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APPENDIX TO HDC-2118

DESIGN CRITERIA

# 100-X REACTOR WATER PLANT

## GENERAL DESCRIPTION

SECTION II

Classification Cancelled and Changed To

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By Authority of RM Olten
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GENERAL ELECTRIC COMPANY

HANFORD WORKS PROJECT RDA-DC-6

SUBCONTRACT NO. G-363 MODIFICATION NO. 2

[redacted]

CHAS. T. MAIN, INC.

80 FEDERAL ST., BOSTON, MASS.

MARCH 1952

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APPENDIX

To

HDC 2118 DESIGN CRITERIA - SECTION II

March 29, 1952

General Electric Company
Hanford Works - Project RDA-DC-6
Subcontract No. G-363 - Modification No. 2

Prepared by:

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This appendix summarizes the reasons for the various design features of HDC-2118, Design Criteria, 100-X Reactor Water Plant.

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# CONTENTS







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## COMPARISON WITH EXISTING PLANTS

CONTENTS

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Discussion

The factors responsible for the advances of 100-X compared with the older areas are:

Simplification of the process, such as elimination of separate process water clearwells, by having the filtered water reservoirs perform that function.

Combination of separate buildings into one building, such as combining filter pump house and process pump house.

Use of electric standby.

Use of higher capacity pumps and filter basins, and so fewer number of units.

Centralization of control and operation.

More compact arrangement of plant components.

Use of waste heat for space heating, recovered from reactor effluent, backed up by steam plant.



[redacted]

(Revised May 1, 1952, by, JHS)

[redacted]



Comparison of 100-X Area (2 Plants) with Total of All of Existing 100 Areas

| | | | |
|---|---|---|---|
| Yearly fuel consumption<br>Equivalent tons of coal | 18,000<br>(50,000<br>bbls oil) | 500,000 | Approx. |
| Approximate yearly fuel cost | $100,000 | $3,500,000 | Approx. |
| Electric Load - KVA | 140,000 | 100,000 | |
| Approximate number of operating points | 6 - 7 | 51 | |





[redacted]

(Revised May 1, 1952 by, JHS)

[redacted]



Comparison of Features of Single Plants

| | 1942 Design 100-B | 1950 Design 100-C | 1952 Design 100-X 1 Plant |
|---|---|---|---|
| Reactor water flow - gpm | 30,000 | 62,000 | 140,000 |
| Reactor water pressure - psig | 340 | 525 | 600 |
| Electric load - KVA | 13,000 | 30,000 | 70,000 |
| Boiler capacity installed, #/hr. | 460,000 | Used excess capacity in 184-B | 120,000 |
| Normal steam generation | | | |
| Summer - #/hr. | 121,000 | 43,000 | 12,000 |
| Winter - #/hr. | 178,000 | 92,000 | 12,000 |
| Emergency steam generation (Max.) | | | |
| Summer - #/hr. | *286,000 | 121,000 | 75,000 |
| Winter - #/hr. | *341,000 | 170,000 | 75,000 |
| | *(These have reduced some now) | | |
| Fuel consumption per year as percentage of 100-B | Base | 40% | 9% |
| Fuel consumption per year per gpm to reactor, as percentage of 100-B | Base | 20% | 2% |
| Boiler capacity installed per gpm to reactor as percentage of 100-B | Base | | 5.6% |
| Number of pumps in #181 river pump house | 10 | 11 | 6 |
| Number of filter plant basins | 12 | 8 | 6-8 (possible future) |
| Number of filters | 12 | 12 | 12-16 (possible future) |
| Number of main pump sets in #190 | 12 | 10 | 6 |



[redacted]

[redacted]



Comparison of Features of Single Plants (Cont'd)

| | 1942 Design 100-B | 1950 Design 100-C | 1952 Design 100-X 1 Plant |
|---|---|---|---|
| Buildings in which operators are required: | | | |
| River Pump House | x | x | |
| Reservoir Pump House | x | No Bldg. | No Bldg. |
| Head House | x | x | x |
| Filters | x | x | No Bldg. |
| Filter Pump House | x | x | No Bldg. |
| Main Pump House #190 | x | x | |
| Reactor | x | x | x |
| Power House | x | x | x |
| Roving Fuel Handling Crew | x | x | |
| 151 Substations | x | x | ? |
| Total number of operating points | 10 | 9 | 3-4 |





[redacted]

[redacted]



## GENERAL FEATURES

## CONTENTS







[redacted]

Site Selection

The new plants are to be in the area known as "Coyote Rapids", adjacent to the Columbia River and between existing areas 100-B and 100-D.

