Response to Comments on New Bedford High School Partial Permanent Solution with Conditions Statement

CLEAN

1. The Executive Summary states that the PS is for soil only. However, large portions of the text include discussions of groundwater including sections on nature and extent as well as risk characterization. This is confusing and references to groundwater, wherever possible, should be removed as it does not appear relevant to the PS for soil only.

The Executive Summary does not indicate that the PS is "for soil only". The document identifies that the PS is for a soil remedy and does not include the Immediate Response Action area (RTN 4-22409) located in the vicinity of (beneath) the Mechanical Room (Room B-114) in the NBHS building where soil and groundwater are impacted by a separately tracked and managed release. Groundwater impacts and risk assessment sections are included as they relate to impacts to soil and groundwater from historic fill tracked under RTN 4-15685 only. This will be clarified in the Executive Summary and Introduction sections.

2. CLEAN did not review any of the conclusions related to groundwater as the PS was said to relate only to soil. As such, the absence of comment must not be interpreted to mean concurrence with any of the conclusions or opinions about the mechanical room or groundwater in general. These comments will be made when the relevant documents are provided for comment.

As previously stated in the response to Comment 1 above, the PS is not "for soil only" and does not address Mechanical Room impacts. CLEAN will have the opportunity to comment on future submittals under RTN 4-22409 that address impacted media associated with the Mechanical Room.

3. The Conceptual Site Models presented appear to be incomplete. They reference the site history, contaminants, and media but fail to address migration pathways, exposure routes, and receptors.

A Conceptual Site Model Schematic Figure that includes migration pathways, exposure routes, and receptors will be included in the final document and is included as Attachment A to this Response to Comments document.

4. The presence of dioxins and the adequacy of the investigations for dioxin have been commented on many times for more than five years and remains an area of concern.

a. Based on the information in Section 2.3.3, there were approximately 700 borings advanced in the 10 areas on the High School Campus. However, only 22 borings, approximately 3% of the total, had samples collected and tested for dioxins.

b. Furthermore, including post-remediation soil samples for dioxins, 30% of the samples tested exceeded the MassDEP Method 1 Standards (see Table 2-11).

c. Unpaved areas with significant potential exposure to children such as the playing fields (HS-2 and HS-3) are represented by a single boring each.

d. Correlation between PCB concentrations and dioxins has not been established and, in 2011, TRC's risk assessor stated that there were not enough samples to establish such a correlation.

In light of the information above, CLEAN does not believe that adequate characterization has occurred at the Site for dioxins. More testing for dioxins is clearly warranted. Thousands of soil testing results for all parameters have shown significant variability such that a single sample location in playing fields, for example, is clearly inadequate to characterize dioxin presence/absence or exposure. The variability in contaminant distribution throughout the Site is demonstrated by the testing results as well as discussed in the text of the draft PS. More dioxin testing is warranted to demonstrate the presence/absence of this contaminant particularly in high potential exposure areas.

Please see attached a detailed response to Comment 4 included as Attachment B to this Response to Comments document. MassDEP has reviewed the response and has found that it "effectively demonstrates that the approach used to determine where to sample for dioxin and the amount of dioxin samples collected was consistent with pre-implementation planning and was adequate to characterize the presence of dioxin at NBHS, as well as the associated risk."

5. Other comments:

i. CAM does not include dioxins or PCB congeners.

The text will be revised to indicate that the soil sample analysis of PCB congeners and dioxins/furans were analyzed by non-CAM methods.

ii. Section 3.1.2.1 does not discuss dioxins, only the other COPCs.

Section 3.1.2.1 will be revised to include dioxins.

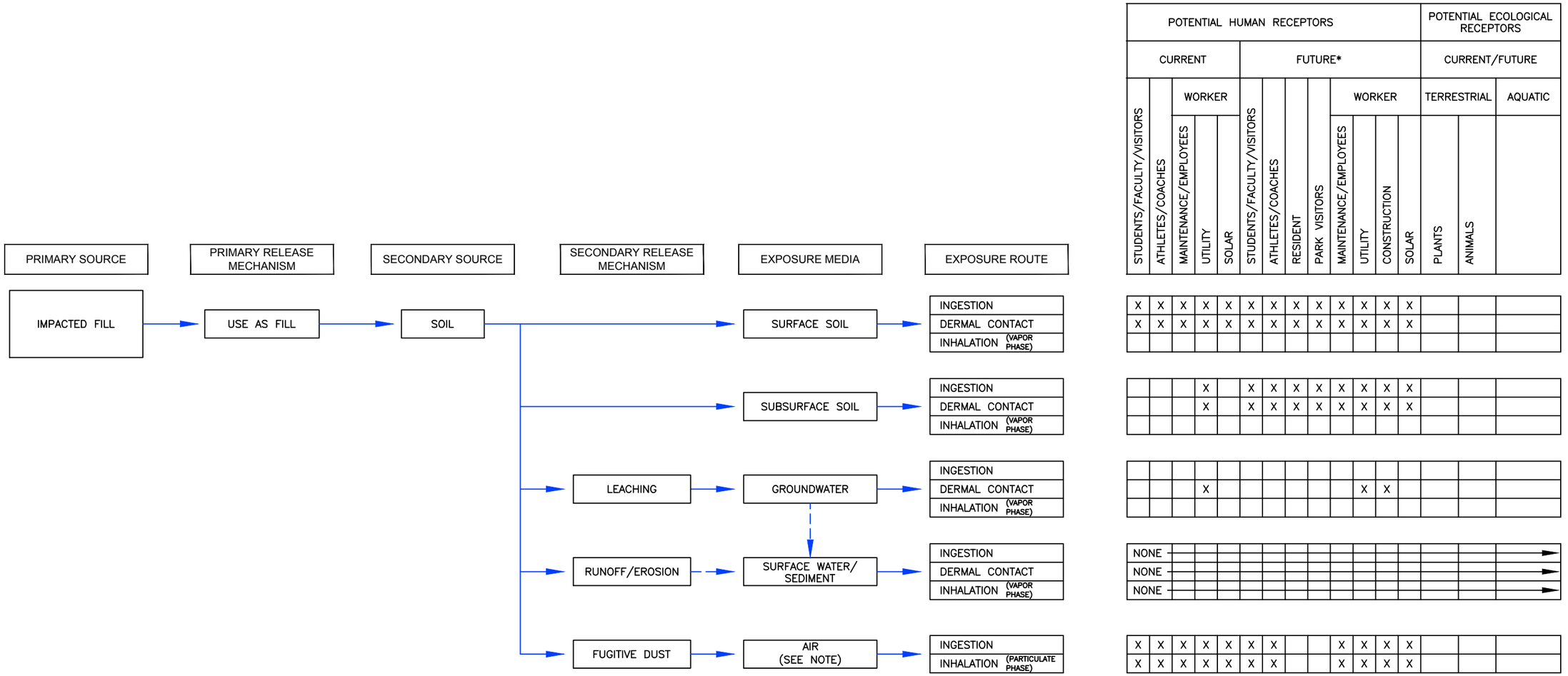
iii. Partial Permanent Solution term should be used throughout. For example, the last sentence of the 2nd paragraph of the executive summary does not include the word "Partial". Furthermore, the use of the term PS-P is present in the AUL but not the report. It would be best to include the term PS-P in the report.

