7/16/81

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
UNION ELECTRIC COMPANY	)	Docket No. STN 50-483-OL
	)	
(Callaway Plant, Unit 1)	)	

RESPONSE TO APPLICANT'S INTERROGATORIES AND REQUESTS FOR DOCUMENT PRODUCTION (SET NO. 1) TO JOINT INTERVENORS ON THEIR CONTENTION 2

Joint Intervenors submit the following Response to Applicant's Interrogatories and Requests for Document Production (Set No. 1) to Joint Intervenors on their Contention No. 2. All documents identified, unless otherwise indicated, are in the possession and/or control of Kenneth M. Chackes, Attorney for Joint Intervenors and will be made available for inspection and/or copying upon reasonable request. The answers provided below contain all of the information presently available to Joint Intervenors. Additional information that would be responsive to these interrogatories is presently being sought via Joint Intervenors' discovery to Union Electric and the NRC Staff. For all questions not answered Joint Intervenors have no responsive information. Where "not determined" is provided in response to questions dealing with identification of our witnesses, Joint Intervenors mean that at present we do not plan to call any witnesses. If Joint Intervenors determine that witnesses will be called their identities will be immediately disclosed to the Applicant and NRC Staff. Joint Intervenors are unable to answer many of the questions pertaining to Contention No. 2 because of the unavailability of the technical specifications, and the FES and SER.

1. Regarding the 25 documents listed by the Applicant, all will or may be used in connection with Contention 2 with the following exceptions or changes: Number (10) will not be used; and updating of Number (11) may be needed; Volume 3 of WASH-

D503
S
1/1

1258 may be used; the radiological surveillance study at Yankee-Rowe may be used (RD 71-1); additional NCRP Reports may be used; the Thomas H. Pigford document that may be used is Teknekron Report No. EEED-101 prepared for the EPA entitled "Fuel Cycles for Electric Power Generation," March 1975 revision, not the document listed as (24); and finally, 61st Edition, 1980-1981, of the CRC Handbook of Chemistry and Physics will be used.

2. Joint Intervenors are not able to answer this interrogatory at this time.

3. See responses below and documents identified therein.

4. See No. 3.

A-1(1). (a) The Applicant has not adequately assessed the amount of the radioative pollutants to be released from Callaway Plant, Unit I into the Missouri River by:

(1) Failing to account for the full range of isotopes which are released as products of the nuclear reaction and for which many are potential radioactie pollutants. For example, the Applicant considers only 29 isotopes when assessing the release of radioactive pollutants from Callaway Plant, Unit I (SNUPPS FSAR, Table 11.2-1). There are however, many additional significant fission, activation and corrosion products created in a nuclear power plant with half-lives sufficiently long to be potential radioactive pollutants which the Applicant has failed to consider ("Fuel Cycles for Electrical Power Generation", (T. Pigford, pages 25-26; see Answers to A-2 and A-3).

(2) Failing to account fully for the amount of individual radioactive pollutants that may be released to the Missouri River by excluding them from consideration, as described in

(1) above, or by understanding the amount to be released in the event of an "unplanned release" by not considering the consequences of an accident more severe than Class 8 (Final Environmental Statement Related to the Proposed Callaway Plant Units I and II, NRC, March, 1975, Section 7.1 and 7.2)

In addition, for all the classes of accidents or conditions, that are considered (SNUPPS FSAR, Conditions I-IV described in Sections 15.0 - 15.0.1.4), none are assigned any probability that they may induce the accidental release of liquid effluent, having a higher than permissible level of radioactive pollutants directly into the Missouri River. For example, a SNUPPS FSAR description of accidents involving a Radioactive Liquid Waste System leak or failure (Section 15.7.2) allows for no dispersal of unmonitored and/or unprocessed liquid radioactive wastes into the river, although postulated accident conditions include equipment malfunction or tank failure or rupture. Only atmospheric release and dispersion of radioactivity is considered for this type of accident; the likelihood that monitor-failure may allow release of high radioactive pollutant concentrations into the Missouri River is not discussed. Since monitoring of waste tank contents is to be done on a batch-sample basis only (FSAR Site Addendum, Section 11.5.2.2), it seems very plausible that unmonitored plant effluent containing harmful levels of radioactive pollutants could be released, undetected, directly into the river. There is a clear historical record supporting the likelihood that such harmful releases could occur. For

example, between 1969 and March, 1981, there were 26 events at PWR nuclear plants where an unplanned release of liquid plant effluent caused greater amounts of radioactivity to be released to the environment than is permitted by NRC regulations. ("Licensee Event Report Output or Events Involving Released Activity from 1969 to the Present," NRC, March 1981). In light of this record of evidence, the Applicant's neglect of any likelihood that direct river contamination will occur from plant accidents or abnormal operation amounts to an inadequate assessment of the amount of radionuclide release to the Missouri River that could occur during the operation of Callaway Plant, Unit I. The only pathway the Applicant considers for allowing the unplanned input of radioactivity into local surface water is by groundwater dispersion of radioactive pollutants from a leak or rupture in tanks containing liquid radwaste into Mud Creek and Logan Creek via tributaries (FSAR Site Addendum, Section 2.4.13.3).

The Applicant does, however, acknowledge the inflexibility of liquid waste-processing systems to handle irregular levels of radioactive pollutants with the statement: "When processing floor drain waste by either evaporation and demineralization . . or by demineralization only, it is highly desirable to operate with a known influent quality to insure optimum system performance." (SNUPPS FSAR, p. 11.2-4). At this time, the technical specifications for the actual monitoring systems to be employed at Callaway Plant Units

I and II are not available for review by the Intervenors (SNUPPS FSAR, Ch. 16.0). However, the state of the art of monitoring equipment still has room for improvement, as is noted by NRC staff: "Monitoring and analytical techniques are continually developing and may improve before the operating program is put into effect." (EIS, 1975, Section 6.1.2). Inadequacies of currently available systems are often discussed in the literature. For example, according to a discussion of monitoring capabilities in a December, 1976, NRCP report:

> "[T]he extremely low release rates and consequent low doses to members of the public permitted by regulatory organizations from relatively local sources emphasize the need for complementary measurements and calculations." (NRCP, Report No. 50, Environmental Radiation Measurements, p. 193)

A 1974 EPA study of radionuclide emissions monitoring at the Haddam Neck (Yankee CT) Plant makes the statement: "Samples taken at the station usually show numerous radionuclides, including some that decay rapidly or are not readily detectable by the preferred method of gamma-ray spectrometry." (p. 1). With regard to on-site monitoring, the same study recommends that: "Measurements at the source must include all significant pathways and . .nuclides during the entire period of operation; critical radionuclides can be missed by monitoring only the obvious effluents and the easily measured radionuclid or by ignoring the effects

of changes in the operating cycle." (p. 118, Radiological Surveillance Study at the Haddam Neck PWR Nuclear Power Starter, EPA-520/3 - 74-007, December, 1974). A June, 1974, revision to the NRC Regulatory Guide contains the statement that, ". . . in the case of radionuclides which have no gamma rays and weak beta radiation (e.g., Fe-55, Ni-63, etc.), it may be more appropriate to calculate releases of such radionuclides . . ." (pages 1.21-4 and 1.21-5).

In addition to the present inadequacies of monitoring equipment in detecting the full range of radioactive pollutants being discharged with liquid plant effluent, or in responding to sudden fluxes in effluent quality, the historical record shows that monitoring systems are likely to fail altogether under accident conditions and allow large quantitites of radioactivity to be released unrecorded. For example, in the past 11.5 years, there have been 5 incidents of unplanned releases of radioactive liquid effluent to the environment at nuclear power plants where monitoring systems also malfunctioned ("Licensee Event Report Output Events Involving Released Activity from 1969 to the Present", NRC, March, 1981). In addition a recent example of a systemic liquid effluent monitoring deficiency which could allow high levels of undetected, untreated radioactive pollutants to be discharged has been identified at Indian Point Units 2 and 3 and H.B. Robinson Unit 2, where the cooling water system for the containment cooler fan motor is designed to bypass containment coolant effluent monitors and discharge directly

into the effluent stream. Any leaks in the fan coolant system would provide a unmonitored release point for radioactive containment effluent if containment were to reach design pressure during an accident. (NRC IE Circular No. 81-09: "Containment Effluent Water that Bypasses Radioactivity Monitor," July 10, 1981.).

Given the record of evidence to date concerning the likelihood of unplanned, untreated liquid radwaste releases, as well as the inadequacies of state of the art monitoring equipment in detecting certain routinely released isotopes, or responding to abnormally high levels of radionuclides in liquid discharges, it is a serious oversight for the Applicant to rule out, per se, any possible direct discharge of higher-than-permissible amounts of radioactive pollutants directly the the Missouri River via the plant effluent stream. Combined with the incomplete range of isotopes the Applicant has considered in calculating expected normal and accidental liquid radwaste releases, we find that the Applicant's failure to consider direct river contamination with radioactive pollutants constitutes an inadequate assessment of the amount of radioactive pollutants to be released into the Missouri River by Callaway Plant, Unit I.

(b) See A-1(1)(a).

(c) See Objection No. 1.

(d) Not determined.

A-1(2). (a) For the reasons listed in A-1(1) regarding incomplete radionuclide consideration by the Applicant, along with the documents listed in A-1(1) in support

thereof, and also for the reasons stated in A-7 regarding impossibility of prediction and the accompanying documentation, we contend that the Applicant cannot accurately predict the amount of the radioactive pollutants to be released from Callaway Plant, Unit I, into the Missouri River. (See answers to A-1(1) and A-7).

(b) See A-1(1) and A-7.

(c) See Objection No. 1.

(d) Not determined.

A-1(3). (a) The amount of dilution to be afforded by the Missouri River has not been adequately assessed by the Applicant for the following reasons:

The "low flow" estimate of 6,300 cfs used to calculate future minimum dilution capacity for the river (Table 2.4-6, "Environmental Report—Operating License Stage," Vol. 2, Union Electric Co.) is over-optimistic. Increased water withdrawal from the Missouri River is projected over the next 40 years ("Missouri River Corridor Inventory," Kansas City District, U.S. Corps of Engineers (COE) and Missouri Department of Natural Resources (DNR), February, 1981, p. 9) but was not considered in deriving a low-flow estimate; historical data spanning 22 years (1953-73, 1979) was the basis for the 7 day, 100-year frequency low-flow estimate and do not even include the dry period conditions of the 1930's; and future runoff conditions in the river basin that might accompany a 100-year drought were not considered.

The estimated mean flow for the Hermann Station of 69,000 cfs, based on 1952-77 data ("Environmental Report", p. 2.4-4—as above), does not take into account abnormally low flow conditions. For example, a worst-case, 7-day condition could be approximated by assuming a 6,300 cfs flow coincides with an unplanned, concentrated release of radioactivity from the plant into the river. However, no worst-case analysis was presented; instead, a constant average flow of 69,000 cfs was used as a basis for dilution projections (SNUPPS, FSAR Addendum, Tables 11.2-1, and 11.2-2). Thus, point-in-time drought effects on long-term, project-related water-withdrawal

effects are not reflected in the estimated river dilution capability. A somewhat more representative approach would have been to use the annual, 100-year frequency, average low-flow rate of 25,500 cfs ("Environmental Report," Table 2.4-6), which is almost two-thirds less than the average flow used.

Moreover, using a straight-line average, per se, is an inadequate method of anticipating special dilution problems during the plant's operation, since both river flow patterns and plant effluent releases are apt to be episodic and non-linear ("Radionuclide Materials Released from Nuclear Power Plants, Annual Report, NUREG CR-1497, BNL-NUREG 51192, p. A 1-686, 1981). The truly meaningful result to be obtained from a projection of dilution factors is an estimate of the likelihood that an extreme condition will occur—such as a very low flow coupled with a large, unplanned, radionuclide release from the plant. A pattern of variations in conditions, not an average, should instead be used to model future dilution capabilities and obtain information about the likelihood that an extreme condition could occur and create a serious health problem.

Because over-optimistic and simplistic (i.e., average) parameters have been used to project future dilution capabilities of the Missouri River, the actual dilution to be afforded by the river has not been adequately assessed.

(b) See A-1(3)(a).

(c) See Objection No. 1.

(d) Not determined.

A-1(4). See A-1(3).

A-1(5). (a) The food web in the river is very complex. The only way to know how much radioactivity is in fish is to measure it. The Applicant's projection of bioconcentration does not adequately account for the intake of radionuclides, adsorbed by the sediment, on bottom feeders. See responses to A-1(1) through (4) above, and A-26 and 27, below.

. . . .

(b) Radiological Surveillance Studies, EPA: (a) Yankee-Rowe RD 71-1 (1971); and (b) Haddam Neck EPA-520/3-74-007 (1974).(c)See Objection No. 1.