100-B is a twin plant area consisting of both 100-B and 100-C plants. In the same way 100-D is a twin plant area consisting of 100-D and 100-DR.

The distance between 100-B and 100-D areas is approximately 7 miles. If the new 100-X plants had been located exactly midway between B and D areas, the cost of construction would have been considerably more than for the site chosen in this report. The reason for this is that at a point midway between B and D areas the new plant would have been getting into hilly country with more excavation required. It would have been necessary to relocate about 2-1/2 miles of main line railroad track. The river pump houses would have been a greater distance from the edge of the river, requiring more excavation for forebays. The water plants would have been further from the river pump houses, requiring longer lines for raw water, drainage sewers and process sewers.

The site selected by this report keeps the 100-X area the maximum distance possible from 100-B area without relocating the main line railroad. It has good contours, both for the water plant and for the river pump houses and, in all respects, appears to be an optimum combination of desirable features.

The airline distance between nearest reactors on 100-B and 100-X areas is about 2.4 miles. The 100-X area is north east of 100-B area and so not directly in line with the prevailing west wind from 100-B area.

It is probably better to have a greater distance between 100-X and 100-D areas than between 100-B and 100-X areas because the potential wind contamination in the event of a reactor disaster is greater from 100-X than from 100-B. In other words, in the event of a disaster at 100-X, it is well to have as much distance as possible between 100-X and the next down wind plant, which is 100-D.

It would be quite expensive to build the 100-X plants nearer to 100-D than 100-B, because of the hilly nature of the ground towards 100-D.

In connection with distance between adjacent 100 areas, it should be noted that the distance between two existing areas, 100-D and 100-H, is 2-1/2 miles, which is about the same as the proposed distance between 100-B and 100-X.

[redacted]



Plant Arrangement

The basic considerations leading to the proposed plant arrangement are as follows:

For reliability and economy, it is desirable to keep the reactors and process pump houses as close to the river as possible in order to have short water supply pipes and short sewer lines.

To keep the design of the two plants similar, it is desirable to have similar buildings at the same elevation. Not only does this keep building design similar but it also makes for similar design and operating conditions of corresponding pumps and reservoirs in the two plants.

It is desirable to keep the main electric substation as close to the major electrical loads (main pump houses) as possible.

For maximum reliability in connection with bomb damage, components which are alternates to one another should be separated as much as possible. In this connection, the water storage in basins and reservoirs is on the opposite side of the reactors from the river, the emergency power plants are remote from the incoming electric substation, and the main pump houses are remote and on the opposite side of the reactor from the river pump houses.

The location of the plants on the site is determined by the reactors. They are set on the contours so that their operating floors will be at elevation 465 ft. in order to get sufficient height above the retention basins to permit flow into the retention basins, and emptying of the retention basins with flood level of the river.

Placing both reactors on the 465 ft. contour also has the advantage that the filter plant basins have their long direction parallel to the contours, which makes for minimum amount of excavation.

The Administration Buildings and Shops are centrally located midway between the reactors and main pump houses and control buildings of the two plants.

Two drainage sewers to the river are used because with two plants at the same elevations, it would be difficult to connect the sewer system of one plant into that of the other and, in addition, the expense of a combined central sewer between the two plants would have been greater because another trench would have to be dug and building sewer connections would have been longer. As it is, the drainage sewer for each plant will be installed in the same trench with the raw water lines from the river pump house.



[redacted]

[redacted]



The reactors, with their operating floor of 465, are well above the estimated 446 ft. level for Coulee disaster flood wave. In fact, all parts of the water plant and reactor are above Coulee disaster level with the exception of river pump houses, and there will be time to dry out river pump house motors and put them back into service after a Coulee disaster, while the plant is on shutdown flow and taking water from storage in the filter plant.

The outfalls of the two retention basin areas are in a common excavation into the river, and empty downstream of both river pump houses.

All piping within each plant runs in a central tunnel which is a sort of backbone and central nerve system for the whole plant. This makes for minimum excavation, maximum reliability, and an easy construction program by eliminating all lines running around the outside edges of the plants. The electrical and control lines are also in this same tunnel system, and the sewer is directly beneath the tunnel and an integral part of it.

The retention basins are sufficiently far from the nearest buildings and roads so that there should be no danger from radioactive vapors coming from them. In the down wind direction from the retention basins, the nearest building is 900 ft. away.

It is of interest that all the various considerations, such as arrangement for minimum operating cost, arrangement for minimum cost of construction, and arrangement for maximum reliability, all have the same requirements and all acted to force the plant arrangement into the same form.



