

**MASS SPEC SERVICES**  
**Division of Geonuclear, Inc.**  
P.O. Box 163  
Orangeburg, NY 10962

CH2M HILL, Inc.  
2020 SW 4<sup>th</sup> Avenue, 3<sup>rd</sup> Floor  
Portland, OR 97201

04/23/09

Attn: Patrick Heins

### **REPORT NARRATIVE**

Sediment chronology radiochemical analyses  
Project 358932.PH.OF, NW Pipe 2007 Stormwater  
Purchase Order 932794  
MSS Work Order Pb0165

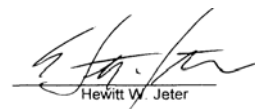
Received sediment samples, partially frozen in plastic jars, on 03/11/09. Custody seals of the shipping container were intact. The samples were in good condition and were accompanied by chain-of-custody (COC) forms. Verified that the numbering of all sample jars conformed to the COC forms and signed the forms. The COC documents indicated that about half of the samples were to be analyzed for Pb-210 and Cs-137; the other samples were to be held in archive without being analyzed.

Assigned MSS work order Pb0165 to the project. Assigned sequential MSS sample numbers to the samples to be analyzed and entered them on the COC forms. Wrote the MSS sample numbers on the corresponding sample jars. Transferred the samples to be analyzed into labeled, tared beakers and weighed them. Placed the beakers in a laboratory oven and dried them for 48 hours with temperature ramping from 90 to 140 degrees C. Allowed the samples to cool after drying, then re-weighed to determine moisture fraction. Pulverized the dried samples with a mortar and pestle to a fine powder and returned the samples to the numbered beakers. Noted a visual description of each dried sample for inclusion in the final reports. Archived the samples which were not to be analyzed in a secure storage area of the laboratory. Refrigeration is not needed for sediment samples for Cs-137 and Pb-210 analyses. Holding times do not apply because the radioactive half-lives of these radionuclides both exceed 20 years.

Weighed a portion of each dried and pulverized sample (near 10 grams) for Pb-210 analysis into a labeled beaker. Also prepared laboratory control samples consisting of a soil matrix spike and a water blank. Other portions of the dried and pulverized samples designated for Cs-137 analyses were sent to the Environmental Inc. Midwest Laboratory for gamma spectral analysis according to method Ga-01-R of the Environmental Measurements Laboratory, U.S. Department of Energy, HASL-300 Procedures Manual. Those analyses were performed from 03/17/09 to 03/28/09.

Radiochemical separations for the Pb-210 analyses were performed at Mass Spec Services on 03/23/09 according to method 7.2.3 of the Oak Ridge National Laboratory Master Analytical Manual. The resulting mounted precipitates were sent to the Environmental Inc. Midwest Laboratory and were analyzed on beta detectors on 03/25/09. Laboratory control spikes processed with the Pb-210 and Cs-137 analytical groups produced satisfactory results according to the  $\pm 15\%$  control limits specified in EPA-600/7-77-088 "Handbook for Analytical Quality Control in Radioanalytical Laboratories" (all aspects of quality control at the laboratories, including prevention of sample cross-contamination, conform to this publication). Laboratory control blanks processed with the analytical groups resulted in no detection of Pb-210 or Cs-137. Check source and blank performance tests of both the beta and the gamma detectors at the laboratory were satisfactory during the analysis periods. Standard calibration and quality control procedures were observed during all phases of the analyses. No non-conformances were observed.

Chronology interpretation of the analytical results was performed according to Jeter, Hewitt W., "Determining the Ages of Recent Sediments Using Measurements of Trace Radioactivity", Terra et Aqua 78, 21-28, March 2000. Reports analysis and interpretation were sent to CH2M HILL by Email attachment on 03/30/09.

