A BIOLOGICAL SURVEY OF THE SUSQUEHANNA RIVER

IN THE VICINITY OF YORK HAVEN, PA.

1969 PROGRESS REPORT

prepared for

PENNSYLVANIA POWER & LIGHT COMPANY

and

METROPOLITAN EDISON COMPANY

By

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submitted

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CONCLUSIONS

1. The Susquehanna River in the vicinity of York Haven Dam has been subjected to biological depression for three successive years as measured by the species diversity of the resident fauna. The fauna of macroinvertebrates sampled included 145 species in 1967, 119 species in 1968, and 79 species in 1969.

2. The 1969 collections show relatively low variance among the eight stations studied, and this reflects similar ecological conditions among the stations.

3. There are strong indications that a toxicant has been introduced into the river from above the study area. The toxicant appears to be incipiently persistent or regularly recurrent.

4. The causative agent of the biological depression is more pronounced above the York Haven Dam than below it. This is reflected in the high coefficient of correlation values found above the dam in 1969.

5. The discharge from the Brunner Island Plant appears to have a retarding effect on river biology as far downstream as Station 8, but not as far downstream as Station 9.

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INTRODUCTION

This survey was the third biological survey undertaken in the interests of the Pennsylvania Power & Light Company and the Metropolitan Edison Company. The survey represents a study of the macroinvertebrate fauna (bottom organisms) at each of a series of eight stations. The field work was done from August 4 through August 8, 1969.

STATIONS

The location of each of the eight stations sampled is indicated on Figure 1 of the first progress report submitted August 9, 1968. The stations collected are listed below.

Station 1. This station was in the riffle area above Threemile Island and between the head of Fall Island and the eastern shoreline of the river.

Station 2. This station was between the northern tips of Threemile Island and Shelley Island to the west of Threemile Island.

1590 116

Station 3. This station extended from the southern tip of Shelley Island to the western shore of Threemile Island at the "Bali Lai" summer cottage.

Station 4. This station extended from the southern tip of Shelley Island to the southern tip of the next island west of Shelley Island.

Station 5. Deleted from the survey after the 1968 study.

Station 6. This station was located along the western shore of the river above the mouth of the Conewago Creek diversion channel that skirts the northern edge of the Brunner Island Plant site.

Station 7. This station was located between the northern tip of Haldeman Island (=Elliot Island) and the eastern shore.

Station 8. This station was located along the western shore of the river about one mile below the discharge canal of the Brunner Island Plant.

Station 9. This station was located at the western edge of Haldeman Riffle above the mouth of Codorus Creek.

WATER QUALITY

On August 7, 1969, one set of water samples was taken for water quality analyses. These analyses were performed by the laboratory personnel of the Pennsylvania Power & Light Company.

Results of these analyses, expressed as parts per million, are presented in Table 1.

TABLE 1

Water Quality Characteristics

Station	Methyl Orange Alkalinity (as $CaCO_3$)	Total Hardness (as $CaCO_3$)	Chlorides (as NaCl)	Suspended Matter
1.	22.0	96.0	15.0	37.0
2.	14.0	106.0	15.0	39.5
3.	17.0	98.0	15.0	32.2
4.	22.0	84.0	13.0	13.2
6.	61.0	102.0	16.0	26.2
7.	19.0	108.0	17.0	42.2
8.	60.0	101.0	17.0	42.5
9.	56.0	93.0	16.0	29.9

Table 2 presents the average value for each of the water quality characteristics of Table 1 for each of the three years of study. Results are expressed as parts per million.

TABLE 2

Average Water Quality

Year	Methyl Orange Alkalinity (as $CaCO_3$)	Total Hardness (as $CaCO_3$)	Chlorides (as NaCl)	Suspended Matter
1967	43.9	104.9	13.8	15.2
1968	58.1	180.1	24.2	12.4
1969	33.9	98.5	15.5	32.8

The variation in water quality from year to year reflects the variation in runoff preceding the time of sampling. Average river flow during the twelve days preceding each of the annual surveys were as follows: 1967, 19,590 cfs; 1968, 7,490 cfs; 1969, 30,991 cfs. With increased discharge the methyl orange alkalinity, total hardness, and chlorides are diluted. At the same time, scouring increases the load of suspended matter in the water. From the data presented it is apparent that the resident fauna of the river is adapted to wide fluctuations in water quality.

