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Site ID (Document ID):	NCD082362989
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STATE OF NORTH CAROLINA

Department of Environment, Health, and Natural Resources
Division of Solid Waste Management
Superfund Section

Tungsten Queen Mine
NCD 082362989

Phase II
Screening Site Inspection

References

August 1991

By:

Greenhorne & O'Mara, Inc.

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EPA ID NUMBER - NCD 082362989

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REFERENCE 1

Reference 1

Hecla Mining Company

February 26, 1985

Mr. Grover Nicholson
North Carolina Division of Health Services
P.O. Box 2091
Raleigh, North Carolina 27602

Re: Tungsten Queen Property
Hecla Mining Company

Dear Mr. Nicholson:

As you previously requested by phone, I am transmitting to you the only analytical data in our possession on the Tungsten Queen tailings ponds. We have also included a short summary on the history of the mine and a process flow diagram.

Because of the sensitive nature of the ore reserve estimates in the Meyertons report, Hecla Mining Company formally requests that this report be classified as proprietary and confidential.

If you should decide to conduct water sampling of the area, please contact me at 208-752-1251 so that I may arrange to accompany you and collect samples for our own analysis. Also, if you should have any further questions on the property, please give me a call.

Sincerely,

Colleen D. Kelley

Colleen D. Kelley
Environmental Supervisor

CDK/jr
Enclosure

P.O. Box 320, Wallace, Idaho 83873 • (208) 752-1251 • TELEX 326476

HISTORY

The Tungsten Queen Mine

The Tungsten Queen Mine is located at Tungsten, N.C., 16 miles northwest of Henderson, N.C. and 2 miles south of the Virginia state line. The ore occurs in a near vertical vein varying in width from a few inches to several feet. Huebnerite is the principal tungsten mineral and is accompanied by a minor amount of scheelite. Pyrite is the predominate metallic mineral found in the quartz veins and is accompanied by lesser amounts of chalcopyrite, galena, sphalerite, and tetrahedrite.

The property was discovered by Joseph and Richard Hamme in May 1942, while searching for strategic minerals for use in World War II. They worked the vein until 1944, then sold the property to Haile Mines, Inc. The mine was brought into production at a time when the U.S. was consuming twice as much tungsten as it was producing. The deposit was regarded as a unique national resource, and soon became the largest producer of tungsten in the country.

The mine reopened in May 1960, but closed again in 1963, when prices failed to improve.

An economic study of tungsten was conducted by Ranchers in 1966 which confirmed that the demand for tungsten was increasing. The Company's geologists immediately began a systematic search of existing tungsten deposits. The end result of this search was that, in 1968, Ranchers acquired an option to purchase the Hamme Mine, the most promising prospect encountered during this search.

The property was dewatered and ore reserves were evaluated. The results were reassuring, and in December the property was purchased and renamed the Tungsten Queen. Some 13 months later, after a period of intense activity which included repair and deepening of the main shaft, rehabilitation of existing drifts, and completion of engineering and metallurgical studies, ground was broken January 1970 for a new processing mill which was completed in August 1970.

By late October of 1970, the mill was in production. A very elementary process flowsheet for the mill is attached. Process flow problems coupled with falling tungsten prices forced the closure of the mill in August of 1971. Some of the alternatives examined after the shutdown included suggestions to modify the existing milling circuit to make it more efficient, and the possibility of reprocessing the previously deposited tailings. Although studies were done to examine both of these possibilities, nothing further than the initial studies were done.

The study, aimed at reprocessing the tailings, found the overall weight averaged tailings grade to be approximately 0.2% WO_3. Previous work done on the tailings indicated the overall average tailings grade to be on the order of 0.1% WO_3. A semi-quantitative analysis was performed on one of the higher grade tailings samples. The results of this analysis is attached. The amount of impounded tailings reported by this study was 2,038,000 tons.

RESCENT
X RAY
SPEC TROGRAPHIC
Analytical Laboratory

CONFIDENTIAL

718 Sherman Street (re
Denver, Colorado 80
Phone 255-9
Merlyn L. Salmon, Mana

XXXX QUALITATIVE
XXXX SEMI-QUANTITATIVE
____ QUANTITATIVE

ANALYTICAL REPORT

Job Number 18921
Page 2 of 2 Pages
Date 5 Nov 1975

TO:

R. Meyertons

SAMPLE: TQ Tailing Pit 10

NOTE: The values below are estimated percentage the metal equivalent of the indicated elements. check was made for elements with atomic numbers than 22 (below titanium).

Copper	0.15	Iron	6.3	Lanthanum	
Silver	0.008	Cobalt		Cerium	
Gold		Nickel	0.008	Praseodymium	
Zinc	0.17	Cesium		Neodymium	
Cadmium	0.006	Rubidium	0.11	Samarium	
Mercury		Barium	0.012	Europium	
Gallium		Strontium	0.005	Gadolinium	
Indium		Titanium	0.13	Terbium	
Thallium		Zirconium	0.011	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	0.18	Vanadium	0.008	Thulium	
Arsenic	0.003	Columbium		Ytterbium	
Antimony	0.020	Tantalum		Lutetium	
Bismuth		Chromium	0.007	Yttrium	
Selenium		Molybdenum	0.012		
Tellurium		Tungsten	0.34		
Bromine		Uranium			
Iodine		Manganese	0.13		

By Merlyn L. Salmon

NOTE: A PORTION OF THE [illegible]

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A PRELIMINARY ESTIMATE

OF

TUNGSTEN CONTENT OF TUNGSTEN QUEEN TAILING

FOR

RANCHERS EXPLORATION & DEVELOPEMENT CORPORATION

1776 MONTANO ROAD

ALBUQUEQUE, N.M. 87107

Ralph Meyertons

November 15, 1975

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INTRODUCTION AND SUMMARY

Ranchers Exploration and Developement Corporation requested a preliminary investigation of the the tungsten content of the Tungsten Queen Tailing pond.

Thirteen pits were excavated in the pond using a backhoe. Samples were taken from each pit for size and chemical analyses. A topographic map prepared by Aero Services Corporation for Ranchers in 1969 was used to estimate volume of material present. The pond is estimated to contain 2,038,000 tons of material averaging 0.218 % WO_3 for a total content of 445,600 STU WO_3. This is classed as a probable reserve rather than "proven" or "possible" reserve.

The tungsten is concentrated in the fine sands and slimes, with lessor concentrations in the coarse sands lying immediately below the former Tungsten Mining Corporation mill. A summary of the tungsten distribution is presented in table 1.

TABLE 1

DISTRIBUTION OF TUNGSTEN IN TUNGSTEN QUEEN TAILING

ZONE	QUANTITY TONS	SIZE ANALYSES % -400 mesh	TUNGSTEN ANALYSES % WO_3	CONTENT STU WO_3
1	80,000	4	0.239	19,100
2	600,000	6	0.088	52,900
3	600,000	45	0.251	150,600
4	383,000	80	0.410	157,000
5	375,000	5	0.176	66,000
TOTAL	2,038,000		0.218	445,600

The pits ranged from five to eight feet deep, and did nowhere reach to the bottom of the sand. Pond material appears to be about thirty feet deep over most of the pond, increasing to forty feet in narrow zone under the 1970 tailing dam.

The data indicates that the value of the tungsten in the tailing is contingent upon developement of a process to recover minus 400 mesh size hubnerite and separate it from sericite & muscovite.

SAMPLING PROCEDURES

Pits were excavated in the tailing pond material with a backhoe. Depth of the holes ranged from five to eight feet depth. The holes dug in sand filled rapidly with water and the sides collapsed as the hole was excavated. Water table ranged from one to two feet. Pits in fine sand and slime did not backfill or collapse since the fine material has a very low permiability. Slime holes remained open for days.

Material excavated from the pits was piled adjacent to each hole. Sands were sampled with an auger, taking about 15 auger samples per pit. Slimes were sampled by cutting a vertical channel in each side of the pit. Each sample contained about ten pounds of material.

Individual samples were dried, lumps broken by passing through a riddle and cut down with a Jones splittor. About 150 grams of each was sent for analyses to Hazen Research Inc. The analytical laboratory pulverized each sample to minus 200 mesh with a Blueler mill prior to analyses. The thiocyanate colorimetric method was used to make the tungsten determination.

TONNAGE FACTOR

The in place density of slime zone material was measured by a liquid displacement pocedure on solid pieces of slime. A factor of 23.5 cubic feet per ton was obtained. A factor of 20 cubic feet per ton was assumed for sands.

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TUNGSTEN CONTENT OF THE TAILING POND

An estimate of the tungsten content of the tailing pond was prepared from analyses of thirteen pit samples and volume data indicated on the Aero Services Corporation map, a portion of which is shown as figure 1. The map indicates elevation at a number of locations on the surface of the sands as well as the approximate location of the former 275 foot contour under the pond material.

The analytical data was grouped to represent four zones of different size and composition. Zone 1, represented by pit 13, contains coarse sand relativly rich in tungsten at the base of the former Tungsten Mining Corporation mill. Zone 2, with seven pits, contains coarse sand carrying one to two pounds tungstic oxide per ton. It is located below the dam built in 1970 to impound tailing from the Ranchers' mill. Zone 3, with two pits, represents fine sand containing about five pounds tungstic oxide per ton. Zone 4, with three pits, represents the slime zone. The slimes carry seven to nine pounds tungstic oxide per ton. A fifth zone was defined as that material under water impounded by the 1970 dam. Analyses of this zone was eastimated from pits 1 and 13.

Data and calculations used to estimate tungsten content of each zone are shown in table 2. Location of the sample pits is indicated by the numbered circles on the topographic map.

MINERALOGY

Coarse sands are composed mainly of quartz, with less than ten percent sericite and heavy minerals. Tungsten minerals are present as locked middling grains.

Fine sands and slimes are predominantly sericite and micas. Wood fiber constitutes one to three percent of the slime. Tungsten minerals, pyrite and other heavy minerals appear to be completly liberated.

CORRELATION OF TUNGSTEN ANALYSES WITH SIZE

The graph illustrating the relationship of tungsten analyses to minus 400 mesh size, figure 2, indicates that tungsten content is related to slime content of an individual sample. This is not true of zone 1, where middlings predominate. Size data are presented in table 3. Chemical analyses by Hazen Research and X Ray analyses by Fluo X Spec Laboratory are appended.

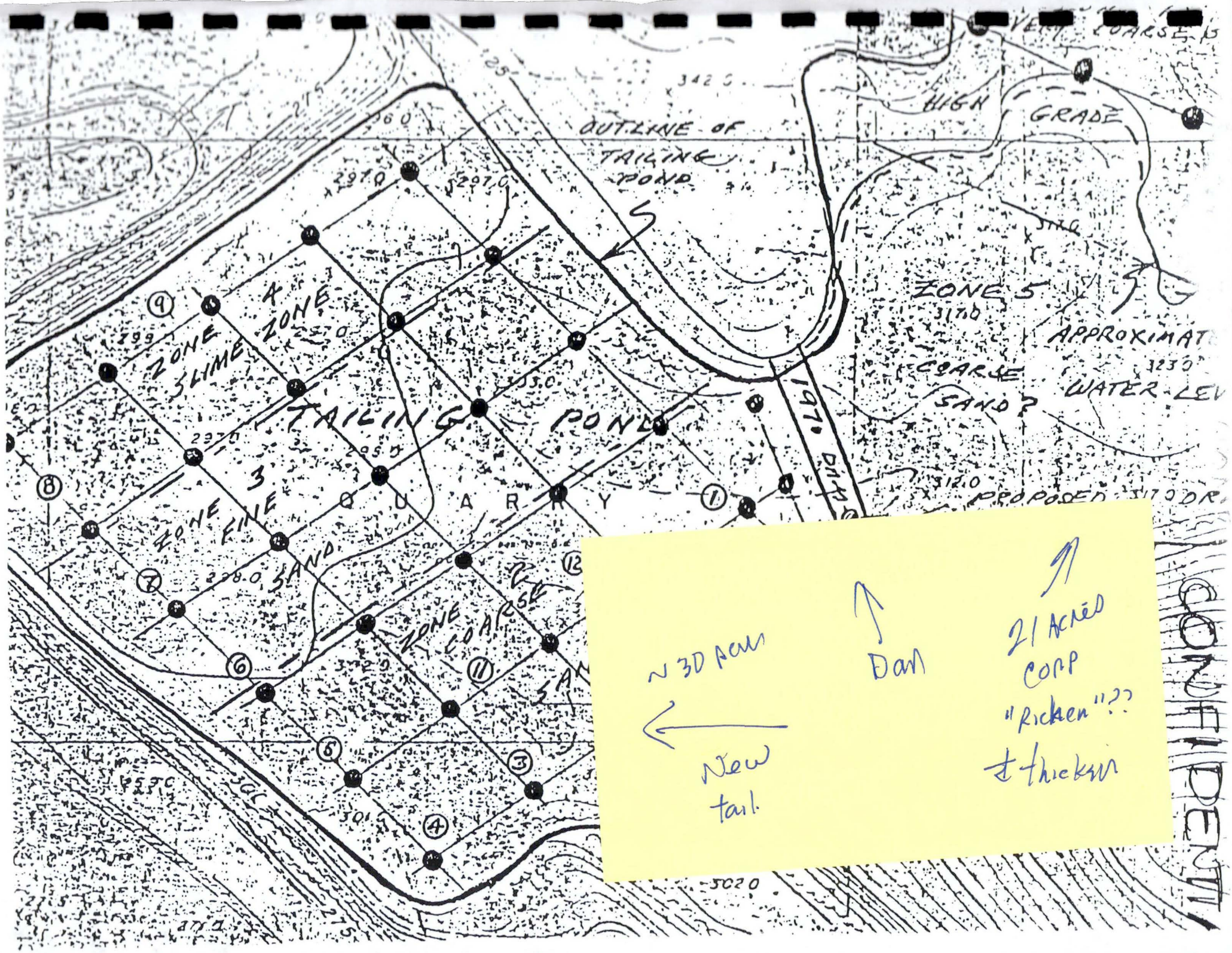
OUTLINE OF TAILING POND
HIGH GRADE
ZONE 5
COARSE SAND?
APPROXIMAT
WATER-LEV
ZONE 4
ZONE SLIME
TAILING POND
ZONE 3
ZONE FINE SAND
QUARRY
ZONE COARSE
1970 DAM
PROPOSED
N 30 Acres
New tail.
Dam
21 Acres
Corp
"Ricken"??
+ thicker

TABLE 2

TUNGSTEN QUEEN TAILING POND

ESTIMATION OF PROBABLE TUNGSTEN RESERVE

Material:	ZONE 1 Coarse Sand		ZONE 2 Coarse Sand		ZONE 3 Fine Sand		ZONE 4 Slime		ZONE 5 Coarse Sand		TOTAL
	PIT	% WO_3	PIT	% WO_3	PIT	% WO_3	PIT	% WO_3	PIT	% WO_3	
	13	0.239	1	0.114	6	0.249	8	0.389	1	0.114	
			2	0.088	7	0.253	9	0.388	13	0.239	
			3	0.065			10	0.453			
			4	0.099							
			5	0.112							
			11	0.069							
			12	0.070							
Average Analyses		0.239		0.0881		0.251		0.410		0.1765	0.218 7
Area of Zone, ft^2		160,000		400,000		400,000		300,000		250,000	
Estimated depth, ft		10		30		30		30		30	
Volume, ft^3		1,600,000		12,000,000		12,000,000		9,000,000		7,500,000	
Tonnage Factor, ft^3/t		20		20		20		23.5		20	
Quantity, tons		80,000		600,000		600,000		383,000		375,000	2,038,000
Tungsten Content, STU		19,100		52,900		150,600		157,000		66,000	445,600

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TABLE 3

TUNGSTEN QUEEN TAILING POND

TUNGSTEN AND SIZE ANALYSES - PIT SAMPLES

PERCENT WEIGHT

PIT	ANALYSES %WO_3	MESH	10	14	20	28	35	48	65	100	200	270	400	-400
1	0.114	Increm	0.3	2.7	8.1	10.9	12.4	16,2	15.6	13.2	13.5	1.9	1.7	3.4
		Cumul.		3.0	11.1	22.0	34.4	50.6	66.2	79.4	93.0	94.9	96.6	100.0
2	0.088	Increm	0.6	3.6	9.6		19.1	13.8	15.5	13.8	16.6	2.0	1.9	3.4
		Cumul.		4.2	13.8		32.9	46.7	62.3	76.1	92.7	94.7	96.6	100.0
3	0.065	Increm	0.6	3.7	7.9	9.2	8.1	12.2	14.1	15.1	20.2	2.8	2.6	3.5
		Cumul.		4.3	12.2	21.4	29.6	41.8	55.9	71.1	91.1	94.0	96.5	100.0
4	0.099	Increm					11.8	5.2	8.3	13.7	38.9	8.2	7.2	6.6
		Cumul.						17.0	25.3	39.0	77.9	86.1	93.4	100.0
5	0.122	Increm					2.7	1.3	3.1	8.7	40.1	11.6	14 1	18.3
		Cumul.						4.1	7.2	15.9	56.0	67.6	81.7	100.0
6	0.249	Increm					0.2	0.2	0.6	2.9	24.3	10.4	19.5	42.0
		Cumul.						0.4	1.0	3.8	28.2	38.5	58.0	100.0
7	0.253	Increm							0.1	0.5	17.0	12.8	21.1	45.5
		Cumul.								0.6	17.6	30.4	54.5	100,0
8	0.389	Increm					0.1	0.1	0.1	0.1	4.5	5.4	20.6	69.1
		Cumul.						0.2	0.3	0.4	4.9	10.3	30.9	100.0
9	0.388	Increm						0.1	0.1	0.2	2.6	2.9	13.5	80.6
		Cumul.							0.2	0.4	3.0	5.9	19.4	100.0
10	0.453	Increm							0.1	0.1	1.4	1.8	9.6	87.0
		Cumul.								0.2	1.6	3.4	13.0	100.0
11	0.061	Increm	0.1	4.2	5.2	9.1	9.2	7.1	13.2	15.5	24.2	3.6	3.6	4.0
		Cumul		4.3	9.5	18.6	27.8	34.9	48.1	63.5	88.7	92.3	96.0	100.0

TABLE 3 Continued

PIT	ANALYSES % WO_3	MESH	10	14	20	28	35	48	65	100	200	270	400	-400
12	0.070	Increm	0.6	3.8	8.1	9.5	9.2	12.7	14.9	14.8	18.4	2.4	2.3	3.3
		Cumul.		4.4	12.6	22.1	31.2	43.9	58.8	73.7	92.1	94.6	96.7	100.0
13	0.239	Increm	0.6	3.3	7.7	11.3	12.5	16.2	15.7	12.0	13.0	1.6	1.8	4.2
		Cumul.		3.9	11.7	23.0	35.5	51.7	67.4	79.4	92.3	94.0	95.8	100.0

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TUNGSTEN QUEEN TAILING

RELATIONSHIP OF TUNGSTEN CONTENT TO SIZE ANALYSES

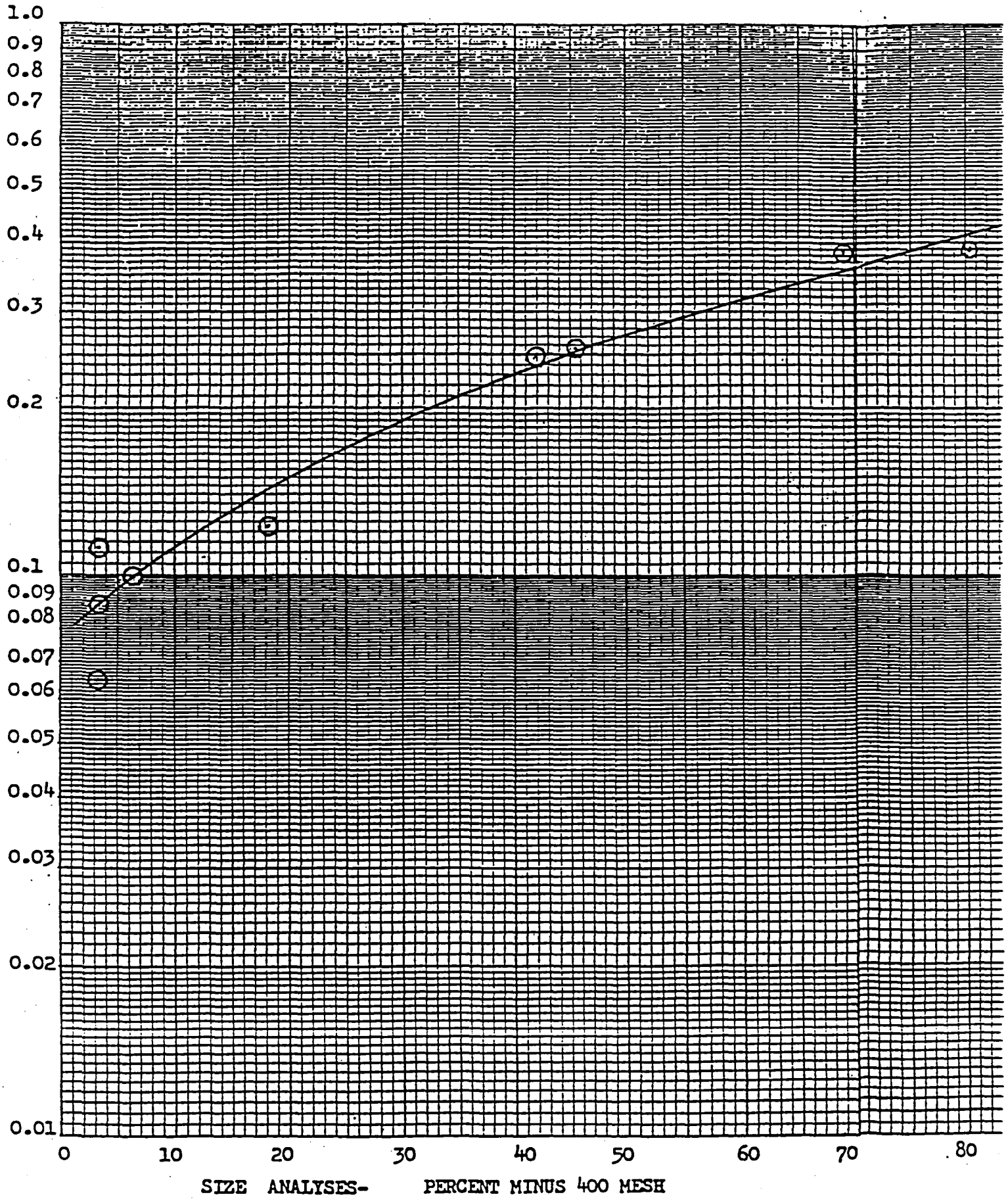


FIGURE 2

HAZEN RESEARCH, INC.

4601 INDIANA STREET
GOLDEN, COLORADO • 80401
TELEPHONE 303/279-4501

REPORT OF ANALYSIS

Mr. Ralph Meyertons
Box 160
Townsville, North Carolina 27584

Date: November 6, 1975

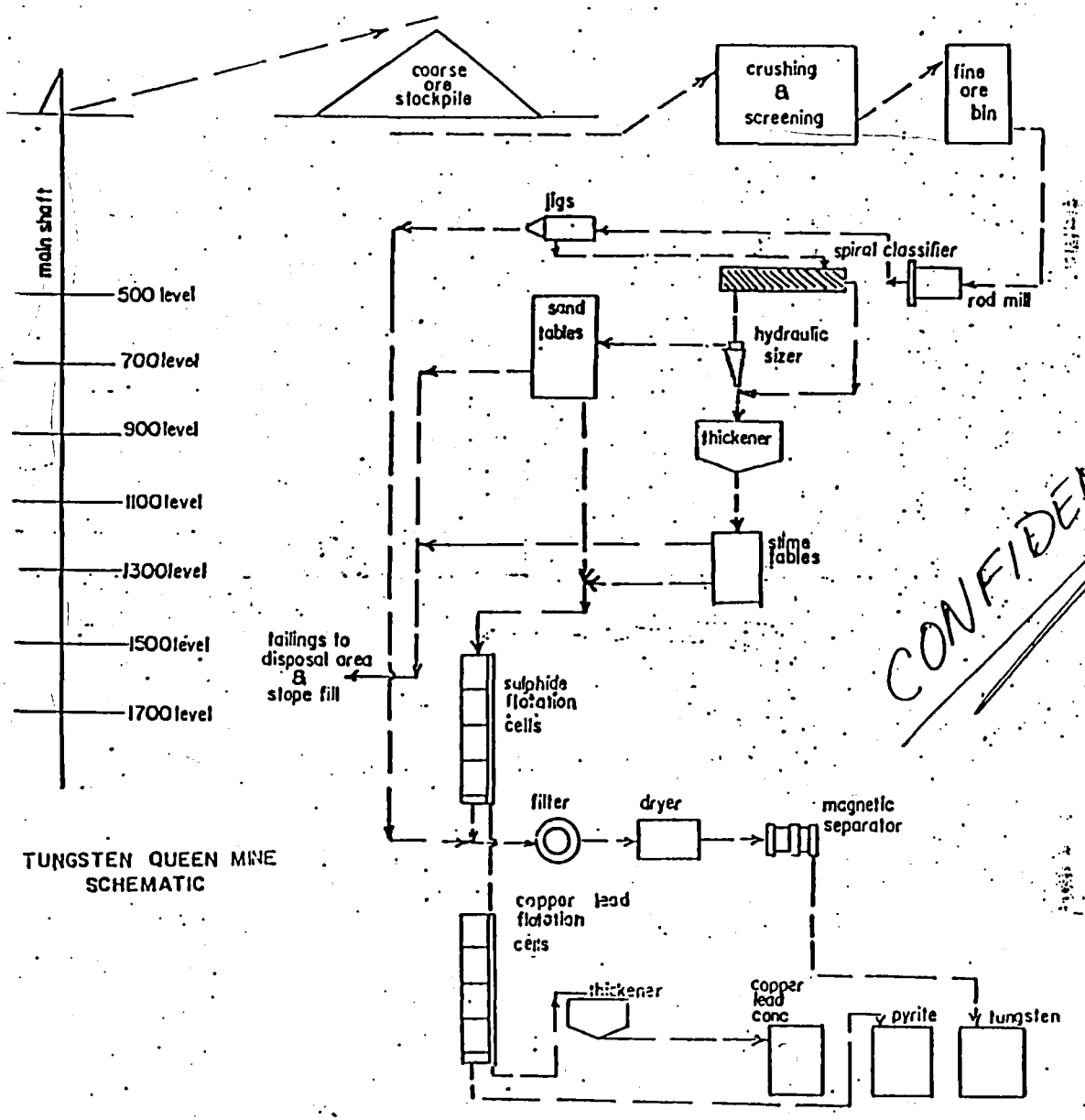
HRI Project No. 1618-04
HRI Series No. 8863
Samples Rec'd 10/31/75

Analysis No.	Sample Designation	% WO_3
8863-1	TQ Tail Pit 1	0.114
-2	TQ Tail Pit 2	0.088
-3	TQ Tail Pit 3	0.065
-4	TQ Tail Pit 4	0.099
-5	TQ Tail Pit 5	0.122
-6	TQ Tail Pit 6	0.249
-7	TQ Tail Pit 7	0.253
-8	TQ Tail Pit 8	0.389
-9	TQ Tail Pit 9	0.388
-10	TQ Tail Pit 10	0.453
-11	TQ Tail Pit 11	0.061
-12	TQ Tail Pit 12	0.070
-13	TQ Tail Pit 13	0.239

By: John C. Jarvis
John C. Jarvis
Manager, Analytical Laboratory

eam

DJB PCB FILE



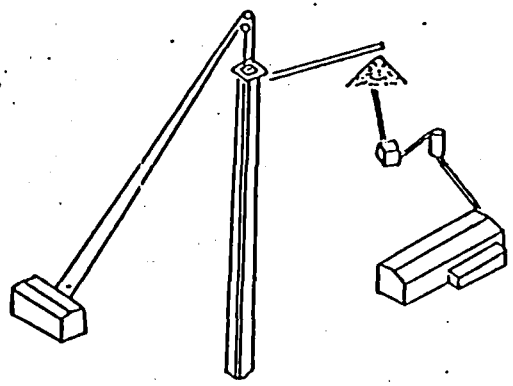
TUNGSTEN QUEEN MINE
SCHEMATIC

CONFIDENTIAL

RANCHERS EXPLORATION & DEVELOPMENT CORP.

TUNGSTEN QUEEN MINE

TUNGSTEN, N.C.



REFERENCE 2

Reference 2

KIRK-OTHMER

ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY

THIRD EDITION

VOLUME 23

THYROID AND ANTITHYROID PREPARATIONS
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VINYL POLYMERS

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TUNGSTEN AND TUNGSTEN ALLOYS

Tungsten (wolfram) [*7440-33-7*] is a silver-gray metallic element with atomic number 74 and appearing in Group VIB of the periodic table below chromium and molybdenum. Its atomic weight is 183.85. The five stable isotopes are given in Table 1. Tungsten has the highest melting point of any metal, 3695 K, a very low vapor pressure, and the highest tensile strength of any metal above 1650°C.

The name tungsten, meaning in Swedish heavy (tung) stone (sten), was first applied to a tungsten-containing mineral in 1755. The mineral was subsequently identified by Scheele in 1781 as containing lime and a theretofore unknown acid which he called tungstic acid. The mineral was then named scheelite. Metallic tungsten was first produced by the carbon reduction of tungstic acid in 1783 in Spain and termed wolfram. This designation became common usage in German. In 1957, the IUPAC chose the English name tungsten and the French name tungstene with wolfram as an alternative. However, W is still used as the chemical symbol.

During the nineteenth century, tungsten remained a laboratory material. The latter half of the century saw the development of high speed tool steels containing tungsten which became the prime use for the metal in the first half of the twentieth century. The pure metal itself was first used as a filament for electric lamps at the beginning of the twentieth century. After some limited success with paste-extruded tungsten powder, the Coolidge process was developed in 1908, by which a pressed and sintered tungsten ingot could be worked at high temperatures by swaging and drawing to form a fine-wire filament. This was a landmark in the development of the incandescent-lamp industry and, later, in the use of tungsten as a welding electrode. In the 1920s, the search for an alternative to expensive diamond dies required for the drawing of the tungsten wire led to the manufacture of cemented carbides now accounting for over half of the tungsten consumption in the world.

Tungsten is the eighteenth most abundant metal having an estimated concentration in the earth's crust of 1–1.3 ppm. Of the more than 20 tungsten-bearing minerals, only four are of commercial importance: ferberite (iron tungstate), huebnerite (manganese tungstate), wolframite (iron–manganese tungstate containing ca 20–80% of each of the pure components), and scheelite (calcium tungstate).

The WO_3 content of wolframite minerals varies from 76.3% in $FeWO_4$ to 76.6% in $MnWO_4$. They are commonly called black ores, as their colors range from black to brown. They occur as well-defined crystals to irregular masses of bladed crystals. They have Mohs hardness 5.0–5.5, a specific gravity 7.0–7.5 and tend to be very brittle. They

Table 1. Isotopes of Tungsten

Isotope	CAS Registry No.	Abundance, %
^{180}W	[*14265-79-3*]	0.14
^{182}W	[*142*[illegible]	26.41
^{183}W	[*14265-81-7*]	14.40
^{184}W	[*14265-82-8*]	30.64
[illegible]	[illegible]	28.41

are also weakly magnetic. Scheelite contains 80.6% WO_3. It is white to brown and strongly fluorescent in short-wave ultraviolet radiation. Scheelite occurs as massive crystals and small grains. It has Mohs hardness 4.5–5.0, a specific gravity 5.6–6.1, and is very brittle.

Tungsten deposits occur in association with metamorphic rocks and granitic igneous rocks throughout the world (see Table 2). Deposits in the People's Republic of China constitute >50% of the world reserves and over five times the reserves of the second largest source, Canada.

Table 2. World Tungsten Resources, 10^3 Metric Tons[a]

Country	Reserves	Other[b]	Total
North America			
United States	125	325	450
Canada	270	320	590
Mexico	20	5	25
other	1	2	3
Total[c]	*420*	*650*	*1070*
South America			
Bolivia	39	86	125
Brazil	18	40	58
other	2	2	4
Total[c]	*60*	*130*	*190*
Europe			
Austria	18	55	73
France	16	2	18
Portugal	24	30	54
USSR	210	320	530
UK	0.5	65	65
other	30	9	39
Total[c]	*300*	*480*	*780*
Africa			
Zimbabwe	5	5	10
other	5	14	19
Total[c]	*10*	*18*	*28*
Asia			
Burma	30	75	105
People's Republic of China	1400	2300	3700
Democratic People's Republic of Korea	110	140	250
Republic of Korea	80	80	160
Malaysia	15	30	45
Thailand	20	20	40
Turkey	75	14	89
other	5	5	10
Total[c]	*1700*	*2620*	*4320*
Oceania			
Australia	110	260	370
other	0.5	2	3
Total	*110*	*260*	*370*
World Total[c]	*2600*	*4200*	*6800*

[a] Ref. 1.
[b] Derived in collaboration with the U.S. Geological Survey.
[c] Data may not add to totals shown because of independent rounding.

Physical Properties

Some of the physical properties of tungsten are given in Table 3. Although in general these data are reliable, the original references should be consulted if precise values are required. For further property data, see refs. 12–14. For thermodynamic values, refs. 4, 15–16 should be consulted. Two values are given for the melting point. The value of 3660 K was selected as a secondary reference for the 1968 International Practical Temperature Scale. However, since 1961, the four values that have been reported ranged from 3680 to 3695 and averaged 3688 K.

Chemical Properties

The oxidation states of tungsten range from +2 to +6, and some compounds with zero oxidation state also exist. Above 400°C, tungsten is very susceptible to oxidation. At 800°C, sublimation of the oxide becomes significant and oxidation is destructive. Very fine powders are pyrophoric. Above 600°C, the metal reacts vigorously with water to form oxides. In lamps, in the presence of water vapor, a phenomenon called the water cycle occurs in which the tungsten is oxidized in the hottest part of the filament and then reduced and deposits on the cooler portion of the filament. Tungsten is stable in nitrogen to over 2300°C. In ammonia, nitrides form at 700°C. Carbon monoxide and hydrocarbons react with tungsten to give tungsten carbide at 900°C. Carbon dioxide oxidizes tungsten at 1200°C. Fluorine is the most reactive halogen gas and attacks tungsten at room temperature. Chlorine reacts at 250°C, whereas bromine and iodine require higher temperatures.

Tungsten is resistant to many chemicals. At room temperature, it is only rapidly attacked by a mixture of hydrofluoric and nitric acids. Attack of aqua regia is slow. Hot sulfuric, nitric, and phosphoric acids also react slowly. Sodium, potassium, and ammonium hydroxide solutions slowly attack tungsten at room temperature in the presence of an oxidizing agent such as potassium ferricyanide or hydrogen peroxide. Molten sodium and potassium hydroxide attack tungsten only moderately. The attack is accelerated by addition of an oxidizer. Tungsten resists attack by many molten metals. The maximum temperature of stability for various metals is given below:

Metal	Mg	Hg	Al	Zn	Na	Bi	Li
temperature, °C	600	600	680	750	900	980	1620

In contact with various refractories (qv), tungsten is stable in vacuum as shown below:

Refractory	Al_2O_3	BeO	MgO	ThO_2	ZnO_2
temperature, °C	1900	1500	2000	2200	1600

In reducing atmospheres, these temperatures are lower.

Manufacture

Mining and Beneficiation. Tungsten mines are generally small, producing less than 2000 metric tons of raw ore per day. Worldwide, there are only about 20 mines producing over 300 t/d. Many small mines are inactive at times, depending on the price of tungsten. They are primarily limited by the nature of the ore body and mining is almost exclusively by underground methods. Where open-pit mining has been em-

Table 3. Physical Properties of Tungsten

Property	Value	Ref.
crystal structure, bcc		
lattice constant at 298 K, nm	0.316524	
shortest interatomic distance at 298 K, nm	0.2741	
density[a] at 298 K, g/cm^3	19.254	
melting point, K		
	3660	2
	3695 ± 15	3
boiling point	5936	4
linear expansion per K		5
293–1395 K	$4.266 \times 10^{-6} (T - 293) + 8.479 \times 10^{-10} (T - 293)^2 - 1.974 \times 10^{-13} (T - 293)^3$	
1395–2495 K	$0.00548 + 5.416 \times 10^{-6} (T - 1395) + 1.952 \times 10^{-10} (T - 1395)^2 + 4.422 \times 10^{-13} (T - 1395)^3$	
2495–3600 K	$0.01226 + 7.451 \times 10^{-6} (T - 2495) + 1.654 \times 15^{-9} (T - 2495)^2 + 7.568 \times 10^{-14} (T - 2495)^3$	
specific heat, C_p, 273–3300 K, J/(mol·K)[b]	$24.94 \left(1 - \frac{4805}{T^2}\right) + 1.674 \times 10^{-3} T + 4.25 \times 10^{-10} T^3$	6
enthalpy, $H_T - H_{298}$, J/mol[b]	$24.94 \left(T + \frac{4805}{T}\right) + 8.372 \times 10^{-4} T^2 + 1.062 \times 10^{-10} T^3 - 7917.8$	6
entropy at 298 K, J/mol[b]	32.66	4
heat of fusion, kJ/mol[b]	46.0	7
heat of sublimation, 298.13 K, kJ/mol[b]	859.8	8
vapor pressure, 2600–3100 K, Pa[c]	$\log P_{Pa} = \frac{-45395}{T} + 12.8767$[d]	
thermal conductivity at K, W/(cm·K)		9
0	0	
10	97.1	
50	4.28	
100	2.08	
500	1.46	
1000	1.18	
2000	1.00	
3400	0.90	
electrical resistivity, ρ, 4–3000 K, nΩ·m	$\frac{0.04535\, T^{1.2472} - 2.90 \times 10^{-9}\, T^3}{1 + \frac{3.442 \times 10^5}{T^{2.98}}} + \rho o$	10
total emissivity, ϵ_H, 1600–2800 K	$-2.685790 \times 10^{-2} + 1.819696 \times 10^{-4} T^4 - 2.194616 \times 10^{-8} T^2$	11

[a] Determined by x-ray.
[b] To convert J to cal, divide by 4.184.
[c] To convert Pa to mm Hg, multiply by 0.0075.
[d] To convert $\log P_{Pa}$ to $\log P_{mm\ Hg}$, subtract 2.1225.

moved, underground methods are used as the deposit diminishes. Ore deposits usually range from 0.3 to 1.5% WO_3, with exceptional cases as high as 4% WO_3. Because of the low tungsten content of the deposits, all mines have beneficiation facilities which produce a concentrate containing 60–75% WO_3.

Since scheelite and wolframite are both friable, care must be taken to avoid over-grinding which can lead to sliming problems. The ores are crushed and ground in stages, and the fines are removed after each stage. Jaw crushers are employed for the first stage because the tonnages are low. Either jaw- or cone-type crushers are used for the second stage. In some cases, sizes are further reduced by rod milling. After each stage, the fines are removed and the coarse fraction is recirculated. Screening is the preferred method for fairly large particle sizes. Mechanical and hydraulic classifiers can also be used.

Since tungsten minerals have a high specific gravity, they can be beneficiated by gravity separation, usually by tabling. Flotation is used for many scheelites with fine liberation size but not for wolframite ores. Magnetic separators can be used for concentrating wolframite ores or cleaning scheelites.

Extractive Metallurgy. In extractive metallurgy, a relatively impure ore concentrate is converted into a high purity tungsten compound that can subsequently be reduced to metal powder. This is a particularly important step since high purity is required for all uses of tungsten except as a steel-alloying additive. The two most common intermediate tungsten compounds are tungstic acid, H_2WO_4, and ammonium paratungstate (APT), $(NH_4)_{10}W_{12}O_{41}.5H_2O$ (see Fig. 1). Most commercial processes today use APT. Depending on their source, the impurities in ore concentrates vary considerably, but those of most concern are sulfur, phosphorus, arsenic, silicon, tin, lead, boron, and molybdenum compounds.

The concentrate may be first pretreated by leaching or roasting. In scheelite concentrates, hydrochloric acid leaching reduces phosphorus, arsenic, and sulfur contents. Roasting of either scheelite or wolframites eliminates sulfur, arsenic, and organic residues left from the flotation process.

Next, the concentrate is digested to extract the tungsten. For lower grade scheelites, the high pressure soda process is commonly employed. The concentrate is first ground to <100 μm (−150 mesh) size, and then digested in an autoclave with sodium carbonate at ca 200°C at a pressure of >1.2 MPa (ca 11.9 atm):

$$NaCO_3 + CaWO_4 \rightarrow Na_2WO_4 + CaCO_3$$

The sodium tungstate solution is filtered from the resulting slurry. Similarly, in the alkali roasting process, the concentrate, either scheelite or wolframite, is heated with sodium carbonate in a rotary kiln at 800°C and then leached with hot water to remove the sodium tungstate. Wolframite ores are also decomposed by reaction with a sodium hydroxide solution at 100°C:

$$(Fe,Mn)WO_4 + 2\,NaOH \rightarrow (Fe,Mn)(OH)_2 + Na_2WO_4$$

The insoluble hydroxides are removed by filtration.

In another process, scheelite is leached with hydrochloric acid:

$$CaWO_4 + 2\,HCl \rightarrow CaCl_2 + H_2WO_4$$

In this case, the tungstic acid is insoluble and is removed by filtration and washed. For purification, it is digested in aqueous ammonia to give an ammonium tungstate

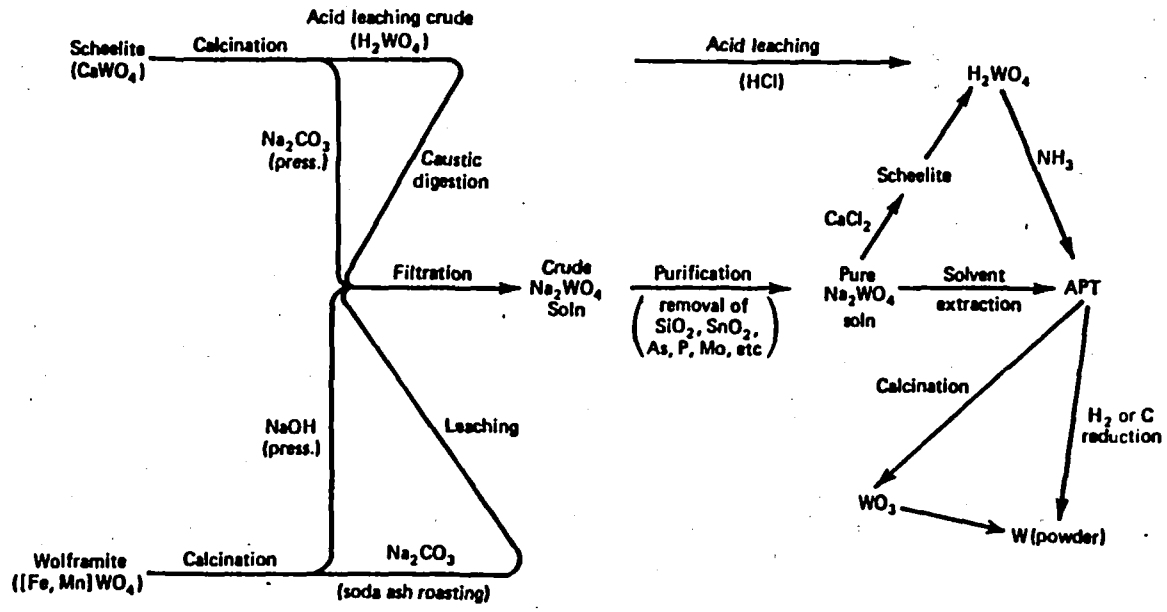

Figure 1. Production of tungsten materials from ores (17).

solution. Magnesium oxide is added to precipitate magnesium ammonium phosphates and arsenates. Addition of activated carbon removes collodial hydroxides and silica which are filtered. Evaporation of the ammonium tungstate solution gives APT. The evaporation is not carried to completion so that most of the impurities still present remain in the mother liquor and are removed.

The sodium tungstate from the soda and caustic processes is purified by first adding aluminum and magnesium sulfates to remove silicon, phosphorus, and arsenic, whereas sodium hydrogen sulfide removes molybdenum and other heavy metals. The pH is controlled and the impurities are removed by filtration. Then, the sodium tungstate is converted to ammonium tungstate by means of a liquid ion-exchange process. Since this involves the exchange of anions, most of the impurities which are present as cations are left behind. The ammonium tungstate solution is then evaporated to a fixed specific gravity under constant agitation to give APT.

Reduction to Metal Powder. The metal powder is obtained from APT by stepwise reduction with carbon or hydrogen. The intermediate products are the yellow oxide, WO_3; blue oxide, W_4O_{11} (which is actually a mixture of two oxides, $W_{18}O_{49}$ and $W_{20}O_{58}$); and brown oxide, WO_2. Because carbon introduces impurities, hydrogen is preferred. The reduction is carried out either in tube furnaces or rotary furnaces, heated by gas or electricity and having three separately controlled zones. A tube furnace consists of many tubes, 7–9 m long with a diameter of 80–150 mm. The boats containing the oxide have rectangular or semicircular cross sections and are 375–450 mm long. Both tubes and boats are made of Inconel or a similar heat-resistant alloy (see High temperature alloys). The boats are either manually or automatically stoked through the furnaces. Hydrogen is fed through each tube countercurrent to material flow. The hydrogen is recirculated and is scrubbed, purified, and dried, and new hydrogen added with each cycle. A rotary furnace consists of a large tube 3–>10 m long. It is partitioned into three sections to restrict powder movement down the tube and has longitudinal vanes to carry the powder. The tube is tilted at a small angle and rotated to provide continuous flow of powder through the furnace.

Ammonium paratungstate is decomposed to the yellow oxide by heating in air at 800–900°C. The blue oxide is obtained in a hydrogen atmosphere. Metal powder can be made directly from APT but particle size is better controlled with a two-stage reduction by controlling temperature, bed depth, and hydrogen flow. Since rotary furnaces have effectively a shallow bed, they tend to produce fine powders, and tube furnaces are preferred for the final reduction. Temperatures of 600–900°C are used to produce particle sizes of 1–8 μm.

For the production of lamp-filament wire, aluminum, potassium, and silicon dopants are added to the blue oxide. Some dopants are trapped in the tungsten particles upon reduction. Excess dopants are then removed by washing the metal powder in hydrofluoric acid. For welding electrodes and some other applications, thorium nitrate is added to the blue oxide. After reduction, the thorium is present as a finely dispersed thorium oxide.

Consolidation. Because of its high melting point, tungsten is usually processed by powder metallurgy techniques (see Powder metallurgy). Small quantities of rod are produced by arc or electron-beam melting.

For rod and wire production, ingots ranging in size 12–25 mm square by 600–900 mm are mechanically pressed at ca 200 MPa (20 atm). The bars are very fragile and are presintered at 1200°C in hydrogen to increase their strength. Sintering is done

by electric resistance heating. The ingot is mounted between two water-cooled contacts inside a water-jacketed vessel containing a hydrogen atmosphere. A current is passed through the ingot heating it to about 2900°C. This not only sinters the bar to a density of 17.2 to 18.1 g/cm^3 but also results in considerable purification by volatilization of the impurities. Larger billets for forging or rolling are isostatically pressed. The powder is placed in a plastisol bag, sealed tightly, and placed in a fluid in a high pressure chamber at 200–300 MPa (20–30 atm). Sintering takes place in an electric-resistance or induction-heated furnace at 2200°C in a hydrogen atmosphere. Densities after sintering are 17.8–18.1 g/cm^3. Small parts are made by mechanically pressing powder to which a lubricant has been added, followed by sintering at 1800–2100°C. For some applications, the sintering temperature can be lowered to 1500°C by the addition of small amounts of nickel or palladium which, however, embrittle the tungsten.

Metalworking. Tungsten is unusual as its ductility increases with working. As sintered or after a full recrystallization annealing, it is as brittle as glass at room temperature. For this reason, it is initially worked at very high temperatures and large reductions are required to achieve ductility. Furthermore, the low specific heat of tungsten causes it to cool very rapidly and any working operation requires rapid transfer from furnace to working equipment and frequent reheating during the working operation.

Swaging is historically the oldest process used for the metalworking of tungsten and is the method used first for the manufacture of lamp wire (Coolidge process). Swaging temperatures start at 1500–1600°C and decrease to ca 1200°C [illegible] worked. These temperatures are just below the recrystallization temperature and the working is, therefore, technically cold working. Reductions per pass start as low as 5% but then increase to as high as 40% as the size decreases. Total reductions of ca 60–80% are typical between annealings. For rod and wire production, rod rolling or more recently, Kocks rolling is also applied, at least in the initial breakdown stages. For rod rolling, oval-to-square sequences are used with reductions of 15–25% per pass. A Kocks mill consists of 8–12 roll stands in sequence, with each stand consisting of three rolls at 120° to each other producing a hexagonal cross section. The material is rolled through the stands at very high speeds to avoid cooling problems. Wire drawing starts at ca 4 mm and at temperatures as high as 1000°C, decreasing to 500°C for fine wire. The graphite lubricant required must be replaced after each draw pass. Reduction per pass is 35–40% at the start of drawing and drops to 7–10% in fine wire. For drawing dies, tungsten carbide is used to a diameter of 0.25 mm; for smaller diameters, diamonds are used.

For larger-diameter rod or plate, rolling is also employed with temperatures starting at 1600°C. However, when rolling large cross sections, most equipment is not powerful enough to handle large reductions and, as a result, large center-to-edge variations develop. These variations lead to center bursting or nonuniform structures after annealing. Large total size reductions overcome this effect. As the material is worked to larger reductions, the temperature is gradually lowered to avoid recrystallization during reheating. Once reductions of >95% are achieved, temperatures can be as low as 300°C.

Forging is also used on tungsten. Hammer forging is generally preferred to press forging because the temperature is better maintained with the higher rate of deformation. Temperature control is also critical here and even more critical with extrusion. Conventional extrusion of glass-coated billets is employed. A rather delicate balance

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Table 4. T[illegible]

[illegible]ear
late 1950s
1962
1977
1982

[illegible] To conver[illegible]
[illegible]9.07 kg W

Table 5. W[illegible]

Country
United Stat[illegible]
Australia
Austria
Bolivia
Brazil
Burma
Canada
Republic of [illegible]
Mexico
Portugal
Thailand
Turkey
other marke[illegible]
People's Re[illegible]
USSR
other Comm[illegible]
Total

[illegible] Ref. 18.

...ween heat loss in the billet and heat generation in the die is required for good re-...ts.

Economic Aspects

Because of fluctuation in the stockpiling policies of the General Services Ad-...nistration (GSA), tungsten prices in the past 25 years varied greatly, as shown in Table 4. The GSA has redefined its stockpile objective several times and it now stands ...26,810 metric tons, which is about a 3-yr supply for the United States.

World production is given in Table 5. The relatively stable market and the di-...ished influence of the GSA has improved the atmosphere for the development of ...w mines and expansion of existing facilities (see Table 6). This activity has led to ...n increase in the tungsten production capacity in North America from 4900 t in 1976 ...a projected 12,065 t in 1985, ca 20% of the world's capacity. The forms of tungsten produced, and the distribution by industry, are given in Tables 7 and 8, respectively. ...sten carbide products accounted for >65% of tungsten usage.

Primary U.S. tungsten requirements in the year 2000 are estimated to be 23,130 ...which represents an annual growth rate of 4.5%. For the rest of the world, 61,240 t

Table 4. Tungsten Prices, $/kg[a]

Year	WO_3	W
late 1950s	2.42	3.05
1962	0.88	1.10
...977	17.60	22.19
1982	10.63	13.40

[a] To convert $/kg to STU (short ton unit), multiply by 9.07: The STU contains 9.07 kg WO_3 or 7.19 kg W.

Table 5. World Tungsten Mine Production, 1980[a]

Country	Production, metric tons
United States (mine shipments)	3,200
Australia	3,400
Austria	1,000
Bolivia	2,800
Brazil	1,400
Burma	500
Canada	3,100
Republic of Korea	2,600
Mexico	200
Portugal	1,400
Thailand	2,000
Turkey	300
other market-economy countries	3,600
People's Republic of China	13,200
USSR	8,900
other Communist countries	2,200
Total	*49,800*

[a] Ref. 18.

Table 6. Tungsten Mine Expansions and Openings, 1975–1985[a]

Location	Mine	Year Opened	Year Expanded	Annual production, 10^6 kg 1975	1980	1985
Canada	Cantung		1976–1979	1.2	3.3	
Australia	King Island		1975–1977	1.2	2.0	
Australia	Mount Carbine		1977	0.1	0.7	
Thailand			1978	0.7	1.8	
Bolivia			1975	0.1	0.7	
Austria	Mittersil	1978			1.2	
Australia	Glen Innes	1979			0.6	
United States, Nevada	Emerson	1975			0.5	0.9
Brazil	Boca DeLaga	1977			0.5	
United States, California	Strawberry		1978		0.4	
Canada	Mount Pleasant	1982				1.5
United States, Nevada	Springer	1982				0.7
Canada	Mactung (estd)	1984				3.2
UK	Hemerdon (estd)	1985				1.8

[a] Ref. 19.
[b] Initial capacity.

Table 7. U.S. Production, Metric Tons Contained Tungsten[a]

Property	1975	1979
metal powder	2454	2738
WC powder	4526	5347
crushed and crystalline WC	759	1009
chemicals	992	363
others	210	149
Total	8931	*9606*

[a] Ref. 20.

Table 8. U.S. Tungsten Distribution, Metric Tons[a]

Property	1975	1979
machinery		
metalworking	5,755	6,092
construction and mining	2,161	2,277
transportation	954	1,036
lighting	626	658
electrical	375	395
chemical	165	177
other	111	116
Total	10,111	*10,751*

[a] Ref. 1.

are predicted for a 3.2% annual growth. The main area of growth is expected to be in cutting, wear-resistant, and hard-facing applications.

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specifications; A

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Uses

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Table 9. 1980 ASTM

ASTM number
B 110-68
B 130-76
B 150-67
B 162-68
E 139-68
E 397-73
F 73-76
F 204-76
[illegible]
F 288-76
F 290-68

Specifications; Analytical Methods

The 1980 ASTM specifications are given in Table 9.

Tungsten is usually identified by atomic spectroscopy. With optical emission spectroscopy, tungsten in ores can be detected at concentrations of 0.05–0.1%, whereas x-ray spectroscopy detects 0.5–1.0%. Scheelite in rock formations can be identified by its luminescence under ultraviolet excitation. In a wet method, the ore is fired with sodium carbonate and then treated with hydrochloric acid; addition of zinc, aluminum, or tin produces a beautiful blue color.

In the classical method for the quantitative analysis of tungsten in ore concentrates, the ore is digested with acid, the tungsten is complexed with cinchonine, purified, ignited, and weighed. More commonly, x-ray spectrometry is used and its accuracy is enhanced with tantalum as an internal standard. Plasma spectroscopy determines concentrations as low as 0.1 ppm in solutions and 10 ppm in solids. Atomic absorption is a very rapid method but not accurate enough for assay-grade analyses. The thiocyanate–tungsten color complex is specific for tungsten and used for colorimetric analyses for concentrations in the 0.1–1% range. It is not accurate enough for roasting concentrates.

Health and Safety Factors

There are no documented cases of tungsten poisoning in humans. However, numerous cases of pneumoconiosis have been reported in the cemented-carbide industry, but its cause, ie, WC or cobalt, has not been definitely determined. No cases have been reported among workers exposed to tungsten or its compounds. In fact, any hazards encountered seem to be caused by substances associated with the production and use of tungsten, eg, As, Sb, Pb, and other impurities in tungsten ores, Co fumes and dust in the carbide industry, and thoria used in welding electrodes. Exposure limits of 5 mg/m^3 insoluble tungsten and 1 mg/m^3 soluble tungsten have been established.

Uses

Tungsten is used in four forms: tungsten carbide, as an alloy additive, essentially pure tungsten, and tungsten chemicals. Tungsten carbide, because of its high hardness

Table 9. 1980 ASTM Tungsten Specifications

Number	Use
[illegible]	unalloyed sintered billets, bars, rods, and preforms for forging
[illegible]	particle-size distribution of refractory metal powders by turbidimetry
[illegible]	tungsten-base, high density metals
[illegible]	preparation of tungsten and tungsten alloys for electroplating
[illegible]	hydrogen loss of copper, tungsten, and iron powders
[illegible]	chemical analysis
[illegible]	wire for electronic devices and lamps
[illegible]	surface flaws in seal rod and wire
[illegible]	sag of wire
[illegible]	wire for electronic devices and lamps
[illegible]	round wire for winding electron-tube grid laterals

at high temperatures, is used for cutting tools, abrasion-resistant surfaces, and forming tools. This application accounts for ca 65% of tungsten usage, mostly in the form of cemented carbides. Tungsten carbide is produced by the reaction of tungsten powder with carbon black at 1500°C. The tungsten carbide is then milled and blended with 3–25% cobalt and pressed and sintered at ca 1400°C. Addition of tantalum and titanium carbides improves hardness and wear resistance. Cemented carbides are used for cutting tools, mining and drilling tools, forming and drawing dies, bearings, and numerous other wear-resistant applications.

About 16% of tungsten usage is as an alloy additive. Tungsten added to steels forms a dispersed tungsten carbide phase which imparts a finer grain structure and increases the high temperature hardness. The finer grain size improves toughness and produces a more durable cutting edge. For this type of application, up to 3% tungsten is used, usually with 1–4% chromium. For hot-work tool steels, up to 18% tungsten is added. Such steel, when quenched from a very high temperature and tempered, retains its hardness up to a red heat. Tungsten is also used as an additive to nickel- and cobalt-base superalloys. Here again, tungsten imparts high temperature strength and wear resistance (see High temperature alloys).

Metallic tungsten accounts for 16% of tungsten consumption. Frequently, tungsten is used because of its high melting point and low vapor pressure. The best known use is the manufacture of lamp filaments, where potassium, silicon, and aluminum dopants are added to the oxide. After sintering, about 60 ppm potassium is retained in small voids. During working, these voids are stretched into long stringers. Upon heating, they form rows of tiny bubbles which control grain boundary movement resulting in grains that are much longer than the wire diameter and whose boundaries are at a small angle to the wire axis. This structure is very creep resistant and allows the coil to maintain its shape throughout life. Tungsten is widely employed as an electron emitter because it can be used at very high temperatures. Thoria is added to reduce the work function and improve emission. It also improves arc stability and gives longer life to welding electrodes. Tungsten is used as the target in high intensity X-ray tubes. Other high temperature applications include furnace elements, heat shields, vacuum metallizing coils and boats, glass-melting equipment and arc-lamp electrodes. Because of its high elastic modulus and wear resistance, tungsten is used as the target in high modulus and wear resistance, tungsten is used in high speed impact printers. Its low thermal expansion makes it ideal for glass-to-metal seals and as base for silicon semiconductors. There are few tungsten-base alloys. W–Re alloys are used for thermocouple wire and for shock-resistant lamp filaments. Alloys of tungsten with various combinations of iron, nickel, and copper are called heavy alloys. They have the high density of tungsten but in a more machinable form. These are used as counterweights, armor-piercing penetrator cores, x-ray shielding, gyroscope rotors, dart bodies, and other high density applications. A similar material is made by infiltrating porous tungsten with copper or silver. Such alloys are used as electrical contact materials and rocket nozzles. Composite materials with barium and strontium compounds are used in electron-emitting devices.

Nonmetallurgical uses include brilliant organic tungsten dyes and pigments which can be used in a variety of materials. Tungstates are used as phosphors in fluorescent lights, cathode-ray tubes, and x-ray screens. Tungsten compounds are used as catalysts in petroleum refining.

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JAMES A. MULLENDORE
GTE Product Corp.

REFERENCE 3

Tungsten Queen

NCD 082362989

5-21-91

Reference 3

Hecla
MINING COMPANY
Centennial
1891 1991

DAVID E. HOLLAND
Environmental Specialist

6500 Mineral Drive
Box C-8000
Coeur d'Alene, Idaho 83814-1931
208/769-4100
FAX 208/769-4122

DIETZGEN

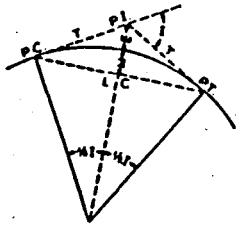
FIELD BOOK

DIETZGEN CORPORATION

EVERYTHING FOR DRAFTING
SURVEYING & PRINTMAKING

CURVE AND REDUCTION TABLES

Published by Eugene Dietzgen Co.



CURVE FORMULAS

1. Radius : $R = \frac{50}{\sin D/2}$
2. Degree of Curve: $D = 100 \frac{I}{L}$. Also, $\sin D/2 = \frac{50}{R}$
3. Tangent : $T = R \tan \frac{1}{2} I$. Also, $T = \frac{T \text{ for } 1° \text{ curve}}{D} + C$.
4. Length of Curve: $L = 100 \frac{I}{D}$
5. Long Chord : $L.C. = 2R \sin \frac{1}{2} I$.
6. Middle Ordinate: $M = R (1 - \cos \frac{1}{2} I)$
7. External : $E = \frac{R}{\cos \frac{1}{2} I} - R$. Also, $E = T \tan \frac{1}{4} I$.

EXPLANATION AND USE OF TABLES

Given P.I. Sta. 83+40.7, I = 45° 20′ and D = 6°30′ find:

Stations – P.C. = P.I. – T. $T = \frac{T \text{ for } 1° \text{ Curve}}{D} + C$. From Tables V and VI $T = \frac{2302.8}{6.5} + .197 = 368.32 = 3 + 68.32$. Sta. P. C. = 83+40.7 – (3+68.32) = 79+72.38. P. T. = P. C. + L, and $L = 100 \frac{I}{D} = 100 \frac{45.33}{6.5} = 697.38$ Therefore, P. T. = (79+72.38) + (6+97.38) = 86+69.76

Offsets—Tangent offsets vary (approximately) directly with D and with the square of the distance. From Table III Tangent Offset for 100 feet = 5.669 feet. Distance = 80 – Sta. P. C. = 27.62. Hence offset $= 5.66 \times \left(\frac{27.62}{100}\right)^2 = .432$ ft. Also, square of any distance, divided by twice the radius equals (approximately) the distance from tangent to curve. Thus $(27.62)^2 \div (2 \times 881.95) = .432$ ft.

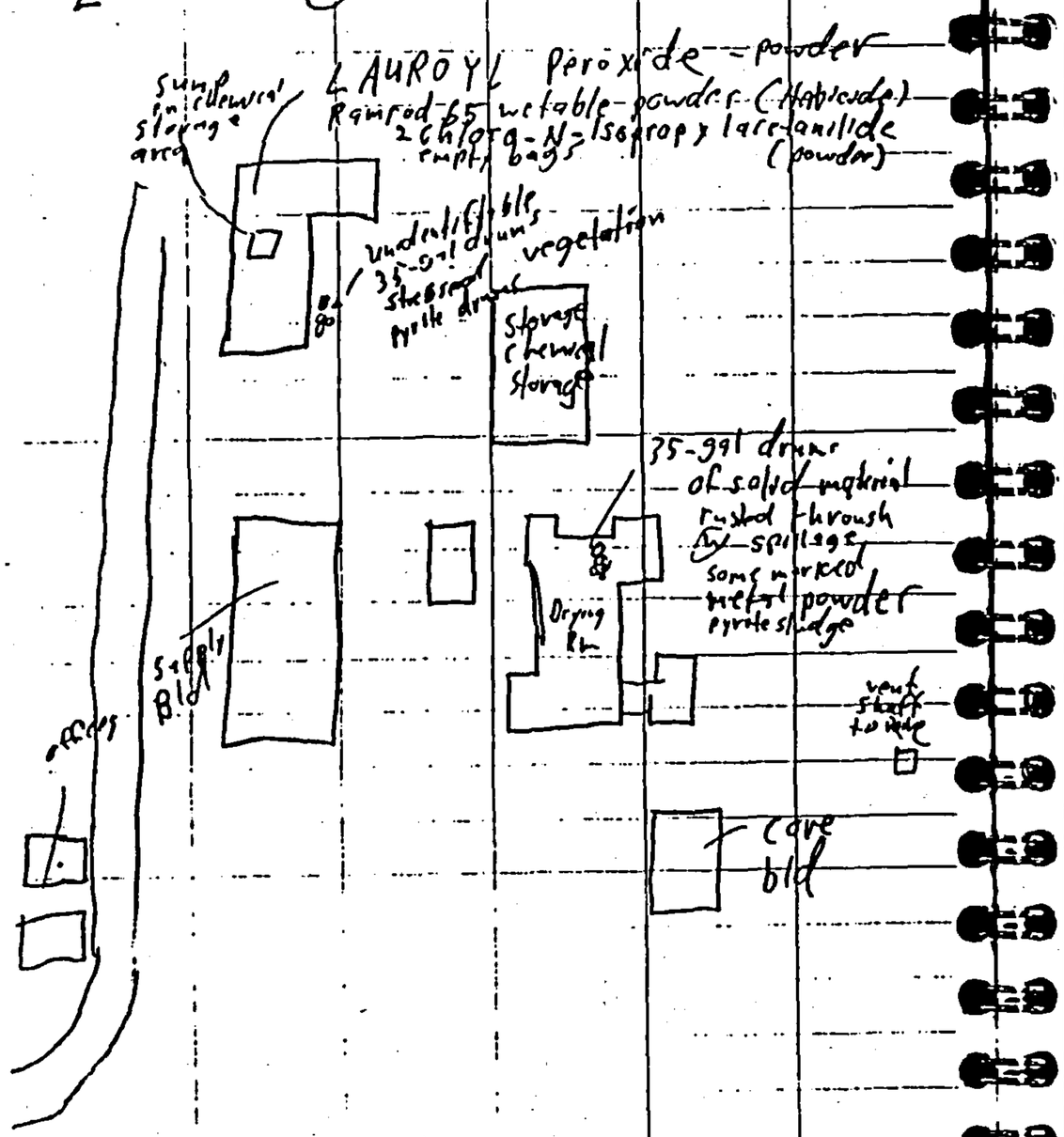
Deflections—Deflection angle = ½ D for 100 ft., ¼ D for 50 ft., etc. For "X" ft. Deflection Angle (in minutes) = .3 × X × D. For Sta. 80 of above curve Deflection Angle = .3 × 27.62 × 6.5 = 53.86′. Also Deflection Angle = diff. for 1 ft. from Table III × X = 1.95 × 27.62 = 53.86′. For Sta. 181 Deflection Angle = $53.86' + \frac{6° 30'}{2} = 4° 8.86'$.

Externals—From Table V for 1° curve, with central angle of 45° 20′, E = 479.6. Therefore, for 6° 30′ curve, $E = \frac{479.6}{6.5}$ + Correction from Table VI = 7.378 + .039 = 7.417.

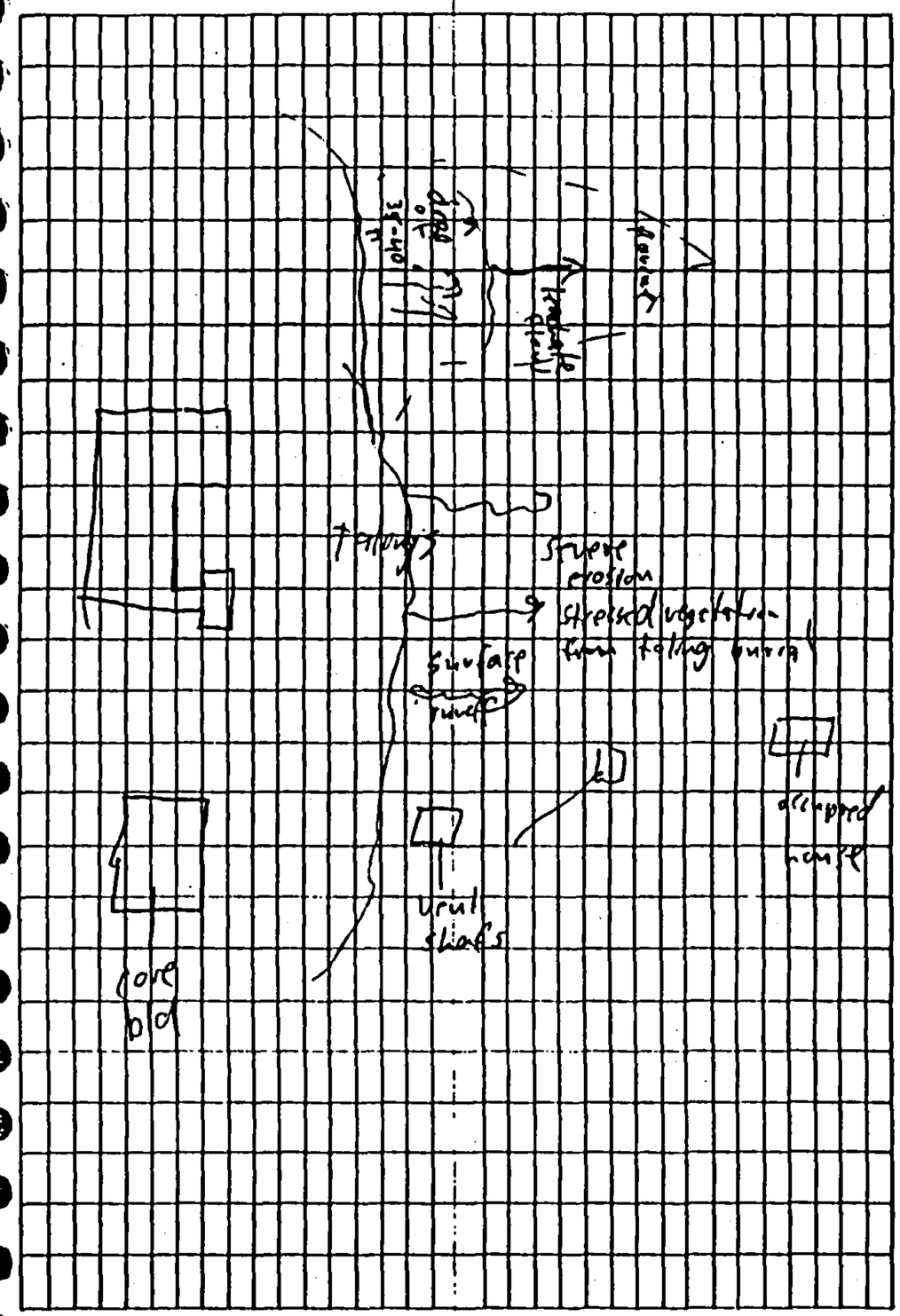
7:45 Arrive on-site

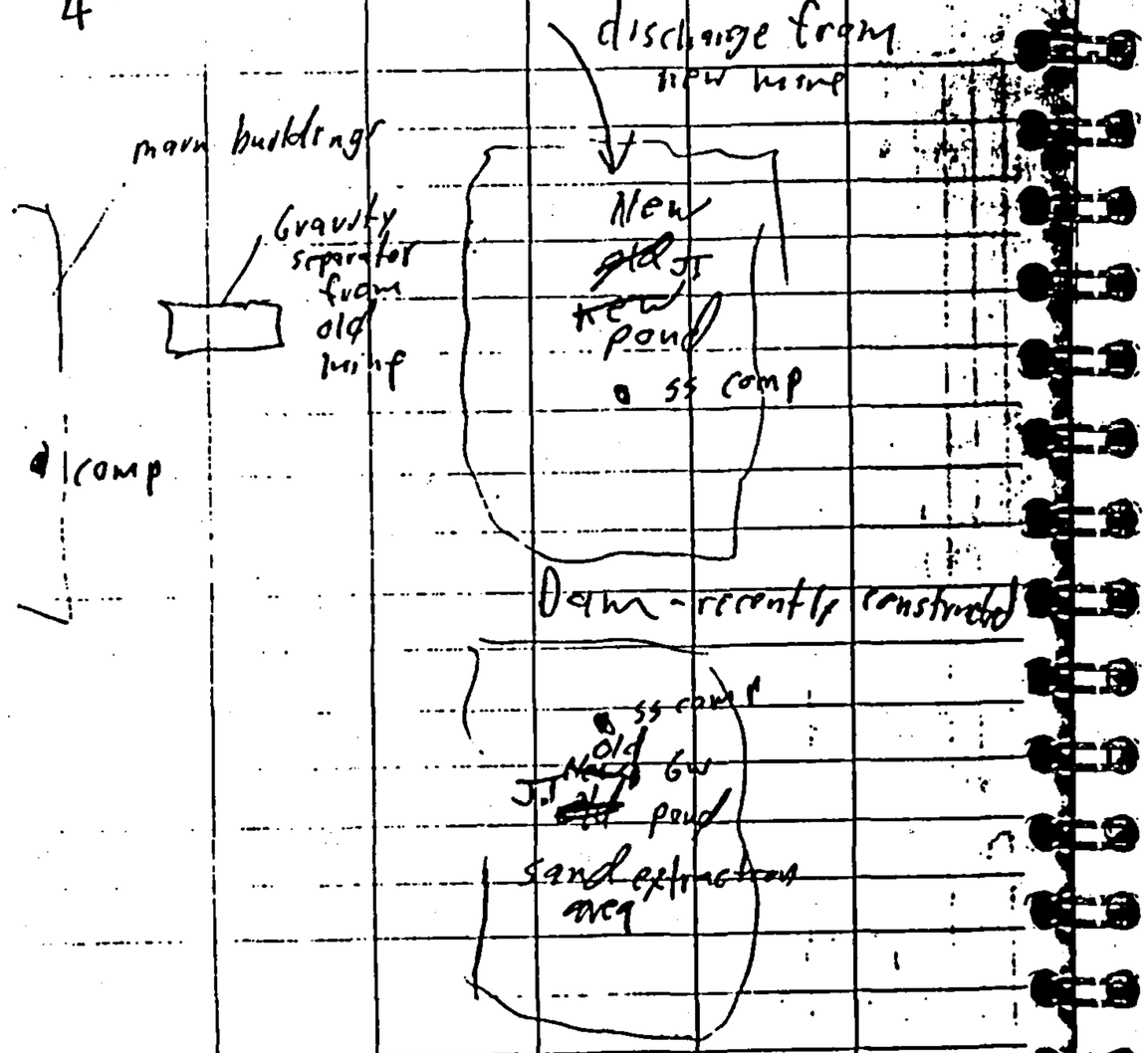
0900- sign-in. Refer to on-site Health + safety Plan for names.

2


water Tower
AUROYL Peroxide - powder
Ramrod 65 wetable powder (Alachlor)
2 chloro-N-Isopropyl lacetanilide (powder)
empty bags
Sump in chemical storage area
undetectable vegetation
35-gal drum stressed pyrite drum
Storage chemical Storage
35-gal drum of solid material rusted through spillage
some marked metal powder pyrite sludge
Drying Kiln
vent stack to air
Supply Bldg
access
core bld
core bld

3.


flow
tailings
severe erosion
stressed vegetation from tailing runoff
surface runoff
drill shafts
dropped core



0945:

Interview with Howard Compton
worked 22 years from the start

- sulfuric acid - good storage 3-4 drums

- drums of sludge - pyrite tailings
Drying room.

- Fill Tailings only

- Mines 1500 ft New
1600 ft old

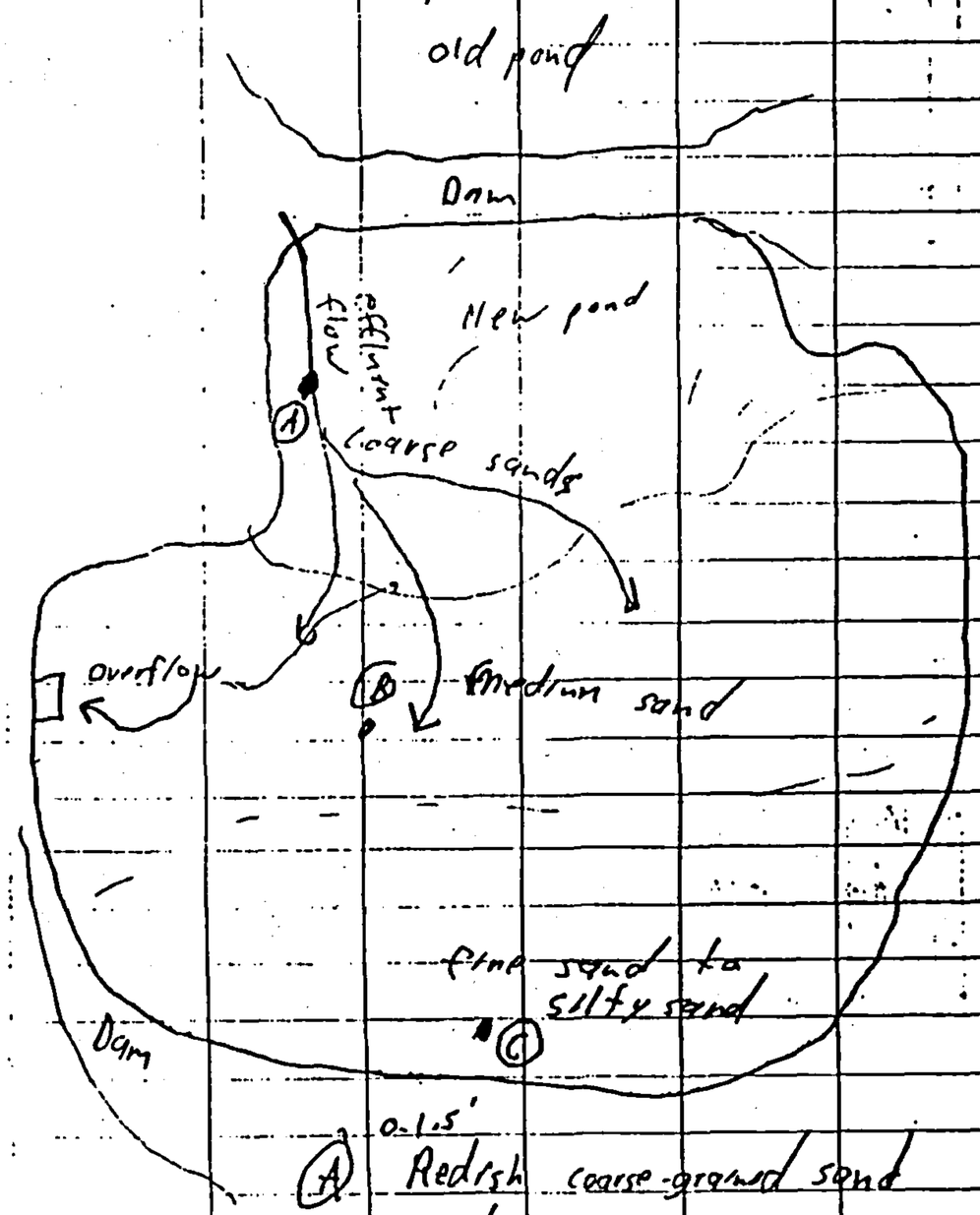
- Mine cuttings pumped out
in water

- Aggregates - very little

- Drum storage on-site predominantly
for tailings, pyrite

- sulfuric discharge at mill building
all treatment/separation at that
building

11:15 sample SS02 (comp)



A 0-1.5' Redish coarse-grained sand

B 0-1.5' white medium grained sand

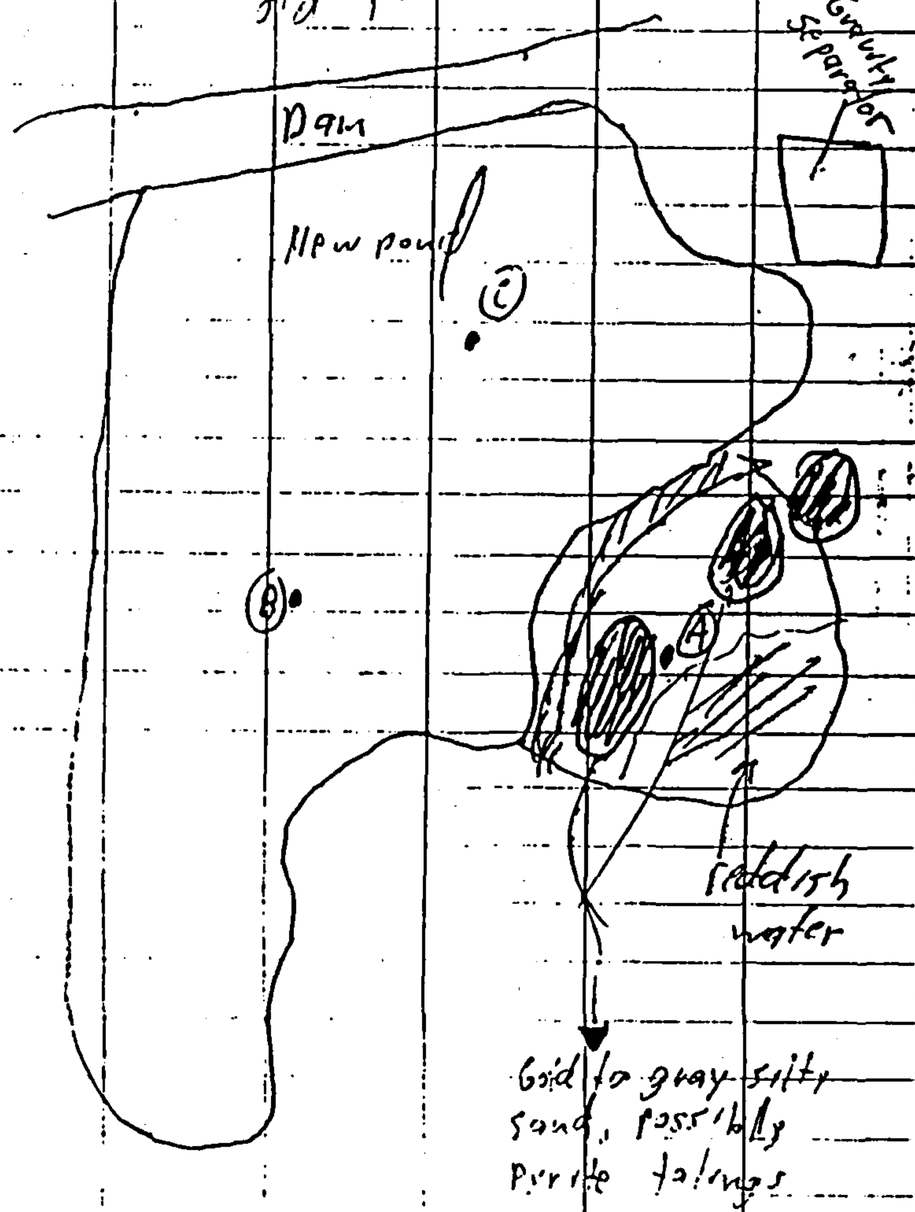
C 0-1.5' red fine silty sand
= VOC's

SS02 comp

VOC's were taken at location C due to lowest permeability rates.

