II. REMEDIATION

A. General

The excavation of contaminated soils at Resolution island was completed this year. At the S1/S4 beach area, the remaining small area containing CEPA soil was excavated; two small areas in the S1/S4 buildings area were also found to contain CEPA soil. Approximately 260 m^3 of CEPA soil was excavated this year. All excavated CEPA soil was containerized and shipped off site in September 2005. All Tier II soils were placed in the Tier II lined landfill near the imploded tank. All Tier I soils were also transported to the Tier II landfill for use as filler or as part of the capping below the top liner. Most of the excavation work was conducted in the S1/S4 valley and S1/S4 beach areas. The other areas that were excavated were the PCL dump, the north slope dump, the DND Helipad area, the maintenance dump and the beach dump. The excavations of the contaminated soils are described in sections C to I. Section B describes the methodology used in this work and QA/QC relating to the analytical work is given in Chapter III, section N.

B. Methodology

1. Excavation

a) CEPA Soils

The following is the general methodology that was used to excavate CEPA soils.

Ropes and spray paint of various colours were placed on the ground to indicate the extent of PCB contamination at the >2000 ppm (green), CEPA (yellow), Tier II (blue) and Tier I (pink) levels. Spray paint was found to be more useful when heavy equipment was working in the vicinity. CEPA soils were excavated and taken to the screening plant. Material not passing through the screener was classified as Tier II and stockpiled. The CEPA material passing through the 2 inch screen was classified as CEPA soil and taken to the main PCB storage facility. At the PCB storage facility the soil was placed into conical steel containers. After excavating to the depth indicated from the sampling/analysis work, generally 30 cm, the soil in the area was tested to ascertain if its concentration was now below the CEPA criterion. If not, further excavation was carried out. The soils were dug up with an excavator equipped with a bucket or clam. However, in many areas the bedrock needed to be further cleared of PCB-contaminated soils which could not be excavated with heavy machinery. This was achieved by shoveling by hand and by using a vacuum truck.

Decontamination centers were set up for personnel at all locations where contaminated soils were being dealt with. The large decontamination trailer was used at B2 where containers were being filled. Smaller units comprised of containers of wash water and supplies of personal protective equipment were used elsewhere. The personal protective equipment used is given in the Health and Safety Plan and was described fully in the 1999 ASU report. Tyvec suits, gloves and rubber boots were always worn when working in contaminated areas. In general, half-faced respirators were used whenever the odour of Askarel (PCB mixture) was encountered; dust masks were worn whenever it was dusty.

b) Tier II Soils

In 2004 the ASU produced a "Resolution Island Excavation Protocol for Tier I and Tier II Soils".

This year all Tier II soils were placed in the Tier II landfill. Soils were removed by heavy equipment by taking off the first 0-30 cm. A composite sample of the excavated area was then taken and analyzed. If necessary, excavation was continued by taking off 30 cm at a time until the remaining soil is < 5.0 ppm PCBs or bedrock was reached. All soil which could be safely removed by heavy equipment was removed. In difficult to access areas or areas with small soil volumes, Tier I and Tier II soils were excavated together and placed in the Tier II landfill.

c) Tier I soils

All Tier I soils were removed and placed in the non-hazardous engineered landfill or the Tier II landfill if required. As described above for the Tier II soils, excavation should proceed by taking off 30 cm at a time until the remaining soil is < 1.0 ppm PCBs or bedrock is reached. This method will not be strictly enforced as there is no landfill size limitation for Tier I soils. If it is easier to remove the Tier I soil to bedrock rather than by 30 cm stages, then this may be done. However, the extra work involved this approach versus the dig and test technique should be considered, and the appropriate method used at each location. If excavation is not practical the Tier I soil may be covered in place with 0.5 m of clean fill.

2. Sampling

Soil samples were collected using plastic scoops and placed in WhirlPak bags. Discrete sampling locations were marked with a six inch nail to which was attached a numbered metal disk and a piece of flagging tape. However, most soil samples taken this year were composite samples for areas that had been excavated. The size of the areas from which composite samples were taken depended on the overall size of the area excavated, and the terrain. The general guidelines were to take four confirmation samples per quadrant or to sample 3 m by 3 m areas depending on the topography. Tables containing the analytical results cross reference sample numbers with location. Soil samples were generally restricted to the upper 10 cm but in order to determine the depth of contamination, test pits were also excavated (manually and by machine) and samples collected at specific depths.

Water samples for PCBs were collected in 1 L Teflon bottles or 1 L glass bottles with teflon lined lids.

Most samples were analysed on site in the mobile laboratory. Other samples were shipped by air freight to Queen's University for testing. In order to conform with regulations regarding sample control, a rigorous chain of custody was maintained. Chain-of-custody forms were filled out and checked for each sample before shipment from the North, and the contents of shipments were verified upon receipt in the laboratory. The relevant documentation is available on request.

