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October 28, 1998

LCV-0897-D

Docket Nos.: 50-424
50-425

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington D. C. 20555-0001

Ladies and Gentlemen:

VOGTLE ELECTRIC GENERATING PLANT (VEGP) RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION CONCERNING GL 96-06, ASSURANCE OF EQUIPMENT OPERABILITY AND CONTAINMENT INTEGRITY DURING DESIGN-BASIS ACCIDENT CONDITIONS

By letter dated January 27, 1997, Southern Nuclear Operating Company (SNC) provided a response to GL 96-06 for VEGP Units 1 and 2. On August 10, 1998 the NRC requested additional information relating to the VEGP response. Attached are specific answers to some of the questions asked by the NRC; however, resolution of several questions are pending the completion of the EPRI technical basis report for this issue which is currently scheduled for July 31, 1999. Therefore, additional information in response to the NRC's request will be submitted following receipt of the EPRI report.

Please contact this office if you have any questions.

Sincerely,

J. B. Beasley, Jr.

JBB/BHW/gmb

A072 1/1

xc: (See next page)

xc: Southern Nuclear Operating Company
Mr. J. T. Gasser
Mr. M. Sheibani
SNC Document Management

U. S. Nuclear Regulatory Commission
Mr. L. A. Reyes, Regional Administrator
Mr. D. H. Jaffe, Senior Project Manager, NRR
Mr. J. Zeiler, Senior Resident Inspector, Vogtle

Response to GL 96-06 RAI

Introductory Note

Southern Nuclear Operating Company (SNC), along with other utilities, is participating in an EPRI managed project to develop a common technical basis report (TBR) that can be used to support resolution of GL 96-06 RAIs. SNC expects that the TBR will address many of the assumptions, judgments and/or methodologies that are useful to the VEGP understanding and resolution of GL 96-06 issues. Therefore, the responses to various RAI items for VEGP are deferred pending completion of the EPRI TBR and subsequent review of this report by SNC.

1. <u>NRC Request</u>

Provide a detailed description of the "worst case" scenarios for waterhammer and two-phase flow, taking into consideration the complete range of event possibilities, system configurations, and parameters. For example, all waterhammer types and water slug scenarios should be considered, as well as temperatures, pressures, flow rates, load combinations, and potential component failures. To the extent that the possibility for waterhammer and two-phase flow to occur is eliminated, describe the minimum margin to boiling that will exist.

<u>SNC Response</u>

The response to this item is deferred pending completion and review of the EPRI technical basis report for GL 96-06 RAIs.

2. <u>NRC Request</u>

If a methodology other than that discussed in NUREG/CR-5220, "Diagnosis of Condensation-Induced Waterhammer," was used in evaluating the effects of waterhammer, describe this alternate methodology in detail. Also, explain why this methodology is applicable and gives conservative results (typically accomplished through rigorous plant-specific modeling, testing, and analysis).

<u>SNC Response</u>

The response to this item is deferred pending completion and review of the EPRI technical basis report for GL 96-06 RAIs.

3. NRC Request

Identify any computer codes that were used in the waterhammer and two-phase flow analyses and describe the methods used to validate and bench mark the codes for the specific application and loading conditions involved.

SNC Response

The computer program HSTA (Hydraulic Systems Transient Analysis) was used for the water hammer analysis of the Containment Air Cooler System at Vogtle. This program is a generalized finite difference code developed by Bechtel Corporation and used extensively over the last 20 years for water hammer design and diagnostic purposes in nuclear and non-nuclear piping systems. The method of characteristics is used to solve the hyperbolic partial differential equations (of continuity and momentum) to obtain the liquid velocity and pressure head at a known grid location. These flow variables are then utilized to generate the dynamic forcing functions on specified pipe run segments. HSTA can model a complex piping system containing one or more of the several different types of flow devices (boundary conditions) present in the system. Examples of these boundary conditions are: time dependent pressure/flow reservoirs, valves, branches, pumps, surge and air tanks, vacuum breakers, etc.

The code allows for modeling of liquid (water) column separation when the pressure falls to the vapor pressure of the liquid. Two computational schemes are available:

- A conventional scheme of generating a vapor pocket at each computational node and tracking its size. The vapor pocket is attached to the node and does not move along the system. This commonly used methodology works well if the vapor pocket size is less than the distance between two adjacent node ("nodal distance" or "reach length"). For larger vapor pocket sizes, the accuracy of results by this scheme is questionable.

- A special "line filling" scheme that treats the vapor pocket as bounded by two vapor/liquid interfaces. These liquid interfaces are tracked independently thus allowing for accurate representation of these pockets and their growth/collapse irrespective of the pocket size relative to the nodal distance. This method also allows the entire vapor pocket to effectively move along the piping system due to the motion of both the upstream and downstream interfaces . This method allows for starting a transient with a pre-existing steam bubble or multiple bubbles present and is well suited for GL 96-06 type water hammer applications.

Since the vapor pocket sizes in the specific application were large compared to nodal distance in the Vogtle Units 1 and 2 models, the second computational scheme was used.

For the validation of the HSTA code, emphasis was placed on comparison with experimental or test data. This was supplemented by comparisons against independent numerically predicted results available. When comparing time-history predictions of pressure, velocity, etc. in a piping system, both the magnitude and frequency of the variable compared could be important depending on the piping response. For this reason the comparisons are given by directly superimposing the HSTA predicted on the measured (or calculated) variable time-histories and not just by defining the percentage agreement or disagreement between them.

The formal HSTA program documentation includes the validation of the following HSTA capabilities:

1. Validation of valve actuation transient and pressure wave reflection/transmission at branches/area changes in complex piping networks is against data given in the standard text books by Wylie and Streeter, and Parmakian.

2. Validation of centrifugal and reciprocating pump actuation, surge vessels and air tank mitigation devices is against various test data (available in open literature and in other Bechtel proprietary data).

