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RADIATION CONTROL

OF

ACCIDENTALLY CONTAMINATED SEEPAGE PONDS

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by

G. E. Backman
Chemical Processing Department
General Electric Company
Richland, Washington

L. W. Roddy
Chemical Processing Department
General Electric Company
Richland, Washington

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INTRODUCTION

The Chemical Processing Department is located in approximately the center of a 600 square mile reservation in south central Washington state controlled by the Atomic Energy Commission. There are several major production facilities within the department. These facilities receive irradiated fuel elements from which plutonium, uranium and occasionally other radionuclides are recovered in a relatively pure state. Large quantities of process cooling water pass through the plants on a single pass basis and are discharged to low depressions in the surrounding area, where permanent ponds having volumes on the order of tens of millions of gallons are formed. The cooling water is normally uncontaminated with radioactive materials. However, the potential for contamination does exist, should process equipment fail or operating errors occur. During June of 1964, a failure of the cooling coils in one of the process vessels occurred and an unusual contamination condition resulted in two of the ponds associated with one of the major production facilities.

DESCRIPTION OF THE INCIDENT

On June 11, 1964, the cooling coil of a process waste inventory tank (F-15) in the Purex Plant apparently developed a leak since the volume in the tank increased when no streams were knowingly being added to the tank. To verify the existence of a leak, the cooling water supply was cut off and an air purge substituted. The cooling water flow was later

restored as part of the leak test and for temperature control. It was later surmised that during the period when the air purge was conducted, liquid from the tank seeped into the cooling coil. During the early morning on June 12, the cooling water was restored which flushed the material that had seeped into the coils into the cooling water ponds. Shortly after, the cooling water discharge line from this waste tank was disconnected to prevent additional waste from being discharged to these ponds. Radiation surveys were made at the two pond sites. Initial surveys showed gamma radiation levels as high as 5 R/hr eight feet from the pond inlets. Further surveys showed that algae had concentrated the radioactive materials and radiation levels of 7 to 50 rads per hour could be detected over the areas of concentrated algae growth.

One of the ponds ("B" Swamp) has been in service almost since plant start up. It consists of a narrow ditch about a mile long ending in a relatively shallow, open pond (approximate volume of ten million gallons). Roughly one-fourth of the cooling water flow was being discharged to this pond. Algae and other plant growth within the long ditch was substantial and actually served as an excellent filter, removing most of the radioactive material rather than allowing it to be discharged into the open pond, itself. The other pond (Gable Mountain Swamp) has only a short ditch and then opens into a reasonably large expanse of water (approximate volume of fifty million gallons). The remaining three-fourths of the cooling water flow was discharged into this pond. There was only a small amount of algae growth within the trench itself and the radioactive materials that were discharged, were dispersed almost uniformly through the entire liquid volume.

IMMEDIATE ACTION TAKEN

The radiation surveys indicated general high radiation levels and efforts were immediately directed toward preventing any undue personnel exposure. All roadways approaching the ponds were barricaded and posted with appropriate radiation signs. The plant patrol operation was instructed to allow no unauthorized entry beyond these barricades. Water and mud samples were procured from both ponds and sent to the analytical laboratories for analysis. Efforts were made to drive off water fowl that were present in small numbers on both ponds. These efforts were relatively unsuccessful. The fowl appeared to be residents of these areas and only moved to another location on the ponds when attempts were made to frighten them away.

These ponds were known to be frequented by migratory water fowl during certain periods of the year. Shortly after the incident, members of the Biology Department, now with the Battelle Northwest Laboratories, but then a part of General Electric Company, were counsulted for their opinion about the water fowl problem. They indicated that in all likelihood all water fowl present were residents rather than migrants, and that it was unlikely that they would leave the project. They also indicated that it would be at least six to eight weeks before any migratory fowl would be expected.

DISCUSSION OF THE INCIDENT

The process waste inventory tank in which the coil leak occurred is used for temporary storage of concentrated fission product waste. The waste is sampled at this point for inventory purposes and to determine the quantity of chemical reagents needed for neutralization. The content of this tank is transferred to another tank for neutralization and is then

normally sent to underground storage tanks. The concentration of radioactive materials is sufficiently high to cause these underground tanks content to boil. Estimates were made of the amount of activity that escaped to the ponds by determining the radioactive concentration in the solution in the waste tank and estimating the amount of solution that could have seeped into the cooling coils. On the order of 10,000 curies of fission products evidently escaped to the ponds. The following table gives a rough estimate of the percentage of the various radionuclides that were present in any significant concentrations.

TABLE I

RADIONUCLIDE	PERCENT OF TOTAL ACTIVITY	RADIONUCLIDE	PERCENT OF TOTAL ACTIVITY
Sr-89	9.5	1Te-129	0.21
Sr-90	0.4	2Te-129	0.21
Y-90	0.4	Cs-137	0.33
2Y-91	11.5	Ba-137	0.33
Zr-95	14.8	Ba-140	0.28
1Nb-95	0.3	La-140	0.33
2Nb-95	23.2	Ce-141	4.7
Ru-103	5.6	Pr-143	0.4
Rh-103	5.6	Ce-144	9.3
Ru-106	0.75	Pr-144	9.3
Rh-106	0.75	Pm-147	1.35

1- GROUND STATE 2- META-STABLE

After the immediate protective action was completed, a Task Force, consisting of operations management personnel, process engineers, a senior chemist, a geologist-hydrologist, a waste disposal engineer, a biologist, and health physicists, was formed to determine further courses of action. The situation was, as best the Task Force could determine, relatively stable and it appeared that there was a reasonable amount of time available for conducting various studies that might aid in suggesting a practical course of action. Several

different types of investigation were conducted on ways to return the ponds to an acceptable status. Each investigation will be discussed as a separate entity, however, these investigations were frequently being conducted concurrently.

