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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUL 11 1979

Project M-3
Docket No. 70-1257

Exxon Nuclear Company, Inc.
ATTN: Mr. Warren S. Nechodom, Manager
Licensing and Compliance
Research and Technology Center
2955 George Washington Way
Richland, Washington 99352

Gentlemen:

The purpose of this letter is to transmit for your information an increment of the analysis of the effects of natural phenomena relative to your plutonium fabrication operations at Richland, Washington. The subject increment of analysis is a review of hydrologic considerations applicable to the geographic area around your facility. The enclosed report is a revision of the hydrological report sent to you with a transmittal letted dated October 17, 1977.

Any comments on the enclosed analysis should be addressed to James E. Ayer of this Branch. He will direct resolution of comments and any justifiable revision of the analysis.

Sincerely.

Peter Loysen for

Leland C. Rouse, Acting Chief
Fuel Reprocessing and Recycle Branch
Division of Fuel Cycle and
Material Safety

Enclosure:
Revised Evaluation of
Possible Flooding, etc.

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REVISED EVALUATION OF POSSIBLE FLOODING AT
EXXON NUCLEAR FUELS FACILITY

1. Hydrologic Description

a. General

The Exxon Nuclear site is a square-shaped 160 acre area within the city of Richland and located on the south side of Horn Rapids Road 0.9 miles west of Stevens Drive and approximately 1.75 miles west of mile 343 on the Columbia River. It consititutes the southwest quarter of Section 15, Township 10 North. The site is mostly flat at an elevation of 371.5 feet above sea level (msl), but contains a series of wind-formed ridges ranging from 5 to 30 feet high.

Natural barriers along the Columbia River east of the Exxon facility (mile 344) prevent flooding of the site from natural floods up to the magnitude of the Regulated Probable Maximum Flood (RPMF). However, flood waters from the RPMF would reach the plant by backing in at mile 340.

b. Basin Description

The Columbia River, with its tributaries, drains an area of 260,000 square miles. The drainage area at Richland, Washington is about 98,000 square miles. The Snake River, which drains 109,000 square miles, enters the Columbia about 14 miles below Richland. The Columbia rises in Columbia Lake, British Columbia, Canada, and flows northwesterly, parallel to the Rocky Mountains, for about 191 miles and then turns southward and flows about 270 miles to the international boundary. In its course of about 745 miles in the United States, it flows generally southward across the State of Washington, paralleling the Cascade Range to the Washington-Oregon boundary where it is joined by the Snake River. It then flows in a westward direction along the state line through the Cascade and Coast Ranges to enter the Pacific Ocean near Astoria, Oregon.

The Upper Columbia drains the rugged mountainous areas of British Columbia, western Montana, and northern Idaho. These areas receive heavy precipitation during the winter with deep accumulations of snow in the mountains. The middle Columbia drains mainly the east side of the Cascades in Washington and British Columbia and some additional areas in eastern Washington. This is a relatively low-runoff producing area, except for the mountainous region.

c. Reservoirs and Lakes

Several dams have been built during the past 40 years creating reservoirs over a large portion of the main stem and major tributaries. The reservoirs meet various functional requirements including flood control, hydroelectric power, irrigation, navigation, recreation, fish and wildlife, municipal and industrial water supply, and low flow augmentation. These projects have been built by a variety of Federal and non-Federal interests, and they are mostly planned and operated for multiple purpose use. Although many of the run-of-the-river projects have limited effect upon flood flows, there is presently sufficient storage in major reservoir projects to provide a significant control of major floods. The regulation of Columbia River floods by reservoir storage is accomplished by joint use of reservoir storage space provided mainly for irrigation or hydroelectric power in accordance with flood control operating plans developed for each project. The usable reservoir storage space is small (20 to 25%) in comparison to the total seasonal runoff volume.

Several major natural lakes within the Columbia River Basin, including Arrow and Kootenai Lakes in Canada, have a marked effect upon runoff. Dams have been constructed at or near the outlets of these lakes to control the water surface elevation during low flow periods and to preserve the natural storage effect of the lakes for flood reduction during high water periods.