The document will be searched and revised to indicate that it is for a Partial Permanent Solution throughout the document.

iv. Text in the AUL will need to be revised if text in the report is changed.

Noted.

ATTACHMENT A



LEGEND:

X	POTENTIALLY COMPLETE EXPOSURE PATHWAYS IDENTIFIED
- - - →	CURRENTLY ASSUMED TO BE AN INCOMPLETE PATHWAY
*	ASSUMES UNRESTRICTED FUTURE USE

NOTE:

THE MECHANICAL ROOM IN THE HIGH SCHOOL IS THE ONLY AREA ON THE NBHS CAMPUS WHERE THE VAPOR INTRUSION EXPOSURE PATHWAY IS POTENTIALLY COMPLETE. THE MECHANICAL ROOM PORTION OF THE SITE IS NOT INCLUDED IN THIS PARTIAL PERMANENT SOLUTION, AND IS BEING ADDRESSED UNDER RTN 4-22409.

NEW BEDFORD HIGH SCHOOL
NEW BEDFORD, MASSACHUSETTS

SCHEMATIC
CONCEPTUAL SITE MODEL

TRC
Wannalancit Mills
650 Suffolk Street
Lowell, MA 01854
(978) 970-5600

DRAWN BY: MAN
CHECKED BY: DNP
DATE: MARCH 2016

FIGURE
5-1

FILE: T:\E_CAD\115058\NBHS SCHEMATIC SITE MODEL_3.dwg

ATTACHMENT B

TRC
650 Suffolk Street
Lowell, MA 01854

Main 978.9705600
Fax 978.453.1995

Memorandum

To:	Michele Paul, LSP – Director, Dept. of Env. Stewardship
From:	David M. Sullivan, LSP – TRC Environmental Corporation
Subject:	Response to March 4, 2016 Comments to the Draft Partial Permanent Solution with Conditions for New Bedford High School Campus - Focus on Comment 4 Regarding the Presence of Dioxin and Adequacy of Investigation
Date:	June 16, 2016
CC:	

The purpose of this memorandum is to provide a focused response to Comment 4 from the March 4, 2016 Comments to the Draft Partial Permanent Solution with Conditions for New Bedford High School Campus. Comment 4 which expressed concerns about the presence of dioxin and the adequacy of investigation is reprised below in its entirety in italics followed by the response to the comment.

4. *The presence of dioxins and the adequacy of the investigations for dioxin have been commented on many times for more than five years and remains an area of concern.*
   a. *Based on the information in Section 2.3.3, there were approximately 700 borings advanced in the 10 areas on the High School Campus. However, only 22 borings, approximately 3% of the total, had samples collected and tested for dioxins.*
   b. *Furthermore, including post-remediation soil samples for dioxins, 30% of the samples tested exceeded the MassDEP Method 1 Standards (see Table 2-11).*
   c. *Unpaved areas with significant potential exposure to children such as the playing fields (HS-2 and HS-3) are represented by a single boring each.*
   d. *Correlation between PCB concentrations and dioxins has not been established and, in 2011, TRC's risk assessor stated that there were not enough samples to establish such a correlation.*

In light of the information above, CLEAN does not believe that adequate characterization has occurred at the Site for dioxins. More testing for dioxins is clearly warranted. Thousands of soil testing results for all parameters have shown significant variability such that a single sample location in playing fields, for example, is clearly inadequate to characterize dioxin presence/absence or exposure. The variability in contaminant distribution throughout the Site is demonstrated by the testing results as well as discussed in the text of the draft PS. More dioxin testing is warranted to demonstrate the presence/absence of this contaminant particularly in high potential exposure areas.