[redacted]

Reliability of Water Supply

The arrangement of the water plants on the site, and the detailed design of each of the components, and their equipment, provide a maximum of reliability of water supply to the reactors, both in peace-time and in war-time with the possibility of damage from bombing and guided missiles.

The features which aid in obtaining maximum reliability are outlined on Page 2.302 of Document HDC-2118. In general, there are provided: three widely separated water sources for emergency, four independent and widely separated pumping stations and three independent and widely separated power supplies.

Two river pump houses are used instead of one, because they add so much to the reliability of water supply. If only one river pump house were installed it would then be desirable to have two separate routes for the raw water lines, one route to each plant and therefore nothing would be saved on excavating for the raw water lines and drainage sewers.

If it should happen that the two plants were built at different times, it would be easier construction to build the second river pump house as a separate structure because it could be built in the dry and forebay excavated afterwards.

The use of two river pump houses is consistent with the "unit" design used throughout the 100-X plants, and makes it easier to adapt this design for use as a single plant which might be built on some existing area such as 100-F or 100-H.

There would not be a great deal of cost saving by combining the two river pump houses. It appears that the total cost of the two river pump houses is about 3% of the total cost of the two water plants, and by combining the two river pump houses, not more than a total of $300,000 could be saved, and the saving might actually be considerably less than this figure.

It is proposed that no import raw water be brought in from the emergency raw water system which connects all of the existing 100 areas. The existing raw water system is spread out over a lot of area and is vulnerable to bomb damage. Its capacity appears to be quite limited, to the extent that there is a question as to whether water would be available for the 100-X from this system, even if the lines were not interrupted by bombing. The cost of bringing in this extra raw water line, of doubtful value, would be considerable, as the length of the connection to 100-X area from the nearest point on the existing raw water system would be about 2-1/2 miles.

Only one substation for the supply from the outside power system is provided, because two substations would cost considerably more, and would increase the reliability by little, if any. Actually, the transmission lines supplying the substation are probably more vulnerable than the substation itself, as far as bombing is concerned, and even if two substations were used it would not increase the reliability, which is limited by the supply transmission lines.

Bombing Considerations

To provide maximum reliability in the face of possibility of damage from bombing, the plant arrangement has the following features:

All interdependent components, such as reactor and 165 control building and connections between them are grouped in a small target area. The reactor building itself apparently has some bomb resistance and the control building, housing everything essential for water supply to the reactor, is of Class I bomb resistant construction. The tunnels between the 165 and the reactor are also of bomb resistant construction, and will be divided by a central wall into two sections, making it quite unlikely that a direct hit by a high explosive bomb would knock out both sides of the tunnel. This is particularly true of a near miss on either side of the tunnel.

All components which serve as alternates to one another have been as widely separated as possible.

All connections between components have been made as short as possible.

All structures have been kept as low as possible. The pump house extension is only 30 feet above the ground, and the highly important control building #165 is only 15 feet above the ground.

Water storage in the reservoir has been kept below ground level to prevent flooding of adjacent buildings in case of a bomb hit.

In connection with keeping all structures low in protection against bomb damage, it appears undesirable to have reactor high tanks. The reliability of water supply to the reactor appears to be just as good with the proposed design without the high tanks, and storing several thousand tons of water 150 feet in the air appears to be a real danger. To avoid the possibility of one or both high tanks falling onto the reactor or control building or main pump house, they would have to be located a considerable distance from the reactor and the length of connections between them and the reactor then becomes great enough so that their value to the reactor in the face of bombing is questionable.

Raw water can go directly to the reactor from the river pump house without passing through the filter plant area. Thus, if the filter plant and main pump house are bombed out of operation it is probable that water could still be delivered to the reactor directly from the river pump house for shutdown flow.

There are no above ground pipes or electrical circuits of any kind. All piping and wiring is below ground either in the tunnel system or with appreciable earth cover.



[redacted]

The 165 control building houses all of the things essential to water supply to the reactor, including: emergency power plant, electrical switchgear, main control room and all of the main water valves. This building, being of Class I bomb resistant construction, should last longer against bombing than any other of the plant components. There is sufficient room within it to function as a personnel shelter and it has all of the services and facilities necessary for this purpose.

Fuel oil for the emergency power stations is stored underground in bomb resistant concrete tanks close by the emergency power plant.

[redacted]



Operation at Varying Filtration Rates, and Plant Capacity to be Installed

Each of the water plants has been designed to operate at any flow up to 125,000 gpm to the reactor. At this flow the filtering rate would be 4.75 gpm/sq.ft.

