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TITLE

CHEMICAL DISPOSAL TO THE COLUMBIA RIVER BY 100-N AREA

AUTHOR

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ABSTRACT

As a result of an AEC directive, a review has been made of the disposal of chemicals to the Columbia River by 100-N, to determine if any water pollution hazards exist. The search revealed that no chemicals are released continuously in hazardous concentrations; that three cases exist where hazardous concentrations might be released intermittently under worst-case conditions; that two cases exist where intermittent releases result in questionable conditions; and that two cases exist where accidental release from storage might result in hazardous conditions. Recommendations for corrective action are given in all cases.

CHEMICAL DISPOSAL TO THE COLUMBIA RIVER BY 100-N OPERATIONS

I. INTRODUCTION

A recent letter(1) from the Atomic Energy Commission transmitted a Governmental Executive Order(2) directing a review of existing government facilities to determine whether or not current liquid waste disposal practices surpass or meet the standards set forth in the Order(2).

A review has been made of all chemicals in routine use at 100-N and their disposal practices. This report presents the results of this review.

II. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

1. No streams containing chemicals in hazardous concentrations are continuously released to the Columbia River by 100-N.

2. Three cases exist where intermittent release of chemicals in hazardous concentrations can occur, under worst-case circumstances. (See B. 2. below for recommendations for corrective action.) These are:

   a. Dummy decontamination tanks are drainable only to the river and could present a potential problem, depending upon the contents of the tanks and the rate of release to the river.

   b. The chemical waste sump at the 108 building could also present a problem, depending upon the contents of the sump and the rate of release to the river.

   c. Single-pass reactor cooling water, used infrequently, contains sodium sulfite in concentrations above acceptable limits, and must be adequately diluted before release.

3. Two cases exist where intermittent release of chemicals occur where doubt exists as to the degree of hazard. (See B. 3. below for recommended action.) These are:

   a. Filter plant backwash is released to the river for about seven minutes once each shift. No hazardous concentrations of dissolved chemicals are released; however, undissolved alum-produced floccules, along with the turbidity removed from the river water by the filtration process, may be released at concentrations up to a peak of 100 to 200 ppm during this period.

   b. Chemical discharges of spent regeneration chemicals occur four to eight times daily for periods of 30 to 90 minutes each. The peak variation of pH in the water released to the river may be out of the accepted safe range for short periods during these releases, but hazardous conditions are not clearly indicated.

4. Two cases exist where accidental release of hazardous amounts of chemicals might occur in the event of quantity release from storage tanks. (See B. 4. below for recommended action.) These are:

   a. Leakage of large amounts of chemical from either the acid or caustic storage tanks inside the 163 building would reach the river in hazardous concentration.

   b. Release of large quantities of condensate quality water from the afterheat removal water storage tank might present hazard. The unknown in this case is a definition of the concentration of morpholine which is hazardous.

5. In some cases listed above, the calculated concentrations of chemicals being released are close enough to the accepted release limits that actual field determinations will be required to determine whether or not limits are in fact exceeded.

B. Recommendations

1. Samples should be taken of the pertinent waste streams at the appropriate times and analyzed to determine the validity of the assumptions and calculations herein.

2. The following corrective actions should be taken promptly to prevent hazardous release of chemicals from the three facilities noted in A. 2. above:

   a. Procedures should be set up for control of release of chemicals from the dummy decontamination tanks. Procedures would include sampling and analyses of the liquids in the tanks and control of release rates and dilution water flows.

   b. Generally similar procedures should be set up for release of chemicals from the 108 chemical sump. A restriction should be placed in the eductor suction line to lengthen the pit emptying time.

   c. Operational procedures should be established to set minimum dilution water flow requirements for reactor single-pass cooling water effluent.

3. The following actions should be taken to clearly establish the degree of hazard involved, if any, by the releases described in A. 3. above.

   a. Secure and analyze samples as recommended in B. 1. above.

   b. Request authoritative determination of the degree of hazard involved in the concentrations of chemicals which actually exist.

4. The following actions will be necessary to prevent accidental release of hazardous amounts of chemicals from storage, as described in A. 4. above:

   a. At the 163 building, provide a new catch basin to the west of the building adequate to contain accidental quantity release of acid and caustic.

   b. Request authoritative determination of the degree of hazard involved with dilute concentrations of morpholine at the levels found in condensate. If the determination is unfavorable, corrective action will be needed in the area of the afterheat removal water storage tank, such as diking and provisions for dilution of overflow and drainage.

III. DIRECT RIVER DISPOSAL

A. Major Shore Release (See Figure 1.)

1. Major Raw Water Flows

The normal major flow through this stream is the turbine condenser effluent cooling water, plus the graphite cooling system heat exchanger cooling water. This flow is untreated raw Columbia River water at a fairly steady rate of about 78,000 gpm.[4] This flow does not vary greatly whether the reactor is operating or shut down.[5] This main flow has no chemicals added to it; provisions are made for chlorination if required but this has never been used.

