UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

MEMORANDUM TO: Frank J. Miraglia, Jr., Acting Director
Office of Nuclear Reactor Regulation

FROM: Thomas T. Martin, Director
Division of Reactor Program Management

SUBJECT: LWR OCCUPATIONAL DOSE DATA FOR 1995

Attached for your information is the 1995 occupational dose summary for operating U.S. nuclear power plant facilities. This summary contains a listing of the occupational dose for each of the 109 nuclear plants included in the 1995 tabulation, as well as a listing of the number of people receiving doses in each of 13 dose ranges for each of these plants. In addition, this report contains a ranking of PWRs and BWRs in ascending order of collective dose per reactor for 1995 and graphical representations of LWR data (average collective dose, number of workers, number of operating plants, and gross electricity generated) over the twenty-three year period between 1973 and 1995. For the five PWR and five BWR sites which had the highest per unit doses in 1994, this report contains a listing (with corresponding person-rem doses) of the major activities which contributed to these high doses. Over 85% of the collective dose at these sites was accrued during outage periods.

The number of operating reactors in 1995 remained the same as last year's total of 109 units. The average collective dose per reactor for these 109 LWRs was 199 person-cSv (person-rem). This is the same as the 1994 LWR dose average and, together with the average dose for 1994, is the lowest LWR average dose since 1969 (when there were only seven operating LWRs).

The average dose per reactor for the 72 operating PWRs in 1995 was 170 person-cSv (person-rem). This represents a 28% increase over the 1994 average of 133 person-cSv (person-rem) per reactor but it is still the third lowest average PWR dose ever recorded (behind 133 person-cSv (person-rem) per reactor recorded in 1994 and 165 person-cSv (person-rem) per reactor, recorded in 1969, the first year when records were kept).

The average dose per reactor for the 37 operating BWRs in 1995 was 256 person-cSv (person-rem). This is significantly lower than the 1994 average of 327 person-cSv (person-rem) per reactor.

As stated earlier, the average LWR dose per reactor in 1995 of 199 person-cSv (person-rem) is the lowest measured average LWR dose since 1969 (the first year in which the NRC began tabulating these figures). The 1995 average dose is over 550 person-cSv (person-rem) per reactor less than the 1983 LWR average

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of 753 person-cSv (person-rem) per reactor (1983 is the year when the LWR average dose per unit last peaked). In this same time span, the average measurable dose per worker for LWRs has dropped by more than half, from 0.66 rem in 1983 to 0.25 rem in 1995.

As part of a separate memorandum from the Emergency Preparedness and Radiation Protection Branch, copies of the attached report have been sent to the regional HP management, the Office for Analysis & Evaluation of Operational Data, the Office of Public Affairs, the Office of Research, the Public Document Room, and individuals in the nuclear industry who have expressed an interest in this report in the past.

This report was compiled by Charles Hinson, NRR, NRC, with the assistance of our contractor, SAIC, which supplied some of the data. Any questions concerning the content of this report should be directed to Charles Hinson at (301) 415-1845.

Attachment: As stated

LWR OCCUPATIONAL DOSE DATA FOR 1995

This is a compilation and analysis of occupational radiation doses reported from light-water-cooled reactors (LWRs) for the year 1995. The information was derived from individual worker dose reports submitted to the Commission in accordance with 10 CFR 20.2206.

In 1995 the total number of LWRs included in the list of operating reactors remained the same as last year's total of 109 units (a reactor is added to this list after it has completed its first full year of commercial operation). Reactors which are no longer included in the compilation of reactor data are: Indian Point 1, Rancho Seco, San Onofre 1, Three Mile Island 2, Trojan, and Yankee-Rowe (all pressurized water reactors [PWRs]); Dresden 1, Humboldt Bay, and LaCrosse (all boiling water reactors [BWRs]); and Fort St. Vrain (a high temperature gas cooled reactor).

The total collective dose for all 109 LWRs included in the 1995 listing was 21,674 person-cSv (person-rem) (see Table 1a). This is slightly lower than last year's total of 21,695 person-cSv (person-rem). [Note: In last year's dose report, the 1994 annual dose for Farley 1 and 2 was mistakenly reported as being 89 person-cSv (person-rem). In actuality, Farley's dose in 1994 was 250 person-cSv (person-rem). This correction changes the total LWR collective dose from the previously reported 21,534 person-cSv (person-rem) to the correct value of 21,695 person-cSv (person-rem).] The average collective dose per reactor for LWRs in 1995 was 199 person-cSv (person-rem). This is the same value as the 1994 LWR average dose per reactor (see Figure 1) and it is, along with last year's average, the lowest LWR average dose since 1969 (when there were only seven LWRs operating). The number of workers with measurable dose per reactor increased slightly from 764 in 1994 to 803 in 1995 (see Figure 1). The number of operating reactors and the electrical generation data are shown in Figure 2. The average measurable dose per worker for LWRs has decreased to 0.25 cSv (rem) from the 1994 value of 0.26 cSv (rem) (see Figure 3). This

Attachment

average dose per worker is 30% of what the average worker dose was 20 years ago. The collective dose per gross megawatt-year (MWe-year) has decreased slightly from a value of 0.28 in 1994 to 0.27 in 1995 (see Figure 3). This is the lowest average yearly value yet measured for this number.

In 1995, the total collective dose for PWRs was 12,207 person-cSv (person-rem) for 72 reactors. The resulting average collective dose per reactor for PWRs in 1995 was 170 person-cSv (person-rem) per reactor (see Figure 1). This represents a 28% increase over the 1994 value of 133 person-cSv (person-rem) per reactor but it is still the third lowest average PWR dose ever recorded (behind 133 person-cSv (person-rem) recorded in 1994 and 165 person-cSv (person-rem) per reactor, recorded in 1969, the first year when records were kept). The average number of personnel with measurable doses per PWR increased from 613 in 1994 to 720 in 1995. The average measurable dose per worker for PWRs in 1995 is 0.24 cSv (rem). This is slightly higher than the 1994 value of 0.22 cSv (rem).

In 1995, the total collective dose for BWRs was 9,467 person-cSv (person-rem) for 37 reactors. The resulting average collective dose per unit for BWRs in 1995 was 256 person-cSv (person-rem) per unit. This is significantly (22%) lower than the 1994 value of 327 person-cSv (person-rem) per unit. The average number of personnel with measurable doses per BWR decreased from 1,057 in 1994 to 964 in 1995. The average measurable dose per worker also decreased, from 0.31 cSv (rem) in 1994 to 0.27 cSv (rem) in 1995.

The compilation in Table 1a represents a breakdown of the collective dose incurred at each LWR that had completed at least one full year of commercial operation by the end of 1995. Table 1a also lists the reactor type and the annual whole body dose distributions for each of the 109 LWRs in this year's compilation. Table 1b presents the same type of dose breakdown for those LWRs which are either no longer in operation or have been in operation for less than one year. The collective dose figures listed in Table 1 are actual total dose figures submitted by the licensee in response to the requirements of 10 CFR 20.2206.

Figure 1 shows the average collective dose figures for PWRs, BWRs, and LWRs for the years 1973-1995. For the twenty-second consecutive year, the average collective dose per reactor for BWRs has remained higher than that for PWRs. The lower half of Figure 1 shows the number of workers with measurable dose per reactor for the years 1973-1995. This number has been gradually decreasing since 1984, when it peaked at an average of 1522 personnel with measurable doses per plant. Figure 2 is a plot of the total number of operating reactors and the gross electricity generated for each of the years from 1973-1995. As can be seem from these figures, the gross electricity generated has continued to increase (growing 20% in the past eight years), even though the number of operating reactors leveled out five years ago.

Table 2a lists the 72 PWRs in ascending order of collective dose per reactor for 1995. As stated previously, the PWR average collective dose per reactor in 1995 was 170 person-cSv (person-rem). The number of PWRs which reported collective doses of 100 person-cSv (person-rem) per reactor or less was down from thirty reactors in 1994 to fifteen reactors in 1995 (21% of the PWR units in Table 2a). Ten years ago, only four PWRs reported average collective doses of 100 person-cSv (person-rem) per reactor or less. One hundred person-cSv (person-rem) is the annual dose limit that is being used as the goal for the advanced reactor designs. The five PWR sites (six individual reactors) with the highest collective doses in 1995 all exceeded 398 person-cSv (person-rem) per reactor. These reactors were Maine Yankee, Indian Pt. 2, Palisades, Haddam Neck, and Zion 1 and 2. Although representing only 8% of the 72 PWRs counted in 1995, they contributed nearly 24% of the total collective dose at PWRs. Some of the activities which contributed to the collective dose accumulated at the PWR with the highest average dose per reactor in 1995 [Maine Yankee, with 653 person-cSv (person-rem)] were steam generator related work (including tube sleeving, eddy current testing, and sludge lancing), reactor coolant pump work, outage support, valve work, decontamination, refueling activities, and in-service inspection. In 1995, the collective dose per MWe-year for PWRs was 0.22. This indicates a better than 4:1 ratio of MWe-years generated to the collective dose accumulated during 1995.

Tables 2a and 3a include a listing of the "CR" values for each reactor. The "CR" value is defined as the ratio of the annual collective dose delivered at individual doses exceeding 1.5 cSv (rem) to the total annual collective dose. The United Nations

Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) recommends that this parameter remain in the range between 0.05 and 0.50. There were no reactors which exceeded this recommended range in 1995.

