	Frequency of Detection	Range of SQLs (mg/kg)	Screening Level (mg/kg)	Screening Level Reference	COPC?	Rationale
Polychlorinated Biphenyls									
Total PCBs	0.04	3400	B-15E20	392 / 500	0.035 - 0.067	1	SCO	YES	ASV
Metals									
Aluminum	13200	13200	VP-09	1 / 1	NA - NA	77000	RSL	no	BSV
Arsenic	1.5	97.5	VP-09	3 / 3	NA - NA	16	SCO	YES	ASV
Barium	5.6	152	VP-09	3 / 3	NA - NA	400	SCO	no	BSV
Cadmium	0.01	267	VP-09	5 / 5	NA - NA	4	SCO	YES	ASV
Chromium - soluble	1.2	26300	VP-09	48 / 48	NA - NA	180	SCO	YES	ASV
Cobalt	6.2	6.2	VP-09	1 / 1	NA - NA	10000	SCO	no	BSV
Copper	62	62	VP-09	1 / 1	NA - NA	270	SCO	no	BSV
Iron	5720	5720	VP-09	1 / 1	NA - NA	10000	SCO	no	BSV
Lead	0.96	285	VP-09	3 / 3	NA - NA	400	SCO	no	BSV
Manganese	119	119	VP-09	1 / 1	NA - NA	2000	SCO	no	BSV
Mercury	0.19	0.19	VP-09	1 / 1	NA - NA	0.81	SCO	no	BSV
Nickel	13	13	VP-09	1 / 1	NA - NA	310	SCO	no	BSV
Silver	0.1	0.1	B-16810	1 / 1	NA - NA	180	SCO	no	BSV
Vanadium	16.8	16.8	VP-09	1 / 1	NA - NA	390	RSL	no	BSV
Zinc	4020	4020	VP-09	1 / 1	NA - NA	10000	SCO	no	BSV
Miscellaneous									
Carbon	28000	28000	VP-09	1 / 1	NA - NA	100	SCO	YES	ASV
Chloride	9.7	9.7	VP-09	1 / 1	NA - NA	100	SCO	no	BSV
Cyanide	76.3	76.3	VP-09	1 / 1	NA - NA	27	SCO	YES	ASV
Sulfate	145	145	VP-09	1 / 1	NA - NA	10000	SCO	no	BSV

Notes:
(a) Maximum detected concentrations were compared to screening levels to identify COPCs.
ASV – Above screening value
BSV – Below screening value
COPC – Chemical of potential concern
mg/kg – Milligrams per kilogram
NA – Not available
RSL – USEPA regional screening level for residential soil
SCO – NYSDEC restricted residential soil cleanup objective
SQL – Sample quantitation limit

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Table 3-1. Exposure Point Concentration Summary – Bethpage Park Soil, Utility Worker
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Soil, 2-6 feet (a)
Exposure Point: Bethpage Park

Chemicals of Potential Concern	Mean (b) (mg/kg)	Data Distribution	95% UCL (mg/kg)	95% UCL Method	Maximum Detected Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	EPC Statistic (c)
Volatile Organic Compounds							
1,1,2-Trichloroethane	1.2	NP	0.48	95 KM t	4	0.48	UCL
cis-1,2-dichloroethene	61	NP	139	97 KM	1300	139	UCL
Ethylbenzene	29	NP	34	97 KM	220	34	UCL
Toluene	167	NP	691	97 KM	8200	691	UCL
Trichloroethylene	139	NP	667.2	97 KM	8200	667	UCL
Xylene (total)	50	NP	64	97 KM	120	64	UCL
Semivolatile Organic Compounds							
bis(2-chloroethyl)ether	0.27	NP	0.25	95 KM t	1.1	0.25	UCL
bis(2-ethylhexyl)phthalate	116	NP	549	99 KM	1500	549	UCL
Polycyclic Aromatic Hydrocarbons							
Benzo(a)anthracene	1.2	NP	1.6	95 KM (BCA)	17	1.6	UCL
Benzo(a)pyrene	1.1	NP	1.4	95 KM (BCA)	16	1.4	UCL
Benzo(b)fluoranthene	1.4	NP	1.8	95 KM (BCA)	21	1.8	UCL
Benzo(k)fluoranthene	1.8	NP	2.4	95 KM	6.5	2.4	UCL
Chrysene	2.2	NP	3.2	95 KM	17	3.2	UCL
Dibenzo(a,h)anthracene	0.24	NP	0.25	95 KM (BCA)	1.7	0.25	UCL
Indeno(1,2,3-cd)pyrene	0.49	NP	0.56	95 KM (BCA)	4.4	0.56	UCL
Polychlorinated Biphenyls (PCBs)							
Total PCBs	13	NP	31	97 KM	880	31	UCL
Metals							
Aluminum	14938	NP	36697	95 KM	110000	36697	UCL
Antimony	183	NP	709	99 KM	1180	709	UCL
Arsenic	17	NP	37	95 KM	1110	37	UCL
Barium	244	NP	418.7	Cnp97	5470	419	UCL
Cadmium	7.1	NP	13.9	99 KM	480	13.9	UCL
Chromium - Soluble	1202	NP	4153	Cnp97	124000	4153	UCL
Chromium (Hexavalent Compounds)	114	NP	72	95 KM t	560	72	UCL
Copper	237	LN	499	Cln95	4100	499	UCL
Iron	10845	G	13050	Gapx	42700	13050	UCL
Lead	223	NP	370	Cnp99	2000	370	UCL
Mercury	0.62	NP	0.9	97 KM	19	0.9	UCL
Thallium	4.4	NP	3.3	95 KM t	17	3.3	UCL
Zinc	3684	LN	21395	Cln97	29200	21395	UCL

Notes:
(a) Also includes select samples from deeper utility easements up to 10 feet in depth (samples G-5, P-3 through P-16, B-28, B-60, TP-1, TP-2, GP-P5A and GP-P5B).
(b) The mean is calculated based on the distribution.
(c) The EPC is the lesser of the 95% UCL and the maximum detected concentration.
EPC – Exposure point concentration
LN – Indicates that data were lognormally distributed
G – Indicates that data were gamma distributed
NP – Indicates non-parametric data (data follows no distribution pattern)
mg/kg – Milligrams per kilogram
MVUE – Minimum variance unbiased estimate
UCL – The 95 percent one-tailed upper confidence limit (UCL) on the mean
95 KM t – 95% Kaplan-Meier (Student's t) UCL
95 KM – 95% Kaplan-Meier (Chebyshev) UCL
95 KM (BCA) – 95% Kaplan-Meier (bias-corrected accelerated bootstrap method) UCL
97 KM – 97.5% Kaplan-Meier (Chebyshev) UCL
99 KM – 99% Kaplan-Meier (Chebyshev) UCL
Gapx – Approximate Gamma 95% UCL
Cln95 – 95% Chebyshev (MVUE) UCL
Cln97 – 97.5% Chebyshev (MVUE) UCL
Cnp97 – 97.5% Chebyshev (mean, standard deviation) UCL
Cnp99 – 99% Chebyshev (mean, standard deviation) UCL

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Table 3-2. Exposure Point Concentration Summary – Bethpage Park Soil, Construction Worker
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Soil, 2-6 feet
Exposure Point: Bethpage Park

Chemicals of Potential Concern	Mean (b) (mg/kg)	Data Distribution	95% UCL (mg/kg)	95% UCL Method	Maximum Detected Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	EPC Statistic (c)
Volatile Organic Compounds							
1,1,2-Trichloroethane	1.2	NP	0.50	95 KM t	4	0.50	UCL
cis-1,2-dichloroethene	63	NP	143	97.5 KM	1300	143	UCL
Ethylbenzene	31	NP	34	97.5 KM	220	34	UCL
Toluene	169	NP	713	97.5 KM	8200	713	UCL
Trichloroethylene	141	NP	690.2	97.5 KM	8200	690	UCL
Xylene (total)	51	NP	64	97.5 KM	120	64	UCL
Semivolatile Organic Compounds							
bis(2-chloroethyl)ether	0.27	NP	0.25	95 KM Bootstrap	1.1	0.25	UCL
bis(2-ethylhexyl)phthalate	83	NP	443	99 KM	1200	443	UCL
Polycyclic Aromatic Hydrocarbons							
Benzo(a)anthracene	1.2	NP	1.7	95 KM (BCA)	17	1.7	UCL
Benzo(a)pyrene	1.1	NP	1.4	95 KM (BCA)	16	1.4	UCL
Benzo(b)fluoranthene	1.4	NP	1.9	95 KM (BCA)	21	1.9	UCL
Benzo(k)fluoranthene	1.8	NP	2.6	95 KM	6.5	2.6	UCL
Chrysene	2.3	NP	3.4	95 KM	17	3.4	UCL
Dibenzo(a,h)anthracene	0.24	NP	0.26	95 KM (BCA)	1.7	0.26	UCL
Indeno(1,2,3-cd)pyrene	0.49	NP	0.57	95 KM (BCA)	4.4	0.57	UCL
Polychlorinated Biphenyls (PCBs)							
Total PCBs	14	NP	32	97.5 KM	880	32	UCL
Metals							
Aluminum (a)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Antimony	163	NP	688	99 KM	1180	688	UCL
Arsenic	18	NP	39	95 KM	1110	39	UCL
Barium	255	NP	438.5	Cnp97	5470	439	UCL
Cadmium	5.7	NP	8.1	95 KM	96	8.1	UCL
Chromium - Soluble	1208	NP	4297	Cnp97	124000	4297	UCL
Chromium (Hexavalent Compounds)	114	NP	73	95 KM t	560	73	UCL
Copper	94	G	143	Gapx	396	143	UCL
Iron	10321	G	12365	Gapx	42700	12365	UCL
Lead	231	NP	378	Cnp99	2000	378	UCL
Mercury	0.61	NP	0.9	95 KM	19	0.9	UCL
Thallium	4.4	NP	3.4	95 KM t	17	3.4	UCL
Zinc	3594	ln	18126	Cln97	29200	18126	UCL

Notes:
[1] Aluminum was not detected above its associated screening level in the 2-6 foot soils. The maximum detected concentration was detected at 10 feet bgs in sample TP-01. Therefore, aluminum is not retained as a COPC for the construction worker.
(a) The mean is calculated based on the distribution.
(b) The EPC is the lesser of the 95% UCL and the maximum detected concentration.
COPC – Chemical of potential concern
EPC – Exposure point concentration
ln – Indicates that data were lognormally distributed
G – Indicates that data were gamma distributed
NP – Indicates non-parametric data (data follows no distribution pattern)
mg/kg – Milligrams per kilogram
MVUE – Minimum variance unbiased estimate
N/A – Not applicable
UCL – The 95 percent one-tailed upper confidence limit (UCL) on the mean
95 KM t – 95% Kaplan-Meier (Student's t) UCL
95 KM – 95% KM (Chebyshev) UCL
95 KM (BCA) – 95% Kaplan-Meier (bias-corrected accelerated bootstrap method) UCL
95 KM Bootstrap – 95% Kaplan-Meier Bootstrap
97.5 KM – 97.5% Kaplan-Meier (Chebyshev) UCL
99 KM – 99% Kaplan-Meier (Chebyshev) UCL
Gapx – Approximate Gamma 95% UCL
Cln97 – 97.5% Chebyshev (MVUE) UCL
Cnp97 – 97.5% Chebyshev (mean, standard deviation) UCL
Cnp99 – 99% Chebyshev (mean, standard deviation) UCL

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Table 3-3. Exposure Point Concentration Summary – Access Road Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Soil, 0-10 feet
Exposure Point: Access Road

Chemicals of Potential Concern	Mean (a) (mg/kg)	Data Distribution	95% UCL (mg/kg)	95% UCL Method	Maximum Detected Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	EPC Statistic (b)
Polychlorinated Biphenyls (PCBs)							
Total PCBs	16.26	NP	55.733	97.5 KM	3400	56	UCL
Metals							
Arsenic (c)	N/A	N/A	N/A	N/A	97.5	98	MAX
Cadmium (d)	133.85	N/A	N/A	N/A	267	267	MAX
Chromium	661	NP	7038	99 Chebyshev	26300	7038	UCL
Miscellaneous							
Cyanide (c)	N/A	N/A	N/A	N/A	76.3	76	MAX
Carbon (c)	N/A	N/A	N/A	N/A	28000	28000	MAX