3. Validation of water column separation and rejoining calculation schemes includes the validation of both conventional and line filing schemes described above.

   The conventional scheme is validated against test data from several careful laboratory experiments in Europe for two different piping geometries. Further validation is against laboratory tests done for water hammer predictions in a piping system at a nuclear power plant in U.S.

   For the line filling calculational scheme, the HSTA validation was performed as follows:

   a) Comparisons against laboratory test data from Europe.
   b) Comparisons against in-plant test data from a nuclear power plant in U.S.
   c) Comparisons against predictions from a totally different computer program that used a simpler calculational scheme and not the Method of Characteristics that are used by HSTA.
   d) Comparisons against predictions from the conventional calculational scheme in HSTA for vapor pockets smaller than a nodal distance in length.

Besides the validation in the formal code documentation discussed above, the HSTA code participated in the EPRI water hammer computer code evaluation program during the 1987-1992 EPRI sponsored research effort into water hammer. In this program, the results from HSTA were compared against those from several other participating codes for a set of six varied water hammer simulation problems. In the problems for which data (test and analytical) was available, HSTA results compared very well against such data.

The HSTA program methodology and its application has been published widely (six papers) both in national and international conferences.

4. NRC Request

Describe and justify all assumptions and input parameters (including those used in any computer codes) that were used in the waterhammer and two-phase flow analyses, and provide justification for omitting any effects that may be relevant to the analyses (e.g., fluid structure interaction, flow induced vibration, erosion). Confirm that these assumptions and input parameters are consistent with the existing design and licensing basis of the plant. Any exceptions should be explained and justified.

SNC Response

The response to this item is deferred pending completion and review of the EPRI technical basis report for GL 96-06 RAIs.

5. NRC Request

Explain why voiding in the CACs is limited to the 2 top coils (i.e., is this an assumption or is it based on heat transfer considerations).

SNC Response

The waterhammer evaluation performed for the VEGP containment cooling units includes a case in which the top two coils of the containment air coolers (CACs) are assumed to completely drain. This assumption was made based on a drain down analysis of these coolers which indicated that the actual drain down would be less than the assumption of the top two coils. The drain down analysis is a hydraulic analysis (not based on heat transfer characteristics) that assumes thermal conditions which maximize the calculated drain down. Specifically, water in the tubes of the coolers is assumed to reach the containment steam/air temperature instantaneously. Thus, the steam pressure inside the tubes is assumed to be the same as the saturation pressure corresponding to the containment temperature. Utilizing the steam pressure in the tubes along with elevation differences as the driving potential, drain down flow rates were calculated for specific time intervals (quasi steady-state analysis) based on modeled system hydraulic resistance. The cumulative drain down volume was then calculated over the time frame of the drain down period. For purposes of the waterhammer evaluation, drainage of the top two coils was assumed which bounds the results of the drain down analysis.

6. NRC Request

The January 27, 1997, response indicated that additional analyses would be completed to determine if modifications or system operational changes would be required to reduce waterhammer stresses. Describe the additional analyses that were completed and conclusions that were reached.

SNC Response

Additional engineering analyses were completed and concluded that modifications would be required to the NSCW piping supports to reduce piping and support stresses to meet VEGP design requirements. As part of the effort, an analysis of the Unit 2 train B (2B) NSCW system was performed similar to the previous analysis performed for Unit 1 train A (1A). The hydraulic transient (waterhammer) portion of the analysis was performed using Bechtel's Hydraulic System Transient Analysis (HSTA) computer program. Results of the 2B transient analysis are similar to the results of the 1A analysis. The calculated forcing functions from the 2B transient analysis were used as inputs in the dynamic piping stress models to determine piping stresses and support loads due to the waterhammer event. Again, the results from the 2B pipe stress and support evaluation are similar to the 1A results. The 2B piping and supports will remain intact and capable of performing their safety related function. However, modifications such as addition of tie-back type pipe supports at various locations are needed to meet VEGP design requirements. As described in the response to item 16, design change packages have been prepared to accomplish these modifications.

7. NRC Request

Explain and justify all uses of "engineering judgement" that were credited in the waterhammer and two-phase flow analyses.

SNC Response

The response to this item is deferred pending completion and review of the EPRI technical basis report for GL 96-06 RAIs.

8. NRC Request

Discuss specific system operating parameters and other operating restrictions that must be maintained to assure that the waterhammer and two-phase flow analyses remain valid, and explain why it would not be appropriate to establish Technical Specification requirements to acknowledge the importance of these parameters and operating restrictions. Also, describe and justify use of any non-safety related instrumentation and controls for maintaining these parameters.

SNC Response

There are no specific operating parameters or restrictions that must be maintained to assure the validity of the analyses, other than those that are already established to maintain the operation of the system within its design limitations. Current VEGP Technical Specification surveillance requirements include verification of basin water level and temperature, and verification of flow paths for safety related equipment serviced by NSCW. The waterhammer analyses performed in response to GL 96-06 are based on system operating parameters that currently exist. Design changes made to the system as a result of GL 96-06 are described in the response to item 16 and are aimed at improving the structural capability of the system in withstanding loads that result from the postulated waterhammer scenarios. These design changes do not change system operating parameters or the functional operation of the system. Non-safety related instrumentation and controls are not required to maintain parameters that are important to the validity of the waterhammer or two-phase flow analyses.

9. NRC Request

Implementing measures to minimize or eliminate waterhammer and two-phase flow conditions may be a viable approach for addressing these issues. However, all scenarios must be considered to assure that the vulnerability to waterhammer and two-phase flow has been eliminated. Confirm that all scenarios have been considered, including those where the affected containment penetrations are not isolated (if this is a possibility), such that the measures that have been established (or will be established) are adequate to address the waterhammer and two-phase flow concerns during (and following) all applicable accident scenarios.

SNC Response

The response to this item is deferred pending completion and review of the EPRI technical basis report for GL 96-06 RAIs.