(d) Not determined.

A-2. Although hundreds of radioisotopes have been identified to date as fission products, radioactive products and actinides produced in reactors, the Applicant only specifies 29 in its Table 11.1-2. (SNUPPS FSAR). Some of the isotopes not included in the Applicant's table entitled, "Calculated Annual Effluent Releases — Liquid and Gaseous" and therefore lumped in the category "all others", include isotopes detected in the liquid and gaseous waste releases of other light water reactors, and specifically, other Westinghouse pressurized water reactors.

The Applicant predicts in Table 11.1-2 that .17 curies of twenty-eight radioisotopes will be released to the Missouri River in the liquid effluent each year from Callaway Unit I, plus 410 curies of tritium and 0.00007 curies of "all others." The Intervenors contend there are many radioisotopes which should have been individually assessed and added to this list, and that the resulting total would be more than the estimated 0.00007 of "all others," based on many documents available to the Applicant.

(a) Some of the isotopes omitted from Table 11.1-2 include the following: Niobium-95, Nb-97, Nb-99, Cerium-141 and Ce-144. All of these have half-lives of an hour or more, have high fission yields, and are listed in authorative sources (Pigford), (Nero, Table 3.1) as radionuclides produced in a 1000-MWe Uranium-fueled light-water reactor. Nb^{95} is a gamma-emitter, and is listed by the IAEA (IAEA Report "Safe Handling of Radioisotopes", Geneva, 1968) as being of moderate toxicity. U.E. does not list any cerium among those elements to be released into the Missouri River and yet National Council on Radiation Protection Report #60, p. iii, states taht cerium is "produced in abundance in nuclear fission reactions associated with nuclear industry operations". A review of an annual report of radioactive releases from 1978 indicates that all but two Westinghouse reactors in operation released cerium that year into the

river or lake or other cooling water source, (that is, all but San Onofre and Salem, as per NUREG/CR-1497).

Cerium was reported among the liquid effluents released from eleven of the sixteen Westinghouse nuclear power plants in 1977. ("Radioactive Materials Released from Nuclear Power Plants - Annual Report 1977," NUREG-0521).

"In a typical low-enrichment light-water reactor, cerium-144 is produced at the annual rate of 5.3 kilograms per 1000 megawatts of electric power . . . which is equivalent to about 17 million curies per thousand megawatt years of electric power. Other radioactive isotopes of cerium (141, 143, 145, and 146) are produced from uranium fission but they have shorter radioactive half-lives and do not accumulate to as great an extent as cerium-144." (NCRP Report No. 60, p. 11). "Each (Callaway) unit is designed . . . to produce a nominal net output of 1120 MWe." (about a thousand megawatts of electric power per year; quoted from "Final Environmental Statement Related to the Proposed Callaway Plants, Units I and II," U.S. Nuclear Regulatory Commission, NUREG-75/011, March 1975, p. 1-1).

Cerium-144 has a half-life of 285 days; cerium-141, 33 days, 143, 33 hours; 145, 3 minutes; and 146, 14 minutes. Cerium-139 is also listed among reactor effluents; it has a half-life of 140 days.

Cerium-144 is listed as one of the thirteen "radionuclides of probable ecological significance released from nuclear power plants," by T.R. Rice and J.P. Baptist in "Ecologic Effects of Radioactive Emissions from Nuclear Power Plants." (in Human and Ecologic Effects of Nuclear Power Plants, Sagan, L.A., Ed., published by Charles C. Thomas, Springfield, Illinois, 1974). Ce^{144} is also listed by E.E. Lewis (Nuclear Power Reactor Safety, John Wiley and Sons, 1977) in his Table 1-2, "Characteristics of Important Long-Half-Life Fission-Product Isotopes." Cerium-144 is listed by the IAEA as being of high toxicity. ("Safe Handling of Radioisotopes," Geneva, 1968).

(b) Also among the radionuclides omitted by U.E. from Table 11.1-2 are:

(1) Tellurium-131

(2) Ruthenium-106

(3) Strontium^{90} (listed in Table 11.1-2 only as a gas)

(4) Iodine-134

Although 6 isotopes of tellurium are listed in Table 11.1-2, Te^{131} is not listed - an omission the Intervenors regard as arbitrary and capricious. U.E., for example, listed Te^{129} which has a half-life of 72 minutes and a fission yield of 0.32%. Te^{129} has an activity (in kilocuries per megawatt of thermal power) of 9.5 at shutdown. Te^{131}, on the other hand, has a half-life of 25 minutes and an activity of 26 at shutdown. Further, Sax lists Te^{131} with a fission yield over 10 times that of Te^{131M}, which is listed by U.E. (Sax, N. Irving, Dangerous Properties of Industrial Materials. NY: Reinhold; 2nd Edition, 1963, Table 4, Section 8).

Ru^{106} is not listed by U.E. in Table 11.1-2, yet it is listed as one of only 7 isotopes by E.E. Lewis in his Table 1-2, "Characteristics of Important Long-Half-Life Fission-Product Isotopes." Ru^{106} is also listed in Pigford and by the IAEA as being of "high toxicity." Its omission from Table 11.1-2 appears to be unjustified.

The highly important radioisotope Sr^{90} is not listed among liquid effluents in Table 11.1-2, although Sr^{89} is listed. This is unusually curious, since Sr^{90} is both more abundent than Sr^{89} as a fission product, has higher toxicity (IAEA lists Sr^{90} as being of "very high toxicity", Sr^{89} as being of "high toxicity."), and is listed, just as is Sr^{89}, in Pigford.

The radioisotopes of I^{130} through I^{135} are listed with the striking omission of I^{134}, which is listed by Pigford as contributing more than any iodine isotope to the reactor inventory. Similarly, Lewis lists I^{134} in his Table 1.1 (Characteristics

of Important Short-Half-Life Fission-Product Isotopes) as having a higher activity at shutdown than any of its sibling isotopes.

(c) The PWR-GALE Code as the computerized mathematical model used by NRC licensees for calculating the release of radioactive material does not individually identify radionuclies that contribute less than .00001 curies per year (Supplemental Answers of Union Electric Company to Interrotgatives Propounded by Appellants," answer to NPDES Appeal Inerrog. 5). However, the presence of an aggregate of radionuclides, even if individually in amounts below the model's reporting level, may nevertheless constitute a menace to public health and welfare.

Some of the long-lived isotopes which may be released each year in amounts which fall below the PWR-GALE Code's "level of attention" (Hoyt Whipple, Transcript of hearing on appeal from granting NPDES permit No. MO-0098001, before the Clean Water Commission of Missouri, page 583) include:

(1) Iodine-129 which has a half-life of seventeen million years. Although few picocuries may be released in comparision with shorter-lived isotopes, such as iodine-131 (half-life of 8 days), iodine-129 is one of only a few isotopes specifically regulated by the EPA through its Environmental Standards for the Uranium Fuel Cycle, 40 CFR 190.10(b) — along with krypton-85, and plutonium-239 and other alpha-emitting transuranic radionuclides with half-lives greater than one year. (The release per year of iodine-129 from the production, use and reprocessing of the uranium fuel for a 1000-megawatt reactor must be kept below five millicuries per year).

(2) Tc-99 which has a half-life of 210,000 years. According to the Federal Register, Vol. 46, No. 42, March 4, 1981, p. 15155: "Technetium-99 releases are not given in Table S-3. The

Fuel Cycle Rule Hearing Board concluded that the conservative assumption of complete release of iodine-129 tended to compensate for the omission of technetium from the table. However, the Commission decided that the emissions of technetium, together with an appraisal of the impacts associated with them, could be considered in individual reactor licensing proceedings." The Intervenors believe Tc-99 should be considered in the Callaway proceedings because of the admitted presence of its progenitors, Mo-99 and Tc-99m. Furthermore, according to the "Assessment of 99Tc Releases to the Atmosphere - A Plea for Applied Research," by J.E. Till, et al., ORNC/TM-6260, June 1978, p. 2: "The yield from thermal neutron fission of 235U for 99Tc is high, 6.2% fission, or about 0.84 kg per metric ton of uranium in typical spent pressurized water reactor fuel (compared to 1.3 kg per metric ton of 137Cs and 0.55 kg per metric ton of 90Sr)."

(d) Among the radioisotopes not listed with the corrosion and activation products in Table 11.1-2 are isotopes of Ni, Zr, Sb, Ru and others which <u>are</u> mentioned in Pigford, as well as in NUREG-0686 (Dresden Chemical Decontamination EIS, October 1980) and in WASH-1258 (AEC - Vol. 2 Analytical Models and Calculations). Mn^{56} is not listed in Table 11.1-2, although it is listed in IAEA as of toxicity equal to that of Mn^{54} (which is listed by U.E.) and is listed by the AEC (WASH-1258 above) in Table B-6 as having a calculated concentration higher than that of isotopes listed by U.E. Zr^{95}, not listed by U.E., is prominently mentioned in NUREG-0686 (Table 2-1) and in IAEA (moderate toxicity). The critical dependence of relative percentage concentration of

corrosion and activation product radioisotopes in reactors on years of operation is strikingly described in NUREG-0586:

> "A PWR that has been operated only a short time will contain ^{60}Co as the largest contributor to radiation dose. In this case, the integrity of the entombing structure need only be maintained for a few hundred years, as the disappearance of radioactivity is controlled by the 5.27-year half-life of ^{60}Co. If, on the other hand, the reactor has been operated for 30 or 40 years, substantial amounts of ^{59}Ni and ^{94}Nb (80,000-year and 20,000-year half-lives) will have been accumulated as activation products in the reactor vesel internals. The dose rate from the ^{94}Nb present in the reactor vessel internals has been estimated to be approximately 2 rem/hour (about 17,000 rem/year) while the dose from the ^{59}Ni in the internals is 0.1 rem/hour (about 880 rem/year). These dose levels are substantially above acceptable residual radioactivity levels and, because of the long half-lives of ^{94} Nb and ^{59}Ni, would not decrease by an appreciable amount, due to radioactive decay, for thousands of years." (from Draft Generic EIS on Decommissioning of Nuclear Facilities, January 1981, pages 4-6).

Additional activation products found in significant quantities in the primary coolant at the Yankee-Rowe and Haddam Neck Westinghouse plants, but not listed at Callaway, include sodium-24 (half-life of 15 hours) and silver-110m (half-life of 253 days). (References: Radiological Surveillance Studies, EPA, RD 71-1, p. 16 and EPA-520/3-74-007, pp. 18 and 56).

(e) Neptunium, plutonium and other actinides:

In its supplemental answers of March 16, 1981, to interrogatories propounded by the Callaway NPDES permit appellants, Union Electric explained that neptunium-239 had been "inadvertently omitted" from Table 11.1-2 and said further that the table was to be revised to include it. The significance of the presence of neptunium was explained by Dr. Hoyt Whipple during cross examination as follows: "Every atom of Neptunium 239 that decays, decays to an atom of Plutonium 239." (Tr. 586). In Table 3-1 of Nero (see p. 35), adapted from Pigford, are listed the following actinides: Th, Pa, U, Np, Pu, Am, Cm. These, according to this table, contribute over 20% to the total reactor inventory (3,614 x 10^6Ci out of 15,600 x 10^6Ci). The actinides, furthermore, are well-known to be of very high toxicity (IAEA).

(f) Noble Gases:

Union Electric relies on the PWR-GALE computer code to estimate the amount of radioactivity the Callaway plant is expected to release to the environment each year in water. However, "(n)oble gases and water activation products, e.g., N-16, are not considered in the (PWR-GALE) liquid code." (NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors, PWR-GALE Code," April 1976, p. 1-12).

In response to an interrogatory in the NPDES proceeding asking why dissolved or entrained noble gases were not included in Table 11.1-2, the Applicant responded that "the noble gases such as xenon and krypton, which have a relatively low solubility in water, are considered to be significantly stripped from the liquid effluent streams. . ." And yet, according to the EPA publication, "Summary of Radioactivity Released in Effluents from Nuclear Power Plants from 1973 thru 1976," (EPA-520/3-77-012, December 1977, pp. 73 through 77), dissolved noble gases were released to the environment in liquid effluents from pressurized water reactors, including from those manufactured by Westinghouse. The noble gases about which the appellants specifically inquired were the following: xenon-127 (36.4 day half-life), xenon-133 (5.27 days), krypton-81 (210,000 years), and krypton-85 (10.76 years). The release of argon, xenon and/or krypton was also reported from Westinghouse reactors in the 1977 annual report, "Radioactive Materials Released from Nuclear Power Plants," NUREG-0521.