Notes:
(a) The mean is calculated based on the distribution.
(b) The EPC is the lesser of the 95% UCL and the maximum detected concentration.
(c) Only one sample was analyzed for arsenic, carbon, and cyanide.
(d) Only two samples were analyzed for cadmium.
EPC – Exposure point concentration
N/A – Not applicable
NP – Indicates non-parametric data (data follows no distribution pattern)
mg/kg – Milligrams per kilogram
MAX – Maximum detected concentration
UCL – The 95 percent one-tailed upper confidence limit (UCL) on the mean
97.5 KM – 97.5% Kaplan-Meier (Chebyshev) UCL
99 Chebyshev – 99% Chebyshev (Mean, Sd) UCL

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Table 4-1. Summary of Exposure Factors for Industrial/Commercial Receptors
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation
Ingestion	Utility Worker	Adult	Bethpage Park	CS	Chemical Concentration in Soil	See Table 3-1	mg/kg	See Table 3-1	Intake (mg/kg-d) =
				IR	Ingestion Rate	100	mg/day	MADEP 2002; USEPA 2002a	CS x IR x EF x ED x CF x FI
				EF	Exposure Frequency	3	days/year	Professional judgment	BW x AT
				ED	Exposure Duration	25	years	USEPA 2004	
				FI	Fraction Ingested from Site	1	unitless	USEPA 1989a	
				CF	Conversion Factor	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA 1989a	
				ATc	Averaging Time - cancer	25,550	days	USEPA 1989a	
				ATnc	Averaging Time - noncancer	9,125	days	USEPA 1989a	
Dermal	Utility Worker	Adult	Bethpage Park	CS	Chemical Concentration in Soil	See Table 3-1	mg/kg	See Table 3-1	Intake (mg/kg-d) =
				SA	Surface Area	3,300	cm^2	USEPA 2004	CS x SA x AF x ABS x EF x ED x CF
				AF	Adherence Factor	0.20	$mg/cm^2/day$	USEPA 2004	BW x AT
				ABS	Dermal absorption fraction	chemical specific	unitless	USEPA 2004	
				EF	Exposure Frequency	3	days/year	Professional judgment	
				ED	Exposure Duration	25	years	USEPA 2004	
				CF	Conversion Factor	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA 1989a	
				ATc	Averaging Time - cancer	25,550	days	USEPA 1989a	
				ATnc	Averaging Time - noncancer	9,125	days	USEPA 1989a	
Inhalation	Utility Worker	Adult	Bethpage Park	CS	Chemical Concentration in Soil	See Table 3-1	mg/kg	See Table 3-1	Intake (mg/m^3) =
				ET	Exposure Time	8	hours/day	Professional judgment	CS x ET x EF x ED x 1/PEF or 1/VF
				EF	Exposure Frequency	3	days/year	Professional judgment	AT x CF
				ED	Exposure Duration	25	years	USEPA 1989a	
				ATc	Averaging Time - cancer	25,550	days	USEPA 1989a	
				ATnc	Averaging Time - noncancer	9,125	days	USEPA 1989a	
				CF	Conversion Factor	24	hours/day		
				PEF	Particulate Emission Factor	1.4E+09	m^3/kg	USEPA 2002a	
				VF	Volatilization Factor	chemical specific	m^3/kg		
Ingestion	Utility Worker	Adult	Plant 24 Access Road	CS	Chemical Concentration in Soil	See Table 3-2	mg/kg	See Table 3-2	Intake (mg/kg-d) =
				IR	Ingestion Rate	100	mg/day	MADEP 2002; USEPA 2002a	CS x IR x EF x ED x CF x FI
				EF	Exposure Frequency	3	days/year	Professional judgment	BW x AT
				ED	Exposure Duration	25	years	USEPA 2004	
				FI	Fraction Ingested from Site	1	unitless	USEPA 1989a	
				CF	Conversion Factor	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA 1989a	
				ATc	Averaging Time - cancer	25,550	days	USEPA 1989a	
				ATnc	Averaging Time - noncancer	9,125	days	USEPA 1989a	

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Table 4-1. Summary of Exposure Factors for Industrial/Commercial Receptors
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation
Dermal	Utility Worker	Adult	Plant 24 Access Road	CS	Chemical Concentration in Soil	See Table 3-2	mg/kg	See Table 3-2	Intake (mg/kg-d) =
				SA	Surface Area	3,300	cm^2	USEPA 2004	$\frac{CS \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$
				AF	Adherence Factor	0.20	$mg/cm^2/day$	USEPA 2004	
				ABS	Dermal absorption fraction	chemical specific	unitless	USEPA 2004	
				EF	Exposure Frequency	3	days/year	Professional judgment	
				ED	Exposure Duration	25	years	USEPA 2004	
				CF	Conversion Factor	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA 1989a	
				ATc	Averaging Time - cancer	25,550	days	USEPA 1989a	
				ATnc	Averaging Time - noncancer	9,125	days	USEPA 1989a	
Inhalation	Utility Worker	Adult	Plant 24 Access Road	CS	Chemical Concentration in Soil	See Table 3-2	mg/kg	See Table 3-2	Intake (mg/m^3) =
				ET	Exposure Time	8	hours/day	Professional judgment	$\frac{CS \times ET \times EF \times ED \times 1/PEF \text{ or } 1/VF}{AT \times CF}$
				EF	Exposure Frequency	3	days/year	Professional judgment	
				ED	Exposure Duration	25	years	USEPA 1989a	
				ATc	Averaging Time - cancer	25,550	days	USEPA 1989a	
				ATnc	Averaging Time - noncancer	9,125	days	USEPA 1989a	
				CF	Conversion Factor	24	hours/day		
				PEF	Particulate Emission Factor	1.4E+09	m^3/kg	USEPA 2002a	
				VF	Volatilization Factor	chemical specific	m^3/kg		
Ingestion	Construction Worker	Adult	Bethpage Park	CS	Chemical Concentration in Soil	See Table 3-1	mg/kg	See Table 3-1	Intake (mg/kg-d) =
				IR	Ingestion Rate	100	mg/day	MADEP 2002; USEPA 2002a	$\frac{CS \times IR \times EF \times ED \times CF \times FI}{BW \times AT}$
				EF	Exposure Frequency	60	days/year	Professional judgment	
				ED	Exposure Duration	1	years	USEPA 2004	
				FI	Fraction Ingested from Site	1	unitless	USEPA 1989a	
				CF	Conversion Factor	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA 1989a	
				ATc	Averaging Time - cancer	25,550	days	USEPA 1989a	
				ATnc	Averaging Time - noncancer	365	days	USEPA 1989a	
Dermal	Construction Worker	Adult	Bethpage Park	CS	Chemical Concentration in Soil	See Table 3-1	mg/kg	See Table 3-1	Intake (mg/kg-d) =
				SA	Surface Area	3,300	cm^2	USEPA 2004	$\frac{CS \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$
				AF	Adherence Factor	0.10	$mg/cm^2/day$	USEPA 2004	
				ABS	Dermal absorption fraction	chemical specific	unitless	USEPA 2004	
				EF	Exposure Frequency	60	days/year	Professional judgment	
				ED	Exposure Duration	1	years	USEPA 2004	
				CF	Conversion Factor	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA 1989a	
				ATc	Averaging Time - cancer	25,550	days	USEPA 1989a	
				ATnc	Averaging Time - noncancer	365	days	USEPA 1989a	

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Table 4-1. Summary of Exposure Factors for Industrial/Commercial Receptors
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation
Inhalation	Construction Worker	Adult	Bethpage Park	CS	Chemical Concentration in Soil	See Table 3-1	mg/kg	See Table 3-1	Intake (mg/m^3) =
				ET	Exposure Time	8	hours/day	Professional judgment	CS x ET x EF x ED x 1/PEF or 1/VF
				EF	Exposure Frequency	60	days/year	Professional judgment	AT x CF
				ED	Exposure Duration	1	years	USEPA 1989a	
				ATc	Averaging Time - cancer	25,550	days	USEPA 1989a	
				ATnc	Averaging Time - noncancer	365	days	USEPA 1989a	
				CF	Conversion Factor	24	hours/day		
				PEF	Particulate Emission Factor	1.4E+09	m^3/kg	USEPA 2002a	
				VF	Volatilization Factor	chemical specific	m^3/kg		

Notes:

Surface/subsurface soil for Bethpage Park is defined as 0-6 feet below ground surface, with the exception of select utility locations within the park that extend down to 10 feet.
Surface/subsurface soil for the Access Road is defined as 0-10 feet below ground surface.
cm^2 – Square centimeter
kg – Kilogram
kg/mg – Kilograms per milligram
m^3/kg – Cubic meters per kilogram
$mg/cm^2/day$ – Milligrams per square centimeter per day
mg/day – Milligrams per day
mg/kg – Milligrams per kilogram

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Table 4-2. Calculation of Volatilization and Particulate Emission Factors for Soil Exposure
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Constituent	Solubility in Water (mg/L) (S)	Saturation Limit in Soil (mg/kg) (Csat)	Diffusivity in Air (cm^2/sec) (D_{air})	Diffusivity in Water (cm^2/sec) (D_{wat})	Henry's Law Constant (unitless) (H_o)	Partition Coefficient (L/kg) (Koc)	Apparent Diffusivity (cm^2/sec) (D_A)	Volatilization Factor (a) (m^3/kg) (VF)	Combined VF and PEF (m^3/kg) (VF/PEF)
Volatile Organic Compounds (VOCs)									
1,1,2-Trichloroethane	4,400	1,800	7.80E-02	8.80E-06	3.70E-02	5.01E+01	3.77E-04	6.39E+03	6.39E+03
cis-1,2-dichloroethene	6,410	2,500	7.36E-02	1.13E-05	1.67E-01	4.38E+01	1.66E-03	3.05E+03	3.05E+03
Ethylbenzene	169	550	7.50E-02	7.80E-06	3.22E-01	5.18E+02	3.94E-04	6.25E+03	6.25E+03
Toluene	526	930	8.70E-02	8.60E-06	2.71E-01	2.68E+02	7.14E-04	4.64E+03	4.64E+03
Trichloroethylene	1,280	750	7.90E-02	9.10E-06	4.03E-01	6.77E+01	2.91E-03	2.30E+03	2.30E+03
Xylene (total)	106	300	7.14E-02	9.34E-06	2.71E-01	4.43E+02	3.67E-04	6.48E+03	6.48E+03

Particulate Emission Factor:			
PEF =	1.40E+09	m^3/kg	Particulate emission factor (m^3/kg)

Model Parameters			
Foc =	0.006	unitless	Fraction organic carbon (USEPA 2002a, default)
r_b =	1.5	g/cm^3	Soil dry bulk density (USEPA 2002a, default)
q_T =	0.434	unitless	Total soil porosity (USEPA 2002a, default)
q_{as} =	0.284	unitless	Air-filled soil porosity (USEPA 2002a, default)
q_{ws} =	0.15	unitless	Water-filled soil porosity (USEPA 2002a, default)
Q/C =	68.18	(g/m^2/sec)/(kg/m^3)	Volatilization flux per unit concentration (USEPA 2002a, default)
RPF =	0.036	g/m^2/hour	Respirable particle fraction (USEPA 2002a).
T =	9.5E+08	sec	Exposure interval (USEPA 2002a)

Notes:
(a) See equation 4-8 in USEPA 2002a.
cm – Centimeter
g – Gram
kg – Kilogram
L – Liter
m – Meter
mL – Milliliter
sec – Second

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Table 4-3. Summary of Parameter Values Used in the Adult Lead Model (ALM) for Evaluation of Non-Residential Lead Risks Associated with Exposure to Soils at Bethpage Park Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Exposure Variable	Description	Units	Construction Worker
PbS	Average lead concentration in soil from Bethpage Park	ppm	219
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9 (a)
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4 (a)
GSD_i	Geometric standard deviation PbB	--	2.0 (b)
PbB_0	Baseline PbB	µg/dL	1.9 (b)
$IR_{S,D}$	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.10 (c)
$AF_{S,D}$	Absorption fraction, Pb in soil and dust	--	0.12 (a)
$EF_{S,D}$	Exposure frequency, Pb pathway	days/year	60 (d)
$AT_{S,D}$	Averaging time, Pb pathway	days/year	84 (e)

Notes:

Lead exposures were evaluated based on parameters for non-Hispanic white ethnicity in the Northeast Region because this is the predominant race in Bethpage, New York (94% of total population). Statistics obtained from the 2002 U.S. Census Bureau. Available at www.census.gov.