Response to Comment: The conservative and technically-justified approach to sampling that factored in both exposure potential and chemical characteristics of impacts, the strength of the correlations demonstrated between total PCB and dioxin compound concentrations, and the site-specific and health-protective nature of the risk characterization provide multiple lines of evidence which indicate that sufficient data have been collected to support the partial permanent solution without additional response actions or data collection for

dioxin compounds. For background, it should prove helpful to recount in some detail the unfolding and technical rationale of the investigative approach for dioxins in soil at New Bedford High School (NBHS), which was deliberate, based on detailed observation of existing conditions and a health-protective, iteratively-developed, soil data set. The investigative approach was developed in collaboration with the Massachusetts Department of Environmental Protection (MassDEP) and their technical experts in the Office of Research and Standards (ORS), the U.S. Environmental Protection Agency (EPA), and a risk assessment team consisting of a toxicologist and environmental health specialist.

March 2010 - Basis for Initial Round of Dioxin/Furan Sampling and Results. In March 2010, TRC outlined a technical approach for conducting an environmental investigation for polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and dioxin-like PCBs, collectively referred to as "dioxin compounds" and evaluated as a toxicity equivalents (total TEQ), in soil at the NBHS campus. The approach was developed as an initial step in an iterative approach to the evaluation of dioxin compounds. The key premise of the 2010 investigation was the collection of fill-impacted soil samples for dioxin compound analysis from the NBHS campus to evaluate the potential presence of dioxin compounds biased in a manner to detect elevated dioxin concentrations, estimate the potential risk posed by the presence of any detected dioxin compounds, and *assess the relationship between any detected dioxin compounds (i.e., the total TEQ) and potential precursor compounds and other contaminants*. This approach was developed in collaboration with ORS of MassDEP and EPA. In addition, the Technical Assistance Services for Communities (TASC) group prepared comments on the scope on behalf of CLEAN and generally approved of the approach.

The premise of the sampling approach was based on studies indicating the conversion of chlorinated organic precursor compounds (e.g., PCBs, chlorobenzenes, chlorophenols) to dioxin compounds during combustion. A TRC Senior Chemist with expertise in PCBs, dioxins and furans reviewed the available soil analytical data in combination with available physical information (e.g., boring logs) and focused on:

- Identifying discrete soil samples collected from within the ashy fill material and analyzed for PCBs, PAHS, and metals exhibiting elevated chemical concentrations.
- In the absence of discrete samples analyzed for all targeted compounds/metals, discrete locations with evidence of pre-cursors were identified.
- Evidence of elevated concentrations of pre-cursors was supplemented with evidence of combustion through review of associated composite soil samples.

This in-depth review of the soil data indicated that PCBs are the only chlorinated dioxin/dibenzofuran precursor compounds at the Site. There was no other indication of the presence of any other chlorinated organic compounds with the potential to serve as chlorinated dioxin/dibenzofuran precursors based on available data for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs) and pesticides.

Subsequently, sample locations were selected based on the presence of ash/cinders, metals enrichment, and elevated concentrations of PAHs (indicative of combustion); elevated PCB concentrations (the dioxin compound precursor); and to provide geographic coverage across the most impacted portion of the campus. TRC focused the sampling to a broad area on the western half of the NBHS campus displaying the highest concentration of PCBs, PAHs and metals, and selected locations suitable to test the hypothesis that elevated PCB concentrations are the primary dioxin precursor at the site. Some of the locations had the worst-case PCB concentrations with evidence of combustion, while others had the worst-case lead or PAH concentrations with lesser concentrations of PCBs, or were located in areas where these conditions were generally evident, since we sought both the presence of chlorinated precursors and evidence of combustion suggesting the potential for conditions that converted the PCBs into dioxin compounds. By this rationale, if elevated PCBs were present

without some evidence of combustion, the potential for dioxin compound formation at that location was thought to be low.

Five previously-sampled soil locations were identified as being likely, under the above-described estimated worst-case scenario, to have elevated concentrations of dioxin compounds based on a review of available soil data. These sample locations were HB-26, HF-14, HF-31D, HF-40 and HG-2. The sample locations were selected from the western side of the NBHS campus (i.e., the Hathaway Boulevard side), which is the portion of the campus historically displaying a higher degree of fill-related impacts, especially PCBs and certain PAHs and metals. Sample locations were selected to provide areal coverage across the western half of the property demonstrating the potential for elevated dioxin concentrations as follows: one location from the very northern end of the campus (HG-2 in exposure area HS-8, the current location of the solar park); one location from the area immediately north of the Houses (HF-14 in exposure area HS-6), one location from the flag pole area (HB-26 in exposure area HS-5), one location from the area between the girl's gymnasium and Hathaway Boulevard (HF-31D in exposure area HS-4) and one from the southern end of the campus (HF-40, also in exposure area HS-4). The general rationale for the selection of the five sampling locations follows:

- **HG-2 (1-3'; 2004) –** Of the sampling locations within exposure area HS-8 discretely analyzed for total PCBs, PAHs, and metals, HG-2 (1-3') was the location with the highest concentrations of total PCBs, PAHs and metals.
- **HF-14 (2-3'; 2004) –** Though the total PCB concentration at HF-14 (0.72 mg/kg) was less than the MCP Method 1 S-1 soil standard, this location displayed some of the highest concentrations of carcinogenic PAHs, arsenic, barium, cadmium, and chromium across exposure area HS-6.
- **HB-26 (0.5-3'; 2004) –** This location displayed a total PCB concentration of 5.2 mg/kg. Though this location was not analyzed for PAHs and metals, it was combined with adjacent location HB-25 (1-3') to create a composite that was analyzed for and displayed elevated PAHs and metals and so was considered as a whole, along with the presence of a relatively thick layer of fill (over 3 feet).
- **HF-31D (1-3': 2009) and HF-40 (2.5-3'; 2004) –** These two locations were selected from exposure area HS-4, one from its northern extent (HF-31D) and one from its southern extent (HF-40). Samples HF-31D and HF-40 displayed total PCB concentrations of 71.6 mg/kg and 25.5 mg/kg, respectively. Sample location HF-31D (1-3') was selected because it exhibited the highest concentration of total PCBs detected in soil at the NBHS campus.[1] Though sample HF-31D was not analyzed for PAHs, it did display an elevated concentration of lead, but clearly as the highest detected PCB sample on campus, HF-31D was identified as a target of interest. Sample HF-40 was composited with location HF-35 and the composite analyzed for PAHs and metals; the HF35+HF40 composite sample displayed elevated concentrations of PAHs, cadmium, and lead and was thus selected to represent the southern extent of exposure area HS-4.