These flows empty into piping which becomes a 66-inch drain emptying in turn into the north part of the outfall structure. From the outfall structure, the water flows down a concrete flume into the river at the shore.[11]

2. Minor Water Flows

The following flows also contain no chemicals normally, or, at most, contain only very minor amounts such as might be spilled on a floor and be flushed to a sump.

   a. 182 cooling waters.[6] This consists of cooling water from diesel engine jacket water coolers, lube oil coolers, and gear increaser oil coolers; from air compressor intercoolers; and from high pressure injection pump fluid coupling and lube oil coolers.

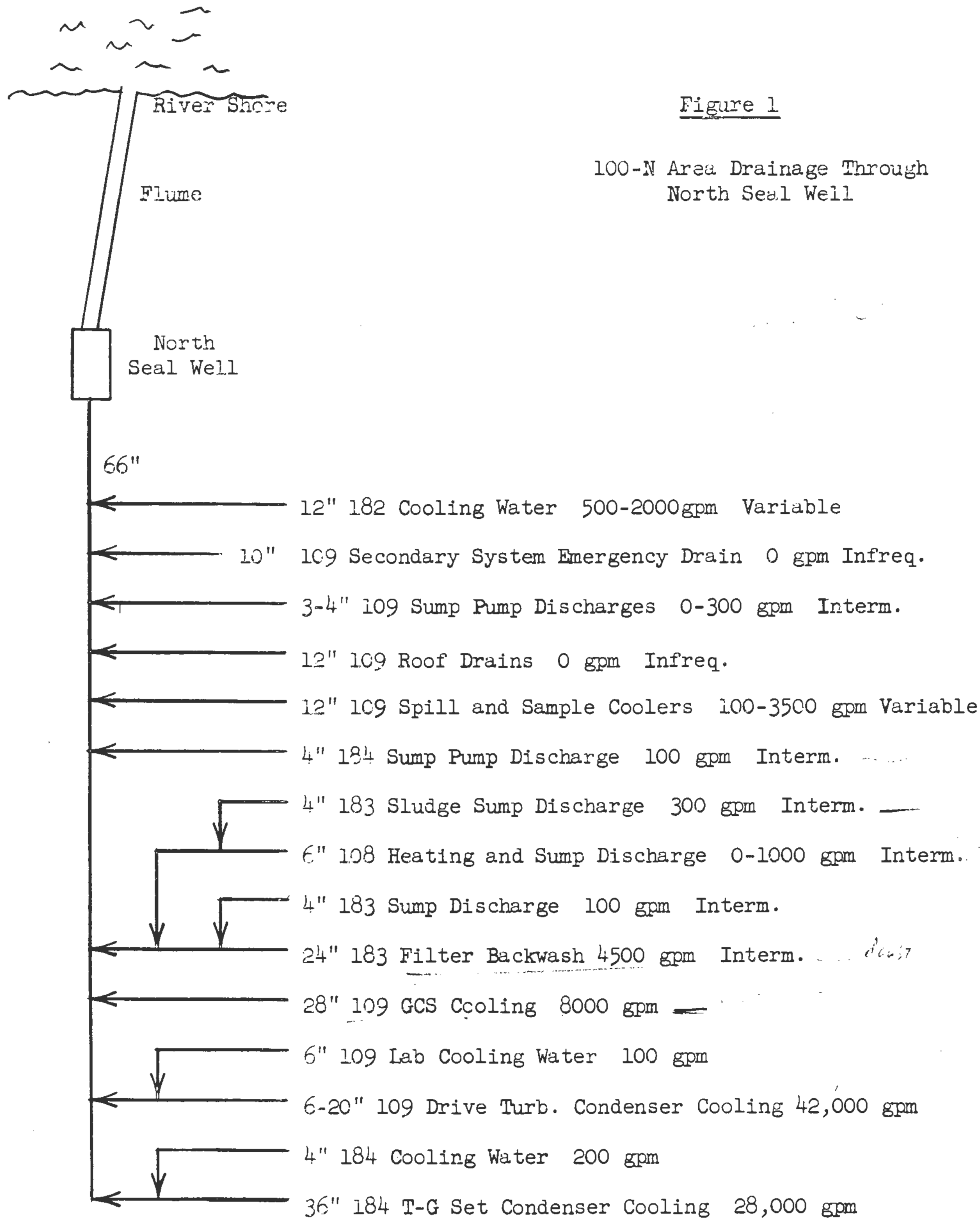
   b. 109 secondary system emergency drain.[7] This is an emergency drain with no normal flow.

   c. 109 turbine bay sump pump discharges.[8] Floor sumps in the basement of the turbine bay handle small amounts of drainage.

   d. 109 roof drains.[8] Handle rain water or other drainage from the 109 building roof.