It was first recommended by the Task Force that efforts to reduce the high radiation levels should begin as soon as practical so that the potential for personnel exposure would be removed. The first course of action was, therefore, to excavate new trenches into both ponds and to back-fill the old ones. This action was completed toward the end of July, 1965, and as a result surveillance of the area by patrol was no longer required. During this period, operations personnel were successful in keeping the liquid levels of both swamps to nearly the same levels that existed at the time of the incident. The contaminated area was, therefore, not enlarged nor were already contaminated areas allowed to dry out so that the wind could cause further contamination spread.

Shortly after the incident some of the resident water fowl were periodically harvested to determine the amount of external contamination and internal deposition. Tables II and III indicate the results of this program.

TABLE II

WATER FOWL EXTERNAL CONTAMINATION

TYPE OF FOWL	DATE	LOCATION	RADIATION MEASUREMENT (CP Meter Scale Reading)
Teal	6/22/64	Gable Mountain Swamp	100 mrads/hr
Coot	6/22/64	Gable Mountain Swamp	60 mrads/hr
Mallard	6/22/64	Gable Mountain Swamp	40 mrads/hr
Coot	6/22/64	Gable Mountain Swamp	100 mrads/hr

TYPE OF FOWL	DATE	LOCATION	RADIATION PEAK READING (CP Meter Scale Reading)
Coot	6/22/64	Gable Mountain Swamp	50 mrads/hr
Coot	6/23/64	Gable Mountain Swamp	25 mrads/hr
Coot	6/23/64	Gable Mountain Swamp	35 mrads/hr
Coot	6/23/64	Gable Mountain Swamp	60 mrads/hr
Coot	6/23/64	Gable Mountain Swamp	15 mrads/hr
Coot	6/23/64	Gable Mountain Swamp	10 mrads/hr
Goose	6/24/64	Redox Swamp*	Bkg (GM Meter)
Coot (3)	6/24/64	Redox Swamp	Bkg (GM Meter)
Mallard	6/24/64	"Y" Swamp*	Bkg (GM Meter)
Ruddy Duck	6/24/64	"Y" Swamp	Bkg (GM Meter)
Teal (5)	6/24/64	"Y" Swamp	Bkg (GM Meter)
Coot	6/29/64	Gable Mountain Swamp	35 mrads/hr
Shoveler	6/29/64	Gable Mountain Swamp	15 mrads/hr
Coot (5)	6/30/64	Gable Mountain Swamp	20 mrads/hr
Mallard	6/30/64	Gable Mountain Swamp	30 mrads/hr
Teal	6/30/64	Gable Mountain Swamp	20 mrads/hr
Coot (3)	7/1/64	Gable Mountain Swamp	35 mrads/hr
Ruddy Duck	7/1/64	Gable Mountain Swamp	30 mrads/hr
Shoveler	7/1/64	Gable Mountain Swamp	35 mrads/hr
Mallard (2)	7/8/64	Honey Hill**	30,000 c/m (GM Meter)
Pintail	7/8/64	Honey Hill	8,000 c/m (GM Meter)
Teal	7/8/64	Honey Hill	20,000 c/m (GM Meter)
Teal	7/8/64	Honey Hill	4,500 c/m (GM Meter)
Teal	7/8/64	Honey Hill	2,000 c/m (GM Meter)
Teal	7/15/64	Honey Hill	10,000 c/m (GM Meter)
Mallard	7/15/64	Honey Hill	400 c/m (GM Meter)
Pintail	7/15/64	Honey Hill	3,000 c/m (GM Meter)
Teal	7/15/64	Honey Hill	80,000 c/m (GM Meter)
Mallard	7/15/64	Honey Hill	1,000 c/m (GM Meter)
Mallard	7/15/64	Honey Hill	5,000 c/m (GM Meter)
Teal	7/15/64	Honey Hill	10,000 c/m (GM Meter)
Domestic	9/29/64	Gable Mountain Swamp	7,000 c/m (GM Meter)
Domestic	9/29/64	Gable Mountain Swamp	500 c/m (GM Meter)
Scaup (8)	11/3/64	Gable Mountain Swamp	900 c/m (GM Meter)
Mallard (3)	11/3/64	Gable Mountain Swamp	1,000 c/m (GM Meter)
Pintail	11/3/64	Gable Mountain Swamp	2,500 c/m (GM Meter)
Teal (2)	11/3/64	Gable Mountain Swamp	500 c/m (GM Meter)
Coot (5)	11/3/64	Gable Mountain Swamp	5,000 c/m (GM Meter)

* Swamps associate with other chemical processing facilities ~6 miles from the contaminated swamp where the incident occurred.