2. Climate

The climate in the Columbia River Basin ranges from a moist, mild maritime condition near the mouth to a near-desert climate in some of the inland valleys. Topography causes striking climatological variations in the basins, although distance from the ocean is also an important influence. Normal annual precipitation varies from about 180 inches over small areas in the Cascade Range to less than 6 inches over portions of the plains areas of southern Idaho and eastern Washington. A big portion of the basin normally receives less than 20 inches of precipitation annually. Maximum precipitation occurs during the winter months over most of the basin. In the eastern mountainous portions where the effect of the Continental Divide predominates, the maximum precipitation occurs in May and June. Heavy showers and occasional cloudbursts also occur in these areas during the spring and summer months.

The entire basin is influenced by maritime air of the prevailing westerly winds. Relatively mild winter climate usually prevails. Occasionally, polar continental air flows into the basin causing short periods of extremely low temperatures. Throughout the basin lower humidity, higher temperatures, less precipitation and more sunshine occur during the summer months than during the winter months.

The topographical characteristics of the basin have a greater influence on the climate. The Rocky Mountain System, in the eastern portion of the basin, is characterized by deep valleys surrounded by high mountains. The Columbia Plateau, with a general elevation of 4,000 feet, covers more than 100,000 square miles of the central portion of the basin. The air masses entering the basin are forced to ascend

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the Cascade Range causing relatively heavy precipitation on the western slopes and aridity on the Columbia Plateau east of the Cascades.

Storms in the Columbia River Basin vary greatly in intensity and extent according to the locality and topography of the region. The Aleutian low is at its greatest extent and intensity in the winter, and this is when the basin is exposed to frequent cyclonic and frontal passages. Normally most of the precipitation from this moisture laden air is deposited west of the Cascade Range. As the air mass moves eastward, each succeeding mountain range extracts some of the moisture. The normal decrease in temperature, which accompanies increases in elevation, causes a large part of winter precipitation at the higher elevations to fall as snow.

3. Floods

Columbia River floods at Richland occur in May and June as the result of snowmelt. Major floods result from rapid spring melting of the snowpack over a wide area, generally augmented by rain. The snowfall and individual snowstorms may vary from year to year, but the integration of all storms over the winter period smoothes the irregularities with the result that the distribution of the flood runoff is reasonably constant from year to year.

The maximum flood of record is that of 1884 which resulted from a combination of hydrometeorological conditions, including a heavy accumulated snow pack and rapid melt plus rainfall. The April through September volume of the 1894 flood was 177 million acre-feet and the peak discharge was 1,240,000 cubic feet per second (cfs) at the Dalles. The peak discharge near Hanford was 800,000* cfs.

The following table shows discharge-frequency information applicable for the reach of the Columbia River near the Exxon plant:

TABLE I

Columbia River Discharge Frequencies at Exxon Site

Average Recurrence Interval in Years	Exceedence Frequency, %	Regulated Discharge	Expected Confidence Limits .05 Limit cfs	Expected Confidence Limits .95 Limit cfs
2	50	206,000	233,000	183,000
5	20	292,000	239,000	255,000
10	10	352,000	418,000	299,000
25	4	432,000	525,000	354,000
50	2	496,000	610,000	393,000
100	1	563,000	699,000	432,000
200	.5	634,000	791,000	470,000
500	.2	737,000	921,000	521,000

*Previously carried in U.S. Geological Survey Water Supply Papers as 740,000 cfs. Revised after study of 1948 flood.

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Annual maximum daily flows on the Columbia River near Priest Rapids were used as a basis for the frequency studies. These flows were furnished by the U. S. Army Corps of Engineers[1] and are based on computer simulation studies for the years 1894 and 1929 through 1958. The simulations include 1975 level of upstream storage development and 1985 level of irrigation development.

The confidence limits are based only on the maximum daily flows from the simulation studies. They do not account for any assumptions embodied in the simulation studies or subsequent adjustments by the Corps of Engineers. The discharges have been converted to water surface elevation at River Mile 340 and are presented graphically in Exhibit 1.

Exhibit 1 shows a rating curve (discharge vs. water surface elevation) for River Mile 340, applicable for situations where flood waters would reach the plant site by backing in and moving north from that location. The plant site elevation of 371.5 corresponds to a discharge of 1 million cfs at Mile 340. This discharge is about twice the regulated 100-year discharge for that location. The rating curves on Exhibit 1 are based on backwater computations of the Corps of Engineers and are considered to be accurate within plus or minus 4 feet for the PMF.