  
Hewitt W. Jeter

CH2M HILL, Inc.  
 2020 SW 4th Avenue  
 3rd Floor  
 Portland, OR 97201  
**Attn:** Patrick Heins

# MASS SPEC SERVICES

Division of Geonuclear, Inc.  
 P.O. Box 163, Orangeburg, NY 10962


## Report of Analysis Sediments

NW Pipe 2007 Stormwater Project

<b>Report Date</b>	03/30/09
<b>MSS No.</b>	Pb0165
<b>CH2M Project</b>	358932.PH.OF
<b>CH2M Purchase Order</b>	932794
<b>Samples Rec'd</b>	03/11/09
<b>Task Supervisor</b>	H. Jeter

MSS No.	Identity	Depth ft	Moisture Fraction	*	Radiometric Results in pCi/g dry		Pb-210 Prep	Pb-210 Count	Cs-137 Prep	Cs-137 Count
					Pb-210	Cs-137				
Pb0165-1	SED21-0-A	0.0 - 0.2	0.55	1	1.71 ± 0.18	0.071 ± 0.036	03/23/09	03/25/09	03/13/09	03/17/09
Pb0165-2	SED21-1-A	1.0 - 1.2	0.50	1	1.24 ± 0.14	0.073 ± 0.039	03/23/09	03/25/09	03/13/09	03/18/09
Pb0165-3	SED21-2-A	2.0 - 2.2	0.46	1	1.18 ± 0.15	0.158 ± 0.038	03/23/09	03/25/09	03/13/09	03/19/09
Pb0165-4	SED21-3-A	3.0 - 3.2	0.50	1	0.66 ± 0.11	0.307 ± 0.053	03/23/09	03/25/09	03/13/09	03/19/09
Pb0165-5	SED21-4-A	4.0 - 4.2	0.56	1	0.68 ± 0.12	0.871 ± 0.071	03/23/09	03/25/09	03/13/09	03/20/09
Pb0165-6	SED21-5-A	5.0 - 5.2	0.47	1	0.56 ± 0.10	< 0.045	03/23/09	03/25/09	03/13/09	03/21/09
Pb0165-7	SED21-6-A	6.0 - 6.2	0.33	1	0.35 ± 0.09	< 0.043	03/23/09	03/25/09	03/13/09	03/22/09
Pb0165-8	SED21-7-A	7.0 - 7.2	0.49	1	0.35 ± 0.10	< 0.036	03/23/09	03/25/09	03/13/09	03/22/09
Pb0165-9	SED21-8-A	8.0 - 8.2	0.40	1	0.41 ± 0.10	< 0.051	03/23/09	03/25/09	03/13/09	03/24/09
Pb0165-10	SED22-0-A	0.0 - 0.2	0.48	1	0.63 ± 0.11	0.071 ± 0.035	03/23/09	03/25/09	03/13/09	03/24/09
Pb0165-11	SED22-1-A	1.0 - 1.2	0.32	1	0.34 ± 0.10	< 0.042	03/23/09	03/25/09	03/13/09	03/25/09
Pb0165-12	SED22-2-A	2.0 - 2.2	0.32	2	0.21 ± 0.11	< 0.032	03/23/09	03/25/09	03/13/09	03/25/09
Pb0165-13	SED22-3-A	3.0 - 3.2	0.34	2	0.27 ± 0.12	< 0.041	03/23/09	03/25/09	03/13/09	03/25/09
Pb0165-14	SED22-4-A	4.0 - 4.2	0.36	2	0.31 ± 0.10	< 0.042	03/23/09	03/25/09	03/13/09	03/26/09
Pb0165-15	SED22-5-A	5.0 - 5.2	0.32	2	0.29 ± 0.10	< 0.031	03/23/09	03/25/09	03/13/09	03/26/09
Pb0165-16	SED22-6-A	6.0 - 6.2	0.38	2	0.37 ± 0.11	< 0.031	03/23/09	03/25/09	03/13/09	03/26/09
Pb0165-17	SED22-7-A	7.0 - 7.2	0.38	2	0.31 ± 0.10	< 0.034	03/23/09	03/25/09	03/13/09	03/26/09
Pb0165-18	SED22-8-A	8.0 - 8.2	0.35	2	0.28 ± 0.09	< 0.035	03/23/09	03/25/09	03/13/09	03/27/09
Pb0165-19	SED22-9-A	9.0 - 9.2	0.34	2	0.28 ± 0.09	< 0.031	03/23/09	03/25/09	03/13/09	03/27/09
Pb0165-20	SED22-10-A	10.0 - 10.2	0.36	2	0.25 ± 0.09	< 0.030	03/23/09	03/25/09	03/13/09	03/28/09
* Visual description:		1	silt, a little fine sand							
		2	silt, a little very fine sand							

Target Detection Limits:	Pb-210	0.1 pCi/g	Bismuth Beta Counting Method
	Cs-137	0.1 pCi/g	Gamma Spectral Analysis



Hewitt W. Jeter

Tolerances are 2 sigma counting uncertainties.  
 Detection limits are at the 4.66 sigma level.