10. NRC Request

Confirm that the waterhammer and two-phase flow analyses included a complete failure modes and effects analysis (FMEA) for all components (including electrical and pneumatic failures) that could impact performance of the cooling water system and confirm that the FMEA is documented and available for review, or explain why a complete and fully documented FMEA was not performed.

SNC Response

Existing design documentation for the VEGP NSCW system includes a failure modes and effects analysis (FMEA) that evaluates failures of active components. The results of the FMEA are presented in FSAR Table 9.2.1-2. The evaluated failures include components utilized in the waterhammer mitigation (slow fill) feature of the existing design. Design changes made to the system as a result of GL 96-06 are described in the response to item 16 and are aimed at improving the structural capability of the system in withstanding loads that result from the postulated waterhammer scenarios. These design changes do not change the functional operation of the system and do not involve changes to active components. Therefore, no revision is required to the existing FMEA. The FMEA documentation is available for review upon request.

11. NRC Request

Describe the uncertainties that exist in the waterhammer and two-phase flow analyses, including uncertainties and shortcomings associated with the use of any computer codes, and explain how these uncertainties were accounted for in the analyses to assure conservative results.

SNC Response

The response to this item is deferred pending completion and review of the EPRI technical basis report for GL 96-06 RAIs.

12. NRC Request

The waterhammer and two-phase flow analyses assume that there is no back flow through the containment supply check valves. Describe measures that exist that assure that these valves will remain leak-tight over the life of the plant.

SNC Response

Considering the volume of water that is expected to drain from the outlets of the containment coolers or containment auxiliary coolers during the postulated scenarios, a relatively small amount of leakage through the containment cooler/auxiliary cooler check valves is not important to the outcome of the analyses. It is only important that the check valves function to prevent gross backflow of water which could significantly increase the drain down volume. Conservative assumptions regarding drain down volume were made in the waterhammer and two-phase flow analyses that bound the effects of minor leakage through the check valves. Therefore, assurance of leak-tightness is not required to maintain the validity of the waterhammer and two-phase flow analyses. The check valves in the NSCW supply lines to the containment cooling units will be periodically disassembled for cleaning and inspection at an appropriate frequency to be determined. This maintenance is performed to provide assurance that the check valves can accomplish their design function.

13. NRC Request

The response seems to indicate that two-phase flow due to fluid conditions in concert with the pressure drop associated with various system components was not considered. Confirm that the potential for two-phase flow throughout the affected system was evaluated and that two-phase flow conditions do not exist for any of the applicable accident scenarios. If it is determined that two-phase flow does exist, then heat transfer, structural, and system integrity concerns must be addressed. For example the following two-phase flow effects would be relevant:

- *the effects of void fraction on flow balance and heat transfer;*
- *the consequences of steam formation, transport, and accumulation;*

- *cavitation, resonance, and fatigue effects; and*
- *erosion considerations.*

Licensees may find NUREG/CR-6031, "Cavitation Guide for Control Valves," helpful in addressing some aspects of the two-phase flow analyses.

SNC Response

The response to this item is deferred pending completion and review of the EPRI technical basis report for GL 96-06 RAIs.

14. NRC Request

The waterhammer analysis was based on analyses of the NSCW system associated with Unit 1, Train A. Confirm that the analyses that were completed are bounding for the other NSCW trains for both of the Vogtle units.

SNC Response

As described in the response to item 6, a waterhammer analysis of the Unit 2 train B (2B) NSCW system was performed similar to the analysis performed for Unit 1 train A (1A). This analysis included the calculation of peak pressures and forcing functions on piping segments inside the containment. The results of the 2B analysis are similar to the results of the 1A analysis. As is the case for the 1A analysis, the 2B analysis concludes that the NSCW system piping and supports are capable of sustaining waterhammer loads without failure and performing their intended safety function. Also like the 1A analysis, the 2B analysis concludes that modifications to piping supports are required at various locations to meet VEGP design requirements. Upon completion of the 2B analysis, a decision was made to implement physical modifications to the piping supports for all four NSCW trains (i.e. 1A, 1B, 2A and 2B). Subsequently, specific waterhammer hydraulic transient analyses were performed for the remaining two NSCW trains (i.e. 1B and 2A) similar to the previous analyses in order to develop the specific forcing functions to be applied to these trains. The results of the 1B and 2A transient analyses are similar to the previous analyses and were used as inputs in the dynamic stress models to verify that these trains, after modification, would meet VEGP design requirements. In summary, all four NSCW trains have now been specifically analyzed and the appropriate forcing functions have been developed for use in implementing physical modifications to the piping and/or supports. See the response to item 16 for a description of the modifications that have been or are planned to be implemented.

15. NRC Request

Provide a simplified diagram of the affected system, showing major components, active components, relative elevations, lengths of piping runs, and the location of any orifices and flow restrictions.

SNC Response

A simplified diagram of the Unit 1, train A NSCW system is attached. There is close similarity between all trains/units of the VEGP NSCW system, although there are some differences. As can be seen by review of the NSCW P&IDs, differences include the use of manual valves for throttling in the vicinity of the CCW and ACCW heat exchangers, the location/use of certain orifices, and the configuration of branch locations. The simplified diagram provides approximate lengths of the major piping runs between the indicated junction/interface points. The diagram also provides approximate elevations of major equipment. Unless otherwise indicated, the elevations shown represent the elevation of the piping at the inlet connection to the equipment. Please note that a partial system isometric sketch was previously provided with the VEGP response to GL 96-06.