Table 2b lists the three-year average doses per PWR in ascending order, as well as the collective dose per reactor for the last three years. Several PWRs have consistently achieved very low collective doses and therefore appear near the top of Table 2b. Some of these low dose plants, such as Seabrook, Commanche Peak 1 and 2, and South Texas 1 and 2, are relatively young plants, while others, such as Prairie Island 1 and 2 and Kewaunee, have been in operation for over two decades. The five PWR sites with the highest doses per reactor in 1995 are indicated with an asterisk to give an indication of their performance over the last three years. Several of these PWRs are consistently among the highest dose plants as evidenced by their high three-year dose averages. Table 4b gives a breakdown of some of the major activities which contributed to the collective dose received at these high dose plants in 1995. It appears that the activities which most frequently contributed to these high collective doses in 1995 were steam generator related work, valve related maintenance and repair work, refueling activities, scaffolding and insulation installation and removal, in-service inspections, health physics coverage, and reactor coolant pump maintenance.

Table 3a lists the 37 BWRs in ascending order of collective dose per reactor for 1995. The average BWR dose per reactor in 1995 was 256 person-cSv (person-rem). Six BWR units--Fermi 2, Monticello, Big Rock Point, Perry, River Bend 1, and Oyster Creek--reported collective doses in 1995 which were less than 100 person-cSv (person-rem) per reactor. The annual collective dose for one of these reactors, Oyster Creek, has historically been one of the highest in the country. In 1995, the five BWR sites (seven individual reactors) with the highest collective doses all exceeded 379 person-cSv (person-rem) per reactor. These reactors were Millstone Point 1, Pilgrim, Washington Nuclear 2, Dresden 2 and 3, Nine Mile Point 1 and 2. [Note: The average dose per reactor at these five sites in 1995 was 456 person-cSv (person-rem) compared to an average of 675 person-cSv (person-rem) per reactor at the five highest dose reactor sites in 1994]. Although the seven reactors at these five sites represented only 19% of the 37 BWRs, they contributed a third of the total collective dose incurred at BWRs in 1995. Some of the activities which contributed to the collective dose accumulated at the BWR site with the highest collective dose per

reactor [Millstone Point 1 with a total of 620 person-cSv (person-rem)] were weld repair, in-service inspection, hangar work, insulation removal and replacement, staging work, and refueling activities.

Table 3a and Figure 3 also give the collective dose per gross MWe-year for BWRs to indicate their power generation performance as it relates to the collective dose incurred by the workers at these plants. In 1995, the collective dose per MWe-year of 0.38 for BWRs was below 0.50 for the first time. As in previous years, the collective dose per MWe-year remains higher for BWRs than for PWRs. One contributing factor for this difference is the larger power generation capacity of most PWRs.

Table 3b lists the three-year average doses per BWR in ascending order, as well as the collective dose per reactor for the last three years. The BWRs with the lowest and the third lowest three-year average doses, Fermi 2 and Limerick 1 and 2, are relatively young plants, while Big Rock Point, Vermont Yankee, and the next several BWRs near the top of Table 3b have been in operation for much longer periods of time. The five BWR sites with the highest doses per reactor in 1995 are indicated with an asterisk to give an indication of their performance over the last three years. As was the case for PWRs, several of the BWRs with the highest collective doses in 1995 are also among the plants with the highest three-year dose averages. Table 4a gives a breakdown of some of the major activities which contributed to the collective dose received at these high dose plants in 1995. The activities which most frequently contributed to these high collective doses were in-service inspections, valve maintenance work, refueling activities, shielding installation and removal, and area and system decontamination.

As can be seen from Figure 1, the LWR average collective dose has continued on a general downward trend from the peak doses seen in the early 1980s and the 1995 LWR average dose (which has not changed from last year's value) is the lowest yearly average dose recorded since 1969. The average measurable dose per worker of 0.25 person-cSv (person-rem) is also the lowest yearly average yet recorded for this number. Along with the completion of a majority of the TMI-mandated fixes (a contributor to higher doses after the 1979 accident), one of the major reasons for this decreasing dose trend at LWRs is the increased emphasis being placed by the utilities,

industry, the NRC (through the BNL ALARA Center), and INPO on the importance of effectively applying ALARA principles at LWRs. All of the plants contacted in gathering data for this report had dedicated ALARA coordinators on their staff for the purpose of ensuring that ALARA principles and practices are factored into all maintenance and operations work to reduce overall personnel exposures. All plants contacted maintained detailed records of job-specific doses incurred during both outage and non-outage periods. Many of these plants also recorded good practices and identified areas for improvement associated with high dose tasks. Such a detailed job and dose tracking system is a vital part of a good ALARA program because it provides a good lessons learned data base for future reference and use. Most plants contacted made use of this type of historical data to set aggressive dose goals.

Tables 4a and 4b list the major activities contributing to the doses for the five BWR and five PWR sites, respectively, which had the highest collective doses in 1995. These tables also list the outage dose and duration for each of these LWRs in 1995. As can be seen from these data, on the average, over 85% of the annual collective dose for these plants is accrued during outages. This supports the findings from an earlier study (Memo from C. Hinson (NRC), "Representative Daily Collective Doses at PWRs and BWRs During Both Outage and Non-Outage Conditions", March 1, 1990) which showed that the average daily outage doses exceeded the average daily non-outage doses by a factor of 31 for PWRs and by a factor of 9 for BWRs. In addition, the ten LWR sites (thirteen units) which had the highest collective doses in 1995 spent an average of 113 days down per unit for outage work in 1995 (compared with 100 outage days per unit in 1994).

One way to reduce a plant's annual collective dose is to reduce the frequency and duration of plant outages by detailed outage planning and scheduling of jobs to minimize critical path time. There are several ways in which outage doses can be reduced. The use of permanent scaffolding to access high dose rate areas where frequent maintenance/inspection is performed would eliminate both the downtime necessary to erect and take down this scaffolding each outage and also the corresponding personnel doses associated with scaffolding erection and tear-down. Wider use of permanent scaffolding or platforms in high dose rate areas (such as around steam generators, recirculation piping, and reactor coolant pumps) can also contribute to the lowering of plant collective doses. In plant areas where the

installation of permanent scaffolding is not practical, the use of transportable scissor-type lifts, such as "lift-a-lofts", in place of standard scaffolding may result in savings of both outage time and personnel dose. If standard scaffolding is used, then time and dose can be reduced by storing these scaffolding materials in designated areas near where the scaffolding is normally used (scaffolding normally used in containment should be stored inside of containment, if possible, between outages).

Another means of reducing outage doses is to improve the use of shielding. Use of permanent shielding versus temporary shielding in high dose rate areas would reduce the doses associated with the installation and removal of temporary shielding during outages. In instances where it is not feasible to install permanent shielding, the installation of temporary shielding could be facilitated by installing permanent hooks/hangers in areas where this temporary shielding is required. Use of such hooks/hangers would reduce the time needed to install this shielding in radiation areas. Some areas where hooks/hangers for temporary shielding have been installed are in the vicinity of the recirculation system piping and around some unshielded turbine components at BWRs. Prior to installing any temporary or permanent shielding, one should evaluate the effects of shielding weight on plant structures and components. Inflatable shields which can be filled with water or lead shot have been used at many facilities. The advantages of using this type of shielding are that it is portable and a large uninflated shield can be easily carried by an individual to the installation area and filled in-situ. Other facilities have reported success using prefabricated plate lead or lead-impregnated molded plastic. This type of shielding can be specifically molded for the component to be shielded. Because this shielding is custom-made for a specific component, it provides much more effective shielding than bulk shielding. Several facilities have realized considerable dose savings by using reactor head shields (during refuelings) and steam generator manway shields (for steam generator tube work). By practicing installation on mockups prior to shielding the actual component, shield installation time in the field can be reduced.

The removal and reinstallation of component insulation to permit in-service inspection and testing can also be a fairly dose-intensive job. Providing temporary storage areas for this insulation can reduce the amount of insulation which is misplaced or damaged due to improper storage. Storage of this insulation near the work area will minimize transit time for transporting this insulation and reduce worker doses. Proper labeling

of insulation will facilitate retrieval and reinstallation of the insulation. Component/system flushing or decontamination prior to maintenance of the component or system can greatly reduce area dose rates and result in lower personnel doses. Several facilities are considering decontamination of the entire reactor coolant system. Indian Point 2 performed the first full-scale chemical decontamination of the entire reactor coolant system in 1995 in an attempt to reduce the high containment source term. This high source term has been one of the reasons why the annual doses at Indian Point 2 have been amoung the highest in the country over the past several years. This full system decontamination resulted in an average contact decontamination factor of 7.8 and an estimated dose savings of over 600 person-cSv (person-rem). Robotics, which are playing a larger role every year in facilitating work functions at nuclear power plants, have led to a reduction in the overall doses received by plant personnel. Use of robots to perform such tasks as steam generator tube plugging, sleeving, and eddy current testing in PWRs has led to a tenfold reduction in personnel doses accrued during the performance of these tasks. Robotics have also been used to reduce doses during in-service inspection work, control rod drive changeout, and pipe welding. Mobile robots have been used by many utilities to perform remote surveillance and sampling functions in hostile or high dose environments.

Many facilities have installed remote video cameras with tilt and pan capabilities in various parts of the plant. These cameras are used to observe jobs being performed in high radiation areas. They have also been used for remote area surveillance, thereby minimizing the need for walkdowns in certain parts of the plant. Several plants contacted use powerful zoom cameras attached to telescoping poles for in-service inspections and valve inspections. In many cases, the use of these cameras has precluded the need for the erection of scaffolding. Many plants which have recently replaced their steam generators have used a series of remote closed-circuit video cameras during the replacement project to monitor various job evolutions from low dose areas. The job evolutions recorded on these video cameras will be used as training films for other utilities planning to replace their steam generators. Like the use of remote video cameras, teledosimetry is being used at more and more utilities. The use of teledosimetry permits health physics personnel located in low dose rate areas to accurately monitor the doses of people working in higher dose rate areas, thereby reducing the overall collective dose to perform the job.