BIOLOGICAL COLLECTIONS

A total of 79 species of macroinvertebrates was collected during the 1969 survey. The corresponding collections for 1967 and 1968 respectively were 145 species and 119 species. It is apparent that the river has been suffering from a biological decline since the investigations began. The species collected in 1969 are listed in Appendix A along with their distribution among the eight stations.

Table 3 summarizes the collections from the three years of study.

TABLE 3

Numbers of Macroinvertebrate Species

Station	Non-insects			Insects			All Species		
	'67	'68	'69	'67	'68	'69	'67	'68	'69
1	20	23	12	23	31	22	43	54	34
2	18	20	5	28	22	24	46	42	29
3	19	15	8	16	12	8	35	27	16
4	20	13	5	28	13	8	48	26	13
6	12	14	6	44	24	26	56	38	32
7	13	10	7	32	29	22	45	39	29
8	7	3	4	32	7	11	39	10	15
9	13	19	4	57	35	22	70	54	26

Four dominant species (5% of the total) are recognized herein. The first of these is the bryozoan, Plumatella repens, the second is the snail, Physa heterostropha, and the third and fourth are midge larvae, Ablabesmyia mallochi and Polypedilum illinoense. Dominant species in 1967 represented 6% of the total collected, and, in 1968, 5%.

Of the 79 species collected in 1969, 39 (49%) were unique in the sense that they were collected at only one of the eight stations. In 1967 there were 53 (37%) unique species; in 1968 there were 52 (44%) unique species.

The 1968 collections of 119 species represented a loss of 18% of the species from the 145 species collected in 1967. The 1969 collections represented a drop of 45.5% from the 1967 species diversity and a drop of 33.6% from the 1968 species diversity.

It is of importance to note that many of the species records presented in Appendix A are represented by single specimens. With some species, notably larger animals, aggressive predators, or rare forms, this is not unusual. However, in the 1969 collections some groups were severely reduced in numbers. Some forms that represent an unnaturally low frequency of occurrence are mentioned below.

The snails Campeloma integrum and Nitocris carinatus were represented by single specimens. Usually these snails occur commonly in those habitats suited to them. The scud Hyalella azteca is usually abundant within a suitable habitat. In 1969 a single specimen was taken at Station 1. The dragonflies, which are generally very hardy organisms, were represented by a single specimen from Station 8. The caddisflies, usually common when they are in a suitable habitat, were also represented by a single specimen (from Station 1). The same condition prevailed for the large water strider, Gerris sp. 1, which was taken at Station 7. With the exception of the midge larvae, only one fly larva was collected. This was a specimen of a cranefly (Tipulidae).

Other species were also represented by single specimens, but, as mentioned above, this is not necessarily unusual. At the same time, if "single-specimen" species were deleted from Appendix A the total number of species reported for 1969 would be reduced from 79 to 57. (If "single-specimen" species were deleted from the 1967 and 1968 collections the numbers of species reported in the progress reports covering those surveys would also be reduced. However, the reductions would not be of the same magnitude as occurs with the 1969 collections.) Table 4 indicates the number of species found at each station in 1969 if "single-specimen" species are deleted.

TABLE 4

Species Represented by Multiple Specimens

Station	Species
1	29
2	25
3	14
4	12
6	27
7	27
8	13
9	24

The basic descriptive statistics developed from the biological data include the mean ($\overline{x}$), standard deviation (s), variance (s^2), and the coefficient of variation (V). Table 5 presents these descriptive statistics for each of the three years of study.

1590 122

TABLE 5

Descriptive Statistics

	$\bar{x}$	s	s^2	V
1967				
Non-insects	15	4.72	22.29	31.5%
Insects	33	12.75	162.57	38.6%
Total Species	48	10.93	119.43	22.8%
1968				
Non-insects	15	6.31	39.86	42.1%
Insects	22	10.05	101.29	45.7%
Total Species	36	14.89	222.00	41.4%
1969				
Non-insects	6	2.70	7.29	45.0%
Insects	18	7.72	59.57	42.9%
Total Species	24	8.31	69.14	34.6%

It is apparent from the data of Table 3 and the statistics of Table 5 that the Susquehanna River differed widely in its biological structure during the three years of study. During the three years of study the river has suffered continuing attrition in species diversity. To the extent that the coefficient of variation reflects increasing stability with lowering values it would appear that the river passed through a period of degradation before the 1968 collections were made, but that this has stabilized at a new, lower level of species diversity. This could be interpreted as meaning that whatever the cause of the degradation it is now incorporated into the environment as a constant, or regularly recurring, factor. Whatever the cause, it extends throughout the entire geographic area studied.