Consistent with the ALM guidance (USEPA 2003a; 2007b), the arithmetic mean of lead concentrations was used in the ALM.

Consistent with USEPA (2003a; 2004; 2007b) guidance, dermal exposures to lead in aqueous and non-aqueous media were not quantitatively evaluated with the ALM due to the uncertainty in assigning a dermal absorption fraction that would apply to the numerous inorganic forms of lead that are typically found in environmental settings.

(a) Default value (USEPA 2003a).

(b) Default value for non-Hispanic white populations from the Northeast region (USEPA 2002b).

(c) Default central tendancy exposure (CTE) value for soil ingestion for contact-intensive adult scenarios (USEPA 2007b).

(d) Exposure frequency represents 5 days per week for 12 weeks (5 days/wk x 12 weeks = 60 days/year).

(e) Averaging time is based on exposure frequency (EF) to avoid diluting exposures over the entire year (7 days per week x 12 weeks/year = 84 days/year).

µg/dL – Micrograms per deciliter

g/day – Grams per day

ppm – Parts per million

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Table 5-1. Non-Cancer Toxicity Data (Oral/Dermal)
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Chemical of Potential Concern	Chronic/ Subchronic (a)	Oral RfD		Oral Absorption Efficiency for Dermal (b)	Absorbed RfD for Dermal		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
1,1,2-Trichloroethane	Chronic	4.0E-03	mg/kg/day	>0.50	4.0E-03	mg/kg/day	liver	1000	IRIS	02/01/1995
Aluminum	Chronic	1.0E+00	mg/kg/day	>0.50	1.0E+00	mg/kg/day	NI	NI	PPRTV	09/2008
Antimony	Chronic	4.0E-04	mg/kg/day	0.15	6.0E-05	mg/kg/day	blood	1000	IRIS	02/01/1991
Arsenic	Chronic	3.0E-04	mg/kg/day	0.95	3.0E-04	mg/kg/day	skin	3	IRIS	02/01/1993
Barium	Chronic	2.0E-01	mg/kg/day	0.07	1.4E-02	mg/kg/day	kidney	300	IRIS	07/11/2005
Benzo(a)anthracene	Chronic	3.0E-02	mg/kg/day	0.89	3.0E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Benzo(a)pyrene	Chronic	3.0E-02	mg/kg/day	0.89	3.0E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Benzo(b)fluoranthene	Chronic	3.0E-02	mg/kg/day	0.89	3.0E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Benzo(k)fluoranthene	Chronic	3.0E-02	mg/kg/day	0.89	3.0E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Bis(2-chloroethyl)ether	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	Chronic	2.0E-02	mg/kg/day	>0.50	2.0E-02	mg/kg/day	liver	1000	IRIS	05/01/1991
Cadmium	Chronic	1.0E-03	mg/kg/day	0.025	2.5E-05	mg/kg/day	kidney	10	IRIS	02/01/1994
Carbon	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium III	Chronic	1.5E+00	mg/kg/day	0.013	2.0E-02	mg/kg/day	NI	1000	IRIS	09/03/1998
Chromium VI (particulates)	Chronic	3.0E-03	mg/kg/day	0.025	7.5E-05	mg/kg/day	NI	900	IRIS	09/03/1998
Chromium VI (aerosols)	Chronic	3.0E-03	mg/kg/day	>0.50	3.0E-03	mg/kg/day	NI	900	IRIS	09/03/1998
Chrysene	Chronic	3.0E-02	mg/kg/day	0.89	3.0E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Cis-1,2-dichloroethylene	Chronic	1.0E-02	mg/kg/day	>0.50	1.0E-02	mg/kg/day	NI	NI	PPRTV	09/2008
Cis-1,2-dichloroethylene	Subchronic	1.0E-01	mg/kg/day	>0.50	1.0E-01	mg/kg/day	blood	300	HEAST	07/1997
Cobalt	Subchronic	1.0E-02	mg/kg/day	>0.50	1.0E-02	mg/kg/day	liver	100	ATSDR	10/2004
Copper	Chronic	1.4E-01	mg/kg/day	>0.50	1.4E-01	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Cyanide	Chronic	2.0E-02	mg/kg/day	>0.50	2.0E-02	mg/kg/day	NI	500	IRIS	02/01/1993
Dibenz(a,h)anthracene	Chronic	3.0E-02	mg/kg/day	0.89	3.0E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Ethylbenzene	Chronic	1.0E-01	mg/kg/day	>0.50	1.0E-01	mg/kg/day	liver, kidney	1000	IRIS	06/01/1991
Indeno(123-cd)pyrene	Chronic	3.0E-02	mg/kg/day	0.89	3.0E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Iron	Chronic	7.0E-01	mg/kg/day	>0.50	7.0E-01	mg/kg/day	NI	NI	PPRTV	09/2008
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury (mercuric sulfide)	Subchronic	3.0E-04	mg/kg/day	0.07	2.1E-05	mg/kg/day	immune system	1000	IRIS	05/01/1995
PCBs (Aroclor 1254)	Chronic	2.0E-05	mg/kg/day	0.96	2.0E-05	mg/kg/day	immune system	300	IRIS	11/01/1996
Thallium (sulfate)	Chronic	8.0E-05	mg/kg/day	1	8.0E-05	mg/kg/day	NI	3000	IRIS	09/01/1990
Toluene	Chronic	8.0E-02	mg/kg/day	>0.50	8.0E-02	mg/kg/day	kidney	3000	IRIS	09/23/2005
Trichloroethene	Chronic	1.5E-03	mg/kg/day	>0.50	1.5E-03	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Vinyl chloride	Chronic	3.0E-03	mg/kg/day	>0.50	3.0E-03	mg/kg/day	liver	30	IRIS	08/07/2000
Xylenes	Chronic	2.0E-01	mg/kg/day	>0.50	2.0E-01	mg/kg/day	body weight; mortality	1000	IRIS	02/21/2003
Zinc	Chronic	3.0E-01	mg/kg/day	>0.50	3.0E-01	mg/kg/day	blood	3	IRIS	08/03/2005

Notes:
(a) The same toxicity value was used for both chronic and subchronic exposures when only one toxicity value was available.
(b) USEPA 2004. RAGS Part E. Dermal RfD adjusted when oral absorption <0.50.
mg/kg/day – milligrams per kilogram per day
NA – Not available
NI – No Information
RfD – Reference dose
ATSDR – Agency for Toxic Substances and Disease Registry, Minimal Risk Levels (MRLs)
NYSDEC/NYSDOH – New York State Department of Environmental Conservation/New York State Department of Health. Toxicity values taken from NYS Brownfield Cleanup Program, Development of Soil Cleanup Objectives, Technical Support Document, September 2006
PPRTV– Provisional Peer-Reviewed Toxicity Value
IRIS – Integrated Risk Information System
HEAST – Health Effects Assessment Summary Tables

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Table 5-2. Non-Cancer Toxicity Data (Inhalation)
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Chemical of Potential Concern	Chronic/ Subchronic (a)	Inhalation RfC		Extrapolated RfDi		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC/RfDi	
		Value	Units	Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	Chronic	5.0E-03	mg/m^3	1.4E-03	mg/kg/day	NI	NI	PPRTV	09/2008
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	Chronic	3.0E-05	mg/m^3	8.6E-06	mg/kg/day	development, cardiovascular system, CNS	NI	CalEPA (b)	10/8/2007
Arsenic	Subchronic	1.9E-04	mg/m^3	5.4E-05	mg/kg/day	reproduction, development	NI	CalEPA	10/8/2007
Barium	Chronic	5.0E-04	mg/m^3	1.4E-04	mg/kg/day	fetus	1000	HEAST (b)	07/01/1997
Benzo(a)anthracene	Chronic	1.0E-01	mg/m^3	2.9E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Benzo(a)pyrene	Chronic	1.0E-01	mg/m^3	2.9E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Benzo(b)fluoranthene	Chronic	1.0E-01	mg/m^3	2.9E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Benzo(k)fluoranthene	Chronic	1.0E-01	mg/m^3	2.9E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Bis(2-chloroethyl)ether	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	Chronic	2.0E-05	mg/m^3	5.7E-06	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Carbon	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium III	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium VI (particulates)	Subchronic	1.0E-04	mg/m^3	2.9E-05	mg/kg/day	lung	300	IRIS	09/03/1998
Chromium VI (aerosols)	Subchronic	8.0E-06	mg/m^3	2.3E-06	mg/kg/day	respiratory	90	IRIS	09/03/1998
Chrysene	Chronic	1.0E-01	mg/m^3	2.9E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Cis-1,2-dichloroethylene	Chronic	3.5E-02	mg/m^3	1.0E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Cobalt	Chronic	1.0E-04	mg/m^3	2.9E-05	mg/kg/day	respiratory	10	ATSDR	10/2004
Copper	Chronic	4.9E-01	mg/m^3	1.4E-01	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Cyanide	Chronic	2.5E-02	mg/m^3	7.1E-03	mg/kg/day	NI	100	NYSDEC/NYSDOH	09/2006
Dibenz(a,h)anthracene	Chronic	1.0E-01	mg/m^3	2.9E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Ethylbenzene	Chronic	1.0E+00	mg/m^3	2.9E-01	mg/kg/day	development	300	IRIS	03/01/1991
Indeno(123-cd)pyrene	Chronic	1.0E-01	mg/m^3	2.9E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury (elemental)	Chronic	3.0E-04	mg/m^3	8.6E-05	mg/kg/day	neurophysiological	30	IRIS	06/01/1995
PCBs	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium (sulfate)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	Chronic	5.0E+00	mg/m^3	1.4E+00	mg/kg/day	neurological	10	IRIS	09/23/2005
Trichloroethene	Chronic	4.0E-02	mg/m^3	1.1E-02	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006
Vinyl chloride	Chronic	1.0E-01	mg/m^3	2.9E-02	mg/kg/day	liver	30	IRIS	08/07/2000
Xylenes	Subchronic	1.0E-01	mg/m^3	2.9E-02	mg/kg/day	musculoskeletal	300	IRIS	02/21/2003
Zinc	Chronic	1.0E+00	mg/m^3	2.9E-01	mg/kg/day	NI	NI	NYSDEC/NYSDOH	09/2006

Notes:

(a) The same toxicity value was used for both chronic and subchronic exposures when only one toxicity value was available.
(b) This toxicity value was used by NYSDEC/NYSDOH to calculate soil remediation objectives.
ATSDR – Agency for Toxic Substances and Disease Registry, Minimal Risk Levels (MRLs)
IRIS – Integrated Risk Information System
CalEPA – California EPA
CNS – Central nervous system
HEAST – Health Effects Assessment Summary Tables
mg/kg/day – Milligrams per kilogram per day
mg/m^3 – Milligrams per cubic meter
NA – Not available
NI – No information
NYSDEC/NYSDOH – New York State Department of Environmental Conservation/New York State Department of Health. Toxicity values taken from NYS Brownfield Cleanup Program, Development of Soil Cleanup Objectives, Technical Support Document, September 2006
PPRTV – Provisional Peer-Reviewed Toxicity Value
RfC – Reference dose
RfDi – Reference dose, inhalation