** A small pond approximately one mile from Gable Mountain Swamp.

TABLE III

WILD FOWL INTERNAL CONTAMINATION

TYPE OF FOWL	DATE	LOCATION	pμc/gm Cs-137 CONTENT OF MUSCLE	pμc/gm Sr - Total CONTENT OF MUSCLE
Coot	6/29/64	Gable Mountain Swamp	26,[illegible]	120
Shoveler	6/29/64	Gable Mountain Swamp	18[illegible],[illegible]	NA
Teal	6/30/64	Gable Mountain Swamp	4[illegible],[illegible]	15[illegible]
Mallard	6/30/64	Gable Mountain Swamp	1[illegible],[illegible]	[illegible]
Coot	6/30/64	Gable Mountain Swamp	7[illegible],[illegible]	[illegible]
Coot	6/30/64	Gable Mountain Swamp	1[illegible],[illegible]	120
Coot	6/30/64	Gable Mountain Swamp	[illegible]	NA
Coot	6/30/64	Gable Mountain Swamp	[illegible]	NA
Coot	6/30/64	Gable Mountain Swamp	28,[illegible]	NA
Mallard	7/1/64	Gable Mountain Swamp	69,[illegible]	NA
Shoveler	7/1/64	Gable Mountain Swamp	120,[illegible]	NA
Coot	7/1/64	Gable Mountain Swamp	26,[illegible]	NA
Coot	7/1/64	Gable Mountain Swamp	[illegible]	NA
Coot	7/1/64	Gable Mountain Swamp	67,[illegible]	160
Teal	7/2/64	Gable Mountain Swamp	82,[illegible]	[illegible]
Coot	7/2/64	Gable Mountain Swamp	91,[illegible]	120
Coot	7/2/64	Gable Mountain Swamp	89,[illegible]	270
Coot	7/2/64	Gable Mountain Swamp	92,[illegible]	NA
Coot	7/2/64	Gable Mountain Swamp	70,[illegible]	[illegible]
Mallard	7/8/64	Gable Mountain Swamp	77,[illegible]	NA
Teal	7/8/64	Gable Mountain Swamp	1,[illegible]	NA
Teal	7/8/64	Gable Mountain Swamp	[illegible]	NA
Teal	7/8/64	Gable Mountain Swamp	[illegible]	NA
Pintail	7/8/64	Gable Mountain Swamp	[illegible]	NA
Teal	7/15/64	Honey Hill	5,7[illegible]	NA
Pintail	7/15/64	Honey Hill	2[illegible]	NA
Teal	7/15/64	Honey Hill	1[illegible]	NA
Mallard	7/15/64	Honey Hill	29	NA
Teal	7/15/64	Honey Hill	2[illegible]	NA
Mallard	7/15/64	Honey Hill	15	NA
Mallard	7/15/64	Honey Hill	1[illegible]	NA
Teal	8/15/64	Honey Hill	~[illegible]	NA
Teal	8/15/64	Honey Hill	~1	NA
Teal	8/15/64	Honey Hill	~[illegible]	NA
Teal	8/15/64	Honey Hill	~[illegible]	NA
Teal	8/15/64	Honey Hill	~[illegible]	NA
Mallard	8/31/64	Gable Mountain Swamp	[illegible]	NA
Coot	9/6/64	Gable Mountain Swamp	67	[illegible]
Domestic	9/8/64	Gable Mountain Swamp	1,[illegible]	NA
Domestic	9/8/64	Gable Mountain Swamp	1,[illegible]	NA
Domestic	9/8/64	Gable Mountain Swamp	1,[illegible]	NA
Domestic	9/22/64	Gable Mountain Swamp	1,[illegible]	NA
Domestic	9/22/64	Gable Mountain Swamp	1,[illegible]	NA
Domestic	9/22/64	Gable Mountain Swamp	5,[illegible]	NA
Domestic	9/22/64	Gable Mountain Swamp	5,[illegible]	NA
Domestic	9/29/64	Gable Mountain Swamp	3,[illegible]	NA
Domestic	9/29/64	Gable Mountain Swamp	9[illegible]	NA

TYPE OF FOWL	DATE	LOCATION	pCi/gm Cs-137 CONTENT OF MUSCLE	pCi/gm Sr - Total CONTENT OF MUSCLE
Coot	9/29/64	Gable Mountain Swamp	137	NA
Coot	9/29/64	Gable Mountain Swamp	102	NA
Coot	9/29/64	Gable Mountain Swamp	283	NA
Mallard	9/30/64	Gable Mountain Swamp	195	NA
Mallard	9/30/64	Gable Mountain Swamp	181	NA
Coot	9/30/64	Gable Mountain Swamp	247	NA
Shoveler	10/2/64	Gable Mountain Swamp	112	NA
Scaup	10/9/64	Gable Mountain Swamp	32	NA
Scaup	10/9/64	Gable Mountain Swamp	4	NA
Teal	10/9/64	Gable Mountain Swamp	281	NA
Gadwall	10/9/64	Gable Mountain Swamp	287	NA
Coot	10/13/64	Gable Mountain Swamp	128	NA
Scaup	11/3/64	Gable Mountain Swamp	98	NA
Scaup	11/3/64	Gable Mountain Swamp	85	NA
Scaup	11/3/64	Gable Mountain Swamp	20	NA
Scaup	11/3/64	Gable Mountain Swamp	114	NA
Scaup	11/3/64	Gable Mountain Swamp	121	NA
Scaup	11/3/64	Gable Mountain Swamp	54	NA
Scaup	11/3/64	Gable Mountain Swamp	18	NA
Mallard	11/3/64	Gable Mountain Swamp	3,020	NA
Mallard	11/3/64	Gable Mountain Swamp	869	NA
Mallard	11/3/64	Gable Mountain Swamp	1,750	NA
Pintail	11/3/64	Gable Mountain Swamp	14	NA
Teal	11/3/64	Gable Mountain Swamp	24	NA
Teal	11/3/64	Gable Mountain Swamp	23	NA
Coot	11/3/64	Gable Mountain Swamp	946	NA
Coot	11/3/64	Gable Mountain Swamp	340	NA
Coot	11/3/64	Gable Mountain Swamp	53	NA
Coot	11/3/64	Gable Mountain Swamp	47	NA
Coot	11/3/64	Gable Mountain Swamp	10	NA
Golden Eye	11/30/64	Gable Mountain Swamp	32	NA
Golden Eye	11/30/64	Gable Mountain Swamp	262	NA
Golden Eye	11/30/64	Gable Mountain Swamp	309	NA
Golden Eye	11/30/64	Gable Mountain Swamp	88	NA
Golden Eye	11/30/64	Gable Mountain Swamp	26	NA
Coot	11/30/64	Gable Mountain Swamp	1	NA
Coot	11/30/64	Gable Mountain Swamp	53	NA
Coot	11/30/64	Gable Mountain Swamp	57	NA
Coot	11/30/64	Gable Mountain Swamp	309	NA

All ducks harvested on the Hanford Reservation after January 1, 1965 have contained <200 pi/gm

As seen in Table II, there was a continuing drop in the external contamination levels with time. The water fowl, harvested from ponds six to eight miles distance from the contaminated ponds, showed no significant external contamination. This information reinforced the belief that the water fowl present on the swamps at the time of the incident were resident fowl and stayed in the immediate vicinity. As seen in Table III, the Cs-137 content of the water fowl muscle was high. Because of this, investigations were made to determine if it was feasible to eradicate the entire water fowl population. State Game Commission people were contacted and the contamination problem discussed with them. They could suggest no good solutions but had no objections to the plant forces making efforts to exterminate these fowl. An attempt was subsequently made to poison these fowl by distributing poisoned grains in certain controlled locations near the ponds. This attempt was almost completely unsuccessful, and was discontinued after a short time. All poisoned material was removed.