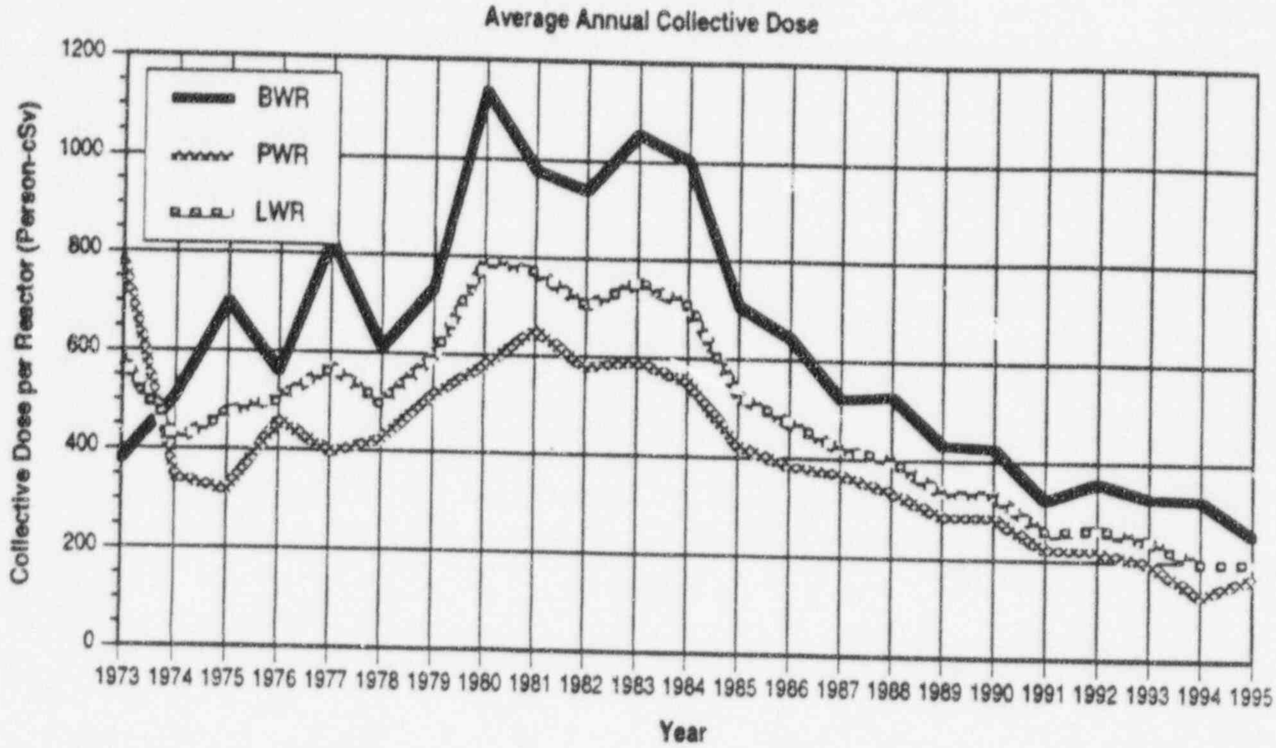
Some other methods of reducing doses during outages are; 1) scheduling jobs to be performed on the same component or in the same area so that they are performed at the same time to eliminate duplication of setup preparations, 2) optimizing work sequences, 3) using skilled workers to perform difficult jobs, 4) providing extensive mockup training using accurate mockups for dose intensive or difficult jobs, 5) minimizing the number of work crew personnel used so that only the number of personnel necessary to perform the job are used, and 6) ensuring cooperation between different groups which may be working together on the same job. Many of the utilities contacted tracked job doses for repetitive jobs performed from one outage to the next. One plant, Oyster Creek, uses a system whereby an exposure tracking number is assigned to each maintenance job performed. Using this number, one can identify the building, elevation, room number, system, and component on which the maintenance was performed. By keeping detailed records of past jobs performed, and by identifying areas for improvement following the completion of each job, licensees will be able to lower job doses by implementing lessons learned from previous jobs.

The preceding paragraphs describe several dose reduction features which can be implemented to reduce doses to plant personnel during plant outages. One way in which overall plant dose rates can be significantly reduced is to reduce the sources of radiation in the plants. The primary source of radiation fields in nuclear power plants is cobalt-60, which is formed as a result of neutron absorption by cobalt-59. Cobalt-59 is the major constituent of Stellite, a hardfacing material used in valve seats, pump journals, and other wear resistant components. Therefore, an effective way to reduce the overall source of radioactivity at nuclear power plants is to reduce the amount of cobalt containing material in contact with the primary coolant system. For plants still in the design stage, this can be accomplished by specifying the use of non- or low Stellite plant components. For operating plants, however, components contributing large amounts of cobalt to the reactor coolant system need to be identified and replaced with components with little or no cobalt content. Several plants contacted have included cobalt content information in the work management system component data so that engineers can identify cobalt reduction opportunities. For some components, non-cobalt replacement materials need to be developed which possess the same wear characteristics as the component to be replaced. Many utilities have already embarked on programs to reduce the sources of cobalt in their plants. These programs include plans for replacing selected valves and piping, control

blades at BWRs, turbine blades, and fuel assembly hardware at PWRs. In an attempt to expedite overall source term reduction, several BWRs have accelerated their programs to replace their existing control blades (which contain cobalt-based pins and rollers) with control blades which contain little or no cobalt. PWRs which have replaced their steam generators in recent years have specified that the tubing in the replacement steam generators be fabricated of low cobalt Inconel 690. As more plants implement such source reduction programs, overall dose rates at LWRs should continue to decline.

In addition to the implementation of ALARA design features, an essential element of a good ALARA program is to have a strong management commitment to maintain plant personnel doses ALARA. Without the support of the corporate office and upper management, it is difficult to operate an effective ALARA program. Performing job planning (including ALARA reviews) well in advance and establishing realistic dose goals are other means of reducing personnel doses. Since most of the collective dose at plants is accrued during outage periods, establishing a detailed fixed outage work scope several months before the outage provides the health physics department with a knowledge of exactly what jobs will be performed during the upcoming outage and allows them adequate time to perform the necessary ALARA job reviews and schedule health physics support and coverage for outage jobs, where needed. As the current generation of LWRs age, plants will be faced with increased maintenance needs. A good ALARA program is necessary to prevent LWR doses from increasing as the maintenance requirements at these plants gradually increase over the years.

