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REACTOR EFFLUENT OUTFALL STRUCTURES - STATUS AND POTENTIAL PROBLEMS

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July 18, 1960

REACTOR EFFLUENT OUTFALL STRUCTURES - STATUS AND POTENTIAL PROBLEMS

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REACTOR EFFLUENT OUTFALL STRUCTURES - STATUS AND POTENTIAL PROBLEMS

PURPOSE AND SCOPE

Design of the existing Hanford production reactors includes disposal of the cooling water effluents in the main channel of the Columbia River in order to maximize dilution of the effluents. The outfall portions of the disposal systems consist of the 1904 outfall structures and the outfall lines extending into the river.

The purpose of this memorandum is to review the recent history and current condition of those outfall systems which are not at present in satisfactory condition, as well as the potential problems which may arise from a failure in these systems.

SUMMARY

Partial structural failure is known to exist at three locations. The worst condition is in the KE/KW outfall lines, both of which are completely separated by as much as five inches. Present in-shore leaks have only a small effect at normal river flows. Further separation is believed to be in prospect as a result of thermal cycling, although the rate of increase is not known; an attempt to obtain additional data by means of further dye tests is planned for this fall. A design and estimate has been prepared for the necessary repairs. At the F outfall, the concrete encasing the concrete pipe sections is cracked and leaking, and a partial separation in the steel section of one line was reported following diver inspection. No surface evidence of these leaks exists at present. At 1904-H, the thrust of the outfall lines resulting from thermal expansion has spalled concrete from the inside of the box. Repairs to the box are scheduled for early fall.

The current approach of the AEC on repairs to these facilities is to postpone major expenditures until evidence of more severe effects of existing failure or of more imminent severe failure can be produced. The presently unsettled policy situation on methods of effluent treatment and disposal seemingly contributes to this attitude. IPD management and engineering personnel are on record that repairs are necessary to prevent future unscheduled outages and should be done on a planned, rather than emergency, basis. However, postponement of major expenditures for repairs at this time should not incur an undue risk of further major failure within the next year. A formal inspection program should be adopted for structures of concern if this postponement is continued.

The consequences of a major outfall line rupture would depend greatly on the location of the break, the reactor involved, and the river flow at the time. The major effects would be felt at downstream reactors if the reactor involved continues in operation; these include production losses (up to $10,000/day for total failure of a K line) as a result of increased raw water temperature, and a potential denial of normal area drinking water supplies. Additional production loss would result at the reactor incurring the break as a result of up to three weeks unscheduled outage time for repair. Reliable predictions of effects from other types and locations of outfall system failure would require additional studies, best accomplished with the currently proposed river model program.

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DESCRIPTION OF FACILITIES

Although details differ from area to area, the outfall systems for each of the existing reactors consist of an open concrete outfall box (1904-) and one or two outfall lines. A spillway flume extends to the shoreline from one side of the 1904 box to prevent excessive back water elevations at the 107 basins during high water or in the event of blockage of the outfall lines. The outfall lines extend outward to or near the centerline of the main river channel for maximum dilution of the effluent. The following table gives individual area details.

REACTOR	NUMBER LINES	DIAMETER -INCHES	1904 TO RIVER APPROXIMATE LENGTH - FT.	INSTALLED	REMARKS
B	1		695	CG-558 (1956)	
C	2	54	680	Original (1951)	
D	2	42	1840	Original (1944)	Vented. Includes 150 feet each of concrete pipe in the on-shore sections.
DR	1	66	1800	CG-558 (1956)	Vented.
H	2	60	750	Original (1949)	
F	2	42	300	Original (1944)	Repaired 1947. Includes 100 feet each of encased concrete pipe in the on-shore sections.
KE/KW	2	84	1345	Original (1954)	KE line repaired 1955. Both lines vented at same time.

SPECIFIC PROBLEMS

Damage to the outfall structures has generally been due to two phenomena - thermal expansion and pumping of air into the outfall lines from the 1904 boxes. One F line broke loose in 1947 and swung downstream, probably in part due to trapped air buoyancy. This line was towed back into place and both lines re-anchored with a concrete encasement. Joint failures have occurred in the D and DR lines and at the 1904-B box, as well as 1904-F and H. The failure with the greatest potential severity was the rupture and flotation of the KE effluent line.