The conservative biased sampling approach *was specifically formulated to avoid underestimating risk from exposure to dioxin compounds in NBHS campus soil*. At each location, a 0 to 1 foot interval and a 1 to 3 foot interval soil sample was collected. A deeper (i.e., greater than 3 feet below grade) subsurface soil sample, targeting the historic fill, was also collected at each location during this initial investigation of dioxin compounds.

On April 15, 2010, fifteen samples plus one duplicate sample were collected and analyzed for dioxins/dibenzofurans, PCB congeners, PCB Aroclors, PAHs, and MCP metals and mercury. The results were

[1] Sample location HF-31D was subsequently removed during Releases Abatement Measure (RAM) related activities coordinate through MassDEP and the Environmental Protection Agency (EPA) under the Toxic Substances Control Act (TSCA; 40 CFR Part 761).

as expected and supported the premise of the sampling approach: Elevated concentrations of dioxin compounds, expressed as the total TEQ, were detected in locations where elevated PCB detections and ash/evidence of combustion were present. Fill material including ash, coal, clinkers, brick, glass and/or wood debris was encountered in each soil boring location with fill material generally observed at depths greater than approximately 2.5 feet below grade (shallow fill material (i.e., approximately 0.5 to 1.25 feet below grade) was observed in the HG-2 soil boring location).

The results of the 2010 sampling bore out the hypothesis that the dioxin compound concentrations would increase with the total PCB concentrations. Please see Table 1 (below) for a summary of the April 2010 soil sampling results from all depths sampled, sorted from highest to lowest concentration based on the total Aroclor results and total PCB congener results.

Table 1 - April 2010 Soil Sampling Results Summary

Location/Depth	Total PCB Aroclors	Dioxin Compounds
HF-40 (3-5')	12	5.5E-04
HF-40 (1-3')	8.0	2.5E-04
HG-2 (1-3')	4.2	9.1E-04
HG-2 (5-7')	4.0	3.6E-04
HF-14 (3-4')	1.0	5.6E-04
HB-26 (1-3')	0.75	5.6E-04
HF-31D (1-3')	0.73	1.2E-04
HB-26 (3-5')	0.72	1.5E-03
HF-14 (1-3')	0.54	5.6E-05
HB-26 (0-1')	0.47	1.4E-04
HF-40 (0-1')	0.33	4.6E-05
HF-14 (0-1')	0.26	3.7E-05
HF-31D (0-1')	0.23	5.5E-05
HF-31D (4-6')	0.13U	5.1E-05
HG-2 (0-1')	0.12U	6.8E-05
Location/Depth	**Total PCB Congeners**	**Dioxin Compounds**
HB-26 (3-5')	16.6	1.5E-03
HG-2 (1-3')	4.9	9.1E-04
HB-26 (1-3')	4.1	5.6E-04
HG-2 (5-7')	3.73	3.8E-04
HF-14 (3-4')	1.15	5.6E-04
HF-14 (1-3')	0.74	5.6E-05
HF-31D (1-3')	0.74	1.2E-04
HB-26 (0-1')	0.47	1.4E-04
HF-40 (0-1')	0.27	4.6E-05
HG-2 (0-1')	0.26	6.8E-05
HF-31D (0-1')	0.19	5.5E-05
HF-14 (0-1')	0.18	3.6E-05
HF-40 (3-5')	0.098	5.5E-04

Table 1 - April 2010 Soil Sampling Results Summary		
Location/Depth	**Total PCB Congeners**	**Dioxin Compounds**
HF-31D (4-6')	0.082	5.1E-05
HF-40 (1-3')	0.066	2.5E-04
Notes: Total PCB Aroclors and Total PCB Congeners in mg/kg Dioxins Compounds in mg/kg (TEQ Summation of Dioxin-like PCB Congeners TEQ and Dioxins TEQ)		

There is an observable trend of increasing dioxin compound concentration with increasing total Aroclor concentration. The positive association between the total PCB congener and dioxin compound results is stronger than noted with the total Aroclor results, likely due to the more precise quantification of congeners versus Aroclors, which relies on pattern matching. Overall, the results are consistent with and supportive of the premise of the investigative effort.

January 2011 - MassDEP Comment Letter. In a letter dated January 13, 2011, representatives of MassDEP's Southeast Regional Office (SERO) acknowledged that the approach utilized by the City to evaluate the NBHS campus for the presence of dioxin compounds was designed to capture the worst-case conditions. MassDEP also expressed the opinion that "*In the absence of…a correlation, additional sampling for dioxin is necessary to complete the characterization of potential risks posed by dioxin in soil at the NBHS campus.*"

MassDEP suggested further sampling at locations where dioxin precursors may be present, as well as at locations where exposure potential is likely to support additional quantification of risk. Such an approach was likely to result in a reasonable upper bound of the risk associated with dioxin compound exposure across the NBHS campus. As a condition, MassDEP asserted that no additional soil sampling for dioxin compounds should take place in locations that are expected to be consolidated/capped and excavated, as well as in locations where future exposure potential will be controlled by the application of an activity and use limitation (AUL). The areas where exposures would be controlled include exposure areas HS-5 (the capped flag pole area), HS-8 (the solar park), and HS-9 (paved areas).