The whole water plant however has been designed to operate at a filtration rate of 5.21 gpm/sq.ft. which should provide a flow of 140,000 gpm to the reactor.

It is believed that the filtration rate will never be below 3.9 gpm/sq.ft. and the proposed plant, under this condition, will supply 100,000 gpm to the reactor. It is probable that a filtration rate of 5 gpm/sq.ft. and perhaps even higher can be obtained through a large part of the year and perhaps all of the year. In any event, the plant as proposed will provide for the flow of 100,000 gpm to the reactor throughout the year and a flow of 100,000 to 125,000 gpm for most of the year at a filtration rate of 4.75 gpm/sq.ft.

After reorificing the reactor, the plant, without any changes, will provide 140,000 gpm to the reactor, with a filtration rate of 5.21 gpm/sq.ft.

Provision has been made so that two more filter plant units can be added to each water plant in the future, if desired, and this would permit a flow of 140,000 gpm to the reactor with a filtration rate of 3.9 gpm/sq.ft.

All of the rest of each water plant, except the filter plant as noted above, will have capacity for ultimate 140,000 gpm flow to the reactor.

The problem of how much capacity should be built into the plant as a first step was studied. One alternative would have been to build each of the water plants for a capacity of only 100,000 gpm but with provision for expanding later to 140,000 gpm at a considerably higher water pressure to the reactor. However, there is appreciable value in being able to operate the reactor at flows between 100,000 to 125,000 gpm. This value has been set at $85 per year per gpm at a flow of 90,000 gpm to the reactor and this value decreases directly with flow increase, to $0 per year per gpm at 140,000 gpm flow to the reactor.

Data on river turbidity conditions throughout the year indicates that the plant should be able to operate at 100,000 gpm to the reactor for 100% of the time (3.9 gpm/sq.ft. filter rate) and at a flow of 125,000 gpm to the reactor for 40% of the time during the year (4.75 gpm/sq.ft. filter rate).



[redacted]

[redacted]



The value of water at 100,000 gpm is $68 per gpm per year and at 125,000 gpm is $25 per gpm per year.

The production value of being able to operate over the range between 100,000 and 125,000 gpm to reactor is approximately $400,000 per year.

$$\frac{\$68 + \$25}{2} \times \frac{100\% + 40\%}{2} \times \frac{125,000 - 100,000}{2} = \$400,000 \text{ per year.}$$

In 190 main pump house, six pump sets provide the best overall reliability because they permit a system of piping to the reactor which combines the flow balancing advantages of a header system with the reliability advantages of a unit unheadered system. There will be one pump set discharging directly to each of the four risers of the reactor. There will be two pump sets which supplement and back up the other four. This system would not be satisfactory with five pump sets and the piping system reliability would not be as good with seven smaller capacity pump sets.

The six pump sets will meet either the 125,000 gpm or the 140,000 gpm condition, because of different system characteristics for these two flows, both of which are at a pressure of about 600 psi.

Maintenance will be done during reactor shutdown time, but in the event of loss of one pump set at other times, the flow reductions using 5 pump sets will not be great. Starting, with six pumps putting out 140,000 gpm at 585 psig, loss of one will reduce flow to 134,000 gpm. Starting with six pumps putting out 125,000 gpm at 600 psig, loss of one will reduce flow to 123,000 gpm.

Therefore, there will be no need to install any additional pumps for the 140,000 gpm flow, and there is no wasted investment for the initial flow range of 100,000 to 125,000 gpm.

Also, at the river pump house, for reliability reasons and for economy, it is desirable to have no header or cross connections between the raw water lines in the vicinity of the river pump house. This arrangement requires the use of at least six pumps.



[redacted]

Electrical Standby

Electrical standby appears to be definitely desirable as compared with steam standby as used in the existing areas.

The installed boiler capacity will be less, and the yearly fuel costs will be very much less with electrical standby, than with steam standby.

With electrical standby, the regular motor driven equipment in each building functions on either the normal or the emergency power supply and no extra pumps, fans, etc. driven by steam turbines are required. For example, in the reactor building the number of supply and exhaust fans can be reduced.

The electric standby system should be more reliable. Any trouble on the distribution system is automatically isolated by circuit breakers. There is no hazard as there would be from a break in a steam line.

With electric standby, remote control of all equipment becomes considerably easier.

With electric standby there is no equipment requiring warming up or special start up procedure, such as steam driven pumps and steam driven fans.

With electric standby the cost of the standby distribution system is saved, because the electric standby system uses the regular electric distribution system, as compared with steam standby where a steam distribution system has to, in effect, duplicate the electrical system.

