Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

February 18, 1983

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Quad Cities Station Units 1 and 2
Transmittal of Supplement 9 of
Revision 1 to the Licensing Report
on High Density Fuel Racks
NRC Docket Nos. 50-254 and 50-265

Reference (a): R. F. Janecek letter to H. R. Denton
dated March 26, 1981.

Dear Mr. Denton:

Enclosed is Supplement 9 to Revision 1 of the report prepared by Joseph Oat Corporation for Commonwealth Edison entitled "Licensing Report on High Density Spent Fuel Racks for Quad Cities Units 1 and 2."

The primary changes are the reduction in the number of storage cells to be installed and the related effect on the thermal and radiological analysis and revision to the minimum spacing between rack modules, the fuel pool wall and fuel pool wall fixtures. The revised spacing arrangement is consistent with our seismic and thermal-hydraulic analyses approved by the NRC. Additionally, minor corrections were incorporated. The following corrected sheets are attached: Pages 1-3, 2-1, 2-2, 2-3, 3-4, 3-5, 5-4, 5-11, 8-2, 10-2, 11-5, 11-6, Table 1.1, Figure 2.1, Figure 2.2, and Figure 3-7.

Please address any questions you may have concerning this matter to this office.

One (1) signed original and forty (40) copies of this transmittal (with enclosure) are provided for your use.

Very truly yours,

B. Rybak

B. Rybak
Nuclear Licensing Administrator

lm

Enclosure

cc: Region III Inspector - Quad Cities
R. Bevan - NRR

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Commonwealth Edison Company, in its function as operator, proposes to increase the spent fuel storage capacity by replacing the present spent fuel storage racks with new, high-density storage racks. This modification will include the use of a neutron absorber material in the racks, at an increase of k_{eff} from 0.90 to 0.95. The March 26, 1981, letter to the NRC requests a modification to Quad Cities Technical Specification 5.5B, "Fuel Storage," to implement this change in k_{eff}.

The specification for design, construction, and quality assurance of the high-density storage racks was prepared by Quadrex, a San Jose-based company. The mechanical design, seismic analysis, thermohydraulic analysis, and other related calculations as well as the fabrication of the hardware will be performed by Joseph Oat Corporation. Joseph Oat Corporation, based in Camden, N.J., possesses ASME Code stamps for Section III, Classes 1, 2, and 3, and MC pressure vessels and components. Southern Science Applications, Inc., of Dunedin, Florida, is serving as a consultant to Joseph Oat Corporation in the areas of criticality analysis and other radionuclide evaluations.

Consulting support on the overall effort is provided by NUS Corporation of Gaithersburg, Maryland.

2. GENERAL ARRANGEMENT

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The high-density racks are engineered to achieve the dual objective of maximum protection against structural loadings (such as ground motion) and the maximization of available storage locations. In general, a greater width to height aspect ratio provides greater margin against rigid body tipping. Hence, the modules are made as wide as possible within the constraints of transportation and site-handling capabilities. The high-density spent fuel racks will be installed in the Unit 1 and Unit 2 spent fuel pools, each of which is 33 feet wide by 41 feet long.

The Quad Cities Unit 1 pool will contain 19 high-density fuel racks in 9 different module sizes. The module types are labelled A through K in Figure 2.1, which also shows their relative placement. 9
There will be a total of 3657 storage locations in the Quad Cities Unit 1 pool.

The Quad Cities Unit 2 pool will contain 20 high-density fuel racks in 9 different module sizes. The module types are labelled A through K in Figure 2.2, which also shows their relative placement. 9
There will be a total of 3897 storage locations in the Quad Cities Unit 2 pool.

Table 2.1 gives the detailed module data (e.g., weight, quantity, and number of storage locations).

The spent fuel rack modules are not anchored to the pool floor or connected to the pool walls. The minimum gap between any two spent fuel rack moduels will be 3.0 inches along the top edge. The minimum 9
gap between the fuel pool wall and spent fuel rack modules

will be 6-3/4 inches. The minimum gap between the top of the spent fuel rack modules and pool wall fixtures will be 1½ inches. Adequate clearance from other existing pool hardware will also be provided. Due to the gaps provided, the possibility of interrack impact, or rack collision with pool walls or other pool hardware during the postulated ground motion events will be precluded. 9

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Type	Quantity	Number of Cells/Module	Array Size	Approximate Weight Lbs/Module	
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V. Other References

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Procedures and specifications will be used to control all operations required to remove existing and install new spent fuel racks. A sequencing system will be employed for relocation of spent fuel within the pools. Initially, several existing racks will be emptied of spent fuel and removed from the pool, thereby creating the required space for the first new racks to be installed. Relocation of fuel to the new racks will then allow additional existing racks to be removed. No

old racks or new racks will be lifted over stored fuel or near enough to fuel so that any postulated lifting fig failure would result in any fuel damage. A diver will assist in leveling the new racks with shims during the installation project. This will necessitate maintaining separation between the diver and the spent fuel stored in nearby racks.

Initial washdown of the existing racks will be performed at the central decontamination area on the fuel handling floor. The racks will then be shredded, the pieces put into 55 gallon drums, and sent to a burial site. 9

The new racks will be lifted and transported to the decontamination area using the lifting frame and rigging assembly shown on Figure 3.8. Four sets of holes allow the frame to accommodate all seven new rack configurations. The lifting rods and plugs shown on Figure 3.8 will extend and thread into the leg portion of each rack. This assembly will also be used to lower the racks into final pool positions.

In addition to the procedures which will be developed for rack handling, other areas which will be addressed are: acceptance procedures; equipment and specifications for removal of existing rack supports where necessary; interim fuel pool liner repair guidelines; and controls for final disposal of existing racks.

(Ref. Table 1.1). This is when the inventory of fuel in the pool will be at its maximum resulting in an upper bound on the computed decay heat rate.* 9

In the past, Quad Cities reactors have operated on what is commonly referred to as "18 month cycle." Quite often, system planning requires extended reactor coastdown operation (sometimes to 40% of rated power) after the end of full power reactivity (19000 MWD/STU) has been reached. The batch average discharge burn-up of current fuel batches is approximately 25000 MWD/STU. In the future, due to present lack of spent fuel reprocessing in the U.S., it is conceivable that the average discharge exposure can approach 30,000 MWD/STU due to higher initial enrichments and longer coastdowns. A longer coastdown period implies a greater value of t_o in the foregoing equation, it also implies a smaller value of P_o. It can be shown that an exposure period, t_o, equal to 4.5 years (3-18 month refueling cycles) along with the rated reactor power produces an upper bound on the value of P. This is due to the fact that f (to,ts) is a weak monotonically increasing function of t_o. Hence, the reactor operating time is assumed to be 4.5 years (t_o=1.42x10^8 secs).

Having determined the heat dissipation rate, the next task is to evaluate the time temperature history of the pool water. Table 5.1.1 identifies the loading cases examined. The pool bulk temperature time history is determined using the first law of thermodynamics (conservation of heat). The system to be analyzed is shown in Figure 5.1.1.

A number of simplifying assumptions are made to render the analysis conservative. The principal ones are:

1. The cooling water temperature in the fuel pool cooler and the RHR heat exchangers are based on the maximum postulated values given in the FSAR.

* Because of the elimination of 130 cells from the originally proposed expanded storage capacity, additional conservatism is 9
introduced into the computed results presented in this section.

actual rack floor space is drawn. It is further assumed that the cylinder with this circle as its base is packed with fuel assemblies at the nominal pitch of 6.22 inches (see Figure 5.2.1).

c. The downcomer space around the rack module group varies, as
shown in Figures 2.1 and 2.2. The nominal downcomer gap 9
available in the pool is assumed to be the total gap available around the idealized cylindrical rack; thus, the maximum resistance to downward flow is incorporated into the analysis.

d. No downcomer flow is assumed to exist between the rack modules.

In this manner, a conservative idealized model for the rack assemblage is devised. The water flow is axisymmetric about the vertical axis of the circular rack assemblage, and thus, the flow is two-dimensional (axisymmetric three-dimensional). The governing equation to characterize the flow field in the pool can now be written. The resulting integral equation can be solved for the lower plenum velocity field (in the radial direction) and axial velocity (in-cell velocity field), by using the method of collocation. It should be added here that the hydrodynamic loss coefficients which enter into the formulation of the integral equation are also takne from well-recognized sources[4] and wherever discrepancies in reported values exist, the conservative values are consistently used.