3. Mapping

A 20 x 20 m grid system, graphically constructed using Autocad Map 2000 was previously established for both the S1/S4 Beach and S1/S4 Valley and Buildings Areas. For the S1/S4 Beach Area, the grid was labeled 3 to 9 in a N/S orientation and B to G in a W/E orientation. For the S1/S4 Valley and Buildings Area the grid was labelled A to S in a N/S orientation and 1 to 25 in a W/E orientation. Each grid reference relates to the bottom right hand corner of the relevant 20 x 20 m square. The co-ordinates required to set-up the grid were exported to a Reliance mapping program and uploaded as a waypoint file to a GPS FS/2 handheld controller unit. On Resolution Island, the Ashtech Reliance differential GPS mobile receiver system was operated in 'rover mode' which allowed navigation to the individual grid points to within 1 m accuracy. Individual grid points were marked with flags and an "X", using spray paint. The grid co-ordinates were marked in several locations within the confines of the grid, on available surfaces and rocks. This provided a convenient reference point for workers and provided the scientific team with an accurate method of documenting the cleanup process. Grids were re-established each season by GPS or measuring tape as required.

Three map binders were constructed for each of the two areas. The first contained individual maps for all the quadrants containing PCB contaminated soil. These maps included colour coded contamination levels, previous sampling locations, tag and sample numbers and rope locations pertaining to the site as it appeared at the beginning of the field season. When any sampling or excavation occurred in a grid, the details were recorded on a quadrant log sheet and were sketched onto the relevant map. Where possible, samples were restricted according to the grid lines and sampling areas did not cross grid lines. Ongoing map and log sheets were placed in a second binder 'Map Work in Progress'. A new map was used and updated every day work occurred in that grid. When the grid had been excavated such that any remaining soil tested was less than the appropriate criteria, or was completely removed, the quadrant log sheet was dated and signed by a Queens Representative (Team Leader), an Engineering representative and a QC representative (Site Supervisor). All of the individual maps for that quadrant were attached to the log sheet and transferred to a third binder 'Completed Map Quadrants'. Copies of the completed documents were given to the engineering company (Sinanni) and to the Qikiqtaaluk Corporation. For each quadrant there was a separate sheets for CEPA soils and Tier I/II soils. Copies of all quadrant log sheets completed this year are included in Chapter VII: Appendix.

4. *PCB Analysis*

Two methods were available at Resolution Island to analyze for PCBs in soils, namely the standard laboratory technique using gas chromatography with an electron capture detector (GC/ECD) and the field method using immunoassay test kits. As the GC/ECD method worked without any major problems the test kits were not employed this year. Analysis of other matrices by the GC/ECD method were conducted at the ASU laboratory in Kingston.

a) Laboratory Analyses (GC/ECD) (Soil Samples)

The standard analytical procedure for the analysis of PCBs, namely gas chromatography with an electron capture detector (GC/ECD) was used. These analyses were performed at the Mobile Laboratory on-site and at the Analytical Services Unit, Queen's University by one of the three following procedures. For all procedures a separate soil sample was first taken for the determination of wet weight/dry weight ratio. Soils were analyzed by using approximately 10 g (dry weight equivalent), spiking with an internal standard solution (decachlorobiphenyl) and extracting. The soxhlet method used approximately 250 mL dichloromethane in a soxhlet extractor for four hours. The DCM shaker method used 3 times 25 mL dichloromethane with agitation on a platform shaker for 20 minutes for each extract. The ACHX shaker method used a single extraction with 50 mL of a 1:1 mixture of acetone and hexane with agitation on a platform shaker for 20 minutes.

The shaker methods were used for most soil samples while the soxhlet method was generally used for other solid matrices. The solutions obtained from the soxhlet and DCM extraction methods were concentrated to 1-2 mL and the solvent exchanged for hexane. This concentrate was then applied to a Florisil column (Supelco SPE tube) and the resulting eluent analyzed using an HP 5890 Series II Plus gas chromatograph equipped with electron capture detector and a 30 m SPB-1 capillary column and calibrated with Aroclor 1260 standards. For the ACHX method, the extraction was applied directly to the GC.

b) Laboratory Analyses (GC/ECD) (Other Matrices)

Samples of metal, wood and barrier absorbent materials were analyzed as for soil by using the soxhlet extraction techniques. Water was analyzed by using approximately 800 mL of sample, spiking with internal standard and extracting three times with dichloromethane. The extract was filtered through sodium sulphate and concentrated to 1-2 mL and the solvent exchanged for hexane. This concentrate was then applied to a Florisil column for cleanup of the extract and the resulting eluent analyzed by GC/ECD. For samples requiring a lower detection limit, extracts were concentrated to 0.5 mL before analysis on the GC. Air samples were analysed according to NIOSH Method 5503 by desorbing both the filter and absorbent with hexane and running the samples on a GC/ECD system.