A number of tame ducks were procured to use as a means to further investigate the potential external - internal radiation problem. Groups of three ducks were placed on each swamp at various times after the water contamination level dropped to where it was not considered a major problem ($<10^{-4}$ μCi/cc). These ducks were harvested when possible, after a residence time of one to two weeks in an attempt to evaluate how serious the problem of contaminating wild migratory water fowl might be. It was the opinion of some members of the Task Force that the resultant contamination of these fowl would represent a worse case since these tame ducks could not fly and were forced to scavenge all their food in the immediate vicinity of the ponds. The ducks placed

on the larger body of water showed measurable levels of external contamination and internal deposition even after the water concentrations had dropped to $<10^{-4}$ μ Ci/cc. The wild water fowl harvested at about the time the tame ducks were harvested did show somewhat lower levels of both external and internal contamination but not to the extent anticipated. The analyses of wild fowl that have been sampled since the abandonment of the Task Force indicate a reduction in Cs-137 deposition.

The tame water fowl (not shown in the tables) which were placed on "B" Swamp showed no detectable external contamination and essentially no internal deposition. This was expected since a very high percent of the activity that had been discharged in this swamp was trapped in the ditch that was later back-filled. Overall, the "B" Swamp did not prove to be a problem after the back-filling, other than that the old trench was a future potential radiation material source for vegetation uptake.

The Environmental Evaluation and Studies Section of the Battelle Northwest Laboratories conducts an annual audit* of the deposition of radioactive materials in water fowl harvested by hunters in the Hanford Area. Hunters are requested to send the heads of the fowl to Battelle Northwest Laboratories for analyses. Of the nearly 200 fowl analysed, one analysis showed 100 pCi/gm Cs-137, seven others showed detectable Cs-137 but all were less than 5 pCi/gm. The internal deposition of Cs-137 to personnel in the immediate environs caused by this incident, therefore, does not appear to be significant.

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* Battelle Northwest Laboratories Environmental Studies and Evaluation Staff, Evaluation of Radiological Conditions in the Vicinity of Hanford for 1964, BNWL - 90.

Copper sulfate was added on two occasions in Gable Mountain Swamp to eliminate the algae and invertebrate life, thus breaking important links in the food chain of the water fowl. The copper sulfate was added at a reasonably uniform rate at the inlet for about a one week period. Three parts per billion was the desired concentration. It was necessary to broadcast copper sulfate by hand in some areas of the swamp because of apparent water stagnation at these locations. Copper sulfate was not added to the "B" Swamp immediately, since most of the contamination was trapped in the long ditch which was to be backfilled. It was thought that killing the algae in the ditch might release some of the trapped material into the open pond. After the backfilling had been completed copper sulfate was added on one occasion. The addition of this chemical successfully rid the swamps of most of the algae growth. The concentrations of radioactive materials in the water was several orders of magnitude lower before algae began to grow back to any significant extent. The opportunity for algae to concentrate the activity was, therefore, significantly reduced.

Some vegetation samples were collected around the pond perimeters. Complete analyses was not made. However, it is obvious that the uptake of some of the radionuclides was significant from scanning the results in Table IV.

TABLE IV

UPTAKE OF CERTAIN RADIONUCLIDES BY VEGETATION

VEGETATION	pCi Sr-89	pCi Sr-90	pCi Cs-137
Millet Leaves			910
Millet Leaves			2,700
Millet Seed			1,700
Millet Seed			3,100
Swamp Willow Leaves	260	130	13
Swamp Willow Leaves	34	230	1
Swamp Willow Leaves	45,400	22,400	220
Swamp Willow Leaves	3,140	1,580	1,100

These findings indicated a definite need for a soil sterilization program and such a program was carried out. The soil sterilization program had an additional benefit in that it prevented the growth of wild grains that serve as a major food source for wild fowl. There were wild grains (millet) growing in the vicinity of these cooling water waste areas and in an attempt to make these areas as undesirable as possible to water fowl, these grains were destroyed by burning with kerosene.