**REPORT OF LABORATORY CONTROL SAMPLES**

**MASS SPEC SERVICES**  
**Division of Geonuclear, Inc**

**MSS No.** Pb0165

CH2M HILL, Inc.  
 Project Number: 358932.PH.OF

**Pb-210 Spike and Blank**

<b>MSS No.</b>	<b>Sample Identity</b>	<b>Matrix</b>	<b>Count Date</b>	<b>Pb-210 Result</b>	<b>Expected</b>	<b>Units</b>
SSP-79	Soil Matrix Spike	Soil	03/25/09	8.29 ± 0.38	8.90 ± 0.15	pCi/g dry
WBL-104	Water Blank	Water	03/25/09	< 0.12	Non detect	pCi/g wet

**SSP-79 spike level:** 7.93 pCi/g spike + 0.97 ± 0.15 pCi/g from matrix = 8.90 ± 0.15 pCi/g expected

**Cs-137 Spike and Blank**

<b>MSS No.</b>	<b>Sample Identity</b>	<b>Matrix</b>	<b>Count Date</b>	<b>Cs-137 Result</b>	<b>Expected</b>	<b>Units</b>
SPSPK-1	Water Spike	Water	03/19/09	20.20 ± 0.68	17.90	pCi/g wet
SPBKG-1	Water Blank	Water	03/18/09	< 0.036	Non detect	pCi/g wet

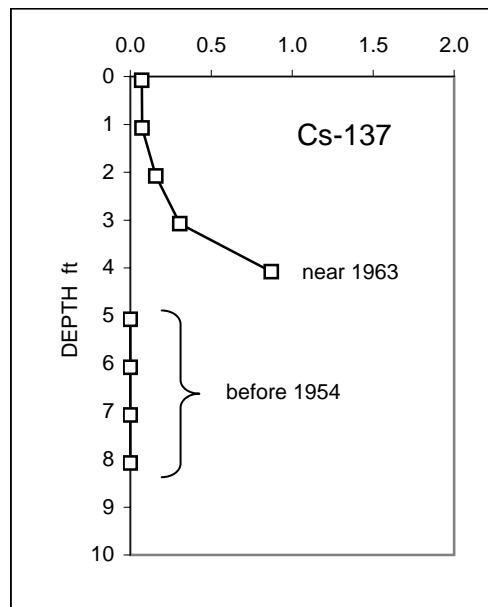
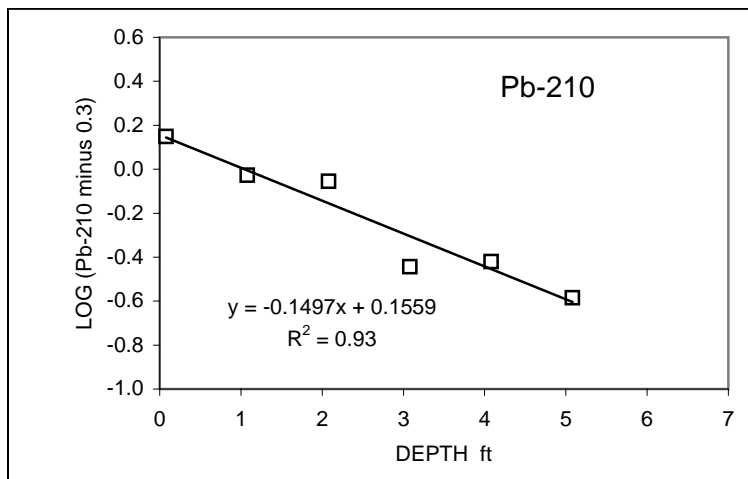
**CH2M HILL, Inc.**

Attn: Patrick Heins  
 Project 358932.PH.OF  
 NW Pipe 2007 Stormwater Project

**MASS SPEC SERVICES**

**Division of Geonuclear, Inc.**  
 Sediment Chronology Interpretation  
 MSS No. Pb0165

**Core SED21**  
 Collected 07/10/08



**Pb-210 Chronology**

Supported Pb-210 is found to be near 0.3 pCi/g dry based on deep data from both cores.