Figure 1
Average Collective Dose and Number of Workers per Reactor 1973 – 1995



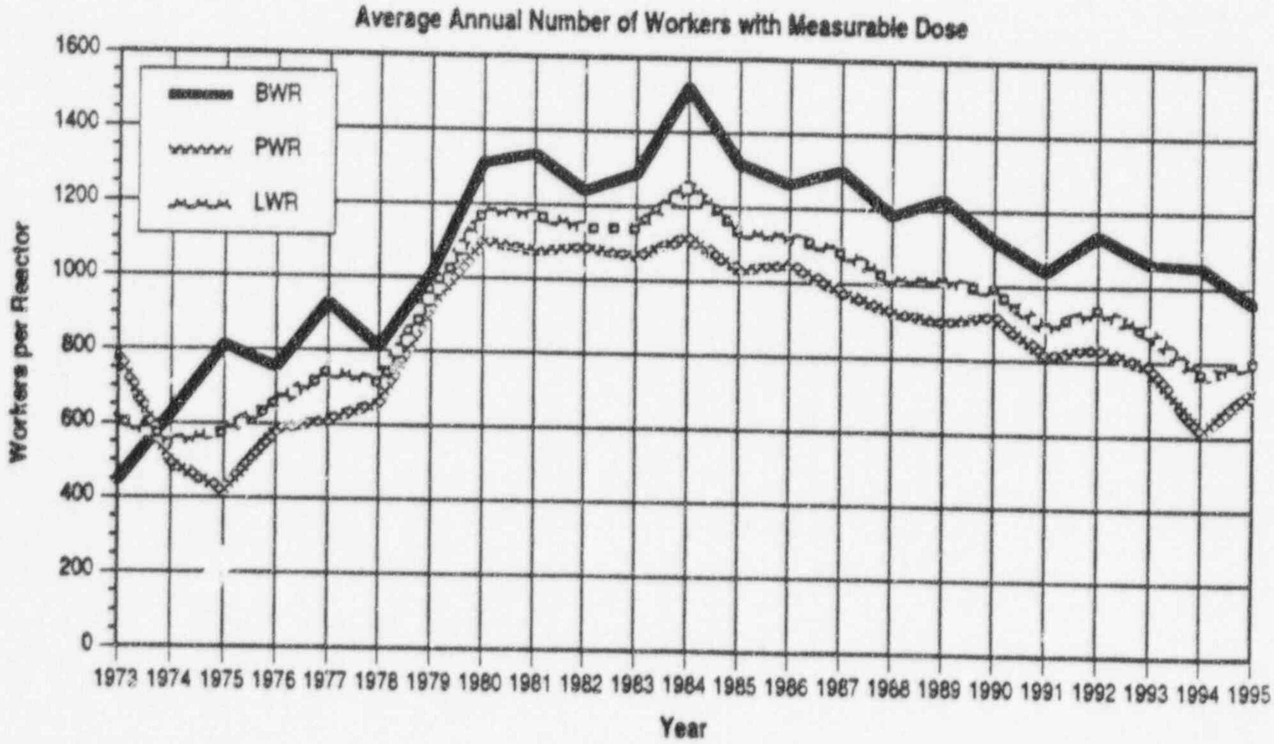
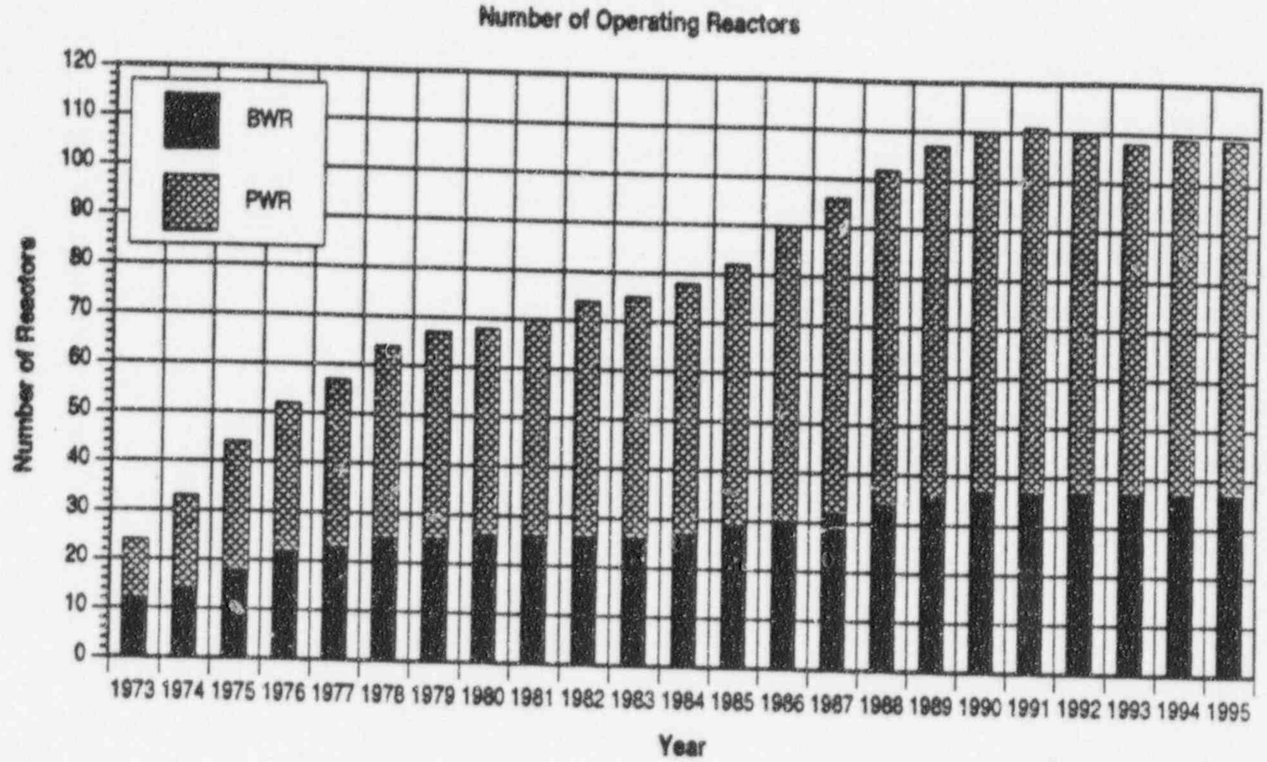


Figure 2
Number of Operating Reactors and Gross Electricity Generated 1973 – 1995



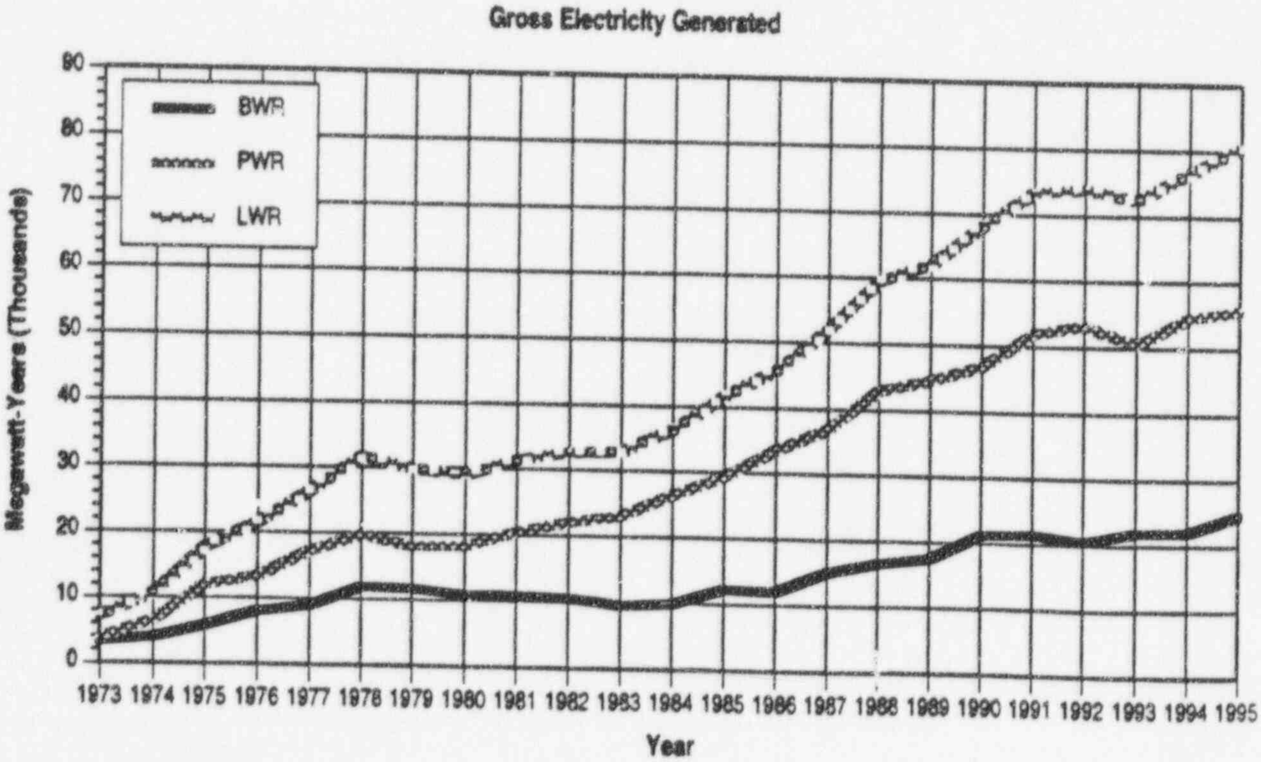
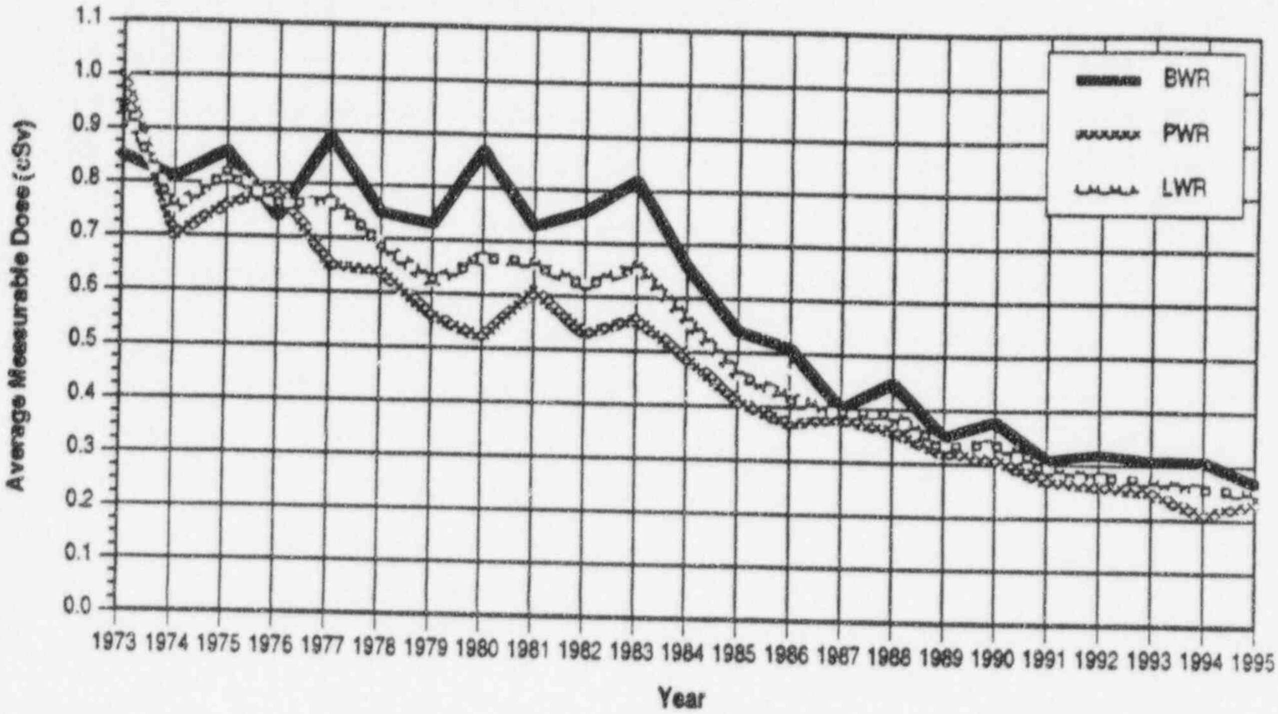


Figure 3
Average Measurable Dose per Worker and Collective Dose per Megawatt-Year 1973 – 1995