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Table 6-1. Cancer Toxicity Data (Oral/Dermal)
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (1)	Absorbed Cancer Slope Factor for Dermal		Weight of Evidence/ Cancer Guideline Description	CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
1,1,2-Trichloroethane	5.7E-02	(mg/kg/day)-1	>0.50	5.7E-02	(mg/kg/day)-1	C	IRIS	02/01/1994
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	1.5E+00	(mg/kg/day)-1	0.95	1.5E+00	(mg/kg/day)-1	A	IRIS	04/10/1998
Barium	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	7.3E-01	(mg/kg/day)-1	0.89	7.3E-01	(mg/kg/day)-1	B2	IRIS	11/01/1994
Benzo(a)pyrene	7.3E+00	(mg/kg/day)-1	0.89	7.3E+00	(mg/kg/day)-1	B2	IRIS	11/01/1994
Benzo(b)fluoranthene	7.3E-01	(mg/kg/day)-1	0.89	7.3E-01	(mg/kg/day)-1	B2	IRIS	11/01/1994
Benzo(k)fluoranthene	7.3E-02	(mg/kg/day)-1	0.89	7.3E-02	(mg/kg/day)-1	B2	IRIS	11/01/1994
Bis(2-chloroethyl)ether	1.1E+00	(mg/kg/day)-1	>0.50	1.1E+00	(mg/kg/day)-1	B2	IRIS	02/01/1994
Bis(2-ethylhexyl)phthalate	1.4E-02	(mg/kg/day)-1	>0.50	1.4E-02	(mg/kg/day)-1	B2	IRIS	02/01/1993
Cadmium	3.8E-01	(mg/kg/day)-1	0.025	1.5E+01	(mg/kg/day)-1	NI	NYSDEC/NYSDOH	09/2006
Carbon	NA	NA	NA	NA	NA	NA	NA	NA
Chromium III	NA	NA	NA	NA	NA	NA	NA	NA
Chromium VI	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	7.3E-03	(mg/kg/day)-1	0.89	7.3E-03	(mg/kg/day)-1	B2	IRIS	03/01/1994
Cis-1,2-dichloroethylene	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	NA	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	7.3E+00	(mg/kg/day)-1	0.89	7.3E+00	(mg/kg/day)-1	B2	IRIS	11/01/1994
Ethylbenzene	3.5E-03	(mg/kg/day)-1	>0.50	3.5E-03	(mg/kg/day)-1	NI	NYSDEC/NYSDOH	09/2006
Indeno(123-cd)pyrene	7.3E-01	(mg/kg/day)-1	0.89	7.3E-01	(mg/kg/day)-1	B2	IRIS	11/01/1994
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Lead	5.7E-03	(mg/kg/day)-1	>0.50	5.7E-03	(mg/kg/day)-1	NI	NYSDEC/NYSDOH	09/2006
Mercury	NA	NA	NA	NA	NA	NA	NA	NA
PCBs (high risk)	2.0E+00	(mg/kg/day)-1	0.96	2.0E+00	(mg/kg/day)-1	B2	IRIS	06/01/1997
Thallium	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethene	5.7E-03	(mg/kg/day)-1	>0.50	5.7E-03	(mg/kg/day)-1	NI	NYSDEC/NYSDOH	09/2006
Vinyl chloride (adult)	7.2E-01	(mg/kg/day)-1	>0.50	7.2E-01	(mg/kg/day)-1	A	IRIS	08/07/2000
Vinyl chloride (child + adult)	1.4E+00	(mg/kg/day)-1	>0.50	1.4E+00	(mg/kg/day)-1	A	IRIS	08/07/2000
Xylenes	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
A – Human carcinogen, sufficient evidence in humans
B2 – Probable human carcinogen
C – Possible human carcinogen
CSF – Cancer slope factor
IRIS – Integrated Risk Information System
mg/kg/day – Milligrams per kilogram per day
NA – Not available
NI – No information
NYSDEC/NYSDOH – New York State Department of Environmental Conservation/New York State Department of Health. Toxicity values taken from New York State Brownfield Cleanup Program, Development of Soil Cleanup Objectives, Technical Support Document, September 2006.

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Table 6-2. Cancer Toxicity Data (Inhalation)
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk/Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
1,1,2-Trichloroethane	1.6E-05	$(\mu g/m^3)^{-1}$	5.6E-02	(mg/kg/day)-1	C	IRIS	02/01/1994
Aluminum	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA
Arsenic	4.3E-03	$(\mu g/m^3)^{-1}$	1.5E+01	(mg/kg/day)-1	A	IRIS	04/10/1998
Barium	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	1.1E-04	$(\mu g/m^3)^{-1}$	3.9E-01	(mg/kg/day)-1	B2	CalEPA (a)	09/2008
Benzo(a)pyrene	1.1E-03	$(\mu g/m^3)^{-1}$	3.9E+00	(mg/kg/day)-1	B2	CalEPA (a)	09/2008
Benzo(b)fluoranthene	1.1E-04	$(\mu g/m^3)^{-1}$	3.9E-01	(mg/kg/day)-1	B2	CalEPA (a)	09/2008
Benzo(k)fluoranthene	1.1E-05	$(\mu g/m^3)^{-1}$	3.9E-02	(mg/kg/day)-1	B2	NYSDEC/NYSDOH	09/2006
Bis(2-chloroethyl)ether	3.3E-04	$(\mu g/m^3)^{-1}$	1.2E+00	(mg/kg/day)-1	B2	IRIS	02/01/1994
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA
Cadmium	1.8E-03	$(\mu g/m^3)^{-1}$	6.3E+00	(mg/kg/day)-1	B1	IRIS	06/01/1992
Carbon	NA	NA	NA	NA	NA	NA	NA
Chromium III	NA	NA	NA	NA	NA	NA	NA
Chromium VI (particulates)	1.2E-02	$(\mu g/m^3)^{-1}$	4.2E+01	(mg/kg/day)-1	A	IRIS	09/03/1998
Chromium VI (aerosols)	1.2E-02	$(\mu g/m^3)^{-1}$	4.2E+01	(mg/kg/day)-1	A	IRIS	09/03/1998
Chrysene	1.1E-05	$(\mu g/m^3)^{-1}$	3.9E-02	(mg/kg/day)-1	B2	IRIS	03/01/1994
Cis-1,2-dichloroethylene	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA
Cyanide	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	1.1E-03	$(\mu g/m^3)^{-1}$	3.9E+00	(mg/kg/day)-1	B2	NYSDEC/NYSDOH	09/2006
Ethylbenzene	1.0E-06	$(\mu g/m^3)^{-1}$	3.5E-03	(mg/kg/day)-1	NI	NYSDEC/NYSDOH	09/2006
Indeno(123-cd)pyrene	1.1E-04	$(\mu g/m^3)^{-1}$	3.9E-01	(mg/kg/day)-1	B2	CalEPA (a)	09/2008
Iron	NA	NA	NA	NA	NA	NA	NA
Lead	1.2E-05	$(\mu g/m^3)^{-1}$	4.2E-02	(mg/kg/day)-1	NI	NYSDEC/NYSDOH	09/2006
Mercury	NA	NA	NA	NA	NA	NA	NA
PCBs (high risk)	5.7E-04	$(\mu g/m^3)^{-1}$	2.0E+00	(mg/kg/day)-1	B2	CalEPA	09/2008
Thallium	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA
Trichloroethene	2.0E-06	$(\mu g/m^3)^{-1}$	7.0E-03	(mg/kg/day)-1	NI	CalEPA (a)	09/2008
Vinyl chloride (adult)	4.4E-06	$(\mu g/m^3)^{-1}$	1.5E-02	(mg/kg/day)-1	A	IRIS	08/07/2000
Vinyl chloride (child + adult)	8.8E-06	$(\mu g/m^3)^{-1}$	3.1E-02	(mg/kg/day)-1	A	IRIS	08/07/2000
Xylenes	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA

Notes:

(a) This toxicity value was used by NYSDEC/NYSDOH to calculate soil remediation objectives.

A – Human carcinogen, sufficient evidence in humans.

B2 – Probable human carcinogen

C – Possible human carcinogen

CalEPA – California Environmental Protection Agency

CSF – Cancer slope factor

IRIS – Integrated Risk Information System

mg/kg/day – milligrams per kilogram per day

$\mu g/m^3$ – micrograms per cubic meter

NA – Not available

NI – No information

NYSDEC/NYSDOH – New York State Department of Environmental Conservation/New York State Department of Health. Toxicity values taken from New York State Brownfield Cleanup Program, Development of Soil Cleanup Objectives, Technical Support Document, September 2006

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Table 7-1. Calculation of Potential Risks and Hazards - Future Utility Worker Exposure to Bethpage Park Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Exposure Pathway	Chemicals of Potential Concern	EPC (mg/kg)	ABS_d	VF + PEF (m^3/kg)	Non-Cancer Intake (a)	Non-Cancer Toxicity Value (b)	Hazard Quotient (unitless)	Cancer Intake (c)	Cancer Toxicity Value (d)	Excess Cancer Risk (unitless)
Ingestion	Volatile Organic Compounds									
	1,1,2-Trichloroethane	0.48	—	—	5.7E-09	4.0E-03	1.4E-06	2.0E-09	5.7E-02	1.2E-10
	cis-1,2-dichloroethene	139	—	—	1.6E-06	1.0E-02	1.6E-04	5.8E-07	NA	—
	Ethylbenzene	34	—	—	3.9E-07	1.0E-01	3.9E-06	1.4E-07	3.5E-03	4.9E-10
	Toluene	691	—	—	8.1E-06	8.0E-02	1.0E-04	2.9E-06	NA	—
	Trichloroethylene	667	—	—	7.8E-06	1.5E-03	5.4E-03	2.8E-06	5.7E-03	1.6E-08
	Xylene (total)	64	—	—	7.5E-07	2.0E-01	3.7E-06	2.7E-07	NA	—
	Semivolatile Organic Compounds									
	bis(2-chloroethyl)ether	0.25	—	—	2.9E-09	NA	—	1.0E-09	1.1E+00	1.1E-09
	bis(2-ethylhexyl)phthalate	549	—	—	6.4E-06	2.0E-02	3.2E-04	2.3E-06	1.4E-02	3.2E-08
	Polycyclic Aromatic Hydrocarbons						—			
	Benzo(a)anthracene	1.6	—	—	1.9E-08	3.0E-02	6.2E-07	6.7E-09	7.3E-01	4.9E-09
	Benzo(a)pyrene	1.4	—	—	1.7E-08	3.0E-02	5.6E-07	6.0E-09	7.3E+00	4.4E-08
	Benzo(b)fluoranthene	1.8	—	—	2.1E-08	3.0E-02	7.0E-07	7.5E-09	7.3E-01	5.5E-09
	Benzo(k)fluoranthene	2.4	—	—	2.9E-08	3.0E-02	9.6E-07	1.0E-08	7.3E-02	7.5E-10
	Chrysene	3.2	—	—	3.8E-08	3.0E-02	1.3E-06	1.3E-08	7.3E-03	9.9E-11
	Dibenzo(a,h)anthracene	0.25	—	—	2.9E-09	3.0E-02	9.8E-08	1.0E-09	7.3E+00	7.7E-09
	Indeno(1,2,3-cd)pyrene	0.56	—	—	6.6E-09	3.0E-02	2.2E-07	2.3E-09	7.3E-01	1.7E-09
	Polychlorinated Biphenyls (PCBs)									
	Total PCBs	31	—	—	3.6E-07	2.0E-05	1.8E-02	1.3E-07	2.0E+00	2.6E-07
	Metals									
	Aluminum	36697	—	—	4.3E-04	1.0E+00	4.3E-04	1.5E-04	NA	—
	Antimony	709	—	—	8.3E-06	4.0E-04	2.1E-02	3.0E-06	NA	—
	Arsenic	37	—	—	4.3E-07	3.0E-04	1.4E-03	1.5E-07	1.5E+00	2.3E-07
	Barium	419	—	—	4.9E-06	2.0E-01	2.5E-05	1.8E-06	NA	—
	Cadmium	14	—	—	1.6E-07	1.0E-03	1.6E-04	5.8E-08	3.8E-01	2.2E-08
	Chromium - Soluble	4153	—	—	4.9E-05	1.5E+00	3.3E-05	1.7E-05	NA	—
	Chromium (Hexavalent Compounds)	72	—	—	8.4E-07	3.0E-03	2.8E-04	3.0E-07	NA	—
	Copper	499	—	—	5.9E-06	1.4E-01	4.2E-05	2.1E-06	NA	—
	Iron	13050	—	—	1.5E-04	7.0E-01	2.2E-04	5.5E-05	NA	—
	Lead	370	—	—	4.3E-06	NA	—	1.6E-06	5.7E-03	8.8E-09
	Mercury	0.86	—	—	1.0E-08	3.0E-04	3.4E-05	3.6E-09	NA	—
	Thallium	3.3	—	—	3.9E-08	8.0E-05	4.9E-04	1.4E-08	NA	—
	Zinc	21395	—	—	2.5E-04	3.0E-01	8.4E-04	9.0E-05	NA	—
	(Total)						4.9E-02			6.4E-07