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K Area

In April, 1955, the KE line was observed floating partially submerged just off-shore. Subsequent inspection revealed a partial rupture and "wrinkling" of the KW line. As emergency maintenance, both KE and KW lines were weighted down with steel rails and concrete blocks, and the rupture in the KE line banded and encased in concrete. In addition, vent holes were cut in both lines to permit the escape of air which was being pumped into the lines from the 1904 box, and 107-K basin operation was changed from batch to continuous discharge in order to minimize flow cycling of the outfall lines as much as possible. Some concern was expressed at the time both as to the permanency of these repairs and as to the effect of the near-shore effluent leakage from the vents and cracks. Although repeated exterior inspections during the following year showed no further damage, a project proposal for design of replacement lines was initiated as CG-703 in September, 1956. After several discussions between operating, engineering, and Commission representatives, AEC Directive HW-437 was issued in May, 1957, authorizing expenditure of $15,000 (later revised to $25,000) for engineering studies and preliminary design only. Repeated attempts at diver inspection of both the inside and outside of the two lines were made in 1958 and finally completed in 1959. During these inspections, separations in both lines were observed, much wider than the original breaks and showing evidence of relative movement between the broken ends in three directions. No significant increase was observed in the KW line separation between January and November of 1958, however.

In the meantime, dye tests and other studies were made to determine the effect of the leakage from the existing breaks and to evaluate the potential severity of that rupture. The dye tests indicated leakage, mostly from the KW line, of about 17,000 gpm (10 per cent of one K Reactor effluent flow rate) at a river flow of about 65,000 cfs; the effect of this leakage on D Area was felt to be slight. Subsequent calculations show an average increase in D Area raw water temperature of about 0.1°C from a leak of this size, which by the usual methods of calculation would cause production losses at D and DR Reactors valued at $20,000 to $30,000 per year. A separate study [1] by HLO, including detailed sampling and measurement, showed a potential for much more severe effects in the event of total failure. These results are discussed below under POTENTIAL SEVERITY OF FAILURE. Figure 1 shows the present leak ratio and distribution of effluent; Figure 2 shows the probable distribution pattern from a line break at the end of the K jetty.

The outcome of these various studies was a scope document [2] for permanently repairing and anchoring the lines instead of replacement, and a planned maintenance item of $90,000 for these repairs was included in the revised and approved FY 1960 Operating Budget for accomplishing the repairs as scoped. MJA-23 for $65,000 was subsequently prepared and approved by IPD management in September, 1959. Investigation of repair procedures and discussions with McCray Marine Construction representatives indicated that the cheapest and most feasible

(1) HW-54756 (SECRET), Predicted Effects on 100-D Area Water Supply From 100-K Area Outfall Line Failure", M. W. McConga and J. K. Soldat, dated February 10, 1958.
(2) HW-58899 (CONFIDENTIAL), "CG-704 - 100-K Outfall Study - Final Report", D. F. Watson, dated January 31, 1959.
(3) Letter, W. J. Nicklason to W. J. Morrell, Property Management Branch, HOO-AEC, "Anchor 100-K Outfall Lines", dated November 18, 1959.

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K Area (Continued)

method of doing the work would be with the aid of an earth jetty to be built upstream of the lines in order to reduce the current. Letters [3,4] requesting the AEC to secure approval of the Corps of Engineers to construct this jetty were sent to the HOO in November, 1959, and again on January 12, 1960, after informal discussions with HOO Engineering personnel had revealed some reluctance on the part of the HOO to agree to proceeding with this work. On January 18, 1960, a letter [5] was sent by an HOO Reactor Branch representative to the G.E. Project Engineer stating that approval of the Corps of Engineers to construct the desired jetty would not be requested, that model studies or future reduction of effluent activity might make repairs unnecessary, that the apparent rate of line separation did not appear critical, and that therefore it was requested that the proposed repairs be postponed. On February 24, 1960, after further review by G.E. personnel, a letter [6] was sent by the Manager, IPD Facilities Engineering, to the Director, Process Engineering and Manufacturing Division, HOO-AEC, again requesting permission to build the jetty, stating also that model results would not be available for several years and affirming the need for the proposed work. A follow up dye test performed on March 4, 1960, showed no apparent change since October, 1958. A return letter [7] from the HOO dated March 24, 1960, re-affirmed the Commission's position that the situation did not appear critical at this time, and again requesting that the work be postponed "Until greater evidence of its need has been produced". The proposed repairs have again been submitted as planned maintenance in the FY 1961 Operating Budget, but the availability of funds is unknown. Another dye test is tentatively planned for this fall following high water. K Reactor management does not intend at present to make the scoped repairs unless evidence of further deterioration is found.