A chi square analysis comparing the 1967 and 1968 collections produced a chi square value of 19.93. This represented a statistically significant difference with p=0.005-0.010. A chi square analysis comparing the 1968 and 1969 collections produced a chi square value of 8.16. This is not statistically significant (p=0.250-0.500). This would tend to support the opinion that the river's biological structure has come into equilibrium at a lower level of species diversity.

Using rank order correlation the 1967 collections when compared with the 1968 collections had a rho value of 0.375, which is not significant. The same analysis applied to the 1968 and 1969 collections produced a rho value of 0.714, which is significant at the 5% level. Once again, this tends to support the opinion that the river was in a transitional stage toward biological depression in 1968, and that in 1969 this had stabilized at a lower level of species diversity.

Comparisons have been made between the group of four stations (1-4) above the York Haven Dam and the group of four stations (6-9) below the dam. In 1967 no significant difference was found between these two groups (chi square value was 2.26 with p=0.500-0.750). In 1968 a significant difference between the two groups was found (chi square value was 20.30 with p= 0.005).

In 1969 conditions reverted to the 1967 situation with no significant difference found between these two groups of stations (chi square value was 3.89 with p=0.250-0.500). As suggested in the 1968 progress report, this appears to be a corollary of stream flow. During both 1967 and 1969 river discharge was high enough to be spilling from the York Haven Dam pool by way of the spillway. During 1968 the river discharge was so low that the river below the dam received only that water which came through the hydro plant. Flows as low as this would severely limit the transport and distribution of bottom organisms. Further discussion of the influence of flow conditions was presented in the 1968 progress report submitted 24 January 1970.

The descriptive statistics for the above-dam and below-dam faunal groups are presented in Table 6.

TABLE 6

Descriptive Statistics

Above Dam

	$\bar{x}$	s	s^2	V
1967				
Non-insects	19	1.00	1.00	0.05%
Insects	24	5.68	32.53	23.7%
All Species	43	5.71	52.66	13.3%
1968				
Non-insects	18	4.58	21.00	25.4%
Insects	20	8.91	79.33	44.6%
All Species	37	13.35	178.33	36.1%

TABLE 6, cont'd.

	$\bar{x}$	s	s^2	V
1969				
Non-insects	8	3.37	11.33	42.1%
Insects	16	8.72	76.00	54.5%
All Species	23	10.10	102.00	43.9%
		Below Dam		
1967				
Non-insects	11	2.88	8.33	26.2%
Insects	41	11.80	139.33	28.8%
All Species	56	14.21	202.00	25.4%
1968				
Non-Insects	12	6.97	48.67	58.1%
Insects	24	12.04	145.00	50.2%
All Species	35	18.36	337.00	52.5%
1969				
Non-insects	5	1.53	2.33	30.6%
Insects	20	6.32	40.00	31.6%
All Species	26	7.44	55.33	28.6%

As stated in the 1968 progress report, the biological structure of the river as found in 1968 reflected a loss of biological stability from the conditions of 1967 and the fauna was apparently in a state of flux. By 1969 a considerable degree of stability had returned to the river as reflected by the reduced variance (s^2). This is even more evident below the York Haven Dam where the coefficient of variation (V) has returned to levels comparable to those found in 1967. The pool above the dam has not yet achieved this degree of stability. This indicates that the influencing factor has its origins above the study area.

During the 1968 field work dead unionid clams were observed at Station 4. Death had been so recent that muscle tissue was still adhering to the inside of the shells. Similar observations were made in 1969. A dead clam (Anodonta cataracta) was found at Station 3 with adhering tissues. This indicates death within the preceding 48 to 96 hours. In the headwaters of the York Haven Dam two dead clams (Elliptio complanata) were seen floating on August 4th. Clams float only when the soft parts of the animal have decomposied to the point where gases are generated, but the tissues have not been totally destroyed. These animals must have died within the preceding 24 to 48 hours. These observations indicate that some toxicant is being introduced at low levels and the clam population is continuing to suffer attrition. Other species are also subject to death by this influence, but are not so readily apparent in the field. The dead clams observed would be several years old, so no massive discharge of a toxicant has occurred. If a massive discharge had occurred the total population would be annihilated at the same time. This has not happened.