Furthermore, the NRC Regulatory Guide 1.21 requires that "a representative sample from at least one representative batch per month should be analyzed for dissolved and entrained fission and activation gases." (p. 9). In its Partial Answers to Interrogatories in the NPDES proceeding, at page 5, Union Electric says its effluent release reports will follow the reporting guidelines of Reg. Guide 1.21, Appendix B, which includes an accounting of the gases. Therefore, Table 11.1-2 Sheet 1-Liquid, should include noble gas isotopes which are known to be dissolved and entrained

in the effluent and solid daughter products from relatively short-lived dissolved and entrained noble gases.

A-3 See documents cited A-2, and the following:

(a) CRC Handbook of Laboratory Safety, Cleveland Rubber Co., 1967, Chapter 7.1 on Radioactivity, including the "Safe Handling of Radioisotopes," IAEA, Vienna, 1958.

(b) Sax, N. Irving, Dangerous Properties of Industrial Materials, 2nd Edition, 1963. NY:Reinhold; Table 4, Section 8.

(c) Lewis, E.E. Nuclear Power Reactor Safety, New York:John Wiley. 1977.

(d) Westinghouse Electric Corporation, WCAP-8253, "Source Term Data for Westinghouse Pressurized Water Reactors," May 1974.

A-4. As has been shown by the Intervenors in response to many of the interrogatories above, difficulties in predicting incidents caused by human error, equipment failure, monitoring mishaps, lack of knowledge concerning the manner in which radioisotopes enter the human food chain, as well as inability to measure specific isotopic radioactivity - these and other factors make it difficult to predict accurately the amount of specific radioactive pollutants which will be released into the Missouri River. If nothing else, the history of reactor accidents, as detailed in the LER list referred to above, highlights this lack of predictability. Two examples of radioisotopes which may be difficult to predict accurately are given below:

(1) Radioiodine:

(a) The environmental monitoring of radioiodine is difficult and its accuracy is not proven:

The EIS of 1973, "Numerical Guides for Design Objectives" (WASH-1258), makes it clear that concentrations of radioiodine, both elemental and in

compounds, in air and on vegetation, are exceedingly difficult to measure, due to "imperfect sampling and analytical procedures, limitations of data acquisition, and miscellaneous variables in the environment." In 1973, the need for experimental data to support or verify decontamination factors seems to have been felt. Controlled experiments with releases into the atmosphere (Vol. I, p. 9-11) are reported to have been done, though analysis of the results was not yet done. A major "Iodine-Pathway Study" of the "air-grass-milk food chains" around 3 reactors was being undertaken in 1973 (pp. 9-16 to 9-21). In the 1976 publication, NUREG 0017, "Calculation or Releases of Radioative Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors," the PWR-GALE Code, neither these experiments and study, nor their results are mentioned. This is the document on which U.E. bases its predictions of effluent release; there are no experimental data cited in NUREG 0017 to justify the estimates of the many decontamination factors.

(b) Control of radioiodine on site is not easily predicted either:

As far as removal of iodine within the plant site, little seems to have changed between 1973, when the text was prepared for the Environmental Statement (see Section 9.0 pages 9-11) and 1976 when the PWR-GALE Code was published (see page 2-29). "The iodine removal efficiency of activated carbon varies greatly, even in

carbon of the same lot," which "makes the comparison of reported data difficult." "There are very limited data available concerning the removal of iodine at trace concentrations" and many factors decrease adsorber efficiency, like "poor initial bed packing," "settling during use," or just the presence in the stream of other substances which are more readily adsorbed by the charcoal. Data were still "being developed" in 1976 for iodine removal at trace levels, and U.E., relying on the PWR-GALE Code, has not shown the facts to support all the estimates and theoretical assumptions given.

(c) Even the data given are incomplete:

Radioiodine is a daughter product of tellurium. SNUPPS Table 11.1-2 lists several isotopes of both tellurium and iodine, but doesn't list others which are, for various reasons, of interest. Te-131, which has the highest fission yield of all the tellurium isotopes, is not listed, perhaps because its half-life is 25 minutes. But I-129, with a half-life of 17 million years is not listed either, and obviously not because its half-life is too short. In between, I-134, which the NRC's 1975 EIS for the Callaway Plant (NUREG-75/011) admits to, is also not listed, although it has the highest yield per fissioned uranium-235 atom; and is mentioned in the Reactor Inventory published by Thomas Pigford. ("Fuel Cycles for Electric Power Generation," p. 25).

(d) In sum, the iodine picture shown by U.E. has big holes in it:

Measurements are difficult; the complex behavior and interactions of iodine and its various chemical compounds both within and outside the plant are incompletely understood; the experimental data are either not analyzed or the analyses are not reported by the NRC; the SNUPPS tables of September 1980 have unexplained missing isotopes. It seems clear that the tables present arbitrary and inadequate data.

(2) Tritium:

The Applicant states that its method for estimating the amount of tritium produced in the reactor coolant from the neutron activation of boron, lithium, and deuterium "is based on data from operating reactors" (Supplemental Answer to NPDES proceeding Interrog. #22), and that "the amount of ternary fission tritium expected to be produced in the SNUPPS reactors has not been specifically calculated for the Callaway Plant." (Supplemental Answer to NPDES proceeding Interrog. #19). According to Section 11.1 of SNUPPS-FSAR, the amount of tritium in the reactor coolant is projected to be one microcurie per gram irrespective of the percentage of fuel rods with defective cladding. That is, the amount of tritium expected to be found in the reactor coolant is projected to be the same regardless

of whether .25% or 1% of the fuel rod cladding is defective.

The Intervenors consider that a proper estimate of the amount of tritium in the gaseous and liquid effluents should specifically take into account the percentage of fuel rod cladding failure, and should be revised periodically according to new data on fuel rod failure and failure detection.

A-5. See A-4.

A-6. An adequate assessment of the amount of radioactive pollutants to be released into the Missouri River must take into account the information provided in response to A-1 through A-5.

A-7. The Joint Intervenors contend that the Applicant cannot predict the amount of radioactivity before actual release from the Callaway Plant into the Missouri River. For example:

The PWR-GALE Code uses an estimate of 0.4 Ci/yr/MWt of tritium released to the environment primarily based on an analysis of the Ginna plant (1500 MWt) and further supported by data from nine reactors from 1972-1974 all of which are considerably smaller than Callaway (3579 MWt, as per NUREG-75/011). Thus no data on a reactor of comparable size have been used in estimating the tritium releases from Callaway. (NUREG-0017, pp. 2-39 through 2-41).

An important source of tritium in the primary coolant which determines the level of tritium ultimately released comes from diffusion of ternary fission produced tritium which diffuses through intact fuel rod cladding. No consensus exists in the literature about nuclear power plants to indicate the percentage of ternary fission tritium that diffuses through intact zirconium alloy fuel rod cladding, as is intended for use at Callaway.

(a) "Thus, it appears that tritium is released only through defects in zirconium alloy clad fuels. . . the release of fission product tritium by operating PWRs using zirconium alloy clad fuel is limited to 0.1 to 1 percent of that produced." (NCRP No. 62, Tritium in the Environment, p. 11).

(b) According to Westinghouse, 10% of the ternary fission tritium diffused through the zirconium cladding at Ginna, the one reactor at which Westinghouse studied the rate of diffusion. ("Source Term Data for Westinghouse Pressurized Water Reactors," WCAP-8253, May 1974, p. 3-5).

(c) Further uncertainties regarding the rate of diffusion are discussed in Environmental Contamination by Radioactive Materials, the proceedings of a seminar in Vienna in 1969, published by the Intl. Atomic Energy Agency; from a paper by H.T. Peterson, et al., p. 43.

Furthermore, such predictions involve a tremendous number of assumptions (see PWR-GALE Code) and do not take into account accidental or unplanned releases. Previous history from operating PWR reactors (LER Output on PWR Events and TMI) clearly deomonstrate that unplanned releases are to be expected. Since these accidental releases cannot be estimated we can make no accurate prediction of the amount of radioactivity to be released from the Callaway plant. In fact, we do not believe it is possible for anyone to make this prediction accurately prior to actual release.

A-8. An adequate assessment of the dilution from the Missouri River would include changing the parameters to reflect extreme conditions instead of just averages. That is, a worst case analysis is needed which would assess the likelihood of a large unplanned release of radionuclides coinciding with low river flow conditions — e.g., a

design basis accident occurring during a 3,500 cfs low flow (January, 1940 as per Callaway Environmental Report - Operating License Stage, p. 2.4-6).

A-9. An "accurate prediction" of the amount of dilution to be afforded by the Missouri River cannot be made without access to accurate predictions of the effects of weather (drought) and future water consumption proposals and diversion projects for the Missouri River watershed.

A-10. A watershed is a region or area bounded peripherally by a water parting and draining ultimately to a particular water course or body of water. (Webster's Third New International Dictionary, Unabridged. Merriam-Webster, 1971).

The Missouri River watershed would include those waterways in the 10-state area of the Missouri River basin which drain into the Missouri River. ("Specific Problem Analysis, 1975 National Assessment of Water and Related Land Resources — Missouri Region," Abridged Report published by the Missouri River Basin Commission, August 1977).

A-11. The following water diversion projects for the Missouri River watershed area being considered:

(a) A 360 or 620-mile canal to be constructed by the U.S. Army Corps of Engineers would divert between 1 million to 6.4 million acre feet of water annually to the states that now depend on the depleting Ogallala Aquifer (for energy industries and agricultural developments);

(b) Coal gasification and other synthetic fuel plants which would require large volumes of water are being considered for the Missouri River Basin (Section 13(a) Water Assessment Report - Synthetic Fuel Development);

(c) Continuing population growth in the midwestern and western states could also result in the further diversion of water to support this

growth. (From the St. Louis Post-Dispatch series entitled "The Draining of America;" June 22, 1981). "In the two decades before 1975, the state's population grew 17 percent, to 4.8 million. Water use by Missourians during the same period climbed to 4.1 billion gallons a day, an increase of 78 percent." (From the St. Louis Globe-Democrat, Associated Press article, April 2, 1981).

According to the Corps of Engineers, Kansas City District: "Streamflow depletions have been occurring on the Missouri River in the past and will continue to occur as a result of future water resource development. Depletions are reductions in flow which can be caused by irrigation, municipal or industrial use, thermal power generation, evaporation from ponds and lakes, livestock use, watershed treatment, coal development, and other purposes." ("Missouri River Corridor Inventory," February 1981, p. 9).

A-12. Callaway Plant Environmental Report Operating License Stage, Vol. II., p. 2.4-6 states that the record low discharge of 4,200 cfs for the Missouri River at Hermann was observed from January 10 to 12, 1940, during a period of extensive river freezing. The low river discharge near the Callaway site is estimated at 3,500 cfs for the same three days in 1940.

Studies from the U.S. Army Corps of Engineers, Kansas City District, have shown the drought of the 1930s and 1950s to have caused the lowest flows of record, "with the 1934 to 1942 period being the most severe for the entire Missouri River Basin. No recurrence interval has been assigned to this event." (From a letter from Donald L. Fritts, Assistant Chief, Engineering Divsion to Kay Drey, 29 October 1980).

A-13. We believe that there is a 100% likelihood that conditions of drought would lower the amount of dilution water available to a degree sufficient to raise the

concentrations of radioactive material in the Missouri River to levels higher than calculated by Applicant.

A-14. Since U.E. has based its projected dilution of radionuclides on an average river flow of 69,000 cfs (or 31 million gallons per minute), it is obvious that a drought-induced reduction in the flow rate below this average would decrease the amount of water available for dilution - thereby allowing the concentration of radioactive materials to be greater than calculated by Applicant. (Callaway Environmental Report - Operating License Stage - Vol. II, Table 2.4-6).

A-15. There is a 100% likelihood that conditions of freezing (ice jams) on the Missouri River, such as, for example, those which occurred between January 10 and 12, 1940, would lower the amount of dilution water available to a degree sufficient to raise the concentration of radioactive material in the Missouri River to levels higher than calculated by Applicant.

A-16. (a) The Callaway Plant Environmental Report Operating Stage, Volume II, page 2.4-6 states that the record low discharge of 4200 cubic feet per second was observed at Hermann, Missouri, from January 10 to 12, 1940. "Below river discharge near the site is estimated at 3500 cfs for the same period." (Callaway Plant Environmental Report - Operating License Stage, Vol. II, p. 2.4-6). Thirty-year low flow of 5500 cfs was selected by the Applicant as the preliminary low flow design base for the water supply intake on the Missouri River. The 1940 record low discharge occurred during a period of extensive river freezing.

(b) In addition to not including the historically recorded low-flow of 3500 cfs for the site in computing an average dilution flow rate for the river, we contend that Applicant has by-passed considerations of important worst-case, reduced river effects due to ice jams and freezing by using only average flow rates, as discussed in U.E. Interrogatory answer A-1(4). These observations support our assignment of a

100% probability to the occurrence of radioactive material concentrations in the river during periods of freezing that are larger than calculated by Applicant.