At present, then, both K Area outfall lines are completely ruptured, with separations on all three planes and up to five inches lengthwise. The lines appear to be adequately anchored to prevent flotation, but it is believed that thermal cycling will cause further separation as a result of jacking against surrounding material, even though there was no apparent change between dye tests in 1958 and 1960. The rate of separation and the size of separation that would be critical from a leak standpoint is not known. A possibility of partial blocking of the KW line also exists. At the separation, the line is partially imbedded in cobbles, with two large concrete blocks resting on the pipe. As the separation increases in size, the greater will be the probability of sufficiently large material falling into the pipe to create a partial flow blockage. A design and estimate for repair of these lines is on hand, but would require under emergency conditions three weeks to accomplish. This estimate is based on the reasonable assumption that damage to the existing line would not be so severe as to require procurement of additional pipe and extend the loss period thereby by weeks or months.

(4) Letter, W. J. Nicklason to R. B. St. John, Reactor Branch, HOO-AEC, "MJA-23, Anchor 100-K Outfall Lines", dated January 12, 1960.
(5) Letter, R. B. St. John to W. J. Nicklason, "MJA-23, Anchor 100-K Outfall Lines", dated January 18, 1960.
(6) Letter, R. T. Jessen to A. T. Gifford, "MJA-23, Anchor 100-K Outfall Lines", dated February 24, 1960.
(7) Letter, A. T. Gifford to R. T. Jessen, "MJA-23, Anchor 100-K Outfall Lines", dated March 24, 1960.

F Area

In April, 1959, an effluent bubble near-shore was observed during routine operations patrol. Subsequent conversations with HLO personnel making routine river surveys revealed that an indication of such a leak had been observed intermittently for some months past. Inspection by a diver the same month revealed a crack in the downstream line about 20 feet off shore, about 1/8" wide and extending at least a quarter of the circumference. The upstream line had been covered with backfill, dumped to give protection from the current to the diver, and could not be seen. Since the river was rising and the situation did not appear critical, action was postponed until after high water. It was noted, however, that a sizeable stream of effluent was issuing from the river bank over the lines and that extensive cave-ins had occurred. Inspection of the 1904-F interior showed that the joints where the concrete sections of the line left the 1904 structure were open and that a hole several inches in diameter was permitting water to leak into the box. On the basis of these observations, a scope [8] for repair of the steel line and replacement of the remaining 100 feet of concrete pipe as emergency maintenance was prepared and issued in August, 1959, and MJA-22 for $69,000 prepared and approved. A letter [9] from the Assistant Manager for Technical Operations, HOO, to the General Manager, IPD, was received in September, 1959, withholding approval of the proposed work pending further investigation. Excavation of the concrete portion of the lines and around the 1904-F structure in September and October, 1959, confirmed the open joints and extensive leakage. However, this inspection also revealed the existence of a massive concrete encasement, not shown on plant drawings, around the concrete pipes, which although badly cracked and leaking would require extended reactor downtime for removal. Although replacement was still felt to be necessary eventually, the condition was not felt to be sufficiently critical to require replacement at this time. During these inspections, it was also noted that the off-shore effluent bubble from the crack in the steel pipe had disappeared. It is believed that sufficient backfill from the temporary jetty placed in April, 1959, piled upon the cracked pipe to prevent visible leakage. The major immediate concern remaining was for the stability of the 1904 structures. A Work Order was therefore issued to J. A. Jones Construction for drilling through the floor of the box, grouting the voids, and caulking the entrance joints. This work was done for less than $10,000, since which no further evidence of leakage has been observed.