APPENDIX A

MACROINVERTEBRATE SPECIES

	Stations							
	1	2	3	4	6	7	8	9
FLATWORMS								
1. Dugesia Tigrina			X					
WORMS								
2. Limnodrilus cf. hoffmeisteri		X	X	X		X		
3. Branchiura sowerbyi							X	
4. Lumbriculidae g. sp. 1	X			X				
BRYOZOANS								
5. Plumatella repens	X	X	X		X	X	X	X
6. Lophopodella carteri							X	
CLAMS								
7. Sphaerium sp. 1	X			X		X		
8. Pisidium sp. 1	X							
SNAILS								
9. Campeloma integrum			X					
10. Amnicola cf. limosa	X							
11. Goniobasis virginica	X							
12. Nitocris carinatus	X							
13. Ferrissia cf. tarda	X			X	X	X		X
14. Physa heterotropha	X	X	X		X	X	X	X
15. Helisoma anceps			X					
16. Lymnaea humilus	X	X	X		X	X		X
CRAYFISH								
17. Orconectes sp. 1	X	X			X			
SCUDS								
18. Hyalella azteca	X							
19. Gammarus fasciatus			X	X	X	X		
MAYFLIES								
20. Stenonema sp. 2						X		
21. Stenonema sp. 5		X						
22. Tricorythodes sp. 6		X	X	X		X		
23. Leptohyphes sp. 1				X				
24. Cloeon sp. 1						X		X
25. Baetinae g. sp. 1	X	X			X			
26. Baetinae g. sp. 2		X						
DRAGONFLIES								
27. Gomphoides sp. 1							X	

1590 128

	Stations							
	1	2	3	4	6	7	8	9
DAMSELFLIES								
28. Enallagma sp. 2	X							
29. Enallagma sp. 5	X							
30. Enallagma sp. 7					X			
31. Ischnura sp. 1	X							
32. Ischnura sp. 2	X	X					X	
33. cf. Teleallagma sp. 1		X						
34. Hetaerina sp. 1							X	
35. Early instars			X			X	X	X
WATER STRIDERS AND WATER BUGS								
36. Gerris sp. 1						X		
37. Metrobates sp. 1	X							X
38. Trepobates sp. 1	X	X			X	X		X
39. Trepobates sp. 2		X			X		X	X
40. Trepobates sp. 4					X	X		
41. Rheumatobates sp. 1							X	
42. Mesovelia cf. mulsanti	X				X	X		X
43. Corixidae g. sp. 1	X				X			
44. Belostoma sp. 1					X	X		
CADDISFLIES								
45. Cheumatopsyche sp. 1	X							
LARVAL BEETLES								
46. Elmidae g. sp. 1	X							
47. Elmidae g. sp. 2		X	X	X				
48. Elmidae g. sp. 3						X		
49. Elmidae g. sp. 6		X						
50. Elodes sp. 1					X			
51. Hydrophilidae g. sp. 1		X						
52. Hydrophilidae g. sp. 2					X			
ADULT BEETLES								
53. Hydrochus sp. 1	X	X			X	X		X
54. Stenelmis					X			
55. Fam. g. sp. 1					X			
56. Fam. g. sp. 2								X
CRANEFLIES								
57. Tipulidae g. sp. 1	X							
MIDGE LARVAE								
58. Procladius sp. 1	X	X			X	X	X	X
59. Conchapelopia sp. 1					X			
60. Ablabesmyia mallochi	X	X	X	X	X	X	X	
61. Ablabesmyia auriensis	X	X	X			X		X
62. Labrundinia virescens		X						
63. Cricotopus sp. 2 Roback		X			X			X
64. Cricotopus bicinctus		X			X			
65. Cricotopus nr. trifasciatus					X			
66. Nanocladius sp. 1		X				X	X	

1590 129

		Stations							
		1	2	3	4	6	7	8	9
67.	Polypedilum illinoense	X	X	X	X	X	X		X
68.	Polypedilum sp. 1				X	X			X
69.	Polypedilum halterale		X	X		X			X
70.	Cryptochironomus fulvus		X		X				X
71.	Cryptochironomus blarina		X			X	X		X
72.	Parachironomus sp. 1	X							
73.	Dicrotendipes nr. modestus			X		X	X	X	X
74.	Dicrotendipes sp. 1						X	X	X
75.	Glyptotendipes lobiferus								X
76.	Chironomus sp. 1	X			X	X	X		X
77.	Chironomus sp. 2	X				X	X		X
78.	unidentified Chironomini						X		
79.	Rheotanytarsus sp. 1	X	X						X