A-17. Since the Intervenors contend that the Applicant will not be able to predict the radioactive contents of the effluent accurately (see Answers to Interrogatories A-1 through A-5), it follows that the Applicant will not be able to estimate accurately the resulting bioaccumulation of radionuclides in fish affected by the plant effluent, even using the factors given in Table A-1 of NRC Regulatory Guide 1.109.

A-18. At this time, as far as our research indicates, we do not contest the validity of the steady-state stream tube model in evaluating the transport of radionuclides in the Missouri River. It is a reasonable approximation of the average. It is deceptive, however, to put only one set of average data into the model and expect the model to approximate the variety of conditions that exist in nature. Instead of modeling out just the average value of stream flow, for example, a variety of different assumptions should be fed into the model.

A-19. No.

A-20. Yes. Table 2.4-6 contains estimated day duration and frequency of different low flows at Hermann, and at the plant outlet. (Callaway Plant, Environmental Report Operating License Stage). The 7-day duration 100-year frequency low flow was estimated from historical data (1953-1973,1979) to be 6,300 cfs. (Data from 1974-1978 were omitted). Increased withdrawals and diversions are projected for the Missouri River during the lifetime of the Callaway Reactor ("Missouri River Corridor Inventory," Kansas City District, U.S. Army Corps of Engineers and Missouri Department of Natural Resources, Feb. 1981, p. 9). The record used for computation was only 22 years long and did not include as dry a period as the 1930's. The low flow figures may be considered too high. Thus they should be considered maximum estimates. No estimate of runoff conditions in the basin coinciding with a 100 year drought was computed.

Only 69,000 cfs (mean flow estimated for the station based on Hermann data 1952-1977). (Callaway Plant, Environmental Report, Operating License Stage, p. 2.4-4). This does not take into account conditions during abnormally low flows. For example, the worst situation during a week can be crudely approximated by using a flow of 6,300 cfs, assuming a person swimming downstream during a concentrated batch release. The person would be assumed to be in the area of highest concentration. There is enough nuclear power plant operating experience to evaluate the probability of the release of radionuclides in excess of permissible concentrations. The conditions during such an event were not computed by the Applicant. Only an "average" flow of 69,000 cfs was used to estimate the dilution (Callaway Plant, SNUPPS Callaway Addendum Final Safety Analysis Report, Tables 11.2-1 and 11.2-2). This average value does not take into account dry years (low rainfall) or upstream withdrawals ("Missouri River Corridor Inventory," p. 9). The 100 year frequency low flow average yearly discharge of 25,500 cfs (Callaway Plant, Environmental Report Operating License Stage, Table 2.4-6) should have been used. The mean flow figure used is 2.7 times higher.

The flow of the Missouri River varies from time to time. Nuclear power plant effluent is frequently released in batches ("Radioactive Materials Released from Nuclear Power Plants, Annual Report 1978," NUREG CR-1497, BNL-NUREG 51192, published in 1981, p. A 1-686). The fluvial system is episodic and non-linear. Nuclear power plant effluent releases are apt to be episodic and non-linear over time as well. Non-linear, episodic systems should not be represented by averages; to do so is deceptive. Instead, best and worst case scenarios should be modeled with the average and the uncertainties (statistical) and probabilities of occurrence estimated. All assumptions providing the basis for the computations should be revealed.

A-21. We do not take issue with the computer program, DISPERN, but we take issue with the limited number of average parameters that were fed into the

program, and the single set of resulting outputs. (Table 11.2-1, Si Addendum). See also Answer to Interrogatory A-20.

A-22. Yes. We take issue with the Applicant's selection of surface water model parameters in its routine effluent analysis. See answer to A-20 for supporting discussion and documentation.

A-23. We do not contest the surface-water model parameter values, based on the assumptions used by the Applicant, but we do question whether the assumptions are statistically valid for the thirty-year lifespan of the Callaway Plant, given the proposed withdrawals of water during that period, as outlined in Interrogatory Answer A-12.

A-24. Yes. The analysis should at least have been conducted close to the St. Louis City and County waterworks. We object to the use of only one set of average parameters for stream flow, as per answer to interrogatories A-1(4) and A-20. We also object, for example, to the use of the half-life on only one isotope, that is tritium, to represent a range of isotopes and their respective half-lives. For an isotope with a longer half-life than tritium (4,478 days or 12.26 years), the results of the modeling analysis would not reflect the actual accumulation conditions near the outfall pipe and elsewhere.

A-25. We disagree with Applicant's assignment of zero value to cross-stream point radionuclide concentrations below 0.3777×10^{-10} curies per cubic foot, or 37.7 picocuries/cu. ft. The concentration of 37.7 pCi/ft^3 is equivalent to 13.5 pCi/liter. The NRC limits the radioactive concentration of liquid effluent at the discharge pipe, for a mixture of unknown isotopes, to 30 pCi/1, as per 10 CFR 20, Note 2.d. The Applicant has chosen 13.5 pCi/1 as the level below which the presence of radionuclides would be considered of zero value in calculating average concentrations in environmental water samples. One does not generally denote 40% of a maximum permissible concentration as being equivalent to the absence of that quantity, or of zero value.

Furthermore, it must be remembered that the state-of-the-art monitoring equipment often is inadequately sophisticated or sensitive to detect pollutants in river samples, even though the pollutants may be present. (See Answer to Interrogatory A-1(1) and supporting documents). Problems start with the collection of the samples:

> "One of the most important - and most neglected - parts of any analytical procedure is the initial decomposition of the sample. . . . An analytical procedure can be - and generally is - a very complicated combination of many individual unit operations. the number of different chemical reactions - both intended and inadvertent - that can occur from the time the sample is collected until the final measurement is made is enormous." (Claude W. Sill, "Problems in Sample Treatment in Trace Analysis," from the National Bureau of Standards Special Publication 4-22; presented in 1974).

See also the NRC Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment," February 1979.

Other environmental monitoring deficiencies are still unresolved which would affect the validity of measurements of river samples containing concentrations at the 13.5 pCi/1 level and at levels above and below. The lack of ability to detect these low levels of radioactive pollutants does not mean they are absent, that is, "of zero value," even for purposes of averaging.

> "The preparation of environmental water samples for analysis presents a number of problems not shared by other sample types and for which clearly defined answers are not available. The problems are caused principally by two situations; the samples are two-phase systems (i.e., the water contains some insoluble material), and the behavior of many substances at very low concentrations is unpredictable or poorly understood. The variable composition of natural waters adds to the problem. The question of how, if at all, to treat samples between collection and analysis has not been unequivocally resolved, and there is little experimental evidence on which to base a decision." ("Environmental Radiation Measurements," NCRP Report No. 50; December 1976; pp. 137-8).

A-26. Yes. The limitations of such a simulation model have not been adequately addressed. Parameter values listed in Table 11.2-1 of the FSAR Site Addendum are used as assumed values, and it is noted these values are for regulated flow conditions.

The use of average river conditions as a basis for estimating processes that may be very dependent on actual flow is unrealistic.

The model ignores the seasonal development cycles of biota. There is no justification for the implicit assumption that seasonal fluctuations in flow do not affect the rate of accumulation of radionuclides by biota other than man. If the season of the most rapid growth of fish coincides with a period below-average river flow (and hence higher concentration levels of contaminants) the accumulation rates in aquatic organisms may be greatly in excess of that predicted by LADTAP. (Tables 11.2-1 and 11.2-2 of FSAR Site Addendum, Vol. 5). ("Bioaccumulaton of Radioisotopes Through Aquatic Food Chains," J.J. Davis and R.F. Foster, Ecology, Vol 39 (July 1958), pp. 530-534).

Seasonal abnormalities in river water temperature near the plant site due to effluent releases may further aggravate the accumulation of radionuclides in fish. For instance, in the winter months, when many species are normally in an inactive state and do not feed because of low temperatures, the higher water temperatures in the effluent canal may attract some species and cause them to feed and remain unseasonally active. If an unusual freezing spell should occur, lowering river flow and hence raising radionuclide concentrations, the species living in the warm effluent path could ingest even higher amounts of radionuclides. ("Radiological Surveillance Study at the Haddam Neck PWR Nuclear Power Station," EPA, 1974, p. 71).

A-27. There is no Table A-8 in USNRC Reg. Guide 1.109 (Revision 1, October 1977). Table A-8 is also referred to in the FSAR Site Addendum, 11.2.3.4.1. Assuming that the correct reference is to Table A-1, we provide the following answer:

A necessary but not sufficient condition to predict bioaccumulation in the river is knowledge of the river's discharge. Given the multiple claims on the water from the Missouri River (see, for example, the series of eight articles in the St. Louis Post-Dispatch, June 21 through 28, 1981), this first necessary condition is not met.

Accepting for the moment all of the assumptions on which the calculation of bioaccumulation is based (as stated in Regulatory Guide 1.109), fish growth is, of course, not constant with time. The value of the inputs into the model are all averages (Table 11.2-1). The concentrating of nuclides depends on the flow. Hence the values of the flow weighted to match the growth over time of the fish is the correct flow to use. This could be very different from the average flow value.

In addition, there is no evidence that the Applicant has considered that fish - being poikilothermic - feeding or swimming near the effluent site will accumulate tritium in the exchangeable protons of their proteins that will then be lost at a much slower rate than if accumulated as the fish swims upstream, downstream or across stream into cooler water. That is, the fish acquires tritium more rapidly in warm water than it loses in cool water.

A-28. Yes. See answers to A-1 through A-27.

A-29. The factual bases and supporting documents for any of the previous eleven interrogatories for which we have answered "yes" are included in those answers. Witnesses are not yet determined.

A-30. Within the constraints on resources and time available to us we have identified in our answers to interrogatories those technical anaylyses or methods, including computer programs, codes, models, Regulatory Guide criteria and tables we believe the Applicant has improperly relied upon in its effluent analysis. There may be others, but we lack the time to assess their context with regard to the Applicant's effluent analysis.

A-31. See A-30.

B-1. (a) The Applicant has said that no drinking water pathway exists within 50 miles of the plant and that the primary liquid pathway of radiological total-body exposure to an individual is through ingestion of fish caught in the Missouri River downstreaam of the plant's discharge structure. (Callaway Plant Environmental Report,

Vol. II, Page 5.2-8). This completely ignores the potential impact on the drinking water supply of the population of the St. Louis area of radioactive releases such as tritium (410 curies /yr.), Iodine 131 (.043/yr.), Cesium 137 (.026), Cesium 134 (.034), various isotopes of Jellurium which transmutate into Iodine, Strontium 89, Neptunium 239 and its daughter product, Plutonium 239 with a half life of 24,400 yrs. The U.S. Geological Survey estimates that such releases could reach the drinking water intake pipes of the St. Louis area within 23-26 hours after being released from the plant. Moreover, if U.E.'s grab-batch sampling techniques show that "doses from a particular pathway are observed to be sufficiently small, the number of media sampled and the frequency of sampling may be appropriately reduced." (Callaway Plant Environmental Report, Vol. II, page 6.2-1). Such sampling methods are inadequate to detect routine or accidental releases and Applicant is proposing to eliminate even these cursory monitoring measures.

(b) Callaway Plant Environmental Report, Vols. I & II.

(c) See Objection No. 1.

(d) Not determined.

B-2. We agree that the closest municipal user at the present time of the Missouri River water downstream from the Callaway Plant is St. Louis City, approximately 78 river miles downstream. The closest St. Louis County drinking water intake is about one-half mile farther. However, this evaluation completely ignores "potential" municipal users of Missouri River water downstream, especially as groundwater sources and surface streams in the Missouri River watershed become depleted.

The Callaway Plant Environmental Report Vol. 1 (Figure 2.1-17) notes that popluation within the 50 mile radius of the nuclear plant is projected to increase substantially over the next 10 years, particularly in St. Charles, Franklin and Warren Counties. Such growth will create additional demand for water from the Missouri River as ground water and surface streams become inadequate.

In addition, it must be noted that Applicant's evaluation of water usage downstream from the Callaway site, which provides that the closest municipal user of Missouri River water downstream from the Callaway Plant is St. Louis City is based on the "Census of Missouri Public Water Supplies, 1977," compiled by the Missouri Department of Natural Resources (DNR) and from unpublished information from DNR's files. The Callaway Plant Environmental Report Vol. 1, (page 2.1-18, 19) states that use of such date must consider the following disclaimers provided by the State of Missouri:

a. Only major users (25,000 gallons per daily average for 30 days) reported;
b. Report submitted was based primarily upon the reporting institution's desire to comply with the law;
c. No direct statewide inventory was made; and
d. Accuracy ranges from meter readings (considered acceptable) to "wild guesses."