Figure 1

100-N Area Drainage Through North Seal Well



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e. 109 spill and sample coolers.[9] Cooling water effluent from heat exhangers cooling emergency spill from the primary system and sample coolers cooling water quality sample streams being routed to the laboratory.

f. 184 sump pump discharge.[10] A floor sump in the boiler house handles minor drainage and spills.

g. 109 laboratory cooling water.[11] Effluent from sample coolers in the water quality laboratory.

h. 184 cooling water.[12] Effluent from air compressor coolers, generator hydrogen coolers, lube oil coolers, and feedwater pump coolers in boiler house.

TABLE I
CHEMICAL USAGE AT 100-N

Basic data obtained from E. Bailey, Essential Materials Specialist.

Note: All figures have been corrected to exclude any water of solution or crystalization.

Material	Pounds per month - 1965			Pounds in Storage - Jan. 1966
	Average	High	Low	
Alum as $Al_2(SO_4)_3$	21,000	34,100	7,700	28,000
Ammonium hydroxide as NH_3	18,500	29,000	5,500	10,000
Chlorine as Cl_2	1,875	3,340	880	19,000
Helium as He	5,900	11,200	2,900	2,800
Morpholine as $NH(CH_2)_2O(CH_2)_2$	265	*	*	2,800
Nitrogen as N_2 (3-month period)	3,900	4,400	2,900	6,300
Separan (or equivalent)	70	*	*	400
Sodium dichromate as $Na_2Cr_2O_7$	940	1,600	0	9,600
Sodium hydroxide as NaOH	73,550	159,100	25,500	295,000
Sulfuric acid as H_2SO_4	104,700	171,300	21,200	285,000
Hydrazine as N_2H_4	770	*	*	1,900
No. 6 fuel oil	9,910,500	13,460,500	7,120,000	8,960,000
Diesel oil	39,500	107,600	9,800	1,710,000

*The use rate is small enough that figures for monthly withdrawal from inventory have no significance.

TABLE II

EFFECT OF ACID AND CAUSTIC ON RIVER WATER pH

Experimental results obtained in 109 water quality laboratory.

Initial raw river water pH: 7.95

H_2SO_4		
	25 ppm	6.6
	50 ppm	5.9
	100 ppm	3.3
NaOH		
	10 ppm	8.9
	25 ppm	9.2
	50 ppm	9.7
	100 ppm	10.1

3. Flows Containing Chemicals

a. 183 filter backwash.(13) The alum which is added to the water in the filter plant precipitates aluminum hydroxide. The 21,000 pounds of $Al_2(SO_4)_3$ used per month (ref. Table I) will precipitate as 9,600 pounds per month of $Al(OH)_3$. The major portion of this material is removed by the filters, a lesser amount settles and is removed by the sludge blowdown (see 3. b., below).

(The sulfate radical from the alum stays in solution in the filtered water and is well below drinking water standards.)

The dirt from the filters is removed by a periodic backwash at 4500 gpm for seven minutes at a varying frequency depending on plant load and raw water conditions. Normal frequency, however, is about one filter backwash per 8-hour shift.(14)

An average of about 100 pounds of $Al(OH)_3$ is removed in seven minutes of backwash. With the dilution flow of 83,000 gpm, an average concentration of about 20 to 25 ppm of $Al(OH)_3$ exists in the 66-inch outfall for a period of seven minutes out of every eight hours. The peak concentration of sludge at the start of the backwash is considerably higher than this, possibly in the 100 to 200 ppm range.

TABLE III

DRINKING WATER STANDARDS

Extracted from "U. S. Public Health Service Drinking Water Standards, 1962."

NOTE: Application of these data requires consideration of other modifying factors. They are presented here only for general information.

A. "The following chemical substances should not be present in a water supply in excess of the listed concentrations where . . . other more suitable supplies are or can be made available."

Substance	Concentration ppm*
Alkyl Benzene Sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250.
Copper (Ca)	1.
Carbon Chloroform Extract (CCE)	0.2
Cyanide (CN)	0.01
Fluoride	(dependent on temperature)
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (NO_3)	45.
Phenols	0.001
Sulfate (SO_4)	250.
Total Dissolved Solids	500.
Zinc (Zn)	5.

B. "The presence of the following substances in excess of the concentrations listed shall constitute grounds for rejection of the supply."

Substance	Concentration ppm*
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chronium (hexavalent) (Cr^{+6})	0.05
Cyanide (CN)	0.2
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

*Concentrations are expressed in miligrams per liter, essentially the same as parts per million.