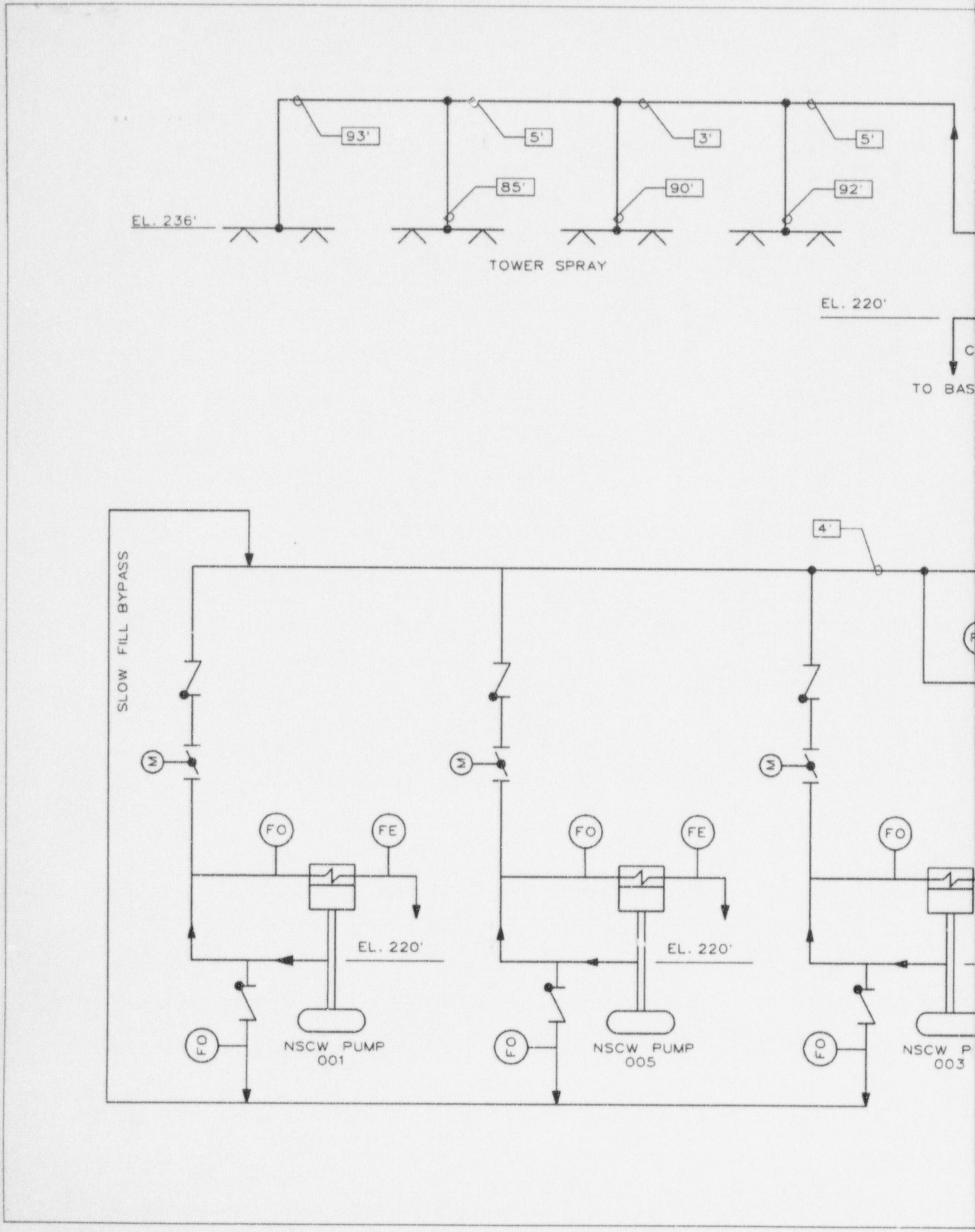
16. NRC Request

Describe in detail any plant modifications or procedure changes that have been made or are planned to be made to resolve the waterhammer and two-phase flow issues, including schedules for completion.