April 2011 - Follow-up Sampling Approach and Results. The City worked closely with MassDEP SERO to outline an approach for additional dioxin compound sampling. Eliminating locations sampled in April 2010 from consideration, the sampling locations selected in 2011 included previous soil investigation locations estimated overall as representative of a reasonable upper bound scenarios based on a review of available soil data (i.e., using the same approach as outlined in March 2010 (including SB-362, SB-359, HA43+HA44 and HB-22), and also locations that provide data that are representative of potential current and future exposures across the NBHS campus (i.e., PG-6, SS-28, SS-38, SB-365 and SS-52). TRC selected sample locations from representative areas that would have exposed surface soil at the conclusion of the remedial action to further evaluate where exposure potential is likely to support additional quantification of risk.

Eighteen soil samples were collected in June 2011 from nine sample locations and analyzed for chlorinated dioxins/furans and PCB congeners. The 2011 samples were not analyzed for PCB Aroclors. These sample locations included: SB-362, SB-359, HA-43+HA-44, HB-22, PG-6, SS-28, SS-38, SB-365, and SS-52, and provide coverage for each of the exposure areas where soil exposures can occur at the NBHS campus. The rationale for selection of each of the sample locations is summarized below:

- **SB-362 (0-1' and 1-3'; 2009) –** This location is found within exposure area HS-7, the "hang-out area." Exposure area HS-7 is one of the exposure areas displaying minimal fill-related impacts. None of sampling locations within exposure area HS-7 displayed elevated concentrations of

PAHs or PCBs, and only two location, SB-362 and SB-363, displayed elevated concentrations of lead. However, the highest total PCB concentration detected across exposure area HS-7 (0.51 mg/kg) was reported at location SB-362 in the 0-1' interval. Therefore, location SB-362 represented a worst-case exposure for exposure area HS-7.

- **SB-359 (0-1' and 1-3'; 2009), HA-43+HA-44 (0.75-3'; 2005) and HB-22 (0-1' and 1-3'; 2009)** – These locations are found within exposure area HS-10, the tree belts. This exposure area provides for broad exposure since the grassed tree belts are scattered throughout the NBHS campus. Location SB-359 is found in the southeastern portion of the campus (corner of Hathaway Boulevard and Parker Street), location HA-43+HA-44 is found in the southwest portion of the campus (corner of Parker and Liberty Streets), and location HB-22 is found in the western central portion of the campus, near the Houses (A-Block). These three locations were chosen to represent a range of PCB, PAH and metals concentrations across the exposure area. Location SB-359 had detectable but not elevated concentration of PAHs, PCBs and metals. The HA-43+HA-44 composite sample location had moderate concentrations of PCBs (slightly less than 1 mg/kg) and slightly elevated concentrations of benzo(a)pyrene and lead. Location HB-22 had elevated PCBs (greater than 1 mg/kg), PAHs and metals.
- **PG-6 (0-0.5' and 0.5-3'; 2006) –** This location is found within exposure area HS-1, the children's playground area. PCBs were not detected in any sample collected from exposure area HS-1, and PAHs and metals were not elevated (i.e., less than MCP Method 1 soil standards). This location was chosen for sampling to provide confirmation that the lack of PCBs and other indications of dioxin compound formation truly indicated low (e.g., background levels) of dioxin compounds. In addition, because this area is frequented by the most sensitive receptor at NBHS, the daycare/preschool child, it was important to obtain dioxin compound data from this area.
- **SS-28 (0.5' and 1.5'; 2008) –** This location is found within exposure area HS-2, the fenced playing fields east of the boy's gymnasium. The majority of samples collected from this exposure area had concentrations of PCBs, PAHs and metals that were less than or only slightly greater than MCP Method 1 S-1 soil standards. Location SS-28 displayed PCB concentrations up to 4.2 mg/kg, surpassed only by location SS-19 (4.9 mg/kg). Neither of these samples had elevated PAHs, while both displayed elevated lead. Location SS-28 was selected to represent a high-end exposure for exposure area HS-2 as it was centrally located within the exposure area.
- **SS-38 (0.5' and 1.5'; 2008; 1-3'; 2009) –** This location is found within exposure area HS-3, the unfenced playing fields east of D-Block. None of the samples collected from this exposure area displayed PCBs greater than 1 mg/kg. Sampling results for location SB-38 indicated that it had nearly the highest concentrations of PCBs (up to 0.61 mg/kg) and displayed elevated lead concentrations. The only location with a higher PCB concentration within HS-3 (HRJ.75-17; 0.76 mg/kg) was not analyzed for PAHs and metals. The single location within this exposure area with elevated PAHs (SS-37) had significantly lower PCB concentrations than location SS-38. Therefore, location SS-38 was selected to represent a high-end exposure for this area.
- **SB-365 (0-1' and 1-3'; 2009) –** This location is found within exposure area HS-4, the gym area. Because two worst-case locations were selected for sampling in 2010 (locations HF-31D and HF-40), a location with minimal impacts was selected for sampling in 2011 to provide more representative exposure data. The SB-365 location is located midway between the HF-31D and HF-40 locations.
- **SS-52 (0-0.5'; 2008; 1-3'; 2009) –** This location is found within exposure area HS-6, the House (A-Block) area. Location HF-14, sampled in 2010 from this exposure area, was selected due to elevated concentrations of PAHs and lead, not due to an elevated concentration of PCBs. Therefore, location SS-52 was selected in 2011 to provide representative coverage for a location

displaying elevated concentrations of PCBs (up to 3.2 mg/kg), but with low concentrations of PAHs and metals.