5. *Metal Determinations*

a) Copper, Lead and Zinc by XRF

A TN Technologies, Inc. Spectrace 9000 Field Portable X-Ray Fluorescence Analyzer (FPXRF) was used for copper, lead and zinc. The FPXRF is equipped with a high resolution solid state (mercuric iodide) detector and fundamental parameters quantitative analysis software. This software measures all major elements present and compensates for the effects of the interferences on one another by computer calculations. This allows for a good estimate of inorganic element concentrations for all soil matrix types without the necessity of calibrating with several standard reference materials having the same general concentrations and matrix. Pure elements or standard reference materials were therefore used for calibration standards.

The FPXRF employs three radioactive sources for X-Ray generation. The acquisition times used for analysis were Fe-55, 200 sec: Cd-109 1000 sec: and Am-241 50 sec. The soil samples were analyzed using the following procedure. Sub-samples were spread out on absorbent paper towels and allowed to air dry overnight. Large stones and pebbles were removed and the sample ground with a pestle and mortar. The ground sample was placed in the sample cup and covered with Mylar film and sample ring. The filled sample cup was inverted (Mylar side down), tapped gently to settle and compact the contents, placed on the probe and analyzed.

b) Metals by ICP/AES

Samples were air-dried and ground to a fine powder with a mortar and pestle; large stones were removed as they would not be expected to contain any anthropogenic environmental contamination. Approximately 0.5 g of this dried material was heated with 2 ml nitric acid and 6 ml hydrochloric acid overnight so that the volume was reduced to 1-2 ml. This solution was then made up to 25 ml, and analyzed by inductively coupled plasma atomic emission spectroscopy (ICP/AES). While it is recognized that the digestion procedure used may not bring all metals into solution (some metals may be locked into silicate minerals), it is felt that the metals released into solution are of greater environmental significance than true total metals. The ICP/AES analysis was conducted using a Varian Vista Pro Spectrophotometer with axial configuration.

C. S1/S4 Beach Area

1. Background

The original delineation of the S1/S4 beach area was conducted in 1994. Additional sampling and analysis was undertaken in 2000 and 2002 in order to better define the contaminated area and also to confirm the location of the line between the uncontaminated zone required for a road turnaround area at the base of the cliff and the Tier I area adjacent to it. It was found in 1994, and confirmed in 2003, that PCB test kits do not give reliable results on soils from this location. The area was mapped by GPS in 2000 and 2003. A grid, similar to that which was used in the S1/S4 valley was created for use at the S1/S4 beach area. In total 26 points each at the corner of a 20 m x 20 m grid were located and survey flags and spray paint used to mark these locations. In 2004, excavation of the CEPA soil was carried out starting at the steepest point that could safely be reached at the base of the cliff. This corresponded to 3C and the lower part of 3D on Map II-1. Fourteen out of the 18 quadrants that contained CEPA soil were successfully excavated leaving only a small amount of CEPA soil at this location.