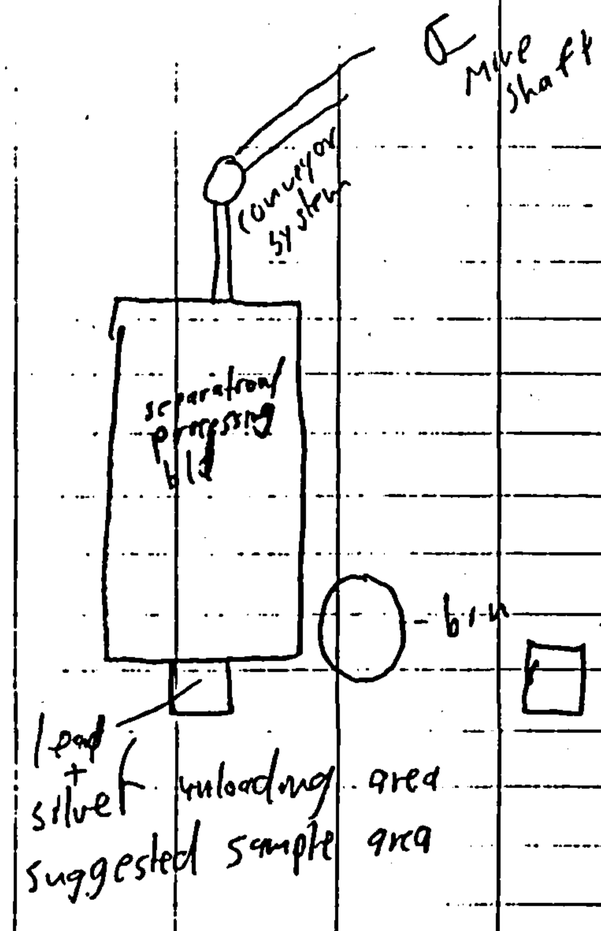
Sample locations choosen based upon differences in flow regimes which effect sedimentation. Coarse grained sands are found closest to the tailing discharge point with decreasing grain sizes away from the discharge point. Composite sampling locations are designed to characterize different areas and possible differences in associated metal concentrations.

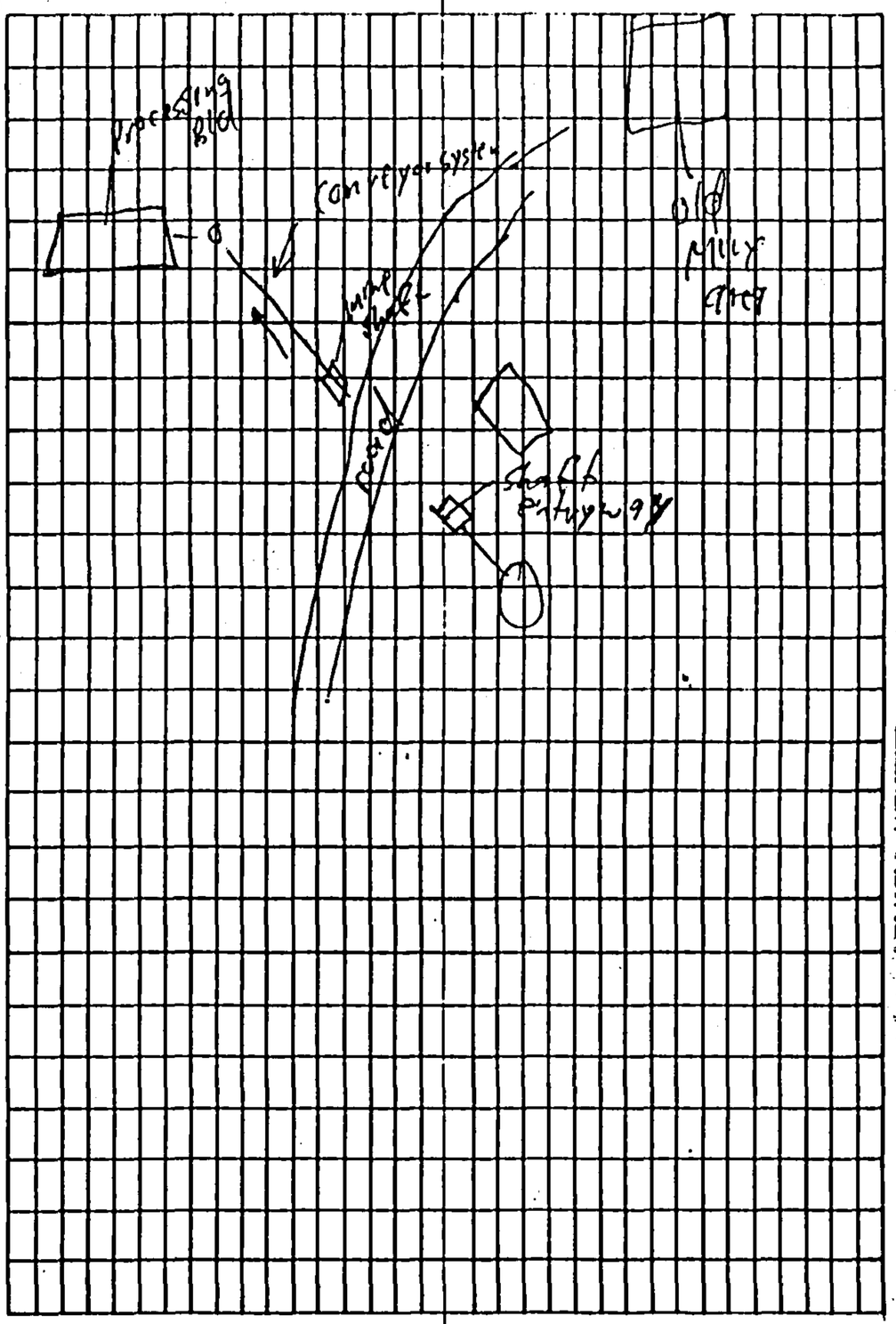
SS03 (comp)



Sample SS03 @ 13:45

14:00 returned New mill building area. Have suggested an additional surface soil sample (composite) to Harvey Allen to characterize possible metal contamination. Areas have been identified where pyrite, filled ash containing tailings have been stored. At this time, Harvey Allen has stated that he will consider this request.


Mine shaft
conveyor system
separation/processing bld
bin
lead + silver unloading area
suggested sample area


processing bld
conveyor system
mine shaft
old mill area
shaft entryway

Photos 8-10 on new roll is SS04 Note drums and dead trees.

Sodium Cyanide
Cyanamid - company name unknown
chemical 3 drums sealed. Not in acid bearing

- Potassium Amyl Xanthate
  - may cause irritation to skin.
- 100 lbs bags of powder substance: sodium sulfide anhydrous

Helene K. Kassel
5/2/19

Some of bags ripped. Powder substance on floor.
35 bags of sodium sulfite anhydrous.

Bags of dolomitic limestone. 12 bags. One broken.

1 drum - cardboard
Cyanamid
Superfloc 127
flocculant

Methyl Isobutyl
- 55 gallon drum
Sealed. Corrosion
on bottom. Have
leak soon.

1 10 gallon drum
of ethyl alcohol
Sealed & intact.

Helene R. Kessler
5/21/91

55 gallon drum almost full. Contents unknown. Drum in fairly good condition. Slightly dented.

Base of wall is corroding. Northeast end of building

Concrete floor in good condition. No cracks. No floor drains.

Photo 11 - Sodium cyanide & sodium sulfide & xanthate

Photo 12 - close up of extensively corroded drum

Helene L. Kassel
5/21/91

Photo 13 - corroded cell.

Length 60 feet
width 30 feet
height 15 feet

Approx 55 ~~gal~~
30- gallon drums.
Roof not intact. Rain causes drums to rust; however these drums do not contain haz. waste.

Chemicals used in mill process
Photo 14
← Hoading dock area right outside of corroded cell

Helene R. Kassel
5/21/91

is deteriorated.

Jerry taking soil sample (part of south outside wall where sodium cyanide was stored.

Smell strange odor outside of chemical storage building

20 - 20 gallon drums. Contents unknown. Drums in good condition.

1 drum of copper metal in main storage building.

Photo 15 - exterior of chemical storage bldg. Shows door does not close.

Helene L. Kassel 5/21/91

Photo 16
10 drums that looked like they leaked. 35 gallons wide open. Sludge leaking on floor. by the drums. contained metal powder. Jeff took picture of these.

4 - 10 gallon drums good condition
Reda #4 oil → lubricating oil

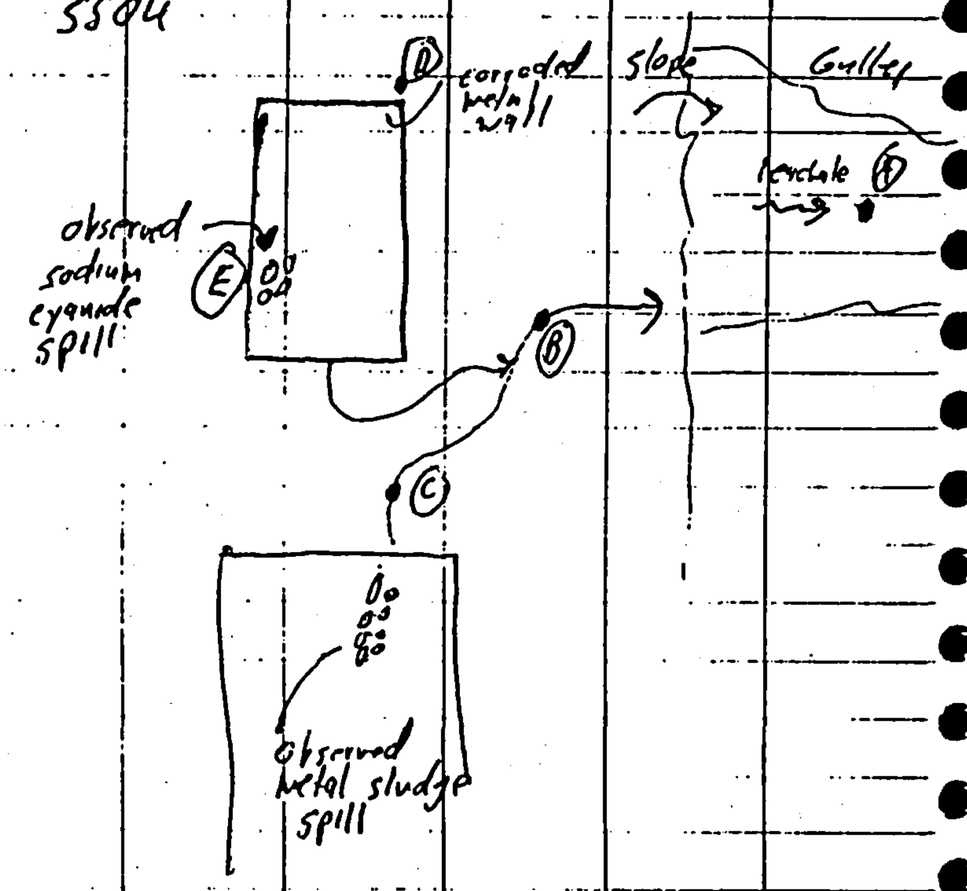
Photo 17 & 18 → main storage Bldg. Note collapsing roof no doors.
Photo 19 - chemical storage bldg. but leaking roof.

windows broken.
Helena R. Kaufman
5/21/91

Sample summary

1. SS01 - Control
2. SS02 - Lower pond (comp)
3. SS03 - upper pond (comp)
4. SS04 - Building storage area (comp)
5. GW02 - Lower pond

SS04



1600 Harvey Allen Has collected a surface soil sample (composite) around the new mill building. This is the location we've previously discussed in these notes

1740 Leave site
5-21-91

TUNGSTON QUEEN
MINE
NCD 08236029

403NW

DIETZGEN

H Kasser
5/21/91

7:45: arrive at site
8:00 sign-in
8:35: Calibrate equipment (HNu's)
8:30 Harvey went on tour of site w/ Health Department officials did not take Jeff Tyburski of G&O with him or David Holland of Hecla Mining Comp.

8:45 Reporter from Herald Sun showed up.

10:50 - started GW02 located in lower tailing pond. H2O water at 6 inches below ground surface.

0 - 3 ft - white sands
3 ft - gray sands

11:15 took HNO reading
0.8 ppm in breathing zone and in hole

11:50 completed sampling at GW02. Duplicate H_2O samples were collected at this location.

Temperature at GW02
21.9° C

Conductivity at GW02
0.731

Photos 1-8 → GW02 & SS02
Photo 9 - facing northeast looking at channel ~~[illegible]~~ separating two ponds

Photo 10 → facing south looking at lower dam

Photo 11 - 14 → on top of dam. Panaramic view of

Photo 15-20 → on top of dam. Panaramic views of

Background sample by freshwater tank

SS01 13:30

CONTROL SOIL SAMPLE (GRAB) TAKEN IN WOODS, APPROX. 300' WEST OF THE SOUTHWESTERN CORNER OF THE NEWER MILL BUILDING. SAMPLING POINT IS NEAR TOP OF HILL AND WELL ABOVE THE OPERATIONS AREA.

0-6" TOPSOIL
6"-2.5' REDISH TAN SANDY CLAY

5-21-91

Gentleman who has worked here will give Harley a site plan.

Left site at 1740 WS

REFERENCE 4

DATE: 18 February 1985

TO: File

FROM: Grover Nicholson GN

RE: PA for Tungsten Queen Mine

Today I spoke with Mr. Roger Kaufman and Ms. Colleen Kelley by telephone. Mr. Kaufman is the Manager of New Mines and Industrial Mineral Division and Ms. Kelley is the Environmental Supervisor for Hecla Mining Company. From them, I received the following information.

The Tungsten Queen Mine is now owned by Hecla Mining Company, P.O. Box 320, Wallace, Idaho 83873. The mine was previously owned by Ranchers Exploration and Development Corporation of New Mexico. The companies merged in July 1974 and became Hecla.

The mine was closed in 1972 and has not been reopened.

The caretaker of the mine is Mr. Howard Compton. He used to be an electrician at the mine and is now also the sheriff in Townsville.

GN/lw/2071A

REFERENCE 5

Date: 6 August 1987

To: File

From: Grover Nicholson

Re: Tungsten-Queen Mine NCD 082 362 989

Colleen Kelley, Environmental Supervisor for Hecla Mining Company, called today and spoke with Lois Walker. She said that the Tungsten-Queen Mine in Vance County, North Carolina has been sold by Hecla Mining Company to Atlas Mine and Mill. The contact person at Atlas is Shawn Fzambathy, N. 1115 Havanna Street, Spokane, Washington, 99202, telephone (509) 535-2039.

REFERENCE 6

Reference
Ronald H. Levine, M.D., M.P.H.
STATE HEALTH DIRECTOR

DIVISION OF HEALTH SERVICES
P.O. Box 2091
Raleigh, N.C. 27602-2091

Date: July 20, 1982

Mr. James M. Rosel
Ranchers Exploration and
Development Corporation
Box 6217
Albuquerque, New Mexico 87197

Re: Facility ID No. NCD082362989

Dear Mr. Rosel:

Based on information supplied by you we have processed and accepted at the State level your request for the facility identified with the above ID number to receive the indicated change in classification under RCRA:

Add As	Delete As	
☐	☒	generator
☐	☐	transporter
☐	☐	treater
☐	☐	storer
☐	☐	disposer
☐	☐	small generator

We are advising EPA of the change in your status. Please notify us if there is any further change in your operations which would again affect your status. Your EPA ID NO. is ☒ is not ☐ being cancelled.

Cordially,

O. W. Strickland, Head
Solid & Hazardous Waste Management Branch
Environmental Health Section

OWS

cc: John Herrmann
EPA Region IV
Emil Breckling

DHS Form 3048 3/82
Solid & Haz. Waste Mgt. Branch

REFERENCE 7

NUS CORPORATION
SUPERFUND DIVISION

PROJECT NOTES

TO: North Carolina Project Files

DATE: December 4, 1989

FROM: Joan Dupont

COPIES:

SUBJECT: North Carolina sites with no current RCRA classification

According to the North Carolina Department of Human Resources, Solid and Hazardous Waste Facilities (printout dated August 10, 1989), the following facility is not currently classified as a RCRA facility. Also, according to North Carolina RCRA file room personnel, the facility has not undergone a name change or, if the name has changed, the facility is not currently listed as a RCRA facility under its new name.

Site Name:

Tungsten Queen Mine
Townsville, Vance Co., North Carolina
NCD 082362989

REFERENCE 8

Reference 8

Hecla Mining Company

December 9, 1985

Mr. Grover Nicholson
Solid and Hazardous Waste Management Branch
Environmental Health Section
North Carolina Dept. of Human Resources
P. O. Box 2091
Raleigh, North Carolina 27602-2091

Re: Tungsten-Queen Mine

Dear Mr. Nicholson:

Thank you for the copy of the Preliminary Assessment of the Tungsten-Queen Mine. For your records, we have just completed the removal of two underground fuel storage tanks at the Tungsten-Queen. A 600-gallon gasoline tank, which was installated the time of construction of the new mill approximately 1970, was removed and found to be dry. No leakage was observed. A second tank, estimated to be approximately 12,000 gallons and dating back to the original mill construction approximately 1942, was also removed. This tank was approximately half full of what appears to be diesel fuel with probably some water dilution. Again, no leakage was observed. Arrangements are currently being made for removal and disposal of the remaining diesel fuel. If you should have any questions about the tanks, please give me a call.

Sincerely,

Colleen D Kelley

Colleen D. Kelley
Environmental Supervisor

CDK:jr
xc: Howard Compton

P.O. Box 320, Wallace, Idaho 83873 • (208) 752-1251 • TELEX 326476

REFERENCE 9

Reference 9

EPA

POTENTIAL HAZARDOUS WASTE SITE PRELIMINARY ASSESSMENT
PART 1 - SITE INFORMATION AND ASSESSMENT

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D082362989

II. SITE NAME AND LOCATION

01 SITE NAME (Legal, common, or descriptive name of site)	02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER
Tungsten Queen Mine	SR 1348 Near Tungsten, NC

03 CITY	04 STATE	05 ZIP CODE	06 COUNTY	07 COUNTY CODE	08 CONG DIST
Townsville	NC	27584	Vance	091	02

09 COORDINATES LATITUDE	LONGITUDE
36 30 50 . 0	078 28 25 . 0 (CCW)

10 DIRECTIONS TO SITE (Starting from nearest public road)
From Townsville, go NW on SR 1348 to Tungsten, NC.

III. RESPONSIBLE PARTIES

01 OWNER (If known)	02 STREET (Business, mailing, residential)
HECLA Mining Co.	PO Box 320

03 CITY	04 STATE	05 ZIP CODE	06 TELEPHONE NUMBER
Wallace	ID	83873	(208) 752-1251

07 OPERATOR (If known and different from owner)	08 STREET (Business, mailing, residential)

09 CITY	10 STATE	11 ZIP CODE	12 TELEPHONE NUMBER
			( )

13 TYPE OF OWNERSHIP (Check one)
☒ A. PRIVATE ☐ B. FEDERAL: _____ (Agency name) ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL
☐ F. OTHER: _____ (Specify) ☐ G. UNKNOWN

14 OWNER/OPERATOR NOTIFICATION ON FILE (Check all that apply)
☐ A. RCRA 3001 DATE RECEIVED: / / (MONTH DAY YEAR) ☐ B. UNCONTROLLED WASTE SITE (CERCLA 103 c) DATE RECEIVED: / / (MONTH DAY YEAR) ☒ C. NONE

IV. CHARACTERIZATION OF POTENTIAL HAZARD

01 ON SITE INSPECTION
☐ YES DATE / / (MONTH DAY YEAR)
☒ NO

BY (Check all that apply)
☐ A. EPA ☐ B. EPA CONTRACTOR ☐ C. STATE ☐ D. OTHER CONTRACTOR
☐ E. LOCAL HEALTH OFFICIAL ☐ F. OTHER: _____ (Specify)
CONTRACTOR NAME(S): _____

02 SITE STATUS (Check one)
☐ A. ACTIVE ☒ B. INACTIVE ☐ C. UNKNOWN

03 YEARS OF OPERATION
_____ BEGINNING YEAR | _____ ENDING YEAR ☒ UNKNOWN

04 DESCRIPTION OF SUBSTANCES POSSIBLY PRESENT, KNOWN, OR ALLEGED
This tungsten mine was closed in 1972 and has not been reopened. The mine does have a large tailings pond on the bank of Island Creek. It is suspected that metals contamination may be present.

05 DESCRIPTION OF POTENTIAL HAZARD TO ENVIRONMENT AND/OR POPULATION

V. PRIORITY ASSESSMENT

01 PRIORITY FOR INSPECTION (Check one. If high or medium is checked, complete Part 2 - Waste Information and Part 3 - Description of Hazardous Conditions and Incidents)
☐ A. HIGH (Inspection required promptly) ☐ B. MEDIUM (Inspection required) ☒ C. LOW (Inspect on time available basis) ☐ D. NONE (No further action needed, complete current disposition form)

VI. INFORMATION AVAILABLE FROM

01 CONTACT	02 OF (Agency/Organization)	03 TELEPHONE NUMBER
Colleen Kelley Envir. Super.	Hecla Mining Co.	(208) 752-1251

04 PERSON RESPONSIBLE FOR ASSESSMENT	05 AGENCY	06 ORGANIZATION	07 TELEPHONE NUMBER	08 DATE
Grover Nicholson/Lee Crosby	NC DHR/ DHS	Sol. & Haz. Waste Mgt. Br.	(919 733-2178	2/18/85 (MONTH DAY YEAR)

EPA FORM 2070-12 (7-81)

EPA

POTENTIAL HAZARDOUS WASTE SITE PRELIMINARY ASSESSMENT
PART 2 - WASTE INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D082362989

II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS

01 PHYSICAL STATES *(Check all that apply)*

- ☐ A. SOLID
- ☐ B. POWDER, FINES
- ☐ C. SLUDGE
- ☐ D. OTHER _____ *(Specify)*
- ☐ E. SLURRY
- ☐ F. LIQUID
- ☐ G. GAS

02 WASTE QUANTITY AT SITE *(Measures of waste quantities must be independent)*

TONS _____

CUBIC YARDS _____

NO. OF DRUMS _____

03 WASTE CHARACTERISTICS *(Check all that apply)*

- ☐ A. TOXIC
- ☐ B. CORROSIVE
- ☐ C. RADIOACTIVE
- ☐ D. PERSISTENT
- ☐ E. SOLUBLE
- ☐ F. INFECTIOUS
- ☐ G. FLAMMABLE
- ☐ H. IGNITABLE
- ☐ I. HIGHLY VOLATILE
- ☐ J. EXPLOSIVE
- ☐ K. REACTIVE
- ☐ L. INCOMPATIBLE
- ☐ M. NOT APPLICABLE

III. WASTE TYPE

CATEGORY	SUBSTANCE NAME	01 GROSS AMOUNT	02 UNIT OF MEASURE	03 COMMENTS
SLU	SLUDGE			
OLW	OILY WASTE			
SOL	SOLVENTS			
PSD	PESTICIDES			
OCC	OTHER ORGANIC CHEMICALS			
IOC	INORGANIC CHEMICALS			
ACD	ACIDS			
BAS	BASES			
MES	HEAVY METALS			

IV. HAZARDOUS SUBSTANCES *(See Appendix for most frequently cited CAS Numbers)*

01 CATEGORY	02 SUBSTANCE NAME	03 CAS NUMBER	04 STORAGE/DISPOSAL METHOD	05 CONCENTRATION	06 MEASURE OF CONCENTRATION

V. FEEDSTOCKS *(See Appendix for CAS Numbers)*

CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER	CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER
FDS			FDS		
FDS			FDS		
FDS			FDS		
FDS			FDS		

VI. SOURCES OF INFORMATION *(Cite specific references, e.g., state files, sample analysis, reports)*

EPA FORM 2070-12 (7-81)

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D082362989

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 ☐ A. GROUNDWATER CONTAMINATION
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ B. SURFACE WATER CONTAMINATION
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ C. CONTAMINATION OF AIR
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ D. FIRE/EXPLOSIVE CONDITIONS
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ E. DIRECT CONTACT
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ F. CONTAMINATION OF SOIL
03 AREA POTENTIALLY AFFECTED: _____ (Acres)
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ G. DRINKING WATER CONTAMINATION
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ H. WORKER EXPOSURE/INJURY
03 WORKERS POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ I. POPULATION EXPOSURE/INJURY
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D082362989

II. HAZARDOUS CONDITIONS AND INCIDENTS *(Continued)*

01 ☐ J. DAMAGE TO FLORA — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ K. DAMAGE TO FAUNA — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION *(Include name(s) of species)*

01 ☐ L. CONTAMINATION OF FOOD CHAIN — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ M. UNSTABLE CONTAINMENT OF WASTES *(Spills/runoff/standing liquids/leaking drums)* — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ 04 NARRATIVE DESCRIPTION

01 ☐ N. DAMAGE TO OFFSITE PROPERTY — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ O. CONTAMINATION OF SEWERS, STORM DRAINS, WWTPs — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

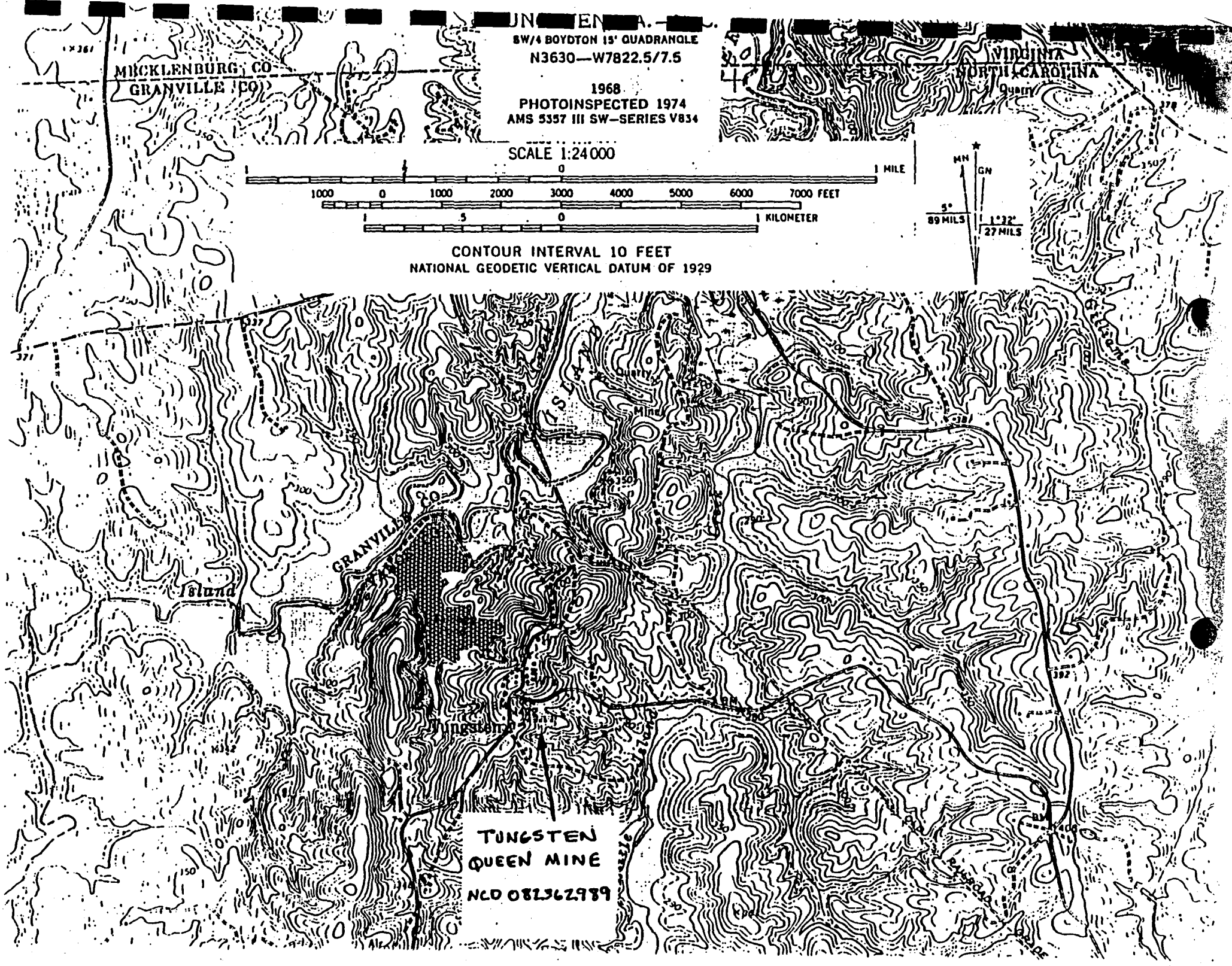
01 ☐ P. ILLEGAL/UNAUTHORIZED DUMPING — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

05 DESCRIPTION OF ANY OTHER KNOWN, POTENTIAL, OR ALLEGED HAZARDS

III. TOTAL POPULATION POTENTIALLY AFFECTED: _____

IV. COMMENTS

V. SOURCES OF INFORMATION *(Cite specific references, e.g., state files, sample analysis, reports)*


SW/4 BOYDTON 15' QUADRANGLE
N3630—W7822.5/7.5
1968
PHOTOINSPECTED 1974
AMS 5357 III SW—SERIES V834
MECKLENBURG CO
GRANVILLE CO
VIRGINIA
NORTH CAROLINA
SCALE 1:24000
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
MN
GN
5°
89 MILS
1°32'
27 MILS
GRANVILLE
Island
Tungsten
Mine
Quarry
TUNGSTEN
QUEEN MINE
NCD 082362989

REFERENCE 10

"...in the Rain"®

ALL-WEATHER

LEVEL

Notebook No. 311

...ish Queen Mine

...: F4-8911-99

...e, Vance County, North Carolina

Manager: Daniel L. Howard

Reference 10

LOGBOOK REQUIREMENTS
REVISED - NOVEMBER 29, 1988

NOTE: ALL LANGUAGE SHOULD BE FACTUAL AND OBJECTIVE

1. Record on front cover of the Logbook: TDD No., Site Name, Site Location, Project Manager.
2. All entries are made using ink. Draw a single line through errors. Initial and date corrections.
3. Statement of Work Plan, Study Plan, and Safety Plan discussion and distribution to field team with team members' signatures
4. Record weather conditions and general site information.
5. Sign and date each page. Project Manager is to review and sign off on each logbook daily.
6. Document all calibration and pre-operational checks of equipment. Provide serial numbers of equipment used onsite.
7. Provide reference to Sampling Field Sheets for detailed sampling information.
8. Describe sampling locations in detail and document all changes from project planning documents.
9. Provide a site sketch with sample locations and photo locations.
10. Maintain photo log by completing the stamped information at the end of the logbook.
11. If no site representative is on hand to accept the receipt for samples, an entry to that effect must be placed in the logbook.
12. Record I.D. numbers of COC and receipt for sample forms used. Also record numbers of destroyed documents.
13. Complete SMO information in the space provided.

We the undersigned have read and understand the work plan for this SSI, Phase I report for this facility.

Daniel L. Howard
Walter Kelley

11:09 Arrived at facility PH it slightly over cast, mild breeze, temp 45°F. The facility is not in operation. The facility is completely fenced in with a chain and lock on the front gate. The tailing pond is on the back side of the facility and could not be seen from the front gate.

11:30 The closest resident is on SR 1348 approximately 300 ft south of the facility. The ~~home~~ DLH residences are on private well water. There are about 4 houses across from the nearest house they all obtain their water from a well located at an abandon house approx 400 feet ~~with~~ DLH north.

Daniel Howard

[illegible] facility [illegible]

[illegible] the facility is [illegible] the Mine of the Kingdom take place approx 1 mile from the office area and warehouse, on the right side of the SR 14/18 there is a mound of rock that could have been taken from the mine.

12:21 While at the facility two men entered the second part of the facility in a truck.

12:26 There is a sign posted at the facility:

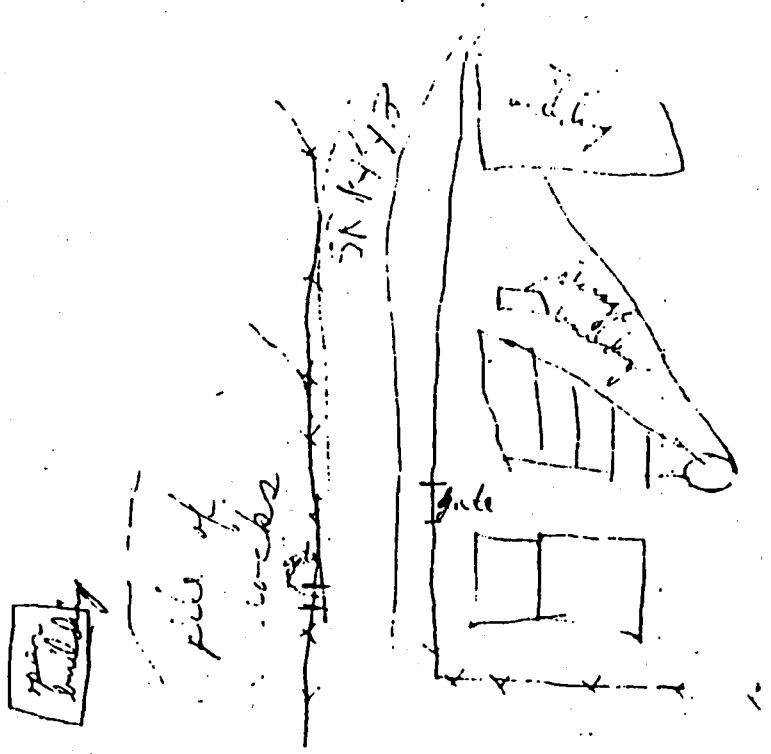
Posted
Hunting or discharging Firearms Prohibited Without Entry Permit
For Permit information Contact
Name Howard Campton

Property registered with Lance County Sheriff Department

Daniel Stewart

Daniel Stewart

000003



The Dr Lamoille area seems to be on private well water.

060005

Case No. _____

Low Concentration yes/no

Organics

	Media	Lab	Airbill
BOD	Soil		
	Water		
Inorganics			
	Soil	Lab	Airbill
	Water		

F4-8911-99
1-10-90 Daniel Howard
1115
Tungsten Queen Mine, Townsville
Vance County, North Carolina
Front of the facility general house warehouse in background, water tower and fence. Gate to the facility was locked

100 # F4-8911-99
1-10-90 Daniel Howard
1125
Tungsten Queen Mine, Townsville,
Vance County, North Carolina
Front of facility where the office laboratory and warehouse is located facing northwest.

F4-8911-99
1-10-90 Daniel Howard
1118
Tungsten Queen Mine, Townsville
Vance County, North Carolina
Picture showing Posted sign and lock on front gate. 2 pictures
A1 + A2.

000041

F 4-8911-99
1-10-90 Daniel Howard
1130
Tungsten Queen Mine, Townsville
Vance County, North Carolina
The Company who was to provide
facility before the Mining Company
bought it (3 pictures) B1, B2 + B3

F 4-8911-99
1-10-90 Daniel Howard
1120
Tungsten Queen Mine, Townsville
Vance County, North Carolina
Sign at front gate where the
office, laboratory and warehouse is
located (2 pictures) C1 + C2

F 4-8911-99
1-10-90 Daniel Howard
1127
Tungsten Queen Mine, Townsville
Vance County, North Carolina
Sign showing the name of the
community which is Tungsten
3 pictures D1, D2 + D3

F 4-8911-99
1-10-90 Daniel Howard
1210
Tungsten Queen Mine, Townsville
Vance County, North Carolina
Second part of the facility 2-3 mile
east of the office. This area looks like
the mine shaft location

F 4-8911-99
1-10-90 Daniel Howard
1214
Tungsten Queen Mine, Townsville,
Vance County, North Carolina
Build to the right of the mine
shaft

F-4-8911-99
1-10-90 Daniel Howard
1217
Tungsten Queen Mine, Townsville
Vance County, North Carolina
Building across the road from
mine shaft and a mound of rock
2 pictures E1 + E2

060043

F4-0711-99
1-10-70
1220

Daniel Howard

Tungsten Queen Mine, Townsville
Vance County, North Carolina
Lodgepole at entrance to building
across the road from the main shaft

000045

REFERENCE 11

NUS CORPORATION
1927 LAKESIDE PARKWAY
SUITE 614
TUCKER, GEORGIA 30084
404-938-7710

C-586-2-1-66

February 13, 1991

Mr. A.R. Hanke
Waste Programs Branch
Waste Management Division
Environmental Protection Agency
345 Courtland Street, N. E.
Atlanta, Georgia 30365

Date: _____
Site Disposition: _____
EPA Project Manager: _____

Subject: Screening Site Inspection, Phase I
Revision 0
Tungsten Queen Mine
Townsville, Vance County, North Carolina
EPA ID No. NCD082362989
TDD No. F4-8911-99

Dear Mr. Hanke:

FIT 4 conducted a Screening Site Inspection, Phase I for Tungsten Queen Mine, in Townsville, Vance County, North Carolina. The inspection included a review of state and EPA file material, completion of a target survey, and an offsite reconnaissance of the facility and surrounding area.

Tungsten Queen Mine is located on State Road 1348 in the northern portion of Vance County, 3.5 miles northwest of Townsville, North Carolina. The land surrounding the mine is predominantly rural and forested. The John H. Kerr Reservoir is located approximately 2 miles north of the mine (Refs. 1, 2).

The Tungsten Queen Mine is an approximately 150-acre property which consists of several buildings and a guard house, along with a mine shaft, associated processing mills, and several tailing ponds (Ref. 3). An office building is located approximately 0.5 mile south of the pond area (Refs. 1, 3). The mine is owned by Atlas Mine and Mill of Spokane, Washington, and is not currently active (Refs. 3, 4).

The mine was discovered by Joseph and Richard Hamme in May 1942, and was the largest U.S. producer of tungsten for a 2-year period. They subsequently sold the property to Haile Mines, Inc., and in December 1968, the mine was acquired by Ranchers Exploration. This company repaired and deepened the shaft and rebuilt the processing mill. In July 1974, Ranchers merged with Hecla Mining Company, which retained ownership of the mine until July 1987. At that time the mine was sold to the present owner. Records indicate that the mine was worked for a total of 6 years between 1942 and 1972 (Refs. 2, 5, 6).

While the mine was in operation, huebnerite and scheelite mineral ores (containing tungsten) were extracted from an underground vertical vein. The crude ore was crushed and milled, and then concentrated via gravity separation, hydraulic sizing, and magnetic separation. Tailings remaining were used as slope fill and placed in tailing ponds (Ref. 5). Common impurities in tungsten tailings

are sulfur, arsenic, tin, lead, boron, and molybdenum (Ref. 7). An analysis of the tailings, conducted for Ranchers Exploration in November 1975, detected significant amounts of copper, zinc, lead, iron, and titanium. The estimated amount of tailings present at Tungsten Queen Mine is 2,038,000 tons (Ref. 5).

In 1985, two underground fuel storage tanks were removed from the Tungsten Queen Mine property. One tank was dry, and the other contained diesel fuel. No leakage near the tanks was observed (Ref. 8).

Tungsten Queen Mine was initially classified as a RCRA generator, but was deleted as a generator, with its EPA identification number canceled, in July 1982 (Ref. 9). Currently, it is not a RCRA-classified facility (Ref. 10).

The Tungsten Queen Mine facility is located in the Piedmont-Blue Ridge Physiographic Province, which is typified by a thick regolith overlying fractured crystalline and metamorphosed sedimentary rocks. The bedrock found in the area is typically a granite or migmatic gneiss (Ref. 11, pp. 251, 252). Vance County has a moist, temperate climate with a net annual rainfall of 3 inches, and a 1-year, 24-hour rainfall of 2.8 inches (Refs. 12, pp. 23, 48; 13, p. 93).

The aquifer normally used in this area is the crystalline rock aquifer located commonly at depths between 75 and 200 feet below land surface (bls) (Ref. 14, p. 330). There were three wells drilled at the mine itself. These wells were drilled into Granodiorite and ranged from 31 to 142 feet deep. One well had a water level of 17 feet bls (Ref. 15, pp. 91, 92). The regolith that develops above granites and gneisses is the layer of lowest hydraulic conductivity between the surface and the aquifer. Sediments of this type have been shown to have hydraulic conductivities that range between 1×10^{-5} and 1×10^{-7} cm/sec (Ref. 16, p. 29).

There are no known municipal water systems within a 4-mile radius of the mine. Residents obtain their potable water from private wells, and the nearest private well is 300 feet south of the mine property on State Road 1348 (Ref. 3). A total of 1,159 people (305 houses x 3.8 persons/household) utilize private wells within 3 miles of the mine, with an additional 1,098 persons (289 houses x 3.8 persons/household) between a 3- and 4-mile radius (Ref. 1). Two noncommunity wells were also identified between 3 and 4 miles from the mine. The Vance City Wildlife Club well serves 35 persons, and the New Hope Elementary School well serves 400 people (Ref. 17). The total number of groundwater targets identified within 4 miles of the mine is 2,657.

Surface water run-off from the tailings ponds would travel 100 feet northwest into Island Creek. This creek flows northeast 4.2 miles and then enters the John H. Kerr Reservoir, which flows to the east for the remainder of the 15-mile, surface water pathway (Ref. 1). The surface water intake for Henderson, North Carolina, is located on a portion of the John H. Kerr Reservoir that is not located along the surface water pathway (Refs. 1, 18). The town of Boydton, Virginia, does not use the reservoir as a potable water source (Ref. 19). The creek and reservoir are used for various recreational purposes, including boating, swimming, and fishing. Fishing is both recreational and commercial (Refs. 1, 20). The Elm Hill State Game Management area is located on the northern side of Kerr Reservoir. A freshwater wetland area is located along the surface water pathway, 0.8 mile northeast of the mine (Ref. 1). The property is completely fenced and locked, with posted "no trespassing signs" (Ref. 3). The estimated population within the study area is as follows (number of houses on topographic map x 3.8 persons/household): 0-1 mile, 80 people; 1-2 miles, 346 people; 2-3 miles, 733

people; and 3-4 miles, 1,098 people (Ref. 1). The nearest residence is 300 feet south of the mine property on State Road 1348 (Ref. 3). The nearest school is in Townsville on Highway 39, approximately 3.2 miles southeast of the mine (Ref. 1). The bald eagle (Haliaeetus leucocephalus) is a state-designated endangered species found in Vance County. No critical habitats have been identified in the area (Refs. 21, 22).

Due to the amount of waste present in the tailing ponds and the large number of groundwater and surface water users, FIT 4 recommends that Phase II of this Screening Site Inspection be conducted at the Tungsten Queen Mine on a high-priority basis. If you have any questions or comments regarding this assessment, please feel free to contact me at NUS Corporation.

Very truly yours,

Jancie S. Hatcher

Jancie S. Hatcher
Project Manager

JH/tb

Enclosures

Approved:

Bob Donaghue

REFERENCES

1. U.S. Geological Survey, 7.5 minute series Topographic Quadrangle Maps of North Carolina and Virginia: Clarksville South, VA.-N.C. 1968 (Photorevised 1981), Tungsten, VA.-N.C. 1968 (PR 1974), Townsville, N.C. 1970, Stovall, N.C. 1981, scale 1:24,000.

2. Potential Hazardous Waste Site Preliminary Assessment (EPA Form 2070-12) and attachments for Tungsten Queen Mine. Filed by Grover Nicholson, North Carolina Division of Health Services, February 18, 1985.

3. NUS Corporation Field Logbook No. F4-1937 for Tungsten Queen Mine, TDD No. F4-8911-99. Documentation of facility reconnaissance, January 10, 1990.

4. Grover Nicholson, North Carolina Division of Health Services, memorandum to file, August 6, 1987. Subject: Tungsten Queen Mine.

5. Colleen D. Kelley, Hecla Mining Company, letter and attachments to Grover Nicholson, North Carolina Division of Health Services, February 26, 1985. Subject: Tungsten Queen Mine.

6. Grover Nicholson, North Carolina Division of Health Services, memorandum to file, February 18, 1987. Subject: Preliminary Assessment for Tungsten Queen Mine.

7. James A. Mullendore, "Tungsten and Tungsten Alloys," Kirk-Othmer Encyclopedia of Chemical Technology, 3rd edition, Vol. 23 (New York: John Wiley & Sons, 1983).

8. Colleen D. Kelly, Hecla Mining Company, letter to Grover Nicholson, North Carolina Division of Health Services, December 9, 1985. Subject: Tungsten Queen Mine.

9. O.W. Strickland, North Carolina Division of Health Services, letter to James M. Rosel, Ranchers Exploration and Development Corporation, July 20, 1982. Subject: Removal of facility NCD082362989 from RCRA listing.

10. Joan Dupont, NUS Corporation, memo to file for Tungsten Queen Mine, December 4, 1989. Subject: RCRA status of Tungsten Queen Mine.

11. Linda Aller, et al. DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings, EPA 600/2-87-035 (Ada, Oklahoma: EPA, April 1987).

12. U.S. Department of Commerce, Climatic Atlas of the United States (Washington, D.C.: GPO, June 1968) Reprint: 1983, National Oceanic and Atmospheric Administration, pp. 43, 63.

13. U.S. Department of Commerce, Rainfall Frequency Atlas of the United States, Technical Paper No. 40 (Washington, D.C.: GPO, 1961), p. 93.

14. U.S. Geological Survey, National Water Summary 1984: Hydrologic Events, Selected Water Quality Trends, and Ground-Water Resources, Water Supply Paper 2275 (1984), pp. 329-334.

15. V. Jeff May, Geology and Ground-Water Resources in the Raleigh Area North Carolina, Ground-Water Bulletin No. 15 (Raleigh, North Carolina: North Carolina Department of Water and Air Resources, November 1968), pp. 91, 92.

16. R. Allan Freeze and John A. Cherry, Groundwater (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1979), p. 29.

17. North Carolina Department of Human Resources, Environmental Health Section, Water Supply Branch. Alphabetical Within County Listing of Active Community and Non-Community Public Water Systems for Vance County, July 26, 1990.

18. North Carolina Surface Water Intakes, printout for Vance County, July 11, 1990.

19. Charlie Tooler, Mayor of Boydton, telephone conversation with Jancie Hatcher, NUS Corporation, November 19, 1990. Subject: Intake location for Boydton's water.

20. Arlene Evans, North Carolina Inland Fisheries, telephone conversation with Jancie Hatcher, NUS Corporation, November 13, 1990. Subject: Fishing in the John H. Kerr Reservoir.

21. North Carolina Natural Heritage Program Element List for Vance County, February 19, 1990.

22. U.S. Fish and Wildlife Service, Endangered and Threatened Species of the Southeastern United States (Atlanta, Georgia, 1988).

CERCLA ELIGIBILITY QUESTIONNAIRE

Site Name: Tungsten Queen Mine

City: Townsville State: NC

EPA I.D. Number: NCD082362989

I. CERCLA ELIGIBILITY	YES	NO
Did the facility cease operations prior to November 19, 1980?	X	

If answer YES, STOP, facility is probably a CERCLA site
If answer NO, Continue to Part II

II. RCRA ELIGIBILITY	YES	NO
Did the facility file a RCRA Part A application?		
If YES:		
1) Does the facility currently have interim status?		
2) Did the facility withdraw its Part A application?		
3) Is the facility a known or possible protective filer? (facility filed in error)		
4) Type of facility: Generator___ Transporter___ Recycler___ TSD (Treatment/Storage/Disposal)___		
Does the facility have a RCRA operating or post closure permit?		
Is the facility a late (after 11/19/80) or non-filer that has been identified by the EPA or the State? (facility did not know it needed to file under RCRA)		

If all answers to questions in Part II are NO, STOP, the facility is a CERCLA eligible site.

If answer to #2 or #3 is YES, STOP, the facility is a CERCLA eligible site.

If #2 and #3 are NO and any OTHER answer is YES, site is RCRA, continue to Part III.

III: RCRA SITES ELIGIBLE FOR NPL	YES	NO
Has the facility owner filed for bankruptcy under federal or state laws?		
Has the facility lost RCRA authorization to operate or shown probable unwillingness to carry out corrective action?		
Is the facility a TSD that converted to a generator, transporter or recycler facility after November 19, 1980?		

SSI PHASE I
RECONNAISSANCE DOCUMENTATION CHECKLIST

This information is required for all SSI Phase Is. Much of it will be detailed in your letter report, logbook, or topo map. In such cases, provide only brief descriptions and reference citations on the checklist to avoid duplication. Cite the source for all information obtained for all sections. Lists of HRS-specific definitions and sensitive environment identifications are attached.

Site Name: Tungsten Queen Mine

City, County, State: Townsville, Vance County, North Carolina

EPA ID No.: NCD082362989

Person responsible for form: Jancie Hatcher

Date: November 14, 1990

DESKTOP DATA COLLECTION
(Can be done before or after recon. Include attachments as necessary).

I. **Groundwater Use** (See project geologist for this information)

- Identify aquifer(s) of concern.

  Crystalline rock aquifer (Ref. 14).

- Identify any areas of karst terrain within the 4-mile site radius, and confining layers and hydraulic interconnections within 2 miles of the site.

  N/A

II. **Surface Water Use**

- Identify uses along the 15-stream-mile surface water pathway (i.e. drinking water, fishing, irrigation, industrial).

  Fishing, boating, swimming (Ref. 20). There are no downstream surface water intakes within the 15-mile pathway.

- Identify any designated recreational areas, sensitive environments, and fisheries along the surface water pathway. Specify whether fishing is recreational, subsistence, or commercial. Information for smaller water bodies can be confirmed or obtained from local sources during the recon.

  Various recreational and public use areas are located on the banks of John D. Kerr Reservoir (Ref. 1). Fishing is both recreational and commercial (Ref. 20).

III. **Sensitive Environments**

- Identify any sensitive environments within 4 radial miles of the site (See Table 4-23 of the February 15, 1990 HRS Draft Final Rule, attached). Remember, sensitive environments are not limited to critical habitats.

  A wetland area is located 0.8 miles northeast of the mine (Ref. 1).

DRIVE-BY RECONNAISSANCE DATA COLLECTION
(This information should be recorded in logbooks with attachments).

I. **Groundwater Use** (This information can generally be obtained from local water departments, or city hall in rural areas).

- Identify on copies of topos the extent of all municipal systems and areas served by private wells within 4 miles of the site.

  All residences within 4 miles use private wells.

- Locate on copies of topos all municipal well locations in the site area, including any wells of a blended system >4 miles from site. Specify if water from these wells is partially or fully blended prior to or during distribution, and if any surface water intakes contribute to a blended system (whether or not they draw from the target sw pathway).

  N/A

- Note the depth, pumpage, and population served for all municipal wells within the 4-mile site radius. Complete well survey forms.

  N/A

- Document other groundwater uses (e.g. irrigation, industrial).

  N/A

II. **Surface Water Use**

- Identify on topos the 15-mile surface water pathway.

  See Ref. 1.

- Identify and locate on topos any surface water intakes within 15 miles downstream of the site (to be obtained from local water department).

III. **Site and Area Use Data Collection** (May be obtained before or during recon)

- Describe any barriers to travel (e.g. rivers) within 1 mile of the site (consult topo).

  The John D. Kerr Reservoir presents a partial water barrier to travel (Ref. 1).

- Describe population within the immediate site vicinity and within the 4-mile radius (e.g. sparsely populated rural areas, commercial/industrial areas, densely populated urban areas, etc.).

  Area is very sparsely populated.

- Obtain aerial photos of site and immediate vicinity whenever available (from county offices).

  None available.

- Note if the facility is on sewers or septic tanks (consult water or public works department).

  N/A

- Obtain current property owner information from the county tax assessor's office.

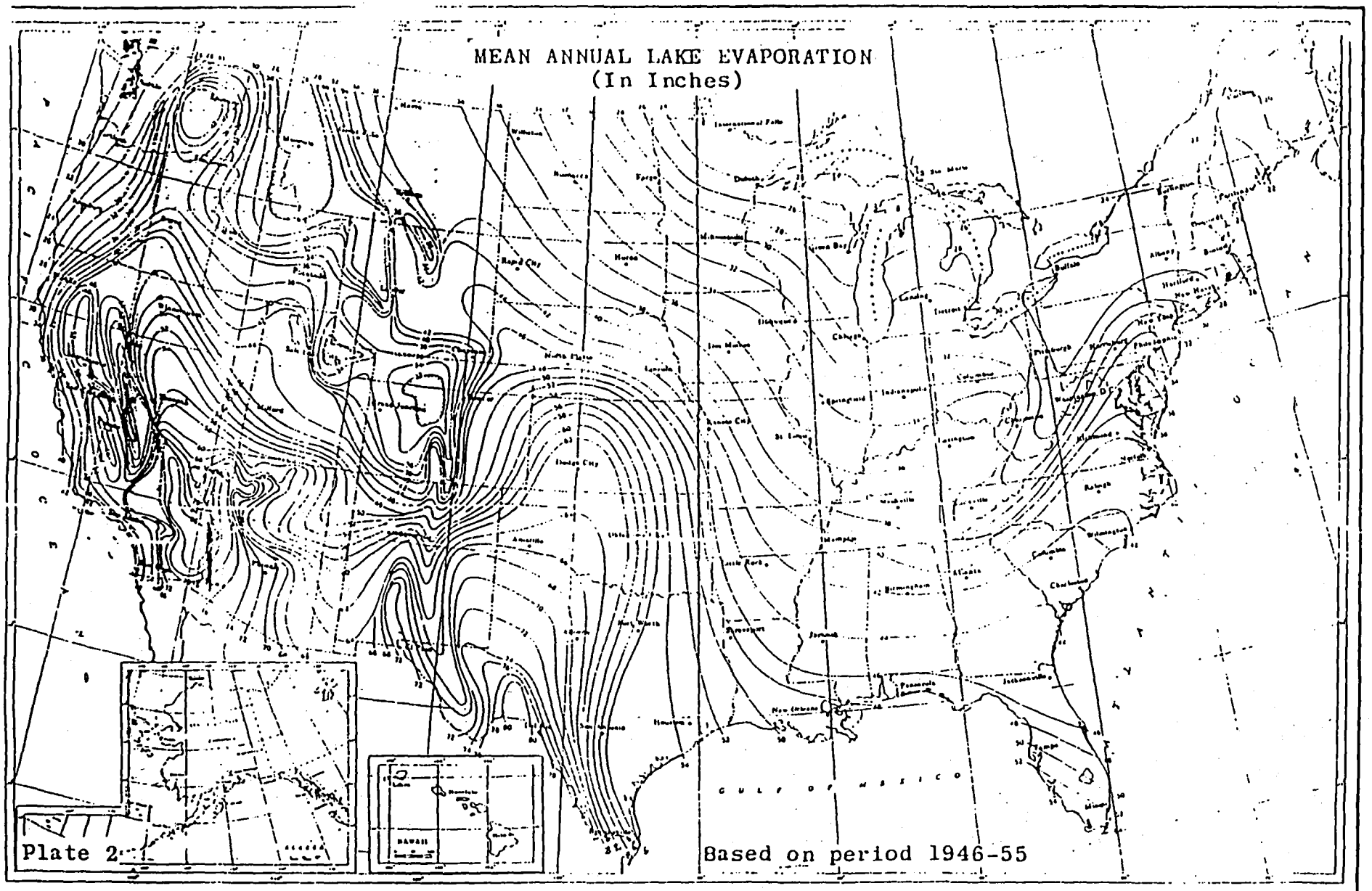
  Atlas Mine and Mill (Ref. 4).

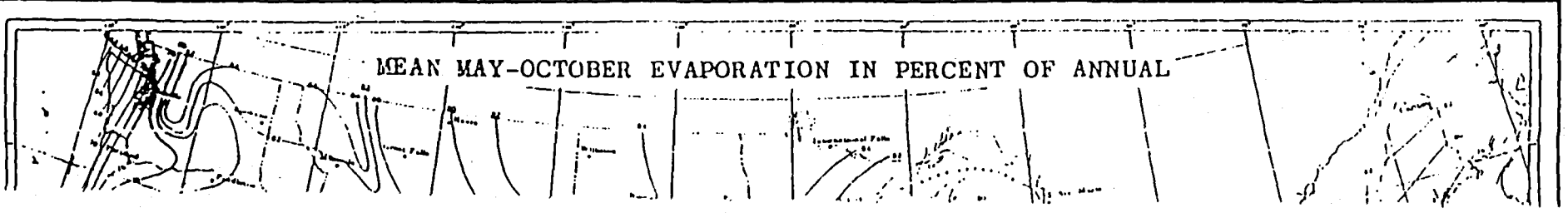
REFERENCE 12

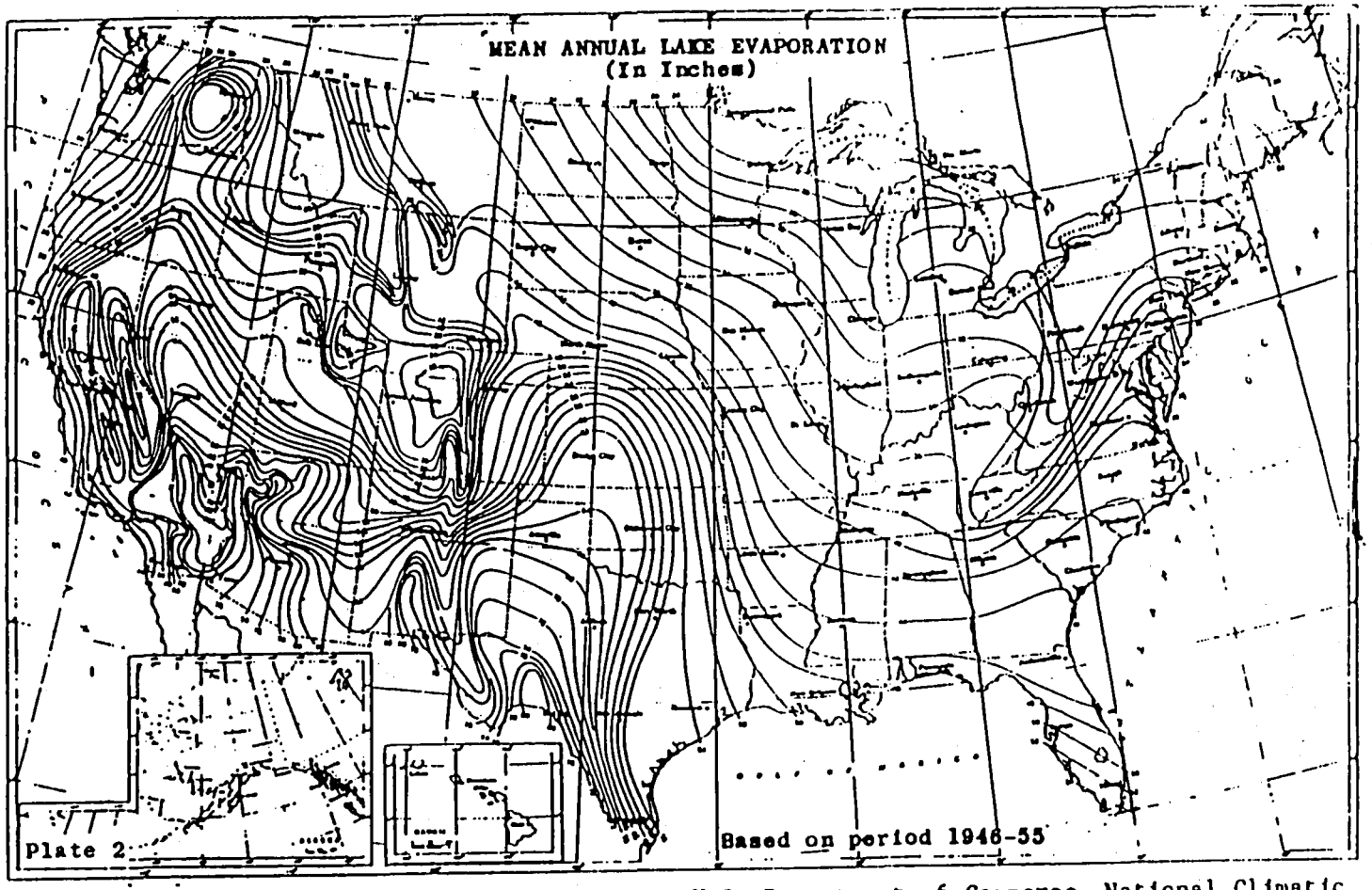
SEE FIGURE 3 IN APPENDIX A

REFERENCE 13

Climatic Atlas of the United States, US Department of Commerce, National Climatic Center, Asheville, NC, 1979.

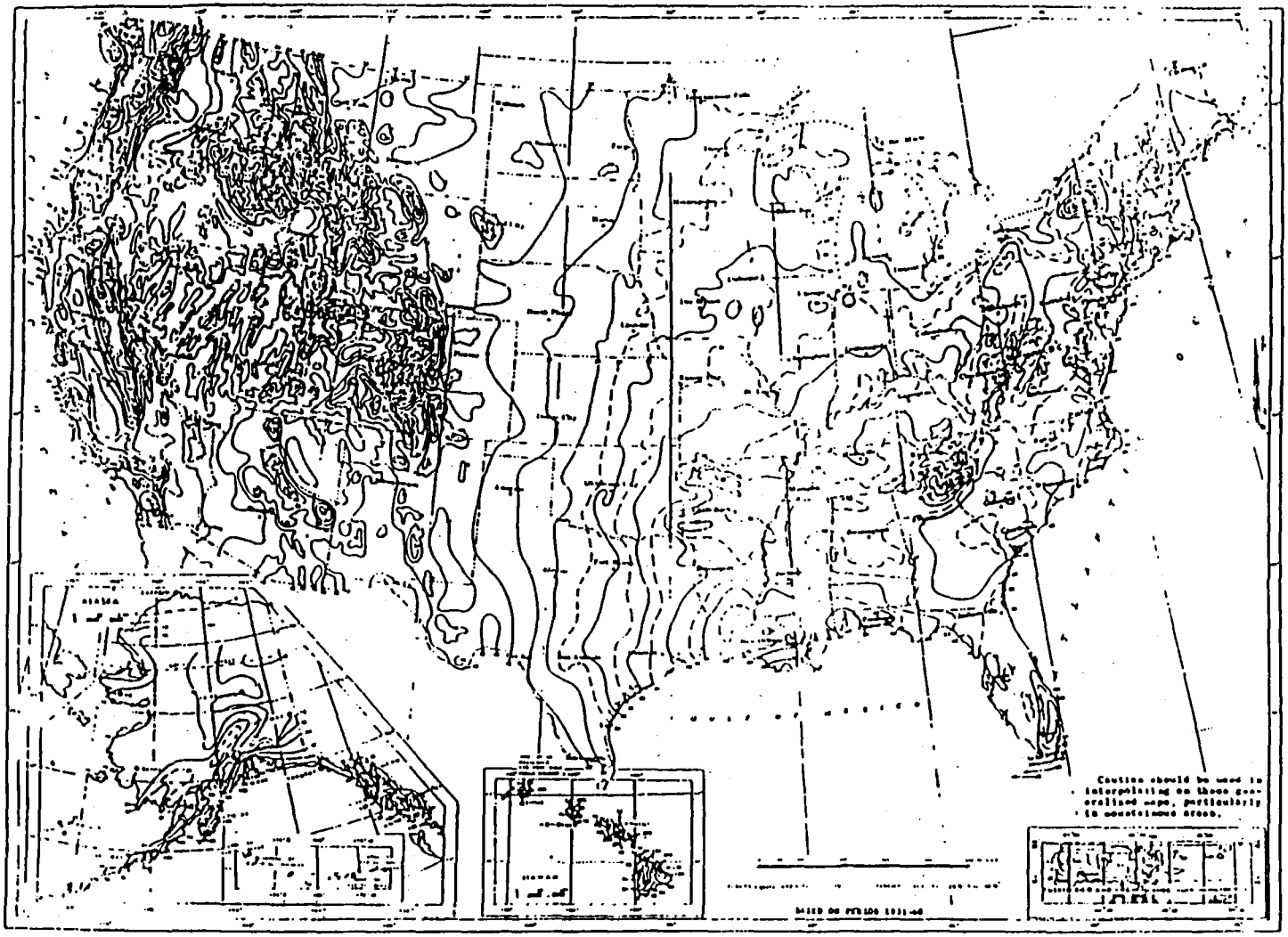

MEAN ANNUAL LAKE EVAPORATION
(In Inches)
GULF OF MEXICO
HAWAII
Plate 2
Based on period 1946-55


MEAN MAY-OCTOBER EVAPORATION IN PERCENT OF ANNUAL



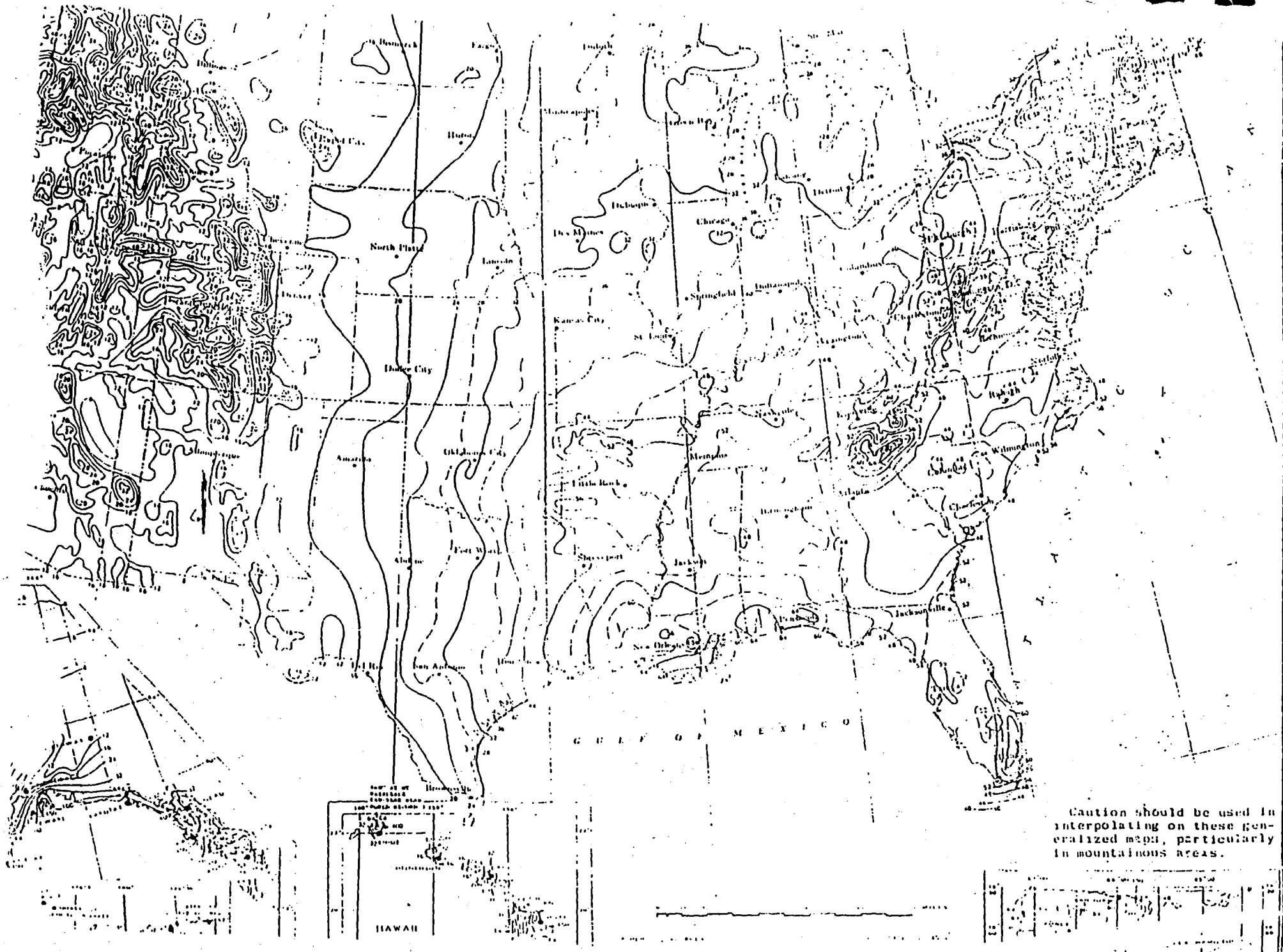
Source: Climatic Atlas of the United States, U.S. Department of Commerce, National Climatic Center, Ashville, N.C., 1979.

FIGURE 4
MEAN ANNUAL LAKE EVAPORATION
(IN INCHES)



Source: Climatic Atlas of the United States, U.S. Department of Commerce, National Climatic Center, Asheville, N.C., 1979.

FIGURE 5
NORMAL ANNUAL TOTAL PRECIPITATION (INCHES)

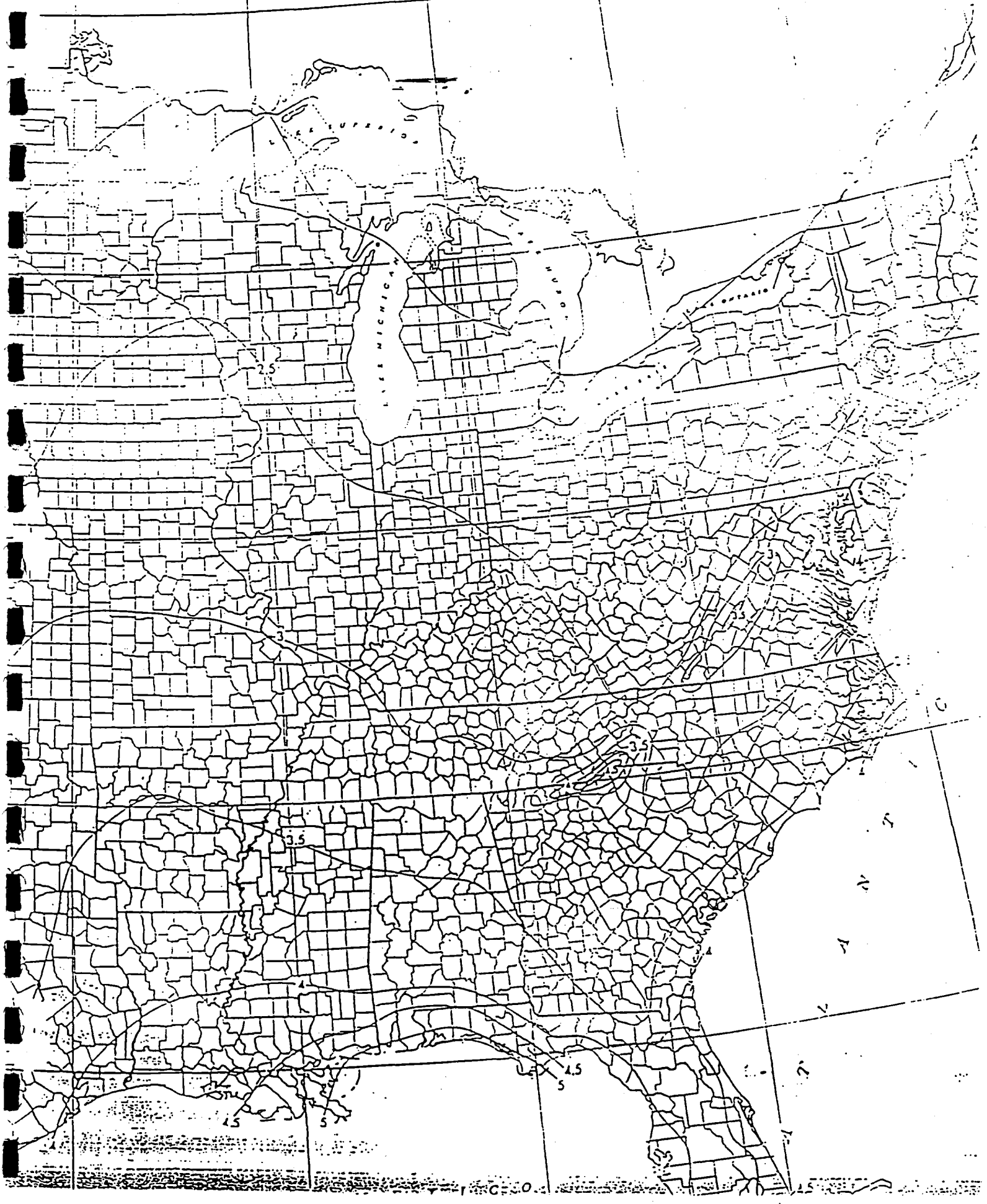


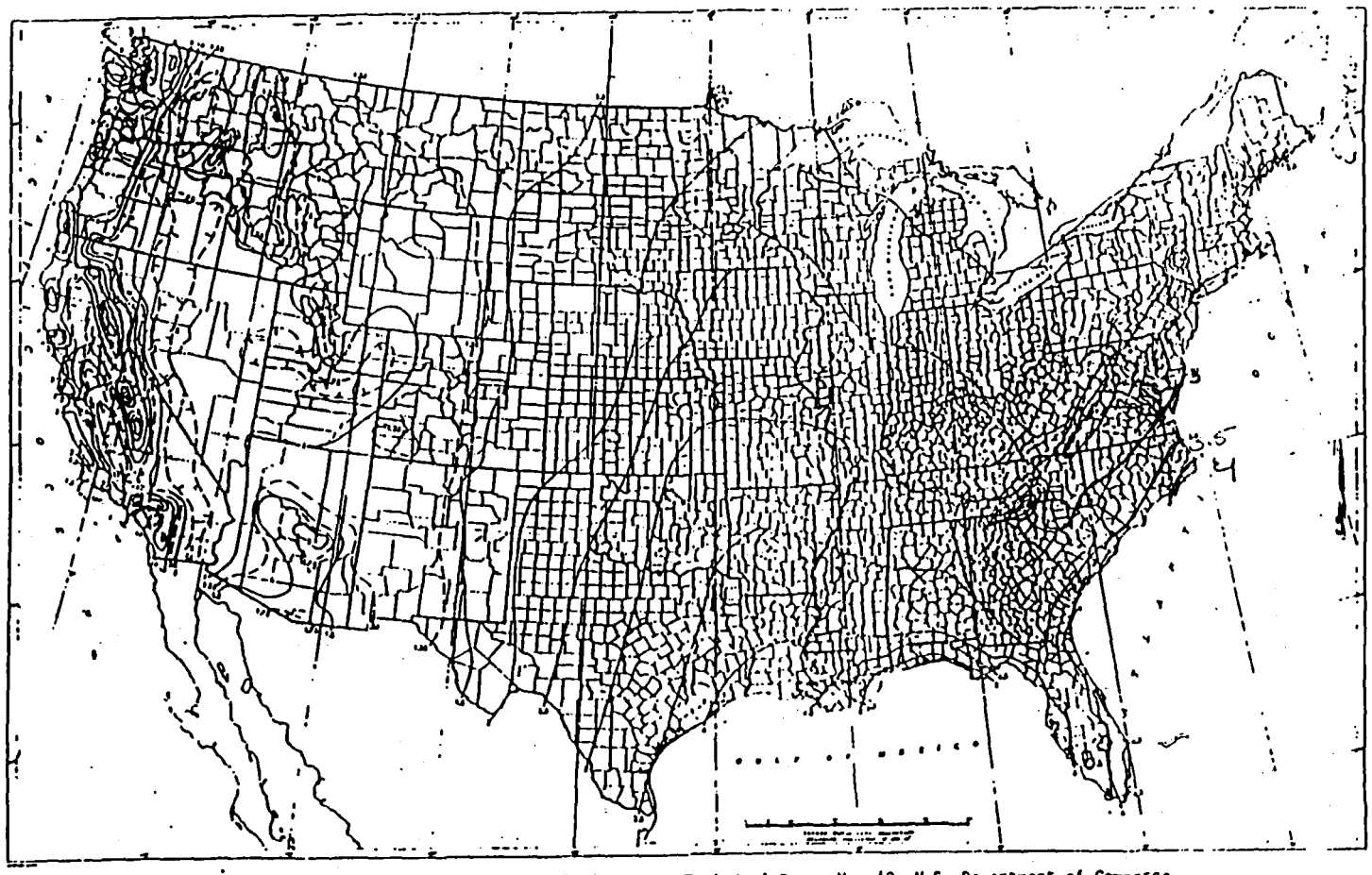
Caution should be used in interpolating on these generalized maps, particularly in mountainous areas.

REFERENCE 14

Rainfall Frequency Atlas of the United States, Technical Paper No. 40, US Department of Commerce, US Government Printing Office, Washington, DC, 1963.

RAINFALL (INCHES)





Source: Rainfall Frequency Atlas of the United States, Technical Paper No. 40, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C., 1963.

FIGURE 8
1-YEAR 24-HOUR RAINFALL
(INCHES)

REFERENCE 15

Reference 15

EPA-600/2-87-035
April 1987

DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings

by

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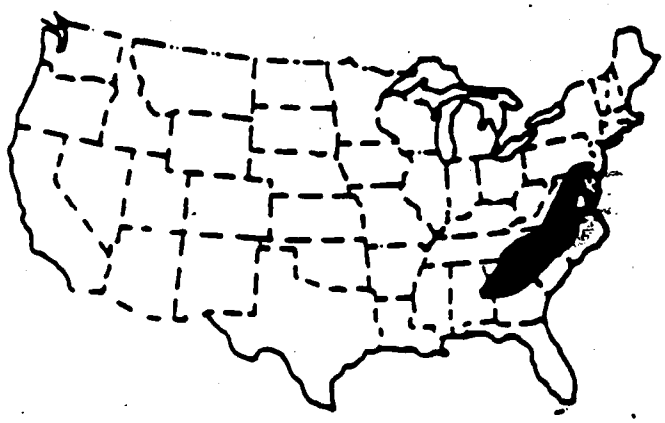
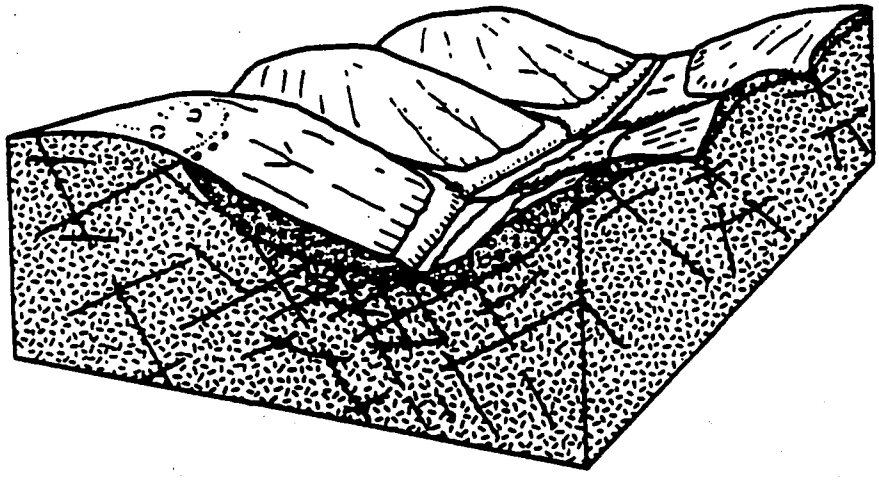
8. PIEDMONT BLUE RIDGE GROUND-WATER REGION





8A	Mountain Slopes
8B	Alluvial Mountain Valleys
8C	Mountain Flanks
8D	Regolith
8E	River Alluvium
8F	Mountain Crests
8G	Swamp/Marsh

8. PIEDMONT BLUE RIDGE REGION

(Thick regolith over fractured crystalline and metamorphosed sedimentary rocks)

The Piedmont and Blue Ridge region is an area of about 247,000 km2 extending from Alabama on the south to Pennsylvania on the north. The Piedmont part of the region consists of low, rounded hills and long, rolling, northeast-southwest trending ridges whose summits range from about a hundred meters above sea level along its eastern boundary with the Coastal Plain to 500 to 600 m along its boundary with the Blue Ridge area to the west. The Blue Ridge is mountainous and includes the highest peaks east of the Mississippi. The mountains, some of which reach altitudes of more than 2,000 m, have smooth-rounded outlines and are bordered by well-graded streams flowing in relatively narrow valleys.

The Piedmont and Blue Ridge region is underlain by bedrock of Precambrian and Paleozoic age consisting of igneous and metamorphosed igneous and sedimentary rocks. These include granite, gneiss, schist, quartzite, slate, marble, and phyllite. The land surface in the Piedmont and Blue Ridge is underlain by clay-rich, unconsolidated material derived from in situ weathering of the underlying bedrock. This material, which averages about 10 to 20 m in thickness and may be as much as 100 m thick on some ridges, is referred to as saprolite. In many valleys, especially those of larger streams, flood plains are underlain by thin, moderately well-sorted alluvium deposited by the streams. When the distinction between saprolite and alluvium is not important, the term regolith is used to refer to the layer of unconsolidated deposits.

The regolith contains water in pore spaces between rock particles. The bedrock, on the other hand, does not have any significant intergranular porosity. It contains water, instead, in sheetlike openings formed along fractures (that is, breaks in the otherwise "solid" rock). The hydraulic conductivities of the regolith and the bedrock are similar and range from about 0.001 to 1 m day^{-1}. The major difference in their water-bearing characteristics is their porosities, that of regolith being about 20 to 30 percent and that of the bedrock about 0.01 to 2 percent. Small supplies of water adequate for domestic needs can be obtained from the regolith through large-diameter bored or dug wells. However, most wells, especially those where moderate supplies of water are needed, are relatively small in diameter and are cased through the regolith and finished with open holes in the bedrock. Although, as noted, the hydraulic conductivity of the bedrock is similar to that of the regolith, bedrock wells generally have much larger yields than regolith wells because, being deeper, they have a much larger availble drawdown.

REFERENCE 16

Reference 16

GEOLOGY AND GROUND-WATER RESOURCES IN THE RALEIGH AREA NORTH CAROLINA

DIVISION OF GROUND WATER

GROUND WATER BULLETIN NO. 15

North Carolina
Department of Water Resources

RALEIGH
NOVEMBER
1968

GEOLOGY AND GROUND-WATER RESOURCES IN THE RALEIGH AREA NORTH CAROLINA

By

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CHEMICAL QUALITY OF WATER SECTION

By

J. D. THOMAS

CHEMIST, U. S. GEOLOGICAL SURVEY

GROUND WATER BULLETIN NUMBER 15

NORTH CAROLINA
DEPARTMENT OF WATER AND AIR RESOURCES
George E. Pickett, *Director*

Division of Ground Water
Harry M. Peek, *Chief*

PREPARED COOPERATIVELY BY THE GEOLOGICAL SURVEY
UNITED STATES DEPARTMENT OF THE INTERIOR
AND THE NORTH CAROLINA
DEPARTMENT OF WATER AND AIR RESOURCES

NOVEMBER 1968

GEOLOGY AND GROUND-WATER RESOURCES IN THE RALEIGH AREA, NORTH CAROLINA

By

V. Jeff May and J. D. Thomas

ABSTRACT

The Raleigh area is in the northeastern part of central North Carolina and includes the following counties: Franklin, Granville, Vance, Warren, and Wake. The combined area of the five counties is 2,592 square miles, and the population in 1960 was 282,601.