See the following documents: Environmental Report, 5.2.4.1; FSAR Site Addendum, 11.2.3.3.3; Census of Missouri Public Water Supplies, 1980, published by the Division of Environmental Quality, Missouri Dept. of Natural Resources; Missouri River Corridor Inventory, February 1981, Kansas City District, Corps of Engineers.

B-3. Yes. During conditions of drought, it is possible that local streams would be inadequate for irrigation and that water from the Missouri River would be used. This pathway should be evaluated. (See Corps of Engineers study, Missouri River Corridor Inventory, February 1981). Further, the Callaway Plant Environmental Report, Vol. 1, page 2.1-13, notes that within 5 miles of the plant, most croplands are located on the floodplain of the Missouri River. Therefore, the "irrigation" provided by flooding should be considered as a potential pathway of liquid effluens to man in the vicinity of the Callaway Plant site.

B-4. Presently, drinking water within 50 miles downstream of the Callaway Plant discharge is provided by groundwater wells. However, drought conditions, population growth, agricultural, industrial and other uses upstream will deplete

groundwater supplies. Supplementary drinking water may have to come from the Missouri River. See Missouri River Corridor Inventory, Corps of Engineers, February 1981.

B-5. Yes. Site specific fish consumption data will provide a more accurate determination of radionuclide uptake by fish than does the LADTAP program.

Moreover, NRC Reg. Guide 1.109, Revision 1, October 1977 notes that "NRC Staff encourages the use of site-specific data, whenever possible. Such data should be documented." (1.109-11).

B-6. Applicant should evaluate effect on drinking water supplies, both of present consumers (St. Louis area) and potental users (between Callaway Plant and St. Louis area). Routine releases, abnormal and accidental releases to the Missouri River should be evaluated for their possible effect on drinking water. Also, the Applicant should provide information on the effect that flooding by the Missouri River downstream of the Callaway Plant will have on farmland and drinking water supplies, both direct contamination and contamination by percolation of radioactive water into the groundwater. The Callaway Plant Environmental Report, Vol. 1, page 2.1-15, notes that within 5 miles of the plant, most croplands are located on the floodplain of the Missouri River.

B-7. Yes. Fishermen operating out of Hermann, Missouri, for example, routinely catch fish in the Missouri River for their own consumption and for sale. Hermann is about 19 miles downstream from the plant and fishermen catch fish both upstream and downstream from Hermann. Applicant has not considered the economic impact of radioactively contaminated fish on the livelihood of these fishermen. Such contamination occurred in Tsuruga, Japan, in May, 1981.

B-8. (1) See B-2 through B-7 above.

(2) See B-2 through B-7 above.

(3) Not determined.

B-9. See B-7 above.

D-1(1) (a) Applicant has only followed Westinghouse and NRC design basis criteria and has not considered the actual annual average radioactive material discharge from currently operating nuclear reactors under routine and non-routine conditions.

(b) The SNUPPS FSAR contains an overwhelming majority of references to guideline documents and redundant cross-references with little or no reference to operating experiences at other facilities.

(c) See Objection No. 1.

(d) Not determined.

D-1(2) (a) NRC publications on non-routine releases demonstrate that such predictions as are claimed cannot be made with a high degree of certainty. The following examples taken from the LER Output cited below show documented non-predicted releases from plants of Westinghouse PWR design similar to that of Callaway:

1. Prairie Island I (August 10, 1975) page 83. Release rate of long lived halogens and particulates were twice the disign standards over a 3-month period from 5-11-75 to 8-10-75. Conclusion: Release rates of halogens and particulates are more conservative than those calculated in accordance with Regulatory Guide 1.42, Revision 1.
2. Robert E. Ginna I (June 5, 1971), page 85. Following return to power, gaseous release rates from the auxiliary ventilation system leveled off at a rate of 132% over the Iodine 131 limit. This release occurred as a result of a gasket leak around the pressure control valve on the volume control tank.
3. Robert E. Ginna I (April 19, 1972), page 86. During routine shutdown operations Iodine 131 was released which exceeded

design specification (1.3 times license limit). It was caused by a leaky flange on the boric acid evaporator.

4. Surry I (September 4, 1974), page 92. Over a 25 day period an "unspecified" amount of radioactive gases was released. These "unspecified" amounts were in excess of technical specification limits by from 4 to 22 percent. Stream generator A had a primary to secondary leak.

5. Surry I (September 29, 1975), page 96. From 9-29-75 through 10-23-75 gaseous waste was released through the ventilation vent. These releases reached rates as high as 43.5 percent of M.P.C. for one day. "Leaking equipment caused accumulation of contaminated water in the containment (building) floor. This entered the iodine filters and saturated the charcoal. Design change being processed."

6. Zion II (January 27, 1976), page 129. Over a 3-month period (fourth quarter of 1975) 26,658 curries of noble gases were vented into the atmosphere. This more than exceeded twice the annual objectives of Zion II. Union Electric's estimated annual release of noble gases at Callaway is 2,822 curies (as corrected). The Licensee Event Report at Zion II corresponds to over nine times Union Electric's estimated annual release of noble gases.

(b) (1) NRC: "Licensee Event Report (LER) Output on PWR Events Involving Released Activity from 1969 to the Present" (through March 10, 1981).

(2) Annual radioactive release reports from the NRC, e.g., NUREG/CR-1497, BNL-NUREG-51192, for the year 1978.

(3) Slade, D.H., Editor, Meteorology and Atomic Energy 1968, Atomic Energy Commission.

(c) See Objection No. 1.

(d) Not determined.

D-1(3) (a) We consider an adequate assessment to include at least consideration of the average annual isotopic releases from all operating reactors in routine and non-routine conditions over the last 5 years. The fact is that U.E. has not done this.

(b) None of the U.E. documents shows that U.E. meets our criterion (stated above) for assessing the expected discharge rate; hence we rely on them for this factual statement.

(c) See Objection No. 1.

(d) Not determined.

D-1(4) See D-1(1) and D-1(2).

D-1(5) (a) The atmosphere only appears statistically gaussian over a long term — 1-5 years. Dispersion is governed by short-term (non-gaussian) conditions as well as long-term. U.E. has relied heavily on NRC documentation (Meteorology and Atomic Energy - 1968 and Regulatory Guide 1.111) that are heavily dependent on gaussian assumptions. Hence short-term predictions of dispersion of prime importance during non-routine releases cannot be well described since, on that short time scale, gaussian assumptions fail. We feel accurate dispersion predictions should be within $\pm$ 20% of actual 90% of the time — something that current gaussian models cannot achieve.

(b) Reports on the inadequacies of gaussian dispersion models are seen in the Journal of the Air Pollution Control Association, Atmospheric Environment, and Bulletin of the American Meteorological Society.

(c) See Objection No. 1.

(d) Not determined.

D-1(6) (a) If Applicant cannot predict dispersion adequately (as indicated in (5) above) then he cannot accurately predict the interaction of the radioactive plume with the ground. They cannot predict dry deposition unless they know the plume's interaction with ground (as well as the specific removal rate for various isotopes). Hence they cannot accurately ($\pm$ 20% of the real world 90% of the time) predict the dry removal rate, much less the net removal rate. Thus the fallout rates U.E. predicts will not meet our criteria of accuracy.

(b) No specific references are necessary since the logic of this argument ties to previous reference.

(c) See Objection No. 1.

(d) Not determined.

D-2 An "adequate assessment" of atmospheric radioactive pollutants would incorporate:

1. The worst case engineering prediction of routine releases of each isotope;
2. Operating experience with unplanned isotopic releases over the past 5 to 10 years;
3. Any analysis of the release of radioisotopes that have been heretofore overlooked by the nuclearr industry as per answers to A-2 and A-4.

D-3 The "adequate assessment" above will be the closest approach to an "accurate prediction" of the releases. A truly "accurate prediction" would invclve knowledge of the future.

D-4 See D-2 above.

D-5 Not possible.

D-6 We refer to the radioisotopes cited by U.E. in Table 11.1 - 2 of the SNUPPS FSAR plus those omitted as per answers to A-2 and A-4.

D-7 See response to NRC Staff Interrogatories No. Q-4(e).

D-8 None.

D-9 "Fallout rate" is defined as the summation of dry and wet deposition along with decay of radioactive isotopes to ultimately stable isotopes.

D-10 Not-for long-term (1.5 year) averages. Yes—if the straight line method is used for short-term conditions.

D-11 No.

D-12 No.

D-13 See the answer to D-7 above.

D-14 See response to NRC Staff Interrogatories No. Q-4(a). Witness(es) not determined.

D-15 See Response to NRC Staff Interrogatories No. Q-4(a). Witness(es) not determined.

E-1 (a) (1) No <u>continuous</u> monitoring of low level beta emitters is planned for Callaway; therefore, there is no direct way of preventing the release of levels of some radionuclides including tritium exceeding 40CFR190 or even 10CFR20 Appendix B levels. Monitoring for these radionuclides, according to NRC Reg. Guide 1.21, will be performed by composite samples analyzed on a <u>monthly</u> basis. This will be totally inadequate to detect

"spikes" of radioactive release. E.g., if monthly composite samples consisted of 1 sample per day and all samples except 1 were much less than the M.P.C. (e.g.1%) it would be possible for that one sample to exceed and be 30 times M.P.C. without detection.

(2) A serious accident might interrupt normal operating procedures and prevent the routine sampling of effluents. Furthermore an acidental release might remain undetected as stated above. Only continuous monitoring could prevent this.

(3) Similar arguments used above in (1) and (2) apply to grab sample composite analysis for these radionuclides also.

(4) See (2) above.

(5) Where quantities are below the level of detection of commercial monitoring equipment there will in effect be no monitoring.

(6) See (2) above.

(b) See E-1(a) above.

(c) See Objection No. 1.

(d) Not determined.

E-2. We believe that the Applicant's proposed monitoring efforts (see SNUPPS and NRC Reg. Guide 1.21) are seriously inadequate to assure accurate prediction of the amount of radioactivity released to the environment and we suggest the following improvements in addition to U.E.'s proposed program (see 6.2.1 of Environmental Report, Operating License Stage, Vol. II):

(1) Weekly reports to Missouri Department of Natural Resources of the amounts of liquid effluent released and all aquatic

environmental monitoring from radiological release report generation system (RRRGS) as described in 11.5.2.1.1 FSAR SNUPPS.

(2) Monitoring of monthly samples of bottom sediment (actual samples) of both bottom and suspended sediments (bed load and wash load) for gross alpha, gross beta and gamma spectrum radioactivity, samples to be taken at at least three "downstream" sites and at three sites at the Western boundary of St. Louis County.

(3) Daily "downstream" water grab samples with weekly composite analysis for tritium, dissolved and entrained noble gases and gross alpha, gross beta and gamma spectrum radioactivity and with weekly reporting, including relevant discharge rates at the time of sampling as recommended in Environmental Radioactivity Surveillance Guide ORP/SID 72-2. An immediate telephone report shall be made to Missouri Department of Natural Resources of any concentration of any radionuclide in a single weekly sample which exceeds fifty percent of Table IV-2A of Appendix B of National Interim Primary Drinking Water Regulations, EPA-570/9-76-003, followed by letter within five days.

(4) Specific stations for "downstream" and "Western boundary of St. Louis County" water and sediment sampling to be set forth in the permit. "Downstream" to be reasonably close to effluent pipe. All such sites to be determined on the basis of hydrological data.

(5) Continous flow monitoring of low level beta radioactivity (tritium and carbon-14) in discharges M29 and M31 from Figure 11.1A-1 of FSAR SNUPPS, before dilution, by an anthracene or plastic scintillator flow cell or similar state of the art device. While normal releases may be near the lower limit of detection (LLD) of this instrument, a monitor of this type is essential for the assessment of accidental or unplanned releases.

(6) Monitoring of each batch release of liquid effluent from the radwaste building, prior to each release, for tritium, dissolved and entrained noble gases, and for gross alpha, gross beta and gamma spectrum radioactivity.

(7) Monitoring of groundwater and aquatic biota as in existing permit except gamma to be "gamma spectrum" instead of "gross gamma."

(8) All above monitoring to be done with the latest state of the art monitoring equipment, updated as significant improvements become available, e.g., devices for continous monitoring of effluent.

(9) All monitoring reports to be submitted in terms of pico curies per liter.

(10) The standards of 40 CFR 190 and 40 CFR 141 should be expressly recognized in the permit as national standards of performance.

For further explanation of these recommendations see transcript on appeal before the Clean Water Commission, State of Missouri, NPDES permit No. MO-0098001; and Appellants' Post Hearing Brief.

E-3. See A-2(f), above.

E-4. "Accidental releases" are unplanned releases such as those described in Licensee Event Reports (LERs) and in Evaluation of Steam Generator Tube Rupture Events, NUREG-0651, March, 1980.

E-5. We refer to the equipment Applicant intends to use at the Callaway Plant.