The electrical distribution system requires less maintenance than a steam distribution system with its traps, insulation, vents and drains.

The electric standby system gets away from the complication of an emergency electric generator to be started up from standstill in an emergency, and the complication of emergency electric busses and throw-over switches in each of the buildings.

The electrical system in each building will function without regard to whether or not it is receiving power from the normal electric supply or the emergency electric supply.

The installed cost of an electric standby system will be less than a steam standby system because of smaller boilers, no duplication of distribution system, and no pumps or fans required with steam turbine drives.

Oil Fuel

Heavy fuel oil (No. 6) is to be used because it provides for lower investment, better reliability against bomb damage, and easier and more efficient operation. It also has many other advantages for this particular type of plant.

With oil fired boilers, the power plant can be kept very low and be in a Class I bomb resistant building. This is impractical with a coal fired plant.

The fuel handling with oil becomes quite easy. Normally one tank car of fuel will last for over three days. Tank cars will unload by gravity into an underground oil storage tank and oil will be pumped from this tank to the boilers. No fuel handling crews will be required as in the existing plants.

There is no ash to dispose of and no crew required for handling ashes.

There are no banking losses as there would be with coal firing in this type of plant, where the normal load on the power plant can be practically zero but where the plant must be ready to pick up full load immediately. Fuel oil also will allow easier and quicker pickup than would be in the case of coal firing.

Smaller boilers can be used with oil firing because boiler efficiency at maximum load is not important. With oil firing, the heat release in the boiler furnaces can be allowed to go fairly high under maximum load conditions. This cannot be done with coal firing because of slagging problems at high furnace heat release rates.

Oil fired boilers will have lower maintenance cost than would coal fired boilers. There are no grates or coal preparation machinery to be maintained.

The number of operators required for oil firing will tend to be less than the coal firing because of the essential simplicity of the oil firing process.

The investment cost for oil firing will be substantially less than that for coal firing because of the less expensive fuel system, smaller building, and smaller and less expensive boilers.

Storage of oil is easier than that of coal, since oil has no spontaneous combustion problems and no field loss from storage. Also, there is no dust problem as there would be with a storage coal pile.

[redacted]



The only reason that many boiler plants in the U. S. install boiler plant equipment suitable for coal firing (as well as fuel oil and gas) is that in some parts of the country and at some periods, coal may be cheaper and easier to obtain than fuel oil. For the type of operation at 100-X plant, where the power plants operate at zero load and are for standby purposes only, the amount of fuel used is so little that it appears that oil firing would definitely be cheaper and that the small amount of oil required would always be available, particularly considering the priority which this plant would have. It should be kept in mind that on the basis of equivalent water flow to the reactor, 100-X will use only 1/50th of the fuel used by the older 100 areas.

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[redacted]

## Steam-Electric Plant VS Diesel-Electric or Gas Turbine-Electric Plant

The steam-electric type of plant appears to be better for this project then either a diesel-electric plant or a gas turbine-electric plant.

The steam-electric plant can use any type of oil, including the heavy No. 6 oil which is cheaper than the lighter fuel oil that diesels and gas turbines require.

The steam plant has the advantage that it serves as backup for the process sewer heat recovery equipment, and can supply all the heat required by the circulating hot water heating system whenever the process sewer heat exchanger might be out of service.

The steam plant will have considerably less maintenance than the diesel plant, particularly since the plants will be run at full speed, low load. This is easy service for a steam plant but a diesel plant would probably require considerable maintenance under this type of operation.

The steam-electric plant will have much lower fuel consumption at low load operation than would the gas turbine which is not efficient at low loads.

The cost of fuel will probably be less with a steam plant than with either a diesel plant or gas turbine plant because it can burn the cheaper heavy fuel oil, as compared with the more expensive lighter fuel oils required by either diesels or gas turbines.

Elimination of Above-Ground Clearwells

The existing plants all have water stored upstream of the 190 main pump house in above-ground clearwells.

The 100-X plants eliminate the above-ground clearwells, by having the main pump house take suction directly from the filtered water reservoirs located below ground level.

This eliminates the filter pump house and one operating crew.

It eliminates danger from flooding resulting from rupture of above-ground clearwells.

It eliminates any worry about water freezing in the clearwells.

[redacted]



# PLANT COMPONENTS

## CONTENTS





[redacted]

## 181 - River Pump House

The 181 pump house is a reinforced concrete structure set into the river bank. The two by three cell shape was chosen because it requires the minimum material and because this shape gives sufficient stability for the pump house to take the thrust of the raw water lines, and the earth pressure.