In this area, then, there is a badly cracked encasement around the original concrete lines and at least one partial steel line rupture off-shore. Neither condition appears at present to require immediate attention. There is some question, in fact, as to what the significance would be of a complete line failure at F Area. Aside from special monitoring costs and the possible need for additional control measures at the Hanford Ferry and along the river bank immediately downstream, it is probable that the consequences would not be serious if not permitted to continue for too long a period, say a month or more. Nevertheless, in view of the length of time required to remove the existing concrete encasement, severe failure in this section could cause the loss of several weeks of production at F Area if repairs became mandatory on an unplanned basis.

(8) Memorandum, "Scope of Repair Work for 100-F Outfall Lines", L. B. Brinkman, dated August 7, 1959.

(9) Letter, H. H. Schipper to A. B. Greninger, "Contingency Maintenance Job - MJA-22 - Repair of 100-F Outfall Lines", dated September 9, 1959.

H Area

Inspection of 1904-H in September and October, 1959, showed extensive spalling of concrete around the anchor-rings of the outfall lines. No provision for expansion was incorporated in the original design. Repairs and joint modifications have been scoped for an estimated cost of $11,800, and will be done as soon as low water and sufficient outage time permit.

Other Areas

None of the other 1904 structures or outfall lines have been closely inspected since CG-558. No external signs of damage exist, although some concrete erosion is probable at all the older 1904 structures. The present systems are believed to be serviceable for some years before extensive repairs become necessary.

POTENTIAL SEVERITY OF FAILURE

Although the potential problems of shoreline effluent discharges have been touched on briefly in a number of documents, the most pertinent reference are letters by Parker [10] in 1957 and Jerman [11] in 1959 and a document by McConiga and Soldat [2] giving specific calculations for a K line break. The first two references agree that, aside from a minor juvenile fish kill during a late fall or winter occurrence, the off-plant effects of even a major break would be minor. A slightly higher P^{32} content in fish and a slightly higher activity level in foam and trash around the Richland boatdocks might occur, but over a limited period could be ignored. Except at high river flows, however, a major shoreline discharge at any area except F would cause excessive concentrations of both radioactivity and hexavalent chromium at the next downstream reactor (and possibly others). In addition, the increase in raw water temperature resulting from the increased effluent uptake would cause some loss of production at downstream reactors during any period in which power levels were limited by outlet temperatures. Any rupture occurring off-shore would be less severe in its effects, providing that effluent discharge was not blocked by debris and consequent flume overflow did not occur.

As an example of the potential consequences of total line failure, estimates of the effluent pick up at D Area as a result of complete failure of the K outfall lines at extreme low water (36,000 cfs river flow) are given in reference [1] based on velocity and concentration profiles, and in reference [2] based on dye test sampling. Calculated percentage intakes at NPR and at D for the case of one K line only discharging further in-shore gave similar results. These estimates indicate that from 5 to 10 per cent of the K effluent (a factor of 10 higher than the normal intake) released near the existing K line failures would be taken in at 181-D. The resulting Cr^{+6} concentrations in the D Area drinking water would probably exceed the Public Health Service maximum permissible concentration of 0.05 ppm, which would in itself necessitate another source of D Area drinking water while the situation existed. Under the same conditions, radioactivity in the drinking water would exceed the recommended

(10) Letter, H. M. Parker to A. B. Greninger, "Shoreline Discharge of Reactor Effluents", dated March 13, 1957.
(11) Letter (COMPANY PRIVATE), P. C. Jerman to E. J. Filip and C. N. Gross, "Reactor Effluent Shoreline Discharge", dated December 4, 1959.

POTENTIAL SEVERITY OF FAILURE (Continued)

limit of 10 per cent of the occupational MPC_{GI}, although this would be tolerable for a short period. Employee reaction might of course create a relations problem. Similar estimates indicate relatively high, but tolerable, dose rates of 100-200 mr/hr on filter beds with some inconvenience due to radioactivity throughout the water plant. The raw water temperature increase of 4 to 8°C resulting from the 5 to 10 per cent uptake of K effluent would cause some production loss at D and DR Reactors during the winter months and up to $8,000 per day during the early fall in a dry year. Similar effects, although of lesser degree, would occur at NPR, H, and F Reactors. Major shoreline discharges at B, C, D, or H Reactors would also have similar effects to those presented above at each reactor downstream, although probably of lesser degree due to smaller flows and differing locations.