After the axial velocity field is evaluated, it is a straightforward matter to compute the fuel assembly cladding temperature. The knowledge of the overall flow field enables pinpointing the storage location with the minimum axial flow (i.e., maximum water outlet temperature). This is called the most "choked" location. It is recognized that some storage locations, where rack module supports are located, have some additional hydraulic resistance not encountered in

The radiological consequences of storing the additional quantity of aged fuel have been evaluated. To ensure a conservative evaluation of the storage of failed fuel, it was assumed that the spent fuel storage pool is entirely filled with high-burnup spent fuel (28,500 Mwd/MtU burnup), ranging from newly removed fuel (1 core load of 724 fuel assemblies) to aged fuel with a cooling time of approximately 18 years. The maximum fission-product inventory in the stored fuel in each pool whould result from an idealized fuel cycle in which approximately 181 spent fuel elements were removed from the core and placed in the pool annually. With this fuel cycle, the expanded storage pool capacity, when completely filled, would contain the following:

(1) For currently authorized storage capcity	724 newly removed assemblies (full core load) and 4 refueling discharges of 181 assemblies with storage periods of 1, 2, 3, and 4 years, respectively.
(2) Aged fuel in expanded* storage capacity	13 refueling discharges of 181 assemblies with storage periods of 5 to 17 years and any remaining capacity (up to 170 assemblies), containing fuel stored for 18 years. | 9

Reduced fuel burnup or increased cycle length would result in a lower fission-product inventory or longer storage (decay) periods. Thus, the assumed storage pool composition should result in a conservative estimate of any additional radiological impact due to the expanded storage capacity.

* Because of the elimination of 130 cells from the originally proposed expanded storage capacity, additional conservatism has been introduced through the use of these values to calculate fission-product inventory. 9

and suspended from the spent fuel pool wall. Eighteen test samples are to be fabricated in accordance with Figure 10.1 and installed in the pool when the racks are installed.

The procedure for fabrication and testing of samples shall be as follows:

a. Samples shall be cut to size and carefully weighed in milligrams.
b. Length, width, and average thickness of each specimen to be measured and recorded.
c. Samples shall be fabricated in accordance with Figure 10.1 and installed in the pool.
d. Two samples shall be removed at each time interval per the schedule shown in Table 10.1.

10.4 Specimen Evaluation

After removal of the jacketed poison specimen from the fuel pool at the designated time, a careful evaluation of that specimen will be made to determine its actual condition as well as its apparent durability for continued function. Separation of the poison from the stainless steel specimen jacket must be performed carefully to avoid mechanically damaging the poison specimen. Immediately upon removal, the specimen and jacket section should be visually examined for any effects of environmental exposure. Specific attention should be directed to the examination of the stainless steel jacket for evidence of physical degradation. Functional evaluation of the poison material is accomplished by the following measurements:

a. 9

b. Nuetron attenuation measurements will allow evaluation of the continuing nuclear effectiveness of the poison. Consideration must be given in the analysis of the attenuation measurements for the level of accuracy of such measurements

area will not change. Therefore, personnel exposure will not significantly change because of the expansion. As explained in Section 8.2, there is also expected to be little to no change in gaseous radioactive release because of the expansion. Thus, there will be very little to no change in the release of radioactivity and subsequent personnel exposure as a result of expanding the spent fuel storage capacity of the Quad-Cities spent fuel pools.

- Chemical Discharges

The only chemical discharge that could be affected by the proposed expansion of the spent fuel pools is the powdered ion exchange resins used in the two filters demineralizers. As explained in Section 8 of this report, the frequency of resin replacement is determined primarily by the need for water clarity. As the particulate material that must be removed to maintain water clarity enters the water during refuelings and is removed well before the next refueling, the frequency of resin replacement is independent of the number of spent fuel assemblies stored in the pools. Therefore, there should be no change in the amount of spent fuel pool purification system filter resin discharged from the plant, because of this modification.

- Heat Dissipation

The two Quad-Cities spent fuel pool cooling system heat exchangers are designed to transfer a total of 7.3×10^6 Btu/hr. It is estimated that, the increased storage will result in about a 10%* 9
increase in heat release when the pool is filled, or an increase of approximately 7.3×10^5 Btu/hr* based on the heat exchanger design. When compared to the over 5×10^9 Btu/hr discharged into the environment by each unit, this increase is seen to have a negligible effect on the environment.

* Because of the elimination of 130 cells from the originally proposed expanded storage capacity, these values will actually be somewhat lower, and are therefore conservative. 9

Table 11.1 Quad Cities Station: Projection for Loss of Full Core Discharge Capability (FCDC) and Reload Discharge Capability (RDC)

Currently Available Spent Fuel Racks

Capacity	=	2280
Capacity with FCDC*	=	1556
Capacity with RDC	=	2080
Lose FCDC	-	9/81
Lose RDC	-	3/83

Currently "On Site" Spent Fuel Racks**

Capacity	=	2440
Capacity with FCDC	=	1716
Capacity with RDC	=	2240
Lose FCDC	-	12/82
Lose RDC	-	3/84

Currently Licensed Spent Fuel Racks

Capacity	=	2920
Capacity with FCDC	=	2196
Capacity with RDC	=	2720
Lose FCDC	-	3/84
Lose RDC	-	5/86

High-Density Spent Fuel Racks

Capacity	=	7554	
Capacity with FCDC	=	6830	9
Capacity with RDC	=	7314	
Lose FCDC	-	3/01	
Lose RDC	-	3/03	

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* Full core capacity = 724

** Eight (8) racks (160 spaces) on site, not in pool, but available for repair and use

Table 1.1 Quad Cit
Fuel Ass

Year	Discharge Assemblies Unit 1	Discharge Assemblies Unit 2	Total Discharge Assemblies In Po Following Refuel
1974	64	144	208
1975	0	4	212
1976	156	164	532
1977	184	0	716
1978	0	180	896
1979	192	180	1268
1980	224	0	1492
1981	0	224	1716
1982	224	0	1940
1983	0	192	2132
1984	184	184	2500
1985	192	0	2692
1986	0	204	2896
1987	200	200	3296
1988	200	0	3496
1989	0	200	3696
1990	200	200	4096
1991	200	0	4296
1992	0	200	4496
1993	200	200	4896
1994	200	0	5096
1995	0	200	5296
1996	200	200	5696
1997	200	0	5896
1998	0	200	6096
1999	200	200	6496
2000	200	0	6696
2001	0	200	6896
2002	200	200	7296
2003	200	0	7496
2004	0	200	7696

*The number of locations available after the completion of

ies Station, Units 1 and 2
embly Discharges

d ol ing	Remaining Storage Capacity*			
	Existing	With Additional Licensed Racks	High-Density Racks	
	2072	-	-	
	2068	-	-	
	1748	-	-	
	1564	-	-	
	1384	-	-	
	1012	-	-	
	788	-	-	
	564	1204	-	
	340	980	5614	
	148	788	5422	
	0	420	5054	
	-	228	4862	
	-	24	4658	
	-	0	4258	
	-	-	4058	
	-	-	3858	
	-	-	3458	9
	-	-	3258	
	-	-	3058	
	-	-	2658	
	-	-	2458	
	-	-	2258	
	-	-	1858	
	-	-	1658	
	-	-	1458	
	-	-	1058	
	-	-	858	
	-	-	658	
	-	-	258	
	-	-	58	
	-	-	0	

that year's scheduled refueling outage.