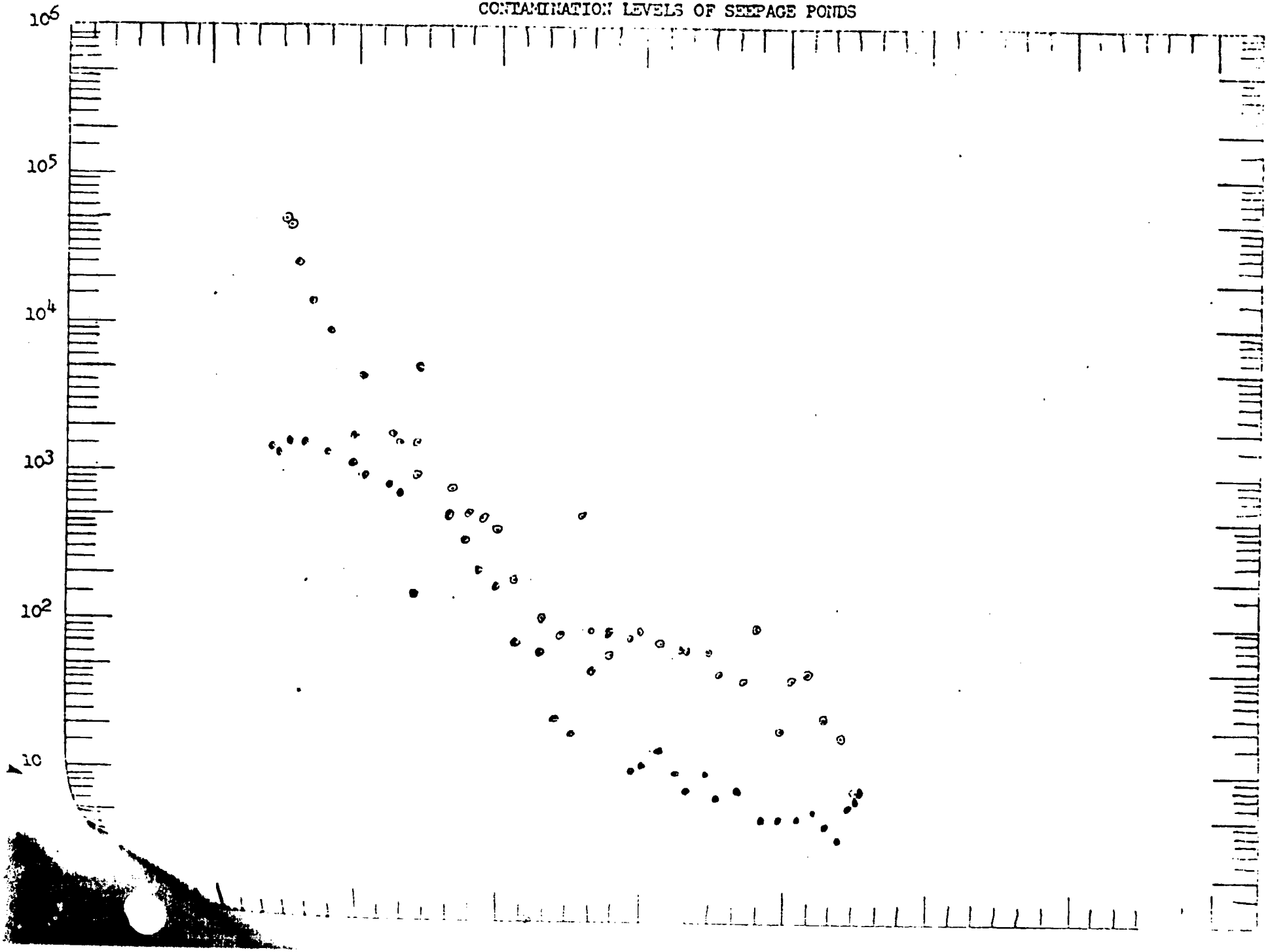
As mentioned previously, the Task Force determined that it would be desirable to maintain the pond liquid levels to that that existed at the time of the incident, until the contamination level of the water dropped to less than 10^{-4} μCi/cc. Table V and Figure 1 show the rate of contamination reduction.

TABLE V

CONTAMINATION LEVELS OF SEEPAGE PONDS

DATE	GABLE MOUNTAIN SWAMP pCi/cc	B - SWAMP pCi/cc
6/16	48,000	1,500
6/17	40,000	1,400
6/19	28,000	1,700
6/23	13,000	1,700
6/26	9,600	1,400
6/30	2,500	1,100
7/2	5,000	950
7/7	2,900	840
7/10	2,200	790
7/14	2,200	5,400
7/14	1,100	150
7/21	810	550
7/24	590	400
7/28	510	260
7/31	410	160
8/4	210	75
8/7	---	60
8/11	140	33
8/14	110	29
8/18	570	57
8/21	150	83
8/25	63	12
8/28	87	13
9/1	93	19
9/4	82	10
9/8	74	8.4
9/10	70	10
9/15	71	7.8
9/17	45	8.0
9/22	43	4.4
9/25	95	4.4
9/29	29	5.1
10/2	43	4.0
10/6	46	3.5
10/9	36	5.0
10/13	28	7.9
10/16	12	12

CONTAMINATION LEVELS OF SEEPAGE PONDS



Most of the contamination that reached the open ponds was actually removed by adsorption on the bottom sediments of the ponds. Some reduction also occurred through radioactive decay. After the level fell below 10^{-4} μCi/cc, it was the intent to raise the liquid level several inches anticipating that the contamination, which was practically all adsorbed on the mud, would then be inaccessible to the water fowl. In addition, the radiation levels around the ponds would be significantly reduced because of the additional water shielding. Tests were conducted using diatomaceous earth to determine how much of this material would have to be added to reduce the percolation rate of the water through the soil to the point that the liquid level would raise on the order of one foot. These studies indicated that approximately forty tons, evenly dispersed over the pond area, should effectively plug the bottom of the pond and cause the water to rise. Application of the diatomaceous earth in a satisfactory manner turned out to be a most difficult problem and after adding some six and a half tons nonuniformly through various methods, with no significant rise in the liquid level, other methods were sought. The use of airplanes to dust the diatomaceous earth on the ponds was investigated and actually would have been employed. However, bulldozers were already employed in filling the edges around the large pond and this operation proved to be more successful than was anticipated. By the time dirt was pushed into the pond an average of twenty feet all around the perimeter, the liquid level rose rapidly and before long was well above that originally planned. Apparently most of the liquid actually percolated through the soil to the ground water at the edges of the ponds.

Some studies were conducted to determine if it were possible to reduce the radioactive contamination level in the water by adding flocculation

materials and having these materials scavenge the radioactive nuclides and then deposit on the bottom sediments. Laboratory studies indicated that with the pH of the pond water (8.5 to 9.5) various scavenging agents tried should be effective in removing greater than 95% Zr-Nb-95 and the Ce-141 and 144 and approximately 80% of the Ru-103 and 106. Concentrations of fifty to one hundred parts per million were most effective. Some of the more biologically significant radionuclides, i.e. Sr-89 and 90 and Cs-137, were not removed to any measurable degree in the tests. No attempts were actually made to remove radioactive materials from the water in the ponds using these scavenge methods, however, the information generated on this subject may prove useful should future incidents occur. The types of floc used in the lab studies were $Fe(NO_3)_3$ and $FeSO_4 + KMnO_4 \rightarrow Fe(OH)_3 + MnO_2 + \cdots$.