E-6. This interrogatory cannot be answered until the technical specifications for the Callaway Plant, Unit I are available.

E-7. See E-2 above.

G-1(1) (a) See Response to NRC Staff Interrogatory Q-6(a).

(b) (1) SNUPPS FSAR, Callaway Site Addendum and Environmental Report.

(2) Storage of Spent Fuel Elements, Proceeding of the Nuclear Energy Agency seminar, Madrid, June 1978.

(3) NRC Regulatory Guide 1.112, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Colled Power Reactors."

(c) See Objection No. 1.

(d) Not determined.

G-1(2) (a) The loss of steam generator tube integrity has been a recognized problem since at least 1974 (NRC Annual Report - 1975, page 92) and causes the leakage of radioactive primary cooling water into the secondary coolant and potentially into the environment. Some Westinghouse steam generators (such as at the Turkey Point Plant in Florida) have lasted less than 10 years instead of the original 40 year design life. The need to overhaul or replace a steam generator is a leading cause of radiation exposure among nuclear power plant workers, as at the San Onofre Westinghouse

plant in California in 1980. The Callaway Plant plans to use Westinghouse steam generators. Westinghouse has experienced the greatest degree of steam generator tube degradation. "Corrosion resulting in steam generator tube wall thinning has been observed in several Westinghouse and Combustion Engineering plants for a number of years. Another major corrosion related phenomenon has also been observed in a number of plants in recent years, resulting from a build-up of support plate corrosion products in the annulus between the tubes and the support plates. This build-up eventually causes a diametral reduction of tubes, called "denting", and deformation of the tube support plates. This phenomenon has led to other problems, including stress corrosion cracking, leaks at the tube/support plate inersection, and U-bend section cracking of tubes which were highly stressed because of support plate deformation. The significant developments in the Westinghouse steam generators since June 1977 were the following:

-Countinued tube denting at Indian Point Unit 2, San Onofre Unit 1, Surry Units 1 and 2, Turkey Point Units 3 and 4 and lesser amounts of denting at a number of other Westinghouse designed reactors.
-Discovery of support plate cracking (related to denting) at Indian Point Unit 2 and San Onofre Unit 2.
-Removal of several tubes and a section of support plate at Indian Point Unit 2 to investigate the potential for steam generator cleaning revealed continued active corrosion of the support plates. (Identification of Unresolved Safety Issues Relating to Nuclear Power Plants: Report to Congress, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission (NUREG-0510) January 1979, page A-5. NRC Program for the Resolution of Generic Issues Related to Nuclear Power Plants, U.S. Nuclear Regulatory Commission. Report to Congress, January 1, 1978).

Discussions of specific problems associated with steam generator tube integrity occurring at operating reactors were provided in two reports: "Operating Experience with Recirculation Steam Generators" (NUREG-

0523, January 1979) and "Operating Experience with Once Through Steam Generators" (NUREG-0571, March 1980).

The significant developoments in Westinghouse steam generators since July 1979 were the following:

-Steam generators inspections at Point Beach Unit 1 (Wis.) during August and October 1979 indicated extensive caustic-induced, intergranular attack and stress corrosion cracking of the steam generator tubes in the tube/tubesheet crevices. Because of concerns regarding the apparent high rate of tube degradation, the large number of tubes affected, and the detectability of cracking of tubes in the tubesheet crevices, the unit is currently operating under restrictions imposed by Orders dated November 30, 1979 and April 4, 1980. The results of required inspection in March and August 1980 indicated that the tubesheet crevice degradation phenomenon is still active, although the number of newly defective tubes found during these inspections was significantly smaller than in previous inspections. The need for confirming, by Order, the licensee's plans to perform another steam generator inspection during its scheduled refueling outage in November 1980 was under consideration by the staff at the close of the report period.

-Five units (Point Beach Units 1 and 2, H.B. Robinson Unit 2 (S.C.), R.E. Ginna (N.Y.), and Prairie Island Unit 1 (Minn.), incurred inservice steam generator leaks due to the tube-sheet crevice phenomenon since August 1979. Two additional units, Prairie Island Unit 2 and San Onofre Unit 1 (Cal.), are also known to have experienced the tubesheet crevice phenomenon. In comparison to Point Beach Unit 1, the numbers of affected tubes identified at these other units to date are considerably smaller, in some cases amounting to only one or two tubes.

-San Onofre Unit 1 has been shut down since a steam generator leak occurrence on April 7, 1980, attributable to at least five defective tubes. Multifrequency eddy current examinations and laboratory examinations of tube specimens removed from the plant indicated the leaking tubes to be among approximately 1,000 tubes with extensive caustic-induced, intergranular attack and circumferential cracking at the top of the tubesheet elevation. The licensee has initiated a repair program to install sleeves in all steam generator tubes within the zone of the tube bundle where this phenomenon is occurring. The program is intended as a long-term corrective action.

-Trojan Unit 1 (Ore.) and Farley Unit 1 (Ala.) were shut down on October 12, 1979 and June 13, 1980, respectively, because of steam generator, leaks occurring in the U-bend region of Row-1 tubes. Similar defects, which occasioned only slight leakage and did not lead to plant shutdown, were observed at North Anna Unit 1 (Va.) during the December 1979 refueling outage. These U-bend leaks are not denting-related, but the definite cause is uncertain and their safety significance is presently under staff review. In

cooperation with the Portland General Electric Company, the Westinghouse Corporation has initiated an intensive program of laboratory examination and analysis of tube specimens removed from the Trojan steam generators. Besides seeking to establish the cause and significance of these defects, the esamination will employ non-destructive methods to identify tubes which may eventually develop such defects.

-On October 2, 1979, Prairie Island Unit 1 underwent a steam generator tube rupture leading to a primary-to-secondary leak of 400 gallons-per-minute. The reactor was brought to a cold shutdown in a routine manner following the emergency procedures for such an event. Subsequent inspection revealed that the tube rupture was caused by mechanical wear of the tube by a foreign object leading eventually to a pressure burst. The foreign object was later identified as a spring, jammed by the flow-blocking device; it is believed that the spring was part of sludge removal equipment and was inadvertently left in the steam generator during a previous outage.

-The January 1980 inspection of the Prairie Island Unit 2 steam generators resulted in the finding of 132 tubes with wall-thinning indications. A laboratory analysis of the tube specimen removed from the unit indicates that the tube wall thinning was corrosion-induced, possibly related to resin carryover from the condensate polisher. The corrosion mechanism is still under investigation.

-During the first refueling and steam generator inspection outage at North Anna Unit 1 in Septmeber 1979, support plate/tube intersection corrosion cracking — and/or possible support-plate-ligament cracking — was detected. The latter is indicative of an early stage of denting. (Tube-denting is discussed in the NRC Annual Reports of 1978 and 1979). A review of the plant-chemistry data indicated that a major discharge of resins from the condensate polisher into the steam generators occurred in February 1979. The resins are believed to have decomposed in the steam generator operating environment, producing sulfuric acid. This, in turn, led to magnetite formation within the support plate crevices. A program of boric acide treatment was implemented in an attempt to stop further magnetite formation.

-Replacement of the Surry Unit 2 (Va.) steam generators has been completed, and replacement of the Surry Unit 1 steam generators in September 1980. Replacement is also planned at Turkey Point Units 3 and 4 (Fla.) subject to a hearing ordered by the Atomic Safety and Licensing Board. In the interim and prior to replacement, these units (which are extensively degraded by denting) are operating under restructions imposed by the NRC." (NRC Annual Report - 1980, pp. 46-49).

As any hydraulic system ages, leaking occurs at pump and valve seals. The two methods of remedy for this leaking, are (1) routine replacement of all seals at periodic intervals, or (2) replacing seals or entire pumps and valves as leaks are observed. The first method is very costly and no evidence has been offered that the Applicant intends to do this on a periodic basis. The second method allows some leakage to occur before the repair, hence the older plant does get leakier. In either case, the handling for replacement of radioactive seals, valves and pumps presents a health hazard to the power plant workers.

The presence of radioisotopes accelerates the corrosion rate of metallic materials. Thus piping and equipment may deteriorate more quickly than normal and wear out or develop leaks within the life time of the nuclear power plant. The entire issue of age-related fatigue related to metals being subjected to neutron irradiation is still an open, unresolved safety issue. Fracture toughness decreases with constant environmental contact with radioactive materials which increases the potential for a fracture and subsequent leakage, such as with the reactor vessel itself and with PWR steam piping (unresolved safety tasks A-11 and C-7).

Pressure relief valves vented to the atmosphere or to controlled release accumulators somtimes stick in the open position as they age and the valve action becomes corroded or caked with mineral deposits.

Scaling in the pipes and water hammer can cause higher pressures than designed, which in turn can over time cause leaks in joints, welds or seals. The unresolved safety issue of water hammer (Task A-1) is also very important. Since 1971, over 100 incidents involving water hammer in nuclear power reactors have been reported. "These incidents have involved many types of fluid systems, including steam generator

feed-rings, feedwater and steam supply piping, residual heat removal systems, emergency core cooling systems, containment spray systems, and service water systems." (NUREG-0510, p. A-3). As piping becomes older and more susceptible to fracturing due to the above mentioned problem the potential for a water ham...er incident causing release of radioactive water to the environment will dramatically increase. Improper vibration isolation from equipment can cause cracks to develop in the hydraulic system. For example, there has been a problem with fracture toughness of steam generator and reactor coolant pump supports. This unresolved generic problem (A-12) deals with the PWR steam generator and reactor coolant pump supports and their inability to resist fracture breaks and lamellar tearing. This is of extreme importance because a failure here would impair the emergency cooling system. "During the course of licensing review for a PWR a number of questions were raised as to (1) the adequacy of the fracture toughness properties of the material used to fabricate the reactor coolant pump supports and steam generator supports and (2) the potential for failure due to lamellar tearing of those same supports. The safety concern is that, although these supports are designed for worst-case accident conditions, poor fracture toughness or lamellar tearing could cause the supports to fail during such accidents. Support failure could conceivably impair the effectiveness of systems designed to mitigate the consequences of the accident. (An example of a postulated event sequence of potential concern would be a large pipe break in the reactor coolant system which severely loads the supports, followed by a support failure of sufficient magnitude that a major component such as a steam generator is severely displaced resulting in failure of the emergency core cooling system

piping which is needed to provide cooling water to the core)." (NUREG-0510, p. A-11). This would result in a core melt-down which, by anyone's standards, would result in highly signficant contamination to the Missouri River and local ground water supplies.

G-1(2) (b) See G-1(2)(a).

(c) See Objection No. 1.

(d) Not determined.

G-1(3) (a) The Callaway Plant Environmental Report Operating License Stage Volume II from Union Electric Company Table 5.2-4 lists the annual "Expected Concentrations of Radioactive Materials from Liquid Effluents of the Callaway Plant." Only one series of numbers for annual discharge is listed. These release rates are not a function of time, but are simply listed as a constant independent of plant age.

(b) See G-1(3)(a)

(c) See Objection No. 1.

(d) Not determined.

G-1(4). (a) Applicant does not list corrosion products which would be released as a result of chemical decontamination. See A-2(d) above and G-4, G-6 and G-7 below.

(b) See G-1(4)(a) above.

(c) See Objection No. 1.

(d) Not determined.

G-2 The Applicant has not included the release of any fission, activivation, corrosion products or actinides present in the spent fuel pool water in its estimates of annual releases to the environment. "One spent fuel pool volume will be processed per day," (SNUPPS FSAR, p. 9.1-17) with the potential release of some radioactivity.

In addition, some of the pool leak detection systems would allow the release of up to 60 gallons of pool water before detection (9.3-17, SNUPPS). At least some of the tritium and dissolved and entrained noble gases will ultimately be released to the environment, and containment of 100% of the rest of the contaminants is not possible.

G-3. Yes.

G-4 See response to G-1. The sources of increased releases as the plant gets older include decontamination procedures (see G-6 and G-7), possible on-site evaporation of decontamination sludge and solvents, and possible migration of radionuclides into the human environment due to the use of chelating agents as solvents. The factual basis is general engineering experience. Along with the references cited, the problems identified are substantiated by their generic similarity to those in conventional high temperature, high pressure steam systems.

G-5. Yes.