Qualitatively, the results were as expected, with evident co-occurrence of total PCBs with dioxin compounds and the presence of ash/cinders, metals enrichment, and PAHs, further supporting the hypothesis that the highest dioxin compound concentrations would be associated with the highest total PCB concentrations. With the exception of soil boring PG-6, which exhibited some of the lowest detected concentrations of PCB congeners and dioxins, fill material including ash, coal ash, cinders, clinkers, coal, brick, glass and/or wood debris was encountered in each soil boring location. Soil borings were terminated at 4 feet below grade or less, with fill material generally observed between 1 and 4 feet below grade. Table 2 summarizes the April 2011 soil sampling results, sorted from highest to lowest based on the total PCB congener results.

Table 2 - April 2011 Soil Sampling Results Summary

Location/Depth	Total PCB Congeners	Dioxin Compounds
HB-22 (1-3')	1.4	1.6E-03
SS-52 (1-3')	1.4	1.9E-05
SS-38 (0-1')	1.1	4.1E-05
SS-52 (0-1')	1.0	1.1E-05
HB-22 (0-1')	0.87	2.2E-05
SB-362 (0-1')	0.78	9.9E-06
SS-28 (0-1')	0.54	1.4E-05
SB-365 (1-3')	0.39	3.1E-06
SB-362 (1-3')	0.28	7.0E-06
HA-43/44 (0-1')	0.26	9.8E-06
HA-43/44 (1-2')	0.18	1.1E-05
SS-38 (1-3')	0.063	4.2E-06
SB-359 (0-1')	0.059	5.3E-06
SB-365 (0-1')	0.024	2.9E-06
SS-28 (1-3')	0.023	1.2E-06
PG-6 (1-3')	0.0059	4.6E-07
SB-359 (1-3')	0.0056	1.7E-06
PG-6 (0-1')	0.0017	3.1E-07

Notes:

Total PCB Congeners in mg/kg
Dioxin Compounds in mg/kg (TEQ Summation of Dioxin-like PCB Congener TEQ and Dioxins TEQ)

Consistent with the 2010 sampling event, there is a strong positive trend of the total PCB congener concentrations with the dioxin compound concentrations, consistent with the premise of the investigative effort.

The results for location HB-22 prompted additional dioxin/furan sampling in October 2011 to delineate dioxin-impacted soils in the vicinity of this location in the 1-3 foot soil horizon, where the dioxin concentration was at least two orders of magnitude higher than the applicable soil cleanup criteria. Lateral soil "step out" samples HB-22A, HB-22B, HB-22C and HB-22D were collected and analyzed for PCDDs/PCDFs (no PCB congener

sampling was performed) in October 2011 and were determined to represent appropriate excavation bounds. Removal activities for this location were completed in December 2011.

December 2011 - New EPA Reference Dose (RfD). After soil excavations were completed at location HB-22, MassDEP adopted EPA's newly published reference dose (RfD) for dioxin compound risk estimation. Consequently, non-cancer health effects associated with the surface soil total TEQ Exposure Point Concentration (EPC) (based on a 95% Upper Confidence Limit [UCL] on the arithmetic mean) were now associated with an unacceptable risk, specifically for the daycare child exposure scenario. The issue primarily resulted from the small size of the total TEQ data set for the 0 to 3 foot interval as a result of the execution of the soil removals and capping (which effectively reduced the number of results available for calculation from 29 to 18) coupled with the variability in the remaining data set.

As a result of the changes in the toxicity value and consistent with discussions between the City and MassDEP, TRC conducted additional soil investigation activities in February 2014 in the vicinity of location HB-22 in support of supplemental excavation activities. TRC collected step out samples in the HB-22B (HB-22F and HB-22J) and HB-22C directions (HB-22G and HB-22K). The samples were analyzed for dioxin-like PCBs and PCDDs/PCDFs. In addition, sample volume was collected from the HB-22A and HB-22D locations and analyzed for dioxin-like PCBs to provide data to calculate a total TEQ at these locations, since the October 2011 samples at these two locations were only analyzed for PCDDs/PCFDs. The A, D, J and K locations were determined to be the bounds of the required supplemental excavation.

The additional soil material in the vicinity of sampling location HB-22 was excavated in April 2014. The updated risk calculations, using an updated total TEQ 95% UCL, indicated a Condition of No Significant Risk in support of a permanent solution for the NBHS Campus could now be achieved.

Correlating Total PCBs and Total TEQ Concentrations.

Though TRC did not set out to achieve a statistical correlation between total PCBs and the total dioxin compound concentration, expressed as a total TEQ, the following evaluation documents a positive association between total dioxin concentrations, expressed as a TEQ, and total PCB concentrations, lending support to the conservative nature of the sampling approach utilized to characterize the upper bound risk at NBHS.

TRC applied straight-forward graphing and least-squares linear regression analysis to compare total PCB congener results versus total TEQ results, for the top 3 feet of soil at NBHS using data collected from the April 2010 and April 2011 soil sampling events, and presented above. The top three feet in areas of exposed soil was the focus because of exposure potential and data quantity. Exposure to the deeper soils and to soils beneath exposure barriers will be controlled by the use of an AUL.

The results of the graphing and least-squares linear regression analysis are summarized below. Note that because the total PCB results span up to three orders of magnitude and the total TEQ results span up to five orders of magnitude, a logarithmic transformation of the data was required as a data processing step.