Average Measurable Dose per Worker



Collective Dose per Megawatt-Year

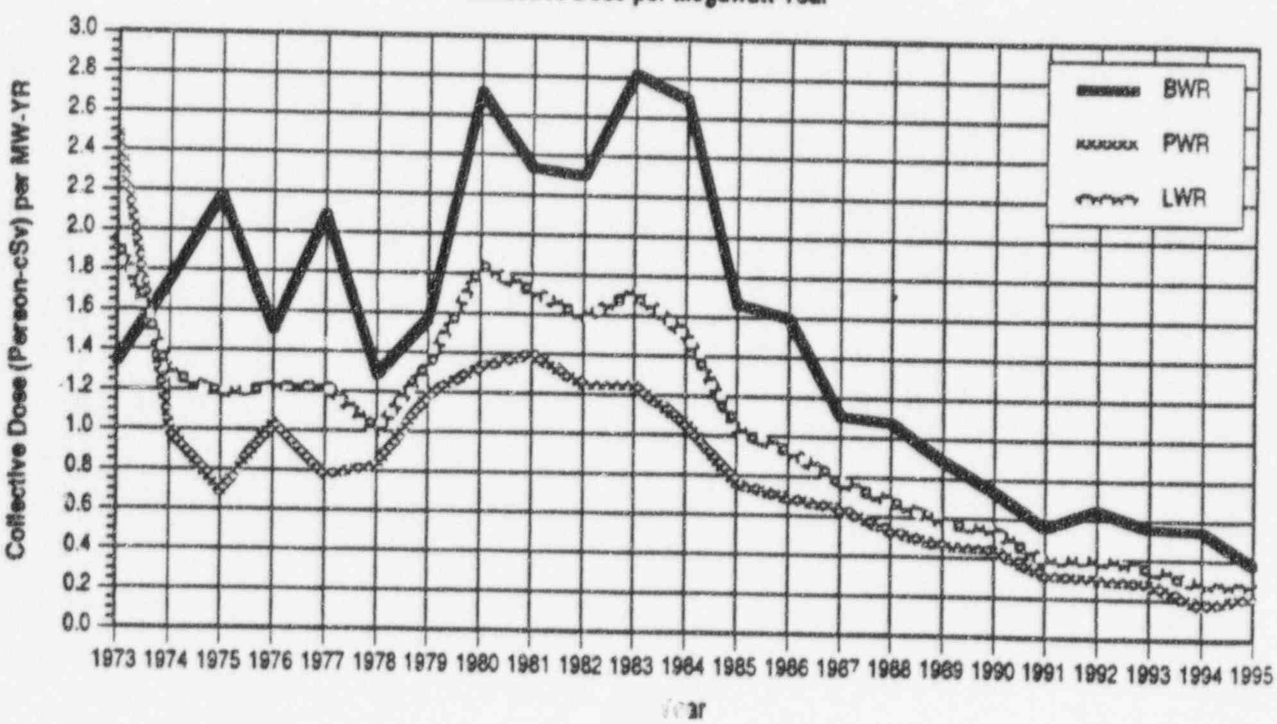


TABLE 1a
ANNUAL WHOLE BODY DOSES AT LICENSED NUCLEAR POWER FACILITIES
CY 1995

PLANT NAME	TYPE	Number of Individuals with Whole Body Doses in the Ranges (cSv or rems) No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-7.00	7.00-12.00	>12.0	TOTAL NUMBER MONITORED	NUMBER WITH MEAS. DOSE	TOTAL COLLECTIVE DOSE (person-cSv, rem)
ARKANSAS 1,2	PWR	1,437	1,244	532	301	107	39	38	-	-	-	-	-	-	-	3,696	2,259	386
BEAVER VALLEY 1,2	PWR	1,221	494	395	350	183	64	69	1	-	-	-	-	-	-	2,757	1,536	453
BIG ROCK POINT	BWR	124	113	25	34	11	8	18	-	-	-	-	-	-	-	329	205	54
BRAIDWOOD 1,2	PWR	1,224	484	324	235	84	15	12	-	-	-	-	-	-	-	2,358	1,134	238
BROWNS FERRY 1,2,3	BWR	2,400	1,285	677	438	115	23	2	-	-	-	-	-	-	-	4,940	2,540	409
BRUNSWICK 1,2	BWR	1,534	1,237	481	473	207	151	108	-	-	-	-	-	-	-	4,191	2,657	683
BYRON 1,2	PWR	1,349	399	291	203	133	50	34	-	-	-	-	-	-	-	2,456	1,107	306
CALLAWAY 1	PWR	958	524	289	189	50	19	11	-	-	-	-	-	-	-	2,020	1,082	187
CALVERT CLIFFS 1,2	PWR	1,607	568	309	200	79	40	7	-	-	-	-	-	-	-	2,810	1,203	235
CATAWBA 1,2	PWR	1,720	753	493	387	129	73	57	-	-	-	-	-	-	-	3,612	1,892	462
CLINTON	BWR	928	368	307	322	138	29	18	-	-	-	-	-	-	-	2,110	1,182	316
COMANCHE PEAK 1,2	PWR	586	465	238	151	70	22	5	-	-	-	-	-	-	-	1,537	951	179
COOK 1,2	PWR	1,159	679	375	174	58	18	8	-	-	-	-	-	-	-	2,469	1,310	203
COOPER STATION	BWR	1,121	494	260	219	87	24	11	-	-	-	-	-	-	-	2,216	1,095	228
CRYSTAL RIVER 3	PWR	851	195	14	-	-	-	-	-	-	-	-	-	-	-	1,060	209	8
DAVIS-BESSE	PWR	790	240	14	2	-	-	-	-	-	-	-	-	-	-	1,046	256	7
DIABLO CANYON 1,2	PWR	1,739	827	327	222	85	32	42	-	-	-	-	-	-	-	3,354	1,615	286
DRESDEN 2,3	BWR	2,106	867	509	455	261	175	215	-	-	-	-	-	-	-	4,588	2,482	875
DUANE ARNOLD	BWR	787	408	241	211	116	96	57	-	-	-	-	-	-	-	1,916	1,129	357
FARLEY 1,2	PWR	769	572	379	342	123	87	75	3	-	-	-	-	-	-	2,350	1,581	483
FERMI 2	BWR	1,440	304	69	16	1	-	-	-	-	-	-	-	-	-	1,830	390	28
FITZPATRICK	BWR	1,188	528	279	210	114	77	41	-	-	-	-	-	-	-	2,437	1,249	327
FORT CALHOUN	PWR	595	258	161	124	62	17	5	-	-	-	-	-	-	-	1,222	627	139
GINNA	PWR	873	374	193	109	35	15	12	-	-	-	-	-	-	-	1,611	738	136
GRAND GULF	BWR	1,138	786	339	253	115	58	38	-	-	-	-	-	-	-	2,727	1,589	342
HADDAM NECK	PWR	785	286	183	190	130	91	124	2	-	-	-	-	-	-	1,791	1,006	442
HARRIS	PWR	912	618	223	146	45	15	21	-	-	-	-	-	-	-	1,980	1,068	174
HATCH 1,2	BWR	970	519	314	285	150	78	107	5	-	-	-	-	-	-	2,428	1,458	488
HOPE CREEK 1	BWR	819	906	384	201	62	19	18	1	-	-	-	-	-	-	2,390	1,571	196
INDIAN POINT 2	PWR	850	801	365	327	186	115	90	6	-	-	-	-	-	-	2,540	1,690	548
INDIAN POINT 3	PWR	907	388	188	54	6	2	-	-	-	-	-	-	-	-	1,545	638	67
KEWAUNEE	PWR	264	148	101	102	34	18	12	-	-	-	-	-	-	-	679	415	109
LASALLE 1,2	BWR	1,195	506	378	343	247	92	57	-	-	-	-	-	-	-	2,818	1,623	512
LIMERICK 1,2	BWR	2,088	899	344	227	59	32	19	1	-	-	-	-	-	-	3,669	1,581	260
MAINE YANKEE	PWR	659	217	226	249	160	96	192	24	3	-	-	-	-	-	1,826	1,167	653
MCGUIRE 1,2	PWR	2,283	793	336	103	24	3	-	-	-	-	-	-	-	-	3,542	1,259	138
MILLSTONE POINT 1	BWR	595	328	175	164	79	53	98	14	1	-	-	-	-	-	1,505	910	620
MILLSTONE POINT 2,3	PWR	1,105	609	326	305	148	99	178	25	1	-	-	-	-	-	2,796	1,691	416
MONTICELLO	BWR	592	68	65	51	14	-	2	-	-	-	-	-	-	-	792	200	44
NINE MILE POINT 1,2	BWR	1,239	794	546	442	246	112	153	11	-	-	-	-	-	-	3,543	2,304	759