These estimates are of course based on extrapolation. It is significant, however, that estimates reached by independent methods agree within a factor of two. The suggestion has been made in one letter from the local office of the AEC that repairs should wait on a test on the proposed river model to determine the degree of these effects. Such tests, part of the planned program for the river model, will be valuable for predicting effects at other areas, from other potential failures, and with changing river conditions. The estimates presented here, however, are believed to predict the effects of the most probable severe failure within a factor of two.

FUTURE STATUS

The current HOO-AEC position on outfall system repairs appears to be to postpone any major expenditures until the future policy of effluent disposal or treatment is determined, or at least until evidence of significant losses or accelerated deterioration is found. Any attempt to make such repairs requiring AEC approval for expenditure is therefore apt to be difficult unless such evidence can be presented. A program for routine inspection should therefore be a corollary of this approach.

No program exists at present for routine interior or underwater inspection of the 1904 structures or outfall lines. Visual inspection of the 1904 interiors on an annual basis would probably reveal damage sufficiently in advance to make necessary repairs with little risk of sudden failure. For the lines, the problem is less simple. Diver inspection of the exterior of unburied portions is possible, but is expensive, difficult to schedule, and can seldom be complete. Interior inspection is possible only on portions of the lines. In general, such inspections are difficult to justify except where some evidence of damage is known to exist. Dye tests, in conjunction with aerial photography or special sampling, are relatively easy and inexpensive. Although less sensitive and less reliable than inspection, such tests should reveal initial line rupture well before total failure.

Future changes in plant flows would affect both the severity and probability of effluent system failure. The severity should be proportional to the increased process flows, but the increased probability in much more difficult to predict. Greater concrete erosion and increased mechanical stresses would exist, but are not expected on the basis of preliminary calculations to cause a significant problem with structures in good repair. The problem of increased flow-rates through the K lines in their present condition deserves further study.

FUTURE STATUS (Continued)

Previous studies on the effects on Hanford operations of navigation channel or a dam at river mile 348 treated briefly the effects of an effluent system failure. Increased stratification behind a dam would tend to lessen the severity of an incident, but otherwise the effect of these projects on severity of an incident cannot realistically be predicted at this time.

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Drawings

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H-1-26050, Sheet 2 - Effluent Line, 107-B to River - Plan and Profile (1954).

1904-C - P-5552 - Process Sewer - Outfall Structure, Sheet I.
P-5542 - Process Sewer - Outfall Structure, Sheet II.

1904-D - W-72092 - Process Sewer - 1904-D - Plan, Profile and Concrete.

1904-DR - H-1-9911-DR - Outfall Structure - Arch. and Structural (1954).
H-1-9910-DR, Sheet 2 - 107-DR to River - Plan and Profile (1954).

1904-F - W-72093 - Process Sewer - 1904-F - Plan, Profile and Concrete.
H-1-488 - Process Sewer - 1904-F - Plan and Profile (1947).
H-1-26718 - Effluent Line - Plan and Profile (1954).

1904-H - P-4319 - 1904-H Discharge Structure - Plan, Profile, and Details.

1904-K - H-1-23381 - Outfall Structure - Concrete Plans, Sections, and Details.
H-1-25078 - Process Sewer Outfall - Plan, Profile, and Details.
SK-1-20902 - Examination and Repair of 100-K Effluent Lines.
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(1) HW-54756 (SECRET), "Predicted Effects on 100-K Area Water Supply from 100-K Area Outfall Line Failure", M. W. McConiga and J. K. Soldat, dated February 10, 1958.

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Rev. 1, HW-437.

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Rev. 2, HW-437.

(2) HW-58899 (CONFIDENTIAL), "CG-704 100-K Outfall Study - Final Report", D. F. Watson, dated January 31, 1959.

MJA-23, "Anchor K Outfall Lines", dated September 30, 1959.

(3) Letter, W. J. Nicklason to W. J. Morrell, Property Management Branch, HOO-AEC, "Anchor 100-K Outfall Lines", dated November 18, 1959.

(4) Letter, W. J. Nicklason to R. B. St. John, Reactor Branch, HOO-AEC, "MJA-23 Anchor 100-K Outfall Lines, dated January 12, 1960.