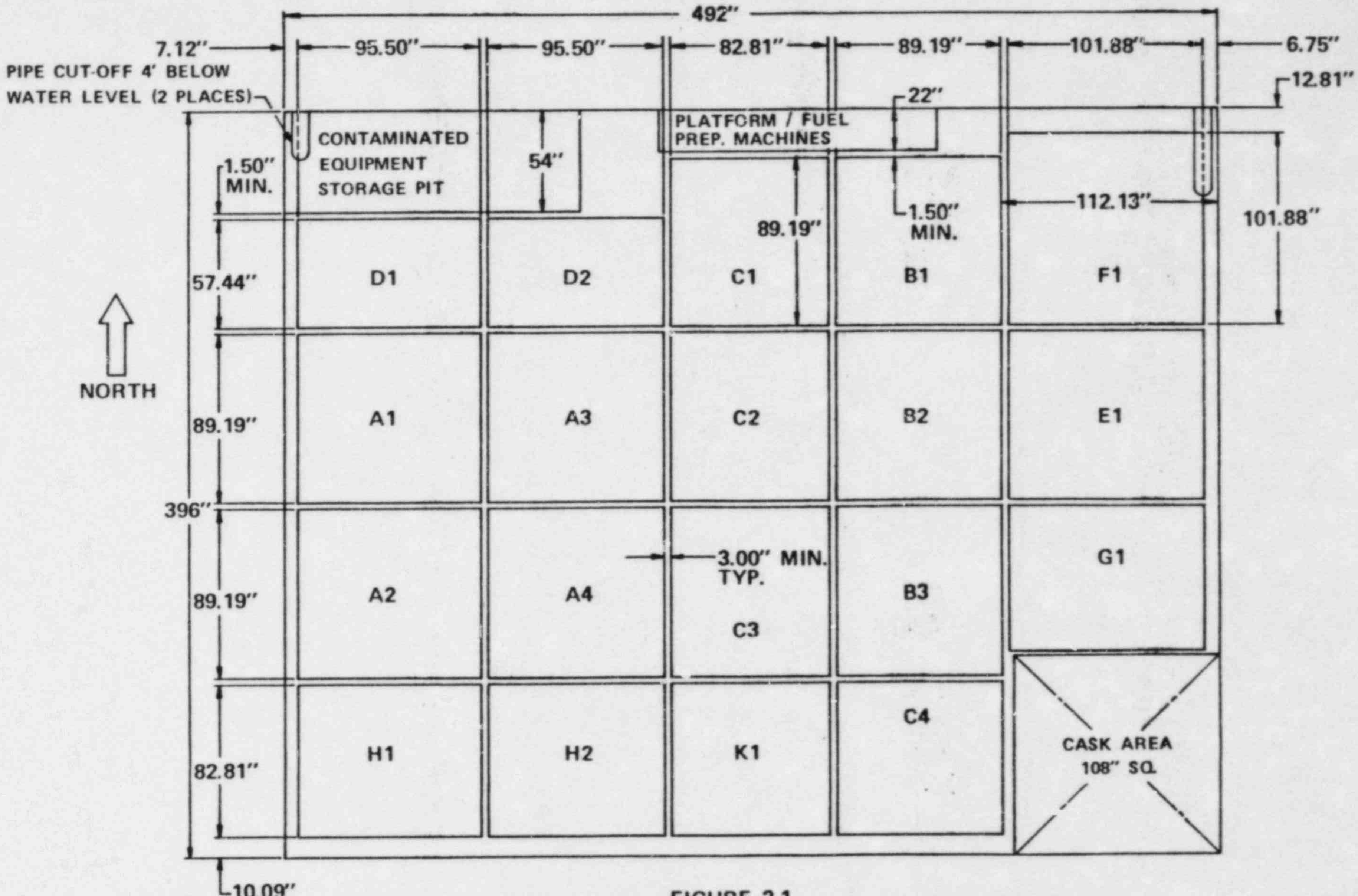

FIGURE 2.1

GENERAL ARRANGEMENT OF RACK MODULES FOR QUAD CITIES UNIT 1
(3657 CELLS)

9

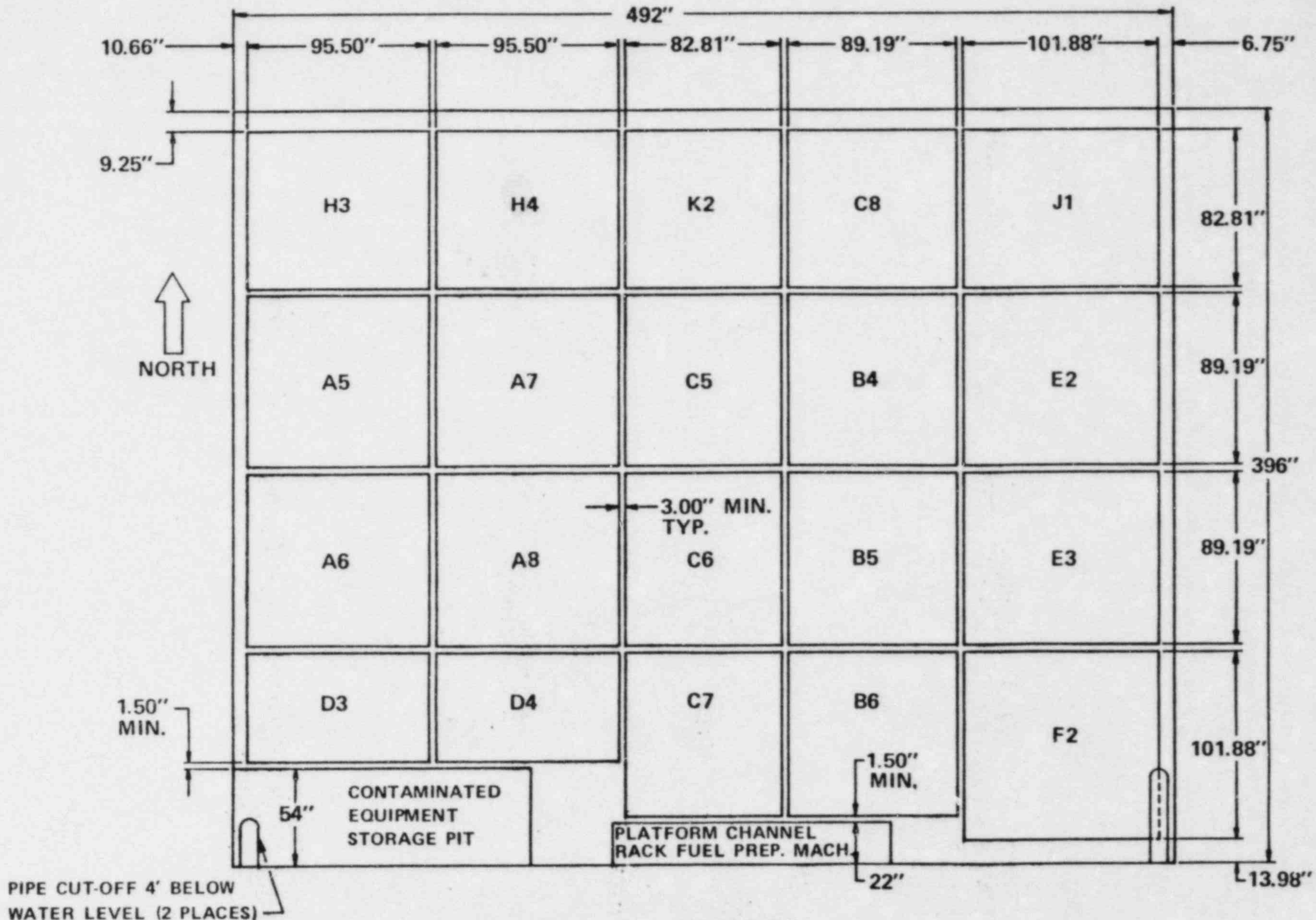

FIGURE 2.2

GENERAL ARRANGEMENT OF RACK MODULES FOR QUAD CITIES UNIT 2
(3897 CELLS)

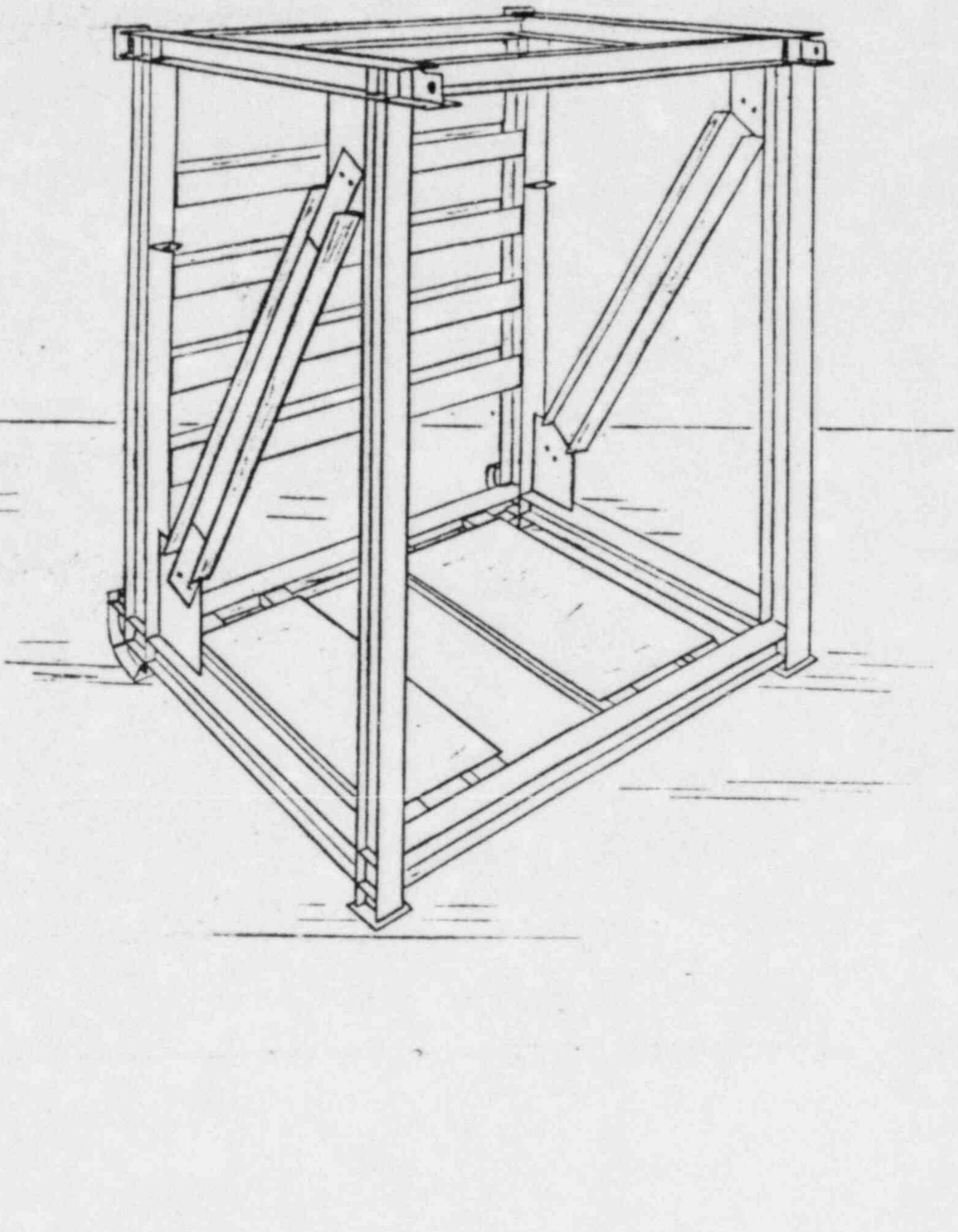

FIGURE 3-7 – SPENT FUEL RACK UPLIFTING CRADLE

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After the axial velocity field is evaluated, it is a straightforward matter to compute the fuel assembly cladding temperature. The knowledge of the overall flow field enables pinpointing the storage location with the minimum axial flow (i.e., maximum water outlet temperature). This is called the most "choked" location. It is recognized that some storage locations, where rack module supports are located, have some additional hydraulic resistance not encountered in