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b. 183 sludge sump discharge.[13] Under current modes of operation, most of the sludge from the filter plant is removed in filter backwash, as described in 3. a., above. A part, however, perhaps about 10 to 20 percent, is removed by blowing down the coagulators to a sump for a period of two minutes every two to three hours.[14] This sludge is disposed of by pumping into the backwash effluent line and would give similar concentrations of $Al(OH)_3$ in the 66-inch line discharge.

c. 183 sump discharge.[15] This sump receives drainage and spills from the filter plant and is emptied periodically by syphon effect into the backwash effluent line. The normal amount of chemicals in this waste is small.

d. 108 heating water and sump discharge.[16] The 108 building handles storage and pumping of caustic and sulfuric acid for the demineralization plant. A supply of raw water, heated by the direct injection of steam, is used as the heating medium in heat exchangers to keep the caustic above its crystalization temperature. No chemicals are normally added to this stream.

Raw water is also used in an eductor to remove waste from a neutralization pit. This pit received acid and caustic drainage from spills and leaks, then is sucked out to waste when required by manual initiation. The pit has a working volume of a little less than 1,000 gallons[17] and is usually emptied in about 20 minutes,[14] an effective flow rate of about 50 gpm.

In the worst possible case, the pit filled with concentrated sulfuric acid, the H_2SO_4 concentration in the 66-inch outfall would be about 1100 ppm during the 20-minute educting period. Filled with concentrated caustic (50% NaOH), the extreme case on the basic side, the water released to the river would contain about 500 ppm NaOH.

B. Major River Center Release (See Figure 2.)

1. Major Raw Water Flows

a. The normal major flow through this stream is the dump condenser cooling water effluent. This flow is untreated raw Columbia River water at a fairly steady rate of about 290,000 gpm.[4] This flow does not normally vary greatly whether the reactor is operating or shut down; however, it may be lessened at times when one or more of the dump condensers is out-of-service for some reason, or the flow on occasion may be considerably less during a reactor shutdown if one or two of the river water pumps are not operating.[5]

These flows empty into piping which becomes a 108-inch drain emptying in turn into the south part of the outfall structure. From the outfall structure, the water flows down a 102-inch pipe to be released at a point in the main flow channel of the river.[11]