G-6. The decontamination procedures include any of five methods being tested by the NRC as listed on page 167 of Appendix E from NUREG-0371, Vol. 1 no. 1 December 1977, Approved Task Action Plans for Category A Generic Activities:

(a) Strong chemical decontamination

(b) Weak chemical decontamination

(c) On line chemical decontamination additions to the primary coolant system (hydrozine and peroxide additions)

(d) Hydraulic methods (high pressure jets)

(e) Mechanical decontamination (sand blasting using zirconium oxide)

and/or listed on page 21 of NUREG-0510, Identification of Unresolved Safety Issues Relating to Nuclear Power Plants, Report to Congress, January 1979:

(a) Chemical Decontamination

(b) Electropolishing

(c) Mechanical Decontamination

(d) Hydraulic Decontamination

G-7. Yes, it is necessary for Applicant's estimates of annual emissions to take into account releases from decontamination procedures, because:

(1) As stated in NUREG-0510 Identification of Unresolved Safety Issues Relating to Nuclear Power Plants, Report to Congress January 1979, "the presence of a layer of highly radioactive corrosion products adhering to the interior surfaces of the primary coolant system has, in one case, prevented licensees from carrying out some of the less important inservice inspections required by their technical specifications (page 20); decontamination has "the purpose of reducing the rate of steam generator tube degradation" (page 21); "decontamination [will be used at Dresden 1] to reduce occupational exposures during [Commission-ordered] modifications and primary coolant system inspections (page 21); the NRC's regulations require that radiation exposures should be maintained as low as is reasonably achievable, whereas occupational radiation exposures at operating nuclear facilities are generally increasing with time (page 42);

(2) As stated in NUREG-0371, Vol 1, No. 1 December 1977, "It has also become evident that the occupational radiation exposures received by personnel conducting required inspections, repairs and maintenance on primary system piping and components are increasing and may eventually limit the efficacy of these actions." (page 164). "The increased occupational exposure caused by activated corrosion products present throughout the primary coolant system is a matter of significant concern because of the following:

(a) Increased exposure rates in conjunction with poor accessibility on older reactors may prevent licensees from carrying out required inservice inspections.

(b) Repairs and modifications carried out in high radiation fields could limit the availability of specially qualified employees such as welders and inspectors when they reach their quarterly or annual radiation exposure limits." (page 166).

(3) Since the periodic removal of the corrosion products will be necessary to resolve the problems cited in G-7(1) and (2), above, these additional radionuclides will constitute an additional parameter which must be taken into account.

(4) See also A-2(d) above.

G-8. (1) See G-3, G-5 and G-7 above.

(2) See G-3, G-5 and G-7 above, and NRC, NUREG-0686, October, 1980; and Nuclear Regulatory Commission 1980 Annual Report.

(3) Not determined.

I-1. Yes.

I-2. Yes.

I-3(1). (a) "Delayed Effects of A-Bomb Radiation: A Review of Recent Mortality Rates and Risk Estimates for 5 Year Survivors," by Alice M. Stewart, a manuscript submitted to the British Journal of Epidemiology and Community Health on May 1, 1981.

(b) Stewart, A.M., "Childhood Cancers and the Immune System", Cancer Immunology (1980), Vol. 9, pages 11-14.

(c) Stewart, A.M., Kneale, G.W., and Mancuso, T.F., "Hanford II B; The Hanford Data — A Reply to Recent Criticisms," Ambio (1980), Vol. 9, pages 66-73.

(d) Kneale, G.W., Mancuso, T.F., and Stewart, A.M., "a Cohort Study of the Cancer Risks from Radiation to Workers at Hanford (1944 to 1977 Deaths) by the Method of Regression Models in Life-Tables.", British Journal of Industrial Medicine, in press, 1981.

(e) Kneale, G.W. and Stewart, A.M., "Pre-Cancers and Liability to Other Diseases," British Journal of Cancer (1978), Vol. 37, pages 448-457.

(f) Ugeno, Y., "Carcinogenic Hazard from Natural Background Radiation in Japan," Journal of Radiation Research (1978), Vol. 19, pages 205-212.

(g) "Revised Dose Estimates at Hiroshima and Nagasaki," (abstract) by W.E. Loewe - 29th annual meeting of the Radiation Research Society - Minneapolis, MN., June 1981.

(h) Baverstock, K.F., et al., "Risks of Radiation at Low Dose Rates', Lancet, February 21, 1981, pages 430-433.

(i) Gofman, J.W., Radiation and Human Health. In Press. San Francisco, California: Sierra Club Books. Scheduled for publication October, 1981.

(j) Hearings before the House Commerce Subcommittee on Health and the Environmnt, Ninety-Fifth Congress, on the Effect of Radiation on Human Health, Vol. I, testimony of Ethel S. Gilbert, Pacific Northwest Laboratories, February 8, 1978.

(k) Loewe, W.E., and Mendelsohn, E., "Revised Estimates of Dose at Hiroshima and Nagasaki, and Possible Consequences for Radiation-Induced Leukemia," D-80-14, Lawrence Livermore National Laboratory (1980).

(1) Other data on the health effects of low-level radiation were recently cited by the Work Group on Science of the Interagency Task Force on the Health Effects of Ionizing Radiation in its report of June 1979:

(1) Studies are cited on page 18 of the report concerning 35,000 workers employed since 1944 at the nuclear facilities in Hanford, Washington. Several of these reports by Mancuso, Stewart and Kneale indicate increased mortality from multiple myeloma and pancreatic cancer possibly associated with occupational radiation exposure. Similar patterns of excess cancer mortality in Hanford workers were described in an earlier analysis of death certificates by Milham. "Some, but not all, of these analyses have also suggested statistically significant excess mortality for lung cancer and for all cancers as a group."

(2) The Science Work Group also cites evidence on Page 17 of the mortality statistics for radiologists in the U.S. and Britain which have been compared with statistics for other physicians and for the general population in several studies over the past 35 years. Increased risk of leukemia and other cancers has been regularly documented, particularly for older physicians exposed in the early days of radiologic practice when radiation hazards were not fully appreciated (Matanoski, Seltzer and Sartwell). Table 1, (page 8) indicates that radiologists show strong associations with cancers linked to radiation.

(3) Several epidemiologic studies cited on pages 15 and 16 examined the risk of childhood cancer following in utero exposure via pelvic x-rays during pregnancy. The largest of these studies is an ongoing investigation in Great Britain, begun in 1954, in which histories of in utero exposure have been compared for children who died of cancer and for living children without cancer (Bithell, Stewart). A 50 percent overall increase in cancer risk was estimated for children irradiated in utero, risk increasing in rough proportion to the numbers of x-ray films taken. Similar estimates of total risk have been obtained in 2 other major studies. MacMahon assessed frequency of in utero radiation exposure among 7,242 cases of childhood cancer in New England. The other (part of the so-called Tri-State Leukemia Study) compared a variety of past exposures and illneses in 313 childhood leukemia cases and 854 age-matched controls, identified in parts of New York, Maryland, and Minnesota (Grahm, Levin, Lilienfeld, et al.).

(m) Recent findings by R.P. Larsen and R.D. Oldham, of the Radiological and Environmental Research Division of the Argonne (Illinois) National Laboratory reveal that platonium poses risks for the digestive system in addition to the long-recognized risks to the respiratory system:

Working under the auspices of the U.S. Department of Energy, Larsen and Oldham conducted experiments using samples of actual Chicago drinking water and of a synthetic Chicago drinking water. They analyzed the waters at the time of chlorination, and again

24 hours later, to determine the amount of plutonium in each oxidation state. After 24 hours, the proportion of Pu(VI) to Pu(IV) was markedly greater than at the time of cholorination, as is shown in the table provided in their report in Science, Vol. 201, September 15, 1978. ("Plutonium in Drinking Water: Effects of Chlorination on Its Maximum Permissible Concentration," R.P. Larsen and R.D. Oldham Science, Vol. 201, September 15, 1978, pages 1008-1009.

According to Larsen and Oldham, "We have established that Pu(IV) is oxidized to Pu(VI) by chlorine in water treatment plants and distribution systems." (Id.) In the abstract prefacing their report, the authors add that, "Under certain conditions, Pu(VI) is readily absorbed from the gastrointestinal tract. It appears that due consideration has not been given to the effect that the presence of plutonium in this oxidation state may have on the maximum permissible concentration of plutonium in drinking water." (Id.)

Larsen and Oldham call into question conclusions reached by Committee 2 of the International Commission on Radiological Protection (ICRP) in 1965. The ICRP's Committee 2 had established a task force to investigate the metabolism of plutonium and related elements. One of the task group's conclusions, in an article published by the ICRP in 1972 (A. Lindenbaum et al., "The Metabolism of Plutonium and Other Actinides" (ICRP Publication 19, Pergamon, New York, 1972), was that "the current value for the gastrointestinal absorption factor, 3×10^{-5}, appears to be reasonable for soluble plutonium compounds. In drawing this conclusion, the task group either did not consider the possibility

that Pu(VI) would be formed during water treatment or, if they did, they concluded either that the data obtained by Weeks et al. (M.H. Weeks et al., Radiation Research 4, 339 (1956)) on the absorption of Pu(VI) were invalid or that Pu(VI) would be rapidly reduced to Pu(III) or Pu(IV), or both, in the gastrointestinal tract." (Plutonium in Drinking Water: Effects of Chlorination on Its Maximum Permissible Concentration," R.P. Larsen and R.D. Oldham Science, Vol. 201, September 15, 1978, pages 1008-1009).

In the experiments conducted by Weeks et al., referenced above, plutonium in the oxidized state was administered to food-deprived rats to measure the rate of absorption and degree of retention in the gastrointestinal tract. The results showed that, at 80 days, retention of Pu(VI) was much higher than that of Pu(III) or Pu(IV). Larsen and Oldham describe the findings of Weeks et al. as "quite definitive." They point out that, while the ICRP task force was aware of the experiments by Weeks et al., they doubted the validity of the data and characterized the evidence as "meager."

Because the oxidizing effects of chlorine on plutonium were not given adequate consideration in the past, Larsen and Oldham point out, "present values for the maximum permissible concentration (MPC) of plutonium in drinking water (5pCi/ml for the general public) (Standards for Radiation Protection (Energy Research and Development Administration Manual, Washington, D.C., April, 1975, chapter 0524.) appear to be too high by several orders of magnitude. . . It is our view that. . . due consideration was not given to evidence in the literature that the absorption of Pu(VI) is higher by three orders of magnitude than that for Pu(IV)

or to the possibility the Pu(VI) could formed during water treatment." (Id.).

(n) A "Plea for Applied Research" on technetium-99 was issued by the Oak Ridge National Laboratory in 1978, and was published in 1979 in Health Physics (Vol. 36, pp. 21-30):

p. 21: "Little information is available to provide insight into possible long-term retention of Tc-99 in organs of interest (notably the thyroid); such data are needed tc accurately assess the dose due to chronic exposure to routine releases from a nuclear facility. There is an urgent need for information describing the uptake and retention of Tc-99 in children, since they could comprise the critical segment of the population at risk." (emphasis added. by J.E. Till, et al.).

Health Physics, Vol. 36, pp. 21-30, Pergamon Press Ltd. 1979 (Research sponsored by the Department of Energy under contract with Union Carbide Corp. J.E. Till, F.O. Hoffman and D.E. Dunning, Jr., Health and Safety Research Division, Oak Ridge National Laboratory.):

> "Because of the inadequacy off the data currently available, we feel that it is not possible to derive a 'best estimate' of the soil-to-plant concentration factor for 99Tc. However our analysis of reported concentration factors for 99Tc in soil and plants suggests that the value presently being used, 0.25 significantly underestimates the uptake of 99Tc through the roots. On the other hand, it is entirely possible that the concentration factors obtained under laboratory conditions could be overestimates. Nevertheless, one cannot be justified at this time in disregarding the data shown in Tables 1 and 2 and continuing to assume a concentration factor of 0.25." (p. 24)

> "Finally, we should emphasize that this analysis does not include the contribuiton to dose via liquid effluent pathways. Therefore, the total dose from

99Tc may be higher than that calculated here when all pathways of exposure are considered." (p. 27)

"This assessment indicates that 99Tc is a potentially critical radionuclide in the nuclear fuel cycle. However, the confirmation of this assessment can only be determined after improving the state of knowledge about the environmental behavior and dosimetric properties of this isotope." (p. 28)

(o) CRC Handbook of Chemistry and Physics, 61st Edition, 1980-81, page B-41: "Technetium-99 has a specific activity of 6.2×10^8 disintegrations per second/g. Activity of this level must not be allowed to spread. Tc^{99} is a contamination hazard and should be handled in a glove box."

(p) A BEIR Report (Biological Effects of Ionizing Radiations) by a committee of National Academy of Sciences members, was prepared in 1972 ("The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," Report of the Advisory Committee on the Biological Effects of Ionizing Radiations, Div. of Medical Sciences, National Academy of Sciences, National Research Council, Wash., D.C. 1972) for the Federal Radiation Council (which has since become a part of the Environmental Protection Agency). In 1976, EPA requested another study which was submitted by the 20-member committee in May 1979 with conclusions similar to the 1972 report. ("The Effects on Populations of Exposure to Low Levels of Ionizing Radiations," Report of the Committee on the Biological Effects of Ionizing Radiations, Division of Medical Science Assembly of Life Sciences, National Research Council, National Academy of Sciences, 1979; hereafter "1979 BEIR"). This 1979 report was recalled, however, at the request of six of the 20

members, and the six revised the chapter on somatic effects over the period of a year, publishing the final report in June 1980. ("The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," Committee on the Biological Effects of Ionizing Radiations, Division of Medical Science, Assembly of Life Science, National Research Council, National Academy of Science 1980; hereafter "1980 BEIR"). The final report was never acted upon by the 20-member committee.