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K Area (Continued)

(5) Letter, R. B. St. John to W. J. Nicklason, "MJA-23 Anchor 100-K Outfall Lines", dated January 18, 1960.

(6) Letter, R. T. Jessen to A. T. Gifford, "MJA-23 Anchor 100-K Outfall Lines", dated February 24, 1960.

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(10) Letter, H. M. Parker to A. B. Greninger, "Shoreline Discharge of Reactor Effluents", dated March 13, 1957.

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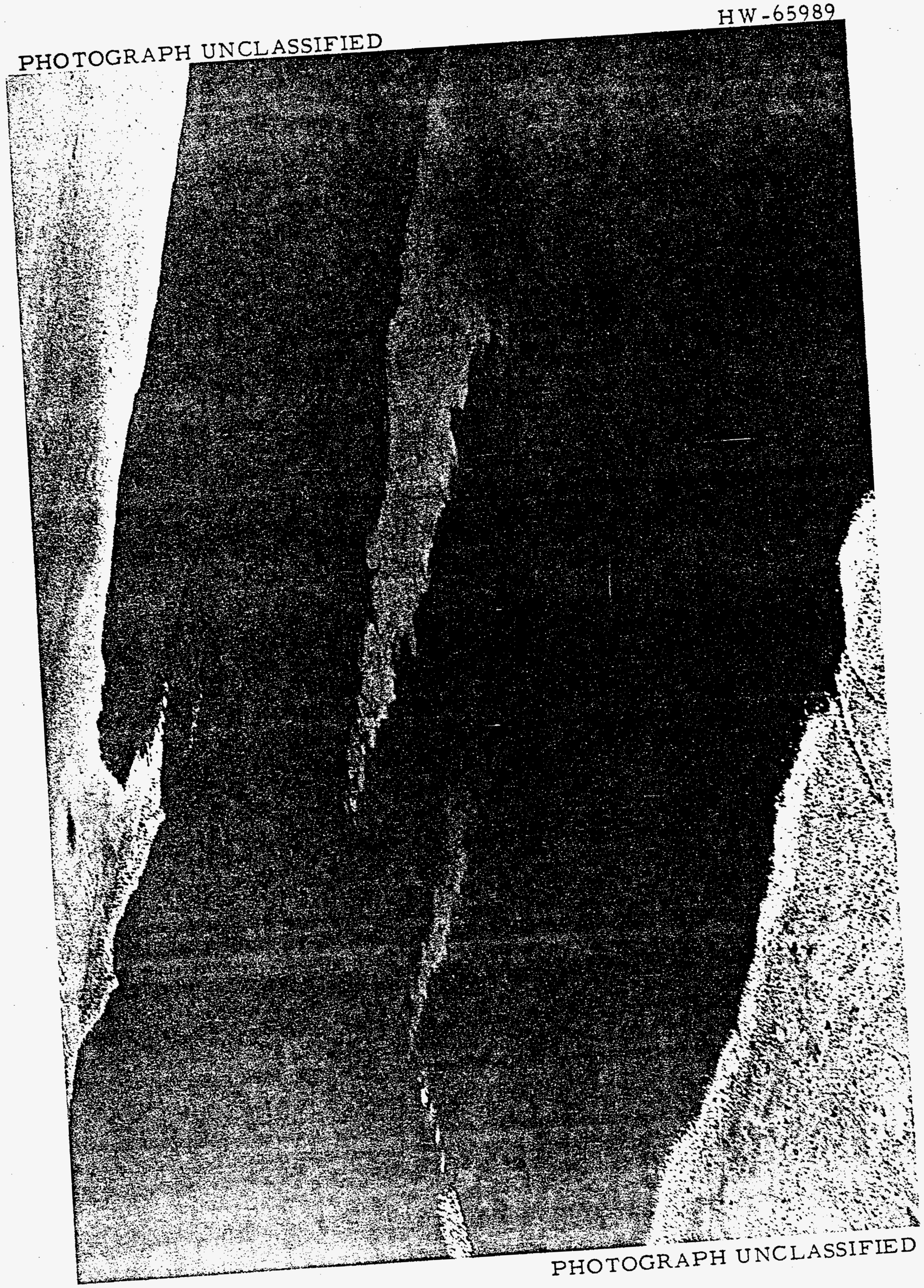

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