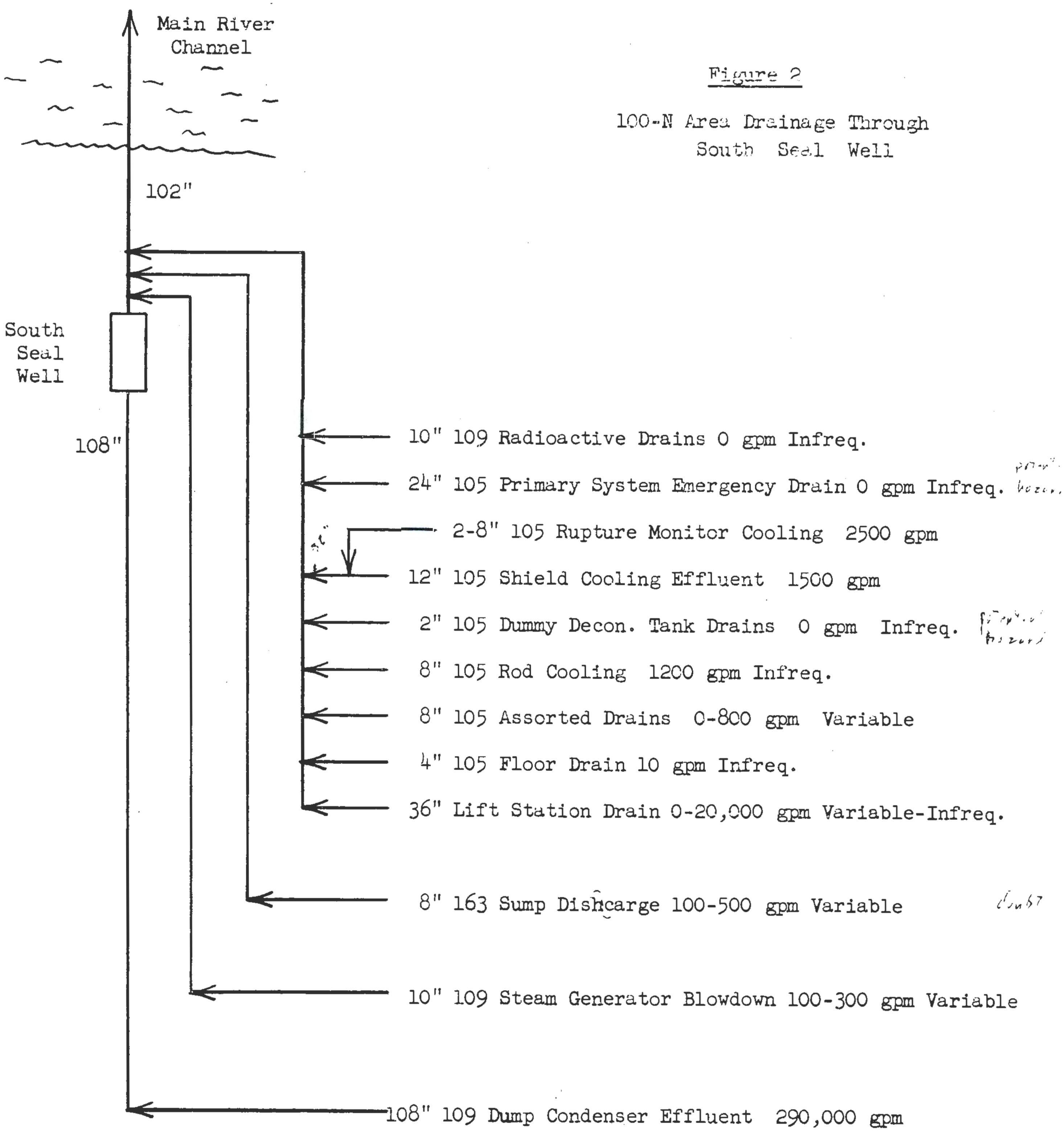

Figure 2

100-N Area Drainage Through South Seal Well

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b. A second major water flow enters the 102-inch outfall line via the 36-inch line[18] shown in Figure 2. The normal main flow through the 36-inch is the sum of 105 shield cooling and 105 rupture monitor cooling, a total flow of about 4,000 gpm of untreated raw or filtered water.[19]

2. Minor Water Flows

The following flows also contain no chemicals normally, or, at most, contain only very minor amounts such as might be spilled on a floor and be flushed to a sump.

a. 105 assorted drains.[19] A large number of assorted small drains in the 105 building empty into a piping network culminating in an 8-inch emptying into the 36-inch. These include such items as drinking fountain drains, evaporative cooler drains, ventilation fan cooler drains, elevator hydraulic power unit cooler drains, floor drains, etc. Any chemical contamination of these streams would normally be minor and incidental.

b. 105 floor drains.[19] Other 105 floor drains collect into a 4-inch drain emptying to the 36-inch. These flows are normally very minor.

3. Other Possible Clean Flows

Several flows are possible, but normally are either nonexistent or are routed to some other disposal point. These are:

a. 109 radioactive drains.[18] Normally routed to the 1301 crib.

b. 105 primary system emergency drain.[19] Intended for emergency use only, but can be used for single-pass effluent. (See Section 4. d. below.)

c. 105 rod cooling.[19] Normally routed to 1301 crib.

d. 105 lift station drain.[19] Normally pumped to 1301 crib.

4. Flows Containing Chemicals

a. 105 dummy decontamination tank drains.[19] The dummy decontamination facility in 105-N consists of two 1,000-gallon chemical tanks and one 1,000-gallon rinse tank. These tanks can be drained by manually opening the drain valve on a tank. It takes about twenty minutes to drain a tank with the drain valve fully opened.[20] The acid tank presently contains about 1,200 pounds of H_2SO_4 per batch.[21] If a fresh batch of acid were drained directly through a full open valve, the acid concentration at the point of river release would be about 25 ppm.

b. 163 sump discharge.[22] [23] Waste flows from the 163 demineralization plant are collected in a sump provided with two 500 gpm sump pumps and an automatic control system which maintains a nearly constant quantity of about 2,500 gallons in the sump.[30] Effluents from cation and anion regenerations flow into this sump as do many fairly large clean water streams. At the peak sulfuric acid flow,[14] taking no account of any neutralization, the acid concentration at the 102-inch river discharge would be about 60 ppm. During primary anion bed regeneration, the sodium hydroxide concentration, also taking no account for neutralization, would be about 8 ppm, because of the lower concentration used in regenerating anion resins.

c. 109 steam generator blowdown. Water quality control blowdowns from the secondary side of the primary steam generators are routed to the 102-inch line. This water, before dilution, contains about 0.3 ppm of hydrazine and enough morpholine and ammonia for a pH of about 8.8.[21] After dilution of about 300 to 1 or greater, the chemical concentrations from this source are well below limits.

d. Reactor single-pass effluent. During certain plant outage conditions requiring stopping of normal recirculating primary coolant, single-pass filtered water coolant is provided at rates in the range of 5,000 to 10,000 gpm.[5] This effluent can be routed to crib, or to the river via the 105 primary system emergency drain, emerging into the 102-inch outfall line.

The single-pass coolant may have up to 120 ppm of sodium sulfite added for corrosion inhibition.[21] An adequate dilution flow can be maintained in the 102-inch line to dilute the sodium sulfite below the 10 ppm limit needed.