TABLE 1a (Continued)
ANNUAL WHOLE BODY DOSES AT LICENSED NUCLEAR POWER FACILITIES
CY 1995

PLANT NAME	TYPE	Number of Individuals with Whole Body Doses in the Ranges (cSv or rems)														TOTAL NUMBER MONI-TORED	NUMBER WITH MEAS. DOSE	TOTAL COLLECTIVE DOSE (person-cSv, rem)
		No Meas. Exposure	Meas <0.10	0.10-0.25	0.25-0.5	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-7.00	7.00-12.00	>12.0			
NORTH ANNA 1,2	PWR	1,373	844	403	287	113	58	37	1	-	-	-	-	-	-	2,824	1,551	387
OCONEE 1,2,3	PWR	1,751	708	477	288	74	19	18	4	-	-	-	-	-	-	3,337	1,586	304
OYSTER CREEK	BWR	538	472	178	88	15	5	3	-	-	-	-	-	-	-	1,299	761	90
PALISADES	PWR	464	403	214	266	140	102	98	7	-	-	-	-	-	-	1,894	1,230	462
PALO VERDE 1,2,3	PWR	1,723	824	398	332	161	83	77	-	-	-	-	-	-	-	3,598	1,875	482
PEACH BOTTOM 2,3	BWR	1,747	983	437	290	120	62	48	-	-	-	-	-	-	-	3,687	1,940	396
PERRY	BWR	1,159	338	194	51	4	-	-	-	-	-	-	-	-	-	1,746	587	64
PILGRIM	BWR	853	325	284	277	224	124	60	-	-	-	-	-	-	-	2,147	1,294	482
POINT BEACH 1,2	PWR	437	171	120	101	78	39	39	-	-	-	-	-	-	-	985	548	190
PRAIRIE ISLAND 1,2	PWR	581	220	119	104	43	12	1	-	-	-	-	-	-	-	1,080	499	107
QUAD CITIES 1,2	BWR	1,213	626	438	392	273	145	164	-	-	-	-	-	-	-	3,254	2,041	738
RIVER BEND 1	BWR	1,522	414	146	83	14	7	3	-	-	-	-	-	-	-	2,189	667	85
ROBINSON 2	PWR	862	492	256	200	75	19	16	-	-	-	-	-	-	-	1,920	1,058	215
SALEM 1,2	PWR	622	689	277	153	47	15	14	-	-	-	-	-	-	-	1,817	1,195	218
SAN ONOFRE 2,3	PWR	3,304	783	448	379	220	62	22	-	-	-	-	-	-	-	5,218	1,914	455
SEABROOK	PWR	1,293	445	243	99	13	-	-	-	-	-	-	-	-	-	2,093	800	102
SEQUOYAH 1,2	PWR	1,684	727	408	272	133	46	33	1	-	-	-	-	-	-	3,302	1,618	358
SOUTH TEXAS 1,2	PWR	1,711	708	372	249	96	41	19	-	-	-	-	-	-	-	3,196	1,485	291
ST. LUCIE 1,2	PWR	1,083	583	366	324	114	65	59	7	-	-	-	-	-	-	2,581	1,498	413
SUMMER 1	PWR	801	217	37	3	-	-	-	-	-	-	-	-	-	-	1,058	257	13
SURRY 1,2	PWR	1,009	957	358	343	113	58	46	8	-	-	-	-	-	-	2,892	1,883	408
SUSQUEHANNA 1,2	BWR	1,569	688	431	336	183	74	61	-	-	-	-	-	-	-	3,342	1,773	476
THREE MILE ISLAND 1	PWR	785	693	273	174	57	22	1	-	-	-	-	-	-	-	2,005	1,220	213
TURKEY POINT 3,4	PWR	1,197	505	328	218	87	17	7	-	-	-	-	-	-	-	2,339	1,142	215
VERMONT YANKEE	BWR	1,254	235	215	191	71	19	6	-	-	-	-	-	-	-	1,991	737	182
VOGTLE 1,2	PWR	853	408	273	169	76	15	14	-	-	-	-	-	-	-	1,808	953	199
WASHINGTON NUCLEAR 2	BWR	1,216	772	290	280	191	104	57	-	-	-	-	-	-	-	2,910	1,694	456
WATERFORD 3	PWR	1,088	629	282	137	28	9	7	-	-	-	-	-	-	-	2,180	1,092	153
WOLF CREEK 1	PWR	957	208	25	8	1	-	-	-	-	-	-	-	-	-	1,199	242	14
ZION 1,2	PWR	1,496	506	302	386	225	161	221	4	-	-	-	-	-	-	3,303	1,807	797
TOTALS: 37 BWRs		31,335	15,264	7,986	6,332	3,117	1,567	1,360	32	1	-	-	-	-	-	66,994	35,659	9,467
TOTALS: 72 PWRs		49,697	23,311	12,259	8,947	3,767	1,769	1,717	93	4	-	-	-	-	-	101,564	51,867	12,207
TOTALS: 109 LWRs		81,032	38,575	20,245	15,279	6,884	3,336	3,077	125	5	-	-	-	-	-	168,558	87,526	21,674

TABLE 1b

ANNUAL WHOLE BODY DOSES AT LICENSED NUCLEAR POWER FACILITIES

FACILITIES NOT IN OPERATION OR IN OPERATION LESS THAN ONE YEAR

CY 1996

PLANT NAME	TYPE	Number of Individuals with Whole Body Doses in the Ranges (cSv or rems)														TOTAL NUMBER MONI-TORED	NUMBER WITH MEAS. DOSE	TOTAL COLLECTIVE DOSE (person-cSv, rem)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.5	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-7.00	7.00-12.00	>12.0			
BELLEFONTE	PWR															-	-	-
DRESDEN 1 *	BWR	Reported with Dresden 2,3																
FORT ST. VRAIN *	HTGR	460	62	52	40	29	15	43	34	3	-	-	-	-	-	738	278	210
HUMBOLDT BAY *	BWR	156	39	3	-	-	-	-	-	-	-	-	-	-	-	198	42	2
INDIAN POINT 1 *	PWR	Reported with Indian Point 2																
LACROSSE *	BWR	80	17	12	2	-	-	-	-	-	-	-	-	-	-	111	31	3
RANCHO SECO *	PWR	177	15	1	-	-	-	-	-	-	-	-	-	-	-	193	16	1
SAN ONOFRE 1*	PWR	Reported with San Onofre 2,3																
THREE MILE ISLAND 2*	PWR	124	109	43	27	9	3	-	-	-	-	-	-	-	-	315	191	2
TROJAN *	PWR	220	48	27	32	19	9	6	-	-	-	-	-	-	-	361	141	44
WATTS BAR 1,2	PWR															-	-	-
YANKEE-ROWE *	PWR															-	-	-
TOTAL REPORTING: 6		1,217	290	138	101	57	27	49	34	3						1,916	699	262

* Indicates plants that are no longer in commercial operation

TABLE 2a
PRESSURIZED WATER REACTORS LISTED IN ASCENDING ORDER OF COLLECTIVE DOSE PER REACTOR
1995

Site Name	Collective Dose per Reactor (rems or cSv)	Collective Dose per Site (rems or cSv)	Average Dose per Worker (rems or cSv)	Collective Dose per MW-Yr (rems or cSv)	CR
DAVIS-BESSE	7	7	0.03	0.0	0.00
CRYSTAL RIVER 3	8	8	0.04	0.0	0.00
SUMMER 1	13	13	0.05	0.0	0.00
WOLF CREEK 1	14	14	0.06	0.0	0.00
PRAIRIE ISLAND 1,2	54	107	0.21	0.1	0.00
INDIAN POINT 3	67	67	0.11	0.4	0.00
MCGUIRE 1,2	69	138	0.11	0.1	0.00
COMANCHE PEAK 1,2	90	179	0.19	0.1	0.00
POINT BEACH 1,2	95	190	0.35	0.2	0.04
VOGTLE 1,2	100	199	0.21	0.1	0.00
OCONEE 1,2,3	101	304	0.19	0.1	0.09
COOK 1,2	102	203	0.15	0.1	0.00
SEABROOK	102	102	0.13	0.1	0.00
TURKEY POINT 3,4	108	215	0.19	0.2	0.00
KEWAUNEE	109	109	0.26	0.2	0.00
SALEM 1,2	109	218	0.18	0.4	0.02
CALVERT CLIFFS 1,2	118	235	0.20	0.2	0.00
BRAIDWOOD 1,2	118	236	0.21	0.1	0.01
GINNA	136	136	0.18	0.3	0.06
FORT CALHOUN	139	139	0.22	0.3	0.00
DIABLO CANYON 1,2	143	286	0.18	0.1	0.06
SOUTH TEXAS 1,2	146	291	0.20	0.1	0.00
BYRON 1,2	153	306	0.28	0.2	0.06
WATERFORD 3	153	153	0.14	0.2	0.00
PALO VERDE 1,2,3	161	482	0.26	0.1	0.05
HARRIS	174	174	0.16	0.2	0.01
SEQUOYAH 1,2	179	358	0.22	0.2	0.02
NORTH ANNA 1,2	184	367	0.24	0.2	0.05
CALLAWAY 1	187	187	0.18	0.2	0.00
ARKANSAS 1,2	193	386	0.17	0.3	0.03
SURRY 1,2	203	406	0.22	0.3	0.10
ST. LUCIE 1,2	207	413	0.28	0.3	0.07
MILLSTONE POINT 2,3	208	416	0.25	0.3	0.51
THREE MILE ISLAND 1	213	213	0.17	0.3	0.00
ROBINSON 2	215	215	0.20	0.3	0.00
BEAVER VALLEY 1,2	227	453	0.29	0.3	0.02
SAN ONOFRE 2,3	228	455	0.24	0.3	0.00
CATAWBA 1,2	231	462	0.24	0.2	0.03
FARLEY 1,2	232	463	0.29	0.4	0.08
ZION 1,2	399	797	0.44	0.5	0.15
HADDAM NECK	442	442	0.44	1.0	0.14
PALISADES	462	462	0.38	0.8	0.10
INDIAN POINT 2	548	548	0.32	0.9	0.07
MAINE YANKEE	653	653	0.56	27.7	0.26
Number of Reactors: 72	**170**	**12,207**	**0.24**	**0.2**	

TABLE 2b
PRESSURIZED WATER REACTORS LISTED IN ASCENDING ORDER OF THREE YEAR AVERAGE COLLECTIVE DOSE PER REACTOR
1993 - 1995