Samples of mud from Gable Mountain Swamp were subjected to treatment with 0.1N HNO_3 in an effort to force migration of radioactive materials through the mud. No significant movement was detected after a total flow equivalent to 26 gal/ft^2. This is indicative of the tenacity with which the isotopes are bound to the sediments.

The ground water obtained from wells in the near vicinity of Gable Mountain Swamp was sampled. The wells were located generally north northeast of the pond. The analyses of the samples showed the results given in Table VI.

TABLE VI

DATE	pCi/cc
8-5-64	49
8-26-64	40
10-28-64	11

The bulk of the activity was Ru-103 and Ru-106 and some Zr-Nb-95. Samples of ground water taken from wells down gradient from those which showed contamination were at background levels. It was concluded from these results that contamination of the ground water was not a significant problem.

CONCLUSION

The Task Force was abandoned in the middle of October when it was apparent that the more serious problems were under control. The remaining radioactive materials were essentially all adsorbed on the bottom sediments of the swamp, and the rise in water level provided a reasonably good barrier for both wildlife and people. Water fowl harvested after the Task Force was dismissed did occasionally show some external contamination on the order of a few thousand counts per minute as measured with a GM Meter. Internal contamination of fowl harvested since the January 1, 1965, has been as high as 200 pCi/gm of muscle, and on the average about the same as the internal deposition noted in the caribou in Alaska.* The radiation exposure potential from this source to personnel in the environs is considered insignificant.

Close surveillance of the area will continue to be conducted because of the relatively large inventory of fission products affixed to the soil and to assure that potential vegetation contamination is under control.

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* Hanson, W. C., and Palmer, H. E., Cesium Cycle of Cs-137 In Some Alaskan Natives and Animals, HEALTH PHYSICS JOURNAL, Volume 11, 12, to be published.

Appendix

SUMMARY OF THE GABLE MOUNTAIN SWAMP AND B SWAMP CONTAMINATION INCIDENT

A brief summary of the Purex Concentrated Waste Sampling Tank (F-15) coil failure and subsequent Gable Mountain Swamp and B Swamp contamination incident and action taken to date following the incident is shown below in chronological order.

June 11, 1964	A leak was detected in the F-15 coil.
June 12, 1964	Radioactive waste seeped into the coil and was subsequently flushed to the swamps. First estimates indicated the total activity to be 60,000 to 70,000 curies.
	Water and mud sampling programs were initiated. First samples indicated contamination levels in the order of tenths of μc's/cc.
	Radiation surveys were conducted; exposure rates of ~ 3 - 5 rads/hr at 3' were noted along the inlets of both swamps.
	All entry ways to the swamps were barricaded.
June 15, 1964	Biology personnel investigated the wildlife associated with the swamps and reported all fowl were residents rather than migratory animals.
June 16, 1964	A conference of Purex and Hanford Laboratory personnel was held to determine studies for ~~cause~~ course of action. The use of floc, a wildlife sampling program, Gable Mountain Swamp volume and size, and cost of construction of new inlet ditches were to be investigated.

June 18, 1964 — Recommendations were made by RPO that new swamp inlets be excavated and the old inlets backfilled. Estimated costs were $24,500.

June 19, 1964 — Equipment was moved in to Gable Mountain Swamp to start excavation. Surveys indicated no spread of contamination outside of the swamp. Water samples taken on the 16th indicated contamination levels on the order of 5×10^{-3} μc/cc and 10^{-3} μc/cc at Gable Mountain Swamp and B Swamp, respectively.

June 22, 1964 — Excavation of the new inlet started at Gable Mountain. Volume of the swamp estimate was revised upward to 20 million gallons from an earlier estimate of 8 million.

Waterfowl which had been harvested had external contamination levels of 100 mrads/hr (dial reading CP). It was recommended that the use of copper sulfate for algae kill be investigated.

June 24, 1964 — It was recommended by RPO that copper sulfate be added to Gable Mountain swamp in concentrations of ~ 3 ppm for algae and invertebrate animal kill. The activity in B swamp is concentrated in the inlet ditch which is to be backfilled so it was recommended that no copper sulfate be added at least until the old ditch is backfilled. Waterfowl sampled from Redox and U swamps showed no external contamination.

June 26, 1964	The new Gable Mountain Swamp inlet is in use; some backfilling is still in progress. Radiation exposure rates at the inlet are now ~ 50 mr/hr at 3 feet. The addition of copper sulfate to Gable Mountain started. Purex personnel have estimated that ~ 10,000 curies of activity was discharged to the two swamps. The possibility of partially sealing the bottom of Gable Mountain Swamp to raise the liquid level after nearly all the contamination is sealed in the mud is being investigated. The excavation of a new inlet for B Swamp also started.
June 30, 1964	The addition of copper sulfate to Gable Mountain Swamp has been completed. A second dragline is being used for B Plant Ditch excavation. It is estimated that 20 days will be required to complete the excavation.
July 1, 1964	Investigation of the Gable Mountain Swamp indicated a reasonably good algae kill. There were a few small areas where the algae appeared to be alive.
July 2, 1964	Water samples of Gable Mountain swamp contained < 0.2 ppm copper sulfate; however, samples of the algae that appeared to be still alive contained ~ 20 ppm and it is anticipated that it will die. The water volume of B Swamp was estimated to be 9 million gallons by CET personnel.

To date most of the effort has been devoted to Gable Mountain Swamp since it is larger and nearly all waterfowl reside in this location. Most of the activity discharged to B Swamp is contained in the long inlet ditch and it is anticipated that once it is backfilled the principal portion of the activity will be contained.