The area lies entirely in the Piedmont physiographic province except for a small area in southern Wake County that is part of the Fall Zone. The land surface, which has a gentle southeast slope, has flat to rounded interstream areas separated by small streams that are controlled largely by structure and by larger streams which cut across structure.

The geology in the Piedmont province is complex. The Piedmont is underlain by gneiss, schist, granitic rocks, metamorphosed volcanic and sedimentary rocks, and Triassic sedimentary rocks of the Newark Group. In the Fall Zone metamorphic and igneous rocks of the Piedmont are unconformably overlain by unconsolidated sand and clay deposits of Cretaceous age.

Several towns and industries in the Raleigh area obtain their water supplies from wells. Ground water is the source for all private supplies.

The permeability of the rock units depends largely upon the occurrence of secondary interstices such as fractures and cleavage planes. Because the nature and abundance of these interstices vary in the different rock types, the yields of wells differ greatly from place to place.

The yield of wells in all of the metamorphic and igneous rocks, except greenstone, ranges from 12 to 22 gallons per minute. Adequate domestic supplies and small to moderate industrial and municipal supplies are obtained from these rocks.

The Triassic sedimentary rocks are poor aquifers. Most wells in these rocks yield less than 10 gallons per minute.

Topographic location has an important bearing on the yields of wells. The average yield of wells in draws is greater than twice the average yield of wells at other topographic locations.

The permeability of the rocks decreases with depth. Generally, little water is contained in the rocks below a depth of 200 to 250 feet.

Ground waters in the Raleigh area are mostly calcium and sodium bicarbonate type water. Some highly mineralized waters for this area are produced from the Triassic and metavolcanic rocks. The bromide concentration in ground water is probably from residual sea water. The well waters containing above-normal amounts of nitrate in the area have been polluted because of improper well casing.

VANCE COUNTY

(Area: 249 square miles; population in 1960: 32,002)

GEOGRAPHY

Vance County lies in the north-central part of the Raleigh area; it is the smallest of the five counties. It is bounded on the east by Warren County, on the south by Franklin County, on the west by Granville County, and on the north by Virginia. Henderson, population 12,740, is the county seat and largest town in the county. Other population centers include Middlesburg, Townsville, and Kittrell.

The county is largely agricultural, tobacco being the chief crop. Cotton, corn, and dairy products are also important sources of income. Several industrial establishments are centered in and around Henderson. Chief among these are textile manufacturing, tobacco processing, and lumbering. Graystone quarry, located 1 mile north of Henderson, is one of the largest quarries in the State, and it produces large quantities of crushed stone.

Vance County is in the Piedmont physiographic province, and the topography is typical of that province. The uplifted surface has been dissected by small streams forming draws and small valleys that have floors generally less than 75 feet below the upland surfaces. Elevations range from slightly more than 300 feet above mean sea level, to almost 600 feet. The lowest elevations are in the northeastern corner of the county, and the highest are in the west central part near Dabney.

Vance County is drained by small streams which are tributary to either the Roanoke or Tar Rivers. Those tributary to the Roanoke River flow northward into the John H. Kerr Reservoir. The streams in the southern part of Vance County flow south or southeast to the Tar River which forms the southern boundary of the county. The drainage divide between the two major drainage basins extends in an east-west direction across the central part of the county. Stream gradients are moderate and flood plains are narrow.

GEOLOGY

Mica gneiss crops out as a northeast-trending zone across the eastern half of the county. Predominantly the rock is a medium- to coarse-grained biotite-feldspar gneiss containing at most places metacrysts of feldspar that give it a porphyritic texture. The feldspar is mostly orthoclase which commonly comprises as much as 50 percent of the rock. Other minerals include quartz, plagioclase feldspar, muscovite, and minor amounts of opaque minerals. The contact between the granite and gneiss appears to be gradational, which at most places was mapped by characteristic soil types between isolated outcrops. The granite may have intruded the rocks that are now gneissic and partly assimilated and hydrothermally altered them. The gneiss near the granite may properly be called granite gneiss. Gneissic texture and foliation trend northeast.

Phyllitic rocks included in the metavolcanic unit are exposed in western Vance County. They are primarily fine-grained greenish-gray rocks composed of micaceous minerals, chiefly sericite and chlorite. Cleavage, which is well developed, strikes northeast and dips steeply to the northwest.

These rocks were mapped as metavolcanic (metamorphosed fine-grained tuffs) because there seemed to be no definite contact between them and recognized metavolcanic rocks in Granville County to the west.

Greenstone underlies a small area in northwestern Vance County. It is a fine-grained dark-green rock composed mostly of chlorite, but containing small amounts of epidote, hornblende, feldspar, quartz, and sericite. Cleavage is moderately to well-developed and strikes northeast. At places amygdules containing feldspar and quartz are elongated in the direction of cleavage. Apparently the rock is a metamorphosed mafic extrusive.

A granodiorite body, elongate in a northeast direction, is exposed across western Vance County. The granodiorite is medium- to coarse-grained, and is composed predominantly of feldspar, quartz, and mica. Accessory minerals include sericite, muscovite, pyrite, magnetite or ilmenite, and epidote (Parker, in press). The feldspar is chiefly albite, but orthoclase feldspar is commonly present as a minor constituent. Total feldspar content is generally 50 percent or greater. Quartz composed 25 to 35 percent of the rock as clear, gray, and rarely as pale blue grains.

Phyllitic rocks of the metavolcanic sequence and granodiorite are interlayered near the edge of the granodiorite body. Inclusions of phyllite occur in the granodiorite, but are less numerous near the center of the body. Neither the inclusions or the phyllite in the interlayered zone show evidence of intense dynamic or thermal metamorphism. At places phyllite appears to grade laterally into granodiorite.

Granite underlies a small area in the southeastern part of the county. It is part of a large pluton which crops out more extensively in Franklin and Wake Counties. The granite is a light-gray biotite granite, equigranular and medium to coarse grained. Pegmatite dikes, composed almost entirely of microcline feldspar and quartz, are associated with the granite.

GROUND WATER

Henderson has the only municipal water supply in the county and it obtains its water from ponds. Most of the domestic supplies are obtained from wells. Springs are a source of water for a few homes, and one large spring (tested at 38 gpm) supplies water for a prison camp located 4 miles southeast of Henderson.

Most domestic water supplies are obtained from dug or bored wells. They generally range in depth from 20 to 50 feet and most yield less than 10 gpm. However, a yield of 1 gpm may be adequate for domestic uses because of the large storage capacity of the wells. Rocks of the mica gneiss unit and metavolcanic sequence are at most places sufficiently weathered to permit construction of dug and bored wells to a few feet below the water table.

Because the granite and granodiorite are not as deeply weathered, it is more difficult to construct satisfactory wells of this nature in areas underlain by these rocks.

Records of 122 wells in Vance County are included in the table of well data (table 23). Records of three springs are given in table 24. Sufficient data were collected on 89 drilled wells to compile the comparative table given below (table 22).

Table 22.--Summary of data on wells in Vance County

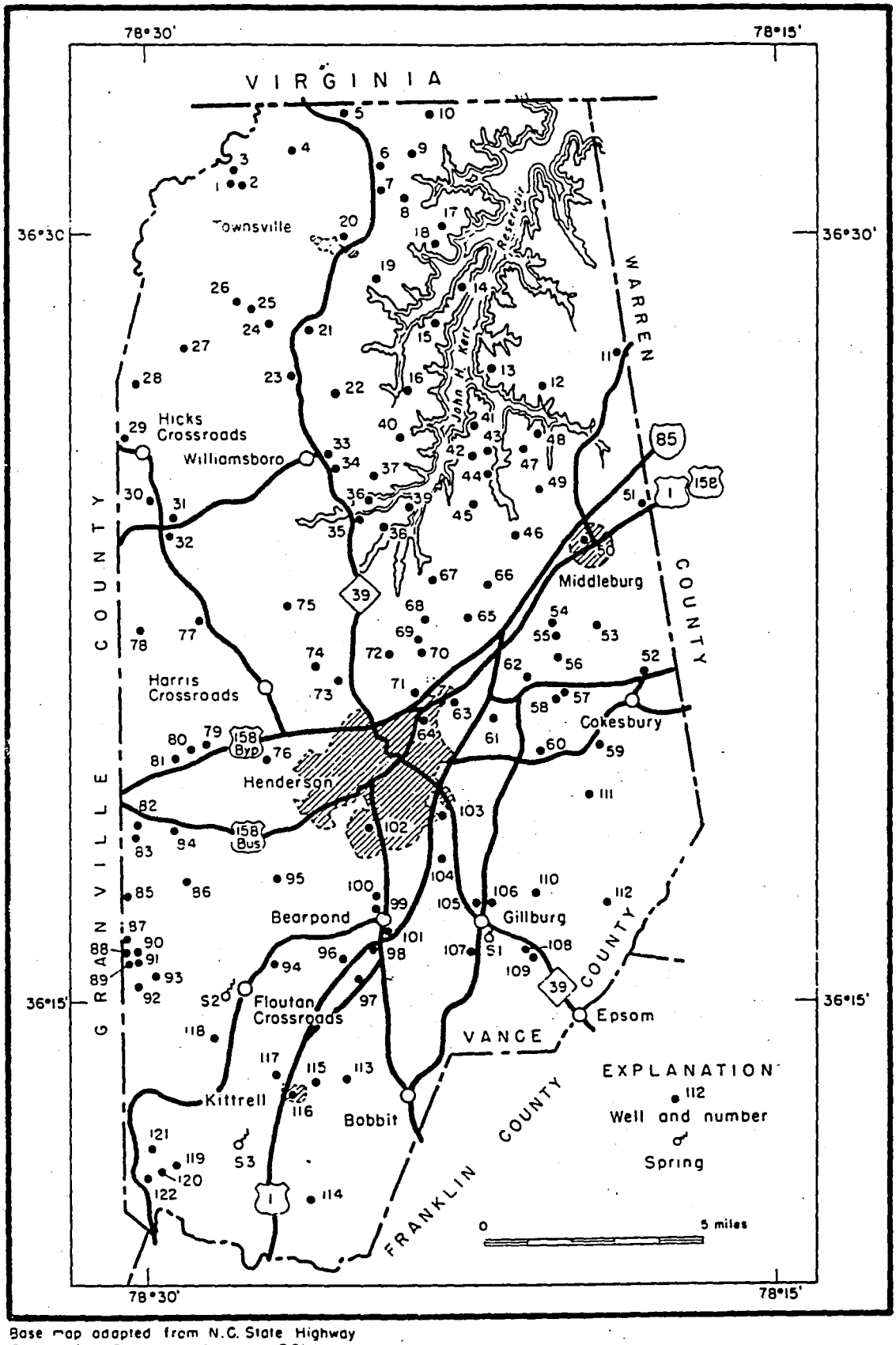
Map Unit	Number of wells	Average depth (feet)	Yield (gpm) Range	Yield (gpm) Average	Yield (gpm) Per foot of well	Percent of wells yielding 1 gpm or less
ACCORDING TO ROCK TYPE						
Mica Gneiss	32	187	1-40	10	0.06	3.1
Meta-volcanic Sequence	12	105	3-36	12	.11	0
Granodiorite	33	123	.5-75	11	.09	6.1
Granite	12	140	1-90	23	.16	8.3
All wells	89	139	.5-90	12	.13	4.5
ACCORDING TO TOPOGRAPHIC LOCATION						
Hill	42	136	1-75	12	0.09	4.8
Flat	13	126	1-82	8	.06	7.7
Slope	26	158	.5-90	14	.09	3.9
Draw	8	112	12-36	18	.16	0

Drilled wells in granite have the highest average yield (23 gpm), and the highest average yield per foot of well (0.16 gpm per foot of well). However, there are more wells in granite that yield 1 gpm or less than in any other rock type. About one out of 10 wells in granite falls into this category.

Adequate domestic supplies of water can be obtained from drilled wells at most places. Topographic features are important indicators of favorable ground-water locations and can be used in selecting well sites. As is shown by table 22, wells located in draws have the highest average yield and average yield per foot of well. Other visible features indicative of favorable ground-water conditions include quartz veins, coarse-grained granite or pegmatite dikes, and deeply weathered areas.

Complete analyses of seven water samples from wells in Vance County are given in table 25. Ground water in Vance County is principally of the calcium and sodium-bicarbonate type. Fifty-seven percent of the waters sampled were soft. Ground water in Vance County is suitable for most domestic, municipal and industrial uses.

Analysis of one sample from granite and one from mica gneiss indicate that these rocks yield a water that is soft and has a low iron content. Water from granodiorite is generally of good quality although at places it may be moderately hard to hard. The hardness of water from granodiorite ranged from 14 to 138 ppm and the iron content did not exceed 0.24 ppm. Two samples of water from rocks of the metavolcanic sequence were analyzed, and both were very hard. One sample had 9.0 ppm iron, but the water is corrosive and a large percentage of the iron probably comes from corrosion of the pipes in the distribution system.



Base map adapted from N.C. State Highway Commission County road map 1961

Figure 24.--Map of Vance County showing locations of wells and springs.

Table 23.--Records of wells in Vance County

Well No.	Location	Owner	Type of well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
1	2 3/4 miles NW of Townsville	Tungsten Mining Company	Drilled	90	8	62	Granodiorite	------	13		Draw	
2	2 3/4 miles NW of Townsville	Tungsten Mining Company	do	31	6	21	do	------	------		Hill	
3	2 3/4 miles NW of Townsville	Tungsten Mining Company	do	142	6	40	do	-17	------		do	Combined yield of wells 2 and 3 is about 12 gpm
4	2¾ miles N of Townsville	A. B. Keeton	do	60	6	------	do	-30	9		do	
5	3 miles N of Townsville	John Wilson	do	99	6	80	do	-30	5		do	Water is sometimes turbid.
6	2 miles N of Townsville	Mrs. E. C. Norwood	do	61	6	50	do	------	------		------	Analysis in table
7	1½ miles N of Townsville	J. H. Brewer	do	85	6	40	do	-45	8		Hill	
8	2 miles NE of Townsville	Woodworth Church	do	60	6	43	do	-20	9		Flat	
9	3¾ miles NE of Townsville	Jack Brewer	do	85	6	------	do	------	7½		do	Reported slightly hard water
10	3 3/4 miles NE of Townsville	O. E. Brewer	Dug	25	36	------	do	-20	------		Hill	
11	4¼ miles N of Middleburg	Mrs. M. B. White	Drilled	168	6	15	Mica gneiss	-30	5+		do	Adequately supplies 2 families. Water moderately hard
12	3 3/4 miles N of Middleburg	F. D. Bullock	do	82	6	44	do	-25	10		Slope	
13	4½ miles NE of Williamsboro	N. C. State Park Service	do	100	6	52	Metavolcanic sequence	-30	5½		do	
14	5 miles NE of Williamsboro	Huffman Oil Company	do	67	6	40	Granodiorite	-12	8		Flat	Water turbid
15	4 miles NE of Williamsboro	Leon Tuder	Drilled	126	6	99	Granodiorite	-25	7½		Hill	
16	2½ miles NE of Williamsboro	Mrs. Lena Thomas	do	166	6	53	do	-40	7		Slope	Hard water reported
17	2¼ miles E of Townsville	R. A. Reese	Bored	51	24	51	do	-35	10		Hill	
18	2 miles E of Townsville	W. T. Reese	Drilled	115	6	90	do	-28	3		do	
19	1 mile SE of Townsville	S. H. Johnston	Bored	40	24	40	do	-25	------		do	Analysis in table
20	Townsville	E. E. Moss	Drilled	61	6	------	do	------	9		do	
21	1 3/4 miles S of Townsville	C. U. Samford	do	67	6	46	do	------	5		Slope	Supplies 5 families
22	2 miles N of Williamsboro	W. W. Neel	do	97	6	63	do	-20	20+		Draw	
23	2 miles N of Williamsboro	R. A. Fisher, Jr.	Bored	36	24	36	do	-22	------		Slope	
24	2¼ miles SW of Townsville	John Norwood	Drilled	75	6	29	do	-30	12		Hill	Slightly hard water reported
25	2¼ miles SW of Townsville	F. W. Morgan	do	150	6	16	do	-20	75		do	Adequately supplies 4 families.
26	2¼ miles SW of Townsville	F. W. Morgan	do	75	6	20	do	-45	9		Draw	
27	2¾ miles N of Hicks Crossroads	J. E. Twisdale	do	116	6	86	Metavolcanic sequence	-28	15-18			Adequately supplies 5 families.
28	1½ miles N of Hicks Crossroads	L. B. Elliott	Dug	62	36	------	do	------	1-3		Hill	Hard water reported
29	½ mile NW of Hicks Crossroads	R. T. Satterwhite	Drilled	123	6	40	do	-8	9		do	Slightly hard water reported
30	1¼ miles S of Hicks Crossroads	S. W. Green	Drilled	78	6	60	Metavolcanic sequence	-18	36		Draw	Water contains iron
31	1 3/4 miles S of Hicks Crossroads	V. E. Knott	do	75	6	------	do	-35	10+		Hill	
32	2 miles S of Hicks Crossroads	Z. W. Clark	do	53	6	------	do	------	3		do	
33	½ mile E of Williamsboro	T. L. Williamson	Bored	48	24	48	Granodiorite	-20	------		do	
34	½ mile SE of Williamsboro	Carrie Morrow	Drilled	95½	6	83	do	------	10+		do	Moderately hard water reported
35	1 3/4 miles SE of Williamsboro	Mrs. Ollie Ascue	do	430	6	------	do	------	3		Slope	
36	1½ miles SE of Williamsboro	T. M. Hunter	do	105½	6	52½	do	------	2		Hill	Moderately hard water reported
37	1½ miles E of Williamsboro	Will Jefferson	do	154	6	27	do	------	½		Slope	Hard water reported
38	2¼ miles SE of Williamsboro	Thomas Royster	do	257	6	28	do	------	8½		do	

Table 23.--Records of wells in Vance County--Continued

Well No.	Location	Owner	Type of well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
39	2¼ miles SE of Williamsboro---	N. C. State Park Service-------	--do---	55	5	47	--do--------	-25	15		--do--	Drawdown 2½ feet after 12 hours of pumping at 15 gpm
40	2 miles E of Williamsboro---	T. Hunter-------	--do---	166	6	53	--do--------	-40	7		Hill--	Hard water reported-------
41	3½ miles NW of Middleburg-----	N. C. State Park Service-------	--do---	62	6	30	Metavolcanic sequence	-18	7		--do--	Drawdown 24 feet after 12 hours of running at 7 gpm--------
42	3½ miles NW of Middleburg-----	Henry White-----	--do---	160	6	35	--do--------	-35	5		--do--	
43	3 miles NW of Middleburg-----	F. M. White-----	--do---	165	6	62	Mica gneiss	-35	2½		--do--	
44	2 3/4 miles NW of Middleburg-----	Tom White-------	--do---	62	6	------	--do--------	-25	5		--do--	
45	3 miles W of Middleburg-----	J. H. Huffman----	Drilled	78	6	40	Mica gneiss--	------	4		Hill--	
46	1 3/4 miles W of Middleburg-----	F. H. Spain------	--do---	458	6	16	--do--------	-26	10		--do--	Adequately supplies 3 families-----
47	2½ miles NW of Middleburg-----	Middleburg Girl Scout Camp----	--do---	95	6	16	--do--------	-8	12		Draw--	Hard water reported-------
48	2 3/4 miles N of Middleburg-----	D. L. Meskins----	--do---	69	6	41	--do--------	------	30+		Hill--	Adequately supplies trailer park of 60 trailers. Hard water reported-----
49	1 3/4 miles N of Middleburg-----	H. J. Richardson	--do---	313	6	40	--do--------	-40	1		--do--	
50	Middleburg-------	J. T. Satterwhite	--do---	230	6	58	--do--------	-25	3		Flat--	
51	1½ miles NE of Middleburg-----	P. G. Currin-----	--do---	77	6	67	--do--------	-32	9		Hill--	
52	2/4 miles NE of Cokesbury------	T. P. Rose, Jr.---	--do---	120	6	30	--do--------	-31	15		--do--	
53	1 3/4 miles N of Cokesbury------	J. T. Satterwhite	--do---	488	6	18	--do--------	-8	2½		Slope	Hard water reported-----
54	2½ miles NW of Cokesbury------	W. H. Currin-----	Bored--	39	30	39	--do--------	-15	5+		Hill--	
55	2½ miles NW of Cokesbury------	Russell Dillard--	Drilled	161	6	19	--do--------	-15	9		Flat--	Slightly hard water reported
56	2 miles NW of Cokesbury------	F. H. Ellington--	--do---	90	6	45	--do--------	------	10		Hill--	Adequately supplies 2 families-----
57	1½ miles W of Cokesbury------	L. C. Purdue-----	--do---	408	6	40	--do--------	-39.20	40+		--do--	Water too hard for domestic use. Water level measured 11/9/61. Observation well
58	1½ miles N of Cokesbury------	L. C. Purdue----	--do---	65	6	40	--do--------	-10	8		Slope	Adequately supplies 3 families
59	1 3/4 miles SW of Cokesbury------	R. C. Daniels----	Drilled	103	6	80	Mica gneiss--	-25	6		Slope--	
60	2½ miles SW of Cokesbury------	Raymond Abbott---	--do---	72	6	44½	--do--------	------	30		--do--	Slightly hard water reported-----
61	2½ miles NE of Henderson------	Carey's Chapel Baptist Church	--do---	117	6	58	--do--------	-41	20		--do--	
62	3½ miles NE of Henderson------	J. P. Rogers----	--do---	164	6	48	--do--------	-34	20+		Hill--	
63	Henderson--------	W. B. Daniel, Jr.	--do---	127	6	------	--do--------	------	5		Flat--	Slightly hard water reported-----
64	Henderson--------	Greystone Concrete Products Company	--do--	172	6	41	--do--------	-8	22		--do--	Hard water reported-----
65	3 3/4 miles NE of Henderson------	Fletcher Satterwhite---------	--do---	144	6	45	--do--------	------	3½		--do--	Hard water reported-----
66	2½ miles SW of Middleburg-----	Flat Rock Church	--do---	102	6	63	--do--------	-20	6		Slope--	Bored 22 feet. Moderately hard water reported.---
67	4 miles N of Henderson------	Frank Powell----	--do---	391	6	50	--do--------	-52	2½		Hill--	Corrosive water reported-----
68	2 miles N of Henderson------	J. C. Gardner---	--do---	165	6	40	--do--------	-----	5		--do--	Slightly hard water reported
69	2 3/4 miles N of Henderson------	M. J. Jackson---	Dug----	33	24	33	--do--------	-25	-----		--do--	Adequately supplies 3 families. Hard water reported-----
70	2½ miles N of Henderson------	James Reavis----	Drilled	146	6	22	--do--------	-40	1½		--do--	Slightly hard water reported
71	Henderson--------	Edward Harris---	--do---	97	6	70	--do--------	-27	6		--do--	Slightly hard water reported
72	2½ miles N of Henderson------	R. M. Hawkins---	Dug---	55	36	55	Metavolcanic sequence	-33	10+		--do--	

Table 23.--Records of wells in Vance County--Continued

Well No.	Location	Owner	Type of well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
70	2 miles NW of Henderson------	W. E. Hedrick----	Drilled	176	6	21	Metavolcanic sequence	-23	20+		Draw--	Hard water reported----
71	2 3/4 miles NW of Henderson------	Tommy Richardson	--do---	185	6	20	Granodiorite	------	4		Hill---	
72	1 3/4 miles N of Harris Cross-roads----------	W. B. Grenzer---	--do---	181	6	23	--do--------	-29	7		Slope--	Analysis in table-------
73	1 3/4 miles S of Harris Cross-roads----------	T. L. Wrightle---	--do---	169	6	30	--do--------	-21	15-20		Draw---	Adequate supply for home and farm------
74	2 miles NW of Harris Cross-roads----------	E. A. Green-----	--do---	[illegible]	6	20	--do--------	[illegible]	[illegible]		Hill---	[illegible] feet. Inadequately supplies 2 families----
75	3 miles NW of Harris Cross-roads----------	L. I. Parker----	--do---	119½	6	75	Metavolcanic sequence	-20	5		--do---	
76	2 miles SW of Harris Cross-roads----------	Clarence Greenway	--do---	122	6	20	Granodiorite	-30	7		--do---	Slightly hard water reported----
80	2½ miles SW of Harris Cross-roads----------	Charlie Greenway	--do---	112	6	31	--do--------	-----	1		Slope-	Slightly hard water reported----
81	2½ miles SW of Harris Cross-roads----------	Lewis Greenway--	Bored--	30	24	30	--do--------	-20	7		--do---	
82	4¼ miles SW of Harris Cross-roads----------	Mrs. Walter T. Barnes-------	Drilled	90	6	-----	--do--------	------	20+		--do---	Hard water reported----
83	4½ miles SW of Harris Cross-roads----------	J. A. Wright----	Dug----	50	10	------	--do--------	------	25		Hill---	Moderately hard water reported----
84	4 miles SW of Harris Cross-roads----------	R. F. Wade------	Bored--	40	30	40	--do--------	------	------		Slope-	Adequately supplies 2 families-----
85	3¼ miles NW of Flovtan Cross-roads----------	H. L. Wright------	Dug----	45	36	------	Granodiorite	------	------		Hill---	Hard water reported---
86	2 3/4 miles NW of Flovtan Cross-roads----------	R. C. Wade-------	--do---	47	10	------	--do--------	------	------		--do---	Hard water reported---
87	3 miles NW of Flovtan Cross-roads----------	W. E. Stovall----	Bored---	35	26	35	--do--------	------	------		Slope--	
88	2 3/4 miles NW of Flovtan Cross-roads----------	F. T. Wrenn------	Drilled	31	6	30	--do--------	------	10+		Hill---	Adequately supplies 2 families---
89	2½ miles NW of Flovtan Cross-roads----------	Douglas Bredlove	Dug----	40	30	------	--do--------	------	------		Flat---	Moderately hard water reported---
90	2½ miles NW of Flovtan Cross-roads----------	J. T. Wrenn, Estate--------	--do---	25	36	------	--do--------	-30	10		Slope	
91	2¼ miles NW of Flovtan Cross-roads----------	J. C. Capps-----	--do---	36	-----	-------	--do--------	-16	10		Hill---	Water hard, uses softener
92	2½ miles W of Flovtan Cross-roads----------	Mrs. John Mitchell	Drilled	120	6	95	--do--------	------	30		--do---	Hard water reported----
93	2 miles W of Flovtan Cross-roads---------	L. C. Bredlove--	--do---	52	6	21	--do--------	------	1+		--do---	Field induced-- ate-------
94	1 mile NE of Flovtan Cross-roads---------	Edwin Bowen-----	Bored--	37	30	37	Mica gneiss	-12	-----		--do---	
95	2½ miles N of Flovtan Cross-roads---------	W. W. McCracken	Drilled	141	6	22	Metavolcanic sequence	-70	12		--do---	Adequately supplies 4 homes. Analysis in table------
96	1½ miles SW of Bearpond-------	Mrs. Nora E. Pegg	Drilled	139	6	------	Granite------	------	18-20		Flat---	Adequately supplies 2 families---
97	1½ miles S of Bearpond-------	T. A. Stove, Jr.	--do---	82	6	10	--do--------	------	3		Slope--	[illegible] feet. Slightly hard water reported----------
98	½ mile S of Bearpond-------	Mrs. T. P. Stewart--------	--do---	202	6	20	--do--------	------	------		Flat---	Hard water reported----
99	½ mile N of Bearpond-------	Vance Trucking Company-------	--do---	110	6	10	--do--------	-8.10	1		--do---	Water level measured 11/9/61. Observation well--------
100	½ mile N of Bearpond-------	Vance Trucking Company--------	--do---	75	6	15	--do--------	------	6		--do---	Hard water reported----
101	Bearpond---------	Mrs. W. I. Harris	--do---	81	8	23½	--do--------	-8	8		--do---	

Table 23.--Records of wells in Vance County--Continued

Well No.	Location	Owner	Type of well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
102	Henderson	Pepsi Cola Bottling Company	do	400	8	15	do		90		Slope	Water treated
103	Henderson	B. H. Hicks	do	162	6	66½	Mica gneiss	-30	5		Flat	
104	2 miles NE of Dearmond	J. F. Lassiter	Bored	42	24	42	Granite	-23			Hill	Hit hard rock at 42 feet. Adequately supplies 3 families
105	½ mile N of Gillburg	Mrs. M. E. Ellis	Drilled	105	6	71½	do	-30	20		Slope	Slightly hard water reported
106	½ mile NW of Gillburg	D. G. Faulkner	do	73	6	44	do	-18	15+		do	Drawdown less than 1 foot after 18 hours pumping at 15 gpm
107	3/4 miles S of Gillburg	W. S. Smith	Drilled	119	6	50	Granite	-27	4		Slope	
108	1¼ miles SE of Gillburg	S. G. Satterwhite	Drilled	175	6	40	Granite	-19	90		Slope	Drawdown 10 feet after pumping 8 hours at 90 gpm. Analysis
109	1½ miles SE of Gillburg	E. M. Newman	do	214	8	57	do		16		do	Adequately supplies 2 families
110	1½ Miles NE of Gillburg	Allison A. Faulkner	do	79	6	55	do	-22	10+		do	
111	2¼ miles SW of Cokesbury	S. T. Franklin	Bored	38	24	38	Mica gneiss	-18	7		do	Analysis in table
112	3 miles E of Gillburg	T. H. Waldon, Sr.	Drilled	66	6	43½	do		20		Hill	Slightly hard water reported
113	1½ miles W of Bobbitt	J. K. Spenser, Jr.	do	53	6	20	do		7		Slope	Water contains iron
114	2½ miles S of Kittrell	Barker Wynn	Bored	45	24	45	do	-11	5+		Flat	
115	½ mile NE of Kittrell	Thomas Rodgers	Drilled	64	6		do		5		do	Bored 24 feet to rock
116	Kittrell	A. L. Overton	do	63	6	15	do	-15	9		Slope	
117	¼ mile NW of Kittrell	Kittrell College	do	181	8		do	-14			do	Moderately hard water reported
118	1¼ miles S of Flowtan Cross roads	Mrs. A. L. Vandyke	do	94	8		do				Hill	Adequately supplies 2 families
119	3 miles SW of Kittrell	C. T. Brummitt	do	216	6	20	do	-16.70	2-		Slope	Water level measured 11/9/61. Observation well
120	3 miles SW of Kittrell	C. T. Brummitt	Dug	25	40		Mica gneiss	-16.0			Slope	Water level measured 9/25/61
121	3½ miles SW of Kittrell	W. H. Milton	Drilled	63	6	32	Metavolcanic sequence		10		Hill	
122	3 3/4 miles SW of Kittrell	Victor Roberts	do	325	6	20	do	-30	½-		do	Analysis

Table 24.--Records of springs in Vance County

Spring Number	Location	Owner	Yield (gpm)	Chief Aquifer	Topography	Remarks
S_1	1/2 mile S of Gillburg-------	N. C. State Prison Department-----	38	Granite	Draw--------	Spring fed from fractures in granite. Yield has been measured at 38 gpm and is the only water supply for prison camp-----
S_2	1/2 mile SW of Flovtan Crossroads----------	B. B. Ayscue---	-----	Mica gneiss	--do--------	Water issues from fracture opening in biotite gneiss. Temp. 59°F----------
S_3	1-1/2 miles SW of Kittrell--------	William Moss---	1-3	--do--	--do--------	Seep area developed by excavating to rock and installing terra cotta pipe reservoir. Water obtained from biotite gneiss saprolite overlying hard rock----------

Table 25.--Chemical analyses of ground water from Vance County. (Numbers at heads of columns correspond to well numbers in table 23.)

(Parts per million)

	6	19	75	95	108	111	122
Date of Collection	2/6/63	2/13/62	2/13/62	2/13/62	2/13/62	2/13/62	2/13/62
Silica (SiO_2)	38	31	40	32	20	23	24
Aluminum (Al)	.0	.1	.0	.0	.0	.0	.0
Iron (Fe)	.03	.17	.08	.05	.24	.09	9.0
Manganese (Mn)	.00	.00	.00	.04	.00	.00	.03
Calcium (Ca)	3.8	14	34	51	5.4	3.2	63
Magnesium (Mg)	1.1	.7	13	8.1	.9	1.1	32
Sodium (Na)	6.7	4.4	48	10	9.2	7.6	10
Potassium (K)	.3	.6	4.0	5.2	1.6	1.5	1.9
Lithium (Li)	.0	.0	.0	.0	.0	.0	.0
Bicarbonate (HCO_3)	26	37	126	203	10	18	313
Sulfate (SO_4)	2.2	4.6	22	6.4	1.8	5.0	33
Chloride (Cl)	4.0	2.0	66	6.6	5.6	4.6	7.4
Fluoride (F)	.1	.1	.2	.1	.1	.0	.2
Nitrate (NO_3)	1.8	4.0	18	2.6	24	5.5	.3
Phosphate (PO_4)	.2	.7	.8	.3	.2	.1	.2
Dissolved Solids	71	80	308	222	74	61	326
Hardness as $CaCO_3$	14	38	138	162	17	12	288
Noncarbonate	0	7	35	0	9	0	31
Specific Conductance	58	110	537	357	96	69	548
pH	6.5	7.3	6.6	7.2	6.1	6.2	6.7
Color	5	15	5	3	3	3	7
Map Unit	Granodio-rite	Granodio-rite	Granodio-rite	Meta-volcanic	Granite	Mica gneiss	Meta-volcanic

REFERENCE 17

Reference 17

R. Allan Freeze

Department of Geological Sciences
University of British Columbia
Vancouver, British Columbia

John A. Cherry

Department of Earth Sciences
University of Waterloo
Waterloo, Ontario

GROUNDWATER

Prentice-Hall, Inc.
Englewood Cliffs, New Jersey 07632

Table 2.2 Range of Values of Hydraulic Conductivity and Permeability

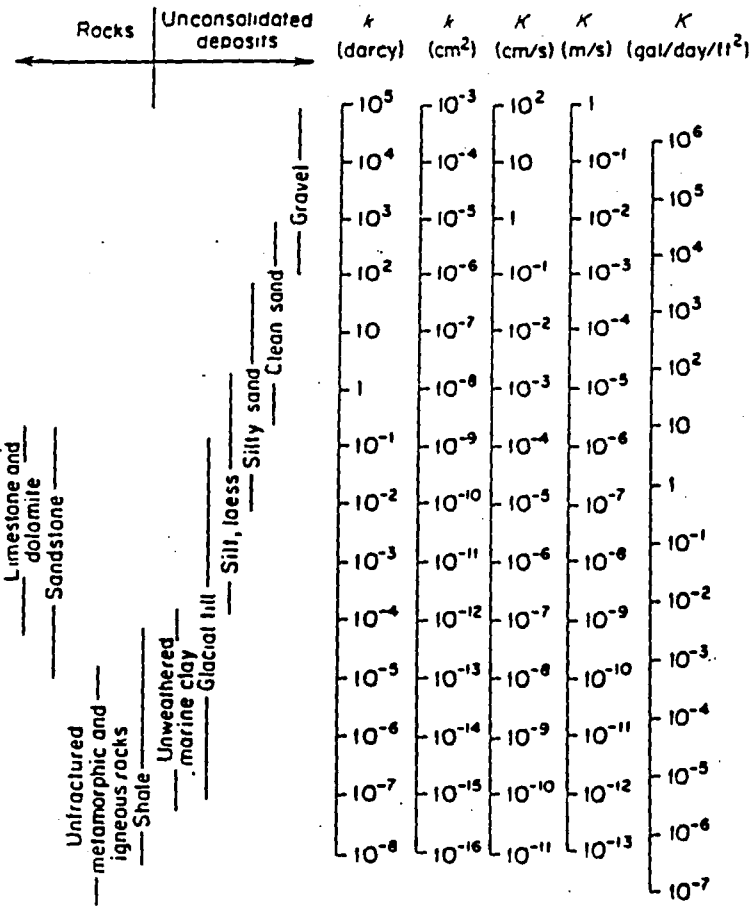


Table 2.3 Conversion Factors for Permeability and Hydraulic Conductivity Units

	Permeability, k*			Hydraulic conductivity, K		
	cm²	ft²	darcy	m/s	ft/s	U.S. gal/day/ft²
cm²	1	1.08×10^{-3}	1.01×10^{8}	9.80×10^{2}	3.22×10^{3}	1.85×10^{9}
ft²	9.29×10^{2}	1	9.42×10^{10}	9.11×10^{5}	2.99×10^{6}	1.71×10^{12}
darcy	9.87×10^{-9}	1.06×10^{-11}	1	9.66×10^{-6}	3.17×10^{-5}	1.82×10^{1}
m/s	1.02×10^{-3}	1.10×10^{-6}	1.04×10^{5}	1	3.28	2.12×10^{6}
ft/s	3.11×10^{-4}	3.35×10^{-7}	3.15×10^{4}	3.05×10^{-1}	1	6.46×10^{5}
U.S. gal/day/ft²	5.42×10^{-10}	5.83×10^{-13}	5.49×10^{-2}	4.72×10^{-7}	1.55×10^{-6}	1

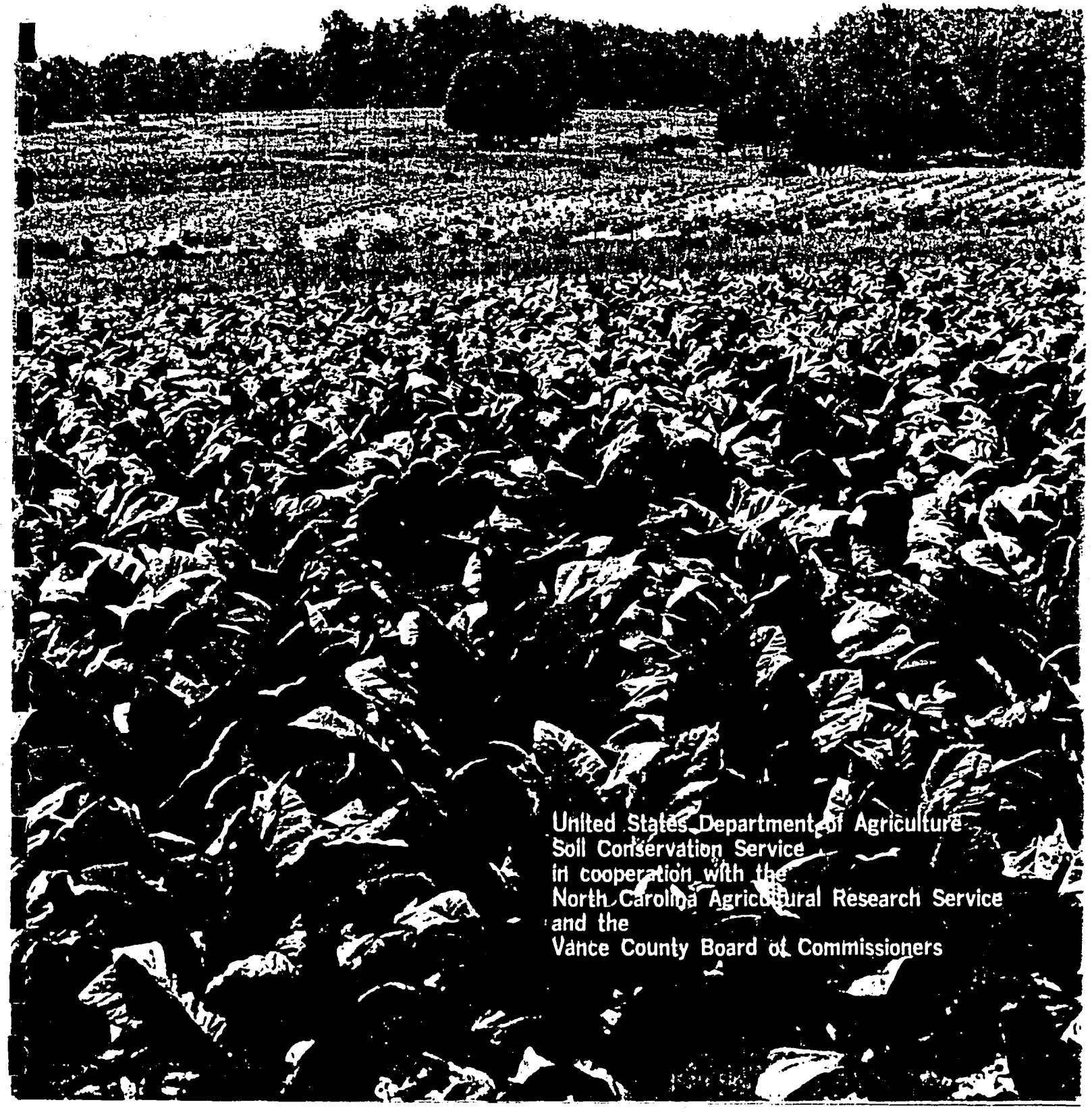
*To obtain k in ft², multiply k in cm² by 1.08×10^{-3}.

REFERENCE 18

Reference 18

SOIL SURVEY OF

Vance County, North Carolina



United States Department of Agriculture
Soil Conservation Service
in cooperation with the
North Carolina Agricultural Research Service
and the
Vance County Board of Commissioners

consists mainly of decomposed rock. Most of the areas are graded, leveled, and seeded with grass. The areas range from 5 to about 40 acres.

These borrow areas support sparse plant growth. A few areas are naturally reseeded in wild grasses, weeds, and shortleaf and Virginia pines. Potential is low for plant growth because of low available water capacity and erodibility.

Included with this soil in mapping are small, relatively undisturbed areas that still contain the clayey subsoil and part of the loamy topsoil.

The potential of Pits for urban development is variable. Many areas are graded to the level of an adjoining roadway and have high potential for industrial or commercial development. Some areas are cut below the remaining original ground level and have low potential for urban development.

Recommendations for reclamation and use of these areas require onsite investigation.

These Pits are not assigned to a capability subclass or woodland group.

TaE—Tatum silt loam, 15 to 30 percent slopes. This well drained soil is on side slopes adjacent to some of the major drainageways, mainly in the northwestern part of the county. The mapped areas are commonly narrow and oblong and irregular in width. The areas range from 4 to about 75 acres, but areas of 10 to 30 acres are most common.

Typically, the surface layer is dark brown silt loam 1 inch thick. The subsurface layer is brown silt loam 4 inches thick. The subsoil is 30 inches thick. The upper part of the subsoil is red silty clay, and the lower part is red silty clay loam. The underlying material to a depth of 50 inches is mottled red, yellowish red, pink, and yellowish brown silt loam.

The organic matter content of the surface layer is low. Permeability is moderate, available water capacity is medium, and shrink-swell potential is moderate. The subsoil is very strongly acid or strongly acid. Depth to bedrock ranges from 40 to more than 60 inches. The seasonal high water table is below 6 feet.

Included with this soil in mapping are small areas where the slopes are either less than 15 percent or slightly more than 30 percent. Georgeville and Nason soils are in areas where the slope is less than 15 percent, and the Goldston soils are where the slope is greater than 30 percent.

Most areas of this Tatum soil are in woodland and pasture.

This soil has low potential for row crops, hay, and pasture forages.

This soil has moderately high potential for broad-leaved and needle-leaved trees. The dominant trees are yellow-poplar, hickory, maple, beech, chestnut oaks, loblolly pine, shortleaf pine, and Virginia pine. The main understory includes dogwood, redbud, holly, and sassafras. Slope is the main limitation for woodland use and management.

Potential is low for most urban and recreational uses because of slope. Erosion is a hazard when the vegetative cover is removed.

This Tatum soil is in capability subclass IVe and in woodland group 3r.

UL—Udorthents. This map unit consists of areas where soil has been altered by sanitary landfill operations. These are excavated areas consisting of deeply graded trenches that are backfilled with alternat layers of solid refuse and soil material. A cover of 2 to feet of soil is on the surface. After the final cover is added, the surface ranges from nearly level to gently sloping. About 100 acres are mapped in the county. Th composition of this unit is more variable than that of others in the county, but it has been controlled well enough to be interpreted for the expected use of the soils.

Included in areas of this unit in mapping are small areas of undisturbed soil.

These areas have low potential for plant growth. Mo areas are seeded to grass or are planted to trees. Available water capacity is generally low. The erosion hazard is severe. Permanent vegetative cover is essential to protect these areas from erosion.

These areas are unsuitable for most building purpos because of subsidence and the danger of hazardous methane gas, which is produced by refuse in the landfi

Recommendations for use and management require onsite investigation.

This unit is not assigned to a capability subclass or woodland group.

VaB—Vance sandy loam, 2 to 8 percent slopes. This well drained soil is on smooth ridges. Typically, areas are irregular in shape and range from 10 to 40 acres. The largest area, about 800 acres, is in the vicinity of Dabney.

Typically, the surface layer is yellowish brown sandy loam 8 inches thick. The subsoil is 32 inches thick. Th upper part of the subsoil is yellowish red clay, and the lower part is yellowish red clay loam. The underlying material to a depth of 72 inches is reddish yellow saprolite that crushes to sandy clay loam in the upper part and yellow sandy loam in the lower part.

The organic matter content of the surface layer is lo Permeability is slow, available water capacity is mediur and shrink-swell potential is moderate. The subsoil is very strongly acid or strongly acid. Depth to bedrock is more than 60 inches. The seasonal high water table is below 6 feet.

Included with this soil in mapping are a few small areas of soils that have a clay loam surface layer and areas where slopes are slightly greater than 8 percent. Also included in the large units are the less firm Applin soils and the wetter Helena soils at the heads of and along the small drainageways. Wedowee soils are common on the included slopes that exceed 8 percen

B23t—32 to 40 inches; brownish yellow (10YR 6/6) clay loam; common medium distinct light yellowish brown (2.5Y 6/4) and common medium prominent yellowish red (5YR 5/8) mottles; moderate medium subangular blocky structure; friable, slightly sticky and slightly plastic; few fine quartz pebbles; common distinct clay films on faces of peds; very strongly acid; gradual wavy boundary.

B24t—40 to 49 inches; mottled strong brown (7.5YR 5/6), red (2.5YR 4/6), light yellowish brown (2.5Y 6/4), and light brownish gray (2.5Y 6/2) sandy clay loam; moderate medium subangular blocky structure; friable, slightly sticky and slightly plastic; few fine quartz pebbles; very strongly acid; gradual wavy boundary.

B3—49 to 62 inches; mottled strong brown (7.5YR 5/6), red (2.5YR 4/6), pale yellow (2.5Y 8/4), and white (2.5Y 8/2) sandy loam; platy parting to weak medium subangular blocky structure; friable; few fine quartz pebbles; few bodies of sandy clay loam; few fine flakes of mica; about 50 percent saprolite; very strongly acid.

Thickness of the loamy Bt horizon ranges from 24 to 48 inches or more. Bedrock is below 60 inches. The subsoil is very strongly acid or strongly acid. Coarse fragments range from 0 to 5 percent throughout.

The Ap or A1 horizon has hue of 10YR, value of 4 or 5, and chroma of 2 or 3. The A2 horizon has hue of 10YR, value of 6 or 7, and chroma of 2 to 4.

The Bt horizon has hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 4 to 8. Faint to prominent red, brown, and gray mottles are in the lower B horizon of some pedons. This horizon is sandy clay loam or clay loam.

The B3 horizon is mottled red, strong brown, pale yellow, or white. This horizon is sandy clay loam or sandy loam. Gray mottles are common in some pedons. The B3 horizon contains some saprolite in most pedons.

Georgeville series

The Georgeville series consists of well drained, moderately permeable soils on the Piedmont Upland. These soils formed in residuum weathered from fine grained rocks, such as slate and phyllite. They are on broad ridgetops and sides of ridges. Slopes range from 2 to 15 percent.

A typical pedon of Georgeville silt loam, 2 to 8 percent slopes, 9 miles north on North Carolina Highway 39 from U.S. Highway 158 Bypass at Henderson, 3 miles northwest on State Road 1342 to Marrows Chapel, and 50 feet north of State Road 1342 in woods:

O2—1/2 inch to 0; partly decomposed leaves and woods litter.

A1—0 to 1 inch; brown (10YR 5/3) silt loam; weak medium granular structure; very friable; many fine and medium roots; few medium quartz pebbles; medium acid; abrupt smooth boundary.

A21—1 to 5 inches; brown (7.5YR 5/4) silt loam; weak fine and medium granular structure; very friable; many fine, medium, and large roots; few medium quartz pebbles; medium acid; abrupt smooth boundary.

B1—5 to 7 inches; strong brown (7.5YR 5/8) silty clay loam; weak medium subangular blocky structure; friable, sticky and slightly plastic; many fine and medium roots; many fine and medium pores; strongly acid; clear smooth boundary.

B21t—7 to 30 inches; red (2.5YR 4/8) silty clay; moderate medium subangular blocky structure; firm, sticky and plastic; few fine roots; common fine and medium pores; thin distinct continuous clay films on faces of peds; strongly acid; gradual wavy boundary.

B22t—30 to 50 inches; red (2.5YR 4/8) silty clay; few fine distinct strong brown mottles; moderate medium subangular blocky structure; firm, sticky and plastic; common fine and medium pores; thin distinct continuous clay films on faces of peds; strongly acid; diffuse irregular boundary.

B3—50 to 65 inches; red (2.5YR 5/8) silty clay loam; few medium faint reddish yellow (5YR 6/8) mottles which increase with depth, few fine prominent white mottles; weak medium subangular blocky structure; friable, sticky and plastic; common fine and medium pores; thin patchy clay films on faces of peds; strongly acid; diffuse irregular boundary.

C—65 to 78 inches; red (2.5YR 5/8) saprolite of slate that crushes to loam; many medium distinct brownish yellow (10YR 6/8) and common fine pink mottles; weak coarse platy structure; very friable, slightly sticky and slightly plastic; common fine pores; strongly acid.

The clayey Bt horizon ranges from 24 to 48 inches in thickness. Depth to bedrock is more than 60 inches. Coarse fragments range from 0 to 15 percent in the surface layer. The subsoil is very strongly acid or strongly acid.

The A horizon has hue of 7.5YR and 10YR, value of 4 or 5, and chroma of 2 to 4. The A2 horizon, where present, has hue of 7.5YR and 10YR, value of 5 or 6, and chroma of 3 or 4.

The B1 horizon has hue of 7.5YR and 5YR, value of 4 or 5, and chroma of 4 to 8.

The B2t horizon has hue of 10R and 2.5YR, value of 4 or 5, and chroma of 6 to 8. This horizon is silty clay or clay. The B3 horizon is silty clay loam or silt loam.

The C horizon is red or brownish yellow saprolite of slate that crushes to silt loam or loam.

Goldston series

The Goldston series consists of shallow, well drained, moderately rapidly permeable soils on the Piedmont

B2t—10 to 24 inches; strong brown (7.5YR 5/8) silty clay loam; common medium distinct yellowish red (5YR 5/8) and common medium distinct yellow (10YR 7/6) mottles; moderate medium subangular blocky structure; friable, few fine roots; many fine pores; common dark streaks; very strongly acid; gradual wavy boundary.

B3—24 to 32 inches; strong brown (7.5YR 5/8) silt loam; common medium distinct yellowish red (5YR 5/8) and common medium distinct yellow (10YR 7/6) mottles; weak medium subangular blocky structure; friable; common dark streaks; 20 percent sericitic schist saprolite; strongly acid; gradual wavy boundary.

C1—32 to 48 inches; strong brown (7.5YR 5/8) sericitic schist saprolite that crushes to silt loam; massive; friable; common streaks of dark and light colored minerals; medium acid; gradual wavy boundary.

Cr—48 to 60 inches; strong brown (7.5YR 5/8) sericitic schist saprolite that crushes to silt loam; common fine distinct very pale brown mottles; massive; friable; medium acid.

The Bt horizon ranges from 10 to 24 inches in thickness. Depth to bedrock ranges from 40 to 60 inches. The surface horizon contains 15 to 20 percent coarse fragments of weathered slate schist or quartz gravel. The subsoil is very strongly acid or strongly acid.

The Ap or A1 horizon has hue of 10YR, value of 4 or 5, and chroma of 2 to 4. The A2 horizon, where present, has hue of 10YR, value of 5 to 7, and chroma of 3 or 4.

The B1 horizon has hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 4 to 6. This horizon is silt loam or silty clay loam.

The B2t horizon has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 6 to 8. This horizon is silty clay, clay, or silty clay loam. The B3 horizon, where present, has hue of 2.5YR or 7.5YR, value of 5 or 6, and chroma of 6 or 8, or it is mottled. This B3 horizon is silt loam or silty clay loam.

The C horizon is strong brown, yellowish red, or brownish yellow, or mottled saprolite that crushes to silt loam or very fine sandy loam. This horizon contains few to many fragments of slate or schist.

Pacolet series

The Pacolet series consists of well drained, moderately permeable soils on the Piedmont Upland. These soils formed under forest vegetation in residuum weathered from acid crystalline rock. Slopes range from 15 to 40 percent.

Typical pedon of Pacolet sandy loam, 15 to 40 percent slopes, 9.6 miles north on North Carolina Highway 39 from intersection of North Carolina Highway 39 and I-85, to State Road 1342, 1.5 miles on State Road 1342 to Coon Creek Farm, follow farm road 1.3 miles and 300 feet east in woods:

O1—2 inches to 0; partly decomposed leaves and hardwood litter.

A1—0 to 5 inches; dark grayish brown (10YR 4/2) sa loam; weak fine granular structure; very friable; many fine and medium roots; medium acid; abru smooth boundary.

B1—5 to 7 inches; yellowish red (5YR 4/6) clay loam weak medium subangular blocky structure; friabl few fine and medium roots; medium acid; abrupt smooth boundary.

B2t—7 to 19 inches; red (2.5YR 4/6) clay; moderate medium subangular blocky structure; firm, sticky plastic; many fine and medium roots; thin distinct patchy clay films on faces of peds; few fine flake mica; strongly acid; clear wavy boundary.

B3—19 to 27 inches; yellowish red (5YR 5/8) loam; f medium distinct strong brown (7.5YR 5/6) mottle weak medium subangular blocky structure; friable few fine and medium roots; few fine flakes of mic strongly acid; gradual wavy boundary.

C1—27 to 52 inches; yellowish red (5YR 5/8) saprolit that crushes to sandy loam; common red, brown, and white mottles; massive; very friable; few fine flakes of mica; strongly acid; gradual wavy bound

C2—52 to 60 inches; brownish yellow (10YR 6/6) saprolite that crushes to sandy loam; common wl and yellowish streaks; massive; very friable; stron acid.

Thickness of the clayey Bt horizon ranges from 12 t 20 inches. Depth to bedrock is more than 60 inches. subsoil ranges from very strongly acid to medium acid Few to common flakes of mica are in most pedons.

The Ap or A1 horizon has hue of 10YR, 7.5YR, and 5YR; value of 4 or 5; and chroma of 2 or 3. The A2 horizon, where present, has hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 3 or 4.

The B1 horizon, where present, has hue of 2.5YR o 5YR, value of 4 or 5, and chroma of 6 to 8. The B1 horizon is clay loam or sandy clay loam.

The B2t horizon has hue of 2.5YR or 10R, value of or 5, and chroma of 6 to 8. This horizon is clay loam c clay. The B3 horizon has hue of 2.5YR or 5YR, value 4 or 5, and chroma of 6 or 8, or contains pinkish or brownish mottles or minerals. The B3 horizon is sandy clay loam or loam.

The C horizon is yellowish red, red, or brownish yellow, or mottled brown, strong brown, pink, or light re saprolite that crushes to loam or sandy loam.

Tatum series

The Tatum series consists of well drained, moderate permeable soils on the Piedmont Upland. These soils formed in residuum weathered from sericitic schist. Slopes range from 15 to 30 percent.

Typical pedon of Tatum silt loam, 15 to 30 percent slopes, 9 miles north of the intersection of U.S. Highwa

158 and North Carolina Highway 39 in Henderson, 3 miles northwest on State Road 1342 to Marrows Chapel church, and 200 yards north of church in woods:

O1—1 inch to 0; partly decomposed leaves and forest litter.

A1—0 to 1 inch; dark brown (10YR 4/3) silt loam; moderate medium and fine granular structure; very friable; many fine and medium roots; common fine and medium quartz pebbles; strongly acid; abrupt smooth boundary.

A2—1 to 5 inches; brown (10YR 5/3) silt loam; weak medium granular structure; very friable; many fine and medium roots; common fine and medium quartz pebbles; strongly acid; clear wavy boundary.

B21t—5 to 20 inches; red (2.5YR 4/8) silty clay; moderate medium and fine subangular blocky structure; firm, sticky and plastic; few fine and medium roots; common fine and medium pores; thin continuous clay films on faces of peds and in pores; few fine flakes of mica; strongly acid; gradual wavy boundary.

B22t—20 to 28 inches; red (2.5YR 4/8) silty clay; few fine prominent brownish yellow mottles and few fine reddish yellow mottles; moderate medium and fine subangular blocky structure; firm, sticky and plastic; few fine and medium roots; common fine and medium pores; thin continuous clay films on faces of peds; few fine flakes of mica; strongly acid; gradual wavy boundary.

B3—28 to 35 inches; red (2.5YR 4/8) silty clay loam, with pockets of clay; common fine distinct strong brown mottles and few fine distinct pink mottles; weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; common fine flakes of mica; few fine white schist and quartz fragments; common fragments of saprolite; strongly acid; gradual wavy boundary.

C—35 to 50 inches; mottled red (2.5YR 4/6) (10R 4/6), yellowish red (5YR 5/8), pink (5YR 7/3), and yellowish brown (10YR 5/8) saprolite that crushes to silt loam; massive; very friable; few fine flakes of mica; strongly acid.

R—50 to 54 inches; moderately hard red, yellowish red, pink, and yellowish brown slate saprolite that is difficult to cut with an auger; strongly acid.

R—54 inches; hard slate rock.

Thickness of the clayey Bt horizon ranges from 10 to 24 inches. Depth to bedrock ranges from 40 to 60 inches. The subsoil is very strongly acid or strongly acid. Coarse fragments of gravel size range from 2 to 10 percent in the surface horizon. Few to common flakes of mica are present in most pedons.

The Ap or A1 horizon has hue of 10YR, value of 4 or 5, and chroma of 2 to 4. The A2 horizon, where present, has hue of 10YR, value of 5 or 6, and chroma of 3 or 4. The B2t horizon has hue of 2.5YR or 10R, value of 4 or 5, and chroma of 6 or 8. This horizon is silty clay or clay. The B3 horizon is similar in color to the B2t horizon, or mottled with brownish yellow, strong brown, or pink in some pedons. This B3 horizon is silty clay loam or silt loam.

The C horizon is red, yellowish red, pink, and yellowish brown saprolite that crushes to silt loam or very fine sandy loam.

Vance series

The Vance series consists of well drained, slowly permeable soils on the Piedmont Upland. These soils formed in residuum weathered from acid crystalline rock. They are on ridges and sides of ridges. Slopes range from 2 to 8 percent.

Typical pedon of Vance sandy loam, 2 to 8 percent slopes, 2.2 miles north on Satterwhite Point Road from overpass of I-85 and in field 50 feet west of road:

Ap—0 to 8 inches; yellowish brown (10YR 5/4) sandy loam, weak medium granular structure; very friable; common fine roots; medium acid; abrupt smooth boundary.

B2t—8 to 22 inches; yellowish red (5YR 5/8) clay; few fine distinct red and yellow mottles; strong coarse and medium subangular and angular blocky structure; very firm, very sticky and very plastic; common fine roots between peds; few fine pores; thin distinct continuous clay films on faces of peds and old root channels; common fine flakes of mica and grains of feldspar; strongly acid; gradual wavy boundary.

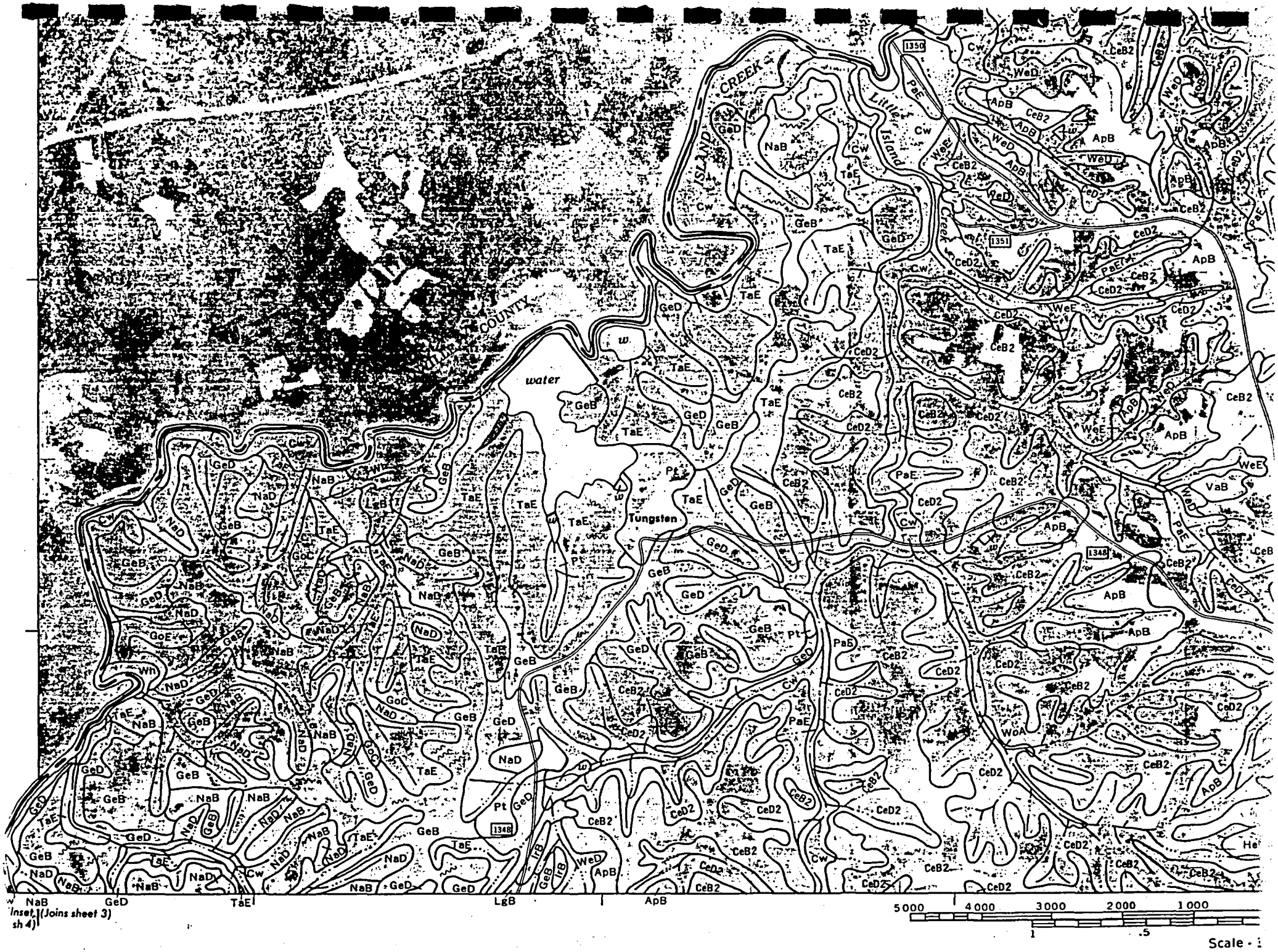
B3—22 to 40 inches; yellowish red (5YR 5/8) clay loam that has common coarse peds of very firm, very plastic, red (2.5YR 4/8) clay; massive parting to weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; thin distinct continuous clay films on faces of peds; common fine flakes of mica and many grains of feldspar; very strongly acid; gradual wavy boundary.

C—40 to 72 inches; reddish yellow (5YR 6/8) saprolite that crushes to sandy clay loam; many coarse distinct red (2.5YR 4/8) mottles; massive; very friable; common fine flakes of mica and many grains of feldspar; very strongly acid.

The clayey Bt horizon ranges from 10 to 18 inches in thickness. Depth to bedrock is more than 60 inches. The subsoil is very strongly acid or strongly acid. Fine to medium coarse fragments range from 0 to 5 percent in the surface layers.

The Ap or A1 horizon has hue of 10YR, value of 4 to 6, and chroma of 2 to 4.

The B2t horizon has hue of 5YR, 7.5YR, or 10YR; value of 4 or 5; and chroma of 6 to 8. This horizon is clay, sandy clay, or clay loam. The B3 horizon is similar in color to the B2t horizon or mottled with red, and texture is sandy clay loam, loam, or clay loam. Distinct to


Little Island Creek
ISLAND CREEK
COUNTY
water
Tungsten
1350
1351
1348
1348
NaB
GeD
TaE
LgB
ApB
5000
4000
3000
2000
1000
1
.5
Scale - 1
Inset. (Joins sheet 3)
sh 4)

REFERENCE 19

September 16, 1991

TO: Technical Staff

FROM: Pat DeRosa

RE: US Census Bureau 1990 Population Data
Persons Per Household by County
Persons Per Household by Town
Total Population by County
Total Population by Town

Please find attached the subject population data which I recently received from the US Census Bureau. Please note that the Persons Per Household by County data which I distributed in June has not been revised and is still accurate as included here. I have also included the remainder of Table 6 which lists information on Persons Per Household by Town, and Table 5 which lists Total Population Values for each County or Town. Please let me know if you have any questions about using this data or if you require additional census data.

Attachments

Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Householder living alone: Total	Householder living alone, 65 years and over: Total	Householder living alone, 65 years and over: Female	Persons per— Household	Persons per— Family	Persons in group quarters: Total	Persons in group quarters: Institutionalized persons	Persons in group quarters: Other persons in group quarters
COUNTY—Con.														
Vance County	38 060	14 166	10 502	7 408	2 584	3 664	3 238	1 440	1 137	2.69	3.16	812	517	295
Wake County	408 267	165 743	109 543	88 567	16 581	56 200	42 662	8 449	7 828	2.46	3.01	15 113	6 571	8 542
Warren County	16 918	6 305	4 762	3 357	1 127	1 543	1 422	742	559	2.68	3.15	347	332	15
Washington County	13 762	5 052	3 839	2 826	833	1 213	1 151	584	454	2.72	3.21	235	234	1
Watauga County	32 476	13 693	8 415	7 121	975	5 278	3 437	1 041	833	2.37	2.88	4 476	279	4 197
Wayne County	97 572	36 889	27 577	21 107	5 320	9 312	8 263	3 258	2 642	2.65	3.11	7 094	2 488	4 606
Wilkes County	58 787	23 021	17 586	14 634	2 274	5 435	4 855	2 182	1 723	2.55	2.96	606	586	20
Wilson County	64 414	25 093	18 031	12 996	4 180	7 062	6 277	2 679	2 184	2.57	3.08	1 647	876	771
Yadkin County	30 063	12 058	9 173	7 720	1 124	2 895	2 669	1 333	1 050	2.49	2.90	435	424	11
Yancey County	15 235	6 124	4 683	4 010	510	1 441	1 354	729	586	2.49	2.90	184	184	-
PLACE AND COUNTY SUBDIVISION														
Aberdeen town, Moore County	2 679	1 154	773	587	150	381	336	188	162	2.32	2.87	21	-	21
Ahoskie town, Hertford County	4 258	1 769	1 164	770	356	605	576	272	229	2.41	3.07	133	130	3
Alamance village, Alamance County	258	112	80	67	11	32	30	17	13	2.30	2.76	-	-	-
Albemarle city, Stanly County	14 403	6 054	4 169	3 205	812	1 885	1 746	913	762	2.38	2.92	536	459	77
Alexander Mills town, Rutherford County	662	279	176	111	55	103	93	59	50	2.37	2.97	-	-	-
Alliance town, Pamlico County	583	232	182	150	28	50	40	29	23	2.51	2.91	-	-	-
Altamahaw-Ossipee CDP, Alamance County	1 076	424	307	233	57	117	113	56	44	2.54	3.06	-	-	-
Andrews town, Cherokee County	2 520	1 055	738	564	139	327	302	191	153	2.37	2.88	31	31	-
Angier town, Harnett County	2 230	901	637	449	154	264	236	97	86	2.48	2.98	5	-	5
Ansonville town, Anson County	614	203	165	108	47	38	36	20	18	3.02	3.45	-	-	-
Apex town, Wake County	4 898	1 752	1 378	1 132	196	374	318	115	106	2.80	3.19	70	67	3
Arapahoe town, Pamlico County	430	175	129	108	15	46	44	26	21	2.44	2.93	-	-	-
Archdale city	6 913	2 803	2 085	1 758	248	718	643	183	155	2.47	2.90	-	-	-
Guilford County	234	82	72	66	5	10	8	3	3	2.85	3.07	-	-	-
Randolph County	6 679	2 721	2 013	1 692	243	708	635	180	152	2.45	2.89	-	-	-
Arlington town, Yadkin County	795	333	239	170	57	94	91	52	41	2.39	2.86	-	-	-
Asheboro city, Randolph County	15 682	6 977	4 455	3 357	830	2 522	2 256	979	820	2.25	2.84	680	636	44
Asheville city, Buncombe County	59 322	27 027	16 218	11 717	3 750	10 809	9 511	4 233	3 500	2.19	2.84	2 285	1 269	1 016
Askewville town, Bertie County	201	81	60	56	4	21	21	15	14	2.48	3.00	-	-	-
Atkinson town, Pender County	275	119	85	67	13	34	31	21	20	2.31	2.79	-	-	-
Atlantic Beach town, Carteret County	1 887	935	516	434	63	419	335	56	37	2.02	2.62	51	-	51
Aulander town, Bertie County	1 209	454	320	213	98	134	123	76	58	2.66	3.29	-	-	-
Aurora town, Beaufort County	654	260	181	119	53	79	73	51	40	2.52	3.11	-	-	-
Autryville town, Sampson County	166	73	55	40	9	18	16	8	7	2.27	2.58	-	-	-
Avery Creek CDP, Buncombe County	1 144	408	341	304	27	67	60	15	11	2.80	3.13	-	-	-
Ayden town, Pitt County	4 735	1 795	1 305	854	385	490	445	230	199	2.64	3.13	5	5	-
Badin CDP, Stanly County	1 481	616	420	315	87	196	183	119	103	2.40	2.97	-	-	-
Bailey town, Nash County	553	245	151	118	26	94	89	55	42	2.26	2.97	-	-	-
Bakersville town, Mitchell County	326	148	99	71	17	49	44	21	15	2.20	2.71	6	6	-
Bald Head Island village, Brunswick County	78	39	32	31	1	7	7	-	-	2.00	2.22	-	-	-
Balfour CDP, Henderson County	1 119	494	344	280	51	150	132	58	47	2.26	2.72	-	-	-
Banner Elk town, Avery County	336	163	89	67	18	74	64	24	19	2.08	2.80	504	-	504
Barker Heights CDP, Henderson County	1 137	468	345	248	84	123	107	47	33	2.43	2.83	-	-	-
Barker Ten Mile CDP, Robeson County	1 067	372	329	292	26	43	34	12	10	2.92	3.12	-	-	-
Bath town, Beaufort County	154	81	41	29	12	40	36	25	20	1.90	2.66	-	-	-
Battleboro town	447	176	127	87	30	49	46	23	19	2.54	3.06	-	-	-
Edgecombe County	280	100	73	39	26	27	25	9	6	2.80	3.34	-	-	-
Nash County	167	76	54	48	4	22	21	14	13	2.20	2.67	-	-	-
Bayboro town, Pamlico County	720	283	201	130	63	82	75	31	29	2.54	3.10	13	13	-
Bayshore CDP, New Hanover County	1 661	605	517	471	30	88	80	26	22	2.75	3.00	-	-	-
Beargrass town, Martin County	77	35	24	19	4	11	11	6	6	2.20	2.75	-	-	-
Beaufort town, Carteret County	3 795	1 721	1 075	741	292	646	581	255	197	2.21	2.83	13	13	-
Beech Mountain town	239	109	78	75	1	31	25	6	4	2.19	2.55	-	-	-
Avery County	7	3	2	2	-	1	1	-	-	2.33	3.00	-	-	-
Watauga County	232	106	76	73	1	30	24	6	4	2.19	2.54	-	-	-
Belhaven town, Beaufort County	2 241	840	588	359	192	252	233	138	110	2.67	3.29	28	28	-
Belmont city, Gaston County	7 774	3 049	2 149	1 803	407	900	811	354	294	2.55	3.09	660	-	660
Belville town, Brunswick County	66	28	12	7	5	16	11	4	2	2.36	3.75	-	-	-
Belwood town, Cleveland County	631	259	193	164	19	66	50	29	21	2.44	2.87	-	-	-
Benson town, Johnston County	2 728	1 137	718	456	207	419	368	222	176	2.40	3.08	82	67	15
Bent Creek CDP, Buncombe County	1 487	532	452	367	45	80	71	27	18	2.80	3.06	-	-	-
Bessemer City city, Gaston County	4 698	1 762	1 337	975	288	425	366	176	144	2.67	3.10	-	-	-
Bethel town, Pitt County	1 842	709	505	329	159	204	188	101	86	2.60	3.15	-	-	-
Bethlehem CDP, Alexander County	3 186	1 186	966	848	85	220	191	47	35	2.69	2.95	-	-	-
Beulaville town, Duplin County	921	411	274	194	67	137	122	63	52	2.24	2.77	12	12	-
Biltmore Forest town, Buncombe County	1 327	540	420	387	26	120	116	72	58	2.46	2.84	-	-	-
Biscoe town, Montgomery County	1 478	513	389	281	88	124	103	52	38	2.88	3.34	6	6	-
Black Creek town, Wilson County	615	243	192	167	24	51	46	27	24	2.53	2.89	-	-	-
Black Mountain town, Buncombe County	5 032	2 256	1 462	1 168	241	794	722	441	366	2.23	2.81	386	331	55
Bladenboro town, Bladen County	1 768	758	521	358	143	237	228	120	101	2.33	2.91	53	53	-
Blowing Rock town	1 179	570	333	296	34	237	213	85	66	2.07	2.73	78	76	2
Caldwell County	44	21	14	12	2	7	6	3	2	2.10	2.57	-	-	-
Watauga County	1 135	549	319	274	32	233	207	82	64	2.07	2.74	78	76	2
Boger City CDP, Lincoln County	1 373	566	411	341	63	155	143	56	42	2.41	2.89	-	-	-
Boiling Spring Lakes city, Brunswick County	1 650	666	523	447	53	143	122	54	38	2.48	[illegible]	-	-	-
Boiling Springs town, Cleveland County	1 675	668	493	380	89	175	148	50	55	2.51	2.84	770	44	726
Bolivia town, Brunswick County	229	87	64	50	12	23	21	15	13	[illegible]	[illegible]	-	-	-
Bolton town, Columbus County	[illegible]	[illegible]	[illegible]	65	43	58	56	34	22	2.55	3.16	-	-	-
Bonnie Doone CDP, Cumberland County	3 883	1 500	1 009	637	315	581	431	41	24	2.45	2.94	5	-	5
Boone town, Watauga County	8 607	4 053	1 470	1 141	248	2 583	1 305	275	238	2.12	2.71	4 308	127	4 181
Boonville town, Yadkin County	908	403	299	247	40	104	97	62	54	2.48	2.93	11	-	11
Bostic town, Rutherford County	371	137	111	92	15	26	22	11	8	2.71	3.04	-	-	-
Brevard city, Transylvania County	4 809	2 072	1 331	1 026	272	741	667	421	365	[illegible]	[illegible]	779	168	611
Bridgeton town, Craven County	453	193	130	103	16	63	57	20	17	2.35	[illegible]	-	-	-
Broadway town	973	362	286	247	32	76	71	37	28	2.69	3.06	-	-	-
Harnett County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lee County	973	362	286	247	32	76	71	37	28	2.69	3.06	-	-	-
Brogden CDP, Wayne County	3 246	1 059	851	624	182	208	162	[illegible]	25	3.07	3.44	-	-	-
Brookford town, Catawba County	451	189	133	83	27	56	52	31	21	2.39	2.85	-	-	-
Brunswick town, Columbus County	332	106	81	62	15	25	24	8	7	2.85	3.37	-	-	-
Bryson City town, Swain County	1 063	491	300	233	57	189	171	100	84	2.16	2.73	82	82	-

TPSII [POSTSCRIPT] CPH137 CENSUS90 ... 04/23/91 ... MACHINE: C DATA CENSUS90 PHIT ... OUTPUT ... PAGE: 106
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NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

REFERENCE 20

GREENHORNE & O'MARA, INC.

ENGINEERS • ARCHITECTS • PLANNERS • SCIENTISTS
SURVEYORS • PHOTOGRAMMETRISTS

BY MJG DATE 7/5/91 SUBJECT Tungsten Queen Mine SHEET NO. 1 OF 1
Revised 11/13/91 Townsville, Vance County JOB NO.
REV. BY DATE NCD 082 362 989 FILE NO.

Population Calculations

Radius	# of Houses	Persons/Household	Total Radial Populatio
1/4-mile	21	2.69	56
1/2-mile	0	2.69	0
1-mile	0	2.69	0
2-mile	91	2.69	245
3-mile	193	2.69	519
4-mile	289	2.69	777

400 people utilize well at New Hope Elementary School, (located between 3 and 4 miles from the site).