4. Design Floods

The Standard Project and Probable Maximum Floods (SPF & PMF) for the lower Columbia River Basin were derived by the Corps of Engineers[2]. Both floods are considered to be caused primarily by snowmelt over an extended period of two or three months, but with significant runoff contributions from storm rainfall during the snowmelt period. Basically, they are similar to the larger annual spring floods such as those of 1894 and 1948, except that the severity of the hydrometeorological conditions was increased to be consistent with the definitions of the SPF and PMF as described in Regulatory Guide 1.59, "Design Basis Flood for Nuclear Power Plants." The combination of conditions for the SPF was the most severe considered "reasonably characteristic" of the Columbia River Basin. The combination of conditions for the PMF derivation was the most severe considered "reasonably possible" in the basin.

The water equivalent of the snow on the ground at the onset of spring melting was developed on the basis of exceptionally cold and wet weather during the seven-month snow accumulation season, October-April. The conditions assumed for May and June were conducive to unusually rapid melt rates over the entire basin. Two basinwide rainstorms were assumed to occur during the main snowmelt season; one in mid-May and the other in early June.

The approximate magnitude and time of occurrence of such floods are forecastable because the basic cause is the spring snowmelt runoff. The Flood Control Operating Plan for the Columbia River and Tributaries defines the flood control storage space which must be provided in upstream reservoirs as a function of the forecast seasonal runoff volume and the time of the year. It also defines reservoir releases during the control period and other flood control criteria. Determinations of the regulated flood peaks were on the basis of 1975 conditions of reservoir development, by which time the major projects were scheduled to be completed.

The hydrologic model used to estimate the PMF and SPF utilized subbasin storage routing coefficients for surface, subsurface and base flow routing. The channel routing routine for unsteady flows applied the law of continuity by successive finite storage routings through non-linear reservoirs. The various routing coefficients were based on analysis of past floods and physical characteristics of the channels.

The regulated SPF in the vicinity of Hanford is 570,000 cfs. The natural and regulated PMF for that vicinity is 1,780,000 and 1,440,000 cfs, respectively.

The Yakima River joins the Columbia River at Mile 336 and has a drainage area of about 5600 square miles. The Snake River joins the Columbia River at Mile 325 and has a drainage area of about 103,000 square miles. A Probable Maximum Flood on the Snake River coincident with a Standard Project Flood on the Columbia River above the junction would not raise water levels on the Columbia River at Mile 340 (entrance for backwater to Exxon NFF) as high as those resulting from the PMF for the Columbia River.

A detailed PMF analysis for the Yakima River in the vicinity of Richland has never been done to our knowledge. However, a comparison of the Yakima and Snake River drainage areas at the mouths suggests that the effect of the Yakima River on the Exxon NFF would not be as critical as the effect of the Snake River. Additionally, the Yakima River spreads out in a fairly wide valley at its mouth, which would have a significant effect on attenuation of the peak discharge. In view of the above consideration it can be concluded, with reasonable assurance, that a PMF on the Yakima River will not exceed the elevation of the PMF on the Columbia River at the Exxon NFF site.

5. Ice Jam Flooding

The Columbia River is subject to reduced flows and limited flooding for short periods of time due to ice blockage. Ice blockage is most likely to occur during cold spells when river temperatures and discharge are low. During the winter of 1936-37 when icing was the most extensive of recent years, thick sheets of ice formed on the river. The icing resulted primarily because of the low flows in the river. The mouths of numerous tributaries are frequently blocked by ice with backup of flood waters, but complete blockage does not occur. Extreme cold spells last less than two weeks and the thickness of ice that can form in that period of time is limited. The longest sustained cold period of recent years occurred in 1969-70. No critical problems occurred at any dam or pumphouse intake although some protective booming was required. Low power navigation was impeded above McNary Dam. Ice accumulation took place on the shores, but open water existed at all points on the river above Richland.

With the completion of the upstream storage dams the winter regime of the river has been altered. Winter flows are larger, and water temperatures are higher with minimums occurring later in the season. Based on past experience and observations during 25 years of operation of the Hanford Production plants, the potential for significant flooding at Hanford as the result of ice jams is insignificant.