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Table 7-1. Calculation of Potential Risks and Hazards - Future Utility Worker Exposure to Bethpage Park Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Exposure Pathway	Chemicals of Potential Concern	EPC (mg/kg)	ABS_d	VF + PEF (m^3/kg)	Non-Cancer Intake (a)	Non-Cancer Toxicity Value (b)	Hazard Quotient (unitless)	Cancer Intake (c)	Cancer Toxicity Value (d)	Excess Cancer Risk (unitless)
Dermal	Volatile Organic Compounds									
	1,1,2-Trichloroethane	0.48	—	—	—	4.0E-03	—	—	5.7E-02	—
	cis-1,2-dichloroethene	139	—	—	—	1.0E-02	—	—	NA	—
	Ethylbenzene	34	—	—	—	1.0E-01	—	—	3.5E-03	—
	Toluene	691	—	—	—	8.0E-02	—	—	NA	—
	Trichloroethylene	667	—	—	—	1.5E-03	—	—	5.7E-03	—
	Xylene (total)	64	—	—	—	2.0E-01	—	—	NA	—
	Semivolatile Organic Compounds									
	bis(2-chloroethyl)ether	0.25	0.1	—	1.9E-09	NA	—	6.9E-10	1.1E+00	7.6E-10
	bis(2-ethylhexyl)phthalate	549	0.1	—	4.3E-06	2.0E-02	2.1E-04	1.5E-06	1.4E-02	2.1E-08
	Polycyclic Aromatic Hydrocarbons						—			
	Benzo(a)anthracene	1.59	0.13	—	1.6E-08	3.0E-02	5.3E-07	5.7E-09	7.3E-01	4.2E-09
	Benzo(a)pyrene	1.44	0.13	—	1.5E-08	3.0E-02	4.8E-07	5.2E-09	7.3E+00	3.8E-08
	Benzo(b)fluoranthene	1.79	0.13	—	1.8E-08	3.0E-02	6.0E-07	6.4E-09	7.3E-01	4.7E-09
	Benzo(k)fluoranthene	2.45	0.13	—	2.5E-08	3.0E-02	8.2E-07	8.8E-09	7.3E-02	6.4E-10
	Chrysene	3.22	0.13	—	3.2E-08	3.0E-02	1.1E-06	1.2E-08	7.3E-03	8.5E-11
	Dibenzo(a,h)anthracene	0.25	0.13	—	2.5E-09	3.0E-02	8.4E-08	9.0E-10	7.3E+00	6.6E-09
	Indeno(1,2,3-cd)pyrene	0.56	0.13	—	5.6E-09	3.0E-02	1.9E-07	2.0E-09	7.3E-01	1.5E-09
	Polychlorinated Biphenyls						—			
	Total PCBs	31	0.14	—	3.4E-07	2.0E-05	1.7E-02	1.2E-07	2.0E+00	2.4E-07
	Metals									
	Aluminum	36697	—	—	—	1.0E+00	—	—	NA	—
	Antimony	709	—	—	—	6.0E-05	—	—	NA	—
	Arsenic	37	0.03	—	8.6E-08	3.0E-04	2.9E-04	3.1E-08	1.5E+00	4.6E-08
	Barium	419	—	—	—	1.4E-02	—	—	NA	—
	Cadmium	14	0.001	—	1.1E-09	2.5E-05	4.3E-05	3.8E-10	1.5E+01	5.8E-09
	Chromium - Soluble	4153	—	—	—	2.0E-02	—	—	NA	—
	Chromium (Hexavalent Compounds)	72	—	—	—	7.5E-05	—	—	NA	—
	Copper	499	—	—	—	1.4E-01	—	—	NA	—
	Iron	13050	—	—	—	7.0E-01	—	—	NA	—
	Lead	370	—	—	—	NA	—	—	5.7E-03	—
	Mercury	0.86	—	—	—	2.1E-05	—	—	NA	—
	Thallium	3.3	—	—	—	8.0E-05	—	—	NA	—
	Zinc	21395	—	—	—	3.0E-01	—	—	NA	—
	(Total)						1.7E-02			3.7E-07

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Table 7-1. Calculation of Potential Risks and Hazards - Future Utility Worker Exposure to Bethpage Park Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Exposure Pathway	Chemicals of Potential Concern	EPC (mg/kg)	ABS_d	VF + PEF (m^3/kg)	Non-Cancer Intake (a)	Non-Cancer Toxicity Value (b)	Hazard Quotient (unitless)	Cancer Intake (c)	Cancer Toxicity Value (d)	Excess Cancer Risk (unitless)
Inhalation	Volatile Organic Compounds									
	1,1,2-Trichloroethane	0.48	—	6.4E+03	2.1E-07	NA	—	7.4E-08	1.6E-02	1.2E-09
	cis-1,2-dichloroethene	139	—	3.0E+03	1.2E-04	3.5E-02	3.6E-03	4.5E-05	NA	—
	Ethylbenzene	34	—	6.3E+03	1.5E-05	1.0E+00	1.5E-05	5.2E-06	1.0E-03	5.2E-09
	Toluene	691	—	4.6E+03	4.1E-04	5.0E+00	8.2E-05	1.5E-04	NA	—
	Trichloroethylene	667	—	2.3E+03	7.9E-04	4.0E-02	2.0E-02	2.8E-04	2.0E-03	5.7E-07
	Xylene (total)	64	—	6.5E+03	2.7E-05	1.0E-01	2.7E-04	9.6E-06	NA	—
	Semivolatile Organic Compounds						—			
	bis(2-chloroethyl)ether	0.25	—	1.4E+09	4.9E-13	NA	—	1.7E-13	3.3E-01	5.7E-14
	bis(2-ethylhexyl)phthalate	549	—	1.4E+09	1.1E-09	NA	—	3.8E-10	NA	—
	Polycyclic Aromatic Hydrocarbons						—			
	Benzo(a)anthracene	1.59	—	1.4E+09	3.1E-12	1.0E-01	3.1E-11	1.1E-12	1.1E-01	1.2E-13
	Benzo(a)pyrene	1.44	—	1.4E+09	2.8E-12	1.0E-01	2.8E-11	1.0E-12	1.1E+00	1.1E-12
	Benzo(b)fluoranthene	1.79	—	1.4E+09	3.5E-12	1.0E-01	3.5E-11	1.2E-12	1.1E-01	1.4E-13
	Benzo(k)fluoranthene	2.45	—	1.4E+09	4.8E-12	1.0E-01	4.8E-11	1.7E-12	1.1E-02	1.9E-14
	Chrysene	3.22	—	1.4E+09	6.3E-12	1.0E-01	6.3E-11	2.2E-12	1.1E-02	2.5E-14
	Dibenzo(a,h)anthracene	0.25	—	1.4E+09	4.9E-13	1.0E-01	4.9E-12	1.7E-13	1.1E+00	1.9E-13
	Indeno(1,2,3-cd)pyrene	0.56	—	1.4E+09	1.1E-12	1.0E-01	1.1E-11	3.9E-13	1.1E-01	4.3E-14
	Polychlorinated Biphenyls						—			
	Total PCBs	31	—	1.4E+09	6.1E-11	NA	—	2.2E-11	5.7E-01	1.2E-11
	Metals						—			
	Aluminum	36697	—	1.4E+09	7.2E-08	5.0E-03	1.4E-05	2.6E-08	NA	—
	Antimony	709	—	1.4E+09	1.4E-09	NA	—	5.0E-10	NA	—
	Arsenic	37	—	1.4E+09	7.2E-11	3.0E-05	2.4E-06	2.6E-11	4.3E+00	1.1E-10
	Barium	419	—	1.4E+09	8.2E-10	5.0E-04	1.6E-06	2.9E-10	NA	—
	Cadmium	14	—	1.4E+09	2.7E-11	2.0E-05	1.4E-06	9.7E-12	1.8E+00	1.7E-11
	Chromium - Soluble	4153	—	1.4E+09	8.1E-09	NA	—	2.9E-09	NA	—
	Chromium (Hexavalent Compounds)	72	—	1.4E+09	1.4E-10	1.0E-04	1.4E-06	5.0E-11	1.2E+01	6.0E-10
	Copper	499	—	1.4E+09	9.8E-10	4.9E-01	2.0E-09	3.5E-10	NA	—
	Iron	13050	—	1.4E+09	2.6E-08	NA	—	9.1E-09	NA	—
	Lead	370	—	1.4E+09	7.2E-10	NA	—	2.6E-10	1.2E-02	3.1E-12
	Mercury	0.86	—	1.4E+09	1.7E-12	3.0E-04	5.6E-09	6.0E-13	NA	—
	Thallium	3.3	—	1.4E+09	6.5E-12	NA	—	2.3E-12	NA	—
	Zinc	21395	—	1.4E+09	4.2E-08	1.0E+00	4.2E-08	1.5E-08	NA	—
	(Total)						2.4E-02			5.7E-07
						Hazard Index	0.1		Total Risk	2E-06

Notes:

(a) Non-cancer intakes for oral and dermal pathways are in mg/kg/day. Non-cancer intakes for the inhalation pathway are in mg/m^3.

(b) Non-cancer toxicity values for oral and dermal pathways, i.e., RfD_o and RfD_d, are in mg/kg/day. Non-cancer toxicity values for the inhalation pathway, i.e., RfC, are in mg/m^3.

(c) Cancer intakes for oral and dermal pathways are in mg/kg/day. Cancer intakes for the inhalation pathway are in mg/m^3.

(d) Cancer toxicity values for oral and dermal pathways, i.e., CSFo and CSF_d, are in $(mg/kg/day)^{-1}$. Cancer toxicity values for the inhalation pathway, i.e., URF, are in $(mg/m^3)^{-1}$.

RfD – Reference dose
RfC – Reference concentration
EPC – Exposure point concentration
ABS_d – Dermal absorption factor
PEF – Particulate emission factor
VF – Volatilization factor
NA –Not available

CSF – Cancer slope factor
URF – Unit risk factor
m^3/kg – Cubic meters/kilogram
mg/kg – Milligrams/kilogram
mg/kg/day – Milligrams/kilogram/day
mg/m^3 – Milligrams per cubic meter

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Table 7-2. Calculation of Potential Risks and Hazards - Future Utility Worker Exposure to Access Road Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Exposure Pathway	Chemicals of Potential Concern	EPC (mg/kg)	ABS_d	VF + PEF (m^3/kg)	Non-Cancer Intake (a)	Non-Cancer Toxicity Value (b)	Hazard Quotient (unitless)	Cancer Intake (c)	Cancer Toxicity Value (d)	Excess Cancer Risk (unitless)
Ingestion	Polychlorinated Biphenyls									
	Total PCBs	56	—	—	6.6E-07	2.0E-05	3.3E-02	2.3E-07	2.0E+00	4.7E-07
	Arsenic	98	—	—	1.1E-06	3.0E-04	3.8E-03	4.1E-07	1.5E+00	6.1E-07
	Cadmium	267	—	—	3.1E-06	1.0E-03	3.1E-03	1.1E-06	3.8E-01	4.3E-07
	Chromium	7038	—	—	8.3E-05	1.5E+00	5.5E-05	3.0E-05	NA	—
	Cyanide	76	—	—	9.0E-07	2.0E-02	4.5E-05	3.2E-07	NA	—
	Carbon	28000	—	—	3.3E-04	NA	—	1.2E-04	NA	—
	(Total)						4.0E-02			1.5E-06
Dermal	Polychlorinated Biphenyls						—			
	Total PCBs	56	0.14	—	6.1E-07	2.0E-05	3.0E-02	2.2E-07	2.0E+00	4.3E-07
	Arsenic	98	0.03	—	2.3E-07	3.0E-04	7.6E-04	8.1E-08	1.5E+00	1.2E-07
	Cadmium	267	0.001	—	2.1E-08	2.5E-05	8.3E-04	7.4E-09	1.5E+01	1.1E-07
	Chromium	7038	NA	—	—	2.0E-02	—	—	NA	—
	Cyanide	76	NA	—	—	2.0E-02	—	—	NA	—
	Carbon	28000	NA	—	—	NA	—	—	NA	—
	(Total)						3.2E-02			6.7E-07
Inhalation	Polychlorinated Biphenyls									
	Total PCBs	56	—	1.4E+09	1.1E-10	NA	—	3.9E-11	5.7E-01	2.2E-11
	Arsenic	98	—	1.4E+09	1.9E-10	3.0E-05	6.4E-06	6.8E-11	4.3E+00	2.9E-10
	Cadmium	267	—	1.4E+09	5.2E-10	2.0E-05	2.6E-05	1.9E-10	1.8E+00	3.4E-10
	Chromium	7038	—	1.4E+09	1.4E-08	1.0E-04	1.4E-04	4.9E-09	1.2E+01	5.9E-08
	Cyanide	76	—	1.4E+09	1.5E-10	2.5E-02	6.0E-09	5.3E-11	NA	—
	Carbon	28000	—	1.4E+09	5.5E-08	NA	—	2.0E-08	NA	—
	(Total)						1.7E-04			6.0E-08
						Hazard Index	0.07		Total Risk	2E-06

Notes:

(a) Non-cancer intakes for oral and dermal pathways are in mg/kg/day. Non-cancer intakes for the inhalation pathway are in mg/m^3.