Population Table

Radius	Population / Radii	Cumulative Population
1/4-mile	56	56
1/2-mile	0	56
1-mile	0	56
2-mile	245	301
3-mile	519	820
4-mile	1,177	1,997

GREENHORNE & O'MARA, INC.
ENGINEERS • ARCHITECTS • PLANNERS • SCIENTISTS
SURVEYORS • PHOTOGRAMMETRISTS

BY MJG DATE 2/5/91 SUBJECT Tungsten Queen Mine SHEET NO. 1 OF 1
CHKD. BY ____ DATE ____ Townsville, Vance County JOB NO. ____
REV. BY ____ DATE ____ NC D 082 362 989 FILE NO. ____

Population Count

Radius	# of houses	persons / household	Total radial population
1/4 mile	21	2.95	62
1/2 mile	0	2.95	0
1 mile	0	2.95	0
2 mile	91	2.95	268
3 mile	193	2.95	569
4 mile	289	2.95	853
		Total	1,752

Population Table

Radius	Population / Radii	Cumulative Population
1/4 mile	62	62
1/2 mile	0	62
1 mile	0	62
2 mile	268	330
3 mile	569	899
4 mile	853	1,752

REFERENCE 21

PORT DATE 07/26/90

REPORT W0415NCP-ALPHA (WANG)
DHR - ENVIRONMENTAL HEALTH SECTION - WATER SUPPLY BRANCH
ALPHABETICAL WITHIN COUNTY LISTING OF ACTIVE NON-COMM PWS

WS NAME	PWID	RES NAME	ADDRESS	CITY	ZIP	T	A	POP.SRV	S	PHONE
T PAUL CHRISTIAN CHURCH	0291446	HENRY PLUMMER OR DIR	SR 1369	MIDDLEBURG	27556	N	A	200	G	919-492-0828
IEVE'S GRO & GRILL	0291509	STEVE ELLINGTON OR M	RT 6 BOX 401	HENDERSON	27536	N	A	50	G	- -
ARHEEL MARINA	0291504	JOYCE BOBBITT OR MGR	SATTERWHITE PT RD.	HENDERSON	27536	N	A	75	G	919-438-8613
HE GROVE	0291424	HENRY DICKERSON OR M	PO BOX 144	HENDERSON	27536	N	A	132	G	919-438-8320
HOMAS CHAPEL PHC	0291468	STEVE K ENLOE OR MGR	RT 2 BOX 618 ST RD	HENDERSON	27536	N	A	90	G	919-438-8427
INY TOT NURSERY	0291442	TINY TOT NURSERY	HWY 39	HENDERSON	27536	N	A	25	G	919-438-6024
NC CHAPEL HILL KERA LAK	0291474	PREDERIC W SCHROEDER	UNC CHAPEL HILL STE	CHAPEL HILL	27514	N	A	25	G	- -
NC-CH KERR LAKE REC ARE	0291475	FREDERIC SCHRDEDER O	BOX 297	TOWNSVILLE	27584	N	A	25	G	919-962-2211
NC-CH KERR LAKE REC ARE	0291473	FREDERIC SCHROEDER O	BOX 297	TOWNSVILLE	27584	N	A	25	G	919-962-2211
ANCE CTY WILDLIFE CLUB	0291112	CLAY ROWLAND OR MGR	SR 1346	TOWNSVILLE	27584	N	A	35	G	919-492-1426
DDMONT PETROLEUM INC (	0291506	JERRY STEVENSON OR M	BOX 1938	HENDERSON	27536	N	A	39	G	919-492-5189

COUNTY =091 NUMBER OF RECORDS = 60 TOTAL POPULATION = 5,679

Reference 21

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
BOYDS EXXON	0291427	BOYDS EXXON	I-85 & SR 1319	HENDERSON	27536	N	A	25	G	919-492-6774	
CAMP GRAHAM GSA	0291478	MARK JOHSON OR DIREC	RT 3 BOX 878	HENDERSON	27536	N	A	28	G	919-492-0835	
CAMP GRAHAM-KAY MCGAVEN	0291477	MARC JOHNSON OR DIRE	RT 3 BOX 878	HENDERSON	27536	N	A	120	G	919-492-0835	
CAMPER PRODUCTS	0291400	CAPT HILLIARD	RT 4	HENDERSON	27536	N	A	100	G	919-492-2111	
CAREY'S BAPTIST CHURCH	0291465	RONALD VAUGHAN OR PA	RT 2 SR 1519	HENDERSON	27536	N	A	150	G	919-438-7781	
CARVER ELEMENTARY SCHOOL	0291413	E C MOSS OR MAINT SU	RT 6 BOX 496	HENDERSON	27536	N	A	358	G	919-492-2127	
COGHILLS MINUTE MART	0291404	OWNER OR MANAGER	RT 1	HENDERSON	27536	N	A	35	G	919-492-9515	
COKESBURY UMC	0291460	DAVID PARRISH OR PAS	STATE RD 1512	HENDERSON	27536	N	A	100	G	- -	
DABNEY ELEMENTARY SCHOOL	0291410	E C MOSS OR MAINT SU	RT 3	HENDERSON	27536	N	A	412	G	919-438-6918	
E O YOUNG ELEMENTARY SCH	0291406	E C MOSS MAINTENANCE	BOX 160	MIDDLEBURG	27556	N	A	340	G	919-492-2127	
FLAT CREEK BAPT CH	0291436	FLAT CREEK BAPT CH	RT 4	HENDERSON	27536	N	A	125	G	- -	
FRAN'S PANTRY	0291425	FRANCIS PROHST OR A	PO BOX 175	TOWNSVILLE	27584	N	A	33	G	919-492-2946	
FRAZIER BROTHERS	0291448	JOHN H BOWER OR MGR	RFD 4 BOX 30	HENDERSON	27536	N	A	25	G	919-438-8225	
GILLBURG UNITED METHODIS	0291466	REV GENE COBB OR PAS	HWY 39 RT 1	HENDERSON	27536	N	A	200	G	919-492-8155	
GRANNYS COKESBURY NE PRE	0291513	BEULAH PEGRAM OR MAN	RT 2 BOX 104	HENDERSON	27536	N	A	30	G	919-492-1485	
GREENGLO CHILD CARE CENT	0291514	GLORIA STENNETT OR M	PO BOX 1787	HENDERSON	27536	N	A	30	G	919-492-8228	
HAPPY DAY NURSERY	0291440	HAPPY DAY NURSERY	SR 1519	HENDERSON	27536	N	A	25	G	919-492-0776	
HENDERSON CO MAINT YD DO	0291479	R S MANGUM LANDSCAPE	PO BOX 15580	DURHAM	27704	N	A	60	G	919-683-6851	
HENDERSON HEADSTART DAYC	0291515	FVW OPPORTUNITY INC	PO BOX 1453	HENDERSON	27536	N	A	30	G	919-438-8121	
HENDERSON MAINTENANCE YA	0291462	STEVE BASS OR PASTOR	RT 1	HENDERSON	27536	N	A	140	G	919-492-4590	
HIBERNIA PARK	0291451	HIBERNIA PARK	NC 39 NORTH	HENDERSON	27536	N	A	25	G	- -	
HUMPTY DUMPTY AFTERSCHOO	0291443	M/M ROBERTS	RT 7 BOX 485	HENDERSON	27536	N	A	30	G	919-438-8138	
ISLAND CREEK BAPT CH	0291435	ISLAND CREEK BAPT CH	SR 1529 RT 1	HENDERSON	27536	N	A	600	G	- -	
JACK & JILL DAYCARE CENT	0291516	LINDA MCCANN OR MANA	RT 6 BOX 749	HENDERSON	27536	N	A	30	G	919-492-9975	
KERR LAKE-METHODIST CAMP	0291511	ALLEN WENTZ OR MGR	PO BOX 10955	RALEIGH	27605	N	A	40	G	919-832-9560	
KERR RESERVOIR COUNTY LI	0291464	HOWARD L. STEWART OR	RT 3 BOX 800	HENDERSON	27536	N	A	25	G	919-438-7791	
KERR RESERVOIR HIBERNIA	0291491	HOWARD L STEWART OR	RT 3 BOX 800	HENDERSON	27536	N	A	25	G	919-438-7791	
KERR RESERVOIR HIBERNIA	0291489	HOWARD L STEWART OR	RT 3 BOX 800	HENDERSON	27536	N	A	25	G	919-438-7791	
KERR RESERVOIR NUTBUSH N	0291497	HOWARD L STEWART OR	RT 3 BOX 800	HENDERSON	27536	N	A	25	G	919-438-7791	
KERR RESERVOIR NUTBUSH N	0291498	HOWARD L. STEWART OR	RT 3 BOX 800	HENDERSON	27536	N	A	25	G	919-438-7791	
KERR RESERVOIR-KIMBALL P	0291492	HOWARD L. STEWART OR	RT 3 BOX 800	HENDERSON	27536	N	A	25	G	919-438-7791	
KERR RESERVOIR-KIMBALL P	0291493	HOWARD L. STEWART OR	RT 3 BOX 800	HENDERSON	27536	N	A	25	G	919-438-7791	
KERR RESERVOIR-KIMBALL P	0291494	HOWARD L. STEWART OR	RT 3 BOX 800	HENDERSON	27536	N	A	25	G	919-438-7791	
KERR RESERVOIR-KIMBALL P	0291495	HOWARD L. STEWART OR	RT 3 BOX 800	HENDERSON	27536	N	A	25	G	919-438-7791	
KERR RESERVOIR-KIMBALL P	0291496	HOWARD L STEWART OR	RT 3 BOX 800	HENDERSON	27536	N	A	25	G	919-438-7791	
KERR RESEV HIBERNIA PRCH	0291487	HOWARD STEWART MGR	RT 3 BOX 800	HENDERSON	27536	N	A	84	G	919-438-7791	
KERR-VANCE ACADEMY	0291409	MR DON BURKE OR SUPT	ROUTE 4 BOX 213	HENDERSON	27536	N	A	365	G	919-492-0018	
KIDSWORLD	0291517	FAYE M STEWARDSON OR	RT 3 BOX 25-C	HENDERSON	27536	N	A	30	G	919-492-1829	
LITTLE PEOPLE NURSERY	0291518	ANN JONES OR MANAGER	RT 7 BOX 125	HENDERSON	27536	N	A	30	G	919-492-3458	
MIDDLEBURG INTERSTATE SH	0291507	FRED FOGG OR MGR	RT 3 BOX 92	HENDERSON	27536	N	A	32	G	919-492-1048	
MIDDLEBURG STEAKHOUSE	0291512	TOMMY GREENWAY OR MG	RFD 2	MIDDLEBURG	27556	N	A	46	G	919-492-7088	
NEW HOPE ELEMENTARY SCHO	0291411	E C MOSS OR MAINT SU	RT 5	HENDERSON	27536	N	A	400	G	919-438-6549	
P & M DAIRY BAR	0291408	RALPH PEGRAM OR MGR	RT 5	HENDERSON	27584	N	A	50	G	919-492-2292	
REHOBOTH UNITED METH CHU	0291423	GILBERT CAPPS OR PAS	PO BOX 302 RT 4	HENDERSON	27536	N	A	75	G	919-439-6740	
ROBERSONS STOP & SHOP	0291430	ROBERSONS STOP & SHO	SR 1548 & SR 1547	HENDERSON	27556	N	A	25	G	- -	
ROSES STORES INC. MERCHA	0291447	H B BOBBITT OR MGR	208 GARNETT ST	HENDERSON	27536	N	A	50	G	919-438-3125	
SATTERWHITE RD 66 SER	0291429	SATTERWHITE RD 66 S	I85 & SR 1319	HENDERSON	27536	N	A	25	G	919-438-8813	

REFERENCE 22

7/11/90

North Carolina Surface Water Intakes

DEM#	LATITUDE	LONGITUDE	COUNTY	RIVER	USE-CLASS
123.3	35 28 56.54	80 42 59.84	Rowan	Coddle Creek	WS-I
124.1	35 35 06.00	80 38 05.00	Rowan	Lake Right	WS-I
124.2	35 33 48.95	80 36 08.29	Rowan	Lake Corrier	WS-I
125.0	35 44 48.85	80 27 36.62	Rowan	Yadkin River	WS-III
125.1	35 44 51.52	80 27 39.06		Yadkin River	
126.0	35 14 21.29	81 46 18.43	Rutherford	Second Broad River	WS-III
127.0	35 23 04.63	81 51 31.58	Rutherford	Second Broad River	WS-I
128.0	35 18 27.37	81 59 31.88	Rutherford	Broad River	WS-III
129.1	35 28 18.73	80 08 51.20	Stanly	Badin Lake	WS-III
129.2	35 29 38.30	80 11 05.38	Stanly	Tuckertown Lake	
130.0	35 25 09.83	80 05 44.29	Montgomery	Badin Lake	WS-III
131.0	35 14 29.53	80 06 24.64	Stanly	Lake Tillery	WS-III
132.0	36 13 15.02	80 25 58.29	Stokes	Yadkin River	WS-III
132.1	36 16 00.15	80 14 21.21	Stokes	Town Creek	WS-I
133.0	36 24 45.44	80 43 29.47	Surry	Fisher River	WS-II
134.0	36 15 43.04	80 52 03.03	Surry	Big Elkins Creek	WS-II
135.1	36 31 28.00	80 36 59.00	Surry	Lovills Creek	WS-II
135.2	36 29 45.66	80 39 01.46	Surry	Stewarts Creek	WS-II
136.0	36 23 59.79	80 29 14.46	Surry	Toms Creek	WS-I
137.0	35 27 59.78	83 28 00.60	Swain	Lands Creek	WS-I
138.0	35 12 37.08	82 46 58.54	Transylvania	Catheys Creek	WS-I
139.0	34 57 56.90	80 18 33.76	Union/Anson	Lanes Creek	WS-II
140.1	34 57 57.25	80 30 42.15	Union	Lake Lee	WS-II
140.2	35 02 10.00	80 28 39.99	Union	Lake Twitty	WS-II
141.0	36 26 26.08	78 21 35.29	Vance	Kerr Reservoir	WS-III
143.1	35 54 40.04	78 33 34.71	Wake	Falls Reservoir	WS-III
143.3	35 39 43.13	78 36 42.60	Wake	Swift Creek	WS-II
144.0	35 58 15.29	78 29 13.92	Wake	Smith Creek	WS-I
145.0	35 49 58.25	78 21 27.37	Wake	Little River	WS-I
145.1	35 41 39.42	78 41 40.07	Wake	Lake Wheeler	WS-II
146.0	36 14 33.19	81 40 04.29	Watauga	Howards Creek	WS-I
146.1	36 14 18.45	81 40 12.92	Watauga	ASU Lake	WS-I
147.1	36 11 40.80	81 52 02.86	Watauga	Pond Creek #1	WS-I
147.2	36 12 57.81	81 54 33.11	Watauga	Buckeye Creek	WS-I
147.3	36 13 19.52	81 52 38.90	Watauga	Pond Creek	WS-I
148.0	36 08 36.01	81 40 19.76	Watauga	Reid House Creek	WS-I
148.1	36 10 32.37	81 41 07.21	Watauga	Winklers Creek Res.	WS-I
149.1	36 11 47.55	81 40 22.55	Watauga	Winklers Creek	WS-I
149.2	36 12 15.18	81 38 59.62	Watauga	S.F. New River	WS-I
150.0	35 23 38.73	78 01 37.71	Wayne	Little River	WS-III
151.1	35 22 30.46	78 01 48.10	Wayne	Neuse River	WS-III
151.2	35 24 15.19	78 00 49.63	Wayne	Little River	WS-III
152.0	36 09 48.40	81 09 40.96	Wilkes	Reddies River	WS-I
153.0	36 08 40.51	81 10 44.89	Wilkes	Yadkin River	WS-III
154.1	35 44 37.46	77 54 09.82	Wilson	Toisnot Swamp	WS-II
154.2	35 41 17.09	77 56 54.92	Wilson	Contentnea Creek	WS-III
154.3	35 47 19.55	77 55 15.26	Wilson	Lake Wilson	WS-II
154.4	35 48 46.29	77 56 52.94	Wilson	[illegible]	WS-II

Reference 22

REFERENCE 23

NUS CORPORATION AND SUBSIDIARIES *ON NOTE*

CONTROL NO.	DATE: 11-13-90	TIME: 1350

DISTRIBUTION:

Tungsten Queen Mine

BETWEEN: Arlene Evans	OF: NC Inland Fisheries - Raleigh Office	PHONE: (919) 733-3633

AND: Jancie Hatcher, NUS Corporation

Jancie Hatcher

DISCUSSION:

Ms. Evans informed me that there is fishing, both commercial and recreational, in the John H. Kerr Reservoir. It is all freshwater.

NUS 067 REVISED 0685

REFERENCE 24

Refe.

ENDANGERED AND THREATENED SPECIES

U.S. FISH AND WILDLIFE SERVICE

REGION 4 - ATLANTA

Federally Listed Species by State

NORTH CAROLINA

(E=Endangered; T=Threatened; CH=Critical Habitat determined)

Mammals	General Distribution
Bat, gray (*Myotis grisescens*) - E	Extreme Southwest
Bat, Indiana (*Myotis sodalis*) - E	West
Bat, Virginia big-eared (*Plecotus townsendii virginianus*) - E	Avery County
Cougar, eastern (*Felis concolor cougar*) - E	Entire state
Manatee, West Indian (*Trichechus manatus*) - E	Coastal waters
Shrew, Dismal Swamp southeastern (*Sorex longirostris fisheri*) - T	Dismal Swamp; Camden, Gates Pasquotank and Perquimans Counties
Squirrel, Carolina northern flying (*Glaucomys sabrinus coloratus*) - E	Western mountains (Yancy County)
Whale, finback (*Balaenoptera physalus*) - E	Coastal waters
Whale, humpback (*Megaptera novaeangliae*) - E	Coastal waters
Whale, right (*Balaena glacialis*) - E	Coastal waters
Whale, sei (*Balaenoptera borealis*) - E	Coastal waters
Whale, sperm (*Physeter catodon*) - E	Coastal waters

Birds	
Eagle, bald (*Haliaeetus leucocephalus*) - E	Entire state
Falcon, American peregrine (*Falco peregrinus anatum*) - E	Western mountains
Falcon, Arctic peregrine (*Falco peregrinus tundrius*) - T	Entire State
Plover, piping (*Charadrius melodus*) - T	Coast
Stork, wood (*Mycteria americana*) - E	Coast
Warbler, Bachman's (*Vermivora bachmanii*) - E	East
Warbler, Kirtland's (*Dendroica kirtlandii*) - E	Northwest, Central, Southeast
Woodpecker, ivory-billed (*Campephilus principalis*) - E	Southeast
Woodpecker, red-cockaded (*Picoides* (=*Dendrocopos*) *borealis*) - E	East

Reptiles

Alligator, American (*Alligator mississippiensis*) - T (S/A)*	Coastal plain
Turtle, Kemp's (Atlantic) ridley (*Lepidochelys kempii*) - E	Coastal waters
Turtle, green (*Chelonia mydas*) - T	Coastal waters
Turtle, hawksbill (*Eretmochelys imbricata*) - E	Coastal waters
Turtle, leatherback (*Dermochelys coriacea*) - E	Coastal waters
Turtle, loggerhead (*Caretta caretta*) - T	Coastal waters

Fishes

Chub, spotfin (*Hybopsis monacha*) - T,CH	Little Tennessee River, Swain and Macon Counties
Shiner, Cape Fear (*Notropis mekistocholas* - E,CH	Randolph, Moore, Lee, and Chatham Counties
Silverside, Waccamaw (*Menidia extensa*) - T	Lake Waccamaw and Upper Waccamaw R., Columbus County
Sturgeon, shortnose (*Acipenser brevirostrum*) - E	Coastal rivers

Mollusks

Mussel, Tar River spiny (*Elliptio* (*Canthyria*) *steinstansana*) - E	Tar River, Edgecombe County; Sandy Creek, Franklin County; Swift Creek, Nash County
Snail, noonday (*Mesodon clarki nantahala*) - T	Swain County

Plants

Hudsonia montana (mountain golden heather) - T,CH	Burke and McDowell Counties
Isotria medeoloides (small whorled pogonia) - E	Macon and Henderson Counties

*Alligators are biologically neither endangered nor threatened. For law enforcement purposes they are classified as "Threatened due to Similarity of Appearance." Alligator hunting is regulated in accordance with State law.

Liatris helleri (Heller's blazing star) - T	Ashe, Avery, Caldwell, Burke Counties
Lindera melissifolia (pondberry) - E	Bladen County
Lysimachia asperulaefolia (rough-leaved loosestrife) - E	Carteret, Scotland, Cumberland/Bladen, Brunswick, Pender, and Hoke Counties
Oxypolis canbyi (Canby's dropwort) - E	Scotland County
Sagittaria fasciculata (bunched arrowhead) - E	Henderson County
Sarracenia oreophila (green pitcher plant) - E	Clay County
Solidago spithamaea (Blue Ridge goldenrod) - T	Avery and Mitchell Counties

REFERENCE 25

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

ENVIRONMENTAL SERVICES DIVISION
ATHENS, GEORGIA 30613

TO WHOM IT MAY CONCERN

Enclosed is one copy of the latest revision (February 1, 1991) of the US EPA, Region IV, Environmental Services Division, Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual (SOPQAM). This SOPQAM was prepared exclusively for use by the Environmental Compliance Branch. Any part of this SOPQAM may be reproduced for use by your organization. However any direct reproductions, in whole or in part, should be referenced as follows:

> Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual, US-EPA, Region IV, ESD, Athens, GA, February 1, 1991 (and subsequent revisions).

If you have received a copy on disk, please be advised that it is in WordPerfect® 5.1 format. You will notice that the following figures are not on the disk:

Figure 1.8.1	Environmental Compliance Branch Time Accounting
Figure 1.8.2	Payroll Distribution Timesheet
Figure 3.2.1	Sample Tag
Figure 3.3.1	Chain-Of-Custody Record
Figure 3.3.2	Custody Seal
Figure 7.2.5	Example of Site Map Showing Traverse Points Used To Locate Monitoring Wells

Should you have any comments or suggestions concerning the SOPQAM, please contact either Michael R. Carter (404-546-3117) or Bill Bokey (404-546-3300).

Sincerely yours,

John T. Marlar

John T. Marlar, Chief
Environmental Compliance Branch

This diskette contains the complete text of the US-EPA, Region IV, Environmental Services Division, Environmental Compliance Branch standard operating procedures manual, dated February 1, 1991. The document is correctly referenced as follows: Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual, February 1, 1991 (ECBSOPQAM).

The procedures described within the ECBSOPQAM may be modified as necessary (procedures for modification are described within the document), with the following proviso: If the procedures are changed they may no longer be referred to as the procedures described in this document. The Environmental Compliance Branch (which is an integral part of the document review and field overview process in Region IV) will strongly resist any attempt to modify these procedures and have them submitted for review as the original procedures.

The files are in WordPerfect(c) 5.1 format. The files are organized such that each major section of the sop is in its own directory, with each major sub-section saved as a separate file. As stated above, the text is complete, however, two figures (3.2.1 and 3.3.1) are not included because these figures were reproduced by photocopy in the original document. The files are saved in a prestige elite (12p) font and are formatted for printing on a Hewlett-Packard Laser Jet(c) printer. We are unable to support other files at this time, although this file is saved in ASCII format to enable any user to read it.

ENVIRONMENTAL COMPLIANCE BRANCH

STANDARD OPERATING PROCEDURES

AND

QUALITY ASSURANCE MANUAL

FEBRUARY 1, 1991

U. S. Environmental Protection Agency
Region IV
Environmental Services Division
College Station Road
Athens, Georgia 30613

FOREWORD

This manual contains the standard operating and field quality assurance procedures used by Environmental Compliance Branch employees during field operations. The specific procedures outlined are based on the experience of Branch personnel over the years or are specifically referenced at the end of each chapter. The specific quality control procedures outlined in the manual are provided as required by the Agency's Mandatory Quality Assurance Policy.

This manual shall be provided to each Branch employee engaged in field operations. Each employee is expected to read and be familiar with each section of the manual. This manual will serve as a source-book for training new employees as well as a reference for current employees. The manual is meant to be a dynamic document. It will be periodically reviewed and updated. When changes are made in the manual, a memo will be sent to each Branch employee. Each employee will be responsible for keeping his or her manual current. To assist in this updating, a log is included inside the front cover for tracking revisions of individual sections.

The SOP and specific quality assurance procedures outlined in this manual (SOPQAM) are to be incorporated by reference into all study plans issued by Branch personnel. Any deviation from this SOP or specific quality assurance procedures as outlined in this manual must be thoroughly documented and cleared (if possible) with the appropriate Unit Chief and/or Section Chief. Any deviation from this SOPQAM shall also be documented in all study plans and reports resulting from that project.

DISCLAIMER

This SOPQAM has been prepared for use by the Environmental Compliance Branch, Environmental Services Division, Region IV, United States Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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1.0 STANDARD OPERATING POLICIES AND PROCEDURES

1.1 INTRODUCTION

This section presents the standard operating policies and procedures of the Environmental Compliance Branch (ECB) as well as a description of Branch activities. The basic objectives of this section are to present:

- the Branch functional statement and organization;
- how requests for field investigations and technical assistance are received, processed, and implemented;
- the basic flow of project activities, including the assignment of personnel to projects, preparation of study plans, report preparation, and peer review;
- basic rules for employee conduct and legal requirements for entry procedures during field investigations;
- Branch procedures for handling basic administrative functions such as travel, overtime, purchase requisitions, and typing requests;
- Branch procedures for obtaining analytical support;
- the Branch quality assurance plan; and
- the Branch basic safety program.

1.2 BRANCH ORGANIZATION

1.2.1 General

The Branch is organized into two sections: the Hazardous Waste Section and the Air and Water Compliance Section. The Hazardous Waste Section is composed of the RCRA Unit and the Superfund Unit. The Air and Water Compliance Section is composed of the Water Compliance Unit and the Air Compliance Unit. The staffing plan for these sections is presented in Section 1.2.2. The functional statements for the Branch and each Section are presented in the following section. The Branch structure is shown in Figure 1.2.1.

1.2.1.1 Environmental Compliance Branch -- Responsible for planning, coordinating, executing, and evaluating investigations of toxic and hazardous substances; pesticides; waste, air and wastewater management problems; water treatment facilities; UIC facilities and groundwater related problems; and related environmental studies within the Region. Provides technical assistance and multimedia overview to other federal agencies, states, local agencies, the private sector, and EPA contractors in municipal and industrial operations, field investigative procedures, and toxic and hazardous wastes investigations. Maintains expertise in air monitoring methodology. Develops and presents direct training courses. Reviews and comments on remedial investigations/feasibility study work plans, remedial investigation reports, RCRA facility investigations, Record of Decision documents, NPDES permits, UIC permits, State/local agency QA/SOP Plans, and federally licensed construction projects and provides requested field investigatory support of these programs.

1.2.1.2 Hazardous Waste Section -- Responsible for planning, directing, and conducting assessments and investigations for program and enforcement purposes (civil and criminal) related to hazardous substances, including: RCRA related sampling and non-sampling facility inspections (pre- and post-permit issuance), solid waste dumps and landfills, and Superfund remedial and pre-remedial investigations such as at abandoned hazardous waste sites and related multimedia environmental and technical assistance studies. Responds to requests for assistance with oil and hazardous material spill investigations, and related multimedia environmental and technical assistance studies. When required, provides support and technical assistance for TSCA and FIFRA inspections and investigations.

In conjunction with the Analytical Support Branch, manages the Regional Sample Control Center (RSCC) for the national Contract Laboratory Program (CLP) and provides logistical support and scheduling for all Superfund related field investigations conducted by the Section and program contractors. Provides overview (field and document related) and quality assurance of Superfund contractors in conjunction with the Waste Management Division.

Provides technical assistance, training, and multimedia and routine overview to other federal agencies, state agencies, local agencies, and EPA contractors in conducting multimedia hazardous waste inspections, toxic waste monitoring, and RCRA inspections.

Provides related input to permitting, enforcement, and other associated regional programs.

1.2.1.2.1 RCRA Unit -- The RCRA Unit has the primary responsibility for all Hazardous Waste Section RCRA activities, including the conduct of RCRA compliance inspections, sampling and non-sampling field investigations, technical support, technical assistance, and testimony for RCRA related facility and/or site related investigations in support of civil and/or criminal enforcement actions; overview of the state RCRA field program activities including on-site overview of state RCRA inspections as well as field program mid-year and end-of-year reviews; review of state RCRA grants and related documents; development of standard operating procedures and inspection protocols for RCRA field activities; as well as technical assistance and training for local, state, EPA program, and other federal personnel in the field aspects of RCRA investigations. The RCRA Unit has the primary responsibility for coordinating the training activities conducted by the Section and training received by Section personnel. When required, provides the primary Section support for TSCA and FIFRA inspections and investigations.

1.2.1.2.2 Superfund Unit -- The Superfund Unit has the primary responsibility for all Hazardous Waste Section Superfund activities including the conduct of abandoned hazardous waste site inspections and investigations, both sampling and geophysical; field investigations, technical assistance, and testimony in support of Superfund civil and criminal enforcement actions; responds to requests from the Waste Management Division for assistance in monitoring oil and hazardous material spill situations, as well as assistance in investigating potential immediate removal Superfund sites; and operation of the Section's portion of the RSCC. In conjunction with the Waste Management Division, schedules all Superfund investigations in the Region conducted by Section and EPA contractor personnel; conducts on-site field quality assurance overview of contractor field investigations and overviews contract related investigation documents (study plans, RI/FS work and site operation plans, study reports, etc.); overviews state hazardous waste programs that are Superfund related; participates in and develops specific Superfund related training and field standard operating procedures as well as participates in training courses for local, state, EPA programs, other federal field personnel, and contractors; and provides technical support for Superfund investigations and inspections to state and other federal programs. The Superfund Unit has the primary responsibility for the Branch's field health and safety program.

1.2.1.3 Air and Water Compliance Section -- Responsible for planning, coordinating, and executing investigations of municipal and industrial wastewater treatment facilities, and investigations in support of the Regional UIC and drinking water programs. Provides technical assistance and overview to states, local agencies, and other federal agencies in municipal and industrial wastewater operations, and air monitoring studies. Develops and presents direct training courses; reviews and comments on NPDES permits, and federally licensed construction permits; and provides expert testimony.

1.2.1.3.1 Water Compliance Unit -- Responsible for planning, directing, and conducting assessments and investigations including data interpretation and

investigative reports related to municipal and industrial wastewater treatment facilities.

Responsible for studies relating to facility operations, including their impact upon receiving waters as well as the persistence and fate of their contaminants in the aquatic environment and ground water. Provides related input to permitting, enforcement, and other associated regional programs.

Overviews and provides technical assistance and troubleshooting to state, local, and other federal agencies and the private sector concerning municipal operations in order to correct operational problems at existing facilities.

Conducts in-depth diagnostic evaluations of wastewater treatment facilities to provide technical details for enforcement actions, consent decrees, etc., in support of the Water Management Division.

Monitors and overviews NPDES delegated states as well as conducts independent studies of municipal and industrial facilities including CSIs, CEIs, PAIs, etc. Reviews and suggests corrections for self-monitoring techniques at municipal and industrial facilities and provides input to enforcement actions.

Provides technical assistance, training, and overview to state, local, and other federal agencies concerning municipal and industrial facility investigative techniques, operational control techniques, and data interpretation.

At the request of the Water Management Division, responsible for conducting field investigations of water treatment facilities and field investigations in support of the UIC, Drinking Water, UST and the Regional ground water monitoring program including associated water quality investigations.

1.2.1.3.2 <u>Air Compliance Unit</u> -- Responsible for conducting state and local agency Performance Audits; Quality Assurance Plan (QA/SOP) reviews and approvals; conducting National Air Monitoring (NAMS), State and Local Air Monitoring (SLAMS), and Special Purpose Monitoring (SPM), and National Performance Audit Program (NPAP) participation including the distribution of particulate filters; conducting data validations; tracking and submitting Precision and Accuracy (PARS) data submittals; conducting an annual state/local agency training workshop; and conducting special studies.

Responsible for maintaining the Region's expertise in air toxics monitoring methodology, which includes conducting, planning, and arranging air toxics studies. Provides technical assistance to federal, state, and local agencies on air monitoring and analytical methods for both toxics and criteria air pollutants.

Conducts air monitoring in support of CERCLA and RCRA site ranking studies, and performs air sampling for specific pollutants in response to emergency response requests from the Waste Management Division. Reviews hazardous waste site clean-up and remedial action plans for air toxics monitoring activities and overviews contractor air monitoring activities.

Maintains an air monitoring laboratory equipped with sophisticated air monitoring instrumentation, air toxics screening instrumentation, air toxics sampling equipment, calibration equipment, computerized data acquisition equipment, and a NBS Standard Reference Photometer in condition ready to produce valid air quality data. Some air monitoring equipment is maintained for use by state and local agencies for special studies or emergencies.

Provides assistance to the Air, Pesticides and Toxics Management Division by arranging, planning and conducting regional studies; reviewing state and local agency workplans; and conducting National Ambient Air System (NAAS) Audits.

Verifies that state/local Hi-Vol orifices meet regulatory specifications and certifies ozone photometers and calibration systems.

1.2.2 Line of Authority

The purpose of this section is to establish the line of authority, in the Branch and in each Section, in the event of the absence of the Branch or respective Section Chiefs.

Branch:

John Marlar
Mike Carter
Bill Bokey
Steve Hall
Ron Barrow
Herb Barden
Bill Cosgrove

Hazardous Waste Section:

Bill Bokey
Steve Hall
Bill Cosgrove
Rod Davis
Bruce Ferguson
Dan Thoman
Charles Till
Don Hunter
Jim Gray
Fred Sloan
Sharon Matthews
Pat Boyle
John Trudell
Roger Carlton
John Vail
Terry Thomas
Laura Childs

Air and Water Compliance Section:

Mike Carter
Ron Barrow
Herb Barden
Danny France
Joe Compton
Louis Salguero
Jerry Burger
Mike Bowden
Chuck Padgett
Tim Slagle
Jeff Lovell

FIGURE 1.2.1
STAFFING CHART
U. S. ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL SERVICES DIVISION
ENVIRONMENTAL COMPLIANCE BRANCH
COLLEGE STATION ROAD
ATHENS, GEORGIA 30613
FTS Access - 250

BRANCH CHIEF
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Cathy Murphy - Secretary
Sandy McClain - Clerk Typist

AIR AND WATER COMPLIANCE SECTION
Michael R. Carter - Chief (404) 546-3317
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Roger Carlton
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Don Hunter
Fred Sloan
Dan Thoman
Charles Till
John Vail
ESAT Field Staff

RCRA UNIT
Bill Cosgrove, Chief
Pat Boyle
Rod Davis
Bruce Ferguson
Sharon Matthews
Terry Thomas
John Trudell
Laura Childs
Pat Thomas - Warehouse
Chuck Zimmerman - Warehouse
Milton Henderson - Warehouse
ESAT Warehouse Staff

WATER COMPLIANCE UNIT
Ron Barrow, Chief
Mike Bowden
Joe Compton
Louis Salguero
John Williams
Jeff Lovell

AIR COMPLIANCE UNIT
Herb Barden, Chief
Jerry Burger
Jim
Danny France
Richard Guillot
Margaret Hale
Chuck Padgett
Tim Slagle

1.3 PROJECT ACTIVITY FLOW

The Branch receives requests for field investigations and technical assistance activities from a variety of sources including federal, state, and local agencies; EPA Headquarters (including NEIC's Office of Criminal Investigations), EPA regional operating divisions (primarily the Water Management Division and the Waste Management Division); U.S. Department of Justice; as well as the private sector.

All requests for non-routine field studies or technical assistance activities shall be directed to the Director, Environmental Services Division with a copy to the appropriate Section Chief. Any request that is forwarded in any other manner shall be immediately routed to the Director's office. Requests for field studies that are received by Branch staff by telephone shall be discussed with the appropriate Unit Chief who will notify the Section Chief and/or the Branch Chief. All such requests shall be followed up by a memo or letter from the requestor. Non-supervisory Branch personnel are not to commit the Branch or the Division to field studies without the approval of the Division Director and Branch Chief (or appropriate Section Chief in his/her absence). All emergency requests for field studies shall be handled expeditiously, but all such requests shall be followed up by a written memo or letter from the requestor. All requests for routine field studies or technical assistance activities (i.e., those activities committed to in the annual work plan) shall be directed to the appropriate Section Chief who will assign the activity to the appropriate Unit.

The receipt of an investigation or technical assistance request shall be acknowledged as soon as possible. This is normally the responsibility of the Division Director, the Branch Chief, or the appropriate Section Chief. If the request is accepted, the requestor will be so notified, and the Branch Chief shall assign it to the appropriate Section. The Section Chief shall then assign the request to the appropriate Unit Chief who will log the request into the computerized project tracking system. The Unit Chief, in consultation with the Section Chief, shall select a tentative study date and assign a project leader or field investigator as appropriate.

The assigned project leader or field investigator shall discuss the technical merits of each project with his/her Unit Chief. The objectives and scope of each investigation or technical assistance project will be mutually agreed upon during this session. The project leader or field investigator will then contact the requestor and obtain necessary background information to formulate a study plan. A reconnaissance trip may be necessary in some cases. Trips to the EPA regional office or state and local regulatory agency offices may also be required. When the project leader has collected all of the relevant material, he/she shall prepare a study plan and, if appropriate, discuss the resource requirement of the project with his/her Unit Chief. When required, additional staff from other Units will be assigned by the Section Chief or Branch Chief. In studies involving more than one Branch, appropriate staff will be assigned by the Branch Chiefs or Division Director/Deputy Division Director. Concurrently, the Unit Chief and/or project leader shall discuss the analytical requirements with appropriate Analytical Support Branch

personnel. Draft study plans and final study plans shall be prepared as outlined in Section 1.5 and shall be reviewed in accordance with the Regional peer review policy.

After the study plan has been prepared, the project leader/field investigator shall prepare a request for travel orders and overtime/compensatory time and submit them to the appropriate Section Secretary. This request should be submitted at least 10 working days in advance of routine studies. Concurrently, the project leader shall coordinate equipment and vehicle needs with the Branch warehouse staff coordinator and procure any needed special equipment.

After the field study has been conducted, the project leader/field investigator shall prepare an outline or draft of the study report for review and concurrence of the appropriate Unit Chief (not required for routine inspections). If samples were collected during the study or investigation, the Analytical Support Branch will submit data to the appropriate Section Chief. The Section Chief will distribute the analytical data, through the appropriate Unit Chief, as soon as possible to the project leader/field investigator. The project leader shall prepare a draft of the final report (not required for routine inspections) for review by the Unit Chief and Section Chief. Once the report has been cleared by the appropriate Unit Chief and Section Chief, it shall then be reviewed in accordance with the Regional peer review policy. The review comments shall be considered and incorporated where appropriate. A final report shall then be prepared and distributed as outlined in Section 1.6. Routine inspection reports shall be prepared in final form for review by the Unit Chief and the Section Chief or his/her designee and shall be promptly transmitted (Section 2).

After the final report has been transmitted, the project leader/field investigator shall collect all relevant material including the report, etc., as outlined in Section 3, place it in the project file, and submit it to the appropriate Section Secretary for filing. Completion of the project shall be entered by the appropriate Section Chief or Unit Chief into the appropriate computerized project log.

1.4 PROJECT LEADER RESPONSIBILITIES

The project leader has overall responsibility for seeing that field operations are carried out expeditiously and that the project objectives are met. Specifically, these responsibilities include:

- study plan preparation and coordination;
- logistical arrangements including the submission of travel and purchase order requests;
- overall technical supervision of assigned project personnel during field operations and assurance that standard field operating procedures are followed (any deviations shall be documented in the field log book as well as in the final report);
- overall responsibility for project field safety;
- overall responsibility for making study plan modifications in the field as required;
- certifying and keeping accurate records of all overtime, compensatory time, and hazardous duty time earned by project personnel in the field;
- project data interpretation and final report preparation; and
- coordinating any necessary project follow-up activities such as attending show-cause hearings, presenting testimony, etc.

1.5 STUDY PLANS

Study plans shall be prepared and issued for all investigations, inspections, and field studies conducted by Branch personnel. The responsibility for preparing study plans rests with the assigned project leader or field investigator. Study plans shall be issued at least 10 working days in advance of the study for routine inspections and investigations and at agreed upon time frames (agreed upon with the requestor) for more complex studies. The only exceptions are those investigations and inspections that are conducted in response to emergency episodes and spills. No specific requirements for study plans for emergency episodes or spills shall be made. However, if time permits, a study plan should be prepared.

Study plans for routine inspections such as compliance sampling (CSI), case development investigation evaluations (CDIE), performance audit inspections (PAI), etc., shall consist of a notification that the inspection will be conducted, who will conduct it, the inspection dates, the number and types of samples to be collected (if appropriate), analyses required (if appropriate) and a statement that the procedures outlined in this SOPQAM will be followed. These study plans shall be prepared as one or two page memorandums. These standard study plans shall be distributed to appropriate Regional staff as well as the appropriate state regulatory agency (if appropriate). Where required, safety plans should be prepared for routine investigations (Appendix K).

Study plans for non-routine investigations and field studies need to be more detailed. In general, these study plans should contain the following elements:

- Introduction -- a brief history and statement of the problem to be investigated.
- Objectives -- a statement as to what the investigation is to accomplish and how the information is to be used.
- Scope -- a definition of the limits of the study.
- Time Schedule -- a statement outlining when the study will be conducted, analytical results will be available, the draft report will be written, and the final report will be available.
- Study Procedure -- the specific plan to collect the required information (not field methodology).
- Methodology -- specific field techniques to be employed. A statement that the techniques in this SOPQAM will be employed shall be included. The use of any techniques not included in this SOPQAM shall be justified.
- Analytical Requirements -- a complete listing of all samples to be collected, required analyses, and which laboratory(s) will analyze the samples.

- Logistics -- a complete listing of the manpower requirements and specific functions of all project personnel, special equipment and vehicles to be used, use of mobile laboratories, how samples are to be transported to the laboratory, etc.

- Safety Plan -- where required, a safety contingency plan will be included (Appendix K).

Draft study plans for the non-routine investigations shall be prepared and reviewed in accordance with the Regional peer review policy. Information copies of the draft study plan should be sent to all relevant program staff and to the Analytical Support Branch staff. If significant changes are made to the draft study plan, it shall be rewritten and reviewed again in accordance with the Regional Peer Review Policy. A final study plan will be prepared and transmitted to appropriate Regional, OCI, and/or Headquarters staff as well as appropriate state regulatory agency staff utilizing a transmittal memorandum.

1.6 STUDY REPORTS

Almost all investigations, inspections, and field studies conducted by Branch personnel will result in the issuance of a technical report. The project leader/field investigator is responsible for the preparation of the report.

Routine inspection reports such as CSI's, CDIE's, PAI's, etc., shall include the completion of any appropriate standard forms along with a transmittal memo detailing the significant findings of the inspection. Specific requirements for routine inspection reports are given in Section 2. The reports shall be distributed to appropriate Regional or Headquarters personnel utilizing a transmittal memorandum. Reports distributed to state or local personnel will be by use of an official EPA letter.

No firm format is given for non-routine technical reports. The following report outline shall be used as a guide and modified as necessary. Generally, report formats should include:

- Introduction -- should include a statement of the problem, who requested the study, when the study was conducted, who conducted the study, the objectives of the study, and any necessary acknowledgements.
- Study Area -- a description of the area studied.
- Study Findings -- a brief summary of study findings, results, and any relevant conclusions.
- Recommendations -- any recommendations resulting from study findings.
- Study Methodology -- field and analytical methods employed during the study.
- Appendices -- a listing of all relevant data collected during the study.

As a general rule, reports prepared for enforcement purposes, or reports prepared in anticipation of possible enforcement actions, should contain only factual information. These reports shall not contain conclusions, recommendations, or personal opinions. Conclusions, recommendations, and personal opinions for these investigations may be included in a separate memorandum with the concurrence of the Branch or appropriate Section Chief. When this is done, the transmittal memorandum should be stamped "Confidential - This document is prepared in anticipation of enforcement litigation. It is not subject to discovery."

The draft study report shall be reviewed in accordance with the Regional peer review policy. Although the Regional peer review policy excludes enforcement related reports, the Regional Quality Assurance Officer shall be sent a copy of all draft enforcement related reports for peer review with the exception of criminal investigative reports. The final report shall be distributed to appropriate Regional or Headquarters personnel utilizing a transmittal memo.

1.7 EMPLOYEE CONDUCT

1.7.1 General

EPA employees are required to perform their duties in a professional and responsible manner, refraining from any use of official position for private gain. Branch employees are also required to collect and report the facts of an investigation or inspection completely, accurately, and objectively. They must conduct themselves at all times in accordance with the Environmental Protection Agency Regulation on Employee Responsibilities and Conduct (1) and shall adhere to the Code of Ethics for Government Service. The following paragraphs review some topics in the regulations especially applicable to the work of Branch employees.

Employees shall avoid conflicts of interest through outside employment or other private interests. A conflict of interest may exist whenever an EPA employee has a personal or private interest in a matter which is related to his/her official duties and responsibilities. It is important to avoid even the appearance of a conflict of interest because the appearance of a conflict damages the integrity of the Agency and its employees in the eyes of the public. All employees must, therefore, avoid situations which are, or give the appearance of, conflicts of interest when dealing with others in or outside the government.

Good public relations and common sense dictate that employees dress appropriately for the activity in which they are engaged.

It is important that cooperation be obtained and good working relations established when working with the public. This can best be accomplished by using diplomacy, tact, and persuasion. Employees should not speak of any person (including other regulatory agency or facility personnel) in a derogatory manner, and should use discretion when asked to give a professional opinion on specific products. All information acquired during an employee's duties is for official use only.

An employee is forbidden to solicit or accept any gift, gratuity, entertainment, favors, loans, or any other thing of monetary value from any person, corporation, or group which has a contractual or financial relationship with EPA; which has interests that may be substantially affected by such employee's official actions; or which conducts operations regulated by EPA.

1.7.2 Entering A Facility

1.7.2.1 Authority -- Various federal environmental statutes grant EPA enforcement personnel authority to enter and inspect facilities. The authority granted in each statute is similar to that stated below in Section 308 of the Clean Water Act:

> "(a)(B) the Administrator or his authorized representative, upon presentation of his credentials (i) shall have a right of entry to, upon, or through any premises in which an effluent source is located or in which any records required to be maintained. . .are located, and

(ii) may at reasonable times have access to and copy any records, inspect any monitoring equipment or method required. . . , and sample any effluents which the owner or operator of such source is required to sample. . ."

For the specific requirements on conducting inspections and collecting data pursuant to a particular Act, see: Section 308 of the Clean Water Act; Section 9 of the Federal Insecticide, Fungicide, and Rodenticide Act; Section 3007 of the Resource Conservation and Recovery Act; Section 8 of the Toxic Substances Control Act; Section 1445 of the Safe Drinking Water Act; Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund); and Titles I, III, and IV of the Clean Air Act.

1.7.2.2 Unreasonable Search and Seizure -- EPA authority under the various Acts is subject to the "unreasonable search and seizure" provisions of the Fourth Amendment to the Constitution. The prohibition is not against all searches and seizures, but only those which are unreasonable or to which valid consent, if required, has not been given. Consent, in this context, means the intentional foregoing of right to privacy which is not the result of either fear, ignorance, or trickery.

To comply with the Acts and avoid any "unreasonable search" and procedural problems, a facility should be entered in the following manner:

1. The facility premises should be entered through the main gate or through the entrance designated by the source if in response to an inspection notification letter (a 308 letter for example).

2. The employee shall introduce herself/himself in a dignified, courteous manner to a responsible plant official. A responsible plant official may be the owner, operator, officer, or agent in charge for the facility, including the plant environmental engineer. Identification credentials shall always be shown.

3. If only a guard is present at the entrance, the employee shall present her/his credentials and suggest that the guard call his superior on the phone. If the inspector knows the name of the responsible official he/she is to see, he/she shall request the guard to call him/her directly.

4. If the company provides a general sign-in sheet, it is acceptable to sign it. Branch employees shall not sign a release of liability (waiver) when entering a facility under the authority of Federal law.

5. If entry is refused, the employee shall not contest the issue with the facility representative, but will immediately do the following:

   - obtain name and position of individual denying entry to the facility, and record the date and time;

   - cite the appropriate EPA-administered legislation, ask

if he/she heard and understood the reason for your presence, and record the answer and any reasons given for denial of entry; and

- leave the premises immediately.

After leaving the facility, the employee shall, at the earliest possible time, inform their immediate supervisor and the Office of Regional Counsel, by telephone of the events which took place and seek guidance on how to proceed.

1.7.3 Requesting Information

The various laws and statutes under which EPA operates address the protection of trade secrets and confidential information. As a general policy, Branch staff should not accept confidential information unless it is necessary for carrying out Agency functions under a particular Act. As a matter of Branch policy, request for confidential information can only be signed by a responsible party in one of the operating Divisions or by an attorney in the Office of Regional Counsel.

In compliance with EPA regulations, an EPA request for company information, pursuant to statutory authority, will contain a statement allowing the facility to designate all or part of the information requested by the Agency as confidential by marking it according to: Code of Federal Regulations, Title 40, Part 2, Section 203.41; or Federal Register, 41 FR 36902. In addition to citing the appropriate regulations, the request for confidential information will state that:

(1) The business may, if it desires, assert a business confidentiality claim covering part or all of the information in the manner described by [the applicable regulation], and that information covered by such a claim will be disclosed by EPA only to the extent, and by means of the procedures, set forth in [the applicable regulations]; and that

(2) If no such claim accompanies the information when it is received by EPA, it may be made available to the public by EPA without further notice to the business.

If the collection of confidential information is required to carry out the responsibility of the Branch, personnel should consult carefully with the appropriate operating Division staff and the Office of Regional Counsel attorneys. In general, when such information is needed by Branch personnel, the request should state that this information will be transmitted directly to the Office of Regional Counsel.

In general, Branch personnel shall not accept confidential information when conducting a plant evaluation, inspection, or reconnaissance. When Branch personnel must collect or observe confidential information, a separate logbook shall be maintained. When confidential information is entered into an inspector's logbook, the entire logbook and each page containing confidential information shall be marked "CONFIDENTIALITY CLAIM." Upon return to the EPA Region

IV, ESD facility, all such information shall be maintained in a locked filing cabinet and the Office of Regional Counsel shall be notified for ultimate disposition of the material.

1.7.4 Disclosure of Official Information

It is EPA policy to make information about EPA and its work available, freely and equally, to all individuals, groups, and organizations. This policy, however, does not extend to confidential information or to investigatory information and evidence relating to the suspicion of a violation of federal environmental laws.

Any Branch employee who receives a request, written or oral, for inspection or disclosure of EPA investigatory records, whether made under judicial discovery procedures or the Freedom of Information Act, shall immediately advise the Division's Freedom of Information (FOI) Act Coordinator and/or the Regional FOI Coordinator of the request. Such records shall not be released without the specific concurrence of the Regional FOI coordinator. RCRA, Superfund, and TSCA program offices will make all third party distribution of data and investigative reports.

1.8 BASIC ADMINISTRATIVE FUNCTIONS

1.8.1 Timekeeping

Each Section Secretary is that particular Section's timekeeper. The timekeeper shall be kept informed of all leave taken as well as the overtime and compensatory time earned and taken by each employee. Branch employees shall obtain approval from their respective Unit, Section, or Branch Chief before taking annual leave. A leave request form (SF-71) must be completed when more than 40 hours of annual leave is taken or whenever any leave is taken and the employee anticipates being unavailable to initial his/her timecard. All Branch employees shall utilize the appropriate Section roster, located on the bulletin board in their respective Section Secretary's office, to post leave taken. If an employee is too sick to report for duty, the employee shall notify the respective Section Secretary by telephone as soon as possible. The appropriate Section Secretary, as well as the employee's immediate supervisor, shall always be kept informed of all travel plans (even those made to the regional office). The appropriate Section Secretary is responsible for notifying the Division Director's Secretary in writing of any scheduled travel by COB on Thursday prior to the following week's travel. Emergency or unscheduled travel will be reported via telephone to the Division Director's Secretary by the appropriate Section Secretary once the travel is known. All employee's time must be charged to appropriate specific account numbers. This is accomplished by having each Branch employee utilize the form shown in Figure 1.8.1 to account for all work hours. This form shall be filled out by each Branch employee to the nearest whole hour. For the Activity Code in Figure 1.8.1, each employee shall use the most relevant Activity Code from Table 1.8.1. The form shall be submitted to the appropriate Section Timekeeper no later than close of business on the first Monday of each pay period. All leave, compensatory time, and overtime, whether earned or taken, must be turned in to the appropriate Section Timekeeper by 0900 on the second Thursday of each pay period. These times/days may vary on holidays. A notice will be posted in each Section Secretary's office if leave should be turned in earlier.

Each employee with either a fixed Superfund account number or any employee who works on any Superfund activity during a pay period shall also complete the EPA Payroll Distribution Timesheet (Figure 1.8.2). This form shall be filled out to the nearest hour for regular hours worked and to the nearest quarter hour for overtime. The report shall be signed and dated by each employee prior to turning it in to their Section Timekeeper on the first day of each pay period. The Timekeeper gives the supervisor the form to review, sign, and date. By noon on the second day of each pay period, the Supervisor returns the form to the Section Timekeeper.

All requests for compensatory time and overtime must be submitted in advance of projects and approved before it can be earned. Overtime/compensatory time requests should be submitted to the appropriate Section Secretary on the bottom of the Request for Travel Order Form (Figure 1.8.3). These requests should be submitted at least two weeks in advance of projects, and shall be initialed by the employee's immediate supervisor. The appropriate Section Secretary shall complete the Request for Authorization of Overtime Work (EPA Form 2560-7) for approval by the Division Director.

All overtime and compensatory time earned shall be submitted to the appropriate Section Timekeeper utilizing the form shown in Figure 1.8.4. This form should be signed by the project leader/field investigator, initialed by the appropriate Unit Chief, and signed by the appropriate Section Chief. When field operations are conducted during the second week of the pay period, the project leader or field investigator shall call the appropriate Section Timekeeper by 0900 on Thursday and report any overtime and compensatory time earned by project personnel.

Blanket authorization for hazardous duty pay is approved on an annual basis for Hazardous Waste Section personnel. The Overtime/Compensatory Time/ Hazardous Duty Pay Approval Form (Figure 1.8.4) must be completed for all approved personnel earning hazardous duty pay. The form shall be completed upon return from the field investigation for approval by the Chief, Hazardous Waste Section. The justification for hazardous duty pay shall be signed by the Project Officer, the Section Safety Officer, and the Chief of the Hazardous Waste Section.

1.8.2 Purchase Requisitions

All purchase requests shall be submitted on EPA Form 1980-8 (Procurement Request/Requisition). This form shall be routed through the appropriate Unit Chief to the Section Chief. All purchase requests shall contain a specific written justification on a separate sheet of paper attached to EPA Form 1980-8 as to why the purchase is necessary (if the request is for Superfund, it should be so noted below the written justification). This form and written justification shall also be used when purchases are made utilizing petty cash.

1.8.3 Travel Authorization Requests

All travel requests shall be made on the Request for Travel Orders Form (Figure 1.8.3), initialed by the immediate supervisor, and (if possible) shall be submitted to the appropriate Section Secretary at least 10 working days in advance of the scheduled travel.

1.8.4 Word Processing Procedures

To minimize risks of multiple copies, all reports and memos will be finalized through the clerical staff. The clerical staff will be responsible for proper formatting, editing, and final distribution of each document. Once a document has been submitted for finalization, no further editing should occur to the document unless it is on the "official working copy" which has been submitted to the clerical staff.

1.8.5 Report and Correspondence Distribution

After report distribution memos and correspondence have been signed, these items will be returned to the appropriate Section Secretary or Clerk-Typist for distribution. In general, other Branch employees will not make distribution of such items. Memos or correspondence for the Division Director (or higher level authority) must be initialed by the originator, the Unit Chief, the Section Chief, and the Branch Chief prior to submittal to the Division Director's

Secretary. The appropriate Section Secretary will carry all correspondence for the Division Director's signature directly to the Division Director's Secretary.

1.8.6 Vehicle Use and Check-Out

The keys for Branch sedans are kept in the Air and Water Compliance Section Secretary's office in a locked box, and the keys for Branch field vehicles are kept in the Hazardous Waste Section Secretaries's office in a locked box. All vehicles shall be checked out by Branch personnel utilizing the check-out sheet located in the appropriate Section Secretary's office. Any needed repairs shall be noted on the check-out sheet along with the ending vehicle mileage at the conclusion of a trip when the keys are returned. The gas tank for all vehicles shall be at least three quarters full when returned to the Athens facility.

1.8.7 Field Equipment Check-Out

Branch field personnel shall use the current field equipment load-out form (Figure 1.8.5) to specify the field equipment needed for specific field studies. All requested information (including account number, project number, and activity code for which the investigation is charged) shall be completed prior to submittal to the warehouse staff. The load-out form should be submitted to the warehouse staff at least five working days prior to the time the equipment is needed (except in an emergency).

1.8.8 CERCLA/RCRA Site Map Requests

Requests for hardcopy production of site maps and other graphic output to be produced by the Hazardous Waste Section AutoCAD/Mapping workstation should be completed using the form shown in Figure 1.8.6 or equivalent. Requests for non-CERCLA/RCRA work as well as requests by non-HWS Section personnel require approval by the HWS Chief.

1.8.9 Requests for Analytical Data Summary Tables

The Hazardous Waste Section has developed computer programs that produce tables summarizing ESD/ASB and CLP laboratory analytical data results. Since these programs require direct access to the ESD/ASB computer databases and appropriate accounts and access rights on the laboratory's computer, requests should be made to the HWS using the form shown in Figure 1.8.7 or equivalent.

FIGURE 1.8.3
REQUESTS FOR TRAVEL ORDERS

Names_____

_____

Dates of Travel_____

Site Name(s)_____

Site Location(s)_____

Site Account Number(s)_____

Purpose of Trip_____

_____

****

LODGING

City/County_____Hotel_____

Cost_____Actual Expenses_____

****

DO YOU NEED FLIGHT RESERVATIONS? Yes ( ) No ( )

Beginning Date_____LV_____Time_____Flight #_____

AR_____Time_____

Returning Date_____LV_____Time_____Flight #_____

AR_____Time_____

****

DO YOU NEED A RENTAL CAR? Yes ( ) No ( )

Confirmation #_____Agency_____

Rate_____Size_____

****

REQUEST FOR OVERTIME/COMP TIME

No. of Hrs_____

_____

Submitted By:_____

Approved By:_____Unit Chief

_____Section Chief

FIGURE 1.8.4

OVERTIME/COMPENSATORY TIME/HAZARDOUS DUTY PAY APPROVAL FORM

USE ONE FORM FOR EACH PROJECT

PROJECT NAME:_____ PROJECT NUMBER:_____

ACCOUNT NUMBER_____ PROGRAM ELEMENT:_____

NAME	DATE	OVERTIME	COMP TIME	HD PAY

PROJECT LEADER:_____ APPROVAL/DATE _____

CHIEF, HWS_____ APPROVAL/DATE_____

_____

HAZARDOUS DUTY PAY JUSTIFICATION

_____

_____

_____

SAFETY OFFICER: _____ APPROVAL/DATE_____

CHIEF, HWS:_____ APPROVAL/DATE_____

FIGURE 1.8.5
HAZARDOUS WASTE SECTION
LOAD OUT SHEET

Project Leader_____EXT._____
Study(s)_____ST._____
Account No(s)_____RCRA? CERCLA?

Activity Code_____
Project No. _____
Vehicles(s) _____
_____

Loadout Date
___/___/___

SOIL/SEDIMENT/WASTE

___S. S. Shovels

___Hand Augers 4" heads
___Extensions
___Pins (jar)
___Handles

___(L) S.S. Spoons
___(S)

___(L) Glass Pans
___(S)

___Scoops
___Scoop Brackets
___Conduit Pipe

___(L) S.S. Ponar Dredge
___(S)
___3/8" Rope (ft)

Miscellaneous
___Glass Tube
___Bacon Bomb
___Coliwasa Tubes
___S.S. Push Head (ea)
___Shelby Tube/pushhead(ea)

WATER
___Well Sounder #_____
___2" Teflon® Bailers
___Bailer Rope (spool)
___Phase Detector #_____
___Graduated Cylinder

GLOVES
___Surgical (latex) (Box)
___Neoprene Rubber (Box)
___Butyl Rubber (ea)
___PVC (ea)
___Cotton Work (ea)
___Silver Shields

WELL INSTALLATION
___Lil' Beaver®
___Auger Points
___Auger Flights
___2" Sand Points
___2" Well Casings

PUMPS

___Peristaltic Pump(s)#___
___Silastic Tubing (coil)
___Teflon® Tubing (25'roll)
___Vacuum Inserts (jar)
___M. Flex Cables (set)

___Fultz® Pump(s)#_____
#_____#_____
___Extra Fultz Heads (S/L)
___Power pack
___24v Cables (set)
___Charging Units (ea)
___24v Generator

___Goulds Pump #_____
___Extension Cord
___110v Generator
___Hose (ft)
___3/8" Rope (ft)
___Tripod

___Geo Guard #_____
___Geo Guard Control Box
___Geo Guard Compressor

___Well Wizard #_____
___3011 Controller (elect.)
___3111 Controller (gas)
___Air Connector
___12v Connector

BATTERIES
___12 volt
___ _____

SURVEYING EQUIPMENT
___Transit #_____
___Level #_____
___Rod #_____
___Altimeter
___Steel Tape (ea)
___Fiberglass Tape (ea)
___Aerial Targets (ea)
___Flagging (ea)
___Cloth Tape (ea)
___Tacks
___Wood Stakes (ea)
___Sledge Hammer (ea)
___Hammer (ea)
___Orange Vests
___Plumb Bob

TOPCON

___Topcon#_____
___Prisms
___Prism Tripods
___Thermometer
___Barometer
___Field Book

GEOPHYSICAL
___Magnetometer #___
___Metal Det. (L),(S)#
___EM-31#_____
___EM-34 #_____
___Wadi

LIQUID CONTAINERS

Liquid
___1Gal.(Ext/Pest)
___1L Poly Met/Cyanide
___40-ml VOAs-3/sample
____Chlorinated
____Non-Chlorinated
___500ml Glass(Phenol)

Soil/Sed/Sludge
___8oz Ext/Pest/Cyan
___2oz VOAs

Miscellaneous
___1 Gal Plastic
___4oz white-cap jars
___500-ml Polyeth.
___1/2 Gal Plastic
___1 L. W/M Clr. Glass

Concentrated Waste
___8oz Glass (jar)

REAGENTS

___HNO_3 (500ml)
___NaOH (bottle)
___H^2SO_4 (500ml)
___Thiosulfate
___Zinc Acetate
___KCL
___Ascorbic Acid

FIGURE 1.8.5 (CON'T)

FIELD ANALYSES

___pH Paper
___pH Meter (old)____
___pH Meter (new)____
___pH Buffer (set)
___Storemore jars
___Cond. Meter#_____
___D.O. Meter#_____
#_____
#_____

___ICE CHESTS (L,S, 6pck)
___ ___ ___ ___ ___ ___
___Plastic Crates (L,S)

Plastic Bags
___Large
___Medium
___Small
___Whirl-Paks®

TAPE
___Fiber (ea)
___Duct (ea)
___Electrical (ea)
___Masking (ea)

SAMPLE SHIPPING
___Vermiculite (Bag)
___Dust Masks (Box)

Sample Cans w/ Clips
___Gallon (ea)
___Quart (ea)

Shipping Boxes/ Styrofoam Inserts
___1 Quart (ea)
___4 Quart (ea)
___1 Gallon (ea)

SAFETY EQUIPMENT

	XL	L	M	S
___Tyvek	___	___	___	___

___Green One Piece Suit
___Yellow Splash Suit (ea)
___Disposable Booties (pr)
___Tent (ea)
___Drink Cooler (ea)
___Chair(s) (ea)
___Tables (ea)
___Cooling Vests
___Brass Tools (set)
___Rangers (set)
___Extra Air Tanks (ea)
___Ultra Twin Canist.(set)
___Cascade System
___Boundary Tape-Excl Zone
___Boundary Tape-Supp Zone
___Boundary Tape-Cont Zone
___Eye Wash System
___Cooling Vest & Batteries

SAFETY MONITORING

___Air Monitoring Box#____
___OVA#_____
___Tip II #_____#_____

FIELD CLEANING
___Wash Tubs (ea)
___Pump Sprayer (ea)
___Distilled Water (gal)
___Organic Free Water (gal)
___Milli-Q Water System
___Isopropanol (gal)
___Liquinox (bott)
___Graduated Bucket (ea)
___Brushes (ea)
___Aluminum Foil (box)
___Garbage Bags (ea)
___Oil Wipes (ea)
___Saw Horses (pr)
___Plastic Sheets (box)

PROJECT LEADER

___Tags (bundle)
___Custody Seals (box)
___Custody Sheets
___Sample Receipt
___Travel Orders
___Hotel RSVP
___Topo/Quad/Photo
___Hand Radios
___Hand Rad. Charger
___Safety Bag(s)
___Camera
___Film
___Instruction Manuals
___Notebook(s)
___Traffic Reports
___Air Bill(s)
___Hazardous Manifest

MISCELLANEOUS
___Extension Cord
___Trailer (large)
___Trailer (small)
___Trailer (H) Hearse)
___Bungi Cord (ea)
___Gas Can (ea)
___Boat
___Life Vest(s) (ea)
___Oar(s) (ea)
___Waders (pr)
___Flashlight (ea)
___Machete (ea)
___Whizz Witch
___Jumper Cables (set)
___Safety Harness (ea)
___Fluorescent Paint
___12v Floodlights
___Tool Box (ea)
___Paper Towels (pks)
___Garden Hose
___Gator Aid (pks)
#CHECK PAGE ONE
__*__Reagents
__*__Lit' Beaver®
__*__24v Generator
__*__110v Generator
__*__PUMPS

Special Requests _____

Released By: _____ Date: _____ Returned To: _____ Date: _____
Released To: _____ Date: _____ Returned To: _____ Date: _____

FIGURE 1.8.6
AUTOCAD REQUEST FORM

REQUESTOR'S NAME:_____

TYPE OF REQUEST: CERCLA_____ RCRA_____ OTHER_____

DATE OF REQUEST:_____ DATE REQUIRED:_____

PROJECT NUMBER:_____ ACCOUNT NUMBER:_____

PROGRAM ELEMENT:_____ FIGURE NUMBER:_____

NAME OF OLD DRAWING TO USE AS TEMPLATE:_____
(IF APPLICABLE)

HAZARDOUS WASTE SECTION CHIEF SIGNATURE:_____
(REQUIRED FOR ALL NON-CERCLA/RCRA OR NON-HWS REQUESTS)

COMMENTS:

_____

_____

_____

_____

_____

_____

_____

_____

_____

COMPLETED BY:_____ DATE:_____

FIGURE 1.8.7

DATA TABLE DEFINITION ENTRY SHEET

FIRST and LAST INITIALS: __ __

PROJECT NUMBER: ____ - _____

(computer will assign the DBNAME based on info at left, WRITE IT DOWN!)

TABLE ID: (1 or 2 char): __ __

DBNAME = __ __ __ __ __ __ __ __

YOUR LAST NAME: _____

DATE TO RUN: __ __ / __ __ /__ __
M M D D Y Y

INCLUDE NONDETECTABLES (Y or N)? ___ ("Y"es will give all "U" values)

SORT COMPOUNDS ALPHABETICALLY? (Y or N)? ___ ("N"o is the default)

****

* ANALYSES TO PULL (Answer Y or N):

ALL __ VOAORG __ EXTORG __ PEST/PCB __ METALS __ SPECIFIED (CN) __

****

* (You may enter up to 5 titles, up to 40 characters each) EXAMPLE:

TABLE TITLE #1: _____

TABLE TITLE #2: _____

TABLE TITLE #3: _____

TABLE TITLE #4: _____

TABLE TITLE #5: _____

TABLE 1

ANALYTICAL DATA SUMMARY
BOZO'S TOXIC WASTE, INC
FUME CITY, NEW JERSEY

JANUARY, 1988

****

	SAMP 1	SAMP 2	SAMP 3	SAMP 4	SAMP 5	SAMP 6	SAMP 7	SAMP 8
SAD #1:	_____	_____	_____	_____	_____	_____	_____	_____
SAD #2: (optional)	_____	_____	_____	_____	_____	_____	_____	_____
STATION: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____
DESCRIP: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____
DESCRIP: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____

	SAMP 9	SAMP 10	SAMP 11	SAMP 12	SAMP 13	SAMP 14	SAMP 15	SAMP 16
SAD #1:	_____	_____	_____	_____	_____	_____	_____	_____
SAD #2: (optional)	_____	_____	_____	_____	_____	_____	_____	_____
STATION: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____
DESCRIP: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____
DESCRIP: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____

TABLE 1.8.1
ACTIVITIES CODES

RESOURCE.. TRACKING SYSTEM
GENERAL (USE APPROPRIATE ACCOUNT)

Program Element	Activity
	General Administrative
010	Administrative - Personnel, Performance, Travel, Etc.
012	Timekeeping
013	Training Attended
014	Safety Training
015	Training Plan Development
016	Property Inventory
017	Procurement
018	Clerical
020	Equipment Maintenance
021	Vehicle Maintenance
023	Equipment Repair
	Leave
051	Annual
052	Sick
053	Holiday
054	Administrative
055	Hazardous Weather
056	Jury
057	LWOP
058	Compensatory Time (Taken)
	Management/Supervision
100	General
101	Review of National Guidance
102	Work Plan Development/Review
103	Regional Program Reviews
104	Regional Program Planning
106	Literature Review
107	Workload Model Review/Input
108	End of Year Review (Personnel)
109	Mid-Year/End-Of-Year Review (Personnel)
110	SPMS/STAR Report/Preparation
111	Study/Project Plan Review
112	Peer Review Reports
113	Report Preparation
120	Office/Lab Cleanup/Move
121	Employee Physical
122	Attendance at Conference, Seminars, Conventions, Etc.
123	Staff Meetings
124	Health and Safety Meetings
125	FOI Requests
126	Committee Meetings
127	Program Meetings
128	General Meetings
133	Congressional Response/Inquiry

AIR MONITORING (A2304P009)

Program Element	Activity
	Technical Assistance
201	Develop State/Local Agency Capabilities
202	TA to EPA Program Personnel
203	TA to State/Local Agency Personnel
204	TA to HQ Personnel
205	TA to Other Federal Agency Personnel
206	On-site TA
207	General TA
208	Assistance to State/Local Agencies - Acid Rain
209	Assistance to State/Local Agencies - Air Toxics
211	Training Conducted
282	Trends Analysis
551	QA/SOP Plan Reviews including Branch SOPQAM Revisions
	Evaluations
251	Project/Study Plan Review and Preparation
252	State/Local Agency Lab Evaluations
254	Site Evaluations
255	NAMS (New Sites)
256	NAMS (Existing Sites)
257	SLAMS (New Sites)
258	SLAMS (Existing Sites)
261	NAMS Documentation
262	SLAMS Documentation
263	QAMS Audit
264	EMSL Audit
265	NAAS System Audits
266	Pre-audit Preparation
267	Audit Report Preparation
268	Performance Audits
	Precision & Accuracy and Data Submittals/Retrievals
259	P&A Reports
260	P&A Evaluations
287	SAROAD Retrieval/System Support
	Air Toxics Monitoring/Special Studies
269	Air Toxics Monitoring Studies - Ambient
270	Air Toxics Monitoring Studies - Superfund
283	Air Monitoring Policy Manual
	Criteria Monitoring
284	Orifice Calibration/Certification
285	Ozone Calibrator/Monitor Certification
286	CO Saturation Monitoring
287	PM_{10} Saturation Monitoring
	Network Design/Redesign
271	Ozone Network Redesign
272	CO Network Redesign
273	TSP, SO_2, & Pb Network Redesign

	Special Enforcement Activity
271	Criminal Investigations
272	Civil Investigations
273	Admin. Enf. Actions

WATER QUALITY ENFORCEMENT (AFE04P000)

Program Element	Activity
	Technical Assistance
202	TA to EPA Program Personnel
203	TA to State Agency Personnel
204	TA to HQ Personnel
205	TA to Federal Agency Personnel
207	On-site TA
211	Training Conducted
551	QA/SOPQAM Activities/Updates
101	Review of National Guidance
	Inspections
301	PAI - Major Municipal
302	PAI - Minor Municipal
303	PAI - Major Industrial
304	PAI - Minor Industrial
305	PAI - Federal Facility
306	CSI - Major Municipal
307	CSI - Minor Municipal
308	CSI - Major Industrial
309	CSI - Minor Industrial
310	CSI - Toxics
311	CSI - Federal Facility
312	CEI - Major Municipal
313	CEI - Minor Municipal
314	CEI - Major Industrial
315	CEI - Minor Industrial
316	CEI - Federal Facilities
318	RI - Major Municipal
319	RI - Minor Municipal
320	RI - Major Industrial
321	RI - Minor Industrial
322	RI - Federal Facilities
323	LSI - Major Municipal
324	LSI - Minor Municipal
325	LSI - Major Industrial
326	LSI - Minor Industrial
327	LSI - Federal Facilities
328	DE - Major Municipal
329	DE - Minor Municipal
330	DE - Major Industrial
331	DE - Minor Industrial
336	DE - Federal Facilities
400	DE (MWPP)
401	DE (Tech Transfer)
341	Biomonitoring
337	Toxicity Study
357	Toxic Sludge

Program Element	Activity
	State Overview
250	General
	Special Enf. Activities
409	Show Cause Hearings
402	Consent Decree
403	AO
404	Attorney Consultation
372	Criminal Investigations
373	Civil Investigations
	Pretreatment Inspections
360	Pretreatment Compl Insp.
361	Pretreatment Check
362	Pretreatment Audit
	Underground Injection
368	UIC
	Special Water Quality Studies
347	Water Qual Monitoring
348	Toxicity Studies
363	Support Permit Activities
364	NPDES Enforcement
	Wetlands/Oceans
338	Field Investigation
	Miscellaneous
279	EIS Review

TABLE 1.8.1 (CONTINUED)

WATER QUALITY MONITORING (A5304P009)

Program Element	Activity
	Technical Assistance
101	Review of National Guidance
105	Review of Water Monitoring Strategy
211	Training Conducted
280	Review of Annual Workplans
551	QA/SOPQAM Review/Update
	Program Evaluation
103	Regional Program Review
280	State Program Review
	Technical Assistance to States
201	Developing State Capabilities
207	General TA
210	Multimedia Geographical Area Assessments
	Water Quality Technical Assessments
202	Review of Regional Documents
203	Review of State Prepared Documents/Reports
250	Emerging Problems
274	Success Stories/PR
282	Trend Analysis
	Technical Assistance to HQ
366	Field Investigations
204	Other Assistance
	Technical Assistance to Region
366	Field Investigations
	Special Monitoring for States
366	Field Investigations
	Estuarine/Marine Program
103	Program Review
207	Technical Assistance
251	Overview of Work Plans and Work Products

HAZARDOUS WASTE MANAGEMENT (A8004P009)

Program Element	Activity
	Technical Assistance
101	Review of Program Guidance (Not Enforcement Related)
211	Training Conducted
551	QA Activities Including SOPQAM Revisions
207	Technical Review of Waste Analysis Plans
	State Program Reviews, Training, Technical Assistance
201	Review of State Grant Package
280	Review of State Program Plan
281	Mid-Year or End-of-Year Program Reviews
203	Technical Assistance for State or Local Agencies
211	Training Presented to State or Local Agencies
	Program Planning, Training, Technical Assistance
104	Program Planning
211	Training Presented to EPA Program Personnel
202	Technical Assistance for EPA Program Personnel
211	Training Presented to Other Federal Agency Personnel
205	Technical Assistance for Other Federal Agency Personnel

HAZARDOUS WASTE ENFORCEMENT (AGD04P009)

Program Element	Activity
	Technical Assistance
101	Review of National Enforcement Guidance
211	Training Conducted
551	QA Activities Including SOPQAM Revision
202	Technical Assistance to Program Staff - Civil/Criminal/Admin.
203	Technical Assistance to State Personnel
206	On-Site Technical Assistance
289	State/Contractor Field Overview
295	Document Review
	Investigations and Inspections
350	Comprehensive Groundwater Monitoring Evaluations - TSD - Major
352	Comprehensive Groundwater Monitoring Evaluations - Federal Fac.
353	Comprehensive Groundwater Monitoring Evaluations - State Facility
354	Case Development Investigations/Evaluations - TSD - Major
356	Case Development Investigations/Evaluations - Federal Facility
357	Case Development Investigations/Evaluations - State Facility
	Field Support
372	Field Investigative Support for Civil Enforcement Actions
373	Field Investigative Support for Criminal Enforcement Actions
366	Field Investigative Support for Administrative Enforcement Actions
	Litigation Support
407	Litigation Support for Civil Enforcement Actions
408	Litigation Support for Criminal Enforcement Actions
403	Litigation support for Administrative Enforcement Actions
	State Program Oversight/Technical Assistance
280	State Program Review

HAZARDOUS SUBSTANCE SPILL AND SITE RESPONSE (TFA04P700)

Program Element	Activity
	Technical Assistance
101	Review of National Guidance (Not Enforcement Related)
211	Training Conducted
551	QA Activities Including SOPQAM Revisions
	Sample Control Center
538	Operation of the Sample Control Center (RSCC)
369	Scheduling ESD Field Inspections
	Contractor Overview
295	Review of EPA Fund-Lead RI/FS Contractor Documents
289	On-Site Overview of Fund-Lead RI/FS Contractor Field Activity
296	Review of EPA Enforcement Lead RI/FS PRP Contractor Document
290	Review of EPA Enforcement Lead RI/FS PRP Contractor Field Activity
297	Review of State or State Contractor Prepared RI/FS Documents
292	On-Site Overview of State or State Contractor RI/FS Field Activity
298	Review of State Enf. Lead PRP Contractor Prepared RI/FS Doc.
291	Review of State Enf. Lead PRP Contractor RI/FS Field Activity
295	Review of FIT Study Plans
293	Review of FIT Reports
294	On-Site Overview of FIT Field Activity
	State Overview Activity
278	On-Site OV of State or State Contractor Screening Site Inspections (SSI)
281	Mid-Year Evaluation of State Superfund Grant Program
	Technical Assistance and Training
202	Technical Assistance to EPA Personnel
203	Technical Assistance to State Agency Personnel
211	Training Presented

HAZARDOUS SUBSTANCE RESPONSE AND ENFORCEMENT (TGB04P009)

Program Element	Activity
	Technical Assistance
101	Review of National Enforcement Guidance
211	Training Conducted
551	QA Activities Including SOPQAM Revisions
	Field Investigations in Support of Enforcement Activities
373	Field Investigations in Support of Civil Enforcement Actions
372	Field Investigations in Support of Criminal Enforcement Actions
366	Field Investigations in Support of Adm Enforcement Actions
374	Field Investigations in Support of State Enforcement Actions
	Litigation Support or Technical Assistance for Enf. Actions
407	Litigation or Technical Support for EPA Civil Enf. Actions
410	Support for EPA Superfund Cost Recovery Program
408	Litigation or Technical Support for EPA Criminal Enf. Actions
403	Litigation or Technical Support for EPA Adm. Enf. Actions
406	Litigation or Technical Support for State Enf. Actions
	Contractor Overview
296	Review of EPA Enf. Lead Contractor Prepared RI/FS Documents
290	On-Site Overview of EPA Enf. Lead PRP RI/FS Field Activity
297	Review of State Agency Enf. Lead PRP Contractor Prepared RI/FS Doc
291	On-Site OV of State Agency Lead PRP Contractor RI/FS Field Act.
294	On-Site OV of EPA Enforcement Contractor Field Activity

TABLE 1.8.1 (CONTINUED)

DREDGE AND FILL (AGM04P009)

Program Element	Activity
	Program Assistance
207	Desk-Top Environmental Assessment
206	On-Site Technical Advice
413	Expert Witness/Consultant for Litigation/Settlement
366	Field Investigation
279	EIS Review

DRINKING WATER (A7004P009)

Program Element	Activity
366	Field Investigation
202	Technical Assistance to EPA Personnel
203	Technical Assistance to State Agency Personnel
204	Technical Assistance to HQ

UNDERGROUND STORAGE TANKS (A4E05GOSL)

Program Element	Activity
101	Review of National Guidance
202	Technical Assistance to EPA Personnel
203	Technical Assistance to State Personnel
366	Field Investigation

1.9 BRANCH PROCEDURES FOR OBTAINING ANALYTICAL SUPPORT

1.9.1 General

Analytical support for Branch field investigations is available from a number of sources including in-house analytical support from the Analytical Support Branch (ASB), other EPA laboratories, the National Contract Laboratory Program (CLP), or other private contract laboratories. Procedures to be followed for obtaining this support are contained in the following paragraphs.

1.9.2 Specific Procedures

All arrangements for analytical support are ultimately channeled to the Analytical Support Branch (ASB). All requests for in-house (ASB) analytical support, or for contract laboratory support other than from the National Contract Laboratory Program (CLP), are handled directly by the ASB. Requests for CLP support (Superfund) are normally directed to the Regional Sample Control Center (RSCC - i.e., Chief, Hazardous Waste Section).

In either case, the ASB Sample Custodian assigns project numbers for all projects as they are received. Requests for analytical support should be submitted as far in advance as possible to insure that the support can be obtained and the analytical capacities of the analytical laboratories are not exceeded. The ASB will not accept samples without a project number, except in an emergency.

The Sample Custodian requires the following information to assign a project number:

- project name/facility name;
- location of project/facility (city and state);
- type of study, activity, and program element;
- date of study and sample shipping dates;
- number of samples by media;
- analyses required by media and analysis type; and
- the analytical turn-around time required.

Branch personnel should not routinely request quick turn-around for analyses unless it is absolutely required.

Blind spike and blank samples for inclusion with CLP sample shipments or for other purposes are obtained from the ASB (see Section 4.6).

1.9.3 Definitions

1.9.3.1 National Contract Laboratory Program (CLP) -- The CLP generally supports the Superfund Program. The program can be used for regional laboratory support by contacting either the Regional Sample Control Center (RSCC, Chief, Hazardous Waste Section) or the Technical Project Officer (TPO, Chief, Organic Chemistry Section). All aspects of the CLP including the proper completion of CLP forms and shipping procedures are given in the Users Guide to the Contract Laboratory Program (2).

1.9.3.2 Routine Analytical Service (RAS) -- Analysis conducted by the CLP which includes volatile organic compounds, semivolatile organic compounds, pesticides, metals, and cyanide. These individual parameters are listed on the Target Compound List (TCL) and the Target Analyte List (TAL).

1.9.3.3 Target Compound List and Target Analyte List -- The list of organic (TCL) and inorganic (TAL) parameters normally analyzed for by both the ASB and the CLP. These compounds/analytes are included in the Users Guide to the Contract Laboratory Program (2).

1.9.3.4 Special Analytical Services (SAS) -- Analyses that can be conducted by the CLP other than those included in the TCL/TAL. These need to be requested through the ASB as soon as possible since protocols for analyses have to be developed for the CLP.

1.9.3.5 Detection Limits -- The optimum detection limits for organic and inorganic constituents in water and soil/sediments by both the ASB and the CLP are listed in Tables 1.9.1 and 1.9.2. Optimum detection limits for organic and inorganic compounds for other media, i.e., concentrated waste, aquatic organisms, etc., can be obtained from the ASB on request. The detection limits for other standardized analytical procedures are contained in the Analytical Support Branch, Operation and Quality Control Manual (3).

1.9.3.6 Regional Sample Control Center (RSCC) -- The RSCC coordinates all aspects of the scheduling of Superfund investigations and analytical support (ASB and CLP) that involve sampling activities. The RSCC is accessed through the Chief, Hazardous Waste Section. The information required to obtain analytical support is the same as outlined in Section 1.9.2. Normally, analytical support for samples to be collected by EPA contractors is coordinated with the RSCC for Superfund projects through the Environmental Services Assistance Team (ESAT), Sample Control Coordinator located in the Waste Management Division (WD). Support for Environmental Services Division Superfund activities is coordinated by the Hazardous Waste Section's, Superfund Unit Chief.

In addition to coordinating the scheduling of Superfund sampling activities, the RSCC is responsible for estimating the needed regional CLP support for the National Superfund Program.

The RSCC is also responsible for obtaining sample containers for Branch Superfund and RCRA activities conducted by Branch personnel.

1.9.4 Distribution of Analytical Data

1.9.4.1 ASB Laboratory Reports -- Normally, two copies of the results of analysis will be sent to the Chief, Hazardous Waste Section for all Superfund and RCRA projects and to the Chief, Air and Water Compliance Section for all municipal and industrial investigations. Analytical data will be reported as it is completed. When all project data have been submitted, the ASB will notify the data requestor that the analyses are complete and request that disposal of the unused portion of samples be approved.

1.9.4.2 CLP Laboratory Reports -- Normally, two copies of the results of analyses for Branch projects will be distributed as outlined in Section 1.9.4.1.

TABLE 1.9.1
OPTIMUM DETECTION LIMITS
ORGANIC COMPOUNDS
WATER AND SOIL/SEDIMENT SAMPLES
(BASED ON CLEAN SAMPLES)

Concentration Description	Reported As	ASB Detection Limits	CLP Detection Limits
		Purgeables	**Purgeables**
Low Water	NA	5-20 ug/l	10 ug/l
Low Soil/Sediment	Dry Weight	10-20 ug/kg	10 ug/kg
Medium Water	NA	5-21 ug/l	10 ug/l
Medium Soil/Sediment	Dry Weight	10,000-50,000 ug/kg	1200 ug/kg
		Extractables	**Extractables**
Low Water	NA	10-20 ug/l	10-50 ug/kg
Low Soil/Sediment	Dry Weight	2,000-4,000 ug/kg	1,700-3,000 ug/kg
Medium Water	NA	10-20 ug/l	10-50 ug/l
Medium Soil/Sediment	Dry Weight	10,000-20,000 ug/kg	10,000-50,000 ug/kg
		Pesticides (PCB's)	**Pesticides (PCB's)**
Low Water	NA	0.05-5.0 ug/l (1.0-3.0 ug/l)	0.05-5.0 ug/l (1.0-2.0 ug/l)
Soil/Sediment	Dry Weight	50-5,000 ug/l (500-1500 ug/kg)	1.7-170 ug/l (33-67 ug/kg)
Medium Water	NA	0.05-5.0 ug/l (1.0-3.0 ug/l)	0.05-5.0 ug/l (1.0-2.0 ug/l)
Medium Soil/Sediment	Dry Weight	50-25,000 ug/kg (2500-7500 ug/kg)	1.7-170 ug/l (33-67 ug/kg)

1 - Detection limits may increase because of varying sample size and/or interferences requiring dilutions

Note: Soil/Sediment Extracting Methods, Medium Level Versus low Level: The primary difference in the methods is the size of sample used for extraction. The low level method uses 30 gm (wet weight) of sample, whereas the medium level method uses 2-3 gm (wet weight) of sample. The negative aspects of the medium level method are (1) the quantitation limit is higher and (2) the smaller sample size is less representative of the sample. The positive aspect is the much simpler and faster sample extraction time. It takes less than an hour to extract a medium level sample and four hours to prepare a low level sample while the difference in quantitation limit is only a factor of five (1000 ug/kg for low level extractable organics and 5000 ug/kg for medium level). This is very significant with the increasing work load and also considering the lack of information on whether this factor of five increase in quantitation limit is necessary.