The radiological consequences of storing the additional quantity of aged fuel have been evaluated. To ensure a conservative evaluation of the storage of failed fuel, it was assumed that the spent fuel storage pool is entirely filled with high-burnup spent fuel (28,500 Mwd/MtU burnup), ranging from newly removed fuel (1 core load of 724 fuel assemblies) to aged fuel with a cooling time of approximately 18 years. The maximum fission-product inventory in the stored fuel in each pool whould result from an idealized fuel cycle in which approximately 181 spent fuel elements were removed from the core and placed in the pool annually. With this fuel cycle, the expanded storage pool capacity, when completely filled, would contain the following:

(1) For currently authorized storage capcity	724 newly removed assemblies (full core load) and 4 refueling discharges of 181 assemblies with storage periods of 1, 2, 3, and 4 years, respectively.
(2) Aged fuel in expanded* storage capacity	13 refueling discharges of 181 assemblies with storage periods of 5 to 17 years and any remaining capacity (up to 170 assemblies), containing fuel stored for 18 years. 9

Reduced fuel burnup or increased cycle length would result in a lower fission-product inventory or longer storage (decay) periods. Thus, the assumed storage pool composition should result in a conservative estimate of any additional radiological impact due to the expanded storage capacity.

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and suspended from the spent fuel pool wall. Eighteen test samples are to be fabricated in accordance with Figure 10.1 and installed in the pool when the racks are installed.

The procedure for fabrication and testing of samples shall be as follows:

a. Samples shall be cut to size and carefully weighed in milligrams.
b. Length, width, and average thickness of each specimen to be measured and recorded.
c. Samples shall be fabricated in accordance with Figure 10.1 and installed in the pool.
d. Two samples shall be removed at each time interval per the schedule shown in Table 10.1.

10.4 Specimen Evaluation

After removal of the jacketed poison specimen from the fuel pool at the designated time, a careful evaluation of that specimen will be made to determine its actual condition as well as its apparent durability for continued function. Separation of the poison from the stainless steel specimen jacket must be performed carefully to avoid mechanically damaging the poison specimen. Immediately upon removal, the specimen and jacket section should be visually examined for any effects of environmental exposure. Specific attention should be directed to the examination of the stainless steel jacket for evidence of physical degradation. Functional evaluation of the poison material is accomplished by the following measurements:

a. 9

b. Nuetron attenuation measurements will allow evaluation of the continuing nuclear effectiveness of the poison. Consideration must be given in the analysis of the attenuation measurements for the level of accuracy of such measurements

area will not change. Therefore, personnel exposure will not significantly change because of the expansion. As explained in Section 8.2, there is also expected to be little to no change in gaseous radioactive release because of the expansion. Thus, there will be very little to no change in the release of radioactivity and subsequent personnel exposure as a result of expanding the spent fuel storage capacity of the Quad-Cities spent fuel pools.

- Chemical Discharges

The only chemical discharge that could be affected by the proposed expansion of the spent fuel pools is the powdered ion exchange resins used in the two filters demineralizers. As explained in Section 8 of this report, the frequency of resin replacement is determined primarily by the need for water clarity. As the particulate material that must be removed to maintain water clarity enters the water during refuelings and is removed well before the next refueling, the frequency of resin replacement is independent of the number of spent fuel assemblies stored in the pools. Therefore, there should be no change in the amount of spent fuel pool purification system filter resin discharged from the plant, because of this modification.

- Heat Dissipation

The two Quad-Cities spent fuel pool cooling system heat exchangers are designed to transfer a total of 7.3×10^6 Btu/hr. It is estimated that, the increased storage will result in about a 10%* 9
increase in heat release when the pool is filled, or an increase of approximately 7.3×10^5 Btu/hr* based on the heat exchanger design. When compared to the over 5×10^9 Btu/hr discharged into the environment by each unit, this increase is seen to have a negligible effect on the environment.

* Because of the elimination of 130 cells from the originally proposed expanded storage capacity, these values will actually be somewhat lower, and are therefore conservative. 9

Table 11.1 Quad Cities Station: Projection for Loss of Full Core Discharge Capability (FCDC) and Reload Discharge Capability (RDC)

Currently Available Spent Fuel Racks

Capacity	=	2280	
Capacity with FCDC*	=	1556	
Capacity with RDC	=	2080	
Lose FCDC	-	9/81	
Lose RDC	-	3/83	

Currently "On Site" Spent Fuel Racks**

Capacity	=	2440	
Capacity with FCDC	=	1716	
Capacity with RDC	=	2240	
Lose FCDC	-	12/82	
Lose RDC	-	3/84	

Currently Licensed Spent Fuel Racks

Capacity	=	2920	
Capacity with FCDC	=	2196	
Capacity with RDC	=	2720	
Lose FCDC	-	3/84	
Lose RDC	-	5/86	

High-Density Spent Fuel Racks

Capacity	=	7554	
Capacity with FCDC	=	6830	9
Capacity with RDC	=	7314	
Lose FCDC	-	3/01	
Lose RDC	-	3/03	

* Full core capacity = 724

** Eight (8) racks (160 spaces) on site, not in pool, but available for repair and use

Table 1.1 Quad Citi
Fuel Asse

Year	Discharge Assemblies Unit 1	Discharge Assemblies Unit 2	Total Discharged Assemblies In Poo Following Refueli
1974	64	144	208
1975	0	4	212
1976	156	164	532
1977	184	0	716
1978	0	180	896
1979	192	180	1268
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1981	0	224	1716
1982	224	0	1940
1983	0	192	2132
1984	184	184	2500
1985	192	0	2692
1986	0	204	2896
1987	200	200	3296
1988	200	0	3496
1989	0	200	3696
1990	200	200	4096
1991	200	0	4296
1992	0	200	4496
1993	200	200	4896
1994	200	0	5096
1995	0	200	5296
1996	200	200	5696
1997	200	0	5896
1998	0	200	6096
1999	200	200	6496
2000	200	0	6696
2001	0	200	6896
2002	200	200	7296
2003	200	0	7496
2004	0	200	7696

*The number of locations available after the completion of t

es Station, Units 1 and 2
mbly Discharges

1 ng	Remaining Storage Capacity*		
	Existing	With Additional Licensed Racks	High-Density Racks
	2072	-	-
	2068	-	-
	1748	-	-
	1564	-	-
	1384	-	-
	1012	-	-
	788	-	-
	564	1204	-
	340	980	5614
	148	788	5422
	0	420	5054
	-	228	4862
	-	24	4658
	-	0	4258
	-	-	4058
	-	-	3858
	-	-	3458
	-	-	3258
	-	-	3058
	-	-	2658
	-	-	2458
	-	-	2258
	-	-	1858
	-	-	1658
	-	-	1458
	-	-	1058
	-	-	858
	-	-	658
	-	-	258
	-	-	58
	-	-	0

year's scheduled refueling outage.