The nearly square pump platform gives maximum work area around the pumps and good access to the pumps, valves and screens.

The outdoor type pump house was chosen in the interest of economy and simplicity. The pumping equipment is probably less subject to bomb damage than it would be in a Class II building.

The normal ground elevation at the locations chosen is about 400 feet. This necessitates a minimum excavation for construction and for the forebay, but allows the original ground to serve as a dyke during construction at low water periods.

The twenty foot high embankment to the pump house will be built with the excavated material from the forebay and inland areas. The pump house, the sides of the forebay and the upstream side of the embankment will be faced with riprap for protection from errosion during flood periods.

It was not considered necessary to raise the pump house floor to be above the Coulee disaster flood level. This flood could not occur without sufficient warning to have the pile cooled down to minimum flow, then the water in storage in the reservoirs and basins would be available.

The cost and operating disadvantages of raising the floors and lengthening the pumps 30 feet, or to make watertight submergable pump rooms, were considered great enough to make it impractical to attempt to try to keep the pump house operating during Coulee flood.

After the Coulee disaster flood wave passed, the motors could be dried out and be back in operation by the time the water in storage in the filter plants was used up.

The pumps at the River Pump House were selected to have a capacity of 32,000 gpm to meet the initial flow of 115,000 gpm and the future flow of 156,000 gpm required through the Water Plant.

Five pumps, including one spare, could take care of the initial flow. This would mean that three pumps would be connected to one 60" line and two pumps connected to the other 60" line. If one pump was lost on the line having two pumps connected, only one pump would be left and the flow through these two 60" lines would be very unequal without a header system at the pump house. Future flows would require six pumps including one spare, so to save cost of header, valves, etc., six pumps are being installed initially.

Automatically operated cone valves are used on the discharge of the pumps to prevent water hammer in the 60" lines in case of a power failure.

## 183 - Filter Plant

### 183.1 Head House

The plants are set up to use liquid alum because it appears that this will result in a yearly saving in cost of chemicals for the two 100-X plants in the order of $200,000 to $350,000 per year. Whether or not the existing plants are converted to dry alum or liquid alum has no bearing on whether or not liquid alum should be used for the 100-X plants, because the 100-X plants will use as much chemicals as all of the existing plants combined (including 100-C).

Seven days' storage of liquid alum will be provided, based on the maximum rate of use. This will be equivalent to a months' storage at the average rate of use. In addition, three months' supply of dry alum will be stored on the site in a warehouse fairly close to the head house and this can be used in the event of interruption of supply of liquid alum.

The batch method of aging activated silica is proposed because there appears to be no other system which has demonstrated its feasibility for plants of this size. The use of sulfuric acid for activating the silica is proposed for the same reason.

It is proposed that chlorine be delivered in tank cars to save cost.

Chemicals will be injected into the raw water lines at one point for each half of the filter plant. This should be entirely satisfactory and will save the long runs of chemical lines and additional flow measuring devices which would be required if chemicals were injected just ahead of each flash mixer.

### 183.2 - Flash Mixers, Flocculators and Sedimentation Basins

Flash mixers are to be located on the centerline of each basin instead of grouped as in other areas, in order to make a complete unit set-up right through the whole filter plant. This unit set-up will consist of one flash mixer, two flocculators, one sedimentation basin and two filters.

Two flocculators are used per sedimentation basin because one flocculator would be too wide for dependable shafting and is not recommended by the manufacturers.

Six sedimentation basins are used because this works out well with the capacity of flash mixers and arrangement of filters. It also saves materially in cost as compared with twelve basins, because of the fewer number of concrete walls.

Two sludge removal rakes are used for each basin because the basin's width is too great for one rake.

There should be no trouble from ice formation on the water on the basins, because the only way the water can leave the basins is over the downstream weir. Any ice forming at that point will either be lifted up, or prevented from increasing in thickness by the velocity of the water passing over the overflow outlet weir. Any attempt by the ice to shut off flow over the outlet weir would cause the water level in the basin to rise and lift the ice free of the outlet weir.

183.3 - Filters

The arrangement of filters, as proposed, provides a unit arrangement with the rest of the filter plant and makes easier water connections.

The filters will be automatically backwashed to save manpower and to obtain more uniform conditions.

Filter samples will be pumped to the head house for analysis because all testing equipment is in the laboratory there and because backwash control is located in the head house.

No operators will be required at the filters so no housing will be provided over the filters. The filters will operate satisfactorily even if ice should form on them, to any thickness. However, provision will be made so that should it ever be desired to, covers can be added over the filters.