1590 130

SECTION VI

1590 131

SECTION VI

FUTURE ENVIRONMENTAL PROGRAMS

Metropolitan Edison Company has retrained Dr. G. Hoyt Whipple as a consultant for the Environmental Program for the Three Mile Island Nuclear Station. He has enlarged the scope of the previous program and with Metropolitan Edison Company personnel along with Dr. Donald Davis of Millersville State College is starting the following Phase Two environmental program for Metropolitan Edison Company.

PHASE TWO

Investigations have been started to identify pathways of potential significance by which radioactive materials attributable to station operation may enter human food, to determine what the concentration factors for isotopes of concern may be in these pathways and to establish practical ways for monitoring the significant pathways. Work done to date indicates that river fish and milk are probably the most significant food materials of interest.

Starting during the summer of 1970, measurements will be made of the ratios of stable element concentrations in river fish compared to river water to determine concentration factors in this pathway. The elements to be measured will include those which may be present in significant amounts as radioactive isotopes in plant liquid effluents (e.g., including significant ones listed in Table VI-1). The concentration ratios measured, along with other information, will be used as one basis for determining whether effluent discharge limits will be affected by consideration of human food.

PHASE THREE

The pre-operational radioactivity survey will begin about fifteen to eighteen months prior to criticality and will end when criticality is achieved. It will include a period of about six to twelve months during which sample locations and measurement intervals and techniques will be the same as proposed for Phase 4, the operational survey. The purposes of this phase will be (1) to train personnel, (2) insure proper equipment operation, (3) to verify that the sample locations chosen are suitable and that internally consistent data can be obtained, and (4) to obtain an indication as to measurement sensitivity and statistical variation of background radiation levels.

PHASE FOUR

The operational survey will be a continuation of the measurements made in the Phase 3 pre-operational survey and will commence at the date when criticality is achieved.

The principle guiding the selection of sample station locations is that for each type of sample, measurements will be made at both indicator stations and background stations. The indicator stations are to be located where the average concentration of water-borne or air-borne radioactivity discharged from the plant is estimated to be near a maximum in the environment. The background stations will be placed where such concentrations of radioactivity in the environment are estimated to be less than one percent of that at corresponding indicator stations. Thus, if radioactivity attributable to the plant can be measured in the environment, it should be detected by indicator stations. The background stations will provide concurrent background radiation measurements with which the indicator station measurements can be corrected.

The sampling interval and the type of measurement made in Phase 4 will be adjusted depending on the amount of radioactive material released from the plant as determined from measurements made prior to release. If these releases reach a level greater than 1/10 the allowable long-term average release limits established in the technical specifications (expressed, for example, as uCi/cc in water or Ci/sec in air), the environmental network will be operated in the most intensive regime, Regime III. If the long-term average releases are in the range of 1/30 to 1/10 of these limits, the network will be operated in Regime II. If they are less than 1/30 of limits, it will opeate in Regime I. The rules for changing from one regime to another outlined above are predicated on the assumption that release limits will be consonant with those derivable from the numerical limits specified in 10CFR Part 20.

The typical indicator and background stations and typical sample types and measurement intervals associated with each regime are indicated in Table VI-2. Preliminary locations for sampling will be established in the summer of 1970 and will be finally selected six to twelve months before Phase 4 commences. If methods become available for obtaining reproducable measurements of radioactivity, sediment samples will be added to the list in Table VI-2.

For the first year after criticality, in order to try to measure radiation attributable to the plant, the survey will be conducted in Regime III no matter what the plant releases turn out to be and even if estimates indicate levels in the environment are too low to be measured. If no significant differences between indicator and background levels are observed during this period and if calculations and pre-operational measurements indicate that no significant differences should be observed, the survey will then be operated under Regime I. It will continue under

Regime I until plant discharges average significantly more than during the first year (e.g., by a factor of five). If this occurs, Regime III will be put into effect for another period, again to try to measure plant effects. This process will be repeated each time average discharge rates are a significant factor above those during previous Regime III operations until differences between indicator and background stations are observed. Such differences, if they are ever observed, will provide a basis for confirming or changing estimates of concentration factors in principle food pathways and/or in the relationship between atmospheric and liquid release rates and concentrations in environmental air and water.