HANFORD LABORATORIES
GENERAL ELECTRIC
RICHLAND, WASHINGTON
99352

Appendix

October 7, 1964

A. R. Keene, Manager
Radiation Protection

STATUS OF THE PUREX SWAMPS - OCTOBER 7, 1964

On June 12, 1964, the B Plant and Gable Mountain waste water swamps became contaminated when a cooling coil in a Purex waste tank (F-15) failed, allowing process waste material to leak from the tank into the coil. First estimates indicated a total of about 60,000 to 70,000 curies of fission products were released, but the estimate was later revised to 10,000 curies. Radiation surveys showed exposure rates as high as 5 R per hour at the inlet to the swamps immediately after the incident, and the concentration of fission products (principally Zn-95-Nb-95, Ru-103 and Ce-141-144) in the water of the swamps approached 0.1 μc/cc. With the continued addition of "normal" (clean) water to the swamps, the concentrations of fission products in the swamp water diminished with a "half-life" of about one week. By the end of August the concentration in the water of "B" Swamp was 10^{-5} μc/cc (near normal). Samples of water from the Gable Mountain swamp have shown considerable variation, but most results for September indicated concentrations between 10^{-5} μc/cc.

Backfilling of the original inlet areas of the swamps buried much of the contamination and reduced the dose rates. Backfilling was especially effective for "B" Swamp because of the long, vegetation filled ditch that trapped most of the contamination. With completion of backfilling of the "B" Swamp inlet ditch by mid-August, radiation levels around this swamp were reduced to less than 10,000 c/m (except for one small area that showed less than 6 mR/hour).

When a new inlet ditch for the "B" Swamp was finished and placed in service July 21, an unexpected rise in water level of the "B" Swamp began. (Perculation through the bottom of the new ditch was much less than through the old ditch--- the reverse had been anticipated.) The water level in "B" Swamp stabilized at the end of August at about eight inches above the original level. This rise was beneficial in covering and providing additional shielding for the contamination fixed in the bottom sediments. Domestic ducks placed on "B" Swamp at the end of August and sampled a few days later showed no detectable external contamination, and thus satisfactory control of the contamination in this swamp.

The Gable Mountain Swamp has presented more difficult control problems than the "B" Swamp because of its larger area, short inlet ditch (that did not retain much of the contamination), and its attraction for migratory water fowl. Wild ducks and coots inhabiting the Gable Mountain Swamp at the time of the incident were found to have enough contamination to give readings as high as 100 mrads/hr on a CP instrument.

Maximum concentrations of Cs-137 in the flesh of ducks was 0.24 μc/gm. These ducks were "sampled" as rapidly as possible and copper sulfate was added to the water to kill the algae and interrupt the food chain transfer of Cs-137 to the ducks. With the approval of the State Game Department, attempts were made to poison the ducks that remained at the end of July. Poisoning was not successful, however.

In mid-August, when most of the fission products in Gable Mountain Swamp had become fixed to the bottom sediments, attempts were begun to raise the water level in order to inundate the contaminated shoreline and increase the water depth above the highly contaminated bottom. The addition of Bentonite clay was believed to be the best means of reducing perculation through the bottom of the swamp and this was begun at the end of July. By the end of August, about six tons of Bentonite had been added, essentially by hand, with no significant effect on the water level. Ducks using the swamp were much less contaminated than in June but still had as much as 100,000 c/m external contamination. In order to effect an immediate rise in water level, Purex increased the flow to the swamp. More clay was also ordered and arrangements made for application by a crop-dusting airplane.

Additional backfilling around the edges of Gable Mountain Swamp was begun in mid-September, primarily as a means of burying near-shore contamination wherever practical. Rather unexpectedly, the water level in the swamp began to rise as the backfilling proceeded, and by the end of September was up about eight inches. Application of the Bentonite has been stopped but backfilling has continued to date. Domestic ducks placed on the swamp and samples of wild ducks sampled in the area showed external contamination in the range of 3,000 to 10,000 c/m early in October. Food and other plants attractive to the ducks are to be burned in an effort to reduce the contamination level further.

Meetings between HL and Purex staff members have been held at about weekly intervals since June 16, to plan the course of action and keep abreast of the status.

finding From RL-SA-15

CHEMICAL PROCESSING DIVISION

RADIATION OCCURRENCE

R. W. McCullugh, Manager
Processing
Purex Operation

RADIATION OCCURRENCE FACTS

DATE: 6-12-64 | TIME: 12-8

LOCATION: Purex Cooling Water Swamp

RADIATION OCCURRENCE TYPE: 3-C

Uncontrolled radiation or contamination inside a Radiation Zone

CAUSE CODE: 1-B

Failure of Equipment

COMPLETE DESCRIPTION AND CAUSE

Fission products contamination was released to the B- and Gable Mountain cooling water swamps from a leaking cooling coil in a 202-A process waste tank (F-15).

Observations

1. Cooling water (usually slightly contaminated) used to purge process vessels is routed to the swamps via a common line from 202-A. A diverter section divides the flow between B Swamp and Gable Mountain Swamp.

2. A cooling coil on the F-15 Tank developed a leak on 6-11-64. At 0100 on 6-12-64 the cooling water was turned off and the coil was air-purged until the cooling water was restored at 0130. At 0200 the cooling water was again turned off and restored at 0750.

3. The cooling water in the coil provided sufficient pressure to prevent the highly contaminated waste solution from leaking from the tank into the coil. However, this pressurization was apparently not maintained during the air purges and the contaminat liquid which leaked into the coil was discharged to the swamps when the cooling water was restored to the coil. A survey at the 201-A Tank (which received cooling water discharged from 202-A) after the 0130 restoration did not disclose any unusual activities in the water.

4. The following radiation levels were detected during surveys on 6-12-64:

B Swamp

On ditch bank over inlet	2 R/hr. at 8'
At edge of inlet flume	5 R/hr. at 5'
	7 R/hr. at 2"
	50 rads/hr. at 2" (on algae)
Maximum along road parallel to swamp (east-west)	150 mR/hr.