- **Visually evident correlative trends –** Figures 1 through 2 demonstrate a trend of increasing total TEQ concentrations with increasing total PCB concentrations for PCB congeners for the 0-1 foot and 1-3 foot intervals.

- **Strength of linear trend –** The linear regression analysis for Log PCB Congeners versus Log total TEQ for both depth intervals is statistically significant at a 5-percent probability level, and nearly statistically significant at a 1-percent probability level (see Table 3 below).

Table 3 - Correlation Coefficient (R^2) Comparison - PCB Congeners vs. Dioxin Compound TEQ				
			r values for two-tailed probabilities (*P*)	
Depth	**R^2**	**Sample size per interval**	**5%**	**1%**
0-1 feet	0.5591	14	0.53	0.66
1-3 feet	0.5945			
Notes: R^2 - Correlation coefficient from linear regression Gray shading indicates probability level exceeded for R^2 value				

Concluding Remarks. The strength of the correlations, the approach to sampling, and the alignment of multiple lines of evidence suggest that sufficient data have been collected to support the partial permanent solution without additional response actions or data collection for dioxin compounds for the following reasons:

- **Biased Sampling –** Sampling was conducted with bias, targeting areas and depths that were likely to have resulted in an overestimate of the dioxin compound EPCs. As noted above, for example, soil samples collected from the HS-7, HS-2, and HS-3 exposure areas for dioxin compound analysis were deliberately collected from locations with *the highest or nearly the highest PCB concentrations, elevated metals and other biasing criteria (e.g., presence of ash deposition) to intentionally avoid underestimating risk.*
- **Health-Protective Estimation of risk –** While a biased sampling strategy is commonly used for site characterization, *the dioxin compound soil data set collected using this approach likely over-represents the impacts present across the campus, resulting in an overestimation of the risks and hazards*. This enhances the protectiveness of the remedy, especially considering the area of the campus that underwent excavation and backfilling with documented clean soil (approximately 10-percent of the exposed soil areas on the campus). These areas of clean soil were not factored into the calculation of the dioxin compound EPCs.
- **Conservatism of Aroclor versus Congener Data –** Another factor contributing to the health-protective nature of the risk evaluation is the large Aroclor data set, which while more variable, generally displayed higher concentration readings compared to the PCB congener data (on the order of 18-percent higher overall). Risk and hazard estimation for total PCBs was based on the Aroclor data, again providing for a health-protective remedy.
- **Well characterized -** Unidentified areas of fill impacts should be minimal since an extensive number (more than 1,000) of soil samples were collected during the investigations at the Site and over 140,000 square feet of ground surface was excavated and replaced with clean imported soil or secured with a barrier to prevent exposure. The approach for dioxin compounds was focused on developing a data set representative of campus-wide impacts that would not under-represent the risk associated with dioxin compound exposure, based on consideration of the data provided by the more than 1,000 soil samples collected.

As a final note, the commenter was concerned because 30% of the soil samples analyzed for dioxin compounds exceeded its MCP Method 1 S-1 soil standards. These standards are only applicable when using a Method 1 risk characterization, and the specific dioxin standard (2E-05 mg/kg), though based on background, correspond to a cancer risk of 2.5E-06 and a non-cancer hazard of 0.33 for a residential scenario. A Method 3 risk characterization was used to evaluate cumulative risk and hazard at the NBHS campus, based on activities

specifically known to be occurring at the school, at a lesser frequency and intensity of use than assumed for a residential yard. Though the MCP Method 1 standards are not applicable to the NBHS campus risk characterization, they were used to determine whether or not a 95% Upper Confidence Limit of the arithmetic mean was required for use as the EPC. Because more than 25% of the data points exceeded the Method 1 S-1 standard for dioxin compounds, a 95% UCL was selected for use as the EPC. Use of a 95% UCL rather than an average provides an additional margin of safety in the risk estimation process because the 95% UCL is greater than the arithmetic mean.

Based on the information presented herein concerning sampling design, chemical correlations, and risk characterization, sufficient data have been collected to support the partial permanent solution without additional response actions or data collection for dioxin compounds.