Fitted curve:  $y = -0.1497x + 0.1559$  Correlation R square: 0.93

Inferred sedimentation rate:  $-0.01352 / -0.1497 = 0.090 \text{ ft/y (1.1 in/y)}$

**Cs-137 Chronology**

A 1963 Cs-137 maximum lies near 4.1 ft depth, resulting in a calculated sedimentation rate:  $4.1 \text{ ft} / (45 \text{ y between 1963 and 2008}) = 0.091 \text{ ft/y (1.1 in/y)}$

The 1954 Cs-137 horizon lies between 4.1 and 5.1 ft depth, resulting in a calculated sedimentation rate **between 0.076 and 0.094 ft/y (between 0.91 and 1.13 in/y).**

**Summary**

A steady sedimentation rate of 1.1 in/y is found in the upper 5 feet of sediment, with excellent agreement between the results of the Pb-210 and the Cs-137 methods. At depths greater than 5 feet, the sediments are known to be older than 1954 but it is not known whether the sedimentation rate remains at 1.1 in/y.

**Sample Data**

Depth ft	Visual Description	Moisture Fraction	Radiometric Results in pCi/g dry	
			Pb-210	Cs-137
0.0 - 0.2	silt, a little fine sand	0.55	1.71 ± 0.18	0.071 ± 0.036
1.0 - 1.2	silt, a little fine sand	0.50	1.24 ± 0.14	0.073 ± 0.039
2.0 - 2.2	silt, a little fine sand	0.46	1.18 ± 0.15	0.158 ± 0.038
3.0 - 3.2	silt, a little fine sand	0.50	0.66 ± 0.11	0.307 ± 0.053
4.0 - 4.2	silt, a little fine sand	0.56	0.68 ± 0.12	0.871 ± 0.071
5.0 - 5.2	silt, a little fine sand	0.47	0.56 ± 0.10	< 0.045
6.0 - 6.2	silt, a little fine sand	0.33	0.35 ± 0.09	< 0.043
7.0 - 7.2	silt, a little fine sand	0.49	0.35 ± 0.10	< 0.036
8.0 - 8.2	silt, a little fine sand	0.40	0.41 ± 0.10	< 0.051

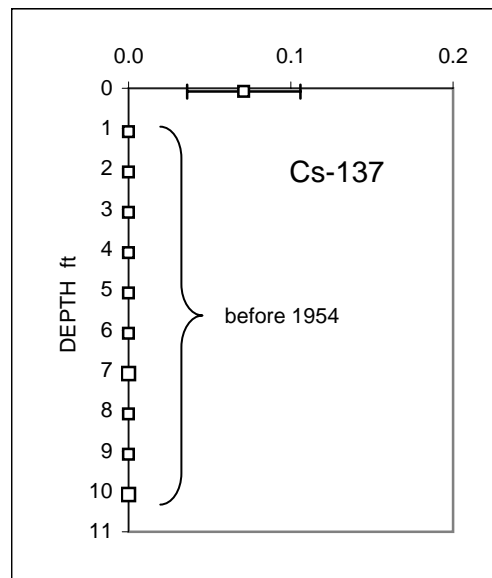
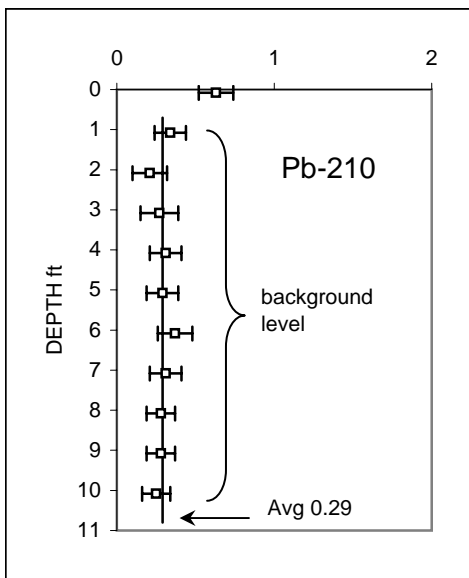
**CH2M HILL, Inc.**