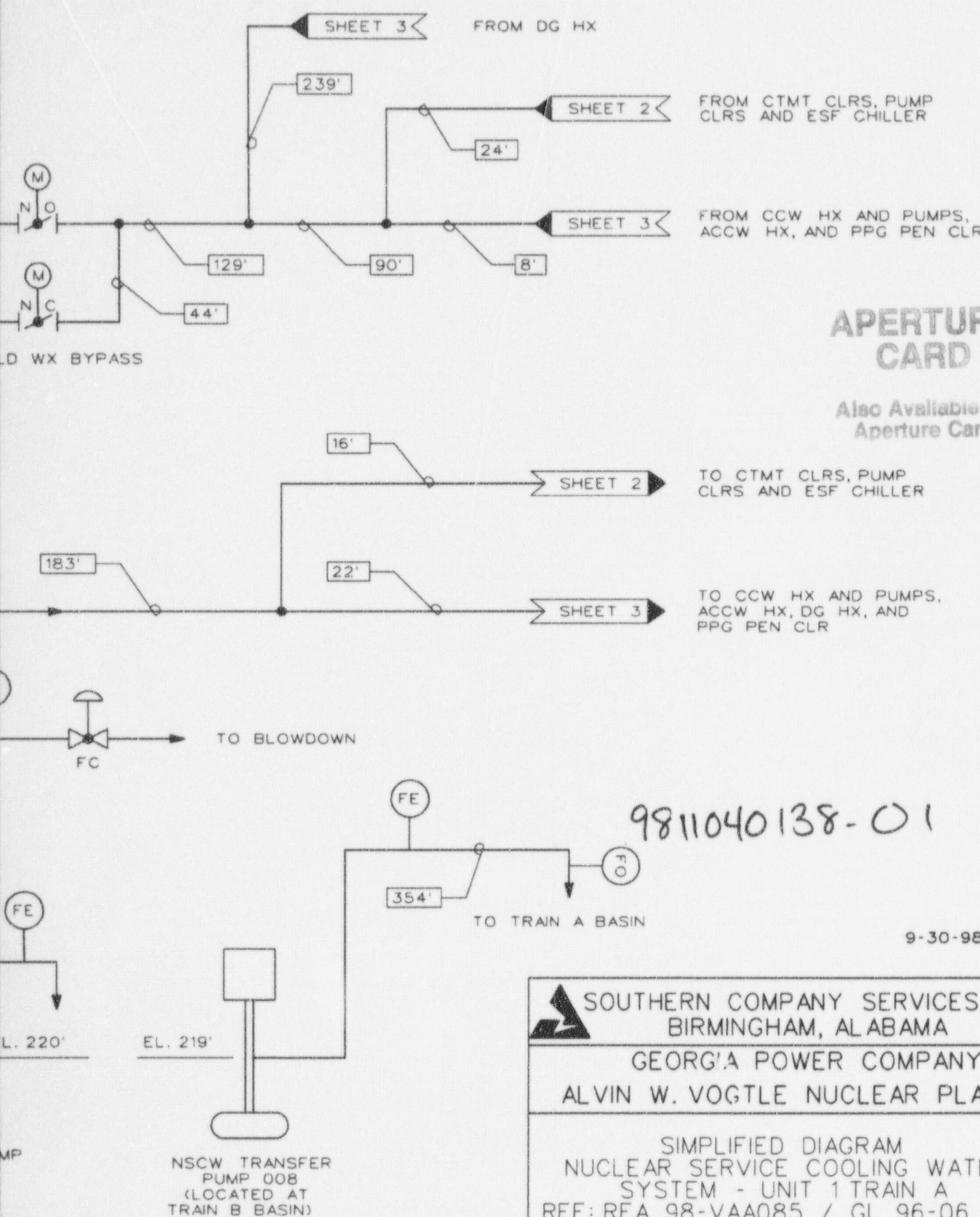
SNC Response

For Unit 2, design changes in response to GL 96-06 were implemented during the sixth refueling outage during the Spring of 1998. The changes improve the capability of NSCW piping and supports to withstand potential waterhammer loads. The changes are associated with safety related NSCW supply and return piping to and from the containment coolers, containment auxiliary coolers and/or reactor cavity coolers. The nature of the changes include the following: addition of new tie-back type supports at various root, vent, drain, test and relief valve locations; modification to replace various existing snubbers with rigid struts; deletion of various existing snubbers; deletion of an existing spring support; and modification to improve the dynamic capability of various existing supports.

For Unit 1, a design change package in response to GL 96-06 has been issued and the changes are scheduled to be implemented during the eighth refueling outage during the Spring of 1999. The changes will improve the capability of NSCW piping and supports to withstand potential waterhammer loads. The changes are associated with safety related NSCW supply and return piping to and from the containment coolers, containment auxiliary coolers and/or reactor cavity coolers. The nature of the changes planned include the following: addition of new tie-back type supports at various root, vent, drain, test and relief valve locations; modification to replace various existing snubbers with rigid struts; deletion of an existing snubber and an existing pipe support; modification to various existing supports to improve their dynamic capability or to accommodate the new tie-back supports; and deletion of the outboard valve in a double valve arrangement at various locations of vent, drain and test valves.



93'
5'
3'
5'
85'
90'
92'
EL. 236'
TOWER SPRAY
EL. 220'
TO BAS
4'
SLOW FILL BYPASS
M
M
M
FO
FE
FO
FE
FO
EL. 220'
EL. 220'
FO
FO
FO
NSCW PUMP 001
NSCW PUMP 005
NSCW P
003