2. Soil Excavation

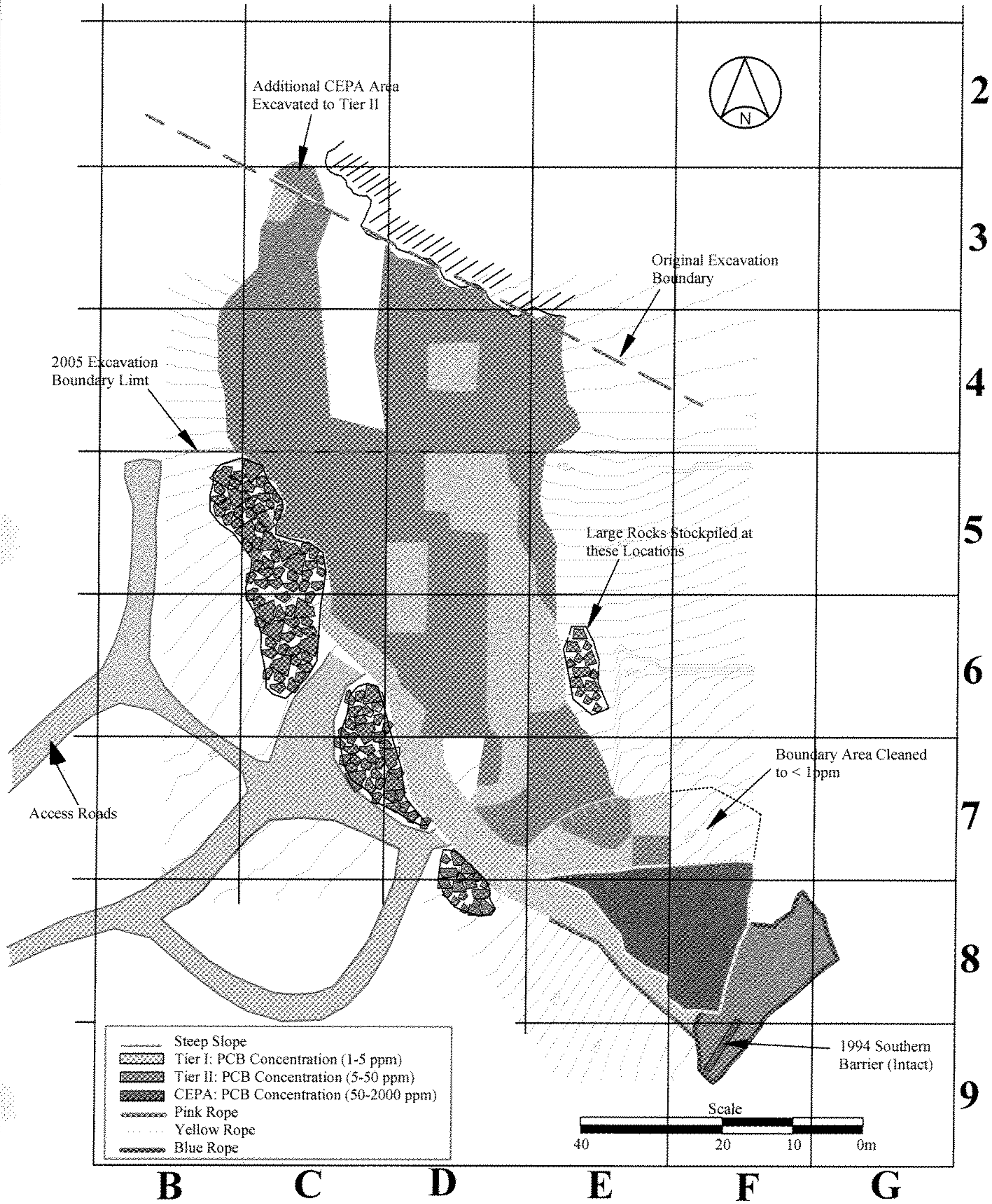
The grid markers in the form of flags, spray paint and ropes were re-established and as necessary due to wear and tear over the winter. Excavation of the remaining CEPA was quickly achieved in only 2 days as confirmation testing after the initial excavation showed that levels had been reduced to less than 50 ppm PCBs. The southern barrier constructed in 1994 (Photographs II-1, II-2 and VI-5) was then removed. Tier II excavation then proceeded on several fronts (Photographs II-3, II-4 and II-5). Although it had been discussed at the PMT meetings that Tier II soils could not be excavated very far up the slope after the CEPA soils had been excavated in 2004, it was found that excavation could safely be undertaken up to and including quadrants 5C, 5D and 5E (Photograph II-6). After the Tier II areas had been systematically removed, Tier I soils were then excavated. All excavated soils were taken to the Tier II landfill.

As previously discussed, Tier II soil remained in inaccessible grids 3C, 3D, 4B, 4C, 4D and 4E. All accessible Tier I has been removed. Areas of the road (7E and 7D) were excavated and cleared for <1 ppm before large rocks were placed on the soft fill to accommodate the heavy trucks transporting the soil. The Tier I excavation uncovered a clay layer, which was useful in the construction of the new barrier at the base of the slope

(Chapter VI). Tier I soils under a 3 meter high pile of boulders in grid 7D have been left in place; this has an approximate volume of 20 m^3. Some Tier I still remains in grids 8F and 9F; this was inaccessible due to the steep terrain. Confirmatory samples were taken from clean fill roads used to access grids 6C, 7C and 7D.

Map II-2 shows the areas still containing PCBs at the end of the excavation work and, photograph II-7, the remediated site. The position of the new permanent barrier designed to capture any mobilized PCBs is also shown on the map. A clay layer was found at the excavated area it now occupies (Photograph II-8). The construction and monitoring of the new permanent barrier is described in chapter VI. Table II-1 gives all the analytical results for samples taken during the remediation. Some results therefore were used to indicate further excavation was necessary while others served as confirmatory samples showing that the excavation was complete. The results are cross referenced to the sign-off sheets for the quadrants given in Chapter VII and therefore indicate which represent excavation or confirmatory samples.

Map II-1: The S1/S4 Beach Area Showing the Contaminated Zones and the Quadrants at the Start of the 2005 Field Season



Map II-2: The S1/S4 Beach Area Showing the Contaminated Zones and the Quadrants at the End of the 2005 Field Season