Attn: Patrick Heins  
 Project 358932.PH.OF  
 NW Pipe 2007 Stormwater Project

**Core SED22**  
 Collected 07/24/08

**MASS SPEC SERVICES**

**Division of Geonuclear, Inc.**  
 Sediment Chronology Interpretation  
 MSS No. Pb0165



**Pb-210 Chronology**

Only the surface sample shows an elevated Pb-210 concentration which indicates relatively recent sedimentation. The samples from 1 to 10 foot depth all appear to be older than about 60 years when fallout Pb-210 would have decayed to near background levels.

**Cs-137 Chronology**

Only the surface sample shows detectable Cs-137. All the deeper samples appear to be older than 1954 when Cs-137 first became detectable in sediments.

**Interpretation**

Relatively recent sedimentation is limited to a layer at the surface which is less than 1.1 foot thick. This could be caused by a slow sedimentation rate. Because the 1954 Cs-137 horizon appears to lie between 0.1 and 1.1 feet depth, the calculated sedimentation rate is **between 0.002 and 0.020 ft/y (between 0.024 and 0.24 in/y)**.

Another possible interpretation is that at some time within the last decade, surface sediments were removed by a natural process such as water currents or by an artificial process such as dredging. This process could remove the elevated Pb-210 and the fallout Cs-137. After this hypothetical process, sedimentation at a moderate rate could add fallout Pb-210 and Cs-137 at the surface.

**Sample Data**

Depth ft	Description	Moisture Fraction	Radiometric results in pCi/g dry		
			Pb-210	Cs-137	
0.0 - 0.2	silt, a little fine sand	0.48	0.63 ± 0.11	0.071 ± 0.035	
1.0 - 1.2	silt, a little fine sand	0.32	0.34 ± 0.10	< 0.042	
2.0 - 2.2	silt, a little very fine sand	0.32	0.21 ± 0.11	< 0.032	
3.0 - 3.2	silt, a little very fine sand	0.34	0.27 ± 0.12	< 0.041	
4.0 - 4.2	silt, a little very fine sand	0.36	0.31 ± 0.10	< 0.042	
5.0 - 5.2	silt, a little very fine sand	0.32	0.29 ± 0.10	< 0.031	
6.0 - 6.2	silt, a little very fine sand	0.38	0.37 ± 0.11	< 0.031	
7.0 - 7.2	silt, a little very fine sand	0.38	0.31 ± 0.10	< 0.034	
8.0 - 8.2	silt, a little very fine sand	0.35	0.28 ± 0.09	< 0.035	
9.1 - 9.2	silt, a little very fine sand	0.34	0.28 ± 0.09	< 0.031	H. Jeter
10.0 - 10.2	silt, a little very fine sand	0.36	0.25 ± 0.09	< 0.030	03/30/09