TABLE 1.9.2
OPTIMUM DETECTION LIMITS
INORGANIC CONSTITUENTS
WATER AND SOIL/SEDIMENT SAMPLES

	Water (ug/l)		Soil (Dry Weight) (mg/kg)	
	ASB	CLP	ASB	CLP
Silver	10	10	1	5
Arsenic	30	10	3	5
Barium	20	200	2	100
Beryllium	10	5	1	2.5
Cadmium	10	5	1	2.5
Cobalt	20	50	2	25
Chromium	10	10	1	5
Copper	10	25	1	12.5
Molybdenum	20	--	2	--
Nickel	20	40	2	20
Lead	30	5	3	2.5
Antimony	30	60	3	30
Selenium	40	5	4	2.5
Tin	100	40	10	20
Strontium	10	--	1	--
Tellurium	40	--	4	--
Titanium	10	--	1	--
Thallium	--	10	--	5
Vanadium	10	50	1	25
Yttrium	10	--	1	--
Zinc	10	20	1	10
Mercury	0.2	0.2	0.05	0.05
Aluminum	100	200	10	100
Manganese	25	15	2.5	7.5
Calcium	1000	5000	100	2500
Magnesium	100	5000	10	2500
Iron	100	100	10	50
Sodium	1000	5000	100	2500
Potassium	--	5000	--	2500

NOTE: -- Indicates that the constituent is not analyzed for.

1.10 QUALITY ASSURANCE PLAN

1.10.1 General

The procedures outlined in this manual are the basis of the Branch Quality Assurance Plan. Where appropriate, each section within this SOPQAM addresses the specific quality control aspects of the subjects covered by that section. The Branch Chief shall designate the Branch Quality Assurance Coordinator for the Branch. The current Quality Assurance Coordinator is the Chief, Hazardous Waste Section. The Quality Assurance Coordinator is responsible for: seeing that the specific quality control procedures as outlined in this SOPQAM are followed, and for tracking and recording the results of specific quality control (QC) programs (such as that outlined in Section 4 - Sampling Procedures). The Branch Quality Assurance Coordinator is responsible for the field analysis QC program, periodically checking the equipment logbooks, and notifying the appropriate Section Chiefs, Unit Chiefs, and Branch Chief of any observed problems.

The Branch and Section Chiefs are responsible for seeing that Branch personnel receive adequate training in order to provide the required quality control for Branch operations. In addition, the Section Chiefs and/or Unit Chiefs may periodically observe the professional and paraprofessional employees, in their respective sections, under actual field operating conditions to insure that the Standard Operating Procedures, as outlined in this manual, are being followed.

1.10.2 Corrective Actions

Corrective actions will be taken any time when deemed necessary. Problems with field quality control may result from contamination of field blanks or contamination of field equipment and supplies either from the vendor, during the cleaning/loadout process, or during field operations. Corrective actions must be taken immediately when data or field procedures are of questionable quality. These corrections may range from modifying certain procedures to reconducting an entire field investigation. The Regional QA Officer (QAO) shall be notified (through the Branch and appropriate Section Chief) of any suspected problems. A Corrective Action Plan shall be developed in cooperation with the QAO.

1.10.3 Peer Review

All non-routine reports and study plans generated by the Branch shall be peer reviewed in accordance with Region IV Order R2200.1 - Review and Clearance of Materials for Public Distribution. The appropriate Section secretary shall be responsible for distribution of documents for peer review after the Peer Review Clearance Form has been signed by the Division Director. All comments from reviewers shall be considered by the project leader. If the document receives a nonconcurrence, the Branch and appropriate Section Chief shall be immediately notified. Appropriate changes/corrections shall be made and the entire document shall be resubmitted for peer review.

1.11 SAFETY PROGRAM

The Branch safety program includes the following regulations and policies in addition to safety practices specified in Appendix N of this SOPQAM:

- Safety and Health Manual, United States Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia, 1990 (4).

  This manual covers safety practices and rules governing activities at the EPA facilities in Athens, Georgia. Included in its contents are accident reporting procedures, procedures for natural and manmade emergencies, safety guidelines for offices and laboratories, and special rules for storage of equipment and wastes.

- Field Health and Safety Manual, USEPA, Region IV, 1990 (5).

  This manual covers safety involved in all field activities performed in Region IV. It includes regional policy regarding training requirements, medical monitoring, and personal protection.

- 29 CFR, Part 1910, Hazardous Waste Operations and Emergency Response; Final Rule, March 1989 (6).

  This is the title for the Department of Labor, Occupational Safety and Health Administration (OSHA) regulations governing workers at hazardous waste sites. It covers requirements for training, equipment, and practices involved in specific hazardous waste activities.

1.12 REFERENCES

1. Ethics In A Nutshell...Ethical Conduct for EPA Employees...in Brief, US-EPA, Office of Inspector General, Washington, D.C., March 1988 (or 40 CFR, Part 3, Chapter 1, Subchapter A, pp. 71-95, July 1, 1989).

2. EPA Users Guide to the Contract Laboratory Program, Us-EPA, Office of Emergency and Remedial Response, Washington, D. C. 20460, December 1988.

3. Analytical Support Branch Operation and Quality Control Manual, Region IV, US-EPA, ESD, September 1990 (and subsequent revisions).

4. Safety and Health Manual, United States Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia, 1990.

5. Field Health and Safety Manual, United States Environmental Protection Agency, Region IV, 1990.

6. 29 CFR, Part 1910, Hazardous Waste Operations and Emergency Response; Final Rule, March 1989.

EXHIBIT 1

REGION IV ESD FIELD OVERVIEW CHECKLIST

Facility/Site Name_____

Address_____

Project No._____ EPA ID No._____

Facility Contact_____ Phone No.(_____)-_____

Overview Personnel_____ Date_____

State/Contractor Project Leader_____

Affiliation_____ Phone No.(_____)-_____

Address_____

_____

Sampling Personnel_____

_____

Other Personnel & Affiliation_____

_____

_____

Type of study?_____

Study plan issued?_____ Date issued?_____

Study plan reviewed by ESD? Yes_____ No_____ Acceptable? Yes_____ No_____

Was study plan followed? Yes_____ No_____

Comments_____

Was a safety plan prepared for the study? Yes_____ No_____

Was the safety plan adequate? Yes_____ No_____

Comments_____

Was the safety plan followed? Yes_____ No_____

Comments_____

Additional Comments or Information_____

_____

Checklist sections completed for this overview: 1_____2_____3_____4_____5_____6_____

KEY: 1 General Procedures; 2 Ground Water Sampling; 3 Soil, Sediment Sampling
4 Surface Water Sampling; 5 Waste Sampling; 6 Monitoring Well Installation

SECTION 1 - GENERAL PROCEDURES - SAFETY, RECORDS, QA/QC, CUSTODY, ETC.

1) Type samples collected?_____

2) Were sampling locations properly selected? Yes_____ No_____

Comments_____

3) Were sampling locations adequately documented in a bound field log book using indelible ink? Yes_____ No_____

Comments_____

4) Were photos taken and a photolog maintained? Yes_____ No_____

5) What field instruments were used during this study?_____

_____

_____

6) Were field instruments properly calibrated and calibrations recorded in a bound field log book? Yes_____ No_____

Comments_____

7) Was sampling equipment properly wrapped and protected from possible contamination prior to sample collection? Yes_____ No_____

Comments_____

8) Was sampling equipment constructed of Teflon®, glass, or stainless steel?

_____

9) Were samples collected in proper order? (least suspected contamination to most contaminated?) Yes_____ No_____

Comments_____

10) Were clean disposable latex or vinyl gloves worn during sampling? Yes_____ No_____

Comments_____

11) Were gloves changed for each sample station? Yes_____ No_____

Comments_____

12) Was any equipment field cleaned? Yes_____ No_____

13) Type of equipment cleaned?_____

14) Were proper field cleaning procedures used? Yes_____ No_____

Comments_____

15) Were equipment rinse blanks collected after field cleaning?
Yes_____ No_____

Comments_____

16) Were proper sample containers used for samples? Yes_____ No_____

Comments_____

17) Were split samples offered to the facility owner or his representative?
Yes_____ No_____

Comments_____

18) Was a receipt for samples form given to facility representative?
Yes_____ No_____

19) Were any duplicate samples collected? Yes_____ No_____

Comments_____

20) Were samples properly field preserved? Yes_____ No_____

Comments_____

21) Were preservative blanks utilized? Yes_____ No_____

Comments_____

22) Were field and/or trip blanks utilized? Yes_____ No_____

Comments_____

23) Were samples adequately identified with labels or tags? Yes_____ No_____

Comments_____

24) Were samples sealed with custody seals after collection? Yes_____ No_____

Comments_____

25) What security measures were taken to insure custody of the samples after collection?

_____

26) Were chain-of-custody and receipt for samples forms properly completed?
Yes_____ No_____

Comments_____

27) Were any samples shipped to a laboratory? Yes_____ No_____

28) If yes to No. 27, were samples properly packed? Yes_____ No_____

Comments_____

29) If shipped to a CLP lab, were Traffic Report Forms properly completed?
Yes_____ No_____

Comments_____

30) What safety monitoring equipment, protection, and procedures were used prior to and during sampling?_____

_____

31) Was safety monitoring equipment properly calibrated and calibrations recorded in a bound field log book? Yes_____ No_____

Comments_____

SECTION 2 - SAMPLING - GROUND WATER WELLS

1) Type of wells sampled? (monitoring, potable, industrial,etc.)_____

_____

2) Were wells locked and protected? Yes_____ No_____

Comments_____

3) Were identification marks and measurement points affixed to the wells? Yes_____ No_____

Comments_____

4) What were the sizes and construction materials of the well casings?

_____

5) Were the boreholes sealed with a concrete pad to prevent surface infiltration? Yes_____ No_____

Comments_____

6) Was there a dedicated pump in the well? Yes_____ No_____

7) Was clean plastic sheeting placed around the wells to prevent contamination of sampling equipment and containers? Yes_____ No_____

8) Were total depths and depths to water determined before purging? Yes_____ No_____

9) What device was used to determine depths?_____

10) Were measurements made to the nearest 0.01 ft? Yes_____ No_____

11) Was the measuring device properly cleaned between wells? Yes_____ No_____

Comments_____

12) Was the standing water volume in each well determined? Yes_____ No_____

13) How was the volume determined?_____

14) Was a sufficient volume purged prior to sampling? Yes_____ No_____

Comments_____

15) How many volumes?_____

16) How was the purged volume measured?_____

8) Were total depths and depths to water determined before purging?
Yes_____ No_____

9) What device was used to determine depths?_____

10) Were measurements made to the nearest 0.01 ft? Yes_____ No_____

11) Was the measuring device properly cleaned between wells?
Yes_____ No_____

Comments_____

12) Was the standing water volume in each well determined?
Yes_____ No_____

13) How was the volume determined?_____

14) Was a sufficient volume purged prior to sampling? Yes_____ No_____

Comments_____

15) How many volumes?_____

16) How was the purged volume measured?_____

17) What was the method of purging?_____

_____

18) Were pH, conductivity, and temperature measurements taken and recorded at least once during each well volume purged? Yes_____ No_____

Comments_____

19) Were pH, conductivity, and temperature readings stable prior to sampling? Yes_____ No_____

Comments_____

20) How many wells were sampled?_____Upgradient?_____Downgradient?_____

21) How were the samples collected? Bailer_____Pump_____Other_____

Comments_____

22) If pump was used, what type?_____

23) If a pump was used, was it properly cleaned before and/or between wells?
Yes_____ No_____

Comments_____

24) What were the cleaning procedures?_____

_____

25) Did bailers have Teflon® coated wire leaders to prevent rope from coming into contact with water? Yes_____ No_____

26) Were bailers open or closed top?_____

27) Was a clean bailer and new rope used at each well? Yes_____ No_____

Comments_____

28) Were samples properly transferred from the sampling device to the sample containers? (i.e., purgeable sample first - not aerated, etc.) Yes_____ No_____

Comments_____

29) Was pH of preserved samples checked to insure proper preservation? Yes_____ No_____

Comments_____

30) Were samples iced immediately after collection? Yes_____ No_____

31) For what analyses were the samples collected?_____

_____

32) If samples were split, what were the sample/station numbers for these?

_____

_____

Other comments or observations_____

_____

_____

_____

SECTION 3 - SAMPLING - SOIL, SEDIMENT, SLUDGE, ETC. (Non-containerized)

1) Type of samples collected?_____

2) General description of samples?_____

_____

3) How many samples were collected?_____

4) Were background and/or control samples collected? Yes_____ No_____

Comments_____

5) Were representative samples collected? Yes_____ No_____

Comments_____

6) Were grab or composite samples collected?_____

7) Were composite samples areal or vertical?_____

8) How many aliquots were taken for the composite sample?_____

9) What procedures and equipment were used to collect samples?_____

_____

_____

10) Were samples thoroughly mixed prior to putting them into the sample containers? Yes_____ No_____

Comments_____

11) Were samples properly placed into sample containers? Yes_____ No_____

Comments_____

12) Were samples iced immediately after collection? Yes_____ No_____

13) For what analyses were the samples collected?_____

14) If samples were split, what were the sample/station numbers for these?

_____

15) Was a drilling rig, back hoe, etc., used to collect soil samples? _____

16) Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the ESD SOP, Appendix B, prior to arriving on site? Yes_____ No_____

Comments _____

17) What was the condition of the drilling and sampling equipment when it arrived on site? _____

_____

18) Was a decontamination area located where the cleaning activities would not cross-contaminate clean and/or drying equipment? Yes_____ No_____

Comments _____

19) Was clean equipment properly wrapped and stored in a clean area?
Yes_____ No_____

Comments _____

20) Was the drilling rig(s) properly cleaned between well borings?
Yes_____ No_____

Comments _____

21) Were the cleaning and decontamination procedures conducted in accordance with the ESD SOP? Yes_____ No_____

Comments _____

22) Other comments or observations _____

_____

_____

SECTION 4 - SAMPLING - SURFACE WATER (Pond, Stream, River, Leachate, Etc.)

1) Type of samples collected?_____

2) General description of samples?_____

3) How many samples were collected?_____

4) Were background and/or control samples collected? Yes_____ No_____

Comments_____

5) Were grab or composite samples collected?_____

6) How many aliquots were taken for the composite sample?_____

7) What procedures and equipment were used to collect the samples?

_____

_____

8) Were samples collected directly into sample containers? Yes_____ No_____

Comments_____

9) Did the sampler wade in the stream to collect the samples? Yes_____ No_____

Comments_____

10) Were the samples collected upstream from the sampler? Yes_____ No_____

Comments_____

11) Did the sampler insure that roiled sediments were not collected along with the water samples? Yes_____ No_____

Comments_____

12) Were representative samples collected? Yes_____ No_____

Comments_____

13) Was the pH of preserved samples checked to insure proper preservation? Yes_____ No_____

Comments_____

14) Were samples iced immediately after collection? Yes_____ No_____

15) For what analyses were the samples collected?_____

_____

16) If samples were split, what were the sample/station numbers for these?

_____

_____

Other comments or observations_____

SECTION 5 - OTHER SAMPLING - DRUMS, TANKS, BARRELS, ETC. (Containerized)

1) Type of samples collected? (Oil, sludge, waste?)_____

2) Description of containers or sources sampled?_____

3) How many samples were collected?_____

4) What type of equipment was used to collect the samples?_____

5) What procedures were used to collect the samples?_____

6) For what analyses were the samples collected?_____

7) If samples were split, what were the sample/station numbers for these?

8) Were any special safety measures taken during collection of the samples?

9) What level of safety protection was required for collection of the samples?

Other comments or observations_____

SECTION 6 - MONITORING WELL INSTALLATION

General

1) Were the wells installed in the proper locations in accordance with the study plan and/or project operations plan (POP)? Yes_____ No_____

Comments_____

2) Were the wells installed starting in the least contaminated area and proceeding to the most contaminated area? Yes_____ No_____

Comments_____

3) Were proper safety protocols employed during the well installations? Yes_____ No_____

Comments_____

4) Were samples of the drilling mud, water, bentonite pellets, filter pack materials, etc., collected for quality control analyses? Yes_____ No_____

Comments_____

Equipment Decontamination

5) Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the ESD SOP, Appendix B, prior to arriving on site? Yes_____ No_____

Comments_____

6) What was the condition of the drilling and sampling equipment when it arrived on site?_____

_____

7) Was a decontamination area located where the cleaning activities would not cross-contaminate clean and/or drying equipment? Yes_____ No_____

Comments_____

8) Was clean equipment properly wrapped and stored in a clean area? Yes_____ No_____

Comments_____

9) Was the drilling rig(s) properly cleaned between well borings? Yes_____ No_____

Comments_____

10) Were the cleaning and decontamination procedures conducted in accordance with the ESD SOP? Yes_____ No_____

Comments_____

Drilling

11) What type of drilling method(s) was used to install the wells? _____

_____

12) Was this drilling method(s) the same as proposed in the study plan and/or POP? Yes_____ No_____

Comments_____

13) Were soil samples collected for logging and analyses as the wells were installed? Yes_____ No_____

14) If yes to 13, at what intervals and by what method?_____

_____

15) If air rotary was used:
Was an in-line organic air filter employed? Yes_____ No_____
Was a cyclone velocity dissipator used? Yes_____ No_____

Comments_____

16) What diameter borehole(s) were installed?_____

17) Were surface outer casings used? Yes_____ No_____

18) If yes to 17, what size and to what depth?_____

_____

19) Were the wells double cased? Yes_____ No_____

20) If yes to 19, explain procedure._____

_____

Well Installation

21) What type of well casing(s) and screen(s) were used?_____

_____

22) What diameter were the well casing(s)?_____screen(s)?_____

23) Was there a minimum two inch annulus around the casing (between casing and borehole wall or inside augers)? Yes_____ No_____

Comments_____

24) What was the length of the well screen(s)?_____

25) What was the slot size of the well screen(s)?_____

26) Was the well screen(s) commercially manufactured? Yes_____ No_____

If yes, by whom?_____

27) Was the bottom of the well screen(s) plugged or capped? Yes_____ No_____

Comments_____

28) Were sand and/or gravel (filter) packs installed? Yes_____ No_____

Comments_____

29) Specify type of materials in 28 [(play sand, Ottawa sand, etc.) and grain size (20/30, 20/40, etc.)], if known._____

_____

30) Was a sieve analysis conducted to determine well screen slot size and filter pack grain size? Yes_____ No_____

Comments_____

31) Were the wells installed to the proper depths? Yes_____ No_____

Comments_____

32) Were well screens placed at the proper intervals? Yes_____ No_____

Comments_____

33) Were the filter packs placed a minimum of two feet above the well screens? Yes_____ No_____

Comments_____

34) Was the tremie tube method used to place the filter packs? Yes_____ No_____

Comments_____

35) Were seals placed above the filter packs? Yes_____ No_____

36) If yes to 35, what material was used for the seals?_____

37) Was the vertical thickness of the seals a minimum of two feet? Yes_____ No_____

Comments_____

38) If bentonite pellets were used for the seals above the filter packs, were they allowed to hydrate a minimum of 8 hours? Yes_____ No_____

Comments_____

39) Did contractor/driller have documentation from manufacturer stating recommended hydration time? Yes_____ No_____

Comments_____

40) Was the tremie tube method used to place the bentonite pellets? Yes_____ No_____

Comments_____

41) Was the annulus grouted from the seal to within two feet of the ground surface, or below the frost line? Yes_____ No_____

Comments_____

42) Was the tremie tube method used to place the grout in the annulus? Yes_____ No_____

43) If no to 42, what method was used?_____

44) What type of grout was used to seal the annulus (neat cement, cement/bentonite, cement/sand, etc.)?

_____

45) What grout mix ratio was used? (should be stated in the POP)_____

_____

46) What was the density of the grout? (lb./gal., etc.)_____

47) If bentonite grout was used, was the density at least 9.4 lb./gal.? Yes_____ No_____

48) Was the density determined using a mud balance? Yes_____ No_____

49) Was the grout allowed to set a minimum of 24 hours before the surface pad was installed? Yes_____ No_____

Comments_____

50) Was a concrete surface pad installed, with an outer protective casing and locking cap? Yes_____ No_____

Comments_____

51) How far below the ground surface did the concrete pad extend?_____

52) What were the dimensions of the concrete pads?_____

53) Did the well casings extend to a minimum of 2.5 feet above the ground surface? Yes_____ No_____

Comments_____

54) How far above the ground surface did the outer protective casings extend?

_____

55) Did the outer protective casings have weep holes? Yes_____ No_____

Comments_____

56) Were the wells properly developed? Yes_____ No_____

Comments_____

57) Describe method of development._____

_____

58) Give a general evaluation of the activities observed during the installation of the wells.

_____

_____

_____

_____

_____

51) How far below the ground surface did the concrete pad extend?_____

52) What were the dimensions of the concrete pads?_____

53) Did the well casings extend to a minimum of 2.5 feet above the ground surface? Yes_____ No_____

Comments_____

54) How far above the ground surface did the outer protective casings extend?

_____

55) Did the outer protective casings have weep holes? Yes_____ No_____

Comments_____

56) Were the wells properly developed? Yes_____ No_____

Comments_____

57) Describe method of development._____

_____

58) Give a general evaluation of the activities observed during the installation of the wells.

_____

_____

_____

_____

_____

3.0 SAMPLE CONTROL, FIELD RECORDS, AND DOCUMENT CONTROL

3.1 INTRODUCTION

The objectives of this section are to present the Branch standard operating procedures for sample identification, sample control and chain-of-custody, maintenance of field records, and document control.

A sample is defined as physical evidence collected from a facility, site, or the environment. For the purposes of this section, the term "physical evidence" also includes photographs, records, or any other tangible article collected from the environment, facility, or site.

All sample identification, field records, and chain-of-custody records shall be recorded in waterproof, non-erasable ink. If errors are made in any of these documents, Branch personnel will make corrections by simply crossing a single line through the error and entering the correct information. All corrections shall be initialed and dated by the investigator. If possible, all corrections should be made by the individual making the error.

If information is entered onto sample tags, logbooks, or sample containers utilizing stick-on labels, these labels should not be capable of removal later without leaving obvious indications of the attempt. Labels should never be placed over previously recorded information Corrections to information recorded on stick-on labels should be made as stated in the previous paragraph.

3.2 SAMPLE AND EVIDENCE IDENTIFICATION

3.2.1 General

The method of sample identification utilized depends on the type of sample collected. Samples collected for in-situ field analyses are those collected for specific field analyses or measurements where the data are recorded directly in bound field logbooks or recorded directly on the Chain-of-Custody Record, with identifying information, while in the custody of the sampling team. Examples of such in-situ field measurements and analyses include pH, temperature, and conductivity. Also included in this category are those field measurements or analyses such as flow measurements, geophysical measurements, surveying measurements, etc. that are made with field instruments or analyzers, where no sample is actually collected.

3.2.2 Sample Identification

Samples, other than those collected for in-situ field measurements or analyses, are identified by using a standard sample tag (Figure 3.2.1) which is attached to the sample container. In some cases, particularly with biological samples, the sample tag may have to be included with or wrapped around the sample. The sample tags are sequentially numbered and are accountable documents after they are completed and attached to a sample or other physical evidence. The following information shall be included on the sample tag:

- ESD project number;
- field identification or sample station number;
- date and time of sample collection;
- designation of the sample as a grab or composite;
- type of sample (water, wastewater, leachate, soil, sediment, etc.) and a very brief description of the sampling location;
- the signature(s) of the sampler(s) or of the designated sampling team leader (a team leader is a field investigator assigned by the project leader to be present during the collection of a specific sample and to be responsible and knowledgeable of all activities directly related to the collection of that sample).
- whether the sample is preserved or unpreserved;
- the general types of analyses to be conducted (checked on front of tag); and
- any relevant comments (such as readily detectable or identifiable odor, color, or known toxic properties).

Samples or other physical evidence collected by Branch personnel during criminal investigations are to be identified by using the "criminal sample tag."

This tag is identical to the standard sample tag shown in Figure 3.2.1, except that it has a red border around the front and a red background on the back of the tag.

The field sample station number is assigned by the project leader or field investigator. This number is ordinarily an alpha-numeric code, designed for a particular inspection or investigation. For example, if a sample is collected from a monitoring well installed during a site screening investigation conducted at the Abercrombie Widget Company, the alpha-numeric sample number code could be AW-001W. A surface soil sample from this facility might be identified as AW-002S. Each separate monitoring location should have a different numerical designation. Frequently, water and sediment samples are collected from the same sampling station and could have the same numerical designation. For example, water and sediment samples collected from the same location in the Oconee River at Station 001 would be identified as OR-001W and OR-001S, respectively. The project leader or field investigator shall exercise due caution to insure that sample station numbers are not duplicated during studies. The exact description of all sampling stations associated with field identification or sample station numbers shall be documented in the bound field logbooks.

If a sample is split with a facility, state regulatory agency, or other party representative, sample tags or labels with identical information should be attached to each of the sample containers by the party receiving the split sample. Also, all tags for blank or duplicate samples will be marked "blank" or "duplicate," respectively. This requirement does not apply to "blind" spiked or blank samples which are to be submitted for laboratory quality control purposes. "Blind" spiked or blank samples shall not be identified as such, but will be submitted as outlined in Section 4.6.9. This identifying information shall also be recorded in the bound field logbooks and on the Chain-Of-Custody Record as outlined in Section 4.4.

3.2.3 Photograph Identification

All photographs taken by Branch personnel shall be identified on the back of the print with the following information:

- an accurate description of what the photograph shows, including the name of the facility or site and the location.
- date, time and the location that the photograph was taken;
- the orientation of the photograph (i.e., looking northeast, etc.);
- the signature of the photographer.

If the photograph was taken with a Polaroid camera, the information shall be entered on the back of each photograph as soon as it is taken. If a 35 mm camera is used, a serial type record of each frame exposed shall be kept in the bound field logbook along with the information required for each photograph. The film shall be developed with the negatives supplied uncut. The field investigator shall then enter the required information on the prints, using the serialized photographic record from the bound field logbook, to identify each

photograph. For criminal investigations, the negatives must be maintained with the bound field logbook in the project file and stored in the secured file cabinet.

3.2.4 Identification of Physical Evidence

Physical evidence, other than samples, shall be identified by utilizing a sample tag or recording the necessary information on the evidence. When samples are collected from vessels or containers which can be moved (barrels for example), the field investigator shall mark the vessel or container with the field identification or sample station number for future identification, if necessary. The vessel or container shall be marked by utilizing a sharp instrument or spray paint. The vessel or container need not be marked if it already has a unique marking or serial number; however, these numbers shall be recorded on the sample tag and in the bound field logbooks. In addition, it is suggested that photographs of any physical evidence (markings, etc.) be taken and the necessary information recorded in the field logbook.

Occasionally, it is necessary to obtain recorder and/or instrument charts from facility owned analytical equipment, flow recorders, etc., during field investigations and inspections. Field investigators should mark the charts and write the following information on these charts while they are still in the instrument or recorder (along with the field investigators initials):

- if possible, starting and ending time(s) and date(s) for the chart;
- if possible, the field investigator shall take an instantaneous measurement of the media being measured by the recorder. The instantaneous measurement shall be entered at the appropriate location on the chart. The field investigator shall enter the date and time of the measurement and then enter his/her initials;
- a description of the location being monitored and any other information required to interpret the data such as type of flow device, chart units, factors, etc.

After the chart has been removed, the field investigator shall indicate on the chart who the chart (or copy of the chart) was received from and enter the date and time, as well as the investigator's initials.

Documents such as technical reports, laboratory reports, etc., should be marked with the field investigator's signature, the date, the number of pages, and from whom they were received. Branch personnel shall not accept confidential documents, except in special circumstances such as process audits, hazardous waste site investigations, etc.

FIGURE 3.2.1
SAMPLE TAG

FRONT

BACK

3.3 CHAIN-OF-CUSTODY PROCEDURES

3.3.1 General

The possession of samples or other physical evidence shall be traceable from the time they are obtained until they are introduced as evidence in legal proceedings. This section covers only that portion of the Environmental Services Division chain-of-custody procedures that are the responsibility of Branch personnel.

3.3.2 Sample Custody

A sample or other physical evidence is in custody if:

- it is in the field investigator's or the transferee's actual possession; or
- it is in the field investigator's or the transferee's view, after being in his/her physical possession; or
- it was in the field investigator's or the transferee's physical possession and then he/she secured it to prevent tampering; or
- it is placed in a designated secure area.

3.3.3 Chain-of-Custody Record

The field Chain-Of-Custody Record (Figure 3.3.1) is used to record the custody of all samples or other physical evidence collected and maintained by Branch personnel. This form shall not be used to document the collection of split or duplicate samples where there is a legal requirement to provide a receipt for samples (see Section 3.4). The Chain-Of-Custody Record also serves as a sample logging mechanism for the Analytical Support Branch (ASB) sample custodian.

The following information must be supplied in the indicated spaces (Figure 3.3.1) in detail to complete the field Chain-Of-Custody Record.

- The ESD project number.
- The project name.
- All samplers and /or sampling team leader must sign in the designated signature block.
- The sampling station number, date, and time of sample collection, grab or composite sample designation, and a brief description of the type of sample and the sampling location must be included on each line (each line shall contain only those samples collected at a specific location).

- The sampling team leader's name should be recorded in the right or left margin of the Chain-Of-Custody Record when samples collected by more than one sampling team are included on the same form. The sampling team leader is an individual designated by the project leader to be responsible for all activities related to the collection of samples by a specific team of sampling personnel.

- The total number of sample containers must be listed in the indicated space for each sample. The total number of individual containers must also be listed for each type of analysis under the indicated media or miscellaneous columns. Note that it is impossible to have more than one media type per sample. The type of container and required analyses should be circled as indicated on the Record.

- The tag numbers for each sample and any needed remarks are to be supplied in the indicated column.

- The field investigator and subsequent transferee(s) must document the transfer of the samples listed on the Record in the spaces provided at the bottom of the Record. One of the samplers documented under the sampler(s) section must be the person that originally relinquished the samples or evidence or a designated field sample custodian who receives secured samples from sampling teams and maintains these samples under secure conditions. Both the person relinquishing the samples and the person receiving them must sign the form; the date and time that this occurred must be documented in the proper space on the Record. Usually, the last person receiving the samples or evidence should be a laboratory sample custodian or other evidence clerk.

- The remarks column at the bottom of the Record is used to record airbill numbers or registered or certified mail serial numbers.

The Chain-Of-Custody Record is a serialized document. Once the Record is completed, it becomes an accountable document and must be maintained in the project file. The suitability of any other form for chain-of-custody should be evaluated based upon its inclusion of all of the above information in a legible format.

3.3.4 Field Custody Procedures

- To simplify the Chain-Of-Custody Record and eliminate potential litigation problems, as few people as possible should handle the sample or physical evidence during the investigation or inspection.

- The field investigator is responsible for the proper handling and custody of the samples collected (Section 3.3.2) until they are properly and formally transferred to another person or facility.

- Sample tags (Figure 3.2.1) shall be completed for each sample, using waterproof, non-erasable ink as specified in Section 3.3.2.

- All samples shall be sealed immediately upon collection utilizing the EPA custody seal (EPA Form 7500-(R7-75)) shown in Figure 3.3.2. The field investigator may write the date and his/her signature on the seal. This requirement shall be waived if the field investigator keeps the samples in his/her continuous custody from the time of collection until they are delivered to the laboratory analyzing the samples.

- All samples must be documented in bound field logbooks.

- A Chain-Of-Custody Record will be completed for all samples or physical evidence collected as specified in Section 3.3.3. A separate Chain-Of-Custody Record will be utilized for each final destination or laboratory utilized during the inspection or investigation.

- If chain-of-custody is required for documents received during investigations, they should be placed in large envelopes, and the contents should be noted on the envelope. The envelope shall be sealed and an EPA custody seal placed on the envelope such that it cannot be opened without breaking the seal. A Chain-Of-Custody Record shall be maintained for the envelope. Any time the EPA seal is broken, that fact shall be noted on the Chain-Of-Custody Record and a new seal affixed. The information on the seal shall include the field investigator's signature, as well as the date and time of sealing.

- Other physical evidence such as video tapes or other small items shall be placed in Zip-Loc® type bags or envelopes and an EPA custody seal should be affixed so that they cannot be opened without breaking the seal. A Chain-Of-Custody Record shall be maintained for these items. Any time the seal is broken, a new seal shall be affixed. The information on the seal shall include the field investigator's signature, as well as the date and time of sealing.

- In general, Branch personnel shall not accept samples from other sources unless the sample collection procedures used are known to be acceptable, can be documented, and the sample chain-of-custody can be established. If such samples are accepted by Branch personnel, a standard sample tag containing all relevant information and the Chain-Of-Custody Record, shall be completed for each set of samples.

- EPA custody seals can be used to maintain custody on other items when necessary by using similar procedures as those outlined previously in this section.

3.3.5 Transfer of Custody and Shipment

- All physical evidence or sample sets shall be accompanied by a Chain-Of-Custody Record. When transferring the possession of samples, the individual receiving the samples shall sign, date, and note the time that he/she received the samples on the Chain-Of-Custody Record. This Chain-Of-Custody Record documents transfer of custody of samples from the field investigator to another person, to the ASB, other laboratories, or other organizational elements.

- Samples shall be properly packaged for shipment (Appendix C) and delivered or shipped to the ASB or other designated laboratory for analyses. Shipping containers shall be secured by using nylon strapping tape and EPA custody seals. The custody seals shall be placed on the container so that it cannot be opened without breaking the seals. The seal shall be signed and dated by the field investigator.

- When samples are split with a facility, state regulatory agency, or other government agency, the facility, state regulatory agency, or other government agency representative should sign the Chain-Of-Custody Record. The only exception is that a Receipt For Samples Form will be used for RCRA, TSCA, and CERCLA samples as required by the appropriate regulations (Section 3.4).

- All samples shall be accompanied by the Chain-Of-Custody Record. The original and one copy of the Record will be placed in a plastic bag inside the secured shipping container if samples are shipped. One copy of the Record will be retained by the field investigator or project leader. The original Record will be transmitted to the field investigator or project leader after samples are accepted by the laboratory. This copy will become a part of the project file.

- If sent by mail, the package shall be registered with return receipt requested. If sent by common carrier, a Government Bill of Lading (GBL) or Air Bill should be used. Receipts from post offices, copies of GBL's, and Air Bills shall be retained as part of the documentation of the chain-of-custody. The Air Bill number, GBL number, or registered mail serial number shall be recorded in the remarks section of the Chain-Of-Custody Record or in another designated area if using a form other than that shown in Figure 3.3.1.

3.4 RECEIPT FOR SAMPLES

3.4.1 General

Section 3007 of the Resource Conservation and Recovery Act (RCRA) of 1976 and Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) of 1980 require that a "receipt" for all facility samples collected during inspections and investigations be given to the owner/operator of each facility before the field investigator departs the premises. The Toxic Substances Control Act (TSCA) contains similar provisions.

3.4.2 Receipt for Samples Form

The Receipt For Samples Form (Figure 3.4.1) is to be used by Branch personnel to satisfy the receipt for samples provisions of RCRA, CERCLA, and TSCA. The form also documents that split samples were offered and accepted or rejected by the owner/operator of the facility or site being investigated. The following information must be supplied and entered on the Receipt For Samples Form.

- The ESD project number, project name, name of facility or site, and location of the facility or site must be entered at the top of the form in the indicated locations.

- The sampler(s) must sign the form in the indicated location.

- The facility/site owner/operator's acceptance or rejection of split samples must be checked in the appropriate place in the Split Samples Offered section of the form. The owner/operator should be requested to initial his acceptance or rejection by the check mark and to sign his name in this block indicating that he has been offered this choice if the offer is refused.

- Each sample collected from the facility or site must be documented in the sample record portion of the form. The sample station number, date and time of sample collection, composite or grab sample designation, whether or not split samples were collected (yes or no should be entered under the split sample column), the tag numbers of samples collected which will be removed from the site, a brief description of each sampling location, and the total number of sample containers for each sample must be given. If EPA sample tags are used for split samples, these tag numbers should be recorded under the remarks column.

- The bottom portion of the form is used to document the receipt of split samples by the owner/operator of the facility or site. One of the samplers must be requested to sign and complete the information in the "transferred by" section (date and time must be entered). The owner/ operator of the site must sign the "received by" section of the form (the owner/operator must give his title, and telephone number and give the date and time he/she signed the form). If the owner/operator refuses to sign the form, the sampler(s) should note

this fact in the owner/operator's signature block and initial this entry.

The copy of the form is to be given to the facility or site owner/operator. The Receipt for Samples Form is serialized and becomes an accountable document after it is completed. The original copy of this form must be maintained in project files.

3.5 FIELD RECORDS

Branch personnel shall use only bound field logbooks for the maintenance of field records. The standard field logbooks utilized by Branch personnel are those obtained from the General Services Administration federal supply schedule numbers 7530-00-274-5494 and 7530-00-222-3525. Other bound logbooks such as bound surveyors logbooks are acceptable so long as pages cannot be removed without tearing them out.

Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project code should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and initial indicating the conclusion of the entry or the days activity.

All aspects of sample collection and handling as well as visual observations shall be documented in the field logbooks. All sample collection equipment (where appropriate), field analytical equipment, and equipment utilized to make physical measurements shall be identified in the field logbooks as outlined in Sections 4, 5, 6, and 7 of this SOPQAM. All calculations, results, and calibration data for field sampling, field analytical, and field physical measurement equipment shall also be recorded in the field logbooks. All field analyses and measurements must be traceable to the specific piece of field equipment utilized and to the field investigator collecting the sample, making the measurement, or analyses.

All entries in field logbooks shall be dated, shall be legible, and shall contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and must be maintained as part of project files.

3.6 DISPOSAL OF SAMPLES OR OTHER PHYSICAL EVIDENCE

Disposal of samples or other physical evidence obtained during Branch investigations is conducted on a case-by-case basis. Before any samples analyzed by the ASB are disposed, ASB personnel shall contact the Branch field investigator or Branch or Section Chief, in writing, requesting permission to dispose of the samples. The samples will not be disposed until the Branch field investigator or Branch or Section Chief completes the appropriate portions of the ASB memo, signs and returns the memo to the ASB, specifically giving them permission to dispose of the samples. Branch personnel should check with the EPA Program Office requesting the inspection or investigation before granting permission to dispose of samples or other physical evidence. The following general guidance is offered for the disposal of samples or other physical evidence:

- No samples, physical evidence, or any other document associated with a criminal investigation shall be disposed without written permission from EPA's Office of Criminal Investigation, the Office of Regional Counsel, or the Department of Justice.

- Quality assurance samples are routinely disposed after the analytical results are reported. ASB does not advise the Branch on the disposal of these samples.

- Samples associated with routine Branch inspections may be routinely disposed.

After samples are disposed, the ASB shall send the sample tags to the Branch field investigator. These sample tags are accountable and must be placed and maintained in the project files.

3.7 DOCUMENT CONTROL

The term document control, as it applies to Branch inspections and investigations, refers to the maintenance of inspection and investigation project files. All project files shall be maintained by the appropriate Section Secretary. All documents as outlined below shall be kept in project files. Branch personnel may keep their own files, however, all official and original documents relating to Branch inspections and investigations shall be placed in the official project files. The following documents shall be placed in the project file:

- a copy of the study plan;
- original Chain-Of-Custody Records and bound field logbooks;
- a copy of the Receipt For Sample Forms;
- all records obtained during the investigation;
- a complete copy of the analytical data and memorandums transmitting analytical data;
- sample tags from samples that have been disposed of by the ASB;
- all official correspondence received by or issued by the Branch relating to the investigation including records of telephone calls;
- one copy of the draft report (without review comments; however, peer review clearance forms shall be included);
- one copy of the final report and transmittal memorandum(s); and
- any other relevant documents related to the original investigation/inspection or follow-up activities related to the investigation/inspection.

Under no circumstances are any personal observations or irrelevant information to be filed in the official project files. The project leader or field investigator shall review the file at the conclusion of the project to insure that it is complete.

4.0 SAMPLING PROCEDURES

4.1 INTRODUCTION

This section discusses the standard practices and procedures utilized by Branch personnel during field operations to ensure the collection of representative samples. All sampling activities conducted by Branch personnel are conducted with the expectation that they will be used for enforcement purposes, unless specifically stated to the contrary in advance of the field investigation. Therefore, the use of proper sampling procedures cannot be over emphasized. The collection of representative samples depends upon:

- ensuring that the sample taken is representative of the material or medium being sampled;
- using proper sampling, sample handling, preservation, and quality control techniques;
- properly identifying the collected samples and documenting their collection in permanent field records (field log books, Chain-Of-Custody Records); and
- maintaining sample chain-of-custody.

The objectives of this section are to present:

- general considerations that must be incorporated in all sampling operations conducted by the Branch;
- Branch sampling site selection and collection procedures for an individual medium;
- Branch sampling quality assurance procedures; and
- equipment calibration and maintenance requirements for Branch sampling equipment.

4.2 GENERAL CONSIDERATIONS

The following factors and procedures shall be considered and implemented in planning and conducting all Branch sampling operations. All these factors and procedures must be considered in view of specific objectives and scope of each individual field investigation.

4.2.1 Selection of Representative Sampling Sites

Representative sampling sites are dependent on the type of investigation undertaken and are discussed under type of sample procedures for each medium later in this section.

4.2.2 Selection and Proper Preparation of Sampling Equipment

The type of sampling equipment to be used is dictated by the investigation and is discussed for each medium later in this section. Appendix B describes the standard equipment cleaning procedures.

4.2.3 Sampling Equipment Construction Material

The material that sampling equipment is constructed of can affect sample analytical results. Materials used must not contaminate the sample being collected and must be readily cleaned so that samples are not cross-contaminated. The standard materials for sampling equipment used to collect samples for trace organic compounds or metals analyses are, in order of decreasing desirability; Teflon®, glass, stainless steel, and steel.

4.2.4 Selection of Parameters to be Measured

Parameters to be measured are usually dictated by the purpose of an investigation and should be based on required monitoring conditions (NPDES or RCRA permits for example) or on the field investigator's or requestor's knowledge of the problem being investigated.

4.2.5 Required Sample Volumes

The volume of sample obtained should be sufficient to perform all required analyses with an additional amount collected to provide for quality control needs, split samples, or repeat examinations. When using a peristaltic pump, individual aliquots of a composite sample should be at least 100 milliliters in order to minimize sample solids bias.

Although the volume of sample required by contract laboratories depends on the analyses to be performed, the amount of sample required for a complete water or wastewater analysis is normally two gallons (7.6 liters) for each laboratory receiving a sample. The amount of soil/sediment required for a complete analysis is approximately 16 ounces. However, the laboratory receiving the sample should be consulted for any specific volume requirements.

The volumes of samples collected from waste sources at hazardous waste sites or samples from sources which are known to be toxic should be kept to an absolute minimum.

Sample volumes to be collected by Branch personnel for routine analyses by the Environmental Services Division (ESD), Analytical Support Branch (ASB) laboratory are in Appendix A. The sample volume required for each analysis is the volume of the standard container less ullage (empty space) required for sample mixing by laboratory personnel and safe shipment of samples to the laboratory. Branch personnel shall allow a minimum of ten percent ullage in every sample container for this purpose. The only exception is samples collected for purgeable organic analyses (VOA) or dissolved gases such as sulfides for which sample containers must be completely filled.

4.2.6 Selection and Proper Preparation of Sample Containers

The type of sample container is dictated by the analyses required. Standard sample containers used by Branch personnel are presented in Appendix A. Special sample container preparation requirements are in Appendix B.

4.2.7 Sample Preservation

Samples for some analyses must be preserved in order to maintain their integrity. Preservatives required for routine analyses of samples collected by Branch personnel are given in Appendix A. All chemical preservatives used by Branch personnel will be supplied by the ASB. All samples requiring preservation should be preserved immediately upon collection in the field. Samples that should not be preserved in the field are:

- Samples collected within a hazardous waste site that are known or thought to be highly contaminated with toxic materials. Barrel, drum, closed container, spillage, or other source samples from hazardous waste sites are not to be preserved with any chemical. These samples may be preserved by placing the sample container on ice, if necessary.

- Samples that have extremely low or high pH or samples that may generate potentially dangerous gases if they were preserved using the procedures given in Appendix A.

- Samples for metals analyses which are shipped by air shall not be preserved with nitric acid in excess of the amount specified in Appendix C.

- Samples for purgeable organic compounds analyses which are shipped by air shall not be preserved with hydrochloric acid in excess of the amount specified in Appendix C.

All samples preserved with chemicals shall be clearly identified by indicating on the sample tag that the sample is preserved. If samples normally requiring preservation were not preserved, field records shall indicate why.

4.2.8 Sample Holding Times

The elapsed time between sample collection and initiation of laboratory analyses must be within a prescribed time frame for each individual analysis to be performed. Sample holding times for all routine samples collected by Branch personnel are shown in Appendix A.

4.2.9 Special Precautions for Trace Contaminant Sampling

Some contaminants can be detected in the parts per billion and/or parts per trillion range. Extreme care must be taken to prevent cross-contamination of these samples. The following precautions shall be taken when trace contaminants are of concern:

- A clean pair of new, disposable gloves will be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

- Sample containers for source samples or samples suspected of containing high concentrations of contaminants shall be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

- If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples shall be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples shall never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants shall be lined with new, clean, plastic bags.

- If possible, one member of the field team should take all the notes, fill out tags, etc., while the other members collect all of the samples.

- When sampling surface waters, the water sample should always be collected before the sediment sample is collected.

- Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

- Branch personnel should use equipment constructed of Teflon®, stainless steel, or glass that has been properly precleaned (Appendix B) for collecting samples for trace metals or organic compounds analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern. Equipment constructed of

plastic or PVC shall not be used to collect samples for trace organic compounds analyses.

4.2.10 Sample Handling and Mixing

After collection, all sample handling should be minimized. Branch personnel should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, personnel should ensure that melted ice cannot cause sample containers to become submerged, as this may result in sample cross-contamination. Plastic bags, such as Zip-Lock® bags, should be used when small sample containers (e.g., VOA's or bacterial samples) are placed in ice chests to prevent cross-contamination.

Once a sample has been collected, it may have to be split into separate containers for different analyses. The best way to split liquid samples is to continually stir the sample contents with a clean pipette or precleaned Teflon® rod and allow the contents to be alternately siphoned into respective sample containers using Teflon® or PVC (Tygon® type) tubing. Teflon® must be used when analyses for organic compounds or trace metals are to be conducted. Any device used for stirring, or tubing used for siphoning, must be cleaned in the same manner as other equipment (Appendix B). However, samples collected for purgeables organic compounds analyses may not be split using this procedure.

A true split of soil, sediment, or sludge samples is almost impossible to accomplish under field conditions. The higher the moisture content, the more difficult it is to split the sample.

It is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. The most common method of mixing is referred to as quartering. The soil in the sample pan is divided into quarters. Each quarter is mixed, then all quarters are mixed into the center of the pan. This procedure is followed several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion and occasionally turning the material over. Soil and sediment samples collected for purgeable organic compounds analyses should not be mixed. The 2-ounce (60-ml) sample container should be filled completely; no head space should remain in the sample containers.

4.2.11 Purgeable Organic Compounds Sampling (VOA)

Water samples to be analyzed for purgeable organic compounds should be stored in 40-ml septum vials with screw cap and Teflon®-silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program.

The vials (40-ml) should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule,

it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, repeat the procedure. Since the VOA vials are pre-preserved, extreme caution should be exercised when the vials are used as the collection device for surface water samples in order to prevent the loss of the preservative. When collecting water samples for purgeable organic compounds, triplicate samples should always be collected from each location. Three 40-ml vials containing four drops of concentrated HCl should be filled the with sample.

4.2.12 Sample Identification

All samples will be fully documented, as outlined in Section 3, in the field records, on the field sample Chain-Of-Custody Record, and on the sample tags.

4.2.13 Procedures for Identifying Potentially Hazardous Samples

Any sample either known or thought to be hazardous should be so identified on both the sample tag and the field sample Chain-Of-Custody Record. Information explaining the hazard, i.e., corrosive, flammable, poison, etc., shall also be listed.

4.2.14 Collection of Auxiliary Data

All auxiliary data such as flow measurements, photographs of sampling sites, meteorological conditions, and other observations shall be entered onto the field records when the auxiliary data are collected. Auxiliary data relative to a particular sampling location should be collected as close to the sample collection time as possible. Specific types of auxiliary data to collect for each medium sampled are discussed later in this section.

4.2.15 Time Records

All records of time shall be kept using local time in the 2400 hour time format and shall be recorded to the nearest minute.

4.2.16 Transporting and Shipping of Samples

Samples may be hand delivered to the laboratory using government owned (or rented) vehicles or they may be shipped by common carrier. All Branch personnel must be aware that certain samples are hazardous materials and, as such, are regulated by the U. S. Department of Transportation under the Transportation Safety Act of 1974. These regulations are contained in Title 49, CFR, Parts 110-119. Shipment of dangerous goods by air cargo is also regulated by the United Nations/International Civil Aviation Organization (UN/ICAO). The Dangerous Goods Regulations promulgated by the International Air Transport Association (IATA) meet or exceed DOT and UN/ICAO requirements and should be used for shipment of dangerous goods via air cargo. Shipment of samples by EPA employees is also governed by EPA Order No. 1000.18 (1). The standard Branch procedure for

shipping environmental samples is in Appendix C. All Branch employees shall meet the intent of the Transportation Safety Act of 1974 when shipping samples by common carrier.

4.2.17 Sample Chain-of-Custody

Branch employees shall maintain sample chain-of-custody during all field investigations for all samples collected. The standard sample chain-of-custody procedures used by Branch employees are given in Section 3.3.

4.3 DEFINITIONS

4.3.1 Grab Sample

An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes. Grab samples are associated with surface water, groundwater, wastewater, waste, contaminated surfaces, soil, and sediment sampling. Grab samples are typically used to characterize the media at a particular instant in time. See Appendix A for additional guidance concerning parameters requiring a grab sample and for monitoring that indicates that grab samples must be collected.

4.3.2 Composite Samples

A sample collected over time that typically consists of a series of discrete samples which are combined or "composited". Four types of composite samples are listed below:

- Time Composite (TC): A sample comprised of a varying number of discrete samples collected at equal time intervals during the compositing period. The TC sample is typically used to sample wastewater or streams.

- Flow Proportioned Composite (FPC): A sample collected proportional to the flow rate during the compositing period by either a time-varying/constant volume (TVCV) or time-constant/varying volume (TCVV) method. The TVCV method is typically used with automatic samplers that are paced by a flow meter. The TCVV method is a manual method that individually proportions a series of discretely collected samples. The FPC is typically used when sampling wastewater.

- Areal Composite: A sample collected from individual grab samples collected on an areal or cross-sectional basis. Areal composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from grid points.

- Vertical Composite: A sample collected from individual grab samples collected from a vertical cross section. Vertical composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes and estuaries.

4.3.3 Quality Control Samples

The majority of ECB field studies require the collection of additional samples for various quality control purposes. These include the isolation of site effects (control samples), define background conditions (background sample), evaluate field/laboratory methodology (spikes and blanks, trip blanks, duplicate samples), or to assess sampling equipment (sampler blanks and equipment rinse

blanks). In addition, it may be necessary to provide split or duplicate samples to assess field sampling procedures.

Miscellaneous sampling definitions are listed below:

- Sample Aliquot: A portion of a sample that is representative of the entire sample.

- Split Sample: A sample which has been portioned into two or more containers from a single sample container or sample mixing container.

- Duplicate Sample: Two or more samples collected simultaneously into separate containers from the same source under identical conditions.

- Control Sample: A sample collected upstream or upgradient from a source or site to isolate the effects of the source or site on the particular ambient medium being sampled.

- Background Sample: A sample collected from an area, water body, or site similar to the one being studied, but located in an area known or thought to be free from pollutants of concern.

- Biased Sample: A sample which is known to be non-representative of the entire site being studied. An example is samples collected during Superfund Site Screening Investigations that are intentionally biased towards suspected areas of contamination.

- Trip Blanks: Trip blanks are prepared prior to the sampling event in the actual sample container and are kept with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and sent for analysis. At no time after their preparation are the sample containers to be opened before they reach the laboratory. ESD utilizes volatile organic trip blanks to determine if samples were contaminated during storage and transportation back to the laboratory. If samples are to be shipped, trip blanks are to be provided per shipment but not per cooler.

- Equipment Blanks: Equipment field blanks are defined as samples which are obtained by running organic-free water over/through sample collection equipment after it has been cleaned. These samples will be used to determine if cleaning procedures were adequate. (The equipment could have been cleaned in the field or prior to the field operation.)

- Pre and Post Preservative Blanks: To determine if the preservative used during field operations were contaminated, pre and post preservative blanks are prepared. On small studies, usually only a post preservative sample will be prepared. These samples are prepared by putting analyte-free/organic-free water in the container and then preserving the sample with the appropriate preservative.

- Field Blanks: Organic-free water is taken to the field in sealed containers and poured into the appropriate sample containers at pre-designated locations. This is done to determine if any contaminants present in the area may have an affect on the sample integrity. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.

4.4 DATA QUALITY OBJECTIVES

As defined in Data Quality Objectives for Remedial Response Activities (29), "Data Quality Objectives (DQO's) are qualitative and quantitative statements which specify the quality of the data required to support Agency decisions during remedial response activities". DQO's should be considered when planning any study. DQO's provide information on the limits of the data, which in turn dictate the proper uses of the data. DQO's were originally developed to guide the analytical program of Superfund (29), but the concept also has application for other field sampling efforts. Data collected in the field include samples and site information. The methods by which samples are collected may limit the uses of the subsequent analytical data. The methods by which site information, such as physical measurements, photographs, field notes, etc., are collected, may reduce their accuracy. The manner in which sampling equipment is cleaned will also affect the DQO level of the data. The various DQO levels are numbered I through V, with I being the lowest and IV the highest quality data. Level V data are collected using special or non-standard methods. Higher quality methods may be substituted for lower level work.

4.4.1 DQO Level I

Sampling equipment and sample containers must be cleaned using soap and tap water, visibly free of contamination, and free of detectable analytes using the analytical screening methods specified for the study. Use of organic vapor survey methods to determine locations or media fractions for higher level analysis is an example of DQO Level I field work. However, this technique is not appropriate for compounds that are not volatile or produce low instrument response. Data produced from such samples may not be used for other than the stated purpose.

4.4.2 DQO Level II

Field methods, decontamination procedures, and sampling equipment construction materials for DQO Level II analyses are as specified elsewhere in this document. The construction materials for sampling equipment may vary if rinse blanks analyzed using the field analytical procedures show that the substituted equipment does not contribute detectable analytes, and the materials would not reasonably be expected to contribute detectable analytes. For example, it may be acceptable to use PVC sampling equipment to collect samples that are only being analyzed for metals, or to use equipment made of chrome plated material for samples being analyzed only for organic compounds. Field cleaning procedures for sampling equipment used to collect samples that will be analyzed at this DQO level may consist of:

- Soap and potable water wash with brush (steam may also be used), followed by potable water rinse.

- Water rinse. The quality of the water is determined by the contaminants of concern and the minimum quantitation limits of the analytical methods used. For example, if an atomic absorption (AA) unit is being used to analyze water samples for lead only, and the

minimum quantitation limit is 20 ug/l, water containing up to 10 ug/l lead (one-half the minimum quantitation limit) may be used as decontamination water.

A minimum of five percent of samples collected for DQO Level II analyses should be split for DQO Level IV analysis. These samples must be representative of all samples submitted to the field laboratory.

4.3.3 DQO Level III

Field methods, decontamination procedures, and sampling equipment construction materials for DQO Level III analyses are as specified elsewhere in this document. Some modifications of these specifications are allowable in certain limited instances, as specified below.

If DQO Level III analytical services are being used in support of drilling or excavation operations, the cleaning procedures for the down-hole drilling or excavation equipment only may be cleaned as specified in Appendix E.9, with the omission of steps 3, 4, and 5. All other cleaning and decontamination procedures specified in that appendix apply.

When wells are constructed using materials that are not inert with respect to the contaminants being analyzed, data collected from those wells are DQO Level III or lower for those incompatible analytes, even if DQO Level IV analytical procedures are used.

A minimum of one equipment rinse blank per week for each week sampling equipment is field cleaned is required to be analyzed. If samples are preserved, a preservative blank must be collected and analyzed in the field at the beginning and end of the study. A blank of the rinse water must be collected and analyzed prior to beginning the study and at the end of each week sampling equipment is field cleaned.

A minimum of five percent of samples collected for DQO Level III analysis should be split for DQO Level IV analysis. These samples must be representative of all samples submitted to the field laboratory.

4.4.4 DQO Level IV

Field methods and equipment decontamination procedures described in this document are considered to be level IV methods. These are the standard methods to be used on all studies requiring DQO Level IV quality data. Any deviations from these methods must be documented in the field logbook or the approved study plan. The sampler must be aware that such deviations in the field work may reduce the DQO level of the data, with a subsequent reduction in the data uses. The field notes are always collected as specified in Section 3.5. Photographs are always logged as specified in Section 3.2.3.

4.4.5 DQO Level V

Because DQO Level V procedures are by definition non-standard, they are not discussed in detail. The project leader must be aware that special analytical procedures may require specialized field procedures and equipment. These must be specified in the approved study plan prior to beginning the study.

4.5 INVESTIGATION DERIVED WASTE

4.5.1 General

Many field investigations conducted by the Branch generate waste materials. These waste materials are known as investigation derived waste (IDW) (30). Some of these waste materials may be hazardous wastes which must be properly disposed in accordance with EPA regulations. Most, but not all, of these hazardous wastes will be associated with investigations of hazardous waste sites.

4.5.1.1 Types of IDW -- Materials which may become IDW requiring proper treatment, storage and disposal are:

- Personnel protective equipment (PPE). This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.
- Disposable equipment (DE). This includes plastic ground and equipment covers, aluminum foil, conduit pipe, coliwasa samplers, Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.
- Soil cuttings from drilling or hand auguring.
- Drilling mud or water used for water rotary drilling.
- Groundwater obtained through well development or well purging.
- Cleaning fluids such as spent solvent and washwater.

4.5.1.2 Management of Non-Hazardous IDW -- Disposal of non-hazardous IDW from hazardous waste sites should be addressed in the study plan. Non-hazardous IDW such as PPE and DE may be double-bagged and brought back to the Branch warehouse for disposal in the warehouse trash containers. To reduce volume for transportation back to the warehouse, it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum. If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE and DE IDW into the facilities dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a permitted landfill local to the site. On larger studies, waste hauling services may be obtained and a dumpster located at the study site. They may also be buried on site near the contamination source, with the burial location noted in the field logbook.

Disposal of non-hazardous IDW such as drill cuttings, purge or development water, decontamination fluids, drilling muds, etc., should be specified in the approved study plan. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place the liquid IDW into the facilities treatment system. It may be feasible to spread drill cuttings around the borehole, or if the well is temporary, to replace the cuttings back into the borehole. Cuttings, purge

water, or development water may also be placed in a pit in or near the source area. Monitoring well purge or development water may also be poured onto the ground downgradient of the monitoring well. Purge water from private potable wells which are in use may be discharged to the ground surface.

4.5.1.3 Management of Hazardous IDW -- Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan. Hazardous IDW must be disposed as specified in USEPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed of in the source area from which they originated, if doing so does not endanger human health and the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to permit arrangements for proper containerization, labelling, transportation, and disposal/treatment in accordance with USEPA regulations.

Hazardous investigation derived waste should be kept to a minimum to conserve Branch resources. Most of the routine studies conducted by the Branch should not produce any IDW that are hazardous, with the possible exception of purged groundwater. Many of the above PPE and DE wastes can be deposited in municipal dumpsters if care is taken to keep them segregated from hazardous waste contaminated materials. Disposable equipment can often be cleaned to render it non-hazardous, as can some PPE, such as splash suits. The volume of spent solvent waste produced during equipment decontamination can be reduced or eliminated by applying only the minimum amount of solvent necessary.

4.6 SPECIFIC SAMPLE COLLECTION QUALITY CONTROL PROCEDURES

4.6.1 General

This subsection provides guidelines for establishing quality control procedures for Branch sampling activities. Specific guidelines for sample site selection, selection of sampling equipment, types of samples to be collected, standard sample collection procedures, specific maintenance and calibration procedures for sampling equipment, and other considerations are presented for each medium later in this Section. Specific requirements for all sampling activities are presented in Section 4.2. Strict adherence to all of the standard operating procedures outlined in this chapter form the basis for the Branch sampling quality assurance program.

4.6.2 Experience Requirements

There is no substitute for field experience. Therefore, all professional and paraprofessional Branch employees shall have the equivalent of six months field experience before they are permitted to select sampling sites on their own initiative. This field experience shall be gained by on-the-job training using the "buddy" system. Each new Branch field employee shall accompany an experienced employee on as many different types of field studies as possible. During this training period, the new employee will be permitted to perform all facets of field investigations, including sampling, under the direction and supervision of senior Branch technical staff.

4.6.3 Traceability Requirements

All sample collection activities shall be traceable through field records to the person collecting the sample and to the specific piece of sampling equipment (where appropriate) used to collect that sample. All maintenance and calibration records for sampling equipment (where appropriate) shall be kept so that they are similarly traceable.

4.6.4 Measurement of Relative Sampling Precision

The following duplicate sampling procedures shall be used during the collection of Branch samples as a relative measure of the precision of the sample collection process. Duplicate grab and/or composite samples shall be collected during all major investigations and studies (more than 20 samples) conducted by the Branch. No more than ten percent of all samples shall be collected in duplicate. These samples shall be collected at the same time, using the same procedures, the same equipment, and in the same types of containers as the required samples. They shall also be preserved in the same manner and submitted for the same analyses as the required samples. The collection of duplicate composite samples shall require the installation of duplicate automatic sampler setups if automatic samplers are used for sample collection.

These data will be examined by the project leader to determine if any problems are evident with specific types of media samples or with the procedures used by specific Branch personnel. The project leader will advise the Branch Quality Assurance Officer who will in turn advise the Branch and appropriate

Section Chiefs of any problems encountered so that corrective action can be taken.

4.6.5 Measurement of Sample Handling Effectiveness

The effectiveness of Branch personnel sample handling techniques will be monitored by utilizing field blank samples. For routine studies these blank samples will be prepared by ASB personnel. Branch personnel shall request that these samples be provided at least one week in advance of scheduled field investigations and inspections and never (except in emergency situations) less than two days in advance of scheduled field investigations and inspections. These samples should not be picked up by Branch personnel earlier than the morning of departure for the scheduled inspection/investigation. On larger studies, where organic-free water is generated in the field, these blank samples may be made in the field. The following field blank samples are required:

- Water Sample VOA Trip Blank -- A water sample VOA trip blank is required for every study where water samples are collected for VOA analysis. Two sealed preserved (or unpreserved if appropriate) 40-ml VOA vials will be transported to the field. These field blanks will be handled and treated by Branch personnel in the same manner as the water samples collected for purgeable organic compounds analysis on that particular study. These samples will be clearly identified on sample tags and Chain-Of-Custody Records as trip blanks.

- Soil Sample VOA Trip Blank -- A soil sample VOA trip blank is required for every study where soil samples are collected for purgeable organic compounds analysis. One 2-oz. soil VOA vial will be transported to the field. This field blank will be handled and treated by Branch personnel in the same manner as the soil samples collected for purgeable organic compounds analysis on that particular study. These samples will be clearly identified on sample tags and Chain-Of-Custody Records as trip blanks.

The following blanks are prepared in the field:

- Inorganic Sample Preservative Blanks -- Metals and general inorganics sample containers filled with blank water will be transported to the field and preserved and submitted for the same analyses as the other inorganic samples collected. These samples will be clearly identified as preservatives blanks on sample tags and in the Chain-Of-Custody Record(s). At least one preservative blank for each type of preserved sample should be collected at the end of routine field investigations. A minimum of one preservative blank should be prepared at the beginning and end of all major Branch field investigations (20 samples or more).

- Automatic Sampler Blanks -- The procedure for collecting automatic sampler blanks is given in Section 4.5.4. In general, cleaning procedures outlined in Appendix B should be adequate to insure sample integrity. However, it is the standard practice of the

Branch to submit automatic sampler blanks for analyses when automatic samplers are used to collect samples for organic compounds analyses. Automatic sampler blanks for other standard analyses shall be submitted at least once per quarter.

The ASB will advise the Branch Quality Assurance Officer when trip blanks or preservative blanks are unacceptably contaminated. The Branch Quality Assurance Officer will immediately initiate an investigation to determine the cause of the problem. The results of this investigation will be promptly reported to the Branch and appropriate Section Chief so that corrective action can be initiated.

4.6.6 Measurement of Sample Container, Sample Equipment, and Cleaning Procedure Integrity

Specific quality control procedures are outlined in Appendix B.

4.6.7 Measurement of Field Generated Organic-Free Water

On larger studies, organic-free water may be prepared in the field. When this is done, a system blank should be collected prior to use and at the end of the study. If the study lasts more than one week, at least one sample per week shall be collected. Blank samples should be analyzed for all analytes of interest.

4.6.8 Special Quality Control Procedures for Water Samples for Extractable, Pesticide, or Herbicide Organic Compounds Analyses

Branch personnel shall submit duplicate water samples for extractable, pesticide, and/or herbicide organic compounds analyses from at least one sampling location per project and laboratory used. This sample should be collected from a location expected to be relatively free from contamination, since this sample will be used for laboratory quality control purposes. The duplicate sample should be clearly identified as "Duplicate Sample for Matrix Spike" on the sample tag, Chain-Of-Custody Record, in the field logbook, and on the Contract Laboratory Program (CLP) Traffic Report Form (if appropriate). This procedure shall be followed for all Branch projects where water samples are collected for the indicated organic compounds analyses, whether the samples are submitted to the ASB or the EPA CLP.

4.6.9 Special Quality Control Procedures for EPA Contract Laboratories

Special quality control procedures are used when samples are submitted to the EPA CLP. A series of blank and spiked samples are provided by ASB personnel that are to be submitted along with the regular samples to each contract laboratory utilized. These samples will be provided by the ASB along with the necessary CLP Traffic Report Forms for each blank and spike sample. These samples shall be submitted to the respective contract laboratories on a blind basis. Fictitious station numbers will be used on the Traffic Report Forms; the contract laboratories are not to know which samples are spikes and blanks. These samples are identified as spikes or blanks only on the copy of the Traffic Report Forms that are returned to the ASB.

These spike and blank samples are to be obtained from the ASB utilizing the procedures outlined in Section 4.4.5.

The ASB TPO (See Section 1.9.3.1) may request, on a case-by-case basis, that Branch personnel collect split samples (or duplicate samples if appropriate) for analysis by both the ASB and contract laboratories. The split samples are to be submitted to the ASB using established procedures. The contract laboratory involved shall not be notified in any way that samples were split, i.e., there should be no indication on Chain-Of-Custody Records or CLP Traffic Report Forms submitted to the contract laboratories that these samples were split with the ASB.

4.6.10 Special Quality Assurance Procedures for Dioxin (2,3,7,8-TCDD or Other Isomers)

All samples collected for dioxin (2,3,7,8-TCDD or isomers) analyses are analyzed by other EPA laboratories or through contract laboratories. The ASB does not conduct in-house analyses for dioxin. The ASB maintains a package that outlines all current quality control procedures to be used by Branch personnel when collecting samples for dioxin (2,3,7,8-TCDD or other isomers) analyses. The ASB must be consulted before any such samples are collected.

4.7 WASTEWATER SAMPLING

4.7.1 General Considerations

The variety of conditions at different sampling locations require that considerable judgment be made regarding the methodologies and procedures for collection of representative samples of wastewater. Each sampling point warrants attention commensurate with its complexity. There are, however, basic rules and precautions generally applicable to sample collection. The procedures used by the Branch are generally those outlined in the NPDES Compliance Inspection Manual (2). Additional guidance is given in the agency's handbook, Monitoring Industrial Wastewater (3). Some important considerations for obtaining a representative wastewater sample include:

- The sample should be collected where the wastewater is well mixed. Therefore, the sample should be collected near the center of the flow channel, where the turbulence is at a maximum and the possibility of solids settling is minimized. Skimming the water surface or dragging the channel bottom should be avoided; however, allowances should be made for fluctuations in water depth due to flow variations.

- In sampling from wide conduits, cross-sectional sampling should be considered. Rhodamine WT dye (See Section 7.8.2.3 for procedures) may be used as an aid in determining the most representative sampling point(s); and

- If manual compositing is employed, the individual sample bottles must be thoroughly mixed before pouring the individual aliquots into the composite container.

4.7.2 Site Selection

Where applicable, wastewater samples should be collected at the location specified in the NPDES permit (if the source has such a permit). In some instances the sampling location specified in the permit, or the location chosen by the permittee, may not be acceptable for the collection of a representative wastewater sample. In such instances, the project leader or field investigator is not limited by permit specifications from collecting a sample at a more representative location. When a conflict exists between the permittee and the regulatory agency regarding the most representative sampling location, both sites should be sampled, and the reason for the conflict should be noted in the inspection or study report and field notes. Recommendations and reasons for a change in sampling location should be given to the appropriate permitting authority.

4.7.2.1 Influent -- Influent wastewaters are preferably sampled at points of highly turbulent flow in order to ensure good mixing; however, in many instances the most desirable location is not accessible. Preferable influent wastewater sampling points include: (1) the upflow siphon following a comminutor (in absence of grit chamber); (2) the upflow distribution box following pumping from main plant wet well; (3) aerated grit chamber; (4) flume throat; or (5) pump

wet well when the pump is operating. When possible, raw wastewater samples should be collected upstream from sidestream returns.

4.7.2.2 Effluent -- Effluent samples should be collected at the site specified in the permit, or if no site is specified in the permit, at the most representative site downstream from all entering wastewater streams prior to discharge into the receiving waters. If a conflict exists between the permittee and inspector regarding the source being sampled or the location of the most representative site, follow the procedure outlined in Section 4.7.2.

4.7.2.3 Pond and Lagoon Sampling -- Generally, composite effluent wastewater samples should be collected from ponds and lagoons. Even if the ponds or lagoons have long retention times, composite sampling is necessary because of the tendency of ponds and lagoons to have flow paths that short circuit the detention time. However, if dye studies or facility data indicate a homogeneous discharge, a grab sample may be taken as representative of the waste stream.

4.7.3 Sampling Techniques - General

Sampling and flow measuring are mutually dependent for a complete evaluation of a wastewater treatment plant. The investigator must know the wastewater flow variability before a sampling program can be initiated.

The choice of a flow proportional or time composite sampling scheme depends on the variability of the wastewater flow or concentration, equipment availability, and sampling location. If an investigator knows or suspects that there is significant variability in the wastewater flow or if the investigator knows nothing about the facility, a flow proportional sample should be collected. Otherwise a time composite sample would be acceptable.

Prior to sampling, the flow measuring system (primary flow device, totalizer, and recorder) should be examined (methods described in Section 5). If the flow measuring system is unacceptable, the investigator may have to install flow measurement instrumentation (Section 5). If the flow measuring system is acceptable, samples can be collected by the appropriate method.

Time composite samples collected by the Branch are based on a constant time interval between samples. A time composite sample can be collected either manually or with an automatic sampler.

Flow proportional samples can be collected automatically with an automatic sampler and a compatible pacing flow measuring device, semi-automatically with a flow chart and an automatic sampler capable of collecting discrete samples, or manually. Refer to Appendix E for procedures describing the first method and to the NPDES Compliance Inspection Manual (2) for details on the latter two methods.

4.7.4 Use of Automatic Samplers

4.7.4.1 General -- Automatic samplers may be used when several points are to be sampled at frequent intervals or when a continuous sample is required. Automatic samplers used by the Branch must meet the following requirements:

- Sampling equipment must be properly cleaned to avoid cross-contamination which could result from prior use (see Appendix B for cleaning procedures).

- No plastic or metal parts of the sampler shall come in contact with the water or wastewater stream when parameters to be analyzed could be impacted by these materials (See Section 4.7.6).

- The automatic sampler must be able to provide adequate refrigeration during the sampling period. This can be accomplished in the field by using ice.

- The automatic sampler must be able to collect a large enough sample for all parameter analyses (see Appendix A for required sample volumes).

- A minimum of 100 mls should be collected each time the sampler is activated if a peristaltic pump is used.

- The automatic sampler should provide a lift of at least 20 feet and the sampler should be adjustable so that the volume is not be a function of the pumping head.

- Pumping velocity must be adequate to transport solids and not allow solids to settle.

- The intake line leading to the pump must be purged before each sample is collected.

- The minimum inside diameter of the intake line should be 1/4 inch.

- An adequate power source should be available to operate the sampler for 48 hours at a 30-minute sampling interval.

- Facility electrical outlets may be used if available.

- Facility automatic samplers may be used for conventional parameters if they meets SOP criteria.

Specific operating instructions, capabilities, capacities, and other pertinent information for automatic samplers presently used by the Branch are included in the respective operating manuals and are not presented here.

4.7.4.2 <u>Equipment Installation</u>

4.7.4.2.1 <u>Conventional Sampling</u> -- Automatic samplers may be used to collect time composite or flow proportional samples. In the flow proportional mode, the samplers are activated by a compatible flow meter. Flow proportional samples can also be collected using a discrete sampler and a flow recorder and manually compositing the individual aliquots in flow proportional amounts (2).

All new tubing (Dow® Corning Medical Grade Silastic, or equal, in the pump and either Teflon® or Tygon®, or equal, in the sample train) will be used for each sampler installation.

Installation procedures include cutting the proper length of tubing, positioning it in the wastewater stream, and sampler programming.

For a time composite sample, the sampler should be programmed to collect 200 mls at 30-minute intervals or 100 mls at 15-minute intervals into a refrigerated 3-gallon glass jug. For a 5-gallon compositing container, the volume should be increased

For a flow proportional sample, the sampler should be programmed to collect a minimum of 100 mls for each sample interval, with the interval predetermined based on the flow of the waste stream.

At the end of each 24-hour sampling period, the contents of the glass compositing container with the sample should be stirred and siphoned (poured if there are no visible solids) into the respective containers, followed by immediate preservation, if required.

4.7.4.3 Automatic Sampler Security -- EPA owned equipment is assumed to be in the custody of the permittee as long as it is on their property. This assumption should be made known to permittees whenever equipment is left unattended. A lock or seal may be placed on the sampler to detect tampering. However, this does not prevent tampering with the sample collection tubing. If necessary, seals may be placed on the sampling pole and tubing line to further reduce tampering possibilities.

4.7.4.4 Automatic Sampler Maintenance, Calibration, and Quality Control - To insure proper operation of automatic samplers, and thus the collection of representative samples, the procedures outlined in this section shall be used to maintain and calibrate Branch automatic samplers.

The following maintenance and calibration procedures shall be used; any differences from those prescribed procedures will be documented.

Prior to each field trip, the sampler operation will be checked by warehouse personnel. This includes operation (forward, reverse, automatic) through three cycles of purge-pump-purge; checking desiccant and replacing if necessary; checking 12-volt batteries to be used with the sampler; and repairing any item if necessary.

During each field trip, prior to initiating sampling, the purge-pump-purge cycle shall be checked at least once. The constant pumping volume using a graduated cylinder or other calibrated container will be checked at least twice, and the flow pacer that activates the sampler shall be checked to be sure it operates properly.

Upon return from a field trip, the sampler shall be examined for holes, dents, etc., and repaired, if necessary. The desiccant will be checked and replaced if appropriate. The operation (forward, reverse, automatic, etc.) will

be checked and any required repairs will be made and documented. The sampler will then be cleaned as outlined in Appendix B.

The automatic sampler's pumping rate at multiple heads, the timing mechanisms, the multiplexer, or the flow pacer will be checked against the manufacturer's specifications and documented whenever one or more of these functions appears to be operating improperly.

Automatic sampler blanks must be collected for organic compounds and metals analyses when collecting samples for trace organic compounds analyses as described in section 4.7.6.1.

4.7.5 Manual Sampling

Manual sampling is normally used for collecting grab samples and/or for immediate in-situ field analyses. However, it can also be used in lieu of automatic equipment over extended periods of time for composite sampling, especially when it is necessary to evaluate unusual waste stream conditions.

The best method to manually collect a sample is to use the actual sample container which will be used to transport the sample to the laboratory. This eliminates the possibility of contaminating the sample with an intermediate collection container. The actual sample container must always be used for collecting samples for oil and grease and bacterial analyses.

A separate collection container can be used to collect the sample, from which the sample can be redistributed to other containers. If this is done, however, the container used to collect the sample must be properly cleaned (Appendix B) and must be made of a material that meets the requirements of the parameter(s) being investigated. Also, a separate container will be used at each sampling station. This will prevent cross contamination between sampling station.

If the water or wastewater stream cannot be physically reached by the sampling personnel or it is not safe to reach for the sample, an intermediate collection container may be used. The sample is collected by lowering a properly cleaned Teflon®, plastic, glass, or stainless steel collection vessel (type of collection vessel used depends on the parameter being investigated) into the material to be sampled. The collection vessel may be lowered by hand or attached to a pole or rope and then lowered into the stream.

In some cases it may be best to use a pump, either power or hand operated, to withdraw a sample from the water or wastewater stream. If a pump is used, it is imperative that all components of the pump that come in contact with the liquid are properly cleaned (Appendix B) to insure the integrity of the sample.

Samples are manually collected by tipping the collection container in the water or wastewater stream so the mouth of the container faces upstream. The container should be rinsed with this procedure at least twice before the sample is collected (exceptions to this rinsing procedure exist if preservatives are present in the sampling container and for certain analyses such as oil and grease and bacteria).

4.7.6 Special Sample Collection Procedures

4.7.6.1 Trace Organic Compounds and Metals -- Trace organic compounds and metals detection limits are usually in the parts per billion range, so extreme care must be exercised to insure sample integrity.

All containers, composite bottles, tubing, etc., used in sample collection for trace organic compounds and metals analyses should be prepared as described in Appendix B.

When possible, the sample should be collected directly into the appropriate sample container. If the material to be sampled cannot be physically reached, an intermediate collection device may be used. This should be a Teflon®, glass, or stainless steel vessel on a pole or rope or Teflon® tubing via a peristaltic type pump and a Teflon® vacuum container attachment which converts a sample container into a vacuum container. The device which is used should be cleaned as described in Appendix B.

Personnel handling the sample should always wear a new pair of disposable surgical gloves with each set of samples collected and change as often as needed. This is necessary to prevent cross-contamination. A more detailed discussion is given in Section 4.2.10 under special precautions for trace contaminant sampling.

When an automatic sampler is used for collecting samples for trace organic compounds and metals analyses, the installation procedures include cutting the proper length of new Teflon® tubing, water rinsing of the entire collection system with a minimum of two gallons of Milli-Q® water, and blank collection for organics and metals. In the Milli-Q® water rinse, approximately one-half gallon is initially pumped into the composite sampler container and discarded. An additional one and one-half gallons are then pumped into the composite sampler container for distribution into the appropriate blank container. Nitric acid must be added to the metals blank container. Finally the collection tubing should then be positioned in the wastewater stream and sampler programming initiated.

4.7.6.2 Bacterial -- Samples for bacterial analysis will always be collected directly into the prepared glass or plastic sample bottle. The sample bottle should be kept unopened until it is to be filled. When the cap is removed, care should be taken not to contaminate the cap or the inside of the bottle. The bottle should be held near the base and filled to within about one inch of the top without rinsing and recapped immediately. The bottle should be plunged, neck downward, below the surface and turned until the neck points slightly upward. The mouth should be directed toward the current (4, 5). Appendix A presents preservation procedures and holding times.

When the sample bottle must be lowered into the waste stream, either because of safety or impracticality (manhole, slippery effluent area, etc.), care must be taken to avoid contamination.

4.7.6.3 Immiscible Liquids/Oil and Grease -- Oil and grease may be present in wastewater as a surface film, an emulsion, a solution, or as a combination of

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these forms. Since it is very difficult to collect a representative sample for oil and grease analysis, the inspector must carefully evaluate the location of the sampling point. The most desirable sampling location is the point of greatest mixing. Quiescent areas should be avoided. Because losses of oil and grease will occur on sampling equipment, the collection of a composite sample is impractical. Individual portions collected at prescribed time intervals must be analyzed separately to obtain the average concentrations over an extended period.

4.7.6.4 Purgeable Organic Compounds Analyses (VOA) -- Samples to be analyzed for purgeable organic compounds should be collected in 40-ml septum vials with screw caps with a Teflon® lined silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program.

When sampling for purgeable organic compounds, triplicate samples should always be collected from each location. The investigator should determine if the water to be sampled contains chlorine. If the water contains no chlorine, three 40-ml vials containing four drops of concentrated HCl should be filled with the sample. The samples may be held up to 14 days before analysis. When preservation (HCl) is not feasible, samples can be held up to 7 days before analysis for purgeable aromatic hydrocarbons and 14 days for purgeable hydrocarbons compounds.

If the water contains chlorine, the following sampling and preservation procedure should be followed:

Fill an 8-ounce VOA sampling container with 8 drops of a 25% ascorbic acid solution and the water sample. Cap and mix thoroughly but gently by swirling to eliminate residual chlorine. Transfer the sample to three 40-ml VOA vials containing four drops of concentrated HCl*. Label each 40-ml vial with "P" (preserved/ascorbic acid).

* The ascorbic acid and acid preservatives must be added in this order and in two separate steps.

The purgeable organics vials (40-ml) should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles; if any are present, repeat the procedure using a new 40-ml vial.

Sampling containers with preservatives should be prelabeled (i.e., P) prior to any field activities. This will reduce the chances of confusion during sampling activities by the investigation team. Sample preservation, containers, holding times, and sample volumes are listed in Appendix A.

4.7.7 Special Process Control Samples and Tests

Special process control samples collected and field tests performed on these samples are given in Appendix H.

4.7.8 Auxiliary Data Collection

While conducting wastewater sampling, the following information will also be obtained (if applicable):

- Field measurements - pH, DO, conductivity, temperature (see Section 6 and Appendix D for standard field analytical techniques);
- Flows associated with the samples collected -- continuous flows with composite samples and instantaneous flows with grab samples (Section 5);
- Diagrams and/or written descriptions of the wastewater treatment systems (if available);
- Photographs of pertinent wastewater associated equipment, such as flow measuring devices, treatment units, etc. (keep photolog as specified in section 3.2.3);
- Process control information on the wastewater treatment process (if applicable); and
- Completion of applicable forms required during specific investigations.

All observations, measurements, diagrams, etc., will be entered in bound field logbooks or attached thereto (where applicable as specified in Section 3.5).

4.8 SURFACE WATER AND SEDIMENT SAMPLING

4.8.1 General

Selection of a surface water sampling location for water quality studies is based on many factors, including: study objective, water use, point source discharges, nonpoint source discharges, tributaries, changes in stream characteristics, types of stream bed, stream depth, turbulence, presence of structures (weirs, dams, etc.), accessibility, personnel available, etc. When sampling in estuarine systems, tidal effects must be considered in selecting sampling locations.

If the study objective is to investigate a specific location as a source of water supply, recreation, or other discrete use, then considerations such as accessibility, flow, velocity, physical characteristics, etc., are not as critical from a water quality investigation standpoint.