(Continued)

C: WM Harty-GEC
SG Smolen
RW Harvey (2)
RM File

ACTION TAKEN

1. Appropriate radiation surveys were made.
2. Roads to involved areas were barricaded.
3. Appropriate contacts were made to RPO-HL.
4. The cooling water discharge jumper from the coil to the building discharge header was disconnected.

INVESTIGATED BY: G. E. Cunningham

DATE OF INVESTIGATION: 6-12-64 thru 6-16-64

EXPOSED EMPLOYEES

None

6640-002 (3-

B Swamp (Continued)

Along ditch bank (several locations)	2.5 R/hr. at 2" 3.2 R/hr. at 2"
Along shore of swamp	600 MR/hr. at 2" 3000 c/m

Gable Mountain Swamp

Over inlet	15 to 22 rads/hr. at 2" (probably algae)
Edge of inlet	500 mR/hr. at 2"
Along south shore	500 mR/hr. at 2"
Far end of swamp	Nothing above normal backgrou

Station surveys made on 6-16-64 are shown on the attached drawing.

Observations

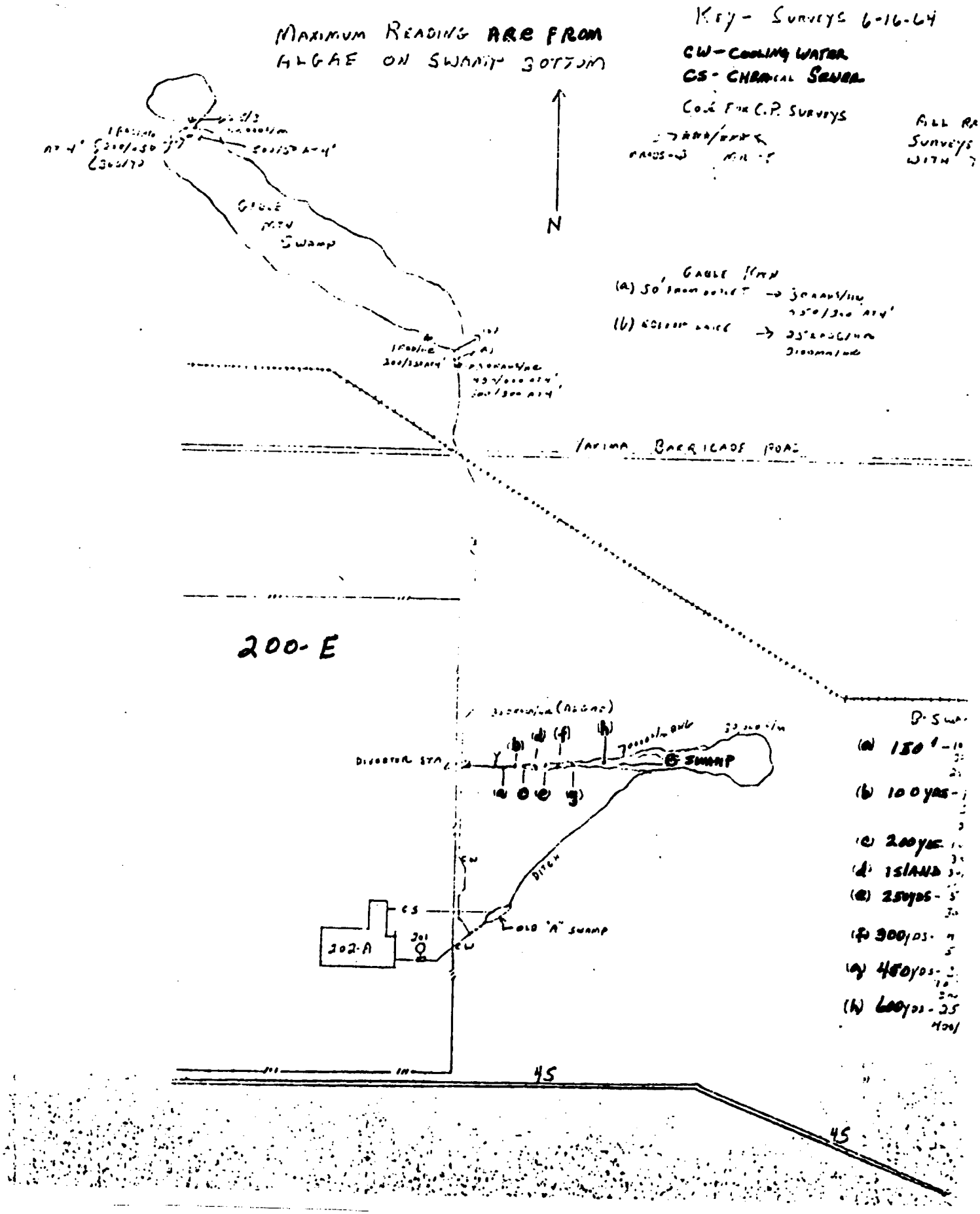
5. Affected areas were barricaded to prevent inadvertent entry of personnel.

6. Caustic was added to the swamps via the cooling water line to precipitate the contamination.

7. Appropriate RPO-HL groups were notified and a study group of HL and CPD personnel has been formed to evaluate the problem.

8. No unplanned exposure of personnel was involved.

9. An engineering study has been initiated leading to improved equipment design which will preclude tank outleakage to coils.


MAXIMUM READING ARE FROM ALGAE ON SWAMP BOTTOM
Key - Surveys 6-16-64
CW - COOLING WATER
CS - CHEMICAL SEWER
N
GAGLE MTN SWAMP
YAKIMA BARRICADE ROAD
200-E
DIVERTOR STA
SWAMP
DITCH
OLD "A" SWAMP
202-A
45
(a) 150'
(b) 100 yds
(c) 200 yds
(d) ISLAND
(e) 250 yds
(f) 300 yds
(g) 450 yds
(h) 600 yds