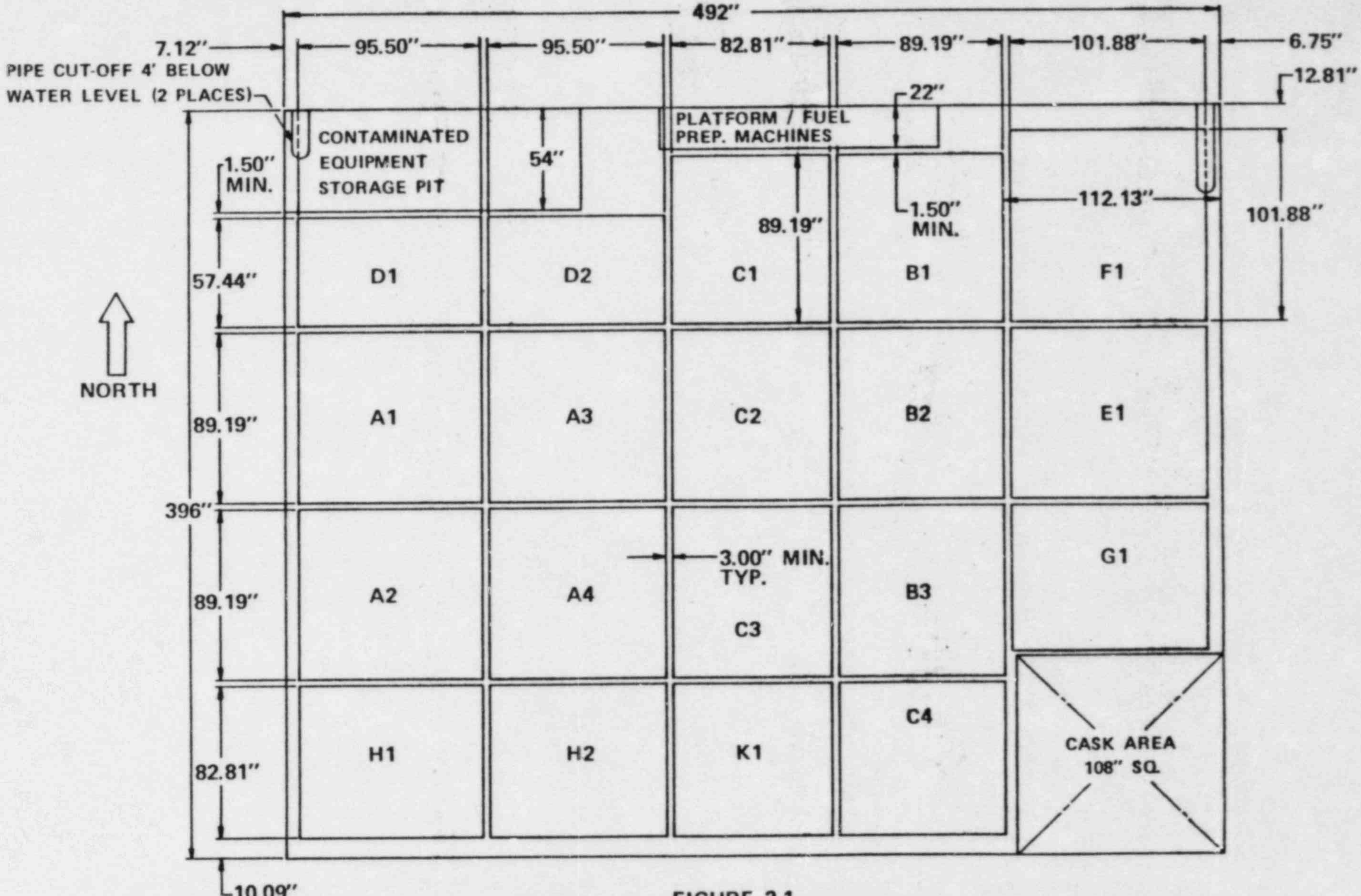

FIGURE 2.1

GENERAL ARRANGEMENT OF RACK MODULES FOR QUAD CITIES UNIT 1
(3657 CELLS)

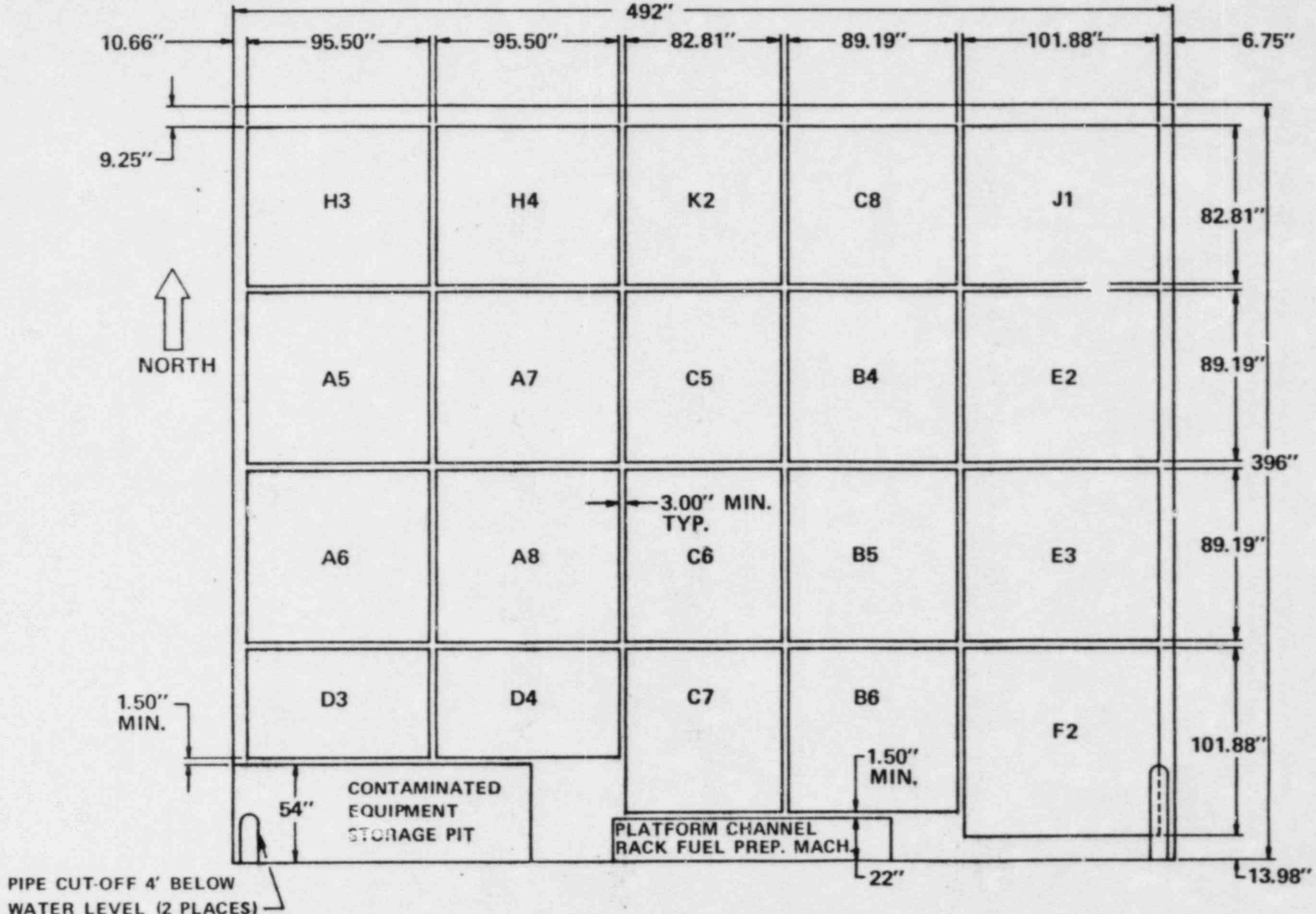

FIGURE 2.2

GENERAL ARRANGEMENT OF RACK MODULES FOR QUAD CITIES UNIT 2
(389 CELLS)