If the objective of a water quality study is to determine patterns of pollution, provide data for mathematical modeling purposes, conduct assimilative capacity studies, etc., where more than a single sampling location is to be investigated, then several factors become interrelated and need to be considered in sampling location selection. An excellent guide to conducting surface water stream studies is F. W. Kittrells, "A Practical Guide to Water Quality Studies" (6).

4.8.2 Sample Site Selection

Before any sampling is conducted, an initial reconnaissance should be made to locate suitable sampling locations. Bridges and piers are normally good choices as sites since they provide ready access and permit water sampling at any point across the width of the water body. However, these structures may alter the nature of water flow and thus influence sediment deposition or scouring. Additionally, bridges and piers are not always located in desirable locations with reference to waste sources, tributaries, etc. Wading for water samples in lakes, ponds, and slow-moving rivers and streams must be done with caution since bottom deposits are easily disturbed, thereby resulting in increased sediment in the overlying water column. On the other hand, wadeable areas may be best for sediment sampling. In slow-moving or deep water, a boat is usually required for sampling.

Sampling station locations can be chosen without regard to other means of access if the stream is navigable by boat, especially in estuarine systems where boats frequently provide the only access to critical sampling locations.

Wading to collect samples may be feasible in some cases, but this method usually will be chosen for only very small streams. A field investigator usually has to carry a considerable amount of sampling equipment, field analytical instruments, and water samples. When it also is necessary to wear rubber boots to walk the streambed or to wade out to the main current, the physical effort involved often makes this method too difficult to be practical.

Fresh water environments are commonly separated into two types: (1) rivers, streams, and creeks; and (2) lakes, ponds, and impoundments. Since these waterways differ considerably in general characteristics, site selection must be adapted to each. Estuarine environments are a special case and are discussed separately.

4.8.2.1 Rivers, Streams, and Creeks -- In the selection of a surface water sampling site on rivers, streams, and creeks, areas that exhibit the greatest degree of cross-sectional homogeneity shall be located. When available, previously collected data may indicate if potential sampling locations are well mixed or vertically or horizontally stratified. Since mixing is principally governed by turbulence and water velocity, the selection of a site immediately downstream of a riffle area will insure good vertical mixing. These locations are also likely areas for deposition of sediment since the greatest deposition occurs where stream velocity slows down. Horizontal (cross-channel) mixing occurs in constrictions in the channel, but because of velocity increases, the stream bottom may be scoured, and therefore, a constriction is a poor sediment sample location. In the absence of turbulent areas, the selection of a site that is clear of immediate point sources, such as tributaries and industrial and municipal effluents, is preferred for the collection of water samples.

Typical sediment depositional areas are located inside of river bends, downstream of islands, and downstream of obstructions in the water. Sites that are located immediately upstream or downstream from the confluence of two streams or rivers should generally be avoided since flows from two tributaries may not immediately mix, and at times due to possible backflow can upset the normal flow patterns.

When several stations along a stream reach are to be sampled, they should be strategically located:

- They shall be spaced at intervals based on time-of-water-travel, not distance. For example, sampling stations may be located about one-half day time-of-water-travel for the first three days downstream of a waste source (the first six stations) and then approximately one day through the remaining distance.

- If the study is to be compared to a previous study, the same sampling stations should be used, if possible, for comparison purposes.

- A station should be located whenever a marked physical change occurs in the stream channel. Example: A stream reach between two adjacent stations should not include both a long rapids section of swift shallow water with a rocky bottom, and a long section of deep, slow-moving water with a muddy bottom. Stations at each end of the combined reach would yield data on certain rates of change, such as reaeration, that would be an unrealistic average of two widely different rates. Much more would be learned of the actual natural characteristics of the stream by inserting a third sampling station within the reach, between the rapids and the quiet water sections.

- Station locations should be selected to isolate major discharges as well as major tributaries.

Dams and weirs cause changes in physical characteristics of a stream. They usually create quiet, deep pools in river reaches that, historically were swift and shallow. Such impoundments should be bracketed. When times of water travel through them are long, stations should be established within the impoundments.

Some stream structures, such as dams, permit overflow that accomplishes significant reaeration of oxygen deficient water. In such cases, stations should be located short distances upstream and downstream from the structures to measure the rapid, artificial increase in dissolved oxygen (DO), which is not representative of natural reaeration.

A minimum of three stations located between any two points of major change in a stream is a desirable precaution, when feasible, even when the time-of-travel between the points of change is short. Major changes may consist of a waste discharge, a tributary inflow, or a significant difference in channel characteristics. The use of three stations is especially important when rates of change of unstable constituents are being determined. If results from one of only two stations in a subreach are in error for some unforeseen reason, it may not be possible to judge which of the two sets of results indicate the actual rate of change. Results from at least two of three stations, on the other hand, will probably support each other and indicate the true pattern of water quality in the subreach.

If there is interest in the effects of certain discharges or tributary streams on ambient water quality, sites should be located both upstream and downstream from the tributaries or discharges.

Unless a stream is extremely turbulent, it is nearly impossible to measure the effect of a waste discharge or tributary immediately downstream of the source. Inflow frequently "hugs" the stream bank with very little horizontal (cross-channel) mixing for some distance. This is a major consideration in estuarine environments. Samples from quarter points may miss the wastes altogether and reflect only the quality of water above the waste source. Samples taken directly in the portion of the cross section containing the wastes would indicate excessive effects of the wastes with respect to the river as a whole.

Tributaries should be sampled as near the mouth as is feasible. This may be a bridge some distance upstream from the mouth. Frequently, the mouths of tributaries may be entered from the main stream for sampling by boat. Care should be exercised to avoid collecting water from the main stream that may flow into the mouth of the tributary on either the surface or bottom because of differences in density resulting from temperature, dissolved salts, or turbidity.

Actual sampling locations will vary with the size of the water body and the amount of turbulence in the stream or river. Generally, with small streams less than 20 feet wide, a sampling site can be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth at the center of the channel is adequate to represent the entire cross-section. A sediment sample can

also be collected at the center of the channel. For slightly larger streams, at least one vertical composite should be taken from mid-stream, with samples taken just below the surface, at mid-depth, and just above the bottom. Of course, DO, pH, temperature, conductivity, etc. should be measured on each aliquot of the vertical composite. For large rivers, several locations across the channel width should be sampled. Vertical composites across the channel width should be located in a manner that is roughly proportional to flow, i.e., they should be closer together toward mid-channel, where most of the flow travels, than toward the banks, where the proportion of total flow is smaller. The number of vertical composites required and the number of depths sampled for each are usually determined in the field by the sampling crew. This determination is based on a reasonable balance between the following two considerations.

1. The larger the number of subsamples, the more nearly the composite sample will represent the water body.

2. Taking subsamples is time-consuming and expensive, and increases the chance of contamination.

In most circumstances, a number of sediment samples should be collected along a cross-section of a river or stream in order to adequately characterize the bed material. A common procedure is to sample at quarter points along the cross-section of the site selected. When the sampling technique or equipment requires that the samples be extruded or transferred at the site, they can be combined into a single composite sample. However, samples of dissimilar composition should not be combined but should be stored for separate analysis in the laboratory. To insure representative samples, the preferred method is diver deployed coring tubes.

4.8.2.2 Lakes, Ponds, and Impoundments -- Lakes, ponds, and impoundments have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained. Occasionally, an extreme turbidity difference may occur vertically where a highly turbid river enters a lake, and each layer of the stratified water column needs to be considered. Since the stratification is caused by water temperature differences, the cooler, heavier river water is beneath the warmer lake water. A temperature profile of the water column as well as visual observation of lake samples can detect the different layers and they can be sampled separately.

The number of water sampling sites on a lake, pond, or impoundment will vary with the purpose of the investigation as well as the size and shape of the basin. In ponds and small impoundments, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is to be conducted on each vertical composite aliquot. In naturally-formed ponds, the deepest point is usually near the center; in impoundments, the deepest point is usually near the dam.

In lakes and larger impoundments, several vertical subsamples should be composited to form a single sample. These vertical sampling locations are often taken along a transect or grid. Again, the number of vertical subsamples and the depths at which subsamples are taken are usually at the discretion of the

sampling crew. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones, but normally a composite shall consist of several vertical subsamples collected at various depths.

In lakes with irregular shape and with several bays and coves that are protected from the wind, additional separate composite samples may be needed to adequately represent water quality. Similarly, additional samples should be taken where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

When collecting sediment samples in lakes, pond, and reservoirs, the site selected should be approximately at the center of water mass. This is particularly true for reservoirs that are formed by the impoundment of rivers or streams. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir, and the bed sediments near the center of the water mass will be composed of fine-grained materials. The shape, inflow pattern, bathymetry, and circulation must be considered when selecting sediment sampling sites in lakes or reservoirs.

4.8.2.3 Estuarine Waters -- Estuarine areas are zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types, dependent upon freshwater inflow and mixing properties (7, 8, 9, and 10):

- Mixed estuary -- Characterized by an absence of vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is found in major freshwater sheetflow areas, featuring shallow depths.

- Salt wedge estuary -- Characterized by a sharp vertical increase in salinity and channelized freshwater inflow into a deep estuary. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase.

- Oceanic estuary -- Characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh saline water mixing occurring near, or at, the vegetated shore line.

A reconnaissance investigation should be conducted for each estuarine study unless prior knowledge of the estuarine type is available. The reconnaissance should focus upon the freshwater and oceanic water dynamics with respect to the study objective. In this regard, National Oceanic Atmospheric Administration tide tables and USGS freshwater surface water flow records provide perspective to the estuary dynamics. The basic in-situ measurement tools for reconnaissance are: a boat, recording fathometer, salinometer, and dissolved oxygen meter. These instruments coupled with the study objective or pollution source location, whether it is a point or nonpoint source problem, provide the focus for setting

sampling locations. More often than not, preplanned sampling locations in estuarine areas are changed during the actual study period. Because of the dynamics of estuaries, initial sampling often reveals that the study objective could be better served by relocating, adding, or deleting sampling locations.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (11).

All estuarine sampling programs conducted by Branch personnel shall include vertical salinity measurements at one- to five-foot increments coupled with vertical DO and temperature profiles. A variety of water sampling devices are used, but in general, the Van Dorn (or similar type) horizontal sampler is employed.

Samples are normally collected at mid-depth in areas where the depths are less than 10 feet, unless the salinity profile indicates the presence of a halocline (salinity stratification). In that case, samples are collected from each stratum. Depending upon the study objective, when depths are greater than 10 feet, water samples may be collected at the one-foot depth, mid-depth, and one-foot from the bottom.

In general, estuarine investigations are two phased, with study investigations conducted during wet and dry periods. Depending upon the freshwater inflow sources, estuarine water quality dynamics cannot normally be determined by a single season study.

For a complete discussion of estuarine systems, refer to references 7, 8, 9, and 10.

4.8.2.4 Control Stations -- In order to have a basis of comparison of water quality, the collection of samples from control stations is always necessary. A control station above the source of waste is fully as important as are stations below, and should be chosen with equal care to ensure representative results. At times it may be desirable to locate two or three stations above the waste inflow to establish the rate at which the unstable material is changing. The time of travel between the stations should be sufficient to permit accurate measurement of the change in the constituent under consideration.

4.8.3 Sampling Equipment and Techniques

4.8.3.1 General -- Any equipment or sampling techniques used to collect a sample are acceptable as long as they do not cause the integrity of the sample to be violated and which provide a sample which is representative of the stream being sampled.

4.8.3.2 Water Sampling Equipment/Techniques -- The physical location of the investigator when collecting a sample may dictate the equipment to be used. If surface water samples are required, direct dipping of the sample container into the stream is desirable. This is possible, however, only from a small boat, a pier, etc., or by wading in the stream. Wading, however, may cause bottom deposits to rise and bias the sample. Wading is acceptable if the stream has a noticeable current (is not impounded), and the samples are collected directly

into the bottle while pointed upstream. If the stream is too deep to wade or if the sample must be collected from more than one water depth or from a bridge, etc., supplemental sampling equipment must be used.

Teflon® bailers may be used for surface water sampling, if the data requirements do not necessitate a sample from a strictly discrete interval of the water column. A closed top bailer with a bottom check-valve is sufficient for many studies. As the bailer is lowered through the water column, water is continually displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. This technique may not be successful where strong currents are found, or where a discrete sample at a specific depth is required.

If discrete samples are desired at a specific depth, and the parameters to be measured do not require a Teflon® coated sampler, a standard Kemmerer or Van Dorn sampler may be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends of the sampler open while being lowered in a vertical position to allow free passage of water through the cylinder. The Van Dorn sampler is plastic and is lowered in a horizontal position. In each case, a messenger is sent down a rope when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill respective sample bottles. With a rubber tube attached to the valve, DO sample bottles can be properly filled by allowing an overflow. With multiple depth samples, care should be taken not to stir up the bottom sediment and thus bias the sample.

A plastic bucket can be used to collect samples if the parameters to be analyzed do not preclude it. However, the bucket should be rinsed twice with the sample water prior to collection of the sample. All field equipment should follow standard cleaning procedures.

4.8.3.3 <u>Sediment Sampling Equipment/Techniques</u> -- To collect a sediment sample from a streambed, a variety of methods can be used. Dredging (Peterson, Eckman, Ponar), coring, and scooping (BMH-60) are available. Regardless of the method used, precautions shall be taken to insure that the sample collected is representative of the streambed. These methods are discussed in the following paragraphs.

4.8.3.3.1 <u>Dredging</u> -- For routine analyses, the Peterson dredge can be used when the bottom is rocky, in very deep water, or when the stream velocity is high. The dredge should be lowered very slowly as it approaches bottom, because it can displace and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high velocities. It should not be used from a bridge more than a few feet above the water, because the spring mechanism which activates the sampler can be damaged by the messenger if dropped from too great a height.

The Ponar dredge is a modification of the Peterson dredge and is similar in size and weight. It has been modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave." The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

4.8.3.3.2 Corers -- Core samplers are used to sample vertical columns of sediment. They are particularly useful when a historical approach to sediment deposition is desired for they preserve the sequential layering of the deposit. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand push tubes to weight or gravity driven devices.

Coring devices are particularly useful in pollutant monitoring because the "shock wave" created by descent is minimal, thus the fines of the sediment-water interface are only minimally disturbed; the sample is withdrawn intact permitting the removal of only those layers of interest; core liners manufactured of glass or Teflon® can be purchased, thus reducing possible sample contamination; and the samples are easily delivered to the lab for analysis in the tube in which they were collected. The disadvantage of coring devices is that a relatively small surface area and sample size is obtained often necessitating repetitive sampling in order to obtain the required amount for analysis. Because it is felt that this disadvantage is offset by the advantages, coring devices are recommended in sampling sediments for trace organic compounds or metals analyses.

In shallow, wadeable waters, the direct use of a core liner or tube manufactured of Teflon® or glass is recommended for the collection of sediment samples. Their use can also be extended to deep waters when SCUBA equipment is available. Teflon® is preferred to avoid glass breakage and possible sample loss. Stainless steel push tubes are also acceptable and provide a better cutting edge and higher strength than Teflon®. The use of the glass or Teflon® tube by itself eliminates any possible metal contamination from core barrels, cutting heads, and retainers. The tube should be approximately 12 inches if only recently deposited sediments (8 inches or less) are to be sampled. Longer tubes should be used when the depth of the substrate exceeds eight inches. Soft or semi-consolidated sediments such as mud and clays have a greater adherence to the inside of the tube and thus can be sampled with larger diameter tubes. Because coarse or unconsolidated sediments such as sands and gravel tend to fall out of the tube, a small diameter is required for them. A tube about two inches in diameter is usually the best size. The wall thickness of the tube should be about 1/3 inch for either Teflon® or glass. The inside wall may be filed down at the bottom of the tube to facilitate entry of the liner into the substrate.

Caution should be exercised not to disturb the area to be sampled when the sample is obtained by wading in shallow water. The core tube is pushed into the substrate until only four inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is pushed will facilitate greater penetration and cut down on core

compaction. The tube is then capped with a Teflon® plug or a sheet of Teflon® held in place by a rubber stopper or cork. After capping, the tube is slowly extracted, the negative pressure and adherence of the sediment keeping the sample in the tube. Before pulling the bottom part of the core above the water surface, it too is capped.

For a detailed description of several types of coring devices, refer to "Sampling Protocols for Analysis of Toxic Pollutants in Ambient Water, Bed Sediment and Fish" (12).

4.8.3.3.3 Scooping -- If the water is wadeable, the easiest way to collect a sediment sample is to scoop the sediment using a stainless steel spoon or scoop. This reduces the potential for cross-contamination. This can be accomplished by wading into the stream, and while facing upstream (into the current), scooping the sample along the stream bottom in the upstream direction. If the stream is too deep to wade but less than eight feet deep, a stainless steel scoop attached to a piece of conduit can be used either from the banks if the stream is narrow or from a boat.

If the stream has a significant flow and is too deep to wade, a BMH-60 sampler may be used. It is not particularly efficient in mud or other soft substrates because its weight will cause penetration to deeper sediments, which are not desired when sampling for priority pollutants. It is also difficult to release secured samples in an undisturbed fashion that would readily permit subsampling. The BMH-60 may be used for priority pollutant sampling provided that caution is exercised by only taking subsamples that have not been in contact with the metal walls of the sampler.

4.8.3.3.4 Mixing -- Regardless of the method of collection, sediment samples collected for chemical analysis should be thoroughly mixed (except for purgeable organic compounds analysis) before being placed in the appropriate sample containers, as specified in Section 4.2.10.

4.8.4 Special Sample Collection Techniques

4.8.4.1 Trace Organic Compounds and Metals -- Since trace organic compounds and metals are usually found in extremely low concentrations in ambient waters, the possibility of contamination is greater than with sediment or fish. Precautions must be taken with sampling equipment and preservatives to ensure that contamination does not occur.

Direct dipping of the sample containers is the preferred method of collecting surface water sample for trace levels pollutants analyses. If samples are to be split for enforcement or quality control purposes, and duplicate samples will not suffice, a sufficient volume for all sample containers should be collected in a large glass compositing container and then, with mixing, be alternately siphoned or poured into the respective sample bottles. This technique is not to be used for samples collected for purgeable organic compounds analysis.

Many contaminants are partitioned more strongly to sediments than water; thus, if these contaminants have been deposited recently and are not quickly degraded or desorbed, they are evident in the sediment analysis. Ideally, only Teflon®, stainless steel, or glass should be used in sediment sampling for trace level contaminant analyses. The method using glass or Teflon® coring tubes, was discussed previously, is the preferred technique.

In many situations when the water is deep, divers are not available, or the only sampling location is from a bridge, a dredge may be used. In these cases, a high grade stainless steel Ponar dredge (properly cleaned, Appendix B) shall be used to collect the sediment samples. Direct scooping of the streambed sediment as described earlier is acceptable.

4.8.4.2 Bacterial -- Samples for bacteriological examination must be collected in bottles properly sterilized and protected against contamination. The preferable method is to scoop up the water with the open bottle just below the surface. This method usually is used when sampling by boat. While the bottle is open, both bottle and stopper must be protected against contamination. A small amount of water should be poured from the bottle after filling to leave an air space for subsequent shaking in the laboratory. The bottle should be closed at once.

When sampling from a bridge, the sterilized sample bottle can be placed in a weighted frame, opened, and then lowered to the water with a string or rope. The bottle can also be lowered by attaching twine directly to it. Care should be taken not to dislodge dirt or other material from the bridge that will fall into the open bottle. The mouth of the bottle may be faced upstream by swinging the bottle downstream under the bridge and dropping it quickly but without excessive slack in the rope. The bottle is then pulled upstream and out of the water.

Special equipment for collecting sterile samples at various depths is available. The JZ sampler, for example, includes a metal frame to hold the sample bottle, two sterile glass tubes connected by a rubber tube and inserted through the sterile bottle stopper, and a messenger. One of the glass tubes is bent so that the upper portion is horizontal. This portion is positioned next to a rope. The messenger breaks the tube, which allows the bottle to fill. The bottle, glass tube and rubber tube must be properly sterilized before use. Additional guidance for collecting samples for bacterial analyses is given in References 4 and 5.

4.8.5 Auxiliary Data Collection

A bound field log book will be used to record daily activities, describe sampling locations and techniques, list photographs taken, etc., as specified in Section 3.5. Visual observations are particularly significant and may prove invaluable in interpreting water quality study results. These visual observations, including weather and stream conditions (including tide stage) during the investigation should also be recorded in field records.

4.8.6 Specific Sampling Equipment Quality Assurance Procedures

All water and sediment sampling equipment shall be cleaned as outlined in Appendix B after field use and before being stored. This equipment shall be inspected and tested before being issued for each field study. Any repairs necessary shall be made and recorded.

During field studies, this equipment shall be cleaned as outlined in Appendix B and all such cleaning procedures shall be documented in field records.

4.9 GROUND WATER SAMPLING

4.9.1 General

Ground-water sampling may be required for a variety of reasons, such as examining potable or industrial water supplies, checking for and/or tracking contaminant plume movement in the vicinity of a land disposal or spill site, RCRA compliance monitoring, or examining a site where historical information is minimal or non-existent but where it is thought ground water contamination could have occurred.

Ground water is usually sampled through an in-place well, either temporarily or permanently installed. However, it can also be sampled anywhere ground water is present, as in a pit or a dug or drilled hole.

Occasionally, a well will not be in the ideal location to obtain the sample needed (for example, to track a contaminant plume). In that case, a well will have to be installed, and it may be either a temporary or permanently installed well. An experienced and knowledgeable person will need to locate the well and supervise its installation so that the samples ultimately collected will be representative of the ground water.

The procedures covered in this section are those used by the Branch. Additional guidance is given in the "RCRA Ground Water Monitoring Technical Enforcement Guidance Document" (TEGD) (13); the ground water sampling procedures used by Branch personnel will meet or exceed the requirements of this document.

4.9.2 Site Selection

The relationship of the following factors to potential pollution sources shall be considered and evaluated when selecting ground-water sampling sites:

- the direction of ground-water flow, depth to ground water, thickness of the aquifer (if applicable);
- type of stratigraphy;
- presence of perched water tables;
- types of soils;
- depth to bedrock;
- type of vegetation;
- surface drainage patterns;
- type of topography;
- general land use;

- and surface features such as rock outcrops, seeps, springs, streams, rivers, and wet areas (14).

The area of interest should be located on an aerial photograph, a USGS 7.5 minute quadrangle map, a USDA soils map, and/or any other appropriate map that shows topography and general relationships between surface features. Aerial photographs can usually be obtained at the local Agricultural Stabilization Conservation Service (ASCS) office or the local county tax office. USGS 7.5 minute quadrangle maps can be acquired from the State Geological Survey or from the USGS, and soils maps from the USDA-SCS (Soil Conservation Service). A visual inspection of the area may be sufficient to evaluate and determine the surface conditions and their relationship to the subsurface conditions (14). In some cases, surface conditions and subsurface conditions cannot be correlated by site inspection or reconnaissance. When this occurs, a more detailed study, possibly involving test drilling, will have to be conducted.

It is extremely important to sample the unconfined or surficial aquifer downgradient of potential pollution sources or spills to determine if it (the most easily contaminated aquifer) has been affected. Generally the direction of ground-water flow can be estimated by two vectors - one in the direction of surface water flow (i.e., downstream) and another toward the nearest surface water stream or river, if present. The relative magnitude of these vectors will vary according to site conditions and in some instances both direction and magnitude may be changed by construction activities. If both a shallow and a deep aquifer are involved in the zone of interest, a screening study will reveal whether or not the deep aquifer should be sampled and a more detailed study is required. To adequately assess subsurface conditions, a minimum of three wells is required; one in the upgradient portion of the area of interest, one in the middle portion, and one in the downgradient portion. In some cases, a more complex system of wells may be needed to define the subsurface conditions, especially in establishing the depth to the shallow ground-water aquifer and the direction of ground-water movement. Site conditions and the scope of the project will determine the total number of wells required. Existing wells should be used when possible. Where permanent well installation is necessary, the wells should be installed according to the procedures in Appendix E.

4.9.3 Purging Equipment and Techniques

4.9.3.1 General -- Wells shall be purged before taking samples in order to clear the well of stagnant water which is not representative of aquifer conditions. The method of purging is to pump the well until three to five times the volume of standing water in the well has been removed and until the specific conductance, temperature, and pH of the ground water stabilizes. Normally, a combination of the two methods is employed (i.e., specific conductance, temperature, and pH are measured at intervals and three to five volumes are purged). If a well is pumped dry, this constitutes an adequate purge and the well can be sampled following recovery (15, 17). However, if possible, monitoring wells should not be pumped dry. If the well is pumped dry, water that has been trapped in the sandpack may be sampled. In addition, as water re-enters the well it may cascade down the well screen and strip volatile contaminants.

4.9.3.2 Equipment Available -- Monitoring well purging is accomplished by using in-place plumbing/pumps or when in-place pumps are not available, by using EPA equipment; either a peristaltic, turbine, bladder, centrifugal, or other appropriate pump, depending on well depth. A Teflon®, closed top bailer may be used for purging; however, bailing may stir up sediment in the well if conducted improperly.

Other monitoring equipment used during purging includes water level indicators, pH meters, thermometers, and conductivity bridges (See Section 6, Field Analytical Procedures).

4.9.3.3 Purging Techniques (Wells Without Plumbing or In Place Pumps)

4.9.3.3.1 General -- For permanently installed wells, the depth of water shall be determined (if possible) before purging. This can be accomplished by attaching a weight on the end of a tape and lowering it into the well until it touches the water, or by use of a mechanical or electrical water level indicator (see Ground-Water Level Measurement Techniques, Section 7.7). Branch personnel shall exercise extreme caution during this procedure to prevent contamination of the ground water. This is a critical concern when samples for trace organic compounds or metals analyses are collected.

4.9.3.3.2 Using Pumps to Purge -- When suction lift or centrifugal pumps are used, only the intake line is placed into the water column. To minimize contamination, the line placed into the water is either standard cleaned (see Appendix B) Teflon®, in the case of the suction lift pumps, or standard cleaned stainless steel pipe attached to a hose, when centrifugal pumps are used.

When submersible pumps (bladder, turbine, displacement, etc.) are used, the pump itself is lowered into the water column. The pump must be cleaned as specified in Appendix B.

4.9.3.3.3 Using Bailers to Purge -- Standard cleaned (Appendix B) closed-top Teflon® bailers with Teflon® leaders and new nylon rope are lowered into top of the water column, allowed to fill, and removed and then the water is discarded.

4.9.3.3.4 Field Care of Purging Equipment -- Regardless of which method is used for purging, new plastic sheeting shall be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they need to be placed on the ground during the purging or they accidentally come into contact with the ground surface. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool, both during transporting and during field use, to further minimize contamination from the transporting vehicle or ground surface.

4.9.3.3.5 Purging Entire Water Column -- The pump/hose assembly or bailer used in purging should be lowered into the top of the standing water column and not deep into the column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. If the pump is placed deep into

the water column, the water above the pump may not be removed, and the subsequent samples collected may not be representative of the ground water.

To minimize cross contamination between wells, no more than three to five feet of hose should be lowered into the water column. If the recovery rate of the well is faster than the pump rate, the pump may be left hanging at the initial level until an adequate volume has been purged. If the pump rate exceeds the recovery rate of the well, the pump will have to be lowered, as needed, to accommodate the drawdown.

After the pump is removed from the well, all wetted portions of the hose and the pump shall be cleaned as outlined in Appendix B.

Careful consideration shall be given to using pumps to purge wells which are excessively contaminated with oily compounds, because it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When these type wells are encountered, alternative purging methods, such as bailers, should be considered.

4.9.3.4 Purging Techniques - Wells With In Place Plumbing

4.9.3.4.1 General -- In-place plumbing is found at water treatment plants, industrial water supply wells, private residences, etc. The objective of purging is the same as with monitoring wells without in place pumps, i.e., to ultimately collect a sample representative of the ground water.

The volume to be purged depends on several factors: whether the pumps are running continuously or intermittently; how close to the source the sample can be collected; and the presence of any storage/pressure tanks between the sampling point and the pump. If storage/pressure tanks are present, an adequate volume must be purged to totally exchange the volume of water in the tank.

4.9.3.4.2 Continuously Running Pumps -- If the pump runs continuously, and the sample can be collected prior to a storage/pressure tank, no purge, other than opening a valve and allowing it to flush for a few minutes, is necessary.

4.9.5.4.3 Intermittently Running Pumps -- If the pump runs intermittently, it is necessary to determine the volume to be purged, including storage/pressure tanks that are located prior to the sampling location. The pump should then be run continuously until the required volume has been purged.

4.9.4 Sampling Equipment and Techniques

4.9.4.1 Equipment Available -- Sampling equipment used by the Branch includes closed-top Teflon® bailers and the peristaltic pump/vacuum jug assembly.

Other monitoring equipment used during sampling includes water level indicators, pH meters, thermometers, and conductivity bridges (see Sections 6 and 7).

4.9.4.2 Sampling Techniques -- Wells With In Place Plumbing -- Samples should be collected following purging from a valve or cold water tap as near to

the well as possible. Samples should be collected directly into the appropriate containers (see Standard Sample Containers, Appendix A). Also, refer to the Potable Water Supply discussion in Section 4.10.

4.9.4.3 Sampling Techniques -- Wells Without Plumbing -- Following purging, samples should be collected using a peristaltic pump/vacuum jug procedure, if possible, or with a closed top Teflon® bailer. The pump used for purging generally should not be used for sampling. When the peristaltic pump is used, samples for purgeable organic compounds analyses should be collected using a bailer or by allowing the Teflon® tube to fill and then allowing the water to drain into the sample vials. All equipment shall be cleaned using the procedures described in Appendix B. Also, refer to the Potable Water Supply discussion, Section 4.10, for additional information.

When bailing, new plastic sheeting should be placed on the ground around each well to provide a clean working area. The nylon rope should be attached to the bailer via a Teflon® coated stainless steel wire. This coated wire is attached to the bailer semi-permanently and is decontaminated for reuse as the bailer is cleaned.

4.9.5 Special Sample Collection Procedures

4.9.5.1 Trace Organic Compounds and Metals -- Special sample handling procedures shall be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which come into contact with the water in the well must be cleaned in accordance with the cleaning procedures described in Appendix B. Pumps shall not be used for sampling, unless the interior and exterior portions of the pump and discharge hoses can be thoroughly cleaned. Blanks should be collected to determine the adequacy of cleaning prior to collection of any sample using a pump. Peristaltic pumps using Teflon® tubing and a Teflon® insert can be used to collect samples without the sample coming into contact with the pump. This is accomplished by placing the Teflon® insert into the opening of a standard cleaned 4-liter glass container. The Teflon® tubing connects the container to the pump and sample source. The pump creates a vacuum in the container, thereby drawing the sample into the container without coming into contact with the pump tubing. Samples for purgeable organic compounds analyses shall be collected with well bailers. The procedures given in the General Considerations, Special Precautions for Trace Contaminant Sampling (Section 4.2.9) shall be followed.

4.9.5.2 Filtering -- As a standard Branch policy, ground-water samples will not be filtered. However, if samples are filtered, then both filtered and non-filtered samples will be submitted for analyses. Proper well installation and development (Appendix E) as well as proper well purging techniques should be utilized to minimize the turbidity of samples. If filtered samples for metals analyses must be collected, an additional unfiltered sample will also be collected for metals analyses. Samples for organic compounds analyses shall not be filtered.

4.9.5.3 Bacterial Sampling -- Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well. Further information regarding bacteriological sampling is available in Sampling for Organic Chemicals and Microorganisms in the Subsurface (19) as well as References 4 and 5. Additional information on bacterial sampling is also included in Section 4.10 (Potable Water Supplies), Section 4.7 (Wastewater Sampling), and Section 4.8 (Surface Water Sampling).

4.9.6 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground-water samples shall be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of field studies. Cleaning procedures conducted in the field (Appendix B), or field repairs shall be thoroughly documented in field records.

4.9.7 Auxiliary Data Collection

Water table measurements from the top of the well casings (referenced to National Geodetic Vertical Datum) in permanent wells, and ground surface elevations in temporary wells should be made to determine the general direction of ground-water flow and gradient. The methodology to be used to determine well water levels are given in Section 7. Tracer dyes and radioactive and thermal detection methods can be used to determine direction and velocities of flow (14). Also, a study of the general topography and drainage patterns will generally indicate direction of ground-water flow.

Water table measurements shall not be taken until the water table has stabilized, preferably 24 hours after well installation for permanent wells (20). The ground surface elevation at the wells should be determined by standard engineering survey practices as outlined in Section 7.

In addition to water level measurements, the pumping rate used to purge a well, the volume of water in wells, and drillers' logs are examples of auxiliary data that should be collected during ground-water sampling activities. This information should be documented in field records. Methodology for obtaining these data are given in the following sections.

Temperature, specific conductance, and pH shall be measured each time a well is sampled. Stabilization of these parameters is measured during the purging process to evaluate the adequacy of the purging procedure. In this situation, the final measurements for these parameters prior to sampling shall be considered the measurement of record for the well. If these parameters were not evaluated during purging, they shall be obtained prior to sampling. Methodology for obtaining these data are given in Section 6.

4.9.7.1 Well Pumping Rate - Bucket/Stop Watch Method -- The pumping rate of a pump can be determined by collecting the flow of water from the pump in a bucket of known volume and timing how long it takes to fill the bucket. The pumping rate should be in gallons per minute. This method shall be used only with pumps with a constant pump rate, such as gasoline powered or electric

submersible pumps. It should not be used with battery powered pumps. As the batteries lose their charge, the pump rate decreases so that pumping rate calculations using initial, high pump rates are erroneously high.

4.9.7.2 Volume of Water in Wells -- In order to purge wells, the volume of water in the well should be known. To determine the volume, the following method should be used; measure the distance from the bottom of the well to the static water level, then measure the inside diameter of the well or casing. Obtain the volume of the well by the formula:

$$V = 0.041 \quad d^2h$$

Where h = depth of water in feet
d = diameter of well in inches
V = volume of water in gallons

If preferred, a quick reference nomograph or table may be used.

Additional ground-water related data can be obtained from most local, state, and federal agencies dealing with water resources. Some states require well drillers to be licensed, and all work performed on wells must be reported to the state on prescribed forms. These forms are available to the public, so a study of wells installed in the area of interest may provide background information as to the subsurface conditions. State geological surveys, as well as the USGS, have various types of water related papers and reports on all phases of ground-water studies in each state. City and county governments usually have departments that deal with water related projects that may provide data for the local area. Federal agencies such as the SCS, U. S. Army Corps of Engineers, the Bureau of Reclamation, U. S. Forest Service, Science and Education Administration, and the U. S. Public Health Service have water programs which may provide data. Other sources include the Bureau of Mines, colleges, universities, and technical societies such as American Association of Petroleum Geologists, American Institute of Mining and Metallurgical Engineers, American Water Well Association, Association of Engineering Geologists, and Geological Society of America (14, 21).

4.10 SAMPLING OF POTABLE WATER SUPPLIES

4.10.1 General

When sampling potable water supplies, utmost care must be taken to insure that samples are representative of the water supply being sampled. This is important not only from a technical and public health perspective, but also from a public relations standpoint. Poor sampling techniques may result in incorrect results (either not detecting a compound which is present or by contaminating the sample and falsely indicating a compound which is not present). If incorrect results are disclosed to the public, it may be impossible to change public opinion when correct results are reported.

4.10.2 Sampling Site Selection/Sampling Techniques

Even though the same care and techniques used in wastewater, ground-water, etc., sampling (including thorough documentation of location, date, time, etc.) are used by Branch personnel in potable water supply sampling, there are certain additional special procedures which shall be used.

When water samples are collected from wells, either by mechanical or hand pumping, the wells must be purged before the sample is collected (see Section 4.9 for ground-water sampling methods). This procedure insures that water representative of the formation is sampled, not the standing water in the well casing, pipes, or holding tank. As a rule of thumb, at least one volume of water in the well casing and storage tank should be evacuated (a 15-minute period is usually sufficient for residential wells). After purging for about 15 minutes, the pH, conductivity, and temperature should be measured until constant values are obtained. This procedure insures that any contaminants that might have entered the area of the tap from external sources have been removed (19).

Potable water samples shall be representative of the water quality within a given segment of the distribution network. Taps selected for sample collection should be supplied with water from a service pipe connected directly to a water main in the segment of interest and should not be separated from the segment of interest by a storage tank. The sampling tap must be protected from exterior contamination associated with being too close to the sink bottom or to the ground. Contaminated water or soil from the faucet exterior may enter the bottle during the collecting procedure since it is difficult to place a bottle under a low tap without grazing the neck interior against the outside faucet surface. Leaking taps that allow water to flow out from around the stem of the valve handle and down the outside of the faucet, or taps in which water tends to run up on the outside of the lip, are to be avoided as sampling locations. Aerator, strainer, and hose attachments on the tap must be removed before sampling. These devices can harbor a bacterial population if they are not cleaned routinely or replaced when worn or cracked. Whenever a steady stream of water cannot be obtained from taps, after such devices are removed, a more suitable tap shall be sought. Taps where the water flow is not steady should be avoided because temporary fluctuation in line pressure may cause sheets of microbial growth that are lodged in some pipe section or faucet connection to break loose. The cold water tap should be opened for two or three minutes or for sufficient time to permit clearing the service line; a smooth-flowing water stream at moderate

pressure without splashing should be obtained. Then, without changing the water flow which could dislodge some particles in the faucet, the samples can be collected (19).

Occasionally, samples are collected to determine the contribution of transmission pipes, water coolers. water heaters, etc., to the quality of water in private residences, offices, etc. The purpose of these investigations may be to determine if metals, e.g., lead, are being dissolved into the water supply. In these cases, it may be necessary to insure that the water source has not been used for a specific time interval, e.g., over a weekend or a three- or four-day holiday period. Sample collection may consist of collecting a sample of the initial flush, collecting a sample after several minutes, and collecting another sample after the system being investigated has been completely purged.

Regardless of the type of sample bottle being used, the bottle cap should not be placed on the ground or in a pocket. Instead, hold the bottle in one hand and the cap in the other, using care not to touch the inside of the cap. Exercise care not to lose the Teflon® liner in certain bottle caps. Avoid contaminating the sample bottle with fingers or permitting the faucet to touch the inside of the bottle. When sampling for bacterial content, the bottle should not be rinsed before use. This may not only contaminate the bottle but also remove the thiosulfate dechlorinating agent (if used). When filling any container, care should be taken so splashing drops of water from the ground or sink do not enter into either the bottle or cap. In order to avoid dislodging particles in the pipe or valve, do not adjust the stream flow while sampling.

When sampling at a water treatment plant, samples should be collected both from the raw water supply and after chlorination.

Triplicate samples will always be collected for purgeable organic compounds analyses and duplicate samples for bacterial analyses. Single samples may be collected for extractable organic compounds, metals, phenol, cyanide, and conventional parameter analyses. The procedures given in Section 4.2.11 (Special Precautions for Trace Contamination Sampling) and in Section 4.7.6.4 (Purgeable Organic Compounds Sample Collection) shall always be followed when potable water supplies are sampled.

Branch personnel shall always obtain the name(s) of the resident or water supply owner/operator and the resident's exact mailing address, as well as the resident's home and work telephone numbers. The information is required so that the residents or water supply owner/operators can be informed of the results of the sampling program.

4.10.3 Sampling Equipment/Specific Sampling Equipment Quality Assurance Techniques

Sampling equipment and specific equipment quality assurance techniques are contained in Section 4.8 (Surface Water Sampling) and Section 4.9 (Groundwater Sampling).

4.11 SOIL SAMPLING

4.11.1 General

Soil sampling at hazardous waste sites will typically be approached in a totally different manner than sampling of other media. Sampling locations and rationale for other media are usually easily defined. For example, ground water samples may be collected at existing monitoring wells; surface water and sediment samples are usually collected from well defined surface drainage patterns at easily rationalized locations with respect to the suspected problem; and waste sources, such as drums, tanks, and piles, are easily identified sampling targets. Occasionally, surface soils may be stained or show evidence of vegetative stress, indicating that a contaminant may be present, but in many cases there may not be any direct evidence to suggest that a particular location is a candidate for soil sampling. The sampler may, in fact, be faced with investigating a virtually invisible contaminant distribution pattern, both in the surficial material, as well as in the subsurface region.

4.11.2 Sampling Location/Site Selection

Areas selected for soil sampling shall be strategically located in order to collect a representative fraction of the soils with the minimum number of samples. Although it is not always feasible to conduct a site reconnaissance prior to an investigation, a site reconnaissance can eliminate many uncertainties with respect to site characteristics and result in more complete and successful soil sampling studies. A surface inspection of the subject area should be made to locate pertinent features (e.g., rock outcrops, drainage patterns, surface runoff, ponds, lakes, wet areas, seeps, springs, permanent structures, fill areas, erosional areas, depositional areas, etc.) and to evaluate the relationship between these features and potential sources of pollution. A knowledge of these relationships and conditions, particularly soil conditions (type and thickness of soil overburden) and water table conditions are extremely important in developing sampling plans.

In addition to what is normally considered soil, i.e., in situ weathered rock overburden, soil samples may also consist of what is more correctly considered sediment, which has been deposited by both overland sheet runoff, as well as flow in normally dry wet-weather swales. The location of sediment sampling locations in these types of depositional areas is a useful screening tool, providing an indication of the presence of contaminants from the larger area contributing the sediment.

Initial investigations at most sites will consist of "screening-type" studies. Sampling for these investigations will generally be confined to a small number of surface or shallow subsurface samples. Typically, samples would be collected from depositional areas within and around the periphery of the site, as well as from obviously contaminated areas. Based on the results of the initial site-screening studies, more detailed studies, involving considerably more samples and with a greater emphasis on subsurface sampling, are usually required to fully characterize soil contamination at a site.

Study plans or work plans for soil sampling investigations must be carefully conceived with respect to the study objectives. This, in turn, requires a careful consideration of the types of samples to be collected, as well as the sampling methods to be employed. These areas are discussed below.

4.11.3 Basic Considerations for Soil Sampling

Three basic considerations, with respect to sample type, should be evaluated when developing a soil sampling plan and establishing investigation objectives. Should the samples be random, biased, or grid-based? Will they be collected from the surface or subsurface? Will a particular sample be a grab sample or a composite sample? When all of these questions are answered, it will be found that many investigations will involve the collection of most combinations of the above types of samples. A discussion of these considerations is found in the following sections.

4.11.3.1 Random, Biased and Grid-Based Sampling -- Generally, unless there is a strong indication of contamination, such as staining, or there are distinct depositional areas which provide excellent screening samples, soil samples collected for small investigations with limited areal extent, such as screening site investigations, must be randomly selected from several areas within the suspected area of contamination. Random in this sense is synonymous with casual, i.e., locations are often subjectively selected based purely on personal judgement.

If any areas show evidence of contamination, such as staining or vegetative stress, biased samples should be collected from each of the areas to characterize the contamination present in each area. If surface drainage patterns such as dry washes or swales are discernable, soil/sediment samples may be collected from the deposits in these features to characterize the immediate areas. Background and control samples are also biased, since they are collected in locations dictated by expected clean conditions or by anticipated impact from adjacent off-site areas.

When soil sampling investigations involve large areas, measured in acres for example, a systematic approach must be taken, not necessarily to the exclusion of other approaches, to characterize the presence and distribution of contaminants. In these situations, a grid-based soil sampling program is employed. There is no single grid size that is appropriate for all sites; however, in most cases, the smaller the site, the smaller the grid size. Common grid sizes are developed on 50-foot and 100-foot centers, although other sizes may be appropriate in given situations. It may be appropriate and acceptable to integrate several different grid sizes in a single investigation.

When the site is extremely large, over several acres for example, it may be impossible to consider sampling every grid and it will be necessary to statistically select a sub-set of the total number of grids in order to reduce the number of samples collected for the study. On the other hand, it may sometimes be appropriate to sample every grid and use relatively inexpensive and quick screening-level analytical techniques to define the areas which must be sampled and analyzed for a higher level of data quality. Because the screening level

analysis is relatively quick, the second phase sampling can sometimes be conducted during the same investigation. In all cases, however, the grid centers should be located using a site survey and semi-permanently marked to facilitate relocating the sample locations for subsequent sampling.

4.11.3.2 Surface and/or Subsurface Soil Samples -- In most initial investigations, particularly site screening-type studies, surface soil samples may comprise the great majority of soil samples collected. These are collected to look for the possible presence and distribution of contaminants in surficial materials. Subsurface soil sampling may be limited during initial investigations, but it may comprise the major portion of the soil sampling effort during subsequent phases of the investigation where the vertical extent of contamination in identified areas of surface contamination is the major objective.

4.11.3.3 Grab versus Composite Samples -- When a sample is needed to identify and quantify compounds at a specific location or interval, a grab sample is collected. Grab samples are limited in areal extent (for surface samples) or vertical extent (for subsurface samples). The sample should be comprised of no more than the minimum amount of soil necessary to make up the volume of sample dictated by the required sample containers. Composite samples are a mixture of a given number of subsamples and are collected to characterize the average composition of a given surface area or vertical interval. Areal composites are comprised of subsamples collected from the surface within the selected area. The number of subsamples forming a composite should remain consistent within the context of the study, i.e., a number and pattern for collection of subsamples within a grid should be selected and, for a given grid size, should not be changed. Likewise, if one of the objectives of the study is to determine if any contamination is present within a particular vertical interval, a vertical composite sample, comprised of vertically discrete samples collected over the selected interval may be collected. As with the areal composites, the number of subsamples is dependent on the objectives of the study. With the low analytical detection limits available today, compositing can usually be used to determine the presence or absence of compounds in the area or interval sampled.

There are two potential problems associated with compositing for which the sampler must be aware. Even though modern analytical detection limits allow for qualitative screening in many cases using compositing techniques, the risk still remains that low concentrations, present in individual composite aliquots, may be diluted to the extent that the total composite concentration is below the minimum quantification limit. Also, if the subsamples are predominantly moist and clayey, it will be very difficult to produce a homogenous mixture. The resulting sample, as represented by the portion selected by the analytical chemist, may not be representative, either qualitatively or quantitatively, of an average of all of the subsamples.

4.11.4 Sampling Methodology

This discussion of soil sampling methodology reflects both the equipment used (required/needed) to collect the sample, as well as how the sample is handled and processed after retrieval. Selection of equipment is usually based

on the depth of samples, but it is also controlled, to a certain extent, by the characteristics of the material. Simple, manual techniques and equipment, such as hand augers, are usually selected for surface or shallow, subsurface soil sampling. As the depth of the sampling interval becomes greater, some type of powered sampling equipment is usually needed to overcome torque induced by soil resistance and depth. The following is an overview of the various sample collection methods employed over three general depth classifications: surface, shallow subsurface, and deep subsurface. Any of the deep collection methods described may be used to collect samples from the shallower intervals. See Section 4.2.10 for special sampling considerations for purgeable organic compounds analyses.

4.11.4.1 Manual (Hand Operated) Collection Techniques and Equipment -- These methods are used primarily to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The shallow subsurface interval may be considered to extend from approximately 12 inches below ground surface to a site-specific depth at which sample collection using manual, i.e., hand-powered, methods becomes impractical.

4.11.4.2 Surface Soils -- Surface soils may be collected with a wide variety of equipment. Spoons, shovels, hand-augers, push tubes, and post-hole diggers, made of the appropriate material, may be used to collect surface soil samples. As discussed in the section on powered equipment, surface soil samples may also be collected in conjunction with the use of heavy equipment.

Surface samples are removed from the ground and placed in pans, where mixing, as appropriate (Section 4.2.10), occurs prior to filling of sample containers. Section 4.11.5 contains specific procedures for handling samples for purgeable organic compounds analyses. If a thick, matted root zone is encountered at the surface, it should be removed before the sample is collected.

4.11.4.3 Subsurface Soils -- Hand-augering is the most common manual method used to collect subsurface samples. Typically, 4-inch auger-buckets with cutting heads are pushed and twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of investigation using a hand-auger is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand-augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torquing of hand-auger extensions becomes so severe that in resistant materials, powered methods must be used if deeper samples are required. Some powered methods, discussed later, are not acceptable for actual sample collection, but are used solely to gain easier access to the required sample depth, where hand-augers or push tubes are generally used to collect the sample.

When a vertical sampling interval has been established, one auger-bucket is used to advance the auger hole to the first desired sampling depth. If the

sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a new bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole. Section 4.11.5 contains additional sample handling procedures.

Another hand-operated piece of soil sampling equipment commonly used to collect shallow subsurface soil samples is the Shelby or "push tube". This is simply a thin-walled tube, generally of stainless steel construction and having a beveled leading edge, which is twisted and pushed directly into the soil. This type of sampling device is particularly useful if a relatively undisturbed sample is required. The sampling device is removed from the push-head, then the sample is extruded from the tube into the pan with a spoon or special extruder. Even though the push-head is equipped with a check valve to help retain samples, the Shelby tube will generally not retain loose and watery soils, particularly if collected at lower depths.

4.11.4.3.1 Powered Sampling Devices -- Powered sampling devices and sampling aids may be used to acquire samples from any depth but they are generally limited to depths of 20 feet or less. Among the common types of powered equipment used to collect or aid in the collection of subsurface soil samples are Little Beaver®-type two-man power augers; split-spoon samplers driven with a drill rig drive-weight assembly or hydraulically pushed using drill rig hydraulics; continuous split-spoon samplers; specialized hydraulic cone penetrometer rigs; and back-hoes. The use of each of these is described below.

4.11.4.3.2 Power Augers -- Two-man power augers of the Little Beaver® variety, are commonly used to aid in the collection of subsurface soil samples at depths where hand augering is impractical. This type of equipment is technically a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range for this equipment. It is used to advance a hole to the required sampling depth, at which point a hand auger is usually used to collect the sample.

4.11.4.3.3 Drill Rigs -- Drill rigs offer the capability of collecting soil samples from greater depths. For all practical purposes, the depth of investigation achievable by this method is controlled only by the depth of soil overlying bedrock, which may be in excess of 100 feet.

When used in conjunction with drilling, split-spoon samplers are usually driven either inside a hollow-stem auger or inside an open borehole after rotary drilling equipment has been temporarily removed. The spoon is driven with a 140-pound hammer through a distance of up to 24 inches and removed. If geotechnical data are also required, the number of blows with the hammer for each six-inch interval is also recorded.

Continuous split-spoon samplers may be used to obtain five-foot long, continuous samples approximately 3 to 5 inches in diameter. These devices are

located inside a five-foot section of hollow-stem auger and advanced with the auger during drilling. As the auger advances, the central core of soil moves into the sampler and is retained until retrieval.

4.11.4.3.4 Cone Penetrometer Rigs -- A recent innovation is now available, which involves the modification of a standard split-spoon. The spoon has been modified with a releasable tip which keeps the spoon closed during the sampling push. Upon arrival at the desired depth, the tip can be remotely released and the push continued. During the subsequent push, the released tip floats freely up the inside of the spoon as the soil core displaces it. Split-spoon soil samples, therefore, can be collected without drilling, as has historically been required, by simply pushing the device to the desired depth. This technique is particularly beneficial at highly contaminated sites, because cuttings are not produced as with drill rigs. The push rods are generally retrieved with very little residue. This results in minimal exposure to sampling personnel and very little contaminated residue is produced as a result of equipment cleaning.

4.11.4.3.5 Back-Hoes -- Back-hoes are often utilized in shallow subsurface soil sampling programs. Samples may either be collected directly from the back-hoe bucket or they may be collected from the trench wall if proper safety protocols are followed. Trenches offer the ability to collect samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. Prior to collecting samples from trench walls, the wall surface must be dressed with a stainless steel shovel, spatula, knife, or spoon to remove the surface layer of soil which was smeared across the trench wall as the bucket passed. If back-hoe buckets are not cleaned according to the procedures described in Section B.8.3 of this manual, samples must be collected from material which has not been in contact with the bucket surface.

4.11.5 Special Techniques and Considerations

4.11.5.1 Collection of Soil Samples for Purgeable Organic Compound (VOA) Analyses -- These samples should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with a hand auger, the VOA sample may be collected directly from the auger bucket or immediately after an auger bucket is emptied into the pan. The sample should be placed in the appropriate container with no head-space, if possible, as is the practice with water samples. Samples for VOA analysis are not mixed (Section 4.2.10).

4.11.5.2 Dressing Soil Surfaces -- Any time a vertical or near vertical surface, such as is achieved when shovels or back-hoes are used for subsurface sampling, is sampled, the surface should be dressed to remove smeared soil. This is necessary to minimize the effects of cross-contamination due to smearing of material from other levels.

4.11.5.3 Sample Mixing -- It is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is representative of the interval sampled. Soil samples should be mixed as specified in Section 4.2.10.

4.11.5.4 Special Precautions for Trace Contaminant Soil Sampling - The procedures outlined in Section 4.2.9 shall be followed. All soil sampling equipment used for sampling for trace contaminants should be constructed of stainless steel where possible. Pans used for mixing shall be made of Pyrex®, or equivalent, glass. In no case will chromium, cadmium, or galvanized plated or coated equipment be used for soil sampling operations. Similarly, no painted or plastic equipment shall be used. All paint and primer must be removed from soil sampling equipment by sandblasting or other means before such equipment can be used for collecting soil samples.

4.11.5.5 Specific Sampling Equipment Quality Assurance Techniques - Drilling rigs and other major equipment used to collect soil samples shall be identified so that this equipment can be traced through field records. A log book shall be established for this equipment so that all cleaning, maintenance and repair procedures can be traced to the person performing these procedures and to the specific repairs made. Sampling spoons, hand augers, Shelby tubes, and other minor disposable type equipment are exempted from this equipment identification requirement.

- All equipment used to collect soil samples shall be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of field studies.

- Any cleaning conducted in the field (Appendix B) or field repairs should be thoroughly documented in field records.

4.11.5.6 Auxiliary Data Collection - In addition to information pertaining to an area or specific site/location that may be available in EPA files from previous investigations (i.e., site screenings, water quality, well monitoring studies, etc.), information and data may be obtained from various city, county, state, and other federal agencies.

Samples should be accurately tagged and labeled with all pertinent site information at the time of sampling. See Section 3 for sample labeling and field recording procedures. The latitude and longitude shall be obtained for each site for future STORET data entry.

4.12 WASTE SAMPLING

4.12.1 General

Waste sampling as discussed in this section includes the collection of sludge samples from municipal and industrial wastewater treatment facilities; samples of liquid waste and sludge from pits, ponds, and lagoons; waste samples from open or closed containers such as drums, tank trucks, and storage tanks: and samples of waste piles and landfills.

Generally, the collection of sludge samples from municipal and industrial wastewater treatment plants is a low risk operation. However, the collection of liquid waste and sludge samples from open containers and liquid waste from pits, ponds, or lagoons and solid waste from waste piles may involve sampling operations that are inherently dangerous to the personnel involved. Sampling of closed containers (drums, storage tanks, etc.) shall be considered a high hazard operation by all Branch personnel. The procedures outlined in the Region IV Field Health and Safety Manual (23) will be strictly observed during all potentially hazardous sampling operations. Additional safety guidance is included in the draft EPA Safety Manual for Hazardous Waste Site Investigations (23). Branch specific safety protocols for these types of operations are included in Appendix K.

4.12.1.1 Specific Quality Control Procedures for Sampling Equipment

Sampling equipment contaminated during waste sampling must be cleaned as specified in Appendix B, Section B.1.5 before being returned from the field.

Contaminated disposable equipment and sampling equipment that is to be discarded must be properly disposed of as specified in the site-specific field sampling plan (Section 4.5).

All equipment used to collect waste samples shall be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of a field study. In some instances, special decontamination procedures in excess of the cleaning procedures outlined in Appendix B will be necessary. These procedures will be developed on a case-by-case basis according to the specific material encountered (26).

All air monitoring and field analytical equipment shall be tested before being issued for field studies, as specified in Section 6.0, and Appendix G.

Any cleaning procedures conducted in the field deviating from those specified in Appendix B, and all field repairs, shall be thoroughly documented in the field logbooks.

4.12.1.2 Collection of Auxiliary Information and Data -- The collection of auxiliary information and data is particularly important when collecting waste samples. Any field analyses, including those conducted with safety equipment such as photoionizers, explosion meters or approximate analyses such as those obtained with Ph indicator paper shall be recorded in field logbooks, as outlined in Section 3.5. Sketches of sampling locations, valving arrangements of tank

trucks and storage tanks, markings on drums, tanks, etc., should be thoroughly documented in the logbooks. Photographs are particularly useful for recording this information and they should be used extensively during waste sampling operations. A field log of the photographs taken should be maintained as outlined in Section 3.2.3.

4.12.2 Collection of Municipal Wastewater, Industrial Wastewater, and Municipal Water Treatment Plant Sludge Samples

4.12.2.1 Sampling Equipment -- Branch equipment available for the collection of sludge samples includes: sample containers; stainless steel spoons and shovels; stainless steel ponar dredges; stainless steel scoops attached to a conduit pipe; stainless steel push tubes; and Peterson and Eckman dredges.

4.12.2.2 Sampling Technique -- If the sampling technique involves multiple aliquots or if the final sample will consist of aliquots from several locations, all aliquots should be placed into a Pyrex® dish, or another suitable container, and mixed thoroughly before containerization, as specified in Section 4.2.10. The sample is containerized as specified in Appendix A.

If the sludge layer is shallow or if only the surface is to be sampled, samples can be collected directly into the sample container.

If depth samples are required, the methods described in Section 4.12.3.4.2 may be used.

Regardless of the method used, special care must be taken when collecting sludge sample to minimize the loss of fine materials by the excess water flowing out of the sampling device, thus biasing the sample.

4.12.2.3 Sampling Locations -- Sampling locations must be carefully selected to insure that the samples are truly representative of the material being sampled. The following are suggested locations for different sampling conditions.

4.12.2.3.1 Municipal Sludge Being Drawn to a Drying Bed -- Collect samples from the pipe flowing to the bed or at the discharge into the bed. Take three or more sample aliquots during the draw period to insure that variations in the sludge concentrations and consistency are accounted for.

4.12.2.3.2 Sludge From an Anaerobic Digester -- It is difficult to insure that the contents of these units are well mixed. Samples can be taken from sample ports in the recirculation lines if so equipped. Otherwise, samples can be taken from "thief holes" in the floating top of the digester.

4.12.2.3.3 Sludge From an Aerobic Digester -- It is much easier to sample these units because of the clear view of the contents. Samples should be taken while the contents are being mixed and from between 1/3 and 2/3 of the total depth of the digester.

4.12.2.3.4 Sludge From a Quiescent Holding Basin (Water or Wastewater) - One sample cannot be collected which will be representative of the total contents

of the basin since the material is generally stratified. Near bottom samples can be collected from the upper, relatively clear liquid layer as one would collect any water sample. Generally, a minimum of 3 to 5 grab sludge samples should be collected from the basin. These grab samples should be as representative of the sludge contents as possible. Samples should be collected near the inlet and discharge structures as well as from the open pond area. Samples may be analyzed individually or composited into a single sample. Sludge samples should be collected from the basin from a boat or a platform. Sediment sampling devices are required to collect these samples.

4.12.2.3.5 Sludge From Drying Beds -- After sludge is partially dried and cracked, samples can be collected with a stainless steel spoon, shovel, or similar device. Samples should be collected from three or four locations in the bed and composited to insure a representative sample. The sample should be collected to the full depth of sludge on the bed.

4.12.2.4 Special Precautions for Trace Contaminant Sampling -- See Section 4.7.6.1.

4.12.2.5 Sludge Samples Collected for Purgeable Organic Compounds Analyses See Section 4.7.6.4.

4.12.3 Pits, Ponds, and Lagoons

4.12.3.1 General -- For the purposes of this subsection, pits, ponds, and lagoons refer to any basin, pit, or open tank (lined or unlined) which contains or is suspected of containing unknown concentrated liquid, solid, or sludge chemical wastes. This discussion does not include municipal and industrial treatment ponds or natural or man-made surface water impoundments (discussed in Section 4.8.2).

4.12.3.2 Sampling Locations -- Sampling locations within pits, ponds, and lagoons should yield samples which are representative of that section, or of the entire pit, pond, or lagoon being sampled. All phases (floating solids, all liquid phases, and sludge) in the pit, pond, or lagoon should be sampled. The only exception is situations where representative samples cannot be safely collected or where the investigative team is attempting to determine worst case conditions.

Because of the inherent danger with sampling known or unknown concentrated waste, sampling personnel should never attempt to sample pits, ponds, or lagoons from a boat. All sampling should be accomplished from the banks of pits, ponds, or lagoons or from piers. Any exception must be approved by the appropriate Branch and/or Section Chief.

4.12.3.3 Sampling Equipment -- The following Branch equipment is available for field use in collecting liquid waste samples from pits, ponds, and lagoons: sampling containers; sampling containers affixed to a piece of conduit pipe, stainless steel scoop affixed to a piece of conduit pipe with a scoop bracket, stainless steel spoon affixed to a conduit pipe, peristaltic pump and vacuum jug arrangement, and Bacon-Bomb samplers. For sludge sampling of pits, ponds, and

lagoons; stainless steel ponar dredges, stainless steel scoops attached to conduit pipe, and stainless steel push tubes are available.

4.12.3.4 Sampling Techniques

4.12.3.4.1 Liquid Waste Sampling -- If the sampling technique utilized requires multiple aliquots, or if the final sample will consist of aliquots from several different locations in the pit, pond, or lagoon, all aliquots should be placed into a Pyrex® dish or a large glass sample container, or other suitable compositing container, and mixed thoroughly before containerization (Section 4.2.10).

The presence of individual liquid phases can be determined by using a peristaltic pump. The Teflon® tubing attached to the pump is strapped to a piece of conduit pipe and slowly lowered to the bottom of the unit to be sampled. The pump discharge (and the intake tubing) is examined to determine if phases are present. If phases are present, the top liquid phase can be sampled by direct dipping with the sample container, or dipping with the sample container attached to the conduit pipe - either directly or by way of a fishing pole type arrangement, or dipping the sample with a stainless steel scoop attached directly to conduit pipe with a scoop bracket. Alternatively, all liquid phases can be sampled with a peristaltic pump/vacuum jug arrangement with the Teflon® tubing attached to a conduit pipe and held at the desired depth or with the Bacon-Bomb sampler opened at the desired depth. The Bacon-Bomb sampler can be operated directly from the banks of pits, ponds, and lagoons; from piers; or operated by way of a fishing pole type arrangement, using a piece of conduit pipe.

Floating solids can be sampled directly or with a stainless steel scoop or spoon attached to a piece of conduit pipe.

4.12.3.4.2 Sludge Sampling -- If the sampling technique involves multiple aliquots, or if the final sample will consist of aliquots from several different locations in the pit, pond, or lagoon, all aliquots should be placed into a Pyrex® dish or other suitable container and mixed thoroughly before containerization, as specified in Section 4.2.10. The sample is containerized as specified in Appendix A.

Sludge samples may be collected by pushing a stainless steel push tube into the sludge and emptying the tube contents into a Pyrex® dish or other suitable container. "Emptying" may include shaking to remove sludge or extrusion of thick or gummy sludges with a new wooden dowel. A disadvantage of this technique is the need for multiple insertions of the tube into the sludge to collect sufficient sample volume.

Sludge samples can also be collected with a stainless steel ponar dredge. An advantage of this technique is that one operation of the dredge usually yields sufficient sample volume for most sampling efforts.

One of the easiest methods of collecting a sludge sample consists of attaching a stainless steel scoop to a piece of conduit pipe with a scoop bracket, and inserting the scoop into the sludge. The scoop bracket has a

decided advantage in that it allows sampling personnel to adjust the angle between the scoop and the conduit pipe.

4.12.4 Open and Closed Container Sampling

4.12.4.1 General -- Sampling of closed containers (drums, storage tanks, etc.) should be conducted only when absolutely necessary. Whenever container sampling is necessary, the first priority should be the collection of samples from open containers since they generally present less hazard to the sampling personnel than closed containers (i.e., volatile organic components have already evaporated, extreme acute toxicity would probably be evident from dead animals or vegetation around the site, etc.). Closed containers must be considered as extremely hazardous from either the toxicity, explosion, or fire potential. Acute toxicity may pose a danger in both open or closed containers. Because of the dangers involved with container sampling, the sampling of drums or other containers containing either unknown materials or known hazardous materials shall be considered a hazardous duty assignment. Additional information regarding container sampling is available in the draft EPA Safety Manual for Hazardous Waste Site Inspections (24).

Safety procedures for container sampling will be in accordance with the Region IV Field Health and Safety Manual (23) and Appendix N.

A problem which often arises in container sampling is stratification and/or phase separation of the container contents. When this condition occurs, or is suspected, care must be taken to insure that the sample collected is representative of the container contents. If only one layer or phase is sampled, this should be noted and taken into account when interpreting analytical results. For example, if a large tank is being sampled for PCB's and the only valve or access port available for sampling is at the bottom of the tank, it should be noted that the concentration of PCB's might be biased on the high side, since PCB's are heavy and tend to settle near the bottom of containers.

If stratification is not present, samples may be composited by depth (i.e., collected throughout the entire depth of the container or at several different depths) to provide a representative sample. When a drum or cylindrical container is standing vertically, depth compositing provides a good quantitative estimate of the containers contents. In other cases where such containers are tipped, horizontal, deformed, etc., and stratification is not present, vertical compositing will provide a representative sample at least on a qualitative basis. (Note: a quantitatively representative sample could be collected, but would require sophisticated sampling methodology involving multilayer sampling and volume measurements; this is not recommended unless initial screening indicates it is absolutely necessary). Samples may not be composited across containers.

4.12.4.2 Sampling Equipment -- The following Branch equipment is available for use in collecting waste samples from open and closed containers: a complete set of spark-resistant (beryllium-brass) tools including barrel bung wrenches, adjustable wrenches, etc.; a remote barrel opening device; coliwasa samplers for drum sampling; glass tubes for drum sampling; glass profile tubes for container sampling; Bacon-Bomb samplers for container sampling; and peristaltic pumps and vacuum bottle arrangements for liquid waste sampling from containers.

4.12.4.3 Sampling Techniques -- Closed drums, or other containers (including storage tanks) containing unknown materials or known hazardous materials shall be opened using only spark proof opening devices and while the container is grounded. A remotely controlled device may be used when deemed necessary. Such a device involves the use of a remotely operated pneumatic wrench along with a brass pressure fitted bung socket (25).

The most commonly used Branch sampling device for 55-gallon drums is the coliwasa sampler. The coliwasa sampler is a single use glass sampler, consisting of an outer glass tube with one end tapered, and a separate inner glass tube with a small bulb on one end. In use, the outer tube is slowly lowered into the drum, tapered end first. This must be done slowly for two reasons. One, the drum may contain solid material which might break the tube and injure the sampler. Second, slowly lowering the tube allows the liquid phases in the drum to stay in equilibrium with the coliwasa sampler, ensuring a representative sample. The inner glass tube is inserted (bulb end first) into the outer tube. This may be done very slowly after the outer tube is fully inserted into the drum, or the inner tube may be inserted prior to immersing the outer tube. In the latter case, the bulb tip of the outer tube must be pulled back several inches from the tapered end of the outer tube. After both inner and outer tubes are inserted into the drum to be sampled, the inner tube bulb end is pressed gently against the tapered end of the outer tube, forming a seal. Both tubes are withdrawn from the drum and the ends of the tubes are held over the sample container. By manipulating the inner tube, the sampler can control the rate of flow of the sampled liquid into the sample container.

Samples from drums can also be collected using a four-foot length of glass tube. In most instances, glass tubes with a 1/2-inch or less inside diameter work best. The tube is inserted into the opening of the drum or barrel as far as possible. The open end is then sealed either with the thumb or a rubber stopper to hold the sample in the tube while removing the tube from the container. The sample is then placed in the appropriate container, and the procedure is repeated until an adequate amount of sample is collected. Sample volume shall be held to the absolute minimum required for analysis.

An optional method involves the use of a piercer valve which is inserted into the drum or barrel by use of a remotely operated hydraulic jack (24); however, this method should be used only as a last resort (24). The sample is collected directly from the valve. Several valves may be required at different depths on the drum or barrel if stratification has occurred.

Other sampling procedures including the use of automatic samplers, pumps, siphons, multiple valves and ports, etc., may be used depending on the specific container involved. These procedures should not be used unless it can be established that their use will not constitute a fire or explosion hazard. This determination shall be made only after field reconnaissance, collection of appropriate field data (explosion meter, photoionizer, etc.), and consideration of available file information on the site.

Tank trucks and storage tanks containing liquid wastes present a unique problem. Samples may be collected from access ports on top of these tanks or trucks using the techniques outlined above. Tank trucks are often compartment-

alized, and the investigator should insure that all compartments of the tank truck are sampled. Sampling from discharge valves usually found on tank trucks is not recommended due to potential stratification of the tank contents and the possibility of sticking or broken valves causing a release. However, if the investigator must sample from a tank truck discharge valve, the valving arrangement of the particular tank truck being sampled must be clearly understood to insure that the contents of the compartments of interest are sampled. The same precautions apply to sampling from storage tank valves. In either case, the investigator must realize that samples obtained from valves (particularly those at or near the bottom of tank trucks and storage tanks) may not yield representative samples. Sampling personnel should not utilize valves on tank trucks or bulk storage devices unless they are operated by the owner or operator of the facility, or a containment plan is in place should the valve stick or break.

4.12.5 Waste Piles and Landfills

4.12.5.1 General -- Waste piles consist of sludges and other solid waste, liquid waste mixed with soil, slag, or any type of waste mixed with construction debris, household garbage, etc. Each situation presents a unique challenge to the sampler in the selection of an appropriate sampling location and technique. Sampling at landfills is generally considered a routine operation. However, the sampling personnel must be aware that, in the past, landfills were not selective in the types of waste materials accepted. Therefore, sampling at landfills known or suspected to contain hazardous wastes could involve sampling operations that are inherently dangerous to the personnel involved.

4.12.5.2 Sampling Locations -- Sampling locations should be selected which will yield a sample which is representative of the waste pile or landfill being investigated. The only exception is situations in which representative samples cannot be collected safely or where the investigative team is attempting to determine worst case conditions.

4.12.5.2.1 Waste Piles -- A representative sample from a small waste pile can often be obtained by collecting a single sample. The collection of representative sample from large waste piles presents problems with both the number and locations of samples. For a sample to be truly representative, a statistical approach should be used in selecting both the numbers of samples and the location where they are to be collected. A discussion of statistical methods which can be utilized is given in the Test Methods for Evaluating Solid Waste (SW-846) issued by the EPA Office of Solid Waste and Emergency Response (28).

4.12.5.2.2 Landfills -- Representative samples from landfills are often difficult to obtain because of the heterogenous nature of the wastes deposited. Geophysical instruments may occasionally be useful in locating buried drums and tanks, but the signal is often lost in the background noise of waste ferrous materials. As with samples from waste piles, for a sample to be truly representative, a statistical approach should be used in selecting both the number of samples and the location where they are to be collected. A discussion of statistical methods which can be utilized is given in the Test Methods for Evaluating Solid Waste (SW-846) issued by the EPA Office of Solid Waste and Emergency Response (28). The sampler should be aware that landfills often generate leachate at one or more locations downgradient of the fill material.

Leachate samples can provide a limited overview of materials deposited in a landfill which are migrating via groundwater.

4.12.5.3 Sampling Equipment -- The following Branch equipment is available for field use in collecting samples from waste piles and landfills: stainless steel hand augers, stainless steel push tubes, stainless steel shovels, stainless steel scoops, stainless steel slag hammer/slag pan, drill rig, and stainless steel spoons.

4.12.5.4 Sampling Techniques -- All samples collected should be placed into a Pyrex® dish and mixed thoroughly before containerization, as specified in Section 4.2.10. Samples for volatile organic compounds analyses may not be composited and must not be mixed. Stainless steel shovels, spoons, or scoops should be used to clear away surface materials before samples are collected. Near surface samples can then be collected with a clean stainless steel spoon. Depth samples can be collected from the cleared location by forcing a stainless steel push tube into the waste pile or by augering to the desired depth in the landfill or waste pile with a stainless steel hand auger. When the desired depth is reached with a hand auger, a clean auger head should be used for collecting the sample. An alternate method for collecting depth samples is to dig to the desired depth with a stainless steel shovel or scoop and collecting the sample with a stainless steel spoon.

Sometimes the waste material is too hard to mix in a Pyrex® dish or the sample material retrieved is too large to contain in the sample container (for example slag wastes). This refractory material may be sampled by crushing representative portions of the waste material with the stainless steel slag pan and hammer. Once crushed, the material may be thoroughly mixed and containerized for analysis. Mixing is done as specified in Section 4.2.10 and the sample is containerized as specified in Appendix A. Any remaining waste materials must be properly disposed of, in accordance with the waste handling procedures for that process.

4.12.6 Contaminated Surfaces Sampling

4.12.6.1 General -- Sampling may be required to determine whether or not various surfaces are contaminated, or to evaluate the effectiveness of decontamination procedures. The procedures outlined below are intended for non-absorbent surfaces e.g., metal, concrete, glass, plastic, etc. These types of surfaces may be sampled using wipes or swabs that are purchased commercially. The wipe or swab material must be compatible with the solvent used and the analyses to be performed, and should not come apart in use. The wipes are saturated with either methylene chloride, hexane, or deionized water depending upon the parameters to be analyzed. Sampling personnel should be aware of this and take the proper precautions against skin contact and inhalation of these solvents as outlined in Appendix N. For routine scheduled wipe sampling, ASB requests two weeks notice to prepare the wipes. ASB must be notified as to what analyses are required. ECB should provide sufficient precleaned 8-oz sampling jars to ASB for storage of the prepared wipes. Wipe samples should not be collected for volatile organic compounds analysis.

4.12.6.2 Sampling Locations -- Surfaces contaminated by hazardous wastes may include walls, ceilings, floors, exposed beams, inner walls of tanks, equipment, furniture, etc. Sampling locations will often be dictated by the surface to be sampled. If possible, however, the surface sampled should be horizontal and facing up. Surfaces in this position are generally the most likely to become contaminated by spills, splashing, settling dust, etc.

4.12.6.3 Sampling Equipment -- Branch sampling equipment consists of specially prepared wipes in sample jars. A sufficient number of wipes for each sample are kept in separate containers. These containers are precleaned 8-oz sample jars.

4.12.6.4 Sampling Techniques -- The sample jar containing the prepared wipes is opened and a prepared wipe is removed. Wipes may be handled either with stainless steel tongs, tweezers, or gloves. Gloves may be used only if the contaminants of interest are not present in the glove. The entire area to be sampled is wiped with firm strokes using only one side of the wipe. The wipe is then returned to the sample jar from which it was taken. This process is repeated until the area is visibly free of contamination or no more wipes are left in the jar. Care should be taken to keep the sample jar tightly sealed to prevent evaporation of the solvent. Samplers must also take care to not touch the used side of the wipe, to prevent loss of the contaminants. Unused wipes should not be removed. All wipes in the jar will analyzed by the laboratory.

If surface contamination is to be quantified (e.g., ug/cm^2) the surface area that is to be wiped must be measured. This can often be accomplished using a template made of decontaminated aluminum foil with an opening of the desired size, generally 10 cm by 10 cm.

4.12.7 Contaminated Documents Sampling

4.12.7.1 General -- Contaminated documents that require sampling are usually business records that are suspected to be contaminated with hazardous materials. If business records are to be sampled (files, file folders, correspondence, receipts, etc.), care must be taken that no evidentiary materials are destroyed in the sampling process.

4.12.7.2 Sampling Locations -- Blank letterhead, unused receipts, unlabeled file folders, etc., should receive first consideration. If these are not present in sufficient quantity, it may be necessary to collect the sample by removing material from the unused portions of the documents.

4.12.7.3 Sampling Equipment -- A Pyrex® pan and a pair of scissors decontaminated as specified in Appendix B. The handles of the scissors should not be painted or constructed of plastic.

4.12.7.4 Sampling Techniques -- The material selected for sampling should be as representative as possible. Once the sample material has been removed, it must be reduced in size and mixed prior to containerization. This can be accomplished by cutting the paper into small pieces with a pair of scissors and mixing the pieces in a glass pan. The shredded material is then placed into a precleaned 8-oz glass jar.

duration of the non-refrigerated period shall be kept to a minimum but absolutely not more than two days.

4.13.1.4 Analytical Support Branch -- Upon arrival of the metal container at the Athens laboratory, the samples shall be stored in the metal container in a refrigerator until submitted to the chemist for extraction.

4.13.2 Volatile Organic Compounds (VOC) Sampling With SUMMA® Electropolished Stainless Steel Canisters Using Method TO-14

4.13.2.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the cleanup and use of Summa® canisters in sampling air for Volatile Organic Compounds (VOC). This summary is adapted from Method TO-14 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

The following procedures must be followed in the preparation and use of Summa® canisters for sampling VOC.

- All new Summa® canisters must be individually checked for contamination by the ESD laboratory before use. One of each batch of 10 Summa® canisters that are subsequently cleaned must be analyzed to check for contamination.

- All sampler tubing, fittings, and wetted parts of valves must be solvent washed in hexane and heated to >100° C. These parts should then be assembled and flushed with nitrogen for at least 8 hours prior to use in the sample train or in the canister cleanup apparatus.

- Each canister's valve and fitting will be inspected for damage before cleaning. Any damaged valve will be replaced with a previously cleaned (see procedure above) valve. After replacing any valve, the canister will be cleaned and analyzed to verify that it is free of contamination.

- If any canister is used to sample a high concentration source, it must be cleaned and analyzed to verify it is free of contamination before it can be used again.

- Chain-of-custody must be maintained for all samples.

4.13.2.2 SUMMA® Canister Cleanup -- The following cleanup procedure will be followed for the preparation of all Summa® canisters:

- The canisters should initially be pressurized to >2 atm with humidified nitrogen[1] then evacuated to 1 atm. This filling and evacuation sequence shall be repeated five times to dilute any residual contaminants. The addition of the water from the humidified nitrogen may also displace some of the more reactive contaminants that could adhere to active sites on the wall of the canister. After the fifth evacuation to 1 atm, the vacuum pump will

be valved on and left on for a minimum of 3 hours or until a vacuum of <150 millitorr is reached. The identification number of the canister, the date and the final vacuum will be recorded in the canister cleanup logbook. After cleaning, the canister's valve should be capped with a Swagelok® plug. A label will then be affixed to the canister denoting the date it was cleaned and the name of the person who performed the cleaning.

1. (The nitrogen should be certified 99.999% pure by the manufacturer. A molecular sieve scrubber should be attached to the nitrogen line after the regulator to remove any trace impurities).

4.13.2.3 Sample Collection -- Two types of VOC samples can be collected with Summa® canisters. The canister can be opened and allowed to fill rapidly to obtain a grab sample or filled slowly by using a flow controller to collect a time integrated sample. With either type of sample, the following general procedures should be followed:

- An EPA, pre-numbered sample tag should be tied to the handle of the Summa® canister prior to sampling.
- A Chain-Of-Custody Record should be completed detailing time of sampling, sampling interval, and signed by the person taking the sample.
- After the sample has been collected, the Summa® canister should be capped, the pre-numbered EPA tag should be completed, and the canister should be placed in a shipping container with a copy of the Chain-Of-Custody Record and sealed with EPA sample custody tape.

4.13.2.4 Grab Sample Collection -- Before a grab sample for VOC analysis is collected in a Summa® canister, the canister inlet valve should be fitted with a pre-cleaned (Section 4.13.2.2) stainless steel particulate filter. At the sample collection location, the main valve should be opened and the canister allowed to fill. After about one minute (when no audible sound of rushing gas can be heard), close and cap the main valve of the Summa® canister.

4.13.2.5 Time Integrated Sample Collection -- This sample collection method involves the use of a flow controller or a sampler containing a flow controller to slowly meter the flow of air entering a Summa® canister. With this method, a sample is collected over a longer period of time than with a grab sample. If a constant flowrate was maintained, the resulting sample will have a VOC content that is the average of the VOC concentrations for the sampling interval (a time integrated sample).

The following procedures should be followed to collect time integrated samples:

- All sampler systems should be checked for contamination prior to use or after any major repair. This is accomplished by metering zero air or nitrogen[1] to the inlet of the sampler. Excess zero air or nitrogen flow should be vented with a Swagelok® tee from the sampler

4.13 AIR TOXICS MONITORING

4.13.1 Formaldehyde Sampling Using Dinitrophenylhydrazine Cartridges Using Method TO-11

4.13.1.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the handling and field use of dinitrophenylhydrazine (DNPH) cartridges for formaldehyde sampling. This is from METHOD TO-11 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

The following generic procedures should be adhered to at all times.

- Polyethylene or Nylon gloves must be worn whenever handling any of the DNPH cartridges (in the extraction laboratory, during preparation for shipment, during field set-up, in field during preparation for return shipment, and in the laboratory during preparation for analysis and during analysis).

- Coated DNPH cartridge which have been prepared for longer than 90 days shall not be used.

- All padding material shall be either clean tissue paper or polyethylene-air bubble padding. Never use polyurethane foam, cardboard, or newspaper as padding material. DNPH cartridges which have been properly prepared for shipment may be shipped in cardboard containers or preferably in coolers with eutectic salt (Blue Ice) packs.

- Chain-of-custody shall be maintained for all samples.

- A minimum of one trip blank shall be transported per one to ten samples collected.

4.13.1.2 Extraction Laboratory -- Upon completion of preparation of the DNPH cartridges, both ends shall be plugged with polypropylene Luer® male plugs and each DNPH cartridge placed in a borosilicate glass culture tube with polypropylene screw caps (tightened). A serial number, expiration date and a lot number label will be placed on each glass culture tube. The batches of culture tubes shall be placed in sealed friction-top metal containers which contain 1-2 inches of granular activated charcoal (or a pouch filled with a similar amount of charcoal) for storage in the refrigerator in the Air Laboratory. The culture tubes should be enclosed in two Zip-Lock® bags to prevent contamination from charcoal dust.

4.13.1.3 Air Compliance Unit -- The Air Compliance Unit will notify and keep the Extraction Unit informed as to the anticipated number of prepared DNPH cartridges needed for field use. On routine studies, the Air Compliance Unit will notify the Extraction Unit of needs at least two weeks in advance of needed pick-up date. Only the number of DNPH cartridges needed for a maximum of 60 days (including trip blanks and extra DNPH cartridges for breakage) will be requested.

- On the date of shipment or when loading out for a study, the Air Compliance Unit will remove the sealed cans (which contain the DNPH cartridges sealed in glass culture tubes) from the refrigerator in the Air Laboratory. If only a small number of tubes are needed for a particular study, the correct number of tubes will be transferred to another, smaller, solvent-washed shipping can.