6. Dam Failure Floods

Analysis of stability of Grand Coulee Dam and the Forebay Dam for an earthquake severity of 0.25g horizontally in combination with 0.17g vertically was made by the Bureau of Reclamation[3]. The study indicated potential cracking along lift lines at the upstream faces of the two dams and possible failure of some appurtenant structures, such as elevator towers. Failure or malfunction of equipment could conceivably cause unintentional releases of water but any combination of such events would produce a total discharge well below 1,200,000 cubic feet per second. A seismic risk analysis for the Columbia Plateau[4] indicates that the return period for an earthquake with a peak acceleration of 0.25g is >55,000 years. Consideration of exposure of upstream dams to earthquakes of greater than 0.25g peak acceleration, weapons effects, or other extreme events is unproductive for this analysis because of the inability to quantify either the exceedance probability or the confidence limits associated with those cases.

7. Flood Warning Time

A flood of the magnitude of the regulated PMF on the Columbia River would be the result of the accumulation of a heavy snow cover throughout the winter. Snow surveys and collection of similar data are made periodically for operational planning of the Columbia River dams. Forecasts of the flood magnitude would be available about one month in advance of flooding. Additionally, two weeks of warning, before flooding of the Exxon site, would be available after the beginning of the April-May rise. The period of time between the beginning of flooding, 1,000,000 cfs, and time of peak discharge, 1,440,000 cfs, would vary from 10 to 15 days.

8. Local Probable Maximum Flood

The possibility of flooding at the plant site as the result of occurrence of a local storm of Probable Maximum intensity has not been investigated in detail because of lack of necessary typographic maps. Preliminary review of available data indicate that local flooding could not inundate the site to the depth of flooding that would result from the Columbia River Basin PMF. There would be practically no warning time for such an event.

9. Summary

Table II gives the pertinent data on the various floods and those of interest with respect to flooding of the Exxon Nuclear Fuels Facility. The regulated PMF would exceed the plant site elevation of 371.5 by 7.5 feet, plus or minus 4.0 feet. This flooding would occur by backwater flooding from Mile 340. The flood elevations given in Table II include the backwater effects of the downstream McNary Dam. Construction of the Ben Franklin project at Mile 348 was considered by the Corps of Engineers. The project is not presently authorized and, as planned by the Corps of Engineers, would have negligible effect on levels of extreme floods.

TABLE II

FLOOD DATA PERTINENT TO EXXON NUCLEAR FUELS FACILITY

Flood	Peak Discharge 1000 cfs	Elevation, msl, at			Depth 1/ of Flooding at ENFF above elev. 371.5
		Mile 344	Mile 340	ENFF	
50-Yr., Nat.	690	366.0	364.0		
50-Yr., Reg.	491	359.5	358.0		
100-Yr., Nat.	745	367.5	365.0		
100-Yr., Reg.	563	362.0	360.0		
1948, Nat.	690	366.0	364.0		
1948, Reg.	410	356.5	355.0		
1894, Nat.	800	369.0	366.5		
1894, Reg.	480	359.0	357.5		
SPF, Nat.	1,000	373.5	371.0		
SPF, Reg.	570	362.0	360.0		
PMF, Nat.	1,780	386.0	383.5		
PMF, Reg.	1,440	381.5	379.0	379.0	7.5 2/

1/ Wind and wave effects are not included.

2/ Accurate within plus or minus 4 feet.