SEE SHEET 3 FOR NOTES

9811040138-01

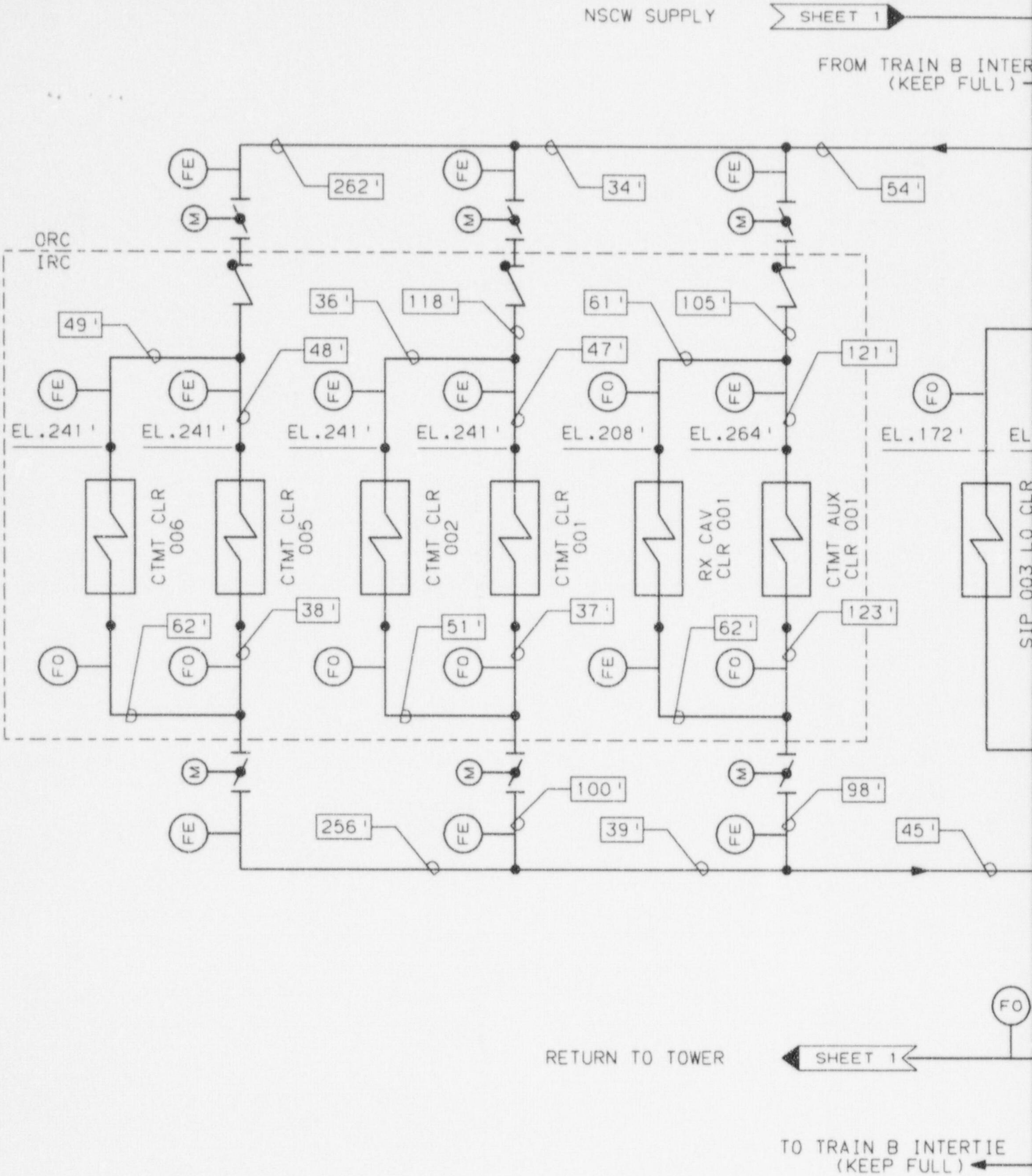
9-30-98

SOUTHERN COMPANY SERVICES, INC.
BIRMINGHAM, ALABAMA

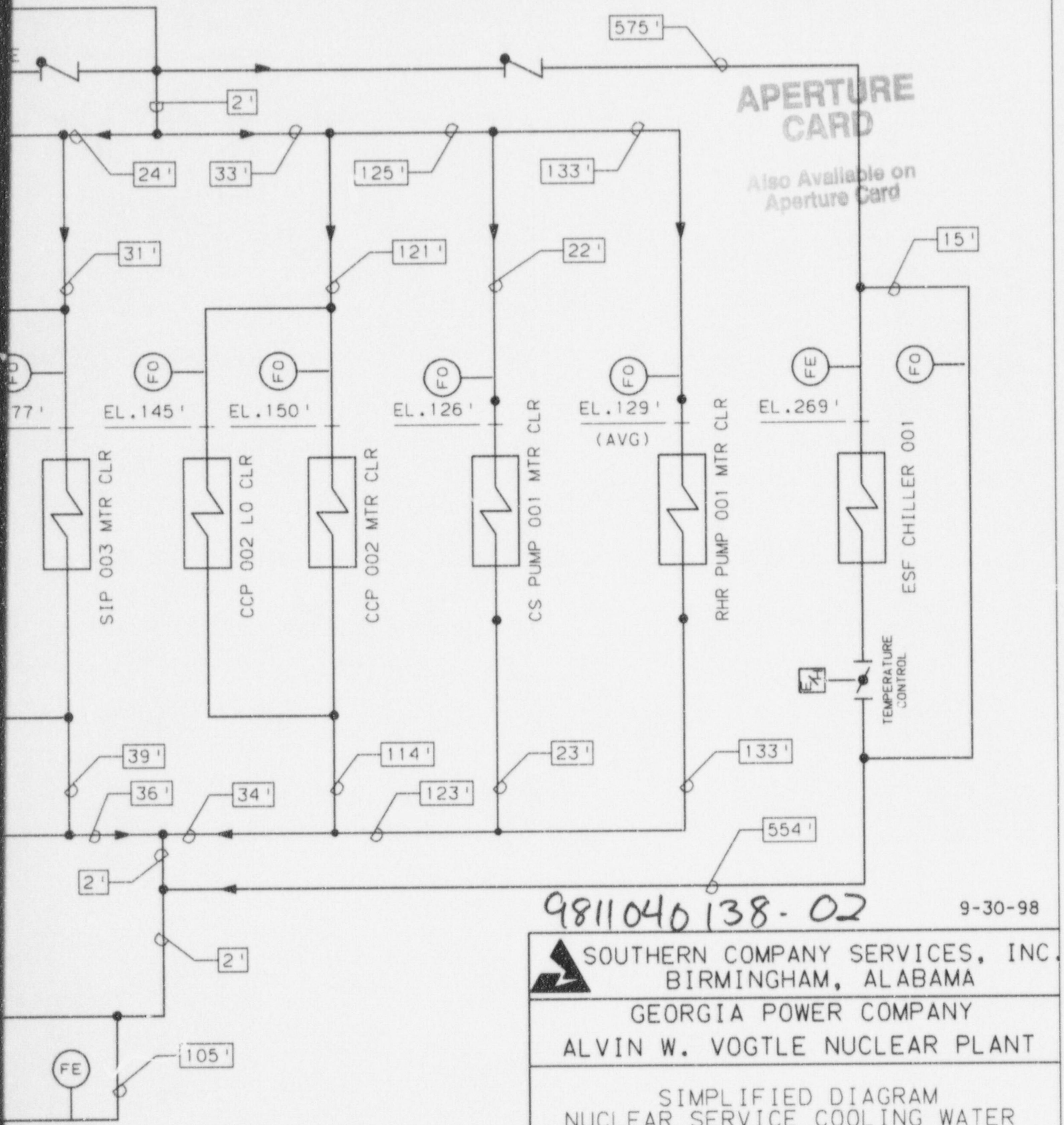
GEORGIA POWER COMPANY
ALVIN W. VOGTLE NUCLEAR PLANT

SIMPLIFIED DIAGRAM
NUCLEAR SERVICE COOLING WATER
SYSTEM - UNIT 1 TRAIN A
REF: REA 98-VAA085 / GL 96-06 RAI

SCALE:	DRAWING NO.	REV
JOB NO. 10604	SHEET 1 OF 3	



NSCW SUPPLY
SHEET 1
FROM TRAIN B INTER
(KEEP FULL)
262'
34'
54'
ORC
IRC
36'
118'
61'
105'
49'
48'
47'
121'
FE
M
FO
EL.241'
EL.241'
EL.241'
EL.241'
EL.208'
EL.264'
EL.172'
EL
CTMT CLR 006
CTMT CLR 005
CTMT CLR 002
CTMT CLR 001
RX CAV CLR 001
CTMT AUX CLR 001
SIP 003 LO CLR
62'
38'
51'
37'
62'
123'
100'
98'
256'
39'
45'
RETURN TO TOWER
SHEET 1
TO TRAIN B INTERTIE
(KEEP FULL)