9

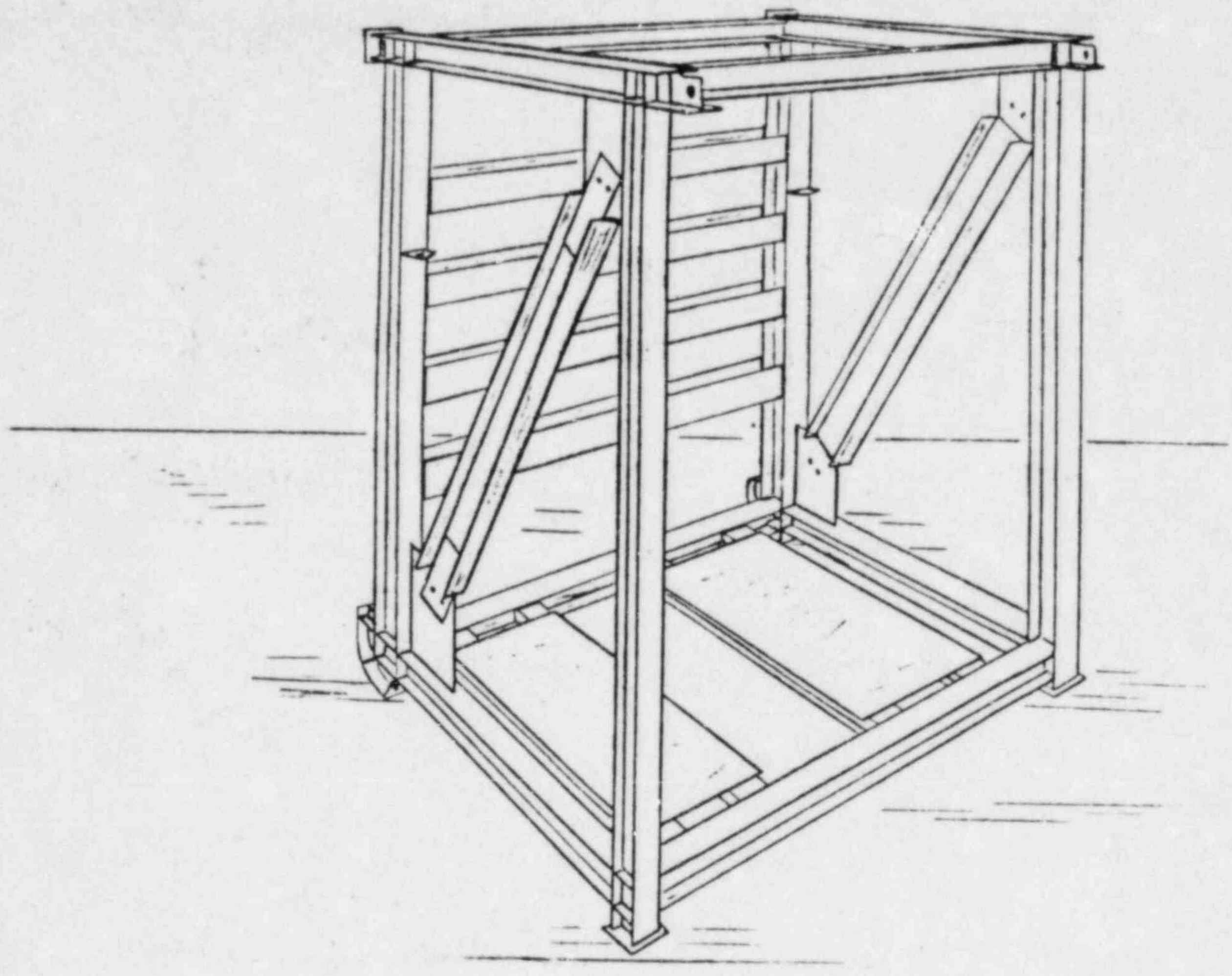

FIGURE 3-7 – SPENT FUEL RACK UPLIFTING CRADLE

racks of the present design, full core discharge and refueling discharge capabilities would be lost after the 1984 and 1986 refueling outages, respectively. No further expansion of the Quad Cities spent fuel storage capacity is possible using the presently approved spent fuel storage rack design. In contrast, high-density spent fuel
storage racks have a capacity of 7554 fuel assemblies. Therefore, 9
full core discharge is possible until the refueling outage of 2001 is completed. Refuel discharge capability would be lost after the refueling outage of the year 2003.

Commonwealth Edison Company, in its function as operator, proposes to increase the spent fuel storage capacity by replacing the present spent fuel storage racks with new, high-density storage racks. This modification will include the use of a neutron absorber material in the racks, at an increase of k_{eff} from 0.90 to 0.95. The March 26, 1981, letter to the NRC requests a modification to Quad Cities Technical Specification 5.5B, "Fuel Storage," to implement this change in k_{eff}.

The specification for design, construction, and quality assurance of the high-density storage racks was prepared by Quadrex, a San Jose-based company. The mechanical design, seismic analysis, thermohydraulic analysis, and other related calculations as well as the fabrication of the hardware will be performed by Joseph Oat Corporation. Joseph Oat Corporation, based in Camden, N.J., possesses ASME Code stamps for Section III, Classes 1, 2, and 3, and MC pressure vessels and components. Southern Science Applications, Inc., of Dunedin, Florida, is serving as a consultant to Joseph Oat Corporation in the areas of criticality analysis and other radionuclide evaluations.

Consulting support on the overall effort is provided by NUS Corporation of Gaithersburg, Maryland.

2. GENERAL ARRANGEMENT

The high-density spent fuel racks consist of individual cells with a 6-inch-square cross section, each of which accommodates a single BWR fuel assembly. The cell walls consist of a neutron absorber sandwiched between sheets of stainless steel. The cells are arranged in modules of varying numbers of cells with a 6.22-inch center-to-center spacing.

The high-density racks are engineered to achieve the dual objective of maximum protection against structural loadings (such as ground motion) and the maximization of available storage locations. In general, a greater width to height aspect ratio provides greater margin against rigid body tipping. Hence, the modules are made as wide as possible within the constraints of transportation and site-handling capabilities. The high-density spent fuel racks will be installed in the Unit 1 and Unit 2 spent fuel pools, each of which is 33 feet wide by 41 feet long.

The Quad Cities Unit 1 pool will contain 19 high-density fuel
racks in 9 different module sizes. The module types are labelled A
through K in Figure 2.1, which also shows their relative placement. 9
There will be a total of 3657 storage locations in the Quad Cities
Unit 1 pool.

The Quad Cities Unit 2 pool will contain 20 high-density fuel
racks in 9 different module sizes. The module types are labeled A
through K in Figure 2.2, which also shows their relative placement. 9
There will be a total of 3897 storage locations in the Quad Cities
Unit 2 pool.

Table 2.1 gives the detailed module data (e.g., weight, quantity, and number of storage locations).

The spent fuel rack modules are not anchored to the pool floor or
connected to the pool walls. The minimum gap between any two spent
fuel rack moduels will be 3.0 inches along the top edge. The minimum 9
gap between the fuel pool wall and spent fuel rack modules

Table 2.1 Module Data

Type	Quantity	Number of Cells/Module	Array Size	Approximate Weight Lbs/Module	
A	8	210	14 x 15	25,100	
B	6	196	14 x 14	23,500	
C	8	182	14 x 13	21,850	
D	4	135	9 x 15	16,400	
E	3	224	14 x 16	26,750	9
F	2	256	16 x 16	30,500	
G	1	192	12 x 16	23,050	
H	4	195	13 x 15	23,400	
J	1	208	13 x 16	24,900	
K	2	169	13 x 13	20,350	

will be 6-3/4 inches. The minimum gap between the top of the spent
fuel rack modules and pool wall fixtures will be 1½ inches. Adequate 9
clearance from other existing pool hardware will also be provided.
Due to the gaps provided, the possibility of interrack impact, or rack
collision with pool walls or other pool hardware during the postulated
ground motion events will be precluded.

applicable portions of Revision 15 of topical report CE-1-A, Commonwealth Edison Company Quality Assurance Program for Nuclear Generating Stations. Revision 15 of this report, dated January 2, 1981, was approved by the NRC in February 1981.

V. <u>Other References</u>

(a) NRC Regulatory Guides, Division 1, Regulatory Guides 1.13, 1.29, 1.71, 1.85, 1.92, and 1.124 (Revisions effective as of April 1980).

(b) General Design Criteria for Nuclear Power Plants, Code of Federal REgulations, Title 10, Part 50, Appendix A (GDC Nos. 1, 2, 61, and 63).

(c) NRC Standard Review Plan, Sections 3.8.3 and 3.8.4.

(d) NRC Standard Review Plan, Section 9.1.2 (as applicable to spent fuel racks).

(e) "NRC Position for Review and Acceptance of Spent Fuel Storage and Handling Applications," dated April 14, 1978, and the modifications to this document of January 18, 1979.

3.3 INSTALLATION AND LEVELING

The new spent fuel storage racks will arrive at the site by truck, packaged on their sides, and secured to shipping rigs. Unloading of the packaged racks will be conducted by station personnel. The racks will be brought through the reactor building receiving bay equipment air lock, uprighted vertically using the
cradle shown on Figure 3.7, and lifted to the spent fuel pool operat- 9
ing floor elevation using the overhead crane.

Procedures and specifications will be used to control all operations required to remove existing and install new spent fuel racks. A sequencing system will be employed for relocation of spent fuel within the pools. Initially, several existing racks will be emptied of spent fuel and removed from the pool, thereby creating the required space for the first new racks to be installed. Relocation of fuel to the new racks will then allow additional existing racks to be removed. No

old racks or new racks will be lifted over stored fuel or near enough to fuel so that any postulated lifting fig failure would result in any fuel damage. A diver will assist in leveling the new racks with shims during the installation project. This will necessitate maintaining separation between the diver and the spent fuel stored in nearby racks.

Initial washdown of the existing racks will be performed at the central decontamination area on the fuel handling floor. The racks will then be shredded, the pieces put into 55 gallon drums, and sent to a burial site. 9

The new racks will be lifted and transported to the decontamination area using the lifting frame and rigging assembly shown on Figure 3.8. Four sets of holes allow the frame to accommodate all seven new rack configurations. The lifting rods and plugs shown on Figure 3.8 will extend and thread into the leg portion of each rack. This assembly will also be used to lower the racks into final pool positions.

In addition to the procedures which will be developed for rack handling, other areas which will be addressed are: acceptance procedures; equipment and specifications for removal of existing rack supports where necessary; interim fuel pool liner repair guidelines; and controls for final disposal of existing racks.

(ref. Table 1.1). This is when the inventory of fuel in the pool will be at its maximum resulting in an upper bound on the computed decay heat rate.* 9

In the past, Quad Cities reactors have operated on what is commonly referred to as "18 month cycle." Quite often, system planning requires extended reactor coastdown operation (sometimes to 40% of rated power) after the end of full power reactivity (19000 MWD/STU) has been reached. The batch average discharge burn-up of current fuel batches is approximately 25000 MWD/STU. In the future, due to present lack of spent fuel reprocessing in the U.S., it is conceivable that the average discharge exposure can approach 30,000 MWD/STU due to higher initial enrichments and longer coastdowns. A longer coastdown period implies a greater value of t_o in the foregoing equation, it also implies a smaller value of P_o. It can be shown that an exposure period, t_o, equal to 4.5 years (3-18 month refueling cycles) along with the rated reactor power produces an upper bound on the value of P. This is due to the fact that f (to,ts) is a weak monotonically increasing function of t_o. Hence, the reactor operating time is assumed to be 4.5 years (t_o=1.42x10^8 secs).