(b)] Non-cancer toxicity values for oral and dermal pathways, i.e., RfD_o and RfD_d, are in mg/kg/day. Non-cancer toxicity values for the inhalation pathway, i.e., RfC, are in mg/m^3.

(c) Cancer intakes for oral and dermal pathways are in mg/kg/day. Cancer intakes for the inhalation pathway are in mg/m^3.

(d) Cancer toxicity values for oral and dermal pathways, i.e., CSF_o and CSF_d, are in $(mg/kg/day)^{-1}$. Cancer toxicity values for the inhalation pathway, i.e., URF, are in $(mg/m^3)^{-1}$.

RfD – Reference dose
RfC – Reference concentration
EPC – Exposure point concentration
ABS_d – Dermal absorption factor
PEF – Particulate emission factor
VF – Volatilization factor
NA –Not available

CSF – Cancer slope factor
URF – Unit risk factor
m^3/kg – Cubic meters/kilogram
mg/kg – Milligrams/kilogram
mg/kg/day – Milligrams/kilogram/day
mg/m^3 – Milligrams per cubic meter

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Table 7-3. Calculation of Potential Risks and Hazards - Future Construction Worker Exposure to Bethpage Park Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Exposure Pathway	Chemicals of Potential Concern	EPC (mg/kg)	ABS_d	VF + PEF (m^3/kg)	Non-Cancer Intake (a)	Non-Cancer Toxicity Value (b)	Hazard Quotient (unitless)	Cancer Intake (c)	Cancer Toxicity Value (d)	Excess Cancer Risk (unitless)
Ingestion	Volatile Organic Compounds									
	1,1,2-Trichloroethane	0.50	—	—	1.2E-07	4.0E-03	2.9E-05	1.7E-09	5.7E-02	9.5E-11
	cis-1,2-dichloroethene	143	—	—	3.4E-05	1.0E-01	3.4E-04	4.8E-07	NA	—
	Ethylbenzene	34	—	—	8.1E-06	1.0E-01	8.1E-05	1.2E-07	3.5E-03	4.0E-10
	Toluene	713	—	—	1.7E-04	8.0E-02	2.1E-03	2.4E-06	NA	—
	Trichloroethylene	690	—	—	1.6E-04	1.5E-03	1.1E-01	2.3E-06	5.7E-03	1.3E-08
	Xylene (total)	64	—	—	1.5E-05	2.0E-01	7.5E-05	2.2E-07	NA	—
	Semivolatile Organic Compounds									
	bis(2-chloroethyl)ether	0.25	—	—	5.8E-08	NA	—	8.4E-10	1.1E+00	9.2E-10
	bis(2-ethylhexyl)phthalate	443	—	—	1.0E-04	2.0E-02	5.2E-03	1.5E-06	1.4E-02	2.1E-08
	Polycyclic Aromatic Hydrocarbons						—			
	Benzo(a)anthracene	1.7	—	—	3.9E-07	3.0E-02	1.3E-05	5.6E-09	7.3E-01	4.1E-09
	Benzo(a)pyrene	1.4	—	—	3.3E-07	3.0E-02	1.1E-05	4.7E-09	7.3E+00	3.4E-08
	Benzo(b)fluoranthene	1.9	—	—	4.4E-07	3.0E-02	1.5E-05	6.3E-09	7.3E-01	4.6E-09
	Benzo(k)fluoranthene	2.6	—	—	6.0E-07	3.0E-02	2.0E-05	8.6E-09	7.3E-02	6.3E-10
	Chrysene	3.4	—	—	7.9E-07	3.0E-02	2.6E-05	1.1E-08	7.3E-03	8.2E-11
	Dibenzo(a,h)anthracene	0.26	—	—	6.1E-08	3.0E-02	2.0E-06	8.7E-10	7.3E+00	6.3E-09
	Indeno(1,2,3-cd)pyrene	0.57	—	—	1.3E-07	3.0E-02	4.5E-06	1.9E-09	7.3E-01	1.4E-09
	Polychlorinated Biphenyls									
	Total PCBs	32	—	—	7.6E-06	2.0E-05	3.8E-01	1.1E-07	2.0E+00	2.2E-07
	Metals									
	Antimony	688	—	—	1.6E-04	4.0E-04	4.0E-01	2.3E-06	NA	—
	Arsenic	39	—	—	9.1E-06	3.0E-04	3.0E-02	1.3E-07	1.5E+00	1.9E-07
	Barium	439	—	—	1.0E-04	2.0E-01	5.1E-04	1.5E-06	NA	—
	Cadmium	8.112	—	—	1.9E-06	1.0E-03	1.9E-03	2.7E-08	3.8E-01	1.0E-08
	Chromium - Soluble	4297	—	—	1.0E-03	1.5E+00	6.7E-04	1.4E-05	NA	—
	Chromium (Hexavalent Compounds)	73	—	—	1.7E-05	3.0E-03	5.7E-03	2.4E-07	NA	—
	Copper	143	—	—	3.4E-05	1.4E-01	2.4E-04	4.8E-07	NA	—
	Iron	12365	—	—	2.9E-03	7.0E-01	4.1E-03	4.1E-05	NA	—
	Lead	378	—	—	8.9E-05	NA	—	1.3E-06	5.7E-03	7.2E-09
	Mercury	0.89	—	—	2.1E-07	3.0E-04	6.9E-04	3.0E-09	NA	—
	Thallium	3.4	—	—	8.0E-07	8.0E-05	1.0E-02	1.1E-08	NA	—
	Zinc	18126	—	—	4.3E-03	3.0E-01	1.4E-02	6.1E-05	NA	—
	(Total)						9.7E-01			5.2E-07

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Table 7-3. Calculation of Potential Risks and Hazards - Future Construction Worker Exposure to Bethpage Park Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Exposure Pathway	Chemicals of Potential Concern	EPC (mg/kg)	ABS_d	VF + PEF (m^3/kg)	Non-Cancer Intake (a)	Non-Cancer Toxicity Value (b)	Hazard Quotient (unitless)	Cancer Intake (c)	Cancer Toxicity Value (d)	Excess Cancer Risk (unitless)
Dermal	Volatile Organic Compounds									
	1,1,2-Trichloroethane	0.50	—	—	—	4.0E-03	—	—	5.7E-02	—
	cis-1,2-dichloroethene	143	—	—	—	1.0E-01	—	—	NA	—
	Ethylbenzene	34	—	—	—	1.0E-01	—	—	3.5E-03	—
	Toluene	713	—	—	—	8.0E-02	—	—	NA	—
	Trichloroethylene	690	—	—	—	1.5E-03	—	—	5.7E-03	—
	Xylene (total)	64	—	—	—	2.0E-01	—	—	NA	—
	Semivolatile Organic Compounds						—			
	bis(2-chloroethyl)ether	0.25	0.1	—	1.9E-08	NA	—	2.8E-10	1.1E+00	3.0E-10
	bis(2-ethylhexyl)phthalate	443	0.1	—	3.4E-05	2.0E-02	1.7E-03	4.9E-07	1.4E-02	6.9E-09
	Polycyclic Aromatic Hydrocarbons						—			
	Benzo(a)anthracene	1.7	0.13	—	1.7E-07	3.0E-02	5.6E-06	2.4E-09	7.3E-01	1.7E-09
	Benzo(a)pyrene	1.4	0.13	—	1.4E-07	3.0E-02	4.7E-06	2.0E-09	7.3E+00	1.5E-08
	Benzo(b)fluoranthene	1.9	0.13	—	1.9E-07	3.0E-02	6.3E-06	2.7E-09	7.3E-01	2.0E-09
	Benzo(k)fluoranthene	2.6	0.13	—	2.6E-07	3.0E-02	8.6E-06	3.7E-09	7.3E-02	2.7E-10
	Chrysene	3.4	0.13	—	3.4E-07	3.0E-02	1.1E-05	4.8E-09	7.3E-03	3.5E-11
	Dibenzo(a,h)anthracene	0.26	0.13	—	2.6E-08	3.0E-02	8.7E-07	3.7E-10	7.3E+00	2.7E-09
	Indeno(1,2,3-cd)pyrene	0.57	0.13	—	5.8E-08	3.0E-02	1.9E-06	8.2E-10	7.3E-01	6.0E-10
	Polychlorinated Biphenyls						—			
	Total PCBs	32.41	0.14	—	3.5E-06	2.0E-05	1.8E-01	5.0E-08	2.0E+00	1.0E-07
	Metals						—			
	Antimony	688	—	—	—	6.0E-05	—	—	NA	—
	Arsenic	39	0.03	—	9.0E-07	3.0E-04	3.0E-03	1.3E-08	1.5E+00	1.9E-08
	Barium	439	—	—	—	1.4E-02	—	—	NA	—
	Cadmium	8.112	0.001	—	6.3E-09	2.5E-05	2.5E-04	9.0E-11	1.5E+01	1.4E-09
	Chromium - Soluble	4297	—	—	—	2.0E-02	—	—	NA	—
	Chromium (Hexavalent Compounds)	73	—	—	—	7.5E-05	—	—	NA	—
	Copper	143	—	—	—	1.4E-01	—	—	NA	—
	Iron	12365	—	—	—	7.0E-01	—	—	NA	—
	Lead	378	—	—	—	NA	—	—	5.7E-03	—
	Mercury	0.89	—	—	—	2.1E-05	—	—	NA	—
	Thallium	3.4	—	—	—	8.0E-05	—	—	NA	—
	Zinc	18126	—	—	—	3.0E-01	—	—	NA	—
	(Total)						1.8E-01			1.5E-07

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Table 7-3. Calculation of Potential Risks and Hazards - Future Construction Worker Exposure to Bethpage Park Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Exposure Pathway	Chemicals of Potential Concern	EPC (mg/kg)	ABS_d	VF + PEF (m^3/kg)	Non-Cancer Intake (a)	Non-Cancer Toxicity Value (b)	Hazard Quotient (unitless)	Cancer Intake (c)	Cancer Toxicity Value (d)	Excess Cancer Risk (unitless)
Inhalation	Volatile Organic Compounds									
	1,1,2-Trichloroethane	0.50	—	6.4E+03	4.3E-06	NA	—	6.1E-08	1.6E-02	9.8E-10
	cis-1,2-dichloroethene	143	—	3.0E+03	2.6E-03	3.5E-02	7.4E-02	3.7E-05	NA	—
	Ethylbenzene	34	—	6.3E+03	3.0E-04	1.0E+00	3.0E-04	4.3E-06	1.0E-03	4.3E-09
	Toluene	713	—	4.6E+03	8.4E-03	5.0E+00	1.7E-03	1.2E-04	NA	—
	Trichloroethylene	690	—	2.3E+03	1.6E-02	4.0E-02	4.1E-01	2.3E-04	2.0E-03	4.7E-07
	Xylene (total)	64	—	6.5E+03	5.4E-04	1.0E-01	5.4E-03	7.8E-06	NA	—
	Semivolatile Organic Compounds						—			
	bis(2-chloroethyl)ether	0.25	—	1.4E+09	9.7E-12	NA	—	1.4E-13	3.3E-01	4.6E-14
	bis(2-ethylhexyl)phthalate	443	—	1.4E+09	1.7E-08	NA	—	2.5E-10	NA	—
	Polycyclic Aromatic Hydrocarbons						—			
	Benzo(a)anthracene	1.7	—	1.4E+09	6.5E-11	1.0E-01	6.5E-10	9.3E-13	1.1E-01	1.0E-13
	Benzo(a)pyrene	1.4	—	1.4E+09	5.5E-11	1.0E-01	5.5E-10	7.8E-13	1.1E+00	8.6E-13
	Benzo(b)fluoranthene	1.9	—	1.4E+09	7.4E-11	1.0E-01	7.4E-10	1.1E-12	1.1E-01	1.2E-13
	Benzo(k)fluoranthene	2.6	—	1.4E+09	1.0E-10	1.0E-01	1.0E-09	1.4E-12	1.1E-02	1.6E-14
	Chrysene	3.4	—	1.4E+09	1.3E-10	1.0E-01	1.3E-09	1.9E-12	1.1E-02	2.1E-14
	Dibenzo(a,h)anthracene	0.26	—	1.4E+09	1.0E-11	1.0E-01	1.0E-10	1.4E-13	1.1E+00	1.6E-13
	Indeno(1,2,3-cd)pyrene	0.57	—	1.4E+09	2.2E-11	1.0E-01	2.2E-10	3.2E-13	1.1E-01	3.5E-14
	Polychlorinated Biphenyls						—			
	Total PCBs	32	—	1.4E+09	1.3E-09	NA	—	1.8E-11	5.7E-01	1.0E-11
	Metals						—			
	Antimony	688	—	1.4E+09	2.7E-08	NA	—	3.8E-10	NA	—
	Arsenic	39	—	1.4E+09	1.5E-09	1.9E-04	8.0E-06	2.2E-11	4.3E+00	9.3E-11
	Barium	438.5	—	1.4E+09	1.7E-08	5.0E-04	3.4E-05	2.5E-10	NA	—
	Cadmium	8.112	—	1.4E+09	3.2E-10	2.0E-05	1.6E-05	4.5E-12	1.8E+00	8.2E-12
	Chromium - Soluble	4297	—	1.4E+09	1.7E-07	NA	—	2.4E-09	NA	—
	Chromium (Hexavalent Compounds)	73	—	1.4E+09	2.9E-09	1.0E-04	2.9E-05	4.1E-11	1.2E+01	4.9E-10
	Copper	143	—	1.4E+09	5.6E-09	4.9E-01	1.1E-08	8.0E-11	NA	—
	Iron	12365	—	1.4E+09	4.8E-07	NA	—	6.9E-09	NA	—
	Lead	378	—	1.4E+09	1.5E-08	NA	—	2.1E-10	1.2E-02	2.5E-12
	Mercury	0.89	—	1.4E+09	3.5E-11	3.0E-04	1.2E-07	5.0E-13	NA	—
	Thallium	3.4	—	1.4E+09	1.3E-10	NA	—	1.9E-12	NA	—
	Zinc	18126	—	1.4E+09	7.1E-07	1.0E+00	7.1E-07	1.0E-08	NA	—
	(Total)						4.9E-01			4.8E-07
						Hazard Index	2		Total Risk	1E-06