Site Name	Collective Dose Per Reactor (Person-rem or Person-cSv) 1993	1994	1995	Three Year Average Collective Dose Per Reactor
PRAIRIE ISLAND 1,2	53	55	54	54
INDIAN POINT 3	60	58	67	62
SEABROOK	6	113	102	74
COMANCHE PEAK 1,2	109	45	90	76
POINT BEACH 1,2	93	85	95	91
KEWAUNEE	106	72	109	96
SOUTH TEXAS 1,2	126	24	146	98
CRYSTAL RIVER 3	60	228	8	99
FORT CALHOUN	157	23	139	106
OCONEE 1,2,3	79	179	101	120
WATERFORD 3	15	191	153	120
COOK 1,2	22	240	102	121
VOGTLE 1,2	184	109	100	131
BRAIDWOOD 1,2	137	149	118	135
SALEM 1,2	204	94	109	136
ARKANSAS 1,2	134	86	193	138
CALLAWAY 1	225	14	187	142
HARRIS	31	222	174	142
WOLF CREEK 1	183	235	14	144
THREE MILE ISLAND 1	206	40	213	153
GINNA	193	138	136	156
TURKEY POINT 3,4	138	238	108	161
DAVIS-BESSE	348	144	7	166
MCGUIRE 1,2	232	199	69	166
BYRON 1,2	216	140	153	170
SEQUOYAH 1,2	186	146	179	170
PALO VERDE 1,2,3	197	154	161	171
FARLEY 1,2	167	125	232	174
CATAWBA 1,2	198	104	231	178
CALVERT CLIFFS 1,2	203	227	118	182
BEAVER VALLEY 1,2	311	22	227	186
DIABLO CANYON 1,2	141	295	143	193
MILLSTONE POINT 2,3	279	94	208	194
SURRY 1,2	192	189	203	195
ROBINSON 2	337	63	215	205
SAN ONOFRE 2,3	384	16	228	209
SUMMER 1	297	374	13	228
ST. LUCIE 1,2	246	253	207	235
NORTH ANNA 1,2	454	97	184	245
PALISADES	289	60	462*	270
ZION 1,2	322	153	399*	291
HADDAM NECK	408	135	442*	328
MAINE YANKEE	377	84	653*	371
INDIAN POINT 2	675	48	548*	424
Annual PWRAverages:	**199**	**133**	**170**	
Total Reactors Included:	**71**	**72**	**72**	

* Indicates high dose-per-reactor sites for 1995

TABLE 3a
BOILING WATER REACTORS LISTED IN ASCENDING ORDER OF COLLECTIVE DOSE PER REACTOR
1995

Site Name	Collective Dose per Reactor (rems or cSv)	Collective Dose per Site (rems or cSv)	Average Dose per Worker (rems or cSv)	Collective Dose per MW-Yr (rems or cSv)	CR
FERMI 2	28	28	0.07	0.0	0.00
MONTICELLO	44	44	0.22	0.1	0.00
BIG ROCK POINT	54	54	0.26	0.9	0.18
PERRY	64	64	0.11	0.1	0.00
RIVER BEND 1	85	85	0.13	0.1	0.00
OYSTER CREEK	90	90	0.12	0.1	0.00
LIMERICK 1,2	130	260	0.16	0.1	0.02
BROWNS FERRY 1,2,3	136	409	0.16	0.4	0.00
VERMONT YANKEE	182	182	0.25	0.4	0.00
HOPE CREEK 1	196	196	0.12	0.2	0.07
PEACH BOTTOM 2,3	199	398	0.21	0.2	0.03
COOPER STATION	228	228	0.21	0.5	0.02
SUSQUEHANNA 1,2	238	476	0.27	0.3	0.05
HATCH 1,2	244	488	0.33	0.4	0.10
LASALLE 1,2	256	512	0.32	0.3	0.02
CLINTON	316	316	0.27	0.4	0.01
FITZPATRICK	327	327	0.26	0.6	0.03
BRUNSWICK 1,2	342	683	0.26	0.5	0.00
GRAND GULF	342	342	0.22	0.4	0.01
DUANE ARNOLD	357	357	0.32	0.8	0.01
QUAD CITIES 1,2	368	736	0.36	0.7	0.01
NINE MILE POINT 1,2	380	759	0.33	0.5	0.12
DRESDEN 2,3	438	875	0.35	1.4	0.07
WASHINGTON NUCLEAR 2	456	456	0.27	0.6	0.03
PILGRIM	482	482	0.37	0.9	0.00
MILLSTONE POINT 1	620	620	0.68	1.2	0.16
Number of Reactors: **37**	**256**	**9,467**	**0.27**	**0.4**	

TABLE 3b
BOILING WATER REACTORS LISTED IN ASCENDING ORDER OF THREE YEAR AVERAGE COLLECTIVE DOSE PER REACTOR 1993 - 1995

Site Name	Collective Dose Per Reactor (Person-rem or Person-cSv) 1993	1994	1995	Three Year Average Collective Dose Per Reactor
FERMI 2	35	213	28	92
BIG ROCK POINT	152	119	54	108
LIMERICK 1,2	109	138	130	125
VERMONT YANKEE	217	38	182	146
HOPE CREEK 1	98	326	196	207
SUSQUEHANNA 1,2	168	221	238	209
COOPER STATION	391	79	228	233
BROWNS FERRY 1,2,3	290	285	136	237
GRAND GULF	332	56	342	243
PEACH BOTTOM 2,3	276	290	199	255
NINE MILE POINT 1,2	317	75	380*	257
RIVER BEND 1	180	519	85	261
CLINTON	498	63	316	292
FITZPATRICK	232	322	327	294
DUANE ARNOLD	407	120	357	295
MONTICELLO	494	395	44	311
HATCH 1,2	335	432	244	337
PERRY	278	691	64	344
LASALLE 1,2	427	363	256	349
MILLSTONE POINT 1	81	391	620*	364
PILGRIM	435	200	482*	372
BRUNSWICK 1,2	436	500	342	426
OYSTER CREEK	416	844	90	450
QUAD CITIES 1,2	425	564	368	452
DRESDEN 2,3	828	417	438*	561
WASHINGTON NUCLEAR 2	469	866	456*	597
Annual BWRAverages:	330	327	256	
Total Reactors Included:	37	37	37	

* Indicates high dose-per-reactor sites for 1995

TABLE 4a
ACTIVITIES CONTRIBUTING TO HIGH COLLECTIVE
DOSES AT SELECTED PLANTS IN 1995

BWR's with High Collective Doses

Millstone Point 1 (620 rem)

Outage dose/duration: 500 rem/59 days
Average daily outage dose: 8.47 rem/day
Average daily operating dose: N/A

- Weld repair (drywell) (152.5 rem)
- ISI (in-service inspection) (drywell) (75.5 rem)
- Hanger work (drywell) (28.6 rem)
- Insulation removal/replacement (drywell) (26.4 rem)
- Staging (drywell) (24.9 rem)
- Refueling (18.9 rem)
- Cleanup valve replacement (drywell) (13.7 rem)
- Shielding (drywell) (10.9 rem)

Dresden 2, 3 (876 rem)

Outage dose/duration (U2): 685 rem/210 days
Outage dose/duration (U3): 23 rem/127 days
Average daily outage dose(U2): 3.26 rem/day
Average daily outage dose(U3): 0.18 rem/day
Average daily operating dose (U2+3): 0.42 rem/day

Unit 2

- RWCU (reactor water cleanup system) pipe and heat exchanger replacement (91.1 rem)
- Valve work/replacement (Total of 87.6 rem)
  - Two 18" MOVs (motor-operated valves) replaced - 52.2 rem
  - MSIV (main steam isolation valve) repair - 18.2 rem
  - Electromagnetic and safety relief valve repair - 17.2 rem
- ISI (in-service inspection) in drywell (70.4 rem)
- Shielding (Total of 47.1 rem)
  - Perm. recirculation ring header shielding installation - 31.2 rem
  - Temporary drywell shielding installation/removal - 15.9 rem
- Outage activities support (Total of 46.7 rem)
  - HP support - 29.2 rem
  - Operations support - 17.4 rem
- Chemical decontamination (recirc and RWCU) (23.7 rem)
- Installed instrument caps on LPCI (low pressure coolant injection) recirc. risers for injecting decon solution (13.7 rem)
- Inspect/clean main condenser water boxes (11.8 rem)
- Insulation removal/replacement in drywell (10.5 rem)
- CRD (control rod drive) removal/installation (10.3 rem)
- Unclog drain line at bottom of reactor vessel (9.4 rem)

Pilgrim (482 rem)

Outage dose/duration: 410 rem/73 days
Average daily outage dose: 5.62 rem/day
Average daily operating dose: 0.25 rem/day

- ISI (in-service inspection) (includes doses due to scaffolding and insulation) (74.5 rem)
- Refueling (Total of 69 rem)
  - Reactor head removal/replacement, cavity decon. - 44.9 rem
- Modifications (63.9 rem)
- MOV (motor-operated valve) repair/replacement (49.5 rem)
- Corrective maintenance (43.5 rem)
- Health physics support (22.6 rem)
- Miscellaneous support (19.1 rem)
- Shielding (15.6 rem)
- Operations support (15.5 rem)
- Preventive maintenance (13 rem)
- Decontamination (6.8 rem)

WNP 2 (456 rem)

Outage dose/duration: 297 rem/49 days
Average daily outage dose: 6.06 rem/day
Average daily operating dose: 0.5 rem/day

- Shielding (drywell) installation/removal (30 rem)
- Reactor disassembly/reassembly (Total of 28.5 rem)
  - Reactor reassembly - 14.3 rem
  - Reactor disassembly - 10.3 rem
- Chemical decontamination of RWCU (reactor water cleanup system) (20.6 rem)
- ISI (in-service inspection) for erosion/corrosion (19.5 rem)
- Main steam relief valve removal/replacement (14.8 rem)