C. Other Shore Releases (See Figure 3.)

1. Tank Overflow Flume[26]

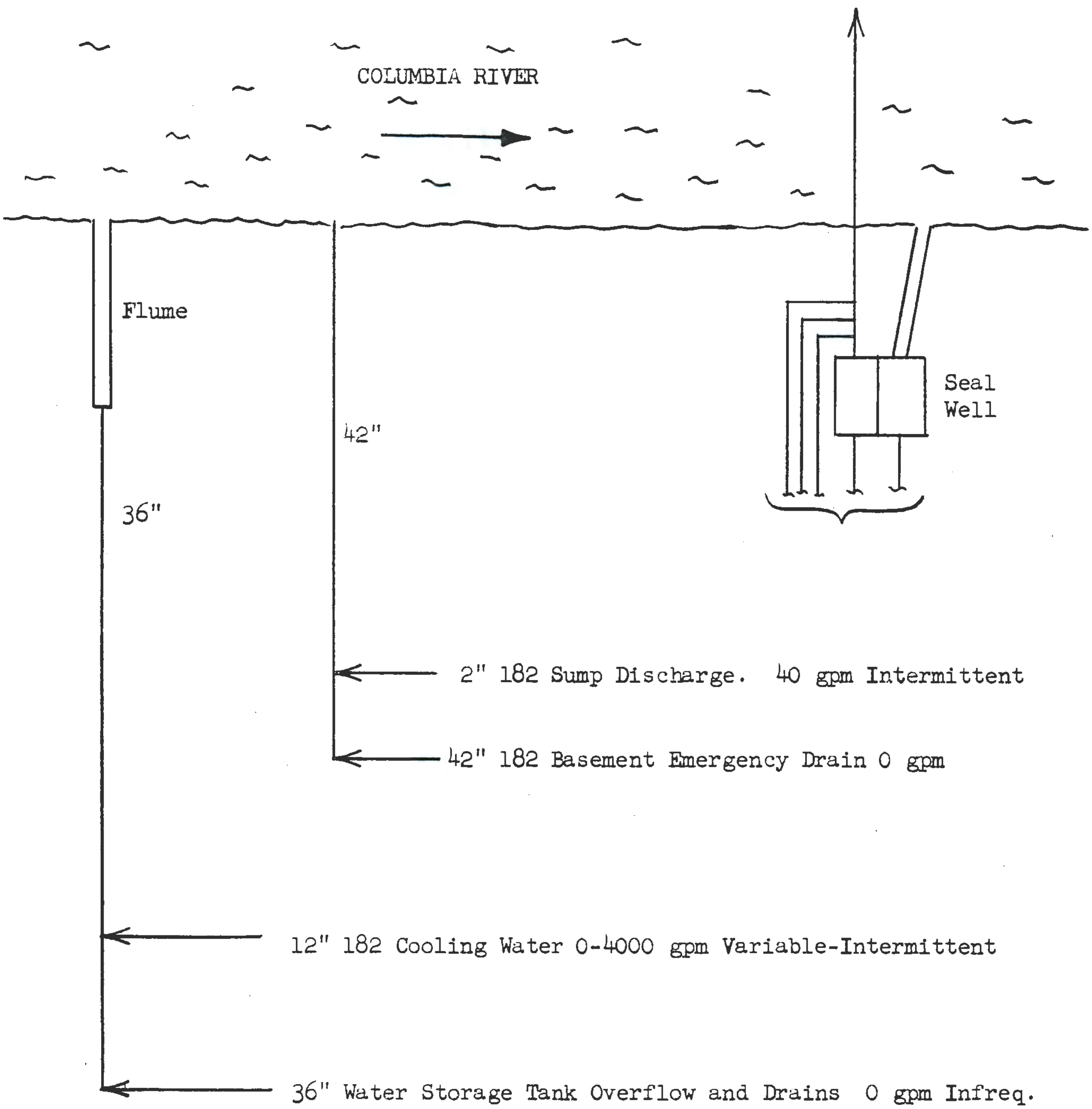
The four water storage tanks located near the 182 building have a common drain and overflow system which discharges at the river shore about 200 yards upstream of the main shore release point. Tank drainage or overflow seldom occurs.

This discharge point also accepts intermittent flows from the 182 building consisting primarily of raw water pump discharge bleeds or test streams. The 182 building roof drains also empty into this system.

The only appreciable amount of chemicals which are likely to enter this system are the hydrazine, morpholine, and ammonia in the water in the afterheat removal water storage tank should it overflow or be drained, an infrequent occurrence.

Figure 3

Direct River Releases
at 100-N



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2. 182 Building Emergency Drain[27]

In the event of the rupture of a major raw water line in the 182 building, critical equipment in the building basement might be flooded. To prevent such flooding, a 42-inch diameter gravity drain line was provided, discharging at the river shore about 100 feet downstream of the tank overflow flume described above.