Having determined the heat dissipation rate, the next task is to evaluate the time temperature history of the pool water. Table 5.1.1 identifies the loading cases examined. The pool bulk temperature time history is determined using the first law of thermodynamics (conservation of heat). The system to be analyzed is shown in Figure 5.1.1.

A number of simplifying assumptions are made to render the analysis conservative. The principal ones are:

1. The cooling water temperature in the fuel pool cooler and the RHR heat exchangers are based on the maximum postulated values given in the FSAR.

* Because of the elimination of 130 cells from the originally proposed expanded storage capacity, additional conservatism is introduced into the computed results presented in this section. 9

actual rack floor space is drawn. It is further assumed that the cylinder with this circle as its base is packed with fuel assemblies at the nominal pitch of 6.22 inches (see Figure 5.2.1).

c. The downcomer space around the rack module group varies, as shown in Figures 2.1 and 2.2. The nominal downcomer gap available in the pool is assumed to be the total gap available around the idealized cylindrical rack; thus, the maximum resistance to downward flow is incorporated into the analysis. 9

d. No downcomer flow is assumed to exist between the rack modules.

In this manner, a conservative idealized model for the rack assemblage is devised. The water flow is axisymmetric about the vertical axis of the circular rack assemblage, and thus, the flow is two-dimensional (axisymmetric three-dimensional). The governing equation to characterize the flow field in the pool can now be written. The resulting integral equation can be solved for the lower plenum velocity field (in the radial direction) and axial velocity (in-cell velocity field), by using the method of collocation. It should be added here that the hydrodynamic loss coefficients which enter into the formulation of the integral equation are also takne from well-recognized sources[4] and wherever discrepancies in reported values exist, the conservative values are consistently used.

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b. Nuetron attenuation measurements will allow evaluation of the continuing nuclear effectiveness of the poison. Consideration must be given in the analysis of the attenuation measurements for the level of accuracy of such measurements

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The only chemical discharge that could be affected by the proposed expansion of the spent fuel pools is the powdered ion exchange resins used in the two filters demineralizers. As explained in Section 8 of this report, the frequency of resin replacement is determined primarily by the need for water clarity. As the particulate material that must be removed to maintain water clarity enters the water during refuelings and is removed well before the next refueling, the frequency of resin replacement is independent of the number of spent fuel assemblies stored in the pools. Therefore, there should be no change in the amount of spent fuel pool purification system filter resin discharged from the plant, because of this modification.

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Capacity	=	2920
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High-Density Spent Fuel Racks

Capacity	=	7554	
Capacity with FCDC	=	6830	9
Capacity with RDC	=	7314	
Lose FCDC	-	3/01	
Lose RDC	-	3/03	

* Full core capacity = 724

** Eight (8) racks (160 spaces) on site, not in pool, but available for repair and use

Table 1.1 Quad Cities Station, Units 1 and 2 Fuel Assembly Discharges

Year	Discharge Assemblies Unit 1	Discharge Assemblies Unit 2	Total Discharged Assemblies In Pool Following Refueling	Remaining Storage Capacity* Existing	Remaining Storage Capacity* With Additional Licensed Racks	Remaining Storage Capacity* High-Density Racks	
1974	64	144	208	2072	-	-	
1975	0	4	212	2068	-	-	
1976	156	164	532	1748	-	-	
1977	184	0	716	1564	-	-	
1978	0	180	896	1384	-	-	
1979	192	180	1268	1012	-	-	
1980	224	0	1492	788	-	-	
1981	0	224	1716	564	1204	-	
1982	224	0	1940	340	980	5614	
1983	0	192	2132	148	788	5422	
1984	184	184	2500	0	420	5054	
1985	192	0	2692	-	228	4862	
1986	0	204	2896	-	24	4658	
1987	200	200	3296	-	0	4258	
1988	200	0	3496	-	-	4058	
1989	0	200	3696	-	-	3858	
1990	200	200	4096	-	-	3458	9
1991	200	0	4296	-	-	3258	
1992	0	200	4496	-	-	3058	
1993	200	200	4896	-	-	2658	
1994	200	0	5096	-	-	2458	
1995	0	200	5296	-	-	2258	
1996	200	200	5696	-	-	1858	
1997	200	0	5896	-	-	1658	
1998	0	200	6096	-	-	1458	
1999	200	200	6496	-	-	1058	
2000	200	0	6696	-	-	858	
2001	0	200	6896	-	-	658	
2002	200	200	7296	-	-	258	
2003	200	0	7496	-	-	58	
2004	0	200	7696	-	-	0	

*The number of locations available after the completion of that year's scheduled refueling outage.

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1980	224	0	1492
1981	0	224	1716
1982	224	0	1940
1983	0	192	2132
1984	184	184	2500
1985	192	0	2692
1986	0	204	2896
1987	200	200	3296
1988	200	0	3496
1989	0	200	3696
1990	200	200	4096
1991	200	0	4296
1992	0	200	4496
1993	200	200	4896
1994	200	0	5096
1995	0	200	5296
1996	200	200	5696
1997	200	0	5896
1998	0	200	6096
1999	200	200	6496
2000	200	0	6696
2001	0	200	6896
2002	200	200	7296
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*The number of locations available after the completion of

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Remaining Storage Capacity*		
Existing	With Additional Licensed Racks	High-Density Racks
2072	-	-
2068	-	-
1748	-	-
1564	-	-
1384	-	-
1012	-	-
788	-	-
564	1204	-
340	980	5614
148	788	5422
0	420	5054
-	228	4862
-	24	4658
-	0	4258
-	-	4058
-	-	3858
-	-	3458
-	-	3258
-	-	3058
-	-	2658
-	-	2458
-	-	2258
-	-	1858
-	-	1658
-	-	1458
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-	-	858
-	-	658
-	-	258
-	-	58
-	-	0

9

hat year's scheduled refueling outage.