9811040138-02

9-30-98

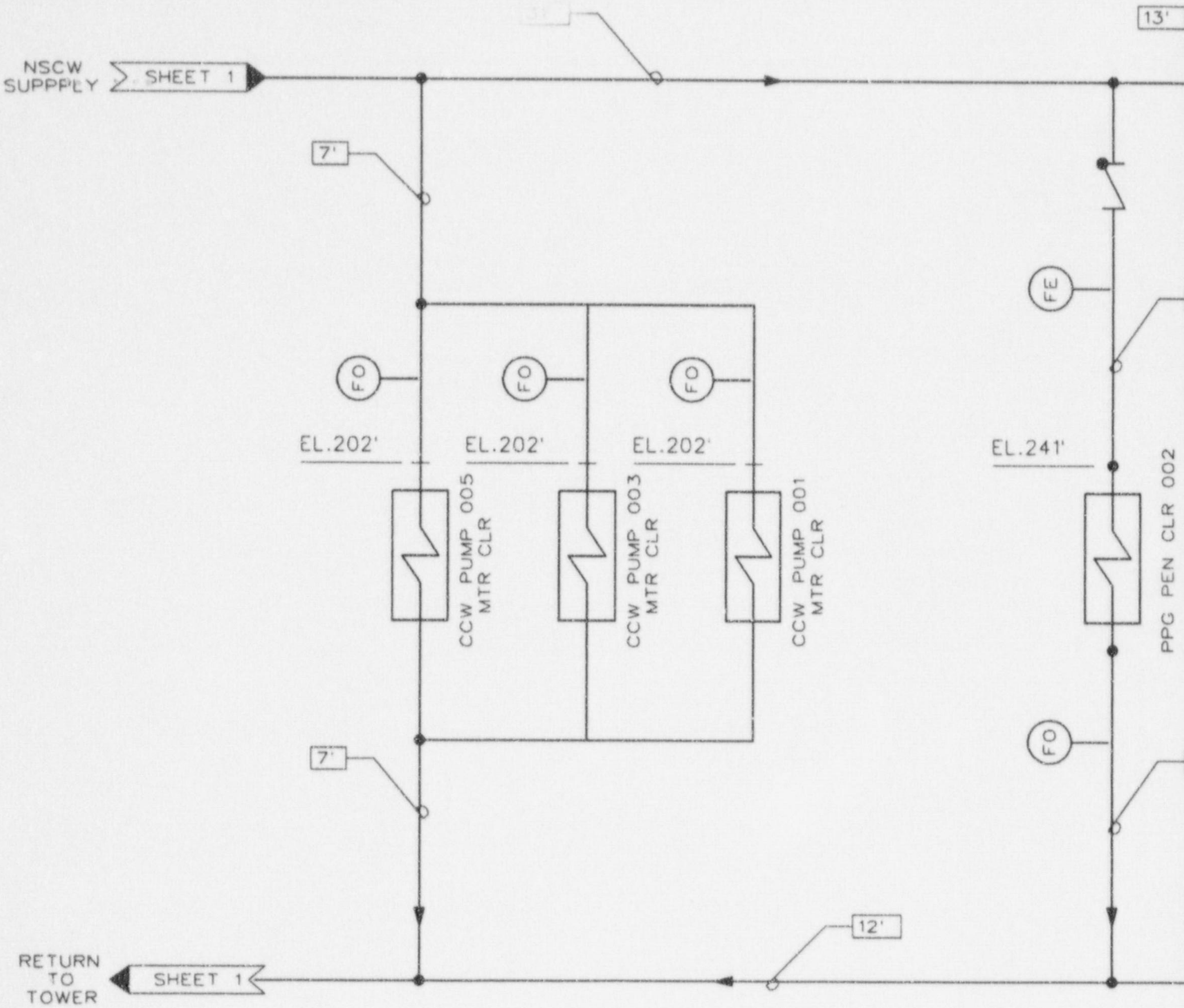
SOUTHERN COMPANY SERVICES, INC.
BIRMINGHAM, ALABAMA

GEORGIA POWER COMPANY
ALVIN W. VOGTLE NUCLEAR PLANT

SIMPLIFIED DIAGRAM
NUCLEAR SERVICE COOLING WATER
SYSTEM - UNIT 1 TRAIN A
REF: REA 98-VAA085 / GL 96-06 RAI

SCALE:	DRAWING NO.	REV
JOB NO. 10604	SHEET 2 OF 3	

SEE SHEET 3 FOR NOTES



ABBREVIATIONS AND ACRONYMS

ACCW	AUXILIARY COMPONENT COOLING WATER
CCP	CENTRIFUGAL CHARGING PUMP
CCW	COMPONENT COOLING WATER
CLR	COOLER
CS	CONTAINMENT SPRAY
CTMT	CONTAINMENT
DG	DIESEL GENERATOR
EL	ELEVATION
ESF	ENGINEERED SAFETY FEATURES
FC	FAIL CLOSED
HX	HEAT EXCHANGER
IRC	INSIDE REACTOR CONTAINMENT
LC	LOCKED CLOSED
MTR	MOTOR
NC	NORMALLY CLOSED
NO	NORMALLY OPEN
NSCW	NUCLEAR SERVICE COOLINC WATER
ORC	OUTSIDE REACTOR CONTAINMENT
PPG PEN	PIPING PENETRATION
RHR	RESIDUAL HEAT REMOVAL
RX CAV	REACTOR CAVITY
SIP	SAFETY INJECTION PUMP