190 - Main Pump House

The pump arrangement proposed appears to give maximum reliability at lowest cost.

In 100-C plant the pumps in 190 had a capacity of about 8000 gpm. If these pumps were used for the 100-X plants, each of the two plants would require about eighteen pumps, as compared with the six pumps proposed. The pumping equipment would cost more, the piping would cost more, and a much larger and more expensive building would be required.

The combination of low head vertical pumps and high head horizontal pumps is proposed in order to permit the elimination of above ground clearwells and combine all pumping facilities in one building (with the exception of the river pump house). It also provides for transition flow and shutdown flow following loss of BPA power with less complication than in any of the existing plants.

Variable speed operation of the high lift pumps will be used to cover the range in reactor pressure requirements between 385 psig and 600 psig. If this requirement were to be met at constant speed operation, the pumps would have to operate at 600 psig all of the time and the 385 psig condition obtained by throttling on the pump discharge. This would be very wasteful of electric power as compared with the variable speed drive.

Fluid drives will not be used for these pumps, because in this high HP size they would be much more expensive than the wound rotor motors. Wound rotor motors are satisfactory also from the standpoint of starting the flywheels because the starting current on them can be held down to a value slightly in excess of the full load running current. It is interesting to note that actually the wound rotor motor plus the liquid rheostats cost apparently less than constant speed induction motors of this size (10,000 HP) and, of course, induction motors would not be able to start the flywheels without excessive heating and without excessive voltage swings on the whole electrical system.

The motors will be water cooled because otherwise there would be so much heat liberated within the relatively small pump house that it would be impractical to keep it cool. Also, water cooled motors will be very much quieter than open motors.

The liquid rheostats for the wound rotor motors will be water cooled by heat exchangers in the rheostat electrolyte system. There is no boiling of the electrolyte and no appreciable loss of it. It operates as a closed system.

[redacted]



## 165 - Control Building

The plant components essential to maintaining water flow to the reactor are all grouped within this Class I bomb resistant building. These include standby power plant, process water piping, main control room, connections between power plant and central electric switch gear, electric switch gear for the whole plant, and offices and locker rooms for operating personnel.

The valve pit which controls the supply of water to the reactor, and the source from which the supply comes, is located within this building.

Practically all control circuits and control inter-connections will be within this building. The main control connections and inter-connections will be between the main control room and the valve pit and the electric switch gear room.



[redacted]

## 107 - Process Sewer, Retention Area, and Outfall

Various materials were investigated for the process sewer lines.

Wood pipe is not considered satisfactory for several reasons. No definite proof could be had that it would stand up under the combination of hot water and vapor. Maintenance would be difficult and if the pipe proved unsatisfactory, it would probably be impossible to line it with anything. If wood pipe were used, it would still be necessary to use some steel pipe at corners and connections. Also the retention basins themselves would be steel and probably the outfall lines to the river could not be made of wood pipe, so even if wood pipe turned out to be satisfactory, it would only be used in part of the system and for that reason is not an answer to corrosion throughout the system.

Wrought iron pipe was considered but no proof could be had that it would withstand corrosion materially better than steel pipe.

It is felt that concrete pipe will not stand up under the expansion stresses set up by the hot water. For the same reason cement lining in steel pipe did not appear desirable.

Various paints and baked on plastic finishes were considered for use inside steel pips, but all of them were either too expensive or could furnish no proof that they would stay on for a long enough time to justify their use.

It is, therefore, proposed that steel pipe be used for the process sewers, for the retention basins and for the outfall lines to the river. The pipe and tanks will be cleaned inside and have an aluminum coating applied by metalizing. The cost of this is less than some of the painting systems which were investigated, and it appears that it should give good service. Steel pipe is the easiest thing to repair in case of damage and the aluminum coating should give good protection because it protects the steel by anodic action. Apparently any porosity in the aluminum film will not be serious because of the anodic protection of the steel by the aluminum.

The retention basins in the plant will be subject to much more severe service than in any existing plants. This is because they will be operating on a batch system. Each tank will be filled and emptied up to as many as eight times a day. The alternate heating and cooling of the tanks preclude the use of concrete. The tanks will be coated on the inside with an aluminum film by a metalizing process.

Studies were made of various means of bringing water into and out of the retention tanks. Bottom inlets and outlets with expansion

[redacted]



joints appear to be the most practical form of connection.

Two process sewers will be used for each reactor, because they will be no more expensive than one large sewer and offer the additional advantage that one will carry reactor shutdown flow and allow maintainence and inspection of the other.