- An appropriate amount of packing material shall be placed in the metal container to prevent breakage of the glass culture tubes. A label shall be affixed onto each metal container listing the number of DNPH cartridges in the container. The metal containers should be shipped in coolers containing eutectic salt packs (such as Blue Ice) to maintain a temperature of approximately 4°C. The DNPH cartridges shall be shipped the same day they are packed.

- On each sampling date, the metal container(s) will be removed from the refrigerator or cooler for transport to the field. At each sampling location the metal container will be opened and one glass culture tube will be removed (wearing clean polyethylene or nylon gloves) and allowed to warm to ambient temperature (before removing the DNPH cartridge from the glass culture tube). The plugged DNPH cartridge will be removed from the culture tube and the two Luer® end plugs will be removed from each end of the DNPH cartridge which will be immediately placed on the sampling train. The Luer® end plugs will be placed back into the glass culture tube and the cap placed on the tube and tightened. The culture tube will be left in the sampler enclosure at the site. The same procedure will be adhered to at each sampling location. A trip blank (in a sealed culture tube) will be placed in a sampler enclosure at one on the sites for the duration of a sampling event.

The sampler will be manually turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

- The operator should collect the sample as soon as possible after the sampling period ends. The sampler should manually be turned on and allowed to run for two minutes and a final flowrate and elapsed time from the elapsed time meter should be recorded on the sample data sheet. The exposed DNPH cartridge will then be removed from the sampling train (wearing clean polyethylene or nylon gloves). The two Luer® end caps will be removed from the glass culture tube and placed on the ends of the DNPH cartridge. The DNPH cartridge will be placed back into the glass culture tube, the lid tightened and placed back into the metal container. The same procedure is to be followed at each sampling site.

- At the end of the day on which the samples are collected, the sealed metal can (which contains the exposed DNPH cartridges) shall be either placed in a refrigerator for storage overnight or placed in a cooler. The cooler will be used to transport the samples to the EPA, Region IV, Analytical Support Branch in Athens, GA. The

inlet to atmosphere. The evacuated canister should then be filled at the normal sampling rate with the zero gas.

- Initial flowrates will be determined with a mass flow meter. The initial flowrate and initial vacuum (at least 29 inches of Hg) should be recorded on the sample data sheet. Adjust the flowrate so that at the end of the sampling interval the ending pressure of the canister is approximately 0.9 atm.

- Final flowrates should also be determined with a mass flow meter. Final flowrate and final vacuum should be recorded on the sample data sheets. The final vacuum should be between 5 inches and 1 inch of Hg. The final flowrate should be at least 1 scc/min.

After sample collection, all canisters should be double checked to verify that each has an EPA pre-numbered tag with all information filled out. Place the canister in a shipping container and seal the container with EPA sample custody tape.

4.13.3 Semi-Volatile Organic Compounds (SVOC) Sampling With High Volume PUF Samplers Using Methods TO-4 & TO-13

4.13.3.1 General -- The following is a synopsis of procedures which should be strictly adhered to for use of the High Volume Polyurethane Foam (PUF) sampling method for sampling semi-volatile organic compounds (SVOC) including pesticides and polychlorinated biphenyls. This summary is adapted from Method TO-4 (pesticides and PCBs) and TO-13 (polynuclear aromatic compounds) of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

The following procedures must be followed in preparation of PUF sampling media and using the High Volume PUF method for sampling for SVOCs:

- All PUF sampling media should be pre-cleaned, loaded into High Volume PUF sample cartridges and sealed in solvent washed cans by the extraction lab prior to use.

- Chain-of-custody shall be maintained for all samples.

4.13.3.2 PUF Cleaning -- The Air Compliance Unit has responsibility for buying the PUF media and cutting the PUF plugs. PUF media should be specified as not containing any fire retardants. It should be stored in the dark to prevent photo-oxidation. It should be less than two years old, and should be stored in a pesticide free environment.

Care should be exercised in cutting the PUF. It should be thoroughly wet with tap water prior to cutting. A drill press and stainless steel PUF cutting die should be used. The drill press area should be free of oil and a polyethylene cutting block should be used to stop the die at the bottom of the drill press stroke (do not use wood). Water should be sprayed on the die as the PUF is cut to help prevent snagging. After the plugs are cut, they should be

rinsed with tap water and followed by a rinse with deionized water. Finally, the excess water should be squeezed out.

The rinsed PUF plugs should be placed in a polyethylene plastic bag and delivered to the Analytical Support Branch extraction laboratory for preparation of the PUF/XAD-2 cartridges. The extraction laboratory will be given a minimum of three weeks notice for cleaning and checking the PUF/XAD-2 cartridges. The cleaned PUF/XAD-2 cartridges should be wrapped in aluminum foil and packed in metal cans cushioned by cleaned polyurethane foam to prevent breakage during shipment. Prepared PUF/XAD-2 sample cartridges that are pre-packed in solvent washed metal cans will be obtained from the extraction laboratory prior to sampling. The cans should be packed inside coolers which are lined with polyurethane foam for shipment.

4.13.3.3 Sample Collection -- The following procedures will be followed for all High Volume PUF sampling.

Nylon gloves will be used when handling all PUF cartridges and quartz particulate pre-filters. Assure that the red silicon upper and lower gaskets, located in the cartridge housing, are in place. Then remove the PUF cartridge from the shipping can, remove from the foil and insert the cartridge into the High Volume PUF Sampler's chamber. The pre-filter should be installed in the filter holder using caution not to over tighten the fittings. The foil should be sealed back in the shipping can. The can should be labeled with site ID, operators name, and sample date, and placed in the High Volume PUF sampler enclosure until the sample is collected.

The High Volume PUF sampler should be turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

The operator should collect the sample as soon as possible after the sampling period ends. The sampler should be manually turned on and allowed to run for two minutes. A final flowrate should be recorded on the sample data sheet. The final flowrate should be at least 150 liters per minute. The PUF cartridge should be removed, and the quartz pre-filter folded and placed in the top of the PUF cartridge. The PUF cartridge and pre-filter should be re-wrapped in the original aluminum foil and placed back in the shipping can. The can should be tightly sealed. Complete the sample data sheet and Chain-Of-Custody Record and seal the shipping can with a sample custody seal. Finally, the shipping can containing the sample should be placed in a cooler containing frozen eutectic salt packs (at a nominal temperature of -4° C). When all samples are collected from all sites, the cooler should be sealed with sample custody tape for transport back to the ASB.

4.13.3.4 Analytical Support Branch -- Upon arrival of the metal container at the Athens ASB laboratory, the samples shall be stored in the metal container in a refrigerator until submitted to the chemist for extraction.

4.13.4 Sampling For Metals Using The High Volume Sampler

4.13.4.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the sampling of metals in air. This summary is adapted from 40 CFR, PART 50, APPENDIX B - Reference Method For The Determination Of Suspended Particulate Matter In The Atmosphere (High Volume Method), and 40 CFR, PART 50, APPENDIX G - Reference Method For The Determination Of Lead In Suspended Particulate Matter Collected From Ambient Air.

The following procedures must be followed in preparation for collecting samples for metals analyses with the High Volume sampler.

- All filters used will be supplied by the EPA National Filter Distribution Program, and of the same quality as supplied to the State and Local Agency Air Monitoring Stations.

- Prior to use, all filters will be checked for pinholes, and desiccated at 15°C - 30°C, ± 3°C, and less than 50 percent relative humidity, ± 5 percent, for at least 24 hours.

- A filter field blank will be taken to the field, but not exposed. Filter field blanks will be analyzed by the Analytical Support Branch (ASB) to determine the background concentration of metals. The number of filter blanks will be determined based on the number of samples collected, or one blank for each ten samples collected.

- Chain-of-custody must be maintained for all samples.

4.13.3.4 Sample Collection Procedures -- Samples will be collected using the High Volume sampler as described, and operated in accordance with 40 CFR, PART 50, APPENDIX B:

- All flow calibration orifices will be traceable to a Primary Standard Rootsmeter. Flows will be corrected to EPA Standard Temperature and Pressure (25°C and 760 mm Hg).

- Digital manometers used to determine flow rates will be checked against a U-Tube water manometer prior to use in each study.

- Air Compliance Unit personnel will remove a 2-inch strip of the exposed filter from one end and discard it. Two 1-inch strips will be cut from the same end and transported to the ASB for analysis.

4.13.4.3 Integrated Sample Collection -- The following procedures should be followed to collect time integrated samples:

- Initial and final flow rates will be determined with a calibrated orifice and a digital manometer.

- After the sample has been collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed.

- A Chain-Of-Custody Record should be completed which contains the time of sampling, the sampling interval, and the signature of the person taking the sample.

After sample collection, all sample envelopes will be placed in an appropriate container. An EPA chain-of-custody seal will be placed on the container. Filters will be cut by the Analytical Support Branch and transported to the ASB for analysis.

4.13.5 Sampling and Analysis of Mercury In Ambient Air Using Arizona Instrument® Mercury Dosimeter Tubes and the Model 511 Gold Film Mercury Vapor Analyzer

4.13.5.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the sampling and analysis of mercury (Hg) in ambient air. This summary is adapted from the Arizona Instruments® (AZI), Model 511, Gold Film Mercury Vapor Analyzer Manual.

The following generic procedures should be adhered to at all times:

- Chain-of-custody shall be maintained for all samples
- A minimum of one trip blank shall be transported per one to ten samples collected.
- All mercury dosimeter tubes shall be cleaned and analyzed each sample day prior to use.

4.13.5.2 Dosimeter Cleanup -- Each dosimeter tube should be connected to the AZI® model 412 dosimeter controller and AZI® Gold Film Mercury Analyzer as shown in Figure 1 of the AZI® model 511 Mercury Analyzer Operation Manual. The mercury analyzer analysis cycle should be started and immediately afterward the dosimeter controller's START button should be depressed. This will cause the gold plated wire inside the dosimeter tube to heat up and liberate any elemental mercury that forms an amalgam on the gold plated wire inside the dosimeter. Continue this cycle until less than 2 ng of Hg is detected from the dosimeter tube. Remove the clean dosimeter tube from the dosimeter controller, tag it with the cleanup date and operators name, and connect the inlet and outlet dosimeter ports together with a clean 8-inch section of 3/16" ID x 1/16" wall Tygon® tubing (this effectively caps the dosimeter tube).

4.13.5.3 Sample Collection -- Each sampling pump will be calibrated with a mass flow meter before and after each sampling event. Connected the dosimeter to the battery powered sampling pump with Tygon® tubing. Adjust the sampling pump to obtain a flowrate of 50 cc/min. The sampling interval should not extend beyond 8 hours. The following steps should be followed to collect each sample.

- Disconnect one end of the Tygon® tubing from the dosimeter tube and connect it to the battery powered sampling pump.

- Program the pump to run the desired number of hours. Position the dosimeter tube inlet so that there is no obstruction of flow. Record the dosimeter tube number, site ID, sample date, start time, and initial flowrate on the sample data form.

- As soon as possible after the sampling event, disconnect the Tygon® tubing from the sample pump and connect the loose end to the inlet of dosimeter tube. Record the elapsed time from the pump display. Check the ending flowrate with a mass flow meter and record it on the sample data form.

4.13.5.4 Sample Analysis -- Before any mercury analysis of dosimeter tubes, the AZI® model 511 should be calibrated. The AZI® model 511 should only be used under laboratory conditions. All glassware should be scrupulously cleaned and used exclusively for mercury analysis. All tygon tubing that is used should be new. The following calibration procedure is adapted from the AZI® model 511 operation manual:

Calibration

- Calibration of the AZI® model 511 is accomplished by the reaction of a mercuric chloride standard solution with stannous chloride which liberates elemental mercury. The elemental mercury is sparged from an impinger for analysis in the mercury analyzer.

- Before calibration, a film heat cycle should be initiated to clean the mercury analyzer sensor.

- Fresh working 100 ng/ml mercuric chloride standards should be prepared daily from a 1000 ug/ml stock solution. From the 100 ng/ml working standard, calibration standards of 10 ng/ml, 20 ng/ml, and 40 ng/ml should be prepared. Use the procedure outlined in the AZI® operation manual to introduce the stannous chloride solution into the impinger containing the 40 ng/ml standard. IMMEDIATELY depress the SAMPLE START button on the analyzer. Use the calibration potentiometer to adjust the analyzer to read 40. Analyze the 10, 20, and 40 ng/ml standards to verify that the calibration curve is linear. All analyzer readings should be within 2 ng of the actual values of the standards. Record the readings in the logbook.

- Once the mercury analyzer is calibrated, connect an exposed dosimeter tube to the model 412 dosimeter controller. Connect a zero filter to the inlet of the dosimeter tube. Simultaneously press the mercury analyzer SAMPLE START button and the dosimeter controller START button. Record the analyzer reading (in ng) in the logbook. Repeat this sequence three times and sum the values. This value is the total ng of mercury that was captured on the dosimeter tube.

- Divide the sum of the mercury analyzer readings (in ng) by the total volume of air sampled (in liters) to give the concentration of mercury present in ug/M^3.

4.13.6 Dioxin and Dibenzofuran Sampling With High Volume PUF Samplers Using Method TO-9

4.13.6.1 General -- The following is a synopsis of procedures which should be strictly adhered to for use of the High Volume Polyurethane Foam (PUF) sampling method for sampling for polychlorinated dibenzo-p-dioxins and dibenzofurans. This summary is adapted from Method TO-9 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

Since this method requires High-Resolution Mass Spectrometry which ESD does not have, all sample media preparation and analysis will have to be contracted. At least one months notice prior to sampling should be given to the Analytical Support Branch to obtain a contract laboratory program (CLP) contract for any dioxin and dibenzofuran analysis. It is important that the contract specify a number of details to assure accurate results:

- All of the PUF media and a representative number of each batch of quartz pre-filters should be checked by the contract laboratory to assure that there is no contamination. Each PUF plug should be pre-spiked by the contract laboratory with dioxin and dibenzofuran surrogates as a check of the accuracy of the method.

- Each set of PUF plugs and quartz filters should be securely packed in sealed containers and in coolers to prevent damage during shipment. The sampling media should be shipped air freight to minimize the time between cleanup and sampling.

- Chain-of-custody shall be maintained for all samples.

4.13.6.2 Sample Collection -- The following procedure will be followed for all High Volume PUF sampling for dioxins and dibenzofurans.

Nylon gloves will be used when handling all PUF cartridges and quartz particulate pre-filters. Assure that the red silicon upper and lower gaskets are in place in the PUF cartridge housing. Remove the PUF cartridge from the shipping can. Unwrap and insert the PUF cartridge into the High Volume (Hi-Vol) PUF sampler's chamber. Install the pre-filter in the filter holder using caution not to over tighten the fittings. The removed aluminum foil should be sealed in the shipping container. The container should be labeled with the site ID, the operators name, and the sample date, and placed in the Hi-Vol PUF sampler enclosure until the sample is collected. The Hi-Vol PUF sampler should be turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

The operator should collect the sample as soon as possible after the sampling period ends. The sampler should be manually turned on and allowed to run for two minutes and a final flowrate recorded on the sample data sheet. The final flowrate should be at least 150 liters/minute. The PUF cartridge should be removed, and the quartz pre-filter folded and placed in the top of the PUF cartridge. The PUF cartridge and pre-filter should be re-wrapped in the original aluminum foil and placed back in the shipping container and the container should

be tightly sealed. Complete the sample data and sample custody sheets. Each shipping container should have a sample custody seal. Finally, the shipping container containing the sample should be placed in a cooler containing frozen eutectic salt packs (at a nominal temperature of ~ 4° C). When all samples are collected from all sites, the cooler should be sealed with sample custody tape for shipment to the contract laboratory.

4.13.6.3 Contract Laboratory -- Upon arrival of the metal container at the contract laboratory, the samples shall be stored in the metal container in a refrigerator until submitted to the chemist for extraction.

4.14 CRITERIA POLLUTANT MONITORING (REFERENCE MONITORS)

4.14.1 Monitoring Ozone In Ambient Air

4.14.1.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the monitoring of ozone in air. This summary is adapted from 40 CFR 50, APPENDIX D - Measurement Principle and Calibration Procedure For The Measurement Of Ozone In The Atmosphere, and the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.7 (EPA-600/4-77-027a).

The following procedures must be followed in monitoring for Ozone in ambient air:

- Calibration systems will meet 40 CFR, Part 50, Appendix D specifications for a Primary Standard Calibration Photometer.
- Calibration systems will be verified against the National Bureau of Standards (NBS) Standard Reference Photometer #10 before use.
- Monitor enclosures will meet the specifications of monitor reference/equivalent designation for temperature control.
- Probes must meet the requirements stated in 40 CFR, Part 58 for materials and sample residence time.
- All flow calibrations will be traceable to a Primary Standard. Flows will be corrected to EPA Standard Temperature and Pressure (25°C and 760 mm Hg).
- Chain-of-custody must be maintained at all times.

4.14.1.2 Monitoring Procedure -- Measurements will be made using the procedure as described, and operated in accordance with 40 CFR, PART 50, APPENDIX D:

- Monitors will be calibrated at the beginning and end of each study, and at least quarterly during the study.
- Monitors will be calibrated after major maintenance or when a quality assurance (QA) check shows an out-of-control condition exists.
- A zero/span check will be conducted daily on all monitors.
- Precision checks of all monitors will be conducted at least weekly.
- Quality assurance audits as specified in 40 CFR, Part 58, Appendix A will be conducted quarterly, or at least once for short duration studies.

controllers. Flow rate look-up tables will be verified using a calibrated orifice on a routine basis, or at least annually.

4.14.2.3 Integrated Sample Collection -- The following procedures should be followed to collect time integrated samples:

- Initial and final flow rate will be determined with a digital manometer based on the manufacturer's flow rate look-up table.
- After the sample is collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed.
- A Chain-Of-Custody Record should be completed detailing the time of sampling and the sampling interval, and the signature of the person taking the sample.

After the sample are collected, all sample envelopes will be placed in an appropriate container. An EPA chain-of-custody seal will be placed on the container and the container transported to the Athens, Georgia facility for final weighing of filters.

4.14.3 Sampling Of Particulate Matter In Air As PM_{10}

4.14.3.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the sampling of particulate matter as PM_{10} in air. This summary is adapted from 40 CFR, PART 50, APPENDIX J - Reference Method For The Determination Of Particulate Matter as PM_{10} In The Atmosphere , and the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.11 (EPA-600/4-77-027a).

The following procedures must be followed in sampling for particulate matter as PM_{10}:

- All filters used will be supplied by the EPA National Filter Distribution Program, and of the same quality as supplied to the State and Local Agency Air Monitoring Stations.
- Prior to use, all filters will be checked for pinholes, and desiccated at 15°C - 30°C ± 3°C, and less than 50 percent relative humidity ± 5 percent, for at least 24 hours.
- Initial and final (exposed) filter weights will be determined by the Air Compliance Unit. One of ten filters will be reweighed as a quality assurance check. For batches less than ten, one filter will be reweighed.
- After sampling, filters will be desiccated as described above.
- Chain-of-custody must be maintained for all samples.

4.14.3.2 Sample Collection -- Samples will be collected using the High Volume sampler as described, and operated in accordance with, 40 CFR, PART 50, APPENDIX J:

- All flow calibration orifices will be traceable to a Primary Standard Rootsmeter. Flows will be corrected to EPA Standard Temperature and Pressure (25°C and 760 mm Hg).

- Digital manometers used for flow rate determination will be checked against a U-Tube water manometer prior to use in each study.

- Volumetric flow controllers will be used on all PM_{10} samplers. Flows will be determined using the manufacturer's flow rate look-up table supplied with the controllers (Section No. 4.14.2.2). Flow rate look-up tables will be verified using a calibrated orifice on a routine basis, or at least annually.

4.14.3.3 Integrated Sample Collection -- The following procedures should be followed to collect time integrated samples:

- Initial flow rate will be determined with a digital manometer based on the manufacturer's flow rate look-up table.

- Final flow rate will be determined with the same method.

- After the sample is collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed.

- A Chain-Of-Custody Record should be completed detailing the time of sampling and the sampling interval, and the signature of the person taking the sample.

After sample collection all sample envelopes will be placed in an appropriate container. An EPA chain-of-custody seal will be placed on the container and the container transported to the Athens, Georgia facility for final weighing of filters.

4.15 SATURATION MONITORING (NON-REFERENCE MONITORS)

4.15.1 Pm_{10} Saturation Monitoring Using Non-Reference Portable Monitors

4.15.1.1 Introduction -- This document gives procedures for use of the PM_{10} Saturation Monitors constructed by Lane Regional Air Pollution Control Authority located in Springfield, Oregon. These monitors are not referenced by the U.S. EPA.

4.15.1.2 General Description -- Each monitor is shipped with the following items:

Description	Qty
Sampler Body	1
PM_{10} Head	1
Filter Holders	2
Rechargeable Battery Packs	2
Battery Charger	1
Sampler Hanger	1
Storage Boxes	2

Procedures for siting requirements, monitor calibration, filter media inspection and preparation, sampler preparation, and battery pack preparation and changing are discussed in Appendix O of the manufacturers Operations Manual.

4.15.1.3 Calibrations -- Calibrations will be performed before and after each study for each sampler. Recalibration will be performed before field use on units which require major maintenance. Detailed calibration procedures are given in Appendix O of the manufacturers Operation Manual.

4.15.1.4 Sampling Procedure -- This sampling technique does not comply with EPA's ambient air monitoring regulations for PM_{10} sampling. The method has been shown to represent effective and efficient means for the collection of quality PM_{10} data.

Sample Preparation:

- Filters will be kept in protective cassettes. Prior to use, all filters will be visually inspected for defects.
- Each filter will have an ID number assigned to it.
- Each battery will be checked before load-out.

Sample Collection:

- Record information on Data Sheets.
- Install clean filter, and start system to check for leaks.
- Set initial flow to 5 L/min, and stop system.

- Input timer program, and verify.
- Input pulse factor into calculator, and start system.

Sample Retrieval:

- Start system, and record the ending flow rate.
- Note the ending sampling conditions, and record any problems on Data Sheets.
- Remove and replace sample filter following the double bag procedure.

Sample Preservation:

- Extreme care must be taken in removing exposed filters and reloading of filter heads.
- Filters will be returned to the original sample cassettes, and the ID number verified.
- Complete data sheets and store them and the filter samples in a container sealed with custody tape.

4.15.1.5 Sample Custody -- Chain-of-custody will be followed at all times during the sampling study. Chain-of-custody procedures can be found in Section 3.3, of this manual.

4.15.2 Carbon Monoxide Saturation Monitoring

RESERVED

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5.0 FLOW MEASUREMENT

5.1 INTRODUCTION

The measurement of flow with surface water and wastewater sampling is essential to almost all water pollution control activities. Activities such as water quality enforcement studies, NPDES permit compliance monitoring, water quality monitoring, municipal operation and maintenance investigations, planning, and research rely on accurate flow measurement data. The importance of obtaining accurate flow data cannot be overemphasized, particularly with respect to enforcement investigations since these data will be used as evidence in enforcement case preparation. NPDES permits often limit the quantity (mass loading) of a particular pollutant that may be discharged, and the calculation of mass loadings are also frequently necessary for water quality studies and other purposes. As much attention and care should be given to flow measurement in the design of a sampling program as to the collection of samples and their subsequent laboratory analysis.

The basic objectives of this section are to:

- outline standard practices for Branch personnel with respect to wastewater flow measurements during water enforcement and NPDES compliance monitoring activities and other studies where wastewater flow measurements are required;
- outline standard practices for obtaining surface water flow during water quality surveys;
- present acceptable, commonly used flow measurement techniques; and
- present general and specific quality assurance procedures for Branch flow measurement equipment and techniques.

A complete discussion of all available flow measurement techniques and the theory behind them is beyond the scope of this manual. However, most of the common techniques currently in use are covered in general terms. A comprehensive list of references is included at the end of this section and a detailed discussion of flow measurement techniques may be found in the references.

5.2 WASTEWATER FLOW MEASUREMENT

5.2.1 General

The USDI Water Measurement Manual (1) is the standard Branch reference for details on checking the installation of primary open channel flow devices. Basic guidance for making wastewater flow measurements and a basic description of all common wastewater flow measurement systems are given in the EPA Compliance Inspection Manual, May 1988 (2). This manual shall be used as Branch guidance for such measurements.

5.2.2 Site Selection

It is the field investigator's responsibility to insure that the wastewater flow measurement system or technique used measures the total wastewater discharged (described by the NPDES permit, if applicable). All recycled waters must be accounted for so that any reported flows accurately reflect the volume of wastewaters discharged. The actual location of wastewater flow measurement is not important so long as these criteria are met, and the location chosen is suitable for the technique or flow measurement system utilized to actually measure flow.

5.2.3 Flow Measurement Systems

Flow may be measured on an instantaneous or a continuous basis. A typical continuous system consists of a primary flow device, a flow sensor, transmitting equipment, a recorder, and possibly a totalizer. Instantaneous flow measurements can be obtained without using such a system.

The heart of a typical continuous flow measurement system is the primary flow device. This device is constructed to produce predictable hydraulic responses which are related to the flow rate of water or wastewater through it. Examples of such devices include weirs and flumes which relate water depth (head) to flow, Venturi and orifice type meters which relate differential pressure to flow, and magnetic flow meters which relate induced electric voltage to flow. Standard primary flow devices have undergone detailed testing and experimentation, and their accuracy has been verified.

A flow sensor is required to measure the particular hydraulic responses of the primary flow measurement device and transmit them to the recording system. Typically, sensors include floats, pressure transducers, capacitance probes, differential pressure cells, electromagnetic cells, etc.

The sensor signal is generally converted using mechanical, electromechanical, or electronic systems into units of flow which are recorded directly on a chart or transmitted into a data system. Systems which utilize a recorder are generally equipped with a flow totalizer which displays the total flow on a real time basis.

Studies that necessitate continuous flow measurements require a complete system. Instantaneous flow measurements do not necessarily dictate the use of any portion of such a system. Techniques which are described later in this Section are available for measuring instantaneous flows with portable equipment.

An important consideration during wastewater studies is that the investigator may want to obtain continuous flow data at a facility where only instantaneous flow data are being measured. If an open channel primary flow device is utilized for making instantaneous measurements, only the installation of a portable field sensor and recorder is necessary. If, on the other hand, the facility being investigated does not utilize a primary flow device, and a continuous flow record is desired, a portable primary flow device will have to be installed. ESD investigators have both open channel equipment and closed conduit flow meters available for field use. This chapter does not cover in detail the installation of primary flow devices, but many of the references cited treat this area quite adequately.

Wastewater flow measurement systems are generally very accurate. The total error inherent in a flow measuring system is the sum of each component part of the system. However, any system that cannot measure the wastewater flow within ± 10 percent of the actual flow is considered unacceptable for use in measuring wastewater flow.

5.2.4 Use of Existing Flow Measurement Systems

The installation of systems to measure wastewater flows can be a time consuming task, particularly if a primary device is not available. Therefore, Branch field personnel shall always use existing facility primary flow devices and flow measurement systems when the accuracy of these devices and the system can be verified. The objective of this section is to outline the responsibilities of Branch field personnel in verifying the accuracy of existing primary flow devices and systems.

The field investigator must verify that any existing flow measurement system (including primary flow device) utilized to measure wastewater flows conforms with recognized design and installation standards, and any deviation from standard conditions shall be thoroughly documented. The accuracy of the primary flow device should be checked by making an independent "calibration" or flow measurement. If there is no usable or existing primary flow measuring device or if the device has been mislocated, the investigator shall attempt to install a portable primary flow device.

If the discharger's flow measurement system is accurate within ± 10 percent of the actual flow, the investigator can use the installed system. The accuracy of flow sensors and recorders can be easily checked for open channel flow devices by making an instantaneous measurement utilizing the primary flow device and comparing this against the recorder reading. The accuracy of the recorder time trace shall be checked by actually marking times on the flow chart and comparing these to the correct time. It is necessary to make an independent flow measurement when closed conduit systems must be checked, although ESD inspectors have a closed conduit system (Polysonics) available. If the existing equipment cannot be calibrated in a timely manner, the investigator should install a portable flow sensor and recorder for the duration of the investigation. The installation and use of such equipment is preferred over attempts to correct erroneous flow measurement systems. The investigator should note the action taken in the study or inspection report and inform the discharger that the equipment should be calibrated as soon as possible if flow is required for calculating mass loadings or is itself a permit monitoring requirement. If non-standard primary flow devices are being used, data supporting the accuracy and precision of the methods being employed should be provided by the discharger.

5.2.5 Specific Techniques

This section outlines and familiarizes the field investigator with the most commonly used methods for wastewater flow measurements and the primary devices that will be encountered during field studies. Volumetric and dilution techniques are presented at the beginning of this section, since they are applicable to both open channel and closed conduit flow situations. The remaining methods are grouped under categories dealing with open channels and closed con-

duits. The general method of checking individual primary flow devices is given, where applicable. Several estimation techniques are presented. However, it should be recognized that flow estimates do not satisfy NPDES permit monitoring requirements unless the permit specifically states that this is permissible. The following methods are included only to enable the field investigator to make accurate flow estimates when necessary.

5.2.5.1 Volumetric Techniques -- Volumetric flow measurement techniques are among the simplest and most accurate methods for measuring flow. These techniques basically involve the measurement of volume and/or the measurement of time required to fill a container of known size.

5.2.5.1.1 Vessel Volumes -- The measurement of vessel volumes to obtain flow data is particularly applicable to batch wastewater discharges. Accurate measurements of the vessel volumes and the frequency that they are dumped are all that is required. An accurate tape to verify vessel dimensions and a stop watch are the only required field equipment. The NPDES Compliance Inspection Manual (2) is a useful reference on the equations for calculating volumes of various containers.

5.2.5.1.2 Sump Pumps -- This measurement is made by observing the sump levels at which the pumps cut on and off and calculating the volume contained between these levels. This volume, along with the number of pump cycles, will give a good estimate of the daily wastewater flow. The inspector must also account for the quantity of wastewater that flows into the sump during the pumping cycle.

5.2.5.1.3 Bucket and Stop Watch -- The bucket and stop watch technique is particularly useful for the measurement of small wastewater flows. It is accurate and easy to use. The only equipment required to make this measurement is a calibrated container (bucket, drum, tank, etc.) and a stop watch. A minimum of 10 seconds to fill the container is recommended. Three consecutive measurements should be made, and the results should be averaged.

5.2.5.2 Dilution Methods -- Dilution methods for water and wastewater flow measurements are based on the color, conductivity, fluorescence, or other quantifiable property of an injected tracer. The dilution methods require specialized equipment, special attention to detail by the investigator, and are time consuming. However, these techniques offer the investigator:

- a method for making instantaneous flow measurements where other methods are inappropriate or impossible to use;
- a reference procedure of high accuracy to check in-situ those primary flow devices and flow measurement systems that are non-standard or are improperly installed; and
- a procedure to verify the accuracy of closed conduit flow measuring systems.

The Turner Designs nomograph (3), the NPDES Compliance Inspection Manual (2), and the Geological Survey publication (4) outline recommended reference

procedures. The dilution method utilizing Rhodamine WT dye is the preferred reference procedure to be utilized by Branch personnel when verifying the accuracy of flow measurement systems.

5.2.5.3 Open Channel Flow Measurements -- The measurement of wastewater flow in open channels is the most frequently encountered situation in field investigations. An open channel is defined as any open conduit, such as a channel or flume, or any closed conduit, such as a pipe, which is not flowing full. The most commonly encountered methods and primary flow devices used in measuring open channel wastewater flows are described in this section. Several flow estimation techniques are also presented.

The measurement accuracies quoted in this section apply only to the specific method or to the primary flow device being discussed. The total error involved in a continuous flow measurement system, which is the sum of the errors of each component, is beyond the scope of this discussion. The reader is referred to the list of references at the end of this chapter for such a discussion.

5.2.5.3.1 Weirs -- A weir is basically defined as an overflow structure built according to specific design standards across an open channel to measure the flow of water. The theory of flow measurements utilizing weirs involve the release of potential static energy to kinetic energy. Equations can be derived for weirs of specific geometry which relate static head to water flow (discharge). Weirs are generally classified into two general categories; broad crested and sharp crested.

Broad crested weirs take the following form; $Q=CLH^{3/2}$. Values for the coefficient C are given in hydraulic handbooks (5, 6). Unless such weirs have been independently calibrated, they are usually not accurate enough for wastewater flow measurements.

Sharp crested weirs are constructed in a wide variety of shapes; the most commonly encountered are: V-notch, rectangular, and Cipolletti weirs. If such weirs are constructed as outlined in the USDI Water Measurement Manual (1), they are considered standard primary flow devices.

All weirs should be inspected to determine if the weir installation and construction conform to the conditions given in the USDI - Water Measurement Manual (1) and provide a uniform influent flow distribution, and the weir is placed squarely across the channel perpendicular to the direction of flow. Useful tools for checking weir construction and installation include a carpenter's level, a framing square, a measuring tape, and a staff gage. Any problems observed during the inspection or study should be noted in the field log book.

A set of weir tables is necessary for calculating flows. The USDI Water Measurement Manual (1), the Stevens Water Resource Data Book (7), and the ISCO Open Channel Flow Measurement Handbook (8) contain a complete set of tables.

5.2.5.3.2 Flumes -- The conditions that must be met in a flume are similar to those that occur at a weir or spillway crest since water passing through the throat should not be impeded by downstream conditions (constrictions, bends in

channel, obstructions). There are several types of flumes, Palmer-Bowlus, Cutthroat, H, and Trapezoidal, but the most widely used is the Parshall flume. The Parshall flume is considered a standard primary flow device when constructed and installed as outlined in the USDI Water Measurement Manual (1). A complete discussion of other types of flumes is given in references 9, 10, 11, and 12.

All flumes should be inspected to determine if entrance conditions provide a uniform influent flow distribution, the flume dimensions conform to those given in the USDI Water Measurement Manual (1), the flume converging throat section is level, and the throat section walls are vertical. Useful tools for checking the construction and installation of Parshall (and other) flumes include a carpenter's level, a framing square, and a measuring tape. The flume should be closely examined to determine if it is discharging freely. If there is any question about free discharge, the downstream head (Hb) should be measured and compared to the head at the proper location (Ha) in the converging section. A staff gage is useful for making head measurements. Any problems observed during the inspection or study should be noted in the field log book.

A set of flume tables is necessary for calculating flows. The USDI Water Measurement Manual (1), the Stevens Water Resources Data Book (7), and the ISCO Open Channel Flow Measurement Handbook (8) contain a complete set of tables. The explanatory material accompanying these tables should be read and understood before they are used. In many cases, tabulated flow values are given for measured heads that are not within the usable measurement range.

5.2.5.3.3 Open Flow Nozzles -- Open flow nozzles such as parabolic or Kennison nozzles are factory calibrated and are ordinarily supplied as part of a flow measurement system. Calibration and installation information for each nozzle should be supplied by or obtained from the manufacturer. The accuracy of these devices is reported to be often better than ± 5 percent of the indicated flow (10). A framing square is useful for checking the installation. A volumetric flow measurement may be used to check accuracy of this device if flow volumes are not excessive.

5.2.5.3.4 Velocity-Area Method -- The basic principal of this method is that the flow in a channel (cubic feet/second) is equal to the average velocity (feet/second) times the cross sectional area (square feet) of the channel. The velocity of the water or wastewater is determined with a current meter; the area of the channel is either measured or calculated using an approximation technique in conjunction with a series of velocity measurements. The USGS mid-section method and the stream gaging techniques described in the USGS publication, Discharge Measurements at Gaging Stations (9) shall be the standard practice of the Branch. This technique shall be used (where appropriate) as an independent flow measurement to verify the accuracy of existing flow measurement systems.

5.2.5.3.5 Slope-Area Method -- The slope-area method consists of using the slope of the water surface, in a uniform reach of channel, and the average cross-sectional area of that reach, to estimate the flow rate of an open channel. The flow rate is estimated from the Manning formula (5, 6). This method is an estimation technique.

5.2.6 Closed Conduit Flow Measurements

The accuracy of closed conduit flow measuring devices shall be checked when necessary, by making an independent flow measurement, preferably using a dilution technique.

5.2.6.1 Venturi Meter -- The Venturi meter employs a conversion of static head to velocity head whereby a differential is created that is proportional to flow. The typical accuracy of a Venturi meter is given at 1 to 2 percent (10, 11, 12, and 13).

5.2.6.2 Orifice Meter -- The Orifice meter is a pressure differential device that measures flow by the difference in static head. Orifice meters require from 40 to 60 pipe diameters of straight pipe upstream of the installation. They can be quite accurate, i.e., within 0.5 percent, although their usable range is limited (10).

5.2.6.3 Flow Nozzle -- The basic principle of operation is the same as that of the Venturi meter. The flow nozzle has an entrance section and a throat, but lacks the diverging section of the Venturi. Flow nozzle accuracies can approach those of Venturi meters (10).

5.2.6.4 Electromagnetic Flow Meter -- The electromagnetic flow meter operates according to Faraday's Law of Induction where the conductor is the liquid stream, and the field is produced by a set of electromagnetic coils. The accuracy of the device is within ± 1 percent of full scale (10).

5.2.6.5 Other Closed Conduct Devices -- References for other closed conduit flow measurement methods such as acoustic flow meters, trajectory methods, pump curves, and water meters can be found in the NPDES Compliance Inspection Manual (2).

5.3 SURFACE WATER FLOW MEASUREMENTS

5.3.1 General

Surface waters are considered to be open channel for flow measurement purposes. All of the techniques utilized by Branch personnel to measure open channel flows have been discussed in the wastewater flow measurement portion of this section. Except for very small surface streams, the installation of primary flow devices is not practical. Most surface water flow measurements are made utilizing classical stream gaging techniques. These techniques involve the use of the velocity-area open channel technique which was discussed in the wastewater portion of this section. Branch personnel shall use the techniques outlined in the USGS publication Discharge Measurements at Gaging Stations (9) to:

- select the flow measuring site;
- perform stream gaging; and
- calculate flow.

5.3.2 Techniques

Where possible Branch stream studies shall be conducted utilizing existing permanent stream gaging stations operated by the USGS, the U. S. Army COE, or other federal or state agencies. These permanent gaging stations have established water stage - discharge relationships that permit the flow to be obtained from water stage measurements. Staff gage or recorder - readings of water stage at these stations may be converted to flow by using the rating curve for that gaging station. The rating curve is available from the operator of the permanent gaging station. An additional benefit of utilizing these permanent gaging stations is that long-term flow records are generally available. These long-term flow records are invaluable in planning water quality studies and assessing data trends.

Where permanent gaging stations are not present, surface water flow will have to be measured utilizing classical stream gaging techniques. If a station is to be used more than one time during a water quality survey, a rating curve should be developed for that station. This may be done by making a series of independent flow measurements and simultaneous tape down or staff gage measurements for that station (see Section 7) at different water levels. The rating curve is developed utilizing the same measurement section each time; at least two, preferably three, flow measurement - tape downs should be made. The flow measurements used to develop the rating curve must bracket the lowest and highest flows encountered during the study. A tape-down rating curve is constructed by plotting the tape-down measurements verses flows on a piece of semi-log graph paper.

5.4 GENERAL QUALITY ASSURANCE PROCEDURES

All Branch personnel shall use the techniques and procedures for making wastewater and surface water flow measurements outlined in this section. The USDI Water Measurement Manual (1), the USGS publication Discharge Measurements at Gaging Stations (9), the EPA NPDES Compliance Inspection Manual (2) and a set of weir and flume tables shall be supplied to all Branch field employees. However, the measurements of wastewater and water flows require considerable experience. Therefore, no Branch employee shall make flow measurements until he/she has at least six months of actual field experience and has performed these measurements under the supervision of a senior member of the Branch staff.

Wastewater flow shall be expressed in million gallons per day (mgd) or the metric equivalent (m^3/day); stream flow shall be expressed in cubic feet per second (second feet) or the metric equivalent (m^3/sec). Time records associated with flow measurements shall be kept in local time, shall be made in the 2400 hour military time format, and shall be recorded to the nearest five minutes.

All flow measurements conducted by Branch personnel shall be thoroughly documented in field records. All measurements shall be traceable both to the individual making the measurements and the equipment utilized.

A log of all maintenance, calibration, and repair for each piece of flow measuring equipment shall be established. The log shall be kept in such a manner that all maintenance and calibrations performed on the equipment are traceable to the person performing them and to the calibration standard utilized. All equipment shall be numbered, or the US-EPA property or serial number shall be

used to facilitate identification.

5.5 EQUIPMENT AVAILABLE

The equipment available to Branch personnel for the measurement of surface water or wastewater flows is categorized as follows: water level/stage hardware and recorders, velocity measuring equipment and assemblies, and direct flow measurement equipment and instrumentation.

The hardware available to Branch personnel to determine the rise and fall of a water surface with time (the water stage) includes the following recording devices: Stevens Model F horizontal drum recorders and Stevens Model A-71 continuous strip chart recorders, ISCO Model 1870 recording flow meters used in the linear head mode, and ISCO Model 2870 recording flow meters that have programmable functions. Non-recording equipment available includes vertical staff gages and tape-down systems (see Section 7).

Instruments and equipment available to make velocity cross-sectional area measurements include current meters and sounding (depth) equipment. The current meters available to Branch personnel are the vertical-axis mounted Price AA and Price pygmy meters (including direct readout meters), and ENDECO solid state memory current meters. Sounding (determination of depth) is accomplished using Ratheon recording fathometers or with a standard top setting wading rod. Width measurements are made by Branch personnel using a Lee-Au galvanized steel tag line which is segmented into equal divisions of length by metal beads.

The equipment available for direct flow measurement includes the following primary devices available for installation by Branch personnel: V-notch weir plates and rectangular weir plates. The corresponding conversion of water level to flow rate can be accomplished instantaneously from stage/staff gage readings corresponding to the primary flow device in use, or by instantaneous readings of the available recording flow meter systems. The continuous recording systems presently available are the ISCO Model 1870 and 2870 recording flow meters.

The Polysonics Ultrasonic Flowmeter (Model UFM84P) is available for measuring flow in closed pipes. The pipe must be flowing completely full and not contain large amounts of air pockets. A coupling jelly is spread on the face of two transducers, and the transducers are mounted opposite each other on the outside of the pipe. The meter must then be calibrated according to the manufacturer's instructions.

5.6 SPECIFIC EQUIPMENT QUALITY CONTROL PROCEDURES

A log book shall be kept of all equipment utilized for measuring water flows, water stage/tape downs, velocity measurements, flow recordings, etc. The following maintenance and calibration procedures shall be implemented.

5.6.1 Stevens Model A-71 and Model F Stage Recorders

See specific equipment and quality control procedures in Section 7.

5.6.2 ISCO Model 1870 and 2870 Recording Flow Meters

The recording flow meter shall be thoroughly tested annually to insure that the accuracy, resolution, and precision are within the technical specifications as established by the manufacturer. This shall be accomplished by operating the instruments in a controlled test environment for a period not less than 24 hours. The test environment shall consist of a controlled atmospheric temperature, power source, and water level/head. Operation during the testing period shall be according to the manufacturer's instruction manual. The functions that shall be tested include: flow meter totalizer accuracy, flow recorder tracing accuracy, and chart speed accuracy.

In addition to the above annual testing program, an abbreviated testing procedure will be conducted on the flow meters and recorders which will include a check on the following functions: flow meter and recorder response to changing heads as shown on the meter's liquid level indicator and the recorder's flow indicator, bubble rate adjust response, flow recorder accuracy, full scale span sensitivity, sample signal initiation response, zero adjust response, and chart speed response. The flow meters and recorders shall be checked through the abbreviated procedure whenever they are scheduled for field use.

The following routine maintenance procedures shall apply whenever the equipment is returned from the field: the exterior of the meter and recorder case will be cleaned with soapy water (Appendix B), the front panel desiccant and external desiccant cartridges will be reactivated, and the bubble line will be inspected and cleaned.

5.6.3 Vertical Staff Gages and Tape Down Systems

See specific equipment and quality control procedures in Section 7.

5.6.4 Price AA and Price Pygmy Current Meters

All meters shall be sent to the USGS for recalibration once every five years. All meters shall be examined before and after each discharge measurement. The examination shall include the meter cups or vanes, pivot and bearing, and shaft for damage, wear, or faulty alignment. Meter balance and alignment shall be checked prior to each use in the field (9). Meters shall be cleaned and oiled daily when in use. Surfaces that shall be cleaned and oiled on a yearly basis are the pivot bearing, pentagear teeth and shaft, cylindrical shaft bearing, and thrust bearing at the cap.

5.6.5 Top Setting Wading Rod

This equipment shall be cleaned and examined before and after each discharge measurement. The examination shall include a check on the sliding rod and lock set mechanism.

5.6.6 Lee Au Tag Line

This equipment shall be inspected for damage and cleaned before and after each discharge measurement. The accuracy of the tag line will be checked initially and then once per year utilizing the Invar steel surveyors chain. The tag

line(s) shall be accurate to 0.1 foot per 100 feet. Any tag lines that do not conform to this accuracy specification shall be repaired, recalibrated, or discarded. Yearly maintenance shall include an inspection for potential breaks, a thorough washing, and a finish oiling.

5.6.7 V-Notch and Rectangular Weir Plates

These plates shall be cleaned and examined before and after each field installation. Construction and condition of weir plates shall conform to recognized standards (2). The plates shall be cleaned with a soapy wash water, followed by a distilled water rinse. The weir plates will be inspected to insure that the upstream edge of the plate remains sharp.

5.7 REFERENCES

1. Water Measurement Manual, Second Edition, Revised, United States Department of Interior, Bureau of Reclamation, 1974. Available from the United States Government Printing Office, D.C. 20402.

2. NPDES Compliance Inspection Manual, United States Environmental Protection Agency, May 1988.

3. Fluorometric Facts, Flow Measurements, Nomograph, Turner Designs Company: Mountainview, California, 1976.

4. "Measurement of Discharge by Dye Dilution Methods," Hydraulic Measurement and Computation, Book 1, Chapter 14, United States Department of the Interior, Geological Survey, 1965.

5. King, H. W., and E. F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw-Hill; New York, 1976.

6. Davis, C. V., and K. E. Sorenson, Handbook of Applied Hydraulics, Third Edition, McGraw-Hill: New York, 1969.

7. Stevens Water Resource Data Book, Third Edition, Leopold Stevens, Inc.: Beaverton, Oregon, 1978.

8. ISCO Open Channel Flow Measurement Handbook, Second Edition, Second Printing, Instrumentation Specialists Company: Lincoln, Nebraska, 1985.

9. "Discharge Measurements at Gaging Stations," Hydraulic Measurement and Computation, Book I, Chapter 11, United States Department of Interior, Geological Survey, 1965.

10. "Sewer Flow Measurement: A State-of-the-Art Assessment," Municipal Environmental Research Laboratory, Office of Research and Development, U. S. Environmental Protection Agency: Cincinnati, Ohio, 600-275027.

11. A Guide to Methods and Standards for the Measurement of Water Flow, United States Department of Commerce, National Bureau of Standards, NBS Special Publication 421, 1975.

12. Wells, E. A. and H. B. Gotaas, "Design of Venturi Flumes in Circular Conduits," American Society of Civil Engineers, 82, Proc. Paper 928, April 1956.

13. American Society of Testing Materials, 1985 Annual Book of ASTM Standards, Volume 11 - Water, American Society of Testing Materials: Philadelphia, Pennsylvania, 1985.

6.0 FIELD ANALYTICAL PROCEDURES

6.1 GENERAL

Field analytical equipment used by Branch personnel should be suitable for the analysis to be accomplished and properly calibrated. In addition to being accurate, field analyses must be conducted on a sample which is representative of the source from which it was collected. Therefore, the type of sample and location of the sampling site are critical. A detailed discussion of sample type and sample site selection is given in Section 4 for the various media investigated by Branch personnel.

The objectives of this section are to:

- list the specific field analytical techniques that shall be used by Branch personnel;
- list the specific quality control procedures and calibration techniques for each piece of field analytical equipment used by Branch personnel;
- list the source of all reagents and standards used to perform field analyses and/or calibrate field analytical equipment; and
- specify the training required of Branch personnel to perform the listed field analyses.

Specific field analytical methodology for each parameter is given in Appendix D.

6.2 SPECIFIC ANALYTICAL TECHNIQUES

The specific field analytical techniques used by Branch personnel are listed below and the specific procedures for each analytical technique and field test are presented in Appendix D.

Analytical Parameter	Method	Reference	Equipment
Temperature	Calibrated glass (mercury), dial (mechanical), or electrometric thermometer	1	Mercury filled glass, mechanical dial type thermometer, or thermistor with electronic readout
pH	Electrometrically using a glass electrode in combination with a reference potential or a combination electrode	1	Portable field pH meter
Dissolved Oxygen (DO)	Modified Winkler or membrane electrode	1	Standard DO kit with fresh sodium thiosul-

			fate, or membrane electrode and electronic readout
Specific Conductance	Wheatstone bridge type or equivalent meter corrected to 25_oC	1	Self-contained conductivity meter, Wheatstone bridge type, or equivalent with automatic temperature compensation to 25_oC or "dial in" temperature compensation
Total Chlorine Residual	Back titration, iodometric with starch or amperometric end-point or DPD colorimetric	1	Iodometric backtitration kit with fresh reagents, or amperometric titrator with fresh reagents, or DPD kit with color standards
Tracer-Fluorescence	Analysis of fluorescent dyes using a fluorometer	2	Rhodamine WT dye and Turner fluorometer
Salinity	Electrodeless Inductive Conductivity Cell Salinometer	3	Beckman RS5-3 Portable Salinometer and Hydrolab Surveyor II Meter

6.3 SPECIFIC QUALITY CONTROL PROCEDURES

Quality assurance procedures for field analysis, and field analytical and test instrumentation calibration are an essential part of these standard operating procedures. All field analytical procedures shall be conducted in duplicate at least 10 percent of the time. A record of these duplicate analyses shall be kept in field logbooks. A significant difference in the replicate analyses (greater than specified in the following sections) shall result in recalibration of the instruments used, re-examination of the analytical methodology being used, or re-examination of the sampling location.

All field analyses must be traceable to the specific individual performing the analyses. Time records shall be kept in local time using the military 2400 hour format and shall be recorded to the minute. This information shall be entered into the field logbooks for all field analyses performed by Branch personnel.

A specific calibration and/or standardization plan for all field analytical equipment is presented in this subsection. Included in this plan are: calibration and maintenance intervals; listing of required calibration standards and conditions requiring recalibration.

6.3.1 Temperature

6.3.1.1 Initial Calibration -- All thermometers shall be initially calibrated against a National Bureau of Standards (NBS) certified thermometer or one traceable to NBS certification.

6.3.1.2 Inspection and Calibration -- Each glass mercury filled thermometer shall be inspected before each field trip to see that it is not cracked and has no air space in the mercury column. If a mechanical dial-type thermometer is used, it should not have a broken face cover or otherwise show damage. A cross-check with a calibrated NBS certified thermometer shall be made at least semi-annually. Thermistors and electronic readout units should be calibrated in the same manner. Recording thermometers shall be checked for recording accuracy before each use. The recorder time scale accuracy shall be checked semi-annually. Before using a thermometer in the field, a visual observation shall be made to assure that it has not been damaged. If a thermistor is used, the instrument shall be checked against a thermometer before field use. Cross-checks and duplicate field analyses should agree within $\pm 0.5^{o}C$.

6.3.1.3 Calibration Records -- A logbook shall be maintained with each thermometer number and/or equipment property number recorded. All calibration information including individuals making the calibrations and dates of calibration shall be recorded.

6.3.1.4 Reporting Units -- Report all temperature data to the nearest $0.5^{0}C$.

6.3.2 pH

6.3.2.1 Equipment -- Only electronic (portable) pH meters with automatic temperature compensation (ATC) should be used. Temperature resistant, combination electrodes should be employed in conjunction with the meters. pH test paper will be used only for determining pH ranges, for determining approximate pH values, or for concentrated hazardous waste samples which would damage the instrument.

6.3.2.2 Equipment Inspection and Calibration -- The pH meter shall be checked before each field trip for any mechanical or electrical failures, weak batteries, and cracked or fouled electrodes. The slope of the meter shall also be checked initially with three fresh standard buffer solutions (e.g., 4, 7, and 10). All pH recorders shall be checked for recording accuracy and time scale accuracy. While in the field, the meter shall be calibrated daily before use with two buffers bracketing the expected sample pH. Thereafter, the meter shall be checked against two buffers when moving to a new sample location. Fresh buffer solutions shall be used for each field trip. In case of an apparent pH violation, the electrode shall be checked with pH 7.0 buffer and recalibrated to the closest reference buffer. Then the sample shall be retested. Duplicate tests should agree within 0.1 standard unit.

6.3.2.3 Reporting Units -- Report pH to the nearest 0.1 standard unit.

6.3.3 Dissolved Oxygen (DO)

6.3.3.1 Equipment -- Modified Winkler kits and membrane electrode DO meters should be used.

6.3.3.2 Equipment Inspection and Calibration -- DO meters shall be checked before each field trip by inspecting the membrane for air bubbles and holes. If the membrane is dry, it shall be replaced and soaked in water before calibrating. Calibration should be made against the modified Winkler test.

DO kits shall be refilled with new standardized sodium thiosulfate before each field trip. Each solution shall be checked for clarity and volume.

Before using the DO meter each day, duplicate deionized or known clean water samples shall be collected by siphoning water from a bucket into two DO bottles. These duplicate samples shall be analyzed by the modified Winkler test for DO content. The DO meter shall be calibrated against the DO content measured by the Winkler test by placing the DO probe in the bucket containing the water used for the Winkler test.

While using the DO meter, the instrument shall be recalibrated at least twice per day or if a change in water quality is noted. If the sample temperature is 5^0C greater than the calibration temperature, the meter shall also be recalibrated.

Duplicate analyses should agree with $\pm$ 0.1 mg/l.

6.3.3.3 Reporting Units -- Results for the DO test should be reported to the nearest 0.1 mg/l.

6.3.4 Specific Conductance

6.3.4.1 Equipment -- A portable specific conductance meter, Wheatstone bridge type or equivalent should be used.

6.3.4.2 Inspection and Calibration -- Each conductivity meter shall be checked before each field trip. Batteries shall be checked, and conductivity cells shall be cleaned and checked against known conductivity standards (KCl).

6.3.4.3 Field Calibration -- Before using in the field, check instrument daily with known standards. Refer to the instrument instructions for temperature conductance calculations. Duplicate field analyses should agree within $\pm$ 10 percent.

6.3.4.4 Reporting Units -- Results should be expressed in micromhos/centimeter (umhos/cm) corrected to 25^0C. Results should be reported to the nearest ten units for readings under 1,000 umhos/cm and the nearest 100 units for readings over 1,000 umhos/cm.

6.3.5 Total Chlorine Residual

6.3.5.1 Equipment -- The iodimetric back titration method with a starch-iodide end point or amperometric end point or a Hach DR 100 colorimetric (DPD) kit may be used.

6.3.5.2 Inspection and Calibration -- Each titration kit or meter shall be checked before each field trip by inspecting the meter for battery strength and fresh reagents. The normality of the iodate should be checked with a distilled water blank to establish a correction factor for the titrant. This will also serve to check the response of the amperometric titrator. Duplicate chlorine residual analyses should agree within ± 0.01 mg/l.

If the Hach DR 100 colorimeter (DPD) kit is used, the method must agree with the requirements of Method 408E, "Standard Methods," 16th Edition, or Method 330.5 "Methods for Chemical Analysis of Water and Wastes," and calibration scales must be calibrated on site at a minimum of three points (blank and two standards) that bracket the expected sample concentration.

6.3.5.3 Reporting Units -- Results should be reported to the nearest 0.01 mg/l residual chlorine.

6.3.6 Fluorescent Tracing

6.3.6.1 Tracer -- Rhodamine WT dye is the standard tracer used by Branch personnel.

6.3.6.2 Fluorometer -- A filter fluorometer (fluorometer) is the instrument used to determine intensity of emitted light or concentration of dye in the sample.

6.3.6.3 Fluorometer Calibration and Calibration Standards -- Before a fluorometer is used in the field, it shall be checked against a set of standard dye solutions. All standard concentrations shall be made relative to the stated concentration of the manufacturer's solution.

All standard solutions shall be made with distilled water. Sufficient solution volumes shall be made to permit calibration checks. Calibration checks shall be conducted whenever the fluorometer has been turned off for an extended period of time.

The fluorometer and all associated equipment shall be thoroughly cleaned between uses.

6.3.6.4 Reporting Units -- Turner Design fluorometer results shall be reported as ± 1 percent of full scale concentration.

6.3.7 Salinity

6.3.7.1 Equipment -- A portable salinometer, electrical conductivity type shall be used.

6.3.7.2 Inspection and Calibration -- Each salinometer shall be checked before every field trip. Batteries shall be checked and the cell inspected to determine if it is free of marine growth and salt. The meter shall be checked against the resistor loop supplied with the meter.

6.3.7.3 Reporting Units -- Results should be reported to the nearest 0.1 part per thousand of salinity.

6.4 SEMI-ANNUAL MAINTENANCE

All analytical and test instruments and kits shall be inspected on a semiannual basis, whether used during the intervening period or not. The purpose of the semi-annual inspection is to maintain the equipment in a ready-to-use condition. This inspection shall consist of a general examination of the electrical system (including batteries) and a calibration against standards. Any expired reagents, broken glassware, or parts shall be replaced.

6.5 SOURCES OF CHEMICALS AND STANDARDS

All chemicals used in test kits and with field analytical instruments as reagents and standards shall be supplied and standardized by the Analytical Support Branch (ASB). Certified pH buffer solutions shall be purchased from chemical supply houses. All reagents and solutions shall have expiration dates attached to the containers. All out-of-date reagents, buffers, and chemical solutions shall be properly disposed of at their expiration date. All field reagent containers shall be identified with the chemical name, concentration, and date prepared.

Tracer-fluorescence standards will be prepared for each study using the actual tracer as outlined in Appendix D.9.

6.6 TRAINING

Each member of the Branch involved in field studies shall undergo an initial review of field analytical and test procedures and equipment. After the initial review, subsequent reviews shall take place annually. The Branch Quality Assurance Officer, in conjunction with personnel from the ASB, shall conduct the instruction. Any new instrumentation adopted by the Branch will be introduced to Branch personnel in a training session before it will be authorized for routine use.

6.7 REFERENCES

1. "Guidelines for Establishing Test Procedures for the Analysis of Pollutants," Federal Register, Volume 49, No. 209, 40 CFR 136, October 26, 1984, and any subsequent revisions.

2. Wilson, J. F., Fluorometric Procedures for Dye Tracing: USGS Techniques of Water-Resources Investigations, Book 3, Chapter A12, United States Department of Interior, Geological Survey, 1968.

3. Standard Methods for the Examination of Water and Wastewater, 1985, 16th Edition.

4. Methods for Chemical Analysis of Water and Wastes, EPA, 600/4-79-020, and all current revisions.

7.0 FIELD PHYSICAL MEASUREMENTS

7.1 GENERAL

Field measurements of topographic features, water levels, time of travel, geophysical parameters, and physical dimensions are frequently required during comprehensive water quality, groundwater, hazardous waste, wastewater treatment system, and related field investigations conducted by the Branch. The scope of such measurements obviously depends on the purpose of the particular investigation.

All sampling locations used during Branch field investigations shall be depicted on an accurate drawing or a topographic or other standard map, or be referenced in such a manner that their location(s) are firmly established. The Region IV library has a complete collection of 7.5 minute USGS (1:24,000 scale) topographic maps and a map copier available.

Each field measurement made by Branch personnel shall be traceable to the actual person making the measurement and to the field equipment used to make that measurement. All equipment maintenance and calibration records shall be kept in log books and field records so that all such procedures are traceable. All time records shall be kept in local time using the 2400 hour format, and time shall be recorded to the nearest minute.

New Branch employees shall perform each of the physical field measurements described in this section under the supervision of a senior technical staff member at least once before being permitted to make these measurements on their own.

The specific objectives of this section are to:

- present the standard practices used by the Branch to make physical field measurements;
- list the field equipment utilized to make such measurements: and
- present specific quality control procedures to insure that such measurements are accurate.

A. SURVEYING (HORIZONTAL CONTROL)

7.2.1 General

Surveying is described as the art and science of determining the area and configuration of portions of the earth's surface, and representing them on maps. Generally, surveying can be divided into two categories or classes: horizontal control surveying and vertical control surveying. Horizontal control surveying pertains to the measurement of the relative difference in the horizontal location of two or more control points. Vertical control surveying involves the measurement of the relative difference in vertical location, or elevation, of two or more control points and is treated separately in Section 7.3. This Section discusses the standard procedures and techniques used by the Branch to survey, or locate sample points or site features horizontally. Basic surveying and field geology textbooks should be consulted for more detailed information on this topic (1, 2, 3).

7.2.2 Introduction

Several field methods may be used to horizontally locate sample points or various site features during hazardous waste site investigations and/or other site investigations that may result in enforcement actions. Traverse methods used by the Branch utilize horizontal angle or direction (azimuth/bearing) measurements and calculated horizontal distances from a starting point to a second point, and from the second to the third, and so forth to the last point. The last point in a traverse is usually a return to the starting point, thus making a closed loop. During a traverse for site control, sample points or site features may be located by employing various techniques at the traverse control points, i.e., by angle (azimuth or bearing) and distance measurements from a control point, by angular intersection from two control points, by perpendicular offset from a line between two control points, by angle from one control point and distance from another control point, etc. (1).

Regardless of the method(s) used, surveying by the Branch should be based on established control points. A network of horizontally (and vertically) located control data points has been established and is continually maintained by the National Oceanic and Atmospheric Administration (NOAA) through its National Ocean Survey (formerly U. S. Coast and Geodetic Survey). The system of horizontal control points, or Triangulation Stations, have established latitude and longitude positions and provide the basis for the coordinate grid systems used by many States (1, 2).

When measuring horizontal angles, compensation must be made for the angle between true north and magnetic north. This angle is called the magnetic declination. Branch field surveying methods must be referenced to true north. The first step in this procedure is to determine from an isogonic map, the declination for the area of work. Isogonic maps may be found in basic surveying and field geology textbooks referenced above.

Sources of existing information on triangulation stations or coordinate grid data and their exact locations may be obtained from local, state or federal departments or agencies. Typically, the engineering or public works departments of counties, cities or towns may have data on file that is near the particular site being investigated. State or federal agencies which are good sources of useful data include: (1, 2, 3)

- State highway or transportation departments
- State geodetic or land surveying offices
- State natural or water resources bureaus
- State geological surveys
- NOAA/National Ocean Survey
- United States Geological Survey
- Corps of Engineers, Department of the Army
- Soil Conservation Service
- Tennessee Valley Authority
- Bureau of Land Management

When the exact locations of sampling points or other physical features at a site are needed, Branch surveying methods must be based on existing control data. In all cases, the site property boundary survey, description, and any physical property corners or monuments must be located by a professional Registered Land Surveyor (RLS). Often times, before or when the surveyor is at a site, the registered surveyor can be requested to set control data points for Branch use. At a minimum, the registered land surveyor will be asked to establish at least two control points upon which the elevation and Universal Transverse Mercator (UTM) coordinates are set. The data on control points shall be of at least third-order accuracy. The control points will be permanent markers set at locations that are unlikely to be disturbed by future site activities.

If no existing control data exists in the site vicinity, an arbitrary point may be established at a permanent location, e.g., set a nail or spike beneath the ground or set a nail and cap in asphalt or foundation. However, the coordinates for that point (and, therefore all other points) should be determined at a later

date. As with all Branch field work, the location of all control data used and all field measurements shall be recorded in the field logbook as outlined in Section 3.5.

7.2.3 Equipment Available

The following Branch equipment is available for field use in conducting surveying in support of site investigations:

- Topcon GTS-2, total station theodolite/electronic distance meter (EDM)
- tripod(s)
- reflector prism(s)
- range pole
- steel tape
- cloth tape
- optical tape measure
- Rola tape
- compass

7.2.4 Specific Equipment Quality Control Procedures

All field surveying methods using Branch equipment shall be made only by those Branch personnel who have been trained to use them. All Branch professional staff and field technicians must be trained and checked out in surveying procedures by qualified staff before using this equipment.

Each piece of field equipment (as appropriate) shall be numbered, and a log book shall be kept containing all maintenance and calibrations made on the equipment. The following specific maintenance and calibration procedures shall be used for all surveying equipment:

7.2.4.1 Theodolite -- This equipment shall:

- be serviced and calibrated by a qualified private service shop annually or sooner if damaged or suspected to be in error;
- be checked out using procedures outlined in basic surveying textbooks and appropriate users manuals before use (1, 2, 3); and
- be cleaned and maintained using procedures outlined in basic surveying textbooks and appropriate users manuals during field use and before being returned to storage (1, 2, 3).

7.2.4.2 Steel and Cloth Measuring Tapes, and Mechanical Rola-Tape -- The following procedures shall be used for all measuring tapes:

- All measuring tapes and the mechanical Rola-tape will be calibrated annually against an Invar steel surveyors chain or the theodolite/EDM both of which are traceable to the National Bureau of Standards (NBS). Those steel tapes that are not within 0.01 foot per 100 feet or cloth tapes not within 0.02 foot per 100 feet shall be discarded. The

7.2.4.2 Steel and Cloth Measuring Tapes, and Mechanical Rola-Tape -- The following procedures shall be used for all measuring tapes:

- All measuring tapes and the mechanical Rola-tape will be calibrated annually against an Invar steel surveyors chain or the theodolite/EDM both of which are traceable to the National Bureau of Standards (NBS). Those steel tapes that are not within 0.01 foot per 100 feet or cloth tapes not within 0.02 foot per 100 feet shall be discarded. The shorter carpenter-type steel tapes (6-12 feet) shall also check within 0.01 foot or they will be discarded.

- All tapes shall be checked to see that they are not damaged and are clean before and after use.

7.2.4.3 Optical Tape Measure -- Each Branch employee using the optical tape measure shall become proficient in its use by measuring known distances before using this equipment in the field.

7.2.4.4 Compass -- All compasses shall:

- be checked for proper movement of the compass meddle. If the compass needle movement is sluggish, the glass cover can be removed by prying a knife point under the spring washer. The copper wire on the needle is then moved until the needle lies level (3);

- be checked for proper alignment of clinometer level. The clinometer is checked by setting the clinometer to 0, and placing the compass on a surface that has been leveled exactly with either a carpenters level or a water tube level. If the horizontal level bubble on the clinometer does not rest at the center, the compass is opened as described above and the clinometer level vial is moved and rechecked as appropriate. If the level vial becomes broken, the compass must be sent to the manufacturer to be repaired (3); and

- be cleaned after use and before storage. If the compass should become wet, the compass is opened as previously described and the interior is dried using a toothpick and a piece of soft cloth or soft paper. They should not be used, exposed to or stored in strong electrical fields (3).

7.2.4.5 Range Poles and Reflector Prisms -- All of this equipment shall:

- be checked for warpage and/or damage before use by sighting through the theodolite/EDM while the poles/prisms are rotated in two planes at 90° intervals. The bullseye bubble will be reset as appropriate; and

- be cleaned daily after use and before being returned to storage.

7.2.5 Procedures for Traversing

When traverse methods are used, at least two stations or control points of known horizontal location (expressed in terms of UTM coordinates and/or the local State coordinate system) must be in the site vicinity. These control points can usually be set for the specific site by a governmental agency or registered land surveyor.

The total station theodolite, which measures horizontal angles, vertical angles, and slope distances, is set up over an existing control point. The theodolite is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads appropriately. Once the bullseye bubble is centered, the theodolite is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The instrument is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman has either a range pole equipped with a reflector prism (single or triple) or a tripod with the reflector prism. The prism is used to reflect the signal from the electronic distance meter in the total station theodolite. While located over the point(s) whose location is desired, the rodman holds the range pole vertically by means of centering the bullseye bubble, or sets up the tripod and reflector prism similarly as stated above. The instrument man sights through the telescope on the theodolite, lines up the horizontal and vertical cross-hairs on the center of the prism and records the horizontal angle (Ah), vertical angle (Av), and the slope distance (Ds) to the prism. The difference in location between the point where the theodolite is set up and the point where the prism is held is determined trigonometrically. A compass and measuring tape could also be used to reference field measurements to a map or vice versa.

The following examples depict some of the field measurements that must be considered and accounted for, the calculations that must be performed, and the conversions that must be made when the Branch uses traverse methods to horizontally locate sampling points or other site features.

EXAMPLE 1: Figure 7.2.1. Horizontal Angle (map view).

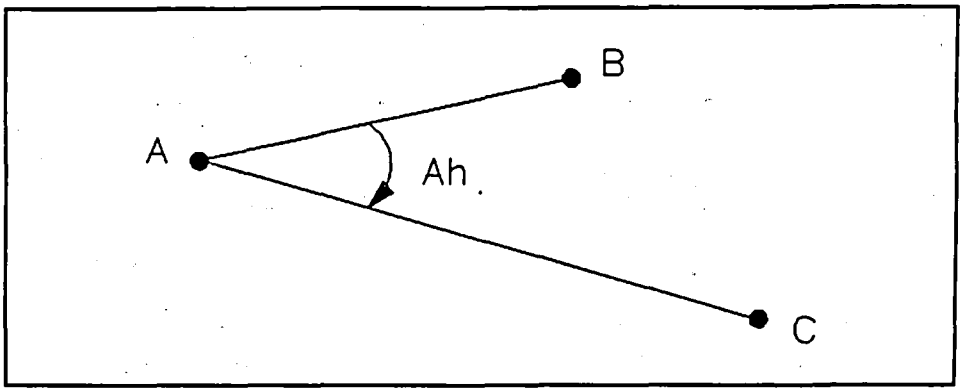
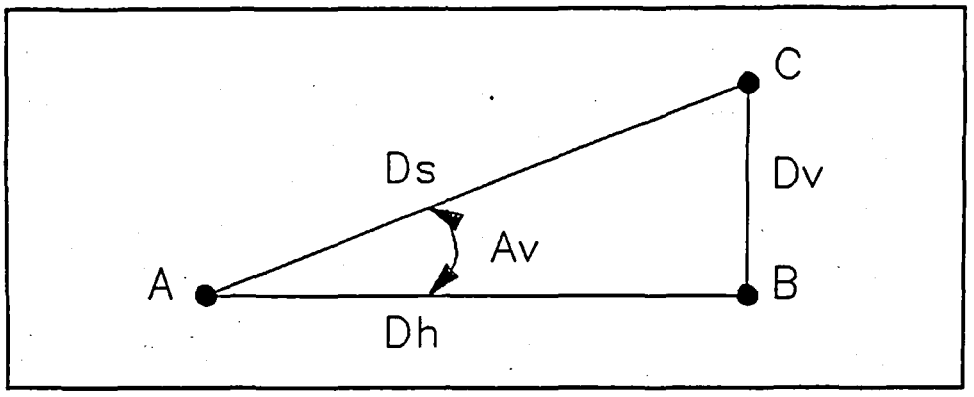


Figure 7.2.1 illustrates that while the instrument is at point A (a control point), one reads the backsight angle (azimuth or bearing) to point B, then turns and measures the foresight angle (azimuth or bearing) to point C. The difference between the two angles is the interior angle included at the intersection of line AB and line AC, or the horizontal angle (Ah).

The field notation for the measurement of the angle above would be represented as angle B-A-C. Typically, the first column to the left in the field book is labeled: (BS - ⊤ - FS) or Station and the second column is labeled Ah (see Example 5 Field Notation).

EXAMPLE 2: Figure 7.2.2. Vertical Angle (side view).



After the horizontal angle is determined, the vertical angle (Av) is measured, in Figure 7.2.2, from point C to point B to determine the angle between the line of sight AC and the horizontal line AB. The vertical angle is the included angle between a line connecting two points of different elevations and a line horizontal to the earths gravity.

To determine the height of the point C, measure the slope distance (Ds) with the electronic distance meter from A to C. Using the theodolite or transit, measure the vertical angle between line AC and AB. The height of point C would be obtained by the formula:

$$Dv = (\sin Av)\ Ds$$

The horizontal distance (Dh), which is the distance used when drawing the map, would be obtained by the formula:

$$Dh = (\cos Av)\ Ds$$

If the vertical distance to be measured was to the top of a building, tree, or other point where the measurement of the slope distance is impractical, simply measure the horizontal distance and determine the height by:

$$Dv = (\tan Av)\ Dh$$

The field notation for the third column from the left in the field book is labeled: Av and the forth column is labeled Ds/Dh (see Example 5 Field Notation).

EXAMPLE 4: Coordinates.

When the local State rectangular grid coordinate points near a particular site are obtained, Branch personnel should be able to convert rectangular coordinates to polar coordinates. This is important since through this conversion, the azimuths and distances between each point can be obtained and then used as the starting control points for the site control traverse. Simple programmable or non-programmable calculators are extremely useful in providing precise results from the field surveying measurements. The following is an example of a conversion from rectangular to polar coordinates:

The instrument is set up at TP1, and given the rectangular coordinates:

Control Point	North (y)	East (x)
TP1	7935.07	6178.78
MCT3	7851.75	6209.99

The relative change in location between the north and east coordinates (from TP1 to MCT3), respectively, are:

$$\Delta N = -83.32, \quad \Delta E = 31.21$$

The negative symbol for ΔN indicates the relative movement from TP1 to MCT3 downward (-) along the y axis. The positive symbol for ΔE indicates relative movement from TP1 to MCT3 to the right (+) along the x axis. Solving for the formula (Pythagorean theorem):

$$c^2 = a^2 + b^2$$

The resulting distance between TP1 and MCT3 is c = 88.97'.

The azimuth is obtained by first computing the inverse tangent of the change in north divided by the change in east:

$$\tan^{-1} (\Delta N \div \Delta E) = -69.4651°$$

This is the negative angle, expressed in decimal degrees, and is measured from the (x) axis into the southeast quadrant. The azimuth from TP1 to MCT3 is obtained, in this case, by changing the sign (- to +) and adding 90° and then converting to degrees, minutes, and seconds. The resulting azimuth from TP1 to MCT3 is 159°27'54".

Note: The trigonometric formula above always gives the angle measured from the (x) axis. When using this procedure, it is wise to make a sketch showing the change in direction between the points relative to north. This will aid in visually and mentally seeing which geometric quadrant that the foresight angle falls in relation to the instrument.

EXAMPLE 5: Figure 7.2.4. Traverse Field Notation.

The following is an example of the field notation for a traverse to horizontally locate sampling points. Figure 7.2.5 shows some of the physical features, sampling points, and traverse control points that should be sketched on the right hand side of the field log book. The coordinates for each point are then determined and usually entered in red ink after the traverse is finished.

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Region IV Site Name
City, State

Pg. 1 of 2
Landis Surveyor - ⊤
Ben Chmark - ⊥
Weather: Clear; 0-5 mph N

-Set traverse points around property to locate the 5 monitoring wells that were recently installed.

Given: TP1: N=7935.07, E=6178.78
MCT2: N=8297.79, E=6598.14
MCT3: N=7851.75, E=6209.99

TP1 to MCT3 : $\Delta N=-83.32$ $\Delta E=31.21$

$$c^2 = a^2 + b^2, \quad c = 88.97'$$

$$\tan^{-1} (\Delta N + \Delta E) = -69.4651$$

$\therefore$ Azimuth TP1 to MCT3 = 159°27'54"

(BS - ⊤ - FS) Station	Ah	Av	Ds / Dh	Coordinates	Remarks/Comments
MCT3-TP1-	Set: Ah= 159°27'54"	90°45'24"	88.98' 88.97'	N=7935.07 E=6178.78	Notes: Instrument (⊤) is set up at TP1, back sight (BS) to MCT3 and set instrument to read 159°27'54".
MCT3-TP1-A	125°26'18"	89°44'06"	502.64' 502.635'	N=7643.63 E=6588.30	Set nail in ground for point A.
MCT3-TP1-MW5	124°09'12"	90°07'21"	375.58' 375.58'	N=7724.22 E=6489.59	Locate MW5.
TP1-A-	Set: Ah= 305°26'18"	--------			Instrument at A, back sight to TP1 and set the reciprocal azimuth, i.e. add 180°.
TP1-A-B	228°00'54"	90°32'54"	470.94' 470.94'	N=7328.60 E=6238.24	Set nail for point B.
A-B-	Set: Ah= 48°00'54"	--------			Reciprocal azimuth as above.
A-B-MW2	343°55'21"	90°21'54"	113.68' 113.68'	N=7437.83 E=6206.76	Locate MW2.
A-B-C	300°46'27"	89°59'54"	762.46' 762.46'	N=7718.72 E=5583.14	Set point C.

EXAMPLE 5: Figure 7.2.4. Traverse Field Notation (continued).

{)-«ᴅ<"^'!-·-´¯£¡¯B)-«ᴅ<"^'!-·-´¯£¡¯B)-«ᴅ<"^'!-·-´¯£¡¯B)-«ᴅ<"^'!-·-´¯£¡¯B)-«ᴅ<"^'!-·-´¯£¡¯B)-«ᴅ<"^'!-·

EXAMPLE 5: Figure 7.2.4. Traverse Field Notation (continued).

01/23/90 Project 90E-000
Region IV Site Name
City, State

Pg. 2 of 2
Landis Surveyor - T
Ben Chmark - ↑
Weather: Clear; 0-5 mph N

Station	Ah	Av	Ds / Dh	Coordinates	Remarks/Comments
B-C-	Set: Ah= 120°46'27"	--------			Reciprocal azimuth.
B-C-D	14°40'24"	89°49'39"	698.34' 698.34'	N=8394.28 E=5760.03	Set point D.
B-C-MW1	24°11'21"	90°21'12"	132.96' 132.96'	N=7840.01 E=5637.62	Locate MW1.
B-C-MW3	26°50'36"	89°44'45"	612.76' 612.754'	N=8265.45 E=5859.83	Locate MW3.
C-D-	Set: Ah= 194°40'24"	--------			Reciprocal azimuth.
C-D-E	67°36'15"	90°03'48"	715.66' 715.66'	N=8666.95 E=6421.71	Set point E.
C-D-MW3	142°17'51"	89°45'03"	163.14' 163.14'	N=8265.20 E=5859.80	Locate MW3 (again, just in case).
D-E-	Set: Ah= 247°36'15"	--------			Reciprocal azimuth.
D-E-MCT2	154°27'09"	90°04'33"	409.08' 409.08'	N=8297.87 E=6598.13	Actual: N=(8297.79), E=(6598.14).
E-MCT2	Set: Ah= 334°27'09"	--------			Reciprocal azimuth.
E-MCT2-A	180°51'42"	89°36'24"	654.28' 654.265'	N=7643.68 E=6588.30	Coordinates first computed to be: N=(7643.63), E=(6588.30).
E-MCT2-MW4	249°56'39"	88°32'48"	85.66' 85.63'	N=8268.50 E=6517.69	Locate MW4.
MCT2-A-	Set: Ah= 360°51'42"	--------			Reciprocal azimuth.
MCT2-A-TP1	305°26'18"	--------	------ (502.635')	N=7935.12 E=6178.78	Should have ended at: N=(7935.07), E=(6178.78).
MCT2-A-MW5	309°13'33"	91°10'36"	127.50' 127.47'	N=7724.29 E=6489.55	Locate MW5 (again, just in case).
					Closure: Σ Dh=4,716.015 N Dh=0.0466', E Dh=0.00'

Figure 7.2.3 - EXAMPLE OF SITE MAP SHOWING TRAVERSE POINTS USED TO LOCATE MONITORING WELLS

Figure available upon request.

7.3 ELEVATION SURVEYS (VERTICAL CONTROL)

7.3.1 Introduction

The field of surveying that pertains to measuring the relative differences in elevation of two or more points is called "running levels" or "Leveling". The two most commonly used methods are Differential Leveling and Trigonometric Leveling. Differential leveling is the most precise and easiest method because it utilizes "level" measurements with simple addition and subtraction. Trigonometric leveling is slightly less precise and more difficult as it uses vertical angle and distance measurements combined with the principles of trigonometry. Differences in elevation can also be determined from controlled altimeter measurements by the method called Barometric Leveling. However, the altitude (elevation) readings are not as precise as elevation measurements obtained from differential or trigonometric leveling since most altimeters permit readings to within about 5 feet of the actual elevation. This subsection discusses the standard procedures and techniques used by the Branch to obtain differences in elevation and are described in more detail in basic surveying and field geology textbooks (1, 2, 3).

Regardless of the method(s) used, elevation surveys by the Branch should be based on established control points. A network of vertically located control data points has been established and is continually maintained by the National Oceanic and Atmospheric Administration (NOAA) through its National Ocean Survey (formerly U. S. Coast and Geodetic Survey). The system of vertical control points, or Benchmarks (B.Ms.), are referenced to a surface of fixed and precisely known elevation above mean sea level and is referred to as the datum or datum plane. The datum for vertical control (elevation) is called the National Geodetic Vertical Datum (NGVD), formerly known as the 1929 sea level datum, established by the U. S. Coast and Geodetic Survey (1).

Sources of existing information on benchmark data and their locations may be obtained from local, state or federal departments or agencies. Typically, the engineering or public works departments of counties, cities or towns may have data on file that is near the particular site being investigated. State or federal agencies that are good sources of useful data include: (1, 2, 3)

- State highway or transportation departments
- State geodetic or land surveying offices
- State natural or water resources bureaus
- State geological surveys
- NOAA/National Ocean Survey
- United States Geological Survey
- Corps of Engineers, Department of the Army
- Soil Conservation Service
- Tennessee Valley Authority
- Bureau of Land Management

When the exact elevations of sampling locations or other physical features are needed, benchmarks of precisely known elevation should be used when leveling. At a minimum, during the course of a site investigation, a registered land surveyor will be asked to set at least two third-order accuracy vertical control points or benchmarks. The vertical control points shall have established Universal Transverse Mercator (UTM) coordinates (see section 7.2.2) and the elevations shall be referenced to NGVD.

If no benchmark is located in the site vicinity, an arbitrary temporary benchmark should be established on a permanent location, e.g., bridge wingwall, foundation, corner post, or a nail or spike in a tree or telephone pole. However, the elevation of the temporary benchmark (and, therefore all other points) should be determined at a later date. As with all Branch field work, the location of all benchmarks used shall be shown on the site sketch map and all field measurements shall be recorded in the field logbook as outlined in Section 3.5.

7.3.2 Equipment Available

The following Branch equipment is available for field use in conducting elevation surveys in support of site investigations:

Differential Leveling

- Lietz B2C, precision automatic level
- tripod
- telescoping level rod

Trigonometric Leveling

- Topcon GTS-2, total station theodolite/electronic distance meter (EDM)
- tripod(s)
- reflector prism(s)
- range pole
- steel tape
- compass

Barometric Leveling

- Micro M-1, American Pauli System altimeter

7.3.3 Specific Equipment Quality Control Procedures

All field surveying methods using Branch equipment shall be made only by those Branch personnel who have been trained to use them. All Branch professional staff and field technicians must be trained and checked out in surveying procedures by qualified staff before using this equipment.