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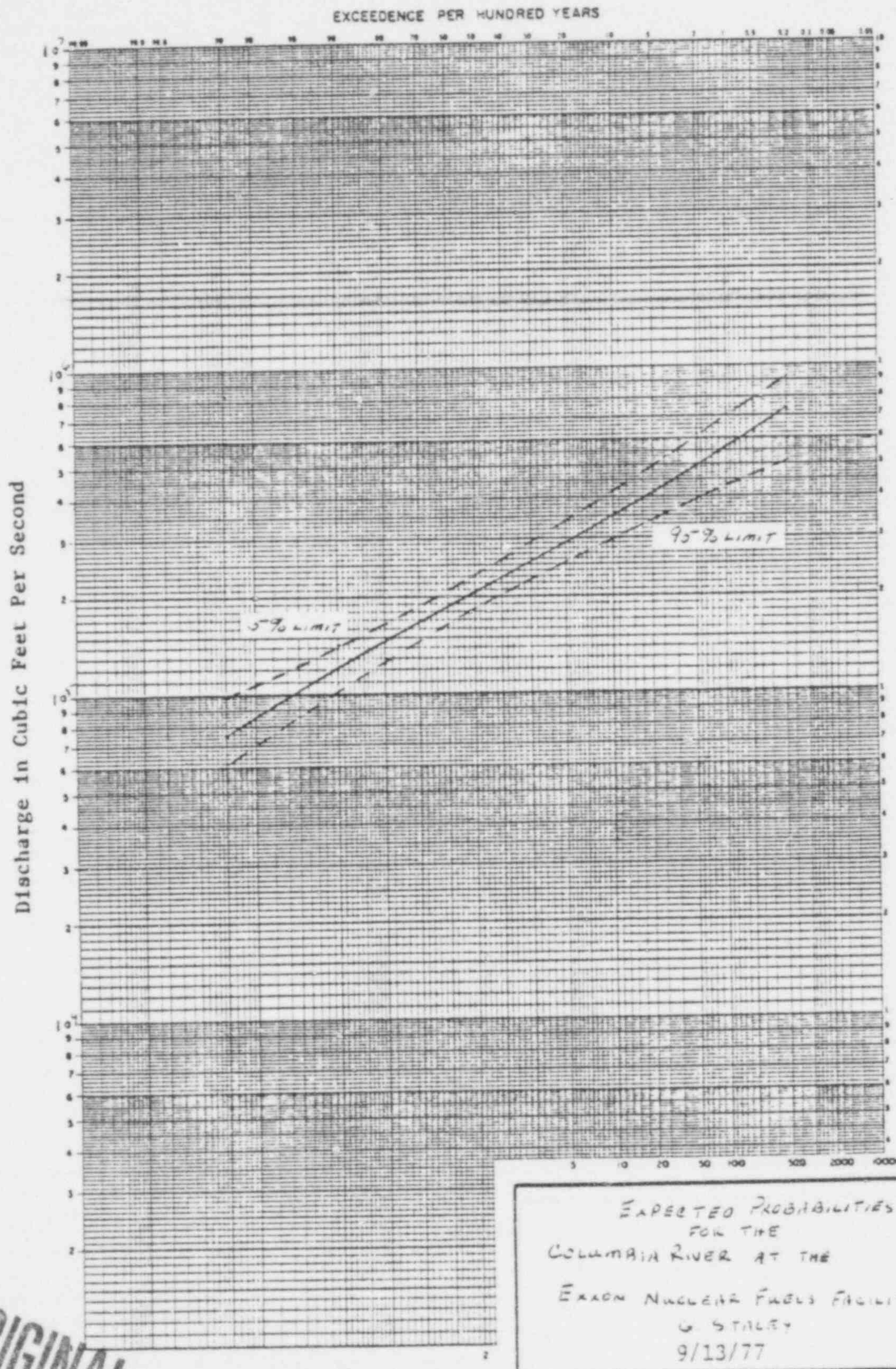
The Probable Maximum Flood for the Columbia River Basin was developed in accordance with accepted practice by the Corps of Engineers and meets the regulatory requirements of the Nuclear Regulatory Commission for a Design Basis Flood from natural hydrometeorological events at nuclear power plants. The normal flood control regulation of the Columbia River system would reduce the PMF peak to 1,440,000 cfs in the Hanford area and produce a flood elevation of 379.0 ft. msl at the plant site. Flooding from backwater at Mile 340 would begin at the plant site at a discharge of about 1,000,000 cfs and would reach a depth of 7.5 feet, plus or minus 4 feet for the discharge of 1,440,000 cfs. Wind and wave effects should be added to that level.

Advance warning of one month of the flood potential could be expected and a two week period would be available before flooding and after the normal annual flood rise began.

REFERENCES

1. Corps of Engineers, North Pacific Division, letter D. C. Spears, Chief, Hydrologic Engineering Section to G. Staley, Nuclear Regulatory Commission, February 24, 1978.
2. Corps of Engineers, North Pacific Division, Memorandum Report, "Lower Columbia River Standard Project Flood and Probable Maximum Flood," September 1969.
3. Bureau of Reclamation, letter H. G. Arthur, Acting Director, Design and Construction, to D. G. Williams, Manager, Richland Operations Office, AEC, Richland, Washington, March 5, 1971.
4. "Seismic Risk Analysis for the Exxon Nuclear Plutonium Facility, Richland, Washington" TERA Corporation, Berkeley, CA, report submitted to Lawrence Livermore Laboratory, 29 September 1978.



EXPECTED PROBABILITIES FOR THE COLUMBIA RIVER AT THE EXXON NUCLEAR FUELS FACILITY

G. STALEY

9/13/77

U. S. NUCLEAR REGULATORY COMMISSION

EXHIBIT 1