TABLE VI - 1

Estimate of Annual Release of Radioactive Liquids to the River

Isotopic Breakdown of Annual Quantities of Activity Released to River

Isotope	Annual Release to River uCi	Concentration in Cooling Tower Effluent uCi/cc	MPC uCi/cc	Fraction of MPC
Rb 88	1.86	1.91×10^{-13}	3×10^{-8}(1)	0.637×10^{-5}
Sr 89	0.028	2.80×10^{-15}	3×10^{-4}	0.933×10^{-11}
Sr 90	0.0025	2.61×10^{-16}	3×10^{-7}	0.870×10^{-9}
Sr 91	0.032	3.20×10^{-15}	7×10^{-5}	0.457×10^{-10}
Sr 92	0.012	1.20×10^{-15}	7×10^{-5}	0.171×10^{-10}
Y 90	6440.0	6.44×10^{-10}	2×10^{-5}	0.322×10^{-4}
Y 91	1530.0	1.54×10^{-10}	3×10^{-5}	0.513×10^{-5}
[illegible] 99	37,200.0	3.73×10^{-9}	2×10^{-4}	0.186×10^{-4}
I 131	2.19	2.20×10^{-13}	3×10^{-7}	0.733×10^{-6}
I 132	3.33	3.34×10^{-13}	8×10^{-5}	0.418×10^{-8}
I 133	2.59	2.60×10^{-13}	1×10^{-6}	0.260×10^{-7}
I 134	0.346	3.47×10^{-14}	2×10^{-5}	0.174×10^{-8}
I 135	1.33	1.33×10^{-13}	4×10^{-5}	0.333×10^{-8}
Cs 136	55.3	5.54×10^{-12}	9×10^{-5}	0.620×10^{-7}
Cs 137	3260.0	3.27×10^{-10}	2×10^{-5}	0.164×10^{-4}
Cs 138	50.4	5.08×10^{-12}	3×10^{-8}(1)	0.169×10^{-3}
Ba 139	0.057	5.74×10^{-15}	3×10^{-8}(1)	0.191×10^{-6}
Ba 140	0.045	4.54×10^{-15}	3×10^{-5}	0.151×10^{-9}
La 140	0.015	1.47×10^{-15}	2×10^{-5}	0.735×10^{-10}
Ce 144	0.0019	1.94×10^{-16}	1×10^{-5}	0.194×10^{-10}
H 3	8.64×10^{9}	8.68×10^{-4}	3×10^{-3}	0.29

Note: (1) MPC value not listed in 10 CFR 20. Utilized most conservative MPC value given in 10 CFR 20 for unlisted isotopes.

Total Activity and Fraction of MPC of Annual Release to River

Type of Activity	Annual Quantity Released uCi	Fraction of MPC in Cooling Tower Effluent
Mixed Fission Products	48,400	0.000249*
Tritium	$8.64 \times 10^{+9}$	0.29

* For the mixture of isotopes, excluding tritium, considered above.

1590 136

Table VI-2 TYPICAL SCHEDULE FOR POST-OPERATIONAL REGIMES

	NUMBER OF		REGIME		
	Indicator Stations	Background Stations	I	II	III
Air	7	5	S-1	C-1	C-1
Precipitation	7	5	S-4	C-4	C-4
Radiation	30	10	F-4	F-4	F-4
Milk	4	2	- -	G-4	G-1
Crops	To be decided		- -	H-52	H-4
River Water	2	1	S-4	C-4	C-1
Columbia Intake	1	-	S-4	C-4	C-1
Clams or Snails	2	1	- -	G-13	G-4
Fish	1	1	- -	- -	G-4

Key: S-1 (S-4): collect continuously for 1 week (4 weeks) and discard without analysis

C-1 (C-4): collect continuously for 1 week (4 weeks) and analyze

F-4: film badge, or TLD exposed for 4 weeks and read

G-1 (G-4): grab sample taken at 1 week (4 week) interval and analyzed

G-13: a grab sample taken 3 times a year (spring, summer, fall) at approximately 13 week intervals, and analyzed

H-52: one grab sample taken at harvest and analyzed

H-4: one grab sample every four weeks during the growing season; analyzed

1590 137