This emergency drain also carries the discharge of the 182 sump pumps,[28] an intermittent flow of 0 to 40 gpm of assorted equipment drains. Only incidental trace chemicals are normally present in this stream.

IV. POSSIBLE RELEASES FROM STORAGE

In the event of rupture of storage tanks or inadvertent opening of tank drain valves, the following would occur: (See Table I for quantities stored.)

A. Alum

Two 8,000-gallon tanks store liquid alum inside the 183 building. Liquid lost from these would spill on the floor of the filter operating gallery, whose floor drains connect to the 183 sump. (See Section III. A. 3. c.) No release of chemical to the river would occur unless specific action were taken to start the sump syphon.

B. Ammonium Hydroxide

The 8,000-gallon storage tank is located over 1,000 feet from the river. The tank drain is not normally connected but must be provided with a hose. Any accidental release would therefore be onto the ground and would not reach the river.

C. Chlorine

Any chlorine released accidentally would vaporize before reaching the river.

D. Helium

No water pollution problem.

E. Morpholine

Stored in 55-gallon drums; quantity release extremely unlikely.

F. Nitrogen

No water pollution problem.

G. Separan

A dry solid, stored in bags. The solution tanks are near the alum storage tanks and similar comments would apply (see A. above).

H. Sodium Dichromate

The larger quantity is stored dry in bags. Solutions are made up in 150-gallon tanks. Loss of solution from the tanks by rupture, overflow, or drainage will flow to the lift station for pumping to the 1301 crib.[19]

I. Sodium Hydroxide

The larger, 76,000-gallon tank is located over 1,200 feet from the river. Fluid lost from the tank would either spill on the ground or go to the 108 neutralization pit which requires manual action to empty. (See Section III. A. 3. d.)

The 10,000-gallon caustic tank in the 163 building would spill to the 163 sump in the event of accidental discharge. This liquid would be pumped into the 102-inch outfall line at high rates and result in excessively high concentrations. (See Section III. B. 4. b.)

J. Sulfuric Acid

Statements concerning sodium hydroxide in the section above would apply here also with the exception that the main storage consists of three 10,000-gallon tanks.

K. Hydrazine

Stored in 55-gallon drums; quantity release extremely unlikely.

L. No. 6 Fuel Oil

Stored in a single 1,375,000-gallon tank, and two 35,000-gallon day tanks. All tanks are adequately diked. Because of its high viscosity, fuel oil released to the ground would not penetrate to the river.

M. Diesel Oil

The four main diesel oil storage tanks of 105,000 gallons each are properly diked. The 2,500-gallon 184 boiler house ignition oil tank is a buried tank. The 15,000-gallon storage tank for the 181 and 182 diesel engines is adequately diked.

In the event of diesel oil spillage onto the ground, ground water contamination will not occur because the soil at 100-N will hold about 12% by volume diesel oil, like a sponge.[29]

V. DISCUSSION OF PROBLEM AREAS

A. Filter Plant Backwash (Ref. III. A. 3. a., and III. A. 3. b.)

A periodic discharge of filter backwash sludge occurs for about seven minutes every eight hours. (The frequency can vary considerably with seasons.) The average concentration of undissolved solids at the river shore during this period would be about 20 to 25 ppm, but the peak concentration at the start of wash would be several times this high.

Although water with this amount of solids in it is probably neither palatable nor aesthetically pleasing, it is not judged to be hazardous.

B. 108 Sump Discharge (Ref. III. A. 3. d.)

Sulfuric acid, or caustic, or a mixture of the two, with varying amounts of water are educted out to the river shore discharge for about a twenty-minute period about once every two weeks or so. As noted in Section III. A. 3. d., under the worst conditions, chemical concentrations at the shore discharge would be very high.

A simple and cheap solution to this problem would be a restriction in the eductor suction line so a longer time is required to empty the pit. Such modifications would cost about $200.

C. Dummy Decontamination Tank Drainage (Ref. III. B. 4. a.)

Drainage of these tanks is under manual control. As in the case of the 108 sump, above, sampling prior to release and control of release rate would hold pollution levels below limits. Drainage of a tank of fresh, unused sulfuric acid (1,200 pounds of H_2SO_4 per 1,000 gallons) would be permissible within the range of pH permitted in the 102-inch outfall. Other chemicals would have to be sampled, calculations made, and the rate of release controlled.

It is expected that only one or two tanks will be drained per month.

D. 163 Sump Discharge (Ref. III. B. 4. b)

Discharges of acid two to four times daily should drop the pH of the 102-inch outfall into the acid range below 6.5 (but above 5.5) for periods of five to ten minutes.

Discharges of caustic occur about as frequently but do not have as great an effect on effluent pH because more dilute solutions are used. Effluent pH should be in the range of 8.5 to 9.0. The effect is considerably longer, however, continuing for 60 to 90 minutes each time.