TABLE 4a (Continued)
ACTIVITIES CONTRIBUTING TO HIGH COLLECTIVE
DOSES AT SELECTED PLANTS IN 1995

BWR's with High Collective Doses

Nine Mile Pt 1, 2 (759 rem)

Outage dose/duration (U1): 312 rem/56 days
Outage dose/duration (U2): 325 rem/55 days
Average daily outage dose (U1): 5.91 rem/day
Average daily outage dose (U2): 5.57 rem/day
Average daily operating dose : N/A

Unit 1

-ISI (in-service inspection) (94.4 rem)
-Valve work/replacement (Total of 62.2 rem)
  EC (emergency cooling) check valve repair - 23.6 rem
  Drywell Limitorque valve work - 19.4 rem
  Modifications to pressure relief valves - 7.3 rem
-CRD (control rod drive) exchanges (16.8 rem)
-Health physics surveys and support (16 rem)
-Refueling (including reactor head removal/replacement, ISI, decon, fuel sipping) (12.3 rem)
-RRP cooler replacement (11.5 rem)
-Operations (drywell) (9.6 rem)
-Shielding (drywell) (8.9 rem)
-Insulation work (8.2 rem)
-Housekeeping (drywell) (5.1 rem)

Unit 2

-ISI (Total of 88 rem)
  Inside bioshield - 43.8 rem
  Outside bioshield - 34.5 rem
-Snubber related work (Total of 47.4 rem)
  Snubber reduction modifications - 26.1 rem
  Snubber functional testing - 21.3 rem
-Valve work/replacement (Total of 38.5 rem)
  MOV (motor-operating valve) testing - 17.2 rem
  SRV (safety relief valve) change out - 9.7 rem
-Refueling (Total of 17.7 rem)
  Reactor head removal/replacement - 11.5 rem
  Operations and support - 6.2 rem
-CRD exchanges (12.5 rem)
-Health physics surveys and job coverage (10.9 rem)
-Temporary shielding (7.1 rem)
-Neutron monitor replacement/repair (7 rem)
-Decontamination (drywell) (5.7 rem)

TABLE 4b
ACTIVITIES CONTRIBUTING TO HIGH COLLECTIVE DOSES AT SELECTED PLANTS IN 1995

PWR's with High Collective Doses

Maine Yankee (653 rem)

Outage dose/duration*: 667 rem/358 days
Average daily outage dose: 1.86 rem/day
Average daily operating dose: N/A
*Outage extended from 1/23/95 to 1/16/96

- Steam generator related work (Total of 272.1 rem)
  - Tube sleeving (17,000 tubes sleeved) - 142.3 rem
  - ECT (eddy current testing) - 83.2 rem
  - Sludge lancing and inspections - 38 rem
  - Manual hard rolling - 7.4 rem
- RCP (Reactor Coolant Pump) work (Total of 90.3 rem)
  - Rotating assembly replacement - 45.3 rem
  - Motor removal/installation - 21 rem
  - Seal replacement - 13.8 rem
- Outage support (Total of 90 rem)
  - Rad Controls outage support - 69.2 rem
- Valve work (Total of 59.6 rem)
  - Valve and SRV (safety relief valve) maintenance - 38.2 rem
  - MOV (motor-operated valve) testing and repair - 21.4 rem
- Decontamination (Total of 48.6 rem)
  - Reactor coolant system loop - 32.4 rem
- Refueling Operation (Total of 42.3 rem)
  - Reactor head removal/replacement - 29.2 rem
  - CEA (control element assembly) shaft replacement - 8.3 rem
- ISI (in-service inspection) (22.1 rem)
- Pressurizer inconel inspection (14.4 rem)
- Temporary shielding (9 rem)

Indian Point 2 (548 rem)*

Outage dose/duration: 499.9 rem/122 days
Average daily outage dose: 4.1 rem/day
Average daily operating dose: 0.20 rem/day
*Indian Point performed a full system decontamination in 1995

- Modifications (Total of 67.8 rem)
  - Steam generator nozzle ring installation - 16.3 rem
  - Reactor vessel head split pin repair - 14.9 rem
- Refueling (55.7 rem)
- Maintenance (51.2 rem)
- Radiation protection (47.3 rem)
- Radwaste (40.4 rem)
- Steam generator work (Total of 36.6 rem)
  - Primary side (eddy current testing) - 32.5 rem
  - Secondary side (sludge lancing) - 4.1 rem
- Scaffolding and insulation installation/removal (34 rem)
- Supervisory plant tours (33.1 rem)
- ISI (in-service inspection) (23.7 rem)
- Full system decontamination (21 rem)
- RCP (Reactor Coolant Pump) work (20 rem)
- Operations (20.3 rem)
- MOV (motor-operated valve) work (16.5 rem)
- Services (lighting, air) (10.6 rem)

Palisades (462 rem)

Outage dose/duration: 421 rem/93 days
Average daily outage dose: 4.53 rem/day
Average daily operating dose: 0.15 rem/day

- Refueling (Total of 68.8 rem)
  - Reactor head removal/replacement - 50.8 rem
  - Fuel movement - 6.3 rem
- ISI (in-service inspection) (Total of 55.2 rem)
  - Inconel weld inspections (26.1 rem)
- Valve work (36.5 rem)
- Insulation removal/replacement (34.6 rem)
- Steam generator work (Total of 32 rem)
  - Nozzle dam installation/removal - 12.2 rem
  - ECT (eddy current testing) - 8.3 rem
- Scaffolding installation/removal (30.6 rem)
- Health Physics surveys (19.2 rem)
- Mechanical maintenance (15.4 rem)
- Pump work (11.1 rem)
- Ventilation system maintenance (10.5 rem)
- Decontamination and cleanup (9.5 rem)
- Temporary shielding (7.3 rem)
- Electrical maintenance (7.1 rem)

TABLE 4b (Continued)
ACTIVITIES CONTRIBUTING TO HIGH COLLECTIVE
DOSES AT SELECTED PLANTS IN 1995

PWR's with High Collective Doses

Zion 1, 2 (797 rem)

Outage dose/duration (U1): 480 rem/98 days
Outage dose/duration (U2): 167 rem/103 days
Average daily outage dose (U1): 4.66 rem/day
Average daily outage dose (U2): 1.62/day
Average daily operating dose: N/A

UNIT 1

-Steam generator work (133.7 rem)
-Valve work (74.1 rem)
-Scaffolding installation/removal (36.6 rem)
-ISI (in-service inspection) (34.4 rem)
-Radiation protection support (30.6 rem)
-Refueling (Total of 24.3 rem)
  Reactor head disassembly/assembly - 21 rem
  Fuel shuffle and inspection - 3.3 rem
-Snubber/hanger work (23.5 rem)
-Shielding (15.9 rem)
-Flange work (15.4 rem)
-Reactor coolant pump work (11.2 rem)
-Operating department routines (10.2 rem)

Unit 2

-Steam generator work (42.7 rem)
-Valve work (24.6 rem)
-Scaffolding installation/removal (20.8 rem)
-ISI (17.7 rem)
-Radiation protection support (15.9 rem)
-Refueling (Total of 15.9 rem)
  Reactor head disassembly/assembly - 12 rem
  Fuel shuffle and inspection - 3.9 rem
-Snubber/hanger work (13.9 rem)
-Shielding (5.7 rem)
-Reactor coolant pump work (5 rem)

Haddam Neck (442 rem*)

Outage dose/duration: 454 rem/81 days
Average daily outage dose: 5.6 rem/day
Average daily operating dose: 0.07 rem/day
*442 rem total year dose measured by TLD,
454 rem outage dose measured by pocket ion chamber

-Steam generator related work (Total of 121.8 rem)
  Eddy current and ultrasonic testing - 42 rem
  Tube plugging and rerolls - 31.5 rem
  Equipment setup/teardown - 14.4 rem
  Remove/install manways - 11.2 rem
  Install/remove nozzle covers - 6.6 rem
  HP surveys/job coverage - 5.7 rem
-Valve related work (Total of 68.5 rem)
  MOV (motor-operated valve) testing and repairs -26.3 rem
  Misc. valve repair - 22.2 rem
  Gate valve pressure locking fix - 20 rem
-Inspection and repair of service water system piping (52.3 rem)
-ISI (in-service inspection) (Total of 45.5 rem)
  UT (ultrasonic tests)/liquid penetrant exams - 16.5 rem
  Insulation removal/replacement - 10.1 rem
  Scaffolding installation/removal - 6.4 rem
-Refueling (40.6 rem)
-Operations (21.3 rem)
-HP coverage (19.2 rem)
-Facilities and waste management (8.8 rem)
-Shielding (7.1 rem)
-RCP (Reactor Coolant Pump) seal replacement (5.4 rem)

of 753 person-cSv (person-rem) per reactor (1983 is the year when the LWR average dose per unit last peaked). In this same time span, the average measurable dose per worker for LWRs has dropped by more than half, from 0.66 rem in 1983 to 0.25 rem in 1995.

As part of a separate memorandum from the Emergency Preparedness and Radiation Protection Branch, copies of the attached report have been sent to the regional HP management, the Office for Analysis & Evaluation of Operational Data, the Office of Public Affairs, the Office of Research, the Public Document Room, and individuals in the nuclear industry who have expressed an interest in this report in the past.

This report was compiled by Charles Hinson, NRR, NRC, with the assistance of our contractor, SAIC, which supplied some of the data. Any questions concerning the content of this report should be directed to Charles Hinson at (301) 415-1845.

Attachment: As stated

cc: L. Callan, EDO
H. Thompson Jr., DEDR
R. Zimmerman, NRR
A. Thadani, NRR
T. Martin, NRR
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