Each piece of field equipment (as appropriate) shall be numbered, and a log book shall be kept containing all maintenance and calibrations made on the equipment. The following specific maintenance and calibration procedures shall be used for all surveying equipment:

7.3.3.1 Theodolite/EDM, Level and Altimeter -- This equipment shall:

- be serviced and calibrated by a qualified private service shop annually or sooner if damaged or suspected to be in error.

- be checked out using procedures outlined in basic surveying textbooks and appropriate users manuals before use (1, 2, 3).

- be cleaned and maintained using procedures outlined in basic surveying textbooks and appropriate users manuals during field use and before being returned to storage (1, 2, 3).

7.3.3.2 Level Rods, Range Poles, Reflector Prisms -- All of this equipment shall:

- be checked for warpage and/or damage before use by sighting through the theodolite/EDM and lining up the two vertical cross hairs on the rod(s). The poles/prisms are rotated at 90° intervals and the bullseye bubble is reset as appropriate.

- be checked for proper alignment of the reflector prism by comparing the measurement obtained with the EDM to the measurement obtained with an Invar steel surveyors chain (see Section 7.2.4.2).

- be cleaned daily after use and before being returned to storage. Level rods should be stored in carrying tubes or a cloth slip cover to protect markings.

7.3.3.3 Steel Tape -- The procedures found in Section 7.2.4.2 shall apply.

7.3.3.4 Compass -- All compasses shall:

- be checked for proper movement of the compass needle. If the compass needle movement is sluggish, the glass cover can be removed by prying a knife point under the spring washer. The copper wire on the needle is then moved until the needle lies level (3).

- be checked for proper alignment of the clinometer level. The clinometer is checked by setting the clinometer to 0, and placing the compass on a surface that has been leveled exactly with either a carpenters level or a water tube level. If the horizontal level bubble on the clinometer does not rest at the center, the compass is opened as described above and the clinometer level vial is moved and rechecked as appropriate. If the level vial becomes broken, the compass must be sent to the manufacturer to be repaired (3).

- be cleaned after use and before storage. If the compass should become wet, the compass is opened as described above and the interior is dried using a toothpick and a piece of soft cloth or soft paper. They should not be used, exposed to or stored in strong electrical fields (3).

7.3.4 Procedures for Differential Leveling

The level, or instrument, is set up by the instrument man at a location not more than 250 feet from the benchmark and at a height above the benchmark and the next point(s). The level is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads accordingly. Once the bullseye bubble is centered, the level is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The level is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman then holds the rod as plumb (vertical) as possible on the benchmark so the instrument man can read where the horizontal cross-hair in the telescope of the level intersects the graduations on the rod. The rodman "rocks" the rod in two planes, when instructed by the instrument man, to obtain a level reading. The rod is white with large red numbers which indicate the foot-marks and smaller black numbers which indicate the tenths of feet and has black graduations the entire length which indicate hundredths of feet. The instrument man sights through the telescope and takes the first rod reading which is called a backsight (denoted BS or + in the field log book). The backsight (+) reading added to the elevation of the benchmark gives the height of the level, or instrument, (denoted H.I. in the field log book). Next the rodman holds the rod on a point (called a turning point and denoted TP) of fixed but unknown elevation such as a nail in the ground, spike in a tree or telephone pole, or the top of a fire hydrant. The instrument man then takes his second rod reading which is called a foresight (denoted FS or - in the field log book). If the foresight (-) reading is subtracted from the H.I. the result is the elevation of the point. That is, the difference between the first reading obtained from the benchmark and the second reading obtained from the point is the difference in elevation between the point and the benchmark. Note that the distance between each sighted reading shall not ordinarily exceed 250 feet with turning point backsight and foresight distances deviating no more than 50 feet from one another.

The instrument man then goes ahead of the rodman, sets the level up as stated before and takes a rod reading (backsight) from the previous turning point. The rodman then moves ahead of the instrument man for a new turning point rod reading (foresight) and so forth until the desired final point is located vertically. Once the final point is located, the instrument man breaks the set up of the level (i.e., changes the H.I.) and relevels the level. The instrument man and rodman then run levels from the last or final point to the first point or benchmark. This is called making a closed circuit or closed level loop.

When practical, leveling should be conducted to form a closed circuit. That is, the level circuit or loop should close back in close agreement to a benchmark by within 0.02 foot of the original reading or third order accuracy whichever is greater. If the level circuit does not close within these limits of accuracy, then the level circuit must be repeated until this accuracy is attained. Third order accuracy is defined by the formula: 0.05 foot × (√number of miles run), which means for a one-mile level circuit, the closure should be within five hundredths of a foot. The following is an example of field notation for differential leveling:

EXAMPLE 1: Figure 7.3.1. Field notation for differential leveling.

01/22/90 Project 90E-000
Region IV Site Name
City, State

Landis Surveyor - ∓
Ben Chmark - ∓
Weather:60's overcast; 5-10mph NW

Station/ Point	+ or BS	H.I.	- or FS	ELEV.	Remarks
B.M. 523	6.13	25.69		19.560	Top of brass cap in concrete mon. marked B.M. 523 El.=19.560'
TP01	2.10	19.58	8.21	17.48	Set nail in ground
TP02			8.39	11.19	RR spike in tele. pole NW corn. Athens St. and Georgia Ave.
MW01			6.17	13.41	Top of casing for MW01
GS01			8.88	10.70	Ground shot at MW01
WSCS			12.13	7.45	Water surface of cyprus swamp
Weir 01			10.30	9.28	Invert of weir 01 south of plant
					(Break set up to run levels back)
TP02	7.89	19.08		11.19	RR spike in tele. pole NW corner Athens St. and Georgia Ave.
T.B.M.01	6.26	20.78	4.56	14.52	Set nail in 24" Oak for temporary bench mark 01
B.M. 523			1.23	19.55	Checked to BM 523 (Off -0.01')

7.3.5 Procedures for Trigonometric Leveling

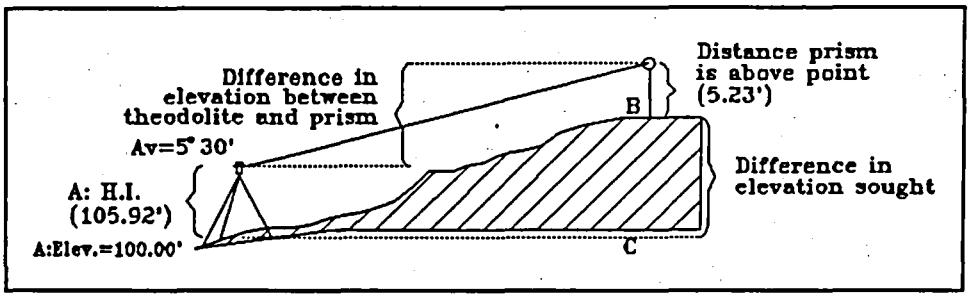
The total station theodolite, or instrument, is usually set up above a benchmark and the elevation of the instrument (H.I.) must be obtained. The theodolite is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads accordingly. Once the bullseye bubble is centered, the theodolite is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The instrument is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman has either a range pole equipped with a reflector prism (single or triple) or a tripod with the reflector prism. The prism is used to reflect the signal from the electronic distance meter in the total station theodolite. While located over the point(s) whose elevation is desired, the rodman holds the range pole level by means of centering the bullseye bubble, or sets up the tripod by means of centering the bullseye bubble with the three-screw leveling heads. The instrument man sights through the telescope on the theodolite, lines up the horizontal and vertical cross-hairs on the center of the prism and takes a reading of both the vertical angle (Av) and the distance to the prism. The difference in elevation between the theodolite and the prism is determined trigonometrically. A compass with a clinometer and a measuring tape could also be used for field measurements or as a map reference.

The following three examples graphically depict the distances that must be considered and accounted for when using the trigonometric leveling method to compute the vertical changes in elevation. The field notation for trigonometric leveling follows.

EXAMPLE 3: Figure 7.3.4. Elevation of point desired is below the instrument.

EXAMPLE 2: Figure 7.3.2. Elevation of point desired is above the instrument.



The elevation at point A in Figure 7.3.2 is 100.00 ft. The instrument is set up 5.92 ft. above point A which makes the height of the instrument (H.I.) 105.92 ft. Given a slope distance (Ds) shot to the prism (distance AB) of 323.88 ft. and a vertical angle (Av) of 5°30', the difference in elevation at point B is computed using the trigonometric formula:

elevation difference = distance AB × sin(Av)

The method described above only accounts for the relative difference in elevation between the theodolite (H.I.) and the center of the prism. The distance that the prism is held above the point in question must be subtracted from the resulting elevation of the prism to obtain the elevation of the point. Substituting in the trigonometric formula:

elevation difference = 323.88 ft. × sin(5°30') = 31.04 ft.

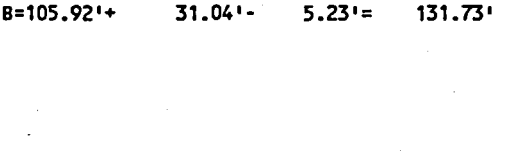
The elevation of point B is: 105.92 ft. + 31.04 ft. - 5.23 ft. = 131.73 ft.

Figure 7.3.3 Field notation for Example 2.

01/22/90 Project 90E-000
Region IV Site Name
City, State

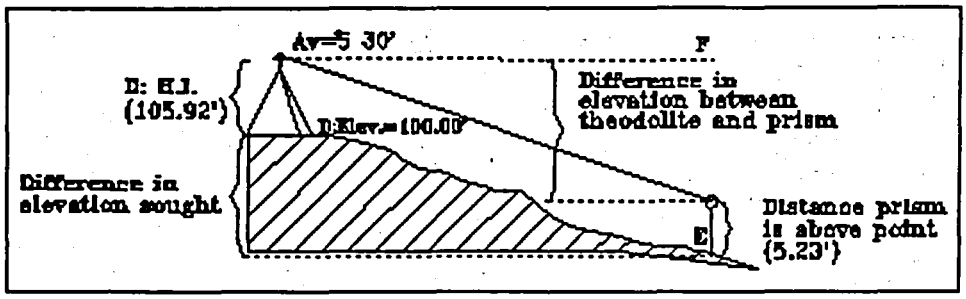
Landis Surveyor - ⊤
Ben Chmark - ⊥
Weather:60's overcast; 5-10mph NW

Station/ Point	+/Ds	H.I.	-/Av	ELEV.	Remarks
@ A	5.92	105.92		100.00	
Dist.A-B	323.88				BC = AB × sin ∠BAC = 323.88' × 0.0958 = 31.04'
V. ∠BAC			5°30'		
@ B			5.23	131.73	B=105.92'+ 31.04'- 5.23'= 131.73'



EXAMPLE 3: Figure 7.3.4. Elevation of point desired is below the instrument.

EXAMPLE 3: Figure 7.3.4. Elevation of point desired is below the instrument.



The elevation at point D in Figure 7.3.4 is 100.00 ft. The instrument is set up 5.92 ft. above point D which makes the height of the instrument (H.I.) 105.92 ft. Given a slope distance (Ds) shot to the prism (distance DE) of 323.88 ft. and a vertical angle (Av) of 5°30', the difference in elevation at point E is computed by substituting in the trigonometric formula:

elevation difference = 323.88 ft. × sin(5°30') = 31.04 ft.

The distance that the prism is held above the point in question must be subtracted from the resulting elevation of the prism to obtain the elevation of the point.

The elevation of point E is: 105.92 ft. - 31.04 ft. - 5.23 ft. = 69.65 ft.

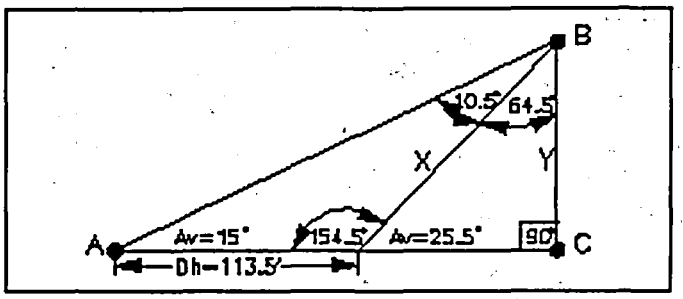
Figure 7.3.5. Field notation for Example 3.

01/22/90 Project 90E-000
Region IV Site Name
City, State

Landis Surveyor - ∓
Ben Chmark - ⊥
Weather:60's overcast; 5-10mph NW

Station/ Point	+/Ds	H.I.	-/Av	ELEV.	Remarks
@ D	5.92	105.92		100.00	D F
Dist.D-E	323.88				EF = DE × sin ∠EDF
V. ∠EDF			5°30'		= 323.88' × 0.0958 = 31.04'
@ E			5.23	69.65	E=105.92'- 31.04'- 5.23'= 69.65'

EXAMPLE 4: Figure 7.3.6. Spot elevation differences using the law of sines.



When the measurement of the slope distance is not possible, differences in elevation can be determined using the law of sines from trigonometry:

$$\frac{\sin \alpha}{a} = \frac{\sin \beta}{b} = \frac{\sin \gamma}{c} \quad \text{or} \quad \frac{a}{\sin \alpha} = \frac{b}{\sin \beta} = \frac{c}{\sin \gamma}$$

Simple spot elevation differences can be determined by taking only a few measurements. The measurements can be obtained with the total station theodolite or by using a compass (equipped with a clinometer) and a measuring tape. In the above example (Figure 7.3.6), the vertical angle (Av) is measured at two locations and the horizontal distance (Dh) between those two measurements is also measured. Since the sum of the interior angles of each triangle should equal 180°, all the other interior angles are calculated. Substituting the measurements into the law of sines and solving for x and y shown in Figure

7.3.5.5:

$$\frac{x}{\sin 15^\circ} = \frac{113.5'}{\sin 10.5^\circ} \qquad \frac{y}{\sin 25.5^\circ} = \frac{161.36'}{\sin 90^\circ}$$

$$x = \frac{(\sin 15^\circ)\ 113.5'}{\sin 10.5^\circ} \qquad y = \frac{(\sin 25.5^\circ)\ 161.36'}{1}$$

$$x = 161.36' \qquad y = 69.4'$$

Note that the method described above only accounts for the relative difference in elevation between point A and the point in question, point B. If an instrument, such as a compass or theodolite, is used at point A, the <u>H.I.</u> at point A <u>must be added</u> to the resulting elevation of the point in question. The field notation would include the figure drawing, all field measurements, and all of the calculations.

7.3.6 Procedures for Barometric Leveling

An "aneroid barometer" or altimeter is an instrument that measures variations in atmospheric pressure. Because the pressure of the earth's atmosphere varies with height above sea level, a barometer could be used to measure the approximate differences in altitude or elevation. However, atmospheric pressure also varies with changes in temperature, humidity and regional or local pressure changes caused by weather conditions. The appropriate corrections for these changes in air column temperature, humidity, and barometric pressure must be applied where maximum accuracy is desired. Humidity corrections are normally negligible, and the additional readings to compensate for humidity are of questionable value. However, temperature and barometric corrections to the altimeter readings are necessary to obtain favorable results. A complete discussion of the altimeter observation corrections as well as the theory and general procedures used in reading the American Paulin System altimeter may be found in Precision Altimeter Survey Procedures - A Comprehensive and Authoritative Treatise on Modern Altimeter Surveys, by Dr. Robert A. Hodgson. The procedures contained herein have been paraphrased from this manual with permission from the American Paulin System.

There are two types of altimeters in common use for determining differences in elevation. They are the American Paulin System altimeter and the Wallace and Tiernan altimeter. The American Paulin System surveying altimeter, used by Branch personnel, offers excellent results when third order accuracy is not of prime importance. The Branch altimeter is graduated in one-foot increments and has an operating range of -1,000 feet to +5,000 feet of altitude. The altimeter is useful when it is desirable to measure differences in elevation on mountainous or wooded terrain; where the use of cumbersome surveying equipment is prohibitive; or, as a supplemental tool used in conjunction with other surveying equipment. The altimeter could also be useful when site specific geologic mapping is necessary. A compass could be used as a field measurement to map reference.

Although the altimeter is specially constructed for rugged field use, as with all sensitive Branch equipment, reasonable care should be exercised to prevent damage to the internal parts of the instrument. The following general procedures for the "single altimeter method with temperature and barometric corrections" should be followed when reading the altimeter and when recording and computing traverse data:

7.3.6.1 Reading the Altimeter

Procedure at the Base Station (See Figure 7.3.7.)

(1) Allow approximately 10 minutes for the altimeter to adjust to the ambient temperature. (Do not place altimeter in direct sunlight at any time. Use shading when possible.)

(2) Place altimeter on the base station (typically a benchmark or other point where the elevation has been previously determined).

(3) Level the altimeter by means of the bullseye bubble on the plastic window.

(4) Balance the altimeter by turning the large pointer knob at the center of the face of the altimeter. By using the reflecting mirror and reading directly above the Balance Indicator needle, the parallax in reading can be avoided.

Note: Always balance the instrument from the positive (+) side of the window. Make sure that the Balance Indicator needle covers its own image in the mirror.

(5) After the altimeter is balanced, the pointer may be set to the desired elevation (elevation of the base station benchmark) by raising and turning the Reset Control knob. While doing this, view the Pointer from directly above (a magnifying glass is provided) so that the sides of the knife edge are not visible when the pointer is directly above the engraved elevation mark.

(6) Record the elevation of the base station, temperature (to the nearest degree), and the time of the reading.

Procedure at Subsequent Stations

(1) Place altimeter at the next station point.

(2) Level the instrument (bullseye bubble).

(3) Balance the instrument using the large pointer knob. (Do not reset small knob).

(5) Record elevation, time, and temperature.

Note: (This procedure is continued at each station. The traverse is considered to be complete by returning to the base station or other benchmark).

7.3.6.2 Recording and Computing Altimeter Data

The American Paulin System altimeter is calibrated to measure true differences in altitude when used at a temperature of 50°F (assuming no change in barometric pressure). When the average temperature of two successive temperature readings fall above or below 50°F, it is necessary to apply a temperature correction to adjust the recorded differences in elevation that are a result of temperature change. The difference in altitude between two successive stations is recorded in the field book as positive when moving from a lower to a higher station (altitude) and negative when moving from a higher to a lower station (altitude). The temperature correction takes the same sign as the difference in altitude when the average temperature is above 50°F and will take the sign opposite the sign of the difference in altitude when the average temperature falls below 50°F.

Temperature corrections can be determined by referencing the tables or graph found in Dr. Hodgson's manual. The following formula may also be used to compute the percent adjustment due to temperature change:

$$\% = (T_1 + T_2 - 100) \times 0.102$$

Example: The temperatures recorded at two successive stations are 40°F and 41°F, respectively. The uncorrected difference in altitude between the two stations is 31 feet. Substituting in the percentage adjustment formula we get:

$$\% = (40 + 41 - 100) \times 0.102 = -1.938\%$$

By multiplying the uncorrected difference in altitude by the percentage factor, we get the temperature correction given in feet:

$$-0.0194 \times 31 \text{ ft.} = -0.6 \text{ ft. (temperature correction)}$$

After the altimeter readings are corrected for temperature, the change in barometric pressure that occurred during the time of the traverse must be applied. For Branch purposes, it will be assumed, that the rate of change of barometric pressure is constant. The change in barometric pressure that occurs

during the time of the traverse is taken to be the difference between the temperature corrected reading of the last station (benchmark or other point of known elevation) and the actual elevation of that last station or benchmark. To obtain the barometric correction (C_B) for each reading, the change in barometric pressure is divided by the number of minutes in the traverse. The barometric change per minute is obtained. By multiplying this factor by the number of minutes between each station, the amount of barometric change for each station is obtained.

Certain considerations should be taken into account when using the altimeter. A sudden change in weather conditions during the time of the traverse may affect the rate of change in the local barometric pressure which could lead to incorrect barometric corrections. A change in wind velocity and turbulence could also adversely affect the recording and, therefore, the barometric correction. Generally, good altimeter traverse results can be obtained during the early morning or late afternoon. Before starting the altimeter traverse, it is a good practice to check the altimeter at two or more base stations or bench marks. This is done to insure that the altimeter is in good working order, to be certain the proper procedures are being used, and to provide a background check on the local barometric conditions. The following is an example of field notation for the above described single altimeter method traverse:

EXAMPLE 5: Figure 7.3.8. Field notation for the single altimeter method.

01/22/90 Project 90E-000 | Landis Surveyor - ⊤
Region IV Site Name | Ben Chmark - ⊥
City, State | Weather: Clear; 0-5 mph NW

No.	Remarks	Time	Reading	T (°F)	▲ in Reading	Av. Σ of Temp.	Temp. %	Cor. Total	Adj. Reading	C_B	Elevation Comp.	Elevation Actual
▲-1	BM-ESD-IV Athens	07:30	747	40°								747
					+31	40.5°	-0.6					
⊕-2	Top of waterfall	07:37	778	41°				-0.6	777.4	+2.9	780	
					+20	41.0°	-0.4					
⊕-3	Invert culvert 4	07:45	798	41°				-1.0	797.0	+6.3	803	
					-93	41.5°	+1.6					
⊕-4	Base of falls	07:55	705	42°				+0.6	705.6	+10.6	716	
					+27	42.5°	-0.4					
▲-1	BM-ESD-IV	08:05	732	43°				+0.2	732.2	+14.8		747
▲-1	BM-ESD-IV	08:15	747	45°								747
					-22	46°	+0.2					
⊕-5	Epps Bridge	08:24	725	47°				+0.2	725.2	+2.2	727	
					-5	48°	+0.02					
⊕-6	Weir W-2 invert	08:30	720	49°				+0.22	720.2	+3.6	724	
					+45	50°	0					
▲-4	BM-UGA-IV	08:37	765	51°				+0.22	765.2	+5.3	770	768
					+21	52°	+0.09					
⊕-7	Athens airport 1	08:45	786	53°				+0.31	786.3	+7.2	793	
					-75	54°	-0.6					
⊕-8	Oconee R. @ 441	08:56	711	55°				-0.29	710.7	+9.8	721	
					+24	55.5°	+0.3					
▲-9	BM-ESD-IV	09:05	735	56°				+0.01	735.0	+12.0		747

7.4 AERIAL IMAGERY

7.4.1 General

Aerial imagery is unique and distinct from the other field measurement tools and procedures discussed in this manual. However, it is frequently an invaluable supplement to field studies. It records a great deal of detail that can provide a guide for other field measurements as well as historical documentation of conditions at the time of acquisition.

Aerial imagery is obtained and interpreted using state-of-the-art techniques to the extent justifiable for the intended use. Photographic interpretation is by its nature, very subjective at times. When an interpretation is questionable, the opinions of several photographic analysts will be solicited. Environmental interpretation, where natural features have been slightly modified by man, is much more subjective than military interpretation, where definite, man-made features are sought out. Therefore, where environmental interpretations are not clear-cut, they should be used only as tentative findings to be further verified or modified by subsequent field investigations.

7.4.2 Litigation

Several limitations apply to photographic missions for the specific purpose of collecting evidence to be used in litigation.

- The military services cannot be used for such purposes (4).
- If a court injunction prohibiting trespassing is in effect against EPA, a search warrant must be obtained for the overflight.
- Even in the absence of a court injunction, if the case is in litigation or in the preparation for likely litigation, the Regional Counsel must be consulted for his/her recommendation on the need for a search warrant.

The following, more general-purpose imagery, can also be used in litigation, subject to the guidance of the Office of the Regional Counsel:

- Imagery or overlays prepared from imagery acquired by the military, or anyone else, for other purposes: i.e., for broad-area mapping or inventorying, routine missions clearly not connected with the litigation, etc.;
- Archival imagery antedating the litigation in question; and
- "Targets of opportunity," such as a stack putting up dense smoke, an unusual discharge from an outfall, etc., which are photographed while on a mission for another purpose or for general surveillance. (This is equivalent to stopping at the side of a road to photograph a suspected violation of any law.)

7.4.3 Access

All requests for aerial imagery and other remote sensing services shall be coordinated through the Regional Remote Sensing Coordinator as specified in the April 2, 1980, memorandum on this subject by the Deputy Regional Administrator (5). The coordinator shall make appropriate contacts with the Remote Sensing Branch, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada (EMSL-LV), with the Environmental Photographic Interpretation Center (EPIC) in Warrenton, Virginia, or with others as necessary; and the coordinator will arrange for direct follow-up contacts between the requestor and the group to provide the service if desired. All Enviropod activities will be under the administrative direction of the Regional Remote Sensing Coordinator. However, to the extent practical, efforts will be made to involve the user of the imagery in the missions for acquiring it.

Interpretation of photographs and other imagery within the Branch will be the responsibility of each individual program, although some limited assistance may be available from the Remote Sensing Coordinator. Requests for this service from groups outside the Region should be initiated as specified above.

7.4.4 Funding

In general, each program requesting remote sensing services will have to pay, from either national or regional funds, for necessary flight time, film and processing costs, and interpretation and preparation expenses. Costs can often be minimized by the Remote Sensing Coordinator by combining missions, locating archival imagery, and by using limited ORD support funds when available. The Remote Sensing Coordinator will arrange for cost estimates as needed.

7.4.5 Enviropod Procedures

The Enviropod will be installed and operated by personnel familiar with the detailed instructions prepared following the Enviropod Installation and Operations Course at EPIC (6). Mission planning will be done using appropriate nomograms supplied by EPIC or with the HP-97 Enviropod Program (7). All flight lines shall be logged on a data sheet. After exposure, film and log sheets should be promptly shipped to EPIC at Vint Hill Farms in Warrenton, VA, for processing.

7.4.6 Specific Quality Control Procedures for Aerial Imagery

All film is processed using the manufacturer's recommendations for temperature, time, and density of solutions. At the end of each Enviropod mission, approximately eight or ten frames will be exposed for trial development for EPIC to determine whether adjustments must be made in processing rates or temperatures to obtain a clear image. These will be noted on the log sheet with notes on lighting and weather conditions. Enviropod personnel at EPIC will be contacted before each mission (or monthly, whichever is less frequent) to determine current experience and recommend f-stop settings for various cloud covers and atmospheric conditions.

7.5 BATHYMETRY

7.5.1 Procedures

Recording fathometers are used to provide bathymetric traces of water depths. Because water depths are time dependent (especially in tidal areas), the date and time of all traces should be noted. Operation manuals provide operation and calibration procedures to be followed. In particular, tide and draft adjustments provide datum calibration in regard to the respective tidal amplitude and sensor probe depth. During the initial setup of each survey, the fathometer calibration should be checked against a field measurement of water depth made using a graduated sounding line. All traces should be noted with transect description, chart speed, direction of travel, and pertinent reference points and then indexed to a site map. When working in tidal areas, a water stage recorder (see Section 7.6) should be positioned to provide a histogram of water levels to correlate with the bathymetric trace.

7.5.2 Equipment Available

The following Branch equipment is available for bathymetric surveys:

- recording fathometers;
- water level recorder and/or referenced gaging station(s); and
- calibrated sounding line(s).

7.5.3 Specific Equipment Quality Control Procedures

All equipment used for bathymetric studies shall be numbered and a record shall be kept of all maintenance and calibration procedures. The following procedures shall be used to maintain and calibrate bathymetric measurement equipment.

7.5.3.1 Recording Fathometers -- These fathometers shall:

- Be calibrated and maintained according to the manufacturer's instructions before use. The chart speed should be checked against a reliable time source before the instrument is sent to the field;
- Be checked in the field against a field measurement of water depth utilizing a calibrated sounding line; and
- Be cleaned daily after use and prior to being stored.

7.5.3.2 Sounding Lines -- All sounding lines will be calibrated against a steel surveyors tape and shall be accurate ± 3 percent.

7.6 SURFACE WATER STAGE/TAPE DOWNS

7.6.1 Procedures

Water level recorders provide a time series record of water levels. Where possible, these instruments should be referenced to National Geodetic Vertical Datum (NGVD). All water level tracings should be noted with beginning and ending date and time, site location, stage scale, and time scale and initialed by the servicing Branch personnel. Standard USGS staff gages should be employed at each water level recorder site to provide a reference and check on the recorder trace. Water stage should be recorded to the nearest 0.01 foot where possible.

Tape downs provide instantaneous water stage as referenced to a known elevation. An engineering tape is fashioned with a plumb bob to measure from a bridge deck or other reference point to the water surface. The plumb bob provides weight for the tape as well as providing a discernible contact with the water surface. All measurements should be to the nearest 0.05 foot accompanied by a date, time, and station location. The exact reference or point from which a tape down is measured shall be permanently marked on the reference (wing wall or bridge rail by etching a reference with a chisel, etc.) and a complete description of the reference shall be made in the field records.

Both of these procedures (water stage and tape downs) are predicated upon accurate references to established measuring points. As mentioned above, the NGVD is an established datum that provides correlation of water surface recordings to engineering structures (bridge, wing walls, sea wall caps, clarifier cat walks, etc.). When recording water level dynamics in relation to a particular flow device, the datum is established in relation to the flow device reference point. Rectangular and V-notch weirs, for instance, are proportional to the water level referenced to the weir crest or, in the case of partially filled pipes, the flow rate is proportional to the depth of flow. Therefore, when employing a water level recorder or tape down on primary flow devices the reference or datum is the weir crest or in the case of pipes, the invert (see Section 5, Flow Measurement).

7.6.2 Equipment Available

The following Branch equipment is available for surface water stage/tape down measurements:

- Model F Stevens Stage Recorder(s);
- Model A-71 Stevens Stage Recorder(s);
- Model 1152 SSM ENDECO Stage Recorder(s);
- ISCO Flow Meter(s) and Recorder(s);
- USGS Staff Gage(s); and
- Weighted steel measuring tapes.

7.6.3 Specific Equipment Quality Control Procedures

A log book will be kept of all equipment used for making water stage/ tape down measurements. The following maintenance and calibration procedures shall be used and recorded in the log book for all equipment using for water stage and tape down measurements.

7.6.3.1 Stevens Model A-71 and Model F Stage Recorders -- These stage recorders shall:

- Be maintained according to the manufacturer's instructions. Once yearly, each unit shall be operated, and the time scale shall be adjusted to read within two percent of full scale. Once yearly, the recorders shall be bench checked by moving the recording mechanism vertically. The units must be accurate and record to within 0.01 foot of the Invar steel surveyor's chain.

- Be checked in the field by comparison with a staff gage. During field measurements, the vertical accuracy shall check within 0.05 foot, and

- Be cleaned and maintained before storage.

7.6.3.2 <u>ENDECO Model 1152 SSM Stage Recorder(s)</u> -- This instrument has no moving parts and uses solid state memory. In addition to water level data, the instrument also measures and stores conductivity and temperature data. The stage recorder shall:

- Be maintained according to manufacturer's instructions and checked in the field by comparison with a staff gage. The vertical accuracy shall check within 0.05 foot.

- Be within $\pm$ 0.55 m^2/cm and $\pm$ 0.2°C of prepared conductivity standards and an NBS thermometer, respectively.

- Be cleaned and maintained before storage.

7.6.3.3 <u>ISCO 1870, 2870 Flow Meter and Recorder(s)</u> -- See specific quality control procedures for this equipment in Section 5, Flow Measurement.

7.6.3.4 <u>USGS Staff Gage(s)</u> -- USGS staff gages shall:

- Be checked on receipt from the vendor. Any staff gage not accurate to within 0.01 foot when compared with the Invar steel surveyor's chain shall be discarded. Gages will be appropriately marked upon calibration.

- Be checked for damage, warpage, legibility, etc., before use. Any damaged or illegible staff gages shall be discarded.

- Be cleaned after use before being stored.

7.6.3.5 <u>Weighted Steel Measuring Tapes</u> -- Weighted steel measuring tapes shall:

- Be calibrated against the Invar steel surveyor's chain. The calibration shall be within 0.01 foot per 10 feet of length.

- Be checked for damage before use; damaged tapes shall be recalibrated or discarded.

- Be cleaned after use before being stored.

7.7 GROUND WATER LEVEL MEASUREMENT

7.7.1 General

The measurement of ground water level in wells is frequently conducted in conjunction with ground water sampling. Data from such measurements are needed to determine the "free" water surface and can be used to establish ground water flow direction and gradients. Specific techniques used by Branch personnel are presented in Appendix E.

Total well depth measurements, along with ground water level measurements, are necessary to determine the volume of water in a well casing prior to purging the well during ground water sampling.

All ground water level measurements, as well as total depth measurements, shall be made in reference to an established reference point on the well casing. This reference point shall be documented in field records. To be useful for establishing ground water gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum. An arbitrary datum common to all wells in a group may be used for an isolated group of wells, if necessary.

7.7.2 Specific Ground Water Level Measuring Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods (8). Method accuracies are noted below for each of the specific methods described.

7.7.2.1 Popper or Bell Sounder -- A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight barely strikes the water. Measurements shall be recorded to the nearest 0.1 foot.

7.7.2.2 Weighted Tape -- This method is similar to the "bell sounder" method, except that any suitable weight, not necessarily one designed to create an audible pop, can be used to suspend the tape. The weight should, ideally, be made of a relatively inert material and should be easily cleaned. Measurements shall be made and recorded to the nearest 0.1 foot.

7.7.2.3 Chalked Tape -- Chalk rubbed on a weighted steel tape will discolor or be removed when in contact with water. Distance to the water surface can be obtained by subtracting the wet chalked length from the total measured length. The tape should be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. Measurements shall be made and recorded to the nearest 0.01 foot. This method is not recommended if samples are to be collected for analyses of organic or inorganic contaminants.

7.7.2.4 Electric Water Level Indicators -- This instrument consists of a spool of dual conductor wire, a probe attached to the end, and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter

light and/or buzzer attached to the spool will signal the contact. Penlight or 9-volt batteries are normally used for a power source. Measurements shall be made and recorded to the nearest 0.01 foot.

7.7.2.5 Other Methods -- There are other types of water level indicators and recorders available on the market such as the sliding float method, air line pressure method, and electrical and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells. Acoustic water level indicators are also available which measure water levels based on the measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated before selection. Any method not capable of providing measurements to within 0.1 foot shall not be used.

7.7.3. Total Well Depth Measurement Techniques

The bell sounder, weighted tape, or electric water level indicators described in Section 7.7.2 can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well. Care must be taken in these situations to ensure accurate measurements. All total well depth measurements must be made and recorded to the nearest 0.1 foot.

7.7.4 Equipment Available

The following Branch equipment is available for ground water level and total well depth measurements:

- weighted steel measuring tapes, and
- electric water level indicators.

7.7.5 Specific Quality Control Procedures

All devices used to measure ground water levels shall be calibrated against the Invar steel surveyor's chain. These devices shall be calibrated to 0.01 foot per 10 feet length. Before each use, these devices shall be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. These devices should be decontaminated according to the procedures specified in Appendix B.7.1 prior to use at the next well. All calibration and maintenance data shall be recorded in a log book.

7.8 TIME-OF-TRAVEL

7.8.1 General

Three principal methods are used to determine travel time in streams, i.e., surface floats, measurements of cross sectional velocity, and tracers such as dye.

A very rough method for preliminary estimates of time-of-water travel con

sists of dropping sticks or other buoyant objects from bridges in the stream reach under observation, and noting the time required for them to float an estimated 10 feet or some other convenient distance. The velocity estimates are too inaccurate for use in interpretation of data or final reporting, but can be useful in preliminary planning of studies and in subsequent more precise measurements of time-of-water-travel.

Stream velocities at gaging stations, measured by the U. S. Geological Survey in developing rating curves, may be applied to the entire reach under observation to estimate time-of-water travel. This is somewhat more refined than the floating objects estimates, but can still be far from accurate. There rarely are more than one or two gaging stations in most stream reaches being studied. Stream channels generally are restricted at gaging stations and velocities there are generally higher than average velocities throughout the reach. Cross sectional velocities can also be determined at locations designated for a particular study.

Tracer dyes provide a direct and highly accurate method of determining time-of-travel. This is the preferred method if resources are available.

7.8.2 Procedures

7.8.2.1 Floats -- Surface floats may be followed downstream and timed for known distances to determine time-of-water-travel. This requires the use of considerable judgment, for floats tend to travel into quiet or eddy areas, or to become stuck on tree limbs, the stream bank, or other obstacles. The floats must frequently be retrieved and returned to the stream current. The principal judgment factors are how long the floats should be left in quiet areas before retrieval and where they should be placed in the current.

Surface water velocity is greater than the average for the entire stream, and a correction factor must be applied to the surface velocity. An average velocity of about 85 percent of that of the surface velocity is a reasonable rule-of-thumb value.

7.8.2.2 Cross Section Measurements -- The measurement of cross sectional velocities at frequent longitudinal intervals and the calculation of average velocity in the stream constitutes a time consuming method of obtaining time-of-water-travel.

The longitudinal intervals at which cross sections should be measured vary with the characteristics of the stream channel. One cross section per mile may be adequate for streams with reasonably uniform channels. Cross sections at every tenth of a mile may be desirable for streams with irregular channels.

Cross section measurement methods are described in detail in Section 5.

7.8.2.3 Tracers -- The most accurate method of measuring time-of-travel involves following a tracer. Some conservative industrial waste constituents, salt, or radioisotopes may serve as tracers; however, dye is most common. The most frequently used dye is Rhodamine WT that can be detected in concentrations as low as 0.01 ppb by a fluorometer.

Prior to injection into the stream, the concentrated dye should be diluted with the stream water. This will help insure immediate maximum dispersion. Addition of concentrated dye without dilution may result in incomplete dispersion, particularly in shallow streams. Calibration curves should be developed for each study with particular emphasis on accounting for natural background fluorescence.

The dye should be distributed across the stream at the upstream point, as nearly instantaneously as possible. The ideal distribution produces a narrow band of tracer in a uniform concentration across the stream. The band of tracer mixes with water ahead of and behind it by diffusion, or longitudinal mixing, as it moves downstream to produce an increasingly wider band. The peak concentration remains near, but somewhat downstream of, the center line of the band and decreases as longitudinal mixing proceeds. The times-of-water-travel to downstream points are the differences between the time the dye was added to the stream and the times the centroid of the dye mass arrives at downstream points. The length of the dye cloud and the peak concentrations produces a measure of instream dispersion.

If Rhodamine WT dye is used as the tracer, peak concentrations from 1.0 to 50 ppb allow satisfactory definition of the dye concentration curve.

Most methods of calculating the dosage of dye needed at the upstream point involve estimates of one or more stream characteristics, such as flow, velocity, length of reach, volume in the reach, cross-sectional area, average depth, and the roughness coefficient, "n", of Manning's formula. The USGS has produced excellent publications regarding to time-of-travel techniques, i.e., "Measurement of Time-of-Travel and Dispersion by Dye Tracing" (9) and "Fluorometric Procedures for Dye Tracing" (10).

The stream should be sampled frequently as the dye arrives at the downstream point to define the tracer concentration versus time curve with special emphasis on the peak. The frequency may be varied from once each minute to once every 10 to 15 minutes, depending on how wide the band of dye has become at the sampling point. The dye may be missed altogether by overestimating the time required for it to travel downstream. Much time may be wasted, on the other hand, waiting for it to arrive if the time-of-travel is underestimated. All information that will contribute to the best possible preliminary estimate of the time required should be used.

There are two primary methods by which the stream water can be sampled and analyzed for dye. A submersible pump can be used to pump dye continuously through a fluorometer or the stream samples can be grabbed (either by hand or by automatic sampler) at specified frequencies and then placed into the fluorometer individually. With the "flow-through" version, a strip chart recorder connected to the fluorometer can be used to plot the tracer concentration versus time. Readings directly from the fluorometer scale or conversion to dye concentration can be manually plotted against time when the grab sampling technique is used.

A version of the grab sampling technique would be to use an automatic water sampler which discharges into separate bottles. The sampler is pre-set to collect samples at certain intervals; at the end of the sample collection time,

the discrete samples shall be analyzed and the concentration determined for each. The concentrations are then plotted against time.

For proper determination of travel time, samples should continue to be analyzed until the stream background concentration following the peak is measured. With a time versus concentration plot from background level to peak to background level, the centroid, and thus actual travel time, can be determined.

The Water Supply Branch of the Water Management Division should be contacted prior to conducting tracer studies in freshwater systems to insure that tracer concentrations do not impart color to downstream public or private water supplies.

7.8.3 Equipment Available

The following Branch equipment is available for time-of-travel studies:

- fluorometers,
- tracer standards,
- automatic samplers,
- pumps,
- recorders,
- flow meters, and
- floats.

7.8.4 Specific Equipment Quality Control Procedures

All of the quality control procedures for equipment utilized in time-of-travel studies has been discussed in Section 4 (Sampling Procedures), 5 (Flow Measurement), or 6 (Field Analyses).

7.9 DILUTION STUDIES

7.9.1 Procedures

A great deal of the previous section (time-of-travel studies) applies to this section and USGS publications provide references to techniques, in particular "Measurement of Discharge by Dye-Dilution Methods" (11).

Dilution studies using tracer dyes evolve from "mass conservation" principles. That is, a known mass of tracer is introduced at an upstream point, and after mixing with the water to be traced, this mass should be accountable at downstream locations. Rhodamine WT provides an adequate tracer for such investigations. This dye is slightly photoreactive and reaction rates are available in the literature (generally K rate is 0.034/day). Other tracers either introduced into an upstream point or in some instances occurring at the upstream point are often used. The high degree of accuracy and detection ability of fluorometers plus the solubility properties of tracer dyes make them the technique of choice.

In dilution studies, the tracer dye is precisely metered into the waters to be traced and then monitored after mixing via a fluorometer at downstream

stations. This series of events requires highly controlled metering rates and very accurate fluorometric analyses. State-of-the-art fluorometers make the dilution study program a valuable assessment tool.

7.9.2 Equipment Available

The following Branch field equipment is available for dilution studies:

- fluorometer,
- metering pump,
- tracer standards, and
- pumps.

7.9.3 Specific Equipment Quality Control Procedures

See previous section. The metering pump shall be calibrated before and during use. Field calibration data shall be recorded in the field records.

The principal of superposition as developed by Kilpatrick and Yotsukura of the USGS is a reliable method to determine dilution levels of wastewaters in the receiving estuary (12). A tracer dye is metered into the wastewater stream during a tidal cycle. Successive slack tide measurements of dye concentrations in the estuary at selective distances from the outfall produce a series of concentration curves. By superposition, the accumulative concentration at each station provides a determination of the ultimate concentrations or steady-state concentration of a continuous discharge. By simple proportioning, with due regard to tracer photo decay, the dilution levels of the discharge can be produced for selective points in the estuary.

Calculation Procedure:

$$C_w = (C_t)(e^{kt})\left(\frac{Vw}{Vt}\right)$$

Where:

C_w = Ultimate concentration of wastewater at point of interest

C_t = Ultimate concentration of tracer (by superposition) at point of interest

e^{kt} = Photo decay of tracer

k = 0.034 tidal day

t = tidal days to ultimate concentration

Vw = Wastewater discharge per tidal day

Vt = Volume dye released in tidal day

For example:

Assume: C_t = 100 ppb

e^{kt} = 1.2 (ultimate concentration obtained in 5 tidal days

Vw = 100,000 gal/tidal day

Vt = 10 gal/for one tidal day

Then: C_w = 1,000,000 ppb
= 0.10% wastewater

Investigations of industrial and municipal facilities for NPDES permit compliance require measurements of discharge rates. Often encountered during these investigations are flow measuring devices such as orifices and magnetic meters which are inaccessible for measurements of flow by standard equations relating to hydraulic head and structure size. The following provides a direct technique for measurement of flow through the above devices using dye tracers.

Discharge rate through any structure can be defined by the following mass balance equation:

MASS BALANCE EQUATION

Q_2

C^2 @ (Q_2+q_1)

q_1, @ C_1

$$(C_1)\ (q_1) = (C_2)\ (Q_2 + q_1)$$

$$Q_2 = \frac{(C_1)\ (q_1) - (C_2)\ (q_1)}{C_2}$$

Where:

Q_2 = pipe flow rate

The following is brief description of the methods available and their applications.

7.10.3.1 Metal Detection -- Metal detectors are used to detect changes in electrical conductivity caused by the presence of metallic materials, both ferrous and non-ferrous. Metal detectors: (1) are limited to shallow depths (0 to 8 feet), (2) can detect large metallic objectives such as buried drums and metallic laden wastes, (3) are light weight and economical, and (4) are insensitive to soil moisture and small metallic objects.

7.10.3.2 Magnetometry -- Magnetometers are designed to detect and accurately measure changes in the earth's magnetic field. The major feature of the magnetometer is ease of operation and reliability.

The magnetometer's primary design function is detection of magnetic objects such as buried drums or large bodies of ore which alter the earth's magnetic field. Magnetometers should not be calibrated or used in or around buildings, near powerlines, or directly on the ground.

7.10.3.3 Electromagnetic Induction (EM) -- A transmitter induced coil directs induced current loops into the ground, which produce secondary fields. These secondary fields are then sensed or detected by the receiver coil, and then amplified and stored on a strip chart recorder or magtape, if desired.

EM instruments measure true soil conductivity in uniform, homogeneous subsurface conditions. EM units also measure apparent soil conductivity in layered soils.

Measurements can be obtained from depths to 60 meters with these instruments. EM units are very effective for rapid site reconnaissance and detection of buried drums, pipes, and metallic type conductors. EM's are not limited by frozen ground, or wet or dry soils.

7.10.3.4 Ground Penetrating Radar (GPR)

Ground penetrating radar (GPR) units radiate short duration electromagnetic pulses directly into the ground from an antenna near the surface. The pulses are reflected back to the receiver from subsurface structures and are plotted on a strip chart recorder.

The depth of GPR penetration is site specific ranging from as little as 3 feet in clay to as much as 100 feet in dry quartz sand. Depths are further reduced if ground water electrical conductivity is high. GPR may be useful in defining boundaries of buried trenches and other subsurface disturbances, but is difficult to use in silty or clay soils.

7.10.3.5 Seismic Refraction Devices (SRD)

Field operation is accomplished by transmitting sound waves into the ground by means of a sound source (hammer, drop weight, explosives, etc.). Reflected sound waves are then detected by receivers or geophones which automatically

translate them into electrical signals, which are recorded and displayed in graph form on a seismograph. Stratigraphic profiles can then be determined based on travel time of the sound waves through the different earth strata.

7.10.3.6 Resistivity

Resistivity is used to measure the electrical resistance of the soil, rock, and ground water. The resistivity method requires that a electrical current be injected into the ground through a pair of surface electrodes. The resulting potential field (voltage) is measured at the surface by a second pair of electrodes. The electrical current flows from the electrodes into the ground through the moisture-filled pore spaces in the soils and rocks. Resistivity is controlled by the amount of pore water present in the soil and rock strata. The resistivity method can be used to locate and map contaminant plumes, locate and define trenches, and determine natural geohydrologic conditions such as depth to ground water, and depth to bedrock. The resistivity method is limited in areas where soils contain little or no moisture, since dry soils will not permit current to flow. Very hard or compacted soils or frozen ground impede the use of resistivity because the electrodes cannot be driven into the ground. Resistivity surveys are costly and time consuming which make the resistivity method unfavorable for a short reconnaissance trip or a quick screening investigation.

7.10.3.7 Very Low Frequency (VLF) Ground Conductivity

The VLF instrument uses the magnetic components of the electromagnetic field generated by already-existing radio transmitters that use the VLF band (Very Low Frequency, 15-30 kHz). Such transmitters are now operating in a number of countries, and are used primarily for long-distance submarine communication.

Electrically conductive structures on the surface or underground, even when covered with thick overburden, locally affect the direction and strength of the field generated by the transmitted radio signal. A weak secondary field is generated around the geological structure, which is most commonly a water-filled fracture or ore body. This field is measured by the instrument. Different VLF instruments available vary in the degree of useful output produced by each instrument. Some merely quantify the secondary field measurement, while others provide real-time current density profiles and structure interpretation of identified anomalies.

7.10.3 Equipment Available

The following Branch equipment is available for geophysical studies:

- EM-31D Non-Contacting Terrain Conductivity Meter,
- Unimag II Portable Proton Magnetometer Model G-846,
- Pipe Seeker 5 metal detector, and
- ABEM Wadi VLF Instrument

7.10.4 Specific Equipment Quality Control Procedures

All geophysical instruments used by Hazardous Waste Section personnel or EPA contractors shall be calibrated in accordance with the manufacturers' specified calibration procedures, and shall only be calibrated by personnel that have been trained to do so. The calibration shall be checked periodically to insure accurate readings, especially on re-entering the study area after having left for a period of time. All calibration procedures and pertinent information shall be documented in the field logbook as outlined in Section 3.5.

Personnel using the geophysical equipment shall be trained in the use and maintenance of such equipment, and shall be able to interpret and present the gathered data in an easily understood manner in charts, graphs, maps, and formal reports. It is the responsibility of each Hazardous Waste Section project leader to insure that the personnel designated to use the geophysical equipment are qualified in the calibration and use of the equipment, and able to gather and interpret the data.

Training on the calibration and use of geophysical equipment that is currently available will be conducted by qualified Hazardous Waste Section personnel and will be given to all Hazardous Waste Section personnel during in-house training sessions scheduled throughout the year.

7.10.4.1 <u>EM-31 Non-Contacting Terrain Conductivity Meter</u>

7.10.4.1.1 <u>Assembly and Calibration Procedure</u>

- Align and connect transmitter tube to control box.
- Check batteries by setting mode switch to operate position and range switch to +B position and then to -B position. The needle should read in the battery mark. If not, replace batteries.
- Align and connect receiver tube to control box.
- Set range switch to 30 millimhos/meter position.
- Set mode switch to comp. position.
- Adjust meter to zero using coarse and fine comp. controls.
- Check phasing, set mode switch to phase position.
- Note meter reading.
- Rotate coarse control to original position. No further adjustments are needed.
- If there is a difference in meter readings, an adjustment is needed.

- Put coarse control in original position.

- Rotate phase potentiometer 1/4 turn clockwise and note meter reading.

- Rotate coarse control one step clockwise and note meter reading.

- If meter reading does not change, no further adjustment is needed. Return coarse control to original position.

- If meter reading changes - repeat above adjustments until meter reading remains the same when coarse control is rotated one step clockwise.

- Meter should read between 75 - 85 percent of full scale (in Black Mark).

- Return coarse control to original position.

- EM-31 is ready for operation!

Note: When calibrating the EM-31 over ground with higher conductivity than 30 millimhos/meter, the range switch should be set at the appropriate range level.

7.10.4.1.2 <u>EM-31 Operating Procedure - Measuring Soil Conductivity</u>

- Adjust the shoulder strap so that the instrument rests comfortably on the hip.

- Switch the mode switch to OPER position and rotate range switch so that meter reads in upper 2/3 of the scale.

- EM-31 can be operated continuously while moving from one measuring station to the other or the EM-31 can be turned off while walking from station to station and then turned on when taking a reading. The latter saves battery life.

- Dismantle EM-31 and clean before storage.

7.10.4.1.3 <u>EM-31 Operating Procedure - Buried Metal Detection</u>

- Set the mode switch to the COMP position.

- Set the range switch to 30 millimhos/meter.

- Adjust the COARSE and FINE compensation controls so that a meter deflection of about 20 percent of full scale is obtained.

- Operate the EM-31 while continuously moving to determine the exact location of the buried objects.

- Dismantle EM-31 and clean before storage.

7.10.4.2 Unimag II Portable Proton Magnetometer Model G-846

7.10.4.2.1 Calibration and Operating Procedure

The Unimag II is completely self-contained and ready for field operation. A few simple procedures should be observed to obtain optimum results.

- Check the sensor for sensor fluid: Shake the instrument gently and listen for a "sloshing" sound. If the fluid is not present or cannot be heard, it will be necessary to fill the sensor with strained kerosene or unleaded gasoline. This procedure is outlined in the operator's manual furnished with the instrument.

- Check the battery: Simply depress the black push bottom and observe the readout. If the readout flashes on/off during the display period, the battery is not fully charged. Refer to the operators manual for battery recharging instructions.

- Lift the Unimag II out of the carrying case and adjust the shoulder strap for a comfortable fit.

- Adjust the "tuning-kilograms" knob to a position that correlates with the earth's magnetic field. The earth's field can be estimated by referring to the world intensity map located in front of the operators manual.

- Depress the black button on top of the instrument and release. The center digit on the readout will, briefly flash. This indicates that the cycle has started. It will take two seconds for the display to illuminate and give the earth's magnetic field in gammas.

- When operating, hold the Unimag II waist high. When depressing black button for reading, hold instrument as still as possible.

- The instrument should exhibit one count stability. If one count stability is not possible, a ferromagnetic object is present or a steep magnetic gradient is being encountered. Verify the one count stability by repeating the measurement with the instrument held in the same position.

  Note: If the earth's magnetic field is 40,000 gammas or less (low magnetic latitudes-equator area), the sensor should be rotated 90°. See operator's manual for the correct procedure. The sensor rotation

is not necessary in Region IV. If problems arise with the instrument, refer to the operator's manual.

- Do not operate the Unimag II in buildings, near high energy sources (powerlines, etc.), or directly on the ground. Hold instrument waist high. Do not wear magnetic objects such as jewelry, keys, watches, zippers, pocket knives, belt buckles, etc.

- Become familiar with the instrument and it's operation before attempting a field survey.

7.10.4.3 Metal Detector - The Tracer Metallic Pipe & Liner Locator

This instrument is a very sensitive piece of equipment and has to be fine tuned (nulled) in order to detect buried objects. The operators's manual should be read and understood before any field operation is attempted.

7.10.4.3.1 Operating Procedure

- Test the battery voltage on the transmitter and receiver (refer to the instructions in the operators manual). Make sure that batteries are fully charged.

- Assembly of the transmitter to the receiver should be accomplished according to the instructions in the operator's manual.

- Null the instrument prior to use. "Nulling" should take place in an area similar to the area of concern but where there are no buried metal objects. Refer to the instructions.

- Practical with the instrument over objects of known size and depth.

- For highest sensitivity, adjust the sensitivity control for an approximately half scale meter reading with the instruments nulled.

- Store instrument in a secure, dry place when not in use.

7.10.4.4 ABEM Wadi VLF Instrument

See owners manual for detailed instructions. The following is a summary of the basic steps for routine operation of the Wadi for site reconnaissance for location of water-filled fractured geologic terrain.

7.10.4.4.1 Operating Procedure

- Turn instrument on.

- Select suitable transmitter. Face the direction of anticipated profile and press STATION key. Wadi will display current radio frequency and signal strength indicator. Turn 360 degrees and observe the indicator. The length of the bar should be longest (or more nearly so) when facing the direction of the profile. If not, and if the numerical value displayed with the bar is less than 10 or greater than 50, a new transmitter must be selected. If a new transmitter is required, enter 0, 0, 0, and press the STATION key again. After about three minutes a frequency scan will appear. After the scan is completed, select strongest signal with large arrows on key pad and check for orientation of transmitter, as before.

- Select profile start point and specify grid. Press COORDINATE key and select starting coordinate, profile separation, and measurement separation distance.

- Conduct measurements along profile. Press MEASURE key. Wait for prompt to press MEASURE key again. Observe inclinometer in lower right portion of screen. A straight line is best, although measurements can be obtained with the open-carrot symbol. If inclination of antenna is too great, instrument will not measure and will indicate this condition. Re-orient antenna and try again. Remain steady while Wadi conducts measurement. Move to next measurement point and conduct next measurement.

- For any additions profiles in the same grid, using large arrows, make turn as required at end of each profile to continue measurements along successive profiles. Wadi automatically stores data for proper interpretation.

- To interpret any anomaly identified on profile, press MEASUREMENT key once and, using small arrows, move cursor to top of selected anomaly. Press INTERPRETATION key. After several seconds, interpretation will appear above anomaly. Identical vertical and horizontal scales allow for estimates to be made of depth of anomaly.

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4. 18 U.S.C. Section 1385 provides, in pertinent part, "whoever, except in

cases and under circumstances expressly authorized by the Constitution or Art of Congress, willfully uses any part of the Army or Air Force ... to execute the laws of the United States shall be fined not more than $10,000 or imprisoned not more than two (2) years, or both."

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REFERENCE 26

DRINKING WATER REGULATIONS

AND HEALTH ADVISORIES

by

Office of Drinking Water
U.S. Environmental Protection Agency
Washington, D.C.
202-382-7571

SAFE DRINKING WATER HOTLINE
1-800-426-4791 (Toll-Free)
202-382-5533 (Washington, D.C.)
Monday thru Friday, 8:30 AM to 4:30 PM EST

November 1990

LEGEND

Abbreviations column descriptions are:

MCLG - Maximum Contaminant Level Goal. A non-enforceable concentration of a drinking water contaminant that is protective of adverse human health effects and allows an adequate margin of safety.

MCL - Maximum Contaminant Level. Maximum permissible level of a contaminant in water which is delivered to any user of a public water system.

RfD - Reference Dose. An estimate of a daily exposure to the human population that is likely to be without appreciable risk of deleterious effects over a lifetime.

DWEL - Drinking Water Equivalent Level. A lifetime exposure concentration protective of adverse, non-cancer health effects, that assumes all of the exposure to a contaminant is from a drinking water source.

(*) The codes for the Status Reg and Status HA columns are as follows:

F - final
D - draft
L - listed for regulation
P - proposed (Phase II and V draft proposals)

Other codes found in the table include the following:

NA - not applicable
PS - performance standard 0.5 NTU - 1.0 NTU
TT - treatment technique

** - No more than 5% of the samples per month may be positive. For systems collecting fewer than 40 samples/month, no more than 1 sample per month may be positive.

*** - guidance

- Large discrepancies between Lifetime and Longer-term HA values may occur because of the Agency's conservative policies, especially with regard to carcinogenicity, relative source contribution, and less than lifetime exposures in chronic toxicity testing. These factors can result in a cumulative UF (uncertainty factor) of 10 to 1000 when calculating a Lifetime HA.

DRINKING WATER STANDARDS AND HEALTH ADVISORIES

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
ORGANICS													
Acenaphthylene	-	-	-	-	-	-	-	-	60	-	-	-	-
Acifluorfen	-	-	-	F	2000	2000	100	400	13	400	-	100	B2
Acrylamide	P	zero	TT	F	1500	300	20	70	0.2	7	-	1	B2
Acrylonitrile	L	-	-	D	20	20	1	4	0.1	4	-	7	B1
Adipates (diethylhexyl)	P	500	500	-	-	-	-	-	700	20000	500	-	C
Alachlor	P	zero	2	F	100	100	-	-	10	400	-	40	B2
Aldicarb	P	10	10*	F	-	-	-	-	1.3	40	10	-	D
Aldicarb sulfone	P	40	40*	F	-	-	-	-	6.0	200	40	-	D
Aldicarb sulfoxide	P	10	10*	F	-	-	-	-	1.3	40	10	-	D
Aldrin	-	-	-	D	0.3	0.3	0.3	0.3	0.03	1	-	0.2	B2
Ametryn	-	-	-	F	9000	9000	900	3000	9	300	60	-	D
Ammonium Sulfamate	-	-	-	F	20000	20000	20000	80000	250	8000	2000	-	D
Anthracene (PAH)	L	-	-	-	-	-	-	-	300	-	-	-	D
Atrazine	P	3	3	F	100	100	50	200	5	200	3	-	C
Baygon	-	-	-	F	40	40	40	100	4	100	3	-	C
Bentazon	-	-	-	F	300	300	300	900	2.5	90	20	-	D
Benz(a)anthracene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	B2
Benzene	F	zero	5	F	200	200	-	-	-	-	-	100	A
Benzo(a)pyrene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	B2*
Benzo(b)fluoranthene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	B2
Benzo(g,h,i)perylene (PAH)	P	-	-	-	-	-	-	-	-	-	-	-	D
Benzo(k)fluoranthene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	B2
bis-2-Chloroisopropyl ether	-	-	-	F	4000	4000	4000	13000	40	1000	300	-	-
Bromacil	-	-	-	F	5000	5000	3000	9000	130	5000	90	-	C
Bromobenzene	-	-	-	D	-	-	-	-	-	-	-	-	-

* Under review.

	Standards			Health Advisories									
					10-kg Child			70-kg Adult					
Chemicals	Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Status HA*	One-day µg/l	Ten-day µg/l	Longer-term µg/l	Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Canc Grou
Bromochloroacetonitrile	L	-	-	D	-	-	-	-	-	-	-	-	-
Bromochloromethane	-	-	-	D	50000	1000	1000	5000	13	500	90	-	-
Bromodichloromethane (THM)	L	-	-	D	7000	7000	400	1300	20	600	-	30	B2
Bromoform (THM)	L	-	-	D	5000	2000	2000	6000	20	600	-	-	B2
Bromomethane	-	-	-	F	100	100	100	500	1	50	10	-	D
Butyl benzyl phthalate (PAE)	P	zero	4	-	-	-	-	-	200	-	-	-	C
Butylate	-	-	-	F	2000	2000	1000	4000	50	2000	350	-	D
Butylbenzene n-	-	-	-	D	-	-	-	-	-	-	-	-	-
Butylbenzene sec-	-	-	-	D	-	-	-	-	-	-	-	-	-
Butylbenzene tert-	-	-	-	D	-	-	-	-	-	-	-	-	-
Carbaryl	-	-	-	F	1000	1000	1000	1000	100	4000	700	-	D
Carbofuran	P	40	40	F	50	50	50	200	5	200	40	-	E
Carbon Tetrachloride	F	zero	5	F	4000	200	70	300	0.7	30	-	30	B2
Carboxin	-	-	-	F	1000	1000	1000	4000	100	4000	700	-	D
Chloral Hydrate	L		-	D	7000	1000	200	600	2	60	50	-	D
Chloramben	-	-	-	F	3000	3000	200	500	15	500	100	-	D
Chlordane	P	zero	2	F	60	60	-	-	0.06	2	-	3	B2
Chlorodibromomethane (THM)	L	-	-	D	7000	7000	2000	8000	20	800	20	-	C
Chloroethane	L	-	-	D	-	-	-	-	-	-	-	-	-
Chloroform (THM)	L	-	-	D	4000	4000	100	500	10	500	-	600	B
Chloromethane	L	-	-	D	9000	400	400	1000	4	100	3	-	
Chlorophenol (2-)	L	-	-	D	50	50	50	200	5	200	40	-	
p-Chlorophenyl methyl sulfide/sulfone/sulfoxide	D	-	-	-	-	-	-	-	-	-	-	-	
Chloropicrin	L	-	-	-	-	-	-	-	-	-	-	-	
Chlorothalonil	-	-	-	F	200	200	200	500	15	500	-	150	
Chlorotoluene o-	L	-	-	F	2000	2000	2000	7000	20	700	100	-	
Chlorotoluene p-	L	-	-	F	2000	2000	2000	7000	20	700	100	-	
Chlorpyrifos	-	-	-	D	30	30	30	100	3	100	20	-	
Chrysene (PAH)	-	zero	0.2	-	-	-	-	-	-	-	-	-	B
Cyanazine	L	-	-	F	100	100	20	70	2	70	10	-	

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Cyanogen Chloride	L	-	-	-	-	-	-	-	-	-	-	-	-
Cymene p-	-	-	-	D	-	-	-	-	-	-	-	-	-
2,4-D	P	70	70	F	1000	3000	100	400	10	400	70	-	D
DCPA (Dacthal)	-	-	-	F	80000	80000	5000	20000	500	20000	4000	-	D
Dalapon	P	200	200	F	3000	3000	300	900	26	900	200	-	D
Dichloroethylene (cis-1,2-)	P	70	70	F	4000	1000	3500	11000	10	400	70	-	D
Dichloroethylene (trans-1,2-)	P	100	100	F	20000	2000	2000	6000	20	600	100	-	D
Dichlorophenol (2,4-)	L	-	-	D	30	30	30	100	3	100	20	-	D
Diazinon	-	-	-	F	20	20	5	20	0.09	3	0.6	-	E
Dibenz(a,h)anthracene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	B2
Dibromoacetonitrile	L	-	-	D	2000	2000	2000	8000	20	800	20	-	C
Dibromochloropropane (DBCP)	P	zero	0.2	F	200	50	-	-	-	-	-	3	B2
Dibromomethane	L	-	-	-	-	-	-	-	-	-	-	-	D
Dibutyl phthalate (PAE)	P	zero	4	-	-	-	-	-	100	-	-	-	D
Dicamba	L	-	-	F	300	300	300	1000	30	1000	200	-	D
Dichloroacetaldehyde	L	-	-	D	-	-	-	-	-	-	-	-	-
Dichloroacetic acid	L	-	-	D	50000	50000	500	2000	5	200	3	-	C
Dichloroacetonitrile	L	-	-	D	1000	1000	800	3000	8	300	6	-	C
Dichlorobenzene p-	F	75	75	F	10000	10000	10000	40000	100	4000	75	-	C
Dichlorobenzene o-,m-	P	600	600	F	9000	9000	9000	30000	89	3000	600	-	D
Dichlorodifluoromethane	-	-	-	F	40000	40000	9000	30000	200	5000	1000	-	D
Dichloroethane (1,1-)	L	-	-	D	-	-	-	-	-	-	-	-	-
Dichloroethane (1,2-)	F	zero	5	F	700	700	700	2600	-	-	-	40	B2
Dichloroethylene (1,1-)	F	7	7	F	2000	1000	1000	4000	9	400	7	-	C
Dichloromethane	P	zero	5	F	10000	2000	-	-	60	2000	-	500	B2
Dichloropropane (1,1-)	-	-	-	D	-	-	-	-	-	-	-	-	-
Dichloropropane (1,2-)	P	zero	5	F	-	-	-	-	-	-	-	50	B2
Dichloropropane (1,3-)	L	-	-	D	-	-	-	-	-	-	-	-	-
Dichloropropane (2,2-)	L	-	-	D	-	-	-	-	-	-	-	-	-
Dichloropropene (1,1-)	L	-	-	D	-	-	-	-	-	-	-	-	-

Chemicals	Standards: Status Reg.*	Standards: MCLG (µg/l)	Standards: MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	10-kg Child: Ten-day µg/l	10-kg Child: Longer-term µg/l	70-kg Adult: Longer-term µg/l	70-kg Adult: RfD µg/kg/day	70-kg Adult: DWEL µg/l	70-kg Adult: Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Dichloropropene (1,3-)	L	-	-	F	30	30	30	100	0.3	10	-	20	B2
Dieldrin	L	-	-	F	0.5	0.5	0.5	2	0.05	2	-	0.2	B2
Diethyl phthalate (PAE)	P	zero	4	D	-	-	-	-	800	-	-	-	D
Diethylhexyl phthalate (PAE	P	zero	4	D	-	-	-	-	20	-	-	300	B2*
Diisopropyl methylphosphonate	-	-	-	F	8000	8000	8000	30000	80	3000	600	-	D
Dimethrin	-	-	-	F	10000	10000	10000	40000	300	10000	2000	-	D
Dimethyl methylphosphonate	-	-	-	D	-	-	-	-	-	-	-	-	-
Dimethyl phthlate (PAE	P	zero	4	-	-	-	-	-	-	-	-	-	D
1,3-Dinitrobenzene	-	-	-	D	40	40	40	140	0.1	5	1	-	D
Dinitrotoluene (2,4-)	L	-	-	D	-	-	-	-	-	-	-	-	-
2,4-/2,6-Dinitrotoluene	-	-	-	D	-	-	-	-	-	-	-	-	-
Dinoseb	P	7	7	F	300	300	10	40	1	40	7	-	D
Dioxane p-	-	-	-	F	4000	400	-	-	-	-	-	700	B2
Diphenamid	-	-	-	F	300	300	300	1000	30	1000	200	-	D
Diquat	P	20	20	-	-	-	-	-	2.2	-	-	-	D
Disulfoton	-	-	-	F	10	10	3	9	0.04	1	0.3	-	E
1,4-Dithiane	-	-	-	D	-	-	-	-	-	-	-	-	-
Diuron	-	-	-	F	1000	1000	300	900	2	70	10	-	D
Endothall	P	100	100	F	800	800	200	200	20	700	100	-	D
Endrin	P	2	2	F	20	20	3	10	3	9	2	-	D
Epichlorohydrin	P	zero	TT	F	100	100	70	70	2	70	-	400	B2
Ethylbenzene	P	700	700	F	30000	3000	1000	3000	100	3000	700	-	D
Ethylene dibromide (EDB)	P	zero	0.05	F	8	8	-	-	-	-	-	0.04	B2
Ethylene glycol	-	-	-	F	20000	6000	6000	20000	2000	40000	7000	-	D
ETU	L	-	-	F	300	300	100	400	0.03	1	-	6	B2
Fenamiphos	-	-	-	F	9	9	5	20	0.25	9	2	-	D
Fluometuron	-	-	-	F	2000	2000	2000	5000	13	400	90	-	D
Fluorene (PAH)	P	zero	0.2	-	-	-	-	-	40	-	-	-	D
Fluorotrichloromethane	-	-	-	F	7000	7000	3000	10000	300	10000	2000	-	D
Fog Oil	-	-	-	D	-	-	-	-	-	-	-	-	-

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Fonofos	-	-	-	F	20	20	20	70	2	70	10	-	D
Formaldehyde	-	-	-	D	10000	5000	5000	20000	150	5000	1000	-	B1-Inhal
Gasoline	-	-	-	D	-	-	-	-	-	-	5(benzene)	-	-
Glyphosate	P	700	700	F	20000	20000	1000	1000	100	4000	700	-	D
Heptachlor	P	zero	0.4	F	10	10	5	5	0.5	20	-	0.8	B2
Heptachlor epoxide	P	zero	0.2	F	10	-	0.1	0.1	0.013	0.4	-	0.4	B2
Hexachlorobenzene	P	zero	1	F	50	50	50	200	0.8	30	-	2	B2
Hexachlorobutadiene	-	-	-	F	300	300	100	400	2	70	1	-	C
Hexachlorocyclopentadiene	P	50	50	-	-	-	-	-	7	200	-	-	D
Hexachloroethane	-	-	-	D	5000	5000	100	500	1	40	1	-	C
Hexane (n-)	-	-	-	F	10000	4000	4000	10000	-	-	-	-	D
Hexazinone	-	-	-	F	3000	3000	3000	9000	30	1000	200	-	D
HMX	-	-	-	F	5000	5000	5000	20000	50	2000	400	-	D
Hypochlorite	L	-	-	-	-	-	-	-	-	-	-	-	-
Hypochlorous acid	L	-	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3,-c,d)pyrene (PAH)	P	zero	0.2	D	-	-	-	-	-	-	-	-	B2
Isophorone	L	-	-	D	15000	15000	15000	15000	200	7000	100	-	C
Isopropyl methylphosphonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopropylbenzene	-	-	-	D	-	-	-	-	-	-	-	-	-
Lindane	P	0.2	0.2	F	1000	1000	30	100	0.3	10	0.2	-	C
Malathion	-	-	-	D	200	200	200	800	20	800	200	-	D
Maleic hydrazide	-	-	-	F	10000	10000	5000	20000	500	20000	4000	-	D
MCPA	-	-	-	F	100	100	100	400	1.5	53	11	-	E
Methomyl	-	-	-	F	300	300	300	300	25	900	200	-	D
Methoxychlor	P	400	400	F	6000	2000	500	2000	50	2000	400	-	D
Methyl ethyl ketone	-	-	-	F	80000	8000	3000	9000	25	900	200	-	D
Methyl parathion	-	-	-	F	300	300	30	100	0.25	9	2	-	D
Methyl tert butyl ether	L	-	-	D	3000	3000	500	2000	5	200	40	-	D
Metolachlor	L	-	-	F	2000	2000	2000	5000	150	5000	100	-	C
Metribuzin	L	-	-	F	5000	5000	300	900	25	900	200	-	D

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Monochloroacetic acid	L	-	-	D	-	-	-	-	-	-	-	-	-
Monochlorobenzene	P	100	100	F	2000	2000	2000	7000	20	700	100	-	D
Naphthalene	-	-	-	D	500	500	400	1000	4	100	20	-	D
Nitrocellulose (non-toxic)	-	-	-	F	-	-	-	-	-	-	-	-	-
Nitroguanidine	-	-	-	F	10000	10000	10000	40000	100	4000	700	-	D
Nitrophenols p-	-	-	-	D	800	800	800	3000	8	300	60	-	D
Oxamyl (Vydate)	P	200	200	F	200	200	200	900	25	900	200	-	E
Ozone by-products	L	-	-	-	-	-	-	-	-	-	-	-	-
Paraquat	-	-	-	F	100	100	50	200	4.5	200	30	-	E
Pentachloroethane	-	-	-	D	-	-	-	-	-	-	-	-	-
Pentachlorophenol	P	200/zero	200/0.1*	F	1000	300	300	1000	30	1000	-	30	B2
Phenanthrene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	-
Phenol	-	-	-	D	6000	6000	6000	20000	600	20000	4000	-	D
Picloram	P	500	500	F	20000	20000	700	2000	70	2000	500	-	D
Polychlorinated byphenyls (PCBs)	P	zero	0.5	P	-	-	-	-	-	-	-	0.5	B2
Prometon	-	-	-	F	200	200	200	500	15	500	100	-	D
Pronamide	-	-	-	F	800	800	800	3000	75	3000	50	-	C
Propachlor	-	-	-	F	500	500	100	500	13	500	90	-	D
Propazine	-	-	-	F	1000	1000	500	2000	20	700	10	-	C
Propham	-	-	-	F	5000	5000	5000	20000	20	600	100	-	D
Propylbenzene n-	-	-	-	D	-	-	-	-	-	-	-	-	-
Pyrene (PAH)	P	zero	0.2	-	-	-	-	-	30	-	-	-	D
RDX	-	-	-	F	100	100	100	400	3	100	2	30	C
Simazine	P	1	1	F	500	500	50	200	2	60	1	-	C
Styrene	P	zero/100	5/100*	F	20000	2000	2000	7000	200	7000	0/100	1	B2/C
2,4,5-T	L	-	-	F	800	800	800	1000	10	350	70	-	D
2,3,7,8-TCDD (Dioxin)	P	zero	$5x10^{-9}$mg/L	F	0.0011	E-04	1E-05	4E-05	1E-06	4E-05	-	2E-05	B2
Tebuthiuron	-	-	-	F	3000	3000	700	2000	70	2000	500	-	D
Terbacil	-	-	-	F	300	300	300	900	13	400	90	-	E
Terbufos	-	-	-	F	5	5	1	5	0.13	5	0.9	-	D

Under review.

Chemicals	Standards: Status Reg.*	Standards: MCLG (µg/l)	Standards: MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	10-kg Child: Ten-day µg/l	10-kg Child: Longer-term µg/l	70-kg Adult: Longer-term µg/l	70-kg Adult: RfD µg/kg/day	70-kg Adult: DWEL µg/l	70-kg Adult: Lifetime µg/l	70-kg Adult: µg/l at 10^{-4} Cancer Risk	Cancer Group
Tetrachloroethane (1,1,1,2-)	L	-	-	F	2000	2000	900	3000	30	1000	70	100	C
Tetrachloroethane (1,1,2,2-)	L	-	-	D	-	-	-	-	-	-	-	-	-
Tetrachloroethylene	P	zero	5	F	2000	2000	1000	5000	10	500	-	70	B2
Toluene	P	2000	2000*	F	20000	3000	3000	10000	100	5	1000	-	D
Toxaphene	P	zero	5*	F	500	40	-	-	100	3.5	-	3	B2
2,4,5-TP	P	50	50	F	200	200	70	300	7.5	300	50	-	D
1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroacetic acid	L	-	-	D	30000	30000	30000	100000	300	10000	200	-	C
Trichloroactonitrile	L	-	-	D	50	50	-	-	-	-	-	-	-
Trichlorobenzene (1,2,4-)	P	9	9	F	100	100	100	500	1	50	9	-	D
Trichlorobenzene (1,3,5-)	-	-	-	F	600	600	600	2000	6	200	40	-	D
Trichloroethane (1,1,1-)	F	200	200	F	100000	40000	40000	100000	35	1000	200	-	D
Trichloroethane (1,1,2-)	P	3	5	F	600	400	400	1000	4	100	3	-	C
Trichloroethanol (2,2,2-)	L	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	F	zero	5	F	-	-	-	-	7	300	-	300	B2
Trichlorophenol (2,4,6-)	L	-	-	D	-	-	-	-	-	-	-	300	B2
Trichloropropane (1,1,1-)	-	-	-	D	-	-	-	-	-	-	-	-	-
Trichloropropane (1,2,3-)	-	-	-	F	600	600	600	2000	6	200	40	-	-
Trifluralin	L	-	-	F	80	80	80	300	7.5	300	5	-	C
Trimethylbenzene (1,2,4-)	-	-	-	D	-	-	-	-	-	-	-	-	-
Trimethylbenzene (1,3,5-)	-	-	-	D	-	-	-	-	-	-	-	-	-
Trinitroglycerol	-	-	-	F	5	5	5	5	-	-	5	-	-
Trinitrotoluene	-	-	-	F	20	20	20	20	0.5	20	2	-	C
Vinyl chloride	F	zero	2	F	3000	3000	10	50	-	-	-	1.5	A
White phosphorus	-	-	-	D	-	-	-	-	0.02	0.5	0.1	-	-
Xylenes	P	10000	10000	F	40000	40000	40000	100000	2000	60000	10000	-	D
Zinc chloride	-	-	-	D	-	-	-	-	-	-	-	-	-

* Under review.

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
INORGANICS													
Aluminum	L	-	-	D	-	-	-	-	-	-	-	-	-
Ammonia	L	-	-	D	-	-	-	-	-	-	30000	-	D
Antimony	P	3	10/5	D	15	15	15	15	0.4	15	3	-	D
Arsenic	P	zero	-	D	-	-	-	-	1	-	-	3	A
Asbestos (fibers/l > 10um)	P	7E+06	7E+06	-	-	-	-	-	-	-	-	-	-
Barium	P	5000	5000*	F	-	-	-	-	70	-	2000	-	D
Beryllium	P	zero	1	D	30000	30000	4000	20000	5	200	-	0.8	B2
Boron	L	-	-	D	4000	900	900	3000	90	3000	600	-	D
Cadmium	P	5	5	F	40	40	5	20	0.5	20	5	-	D
Chloramine	L	-	-	D	1000	1000	1000	4000	10	400	300	-	D
Chlorate	L	-	-	D	40	40	40	100	0.4	10	10	-	D
Chlorine	L	-	-	D	3000	3000	400	2000	40	2000	1000	-	D
Chlorine dioxide	L	-	-	D	300	300	300	1000	3	100	80	-	D
Chlorite	L	-	-	D	100	100	400	400	1	40	30	-	-
Chromium (total)	P	100	100	F	1000	1000	200	800	5	200	100	-	D
Copper	P	1300	1300	-	-	-	-	-	-	-	-	-	D
Cyanide	P	200	200	F	200	200	200	800	22	800	200	-	D
Fluoride	F	4000	4000	-	-	-	-	-	60	-	-	-	-
Lead (at source)	P	zero	5*	-	-	-	-	-	-	-	-	-	B2
Lead (at tap)	P	zero	TT*	-	-	-	-	-	-	-	-	-	B2
Manganese	-	-	-	D	-	-	-	-	140	-	-	-	-
Mercury	P	2	2	F	-	-	-	2	0.3	10	2	-	D
Molybdenum	L	-	-	D	80	80	10	50	1	50	50	-	D
Nickel	P	100	100	F	1000	1000	100	600	20	600	100	-	D
Nitrate (as N)	P	10000	10000	F	-	10000	-	-	1600	-	-	-	D

* Under review.

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Nitrite (as N)	P	1000	1000	F	-	1000	-	-	1600	-	-	-	D
Nitrate + Nitrite	P	10000	10000	-	-	-	-	-	-	-	-	-	-
Selenium	P	50	50	-	-	-	-	-	-	-	-	-	-
Silver	L	-	-	D	200	200	200	200	5	200	100	-	D
Sodium	L	-	-	D	-	-	-	-	-	20000***	-	-	-
Strontium	L	-	-	D	25000	25000	25000	90000	2500	90000	17000	-	D
Sulfate	P	400000/ 500000	400000/ 500000	-	-	-	-	-	-	-	-	-	-
Thallium	P	0.5	2/1	D	7	7	7	20	0.07	2	0.4	-	-
Vanadium	L	-	-	D	80	80	30	100	3	100	20	-	D
Zinc	L	-	-	D	4000	4000	4000	4000	100	4000	4000	-	D
ADIONUCLIDES													
Beta particle and photon activity (formerly man-made radionuclides)	F	zero	4 mrem	-	-	-	-	-	-	-	-	4 mrem/y	A
Gross alpha particle activity	F	zero	15 pCi/L	-	-	-	-	-	-	-	-	-	A
Radium 226/228	F	zero	5 pCi/L	-	-	-	-	-	-	-	-	21/28 pCi/l	A
Radon	T	zero	-	-	-	-	-	-	-	-	-	160 pCi/l	A
Uranium	T	zero	-	-	-	-	-	-	-	-	-	26 pCi/l	A

MICROBIOLOGY

	Status	MCLG	MCL
Cryptosporidium	L	-	-
Giardia lamblia	F	zero	TT
Legionella	F[a]	zero	TT
Standard Plate Count	F[a]	NA	TT
Total Coliforms (Current)	F	NA	varies
Total Coliforms (after 12/31/90)	F	zero	**
Turbidity (before 1/1/91)	F	NA	1 and 5 NTU
Turbidity (after 12/31/90)	F	NA	PS
Viruses	F[a]	zero	TT

Key: PS, TT, F, defined as previously stated.

[a]: Final for systems using surface water; also being considered for regulation under groundwater disinfection rule.

Varies: MCL varies based on analytical method used, sample volume, and number of samples collected per month. Also, two types of MCLs = the monthly average and the "single sample" MCL. Both are based on coliform density.

'1 and 5 NTU": These are two MCLs for turbidity. The monthly average MCL is 1 NTU; the two-day consecutive average MCL is 5 NTU.

SECONDARY MAXIMUM CONTAMINANT LEVELS

Chemicals	Status*	SMCLs (mg/l)
Aluminum	P	0.05 to 0.2
Chloride	F	250
Color	F	15 color units
Copper	F	1
Corrosivity	F	non-corrosive
Dichlorobenzene -o	P	0.01
Dichlorobenzene -p	P	0.005
Ethylbenzene	P	0.03
Fluoride	F	2
Foaming Agents	F	0.5
Hexachlorocyclopentadiene		0.008
Iron	F	0.3
Manganese	F	0.05
Odor	F	3 threshold odor numbers
Pentachlorophenol	P	0.03
pH	F	6.5 - 8.5
Silver	P	0.09
Sulfate	F	250
Toluene	P	0.04
Total Dissolved Solids (TD)	F	500
Xylene	P	0.02
Zinc	F	5

* Status Codes: P - proposed, F - final