Appendix II-C

Three-Dimensional Visualization of Bathymetry and Sediment Core PCB Data for Phase 1 Certification Units (CUs)

1. Introduction

MVS (Mining Visualization System) is state-of-the-art sophisticated software that allows the visualization and analysis of complex three-dimensional problems. The use of this software has allowed the Louis Berger Group Hudson River Project Team to present intuitive visualizations of the data associated with the dredging operations at the Hudson River PCBs Site. Many of our findings were directly derived from and supported with data-based visualization. Individual data components (e.g., sediment core PCB data) were viewed and assessed within the context of the dredging operation so that data issues could be addressed. Multiple types of data (e.g., sediment core PCB data and dredging cut depths) were integrated into one scene for evaluation so that correlation between different types of data could be addressed. In the discussion below, C-Tech's Four-Dimensional Interactive Model (4DIM) Technology was used for visualization of PCB concentrations in sediment cores, and pre- and post-dredging surfaces. A 4DIM contains multiple frames. Each frame is a complete 3D model that can be freely zoomed, moved and rotated.

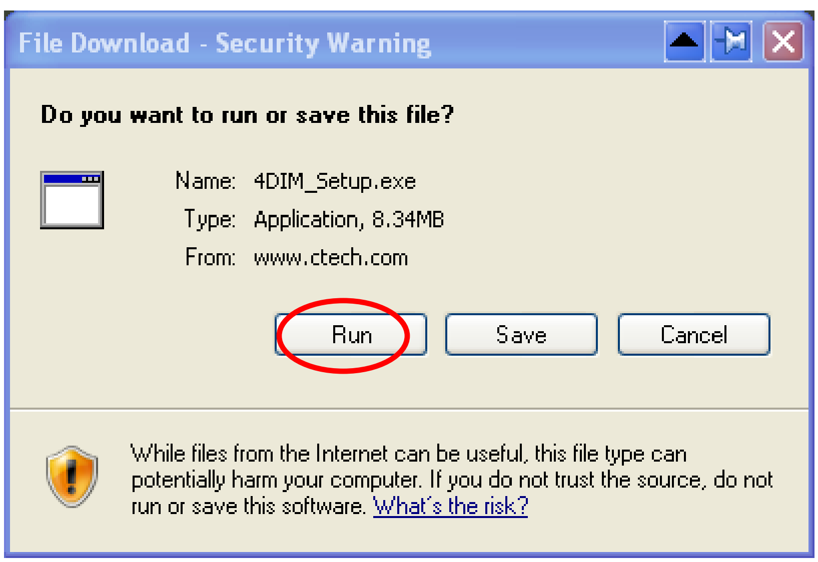
2 Installation of 4DIM Player and Navigation of 4DIMs

2.1 Instructions for Installation of 4DIM Player

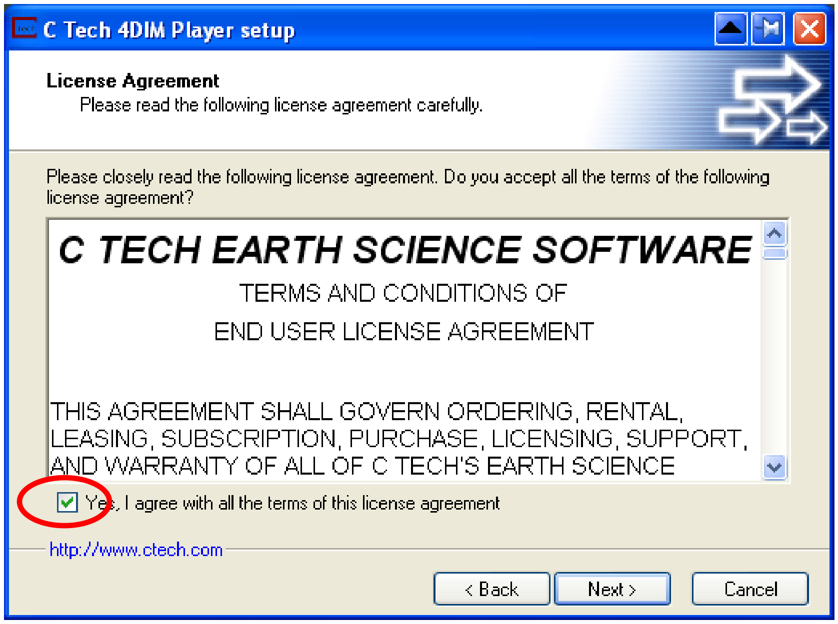
The 4DIMs can be visualized interactively using 4DIM Player, which is a free viewer developed by C-Tech Development Corporation. It is available for download at http://www.ctech.com. The steps for download and installation of 4DIM Player are as follows:

First, simply Ctrl+Click ***HERE***, the C-Tech's file download page will appear:

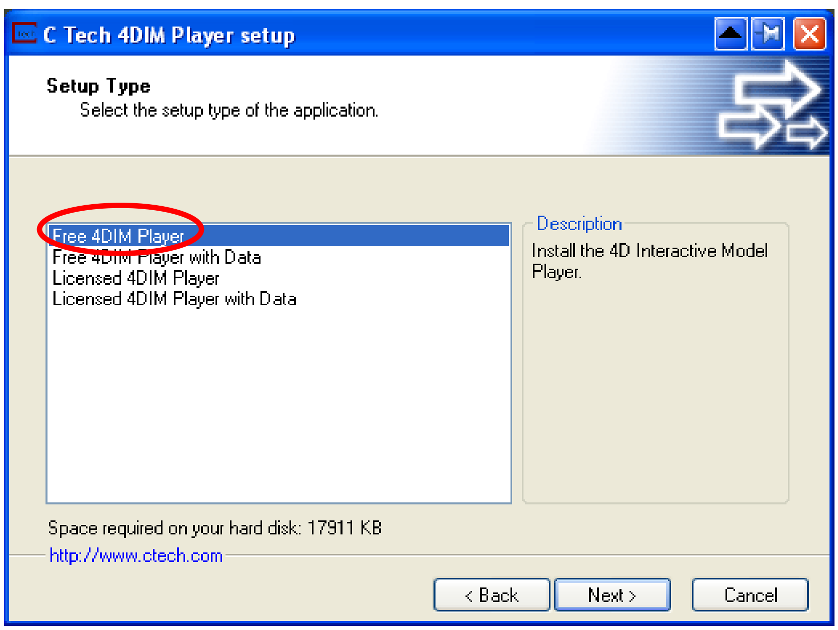
Then, click "Standalone 4DIM Player Installation", the file download window will pop up:



Click Run button, follow the instructions on screen. Then the following window will pop up,



Select "Yes, I agree with all the terms of this license agreement", then the following window will pop up,



Select "Free 4DIM Player", then, click Next button. Follow the screen instruction to finish up the installation.

As an alternative way for downloading 4DIM Player, you can also first access C-Tech's web page (The URL is http://www.ctech.com); click SUPPORT; then click DOWNLOAD to go to file download page. Then go through the same steps for download and installation of 4DIM Player as described above.

2.2 Navigating 4DIMs

Rotate the model: Move the mouse to a location within the viewer portion of the 4DIM Player's window. Hold down the left mouse button and move the mouse pointer in various directions. The model rotates.

Zoom in or out on the model: The middle mouse button on a 3 button mouse can be clicked and dragged to change the zoom level, or a wheel button will also affect the zoom.

Move (Translate or Pan) the model: Hold down the right mouse button and drag the object up, down, and around, then center the model.

Run Animation: 4DIMs II-C-13 through 16 show animations of cross sections for CU-1, CU-4, CU-7 and CU-18, respectively. Click "Run" button in the bottom of 4DIM Player window. The speed of animation can be adjusted by selecting different delay time.

3 4DIM Development for Phase 1 Certification Units

Appendix II-C figures present snapshots of 4DIMs. Detail information about each figure can be obtained through interactive visualization of the 4DIM associated with the figure. A 4DIM file is named the same as the figure which the 4DIM is associated with.

The figures and 4DIMs are present in the following three categories:

- Pre-dredging, post-dredging and backfilled surface elevations for Phase 1 Certification Units (CUs). (See Figures II-C-1 through 10 and the associated 4DIMs II-C-1 through 10).