[redacted]

[redacted]



Electrical System

Four transformers in the main substation appear to be the optimum number. This permits two transformers for each plant. In the event of loss of one of them, the other three can supply both plants at full capacity by going to the forced rating of the transformers.

The two parallel sections of 230 KV bus permit operating the plants with a closed 230 KV loop, even with one transformer out of service.

The transformers are as large in capacity as possible without exceeding the rating of 15 KV switchgear. With one transformer out of service the other three transformers will each be supplying 2000 Amp through their secondary circuit breakers. So, fewer than four transformers cannot be used.

Although it would be possible to supply the high lift pumps in the two 190 buildings direct from switchgear in the 151 substation, this is not done because it so complicates the interlocking necessary between the high lift and the low lift pumps. It appears advantageous to have all of the plant loads controlled by breakers within the 165 control building. The only function of the 151 substation switchgear, then, is to supply power to the 165 buildings.

All main power cables will run in tunnels, which also exist for other purposes such as telephone lines, fire alarm lines, remote control lines, water lines and hot water heating system lines. The cable will be easier to install in the tunnels than it would be in a duct bank. No manholes will be required and cable capacity will be increased because the tunnels will be ventilated and there will be no heating around the cables as there would be in an underground duct bank.

It is planned to use interlocked armor cable in so far as possible. Installation will be easier and will save the cost of conduit.



[redacted]

1800 - Heating System and 150 - Heat Recovery Equipment

The plants will be heated by circulating hot water with the heating source being the hot water in the process sewer.

In the wintertime the process sewer temperature will be about 155° F and this is ample to supply heat to a hot water system operated at 140° F.

Slightly more heating surface will be required in heating coils of unit heaters and ventilating units using the 140° water as compared with steam. However, this will not cost very much and is far outweighed by the savings in fuel.

Heat recovered from the process sewer costs nothing and will save about $40,000 per year, as compared with the fuel cost necessary otherwise.

The cost of the 150 heat recovery equipment will be in the order of $50,000 and this will be repaid in a year or two by fuel cost savings.

The circulating hot water system also has certain advantages as compared with a steam system for a plant of this sort. The heat loss from the distribution system will be less and probably no insulation will be required on the distribution lines. The expansion problems of distribution piping are much less critical. No attention has to be paid the pitching of distribution lines as in the case of steam lines. No traps are required. Less damage will result from a break in the system as compared with steam lines.

[redacted]



## 1900 - Sewers and Piping Between Buildings

The two 60" raw water lines from 181 to the water plant were selected instead of three 54" lines, in order to eliminate headers at the river pump house, control building and head house. The two 60" lines are less expensive than the three 54" lines and there is additional saving due to the elimination of header sectionalizing valves and line sectionalizing valves at the river pump house.

Four 36" lines are proposed between the 165 building and the reactor. Eight 24" lines could be used however and cross connected into four 36" risers at the reactor building.

The drainage sewers will be a concrete box structure instead of concrete pipe, because the box sewer will be less expensive and all materials will be on the site.



[redacted]

## ESTIMATED COST

## CONTENTS

Discussion

The following cost estimate is approximate only.

Its purpose is to indicate an approximate cost for the part of the work covered by this criteria, and to indicate the approximate division of this cost between the major components of the work.

[redacted]



Estimated Cost - 2 Plants

| | |
|---|---|
| 181 - River Pump House and Forebay | $ 2,000,000 |
| 183 - Filter Plant | 21,000,000 |
| 190 - Main Pump House | 12,000,000 |
| 165 - Control Bldg. and Tunnels to 105 and Oil Tanks | 8,000,000 |
| 107 - Retention Area | 3,000,000 |
| 151 - Substation | 3,500,000 |
| 1700 - Misc. Bldgs. and Fences | 1,000,000 |
| 1500 - Electric Lines Transmission and Distribution, Communications, Fire Alarm, Remote Controls | 2,500,000 |
| 1600 - Misc. Yard RR, Roads, Rough Excavation, Septic Systems, Drainage | 2,000,000 |
| 1800 - Heating System and Heat Recovery Equipment | 500,000 |
| 1900 - Outside Piping Including Raw Water and Process Sewer, Drainage Sewer to 105 from 190 | 5,000,000 |
| | 60,500,000 |
| Equipment Usage and Misc. (*30% of Labor) | 6,500,000 |
| Total Direct Construction Cost (year 1951 basis) | 67,000,000 |
| Contingencies | 6,000,000 |
| Escalation (1951 to 1953-54) | 7,000,000 |
| Total Direct Construction Cost (year 1953-54 basis) | $80,000,000 |

*Direct Labor Cost - $21,000,000





[redacted]