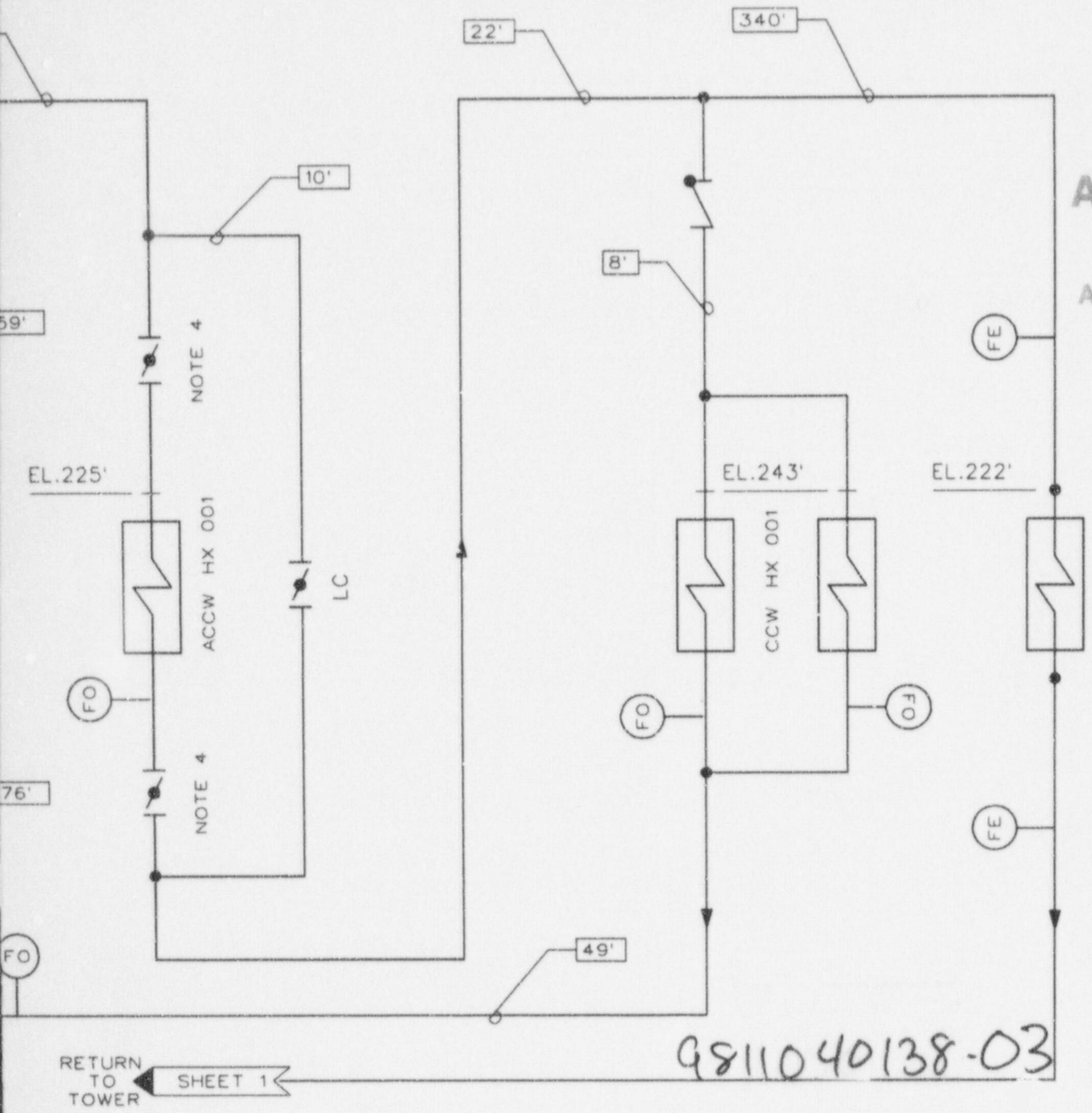
NOTES

1. APPR
SHOWN
PIPING
POINTS

2. UNLE
SHOWN
ELEVAT
THE EC

3. ORIF
ARE DE
MEASUR
RESTRI

4. MAN
INLET
POSITIC



9811040138-03

9-30-98

OXIMATE LENGTHS OF PIPING RUNS ARE
IN BOXES AND APPLY TO THE SEGMENTS OF
BETWEEN THE ASSOCIATED JUNCTION/INTERFACE
(DARK CIRCLES) SHOWN ON THE DIAGRAM.

SS OTHERWISE INDICATED, ELEVATIONS
FOR EQUIPMENT REPRESENT THE APPROXIMATE
ION AT THE PIPING INLET CONNECTION TO
UIPMENT.

CES SHOWN AT VARIOUS PIPING LOCATIONS
SIGNATED AS EITHER "FE" FOR FLOW
ING ORIFICES OR "FO" FOR FLOW
CTING ORIFICES.

AL VALVES AT THE ACCW HEAT EXCHANGER
ND OUTLET ARE LOCKED IN A THROTTLED
N.

SOUTHERN COMPANY SERVICES, INC.
BIRMINGHAM, ALABAMA

GEORGIA POWER COMPANY
ALVIN W. VOGTLE NUCLEAR PLANT

SIMPLIFIED DIAGRAM
NUCLEAR SERVICE COOLING WATER
SYSTEM - UNIT 1 TRAIN A
REF: REA 98-VAA085 / GL 96-06 RAI

SCALE:	DRAWING NO.	REV
JOB NO. 10604	SHEET 3 OF 3	