Project/Contact Information								Total Number of Containers	Requested Analysis			THIS AREA FOR LAB USE ONLY					
Project #		358932.PH.OF							Radioisotope dating Pb-210 & Cs-137				Lab #	Pg 1	of 1		
Project Name		Northwest Pipe Co Sediment											Custody Review				
Report Copy to		Pat Heins											LIMS Verification				
Company Name/Contact		CH2M HILL Pat Heins									Cust Seals Y N Ice Y N						
Sampling		Type		Matrix		Client Sample ID	Depth	Preservative			Cooler Temperature						
Date	Time	Comp	Grab	Water	Soil			Sediment									
											Alternate Description		Lab ID				
7/10/08	13:50	X			X	SED21-0-A	0'	1	X								
7/10/08	13:52	X			X	SED21-0.5-A	0.5'	1					Hold				P60 165-1
7/10/08	13:54	X			X	SED21-1-A	1'	1	X								165-2
7/10/08	13:56	X			X	SED21-1.5-A	1.5'	1					Hold				
7/10/08	13:58	X			X	SED21-2-A	2'	1	X								165-3
7/10/08	14:00	X			X	SED21-2.5-A	2.5'	1					Hold				
7/10/08	14:02	X			X	SED21-3-A	3'	1	X								165-4
7/10/08	14:04	X			X	SED21-3.5-A	3.5	1					Hold				
7/10/08	14:06	X			X	SED21-4-A	4'	1	X								165-5
7/10/08	14:08	X			X	SED21-4.5-A	4.5'	1					Hold				
7/10/08	14:10	X			X	SED21-5-A	5'	1	X								165-6
7/10/08	14:12	X			X	SED21-5.5-A	5.5'	1					Hold				
7/10/08	14:14	X			X	SED21-6-A	6'	1	X								165-7
7/10/08	14:16	X			X	SED21-6.5-A	6.5'	1					Hold				
7/10/08	14:18	X			X	SED21-7-A	7'		X								165-8
7/10/08	14:20	X			X	SED21-7.5-A	7.5'						Hold				
7/10/08	14:22	X			X	SED21-8-A	8'		X								165-9
Relinquished By <i>Pat Heins</i> (Please sign and print name)								Date/Time									
Received By <i>Keith Noyes</i> (Please sign and print name)								Date/Time		<i>3/10/09 1300</i>							
Relinquished By <i>Keith Noyes</i> (Please sign and print name)								Date/Time		<i>3/11/09 09:51 Mass Spec Services</i>							
Received By (Please sign and print name)								Date/Time									
Special Instructions Each sample was taken from a 2" depth section of a core with a 3" diameter																	



Mass Spec Services  
Division of Geonuclear, Inc.

103 South Greenbush Road  
Orangeburg, New York 10962

CAPABILITIES AND EXPERIENCE OF  
MASS SPEC SERVICES

Mass Spec Services was founded in 2000 to continue several analytical capabilities of the Teledyne Isotopes / Teledyne Brown Engineering laboratory when it was relocated from New Jersey to Tennessee. The new company is a geology and radiochemistry laboratory which specializes in chronology studies and mass spectrometry analyses. All technical employees of the company are senior staff members from Teledyne who have more than 20 years experience in their specialty.

Sediment chronology work is based on the analysis and interpretation of Pb-210, Cs-137, and Be-7 on samples taken at various depths in sediment cores. The analytical results are used to derive sedimentation rates and calendar dates in the sediments. This information is used in the characterization and remediation studies of contaminated rivers, streams and estuaries, as well as for university research. The methods are described in a paper by H. W. Jeter which was published in the journal *Terra et Aqua: Determining the Ages of Recent Sediments Using Measurements of Trace Radioactivity*, *Terra et Aqua* 78, pp 21-28, March 2000. It can be viewed at the journal's website: [www.terra-et-aqua.com](http://www.terra-et-aqua.com) by using the archive option in the left hand margin.

In addition to sediment chronology work, the laboratory determines the ages of rocks and minerals by the potassium/argon method and by the rubidium/strontium method. These analyses are used in world-wide geological studies. The laboratory also performs boron isotopic measurements by mass spectrometry for various industrial applications.

More than 140 work orders in sediment chronology have been completed by the new laboratory. These include studies of the Kalamazoo River, Illinois River, Hudson River, Grasse River, Passaic River, Silver Lake, Cedar Creek, three bayous, Laurel Hill site in New York, Lower Duwamish Waterway in Seattle, Piles Creek, the Mare Island Naval Shipyard, and DePue Lake, as well as similar projects for 3 universities in Japan, government agencies in Japan and in the Philippines, and for a Japanese marine engineering firm.

Quality Control of sediment chronology analyses conforms to EPA guidelines for radioanalytical laboratories according to EPA-600/7-77-008. The Quality Control Manual addresses the contents of this publication on a section-by-section basis, using the same document organization and terminology.