The six dissenters used a new formula for estimating cancer deaths from gamma rays which softened the 1979 projections, and chose to ignore the subject of cancer incidence which was detailed in the 1972 and 1979 reports. The following comparisions reflect not only the curious degree to which six are able to outweigh the consensus of 20, but also the irreconcilable differences in assessments of hazards among our leading scientists:

Estimated increase in mortality from a single 10-rad exposure

1979 BEIR pp. 329, 330: female, .5% - 2.7% male, .4% - 2.0%

1980 BEIR p. 191: no assignment by sex .5% - 1.4%

Estimated increase in mortality from continous lifetime exposure of 1 rad/year

1979 BEIR p. 330: female, 8% - 17% male .4%-10%

1980 BEIR p. 194: no assignment by sex 3% - 8%

Estimated increase in cancer incidence from continuous lifetime exposure of 1 rad/year

1979 BEIR p. 330: female, 8.4% - 32.6% male, 5.2% - 17.9%

1980 BEIR no estimates

These estimates were extrapolated from estimated doses from the nuclear explosions at Hiroshima and Nagasaki as calculated in T65D which stands for Tentative Dose Estimates compiled in 1965, and were assembled by John Auxier of Oak Ridge National Laboratory. (In 1972 these original data were shredded by mistake. SCIENCE, Vol. 212, May 22, 1981, p. 902). T65D claimed radiation at Hiroshima was largely from neutrons (high LET — Linear Energy Transfer) with a small amount of gamma rays (low LET); Nagasaki showed negligible neutron evidence as gamma radiation was predominant. Mortality and incidence were higher in Hiroshima, so neutron radiation was deemed responsible.

Now comes "Revised Dose Estimates at Hiroshima and Nagasaki," by W.E. Loewe and E. Mendelsohn (U.C.R.L. 85446 preprint, 1 Oct. 1980, Lawrence Livermore National Laboratory, Livermore, Calif.), presented in May 1981, which shows that neutron radiation was 1/9 that given in T65D, and gamma radiation was three times that given in T65D. Edward Radford ws the chairman of the 1979 and 1980 20-member BEIR committee and has stated that the new evaluation indicates that risk estimates in all BEIR reports (1972, 1979, 1980) are too low. (SCIENCE, Vol. 213, July 3, 1981, p. 6). Other scientists disagree, but all insist furtherr work must be done, and the "data base containing information on the individual Japanese survivors must be revised to reflect" the new estimates. (Id.).

There is no conventional wisdom on ill effects and threshhold tolerances of low-level radiation; new data have served only to

increase the questions which must be answered, and no utility can claim that any amount of low-level radiation is harmless.

I-3(2). (a) Tritium Toxicity: Effect of Low Level ^{3}HOH Exposure on Developing Germ Cells in the Mouse Radiation Research, R. Lowry Dobson and Mary E. Cooper: Radiation Research, 58, 91-100 (1974).

Two orders of magnitude lower concentration: [0.085 microcuries/ml of body water] than ever before given to mice showed decrease in female offsprings' oocytes. This study demonstrates a low than predicted threshold of harmful effects [0.5-1.0 microcurie/ml body water].

(b) R. Lowery Dobson and T. Chinnie Kwan, "The RBE of Tritium Radiation Measured in Mouse Oocytes: Increase at Low Exposure Levels." Radiation Research 66, 615-625 (1976).

RBE increases the lower the dose of tritium whereas Beta RBE lowers the lower the dose of gamma rays. Tritium's relatively low energy compared with gamma rays allows increased LET (Linear Energy Transfer). As dose approaches zero tritium RBE approachs 3 (instead of 1 as is currently used as the basis of determinations of tritium's radiotoxicity).

(c) Ito, T. and Kobayashi, K.: "Mutagenisis in Yeast Cells by Storage in Tritiated Water." Radiation Research 76, 139-144 (1978).

Frequency of mitotic gene convertants increased linearly with the amount of time for which yeast cells were suspended in tritiated water. Efficiency of induction was two to three times higher than by gamma ray irradiation.

(d) Mewissen, D.J., Ugarte, A.S., and Rust, J.H.: "Genetic Effects from Exposure of Male Mice to Tritium for Six Generations" Radiation Research 70 (3): 629 (1977).

Litter size was reduced in fourth and fifth generation from exposure to tritiated drinking water of male genitor. Weight consistently decreased through successive generations. Control mice were fairly constant.

(e) Carsten, A.L. and Commerford, S.L.: "Dominant Lethal Mutations in Mice Resulting from Chronic HTO Ingestion," Radiation Research (66) 609-614 (1973).

Increased early embryo deaths of second-generation parents maintained on tritiated drinking water without corresponding increase of late embryo deaths, indicating a severe genetic defect rather than a physiological defect from exposure of pregnant female to tritiated water.

(f) Hori, Tada-Aki and Nakai, Sayaka: "Unusual Dose Response of Chromosome Aberrations Induced in Human Lymphocytes by Very Low Dose Exposures to Tritium," Mutation Research, 50, 101-110 (1978).

Chromatic breaks increased linearly with high dose; in the lower dose ranges the breaks were higher than expected. That is, the dose/response was not linear; at lower dose tritium was more efficient.

(g) Dobson, R.L., "The Toxicity of Tritium," Vol. 1: "Biological Implications of Radionuclides Released from Nuclear Industries," International Atomic Energy Agency, Vienna 1979 (hereafter IAEA, Vienna, 1979), pp. 203-213.

Abstract Results: Mice injected with tritium (0.07 mCi/g body wt) before birth (9 days after conception) had offspring showing "a significantly decreased weight of brain and genital tract organs." (Table p. 247).

Four and one/half month old offspring had substantially fewer ooctyes (Table 248). Also seminiferous epithelium in state of disintegration (p. 250). At 2 months these offspring were fertile.

"After injection of 0.27 mCi tritium/g neither sex appeared to be fertile at age of 2 months." (p. 250).

"At 18 months the ovarian tumor incidence of exposed offspring was increased approximately 5-fold over controls." (p. 251).

0.54 mCi tritium/g caused 100% perinatal mortality. 0.54 mCi tritium/g injected on days 7, 9, 11, stunted foetuses, but malformations were negligible. (p. 251). Treatment of dams on days 7 and 9 led to resorption of embryos. Those injected with more than 0.81 mCi/g all had resorbed embryos, some dams died. (Table p. 244).

(j) Burki, et al., "Tritiated Uracil, Tritiated Thymidine and Bromodeoxyuridine-Induced Mutations in Eucaryotic Cells," IAEA Vienna 1979, Vol. 1, pp. 255-65.

Abstract Results: Yeast cells growing in tritiated uracil then exposed to very low dose rates: 1.4-27.6 tritium decays/hr. Each decay equivalent to 2.6 rad. Determination of RBE affected by precise experimental conditions employed. "In particular, experiments with mammalian cells will be affected by "hot times" for mutagenesis in the cell cycle and "hot positions" within the

DNA in the nucleus, and also by the position of tritium decays within the DNA incorporated molecule.

(k) Rytomaa, et al., "Radiotoxicity of Tritium-Labelled Molecules," IAEA Vienna 1979, pp. 339-49.

Abstract: Tritiated protein precursors and RNA and DNA precursors were roughly 10, 100 and 1000 times as toxic as ^{3}HOH to rapidly growing malignant cells (p. 347, tables on pp. 342, 343).

"Results indicate that in evaluating the harmful effects of tritium it is essential to consider several factors such as the chemical nature of the tritiated substance entering the body and the metabolic status of the cells of the organism." (p. 347).

Discussion: "Harmful effects. . . of environmental ^{3}H appear often to be underestimated." Essential to remember tritum from tritiated water is converted into organic compounds, in biological systems. "These substances readily cross the placental barrier and become incorporated into the cells of the developing embryo." (p. 347). "It is clear that the biological half-life of tritium and its total body burden are not sufficient as indicators for deducing quantative risk estimates. (p. 348).

Tritium is incorporated into biologically important molecules hence its distribution among them has a great effect on the radiation damage.

(l) Mewissen, et al., "Tritium Distribution and Incorporation from Tritiated Water or Tritiated Precursors of DNA, RNA or Proteins," IAEA Vienna 1979, Behavior of Tritum in the Environment, pp. 469-488.

Abstract Results: Newborn C57 Black/6M mice were injected with tritiated thymidine. The incidence of lymphosarcomas increased. Dose range was 0.3 to 1.5 microcuries/gram of body weight. Newborn and juvenile C57 Bl/6M mice were injected with 1 or 10 microcuries of the following/g of body weight: tritiated thymidine, tritiated uridine or tritiated leucine. Young adult mice were similarly injected. Results when mice were sacrificed and examined after varying lengths of time: A very complex time-dependent and on some cases age-dependent residual activity dynamics both in the organic component and aqueous fractions of tissue. Fifteen day old males injected with 100 microcuries of HTO/g of body weight showed a "significant though small" incorporation of tritium into DNA, RNA and proteins in all organs tested.

In discussion, Mewissen suggests ten times the toxicity for these substances compared to toxicity for HTO. Later he said ingested material is less effective than injected which would tend to lessen the difference somewhat.

(m) Moghissi, "Biological Half-Life of Tritium in Humans," IAEA, Vienna 1979, Behavior of Tritium in the Environment, pp. 501-07.

Two former dial painters using a tritiated luminous compound, predominantly tritiated water, were studied about six months after they quit work. Tritium in urine was well above the minimum limit of detection of about 0.2 curies/liter. The half-lives of tritium for the two workers were 340 and 630 days respectively. Sonusodal pattern "Obviously, temperature, water intake, and certain other factors influence the excretion rate. . . It is clear

that mechanisms other than temperature and water intake are involved.

Discussion: p. 506, L.K.Miettinen: Sharp peaks might be explainable. . . but sharp drops as if metabolism stopped "then started again. Such things do not take place in cetabolism." A.A. Moghissi, "I agree. . . most strange. We checked on various possible pathways of contamination but always drew a blank. At all events the highest value for 1963 tritium in the United States of America was not as high as the peak of the data we have here."

A.A. Moghassi: "Also, several years ago we ran a programme called the "Institutional total diet sampling network," which comprised a bioassey programme. The normal body water concentration in control subjects is in the range 0.2 to 0.5 nano Curies/liter which is much lower than the concentrations we report here." (p. 507).

(n) Osborne, "Diffusion Kinetics of Tritiated Water Through Human Skin," IAEA, Vienna, 1979, Behavior of Tritium in the Environment, pp. 509-20.

The delay in permeation of tritiated water vapor (HTO) through human skin has been estimated from measurements in vivo. HTO absorbed was estimated from urine concentrations. Delay estimates were in range of 8-17 minutes.

I-3(3). See I-3(1) and (2) above.

I-3(4). See Objection No. 1.

I-3(5). Not determined.

Kenneth M. Chackes, attorney for Joint Intervenors Coalition for the Environment, St. Louis Region; Missourians for Safe Energy; and Crawdad Alliance, and authorized as their agent for the purpose of answering the above interrogatories, hereby states to the best of his knowledge, information and belief that the responses provided above are true and contain such information as is presently available to Joint Intervenors.

Kenneth M.Chackes

Subscribed and sworn to before me this 16 day of July, 1981.

Notary Public

My Commission Expires: 5/18/83

CHACKES AND HOARE

Kenneth M. Chackes
Attorneys for Joint Intervenors
314 North Broadway
St. Louis, MO 63102
314/241-7961

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
UNION ELECTRIC COMPANY	)	Docket No. STN 50-483-OL
	)	
(Callaway Plant, Unit 1)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of the Response to Applicant's Interrogatories and Requests for Document Production (Set No. 1) to Joint Intervenors on their Contention 2 have been served on the following by deposit in the United States mail this 16 day of July, 1981.

James P. Gleason, Esq., Chairman
Atomic Safety and Licensing Board
513 Gilmoure Drive
Silver Spring, MD 20901

Mr. Glenn O. Bright
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. Jerry R. Kline
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Thomas A. Baxter, Esq.
Shaw, Pittman, Potts & Trowbridge
1800 M Street, N.W.
Washington, D.C. 20036

Docketing and Service Section
Office of the Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Roy P. Lessy, Jr., Esq.
Office of the Executive Legal Director
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Kenneth M. Chackes
CHACKES AND HOARE