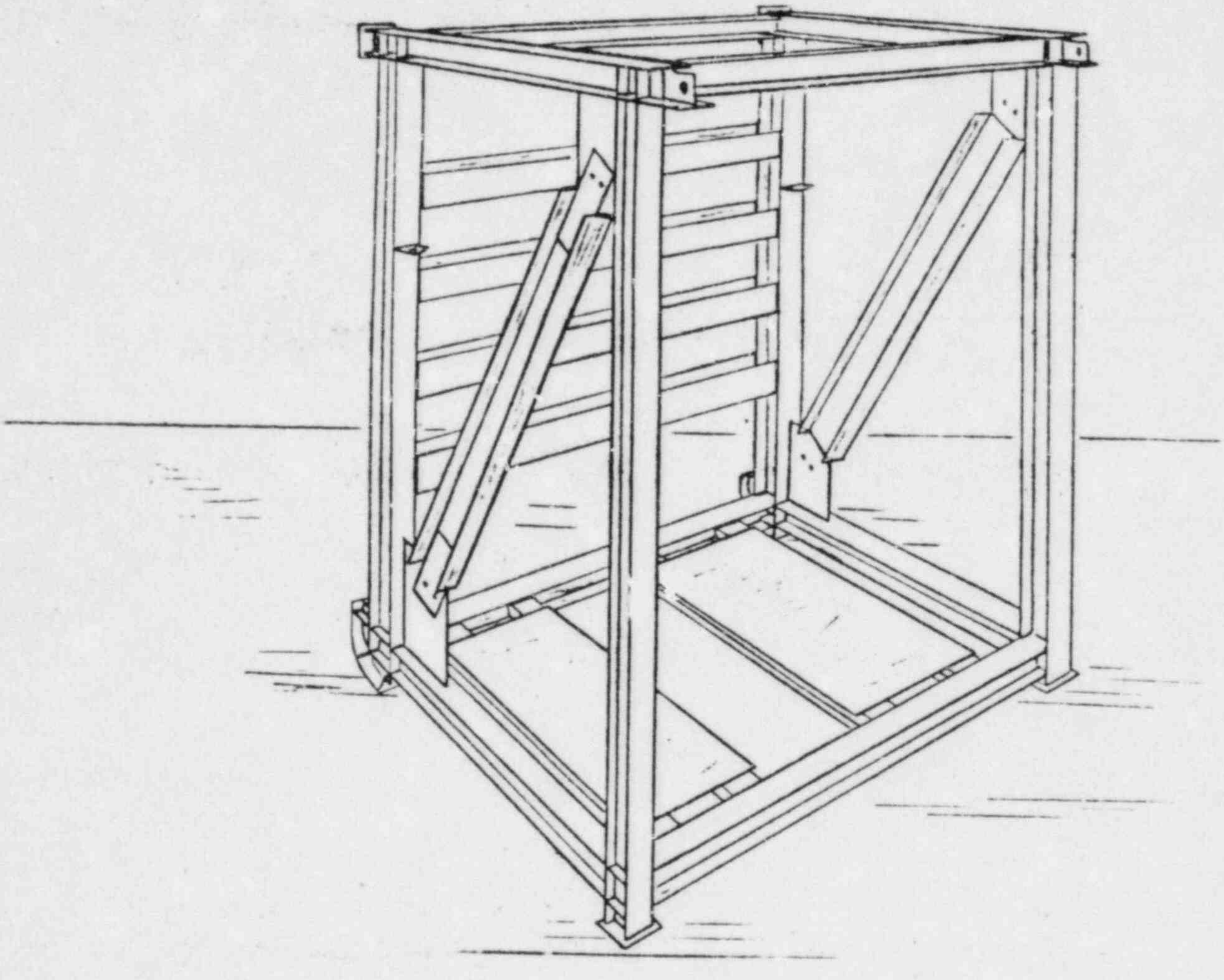

FIGURE 3-7 – SPENT FUEL RACK UPLIFTING CRADLE

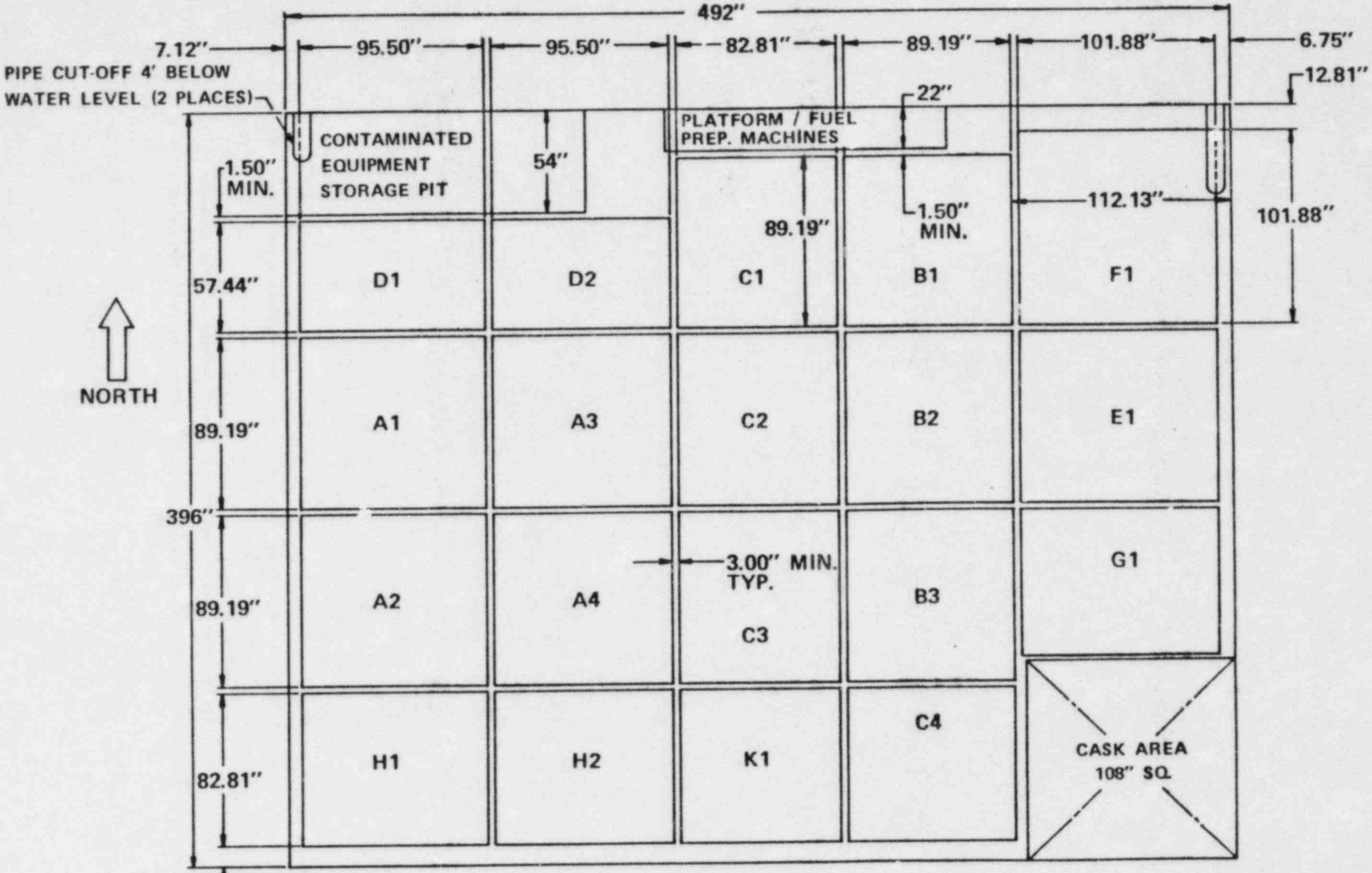

FIGURE 2.1

GENERAL ARRANGEMENT OF RACK MODULES FOR QUAD CITIES UNIT 1
(3657 CELLS)

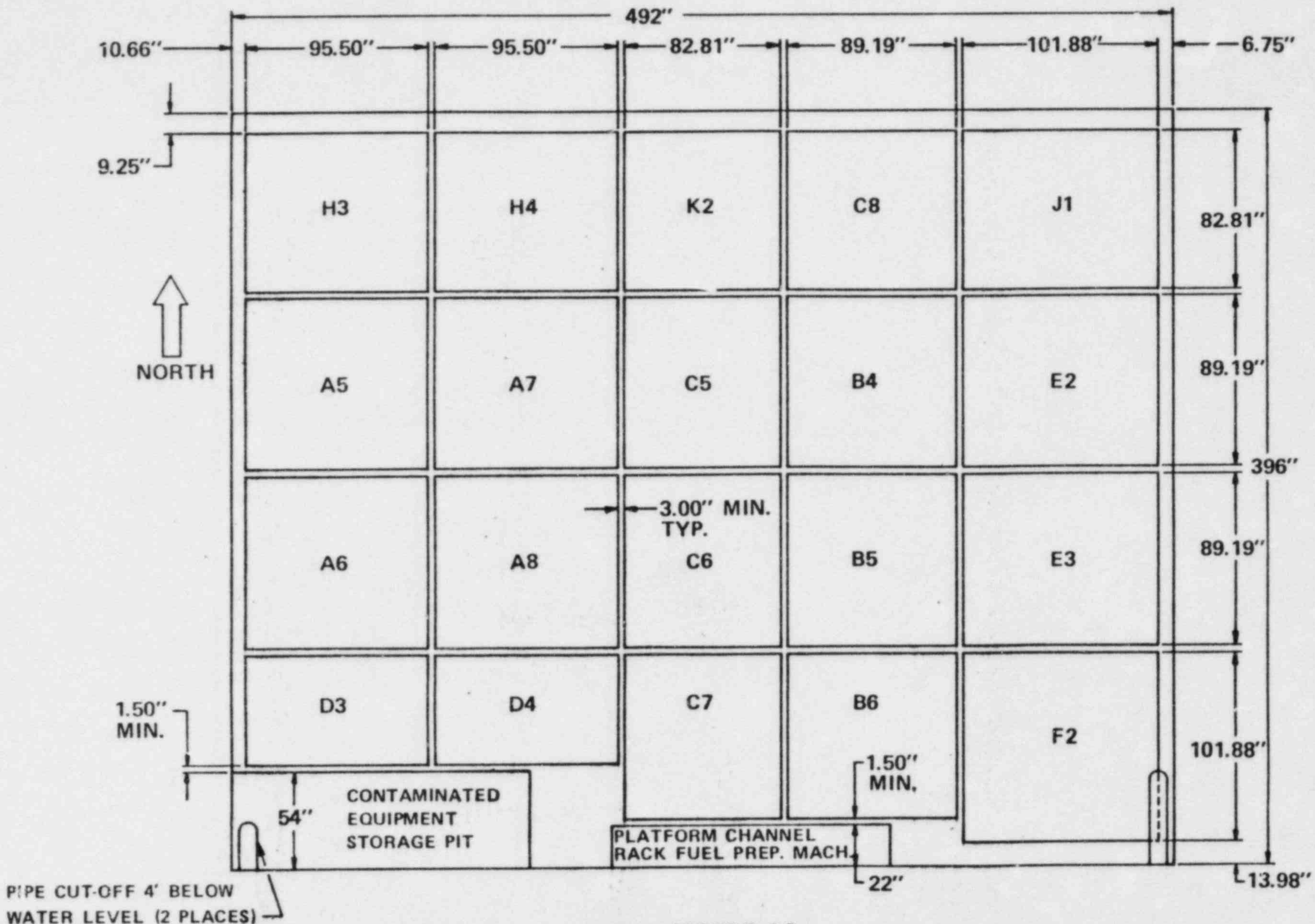

FIGURE 2.2

GENERAL ARRANGEMENT OF RACK MODULES FOR QUAD CITIES UNIT 2
(3897 CELLS)