No relatively simple solution is apparent for reducing or eliminating these releases. Actual tests will be required to determine true concentrations before determining any necessity for corrective action.

E. Drainage or Overflow From Secondary System (Ref. III. C. 1.)

Spillage of large quantities of secondary system condensate from the afterheat removal water storage tank or other sources with no dilution might release water containing sufficient morpholine to be hazardous to fish life.

Reference (3) lists critical ranges for several amines and amino compounds, but morpholine is not among them. For the compounds listed, toxicity was expressed in terms of a "critical range" defined as the range of concentration in ppm below which four test fish lived for 24 hours and above which all four died. For the compounds listed the critical ranges varied from a low of 5-20 to a high of 16,000-30,000, giving at least indirect indication that concentrations of morpholine in the 1 to 2 ppm range may not be of concern. Further information is being sought.

F. Loss of Acid or Caustic From 163 Tank Leakage (Ref. IV. I and IV. J.)

Loss of other than minor quantities of chemical from either of the 163 chemical storage tanks (as from tank rupture, pipe breaks, etc.) would pollute the 102-inch outfall stream.

A relatively low cost provision to prevent this happening would be to provide drainage from the tank area to a new catch pit constructed west of the 163 building. Such a facility would cost about $10,000.

G. Single-Pass Reactor Cooling Water Effluent (Ref. III. B. 4. d.)

During certain reactor outage conditions when normal recirculating cooling is not possible, the reactor is put on single-pass cooling using filtered water. This water has added to it from 60 to 120 ppm of sodium sulfite for corrosion inhibition. The flow rate will normally be about 8,000 gpm but may be as low as 5,000 gpm, or as high as 10,000 gpm.

All that is required to keep the as-released concentration of sodium sulfite below the 10 ppm acceptable limit is to assure that the 102-inch outfall line has adequate diluting water flowing. This will be in the range of 30,000 to 120,000 gpm, depending upon the single-pass flow rate and the sodium sulfite concentration.

REFERENCES

(1) Letter, D. G. Williams to W. E. Johnson, "Prevention, Control and Abatement of Water Pollution by Federal Activities," Ref. H:CNZ, dated January 14, 1966

(2) Executive Order 11258, same title as above letter, dated December 21, 1965

(3) McKee, J. E., and Wolf, H. W., editors, "Water Quality Criteria, 1963," California State Water Quality Control Board

(4) Personal communication, J. Muraoka, February 14, 1966

(5) Personel communication, E. A. Grimm, February 17, 1966

(6) Drawing H-1-29505, "Flow Diagram - Diesel Engine Raw and Jacket Water Systems"

(7) Drawing H-1-29113, "Flow Diagram - Condensate Feed and Fill Water Systems"

(8) Drawing H-1-29167, "Floor & Equipment Drains & Plumbing - Plans & Sections"

(9) Drawing H-1-29109, "Flow Diagram - Raw Water Cooling System"

(10) Drawing H-1-29045, "Floor Drains, Equipment Drains, Roof Drains, and Sanitary System"

(11) Drawing H-1-29451, "Flow Diagram - Circulating Water System"

(12) Drawing H-1-29010, "Flow Diagram - Service Water & Cooling Water Systems"

(13) Drawing H-1-29210, "Flow Diagram - Water Pretreatment System"

(14) Personal communication, filter plant operators

(15) HW-69000 Vol. 2, "100-N Technical Manual," pages 8.2.3-1 and 8.2.3-2

(16) Drawing H-1-29246, "Flow Diagram - Acid, Caustic, Steam, Air, and Water Systems"

(17) Drawing H-1-30538, "Structural - Chemical Unloading Facility - Sheet 2"

(18) Drawing H-1-29625, "Composite Flow Diagram - Radioactive Waste Disposal"

(19) Drawing H-1-28899, "Drainage System Flow Diagram"

(20) Personal communication, S. G. Nelson, February 18, 1966

(21) Personal communication, W. K. Kratzer, February 18, 1966

(22) Drawing H-1-29200, "Flow Diagram - Demineralized Water System"

(23) HW-69000 Vol. 2, "100-N Technical Manual," pages 8.3.2-1 and 8.3.2-2

(24) Drawing H-1-29100, "Flow Diagram - Heat Exchanger Blowdown System"

(25) Drawing H-1-28446, "Flow Diagram - Primary Coolant System"

(26) Drawing H-1-29474, "Flow Diagram - Raw Water System"

(27) HW-69000 Vol. 2, "100-N Technical Manual," page 8.2.7-1

(28) Personal communication, pump house operators

(29) Personal communication, K. C. Knoll, February 21, 1966

(30) Drawing H-1-30807, "Structural - Demineralization Plant Finished Floor Plan"