Notes:

(a) Non-cancer intakes for oral and dermal pathways are in mg/kg/day. Non-cancer intakes for the inhalation pathway are in mg/m^3.

(b) Non-cancer toxicity values for oral and dermal pathways, i.e., RfD_o and RfD_d, are in mg/kg/day. Non-cancer toxicity values for the inhalation pathway, i.e., RfC, are in mg/m^3. Subchronic toxicity values were used when available.

(c) Cancer intakes for oral and dermal pathways are in mg/kg/day. Cancer intakes for the inhalation pathway are in mg/m^3.

(d) Cancer toxicity values for oral and dermal pathways, i.e., CSF_o and CSF_d, are in $(mg/kg/day)^{-1}$. Cancer toxicity values for the inhalation pathway, i.e., URF, are in $(mg/m^3)^{-1}$.

RfD – Reference dose
RfC – Reference concentration
EPC – Exposure point concentration
ABS_d – Dermal absorption factor
PEF – Particulate emission factor
VF – Volatilization factor
NA –Not available

CSF – Cancer slope factor
URF – Unit risk factor
m^3/kg – Cubic meters/kilogram
mg/kg – Milligrams/kilogram
mg/kg/day – Milligrams/kilogram/day
mg/m^3 – Milligrams per cubic meter

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Table 7-4. Calculation of Blood Lead Concentrations (PbBs) for the Construction Worker Exposed to Soils at Bethpage Park
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Exposure Variable	Description of Exposure Variable	Units	Construction Worker
PbS	Soil lead concentration	ug/g or ppm	219
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	2.0
PbB_0	Baseline PbB	ug/dL	1.9
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/year	60
$AT_{S, D}$	Averaging time (same for soil and dust)	days/year	84
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**2.7**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	7.5
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**1.9%**

Notes:

Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).

When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

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See Table 4-3 for sources of exposure variables.

g/day – Grams per day

ug/dL – micrograms per deciliter

ug/g – micrograms per gram

ppm – parts per million

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Table 9-1. Summary of Receptor Risks and Hazards for COPCs - Future Utility Worker Exposure to Bethpage Park Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Future
Receptor Population: Utility Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Non-Carcinogenic Hazard Quotient					Carcinogenic Risk			
				Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Bethpage Park	Volatile Organic Compounds									
			1,1,2-Trichloroethane	liver	1.4E-06	—	—	1.4E-06	1.2E-10	1.2E-09	—	1.3E-09
			cis-1,2-dichloroethene	NI	1.6E-04	3.6E-03	—	3.7E-03	—	—	—	—
			Ethylbenzene	liver, kidney	3.9E-06	1.5E-05	—	1.9E-05	4.9E-10	5.2E-09	—	5.7E-09
			Toluene	kidney	1.0E-04	8.2E-05	—	1.8E-04	—	—	—	—
			Trichloroethylene	NI	5.4E-03	2.0E-02	—	2.5E-02	1.6E-08	5.7E-07	—	5.8E-07
			Xylene (total)	body weight; mortality	3.7E-06	2.7E-04	—	2.7E-04	—	—	—	—
			Semivolatile Organic Compounds									
			bis(2-chloroethyl)ether	NA	—	—	—	—	1.1E-09	5.7E-14	7.6E-10	1.9E-09
			bis(2-ethylhexyl)phthalate	liver	3.2E-04	—	2.1E-04	5.3E-04	3.2E-08	—	2.1E-08	5.3E-08
			Polycyclic Aromatic Hydrocarbons									
			Benzo(a)anthracene	NI	6.2E-07	3.1E-11	5.3E-07	1.2E-06	4.9E-09	1.2E-13	4.2E-09	9.1E-09
			Benzo(a)pyrene	NI	5.6E-07	2.8E-11	4.8E-07	1.0E-06	4.4E-08	1.1E-12	3.8E-08	8.2E-08
			Benzo(b)fluoranthene	NI	7.0E-07	3.5E-11	6.0E-07	1.3E-06	5.5E-09	1.4E-13	4.7E-09	1.0E-08
			Benzo(k)fluoranthene	NI	9.6E-07	4.8E-11	8.2E-07	1.8E-06	7.5E-10	1.9E-14	6.4E-10	1.4E-09
			Chrysene	NI	1.3E-06	6.3E-11	1.1E-06	2.3E-06	9.9E-11	2.5E-14	8.5E-11	1.8E-10
			Dibenzo(a,h)anthracene	NI	9.8E-08	4.9E-12	8.4E-08	1.8E-07	7.7E-09	1.9E-13	6.6E-09	1.4E-08
			Indeno(1,2,3-cd)pyrene	NI	2.2E-07	1.1E-11	1.9E-07	4.1E-07	1.7E-09	4.3E-14	1.5E-09	3.2E-09
			Polychlorinated Biphenyls									
			Total PCBs	immune system	1.8E-02	—	1.7E-02	3.5E-02	2.6E-07	1.2E-11	2.4E-07	5.0E-07
			Metals									
			Aluminum	NI	4.3E-04	1.4E-05	—	4.5E-04	—	—	—	—
			Antimony	blood	2.1E-02	—	—	2.1E-02	—	—	—	—
			Arsenic	skin	1.4E-03	2.4E-06	2.9E-04	1.7E-03	2.3E-07	1.1E-10	4.6E-08	2.8E-07
			Barium	kidney	2.5E-05	1.6E-06	—	2.6E-05	—	—	—	—
			Cadmium	kidney	1.6E-04	1.4E-06	4.3E-05	2.1E-04	2.2E-08	1.7E-11	5.8E-09	2.8E-08
			Chromium - Soluble	NI	3.3E-05	—	—	3.3E-05	—	—	—	—
			Chromium (Hexavalent Compounds)	NI	2.8E-04	1.4E-06	—	2.8E-04	—	6.0E-10	—	6.0E-10
			Copper	NI	4.2E-05	2.0E-09	—	4.2E-05	—	—	—	—
			Iron	NI	2.2E-04	—	—	2.2E-04	—	—	—	—

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Table 9-1. Summary of Receptor Risks and Hazards for COPCs - Future Utility Worker Exposure to Bethpage Park Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Future
Receptor Population: Utility Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Non-Carcinogenic Hazard Quotient					Carcinogenic Risk			
				Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Bethpage Park	Lead	NA	—	—	—	—	8.8E-09	3.1E-12	—	8.8E-09
			Mercury	immune system	3.4E-05	5.6E-09	—	3.4E-05	—	—	—	—
			Thallium	NI	4.9E-04	—	—	4.9E-04	—	—	—	—
			Zinc	blood	8.4E-04	4.2E-08	—	8.4E-04	—	—	—	—
			Chemical Total		5E-02	2E-02	2E-02	0.1	6E-07	6E-07	4E-07	2.E-06
		Exposure Point Total						0.1				2.E-06
	Exposure Medium Total							0.1				2.E-06
Soil Total								0.1				2.E-06
Receptor Total							Receptor HI Total	0.1			Receptor Risk Total	2.E-06

Total Liver HI Across All Media =	0.0006
Total Kidney HI Across All Media =	0.0004
Total Mortality HI Across All Media =	0.0003
Total Immune HI Across All Media =	0.04
Total Blood HI Across All Media =	0.02
Total Body Weight HI Across All Media =	0.0003
Total Skin HI Across All Media =	0.002

Notes:
NA – Not available
NI – No information

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Table 9-2. Summary of Receptor Risks and Hazards for COPCs - Future Utility Worker Exposure to Access Road Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Future
Receptor Population: Utility Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Non-Carcinogenic Hazard Quotient					Carcinogenic Risk			
				Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Access Road	Polychlorinated Biphenyls									
			Total PCBs	immune system	3.3E-02	—	3.0E-02	6.3E-02	4.7E-07	2.2E-11	4.3E-07	9.0E-07
			Arsenic	skin	3.8E-03	6.4E-06	7.6E-04	4.6E-03	6.1E-07	2.9E-10	1.2E-07	7.4E-07
			Cadmium	kidney	3.1E-03	2.6E-05	8.3E-04	4.0E-03	4.3E-07	3.4E-10	1.1E-07	5.4E-07
			Chromium	NI	5.5E-05	1.4E-04	—	1.9E-04	—	5.9E-08	—	5.9E-08
			Cyanide	NI	4.5E-05	6.0E-09	—	4.5E-05	—	—	—	—
			Carbon	NA	—	—	—	—	—	—	—	—
			Chemical Total		4.0E-02	1.7E-04	3.2E-02	7.2E-02	1.5E-06	6.0E-08	6.7E-07	2.2E-06
		Exposure Point Total						0.07				2.E-06
	Exposure Medium Total							0.07				2.E-06
Soil Total								0.07				2.E-06
Receptor Total							Receptor HI Total	0.07			Receptor Risk Total	2.E-06

Total Immune HI Across All Media =	0.06
Total Skin HI Across All Media =	0.005
Total Kidney HI Across All Media =	0.004