Figure 1

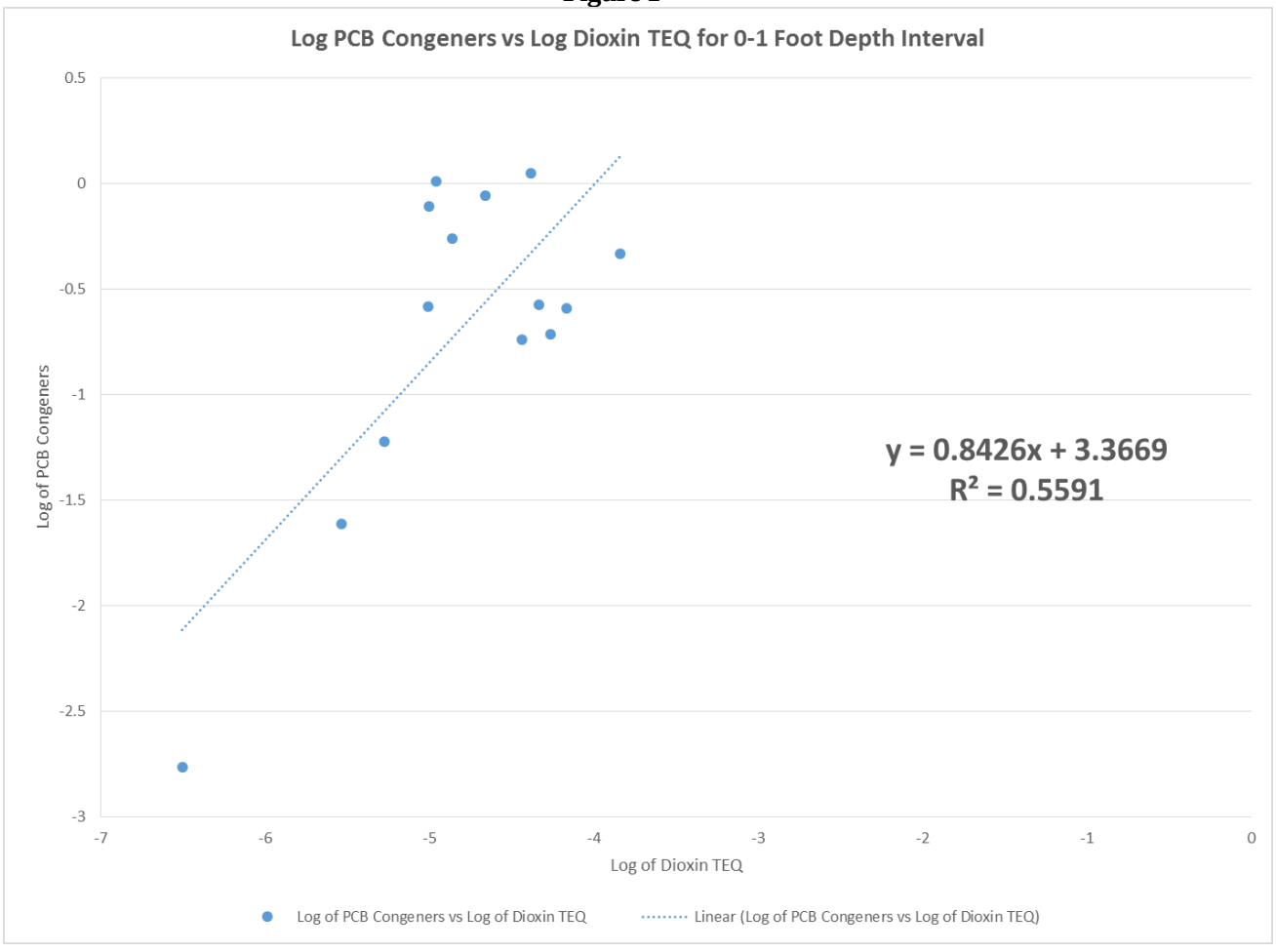
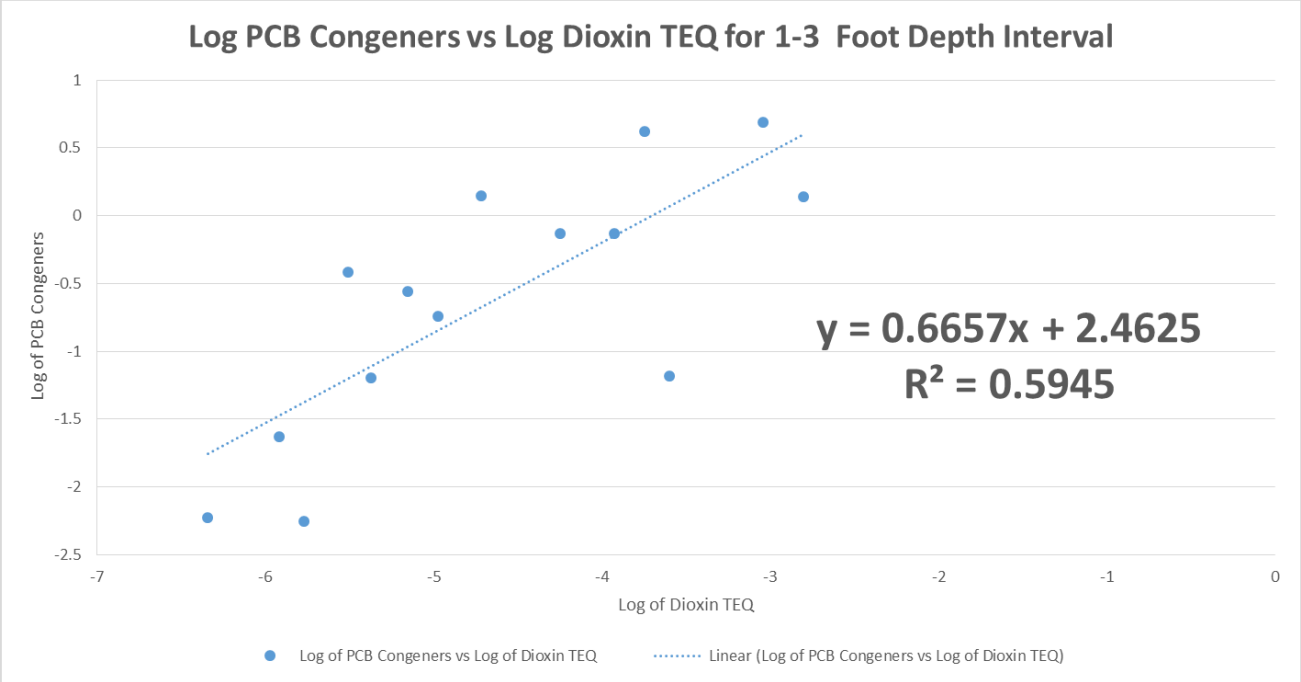


Figure 2


Log PCB Congeners vs Log Dioxin TEQ for 1-3 Foot Depth Interval
Log of PCB Congeners
Log of Dioxin TEQ
y = 0.6657x + 2.4625
R² = 0.5945
Log of PCB Congeners vs Log of Dioxin TEQ
Linear (Log of PCB Congeners vs Log of Dioxin TEQ)