- Three-dimensional representation of PCB concentrations in sediment cores in CU-1. (See Figures II-C-11 and II-C-12 and the associated 4DIMs II-C-11 and II-C-12).

- 3D View of Cross Sections for Phase 1 Certification Units (See Figures II-C-13 through 16 and the associated 4DIMs II-C-13 through 16).

The main observations and findings from these figures and 4DIMs are described below.

4 Visualization of Pre-dredging, Post-dredging and Backfilled Surfaces

The 3D visualization of the sediment surface elevations at different dredging stages (pre-dredging, post-dredging and backfill) for CU-1 through CU-8, CU-17 and CU-18 were conducted and are presented in 4DIMs II-C-1 through 10. Figures II-C-1 through 10 are snapshots of these 4DIMs. In each figure, the surface plots are arranged in clockwise way so that a final dredging surface is shown immediately below the associated design dredging surface for easy comparison of these two surfaces. The surfaces are numbered in the following sequences:

As shown in the figures and 4DIMs, the final dredging depth went deeper than the design dredging depth in all CUs. The final dredging depth was underestimated universally in all CUs. CU-1 represents the worst case for dredging underestimation. Majority of areas in CU-1, which were designed to be dredged to 108 to 116 feet (blue), were eventually dredged to 100 to 104 feet (yellow and orange). The final dredging depth was closer to the designed dredging depth in CU-6, CU-17 and CU-18 than in other CUs. The discrepancy between the final dredging depth and the designed dredging depth was within 2 feet almost everywhere within these three CUs and averaged about 0.7 feet.

5 Visualization of PCBs in SSAP and Post-dredging Pass Cores

Sediment core PCB data were integrated with dredging cut lines for visualization. Model II-C-11 presents Total PCBs concentrations in SSAP cores in CU-1, and the first and final post-dredging pass cores, while 4DIMs II-C-12 presents Tri+ PCBs concentrations in the final post-dredging pass cores. Figures II-C-11 and II-C-12 are the snapshots of these two 4DIMs. As a demonstration of the flexibility in navigating 4DIMs, Figures II-C-12b presents a view looking from below the 3D model of CU-1 (4DIMs II-C-12), while Figures II-C-12a presents a normal view.

The figures and 4DIMs show that in CU-1 most of the post-dredging pass cores, even after five dredging passes, still did not penetrate through the PCB inventory and demonstrates that the depth of contamination estimated from the SSAP cores underestimated the inventory presented in the CU. The test pits cores, which went as deep as elevation 100 feet (NGVD88), penetrated through the inventory of PCBs and reached the depth of contamination. Thus the true depth of contamination is estimated at an approximately elevation of 100 feet.

6 Animation of CU Cross Sections Showing Dredging Cut Lines

Cross-sectional view of dredging cut lines was animated along flow direction for CU-1, 4, 7 and 18. SSAP and final pass cores were also displayed together with the dredging cut lines. Figures II-C-13 through 16 show the snapshots of the animations. The animations are presented in 4DIMs II-C-13 through 16, respectively.

The animations facilitate the evaluation of sediment deposition and erosion throughout a CU. When cross sections depicting dredging cut lines move along the River, it is shown that the gap between the 2005 and 2009 pre-dredging bathymetry is pretty significant in some areas. For example, a gap of 2 feet or more is observed in many areas in CU-4 (refer to 4DIMs II-C-14). Both deposition and erosion are observed.

In the animations, it is clearly shown that the final cut is deeper than the design cut at almost every place in all CUs for which animations were conducted. Among the four CUs, the additional dredging depth below design cut needed in CU-1 is the biggest, while the least additional dredging depth was needed for CU-18. Since majority of SSAP cores (96%) are complete cores in CU-18, the prediction of DoC using SSAP cores is reliable. Incomplete cores comprise 94 percent of SSAP cores in CU-1. Therefore, the design cut based on SSAP core data cannot give appropriate prediction of true DoC in CU-1.

7 Summary

Through visualization of dredging cut lines and SSAP and post-dredging pass core PCB data, it is clearly seen that SSAP cores did not characterized the depth of contamination adequately.