Notes:
NA – Not available
NI – No information

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Table 9-3. Summary of Receptor Risks and Hazards for COPCs - Future Construction Worker Exposure to Bethpage Park Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Non-Carcinogenic Hazard Quotient					Carcinogenic Risk			
				Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Bethpage Park	Volatile Organic Compounds									
			1,1,2-Trichloroethane	liver	2.9E-05	—	—	2.9E-05	9.5E-11	9.8E-10	—	1.1E-09
			cis-1,2-dichloroethene	NI	3.4E-04	7.4E-02	—	7.4E-02	—	—	—	—
			Ethylbenzene	liver, kidney	8.1E-05	3.0E-04	—	3.8E-04	4.0E-10	4.3E-09	—	4.7E-09
			Toluene	kidney	2.1E-03	1.7E-03	—	3.8E-03	—	—	—	—
			Trichloroethylene	NI	1.1E-01	4.1E-01	—	5.2E-01	1.3E-08	4.7E-07	—	4.8E-07
			Xylene (total)	body weight; mortality	7.5E-05	5.4E-03	—	5.5E-03	—	—	—	—
			Semivolatile Organic Compounds									
			bis(2-chloroethyl)ether	NA	—	—	—	—	9.2E-10	4.6E-14	3.0E-10	1.2E-09
			bis(2-ethylhexyl)phthalate	liver	5.2E-03	—	1.7E-03	6.9E-03	2.1E-08	—	6.9E-09	2.8E-08
			Polycyclic Aromatic Hydrocarbons									
			Benzo(a)anthracene	NI	1.3E-05	6.5E-10	5.6E-06	1.9E-05	4.1E-09	1.0E-13	1.7E-09	5.8E-09
			Benzo(a)pyrene	NI	1.1E-05	5.5E-10	4.7E-06	1.6E-05	3.4E-08	8.6E-13	1.5E-08	4.9E-08
			Benzo(b)fluoranthene	NI	1.5E-05	7.4E-10	6.3E-06	2.1E-05	4.6E-09	1.2E-13	2.0E-09	6.6E-09
			Benzo(k)fluoranthene	NI	2.0E-05	1.0E-09	8.6E-06	2.9E-05	6.3E-10	1.6E-14	2.7E-10	8.9E-10
			Chrysene	NI	2.6E-05	1.3E-09	1.1E-05	3.8E-05	8.2E-11	2.1E-14	3.5E-11	1.2E-10
			Dibenzo(a,h)anthracene	NI	2.0E-06	1.0E-10	8.7E-07	2.9E-06	6.3E-09	1.6E-13	2.7E-09	9.0E-09
			Indeno(1,2,3-cd)pyrene	NI	4.5E-06	2.2E-10	1.9E-06	6.4E-06	1.4E-09	3.5E-14	6.0E-10	2.0E-09
			Polychlorinated Biphenyls									
			Total PCBs	immune system	3.8E-01	—	1.8E-01	5.6E-01	2.2E-07	1.0E-11	1.0E-07	3.2E-07
			Metals									
			Antimony	blood	4.0E-01	—	—	4.0E-01	—	—	—	—
			Arsenic	skin	3.0E-02	8.0E-06	3.0E-03	3.3E-02	1.9E-07	9.3E-11	1.9E-08	2.1E-07
			Barium	kidney	5.1E-04	3.4E-05	—	5.5E-04	—	—	—	—
			Cadmium	kidney	1.9E-03	1.6E-05	2.5E-04	2.2E-03	1.0E-08	8.2E-12	1.4E-09	1.2E-08
			Chromium - Soluble	NI	6.7E-04	—	—	6.7E-04	—	—	—	—
			Chromium (Hexavalent Compounds)	NI	5.7E-03	2.9E-05	—	5.7E-03	—	4.9E-10	—	4.9E-10
			Copper	NI	2.4E-04	1.1E-08	—	2.4E-04	—	—	—	—
			Iron	NI	4.1E-03	—	—	4.1E-03	—	—	—	—

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Table 9-3. Summary of Receptor Risks and Hazards for COPCs - Future Construction Worker Exposure to Bethpage Park Surface and Subsurface Soil
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Non-Carcinogenic Hazard Quotient					Carcinogenic Risk			
				Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total	Ingestion	Inhalation	Dermal	Exposure Routes Total
			Lead	NA	—	—	—	—	7.2E-09	2.5E-12	—	7.2E-09
			Mercury	immune system	6.9E-04	1.2E-07	—	6.9E-04	—	—	—	—
			Thallium	NI	1.0E-02	—	—	1.0E-02	—	—	—	—
			Zinc	blood	1.4E-02	7.1E-07	—	1.4E-02	—	—	—	—
			Chemical Total		1E+00	5E-01	2E-01	1.6	5E-07	5E-07	2E-07	1.1E-06
		Exposure Point Total						2				1.E-06
	Exposure Medium Total							2				1.E-06
Soil Total								2				1.E-06
Receptor Total							Receptor HI Total	2			Receptor Risk Total	1.E-06

Total Liver HI Across All Media =	0.007
Total Kidney HI Across All Media =	0.007
Total Mortality HI Across All Media =	0.006
Total Immune System HI Across All Media =	0.6
Total Blood HI Across All Media =	0.4
Total Body Weight HI Across All Media =	0.006
Total Skin HI Across All Media =	0.03

Notes:
NA – Not available
NI – No information

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Table 9-4. Summary of Cancer Risks and Non-Cancer Hazards
Human Health Risk Assessment, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York

Receptor	Exposure Point	Total Cancer Risk (a)	Hazard Index
Utility Worker	Bethpage Park	2.E-06	0.1
	Access Road	2.E-06	0.07
Construction Worker	Bethpage Park	1.E-06	<1 (b)

Notes:

(a) When evaluating potential individual cancer risks, USEPA has established an acceptable risk range of 1 in 1,000,000 (1×10^{6}) to 1 in 10,000 (1×10^{-4}). All cancer risks are on the low end of USEPA's target risk management range.

(b) All organ-specific HI's were found to be less than the target HI of 1.0.

EXPLANATION:

- PROPERTY LINE OF TOWN OF OYSTER BAY BETHPAGE COMMUNITY PARK.
- PROPERTY LINE OF NORTHROP GRUMMAN CORPORATION
- FENCE
- BASIN
- BETHPAGE PARK
- ACCESS ROAD
- SYCAMORE AVENUE RESIDENCES

SITE AREA

N

CHERRY AVENUE EXTENSION

PARK MAIN ENTRANCE

FORMER NURSERY AREAS

BALL FIELDS

TENNIS COURTS

PADDLEBALL COURTS

PLAYGROUND

COVERED PICNIC AREA

BICYCLE RACKS

VALVE PITS

DRAINAGE SWALE

RECHARGE BASIN

SHUFFLE BOARD

BASKETBALL

HORSE-SHOES

McKAY FIELD

SHED

RESTROOM

FOOD PREP. SHELTERS

TRANSFORMER AREA

PICNIC SHELTER

OFFICE

ICE RINK

monument

conc.

STEWART AVE.

GATE

PARKING LOT

BASEBALL FIELD

POOL

PLAYGROUND

FORMER NGC PLANT 24

GATE

ACCESS ROAD

NINTH ST.

EIGHTH ST.

SEVENTH ST.

SIXTH ST.

FIFTH ST.

FOURTH ST.

THIRD ST.

SYCAMORE AVENUE

DRAWING REFERENCE:
DVIRKA AND BARTILUCCI 2003

NORTHROP GRUMMAN SYSTEM CORPORATION
BETHPAGE, NEW YORK
OPERABLE UNIT 3
FORMER GRUMMAN SETTLING PONDS

SITE AREA

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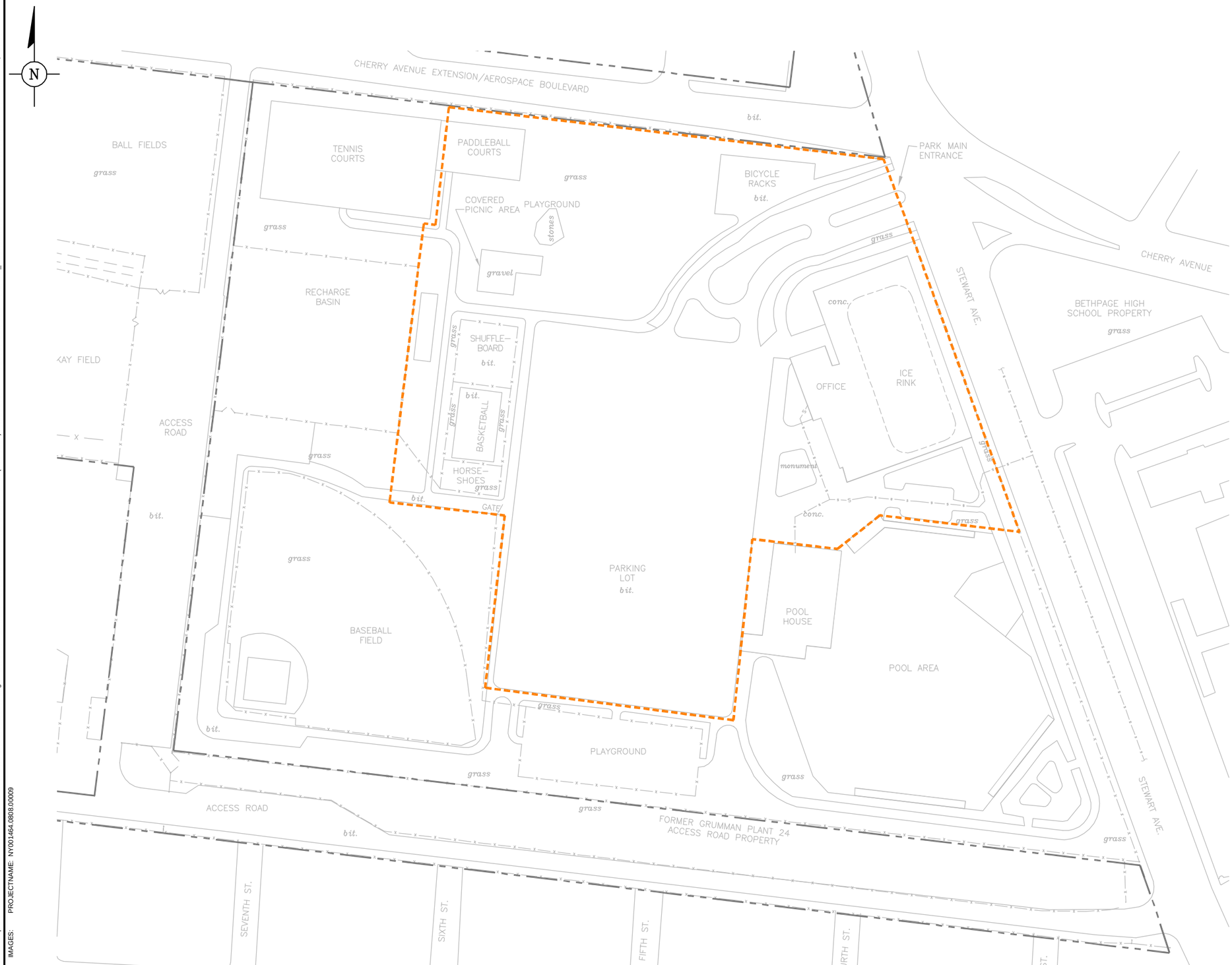
FIGURE 1



EXPLANATION

- NORTHROP GRUMMAN PROPERTY LINE
- FENCE
- bit. BITUMINOUS PAVEMENT
- APPROXIMATE LIMITS OF TOWN OF OYSTER BAY INTERIM REMEDIAL MEASURES

NOTES:

1. PARK FEATURES SHOWN WERE PRESENT PRIOR TO TOWN OF OYSTER BAY REDEVELOPMENT IN 2005.

0 60' 120'
SCALE IN FEET

NORTHROP GRUMMAN SYSTEMS CORPORATION
BETHPAGE, NEW YORK

OPERABLE UNIT 3
FORMER GRUMMAN SETTLING PONDS

TOWN OF OYSTER BAY
INTERIM REMEDIAL MEASURES

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FIGURE
2

LEGEND:

- NORTHROP GRUMMAN PROPERTY LINE
- FENCE
- bit. — BITUMINOUS PAVEMENT
- EXTENT OF METALS IN SOIL (ABOVE RESTRICTED-RESIDENTIAL CLEANUP OBJECTIVE)
- EXTENT OF PCBs IN SOIL (ABOVE RESTRICTED-RESIDENTIAL CLEANUP OBJECTIVE)
- EXTENT OF VOCs IN SOIL (ABOVE RESTRICTED-RESIDENTIAL CLEANUP OBJECTIVE)
- MP MP — EXTENT OF METALS AND PCBs IN SOIL
- PV PV — EXTENT OF PCBs AND VOCs IN SOIL
- EXTENT OF METALS, PCBs AND VOCs IN SOIL
- APPROXIMATE LIMITS OF TOWN OF OYSTER BAY IRM PROGRAM
- PCB — POLYCHLORINATED BIPHENYL
- VOC — VOLATILE ORGANIC COMPOUND
- BGS — BELOW GROUND SURFACE

NOTES:

1. PARK FEATURES SHOWN WERE PRESENT PRIOR TO TOWN OF OYSTER BAY REDEVELOPMENT IN 2005.

NORTHROP GRUMMAN SYSTEMS CORPORATION
BETHPAGE, NEW YORK

EXTENT OF BETHPAGE PARK SOILS ASSUMED TO BE REMOVED 0-2 FEET BELOW GROUND SURFACE

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FIGURE 3